Improving e-waste policies: The role of post-normal indicators

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Cédric Gossart (Associate Professor, Telecom Institute, Cedric.Gossart@telecom-em.eu)

Jaco Huisman (Associate Professor, Delft University of Technology, j.huisman@tudelft.nl)

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Summary

This paper explores the role indicators can play in supporting solutions to solve the e-waste problem.[1] Many parts of the world are witnessing the development of e-waste solutions (policies ...). They involve the development of complex and numerous indicators to evaluate the progress and improve the performance of these initiatives. However, even in Europe there is a lack of good quality data, which makes it difficult to evaluate and compare the performance of e-waste solutions across countries. Having a visible albeit aggregated index of the performance of e-waste solutions would create incentives for countries to catch up with others. This paper suggests developing a post-normal index evaluating the performance of the solutions adopted by countries to solve this crucial problem of modern societies. Indeed, not only does this research seek to conceptualise such an index (the E-waste Solution Index -ESI), it also examines the extent to which it can be applicable in practice, and discusses the potential contribution of post-normal indices to the transition towards sustainable societies.

[1] E-waste is a synonym of Waste of Electronic and Electrical Equipment (WEEE). An EEE becomes waste when its owner decides to dispose of it.

1. Introduction

Waste of Electrical and Electronic Equipment ("WEEE" or "e-waste") flows and stocks are increasing fastly in the world, and many countries are developing and supporting solutions to this acute ecological and societal problem. Indeed, not only is e-waste a hazardous waste; by being shipped to developing nations for dismantling it is also the source of moral dilemmas since rich countries that can afford large amounts of Electrical and Electronic Equipments (EEEs) per inhabitant, do net export potentially toxic substances by not treating its hazardous waste domestically. The aforementioned solutions notably take the form of e-waste policies focusing on the development of take-back systems, which imply to design complex indicators to evaluate their progress and improve their performance. For example, in the EU the pioneering WEEE directive (2002/96/EC) has led to the setting up of formal take-back systems requiring the registration of all firms putting EEE on the EU market, and has imposed the formal collection and treatment of all WEEE. However, even in Europe the solutions adopted to solve the e-waste problem as well as their performance is very heterogeneous, and an improvement of this performance is limited by a lack of good quality data and comprehensive systemic thinking as many actors are involved in collection, logistics, recycling, auditing and financing. Having a visible albeit aggregated indicator evaluating the performance of the solutions adopted in a given country to solve the e-waste problem could help engage citizens and policy-makers in this major challenge. It would create incentives for countries to catch up with others and to collect and diffuse better quality data about this problem and how it is being tackled. It could also increase transparency and foster the development of more reflective and dynamic policies that challenge existing policy frameworks, goals and underlying norms, since better informed stakeholders tend to be empowered to question the very premises of policies beyond their day-to-day performances.

Besides, from a methodological point of view, in spite of the production of comprehensive studies comparing e-waste policies, in the EU for example, there are still huge discrepancies concerning the performances of the solutions developed in member states to solve the e-waste problem. Such studies would benefit from the existence of a well-known and pedagogical index, even if it is not as comprehensive as in describing every single complexity of the take-back system functioning.[2] In order to support the development of "best" e-waste policies,[3] a group of scholars from the StEP initiative in which all e-waste stakeholders are represented,[4] has started a project aiming to construct an aggregated E-waste Solutions Index (ESI). Part of the StEP ADDRESS project,[5] the ESI seeks to evaluate and benchmark the solutions put in place in any country in the world to solve the e-waste problem (Huisman 2010). The ESI would help develop efficient e-waste solutions in both developed and developing countries,

[2] The limits of evaluation studies are regularly underlined by evaluation experts, including the ones working on sustainable development issues. See the last Easy-Eco conference that took place in Brussels in November 2010, http://www.sustainability.eu/easy/?k=conferences&s=brussels.

[3] A policy which outcomes meet the objectives defined in the official e-waste policy of a given country.

[4] Hosted by the United Nations University in Bonn, the StEP (Solving the E-waste Problem) initiative brings together key stakeholders (academics, government officials, NGOs, firms, international organisations, ...) working on solutions to the e-waste problem. See http://www.step-initiative.org.

[5] This StEP project seeks to inform e-waste related research and development work with up-to-date and solid data on the global e-waste status and global quantities of it and estimate future developments as well as trends and improvements made over time.

by stirring up the efforts of these countries to improve the performance of these solutions, for example by collecting and diffusing more reliable and comparable e-waste-related data.

To construct a post-normal index summarising the performance of e-waste solutions in a given country, all stakeholders need to be consulted. Although it will not capture all issues at stake, it should be able to provide a reliable picture of the performance of e-waste solutions in a variety of countries. In addition, the proposed framework should accommodate the cases of both developed and developing regions. Particular attention will be paid to the limits of indicators, since "policy decisions can be ineffective or even counterproductive if they do not consider factors which influence index behaviour", such as the scale of available data and the weighting of indicator data (Mayer (2008).

The ESI is based on previous work carried out within StEP (from the UNU report[6] and the White Paper on take-back systems[7] to the forthcoming StEP Green Paper on e-waste Indicators), and on a consultation of key stakeholders concerned with and involved in the provision of e-waste solutions (international organisations, recyclers, NGOs, OEMs, ...). It expresses with a single number for a given country the percentage of objectives achieved by this country to solve the e-waste problem (collection rate of e-waste, recycling rate, treatment specifications, etc.). This score can then be used to benchmark the performance of countries as regards their efforts attempting to solve the e-waste problem.

Before explaining how the E-waste Solutions Index (ESI) has been constructed and could further be developed, the e-waste problem is introduced and the history and current status of e-waste policies in the world are presented. We then explore the relationships between indicators and policies, and conclude by bringing to the fore ways by which indicators can contribute to the transitions towards sustainable societies.

2. The ambiguous relationships between indicators and policies

An index is a number derived from a series of observations that can be used as an indicator or as a measure to indicate a specific characteristic or property. Examples of indices include:

- The Human Development Index (HDI),
- IFC and Standard & Poor's carbon efficient index for emerging markets,[8]
- U.S. Standard & Poor's Carbon Efficient Index,[9]
- Dow Jones Sustainability Indexes,[10]
- Ethibel Sustainability Index,[11]
- Sustainable Society Index,[12]
- Ecological Footprint (EF),[13]

[6] See http://ec.europa.eu/environment/waste/weee/pdf/final_rep_unu.pdf.
[7] See http://www.step-initiative.org/pdf/white-papers/StEP_TF1_WPTakeBackSystems.pdf.
[8] Aims to encourage carbon-based competition among emerging-market companies, http://www.ifc.org/ifcext/sustainability.nsf/Content/Publications_SustainableInvesting_Brochures.
[9] http://www.standardandpoors.com/indices/sp-us-carbon-efficient.
[10] http://www.sustainability-index.com/.
[11] http://www.ethibel.org/subs_e/4_index/main.html.
[12] See Van de Kerk & Manuel (2008).
[13] For a definition and comparison between the EFI and the ESI, see Siche, Agostinho et al. (2008).

- Environmental Sustainability Index (ESI).[14]

As far as e-waste issues are concerned, initiatives seeking to create simple and visible performance measures have also been taken into account, such as the "Guide to greener electronics"[15] or the "Solar Company Scorecard"[16] (Silicon Valley Toxics Coalition). However, both measures only target one stakeholder out of multiple involved in the take-back systems implementation, being the producers. No simple and visible measures exists that focus on the country perspective.

For subjects broader than e-waste, attempts have been made to construct aggregated indicators, for example to benchmark sustainable development achievements. Van de Kerk & Manuel (2008) have built a sustainable society index (SSI), which "integrates the most important aspects of sustainability and quality of life of a national society in a simple and transparent way" (it consists of 22 indicators grouped into 5 categories and has been developed for 150 countries). Böhringer & Jochem (2007) have underlined the limits of sustainability indices such as the HDI or the ecological footprint (EF) that provide one-dimensional metric to valuate country-specific information. With Hezri & Dovers (2006), we argue that by taking a "post-normal turn",[17] namely provided that they are developed with users, indicator systems can overcome part of these problems and co-optimise both scientific and symbolic objectives. Indeed, as these two authors put it:

> "With a post-normal orientation, indicators are mobilised not only toward instrumental and conceptual utilisation, but encompass tactical, symbolic and political utilisation. In all cases, the marketability of indicators is a critical consideration to ensure they will pass the cognitive screening of potential users, linking the informational content to the chain of action in strategic advocacy."

Böhringer & Jochem (2007) also review the explanatory power of various sustainability indices applied in policy practice, and conclude that "these indices fail to fulfil fundamental scientific requirements making them rather useless if not misleading with respect to policy advice". They find that normalization and weighting of indicators are often associated with subjective judgments, but that scientific rules exist to guarantee consistency and meaningfulness of aggregated indices. In a paper entitled "Sustainability of nations by indices" Siche, Agostinho et al. (2008) suggest ways to overcome these difficulties for the "Environmentalal Sustainability Index", which would for example "be more useful if it disaggregated into its individual components, allowing the user to decide on appropriate weights".

Evaluating environmental policies is key to improve them and to justify their undertaking in the eye of citizens, who pay taxes to finance these policies and who may increasingly support

[14] Composite index published from 1999 to 2005, http://sedac.ciesin.columbia.edu/es/esi/.
[15] See http://www.greenpeace.org/international/campaigns/toxics/electronics/how-the-companies-line-up/.
[16] See http://www.solarscorecard.com.
[17] See Funtowicz & Ravetz (1994)

their objectives. As opposed to policy appraisal,[18] policy evaluation is an ex post analysis that assesses the success of a policy and suggests lessons to be learnt for the future. Policy evaluation can be complemented with policy appraisals to question the legitimacy, accountability and normative justification for public action and its embedded and seemingly neutral instruments (Turnpenny, Radaelli et al. (2009)). As Lehtonen (forthcoming) puts it: "Indicators are employed to monitor policy performance and foster accountability". But indicators are not neutral, as they can for example be used by policy makers to their own advantage. The author argues that they "have been shown or assumed to exert powerful influence on policies and societies at large, not least because they are seen to provide rigorous, quantifiable data".

Therefore, caution must prevail when using indicators to evaluate public policies. This is all the more important since they have a strong indirect influence on frameworks of thought or on how public problems are shaped. And as Gusfield (1980) has shown in his analysis of the "Drinking-Driving" public problem, the initial phase (the construction of the problem itself) of a public policy is paramount. In the next section, we shall examine how the e-waste problem and its policies have emerged, before analysing how indicators have been and could be used to solve this public problem.

3. The construction of e-waste policies

There are seldom policies without a public problem to solve. Therefore, before delving into e-waste policies, we shall start by shedding some light on what e-waste is. There are multiple definitions of e-waste; the following table provides an overview of the ones circulating in the international arena in 2005:

Table 1. Overview of selected definitions of WEEE/e-waste

Reference	Definition
EU WEEE Directive (EU, 2002a)	"Electrical or electronic equipment which is waste... including all components, sub-assemblies and consumables, which are part of the product at the time of discarding." Directive 75/442/EEC, Article 1(a) defines "waste" as "any substance or object which the holder disposes of or is required to dispose of pursuant to the provisions of national law in force."
Basel Action Network (Puckett and Smith, 2002)	"E-waste encompasses a broad and growing range of electronic devices ranging from large household devices such as refrigerators, air conditioners, cell phones, personal stereos, and consumer electronics to computers which have been discarded by their users."
OECD (2001)	"Any appliance using an electric power supply that has reached its end-of-life."
SINHA (2004)	"An electrically powered appliance that no longer satisfies the current owner for its original purpose."
StEP (2005)	E-waste refers to "...the reverse supply chain which collects products no longer desired by a given consumer and refurbishes for other consumers, recycles, or otherwise processes wastes."

Source: Widmer, Oswald-Krapf et al. (2005).

[18] Process of examining ex ante the options for meeting policy objectives and weighing up their costs, benefits, risks and uncertainties.

Electronic products vary in hazardous content, high-value content, and ease of recycling. As a result, the scope of products accepted for recycling within current e-waste recycling systems also varies widely. For example, the European Union now requires the recycling of a broad group of electronic products. The WEEE directive of the European Union, defines 'EEE' (Electrical and Electronic Equipment) as "equipment which is dependent on electric currents or electromagnetic fields in order to work properly". Thus, each EU member state must handle all types of e-waste, but may choose to separate certain types of e-waste into different systems. For example, in the Netherlands, ICT-Milieu handles the category 3 (IT and Telecommunications Equipment), while its counterpart NVMP is responsible for all other categories of e-waste. In other countries, the scope of e-waste products handled within mandated systems is much smaller. For example, the US state of Maine only collects display devices (TVs, computer monitors, and laptop computers).

Finally, the economic, environmental, social and geopolitical consequences of the increasing tension around the trade of rare earths make proper e-waste recycling a must for ICT-driven economies. For example, UMICORE underlines that in 2006 demand for metals has grown by a two digits rate for metals entering the production chain of TV-LCD (+40%), laptops (+30%), digital cameras (+20%), or mobile phones (+15%).[19]

It is therefore paramount to design e-waste policies that are efficient and properly enforced. For this purpose, robust indicators must be constructed and reliable data collected. Then, further improvements will be achieved by learning from best practices in other countries. When the Basel Action Network, an NGO serving as a watchdog for the Basel Convention, released its fist documentary "Exporting Harm: The High-Tech Trashing of Asia" in 2003, the European Community directive 2002/96/EC on waste electrical and electronic equipment (WEEE) was just coming into force. When it released the second movie in 2005 ("The Digital Dump: Exporting Re-Use and Abuse to Africa"), this EU directive which sets collection, recycling and recovery targets for almost all EEE was officially being implemented (13 August 2005).

But this piece of legislation came a long way. The first draft of the WEEE directive was issued in early 1998, but was harshly criticised by industries all over the world (US, EU, Japan, Canada, Australia ...) for failing to back material bans and extension of producer responsibilities with sound scientific evidence. Its scope was said to be too broad and industry had not been consulted. In July 1998 a second draft circulated without further integration of industries' concerns. Although the electronics industry did not officially oppose the principle behind the directive, it started organising a collective counter-attack, especially against the costly matter of material bans. Prepared in a similar fashion, the third draft came out in July 1999. The subsequent versions and revisions of the directive will keep sparking industry fury, leading Huisman (2006) to call it "An old-fashioned Directive". Indeed, they stress that "large parts of the EU WEEE Directive [were] written in a time (around '96) where the thinking was dominated by looking at ways to: 'do good for the environment' with the Extended Producer Responsibility (EPR) principle as a starter", without looking at enforceability. What might be consequence of such old fashion way of crafting European legislation, the WEEE directive

[19] Source: Hagelüken & Buchert (2008).

fell short of meeting its key objective to provide incentives to ecodesign EEE for easier dismantling, recycling, and reuse of components (Castell, Clift et al. (2004)).

The directive required EU member states to transpose its provisions into national laws by 13 August 2004, but only Cyprus could finally meet this deadline. One year later, all member states but Malta and the UK had done so. In other parts of the world, governments have also taken steps to solve the e-waste problem. The bill is supported by environmental groups as well as electronic manufacturers Apple, Dell, and Samsung.[20] China has banned the import e-waste since 2001, and on 5 March 2009, the Chinese e-waste legislation was introduced; it came into effect in January 2011.

All these countries would benefit from a visible index valuing their efforts in solving the e-waste problem, which would also foster information exchange about best practices.

4. Indicators and e-waste policies: The need for a post-normal index

When looking at how e-waste policies have been constructed in Europe and other parts of the world, one can identify that the following actors can contribute to solve the e-waste problem:

- International non-profit & nongovernmental actors :
  - UN agencies
  - European Commission
- National public actors:
  - Parliaments
  - Government bodies
  - Local authorities
- Private actors:
  - Firms:
    - Producers
    - Distributors
    - Recyclers
    - Refurbishers
    - Service Providers
    - Professional organisations
  - Final users of EEEs (households, professional users of household EEEs)
  - Producer associations (lobbies, industry representatives, ...)
  - Consumer associations
  - NGOs

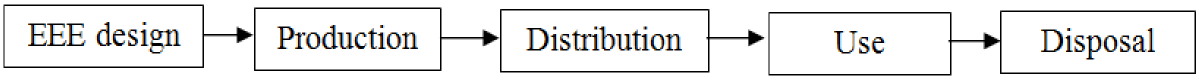
[20] See http://www.electronicstakeback.com/legislation/federal_legislation.htm.

- Labour unions
- Media

- Third Party Organisations (TPOs)[21]

These actors can exert their influence at any of the following stages of e-waste generation, starting from the design of the equipment to its end-of-life:

Figure 1. Stages of the life cycle of an EEE



Therefore, when searching for indicators reflecting the efforts of the relevant stakeholders in trying to solve the e-waste problem, all these actors and stages must be taken into account. The next figure shows the actors involved in the implementation of the French e-waste take-back system (grey boxes concern activities which are subcontracted by a TPO). In this country, TPOs are non-profit organisations formed by companies manufacturing EEEs. Municipalities are free to contractualise with any of them (one being specialised in energy saving hazardous light bulbs) so that they manage the material and financial flows associated with e-waste. [22] It is a rather complex picture, which complicates its assessment e.g. by policy evaluators. We shall now introduce some studies that have attempted to do so.

Different methods have been used to evaluate e-waste policies. For example, to compare take-back system in Switzerland and India, Khetriwal, Kraeuchi et al. (2009) first present an overview of the two systems and then compare them on the basis of four criteria:

- E-waste per capita,
- Employment potential,
- Occupational hazards,
- Emissions of toxics.

But the choice of these criteria is not robustly justified by the authors, since they were chosen "because they feature prominently in discussions related to e-waste". The result of the evaluation gives only a first qualitative review of environmental and social aspects of e-waste.

Table 2. Evaluation results for the comparison criteria

Criterion	Switzerland		India	
	Level	Implication	Level	Implication
E-waste per capita	High	Negative	Low	Positive
Employment Potential	Low	Negative	High	Positive
Occupational Hazard	Low	Positive	High	Negative
Emissions of Toxics	Low	Positive	High	Negative

[21] Whatever their legal status might be: NGOs, private firms, governmental bodies...
[22] About the case of an early moving country like Switzerland, see Khetriwal, Kraeuchi et al. (2009).

A more detailed comparative analysis has been provided by Widmer, Oswald-Krapf et al. (2005), who are using the following framework to construct the e-waste profile of a country:

Table 3. Indicator system to measure and compare WEEE management systems

Aspect	Criterion	Indicator
Structural framework	Politics and legislation	Ratification of Basel Convention and Ban Amendment
		Status of a national waste legislation
		Status of a national e-waste legislation
		Corruption perception index
	Economy	Capital cost (industrial investments)
		Secondary raw material market
	Society and culture	Civil and political liberties
		NGO activities
		Recycling culture
		Environmental awareness in society
	Science and technology	Knowledge in WEEE recycling technologies
		Research in WEEE management / recycling technologies
Recycling system	Material flow	WEEE generation per capita
		Closed loop recycling management
	Technologies	Efficiency of material recovery
		Quality of recovered material
	Financial flow	Financial coverage
		Externalities coverage
		Financial incentives for eco-design
Impacts	Environment	Final disposal of WEEE in unsave landfills
		Emissions of hazardous substances
	Human health	Health and safety implementation at workplaces
		Exposure of neighbouring population to hazardous substances
	Labour	Number of jobs generated
		Income distribution

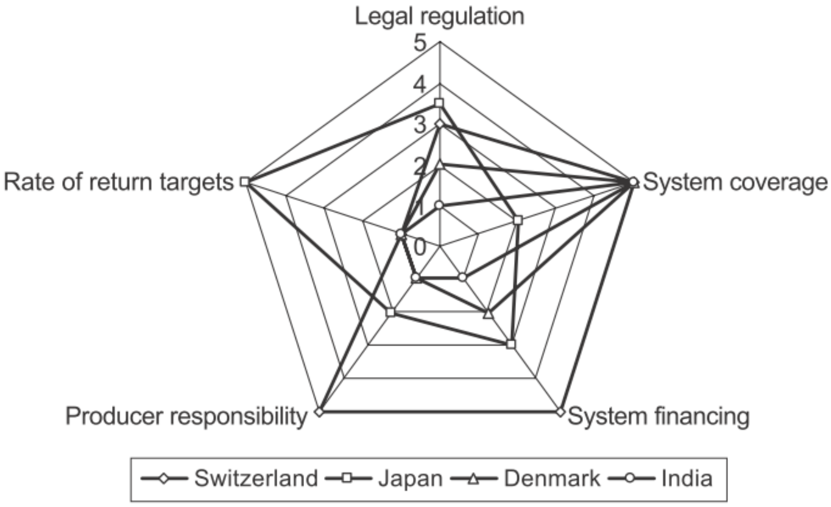
Confronted with the difficulty of collecting more reliable and comparable data, the authors have used the following scale to evaluate the e-waste profile of different countries:

Table 4. Evaluation of e-waste indicators

Comparison indicator	Low (value=0)	Medium (value=3)	High (value=5)
Legal regulation	No existing legal regulation	Existing regulation giving operational flexibility	Existing regulation with no operational flexibility
System coverage	No WEEE handled by system	Few, specific WEEE handled by system	All WEEE handled by system
System financing	No external financing	Partly externally financed system	Fully externally financed system
Producer responsibility	Producer responsibility non-existent	Selective producer responsibility	Strong producer responsibility
Rate of return targets	No legal collection and/or recycling targets	Few collection and/or recycling targets	Preset, legally binding targets for all processes

The outcome of their efforts in trying to represent this evaluation is exemplified by the spider web chart below:

Table 5. Comparison of WEEE management systems



This approach adopts a holistic perspective as it also takes into account societal objectives such as job creation or income distribution in addition to environmental criteria. In many other studies, only the efficiency of the take-back system is considered, which reveals that the political priority may not be geared towards broader societal issues but tends to focus on the efficiency of e-waste take-back systems. Consequently, academic analyses reflect this focus, not to mention that they face constraints of data availability and reliability, which restricts the scope of comparison of e-waste policies across countries. The following table provides a comparative analysis of take-back systems in different countries following a similar approach.

Table 6. Comparing recycling systems

Comparison of Recycling Systems - 2006 Data				Switzerland SWICO	Sweden (EU) El-Kretsen	Netherlands (EU) ICT Milieu	Belgium (EU) Recupel	Norway Elretur	California USA	Maine USA	Maryland USA	Alberta Canada
System Architecture	Product Scope	WEEE Category 3. IT and telecommunications equipment	*Monitors*	✔	✔	✔	✔	✔	✔	✔	✔	✔
			Laptops	✔	✔	✔	✔	✔	✔	✔	✔	✔
			Desktops	✔	✔	✔	✔	✔			✔	✔
			Other	✔	✔	✔	✔	✔			✔	✔
		WEEE Category 4. Consumer equipment	*TVs*	✔	✔		✔	✔	✔	✔	✔	✔
			Other	✔	✔		✔	✔				
		All other EU Categories of WEEE (1,2,5-10)			✔		✔	✔				
	Collection Methods	Retail Store Take-Back?		Yes	No	Old for New	Old for New	Yes	No	No	No	No
		Total # of Collection Points		~6,000	950	~7,000	2904	2500	442	160	18	223
		# of Non-Retail Collection Points		431	950	605	537	unknown	442	160	18	223
	Financial Structure	Who finances the majority of the system?		Consumers (ARF)	Producers	Producers	Producers via ARFs	Producers	Consumers (ARF)	Producers	Producers & Government	Consumers (ARF)
Context	Population	Population	(million)	7.5	9	16.3	10.5	4.7	36.4	1.3	5.6	3.4
		Poulation Density	(per square km)	190	22	489	348	15	90	16	174	5
	Area	Area of Jurisdiction	(sq km)	39,770	410,934	33,883	30,278	307,442	423,971	91,647	32,134	640,045
	Wages	Average Recycling Wage (2004 values)	USD/hour	26.34	14.98	16.34	14.74	23.11	13.46	10.04	15.01	12.54
	Timing	Date each program began operating		1994	Jul-01	Dec-99	Jul-01	Jul-99	Jan-05	Jan-06	Jan-06	Oct-04
Performance	Estimated Annual Costs (Financial)	Collection	(USD/kg)	0.05	unknown	unknown	0.06	unknown	↑	unknown	↑	0.04
		Transportation	(USD/kg)	0.13	unknown	unknown	unknown	unknown	0.37	unknown	0.17	0.07
		Processing	(USD/kg)	0.41	unknown	unknown	unknown	unknown	0.55	0.26	↓	0.59
		System Management	(USD/kg)	0.09	unknown	unknown	unknown	unknown	0.15	0.11	0.08	0.11
		Total Annual Cost (estimated)	(USD/kg)	0.68	N/A	N/A	N/A	N/A	0.70	N/A	0.08	0.81
			(USD)	29 million	N/A	N/A	N/A	N/A	61 million	N/A	unknown	2.3 million
	Annual Quantities (Environmental)	Amount of Category 3 Waste Collected	(million kg)	28.1	27.6	18.1	12.2	10.9	16.8	0.5	0.8	1.9
			(kg per person)	3.8	3.0	1.1	1.2	2.3	0.5	0.4	0.1	0.5
		Total Amount of WEEE Collected	(million kg)	42.1	149.9	18.1	76.1	68.3	58.1	1.8	2.9	2.9
			(kg per person)	5.6	16.5	1.1	7.2	14.6	1.6	1.4	0.5	0.8

Source: Fredholm, Gregory et al. (2008).

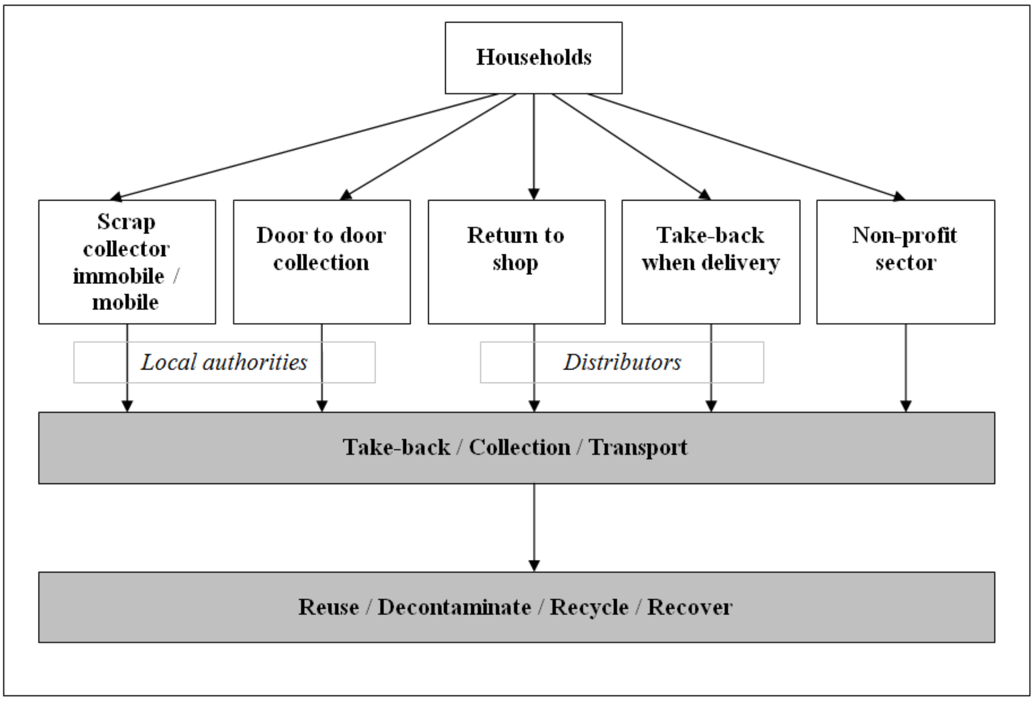
The above approach suffers from several limits. At first, it is a top-down approach since the criteria upon which the study evaluates the policies are not justified. For example, the study focuses on cost-related indicators, thereby assuming that the priority of take-back system designers is cost minimisation, and that for example environmental or societal objectives are not to be integrated in the assessment. Also, the comparison focuses on take-back systems, not on countries, thereby missing out important factors contributing to solve the e-waste problem such as cultural or political ones, which have a strong influence on the ability of a country to enforce an e-waste regulation. Therefore, if such an approach can provide an informative overview of e-waste policies in different countries, as exemplified in StEP (2009), it falls short of providing justifications for the evaluation criteria chosen to compare different countries and considers a scope of EEE limited to the ICT sector (EU Category 3).

In its review of the WEEE directive, the United Nations University (2008) was assigned to focus on the environmental impacts of the regulation. It also highlighted the heterogeneity in its enforcement, which was already underlined by the review of its implementation carried out by the IPTS (2006). In defining the effectiveness of a take-back system, respondents to the interviews conducted for the latter study identified the following indicators:

- Collection rate (kg/inhabitant),
- Percentage of recycling and recovery for each family product,
- Recycling/recovery costs,
- Overall values of reserves within compliance scheme (the lower the better),
- Amount of landfill/incineration volumes.

But these studies were carried out in the beginning of the implementation of the WEEE directive, and many countries had not put in place yet a robust evaluation system. The next section introduces an attempt to overcome these drawbacks and to reflect upon the limits of the use of indicators to evaluate and compare e-waste policies.

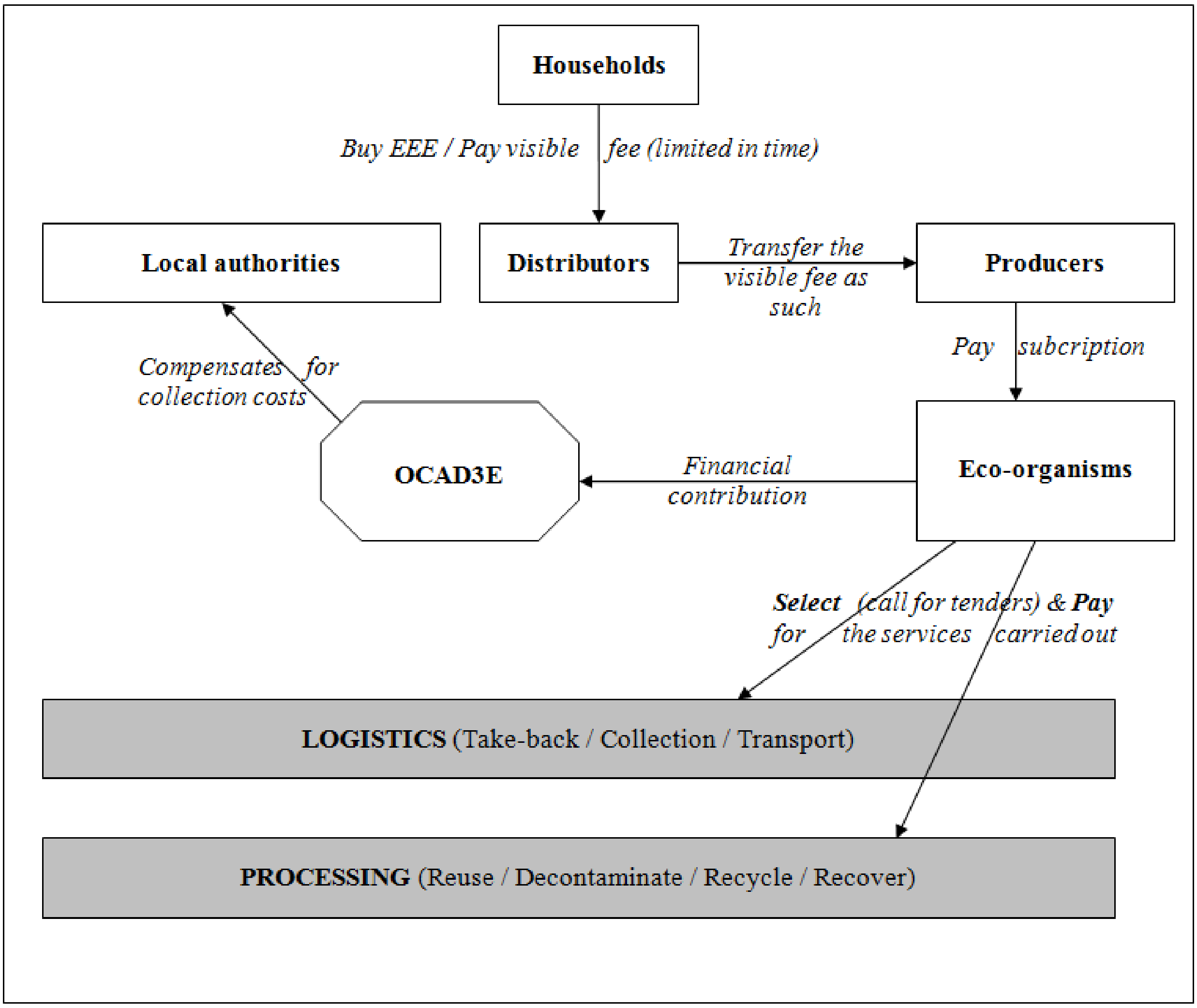
Figure 2. Physical flows of e-waste in France



Source: Adapted from the French Environment Agency (ADEME).

The system is financed by producers who charge its costs to consumers in the form of a "visible fee" (*éco-contribution*) that is apparent on receipts. The following figure shows how this money is collected and where it is going.

Figure 3. Financial flows in the French e-waste take-back system



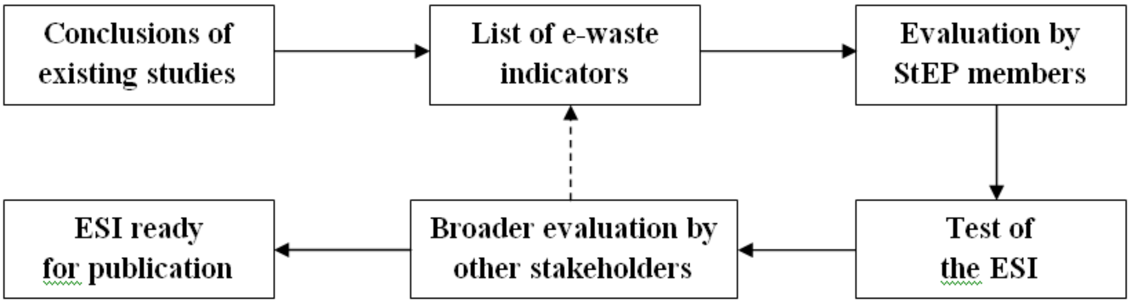
Source: Adapted from the French Environment Agency (ADEME).

Developing complex sets of indicators to monitor and evaluate these systems is timely and costly, and their complexity may not serve their purpose of providing sound policy advice in a transparent and democratic fashion. Therefore, to construct an aggregated index summarising the performance of e-waste solutions in a given country, all stakeholders need to be consulted to build a simple and pedagogical index that will be capable of influencing the policy making process. Although by nature such index will not capture all the issues at stake, it shall provide a reliable picture of the performance of e-waste solutions developed in a variety of countries, including in developing ones where the informal sector tends to play a greater role than in developed nations.

This ESI framework is based on previous work carried out within StEP and expresses with a single number the performance of the e-waste solutions developed by a given country. We have started with a limited number of performance areas weighed differently to make up the

ESI. The performance of each area will be measured with a limited set of criteria and indicators, which will ease the updating of the index in the future. Data sources include publicly collected data, information provided by StEP members, and the databases compiled by C2P-Compliance and Risks about the status of e-waste legislations in the world.

Figure 4. Stages of the ESI project



For each country we will have one ESI number (%) calculated on the basis of the targets set by the country itself. Indeed, policy targets are the outcome of a democratic process and a "one-size-fits-all" approach cannot work here. We are conscious that this may generate a bias since it is tempting for a government to set low targets in order to achieve a high ESI; the construction of the ESI should control such a bias.

In order to select the most important performance areas and the related criteria that will be used to evaluate these areas, a questionnaire has been sent out to StEP members and other experts for comments and will be tested this year. The following table and figure illustrate what the ESI could look like in the case of The Netherlands (early version of the ESI).

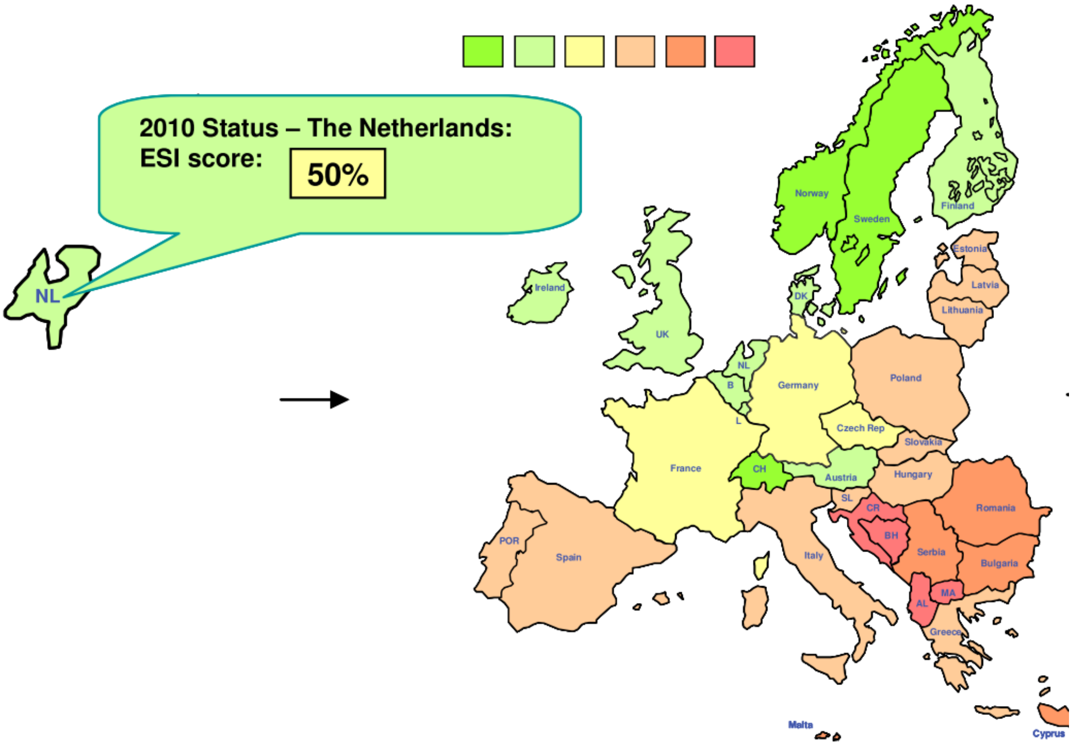
Table 7. Thought starter: Netherlands' example of the ESI Scorecard

ESI - Country X	Status 2009	Relevancy Area	Relevancy to area	Score/ Total
Collection		50,0%		
Kg POM		26,0		
Kg WA		18,60		
Kg C&T		6,2		
	C&T	WA		
Category LHA	1,0	5,0	5,0%	0,5%
Category C&F	2,0	3,2	25,0%	7,8%
Category Small	1,0	4,0	15,0%	1,9%
Category IT	1,0	2,0	20,0%	5,0%
Category Screens	1,0	4,0	20,0%	2,5%
Category Lamps	0,15	0,4	15,0%	3,0%
Subtotal	6,15	18,57	100,0%	**20,7%**
Financing		15,0%		
Financing agreed and operational	100%		40,0%	6,0%
Financing stimulating more collection	0%		40,0%	0,0%
Stakeholder cooperation running	50%		20,0%	1,5%
Subtotal			100,0%	**7,5%**
Consumer Education and Awareness		5,0%		
CSS doing mediacampaings	100%		40,0%	2,0%
Level of consumer awareness/ willingness to hand in WEEE	35%		60,0%	1,1%
Subtotal			100,0%	**3,1%**

ESI - Country X (Continued)	Status 2009	Relevancy Area	Relevancy to area	Score/ Total
Legislation		20,0%		
% of all WEEE categories covered	100%		10,0%	2,0%
Status (from 0% to 100%):			50,0%	10,0%
- *no legislation in place*		*0,0%*		
- *in draft*		*25,0%*		
- *enacted*		*50,0%*		
- *enforced*	*100%*	*100,0%*		
Enforcement items				
POM amounts	50%		10,0%	1,0%
Treatment Annex II/ Haz. Materials	20%		10,0%	0,4%
Recycling % reported and checked	25%		10,0%	0,5%
WEEE imports/exports regular/ continuous checks	50%		10,0%	1,0%
Subtotal			100,0%	**14,9%**
Recycling infrastructure present		10,0%		
State of the art recyclers, sufficient capacity	100%		50,0%	5,0%
Recycling standards developed	25%		10,0%	0,3%
Recycling standards implemented	20%		10,0%	0,2%
Recycling standards audited	10%		10,0%	0,1%
Mass balances tracked daily basis	5%		20,0%	0,1%
Subtotal			100,0%	**5,7%**
Total (ESI)				**51,8%**

If we could calculate the ESI for several countries, we would be able to produce a map illustrating the differences in the e-waste solutions performance as measured with the ESI:

Figure 5. World mapping of e-waste solutions performance by using the ESI



5. Conclusion

In this paper we have introduced a post-normal index capable of measuring the performance of the efforts carried out in any country in the world to solve the e-waste problem. We have argued that such a simple aggregated index is a pedagogical way of stimulating improvements in these efforts and an effective means to communicate how and why significant 'system development' progress was made in certain countries, compared to a more exhaustive, time and money consuming exercise that might be more scientifically robust but less efficient in terms of its influence on the real world.

The transition to sustainable societies is a long path in which all stakeholders need to participate. By making governments, citizens, recyclers, waste collectors, municipalities, producers and all other stakeholders aware of the state of the e-waste problem, pedagogical indicators can, with the help of smart ICT applications, contribute to shift the behaviours of these actors so that they increasingly contribute to solve the multifaceted e-waste problem. This will be all the more feasible since these actors will have contributed to the elaboration of a transparent and well-known E-waste Solutions Index.

6. References

Böhringer, C. and P. E. P. Jochem (2007), "Measuring the immeasurable -- A survey of sustainability indices", *Ecological Economics* 63(1): 1-8.

Castell, A., R. Clift, et al. (2004), "Extended Producer Responsibility Policy in the European Union: A Horse or a Camel?", *Journal of Industrial Ecology* 8(1-2): 4-7.

Fredholm, S. A., J. R. Gregory, et al. (2008). Characterizing architectural options for electronic waste recycling systems. Electronics and the Environment, 2008. ISEE 2008. IEEE International Symposium on.

Funtowicz, S. O. and J. R. Ravetz (1994), "The worth of a songbird: ecological economics as a post-normal science", *Ecological Economics* 10(3): 197-207.

Gusfield, J. R. (1980), *The Culture of Public Problems: Drinking-Driving and the Symbolic Order*, Chicago: The University of Chicago Press.

Hagelüken, C. and M. Buchert (2008), "The mine above ground", IERC, Salzbourg (Austria).

Hezri, A. A. and S. R. Dovers (2006), "Sustainability indicators, policy and governance: Issues for ecological economics", *Ecological Economics* 60(1): 86-99.

Huisman, J. (2006). Where did WEEE go wrong in Europe? Practical and academic lessons for the US.

IPTS (2006), "Implementation of the Waste Electric and Electronic Equipment Directive in the EU", Technical Report Series. Office for Official Publications of the European Communities, Luxembourg: Directorate-General Joint Research Centre

Khetriwal, D. S., P. Kraeuchi, et al. (2009), "Producer responsibility for e-waste management: Key issues for consideration - Learning from the Swiss experience", *Journal of Environmental Management* 90(1): 153-165.

Lehtonen, M. (forthcoming), "Indicators as an appraisal technology: Framework for analysing the policy influence of the UK Energy Sector Indicators", in *Sustainable development, evaluation and policy making*, A. v. Raggamby and e. al., London: Edward Elgar.

Mayer, A. L. (2008), "Strengths and weaknesses of common sustainability indices for multidimensional systems", *Environment International* 34(2): 277-291.

Siche, J. R., F. Agostinho, et al. (2008), "Sustainability of nations by indices: Comparative study between environmental sustainability index, ecological footprint and the emergy performance indices", *Ecological Economics* 66(4): 628-637.

StEP (2009), "E-waste Take-back System Design and Policy Approaches", *StEP White Paper* (1).

Turnpenny, J., C. M. Radaelli, et al. (2009), "The Policy and Politics of Policy Appraisal: Emerging Trends and New Directions", *Journal of European Public Policy* 16(4): 640 - 653.

United Nations University (2008), "Review of Directive 2002/96 on Waste Electrical and Electronic Equipment". UNU, Bonn: United Nations University.

Van de Kerk, G. and A. R. Manuel (2008), "A comprehensive index for a sustainable society: The SSI -- the Sustainable Society Index", *Ecological Economics* 66(2-3): 228-242.

Huisman, J., Luepschen, C., Wang, F., E-waste – How to address the size of the problem? Proceedings of the Care Innovation 2010 Conference, Vienna, Austria, November 2010

Huisman, J., Luepschen, C., Wang, F., WEEE recast: How to avoid another ‘paper’ collection target?, Proceedings of the 2011 International Electronics Recycling Conference, Salzburg, Austria, January 2011

Widmer, R., H. Oswald-Krapf, et al. (2005), "Global perspectives on e-waste", *Environmental Impact Assessment Review* 25(5): 436-458.