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ROUTINES AND FIRMS’ HSE BEHAVIOUR

The cases of European and North African oil refineries

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SPRU – Science and Technology Policy Research
UNIVERSITY OF SUSSEX

February 2005
I hereby declare that this thesis has not been submitted, either in the same or different form, to this or any other University for a degree.
I thank Pr Frans Berkhout, my supervisor, for his encouragement and his helpful advice throughout the process of research and writing.

I am grateful to those who agreed to be interviewed for this research and who provided essential information, notably for the co-operation and hospitality of Mr Zerarka from Naftec and Mr Laraqui from Samir, and for the help of Steve Sorrell in the design of the empirical framework.

For their invaluable support, I also want to thank my parents, who will be happy to hear that I may not be a student anymore.

Finally, for having shared their otherness with me, I wish to thank the invaluable friends I met along the way, notably from Algeria, England, Germany, Greece, Italy, and Spain. They contributed to make this thesis both an intellectual and a human adventure. A very special thanks to Müge for her precious contribution towards the end of the process.
ROUTINES AND FIRMS’ HSE BEHAVIOUR

The cases of European and North African oil refineries
SUMMARY

This thesis investigates the extent to which the evolutionary concept of “routine” can provide a greater understanding of how firms address health, safety, and environmental issues (HSE). Such an improved understanding is needed to shed light on the differences between firms’ attitude and strategies towards HSE issues, as well as to design more efficient HSE policies. Indeed, by identifying mechanisms (HSE routines) that contribute to improve firms’ HSE performance, policies can be designed to trigger lock-out from unsustainable production trajectories. This is done by defining the concept of routine and by identifying its key properties: Action vs. representation, Repetition & persistence, Context dependence to HSE regulatory systems. Then, a methodology is designed to study the HSE behaviour of oil refineries located in four European and North African countries in which different levels of pressures are exerted by the domestic HSE regulatory system.

Two HSE routines are identified: the HSE management routine and the investment decision-making routine. To do so, an analytical framework is designed to study whether the identified HSE mechanisms are used by firms to address HSE issues, and to investigate the extent to which they correspond to routinised patterns of activity. Finally, the identified HSE routines are used to compare the HSE behaviour of firms operating in European and North African countries. Routines and factors external to the firm inhibiting improvements in its HSE performance are brought to the fore, such as the key role played by HSE regulatory systems and notably by the European one, whose specifications on petroleum products are shown to affect all the firms studied in the empirical analysis.
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## Glossary

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Full Form</th>
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<tbody>
<tr>
<td>AD</td>
<td>Algerian Dinar</td>
</tr>
<tr>
<td>ADEME</td>
<td>Agence de l’Environnement et de la Maîtrise de l’Énergie</td>
</tr>
<tr>
<td>ADL</td>
<td>Arthur D. Little</td>
</tr>
<tr>
<td>AFD</td>
<td>Air Framework Directive</td>
</tr>
<tr>
<td>API</td>
<td>American Petroleum Institute</td>
</tr>
<tr>
<td>BAT</td>
<td>Best Available Technique</td>
</tr>
<tr>
<td>BATNEEC</td>
<td>Best Available Technology Not Entailing Excessive Costs</td>
</tr>
<tr>
<td>BIP</td>
<td>Bulletin de l’Industrie Pétrolière</td>
</tr>
<tr>
<td>BOD</td>
<td>Biological Oxygen Demand</td>
</tr>
<tr>
<td>CBA</td>
<td>Cost Benefit Analysis</td>
</tr>
<tr>
<td>CFDD</td>
<td>Commission Francaise du Développement Durable</td>
</tr>
<tr>
<td>CHP</td>
<td>Combined Heat and Power</td>
</tr>
<tr>
<td>COD</td>
<td>Chemical Oxygen Demand</td>
</tr>
<tr>
<td>Concawe</td>
<td>European association for HSE in refining &amp; distribution</td>
</tr>
<tr>
<td>CPDP</td>
<td>Comité Professionnel du Pétrole</td>
</tr>
<tr>
<td>CSR</td>
<td>Corporate Social Responsibility</td>
</tr>
<tr>
<td>DEFRA</td>
<td>Department for the Environment, Food and Rural Affairs</td>
</tr>
<tr>
<td>DHYCA</td>
<td>Direction des Hydrocarbures</td>
</tr>
<tr>
<td>DRIRE</td>
<td>Direction Régionale de l’Industrie et de l’Environnement</td>
</tr>
<tr>
<td>DNV</td>
<td>Det Norske Veritas</td>
</tr>
<tr>
<td>DSP</td>
<td>Department Strategy and Planning</td>
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<tr>
<td>E&amp;P</td>
<td>Exploration and Production</td>
</tr>
<tr>
<td>EASH</td>
<td>European Agency for Safety and Health</td>
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<td>EC</td>
<td>European Commission</td>
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<td>EEA</td>
<td>European Environment Agency</td>
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<td>EFTA</td>
<td>European Free Trade Association</td>
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<td>EIA</td>
<td>Environmental Impact Assessment</td>
</tr>
<tr>
<td>EIONET</td>
<td>European environment information and observation network</td>
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<tr>
<td>EMAS</td>
<td>Environmental Management System</td>
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<tr>
<td>EMP</td>
<td>Euro-Mediterranean Partnership</td>
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<tr>
<td>ENSMP</td>
<td>École Nationale Supérieure des Moteurs et des Pétroles</td>
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<td>ETS</td>
<td>Effluent Treatment System</td>
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<td>EU</td>
<td>European Union</td>
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<td>EUROPIA</td>
<td>European oil refining and marketing industry</td>
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<tr>
<td>FCCU</td>
<td>Fluidised Catalytic Cracking Unit</td>
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<tr>
<td>FODEP</td>
<td>Fonds de Dépollution Industrielle</td>
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<tr>
<td>FR</td>
<td>French franc</td>
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<tr>
<td>GESIP</td>
<td>Groupe d’Etude de Sécurité des industries pétrolières</td>
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<tr>
<td>GHGs</td>
<td>Green House Gases</td>
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<td>GTZ</td>
<td>German aid agency</td>
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<td>HAZIP</td>
<td>Hazard Identification Procedure</td>
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<td>HAZOP</td>
<td>Hazard and Operability Study</td>
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<td>HDS</td>
<td>Hydro-desulphurisation</td>
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<td>HFO</td>
<td>Heavy Fuel Oil</td>
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<td>HSC</td>
<td>Health and Safety Committee</td>
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<tr>
<td>Acronym</td>
<td>Description</td>
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<tr>
<td>HSE</td>
<td>Health Safety Environment</td>
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<tr>
<td>IAP</td>
<td>Institut Algérien du Pétrole</td>
</tr>
<tr>
<td>ICC</td>
<td>International Chamber of Commerce</td>
</tr>
<tr>
<td>IERS</td>
<td>International Environment Rating Systems</td>
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<tr>
<td>IFEN</td>
<td>Institut Français de l’Environnement</td>
</tr>
<tr>
<td>IFP</td>
<td>Institut Français du Pétrole</td>
</tr>
<tr>
<td>IGCC</td>
<td>Integrated Gasification and Combined Cycle</td>
</tr>
<tr>
<td>INERIS</td>
<td>Institut National d’Étude des Risques Industriels et de la Sécurité</td>
</tr>
<tr>
<td>IPC</td>
<td>Integrated Pollution Control</td>
</tr>
<tr>
<td>IRR</td>
<td>Investment Rate of Return</td>
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<tr>
<td>ISRS</td>
<td>International Safety Rating System</td>
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<tr>
<td>LCA</td>
<td>Life Cycle Analysis</td>
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<tr>
<td>LPG</td>
<td>Liquefied Petroleum Gas</td>
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<tr>
<td>MATE</td>
<td>Ministère de l’Environnement et de l’Aménagement du Territoire</td>
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<tr>
<td>MDH</td>
<td>Moroccan Dirham</td>
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<tr>
<td>MEDD</td>
<td>Ministère de l’Écologie et du Développement Durable</td>
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<td>MES</td>
<td>Suspended Matters</td>
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<tr>
<td>METAP</td>
<td>Mediterranean Environmental Technical Assistance Programme</td>
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<tr>
<td>MF</td>
<td>Million Francs</td>
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<tr>
<td>MPCs</td>
<td>Mediterranean Partner Countries</td>
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<tr>
<td>MTBE</td>
<td>Methyl Tertiary-Butyl Ether</td>
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<tr>
<td>NAFTAL</td>
<td>Algerian company for the marketing and distribution of petroleum products</td>
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<tr>
<td>OGI</td>
<td>Oil &amp; Gas Journal</td>
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<tr>
<td>OHS</td>
<td>Occupational Health and Safety</td>
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<td>OSHA</td>
<td>Occupational Health and Safety Agency</td>
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<tr>
<td>PACA</td>
<td>Provence-Alpes-Côte d’Azur</td>
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<tr>
<td>POI</td>
<td>Plan d’Opération Interne</td>
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<td>PPI</td>
<td>Plan Particulier d’Intervention</td>
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<tr>
<td>R&amp;D</td>
<td>Research and Development</td>
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<tr>
<td>RCEP</td>
<td>Royal Commission on Environment and Pollution</td>
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<tr>
<td>RFG</td>
<td>Refinery Fuel Gas</td>
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<td>RFO</td>
<td>Refinery Fuel Oil</td>
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<td>SAMIR</td>
<td>Société Anonyme Marocaine d’Industrie de Raffinage</td>
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<td>SHE</td>
<td>Safety Health Environment</td>
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<td>SMEs</td>
<td>Small and Medium size Enterprises</td>
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<td>SOP</td>
<td>Standard Operating Procedure</td>
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<td>SRU</td>
<td>Sulphur Recovery Unit</td>
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<tr>
<td>TG</td>
<td>Severity Rate</td>
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<td>TOE</td>
<td>Tonnes of oil equivalent</td>
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<tr>
<td>TWG</td>
<td>European Technical Working Group on Refineries</td>
</tr>
<tr>
<td>UFIP</td>
<td>Union Française de l’Industrie du Pétrole</td>
</tr>
<tr>
<td>ULSF</td>
<td>Ultra Low Sulphur Fuel</td>
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<tr>
<td>ULSP</td>
<td>Ultra-Low Sulphur Petrol</td>
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<tr>
<td>USD</td>
<td>United States Dollar</td>
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<tr>
<td>VOCs</td>
<td>Volatile Organic Compounds</td>
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<tr>
<td>ZEVs</td>
<td>Zero Emission Vehicles</td>
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Chapter 1: Introduction

This thesis investigates the extent to which the evolutionary concept of “routine” can provide a greater understanding of how firms address health, safety, and environmental issues (HSE). Few studies have investigated the mechanisms by which firms function when addressing environmental issues. Building on Pavitt (2000), who clarified and used the concept of routine to investigate firms’ innovative behaviour, Becker & Knudsen (2004) have brought to the fore the role routines play in reducing uncertainty, notably the one related to pollution limits set by environmental standards. The role of routines in the storage of knowledge allowing firms in the food industry to adopt ISO standards has been studied by Lazaric & Denis (2001). Thus, as argued by Nelson & Winter (1982), routines allow firms to change their behaviour and adapt themselves to a changing environment, thereby contributing to enhance their economic and environmental performances. But as argue Mulder, Reschke, and Kemp (1999: 30), the concept of routines can also provide a good understanding of “the way in which society is locked-in to particular unsustainable technologies”. And as Sinclair-Desgagné & Soubeyran (2000: 21) put it, although time can be saved by setting up routinised processes, routines can also “account for several behavioural anomalies such as inertia and resistance to change”. Since, as argued by Leonard-Barton (1992) in her study of firms’ “core capabilities” and “core rigidities”, the mechanisms they use to address environmental issues can be both enhancing and inhibiting. This implies that much attention should be paid when designing environmental policies in order to contribute to a sustainable development. For example, as suggested by Ashford & al. (1985) and Porter & Van Der Linde (1995), technological innovation could allow environmental goals to be “co-optimised” with economic growth, provided that environmental standards are properly designed to allow for such “win-win” gains. Consequently, showing that the concept of routines can be used to highlight how firms enhance their environmental performance could help designing what Gouldson & Murphy (1998) and Kemp (1997) have called “innovation-friendly environmental policies”. By offsetting the costs of environmental compliance by fostering economic gains from environmental innovations, these policies could contribute significantly to advances in reaching a sustainable development. For example, according to Hertin and Berkhout (2002) policies fostering co-operative relationships can produce positive-sum solutions.
To investigate the extent to which the evolutionary concept of “routine” can provide a greater understanding of how firms address environmental, as well as health and safety issues, this thesis shall answer two research questions:

RQ1: Can we characterise and identify firms’ HSE routines?

RQ2: What are the differences between the HSE routines used by firms exposed to different levels of pressures from HSE regulatory systems?

To answer these questions, a method is set out for assessing routines in organisations by first identifying three key properties of the concept (Action vs. representation, Repetition & persistence, Context dependence to HSE regulatory systems), and by designing a methodology applied to the specific case of the HSE behaviour of oil refineries located in four European and North African countries. This methodology consists in investigating the mechanisms used by oil refineries to address HSE issues, which were identified as the HSE management routine and the investment decision-making routine, and to evaluate the extent to which they have the aforementioned routine properties. Three hypotheses are tested in pursuit of this aim, following a methodology introduced in the next section:

H1: Firms’ HSE actions can be distinguished from their representations.

H2: Firms’ HSE mechanisms are repetitive and persistent.

H3: Firms’ HSE mechanisms are context-dependent.

This methodology shows that HSE routines can be identified, and in the case of the empirical analysis of this thesis it brings to the fore two HSE routines: the HSE management routine and the investment decision-making routine. On the basis of these findings, the second research question is answered, by comparing the HSE behaviour of firms operating in European and North African countries. Routines and factors external to the firm inhibiting improvements in its HSE performance are brought to the fore, such as the key role played by HSE regulatory systems.
1.1 Research questions and hypotheses

This thesis uses the concept of routine to study firms’ environmental behaviour, notably because it allows us to understand the interplay between firms’ behaviour and their regulatory context. To gain a greater insight into this co-evolutionary process, the range of firms, actions which shall be studied is extended to occupational health and safety (OHS) issues. Indeed, in a similar way to environmental impacts, OHS procedures are strictly regulated, because they both concern areas in which action is spontaneously taken below a certain level of risk for the firm’s survival. Also, OHS issues are often related to environmental ones. For example, in their study on employment and sustainability in two EU manufacturing sectors, Hartnell & al. (1996: 75) point out that:

“For United Kingdom automotive component companies, customers are potentially the most important source of environmental pressure. Health and safety issues can also be a driving force for moving towards less environmental damaging processes.”

This can explain why industrial firms often entrust HSE matters to the case of one single department. Ashford (2000: 67) also underlines that:

“achieving sustainable production and consumption requires (...) understanding that comprehensive technological changes are needed that co-optimise productivity, environmental quality, and worker health and safety.”

Therefore, the study of firms’ environmental behaviour shall be extended to the way they address OHS issues. From now on, when dealing with firms’ behaviour or regulatory systems, the acronym “HSE” shall substitute for the term “environmental”, as it is now often the case in firms’ organisational chart. Therefore, in order to provide a greater understanding of firms’ HSE behaviour, this thesis seeks to answer the following core research question:

RQ1: Can we characterise and identify firms’ HSE routines?
“HSE routines” refer to the routinised mechanisms firms are using to address HSE issues. These routines are not necessarily specifically dedicated to this purpose but were judged as having a major influence on firms’ HSE behaviour. “HSE behaviour” is understood as the set of mechanisms that shape, directly or not, the way firms are addressing HSE issues. The above question implies not only to show that the mechanisms governing firms’ behaviour are routines, but also to explain why it is worth using this concept to analyse firms’ HSE behaviour. Asking this question assumes that it is possible to explore the mechanisms governing this behaviour. It issues two challenges to economists. A theoretical challenge first, because demonstrating that the concept of routine provides a greater insight into this particular behaviour would open up a new research agenda for evolutionary theories of the firm. But this question also issues a political challenge because, as stated in the UK sustainable technologies programme\(^1\) and in the European ETAP programme\(^2\), understanding how firms are addressing HSE issues would help to design policies to foster a sustainable technological change. Therefore, this thesis argues that there is an urgent need to understand the mechanisms governing firms’ HSE behaviour, notably by using a concept of routine that shall not be confined to the analysis of firms’ innovative behaviour.

In Chapter 2, in order to strengthen the case to adopt the evolutionary paradigm, the concept of routine, characterised by three properties (duality between action and representation, repetition and persistence, context dependence) is presented together with other key evolutionary concepts such as path dependency or national systems of innovation. To identify firms’ HSE routines, the mechanisms they are using to tackle HSE issues are brought forward in Chapter 5 following a methodology developed in Chapter 4. They are HSE management systems, investment decision-making processes, and input supply management systems. Building on these findings, chapters 6, 7, and 8 investigate whether these mechanisms are used by other refineries in other countries, and evaluate the extent to which they are routinised mechanisms. Finally, in order to analyse the differences in the HSE behaviour of oil refineries on both sides of the Mediterranean and provide policy guidance to improve the HSE performance of North African firms, a comparative analysis of the HSE

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1 ESRC Sustainable Technologies Programme, http://www.sustainabletechnologies.ac.uk.
routines of case study firms is carried out in Chapter 9 to answer the following research question:

**RQ2: What are the differences between the HSE routines used by firms exposed to different levels of pressures from HSE regulatory systems?**

In Chapter 2, three routine properties were highlighted. As explained in Diagram 3, a routinised behaviour can be understood by looking at three key elements: actions, their representations, and the technologies used to create, replicate, and implement these representations. In order to examine the extent to which an HSE mechanism is routinised, the extent to which it has the properties of a routine is investigated. Three hypotheses corresponding to the three routine properties guide this assessment and are tested following a methodology presented in Section 4.2.2:

- **H₁**: Firms’ HSE actions can be distinguished from their representations.
- **H₂**: Firms’ HSE mechanisms are repetitive and persistent.
- **H₃**: Firms’ HSE mechanisms are context-dependent.

Testing these hypotheses allows us to investigate whether an HSE or an investment decision-making mechanism has a given routine property. This is assessed by evaluating its “degree of routineness” (DR), which indicates the extent to which an HSE mechanism is a routinised activity that contributes to enhance the HSE performance of the firm. Therefore, even if as argued earlier routines can be inhibiting, the HSE routines studied here are the ones that contribute to enhance the HSE performance of an oil refinery. For each routine property, a DR is calculated by adding the scores obtained for each component of the property, following precise criteria defined in sections 4.2.2.1, 4.2.2.2, and 4.2.2.3.

### 1.2 The topic of the study

The objective of this thesis is to show how the evolutionary concept of “routine” can provide a greater understanding of how firms address health, safety, and environmental issues (HSE). Such an improved understanding is needed to shed light
on the differences between firms’ attitude and strategies towards HSE issues, and to improve the efficiency of HSE policies. As far as HSE issues are concerned, HSE regulatory systems are considered as a key driver of changes in firms’ behaviour. Indeed, addressing those issues does not automatically lead to profit-maximisation, which explains why public regulation is needed to improve firms’ HSE performance. Because the concept of routine allows us to apprehend the context-dependency between the mechanisms that govern firms’ HSE behaviour and context, this thesis suggests that it provides a greater insight into how firms address HSE issues, and thus contribute to the elaboration of sustainable development policies in a different way than what for example mainstream economics can do.

Since the 1970s, the neo-classical theory of the firm has been criticised for the inadequacy of its models with respect to firms’ innovative behaviour. “In search of a useful theory of innovation”, Nelson & Winter (1977) explain why a theory based on a profit-maximising model of the firm is unable to explain differences in the rates of technological progress across economic sectors. As Winter (1964: 229) points out, a common criticism of profit maximisation emphasises “the limitations on the information available to the decision makers and the consequent impossibility of profit maximisation”. By studying the mechanisms with which firms function, evolutionary theories of the firm were able to provide a better understanding of firms’ innovative behaviour and contributed to the design of science and technology policies that could foster innovation. This thesis suggests that the concept of routine, which has been used for this purpose, can also allow us to investigate how firms address HSE issues. It clarifies this concept and applies it to an unexplored object of study, the HSE behaviour of oil refineries in European and North African countries. Besides, a greater understanding of how firms function when addressing HSE issues, as well as of their co-evolution with external HSE pressures, would allow to design analytical frameworks which conclusions are useful to sustainable development policies. For example, understanding why some firms can take advantage of environmental policies to innovate would allow design environmental policies which are more favourable to innovation.
1.3 Key concepts for the study of firms’ HSE behaviour

This thesis is concerned with the extent to which the concept of routine can account for the mechanisms firms are using to address HSE issues. Understanding firms’ HSE behaviour is thus at the core of its empirical investigation. The methodology applied in pursuit of this aim consists in characterising and identifying the HSE routines of case study firms, and to compare them among firms located in different countries. HSE behaviour is understood as the set of mechanisms which shape, directly or not, the way firms address HSE issues. It is argued that this behaviour does not amount to a maximising function in which HSE variables are mere costs to be minimised. Indeed, HSE benefits are difficult to calculate, and neo-classical models of the firm need to put into numbers their observed variables, which incurs several biases discussed in Section 2.3.1.

As for the concept of routine, as Pavitt (2000) pointed out, although considerable brainpower has been mobilised to dissect it, for example what are innovative routines remains largely unexplored in practice. In order to apply the concept in the empirical research carried out in this thesis, its definition needs to be clearly stated and its key properties identified. This is the purpose of the next chapter, in which it is argued that routines are executable capabilities for repeated performance characterised by three key properties. Firstly, the action versus representation property suggests that firms carry out a given action by applying a “recipe” which has been successful in the past in responding to changes in the firm’s environment. Its guiding principles are represented in specific storage points called “representative forms” by Pentland & Rueter (1994). For example, the way identical EMAS guidelines are implemented in companies can explain part of the gaps in their environmental performance. This property can be studied by identifying an HSE action and how it is remembered. The repetition and persistence property underlines that when a routine is efficient and properly implemented, its effects last over time and are therefore an indicator of the existence of this routine property. For example, the effects of investment decision-making processes we are concerned with in this thesis are HSE investment projects. These processes are persistent if they last over time, namely if investment projects...
can be identified. Finally, the context dependence property stresses that the mechanisms governing firms’ behaviour co-evolve with the context in which the firm is operating. This sheds light on the importance of the impact of HSE regulatory systems on how firms address HSE issues, which can be studied by investigating regulatory requirements and the extent to which they have been met by firms.

1.4 The approach of the study

This thesis examines the extent to which the evolutionary concept of routine can provide a greater understanding of firms’ HSE behaviour. Two research questions guide the investigation in pursuit of this aim. The first one leads to characterise and identify the HSE routines of case study firms belonging to the same industrial sector, namely oil refineries. The second one is concerned with the differences between these routines across countries which HSE regulatory exert substantially different pressures on firms. Answering the first research question demands both a quantitative and a qualitative approach. Following a review of the literature, which allows us to define the concept of routine and to explain why it provides a richer insight in firms’ behaviour over the neo-classical maximising model of the firm, key routine properties are brought to the fore. Then, an analysis of the factors that play a role in the way oil refineries address a specific HSE issue are brought to the fore using quantitative data on SO2 emissions as well as data on the technological and organisational features of French oil refineries over a period of 17 years. Three HSE mechanisms are identified as having a determining impact on the HSE behaviour of these firms: environmental management systems, investment decision-making processes, and input supply management systems. To identify the HSE routines used by oil refineries, the extent to which the HSE mechanisms of case study firms have the properties of routines is investigated. To do so, interviews with refinery managers (HSE, finance, production, …) and industry experts as well as government regulators are carried out. Documentary evidence from governmental, professional, and company publications is also sought to crosscheck the data and uncover additional evidence. Finally, addressing the second research question calls for a comparative analysis of HSE routines in countries which HSE regulatory systems exert substantially different pressures on firms’ behaviour, namely France and the UK, and Morocco and Algeria.
1.5 Structure of the thesis

The literature review carried out in Chapter 2 brings to the fore the main properties of the concept of routine: duality between action and representation, repetition and persistence, and context dependence.

Chapter 3 presents the empirical context of the thesis, and Chapter 4 the data and methodology used to identify in chapters 6, 7, and 8 the HSE routines of oil refineries and to compare them across different firms in Chapter 9.

To do so, Chapter 5 brings to the fore three HSE mechanisms used by French oil refineries to address a specific HSE issue: HSE management, investment decision-making, and input supply management. Chapters 6, 7, and 8 investigate the extent to which these mechanisms have the three properties of routines so as to answer the core question of the thesis (RQ1): Can we identify and characterise firms’ HSE routines? This requires to investigate in Chapter 6 the pressures exerted by the HSE regulatory systems of European and North African countries on case study refineries. Chapter 9 builds on these findings to answer the second research question of the thesis (RQ2): What are the differences between the HSE routines used by firms exposed to different levels of pressures from HSE regulatory systems? In this chapter, policy recommendations to improve the HSE performance of Moroccan and Algerian oil refineries are formulated. Finally, Chapter 10 brings together the findings of the thesis, highlights its contributions, and suggests directions for future research. The links between research questions, hypotheses, methodological sections, and thesis chapters are summarised in the following diagram.
Diagram 1. Overview of thesis chapters

Chapter 1: Introduction

Chapter 2: Theoretical framework

Chapter 3: Empirical context

Chapter 4: Data and methodology

Chapter 5: The HSE mechanisms used by oil refineries to address HSE issues

Chapter 6: An analysis of the pressures exerted by HSE regulatory systems

Chapter 7: The HSE behaviour of French and English oil refineries

Chapter 8: The HSE behaviour of Algerian and Moroccan oil refineries

Chapter 9: A comparative analysis of HSE routines

Chapter 10: Conclusion
Chapter 2: Theoretical framework

2.1 Introduction
This chapter introduces the theoretical framework allowing us to explain how the concept of routine can be used to investigate firms’ environmental behaviour. Section 2.2 provides a justification of the choice of the evolutionary perspective to do so. An introduction to the evolutionary approach is given in Section 2.2.1 and two major concepts are introduced to support this theoretical choice, innovation systems in Section 2.2.2 and path dependence in Section 2.2.3. Then, in order to build a workable concept of routine, Section 2.3 explains how routines can be used to study firms’ behaviour. On the basis of a literature review of what has been written by evolutionary economists about routines Section 2.3.1 defines the concept, and Section 2.3.2 identifies its key properties so as to study firms’ environmental behaviour (Action vs. representation, Repetition and persistence, Context dependence). In order to contrast the added value of evolutionary concepts when studying firms’ environmental behaviour, the last sub-section (2.3.3) introduces how the neo-classical approach investigates this behaviour by presenting studies investigating relationship between firms’ environmental innovation and public regulation. Section 2.4 examines how routines can be used to better understand firms’ environmental behaviour. In Section 2.4.1, the contribution of routines to the understanding of why firms can take advantage of environmental policies to increase their competitiveness is brought to the fore, and reasons for which they may fail to seize these opportunities are highlighted in Section 2.4.2. Finally, Section 2.5 gives an account of the influence of HSE regulatory systems on firms’ behaviour, and notably on oil refineries’.

2.2 The choice of the evolutionary approach to study firms’ HSE behaviour
Inspired by Nelson & Winter (1982), evolutionary theories of the firm investigate the mechanisms by which firms function and survive in a selective environment with which they co-evolve (p. 126). They are based on a conception of the firm which is different from the neo-classical one and which was formulated by Cohendet & al. (1998: 3) in the following standpoint:
“The firm is an economic institution which performs multiple functions by implementing different mechanisms which interact in complex, sometimes conflicting and still largely unexplored ways.”

To understand the behaviour of a firm, the authors suggest that the neo-classical unidimensional view of most current approaches should be abandoned to address the interaction among these mechanisms. To do so, the firm needs to be seen as “a delicate balance between such interacting processes” (ibid.), and following Nelson & Winter (1982) it can be studied by using the concept of “routines”. In their opinion, this concept characterises “all regular and predictable behavioural patterns of firms”, which suggests that all business behaviours are not routine, such as decision-making of the highest importance (p. 14). For example (p. 97):

“organizations that are involved in the production and management of economic change as their principal function –organizations such as R&D laboratories and consulting firms– do not fit neatly into the routine operation mold.”

However, as they put it: “most of what is regular and predictable about business behaviour is plausibly subsumed under the heading ‘routine’” (p. 15). And in fact even non-routine decisions involve some degree of routine activity and are shaped by “constant dispositions” or “strategic heuristics”. Studies about investment decision-making, such as Mintzberg & al. (1976) and their followers, have stressed that both “low” and “high-order” procedures (p. 16) can be routines. Before defining this concept and explaining how to use it to investigate firms’ HSE behaviour, issues that are central to the evolutionary approach are introduced so as to justify the choice of the evolutionary approach for this study. They include innovation systems and path dependence, which are addressed after a brief introduction of the chosen approach.

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6 Ibid. Also see in Cohen, Burkhart et al. (1996: 662-666) Sidney Winter’s discussion about quasi-generic traits. It apprehends firms’ behaviour in terms of routine heuristics and strategies, paradigms, and cognitive frameworks.

7 Cf. Mintzberg, Raisinghani et al. (1976).
2.2.1 An introduction to the evolutionary approach

As opposed to neo-classical economists who “ordinarily profess a complete lack of interest in the processes by which firms actually make decisions”,8 evolutionary economists attempt to look into the “black box” of the firm and to shed light on the mechanisms which guide their behaviour. For example, building on the work of Herbert Simon and others9, Nelson and Winter (1982: 126) argued that firms “function according to routine” because their rationality is “bounded” or “procedural”10. They also insisted on the fact that economic agents are heterogeneous. Indeed, argue Malerba and Orsenigo (1993), firms are organisations with specific competences at doing something which behaviour co-evolves during the development of an industry along with the technology, demand, and institutions. For other scholars such as neo-classical economists, the firm is a neutral entity identified as the “producer”, a “black box whose input and output channels may be modified by assumption at the convenience of the investigator”. This is because neo-classical economics models require a set of strong initial conditions such as the absence of uncertainty, complete information, and perfect rationality11. In these models, firms are characterised by a production function which describes a set of technical possibilities and associates a certain amount of input with the maximal quantity of output it can produce with this set of possibilities. Underlines Généreux (1995: 53), if we know that the rule of behaviour of this economic agent is to maximise its profits or its present value, its governing processes remain partly unexplained. Moreover, as Winter (1993: 189) puts it:

“Profitability is the imperfect signal that market economies employ to tell firms how useful their activities are to society, and whether more or less of the same is wanted.”

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10 For a discussion about firms’ rationality and sustainable development, see Faucheux & al. (1993).
11 C.f. Guerrien (1993: 20) for and introduction to the concepts used in the neo-classical economic theory.
13 These are among the most criticised aspects of the mainstream framework. For a detailed evolutionary critique of the rational choice perspective, see Lane & al. (1994).
This explains why evolutionary theorists like Nelson & Winter (1982: 14) consider that although firms are motivated by profit, the notion of maximising behaviour as a unique explanation of why decisions are taken should be rejected. Rather, these authors argue that firms’ behaviour depends on the modification of capabilities and decision rules over time, through deliberate problem solving and random events (p. 4). And as Hodgson (1998: 186) underlines: “optimization itself cannot provide a complete explanation of either the origin of rules or the adoption of rule-driven behaviour” and thus “explicit optimization procedures must involve rules”.

A frequent criticism addressed to the neo-classical economic theory of the firm is the alleged perfect rationality of economic agents. For the following reasons, Simon (1997: 93-94) argued that neo-classical agents fall short in at least three ways of such rationality:

1) Rationality requires a complete knowledge of the consequences following from each choice, but knowledge of consequences is always fragmentary;

2) To anticipate the future, imagination supplies the lack of experienced feeling in attaching value to them, and values can be imperfectly anticipated;

3) Rationality requires a choice among all possible alternative behaviours, but only a very few of all these possible alternatives ever come to mind.

For example, to illustrate the “incompleteness of knowledge”14 the author explains that (p. 94):

“to achieve a completely successful application of resources to a city’s fire protection problem, the members of the fire department would need to know in comprehensive detail the probabilities of fire in each portion of the city –in fact, in each structure– and the exact effect upon fire losses of any change in administrative procedure or any redistribution of the fire-fighting forces.”

In this case as in many other circumstances occurring in the real world, a comprehensive and costly inventory of conceivable choices is so complex that it is beyond reach. In fact, as Weil (2000: 28) points out, because of the considerable costs of rational action, it is often rational to act differently. Most of the time, argues Simon (1997: 94), instead of collecting and analysing new information, decision-

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14 Namely the fact that “rationality implies a complete, and unattainable, knowledge of the exact consequences of each choice”.
makers tend to use existing mechanisms such as “routines”\( ^{15} \), which have already demonstrated their efficiency in similar or close situations. Because of the costs associated with developing good rules and changing existing ones, they tend to copy others’ rules, even if they are not the most efficient ones. Their mode of decision is \textit{satisficing} rather than \textit{optimal}, all the more in complex situations where cognitive limits, time pressures, uncertainty and bounded rationality force decision-makers to drift away from purely rational choices. As Alchian (1950: 211) put it:

“Where the economic system includes uncertainty, ‘profit maximisation’ is meaningless as a guide to specific action.”

But then why should mainstream economic theory make such assumptions about firms’ behaviour? For James March, neo-classical economists are blinded by “the myth of individual rationality”. Argues Weil (2000: 134), for them “explaining” a behaviour consists in showing that it is compatible with the axioms of rationality, namely to rationalise it. According to Guerrien (1993: 10), such a development of generalisable theories amounts to asking: “which hypotheses shall we assume to demonstrate that market rules can lead to an optimum?” However, new growth theories introduced technology in their models as an endogenous variable. Whereas old theories of growth were characterised by constant returns as in Solow (156, 1957), Romer (1986, 1990) showed that new \textit{increasing} sources of growth might exist, spurred by investment in a certain factor, by technological innovation, by the accumulation of human capital, and by public goods and infrastructure. These findings have important impacts on technology policies, because as Freeman and Soete (1997: 329) argue:

“once the more realistic picture of increasing returns with which many features of technological change can be associated is introduced in macro-economic growth analysis, it becomes very clear that policies with respect to technology (e.g. R&D subsidies) cannot not be equated with other traditional static efficiency improving micro policies, such as competition policy, but do have a significant dynamic growth impact.”

Dynamism is an important feature of evolutionary approaches and its in fact embedded in the term “evolution”. Underlines Hodgson (1993: 82), for the great

\( ^{15} \) The evolutionary concept of “routines” is developed in the next section.
propagator of the term Herbert Spencer (1892: 10), evolution characterises a “change from an indefinite, incoherent homogeneity, to a definite, coherent heterogeneity through continuous differentiations”. Concerning “economic evolution”, Fagerberg (2002: 4) asserts that it designates “a process of qualitative, economic change taking place in historical time”. Because he considered that innovation was the driving force behind economic, social, and institutional change, that capitalist firms were playing a central role in this change, and because he adopted a historical perspective, Schumpeter made a pioneering contribution to the evolutionary paradigm. In his *Theory of Economic Development* (1912), he underlined the central role of the entrepreneur in the process of innovation. But he also stressed the difficulty in succeeding in the “entrepreneurial function”, notably because of existing knowledge, habits, and beliefs:

“(…) knowledge and habit acquired once becomes as firmly rooted in ourselves as a railway embankment in the earth. It does not require to be continually renewed and consciously reproduced, but sinks into the strata of subconsciousness. (…) Everything we think, feel or do often enough become automatic (…).”

Fagerberg also points out that these routinised mechanisms, both at the individual and the collective level, can bias decision-making against new ways of doing things. Ways of doing things are linked with the systems in which they emerge. Because this can influence the rate and direction of technological change, a branch of the evolutionary literature has developed around the notion of “systems of innovation”, which are introduced in the next section.

### 2.2.2 Systems of innovation

The idea of innovation system was first discussed in the middle of the 1980s, but the roots of the discussion go back to List (1904) and Linder (1961). Nowadays, several approaches exist. For example, Nelson (1993) focuses on the national system of innovation (NSI), which as Freeman (1987: 4) he defines as:

“the networks of institutions in the public and private sectors whose activities and interactions initiate, import, modify and diffuse new technologies.”

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16 Schumpeter (1934: 84), quoted in Fagerberg (2002: 10).
17 Argues Carlsson (2004), over the last fifteen years some 750 studies have been published on innovation systems.
A more micro approach was taken by Lündvall (1992a), who argues that innovation stems from a new combination of knowledge drawn from different sources, notably in the interfaces between firms and their surroundings such as customers and suppliers. Following Lündvall and al. (2002: 225), the supporters of this approach adopt the next definition:

“innovations systems work through the introduction of knowledge into the economy (and into the society at large).”

In this perspective, economic, political, and social infrastructures as well as institutions drive the efficiency of these learning activities, in addition to “past experiences as they are reflected in the tangible and intangible aspects of the structure of production and on values and policies” (pp. 225-226).

Beyond the debate about whether innovation systems follow national borders or not, this systems approach allows us to apprehend the importance of the interactions between actors and institutions. For example, studying the emerging science-based industry of biotechnology in Germany, Kaiser and Prange (2004) highlight on the cooperation between firms and university and non-university research institutes. To do so, they used the framework summarised in Lündvall (1992b: 13), which applies five indicators developed in the NSI literature:

- Regulation,
- Financial system,
- Public technology and innovation policies,
- Research and education systems,
- Corporate activities.

Recent research on NSI provide a more subtle approach of these systems. For example, Kaiser and Prange (2004: 405) show that “certain functions traditionally associated with the NSI have either been delegated towards other territorial levels or supplemented by those levels”. This can also be the case for the management of HSE

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18 Cf. Edquist (1997) for a discussion on this matter.
19 Cf. the «triple-helix» approach of Etzkowitz and Leydesdorff (2000), who put forward the role played by the interactions between universities, firms, and government.
issues. As the OECD (1999: 41) puts it, a greater knowledge about how innovation systems work “offers new rationale for government technology policies”, which have for a long time focused on correcting market failures, for example via R&D tax credits or subsidies. The evolutionary approach allows governments to address systemic failures, such as (ibid.):

- “the lack of interaction between the actors in the system,
- mismatches between basic research in the public sector and more applied research in industry,
- malfunctioning of technology transfer institutions,
- and information and absorptive deficiencies on the part of enterprises.”

The NSI approach also allows us to analyse differences in the way innovation and diffusion occur across different industries, and thus to take into account firms’ heterogeneity. Argues Nelson (1995: 79), the latter can be associated with the fact that firms’ resources or competences are unique. Building on Dosi, Teece, and Winter (1992), the author stresses that “to be effective, a firm needs a package of routines, including those concerned with learning and innovation, that are ‘coherent’” (ibid.). Because they are difficult to reproduce, the mechanisms driving the behaviour of successful firms tend to protect them from being imitated. Indeed, to imitate them competitors need to “adopt a number of different practices at once” (ibid.), and differences in their ability to do so can explain a great deal of the heterogeneity of firms’ behaviour. Including when it relates to environmental issues, the evolutionary approach provides concepts to apprehend this heterogeneity. For example, the concept of routine allows us to identify where and how the knowledge of the firm is stored, used, and reproduced.

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21 For example, studies about sectoral systems of innovation and production can provide policy guidance at industry level. About sectoral systems of innovation, see Malerba (2002) and Geels (2004).
22 Recently, the literature in network economics, which investigate the interactions between socio-economic actors, has increased sharply. For a comprehensive survey of the literature, see Özman (2003).
24 For a study of firms’ heterogeneity in the pharmaceutical industry, see D’Este (2001).
25 For a detailed explanation of how knowledge is stored and transmitted, cf. Foray and Steinmueller (2001).
According to Winter (1971: 244-245), the emergence of different types of behaviour can be fostered by different market conditions. Argues Arthur (1994), even if differences in initial conditions are small, they can have a strong impact on long-term outcomes. As Fagerberg (2002: 30) puts it:

“All technology, firm or location that happened to get an initial advantage may in the presence of increasing returns come into a situation in which these advantages are amplified through time, while those that initially were at a disadvantage risk being marginalized or driven out of the market.”

The long-term effects of this amplification of advantages triggered by increasing returns are investigated by a major branch of evolutionary studies, which is introduced in the following section.

2.2.3 Path dependence

According to Antonelli (1997: 643):

“Path dependence defines the set of dynamic processes where small events have long-lasting consequences that economic action at each moment can modify yet only to a limited extent.”

And for David (1985: 336):

“For such things to happen seems only too possible in the presence of strong technical interrelatedness, scale economies, and irreversibilities due to learning and habituation.”

This suggests that routines, which can be understood as knowledge storage points serving as guides to specific actions, play a role in lock-in phenomena. The nature of the routines governing firms’ environmental behaviour as well as their relationships with their context might therefore shed light on cases of unsustainable lock-in. And as Mulder, Reschke, and Kemp (1999: 30) argue, although little focus has been placed on the relationship between firms’ routines and unsustainable lock-in, evolutionary concepts can provide a good understanding of “the way in which society is locked-in to particular unsustainable technologies”. For example, a study

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of how an inferior pest control technology became dominant was carried out by Cowan & Hulten (1996: 538) and brought forward actor-level factors which may have contributed to this lock-in. According to the authors, such a “regrettable economic opportunity”, to use the word of David (1999: 13), lies in farm-level learning obtained by the new acquisition of the technology, and in the uncertainty about the farmers’ ability to make it work or to educate bank managers and insurance agents about its feasibility and reliability. Because the issue at stake is how knowledge is being stored and transmitted, cases of lock-in can be studied using the concept of routine. For example, psychological inertia can deter the adoption of environmentally friendly decisions because it is difficult for decision-makers to change their decision rules which do not integrate any environmental criterion. For Cohen, Burkhart et al. (1996: 658), this is notably due to the fact that:

“young managers work hard to learn how to ‘choose rationally’ in school and their first jobs, and tend to stick to the patterns they have learned through the remainder of their careers, making rational actions a recurring pattern and potentially a species of routine.”

At a more aggregated level and considering a longer term perspective, individual-level routines can affect the rate and direction of technical change. For example, studying the diffusion of the QWERTY keyboard, David (1985) could explain why it became the standard keyboard layout even if it was not the most efficient typing technique. Introduced by Remington to slowdown typing and avoid jamming of types on mechanical keyboards, it was quickly used by many typists trained by the firm on this inferior technology. When labour demand for typists increased, it was easier to recruit these already trained typists instead of training new ones on more efficient keyboards but which had already lost the race of increasing returns in favour of the QWERTY layout. Indeed, explains Nelson (1995: 73):

“the more a firm uses a technology the better it gets at that technology [and] the more a technology is used, the better it becomes vis-à-vis its competitors.”

The author calls what lies behind these dynamic increasing returns a “cumulative technology” (p. 74):

“In a cumulative technology, today’s technical advances build from and improve upon the technology that was available at the start of the period, and tomorrow’s in turn builds on today’s.”
As Arthur (1989: 116) argues, and this also applies to environmental technologies:

“Modern, complex technologies often display increasing returns to adoption in that the more they are adopted, the more experience is gained with them, and the more they are improved.”

To illustrate the long-term effects of increasing returns, Nelson (1995) takes the example of gasoline engines. In the early history of automobiles the latter were competing with steam and electrical engines, but “by chance inventors tended to concentrate on it, or by chance big advances were made” (p. 75). However, once gasoline cars dominated the market it became too expensive and risky to bet on alternative technologies, which relative price increased in the wake of the fourth “techno-economic paradigm”, to use the concept developed by Perez (1983, 1985). According to the author, different eras are dominated by different fundamental technologies and core resources. To be effective with those technologies, nations need to have a set of compatible supportive institutions. When technological systems form, their persistence and the rate of economic growth incurred depend on the “good match” between the technological and the social system27. In these cases, Freeman and Louça (2001) argue that it can lead to “long waves” of technological progress and economic growth, such as the ones uncovered by Kondratieff (1925).

An important feature of techno-economic paradigms is that they build on what Carlota Perez calls a “key factor” or “key resource” corresponding to a cheap and almost universally available input characterised by falling costs. As illustrated in the following diagram, oil and gas were the key resource of the fourth techno-economic paradigm, since they were used in many sectors and had pervasive effects, including environmental ones. According to Goransson and Soderberg (2004), “With the emergence of the fifth Kondratiev wave, the information and communications sector will replace energy, transport and material as the central sector in the economy” and there will be a transition from energy, material and transport, dominating the economy of the whole industrial age, into microelectronics-biotechnology.

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27 Inspired by Thomas Kuhn’s Structure of Scientific Revolutions (1962), Dosi (1982) called «technological paradigm» these systemic interdependencies and «technological trajectories» the paths defined by these paradigms.
Diagram 2. Summary of techno-economic paradigms

Waves of technological development

<table>
<thead>
<tr>
<th>Period</th>
<th>Key 'carrier' sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td>1770s</td>
<td>Early mechanisation, Textiles, Waterpower, Canals</td>
</tr>
<tr>
<td>1840s</td>
<td>Steam power + Railways, Steam engines + Heavy engineering, Synthetic dyes, Electricity</td>
</tr>
<tr>
<td>1890s</td>
<td>Autos Airlines, Consumer durables, Petro-chemicals, Process plants, Plastics, Highways</td>
</tr>
<tr>
<td>1940s</td>
<td>Energy, (especially oil), Microelectronics</td>
</tr>
<tr>
<td>1990s</td>
<td>ICTs, Biotechnologies, Space/satellite, Environmental technologies</td>
</tr>
</tbody>
</table>

KEY FACTOR INDUSTRIES

Source: Dodgson and Marceau (2000: 2).

In this framework, new technologies emerge from old paradigms, but as Van den Ende and Kemp (1999) showed in the case of programming methods, old ways of doing things tend to constraint the development of new ones. Presenting the argument made by David (1992) about the reasons for the domination of A.C. over D.C. for carrying electricity, Nelson (1995: 75) raises the role of “possibly self-interested professional judgements or political factors as major elements in the shaping of long run economic trends (…). After all, under these theories all it takes may be just a little push”. Such a push was illustrated by Kemp (2002) in a story of the diffusion of zero emission vehicles (ZEVs) in California. The author underlines the impact of the announcement by General Motors (GM) that it would start manufacturing electric vehicles on the launch of the Californian ZEV mandate. In this case, the personal role of the GM chairman Roger Smith was decisive since he supported the project against the advice of other GM executives.
Regulation is the first of the five aforementioned indicators proposed by Lundvall (1992b: 13) to study NSI. As argued in the last section of this chapter, pressures exerted by HSE regulatory systems are a major component of the HSE context with which oil refineries co-evolve. This section has highlighted the fact that evolutionary approaches provide analytical frameworks that can shed a critical light on how regulation may affect firms’ behaviour and on why heavily polluting firms can be locked in unsustainable production trajectories. It therefore strengthens the case for the choice of the evolutionary approach in this thesis. The next section attempts to provide a workable definition of this concept.

### 2.3 Routines and firms’ behaviour

#### 2.3.1 Defining the concept of routine

Nelson & Winter (1982: 97) describe the concept of routine in the following “highly flexible way”:

“It may refer to a repetitive pattern of activity in an entire organization, to an individual skill, or, as an adjective, to the smooth uneventful effectiveness of such an organizational or individual performance.”

The characteristics of this term include (p. 14):

- Well-specified technical routines for procedural things,
- Procedures for hiring and firing, ordering new inventory, or stepping up production of items in high demand,
- Policies regarding investment, research and development, or advertising,
- Business strategies about product diversification and overseas investment.

Teece & Pisano (1994: 545) put forward the learning dimension embedded in routines, which are seen as “patterns of interactions that represent successful solutions to particular problems”. Along the same line, Burkhart & al. (1995) argued that:

“firms are not frictionless reflections of their momentary environments, but rather highly inertial action repertoires, responding to –indeed perceiving– today’s environment largely in terms of lessons learned from actions in days gone by.”
Based on interpretations of the past rather than on anticipations of the future, routines constitute firms’ organisational memory, and shape their behaviour in accordance with the selection environment. It is therefore essential to understand both firms’ routines and context to shed light on how firms behave, because they are not governed by a given maximising mechanism applying ceteris paribus. Indeed, as Cohen, Burkhart et al. (1996: 657) underline, if agents were capable of tailoring their actions to their world, no theory would be required to understand their behaviour. A theory describing the environment to which they flawlessly respond would suffice28.

The evolutionary concept of routine has been used in widely different senses, sometimes drifting away from the Nelson and Winter definition, notably because it is tempting to consider that any feature that looks stable and reproducible has to be a routine. To maintain the explanatory power of the concept, its characteristics and key properties need to be clearly identified. This has led authors to adopt a narrow definition of routines in order to explore a specific field of research, such as learning and other cognitive processes. For example, in Cohen, Burkhart et al. (1996: 695), Egidi adopts the March and Simon definition of “routinised behaviours” based on mental activity-inactivity because it gives him a chance to confirm experimentally his assumptions on bounded rationality, tacitness, and awareness29. The author holds that (p. 686):

“behaviours are the consequence of mental models and more stringently (but provisionally) that routinised behaviours are the outcome of the execution of a set of conditions –action rules, stored in individuals’ long-term memories.”

Other studies at the level of the individual concern psychological research seeking to model routinised decision-making30 and to shed light on knowledge codification31, capital budgeting decisions32, tacit knowledge, learning, or co-operation. But as Dosi argues (p. 678), one can be sceptical about some of these models because they risk

28 Nelson & Winter (1982: 15) argue that the reason for which the neo-classical economic theory has been denying the theoretical relevance of routine mechanisms as a guide to firms’ actions might be that routinised choices do not impose important changes on firms’ profits.
falling into “weak isomorphism” where the modelled “artificial reality” tends to replace empirical investigations. In his opinion (ibid.):

“simulation models (as well as economists’ theorems) are ways of producing coherent and non-intuitive conjectures, but are a far cry from validating the conjectures themselves.”

Rather, he considers with Coriat that it is “urgent to model an explicit co-evolutionary origin of routines, i.e. to model evolutionary processes nested in multiple selection environments” (p. 679). To do so, a broader definition of routines is needed, because as Winter notices “achieving maximum tightness in key definitions may sometimes inhibit progress” (p. 684). According to the latter, a narrow definition of the concept of routine such as the cognitive one “neglects, and hence risks obfuscating, the contextual aspects of routines” (p. 662). Moreover, a broader definition allows us to consider a wider range of facts, which is useful for an empirical investigation of firms’ routines since they are not all observable. For example, indicators to study a given action may not exist to examine the rules used to carry out that action. As suggested by Burkhart, a broad definition of the term should claim that (p. 683):

“A routine is an executable capability\textsuperscript{33} for repeated performance (…) that has been learned\textsuperscript{34} by an organisation in response to selective pressures.”\textsuperscript{35}

Three key properties of the concept of routine can be drawn from this definition. The term “capability” stresses the duality between an action and its representation, the term “repetition” suggests that routines might be persistent, and “selective pressures” that they are context-dependent mechanisms. Building on the evolutionary literature, the next section explores these routine properties in more detail.

\textsuperscript{33} Capacity to generate action stored in some form. 
\textsuperscript{34} Encompasses processes of taciteness and automaticity, which could alter the probability of enactment of the capability. 
\textsuperscript{35} This definition has been elaborated during the Santa Fe meeting which has led to the publication of the paper by Cohen, Burkhart et al. (1996). It was amended by the author of this thesis following a comment made by Pr Murat Yıldızoğlu during the presentation of Gossart (2003b).
2.3.2 The properties of the concept of routine

In a recent review of the literature, Becker (2003) highlights seven characteristics used to define the concept of routine. The first one concerns routines as patterns of behaviour and encompasses two levels of analysis: actions, and their representations. This distinction clarifies the aforementioned definition of routines proposed by Nelson & Winter (1982: 97), which does not clearly discriminate between organisational and individual routines. Nevertheless, the authors recently alleviated confusion by underlining that:

“...In our view, clarity would be served by reserving the term “skills” to the individual level and “routines” to the organizational level.”

In this thesis, routines shall refer to executable capabilities which represent an action used at the organisational level of a firm. Because they codify how actions are to be carried out, these rules are said to represent firms’ actions. This distinction is the first of the three main properties of routines which can be drawn from the evolutionary literature.

Action vs. representation

The distinction between action and representation is not always made in the literature. The key role it plays in the understanding of firms’ behaviour was underlined in Cohen, Burkhart et al. (1996: 658, 672, 686-688) and in Becker (2003). The following diagram shows the interplay between firms’ action (A) and representation (R). It suggests that firms’ behaviour is not governed by a simple maximising principle but rather by a set of interacting mechanisms shaped by the firm’s capabilities and context.

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36 This characteristic also has important bearings on the role of routines as a means for co-ordination and control.
38 As explained in the next routine property, the representation of action is stored in representative forms such as memories of individual actors or via physical artefacts.
Diagram 3. A model of routinised behaviour

Legend:

- Technology of creation
- Technology of replication
- Technology of implementation
- Resources for action
- Representation of action
- Action
- Meta-routine

Source: Own elaboration.

This diagram depicts a learning and routinised process by which the representation of an action is either created, replicated, or implemented with appropriate “technologies” in order to store the knowledge required to (re)produce successful actions. These “routine technologies” are means or resources such as organisational structures or human and financial resources, and are not to be confused with “physical technologies” such as machines. A routine is implemented by way of other technologies to produce an action or another routine. The extent to which a given action can also be considered as a routine obviously depends on the level of observation, and thus on the chosen unit of analysis. This thesis focuses on routines at the organisational level of the firm because it allows for cross-country comparisons. Finally, not all actions originate from routines. For example, strategic actions, although they may use routinised mechanisms such as search processes, have a different model of implementation.

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39 Following Nelson & Sampat (2001) we could call them “social technologies”. A technology of replication encompasses both internal and external sources of knowledge. As underlined in Massini & al. (2002: 1334), Nelson & Winter (1982: 171-172) “distinguish between ‘local’ search for new techniques taking place within the organization (e.g. R&D) and imitation mechanisms by which the organization adopts the successful techniques and strategies of its competitors”. As opposed to routinised response, search is irreversible, uncertain, and contingent (namely take place in some historical context). It thus requires a specific technology designated by “technology of creation” in the diagram.

40 In this case R is a “meta-routine”, which according to Nelson & Winter (1982: 16) encompasses the “routines which operate to modify over time various aspects of their operating characteristics”.
As opposed to what is assumed by their neo-classical counterparts, evolutionary economists consider that there are strong links between rules and actions. For the former, there is a sharp difference between the choice set determined by framework conditions which impose what techniques govern behaviour, and the act of choosing the means used to apply this particular technique, as in the case of profit-maximising functions. In the neo-classical perspective, the set of available techniques is a constant datum, and decision rules are a consequence of maximisation. For evolutionary economists, at any moment in time, these two elements reflect “the historically given routines governing the actions of a business firm”\(^{41}\). Such a history of firms’ behaviour can to a very limited extent be apprehended using a maximising function, which as argued below do not for example allow to distinguish between the rule and its application.

Three characteristics of routines used in the literature relate to this dual one: routines are processual, they can trigger action, and they embody collective knowledge. The processual nature of routines indicates that if studying how actions happen is important to understand firms’ behaviour, it is also essential to shed light on the process\(^{42}\) of implementation of the rules leading to action. This suggests that firms’ behaviour should be understood as a dynamic process which can be improved through a learning and routinised process, rather than based, as Sinclair-Desgagné (1999) puts it, on “firms [which] are perfect and never fail to implement a profit maximising strategy”. As for the property of routines as triggers, it highlights the existence of “meta-routines” that can trigger other routines, and underlines that a routine is often the starting point of action, although not the only one as in the aforementioned case of long-term strategic decisions. In the neo-classical model of the firm, there is no such distinction between different hierarchical levels of rules governing firms’ behaviour, as opposed to evolutionary approaches which can therefore explain why there can be inertia in decision-making due to competing objectives and rules of behaviour of different departments within the firm, for example between Production and Finance, or between Marketing and Environment.

As argued in Nelson and Winter (1982: 18), high-level routines govern the

\(^{42}\) A “process” is defined as “a series of actions that produce a change or development” (Collins English electronic dictionary, Harper Collins Publishers, 1995, version 2.0b, Novell Inc.).
modification of lower level routines in what the authors call a “search” process corresponding to “routine-guided, routine changing processes”. And as explained in the above diagram, a firm can do search in two different ways, either by creating a new routine or by adapting an existing one.

Finally for this routine property, the collective nature of routines suggests that neither rules nor actions are centralised patterns of behaviour. Rules can be executed by a wider range of actors following a specific division of labour within the action. The related knowledge about how these actions might be carried out is also distributed among different actors of the firm, which implies that knowledge held by different members does not completely overlap. This suggests that the same mechanism can be used in different ways by different actors, which is not possible to apprehend with the neo-classical model of the firm. This can be due to differences in the way these mechanisms have been learnt and stored, and thus notably depends on individual skills and on the way knowledge has been distributed and stored. Knowledge about the rules codifying how to carry out given actions (A) is remembered by being stored in what Pentland & Rueter (1994) call “representative forms” (R). The authors underline that this distinction is important to understand firms’ behaviour, which is also shaped by movements from ‘R’ to ‘A’ (p. 486). For example, as argued earlier the way identical EMAS guidelines are implemented in companies can explain part of the gaps in their environmental performance.

Repetition and persistence
Gerosky & al. (1997) studied what was keeping firms innovative over time. They found that “very few innovative activities [were] persistently innovative”, suggesting that the mechanisms allowing for such a persistence are difficult to put in place (p. 33). On the other hand, Cefis & Orsenigo (2001) argued that there were stable inter-sectoral differences in innovative persistence across countries, which according to them suggests a strong link with technological variables. As opposed to the former, they find evidence of the existence of persistence in innovative activities, which tends to corroborate the contribution of routines to innovative activities. But this evidence is not clear-cut and firm-level investigation of innovative persistence is

43 See below.
needed to shed light on the mechanisms underlying such a behaviour. The persistence of routines is linked to their repetition, because repetition without much change renders them stable and reproducible. This characteristic plays a key role in the mechanisms of co-ordination and control inside and outside the firm. It relates to the previous routine in the sense that a routine is persistent if it was conceived to be easily repeated and if users were trained to use it and have means to do so. In other words, provided that the firm acquired and/or developed an efficient technology of replication, which notably implies to44:

(i). Learn a language within which to code successful routines,

(ii). Create cognitive artefacts that can be diffused (through flowcharts and other replicable representations),

(iii). Translate the high level description contained in the cognitive artefact in actual practice, generating a new routine adapted to the new context.

At the individual level, routines contribute to the “truce” between workers and managers, because as Nelson & Winter (1982) put it:

“the usual amount of work gets done, reprimands and compliments are delivered with the usual frequency, and no demands are presented for major modifications in the terms of the relationship.”

Routine persistence also allows agents to economise on resources such as cognitive ones, thereby making up for agents’ bounded rationality45. By freeing up mental resources, it reduces uncertainty and allows them to cope with more complex situations. As Becker (2003: § 2.13) underlines:

“[stability] enables feedback mechanisms to assess the changes, to compare, and to make improvements –Tyre & Orlikowski (1996), or more generally, to learn – Langlois (1992); Postrel & Rumelt (1992), Shapira (1994).”

At the organisational level, routines are also considered as firms’ “organizational memory”46 and “represent successful solutions to particular problems”47. For

example, in a recent paper Becker and Knudsen (2004) highlight the role of organisational routines to reduce pervasive uncertainty in decision-making. The authors studied how selected Danish industries surveyed in 1999 responded to different levels of uncertainty related to environmental issues in the form of different levels of pollution, which can trigger different levels of stakeholder claims. The authors underline that according to Hoffman (1999), prominent causes of this uncertainty related to environmental issues are a lack of institutionalised practices and an unstable regulatory regime. Becker and Knudsen could notably test the following hypothesis formulated by Heiner (1983: 570) according to which:

“greater uncertainty will cause rule-governed behavior to exhibit increasingly predictable regularities, so that uncertainty becomes the basic source of predictable behaviour.”

Their results suggest that “increasing routinisation will decrease the decision-maker’s experience of pervasive uncertainty related to environmental issues”. Indeed, decision-makers can free cognitive resources by avoiding their ineffective use when trying to tackle pervasive risks or uncertainties, and direct them to problems that can actually be solved and to risks that can be reduced. By doing so, they can use their cognitive resources to set up routines enabling behavioural change. Following a point made by Feldman (2000), according to which endogenous change is comprised in routines, the authors claim that their work “provides support for the argument that routinization and change are not necessarily in contradiction”. It is therefore important to identify these routinised mechanisms and to understand how they interact with each other in order to analyse differences in firms’ behaviour. In Cohen, Burkhart et al. (1996: 673-674), Warglien argues that:

“what is often reproduced is not the routine itself, but some kind of ‘coded knowledge’ which usually implies a mix of linguistic representation, rules and artefacts.”

For example, Massimo Egidi underlines that (p. 686):

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48 Pervasive uncertainty denotes «the situations in which uncertainty prevails because it is impossible to associate point probabilities with events». 
“when we observe a team of workers performing a task in a routinised way, we observe a set of co-ordinated actions repeatedly realised over time by the team, but do not directly observe motivations and rules.”

For the firm to reproduce this routine, a template or other means of knowledge storage is needed to represent how a given action shall be carried out. According to Cohen, Burkhart et al. (1996: 661), the representation of action is maintained:

1. In the memories of individual actors,
2. By means of locally shared language,
3. Via physical artefacts (tools, spatial arrangements, written codes of standard operating procedures, computer systems),
4. Via organisational practices (archives, rotations of personnel, maintenance of working examples, key assumptions built into organisational structure),
5. By means of globally shared language forms (formalised oral codes or pledges, widely retold “war stories”).

A complement to the third representative form can be found in Nelson & Winter (1982: 105) where the authors argue that an organisation also remembers by keeping its equipment, structures, and work environment in some degree of order and repair. This suggests that these latter are also representational forms and can thus shed light on firms’ behaviour. As Nelson and Sampat (2001: 42) put it:

“the productive operation of any particular routine generally is keyed to and made effective by the embodiment of the operation of their routines in materials and equipment.”

Context dependence
Because firms are not closed systems, routines are always influenced by some context. Argues Becker (2001):

“Routines have empirically been found to be ‘intimately connected to the social, cultural, and economic milieu in which the firm exists’ (Costello (1996: 596-597)), that is, to be context-dependent.”

49 About routines embedded in machines, the authors point to Langlois (1999). Indeed, when the stove is turned on it carries out its own routine.
Cohen & Bacdayan (1994) provided empirical support in favour of a historical specificity of routines, and Massini, Lewin et al. (2002: 1346) found that the Western firms seem to have imitated practices embedded in Japanese firms. Argues Winter in Cohen, Burkhart et al. (1996):

“Context dependence is fundamental; the effectiveness of a routine is not measured by what is achieved in principle but by what is achieved in practice; this generally means that the routine might be declared effective in some specific contexts, but perhaps not in others.”

Becker (2003: § 2.7) underlines that the application of routines takes place in a specific context which characteristics strongly influence their chances of success and failure. The fact that routines co-evolve with their environment can explain why it is difficult to copy routines by isolating a transferable piece of routinised behaviour and reinserting it in a different context. Indeed (ibid.):

“a whole ensemble is required in order to put routines into application. Because routines are embedded and interlinked –Nelson (2000), they are able to identify supporting complementary elements that are necessary for their implementation in a specific context. They are ‘keyed’ to certain ‘elements’ of the environment that act as triggers –(Nelson & Winter (1973)).”

For example, external rules like patent laws can be a strong incentive for firms to innovate, and environmental policies can push firms to invest in cleaner technologies. In Cohen, Burkhart et al. (1996), Winter mentions two key features of these contexts:

“One important aspect of total context is the physical, which includes both the local/artefactual complements to the routine (e.g. the requisite plant and equipment) and the broader physical environment that was not produced for the benefit of the routine (e.g. climate, air pollution, radiation). A second major aspect of context is motivational/relational: what is the explanation for the fact that the human beings involved in the performance are willing to do what they do?”

The first feature confirms the role of technology as a key indicator of firms’ behaviour, which can be considered as part of a routine’s context at the level of an individual, or as a routine in itself at the level of an organisation. For example, in Cohen, Burkhart et al. (1996: 668-669), Warglien suggests that context can also act “as an external memory and information processor”, and even represent portions of
the routine such as the arrangement of machines in space (p. 683). The second feature follows a behavioural stance which puts forward that agents’ motivation may differ from firms’ objectives and undermine their achievement. This suggests that routines can be both enabling and inhibiting, as argued by Leonard-Barton (1992) in her study of firms’ core capabilities and core rigidities. The author defines the concept of core capabilities as “the knowledge set that distinguishes and provides a competitive advantage”, which encompasses features which are similar to the ones attributed to the organisational routines used in this thesis. Indeed, the content of this knowledge set is embodied in four dimensions which include: employee knowledge and skills, technological systems, management systems, values and norms. She also underlines that core capabilities are context-dependent, that if they are too rigid to adapt to context changes they can be seen as “core rigidities”, and that context changes can have different magnitudes of impact on different units of the firm. For example, an environmental policy seeking to change product specifications may have a strong impact on EMAS but not on investment decision-making processes, notably because finance managers may not be committed enough to reducing pollution. In the same way to core capabilities, routines can be both enabling and inhibiting: for example, the same mechanism can contribute to improve production efficiency in one firm and deter it in another, notably because it is too rigid to allow for the co-evolution with the firm’s context, or because this context may not be favourable to improvement.

Building on the previous literature review, the next section offers a deeper insight into how the two theoretical approaches can shed light on how firms address environmental issues. To do so, the way they investigate firms’ environmental behaviour is examined through the debate on the relationships between environmental policies and innovation.

50 See in Nelson & Winter (1982: 34) the “managerial critique” arguing that the main problem with neo-classical models is their “failure to represent correctly the motives that directly operate on business decisions”.

51 Nevertheless, as opposed to the choice made in this thesis Leonard-Barton focuses on knowledge rather than on organisational structures.

52 This characteristics has strong bearings for the design of innovation-friendly environmental policies, as it underlines the importance of the knowledge of the mechanisms governing firms’ environmental behaviour to reach a given environmental policy objective.
2.3.3 The neo-classical approach and firms’ environmental behaviour

To contrast the added value of evolutionary concepts when studying firms’ environmental behaviour, this section introduces how the neo-classical approach investigates this issue in studies that examine the relationship between firms’ environmental innovation and public regulation. According to Jaffe & al. (2001), the neo-classical perspective on how innovation can be based to modify firms’ environmental behaviour can be called the “induced innovation approach”. First articulated by Hicks (1932), it postulates that:

“a change in the relative prices of the factors of production is itself a spur to invention, and to invention of a particular kind – directed to economising the use of a factor which has become relatively expensive.”

For Hicks, “invention” encompasses both invention and innovation, and is induced by price variations. Since environmental policies can affect input prices, in this perspective costs are the key variable to study how firms react to environmental policies. Because costs directly impact firms’ productivity, neo-classical analyses of firms’ environmental behaviour focused on firms’ economic performance proxied by an indicator of productivity. Because this indicator reflects variations in factor prices, it also accounts for changes in (induced) innovation aiming to meet environmental policy requirements.

A sectoral study of the induced effects of environmental policies on firms’ behaviour was carried out by Berman & Bui (1998), who looked at the impact of local air quality regulation on the productivity of oil refineries in the Los Angeles Air Basin. The authors concluded that in spite of high environmental compliance costs imposed in the Basin, productivity has risen sharply between 1987 and 1992, whereas it has decreased in other regions. This suggests that firms’ environmental behaviour, measured with productivity changes, has been positively influenced by environmental policies. But the authors cannot provide a satisficing answer to the

53 As defined by the US OTA (1994): “Productivity is generally measured in two ways, total factor (or multi-factor) productivity, which relates outputs (value of the products the plant or firm produces) to all inputs to the firm, including capital, labor, purchased inputs, energy and raw materials, and single factor productivity (e.g., labor productivity), which relates outputs to the amount of a single factor (e.g., labor)”.

54 The econometric study carried out by Greenstone (1998) also revealed that air pollution regulation had a significant but very small impact on overall costs of the US manufacturing sector following the 1970 and 1977 Clean Air Act Amendments.
following question: if productivity gains can arise from the adoption of environmentally-friendly new technologies, why did profit-maximising firms located outside the region not pick these “low-hanging fruits”? In their opinion, local firms may have pre-empted new environmental technological requirements in order to increase the costs to enter the regional market, and to reduce uncertainty under future regulation. As there are high capital costs associated with the new technology, they conclude that it may have proved difficult for plants located outside the regulatory region to adopt this technology. Besides, a twofold uncertainty related to future regulatory levels and to the reliability of untested abatement technologies may have pushed these plants which are not from the Basin to wait as long as possible before making their investment decision. The authors assert that both assumptions were given support by discussions with environmental engineers interviewed during plant visits. But within-firm factors allowing firms to take advantage of economic opportunities arising from environmental policies are disregarded because all of them are assumed to have a homogenous behaviour. The authors argue that the reason for which external firms did not adopt environmentally friendly new technologies is that local firms pre-empted regional environmental standards. But another explanation of this difference in firms’ environmental behaviour can be given using factors that are internal and not external to the firm. For example, external firms may not be endowed with the same technological capabilities compared to local firms.

In another study on the energy sector, Newell & al. (1999) investigate the induced innovation effects of changes in energy prices on the energy efficiency of several energy appliances. They find evidence that between the date of enactment and the deadline for enforcement (1987-1990) both energy prices and government regulation increased by 25 to 50% the energy efficiency of room air conditioners, central air conditioners, and gas water heaters, respectively available on the market between 1958 and 1993, 1967 and 1988, and 1962 and 1993. This suggests that firms’ environmental behaviour was modified by government policy, but neither do the authors explain why nor how this happened. Indeed, in their model firms’ behaviour is homogenous, whereas differences in intra-firm characteristics can also explain differences in firms’ behaviour. For example, DeCanio (1996: 20) showed that characteristics of firms such as the number of employees affected the decision of U.S.A firms to join the EPA’s Green Light programme of investments in lighting
efficiency. Consequently, the overall modest positive impact of environmental regulation on energy-efficiency, and thus on firms’ environmental behaviour, found by the authors may hide a huge variance across firms.

Because it is central to the neo-classical approach to firms’ environmental behaviour, the problem of using environmental costs as a proxy for this behaviour is now discussed. Several authors suggest that neo-classical studies of firms’ environmental behaviour fail to reveal negative environmental costs, namely win-win benefits, and that the costs of complying with environmental regulation might be overvalued. For example, Haq & al. (2001) underlined severe biases in the collection of environmental compliance costs. The authors present five case studies in which industry provided in the course of the negotiations environmental compliance costs that were higher than actual costs for implementing them (p. 136):

“In short industry tended towards overestimation of predicted compliance costs and, in certain cases, based its substantive opposition to regulations on such cost estimates.”

As suggested in EuroStrategy Consultants (1995: vii) this is notably due to the fact that environmental investment tends to be viewed as a mere cost. Besides, Morgenstern, Pizer et al. (1999) underline that model specifications strongly affect the results of such studies. Whereas earlier research has found substantial understatement of regulatory costs, the authors observe that overstatement is also possible because of “production complementarities/economies of scope” or “poor accounting” (p. 28). Economies of scope notably arise when environmental improvements are carried out along with non-environmental modifications, such as routine oil refineries turnaround or other forced downtimes. Indeed (ibid.):

“Since it is cheaper to do the two modifications together rather than separately, this represents economies of scope. If the cost of the downtime is entirely allocated to the environmental project, it would not be surprising to find savings in conventional production associated with the increased expense on environmental activities.”

Thus, the authors call for better measures of environmental benefits and costs. But the latter are difficult to evaluate. A study on 1,400 SMEs and 60 MNFs shows that of the manufacturers which reported having taken action in response to
environmental regulations, only 30% were able to estimate the total cost of these actions. For example, among large manufacturers, substantial financial commitments were declared by sectors with a high potential to cause environmental harm, such as oil refining and electricity generation. Costs biases also originate from the fact that most sizeable benefits occur outside the firm, such as increased productivity of natural resources from lower levels of pollution (e.g. increased agricultural or fisheries yield), reduced health care costs, maintenance costs (e.g. for buildings), and capital expenditures on environmental controls (e.g. public water treatment plants). Given the lack of attention paid to negative environmental externalities, Alm (1991) argues that the benefits of environmental regulation may outweigh the costs. This raises additional problems of accountability, which according to the US OTA (1994) relate to the fact that if net environmental benefits exceed costs, benefits are likely to occur in a longer term than costs. Also, if costs can be concentrated on specific socio-economic actors, benefits might be diffuse. Finally for cost biases in neo-classical studies of firms’ environmental behaviour, if pollution reduction generated by abatement inputs is not included as an output in conventional productivity measures, by definition compliance costs lower total factor productivity because economic benefits from environmental policies are not included in firms’ outputs. For example, introducing environmental benefits of a cleaner environment in productivity calculation, Repetto (1990) finds that productivity increases by between 0.33% and 0.62% a year.

By using the concept of routine to study firms’ environmental behaviour, the aforementioned drawbacks could be avoided and a richer insight into how firms are addressing HSE issues could be provided. The next section explains in more detail the potential contribution of the evolutionary approach to the specific analysis of firms’ environmental behaviour.

55 On problems of quantifying environmental costs, see Ditz & Darryl (1995).
56 For example, the mineral oil refining sector declared ECU1.2 billion for 1994 global estimated environmental expenditure and ECU10-20 million of increased operating costs. See EuroStrategy Consultants (1995: 80).
57 The author includes in productivity measures both electricity and economic damages from pollutants, such as crop losses or morbidity.
2.4 The contribution of the evolutionary concept of routine to the understanding of firms’ environmental behaviour

This section brings forward the advantages provided by the evolutionary approach when studying firms’ behaviour. For example, the concept of routine can allow us to explain why mechanisms governing firms’ environmental behaviour can enable to improve environmental performance and lead them to take advantage of win-win opportunities, but also why other mechanisms can inhibit this performance and lock them in unsustainable production trajectories.

2.4.1 Routines as enabling mechanisms

According to the “win-win hypothesis”, firms might be able to gain a competitive advantage from environmental improvements spurred by environmental policies. As opposed to the neo-classical model of the firm, the concept of routine can shed light on the mechanisms enabling such environmental behaviour, as evidenced by a number of case studies. Building on earlier work by Ashford & al. (1985) according to which technological innovation allows environmental goals to be “co-optimised” with economic growth, Porter & Van Der Linde (1995: 120) formulated the “win-win hypothesis” in the following way:

“Properly designed environmental standards can trigger innovations that lower the total cost of a product or improve its value.”

The US OTA (1994) has also stressed the role of regulation in making environmental projects profitable:

“even though aggressive pollution prevention efforts can reduce compliance costs, particularly when compared to the current end-of-pipe approach, in most cases they are not cost effective in the absence of regulation.”

Several arguments support this hypothesis. Firstly, because environmental policies can foster innovation and improve production efficiency, they should be carefully designed. This assumes that firms’ environmental behaviour is influenced by their

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58 As Mulder, Reschke et al. (1999: 22) argue, since positive externalities exist with respect to R&D and as firms tend not to internalise positive spillovers, “environmental regulation is needed to compensate for insufficient R&D in environmentally-friendly technologies”. Also, “environmental regulation may trigger complex change in processes which cannot be solely understood in terms of changing costs and demand conditions”.

environmental context, which notably encompasses HSE regulatory systems. Secondly, as Porter & Van Der Linde (1995: 122) put it, because “pollution often is a form of economic waste” and “often reveals flaws in the product design or production process”. Numerous case studies exhibit win-win situations, such as Doniger (1978) in the vinyl chloride sector, or Dorfman & al. (1992) who document evidence of environmental and economic benefits of preventing the generation of toxic and hazardous waste. By analysing 181 specific source reduction activities in 29 chemical manufacturing plants, they show that if one in six source reduction activities have a positive cost, two out of three pay themselves back in less than six months (p. 22). In another study on six industries, the MEB (1996) finds that although costs incur from environmental policies, environmental regulations also spur innovation and lead to an increased competitive advantage of many firms in process efficiency and product quality. The case of 3M was studied by Smart (1992), notably its “Pollution Prevention Pays” programme which generated 3,000 projects allowing the group to prevent 575,000 tonnes of pollution and to save more than $530 million between 1975 and 1992. Meyer (1993) finds that US states with stricter environmental laws have better economic performance than states with lower standards. These example suggest that firms’ inefficiency can be revealed pursuing environmental objectives.

Investigating the environmental behaviour of British Speculative House Builders in the 1990s, Barlow & Bhatti (1997) provide evidence of environmental performance stimulated by regulatory standards. Indeed, the increasing stringency of thermal requirements for new and existing dwellings, which aimed to reduce energy use in home, has allowed British house builders to use energy efficiency as a competitive lever. This was carried out through a sound corporate environmental policy which provided the framework for taking advantage of both non-market and market opportunities. It underlines the co-evolution of firms’ internal mechanisms with their external context, as well as the strong impact this context and routine properties can have on firms’ environmental behaviour, provided that they are capable of implementing efficient mechanisms to respond to the pressures exerted by environmental regulatory systems.

Howes & al. (1995) give further evidence that well designed environmental regulation encourages innovation and resource productivity at the firm level, for example by conferring innovating firms an “early mover advantage” through a “green differentiation” of their products. The UK electronics industry established in 1993 the Industry Consortium for Electrical and Electronic Waste Recycling (ICER), a voluntary and cross-sector initiative aiming to develop a framework waste strategy and to begin pilot recycling schemes to test collection and recycling methods for electronic goods. In 1995, an experiment took place in West Sussex and managed to restrict the volume of equipment going to the landfill by implementing a structured response in the form of a scheme (R) representing the action (A) of recycling to be carried out on a regular and repetitive basis.

Llerena (1992) gives another example of external pressures contributing to modify firms’ environmental behaviour with the case of industrial organisations which foster the exchange of best practices. In 1990, a cross-sector organisation was created in Germany (Duales System Deutschland GmbH) to facilitate the recycling of domestic waste. This initiative enabled the development of a German recycling industry, which inspired the French programme “Eco-emballage”.

Research carried out by Smith & al. (1998) show that other kinds of environmental instruments such as life cycle analyses also have a positive impact on firms’ competitiveness. They conclude that “final goods producing firms do see long-term benefits of applying life cycle approaches”.

Studies carried out in developing countries confirm that environmental policies can foster economic competitiveness. For example, Jenkins (1998) compares the patterns of industrial pollution at national and firm levels in Mexico and Malaysia. He concludes that even if international markets consider environmental performance as a non-negligible factor of competitiveness, the driving force behind environmental performance remains government regulation:

“Most foreign firms did not report that they were required to meet parent company corporate standards and the most common pattern was that the parent required the subsidiary to comply with local environmental regulations and norms.”
This suggests that in developing countries too, firms’ environmental behaviour is strongly influenced by their context such as environmental regulatory systems. But as Porter & Van Der Linde (1995) argue:

“These examples and many others like them do not prove that companies always can innovate to reduce environmental impacts at low costs.”

Rather, they suggest that “the opportunity to reduce costs by diminishing pollution should thus be the rule, not the exception” (ibid.), in spite of industry opposition to environmental policies. Along the same line, Jaffe & al. (1995) stress that “the literature on the ‘Porter hypothesis’ remains one with a high ratio of speculation and anecdote to systematic evidence”. Using the concept of routine to study firms’ environmental behaviour and to understand how they can take advantage of win-win opportunities may allow us to undertake a more systematic investigation of the relationships between environmental policies and firms’ behaviour, as well as to design the former in such a way that they can foster environmental innovation instead of inhibiting it⁶⁰.

As Kemp (1998) argues, environmental policies have seldom been designed to foster innovation. This may have led to increase firms’ costs without allowing them to reap the benefits from their environmental expenditures. The author concludes that (p. 35):

“there is a great need for gaining a better insight in the ways in which specific regulations impact on innovation processes and technology choices, and a need to better understand the interaction between innovation and regulatory processes. There is less need for doing statistical analysis using aggregate data.”

The fact that routines might be an appropriate concept to shed light on the mechanisms enhancing firms’ environmental performance is confirmed by the use of this concept by innovative studies to explain why some firms innovate and others do not⁶¹. Besides, several studies put forward similarities between sources of innovative and environmental performance. For example, Florida (1996) gives evidence that positive environmental records are often reached by conventional competitive levers.

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⁶¹ Cf. Freeman and Soete (1997: 197-226), Chapter 8: «Success and failure in industrial innovation». 
In a study of 450 firms selected from the Standard and Poor directory of manufacturing firms, the author argues that firms leverage their industrial modernisation strategies for environmental ends by favouring source reduction, recycling, and production process improvement over treatment and end-of-pipe control technology. This is notably achieved through a close relationship between green R&D spending, product innovation, and a range of advanced manufacturing practices, including employee involvement in continuous manufacturing process and close supplier relations. Technological improvements, customer demands, and productivity improvements are also seen as important drivers of environmental manufacturing strategies. And close relationships across the production chain—and between end-users and suppliers in particular—are said to facilitate the adoption of advanced manufacturing practices by creating new opportunities for joint improvements in productivity and environmental outcomes. The similarity between innovative and environmental routines has also been exemplified by Détrie & Quelin (1993), who explain how the Swedish firm Electrolux has managed to produce the first CFC-free refrigerator thanks to a close co-operation with its suppliers. When CFCs were banned by the 1987 Montreal Protocol and the 1991 London Convention, firms belonging to the CFC sector had two options to stay in business: innovate, or buy the patent of a CFC substitute. For this sector, shifting from CFCs implied huge R&D investments and so production costs were likely to increase under the pressures of environmental regulations. Nevertheless, economies were achieved by fostering vertical co-operation, as new product specifications were affecting the whole sector. Electrolux was using CFC$_{11}$ as a liquid cooler and CFC$_{12}$ as a thermal insulator. Before the Montreal Protocol, the Swedish Parliament had negotiated with CFC consumers to adopt in May 1988 a legislation aiming to ban CFCs before 1995. Consequently, as soon as April 1989, Electrolux had halved its consumption of CFC$_{12}$. Then, thanks to a research cooperation with its CFC suppliers (Hoechst and ICI), the company set up the substitute HCFC$_{123}$, which adaptation to industry was carried out jointly with ICI, Dow, Bayer and Montedison. Concerning CFC$_{11}$, the substitute HFC$_{134a}$ was found through to a collaboration with Zanussi (Electrolux’ subsidiary for compressors), Daufoss (its main compressor supplier) and Montedison. Co-operating with downstream partners allowed Electrolux to use environmental regulation a competitive lever, and to put on the market in May 1990
the first fridge stamped “CFC free”. A point made by Elkington (1994: 99) illustrates this win-win strategy:

“The challenge facing individual companies will be to work out new ways of cooperating with their suppliers, customers, and other stakeholders—including competitors— in this key area of business activity, while ensuring that they benefit not only in corporate citizenship terms, but also in terms of competitive advantage.”

By the same token, a detailed study of the competitiveness of several European industries carried out by Berkhout & al. (2000: 380) concludes that:

“the competitiveness of both producers and suppliers in industrial ‘clusters’ are significant to improving environmental performance. Innovation in processes, products and abatement technology, depends on close interactions between users and producers of technology (capital goods, chemical inputs and architect-engineers).”

Moreover (p. 381):

“the competitiveness of the entire industrial cluster is vital to the environmental performance of production systems. Deep interaction between producers and suppliers is fundamental to innovation in capital-intensive sectors, innovation is central to the competitiveness of the sector and also critical to its environmental profile.”

The factors of environmental performance brought forward by the aforementioned studies shape firms’ environmental behaviour and are similar to the ones shaping firms’ innovative behaviour. This suggests that the mechanisms firms apply to improve their innovative and environmental performances might be similar, and confirms the usefulness of the evolutionary concept of routine to investigate these behaviours. The next section suggests that it can also shed light on the mechanisms inhibiting both performances.

2.4.2 Routines as inhibiting mechanisms
Quoting a US report dealing with strategies to reduce waste in electroplating and degreasing industries, Ashford (1993) underlines that barriers to technological

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62 For a pioneering study on the factors driving firms’ technological innovation, including a close relationship between producers and suppliers, see the SAPPHO report by SPRU (1972).
change are not only technological but also financial, labour force-related, regulatory, consumer-related, supplier-related, and managerial. About the latter barrier, the author argues that the innovation-adverse lack of top management commitment is caused by four factors (p. 295):

1) Lack of information from the financial department to top management concerning the profitability of waste reduction technologies,

2) Lack of confidence in the performance of new technologies,

3) Lack of managerial capacity and capital to deal with transition costs, reorganisation of production, educational programmes, consumers demands, or discharge waivers,

4) Lack of awareness of long-term benefits of waste reduction approach, resulting in waste reduction being a low priority issue.

This example suggests that routines may also be used to understand within-firm factors that can lead to situations of technological lock-in. Cohendet & Llerena (1998) argue that if routines can be enabling, because they are usually hard to change they can also be constraining and responsible for inflexibility and inertia in organisational behaviours, which Becker (2003) calls the “twin role” of routines. As underlined by Edmondson & al. (2001: 685), they can help understand why firms do not see external innovations, are trapped in current competencies or business models, are paralysed by core rigidities, and are handicapped by a lack of relevant expertise. Also, as argued by Orlikowski (2000), a “self-reinforcing cycle of stability” tends to appear around the routines serving existing technologies, thereby providing a source of resistance to organisational change. This tendency to stability is reinforced by the fact that routines build on the past and “adapt to experience incrementally in response to feedback about outcomes”. They have a strong cohesive

63 For a model showing that endogenous technical change makes the win-win hypothesis feasible, see Mohr (2002). The author suggests that Porter’s argument supports policy tools generating economies of scale on cleaner technologies. These economies can be fostered by governmental protection and/or subsidy of sustainable technologies. A similar argument was used in the debate on “infant-industries” (p. 167), and originates in the idea of “educational protectionism” developed by the German economist List (1904) in 1840.


function, and largely survive the replacement of the people who created them. Also, measuring the amount of time spent to perform a given task, Sinclair-Desgagné & Soubeyran (2000) suggest that time can be saved by setting up routinised processes. But they add that (p. 21):

“although routines constitute a rational answer to time scarcity, they can account for several behavioural anomalies such as inertia and resistance to change, unresponsiveness to monetary rewards, and satisficing under time pressure.”

According to Winter (1993: 191) this is notably due to the fact that routines can carry the costs burdens of a number of blunders when they are reproduced, and:

“in that case, the profit incentives and evolutionary mechanisms favoring the replication of overall success can lead to the replication of the blunders along with the competitive advantages of the total system.”

Some of these blunders might be responsible for environmental inertia. For example, if the maintenance system of a refinery is not efficient enough, leaks might be detected lately and cause feedstock losses and ground pollution. This example illustrates the point made by Nelson & Winter (1982: 116) about the fact that “control processes of (surviving) organizations tend to resist mutations”. Indeed (p. 117):

“Time and environmental changes buffet the organization with potentially mutagenic events, against which its control systems struggle. (…) The fact that organizations need to have routinised forms of resistance to unwanted change in routines thus becomes yet another reason why organizational behaviour is so strongly channelled by prevailing routine.”

In this particular case, studying control routines can shed light on the extent to which a given firm can be locked in a technological trajectory that does not co-evolve with its context for being impervious to external pressures. This can for example explain why some firms have difficulties in integrating environmental issues into occupational health and safety (OHS) systems. Indeed, EMAS are new practices that are changing existing ones, which as explained in Section 2.2.3 can be constrained by path dependencies.

69 Hence the importance of policies aiming to shape this context in a sustainable way.
70 Environmental Management Systems.
Using the definition and properties of routines provided earlier in this chapter, in Chapter 4 a methodology is elaborated to test empirically the explicative power of this concept as regards firms’ environmental behaviour. But at first, because firms co-evolve with their environmental context, it is necessary to explain what the latter encompasses.

### 2.5 Firms’ environmental context

In this thesis, firms’ environmental context relates to environmental regulatory systems. Indeed, as suggested in this section, those systems have a substantial influence on the behaviour of the oil refining industry we are interested in. To account for this influence, this section proceeds in two stages. Firstly, in Section 2.4.1, because meeting environmental requirements in heavily-polluting industries has led them to undertake huge investment programmes, investment expenditures of oil refining industries in different regions of the world are examined to shed light on the influence of environmental policies on oil refineries’ environmental behaviour\(^{71}\). The magnitude of these investments suggests a strong influence of environmental policies in firms’ environmental behaviour. Because the impact of regulatory systems on firms’ behaviour is not only identifiable by looking at investment expenditures, the technological and organisational impacts of environmental regulation on the oil refining industry studied in the TEP project are summarised\(^{72}\). Secondly, the environmental policy making process is introduced in order to shed light on how it might be able to influence the environmental behaviour of socio-economic actors (Section 2.4.2).

#### 2.5.1 The influence of environmental policies on oil refineries’ environmental behaviour

The impact of environmental policies on oil refineries can be looked at through the amount of investment spent to meet their demands, and they have been massive in the case of this industry. These investments do not only reveal information about

\(^{71}\) As explained in the following chapter, the empirical analysis carried out in this thesis concerns oil refineries.

\(^{72}\) The Technology and Environmental Policy project has investigated the impact of the Air framework directive (AFD) on UK oil refineries. Cf. Sorrell (2000).
amounts of money spent but also about their allocation to achieve different objectives, which are often set by regulatory systems. For example, Barnett (1994) underlines that:

“new environmental requirements are already having a great effect on the refining industry in Europe, and will continue to do so as legislation is tightened. Europia estimates that required investment to meet the new regulations is in the region of USD50-100 billion in the downstream sector.”

Another study gives an evaluation of potential environmental requirements for the refining industry, and investment implications in the EU are huge.

Table 1. Potential environmental investment spending of European refineries

<table>
<thead>
<tr>
<th>Measures</th>
<th>USD billion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reduce VOC emissions</td>
<td>1.8</td>
</tr>
<tr>
<td>Lower aromatics (10%) and sulphur (0.02%) content of diesel</td>
<td>34</td>
</tr>
<tr>
<td>Increase cetane number in diesel</td>
<td>2.66</td>
</tr>
<tr>
<td>Lower distillation point of diesel (340°C)</td>
<td>3.3</td>
</tr>
<tr>
<td>Lower sulphur level in petrol (0.05%)</td>
<td>3.3</td>
</tr>
<tr>
<td>Lower volatility of petrol</td>
<td>0.4</td>
</tr>
<tr>
<td>Lower benzene level in petrol (1%)</td>
<td>2.2</td>
</tr>
<tr>
<td><strong>TOTAL (petrol and diesel)</strong></td>
<td><strong>47.3-51.4</strong></td>
</tr>
<tr>
<td>Other environmental initiatives</td>
<td>20</td>
</tr>
<tr>
<td><strong>TOTAL (round figure)</strong></td>
<td><strong>70</strong></td>
</tr>
</tbody>
</table>


A similar figure is provided by the consulting firm ADL quoted in Barnett (1994):

“Between 1990 and 2010 the refinery industry in the USA, OECD Europe and the Far East would invest USD69.4 billion to meet expected requirements as to product quality. This figure comes on top of the USD50-70 billion of world-wide refinery investments in normal revamping and replacements.”

Studying the pulp and paper industry, Gray & Shadbegian (1998) point out that pollution abatement investment has almost entirely crowded out productive investment. As for European chemical companies, Scharer (1994: 109) has underlined that they allocated 10 to 15% of their total investments to environmental improvements. These figures tend to show a strong impact of environmental policies on firms’ environmental behaviour, suggesting that the way these policies are shaped needs to be examined to understand how they might affect this behaviour. But the magnitude of the influence of environmental policies on oil refineries’ behaviour can
be looked at under another angle than investment figures, such as the one of technological change.

As argued in Sorrell (2000: 153), the TEP project notably investigates the technological, economic and environmental impact of the AFD at oil refineries in England & Wales. The author points out that in many cases “refinery emissions have reduced as a by-product of actions taken for other reasons” but nevertheless that “it has been valuable for the companies involved” (p. 164). For example, Conoco has fitted an electrostatic precipitator to its FCCU to reduce particulates73, and concerning VOCs in most plants secondary seals on product storage tanks were retrofitted (p. 160). Input supplies were also used to change oil refineries’ environmental behaviour (p. 134):

“Particulate emissions from combustion plant have been reduced by the general trend towards using more RFG in the fuel system, together with the replacement of oil fired boilers with RFG fired CHP units. This in turn has been facilitated by the greater use of light crudes to meet market demand and product quality requirements.”

But as the author argues, “The most obvious and significant outcome of IPC has been the improved monitoring and reporting of emissions” (p. 160), underlining that when looking at variables others than investment expenditures, the strong impact of environmental policies on firms’ environmental behaviour is also brought forward. Therefore, as shown in the following diagram, pressures exerted by HSE regulatory system are the strongest oil refineries have to face74.

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73 Fluidised Catalytic Cracker Unit (p. 133).
74 As explained in Chapter 1, environmental issues are extended to OHS issues to study HSE issues.
The following section introduces the environmental policy making process in order to show how it co-evolves with firms and can influence their behaviour.

### 2.5.2 The environmental policy making process

As argued earlier, environmental policies are a major component of the context of environmental routines, this section seeks to provide a better understanding of how environmental policies are shaped and function, and thereby to shed light on how they might impact firms’ environmental behaviour. Most economists agree that the role of environmental policies is to correct market failures, which according to

```plaintext
Legend:  Strong influence on firms’ HSE behaviour ($H_2$)

Moderate influence

Minor influence

*Notably because the HSE regulatory system includes product specifications.

Source: Author’s own.
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Lévêque (1998: 7) corresponds to “situations where the link between the pursuit of private interests of consumers and producers and the satisfaction of general interest is broken”. For Godard (2002: 77), they allow to define “quantitative limits to actions which are likely to damage public goods”. Kemp (1998) underlines that environmental policies are “policy packages” using different instruments summarised in the following table.

**Table 2. Environmental policy instruments**

<table>
<thead>
<tr>
<th>Direct regulation</th>
<th>Economic instruments</th>
<th>Communicative instruments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Product standards</td>
<td>Pollution (effluent) taxes</td>
<td>Information provision</td>
</tr>
<tr>
<td>Pre-market approval</td>
<td>Product charges</td>
<td>Covenants (environmental agreements)</td>
</tr>
<tr>
<td>Product bans</td>
<td>Emissions trading (permits)</td>
<td>Technology compacts</td>
</tr>
<tr>
<td>Process performance standards</td>
<td>Environmental subsidies</td>
<td>Network creation (‘match making’)</td>
</tr>
<tr>
<td>Technology specifications</td>
<td>Deposit-refund systems</td>
<td></td>
</tr>
<tr>
<td>Environmental management requirements</td>
<td>Producer responsibility</td>
<td></td>
</tr>
<tr>
<td>Take back requirements</td>
<td></td>
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</tr>
</tbody>
</table>


But as Majone (1996b: 9) argues:

“regulation is not only achieved by simply passing a law, but requires detailed knowledge of, and intimate involvement with, the regulated activity.”

This notably implies to gain greater knowledge about the style of regulatory policy in place in a given country, which according to Blackman & Harrington (1999: 2) can be classified using the following categories:

1) Command and control (CAC) regulations dictate how much to abate and what abatement technology to use, or simply create financial incentives for firms to abate,

2) Economic incentives policies create financial incentives for abatement by putting an explicit or implicit price on emissions without dictating abatement decisions.

Because different environmental policies mix can have different impacts on firms’ environmental behaviour, it is important to be able to characterise a given type of environmental policy. For example, Jaffe & al. (2001: 23) point out that “technology forcing” CAC instruments can “freeze the development of technologies that might otherwise result in greater levels of control”. As opposed to emissions levels, these standards offer no financial incentive to exceed control targets, which discourages
the adoption of new technologies, notably because of a problem of appropriability. They put forward that if a company’s environmental innovation becomes a standard, it will not benefit from its investment except if it is difficult for competitors to reach the new standard, which is opposed to the objective of the diffusion of cleaner technologies. To avoid these problems, technology-forcing policies should then make sure that third parties are able to develop a market for the new standard, and the authors point out our lack of theoretical and empirical knowledge about such policies. Wheeler (1992) underlines that as regulatory agents are key players in the implementation of CAC instruments, training of human resources should be an investment priority for new environmental protection agencies. However, economists have increased their understanding of environmental policy making processes, inspired by the work of policy scientists. For example, Cropper & Oates (1992: 696) point out that:

“Not only must the regulatory agency set the usual policy parameters (emissions limitations or fees), but it must also decide upon an enforcement policy which involves both monitoring procedures and levels of fines for violations.”

By the same token, Jänicke (1997: 4) explains that:

“successful environmental protection is brought about by a complex interaction of influences and not by a single, isolated factor, nor a favourite instrument, nor a single type of actor, nor a particular framework condition or institution. The literature on environmental policy and management is full of such proposals of a particular measure, regardless of its context.”

As for Kemp (1998: 13), he argues that the institutional framework in which policy instruments are used has even a stronger impact on their performance than their technical characteristics. As Majone puts it:

“The actual outcomes of environmental policies are affected more by the institutional arrangements emerging from the political process than by the technical characteristics of the instruments employed; to use a statistical image, the ‘within group’ effects (the different results obtained when the same tool operates under different institutional circumstances) dominate the ‘between group’ effects (the results of different tools used under approximately equal conditions). In other words, the significant choice is not among abstractly
considered policy instruments but among institutionally determined ways of operating them.\textsuperscript{75}

Wasserman (1992: 22) underlines that the aspects of compliance and effectiveness of enforcement are important for several reasons\textsuperscript{76}:

1) Effectiveness: compliance is the bottom line of the benefits envisioned by environmental policies instruments. However, CBA and other cost-effectiveness studies usually assume full compliance\textsuperscript{77},

2) Efficiency: if environmental policies instruments are designed to economically efficient, inconsistent enforcement will lead to economically inefficient results,

3) Equity: a consistent enforcement response limits free-riding behaviour and allows homogeneous treatment of regulatees,

4) Credibility: the expectation that violations will generate a predictable and proportionate enforcement response is essential to the credibility of governmental regulations and institutions.

This dual aspect of regulatory processes needs to be understood to analyse the context with which firms co-evolve. But as argues Majone (1996c: 34), economic theories “are basically institution-free theories of regulation” in which regulatory institutions are at best treated as passive entities:

“This is the logical consequence of a presumed chain of control: interest groups control politicians and politicians control regulators, so the groups get what they want. Regulatory policy will reflect the underlying balance of power among economic interests. If one assumes such a chain of control, there is little to be gained by modelling the behaviour of political and bureaucratic institutions which simply operate to provide a smooth, faithful translation of private interests into policy.”

\textsuperscript{75} Quoted in Kemp (1998: 13-14).

\textsuperscript{76} The author provides a detailed survey of basic theories on compliance and enforcement (pp. 23-26) as well as of enforcement programmes (pp. 26-51). For a survey of the enforcement literature in environmental economics up to 1985, see Russell & al. (1986). On literature providing stylised facts of compliance and enforcement behaviour, see Harrington (1988), Wasserman (1992), and Russell (1990). See Heyes (1998) for a more recent survey, and Heyes (2002) for a presentation of a stylised model of enforcement. On a critical analysis of these models, see Russell (1992), Hawkins (1984) for a more practical approach, and Cohen (1998) for suggestions for future research.

\textsuperscript{77} This is confirmed in Cropper & Oates (1992: 695-696): “The great bulk of the literature on the economics of environmental regulation simply assumes that polluters comply with existing directives: they either keep their discharges within the prescribed limitation or, under a fee scheme, report accurately their levels of emissions an pay the required fees. Sources, in short, are assumed both to act in good faith and to have full control over their levels of discharges so that violations of prescribed behaviour do not occur”.
This suggest that not only environmental institutions contribute to shape firms’ environmental behaviour, they also co-evolve with socio-economic actors. Argues Nelson (1995: 77), when industry or trade associations form, they can “lobby on its behalf for regulation to its liking, for protection from competition from outside the group, for public programmes to support it, etc.”. The author argues that such behaviour can “lock in the status quo” (ibid.). For example, Blackman & Harrington (1999: 28-29) shed light on how industrial lobbies can thwart regulatory ambitions, even in an advanced industrialised country like Sweden where:

“industry’s resultant lobbying efforts succeeded in not only in completely eliminating carbon taxes but also in lowering complementary energy taxes, thereby actually reducing real energy prices paid by industry (…).”

Nelson underlines how an industry can influence its selection environment (op. cit.):

- “Through the rules of behaviour and interaction among firms that evolve spontaneously,
- Through the formation of a variety of industry-related organizations that decide matters like standards,
- Through political action.”

Policy network analyses have studied interest groups intermediation in the policy making process78:

“The policy network approach draws attention to the importance of the institutional context for the issue of governance. If policy takes place within a certain institutionalised context (i.e. stable relation pattern between organisation), it becomes important to understand that context.”79

According to Smith (2000: 96), this approach assumes that “policy-making is sectorised and takes place within networks of public and private policy actors” and “illustrates how some actors are denied a voice in policy processes by structural means”. Power-dependency is a core analytical device, because “modern policy problems are complex and no state agency has the resources to address issues single handedly: they are dependent upon the cooperation and resources of other actors” (ibid.). Contrary to rational choice approaches, which privilege agents over structure

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and assume preferences, policy network studies explore the different kinds of relationships between interest groups and government, and provide evidence that networks do involve structures as well as patterns of interaction between agents. For example, in a study of the networks dealing with offshore health and safety in Britain and Norway, Cavanagh has put forward the close identification of interests between oil companies and the UK government. Together with the exclusion of union interests, these networks managed to give a disproportionate influence of production and exploration matters over safety issues, which were therefore neglected. These policy networks studies put an emphasis on the co-evolution of firms and their regulatory context, corroborating what was argued in this section about the role of institutions in shaping the context with which firms co-evolve, and notably the one concerning environmental regulatory systems. This suggests that environmental regulatory institutions need to be examined to understand how they might influence the mechanisms governing firms’ environmental behaviour. This is done in Chapter 6.

2.6 Summary

The literature review carried out in this chapter highlighted the added value of evolutionary concepts, notably the one of routine, in providing a greater understanding of firms’ environmental behaviour. Building on the evolutionary literature on routines, it brought forward three key HSE routine properties: the duality between actions and their representation, repetition and persistence, and the context dependence of routines from HSE regulatory systems. It also suggested that routines can both inhibiting and enhance HSE performance, and that environmental regulatory pressures can have a strong impact on heavily polluting industries. They should therefore be analysed carefully in order to investigate the contribution of the evolutionary concept of routine to the understanding of how firms address, or do not address, HSE issues. The next chapter will now introduce the empirical context of the thesis.

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80 For an explanation of policy change and stability in UK industrial pollution policy using policy networks and advocacy coalitions, see Smith (2000).
Chapter 3: **Empirical context**

3.1 Introduction

The object of empirical study in this thesis is the oil refining industry in four Euro-Mediterranean countries. This chapter explains why it was chosen to answer the two research questions of the thesis. A focus is placed on a specific industrial sector, the oil refining industry, and takes place within a particular geopolitical region, the Euro-Mediterranean area. More precisely, it studies and compares how oil refineries located in two European and in two North African countries are addressing HSE issues. A single sector is studied because the nature of firms’ HSE actions depends very much on the nature of their activity. Since HSE impacts are sector-specific firms carrying out the same production activity, such as the transformation of crude oil into petroleum products, are likely to have a similar HSE behaviour. The choice of a heavily polluting industry is explained by the fact that, compared to other industries, it has much stronger HSE impacts and it is more likely to have taken observable HSE actions to address them. Indeed, notably in industrialised countries, strong HSE regulatory pressures are exerted on heavily polluting industries such as oil refining, which according to Jänicke & al. (1997) is one of the heaviest polluters. Also, oil refineries are located in countries which HSE pressures are likely to differ, like in the countries of the Euro-Mediterranean Partnership (EMP).

In addition to the theoretical challenge of identifying the mechanisms governing firms’ HSE behaviour, studying firms located in different countries of this region also issues a political challenge. Indeed, most European and Mediterranean countries are involved in the Partnership, which places a strong emphasis on sustainable development\(^2\). Therefore, not only can this thesis contribute to gain a greater understanding of how firms are addressing HSE issues, it can also allow us to compare differences in firms’ HSE behaviour on both sides of the Mediterranean. And this is all the more important since the EMP aims to upgrade the HSE performance of firms located in Mediterranean partner countries (MPCs), as well as to harmonise their HSE standards with European ones. For this purpose, the EU is providing financial and technical support to them to address HSE issues\(^3\). A greater

\(^2\) Cf. Section 3.4.

\(^3\) Ibid.
understanding of how industrial firms are addressing HSE issues on both sides of the Mediterranean will allow us to make policy recommendations to achieve these objectives. Finally, the empirical analysis of the thesis focuses on four case study countries, namely France, the UK, Morocco, and Algeria. This is because the pressures exerted by their HSE context are likely to differ as well as the HSE performance of the firm located in these countries. This is likely to provide interesting comparative perspectives to answer the second research question.

3.2 The oil refining industry

This section introduces the oil refining industry so as to provide a better understanding of HSE problems and solutions in the sector. Crude oil is a naturally occurring liquid hydrocarbon mixture which accumulates underground. It is the first source of energy in the world, and many of its hydrocarbon compounds can be used for other purposes after having been refined. It also contains potentially harmful by-products which need to be removed such as sulphur, nitrogen, or nickel. Among the three hydrocarbon sources of energy, oil has the highest rate of CO₂ emissions per unit of output. These pollution-intensive patterns are costly for the oil refining industry. Indeed, there are for example HSE regulations on both the sulphur content of refined oil products and on sulphur emissions generated by the combustion of these products. In addition to the cost of complying with HSE regulations, this awards a price premium to sweet and light crude oils which contain less sulphur and which share in the overall production of refineries has strongly increased over the past two decades. In the early days of the industry, only the kerosene contained in crude oil was used to replace vegetable and animal oil fuels in lamps. But it had an obnoxious smell, was burning with a smoky flame, and engine technology was improving fast and kept requiring better quality fuel and new refining processes.

It takes two steps to convert crude oil into a range of different products: distillation, which separates oil into feedstock fractions of different boiling points; and upgrading, which changes the chemical structure of the feedstock to improve its quality and meet product specifications such as the octane number. Once crude oil is

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84 The data used in this thesis is presented in Section 4.4.
desalted and separated into fractions through atmospheric or vacuum distillation, each fraction is cracked and treated to remove unwanted compounds. A refinery is also equipped with a number of supporting operations such as water treatment, combustion plants, storage tanks, or loading facilities, which all raise specific environmental issues.

Primary products of the oil industry fall into three broad groups: fuels, finished non-fuel products, and chemical feedstock. These products are used as a primary input to a vast number of other products such as fertilisers, pesticides, paints, waxes, thinners, solvents, cleaning fluids, detergents, refrigerants, anti-freeze, plastics and synthetic fibres. The portfolio of manufactured products influences the degree of complexity of the plant, which also depends on the properties of the crude mix. Simpler refineries use physical separation processes such as distillation, with only limited use of conversion. By contrast, complex refineries make extensive use of energy-intensive conversion processes such as hydro-treating or catalytic cracking, in order to maximise the production of lighter and high-value products such as gasoline, and to minimise the production of heavy and low value residues. In the case of very complex refineries, advanced technology is employed to either break residual fuel (HFO\textsuperscript{86}) into lighter components or to produce petrochemical feedstock. Each configuration leads to a specific product portfolio.

<table>
<thead>
<tr>
<th></th>
<th>Simple</th>
<th>Complex</th>
<th>Very complex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>30</td>
<td>50</td>
<td>65</td>
</tr>
<tr>
<td>Kerosene</td>
<td>10</td>
<td>19</td>
<td>20</td>
</tr>
<tr>
<td>Gasoil</td>
<td>20</td>
<td>17</td>
<td>25</td>
</tr>
<tr>
<td>Residual</td>
<td>35</td>
<td>20</td>
<td>0</td>
</tr>
</tbody>
</table>


### 3.3 Emissions of oil refineries

Pollution intensity and quantity vary per refinery depending on the nature of crude oil, on refinery processes and treatment capacities, on pollution abatement measures, and on general level of maintenance and housekeeping. For example, for every

\textsuperscript{86} Heavy fuel oil (HFO) is a sulphur intensive by-product of the manufacture of light products (LPG, gasolines, kerosene, diesel).
59 million tonne of crude oil processed, refineries emit between 30 to 6,000 tonnes of sulphur oxides. This gap can notably be explored by examining the differences in the degree of integration of refineries, reflected by their complexity, and as suggested by the IPTS (2001: ii). Emissions to air are the main pollutants generated by oil refineries. They come from cracking units, coke plants, sulphur recovery units, combustion processes, storage and loading operations, catalyst regeneration, vents, fugitive emission sources, and flares. Primary pollutants are sulphur dioxide, nitrogen oxides, particulates, carbon oxides, VOCs, and odorous compounds such as mercaptans. A wide array of techniques are available to reduce pollution in oil refineries. For example, 600 of them are considered in the determination of best available technologies, including 180 to tackle atmospheric pollution, 101 for solid waste, and 100 for waste water (p. iii). The refining industry also poses problems of safety, notably concerning the risks of explosion or leaks, as well as health problems due to the toxicity of products and by-products. This explains why regulatory bodies exert strong HSE pressures on the industry in Europe.

Therefore, the HSE action studied in Chapter 5 issues a big challenge to oil refineries. Indeed, according to the IPTS (2001: 82), SO2 emissions are the second biggest source of overall atmospheric emissions in oil refineries. As evidenced in the following table, they are even the main source of emissions in UK oil refineries.

<table>
<thead>
<tr>
<th></th>
<th>Emissions (ktonnes)</th>
<th>Emissions per ktonne of refinery CO2 emissions (tonnes)</th>
<th>Emissions per ktonne of refinery throughput (tonnes)</th>
<th>Emissions per ktonne of refinery fuel use (tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide</td>
<td>5.80</td>
<td>0.34</td>
<td>0.07</td>
<td>1.06</td>
</tr>
<tr>
<td>Particulates</td>
<td>3.11</td>
<td>0.18</td>
<td>0.04</td>
<td>0.57</td>
</tr>
<tr>
<td><strong>Sulphur dioxide</strong></td>
<td><strong>99.51</strong></td>
<td><strong>5.91</strong></td>
<td><strong>1.20</strong></td>
<td><strong>18.19</strong></td>
</tr>
<tr>
<td>Nitrogen dioxide</td>
<td>27.43</td>
<td>1.63</td>
<td>0.33</td>
<td>5.01</td>
</tr>
<tr>
<td>VOCs</td>
<td>50.44</td>
<td>2.99</td>
<td>0.61</td>
<td>9.22</td>
</tr>
<tr>
<td>Carbon dioxide</td>
<td>16,850.83</td>
<td>1,000.00</td>
<td>203.89</td>
<td>3,080.59</td>
</tr>
</tbody>
</table>

Source: Sorrell (2000: 24, Table 3.1).
The importance of this source of pollution is confirmed in the following table, which underlines that SO₂ emissions are the biggest contribution to air pollution from oil refineries in the UK.

<table>
<thead>
<tr>
<th>Pollutant (1995)</th>
<th>Refinery emissions (ktonnes)</th>
<th>UK emissions (ktonnes)</th>
<th>Refineries as % of UK total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon dioxide</td>
<td>6,000</td>
<td>148,000</td>
<td>4.1</td>
</tr>
<tr>
<td>Sulphur dioxide</td>
<td>196</td>
<td>2,365</td>
<td>8.3</td>
</tr>
<tr>
<td>Nitrogen oxides</td>
<td>47</td>
<td>2,295</td>
<td>2.0</td>
</tr>
<tr>
<td>Carbon monoxide</td>
<td>6</td>
<td>5,478</td>
<td>0.1</td>
</tr>
<tr>
<td>VOCs</td>
<td>180</td>
<td>2,337</td>
<td>7.7</td>
</tr>
</tbody>
</table>

Source: Sorrell (1998: 36, Table 4.2).

Also, as opposed to other pollutants, SO₂ emissions data could be collected for seven French oil refineries since 1985, a period of time long enough to investigate the relationships between oil refineries’ HSE behaviour and SO₂ emissions87.

3.4 The Euro-Mediterranean Partnership and sustainable development

The end of the East-West conflict paved the way to a new North-South relationship. The large number of interactions in fields such as trade, in particular energy supply, migration, security, terrorism or environment created the need to put the European Union’s ties with its Mediterranean neighbours on a broader and firmer basis to tackle issues causing concerns and common challenges. Consequently, the 1994 Corfu European Council requested the European Commission to draft a proposal for a new policy, which led to the Barcelona Declaration.

3.4.1 Objectives of the EMP

Negotiated in November 1995 during the Euro-Mediterranean Conference of Foreign Ministers in Barcelona, the Euro-Mediterranean Partnership was signed by the 15 member states of the European Union and 12 Mediterranean Partners88. Its objective is not only to gradually create the Euro-Mediterranean Free-Trade Area by 2010, but

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87 Cf. Section 4.4 for a presentation of this data.
88 Algeria, Cyprus, Egypt, Israel, Jordan, Lebanon, Malta, Morocco, Syria, Tunisia, Turkey, Palestinian Territories.
also to address the issues raised in its three chapters. The first one deals with political and security issues and aims to create a common area of peace and stability. The second one deals with social, cultural and human issues and aims to develop human resources and to promote understanding between cultures and exchanges between civil societies. The third one deals with economic and financial issues and aims to create a zone of shared prosperity. HSE issues are notably dealt with in the declaration by promoting co-operation to address environmental issues in MPCs, sustainable agriculture, or the transfer of European legislation. More specifically, among other sectoral issues, its economic and financial chapter contains a section on the environment mentioning several key areas of co-operation:

- Evaluation of environmental problems in the Mediterranean basin and definition of appropriate initiative to address them,
- Formulation of propositions to elaborate and update a short and medium term programme of priority actions for integrated water management, for the prevention of air pollution, for waste management, etc.
- Setting up of a regular dialogue to follow the implementation of the aforementioned short and medium term programme,
- Strengthening of regional and sub-regional co-operation and reinforcement of the co-ordination with the Mediterranean Action Plan,
- Encouragement to co-ordinate better the various sources of investment and to enforce international conventions,
- Promotion, adoption and implementation of regulatory instruments such as preventive measures and high-level standards.

3.4.2 Means

The main financial instrument of the EU for the implementation of the EMP is the MEDA programme. For the period 1996 to 1999, MEDA accounted for over €3,400 million out of the total funds of €4,685 million allocated to the Mediterranean Partners. For the period 2000 to 2006, more than €5 billion were allocated. In addition, the EIB provides more than €7 billion in loans.

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89 Source: http://www.euromed.net/euromed-books2/private-sector/default.htm, accessed 30/06/00, last modified 27/10/99.

90 MEDA means «financial and technical measures to accompany the reform of social and economic structures in the Mediterranean non-member countries». Source: http://www.euromed.net.

<table>
<thead>
<tr>
<th>Country</th>
<th>TOTAL</th>
<th>Regional</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>346</td>
<td>6%</td>
<td>4,374</td>
</tr>
<tr>
<td>Cizj./Gaza</td>
<td>389</td>
<td>7%</td>
<td>1,070</td>
</tr>
<tr>
<td>Egypt</td>
<td>881</td>
<td>16%</td>
<td>5,444</td>
</tr>
<tr>
<td>Jordan</td>
<td>423</td>
<td>8%</td>
<td>735</td>
</tr>
<tr>
<td>Lebanon</td>
<td>238</td>
<td>4%</td>
<td></td>
</tr>
<tr>
<td>Morocco</td>
<td>1,181</td>
<td>22%</td>
<td></td>
</tr>
<tr>
<td>Syria</td>
<td>182</td>
<td>3%</td>
<td></td>
</tr>
<tr>
<td>Tunisia</td>
<td>735</td>
<td>14%</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>4,374</td>
<td>80%</td>
<td>5,444</td>
</tr>
<tr>
<td>Bilateral</td>
<td>1,070</td>
<td>20%</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>5,444</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Source: http://www.euromed.net. As of 31/12/2003 (€ million).

To address environmental issues in the fragile ecosystems of the Euro-Mediterranean area, five specific programmes were set up:

- The Short and Medium Term Priority Environmental Action Programme (SMAP) funds projects (through MEDA) related to Integrated Water Management, Integrated Waste Management, Integrated Coastal Zones Management, Hot Spots (including highly polluted areas, as well as vulnerable biodiversity), and Combating Desertification.
- The Mediterranean Action Plan (MAP) develops policy recommendations and/or legal instruments and covers coastal zone management, pollution assessment and control, links between environment and development, protection of ecosystems and preservation of biodiversity.
- The Mediterranean Commission for Sustainable Development (MCSD) is an Advisory Forum consisting of representatives of Mediterranean governments, local/regional organisations, private enterprises and NGOs.
- The Mediterranean Technical Assistance Programme (METAP) is a joint Programme of big donors (EIB, World Bank, EC, UNDP, some countries) which offers technical assistance for capacity building through studies and pilot projects and assistance to programme managers. METAP-Phase IV (2001-2005) focuses on Water and Coastal Resources Management, Solid Waste Management, Policy Instruments facilitating environmentally sound investments, and has two cross-cutting issues: Knowledge management and Local Agenda 21.
- “LIFE-Third Countries” is one of the three envelopes of the EU LIFE financial instrument. Primarily addressed to national administrations, it aims at co-financing environmental actions.

3.4.3 Achievements of the EMP

Over the period 1995-1999, MEDA-committed funds went to four main types of operations: Support to structural adjustment (16%), Support to economic transition and private sector development (30%), Classical development projects to strengthening the socio-economic balance (40%), Regional projects (14%). The

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91 72% paid in 2002.
The following table provides an example of the sectoral distribution of the MEDA commitments for Algeria, which accounted for 5% of MEDA I commitments.

**Table 7. MEDA commitments for Algeria per sector/programme (1995-1999)**

<table>
<thead>
<tr>
<th>Sector/programme</th>
<th>€ million</th>
<th>Share</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>A. Support to economic transition</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. EIB: interest subsidies - reducing industrial pollution</td>
<td>129</td>
<td>79%</td>
</tr>
<tr>
<td>2. Support to SMEs/SMIs</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>3. Support to industrial restructuring and privatisation</td>
<td>38</td>
<td></td>
</tr>
<tr>
<td>4. Support to financial sector modernisation</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td><strong>B. Structural/sectoral adjustment facilities</strong></td>
<td>30</td>
<td>18%</td>
</tr>
<tr>
<td>5. Structural adjustment facilities</td>
<td>30</td>
<td></td>
</tr>
<tr>
<td><strong>C. Socio-economic balance support</strong></td>
<td>5</td>
<td>3%</td>
</tr>
<tr>
<td>6. Support to NGOs</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL A + B + C</strong></td>
<td><strong>164</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Source: http://www.euromed.net.

**Table 8. Examples of activities directly related to SMAP in Algeria**

<table>
<thead>
<tr>
<th>Year</th>
<th>Title</th>
<th>In Partnership with</th>
<th>EC Contribution</th>
</tr>
</thead>
<tbody>
<tr>
<td>2001</td>
<td>Regional Project for the Development of Marine and Coastal Protected Areas in the Mediterranean Region</td>
<td>Cyprus, France, Israel, Italy, Malta, Morocco, Spain, Syria, Tunisia</td>
<td>1,748,374 76%</td>
</tr>
<tr>
<td>2001</td>
<td>Implementation of a PV Water Pumping and Purification Program in Mediterranean Countries</td>
<td>France, Morocco, Spain, Tunisia</td>
<td>2,587,023 79%</td>
</tr>
<tr>
<td>2001</td>
<td>Regional Solid Waste Management Project in METAP Mashreq and Maghreb Countries</td>
<td>Egypt, Jordan, Lebanon, Morocco, Spain, Syria, Tunisia, Palestinian Authority</td>
<td>5,000,000 80%</td>
</tr>
</tbody>
</table>


The previous sections explained that if the EMP aimed to create a free trade area, it also provides support to MPCs to reach a sustainable development. However, the extent to which firms located in Partner countries will be able to improve their HSE performance and catch up on their European counterparts is not clear yet. This thesis suggests that the concept of routine can be used to analyse and compare how different firms located in different countries address HSE issues. The next chapter presents the data and methodology used in this thesis to identify HSE routines and to compare them across firms located in several Euro-Mediterranean countries. Herein it contributes to a greater understanding of the capacity of Moroccan and Algerian oil refineries to meet the challenge of sustainable development.
Chapter 4: **Data and methodology**

4.1 Introduction

This chapter presents the data and methodology used in the thesis, and explains how the research questions shall be answered and the hypotheses falsified. In order to characterise and identify firms’ HSE routines and to answer the first research question, this thesis proceeds in three steps. The first one consisted in the identification in Chapter 2 of the three key properties of the concept of routine: duality between action and representation, repetition and persistence, context dependence. Secondly, the mechanisms oil refineries are using to address HSE issues are identified, and the extent to which they have the properties of routines is examined. The mechanisms are identified in Chapter 5 following a methodology developed in Section 4.2.1. It allows us to bring forward three HSE mechanisms: investment decision-making processes, input supply management, HSE management. In chapters 6, 7, and 8, the extent to which these mechanisms have the properties of routines is examined following a methodology presented in Section 4.2.2. It allows us to bring to the fore two HSE routines which are used by oil refineries to address HSE issues: HSE management routines, and investment decision-making routines. Finally, to answer the second research question and following a methodology developed in Section 4.3, the HSE routines of case study oil refineries located in European member countries and in Mediterranean partner countries are compared in Chapter 9. This is to highlight the differences in the structure and execution of HSE routines, and to formulate policy recommendations about how to improve the HSE performance of firms located in Morocco and Algeria. It also suggests that the concept of routine can be used to understand how firms address HSE issues and why their HSE behaviour can differ across countries.

4.2 Answering RQ1: Can we characterise and identify firms’ HSE routines?

This section explains the rationale and methodology used to answer the core research question of the thesis. Following the definition of the properties of routines carried out in Chapter 2, its second and third steps consist in identifying HSE mechanisms and to test the extent to which they are routinised activities, namely to test to what
extent they have the three routine properties. The methodology used to identify HSE mechanisms in oil refineries is developed in Section 4.2.1. In Section 4.2.2 is explained how the three routine properties are tested on the three HSE mechanisms.

4.2.1 Identifying HSE mechanisms in French oil refineries

In order to highlight the mechanisms oil refineries are using to address HSE issues, an analysis of emissions data of seven French oil refineries is carried out. It allows us to distinguish two groups of firms, depending on whether their level of SO2 emissions per unit of output is high (Group 1) or low (Group 2). A preliminary investigation of the factors affecting these emissions in oil refineries is carried out in Section 5.2 using technical reports and interviews with refinery environment managers undertaken for the TEP project92. It brings to the fore five categories of factors which are likely to influence the pattern of SO2 emissions in oil refineries:

- Technology (Section 5.3),
- Input supplies (Section 5.4),
- Product mix (Section 5.5),
- Sulphur management schemes (Section 5.6),
- Environmental regulation (Section 5.7).

To examine the influence of the type of technology used, the technological specificity of refineries is highlighted using a classification of refining plants according to their degree of complexity. Results suggest that differences in technological endowments may lead to differences in SO2 emissions, in spite of the fact that, notably in Europe, all refineries are subjected to the same emission limits. A first indication of the impact of a specific technological process on SO2 emissions is that the greater the combustion capacity the higher the SO2 emissions. For example, the IPTS (2001: 15) report underlines that “typically, more than 60% of refinery air emissions are related to the production of energy for the various processes”. Combustion processes are utilities supplying energy to refining plants, suggesting that the bigger a plant size the higher its emissions. Because size effects

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might offset the influence of the nature of the technology on emissions, the impact of size on emissions is assessed for the two groups of refineries.

The impact of the sulphur content of crude oil on oil refineries’ SO₂ emissions is mentioned in several reports on the sector. For example, the IPTS (2001: 87) report points out that “there is a direct relation between the sulphur content of the fuel and the amount of SO₂ emitted”. This relationship is investigated in the case of the seven French refineries by examining if the group of refineries which crude oil has a high sulphur content is also the heaviest emitter of SO₂. Because the choice of crude oil might be influenced by differences in crude oil prices, this aspect of input supply is also examined to shed light on the mechanisms governing crude oil supplies. Indeed, “cleaner” low-sulphur crude is more expensive than high-sulphur crude. If input prices have a strong influence on their sales, input supplies will tend to be driven by this factor, which is external to the firm, rather than by internal factors such as input supply routines. On the other hand, if the price of crude oil neither does influence strongly the choice of input nor SO₂ emissions, since cheap crude oil is sulphur-intensive, it might be possible to identify an internal mechanism governing input supplies which indirectly influences SO₂ emissions.

The impact of the product mix is addressed in Section 5.5, notably by examining the influence of HFO₉⁵ on SO₂ emissions. The product mix of two refineries having opposite emission patterns is also compared, and the strong influence of the nature of the market demand is highlighted. Indeed, petroleum products are subjected to stringent product specifications, which suggests that the HSE regulatory context may have a strong influence on oil refineries’ SO₂ emissions.

Sulphur management schemes are examined in Section 5.6 using data on the amount of sulphur eliminated by French oil refineries and their investment programme per destination. Results notably suggest that sulphur management schemes mostly aim at meeting product specifications, which tends to confirm the strong impact of HSE regulatory systems on firms’ HSE behaviour.

Finally for Chapter 5, the role of the HSE context, in the form of environmental regulation, is examined in Section 5.7. The main regulations⁹⁴ affecting the oil industry are highlighted, as well as their period of entry into force. This allows us to

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⁹³ Heavy Fuel Oil.

⁹⁴ They concern emission limits as well as product specifications.
examine their impact on the concomitant variations in the SO\textsubscript{2} emissions of the seven French oil refineries and on their achievements following the large combustion plant directives, and on the volume of investment they spent to comply with the regulation.

4.2.2 Testing routine properties

In Chapter 2, three routine properties were highlighted. As explained in Diagram 3, a routinised behaviour can be understood by looking at three key elements: actions, their representations, and the technologies used to create, replicate, and implement these representations. In order to examine the extent to which an HSE mechanism is routinised, the extent to which it has the properties of a routine is investigated. Three hypotheses corresponding to the three routine properties guide this assessment and are tested following a methodology presented below. Testing these hypotheses allows us to investigate whether an HSE or an investment decision-making mechanism has a given routine property.

H\textsubscript{1}: Firms’ HSE actions can be distinguished from their representations.

H\textsubscript{2}: Firms’ HSE mechanisms are repetitive and persistent.

H\textsubscript{3}: Firms’ HSE mechanisms are context-dependent.

The extent to which an HSE mechanism is a routine or is not a routine cannot be answered in a binary way, but can rather be appraised by evaluating its “degree of routineness” (DR). This indicator evaluates to what extent an HSE mechanism has the characteristics of an HSE routine property. In other words, a DR indicates the extent to which an HSE mechanism is a routinised activity that contributes to enhance the HSE performance of the firm. Therefore, even if the study of firms’ HSE behaviour carried out in this thesis can bring out inhibiting routines as in the comparative analysis of Chapter 9, the HSE routines studied here are the ones that contribute to enhance the HSE performance of an oil refinery. For each routine property, a DR is calculated by adding the scores obtained for each component of the property following a methodology developed in the next three sections. The strength of the degree of routineness of an HSE mechanism can be illustrated by using the following “scale of routineness”.

Diagram 5. The scale of routineness (by increasing DR)

<table>
<thead>
<tr>
<th>0</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very Weak</td>
<td>Weak</td>
<td>Medium</td>
<td>Strong</td>
<td>Very Strong</td>
<td></td>
</tr>
</tbody>
</table>

How each property is assessed and hypothesis tested is now developed.

4.2.2.1 First hypothesis: Firms’ HSE actions can be distinguished from their representations

Testing the first research hypothesis of the thesis (H1) allows us to evaluate whether an HSE mechanism has the first routine property. As argued earlier, the distinction between actions and their representation is useful when studying how firms address HSE issues, because differences in firms’ HSE behaviour can be explained by differences in the stages of the creation, replication, and implementation of the representation of an action. For example, to set up an environmental management system, a firm can build an in-house system stored in home-made representative forms, and another one may use the European EMAS standard. Their environmental performance will depend on the quality of the system and on how it is implemented. A third firm may also use an EMAS, but its environmental performance might differ from the performance of the second firm because it implemented the EMAS in a different way.

As argued earlier and summarised in Diagram 3, when studying how a routine is put in place, three elements should be brought to the fore: one action (A), its representation (R), and the technology used to create, replicate, and implement the latter. To test the first hypothesis, firms’ HSE actions need to be distinguished from their representations. To do so, an HSE action, its representational forms, and the technologies used to create, reproduce, and implement them are investigated. As argued in Chapter 2, following Cohen & al. (1996: 661) and using the expression of Pentland & Rueter (1994), the representation of action can be maintained by using “representative forms” such as:

1. In the memories of individual actors,
2. By means of locally shared language,
3. Via physical artefacts (tools, spatial arrangements, written codes of standard operating procedures\textsuperscript{95}, computer systems),

4. Via organisational practices (archives, rotations of personnel, maintenance of working examples, key assumptions built into organisational structure),

5. By means of globally shared language forms (formalised oral codes or pledges, widely retold “war stories”).

When studying the first routine property in relation to the HSE management mechanism (M\textsubscript{1}), the action at stake is the monitoring and improvement of HSE performance of an oil refinery. When testing H\textsubscript{1} on the investment decision-making mechanism (M\textsubscript{2}), the action at stake is the undertaking of an investment project aiming to improve the HSE performance of an oil refinery. To remember how to carry out these actions, the firm stores its knowledge in one or in several of the aforementioned representative forms. For example, to reduce air emissions, the firm may set up physical artefacts (representative form n° 3) such as monitoring tools, and to prevent occupational accidents set up standard operating procedures for maintenance operations (representative form n° 5). To express its commitment to HSE issues, it may use shared language forms which can be expressed via HSE charters or codes of conduct. For investment projects, physical artefacts concern the analytical tool used to calculate the investment rate of return of the project such as cash flow analyses, which may or may not include HSE criteria. As for the technologies used to create, reproduce, or implement a “recipe” producing a specific action, they can either be organisational, by the creation of an HSE department for example, human, through HSE training programmes, or financial. For HSE mechanisms (M\textsubscript{1}), this financial technology points to the financial resources allocated by the firm to HSE projects. For investment decision-making mechanisms (M\textsubscript{2}), it concerns the way investment decisions are made, for example whether they go through a centralised or a decentralised process or what is the financial autonomy of the plant. To conclude on this routine property, its DR is increased by the following scores:

- +0 : No representative forms used at all,
- +1 : Physical artefacts are used to memorise action (fire and smoke

95 SOP.
detectors, SOP; analytical tools used to make an investment decision, …)

➢ +1 : Globally shared language forms are used to memorise action (sustainable development charter, HSE code of conduct; belief that HSE specifications are a stay-in-business decision or can bring up win-win opportunities, sustainable HSE investment charter, …).

These two representative forms (n°3 and n°5) are used because they allow for easier empirical observations at a firm-level study. The fourth representative form is accounted for by the category “organisational technology” mentioned below.

Secondly, to give an account of the technologies used to create, reproduce, and implement the earlier “recipes”, the DR of this routine property will be increased by one for each routine technology used⁹⁶:

➢ +0 : No routine technology used at all,
➢ +1 : Organisational technology used (e.g. creation of an HSE department; financial autonomy of the plant),
➢ +1 : Human technology used (HSE training, personnel evaluation integrating HSE performance; training of finance managers on HSE issues, …),
➢ +1 : Financial technology used (% investments dedicated to HSE; investment decision-making process centralised/decentralised).

4.2.2.2 Second hypothesis: Firms’ HSE mechanisms are repetitive and persistent
To test the second hypothesis (H₂), indicators of the persistence of an HSE action need to be defined. By “persistence” we mean that the effects of an action last over time. Because these effects persist provided that repetitive mechanisms are set up, if evidence is found of persistence, the repetitive property is assumed to be verified. To give an account of the persistence of an HSE mechanism, data showing that its effects last over time, and thus that its HSE objectives have been achieved, are analysed. Two elements are appraised to evaluate the DR of the first mechanism for this routine property (M₁: HSE management). At first, HSE data collected are analysed and the DR increased by the following scores:

➢ +0 : No HSE data collected at all,

⁹⁶ As argued in Chapter 2, rather than physical technologies, following Nelson & Sampat (2001) these routine technologies can be considered as “social technologies”.

- +1 : OHS data collected as well as at least one type of environmental data (air, water, waste, soil), but environmental data is only used to measure production efficiency,
- +2 : OHS data collected + at least two types of environmental data.

Secondly, the diffusion of HSE data is also investigated, because if a persistent HSE action produces positive results firms are eager to diffuse them. Therefore, after the collection of HSE data, the next step on the ladder of an enhancing HSE management routine is the diffusion of HSE data inside and outside the firm. The DR shall thus be increased by the following scores:

- +0 : No HSE data diffused at all,
- +1 : HSE data only diffused in-house,
- +2 : Some HSE data diffused to the public,
- +3 : Many HSE data diffused to the public.

As for the second mechanism (M₂: investment decision-making), its DR of this routine property indicates that the aim of the action, namely carrying out an HSE-enhancing investment project, lasts over time. Indicators for this property give an account of the willingness of the firm to use investment projects to improve its HSE performance. We propose to use two of them. The first one accounts for the extent to which HSE investments were in the long-term planned by the firm, which is an indicator of the potential persistence of HSE investment decisions. The DR is increased as follows:

- +0 : No HSE investment planned at all,
- +1 : Occasional HSE investment projects,
- +2 : Regular HSE investment planning.

Secondly, the firm should be able to provide evidence of major HSE investment projects undertaken to improve the HSE performance of the plant. The DR is increased as follows:

- +0 : No major HSE investment project undertaken,
- +1 : HSE performance-enhancing investment project undertaken only for production purposes (indirect environmental benefits),
+2 : Small HSE investment projects undertaken,
+3 : Big investment project undertaken.

Since investment decisions are a strategic matter for firms, detailed data about investment decision-making processes are difficult to collect in case studies. Taking into account investment planning as well as investment projects broadens the scope of information available to analyse investment decision-making routines of oil refineries.

4.2.2.3 Third hypothesis: Firms’ HSE mechanisms are context-dependent

The third hypothesis (H3) is tested by using two sources of evidence. The first one builds on the results of the case studies carried out in oil refineries and allows us to fill in the third column (P3) of the following table. It reveals the extent to which the HSE regulatory system influences the HSE behaviour of case study firms. The stronger this influence, the higher the DR of the studied mechanism. For example, if HSE investments are driven by regulatory requirements, then the DR of the second mechanism will be very high for this routine property, since it reveals a very strong context dependence. Indeed, as argued in Chapter 2, for oil refineries the main component of their context are HSE regulatory systems. Thus, by “context dependence” we mean “dependence from HSE regulatory systems”\(^7\). The DR is increased as follows for environmental and OHS issues, the fifth score being attributed using a second source of evidence described below.

<table>
<thead>
<tr>
<th>Context dependence of environmental actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>+0 : No context dependence at all,</td>
</tr>
<tr>
<td>+1 : Weak context dependence,</td>
</tr>
<tr>
<td>+2 : Strong context dependence.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Context dependence of OHS actions</th>
</tr>
</thead>
<tbody>
<tr>
<td>+0 : No context dependence at all,</td>
</tr>
<tr>
<td>+1 : Weak context dependence,</td>
</tr>
</tbody>
</table>

\(^7\) However, other external conditions can affect firms’ HSE behaviour such as the perception of risk or the tightness of profit margins which can force a firm to pick up inefficiencies more systematically, and thus to reduce costs.
 ➤ +2 : Strong context dependence.

On the basis of the two latter elements a provisional version of the following table is completed.

**Table 9. Summary of the DRs of the HSE mechanisms used by case study oil refineries**

<table>
<thead>
<tr>
<th>HSE routines</th>
<th>Routine properties</th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 HSE management</td>
<td>France</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2 Investment decision-making</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1 HSE management</td>
<td>UK</td>
<td>Texaco</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2 Investment decision-making</td>
<td>Texaco</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1 HSE management</td>
<td>Algeria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2 Investment decision-making</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1 HSE management</td>
<td>Morocco</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M2 Investment decision-making</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Context dependence of the DR**

As explained below, using a second source of evidence, a new version of the previous table is completed by adding a score of zero or one to the third routine property. It is used to investigate the magnitude of the impact of the strongest source of external HSE pressures on oil refineries, namely the pressures exerted by HSE regulatory systems. It combines the scores of the DR of each firm summarised in the above temporary table with the corresponding level of pressure exerted by the domestic HSE regulatory system of case study countries. This level is evaluated in Chapter 6 by examining both the number of HSE issues that are being tackled and the way they are addressed. The number of HSE issues tackled is accounted for by the “scope” of the legislation, which indicates the level of commitment of a government to address a more or less broad range of HSE issues. How a given issue is addressed is accounted for by analysing the content of the legislation and the way
it is enforced by specialised institutions. Following these “scope” and “content” analyses of the HSE regulatory systems of case study countries, the level of pressure they exert on firms is evaluated and summarised in the following table. For the criterion of scope is calculated a percentage of the number of laws voted in favour of environmental or OHS issues out of the total number of these laws for all the countries plus the EU. Concerning the content of HSE legislation, its relevance is estimated by attributing for each country one of the following marks:

- 1 : Relevant to the problems to address,
- ~ : Average relevance: when the legislation is not totally irrelevant but suffers from major flaws, like an unbalance between OHS and environmental issues,
- 0 : Irrelevant, for example if its content or related institutions are obsolete.

Finally, on the basis of the scope and content results, a “High” or a “Low” level is attributed to the pressures exerted by the HSE regulatory system of each region or country studied.

**Table 10. Evaluation of the level of pressure exerted by the HSE regulatory system of case study countries**

<table>
<thead>
<tr>
<th>Countries</th>
<th>Criterion</th>
<th>Scope (%)</th>
<th>Content</th>
<th>Level of pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Environment</td>
<td>OHS</td>
<td>Environment</td>
</tr>
<tr>
<td>EU + European</td>
<td>EU</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>countries</td>
<td>France</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>UK</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPCs</td>
<td>Algeria</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>countries</td>
<td>Morocco</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

How this table is completed is now explained in greater detail. To evaluate the scope of the legislation in case study countries and in the EU, the number of voted laws affecting the environmental behaviour of oil refineries is counted for each of the following categories: Air, Water, Soil, Waste, Refining sector, Enforcement, Information, Integration into other policies, and OHS. The table shows the distribution of the laws per country or region and per type of law (environmental or OHS), 100% being the total number of laws voted in the five countries and region. A
large distribution of the number of voted laws into multiple categories would suggest, notably in command-and-control regulatory regimes, a high level of commitment to address HSE issues.

The comparison of the content of the legislation affecting oil refineries in each country is investigated by analysing the requirements of the main voted laws, such as the European Directive 98/70 on fuel specifications. In this case, the authorised level of pollution content of petroleum products is an indicator of the magnitude of the pressures exerted by HSE regulatory systems. Nevertheless, the comparative analysis of the HSE regulatory system of European and North African countries is limited by the fact that in the latter there were very few laws voted and institutions created to address HSE issues to allow for a sound comparison with European countries. However, it was possible to carry out an analysis of the content of the French and Moroccan water regulatory systems, because both countries have enforced water laws and empowered appropriate institutions. This example demonstrates that even if only qualitative data exist, the level of pressure that HSE regulatory systems exert on firms can be compared. How this analysis of HSE regulatory systems is used to test the third routine property is now explained.

As argued in Chapter 2, because HSE regulatory systems are the main influencing context for oil refineries, if the mechanisms guiding their behaviour are routines, they should be strongly influenced by the pressures HSE regulatory systems exert on firms. For example, if the DR of French oil refineries are high for the three routine properties and if the pressures exerted by the French HSE regulatory system are strong, the context dependence of the HSE mechanisms used by French oil refineries would be confirmed. To account for this influence, the DR of the third routine property would be increased by a score of +1. The following table explains how the DR is increased following the analysis the second source of evidence of the context dependence routine property.

Table 11. Impact of the level of HSE pressures exerted by HSE regulatory systems on the DRs

<table>
<thead>
<tr>
<th>Level of HSE Pressures Degree of routineness</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>+1</td>
<td>+0</td>
</tr>
<tr>
<td>High</td>
<td>+0</td>
<td>+1</td>
</tr>
</tbody>
</table>
Since this second source of evidence might increase by one the DR obtained by a given mechanism for the third routine property, a final table summarising all the DR is provided to account for the result of this analysis. The next section provides a summary of how routine property are tested.

4.2.3 Summarising firms’ HSE routines

On the basis of the DRs obtained for each case study firm, two HSE routines are brought to the fore: the HSE management routine and the investment decision-making routine. They can be used to compare firms’ HSE behaviour following a methodology developed in the next section. The following table is completed in a specific section for each firm to present in a tabled form its HSE routines (Section 7.2.5 for French refineries, Section 7.3.5 for English ones, Section 8.2.5 for Algerian ones, and Section 8.3.5 for Moroccan ones). It contains the data collected during the fieldwork thanks to the questionnaire attached in appendix, and allows us to bring forward after each table what have caused these routines to emerge and to last. In the case of a weak DR, this allow us to bring forward HSE routines that may inhibit the HSE performance of some oil refineries. The details of the components of the routine property have been detailed above.

Table 12. Summary table of firms’ HSE routines (R1: HSE management, R2: Investment decision-making)\(^98\)

<table>
<thead>
<tr>
<th>P₁</th>
<th>P₂</th>
<th>P₃</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P₁</strong></td>
<td><strong>P₂</strong></td>
<td><strong>P₃</strong></td>
</tr>
<tr>
<td>Action vs. Representation</td>
<td>Repetition &amp; persistence</td>
<td>Context dependence (CD)</td>
</tr>
<tr>
<td>Action: Monitor and improve HSE performance</td>
<td>Data collection</td>
<td>CD of environmental actions</td>
</tr>
<tr>
<td>Representation of the action</td>
<td>+0: None</td>
<td>+0: None</td>
</tr>
<tr>
<td>+1: Physical artefacts</td>
<td>+1: OHS data collected + at least one type of environmental data (air, water, waste, soil) only used for production efficiency.</td>
<td>+1: Weak</td>
</tr>
<tr>
<td>+1: Language forms</td>
<td>+2: OHS data collected + at least two types of environmental data</td>
<td>+2: Strong</td>
</tr>
<tr>
<td>Routine technologies</td>
<td>Data diffusion</td>
<td>CD of OHS actions</td>
</tr>
<tr>
<td>+0: None</td>
<td>+0: None</td>
<td>+0: None</td>
</tr>
<tr>
<td>+1: Organisational</td>
<td>+1: HSE data only diffused in-house</td>
<td>+1: Weak</td>
</tr>
<tr>
<td>+1: Human</td>
<td>+2: Some HSE data diffused to public</td>
<td>+2: Strong</td>
</tr>
<tr>
<td>+1: Financial</td>
<td>+3: Many HSE data diffused to public</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Level HSE Pressures</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Low</td>
</tr>
<tr>
<td><strong>DR</strong></td>
<td><strong>Weak</strong></td>
<td>+1</td>
</tr>
<tr>
<td><strong>Strong</strong></td>
<td>+0</td>
<td>+1</td>
</tr>
</tbody>
</table>

98 Examples are given for every component between parentheses, and mechanisms inhibiting HSE performance are underlined.
4.3 Comparing HSE routines (RQ2)

In order to analyse the differences in the HSE behaviour of oil refineries on both sides of the Mediterranean and provide policy guidance to improve their HSE performance, a comparative analysis of their HSE routines is carried out in Chapter 9. It allows us to answer the second research question of the thesis:

**RQ2: What are the differences between the HSE routines used by firms exposed to different levels of pressures from HSE regulatory systems?**

On the basis of the results summarised in the above table, differences in the structure and execution of HSE routines in case study firms are highlighted. To do so, the routine properties of each HSE routine used by two case study firms located in one European member state and in one MPCs are compared in Chapter 9. Section 9.2 deals with the HSE routines of Naftec and Total, and Section 9.3 with the ones of Texaco/Conoco and Samir. The results of this comparative analysis are summarised in a table which highlights the main differences in the HSE behaviour of case study firms. For example, routines that inhibit improvements in the HSE performance are highlighted. On their basis, policy recommendations are made to improve the HSE performance of oil refineries in MPCs.

4.4 The data

Data on four case study countries were used, because good quality data was expected to be collected about their HSE regulatory systems and the HSE behaviour of their firms. Indeed, many people in Morocco and Algeria speak French. In the UK, several interviews carried out by Sorrell (2000) with English HSE managers and
environmental inspectors for the Technology and Environmental Policy (TEP) project could be used, as well as information gathered by Simon (1999) on oil refineries located in France for this project. Company reports and data collected on firms’ web sites as well as mail, email, and telephone inquiries were also used. However, France is the only country for which reliable data on a specific environmental action, namely reducing SO₂ emissions, could be collected over a long period of time. This explains why the identification of oil refineries’ HSE mechanisms carried out in Chapter 5 is based on a group of French firms. As evidenced in the following table, the seven studied refineries account for 59% of the amount in tonnes of petroleum products shipped from France in 2001.

The data used to answer the research questions and to falsify the hypotheses include publicly available data as well as interviews with plant managers and government officials. 35 face-to-face interviews⁹⁹ were carried out in a semi-structured format¹⁰⁰, which allows follow-up on what interviewees said and for relevant issues to be explored in more detail.

<table>
<thead>
<tr>
<th>Table 13. Shipments per refinery and per petroleum process</th>
</tr>
</thead>
<tbody>
<tr>
<td>(tonnes)</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>Gonfreville</td>
</tr>
<tr>
<td>Donges</td>
</tr>
<tr>
<td>Port-Jérôme</td>
</tr>
<tr>
<td>Lavéra</td>
</tr>
<tr>
<td>La Méde</td>
</tr>
<tr>
<td>Mardyck</td>
</tr>
<tr>
<td>Feyzin</td>
</tr>
<tr>
<td>Petit-Couronne</td>
</tr>
<tr>
<td>Fos-sur-Mer</td>
</tr>
<tr>
<td>Grandpuits</td>
</tr>
<tr>
<td>Berre</td>
</tr>
<tr>
<td>Reichstett</td>
</tr>
<tr>
<td>Gravenchon</td>
</tr>
<tr>
<td>TOTAL</td>
</tr>
<tr>
<td>Sum case study refineries</td>
</tr>
</tbody>
</table>

Source: CPDP (2002).

⁹⁹ Cf. «List of interviewees» in appendix.
¹⁰⁰ Cf. «Questionnaire» in appendix.
The following table summarises the plants and firms studied for each case study country.

**Table 14. Case study firms and countries**

<table>
<thead>
<tr>
<th>Country</th>
<th>Firms</th>
<th>Plants</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>France</strong></td>
<td>Total</td>
<td>Dunkirk</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Feyzin</td>
</tr>
<tr>
<td></td>
<td></td>
<td>La Mède</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Gonfreville</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Donges</td>
</tr>
<tr>
<td><strong>UK</strong></td>
<td>Conoco</td>
<td>Humber</td>
</tr>
<tr>
<td></td>
<td>Texaco</td>
<td>Pembroke</td>
</tr>
<tr>
<td><strong>Morocco</strong></td>
<td>Samir</td>
<td>Mohammedia</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sidi Kacem</td>
</tr>
<tr>
<td><strong>Algeria</strong></td>
<td>Naftec</td>
<td>Algiers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Arzew</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Skikda</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hassi Messaoud</td>
</tr>
</tbody>
</table>

Source: Author’s own.

An introduction to case study refineries is provided at the beginning of the section dedicated to each country. Data used in Chapter 5 to identify the mechanisms used by French oil refineries to reduce SO₂ emissions have been collected in the CPDP (2002) report, as well as in earlier issues going back to the beginning of the 1980s. The author is indebted to Steve Sorrell for access to the full text of his interviews carried out for the TEP project with UK refinery environment managers between October and December 1999. This material was used in Chapter 5 to frame the list of factors influencing oil refineries’ SO₂ emissions. Data on these emissions have been collected in France through telephone and email enquiries with all the regional industry and environment directorate (DRIRE) able to provide them. As for information about input supplies, it has been very difficult to collect it, because the composition of the crude mix or the RFG/RFO ratio are confidential information for oil refineries since they can reveal strategic choices. This has strongly undermined the empirical study of this HSE mechanism. As for data on investment decision-making processes, most of them were collected during interviews with Finance managers, since very little detailed investment data is released by refineries to the public.
4.5 Summary

In Chapter 2 the concept of routine is defined and three key properties highlighted so that it can be used to investigate firms’ HSE behaviour. Following Cohen, Burkhart et al. (1996: 683), a routine is defined as “an executable capability for repeated performance (…) that has been learned by an organisation in response to selective pressures”. The three properties of routines identified for the purpose of this research are Action vs. representation, Repetition and persistence, and Context dependence. In Chapter 5, a study of how oil a group of French refineries address a specific environmental action in the form of reducing SO₂ emissions is carried out. It brings to the fore three mechanisms used to do so: investment decision-making processes, input supplies management, and HSE management. The aim of the next three chapters is to investigate to what extent are these mechanisms used to address HSE issues in several refineries located in countries having different HSE regulatory systems. At first, in Chapter 6 the level of pressure exerted by these systems is evaluated, and not surprisingly a high level is found in European countries and a low level in MPCs. Then, chapters 7 and 8 study the HSE behaviour of oil refineries located in the four case study countries, namely in France, the UK, Morocco, and Algeria. They provide evidence that despite the weak pressures exerted by the Algerian and the Moroccan HSE regulatory systems, HSE routines are emerging in Naftec and in Samir. Indeed, it was possible to find some degree of routineness in the way the two HSE mechanisms (M₁ and M₂) were used in both plants. Finally, based on the results obtained on the HSE routines of case study firms, differences in their HSE behaviour are highlighted and analysed in Chapter 9. This allows us to formulate policy recommendations to improve the HSE performance of Moroccan and Algerian oil refineries in the perspective of the EMP.
Chapter 5: The HSE mechanisms used by oil refineries to address HSE issues

5.1 Introduction
In Chapter 2, it was suggested that the evolutionary concept of routine may allow a greater understanding of how firms address HSE issues. In Chapter 4, a methodology aiming to investigate the extent to which the mechanisms governing firms’ HSE behaviour can be identified as routines were presented. The objective of this chapter is to identify the mechanisms applied by oil refineries to carry out a specific HSE action: reducing SO2 emissions. The evolution of SO2 emissions in seven French oil refineries since 1985101 is analysed, as well as changes in the factors influencing these emissions. The relationship between the two variables is examined to highlight the mechanisms which impact on SO2 emissions could be inferred from the study of these relationships. These mechanisms shall be identified as the ones used by oil refineries to address this HSE issue. This allows us to further examine the extent to which they are used to tackle a broader range of HSE issues in a variety of other firms, as well as their DR. The next section introduces the pollution patterns as regards SO2 emissions of the oil refining industry.

5.2 SO2 emissions in French oil refineries
This section introduces oil refineries’ pollution patterns as regards SO2 emissions and highlights the factors which most influence them. In oil refineries, the main source of pollution are sulphur emissions, generated by most petroleum processes. Data collected for seven representative French oil refineries show that SO2 emissions in volume and per unit of output vary widely across refineries, as these emissions are for them nearly always above the emissions of the others.

101 These seven plants account for 58% of the total of tonnes shipped by French oil refineries. Source: CPDP, calculation by the author. # Data on SO2 emissions are the only reliable one available for such a period of time. Source: interviews with environmental inspectors who supplied these data.
Graph 1. SO$_2$ emissions of French oil refineries

Source: CPDP, various years.

Is this due to a size effect? Heavy polluters might be dirtier because they process more crude oil. If they did, the three heaviest polluters should also be the biggest producers. The following graph shows that this is not the case, as the lightest polluter (Donges) is ranked second biggest producer, and also because among the first three producers we only find one of the three heaviest polluters (Port-Jérôme).

Graph 2. Shipment per refinery in 2001

Source: CPDP, various years.
The fact that size does not seem to influence SO₂ emissions is confirmed in the following graph, which shows the percentage of variation from the average of each refinery’s SO₂ emissions per unit of output.

**Graph 3. Tonnes of SO₂ emitted per thousand of tonnes shipped (% variation from the mean)**

![Graph showing SO₂ emissions variation from the mean from 1985 to 2000 for different refineries.]

Source: CPDP, various years.

It confirms the existence of a gap between two groups of refineries: Group 1, comprising the most polluting refineries (Gonfreville, Port-Jérôme, Petit-Couronne, and Berre) and Group 2, composed of the refineries which SO₂ emissions per unit of output are below the average of the seven studied refineries. The following table shows that between 1985 and 2000, the average level of SO₂ emissions per unit of output of Group 1 is twice as high as the one of Group 2 (+99%).
Table 15. Tonnes of SO₂ emitted per thousand of tonnes shipped (difference with the average of Group 2)

<table>
<thead>
<tr>
<th>1985-2000</th>
<th>Difference between the average of Group 1 and the average of Group 2 (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonfreville (Total)</td>
<td>+8 %</td>
</tr>
<tr>
<td>Port-Jérôme (Esso)</td>
<td>+21 %</td>
</tr>
<tr>
<td>Shell Berre</td>
<td>+26 %</td>
</tr>
<tr>
<td>Petit-Couronne (Shell)</td>
<td>+24 %</td>
</tr>
<tr>
<td><strong>Group 1</strong></td>
<td>+99 %</td>
</tr>
</tbody>
</table>

Source: DRIRE for SO₂ emissions and CPDP (2002) for volumes of shipment.

The following graphs also show that in 1985 and 2000, Group 1 refineries were always the heaviest polluters, which exhibits a certain stability in the composition of the two groups over time.

Graph 4. Tonnes of SO₂ emitted per thousand of tonnes shipped in 1985

Graph 5. Tonnes of SO₂ emitted per thousand of tonnes shipped in 2000

\[\Sigma = 100\%\] \hspace{1cm} \[\Sigma = 100\%\]

Source: CPDP (2002), and several other years.

For example, the following table shows that Berre emits three times as much SO₂ per tonne shipped as Donges, which is the largest variance in our sample.
Table 16. Tonnes of SO$_2$ emitted per thousand of tonnes shipped

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonfreville (Total)</td>
<td>3.35</td>
<td>4.16</td>
<td>4.38</td>
<td>4.86</td>
<td>5.02</td>
<td>5.42</td>
<td>4.17</td>
<td>4.64</td>
</tr>
<tr>
<td>Port-Jérôme (Esso)</td>
<td>3.88</td>
<td>3.70</td>
<td>3.92</td>
<td>4.43</td>
<td>3.44</td>
<td>3.85</td>
<td>3.16</td>
<td>3.35</td>
</tr>
<tr>
<td>Shell Berre</td>
<td>3.71</td>
<td>3.62</td>
<td>4.20</td>
<td>3.09</td>
<td>3.33</td>
<td>3.26</td>
<td>2.77</td>
<td>2.49</td>
</tr>
<tr>
<td>Petit-Couronne (Shell)</td>
<td>2.66</td>
<td>3.58</td>
<td>3.41</td>
<td>3.83</td>
<td>3.26</td>
<td>3.26</td>
<td>3.85</td>
<td>3.36</td>
</tr>
<tr>
<td><strong>Average Group 1</strong></td>
<td><strong>3.40</strong></td>
<td><strong>3.76</strong></td>
<td><strong>3.98</strong></td>
<td><strong>4.05</strong></td>
<td><strong>3.76</strong></td>
<td><strong>3.95</strong></td>
<td><strong>3.49</strong></td>
<td><strong>3.46</strong></td>
</tr>
<tr>
<td>Feyzin (Total)</td>
<td>1.90</td>
<td>1.94</td>
<td>1.65</td>
<td>1.59</td>
<td>1.95</td>
<td>1.71</td>
<td>1.79</td>
<td>2.09</td>
</tr>
<tr>
<td>Donges (Total)</td>
<td>0.90</td>
<td>1.06</td>
<td>1.17</td>
<td>0.92</td>
<td>0.97</td>
<td>0.88</td>
<td>0.90</td>
<td>0.96</td>
</tr>
<tr>
<td>Gravenchon (Mobil)</td>
<td>1.86</td>
<td>3.12</td>
<td>2.21</td>
<td>2.84</td>
<td>3.04</td>
<td>2.71</td>
<td>2.73</td>
<td>2.12</td>
</tr>
<tr>
<td><strong>Average Group 2</strong></td>
<td><strong>1.55</strong></td>
<td><strong>2.04</strong></td>
<td><strong>1.68</strong></td>
<td><strong>1.79</strong></td>
<td><strong>1.99</strong></td>
<td><strong>1.77</strong></td>
<td><strong>1.80</strong></td>
<td><strong>1.72</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th></th>
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<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonfreville (Total)</td>
<td>3.97</td>
<td>3.85</td>
<td>4.08</td>
<td>3.52</td>
<td>3.24</td>
<td>2.56</td>
<td>2.48</td>
<td>1.82</td>
<td>1.82</td>
</tr>
<tr>
<td>Port-Jérôme (Esso)</td>
<td>3.37</td>
<td>4.09</td>
<td>4.19</td>
<td>3.02</td>
<td>2.92</td>
<td>3.03</td>
<td>2.85</td>
<td>2.04</td>
<td>2.04</td>
</tr>
<tr>
<td>Shell Berre</td>
<td>3.04</td>
<td>3.08</td>
<td>2.97</td>
<td>3.07</td>
<td>2.56</td>
<td>2.63</td>
<td>3.53</td>
<td>2.12</td>
<td>2.12</td>
</tr>
<tr>
<td>Petit-Couronne (Shell)</td>
<td>3.05</td>
<td>3.09</td>
<td>2.88</td>
<td>2.67</td>
<td>2.60</td>
<td>2.28</td>
<td>2.67</td>
<td>2.10</td>
<td>2.10</td>
</tr>
<tr>
<td><strong>Average Group 1</strong></td>
<td><strong>3.36</strong></td>
<td><strong>3.53</strong></td>
<td><strong>3.53</strong></td>
<td><strong>3.07</strong></td>
<td><strong>2.83</strong></td>
<td><strong>2.62</strong></td>
<td><strong>2.88</strong></td>
<td><strong>2.02</strong></td>
<td><strong>3.73</strong></td>
</tr>
<tr>
<td>Feyzin (Total)</td>
<td>1.83</td>
<td>1.78</td>
<td>1.79</td>
<td>1.91</td>
<td>1.98</td>
<td>1.63</td>
<td>1.66</td>
<td>1.56</td>
<td>1.56</td>
</tr>
<tr>
<td>Donges (Total)</td>
<td>1.06</td>
<td>0.95</td>
<td>0.99</td>
<td>1.11</td>
<td>0.97</td>
<td>0.86</td>
<td>0.98</td>
<td>0.72</td>
<td>0.72</td>
</tr>
<tr>
<td>Gravenchon (Mobil)</td>
<td>1.89</td>
<td>2.12</td>
<td>2.25</td>
<td>2.17</td>
<td>1.89</td>
<td>2.06</td>
<td>2.11</td>
<td>1.63</td>
<td>1.63</td>
</tr>
<tr>
<td><strong>Average Group 2</strong></td>
<td><strong>1.59</strong></td>
<td><strong>1.62</strong></td>
<td><strong>1.68</strong></td>
<td><strong>1.73</strong></td>
<td><strong>1.61</strong></td>
<td><strong>1.52</strong></td>
<td><strong>1.58</strong></td>
<td><strong>1.30</strong></td>
<td><strong>1.79</strong></td>
</tr>
</tbody>
</table>

Which mechanisms contribute to these differences across refineries as regards their SO$_2$ emissions per unit of output? According to Sorrell (2000: 27), a multiplicity of factors influence SO$_2$ emissions in oil refineries:

1. The crude mix, including specific gravity and sulphur content,
2. The product mix, including the proportion taken by residue fuel and its corresponding sulphur content,
3. The refinery size and process complexity, measured in part by the total capacity of combustion plant,
4. The utilisation of different combustion units and the energy efficiency of processes,
5. The balance between self generated electricity and imports, since this affects the balance between on and off site emissions,
6. The mix between RFG$^{102}$ and RFO$^{103}$ in the refinery fuel system,
7. The sulphur content of the FCCU$^{104}$ feed,
8. The efficiency of sulphur recovery units,
9. The reliability of sulphur recovery units,

$^{102}$ Refinery Fuel Gas.
$^{103}$ Refinery Fuel Oil.
$^{104}$ Fluidised Catalytic Cracking Unit.
10. The extent to which sour gas is routed to the SRU or incinerated.

The Sulphur Protocol mentions two key options to reduce sulphur emissions from combustion\textsuperscript{105}:

**Energy management measures:**

1. **Energy saving** (rational use of energy),
2. **Energy mix** (increase the proportion of non-combustion energy sources),

**Technological options:**

3. **Fuel switching** from high- to low-sulphur content coals and/or liquid fuels or from coal to gas,
4. **Fuel cleaning** of natural gas or desulphurisation of liquid fuels: hydro-cracking and full conversion technologies have matured and combine high-sulphur retention with improved yield of light products, but increase energy consumption and investment costs,
5. **Advanced combustion** technologies: fluidised-bed (FBC), integrated gasification combined-cycle (IGCC), combined-cycle gas turbines (CCGT),
6. **Process and combustion modifications** such as the injection of an agent into the combustion unit,
7. **Flue gas desulphurisation** (FGD) processes (“secondary measures” aiming at removing already formed sulphur oxides): wet, dry, semi-dry, catalytic chemical.

This underlines several mechanisms by which oil refineries can tackle SO\textsubscript{2} emissions. Finally, according to the head of the Environment Department of the French refining lobby\textsuperscript{106}, the main variables influencing SO\textsubscript{2} emissions in oil refineries are the sulphur content of crude oil, the share of HFO in the product mix, and product specifications. Taking these findings into account as well as data availability, the influence of the following categories of factors on oil refineries’ SO\textsubscript{2} emissions shall be investigated:

- The technology,
- The sulphur content of crude oil,
- The product mix,


\textsuperscript{106} Mr Legalland, Union Française de l’Industrie du Pétrole (UFIP), interviewed on 31/10/02, Paris.
- Sulphur management schemes,
- Environmental regulation.

The following sections analyse the contribution of each factor to SO₂ emissions so as to identify the mechanisms oil refineries apply to address environmental issues.

5.3 The technology

This section examines the extent to which technological factors affect oil refineries’ SO₂ emissions. The array and nature of the products manufactured by an oil refinery are key variables to determine its technological structure, which in turn influences the kind of crude oil to be processed. For example, FCCs used in complex refineries can process poorer quality crudes with a high-sulphur content, which illustrates that the kind of technology used by the refiner influences its SO₂ emissions. Moreover, the greater the complexity, the lower the HFO yield.

Table 17. Refinery degree of complexity and HFO yield

<table>
<thead>
<tr>
<th>Refinery type by increasing degree of complexity</th>
<th>HFO yield (% weight) with an average crude</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Simple refinery</strong> (atmospheric distillation, reforming, HDS)</td>
<td>40-45%</td>
</tr>
<tr>
<td><strong>Classic conversion</strong> (atmospheric distillation, catalytic cracking or hydrocracking, thermal cracking)</td>
<td>12-20%</td>
</tr>
<tr>
<td><strong>Deep conversion</strong> (deasphalting or coking or hydroconversion)</td>
<td>6-10%</td>
</tr>
</tbody>
</table>


The degree of complexity is notably determined by the nature and the combination of the technological processes operated. Thus, if refineries with a different degree of complexity have different environmental impacts, this is mostly due to differences in their technological characteristics. For example, as UFIP (2001: 8) argues, the greater the extraction of light products, the higher the sulphur content of HFO. This is confirmed by the following tables. A study of 70 Western oil refineries carried out by Concawe suggests that combustion processes are the main source of sulphur emissions (60%).
The fact that combustion processes are the main source of SO₂ emissions in oil refineries is confirmed by the following table, which shows the break down of these emissions per destination:

### Table 19. Distribution of Western oil refineries’ sulphur output per destination

<table>
<thead>
<tr>
<th>Destination</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Trapped into products for combustion (mainly into fuel oil)</td>
<td>40.1 %</td>
</tr>
<tr>
<td>Recovered as elemental sulphur</td>
<td>36.3 %</td>
</tr>
<tr>
<td>Trapped into oil products not for combustion</td>
<td>14.6 %</td>
</tr>
<tr>
<td>Emitted by refinery operations</td>
<td>9 %</td>
</tr>
</tbody>
</table>

**Total (% Total volume): 100 %**

**Total volume (Kt.): 4,994**


Another study releasing information from public registers on UK refinery emissions by process type in 1996 corroborates this statement.

### Table 20. Foster & Wheeler estimates of UK refinery emissions by source

<table>
<thead>
<tr>
<th>Source (1996, % Total)</th>
<th>SO₂ emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Combustion</td>
<td>54</td>
</tr>
<tr>
<td>FCCU</td>
<td>17</td>
</tr>
<tr>
<td>SRU</td>
<td>19</td>
</tr>
<tr>
<td>Calciner</td>
<td>-</td>
</tr>
<tr>
<td>Unallocated non combustion</td>
<td>10</td>
</tr>
</tbody>
</table>

**Total**: 100

**Contribution of ‘existing’ LCP**: 47


---


108 Namely combustion plants with a thermal input higher than 50 MWh and built prior to 1987.
An analysis of the data collected for UK refineries leads to the same conclusion, as it shows that the two refineries which have the biggest LCP capacity are also the two heaviest polluters in terms of SO2 emissions.

### Table 21. Air emissions from England and Wales refineries in 1998

<table>
<thead>
<tr>
<th>(%)</th>
<th>BP Coryton</th>
<th>Conoco</th>
<th>Elf</th>
<th>Esso</th>
<th>Lindsey</th>
<th>Phillips</th>
<th>Shell Haven</th>
<th>Shell Stanlow</th>
<th>Texaco</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sulphur dioxide</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17.3</td>
<td>5.9</td>
<td>8.1</td>
<td>17.5</td>
<td>15.2</td>
<td>1.3</td>
<td>5.5</td>
<td>20.2</td>
<td>9.0</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>


### Table 22. Contribution of refinery’s LCP capacity to total UK refinery LCP capacity (%)

<table>
<thead>
<tr>
<th>(%)</th>
<th>BP Coryton</th>
<th>Conoco</th>
<th>Elf</th>
<th>Esso</th>
<th>Gulf</th>
<th>Lindsey</th>
<th>Phillips</th>
<th>Shell Haven</th>
<th>Shell Stanlow</th>
<th>Texaco</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total MW</strong></td>
<td>11%</td>
<td>13%</td>
<td>6%</td>
<td>19%</td>
<td>5%</td>
<td>10%</td>
<td>2%</td>
<td>8%</td>
<td>17%</td>
<td>11%</td>
<td>100%</td>
</tr>
</tbody>
</table>


The above analysis suggests that combustion processes are strong contributors to oil refineries’ emissions. But all refineries are equipped with such utilities, thus it might be interesting to look at the impact of technological differences on sulphur emissions. To do so, as argued below case study refineries can be classed into two groups according to their pollution-intensity. But at first we shall study the correlation between the kind of technology used by oil refineries and their SO2 emissions. The following calculations are based on data presented in Graph 1 for SO2 emissions, and on data published by the CPDP on the capacity of the petroleum processes used by studied refineries between 1985 and 2000. The following graph presents the significant coefficients of correlation obtained for six French oil refineries. They illustrate the extent to which the capacity of a specific petroleum process in a given refinery follows the variations across time of the SO2 emissions of this refinery. In other words, it indicates the strength of the linear relationship between them.
The strongest positive correlation is found for Berre and concerns thermal cracking\textsuperscript{110}, which suggests an important contribution of this process to \( \text{SO}_2 \) emissions. As statistical evidence cannot be provided, the technological features of the heaviest polluters in terms of \( \text{SO}_2 \) emissions are explored so as to investigate whether a specific technological endowment tends to generate high-sulphur emissions. Firstly, the distribution of the volume treated per petroleum process shows that heavy polluters (Group 1) have a higher atmospheric distillation capacity than lighter polluters (Group 2). Atmospheric distillation is the main petroleum process in terms of volume of crude oil treated because all the incoming crude oil needs to be distilled.

\textsuperscript{109} With \( t^* (0,05, 16) = 2,120 \), \( t < t^* \) for all refineries and processes.

\textsuperscript{110} 0,69. Significant in a two-tailed test at 0,01.
Table 23. Distribution of the capacities of each petroleum process per refinery in 2001

<table>
<thead>
<tr>
<th>(% Total refinery)</th>
<th>Atmospheric distillation</th>
<th>Catalytic reforming</th>
<th>Thermal cracking</th>
<th>Catalytic cracking</th>
<th>Desulphurisation</th>
<th>TOTAL refinery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonfreville</td>
<td>57%</td>
<td>9%</td>
<td>5%</td>
<td>9%</td>
<td>21%</td>
<td>100%</td>
</tr>
<tr>
<td>Port-Jérôme</td>
<td>60%</td>
<td>6%</td>
<td>0%</td>
<td>15%</td>
<td>19%</td>
<td>100%</td>
</tr>
<tr>
<td>Berre</td>
<td>60%</td>
<td>8%</td>
<td>0%</td>
<td>10%</td>
<td>21%</td>
<td>100%</td>
</tr>
<tr>
<td>Petit-Couronne</td>
<td>57%</td>
<td>10%</td>
<td>6%</td>
<td>10%</td>
<td>16%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Group 1</strong></td>
<td><strong>58%</strong></td>
<td><strong>8%</strong></td>
<td><strong>3%</strong></td>
<td><strong>10%</strong></td>
<td><strong>20%</strong></td>
<td><strong>100%</strong></td>
</tr>
<tr>
<td>Feyzin</td>
<td>51%</td>
<td>4%</td>
<td>9%</td>
<td>13%</td>
<td>23%</td>
<td>100%</td>
</tr>
<tr>
<td>Donges</td>
<td>53%</td>
<td>7%</td>
<td>9%</td>
<td>13%</td>
<td>18%</td>
<td>100%</td>
</tr>
<tr>
<td>Gravenchon</td>
<td>69%</td>
<td>10%</td>
<td>0%</td>
<td>0%</td>
<td>22%</td>
<td>100%</td>
</tr>
<tr>
<td><strong>Group 2</strong></td>
<td><strong>54%</strong></td>
<td><strong>7%</strong></td>
<td><strong>8%</strong></td>
<td><strong>11%</strong></td>
<td><strong>20%</strong></td>
<td><strong>100%</strong></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>59%</strong></td>
<td><strong>3%</strong></td>
<td><strong>8%</strong></td>
<td><strong>15%</strong></td>
<td><strong>15%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>


This feature is stable across time and when controlling for the production capacity of each refinery:

Table 24. Capacity of each petroleum process per tonne shipped in 1985 and 2001

<table>
<thead>
<tr>
<th>(tonnes)</th>
<th>Atmospheric distillation</th>
<th>Catalytic reforming</th>
<th>Thermal cracking</th>
<th>Catalytic cracking</th>
<th>Desulphurisation</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sum per refinery in 1985</strong></td>
<td>9.66</td>
<td>1.34</td>
<td>0.76</td>
<td>2.47</td>
<td>3.28</td>
<td>17.50</td>
</tr>
<tr>
<td>%</td>
<td><strong>55%</strong></td>
<td><strong>8%</strong></td>
<td><strong>4%</strong></td>
<td><strong>14%</strong></td>
<td><strong>19%</strong></td>
<td><strong>100%</strong></td>
</tr>
<tr>
<td><strong>Sum per refinery in 2001</strong></td>
<td>8.45</td>
<td>1.16</td>
<td>0.59</td>
<td>1.45</td>
<td>2.90</td>
<td>14.54</td>
</tr>
<tr>
<td>%</td>
<td><strong>58%</strong></td>
<td><strong>8%</strong></td>
<td><strong>4%</strong></td>
<td><strong>10%</strong></td>
<td><strong>20%</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>


Data on the energy use of petroleum processes based on the average energy use per process provided by the US-DOE\textsuperscript{111} allow us to calculate equivalent figures for the capacities of the seven case study refineries. This analysis reveals that atmospheric distillation is by far the first energy consumer of an oil refinery, accounting for more than one third (35%) of the total amount of energy used. This percentage is even higher when considering the average amount of energy used per process and per tonne shipped (37%). Besides, if the average total amount of energy used per tonne

\textsuperscript{111} C.f. Energetics Inc. (1998: 33).
shipped of Group 1 is not very different from the average of Group 2 (+1%), the same average of Group 1 for atmospheric distillation is 13% higher than for the one of Group 2. This stresses that if heavier polluters tend to have higher atmospheric distillation capacities, they also tend to use more energy per unit of feedstock processed than cleaner refineries. They also tend to use more energy per tonne shipped to desulphurise their feedstock than refineries belonging to the second group (+33%), which reflects that they put more stress on their desulphurisation units. Because their atmospheric distillation units are more energy-intensive than lighter polluters, Group 1 refineries make a more intensive –and extensive as argued earlier– use of their combustion plants. As the latter are the main source of SO2 emissions in oil refineries, this suggest that atmospheric distillation units are likely to be indirectly the main contributor to these emissions. The two following tables, in which we control for the size of each refinery, tend to confirm the influence of atmospheric distillation on SO2 emissions, as Group 1 refineries have a higher atmospheric distillation capacity than the Group 2 (+13% in 2001).

**Table 25. Capacity of each petroleum process per tonne shipped in 2001**

<table>
<thead>
<tr>
<th>(tonnes)</th>
<th>Atmospheric distillation</th>
<th>Catalytic reforming</th>
<th>Thermal cracking</th>
<th>Catalytic cracking</th>
<th>Desulphurisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonfreville</td>
<td>1.23</td>
<td>0.19</td>
<td>0.10</td>
<td>0.18</td>
<td>0.44</td>
</tr>
<tr>
<td>Port-Jérôme</td>
<td>0.97</td>
<td>0.10</td>
<td></td>
<td>0.24</td>
<td>0.31</td>
</tr>
<tr>
<td>Berre</td>
<td>1.65</td>
<td>0.23</td>
<td></td>
<td>0.29</td>
<td>0.58</td>
</tr>
<tr>
<td>Petit-Couronne</td>
<td>1.23</td>
<td>0.22</td>
<td>0.13</td>
<td>0.22</td>
<td>0.35</td>
</tr>
<tr>
<td><strong>Average group 1</strong></td>
<td><strong>1.27</strong></td>
<td><strong>0.18</strong></td>
<td><strong>0.11</strong></td>
<td><strong>0.23</strong></td>
<td><strong>0.42</strong></td>
</tr>
<tr>
<td>Feyzin</td>
<td>0.90</td>
<td>0.08</td>
<td>0.16</td>
<td>0.24</td>
<td>0.41</td>
</tr>
<tr>
<td>Donges</td>
<td>1.16</td>
<td>0.16</td>
<td>0.20</td>
<td>0.27</td>
<td>0.39</td>
</tr>
<tr>
<td>Gravenchon</td>
<td>1.31</td>
<td>0.18</td>
<td></td>
<td></td>
<td>0.41</td>
</tr>
<tr>
<td><strong>Average group 2</strong></td>
<td><strong>1.12</strong></td>
<td><strong>0.14</strong></td>
<td><strong>0.18</strong></td>
<td><strong>0.26</strong></td>
<td><strong>0.40</strong></td>
</tr>
</tbody>
</table>

Table 26. Difference between the capacities of Group 1 and the average of Group 2

<table>
<thead>
<tr>
<th></th>
<th>Atmospheric distillation</th>
<th>Catalytic reforming</th>
<th>Thermal cracking</th>
<th>Catalytic cracking</th>
<th>Desulphurisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonfreville</td>
<td>9%</td>
<td>33%</td>
<td>-46%</td>
<td>-28%</td>
<td>10%</td>
</tr>
<tr>
<td>Port-Jérôme</td>
<td>-14%</td>
<td>-28%</td>
<td>-8%</td>
<td>-24%</td>
<td></td>
</tr>
<tr>
<td>Berre</td>
<td>47%</td>
<td>65%</td>
<td>12%</td>
<td>45%</td>
<td></td>
</tr>
<tr>
<td>Petit-Couronne</td>
<td>10%</td>
<td>61%</td>
<td>-29%</td>
<td>-13%</td>
<td>-13%</td>
</tr>
<tr>
<td>Average group 1</td>
<td>13%</td>
<td>33%</td>
<td>-38%</td>
<td>-9%</td>
<td>5%</td>
</tr>
</tbody>
</table>


We can notice that in the case of Berre, the heaviest polluter, the capacity of atmospheric distillation is 47% higher than the average capacity of Group 2 refineries. This tends to confirm the relation between the capacity of atmospheric distillation units and SO₂ emissions in oil refineries. Another striking technological feature is that for the same volume of crude oil processed (1.23 tonnes distilled per tonne shipped), the desulphurisation capacities of Gonfreville and Petit-Couronne are fairly different although they are both in Group 1. This could explain the differences in their SO₂ emissions (1.82 versus 2.10)\(^\text{112}\). This suggests that desulphurisation processes have little influence on SO₂ emissions in oil refineries, and that other factors such as the sulphur content of crude oil have a stronger influence.

The case of Berre is even more striking. Indeed, it is the heaviest SO₂ emitter of the seven refineries in spite of the fact that its desulphurisation capacity is 45% higher than the average desulphurisation capacity of lighter polluters (Group 2). This indicates that Berre’s desulphurisation processes are not efficient enough to remove a lot of sulphur, which thereby ends up in combustion processes and contributes to SO₂ emissions. It can also imply that the sulphur content of the crude oil used in the refinery is so high that even a large desulphurisation capacity does not suffice to lower SO₂ emissions in the plant. Another interesting technological feature, which can be observed in this data, is that the weakest polluter (Donges) has the highest thermal cracking capacity of the seven refineries (0.20 tonnes per tonne shipped). Thermal cracking is used to increase the yield of gasoline coming from distillation units and the one of other light fuels by applying heat and pressure to break large, heavy hydrocarbon molecules into smaller ones in the range of gasoline and other

\(^{112}\) Cf. Table 16, p. 83.
light products such as naphtha and gas oil. Residue that cannot be cracked goes to catalytic crackers\textsuperscript{113}. But as Sorrell (1998: 19) argues, thermal cracking has been largely replaced by catalytic cracking, and most European refiners no longer employ it. Indeed, catalytic cracking favours the production of gasoline, of less heavy fuel oils, and of light gases, making it a more prevalent and profitable option than thermal cracking\textsuperscript{114}. Also, catalytic crackers are flexible enough to allow for frequent changes in the structure of input and output. For example, technological designs have evolved to enable FCCs to handle increasingly poor quality feedstocks with higher percentages of sulphur, metals, and carbon residue. Finally, a growing demand for light olefins\textsuperscript{115} has forced many refineries to increasingly operate their FCCs in a maximum olefin mode rather than in a maximum gasoline mode, thereby increasing operating severity and placing a considerable strain on FCC units\textsuperscript{116}. The following table confirms that Group 1 refineries have moved away from thermal cracking processes\textsuperscript{117}, and have increased their atmospheric distillation capacity compared to Group 2 refineries (6% of difference in 1985 –but strong influence of Berre– and -38% in 2001 with 2 refineries which have stopped using it).

Table 27. Difference between the capacities of Group 1 and the average of Group 2

<table>
<thead>
<tr>
<th></th>
<th>Atmospheric distillation</th>
<th>Catalytic reforming</th>
<th>Thermal cracking</th>
<th>Catalytic cracking</th>
<th>Desulphurisation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gonfreville</td>
<td>-24%</td>
<td>29%</td>
<td>-23%</td>
<td>-46%</td>
<td>4%</td>
</tr>
<tr>
<td>Port-Jérôme</td>
<td>-23%</td>
<td>-28%</td>
<td></td>
<td>-47%</td>
<td>-31%</td>
</tr>
<tr>
<td>Berre</td>
<td>-5%</td>
<td>5%</td>
<td>65%</td>
<td>-2%</td>
<td>-14%</td>
</tr>
<tr>
<td>Petit-Couronne</td>
<td>1%</td>
<td>35%</td>
<td>-23%</td>
<td>-50%</td>
<td>-34%</td>
</tr>
<tr>
<td>Group 1</td>
<td>-13%</td>
<td>10%</td>
<td>6%</td>
<td>-36%</td>
<td>-19%</td>
</tr>
</tbody>
</table>


Three main conclusions can be drown from the comparison between the last two tables. Firstly, heavy polluters (Group 1) have invested to move away from thermal cracking technology, notably to catch up on their catalytic cracking capacity which

\textsuperscript{115} Such as propylene, isobutylene, isoamylene.
\textsuperscript{117} Since 1985, the gap between the thermal cracking capacities of both groups has increased continuously.
allows to process a wider range of crudes. This tends to confirm that thermal cracking does not seem to be a technology that affect SO₂ emissions, as argued earlier in the case of Donges. Secondly, Group 1 refineries have increased their relative share of catalytic reforming as well as of atmospheric distillation, which underlines that the latter process may have an important impact on oil refineries’ SO₂ emissions. Thirdly, Group 1 refineries have reduced the gap with Group 2 refineries as regards their catalytic cracking capacity. Given that catalytic cracking is “one of the largest sources of air emissions in refineries”¹¹⁸, this technological change may have led to an increase in SO₂ emissions for upgraded refineries. The shift from thermal cracking to catalytic cracking evidenced in the evolution of the distribution of the production capacity of French oil refineries suggests that firms have decided to move to a catalytic cracking technology. The existence of this new technology in a refinery indicates that a decision to change was taken, and the state of this technology reveals some of the lessons the firm has learned in days gone by. For this reason, as underlined in Chapter 2, authors consider that technology can be considered as a routine. But one can go beyond this identification of technologies as routines by using the first characteristic of this concept developed in Chapter 2: the distribution between actions and representations. If technology indicates that a learning process has taken place, then what is this process which has determined which technology was going to be used in a given refinery? In the definition of the concept in Chapter 2, it was argued that firms function according to routines, and that a key characteristic of these mechanisms was that some routines are rules that determine other routines which are actions. To understand why some actions occur, one needs to investigate the rules which have produced it. For example, if a more polluting technology is adopted, why environmental aspects have not been taken into account in the rules which have led to the acquisition of this technology? In firms, the rules that determine the acquisition of a given technology are embedded in the decision to invest in this technology. This decision can be to invest in physical, organisational or social capital, but it is concomitant to the setting up of a new technology in a firm. It is important to stress that an investment decision does not necessarily imply direct spending as in the case of greenfield projects. Indeed, even considering that a firm does not have to pay to acquire a new technology, and even if

¹¹⁸ Ibid.
this technology does not require an investment in a learning process to transfer the related tacit knowledge, it will still require some time to put this technology in place, even if it is just the matter of downloading a free software from the Internet. To conclude, this section on the impact of technological choices on the SO\textsubscript{2} emissions of oil refineries has underlined the strong impact of the technological choices made by oil refineries on their SO\textsubscript{2} emissions. Because these choices result from investment decision-making processes, the latter can be considered as a key mechanism driving oil refineries’ behaviour as regards SO\textsubscript{2} emissions. The following section examines a second important factor likely to affect this behaviour: the mechanisms with which oil refineries manage their input supplies.

5.4 Input supplies
This section examines the influence of the way input supplies are managed in oil refineries on their SO\textsubscript{2} emissions. Oil is mostly composed of carbon (82 to 87\%) and hydrogen (12 to 15\%), but also contains non-hydrocarbon compounds such as of sulphur, nitrogen, and oxygen. Sulphur is the third most abundant atomic constituent of crude oils, and its concentration is higher in medium and heavy fractions, which also have a higher specific gravity. The amount of sulphur in crude oil varies from below 0.05\% to about 2\% for Middle Eastern crudes and beyond 5\% or more for heavy Mexican or Mississippi crudes. Sulphur intensive crude oil needs to be treated because sulphur oxides can be released into the atmosphere and contribute to acid rain, but also because modern engines require low-sulphur gasoline. But crude oil is not the sole input used by oil refineries which can affect their environmental behaviour. Indeed, the kind of energy used also influences SO\textsubscript{2} emissions, because some energy sources release more sulphur than others. Therefore, how are these inputs chosen influences oil refineries’ environmental behaviour and need to be investigated.
Crude oil supply

Most refineries choose the quantity and quality of their inputs using linear programming. This technique takes into account the product mix, the price and quality of outputs, and the industrial structure of the plant. As argued in Wood Mackenzie (2002: 4), the supply routine of crude oil is driven by three main factors:

- Regional refining crude slate (regional refining call on crude, regional and global oil demand, regional and global crude supply, and quality from OPEC and non-OPEC),
- Regional pressures on refining (product, demand mix, refinery investment, product quality),
- Crude price differentials (depends on a and b).

These three elements contribute to the level of a region’s call on crude oil, which is itself influenced by the region’s “captive” crude supplies\textsuperscript{119}. Therefore, in addition to firms’ crude needs, there are external factors that influence the mechanisms governing the choice of its input supplies and which indirectly affect SO\textsubscript{2} emissions.

Concerning the third aforementioned factor, data are available to test the extent to which crude price differential affect oil refineries’ crude mix. If we assume that one objective of oil refineries is to minimise production costs, then the cheaper the crude the higher its volume. To test this hypothesis, three kinds of data are available for French refineries: the origin and volume of the crude oil processed by all domestic refineries, the sulphur content of these crudes\textsuperscript{120}, and the evolution of their price between 1985 and 2001.

\textsuperscript{119} Supplies upon which a consuming region can be expected always to have first call. They are made up first and foremost of domestic production and those adjacent supplying regions (North Sea for Europe, which is likely to capture North and West African as well as Caspian supplies in the future; Alaska and Gulf of Mexico for the USA, which will capture supplies from Mexico and Venezuela).

Table 28. Origin of the crude oil used by French oil refineries

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td>2575</td>
<td>2960</td>
<td>3118</td>
<td>3152</td>
<td>3075</td>
<td>2882</td>
<td>2761</td>
<td>2700</td>
<td>2611</td>
</tr>
<tr>
<td>America</td>
<td>3266</td>
<td>3329</td>
<td>4824</td>
<td>4065</td>
<td>3053</td>
<td>2865</td>
<td>2587</td>
<td>2160</td>
<td>1681</td>
</tr>
<tr>
<td>Middle East, including Saudi Arabia</td>
<td>20159</td>
<td>27844</td>
<td>21739</td>
<td>19922</td>
<td>30146</td>
<td>31195</td>
<td>36112</td>
<td>33203</td>
<td>38931</td>
</tr>
<tr>
<td>Africa, including</td>
<td>4326</td>
<td>14939</td>
<td>7004</td>
<td>11237</td>
<td>13054</td>
<td>14645</td>
<td>20061</td>
<td>19177</td>
<td>21663</td>
</tr>
<tr>
<td>Algeria</td>
<td>18133</td>
<td>16995</td>
<td>11643</td>
<td>17271</td>
<td>15761</td>
<td>19075</td>
<td>21414</td>
<td>17987</td>
<td>14100</td>
</tr>
<tr>
<td>Libya</td>
<td>2345</td>
<td>1730</td>
<td>513</td>
<td>930</td>
<td>1522</td>
<td>1731</td>
<td>2623</td>
<td>1700</td>
<td>801</td>
</tr>
<tr>
<td>Nigeria</td>
<td>2856</td>
<td>2022</td>
<td>1858</td>
<td>3641</td>
<td>2550</td>
<td>2930</td>
<td>3674</td>
<td>3351</td>
<td>1875</td>
</tr>
<tr>
<td>Others</td>
<td>8236</td>
<td>6385</td>
<td>4245</td>
<td>3888</td>
<td>3245</td>
<td>2905</td>
<td>3910</td>
<td>4337</td>
<td>5424</td>
</tr>
<tr>
<td>North Sea</td>
<td>19602</td>
<td>11441</td>
<td>16783</td>
<td>13927</td>
<td>11173</td>
<td>9949</td>
<td>10619</td>
<td>10795</td>
<td>13928</td>
</tr>
<tr>
<td>CIS (USSR before 1989)</td>
<td>2936</td>
<td>4977</td>
<td>5008</td>
<td>9199</td>
<td>5382</td>
<td>5099</td>
<td>1784</td>
<td>5592</td>
<td>5955</td>
</tr>
<tr>
<td>Sum main providers</td>
<td>66671</td>
<td>67546</td>
<td>63115</td>
<td>67536</td>
<td>68590</td>
<td>71065</td>
<td>75277</td>
<td>72437</td>
<td>77206</td>
</tr>
<tr>
<td>TOTAL</td>
<td>69550</td>
<td>68227</td>
<td>63953</td>
<td>68110</td>
<td>69023</td>
<td>71533</td>
<td>75751</td>
<td>72892</td>
<td>80698</td>
</tr>
</tbody>
</table>

Source: CPDP (2002), and other years.

The sulphur content of the different types of crude oil used by French refineries allows us to classify them into two groups having either a low (LS) or a high (HS) sulphur content, and to examine the relation between their volumes and their prices.
A first testable hypothesis holds that the lower the price of crude oil, the higher its volume. Results show that if prices co-evolve across time\textsuperscript{121}, HS crudes tend to be cheaper than LS crudes\textsuperscript{122}. This corroborates the so-called “sulphur crunch”, according to which LS crudes carry a price premium for their increasing rarity, as well as because of restrictions becoming more stringent on the sulphur content of petroleum products. Let us examine the co-evolution of the price and volume of the two groups of crude oil. For HS, the correlation between price and volume between 1985 and 2001 is weak and negative (-0.52). This indicates that although the two variables tend to evolve in an opposite direction, the volume of HS is not very elastic to price, otherwise we would find a stronger negative correlation. Concerning LS, the correlation is positive but weak (0.3).

Another hypothesis holds that variations in the price of one type of crude oil may affect the volume of the other type of crude oil. Again, this hypothesis cannot be accepted because the coefficients of correlation are not significant (0.23 and -0.40). This is in spite of the fact that the price of LS can be up to 30% higher than the price of HS. These findings tend to confirm the lack of impact of the price of crude oil on its volume of trade, and therefore that non-cost variables may have a stronger impact on the rules governing the input supplies of French oil refineries than a profit-maximising criterion.

Finally, the incidence of price variations on the energy mix of oil refineries, which can notably be examined through the RFO to RFG ratio, seems important but unobservable. Indeed, such a ratio is a strategic information which is not disclosed by oil refineries. Nevertheless, an interview with B. Poot from Total’s head office\textsuperscript{123} revealed that Donges’ energy supply relied on co-generation units since 1999. This is not the case of Gonfreville, an older refinery which is more energy-intensive and more polluting in terms of SO\textsubscript{2} emissions, which is not equipped yet with co-generation units, and which has a higher RFO to RFG ratio. Lowering this ratio is expensive as RFO (2) is cheaper than RFG (1) but it has a higher sulphur content and thus generates more sulphur emissions:

\textsuperscript{121} \sigma = 0.96.
\textsuperscript{122} Between 1985 and 2002, the price of LS has been on average 14% higher that the price of HS.
\textsuperscript{123} Responsible for Air and Water pollution in the Refining branch of the group, interviewed in Paris on 27/11/02.
Table 29. Sulphur emissions and RFO/RFG ratio

<table>
<thead>
<tr>
<th></th>
<th>Sulphur content</th>
<th>SO₂ emissions from a power plant if fired with (1) or (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) Refinery gas</td>
<td>20 – 1,700 mg H₂S/Nm³</td>
<td>1.81 kg/t feed</td>
</tr>
<tr>
<td>(2) Liquid refinery fuel</td>
<td>&lt; 0.1 – 7% S</td>
<td>8.2 kg/t feed</td>
</tr>
</tbody>
</table>


As utilities are managed on refineries’ decentralised budget, the cheapest solution tends to prevail, as long as environmental mandatory targets are not exceeded. Finally, because of an increase in conversion capacities, refinery fuel consumption is likely to increase in the future while its most polluting component (RFO) might be phased out. Consequently, the mechanisms governing input supplies may have to be modified to reduce SO₂ emissions. This would also impact on investment routines because reducing the consumption of polluting liquid fuels implies to invest in additional distillation residue upgrading units like coking, thermocracking or gasification. To conclude on these aspects of crude oil prices, it seems that non-cost variables have a stronger influence on oil refineries’ SO₂ emissions. This suggests that this aspect of firms’ environmental behaviour cannot be addressed by neo-classical theories of the firm but by a more contextual approach which can for example can allow to examine the link between the geographical origin of crude oils and refineries’ SO₂ emissions.

Origin of the crude oil processed by French oil refineries

Since 1985, in France the share of low-sulphur crude oil in overall crude oil supply has always been higher than 50%. Between 1985 and 2001, the average share of low-sulphur crude is 58%, with a stagnation between 1989 and 1993 around 50%. Since then, it has followed an upward trend and in 2001 peaked out to 69%. Examining total SO₂ emissions of the seven studied refineries between 1985 and 2000 allows us to distinguish three salient periods.

---

125 Except in 1993 (47%).
Table 30. SO₂ emissions and share of high-sulphur crude oil in total crude supply

<table>
<thead>
<tr>
<th>Period (pₙ)</th>
<th>Average emissions (t/y) and variation pₙ/pₙ₋₁</th>
<th>Share high-sulphur crude (% Total)</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 1985-1988</td>
<td>17,224 (+4%)</td>
<td>40</td>
<td>Share stable but emissions increase</td>
</tr>
<tr>
<td>2 1989-1993</td>
<td>17,912 (-15%)</td>
<td>50</td>
<td>More high-sulphur and emissions increase</td>
</tr>
<tr>
<td>3 1994-2001</td>
<td>15,299 (-15%)</td>
<td>39</td>
<td>More low-sulphur and emissions decrease</td>
</tr>
</tbody>
</table>

Source: Author’s own.

We can see that increases in the share of high-sulphur crude oil in the supply of French refineries correspond to increases in the SO₂ emissions of our seven refineries, which account for 58% of the tonnes shipped by French refiners. This tends to demonstrate that the sulphur content of crude oil influences oil refineries’ SO₂ emissions. This is confirmed by the following analysis of the relation between the average sulphur content of the crude oil processed by French refineries and their level of SO₂ emissions, the amount of sulphur eliminated, and the ratio of the amount of sulphur produced to the amount of sulphur eliminated:

Table 31. Correlation between SO₂ emissions and the average sulphur content of crude oil, the amount of HFO produced, and the ratio sulphur produced/sulphur eliminated

<table>
<thead>
<tr>
<th></th>
<th>Correlation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average sulphur content</td>
<td>0.86</td>
</tr>
<tr>
<td>HFO produced</td>
<td>0.96</td>
</tr>
<tr>
<td>Ratio Sulphur produced/Sulphur eliminated</td>
<td>-0.93</td>
</tr>
</tbody>
</table>

Source: UFIP (2002), Unpublished data.

We can see that there is a strong correlation between SO₂ emissions and the sulphur content of crude oil, as well as with the amount of HFO produced. This confirms that the quality of crude oil supplies has a strong impact on SO₂ emissions and affects oil refineries’ environmental behaviour. Consequently, we can argue that the mechanism by which oil refineries choose their crude oil influences their environmental behaviour. We can also notice the strong negative correlation between SO₂ emissions and the ratio measuring the amount of sulphur produced to the amount of sulphur eliminated. This suggests that the higher the amount of sulphur recovered, the lower the SO₂ emissions. This obvious relation stresses the role of sulphur removal processes which are often the result of environmental requirements. To conclude, if
information on the sulphur content of crude oil is not disclosed to the public, aggregate data for the two former French Esso refineries could be accessed126.

Table 32. Origin of crude oil processed by the refineries of Fos-sur-Mer and Port-Jérôme (% per country)

<table>
<thead>
<tr>
<th>Year</th>
<th>Low-sulphur crude (“LSC”, %)</th>
<th>TOTAL LSC (%)</th>
<th>High-sulphur crude (“HSC”, Middle East, %)</th>
<th>Misc. (%)</th>
<th>TOTAL LSC + HSC (Mt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>7.6 5.6 - - -</td>
<td>13</td>
<td>84</td>
<td>3</td>
<td>11.8</td>
</tr>
<tr>
<td>1983</td>
<td>9.5 25.3 - - -</td>
<td>35</td>
<td>58</td>
<td>7</td>
<td>9.5</td>
</tr>
<tr>
<td>1984</td>
<td>13 41 - - -</td>
<td>54</td>
<td>40</td>
<td>6</td>
<td>8.8</td>
</tr>
<tr>
<td>1985</td>
<td>13 43 - - -</td>
<td>56</td>
<td>31</td>
<td>13</td>
<td>8</td>
</tr>
<tr>
<td>1986</td>
<td>13 5 - - -</td>
<td>18</td>
<td>73</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>1987</td>
<td>9.5 16 - - -</td>
<td>26</td>
<td>66</td>
<td>9</td>
<td>9.5</td>
</tr>
<tr>
<td>1988</td>
<td>5.5 14 - - -</td>
<td>20</td>
<td>75</td>
<td>6</td>
<td>9.2</td>
</tr>
<tr>
<td>1989</td>
<td>5 17.2 - - -</td>
<td>22</td>
<td>74</td>
<td>4</td>
<td>9.9</td>
</tr>
<tr>
<td>1990</td>
<td>5 14 - - -</td>
<td>19</td>
<td>54</td>
<td>27</td>
<td>9.8</td>
</tr>
<tr>
<td>1991</td>
<td>5 18 - - -</td>
<td>23</td>
<td>61</td>
<td>16</td>
<td>10.8</td>
</tr>
<tr>
<td>1992</td>
<td>6 20 - - -</td>
<td>26</td>
<td>57</td>
<td>17</td>
<td>10.8</td>
</tr>
<tr>
<td>1993</td>
<td>5 32 - - -</td>
<td>37</td>
<td>46</td>
<td>17</td>
<td>10.2</td>
</tr>
<tr>
<td>1994</td>
<td>3 - 14 57 - -</td>
<td>74</td>
<td>24</td>
<td>2</td>
<td>12.1</td>
</tr>
<tr>
<td>1995</td>
<td>2 - 7 46 - -</td>
<td>55</td>
<td>41</td>
<td>4</td>
<td>12.4</td>
</tr>
<tr>
<td>1996</td>
<td>2 - 3 32 - -</td>
<td>37</td>
<td>56</td>
<td>7</td>
<td>11.9</td>
</tr>
<tr>
<td>1997</td>
<td>2 - 4 32 11</td>
<td>49</td>
<td>51</td>
<td>0</td>
<td>11.6</td>
</tr>
<tr>
<td>1998</td>
<td>2 - 10 23 - -</td>
<td>49</td>
<td>51</td>
<td>0</td>
<td>11.3</td>
</tr>
</tbody>
</table>

Source: Esso annual reports, several years. Data obtained from the IFP Information Centre, RueilMalmaison, France.

* % may not round up because minor of LSC were not mentioned in the original data.

The coefficient of correlation calculated between the available SO2 emissions for Port-Jérôme127 and the above percentage of sulphur-intensive crude oil used by the two Esso refineries is not significant (0.3). This may be due to the fact that available figures do not discriminate between the origin of crude oil among the two former Esso refineries, which may have had a different crude mix. In fact, the highest correlation coefficient is found between 1988 and 1991 (0.77), but it is too short a period to draw any conclusion on the impact of heavy-sulphur crude oil on SO2 emissions. If the CPDP publishes annual data on the origin of the crude oil processed

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126 Fos-sur-Mer and Port-Jérôme, which now belong to BP-Mobil. In 2000, the refineries of Port-Jérôme and Gravenchon merged.
127 Data not available for Fos.
by French refineries, it does not break down this strategic information per refinery. In the case of Donges, an interview with the environmental inspector in charge of the plant revealed that the share of LS represents between 75 and 80% of the total crude oil supply. This confirms the role of the nature of crude oil, and thus of the mechanisms that decide on the mix of this input, on oil refineries’ SO$_2$ emissions, and thus on their environmental behaviour.

Finally for this section, although it is difficult to obtain plant-level data and to shed light on the extent to which the sulphur content of crude oil influences oil refineries’ SO$_2$ emissions, as an IPTS (2001: 87) report argues, a network of facts suggests that:

“There is a direct relation between the sulphur content of the fuel and the amount of SO$_2$ emitted (for example, a fuel with 1% sulphur generates a flue gas with 1,700 mg/Nm$^3$).”

Therefore, the mechanisms used to manage input supplies in oil refineries seem to have a strong influence on the studied HSE behaviour. We shall now investigate whether the range and quality of products manufactured by oil refineries affect their SO$_2$ emissions.

### 5.5 Product mix

The range of products manufactured by a refinery influences the type of input it uses. As heavy crudes (HC) have a higher ratio of carbon to hydrogen atoms, refining them produces more heavy petroleum products like gas oil, heavy fuel oil and bitumen. Light crudes (LC) allow to produce more light products such as gasoline, naphtha, and kerosene, which currently represent the main outputs of oil refineries because of the importance of road and air transports, the primary end users of oil products in the OECD. LC are characterised by a high degree of API gravity, and HC by a low API degree. The relation between the API gravity and the sulphur content of 243 different world crude oils listed by HPI consultants exhibits a negative

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128 Telephone interview with Mr Fayol, environmental inspector in the DRIRE Pays-de-la-Loire, 21/10/2002. This latter obtained the information from Mr Génin, former director of the Gonfreville oil refinery now head of the group’s research centre.


130 The API degree measures the API gravity, an arbitrary scale expressing the gravity or density of liquid petroleum products devised jointly by the American Petroleum Institute and the US National Bureau of Standards. Oil with the least specific gravity has the highest API gravity, which is equal to 141.5/(Specific Gravity at 60 °F) − 131.5.
correlation between the two variables (-0.68), suggesting the following tendency: the higher the API, the lower the sulphur content. As LC have a high API gravity, they tend to have a lower sulphur content than HC. Consequently, we can assume that refineries making products doing extensive use of LC should have a lower sulphur content of crude oil, which influences their SO₂ emissions. Otherwise, it would mean that they needed to desulphurise more than other refineries per unit of output, which is not the case. To investigate this possibility, the product mix of two refineries which SO₂ emissions differ the most (Berre and Donges) is analysed. In Berre, between 1985 and 2000, SO₂ emissions per tonne shipped are three times higher than in Donges. For Donges, there is no strong correlation between SO₂ emissions and the volume of products, whereas for Berre there is a significant correlation between the volume of SO₂ emissions and the volume of HFO. Also, for both refineries the volume of feedstock desulphurised correlates with the volume of diesel oil produced, indicating the impact of diesel sulphur specifications on environmental investments.

Table 33. Current sulphur product specifications in France

<table>
<thead>
<tr>
<th>Product</th>
<th>Sulphur Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gasoline</td>
<td>150 ppm</td>
</tr>
<tr>
<td>Diesel oil</td>
<td>350 ppm</td>
</tr>
<tr>
<td>HFO (01/01/03)</td>
<td>10,000 ppm</td>
</tr>
</tbody>
</table>


When crude oil is processed, some 20% of HFO is produced. HFO is a heavy blend of petroleum residues used in power stations, large industrial boilers and duty diesel engines (bunker fuel). In oil refineries, it is used as energy input for furnaces which produce steam and destroy refuse. Recently, the refining industry was making more light products for road and air transports. To do so, refining processes have moved from simple distillation, to double distillation which uses two different levels of pressure, and eventually to catalytic cracking conversion of intermediate products and to thermal cracking of heaviest products. The basic elements of a typical modern oil refinery, an atmospheric distillation unit, a vacuum distillation unit, a catalytic cracker, and a thermal cracker, all generate HFO. Residues are concentrated in the heaviest products which come from the bottom of petroleum processes (“bottom residues”), lighter and cleaner fractions being extracted to be sold as high-value added products. Heavy fractions thus contain many unwanted compounds such as sulphur, nitrogen, and metals. For example, the sulphur content of the Brent blend
crude is 0.37% and 1.12% for its heavy fractions distilled at more than 550 °C. For the Arab Light crude, these percentages are respectively 1.77 and 4%\textsuperscript{131}. This explains why HFO is responsible for 72% of sulphur emissions when it only accounts for 28% of fuel consumption\textsuperscript{132}. This is confirmed by the fact that between 1990 and 1997, SO\textsubscript{2} emissions in France have decreased by 33%, while the share of HFO with a sulphur content lower than 2% has increased from 23.5% in 1990 to 58.9% in 1998\textsuperscript{133}. The diffusion of catalytic cracking processes, which allow to treat high-sulphur feedstocks, and the increasing stringency of environmental regulations and product specifications also contributed to this evolution.

Can we explain the intensity of SO\textsubscript{2} emissions in Berre against the ones of Donges by a specialisation in heavy products? To investigate this question, each refinery’s output is classified into two groups of light (LP) and heavy products (HP). Between 1985 and 2001, LP represent 76% of the production of both refineries, which shows that they produce the same amount of HP and LP per unit of output. The kind of product they manufactured in 2001 is not very different either, except for bitumen which represented 8% of Berre’s output and 4% of Donges’. But if bitumen is a HP, it is often used to trap sulphur residues, and so producing more such HP should help reducing SO\textsubscript{2} emissions. It seems to be the case with HFO, which share in the product mix is higher in Donges than in Berre.

Finally, as commented in the BIP (2002) the director of the Refining and Marketing department of Total, changes in the structure of demand for oil products also influence refineries’ environmental behaviour. Western Europe has a 20 Mt gasoline surplus due to an increasing efficiency of car engines and to a saturation of the car fleet\textsuperscript{134}. It also has a 22 Mt distillate deficit, due to an increasing demand for diesel which generates less CO\textsubscript{2} and benefits from fiscal advantages as in France. Finally, there is an annual decrease of 10 to 15% in the demand of HFO. These changes impose a modification of the group’s industrial structure to meet the 2005 diesel specifications, such as the 50 ppm sulphur content. To achieve this objective, only changes of investment routines generating technological changes are mentioned. In

\textsuperscript{131} C.f. UFIP (2001: 6-7).
\textsuperscript{132} C.f. CONCAWE (1998: 8).
\textsuperscript{133} C.f. DHYCA (1999: 67).
\textsuperscript{134} Nowadays, for the same power a European car consumes 20 to 25% less fuel than 10 years ago.
Gonfreville, the IFP technology “Prime G” will be used to treat gasoline, other refineries will use a splitter, debottleneck, or increase hydrotreatment capacities, for a cost of some €10,000. This aims to anticipate the 2008 product specifications such as the 10 ppm sulphur content. In Donges, a new HDS unit will be built, which also implies changes in the investment behaviour as in Gonfreville, where a 260 MW cogeneration plant is being set up for a €230 million investment. This refinery will also increase the production of distillates by installing a hydrocracker costing between €280 and 300 million. The mechanisms governing input supplies are not brought forward as a means to reach these environmental improvements, suggesting that refiners cannot use this levy anymore to modify their environmental behaviour. However, the manager stresses that the modification of investment decisions also depends on the type of governmental incentives to be used, reflecting upon the debate of innovation-friendly environmental policies:

“The economic profitability of such a project will depend on the kind of ecological taxation that will be decided in the months to come.” (ibid.)

In sum, the extent to which the product mix influences SO2 emissions seems to be strongly related to the nature of market demand, and therefore to petroleum product specifications in the case of this industry, which confirms the strong impact of environmental policies on firms’ HSE behaviour. The next section explores the impact of sulphur management schemes on oil refineries’ SO2 emissions.

5.6 Sulphur management schemes

The management of sulphur in oil refineries is part of environmental management programmes which have access to a variety of technological options to reduce SO2 emissions\textsuperscript{135}:

- Amine treating and regeneration units (remove H\textsubscript{2}S and other sulphur-containing compounds from off-gases and fuel gas and/or LPG),
- Sour water strippers,
- Claus sulphur units (recover elemental sulphur from acid gases from amine units and water strippers),
- Tail gas clean-up units (boost sulphur recovery to over 99\%)\textsuperscript{136}.

\textsuperscript{135} See the exhaustive document published by the IPTS (2001).
The two following tables show that in the 1990s, although the greatest share of their investments was dedicated to improve the octane number, French refineries have spent 12% of their total investments on desulphurisation.

Table 34. General investment programme of the French refining industry

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Octane improvement (1)</td>
<td>1,021</td>
<td>757</td>
<td>382</td>
<td>187</td>
<td>207</td>
<td>49</td>
<td>115</td>
<td>282</td>
<td>57</td>
<td>3,057</td>
</tr>
<tr>
<td>Desulphurisation (2)</td>
<td>128</td>
<td>237</td>
<td>372</td>
<td>498</td>
<td>434</td>
<td>119</td>
<td>171</td>
<td>212</td>
<td>81</td>
<td>2,252</td>
</tr>
<tr>
<td>Conversion (3)</td>
<td>321</td>
<td>452</td>
<td>469</td>
<td>113</td>
<td>261</td>
<td>272</td>
<td>114</td>
<td>117</td>
<td>50</td>
<td>2,167</td>
</tr>
<tr>
<td>Lubes (4)</td>
<td>114</td>
<td>230</td>
<td>381</td>
<td>190</td>
<td>252</td>
<td>230</td>
<td>171</td>
<td>107</td>
<td>49</td>
<td>1,723</td>
</tr>
<tr>
<td>Bitumen (5)</td>
<td>23</td>
<td>37</td>
<td>49</td>
<td>51</td>
<td>12</td>
<td>5</td>
<td>11</td>
<td>5</td>
<td>9</td>
<td>202</td>
</tr>
<tr>
<td>Storage (6)</td>
<td>329</td>
<td>411</td>
<td>368</td>
<td>333</td>
<td>235</td>
<td>328</td>
<td>409</td>
<td>322</td>
<td>132</td>
<td>2,866</td>
</tr>
<tr>
<td>Utilities (7)</td>
<td>368</td>
<td>314</td>
<td>294</td>
<td>270</td>
<td>274</td>
<td>200</td>
<td>168</td>
<td>144</td>
<td>124</td>
<td>2,155</td>
</tr>
<tr>
<td>Misc.</td>
<td>640</td>
<td>494</td>
<td>707</td>
<td>697</td>
<td>362</td>
<td>416</td>
<td>564</td>
<td>636</td>
<td>615</td>
<td>5,131</td>
</tr>
<tr>
<td>Total</td>
<td>2,943.4</td>
<td>2,930.8</td>
<td>3,021.2</td>
<td>2,338.1</td>
<td>2,035.6</td>
<td>1,617.8</td>
<td>1,722.6</td>
<td>1,824.4</td>
<td>1,117.3</td>
<td>19,551.2</td>
</tr>
</tbody>
</table>


Table 35. General investment programme of the French refining industry (annual share of the total)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Octane improvement (1)</td>
<td>35%</td>
<td>26%</td>
<td>13%</td>
<td>8%</td>
<td>10%</td>
<td>3%</td>
<td>7%</td>
<td>15%</td>
<td>5%</td>
<td>16%</td>
</tr>
<tr>
<td>Desulphurisation (2)</td>
<td>4%</td>
<td>8%</td>
<td>12%</td>
<td>21%</td>
<td>21%</td>
<td>7%</td>
<td>10%</td>
<td>12%</td>
<td>7%</td>
<td>12%</td>
</tr>
<tr>
<td>Conversion (3)</td>
<td>11%</td>
<td>15%</td>
<td>16%</td>
<td>5%</td>
<td>13%</td>
<td>17%</td>
<td>7%</td>
<td>6%</td>
<td>4%</td>
<td>11%</td>
</tr>
<tr>
<td>Lubes (4)</td>
<td>4%</td>
<td>8%</td>
<td>13%</td>
<td>8%</td>
<td>12%</td>
<td>14%</td>
<td>10%</td>
<td>6%</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>Bitumen (5)</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
<td>2%</td>
<td>1%</td>
<td>0%</td>
<td>1%</td>
<td>0%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Storage (6)</td>
<td>11%</td>
<td>14%</td>
<td>12%</td>
<td>14%</td>
<td>12%</td>
<td>20%</td>
<td>24%</td>
<td>18%</td>
<td>12%</td>
<td>15%</td>
</tr>
<tr>
<td>Utilities (7)</td>
<td>12%</td>
<td>11%</td>
<td>10%</td>
<td>12%</td>
<td>13%</td>
<td>12%</td>
<td>10%</td>
<td>8%</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Misc.</td>
<td>22%</td>
<td>17%</td>
<td>23%</td>
<td>30%</td>
<td>18%</td>
<td>26%</td>
<td>33%</td>
<td>35%</td>
<td>55%</td>
<td>26%</td>
</tr>
<tr>
<td>Total</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
<tr>
<td>Annual variation (%)</td>
<td>0%</td>
<td>3%</td>
<td>-23%</td>
<td>-13%</td>
<td>-21%</td>
<td>6%</td>
<td>6%</td>
<td>-39%</td>
<td>-62%</td>
<td>0%</td>
</tr>
</tbody>
</table>

(1) Catalytic reforming, isomerisation, polymerisation, alkylation, MTBE, ETBE.
(2) HDS, H2S absorption, sulphur production.
(3) FCC, hydrocracking, thermal cracking.
(4) Lubes and related utilities.
(5) Bitumen and related utilities.
(6) Storage, shipping facilities, crude and petroleum products supply facilities.
(7) Production, treatment, distribution networks.

To what extent have these investments in desulphurisation reduced SO₂ emissions? The following table shows that total treatment of French refineries has decreased since the mid-1970s, as well as SO₂ emissions, average sulphur content, and production of HFO. The opposite evolution of the sulphur content and the decrease of SO₂ emissions tends to argue in favour of the aforesaid importance of input supply management schemes to modify oil refineries’ HSE behaviour. The decreasing production of HFO relates to changes in market demand for this sulphur-intensive product. Finally, the data on the production of sulphur, which is increasing, suggest an increasing efficiency of its recovery, corroborated by the ratio sulphur produced/sulphur eliminated, which increasing trend points out that over time relatively more sulphur was produced and less eliminated. The ratio of the amount of sulphur produced to the amount of sulphur eliminated by French oil refineries shows that, over time, more sulphur is being produced instead of being eliminated.
Table 36. SO$_2$ emissions and elimination of sulphur by French oil refineries

<table>
<thead>
<tr>
<th>Year</th>
<th>Crude oil processed ('000 t/y)</th>
<th>Total treatment ('000 t/y)</th>
<th>Average sulphur content (%)</th>
<th>SO$_2$ emissions (t/y)</th>
<th>Sulphur eliminated (tonnes)</th>
<th>Sulphur produced/Sulphur eliminated (%)</th>
<th>Sulphur produced ('000 tonnes)*</th>
<th>HFO produced ('000 tonnes)*</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>128,301</td>
<td>128,301</td>
<td>1.46</td>
<td>335,388</td>
<td>91,549</td>
<td>4.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1975</td>
<td>109,135</td>
<td>109,135</td>
<td>1.54</td>
<td>300,560</td>
<td>114,516</td>
<td>6.8</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1976</td>
<td>121,875</td>
<td>121,875</td>
<td>1.55</td>
<td>321,798</td>
<td>148,481</td>
<td>7.9</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>1977</td>
<td>118,306</td>
<td>118,306</td>
<td>1.58</td>
<td>319,732</td>
<td>170,996</td>
<td>9.1</td>
<td>146.3</td>
<td>37,675.3</td>
</tr>
<tr>
<td>1978</td>
<td>118,585</td>
<td>118,585</td>
<td>1.59</td>
<td>316,294</td>
<td>192,641</td>
<td>10.2</td>
<td>161</td>
<td>35,982.8</td>
</tr>
<tr>
<td>1979</td>
<td>126,339</td>
<td>126,339</td>
<td>1.61</td>
<td>312,089</td>
<td>214,847</td>
<td>10.6</td>
<td>184.3</td>
<td>38,497.6</td>
</tr>
<tr>
<td>1980</td>
<td>113,282</td>
<td>113,282</td>
<td>1.62</td>
<td>335,103</td>
<td>237,620</td>
<td>12.9</td>
<td>222.3</td>
<td>32,371.0</td>
</tr>
<tr>
<td>1981</td>
<td>97,563</td>
<td>97,563</td>
<td>1.67</td>
<td>245,986</td>
<td>255,635</td>
<td>15.7</td>
<td>215.3</td>
<td>27,816.5</td>
</tr>
<tr>
<td>1982</td>
<td>81,645</td>
<td>81,645</td>
<td>1.47</td>
<td>258,230</td>
<td>209,155</td>
<td>17.4</td>
<td>180.8</td>
<td>19,335.2</td>
</tr>
<tr>
<td>1983</td>
<td>82,653</td>
<td>82,653</td>
<td>1.38</td>
<td>226,689</td>
<td>186,163</td>
<td>16.3</td>
<td>157.1</td>
<td>16,711.1</td>
</tr>
<tr>
<td>1984</td>
<td>76,622</td>
<td>77,843</td>
<td>1.25</td>
<td>191,366</td>
<td>179,165</td>
<td>19.8</td>
<td>162</td>
<td>15,494.5</td>
</tr>
<tr>
<td>1985</td>
<td>76,351</td>
<td>81,905</td>
<td>1.04</td>
<td>185,314</td>
<td>164,358</td>
<td>20.1</td>
<td>161</td>
<td>13,603.6</td>
</tr>
<tr>
<td>1986</td>
<td>69,236</td>
<td>73,336</td>
<td>1.35</td>
<td>188,211</td>
<td>203,393</td>
<td>22.1</td>
<td>192.6</td>
<td>13,025.7</td>
</tr>
<tr>
<td>1987</td>
<td>65,575</td>
<td>72,902</td>
<td>1.28</td>
<td>187,161</td>
<td>212,497</td>
<td>24</td>
<td>188.4</td>
<td>11,990.5</td>
</tr>
<tr>
<td>1988</td>
<td>72,366</td>
<td>81,507</td>
<td>1.13</td>
<td>188,907</td>
<td>246,982</td>
<td>27.2</td>
<td>225</td>
<td>11,625.1</td>
</tr>
<tr>
<td>1989</td>
<td>74,449</td>
<td>79,442</td>
<td>1.29</td>
<td>190,714</td>
<td>264,263</td>
<td>27.6</td>
<td>239.1</td>
<td>11,520.3</td>
</tr>
<tr>
<td>1990</td>
<td>73,091</td>
<td>79,091</td>
<td>1.27</td>
<td>191,687</td>
<td>231,274</td>
<td>27.2</td>
<td>230.5</td>
<td>11,662.3</td>
</tr>
<tr>
<td>1991</td>
<td>77,103</td>
<td>83,582</td>
<td>1.27</td>
<td>180,828</td>
<td>238,267</td>
<td>25.8</td>
<td>219.1</td>
<td>11,765.3</td>
</tr>
<tr>
<td>1992</td>
<td>74,493</td>
<td>83,614</td>
<td>1.22</td>
<td>182,509</td>
<td>267,160</td>
<td>27</td>
<td>230.9</td>
<td>11,772.3</td>
</tr>
<tr>
<td>1993</td>
<td>78,845</td>
<td>84,336</td>
<td>1.25</td>
<td>184,530</td>
<td>303,885</td>
<td>29.6</td>
<td>241.9</td>
<td>11,724.8</td>
</tr>
<tr>
<td>1994</td>
<td>78,414</td>
<td>84,855</td>
<td>1.16</td>
<td>182,617</td>
<td>261,656</td>
<td>27.5</td>
<td>219</td>
<td>9,769.6</td>
</tr>
<tr>
<td>1995</td>
<td>80,583</td>
<td>86,713</td>
<td>1.09</td>
<td>182,791</td>
<td>270,721</td>
<td>29.7</td>
<td>243.3</td>
<td>9,623.5</td>
</tr>
<tr>
<td>1996</td>
<td>83,515</td>
<td>87,706</td>
<td>1.05</td>
<td>175,147</td>
<td>259,576</td>
<td>29.6</td>
<td>235.5</td>
<td>9,499.0</td>
</tr>
<tr>
<td>1997</td>
<td>88,787</td>
<td>92,542</td>
<td>0.99</td>
<td>169,724</td>
<td>291,698</td>
<td>32.7</td>
<td>263.5</td>
<td>10,040.8</td>
</tr>
</tbody>
</table>


* Source: CPDP, Pétrole Infos, various years.

At the organisational level of the firm, such an effort put in desulphurisation technologies suggests that the process which has led to undertake these investments has integrated an environmental variable, stressing the role of investment decision-making processes in changing firms’ HSE behaviour. However, the following comparison shows that technology is not always sufficient to address HSE issues. Indeed, Berre and Donges have both made investments to eliminate sulphur. But as
evidenced in the following graph, although Berre has a higher desulphurisation capacity than Donges, it emits more SO$_2$ per unit of output.

**Graph 7.** Tonnes desulphurised per thousand of tonnes shipped in 2001 (% of the total of case study refineries)

![Graph showing desulphurisation capacity of different refineries]

Port-Jérôme (Esso) 11%
Petit-Couronne (Shell) 12%
Donges (TFE) 13%
Feyzin (TFE) 14%
Gravenchon (Mobil) 14%
Gonfreville (TFE) 15%
Berre (Shell) 21%

Source: Author’s own, based on CPDP data.

This can be explained by differences in the way environmental issues are managed in both refineries, which brings forward the impact of environmental management systems on firms’ HSE behaviour. Because both refineries are subjected to the same European standards and because local pollution monitoring systems are alike, differences in local environmental standards cannot explain why the patterns of SO$_2$ emissions in Berre and Donges are substantially different. Indeed, NGOs in charge of monitoring air pollution in the region of Loire$^{137}$ and around the Berre pond$^{138}$ both manage continuous monitoring systems which allow to anticipate emissions and avoid accidental exceeding of peak emission limits. Emissions levels are regulated by the same prefectorial decree, and regional differences in emission limits are only authorised for peak values. Indeed, the latter are calculated with a computer model which takes into account local environmental conditions in order to require the firm to use a BATNEEC to avoid such peaks to be attained or exceeded$^{139}$. Finally for this section, it appears that sulphur management schemes have a strong impact on SO$_2$ emissions through the technologies they are using and the way they are managed. This corroborates the importance of investment decision-making process on firms’

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$^{137}$ http://www.airpdl.org.
$^{138}$ http://www.airfobep.org.
$^{139}$ Source: Interview with Mr Hannotte, chief engineer at the DRIRE Martigues, 18/03/03.
HSE behaviour, as well as of environmental management systems that co-ordinate sulphur management schemes and which role was stressed in the cases of Donges and Berre. The influence of environmental regulation on the HSE behaviour of French oil refineries is now examined.

5.7 Environmental regulation

Environmental regulation of sulphur aims to reduce the sulphur content of petroleum products as well as the emission of SO\textsubscript{2}. The following tables summarise the legislation which affect sulphur emissions of French oil refineries.

Table 37. Protocols adopted within the UNECE framework on long distance movements of air pollution

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Objective Achieved</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>First sulphur protocol\textsuperscript{140}</td>
<td>Initial commitment: -30% between 1980 and 1993, Additional voluntary commitment: -60% between 1980 and 1993</td>
<td>-66%</td>
</tr>
<tr>
<td>Göteborg protocol\textsuperscript{142}</td>
<td>400 Kt (2010)</td>
<td>660 Kt</td>
</tr>
</tbody>
</table>


Table 38. Large combustion plant directives\textsuperscript{143} (’000 tonnes of sulphur)

<table>
<thead>
<tr>
<th>Phase</th>
<th>Emission ceilings\textsuperscript{144}</th>
<th>Achieved</th>
<th>Conclusion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase 1 (1993)</td>
<td>1146</td>
<td>415</td>
<td>Objective achieved</td>
</tr>
<tr>
<td>Phase 2 (1998)</td>
<td>764</td>
<td>382</td>
<td>Objective achieved</td>
</tr>
<tr>
<td>Phase 4 (2010)*</td>
<td>375</td>
<td>–</td>
<td>–</td>
</tr>
</tbody>
</table>


* Source: Council directive 2001/81/EC on national emission ceilings for certain atmospheric pollutants.

\textsuperscript{140} Helsinki, 08/07/85.
\textsuperscript{141} Oslo, 14/06/94.
\textsuperscript{142} 01/12/99.
\textsuperscript{143} LCPD 88/609 CEE (24/11/88, JOCE 07/12/88) and 2001/80/CE (23/10/01, JOCE 27/11/01).
\textsuperscript{144} Only for existing plants.
3) Product specifications

- Council directive 93/12/EEC relating to the sulphur content of certain liquid fuels.
- Council directive 1999/32/EC relating to a reduction of the sulphur content of certain liquid fuels (amends 93/12).
- Council directive 1999/30/EC relating to limit values for SO₂, NO₂ and NOₓ, particulate matter and lead in ambient air (to respect from 19/07/01 in France).

<table>
<thead>
<tr>
<th>Period</th>
<th>Evolution</th>
<th>Variation</th>
<th>Regulatory deadlines</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986-1990</td>
<td>Stable</td>
<td>+3%</td>
<td></td>
</tr>
<tr>
<td>1991</td>
<td>Sharp drop</td>
<td>- 9%</td>
<td>First sulphur protocol</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>LCPD phase 1 (1993)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Council directive 93/12/EEC</td>
</tr>
<tr>
<td>1992-1995</td>
<td>Stable</td>
<td>+2.5%</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Council directive 98/70/EC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Council directive 1999/32/EC</td>
</tr>
<tr>
<td>1999</td>
<td>Sharp increase</td>
<td>+16%</td>
<td>Second sulphur protocol (2000)</td>
</tr>
<tr>
<td>2000</td>
<td>Sharp drop</td>
<td>- 33%</td>
<td>Council directive 2001/80/EC</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Council directive 2001/81/EC</td>
</tr>
</tbody>
</table>

Source: Author’s own.

Both sulphur protocols and the two phases of the LCPD seem to have strongly influenced the SO₂ emissions of French oil refineries, as evidenced by several of emissions drops in 1991 (-9%), between 1996 and 1998 (-24%, namely -8% per year), and in 2000 (-33%). To conclude, the targets set by environmental regulators seem to have been a major source of change in the environmental behaviour of French oil refineries, at least as regards the management of SO₂ emissions. Because emission reduction is achieved by investing in cleaner or clean-up processes and by setting up environmental policies and management schemes, it seems that environmental regulation affects the investment routines of oil refineries, as well as
their policy and management routines. This is confirmed by the distribution of the investment of oil refineries in France between 1985 and 2001:

**Table 40. Investments of the petroleum industry in France (€ million exclusive of VAT)**

<table>
<thead>
<tr>
<th></th>
<th>Period 1</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Period 2</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Refining</td>
<td>382</td>
<td>328</td>
<td>368</td>
<td>364</td>
<td>211</td>
<td>320</td>
<td>576</td>
<td>437</td>
<td>372</td>
</tr>
<tr>
<td>Average refining</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1985-2001</td>
<td>319</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Refining</td>
<td>292</td>
<td>247</td>
<td>201</td>
<td>202</td>
<td>291</td>
<td>169</td>
<td>225</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average refining</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1995-2001</td>
<td>319</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Annual average</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Difference from</td>
<td>3%</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>the mean</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Source: CPDP (2002), and several other years.

The biggest annual investments were spent at the beginning of the 1990s, when all the main regulatory instruments were about to be enforced. And as we saw earlier, an important share of oil refineries’ investments is directly related to environmental specifications. A study by EuroStrategy Consultants (1995: vi-vii) on 1,400 SMEs and 60 MNFs also underlines the importance of environmental policies in changing firms’ environmental behaviour:

“External factors are the primary driver of environmental actions – industry will not respond on a voluntary basis unless there are clear (perceived) commercial benefits and (perceived/actual) penalties and enforcement.”

This corroborates the strong influence of environmental policies on oil refineries’ HSE behaviour, and therefore the need for an economic analysis of this behaviour to take into account such a determining external factor.

**5.8 Summary**

This chapter aimed to shed light on the mechanisms used by French oil refineries to address a specific HSE action, so that their DR can further be evaluated in chapters 6, 7, and 8. The introduction of the case study sector and of the patterns of the
environmental impact, which the studied HSE action aims to address, has highlighted a series of factors which may influence the course of this action. Then, the contribution of each factor to the action is explored in greater detail by analysing data on French oil refineries. Results from these quantitative analyses point out three key mechanisms which strongly influence the way oil refineries carry out HSE actions. Firstly, because physical technologies are widely used for this purpose, the mechanisms generating them, namely investment decision-making processes, should have a strong influence on firms’ HSE behaviour. Second, although there are very few plant-level quantitative data diffused on the nature of oil refineries’ input supplies, a network of facts suggests that the way they are managed has a strong influence on the studied HSE action. The third identified mechanism is HSE management, notably because of the impact of sulphur management systems. Indeed, the latter are part of two opposite environmental management systems, which influence has also been pointed out in the contrasted cases of Berre and Donges. Finally, the strong external influence of HSE regulatory systems on oil refineries’ HSE behaviour was underlined. The next chapter investigates the pressures they might exert on case study firms by estimating the magnitude of the differences between the HSE regulatory systems in force in the four case study countries. This allows us to evaluate the DR of the context dependence routine property.
Chapter 6: An analysis of the pressures exerted by HSE regulatory systems

The aim of this chapter is to evaluate the magnitude of the differences between the pressures exerted by the HSE regulatory systems of case study countries. Börzel (1999) argues that there is no reason to assume that the regulatory systems of European countries exert stronger pressures than the ones of Southern partner countries. Applying the methodology developed in Section 4.2.2.3 to test the context dependence property of routines, this chapter shows that on the contrary there are substantial differences between the pressures exerted by the HSE regulatory system of case study European countries (France and the UK) and the ones exerted by the HSE regulatory system of North African countries (Morocco and Algeria). In Chapter 7 the context dependence property of routines is tested for each of the three mechanisms highlighted in the previous chapter. Indeed, as if the pressures exerted by North African HSE regulatory systems are weaker than the ones exerted by European HSE regulatory systems, the degrees of routineness of the HSE mechanisms of North African refineries should be lower than the ones of their European counterparts. As argued in Section 4.2.2.3, the pressures exerted by HSE regulatory systems can be compared studying the scope (Section 6.1) and the content (Section 6.2) of HSE legislation, as well as the institutions in charge of its enforcement (Section 6.3).

6.1 Analysing the scope of HSE legislation

The scope of a legislation indicates the array of problems a government is willing to tackle. The following table indicates the number of laws voted per legislative area in each case study country as well as in the EU, because the European legislation has a strong influence on the ones of member states and of Mediterranean Partner Countries.
Table 41. An analysis of the scope of HSE legislation

<table>
<thead>
<tr>
<th></th>
<th>Morocco</th>
<th>Algeria</th>
<th>France</th>
<th>UK</th>
<th>EU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air</td>
<td>2</td>
<td>1</td>
<td>35</td>
<td>4</td>
<td>20</td>
</tr>
<tr>
<td>Water</td>
<td>7</td>
<td>5</td>
<td>33</td>
<td>9</td>
<td>8</td>
</tr>
<tr>
<td>Soil</td>
<td>5</td>
<td>1</td>
<td>18</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Waste</td>
<td>2</td>
<td>-</td>
<td>30</td>
<td>2</td>
<td>15</td>
</tr>
<tr>
<td>Refining sector</td>
<td>23</td>
<td>19</td>
<td>4</td>
<td>1</td>
<td>28</td>
</tr>
<tr>
<td>Enforcement</td>
<td>5</td>
<td>3</td>
<td>26</td>
<td>1</td>
<td>16</td>
</tr>
<tr>
<td>Information</td>
<td>1</td>
<td>2</td>
<td>8</td>
<td>-</td>
<td>9</td>
</tr>
<tr>
<td>Integration</td>
<td>-</td>
<td>1</td>
<td>-</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>OHS</td>
<td>-</td>
<td>19</td>
<td>97</td>
<td>41</td>
<td>12</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>45</strong></td>
<td><strong>51</strong></td>
<td><strong>251</strong></td>
<td><strong>63</strong></td>
<td><strong>109</strong></td>
</tr>
</tbody>
</table>


Legislation taken into account are voted HSE laws affecting oil refineries. This table shows that their number is higher in European countries than in MPCs, which nevertheless seem to have dealt with HSE issues, to the exception of waste in Algeria and of OHS in Morocco. However, to interpret these results the specificity of each country’s regulatory system needs to be taken into account. In France, the fact that command-and-control instruments predominate might explain why this country has the highest number of voted laws, as opposed to the UK. The HSE regulatory systems of Morocco and Algeria are largely inspired by the French system. Thus, one would expect them to have a high number of voted laws, which is not the case. This would tend to indicate a narrow scope of HSE legislation and a lack of political commitment to address HSE issues in Morocco and Algeria. But as evidenced in the case of the UK regulatory system, the number of laws does not suffice to evaluate the degree of pressure exerted by an HSE regulatory system. The next section thus investigates the content of the HSE legislations of case study countries.

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145 Additional source: interview with Mr Bachir, head of the Department Legislation in the Ministry of the Environment, Rabat, 06/07/01.
6.2 Content analysis of HSE regulatory systems
This section compares the content of the HSE legislation affecting oil refineries in case study countries. Firstly, Section 6.2.1 analyses the content of two HSE laws which have issued a major challenge to this industry in European countries: the European directives dealing with petroleum product specifications and with emissions from large combustion plants (LCP). Then, the HSE legislation of the two MPCs is analysed (sections 6.2.2 and 6.2.3), and an example of a comparative analysis of the content of water regulatory systems in France and in Morocco is carried out in Section 6.2.4.

6.2.1 European legislation affecting oil refineries
European HSE legislation is very developed, and it is not possible here to analyse the content of all the directives and additional national laws. Because our objective is to evaluate the pressures that the content of an HSE legislation is likely to have on the behaviour of oil refineries, this section is focusing on two European directives which have been transposed into French and UK legislation, and which have had a strong impact on European oil refineries. As for the European OHS legislation, it is based on the Council Directive 89/391 of 12 June 1989 on the introduction of measures to encourage improvements in the safety and health of employees at work\(^{146}\), and data on OHS issues are collected and diffused\(^{147}\). We shall see that this comparison suffices to shed light on the substantial differences between the pressures exerted by European and North African HSE regulatory systems. The European Directive 98/70/CE on fuel specifications\(^{148}\) has had a strong influence on the HSE behaviour of European oil refineries as well as on any firm willing to export such petroleum products to the European market. The following table shows that pollution limits are clearly mentioned in the directive, and that they are lowered over time. This directive also abolishes leaded gasoline from 1\(^{st}\) January 2000.

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\(^{148}\) Cf. OJEC, 28/12/98.
Table 42. European pollutants content specifications in the EU for two main petroleum products

<table>
<thead>
<tr>
<th></th>
<th>Previous specifications</th>
<th>01/01/2000</th>
<th>01/01/2005</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gasoline</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphur (ppm mass, max)</td>
<td>500</td>
<td>150</td>
<td>50</td>
</tr>
<tr>
<td>Benzene (% volume, max)</td>
<td>5</td>
<td>1</td>
<td>To be defined</td>
</tr>
<tr>
<td>Aromatics (% volume, max)</td>
<td>-</td>
<td>42</td>
<td>35</td>
</tr>
<tr>
<td>Olefins (% volume, max)</td>
<td>-</td>
<td>18</td>
<td>To be defined</td>
</tr>
<tr>
<td><strong>Diesel</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sulphur (ppm mass, max)</td>
<td>500</td>
<td>350</td>
<td>50</td>
</tr>
<tr>
<td>Poly-aromatics (% mass, max)</td>
<td>-</td>
<td>11</td>
<td>To be defined</td>
</tr>
</tbody>
</table>


Another key legislation is the LCP directive, a ‘daughter’ directive to the 1984 Air Framework Directive 84/360/EEC, which regulates emissions to air from new and existing large combustion plants. The approach to regulate emissions from new plants is classic command-and-control, which sets uniform emission limit values differentiated by plant size and fuel type for a range of pollutants (SO$_2$, NO$_x$, dust). By contrast, the approach taken to regulate existing plants is much more flexible: it establishes progressive staged national emissions reduction targets, also expressed as national emissions ceilings for SO$_2$ and NO$_x$. It also imposes monitoring and reporting requirements on member states, as well as the submission of periodic progress reports to the Commission. The following table shows that this directive has achieved significant pollution reduction, notably in France and in the UK.

Table 43. Environmental goal attainment for LCP-Directive (national SO$_2$ reduction targets)

<table>
<thead>
<tr>
<th></th>
<th>LCP-Directive</th>
<th>France</th>
<th>UK</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>% reduction required</td>
<td>40</td>
<td>20</td>
</tr>
<tr>
<td></td>
<td>% reduction achieved</td>
<td>78</td>
<td>40</td>
</tr>
<tr>
<td>1996</td>
<td>% reduction required (interpolated)</td>
<td>50</td>
<td>30</td>
</tr>
<tr>
<td></td>
<td>% reduction achieved</td>
<td>80</td>
<td>62</td>
</tr>
<tr>
<td>1998</td>
<td>% reduction required</td>
<td>70</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>% reduction achieved</td>
<td>80</td>
<td>69</td>
</tr>
</tbody>
</table>

As these two countries, many states have over-complied with the directive. This suggests that there is an important margin for HSE improvement in many of them, which could be spurred by supra-national regulation. It also underlines that precisely defined emission limits as well as rigorous monitoring and reporting tend to have a strong impact on firms’ HSE behaviour. The content of the HSE legislation of Algeria and Morocco is now examined in order to compare the pressures it can exert on firms relatively to the ones exerted by European regulatory systems.

6.2.2 Algerian HSE legislation

Environmental legislation in Algeria has been considerably influenced by the French colonial legislation, even after its update following the independence in 1962. Existing legislation covers hunting, national parks, and forests. But as argues Benaceur (1995: 479) in his study of forest management it has been counterproductive. Algerian environmental regulation is based on the law 83/03 of 5th February 1983 relating to the protection of the environment. As Benabdeli (1998: 205) explains, this law defines the general policy concerning the protection of the environment and the fight against any kind of pollution and deterioration of areas. Its objectives are to protect, restructure and develop natural resources, to prevent and fight any kind of nuisance and to improve the living environment and the quality of life. Following this law, many others were promulgated but never enforced. A report on the implementation of the Agenda 21 in Algeria published by the Haut conseil de l’environnement et du développement durable (1997: 9) recognises that even if more than 300 laws related to environmental issues have been published in the country, little progress was made so far because:

- Too many laws published before 1983 contradict the law 83/03 which does not include any abrogation clause,
- Laws published after the law 83/03 are not coherent with it,
- Many of the legal principles are not followed by implementation decrees, notably because of a lack of co-ordination and dialogue.

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These limits shed light on the lack of political will and expertise in Algeria to address environmental issues. Concerning air pollution, only one law was voted (n° 93/165) and little resources are allocated to enforce it\(^\text{150}\). A similar statement can be made about the law n° 93/160 on industrial liquid discharges. In 1995, an environmental policy framework was built with the support of the World Bank via a METAP\(^\text{151}\) donation. Also, the law 83/03 is currently under review in order to update it and to integrate it in an environmental code. On the other hand, OHS legislation is much more developed and covers 7 topics such as working conditions, medicine, fires, or ergonomics\(^\text{152}\). For example, the decree of 29/09/98 sets the boundaries of nuisance indemnities. The law n° 88-07 of 26/01/88 concerning health, safety, and medicine at work organises OHS procedures, including their monitoring and sanctions. Following this law, the decree n° 91-05 of 19/01/91 sets precise OHS measures such as fire prevention, regular monitoring, circulation flows within plants, prevention of falls from high locations, aeration, or water treatment. Algeria also created in 1972 a National Health and Safety Institute.

To conclude on the Algerian HSE regulatory system, there is a clear unbalance between the concern for environmental issues and the one for OHS issues, which might be reflected in the way Algerian oil refineries address these two issues. However, even the aforementioned analysis of the content of the Algerian HSE legislation is far from being able to exert the same pressures than the European one\(^\text{153}\). Therefore, the pressures exerted by the Algerian HSE regulatory system are likely to be much weaker than the ones exerted by European systems.

### 6.2.3 Moroccan HSE legislation

Some 235 environmental laws have been published in Morocco between 1913 and 1978\(^\text{154}\). But as Mekouar (1988b: 15) argues, they have for a long time neither been enforced nor adapted to modern challenges. The origins of the Moroccan legislation partly explain their obsolescence, as most of them have been enacted under the

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\(^{150}\) Source: interview with Mr Benaceur, Professor of Law, University of Oran-Es Sénia, 03/07/01.


\(^{152}\) Source: http://www.ilo.org/.

\(^{153}\) For example, the International Network for Environmental Compliance and Enforcement (INECE) does not mention anything on North African Countries. Cf. http://www.inece.org/region_africa.html/.

\(^{154}\) Cf. MHAT (1983).
Franco-Spanish protectorate, which was more keen on exploiting than on protecting natural resources. This legislation got old, and was only updated to present needs at the beginning of 2004. The author underlines that the scope of this legislation is incomplete, because issues such as fighting pollution and nuisances were not addressed by laws dating to the pre-industrialisation period. Also, the system was oriented towards repression and prohibition, neglecting prevention and integration of environmental issues into other policies. However, at the beginning of 2003, four major laws have been promulgated on the protection of the environment, environmental impact assessment, air pollution, and accidental sea pollution\textsuperscript{155}. The law n° 01/03/59 sets ambitious targets to the young Ministry of the Environment and Planning. For example, it incorporates the polluter-pays principle, town and country planning, and the management of registered plants. It also specifies (Article 12) that any plant must respect environmental standards, and that new constructions must integrate them since their inception. Article 14 underlines that public authorities can force a producer to set up monitoring systems and to communicate regularly the results for all kinds of pollution. Article 26 subjects to authorisation any kind of deforestation. However, if many environmental issues are covered by articles or more, it is always in a general way. In other words, to the exception of air pollution\textsuperscript{156}, they are not enforceable yet, in spite the creation of the National Observatory for the Environment and its regional observation network (Article 57), of a system of incentives (Article 58), and of the legal legitimisation of the FODEP (Article 58), which has been created with the technical and financial support of the German aid agency GTZ\textsuperscript{157}. Other important articles for the future of the Moroccan environmental policy include the Article 63, which sets the principle of liability, the Article 76, which capacitates legal entities to ask for an inquiry if their health or their goods are damaged by pollution, Articles 77, 78, and 79, which provide for enforcement agents whose control visits can lead to lawsuits, and the last article (n° 80) containing an awaited abrogation clause. In June 1995 was published a National action plan for the environment (NAPE), which aimed at effectively enforcing environmental policies, at reinforcing institutional, legal, technical and

\textsuperscript{156} Cf. the Air act accessible at the above website, which nevertheless does not specify any quantitative emissions limits.
\textsuperscript{157} Cf. Section 5.3.3.
human frameworks, at continuously monitoring and evaluating the state of the environment, at addressing water and desertification problems, and at raising public awareness\textsuperscript{158}. No wonder that recently voted laws are a major step towards meeting these objectives. But their actual enforcement will rely on the enactment of implementation decrees and on the allocation of human and financial resources, which will have to counterbalance firms’ bargaining power. Therefore, if it is not reinforced by appropriate means, the Moroccan HSE regulatory system may suffer, as many other developing countries argues Mekouar (1988b: 16), from endemic weak environmental enforcement\textsuperscript{159}. According to the author, this is notably attributable to a voluminous and scattered environmental legislation, to obsolete enforcement infrastructures, to an intense lobbying from heavily polluting industries, to the lack of environmental lawyers and of precise environmental norms, to the weakness of environmental NGOs, and to the lack of concern and information of the public opinion (p. 17). Concerning OHS legislation, it has not been updated yet as in the case of insalubrious establishments\textsuperscript{160}, which legislation dates back to 1914 and has remained unchanged since 1933\textsuperscript{161}. To conclude on the pressures exerted by the Kingdom’s HSE regulatory system, although they have recently evolved, notably concerning environmental issues, they remain far behind the ones exerted on European oil refineries.

Finally for the analysis of the content of the HSE legislation of case study countries, the next section carries out a comparative analysis of two regulatory systems both aiming to protect water resources in France and in Morocco.

\textbf{6.2.4 A comparative analysis of the French and Moroccan water regulatory systems}

The comparison between the water regulatory systems of these two countries is facilitated by common historical roots\textsuperscript{162}. Two elements frame this comparative


\textsuperscript{159} At the beginning of the 1980s, the MHAT (1983: 4) itself wrote that “depending on the circumstances the law is either violated, bypassed or purely and simply ignored”.

\textsuperscript{160} Dahir 25 August 1914 “portant règlementation des établissements insalubres, incommodes ou dangereux” (O.J. 7 September 1914: 703). This obsolescence is also underlined in Bedhri (1993: 137).

\textsuperscript{161} The last law on registered plants dates back to 1960. Source: http://www.ilo.org/.

\textsuperscript{162} In Algeria too but the Water Act has not been voted yet.
analysis\textsuperscript{163}: the institutions in charge of enforcement, and the instruments used to fight water pollution. In France, the Water Act n° 92/3 of 3\textsuperscript{rd} January 1992 was replaced by the provisions of the Environmental Code\textsuperscript{164}. In Morocco, the corresponding law is the dahir n°1/95/154 of 16\textsuperscript{th} August 1995 promulgating the Water Act 10/95. The following institutions are in charge of water management in France:

- The National Water Committee (Article L213-1, Section 1), which advises the government,
- Basin Committees (Articles L213-2 à L213-4), which include representatives from users, regions local communities, and the State (they are consulted),
- Water Agencies (Articles L213-5 à L213-7), which contribute to studies, research and works related to basins, as well as to their operating budget, and which collect the water pollution tax,
- The National Water Fund (Article L213-8), which is used to develop water conveyance and other water works, to reduce diffuse pollution, to supply equipment, to collect data, and since 1\textsuperscript{st} January 2000, which also collects a solidarity levy paid by Water Agencies to the State,
- Local Water Communities (Article L213-9), which aim to facilitate the realisation of the objectives defined in the water planning and management scheme.

In Morocco, there are fewer institutions and their attributions are broader:

- The High Council for Water and Climate (CSEC, Article 13), which formulates the general orientation of the national water and climate policy, and advises on the national water plan as well as on the steps taken to preserve water resources,
- Basin Agencies (Articles 20 à 24), which elaborate the Water Resources Integrated Planning (PAIRE) of their area and look after its implementation, and which also issue concessions and authorisations, manage water quality, and enforce the Water Act.

As in France, any unloading requires an authorisation (Article 52), which is issued once the Water Agency has carried out an inquiry. Water is a rare good in Morocco.

\textsuperscript{163} According to J. S. Mill’s terminology developed in A System of Logic, we are using here a method of difference as we compare two similar contexts (water regulatory systems) and look at internal differences between them.

\textsuperscript{164} Available at http://www.legifrance.gouv.fr/html/accueil.htm.
A dry climate and the geology of the country make its conservation a priority for the government, agriculture representing some 20% of the GDP and occupying more than 50% of the active population. Considering this challenge, institutions in place do not seem equal to the situation:

- The institution of expertise is split up between two titanic tasks (water and climate), whereas France has a National Water Committee in addition to Water Agencies, the former being independent from the elaboration of the national water policy, as opposed the CSEC in Morocco.

- Moroccan Basin Agencies are both judge and judged, as they implement the measures and fight with the CSEC over their elaboration.

- There is no inter-wilayas\textsuperscript{165} co-ordination, whereas since the laws on decentralisation of 1982 France has representative Basin Committees.

- Financial support is limited to Basin Agencies, whereas France also has a National Water Fund as well as a solidarity levy.

There is no doubt that progress has been made in the Kingdom to manage water resources more efficiently. But there are important differences between the degree of pressure exerted by the Moroccan regulatory system and the ones exerted by the French system. The mechanisms used to enforce the Water acts in the two countries are now examined.

In France, these mechanisms are of two kinds:

- Administrative sanctions (Articles L216-1 à L216-2): The prefect can force anyone into undertaking works and repair damages, and can suspend any water authorisation,

- Penal sanctions (Articles L216-6 à L216-13): Any pollution is sentenced to two years and fined €90,000.

In order to record offences (Articles L216-3 à L216-5), the French legislation notably capacitates civil servants and researchers.

In Morocco, the Chapter 13 of the Water Act deals with water police and sanctions. Police officers or on oath agents are capacitated to deal with offences (Article 104),

\textsuperscript{165} Prefecture.
and the police can be called to stop the works in case of flagrante delicto. Sanctions include jail sentences from 1 to 12 months, works destruction, joint liability for damages, and fines from €60 to €500 (Articles 110 and 118).

Means to enforce the legislation exist in both countries, but the range of people that can be called on oath is much more limited in Morocco. Also, if jail sentences can go up to one year of prison (half of the maximum jail sentence in France), fines are not very dissuasive, even compared to the Moroccan standard of living\textsuperscript{166}. Consequently, the joint liability clause looses its deterrent effect.

Another interesting element of comparison between these two regulatory systems is the definition given to the term “pollution”, because people can be sentenced for it. In France (Articles L216-6 to L216-13), pollution concerns:

“The action of directly or indirectly throwing, pouring or let leaking into surface, underground or sea French waters, any of the substances which action or reactions cause even temporary noxious effects on health or damages to the flora or to the fauna, with the exception of the damages mentioned in the articles L. 218-7\textsuperscript{167} and L. 432-2\textsuperscript{168}, and of significant modifications of the normal water supply regime or of the common limitations of bathing areas.”

In Morocco, water is polluted if (Article 51):

“(…) because of human activity and under the action of a biological of geological effect, it has directly or indirectly undergone a modification of its composition or of its state, which consequence is that it becomes inappropriate for its intended use.”

The latter definition is equivocal and could be easily bypassed. For example, it does not mention the consequences of damages to waters that carry animal or vegetal life, whereas Morocco has one of the richest biodiversity in the world\textsuperscript{169}. Also, the perception of water is purely utilitarian, as the definition does not encompass the flora and the fauna as water users. In sum, it weakens the ability of environmental

\textsuperscript{166} In Morocco, the minimum wage is approximately €120 per month.

\textsuperscript{167} Noxious waste dumped in the sea.

\textsuperscript{168} Protection of the piscicultural fauna.

\textsuperscript{169} Cf. UNEP’s Global Environmental Outlook.
NGOs and other socio-economic actors to sue polluters. Besides, the Moroccan Water Act has not been used to legislate on the quality of bathing water.

Finally for this section about the comparison of the scope and of the content of legislation affecting oil refineries in case study European and North African countries, it appears that there are substantial differences between the pressures they can exert on firms’ HSE behaviour. Indeed, the ones exerted in Algeria and Morocco are substantially weaker than the ones exerted in European countries. This conclusion is confirmed by the following comparison of the ability of HSE institutions to enforce regulation on both sides of the Mediterranean.

6.3 HSE institutions in the EU and case study countries

In many ways institutions contribute the pressures HSE regulatory systems can exert on firms’ behaviour. They design and enforce the legislation, they diffuse it as well as HSE data, and they are valuable advisers on HSE issues. This section evaluates the differences between the pressures that are likely to be exerted by HSE institutions in place in European and North African countries.

6.3.1 HSE institutions in the EU, France and the UK

European HSE institutions have a strong influence on the level of pressures exerted by member states’ HSE regulatory systems. For example, in his history of the European legislative process, Lévêque (1996) underlines that in France two voted laws out of three are mere transcriptions of European legislation (p. 19ff.), which is not the case in Mediterranean Partner Countries. The European legislative process is precisely defined, transparent, its enforcement is monitored, and it offers the possibility for socio-economic stakeholders to intervene in the decision-making process. On the contrary, because their regulatory systems do not have these features, the bargaining power of heavily polluting firms in Mediterranean Partner Countries can be used to undermine HSE policies and is more difficult to control. Also, as indicated in Chapter 2, policy networks can have a strong influence on the

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173 Cf. the example of the programme Auto Oil II: http://europa.eu.int/comm/environnement/autooil.
policy making process, all the more since governmental institutions are not very powerful. An effort of transparency contributes to enforce the legislation and limits the potential influence of such networks, notably because provided that there is an efficient national legal system, it is easier for socio-economic actors to take legal actions against offenders.

Diffusing information on HSE issues is an important dimension of an efficient HSE regulatory system, because it raises public awareness and increases its ability to participate in the design and enforcement of HSE policies. Several European institutions created for this purpose do not exist yet in Morocco and in Algeria. For example, the European Environment Agency (EEA) aims to “deliver timely, targeted, relevant and reliable information to policy-makers and the public for the development and implementation of sound environmental policies in the EU and other EEA member countries”\(^{174}\). The Agency carries out its mission by using EIONET, a network of environmental bodies and institutions active in member countries\(^{175}\).

In France, the Ministry of Ecology and Sustainable Development (MEED) is the core of a command-and-control regulatory system, which enforcement is decentralised in the hands of 22 regional agencies\(^{176}\). This country also has specific institutions which collect environmental data, such as the IFEN\(^{177}\), or advise on HSE policies, such as the ADEME\(^{178}\) and the INERIS\(^{179}\).

The responsibilities of HSE institutions are also precisely defined in the UK. For example, the Environment Agency assists the Department for the Environment, Food and Rural Affairs (DEFRA) to design and enforce environmental policies, the latter being decentralised in 26 area offices and is also in charge of collecting and diffusing environmental data. Moreover, several institutions advise the government on HSE issues such as the Health and Safety Executive, the British Government Panel on Sustainable Development, and the Royal Commission on Environment and Pollution.

\(^{174}\) In European Environment Agency (1999: 5).


\(^{176}\) Direction Régionale pour l’Industrie, la Recherche et l’Environnement (DRIREs).

\(^{177}\) Institut Français de l’Environnement: http://www.ifen.fr/.


(RCEP). As in France, enforcement tools make wide use of the Internet, as in the cases of RIDDOR 95\textsuperscript{180}, of the HSE Public register of prosecutions\textsuperscript{181}, and of NERC’s funds for scientific research\textsuperscript{182}.

The strong capacity of European HSE institutions to exert pressures on oil refineries is now contrasted with the one of North African HSE institutions.

6.3.2 Algerian HSE institutions

If the profusion of laws is one of the sources of the lack of efficiency of the Algerian HSE policy, the confusion of institutional responsibilities is another. For example, the HCEDD\textsuperscript{183} created in December 1994 only employs 24 people and has to define strategic environmental options, to assess the state of the environment on a regular basis, to evaluate the degree of enforcement of the legislation and to take action to improve it, to follow international environmental negotiations, to advise the MATE\textsuperscript{184} on specific issues, and last but not least to present an annual report on the state of the environment and of the enforcement of environmental legislation. Very recently, Algeria set up a permanent Ministry of the environment\textsuperscript{185}, which shows some progress in the institutionalisation of environmental issues in the country. Its main department, the Directorate General for the Environment (DGE), is in charge of preventing any kind of pollution and environmental degradation, of preserving biological diversity, of looking after the enforcement of the legislation, of monitoring the state of the environment, of delivering environmental authorisations, of approving EIAs, and of fostering environmental education, communication and popularisation. It is supported by the General inspectorate which controls the enforcement of environmental regulations and upgrades HSE warning systems\textsuperscript{186}, and

\textsuperscript{180} Reporting of Injuries, Diseases and Dangerous Occurrences Regulations: http://www.hse.gov.uk/.
\textsuperscript{181} http://www.hse-databases.co.uk/prosecutions/.
\textsuperscript{182} Natural Environment Research Council: http://www.nerc.ac.uk/.
\textsuperscript{183} “Haut conseil de l’environnement et du développement durable”.
\textsuperscript{184} Ministère de l’Aménagement du Territoire et de l’Environnement (Ministry of Environment and Planning).
\textsuperscript{185} Cf. décret exécutif n° 01-08 du 12 Chaoual 1421 (07/01/01).
\textsuperscript{186} Created by the décret n° 96-59 (27/01/96). Each wilaya is also endowed with its own environmental inspectorate (décret n°96-60 du 27/01/96), which make environmental inspectors dependent from the good will of the walis. Cf. Rebah (1993).
by the Directorate General for Industrial Environmental Policy, which missions encompass OHS issues and aim to:

- Initiate, elaborate and enforce the legislation related to industrial pollution and nuisances,
- Initiate any study and research fostering the use of “clean technologies” and the recycling of industrial waste,
- Propose, elaborate, and enforce norms,
- Initiate any study, research, and action fostering the prevention of industrial pollution and nuisances, the setting up of industrial remediation projects, the elaboration of risk maps, and the participation to the world ozone action programme.

This division of the DGE is divided into four central sub-directorates dealing with dangerous wastes and products, registered plants, clean technologies and waste recycling, and programmes of industrial remediation and major risks. As opposed to what happens in Europe, the same institution is in charge of both OHS and environmental issues, and is hardly decentralised at all. Nevertheless, Algeria is developing instruments to enforce HSE policies such as the National Fund for the Environment (December 1991), funds to finance pollution reduction activities, environmental monitoring and research, emergency operations in case of accidental pollution, expenses to raise public awareness, and subsidies to environmental NGOs. Also, the DGE has launched a national system of environmental news, a database gathering data collected through a national network allowing to produce annual reports on the state of the environment. The first phase of the project was to create the RIDE187 to collect environmental data. Then, the DGE created a journal called “Algérie Environnement” and launched its web site188. The result is not very conclusive as the web site is rarely updated and contains very little information. For example, the report on the state of the environment only provides general data about climate, population, human activities, consumption, and poverty. It does not give any measure of pollution, which tends to show that the country is not yet able to monitor it properly. Finally, NGOs can also contribute to enforce HSE policies, as evidenced by the ASMIDAL case presented by Soltani (1995). Created in 1990 after many years of citizens complaints about pollution in Annaba, the NGO APEP has sued the

187 Recueil d’Informations et de Données Environnementales.
188 http://www.environnement-dz.org (in construction since 17th December 2002).
national chemical company ASMIDAL and forced it to close down two of its most polluting plants producing feedstock for fertilisers. Many environmental NGOs are active in the country, such as the ARCE\textsuperscript{189} which provides national expertise for the UNEP. But it is generally difficult to influence firms’ HSE behaviour, industries’ bargaining power being very strong and hardly controllable by a weak HSE regulatory system. Recent efforts have been made to increase the pressures exerted by the Algerian HSE regulatory system by redesigning its obsolete legislation, empowering enforcement agencies, training people on HSE issues, and delivering more HSE information to the public. Reports Ghada (2001), the Minister in charge of the environment Mr Rahmani asserted that “environmental laws are ready”. At the end of 2003 they had not appeared on the ANP agenda yet\textsuperscript{190}, but were promulgated in Spring 2004. Consequently, the pressures that Algerian HSE institutions are likely to exert on domestic oil refineries are very far from the ones exerted on refineries located in European member states.

6.3.3 Moroccan HSE institutions
In Morocco, the concept of “environment” has appeared a couple of weeks before the beginning of the 1972 Stockholm conference. Mekouar (1988a: 27) underlines that the first inter-ministerial institution, the National Council for the Environment, was founded two years after the summit. Nevertheless, the latter really started working in 1995 when it was given the mission to reorganise environmental institutions. It currently represents the Kingdom during international environmental meetings, and publishes for the government an annual report on the state of the national environment. A Ministry of the Environment was created in 1995, transformed in 1997 into a Secretary of State, and again into a proper ministry with the enthronement of Mohammed VI. Its aims to reinforce the institutional and legal framework, to protect natural resources, to set up appropriate instruments, to monitor and control the state of the environment, to carry out EIAs, to prevent and fight any kind of pollution and nuisance, to integrate the environmental dimension into development programmes, notably the ones dealing with education, training, research, and information. With the support of international organisations and

\textsuperscript{189} Association pour la Recherche sur le Climat et l’Environnement.
\textsuperscript{190} Assemblée Nationale Populaire: http://www.apn-dz.org/, checked 21/11/03.
agencies, several instruments were created to design and implement HSE policies in Morocco. For example, in 1996 the UNDP programme “Capacity 21” supported the formulation of the country’s national environmental action plan (NEAP) through an elaborate participatory process, involving a series of national workshops and working committees over a period of 18 months\(^\text{191}\). Then, the Moroccan government created a Ministry of Environment, reorganised its National Council for the Environment, established Regional Councils, and approved a National Strategy for the Environment and Sustainable Development. Completed in December 1998, the NEAP became Morocco’s environmental policy. An information campaign has also been launched to raise awareness on environmental issues, and environmental sustainability classes were introduced into schools’ curricula. With the support of the German aid agency GTZ, the Ministry of the Environment launched a training programme for journalists, which aim is to raise the priority level of environmental issues in the media, and a Sustainable Development Network was created with the support of the UNDP. Educational activities are reinforced by a dense network of NGOs dealing with water resources (67%), solid waste (51%) and liquid draining (49%). But according to Bennani & al. (2000), they lack resources such as Internet access\(^\text{192}\). To improve this situation, one department of the Ministry of the Environment is in charge of empowering these actors\(^\text{193}\), but its resources are limited. Finally, the “Fonds de Dépollution Industrielle” (FODEP) provides a good example of a new environmental policy instrument implemented in Morocco. Supported by GTZ, it is a strong incentive for firms to invest in cleaner technologies\(^\text{194}\). As explained in MATUHE (2000), it promotes voluntary clean up measures (firms apply to fund a specific project) and allows Moroccan firms to upgrade their production systems to international standards. It focuses on SMEs and only funds end-of-pipe or

\(^{191}\) This led to the creation in 1997 of the aforementioned programme “Action 30” (for the 30 million Moroccan subjects in 2000).

\(^{192}\) If 91% have a telephone line and 60% a computer, only 13% of them have an email.

\(^{193}\) Source: Interview with Mrs Lamsari, Ministry of the Environment and Planning (MATE), Head of the service “Partnership with economic actors and NGOs”, Rabat, 04/07/01.

\(^{194}\) http://www.minenv.gov.ma/projets/fodep/.
new technologies having a long-term impact on pollution reduction\textsuperscript{195}. There is no specific OHS institution in Morocco\textsuperscript{196}.

To conclude on Moroccan HSE institutions, although the pressures they could exert on firms to modify their HSE behaviour seem to have increased recently, resources allocated to them are not equal to their tasks. Therefore, as in Algeria, these pressures are substantially weaker than the ones exerted by European HSE regulatory systems.

6.4 Summary

This chapter aimed to elaborate and apply a methodology to evaluate the differences between the pressures exerted by the HSE regulatory systems of European and North African countries. In Algeria, environmental legislation is obsolete, as opposed to OHS legislation and institutions which are much more developed. This provides interesting results to be used in Chapter 8 to investigate the extent to which the environmental and OHS behaviour of Algerian oil refineries co-evolve with their HSE context. Morocco bears opposite features, as it is the environmental regulatory system which has been recently improved as opposed to its old OHS regulatory system. On the basis of these results, we can conclude that the pressures exerted by North African HSE regulatory systems are substantially weaker than the ones exerted by European HSE regulatory systems. The following tables provide a summary of the differences between the pressures exerted by the HSE regulatory systems of case study countries, using European systems as a benchmark for North African systems.

\textsuperscript{195} It does not fund clean up programmes in progress. Source: Interview with the head of the programme, Rabat, 06/07/01.

Table 44. Data to calculate the scope of HSE legislation in case study countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Criterion</th>
<th>Scope</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Environment</td>
<td>OHS</td>
</tr>
<tr>
<td>EU + European countries</td>
<td>EU</td>
<td>97</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>154</td>
<td>97</td>
</tr>
<tr>
<td></td>
<td>UK</td>
<td>22</td>
<td>41</td>
</tr>
<tr>
<td>MPCs countries</td>
<td>Algeria</td>
<td>32</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Morocco</td>
<td>45</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Author’s own.

This table is based on Table 41 and gives the number of laws voted in favour of environmental or OHS issues of the country or region.

Table 45. Summary of the levels of pressure exerted by the HSE regulatory systems of case study countries (%)

<table>
<thead>
<tr>
<th>Countries</th>
<th>Criterion</th>
<th>Scope</th>
<th>Content</th>
<th>Level of pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Environment</td>
<td>OHS</td>
<td>Environment</td>
</tr>
<tr>
<td>EU + European countries</td>
<td>EU</td>
<td>19 %</td>
<td>2 %</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>30 %</td>
<td>19 %</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>UK</td>
<td>4 %</td>
<td>8 %</td>
<td>1</td>
</tr>
<tr>
<td>MPCs countries</td>
<td>Algeria</td>
<td>6 %</td>
<td>4 %</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>Morocco</td>
<td>9 %</td>
<td>0 %</td>
<td>0</td>
</tr>
</tbody>
</table>

Source: Author’s own.

This table is based on the previous one and on Table 41 and gives the percentage of laws voted in favour of environmental or OHS issues of the country or region out of the total number of these laws for all the countries plus the EU (i.e. 519).

Finally, the appropriateness of HSE institutions can be examined by classifying them in terms of the missions they have been assigned.
## Table 46. Institutions for HSE policies in case study countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Institution</th>
<th>Design</th>
<th>Enforcement</th>
<th>Diffusion &amp; expertise</th>
</tr>
</thead>
<tbody>
<tr>
<td>EU</td>
<td>European Commission</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>European Parliament</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Key players</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>EEA</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EIONET</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>EASH</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Court of Justice</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Environment Agency</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>HSE</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HSC</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>LAU</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>HELA</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DEFRA</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Natural Environment Research Council</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>RCEP</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>BG Panel on Sustainable Development</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>MEDD</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DHYCA</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ADEME</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>DRIREs</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>CSIC</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>IFEN</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>CFDD</td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>INERIS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>France</td>
<td>MATE</td>
<td>X</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>National Fund for the Environment</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agency for the rationalisation of energy use</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Agency for drinking and industrial water and for draining</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>National Health and Safety Institute</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High Council for the Environment and SD</td>
<td></td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>Algeria</td>
<td>Ministry of the Environment</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td></td>
<td>FODEP</td>
<td></td>
<td></td>
<td>X</td>
</tr>
</tbody>
</table>

Source: Author’s own.

It tends to confirm the underdevelopment of HSE institutions in the studied MPCs. The next chapter examines the extent to which the HSE mechanisms highlighted in Chapter 4 are routinely used by French and English oil refineries.

---

197 Cf. list of acronyms in Glossary.
Chapter 7: The HSE behaviour of French and English oil refineries

7.1 Introduction
Following a methodology developed in Section 3.3.3, this chapter investigates the extent to which the HSE mechanisms identified in Chapter 4 are used by French and English oil refineries, and evaluate their degree of routineness (DR) for each of the three routine properties brought forward in Chapter 2. It allows us to identify the HSE routines governing oil refineries’ HSE behaviour in European countries.

7.2 The HSE behaviour of oil refineries in France

7.2.1 The refining sector in France
Since the beginning of the 1990s, petroleum products and refineries have accounted for more than half of SO₂ emissions in France, according to the DHYCA (1999: 71, Table 5). The main producer in the country is the Total group, which has emerged from the successive mergers between Total, Fina, and Elf, as evidenced in the following table on the main production capacities of oil refineries located in the country at the end of the 1990s.

Table 47. Main production capacities of oil refineries in France

<table>
<thead>
<tr>
<th></th>
<th>Atmospheric</th>
<th>Reforming</th>
<th>Catalytic desulphurisation</th>
<th>Diesel thermal cracking</th>
<th>Catalytic cracking</th>
<th>TOTAL</th>
<th>% Σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total</td>
<td>51,280</td>
<td>6,250</td>
<td>16,745</td>
<td>5,560</td>
<td>10,930</td>
<td>90,765</td>
<td>54</td>
</tr>
<tr>
<td>Shell</td>
<td>13,300</td>
<td>2,040</td>
<td>3,925</td>
<td>680</td>
<td>2,200</td>
<td>22,145</td>
<td>13</td>
</tr>
<tr>
<td>Esso</td>
<td>13,100</td>
<td>1,610</td>
<td>4,850</td>
<td>-</td>
<td>3,200</td>
<td>22,760</td>
<td>14</td>
</tr>
<tr>
<td>BP</td>
<td>10,800</td>
<td>460</td>
<td>2,060</td>
<td>1300</td>
<td>2,450</td>
<td>17,070</td>
<td>10</td>
</tr>
<tr>
<td>Mobil</td>
<td>3,200</td>
<td>600</td>
<td>1,740</td>
<td>-</td>
<td>-</td>
<td>5,540</td>
<td>3</td>
</tr>
<tr>
<td>CRR</td>
<td>4,000</td>
<td>630</td>
<td>1,050</td>
<td>950</td>
<td>800</td>
<td>7,430</td>
<td>4</td>
</tr>
<tr>
<td>SARA</td>
<td>800</td>
<td>130</td>
<td>450</td>
<td>-</td>
<td>-</td>
<td>1,380</td>
<td>1</td>
</tr>
<tr>
<td>Σ</td>
<td>96,480</td>
<td>11,720</td>
<td>30,820</td>
<td>8,490</td>
<td>19,580</td>
<td>167,090</td>
<td>100</td>
</tr>
</tbody>
</table>

Source: DHYCA (1999: Table 1).
Given that Total accounts for more than 50% of the French refining capacity, this section shall focus on refineries belonging to this group, of which a brief presentation is given below. On Sunday 12th September 1999, Thierry Desmarest (Total Fina) and Philippe Jaffré (Elf) have created the fourth petroleum group in the world. As indicated in Galinier (2002), it employs 130,000 people and in spite of the “Erika”\textsuperscript{198} and AZF catastrophes\textsuperscript{199} has made €7.64 billion profit in 2001 (a 134% annual increase). The 2000 corporate annual report mentions a refining capacity of 2.6 million barrels of oil equivalent per day, sales of 3.7 million barrels per day, and €1.2 billion of investment. Record profits are explained upstream by strong increases in the prices of crude oil and of the dollar, and downstream by increased refinery margins (USD6.9 per tonne in 1998, 9.7 in 1999, 23.8 in 2000) and by a strengthening of the dollar in comparison with the Euro\textsuperscript{200}. 30% of this performance is explained by internal factors such as the joint management of European refineries and costs reduction programmes, which contributed to lower the break-even point to USD10 per tonne for main products. However, downstream investments decreased by 9% to €1,163 million\textsuperscript{201}, as opposed to upstream investments which rose by 10% to €5,639 million\textsuperscript{202}. Between 1998 and 2000, group investments decreased by 5.3%, notably in Europe which concentrates 26% of them, as points out Pogam (2002). Two thirds were allotted to upstream, which represents 23% of the sales but the greatest share of profits.

The Grandpuits refinery was built by Elf in 1966. Two additional units were built and brought into stream in 1976 and 1981. It currently processes 4.5 million tonnes per year, and between 1977 and 1979 the refinery was modernised\textsuperscript{203}. Following the 1980s swing towards unleaded gasoline and low-sulphur products, the firm needed to

\textsuperscript{198} On 12\textsuperscript{th} December 1999 an old tanker broke into two pieces in the middle of a storm off Brittany with 31,000 tonnes of heavy fuel on board. The group spent more than €150 million to clean up the cost, and the group’s 2000 annual report mentions that “by 1 August 2000 there is no further risk of major pollution danger”. Cf. Total Fina Elf (2000b: 28).


\textsuperscript{200} Cf. Total Fina Elf (2000a: 58).

\textsuperscript{201} Chemicals investments have also decreased by 19% to €1,353 million, which confirms the group’s strategy to focus its financial outlay on exploration and production.

\textsuperscript{202} Cf. Total Fina Elf (2000a: 74).

\textsuperscript{203} Automation + catalytic cracking capacity increased by 60% from one million tonne to 1.6 million tonnes per year.
build hydro-desulphurisation, hydrotreating, reforming and alkylation units, which
required massive investments. As for the Donges refinery, it currently processes
some 10 million tonnes of crude oil per year and employs 530 people. Originally
built in 1917 to supply the U.S.A. Army during the war, the refinery was destroyed,
rebuilt in 1948, and re-organised in 1982. The Feyzin refinery was commissioned by
Elf in 1964, currently processes 5 million tonnes of crude oil per year, and employs
600 people. The refineries of Gonfreville and La Mède belonged to Total, which also
owned shares of the Reichstett refinery in Alsace before selling them to Shell. Each
refinery is operated by a separate management team and represents a separate profit
centre. The Provençal refinery of La Mède was inaugurated in 1935, and is sadly
famous for the explosion that killed several people in 1992, and for the fire that
destroyed it in 1993. Its crude oil capacity was extended from 400,000 tonnes to 6.2
million tonnes, and an FCC unit was commissioned anew in mid-1994. The
Gonfreville refinery was commissioned in 1933 with a crude oil treatment capacity
of 800,000 tonnes. Commissioned in 1974, the Flandres Mardyck refinery is the last
refinery to be built in France. Its annual distillation capacity is 6.3 million tonnes of
crude oil and it employs 300 people. Data on crude oil supplies could not be
collected for each site, but in all the interviews carried out in the Total head offices
the sulphur content of crude oil was mentioned as a key factor of environmental
performance as far as this criterion is concerned. However, the degree of routineness
could not be evaluated for this mechanism.

7.2.2 HSE management in French oil refineries (M₁)
Following a methodology developed in Section 4.2.2, this section analyses the
degree of routineness of the HSE management mechanisms French oil refineries are
using to address HSE issues. It focuses on the group Total and examines the extent to
which the HSE management of its oil refineries has the three properties of routines
by evaluating its degree of routineness. This DR shall be used to identify HSE
routines and to compare them across firms in Chapter 9.

P₁- The action vs. representation routine property (M₁–Total)
As argued in Chapter 2, the dual property of routines comprises three elements which
need to be taken into account to evaluate the DR of an HSE mechanism.
Action
The action aimed at by HSE management mechanisms is to monitor and improve the HSE performance of the refinery, notably by setting up HSE management systems.

Representation
Physical artefacts (standard operating procedures, tools, techniques, ...) 
Since the beginning of the 1990s, for the most important sites (refining and petrochemicals) the group Total has set up safety management systems built in-house or based on DNV’s ISRS\textsuperscript{204}, and Total’s Health and Safety Committee has developed a specific software to evaluate the risks of dangerous exposures. With the assistance of an external consultant, good safety practices have been revised between 2000 and 2003, and their guidelines are now stored on the computer network and on CD-ROMs, thereby reducing paper use, easing the updates and increasing the flexibility of information accessibility\textsuperscript{205}. Concerning environmental management, the firm has focused on voluntary approaches such as ISO 14.001 or EMAS, 60 sites being labelled ISO 14.001 in Europe (7 refineries and 5 oil depots). This process has helped to make the personnel sensitive to environmental issues and to increase watchfulness, which has had a positive effect on the control of production costs, in addition to improving the image of the site and of the quality of the products\textsuperscript{206}. In the Gonfreville refinery in Normandy, a three year programme was carried out to reduce SO\textsubscript{2} emissions by 30\%, the main thrust being to equip Claus units with additional sulphur recovery equipment in order to boost efficiency to 99.5\% and to cut emissions by 3,500 tonnes per year. Besides, a new vapour recovery unit was set up to recover most VOCs during the loading of tanker trucks, railway wagons and barges, which has allowed to reduce emissions to 2 g/Nm\textsuperscript{3}, the legal limit\textsuperscript{207} being 35 g/Nm\textsuperscript{3}. Besides, a specific system was set up in 1988 to control dust, and ever since the Norman Air Monitoring Agency has not recorded any exceeding of the

\textsuperscript{204} The International Safety Rating System was designed by Det Norske Veritas. This system requires a strong involvement of management and personnel, particularly of first level managers such as chief operators. Based on the control of ‘losses’ (human, facilities, products, environment), the method is divided into chapters dealing with training, planned audits and maintenance, inquiry and analysis of accidents and incidents, medical follow-up, etc. It allows to test safety performance and to set a working programme to improve it.

\textsuperscript{205} Source: email from Guy Arnaud, former Total’s HSE Refining and Marketing manager, 25/02/02.

\textsuperscript{206} Cf. Total Fina Elf (2000b: 18-19).

\textsuperscript{207} Cf. Elf (1999).
European 150 µg/m³ limit. Overall NO₂ emissions have amounted to some 4,000 tonnes per year, and was controlled with low-NOₓ burners.

Many physical artefacts are used by Total to store knowledge about how to monitor and improve its HSE performance. This allows us to attribute a score of +1 to this routine component.

*Globally shared language forms (formalised oral codes, pledges, ...)*

Before the merger, Elf had committed to a voluntary agreement signed to reduce greenhouse gases by 15% up to 2010 and based on the levels of 1990. This shows a certain concern for environmental issues, corroborated by the fact that the firm has an Environmental Division since 1971. In its 1999 annual report, the group Total Fina has argued that it was complying with the legislation in force in any country it operated, and that it was aiming to adopt the highest existing HSE standards. In 1992, the year of the accident in La Mède, the group had adopted an 8 points “Environment and safety charter”, which notably claims that “No economic priority is pursued at the expense of safety at work or of the environment”. In 2000, the group’s “Environment and Safety Report” has stressed that all its activities were following the “Safety Environment and Quality” charter signed by the CEO. The first of ten articles argues that top priorities are safety, health, the respect of the environment, and the satisfaction of clients. Other commitments to sustainable development mentioned in Total Fina Elf (2000b: 27) include transparency, training, and personnel assessment according to HSE criteria. Finally, the group has joined “Global Compact”, a UN initiative by which more than 500 firms commit themselves to respecting nine basic principles, such as human and employees’ rights or environmental protection.

In order to express its commitment towards HSE issues and diffuse it among its employees, Total is using a variety of language forms, which allows us to attribute a score of +1 to this routine component.

**Technologies**

**Organisational**

Before the merger with Elf, the group Total Fina had started to put sustainable development on its agenda and to integrate HSE issues into its organisational structure. For example, it created a special task force to formulate sustainable
policies and to stimulate its implementation “as part of the business process”\textsuperscript{208}. In 2001, following the AZF and Erika catastrophes, the department of the Total group called “Environment and Safety” was separated into two parts: “Industrial Safety” on one side, “Sustainable Development and Environment” on the other. Their directors are members of the group’s Management Committee and of the Risk Committee in charge of assessing the risks related to any new project or investment\textsuperscript{209}. The Environment and Safety Committee has not been changed, and a Sustainable Development Steering Committee was set up. Also, a Crisis Steering Committee was created to be activated if needs be, as well as a permanent team in charge of helping every branch to design crisis management action plans and to assess each branch’s Specific Crisis Management Units and Plans. Concerning occupational health, the group has created a Medical Steering Committee, which experts analyse and research the impacts of the industry and of climate change on health. Also, a Health and Safety Committee is in charge of looking after the quality of the working environment on each site, and each head office department has an HSE unit. The group has also hired an “olfactometry” team in Lacq to identify and reduce odours. Finally, in March 2002 an independent Environment and Safety Department was created again and integrated into the General Management Department.

Several types of organisational technologies are used by Total to carry out HSE actions, and HSE departments are well integrated in the firm’s hierarchy including at the highest level, which indicates a strong legitimacy of HSE actions in the firm. Thus, this routine component is given a score of +1.

\textit{Human}

The group Total estimates that 1,500 people are working full time on HSE issues and are receiving regular training, including on crisis management training. In 2002, Total has elaborated a new HSE training programme based on three kinds of training:

1. On-site (basic safety: prevention and intervention),
2. Within the group (causes tree, legal responsibility, project management, Seveso, crisis management, …),
3. External: GESIP (POI, big fires), safety management (ISRS).

\textsuperscript{208} Cf. Total Fina Elf (2000b: 27).

\textsuperscript{209} Cf. Total Fina Elf (2001: 5).
Safety has always been part of the annual individual assessment meeting, and part of the profit-sharing scheme is to be directly based on HSE results. Finally, the group is also training a nose on-site to identify more than 20 of the most unpleasant molecules to fight odours, which are a key concern of the neighbouring population. This shows that Total allocates important human resources to carry out HSE actions, and allows us to rate the score of this routine component at +1.

Financial

Although it was cutting down fixed costs, Elf has invested FR6.3 billion in environmental protection in 1997, which tends to confirm its lasting commitment to environmental issues. Nowadays, the group Total claims to spend €1 billion per year on HSE issues. In Donges, a FR2 billion project was undertaken in 1997 to make up for the giving up of the new HDS project in 1995\textsuperscript{210} and to upgrade the plant, including on environmental grounds. In Feyzin, between 1991 and 1996, the refinery has spent 10% of its investments and 5% of its operating expenses on environmental protection. In the group Total, between 10 to 30% of an investment budget is allocated to HSE issues\textsuperscript{211}. The investment programme undertaken by the industry between 1992 and 2000 shows the amount of financial resources allocated to desulphurise and to improve the octane number.

### Table 48. General investment programme of the French refining industry

<table>
<thead>
<tr>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Octane improvement</td>
<td>1,021</td>
<td>757</td>
<td>382</td>
<td>187</td>
<td>207</td>
<td>49</td>
<td>115</td>
<td>282</td>
<td>57</td>
<td>3,057</td>
</tr>
<tr>
<td>Desulphurisation</td>
<td>128</td>
<td>237</td>
<td>372</td>
<td>498</td>
<td>434</td>
<td>119</td>
<td>171</td>
<td>212</td>
<td>81</td>
<td>2,252</td>
</tr>
<tr>
<td>Conversion</td>
<td>321</td>
<td>452</td>
<td>469</td>
<td>113</td>
<td>261</td>
<td>272</td>
<td>114</td>
<td>117</td>
<td>50</td>
<td>2,167</td>
</tr>
<tr>
<td>Lubes</td>
<td>114</td>
<td>230</td>
<td>381</td>
<td>190</td>
<td>252</td>
<td>230</td>
<td>171</td>
<td>107</td>
<td>49</td>
<td>1,723</td>
</tr>
<tr>
<td>Bitumen</td>
<td>23</td>
<td>37</td>
<td>49</td>
<td>51</td>
<td>12</td>
<td>5</td>
<td>11</td>
<td>5</td>
<td>9</td>
<td>202</td>
</tr>
<tr>
<td>Storage</td>
<td>329</td>
<td>411</td>
<td>368</td>
<td>333</td>
<td>235</td>
<td>328</td>
<td>409</td>
<td>322</td>
<td>132</td>
<td>2,866</td>
</tr>
<tr>
<td>Utilities</td>
<td>368</td>
<td>314</td>
<td>294</td>
<td>294</td>
<td>270</td>
<td>274</td>
<td>200</td>
<td>168</td>
<td>144</td>
<td>2,155</td>
</tr>
<tr>
<td>Misc.</td>
<td>640</td>
<td>494</td>
<td>707</td>
<td>697</td>
<td>362</td>
<td>416</td>
<td>564</td>
<td>636</td>
<td>615</td>
<td>5,131</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>2,943</strong></td>
<td><strong>2,931</strong></td>
<td><strong>3,021</strong></td>
<td><strong>2,338</strong></td>
<td><strong>2,036</strong></td>
<td><strong>1,618</strong></td>
<td><strong>1,723</strong></td>
<td><strong>1,824</strong></td>
<td><strong>1,117</strong></td>
<td><strong>19,551</strong></td>
</tr>
</tbody>
</table>


\textsuperscript{210} Cf. Total Fina Elf (2000b: 19 & 24).

\textsuperscript{211} Ibid.
Given the big amount of financial resources allocated by Total to address HSE issues, a score of +1 is given to this routine component.

To conclude on the HSE management mechanism of Total’s oil refineries, it appears that it is a very highly routinised mechanism since its DR has a value of +5 when adding the scores of its routine components. The fact that it was possible to distinguish between the various components of this routine property suggests that HSE issues might be addressed by routinised mechanisms, which other properties need to be investigated to confirm this finding.

P2- The repetition and persistence routine property (M1-Total)

As explained in Chapter 4, the DR of HSE management in Total’s oil refineries is tested by examining the extent to which the effects of an HSE management action last over time. This can be observed by looking at HSE data collected and published by a given firm.

Data collection

Elf’s 1998 environmental report, presents the evolution of pollution reduction since 1984, suggesting that HSE mechanisms have had a long-lasting effect on the firm’s environmental performance.

Table 49. Elf’s pollution reduction achievements over time

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂ (‘000 t/y)</td>
<td>192</td>
<td>127</td>
<td>129</td>
<td>105</td>
<td>81</td>
<td>68</td>
</tr>
<tr>
<td>NOₓ (‘000 t/y)</td>
<td></td>
<td>45</td>
<td>45</td>
<td>44</td>
<td>42</td>
<td>40</td>
</tr>
<tr>
<td>CO (million t/y)</td>
<td></td>
<td>36</td>
<td>37</td>
<td>37</td>
<td>37</td>
<td>34</td>
</tr>
<tr>
<td>Greenhouse gases (million tonnes equivalent CO₂ per year)</td>
<td></td>
<td>45</td>
<td>46</td>
<td>47</td>
<td>47</td>
<td>44</td>
</tr>
</tbody>
</table>


As for the firm Total, its 1998 annual report only mentions economic objectives such as:

- Increase the profitability of refining and productivity gains, by developing the activities and the production on the most promising markets,
- Optimise the shareholder value,
- Develop the upstream sector, which offers the best profit opportunities.
Therefore, before the merger the persistence of HSE efforts was uneven across the different components of the group. As for safety ratings they also vary across sites, because if former Total and Fina sites (Donges, La Mède, Anvers, Vlissingen, Lindsey, Rome, Port Arthur USA) reach the ISRS level 8 or 7 (Martinique), former Elf sites (Donges, Grandpuits, Feyzin) were still in the process of converging towards DNV’s system when they were audited at the end of 2002. Therefore, the modification of Total’s HSE mechanisms following the merger seems to have had lasting positive effects, including concerning the reduction of pollution.

<table>
<thead>
<tr>
<th>Table 50. Emissions of Total’s oil refineries</th>
</tr>
</thead>
<tbody>
<tr>
<td>(‘000 t/y)</td>
</tr>
<tr>
<td>NO&lt;sub&gt;x&lt;/sub&gt;</td>
</tr>
<tr>
<td>SO&lt;sub&gt;2&lt;/sub&gt;</td>
</tr>
<tr>
<td>VOCs</td>
</tr>
</tbody>
</table>


In Total’s petrochemical branch, the total number of accidents has decreased by 20% since 1998, even among subcontractors. All Total sites (Gonfreville, Mardyck, La Mède) were ISO 9002 at the end of 1995 and has reached a level of 7 out of 10 on the ISRS scale, and a level of 8 at the end of 1998. As for ISO 14.001, all the sites were labelled at the end of 2000 and European Fina sites followed the same process. Both standards imply to have routine data collection procedures for a wide array of HSE issues. However, these performances are not mentioned in the 2000 annual report, and the group’s HSE Refining manager has mentioned that “the sites of Elf had adopted another approach which has since then been shifted in order to harmonise the systems of reference used”. In the six pages of its 1998 environmental report, Elf does not mention ISO nor ISRS<sup>212</sup>, which shows that even if Elf was confronted with the same legislation than Total and Fina, their HSE behaviour was different, notably because the HSE routines operated were different. In the Gonfreville refinery, monitoring was strengthened as daily measures are now required by the DRIRE for each of the 23 chimneys of the refinery, as opposed to monthly measures before.

The fact that Total collects a wide array of HSE data since many several years and does it on a regular basis to keep being ISO registered, which imply a yearly

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<sup>212</sup> Cf. Enerpresse (1993: 1).
improvement of performances, suggests that its HSE actions tend to persist over time, and are thus to a certain extent routinised mechanisms. This allows us to attribute a score of +2 to the component of this routine property.

Data diffusion
Since 1998 Elf has been publishing an environmental report, and in 2000 Total Fina published an “Environment and Safety Report”. The group Total also produces colourful annual HSE reports, as well as more specific internal documents, as in the case of the experts of the Medical Steering Committee who diffuse their results through an internal bulletin and training courses. Safety data diffused to the public are not very detailed, and notably include the following LWIF213.

<table>
<thead>
<tr>
<th>Table 51. LWIF for Total’s oil refineries</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Total staff</strong></td>
</tr>
<tr>
<td>1998</td>
</tr>
<tr>
<td>1.3</td>
</tr>
<tr>
<td><strong>External companies</strong></td>
</tr>
<tr>
<td>1998</td>
</tr>
<tr>
<td>3.75</td>
</tr>
</tbody>
</table>

* Average sector (source = Concawe) = 4.5.
** Average sector (source = Concawe) = 9.2.

It is the only safety figure provided in the report, and no explanation is given on the difference between the two groups, which suggests that OHS mechanisms are efficient over time, since accidents are less frequent in-house than in external firms. An inquiry into documents of the professional organisation Concawe confirms that this OHS data reveals a good OHS performance compared to the average of the sector.

Compared to the data it collect to monitor its HSE performance, Total does not provide much detailed information to the public on all the aspects of the HSE behaviour of Total’s oil refineries, but rather keeps it for internal purposes. This routine component shall thus received a score of +2.

If we add up the scores of all the components of this second routine property, we reach a strong degree of routineness of +4.

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213 Lost Workday Injury Frequency is calculated from the number of LWIs divided by the number of hours worked expressed in millions.
P₃- The context dependence routine property (M₁-Total)

This property can be tested for French oil refineries by looking at the extent to which their HSE actions have been influenced by the HSE context, and notably by French and European HSE regulatory systems.

CD of environmental actions

In Total Fina Elf (2000b: 19), the group acknowledges that regulatory pressures have favoured the reduction of NOₓ emissions and the installation of low-NOₓ burners, the modernisation of boilers, recycling of smokes, and the investment in other end-of-pipe technologies. For example, the “DeNOₓ” technology, a selective catalyst reduction process, was installed on a crude distillation unit of the Flessingue refinery in the Netherlands. This innovative project was supported by the government and was aiming to cut NOₓ emissions by 80%. Also, following European directives, VOCs emissions were recovered during loading and transport of hydrocarbons on all refineries and depots. Benzene concentration in gasoline is inferior to the 1% legal requirement. In Donges, HDS units were built since the inception of the plants, and although SRUs were added later, the firm waited for stringent environmental policies to be enacted in Europe and in France to start removing sulphur from its feedstock and products. Hydro-desulphurisation units were modified to comply with Auto-Oil II diesel specifications²¹⁴.

In addition to the evidences gathered about HSE actions spurred by HSE regulatory systems, the firm Total has itself recognised the strong impact of HSE regulation on its HSE behaviour. Therefore, this routine component should be given a score of +2.

CD of OHS actions

Following the merger, a review of best methods, practices and management was undertaken to comply with the Seveso 2 directive in force in 2000. The objective was to extend ISRS to all refining sites and to call for external auditors to evaluate progress. Since the OHS actions of the firm are in accordance with the HSE regulatory system, this routine component is given a score of +2.

Before examining the second source of evidence the previous scores can be added up and summarised in the following temporary table.

²¹⁴ Moving from 0.2% sulphur content to 0.05% before 2005.
Table 52. Temporary DR of M1 for Total

<table>
<thead>
<tr>
<th></th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>+5</td>
<td>+4</td>
<td>+4</td>
</tr>
</tbody>
</table>

CD of the DR
The analysis of the French HSE regulatory system, summarised in Section 6.4, shows that its level of pressure is high, and the previous table shows that the DR of the HSE management mechanism is strong. Therefore, the second source of evidence of the context dependence routine property is given a score of +1, thereby increasing the score of P3 by one to +5.

The next table summarises the final results of the DR of the first HSE mechanism used by French oil refineries.

Table 53. Final DR of M1 for Total

<table>
<thead>
<tr>
<th></th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
</tbody>
</table>

This table shows that the DR is very strong for all the routine properties, and thus that the mechanisms French oil refineries are using to address HSE issues are highly routinised and can be identified as HSE management routines.

7.2.3 Investment decision-making in French oil refineries (M2)
The method developed in Chapter 4 to evaluate the degree of routineness of HSE mechanisms is now applied to the ones dealing with investment decisions.

P1- The action vs. representation routine property (M2-Total)
Action
The action carried out by investment decision-making processes is to undertake investment projects to improve firms’ HSE performance.
Representation

*Physical artefacts (standard operating procedures, tools, techniques, ...)*

The fact that to appraise investment projects, only cash flow analyses are used\(^{215}\). A nil score is given to this component.

*Language forms*

Commitments to integrate HSE criteria when making an investment decisions can be found in the 2000 annual report of Total Fina Elf (2000a: 13), where it is explained that an Ethical Committee is consulted every time it raises an ethical question. In the downstream section of the report of the new group (p. 36), the group mentions its commitment to invest a stable amount of money ($3 per tonne of refining capacity) notably to meet the 2005 fuel specifications. But later (p. 58) we can read that downstream investments have decreased by 9% compared to 1999, whereas in the mean time downstream profits were multiplied by three. But in its 2001 environment and safety report, Total Fina Elf (2001: 5) mentions that both the Industrial safety manager and the Environment and sustainable development manager are members of the board of the group as well as of its Risk committee in charge of evaluating all the risks related to any new investment project. Such a commitment indicates that investment decisions are made following a formalised pledge to take HSE issues into account. The score of this component shall thus be +1.

*Technologies*

*Organisational*

The refinery manager is allowed to undertake investment projects up to €2 million, such as the setting up of hydrodesulphurisation units. The execution of the project is carried out by the refinery itself for small projects, namely up to €2 million, and beyond by the CERT (European Centre for Research and Techniques based in Normandy). However things were different for Elf, because if investment projects were managed by the refinery, sub-contractors were in charge of their implementation\(^{216}\). Beyond this threshold and on the basis of standard cash flow

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216 Source: email from Mr Guy Arnaud, op. cit.
analyses, the decision is in the hands of the Refining and Marketing Group Management Committee\footnote{Task group set up in the head office, which can make use of internal auditors.}, as in the case of the co-generation project\footnote{This project aims to build a 260 MW unit in Gonfreville (Normandy) in partnership with Texaco and EDF for a cost of €230 million. Fired with natural gas but than more profitable than an IGCC, it should start in Autumn 2003. In BIP (2002: 2).}. Since the procedure\footnote{Source of the information for this paragraph: Interview with Mr Legalland, op. cit., based on an unpublished guidance note on in-house investment decision-making process.} for investment decision-making processes in Total guaranties a high level of plant autonomy, a score of +1 is attributed to this component.

**Human**

As no evidence was found that finance managers were trained on HSE issues, the score of this component is nil.

**Financial**

In-house impetus for most investment projects originate from the Manufacturing processes department, which transmits its requests to refinery management a bottom-up approach which is an important decision-making tool to foster incremental technical change. This type of management style fosters incremental technical change, which as Enos (1962) pointed out is an important source of innovations, including the ones that can improve HSE performance.

Since the new Total group adopt a decentralised investment decision-making process, the score of this component is +1.

When adding the scores of all the components of this first routine property, it appears that its DR is medium (+3). This suggest that the way the group addresses HSE issues by undertaking investments is not strongly routinised, although some elements of investment decision-making routines that could enhance the HSE performance of its plants exist such as the solid hierarchical position of HSE departments.
P2- The repetition and persistence routine property (M2-Total)

Planning of HSE investments

The following table provides evidence of the outputs of an investment programme aiming to remove lead from gasoline in Total’s refineries and to comply with an EU directive.

Table 54. Elf’s unleaded investment program (early 1990s)

<table>
<thead>
<tr>
<th>Refinery</th>
<th>Project/type</th>
<th>Cost (USD million)</th>
<th>Completion date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Donges</td>
<td>Cat. Reforming</td>
<td>140.0</td>
<td>1994</td>
</tr>
<tr>
<td></td>
<td>De-isopentanizer</td>
<td>24.5</td>
<td>1993</td>
</tr>
<tr>
<td>Feyzin</td>
<td>Alkylation</td>
<td>59.5</td>
<td>1992</td>
</tr>
<tr>
<td>Grandpuits</td>
<td>Alkylation</td>
<td>148.8</td>
<td>1993</td>
</tr>
<tr>
<td>Gonfreville</td>
<td>Isomerisation</td>
<td>61.3</td>
<td>1991</td>
</tr>
<tr>
<td>La Mède</td>
<td>Fractionation</td>
<td>35.9</td>
<td>1991</td>
</tr>
<tr>
<td></td>
<td>Isomerisation</td>
<td>70.9</td>
<td>1993</td>
</tr>
<tr>
<td>Mardyck</td>
<td>Fractionation</td>
<td>25.7</td>
<td>1991</td>
</tr>
<tr>
<td></td>
<td>Isomerisation</td>
<td>77.9</td>
<td>1993</td>
</tr>
</tbody>
</table>

Source: *Oil and Gas Journal*, several years.

An unpublished report dated from 6th April 2001 shows the distribution of the greatest share (76%) of investments in the group.

Table 55. Total group: Distribution of the main investments in 2001

<table>
<thead>
<tr>
<th>Total refineries (FR M)</th>
<th>690</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy improvements</td>
<td>90</td>
<td>13%</td>
</tr>
<tr>
<td>Upgrading stations</td>
<td>180</td>
<td>26%</td>
</tr>
<tr>
<td>Upgrading gasoline 2000 requirements</td>
<td>160</td>
<td>23%</td>
</tr>
<tr>
<td>Improvement water treatment</td>
<td>100</td>
<td>14%</td>
</tr>
<tr>
<td><strong>Incl. Directly linked to legal requirements</strong></td>
<td><strong>330</strong></td>
<td><strong>48%</strong></td>
</tr>
</tbody>
</table>


These two tables show that, notably to meet EU product specifications, the new group Total is making a precise and regular planning of its HSE investments. The score of this routine component is therefore +2. The persistence of HSE investments can also be investigated by studying outputs of investment decision-making processes, namely investment projects.
HSE investment projects
In the refineries of Donges and Gonfreville, to address VOCs emissions floating-roof tanks were fitted with hermetic seals, and fixed-roof tanks containing lighter products with internal floating decks. Also, to process low-sulphur middle distillates, the firm Total has invested in desulphurisation units in the early 1990s, so that lower sulphur content specifications for diesel could be met by minimising extra costs. This gave the firm a strong competitive advantage in desulphurisation and gasoline in France. Hydrocarbon wastes are now extracted, and if not reused, are incinerated, notably in cement works which can make bricks out of it. One HSE investment project carried out in 1996, the debottlenecking of a desulphurisation unit in a French oil refinery, is now examined in detail.

Case study of an investment project: the debottlenecking of a desulphurisation unit in a French oil refinery

This section aims to shed light on the persistence of a specific HSE investment decision by showing that the output of the decision has led to an investment project that will last over time. Using a technology developed in-house, this environmental investment project aimed to remodel a desulphurisation unit for diesel motor fuels and to move from a 0.15% sulphur content to 0.05%. Indeed, taking into account the evolution of legislation, market demand modelling revealed that there would be no more outlets for diesel fuel with a 0.15 sulphur content. Following a risk assessment procedure, the new unit was modified accordingly since its inception:

a) A system to clean up waste gases and to remove most of H₂S was set up, allowing to reduce the circles of toxic damages and to confine them inside the area accepted by the authorities.

b) The orientation of the pipes was such that flames can not reach the fence of the refinery.

c) Detection devices for H₂S and hydrocarbons are installed to detect potential gas clouds, and safety measures taken to ensure immediate stopping of the furnaces which may set fire to these clouds.

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221 Bottlenecks occur where the output from one refinery process is used as the input to a further process (typically, vacuum gas oil into catalytic cracking).

222 Information on this investment project undertaken in 1995 in a Total refinery (anonymous) was obtained from Guy Arnaud, former Total’s HSE Refining and Marketing manager.
d) Water curtains were set up around furnaces to prevent gases from accessing hot points.

The decision was taken following the modelling of the evolution of market demand and offer. It appeared that there would be no more outlets for diesel fuel with a 0.15% sulphur content, and that this would require to import expensive products. Process studies showed that a second big reactor containing some 200 m$^3$ of catalyst needed to be fitted. Besides, the production of additional H$_2$S required to analyse the consequences of a potential major accident outside the refinery, as demanded by the Seveso directive and by the law on the control of urbanisation. Indeed, the refinery is located near a town of 2,000 inhabitants, and perimeters limiting construction were created in 1988, which implies to carry out a risk analysis to evaluate the impact of a major accident. Risk assessment was carried out following a methodology elaborated between 1985 and 1988 by the petroleum industry. It provided several scenarios for action, the most serious ones corresponding:

1. To the dispersion of a toxic cloud outside the site: it was thus essential to choose cautiously the location of the reactor, as the worst scenario in terms of toxicity corresponded to a breach on the head of the reactor.
2. To the formation of a fire of a hydrogenised gas at the entry of the reactor.
3. To the dispersion of a cloud of hydrocarbon gases which may light on a furnace and end up creating an explosion and a shock wave.

All the risk-reducing measures were integrated into investment costs. They were also used to defend the project in front of the Management Committee, thereby not limiting the arguments to a mere cost-benefit analysis but adopting a precautionary approach. However, we can notice that environmental challenges were drowned into safety issues, which confirms that environmental issues are not well integrated in investment decision-making processes and corroborates the earlier DR of 3 found for the first routine property. Other problems were identified during PCFs$^{223}$, HAZIP and HAZOP reviews$^{224}$, including environmental ones. Indeed, there were too much gases coming from the sour water stripper that were generating problems of incineration.

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$^{223}$ “Plans de Circulation des Fluides”: circuits are tested in relation to their process and to the way they are operated.

$^{224}$ HAZIP: Hazard Identification Procedure. HAZOP: Hazard and Operability Study. Ask various questions such as “What if?” such and such event happens.
and odours. Although causing instability on other units, it was decided to send these gases to the SRU. A pipe and a special burner were fitted, and the stripper was modified to allow for the treatment of a greater capacity without changing the quantity and quality of the waste water discharged into the pond. Besides, an existing project to centralise two control rooms into a single blast-proof room was integrated in the overall project. Finally, the fire network was upgraded to meet in-house specifications. Additional information on this case study reveal that the Environment Department was not consulted on this project at any phase of the investment decision, and environmental criteria were not used to appraise the investment project.

Environmental issues “arose” in the course of the decision-making process, which reveals an absence of systematic environmental appraisal, even when projects are considered environmental. In fact, environmental investment projects often amount to technical upgrades in response to changes in product specifications. This may change with the new group’s environmental strategy, which requires LCAs to be carried out for any project, probably in the perspective of the law of 15th May 2001 on New Economic Regulations, which article 116 requires firms’ “environmental transparency”225. To conclude on this project, the fact that OHS risk assessment were seriously carried out argues in favour of the persistence of the investment decision-making process aiming to undertake the project, even if no EIA was made. It also reveals an additional dimension of the HSE context in the form of industrial risk, which also affects firms’ HSE behaviour.

Since both big and small HSE investment projects are undertaken by Total’s refineries to address HSE issues, the score of this routine component is +3. If we add up the scores obtained by all the components of this second routine property, we have a DR of +5. This suggests that investment projects aiming to improve the HSE performance of Total’s oil refineries are persistent, and thus that they might identified as investment decision-making routines. Before coming to this conclusion one last routine property needs to be examined.

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**P₃- The context dependence routine property (M₂-Total)**

**CD of environmental actions**

As evidenced in the following table, since the beginning of the 1990s, the French refining industry has undertaken massive investment programmes to improve its competitiveness, to respond to an increasing demand for very low-sulphur heavy fuel (<1% sulphur content) and to an improved octane number. These programmes also sought to meet new product specifications such as the phasing out of leaded petrol, the decreasing sulphur content of diesel and domestic fuels, and the reduction of VOCs and other emissions such as SOₓ, NOₓ, and liquid waste.

**Table 56. General investment programme of the French refining industry, annual share of the total (%)**

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Octane improvement (1)</td>
<td>35%</td>
<td>26%</td>
<td>13%</td>
<td>8%</td>
<td>10%</td>
<td>3%</td>
<td>7%</td>
<td>15%</td>
<td>5%</td>
<td>16%</td>
</tr>
<tr>
<td>Desulphurisation (2)</td>
<td>4%</td>
<td>8%</td>
<td>12%</td>
<td>21%</td>
<td>21%</td>
<td>7%</td>
<td>10%</td>
<td>12%</td>
<td>7%</td>
<td>12%</td>
</tr>
<tr>
<td>Conversion (3)</td>
<td>11%</td>
<td>15%</td>
<td>16%</td>
<td>5%</td>
<td>13%</td>
<td>17%</td>
<td>7%</td>
<td>6%</td>
<td>4%</td>
<td>11%</td>
</tr>
<tr>
<td>Lubes (4)</td>
<td>4%</td>
<td>8%</td>
<td>13%</td>
<td>8%</td>
<td>12%</td>
<td>14%</td>
<td>10%</td>
<td>6%</td>
<td>4%</td>
<td>9%</td>
</tr>
<tr>
<td>Bitumen (5)</td>
<td>1%</td>
<td>1%</td>
<td>2%</td>
<td>2%</td>
<td>1%</td>
<td>0%</td>
<td>1%</td>
<td>0%</td>
<td>1%</td>
<td>1%</td>
</tr>
<tr>
<td>Storage (6)</td>
<td>11%</td>
<td>14%</td>
<td>12%</td>
<td>14%</td>
<td>12%</td>
<td>20%</td>
<td>24%</td>
<td>18%</td>
<td>12%</td>
<td>15%</td>
</tr>
<tr>
<td>Utilities (7)</td>
<td>12%</td>
<td>11%</td>
<td>10%</td>
<td>12%</td>
<td>13%</td>
<td>12%</td>
<td>10%</td>
<td>8%</td>
<td>11%</td>
<td>11%</td>
</tr>
<tr>
<td>Misc.</td>
<td>22%</td>
<td>17%</td>
<td>23%</td>
<td>30%</td>
<td>18%</td>
<td>26%</td>
<td>33%</td>
<td>35%</td>
<td>55%</td>
<td>26%</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

**Annual variation (%)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Octane improvement (1)</td>
<td>0%</td>
<td>3%</td>
<td>-23%</td>
<td>-13%</td>
<td>-21%</td>
<td>6%</td>
<td>6%</td>
<td>-39%</td>
<td>-62%</td>
<td></td>
</tr>
<tr>
<td>Desulphurisation (2)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conversion (3)</td>
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<tr>
<td>Lubes (4)</td>
<td></td>
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<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bitumen (5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage (6)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Utilities (7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) Catalytic reforming, isomerisation, polymerisation, alkylation, MTBE, ETB
(2) HDS, H2S absorption, sulphur production.
(3) FCC, hydrocracking, thermal cracking.
(4) Lubes and related utilities.
(5) Bitumen and related utilities.
(6) Storage, shipping facilities, crude and petroleum products supply facilities.
(7) Production, treatment, distribution networks.


The highest rates of investment dedicated to desulphurisation are reached in 1995 and 1996 (21%). This peak is likely to have aimed at meeting product standards set by the European Directive 98/70/CE on fuel specifications. Indeed, these two years account for more than 40% of the amount of money spent in desulphurisation between 1992 and 2000. Finally, between 1997 and 2000, the group has spent...

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227 Cf. OJEC, 28/12/98.
228 The above tables also show that overall investment has decreased by 62% between 1992 and 2000, namely -7% a year.
FR170 million to improve environmental performance, which includes product upgrading, FR200 million to reduce benzene emissions, and FR300 million to change storage tanks. Following the merger, decision-making processes have been harmonised and important financial resources have been spent to undertake HSE investment projects, notably to meet product specifications and other regulatory requirements. This suggests a very strong influence of the regulatory context on HSE investment decisions.

According to Total’s former HSE refining manager Guy Arnaud, two investment projects out of three aim to comply with the regulation, notably the one concerning product specifications. In the Gonfreville refinery, if energy efficiency issues were addressed for cost saving reasons, and health and safety issues for legal precaution, environmental improvements have always been fostered by external factors. For example, as evidenced in the following table, a significant SO2 emission reduction investment programme was undertaken to meet product specifications and emission limits.

Table 57. Investments to reduce SO2 emissions in Gonfreville

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Investments to reduce SO2 emissions (FR million)</td>
<td>38</td>
<td>42</td>
<td>41</td>
<td>49</td>
<td>25</td>
</tr>
</tbody>
</table>

Source: Total, Unpublished document.

Although investments by the firm Total had decreased before the merger, product specifications, notably the ones set by the European Auto Oil programmes as well as energy saving measures, have led to new HSE investments. Between 1973 and 1982, most investments were targeting energy saving measures, and notably co-generation projects which were given priority in order to comply with the Kyoto protocol.

Before 1980, the SOx content of diesel motor fuels was 0.5%, and 0.3 until 1990, when it went down to 0.15%, and to 0.05% in 1996. The group decided to anticipate future tightening of the legislation and headed for a sulphur content of 0.035% (350 ppm).

229 Interview with Mr Legalland, op. cit.
230 The National Programme to Fight Climate Changes (PLNCC), adopted at the beginning of 2000, allows France to commit to the 1997 Kyoto carbon reductions. It notably seeks to stabilise the emissions of the transport sector, first emitter of CO2 in France, at around 40 million tonnes of CO2 per year between 2010 and 2020. Cf. MATE (2002: 21).
Environmental investment projects are strongly driven by the requirements of the regulatory system. Consequently, this routine component is given a score of +2.

**CD of OHS actions**

According to Mr Legalland, health and safety investments projects are always funded. This is due to the fact that the oil refining activity is a risky one and is strictly regulated. In France, several institutions regulate industrial risk, including in oil refineries which are registered plants subjected to the Seveso directives. For example, the Conseil Supérieur des Installations Classées (CSIC) manages the list of classified plants, specifies how to run them and how to meet environmental requirements. According to the law on the inspection of the classified plants (19/07/76), it is the DRIRE (Direction Régionale pour l’Industrie, la Recherche et l’Environnement, Regional Directorate for Industry, Research and Environment) that look after firms’ environmental and risk management. They intervene before plants set up, and also in the course of their operation. The industrial plants presenting the higher risks are submitted to the European “Seveso” Directives (there are 370 classified plants in France). They also control industrial risk studies and their enforcement, make firms sensitive to energy savings, advise and support companies willing as to invest in cleaner technologies, control nuclear sites, and monitor the safety in the industry. Also, the INERIS (directorate for the prevention of pollution and risks of the Ministry of the Environment) elaborates the policy to monitor the risks and nuisances generated by firms, or industrial breeding.

Given this context, the fact that Total’s OHS investments are always funded suggests a strong context dependence of this routine component in Total’s firms, which score should then be +2.

<table>
<thead>
<tr>
<th>Table 58. Temporary DR of M₂ for French oil refineries</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P₁</strong> Action vs. Representation</td>
</tr>
<tr>
<td>M₂</td>
</tr>
</tbody>
</table>

**CD of the DR**

As argued for the first routine property, the level of pressure the French HSE regulatory system is high. Since according to the previous table the DR of the investment decision-making mechanism is strong, the second source of evidence of
the context dependence routine property is given a score of +1, thereby increasing
the score of \( P_3 \) by one to +5.

<table>
<thead>
<tr>
<th>DR</th>
<th>Weak</th>
<th>Strong</th>
<th>+1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level HSE Pressures</td>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
</tbody>
</table>

The next table summarises the final results of the DR of the second HSE mechanism used by French oil refineries.

**Table 59. Final DR of \( M_2 \) for French oil refineries**

<table>
<thead>
<tr>
<th>( M_2 )</th>
<th>( P_1 ) Action vs. Representation</th>
<th>( P_2 ) Repetition &amp; persistence</th>
<th>( P_3 ) Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>+3</td>
<td>+5</td>
<td>+5</td>
</tr>
</tbody>
</table>

This table shows that the DR is very strong for all the routine properties, and thus that the mechanisms French oil refineries are using to carry out HSE investments are highly routinised and can be identified as investment decision-making routines.

**7.2.4 Input supply management in French oil refineries (\( M_3 \))**

The following table presenting the main products of French oil refineries shows that, on average, 10% of the French demand for petroleum products is not satisfied by domestic production.

**Table 60. Main products of French oil refineries (1994-1998)**

<table>
<thead>
<tr>
<th>(Mt/y)</th>
<th>Net production (P)</th>
<th>Domestic demand (D)</th>
<th>% of demand satisfied (P/D)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL</td>
<td>73</td>
<td>74</td>
<td>78</td>
</tr>
<tr>
<td>LPG</td>
<td>2.1</td>
<td>2.2</td>
<td>2.5</td>
</tr>
<tr>
<td>Unleaded</td>
<td>8.3</td>
<td>9.3</td>
<td>10.8</td>
</tr>
<tr>
<td>Naphtha for vapocracker*</td>
<td>3.5</td>
<td>4.2</td>
<td>4.3</td>
</tr>
<tr>
<td>Diesel fuel</td>
<td>19.4</td>
<td>19.6</td>
<td>20.3</td>
</tr>
<tr>
<td>Domestic fuel</td>
<td>10.7</td>
<td>11</td>
<td>13</td>
</tr>
<tr>
<td>Jet fuel</td>
<td>5.3</td>
<td>5.6</td>
<td>6.3</td>
</tr>
</tbody>
</table>

* Total load

This obviously varies across products, France being a net exporter of unleaded gasoline and jet fuel. Consequently, this country has to import diesel and domestic fuel as well as naphtha and liquefied petroleum gas (LPG), mostly from the Middle East (43% in 1998), notably from Saudi Arabia (20%). This has an environmental impact on input supply management because the sulphur content of Middle East inputs is very high (> 2%), so this might influence the SO$_2$ emissions of French refineries. Algeria’s crude oil, which has one of the lowest sulphur content, represents less than 4% of French imports. However, because of the strategic nature of these mechanisms it has been very difficult to find plant-level data, which strongly limits the empirical investigation of this mechanism. The only piece of information that could be collected during the interview with B. Poot about the group’s refineries concerns Donges. This is the cleanest refinery in terms of sulphur emissions per unit of output, and its inputs are using 80% of North Sea crude which has a low-sulphur content. Input supply management is sometimes used as means to avoid pollution peaks during critical periods of the year. For example, since 1990, Total’s refinery of Feyzin has committed itself not to process inputs with a high-sulphur content between mid-November and mid-February. The Gonfreville refinery was in 2000 the first SO$_2$ emitter in the Basse-Seine region, in spite of having lowered sulphured inputs, built two Claus units, used De-SO$_x$ additive in the catalytic cracker, and moved to EDF’s electricity supply, which is cleaner in terms of SO$_2$ emissions than on-site energy production. In the refinery of La Mède, where sensors are operated by the independent AIRFOBEP network, even in case of special meteorological conditions that may hinder the dispersion of pollutants (little air movement, temperature inversion, …), the sulphur content of the fuel burnt is very low. However, given the limited amount of plant-level data that could be collected for French oil refineries, it is not possible to evaluate a DR for this mechanism.

7.2.5 The HSE routines of French oil refineries

Finally for the HSE mechanisms used by studied French oil refineries, the following table summarises their DR when data were available to evaluate them. The high DR obtained for all the properties of the HSE mechanisms used by French oil refineries

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231 Brigitte Poot, Responsible for Air and Water pollution in the Refining branch of Total, Paris, interviewed on 27/11/02.
to address HSE issues confirms that these mechanisms are used by the main French refiners, and suggests that the two HSE mechanisms investigated empirically can be identified as well-founded HSE routines. Also, the strong DR obtained for the third routine property corroborates the major role HSE regulatory systems play in the HSE context of oil refineries.

Table 61. Summary of the degrees of routineness of the HSE mechanisms used by French oil refineries

<table>
<thead>
<tr>
<th>Routine properties</th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td>HSE mechanisms</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M1 HSE management</td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td>M2 Investment decision-making</td>
<td>+3</td>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td>M3 Input supply management</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

On the basis of these results, M1 and M2 can be identified as the HSE routines R1 and R2. The following tables present these two routines in a tabled form, and bring to the fore what caused them to emerge and to persist.

Table 62. The HSE management routine of Total (R1)

| Action: Monitor and improve HSE performance |
| Representation of the action |
| +I: Physical artefacts (safety management systems, specific software to evaluate the risks of dangerous exposures, guidelines are stored on the computer network and CD-ROMs, ISO 14.001 or EMAS, sulphur recovery equipment, vapour recovery unit, specific system in 1988 to control dust) |
| +I: Language forms (voluntary agreement signed to reduce greenhouse gases, annual report highest existing HSE standards, Environment and safety charter, Environment and Safety Report, Safety Environment and Quality, Global Compact) |
| Routine technologies |
| +I: Organisational (special task force to “formulate policy, Industrial Safety” on one side, Environment and Safety Department integrated into group’s management, Environment and Safety Committee, Crisis Steering Committee, Specific Crisis Management Units and Plans, Health and Safety Committee, olfactometry team. |
| +I: Human (1,500 people are working full time, three kinds of training, safety has always been part of the annual individual assessment meeting, training a nose) |
| +I: Financial (€1 billion per year) |

DR +5
HSE routines emerge when a decision to take action has been followed by the use of representative forms and by the allocation of resources to ensure that the rules to carry out the action are going to be remembered. For example, Total has specific equipment to control and to manage safety procedures, as well as social and physical technologies. The action to monitor and improve the HSE performance of a refinery persists because routinised mechanisms were set up such as HSE departments, HSE training, or financial resources. The persistence of Total’s HSE management routines evidenced by HSE data shows that they are embedded in firms’ behaviour. This is not quite the same for investment decision-making processes.
Table 63. The investment decision-making routine of Total (R2)

<table>
<thead>
<tr>
<th>P1</th>
<th>Action vs. Representation</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action</strong>: Invest to enhance HSE performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Representation of the action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: <em>Physical artefacts</em> (standard cash flow analyses without HSE criteria, confirmed by the detailed study of the investment project used for P2)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: <em>Language forms</em> (Ethical and Risk committees consulted on every project: investment decisions made following formalised pledges to take HSE issues into account)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Technology</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: <em>Organisational</em> (high level of plant autonomy, €2 million per project)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: <em>No human technology</em> (no evidence found that finance managers trained on HSE issues)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: <em>Financial</em> (bottom-up approach of investment decision-making)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>P2</strong></td>
<td>Repetition &amp; persistence</td>
<td>DR</td>
</tr>
<tr>
<td><strong>Planning of HSE investments</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2: <em>Regular HSE investment planning</em> (notably to meet EU product specs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>HSE investment projects</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+3: <em>Big and small investment projects</em></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>P3</strong></td>
<td>Context dependence (CD)</td>
<td>DR</td>
</tr>
<tr>
<td><strong>CD of environmental actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2: <em>Strong</em> (highest rates of investment when fuels specs in force)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CD of OHS actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2: <em>Strong</em> (OHS investments always funded).</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CD of the DR</strong></td>
<td>Level HSE Pressures</td>
<td></td>
</tr>
<tr>
<td>DR</td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td>Weak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strong</td>
<td></td>
<td>+1</td>
</tr>
</tbody>
</table>

There are no physical artefacts to represent action and no human resources are allocated to train finance managers on HSE issues. This is in spite of a strong context dependence, which underlines the difficulty to diffuse HSE practices across firms’ departments. However, we can see that there is evidence of a very strong persistence of HSE investments in Total. Since this does not correspond to a strong representation of action inside the company (DR = 3 for P2), this suggests that the pressures exerted by the HSE regulatory system has a very strong influence on the HSE behaviour of Total. A very strong context dependence is confirmed by a DR of
+5 to the third routine property, notably under the pressures of European fuel specifications.

The next section investigates whether they are also used and in a highly routinised way by oil refineries located in another European country where HSE pressures are similar to the ones exerted in France: the UK.

### 7.3 The HSE behaviour of oil refineries in the United Kingdom

#### 7.3.1 The refining sector in the UK

Hydrocarbons, petroleum products and natural gas, are the main source of energy in the UK, and since 1996 the country has been using more natural gas than petroleum. In 2001, 40% of energy needs were relying on natural gas, 33% on petroleum products, 18% on solid fuels, 9% on electricity (nuclear and hydropower), and 1% on renewables. There were 22 refineries in operation in 1970 and 13 in 2000, and the country’s refining capacity has decreased by 33% between 1978 and 2001. Over this period, the production of hydrocarbons has more than doubled to reach 118 million tonnes in 2001, of which 35% of diesel oil, 28% of gasolines, 13% of fuels, 12% of jet fuel, and 2% of bitumen were produced. Finally, since 1993 the country has been a net exporter of crude oil, and a net exporter of refined products since 1978.

Table 64. UK refineries in operation

<table>
<thead>
<tr>
<th>Refinery</th>
<th>Established</th>
<th>Type</th>
<th>Capacity (Mt/y)</th>
<th>% TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Esso Fawley</td>
<td>1921</td>
<td>Residue upgrading</td>
<td>15.6</td>
<td>17.3</td>
</tr>
<tr>
<td>Shell Stanlow</td>
<td>1924</td>
<td>Residue upgrading</td>
<td>12.5</td>
<td>13.8</td>
</tr>
<tr>
<td>BP Grangemouth</td>
<td>1924</td>
<td>Complex</td>
<td>10.2</td>
<td>11.3</td>
</tr>
<tr>
<td>BP Coryton</td>
<td>1953</td>
<td>Complex</td>
<td>9.6</td>
<td>10.6</td>
</tr>
<tr>
<td>Lindsey</td>
<td>1969</td>
<td>Complex</td>
<td>9.4</td>
<td>10.4</td>
</tr>
<tr>
<td>Texaco</td>
<td>1964</td>
<td>Complex</td>
<td>9.1</td>
<td>10.1</td>
</tr>
<tr>
<td>Conoco</td>
<td>1969</td>
<td>Residue upgrading</td>
<td>7.6</td>
<td>8.4</td>
</tr>
<tr>
<td>Elf</td>
<td>1973</td>
<td>Complex</td>
<td>5.3</td>
<td>5.9</td>
</tr>
<tr>
<td>Phillips</td>
<td>1963</td>
<td>Hydroskimming</td>
<td>5.0</td>
<td>5.5</td>
</tr>
<tr>
<td>Shell Haven</td>
<td>1916</td>
<td>Complex</td>
<td>4.3</td>
<td>4.8</td>
</tr>
<tr>
<td>Eastham</td>
<td>1966</td>
<td>Hydroskimming</td>
<td>1.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Nynas UK</td>
<td>1935</td>
<td>Hydroskimming</td>
<td>0.7</td>
<td>0.8</td>
</tr>
<tr>
<td>Gulf</td>
<td>1968</td>
<td>Hydroskimming</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>BP Llandarcy²³²</td>
<td>1921</td>
<td>Complex</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td></td>
<td></td>
<td><strong>90.3</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Sorrell (2000).

²³² The distillation unit at Llandarcy closed in January 1986. Stand alone vacuum distillation capacity continues in use.
### Table 65. UK Refinery Process Plant Capacities

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Esso Fawley</td>
<td>311.2</td>
<td>132</td>
<td></td>
<td>82.4</td>
<td>60.6</td>
<td>21.5</td>
<td>213.46</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shell Stanlow</td>
<td>262</td>
<td>46</td>
<td></td>
<td>73</td>
<td>59</td>
<td>57</td>
<td>73</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BP Grangemouth</td>
<td>206</td>
<td>64.6</td>
<td></td>
<td>18.9</td>
<td>39.6</td>
<td>31.5</td>
<td>31.5</td>
<td>62.1</td>
<td></td>
</tr>
<tr>
<td>Lindsey Texaco</td>
<td>192</td>
<td>92</td>
<td>28.7</td>
<td>48.4</td>
<td>32.6</td>
<td>54</td>
<td>51</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conoco BP</td>
<td>180</td>
<td>185, 68</td>
<td>40</td>
<td>48</td>
<td>47</td>
<td></td>
<td>75</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BP Coryton Elf</td>
<td>108</td>
<td>95</td>
<td></td>
<td>32.5</td>
<td>17.8</td>
<td></td>
<td>102.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Phillips Shell Haven</td>
<td>100</td>
<td>39, 24</td>
<td></td>
<td>17.5</td>
<td>0</td>
<td></td>
<td>94</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elf Eastham</td>
<td>20</td>
<td>17.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>86</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elf Nynas UK</td>
<td>12.8</td>
<td>12</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>3.43</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BP Llandarcy</td>
<td>25.74</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>1,854</td>
<td>848.79</td>
<td>68</td>
<td>94.7</td>
<td>449.45</td>
<td>368.8</td>
<td>55.5</td>
<td>257.8</td>
<td>865.09</td>
</tr>
</tbody>
</table>


The two refining companies studied in the UK are Texaco and Conoco. They account for 22% of the country’s refining capacity, and for 25% of the industry’s air emissions in 1998.

### Table 66. Air emissions from England and Wales refineries in 1998

<table>
<thead>
<tr>
<th>(tonnes)</th>
<th>Esso Fawley</th>
<th>Shell Stanlow</th>
<th>Shell Haven</th>
<th>Elf</th>
<th>Texaco</th>
<th>Conoco</th>
<th>Lindsey</th>
<th>Phillips</th>
<th>BP Coryton</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>CO</td>
<td>1,902</td>
<td>750</td>
<td>200</td>
<td>226</td>
<td>1,700</td>
<td>830</td>
<td>61</td>
<td>10</td>
<td>108</td>
<td>5,787</td>
</tr>
<tr>
<td>Particulates</td>
<td>530</td>
<td>750</td>
<td>173</td>
<td>383</td>
<td>480</td>
<td>380</td>
<td>120</td>
<td>25</td>
<td>261</td>
<td>3,102</td>
</tr>
<tr>
<td>SO₂</td>
<td>17,341</td>
<td>20,000</td>
<td>5,477</td>
<td>8,001</td>
<td>8,900</td>
<td>5,800</td>
<td>15,000</td>
<td>1,284</td>
<td>17,165</td>
<td>98,968</td>
</tr>
<tr>
<td>NOₓ</td>
<td>7,365</td>
<td>4,400</td>
<td>1,952</td>
<td>1,165</td>
<td>2,200</td>
<td>4,100</td>
<td>2,700</td>
<td>589</td>
<td>2,887</td>
<td>27,359</td>
</tr>
<tr>
<td>VOCs</td>
<td>5,354</td>
<td>5,900</td>
<td>3,171</td>
<td>3,258</td>
<td>4,800</td>
<td>7,700</td>
<td>6,500</td>
<td>191</td>
<td>13,520</td>
<td>50,394</td>
</tr>
<tr>
<td>CO₂</td>
<td>3,091,300</td>
<td>2,800,000</td>
<td>1,193,000</td>
<td>1,013,566</td>
<td>1,900,000</td>
<td>2,400,000</td>
<td>1,900,000</td>
<td>269,698</td>
<td>2,242,070</td>
<td>16,809,634</td>
</tr>
<tr>
<td>Total emissions</td>
<td>3,123,792</td>
<td>2,831,800</td>
<td>1,203,973</td>
<td>1,026,599</td>
<td>1,918,080</td>
<td>2,418,810</td>
<td>1,924,381</td>
<td>271,797</td>
<td>2,276,011</td>
<td>16,995,242</td>
</tr>
<tr>
<td>% Total</td>
<td>18%</td>
<td>17%</td>
<td>7%</td>
<td>6%</td>
<td>11%</td>
<td>14%</td>
<td>11%</td>
<td>2%</td>
<td>13%</td>
<td>100%</td>
</tr>
<tr>
<td>Capacity (Mt/y)</td>
<td>16</td>
<td>13</td>
<td>4</td>
<td>5</td>
<td>9</td>
<td>8</td>
<td>9</td>
<td>5</td>
<td>10</td>
<td>78</td>
</tr>
<tr>
<td>% Total</td>
<td>20%</td>
<td>16%</td>
<td>5%</td>
<td>7%</td>
<td>12%</td>
<td>10%</td>
<td>12%</td>
<td>6%</td>
<td>12%</td>
<td>100%</td>
</tr>
<tr>
<td>Emissions / Capacity</td>
<td>200,243</td>
<td>226,544</td>
<td>279,994</td>
<td>193,698</td>
<td>210,778</td>
<td>318,264</td>
<td>204,721</td>
<td>54,359</td>
<td>237,084</td>
<td>Mean = 213,965</td>
</tr>
</tbody>
</table>


Excludes Eastham, BP Llandarcy, and Gulf (the latter closed in December 1997).
**Texaco**

The Pembroke refinery was commissioned in September 1964 at a rated capacity of 5.9 million tonnes per year, later increased to 9 million tonnes in 1973. It cost approximately £500 million to build and currently employs some 750 full time and contract staff. Process units include an atmospheric crude distillation unit, a vacuum distillation unit, a naphtha hydrotreater and reformer (continuous catalytic regeneration), a visbreaker, a kerosene sweetening unit, and a hydrotreater for desulphurisation of kerosenes and diesel oils. They allow to manufacture gasolines, kerosenes, jet fuels, diesel/gas oils, fuel oils and LPG\textsuperscript{233}. In September 2001, the US Federal Trade Commission approved Chevron’s USD39 billion acquisition of Texaco\textsuperscript{234}, which generated global cost savings of USD1.2 billion within six to nine months of the merger’s completion.

**Conoco**

Humber refinery was completed and came on stream in 1969 with a capacity of 4 million tonnes per year, later increased to 6.5 million tonnes. It currently employs some 600 people. Processes include atmospheric and vacuum distillation units, a thermal cracking unit built in 1971, two delayed coking units, a virgin distillate hydrodesulphuriser, a cracked distillate hydrodesulphuriser, a heavy gas oil desulphuriser, two catalytic reforming units, a pentane/hexane isomerisation plant, an aromatics extraction plant, a toluene hydrodealkylation plant, a gas recovery plant, two SRUs, one FCC (1990, US technology), a propylene/butylene catalytic polymerisation unit, a pressure swing absorber for hydrogen recovery and a cryogenic LPG recovery plant, a propylene recovery, and an HF alkylation unit. They produce a broad range of products such as fuel gas, propane, butane, benzene, gasoline, kerosene, diesel fuels, heating oils, sulphur and several types of electrograde cokes\textsuperscript{235}. The fact that it produces petroleum coke to make primarily high-value graphite electrodes for steel and aluminium smelting makes it a unique plant in the UK. Consequently, the refinery tends to use more low-sulphur crude to produce this high-quality coke.

\textsuperscript{233} Source: Institute of Petroleum (1994).

\textsuperscript{234} “Chevron Texaco combining staff and production in UK”, 10/12/2001, Reuters English News Service, 12/10/01, accessed at http://www.texaco.co.uk/ukwww/scripts/PressRelease.asp, 09/05/02.

\textsuperscript{235} Source: Institute of Petroleum (1994).
7.3.2 HSE management in UK oil refineries (M1)

*Texaco*

**P1- The action vs. representation routine property (M1-Texaco)**

**Action**

The action aimed at by HSE management mechanisms is to monitor and to improve the HSE performance of the refinery, notably by setting up HSE management systems.

**Representation**

*Physical artefacts (standard operating procedures, tools, techniques, …)*

In order to reduce emissions of nitrogen oxides, a number of furnaces were fitted with “Low-NOx burners” to minimise their formation and to meet the overall limit or “bubble” set for the refinery by the Environment Agency. Workplace safety was improved by modifying the safety programme implemented since early 1998. It aimed to reinforce safety as the number one priority in the company, by identifying actions that could optimise safety performance and by implementing a programme to improve the communication and the understanding of procedures now stored in a specific database. Finally, environmental monitoring was improved with the setting up of an incident reporting system.

**Diagram 6. Pembroke NOx emissions reductions (tonnes per MM barrels refined)**

![Diagram](image)


The plant also installed two dissolved air flotation units to improve biological treatment. Finally, the refinery tried to develop relations with local environmental groups by organising regular meetings at the refinery and by funding an environmental monitoring teaching pack based on lichen surveys for local schools,
by supporting an Environment Agency schools’ education programme focusing on waste recycling and minimisation, and by setting up a three-year demonstration project at Pembroke sponsored by the European Union to implement sustainable biodiversity action plans for industrial sites. The refinery is not externally registered to ISO 14.001 nor to EMAS and has no intention to do it, since it has a corporate “SHE” (safety, health, environment) system developed by DNV on the basis of their ISRS and IERS 236. Concerning particulates, the firm set up a process that removes particulates from the catalytic cracking unit, and to prevent leaks of VOCs it installed a fence monitoring system. It is relatively low-cost and works by putting absorption tubes around the fence for two weeks, which allows to locate where VOCs emissions come from, in practice mostly at ground level. Finally, the Pembroke refinery supported a European Union project to implement a biodiversity action plan for industrial sites 237. Concerning health and safety issues, in 1994 a major accident due to “a combination of failures in management, equipment and control systems” led Texaco to improve its HSE management system, and the firm is now targeting a zero incidents objective 238.

Since many physical artefacts are used by Texaco to store knowledge about how to monitor and improve its HSE performance. This allows us to attribute a score of +1 to this routine component.

*Globally shared language forms (formalised oral codes, pledges, …)*

The Pembroke Refinery, located in Milford Haven, is Texaco’s only 100 percent owned refinery in Europe, and its HSE policy is the same as the one adopted in the USA. The group puts forward that everyone at Texaco is responsible for maintaining a high standard of HSE performance. The firm aims to comply with the law and to adopt best HSE practices where practical and viable. It endorses the policies and procedures established by the American Petroleum Institute’s Guiding Environmental Principles, the International Chamber of Commerce’s Business Charter for Sustainable Development, the Environmental Guiding Principles of the Joint E&P Forum/EUROPIA’s, and the Global Sullivan Principles for corporate

236 Source: interview given by Dave Harris, Environment Manager in 1999, to Steve Sorrell for the TEP project (op. cit.).
238 Ibid.
social responsibility. It also supports the guidelines developed by the Public Environmental Reporting Initiative. A corporate document approved in March 2000 by the General Manager mentions ten objectives, the first one being to make sure that HSE norms are respected\textsuperscript{239}. It also adopted a corporate policy to fight climate change. However, business strategies presented in an internal report\textsuperscript{240} do not mention any environmental commitment and rather focus on OHS issues. They include:

- Achieving superior performance in the areas of safety, reliability and incident-free operations,
- Remaining committed to being an integrated, regionally focused refiner and marketer, delivering increased shareholder value and strong cash flow,
- Attracting new, qualified resellers and improving ties with branded distributors through training, planning, marketing support and financial counselling,
- Maintaining and developing strong collaborative relationships with the communities in which the company operates.

Argues Jim Hawn, managing director for Marketing and Manufacturing:

“Over the past two years Pembroke and other European refiners have faced some very harsh economic realities, but these plans will position Pembroke to take advantage of changing market conditions. (…) Texaco is committed to a cleaner fuels initiative in the UK. We were one of the first companies to introduce Lead Replacement Petrol and Ultra Low Sulphur Diesel in the UK. Now motorists will be able to switch to the new cleaner ULSP four years ahead of the European Union deadline.”\textsuperscript{241}

Finally, following the USD100 billion merger with Chevron, the new group keeps committing itself to HSE issues and even started to exhibit beyond environmental compliance behaviour as a means to seize win-win opportunities:

“a record of environmentally sound operations makes us more competitive in the global marketplace, helps us gain permission to operate and is essential to profitability. (…) We will constantly strive to create new processes and innovative

\textsuperscript{239} Source: Telephone interview with Brian Whittle, Technical Clerk, Safety, Health and Environment Department of Texaco, 16/08/01.
\textsuperscript{240} Source: unpublished documents, Texaco.
\textsuperscript{241} Interviewed by S. Sorrell, op. cit.
technology that reduce air emissions, protect diverse ecosystems, and produce new efficiencies that conserve energy usage.242

However, compared to what is being done in the USA, common practice in the UK does not seem to be the best available one. Says Dave Harris:

“We don’t do very extensive leak detection and repair –it’s something you see in North American refineries. We’ve done some limited programmes, but nothing substantial. I’m not aware of the other UK refineries doing anything very different.”243

This suggests that the aforementioned pledge for overcompliance may not be that strong a commitment, since more stringent US environmental standards are not implemented in Europe. Finally, in addition to saving lives and costs, this safety commitment is also seen as a positive contributor to the firms’ image. Argues Chevron Texaco’s’s chairman Dave O’Reilly244:

“Operational excellence is no longer the cost of doing business. It’s part of the price of admission. (...) In order to be a preferred partner and admired globally, we must uphold the highest safety standards attainable.”

In order to express its commitment towards HSE issues and to diffuse it among its employees, Texaco is using a variety of language forms. This allows us to attribute a score of +1 to this routine component.

Technologies

Organisational

On the organisational level, the refinery has an Environmental Adviser and an Environmental Assistant working in the “SHE” Department. Environmental achievements are appraised once a month during a plant visit with the environmental inspector, who also discusses future legislation and improvements and visits the site to check the condition of the refinery. Finally, the group has and Emergency Response Team East (ERTE) based in London, which is composed of personnel

242 http://www.chevrontexaco.com/environment, accessed 09/05/02.
243 Ibid.
244 http://www.chevrontexaco.com/environment/health_safety, accessed 09/05/02.
coming from a variety of disciplines and is responsible for responding to an emergency by assisting local business units in managing the incident\(^\text{245}\). Several types of organisational technologies are used by Texaco to carry out HSE actions, and HSE departments are well integrated in the firm’s hierarchy, including at the highest level. This indicates a strong legitimacy of HSE actions in the firm and allows us to give to this routine component a score of +1.

**Human**

An environmental programme to improve effluent water quality led to set up an environmental awareness programme aiming to change employees’ behaviour and to ensure that the operation of the new and existing water treatment facilities is fully optimised. This indicates that Texaco allocates important human resources to carry out HSE actions, and allows us to rate the score of this routine component at +1.

**Financial**

According to John Hubbard, HSE investments, which represent more than 75% of total investments, are indeed considered as the price to pay to stay in business. Given the big amount of financial resources allocated by Total to address HSE issues, a score of +1 is given to this routine component.

To conclude on the HSE management mechanism of Texaco’s oil refineries, it appears that it is a very highly routinised mechanism, since its DR has a value of +5 when adding the scores of its routine components. The fact that it was possible to distinguish between the various components of this routine property suggests that HSE issues might be addressed by operating routinised mechanisms such as HSE pledges, which contribute to motivate the staff to tackle HSE issues.

**P\(_2\)- The repetition and persistence routine property (M\(_1\)-Texaco)**

**Data collection**

A supplement to the 2001 Annual Report mentions that safety performance has improved in the refinery, reaching four million hours worked without a lost-time incident. Concerning sulphur emissions, the refinery’s bubble is 1,300 tonnes for all sources, which notably include the combustion plant, the catalytic cracker, the two

\(^{245}\) Source: http://www.texaco.co.uk/SHE.htm, accessed 22/11/03.
SRUs, and furnaces which are still burning sour gas streams. Apart from these data, very little HSE information is published by the group, to the exception of the Chevron-Texaco’s Pembroke Refinery Biodiversity Management project\(^{246}\). The fact that Texaco collects several types of HSE data on a regular basis suggests that its HSE actions tend to persist over time. This reveals the existence of routinised mechanisms, and allows us to attribute a score of +2 to the component of this routine property.

**Data diffusion**

Texaco does not diffuse a lot of HSE data to the public, despite the fact that because of mandatory requirements it has to do so as other refineries, which suggests that it only diffuses its data in-house. This was confirmed in the interview given by Dave Harris\(^{247}\), and allows us to give to this routine component a score of +2. If we add up the scores of all the components of this second routine property, we reach a strong degree of routineness of +4.

**P\(_3\)**- The context dependence routine property (M\(_1\)-Texaco)

This property can be tested for French oil refineries by looking at the extent to which their HSE actions have been influenced by the HSE context, and notably by English and European HSE regulatory systems.

**CD of environmental actions**

Since 1999, all UK refineries are asked to model their main releases so that plans can be made to reduce their emissions, taking into account the location of the refinery, and thus local environmental conditions. The strong influence of the regulatory context on oil refineries’ HSE behaviour is confirmed by an environment manager who acknowledged that “a lot of things are driven by regulatory standards”, notably for existing plants:

“I think that when you are building a new plant you will tend to build it to the new plant standard, the industry standard of the day –and that automatically will bring about improvement. But with regard to existing plants, obviously there’s a cost incurred and unless you have –whether air quality standards, environmental


\(^{247}\) Conducted by S. Sorrell for the TEP project, op. cit.
quality standards or waterway or whatever— I don’t think you will see significant improvement.248

In addition to the evidences gathered about HSE actions spurred by HSE regulatory systems, the firm has itself recognised the strong impact of HSE regulation on its HSE behaviour. Therefore, this routine component is given a score of +2.

CD of OHS actions
In Texaco, an HSE policy ensures that management provides the necessary resources, training, information and supervision to apply high HSE standards to protect the environment, the health and safety of employees and the communities in which it operates, and to comply with the Seveso 2 directive in force since the year 2000. Since the OHS actions of the firm follow the requirements of the domestic HSE regulatory system, this routine component is given a score of +2.

Before examining the second source of evidence the previous scores can be added up and summarised in the following temporary table.

Table 67. Temporary DR of M1 for Texaco

<table>
<thead>
<tr>
<th></th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>+5</td>
<td>+4</td>
<td>+4</td>
</tr>
</tbody>
</table>

CD of the DR
The analysis of the English HSE regulatory system, summarised in Section 6.4, shows that its level of pressure is high, and the previous table that the DR of the HSE management mechanism is strong. Therefore, the second source of evidence of the context dependence routine property is given a score of +1, thereby increasing the score of P3 by one to +5.

The next table summarises the final results of the DR of the first HSE mechanism used by Texaco.

248 Ibid.
Table 68. Final DR of $M_1$ for Texaco

<table>
<thead>
<tr>
<th></th>
<th>$P_1$ Action vs. Representation</th>
<th>$P_2$ Repetition &amp; persistence</th>
<th>$P_3$ Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_1$</td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
</tbody>
</table>

This table shows that the DR is very strong for all the routine properties, and thus that the mechanisms Texaco is using to address HSE issues are highly routinised and can be identified as HSE management routines ($R_1$).

**Conoco**

$P_1$- The action vs. representation routine property ($M_1$-Conoco)

**Action**

The action aimed at by HSE management mechanisms is to monitor and improve the HSE performance of the refinery, notably by setting up HSE management systems.

**Representation**

*Physical artefacts (standard operating procedures, tools, techniques, ...)*

The Humber refinery is registered to ISO 14.001 since 1999, and was the first Conoco refinery to be awarded this standard. NO$_x$ emissions have fallen by 9% since 1980 when ultra-low NO$_x$ burners were fitted, and particulate emissions from FCCU have been cut by 70% since 1990 thanks to an electrostatic precipitator. Releases of VOCs have been cut by 65% since 1990, mainly through vapour containment projects$^{249}$. Spectroside surveys were used to pinpoint major sources that could be rectified, and all floating roof tanks were equipped with double seals$^{250}$. Many physical artefacts are used by Conoco to store knowledge about how to monitor and to improve its HSE performance. This allows us to attribute a score of +1 to this routine component.

*Globally shared language forms (formalised oral codes, pledges, ...)*

Concerning health and safety issues, Conoco’s policy is summarised in a slogan: “At Conoco, our work is never so urgent or important that we cannot take time to do it safely”. Since a long time, safety has been part of the management of human

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$^{249}$ Source: Conoco (1999: 6).

$^{250}$ Source: Interview with Geoffrey Vickers, op. cit.
resources, as evidenced by the Conoco Annual Awards reported in Conoco (2001: 15), and by the fact that the company exhibits a good world-wide total recordable injury rate of 0.37 in 2000\textsuperscript{251}. Sustainable development is defined with mere economic terms as “the ability to create long-term shareholder value by embracing opportunities and managing economic, environmental and social risks”\textsuperscript{252}. To achieve that goal, the firm integrates economic, environmental and social considerations into strategic planning and business decision-making processes\textsuperscript{253}. Environmental policy is corporate, but local sites can adopt a more active behaviour. As Texaco, Conoco puts forward a beyond compliance HSE behaviour. This is reflected in its percentage consent limits, which reached 44% of the agreed limit (100%) in 1998 for air emissions and 19% for liquid effluent contaminants\textsuperscript{254}.

In order to express its commitment towards HSE issues and diffuse it among its employees, Conoco uses a variety of language forms, which allows us to attribute a score of +1 to this routine component.

**Technologies**

*Organisational*

In Conoco, a “SH&E” department communicates policy information to employees, assesses potential hazards, provides training, and ensures that all operations comply with relevant environment, health and safety laws and regulations.

The fact that Conoco set up a specific HSE departments to address HSE issues indicates a strong legitimacy of HSE actions in the firm, and allows us to give this routine component a score of +1.

**Human**

As argued Alan Green\textsuperscript{255}, managers’ involvement, efficient systems and capabilities are essential to set up efficient HSE mechanisms. It is also essential that employees are well trained and motivated, and have a strong safety culture. In Conoco, HSE awareness training is mandatory for every employee and is handled by consultancy

\textsuperscript{252} Rob McKee, Executive Vice President, Worldwide Exploration and Production, in a letter to employees, September 2000, in CONOCO (2001: 11).
\textsuperscript{253} Cf. CONOCO (2001: 14).
\textsuperscript{254} Source: CONOCO (1999: 9).
\textsuperscript{255} SHE Manager European Region, interviewed on 4\textsuperscript{th} March 2002, London.
firms. Since the firm allocates important human resources to carry out HSE actions, the score of this routine component is rated at +1.

Financial
The Humber refinery spent USD134 million investment to produce ultra-clean motor fuels and meet new product specifications. Given the importance of the financial resources allocated by Conoco to address HSE issues, a score of +1 is given to this routine component.

To conclude on the HSE management mechanism of Conoco’s oil refineries, it appears that it is a very highly routinised mechanism because the value of its DR is +5 when the scores of its routine components are added up. This contributes to perpetuate HSE mechanisms which have proved to be successful in the past to tackle HSE issues.

P2- The repetition and persistence routine property (M1-Conoco)

Data collection
According to Conoco’s “Sustainable Growth Report” published in 2001, the refinery has spent some USD125 million on environmental projects since 1993, and has reduced the total amount of regulated waste and emissions by more than 48 percent per barrel of oil processed, while plant throughput had increased by 22 per cent. In Conoco’s aforementioned report, Humber refinery’s emissions per throughput are said to be the lowest in the UK. It is also claimed that air emissions have decreased since 1998, notably thanks to a £23 million gas-fired plant256. However, Table 66 reveals that it accounts for 10% of UK oil refineries’ capacity and for 14% of their total air emissions. This table also shows that, as opposed to Texaco, it has the highest level of emissions per unit of output (318,965 tonnes per million tonne of capacity), which is 50% higher that the average of UK refineries (213,965 tonnes per million tonne of capacity). Finally, since 1994, refinery waste has decreased from 0.63 to 0.37 kilos per barrel, and sulphur dioxide emissions have been cut by more than 60% since 1980, thanks to a doubling of the capacity of the SRU and an improvement of its efficiency.

256 This plant has allowed to reduce environmental impacts while increasing the productivity of utilities, which underlines that win-win opportunities exist in oil refineries.
The fact that Conoco collects several types of HSE data on a regular basis suggests that its HSE actions tend to persist over time, and are thus supported by routinised mechanisms. This allows us to attribute a score of +2 to the component of this routine property.

**Data diffusion**

Little HSE data was diffused in the 2001 report, even if producing such a document suggests an interest in communicating on HSE issues. However, HSE data exist in the firm, notably because it is mandatory to collect environmental ones for the Environment Agency. This suggests that the firm chose not to diffuse it to the public even if it diffuses it in-house, which allows us to give to this routine component a score of +2.

If we add up the scores of all the components of this second routine property, we reach a strong degree of routineness of +4.

**P3- The context dependence routine property (M1-Conoco)**

**CD of environmental actions**

As for Texaco, Conoco has to meet EU standards, which are strictly enforced. This led the firm to modify its product specifications. However, an environment manager suggested that a pro-active environmental behaviour can also be fostered by other external conditions such as the economic climate, which can force the firm to improve plants’ efficiency, including through environmental measures:

**Steve Sorrell:** Perhaps all this monitoring has made you understand how you’re running your plant better and maybe picked up inefficiencies?

**Geoffrey Vickers:** I think we’ve picked up inefficiencies and I don’t think that’s anything to do with IPC—that’s probably more to do with the economic climate. Just how to minimise the inefficiencies in the operation. That would have been done, and is being done, irrespective of IPC. You’ve got to reduce your costs because of the overall state of the business. The marketplace is not very good.”

As all other UK refining industries, Conoco has to meet national and European HSE regulations, and as evidenced below in the study of the second routine property, it is undertaking massive investment programmes to do so. Another external factor, the
“overall state of the business”, is also mentioned as an incentive to modify Conoco’s environmental behaviour. This confirms that its environmental actions are strongly driven by external pressures, including regulatory ones. Therefore, this routine component is given a score of +2.

CD of OHS actions

In Conoco, health and safety is a number one priority, and this is reflected in the routinised mechanisms set up to ensure a high performance in these areas. The following table shows the good OHS records of the company in the U.S.A.

**Diagram 7. Safety performance comparisons of Conoco in the U.S.A**

API injury/illness recordable rate comparisons (1995-2000) (recordable cases per 100 workers per year or 200,000 hours worked).

This tends to confirm the strong OHS culture of the company, which applies the same standards in European and American plants. In the UK, oil refineries are registered plants and like any other company need to comply with the 1974 Health and Safety at Work Act and with its complementary acts. Since the OHS actions of the firm are in accordance with the UK HSE regulatory system, this routine component is given a score of +2. Before examining the second source of evidence, the previous scores can be added up and summarised in the following temporary table.

**Table 69. Temporary DR of M₁ for Conoco**

<table>
<thead>
<tr>
<th></th>
<th>P₁ Action vs. Representation</th>
<th>P₂ Repetition &amp; persistence</th>
<th>P₃ Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁</td>
<td>+5</td>
<td>+4</td>
<td>+4</td>
</tr>
</tbody>
</table>

CD of the DR

The analysis of the English HSE regulatory system, summarised in Section 6.4, shows that its level of pressure is high, and the previous table that the DR of the HSE management mechanism in Conoco is strong. Therefore, the second source of evidence of the context dependence routine property is given a score of +1, thereby increasing the score of P₃ by one to +5.

<table>
<thead>
<tr>
<th>Level HSE Pressures</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR</td>
<td>Weak</td>
<td>Strong +1</td>
</tr>
</tbody>
</table>

The next table summarises the final results of the DR of the first HSE mechanism used by Conoco.

**Table 70. Final DR of M₁ for Conoco**

<table>
<thead>
<tr>
<th></th>
<th>P₁ Action vs. Representation</th>
<th>P₂ Repetition &amp; persistence</th>
<th>P₃ Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁</td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
</tbody>
</table>

This table shows that the DR is very strong for all the routine properties, and thus that the mechanisms English oil refineries are using to address HSE issues are highly routinised and can be identified as HSE management routines (R₁).

7.3.3 Investment decision-making processes in UK oil refineries (M₂)

**Texaco**

P₁ - The action vs. representation routine property (M₂-Texaco)

**Action**

The action carried out by investment decision-making processes is to undertake investment projects to improve firms’ HSE performance.

**Representation**

*Physical artefacts (standard operating procedures, tools, techniques, …)*

The financial instrument used to appraise the project is cash flow analysis, which does not integrate any HSE variable. Thus the score of this component is 0.
Language forms
USD5 million were used to modify the existing distillation column, and USD10 million to modify tankers and to recover vapours. According to John Hubbard, following the announcement of this new standard the refinery had three options: close down the refinery, sell gas to countries having weaker regulation, or pay the price of this investment to stay in business. As argued in Chevron Texaco (2001: 40):

“Most of the costs of complying with laws and regulations pertaining to company operations and products are embedded in the normal costs of doing business”.

This suggests that the company takes HSE issues into account when running its plants, including when carrying investment projects, which allows us to give a score of +1 to this component.

Technologies
Organisational
All investment projects come from the refinery and are approved in London’s head offices, or in New York over USD10 million. This suggests that the refinery has a certain degree of autonomy to finance HSE projects, notably the ones generating incremental technological improvements. A score of +1 is thus given to this component.

Human
Since no evidence was found that finance managers were trained on HSE issues, the score of this component is 0.

Financial
Since the investment decision-making process in Texaco is decentralised, the score of this routine component is +1.

258 Source: ibid. The manager argued that relocation to so-called “pollution havens” is not seen as a realist option. On pollution havens, halos, and other spaghetti, see Zarsky (1999).

259 Source: Telephone interview with John Hubbard, Investment and Technical Leader, Business and Planning Group, Texaco Ltd, 02/08/01.
When adding the scores of all the components of this first routine property, we can see that its DR is not very strong (+3). It suggests that the way the group addresses HSE issues by undertaking investments is not strongly routinised, although elements of investment decision-making routines that could enhance the HSE performance of its plants do exist, such as organisational ones.

**P₂- The repetition and persistence routine property (M₂-Texaco)**

**Planning of HSE investments**

In order to comply with EU directives, notably the 2005 fuels specifications, although no yearly investment data could be obtained from Texaco, we can infer that such a planning exists since the group manages to anticipate these regulations and give a score of +2 to this routine component.

**HSE investment projects**

To remove benzene from the main stream and to meet the 1% European standard in place at the beginning of 1999, more than USD20 million were spent to modernise the distillation column and the storage system and to set up a vapour recovery system. Other examples of lasting HSE investment projects include a flame and gas system to protect a new process area for the production of ultra low-sulphur gasoline set up in March 2002. The application included detectors for flame, point gas, and \( \text{H}_2\text{S} \), as well as a new control panel.²⁶⁰ Besides, £60 million were spent on upgrading the site and in a safety simulator.²⁶¹ To minimise the amount of oil in the wastewater treatment plant effluent at the refinery, another project allowed to realise a three-fold reduction over six years. Initial progress was achieved through an “oil-buster campaign” targeting the control of oil released to refinery sewers. By minimising releases of process streams to the sewer system, oil in effluent water was cut from 20 ppm in 1991 to an average of 10 ppm between 1993 and 1995. A second phase of improvements led to redesign the system in order to remove more waste from process streams. In 1995, dissolved flotation units were installed to reduce the amount of oil ever reaching the biological section of the treatment plant. This section

²⁶¹ Source: http://wfcxweb.uk.texaco.com/ukwww/History.htm, accessed 09/05/02, last modified 20/12/01.
handles about 15 million litres of wastewater released every day from process units, usually containing ammonia, sulphides, phenols, traces of oil, and coming from the ballast water of ships and storm water containing suspended solid waste from roads and traces of oil. Treatment plant operating procedures were reviewed and additional operator training conducted. These initiatives allowed to routinely operate at monthly average levels of 4-8 ppm of oil in the effluent water and to target the 2002 European threshold of 5 ppm.

Finally, in July 2000, Texaco has announced a USD67 million investment to further upgrade the facilities of its refinery, and to manufacture fuel to EU 2005 standards\textsuperscript{262}. The project included a new SRU using licensed technology and was completed in 2001. According to Roland Kell, Director and General Manager of the plant\textsuperscript{263}:

"Essentially this work will increase our feedstock flexibility, positioning us to supply all of Texaco’s requirements for Ultra Low Sulphur Petrol (ULSP)\textsuperscript{264}, which in turn will be of benefit to the environment."

This win-win strategy underlines the role of the HSE regulatory system in changing oil refineries’ HSE behaviour.

Since both big and small HSE investment projects are undertaken by Texaco’s refineries to address HSE issues, the score of this routine component is +3. They reveal some persistence of investment decision-making processes aiming to address HSE issues in Texaco.

If we add up the scores obtained by all the components of this second routine property, we have a DR of +5.

**P\textsubscript{3} - The context dependence routine property (M\textsubscript{2}-Texaco)**

**CD of environmental actions**

The same remark made earlier for French refineries applies to Texaco, which is also subjected to EU regulations transposed into UK legislation. Consequently, investments dedicated to environmental compliance, which account for 75% of overall investments in the refinery, are now undertaken after an analysis of the state

\textsuperscript{262} Source: http://www.texaco.com, accessed 06/07/00.
\textsuperscript{263} Ibid.
\textsuperscript{264} The European Union specification for ULSP will reduce the sulphur content in fuel from its current level of 150 ppm to 50 ppm, and the percentage of aromatics from 42% to 35%.
and future evolution of the HSE legislation, and following negotiations with the Environment Agency. Argues Dave Harris:

“I think if we can demonstrate to them that the changes we have made are bringing about a significant reduction in, for example, benzene releases to air and, coupled with that, we can demonstrate that we are not having an impact on Air Quality Standards–then, clearly, they are going to be satisfied with our operation. But if they see that there is a problem, that maybe in 2005, 2010 that we are going to be running into problems if we do nothing– then it gives them the opportunity to identify future improvement conditions. A lot will be done by negotiation.”

Environmental investment projects are strongly driven by the requirements of the regulatory system. Consequently, this routine component is given a score of +2.

**CD of OHS actions**

As all European oil refineries, Texaco’s plant needs to meet EU Seveso directives and has to manage the risk related to the industry. This allows us to give a score of +2 to this component.

We obtain a score of +4 if we add up the scores of the four components of the third routine property.

**Table 71. Temporary DR of M2 for Texaco**

<table>
<thead>
<tr>
<th></th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2</td>
<td>+3</td>
<td>+5</td>
<td>+4</td>
</tr>
</tbody>
</table>

**CD of the DR**

As argued for the first routine property, the level of pressure of the English HSE regulatory system is high. Since according to the previous table the DR of the investment decision-making mechanism is strong, the second source of evidence of the context dependence routine property is given a score of +1, thereby increasing the score of P3 by one to +5.

<table>
<thead>
<tr>
<th>Level HSE Pressures</th>
<th>Weak</th>
<th>Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td></td>
<td>+1</td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

265 Source: Interview conducted by Steve Sorrell with the Environment Manager, op. cit.
The next table summarises the final results of the DR of the second HSE mechanism used by Texaco to address HSE issues.

**Table 72. Final DR of M\textsubscript{2} for Texaco**

<table>
<thead>
<tr>
<th></th>
<th>( P_1 ) Action vs. Representation</th>
<th>( P_2 ) Repetition &amp; persistence</th>
<th>( P_3 ) Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M\textsubscript{2}</td>
<td>+3</td>
<td>+5</td>
<td>+5</td>
</tr>
</tbody>
</table>

This table shows that the DR is very strong for all the routine properties, and thus that the mechanisms Texaco is using to carry out HSE investments are highly routinised and can be identified as investment decision-making routines (R\textsubscript{2}).

**Conoco**

\( P_1 \) - The action vs. representation routine property (M\textsubscript{2}-Conoco)

**Action**

The action carried out by investment decision-making processes is to undertake investment projects to improve firms’ HSE performance.

**Representation**

*Physical artefacts (standard operating procedures, tools, techniques, ...)*

The criterion used to appraise investment projects is the IRR, which as opposed to the instrument used by Texaco does include environmental costs\textsuperscript{266}. However, environmental issues are not placed on the same level of priority as safety issues, which are always tackled as soon as they are identified. However, argues G. Vickers, they are fully integrated in investment routines:

> “We will look at the standards and we have a set screening system for all projects, any changes to the process –I see every single minor mode, major project class A design that comes through the refinery. If it is a major project we are part of single project team –to provide the environmental resource and guidance. To give guidance as to what is the best standard, what should we be doing.”\textsuperscript{267}

However, it is interesting to notice that the criterion to buy an SRU technology was BATNEEC and not BAT, as the firm could have acquired a more efficient

\textsuperscript{266} Interview conducted by Steve Sorrell for the TEP project with Geoffrey Vickers, Environment Manager of the Humber refinery in 1999.

\textsuperscript{267} Ibid.
technology (99.98% sulphur recovery) but for twice the price. Benchmarking showed that competitors were doing less than Conoco in that respect, which stresses the influence of market conditions in the absence of regulatory constraints. Given that the tool to make investment decisions integrates an HSE criterion, the score of this component is +1.

Globally shared language forms (formalised oral codes, pledges, ...)
Environmental regulations are not seen as a threat to the firm’s competitiveness. On the contrary, argues Alan Green268, product specifications contribute to enhance the added value of products and to increase profits, as suggested by the win-win hypothesis. Since HSE investments are believed to be profit-enhancing in Conoco, the score of this component is +1.

Technologies
Organisational
The refinery is responsible for its investment plans for projects under €150 million. Beyond this limit, the decision is in the hands of the corporate board269. This shows that oil refineries have a large financial autonomy to undertake HSE investment projects. A score of +1 is attributed to this component.

Human
Since no evidence was found that finance managers were trained on HSE issues, the score of this component is 0.

Financial
Because the investment decision-making process is very decentralised in Conoco, the score of this component is +1.

When adding the scores of all the components of this first routine property, it appears that its DR is not very strong (+3). This suggest that the way the group addresses

268 SHE Manager European Region, interviewed on 4th March 2002, London.
269 Source: Ibid.
HSE issues by undertaking investments is not strongly routinised, even if routinised mechanisms do exist to enhance the HSE performance of Conoco using investment projects, such as organisational ones.

**P₂ - The repetition and persistence routine property (M₂-Conoco)**

**Planning of HSE investments**

The Humber refinery has spent £100 million on environmental improvements in the 1990s, in addition to a £10 million investment in a closed blowdown system for the coker plant to eliminate hydrocarbon vapour emissions.

| Table 73. Environmental investments of the Humber refinery |
|-------------|------|------|------|------|------|------|-------|---|
| Air quality improvement | 16.8 | 15 | 12.5 | 4.8 | 6 | 4 | 59.1 | 68% |
| Water quality improvement | 2.9 | 3.3 | 1.7 | 5.5 | 5 | 3 | 21.4 | 24% |
| Waste controls | 1 | 2.2 | 0.7 | 0.6 | 1 | 1.5 | 7 | 8% |
| **TOTAL** | **20.7** | **20.5** | **14.9** | **10.9** | **12** | **8.5** | **87.5** | **100%** |

Source: Conoco (1999: 12).

This data demonstrate a regular planning of HSE investments in Conoco, and allow us to give a score of +2 to this routine component.

**HSE investment projects**

They include an £8.5 million SRU, a £3 million electrostatic precipitator, a £12 million ETS, and a £5.5 million coke shiploader to reduce particulate emissions\(^{270}\). Dust was also reduced by the CHP\(^{271}\) plant and with a £1.5 million investment project in a coke warehouse.

Since both big and small HSE investment projects are undertaken by Conoco to address HSE issues, the score of this routine component is +3.

If we add up the scores obtained by all the components of this second routine property, we obtain a DR of +5. This indicates that HSE investment decision-making

\(^{270}\) In Conoco (1999: 12).

\(^{271}\) Centralised heat and power plant, a utility that produces energy for the refinery.
processes in Conoco’s refinery are persistent, highly routinised, and embedded in the firm’s daily operations.

**P3- The context dependence routine property (M2-Conoco)**

**CD of environmental actions**

Most investments aim to upgrade processes so as to meet product specifications, a stay-in-business strategy which can sometimes benefit from governmental subsidies. For example, the investment project carried out to produce ULS diesel fuel benefited from tax reductions. Also, the decision to set up a second SRU in 1994 aimed to reach a 99% efficiency and to avoid sulphur releases during the shutdown of SRU1 two or three times a week, as well as to avoid reaching peak legal thresholds. And if the decision was not mandatory when the investment decision was taken, the refinery would have had to do it anyway. The firm just anticipated this mandatory environmental requirement by using the latest technology (Super Claus, 99% efficiency compared to the 95% of SRU1) for a cost of between 8 and USD12 million. Finally, in Conoco (2000: 16) the firm argued that the decision to build a new unit to make cleaner fuels was prompted by tax incentives. Since investments represent USD3 per tonne of refining capacity in Conoco, including HSE specifications, government support to internalise pollution costs was a determining factor to undertake the project.

This suggests that environmental investment projects are strongly influenced by the requirements of the HSE regulatory system. Consequently, this routine component is given a score of +2.

**CD of OHS actions**

The UK HSE regulatory system had a strong impact on Conoco’s investment decisions aiming to undertake HSE projects, notably to meet the Seveso directives and to manage industrial risks. Thus this component is given a score of +2.

We obtain a score of +4 if we add up the scores of the four components of the third routine property.
Table 74. Temporary DR of M2 for Conoco

<table>
<thead>
<tr>
<th></th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2</td>
<td>+4</td>
<td>+5</td>
<td>+4</td>
</tr>
</tbody>
</table>

**CD of the DR**

As argued for the first routine property, the level of pressure of the English HSE regulatory system is high. Since according to the previous table the DRs of the investment decision-making mechanism are strong, the second source of evidence of the context dependence routine property is given a score of +1, thereby increasing the score of P3 by one to +5.

The next table summarises the final results of the DR of the first HSE mechanism used by Conoco.

Table 75. Final DR of M2 for Conoco

<table>
<thead>
<tr>
<th></th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2</td>
<td>+4</td>
<td>+5</td>
<td>+5</td>
</tr>
</tbody>
</table>

This table shows that the DR is very strong for all the routine properties, and thus that the mechanisms English oil refineries are using to carry out HSE investments are highly routinised and can be identified as investment decision-making routines (R2).

### 7.3.4 Input supply management in UK oil refineries (M3)

If in 1978 most of the crude oil imported in the UK was coming from the Middle East (71%), this share has decreased to reach 4% in 2001, whereas the share of European crudes has risen from 8% to 65%. This indicates a dramatic shift in the choice of input supplies from sour to sweet crudes. Apart from this general country

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272 Sweet crudes typically have a sulphur content of less than 0.5% and sour crudes of more than 2.5%. Cf. Sorrell (1998: 5). Current European SO2 emission limits of 1,700 ppm correspond to a fuel sulphur content of 1%. Cf. ENDS (1994: 9).
level data, no information could be collected at plant level\textsuperscript{273} for this mechanism, which DR could not be evaluated.

7.3.5 The HSE routines of English oil refineries

Finally for the HSE mechanisms used by the two studied UK oil refineries (Texaco and Conoco), the following table summarises their DR.

**Table 76. Summary of the degrees of routineness of the HSE mechanisms used by English oil refineries**

<table>
<thead>
<tr>
<th>HSE mechanisms</th>
<th>Routine properties</th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1 HSE management</td>
<td>Texaco</td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td></td>
<td>Conoco</td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td>M2 Investment decision-making</td>
<td>Texaco</td>
<td>+3</td>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td></td>
<td>Conoco</td>
<td>+4</td>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td>M3 Input supply management</td>
<td>Texaco</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>Conoco</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

As argued for French oil refineries, this table confirms that M1 and M2 can be identified as the HSE routines R\textsubscript{1} and R\textsubscript{2} described in the next two tables.

**Table 77. The HSE management routine of Texaco (R\textsubscript{1})**

<table>
<thead>
<tr>
<th>P1 Action vs. Representation</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action:</strong> Monitor and improve HSE performance</td>
<td></td>
</tr>
<tr>
<td><strong>Representation of the action</strong></td>
<td></td>
</tr>
<tr>
<td>+1: <em>Physical artefacts</em> (Low-NO\textsub{X}, burners, safety programme, incident reporting system, dissolved air flotation units, relations with local environmental groups, three-year demonstration project to implement sustainable biodiversity, corporate “SHE” system, process removing particulates, fence monitoring system)</td>
<td></td>
</tr>
<tr>
<td>+1: <em>Language forms</em> (beyond environmental compliance behaviour, saving lives and costs is also seen as a positive contributor to the firms’ image, API’s Guiding Environmental Principles, International Chamber of Commerce’s Business Charter for Sustainable Development, Environmental Guiding Principles of the Joint E&amp;P Forum/EUROPIA’s, Global Sullivan Principles for corporate social responsibility)</td>
<td>+5</td>
</tr>
<tr>
<td><strong>Routine technologies</strong></td>
<td></td>
</tr>
<tr>
<td>+1: <em>Organisational</em> (Environmental Adviser, SHE Department, Emergency Response Team)</td>
<td></td>
</tr>
<tr>
<td>+1: <em>Human</em> (environmental awareness programme)</td>
<td></td>
</tr>
<tr>
<td>+1: <em>Financial</em> (more than 75% of total investments)</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{273} We only know that the Conoco Humber refinery tends to use mostly low-sulphur crude in order to produce high-quality coke.
The representational forms allowing the first HSE routine to emerge and to persist are similar for Texaco and Conoco. Physical artefacts such as HSE management systems or environmental technologies such as low-NO\(_x\) burners were set up, and both firms have released official commitments to address HSE issues and have allocated resources to achieve them. Both companies collect and diffuse HSE data, although little to the public, and their HSE actions are very strongly influenced by HSE regulations. This illustrates the very strong routinisation if HSE mechanisms in the studied UK refineries, which can notably be explained by a strong HSE commitment spurred by stringent HSE regulation and by the allocation of resources to tackle HSE issues with a skilled labour force and powerful HSE institutions and management systems.
Table 78. The HSE management routine of Conoco (R1)

<table>
<thead>
<tr>
<th>P1 Action vs. Representation</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action</strong> Monitor and improve HSE performance</td>
<td></td>
</tr>
<tr>
<td>Representation of the action</td>
<td></td>
</tr>
<tr>
<td>+1: <em>Physical artefacts</em> (ISO 14.001, ultra-low NOx burners, vapour containment projects, Spectroside surveys, floating roof tanks)</td>
<td></td>
</tr>
<tr>
<td>+1: <em>Language forms</em> (company safety slogan, beyond compliance HSE behaviour)</td>
<td>+5</td>
</tr>
<tr>
<td>Routine technologies</td>
<td></td>
</tr>
<tr>
<td>+1: <em>Organisational</em> (“SH&amp;E” department)</td>
<td></td>
</tr>
<tr>
<td>+1: <em>Human</em> (awareness training is mandatory)</td>
<td></td>
</tr>
<tr>
<td>+1: <em>Financial</em> (USD134 million)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P2 Repetition &amp; persistence</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data collection</td>
<td></td>
</tr>
<tr>
<td>+2: <em>OHS data collected + at least two types of environmental data</em> (Conoco collects several types of HSE data on a regular basis)</td>
<td>+4</td>
</tr>
<tr>
<td>Data diffusion</td>
<td></td>
</tr>
<tr>
<td>+2: <em>Some HSE data diffused to public</em> (little HSE data was diffused)</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P3 Context dependence (CD)</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD of environmental actions</td>
<td></td>
</tr>
<tr>
<td>+2: <em>Strong</em> (HSE regulatory system + overall state of the business)</td>
<td></td>
</tr>
<tr>
<td>CD of OHS actions</td>
<td></td>
</tr>
<tr>
<td>+2: <em>Strong</em> (risk + Seveso)</td>
<td>+5</td>
</tr>
<tr>
<td>CD of the DR</td>
<td></td>
</tr>
<tr>
<td><strong>Level HSE Pressures</strong></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>DR</td>
<td>Weak</td>
</tr>
</tbody>
</table>

The second HSE routine is not as strongly embedded in the firms’ daily operations as the first one is, but the two UK refineries have allocated significant resources to make it work. Evidence of a lasting effect of the routinised use of investment decision-making processes to address HSE issues is found in the very high score obtained for the second routine property. The very strong influence of HSE regulation is confirmed with the very strong degree of routineness obtained for the third routine property, which highlights the impact of HSE regulatory systems on the HSE investments of English oil refineries.
### Table 79. The investment decision-making routine of Texaco (R2)

<table>
<thead>
<tr>
<th>P1</th>
<th>Action vs. Representation</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action:</strong> Invest to enhance HSE performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Representation of the action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Physical artefacts (standard cash flow analyses without HSE criteria, confirmed by the detailed study of the investment project used for P2)</td>
<td></td>
<td>+3</td>
</tr>
<tr>
<td>+1: Language forms (HSE issues embedded in the normal costs of doing business)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: Organisational</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Human</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: Financial</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>P2</strong></td>
<td>Repetition &amp; persistence</td>
<td></td>
</tr>
<tr>
<td>Planning of HSE investments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2: Regular HSE investment planning (for EU specs)</td>
<td></td>
<td>+5</td>
</tr>
<tr>
<td>HSE investment projects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+3: Big and small investment projects (flame and gas system, safety simulator, oil-buster campaign, dissolved flotation units, USD67 million upgrading, new SRU)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>P3</strong></td>
<td>Context dependence (CD)</td>
<td></td>
</tr>
<tr>
<td>CD of environmental actions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2: Strong</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD of OHS actions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2: Strong</td>
<td></td>
<td>+5</td>
</tr>
<tr>
<td>CD of the DR</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level HSE Pressures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>High</td>
<td></td>
</tr>
<tr>
<td>Weak</td>
<td>Strong</td>
<td>+1</td>
</tr>
</tbody>
</table>

### Table 80. The investment decision-making routine of Conoco (R2)

<table>
<thead>
<tr>
<th>P1</th>
<th>Action vs. Representation</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action:</strong> Invest to enhance HSE performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Representation of the action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: Physical artefacts (IRR that includes environmental costs)</td>
<td></td>
<td>+4</td>
</tr>
<tr>
<td>+1: Language forms (HSE investments are profit-enhancing)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: Organisational (large autonomy of €150 million)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Human</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: Financial (investment decision-making process is very decentralised)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
7.4 Summary

This chapter investigated the DR of the HSE mechanisms used by France and UK oil refineries to address HSE issues. The DR reveals for each HSE mechanism the extent to which it has the property of a routine. It is not a binary variable, and varies along a scale going from one to five by increasing degree of routineness. To obtain the results presented in the following table, a methodology was designed to apply the concept of routine to the study of firms’ HSE behaviour. It concludes that the HSE mechanisms used by French and UK oil refineries are highly routinised and identifies the use of the two HSE routines R₁ and R₂ in French and English oil refineries. It also points out the factors fostering the emergence of these routines in oil refineries. A lack of accessible data on the management of input supplies did not allow us to investigate the third HSE mechanism (M₃).
Table 81. The DR of the HSE mechanisms used by French and UK oil refineries

<table>
<thead>
<tr>
<th>HSE mechanisms</th>
<th>Routine properties</th>
<th>P₁ Action vs. Representation</th>
<th>P₂ Repetition &amp; persistence</th>
<th>P₃ Context dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>France</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M₁ HSE management</td>
<td></td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td>M₂ Investment</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>decision-making</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>UK</td>
<td></td>
<td></td>
</tr>
<tr>
<td>M₁ HSE management</td>
<td>Texaco</td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td></td>
<td>Conoco</td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td>M₂ Investment</td>
<td>Texaco</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>decision-making</td>
<td>Conoco</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

To conclude, all the DR of the HSE mechanisms of French and UK refineries are above 3, and more than one out of two reaches a level of 5. This reveals that the HSE mechanisms used by European oil refineries to address HSE issues are highly routinised, and thus that they can be identified as well founded HSE routines (R₁ and R₂). We can conclude that the studied European oil refineries are using HSE management routines and investment decision-making routines to address HSE issues. These mechanisms enhance firms’ HSE performance, and they are strongly influenced by the context in which they are developed, and notably by the HSE regulatory system of the country in which they operate. In the next chapter, the DR of the HSE mechanisms of Moroccan and Algerian oil refineries are investigated. In Chapter 9, the HSE routines that could identified in these firms are compared with the ones used in Europe in order to bring to the fore mechanisms that inhibit the improvement of the HSE performance of firms located in MPCs. Thereby, this thesis provides policy guidance about two key objectives of the EMP, the upgrading of HSE regulatory systems of MPCs and the HSE performance of their firms to European standards.

The next chapter applies the methodology used in this chapter to investigate the HSE behaviour of Algerian and Moroccan oil refineries.
Chapter 8: The HSE behaviour of Algerian and Moroccan oil refineries

8.1 Introduction
To identify the HSE routines used by these firms to address HSE issues, this chapter evaluates the DR of the HSE mechanisms used by oil refineries in Algeria (Section 8.2) and in Morocco (Section 8.3). The results of this empirical study are used in Chapter 9 to compare the HSE behaviour of oil refineries on both sides of the Mediterranean.

8.2 The HSE behaviour of oil refineries in Algeria
The degrees of routineness of the HSE mechanisms used by Algerian oil refineries are now evaluated, starting with the HSE management mechanism. At first, an introduction to the Algerian refining sector and to the national refining company Naftec is provided.

8.2.1 The refining sector in Algeria
The national refining company Sonatrach has for a long time been the single actor of the Algerian refining sector. In 1982, the refining activity and the oil product distribution were split to form the national enterprise of refining and oil product distribution (ERDP-Naftal). In 1988, the refining activity was separated from this entity to form the national oil refining company Naftec, which in April 1998 became a subsidiary of the holding group Sonatrach274. In 1999, Naftec was employing 3,817 people working in five refineries275.

274 100% owned by its refining and chemistry branch.
Table 82. Production capacities of Algerian oil refineries

<table>
<thead>
<tr>
<th>Type of refinery</th>
<th>Date *** Commissioned</th>
<th>Capacity (b/d) (% TOTAL)***</th>
<th>Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skikda*</td>
<td>Simple  1980</td>
<td>335,350 (70%)</td>
<td>UOP refining/SNAM Projetti</td>
</tr>
<tr>
<td>Arzew</td>
<td>Simple  1973 and 1984</td>
<td>56,240 (12%)</td>
<td>UOP refining and JGC</td>
</tr>
<tr>
<td>Hassi Messaoud *</td>
<td>Simple  1962 and 1979</td>
<td>23,750 (4.5%)</td>
<td>IFP</td>
</tr>
<tr>
<td>Algiers</td>
<td>Simple  1964</td>
<td>60,420 (12.5%)</td>
<td>TOTAL</td>
</tr>
<tr>
<td>In Amenas278</td>
<td>Simple  1980</td>
<td>7,000 (1%)</td>
<td>ELF</td>
</tr>
<tr>
<td></td>
<td><strong>TOTAL capacity</strong></td>
<td><strong>482,760 (100%)</strong></td>
<td></td>
</tr>
</tbody>
</table>

Sources:  * http://www.mbendi.co.za/real4.htm, modified: 26/06/00, accessed 12/04/01.  

Although production facilities allowed Skikda to export unleaded gasoline to Europe after the 1993 upgrading, Algerian petroleum facilities are relatively old. This explains why Skikda is the main exporter of the group, while other refineries mostly supply the domestic market, for which environmental and product requirements are less demanding than in Europe. As evidenced in the following table, 95% of the volume of refined products are motor fuels. In 1999, 14 million tonnes were exported and 53 million tonnes were used on the domestic market, which cars are still running on a 10 to 15% leaded gasoline.

Table 83. Production of Naftec in 1999

<table>
<thead>
<tr>
<th>Products</th>
<th>Amounts in tonnes</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>LPG</td>
<td>533,672</td>
<td>2.6</td>
</tr>
<tr>
<td>Motor fuels</td>
<td>19,526,763</td>
<td>95.4</td>
</tr>
<tr>
<td>Bitumen</td>
<td>186,608</td>
<td>0.9</td>
</tr>
<tr>
<td>Aromatics</td>
<td>111,965</td>
<td>0.6</td>
</tr>
<tr>
<td>Lubricants</td>
<td>110,843</td>
<td>0.5</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>20,469,851</strong></td>
<td><strong>100</strong></td>
</tr>
</tbody>
</table>

Source: Sonatrach (2000c).

276 Major extension in 1993, using the same technology.
277 Lubes 2 unit, in which the same technology used 11 years later after Lubes 1.
278 Closed in 1986, but to be upgraded in 2004.
8.2.2 HSE management in Algerian oil refineries (M₁)

P₁- The action vs. representation routine property (M₁-Naftec)

Action

The action aimed at by HSE management mechanisms is to monitor and to improve the HSE performance of the refinery, for example by setting up HSE management systems.

Representation

*Physical artefacts (standard operating procedures, tools, techniques, ...)*

There is no systematic pollutant inventory yet in Naftec, but the HSE department is working on the implementation of EIA procedures as well as on the setting up of the ISO 14.001 standard, the next step after the ISO 9.000 for the Standardisation and Quality Committee. Leaks are monitored through variations of pressures in the network, since there is no detection system. If pressure falls too much, the entire pipeline is closed and filled with water to spot the leaking piece where water shows through the surface. To prevent those leaks, approximately once every ten years sounding measures are taken to evaluate the thickness of the pipes every kilometre, and whenever a weakness is detected the old pipe section is replaced. However, this operation is rare because it obliges to lower the production of plants already running at more than 100% of their capacity.

To avoid serious pollution of Algiers’ ground water, Naftec monitors the level of underground pollution every day. Concerning water treatment, the refineries of Skikda and Arzew are equipped with three stages ETS (mechanical, physical chemical, biological). As for the refineries of Hassi Messaoud and Algiers, their ETS only have biological treatment. These techniques allow Naftec’s plants to comply with the national norm requiring a maximum hydrocarbon content of 20 ppm in

---

279 E.g., on 5th May 2001, 500,000 litres of gas oil leaked from an oil pipe coming out of the Skikda refinery. Naftal’s services noticed the leak at four o’clock in the morning when a pressure fall was recorded in the control room of a station near Constantine. Source: Algerian newspaper *Liberté*, 06/05/01.

280 The last one has been carried out in 1996.

281 111% for the topping unit in Arzew, 106% in Algiers, and 103% in Hassi Messaoud. Source: Interview with Mr Zerarka, op. cit. Productivity losses arising from such environmental or maintenance operations can thus hardly be caught up.

282 Source: ibid.
waste water\textsuperscript{283}. However, if one ETS breaks down, as it was the case in Arzew in April 2001, there is no alternative treatment system and water pollution can peak far beyond legal requirements. Other water management procedures include measurements of suspended matters (MES), such as biological oxygen demand, which are taken once every two weeks, or the extraction of hydrocarbons from residual oil and mud. Hydrocarbons are then mixed with the fuel stored in tanks and recovered, and the remaining is washed three times and converted into sand. As for solid waste such as mud, it is used as fuel, and leaded mud is mixed with concrete and transformed into paving stones or stored in barrels. Each production unit is responsible for its own waste, and dangerous waste such as spent catalyst is handled by catalyst providers during turnarounds. As for VOCs, Naftec applied for funding to the World Bank to set up a monitoring network in its refineries. No data is collected to monitor particulate matters, but the HSE manager argues that they are negligible.

To remove sulphur from distillates, an HDS unit was built in Skikda. For the moment, H₂S is burnt in incinerators, which air pollution is randomly measured once or twice a year. No data is available for NH₃, which is not considered an important factor of pollution, neither for C₃, C₄, and C₅ which are burnt, nor for benzene emissions. However, the quantity of benzene in refinery products is being measured\textsuperscript{284}.

Concerning basic safety means such as fire extinguishers, all refineries are equipped since the construction of the plant. The system of control is still working with a pneumatic technology, which needs to employ many people to be efficient enough and is thus subjected to human mistakes. Staff being overabundant\textsuperscript{285} in Naftec, this has not caused much problems. To upgrade the system, an assessment of refineries’ industrial safety was carried out. Priority needs have been identified, budgeted, and the HSE Department is monitoring their implementation through weekly reports drafted by refineries’ Environment units.

Although they are less technologically advanced than in European refineries, many physical artefacts are used by Naftec to store knowledge about how to monitor and to

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\textsuperscript{283} They are all rejecting 10 ppm, except Algiers (20-25 ppm), but waste water is also treated by the ETS of the capital.

\textsuperscript{284} Algerian gasoline now contains 2%, the norm being 1% for Eurosuper.

\textsuperscript{285} There might currently be 3 persons employed for 1 job in Arzew. Source: Interview with Mr Ilias, head of the Safety & prevention service, Arzew, 22/04/01.
improve its HSE performance. This allows us to attribute a score of +1 to this routine component.

Globally shared language forms (formalised oral codes, pledges, …)
Sonatrach’s website contains very little information about HSE issues. There is no other corporate environmental management in Sonatrach than to allow for the production of petroleum products which can be exported to the European market:

• Suppression of lead in gasoline (reduction to 0.40 g/l since 01/01/1999, to 0.15 g/l from 01/01/2002, and unleaded from 01/01/2005),
• Reduction of the sulphur content of diesel,
• Adaptation to new market requirements of the market concerning the quality of oil,
• Introduction of MTBE to produce Eurosuper 95 in 2000,
• Integration (in 2005) of an isomerisation unit to produce Eurosuper 95 which complies with European aromatics content requirements.

Concerning the HSE commitments of Naftec, it is argued in one of its reports that:

“Naftec is one of the companies that, today, is not only initiating policy to take in charge environmental problems but is seeking to put into practice all measures for risk control. Therefore, the main goal through this action is to develop within the company, a real culture of the environment that makes of every agent a heedful actor.”

Concerning air quality standards, Naftec claims to follow the international evolution of pollutant emissions and to be concerned with environmental protection and the improvement of air quality standards. In its journal, Sonatrach (2000b) brought

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286 Source: http://www.naftec-dz.com/our_main_assignments.htm, last modified: 24/05/00, accessed 20/05/03.
287 Algiers was ranked by the World Bank as one of the most polluted cities in the world. Unleaded gasoline has been available since 1998, but sales remain low as vehicles need to be fitted with catalytic converters. It was first introduced in January 1999 and now represents 50% of the market (400 million tonnes). Its development is constrained by the technological lock-in of Naftal’s distribution network, the cost of upgrading it to deliver unleaded being colossal.
288 New national specification is effective since May 1999 and reduces the lead content of gasoline from 0.65 g/l to 0.4 g/l, as mentioned in Sonatrach (2000c: 40).
289 Pipes are ready to supply it but the ongoing debate which started in California in 2000 about the risks of underground pollution due to this additive postponed it.
290 Source: http://www.naftec-dz.com/environment.htm, accessed 22/01/03, last modified: 03/12/02. This page is hardly ever modified.
forward the win-win strategies pursued by its Environment Department. In another issue, Sonatrach (1996) argued that “oil refiners look after green” and consider the environment as “a new field of growth”, suggesting that Algerian firms are also aware of win-win opportunities.

Although not very strong, there is some degree of HSE commitment in Naftec, which allows us to attribute a score of +1 to this routine component.

Technologies

Organisational

Each refinery has an industrial safety department, and environmental responsibilities are assigned to refineries’ Environment Units, which collect information for the HSE department in Algiers and send it weekly reports. But little resources are allocated to them compared to the amount of work to be done. For example, in the second biggest refinery in Arzew, staff is 1,300 and the Environment unit employs two people. Moreover, these units are very small and isolated in refineries’ organisational structures, which reflects the lack of commitment of top management and the fact that Naftec is a very centralised organisation. This is reflected in the lack of autonomy given to Environment units to carry out their own measures of pollution, since they need an authorisation to do so. The current HSE Department was launched in 1998, but only became a central department integrated in the corporate division “Safety, Health, Environment” in February 2000. However, its manager is not represented in any head office committee, but just holds weekly meetings with other central directors to present his achievements and to prepare future plans. Once a month, the same group meets with the directors of the refineries, during which refineries’ HSE reports are presented and the objectives of the HSE department are defended by the HSE manager, who often argues with refinery directors to impose his views. Nowadays, Health and Safety site commissions (one per refinery) are meeting four times per year and are in charge of following up health and safety policies on-site, supported by Environment units.

If on environmental matters the HSE Department is still in the process of creating procedures, structures, and of drawing up an inventory and statement of the state of

291 Source: Interview with Mr Belharbi, head of Arzew’s Environment unit, 22/04/01.
repair in all the refineries, OHS issues have been addressed by ad hoc structures for a long time. At first, there are continuous action plans such as the “Internal Operating Plan” or a small Orsec293 plan in the refinery. At the level of industrial zones, a “Mutual Assistance Pact” organises co-operation with seeks external support, for example in case of a fire. Also, a “Plan to fight pollution” sets the procedures and plans the equipment required if a major pollution occurs in the harbour. At the Unions level, there are two health and safety commissions, composed of representatives from management and workers. As opposed to Samir, which is a member of the GESIP294, Naftec does not belong to any professional association, which limits improvements by learning from others’ best practices and experiences. Concerning the means, extinguishers are checked on a regular basis, but there is no fire detection system in place yet. Prevention is probably the weakest point of Naftec’s OHS system, since only one refinery is equipped with a basic automatic detection system. Nevertheless, the system to detect smoke, fire, flame, and which transmits all this data is required by law and insurance companies. Consequently, an invitation to tender was published in April 2000 to set up this system in Arzew for a cost of AD20 million, following a formal threat by the Lloyds to refuse to insure the site295. But as mentioned earlier, the company has received too few applications, and the ones it got were inadequate. This illustrates the lack of competencies available in the country on specific monitoring and maintenance systems, which according to Sonatrach (1999) itself could foster technological improvement. Although there are weaknesses in the HSE management system of Naftec, the firm has started to set up permanent HSE procedures and other mechanisms artefacts to improve its HSE performance. This routine component is therefore given a score of +1.

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293 Abbreviation that means “ORganisation des SECours”, official measures set up for major civil emergencies in France. Needs to be approved by the wali (prefect).
294 Groupe d’Etude de Sécurité des industries pétrolières.
295 Source: Sehoul Gharbi, head of the “Centre de Prévention & de Protection”, OHS consultant working with Sonatrach, interviewed on 30th April 2001, Oran.
Human

Environmental personnel did not receive any specific environmental training, as opposed to OHS personnel. Indeed, health and safety training programmes are taught in several Algerian universities and institutes, but their curricula do not include environmental issues296. The latter are neither addressed by the new international institute created by Sonatrach in 2002 to carry out R&D and teaching activities for the whole group297. Therefore, for a long time training was limited to production topics such as computer science, technology, management, foreign languages, and most of it takes place in French institutes. In 1999, training was provided to 20,000 employees of Sonatrach, mostly to managers (49%) and foremen (40%), much less to workmen (11%). 96% of this training consisted in short term training (refresher courses), and the remaining in specialisation courses298. In 2000, AD8 million were spent to send 20 people per refinery and 10 from the head office to management training programmes.

Since there is no environmental training provided by Naftec, although the firm has a routinised OHS training programme that could integrate environmental issues, the score of this routine component is 0.

Financial

Financial resources are not a barrier to carry out HSE programmes, since in addition to its own resources, Sonatrach has access to international support. And as Charasse (2000: 24) notices, in 1999, 15% of the €8.1 million allotted by the French ministry of Foreign Affairs to train Sonatrach’s executives remained unused. But no stable environmental credit line was allocated by the Finance department yet. Since Naftec does not allocate a stable and important amount of money to address HSE issues, the score of this component is 0.

The DR of HSE management for the first routine property is not very strong in Naftec (+3), notably because environmental and OHS issues are not dealt with equivalent resources. The latter have been addressed by routinised procedures for a

296 Source: Interview with the director Mr Benbachir and Mr Hentit, respectively director and professor at the Algerian Institute of Petroleum (IAP), 1st May 2001, Oran.
297 In Sonatrach (1998).
long time, whereas environmental routines have been recently being set up. This is notably due to the pressure of European standards, which seem to be the main driver for environmental change in Naftec. However, a major step was taken by creating specific HSE organisational structures. Even if they lack power to enforce their policies and resources to achieve their objectives, they constitute an important step towards a strong routinisation of HSE management in Algerian oil refineries.

P2- The repetition and persistence routine property (M1-Naftec)

Data collection
HSE data is collected by Environment units and is only for internal use. The first two internal HSE reports were published in 1999 and in 2000. An in-house environmental management system is being set up to produce HSE data and information about standard operating procedures. This led to describe HSE actions to be carried out such as identifying a problem, how it can be solved, and follow-up procedures299. On the basis of these weekly reports sent by each refinery, a monthly report is produced and synthesised in an annual document diffused to the Board of directors, to refinery managers, to the Industrial safety department, and on request to the Ministry of the Environment and to the Ministry of Energy and Mining. Subcontractors such as the catalyst provider UOP are also informed about environmental issues. The two following tables summarise OHS data included in the first two internal HSE reports produced in Naftec.

Table 84. Evolution of safety data in Naftec (1993-2000)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Total number of accidents</td>
<td>377</td>
<td>351</td>
<td>378</td>
<td>430</td>
<td>280</td>
<td>362</td>
<td>251</td>
<td>297</td>
</tr>
<tr>
<td>Number of lost working days</td>
<td>1,947</td>
<td>14,471*</td>
<td>3,267</td>
<td>2,016</td>
<td>1,553</td>
<td>8,021</td>
<td>1,637</td>
<td>1,815</td>
</tr>
<tr>
<td>LWIF</td>
<td>27.84</td>
<td>31.83</td>
<td>31.30</td>
<td>32.60</td>
<td>22.18</td>
<td>25.81</td>
<td>17.76</td>
<td>15.3</td>
</tr>
<tr>
<td>TG</td>
<td>0.28</td>
<td>2.07</td>
<td>0.45</td>
<td>0.27</td>
<td>0.20</td>
<td>1.10</td>
<td>0.22</td>
<td>0.24</td>
</tr>
<tr>
<td>Number of hours worked</td>
<td>7,041,400</td>
<td>6,975,346</td>
<td>7,283,895</td>
<td>7,577,566</td>
<td>7,801,559</td>
<td>7,284,974</td>
<td>7,264,922</td>
<td>7,648,056</td>
</tr>
<tr>
<td>Average staff</td>
<td>4,044</td>
<td>3,965</td>
<td>4,078</td>
<td>4,037</td>
<td>4,007</td>
<td>3,804</td>
<td>3,818</td>
<td>3,757</td>
</tr>
</tbody>
</table>

Sources: Naftec (1999); Naftec (2000). * The fatality recorded this year accounted for 6,000 of lost working days.

299 Source: Naftec HSE department, unpublished documents.
Table 85. Naftec safety data per refinery (1999-2000)

<table>
<thead>
<tr>
<th></th>
<th>1999</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Distribution per unit</td>
<td>RA1K</td>
<td>RA1Z</td>
<td>RA1G</td>
<td>HO</td>
</tr>
<tr>
<td>Total number of accidents</td>
<td>130</td>
<td>63</td>
<td>52</td>
<td>6</td>
<td>251</td>
<td></td>
</tr>
<tr>
<td>Number of lost working days</td>
<td>883</td>
<td>437</td>
<td>285</td>
<td>32</td>
<td>1,637</td>
<td></td>
</tr>
<tr>
<td>LWIF</td>
<td>19.4</td>
<td>16.3</td>
<td>22.1</td>
<td>6.9</td>
<td>17.8</td>
<td></td>
</tr>
<tr>
<td>TG</td>
<td>0.33</td>
<td>0.14</td>
<td>0.25</td>
<td>0.07</td>
<td>0.22</td>
<td></td>
</tr>
<tr>
<td>Number of hours worked</td>
<td>2,631,736</td>
<td>3,068,224</td>
<td>1,128,481</td>
<td>436,481</td>
<td>7,264,922</td>
<td></td>
</tr>
<tr>
<td>Average number of staff</td>
<td>1,503</td>
<td>1,528</td>
<td>548</td>
<td>239</td>
<td>3,818</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>2000</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Distribution per unit</td>
<td>RA1K</td>
<td>RA1Z</td>
<td>RA1G</td>
<td>HO</td>
</tr>
<tr>
<td>Total number of accidents</td>
<td>179</td>
<td>61</td>
<td>50</td>
<td>7</td>
<td>297</td>
<td></td>
</tr>
<tr>
<td>Number of lost working days</td>
<td>706</td>
<td>447</td>
<td>652</td>
<td>10</td>
<td>1,815</td>
<td></td>
</tr>
<tr>
<td>LWIF</td>
<td>13.2</td>
<td>16.7</td>
<td>21.2</td>
<td>6.4</td>
<td>15.3</td>
<td></td>
</tr>
<tr>
<td>TG</td>
<td>0.23</td>
<td>0.15</td>
<td>0.6</td>
<td>0.02</td>
<td>0.24</td>
<td></td>
</tr>
<tr>
<td>Number of hours worked</td>
<td>3,105,902</td>
<td>2,992,128</td>
<td>1,083,470</td>
<td>466,556</td>
<td>7,648,056</td>
<td></td>
</tr>
<tr>
<td>Average number of staff</td>
<td>1,491</td>
<td>1,477</td>
<td>538</td>
<td>251</td>
<td>3,757</td>
<td></td>
</tr>
</tbody>
</table>


The LWIF has decreased to 15.3 since 1996, from levels that were similar to the ones reached by the Moroccan refinery in Sidi Kacem\textsuperscript{301}. However, this performance is far from European levels, which are about 4.5 on average in the industry\textsuperscript{302}. Data per refinery in 1999 and 2000 show that the highest LWIF is associated to the refinery of Algiers (RA1G), the oldest plant in the country after Hassi Messaoud. And this is despite the fact that this refinery is located near the head office and that the HSE manager inspects it every week\textsuperscript{303}. This points out a lack of routinisation of OHS procedures, which is confirmed by the next table. As underlined in Naftec (2000: 6), the main cause of accident are human factors in 54% of the cases. And in three cases out of four, motives for intervention are fires and leaks.

\textsuperscript{300} Respectively: refineries of Skikda, Arzew, Algiers, and Head Offices.
\textsuperscript{301} Cf. Section 8.3.
\textsuperscript{302} Source: Martin (2000: 3).
\textsuperscript{303} Source: Interview with Mr Zerarka, op. cit.
Table 86. Causes of OHS accidents in Naftec

<table>
<thead>
<tr>
<th>(%) TOTAL</th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beginning of fire</td>
<td>27</td>
<td>25</td>
<td>41</td>
</tr>
<tr>
<td>Leaks of products</td>
<td>52</td>
<td>45</td>
<td>38</td>
</tr>
<tr>
<td>Accidental product overflowing/spill</td>
<td>8</td>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>Emergency stopping</td>
<td>13</td>
<td>24</td>
<td>19</td>
</tr>
<tr>
<td>TOTAL (%)</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>TOTAL (number of accidents)</td>
<td>158</td>
<td>166</td>
<td>100</td>
</tr>
</tbody>
</table>

Sources: Naftec (1999) and Naftec (2000).

More detailed data reveal that the majority of these incidents occur in the refinery of Skikda, which is explained in the HSE reports by voltage drops of the SONELGAZ network, by ‘internal dysfunction’, and by a high level of product stocks. These three reasons are also given to justify the high number of emergency stopping in the plant. Therefore, the HSE department strongly recommends “to monitor the respect of the permits-to-work procedure”, which was also required for the second biggest refinery in Arzew. Such a reminder would not be necessary if these procedures were highly routinised.

HSE reports also analyse each type of risk, and actions to minimise them are appraised for all refineries. In the category “Prevention” were for example mentioned the regular inspection of pipes in all refineries\(^\text{304}\), the inquiry and analysis of the causes of work injuries in Arzew, and the setting up of a POI, a prevention plan, and an anti-pollution plan in Skikda.

The persistence of a firm’s HSE management is evaluated through the data it collects and diffuses. If no HSE data is diffused to the public in Naftec, it is produced in a detailed format for OHS issues, and a framework to collect environmental data is under construction following the initiative of the new HSE department. Thus, if OHS data tend to reveal the persistence of OHS management procedures, environmental ones are too recent to allow for such a conclusion. This lack of routinisation of HSE management in Naftec may explain the lack of diffusion of HSE data to the public.

\(^{304}\) This comment comes back every year, which points out a lack of routinisation of HSE management mechanisms in Algerian refineries.
Since OHS data are collected as well as several types of environmental data, a score of +2 is given to this component.

Data diffusion
Since collected data is only diffused in-house, the score of this component is +1. If we add up the scores of all the components of this second routine property, we reach a degree of routineness of +3, which is not very strong for the second routine property. This suggests that there is a basis on which the firm can build up to strengthen its HSE management mechanisms and increase their routinisation, for example by pursuing the setting up of a stable and strong HSE management system.

P3- The context dependence routine property (M1-Naftec)
CD of environmental actions
Assessing the DR of Naftec’s HSE management for this property implies to evaluate the magnitude of the influence of the Algerian HSE regulatory system on this HSE mechanism. The assessment of the first routine property pointed out that HSE representative forms in Naftec were unevenly developed for environmental and OHS representations of action, OHS mechanisms being more firmly set up than environmental ones. In Chapter 6, an unbalance was highlighted between the pressures exerted by OHS and environmental regulatory systems in Algeria, since the latter hardly exists. In the case of Naftec, weak environmental regulatory pressures go together with embryonic environmental management, and on the other hand the firm started to set up routines to meet environmental European specifications to export its products to the EU. Therefore, this routine component is given a score of +2.

CD of OHS actions
Since the pressures from the Algerian OHS regulatory system co-exist with a structured OHS system in Naftec, the score of this routine component is +2.

Before examining the second source of evidence the previous scores can be added up and summarised in the following temporary table.
Table 87. Temporary DR of M1 for Naftec

<table>
<thead>
<tr>
<th></th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>+3</td>
<td>+3</td>
<td>+4</td>
</tr>
</tbody>
</table>

CD of the DR

The analysis of the Algerian HSE regulatory system, summarised in Section 6.4, shows that its level of pressure is low, and the previous table shows that the DR of the HSE management mechanism is not very strong but not weak either (medium). Therefore, the second source of evidence of the context dependence routine property is given a score of 0 and the score of P3 does not change and remains at +4.

<table>
<thead>
<tr>
<th>Level HSE Pressures</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Weak</td>
</tr>
<tr>
<td>High</td>
<td>Strong</td>
</tr>
<tr>
<td></td>
<td>+0</td>
</tr>
</tbody>
</table>

The next table summarises the final results of the DR of the first HSE mechanism used by Algerian oil refineries.

Table 88. Final DR of M1 for Naftec

<table>
<thead>
<tr>
<th></th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>+5</td>
<td>+4</td>
<td>+4</td>
</tr>
</tbody>
</table>

This table shows that the DR is quite strong for all the routine properties, and thus that Algerian oil refineries started to set up routinised HSE mechanisms to address HSE issues, in spite of a lack of domestic regulatory incentive and of routines, such as the way profit-margins are fixed or the way spare parts are managed, that seem to inhibit the improvement of HSE performance. However, a regulatory incentive does exist in the place of European product specifications. Therefore, even if they are not very strong yet compared to the ones used by European oil refineries, the mechanisms Naftec uses to address HSE issues can be considered as HSE routines. In Chapter 9, a comparison with the HSE routines of Total will highlight differences with the ones of Naftec and allow us to suggest ways to strengthen them.
8.2.3 Investment decision-making processes in Algerian oil refineries (M₂)

P₁- The action vs. representation routine property (M₂-Naftec)

Action

The action carried out by investment decision-making processes is to undertake investment projects to improve firms’ HSE performance.

Representation

*Physical artefacts (standard operating procedures, tools, techniques, ...)*

Neither the Finance nor the Planning department integrate HSE issues in their investment decision-making process. This is notably due to the fact that Naftec’s profit margins are determined by the government. For example, until 1998\(^{305}\) gasoline prices were just covering labour and maintenance costs, and thus auto-consumption and losses were not taken into account by the parent company\(^{306}\). This has for a long time been a burden for Naftec, as it deterred productive and HSE investment.

In the refinery of Skikda, to recover liquid sprayed contents in flared gases, a project to recover LPG from fuel gas was carried out. According to Sonatrach’s policy diffused on the Internet, “the main objective is environmental protection and to take care of air quality”. In fact, for this project it is the argument to save fuel and therefore to increase sales that convinced the parent company, which is the final decision-maker for such investment projects. The absence of integration of HSE variables in financial tools to appraise investment projects is also reflected in the fact that the firm only uses the investment rate of return, which does not integrate such variables. Even the recent call to rehabilitate and operate the In-Amenas refinery, which was stopped in 1986 because of risks of earthquakes, mentions one “single economic parameter”\(^{307}\). It does not include any environmental commitment in the terms of reference, which are to:

- Rehabilitate process facilities and buildings (according to methods to be approved by Algerian regulatory authorities),
- Operate and maintain the refinery,
- Market the products.

\(^{305}\) According to Mr Zerarka, such ‘hidden’ costs account for 4 to 7% in the industry.

\(^{306}\) The cost of maintenance is high since most spare parts are imported, given the weakness of the technical skills of domestic maintenance companies.

\(^{307}\) Source: http://www.naftec-dz.com/appelse1.htm, accessed 05/02/02, last modified 22/10/01.
Since to appraise investment projects, only cash flow analyses are used, a score of 0 is given to this routine component.

Language forms
No commitment to invest in HSE issues was made by Naftec, therefore the score of this component is also 0.

Technologies
Organisational
Naftec’s oil refineries have some degree of autonomy to undertake investment projects, although much less than their European counterparts. The score of this property is +1.

Human
Since no evidence was found that finance managers are trained on HSE issues, the score of this component is 0.

Financial
Naftec’s investment decision-making process is composed of two circuits. The first one is centralised and manages investments higher than AD10 million (~ €150,000), and the second one is decentralised and concerns remaining projects.

Diagram 8. Investment decision-making process in Naftec

Source: Author’s own, from interview with Mr Zerarka, op. cit.
The investment plan is revised twice a year. Concerning decentralised projects, the Studies and Planning Department communicates the budget available for the year to the HSE Department, which decides how to use it in co-operation with the Finance Department.

The fact that all investment projects have to go through the Executive Committee indicates that the investment decision-making process is very centralised in Naftec. A score of 0 is thus given to this routine component.

When adding the scores of all the components of this first routine property, it appears that its DR is very weak (+1). This suggest that Naftec’s investment decision-making processes are not designed at all to tackle HSE issues, and thus that the investment decision-making mechanisms in place do not contribute to enhance its HSE-performance. On the contrary, the existing routinised mechanisms act as inhibiting routines deterring the improvement of HSE performance. As evidenced by Edmondson & al. (2001) in their study of routines in hospitals, setting up new routines could break old routines and contribute to improve HSE records. For example, finance managers could receive training on HSE issues and HSE criteria could be integrated in the rules used to appraise investment projects, as it is done in Conoco.

**P2- The repetition and persistence routine property (M2-Nafte)**

**Planning of HSE investments**

The following table reproduces investment budgets contained in the medium term plan of Naftec, which includes credit lines allocated to centralised HSE projects.

<table>
<thead>
<tr>
<th>(AD million)</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>Skikda</td>
<td>95</td>
<td>450</td>
<td>1,350</td>
<td>1,350</td>
<td>1,350</td>
</tr>
<tr>
<td>Arzew</td>
<td>135</td>
<td>188</td>
<td>798</td>
<td>675</td>
<td>225</td>
</tr>
<tr>
<td>Algiers</td>
<td>159</td>
<td>150</td>
<td>900</td>
<td>450</td>
<td>0</td>
</tr>
<tr>
<td>Hassi Messaoud</td>
<td>109</td>
<td>150</td>
<td>900</td>
<td>450</td>
<td>0</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>498</strong></td>
<td><strong>938</strong></td>
<td><strong>3,938</strong></td>
<td><strong>2,925</strong></td>
<td><strong>1,575</strong></td>
</tr>
</tbody>
</table>

As evidenced in the following table, these amounts are very small compared to the overall investments of Sonatrach, which are mostly allocated for exploration and production activities.

| Table 90. Evolution of Sonatrach’s investments (1997-1999) |
|---------------|-------------|-------------|-------------|
|               | 1997        | 1998        | 1999        |
| Sonatrach’s investments | 176,000     | 253,000     | 175,000     |


In spite of their weakness, there is a pattern of persistence of HSE investment projects in Naftec, even if what is put under the heading “HSE” can be questioned. They notably include the upgrading of facilities to international norms, the setting up of an isomerisation unit, the choice of a platinum catalyst to improve the octane number, the setting up of a remote detection project. The modification of instrumentation planned in 2002, which consisted in the transition from pneumatic monitoring to numeric is another example. It cost AD900 million for Skikda and the same amount for Arzew (~USD15 million). The initial impetus to the decision is clearly economic, but although it is not a specific environmental investment, it allows safer and more efficient production and has indirect impacts on HSE performance. Other planned investment projects concern product improvement. Among the ones in which the parent company Sonatrach is directly involved are the setting up of an isomerisation unit for naphtha to increase the octane number, and the construction of a catalytic cracker in Skikda, as well as an FCC, which complements the topping-reforming plant to process four million tonnes of good quality fuel, aromatics and bitumen.

To respond to pressures from international markets, Naftec seems to have a regular planning of its HSE investments. Therefore, the score of this routine component is +2.

HSE investment projects

No specific environmental investment project was undertaken before 1998. In addition to the absence of political commitment of top management, there is also the problem, as in Morocco, of the lack of expertise to tackle environmental issues. For

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308 As pointed out in Sonatrach (2001), in 2001 the firm made an international invitation to tender to acquire and bring on stream antipollution equipment.
example, in April 2000 Naftec made an invitation to tender to set up a detection system for gas leaks in Arzew, but did not get enough applications, and the ones it received were considered too expensive. The 1999 report also mentions the requirement to bring on stream a ‘BOD-meter’ to analyse liquid waste, which should have been installed since the inception of the waste treatment plant. At the beginning of 2001, a project was accepted for Skikda to recover flared gases coming from topping-reforming plants. Petroleum processes were modified to increase from 12 to 17% the content of naphtha, a product generating 20% of flared gases. Consequently, the quantity of light products in the distillation column increased, provoking clogging in the head of the column as well as smoke related to overmuch flaring of polluting light compounds. To solve this problem, refinery staff proposed to install two refrigeration modules for C3 and C4 compounds. An invitation to tender was made, and the project was brought on stream in April 2000 for a cost of USD8 million. It allowed Naftec to save 40,000 tonnes of LPG that was previously flared, generating cost savings valued to approximately USD2 million. To convince the board of Sonatrach that this project needed to be undertaken, the argument put forward by the HSE department was that such a measure will sooner or later be required by law, and that there was in the mean time an increasing public concern for the pollution generated by flaring. The Finance department stressed the fact that the project was not profitable, but the HSE department brought forward the gains arising from the recovery of LPG. However, since the price of LPG is set at a very low level by the Algerian government, the benefits of this recovery were not covering the costs of the environmental project. In the end, it was the mandatory argument that convinced the Finance department, suggesting that regulatory pressures can influence firms’ HSE behaviour in Algeria.

309 Beyond a certain (low) threshold set by the Board of directors, the HSE Department needs to find its own sources of funding. In this case, it was obtained from a European programme offering loans at advantageous interest rates. Source: Interview with Mr Zerarka, op. cit.
310 Indeed, the «Biological Oxygen Demand» is a key typical parameter to be measured when treating waste water. Cf. IPTS (2001: 93).
311 Source: Interview with Mr Zerarka, op. cit., and Naftec (1999) and Naftec (2000).
312 Indeed, hydrocarbon energy sources are subsidised as the government determines by decree the prices and margins of the products sold to Naftal. Thus, the firm is currently losing money on LPG, and gasoline is sold at production cost (~AD100 per tonne). This evaluation is very rough as the system of analytic accountancy is not very efficient, given that prices are publicly defined and not really based on production costs. Consequently, the distribution key is biased in order to cushion losses.
Since only small HSE investment projects are undertaken by Naftec to address HSE issues, the score of this routine component is +2.

If we add up the scores obtained by all the components of this second routine property, we obtain a DR of +4, suggesting that there is some degree of routineness in Naftec’s investment decision-making mechanisms that contribute to address HSE issues.

**P₃- The context dependence routine property (M₂-Naftec)**

**CD of environmental and OHS actions**

As demonstrated in Chapter 6, the Algerian HSE regulatory system exerts weak environmental and OHS pressures on domestic firms. In fact, the European regulatory system seems to exert a stronger pressure on Algerian firms than the Algerian system, notably through petroleum product specifications. For example, the setting up of a hydro-desulphurisation unit in Skikda to increase the octane number and to reduce the sulphur content of gas oil was clearly driven by the European 2005 product specifications. In this case the decision was taken by Sonatrach itself to meet EU standards. But the property tested here concerns the influence of national regulatory systems on the HSE behaviour of domestic firms. On this basis, the context dependence between the Algerian HSE regulatory system and Naftec’s environmental and OHS investment decision-making processes is weak. A score of +1 shall thus be given for each one of these two components. The DR of this property shall thus be rated at 2.

Before examining the second source of evidence the previous scores can be added up and summarised in the following temporary table.

**Table 91. Temporary DR of M₂ for Naftec**

<table>
<thead>
<tr>
<th></th>
<th>P₁</th>
<th>P₂</th>
<th>P₃</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₂</td>
<td>Action vs. Representation</td>
<td>Repetition &amp; persistence</td>
<td>Context dependence (CD)</td>
</tr>
<tr>
<td></td>
<td>+1</td>
<td>+4</td>
<td>+2</td>
</tr>
</tbody>
</table>

313 Sulphur content has decreased from 0,65 g/l in 1993 and from 0,53 in 1994 to 0,3 g/l in 2001, and should go down to 0,15 g/l in 2002 and be nil in 2005. In 2001 the national standard was 0,4 g/l. In 2003, an invitation to tender was made to upgrade the three refineries so as to meet EU product specifications. Cf. http://www.naftec-dz.com.
CD of the DR
The analysis of the Algerian HSE regulatory system, summarised in Section 6.4, shows that its level of pressure is low, and the previous table that the DR of the HSE management mechanism is generally weak. Therefore, the second source of evidence of the context dependence routine property is given a score of +1 and the score of P3 goes up to +3.

<table>
<thead>
<tr>
<th>Level HSE Pressures</th>
<th>Weak</th>
<th>Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR</td>
<td>+1</td>
<td>+1</td>
</tr>
</tbody>
</table>

The next table summarises the final results of the DR of the second HSE mechanism used by Algerian oil refineries.

**Table 92. Final DR of M2 for Naftec**

<table>
<thead>
<tr>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2</td>
<td>+1</td>
<td>+4</td>
</tr>
</tbody>
</table>

This table shows that the DR is not very strong for all the routine properties, and thus that the investment decision-making processes which Algerian oil refineries are using to address HSE issues are not strongly embedded in the firm’s routines. Nevertheless, there is some degree of HSE investment planning that could trigger a change in the firm’s investment decision-making routines. At present, they do not strongly contribute to enhance the HSE performance of Naftec’s oil refineries.

**8.2.4 Input supply management in Algerian oil refineries (M3)**

Sulphur does not seem to be a major concern for Naftec, since the sulphur content of its crude oil being very low. Besides, upstream crude wells are selected according to their sulphur content following a ‘segregation’ method. Consequently, the Algerian gasoline has a sulphur content of less than 10 ppm. Besides, national sources of energy supply is gradually switching to low-sulphur gas, which may modify the input supply routine towards a cleaner and cheaper input supply. But as argued for other refineries, it was not possible to collect plant-level data for this particular mechanism, which DR can thus not be evaluated.
8.2.5 The HSE routines of Algerian oil refineries

Finally for the HSE mechanisms used by Algerian oil refineries, the following table summarises their DR when data were available to evaluate them. It suggests that when weak HSE pressures are exerted on oil refineries, their HSE mechanisms are not very routinised, which tends to validate the context dependence routine property and to corroborate the assumption according to which firms are using routines to address HSE issues.

Table 93. Summary of the degrees of routineness of the HSE mechanisms used by Algerian oil refineries

<table>
<thead>
<tr>
<th>HSE mechanisms</th>
<th>Routine properties</th>
<th>P₁ Action vs. Representation</th>
<th>P₂ Repetition &amp; persistence</th>
<th>P₃ Context dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁ HSE management</td>
<td></td>
<td>+3</td>
<td>+3</td>
<td>+4</td>
</tr>
<tr>
<td>M₂ Investment decision-making</td>
<td></td>
<td>+1</td>
<td>+4</td>
<td>+3</td>
</tr>
<tr>
<td>M₃ Input supply management</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

To conclude, in spite of the weak pressures exerted by the Algerian HSE regulatory system, the HSE routines R₁ and R₂ are emerging in Naftec, as illustrated by the routinisation of the two HSE mechanisms used by Naftec. The following tables present these two routines in a tabled way, and below is explained what caused them to emerge and to persist³¹⁴.

Table 94. The HSE management routine of Naftec (R₁)

<table>
<thead>
<tr>
<th>P₁ Action vs. Representation</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Action</strong>: Monitor and improve HSE performance</td>
<td></td>
</tr>
<tr>
<td><strong>Representation of the action</strong></td>
<td></td>
</tr>
<tr>
<td>+1: Physical artefacts (EIA procedures and ISO 14.001 being put in place, leaks monitored with variations in network pressures, once every ten years sounding measures, monitor underground pollution, three stages ETS, measurement MES, HDS unit, benzene measured, fire extinguishers, pneumatic control system)</td>
<td>+3</td>
</tr>
<tr>
<td>+1: Language forms (follow international emission limits, win-win strategies)</td>
<td></td>
</tr>
<tr>
<td><strong>Routine technologies</strong></td>
<td></td>
</tr>
<tr>
<td>+1: Organisational (industrial safety department, refinery Environment units lacking autonomy, HSE Department hierarchically well integrated, Health and Safety site commissions, Internal Operating Plan, Mutual Assistance Pact, Unions health and safety commissions, Naftec does not belong to any professional association, extinguishers are checked on a regular basis, no fire detection system in place,</td>
<td></td>
</tr>
<tr>
<td>+0: Human (OHS training but no environmental one)</td>
<td></td>
</tr>
<tr>
<td>+0: Financial</td>
<td></td>
</tr>
</tbody>
</table>

³¹⁴ Mechanisms inhibiting HSE performance are underlined in the summary table of the HSE routines.
The HSE management routine is not very strong in Naftec. Efforts are being made to develop physical artefacts such as ISO standards to break existing routines that deter improvements in HSE performance. For example, the human detection of fire and flame could be replaced by a more advanced and reliable technology, which would integrate routine detection operations. However, in spite of these recent developments and declarations in favour of HSE issues, Naftec falls short of allocating adequate resources to strengthen these mechanisms. In this respect, there seems to be a tension between the role of European and international product standards fostering the setting up of new routines, and the role of the parent company, which concern for environmental issues is limited and rather focused on providing resources to the state’s budget. In conclusion for the first HSE routine, hopes for improvement in the development of HSE performance-enhancing routines lie in increasing external regulatory and market pressures for an improvement of Naftec’s HSE performance, which could be supported by increasing the stringency of domestic HSE regulatory systems, as stated in the Barcelona declaration of the EMP.
Table 95. The investment decision-making routine of Naftec (R2)

<table>
<thead>
<tr>
<th>P1</th>
<th>Action vs. Representation</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action: Invest to enhance HSE performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Representation of the action</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Physical artefacts</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Language forms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td>+1</td>
<td></td>
</tr>
<tr>
<td>+1: Organisational (some degree of financial autonomy: €150,000)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Human</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Financial (all investment projects have to go through the Executive Committee)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P2</th>
<th>Repetition &amp; persistence</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning of HSE investments</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2: Regular HSE investment planning</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSE investment projects</td>
<td>+4</td>
<td></td>
</tr>
<tr>
<td>+2: Small HSE investment projects (recover flared gases)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P3</th>
<th>Context dependence (CD)</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD of environmental actions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: Weak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD of OHS actions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: Weak</td>
<td></td>
<td></td>
</tr>
<tr>
<td>CD of the DR</td>
<td>+3</td>
<td></td>
</tr>
<tr>
<td>Level HSE Pressures</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>High</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DR</td>
<td>Weak</td>
<td>+1</td>
</tr>
<tr>
<td>Strong</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The second HSE routine is even weaker than the first one. The relatively strong score obtained for the second routine component contrasts with the near absence of routinised mechanisms to address HSE issues by carrying out investment projects. This suggests that HSE investment projects can be undertaken in Naftec, but that their emergence is not based on routinised mechanisms. Therefore, such projects are more a product of casual events than the result of a process embedded in the behaviour of the country. Finally, as opposed to the first HSE routine, the relatively weak context-dependence of this routine suggests that it might be difficult to change...
it by using external pressures. Therefore, internal sources of change such as HSE training programmes for finance managers might be more efficient to break old routines inhibiting improvements in HSE performance.

The next section investigates the DR of the HSE mechanisms used by Moroccan oil refineries to address HSE issues.

8.3 The HSE behaviour of oil refineries in Morocco

This section evaluates the DR of the HSE mechanisms used, or not, by Moroccan oil refineries to address HSE issues. It starts with an introduction to the refining sector in the Kingdom.

8.3.1 The refining sector in Morocco

Morocco has two oil refineries. The main one is located in Mohammedia on the Atlantic Coast north of Casablanca, and is a simple refinery. The second one is a smaller simple cracking refinery located inland in Sidi Kacem, near the royal city of Fès. They now have the same name315 and belong to the group Saudi Corral since their privatisation in 1998. The latter was supposed to foster HSE improvement in accordance with the HSE commitments of the Saudi-owned and Swedish-based group Corral Petroleum Holding AB. Indeed, in exchange for maintaining employment, improving infrastructures and reducing environmental emissions, Corral obtained a five years protection from imports. Five years later, refinery staff had nearly been halved, and the study for a promised USD600 million investment had been postponed to the beginning of 2001. In 1997, Samir made a net profit of MDH514 million316, which means that ceteris paribus the return on investment of the aforementioned project could have been achieved in seven years. In fact, it took less than five years317. This pace can notably be explained by the size of refinery margins, which have reached in 2000 the record level of USD3.55 per barrel318. Consequently,

315 Samir: “Société Anonyme Marocaine d’Industrie de Raffinage”.
316 Namely with the exchange rate of €1 for MDH10,2 some €50,4 million.
317 Source: Interview with Mr Yousfi, head of the Investment and Planning Department in the DSP, Mohammedia, 27/06/01. Sales have gone up by 23% between 1998 and 1999, generating a profit of DH975,6 million. Domestic market has expanded by 11% whereas exports have reached records to increase by 134% (in “La Samir dresse son bilan”, dispatch of L’Économiste, http://www.leconomiste.com, accessed 05/02/02, last modified 28/04/2000.
318 Source: Samir (2001: 3).
Net profits have increased by 56% to reach €133 million in 2000. Before 1995, prices and profits were set by the State, after which prices have been indexed on the Rotterdam market.

In 2000, national demand for petroleum products decreased by 7.2%, but the sector made up these losses by increasing its exports by 16%\(^{319}\). This suggests that an increasing number of products are meeting the standards of the European market, which receives the great bulk of Samir’s petroleum exports. The following two tables show that Samir is in a situation of monopoly on the Moroccan market.

### Table 96. Moroccan and Samir markets for petroleum products (1999-2000)

<table>
<thead>
<tr>
<th>Moroccan market for petroleum products ('000 tonnes)</th>
<th>Samir local market for petroleum products ('000 tonnes)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1999</strong></td>
<td><strong>2000</strong></td>
</tr>
<tr>
<td>Propane</td>
<td>96</td>
</tr>
<tr>
<td>Butane</td>
<td>1013</td>
</tr>
<tr>
<td>Four-star</td>
<td>329</td>
</tr>
<tr>
<td>Regular</td>
<td>80</td>
</tr>
<tr>
<td>Paraffin oil</td>
<td>98</td>
</tr>
<tr>
<td>Jet</td>
<td>286</td>
</tr>
<tr>
<td><strong>Gas oil</strong></td>
<td>2842</td>
</tr>
<tr>
<td><strong>Fuel</strong></td>
<td>1969</td>
</tr>
<tr>
<td>Lubricants</td>
<td>71</td>
</tr>
<tr>
<td>Bitumen</td>
<td>129</td>
</tr>
<tr>
<td>Paraffin</td>
<td>16</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>6930</td>
</tr>
</tbody>
</table>


### Table 97. Samir’s share of the national market (1999-2000)

<table>
<thead>
<tr>
<th>(%)</th>
<th>Propane</th>
<th>Butane</th>
<th>Four-star</th>
<th>Regular</th>
<th>Paraffin oil</th>
<th>Jet</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1999</strong></td>
<td>58</td>
<td>21</td>
<td>93</td>
<td>100</td>
<td>99</td>
<td>97</td>
</tr>
<tr>
<td><strong>2000</strong></td>
<td>51</td>
<td>19</td>
<td>93</td>
<td>100</td>
<td>95</td>
<td>99</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>(%)</th>
<th>Gas oil</th>
<th>Fuel</th>
<th>Lubricants</th>
<th>Bitumen</th>
<th>Paraffin</th>
<th>TOTAL</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>1999</strong></td>
<td>91</td>
<td>97</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td><strong>83</strong></td>
</tr>
<tr>
<td><strong>2000</strong></td>
<td>88</td>
<td>99</td>
<td>100</td>
<td>100</td>
<td>50</td>
<td><strong>81</strong></td>
</tr>
</tbody>
</table>


\(^{319}\) More than 22% of production is exported.
However, this position seems to be declining, and is put at risk by the end of the protection clause granted to Saudi Corral, even if Samir still contributes to 6% of the GDP and to 20% of the national industrial output. Finally, Morocco’s trade deficit increased by 40% between 1999 and 2000, notably because the oil bill rose by 65%. This strengthened the bargaining power of Samir, which is playing an important role in the reduction of this deficit.

Samir in Mohammedia

The Samir refinery in Mohammedia was built in 1959 and has a nominal distillation capacity of 6.25 million tonnes of crude oil per year\(^{320}\). This capacity remained unchanged since the end of the 1990s and represents 75% of Samir’s production.

<table>
<thead>
<tr>
<th>Table 98. Capacity of refinery units (1997, b/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude unit</td>
</tr>
<tr>
<td>Vacuum unit</td>
</tr>
<tr>
<td>Catalytic reformer</td>
</tr>
<tr>
<td>Distillate hydrotreater</td>
</tr>
<tr>
<td>Lubes production</td>
</tr>
<tr>
<td>Asphalt production</td>
</tr>
</tbody>
</table>


Samir supplies 100% of the domestic market of petroleum products, and exports basic oil and petrol, virgin naphtha and waxes. Petroleum processes used to make these products are listed in the table below, which shows that no major investment was made in the refinery over the past 17 years.

\(^{320}\) Source: Arad (2001, slide n° 5).
Table 99. History of the construction of the Samir Mohammedia refinery

<table>
<thead>
<tr>
<th>Name of the unit</th>
<th>Capacity</th>
<th>Constructor</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Main products units</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Topping 1 (atmospheric distillation)</td>
<td>1.5 Mt/an</td>
<td>Italy, SNAM Progetti</td>
<td>1960</td>
</tr>
<tr>
<td>Topping 2</td>
<td>1.25 Mt/an</td>
<td>France, Hydrocarbon engineering (HE)</td>
<td>1972</td>
</tr>
<tr>
<td>Platforming 1 (catalytic reforming)</td>
<td></td>
<td>Italy, Nitch</td>
<td></td>
</tr>
<tr>
<td>Topping 3</td>
<td>4 Mt/an</td>
<td>Procofrance + HE</td>
<td>1978</td>
</tr>
<tr>
<td>Platforming 2</td>
<td></td>
<td>USA, UCP</td>
<td>1978</td>
</tr>
<tr>
<td><strong>Units ‘oil complex’</strong></td>
<td></td>
<td>France, Technip</td>
<td>1984</td>
</tr>
</tbody>
</table>

Source: Interview with Mr Tahiri, head of the Investment and Planning Department, 24th June 2001, Mohammedia.

Samir in Sidi Kacem

The SCP (‘Société Chérifienne des Pétroles’) was created in 1929 for petroleum prospecting purposes. In 1940, a simple distillation unit with a capacity of 130,000 tonnes per year was added by the French company Elf to process the oilfields in the area.\(^{321}\)

Table 100. Capacity of refinery units in Sidi Kacem (1995, b/d)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Crude unit</td>
<td>25,600</td>
</tr>
<tr>
<td>Vacuum unit</td>
<td>7,400</td>
</tr>
<tr>
<td>Catalytic reformer</td>
<td>2,800</td>
</tr>
<tr>
<td>Catalytic hydrotreater</td>
<td>2,800</td>
</tr>
<tr>
<td>FCCU</td>
<td>5,600</td>
</tr>
</tbody>
</table>


\(^{321}\) They are now all exhausted.
Table 101. New units in Sidi Kacem

<table>
<thead>
<tr>
<th>Name of the new unit</th>
<th>Date of construction</th>
<th>Contractor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Topping 1</td>
<td>1965-66</td>
<td>Technip France</td>
</tr>
<tr>
<td>Topping 2</td>
<td>1972</td>
<td>Heurtey</td>
</tr>
<tr>
<td>Reforming 1</td>
<td>1972</td>
<td>Technip France</td>
</tr>
<tr>
<td>Reforming 2</td>
<td>1972</td>
<td>Heurtey</td>
</tr>
<tr>
<td>TCC</td>
<td>1953-54</td>
<td>Mobil</td>
</tr>
<tr>
<td>TCC revamping</td>
<td>1974</td>
<td>Mobil</td>
</tr>
<tr>
<td>TCC gas plant(^{322})</td>
<td>1981</td>
<td>Mobil</td>
</tr>
</tbody>
</table>

Source: Interview in Sidi Kacem with the Production manager Mr Zoubir, 03/07/01.

In 1995, a second revamping took place to increase the capacity by installing a ‘pre-flash’ unit to alleviate the refining process, already operating at more than 100% of its capacity, and to increase the production capacity in the unit. As for the catalytic thermocracking unit (TCC), it is one of the last unit of this kind operating in the world, and was already close to technological obsolescence in 1940\(^{323}\). It was not revamped since in spite of a project to do so but which was cancelled after the privatisation\(^{324}\). In 1994, there were 1,425 people working in the SCP, including 461 in Sidi Kacem. According to Mr Kodade, in 2001 staff of the former-SCP was 350\(^{325}\). Data provided by Ould El Hacen (1994) on the evolution of production between 1989 and 1991 confirms the increasing share of diesel in the refinery’s output (56% in 1991). This data also show that the production of diesel increases whereas overall production declines. Diesel fuel serves the domestic market and does not meet European standards, which sheds light on the strong context-dependence of Samir’s HSE behaviour.

\(^{322}\) Aimed to remove sulphur from LPG to be able to sell it on the European market.

\(^{323}\) As underlined in Freeman & Soete (1997: 98) TCC was, with the Houdriflow process, an improved version of the original fixed bed process. It rapidly declined after 1943, a year after the successful development of the fluidised bed technique by the Jersey Standard oil company, with the assistance of the MIT Chemical Engineering Department.

\(^{324}\) Source: Interview with Mr Abdelhafide Kodade, head of the division “Control”, 29th June 2001, Sidi Kacem.

\(^{325}\) Source: Interview with Mr Kodade, op. cit.
8.3.2 HSE management in Moroccan oil refineries (M₁)

P₁- The action vs. representation routine property (M₁-Samir)

**Action**

The action aimed at by HSE management mechanisms is to monitor and to improve the HSE performance of the refinery, notably by setting up HSE management systems.

**Representation**

*Physical artefacts (standard operating procedures, tools, techniques, ...)*

Even in Mohammedia, Samir’s biggest production site, environmental management amounts to process and water treatment (ETS), which consists in an API separator, a physiological and chemical treatment using coagulant and flocculent, a biological treatment, and a sludge extractor. The refinery is also equipped with 93 gas detectors on LPG spheres, pumps and compressors carrying LPG, LPG loading posts, gas compressors, electric sub-stations, and control rooms. 170 detectors of optical type monitor smoke in conditioning and storing rooms, in the blending area, in all the supplying general warehouse, in the archival storage room for technical documents, in electric sub-stations and technical vacuums of the units of fabrication of ‘grands produits’, and in the new blast proof control room. Interventions are regulated by a PPI (“Plan Particulier d’Intervention”), which organises co-operation with local authorities in case of emergency. It was successfully activated during the 2002 accident. Concerning health checks and safety, employees must attend an annual medical visit, and the occupational medicine department carries out with the safety department monthly analyses of the causes of accidents in order to improve OHS procedures. In spite of all the proposals made by health services, little progress has been achieved since 1997, except that since ten years the occupational medicine department could impose one vaccination per year against the flu for every member of staff.

According to Arad (2001, slide n° 28), water effluents generated by cooling sea water go back to the sea after control. Residual or oily waters (desalting of crude oil,

---

326 Source: Arad (2001, slide n° 41).
tank flushing out, …) are collected, stored in tanks, and treated by the ETS (slide n° 14). The refinery is equipped with one network per type of effluent, namely one for oily waters and one for process waters, sea cooling water, fresh and tempered water, and rainwater (slide n° 17). Ground pollution is monitored with 33 piezometric wells allowing a regular control of ground water (slide n° 41), and leaks are controlled “with personnel’s eyes”, automatic detection being too costly.328 Concerning solid waste, tonnes of barrels and scrap metal are stored on a waste land adjacent to the refinery, and are gradually sold or informally given up to metal merchants. Although their state of degradation seems to be monitored, rainwater may carry residual hydrocarbons to groundwater.

In Sidi Kacem, nothing is planned to improve environmental performance, whereas “concerning occupational health and safety, things are taken seriously”329. The Sidi Kacem refinery is equipped with floating roof tanks which have infrared fire detection, but only for the ones filled with crude oil. Butane spheres are also equipped with gas detection systems, which are also fitted to all gas units.330 On “hot points” (risky ones), sprinkling systems were set up in case of a fire. In 2000, the French institute INERIS carried out a HAZOP study and proposed means to reduce risk for a cost of one million Dirhams. Risk was evaluated by Associated Risk Managers Ltd., which recommended small investments such as databases and specific information sheets. But none of the two suggestions were implemented so far. Concerning emissions, H2S leaks can be detected, and the laboratory controls the smoke of the oven for carbon oxides in order to monitor energy consumption in furnaces, which shows that pollution is a mere indicator of industrial efficiency. Sulphur dioxide is not monitored, in spite of the fact that the refinery uses Arabian crude with a high-sulphur content (3.5%). Mud and other wastes are incinerated on-site, and although tetraethyl poses environmental problems, treacle is sent to cement works for incineration.

In Sidi Kacem the latest POI (“Plan Opération Interne”), which organises personnel training on data, mission, risky scenarios and examples of accidents in other refineries, dates back to 1994. As for propane cigars, they should have been

328 Source: Interview with Mr M’Haidra, Production manager, 28th June 2001, Mohammedia.
329 Ibid.
330 This is a mandatory requirement the Lloyds has managed to impose.
surrounded by an armoured wall as in all European refineries, but the project has
been dragging out for years in spite of the risk ran by houses illegally built too close
to the refinery. Butane spheres seem to be safely managed since they are stored
underground as in European firms. To test the reactivity of safety teams, every
Thursday “spot interventions” are organised. An accident is simulated and incidents
are reviewed and followed up by the refinery manager. The person in charge of
safety, who obtained an in-house fire diploma in 1994, inspects the site every
morning and evening. He writes monthly reports to the director and weekly reports to
the service on incidents. This shows that in spite of the age of the refinery, only
post OHS reporting is carried out and that safety monitoring is very basic.
As in Naftec, although they are less sophisticated than in European refineries, many
physical artefacts are used by Samir to store knowledge about how to monitor and to
improve its HSE performance. This allows us to attribute a score of +1 to this routine
component.

Globally shared language forms (formalised oral codes, pledges, …)
As in Sidi Kacem, there is no environmental strategy nor commitment in
Mohammedia. Health and safety management is more structured and procedures are
clearly identified, stored, and regularly updated. The head of Safety and Inspection
stated in an official document presenting his department that “given that the refinery
of Mohammedia is the main one in the country, safety is primordial”. Given the
lack of environmental commitment in Samir, the score of this component is 0.

Technologies
Organisational
In Mohammedia, the “Loss and Consumption Minimisation” service controls and
analyses the energy use of each process unit, as well as the refinery steam and power
generation in order to minimise energy consumption. The Industrial Safety
department is at the same level in the hierarchy as the Process and Environment

331 In case of fire, cigars go up in fusion. The refinery often protested against these illegal
constructions, but the local government was unable to forbid them.
332 Source: Interview with Mr Benn‘Barek, Safety clerk, 29th June 2001, Sidi Kacem.
333 Source: Arad (2001, slide n° 13). This can partly explain the embryonic state of the HSE system in
the small refinery of Sidi Kacem.
department and as the Production department, but it is much bigger than the former, since it employs 10 times as many people. Its main activities are to prevent accidents and to intervene when they occur, to supervise production so that they do not happen, and to improve safety management. The service “Valorisation” is in charge of maximising the yield of high-value products at the expense of low-value products, namely to maximise the upgrading potential, and the “Environmental Protection Service” supervises, controls and treats all refinery waste.

Even if they have limited power HSE structures do exist in Samir, which allows us to give a score of +1 to this routine component.

**Human**

The service “Protection of the Environment” in Sidi Kacem employs 18 people: the section head, its day to day assistant, and four teams composed of one boss and four operators. Their mission is to monitor aqueous effluents, as well as combustion processes to optimise energy consumption.

The refinery of Mohammedia has an annual training programme, which includes training periods abroad for executives at the INSPM or the CNPP. This training can benefit to other employees if top management is committed to diffusing the knowledge acquired outside the firm, for example on the HAZOP methodology. In April 2000, several department managers (director, maintenance, safety, production, …) took part in a training session in France organised by the Industrial Risk Directorate of INERIS about HAZOP. The case study concerned the furnace F101 from Unit 100 (atmospheric distillation) and aimed to lay down the bases of a proper maintenance system for the furnace and to point out the ‘hot points’ so as to control them. The study concluded that a risk of maximum gravity is probable, which should make INERIS requirements a top priority for the refinery. The latter included basic safety measures such as adding detectors to measure the pressure in several points of the furnace to inform directly the control room, to set up a flame detector equipped with a stopping control on the crude feeder pipe, or to install means to extinguish external fires such as sprinklers under burners. Prevention relies on a

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335 Source: ibid., slide n° 39.
336 Source: ibid., slide n° 40.
338 No concrete steps were taken following this exercise.
training programme any staff working in the refinery receives, including subcontractors and hauliers\textsuperscript{339}, but also on the diffusion of information updated regularly and filled with documents obtained from the GESIP. This allows the refinery to benefit, at least on safety issues, from the experience of other refiners, mostly Europeans, which share how they have solved and reacted to incidents and accidents. Following such exchanges, safety routines can be modified by collecting information to improve procedures. OHS mechanisms are well structured in Mohammedia, but much less in Sidi Kacem. Apart from waste treatment facilities, none of the two refineries are using structured mechanisms to address environmental issues.

Even if the human resources allocated by Samir to address environmental issues are infinitesimal, there is a basis on which the company could build to strengthen the contribution of this routine component to the HSE performance of Samir, for example by entitling the person responsible for the measurement of combustion in the furnace to measure other kinds of emissions such as SO\textsubscript{2} or NO\textsubscript{x}. Consequently, this routine component is given a score of +1.

\textit{Financial}

Since no evidence was found that finance managers were trained on HSE issues, the score of this component is 0.

As for Naftec, the DR of HSE management in Samir is not very strong (+3), because environmental and OHS issues are not given the same degree of priority. The latter have been addressed by routinised procedures for a long time, whereas environmental routines hardly exist yet. But as opposed to its Algerian counterpart, no proper environmental structure exists in Samir, which is reflected in the nil score of the language forms routine component and in the weaknesses of the artefacts routine component\textsuperscript{340}.

\textsuperscript{339} Every haulier has to be approved after having received training and passed a test.

\textsuperscript{340} Mechanisms inhibiting HSE performance are underlined in the summary table of the HSE routines.
P₂- The repetition and persistence routine property (M₁-Samir)

Data collection

At the end of the last decade, a report by the World Resources Institute (1998) stressed the degradation of the environment in the Kingdom of Morocco. The following table summarises its alarming figures.

Table 102. Evolution of atmospheric pollution in Morocco (1982-2020)

<table>
<thead>
<tr>
<th>Year</th>
<th>SO₂</th>
<th>NOₓ</th>
<th>MES*</th>
<th>Lead</th>
</tr>
</thead>
<tbody>
<tr>
<td>1982</td>
<td>129</td>
<td>5</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>1992</td>
<td>180</td>
<td>7</td>
<td>10</td>
<td>-</td>
</tr>
<tr>
<td>2005</td>
<td>301</td>
<td>12</td>
<td>17</td>
<td>-</td>
</tr>
<tr>
<td>2020</td>
<td>540</td>
<td>21</td>
<td>30</td>
<td>-</td>
</tr>
</tbody>
</table>


Oil refineries largely contribute to this degradation with their own emissions, as well as by producing gasoline with a high-sulphur content. The cost of this degradation was measured and is very high, which undermines the aforementioned argument about Morocco’ environmental slack brought forward by Samir’s environment manager.

Table 103. The cost of environmental degradation in Morocco

<table>
<thead>
<tr>
<th>Year 1992</th>
<th>Cost per year (billion Dirhams)</th>
<th>% GDP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water and waste</td>
<td>14.5</td>
<td>6.0</td>
</tr>
<tr>
<td>Air</td>
<td>4.5</td>
<td>1.9</td>
</tr>
<tr>
<td>Ground and natural environment</td>
<td>0.7</td>
<td>0.3</td>
</tr>
<tr>
<td>TOTAL</td>
<td>19.7</td>
<td>8.1</td>
</tr>
</tbody>
</table>

As opposed to Naftec, Samir did not have a web site until the 2002 accident and hardly communicated on environmental issues. Since then it has communicated on the causes of the blaze\textsuperscript{341} to reassure the public about safety and production issues. But no information was released on environmental issues. At the beginning of 2004, the website was updated to provide general information about the firm, including a vague section on the environment which does not contain any data\textsuperscript{342}. In Mohammedia, the person responsible for environmental issues makes casual presentations to reassure the local community as regards the refinery’s environmental impacts. For example, in June 2001 Mr Arad gave a speech to the local community concerning the invitation of Mohammedia’s town hall\textsuperscript{343}. He suggested that Samir was not damaging the environment because pollution should be considered on a regional level and not measured at its source. Once assumed this environmental slack, Samir allow itself to throw out smoke with a 3,500 ppm average sulphur content\textsuperscript{344} (regulatory limit is 1,700 ppm in Europe). Such a wait-and-see attitude illustrates Samir’s lack of concern for environmental issues. No environmental report is produced, but the following internal data could be collected on-site. This tends to confirm that European regulatory systems seem to have more influence on the HSE behaviour of North African oil refineries than their domestic regulatory systems.

\begin{table}[h]
\centering
\caption{Typical analyses carried out in Mohammedia (products’ pollution content)}
\begin{tabular}{|l|c|}
\hline
Hydrocarbons       & 12 mg/l      \\
Matters in suspension & 25 mg/l     \\
Chemical oxygen demand & 180 mg/l   \\
Biological oxygen demand & 55 mg/l    \\
Temperature       & 26°C         \\
pH                & 7            \\
Sulphur           & ? …*         \\
Phenol            & 0.2 mg/l     \\
Lead              & 0.01 mg/l**  \\
\hline
\end{tabular}
\end{table}

\textsuperscript{341} Cf. http://www.samir.ma.
\textsuperscript{342} As opposed to the section about tourism in Morocco which is much more developed.
\textsuperscript{343} Cf. Laraqui (2001, slide n° 38).
\textsuperscript{344} Source: Interview with Mr Arad, head of the division Process and Environment, Mohammedia, 27/06/01.

\textsuperscript{*} According to Mr Arad, before 1994: 50 ppm.
\textsuperscript{**} In his interview Mr Arad gave a different figure: 0,15 mg/l.
As for atmospheric pollution, according to Mr Arad, there are only “small quantities of sulphur, oxygen, nitrogen, etc.” But in his interview, the manager acknowledged that sulphur concentration out of the flare was 3,500 ppm, twice as much as what European standards were allowing at that time (1,700 ppm). The firm does not seem to be willing to reduce sulphur emissions, its argument being:

- We do not have the same levels of pollution as in Europe,
- We have to consider pollution on a local basis, not considering emissions coming out directly from the stacks or the flare.

This justifies the following statement:

“the control of air quality requires to model (with a specific software) the dispersion of pollutants in the air, taking into account fix and mobile measures, weather conditions, etc. Indeed, air quality depends on neighbouring areas (industrial sectors, road traffic, etc.), on the quality of carburation of vehicle engines (tuning, age, etc.), on the quality of fuels.”

As for reporting activities, the head of the laboratory acknowledged that the only measures he was carrying out were dealing with the monitoring of the efficiency of production processes. And if in 2001 water treatment seemed to be working properly, water quality data was not diffused to the public. A year later, the group revealed that the upgrading project was also aiming to provide a better treatment of waste waters of Mohammedia and to preserve the neighbouring sea waters. MDH50 million (€4.9 million) were to be invested, which shows that the quality of released waste water was not equal to water pollution challenges.

In Sidi Kacem, basic OHS data are collected, such as the Lost Workday Injury Frequency (LWIF) and the graveness rate (TG).

345 Source: Arad (2001, slide n° 33).
346 In Arad (2001, slide n° 40).
347 Smoke from furnaces are measured once or twice a week, and give on average 8 to 10% of CO₂, 3 to 5% of O₂, and no CO. Source: Interview with Mr Harmak, head of the refinery laboratory, 26th June 2001 Mohammedia.
348 Source: “Morocco boasts largest oil refining project in Africa and Europe”, op. cit.
349 TG = \( \frac{\text{number of lost days} \times 10^3}{\text{number of hours worked}} \). It is different from the Lost Workday Injury Severity (LWIS), which is the total number of days lost as a result of LWIs divided by the number of LWIs.
Table 105. OHS data in Sidi Kacem

<table>
<thead>
<tr>
<th></th>
<th>1998</th>
<th>1999</th>
<th>2000</th>
</tr>
</thead>
<tbody>
<tr>
<td>LWIF</td>
<td>30.51</td>
<td>29.5</td>
<td>27.31</td>
</tr>
<tr>
<td>TG</td>
<td>0.93</td>
<td>0.67</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Source: Interview with Mr Benm’Barek, head of the safety department, 3rd July 2001.

These data are much higher than the ones obtained for Mohammedia. According to the safety manager, an important qualitative change which does not appear in these figures is that incumbents are less subjected to incidents, whereas it is the opposite for subcontractors, which only receive a one or two days of training so that they can get the diploma required by insurers to work on-site. The director of production mentioned in his interview that there has never been any person burnt in the refinery. This contradicts with the interview carried out with a nurse from the infirmary who acknowledged that several people were seriously burnt each year, and that there has even been several fatalities. In Mohammedia, subcontractors also seem to increase risk exposure, as in one of the worst accidents 3 subcontractors were killed in the mid-1990s for having worked in a tank without observing safety measures.

Concerning OHS issues, as evidenced in the following tables OHS management mechanisms seem to have lasting effects in Mohammedia.

Table 106. Evolution of the number of incidents in Mohammedia per year (1989-2000)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>34</td>
<td>27</td>
<td>23</td>
<td>29</td>
<td>23</td>
<td>11</td>
<td>8</td>
<td>2</td>
<td>7</td>
<td>6</td>
<td>6</td>
<td></td>
</tr>
</tbody>
</table>


Table 107. Evolution of the frequency rate in Mohammedia per year (1989-2000)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>11.9</td>
<td>12.75</td>
<td>10.24</td>
<td>8.57</td>
<td>10.68</td>
<td>6.48</td>
<td>3.97</td>
<td>2.95</td>
<td>0.75</td>
<td>2.71</td>
<td>2.36</td>
<td>6.92</td>
<td></td>
</tr>
</tbody>
</table>


Safety on the production site did not seem to be very strict. While visiting the fire brigade with the head of the safety department, one of the agents came out smoking in an area where it was dangerous to do so and clearly forbidden (my host was not surprised). As opposed to Mohammedia, there are very few safety signs, notably in dangerous areas, which tends to confirm the lack of routinisation of OHS procedures in Sidi Kacem.
The year 1997 marks the beginning of an upsurge in the frequency and severity of the accidents measured.

**Table 108. OHS data in Mohammedia (1996-2000)**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>LWIF</td>
<td>4.31</td>
<td>1.09</td>
<td>2.75</td>
<td>6.63</td>
<td>10.69</td>
</tr>
<tr>
<td>TG</td>
<td>0.18</td>
<td>0.04</td>
<td>0.12</td>
<td>0.40</td>
<td>0.47</td>
</tr>
</tbody>
</table>


According to the HSE manager Mr Laraqui, this is notably due to a change in the rule of counting accidents imposed by Corral. These rates confirm the weakness of health and safety policies in Sidi Kacem compared to Mohammedia, maybe because the former employs more and more subcontractors in order to gain flexibility. The average LWIF between 1996 and 2000 is comparable (5.1) to the one found in European countries\(^{351}\), which is far from being the case in Sidi Kacem.

If many OHS data are collected, very few environmental data are monitored and air emissions are only used for production efficiency, which allows us to attribute a score of +1 to this component.

**Data diffusion**

There is no diffusion of HSE data to the public, neither by Sonatrach nor by Naftec. Since data is collected inside the plant the score of this component is +1.

If we add up the scores of all the components of this second routine property, we obtain a weak degree of routineness (+2). This indicates that although some HSE mechanisms exist they are not routinised enough so as to persist and contribute to improve the HSE performance of the plants, notably the environmental mechanisms. However, the way OHS issues are addressed in Mohammedia suggests that Samir is able to set up strong and stable routine mechanisms to tackle a complex issue. The routine technologies used for this purpose could therefore be used to set up environmental routines to bring up the weak environmental performance of the two refineries of the Moroccan company.

\(^{351}\) According to Concawe the average number for 1994 to 1998 is 4.5. Source: Martin (2000: 3).
P3- The context dependence routine property (M1-Samir)

CD of environmental actions

A new ETS was built in Mohammedia in 1994 for a cost of more than MDH30 million (€2.94 million) to comply with national norms and on the basis of European standards. It was upgraded in 1994 to meet the latest norms concerning liquid waste[^352], and comprises four phases: physical treatment, physic and chemical treatment, biological treatment, and mud treatment[^353]. As for routine maintenance, notably to avoid production losses, it is driven by the legislation, such as the one defining admitted leaks[^354]. Also, Samir mentions in its 2000 annual report that because of the Euro-Mediterranean Free Trade Agreement, measures will have to be taken to meet safety and environmental standards and norms “to anticipate the sustained growth of consumption”[^355]. This corroborates the influence of European HSE policies on the HSE behaviour of North African firms.

In spite of the weakness of the pressures exerted by the Moroccan HSE regulatory system, the few environmental measures taken by Samir are due to regulatory requirements. This indicates a strong context dependence and allows us to give a score of +2 to this routine component.

CD of OHS actions

The pressures exerted by the Moroccan OHS regulatory system co-exist with a structured OHS system in Samir oil refineries. Since a lack of environmental regulatory pressures goes together with a weak routinisation of HSE management, the score of this routine component is rated at +2.

Before examining the second source of evidence the previous scores can be added up and summarised in the following temporary table.

Table 109. Temporary DR of M1 for Samir

<table>
<thead>
<tr>
<th></th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M1</td>
<td>+3</td>
<td>+3</td>
<td>+4</td>
</tr>
</tbody>
</table>

[^352]: In Arad (2001, slide n° 18).
[^353]: Ibid., slides n° 19 to 24.
[^354]: Source: Interview with Mr M'Haidra, op. cit.
CD of the DR

The analysis of the Moroccan HSE regulatory system, summarised in Section 6.4, shows that its level of pressure is low, and the previous table shows that the DR of the HSE management mechanism is not very strong but not weak either (medium). Therefore, the second source of evidence of the context dependence routine property is given a nil score and the score of P3 does not change and remains at +4.

<table>
<thead>
<tr>
<th>Level HSE Pressures</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>Weak</td>
</tr>
<tr>
<td></td>
<td>Strong</td>
</tr>
<tr>
<td></td>
<td>+0</td>
</tr>
</tbody>
</table>

The next table summarises the final results of the DR of the first HSE mechanism used by Moroccan oil refineries.

Table 110. Final DR of M₁ for Samir

<table>
<thead>
<tr>
<th></th>
<th>P₁ Action vs. Representation</th>
<th>P₂ Repetition &amp; persistence</th>
<th>P₃ Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁</td>
<td>+3</td>
<td>+2</td>
<td>+4</td>
</tr>
</tbody>
</table>

This table shows that the DR of Samir’s HSE mechanisms is not very strong, even if the few HSE actions undertaken seem to persist. This suggests that even if Moroccan oil refineries have started to set up routinised mechanisms to address HSE issues, they are not yet strongly embedded in Samir’s behaviour. This could be changed by breaking old routines that deter the improvement of environmental performance, such as the lack of environmental responsibilities of the HSE department or the lack of environmental knowledge of workers due to an absence of training and awareness. This could be achieved in Samir since the firm managed to set up efficient routines to address an issue as complex as occupational health and safety. The current increase in the level of pressure exerted by the domestic environmental regulatory system may foster such a sustainable change.
8.3.3 Investment decision-making processes in Moroccan oil refineries (M2)

P1- The action vs. representation routine property (M2-Samir)

Action

The action carried out by investment decision-making processes is to undertake investment projects to improve firms’ HSE performance.

Representation

*Physical artefacts (standard operating procedures, tools, techniques, ...)*

In Mohammedia, the promoter of an investment project needs to specify the criteria used to appraise it\(^{356}\), including environmental ones. The DSP can also correct the cost of purchase, and is therefore able to integrate HSE costs if they are not mentioned or if they are underestimated. No evidence was found that any of these latter two options was ever used. Finally, a synthetic presentation is given to the Budget Committee. Notwithstanding, investments concerning safety are seldom questioned and are not evaluated on purely economic grounds. As for the absence of environmental criteria in the investment decision-making process, it is justified by the fact that it is not possible to attach an economic value to it, and the only method used is the pay back period\(^{357}\). This has notably led to a MDH10 million investment to set up a computer aided maintenance system. According to the head of the Maintenance department, demands for repair generally come from the department itself, never from the Environment department\(^{358}\). According to Mr Baroual, who manages the Service Equipment\(^{359}\), the maintenance manager is responsible for investments greater than 50,000 Dirhams, which in theory leaves some degree of autonomy to carry out process modifications. He also mentioned that provided that as long as a leak was not damaging production performances, no maintenance was carried out until a more urgent intervention was required, because of the costs incurred with stopping a machine.

Because to appraise investment projects, only pay back methods which do not integrate HSE criteria are used, a score of 0 is given to this routine component.

\(^{356}\) E.g. “Regulation”, “Strategy”, or “Competitiveness”.

\(^{357}\) Source: Interview with Mr Yousfi, op. cit.

\(^{358}\) Source: Interview with Mr Gajjaoui, head of the Maintenance Department, Mohammedia, 26/06/01.

\(^{359}\) Interviewed in Mohammedia on 26/06/01.
Globally shared language forms (formalised oral codes, pledges, ...)

The following incident illustrates Samir’s lack of commitment towards environmental issues. In November 2002, an oil leakage was reported on a 140 meter-long pipeline linking Sidi Kacem to Mohammedia. At the end of 2002, the group started works to replace the leaking section, as well as operations to clean and to collect oil residues which infiltrated water conveyance and disposal channels (some 1,400 tonnes of oil were collected). Following this incident, the group decided to concede from January 2003 the control of the pipeline to a German company that was in charge of cleaning up the area.

The absence of environmental commitment is coherent with this lack of concern for environmental issues. Thus, a score of 0 is given to this component.

Technologies

Organisational

Five years after the privatisation, the investment decision-making process is still very centralised in Samir. It starts with an inquiry of the department Strategy and Planning (DSP) about the needs of the various branches of the company. All the projects are reported to the DSP, which centralises all the budgets elaborated by other services (Sales, Finance, Human Resources, Refinery), in accordance with the strategic plan of the refinery. It contains the origin and the nature of the project, its amount and duration, its justification, but also its economic rate of return, indicator that does not take HSE costs into account unless the decision-maker subjectively increases the payback period or decreases the rate of return. The following diagram as well as the criteria used to appraise investment projects show that the division in charge of HSE issues is never consulted, which confirms that they are not integrated into Samir’s investment decision-making processes.

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363 The procedure to implement and follow up the annual budget of investment is defined in the Memorandum n°2342 of 12th December 2000, unpublished document. It applies to the two references.
Investment projects over MDH10 million (~ €1 million) fall into a specific category and originate in the production department and its sub-components, which since 2000 pass them on to the refinery management after having consulted the DSP. Projects under MDH10 million are decentralised in the hands of refinery and department managers.

Since Samir refineries have an important financial autonomy when undertaking investment projects, a score of +1 is given to this component.

**Human**

No evidence was found that finance managers are trained on HSE issues, which allows us to give a score of 0 to this routine component.

**Financial**

As evidenced in the above diagram, all investment projects have to go through the central division DSP and are approved by the board of directors, is the main
investment projects have to go through the Executive Committee. Given this limited decentralisation, a score of 0 is given to this component.

Finally for this routine property, the weak DR of +1 obtained tends to show that although the investment decision-making process is well structured in Samir, HSE issues are not embedded yet in investment decision-making routines. This finding is consistent with the lack of HSE commitments of the firm, which HSE behaviour is not spurred by the low pressures exerted by the domestic HSE regulatory system. However, because the European market is a key outlet for Moroccan refineries, product specifications could be a strong incentive to launch investment projects aiming to address environmental issues in the Kingdom. A study recently carried out by Foster Wheeler364 for the undertaking of a $700 million development project puts forward that environmental issues were taken into account in this project, notably to produce diesel fuel that meets the 2005 EU product specifications.

P2- The repetition and persistence routine property (M2-Samir)

Planning of HSE investments

The following table shows the evolution of overall investment in Samir. It does not contain any HSE project.

Table 111. Investment programmes in Mohammedia (1997-2000)

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>TOTAL</strong></td>
<td>76</td>
<td>21</td>
<td>45</td>
<td>85</td>
<td>142</td>
</tr>
<tr>
<td><strong>CT</strong> 365</td>
<td>30</td>
<td>9</td>
<td>18</td>
<td>9.5</td>
<td>9</td>
</tr>
<tr>
<td><strong>ST</strong> 366</td>
<td>46</td>
<td>11</td>
<td>27</td>
<td>56</td>
<td>86</td>
</tr>
<tr>
<td><strong>DI</strong> 367</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>19.5</td>
<td>47</td>
</tr>
</tbody>
</table>

Source: Interview with Mr Benbachir, head Division Strategy and Planning (DSP), 28th June 2001.

We can see that the year following the privatisation, investments fell dramatically. Only in 2000 did they recover their level of 1997. They eventually doubled in 2001, notably because of strategic investments preparing the upgrading project described.

365 «Common investments» entail a quick procedure.
366 «Substitution investments» are made on the basis of an inspection report which gives the history of the machinery.
367 Distinctive investments: singles out key important projects. Category created in 2000.
below. Other environmental investments include the purchase of a skimmer pump to recover floating hydrocarbons, and a study to measure the pollution of ground water, which cost MDH1 million and led to the construction of various piezometric wells. This suggests that although Samir does have a routinised investment decision-making process, it does not have a regular planning of HSE investments, therefore which are occasionally undertaken. This allows us to give a score of +1 to this routine component.

**HSE investment projects**

The refinery of Sidi Kacem is equipped with a sour water stripper, and at the time of the interview it was about to build an ETS. According to Mr Kodade in charge of environmental issues, this is because “norms are becoming serious”. The construction started at the beginning of the year 2000 and finished in November 2001, for a capacity of treatment of 50 m³ and a cost of MDH30 million (~€2.94 million). Before this investment, effluent treatment amounted to a mere decanting and recovering of hydrocarbons. The rest was thrown out into the nearest wadi (river), which given the rarity and the cost of water in this dry region led to recurrent and vehement population protests. Since 1998, condensate containing sulphur is stripped and desalted, which does not require heavy investments. In 1995, the Sidi Kacem refinery invested in a pre-flash unit placed before the topping 1 unit in order to alleviate it and to recover more light products. At the beginning of 2002, if the refinery does not close before to remain a mere stoking site, there should be a major revamping of every unit including a shift from pneumatic to centralised control with a new control room. But the 2002 accident re-launched the activity of the refinery until damaged units were repaired in Mohammedia and postponed these projects. Hardly any HSE investments were undertaken in this old refinery. Apart from an ETS project, the main investment project aimed to increase production efficiency by installing the pre-flash unit. The study for this project was carried out

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368 Source: Interview in Sidi Kacem, op. cit. (Sic.)
369 This unit is always working overcapacity, i.e. at 107%, as it produces 1.6 Mt for a theoretical capacity of 1.5 Mt. This implies that production can hardly be stopped for minor maintenance, as there is no productivity slack allowing to make up for production losses.
370 According to Mr Kodade, interview in Sidi Kacem, op. cit.
371 Source: Interview with Miss Lamsari, op. cit.
by the French firm Sofresit, which also installed the process and prepared the procedures for the starting phase, left in the hands of local staff. A manual was designed to store all the information about safety measures and the functioning of this new process. The pre-flash unit was tested once with the French team during three consecutive days and nights, after which the local team was able to work on its own. Production capacity was improved by nearly 10%.

Since only small HSE investment projects were undertaken by Samir to address HSE issues, the score of this routine component is +2.

If we add up the scores obtained by all the components of this second routine property, we obtain a DR of +3, which suggests that HSE issues are not strongly embedded in a routinised investment decision-making process, and so that few HSE projects are undertaken and persist over time. Two main conclusions can be drawn from the aforementioned investment project. At first, if a foreign firm is called for technological expertise, Samir is able to absorb the knowledge required to run the process autonomously, which shows that it has the capabilities to acquire new knowledge and technology. Environmental improvements could be achieved through simple incremental improvements, but there are little in-house or external incentives to do so. The current tightening of environmental regulation in the Kingdom might bring about sustainable changes in Samir’s HSE behaviour.

**P3- The context dependence routine property (M2-Samir)**

**CD of environmental and OHS actions**

As the following table shows, fuel oil is the main output of the refinery.
Table 112. Fuel oil: the main output of Moroccan oil refineries

<table>
<thead>
<tr>
<th></th>
<th>PRODUCTION (‘000 tonnes)</th>
<th>PRODUCTION (% TOTAL)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1998</td>
<td>1999*</td>
</tr>
<tr>
<td>Two-star</td>
<td>72.8</td>
<td>82.0</td>
</tr>
<tr>
<td>Super</td>
<td>280.9</td>
<td>308.6</td>
</tr>
<tr>
<td>Diesel</td>
<td>2,235.7</td>
<td>2,539.3</td>
</tr>
<tr>
<td>Paraffin</td>
<td>79.3</td>
<td>96.3</td>
</tr>
<tr>
<td>Jet fuel</td>
<td>272</td>
<td>279.1</td>
</tr>
<tr>
<td><strong>Fuel oil</strong></td>
<td><strong>1,917.9</strong></td>
<td><strong>2,507.6</strong></td>
</tr>
<tr>
<td>Butane</td>
<td>184.5</td>
<td>212.9</td>
</tr>
<tr>
<td>Propane</td>
<td>67.1</td>
<td>54.5</td>
</tr>
<tr>
<td>Naphtha</td>
<td>385.2</td>
<td>506.6</td>
</tr>
<tr>
<td>Paraffin wax</td>
<td>15.8</td>
<td>7.6</td>
</tr>
<tr>
<td>Oils</td>
<td>118.5</td>
<td>116</td>
</tr>
<tr>
<td>Bitumen</td>
<td>125.1</td>
<td>141.1</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>5,754.8</strong></td>
<td><strong>6,851.6</strong></td>
</tr>
</tbody>
</table>


* provisional or estimated

To diversify its production towards higher valued added products, Samir launched an investment upgrading project in Mohammedia. This strategic project cannot be considered as being the output of a routinised investment decision-making process, but is worth studying because the technologies it will generate are likely to persist and can therefore be considered as routines. Also, because some of their procedures are routines, like search processes for example, the underlying logic can shed light on Samir’s HSE behaviour. This major project aims to valorise fuel oil and to extract more value from the product, but also to meet the 2005 European requirements for sulphur content (50 ppm)\(^{372}\). It is estimated to cost MDH6 billion (€588 million) and is the core of a strategic plan meant to tap local demand for oil products by 2010 by increasing the refining capacity to 2 million tonnes\(^{373}\). The project also seeks to increase the operational flexibility of Moroccan refining plants, to face up international competitiveness, to improve their profitability, and to promote


\(^{373}\) Source: Giovannini & Dolladille (2000).
partnerships with distributors. New units were initially scheduled to start operating at the end of 2004. Was it not for the accident, to anticipate increasing environmental pressures and demand for low-sulphur fuels on the Moroccan market, works should have started in October 2002. They should have replaced the old HDS units (built in 1978, one per topping unit) with a new one supported by public subsidies. According to the production manager, within three years the sulphur content of diesel was to be divided by two.

In the Saudi Arabian newspaper *El Hayat*, the former CEO A.R. Manjour declared that the project would be 50% financed with its own resources and the rest with a USD300 million loan borrowed on international financial markets. The new CEO Abderrahmane Saaïdi declared that the firm needed to “adopt a new way of thinking” and to “shift to a more commercial vision”, as well as to “invest in new norms which are much more stringent otherwise it will shut down.” This “new vision”, which was adopted on the basis of an external consultancy study, does not encompass environmental issues except for product specifications. In 1997, the consultancy Pervil Engers London published the results of their three year study made of 18 scenarios, out of which one case was chosen by Corral. Mr Yousfi from the DSP declared in his interview that this study used environmental criteria in addition to classic market criteria to appraise the project. He also underlined that the Euro-Mediterranean Partnership has a very strong impact on production changes in the refinery, notably through product specifications. But the project had to be postponed again because of a major accident which occurred on 23rd November 2002 and seriously damaged the plant in Mohammedia:

> “Samir general manager said losses are ‘considerable’ and according to first estimates amount to USD150 million, not counting management-linked losses. He also deplored the death of two employees in the fire.”

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374 Source: Interview with Mr M’Haidra, op. cit.
376 Source: “Samir : 12 milliards de DH pour changer de raffinerie”, *L’Économiste*, http://www.leconomiste.com, 05/02/02.
We argued that safety policy and management have always been seriously addressed by Samir, but it could not plan that the absence of environmental management and of a proper maintenance coupled with a natural catastrophe was going to destroy a great part of the plant:

“The refinery’s production was brought to a halt Monday at 4:00 p.m. following flash floods that hit Mohammedia, the source said, adding that despite this preventive measure, floodwaters have caused residual hydrocarbons to get in contact with the refinery’s hot parts and caused fire to break out.”

As a consequence, human and economic costs exceed by far the costs saved on environmental management, which should have controlled the leak of residual hydrocarbons even if SAMIR was 96% insured against risks. Besides, the upgrading project was postponed.

The upgrading project is a strategic investment and was spurred by European regulatory standards. Apart from water management, very little evidence could be gathered about environmental or OHS actions spurred by the Moroccan HSE regulatory system. But evidence was provided that European product specifications or domestic water laws could influence Samir’s HSE investment behaviour. Therefore, a score of +1 is given to the two components of this routine property.

Before examining the second source of evidence the previous scores can be added up and summarised in the following temporary table.

Table 113. Temporary DR of $M_2$ for Samir

<table>
<thead>
<tr>
<th>$M_2$</th>
<th>$P_1$ Action vs. Representation</th>
<th>$P_2$ Repetition &amp; persistence</th>
<th>$P_3$ Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>+1</td>
<td>+3</td>
<td>+2</td>
<td></td>
</tr>
</tbody>
</table>

378 The refinery site was chosen because of its low seismic risks, but the floods which eventually caused the explosion could not be planned by the experts as they came from the mismanagement of an uphill dam.


380 Samir general manager Abderrahmane Saaidi mentioned that two distilling units of the refinery were not affected by the fire, and will resume production 15 days after cleaning and drying. The other units will require 8 to 12 months to be operational again. Along with the Sidi Kacem refinery, the refinery of Mohammedia can ensure 60% of the production capacity, namely 70% of the average demand. The executive said that the 120 to 130 tonnes of gasoline deficit will be largely compensated by imports. Source: “Morocco’s hydrocarbon needs secured for next 15 days”, http://www.arabicnews.com/ansub/Daily/Day/021130/2002113020.html, Morocco, Economics, 30/11/2002.
CD of the DR

The analysis of the Moroccan HSE regulatory system, summarised in Section 6.4, shows that its level of pressure is low, and the previous table that the DR of the HSE management mechanism is weak. Therefore, the second source of evidence of the context dependence routine property is given a score of +1, and the score of P3 goes up to +3.

<table>
<thead>
<tr>
<th>Level HSE Pressures</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR</td>
<td>Weak</td>
<td>+1</td>
</tr>
<tr>
<td></td>
<td>Strong</td>
<td></td>
</tr>
</tbody>
</table>

The next table summarises the final results of the DR of the second HSE mechanism used by Moroccan oil refineries.

Table 114. Final DR of M2 for Samir

<table>
<thead>
<tr>
<th></th>
<th>P1 Action vs. Representation</th>
<th>P2 Repetition &amp; persistence</th>
<th>P3 Context dependence (CD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>M2</td>
<td>+1</td>
<td>+3</td>
<td>+3</td>
</tr>
</tbody>
</table>

This table shows that the DR of Samir’s HSE investment decision-making mechanisms is not very strong, and thus that the processes it uses to address HSE issues are not yet embedded in the firm’s routines. This suggests that the routines in place should be changed, for example under the impetus of product specifications and of increased domestic HSE regulatory pressures.

8.3.4 Input supply management in Moroccan oil refineries (M3)

Saudi Arabia is the main provider of crude oil\(^\text{381}\), was reinforced by the situation of monopoly given to the group after the privatisation. As for inputs, Morocco produces very little crude oil and needed to import 6,653 tonnes in 2000, mostly from Saudi Arabia.

Since the privatisation, the dependence on Saudi Arabian crude oil got worse, which suggests that Samir may not be able to use this variable to modify its HSE behaviour. It is important to underline that the sulphur content of imported crudes is very high (higher than 3%). This implies that heavy treatments need to be made to sell products on the European market, since the sulphur content of gasoline keeps decreasing. Samir needs to make massive investments to comply with EU directives, as current petroleum processes do not allow to produce such low-sulphur contents (this was the objective of the upgrading project). Finally, the fact that the local market mostly consumes gas oil discourages the use of crude oil with a low-sulphur content, which naturally contains little gas oil, is more expensive, and can hardly be imported from Algeria.

However, since no detailed plant-level data could be collected about the way Samir is managing its input supplies, no DR could be evaluated for this HSE mechanism.

### 8.3.5 The HSE routines of Moroccan oil refineries

The following table summarises the DR of Moroccan oil refineries. As in the case of Algeria, it suggests that although weak HSE pressures are exerted on oil refineries, HSE routines R₁ and R₂ can be identified and ways to increase their embeddedness in Samir’s behaviour formulated.

---

382 From 150 ppm (0.15%) in 2000 to 50 ppm (0.05%) in 2005 with the EU programme Auto Oil II.

383 In addition to the relatively high price of Algerian crude, there are political tensions between the two countries around Western Sahara, drug traffic, and terrorism.
Table 116. Summary of the degrees of routineness of the HSE mechanisms used by Moroccan oil refineries

<table>
<thead>
<tr>
<th>HSE mechanisms</th>
<th>Routine properties</th>
<th>P₁ Action vs. Representation</th>
<th>P₂ Repetition &amp; persistence</th>
<th>P₃ Context dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td>M₁ HSE management</td>
<td></td>
<td>+3</td>
<td>+2</td>
<td>+4</td>
</tr>
<tr>
<td>M₂ Investment decision-making</td>
<td></td>
<td>+1</td>
<td>+3</td>
<td>+3</td>
</tr>
<tr>
<td>M₃ Input supply management</td>
<td></td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

The weakness of the HSE management routine in Samir comes from the difference of treatment between OHS and environmental issues. OHS has been tackled and routinised have been put in place, which shows that the firm has the capabilities that could be used to address environmental issues. For example, the incident reporting system could be extended to leaks, and the monitoring of smoke to optimise combustion to the measurement of other pollutants. However, since there are no regulatory pressures to decrease air pollution, no routines are set up for this purpose. On the other hand, waste water is treated because water pollution is monitored given its rarity and value for an agricultural country like Morocco. But such external pressures do not exist yet for air or water pollution. And the privileged situation of Corral allows it not to hurry to allocate resources for the development of environmental routines. Besides, as opposed to Algeria, it belongs to the international expert group GESIP from which it could gain experience on how to do so. However, the strong DR obtained for the context-dependence routine property shows that if they were stronger, external pressures can influence Samir’s HSE behaviour. By the end of 2004, how the new environmental laws will be implemented will tell a lot about the ability of the Moroccan government to break the old routines that inhibit environmental improvements in Samir.
Table 117. The HSE management routine of Samir (R₁)

<table>
<thead>
<tr>
<th></th>
<th>P₁</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P₁</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Action vs. Representation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Action:</strong> Monitor and improve HSE performance</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Representation of the action</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: Physical artefacts (ETS, gas detectors, Plan Particulier d’Intervention, vaccination campaign, residual/oily waters collected, ground pollution monitored, leaks controlled with personnel’s eyes, solid waste stored in open air, floating roof tanks with infrared fire detection, sprinkling systems, sulphur dioxide is not monitored, mud and other wastes are incinerated, propane cigars not surrounded by armoured wall, accident simulation,</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Language forms (SK: concerning occupational health and safety, things are taken seriously, but in Samir nothing about the environment)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Routine technologies</strong></td>
<td></td>
<td>+3</td>
</tr>
<tr>
<td>+1: Organisational (Industrial Safety department, Process and Environment division, Environmental Protection Service)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: Human (although no environmental training good OHS training which could provide a basic structure for the routinisation of environmental training in Samir)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Financial</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>P₂</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P₂</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Repetition &amp; persistence</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Data collection</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: OHS data collected + at least one type of environmental data (air, water, waste, soil) only used for production efficiency (pollution is a mere indicator of industrial efficiency: smoke controlled to monitor energy consumption)</td>
<td></td>
<td>+2</td>
</tr>
<tr>
<td><strong>Data diffusion</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: HSE data only diffused in-house</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>P₃</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>P₃</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Context dependence (CD)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CD of environmental actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2: Strong (ETS built to comply with national norms and on the basis of European standards, routine maintenance to avoid production losses is driven by the legislation)</td>
<td></td>
<td>+4</td>
</tr>
<tr>
<td><strong>CD of OHS actions</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2: Strong</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>CD of the DR</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Level HSE Pressures</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>DR</strong></td>
<td>Weak</td>
<td>Strong</td>
</tr>
</tbody>
</table>

Considering that environmental issues are not addressed by management routines, it is not surprising to find a weak DR for the second HSE routine. Apart from a relatively large financial autonomy of the plants, which could foster incremental environmental changes through the undertaking of environmental investment
projects, no resources are allocated to use investment decision-making processes to address environmental issues, as opposed to HSE issues. However, as for Naftec, hopes for change come from the need for Samir to meet European standards. The massive upgrading project was mainly designed to do so. On the other hand, the fact that Samir produces cleaner fuel does not guarantee that they are produced with limited environmental impacts. For this reason, a rapid increase of the level of pressures exerted by the Moroccan environmental regulatory system is needed.

Table 118. The investment decision-making routine of Samir (R2)

<table>
<thead>
<tr>
<th>P1</th>
<th>Action vs. Representation</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Action:</td>
<td>Invest to enhance HSE performance</td>
<td></td>
</tr>
<tr>
<td>Representation of the action</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Physical artefacts (the criteria used to appraise an investment project needs to be specified, but no environmental one ever used whereas OHS investments are not questioned, the only method used is the pay back period)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Language forms</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Technology</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+1: Organisational (financial autonomy: €1,000,000)</td>
<td>+1</td>
<td></td>
</tr>
<tr>
<td>+0: Human</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+0: Financial</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P2</th>
<th>Repetition &amp; persistence</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Planning of HSE investments</td>
<td>+3</td>
<td></td>
</tr>
<tr>
<td>+1: Occasional HSE investment projects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HSE investment projects</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+2: Small HSE investment projects (sour water stripper, ETS)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>P3</th>
<th>Context dependence (CD)</th>
<th>DR</th>
</tr>
</thead>
<tbody>
<tr>
<td>CD of environmental actions</td>
<td>+1: Weak</td>
<td></td>
</tr>
<tr>
<td>CD of OHS actions</td>
<td>+1: Weak</td>
<td></td>
</tr>
<tr>
<td>CD of the DR</td>
<td></td>
<td>+3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level HSE Pressures</th>
<th>Low</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>DR Weak</td>
<td>+1</td>
<td></td>
</tr>
<tr>
<td>Strong</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
8.4 Summary
This chapter aimed to evaluate the DRs of the HSE mechanisms used by Moroccan and Algerian oil refineries in order to identify their HSE routines. As summarised in the following table, it concludes that although they are less developed than the ones of their European counterparts, HSE management (R₁) and investment decision-making routines (R₂) are being used by North African oil refineries. This is in spite of the weak pressures exerted by HSE regulatory systems in North African countries, which if they were increased could certainly contribute to the development of routines that enhance the HSE performance of oil refineries.

<table>
<thead>
<tr>
<th>HSE routines</th>
<th>Routine properties</th>
<th>P₁ Action vs. Representation</th>
<th>P₂ Repetition &amp; persistence</th>
<th>P₃ Context dependence</th>
</tr>
</thead>
<tbody>
<tr>
<td>France</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M₁ HSE management</td>
<td></td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td>M₂ Investment decision-making</td>
<td></td>
<td>+3</td>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td>UK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M₁ HSE management</td>
<td>Texaco</td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td></td>
<td>Conoco</td>
<td>+5</td>
<td>+4</td>
<td>+5</td>
</tr>
<tr>
<td>M₂ Investment decision-making</td>
<td>Texaco</td>
<td>+3</td>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td></td>
<td>Conoco</td>
<td>+4</td>
<td>+5</td>
<td>+5</td>
</tr>
<tr>
<td>Algeria</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M₁ HSE management</td>
<td></td>
<td>+3</td>
<td>+3</td>
<td>+4</td>
</tr>
<tr>
<td>M₂ Investment decision-making</td>
<td></td>
<td>+1</td>
<td>+4</td>
<td>+3</td>
</tr>
<tr>
<td>Morocco</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>M₁ HSE management</td>
<td></td>
<td>+3</td>
<td>+2</td>
<td>+4</td>
</tr>
<tr>
<td>M₂ Investment decision-making</td>
<td></td>
<td>+1</td>
<td>+3</td>
<td>+3</td>
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</table>

The following chapter builds on these findings to compare the HSE routines of case study firms and to answer the second research question of the thesis.
Chapter 9: A comparative analysis of HSE routines

9.1 Introduction
The aim of this chapter is to carry out a comparative analysis of the HSE routines of case study firms and to answer the second research question of the thesis:

RQ2: What are the differences between the HSE routines used by firms exposed to different levels of pressures from HSE regulatory systems?

It builds on the findings of the previous chapters, and notably on the evaluation of the DR of the HSE mechanisms used by case study firms summarised in Table 119. The latter shows that if HSE routines do exist in North African refineries, they are much less well founded than in European refineries. The comparative analysis carried out in the next two sections allows us to bring forward some explanations of these differences. The HSE routines of Total (France) and Naftec (Algeria) are compared in Section 9.2, and the ones of Samir (Morocco) and UK refineries (Texaco, Conoco) in Section 9.3. This allows us to answer the second research question in Section 9.4.

9.2 HSE routines in Naftec (Algeria) and Total (France)
Studying how action is represented in the HSE management routine of French oil refineries reveals that they are all ISO 14.000, which is not the case of Algerian refineries. This is reflected in the difference of the DR for the first routine property, +5 for French refineries and only +2 for Algerian ones. But if the HSE routines of used by Naftec are not very strong yet, a voluntarily process of certification has started, both to improve quality and to meet international production standards. The existence of this representation of an HSE action through the guidelines of how to achieve an ISO standard provides a basis for Naftec to modify its environmental behaviour. Yet, pollution is mostly used to improve production efficiency as for CO2 or SO2 emissions, whereas in France firms are required to monitor many pollutants. This points out the role of an efficient HSE regulatory system, which also benefits from improvements coming from the European level, since all European laws need to be transposed. As for safety, at the time of the fieldwork it had not been automated yet. Pledges issued by Naftec or Sonatrach are negligible compared to Total’s
commitments, and are mostly driven by the concern of meeting European and international product specification.

Concerning the means to implement this HSE routine, in both countries oil refineries have a specific department to deal with HSE issues, but Naftec’s department lacks autonomy and legitimacy in the centralised Algerian petroleum industry. Even at the refinery level, Environment units are also isolated and lack means and independence to carry out their tasks. And if OHS training is provided, as opposed to what happens in Total it is not the case of environmental training. This unbalance between the concern for these two issues is to be relativised given that Naftec has received a warning by its insurance company urging it to set up a proper smoke, flame and fire prevention system. This points out a lack of means to operate HSE management routines in Naftec, although some improvement has been recently made on environmental issues subjected to external pressures, notably the ones concerning European product specifications, and following the initiative of the former CEO of Naftec who, according to the words of the current HSE manager, wanted “to leave something behind him”. This underlines the influence of individuals’ beliefs, which can be an important source of internal HSE pressure to change the behaviour of a firm.

As for data collection, in both countries oil refineries behave in a similar way as far as OHS data is concerned, but Naftec has only started to collect environmental data recently, which explains the big difference in the DR of the second routine property (+4 against +2). This can notably be explained by the fact that the Algerian HSE regulatory system does not require to monitor environmental pollution and that the capabilities of the firm to do so are limited. For example, leaks are monitored with personnel’s eyes and variations in pipe pressure, which is not the most reliable method to do so.

Finally, the European and French HSE regulatory systems have been the main source of influence on Total’s HSE behaviour. This cannot be the case of Naftec because the Algerian HSE regulatory system does not exert strong pressures on this firm. However, as evidenced by a DR of +4 for R1-P3, European product specifications seem to have a stronger influence on the HSE routines of this company, as suggested in the comparative study of the second HSE routine carried out below.
Investment decision-making routines in Total and Naftec are both very structured. But the threshold of decision autonomy of the refineries is 13 times lower in Naftec, which reduces the potential for incremental changes to improve HSE performance. In both cases, no HSE criterion is integrated in decision-making processes, but Total is pushed by European and French HSE legislation to undertake HSE investment programmes, which explains the difference in the DR of the two countries (+4 against +3).

The comparison of the repetition and persistence routine property of investment decision-making routines in Total and Naftec provides evidence that the outcome of these routines persists because they both lead to lasting investment projects, notably under the pressure of European product specifications. This external supra-national regulatory pressure is found to affect Naftec, which is upgrading its facilities to meet European standards, but only to a small extent as evidenced by the DR of +2 for R2-P3. But it is also a decisive HSE pressure for Total, as shows the DR of +5 for R2-P3, because as the debottlenecking project shows, unless they are mandatory, in which case they are always implemented, environmental improvements stemming from investment projects seem not to be voluntarily undertaken but to derive from improvements in production processes. OHS investments are undertaken by both firms, even if they incur huge expenditures, as evidenced by the numeric instrumentation investments in Arzew and Skikda as well as by the integration of risk assessment into the decision-making process of the debottlenecking project.

9.3 HSE routines in Samir (Morocco) and Texaco & Conoco (UK)

In Texaco, knowledge about the HSE management routine is notably stored or represented in the corporate “SHE” system. Built in-house, it indicates that the firm has adopted a voluntary approach to carry out that HSE action and that it had the “technologies” to do so. Conoco adopted an international standardisation approach as its refinery is ISO 14.001, and like Texaco the group puts forward a beyond-compliance behaviour as regards OHS issues. Its concrete expression is notably given by the integration of environmental issues into business plans and the

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384 Cf. Enos (1958) and Enos (1962) about the importance for incremental technological changes in the oil refining industry.
provision of appropriate training to employees. On the other hand, Samir does not have a standardised HSE process, although OHS issues have been allocated appropriate resources such as the ones mentioned under the heading of organisational and human “technologies”. For example, the Industrial safety department has a powerful position in the hierarchy of the refinery of Mohammedia, and it organises in-house training sessions and sends staff to seminar abroad to train employees, for example on the HAZOP method.

But Samir has no commitment towards environmental issues, which negative impact are voluntarily underestimated, and no environmental training is provided either internally or by external consultants. This confirms that environmental issues are not tackled by Moroccan refineries, which do not collect any environmental data nor allocate resources to do so. However, resources or “technologies” allocated to OHS issues are complementary to the ones required to solve environmental problems in these refineries. Indeed, several cases suggest that OHS routines could enable better environmental performance. For example, the two Moroccan refineries are fitted with effluent treatment plants which imply to have a routinised monitoring activity of the quality of treated water. Other control activities are being carried out for OHS purposes such as the laboratory analysis of combustion to improve production efficiency, which has indirect environmental benefits because it includes carbon monoxide emissions, the use of gas and other infrared detectors to identify and prevent leaks, smoke, and flames in dangerous areas, or the use of piezometric wells to monitor the quality of underground water.

What is hazardous for the production facilities can also be dangerous for the environment, and similar routinised activities can address both OHS and environmental problems. Why are these complementarities not being taken advantage of? The willingness to address environmental issues is a first explanation, which can be related to weak stimuli to do so such as regulatory requirements, citizens pressures, consumer demand, or even staff’s own personnel commitment to those issues. The latter three sources of incentive to address environmental issues stress the importance of training and education to raise people’s awareness about environmental problems.

This leads us to the second explanation of the lack of concern for environmental issues in Moroccan oil refineries, which is that this pattern of behaviour is rooted in people’s and organisational routines. To change this unsustainable behaviour, new
routines need to be set up to replace inhibiting routines. This implies that resources are allocated to generate new representations of actions, which correspond to the “technologies” described in Chapter 2 such as training programmes, financial resources, or organisational structures. Samir’s point of view on local pollution provides a good example of a key assumption built in individuals’ memories leading to a lock-in unsustainable practices. According to Mr Arad, local pollution in the region of Casablanca, the economic capital of the Kingdom, is not important enough to be taken seriously, as opposed to European cities for example. This lack of concern is reflected in the absence of corporate commitment to address environmental issues and of information on environmental damages on the website created following the December 2002 blast. The management of scrap metal also corroborates this lack of environmental concern. This explains the difference in the DRs for the first routine property between English and Moroccan refineries (+3/+3 versus +2).

Texaco and Conoco do not diffuse HSE data, which is left in the hands of local Environment agencies given that firms are not obliged to do so. HSE managers of these two UK firms have recognised the strong impact of European legislation on their HSE behaviour. As for Samir, whose exports are mostly directed to the EU, the upgrading project to be undertaken so as to export petroleum products to Europe suggests that European HSE standards do not only impact European firms but also the ones located in MPCs. Finally for this HSE routine, given that the Moroccan HSE regulatory system does not yet exert strong pressures on domestic firms, the fact that OHS management routines are well founded in Samir tends to question the strength of the impact of HSE regulatory system on firms’ HSE behaviour. In this case, the perception of risk may act as a stimulus for the improvement of HSE performance, which is normally produced by HSE regulation. Indeed, if the plant is to be destroyed by an accident which could not be prevented by the OHS management system, the survival of the firm is put at risk as well as the life of employees. However, Samir’s production manager acknowledged that routine maintenance was determined by the national regulation on admitted leaks (hence the DR of +3 for R1-P3), which suggests that when regulation exists and is enforced in Morocco, it can have a strong impact on firms’ HSE behaviour. Also, the fact that the management of OHS issues in
Mohammedia is very structured may hinder the development of new routines such as environmental ones. For example, safety prevention is undertaken “with personnel’s eyes”, as has argued the production manager of the refinery of Mohammedia, and it is also used to monitor basic environmental problems such as leaks or untreated waste. This routine requires to have enough personnel to do so, which may not be the case anymore in Samir as Corral has cut down on labour force since the privatisation in 1997. Staff abundance combined with weak environmental pressures and with the existence of a strong OHS routine may have led to a situation of lock-in preventing environmental improvement in Moroccan refineries. The OHS routine in place may therefore have inhibited the setting up of environmental management routines. With the decreasing number of staff and the upgrading project, which will require more advanced control methods, new routines might be set up and replace existing ones. However, if environmental regulation is not tightened up, it is unlikely that HSE routines addressing environmental issues are put in place considering Corral’s lack of commitment to them.

The comparative analysis of investment decision-making routines in UK and Moroccan oil refineries sheds light on the differences in the HSE behaviour of these plants (almost all the DR of R2 are +5 for UK refineries versus +2 for Moroccan ones). Neither in Texaco nor in Conoco are HSE issues integrated in the investment decision-making process, as the former uses cash flow analyses and the latter investment rates of return to appraise investment projects. It is also the case in Samir, which uses the pay back period and never corrected the cost of an investment to take into account HSE expenditures. However, these procedures do not specify that the Environment department has to be consulted before undertaking an investment project. The representation of how the investment decision-making routine should be carried out in Texaco specifies that the refinery has a high level of decision autonomy (USD10 million), which has notably allowed to modify tankers to recover vapours. In Samir, the maintenance manager is responsible for investments greater than €5,000 and the refinery manager of investments below €1 million. But as opposed to Texaco, this room for manoeuvre is not used to address environmental issues because there are too little internal and external pressures pushing to put those

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385 This is despite the fact that its investment procedures were allowing it to do so.
issues on the agenda. This is confirmed by the fact that the only important HSE investments carried out in Samir have concerned effluent treatment plants, and as evidenced in Chapter 6, only the Water act is enforced in Morocco.
In Texaco as well as in Conoco, the persistence property of the investment decision-making routine reveals that many HSE projects are undertaken to meet European product specifications. They are considered as stay-in-business decisions, which stresses the importance of widely accepted regulatory standards so that all industries are on the same level of the playing field. This is the case in the EU, as the bulk of investment expenditures are related to European legislation on product specifications or on the reduction of air emissions. For example, when fitting a new SRU, Conoco was anticipating EU regulation. On the other hand, the fact that Texaco has invested a huge amount of money in a safety simulator corroborates the earlier point on OHS issues in Samir which seem to require less external pressures than environmental ones to be addressed.

9.4 Summary
In order to answer the second research question of the thesis, this chapter shed light on the differences between the HSE routines used by firms located in countries which HSE regulatory system exert pressures that are substantially different. In Chapter 6, these pressures were evaluated and two groups of countries were brought to the fore. In the European group composed of France and the UK, the pressures exerted by HSE regulatory systems were proved to be much stronger than the ones exerted in the two North African countries of the second group, namely Morocco and Algeria.

The comparative analysis of HSE routines suggests that there are important qualitative differences between the way European and North African oil refineries address HSE issues. It corroborates the findings summarised in Table 119, which revealed huge differences between the DR of these firms and confirmed the strong influence of HSE regulatory systems on firms’ HSE behaviour. Key differences between the HSE behaviour of European and North African oil refineries notably concern the structures in charge of addressing HSE issues, which power and resources are much weaker in North African plants. But this mostly concerns the ones aiming to address environmental issues, because OHS routines are relatively
well organised. The difference between how firms address these two issues is revealed by the lack of resources allocated to do so, such as training or the absence of integration of environmental variables in investment decision-making processes. This comparative analysis of firms’ HSE routines also suggests that prevailing routines can inhibit the setting up of new mechanisms, and that increased pressures by HSE regulatory systems could foster such a change in firms’ HSE behaviour by “triggering a ‘lock-out’ away from unsustainable systems”, as Mulder, Reschke, and Kemp (1999: 25) put it. Finally, it also underlined the influence of European standards on all case study firms, which suggests that if the domestic HSE regulatory system of MPCs does not exert pressures that are strong enough to change the firms’ HSE behaviour, external pressures can have a powerful indirect influence on this behaviour.
Chapter 10: Conclusion

This chapter brings together the findings of the thesis and explains how they allow to falsify the research hypotheses and to answer the research questions. By proposing and applying a methodology to characterise, identify, and compare HSE routines, this thesis has sought to provide a greater insight into how firms address HSE issues. This greater understanding may allow to design policies to improve firms’ HSE performance, notably in countries where there are too few incentives to do so, such as MPCs. Two research questions guided the investigation in pursuit of this aim. The first one raised the extent to which economists could characterise and identify firms’ HSE routines, and the second one proposed to investigate the differences between the routines used by firms located in countries having different HSE regulatory systems. To answer the first question the economic literature on the concept of routine was reviewed to define it, to bring to the fore three key properties of the concept\(^{386}\), and to explain why it is useful to study firms’ HSE behaviour. Then, an analysis of the factors that play a role in the way oil refineries are addressing a specific HSE matter were highlighted using quantitative data on SO\(_2\) emissions, as well as data on the technological and organisational features of French oil refineries over a period of 17 years. Three HSE mechanisms were identified as having a determining impact on the HSE behaviour of these firms: HSE management systems, investment decision-making processes, and input supply management systems. To identify the HSE routines used by oil refineries, the extent to which these HSE mechanisms had the properties of routines were investigated. Two HSE routines were brought forward: the HSE management routine and the investment decision-making routine. Finally, to address the second research question and to formulate policy recommendation about how to improve the HSE performance of oil refineries in MPCs, the HSE routines operated by several firms located in countries which HSE regulatory systems exert substantially different pressures on firms’ behaviour were compared.

10.1 The properties of the concept of routine

The literature review carried out in Chapter 2 brought forward three key properties of the concept of routine. Identifying these properties led us to assess the extent to

\(^{386}\) Duality between action and representation, repetition and persistence, and context dependence.
which a specific mechanism a given firm uses to modify its behaviour is an HSE routine. The nature of the properties of routines can be understood with the definition of the term adopted in this thesis:

“A routine is an executable capability\textsuperscript{387} for repeated performance (...) that has been learned\textsuperscript{388} by an organisation in response to selective pressures.”\textsuperscript{389}

The term “capability” refers to the duality between actions and their representation, the term “repetition” to the persistence of routines, and “selective pressures” to the fact that they are context-dependent. The first property suggests that routines are knowledge about how to carry out an action which has been successful in the past, and that this knowledge is stored in identifiable representative forms which are either created, replicated, or implemented with appropriate technologies. The second one expresses that if knowledge about how to carry out an action has been properly stored in the aforementioned forms, the action, namely the output of the implementation of the representation of action, can persist because representative forms can be repeated. Finally, the third property stresses that the mechanisms that govern firms’ behaviour co-evolve with the context in which firms operate.

Concerning HSE mechanisms, it was suggested and that HSE regulatory systems were the element of oil refineries’ HSE context which had the strongest influence on their HSE behaviour.

10.2 The pressures exerted by HSE regulatory systems

To compare the pressures exerted by the HSE regulatory systems of case study countries, the scope and the content of each country’s HSE regulations were analysed, as well as the institutions aiming to enforce them. Results suggest that in spite of the difficulties to measure the pressures exerted by regulatory systems, such a comparison is feasible. They also brought forward that the pressures exerted by the HSE regulatory systems of European case study countries are substantially stronger than the ones exerted by the systems of North African countries. Table 45 provides a

\textsuperscript{387} Capacity to generate action stored in some form.
\textsuperscript{388} Encompasses processes of tacitness and automaticity, which could alter the probability of enactment of the capability.
\textsuperscript{389} In Cohen, Burkhart et al. (1996: 683).
summary of the differences between the pressures exerted by the HSE regulatory systems of case study countries. For example, it shows that in Algeria environmental legislation is obsolete as opposed to OHS legislation and institutions, which are much more developed. Morocco was proven to bear opposite features, because its environmental regulatory system was recently improved contrary to its old OHS system. The analysis of the pressures likely to be exerted on firms’ behaviour by HSE institutions of case study countries confirmed that in North African countries, HSE pressures are substantially weaker than in Europe. This conclusion was also reflected in the comparative analysis of the French and Moroccan water regulatory systems.

On the basis of these results, it was shown that the pressures exerted by North African HSE regulatory systems are substantially weaker than the ones exerted by European HSE regulatory systems. Two groups of countries are identified: France and the UK on one side, Morocco and Algeria on the other side.

10.3 Identification and comparison of firms’ HSE routines
The investigation of HSE routines used by oil refineries shed light on the mechanisms governing firms’ HSE behaviour. The identification of HSE routines was carried out in two stages and allowed us to answer the first question of the thesis. Firstly, an empirical study of the HSE mechanisms used by French oil refineries to address a specific HSE problem, namely reducing SO2 emissions, was carried out in Chapter 4. It consisted in the analysis of the relationships between the evolution of SO2 emissions over a long period of time and changes in the factors internal and external to the firm which were assumed to influence the patterns of these emissions in oil refineries. This study allowed us to bring to the fore three main mechanisms used by French oil refineries to reduce their SO2 emissions: HSE management systems, investment decision-making processes, and input supply management systems. Secondly, in chapters 6, 7, and 8, an analysis of the extent to which these mechanisms are routinely used by other refineries to address HSE issues other than SO2 emissions was carried out. To do so, the degree of routineness of these mechanisms was evaluated, which allowed us to answer the first research question positively by identifying two HSE routines used in case study refineries: the HSE management routine and the investment decision-making routine. But even if the
actions carried out by all refineries to address HSE issues were routinised, their DR differed and this needed to be explored in more detail. Finally, the concept of routine was used to compare the HSE behaviour of firms located in different countries and to identify routines that may hinder HSE performance instead of enhancing it. To change these routines, the first step is to identify them, which was the purpose of chapters 6, 7, and 8. The second step is to compare the behaviour of firms having different HSE performance in order to suggest better ways to undertake HSE actions. This was done in the comparative analysis of Chapter 9.

10.4 Policy recommendations
This section brings to the fore how the concept of routine can contribute to design policies to improve firms’ HSE behaviour. As argued in the previous section, this thesis provided evidence that when addressing HSE issues firms function according to routines. Firstly, it explains differences in firms’ HSE behaviour, and thus it allows us to understand why some firms have a lower HSE performance than others. Secondly, on the basis of its results more efficient HSE policies which are not only technology-forcing but innovation-enhancing can be designed. Knowledge about firms’ HSE mechanisms also allows these policies to improve the mechanisms which are not enhancing HSE performance but are rather inhibiting it, leading to situations of lock-in into unsustainable production trajectories. Building on the findings of the field work, cases of routines which enhance HSE performance and of routines which inhibit it are now exemplified.

The first important element that can be brought forward is the “human technology” used to implement the HSE management routine in case study firms. Indeed, a high HSE performance tends to be associated with an extensive training programme as in European firms or in the Moroccan firm Samit. In the latter case, a lot of high-level training was given in foreign institutes, which underlines the lack of HSE expertise in the country, but this also applies to Algeria. The “training technology” of an HSE

390 Because the primary purpose of the thesis was not to analyse firms’ HSE performance, data collected for the empirical analyses did not allow a thorough investigation of this performance and of its relationships with the activation of specific HSE routines.

391 The group Total even takes into account HSE achievements to evaluate staff.
management routine can thus be considered as enhancing. As Lazaric & Denis (2001: 25) notice:

“Training may, however, not be in itself sufficient to sustain organisational change, which requires new representations of its associated tasks and a new identity within the hierarchy.”

The two latter elements can indeed be brought forward as enhancing mechanisms within the HSE management routine. As evidenced in the case of Algeria, “new representations” can take the form of physical artefacts such as the setting up of systems and procedures to monitor pollution. As for the “new identity” mechanism, it is clear that the creation of an ad hoc HSE department in Naftec has led to the emergence of a new HSE agenda. Investment routines can also be enhancing when they integrate HSE issues in well-structured decision-making processes, as in the case of Conoco. But they can also deter HSE improvement if they are not flexible enough to allow for the introduction of a new mechanism that can change existing routines. For example, in the case of Naftec, the fact that profit margins are determined by the state has a strong impact on its investment behaviour. Rigid routines are all the more likely to lead to situations of lock-in that the pressures exerted by the HSE context are weak.

Finally, for the mechanism managing input supplies, which DR could not be evaluated because of the aforementioned difficulties in obtaining data on this strategic issue, its routinisation could also be a source of lock-in, as in the case of Morocco which is tied up with Saudi Arabian crude oil. The supply of spare parts which are all imported in Naftec is another example of the impact of a rigid mechanism of supply on the HSE performance of an oil refinery, as it can deter technological and HSE improvements.

To conclude on the policy recommendations allowing North African firms to meet the challenges of sustainable development, it seems that increasing the level of pressures exerted by domestic HSE regulatory systems would produce important changes in the way HSE issues are addressed. The structures of co-operation set up for the Euro-Mediterranean Partnership could be empowered to foster these changes.

392 If it was to be chosen as the unit of analysis, this mechanism could be studied in greater detail as a routine part of an HSE management meta-routine.
Taking an active part in international and European professional associations could also trigger HSE improvements to break old routines inhibiting positive changes in firms’ HSE behaviour. The situation of monopoly of Samir and Naftec has also been pointed as an obstacle to HSE improvements. But an important obstacle for the two North African countries is the lack of domestic HSE expertise, a major weakness of the national system of innovation of Morocco and Algeria. Indeed, strong domestic HSE capabilities could trigger a lock-out from current unsustainable practices and break old routines by providing innovative technical and organisational solutions, as well as training and education to raise people’s awareness about environmental problems and how to solve them. Finally, beyond the refining sector, which also suffers from a path dependence with the fourth techno-economic paradigm\textsuperscript{393}, developing a strong innovation system able to tackle HSE issues could foster HSE changes in other sectors. It could also influence the behaviour of consumers and of citizens in general, which can be a strong source of external pressure on polluting firms. With the support of the EMP, Morocco and Algeria could initiate a shift away from the oil regime and move towards more sustainable development paths, along the lines of the argument made by Berkhout (2002). The next section concludes the thesis by raising its implications for future research.

10.5 Implications for future research
The research carried out in this thesis has both theoretical and political implications. At the theoretical level, it has proposed an analytical framework allowing to understand why some firms were able to take advantage of win-win opportunities and why others are locked in unsustainable trajectories. For further investigation of firms’ HSE routines, a detailed case study of a specific firm can be carried out to overcome the problems of data collection encountered in the investigation of the third HSE mechanism (input supply management). Extending such analysis to other countries and sectors could allow to design a taxonomy of routines which can enhance HSE performance or inhibit it.

As for the political implications of the results of thesis, they concern the contribution of an improved knowledge on HSE routines to the design of innovation-friendly environmental policies, as well as to the sustainable development of the Euro-

\textsuperscript{393} Cf. Section 2.2.3.
Mediterranean region. The debate about these policies relates to the one about the win-win hypothesis, because it suggests that if properly designed they might be able to more than offset the costs of the internalisation of HSE problems. Research remains to be carried out on the respective influence of different types of environmental policies on firms’ behaviour.394

Last but not least, the analysis of the HSE behaviour of European and North African firms suggests further investigation of the content to be given to sustainable development policies in the Euro-Mediterranean region. The assessment of the context dependence routine property has shed light on the strong influence of European product specifications on the HSE behaviour of Moroccan and Algerian refineries. For example, the deputy director of the Arzew refinery395 as well as Naftec’s HSE manager396 have both stressed in their interviews the importance of the European market for Naftec and therefore of meeting European standards. As argued in Gossart (2003a), this suggests that further research needs to be conducted on the indirect impacts of European HSE policies on the Mediterranean partners of the European Union, in order to foster the sustainable development of the Euro-Mediterranean region.

394 Gouldson & Murphy (1998) and Kemp (1997) provided insightful contributions to this debate.
395 Source: Interview with Mr Ould Ali’s assistant, Arzew, 29/04/01.
396 Source: Interview with Mr Zerarka, Naftec’s HSE manager, Algiers, Naftec head office, 06/05/01.
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List of interviewees

Morocco

1. Mrs Lamsari, Ministry of the Environment and Planning (MATE), Head of the service “Partnership with economic actors and NGOs”, Rabat, 04/07/01.
2. Mr Bachir, head of the Department Legislation in the Ministry of the Environment, Rabat, 06/07/01.
3. Mr Aboud, MATE, in charge of the FODEP, Rabat, 04/07/01.
4. Mr Yacobi, head of the service “Norms and standards”, MATE, Directorate for regulations, Rabat, 04/07/01.
5. Mr Abdelkader Kaioua, Regional inspector of urban and planning, wilaya Grand Casa, telephone interview, 27/06/01.
6. Mr Abdelhafide Kodade, head of the division “Control”, Sidi Kacem, 29/06/01.
7. Mr Benm’Barek, Safety manager, Sidi Kacem, 29/06/01.
8. Mr Arad, head of the division Process and Environment, Mohammedia, 27/06/01.
9. Mr M’Haidra, Production manager, Mohammedia, 28/06/01.
10. Mr Harmak, head of the refinery laboratory, Mohammedia, 26/06/01.
11. Mr Baroual, head Service Equipment, Mohammedia, 26/06/01.
12. Mr Laraqui, Samir HSE manager, Mohammedia, 29/06/01.
13. Mr Yousfi, head of the Investment and Planning Department in the DSP, Mohammedia, 27/06/01.
14. Mr Gajjaoui, head of the Maintenance Department, Mohammedia, 26/06/01.

France

16. Mr Fayol, environmental inspector in the DRIRE Pays-de-la-Loire, 21/10/2002, telephone interview.
18. Mr Hannotte, chief engineer at the DRIRE Martigues, 18/03/03.

397 Face to face, unless stated.
19. Mr Guy Arnaud, former Total’s HSE Refining and Marketing manager, email 25/02/02.


UK

23. Mr Dave Dundo, HSE manager, Exxon-Mobil, 10/01/00.

24. Mr Alan Green, SHE Manager European Region, Conoco, London, 04/03/02.

25. Mr John Hubbard, Investment and Technical Leader, Business and Planning Group, Texaco Ltd, 02/08/01, telephone interview.

26. Mr Brian Whittle, Technical Clerk, Safety, Health and Environment Department of Texaco, 16/08/01.

27. Interview conducted by Steve Sorrell for the TEP project with Geoffrey Vickers, former Environment Manager of the Humber refinery.

28. Interview conducted by Steve Sorrell for the TEP project with Dave Harris, former Environment Manager, Texaco.

Algeria

29. Mr Zerarka, Naftec’s HSE manager, Algiers head offices, 06/05/01.

30. Mr Belharbi, head of Arzew’s Environment unit, 22/04/01.

31. Mr Benbachir, director of the Algerian Institute of Petroleum (IAP), Oran, 01/05/01.

32. Mr Ilias, head of the Safety & prevention service, Arzew, 22/04/01.

33. Mr Hentit, professor at the Algerian Institute of Petroleum (IAP), Oran, 01/05/01.

34. Assistant of Mr Ould Ali, refinery manager, Arzew, 29/04/01.

35. Mr Sehoul Gharbi, OHS consultant, “Centre de Prévention & de Protection”, Oran, 30/04/01.
Questionnaire
HSE ISSUES IN OIL REFINING INVESTMENTS IN ALGERIA

1) Environment (pp. 1-19)

11) Environmental policy and management (of the refinery + specific to the case of investment chosen)

111) ENVIRONMENTAL POLICY

1. Importance of environmental policy for company strategy
2. Strength of environmental pressures in your country or region²
3. Is it increasing?
4. Which environmental standards should you apply? (fairness application EU one)
5. Stringency HSE standards compared with EU standards
6. Which steps does the government take to enforce HSE policies?³
7. Impact HSE policies on competitiveness (rank negative to positive from 1 to 5)
8. Impact Euro-Mediterranean Partnership HSE (rank negative to positive from 1 to 5)
9. History of the firm % HSE actions (ask employees too)

National environmental policy statement (web site): how will do it?

10. “Continue supplying needs in refined products. For the specifications, a program of suppression of lead in gasoline (reduction to 0.40 g/l since 01/01/1999, to 0.15 g/l from 01/01/2002 and only unleaded starting 01/01/2005)”
11. For the gas-oil, a reduction of sulphur content to 0.15 % weight. Also improvement of the oil formulation for their adaptation to the new requirements of the market.

International environmental policy statement: how will do it?

12. Continue to offer some intended refined products to the export to norms on targeted markets by the introduction of the MTBE for the production of gasoline eurosuper 95 for 2000. Starting 2005: integration of an isomerisation unit to produce Eurosuper 95 (aromatics content).
13. For gas-oil, starting 2005, the improvement of the sulphur content: an HDS unit for producing less than 50 ppm sulphur content has to be built
14. Contribute to environmental protection
15. Belongs to any sectoral organisation? (Concawe, IPIECA (International Petroleum Industry Conservation Association), EUROPIA (European Petroleum Industry Association), CERES: Coalition for Environmentally Responsible Economies, …)
16. Signature of any international or national HSE declaration? Which one(s)?
17. Have a PR/communication department that deals with environmental issues? Frequency?

112) ENVIRONMENTAL ORGANISATION AND MANAGEMENT

Policy Statement

1. Is there a written site policy that includes environmental concerns and is it up to date and signed by a senior manager?

Implementation

2. Are company guidelines available, or national codes of practice (COPs) identified as standards for implementation of environmental aspects of company policy?
3. Are responsibilities assigned for implementation of site environmental policy and associated guidelines or codes of practice (COPs)?
4. Is there a management-endorsed plan for the implementation and maintenance of the site environmental programme?
5. Is performance of the environmental function, programmes and personnel regularly reviewed by management?
6. Are contractors provided with environmental protection equivalent to that provided for company employees?

Resources

7. Are there adequate numbers of competent personnel to carry out the necessary environmental programme and what position do they occupy in the company?

¹ Example of the questionnaire which served as a guideline for the interviews carried out during the fieldwork.
² Perception differ across people.
³ Knowledge about regulation & procedures impt: part of environmental capabilities.
⁴ N.B. the following questions from §1 to 8 are adapted from a Concawe report n°99/58.
8. Is the site management team aware of the environmental-related requirements for the site and which power do they have to enforce them?
9. If implementation of the environmental plan relies on location personnel, are they aware of their duties and properly trained and competent?

Communications
10. Have the policy and arrangements for implementation been communicated to all employees, contractors and other potentially affected groups?
11. Does the person responsible for providing environmental advice and services have effective lines of communication?
12. Is there a site Environmental Committee?
13. Is there provision for informing management of regulatory and other relevant developments in environmental issues?

113) ASSESSMENT OF ENVIRONMENTAL IMPACTS

Environmental impacts identification
1. Is there an inventory of all polluting substances present on-site, along with a practice/procedure for keeping the inventory current?
2. Are current material environmental data sheets readily available?
3. Do procurement/purchasing procedures provide for review of environmental impacts before ordering?
4. Do capital projects, facility modifications and new designs include a procedure for competent review of associated environmental impacts?
5. Do procedures provide for review and dissemination of information on significant “new” environmental impacts that are not familiar to the site/personnel?
6. Are environmental impact indicators identified and endorsed by management for tracking the effectiveness of the environmental programme?
7. Do environmental impact indicators provide an insight into the effectiveness of site environmental programmes?

Environmental impact assessment (EIA)
8. Is there a procedure in place to assess environmental impacts in the refinery?
9. Are EIA conducted for all kinds of petroleum processes?
10. Does the EIA programme identify the need for testing the impact of environmental pollution on personnel and the surrounding natural environment?
11. Are monitoring data summarised or analysed statistically for comparison to relevant regulatory standards?
12. Does the EIA process identify higher priority impact tasks or work groups for follow-up exposure monitoring or improved control?
13. Are EIA records and documentation adequate?

Assessment procedure
14. Does the EIA procedure meet accepted criteria?

Communications
15. Have the results of EIAs been properly communicated to management?
16. Is there an effective procedure to communicate the results of EIAs to all persons at risk?
17. Are the results of EIAs publicly available?

Management of identified impacts
18. Are the results of EIAs integrated into overall site management processes?
19. Is provision made for the reassessment of environmental impacts?
20. What are the main factors driving environmental performance in a refinery?

Incident reporting and investigation
22. Are environmental incidents that are potentially related to environmental impacts identified, reported to management and investigated?
23. Are criteria for the classification of environmental incidents established by the environmental function and endorsed by management?
114) NON ROUTINE SITUATIONS

**Emergency Response Planning**
1. Is there an emergency response plan?
2. Does the emergency response plan include an effective organisational structure that includes environmental resources?
3. Are neighbouring industry and community emergency response organisations included in the emergency response plan?
4. Is emergency environmental information available for all environmental impacts?

**Training for Emergencies**
5. Are employees trained in the procedures to be followed in an emergency?

**Breakdown**
6. Are written procedures/practices in place to control environmental impacts during breakdown and unplanned shutdowns?

115) TRAINING AND AWARENESS

**Environmental impact communication**
1. Is information about environmental impacts readily available to potentially concerned workers for all potential impacts?
2. Are appropriate signs mentioning risks of environmental impacts erected in work areas?
3. Are containers and vessels properly labelled as to the environmental impact of their contents?
4. Are the results of EIAs shared with potentially concerned workers?

**Training (ask data in days per person of training)**
5. Is appropriate training on environmental impact assessment and control, and their environmental responsibilities given to managers, supervisors, employees and contractors?
6. Is environmental impact-related training an integral part of the site personnel/training system(s)?
7. Are basic means to reduce environmental impacts included in the induction courses for new employees, and are employees trained on environmental impact-related aspects of new jobs/transfers?
8. Is specific instruction and training given in the use of environmental impact measures and procedures for reporting any observed deterioration in their performance?
9. Is periodic/refresher training provided to all employees?
10. Planning training sessions/programmes to come

**Community Awareness**
11. Have members of the community been advised as to the nature of environmental impacts to the local environment and community that have been identified from the development of emergency response scenarios?
12. Do site policies properly address potential environmental impacts on the community or local environment?

116) DOCUMENTATION, DATA INTEGRITY AND RECORD KEEPING

**Documentation**
1. Are environmental impact-related practices/procedures integrated into standard operating procedures?
2. Are environmental criteria, components and responsibilities documented for key stand-alone programmes that are applicable to the site/facility?
3. Is documentation of environmental impact-related practices and procedures part of the site system(s) for documentation and updating of standard operating procedures?

**Data Integrity**
4. Are samples taken or measurements made using validated methods and reliable instrumentation?
5. Is all sampling equipment properly maintained, tested and calibrated?
6. Are all samples analysed using validated methods?
7. Does the analytical laboratory have an adequate quality control procedure, specific to environmental impact analyses?
8. Does the laboratory participate in an external-quality assurance programme?
9. Is data integrity a key parameter in the management/reporting of the environmental impact programme/activity?

Record keeping
10. Are records kept of key environmental impact-related data?

11) AUDIT AND REVIEW
Inspections and Audits
1. Is there an effective internal self-inspections system in operation?
2. Do corporate/formal audit systems/protocols address environmental impact-related programmes/criteria?
3. Is there an effective system in place for tracking implementation of audit recommendations and closing completed action?

Others
4. Do you use the services of an external company to deal with environmental issues?
5. How would you assess your environmental performance compared to international common practices?
   (rank 1 to 5, 1 = very bad, 5 = excellent)

12) Environmental performance
12. Do you monitor the following emissions? (Sources of atmospheric emissions in a refinery)

<table>
<thead>
<tr>
<th></th>
<th>A</th>
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<th>D</th>
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<th>J</th>
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<tbody>
<tr>
<td></td>
<td>CO₂</td>
<td>SO₂</td>
<td>NOx</td>
<td>CO</td>
<td>PM</td>
<td>VOC</td>
<td>H₂S</td>
<td>HF</td>
<td>Catalyst</td>
<td>Others</td>
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<tr>
<td>1</td>
<td>Desalting</td>
<td>X</td>
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<td>2</td>
<td>Atmospheric distillation</td>
<td>X</td>
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<td>3</td>
<td>Vacuum distillation</td>
<td>X</td>
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<td>4</td>
<td>Thermal cracking</td>
<td>X</td>
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<tr>
<td></td>
<td>Catalytic hydrocracking</td>
<td>X</td>
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<tr>
<td></td>
<td>Alkylation</td>
<td>X</td>
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<tr>
<td>5</td>
<td>Process furnaces</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>6</td>
<td>Boilers</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>7</td>
<td>Gas turbines</td>
<td>X</td>
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<td>8</td>
<td>FCC regenerators</td>
<td>X</td>
<td>X</td>
<td>X</td>
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<td>9</td>
<td>Flare systems</td>
<td>X</td>
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<td>10</td>
<td>Incinerators</td>
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<td>11</td>
<td>Sulphur recovery units</td>
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<td>12</td>
<td>CO boilers</td>
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<td>13</td>
<td>Coking</td>
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<td>14</td>
<td>Storage-handlg facilities</td>
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<td>15</td>
<td>Oil/water sep’ systems</td>
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<td>16</td>
<td>Fugitive em’ sources</td>
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<td>17</td>
<td>Vents</td>
<td>X</td>
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<tr>
<td>18</td>
<td>Polymerisation</td>
<td>X</td>
<td>X</td>
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</tbody>
</table>

2. The remediation systems used, the supplier, source of funding, and year of installation.
3. Which standards do you apply?
4. You are using a remediation system: describe it (indirect/continuous; method & tools, e.g. routine sampling, etc.) & explain why you started using it?
5. You don’t use a remediation system: mention the main reasons why (lack of knowledge about BATs, lack of funds to invest, no political will, etc.).
6. Are operatives aware of the emission prevention system applying?

---

5 Heaters & boilers contribute to more than 60% of SOx & NOx emissions.
6 Odorous compound, a large array of emergency controls are in place to avoid release of abnormal operation.
7 A large array of emergency controls are in place to avoid release of abnormal operation.
8 From steam ejector.
9 Particularly when firing liquid fuels.
10 From caustic washing.
122) WATER EFFLUENTS
1. Are the following effluent monitored? (mention the concentration in mg/l if available)

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<th>A</th>
<th>B</th>
<th>C</th>
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</thead>
<tbody>
<tr>
<td>Distillation units</td>
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<td></td>
<td>Oil, H₂S, NH₃, Phenols, Lead, Carbonaceous material, Benzene, Others</td>
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<tr>
<td>Hydrotreatment</td>
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<td>Visbreaker</td>
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<tr>
<td>Catalytic cracking</td>
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<tr>
<td>Hydrocracking</td>
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<tr>
<td>Lube oil</td>
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<tr>
<td>Spent caustic</td>
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<tr>
<td>Ballast water</td>
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<tr>
<td>Utilities (rain)</td>
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<tr>
<td>Sanitary/domestic</td>
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<tr>
<td>Others</td>
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</tr>
</tbody>
</table>

2. Mention the remediation systems used, the supplier, source of funding, and year of installation.
3. Do you have an effluent treatment system? If so, describe it (structure + capacity treatment + what can be treated + what’s left).
4. What do you do with the sludge of the ETS?
5. Do you have sour water strippers?
6. Benzenes: is there any plan to ban it yet?
7. MTBE: do you aim at producing more of it?
8. Are operatives aware of the effluent treatment system applying?

123) WASTE
1. Who is responsible for it?
2. Describe waste management in the refinery (storage, pre-treatment, disposal)
3. Do some wastes require special treatment?
4. How do you dispose of spent catalysts? (if special procedure, describe it)
5. Do you need a licence to dispose your waste?
6. Any specific insurance cover associated with waste handling?
7. Is there a responsible attitude to acceptance and treatment of wastes? (rank 1 to 5)
8. Are all loads weighted into the site?
9. Are full records kept of all loads received?
10. Is there adequate segregation of waste types? (rank 1 to 5)
11. Is the site secure against intruders? (rank 1 to 5)
12. Does the site have a good safety record? (rank 1 to 5)
13. Is the housekeeping good? (rank 1 to 5)
14. Is the site source of neighbourhood nuisance?
15. Do vehicles leave with dirty tyres?
16. Are there written operating procedures?
17. Are there written emergency procedures?
18. Are there adequate fire fighting facilities? (rank 1 to 5)
19. Are safety & environment protection facilities adequate? (rank 1 to 5)
20. Are operatives aware of the disposal principles applying?

114) SOIL & GROUNDWATER POLLUTION
1. Who is responsible for it?
2. Describe soil pollution management in the refinery (storage, pre-treatment, disposal)

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11 Primary (gravity), secondary (flotation) & tertiary treatments (biological); sour water strippers.
12 Overhead drum waters from distillation columns and vacuum unit ejector condensate may contain significant quantities of dissolved hydrogen sulphide & ammonia.
14 Dangerous procedure, normally part of a TA cf. Schneider (2000)
3. Do you have **regular inspection systems** (e.g. for pipelines & seals, storage tanks, pressure vessels, heaters, etc.).
4. Additional testing e.g. for leaks (e.g. acoustic surveys of tanks, dye testing, flammable gas testing, etc.)?
5. Groundwater monitoring? (one-off or periodic sample collection from monitoring wells)
6. Do some equipment have leak detection systems (e.g. sewers or tanks, by video camera\(^{15}\), hydrostatic head test)?
7. Have you carried out any soil **remediation**?
8. Who did it & how?
9. Mention the corrective action taken to monitor the following pollution as well as additional pollution sources you may have:

<table>
<thead>
<tr>
<th>Source of contaminated water</th>
<th>Tick if in the refinery</th>
<th>Corrective actions</th>
<th>Tick if used in the refinery</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational discharges</td>
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<tr>
<td>Draining water bottom tanks onto the ground</td>
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<td>16</td>
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<tr>
<td>Leaving sampling points running</td>
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<td>17</td>
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<tr>
<td>Cleaning contaminated equipment in unprotected areas</td>
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<td>18</td>
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<tr>
<td>Stripping (draining of residual contents)</td>
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<tr>
<td>Accidental spillage</td>
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<tr>
<td>Continuous:</td>
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<tr>
<td>Leaking pump seals</td>
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<tr>
<td>Leaking valve glands</td>
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<tr>
<td>Leaks from pipes works</td>
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<tr>
<td>Leaks from underground storage tanks, etc.</td>
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<tr>
<td>One-off:</td>
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<tr>
<td>Equipment failures</td>
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<td></td>
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<tr>
<td>Overfilling of tanks</td>
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<tr>
<td>Overfilling of road &amp; rail cars</td>
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<tr>
<td>Others</td>
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</table>

10. Do operative know how to deal with accidental spillage & are they equipped?
11. Oily sludges?
12. Other waste oils e.g. lube/cut/engine oils?
13. Are operatives aware of the disposal principles applying?

13) **Technological capital, input and output**\(^{22}\) (general state of the technology in the refinery + detailed description of the process subject to the investment analysed: to be use for HS&E)

**Structure refinery**: get map to deduce degree of complexity? (hydroskimming/semiCX/CX) c.f. Concawe 99/01-Brief description of the petroleum processes used in the refinery

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\(^{15}\) Costs bet. 100 & 400 € per meter…
\(^{16}\) Connect drain points directly to the sewer system.
\(^{17}\) Provide enclosed sampling loops.
\(^{18}\) Clean only in specially constructed & dedicated areas.
\(^{19}\) Provide dedicated drainage systems.
\(^{20}\) Use more equipment with appropriate design/construction standards coupled with an effective maintenance programme + effective inspection & monitoring regime.
\(^{21}\) Operational procedures & the provision of overfill protection inspection devices. Equipment failure is best guarded against by an effective inspection system.
\(^{22}\) State of the technological art (efficient/modern technologies pollute less and are less risky to operate, some types of technologies are "natural resources augmenting": are ‘negentropic’): which technologies are used? Structure of the refinery (simple? complex?)
<table>
<thead>
<tr>
<th>How many in the refinery</th>
<th>Source of technology-contractor</th>
<th>Age of technology</th>
<th>Source of financing</th>
<th>Major changes + year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Process furnaces</td>
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<tr>
<td>Boilers</td>
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<td>Gas turbines</td>
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<tr>
<td>FCC regenerators</td>
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<tr>
<td>Flare systems</td>
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<tr>
<td>Incinerators</td>
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<tr>
<td>Sulphur recovery units</td>
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<tr>
<td>CO boilers</td>
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<tr>
<td>Coke plants</td>
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<tr>
<td>Storage &amp; handling facilities</td>
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<tr>
<td>Oil/water separation systems</td>
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<td>Fugitive emission sources (flanges etc.)</td>
<td></td>
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<tr>
<td>Vents</td>
<td></td>
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<tr>
<td>Pipelines &amp; seals</td>
<td></td>
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<tr>
<td>Tanks</td>
<td></td>
<td></td>
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<tr>
<td>Sewers</td>
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</tbody>
</table>

1. How have these technologies been chosen by the refinery (use external consultancy, etc.)?
2. **Storage tanks**: underground? Capacity? N° km pipelines?

**Technological changes**
3. Do you have a team responsible for following technological evolution? Do you use external services to do so?
4. Give examples of technological improvements (since mid 1980s)?
5. Describe them: radical/incremental? Who was involved in it? Why did they happen (reduction cost, loss prevention, anti-pollution, quality control, ...)?
6. Is there an incentive system to foster technological change?
7. Do you take/have you taken part in any plan for the transfer of technological knowledge and experience? If you have benefited from any technology transfer, describe it (when, what, which way, which partners)
9. Availability of BATs in the sector
10. How far from current best practices
11. Main policies to focus on to catch up on HSE performance
12. Factors fostering HSE performance?
13. Major obstacles, external to the firm, which have inhibited HSE improvement (absence of necessary technology, high cost of equipment that would be required, high interest rates, lack of incentives for environmental improvements, competition in product markets, lack of local infrastructure, government policies, routines in management thinking, lack of information about pollution sources, other)
14. Major obstacles, internal to the firm, motivating HSE improvements (inadequate finance, other more pressing priorities, lack of interest among top management, lack of trained workers, lack of

23 Have there been any incremental modification of the acquired technology? How & by whom?
24 State of the technology compared to current best practices.
26 Cf. graph of age & spills: max bet. 13-23 years and over 38.
27 Treatment of emissions, discharges, etc., product changes, recycling, housekeeping, process modification, environmental management systems, feedback from clients, feedback from suppliers, quality management, voluntary upgrading: why?). Mention the most important ones and if similar for H&S and E.
28 Direct sales of equipment and services, technical assistance contracts, turnkey projects, wholly owned subsidiaries, licensing agreements, coproduction R&D, agreements, personnel exchanges, information transfers from documents and conferences.
information on suitable technologies, inadequate knowledge of environmental impacts/performance,
other)
15. Major sources of advice used to improve HSE performance (consultants, government organisations,
equipment suppliers, international organisations, customers, foreign parent and/or technology
supplier, industry associations, universities, other)

Input
16. Volume, $, distribution per country, major changes, quality: % sulphur, density, energy consumption,
etc.
17. MTBE: 1991-95 +280% in Arab countries (planned for 1997; source = PGA, 1994-01-06), $450M of
in Arzew: 600,000tpa, $400M methanol (1998):660,000tpa, $1,500M for ethylene/GPL
(2000):500,000tpa]

Output
18. Volume
 baisse Am Nord)? In PGA 1/12/00: X liquides Mtep en 1999: UE 30.5 (52%); Europe hors UE 2.7
(4.6%); Am Nord 15.7 (27%); Am Sud 7.8 (13%); Asie 1.3 (2%); Afq 0.9 (1.5%); PGA 160101:
exportation 1999 = 62% liquides soit 20% brut, 22% condensat, 20% raffinés. 2000?
20. PGA 160101: production raffinés 1999: 95% = carburants (19.5 Mt): composition et destination?
commercialisés > 144Mtep: part produits raffinés et projections pour l’avenir (CA: passe de 13.2
en 1999 à 22.4 Mds$ en 2000: part du raffinage?)
21. Eurosuper: sales since its launch in 2000?
marché interne (14%) +120Mtep externe (86%)
23. Profitability: en hausse too: prospects?
24. Need additional quantities of hydrogen in the future?29

14) Technological capabilities30 (to be use for HS&E)
141) LABOUR FORCE31 (general description + detailed for the one working on process analysed)
1. Composition (number, % of engineers, % external workforce, ..)
   • N° & age
   • Skills
   • Internal/external
2. Skills (background training, in-house training offered, ..)
3. Training in the refinery
   • Do you benefit from the public training system?
   • Engineers: how many % total & where have they been trained?
4. Movement (turnover, exchange with other companies, ..)
   • Turnover?
   • Exchange personnel with other companies?
   • New personnel: where does it come from? Training received once hired?

142) ORGANISATION
1. The investment decision-making process (ANALYSIS OF A SPECIFIC INVESTMENT
PROJECT)
Description of the investment - mention the technology + supplier, date, amount in $M, variation of
production capacity of the process analysed, and purpose:

29 Changes in product quality => higher level of desulphurisation require more hydrogen; while less hydrogen is
produced as aromatics are removed from production.
30 HSE performance comes with better mastery of technology Foray & Grübler (1996), which require a skilled
labour force. Besides, Enos has shown the importance incremental improvements can have on HSE performance
when studying cracking: “the improvements made in the processes subsequent to their initial application were as
significant as the innovations themselves” Enos (1962; Enos (1994). Such improvements happen thanks to a
skilled workforce, as he has also shown it in the case of the improvement of imported techniques by Korean
31 Bibliography: Enos (1994); Enos (1997); Enos (1958); Worledge (1992): 90% accidents are due to human
interaction, Duhamel (1990), Kaplinsky’s AT; Concawe report Martin (2000): fatalities due to road accidents…
1. Improvement (in capacity, quality, both)?
2. Replacement?
3. Downgrading (in capacity, quality, both)?

Description of the investment decision-making process
4. Describe the sequences of the process leading to an investment decision
5. Major organisational changes in the investment decision-making process
6. Who takes the decision: position in the hierarchy, autonomy % DMP, tools to use, dimensions to include in the process
7. Autonomy decision % head offices
8. Organisation: Is the DMP centralised (imposes standard operating procedures without supporting explicit costs) or decentralised (better top down information (legal aspects, audits) and monitoring => costly)? Team-like approach?
9. Is there a standardised process? I.e. in specific conditions act in such way or use such tool, e.g. when comes to take into account HSE pbs: is it a case by case DMP?
10. The decision is taken once all alternatives have been explored and all information collected
11. Criteria used to appraise it (I costs, changes in operation costs and revenues, pay back time, ..)
12. Are all investment decisions optimal?
13. Is there any recurring decision? Has the DMP been programmed?
14. What can undermine the optimality of an investment decision? (subjectivity, risks, lack of information, fuzziness of the organisation, influence external factors)

Tools used during the IDMP
15. How was the cost of the investment determined? (which cost is taken for the equipment: just the supplier cost?) => quid installation costs… & HSE?
16. Do you make a difference between risk and uncertainty? If you do, mention which one and in the next question mention if you use different tools and what for.
17. Mention if the following tools and analyses are Used (x), Frequently used (xx), Unknown (?), Used in a situation of risk (R) or uncertainty (U).
   • PEPS rating and ranking index
   • Composite ICRG risk rating
   • Moody’s sovereign LT debt rating
   • Standard & Poor’s sovereign LT debt rating
   • Institutional Investor credit rating
   • Payback method
   • Sensitivity analysis
   • Probability analysis
   • Computer simulation techniques
   • Shorten the payback period
   • Certainty equivalent value
   • Capital asset pricing model
   • Option value
   • Subjective evaluation of the project (when does the IDMP become subjective?)
   • Other qualitative analyses of the projects (mention)

18. React to the following statements [Agree (1), Disagree (0), Don’t know (?)]
   • The personal attitude to risk of the chairman of the board has a significant influence
   • Personal risk aversion has a strong influence on the DECISION-MAKING PROCESS
   • The further one is away from the conceptual ground zero of risk the less personal risk is perceived
   • A manager with many years experience of risk taking with the inevitable bad decisions becomes more reluctant to take high risks
   • As a manager progresses in age his willingness to take risks reduces
   • The greater the level of motivation the more willing is a person to accept intermediate risk [=> ask later if la fin justifie les moyens ie mettre en situation et demander si decision > 0 ou non]
   • Risk takers rely on little information [=> no matter uncertainty in that case only the goal counts]
   • Managers are less risk adverse in the business investment situation than in the personal investment situation
   • Following a political crisis it is better to stay out of the market
• Following a political crisis it is better to enter but ask for very high rates of return [which is the case with Algeria c.f. UNCTAD WIR 98]
• Following a political crisis it is better to pull out
• In some circumstances the rationality of the decision-maker can be limited (which ones? Influence age of the person on such BR? What else can affect perfect rationality such as ethical values or any kind of risk mentioned above?)

HSE issues at this level (use previous questions):
19. How are they taken into account in the investment decision-making process?
20. Environmental performance (takes previous questions: imptt = impacts + comparison with current best practices
21. HSE measures
22. Training
23. Maintenance

Investments in general
24. Major investments in the refinery (from 1986, mention date, technology, amount in $M, type and purpose)
25. Major HSE investments in the refinery (from 1986, mention date, technology, amount in $M, type and purpose)
26. Areas in which is the refinery most likely to invest in the next 5 to 10 years
   Field development 60%
   Transportation 21%
   Exploration 11%
   Liquefaction 7%
   Others 1%
28. Check repatriation of capital scheme (not if monopoly)
29. Check exit regulations (not if monopoly)
30. Investment programme (web environmental commitments per year)32
• Now gaz++ (65% production totale) : only following the market or not?
• In PGA 1/12/00: 23/11/2000 signature à Paris ligne crédit sur 2 ans avec BNP pour financer M B&S d’origine française: = ? rien HSE?
• Stratégie: in PGA160201: maximisation valeur production, e.g. pétrochimie & aval++: (prévoient 1.5 Mb/j en 2004, source ibid.) => En termes d’investissement prévision d’investir $21 Mds sur 2000-2004 (2/3 dév gisements: 26% partenaires étrangers): quid 1/3 restant: bip 08/12/99: 4.5Mds$ pour raffinage et pétrochimie: i.e. ? 55% en devises: les 20% restants = loans<? Any HSE requirements?
• New refinery in Adrar: HSE criteria dans le cahier des charges? Evaluation HSE des dossiers reçus/output = ? pour les besoins intérieurs++? (c.f. bip 08/12/99) autres prévues?
• Quid project ‘Promos’ (modernisation)?

2. Relations with other firms (JVs, R&D, maintenance, ..)
1. Describe the types of collaborations the refinery has with other firms (R&D? Training? Emergency? Etc.)
2. Specific ones for HSE issues?
3. Participate in symposia and exhibitions?

3. Maintenance33
1. Investments spent per year in maintenance
2. Describe the organisation of the maintenance in the refinery and for the petroleum process analysed (Regular inspections, etc.)

32 The rehabilitation of units The modernization of the instrumentation The debottlenecking of toppings The environment protection The valorization of refined product.
3. Who is in charge of it: specific team? External?
4. Main problems that occur
5. Cause = mostly technical or human?
6. Cases of emergencies? How solved?

4. Financial capabilities (refinery economics of the plant)
1. Profitability of the refinery?
2. Where is the value added located in the plant?
3. Where are the main costs located in the plant?
4. Système de comptabilité analytique?
5. Availability of investment sources (e.g. World Bank loans)
6. Availability of investment sources for HSE projects

*  *  *

*  *

2) Occupational Health & safety (OHS, pp. 21-36)³⁴

21) OHS Policy and management (of the refinery + specific to the case of investment chosen)
211) OHS POLICY
1. how important is environmental policy? + general questions policy
2. how strong are environmental pressures in your country or region
3. do you feel pressure % environmental performance? (perception differ across people)
4. how far from EU standards
5. how will catch up
6. National environmental policy statement: how will do it?
7. “Continue supplying needs in refined products. For the specifications, a program of suppression of lead in gasoline (reduction to 0.40 g/l since 01/01/1999, to 0.15 g/l from 01/01/2002 and only unleaded starting 01/01/2005)”
8. For the gas-oil, a reduction of sulphur content to 0.15 % weight. Also improvement of the oil formulation for their adaptation to the new requirements of the market.
9. International environmental policy statement: how will do it?
10. Continue to offer some intended refined products to the export to norms on targeted markets by the introduction of the MTBE for the production of gasoline eurosuper 95 for 2000. Starting 2005: integration of an isomerisation unit to produce Eurosuper 95 (aromatics content).
11. For gas-oil, starting 2005, the improvement of the sulphur content: an HDS unit for producing less than 50 ppm sulphur content has to be built
12. Contribute to the environment protection
13. Impact Euro-Mediterranean Partnership HSE?
14. Knowledge about regulation & procedures used by the government to enforce policies

212) ORGANISATION AND MANAGEMENT

Policy Statement
1. Is there a written site policy that includes occupational health and safety (OHS) and is it up to date and signed by a senior manager?

Implementation
2. Are company guidelines available, or national codes of practice (COPs) identified as standards for implementation of health and safety protection aspects of company policy?
3. Are responsibilities assigned for implementation of site health and safety policy and associated guidelines or codes of practice (COPs)?
4. Is there a management-endorsed plan for the implementation and maintenance of the site OHS programme?

³⁴ Questions from §1 to 8 are adapted from a Concawe report n°99/58.
5. Is performance of the OHS function, programmes and personnel regularly reviewed by management?
6. Are contractors provided with health and safety protection equivalent to that provided for company employees?

**Resources**
7. Are there adequate numbers of competent personnel to carry out the necessary OHS programme and what position do they occupy in the company?
8. Is the site management team aware of the health and safety-related requirements for the site and which power do they have to enforce them?
9. If implementation of the OHS plan relies on location personnel, are they aware of their duties and properly trained and competent?

**Communications**
10. Have the policy and arrangements for implementation been communicated to all employees, contractors and other potentially affected groups?
11. Does the person responsible for providing occupational hygiene advice and services have effective lines of communication?
12. Is there a site Health and Safety Committee (H&SC)?
13. Is there provision for informing management of regulatory and other relevant developments in OH?

**213) ASSESSMENT OF HEALTH AND SAFETY RISKS**

**Hazard identification**
1. Is there an inventory of all hazardous substances present on-site, along with a practice/procedure for keeping the inventory current?
2. Are current material safety data sheets (MSDSs) or other hazard data readily available for the substances on the inventory?
3. Do procurement/purchasing procedures provide for review of hazards before ordering?
4. Are other (i.e., physical/biological agents and ergonomic factors) health and safety hazards (that are relevant to the site) identified and listed?
5. Do capital projects, facility modifications and new designs include a procedure for competent review of associated health and safety risks?
6. Do procedures provide for review and dissemination of information on significant “new” health and safety hazards that are not familiar to the site/personnel?

**Health and safety risk assessment (HRA)**
7. Is there a procedure in place to assess risks arising from exposures to identified hazards in the workplace?
8. Are HRA conducted for tasks as well as, full shift exposures?
9. Does the HRA programme identify the need for biological monitoring (e.g. benzene metabolites in urine), biological effect monitoring (e.g. audiometry), or biochemical effect monitoring (e.g. DNA-alkylation) and cross-reference results to relevant personal exposure data?
10. Are monitoring data summarised or analysed statistically for comparison to relevant regulatory standards, i.e. 8-hour time-weighted average and short-term (15-minute) exposure limits, as appropriate?
11. Does the HRA process identify higher priority exposures/risks, tasks or work groups for follow-up exposure monitoring or improved control?
12. Are HRA records and documentation adequate?

**Assessment procedure**
13. Does the HRA procedure meet accepted criteria?

**Communications**
14. Have the results of HRAs been properly communicated to management?
15. Is there an effective procedure to communicate the results of HRAs to all persons at risk?
16. Are the results of HRAs publicly available?

**Management of identified risks**
17. Are the results of HRAs integrated into overall site management processes?
18. Is provision made for the reassessment of health and safety risks?
CONTROL OF HEALTH AND SAFETY RISKS

General
1. Is the generally-accepted “hierarchy of controls” applied (i.e., emphasis on engineering control of hazardous exposures, followed by procedural controls, then personal protection)?

Engineering Control
2. Have engineering control options been installed for significant health and safety risks?
3. Where fitted, are engineering controls installed according to accepted engineering standards?
4. Where fitted, are engineering controls properly maintained?
5. Where fitted, are engineering controls checked and tested regularly?

Procedural Control
6. Are documented procedures available that address health and safety hazards encountered during routine operations?
7. Are documented procedures available to address health and safety hazards of non-routine operations, including turnarounds (TAs)?
8. Are health and safety considerations included in Permit to Work (PTW) procedures?

Personal Protective Equipment (PPE)
9. Is there a formal/documented programme for the provision of PPE that is needed for protection against health and safety hazards?
10. Are personnel, facilities and resources available for the selection, use and maintenance of PPE?
11. Are employees given suitable information, instruction and training in PPE use and maintenance?

MONITORING OF PERFORMANCE

Performance indicators
1. Are performance indicators identified and endorsed by management for tracking the effectiveness of the occupational hygiene programme?
2. Do performance indicators provide an insight into the effectiveness of site health and safety protection programmes?

Incident reporting and investigation
3. Are health and safety related incidents (temporary/permanent disability, occupational exposure limit exceedences, complaints, etc.) that are potentially related to workplace exposures identified, reported to management and investigated?
4. Are criteria for the classification of health and safety-related incidents established by the OHS function and endorsed by management?

NON ROUTINE SITUATIONS

Emergency Response Planning
1. Is there an emergency response plan?
2. Does the emergency response plan include an effective organisational structure that includes OHS resources?
3. Are neighbouring industry and community emergency response organisations included in the emergency response plan?
4. Is emergency hazard information available for all hazardous substances?

Training for Emergencies
5. Are employees trained in the procedures to be followed in an emergency?

Turnarounds and Major Maintenance
6. Are health and safety risks considered during planning/procedures development for turnarounds (TA) and major maintenance?

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35 C.f. Concawe 00/52 p. 8.
36 Basic procedural mechanism linked to the health protection plan to specify he risk reduction measures that need to be adopted for individual TA activities.
37 + cf. Concawe report 00/52 appendices 2&3: description of typical operations carried out during TAs + of strategic issues to be considered. Skills are a critical issue: c.f. Schneider (2000): an accident has been well managed thanks to the skills of the personnel.
7. Are the potential exposures among TA and maintenance workers monitored and actively assessed during the TA or major maintenance activity?
8. Describe typical operations carried out during a TA. Frequency TAs = ?
9. Who is involved in TAs (employees, employee reps, contractors, government agencies, local authorities, emergency services, the media).

**Skill requirements**

10. Are planners and managers familiar with and able to apply (rank 1 to 5, 5 = better mark):
- Regulatory standards and requirements
- Company health policy and objectives
- Company occupational health standards
- Operating unit procedures for the protection of workers’ health
- Industry occupational health guidelines
- Communicate effectively with the persons/institutions involved in TAs

11. When the TA is initiated, supervisors should play a key role in monitoring compliance with health procedures. What is the supervisor’s working knowledge of (rank 1 to 5):
- The results of health risk assessments
- The permit to work system and occupational health aspects of operating procedures
- The correct use of control measures
- The effective implementation of a PPE programme
- First aid procedures
- Emergency incident procedures
- Incident investigation procedures, including health-related incidents
- Effective communication skills with employees and contractors, including the ability to lead discussions on hazards and risks, such as ‘toolbox talks’.

12. The areas of principal concern to operators and craftsmen are the recognition of hazardous agents, where they are to be found and the ways to prevent or control exposure. This requires information, instruction and training in (rank level from 1 to 5):
- The recognition of hazardous agents
- The risks to health associated with key agents/tasks
- The correct use of engineering measures to control health risks
- The correct use of personal protective equipment
- First aid procedures
- Emergency incident procedures
- The permit to work system

13. Full and effective co-operation and compliance with occupational health procedures are essential in maintaining a low risk environment. What is their specific training for (rank 1-5):
- Entry to confined space(s)
- Work with hot processes (e.g. welding: soudage)
- Some specified chemical hazards (e.g. HF, benzene, corrosives)
- Use of breathing apparatus
- Do you employ full and part-time first aiders and which training and national certification have they received?

14. Health specialists who may be associated with the TA, including occupational hygienists, ergonomists, occupational physicians and nurses, should be trained and qualified to relevant national standards. Rank their basic skills regarding their ability to carry out (1 to 5):
- Health risk assessments, including job/task exposure monitoring
- Risk control planning
- Compliance assurance checks, including verification activities
- Training of managers, supervisors
- Data collection, analysis and review
- Audits of performance

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38 The permit system is an integral part of the TA process and supervisors should be well-trained so as to be aware of tasks for which a permit is necessary, e.g. confined space entry.
39 Personal protective equipment programme: management system to ensure that PPE is selected, maintained and properly used to control exposure.
15. Same question for **occupational medicine**:
- Health risk evaluations
- Fitness to work evaluations
- Health surveillance of relevant workers
- Clinical management of occupational illnesses and injuries
- Training of managers, supervisors
- Data collection, analysis and review
- Audits of performance

16. **Contractor personnel** may not have an understanding or knowledge of the refinery health hazards or procedures, including the safe systems of work which have been adopted. The specific skills necessary will depend on the nature of the task(s) being carried out and the work area in which the tasks are being conducted, e.g. welding, BA use\(^40\), first aid, etc. (rank):
- Risks associated with contractor activities
- Risks associated with the local area/activities in the refinery
- Controls required to control the health risks
- Permit to work systems
- Local emergency response requirements
- First aid procedures
- Site specific occupational health requirements, e.g. rules on smoking and drinking
- Agreed procedures for the notification of near misses, unsafe acts and conditions and accidents
- Have you clearly defined the links between the refinery and contractor occupational health and safety management systems?

**Breakdown**

17. Are written procedures/practices in place to control health and safety risks during breakdown and unplanned shutdowns?

217) TRAINING AND AWARENESS

**Hazard Communication**
1. Are Material Safety Data Sheets (MSDSs) or similar information, readily available to potentially affected workers for all hazardous substances and preparations on-site?
2. Are appropriate signs and hazard warnings erected in work areas (e.g., noise and radiation as well as hazardous materials)?
3. Are containers and vessels properly labelled as to their contents?
4. Are the results of HRAs shared with potentially affected workers?

**Training**
5. Is appropriate training on hazard identification, assessment and control, and their OHS responsibilities given to managers, supervisors, employees and contractors?
6. Is health and safety-related training an integral part of the site personnel/training system(s)?
7. Are basic concepts of health and safety protection included in the induction courses for new employees, and are employees trained on health and safety-related aspects of new jobs/transfers?
8. Is specific instruction and training given in the use of exposure control measures and procedures for reporting any observed deterioration in their performance?
9. Is periodic/refresher training provided to all employees?

**Community Awareness**
10. Have members of the community been advised as to the nature of the hazards/risks to the local environment and community that have been identified from the development of emergency response scenarios?
11. Do site policies properly address potential health and safety impacts on the community or local environment?

\(^{40}\) Breathing apparatus.
218) DOCUMENTATION, DATA INTEGRITY AND RECORD KEEPING

Documentation
1. Are health and safety-related practices/procedures integrated into standard operating procedures?
2. Are criteria, components and responsibilities documented for key stand-alone programmes that are applicable to the site/facility, such as:
   - hearing conservation
   - respiratory protection
   - other PPE
   - radiation safety
   - exposure assessment
   - exposure monitoring?
3. Is documentation of health and safety-related practices and procedures part of the site system(s) for documentation and updating of standard operating procedures?

Data Integrity
4. Are samples taken or measurements made using validated methods and reliable instrumentation?
5. Is all sampling equipment properly maintained, tested and calibrated?
6. Are all samples analysed using validated methods?
7. Does the analytical laboratory have an adequate quality control procedure, specific to the occupational hygiene analyses?
8. Does the laboratory participate in an external-quality assurance programme?
9. Is data integrity a key parameter in the management/reporting of the OHS programme/activity?

Record keeping
10. Are records kept of key OH-related data, including the following (as applicable):
    - HRAs
    - biological monitoring
    - personal exposure monitoring
    - workforce training
    - analytical results
    - lab QA/QC data
    - equipment calibration
    - training/fitting of PPE
    - checks of controls (e.g., ventilation)?

219) AUDIT AND REVIEW

Inspections and Audits
1. Is there an effective internal self-inspections system in operation, e.g. planned health and safety walk-throughs?
2. Do corporate/formal audit systems/protocols address health and safety-related programmes/criteria?
3. Is there an effective system in place for tracking implementation of audit recommendations and closing completed action?

Others
4. Insurance policy for the site =? Require HAZOP?
5. Do you use the following methods:
6. HAZOP (HAZard & OPerability) studies (to identify risks & prevent them)? (=> need to have an accredited team leader)
7. Task Risk Assessment (TRA- c.f. Concawe report 3/97 + Review 7(1) 04/98) mostly used when new task or new environment)? How?
8. What resources are available to implement OHS plans?
9. Mention the causes of major accidents and what has been done to prevent them?
10. Do you use the services of an external company to deal with OHS issues? (such as Boots & Coots for E&P)
11. How would you assess your OHS performance compared to international common practices? (rank 1 to 5, 1 = very bad, 5 = excellent)
12. Which OHS standards should you apply?
13. How important is the OHS issue for you and why?
14. Do you collect the following data collected in Europe?
<table>
<thead>
<tr>
<th>Sector</th>
<th>Manufacturing</th>
<th>Marketing 41</th>
<th>Both Sectors</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Own Staff</td>
<td>Contractor</td>
<td>All Workers</td>
</tr>
<tr>
<td>Total hours worked (million)42</td>
<td>92 57 149</td>
<td>178 121 299</td>
<td>271 178 448</td>
</tr>
<tr>
<td>Number of fatalities 43</td>
<td>0 2 2</td>
<td>2 4 6</td>
<td>2 6 8</td>
</tr>
<tr>
<td>Number of LWIs 44</td>
<td>411 461 872</td>
<td>654 391 1045</td>
<td>1065 852 1917</td>
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<tr>
<td>Total days lost through LWIs 45</td>
<td>7917 7948 15865</td>
<td>10764 5189 15953</td>
<td>18681 13137 31818</td>
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<tr>
<td>Number of RWIs 46</td>
<td>94 155 249</td>
<td>95 30 125</td>
<td>189 185 374</td>
</tr>
<tr>
<td>Number of MTCs 47</td>
<td>933 636 1569</td>
<td>366 253 619</td>
<td>1299 889 2188</td>
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<tr>
<td>AIF 48</td>
<td>12.5 24.5 17.4</td>
<td>6.5 5.6 6.1</td>
<td>8.3 11.0 9.4</td>
</tr>
<tr>
<td>LWIF 49</td>
<td>4.5 8.1 17.4</td>
<td>3.7 3.2 3.5</td>
<td>3.9 4.8 4.3</td>
</tr>
<tr>
<td>LWI Severity (Days/LWI) 50</td>
<td>15.5 19.5 17.5</td>
<td>22.7 18.5 21.1</td>
<td>19.5 19.1 19.3</td>
</tr>
<tr>
<td>Distance travelled (106 km) 51</td>
<td>474</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Road Accidents 52</td>
<td></td>
<td>429</td>
<td></td>
</tr>
</tbody>
</table>

Source: Results European downstream oil industry safety performance-1999, Concawe report n°1/00 in Martin (2000)

15. Ask this data if available

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41 Marketing includes all non refining activities including “Head Office” personnel.

42 Hours worked by employees and contractors. Estimates should be used where contractor data is not available.

43 This is a death resulting from a work-related injury where the injured person dies within twelve months of the injury. In 1999: 75% = road accidents (6 in marketing…).

44 Lost Workday Injury is a work-related injury that causes the injured person to be away from work for at least one normal shift because he/she is unfit to perform any duties.

45 The number of calendar days lost through LWIs counting from the day after the injury occurred.

46 Restricted Workday Injury is a work-related injury which causes the injured person to be assigned to other work on a temporary basis or to work his/her normal job less than full time or to work at his/her normal job without undertaking all the normal duties.

47 Medical Treatment Case is a work-related injury which requires the attention of a medical practitioner. It excludes first aid treatment.

48 All Injury Frequency which is calculated from the sum of fatalities, LWIs, RWIs and MTCs divided by number of hours worked expressed in millions.

49 Lost Workday Injury Frequency is calculated from the number of LWIs divided by the number of hours worked expressed in millions.

50 Lost Workday Injury Severity is the total number of days lost as a result of LWIs divided by the number of LWIs.

51 This is the distance, expressed in millions of kilometres, covered by company owned delivery vehicles and company cars whether leased or owned. It should also include kilometres travelled in employee’s cars when on company business.

52 Any accident involving any of the vehicles described above.

53 Road Accident Rate is calculated from the number of accidents divided by the kilometres travelled expressed in millions.