DYNAMIX

Decoupling growth from resource use and environmental impacts

DYNAMIX policy mix evaluation

A sound material cycle society in Japan

European Commission

SEVENTH FRAMEWORK PROGRAMME

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DYNAMIX PROJECT PARTNERS

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1. Resource/Issue

Name of resource targeted (or focus of the case study, if the policy mix is broader than the specific resource(s) we have decided to analyse).

This case study looks at management of materials towards ensuring security of supply, with an emphasis on recycling of critical metals.

2. Geographical area of policy mix coverage

Country name, and region or city if appropriate (if policy mix is applied regionally or locally)

The policy mix explored in this case study covers Japan.

3. Policy context

3.1 Needs assessment: The environmental problem /resource challenge

What is the environmental problem/concern (consider both quantity and quality), e.g. soil erosion, excessive use of non-renewable or renewable resources and the crossing of environmental thresholds/tipping points for impact, resource scarcity concerns?

Are there any economic or social problems related to the issue and environmental problems – e.g. is there important price volatility, (risk of) unavailability of resources for the economy or society?

Who is the target group affected that have been, are or will be beneficiaries of the policy response?

Critical metals management, also known as **rare metals**, is a particular case of material management that was addressed in the Japanese policy mix. These are materials at high risk of running short in supply but with critical importance to human technological development and a range of economic sectors. These include Rare earths, whose applications are summarized in Figure 1 below. These materials currently form non-substitutable parts in many electric/electronic and photovoltaic equipment, batteries and catalysts.

Figure 1: Key Applications for rare earths

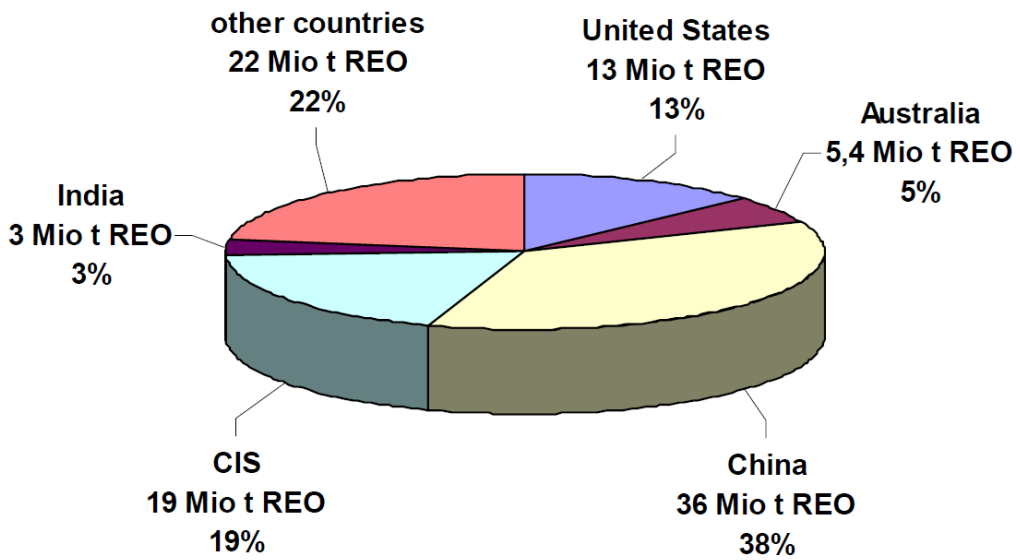
Key applications	○Rare earth magnets (neodymium, samarium, praseodymium, dysprosium, terbium) ・Used in hybrid cars ・Used in technical fields in which Japan is technologically advanced ○Abrasives (cerium) ○Optical glass (lanthanum) ○Nickel hydrogen batteries (mischmetal, lanthanum) ○Fluorescent materials (yttrium, europium, terbium, gadolinium) ・Color TV Braun tubes

Source: Kawamoto, H. 2008. "Japan's Policies to be adopted on Rare Metal Resources, Science and Technology Trends", 27

Indium (In), tungsten (W), germanium (Ge), tantalum (Ta), PGM [platinum group metals, such as ruthenium (Ru), platinum (Pt) and palladium (Pd)], tellurium (Te), cobalt (Co), lithium (Li), gallium (Ga) and rare earths (RE) – such as scandium, lanthanum, and europium - form the most important critical metals. However, there is not a single definition of what critical metals are.

The metals are rare in that they each constitute less than 1 % of the world's total mineral reserves, and they occur in low concentrations and are thus costly to extract. Complicating matters further, critical metals are often found in a very small number of countries, raising issues of a geopolitical nature, as shown in Figure 2. Some of these supplier countries also have less developed or ambitious environmental policies. An example of the concentrated presence of such metals is China, which has a significant global market share in rare earths, a subcategory of critical metals. More than 95 % of rare earths are produced in China (U.S. Department of Energy 2011).[1]

Figure 2: Share of rare earth reserves per country, 2010



Source: Oko-Institut. 2011. "Study on Rare Earths and Their Recycling"

Inadequate disposal of WEEE (Waste Electrical and Electronic Equipment), and other appliances in which critical metals are present, is not only economically inefficient, but also has negative environmental impacts. It is currently very difficult and costly to extract critical

metals from disposed electronics and other equipment, for the materials in question occur in very small quantities and are often mixed with other materials.

Rare earth Magnets, for example, are alloyed metals consisting of roughly two thirds iron and one third rare earth metals; separating the materials is difficult. Circuit boards, for example, contain precious metals like gold, silver and platinum, and also copper, iron, aluminium and several critical metals. A way to of processing this e-waste is by melting the circuit boards and burning the cable sheeting to recover the copper, but in this process, most critical metals are lost, because they occur in too small quantities. Furthermore, as Japan exports so many final goods, a lot of the resources it imports, notably also critical metals, leave the country, often to nations that do not adhere to the same environmental standards as Japan.

The challenges raised by critical metals are not strictly environmentally based. Critical metals also have a strong economic and political component, due to: 1) the important role they play in the production of future sustainable technologies, like low-carbon solutions and renewable energy technology; 2) their relative scarcity; and 3) the concentration of deposits in a small number of countries. Critical metals have gathered much international attention in recent years, for the highly volatile and politicised nature of their trade. Because critical metals play such a crucial part in the production of high-tech technology, particularly in sustainable innovations, demand is expected to increase 50 per cent by 2020, putting at risk security of supply for Japan, especially in the case of Indium (Kawamoto 2008)[2].

While critical metal imports have not yet fallen, demand is otherwise very volatile because of the monopolistic nature of China's market share. With increasing consumption and manufactured goods production, Japan's demand for raw materials, including energy and mineral resources, steeply increased in the three-decade boom of economic growth that started in the mid-1950s and lasted until 1991 (BIOIS 2010).[3] The country, notoriously lacking in natural resources, heavily relies on raw material and fuel imports to satisfy domestic demand and final goods production. Japan's high reliance on strategic resource imports creates a security issue in ensuring reliable, long-term supply of raw materials (BIOIS 2010).[4] The country is therefore focused on improving resource retention through, for example, recycling efforts to maintain its upper hand as a final goods producer, and keep imported resources in the country.

3.2 Policy context and policy needs

What policy challenge(s) did the problem pose and what policy challenges does it still pose?

What is the policy context related to the policy mix being evaluated? What policies have been put in place to address the issues, what policies are currently in place and which ones are already foreseen for future introduction (e.g. to address past, existing and future objectives)?

What sort of policy response did (and does) the problem call for?

Japan is a net importer of critical metals - the country is only self-sufficient in its sulphur supplies, and simultaneously one of the foremost users of critical metals, essential for its high-tech industry. Japanese imports of critical metals feed in electronic equipment, motor vehicles manufacturing and building construction, among others (Statistics Japan 2013).[5] **To prevent becoming too dependent on these imports**, Japan was one of the first countries to adopt a series of environmental and resource policies that aim to both limit resource use, but also to find methods to reuse resources in existing products, which resulted in the

establishment of the SMC (Sustainable Material Cycle) society. Since both Europe and Japan lack domestic supplies of critical materials, there is a distinct need to improve efficiency in their use, so as to minimise negative economic impacts but also environmental impacts.

Despite its current ambitious plans, Japan was relatively late in the game with implementing policy to target resource inefficiency in recycling practices, particularly given the country's high dependence on imports. Before the policies were implemented, from 1955 to 1991, Japanese economy boomed and the country did virtually nothing to prevent 'leakage' of useful resources such as critical metals through inefficient waste management practices. Nor was there much focus on establishing domestic supplies – Japan does have a quite significant resource base of the minerals, but developing a substantial mining practice would take at least a decade. Thus 'wasteful behaviour', as the Japanese coined it, persisted until the start of the 1990s, when the first policy frameworks to more adequately target waste management were implemented.

Effective Utilization of Resources for Japan was first envisioned in 1991 and its legislation was revised 3 times until 2000. Its aim is to reduce the usage of raw materials and foster recycling instead, while promoting economic growth. This legislation does not specifically apply to rare materials. The revision of 2000 established the mandatory reporting of resource used by businesses and the competent ministry would be responsible for contribution of advice. Each industry had criteria of recyclable resource and/or labelling requirements, depending on some factors, such as the technological level of the industry. Failure to comply with the criteria and non-implementation of the advice could result in fines (Law for Promotion of Effective Utilization of Resources 2000).[6] Although there was a change in the mind-set, the policies, such as this law, undertaken in the 90s were not enough to achieve (absolute) decoupling (UNEP 2011).[7]

As first envisioned in 2000, Japan aims to become a Sound Material-Cycle Society (Basic Act for Establishing a Sound Material-Cycle Society 2000)[8], a society in the spirit of the word *"Mottainai",* the practice of treasuring and using all things as long as possible. Through the 3Rs -reduce, reuse and recycle - Japan aims to improve resource efficiency, prevent waste and decrease environmental burden, thus promoting a circular economy. Policy focuses on setting standards for reusability and recyclability that companies have to adhere to by increasing the longevity of products and investments in research and development. Japan is a world leader in terms of R&D expenditure, fostering collaboration between the government and industry, and has invested $1.2 billion on rare earth research alone. Japan also seeks to become more independent in raw resource generation: the country has domestic supplies of rare earths, but setting up mining operations can take up to ten years - finding new supply routes and stockpiling the materials are also considered options.

Following the vision, the first plan for the Sound Material Cycle Society appears in 2003 (Government of Japan 2008)[9]. It aimed at preventing waste, promote recycling and ensure appropriate disposal of waste that cannot be recycled (Japanese Ministry of the Environment 2008).[10] It follows the same ideas as the Second Plan described below that aims at promoting sustainable consumption and production (Government of Japan 2008).[11]

The Japanese Oil, Gas and Metals National Cooperation (JOGMEC) was created in 2004 with the aim of ensuring security of supply of materials, notably of critical metals. JOGMEC defines these rare metals as materials crucial to the Japanese economy and subject to significant supply instability. Its activities include: 1) provision of funds to Japanese firms for

mineral exploration and deposit, 2) analysis of the risk of supply for metals and 3) management of Japan's stock of rare metals.

In 2007, Japan expressed the ambition to become a "leading environmental nation", as declared in its "Strategy in the 21st century: Japan's strategy for a sustainable society" (Japanese Ministry of the Environment 2008).[12] The plan seeks to build a sustainable society through a comprehensive set of measures integrating the three aspects of society, specifically through a "low carbon society", a "sound material-cycle society" and a "society in harmony with nature". The sound material-cycle society component is most relevant to this case study, as it explores the issues of waste management and dependency of natural resources imports, and has turned into an objective to increase resource productivity. Using a Life-Cycle Assessment approach to decrease dependency of materials' imports, Strategy 3 of the Cabinet Meeting Decision 2007 envisions the "Creation of Sustainable Material-Cycles through the 3Rs" (Cabinet Meeting Decision 2007).[13]

The **Second Plan for Establishing a Sound Material-Cycle Society** was approved in 2008. To reach the environmental aims proposed, the plan sets several numerical targets based on the 3Rs and environmental and industrial indicators, with its first targets to be met by 2015, and distributing responsibilities to citizens, national and local governments and businesses, with substantial focus on changing consumer behaviour and making it more sustainable. The Plan also makes reference to action needed in rare metals waste management and recognises their high value added, proposing the recycling of these metals. The policy targets mostly the high-tech industry in Japan, which produces many different products that require critical metals, such as cell phones, computers, solar cells, LED-lamps, batteries, magnets, etc. (Government of Japan 2008).[14] Although it does not tackle critical metals recycling directly, it is the first document to make reference to the importance of critical metals in the economy and sets the stage for later management of critical metals waste.

The foundations for the Sound Material-Cycle Society were laid with the basic environmental law of 1993 and the Fundamental Law on the Environmentally Sound Material Society in 2000 (Basic Act for Establishing a Sound Material-Cycle Society 2000).[15] The latter law was followed by the Fundamental Plan on the Environmentally Sound Material Society in 2003, and the basic environment plan of December 2004. The Sound Material-Cycle Society (SMC) now shapes the central facet of Japan's environmental and waste management framework and is firmly rooted in the 3R principle of Reduce, Reuse and Recycle.

In the last version of the plan, 2015 is the year in which most indicators have specific targets: Resource productivity, defined as GDP/Direct Material Input, is targeted to be Yen 420,000/tonne that is a 60 per cent improvement compared to base year 2000. The resource productivity indicator is also monitored in each industry (Japanese Ministry of the Environment 2008).[16] The Plan also aims at attaining between 14 to 15 per cent of the recycling rate by 2015 and reaching a final disposal amount of 23 billion tonnes.

3.3 Projections into the future: Insights on decoupling

What has been the trend vs. GDP (or other economic performance metrics, such as sectoral growth) and what type of decoupling has been achieved?

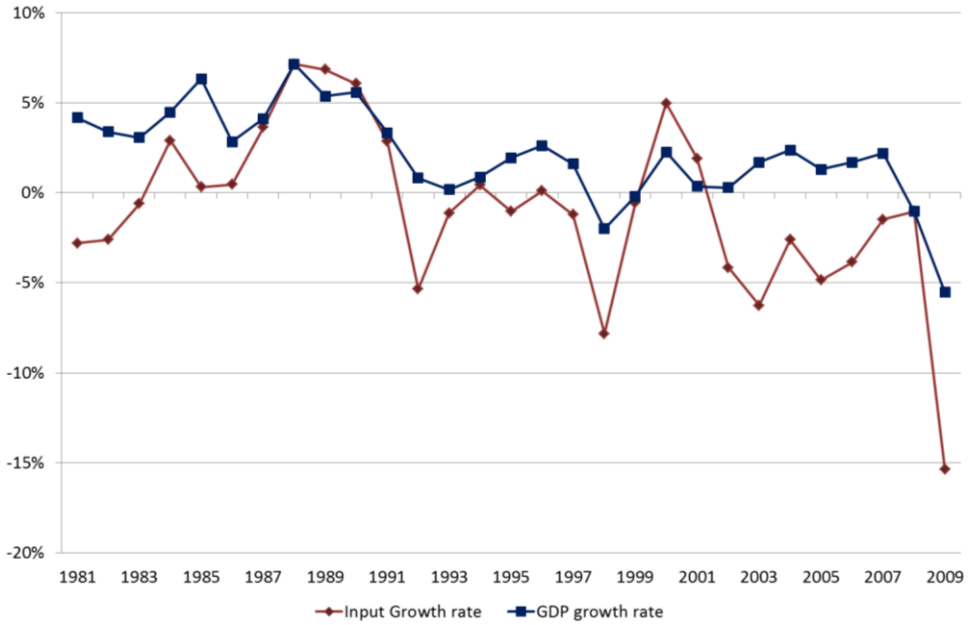
Figure 7 in section 7 shows the evolution of the resource productivity indicator. This indicator, envisioned in the 2003 SMC plan, is the ratio between GDP and natural resource input. As

this ratio increases for the observed period 1980-2009, there is at least relative decoupling for the period starting in 1991, because the growth rate of natural resource input is lower than the GDP growth rate. Moreover, there is also absolute decoupling for the period 2002 onwards, as illustrated in

Figure 3, as from 2002, the growth rate of natural resource input remains negative and lower than the rate of growth of real GDP, meaning absolute resource use of materials has been decreasing since 2002. Decoupling for critical metals remains unclear, but there is some evidence of relative decoupling:

- Imports (of non-ferrous metals) are the main source of domestic critical material input and these have remained relatively stable in the past years;
- Efforts regarding recycling of critical metals have proved to yield some positive results (see Figure 8 and Figure 9).

Figure 3: GDP and Natural Resource growth rate for Japan



Source: Data collected from Environmental Statistics 2012 of the Japanese Ministry of Environment (http://www.env.go.jp/doc/toukei/contents/index.html) for Resource Productivity and World Bank Database (http://data.worldbank.org/) for real GDP growth rate

4. Drivers affecting change: resource use/ environmental issues

What are the drivers affecting resource use (driving demand for the resource and leading to resource overuse) or other environmental impacts?

Drivers that affect the high resource use, and thus need for imports, in Japan can be explained by the magnitude and nature of its economy: Japan is the OECD's second largest

economy, relying heavily on exports of high-value finished products with high technological components, while simultaneously importing most of its raw materials.

In line with the OECD average, the industry sector amounted to around nearly 30 per cent of GDP in 2007, with manufacturing alone accounting for 21.6 per cent (17.5 per cent is the cross-OECD average). Japan is among the largest exporters of manufactured goods. High- and medium-high-technology industries, such as transport equipment, electronics and chemicals, accounted for some 80 % of Japan's exports of manufactured goods in 2007. More traditional sectors, such as steel and metals, also play a key role (OECD 2010). Since wage levels in Japan are high, innovative processes and the production of high quality products is important – (critical) metals are therefore expected to play an increasingly large role in a Japanese economy that will try to stay competitive in a world of low-wage countries. Japan's environmental policy strongly focuses on R&D specifically, rather than just the more broad efficiency or focus on mitigation after the fact. Recycling of the rare metals becomes not only a measure to decrease the environmental burden, but also to foster economic growth as Japan's key sectors are highly dependent on rare metals.

High investment in research and development is therefore a core component of this economic model, as spurring innovation is fundamental for maintaining growth. It is therefore of critical importance that resources like critical metals that are essential for novel technological innovation remain available. In 2007, public and private R&D development accounted for 3.4 per cent of GDP. This interplay between government and industry is fundamental for understanding Japan's motivations and policy development: 78 per cent of research and development is funded and carried out by the business sector, the highest share of all OECD countries. Policy therefore needs to strongly correspond to the needs of industry, but also target companies specifically, as their cooperation in the innovation process is imperative.

In 2004, consumption of some metals in Japan (gold, zinc, manganese) had already reached absolute decoupling with economic growth and other critical metals appeared to be converging towards relative decoupling (UNEP 2011).[17]

Not only economic activity and focus on innovative processes spur Japan's wish to become more sustainable. The public outcry also played an important role. The economic boom caused an increase in municipal solid waste generation that became most apparent in the late 1980s. Public concern over risks of environmental pollution associated with waste treatment processes arose, making it more difficult to expand the capacity of waste treatment facilities. Large investments were consequently made in an attempt to decouple waste generation from economic growth. The recognition of limits of resources was not the direct, primary driving force behind waste prevention, but it has been advocated and recognized that waste prevention and recycling contributes to resource saving (UNEP 2011).[18]

5. Situation/trend prior to introduction of policy mix

Information on the baseline situation before the policy mix was introduced.

The results for the main indicators already envisioned in the first plan are described in

Figure 4. Compared to both 1990 and 2000, resource productivity and cyclical use rates, or recycling rates, in 2005 have increased, while the waste disposed of decreased by a large percentage. This suggests that all the actions taken since the first plan in 1991 and raising awareness through the creation of visions helped Japan shift to a sustainable material cycle society, as envisioned.

Figure 4: Evolution of the main 3 indicators set up in the Fundamental Plan for a Sound Material Cycle Society

		FY1990	FY 2000	FY 2003	FY 2004	FY2005	Comparison with FY 1990	Comparison with FY 2000
Resource productivity	Ten thousand yen per ton	20.7	26.4	29.5	31.1	33.0	+59.4%	+25%
Cyclical use rate	%	7.4	10.0	11.3	11.9	12.2	+ 4.8 points	+ 2.2 points
Final disposal amount	Municipal solid waste (million tons)	20	12	10	9	8	▲60%	▲33.3%
	Industrial waste (million tons)	89	45	30	26	24	▲73.0%	▲46.7%
	Total (million tons)	109	57	40	35	32	▲70.6%	▲43.9%

Source: Government of Japan (2008): Fundamental Plan Establishing a Sound Material Cycle Society

6. Description of policy mix(es)

This section presents the main policy mix that will be the focus of this ex-post assessment.

When the Sound Material-Cycle Society was implemented, Japan was already on a trajectory towards more efficient resource management. This policy mix is therefore a continuous development rather than a sudden change in policy direction and focuses on creating a sustainable society. Moreover, it motivated the actions described in the next section, specific to critical metals.

Lifecycle focus of the policy mix): Whole value chain

Sector(s) covered: All economic sectors (both producers and consumers)

Scale of application of policy mix: National level (Japan)

Implementing body: METI, JOGMEC and others

Objective of policy mix:

This policy mix aims at fostering more effective waste management and urban mining practices. Consumers are incentivised to buy greener, more efficient products through labelling and other awareness campaigns and encouraged, sometimes mandated, to recycle their electrical waste. Producers are encouraged to improve their production process to be more sustainable, adapt products to be easier to recycle and develop new practices to make the extraction of valuable materials easier. The SMC plan recognises the importance of management of critical metals and mentions the importance of collection of these materials.

However, the method to ensure recycling is not specifically addressed here (Government of Japan 2008).[19]

6a. Supplementary context questions including elements pertinent to paradigm discussions in DYNAMIX

Timeline for the different phases of the policy cycle (i.e. rationale and objective-setting; appraisal; implementation and monitoring).

Description of the government in power during each of the three following policy phases: rationale and objective-setting; appraisal; and implementation and monitoring.

Does the mix contain policies that are unusual or not typical of the country/ies or regional/local administration that implemented it?

Names of resource efficiency concepts, terms, models, ranking/classification systems, accounting methods etc. used or relied upon in each of the three phases of the policy cycle: rationale and objective-setting; appraisal; and implementation and monitoring, and how they were used (e.g.: 'waste hierarchy' – used in objective-setting to link policy objectives to more desirable uses for waste).

The supporting and "follow-up" policies cover two fields of action. On the one hand, efforts towards efficient resource use and recycling policies increased, with focus on collection of appliances but not specifically concerning critical metals. On the other hand, as the economic importance of critical metals was recognised, greater efforts and plans to ensure their security of supply emerged, which do not exclusively view recycling as a solution.

Firstly, as mentioned previously, recycling is not economically viable for all materials and it should be assessed where in the life-cycle of production recycling would be better tackled (Kawamoto 2008).[20] Based on rare metals concentration on products, the policies assessed should be the ones that concentration of rare metal intensive products.

An example of progress is the Home Appliance Recycling Law of 2001. Currently, there are 379 designated collection sites where manufacturers of four types of waste home appliances (household air-conditioners, televisions, refrigerators and freezers, washing machines and clothes dryers) and recycling plants for the four types of home appliances are operating in 49 locations across the country. The Law has been effective in ensuring recycling rates higher than 60 per cent for air condition units, 55 per cent for televisions and 50 per cent for refrigerators. In these recycling plants, iron, aluminium, copper, glass, and rare metals used for printed-circuit boards are collected (Japanese Ministry of the Environment 2010).[21] While these recycling numbers do not exactly tell us how much of the critical metals in these appliances are actually recycled, it provides a context for the kind of electrical waste recycling framework already in place. With technological innovation, more effective recycling of critical metals may become more cost-effective (appliances often only contain up to one gram of the materials) and recycling rates could improve proportionally.

In 2002, the End-of-Life Vehicle Recycling Law came into force to oblige producers to be committed to collecting the vehicle parts (Japanese Ministry of the Environment 2008).[22] Motors of hybrid and electric cars use some rare earth materials.[23]

Another example is Japan's Top Runner Program established in 1998. By setting efficiency targets on products based on the standards of the most efficient model in the market, companies get the incentives to invest in R&D to be able to compete in the market. As a result, energy efficiency increased, as well as the speed of innovation.[1] Companies have no legal obligation to comply with these standards, only to make efforts towards their implementation, but non-compliance ruins the firm image in the eyes of their consumers. This practice works due to the corporate culture and "pride" in Japan. Moreover, consumers are informed of the environmental burden of products through labelling to inform about the products' compliance to the Top Runner program standards (UNEP 2011).[24]

In 2001, the Mobile Recycling Network was created by mobile and PHS carriers to incentivize collection of mobile phones. These are composed of gold, silver, copper and rare metals (such as palladium). From 2003 to 2007, a deceleration on recycling could be observed but the new context of reaching a Sound Material-Cycle Society caused acceleration in the number of mobile phones, batteries and battery charges collection.[2] As critical metals become scarcer in the future and their prices increase, recycling rates may go up and more technological developments might take place (OECD 2011b).[25]

Local governments are creating the necessary infrastructure to collect electronic products to increase recycling rates. Local initiatives to promote consumers' involvement have shown to have significant impacts, such as more frequent collection of recycled materials and clear information on recycling in the city of Atsugi (Tsuginosuke).[26] Moreover, projects for rare metal collection have been tested in seven regions in 2009, to examine which are the most efficient collection methods of high tech appliances (Japanese Ministry of the Environment 2010).[27]

Secondly, in July 2009, Japan published the **"Strategy for Ensuring Stable Supplies of Rare Metals"** that aims at 1) ensuring supply of metals for industries dependent on their provision (some new reserves have already been found[3]), 2) ensuring recycling of rare scrap metals, 3) developing alternative materials (palladium like substances have already been developed[4]), and 4) fostering stocking of some rare metals. The Ministry of Economy, Trade and Industry (METI), JOGMEC and the Japan Bank of International Cooperation are the main implementation bodies (U.S. Department of Energy 2011).[28] Technologies for extraction of ocean floor rare metals, such as manganese and cobalt, are being developed (Kawamoto 2008).[29] Research is being carried to develop technologies to reduce the use of dysprosium, substituting it by other substances such as copper (U.S. Department of Energy 2011).[30]

Highlighting the importance of rare metals to the economy, the Japanese budget to deal with the supply risks identified was approximately $650 million in 2011 that also includes recycling and $1.3 billion if the private sector contribution is also accounted for (U.S. Department of Energy 2011).[31]

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[1] http://www.worldchanging.com/archives/011179.html [accessed 30/09/2013]

[2] http://www.ciaj.or.jp/en/news/news2013/2013/06/25/754/ [accessed 27/09/2013]

[3] http://www.telegraph.co.uk/finance/comment/ambroseevans_pritchard/9951299/Japan-breaks-Chinas-stranglehold-on-rare-metals-with-sea-mud-bonanza.html [accessed 27/09/2013]

[4] http://www.telegraph.co.uk/news/worldnews/asia/japan/8236899/Japan-creates-synthetic-version-of-rare-earth-metal-palladium.html [accessed 27/09/2013]

The “Elements Strategy Project” by the Ministry of Education, Culture, Sports, Science and Technology aims at creating alternative substances without any critical metal content, firstly only a research initiative to evolve and be applied in practical uses. The Ministry of Economy, Trade and Industry’s “Development Project on Rare Metals Substitution” aims at developing production processes that use critical metals less intensively and was supposed to run until 2011 (Kawamoto 2008).[32]

The Second Plan for Establishing a SMC Society and the critical metals strategy in 2009 created the necessary conditions for the appearance of business opportunities and fostered the development of substantial research coming from Japan to develop techniques to recycle rare metals (through funding, for example). R&D is one of the key sectors of Japanese economy and many entities have conducted research on the development of techniques to recycle rare metals. Examples include the case of recycling of magnets (Hitachi), batteries (Japan Oil, Gas and Metals National Corporation’s Metals Mining Technology Group - JOGMEC) and electronic scrap (Kosaka Smelting and Refining). However, the techniques are yet too costly for commercial use (Oko-Institut 2011).[33] The vision for 2014 is to create a national system for recycling rare metals (U.S. Department of Energy 2011).[34]

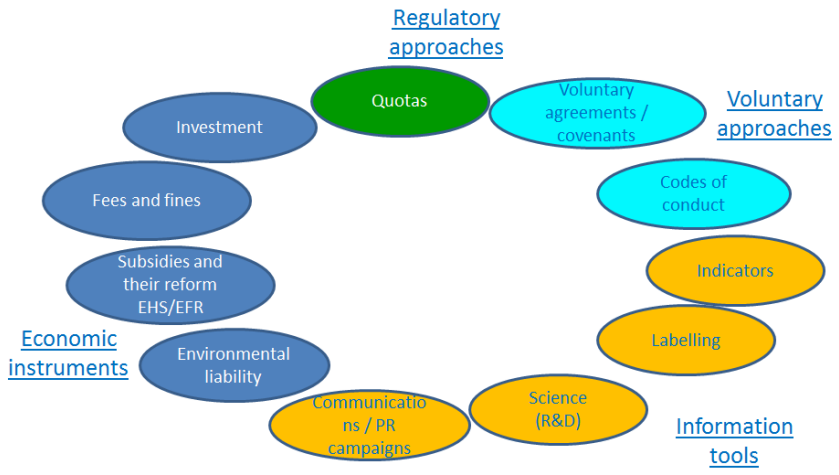
6b. Instruments and orientation of policy mix

Instruments in the mix and whether one type of tool (i.e. regulatory, economic, information) is dominant.

For each instrument, what is its aim? What requirements does it place on relevant players (for example, phasing out a certain substance, meeting minimum recycling targets, etc.)? What reporting requirements exist?

Figure 5 provides an overview of the instruments used across the policy mix. It includes policy instruments of the SMC plan (the 3 indicators, labelling, awareness campaigns and environmental liability), of the Effective Utilization of Resources Law (fines, codes of conduct and quotas), and the initiatives such as the Home Appliances Recycling Law or the Mobile Recycling Network (investment).

Figure 5: Instruments used in the Japanese materials and metals policy mix

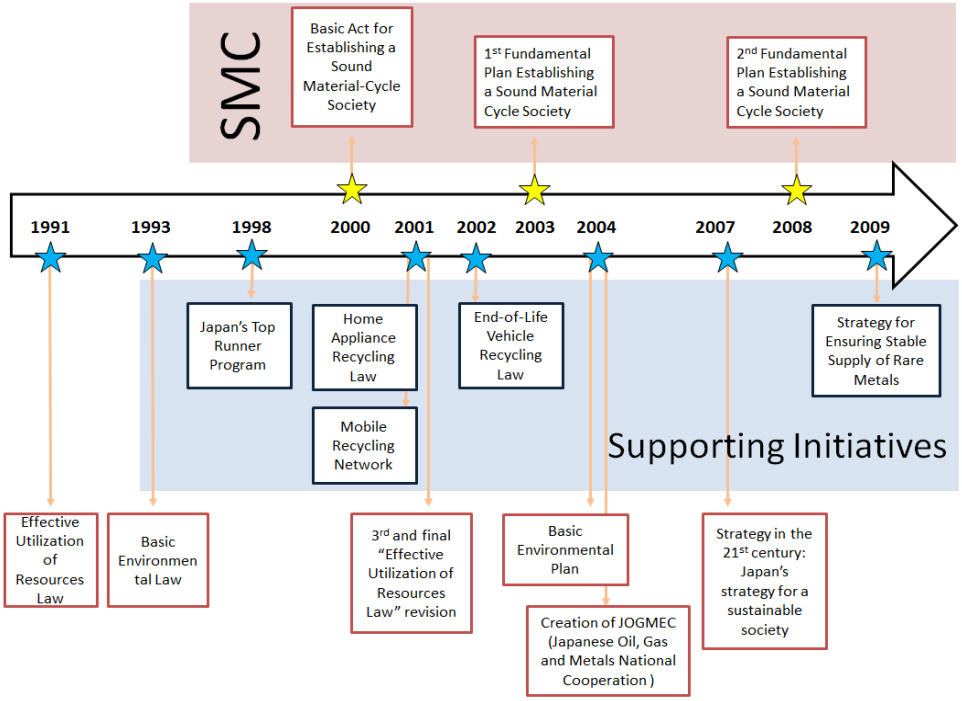


Source: Own compilation

6c. Evolution of policy mix

Evolution of the policy mix throughout its existence –details of the introduction of the first policy tool(s), then all subsequent relevant tools, and related revisions/reforms (e.g. progressive increases in rates applied through economic tools, broader extension of regulation requirements, etc.).

Figure 6: Timeline of the Japanese critical metals policy mix



Source: Own compilation

7. Evaluation of policy mix: effectiveness (environmental sustainability)

Does/did the policy mix result in a positive environmental outcome?

Were its stated objective(s) met? Were the instruments used sufficient to meet the objectives?

Did other, unforeseen/unintended positive outcomes or impacts (environmental, social, economic) result? Did other such negative outcomes or impacts result?

Were these objectives set at a level to meet environmental needs (e.g. avoid crossing environmental thresholds/tipping points or achieve more sustainable levels of resource use/extraction (e.g. maximum sustainable yield (MSY) in fisheries)?

Which sectors/actors were identified as having key impacts/influences on the problem/issue? (e.g. specific industrial/ business sectors, consumers, economy as a whole?) Did any of the

instruments specifically target these key sectors/actors? Was there significant take-up/implementation of (voluntary) instruments by these sectors?

Was the policy mix applied to a sector previously not targeted by policies on the issue under question, or in a new area/issue – thereby aiming to stimulate change?

What were the anticipated and actual outcomes, impacts and effects of the policy mix on the behaviour of sectors and actors targeted? (e.g. reductions in emissions from industry, increased recycling rates, increase/decrease in certain product purchases, etc.).

Relationships between the instruments, identifying positive/negative influences on the overall policy mix or on key instruments in the mix, as well as any positive or negative impacts from changes to the mix (introduction or termination of instrument(s), increase or decrease in tax/levy/charge, etc.). Level of 'connectivity' (strong, weak) between each instrument and the primary one(s).

Are there any indicators, monitoring systems, review processes or other monitoring mechanisms in place to track progress?

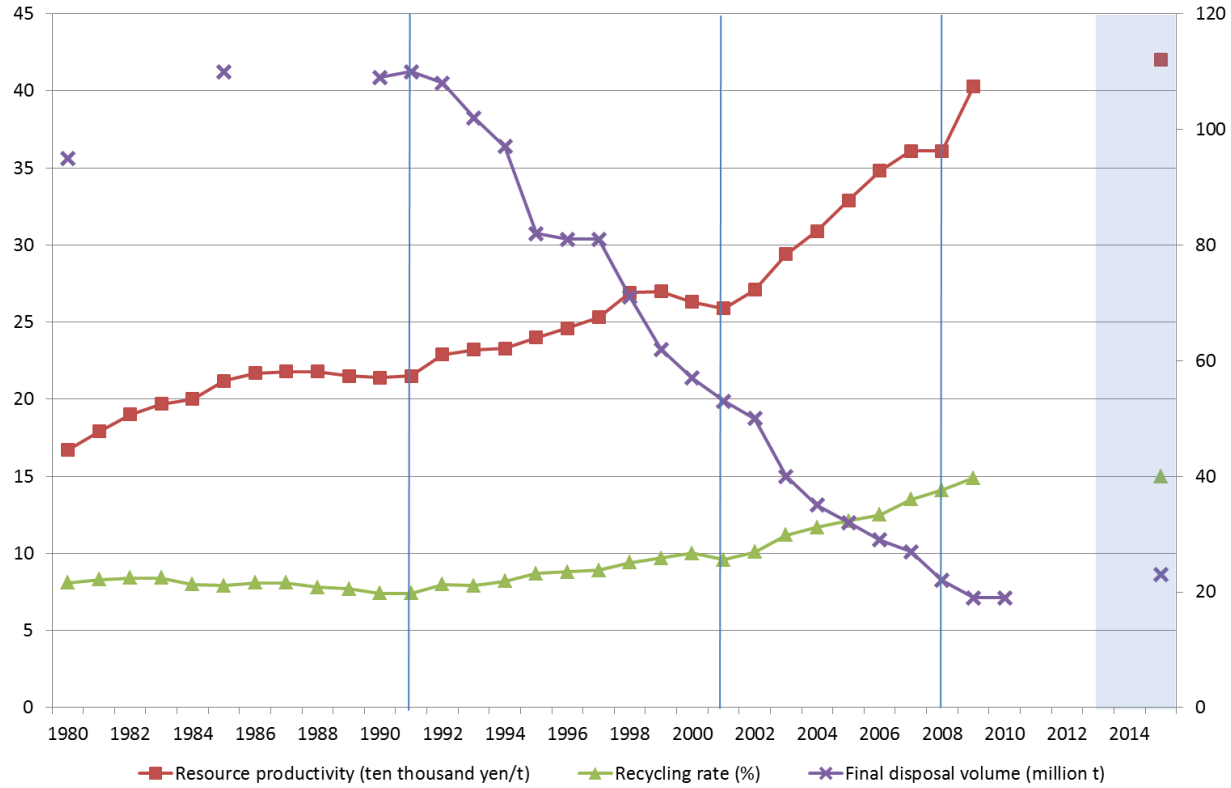
In 2007 1.8 billion tonnes of material flowed through the Japanese economy, 46 per cent of which was accounted for by imports, 41 per cent by domestic resources and the remaining 13 per cent by recycling. Less than half of these materials were added to domestic stock, such as buildings, infrastructure and durable goods, 178 million tonnes was exported and 510 million tonnes were used in industrial energy consumption. 590 million tonnes were generated as waste. While 41 per cent of this waste was recycled, Japan still seeks to make large strides in maintaining and reusing resources. The wasteful incineration of products but also the export of final goods leaves the country with lower resource retention from its resource imports than it seeks to achieve. Moreover, critical metals are among the resources that often disappear through exports of electronic goods such as cell phones abroad. This costly waste in combination with the political will to become less reliant on economies like China, the most common source for rare earths and many other minerals, has created political incentive for the development more efficient production and waste management methods. Moreover, from 2000 to 2007, the employment and value of the market in the sectors of eco-business grew (Ito 2010).[35]

It is important to note that the focus on resource efficiency was not just reflected in environmental policy. Given the importance of resource management for Japan's economy and the political nature of the raw materials trade, it was the Japanese ministry of economic affairs and other institutions who implemented the policy that has positive environmental impacts and targets better reuse practices.

Both the extraction and the disposal of critical metals have very negative effects on the environment. The materials, often highly toxic, can leak into aquifers and taint the soil. Reducing use of the materials, through the development of more efficient production techniques, improvement of the appliances themselves and kick-starting recycling practices, can significantly lessen these negative effects. The policy mix has no associated negative side-effects, although some fear that in attempts to reduce use of critical metals, companies might move to other, more-abundant, harmful materials.

The policy mix is tentative but has shown positive trends towards a more environmentally sustainable society. The policy mix is promising in its ambition and time-frame, as targets need to be reached by 2015.

Figure 7: Evaluation of the main indicators envisioned in the Japanese Sound Material Cycle Society Plan, 1980-2010



Source: Data collected from Environmental Statistics 2012 of the Japanese Ministry of Environment (http://www.env.go.jp/doc/toukei/contents/index.html)

Figure 7 shows the trends of waste reduction for each of the indicators set up in the 2003 and 2008 SMC Plans and with the targets for 2015 highlighted.

Final disposal volume is labelled on the right axis. Results show that most of these indices show significant improvement from 1991 to 2010. The years 1991, 2001 and 2008, when the Effective Utilization of Resources Law, SMC society Law and 2nd SMC Society Plan, respectively, came into force, are highlighted in blue. Between 1991 and 2000, there was modest success in the resource productivity and the recycling rate but impressive results in the final disposal volume. After the SMC law came into force (2001-2008), there was an acceleration of the recycling rates and resource productivity indicators. Recycling rates and Final disposal volumes already reached their 2015 targets, while resource productivity shows promising evolution. Although it is too early to evaluate the effect of the 2008 SMC plan, there seems to have been acceleration in the resource productivity indicator in 2009.

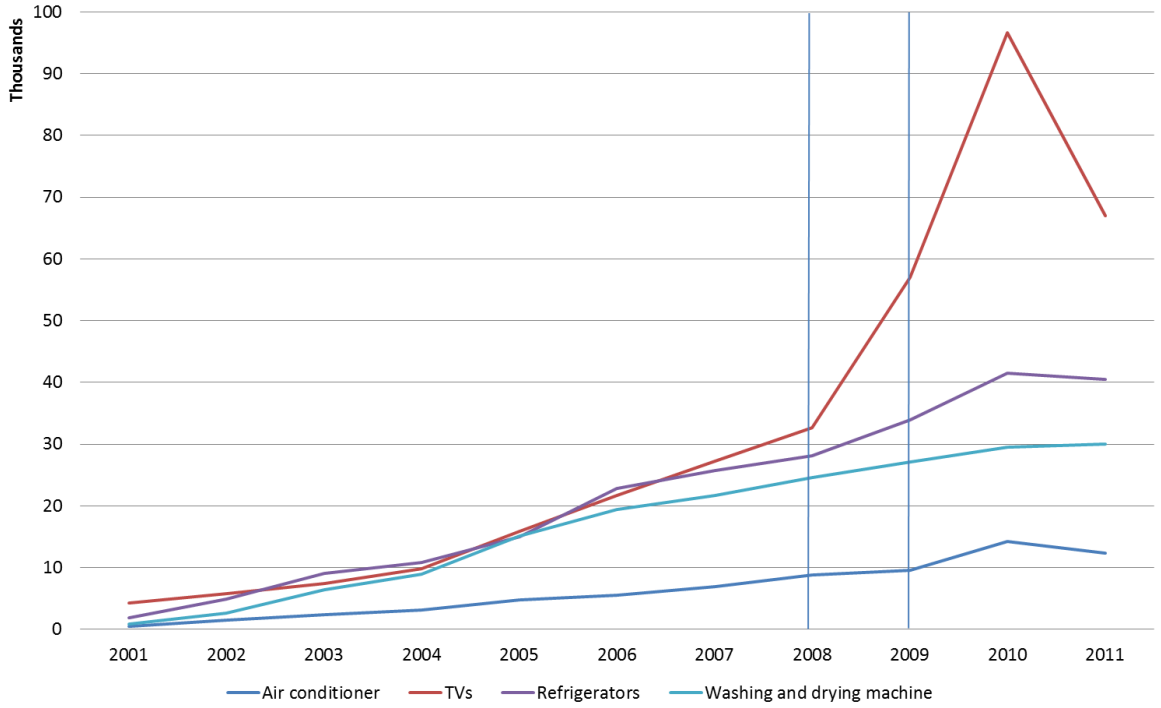
In 2005, as a result of the earlier versions of the policy mix, the per capita material use was in Japan 37 per cent below the OECD average (OECD 2010),[36] reaching 12 tonnes per capita and per year compared to 15.8 for the EU and 27 in the US. Reduction of the amount of waste production decreased by 10 % over the period 2000-2005 for household waste generated per person per day and by 73 % over the period 1990-2005 for municipal waste from business sites.[37]

While the objective of the policy mix for the 2015 targets has not yet been met, prospects look good. The material absolute decoupling that has been achieved is a result of a great mixture

of policies that started in 1991 and were re-enforced in 2001. However, the indicators established do not take into account the indirect flows associated with material imports, which are much higher than direct material input. If considered, the progress of decoupling of material use is more modest in Japan and other OECD countries (OECD 2011a).[38]

This comprehensive set of policy to improve **critical metal** use is relatively recent, but early results seem promising, as illustrated in Figure 8 and Figure 9.

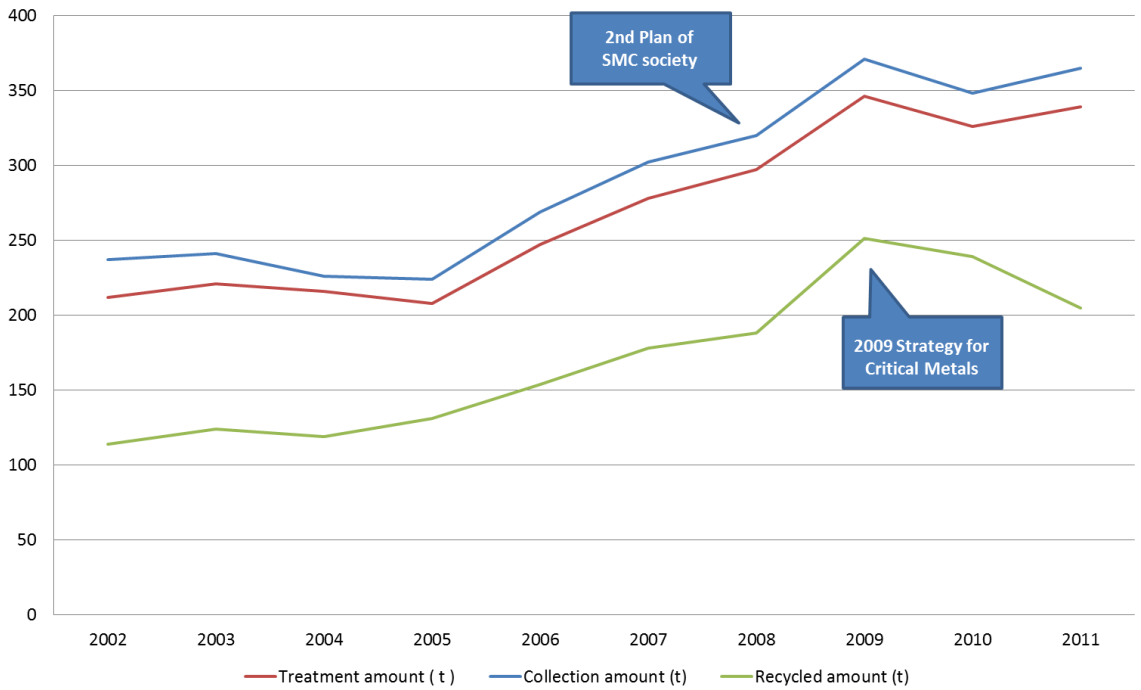
Figure 8: Evolution of the Collection of Materials in Home Appliances



Source: Data collected from Environmental Statistics 2012 of the Japanese Ministry of Environment (http://www.env.go.jp/doc/toukei/contents/index.html)

Figure 8 illustrates the progress of the implementation of the Home Appliance Recycling Law of 2001, as the lines represent the collection of the materials present in Home Appliances, in which the critical metals are included in tonnes. Indium is a major component of notebooks and LCDs, for example (Oko-Institut 2011).[39] There is a clear positive trend since the beginning of the program, illustrating its success in all 4 appliances (air conditioners, TVs, Refrigerators and Washing and drying machines). After 2008, with the introduction of the 2nd SMC plan, the materials collected in TVs and Refrigerators seems to have accelerated, and these collected materials in TVs increased from 32 to 57 thousand tonnes. The 2009 strategy for critical metals may have also contributed to the acceleration of collection in 2009 (up to 97 thousand t), but the materials collected have decreased in 2011.

Figure 9: Amount of collected lithium batteries in Japan, 2002-2011



Source: Data collected from Environmental Statistics 2012 of the Japanese Ministry of Environment (http://www.env.go.jp/doc/toukei/contents/index.html)

Lithium, being one of the critical metals, is used to produce lithium ion batteries, which are used in mobile phones.[5] The figure illustrates the collected, treated and recycled amount of lithium ion batteries in Japan. The trend is positive, and with the adoption of the SMC plan in 2008 there seems to have been an increase in efforts to collect these batteries, resulting in the increase of treated and recycled amounts. However, technological improvements, as envisioned in the 2009 strategy for critical metals, are still to be achieved, as the amount of treated and actually recycled batteries is far from converging.

Metals account for 16 % of all recycled resources and the final disposal of raw materials (including non-ferrous metals) has decreased slightly from 2000 to 2007(Japanese Ministry of the Environment 2010, OECD 2010, Japanese Ministry of the Environment 2010).[40,41] Metal waste has decreased from 2007 until 2009 both in absolute terms and as a percentage of total waste (Japanese Ministry of Environment 2012).[42] As a result of these efforts, Japanese material intensity fell to 37 per cent below the OECD average in 2005 (OECD 2011a).[43] High tech and e-waste recycling rate have increased significantly, with some companies now recycling up to 85 per cent of their total domestic output. Japanese electronics company Hitachi, in collaboration with the Japanese government, for example, has managed to move recycling of its own appliances from a base level of virtually zero in 2008 to nearly ten per cent in 2013. In the context of the 3Rs, the reduction of cerium consumption of critical metals through recycling, conservation and substitution was of approximately 50 per cent in 2011 compared with 2010.

5 http://www.americanmanganeseinc.com/lithium-ion-batteries-and-the-new-%E2%80%9Ccold-war%E2%80%9D/ [accessed 3/10/2013]

The focus on industry collaboration and on R&D rather than just fiscal incentive is positive. Setting both standards to adhere to, but aiding companies in the process, the Japanese government has created both a positive environment more conducive to improvement and prevents companies from seeking loopholes (i.e. use fewer critical metals, but more other harmful materials). Japan wants to become the world leader in the field of critical metal recycling.

8. Evaluation of policy mix: efficiency (economic sustainability)

Is/was the policy mix considered cost-effective?

What has been the level of impact on resource use of the policy mix (the effect)?

What have been the costs of implementing the policy mix for target audience (e.g. business, households, etc.)?

What are the costs (financial, human) of implementing the policy mix for the implementing authority – i.e. the administrative/transaction costs?

Were sufficient resources made available to ensure an effective implementation of the policy-mix?

Was anything foreseen in the policy-mix to address competitiveness concerns (e.g. use of exemptions) or minimise transaction costs (e.g. thresholds below which monitoring wasn't required)?

Did the policy mix involve providing financial support (e.g. subsidies, low interest loans, tax breaks etc.) to key actors (e.g. sector, households, etc.)?

Did the measures generate revenues (e.g. in the case of taxes) and if so, was revenue recycled/re-injected into the economy, and to what levels and activities? Did revenue recycling have positive amplifying effects?

In synthesis - was the policy mix cost-effective?

What elements of the mix were (un)helpful in improving cost-effectiveness?

How was relative/absolute decoupling achieved?

Were resource limits or other thresholds taken into account and how were they addressed?

The policy mix of attaining the SMC society has had positive impacts on economic growth. The policy mix has so far had quite a profound effect on the way Japan recycles waste, namely e-waste, which have had a net-positive effect on society and the economy. The SMC society market grew due to increased demand of scarce raw materials, from a value of € 190 billion in 1990 to € 250 billion in 2005, and it employed 700,000 people (BIOIS 2010).[44] This is not surprising; a large element of the policy plan is economic rather than just environmental.

While critical metals are in itself of crucial importance to the Japanese economy as a whole because of their use in many of the high-tech innovations the country is so famous for, the market itself is relatively small. The U.S. Congressional Research Service (CRS) estimates that global production combines amounts to just 124,000 tons (114,500 tonnes) annually.

Changes in policy targeting the use of the materials are therefore not expected to have a very noticeable effect on employment or the economy as a whole. However, if there should be an effect, it is likely to be positive. If more of the production process is moved domestically, fewer raw materials are imported but rather reused; this will also create more employment opportunities.

The aim of the policy mix was to reduce dependency from imports of critical metals, thus a decrease in the volume of imports would be expected from 2009 onwards, but that does not seem to have occurred yet. Following the financial crisis, there was a drop in non-ferrous metals' imports, from which Japan was recovering until 2010. There is yet no visible increasing or decreasing trend of these imports until August 2013, but the value of imports of non-ferrous metals seems to have stabilized on a level lower than the value before 2008 (Statistics Japan 2013).[45]

The Japanese government has invested significantly in research and development of new technologies to make critical metal recycling easier, for example by offering companies subsidies. These subsidies, in combination with some mandated improvement standards, effectively utilize the knowledge of the collaboration corporations. Many collaborating companies are showing improvement in their practices in a relatively short time-horizon, showing that the resources provided were at least sufficient to facilitate some change. These subsidies allow companies to be competitive amongst each other, but foremost improve Japan's competitiveness in the world as a whole.

The country aims to become a frontrunner in critical metal recycling – a skill expected to become very important in the future. Companies that now focus on critical metal recycling are seeing profits, although the quantities they extract from recycled products are marginally small and the process is still difficult. This proves the high value of the critical metals, although it can be explained by the silver and gold these contractors also extract from used appliances.

More innovation is necessary to make the practice a truly profitable endeavour, but so far the costs of the program are justifiable looking at the results at present, according to the Ministry of the Environment.

9. Evaluation of policy mix: welfare (social sustainability)

What social impacts have you found associated with the policy mix? E.g. jobs created, reduced health impacts, distributional impacts etc.

Were social aspects included in an ex-ante impact assessment of the policy mix if one was undertaken? What were these?

Has monitoring of social impacts been included in implementation, to identify actual effects compared to anticipated ones?

Was the policy mix designed to not be socially regressive? What measures were undertaken to ensure this?

Were equity concerns addressed and, in case of re-structuring of the economy/sector, measures in the area of reskilling of the workforce foreseen?

What other public acceptability elements were addressed or considered?

The Sound Material-Cycle Society as a whole, and the larger context of Japan's environmental plans, will have a profound effect on society in all aspects. The emphasis of the Japanese values of sharing and equality, being in harmony with nature and using only what one needs have come to play a very large role in the development of the plans. Incentivizing recycling and longevity of products counters the wasteful trend of overconsumption that had come to dominate in post-boom Japan. While these effects are not necessarily quantifiable, the Japanese government expects these changes to have an effect in creating a more inclusive society.

With inadequate waste management comes local pollution of, for example, aquifers and soil. Also negative health impacts are likely to be noticeably reduced. Recycling and the adoption of greener, more durable products can minimize some of these effects.

The recycling policy also aims at spreading greater awareness about environmental issues in general - not only to the Japanese people, but also in other countries, especially Asian countries. The SMC will lessen demand for critical metals, which are currently produced under very unsustainable conditions, and will also eventually recycle products Japan has exported abroad. By acting as a frontrunner in critical metal retention, Japan hopes to play a key role in improving resource efficiency in this sector on the world stage.

10. Overall assessment

What is your overall view on the success(es) or failure(s) of this policy mix?

How did the policy mix enable decoupling?

How could it have been improved to achieve its original objective(s) and to achieve absolute decoupling?

While results are preliminary, the policy-mix and the adoption of the Sound Material-Cycle Society has already had impacts on the current trends in Japan's waste management.

Overall, we can call the policy mix towards a more efficient use of critical metals a success. Japan's dedication and the therefore comprehensiveness of the plan is impressive and can be used as a benchmark case for other economies, particularly the focus on R&D and industry collaboration.

Negative environmental impacts of inadequate electrical waste management can be partially curtailed, and perhaps even decoupled completely from growth, with more efficient use of resources in the production process, more eco-friendly design (with a particular focus on recyclability) and greater reuse of products. With time, the development of more technology can increase the efficiency of recycling critical metals from used appliances and innovation will further augment this trend of recycled resources.

The policy mix also proves cost effective so far. The Japanese government has largely places the de facto recycling process in the hands of industry, which so far has been a successful

step. Many of the companies involved have managed, despite the tediousness of the process and the small quantities recovered, to run a profit, and are becoming more innovative in their approaches. The country has been less effective in bringing down loss of valuable material in its export products abroad – one of its aims.

Japan's overall waste management plan has a positive net effect on society. Local pollution and health threats are diminished with more sustainable approaches towards waste reduction, and the country is a step closer to reach its goal of becoming more resource independent. In summary, we can thus consider the plan a success, but it is yet too early to observe the effects of the policies aimed at critical metals' management.

11. Relevance to the EU and transferability

Can the policy mix be applied at the EU level? Is it transferable to other Member States/countries?

What lessons are there that may be of general interest regarding policy mixes and what issues are there as regards transferability of the insights?

Japan and the European Union alike are forerunners when it comes to recycling. Japan recycles 41 per cent of total waste output, higher than the EU average of 35 per cent, but behind member states like Austria, which recycles an impressive 63 per cent, Germany just trailing behind with 62 per cent, Belgium (58 per cent), the Netherlands (51 per cent) and Switzerland (51 per cent). Some EU member states have also recently adopted far-reaching policies to move towards decoupling waste from economic growth and minimize resource inefficiency in general, such as Germany and Belgium.

Although there is some notable dissimilarity between Europe and Japan in the way in which policy is mentioned, there are certainly some lessons to be drawn from the Japanese approach to critical metal retention. Historically, with the exception of the second half of the 20th century, Japan has always had the vision of being a country in harmony in Nature. Until the 1930s, waste management was done efficiently, for example night waste had a monetary value. As the country moved towards industry and manufacturing, the pressures on Nature and the dependency of Japan towards imports became more apparent. Like Japan, the EU is very dependent on critical metals in its production processes, and is seeking ways to improve use of the materials. However, the EU is not yet at the same level of Japan in recycling critical metals. Japan's practice of high investments, R&D and working with industry to develop better methods is an element EU-member states should consider in their policy design. Japan has established its own vision of what a SMC society should be, sharing responsibilities across all economic agents. Towards this vision, several specific projects have been launched, such as the Top Runner Program or the Home Appliance Recycling Law, to create the incentives and infrastructure to make businesses and consumers behave in an environmental friendly way and fulfil the vision of the SMC envisioned. Moreover, innovation is a key factor, as many innovative small scale projects are being implemented at a regional level.

For any transferability to take place, the EU may have to create the same background conditions as Japan did, build a vision and engage businesses and consumers. The EU may also take into account how to make the most of the key economic sectors of the union when

aiming at a material closed-loop society, as Japan did when concentrating efforts in R&D. There is scope for transferability of the indicators established in the SMC plan of resource productivity, recycling rate and final disposal volume (BIOIS 2010).[46]

Evaluation of the policies specific to critical metals may be too early, yet some positive results seem to have been achieved. However, any progress on decoupling is likely due to previous policies, rather than the recent strategy of 2009.

12. Stakeholder contribution

What insights did stakeholders provide?

No stakeholders were consulted for this case study.

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