Ecological modernisation theory and the changing dynamics of the European automotive industry: the case of Dutch end-of-life vehicle policies

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Abstract: In this article, we use ecological modernisation theory to analyse environmental changes in the car chain. We do not intend to cover all environmental aspects of car production and consumption. The focus will be on the handling of cars in the waste phase. We are interested in the interaction between technology and policy. We argue that some technological developments in handling end-of-life vehicles trigger policy questions. But also the other way around: some policy styles favour some development paths of end-of-life vehicle technologies and foreclose others. By this combined treatment of technological and political issues, we hope to contribute to the discussion on the overall organisation of the ELV-dimension of car chains in the future. We have chosen to deepen our understanding of the basic characteristics of the ecological modernisation process in car chains by looking in some detail at the Dutch ELV-economy in the period 1970–2000 and beyond.

Keywords: ecological modernisation theory; car industry; end-of-life vehicle policy; The Netherlands.

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1 Introduction: ecological modernisation theory and the car industry

The car industry is among the most powerful sectors of post-war industrial societies, with millions of people employed in car-manufacturing and related industries. The environmental profile of this sector and its related polluting image is subject to substantial debate among environmentalists. Some argue that our private-car based mobility system is the prototype of a dead-end technology (with regard to, for example, its contribution to worldwide CO_2-emissions), and that we should try to replace it by a radically different system, based on public transport. The ecological modernisation of the traffic system in this perspective cannot start from improving the environmental profile of the car industry, which is charged to have a rather defensive record when it comes to issues of sustainability [1]. Others argue, however that the car industry unavoidably has to be included in any realistic strategy of environmental reform of the traffic system. They point to major achievements (e.g. catalytic converters, improved energy-efficiency etc.) that have been realised over the past 20 years or so, resulting in a substantial reduction of the environmental impacts of the car system. In some cases, actors from the car industry even attained a powerful position in experiments with more sustainable mobility systems, originally designed to offer an alternative to the private car dominated systems [2].

Whilst acknowledging that any policy or theory on sustainable mobility cannot restrict itself to eco-developments in the automotive industry, we consider the ecological modernisation of the production and consumption of private cars to be a key element in the transition to a more sustainable organisation of modern mobility systems. The ecological modernisation of the car industry in Europe [3,4] was prepared in the 1980s but gained momentum only from the early 1990s onward. To understand the overall direction of this process and some of its most important elements and dynamics, ecological modernisation theory can be used as an analytical tool, as was shown in recent studies by Rosette [5] as well as Smink [4]. In this article, we have the more restricted goal of showing that some of the assumptions from ecological modernisation theory indeed can be used to analyse environmental changes in car chains. We do not intend to cover all environmental aspects of car production and consumption but instead focus on one (key) element within the environmental profile of the automotive industry: the handling of cars in the waste phase. We argue that the so-called 'End-of-Life Vehicle' (ELV) policies, which have been developed in the Netherlands and Europe, can be used as a fruitful example to discuss and illustrate three issues:

1 The overall direction of the process of *socio-technical change* in the automotive sector: ecological modernisation theory in this respect put forward the hypothesis of moving away from 'end-of-pipe' solutions applied mainly at the 'end-of-chain' firm-level during the 1970s and early 1980s, to be replaced in the 1990s by

socio-technical options which can be said to be 'preventive' in nature and which are applied at higher system levels, thereby also pre-supposing higher levels of chain integration.

2 The overall development in the *socio-political discourse* concerning the environmental performance of the automotive industry. Ecological modernisation in this respect put forward the hypothesis that policy making is moving away from the local, national level characteristic of the 1970s and 1980s, to be replaced by policies mainly formulated at the transnational level of the European Union. These changes are intended to be accompanied by a shifting and sometimes contested division of tasks and responsibilities of industrial actors and organisations vis à vis (semi) governmental actors, with chain actors attaining a more central role in the overall process of eco-modernisation.

3 The *dynamic interplay* between environmental *technologies* and environmental *policies* in the ecological modernisation process. Until recent times the specific interplay between technology and policy has not been theorised in detail within ecological modernisation theory. With the help of a recently developed basic scheme – put forward by one of the founding fathers of ecological modernisation theory, Martin Jänicke – we are able to show some of the intricate linkages between technological innovations and political innovations within ELV policies.

The structure of the argument is rather simple. We first develop in the next section some theoretical building blocks, which we then apply in Section 3 to ELV policy and technology as they developed in The Netherlands from 1970 to the present. From this empirical investigation we try to learn more about the specific hypotheses put forward above. We conclude with a discussion on the relevance of ecological modernisation theory for understanding environmental dynamics in car chains in Europe.

2 Elements of ecological modernisation theory for analysing ELV policies

We start by introducing ecological modernisation as a theoretical framework for empirical research, elaborating especially on the principles for a more ecologically rational handling of waste-streams in the context of ELV policies. Then we go on to discuss the interplay between technical and political innovations in the ecological modernisation process. Since the socio-political dimension of the innovation and diffusion of environmental technologies turns out to be of decisive importance, we conclude the theoretical section with a short discussion on the organisation of the car chain and the position of some of its most relevant actors.

2.1 Ecological modernisation theory

The theory of ecological modernisation has been developed to analyse the greening of industry processes from a sociological perspective primarily [6–11]. Within this theory, it is argued that in the period from the 1980s onward, ecological criteria gained importance and developed into independent norms to be used alongside socio-economic criteria when making judgements about the performance of technologies and industries in modern industrial societies. The theory states that this ecological modernisation process on the one hand can be seen as strongly related with the emergence of new, more preventive

technologies operating on ever higher system levels, whilst on the other hand the introduction and diffusion of these technologies cannot be understood without looking at a specific set of changes in the policy networks and arrangements which go together with these environmental technologies. These new politics of pollution [12] refer, among other things, to the changing role of the state vis-à -vis the actors in the value chain.

Up till now, the theory has been applied in empirical research at different levels and within different sectors or segments of modern societies and more recently in the context of transitional economies as well. From this empirical research it could be concluded that the general assumptions of the theory seem to be valid to explain environmental change, provided that the general assumptions are translated and made operational in a specific way to fit the industrial sector or country under study. For example, the dynamics of the chemical industry [13] are different from the dynamics of utility sectors [14] and working with the theory in Asia [15–17] means that some of the biases which come along with the European origins of the theory, had to be corrected and adapted to the Asian context. In order to prepare the theory for its application to waste streams in the car industry, we briefly discuss 1) environmental criteria for handling wastes in general, and 2) within the context of the automotive chain of production and consumption

1) Principles for waste handling in general

In the early years of solid waste management, most attention focused on emission control of individual waste processing facilities and landfills. Issues of hygiene, odour nuisance, and local contamination of soil and water dominated the policy agenda. A milestone towards a more encompassing approach was the waste management hierarchy, which was developed in the 1970s by US EPA, and around 1990 became accepted worldwide as a leading principle in waste policy. To date many versions of the hierarchy exist, which differ in the elaboration of options and the distinction of preference levels, but share its general philosophy. The current version of the Dutch government is presented in Figure 1. In the Netherlands, this hierarchy is known as 'the Ladder of Lansink', after the politician who filed the motion that introduced the hierarchy into Dutch national policy in 1979.

Following the waste management hierarchy, technological options for waste management are prioritised with consideration of environmental performance of the waste management system as a whole, not from the angle of local impacts and individual facilities.

Figure 1 The integrated solid waste management hierarchy according to the Dutch Environmental Management Law, Art. 10.1

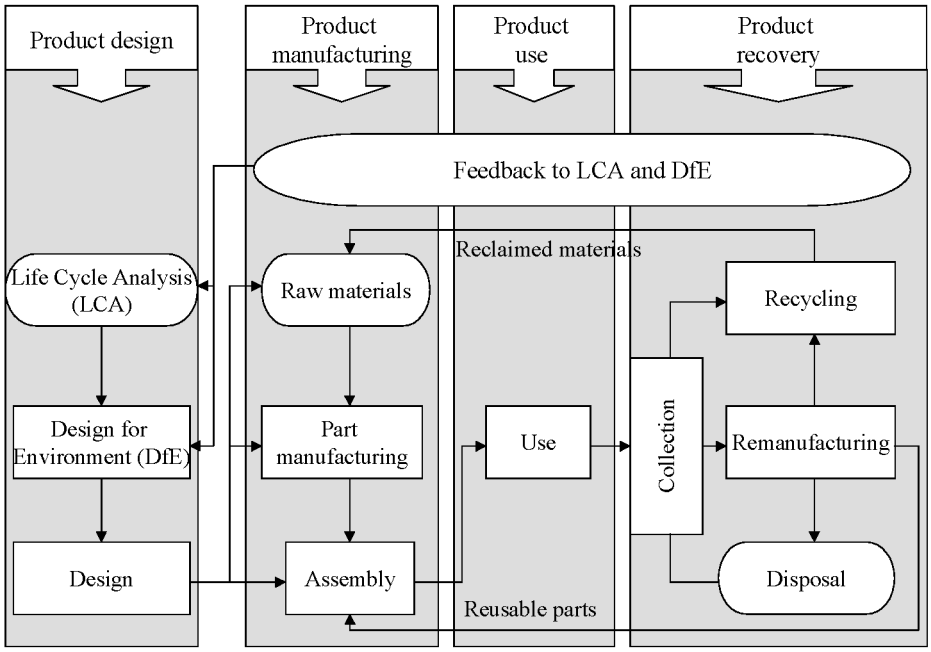
1. Waste prevention (quantitative and qualitative source reduction)
2. Waste recycling (incl. Materials recovery and composting)
3. Use of waste as energy source
4. Waste combustion without energy use
5. Landfilling

2) Waste management and technology at higher system levels

However, this perspective still has limitations because it only regards the last part of the production and consumption chain: the management of waste. A growing number of authors have stressed the need to enlarge the scope of environmental innovation to the full chain of production and consumption, using concepts such as Industrial Ecology, Eco-design or Design for the Environment (DfE), Life Cycle Assessment (LCA) and Life Cycle Management (LCM). An LCM approach to waste management is illustrated in Figure 2.

In the product life cycle perspective, room for improving waste management is extended in several ways. Firstly, it allows a better and more detailed view of waste prevention by differentiating the production stages in the upstream product life, all of which can be further investigated for options of waste prevention. Secondly, it explicitly takes into account upstream modifications as a means of improving recycling and disposal of waste. Innovative tools such as Design for Recycling (DfR) – one out of a cluster of tools referred to as DfE – have high potentials for improved waste management. Thirdly, the product life cycle perspective advocates the assessment of the environmental impacts over the whole life cycle. With the help of LCA, it is possible to identify transfer of environmental impacts to other stages in the product life cycle. Decision makers thus can avoid waste management technologies that shift, rather than solve the problems (e.g. waste treatment technologies that consume high amounts of energy) and refine and modify the rather crude ranking of the waste hierarchy ([cf. 19]).

Figure 2 Interactions among the activities in a product life cycle (the activities within the boxes with rounded edges represent the supporting activities in the associated life stage)



Source: Gungor and Gupta [18,p.812].

As we will try to show in Section 3 of this paper, the application of these subsequent principles of waste management, each one extending the system level of waste management, can be observed in the development of ELV recycling in the Netherlands and Europe. Their application, however, is influenced and conditioned by social context factors.

2.2 The interplay between technology and policy innovation

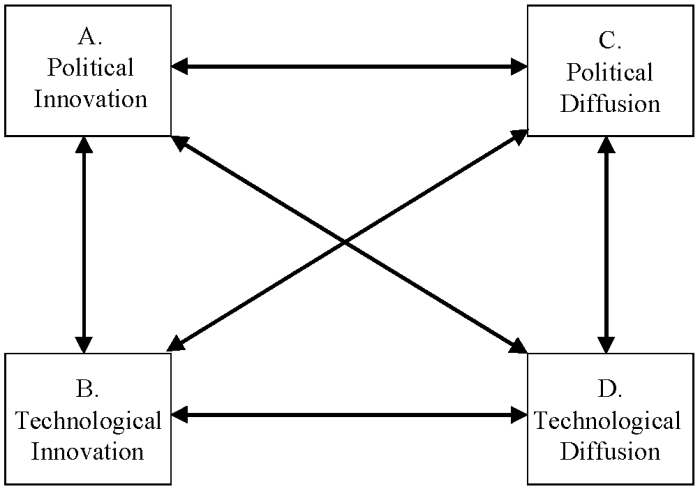
Many researchers have been studying the car chain from an environmental angle (e.g. [18,20–25]). Some of these studies mainly deal with substance flows and technological issues of recycling. Others include considerations of social and policy aspects such as industrial networks and national legislation. They scarcely address in a more direct way the interaction between the socio-technical and the socio-political dimension of ELV politics. Why is it that governments have to take the lead in technological innovations in a sector, which is very well equipped to manage its own environmental business? Why are some less promising and eco-efficient technologies prioritised above environmental technologies, which in the long run can be said to offer the more integrated solutions? Which policy style fits the development of environmental technologies at higher system levels etc? These are the questions that motivated us to look into the interaction between technology and policy in more detail. We argue that some technological developments in handling ELVs trigger policy questions as to how and who should implement these new technologies. But also the other way around: we try to show that some policy styles bring along with them a definition of the problem and a general approach which favours some development paths of end-of-life vehicle technologies and foreclose other, sometimes more promising trajectories. By this combined treatment of technological and political issues in the context of the emerging ELV economy, we hope to contribute to the discussion on the overall organisation of the ELV dimension of the car chains in the future. To lay the conceptual ground for this analysis, we turn to the recent contribution made by the German political scientist Martin Jänicke on this issue.

Jänicke has developed an interesting format to discuss the relationship between technological and political innovation within the broader perspective of ecological modernisation theory [26]. Since within ecological modernisation theory the emphasis is put no longer or exclusively on compensation and end-of-pipe technologies but instead moved to preventive technologies to be applied on different organisational levels, the political dimension of technological change has gained importance. Also, when moving up to more preventive levels higher up in the production-consumption chain, the interaction between technological innovations and political innovations has become more complex and multidimensional. Figure 3 displays a set of possible interactions between technology and policy innovation in the context of ecological modernisation.

The Figure shows different trajectories of environmental change, which can be initiated by technological or political processes and which can be said to be ‘dominated’ or ‘determined’ by either technology or social policy when it comes to characterising the main dynamics of the innovation process. What is not included in Jänicke’s Figure is the system level on which the innovation occurs. This system level can be determined by different factors: the character of the industrial networks involved (production or disposal, or both), the scope of the waste management principles applied (waste

management hierarchy or life cycle management), as well as the scale level of the policy networks involved (local, national, or transnational). Ecological modernisation, as we have observed, would hypothesise an increase of system level on all these aspects. For the interplay of technology and policy it is hypothesised that 'political dominance' and to a certain extent also 'technology forcing' are the more likely to occur in the earlier stages of the ELV development process, when national governments are able to interfere in a direct way in waste policy issues within their national domains. In later phases of the process, technology dominated or triggered routes could become more feasible.

Figure 3 Interactions between technology and policy innovations in the context of ecological modernisation



A~B~C~D = technology forcing
A~B~D~C = triggered by politics
A~C~B~D = political dominance
B~A~C~D = triggered by technology
B~A~D~C= technology dominant
B~D = autonomous technology

Source: Jänicke [26].

2.3 The organisation of the car chain

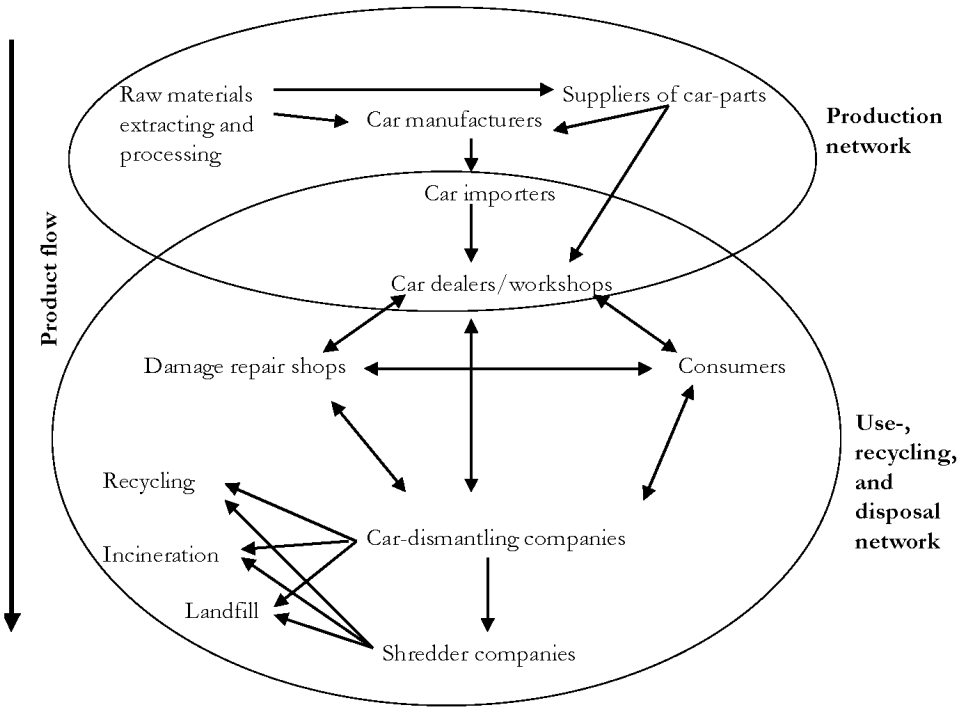
As illustrated in Figure 4, the car chain can be divided into two sub-networks: the production-network and the use, recycling and disposal network. To understand the problems of ELV policy, it is important to observe that these two sub-networks are only weakly linked to each other via the car importers and main dealers. In the past, car manufacturers have shown little interest in connecting with car dismantlers or shredder companies. They have probably even tried to avoid direct association with dismantling activities, which were dispersed, sometimes semi-legal or illegal, and competitive with dealers on the spare parts market [20]. The attitude of dealers is illustrated by a statement we took from a dealer of the Ford Motor Company: "we do not want to collect old Ford vehicles via our dealer network. People who are planning to buy a new car, do not want to see a mound of end-of-life vehicles at the car dealer" [27].

As we will elaborate in this paper, we regard the weak link between the production network on the one hand and the use, recycling and disposal network on the other, as one

of the key issues in ELV recycling. This weak linkage has its roots in the specific history of the ELV sector within the car chain; a history which cannot be explained by economic considerations alone and which differs in some crucial respects from, for example, similar networks in the food chain. Both chains are very much transnational in nature, and both chains are subject to substantive environmental pressures from local and international agencies. In both chains these pressures have resulted in the development of new, more sustainable products and production processes. However, where in the food chain retailers became the key actors in the process of ecological modernisation of the food chain by establishing a link between the sustainable production and the sustainable consumption of food, the intermediaries in the car chain do not perform these kinds of tasks at all. Green cars are not made into selling points by car salespersons, they are promoted by government subsidies and EU policies. As yet, consumers do not (and are not triggered to) establish a link between the ELV policies followed by chain actors in the automotive industry and the environmental performance of the car industry in general.

In this section we have discussed some general characteristics of ecological modernisation theory, and introduced some specific elements, which are necessary for its application to the practices of waste handling in car chains. In the next section, we will deepen our understanding of the basic characteristics of the ecological modernisation process in car chains by looking in some detail at the Dutch ELV economy as it developed from 1970–2000 and beyond.

Figure 4 The car chain and its two sub-networks



Source: Smink [4].

3 The transformation of Dutch ELV recycling from 1970 to 2000 and beyond

Introduction: ELVs and the environment

Recycling and reuse are not a recent phenomenon in the ELV system. From the early days of car repair, people who needed cheap spare parts for their car would often go to a car-dismantler. Car dismantlers typically had many ELVs standing or stored on their terrain, where people could find the parts they needed. After the removal of the more profitable parts of the cars, the metal bodies would generally be sold to a shredder, to be recycled in iron production. From these early days, car-dismantling sites have also been a notorious cause of local environmental problems.

It could take many years before the environmental aspects of car reuse and the local environmental impacts of dismantling activities were addressed in a consistent and encompassing strategy. We will describe and analyse these changes with regard to four main periods from 1970 onwards: 1970–1981, 1981–1992, 1992–2000, and the period from 2000 until the present. For each of these periods, we will look at the general changes in the technology and policy and also describe the interaction between ELV technology on the one hand and the social and political structure of the emerging ELV economy on the other. After a short description of the most important events, we will evaluate each period with the help of the research hypotheses on ecological modernisation as formulated in the first section.

3.1 1970–1981: car-dismantlers forced into the environmental arena

Whereas The Netherlands developed environmental regulations at a high pace in the 1970s, none of these regulations was specifically aimed at problems with ELVs: improving the flow of ELVs from the final owner to the car-dismantling company, and bringing about the environmentally sound storage, processing and use of ELVs. In addition, whilst many companies were provided with environmental permit(s), car-dismantling companies were 'overlooked' [4]. By the late 1970s, it was clear that the disposal of ELVs presented serious environmental problems and needed to be improved in several aspects. The commentary by the Minister of Environment on the draft ELV directive [28] of 1980, a directive aimed at regulating ELV disposal, clearly illustrates the point. The Minister of the Environment identified two main problems [29]. Firstly, dismantling of end-of-life vehicles did not happen in an environmentally sound way, which led to odour nuisance, noise nuisance, soil and surface water pollution and landscape disfigurement. Secondly, and adding to the environmental problems, the disposal of end-of-life vehicles did not happen in an efficient way. The flow of ELVs had serious bottlenecks, and it was often quite difficult for the final owner of an end-of-life vehicle to get rid of it. Repeatedly, ELVs ended up in the countryside or at roadsides. But even when ELVs were delivered to a car-dismantling company, wrecks often stood at the dumping ground for years.

Two main factors were mentioned in the draft Directive [29,p.6] to explain the deplorable state of affairs: 1) the lack of proper legal instruments and 2) the marginal size of car dismantling companies. We will look at both factors in more detail.

At different governmental levels and from different points of view, governments have tried to manage problems with the ELVs, for example via town and country planning,

landscape protection, traffic control, safety and public health. None of these efforts was aimed at the essence of the problem: improving the flow of ELVs from the final owner to the car-dismantling company, and bringing about the environmentally sound storage, processing and use of ELVs. Only by means of the Nuisance Act, could government regulate car-dismantling companies. According to this, car-dismantling companies needed an environmental permit. However, many did not have an environmental permit. In the province of Groningen, for example, only 41 out of 86 car-dismantling companies had an environmental permit [30], and in the province of Zuid-Holland 75% of all car-dismantling companies did not have an environmental permit [31]. But even if they had an environmental permit, they did not necessarily comply with environmental regulations, and they did not necessarily have the required environmental facilities (e.g. liquid-proof floors).

The Netherlands accounted for many (very) small car-dismantling companies in the 1970s. Many of these companies stored only 10–25 ELVs. This entailed various problems. For example, the ELVs stood too long at dumping grounds, which could cause environmental problems, as the ELVs had often not been dismantled in an environmentally sound way. Several kinds of fluids could leak out of the (partly) dismantled ELVs and cause soil and groundwater pollution.

To start tackling these problems, the Ministry proposed the following measures. Firstly, the number of car-dismantling companies should be reduced to approximately 400, within five years. It was expected that a smaller number of large car-dismantling companies would be better equipped to do the investments needed to protect the environment. Secondly, the minister proposed a state allowance of 50% for relocating car-dismantling companies or for closing down companies. Thirdly, a state allowance of 50% was rewarded for the implementation of environmental facilities. And finally, a state allowance was given for the establishment of 150 extra municipal or provincial ELV dumping grounds. The focus of attention of these solutions was very much on 'direct emission control' at the level of individual companies. Issues of hygiene, noise, and local contamination of soil and groundwater dominated the solutions proposed [4].

Evaluation of the 1970–1981 period

At the end of this first period, ELV-handling had entered the environmental arena and was put on the agenda of environmental policy makers. But this was not a smooth process and some actors in the dismantling business in the 1970s were very reluctant to accept whatever environmental regime the governments had in mind for their business. Dismantling terrains are – for good reason since they need space for the storage of sometimes large numbers of vehicles – most of the time situated at the outer edge of the urban community, and some of their owners belong to social groups that are on the margins as well. With part of the dismantling business outside the formal economy and society, it was not an easy task to include the ELV activities and their main actors in the environmental agenda. Before we can talk about environmental technologies and policies developing and moving through different phases, the very fact of their coming into existence is the most relevant conclusion for this period.

If we evaluate this period in terms of Jänicke's analytical scheme, it is only at the end, in 1980, that we see signs of *political innovation*, in the new directive and the related comments of the Ministry. *Technological innovations*, as far as they occurred, took place at the initiative of individual car-dismantling companies. To the production network, the

ELV problem was of little concern. Consequently, *technical diffusion* did not take place, or was negligible.

3.2 1981–1992: car-dismantling is regulated by permit and spatial planning

On 1 July, 1981, article 21 of the Waste Substances Act [32] came into force by Royal decree. The Waste Substances Act had come into effect in 1977 and put restrictions on the environmental burden by waste substances. The Act offered an organisational and legal framework for state, provinces and municipalities [33] for the efficient and environmental sound disposal of waste substances. The new article 21 was dedicated to ELVs, and obliged provinces to prepare a so-called ELV Policy Plan [34] on the disposal of ELVs. These plans had to be determined by Provincial States and had to contain at least the main lines of the provincial ELV policy and, at the same time, a description of the facilities that were needed within the province for the realisation of the plan [4]. In order to support provincial planning, the minister formulated the 'Directive for Provincial Plans regarding the Disposal of ELVs' [35] in 1981. The directive aimed at providing a picture of the desired content of the provincial plans and also offered a format for data handling in the new policies.

When provinces had published their ELV Policy Plans, they started procedures for granting permits. Provinces had to negotiate with all the companies that had to be closed down or relocated, a procedure that could sometimes take about two years. Municipalities were closely involved in this process, since they had to determine whether a company fitted into the zoning plan or not. When a company did not fit in the zoning plan, the municipality or the company had to search for another location at an industrial area. When they did not succeed in finding this location, the company had to close down and the financial allowance was agreed. The period of granting permits was already causing a clear decrease in the number of auto dismantling companies. In 1987, the Netherlands accounted for approximately 2100 car-dismantling companies, in 1990, 1370 were left [4].

Provinces experienced a major lack of resources when implementing their ELV plans. Therefore, in 1987, the national ministry of the Environment launched a regulation aimed at providing provinces with financial means for the implementation of the ELV policy [36]. This regulation was launched in particular with regard to the financial costs caused by the relocation and the closing down of companies that on the basis of the provincial ELV policy plans could not get an environmental permit. Other aspects that had been considered were the establishment of provincial car delivery grounds, the implementation of soil research, deployment of police in case of forced closure, company visits and, occasionally, the implementation of environmental facilities [4].

The emerging ELV policy, with its strong focus on permits, also had some definite consequences for the environmental measures applied in car dismantling practices at the time. In order to obtain an environmental permit, car-dismantling companies had to get an overview of their activities. In terms of the ecological modernisation literature, a full monitoring system had to be set up, making the 'invisible visible'. In order to do so, companies had to register the ingoing and outgoing transport of ELVs (date, quantity, origin, destination), the disposal of liquids (date, kind of liquid, carrier, processing company), and the disposal of waste substances (date, quantity and destination). When it came to the technology applied in this period, ELV strategies put the emphasis on sanitation and emission control by end-of-pipe technologies at the level of individual

car-dismantling companies. The permit procedure included an investigation of soil and groundwater contamination. In many cases, this led to clean up activities at car-dismantling sites. One of the technologies commonly installed at car-dismantling companies was a so-called liquid-proof floor. Gradually, however, more preventive measures were also adopted, improving the operational activities of the dismantlers, e.g. by avoiding spills, better storage of hazardous substances, and removal of oil and batteries from ELVs. Such activities generally referred to as 'good housekeeping' may be regarded as a first step from an end-of-pipe approach towards cleaner production (see for example [37,p.22]). Also, more and more car-dismantling companies started to build up indoor stocks, which led to improved quality of spare parts.

Evaluation of the 1981–1992 period

In Jänicke's terms, this period can be described as one of political dominance and this is in line with the hypothesis put forward by ecological modernisation theory, that one will find these kinds of innovation routes especially in the earlier phases of environmental policy making. The main *policy innovation* was the regulation that required provinces to make an ELV policy plan. The *diffusion* of this policy to the provinces took more time than was planned, but eventually came off, and did not fail to influence the technologies applied in the car dismantling companies. These technologies mainly consisted of end-of-pipe measures, monitoring procedures, and sanitation processes. But they also included preventive measures, particularly measures of good housekeeping. It would be going too far, to describe these as important *technological innovations*, but certainly, existing technologies, and modest innovations found their way to the companies. We may say, therefore, that in this period ELV policy has given a substantial push to *technological diffusion*. If we regard the system level of environmental change, it is striking that the production network, and even major parts of the use-, recycling and disposal network are barely involved. Even the waste management hierarchy does not seem to play an important role, as ELV policy is still very much concentrated on the individual company and its local impacts. Within these companies, however, waste prevention is a growing concern.

3.3 1992–2000: car-dismantling regulated in cooperation with the disposal chain

A major landmark of the ELV policy changes in the early 1990s was the publication of the Implementation Plan End-of-Life Vehicles [38] in 1992 [39]. The Implementation Plan was not a product of the Ministry of Environment, but the outcome of the deliberations of a group of societal, economic and governmental actors. Apart from the Ministries of Environment, Economic Affairs, and Transport, the group included, among others: RAI (representing car manufacturers and importers), BOVAG (car dealers and workshops), FOCWA (damage repair companies), STIBA (car dismantlers), SVN (shredder companies), SNM (representing a large group of environmental NGOs), as well as RIVM and TNO (two large research institutes) [40]. The aims of the Implementation Plan were threefold [39,p.8]:

- to achieve the directional settings of tasks for ELVs and shredder waste by the year 2000 from the policy document 'Prevention and Re-use of Waste Substances'
- to achieve the setting of tasks with regard to prevention, reuse and final disposal
- to bring about a structure, in which policy makers and other actors involved have the possibility of adapting both the implementation plan and the setting of tasks to changing circumstances with regard to technology, environmental policy and market.

To understand the reasons for this development, we should look at both the transformations in policy and the changing landscape of ELV dismantling. In the environmental policy domain, the command-and-control approach of the 1970s and early 1980s had now given way to a new, more communicative and market-oriented approach. With regard to waste policy, the 1988 Memorandum on Prevention and Reuse of Waste Substance, among others initiatives, had established a more integrated approach to waste management, based on the waste management hierarchy.

The landscape of car dismantling had undergone some major changes. The number of car-dismantling companies had been decreasing since the 1980s and continued to shrink in the 1990s. Many of the problems dealt with in the 1980s were diminishing. The next move – stimulated by the waste management policy – was to increase the recycling percentage of ELVs. So far, only a limited number of parts and materials were recycled. When cars were processed by the shredder companies, a large proportion of the non-metal parts of cars, in particular, ended up as shredder waste, to be disposed of in a landfill. Higher costs of landfill have – among other things – stimulated recycling, and increased the demands on car-dismantling companies made by the shredder business. Still, a number of parts and materials remained economically unattractive for recycling, like glass, rear lamps and indicators and PU-foam. Thus, the challenge was to find ways of recycling these unprofitable parts and materials as well. This is why Auto Recycling Nederland was established.

ARN as a central player in Dutch ELV recycling

Auto Recycling Nederland (ARN) was established by the Dutch automobile industry in 1995. Business associations involved are the STIBA (car dismantlers), the RAI (car manufacturers and importers), the BOVAG (car dealers and workshops) and the FOCWA (damage repair companies). ARN has a countrywide network of car-dismantling companies. A car-dismantling company can apply for ARN membership when it has an environmental permit and when a certification body recognised by the Dutch Council for Accreditation approves the company (a kind of Environmental Management System). Registered car- dismantling companies are contractually obliged to dismantle 18 materials (see Table 1), which are decided upon by ARN. Dismantling of these materials has to be administratively verifiable, and will return waste removal premiums. ARN determines the premium payable for each material. In order to be able to disburse waste removal premiums ARN collects waste disposal fees. The waste disposal fee is laid down in the Environmental Management Act. Since 1995, car importers have had to pay a waste disposal fee of € 45 per car [41]. Via the waste disposal fee, car manufacturers met their take-back responsibility. We will come back to this later.

Table 1 Materials to be dismantled by ARN-companies incl. quantities (kg, litre or stk.)

1995	*1996*	*1997*	*1999*	*2002*
Coolant (3.6 litre)	Plastic bumpers (5.5 kg)	Grilles (0.8 kg)	Fuels (petrol/diesel) (5 kg)	Oil filters (0.5 kg)
Used oil (4.9 litre)	Safety belts (0.4 kg)	Rear lamps and indicators (1.4 kg)		
Brake fluid (0.3 kg)	Coconut fibre (0.9 kg)	Hub caps (0.7 kg)		
Batteries (13.6 kg)	Windscreen washer fluid (0.9 kg)			
Glass (25.4 kg)	LPG-tanks			
Tyres (27.3 kg)	(0.06 stk)			
Inner tubes (0.2 kg)				
PU-foam (6.5 kg)				
Rubber strips (7.7 kg)				

Source: ARN [42].

Table 2 Recycling percentage 1997–2000

	1997 (absolute) (Kg)	1997 (%)	1998 (absolute) (Kg)	1998 (%)	1999 (absolute) (Kg)	1999 (%)	2000 (absolute) (Kg)	2000 (%)
Car weight (average)	879	100	887	100	896	100	906	100
Metals (assumption)	659	75	665	75	672	75	679	75
ARN materials	96	10.9	97	10,9	99	11	100	11
Recycling	755	85.9	762	85.9	771	86	779	86
Remaining	124	14.1	125	14.1	125	14	127	14

Source: ARN [42].

Dismantling these materials means a considerable increase in the variety and amount of materials to be recycled. Initially, about 250 to 300 kg of materials of each ELV had to be treated as waste and was disposed of, mainly to landfill [42]. After the foundation of ARN, reuse rapidly increased from 75% to 86% of a car's weight. Since 1999, the recycling percentage has stagnated at 86%, as shown in Table 2. This can be explained by the fact that cars contain more synthetic materials and are equipped with more safety conveniences and extras like airbags and air conditioning.

As we will see in the next section, a recycling percentage of 86% is too low to meet the EU objective of 95% recycling by the year 2015. According to ARN, this percentage can only be achieved when new technologies are applied by other actors in the car chain, for example shredder companies, but also higher up in the chain by manufacturers, as most possibilities of increasing reuse at car-dismantling companies have run dry.

Since ARN determines which materials car-dismantling companies are obliged to dismantle, and what price car-dismantling companies will get for each material, ARN has an eminent influence on the market for recycling. Interviews with car-dismantling companies showed that car-dismantling companies with only ARN contracts have to dismantle at least 1600 ELVs a year in order to make a profit. Dismantling fewer

ELVs requires additional activities, like the sale of second-hand cars and the sale of car parts [4].

ARN does not only stand for maintaining a network of car-dismantling companies and taking care of dismantling procedures and prices, it also selects and controls collection companies [43], recycling companies [44] and probably in the future also shredder companies.

Evaluation of the 1992–2000 period

The main characteristic of this period is the fact that ELV policies at the national level and at the end of the car chain became professionally organised by an organisation – ARN, which brought together market actors and governmental agencies. The main *policy innovation* in this period was the new, integrated and communicative approach to the environmental issues surrounding ELVs. Integration is stimulated by taking a more comprehensive view of ELV waste management, with an emphasis on waste prevention and recycling. The communicative approach is epitomised by the Implementation Plan End-of-Life Vehicles, which was the result of stakeholder consultations and which gave birth to a new organisation, founded and supported by representatives of the Dutch automobile business. In these types of joint policy implementation, innovation and diffusion go hand in hand. The *technological innovation*, brought about by this process, consisted mainly of the monitoring and monetarisation of the relevant substance flows in the emerging ELV economy. Technology in this period also refers to finding new ways of categorising and registration of waste components, and new methods and techniques for cost-effective dismantling of a variety of components. ARN has played a central role in both innovation and diffusion of these techniques.

Looking at the system level, we clearly see that the waste management hierarchy has become a central element in environmental strategy. We can also witness cooperation and optimisation over the use, recycling and disposal network. But we cannot confirm a full life cycle management approach. The lines of communication between ARN and the car manufacturing companies are still weak, i.e. only by the collection of the waste disposal fee, do car manufacturers meet their legal requirement with respect to the take-back principle. In other words, the activities of ARN are still concentrated in the use, recycling and disposal network. As we will elaborate in the conclusion, it is plausible that the reported stagnation in recycling at the end of this period can, at least to some extent, be related to the lack of a broader, international and fully chain-oriented approach.

3.4 Beyond 2000: car-dismantling activities and actors regulated by the EU

In many areas of environmental policy, the EU exerts an increasing influence on national regulation. ELV recycling is no exception. For the period that started around 2000, it is likely that EU policy will be a major factor in the development of car dismantling and recycling. In this section, we will therefore focus on the European level and discuss some of the future implications that EU policies will have for the Dutch ELV sector. Before we turn to a description of EU policies in the ELV area, we will very briefly discuss the position and character of Dutch policies when compared to some other European Member States who are active in the ELV-field.

At the European level, The Netherlands is regarded as a ‘green but small’ Member State. When discussing ELV policies, we have to add to this the fact that The Netherlands

does not have a strong car manufacturing tradition when compared to France, Germany and Italy. In the formation of ELV policies at the EU level, the three major manufacturing countries were the most powerful actors. Den Hond and Groenewegen describe for the period from the 1980s to 2000 how two different regulatory regimes for ELV handling were put forward and discussed: the government led, rather (eco-) strict and formal German model on the one hand and the industry led, informal and voluntary model as suggested by France and Italy on the other [20]. As will be clear from the description above, the Netherlands is situated somewhere in between both types of regimes. Within the ARN there was a strong focus on formal regulation and the use of government subsidies, but market actors were very well represented and acted as stakeholders in the overall development of Dutch ELV policies. Dutch pilot studies on dismantling were a joint effort by industry and government, and there was no organised opposition by the manufacturing industry against the introduction of strict environmental policy targets and principles [45].

In November 1996, the European Parliament called upon the European Commission (EC) to legislate waste streams, in particular ELVs, on the basis of product liability. The EC took the view that a specific directive was necessary given the importance of this type of waste. The Proposal ended in the EU Directive 2000/53/EC, which entered into force on 21 October 2000. The objective of the Directive is: 1) to prevent waste from ELVs, 2) to promote the collection of ELVs, 3) to promote reuse and recovery of ELVs (e.g. components) to protect the environment [46]. In order to prevent waste from ELVs, the Directive states that car manufacturers and material and equipment manufacturers have to (Article 4) [46]:

- endeavour to reduce the use of hazardous substances, when designing cars
- design and produce cars that facilitate the dismantling, reuse, recovery and recycling of ELVs
- increase the use of recycled materials in car manufacture
- ensure that components of cars placed on the market after 1 July 2003 do not contain mercury, hexavalent chromium, cadmium or lead, except in the cases in Annex II.

The Directive also introduces provisions on the collection of all ELVs (Article 5). Member States have to take the necessary measures to ensure that economic operators [47] set up systems for the collection of all ELVs, and make sure that there is adequate availability of collection facilities. Another important aspect with respect to the collection of ELVs is that Member States have to set up a system, in which the final owner needs a certificate of destruction, in order to be able to deregister his or her car. Only authorised car-dismantling companies are able to issue a certificate of destruction. Car-dismantling companies will only be authorised, if they comply with a number of requirements aimed at protecting the environment. Furthermore, the final owner of a car should always be able to deliver the car free of charge to an authorised car-dismantling company ('free take-back'-principle) also in case the car is having a negative market value.

At the moment, at least 75% of the ELV's weight is recycled (metal content). By the entering into force of the Directive 2000/53/EC, the aim is to obtain the following targets (2000/53/EC, article 7 Section 2):

- No later than 1 January 2006, for all ELVs, the reuse and recovery shall be increased to a minimum of 85% by an average weight per vehicle and year. Within the same time frame, the reuse and recycling percentages shall be increased to a minimum of 80% by an average weight per vehicle and year [48].
- No later than 1 January 2015, for all ELVs, the reuse and recovery shall be increased to a minimum of 95% by an average weight per vehicle and year. Within the same time frame, the reuse and recycling shall be increased to a minimum of 85% by an average weight per vehicle and year.

The EU-Directive on ELVs is part of a series of environmental regulations from the EU, adhering to the general guidelines of waste minimisation and the polluter-pays-principle. The Packaging Waste Regulations (EU-Directive 94/62/EC) and the forthcoming Directive on Waste from Electric and Electronic Equipment (WEEE) are other examples of more product-oriented regulations [4]. Various aspects of the Directive are based on the Dutch system. For example, the fact that ELVs have to be transferred to authorised car-dismantling companies, and the fact that car-dismantling companies will only be authorised if they comply with a number of requirements aimed at protecting the environment.

Evaluation

It would be too early to evaluate this period, but it could be labelled the 'dominance of EU-politics'. The European Directive on End-of-Life Vehicles (2000/53/EC) is an important *political innovation,* but its character and impact will be different from the political innovations as they took place in the 1980s at the national level. EU policy making is inherently a form of multi-level and multi-actor governance and this makes the policy context for innovation different from the nation situation. The objectives of the EU regulation are first of all oriented at actors high in the production-consumption chain (most notably, car manufacturers). Producer responsibility has become the key word. Producer responsibility might lead to integration or more communication between the actors in both networks of the car chain, as ELVs have to be transferred to an authorised car-dismantling company, the car manufacturer or a car dealer. Car-dismantling companies will play an important role, as they have the knowledge and the technological means to dismantle ELVs in an environmentally sound way.

Technological innovations will increase the recycling percentage of ELVs. Technological innovations have to be realised via LCM and DfE. In order to achieve the goal of 95% recycling by the year 2015, innovations should not solely take place in the use, recycling and disposal network, but in the production network as well. A central role is allocated to car manufacturers, as they have to give car-dismantling companies information about dismantling processes and materials used in the car. This *technological diffusion* will be the basis for a successful end-of-life policy.

4 Conclusions and discussion

In this paper, we aimed at the combined treatment of technological and political issues in the context of the emerging ELV economy. We made use of the ecological modernisation theory to analyse the emergence and development of ELV policies in the Netherlands

from the 1970s onwards. We divided the period from the 1970s until today into four periods. In each of these four periods, the relationship between technology and political issues could be specified. In all periods, political innovations served as a trigger to environmental change, but over time, technological innovations became increasingly important. Furthermore, an important shift can be recognised with respect to the key-actors in the process. As hypothesised by ecological modernisation theory, in the early stages it was government who formulated policy, made money available for the implementation of ELV policy etc. From the mid-1990s onwards, market actors have gradually and increasingly taken on a leading role, together with a shift in governance level that resulted in the EU becoming the most important framework for ELV policy making.

Although the technology development also followed the expected route from 'end-of-pipe' and 'end of chain' to more preventive technologies at higher chain or system levels, the ELV policies are limited in this respect because of the weak linkages that can be said to exist between the two sub-networks in the car-chains, with the production network having a different commitment and interest in ELV policies compared to the companies in the waste-handling network. Strengthening the cooperation and integration between these two networks seems to be a prerequisite for further development of the ecological modernisation process.

Will the EU-level policies manage to establish closer links between the sub-networks, and what will be the basic attitude of the main European car manufacturers to this? At first sight, it seems that European car manufacturers do not consider dismantling of ELVs as their core business, or as an attractive activity. As Bellmann and Khare observe, "the implementation of recycling solutions by European car manufacturers indicates that they are not eager to take a major control over vehicle dismantling and recycling technologies" [24,p.497]. A typical example of the strategy of car manufacturers is the IDIS (International Dismantling Information System) research program, jointly implemented by European car manufacturers, associated with the European Council for Automotive Research and Development [49] (EUCAR). In July 1999, this program resulted in a CD-ROM with specific recycling instructions, and was distributed to more than 2200 car dismantlers throughout Europe [50]. On this CD-ROM, car-dismantling companies can get dismantling instructions for the products, which each car manufacturer has created [51]. According to ACEA [50], the aim is to deliver appropriate information on fluid drainage and dismantling of parts containing substances, which require special treatment, when dismantling ELVs, and which should not be passed onto the shredder. In other words, most initiatives are aimed at standardising and optimising dismantling activities at a distance from car production, and in a non-competitive, often nationally based way. This strategy is very much in line with the ARN strategy we have analysed in this paper.

But the situation is not unambiguous. In the early 1990s, several European car manufacturers set up car-dismantling pilots, for example: BMW, FIAT, Ford Europe, Mercedes-Benz, Peugeot, Volkswagen and NedCar. These and some later DfR activities were based on initiatives developed by car manufacturers alone or together with car-dismantling companies. In such projects, car manufactures try to develop 'innovatory gain' in compliance with forthcoming regulation [24,p.496]. The potential of innovatory gain therefore seems a significant incentive for car manufacturers to cooperate more actively with the use, recycling and disposal network. Our analysis suggests that, in order

to stimulate a further ecological modernisation of the car chain, EU policies should not only set strict standards for recycling, as they did in the new EU Directive, but also consider the social and economic context of factors that would stimulate a reorganisation of the car chain towards technological innovation over the whole automobile life cycle. How this can be achieved, is beyond the scope of this paper, but one of the options worth considering would be to facilitate an eco-label for cars, which includes in its requirements innovative options for recycling.

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44 Annually, recycling companies in the Netherlands and abroad can submit a tender for the processing of one or more ARN-materials. ARN car-dismantling companies are obliged to deliver their materials to these by ARN selected recycling companies. There is no necessity for recycling companies to be part of the car chain: open loop recycling, into other non-automobile products (e.g. plastics for garden chairs), is also possible.

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