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The Influence of the Waste Hierarchy in Shaping European Waste Management: The Case of Plastic Waste

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1 INTRODUCTION

Waste management in Europe has experienced significant changes since the 1970s. The majority of Member State waste management regimes have shifted from policies based on the control of waste disposal activities, to include goals for waste prevention and recovery.[1] This trend builds on the rationale of protection of human health and the environment, to include resource efficiency and the need for an upstream approach to waste management through a life cycle perspective. Despite increasing attempts to harmonize waste policy objectives at the European level, national waste policies (especially those affecting packaging waste) differ noticeably. These differences are reflected in national waste management objectives, organizational solutions, and technical choices for end-of-life treatment. The need to harmonize European waste policies has been raised, as disproportionate polices created by different rules and conventions of Member States have led to externalities and disturbances in European waste management. These include obstacles such as waste tourism and barriers to free trade.[2] However, while there is a need for each Member State to develop its own policies for meeting European Union (EU) targets, there is also the possibility that a lack of consistency among approaches can lead to increased negative externalities between national regimes, ultimately leading to a potential negative impact upon both free trade and environmental protection.[3]

Plastic production has grown from 1.5 million tonnes in 1950, to an all-time high of 260 million tonnes in 2007.[4] Industry demand for these materials has remained relatively constant since 2001, at between 37 per cent to 38 per cent for the packaging sector; 18 per cent to 21 per cent for building and construction; 7 per cent to 8 per cent for automotive products; and 7 per cent to 8 per cent for electrical and electronic equipment (EEE).[5] During the last decade in Europe, post-consumer plastic waste generation (plastic waste occurring during and after the use phase of a product life cycle, hereinafter plastic waste) has grown 3 per cent per annum resulting in 24.9 million tonnes of plastic waste in 2008. This was predominantly generated in the municipal solid waste, and distribution/industry sectors, 66 per cent and 20 per cent, respectively, in 2002.[6]

Among the countries of Europe, rates of disposal via landfill, recycling, and energy recovery were 48.7 per cent, 21.3 per cent, and 30 per cent, respectively, in 2008.[7] Nevertheless, rates differ significantly between Member States. Plastic recovery (recycling and energy recovery) exceeds 90 per cent in Switzerland, Denmark, Germany, Sweden, Belgium, and Austria (all these countries achieve recycling rates of above 20 per cent, except Denmark). At the other end of the scale, several countries including Malta, Cyprus, Lithuania, and Greece, show recycling rates of less than 10 per cent and no energy recovery.[8]

Still, economically developed Member States have considerably different plastic waste management systems. Germany, France, and the UK possess similar demographics and level of economic development, and represent countries with developed waste management systems. However, figure 1 illustrates the different performance levels of their waste management systems, in the case of plastic packaging waste for the period between 1997 and 2006. Changes for reporting procedures to the EU changed after 2002, explaining the different information provided for this period. Yet the noticeable trends are the decline of recycling and an increase of energy recovery in Germany, increased recycling in France and the UK, and a low energy recovery rate in the UK.

Figure 1 poses several questions, the foremost centred on the issues of European harmonization of the waste hierarchy. The waste hierarchy has been a guiding principle of waste management at the EU level since the 1980s.[9] Notwithstanding attempts to harmonize EU waste policy objectives,[10] the trajectories of Member State waste management systems have shown a slow rate of convergence. What role have Member States played in policy formation at the European level and what role has the waste hierarchy played in the trajectory of these national waste management regimes?

The second question focuses on the legitimacy of the waste hierarchy. Certain actors at the European level (members of the European Parliament (EP) and NGOs) call for the waste hierarchy to take a greater role in European waste policy. At the same time, other actors call for a flexible approach to the waste hierarchy in order to allow specific waste streams to depart from this hierarchy if this results in reduced environmental impacts. Life cycle thinking has become increasingly prominent in EU waste strategy and policy.[11] Life cycle assessment studies have investigated the potential environmental impacts of end-of-life treatment options for different material fractions, including plastics. This raised the question of the legitimacy of the waste hierarchy as a waste management principle and the suitability of life cycle assessment as a test for its qualification.

1.1 Research Aim

This article reviews the role of the waste hierarchy in the development of EU and Member State policies that influence plastic waste. The aim is to determine the role of the waste hierarchy in European plastic waste management, its implementation through different political objectives, and the effect of these objectives on plastic waste management in the context of European harmonization. The purpose of this article is to investigate the implementation of these objectives in the context of the waste management principles they serve, rather than analyse the environmental, economic or social impacts.

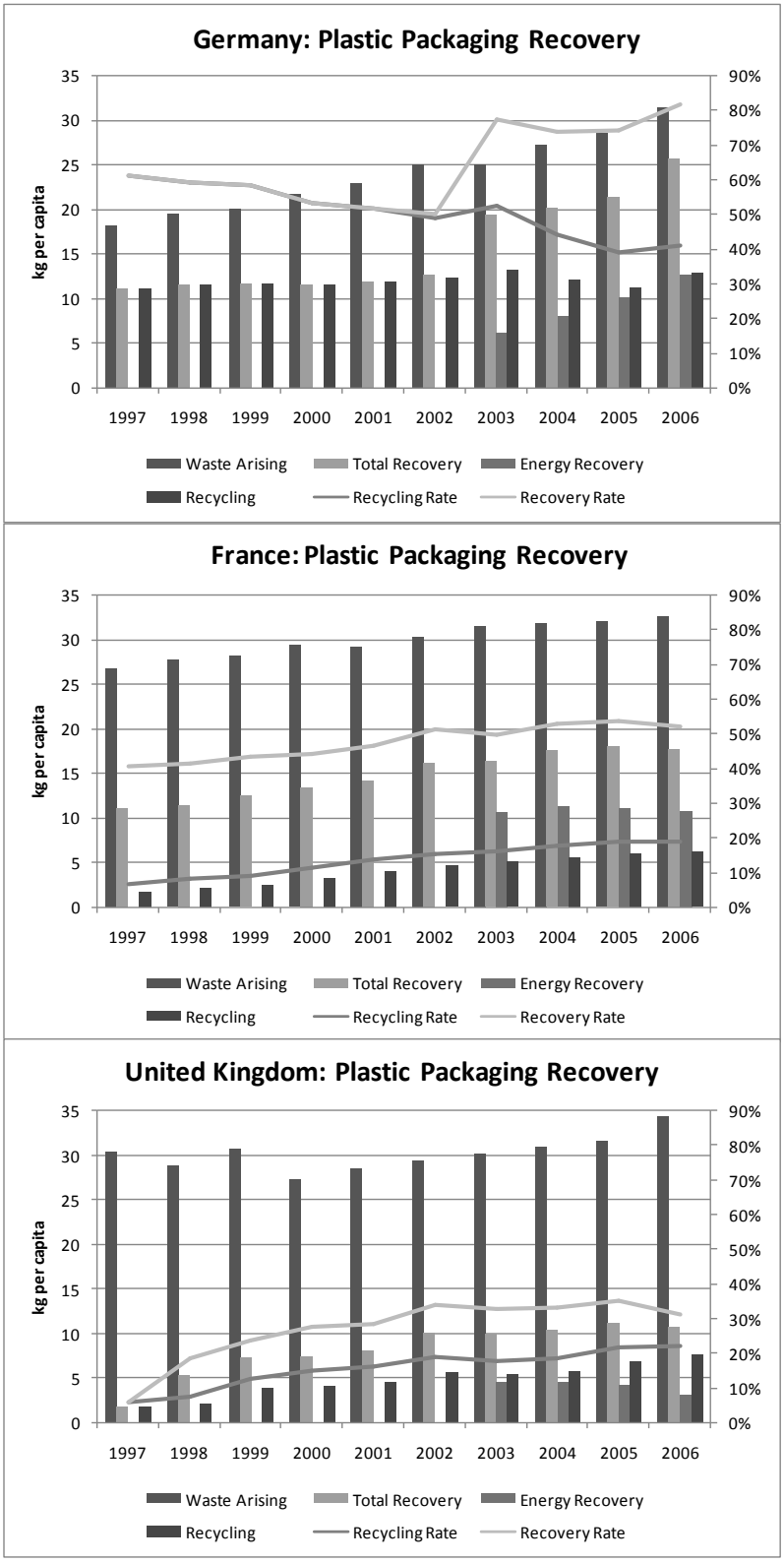


Figure 1. Plastic Packaging Waste Management in Germany, France, and the United Kingdom from 1997 to 2006

Source: Eurostat (2010) (Available at : http://epp.eurostat.ec.europa.en/portal/page/portal/statistics/search_database; accessed 15 March 2010).

Three European countries are considered: Germany, France, and the UK. Although faced with broadly the same problems with plastic waste management (increasing amounts and the societal pressure to treat this waste sustainably), they show diversity in technological and institutional approaches to waste management. This has resulted in different trajectories for plastic waste management, while embedded within a common European framework. Germany is representative of a Northern European country, having the perception of greater environmental consciousness compared to its southern counterparts. France can be seen as a 'middle of the road' country and a good witness of what is happening in the southwest part of Europe together with Italy and Spain. The UK represents a case in which the waste management system struggles to overcome a historical reliance of disposal via landfill. Our analysis focuses on two plastic waste streams — plastic packaging waste and plastics from household waste — as they are the largest streams and have been the focus of European harmonization. This analysis can also lend some insights for the role of the waste hierarchy in developing regions, as the countries investigated range from those having developed waste polices from as early as the mid-1980s to those which have been driven by the EU.

1.2 The Waste Hierarchy

The waste hierarchy (see figure 2) is one of a number of principles of waste management, which include: the prevention principle, precautionary principle, polluter-pays principle (implemented through extended producer responsibility), proximity and self-sufficiency principles, and principle of subsidiarity.[12] Within the EU, some of these principles can be traced back to the start of the oil crisis, in 1973, and others towards the beginning of the sustainability movement in publications such as *Our Common Future*[13] and the Earth Summit's *Rio Declaration*.[14] The version of the waste hierarchy adopted by the EU is a five-tiered hierarchy of: waste prevention, reuse, recycling, recovery, and disposal. This is commonly known outside the waste management field as the 3Rs — reduce, reuse, and recycle. The waste hierarchy is essentially an extension of the precautionary and prevention principles, establishing a priority order for waste treatment options in terms of lowest possible environmental impact and minimization of final waste. This is done in order to provide a framework to support decision making for waste management systems at the local and/or national levels.

Reducing the environmental impacts of plastic waste management is important as 98 per cent to 99 per cent of plastics are produced from crude oil/natural gas.[15] Plastic production uses 8 per cent of world oil production, 4 per cent for plastic feedstock, and 4 per cent as an energy source in manufacturing.[16] The prevention, reuse, recycling, and recovery of plastic waste can, to various extents depending on the end-of-life treatment option, reduce the amount of waste going to the landfill. Recycled plastic can replace virgin plastic and the recovery of energy from plastic incineration can replace energy from other sources.

This article has four main sections. Firstly, the theoretical component behind the comparison of Member States is described. Next, the evolution of the waste hierarchy and its negotiation within European waste policy is discussed. The third section outlines the influence of the waste hierarchy at the Member State level, the nature of objectives established to enforce the hierarchy, and its influence in terms of organizational solutions, consequences, and technical innovation. Lastly, we discuss the waste management regimes in terms of their underlying conventions and the legitimacy of the waste hierarchy as a principle of waste management.

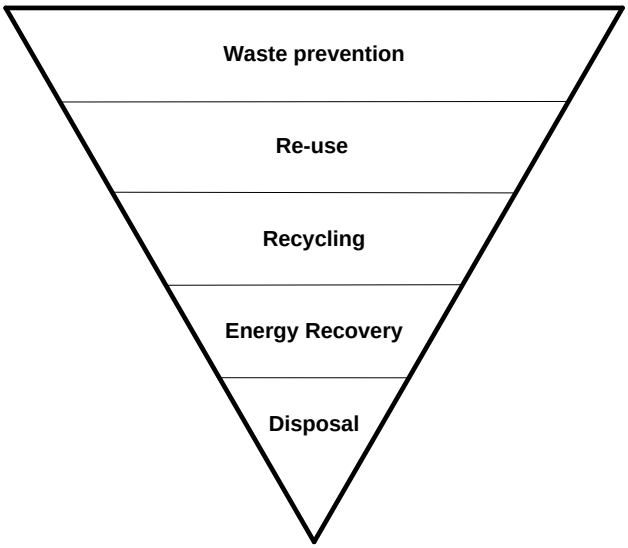


Figure 2. Five-tiered Waste Hierarchy as Established in Directive 2008/98/EC

Source: Department for Environment Food and Rural Affairs (DEFRA), *Waste Strategy for England 2007* (London: DEFRA, Her Majesty's Stationery Office (HMSO), 2007).

2 CONCEPTUAL FRAMEWORK

2.1 Waste Management Regimes

In this article, waste management is viewed in terms of regimes or entire forms of institutional, technical, economic, and social organization.[17] A straightforward comparison of waste management regimes is difficult due to the diversity in institutional structure, organization, and heterogeneity of historical developments within these countries. The benefit of working with regimes is that countries can be compared in terms of common features, or the institutional articulation of conventional principles and political objectives. This framework for analysis takes its point of departure from the theory of economics of conventions,[18] whereby national waste management regimes are seen as consisting of conventional principles and objectives, which are accepted by the agents of society and maintain stability of the regime throughout time.[19]

Boyer and Orléan define conventions as a "collective agreement tacit or explicit, which allows the agents to coordinate their activities".[20] Conventions have several properties; they are self-enforcing, in that each agent abides by certain conventions when he expects others to abide by the same convention. Conventions are also evolutionary stable strategies, whereby in the case of one or more strategies if one strategy is followed by the majority of agents, it cannot be evicted by other strategies.[21] A principle is a "fundamental truth or proposition serving as the foundation for belief of action".[22] Hence, conventional principles are those principles which are borne from conventions, or qualified as conventions, having been established intentionally or not by the agents of society over time. Objectives of regimes, such as definitions, goals, and targets, are instruments for implementation of conventions and principles, and help guide the trajectory of the regime.

Change in the trajectory of a regime is often the result of an evolution in the structure of its existing conventional principles and political objectives[23] (see figure 3). The qualification of conventional principles is a necessary process, a test of their legitimacy proposed by events, with two possible results: (a) their reinforcement in light of the development of knowledge and refinement; or (b) their replacement by new principles.

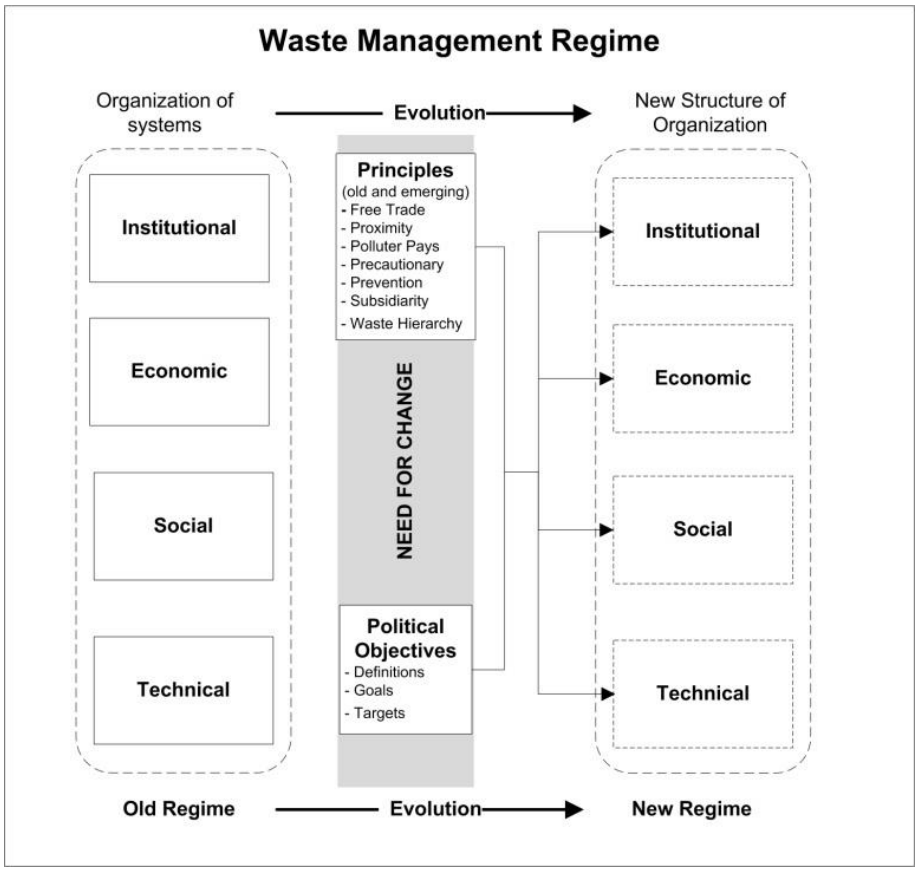


Figure 3. Evolution of Waste Management Regimes

Source: Prepared by the authors.

2.2 Life Cycle Thinking

The other theoretical component we introduce to this conceptual framework is life cycle thinking. The concept of life cycle thinking "seeks to identify possible improvements to goods and services in the form of lower environmental impacts and reduced use of resources across all life cycle stages".[24] One of the core elements of life cycle thinking is that relevant actors (producers and consumers) should be aware of the environmental impacts throughout a product life cycle in order to take measures to address these problems.[25] Life cycle assessment, the analytical tool used in life cycle thinking, aims to describe the potential environmental impacts of a product/service system over its full life cycle, including resource extraction, production, use, transport, and end-of-life.[26] Categories of environmental impacts typically include resource use, human health, and ecological considerations.[27] The benefit of this holistic approach is that it prevents the 'shift of environmental burden' from one life cycle phase to another and from one type of environmental impact to another.[28]

Life cycle thinking and life cycle assessment are closely linked to the notion of the waste hierarchy, as life cycle assessment can be used to quantify the environmental impacts of different waste treatment technologies and strategies. Life cycle thinking and life cycle assessment have been introduced to European waste policy[29] to ensure that the negative environmental impacts are minimized throughout the entire life cycle of resources to identify priorities more easily, and to target policies more effectively.[30]

3 THE EVOLUTION OF THE WASTE HIERARCHY AT THE EUROPEAN LEVEL

3.1 Emergence of the Waste Hierarchy

The waste hierarchy, like most other conventions and principles, does not have its basis in the natural sciences. It developed as a political concept for waste and resource policy from the mid-1970s and was established as a principle in EU waste management policy in the first Waste Framework Directive 75/442/EEC.[31] The directive encouraged the "reduction of quantities of certain wastes, the treatment of waste for its recycling and re-use, the recovery of raw materials and/or the production of energy from certain waste".[32] In effect, *The Limits to Growth*[33] and the oil crisis sparked several Member States, such as the Netherlands, Denmark, and Germany to address the political concern of a scarcity of energy resources.[34] Coupled with shrinking landfill capacity, this sparked the development of waste-to-energy infrastructure[35] and the precedence of waste avoidance before recovery and recovery before landfill.[36]

At a Member State level, the Dutch were among the first to establish the waste hierarchy as a fundamental principle behind their waste management policy, with the adoption by parliament of the prevention priority ladder in 1978. This hierarchy established seven levels of treatment (prevention, product reuse, material reuse, beneficial use, disposal with energy recovery, disposal other than landfill, and landfill) and was prompted by the limitation of space for landfill and the assumption that it was more efficient to place increased priority on waste prevention.[37]

At the same time the waste hierarchy was being used to guide waste management policy in northern European countries, other EU Member States, including the UK, France, and southern European counterparts, took little action to change existing waste management regimes. It was not until the 1990s that France[38] and the UK[39] adopted the waste hierarchy as a principle in waste management policy, moving from regimes based on safe disposal of waste to promoting prevention and recovery. Although the waste hierarchy has emerged as a central principle in the new Waste Framework Directive 2008/98/EC, flexibility in its application has become a central issue of discussion.

3.2 Application of the Waste Hierarchy and Attempts to Harmonize Objectives

Despite previous attempts to harmonize European packaging waste policy,[40] Directive 94/62/EC on packaging and packaging waste[41] was the first directive with a focus which included the end-of-life treatment of the plastic packaging stream. The most recent step to harmonize EU waste policy has been the new Waste Framework Directive 2008/98/EC,[42] an outcome of the European Commission (EC)'s thematic strategy on the prevention and recycling of waste.[43]

European directives are legislative acts requiring Member States to achieve specified results without specifying how these results should be achieved. Directives differ from regulations, also legislative acts, as regulations are instantly enforceable as law in each Member State. Member States are required to transpose directives into national laws, national regulations, and administrative provisions in order to comply with the directives. Directives allow Member States the flexibility of designing policy instruments (administrative, economic, and informative) to suit national conditions, including those of an institutional, economic, social or technical nature. Even though Member States are required to achieve objectives set by directives, they have a role in setting these objectives such as recycling and recovery targets, and material streams to which these targets apply. Of interest to this article are the negotiation of recycling and prevention

targets and the role of the waste hierarchy, as these negotiations illustrate the salience of the waste hierarchy as a principle in national waste management regimes.

Directive 94/62/EC on packaging and packaging waste. The negotiation of Directive 94/62/EC highlights the efforts taken by some Member States to establish the waste hierarchy at the EU level by harmonizing objectives, and efforts taken by others to resist change to their existing regimes. The directive was negotiated over a three-year period, involving a large number of industry lobbyists and a dominant presence from the Netherlands, Germany, France, and the UK. The Commission's first unofficial proposal, based predominantly on the Dutch model, adopted a hierarchy of waste reduction, refilling (bottle refilling), reuse, material recycling, energy conversion, and landfilling as a last resort.[44] During the negotiation process, two coalitions were formed. Germany, Denmark, and the Netherlands, motivated by ambitious national environmental programmes, pushed for high targets or the flexibility for opt-ups (opt-ups allow Member States to make the decision to impose higher targets than set at the EU level).[45]

The opposing coalition consisted of the UK, Portugal, Ireland, Greece, and Spain, favouring low recovery targets and the removal of binding targets for individual material streams. This conflict centred on the implicit hierarchy of recovery options, and thus these countries endeavoured to drop any recycling targets and retain only recovery targets. The political objectives required to implement the principle (recycling and recovery targets) were reduced to the lowest common denominator. Flexible recycling rates were adopted, which had already been achieved by some Member States or planned by others.[46]

High minimum recycling and recovery targets were proposed (see table 1), which would have required a significant change in many national waste strategies. The plastic waste stream proved to pose the greatest challenge, as there was little recycling or recovery in the majority of Member States before the adoption of the Directive. Any significant change would have required the development of new technologies and increased costs. This directive set a material recycling target of 15 per cent for individual material fractions, including plastic. In 2004, targets for individual material fractions were increased. A recycling target for plastic packaging was set at 22.5 per cent to be achieved by 2008, with new Member States permitted to postpone the attainment of these targets. In 2007, only Denmark, France, and Finland had not achieved this target, achieving 21.8 per cent, 21.1 per cent, and 18.4 per cent, respectively.

Directive 2008/98/EC on waste. During the negotiation of the new Waste Framework Directive 2008/98/EC, the focus had transferred to prevention targets, the waste streams recycling targets would be applied to, and the role of the waste hierarchy in the Directive.

Despite the fact that the waste hierarchy was not defined as a central part of the Commission's Directive proposal,[47] the inclusion of a five-tiered waste hierarchy (see figure 2) by the EP was agreed to by the both the Commission and the Council. However, how the waste hierarchy was to be applied was contested by the Council. The different iterations of how the waste hierarchy was to be applied are outlined in table 2. Both the Commission and the Council argued for a flexible approach in the application of the waste hierarchy, due to the differentiation between the recovery steps of reuse, recycling, and energy recovery. Indeed, whether or not the waste hierarchy should be applied as "general rule" or "guiding principle" was highlighted by the EP Rapporteur, UK MEP Caroline Jackson. The MEP noted that the difference in the two phrases would not be perceived by actors at the local level.[48]

Table 1. Development of Directive 94/62/EC on Packaging and Packaging Waste

	Comm 1	**Comm2**	**EPEC1**	**EP1**	**Comm 3**	**Common position**	**EPEC2**	**EP2**	**94/62/ EC**	**2004/12/EC**
Hierarchy	Yes	No	Yes	Yes	No	No	Yes	No	No	No
Opt-ups	No	No	Very Broad	Limited	Limited	Very Limited	Very Limited	Very Limited	Very Limited	Very Limited
5 Yr- total recovery rate	60	No	60	60	60	50-65	50	50	50-65	50-65[1] 60 min[2]
5 Yr - total recycling rate						25-45	25	25-45	25-45	25-45[1] 55-80[2]
5 Yr - min recycling rate for each type of material	40	No	40	40	40	15	25	15	15	15[1]
Plastic packaging										22. 5[2]
10 yr- total recovery rate	90	90	90	90	90	No	No	No	No	No
Ten-year recycling rate for each type of material	60	60	60	60	60	No	No	No	No	No
Ten-year maximum landfill and burning	10	10	10	10	10	No	No	No	No	No

Source: Adapted from L. Fischer, U. Petchow, and N. Buclet, "The Consequences of Implementing Directives in the National Context: The Correct Answer to the Friction between National Regimes?" in N. Buclet, *Municipal Waste Management in Europe, European Policy between Harmonisation and Subsidiarity* (Dordecht: Kluwer Academic Publishers, 2002).

Notes: [1] No later than 30 June 2001;[2] No later than 31 December 2008; Comm1: Directorate General X (Environment, Nuclear Safety and Civil Protection) (DGXI) pre-draft objectives, Comm2: Commission draft directive (12 October 1992), EPEC1: First report by the Environment Committee of the European Parliament (8 June 1993); EP1: First reading by the European Parliament (23 June 1993); Comm3: Revised Commission proposal (9 September 1993); Common Position: of the Council; EP2: Second reading by the European Parliament (4 May 1994); and EPEC2: Second report by the Environment Committee of the European Parliament.

Targets proposed by the EP for waste prevention, reuse, and recycling, and the enforcement of these targets and streams they are applied to were contested by the Commission and the Council. The development of this directive is outlined in table 2. The EP succeeded in legislating reuse and recycling targets of 50 per cent for at least "paper, metal, plastic and glass from households," and 70 per cent for non-hazardous construction and demolition waste. However, industrial and manufacturing waste streams were removed from these targets as the Commission saw these sectors as being too broad.[49] The establishment of qualitative and quantitative waste reduction objectives for 2020 by 2010, were reduced to the setting of waste prevention and decoupling objectives for 2020 by 2014.[50] Decoupling objectives relate to reducing resource use and the generation of waste from the rate of economic growth.

Table 2. Development of Directive 2008/98/EC on Waste

	75/442 /EEC	Comm 1	EPEC1	EP1	Comm2	Common Position	EPEC2	EP2 (2008/98/EC)
Three Level Hierarchy	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Five Level Hierarchy	No	No	Yes	Yes	Yes	Yes	Yes	Yes
LCT applied to the waste hierarchy		'as a matter of priority'	'as a general rule'	'as a general rule'		'as a guiding principle'	'as a general rule'	'as a priority order'
Prevention Targets	No	No	No	Yes [1]	No	No	Yes [1]	Yes [2]
Reuse & Recycling Targets								
Municipal solid waste	No	No	No	50%	50%	No	50%*	50%**
Construction and Demolition	No	No	No	70%	70%	No	70%	70%***
Industrial	No	No	No	70%	No	No	70%	No
Manufacturing	No	No	No	70%	No	No	70%	No

Source: Prepared by the authors.

Notes: [1] Established by 2010; [2] Established by 2014 for 2020; * Text changed to 'household and similar waste'; ** Text changed to 'waste materials such as least paper, metal, plastic and glass from households and possibly other origins as far as these waste streams are similar to waste from household waste'; *** Text changed to 'non hazardous construction and demolition waste…'; 75/442/EC: Council Directive of 15 July 1975; Comm1: Commission Proposal (21 December 2005); EPEC1: First report by the Environment Committee of the European Parliament (15 December 2006); EP1: First reading by the European Parliament (13 February 2007); Comm2: Revised Commission proposal (21 March 2007); Common Position: of the Council (20 December 2007); EP2: Second reading by the European Parliament (5 February 2008); EPEC2: Second report by the Environment Committee of the European Parliament (16 June 2008); and 2008/98/EC: Directive of the European Parliament and of the Council of 19 November 2008 on waste repealing certain Directives.

One of the main focuses of Directive 2008/98/EC was to clarify a number of definitions in the previous Directive (75/442/EC), as uncertainty surrounding key terms led to several key divisions between Member States. This was evident in the case of municipal waste incinerators, classified as recovery in countries such as France but disposal facilities in a number of cases by the European Court of Justice.[51] Denmark and France led a coalition of Members States to include waste incineration with energy recovery as recovery, opposed to its classification as disposal,[52] as these Member States have a strong reliance on incineration with energy recovery. A compromise, where incinerators would be classified as recovery only if they met energy efficiency criteria, was accepted by a narrow margin by the EP.[53]

The direct influence of this directive on plastic waste is unsure, as this Directive is to be transposed by December 2010 and plastic waste only contributes to a small amount (by weight) of both household and construction and demolition waste. Some Member States such as the UK have indicated that the 50 per cent target for household waste would apply to the whole household waste stream, not equally to individual material fractions.[54]

This negotiation does, however, show the importance of the hierarchy to the different actors involved. Pressure from the EP and environmental groups was placed on setting high targets and the application of the waste hierarchy as a general rule. These actors see the waste hierarchy as a general rule, implemented through establishment of challenging prevention and recycling targets,

which all other actors should accept. The majority of Member States have taken an opposing view that the rigid implementation of this principle does not allow for a flexible approach to waste management, and thus life cycle thinking should be used to justify the departure of specific material streams.

As the life cycle approach inspired the EC's thematic strategy on prevention and recycling of waste,[55] life cycle thinking plays a key role in the new Waste Framework Directive 2008/98/EC. While a life cycle approach is mentioned several times in the recitals of Directive 2008/98/EC, the Directive makes a provision for "specific waste streams to depart from the waste hierarchy where this is justified by life-cycle thinking on the overall impacts of the generation and management of such waste".[56]

3.3 Departure from the Waste Hierarchy through Life Cycle Thinking

Differentiation between reuse, recycling, and energy recovery in Directives 94/62/EC and 2008/98/EC created the need to justify the departure of certain material streams from this hierarchy; if, in fact, the order of the hierarchy does not represent the most environmentally preferable option.

During the negotiation of Waste Framework Directive 2008/98/EC, the first report of the Environment Committee of the EP proposed Member States could depart from the waste hierarchy only when "life cycle assessment and cost benefit analyses indicate clearly that an alternative treatment option shows a better record for a specific waste stream".[57] However, justification of departure through life cycle thinking, rather than life cycle assessment, was adopted in Directive 2008/98/EC.

It may be difficult to 'justify' the departure of specific waste streams from the waste hierarchy by life cycle thinking, as life cycle thinking is an approach/concept. One would envisage that if the "overall impacts of the generation and management"[58] are to be justified, some form of assessment would be required. However, the term 'life cycle thinking' does allow a degree of flexibility for the use of assessment tools. Different forms of life cycle assessment exist, including the ISO[59] standardized life cycle assessment, streamline/screening life cycle assessment, input-output based life cycle assessment, and hybrid life cycle assessment. What is apparent from Directive 2008/98/EC is that the justification process must be transparent and involve consultation of citizens and stakeholders.

Studies reviewing life cycle assessments of waste management systems for municipal solid waste and individual material streams have been conducted by Cleary,[60] Björklund and Finnveden,[61] WRAP,[62] and Lazarevic *et al.*[63] Cleary[64] concluded that for the municipal solid waste stream, the weighted results of the life cycle assessment studies reviewed confirmed the validity of the waste hierarchy. The studies reviewed were sourced from a variety of European, North American, South American, and Asian countries, focusing on regional and municipal perspectives. Björklund and Finnveden[65] and WRAP[66] reviewed predominantly European studies, showing cases where certain material streams, specifically paper and plastic, can depart from the waste hierarchy due to the assumptions and system boundaries of the studies. Lazarevic et al.[67] reviewed European studies mainly undertaken in a national context. The studies show parameters such as the ratio at which recycled plastic replaces virgin plastic and the contamination of recyclable plastic by organic waste can have a significant influence on the results of the studies. It is important to consider that the results of these studies are only valid for the environmental impact categories considered. Care should be taken when interpreting the results of these studies beyond their

scope. Nevertheless, these studies show that if the primary objective of waste management is to reduce the environmental impacts of plastic waste management, a case-by-case analysis is required. Although these meta-studies compared the results and methodological considerations of various life cycle assessment studies, none went further to investigate the influence of the geographical context upon the results. This is important when considering if local, regional or national contexts play a significant role in the results of these studies.

4 INFLUENCE OF THE WASTE HIERARCHY AT THE MEMBER STATE LEVEL

4.1 Differing Waste Management Objectives

The nature of objectives, especially the ambition to embody upstream solutions, represents a key variable in waste management policies in Europe.[68] Even though the move towards waste prevention and increased recycling and recovery is a common goal of European waste management regimes, the objectives set by governments to meet these goals have differed in both timing and ambition.

Germany was the first to introduce the waste hierarchy into their waste legislation, through the *Act on Avoidance and Disposal of Waste* in 1986.[69] This act established a hierarchy with avoidance coming before recovery, and recovery coming before disposal but did not legally enforce the hierarchy.[70] The waste hierarchy was established as a principle for French waste management by the *Law of July 1992*,[71] and later in the UK by the 1995 "Strategy for Sustainable Waste Management".[72] In addition to the different timetables for establishing this principle, political objectives varied considerably.

Political objectives focusing on plastic packaging waste are a good indicator to compare the importance of the waste hierarchy within national regimes, as plastic packaging waste management possess several difficulties in terms of the high cost of collection and sorting, and a developing and volatile secondary raw materials market. These objectives are summarized in table 3.

Table 3. Packaging waste objectives in Germany, France and the UK

Country	Waste Stream	Objectives	Time frame
Germany	Packaging Waste	• Strict Hierarchy or treatment options • 72% refill quota for beverage bottles • Plastic Packaging: 64% recycling • Prohibition of energy recovery from plastic packaging	1991-1998
		• 60% recovery (at least 60% to be achieved via mechanical recycling) • Refill quota for beverage bottles removed	1998 - 2008
France	Domestic Packaging Waste	• 75% valorization	1991-2002
United Kingdom	Packaging Waste	• Moving annual business targets for plastic packaging recycling: currently 29%	By 2010

Source: Prepared by the authors.

Germany was the first of these countries to identify packaging waste as a priority waste stream. By 1990, packaging waste constituted approximated 20 per cent by weight and 50 per cent by volume of municipal solid waste.[73] The establishment of the Packaging Ordinance in 1991[74] was a

key point in German waste policy, institutionalizing the idea of 'closed substance cycles' through a top-down approach (policy set at the federal level required to be implemented by lower levels of government).[75] The Packaging Ordinance aimed to avoid waste, reuse packaging, and recycle and recover packaging waste before disposal. In order to achieve these goals, high targets were placed on individual material fractions and a 72 per cent beverage bottle refill quota was introduced. A 64 per cent recycling target was set and a recycling rate of 68 per cent was reported by the Duals Systems Deutschland GmbH (DSD) in 1996.[76] As a result of Directive 94/62/EC and the need to correct the situation for plastic packaging waste, the Packaging Ordinance was amended in 1998, bringing Germany in line with the EU directive. This removed the beverage bottle refill quota and lowered the mechanical recycling target.

In contrast with Germany, the French *Decree of 1 April 1992* on domestic packaging waste introduced a valorization target of 75 per cent for only household packaging waste.[77] Valorization is a generic term for recovery, including all forms of recycling, compositing, incineration with energy recovery, and other forms of energy recovery (mechanization, gasification, etc.). With no differentiation between recycling and recovery, a weak signal was sent to promote recycling over energy recovery. This aided in maintaining the stability of waste-to-energy operations, of which France has the highest number of plants in Europe.[78] The *Decree of 19 November 1996* later transposed Directive 94/62/EC on packaging and packaging waste, fixing the 2001 and 2008 deadlines for recovery and recycling.

Unlike Germany and France, which established policy on packaging waste before legislation at the EU level, the UK policy was derived from the EU directives. Partly due to the confidence that environmental impacts could be brought under control with appropriate waste disposal technologies, the UK did not experience any significant change until 1995 with the release of 'A strategy for sustainable waste management in England and Wales'[79] and the Producer Responsibility Obligations (Packaging Waste).[80] The UK sets annual business targets in order to meet recycling and recovery targets for the material streams outlined in Directive 94/62/EC. Business targets apply only to packaging handled by producers.[81] As small businesses are exempt from producer responsibility, these targets are required to be higher than EU targets and include domestic, industrial, and commercial packaging. In order to achieve the 22.5 per cent recycling target set by Directive 94/62/EC, the UK has set business targets, currently at 29 per cent for plastic packaging by 2010. At the local authority level, the government plays an important role by defining household recycling targets for each local authority, depending upon existing infrastructure and past performance.

4.2 Organizational Solutions

The organization of waste management is an important aspect in order to achieve objectives effectively. In most European countries, the responsibility for waste management lies at the municipal or equivalent local level of government, adhering to the principle of subsidiarity. This is the case in France and the UK; however, Germany decided upon another model of organizational management for packaging waste.

In Germany, waste has been divided into two flows: packaging waste and other waste. Each waste flow has its own operational and financial responsibility borne by the different actors. Packaging waste is managed at the national level by DSD, and other waste streams are managed by municipalities in line with the waste management plans set by the *Länder* (Federal States). DSD is responsible for the collection and sorting of packaging waste. Associations of packaging producers and material converters, "guarantors" (such as the Deutsche Gesellscharft für

Kunststoff-Recycling mbH (DKR) for plastic waste) are responsible for packaging recovery in order to comply with the Packaging Ordinance. The financing for DSD is based on the polluter pays principle. Licence fees are paid by producers depending upon material, weight, and volume or surface area. This entitles the producer to place the "green dot" on the packaging. For plastic packaging, this fee covers the collection, sorting, and recycling/recovery. All plastic packaging waste fractions are collected for recycling/recovery by DSD, except for Polyethylene terephthalate (PET) bottles which are covered by a parallel deposit system. The output of material recovery facilities depends upon local conditions (site capacity and contractual relationships) and as such either high purity single plastic waste streams (e.g., Polyethylene (PE), PET, and Polypropylene (PP) bales) or low quality mixed plastic waste streams can be generated.

In France, in order to achieve the 75 per cent valorization target, Eco-Emballages, a private company managed by industry, was established and made responsible for the organization and support of separate collection, sorting, recycling, and valorization of household packaging waste. Local authorities retain the independence in decision making on collection and sorting techniques, and define valorization objectives (as long as they obtain the 75 per cent valorization target). Three streams of plastic packaging are collected: PE, uncoloured PET, and coloured PET. These three fractions must be separated with no flexibility for local conditions of the plastic scrap market.

Unlike Germany, France, and many other countries that have adopted the "green dot" system of financing extended producer responsibility schemes, the UK developed its own system of packaging recovery notes (PRNs) and packaging export recovery notes (PERNs). These notes are tradable and have a market value depending upon the supply and demand of the recyclable packaging waste, not the value of the material. This system was introduced in order to achieve compliance with EU targets at the least cost to industry. Financial responsibility is allocated to the producers via the producer responsibility obligations.[82] In the UK, producers include manufacturers, converters, packers/fillers, and sellers, which contribute 6 per cent, 9 per cent, 37 per cent, and 48 per cent, respectively, to the cost of packaging waste management.[83] Material recovery facilities are able to produce either single material streams or mixed plastic streams, allowing a flexible approach for sorting strategies to respond to market conditions such as the movement of global plastic scrap prices.

5 CONSEQUENCES AND RESULTING TECHNOLOGICAL INNOVATION

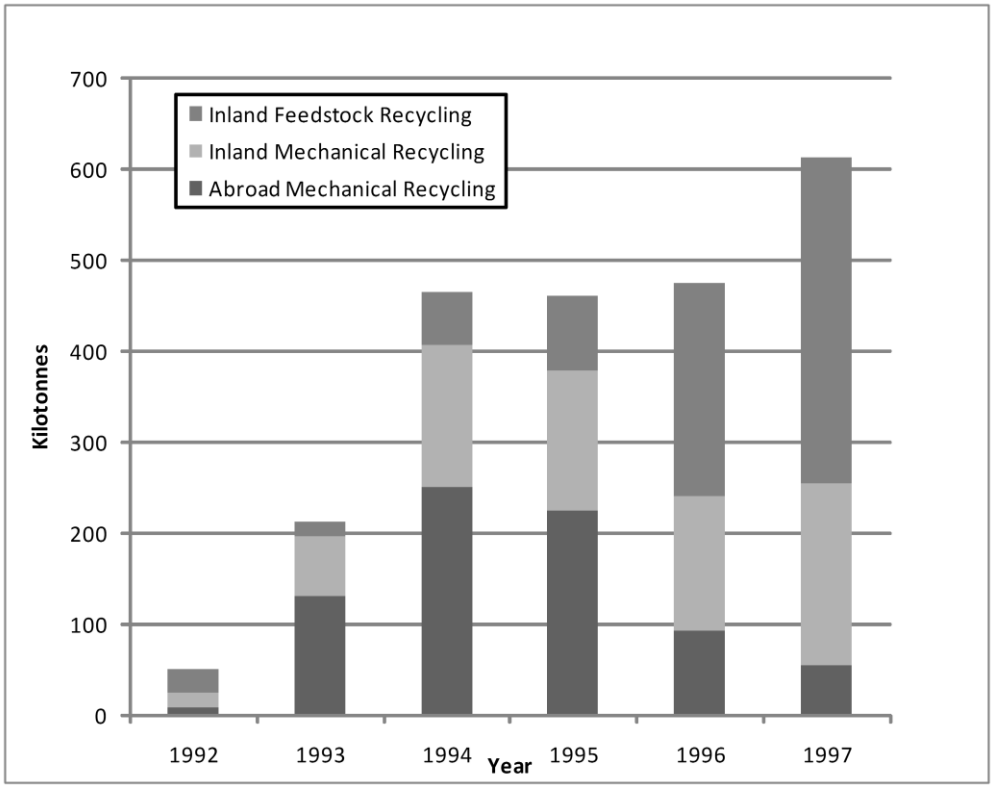
5.1 Consequences of Setting Over-Ambitious Objectives

The rapid increase of plastic packaging recycling in Germany had a number of unintended consequences. In the first years of the Packaging Ordinance,[84] the majority of plastic packaging collected was exported to China, Eastern Europe, and other EU Member States due to lack of national capacity. However, due to pressure from the Chinese population, imports to China was stopped in 1995.[85] In order to provide DSD with guarantees of plastic recycling, the guarantor at the time, Verwertungsgesellschaft fur Gerbrauchte Kunststoffverpackungen (VGK) followed illegal paths such as dumping and incineration abroad in order to avoid legislative constraints and remain in DSD.[86] As a consequence of this activity, DSD participated in the foundation of a new guarantor, DKR, to take over from VKL. Although the system of checks and balances was tightened on the German side, this did not prevent the uncontrolled and illegal dumping/treatment of waste aboard. In 1997, a depot in Asti, Italy, containing 600 tonnes of plastic packaging waste from DKR (accumulated illegally), was set on fire.[87]

Another consequence was the disruption of recycling schemes in countries such as France, Italy, Spain, and England. Plastic packaging waste from Germany was preferred by recycling industries over domestic plastic waste, as they were supplied at a negative price, care of DSD.[88] This introduced "a potential competition distortion as it constitutes an artificial mechanism of price setting and a restriction of outlets that can burden trade among Member States".[89]

Throughout Europe, mechanical recycling (sorting, washing, drying, and melting recycled plastic flakes into pellets) was the dominant form of plastic recycling. However, due to the increasing supply of low quality plastic waste, the development of feedstock recycling processes was accelerated in Germany in order to treat this waste. Feedstock recycling is "the transformation of plastic polymers by means of heat or chemical agents to yield hydrocarbon products that may be used in the production of new polymers, refined chemicals or fuels".[90] Consequently, the development of feedstock recycling and increased mechanical recycling capacity reduced the export of plastic waste and, by 1997, the influence on market distortion was abated (see figure 4).

Figure 4. The Development of Plastic Recycling in Germany between 1992 and 1997



Source: Deutsche Gesellscharft für Kunststoff-Recycling mbH (DKR) (1998) in L. Fischer and U. Petchow, "Municipal Waste Management in Germany" in N. Buclet and O. Godard, *Municipal Waste Management in Europe — A Comparative Study in Building Regimes* (Dordecht: Kluwer Academic Publishers, 2000).

5.2 Technology Innovation

The setting of high recycling targets for plastic packaging waste between 1991 and 1998 and the prohibition of incineration with energy recovery was a key driver of recycling technology innovation in Germany. This was supported by international pressure to commit to self-sufficiency in the treatment of plastic waste. By 1998, 600,000 tonnes of plastic sales packaging were recycled; 43 per cent by mechanical recycling, 56 per cent by feedstock recycling, and 1 per

cent used for research and development.[91] Among the emerging technological options, feedstock recycling became the dominant technology, especially technologies such as gasification and use as a reducing agent in steel manufacture. These technologies were less expensive than other feedstock technologies (e.g., pyrolysis, chemical depolymerization, and catalytic cracking) and are the only technologies operating on a commercial scale. The amendment to the Packaging Ordinance in 1998 established a minimum target of 36 per cent for mechanical recycling to counteract the dominance of feedstock recycling over mechanical recycling.

In France, 1 per cent of domestic plastic packaging was recycled in 1996, rising to 3 per cent in 1998.[92] This can be attributed to the lack of quantitative targets for material recycling and the desire to cause as little disruption as possible to existing waste management systems. Only fractions that could be economically and efficiently recycled at the time were exploited. Since there was a greater proportion of PVC bottles on the French market in the early to mid-1990s, compared to other Europe countries quality standards were difficult to obtain due to inefficient sorting processes. Hence, technological innovation focused on automation of sorting technologies in order to obtain high quality recyclable plastic. Even today, domestic plastic packaging collection and recycling is limited to bottles.

In order to meet EU packaging waste targets and due to the lack of national capacity, the UK exports around two-thirds of plastic packaging waste, predominantly to China.[93] As a strategy to reduce the UK's reliance on export markets, mechanical recycling capacity is being developed, particularly for PET.[94] The technical choices available in the UK reflect the government's approach to the waste hierarchy, whereby the government "does not expect incineration with energy recovery to be considered before the opportunity for recycling and composting has been explored".[95]

6 DISCUSSION

6.1 Conventions Guiding National Regimes

Although all countries have acknowledged a need for the development of material recycling and energy recovery, waste management solutions have not been applied in the same way. The German position has shown some, albeit small, evolution between the salience of recycling and energy recovery. The Packaging Ordinance 1991[96] set high reuse and recycling targets and prohibited energy recovery from plastic waste, illustrating a strict adherence to the waste hierarchy. Even though the Packaging Ordinance was amended in 1998, there is still a strong preference for material recovery, be it mechanical or feedstock recycling.

In France, valorization puts material recycling and energy recovery at the same level. The historical dominance of incineration as a technological option is confirmed in the case for plastic waste, where only easily recyclable plastics (bottles) are submitted to material recycling and energy recovery remains the institutionally favoured recovery technique for household waste.

The UK has been slow to implement the waste hierarchy, although it has been a principle in their waste policy since 1995.[97] Energy recovery has not been implemented to the extent of having any great effect due to public resistance for fears of pollution and lack of political desire. Yet, at the same time, the UK relies on landfills to control pollutants. Only recently has there been a desire to move to a position favouring recycling, although this is driven to a large extent by the need to transpose EU policy, rather than from within.

Here we can see the evolution of three different trajectories of waste management. These have transpired not only as a result of the differences in political objectives and organizational solutions, but can be related to different conventions these regimes are built upon. Buclet and Godard[98] highlight the internalization of basic conventions within waste management regimes, describing these conventions as myths related to the context of a sustainable society. These include: (a) the "myth of mastering" the control of pollutant flows from landfill; (b) the "myth of perpetual materials cycles" supporting economic growth with little virgin material input; and (c) the "myth of a dematerialized of post-consumer society," or prevention at the source. These myths, or beliefs associated with institutions that illustrate cultural ideals, in reality, have inspired certain strategic choices.

Using this classification of underlying conventions, we can see how these myths have been embodied in the waste management regimes of the three Member States. The UK has in the past adhered to the first of these myths, as illustrated by figure 1. France has relied heavily on incineration with energy recovery and landfill to manage plastic waste; rather than supporting the second myth of waste management this approach is more akin to belief in the first myth. Political objectives enforced by the German regime suggest a belief that economic growth can be maintained with the decoupling of virgin material input, supporting the second of these myths. This is further highlighted by the waste policy "Act for Promoting Closed Substance Cycle Waste Management".[99] While all countries acknowledge the desire to be accordant with the myth of a dematerialized post-consumer society (the prevention principle), little action has been taken in the implementation of this principle. Figure 1 supports this notion, showing the total amount of plastic packaging waste per capita rising in each country, most notably Germany.

These myths have a strong correlation to the waste hierarchy, in the belief that waste treatment options have an intrinsic superiority in terms of environmental impact. The first myth relates to the ability of engineered landfills to contain pollutants until the potential effect to humans and ecosystems has passed. The second of these myths relates to the reuse, recycle, and recovery stages of the waste hierarchy, supporting the belief that the environmental impacts of economic growth can be decoupled by closing energy and material loops. The last of these myths connects with the first step of the waste hierarchy, supporting a vision of "zero waste".

It is not possible to explain the function of society as a whole in a rational way. Hence, myths exist to provide society with common references. Zaoual[100] writes: "Any society rests on myths. Put in another way, man without myth is a myth." Certain myths surrounding waste management are required in order to establish this common reference within society. This is not to say that by following myths we are led in a direction of right or wrong. There is little scientific evidence on the validity of these myths. However, it is the evolution of society that has led to negative actions by following these myths.

6.2 The Legitimacy of Imposing a Hierarchy of Technological Options

Legitimacy as a waste management principle. Where does the waste hierarchy stand in terms of its status as a convention or principle of waste management? We can see from the discussion surrounding its application (as a 'general rule' or 'guiding principle') that its capacity to guide technological choices is being tested. Referring back to our comparative framework, the waste hierarchy can hardly be labelled a convention since the majority of actors cannot expect other actors to abide by this principle. There is also contention surrounding the legitimacy of the waste hierarchy as a waste management principle. Previous life cycle assessment studies have shown the departure of specific plastic waste streams, depending upon the system boundaries and assumptions. This is supported by actors calling for individual choices to be made on the basis of scientific assessment, with consideration given to conditions specific to each decision context. If the requirement for this principle is that it be tested for each individual waste stream and decision context, the principle loses its validity as it cannot serve as the basis for belief or action. This qualification process, over time, will see either the confirmation of this principle or its rejection and possible replacement by another.

Benefits and Limitations of Testing the Waste Hierarchy Using a Life Cycle Approach. Directive 2008/98/EC requires the departure of certain waste streams from the waste hierarchy to be "justified by life cycle thinking," placing great expectations on the life cycle approach. We can see from the negotiation at the EU level that life cycle thinking, rather than life cycle assessment, was favoured for the justification of derogations of specific waste streams.[101] However, justification should require some form of analysis or assessment, which (within the life cycle approach) can only be given by carrying out some form of life cycle assessment.

The primary benefit of using life cycle assessment in the context of waste management systems is the advantage of its holistic approach to waste management. Potential environmental impacts/benefits of reuse, recycling, and energy recovery techniques are often more prominent outside the waste management system in question. Environmental benefits from background systems, such as the energy system and production of materials, can have greater significance than the waste management system itself. The quantitative nature of life cycle assessment also allows for the identification of waste priority waste streams, those streams with a high environmental impact compared to other streams. Finnveden *et al*.[102] and Moberg *et al*.[103] used life cycle assessment to test the waste hierarchy in the Swedish context. They found that life cycle assessment could be used to test the waste hierarchy and identify situations where it was not valid. Importantly, they found that the ranking of waste treatment options was not possible without making assumptions and value choices which differ depending upon decision contexts and perspectives.[104]

Despite the benefits of life cycle assessments, the value choices required to be made in life cycle assessment open their results to potential controversy, which draws attention to the legitimacy of life cycle assessment as a tool. Suspicion surrounded early life cycle assessments as studies commissioned by opposing industry groups delivered diverging results.[105] The exploitation of the legitimacy of life cycle assessment for marketing claims was a strong driver for the standardization of life cycle assessment methodology. However, the standardization of life cycle assessment methodology in 1997, through the ISO 14040 series, has not ended the controversy. Recent life cycle assessment studies of plastic packaging have been seen as "unfair" (controversy over allocation procedures) by certain actors and subject to counter-life cycle assessments of the same system delivering diverging results.[106] Recent developments in life cycle assessment methodology have focused on the potential environmental consequences of a decision,[107] as

opposed to the traditional approach of assessing the total environmental impacts of a product/service system. Yet, as we see with regard to decisions made on deposit systems for bottles[108] and establishing high recycling targets, such as the case of Germany in the early 1990s,[109] there is radical uncertainty surrounding the consequences of these decisions. These decisions have the potential to change both product systems and production and consumption patterns. The assessment of the environmental impacts of these types of decisions pushes the limits of current life cycle assessment methodology. Additionally, the application of life cycle assessment to test the waste hierarchy involves an administrative burden. Undertaking studies on a regional basis (such as the case with the UK's "Best Practical Environmental Option") are costly data- and expertise-intensive exercises. Schaltegger[110] points out the inefficiencies of conducting life cycle assessments at the local scale for studies "tend to provide unrepresentative … and very questionable results".

Level of Decision-Making. Although the waste hierarchy has now been established as a principle at the EU level, its further influence in shaping waste management regimes remains unclear. The influence of the waste hierarchy is, inter alia, controlled by the degree of flexibility afforded to regional and local waste management decisions. As seen by the cases of Germany and France, centralized and decentralized approaches to waste policy can have a significant influence on the technical choices made in waste management regimes.

Establishing a hierarchy of waste management techniques at the national level can have an influence on the technical trajectories of waste management regimes. The development of new technological approaches can serve as a launching pad for specific technological trajectories and the basis for more sustainable organization of economic activities.[111] Counterbalancing this argument is the potential cost increase of institutional trajectories favouring technologies beyond the state of the art. This may stem from, firstly, in the short/medium term this approach can reduce the benefits of management options which, at the time, are better adapted to specific waste streams; and, secondly, the benefits of additional costs of research and development and large-scale deployment may be long term.[112]

6.3 The Waste Hierarchy in the Context of Developing Regions

In some ways, the current situation of waste management in developing regions has some similarities with the situation that was present in Europe at the end of the 1970s. Although the problems facing plastic waste management (and waste management, in general) may be similar, one cannot assume the same for the underlying conventions. Thus, caution must be taken when looking for relevant lessons from developed countries. While further research should be conducted on the origins and structure of conventions and principles in waste management regimes of developing regions, some differences are apparent.

Hafkamp[113] suggests the waste management regimes of developed European countries experienced a regime change towards the end of the 1970s and at beginning of the 1980s. The underlying conventions of these regimes shifted from the disposal of waste without risk to public health, the obligation of participation of households and businesses, the obligation of local forms of governments to manage waste, and the cost of waste management to be borne by the households/business (used pays), to those of the precautionary principle, the prevention principle, and the cost of waste management to be borne by the production of goods (extended producer responsibility). The waste management regimes of developed regions have started on a trajectory towards efficient use of materials and energy (although countries are at different positions). The start of this evolution has been self-imposed by European Member States such as

the Netherlands, Germany, and Denmark. These Member States were involved in passing these waste management principles to the EU level, which, in turn, has driven other Member States such as the UK.

The development and manifestation of conventions and principles of these waste management regimes will no doubt be different from developed regions. One apparent driver for sustainable waste management in developing regions is the promotion by international institutions such as the United Nations.[114] If a move towards sustainable waste management in developing regions is required, an evolution of their underlying conventions and principles may be necessary.

When adopting new principles to serve as the foundation of belief, they should synchronize with the existing waste management myths of individual regions, as myths may differ from region to region illustrating different cultural ideals. Focusing on the waste hierarchy, the current debate surrounding the legitimacy and application of the waste hierarchy in Europe may not have relevance to the goals of developing waste management systems. If one of the goals of developing regions is to place waste management regimes on a sustainable trajectory, a principle serving as the foundation for action may be of greater benefit than undertaking studies in order to define a hierarchy of treatment options for individual waste streams. The benefit of applying the waste hierarchy as a principle is that it can be applied quickly, enabling faster action. If the waste hierarchy later becomes an established principle, it may go on to be refined and tested as the regime develops. Furthermore, the adoption of a life cycle approach may be difficult in some regions. Life cycle assessments require expertise, are data and time intensive, and can be a costly exercise. Developing regions not only require the capacity to carry out these types of studies, but also require a common language (definition of waste, reuse, recycling, and recovery) in order to consolidate a common trajectory.[115]

7 CONCLUSION

The drive to harmonize waste policy at the European level has led to two directives influencing post-consumer plastic waste — Directive 94/62/EC on packaging and packaging waste and Directive 2008/98/EC on waste. Directive 94/62/EC set objectives for total packaging recycling of 55 per cent to 80 per cent by 2008, and plastic packaging recycling of 22.5 per cent by 2008. In order to achieve these objectives, the majority of Member States were required to make substantial changes to both their technical and organizational systems. The implementation of these systems differed considerably, based upon different conventions, principles, and institutions established within national waste management regimes. The harmonization of national waste management objectives is of importance in Europe, as highlighted by historical disturbances such as the disruption of free trade and negative influences surrounding Member State waste management systems.

This article has shown waste hierarchy as being a salient factor in the establishment of political objectives such as the establishment of prevention, reuse, and recycling targets. From a European perspective, actors adhering to the concept of life cycle thinking have renewed debate over its legitimacy as a principle of waste management. In doing so, the waste hierarchy principle is increasingly discussed, which has led to increased controversy over its validity. It is no longer a steady conventional principle, but an approach that should be validated case by case through rational tools.

The life cycle approach has been adopted at the EU level, with the perception that it will aid in the optimization of social decisions with the best possible outcome. In that sense, life cycle thinking

is a new attempt to rationalize social decisions, whose validity is still under question. However, scientific uncertainties are still pregnant and conclusions are frequently being contested, which also lead to new controversies. Much energy is being directed towards understanding the differentiation of waste treatment options within the hierarchy. Yet, as we have shown in the case of plastic waste,[116] no steady conclusion is available. Rather than the rationalization of decisions, we consider the holistic nature of the life cycle approach, which allows an understanding of the main areas of environmental importance during the end-of-life phase of products, as being its greatest benefit. It might help to understand in which direction conventional regimes and their embedded principles should evolve in order to improve waste management. Rather than a case-to-case analysis of the best solution, which is much alike the pursuit of the Sisyphus myth,[117] actors require solid principles they can refer to when addressing questions on the organization of waste management.

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