Chapter 13
Innovations for a Sustainable Resource Use – Reflections and Proposals

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13.1 Introduction

The current economic situation is essentially a crisis of resource-intensive industrial mass production based on cheap resources. The success story of this model in the twentieth century has come to its end.

This development does not come unexpected and it has been discussed already in the early 1970s (Meadows et al. 1972). Nearly nothing is new in the discussion as far as the limits to resource-intensive growth are concerned. Already in the early 1970s, material flows were critically analysed in terms of environmental deterioration, even in the Soviet Union. According to Gofman et al. (1974), in the Soviet Union 98.6 % of the material inputs into the production processes were wasted before consumption. (The collapse of the SU was in part due to an extremely inefficient use of resources – this may have been an early warning also for the "Western countries".)

Possible solutions to meet the challenge of resource-intensive growth have been known for a similarly long time. As early as 1974, the Japanese MITI proposed a model of resource-efficient, knowledge-intensive and environmentally friendly industrial production. Later on this MITI vision influenced the concept of "ecological modernisation" in Germany (Jänicke 1984, 2012a). As early as 1978, the German Council of Environmental Advisors (SRU) stressed the "economic advantage" of a "resource-saving environmental policy"; "…technical innovations induced by environmental policy" were seen as an opportunity "for more efficient production processes" and "improved products" (SRU 1978).

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M. Angrick et al. (eds.), *Factor X: Policy, Strategies and Instruments for a Sustainable Resource Use*, Eco-Efficiency in Industry and Science 29,
DOI 10.1007/978-94-007-5706-6_13,

However, the respective shift of paradigm has taken a long time. Today – finally – it has become a mega-trend (Jänicke 2012a). "Eco-efficient innovation" has become a core concept in the EU. The concepts of a "Green New Deal", a "Third Industrial Revolution" (Rifkin 2012) or a "Resource Revolution" (McKinsey Global Institute 2011) symbolize the breakthrough of the old idea of resource-efficient and environmentally friendly production and consumption.

One could ask why it took so long to realize such a trivial idea?

13.2 Dimensions of Material Flows: Environment, Productivity and Employment

13.2.1 Environmental Impacts

Material flows are at the core of resource use. The starting point here is the fact that "more than 95 % of the resources lifted from nature are wasted before the finished goods reach the market. And many industrial products – such as cars – demand additional resources while being used" (Reid and Miedzinski 2008). This is also the central issue of the environmental discourse. Material flows from mining to waste management are associated with related flows of energy use, transports, water and land use. All these carry environmental impacts from emissions and waste to the loss of species and ecosystem functions (Fig. 13.1). Only a part of these impacts is subject to environmental protection. Also in this regard, reducing or substituting material flows very often is the best preventive solution.

Even without scarcity of material resources there is an ecological necessity to use resources in a more sustainable way.

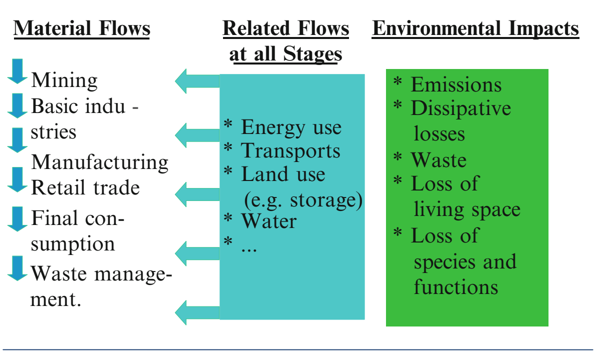

Fig. 13.1 Environmental impacts of material flows

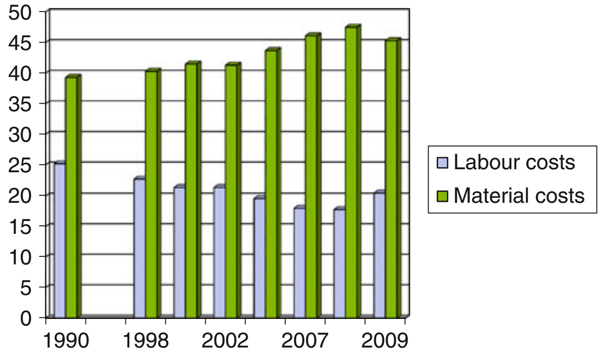

Fig. 13.2 Labour and material costs in German industry 1990–2009 (Source: Statistisches Bundesamt 2011)

13.2.2 Resource Productivity and Labour Productivity

Innovations in the context of sustainable resource use are legitimised not only by the environmental impact of the extensive use or potential scarcities of resources. The traditional mechanism to increase productivity via substituting labour with cheap energy has reached its limits too. Although there has always been some increase in energy and material productivity, throughout the history of industrialisation, the main focus has been put on labour productivity. Even in times of increased cost for materials, this priority has remained unchanged. In the German industry for example the (high) material costs have grown since 1990 (Fig. 13.2). Nevertheless, the focus was on labour costs.

In the twenty-first century we need a new sustainable model of productivity which increases resource efficiency without destructive effects on both, labour and the environment.

13.2.3 A Booming Industry of Eco-Efficient Resource Management

In the last few years it has become clear that there is a high potential for employment if we focus on eco-efficient resource management. A strategy for sustainable resource use can have multiple positive effects on employment: It typically creates "green jobs" in the eco-tech industry, reduces production costs and can lead to increased competitiveness. It may also change investment priorities from labour productivity to resource productivity; a change which could be supported by changes in the tax system.

Table 13.1 Green jobs – different estimates

USA:	>9.0 million in 2007
EU-27:	3.4 million in 2010 (narrow definition)
	19 million 2010 (broader definition)
Germany:	1.934 million in 2008 (narrow definition)
UK:	0.9 million 2007/2008, 1.3 million planned (2017)
Japan:	1.4 million
	2.2 million planned for 2020 (2009)
South Korea:	1 million jobs 2012

Source: UNEP (2009), Federal Ministry… (2011), ASES/MISI (2008), Ecorys (2012)

"Green jobs" and the growing environmental industry are the new promise in the present situation. This is plausible, because the importance and dynamics of this kind of economic activity have been underestimated by far. This underestimation is due not only to imprecise definitions or lack of statistical data: The main reason is the fact that there are not only specialised producers of environmental technologies (the environmental industry). Within environmentally intensive sectors such as chemical or car industry there is a similar tendency to react to environmental pressure by internal innovations, including resource management or eco-design in terms of life-cycle assessment (LCA). There are far more "green jobs" than the jobs which are provided by specialised eco-industries such as waste management or power from renewable energies. If environmental considerations were fully integrated into product design and LCA, it would be difficult to discern a specific "environmental industry" (Jänicke 2012a). Counting "green jobs" in different sectors is at least an additional option (Table 13.1).

The environmental industry must also be differentiated in another respect: actually, this industry has two faces. On the one hand there are (1) producers of *pollution control* technology (services included). On the other hand (2) producers of eco-efficient technology offer means for better *resource management* (Ernst and Young 2006; Ecorys 2012). Traditional pollution control or "end-of-pipe" treatment can be highly effective and also highly innovative as far as certain pollutants are concerned. For example, sulphur dioxide in coal-fired power stations can be reduced by more than 90 %. But the necessary desulphurisation technology requires additional resources (lime). Similarly, Carbon Capture & Storage (CCS) could reduce CO_2 emissions in coal-fired power stations; however it would significantly reduce the resource efficiency of power production. Generally, end-of-pipe treatment has rather negative effects on resource productivity. This is where the resource management part of the eco-industry is different: The positive environmental impacts of resource management are caused by the reduction of resource use. In other words, its contribution to productivity is generally positive.

It is important to know that the boom of the environmental industry in Germany and other OECD countries comes from the resource management part of this industry (Fig. 13.3).

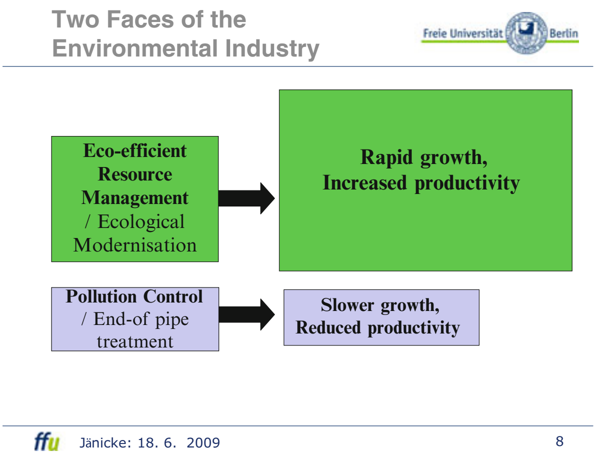

Fig. 13.3 Two faces of the environmental industry

13.3 The Role of Eco-Efficient Innovations

Innovation management is central to the model of eco-efficient resource use. Eco-efficient innovation or ecological modernisation is a necessary condition for long-term industrial growth if critical external damage is to be prevented. In a world of limited resources and sinks, industrial growth has to be "neutralised" by better, more eco-efficient technology. This is an imperative which cannot be ignored in the long run because from time to time it becomes manifest through environmental crises, protests or high damage costs. Since this imperative is associated with long-term industrial growth the technical improvement must be permanent – comparable to the increase of labour productivity. Long-term industrial growth needs eco-innovations *at ever higher levels*. The present crisis of resource-intensive growth and the danger of catastrophic climate change have given an additional urgency to eco-innovation: today, there is a particular necessity to *increase the intensity, scope and speed of eco-innovation*. In other words, the specific improvement of eco-innovations should be more than incremental, for example to overcome rebound effects. Their diffusion should be global and not restricted to niche markets. The speed of the innovation and the learning process (e. g. cost reductions) should be as high as possible. This is more than the market can offer.

Environmental innovations are therefore essentially "policy-driven" (Ernst and Young 2006). Eco-innovations aimed at overcoming the present crisis depend even more on government intervention. They depend on pioneers and national trendsetters, which exert competitive pressure on others. The good news is that countries with a high political and technological capacity can benefit from being more ambitious than others (Jänicke 2012a).

Definitions

"*Ecological modernisation*" is the innovation and diffusion of marketable technologies which provide both, environmental and economic benefits through more efficient use of resources. The concept includes supporting policies and services. The core idea is to "green" the logic of competitive modernisation which is inherent in capitalist market economies (Jänicke 1984). Ecological modernisation differs from "end-of-pipe treatment" (or pollution management) by having a positive impact on resource use.

Eco-efficient innovation, actually a synonym, is the creation and diffusion of new competitive goods, processes and services designed to preserve or improve the environment with a minimal life-cycle use of natural resources.

The *Green New Deal* essentially refers to a *forced political strategy for eco-efficient modernisation* implying a new role of government. It could also be defined as a strategy to increase systematically the intensity, scope and speed of eco-innovation.

It is the imperative of eco-innovation as a condition of long-term industrial growth that has become a strong motor of global markets. And since this imperative is permanent and growth-related, this kind of market has a calculable long-term future. In other words, the process of eco-innovation is not only driven by urgent pressure for change. More and more the advantages of green markets have become visible also to established economic institutions (OECD 2011; World Bank 2012). Eco-efficient innovation has become a dimension of competition. The present boom of eco-friendly technology has come late but it is not at all incidental. The same is true of the learning processes of governments on how to use eco-innovation in stimulus programmes or how to succeed in global regulatory competition for environment-friendly technologies.

13.4 Governance for Sustainable Material Use

13.4.1 Using the Present Crisis, Riding on Mega-trends

So far governments have not been in a strong position to start a Green New Deal and to implement ambitious strategies for sustainable development. Nevertheless, there are strong drivers that could be used and supported by government policies:

The most important driver is the present crisis of the model of mass production based on cheap resources. This crisis has been induced by rising prices of material resources and environmental problems, the most dangerous being climate change. It also has to do with the challenge of *globalisation without global government*. Crises can be perceived as pressure for change. And indeed, the crisis mechanism has become a strong motor of change and innovation. This can be observed not only in the field of energy and climate policy. Not least, the crisis of global government has supported policy learning in the direction of *concerted actions of governments*. Pioneer countries play an important role here, as policy innovators, trend-setters and challenging competitors. There are indeed strong drivers and trends towards improved global and national governance that can be used and strengthened.

13.4.2 General Policy-Design

Governance for eco-efficient innovations generally depends on the policy-design as well as on the optimal points of intervention. There has been broad research on the general policy-design for eco-innovations (Ekins and Venn 2006; Ashford et al. 1985; Jänicke et al. 2000; Klemmer 1999; Reid and Miedzinski 2008). Each eco-innovation may need to be considered separately. But some general insights can be derived:

(1) Ambitious, broadly accepted and reliable *targets* are a necessary condition. The reliability of targets depends on credible implementation measures. If targets are not ambitious there will be no innovation. (2) A *flexible policy mix* supporting the innovation cycle from invention to innovation to diffusion and back to invention is the next necessary step. Regarding invention, targeted support for R&D is essential from the outset. The dynamics of the process strongly depend on successful support for the diffusion of a new environmentally friendly technology. This is a necessary condition for the learning process, i.e. cost reduction and technical improvements. This feedback of the innovation cycle can be forced by government policy. To give an example: when the red-green German government after 1998 started with massive market support for renewable energy, an explosion of new patents for these technologies could be observed. (3) There is no single ideal instrument available in environmental policy. As a rule a *policy-mix* will be necessary. Eco-innovations need a "multi-impulse approach" (Klemmer 1999). However, for many reasons, both the price mechanism (taxes, charges, certificates, market incentives) and regulation (e. g. dynamic standards) play an important role within the policy-mix. The price mechanism can provide general incentives to support certain general tendencies. Specific regulation can mobilise specific innovation potentials and it can help to overcome specific obstacles. The example of the Japanese dynamic top-runner regulation has resulted in remarkable specific improvements. However rebound effects sometimes have reduced the general effect of energy-efficiency increases. This could be counteracted by taxes. In addition, instruments such as dynamic labelling, green public procurement, EMAS, et cetera typically play a supportive role within the policy-mix. (4) Finally, clusters and competent inclusive *networks* have proven to be important in the process of innovation.

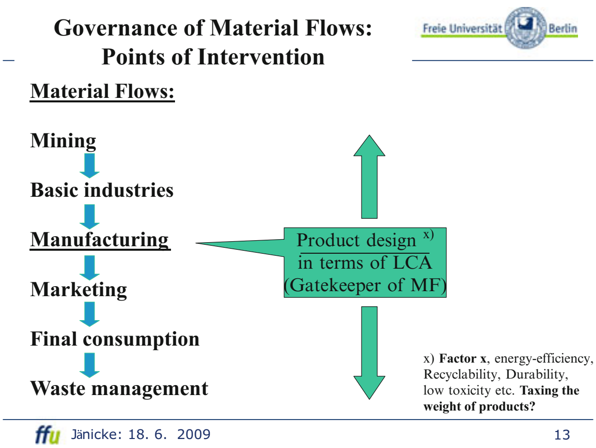

Fig. 13.4 Governance of material flows: points of intervention

13.4.3 *Points of Policy Intervention*

The *points of intervention* to stimulate eco-innovation have become an important topic particularly in the debate on resource management: we have learned that the designers and *producers of final products* (cars, food, or buildings) are the gatekeepers of material flows within the supply chain. Eco-design in terms of life-cycle assessment has become a strategic concept for eco-efficient management of both, products and processes. Final producers and also retailers are capable of influencing material flows through *their* demand – a direct influence which governments will never have (although their *indirect* influence on the framework conditions may be essential). "Greening the supply chain" (Sarkis 2006) by manufacturers or retailers is comparably easy because it is mainly *the supplier* who carries the burden of technical change.

There are several possible points of intervention along the supply chain up to final waste management (Fig. 13.4). Eco-innovation can take place at all stages.

The first stage of the supply chain is mining (or the import of resources). At first sight this seems to be the optimal point of intervention, particularly if input-taxes are concerned. Taxes on sand in Denmark are an example. For many reasons however taxes on mining have proven to be difficult in terms of politics. A new field of possible intervention is "urban mining", which can provide new kinds of resources from urban infrastructures or products in the final stage of their "life". However, except for construction materials, it is not part of general resource management so far. Here we need a better knowledge base.

At the stage of basic industries, incentives to use (and to improve) recycled materials may be a possible instrument. The construction sector in Germany for example has a high recycling rate. However the use of recycled materials for new buildings is still insufficient. This depends on innovation. The potential for new materials can be enlarged e. g. by using coal as raw material instead of burning.

Beyond the already mentioned stage of manufacturing, marketing and demand-side management offer room for potential improvement. It may be the second best point of intervention, because here relevant actors can be addressed: retailers, public administration (green procurement) and the business sector and its demand, which can be influenced e.g. by EMAS and ISO rules. The role of consumers should not be overestimated. They have no control over the process and their capacity for concerted action is generally low. There is no alternative to calculable general government rules for suppliers. Nevertheless consumers play an important role and their information and acceptance is a necessary condition for any demand-side strategy.

The final stage of waste management has for a long time been the preferred point of intervention. We have learned that this often meant no more than fighting symptoms. Resource management in terms of LCA however certainly has to include this stage. Recycling or take-back rules, for example, play an important role in this context.

Contrary to the old-fashioned "instrumentalism" in environmental policy – with its endless search for a single optimal instrument (Jänicke 1996) – we need a broad spectrum of instruments, as mentioned above. There is not only a broad spectrum of points of intervention in resource management. It is also open to a multi-impulse strategy (Klemmer 1999). Such a strategy does not rely on one single strong impulse (e. g. taxes which may be "high enough" but politically unfeasible). Instead it relies on a plurality of impulses at different points.

We still need some trial and error to optimize this management strategy for *material* flows. The knowledge base of *energy*-flow management is by far better. Here we have longstanding experience, including on the role played by international concerted action. Here we are also experiencing a breakthrough of substantial innovations. Are there lessons for material-flow management to be learned from present energy and climate policy? I will discuss this briefly in the context of the German climate policy since 1998.

13.4.4 "Policy Acceleration": Lessons from Climate Policy?

Climate policy in Germany has traditionally been oriented towards technological innovation. Since 1998 it has been explicitly conceived as "ecological modernisation" (e.g. in the coalition treaty). The Kyoto target was ambitious (21 % GHG reduction 1990–2012). Its fulfilment was particularly difficult because not only fossil fuels but also nuclear energy had to be reduced. To a certain degree this policy can be interpreted as an experiment. Only a few points can be mentioned here (without any differentiation).

The German climate policy experiment has become a success story, in terms of both ecology and economy (for similar cases see Jänicke 2012b). The ambitious Kyoto target was significantly surpassed in 2012. The expansion of green power has surpassed its target too. And the economic success is manifested by a fast growing, highly competitive "climate protection industry", which contributes about 5–6 % of GNP. According to studies the cost balance of the present climate programme will show a surplus (Federal Ministry for the Environment, Nature Conservation and Nuclear Safety/Umweltbundesamt 2011).

The applied policy was a goal-oriented multi-impulse strategy using economic and regulatory core instruments (eco tax, feed-in tariffs, emissions trading, but also standards) within a broader policy mix. It encompasses several policy measures with different points of intervention. Most important: the policy started with an ambitious target which was not only credible and agreed upon across party lines, but it was also followed by effective market support for climate-friendly technologies. This successful diffusion of new technologies caused a *feedback of the innovation cycle*: there was an explosion of new patents for renewable energies after 1998. The speed of the innovation process can be illustrated by the example of energy-efficient buildings. Here the technological potential evolved from "energy-efficient heating" to "low energy houses" to "passive houses" and finally to "plus-energy houses", which even supply power for an electric car.

This feedback of the innovation cycle could have been expected as far as the learning curve was concerned. However something was new. We may call it *"policy acceleration",* which could be described as follows: (a) an ambitious policy starting with a certain technological potential for improvement, (b) a process of innovation and diffusion stimulated by this policy leading to, (c) a higher technical potential for improvement and to market success of domestic innovators, which finally suggested even stricter policies (d). It need not be mentioned that such a development tends to enhance general public acceptance. Here another example may be given: There was a broad campaign in Germany against both, the eco-tax (2000) and the Renewable Energy Sources Act. However the success story of both instruments finally made this opposition irrelevant. In 2009 62 % of the population agreed that a strict climate policy is "an economic advantage" (Infratest Dimap).

Eco-efficient management of *material flows* is a more complex field of action compared with energy and climate policy. The materials as well as their prices, options and subsequent problems are often quite different. However, as a first step, the public discourse could be improved. The general environmental impact of material flows (including the related flows of energy, water etc.) would be better perceived if discussed in the context of resource productivity. Including the tax system with its negative impact on employment would provide the third strong argument in this discourse. Based on a better, more targeted public debate a goal-oriented multi-impulse approach to eco-efficient resource management – combining general economic incentives with specific dynamic regulation – could play at least a role similar to the one it has in energy/climate policy. Instead of a "green tax" (often stimulating a too narrow ecological discussion) a general "resource efficiency tax" on products (or their weight) would be preferable. It should be partly used to reduce social security contributions and partly recycled to increase resource productivity in the same sector. Starting with a low tax rate may be necessary to take public resistance into account. Regarding specific regulations the European eco-design policy for products in terms of LCA points in the right direction. However, more ambitious targets for selected goods are necessary. Even tentative strict targets could be helpful if they are open to revision according to the success of their implementation. Specific regulation is necessary both, to overcome specific obstacles and to use specific opportunities. Dynamic regulation and dynamic labels are required to push technologies beyond the present state of art. Long-term targets should it make clear that the innovation process will continue. Selective market support for certain products is required to create success stories. Stimulating markets for resource-efficient products as well as market competition are necessary conditions for policy acceleration. Needless to say, a good infrastructure for research and development is the basis for all this.

Finally, as in climate policy, it may be helpful to support national policies both, by international policy co-ordination and by creating an international policy arena for pioneers and trendsetters of sustainable resource use. There is also a lesson to be drawn from EU climate policy: strict green regulation of the European market not only has stimulated domestic eco-innovation and competitive advantages, but has also forced other countries and foreign firms to adapt to European policies. This has created a regulatory dominance of the EU which has become a strong driver for the diffusion of advanced policies.

13.5 Conclusion

It is time to be more ambitious regarding the eco-efficient management of material flows. The reason is not only the present crisis of resource-intensive industrial growth. The good news is that increasing material productivity beyond the normal trend will provide co-benefits in many other policies: from energy, climate and environmental policy to employment and the general competitiveness of the national economy. Material productivity will surely become a dimension of international competition comparable to energy efficiency. Therefore more ambitious targets together with market incentives and/or dynamic regulation for domestic (lead) markets make sense, at least in countries with advanced innovation capacity. A process of policy acceleration could be stimulated for certain products. Trial and error will be necessary – as always if innovation is concerned. However, without ambition there will be neither innovation nor success in the long run.

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