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Fraunhofer Institute Systems and Innovation Research

New Products and Services. Analysis of Regulations Shaping New Markets

Third Interim Report

Part D:
The Impact of Regulation on the Development of New Technologies in the Environmental Sector

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1 Introduction

With the economic slowdown of the early 2000s, the analysis of the interaction between regulation and innovation has become even more important than before. There are many reasons for regulation. One reason which is not disputed is the existence of external costs. Clearly, environmental problems are one of the most prominent cases for external costs. Thus, since the late 1960s, environmental regulation has been a major political issue in all industrialised countries. Thus, the question arises what the role of regulation has been in shaping new markets with new innovations.

Within environmental regulation, a dichotomy exists between theory and practice. On the one hand, in almost every country, regulation mainly takes to a vast amount the form of command and control policies. Economic theorists, on the other hand, arguing from a top-down view, claim that market-based instruments such as emission taxes or tradable certificates have to be favoured with regard to innovation. However, in contrast to economic theory, other approaches explain the effects of environmental regulation on innovation by the importance of other factors, which are sometimes called soft context factors. This approach claims that factors such as the existence of long-term policy goals, or the style of regulation are much more important for the outcome of innovation than the use of the different policy goals (Klemmer et al. 1999). An often quoted perception is the one by Porter/van der Linde 1995. They argue that constant pressure to adapt to new challenges is necessary to mobilise the innovation potential. Another approach which also plays down the importance of the design of policy instruments is based on the concept of innovation systems. Here the functioning of the system, consisting of all relevant players from R&D institutions over suppliers and users of technology until the end consumers, and their interactions among each other, decides on the level of innovation (see Edquist/McKelvey 2000; Carlsson et al. 2002).

The situation does not become much clearer when evaluations of case studies are taken into account (see Wallace 1995, Jaffee et al. 1995; Kemp 1997, Klemmer et al. 1999; Fischbeck/Farrow 2001). Clearly, environmental innovations have been taken place parallel to regulations in the form of command and control policies. However, this does not resolve the question if these innovations were fostered by environmental regulations, or if they would have taken place even though there were command and control policies at the same time.

The goal of this special report is to examine the relationship between regulation and innovation for two case studies: the water sector and wind power. In addition to environmental regulation, aspects of economic regulation of both water utilities and electric utilities play a role too. This emphasises the need to use a multidimensional framework in which various determinants of innovation are accounted for, instead of a linear causal relationship between regulation and innovation (Kemp et al. 2000). In order to broaden the perspective, a case from the EU was contrasted with the perspective for the U.S. For the European perspective, a special reference to Germany was taken, which is one of the leading exporters of both environmental technologies and wind turbines. The analysis is based on available literature and was supported by various interviews with experts in the field. Fraunhofer ISI was responsible for the case from the EU, the U.S. analysis was performed by Prof. McIntyre from Georgia Tech.

The report is structured as follows: in Chapter 2, the environmental regulatory regime is characterised for both the EU and the U.S. Similarities as well as differences between the systems are identified, with special reference to Germany in order to compare the systems on the country level. Furthermore, a brief comparison of the environmental innovation output for both systems is presented. Chapter 3 describes the results of the case study for water. For each country, the water policy, the innovations which have been observed, and the interaction between innovation and regulation are discussed and compared. In Chapter 4, the results of the case study for wind power are presented. The chapter is organised in a similar way as Chapter 3: first, regulations and policies are described, then the innovations are presented, and finally the interaction is analysed and compared. In Chapter 5, the results are summarised and conclusions for the relationship between innovation and regulation are developed and presented.

2 Principles and Foundations of the Environment Regulatory Regime

2.1 Principles and Foundations of the Environmental Regulatory Regime in the EU

2.1.1 Environmental Policy of the EU

The European Union's first steps in the field of environmental protection began at a meeting in Paris in 1972 as a response to the United Nations Conference in Stockholm, which called for concerted action on the environment. Before 1970 the European Union had no environmental policy. Despite the fact that the word *"environment"* was not mentioned in the treaty establishing the European Economic Community (EEC), referred to as the "Treaties of Rome" (1957), Europe has been working on a Community policy for the environment since 1972. The European Union's first proposal on environmental quality concerned the quality of surface water from which drinking water was drawn. On July 1st 1987 the EEC-Treaty was amended by the Single European Act (SEA). This formally incorporated the integration principle into the EEC Treaty, demanding that "environmental protection requirements shall be a component of the European Union's other policies" (Article 130r). In general the aim of Community environment policy is to preserve, protect, and improve the quality of the environment and to protect people's health. It also sets great store by the prudent and rational use of natural resources. By the late 1980s, both the public and the political authorities had reached the conclusion that a concerted approach had to be developed Europe-wide and internationally in order to save the environment from the damage being done to it. So, in 1993, when the Treaty of Amsterdam was drawn up, the environment and sustainable development became a top-priority Community policy.

The framework and basic principles of the European Union's environmental policy are embodied in several "action programmes". The first action programme covered the 1973-76 period and presented a set of specific ad hoc policy measures targeting the identification of some Europe-wide environmental problems. The second Environmental Programme was prepared for 1977-81 and put forward the idea of taking action in four major fields:

- reduction of pollution and nuisance;
- rational management of land, environment and natural resources;
- protection and improvement of the environment;
- action at international level:

The Third Environmental Action Programme, expanded for the period of 1982-1986, was narrowly linked with the polluter pays principle (PPP). The programme studied the use and introduction of economic instruments for the implementation of the PPP. Thus environmental policy integration constituted one of the key objectives in the Third Environmental Action Programme. The Fourth Environmental Action Programme, which covered the period from 1987 until 1992, included general policy orientation aspects, approaches to pollution control, actions to be taken in specific sectors and the organised management of environmental resources, as well as research and action at international level. The Fourth Environmental Action Programme was expanded on the basis of the treaty revision of the Single European Act. The revision included an environmental chapter captured in Articles 100 a and 130 r-t which introduced the notion of subsidiarity. The change included statutory mandates, objectives and criteria for EU policy, and action with respect to the environment (Karadeloglou, Ikwue, Skea 1995).

The Fifth Environment Action Programme *"Towards Sustainability"* has been an important step in the development of EU policy, because environment law has been amended by market-economy instruments. Furthermore, the action programme has been aligned to integrate environmental aspects into other policy areas and to establish partnerships with shared liability between state, economy and public. The Sixth Environment Action Programme of the European Community *"Our future, our choice"* was launched in Brussels on 24 January 2001 and is prepared for the 2001-2010 period. It continues to pursue some of the targets from the Fifth Environment Action Programme. But the new programme goes further, adopting a more strategic approach. It calls for the active involvement and accountability of all sections of society in the search for innovative, workable and sustainable solutions to the environmental problems. This new programme identified four priority areas:

- climate change;
- nature and biodiversity;
- environment and health;
- natural resources and waste.

To achieve improvements in these areas, the new programme set out five approaches. These emphasised the need for more effective implementation and more innovative solutions. The five key approaches are to

- ensure the implementation of existing environmental legislation;
- integrate environmental concerns into all relevant policy areas;
- work closely with business and consumers to identify solutions;
- ensure better and more accessible information on the environment for citizens;
- develop a more environmentally conscious attitude towards land use.

The new programme provides the environmental component of the European Union's forthcoming strategy for sustainable development. Furthermore, to achieve the goals set down in the EU's 6th Environmental Action Programme and to fulfil the commitments made by the EU at the Word Summit on Sustainable Development in Johannesburg, the Commission adopted its Integrated Product Policy (IPP) Communication. The Integrated Product Policy seeks to minimise environmental degradation caused by product in some way, whether from their manufacturing, use or disposal by looking at all phases of products' life cycle and taking action where it is most effective. IPP is flexible as to the type of policy measure to be used, working with the market where possible. Many different policy measures may influence product design and thus the environmental impact of products – such as taxes, product standards and labelling, and voluntary agreements. But with so many products it makes no sense to prefer any one type of instrument. As mentioned above the only pre-requisite is that the measure used should be the most effective (http://europa.eu.int/comm/environment/ipp). Prior to the adoption of the Green Paper on Integrated Product Policy by the Commission in 2001 studies were commissioned and stakeholders consulted. At present the European Commission calls on business to participate on a voluntary basis in a pilot project exercise to bring IPP to life and show the practical benefits of such an approach (European Commission 2003).

The Single European Act gave solid legal basis to European environmental policy by adding Title VII containing Articles 130r, 130s and 130t on the environment to Part II of the Treaty of Rome. In addition, Article 100a was included which empowers the EU to adopt laws relating to health, safety and the environment on the basis that they contribute to the achievement of the internal market. Article 130r identifies three objectives in relation to the environment which are:

- the preservation, protection, and improvement of the quality of the environment;
- to contribute towards protection of human health; and
- ensure a prudent and rational usage of natural resources.

(1)

The Single European Act (1987) with its explicit discussion of environmental protection is often viewed as the foundation of the European Union's environmental policy, because it made the protection of the environment one of the principal objectives of the European Community. Since then, European regulators have looked at all areas of policy to see how environmental concerns could better be integrated into policy decisions. However, the environmental principles of the Single European Act and policy activism have been marked by the action programmes and the directives of the 1973-1986 period (First –Third EAP). The Single European Act provides the European Commission with a legal basis for future initiatives. It elevates environmental policy to an official assignment of the EU and defines essential principles, upon which EU environmental action must be based:

- the polluter pays principle;
- the precautionary principle;
- the subsidiarity principle.

It is a fundamental principle of European environmental policy, enshrined in Article 130r of the EC Treaty, that the polluter should pay of damage to the environment. The **polluter pays principle** was established to ensure the internalisation of avoidance and damage costs in order to maintain a more cost-efficient application of EU environmental policy. The PPP gained broad acceptance, albeit with differences of interpretation and practices to the extent of the polluters' responsibility (Karadeloglou, Ikwue, Skea 1995). There are two definitions in use. In the broadest sense it means that the polluter is financially responsible for whatever harm its activities may cause, no matter whether they stay within the limits set by the law or not. Even though such a broad range of responsibilities has been theoretically possible under jurisdictions adopted in many countries and encouraged by the OECD since 1991, most policies try to enforce a narrower version. PPP in a strict sense means that the polluter is financially responsible for complying with whatever environmental requirements are set by relevant authorities (Żylicz 1995).

The polluter pays principle is particularly difficult to apply in the context of water pollution, because it may not be possible to trace the pollution back to a particular source. Point source of pollution, such as industrial plants or municipal waste outlets, can generally be identified. Pollution from diffuse sources, such as nitrate pollution from agricultural run-off, is not so easy to pin on a particular farmer or groups of farmers. In some Member States, water suppliers have taken matters into their own hand. In Germany for example, some municipal authorities which are responsible for supplying water have entered into voluntary agreements with farmers, where there were high levels of pesticide residues and nitrates in the water, to encourage farmers to reduce the use of pesticides and fertilisers. While such schemes may have a desirable effect in reducing pollution, their ultimate effect is to make the consumer, and not the polluter, pay. Existing European water legislation has been criticised for failing to apply the PPP. European Policy makers have to address the issue of how to achieve a more equitable balance between water suppliers, consumers and public authorities in applying this principle (Stern 1995).

The **precautionary principle** evolved during the 1980s as a guiding principle of European environmental policy and regulation. It is based on a number of different concepts, including the principle that prevention is better than cure, that ecological space should be safeguarded, that action should be proportionate to the problem addressed, that there is a duty of care for the environment and the intrinsic natural right should be promoted and past ecological damage paid for (Stern 1995). According to this principle there is an increasing emphasis upon a forward-looking approach to environmental management, that is, to encourage continuous improvement with appropriate incentives for development of products and processes which are less damaging to the environment. Another facet of this approach is anticipatory action, whereby full account is taken of the environmental dimension in all stages of the development process. It has several useful consequences, i. e. the establishment of "safe minimum standards" and the use of financial guarantees for the worst possible outcome.

The precautionary principle has been employed in various international agreements and conventions, including the Rio Declaration on Environment and Development (1992). Existing EU water quality legislation is sometimes accused of setting standard on an arbitrary and politically motivated basis, relying on the precautionary principle. The application of this principle therefore features prominently in the water policy debate (Stern 1995).

The **subsidiarity principle** states that policy measures should only be taken at EU level if there is a clear advantage over Member States level. In other words, it can be seen as a "decentralisation principle". In the European Union it has been applied to let the Member States adapt their policies to the Union's directives in a creative way and make them compatible with local preferences (Żylicz 1995). Instruments with which to meet environmental targets should be carefully scrutinised as to the institutional level at which they are to be designed. In applying the subsidiarity principle to environmental policy, it is important to distinguish between objectives and the means by which the objectives are to be attained. Thus, environmental policies have two distinct aspects:

a) the setting of environment quality standards;

b) use of policy instruments (e. g. emission taxes, transferable emission permits, emission or product standards) to achieve a certain environmental quality.

The application of the subsidiarity principle may cause a conflict between environmental and market integration objectives. A fully decentralised approach could result in the setting of very high quality standards in some countries and to disregarding the environment in others. EU intervention is necessary in cases in which environmental problems create important transboundary consequences (Karadeloglou, Ikwue, Skea 1995). In addition, the Single European Act authorises Member States to adopt more stringent national measures to protect the environment than those sanctioned by the EU where these are compatible with the Treaty of Rome.

The Treaty of the European Union signed in **Maastricht** (Treaty of the European Union of 7 February 1992, entered into force as from November 1st 1993) modified the Europeans Union' s role in environmental policy-making by emphasising the issue of subsidiary. The Maastricht Treaty underlines the critical importance of a reinforced environmental policy by rewriting Articles 130 r and 130 s of the treaty. It made the precautionary principle one of the underlying principles on which EU environmental policy should be based (Article 130r). There is, however, no widely accepted definition of the principle, which means the interpretations vary widely. It generally means that the EU must act to protect the environment before damage occurs, even if in specific cases it does not yet have conclusive evidence that damage has taken place. The Treaty of **Amsterdam** (1997, entered into force on May 1st 1999) changed the basics of the European environmental policy. It has enshrined the concept of "sustainable development" as one of the European Union's objectives, while environmental protection requirements have been given greater weight in other Community policies, especially in the context of the single market. The provisions allowing a Member State to apply stricter rules than the harmonised rules had been clarified. Under certain narrowly defined conditions, a Member State may adopt new measures in response to a specific environmental problem. The Treaty of Amsterdam (1997) requires all EU policies to integrate environmental interests. It gave environmental policy integration its current political significance, by introducing it into Part One of the EC Treaty, which established the principles of the Community:

> Environmental protection requirements must be integrated into definition and implementation of the Community policies and activities referred to in Article 3, in particular with a view to promotion of sustainable development (Art.6).

Several European Councils stressed this sustainable and environmentally-friendly aspect in all European policies. The process of environmental integration started at the **Luxembourg European Council** (December 1997). There it was stated that environmental protection requirements must be integrated into the European Union's policies and activities to promote sustainable development.

The process of environmental integration started at the Luxembourg European Council was carried further at the **Cardiff European Council** (June 1998). There the Commission presented an integration strategy, entitled "*Partnership for Integration*" requiring different Council formations to integrate environmental considerations into their respective activities. The so-called **Cardiff process** aims to put into practice the European Union's commitment to environment policy integration through a number of sectoral strategies. These were begun for Energy, Transport, and Agriculture. At a later stage, Industry, Internal Market, Development, Fisheries, Economic and Fiscal Affairs, and General Affairs were also invited to deliver such integration strategies. The Cardiff European Council also requested the development of indicators for monitoring progress. By requiring the nine sectoral formations to produce their own strategies for integrating environment into their work, the Cardiff process has contributed to raising the political profile of integration. The importance of integration was reaffirmed in the Sixth Environment Action Programme which stipulates that "*integration of environmental concerns into other policies must be deepened*" in order to move towards sustainable development.

At the **Vienna European Council** (December 1998), the heads of state and government invited the Council to develop this work further and included European Union policies, thereby involving the Development, Internal Market and Industry Councils. The Vienna European Council concluded that the European Council would review overall progress on integrating environment and sustainable development at its meeting in Helsinki in order to link the sectoral strategies developed by the various formations of the Council.

The **Cologne European Council** (June 1999) considered major issues for the future following the entry into force of the Amsterdam Treaty. The European Council took note of the report by the Commission on "*Integrating environmental aspects into all relevant policy areas*" and of the progress achieved in the Council since the Vienna meeting. It reaffirmed its intention to re-examine overall progress in December 1999 at its Helsinki meeting and called attention to the reports requested. It called upon the General Affairs, Economic and Financial Questions and Fisheries Councils to report back to it on the integration of environmental issues and sustainable development into each of the policy areas.

At the **Helsinki European Council** (December 1999) the heads of state and government reaffirmed their commitment to sustainable development and to integration as the key means to achieve it. They requested proposals for a new environment action programme and a European Union strategy for sustainable development. The European Council took note of the Global Assessment of the 5th Environmental Action Programme and the Report on Environmental and Integration Indicators presented by the Commission and invited the Commission to prepare a proposal for the 6th Environmental Action Programme (by the end of 2000). The Helsinki European Council added a timetable, requesting that a proposal for a long-term strategy for economically, socially and ecologically sustainable development should be presented at the Gothenburg Council in June 2001.

So far, three European Councils have asked nine sectors to present strategies:

- energy, transport, agriculture (Cardiff);
- development, internal market, industry/enterprise (Vienna);
- general affairs, economic and fiscal affairs, fisheries (Cologne).

The **Gothenburg European Council** was held in June 2001. One of the central themes was the EU strategy for sustainable development, which was adopted by the Commission on May 15th 2001. This strategy means that when new proposals are drawn up in the EU, the economic, social and ecological effect must be weighed in each individual proposal. The news from the Gothenburg summit was that the ecological dimension in the strategy for sustainable development must be given the same prominence as social and economic considerations when future policies are formulated. Therewith sustainable development policy was added to economic and social policy as a third area for co-ordination through the Lisbon process[1] (Lisbon European Council, March 2000). The strategy for sustainable development concentrates on four objectives and measures in the sphere of ecology:

1) **Climate:** by 2005 at latest, the EU must demonstrate clear progress in living up to its commitments according to Kyoto. At least 22 % of electricity production within the EU must come from renewable energy sources by 2010.

2) **Transport:** transport policy must include measures against greater traffic volume, congestion, noise and pollution, and encourage environmental-friendly forms of transport. Public and environmental-friendly means of transport, that is track-bound transport such as train and underground, and water transport will be prioritised in the EU guidelines for infrastructure.

3) **Public Health:** the chemical policy for the EU must be adopted by 2004 at latest. An action plan to deal with issues relating to outbreaks of infectious diseases and antibiotic resistance had to be produced by the Commission during 2001.

4) **Natural Resources:** agricultural policies must promote healthy products of good quality, ecological cultivation and protect biological diversity. The EU integrated product policy must be implemented in conjunction with the business sector. The depletion of biological diversity in the EU must cease by 2010.

The following timeline concludes the development in the Europeans Union's environmental policy.

The European Environmental Protection Market in 1994 had a volume of about 90 billion EURO. One third of that market volume accounted for Germany with 32 billion EURO. The second-largest share of the European environmental protection market accounted for France with approximately 17 billion EURO. Great Britain had the third-largest market share with about 11 billion EURO. Further important environmental protection markets are Italy and the Netherlands. Other European Member States like Austria have market shares with a maximum of only 4 %.

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1 The Lisbon process aims to make the EU the most competitive and knowledge-based society in the world by 2010. The Lisbon summit called for a new method of „open co-ordination" to promote sustainable economic growth with more and better jobs and greater social cohesion.

Table 2.1-1: Development of European Union environmental policy

1967	First environmental Directive 67/548 on classification, packaging and labelling of dangerous substances adopted
1972	Paris European Council calls on the Commission to produce a programme for environmental action
1973	First Environment Action Programme (1973-76)
1977	Second Environment Action Programme (1977-81)
1983	Third Environment Action Programme (1982-86)
1987	Fourth Environment Action Programme (1987-92)
	The Single European Act incorporates environmental policy into the Treaty of Rome
1992	Fifth Environment Action Programme (1992-2000)
1993	The Maastricht Treaty gives environmental action the status of an EU policy (Art. 130r)
1994	Formal establishment of the European Environment Agency (EEA) in Copenhagen
1997	Luxembourg European Council (December) Treaty of Amsterdam
1998	Cardiff European Council (June) Vienna European Council (December)
1999	The Amsterdam Treaty makes environmental policy a key political objective of the European Union Cologne European Council (June) Helsinki European Council (December)
2001	Sixth Environment Action Programme (2001-10) Gothenburg European Council

With 37.5 billion EURO (42 % of all environment protection expenditures) waste-water treatment was the most important market segment in the European Union in 1994. Secondary waste management took a share of 25.7 billion EURO (29 %) and air pollution control techniques ranked third with 17.3 billion EURO (19%). These three segments comprehended 90 % of all expenditures for environmental protection (Lemke, Wackerbauer 2000).

Figure 2.1-1: The most important segments in the European Environmental Protection Market (Source: Lemke, Wackerbauer 2000)

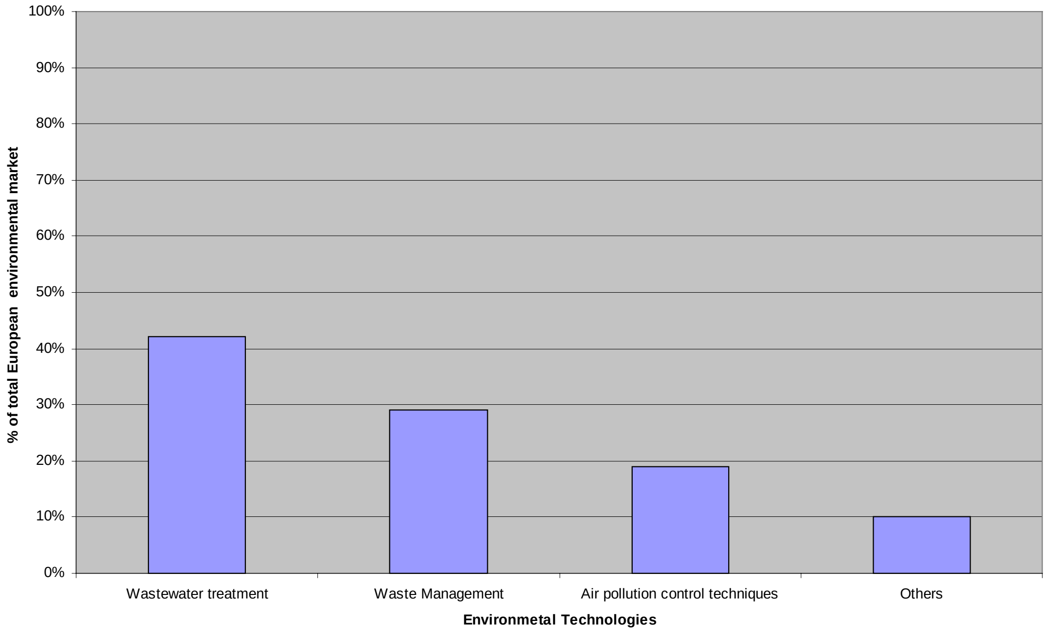
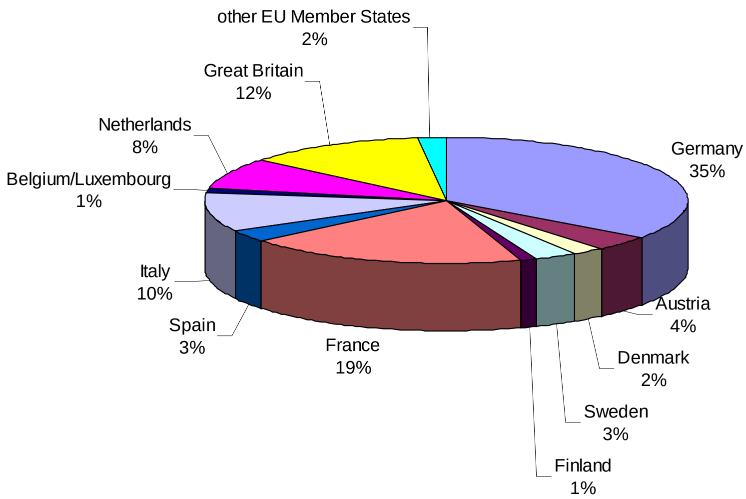


Figure 2.1-2: Market Shares of European Environmental Protection Market in 1994



Source: ECOTEC/BIPE/IFO 1997 in Lemke, Wackerbauer 2000, p. 90

2.1.2 European Union Law

2.1.2.1 European Union Law – Definitions

The European Communities' core objective of achieving European unification is based exclusively on the rule of law. Community law is an independent legal system which takes precedence over national legal provisions. A number of key players are involved in the process of implementing, monitoring and further developing this legal system. In general, EU law is composed of three different – but interdependent – types of legislation:

The primary legislation includes in particular the Treaties and other agreements having similar status. Primary legislation is agreed by direct negotiation between Member State governments. These agreements are laid down in the form of Treaties which are then subject to ratification by the national parliaments. The same procedure applies for any subsequent amendments to the Treaties. The Treaties establishing the European Community have been revised several times, through the Single European Act (1987), the Treaty on European Union - 'Maastricht Treaty' (1992), the Treaty of Amsterdam (1997). The Treaties also define the role and responsibilities of EU institutions and bodies involved in decision-making processes and the legislative, executive and juridical procedures which characterise Community law and its implementation.

The **secondary legislation** is based on the Treaties and implies a variety of procedures defined in different articles thereof. Community law may take the following forms:

- **regulations** which are directly applicable and binding in all EU Member States without the need for any national implementing legislation;
- **directives** which bind Member States as to the objectives to be achieved within a certain time limit while leaving the national authorities the choice of form and means to be used. Directives have to be implemented in national legislation in accordance with the procedures of the individual Member States;
- **decisions** which are binding in all their aspects for those to whom they are addressed. Thus, decisions do not require national implementing legislation. A decision may be addressed to any or all Member States, to enterprises or to individuals;
- **recommendations** and **opinions** which are not binding.

The case law includes judgements of the European Court of Justice and of the European Court of First Instance, for example, in response to referrals from the Commission, national courts of the Member States or individuals.

2.1.2.2 Key Players in the EU Legislative Process

2.1.2.2.1 The Role of the Council of the European Union

The role of the Council of the European Union as the main decision-making institution in Community activities is defined in terms of the three 'pillars' set out in the Treaty of Maastricht. The first pillar - covering a wide range of Community policies such as agriculture, transport, environment, energy, research and development - is designed and implemented according to a well-proven decision-making process which starts with a Commission proposal. Following detailed examination by experts and at the political level, the Council may either adopt the Commission proposal, amend it or ignore it. The Treaty of Maastricht strengthened the role of the European Parliament in this context by creating a co-decision procedure.

The Treaties lay down that, depending on the subject, the Council acts by a simple majority of its members, by a qualified majority or by unanimous decision. Where the Council acts by a qualified majority, the votes of each of its members are weighted. In the Community sphere, a large proportion of legislative decisions are taken by qualified majority. The policy areas in the first pillar which remain subject to unanimity include taxation, industry, culture, regional and social funds and the framework programme for research and technology development. For the other two pillars created by the Treaty on European Union, the Council is the decision-maker as well as the promoter of initiatives. On common foreign and security policy, the Council takes the decisions necessary for defining and implementing this policy, on the basis of general guidelines specified by the European Council. It recommends common strategies to the European Council and implements them, particularly by deciding on joint actions and common positions. On police and judicial co-operation in criminal matters, the Council, at the initiative of a Member State or of the Commission, decides on common positions, framework decisions and decisions, and draws up conventions. Unanimity is the rule in both pillars, except for the implementation of a joint action, which can be decided by qualified majority.

2.1.2.2.2 The Role of the European Commission

Given its central position in the structure of the European Union, the Commission has special links with each of the other institutions. It works most intensively with the Council of the European Union and the European Parliament in drafting EU legislation and attends Council and Parliament meetings. In addition, the President of the Commission participates alongside the heads of state and/or government of the Member States at the twice-yearly meetings of the European Council.

The Commission is answerable to the European Parliament, which has the power to dismiss it by a vote of censure or no confidence. The Commission attends all sessions of the European Parliament and must explain and justify its policies if so requested by members of the house. It must reply to written or oral questions put by Members of Parliament (MEPs).

The Commission's functions regularly involve the European Court of Justice, which is the final arbiter of European law. The Commission refers cases to the Court where directives or regulations are not being respected by governments or companies. The Court can also be consulted by the Member States and enterprises when, for instance, they want to appeal against fines imposed by the Commission.

The Commission's management of the EU budget is scrutinised by the Court of Auditors which is responsible for examining the legality and regularity of revenue and expenditure and for ensuring the sound financial management of the EU budget. The common goal of both institutions is to eliminate fraud and wastage. On the basis of the Court of Auditors' reports, it is the European Parliament which gives the Commission final discharge for the execution of the annual budget.

Finally, the Commission works closely with the Union's two consultative bodies, the Economic and Social Committee and the Committee of the Regions, and consults them on most items of draft legislation.

2.1.2.2.3 The Role of the European Parliament

Originally, the Treaty of Rome (1957) gave the European Parliament (EP) a consultative role only, whereas the Commission was entitled to propose and the Council of Ministers to decide legislation. Subsequent Treaties have extended the EP's influence from a purely advisory role to full involvement in the Community's legislative process. The European Parliament is now empowered to amend and even adopt legislation. Thus, in a large number of areas the power of decision is shared by the Council and the EP. Depending on the individual legal basis, the EP takes part, to varying degrees, in the drafting of Community legislation. The different legal bases and associated procedures defined in the Treaties are as follows.

According to the Amsterdam Treaty, the simplified co-decision procedure shares decision-making power equally between the EP and the Council. A legal act is adopted if Council and EP agree at first reading. If these institutions disagree, a 'conciliation committee' - made up of equal numbers of Members of Parliament and of the Council, with the Commission president - convenes, seeking a compromise on a text that the Council and Parliament can both subsequently endorse. If this conciliation does not result in an agreement, the Parliament can reject the proposal outright by an absolute majority. The co-decision procedure, which strengthens the role of the EP as co-legislator, applies to a wide range of issues, such as the free movement of workers, consumer protection, education, culture, health and trans-European networks.

The consultation procedure requires an opinion from the EP before the Council can adopt a legislative proposal from the Commission. Neither the Commission nor the Council is obliged to accept the amendments listed in the opinion of the EP. Once the EP has given its opinion, the Council can adopt the proposal without amendments or adopt it in an amended form. However, the EP can refuse to give an opinion. The consultation procedure applies to agriculture, taxation, competition, harmonisation of legislation not related to the single market, industrial policy, aspects of social and environmental policy. For the purpose of the approximation of laws and regulations, this procedure also applies to a new framework-decision instrument created by the Amsterdam Treaty under the third pillar.

The co-operation procedure allows the EP to improve proposed legislation by amendment. This requires an opinion and involves two readings by the EP, giving its members ample opportunity to review and amend the Commission's proposal as well as the Council's preliminary position. The Commission indicates which amendments it accepts before forwarding its proposal to the Council. This results in a 'common position' of the Council. At second reading the Council is obliged to take into account those amendments of the EP that were adopted by an absolute majority in so far as they have been taken on board by the Commission. The Treaty of Amsterdam has simplified the various legislative procedures by significantly extending the co-decision procedure, which is in practice almost replacing the co-operation procedure. As a consequence, the co-operation procedure applies to very few cases.

The assent procedure applies to those legislative areas in which the Council acts by unanimous decision, limited, since the Amsterdam Treaty, to the organisation and objectives of the Structural and Cohesion Funds. The EP's assent is also required for important international agreements concluded between the Union and a non-member country or group of countries, such as the accession of new Member States and association agreements with third countries.

2.1.2.2.4 The Role of the Economic and Social Committee (ESC)

The ESC advises the Commission, the Council and the European Parliament by informing them of the Committee's opinion on particular issues. These opinions are drawn up by ESC representatives of the various sectors of economic and social activity in the European Union. There are three different types of opinions the ESC may issue:

- Mandatory consultation:
  In certain areas, a decision can only be taken after the Council or the Commission have consulted the ESC, e. g. for harmonisation of indirect taxation; research and technological development; and environment.
- Voluntary consultation:
  The ESC may also draw up exploratory opinions if the Commission, the Council

or the European Parliament ask the Committee to consider specific issues with a view to future action.

- Own-initiative opinions:
  The ESC may decide to express its views by issuing an opinion on any subject it considers of interest.

2.1.2.2.5 The Role of the Committee of the Regions (COR)

The COR can adopt different types of opinions which are sent to the Council, the Commission and the European Parliament:

- opinions issued at the request of other institutions;
- opinions issued on the initiative of the COR;
- opinions issued at the request of other institutions.

According to the EU Treaty, the Council and the Commission are obliged to consult the COR on certain issues before taking a decision. These cover specific areas, falling within the responsibilities of local and regional authorities. When the Council consults the ESC or the Commission, the COR must also be informed. It may then also issue an opinion on the matter if it considers that regional interests are affected. The COR may issue an opinion in other areas whenever it sees fit.

2.1.2.3 European Union Environmental Law

Since 1972 more than 200 European directives have been published in the area of environmental protection. They are continuously adjusted and amended in view of the best available technology (BAT). In the meantime nearly all aspects of environmental policy are covered European Environmental Law.

The **Aarhus Convention** lays down the basic rules to promote citizens' involvement in environmental matters and enforcement of environmental law. The Aarhus Convention consists of three pillars, each of which grants different rights:
(2)

- the first pillar gives the public the right of access to environmental information;
- the second pillar gives the public the right to participate in decision-making processes; and
- the third pillar ensures access to justice for the public.

2.1.3 European Institutions

2.1.3.1 European Parliament

The European Parliament represents, in the words of the 1957 Treaty of Rome, 'the peoples of the States brought together in the European Community'. Some 375 million European citizens in 15 countries are now involved in the process of European integration through their 626 representatives in the European Parliament. The European Parliament, which derives its legitimacy from direct universal suffrage and is elected every five years, has steadily acquired greater influence and power through a series of treaties. Today the European Parliament, as an equal partner with the Council of the European Union, passes the majority of European laws (see Chapter 2.1.2.2.3). Today, the most important mandates of the European Parliament are the following:
(3)

- Legislative power: The European Parliament considers the Commission's proposals and is associated with the Council in the legislative process by means of various procedures.
- Budgetary power: The European Parliament shares budgetary power with the Council in voting on the annual budget and overseeing its implementation.
- Supervision of the executive: The European Parliament has the power to control the Union's activities through its confirmation of the appointment of the Commission, the right to censure the Commission and through the written and oral questions which can be put to the Commission and the Council.

2.1.3.2 European Council

Since 1975 the European Council has brought together, at least twice a year, the heads of state or government of the Member States of the Union - assisted by the foreign ministers - and the President of the European Commission. It lays down the broad policy guidelines of the Union and discusses topical international issues of major importance.

2.1.3.3 Council of the European Union / Environment Council

The Council of the European Union is the European Union's main decision-making institution and final legislative authority. It is made up of ministers (or their representatives) from each of the member states. It meets periodically in Brussels or Luxembourg to adopt Community legislation, often jointly with the European Parliament under the co-decision procedure. The Council presidency rotates among the member states on a 6-monthly basis. The composition of the Council varies with the subject (finance, environment, foreign affairs, etc.). Its decisions are prepared by the Committee of Permanent Representatives of the Member States.

The main responsibilities of the Council of the European Union are the following:

- The Council is the Community's legislative body. For a wide range of Community issues, it exercises that legislative power in co-decision with the European Parliament.
- The Council co-ordinates the general economic policies of the Member States.
- The Council concludes, on behalf of the European Community, international agreements (which are negotiated by the Commission and require, in some cases, Parliament's consultation or assent) between the Community and a State, a group of States or international organisations.
- The Council and the Parliament constitute the budgetary authority adopting the Community's budget.
- The Council takes the decisions necessary for defining and implementing the common foreign and security policy on the basis of general guidelines established by the European Council.
- The Council co-ordinates the activities of the Member States and adopts measures in the field of police and judicial co-operation in criminal matters.

2.1.3.4 European Commission

The European Commission is the institution that initiates Community legislation, runs European common policies, implements the budget and ensures compliance with the treaties. It is made up of 20 independent members (2 each from France, Germany, Italy, Spain and the United Kingdom and one from each of the other member states). It is appointed for 5 years subject to the approval of the European Parliament, to which it is accountable.

2.1.3.5 Court of Justice of the European Communities

The Court of Justice as a judicial institution and EU control body has had a major influence on the development of Community law and has been given a number of tasks and authorities exceeding its customary juridical function.

The Court of Justice comprises 15 judges and 8 advocates general. The Court ensures compliance with the law in the application and interpretation of the Treaties. Its seat is in Luxembourg. The judges and advocates general are appointed by common accord of the governments of the Member States and hold office for a renewable term of six years. The judges select one of their number to be President of the Court for a renewable term of three years. The President directs the work of the Court and presides at hearings and deliberations. The advocates general assist the Court in its task. They deliver, in open court and with complete impartiality and independence, opinions on the cases brought before the Court. Their duties should not be confused with those of a prosecutor or similar official - that is the role of the Commission, as guardian of the Community's interests.

2.1.3.6 European Court of Auditors

The European Court of Auditors is responsible for examining any revenue or expenditure accounts of the Community or any Community body, ensuring that the European Union spends its money according to budgetary rules and regulations respecting administrative and accounting principles. The mission of the European Court of Auditors is to audit independently the collection and spending of European Union funds and, through this, assess the way that the European institutions discharge these functions. The Court examines whether financial operations have been properly recorded, legally and regularly executed and managed so as to ensure economy, efficiency and effectiveness. In undertaking its work, the Court aims to contribute to improving the financial management of European Union funds at all levels, so as to ensure maximum value for money for the citizens of the Union.

The Court of Auditors is composed of 15 members (one from each Member State) who are appointed for six years by the Council - acting unanimously after consulting the European Parliament. The Court of Auditors provides the Council and the European Parliament with a statement of assurance regarding the reliability of the accounts and the legality and regularity of the underlying transactions annually.

2.1.3.7 Economic and Social Committee (EESC)

The EESC is a forum where the various socio-economic organisations in the Member States of the European Union are represented. The EESC is a consultative assembly which is part of the European Union's institutional system and so provides a link between Europe and civil society. The Committee has six sections:

- Agriculture, Rural Development and the Environment (NAT);
- Economic and Monetary Union and Economic and Social Cohesion (ECO);
- Employment, Social Affairs and Citizenship (SOC);
- External Relations (REX);
- Single Market, Production and Consumption (INT);
- Transport, Energy, Infrastructure and the Information Society (TEN);

The EESC is a non-political body that gives representatives of Europe's socio-occupational interest groups, and others, a formal platform to express their points of views on EU issues. Its opinions are forwarded to the larger institutions - the Council, the Commission and the European Parliament. It thus has a key role to play in the Union's decision-making process.

2.1.3.8 Committee of the Regions (COR)

The Committee of the Regions is the youngest of the European Union's institutions. It was created by the Maastricht Treaty of 1991, as a representative assembly with the job of giving local and regional authorities a voice at the heart of the European Union. The setting up of the COR was a means of addressing two main issues. Firstly, about three quarters of European Union's legislation is implemented at local or regional level, so it makes sense for local and regional representatives to have a say in the development of new European Union laws. Secondly, there were concerns that the public was being left behind as the European Union steamed ahead. Involving the elected level of government closest to the citizens was one way of closing the gap.

The Treaties oblige the Commission and Council to consult the Committee of the Regions whenever new proposals are made in areas which have repercussions at regional or local level. The Maastricht Treaty set out 5 such areas:

- economic and social cohesion;
- trans-European infrastructure networks;
- health;
- education;
- culture.

The Amsterdam Treaty added another five areas to the list

- employment;
- policy;
- social policy;
- environment;
- vocational training;
- transport;

which now covers much of the scope of the European Union's activity. Outside these areas, the Commission, Council and European Parliament have the option to consult the COR on issues if they see important regional or local implications in a proposal. The COR can also draw up an opinion on its own initiative, which enables it to put issues on the European Union agenda. There are three main principles at the heart of the Committee's work:

- **Subsidiarity:** This principle, written into the Treaties at the same time as the creation of the COR, means that decisions within the European Union should be taken at the closest practical level to the citizen. The European Union, therefore, should not take on tasks which are better suited to national, regional or local administrations.
- **Proximity:** All levels of government should aim to be 'close to the citizens', in particular by organising their work in a transparent fashion, so people know who is in charge of what and how to make their views heard.
- **Partnership:** Sound European governance means European, national, regional and local government working together. All four are indispensable and should be involved throughout the decision-making process.

2.1.3.9 Environment Directorate-General (DG)

The Environment DG is one of 36 Directorates General and specialised services which make up the European Commission. Its main role is to initiate and define new environmental legislation and to ensure that measures which have been agreed are actually put into practice in the Member States. The objectives of the Environment DG are:

- to maintain and improve the quality of life through a high level of protection of the natural resources, effective risk assessment and management and the implementation of Community legislation;
- to foster resource-efficiency in production, consumption and waste-disposal measures;
- to encourage the equitable use, as well as the sound and effective management, of common environmental resources;
- to integrate environmental concerns into other EU policy areas;
- to promote growth in the EU that takes account of the economic, social and environmental needs both of the citizens and of future generations;
- to address the global challenges facing the EU, notably combating climate change and the international conservation of biodiversity;
- to ensure that all policies and measures in the above areas are based on a multi-sectoral approach, involve all stakeholders in the process and are communicated in an effective way;
- to work towards a high level of environmental and health protection and improvement of the quality of life;
- to integrate environmental concerns into other policy areas and the provision of environmental information.

2.1.3.10 European Environment Agency (EEA)

The EEA was set up in Copenhagen in November 1994 to provide the Community and the Member States with "the objective information necessary for framing and implementing sound and effective environmental policies" and "to provide the Commission with the information that it needs to be able to carry out successfully its tasks in identifying, preparing and evaluation measures and legislation in the field of the environment (Regulation 1210/90 establishing the EEA)

The EEA maintains sustainable development and helps achieve significant and measurable improvement in Europe's environment. Although the functions of this agency are purely consultative, its work nevertheless (increasingly) plays a key role when new measures are adopted or assessments are carried out on the impact of the adopted decisions.

2.1.3.11 European Environmental Advisory Councils (EEAC)

The EEAC network is a unique collaboration between the councils set up by European governments to provide independent, scientifically based advice on the environment and sustainable development. It aims to exert influence on policy at EU level. Co-operation between advisory councils under the EEAC network started in 1993. More than 30 councils from 20 European countries now participate in the network. The individual councils are statutory bodies with the mission to advise national and regional governments in the above mentioned and related policy fields and/or to provide a dialogue on sustainable development between stakeholders. The core objectives for the network are:

- to improve the advice the individual countries give to national and regional governments;
- to profit from experience and work of councils in other countries;
- to better anticipate forthcoming issues at EU level;
- to exert, where appropriate, an influence on policy developments at EU level by acting co-operatively.

Several working groups are set up for specific issues of common interest. At present, the EEAC has five working groups dealing with:

- environmental governance;
- sustainable development strategies;
- agricultural policy, land use and biodiversity;
- coastal zones and marine environment;
- energy policy.

An important outcome of working groups were the Greening Sustainable Development Strategies (2001), which was elaborated as an input to the EU Sustainable Development Strategy.

2.1.3.12 European Environmental Bureau (EEB)

The EEB is a federation of non-governmental organisations (NGOs). It has consultative status at and relations with the

- Council of Europe;
- Commission of the European Union;
- European Parliament;
- Economic and Social Committee of the European Union;
- OECD;
- UN Commission on Sustainable Development (CSD).

The EEB has 34 member organisations, all non-governmental organisations, dealing with environmental issues and nature protection, in 25 countries.

2.2 Principles and Foundations of the Environmental Regulatory Regime in the U.S.

2.2.1 Agency Mission Statement of the EPA

The mission of the U.S. Environmental Protection Agency (EPA) is to protect human health and to safeguard the natural environment - air, water, and land - upon which life depends.

EPA's purpose is to ensure that:

- all Americans are protected from significant risks to human health and the environment where they live, learn and work;
- national efforts to reduce environmental risk are based on the best available scientific information;
- federal laws protecting human health and the environment are enforced fairly and effectively;
- environmental protection is an integral consideration in U.S. policies concerning natural resources, human health, economic growth, energy, transportation, agri-

culture, industry, and international trade, and these factors are similarly considered in establishing environmental policy;

- all parts of society - communities, individuals, business, state and local governments, tribal governments - have access to accurate information sufficient to effectively participate in managing human health and environmental risks;
- environmental protection contributes to making our communities and ecosystems diverse, sustainable and economically productive;
- the United States plays a leadership role in working with other nations to protect the global environment.

2.2.2 Principles and Foundations of the Environmental Regulatory Regime in the USA

The Federal Water Quality Administration (FWQA) began as a program in the Public Health Service of the department of Health, Education and Welfare (HEW) but was transferred to Interior in 1966. The FWQA was authorised to give technical assistance to states and localities and to distribute construction grants for municipal waste treatment programs. Like the National Air Pollution Control Administration (NAPCA), the FWQA gained enforcement and standard-setting powers in the 1960s, but the actual exercise of these powers fell far short of expectations.

In one of its first actions, the EPA went on the offensive against three cities with noteworthy water pollution problems: Cleveland (of "Burning Cuyahoga" infamy, when the Cuyahoga river was so polluted that it caught fire and burned for some time), Detroit, and Atlanta. EPA gave the mayors of these cities six months to come into compliance or face court action. Four days later, he spoke to a Governors' conference of the "imperative" need for unbiased state pollution control boards. (Lewis 2003).

2.2.3 Major Tendencies of the Environmental Policy in the U.S.

In 1970-1980s there was a remarkable period with an evident public awareness and development of federal environmental legislative and institutional framework. The Congress approved the National Environmental Policy Act (NEPA), 1969, The Clean Air Act (CAA), 1970, The Clean Water Act (CWA), 1977, The Resource Conservation and Recovery Act (RCRA), 1976, Endangered Species Act, 1973 and others. These formed a model of centralisation type of the environmental political system. The last half of the 1990s has been a period in which governments at all levels have struggled to redesign environmental policy for the next century.

The United States Environmental Protection Agency has tried to 'reinvent' environmental regulation through use of community-based environmental protection, collaborative decision-making, public private partnership, and enhancing flexibility in rulemaking and enforcement. New emphases within the EPA and other federal agencies on ecosystem management and sustainable development have sought to foster comprehensive and long-term strategies for environmental protection.

The government plays a permanent role in this policy area because most environmental threats represent public or collective problems. They cannot be resolved through purely private actions. The justification for governmental intervention lies partly in the limits of the market system and the nature of human behaviour. Adopting public policies does not imply that voluntary and co-operative actions by citizens in their communities. In a constitutional democracy like the United States, policymaking is distinctive in several respects: it must take place through constitutional process, it requires the sanction of law, and it is binding on all members of society.

The constitutional requirements for policymaking were established more than two hundred years ago, and they remain much the same today. The U.S. political system is based on a division of authority among three branches of government and between the federal government and the states. Intended to limit government power and to protect individual liberty, this division may impede the ability of government to adopt timely and coherent environmental policy. The principle of federalism means that environmental policy responsibilities are distributed among the federal government, the fifty states, and thousands of local governments.

The confirmed decentralisation idea of the 1990s calls for the extended transfer of environmental policy resources and regulatory authority from Washington D.C. to states and localities. Civil environmentalism stimulates numerous state and local stakeholders to take creative collective actions independent of federal intervention. The proliferation of environmental policy professionals, representing industry, advocacy groups, and particularly state agencies, has created a sizeable base for policy innovation. Environmental policy in many states is further stimulated by direct democracy, facilitating initiatives, referendums, and recall of elected officials not allowed at the federal level. All fifty states now have at least one formal pollution prevention program, with the most common way involving technical assistance to industries and networking services that link potential collaborators. (Lozan 2001).

In the U.S. the number of people that were employed in the environmental protection industry in 1993 range between 800.000 and 1.000.000. (Lemke, Wackerbauer 2000). In Germany 1.370.000 people were employed in the environmental protection industry in 1998 (UBA, Stabu 2002).

The environment protection economy in the U.S. is divided into three areas:

- Environmental services
- Technical equipment
- Resources; drinking water treatment included

The following table shows a survey of the U.S. environmental protection economy. The business volume in 1993 amounted in total to 110.3 billion US$. The business volume in the EU was estimated to 90 billion EURO.

Table 2.2-1: Survey of the U.S. environmental economy in 1993

Offer of product	**Business volume 1993 in billions US$**	
Environmental technologie (producer)	**30.7**	**28%**
among:		
Water/Wastewater	13.2	12%
Measure and control technology	1.8	2%
Air pollution control	3.8	3%
Waste management	11.2	10%
Integrated technologies	0.7	<1%
Services	**62.3**	**56%**
among:		
Environmental analysis	1.5	1%
Waste management	29.4	27%
Hazardous wastes	8.6	8%
Land reclamation	3.2	3%
Industrial cleaning	5.2	5%
Consulting and engineering	14.4	13%
Resources	**17.3**	**16%**
among:		
Secondary raw material	15.2	14%
Regenerative energy sources	2.1	2%
Total	**110.3**	**100%**

Source: Lemke, Wackerbauer 2000, p. 80.

Federal government intervention can increase the cost-effectiveness of water policies when state and local authorities lack the incentive to account for effects their practices may have on third parties. For example, federal support for research and development and for disseminating best management practices could improve efficiency. Current investment subsidies and tax preferences distort prices and undermine incentives for cost-effectiveness. A better approach might involve partial grants, partial loans, or credit assistance, so that reliance on some private funding would help reduce costs and restore market discipline.

2.2.4 Government Sponsorship of Innovation in the Industry

2.2.4.1 Project XL – Innovative Ideas

In 1995 under Bill Clinton, the EPA launched an unprecedented new program, known as Project XL to test innovative ideas that demonstrate environmental excellence and leadership by those covered by EPA regulations and policies. Other programs of similar intent were created later, but Project XL remains the flagship (For others see http://govinfo.library.unt.edu/npr/library/rsreport/251a.html). Basically, the EPA said to all of its partners: "If you have an idea that offers better environmental protection results than what would be achieved under current requirements, then we will work with you and other interested parties to put those ideas to the test." With this single action, the EPA sent an important message that it valued innovation in environmental protection and, above all, wanted results.

This opened the door for a promising set of regulatory experiments to begin. For five years, these experiments have enabled the United States to explore fundamentally new approaches to environmental protection. By working closely with businesses, communities, states, and other government agencies, the EPA has been using pilot projects to test bold new ideas that promise better results for the future. What led EPA to make this offer? Quite simply, a strong interest in accelerating environmental progress. Recognising the growing complexity of environmental problems looming before the country, the opportunity was seized to modify certain constraints and reduce some costs that could be associated with environmental regulations. It was also understood that others outside of the agency had a great deal of insight and expertise that should be applied to environmental problem solving.

From the beginning, Project XL has been one of the most challenging endeavours EPA has ever undertaken. With Project XL the EPA is exploring better alternatives to our own regulations and policies. It is able to initiate this program because high goals were set for superior environmental performance and public involvement in developing projects and public account ability for results were insisted upon. Difficulties that were wrestled with included questions like: "What kind of flexibility should be allowed? How does one define "better results"? What can be done within the existing laws? Who needs to be involved in the discussions?" By investigating these concerns, the EPA learned a lot, made adjustments to the program, and found ways to be more responsive to stakeholder needs. As a result, Project XL is now an active proving ground for new environmental solutions. Today, EPA has experiments to improve environmental protection underway with a variety of partners: Fortune 500 companies, small businesses, and state and local governments. Each project is designed to produce important benefits for the sponsor, and indeed they are doing so. Companies are cutting costs, communities are getting priority concerns addressed, and regulatory agencies are finding ways to target their limited resources more efficiently.

But the intent was never to serve only a select few. The goal of Project XL continues to be much broader to find solutions that can be integrated into our environmental protection system for everyone's benefit. Today, that goal is being achieved in two ways:

- First, by creating more options for environmental management. The United States has one of the strongest systems of environmental protection in the world, but it is neither perfect nor complete. Everyday, conditions are changing. New technology is entering the market, better information is becoming available, and environmental professionals are gaining more understanding and experience in managing their responsibilities. These and other developments mean the system must change too. Perhaps we need to modify a regulation that inadvertently discourages facilities from pursuing environmental improvement, or maybe we see ways to make certain regulatory procedures more efficient. By giving sponsors a chance to identify problems and potential solutions, Project XL provides a means for improving the regulatory system that protects us all.
- Second, by taking a more comprehensive approach to environmental management. In the past, most environmental problems have been approached almost entirely by media: Clean Air Act regulations address air pollution, Clean Water Act regulations focus on improving water quality, etc. This approach has some efficiencies and it has helped remedy obvious problems. But it has not proven to be a complete solution, and in fact, serious problems have been left behind. By emphasising more comprehensive, integrated approaches to environmental protection, such as looking at facilities and communities as a whole, Project XL helps bridge this gap. It helps to optimise environmental, community, and business outcomes by stepping back and considering all the issues affecting environmental quality (EPA 2000).

2.2.4.2 Small Business Innovation Research

The Environmental Protection Agency (EPA) is one of 10 federal agencies that participate in the Small Business Innovation Research (SBIR) program established by the Small Business Innovation Development Act of 1982. The purpose of this Act was to strengthen the role of small businesses in federally funded R&D and help develop a stronger national base for technical innovation. A small business is defined as a for profit organisation with no more than 500 employees. In addition, the small business must be independently owned and operated, at least 51 percent owned by U.S. citizens or lawfully admitted resident aliens, not dominant in the field of operation in which it is proposing, and have its principal place of business in the United States. Joint ventures and limited partnerships are eligible for SBIR awards, provided the entity created qualifies as a small business (Small Business Innovation Research Programme 2003).

EPA issues annual solicitations for Phase I and Phase II research proposals from science- and technology-based firms. Under Phase I, the scientific merit and technical feasibility of the proposed concept is investigated. EPA awards firm-fixed-price Phase I contracts of up to $70,000 and the period of performance for these contracts is typically 6 months. Through this phased approach to SBIR funding, EPA can determine whether the research idea, often on high-risk advanced concepts, is technically feasible, whether the firm can conduct high-quality research, and whether sufficient progress has been made to justify a larger Phase II effort.

Phase II contracts are limited to small businesses that have successfully completed their Phase I contracts. The objective of Phase II is to commercialise the Phase I technology. Competitive awards are based on the results of Phase I and the commercialisation potential of the Phase II technology. In Phase II, EPA awards contracts of up to $225,000 and the period of performance is typically 1 year. EPA also offers up to $100,000 and 1 additional year as Phase II Options for firms with third party financing for accelerating commercialisation and for technologies accepted into the EPA Environmental Technology Verification (ETV) Programme (Environmental Law Institute 1997).

2.2.4.3 Presidential Green Chemistry Challenge

The Presidential Green Chemistry Challenge promotes pollution prevention through an EPA Design for the Environment partnership with the chemistry community. Through high level recognition and support, the Challenge promotes innovative developments in and uses of green chemistry for pollution prevention.

2.2.4.4 Awards

The "Presidential Green Chemistry Challenge Awards Program" is an opportunity for individuals, groups, and organisations to compete for annual awards in recognition of innovations in cleaner, cheaper, smarter chemistry. The Presidential Green Chemistry Challenge Awards Program provides national recognition of outstanding chemical technologies that incorporate the principles of green chemistry into chemical design, manufacture, and use, and that have been or can be utilised by industry in achieving their pollution prevention goals.

The Presidential Green Chemistry Challenge Awards Program invites nominations that describe the technical benefits of a green chemistry technology as well as human health and environmental benefits. The Awards Program is open to all individuals, groups, and organisations, both non-profit and for profit, including academia, government, and industry. The nominated green chemistry technology must have reached a significant milestone within the past five years in the United States (e. g. been researched, demonstrated, implemented, applied, patented, etc.).

An independent panel of technical experts convened by the American Chemical Society judges nominations received for the awards. Typically, five awards are given annually to industry and government sponsors, an academic investigator, and a small business, making the process highly competitive.

2.2.4.5 Grants

Although the Presidential Green Chemistry Challenge Program does not provide an independent vehicle for green chemistry grants, it does support the EPA/NSF partnership for environmental research. NSF International, The Public Health and Safety Company™, is a not-for-profit, non-governmental organisation, that is a world leader in standards development, product certification, education, and risk-management for public health and safety. NSF works with governments around the world in developing standards and regulations. NSF also entered into an agreement on October 1, 2000 with the Environmental Protection Agency (EPA) to form a Drinking Water Systems (DWS) Centre dedicated to technology verifications. Another program is the "Technology for a Sustainable Environment" grant solicitation available through this partnership addresses the technological and environmental issues of design, synthesis, processing, production, and use of products in continuous and discrete manufacturing industries.

The Technology for a Sustainable Environment grant solicitation invites research proposals that advance the development and use of innovative technologies and approaches directed at avoiding or minimising the use or generation of hazardous substances. Eligible applicants include academic and non-profit institutions located in the United States, and state or local governments. Award amounts average $120,000 per award per year, and award durations are typically three years. These figures may vary annually.

2.2.4.6 Federal Government Purchasing Preferences

Before the EPA could effectively encourage private entities to develop and implement innovative environmental technologies, it recognised that the federal government must lead by example. Therefore, one of the first federal initiatives to encourage the development and use of innovative environmental technologies was Executive Order No. 12873, signed by President Clinton on October 20, 1993, relating to federal acquisition, recycling, and waste prevention. This Executive Order, which was recently replaced by the similar Executive Order No. 13101, established federal purchasing and use guidelines that encouraged environmental responsibility. Specifically, the Executive Orders require each executive agency to designate an Environmental Executive who would be responsible for, among other things, co-ordinating environmentally responsible procurement, as well as waste prevention and recycling by each agency. The Executive Orders recommend principles that executive agencies should use in making determinations for the preference and purchase of environmentally preferable products, such as purchasing paper with specified percentages of post-consumer content. These mandates enhanced those already in place under Section 6002 of the Resource Conservation and Recovery Act ("RCRA"), which required the EPA to establish guidelines for the federal procurement and use of items that are or can be produced with recovered materials (Walsh, Singer 1999).

2.2.4.7 Green Chemistry Program

Developed in 1992 as a program initially called "Alternative Synthetic Pathways for Pollution Prevention, EPA's Green Chemistry Program is designed "to promote innovative chemical technologies that reduce or eliminate the use or generation of the hazardous substances and the design, manufacture, and use of chemical products." The program evolved into its current form when President Clinton announced the Presidential Green Chemistry Challenge in 1995. Under the Green Chemistry Program, the Office of Pollution Prevention and Toxics (OPPT) awards grants for research projects that are designed to include pollution prevention in the manufacture, design, or use of chemicals. Academic institutions, non-profit institutions, and state and local governments can apply for such green chemistry grants. The grants typically range from $50,000 to $150,000 per year, with an average of two to three years duration.

2.2.4.8 Environmental Technology Verification Program

In 1995, the EPA Office of Research and Development ("ORD") recognised that many regulatory authorities, permit writers, and businesses are reluctant to accept the use of new environmental technologies until they have been proven in the field. However, such proof is typically unavailable until the technologies are used. To help eliminate this "catch-22" situation, ORD developed the Environmental Technology Verification ("ETV") Program. In this program, EPA provides models that can be used to evaluate the performance of new and innovative environmental technologies.

The ETV programme does not rank technologies or label technologies as acceptable or unacceptable. Rather, the ETV program encourages acceptance and implementation of improved environmental technology through the creation of reliable, credible third-party review. The ETV program works with stakeholders from the public and private sectors to develop and implement test protocols for various types of technologies, and companies that develop innovative technologies can contact the ETV Program and request testing of their technologies under the protocols. If the test proves that the technology works as designed, the ETV Program expects that regulatory authorities and private business will be more willing to accept the technology. This expectation is proving to be true, as several states have signed an agreement with EPA stating that they will accept technologies that have been reviewed under the ETV Programme.

Currently, the ETV program has twelve pilot projects covering a range of technologies, which include advanced monitoring systems, air pollution control technology, drinking water systems, greenhouse gas technologies, innovative coatings and coating equipment, indoor air products, wet weather flow technologies, metal finishing technology, recycling and waste treatment systems, and source water protection technologies.

2.3 Comparative Analysis

A comparison between the EU and the U.S. system requires the perspective of a country level analysis. Thus, in the following section, the EU system is characterised by the German implementation of European and national environmental regulations.

A comparison of the institutional background in the United States and in Germany shows that there are similarities in environmental legislation processes. The development of environmental law with the passing of new statutes, or reformulation of existing statutes in the 1970-1980s was caused in both countries by an increasing public awareness in several fields of environmental protection. Particularly in the German public a very high ecological awareness and a long-term environmental legislation gave impulses to the development of a dynamic environmental industry.

In the late 1980s a new trend arose. General environmental statutes and regulations applicable to all areas of environmental protection were passed. The most important examples are the Environmental Impact Assessment Law and the law on Specific Environmental Liability. Furthermore, in the late 1990s, first steps towards an ecological tax reform discussed for many years were taken in Germany. Another cross-cutting policy was the implementation of the environmental auditing process for companies. Finally, policies to increase the availability of environmental information were implemented in both systems.

The environmental impact assessment requirements as mandated in the Environmental Impact Assessment Law are similar to those in the United States. But there are also important differences. In Germany impact assessment is applied only to concrete projects which need some kind of permit or authorisation. Secondly, impact assessment in Germany is part of permit proceedings. Thirdly, it is not only addressed to federal or state agencies as is the general regime in the United States, but to every person applying for a permit to be issued for projects of specific importance to the environment (Jarass 1993). The Environmental Liability Act provides for strict, joint and several liability and does not supersede the traditional liability under general civil law, comparable to the liability under common law in the United States. The statute provides for compensatory, not for punitive damages, which are not known under German law (Jarass, DiMento 1993). Finally, the policies to increase environmental information are lagging behind in the EU and in Germany, e.g. with regard to the implementation of emission release inventories.

Nevertheless, even though there has been an increase in cross cutting policies, both countries were and still are emphasising environmental policies and standard setting instruments to counteract environmental problems. However, there are some differences in the emphasis of the different approaches available. In Germany, application of the concept of "best available technology" (BAT) has been widely used. Together with a certain flexibility about how to interpret BAT by the decentralised bodies implementing the regulation, this allows a continuous decrease for emission limits of the various technologies if technological progress occurs. In the U.S., however, the legislation focuses more on emission limits which gives less flexibility to the government body implementing the regulation.

In Germany, the federal constitution enables the federal government to legislate in most areas of environmental law. The power is most complete for laws controlling air and noise pollution and for waste disposal management. However, in some fields – mainly water pollution control and the protection of fauna and flora – the legislative power is only that of "framework power". Thus, the German states have a particularly strong influence in these areas. The main executive authority on the federal level is the Federal Ministry for the Environment, Protection of Nature and Nuclear Safety. Additionally, the federal executive encompasses some central agencies with limited powers, most important is the Federal Environmental Agency. Similar to the situation in the United States, the courts are also major actors in the area of environmental protection. In the 1970s, the courts became increasingly involved in implementation of environmental law and indirectly in environmental policy-making as well. Another relevant aspect of the institutional background is a consequence of the constitutional guaranty of local self-government (Cf. Art. 28 Constitutional Law): cities and counties are additional actors in environmental decision-making. In most areas of environmental law – with exception of land use decisions – they have little power to regulate, considerably less than the local authorities in the United States.

In Germany executive regulations and administrative rules are of great practical importance because the parliamentary statutes are rather general in most cases, providing only the general principles of environmental laws or vaguely worded standards. The precise meaning of the standards is found in regulation and administrative rules (Jarass, DiMento 1993). Aside from administrative rules, no federal level instrument exists allowing the federal government to direct the states in their duty to implement and enforce environmental law. No federal agency or ministry can enter into administrative or enforcement proceedings if a state does not enforce the federal law, nor is there a concurrent or subsidiary enforcement power. Compared to the situation in the U.S., the federal government's ability to achieve uniformity among the states is much more limited. For enforcement decisions, in general, no public participation is necessary, there are no formal procedures. The absence of procedural rules for enforcement decisions is another manifestation in German environmental law of an emphasis, more than in the U.S., of use of the permit systems rather than the enforcement process. Many federal environmental statues in the United States are more detailed than the German counterparts. That could be explained by the fact that the responsibility for permitting and enforcement rests in most cases with the lower or, in some cases, middle level, state agencies, whereas the administrative rules are either enacted by the federal or the state ministry. In contrast, in the United States the same agency which promulgates rules may also issue permits and enforce the law. In sum, in the phase of implementation and enforcement of federal law the states are more powerful in Germany than in the United States, compensating the opposite result in the field of legislation (Jarass, DiMento 1993).

In 1994 the business volume of the environmental protection market in the EU reached 90 billion EURO; in the U.S. it was amounted to 110.3 billion US$ in 1993. The number of enterprises in the U.S. environmental market in 1993 was estimated to a total of 52.000. The number of persons working in the environmental protection industry are in Germany and in the U.S. nearly similar. In the U.S. it ranges between 800.000 and 1.000.000 employees in 1993. (Lemke, Wackerbauer 2000). In Germany 1.370.000 people were employed in the environmental protection industry in 1998 (UBA, Stabu 2002).

Comparing the innovations which have been taking place requires the use of innovation indicators. The different indicators used can be grouped in input (e. g. R&D expenditure), intermediate (e. g. patents) and output (e. g. production values) oriented indicators (Grupp 1997). Analysing and comparing the indicator values for Germany, the U.S. and other major players gives an indication how the general rate of environmental innovation might have developed.

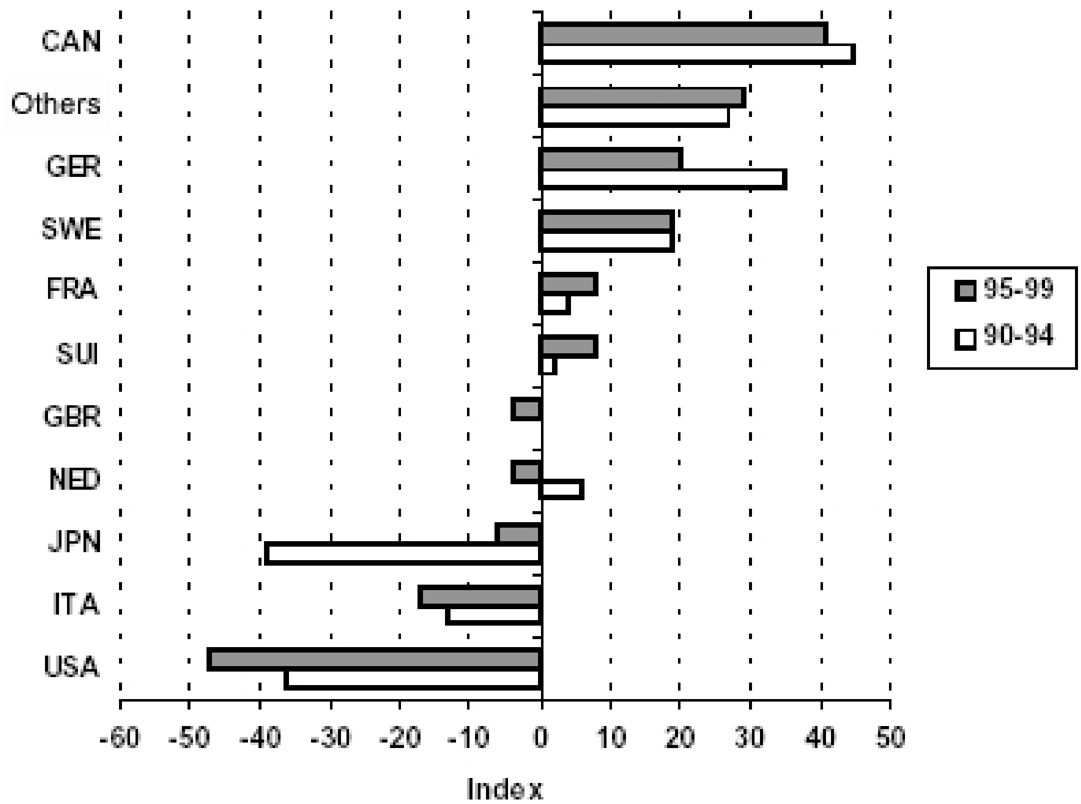
German environmental patents can be found frequently in the European patent market, which is important for future competitiveness. Figure 2.3-1 shows the patent specialisation of environmental technologies in selected countries. Values higher than 0 show an above-average level and vice versa. Two important aspects are worth noting:

- In contrast to the U.S. and Japan, which both have below average patents in environmental technology, Germany, Sweden and Canada have been specialising in environmental technologies.

- For the U.S. and Germany, the specialisation in environmental technologies has been substantially lower in the second half of the 1990s than in the first half.

The latter result is also reflected with the development of the overall number of environmental technology related patents: They increased steadily increasing during the 1980s with a peak level in 1991. However, the proportion of environmental patent applications out of all European patent applications decreased about 20 % afterwards.

Figure 2.3-1: Patent specialisation of environmental technologies in selected countries



Source: Legler et al. 2002.

The patent specialisation in partitions of environmental technologies shows that, in international comparison, noise protection and air pollution control are the most important fields for Germany. Also in the field of recycling technologies and wastewater treatment an above-average specialisation of research findings is achieved. In the case of the United States it is striking that there is an above-average focus on measurement and control technologies, whereas environmental technologies got negative specialisation indexes.

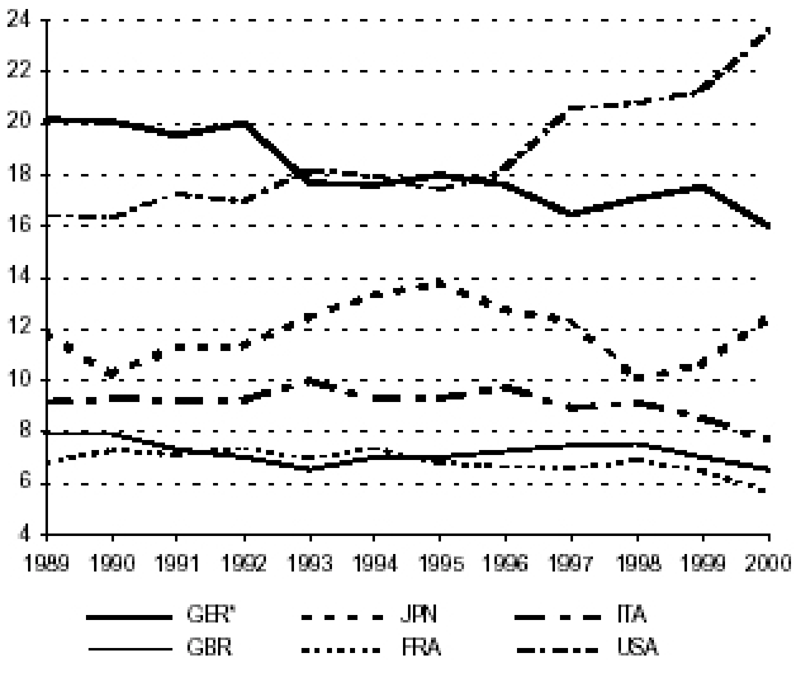
Table 2.3-1: Patent specialisation in partitions of environmental technologies

	Waste management	Recycling	Noise protection	Air pollution control	Measure and control technology	Wastewater management	Total environmental technology
Germany	2	18	47	43	-19	12	20
U.S.	-54	-39	-41	-56	19	-76	-47

Source: Legler et al. 2002.

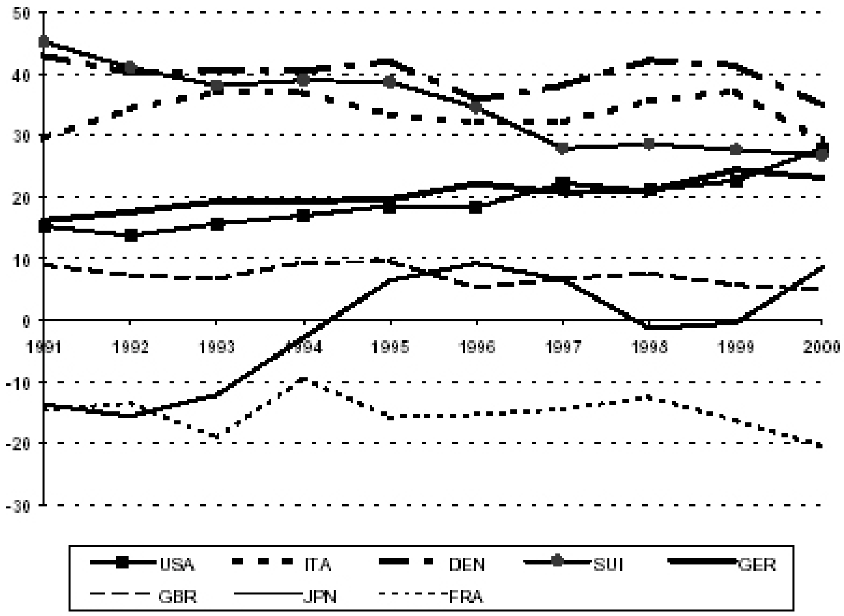
The German exports of environment protection technologies can be ranked high. In some environmental technologies, Germany is the front-runner. In 1997 the German economy exported environmental technologies amounting to 20.5 billion €, that is nearly 5 % of all exports. In 2000 Germany was the world market's second largest exporter with a proportion of 16 % after the U.S. with a proportion of 23.5 %. The EU altogether accounted for 53.2 %

Figure 2.3-2: World trade shares of environmental technology suppliers from 1989 to 2000



Source: Legler et al. 2002.

Figure 2.3-3: Relative Trade Share (RTS) of selected OECD countries in potential environment protection commodities, 1991 to 2000



Source: Legler et al. 2002.

The shares in the world market do not account for both the size of a country and the overall specialisation of a country in the global economy. The German economy, for example, is much smaller than the U.S. economy. Thus, the world market share of environmental technologies, which is in the same order of magnitude for Germany and the U.S. could be interpreted as a clear advantage for the German economy. On the other hand, the German economy in general is much more oriented towards exports than the U.S. economy. In order to account for such differences, innovation indicators such as Relative Trade Share (RTS) and Revealed Comparative Advantage (RCA) are used in addition to world market shares. The positive algebraic sign of the RTS values means that the environmental products share of the world market supply is higher than the total of manufacturing industry. The positive algebraic sign of the RCA values represents that the export/import-relation of that product group is higher than the total of manufacturing industry (Legler et al. 2002).

Germany possesses comparative advantages, i. e. positive values for RCA and RTS indexes in all classes of environmental technologies, particularly in technologies for waste management and air pollution control. Other EU countries with positive RCA-values are the UK, Italy, Denmark, Spain. The same results emerges for the U.S. Thus, these countries have been specialising on trading environmental technologies.

However, interpreting the data on innovation output, the change over the years also is important. Here, it is interesting to see that the position of Germany as world leader of environmental exports at the end of the 1980s has been somewhat diminished during the 1990s, even though the relative specialisation has remained about the same. However, the same applies for the other EU countries. In sum, the world market share of the EU at environmental technologies fell from 66.5 % in 1991 to 53.2 % in 2000.

To sum up the arguments, environmental regulation has been established in the EU and the U.S. following the increasing pressure on the environment and its perception by the public during the 1960s and 1970s. Together with making regulations stricter in the 1980s, this has worked towards an increase in environmental innovations, as indicated by various innovation indicators. However, taking both the development of the patents and the output innovation indicators since the late 1980s together, two possible lines of arguments can be deducted.

- The reduction of the patent specialisation for both Germany and the U.S. in the late 1990s can be interpreted as a reduced innovation dynamics of environmental technologies. This can be explained by - relative to other areas – a lessening of additional requirements in the 1990s. However, this also supports a positive relationship between environmental regulation and innovation.
- Another line of argument is based on the changes in environmental strategies. In the 1970s and 1980s, environmental technologies were mostly so-called end-of-pipe technologies such as filters, catalytic converters, or wastewater treatment plants. During the 1990s, the so-called integrated environmental technologies became much more important. Especially in fields gaining political importance, such as energy and climate policy, integrated technologies play a dominant role (Walz 1999). However, in contrast to the end-of-pipe technologies, it is much more difficult to separate the integrated environmental technologies from the overall technological progress (Jaffee et al. 1995). Therefore the innovation indicators mainly reflect changes in end-of-pipe technologies (Legler et al. 2002). Thus, the innovation indicators used for describing the innovation in the environmental field are probably less representative for describing the situation at the end of the 1990s than they were before. Indeed, the reduction in patent specialisation for Germany and – for most European countries – in overall world market shares at environmental technology might reflect a changing strategy of the environmental first movers. They switch to new paradigms of environmental policy, which do not typically fall under the heading of conventional environmental technology.

Thus, under this perspective, the two case studies on water policy and wind power gain additional importance. The water sector can be characterised as a sector with environmental technologies which are until now rather typical for conventional environmental technologies. Thus, the relationship between environmental regulation and innovation at wastewater treatment plants are typical for incremental innovations along an existing technological paradigm, which are covered rather well with the existing data on innovation indicators. The situation for wind power is rather different. Here a new technological paradigm is competing with conventional electricity generation. At the same time, even though these changes are motivated also from the environmental side, they are very different from the environmental technologies such as scrubbers which were a main field of environmental innovations at power stations in the 1980s (Wallace 1995) and which have been covered by the innovation indicators under the heading of air pollution.

3 Case Study Water Policy

3.1 Water Policy in the European Union

3.1.1 Overview on Water Policy

There is already a considerable body of EU legislation in force which deals with water. Legislation related to water pollution control was the first environmental policy to be developed at the European level. Since the 1970s, a piecemeal approach has been taken to the regulation of water in Europe. Water quality and pollution problems were addressed as they became apparent. The existing EU rules focus on ensuring that water is of a suitable quality for its intended use, and controlling pollution of water resources by named substances.

The initial wave of European water policy aimed at public health protection by setting quality standards for water used by humans, and at controlling the emission of particular harmful substances. The first philosophy of setting quality standards objectives for water intended for particular uses is reflected in the **Directive on Surface Water for Drinking** (75/440/EEC)[2], on **Bathing Water** (76/160/EEC)[3], on **Drinking Water** (80/778/EEC)[4] on **Waters supporting Freshwater Fish** (78/659/EEC)[5] and **Shellfish** (79/923/EEC)[6]. These directives identify parameters according to which the quality of the water should be defined and measured.

The second phase of European water legislation widened the scope to the protection of aquatic life and ecosystems. Community measures in the 1980s and 1990s were based more on the principle of emissions limits. The treatment of urban wastewater in 1991 and measures to combat pollution from nitrates are examples of this.

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2 Council Directive 75/440/EEC concerning the quality required of surface water intended for the abstraction of drinking water in the Member States, OJ EC No. L 194 of 25.7.1975.

3 Council Directive of 8 December 1975 concerning the quality of bathing water, OJ EC No. L 31, p. 1ff. Amended by the following measures: Council Directive 90/656/EEC of 4 December 1990, Council Directive 91/692/EEC of 23 December 1991.

4 Council Directive 80/778/EEC of 15 July 1980 relating to the quality of water intended for human consumption. Amended by the following measures: Council Directive 81/858/EEC of 19 October 1981, Council Directive 90/656/EEC of 4 December 1990, Council Directive 91/692/EEC of 23 December 1991, Council Directive 98/83/EC of 3 November 1998.

5 Council Directive 78/659/EEC of 18 July 1978 on the quality of fresh waters needing protection or improvement in order to support fish life. Amended by the following measures: Council Directive 90/656/EEC of 4 December 1990, Council Directive 91/692/EECof 23 December 1991.

6 Council Directive 79/923/EEC of 30 October 1979 on the quality required of shellfish waters. Amended by Council Directive 91/692/EEC of 23 December 1991.

From 1995, in the third phase of European ambitions to improve water quality, the Community began to adopt a more global approach to water management, because it became evident that European Water Policy (consisting of approximately 25 directives) does not fulfil the aim of efficiently protecting European water resources. This led to the **European Community's Water Framework Directive**[7] which aims at an integrative approach to water management. It seeks to improve sustainable use of water resources and to ensure the coherence of policy in this area. The approach requires that the emission limits and quality standards complement one another. In individual cases the more severe concept will be applied.

The European Community is a party to various international conventions aimed at protection of the marine environment, e. g. the Barcelona Convention for the Protection of the Mediterranean Sea[8] and the Paris Convention for the Protection of the Marine Environment of the North East Atlantic (OSPAR Convention)[9]. Other conventions seek to protect water courses, e. g. the Helsinki Convention on Transboundary Water Courses and International Lakes[10], the Convention on Cooperation for the Protection and Sustainable Use of the River Danube[11] and the Convention on the Protection of the Rhine[12].

3.1.1.1 Wastewater Disposal in Europe Prior to the Urban Waste Water Treatment Directive (91/271/EEC)[13]

Prior to the Urban Waste Water Treatment Directive there was a common understanding in Europe that wastewater treatment needed to be improved throughout Europe to obviate the damaging effects on the environment, but there were crass differences in treatment standards among the European Union Member States, with very low level standards in Southern Europe and advanced standards in Northern European countries. While in former West Germany, 84 % of the total treatment capacity for urban wastewater was tertiary, in Portugal most of the wastewater

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7 Directive 2000/60/EEC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, OJ EC No. L 327, p. 1ff.

8 Council Decisions 77/585/EEC of 25 July 1977; 81/420/EEC of 19 May 1981; 83/101/EEC of 28 February 1983; 84/132/EEC of 1 March 1984.

9 Council Decision 98/249/EC of 7 October 1997.

10 Council Decisions 95/308/EC of 24 July 1995 94/157/EC of 21 February 1994.

11 Communication from the Commission [COM (2001) 615 final – not published in the Official Journal].

12 Council Decision 2000/706/EC of 7 November 2000.

13 Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment, OJ EC No. L 135 of 30.05.1991. Amended by Commission Directive 98/15/EC of 27 February 1998, OJ EC No. L 67 of 07.03.1998.

(about 89 %) was discharged untreated. The situation in Belgium resembled the situation in Portugal – about 70 % of the wastewater reached the receiving waters untreated. In the UK, where almost all wastewater was subject to treatment (84 %), wastewater discharged in the sea received no proper treatment at all and some of the generated sewage sludge was dumped at sea (Hansen, Kraemer 2000). In a study undertaken for the European Commission it became evident that only 45 % of the total organic load generated in the territory of Europe entered wastewater treatment plants in 1984 (COM(89) 518 final).

3.1.1.2 Development of the Urban Waste Water Treatment Directive

There had only been rare attempts to control nutrient loads reaching surface water in a very few European Union Member States before the Urban Waste Water Treatment Directive was established. Therefore, the nutrient level of surface waters was fairly high throughout Europe and a large amount of nutrients was discharged into the seas every year. As a result of this condition for about forty years, European inland and coastal waters were found to be enriched by nutrients, and environmental effects became apparent in the late 1980s, causing the bloom of toxic algae and seal dying in the North Sea.

At the European Environment Ministers Seminar on water policy held in Frankfurt/Main in June 1988 the growing concern about rising nutrient levels in European waters was one of the main issues addressed. The ministers agreed to aim for a 50 % reduction of nutrients discharged to the aquatic environment by reducing the nutrient loads from diffuse and point sources. The development of the Urban Waste Water Treatment Directive was thus initiated and a first proposal was presented in November 1989. The proposal was amended in November 1990. Table 3.1-1 gives an overview of the (development) stages of the Directive.

Table 3.1-1: Development of the Urban Waste Water Treatment Directive 91/271/EC

June 1988	European Environment Ministers Seminar in Frankfurt/Main
November 1989	First proposal for the Directive by European Commission
April 1990	Opinion of the Economic and Social Committee
September 1990	Opinion of the European Parliament
October 1990	Amended proposal by European Commission
21 May 1991	Notification
30 May 1991	Published
19 June 1991	Entry into force
30 June 1993	Final date for implementation in the Member States
27 March 1998	Amendment by Directive 98/15/EC
30 September 1998	Final date for implementation of the Directive 98/15/EC in the Member States

The Urban Waste Water Treatment Directive aims at the protection of freshwater, estuarial and coastal waters from detrimental effects resulting from municipal wastewater and wastewater from the food and beverage industries. The main problem it seeks to control is that of eutrophication of surface waters due to the discharge of nutrients (phosphorous and nitrogen) coming from household and agriculture (Kemp, Smith 2000).

The Directive is an emission standard Directive laying down emission standards, or percentage reductions in pollutant concentrations, or discharges from urban wastewater treatment works serving a population equivalent of 2,000 or more. The Directive sets a timetable for meeting certain standards of discharge from wastewater treatment works, depending upon the population served by them, and the type of broad classes of treatment technology. These classes are:

- primary treatment (physical treatment of contaminants),
- secondary treatment (biological decontamination),
- tertiary treatment (nutrient removal),

but leaves freedom with regard to the choice of technical systems for meeting the requirements. According to the three categories of receiving waters (sensitive, normal, less-sensitive areas), different minimum standards for treatment requirements are set. The Directive introduces mechanical-biological treatment as a minimum standard, and tertiary treatment in sensitive areas. In less sensitive areas, basic mechanical treatment ought to be sufficient. Emissions of indirect emitters are also to be controlled and the dumping of sewage sludge was to be stopped by the end of 1998. The fit between the Urban Waste Water Treatment and prior Member State Practices was not uniform or preordained in all countries but was open to negotiation during implementation. The wider political, social and economic circumstances in each Member State varied and had their own history, was it the dynamics of policy networks or the lobbying activities of actors, for example (Kemp, Smith 2000).

3.1.2 Relationship between Environmental Regulation and Innovation: Case Study of the Implementation of the Urban Waste Water Treatment Directive in Germany

3.1.2.1 Framework Conditions and Implementation of the Urban Waste Water Treatment Directive in Germany

In the case of Germany it is difficult to separate the effect of the Urban Waste Water Treatment Directive from the effect of the German wastewater policies. Incentives for the industrial and urban wastewater treatment were given by the Act on the Regulation of Matters Relating to Water of 1957 (Federal Water Act, last amended in 2002) and by the Wastewater Charges Act of 1976 (last amended in 2001) before the Urban Waste Water Treatment Directive entered into force in 1991. The quality of surface waters in Germany had been improved by rising connection rates to wastewater treatment plants as well as the technological development of its biological treatment required by legislation introduced in the 1970s and becoming more stringent thereafter, particularly in the 1970s and 1980s as a result of enhanced wastewater treatment standards.

The Federal Water Act as a framework law of the Federal Government gives room for a large number of ordinances, regulations and administrative instructions on all administrative levels that specify the technical requirements. It claims that waters are to be safeguarded as a component of the natural balance and as a habitat for fauna and flora. One important aspect of the Federal Water Act is the precautionary principle whereby unnecessary burdens on water are to be avoided and the necessary burdens are to be kept to a minimum. Water, including groundwater and coastal waters, are fully subject to state control. All uses of water (e. g. discharges of substances or removal of water) are, in principle, subject to official authorisation. This is intended to prevent pollution of waters and enforce a precautionary approach to water protection. Special provisions are laid down in the Federal Water Act for pipeline systems transporting hazardous substances. They make it possible to impose safety requirements, grades according to the quantity and hazardousness of the substances used, for the construction and operation of such systems and installations. Important regulations in the Federal Water Act also include the provisions on the construction and operation of wastewater treatment plants and on water protection officers in public and private enterprises, the development of waters and the designation of flood plains. As a further important instrument of water resources management the Federal Water Act, in the interest of water supplies, provides for the designation of water protection areas in which certain activities may be restricted or prohibited. The Federal Water Act, moreover, provides a number of coordinated planning instruments, i. e. wastewater disposal plans, water pollution control regulations, and management plans as well as water resources framework plans (FME 2001a).

In 1976 the 4th amendment of the Federal Water Act § 7a was introduced, with the order to fix minimum requirements for discharges of water, according to the "generally accepted rules of technology". Since the 6th amendment[14] in 1996, § 7a prescribes the "state of the art" for all installations that treat sewage and discharge it into surface waters, including municipal wastewater treatment plants. The permissible pollutant load depends on how emissions into the water can be minimised in the

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14 The 6th amendment of the Federal Water Act Section 7a para. 3 provides that the minimum requirements shall no longer to be laid down in administrative guidelines, but in the Wastewater Ordinance enacted by the Federal Government. This takes account of the requirements of EC law, under which administrative guidelines are not sufficient for the implementation of EC Directives, and legislation with external effect is necessary.

industry in question given compliance with technically and economically practicable processes. Before the 6th amendment, "state of the art treatment technology" was prescribed for facilities treating sewage containing dangerous substances only and all other facilities needed to apply solely "generally accepted rules of technology". While previously urban wastewater treatment was only performed by centralised treatment plants, the 1996 amendment explicitly introduced the option of decentralised wastewater treatment (Hansen, Kahlenborn, Kraemer 2000).

The relevant statutory ordinance, the Wastewater Ordinance[15], represents the formal act of transposition of the Urban Waste Water Treatment Directive on the federal level and was enacted by the federal government in March 1997. Since the entry into force of the Wastewater Ordinance, 45 industry-specific annexes have been added. Wastewater types not yet regulated by ordinance remain subject to the requirements laid down in the existing individual administrative guidelines on wastewater and in the annexes to the Framework Administrative Guideline on Wastewater. All in all, the Wastewater Ordinance and administrative guidelines lay down minimum requirements for the discharge of wastewater from 57 specific origins[16].

The Wastewater Charges Act provides that a charge shall be payable when (treated) wastewater is discharged directly into a body of water. The charge is the first eco-tax levied at the federal level as a steering instrument. It ensures that the polluter pays principle is applied in practice, since it requires direct dischargers to bear at least some of the cost that their use of the environmental medium water involves. The charge is determined on the basis of the quantity and harmfulness of specific constituents discharged into the water. The charge per pollution unit was raised in several stages form the initial €6.14 in 1981 to €35.79 in 1997. The charges were intended to create an economic incentive to reduce wastewater discharges as far as possible. Wastewater charges are payable to the federal states. They are earmarked for measures preventing water pollution. To give incentives for the development and financing of new technologies, investments for wastewater treatment plants could be set against the payments for the wastewater charges.

3.1.2.2 Development of Technologies for Urban Wastewater Treatment

While technologies for abstraction of raw water, for potable water production, treatment and distribution have a long history, the development of technologies for

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15 Ordinance concerning requirements for the discharge of wastewater into waters, most recently amended by ordinance of 09.07.2001, Federal Law Gazette 2001 I, p. 1572ff.

16 Municipal, commercial and industrial wastewater, e.g. annex 1 lays down the minimum requirements for discharges into recipient water courses from municipal sewage treatment plant, annex 40 sets requirements for the treatment of water from the metal plating industry, annex 42 for wastewater that is generated mainly in the alkali chloride electrolysis and annex 48 for the handling of specific dangerous substances.

wastewater treatment began with industrialisation. In general, there are four phases of the development of wastewater treatment technologies:

- since 1850 mechanical wastewater treatment for the reduction of sedimentation of rejects;
- since 1900 biological wastewater treatment for the reduction of organic load;
- since 1950 advanced effluent treatment for the reduction of pollutants that might bio-accumulate;
- since 1985 processes for nutrient elimination (nitrification, denitrification, phosphate elimination) and measures at their points of origin.

The beginning of wastewater treatment activities can be seen in the building of a combined wastewater collection system from 1850 to 1900, in order to combat urban pollution and public health problems. Since the end of the 19th century the development of a separate wastewater collection system appointed, but it was not accomplished until the 1950s. So far, sanitation was the focus of research in wastewater disposal. Diffuse sources of pollution, e. g. agriculture and rainwater, were left unconsidered. Decentralised wastewater disposal works were neither developed nor built because decentralised technologies were thought to be inferior in general. The increased wastewater treatment capacity reduced the pollution of rivers receiving wastewater from cities. That gave rise to a shift-perspective from the sanitation aspect to environmental protection aspects.

After the simple removal of rejects, the first constructions for wastewater treatment were biological processes in land treatment, e.g. sewage fields, which were the standard method for wastewater purification till 1900. The development of contact beds was adopted for lack of space. In the first decades of the 20th century artificial practices of wastewater treatment emerged, e.g. screening plants and strainers. In 1902 the decantation process was based on scientific principles, further scraper constructions in sedimentation basins were developed, e.g. round broaches. Also at the beginning of 20th century, vertical flow through septic tanks were developed. Since fermentation resulted in negative effects for sedimentation and biological processes, Imhoff invented the Emscher tank (activated sludge process) in 1907. By the end of the 19th century, chemical methods of wastewater treatment occurred, first as encouragement in sewage fields, later as autonomous unit operation providing input for the next process stage. Chemical wastewater treatment plants were built at the beginning of the 20th century, for instance in London, Glasgow and Frankfurt/Main, most of them working with precipitation using ferrous salt, aluminium sulphate or lime as precipitating agent.

Biological processes were developed and implemented, as micro-organisms were known to achieve purification in wastewater. At first, trickling filters were developed, whose purification capacity is led back to micro-organisms. In 1914 Fowler developed the activated sludge process in England and in 1926 Imhoff built the first activated sludge process plant in Germany. Difficulties with the pneumatic injection and with blockages resulted in the processing of mechanical aerators such as the Harworth paddle, Bolton spinner or the Kessner scrubber. Investigations about the kinetics of biological processes yielded to the variety of the activated sludge process.

As of the 1950s the design of processes for an advanced effluent treatment were promoted. Removal of nutrients started in the 1970s. A Phosphate Study for Germany (Fachgruppe Wasserchemie 1978) showed that in 1975 80 % of the phosphorous in water bodies stemmed from households and industry. Therefore wastewater treatment plants were extended with aeration ponds, which operated with simultaneous precipitation. During the peak period of treatment plant construction in the early 1970s, simultaneous precipitation was introduced in activated sludge treatment plants. In the 1980s it became the most widely used process. Most of the remaining nitrogen impacts in water bodies stemmed from agriculture and from natural mineralisation. This gave rise to the development of the ordinance on Principles of Good Professional Practice in the Use of Fertilisers[17] to fight the over-fertilisation.

In the context of the Urban Waste Water Treatment Directive, the development of methods for phosphorus and nitrogen removal in the period of 1980s to 1990s is of interest. Nitrification and denitrification processes were developed and implemented into wastewater treatment plants. Technological development focused on process improvements and reduction of energy requirements. Multi-stage biological processes accommodated a higher process stability and durability against impact loads. The optimisation of oxygen enrichment featured additional amelioration in capability and energy input. Since the end of the 1970s to the beginning of the 1980s, the development of nitrogen-elimination with activated sludge process combined with sludge stabilisation commenced. With this method a nitrogen reduction of 70 % could be achieved. Within a large-scale single-stage activated sludge process installation with a preceding denitrification, a nitrogen reduction of 70 % could be attained. In Germany, an activated sludge process installation with a better targeted denitrification was put on stream for the first time in 1986 (Lange, Otterpohl 2000).

Since the beginning of the 1980s, it was known that phosphorus elimination could be obtained to a large extent via chemical processes. Further development of physico-chemical processes in the 1980s caused the removal of suspended particles by micro-sieves, percolation and flocculation with metallic salts, lime and organic flocculators. The development of distillation, electrodialysis, ion exchange and re-

[17] Federal Law Gazette 1996 I, p. 118, most recently amended by ordinance of 16.07.1997, Federal Law Gazette 1997 I, p. 1835.

verse osmosis render possible the removal of organic substances. In contrast, the effectiveness and the scientific foundations of biological phosphorus removal were patchy. But in the late 1980s to the early 1990s there were investigations of the foundations and the capacity of biological phosphorous elimination. In Germany, it was demonstrated with a large-scale installation that compliance with the critical phosphorous value of 1 mg/l was possible, using only biological processes. For the removal of phosphorous and nitrogen ion exchange processes and break-point-chlorination were also applied in addition to biological denitrification.

At the beginning of the 1980s the treatment of rain runoffs were optimised by adoption of rainwater reservoirs, by application of measurement and control technologies and further by enhancing of new methods of analysis for verifying organic halogen compounds.

Table 3.1-2: Patent specialisation in the areas of wastewater management of European Countries and the U.S. (Legler et al. 2002)

	Wastewater management
GER	12
FRA	3
GBR	2
SUI	-28
SWE	23
ITA	-42
NED	22
U.S.	-76

3.1.2.3 Diffusion of Technologies for Urban Wastewater Treatment in Germany

In order to fulfil stringent regulatory requirements given by the Federal Water Act and the Wastewater Charges Act, city councils, municipalities and industry have built wastewater treatment plants. From a technical perspective, the implementation of the Urban Waste Water Treatment Directive did not appear to be a problem in the old federal states, where prior to the adoption of the Directive the majority of agglomerations were already served by secondary (biological) treatment. Additional requirements introduced by the implementation of the Directive were the necessary appliance of phosphorous removal also in treatment plant sizes between 10,000 and 20,000 population equivalents (p. e.) and the deadlines when these requirements need to be applied.

Municipalities in West Germany invested €60 billion in sewers and wastewater treatment plants in the period 1970 to 1991. As a result, 90.6 % of the residential population was connected to the public sewer system in 1991, the majority of them being served by secondary treatment with partial nutrient removal (StBA 1999). While the new federal states were engaged in renewing and rebuilding a basic sewerage infrastructure, the old federal states were focusing on upgrading their treatment plants with nutrient removal devices in order to ban eutrophication and protect drinking water resources from rising nitrate concentrations. Also preventative measures contributed to the reduction of phosphorus influxes from point sources before the Urban Waste Water Treatment Directive was enacted.

The application of phosphorus precipitation in wastewater treatment plants started in the 1980s, and was specially pushed after 1991 due to national and European regulation. Also biological phosphate removal gained importance – in 1991 about 55 % of the wastewater collected in Germany was treated with biological phosphate elimination measures. Phosphorous in washing powder was reduced by national regulation[18] during the first half of the 1980s and phosphorus influxes from industry were also significantly reduced then. The total amount of phosphorus emitted into the river catchment areas in Germany was approx. 37 mg/yr from 1993 to 1997. Phosphorous emissions were reduced by 60 % in comparison to the period of time from 1983 to 1987, by 70 % compared to 1975 (FME 2001b). Before the 1990s, nitrogen had very rarely been eliminated in wastewater treatment processes in Germany, but in 1989 national regulation introduced the requirement of nitrogen and phosphorus elimination for all large German wastewater treatment plants (Hansen, Kahlenborn, Kraemer 2000). In this situation, the Urban Waste Water Treatment Directive was issued in 1991.

The circumstances described above show that German national regulations concerning sewerage services already had put major pressure on the water sector, especially in the new federal states. The Urban Waste Water Treatment Directive contributed to this situation the strict deadlines for the implementation which accelerated the investment needs. Since 1991, the connection rates to sewers and treatment plants as well as the level of treatment has increased in Germany. In 1995 there were 10,273 wastewater treatment plants in operation. The treatment plants have been upgraded especially with nutrient elimination measures from the early 1990s on. While the proportion of nutrient removal capacities were extended from 57 % in

[18] Act concerning the environmental compatibility of detergents and cleaners, published in the announcement of 05.03.1987, Federal Law Gazette 2001 I, p. 305, most recently amended by act of 03.05.2000, Federal Law Gazette 2000 I, p. 632.

1991 to 84 % in 1995 of the total treatment capacities in Germany, the share of treatment capacities that only provide mechanical treatment decreased from 7 % to 4 %. Until 1995 some 3,000 wastewater treatment plants were equipped with phosphorous elimination measures while phosphorous precipitation is the most common technique. About 500 treatment plants have been additionally upgraded with biological phosphorous elimination measures from 1991 to 1995. Around 50 % of tertiary treatment plants applied the technology of biological nitrogen removal with aerobic sludge stabilisation in 1991. But there was activity in building and extending nitrification and denitrification, the more advanced technology reaching much higher elimination rates of nitrogen. Within the period from 1991 to 1995 more than 1,100 treatment plants were equipped with these more advanced measures (Hansen, Kahlenborn, Kraemer 2000).

3.1.2.4 Interaction Between Innovation and Environmental Regulation

One of the challenges facing European policy makers is how to encourage innovation in research and in the development of new processes and technologies. This need for innovation extends to all areas of research, from monitoring techniques and the development of new types of monitoring equipment, to the development of new processes and end-of-pipe solutions to the environmental problems identified. Innovation requires substantial investment, but can result in savings in terms of increased efficiency and reduced energy and raw materials consumption, for example. The main policy objective of regulatory regimes is to protect people and the environment by promulgating and enforcing laws and regulations prescribing standards and technologies polluters have to comply with. But before a law or a regulation becomes effective, an intense discussion about the requirements, such as limit, might already exert an announcement effect on the actors who will be concerned with the regulation. The so-called Porter hypothesis (Porter and van der Linde 1995) asserts that firms can benefit from environmental regulations. It argues that well designed environmental regulations stimulate innovation which, by enhancing productivity, increases firms' private benefits. Market observations showed that when prompted by instruments such as taxes, firms often innovate, e. g. they might discover more efficient production methods. However, the design and implementation of these regulations can have a significant impact on innovation. But not only regulation effects innovation. Regulation can act as an incentive to undertake innovation when it works alongside other key factors within the innovation system. Such innovation factors are among others the (Leone, Hemmelskamp, 2000):

- framework of environmental regulations (requirements, targets),
- influence of further regulatory instruments (e. g. regulations relating to taxes, business operations, distribution systems),
- structure and styles of policy implementation (relationship between regulations and industry),

- characteristics of companies affected by environmental regulation (company size, level of competition),
- technological conditions (available expertise),
- political feasibility of an innovation.

The pollution of water at the beginning of the 20th century caused the development of wastewater treatment technologies. The further development of these technologies took place without the pressure of a regulation, but based on the necessity to find solutions to technical problems. Thus innovations were initiated through an endogenous factor. In the late 1960s and early 1970s environmental problems like eutrophication of waterbodies and fish-dying got apparent and were more and more noted. In order to counteract these problems the authorities in most industrialised countries required a higher quality standards of the water discharged in water bodies by adopting environmental policies and regulatory approaches. With the necessity to fulfil these demands, now an exogenous factor for the development and implementation of new technologies was given by the authorities.

There are a number of ways in which authorities can use policy and legislation in the water field to promote and encourage innovation. Normally fixing environmental standards and regulations requires reference to technological feasibility. Standards will usually be enforceable to the extent that technical possibilities exist or are likely to be developed (Kemp, Smith, Becher 2000). This is why environmental regulations often refer to concepts such as "best available technology" (BAT) or "best practical means" (BPM).

Barde (2000) identified five types of approach to fixing standards:

1. Standards can be based on an existing technology already applied in a number of plants and easily transferable to others. This corresponds to the "currently available" technology, and could be called the "average standard approach".
2. Standards and regulation often refer to the best available technology (BAT). This is an existing technology but applied by advanced and high performing industries. Adopting BAT implies a real effort. This is called the "model standard approach".
3. Governments may decide to implement a technology which is still at the experimental level and has not yet reached the industrial development stage. The challenge for polluters is to achieve this technological development. This can be called the "experimental standard approach".
4. There may be cases where there is a need for stringent and urgent action but no available technology. Public authorities may choose nevertheless to impose standards leaving a predetermined time frame for industry to develop appropriate compliance technology. It is of utmost importance that when fixing such

standards, public authorities implement accompanying measures such as research and development programmes, and pilot and demonstration projects jointly organised and financed by the public and private sectors, otherwise failure is most likely.

5. Finally, the 'economically reasonable standards of technology' approach can be advocated, which takes into consideration the cost of complying with regulations and standards.

These regulatory approaches differ in the incentives they offer for innovation. If quality standards, such as those in the 1980 Drinking Water Directive, are constantly kept under review so they take account of advances in scientific knowledge, those responsible for water treatment and supply can be encouraged to keep up with new technologies and to develop and modify the techniques and equipment used on a continual basis. One of the four main elements of the European Water Resources Framework Directive is that the framework should provide a mechanism to review (Stern 1995). European legislation on a regular basis Technology-forcing standards may promote innovation in that they require the BAT to be implemented in order to reduce pollution, but they provide little incentive to search for more cost-effective ways to do so. However, economic-incentive regulations, such as tradable permits and pollution charges, will lead to the most cost-effective way to counteract environmental problems. Discussion about the possible uses of economic and fiscal instruments as a tool of environmental policy is of particular relevance in this context, as imposing taxes on the use of certain substances. for example, could encourage the development of alternative technologies which rely less heavily on those substances (Stern 1995). While BAT may not provide a strong stimulus to technical change, the fourth approach mentioned above is likely to trigger innovation, such as in the case of urban wastewater treatment. Information can also play an important role in encouraging innovation. As legislation increasingly requires more detailed and comprehensive information to be provided about water quality and the impact of various industrial and other activities on water resources, for instance, more sophisticated and accurate monitoring equipment is required. This in turn enables those setting quality standards, as well as industry and others who are required to comply with those standards, to understand better how the can be met, and to develop the necessary techniques (Stern 1995). For instance, the Drinking Water Ordinance[19] lays down limit values for substances harmful to health (e. g. heavy metals, nitrates, organic compounds) and pathogens, and defines the scope and frequency of testing. Before the ordinance became effective there was no available technology to measure the dangerous substances contained in drinking water. But spurred on the obligation to observe the limit values, technologies to verify and measure these substances were developed within a short time.

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[19] Ordinance on the quality of water for human use (Drinking Water Ordinance) of 21.05.2001, Federal Law Gazette 2001 I, p. 959.

Since the early 1980s to the early 1990s the emphasis of public funded R&D programmes in Germany focused on nutrient removal (Angerer et al. 1996). In the period of 1985 to 1986 15 projects in the area of nutrient removal were promoted. From 1987 to 1990 the number of investigations decreased again. But in 1991 the highest number of investigations and new projects were reached, i. e. that in spite of regulations enacted in 1988[20], 1989[21] and 1991[22] requirements for R&D in the area of nutrient removal was seen. As above mentioned, in 1986 in a pilot project it were demonstrated that a nitrogen reduction of 70 % could be attained. This value was included into annex I of the Framework Administrative Guideline on Wastewater. Furthermore, the foundations of biological removal of phosphorus were included in ATV directives (ATV 1991, ATV 1992) with the consequence that for every enlargement of a wastewater treatment plant the adaptability of biological phosphorous removal has to be assessed. Another example in the range of water protection is the standard concerning allowable levels of certain pesticides in drinking water of the European Commission. In order to effectively enforce these standards it was necessary to make Certified Reference Material (CRM)[23] available to national regulatory agencies, because it is very difficult for them to measure exactly how much pesticide is contained in a particular water sample. For that reason, the European Commission funded efforts, e. g. the Measurements and Testing Programme to develop Certified Reference Materials.

If first of all technologies are developed to remove dangerous substances or nutrients to counteract environmental problems (like in the case of phosphorus and nitrogen initiated by the demands of the European Urban Waste Water Treatment Directive), in some cases a shift in perspective from dangerous substances to resources might occur. The technologies now enable not only environmental protection by keeping back pollutants but the recycling of resources. Regulations for the removal of substances that might pollute waterbodies, e. g. nutrients, are no longer necessary to set up innovations. These substances are now being seen as resources and there is a financial interest for the treatment plant operator to develop advanced technologies for more effective methods to remove and recover these partly scarce resources and to achieve profits out of them.

The intense innovative activity in all areas of the economy leas to a constant improvement of conventional technologies as wall as to a rapidly growing number of new technologies. Innovations in an industry are mostly developed by a closed re-

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[20] Accentuation of critical values for Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD)

[21] Implementation and accentuation of critical phosphorous limits

[22] Implementation of nitrification and denitrification

[23] CRMs are water samples containing specified amounts of a given pesticide that have been freeze-dried.

search community. But in the last decades these closed research communities opened, in order to transfer the outputs and solutions of different research communities to own problems. Examples here are the car industry that took over findings in the area of new materials to construct cars with a lower weight. In the case of water industries they took over innovations in measurement and control technology, sensor technology, information and communication technology. Another example worth mentioning is the membrane technology, which was developed initially for uses in pharmaceutics and chemistry. One possible use of this technology is in reverse osmosis (nano- or microfiltration). Thus, a great number of new options have come about for fulfilling functions of water management in a way that is more cost-efficient, environmentally friendly, and sustainable.

If one compares the applications of industrial wastewater treatment with those of urban wastewater treatment, it will turn out that in the case of industrial wastewater treatment more advanced technologies are implemented and used than in the urban wastewater treatment plants, because it is already forbidden to mix industrial wastewater. That means that in contrast to the urban wastewater treatment incentives for a separate gathering and treatment of wastewater were already given and the recovery of resources is a standard method. Furthermore, the transfer of findings from industrial wastewater treatment to urban wastewater treatment could support the development and implementation of decentralised technologies in the urban wastewater industry without regulation.

3.1.2.5 Future Prospect – the European Community's Water Framework Directive

The European Community's Water Framework Directive came into force on 22 December 2000. The central objective of the Directive is to establish a list of priority substances in the field of water policy, for which quality standards ("good status") and measurements for the reduction of emission controls will be set at Community level. The requirements for good ecological water quality are defined in detail for the different types of waters. In addition, EU-wide minimum requirements are to be developed for some 30 priority substances on the basis of chemical quality objectives, e. g. DEHP (Di(2-ethylhexyl)phthalate), lead (Pb) and nickel (Ni). DEHP is a softener incorporated in lots of products containing PVC such as floors, tubes and soles. Products in which lead is incorporated are for example stabilisers and pigments in plastics, thrust washers in cars or waterproofing of roofs. Nickel is for instance an alloying constituent and therefore included in sanitary appliances e. g. in water taps.

Further key points in the Directive are the combined approach to emission-related and emission-related measures to reduce pollution, and the basic obligation to apply the principle of recovery of costs. The Water Framework Directive must be formally implemented in German Law within three years after its enactment, i. e. by the end of 2003. The programme of measures and river basin management plans for the river catchment areas must be drawn up by the end of 2009. Under the timetable set in the Directive, the objective of "good status" is to be achieved by the end of 2015.

To focus on priority substances is new in the context of water pollution control. Due to this perception on products, new immission paths not previously considered in questions of water protection will be included in future investigations. This will give rise to the development of new analytical methods, alternative substances, new products and technologies to meet the requirements set in the Water Framework Directive.

3.2 U.S. Water Policy

3.2.1 Water Treatment Regulation

3.2.1.1 Origins of the Clean Water Act

The principal law governing pollution of the nation's surface waters is the Federal Water Pollution Control Act, also known as the Clean Water Act (CWA). Originally enacted in 1948, it was totally revised by amendments in 1972 that gave the Act its current shape. The 1972 legislation spelled out ambitious programmes for water quality improvement that have since been expanded and are still being implemented by industries and municipalities. Congress made certain fine-tuning amendments in 1977, revised portions of the law in 1981, and enacted further amendments in 1987. Table 3.2-1 lists the original law and major amendments to it (Copeland 1999).

The Federal Water Pollution Control Act of 1948 was the first comprehensive statement of federal interest in clean water programs, and it specifically provided state and local governments with technical assistance funds to address water pollution problems, including research. Water pollution was viewed as primarily a state and local problem, hence, there were no federally required goals, objectives, limits, or even guidelines. When it came to enforcement, federal involvement was strictly limited to matters involving interstate waters and only with the consent of the state in which the pollution originated.

During the latter half of the 1950s and well into the 1960s, four laws that amended the 1948 statute shaped water pollution control programs. They dealt largely with federal assistance to municipal dischargers and with federal enforcement programs for all dischargers. During this period, the federal role and federal jurisdiction were gradually extended to include navigable intrastate, as well as interstate, waters.

Water quality standards became a feature of the law in 1965, requiring states to set standards for interstate waters that would be used to determine actual pollution levels. By the late 1960s, there was a widespread perception that existing enforcement procedures were too time-consuming and that the water quality standards approach was flawed because of difficulties in linking a particular discharger to violations of stream quality standards. Additionally, there was mounting frustration over the slow pace of pollution cleanup efforts and a suspicion that control technologies were being developed but not applied to the problems. These perceptions and frustrations, along with increased public interest in environmental protection, set the stage for the 1972 amendments.

Table 3.2-1: Clean Water Act and Major Amendments (codified generally as 33 U.S.C. 1251-1387)

Year	Act	Public Law
1948	Federal Water Pollution Control Act	P.L. 80-845 (Act of June 30, 1948)
1956	Water Pollution Control Act of 1956	P.L. 84-660 (Act of July 9, 1956)
1961	Federal Water Pollution Control Act Amendments	P.L. 87-88
1965	Water Quality Act of 1965	P.L. 89-234
1966	Clean Water Restoration Act	P.L. 89-753
1970	Water Quality Improvement Act of 1970	P.L. 91-224, Part I
1972	Federal Water Pollution Control Act Amendments	P.L. 92-500
1977	Clean Water Act of 1977	P.L.95-217
1981	Municipal Wastewater Treatment Construction Grants Amendments	P.L. 97-117
1987	Water Quality Act of 1987	P.L. 100-4

Source: Copeland 1999.

3.2.1.2 Safe Drinking Water Act

In 1976 Congress passed the "Safe Drinking Water Act", which requires the EPA to regulate contaminants which may be health risks and which may be present in public drinking water supplies. Passed in 1974, and revised in 1986 and 1996, SDWA extends public health protection to America's drinking water consumers. Under SDWA, EPA sets legal limits on the levels of certain contaminants in drinking water. The legal limits reflect both the level that protects human health and the level that water systems can achieve using the best available technology. Besides prescribing these legal limits, EPA rules set water-testing schedules and methods that water systems must follow.

The rules also list acceptable techniques for treating contaminated water. SDWA gives individual states the opportunity to set and enforce their own drinking water standards if the standards are at least as stringent as EPA's national standards. Most states and territories directly oversee the water systems within their borders. Between 1974 and 1986, EPA regulated approximately 20 contaminants. Congress's 1986 SDWA revisions named 83 contaminants and required EPA to regulate all of them by 1989.

3.2.1.3 Health Risks Stimulate Regulation

Just as their uses range widely, the health risks that led Congress to require the regulation of these contaminants range widely. Six are probable cancer-causing agents. Others can cause liver and kidney damage, or problems of the nervous system and brain. EPA set different monitoring schedules for different contaminants, depending on the routes by which each contaminant enters the water supply. In general, surface water systems must take samples more frequently than ground water systems because their water is subject to more external influences.

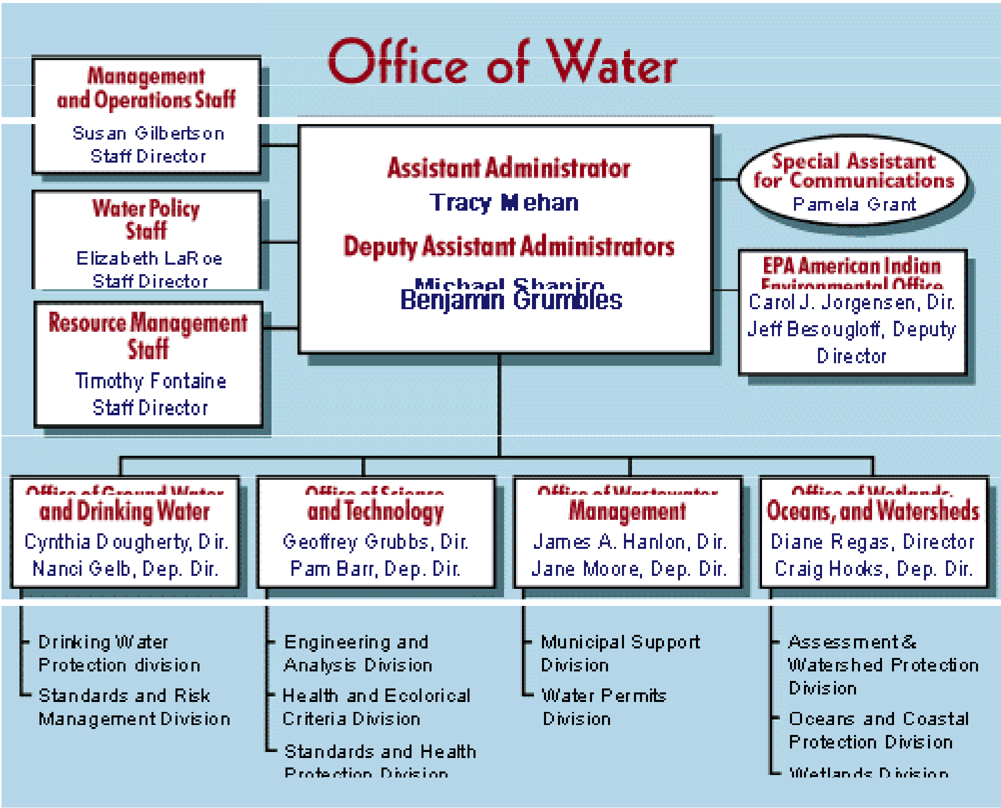
Systems, which prove over several years that they are not susceptible to contamination, can usually get state permission to reduce the frequency of monitoring. Asbestos, for example, is unlikely to appear suddenly in a system's water. If a system has asbestos-concrete water mains and water of certain corrosiveness, or if asbestos is present naturally in an area, the system might detect asbestos in its water. Otherwise, a system which has never detected asbestos, must test for asbestos only once every nine years. If the system were ever to detect asbestos, it would have to begin more frequent monitoring. Nitrate and pesticide levels, on the other hand, vary depending on rainfall and farmers' schedules. Systems in areas prone to nitrate problems test quarterly to track the seasonal variations. If a system does not detect contaminants in initial samples, then repeat sampling frequencies will be lower than initial frequencies.

3.2.1.4 National Drinking Water Advisory Council

The EPA is committed to working with its stakeholders - the people for whom safe drinking water is an important aspect of daily and/or professional life. One of the formal means by which EPA works with its stakeholders is the National Drinking Water Advisory Council (NDWAC). The Council, comprising members of the general public, state and local agencies, and private groups concerned with safe drinking water, advises the EPA Administrator on everything that the Agency does relating to drinking water.

The NDWAC has working groups that make recommendations to the full Council, which in turn advise EPA on individual regulations, guidance, and policy matters. These NDWAC working groups consist of approximately 20 members with a variety of viewpoints. All NDWAC working group meetings and full NDWAC meetings are open to the public.

Figure 3.2-1: Organisational chart of the Office of Water



Source: www.epa.gov/water/programs/orgchart.html.

3.2.1.5 Small Systems Technology, Variances and Exemptions

- **Affordable technologies:** When promulgating new national primary drinking water regulations, EPA is to identify technologies that are affordable and which achieve compliance for categories of systems serving fewer than 10,000. Technologies may include packaged or modular systems and point-of-use (POU)/ point-of-entry (POE) units under the control of the water system (no POU for microbial contaminants).

- **Surface Water Treatment Rule (SWTR):** EPA must list small system technologies that meet the SWTR. The EPA (in consultation with the states) must also list technologies that achieve compliance with all existing regulations.
- **Variance technology:** Whenever an affordable technology cannot be identified that meets a Maximum Contaminant Level (MCL), EPA is required to identify "variance technologies" that are affordable, but do not necessarily meet the MCL. Such technologies shall "achieve the maximum reduction or inactivation efficiency that is affordable considering the size of the system and the quality of the source water." EPA is to issue guidance on variance technologies for existing regulations within 2 years.
- **Small system variances:** States are authorised to grant variances from standards for systems serving up to 3,300 people if the system cannot afford to comply (through treatment, an alternative source, or restructuring) and the system installs the variance technology. The terms of the variance must ensure adequate protection of human health. States can grant variances to systems serving 3,300-10,000 people with EPA approval.
- **Regulations for variances:** Within 2 years EPA, in consultation with the states, must promulgate regulations for variances. Regulations must specify procedures to be used to grant or deny variances, requirements for the installation and proper operation of variance technologies, eligibility criteria for a variance, and information requirements for variance applications.
- **Block on certain variances:** Variances are not available for microbial contaminants or for contaminants regulated prior to 1986.
- **Variance time frames:** A variance must require compliance with its conditions within 3 years of the date it is issued. States may allow an additional 2 years when needed. States must review variances every 5 years following the compliance date established in the variance.
- **Affordability criteria:** Within 18 months of enactment, the EPA, in consultation with the States and the Rural Utilities Service of the Department of Agriculture, must publish information to assist States in developing affordability criteria to use in making variance determinations..
- **Change to existing variance process:** The process for variances (retained from the old law) is streamlined by allowing a system to receive a variance "on the condition" that they install the Best Available Technology[24], rather than after the installation of the technology, as previously required under SDWA[25].
- **Review of variances:** EPA must review/approve variances for systems serving 3,300-10,000 people. EPA may review and object to any proposed variance.

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24 BAT is also sometimes used by the EPA as an abbreviation for „Best Available Treatment".

25 This change applies to ALL system sizes, not just small systems.

Consumers of water systems for which a State proposes a variance may petition EPA to object to a variance. States must respond to EPA objections before granting a variance.

- **Technology information:** EPA may request information from manufacturers, states, and other interested persons on the effectiveness of commercially available treatment systems and technologies for the purpose of developing guidance or regulations related to small system technologies and variances.

3.2.2 Federal and State Responsibilities

It is difficult for the federal government to directly enforce the Clean Water Act, as the Environmental Protection Agency does not have the field personnel to act locally. Therefore the EPA co-ordinates efforts with state and local authorities in both development of new regulations and enforcement efforts. The EPA also provides both financial and technical support for all parties involved, whether state, local or industry.

3.2.2.1 Jurisdiction of the Clean Water Act

Federal jurisdiction is broad concerning the Clean Water Act, particularly regarding establishment of national standards or effluent limitations. The Environmental Protection Agency (EPA) issues regulations containing the Best Practicable Technology (BPT) and BAT effluent standards applicable to categories of industrial sources (such as iron and steel manufacturing, organic chemical manufacturing, petroleum refining, and others). Certain responsibilities are delegated to the states, and this Act, like other environmental laws, embodies a philosophy of federal-state partnership in which the federal government sets the agenda and standards for pollution abatement, while states carry out day-to-day activities of implementation and enforcement. Delegated responsibilities under the Act include authority for qualified states to issue discharge permits to industries and municipalities and to enforce permits[26].

In addition, states are responsible for establishing water quality standards, which consist of a designated use (recreation, water supply, industrial, or other), plus a numerical or narrative statement identifying maximum concentrations of various pollutants, which would not interfere with the designated use. These standards serve as the backup to federally set technology-based requirements by indicating where additional pollutant controls are needed to achieve the overall goals of the Act.

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26 As of December 1998, 43 states had been delegated the permit programme; EPA issues discharge permits in the remaining states.

3.2.2.2 Jurisdiction of Enforcement

While the CWA addresses federal enforcement, the majority of actions taken to enforce the law are undertaken by states, both because states issue the majority of permits to dischargers and because the federal government lacks the resources for day-to-day monitoring and enforcement. Like most other federal environmental laws, CWA enforcement is shared by the EPA and the states, with states having the primary responsibility. However, EPA has oversight of state enforcement and retains the right to bring a direct action where it believes that a state has failed to take timely and appropriate action or where a state or local agency requests EPA involvement. Finally, the federal government acts to enforce against criminal violations of the federal law.

In addition, individuals may bring a citizen suit in U.S. district court against persons who violate a prescribed effluent standard or limitation. Individuals also may bring citizen suits against the Administrator of EPA or equivalent state official (where programme responsibility has been delegated to the state) for failure to carry out a non-discretionary duty under the Act.

3.2.3 Enforcement and its Effect on Innovation

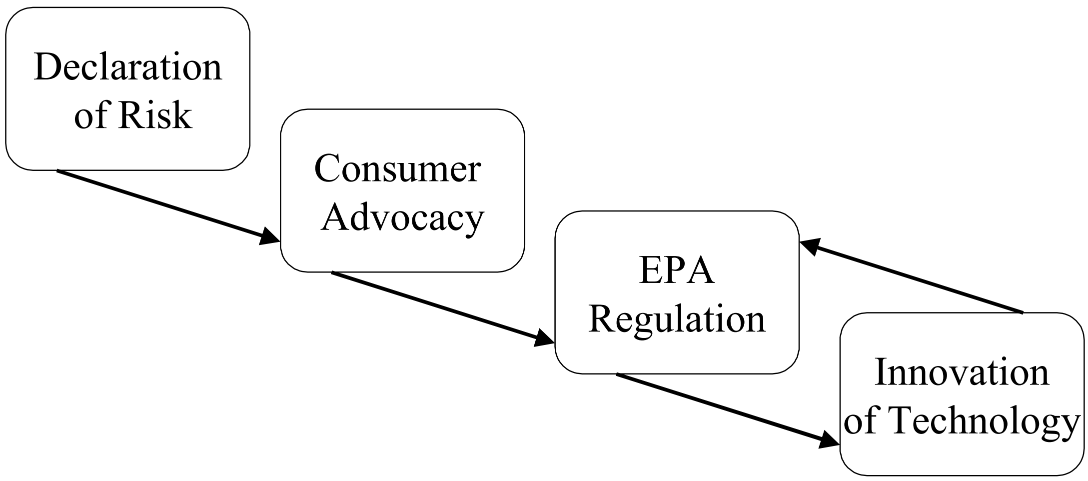
The Safe Water Drinking Act has been termed a technology-forcing statute because of the rigorous demands placed on those who are regulated by it to achieve higher and higher levels of pollution abatement. Industries were given until July 1, 1977, to install "Best Practicable Technology" (BPT) to clean up waste discharges. Municipal wastewater treatment plants were required to meet an equivalent goal, termed "secondary treatment," by that date. Municipalities unable to achieve secondary treatment by that date were allowed to apply for case-by-case extensions up to July 1, 1988. According to EPA, 86 % of all cities met the 1988 deadline; the remainder was put under judicial or administrative schedules requiring compliance as soon as possible. However, many cities, especially smaller ones, continue to make investments in building or upgrading facilities needed to achieve secondary treatment.

The Act required greater pollutant cleanup than BPT by no later than March 31, 1989, generally demanding that industry use the "best available technology" (BAT) that is economically achievable. EPA provides guidance on technologies that will achieve BPT, BAT, and other effluent limitations. Compliance extensions of as long as 2 years are available for industrial sources utilising innovative or alternative technology. Failure to meet statutory deadlines could lead to enforcement action.

In addition, the federal government and the EPA encourage innovation in the water treatment industry by providing financial support and incentives. State and local authorities that use innovative technology receive more funding than those not using innovative methods. Grants are generally available for as much as 55 % of total project costs. For projects using innovative or alternative technology (such as reuse or recycling of water), as much as 75 % federal funding was allowed.

The innovation process for environmental technology consists of a series of feedback loops. There are a number of existing government programmes that focus on directly fomenting innovation through grants, but the great majority of innovation comes from the need of municipalities and industries to comply with updated EPA policies. In regard to water treatment, every year the EPA issues new limits and substances that are considered contaminants. This constantly creates the need for innovation in the industry. For the most part, whenever a new ruling is issued, all parties must use the "Best Available Technology" (BAT) on the market. As technology advances, it also enables the EPA to issue more standards. Often the impetus for change comes from consumer advocacy. When a substance or situation is found to be harmful in some way, advocacy groups lobby for further regulation, which must then be taken up by the EPA and results in the need for more advanced technology. A simple flow chart is located below.

Figure 3.2-2: Process of technological innovation



3.2.3.1 Innovative Technology: Bubble Aggregate Managed Mixing (BAMM)

At 1/10th the size of traditional gravity separation technology, Bubble Aggregate Managed Mixing (BAMM) fits easily into facilities with limited real estate. Few moving parts, efficient use of chemistry and low power requirements keep the BAMM's operating and maintenance costs to a minimum. Through more effective and redundant flotation, the BAMM system removes BOD/COD, TSS, FOG and Bio-Growth from a variety of process streams up to undetectable levels. During the mixing process, fine micro bubbles come into immediate contact with stream contaminants to produce more durable flocks with high solids content. The BAMM has manual and PLC automation to allow for system customisation and real-time stream management. Flotation redundancy at the water's surface allows the clean water to "drain" from the floating particles to the bottom of the tank and eliminate carry over.

Multiple polymer/chemistry capabilities allow the user to 'tune' the system to the specific needs of his stream and produce ideal "charge satisfaction" for flotation. A fourth polymer may be added to collect opposite charges into one flocculent. The Water Air Mixer (WAM) injects pressurised air or gas directly into the stream creating bubbles, which come into immediate contact with the particles to form aggregates of great strength and durability, ideal for flotation. In addition, the WAM's high-energy mixing environment ensures thorough polymer mixing without polymer. The "Servo Sensor" allows the system to respond to changing stream conditions in real-time via PLC automation or manual control. The "Bloom Chamber" allows the bubbles, particles and chemistry to further mix. This reduces flotation retention by increasing bubble-particle contact before the aggregates enter the flotation tank. Unlike any other gravity separation equipment on the market today, the BAMM delivers the bubble-particle solution to the top of the flotation tank which reduces the distance the aggregate has to float, and allows the clean water to 'drain' to the bottom of the tank for discharge. The flotation tank's unprecedented design creates flotation redundancy by re-circulating the aggregate solution at the top of the water's surface. The aggregates created through this process are stronger and more durable, which produce "dryer" solids than traditional gravity separation equipment.

3.2.3.2 Innovative Technology: TiO_2 Photo Catalytic Water Treatment

Titanium dioxide (TiO_2) photo catalytic water treatment technology is used to destroy dissolved organic contaminants from aqueous waste streams. The method focuses on the development of an ambient solid-state process in which contaminated water flows through a fine TiO_2 catalyst bed activated by ultraviolet-A light. The TiO_2 semiconductor catalyst, when excited by light, generates hydroxyl radicals. These radicals react with the waste material to form compounds such as water, carbon monoxide, and oxygen, although more complex by-products can also be formed. It is expected that efficient destruction of dissolved organics occurs between 30 seconds and 2 minutes, depending upon the molecular weight of the organic compound and the presence of other organic molecules.

Organic chemicals are the most ubiquitous form of contamination in the United States. The Department of Energy alone owns over 200 problem sites contaminated with organics. Organic contaminants in the subsurface can exist in soluble form or as an insoluble separate phase, floating on the water table or sinking to the base of the aquifer. Technologies currently exist to treat groundwater contaminated with organics. The state of the art is to pump-and-treat the groundwater, using either adsorption on activated carbon or air stripping to treat the organics. TiO_2 photo catalytic water treatment may provide an effective alternative to currently available technology without generating secondary waste.

The TiO_2 photo catalytic waste technology was accepted into SITE Emerging Technologies Program in 1991. The project was co-funded by DOE as part of an interagency agreement between EPA and DOE to co-fund research and development activities of mutual interest. The following innovations were accomplished:

- Several extended field trials have been conducted on raw effluent contaminated with a variety of organics, mainly BTEX, trichloroethene, and methyl tertiary butyl ether.
- Average treatment time was 60 seconds at a direct operating cost of $1 to $2 per 1,000 gallons.
- The technology has treated effluent with contaminants as high as 1,000 parts per million (ppm), and has achieved effluent qualities as low as 5 parts per trillion.

3.2.3.3 Innovative Technology: Ion-exchange Resin

The R-Reactor of the Savannah River Nuclear Power Plant was shut down in 1964, and is currently maintained in a Surveillance and Maintenance (S&M) mode. The disassembly basin still contains the majority of the water left at shutdown, currently about 5,000,000 gallons. The ASTD deployment was designed to remove the majority of the Cs-137 and Sr-90, using highly nuclide specific ion-exchange resins. The use of highly specific resins would generate the least amount of secondary waste, by removing only the constituents of concern. The treatment was conducted in-situ, with the treated effluent discharged back into the basin. The goal was to treat one to two basin volumes of water, and to remove 67 % to 73 % of each of the radionuclides. At that point, the water could be treated one final time, which would meet the DOE release limits (and perhaps the EPA drinking water limits) and be released directly to a surface stream. Even if the water were not released, treatment of the basin water would reduce the impact to the surrounding groundwater, if the basin were to leak in the near future.

The deployments utilised two technologies for Cs-137 removal. One was a system from the 3M Co., St. Paul, MN (the Selective Separation Cartridge- SSC™) and a commercial water softening resin from Graver Technologies, Glasgow, DE. The 3M SSC™ system for Cs-137 removal treated over 6.8 million gallons of the basin water, or approximately 1.3 basin "turnovers" at 98 to 99 % removal efficiency. The Selion CsTreat® system treated an additional 1.2 million gallons for Cs-137, at 97 to 99 % removal efficiency. The Sr-90 deployment system treated over 5.6 million gallons at greater than 99.9 % removal efficiency. Over 75 % of both radionuclides were removed from the R-Disassembly basin water by the completion of the deployments.

In FY ‘99, the DOE Office of Science and Technology (OST, EM-50) approved a Deployment Plan for the water cleanup at the 105-R Disassembly Basin and provided funding amounting to $550,000 through FY 2001. FDD provided matching funding through EM-60 of $950,000 for these three years. The Deployment Plan, SR-09-DD-61, called for the use of a highly selective NUclide REmoval System (NURES) commercialised by Selion, OY, Finland. Graver Technologies Inc., of Glasgow DE, licensed the NURES technology from Selion, and provided the NURES selective resins and equipment to the SRS.

In FY 2000, FDD also partnered with 3M, St. Paul, MN to deploy a similar highly selective material for Cs-137 at the R-Disassembly Basin. This technology is called the Selective Separation Cartridge (SSC™) technology. The 3M system was developed under a DOE Technical Task Plan FT-06-C-261, overseen by DOE's National Energy Technology Laboratory, Morgantown, WV, who provided the funding for the construction of the 3M system. FDD funded the 3M system deployment costs at the disassembly basin. Neither the Selion, nor the 3M ion-exchange technologies had been previously deployed at a Department of Energy site. The 3M Cs removal system had been tested at the R-Disassembly Basin in 1998 at 5 gpm for a short period of time (2 weeks).

3.2.3.3.1 Selion CsTreat® for Cs-137

The Selion CsTreat® technology is based on a deep bed ion-exchange technique, using very finely divided hexacyannoferrate, with a very high surface area. The bed is operated in a down–flow mode, with preferred flow rates in the range of 10 to 20 bed volumes per hour (BV/hr). At that flow rate, the CsTreat®’s anticipated removal efficiency is greater than 99.9% (a DF; Decontamination Factor of >1,000). The system for the R-Disassembly basin was initially designed to treat 50 gallons/min (3000 gallons/hr, or 400 cu. ft/hr). At 20 bed volumes per hour, his would have required 20 cubic feet of resin. This proved to be too expensive for the available ASTD deployment funding, since the CsTreat® costs ~$16,000 per cu. ft. In order to meet the deployment goals, the target flow rate was reduced to 15 to 20 gpm (~160 cu. ft/hr), and the flow rate was increased to 50 BV/hour. This allowed the use of only ~3 cu. ft of CsTreat®, at a cost of ~$48,000.

3.2.3.3.2 3M Selective Separation Cartridge® (SSC™) for Cs-137

Since the original deployment goal of 50 gpm could not be accomplished with the downsized Selion system, FDD partnered with the 3M Co., St. Paul, MN to deploy 3M’s highly selective Cs-removal system. The 3M system could be also operated at

15-20 gpm. The 3M cartridge membrane is trademarked Selective Separation Cartridge® (SSC™). The high surface area sorbent particles are loaded or enmeshed onto a web or membrane, which is then fabricated into a spiral-wound, cartridge-filter. The R-basin deployment used 22 cylindrical cartridges, 2.3" in diameter by 21" in length, at a total cost of $60,000. The 3M-cartridge technology can provide higher flow rates than a standard packed bed system, and channeling is not a concern for the cartridge technology.

The colbalti-hexacyanoferrate forms an insoluble precipitate with cesium, therefore it was not intended to be regenerated; rather both the 3M and Selion materials will be disposed as low level radioactive waste (LLRW).

3.2.3.3.3 Selion Sr-90 Removal System

The Selion ion-exchange system for Sr-90 is based on a sodium titanium oxide, again with a very small particle size and high surface area. Prior to the system deployment, Selion determined in tests (with simulated R-basin water), that two of the major cations present in the basin water, Ca (at 13 mg/L), and Mg (at 0.5 mg/L) would interfere strongly with strontium-90 removal. Therefore, it was decided to "pre-treat" the basin water with a conventional water softening resin, "GRAVEX® GX–080." This resin is a sulfonated styrene and divinylbenzene strong acid exchange resin, produced by Graver Technologies, DE. The plan was to use the Gravex® water softening resin to remove the majority of the Ca and Mg in the water, prior to a final treatment with the SrTreat®. However, there was insufficient time to utilise the SrTreat® at the end of the Ca/Mg pre-treatment, so the SrTreat® was not deployed. Twelve 100-gallon tanks containing the water softening GRAVEX® GX–080 resin were not regenerated; they were disposed as LLRW.

3.2.3.3.4 3M Strontium Removal (SSC®) Cartridge System

The 3M-strontium selective removal system was based on a sulfonated divinylbenzene compound, similar to Graver’s water softening resin. As with the SrTreat®, calcium and magnesium also compete strongly with Sr-90 removal for the 3M material. Two sets (22 cartridges per set) of the 3M Sr-90 removal cartridges were tested in the R-Basin in June 2000, at 20 gallons per minute. Initial Sr-90 removal during the first 5,000 gallons treated was greater than 99% (DF >100). After this point, Ca and Mg started to saturate the available exchange sites, and 50% breakthrough for Sr-90 occurred at ~12,000 gallons on both sets of filters. The concentration of Ca was ~13 mg/L, while the concentration of natural strontium was 0.15 mg/L in the basin water, a factor of about 100. The 3M cartridges did not demonstrate a high enough selectivity for strontium vs. Ca/Mg for the R-Basin deployment, so no further testing was conducted with the 3M SSC® Sr-90 cartridge removal system.

3.2.3.3.5 Results

Both the 3M and Graver/Selion systems were highly effective at removing Cs-137. The Selion CsTreat® is more sensitive to particulate plugging than the 3M SSC cartridge technology. The 3M SSC® filter cartridges can be used at higher flow rates than the Selion CsTreat®, which is limited by the bed volumes/hr it can treat. The Selion system would work very well at high Cs-137 concentrations and low flows, while the 3M-system will work more effectively at low Cs-137 concentrations and high flow rates.

The "Gravex 080®" resin was shown to be moderately selective for Sr-90 in the presence of Ca and Mg. This allowed the resin tanks to continue to be utilised even after they were saturated with respect to Ca and Mg.

The in-situ approach demonstrated a new and innovative water treatment technology for these radionuclides. The selective and highly efficient ion exchange media removed Cs-137 from the R-Reactor Disassembly Basin water with drastically reduced radiological waste volumes. The innovative in-site technologies saved the DOE an estimated $4 to $5 million at the R-Disassembly Basin compared to conventional baseline technology (transport to and treatment at a centralised wastewater treatment facility).

3.2.3.4 Innovative Technology: Mobile Monitoring Lab

Modern wastewater treatment plants are an impressive ensemble of concrete, pipes, pumps, tanks, gauges and laboratories. At the receiving end of all the sewage, chemicals and toxic waste a city can produce, these plants have to deal with whatever comes down the pike - and that's plenty. Most municipal plants in Georgia are doing a good job, according to state officials who oversee them. But water quality is an increasingly tense issue. The state already monitors for a long list of organic substances. In the past decade, the Environmental Protection Agency has established a list of more than 150 toxics for regulation in public water supplies, and they add 25 or so new contaminants every three years.

When there's a problem, plant managers must make the necessary changes or face stiff fines from the state Environmental Protection Division. Often finding the cause is half the battle. That's where a new mobile water quality lab, developed by British company Capital Controls and researchers at the University of Georgia, can help. Called the Environmental Process Control Laboratory, the lab's detailed, real-time data can diagnose problems in the wastewater system. Probes, sensors and respirometers record levels of dissolved oxygen, suspended solids, ammonium, nitrites, nitrates, phosphates and other organic compounds that are indicators of plant performance.

"The lab is a quantum leap in terms of what you can see and learn, a bit like what I imagine the Hubble telescope is to astronomy," said Bruce Beck, a Georgia Research Alliance eminent scholar and professor in UGA's Warnell School of Forest Resources. "Beyond that, it is also a research platform we can re-engineer to collect data from pulp and paper mills, streams, rivers, and even aqua-culture ponds, in addition to water treatment plants. Rather than measuring bacteria directly, the lab's sensors instead record the level of biochemical activity in the wastewater effluent. Managers can use this information in much the same way doctors use a blood profile to understand what's happening in the body as a result of a bacterial infection.

"Computer models are used so much in this field," said Beck. "But the equations have got to have real applications at some point, and up until now, nobody has been able to collect the data to check out how good the equations really are. "The lab has been field tested for the past year at an Athens/Clarke County wastewater treatment facility, where managers say it has helped them to understand how storm events and seasonal changes in water volume effect the plant's operation and efficiency.

"The data helped us determine that instead of running two aeration basins, we could use just one, and that saves on electricity costs," said David Bloyer, operations coordinator at the water pollution control plant off Will Hunter Road. "We had considered trying this, but we weren't confident about it before. The lab also told us how to go about planning for future permits - like those for phosphorus levels, for example, which are probably on the horizon." Beck, who came to UGA in 1993 as part of the state's push to study and improve water quality, is pleased with the field trials and anxious to make the lab available to other Georgia cities. "Ultimately, I believe the lab could help foster public understanding of the very complex problems of running one of these plants," he said. "These plant managers are really under the gun in many instances. The public is very concerned about water quality, yet few people know much about what's involved in providing clean, safe water to millions of Georgians" (New Lab Pinpoints Water Quality Problems 2001).

3.2.4 Federal Funding of the Clean Water Act

3.2.4.1 Direct Funding of the Clean Water Act

Federal law has authorised grants for planning, design, and construction of municipal wastewater treatment facilities since 1956 (Act of July 9, 1956, or P.L. 84-660). Congress greatly expanded this grant in its programme in 1972. Since that time Congress has authorised $65 billion and appropriated $69 billion in funds to aid wastewater treatment plant construction. Grants are allocated among the states according to a complex statutory formula that combines two factors: state population and an estimate of municipal wastewater treatment funding needs, derived from a biennial survey conducted by EPA and the states. The most recent estimate, completed in 1996, indicates that $140 billion is needed to build and upgrade needed municipal wastewater treatment plants in the United States and for other types of water quality improvement projects that are eligible for funding under the Act.

Under the title II construction grants program established in 1972, federal grants were made for several types of projects (such as secondary or more stringent treatment and associated sewers) based on a priority list established by the states. Grants were generally available for as much as 55% of total project costs. For projects using innovative or alternative technology (such as reuse or recycling of water), as much as 75% federal funding was allowed. Recipients are responsible for non-federal costs but were not required to repay federal grants.

3.2.4.2 Training Funded by the EPA

The EPA offers technical advice and training for industrial participants and government authorities. One training program specifically from the Clean Water Act is called the Drinking Water Academy (DWA). Established by the U.S. EPA Office of Ground Water and Drinking Water, the DWA is a long-term training initiative whose primary goal is to expand EPA, state, and tribal capabilities to implement the 1996 Amendments to the Safe Drinking Water Act (SDWA). In addition to providing classroom and Web-based training, the DWA will act as a resource for training materials pertaining to SDWA implementation. The EPA formed the DWA to help the EPA, states, and Indian tribes enhance program capability to meet the public health protection objectives of the SDWA requirements. The 1996 SDWA Amendments created a number of new programmatic challenges for the states, tribes, and the water systems they regulate. The Amendments also provided new funding opportunities to meet these growing needs. DWA training will support EPA, state, and tribal efforts to implement these new regulations.

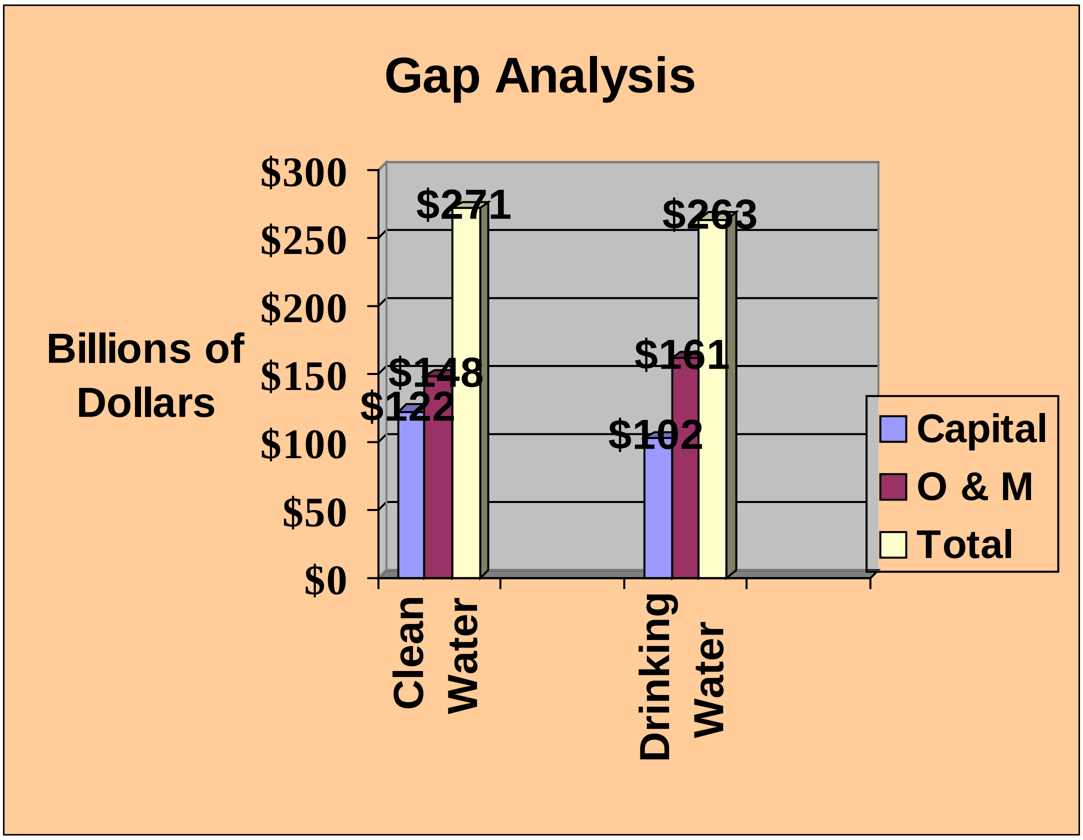
3.2.4.3 Clean Water and Drinking Water Infrastructure Gap Analysis

With the aging of the nation’s infrastructure, the clean water and drinking water industries face a significant challenge to sustain and advance their achievements in protecting public health and the environment. To gain a better understanding of the future challenges facing these industries, the U.S. Environmental Protection Agency (EPA) has conducted "The Clean Water and Drinking Water Infrastructure Gap Analysis", in order to identify whether a funding gap will develop between projected investment needs and projected spending. The study provides an important empirical basis for discussions addressing the critical needs of our water infrastructure. EPA conducts surveys of the nation’s clean water and drinking water infrastructure needs every four years. These surveys formed the starting point for calculating the capital and O&M investment needs.

The Gap Analysis covers a 20–year period from 2000 to 2019 and includes estimates of the funding gap for both capital and operations and maintenance (O&M). The report discusses the methods for calculating the capital and O&M gaps, but does not address the policy implications of the results. For clean water, the estimates of investment needs and spending used to calculate the gaps cover all of the approximately 16,000 publicly owned treatment works (POTWs). The drinking water analysis covers the approximately 54,000 community water systems and the 21,400 not-for-profit non-community water systems in the 50 states, U.S. territories, and tribal areas.

This analysis estimates a total capital payments gap of $122 billion, or about $6 billion per year, for clean water and $102 billion, or about $5 billion per year, for drinking water. The O&M gap is estimated at $148 billion, or $7 billion per year, for clean water and $161 billion, or $8 billion per year, for drinking water. Under the "revenue growth" scenario, the capital gap is $21 billion, or about $1 billion per year for clean water and $45 billion, or about $2 billion per year, for drinking water. The O&M gap is estimated at $10 billion, or $0.5 billion per year, for clean water, while no O&M funding gap would occur for drinking water. This information is represented in the figure below (Industrial Economics, Inc. 2000).

Figure 3.2-3: EPA Gap Analysis



3.2.5 Criticism of the Clean Water Act

Most criticism of the EPA in general and the Clean Water Act specifically comes from industry, and is voiced through the state and local authorities. Much of the focus is on the stringency of the EPA regulations. Due to regional and local variations in geology and environment, regulations have different effects in different areas. Some states and local municipalities have a more difficult time meeting the requirements and do so at a higher cost. In some areas, polluting entities exist at natural concentrations close to or higher than the EPA regulations maximum limits. In these areas, treated water is discharged cleaner than the area's natural waters (Gutermann, Quigley 2001).

3.2.5.1 Funding Criticism

Policymakers have debated the tension between assisting municipal funding needs, which remain large, and the impact of grant programs such as the Clean Water Act on federal spending and budget deficits. Due to the level of technology required and fines placed in enforcement, many municipalities suffer economic hardship in meeting the EPA regulations. However, the federal support conflicts with congressional desire to cut spending deemed unnecessary by some lawmakers who believe funding should come at state and local levels. In the 1987 amendments to the Act, Congress attempted to deal with that apparent conflict by extending federal aid for wastewater treatment construction through fiscal year 1994, yet providing a transition towards full state and local government responsibility for financing after that date. Grants under the traditional title II program were authorised through fiscal year 1990. Under title VI of the Act, grants to capitalise State Water Pollution Control Revolving Funds, or loan programs, were authorised beginning in fiscal year 1989 to replace the title II grants.

States contribute matching funds, and under the revolving loan fund concept, monies used for wastewater treatment construction will be repaid to a state, to be available for future construction in other communities. All states now have functioning loan programs, but the shift from federal grants to loans, since fiscal year 1991, has been easier for some than others. The new financing requirements have been a problem for cities (especially small towns) that have difficulty repaying project loans. Statutory authorisation for grants to capitalise state loan programs expired in 1994. However, Congress has continued to provide annual appropriations.

3.2.5.2 Policy Criticism

Numerous programs under the Clean Water Act are subject to criticism, primarily by special interest groups in some form. Environmentalists often claim regulations are not stringent enough and industrialists who are required to treat discharge water claim they are too stringent. Even individuals and industries that do not actually treat water often find themselves at odds with the EPA. Most of the feedback to the EPA comes from lawmakers, as they are the victims of lobbying efforts of these special interest groups.

Also, there are many aspects of water pollution and treatment that are not yet addressed by the Clean Water Act. It takes lobbying efforts and scientific research to identify areas in need and to specify appropriate regulation. For example, prior to the 1987 amendments, programs in the Clean Water Act were primarily directed at point source pollution, wastes discharged from discrete and identifiable sources, such as pipes and other outfalls. In contrast, except for general planning activities, little attention had been given to non-point source pollution (storm water runoff from agricultural lands, forests, construction sites, and urban areas), despite estimates that it represents more than 50 % of the nation's remaining water pollution problems. As it travels across land surface towards rivers and streams, rainfall and snowmelt runoff picks up pollutants, including sediments, toxic materials, and conventional wastes (e. g. nutrients) that can degrade water quality.

The 1987 amendments authorised measures to address such pollution by directing states to develop and implement non-point pollution management programs (section 319 of the Act). States were encouraged to pursue groundwater protection activities as part of their overall non-point pollution control efforts. In 1999, the EPA updated its regulations covering non-point pollution, making it more stringent by lowering the "total maximum daily load" (TMDL) allowed. Federal financial assistance was authorised to support demonstration projects and actual control activities. These grants cover up to 60 % of program implementation costs.

Recently, the Act's wetlands permit program has become one of the most controversial parts of the law. Some who wish to develop wetlands maintain that federal regulation intrudes on and impedes private land-use decisions, while environmentalists seek more protection for remaining wetlands and limits on activities that take place in wetlands.

3.2.5.3 Financial Effects of the TMDL Plan

Both states and the entities they regulate appear likely to face heightened costs and compliance burdens under the proposed regulations. Administrator Browner indicated that developing and implementing the TMDL plans would cost from $1 to $2 million per state, and the EPA cost estimate for developing a single TMDL under the plan is $25,000. California authorities, however, predict investments of $350,000 for each "medium complexity" TMDL and $1.1 million for more intricate TMDLs. As usually happens with EPA cost estimates, the reality will likely be much worse. For example, when a TMDL was prepared to mitigate nitrogen pollution in the Long Island Sound, costs over a four-year period exceeded $20 million!

State groups have long argued that states do not have the resources to administer their current TMDL obligations, a gap that will only widen under the plan. "The costs for water quality monitoring, assessment, TMDL development and implementation will experience a tremendous increase at every stage of the process," according to comments filed by state regulatory agencies in response to the August 1999 proposal.

The largest cost questions arise, however, with respect to the rulemaking's impact on individual farmers and the livestock industry. Secretary of Agriculture Dan Glickman recently testified before the Senate Agriculture Committee that the EPA needs to analyse how much the extended TMDL program would cost landowners. Concerns are centred on the idea that a regulatory scheme based on non-point sources of pollution will require farmers to expend resources to improve the quality of a nearby water body, regardless of whether the farmer contributed to the pollution of that water body.

3.3 Comparative Analysis

The German Federal Water Act and the U.S. Clean Water Act have involved environmental protection for many years without using the term "environmental law" and without recognition that all these regulatory foci have something in common. After 1960, environmental protection itself became a topic of public attention. As a consequence, in the 1970s many of the environmental protection statutes were reformulated, enlarged and intensified. In the case of the Federal Water Act and the Clean Water Act, both were enhanced and amended in the 1970s and 1980s in order to combat environmental problems in aquatic systems, e.g. eutrophication of the North Sea, fish dying in water bodies or protection of the drinking water supply. In 1977 U.S. industries had to install "best practicable control technology" (BPT) to clean up wastewater discharges, and U.S. municipal wastewater treatment plants were required to meet an equivalent goal, i.e. secondary (biological) treatment. In 1989 the industry had already to use the economically achievable best available technology (BAT), because the act now required a greater pollutant cleanup than BPT. In Germany, an amendment of § 7 a Federal Water Act in 1986 intensified the standards, especially for hazardous substances. The former standard for effluents was the general, relatively lenient one of the "generally accepted control technology", now the more stringent standard of the "best available effluent technology" applied as far as it was specified by administrative rules. For surface water control, this regime has been quite successful, although success is attributable in part to the system of effluent charges supplementing regulation (Jarass, DiMento 1993).

In Germany, incentives to develop and finance innovations and invest in new technologies in the field of water pollution control were given in that investments in innovative wastewater treatment plants could be set against payments for wastewater charges required by the Wastewater Charges Act. By comparison to the United States, innovations were encouraged by providing financial support and incentives, such as grants. State and local authorities that used innovative technology received more funding than those not using innovative methods or technologies.

The German and the U.S. innovation system is also influenced by R&D policies. In both countries there are a number of existing government programmes, e. g. public funded R&D programmes of the Federal Ministry of Education and Research in Germany and Federal Grants Programmes or the Drinking Water Academy in the United States.

So sum up the argument, in both countries the foundations of the environmental regulation in the water sector were developed in the 1970s and made stricter in the 1980s. Thus, the broad development of environmental regulation of the water sector was rather similar between the two countries.

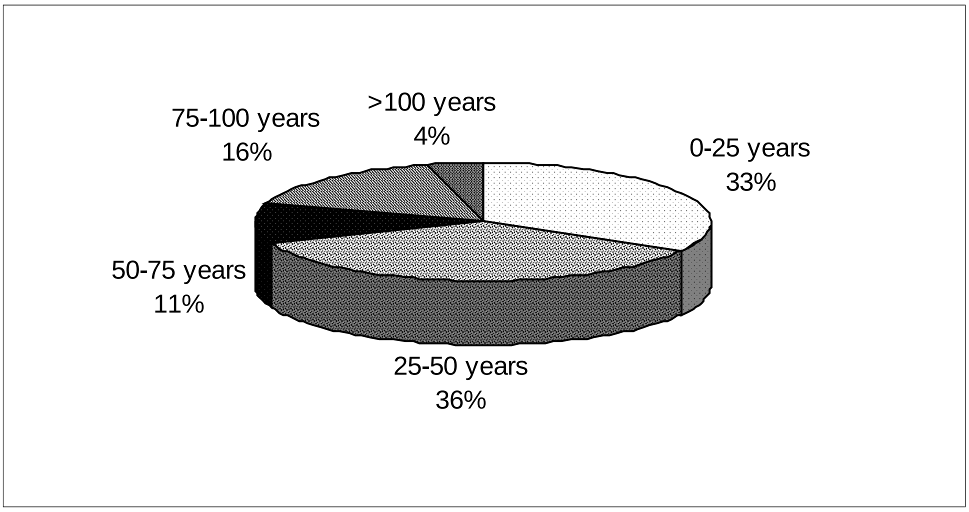
The issue of wastewater in the U.S. is becoming more and more important because of the aging infrastructure for most water and wastewater systems in the U.S. Collapsed storm sewers, co-mingling of stormwater and wastewater, as is the case in Atlanta, for example, and an estimated 20 percent loss from leakage in many drinking water systems point to a significant deterioration in the US's water infrastructure. The role of innovation is therefore critical in handling the shortcomings of purification and wastewater systems that are in some cases one hundreds years old.

The Congressional Budget Office of the U.S. Congress estimates annual costs for investment in water in billion dollar amounts for wastewater systems and almost twice those amounts for annual operations and maintenance. The wide range of project cost estimates derives largely from different assumptions about the rate at which water pipes are replaced, the savings associated with improved efficiency, and the costs of controlling sewer overflows.

Virtually all tariffs, charges and user fees on water of any kind are conducted through the local municipalities that supply the water. 99 % do not base any charges upon wastewater, expect in the case of extremely large users of water (such as certain industrial manufacturers). Instead, the sewage charge is calculated based upon the water consumption. This is because it is assumed that any water consumed will be returned as wastewater in some form or another. Thus, charges are typically based upon volume of water used an only on e water meter us used, for measuring the inflow. In very few communities, there are separate water meter that measure agricultural (sprinklers, etc) usage and do not charge sewer/wastewater fees (Interview with P. McLeheny, American Water Works Association). Total household bills for drinking water and wastewater services will rise over the projected period from 0.5 percent of household income to between 0.6 and 0.9 percent. The range for cost of wastewater is from US$ 0.50 to US$ 1.50 per m³ with a great variation among municipalities in part depending on the nature of the ownership of th water system and the technologies used in waste water treatment (Interview with Professor M. Saunders from GT and Dr J. Taylor). The costs are still low relative to costs in other industrialized countries such as France or Germany. However, the distribution of rising costs will be such that 10 to 20 percent of households will be spending more than 4 percent of income on water bills at the end of the period, and an additional 10 to 23 percent of households, more than two percent.

The situation in Germany is resembling that in the U.S. The age of most of the water infrastructure (36 %) ranges between 25 and 50 years. The following figure shows the ratio of the age pattern of the water infrastructure.

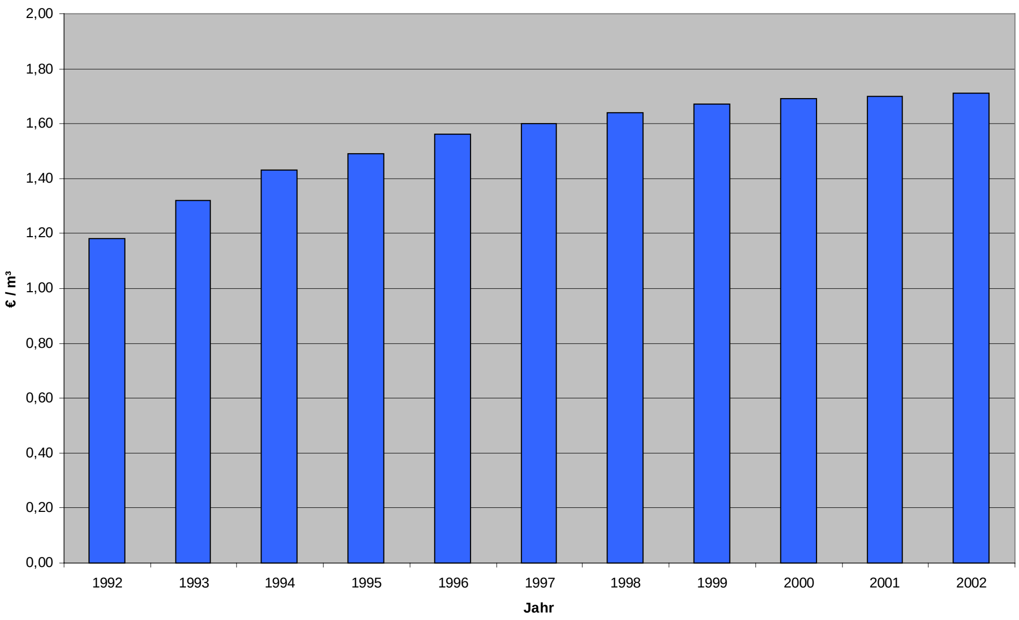
Figure 3.3-1: Ratio of age pattern of the water infrastructure in Germany (Source: Lemke, Wackerbauer 2000).



Due to insufficient maintenance in the past as well as other reasons the water infrastructure, especially the sewer system of most urban areas, is seriously deteriorated and requires rehabilitation or renewal. This requires large investments in a time when municipal budgets are tight. Estimates are that about 17 % (=76.000 km) of Germany's public sewer system (= 446.000 km) require rehabilitation immediately or at least in medium term. This will require investments of 45 billion EURO over the next years.

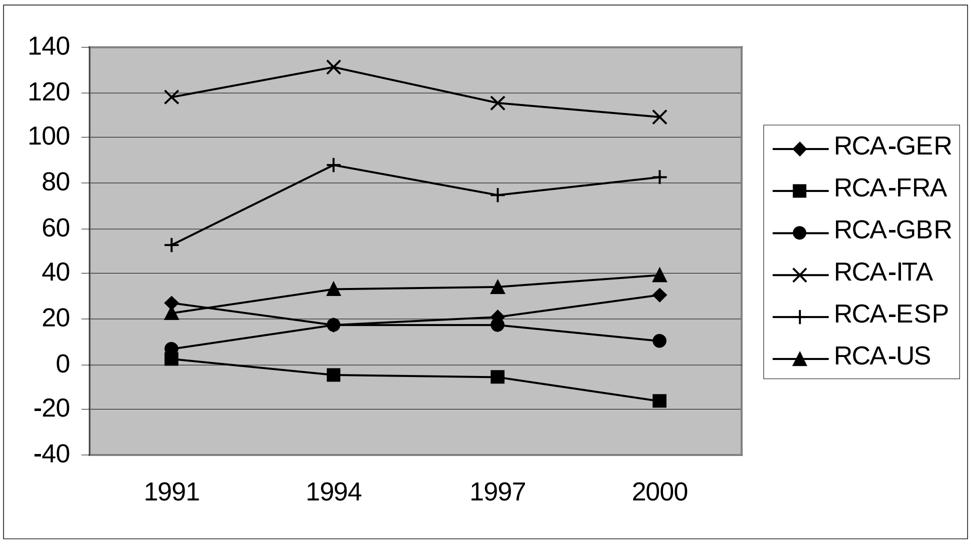
All drinking water supply costs in Germany must, in principle, be covered by the price charged for water. This results in regional price differences, as the water supply conditions vary form place to place. In 1998 the average price for drinking water in households was € 1.69/m³. This price includes value-added tax and the basic price. Thus for a daily consumption of 129 liters the amount paid per head of the population for drinking water was € 0.22 per day or € 80.27 per year (FME 2001). The next figure shows the development of water prices in Germany from 1992 to 2002 (Lübbe 2002).

Figure 3.3-2: Development of water prices in Germany from 1992 to 2002. (Source: Lübbe 2002)



The effect on innovation in both countries can also be judged as being equivalent. Both countries were leading exporters of wastewater treatment technologies at the end of the 1980s. With a little over 20 %, Germany's world market share in wastewater treatment technologies was about equal to its overall share in environmental technologies. For the U.S., the share of 10 % of wastewater treatment technologies was rather lower than its share in all technologies. The same conclusion also holds for the RCA values. Both countries had specialised in wastewater treatment technologies, Germany even more than the U.S. Since 1997 the RCA-value for Germany decreased whereas the RCA-value for the U.S. increased since that time. France has negative RCA-values. In contrast the RCA-values of Spain and Italy are pretty high. That means that the export/import-relation of water technologies is much higher than the total of manufacturing industry in these countries.

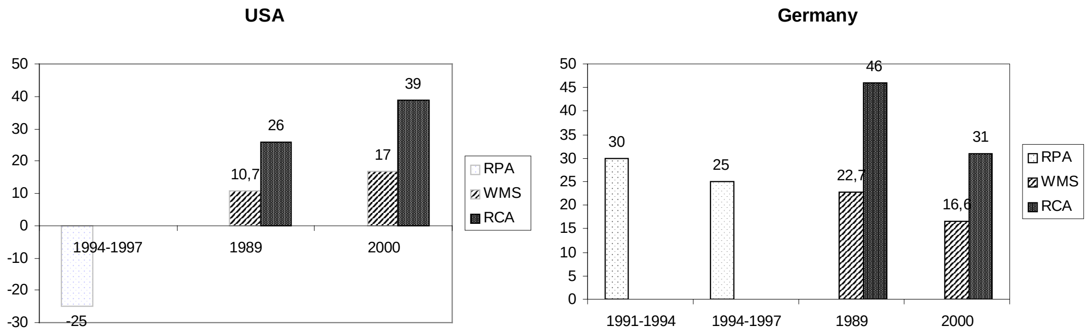
Figure 3.3-3: RCA-values of water protection technologies of European Countries and in the U.S. (Source: Legler, Schmoch, Gehrke, Krawczyk 2002)



This strong position of Germany clearly had been influenced by the environmental regulation. The development of environmental patents in the 1980s for Germany clearly shows a strong increase in the 1980s (Grupp 1999). However, it was not only the regulation with command and control policies which pushed this development. In Germany, the emission charge on wastewater, with increasing tax rates until the early 1990s also contributed to that effect. Furthermore, long-term policy goals were also very important. The achievement of water quality class II in German water bodies is an example for such a long-term strategy that started in the 1980s. Since then that strategy provided continuous guidance for the development of water protection technologies.

The development during the 1990s parallels the development of environmental technologies described in Section 2.3. For Germany, the innovation indicators still show a high specialisation for wastewater treatment, but the figures have been decreasing slightly (Figure 3.3-1). The detailed analysis also showed that most of the innovation challenges can be traced back to the national regulations during the 1980s. Thus, with the exceptions mentioned, the requirements of the EU Urban Waste Water Treatment Directive did not lead to a new strong impulse from regulation. The technological basis, R&D policies, the need to increase water quality in East Germany, plus the elaboration of regulations along existing technological trajectories were strong enough to allow continuity of specialisation in wastewater treatment technologies, but rather with somewhat declining specialisation. Definitely, German industry was not able to fully participate in the diffusion of wastewater treatment technology in other countries during the 1990s. Thus, in the 1990s, Germany was not able to fully exploit the role as lead market of wastewater technologies it had acquired during the 1980s. The U.S., in contrast, was able to increase its world market share during the 1990s, even though it did not specialise in patenting in this area. Thus, the hypothesis can be put forward that the U.S. was able to catch up, because Germany was technologically not pushing further ahead as it had done in the 1980s.

Figure 3.3-4: Innovation indicators for wastewater treatment technologies in the U.S. and in Germany



In Chapter 1, it has been argued that innovation is a complex process which does not follow simple stimulus response mechanisms. Indeed, looking at the innovation system of water policy, there are various aspects which have to be considered as well. The following arguments in particular are important to explain the innovation process in addition to the development of environmental regulation:

- The water sector has been traditionally viewed as a natural monopoly. Public ownership and protection of service areas, together with price regulation can be found in both countries. They lead to the effect that, unless incentive regulation takes place, the pressure to control costs is lower than in sectors subject to high market pressure. Thus, there had been some room for experimenting with new technical solutions, even if they led to some cost increases. On the other hand, as long as the public perception did not make cost increases into a political issue, there was no need to emphasise the importance of innovations which are able to fulfil the environmental requirements with lower costs.
- Particularly in Germany, the R&D output is rather high, as indicated by the positive RPA values. Further analysis also has shown that the standardisation organisations in the wastewater sector, in general, bring together scientists from R&D and users from wastewater treatment organisations. Thus, they form very important bodies for R&D spillovers. Nevertheless, it has also been shown that the innovators from the machinery and appliances industries are less integrated in the standardisation process than the rather traditional experts from civil engineering (ISI 1998).

- In Germany and the U.S., the wastewater treatment institutions are usually locally based, and even restricted to local activities. Thus, they have little incentive or even possibility to engage in the world market. Thus, even if there is an excellent technological basis in the home country, there tends to be a lack of world-market-oriented companies able to supply the world market not only with technological expertise but also with both user experience and the possibility to organise financial resources to finance projects. Furthermore, as mentioned above, the machinery and appliances industries, which are traditionally more world-market-oriented than the construction business, are less integrated in the innovation system.
- Taken together, these aspects help to explain why there is an excellent technological basis in Germany on the one hand, which is, however, not fully reflected in the world market on the other. Furthermore, it has to be kept in mind that the innovations discussed so far have been mainly along the traditional trajectory of wastewater treatment. Very recently, however, new concepts of the water sector employing decentralised technologies and leading towards a new paradigm are getting more and more attention (Hiessl et al. 2003). The strategy of a decentralised water system not only poses new challenges for the development of innovative technologies, but also opens up the perspective of supplying the world market with technologies and concepts also appropriate for developing countries, which will form important part of the world market demand for wastewater concepts in the future. It remains to be seen whether or not EU countries will be mong the first movers seizing that opportunity.

4 Case Study Wind Power

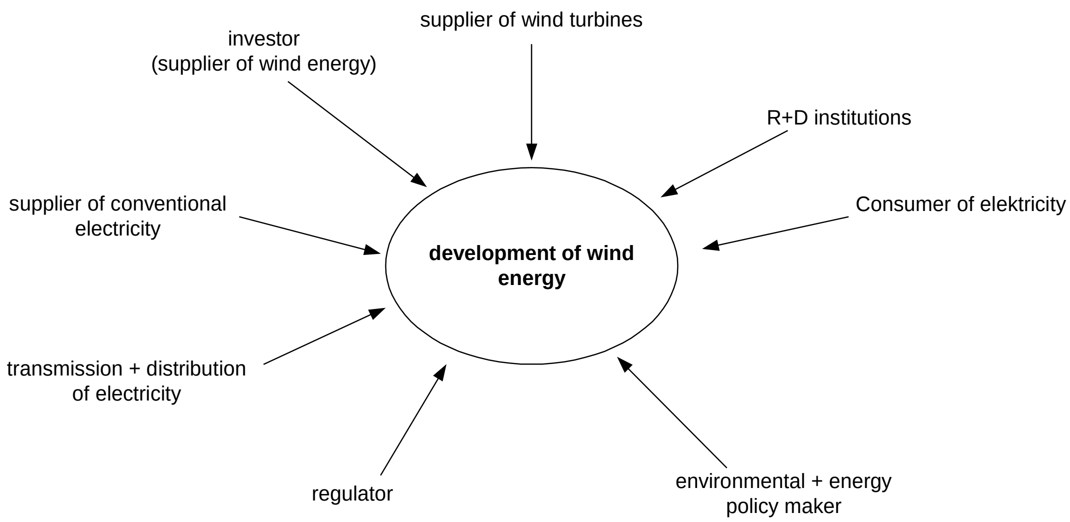
4.1 Wind Power in Europe

4.1.1 Policies and Regulation

4.1.1.1 The Need for Regulation

Policies and regulations which influence innovations of wind turbines can be directed to different actors. Thus, it is important to identify the key actors within the field. First of all, there are the suppliers of wind turbines. They consist of companies which have a quite similar structure such as other companies within the investment good sectors. Secondly, there are the investors in wind power. They consist of the owners of the site, together with the capital owners, which typically are private investors, wind energy funds, and in some instances electric utilities. Thirdly, the electricity produced by the wind turbines must be brought to the customers. Thus, access to the grid is vital for wind power. Here the electric utilities play a key role. They are responsible for the transmission and the distribution of electricity on the one hand, but on the other, electricity from wind is substituting electricity supplied from other conventional power plants. Thus, the electric utilities are at the same time a competitor of wind power.

Figure 4.1-1: Important actors in the interface of regulation and innovation for wind power



The electric utility industry has been traditionally viewed as a natural monopoly subject to regulation. Even after liberalisation, which is based on the starting point that the generation of electricity is no longer a natural monopoly, there clearly is a need for some kind of regulation in order to prevent monopolistic exploitation of the ownership of the grid. Thus, the role of the regulation of access to the grid plays a very important role for the development of wind power.

Another important aspect of the innovation processes in the energy sector are the environmental problems associated with the use of conventional energy sources. The increase in renewable energies plays a very prominent role within the debate about sustainable development. This can be attributed to the effect that renewable energy in general tackles various problems discussed in energy strategies:

- Renewable energy are CO_2-free; thus they are an important piece of Community strategy to reach the Kyoto Targets, and even more important, if one looks into the long-term reductions necessary to reach a stabilisation of CO_2 concentrations.
- Wind energy is a renewable resource; there are no problems of long-term security of supply which are associated with the depletion of fossil fuels.
- Renewables are not dependent on imports; thus, problems of short to medium security of supply, which are debated with regard to the re-concentration of oil resources in the Middle East, do not occur.

Thus, the role of energy and environmental policy-makers is extremely important to the development of wind industry. As long as the external costs and benefits described above (climate change, fossil fuel depletion, security of supply) are not included in the prices, wind energy cannot compete with conventional electricity supply. Thus, policies which in one form or the other work towards a level playing field are a key necessity for further development of wind energy.

The EU calls for a doubling of the use of renewables by 2010. Among the renewable electricity suppliers, wind energy has the highest potential in the short run. Thus, strategies and policies to promote an increase in wind power have a very high legitimacy.

4.1.1.2 Regulation in the EU and Germany

There are different instruments used in most European countries to foster the development of wind power. The most important instruments which are used are:

- support for R&D (EU level and Member State level),
- direct subsidisation of installation of wind power, e.g. by tax measures
- fixed feed-in tariffs (e. g. Germany, Spain, Italy, Austria, Denmark until 2001) in some Member States, and

- quotas/bidding systems (e. g. UK, Ireland, France until 2001, Denmark since 2001).

Table 4.1-1: Instruments used in EU countries to foster wind energy

instrument	**implementation before 2001**	**new implementation since 2001 or planned**
(4) fixed feed-in-tariff	BE, DE, DK, ES, GR, LU, PT	AT, FR
bidding schemes/quotas	IE, SE, UK	DK, IT, NL
tax measures	DE, DK, ES, FI,NL, SE	

Data: PRETIR 2002

Within Germany, different policies have been applied. In the 1980s, there was a substantial R&D programme of the Federal Department for Research and Technology (BMFT), which supported different types of wind turbines (horizontal and vertical axis, different number of blades). Furthermore, the research programme subsidised investment in wind turbines through various demonstration projects. In 1989, a market stimulation programme was introduced which called for an installation of 250 MW of wind power. It guaranteed a fixed payment per kWh of electricity produced, together with investment subsidies for private operators such as farmers. This programme was effective until 1995.

On top of the 250 MW programme, the Electricity Feed-in Act was introduced in 1991. It mandated that grid operators paid 90 % of (average historic) electricity retail prices as feed-in tariffs for electricity generated by certain Renewable Energy Sources (RES) such as wind. Furthermore, it required utilities to accept the electricity delivered by wind turbines.

The Electricity Feed-in Act in its later stage had a cap to prevent very uneven burdens for regional grid operators: a grid operator had to pay these feed-in prices until the share of electricity from RES reached the cap of 5 %. Nevertheless, this regulation still affected the utilities operating the grid asymmetrically. Wind turbines, which benefited most under Energy Feed-in Law, are concentrated in Northern Germany. Thus, grid operators in the North were at a (slight) competitive disadvantage, which created a problem especially since the beginning of electricity market liberalisation. Furthermore, the falling electricity (retail) prices resulting from the liberalisation also lead to lower feed-in prices for electricity from RES. This started to undermine their economic basis, in particular of the numerous wind turbines which had been installed in the previous years. Thus, an intensive debate emerged about the future of the Electricity Feed-in Act.

In the end, the Renewable Energy Act ("Erneuerbare Energien-Gesetz", EEG) (BMU 2000b) of Spring 2000 replaced the Electricity Feed-in Act. As a consequence of the developments described above, under the new EEG feed-in prices are no longer linked to electricity retail prices, but fixed for 20 years. The cap on the share of electricity from RES was abolished. Instead, the total amount of feed-in subsidies will be distributed evenly among all high voltage grid operators. Furthermore, the feed-in tariffs for wind decrease for plants installed after 1st January 2002 (BMU 2000a.).

The EEG is in principle a subsidy with respect to the favoured group (the RES producers), but with the special feature of financing by the end-users of electricity. The incentive is a positive sanction in the form of guaranteed payments for the whole electricity produced. As noted before, the Electricity Feed-in Act started in 1991 and was replaced by the EEG in April 2000. In the EEG, a twofold degression of the feed in tariffs is implemented:

- From 2002 on, new installations of wind receive minus 1.5 % lower tariffs. From 2003 on, new installations of these types receive tariffs lowered by a further 1, 1.5 %, and so on for the following years. This is to retain the incentive for technology producers to offer more efficient products every year.
- Furthermore, the feed-in tariffs are substantially lowered (about one third) after the initial years of installations. Investors in wind power at sites above a reference value receive a substantially lower feed in tariff after 5 years. At sites with below average wind yield, the time period for the higher feed-in tariff is prolonged. The same holds for offshore sites, which are applicable for the higher feed-in tariff of the initial phase for the first 9 years.

Furthermore, the feed-in tariffs are reviewed every two years in the light of technological and price developments, and feed-in tariffs for sites newly installed in the following years can be changed accordingly. For every single installation, the date of *expiration* is in twenty years' time from the date of installation.

Table 4.1-2: Feed-in tariffs for newly installed wind turbines in the year indicated

Year of installation	Calculated feed-in tariff according to old Feed-In Act	First years after installation (5 years or longer)	Following years
1991 to 1999	90 % of average price (8-10 €Cent/kWh	-	-
2000 to 2001	-	9.1	6.2
2002	-	8.96	6.11
2003	-	8.83	6.02
2005	-	8.57	5.84
2010	-	7.94	5.41
2012	-	7.71	5.25
Annual change of feed-in tariffs	-	-1.5 %	-1.5 %

The fixed feed-in tariffs of the EEG are set above the avoided costs. However, it is difficult to calculate the difference exactly. First of all, due to the reduced rates in the second phase, the average feed-in tariffs for a wind power plant depend on its lifetime. Second, it is difficult to calculate the avoided costs of use of transmission and distribution lines which is likely to occur. Nevertheless, a first guess comes to an estimation of the difference between avoided costs and feed-in tariffs in the order of magnitude of perhaps 3-4 €Cents/kWh. However, it has to be taken into account that wind energy is associated with much lower external environmental costs than conventional electricity supply. Indeed, it can be argued that the feed-in tariffs are in the order of magnitude of the avoided costs if the estimations for the external environmental costs are taken into account (Hohmeyer 2002).

4.1.2 Development of Wind Power

4.1.2.1 Generation of Innovations

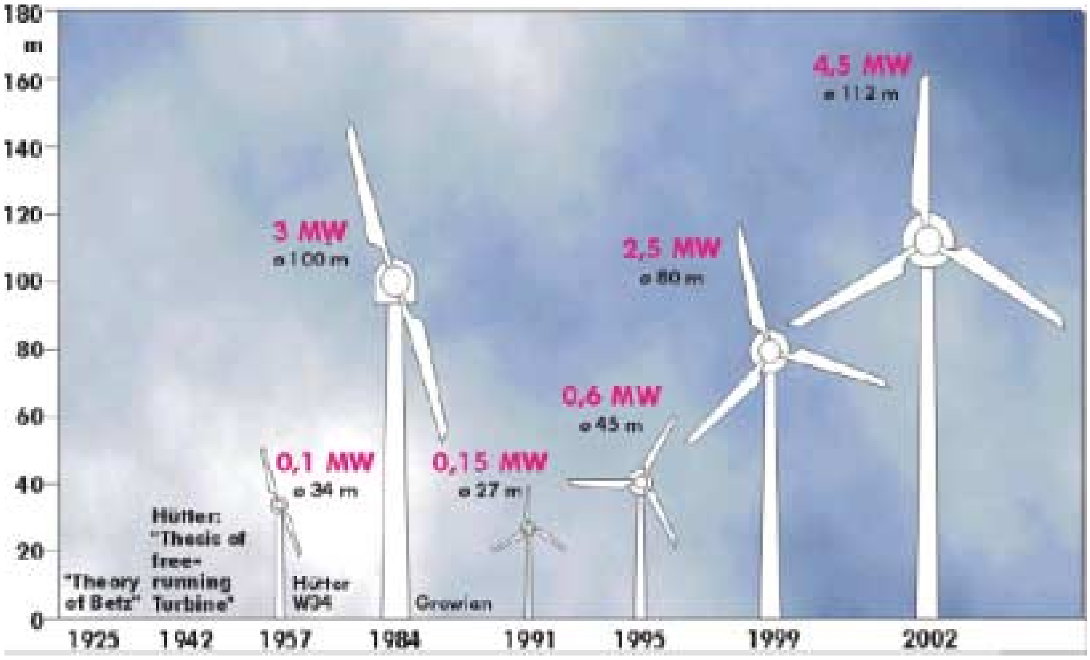
The design of wind turbines can be traced back for decades. However, it was not until the dramatic price increase in oil during the 1970s and early 1980s that the development of wind turbines got on the energy policy agenda. However, the situation in the 1980s was dramatically different to the one observed today. In the 1980s, no dominant design had been developed. There were a variety of turbines experimented with, using both horizontal and vertical axes. At the same time, the number of blades of the turbines ranged from 1 to more than three. There were a number of small actors consisting of only few people experimenting with small-scale wind turbines. Some larger companies also entered the field attempting to build larger turbines with MW size. However, in sum, these attempt in the 1980s were not successful, such as the well known 3 MW GROWIAN plant in Germany which was erected by MAN in 1982 but due to its failure dismantled in 1987. However, during the 1980s, tremendous success was achieved: the costs per kWh were reduced by over 50 %, and with the Danish Micon 55 a standardised wind turbine with a capacity of 55 kW emerged which was installed not only in Denmark but also in great numbers in California.

During the 1990s, the development of the wind turbines continued. The following steps mark especially important milestones of R&D success:

- at the beginning of the 1990s, pitch control, variable RPM and the 150 kW turbine were developed,
- in the mid 1990s, the size of the turbines was increased again to 600 kW,
- at the end of the 1990s, the 1.5 MW turbine and the 2.5 MW turbine were introduced,

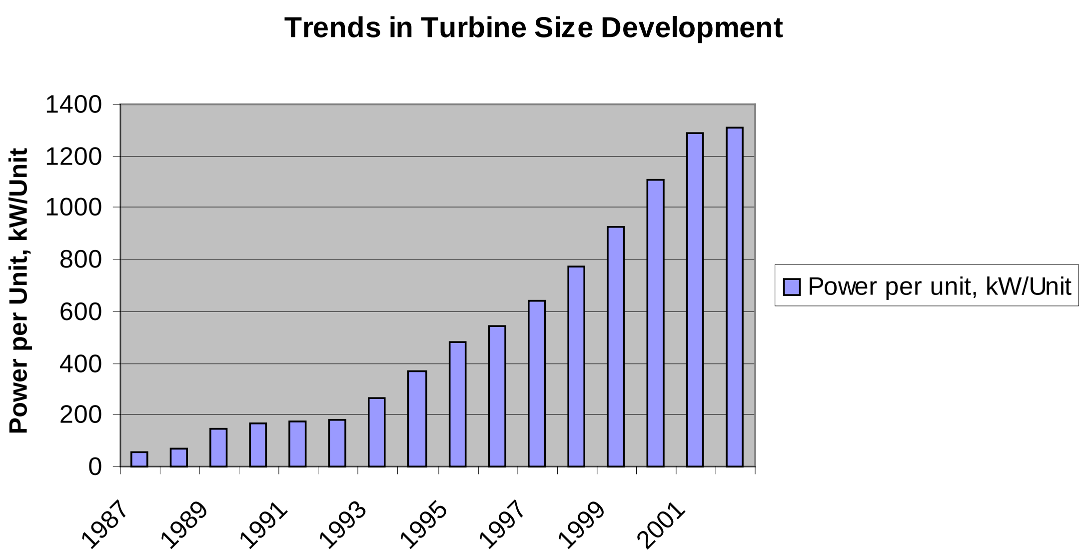
- in the early 2000s, another increase in the size of the turbines to about 4.5 MW is envisaged.

Figure 4.1-2: Milestones in wind turbine development



Source: Durstewitz 2003, p. 6.

Figure 4.1-3: Development of average size of installed wind turbines in Germany

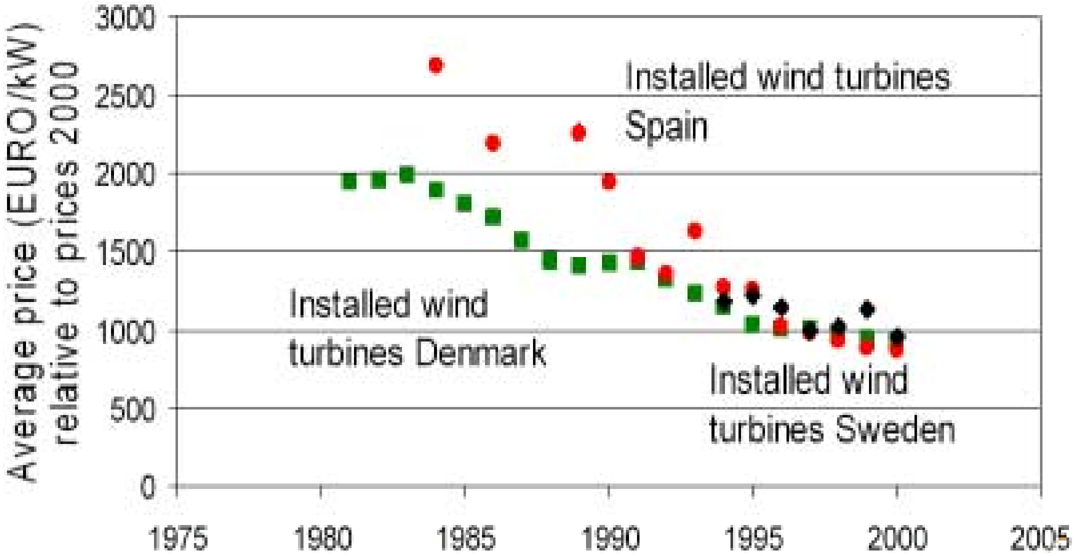


Source: Ender 2002a, p.18.

The increasing sizes of the turbines was not only achieved in R&D demonstration projects. During the 1990s, the average size of the turbines installed continuously increased. Within Germany, for example, the average size of installed turbines at the early 2000s is 20 times higher compared to the late 1980s – a remarkable innovation success in little more than 10 years.

The innovations described above plus the economies of scale also had considerable effects on the economics of wind power. The average investments per kW of installed capacity decreased substantially. At the same time, the cost differences between the countries narrowed. This indicates that within the leading countries, competent suppliers have been emerging which are competing internationally, leading to an erosion of cost differences between the countries. At the same time, the costs of wind power per kWh electricity produced has been constantly reduced. However, the cost degression effect observed in the statistics is likely to be somewhat lower than the cost decrease in specific investments, due to the effect that with improved wind turbines also sites with lower wind yield are used more widely.

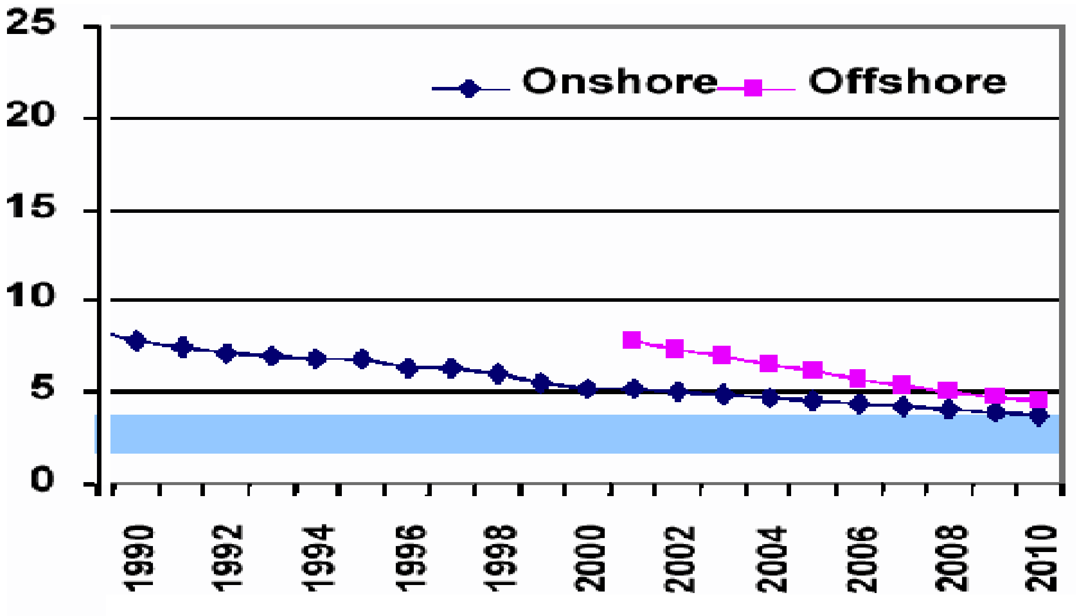
Figure 4.1-4: Specific investments of wind turbines per kW of capacity.



Source: Neij 2003.

The future perspectives of wind turbine development are characterised by further cost degressions. Future challenges are, for example, the use of new materials to lower the weight of the blades, or the increased use of fuzzy controls to increase the efficiency of the turbines. Furthermore, with the increasing number of turbines operating, the question of integrating them in the electricity system without getting problems of stability of the grid are becoming more and more important. Another key challenge is the development of off-shore wind power. Clearly off-shore offers the perspective of huge numbers of sites with very good wind yields becoming available. With good sites becoming more and more scarce onshore, this becomes a key to the future expansion of wind power. However, there are several challenges to be met, such as the installations of the turbines at sea and their anchoring on the sea ground. In general, it can be argued that the future innovations of wind power will require that additional knowledge (e.g. material science, geological science) outside the typical mechanical and electrical engineering is mobilised to meet the future challenges more than in the past.

Figure 4.1-5: Development of costs per kWh electricity produced by wind power in Germany

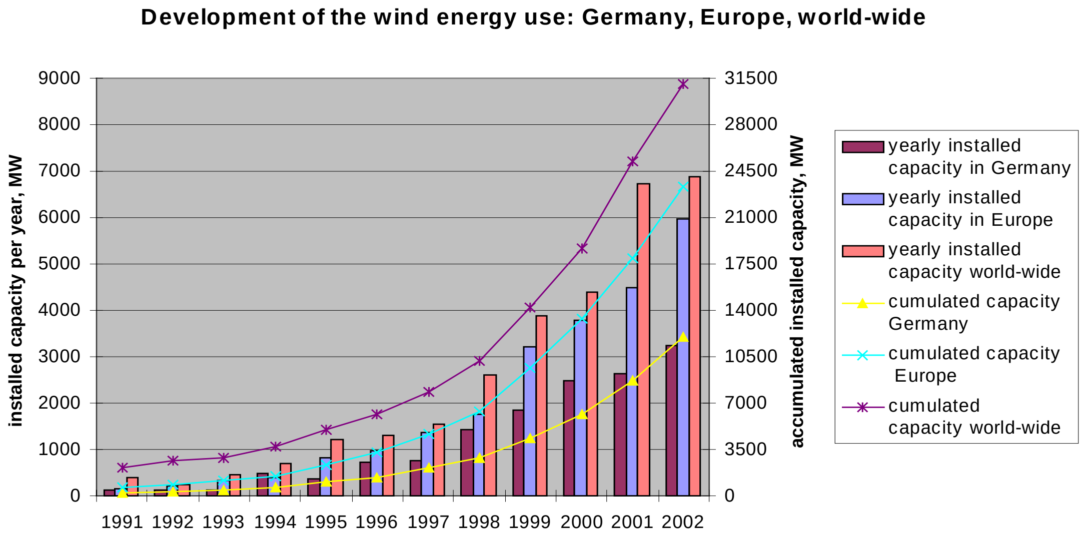


4.1.2.2 Diffusion

The emergence of the innovations described above led to a tremendous diffusion of wind power. The annual installed capacity increased continuously from less than 500 MW at the early 1990s to almost 7000 MW in 2002 world-wide. This resulted in a tremendous increase in the accumulated installed capacity from less than 1000 MW in 1991 to over 30,000 MW in 2002. This development has been mainly driven by the success of wind energy in the EU. In 2002, the EU accounted for about three quarters of the world capacity, up from less than 50 % in 1991. Thus, the EU clearly has taken the lead in wind power in the world.

Within the EU, Germany has increased its share of the installed capacity to more than 50 % in the EU. With about accumulated 12,000 MW installed in 2002, Germany holds more than one third of the world's wind capacity. This success is especially remarkable, because it took place in such a short time. In the 1980s, the diffusion of wind power in Germany wasn't very impressive. At the end of 1989, the accumulated wind power capacity in Germany amounted to only about 20 MW. Thus, Germany's number one position in wind power production was achieved in only one decade.

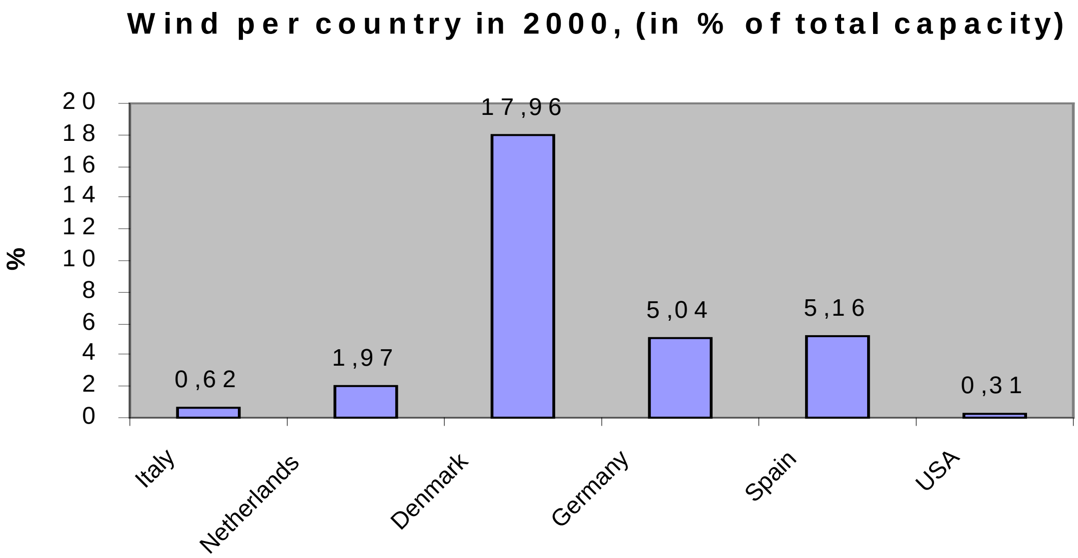
Figure 4.1-6: Development of annual and accumulated installed capacity of wind turbines



Source: data from Ender 2002b and Durstewitz 2003.

Comparing only installed capacities may be misleading, because the electricity generated also depends on the full load hours each installation is operating. There are some differences between the European countries. For Denmark, UK, and the Netherlands, full load hours in the order of magnitude of 2200 to 2300 h/a are common. In other countries, such as Spain, Austria and Germany, the full load hours are somewhat less, reaching on average 1700 to 1800 h/a. Furthermore, in order to evaluate the relative success of the countries, the differences in their size must be accounted for too. In order to do so, the percentage of installed wind capacity at the total electric capacity in 2000 was calculated (Figure 4.1-7). The result demonstrates that Denmark clearly has the highest percentage of wind power, followed by Spain and Germany.

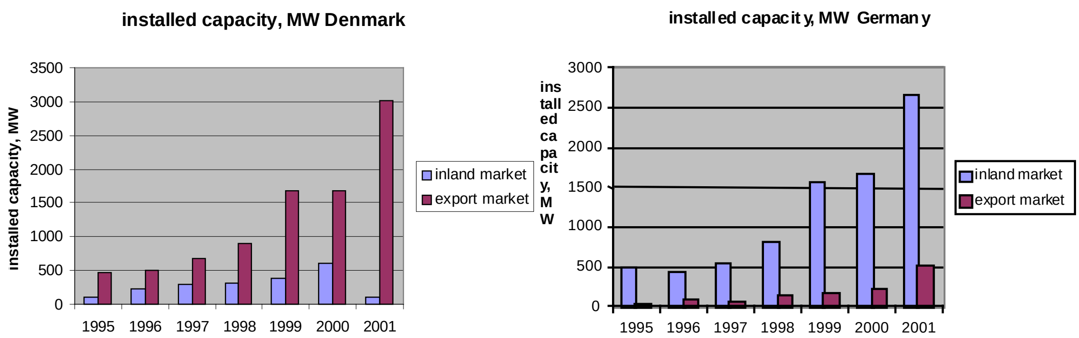
Figure 4.1-7: Percentage of installed wind capacity at total electricity capacity in 2000



Source: data from Energy Information Administration, Bundesverband Windenergie e.V.

Another important aspect which illustrates the international competitiveness is the importance of exports for the national suppliers of wind turbines. Denmark still exports a much higher share of its wind turbine production. Thus, it can be argued that Denmark still possesses the position of a lead market for wind power it occupied clearly in the 1980s. However, this debate is less clear cut than the numbers imply. First, it is getting more and more difficult to attribute a producer such as GE Wind, which incorporates also the production and R&D facilities of the former German Tacke company, to one country only. Second, the domestic market in Denmark has not expanded so much recently, leading the Danish producers to concentrate more on the export markets. The German market, thirdly, has been booming and absorbing most of the capacities of the German producers. They were apparently not able to increase their capacity fast enough to serve a higher share of the world market, which might have been possible given their technological competences.

Figure 4.1-8: Import and export shares of Danish and German wind turbine producers



Source: Ender 2002b, p. 27.

4.1.3 Interaction Between Regulation and Innovation

The remarkable success of wind energy is closely connected to the regulation of the feed-in tariffs. First of all, they guarantee that the investments in wind turbines are profitable for the investors. Second, especially fixed feed-in tariffs are important, because they reduce the risk of fluctuating prices. Especially small-scale investors, who have to refinance their funds through the financial system, claim that the predictability of the feed-in tariffs is a key for securing the funds they need. Clearly fixed feed-in tariffs fulfil this requirement much better than quota or bidding systems. Thus, it is not surprising that the countries leading wind energy diffusion (e. g. Germany, Denmark, Spain) have been relying on that kind of regulation.

The specific form of the German Renewable Energy Act also provides incentives for dynamic economic efficiency. There is a constant incentive for wind turbine producers to become more efficient since, firstly, there is competition for the customers, who can increase their profits by choosing a cheaper technology, and, secondly, the feed-in tariffs decline each year for newly installed equipment. Individual installation owners also have, where technically possible, incentives for efficiency gains, since this increases their profits. It can also be argued that the predictability of the feed-in tariffs, which led to an enormous diffusion of wind power, was also a prerequisite for the development of markets big enough to exploit economies of scale and learning curves, which help to drive technology prices down towards the levels of conventional technologies of electricity production.

In addition to the incentives stemming from the specific form of regulation, interaction between regulation and innovation can also be explained within the wider framework of an innovation system. This framework has been applied traditionally to national innovation systems (see Edquist/McKelvey 1997). More recently, however, it has been also applied to analyse technological systems (e.g.

Carlsson/Stankiewicz 1995). These approaches share the starting point that innovations can be best explained by characterising the components of an innovation system, such as actors, networks and institutions, and their interaction with each other. Furthermore, it has been suggested that a technological innovation system such as wind power can be best analysed by looking at how the different functions an innovation system has to meet are fulfilled (Johnson 1998, Johnson/Jacobsson 2000). The following five functions can be distinguished (Bergek/Jacobsson 2003):

- creation of new knowledge,
- guiding the direction of search process; this includes both the recognition of a growth potential, which is closely connected to the legitimacy of a new technology, and guidance with respect to technological and market choice,
- supply of resources, which is especially important for new technologies which are associated with a higher risk of failure,
- creation of positive external economies through exchange of information and knowledge,
- facilitation of market formation.

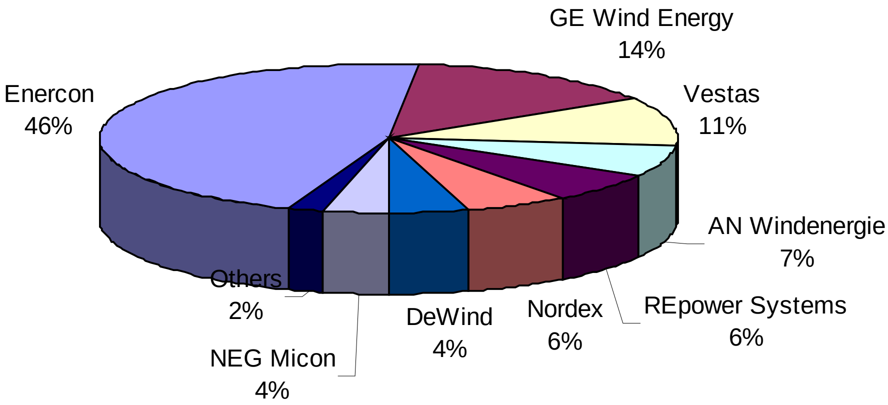
These functions are not independent of each other. Indeed, a very high rate of innovation of the technological system analysed will result if the linkages and feedbacks between the functions are such that a positive virtuous circle between the various functions is set in motion. The framework of functionality of an innovation system allows us to evaluate how well an innovation system supports the development of an industry.

However, the development of an industry goes through different phases (Nelson 1994, Utterback 1994). In general, a first phase of experimentation with frequent entries and exits, many different technological alternatives, and a small market, can be distinguished from a second phase, which is characterised by market growth and consolidation of the suppliers (fewer new entrants, concentration of suppliers). Within these two phases, the importance of the different functions of an innovation system varies (Bergek/Johnson 2003). In the first phase of experimentation, creation of new knowledge and guiding the search process are very important. This requires the creation of both legitimacy of and variety between the technological approaches, and the entry of new actors and the creation of networks to ensure positive external economies. In the phase of market growth, the formation of a mass market becomes the key prerequisite, emphasising also the function of supply of resources.

With the help of this approach, the development of wind power in Germany and the influence regulation had can be explained within a systems view (for more details see Hemmelskamp 1998; Bergek/Johnson 2003). During the 1980s, wind power in Germany was in the phase of experimentation. Guiding the direction of search was substantially facilitated by the R&D programme. A variety of new technical knowledge was provided, because the R&D programme was not limited to one design only. There were many new entrants experimenting with wind turbines. Early legitimacy of wind power was provided, in general, by a comparatively strong environmental movement. The debate of an alternative future for the electricity industry remained even after energy prices fell in the aftermath of the second oil price crisis. This can be attributed to an intensified debate for nuclear phase-out after the Chernobyl accident and the start of the debate about global warming at the end of the 1980s. Furthermore, the expansion of the Danish firms in the 1980s exporting numerous wind turbines to California provided another signal for market entry in the 80's. Finally, a network of suppliers with user linkages emerged around the R&D programme, enabling exchange of information and knowledge and thus positive economic externalities. Thus, the experimentation phase, supported by the R&D policy, provided the German innovation system for wind power with a broad range of variety, many actors and accumulated knowledge and competence to be built upon during the subsequent phase of market expansion.

With the Electricity Feed-in Act of 1991, the German wind energy innovation system entered the phase of rapid market growth. The fixed feed-in tariffs facilitated the enormous market formation described in Section 4.1.2. The reduced risk for investors mobilised not only private capital for investments on a large scale. Part of the economic benefits spilled over to the suppliers of wind turbines which helped to supply the resources for further innovations. At the same time, the supply side of the wind turbine market consolidated considerably, as can be seen in the rising of the concentration levels since 1992 (Hemmelskamp 1998). Among the different wind turbine producers, a few companies emerged as key leaders driving the innovations, with Enercon as the leader. And even though Tacke has been bought by Enron first and General Electric afterwards, the key departments remained in Germany. Thus, together with the Danish companies Vestas, NEG Micon and Bonus plus the Spanish based Gamesa, the three German based companies Enercon, GE Wind (formerly Tacke) and Nordex belong to the world's leading players in wind turbine production, combined almost 80 % of the world market of wind turbines in 2001 (Ender 2002b). With available sites becoming more scarce, the need for up-scaling turbines became more pronounced. Furthermore, the market expansion helped to exploit economies of scale leading to lower prices and increasing profitability. To sum up, during the phase of market growth various virtuous circles were introduced which enabled the German innovation system of wind energy to better fulfil its functions, pushing generation and diffusion of innovation further and further. Clearly, however, this phase of rapid expansion with continuous innovations would not have been possible without the market formation induced by regulation.

Figure 4.1-9: Market shares of wind turbine producers in Germany in 2002



Source: Ender 2002a, p.19.

The future of wind power in Germany will most likely be characterised by further cost reductions and expanding markets. The design of the Renewable Energy Act with its decreasing feed-in tariffs over time gives an additional incentive in that direction. However, it can be argued that the R&D of the suppliers of wind turbines, which at present is characterised by structures similar to engineering consultants, needs to be enhanced in order to meet the future challenges described in Section 4.1.2. It is argued that there is a trend that suppliers already have problems to keep pace with technological development (Hemmelskamp 1998). However, some of the key innovations lying ahead even require that results from basic research are transferred as quickly as possible to R&D. Thus, it most likely will be necessary to increase the knowledge base of the R&D of the wind turbine suppliers by establishing much closer links to basic research institutions in fields such as materials science, geology etc. Perhaps a new R&D policy approach might be necessary, supporting the regulatory approaches used in Germany which have proved to be so successful in fostering innovation.

4.2 Case Study North America

4.2.1 Regulation of the Wind Power Industry

4.2.1.1 The Federal Level

There is very little in the way of federal regulation of the wind power industry in the United States. Most innovation comes from financial subsidies, incentives, and research partnerships. As wind power is virtually non-polluting, there has been little regulation of it. Most regulations from the EPA come from environmental and health risks, and as there are no true risks associated with wind power, there has been a scarcity of regulation.

Nevertheless, there have been several policies affecting wind energy in the past. The Public Utility Policy Act from 1976 stated that the feed-in tariffs from power stations outside the electric utility industry had to been charged at avoided costs. Among others, this also applied for wind energy. Especially in times with rising marginal costs, this provided enormous debates whether or not feed in tariffs above average costs were justified (Walz 1995). Another important policy were the tax incentives for renewable energy which helped to promote the boom in wind energy in California in the late 1970s and early 1980s. Furthermore, the Department of Energy (DOE) spent substantial amounts of money. However, all these incentives were drastically reduced under the Reagan Administration in the 1980s (Brauch 1996). Thus, there have been considerable discontinuities in the U.S. policies.

A key policy for federal policies to foster wind energy is the Federal Energy Policy Act of 1992. The federal government provides a tax credit of 1.5 cents per kWh (adjusted for inflation, 1.8 cents today) for electricity generated by a wind plant during its first 10 years of operation. This credit is intended to "level the playing field" for wind, which must compete with other energy industries that receive billions of dollars in federal subsidies each year. The wind energy credit will expire at the end of this year unless Congress extends it.

On the federal level, there has been considerable discussion on the implementation of a nationwide Renewables Portfolio Standard (RPS). RPS is a "minimum content requirement", which specifies that a certain minimum percentage of electric power must be generated from renewable energy sources (wind, solar, and others). Typically, RPS legislation provides that the minimum percentage increase gradually over time to encourage the sustained, orderly development of the renewable energy industries.

Renewable Energy Credits ("RECs") are central to the RPS. A REC is a tradable certificate of proof that one kWh of electricity has been generated by a renewable-fuelled source and sold to an end-user in the state. RECs are denominated in kilowatt-hours (kWh) and are a separate product from the power itself. Each credit is proof of actual generation and sale of renewable electricity - not merely proof of capacity. The RPS boils down to a requirement that every generator possesses a number of RECs equivalent to a determined percentage of its total annual kWh generation (or sales). For example, if the RPS is set at 5%, and a generator sells 100,000 kWh in a given year, then it would need to possess 5,000 RECs at the end of that year.

For generators that fall short of the required number of credits at the end of the reporting period, an automatic penalty for non-compliance is assessed. The amount of the penalty is three times what it would have cost to purchase each REC that the generator should have acquired. This penalty is estimated to be about 3¢ to 5¢ per REC high enough to encourage full compliance, yet not so high as to encourage litigation. The high penalty level is intended to make the policy self-enforcing by avoiding the need to resort to costly administrative and enforcement measures.

The U.S. Senate approved the Renewables Portfolio Standard (RPS) as part of the Energy Bill S. 217 in 2002. However, the Energy Bill which had passed the House of Representative (H. R. 4) had no similar RPS included. A new Energy Bill has been introduced in the current 108th session of Congress. Currently there is an on-going debate about the role of a nation-wide RPS.

4.2.1.2 The State Level

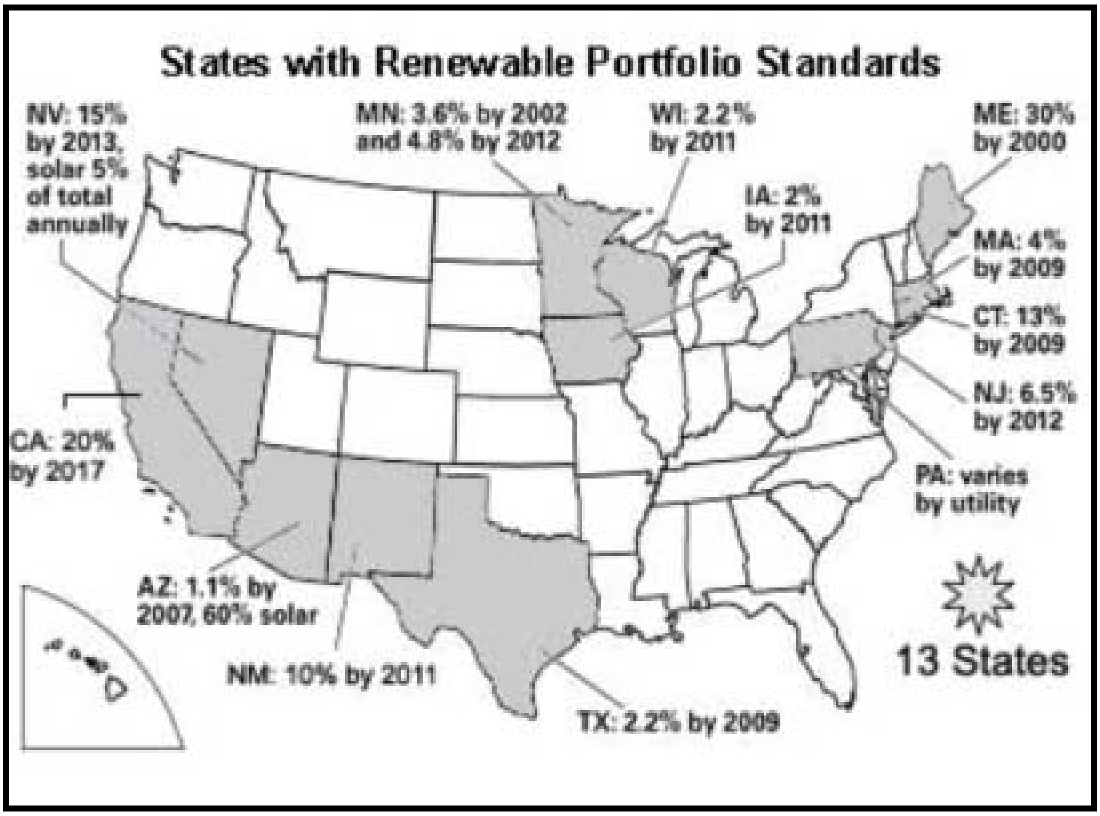
A significant number of state policies have been implemented to support renewable energy development, specifically wind power. The policies identified, described and evaluated here do not represent an exhaustive list of these policies, they do cover most of the basic strategies that have been used or considered at the state level. Many variations and combinations of these policies are possible. There are four main categories of state incentives:

- Renewable Portfolio Standards
- tax incentives,
- direct cash incentives, and
- low-cost capital programmes.

Renewable Portfolio Standards

The mechanism of Renewable Portfolio Standards has been discussed already in the previous chapter. Even before a national legislation has become effective, some states already introduced renewable portfolio standards on their own. Currently there are 13 states with such a scheme, among them California and Texas. The stringency of the standards and the time horizon greatly differs between the states. The highest attention received the RPS of California, which mandates that a 20 % renewable standard is reached in the year 2017.

Figure 4.2-1: Renewable Portfolio Standards in the U.S.



Source: UCS 2003

Tax Incentives

Among the tax incentives, a production tax credit (PTC) provides the investor or owner of qualifying property with an annual tax credit based upon the amount of electricity generated by that qualifying facility. By focusing on energy produced, not capital invested, this type of tax incentive encourages projects that perform adequately. For this reason, PTCs now are widely considered to be a more effective support mechanism than investment tax credits (ITCs), especially for large installations of relatively mature technologies.

Tax credits have been a traditional government approach to supporting social or economic policy objectives. Renewable energy tax credits can enhance after-tax cash flows and, therefore, support investment. Specifically, state production tax credits could be used to stimulate wind development by reducing state income taxes. Although production tax credits traditionally have been more popular than investment tax credits, the Energy Policy Act of 1992 established PTCs (many have opted instead for investment tax credits), but state legislatures have the authority to implement PTCs.

Investment tax credits for renewable energy projects can support investment by enhancing after-tax cash flow. Historically, investment tax credits (ITC) have been one of the predominant approaches taken at the state and federal levels to stimulate renewable energy development. Specifically, state ITCs can be used to increase wind development by reducing the state income tax burden of wind project. The tax credit can be used in the first year of production, or it can be spread over a number of years.

Reductions in state sales taxes can be used to support wind development by decreasing the tax burden (i.e., the tax payment per kWh of electric production) associated with owning a wind power facility, in general due to their high capital costs and low operational costs, the per-kWh sales tax burden on renewable energy facilities is high relative to fossil-fuel-fired facilities. This is because the fossil fuel inputs to generation facilities generally are exempt from sales taxes, whereas sales tax is paid on wind turbines and other equipment.

State and local sales taxes apply to the transfer or exchange of energy, material and land assets (although wind development land is leased in most cases, not purchased). These taxes vary by states and country, but the total tax rate typically ranges between 4 and 8 %. Sales tax incentives can be in the form of full exemptions of reductions in tax rates and could be applied to utility scale and small-scale residential wind systems. Exempting renewable energy facilities from sales taxes or reducing the tax rates can decrease the installed and levelised cost of wind power. State legislatures have the authority to implement these policies. The enactment, implementation and enforcement of such policies may occur independently of electric industry structure and regulation.

Reductions in property taxes can also be used to support wind development by decreasing the tax burden (i. e., the tax payment per kWh of electricity production) associated with owning a wind power facility. In the case of a California hybrid gas/solar-thermal facility, the difference amounted to the solar plant paying more than four times the level of taxes paid by a 100 percent gas-fired plant. The impact would be less for a wind facility today, given its lower cost relative to solar thermal plants. Still, property taxes can represent a more significant cost than sales taxes, depending upon the relative tax rates and assessment methods.

Direct Cash Incentives

Direct cash payments could take the form of investment or production incentives, similar in nature to investment tax credit (ITC) and production tax credits (PTCs), but without a tax basis. Production incentives supply project owners with a direct cash subsidy or price support payment based upon electricity production, not capital investment, and therefore provide the correct incentives for project performance.

For this reason, production incentives typically are considered to be a more effective support mechanism than investment incentives, especially for more mature technologies, such as wind. State production incentives can be used to encourage wind development by reducing the levelized cost of a wind power project.

Although analogous to the PTCs discussed earlier, providing payment through a direct cash incentive rather than through equivalent sized reductions in income taxes provides three primary benefits:

- First, the inability of investors to absorb the full value of a production tax credit is an important barrier to the effective use of tax incentives to support renewable energy development. A direct cash payment has no similar.
- Second, due to the nature of tax credits, they are a benefit to equity investors only, and do not help projects sustain debt. A direct cash incentive, on the other han , would increase revenue directly, allowing more low-cost debt in the capital structure and making equivalent direct cash incentives more powerful than income tax credits.
- Third, unlike PTCs, direct cash payments could be provided to taxable and non-taxable entities (e.g. municipal utilities), therefore ensuring some degree of competitive neutrality.

Another form of subsidisation are direct investment incentives. Although tax incentives for renewable energy projects can enhance after-tax cash flows and therefore support investment, a more direct cash payment would give project developers and owners additional benefits compared to an equivalently sized tax incentive. First, the inability of investors to absorb the full value of a tax credit is a substantial barrier to the effective use of tax incentives to support renewable energy development. A direct cash payment has no similar problems. Second, unlike tax incentives, direct cash payments could be provided to taxable and non-taxable entities, therefore ensuring some degree of competitive neutrality. Third, direct cash payments can be made even more powerful through cost sharing, where the government pays part of plant costs directly, because the private investors would not pay taxes on the cost-shared portion.

Low-Cost Capital Programmes

Low cost capital programmes, e.g. in the form of government-subsidised loans, are important because debt costs significantly affect the cost of energy from wind power systems. Utility-scale wind system debt interest rates are frequently one to two percentage points higher than rates for gas-fired projects, and projects without a secure revenues stream typically are incapable of obtaining debt financing. Smaller-scale (residential, agricultural or commercial) renewable energy facilities can be affected even more by loan terms and conditions because of the higher installed cost per unit of capacity of smaller systems. Private bank loan terms and conditions for these smaller renewable facilities are likely to be even more costly and restrictive than for larger-scale systems.

State governments provide low-cost capital to renewable energy projects to support their development. This can be done directly through a state agency or by making arrangements with private lending institutions, local authorities or electric utilities. Direct loan programmes have taken and can take many shapes, including economic development programmes and green bonds. These programmes can be used to support renewables by providing lower cost debt than is available in the private markets (i. e., lower interest rates or terms that are more favourable). For smaller-scale systems, these programmes also may reduce the transaction costs of arranging a private loan.

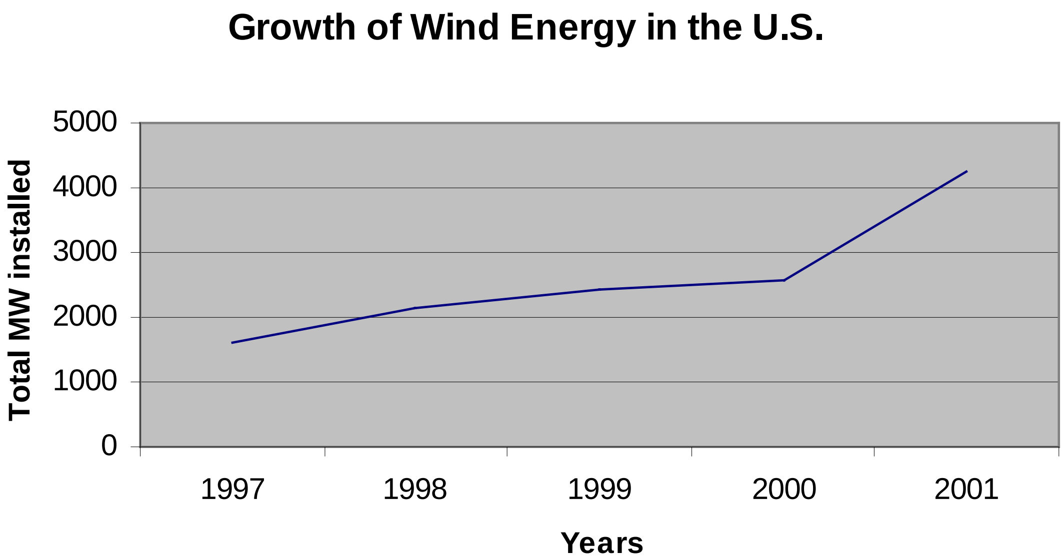
Low cost capital incentives can also take the form of project loan guarantees. Financing costs for renewable energy facilities are substantially higher than those for traditional gas- and coal-fired generation stations. Specifically, utility-scale wind power debt interest rates are often one to two percentage points higher than for gas-fired projects. Additionally, projects without a stable revenue stream guaranteed through contracts often are incapable of obtaining financing. Past unsuccessful projects, poor information about improvements in technology and the market's assessment of fuel and technology risk all are the factors in the higher financing costs of renewable energy projects. Small-scale residential, agricultural and commercial projects, typically financed through bank loans, often are subjected to even higher interest rates.

Project loan guarantees are provided by state governments to reduce the debt costs of wind power developers through an indirect interest rate buy-down. A programme of this type guarantees loan repayment to lenders (banks or institutions) and, therefore, shields the creditors from project risks. In the extreme case, loans simply may not be available without a guarantee for some types of risky wind projects. In this case, loan guarantees provide the assurance lenders need to consider a loan. The cost to the state government of such a programme come from payouts to lenders in the event of project defaults. As security for these guarantees, the guarantor (the state government) would require either a cash pool or explicitly provide security through the government's taxing authority. These guarantees could provide risk insurance for all or a portion of project risks.

4.2.2 Development of Wind Power

In 2001, wind power nearly doubled in capacity in the United States to reach 4,100 MW. Close to 2,000 megawatts of electricity were added, up from 53 MW in 2000 and 732 MW in 1999, according to the American Wind Energy Association. The dramatic increase is largely attributed to a 1.8 cent-per-kilowatt-hour tax credit that wind farm owners and operators can receive.

Figure 4.2-2: Development of installed wind power in the U.S.



Expanded wind capacity has also brought lower costs. Technical improvements in blade design, generator design, and site location continue and the cost of generating a kW-hour of wind power continues to decline. In 1981, the cost of a kWh from a new wind turbine was over $0.35. By 2000, it reached about $0.04, nearly a ninety percent reduction.

Following are the top-ten states for wind power installments in 2002:

(5) California (1,603.95 MW),

(6) Minnesota (273.16 MW),

(7) Iowa (242.39 MW),

(8) Texas (187.22 MW),

(9) Wyoming (73.835 MW),

(10) Oregon (25.1 MW),

(11) Wisconsin (22.98 MW),

(12) Colorado (21.6 MW),

(13) Hawaii (21.06 MW),

(14) New York (18.15 MW).

There are various factors affecting the use of wind power in the different states, such as average wind velocity, or demand for new electricity capacity. However, the existence of different state policies seems to matter too. The major part of the new installments took place in states which have decided to introduce a renewable portfolio standard (compare Figure 4.2-1).

4.2.3 Regulation and Innovation

The federal government's involvement in wind energy research and development began in earnest within two years after the so-called "Arab Oil Crisis" of 1973. Despite the speed with which it was initiated and began to show results, this programme ultimately proved to be largely ineffective because of the interference of political factors and the withdrawal of financial support before success could be achieved.

The U.S. Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy manages the federal wind energy programme in accordance with national energy policy. Wind energy diversifies the nation's energy supply, takes advantage of a domestic resource, and helps the nation meet its commitments to curb emissions of greenhouse gases, which threaten the stability of global climates. There is federal support for comprehensive wind energy research, wind turbine research and development, and for utilities, industry, and international wind energy projects. The DOE's Wind Energy Program is directed by the Office of Wind and Hydropower Technologies under the Assistant Secretary for Energy Efficiency and Renewable Energy. The Wind Energy Program supports this mission by working with members of the wind industry to research and develop advanced, low wind speed turbines that will reduce the cost of wind energy in broader regions of the United States.

The goals of the DOE's wind programme are:

- by 2002 – develop advanced wind turbine technologies capable of reducing the cost of energy from wind to 2.5 cents per kilowatt-hour (in 15 mile per hour winds);
- by 2005 – establish the U.S. wind industry as an international technology leader capturing 25 % of world markets;
- by 2010 – achieve 10,000 megawatts of installed wind-powered generating capacity in the United States.

The federal wind energy programme helps engineers and scientists advance the technology needed to create new wind turbine designs, better understand how to integrate wind into utility systems, and improve U.S. technology to compete in global energy markets. Researchers explore the characteristics of the wind and how wind interacts with a turbine rotor, study the physical and chemical properties of the materials used to make blades and other turbine components, and advance the fundamental scientific principles needed to improve wind technology. As research engineers acquire a deeper understanding of these principles, this knowledge becomes the foundation for computer models and other design tools used to design new technology.

Researchers envision the wind technology that will be required by industry in 10 or 15 years, then plan research projects accordingly. Then, when companies are ready to develop a new turbine, cutting-edge technologies and design tools are ready to help them go to market quickly with new products. The wind industry has neither the time nor the money to invest in long-term basic and applied research.

That is why the DOE has partnered with the U.S. industry (for example, General Electric and Shell) for more than two decades to develop efficient, reliable, cost-effective technologies. The goal of the turbine research conducted at National Renewable Energy Laboratory (NREL) is to assist U.S. industry in developing competitive, high performance wind turbine technology that will compete in global energy markets. Industry partners are selected through competitive solicitations and share in the costs of the project. The National Wind Technology Center (NWTC) researchers work closely with the companies to research, design, build, test and refine advanced large and small wind turbine designs. These public-private partnerships are developing breakthrough technologies that will significantly reduce the cost of wind-generated electricity and, ultimately, expand our domestic renewable energy supply. Wind power was the fastest-growing source of new energy in the 1990s and more reliable and higher quality wind turbines will continue that trend.

There have been various tools developed to help industry build better wind turbines:

- **Computer models:** NREL, Sandia, and university researchers are developing a suite of design and analysis codes that will make it possible for designers to build a new turbine on the computer and refine it for commercialisation without having to build and test prototype turbines.
- **Advanced controls:** NREL is modifying its computer models to include advanced controls. Advanced controls adjust turbine operation to maximise energy production and minimise wear and tear on the machine. In 1998, the laboratory created a new applied research team to lead an effort to develop smart controls for next-generation wind turbines.
- **Adaptive blades:** Adaptive blades, which change shape in response to the wind, could increase turbine performance by as much as 35 %. Sandia researchers are investigating adaptive blade designs for constant- and variable-speed turbines.
- **Advanced research turbines:** A 600-kilowatt wind turbine at the NWTC is the first of several machines NREL will use for experiments to elucidate the basic scientific principles underlying wind power generation. NREL will also use the research turbines to develop advanced components and test promising technolo-

gies that the wind industry is unlikely to pursue because of cost or technical complexity.

- **Certification testing:** NREL's National Wind Technology Center conducts certification testing for new wind turbines. Certification is required in Europe, India, and other major wind energy markets.
- **Standards:** Wind turbine sales abroad depend on American technology complying with international standards. NREL, Sandia, and the American Wind Energy Association are working with international organizations to establish standards for safety, power performance, and blade testing.
- **Technical assistance:** DOE is bringing wind systems to areas where they are most needed by providing technical assistance in wind project planning and implementation. DOE also provides technical assistance for wind resource evaluations and technology development for international projects.

(15)

The federal wind energy programme and its partners in industry and academia play a crucial role in wind energy research, in the development of innovative wind technologies, and in the dissemination of these technologies throughout the world. In recognition of the importance of these efforts, Congress appropriated $34.8 million to support the wind energy programme in fiscal year 2000.

The U.S. Department of Energy's (DOE's) Wind Energy Program is directed by the Office of Wind and Hydropower Technologies under the Assistant Secretary for Energy Efficiency and Renewable Energy. The mission of DOE's Wind Energy Program is to enhance the level of technology development and deployment of the nation's fastest growing and most widely used renewable energy resources.

In 2001, wind power reached 4,100 MW by doubling its capacity in one year. Since 1980, research and testing sponsored by the Wind Program has helped reduce the cost of wind energy from 80 cents (current dollars) per kilowatt-hour (kWh) to between 4 and 6 cents per kWh. The goal of the Wind Energy Program is to further reduce the cost of energy produced by large wind systems to 3 cents per kWh in Class 6 wind resources (average wind speeds of 6.7 meters per second at a 10 meter height) by 2004 and to 3 cents per kWh in class 4 sites (5.8 meters per second at a 10 meter height) by 2010.

4.3 Comparative Analysis and Conclusions

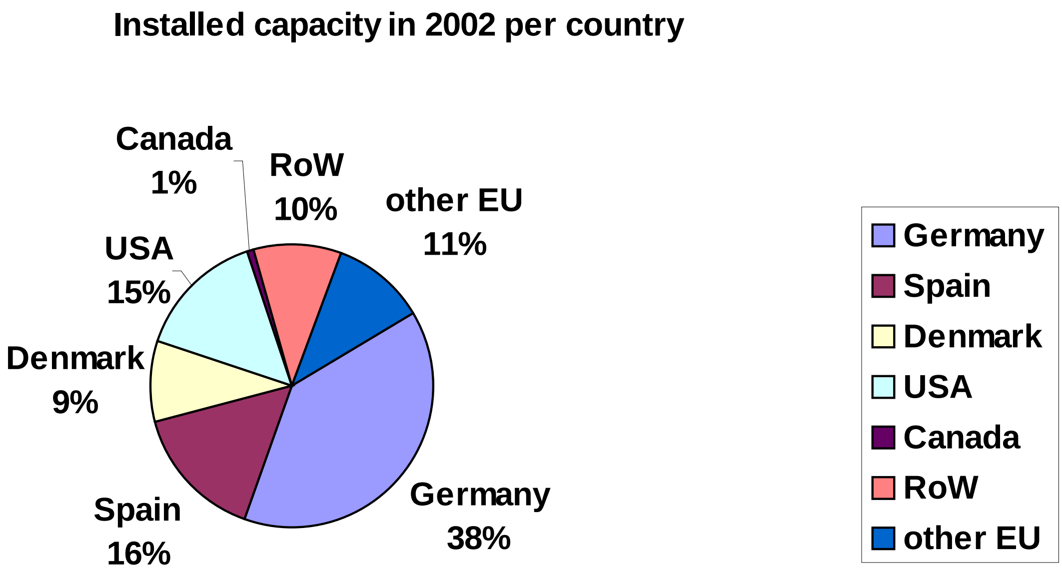
The comparative analysis of the regulatory policies reveals some differences and similarities between the U.S., the EU and Germany in particular. The instrument of R&D policies to spur innovation in the early phase of experimentation is used widely. However, the U.S. was scaling down its effort by about 90 % in the 1980s, marking a substantial break in the continuity of the policy. Furthermore, a substantial part of the California wind energy boom in the 1980s was supplied by Danish firms. Thus, at the beginning of the 1990s, no national wind supply industry existed in the U.S. powerful enough to participate in the world-wide boom to come in the 1990s. In some European countries, however, the R&D policy evolved constantly over time. Thus, even though the strength of the many German actors was rather weak at the beginning of the 1990s, an innovation system for wind energy with a considerable variety and a substantial accumulation of knowledge existed.

This different starting point on the supply side at the beginning of the 1990s was supplemented by different policies to foster diffusion. In the U.S., the primary policy was a subsidy in form of a tax credit, supplemented by a tradable quota system in some states and state subsidies. In some European countries, among them Germany, the main instrument used were fixed feed-in tariffs above the avoided costs of utilities. It is difficult to compare the intensity of subsidisation between the countries. The difference between feed-in tariffs and avoided costs in Germany seems to be larger than the tax credit per kWh granted in the United States. However, for a more complete comparison, the effects of the tradable quota system implemented so far and the state subsidies would have to be included on the U.S. side. Thus, it can be argued that the intensity of subsidisation will narrow down substantially in a more complete analysis.

Probably more important than differences in the intensity of subsidisation might be the predictability of the paybacks in schemes using fixed feed-in-tariffs (e.g. Germany and Spain in Europe) and countries, which use tradable quota systems (e.g. the United States and a few European countries such as the UK, Ireland and Italy). The analysis for Germany and the U.S., which also stand as representative for the two different schemes, both revealed that the predictability of paybacks was identified as a key for the availability and cost of capital to the investors. In contrast to the situation in the U.S., investors under a fixed feed-in-tariff scheme are able to present predictable paybacks for their investments to the financial institutions. The analysis revealed that German investors are much more likely to receive private funds at normal capital costs compared to the investors in the U.S., who are much more likely to be paying premium capital costs. This also helps to explain some of the differences of wind power development within the EU. The difference between both schemes might even become more important if the volatility of the electricity prices increases with liberalisation of the electricity markets.

The detailed comparison of the diffusion process in Germany and the U.S. reveals the importance of both the differences in the functioning of the innovation system from the 1980s onwards and the effects of the regulation. Compared to Germany with a mere of 20 MW installed at the end of 1989, the U.S. clearly seemed to have the lead in the diffusion of wind power in the 1980s. However, the situation changed dramatically in the 1990s. The U.S. did not participate in the take-off of wind power as much as some European countries. Germany, in contrast, had an enormous take off in the 1990s taking the lead in world installations. Indeed, Germany already installed more than 10,000 MW leading the world in total MW of wind power installed. Given the difference in the size of the countries, it can be argued that the U.S. at present is lagging substantially behind. The success of the leading European countries was achieved by fixed feed-in tariffs, which were adjusted to the market trends and needs over time (e. g. levelling out between electric utilities, degression of feed-in tariff). In general, the analysis indicates that the predictability of fixed feed-in tariffs used in Germany, Spain and for a long time in Denmark stimulates market growth more than the alternative instruments of direct subsidisation and quota systems used for example in the United States.

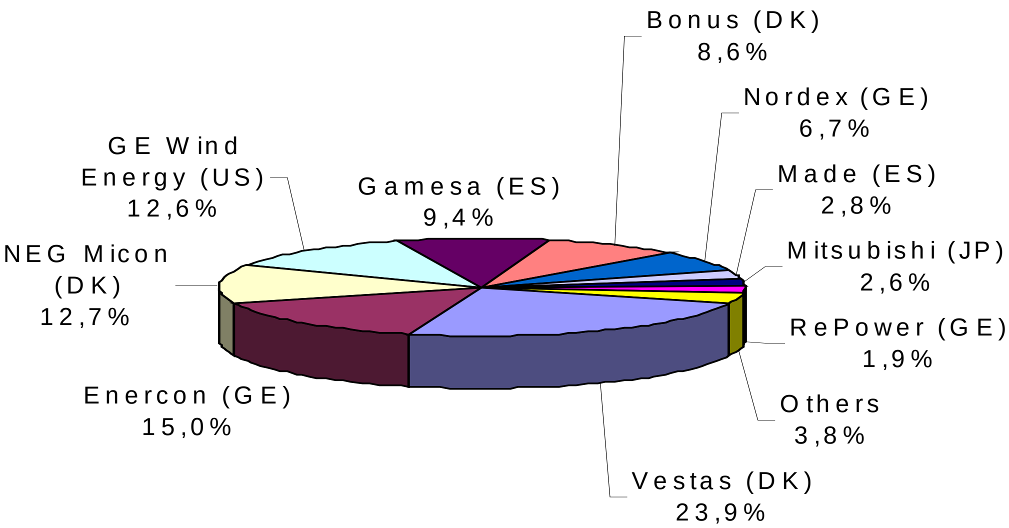
Figure 4.3-1: Shares of installed wind capacity in 2002



Source: AWEA/ EWEA.

The phase of market expansion in Germany led to virtuous circles which let German producers catch up with the Danish ones. Furthermore, the relatively high political weight attributed to environmental issues such as global warming increased the legitimacy of wind power and gave additional guidance for the direction of research. In sum, the German innovation system of wind power had a high functionality during the take-off phase in the 1990s. The result was that, at the beginning of this century, companies in Germany and Spain joined the Danish ones as key players in worldwide wind turbine supply (Figure 4.3-2).

Figure 4.3-2: Market shares of the suppliers of wind turbines world-wide in 2001



Source: Ender 2002b, p. 28.

Table 4.3-1 Annual installations of wind turbines in MW in different countries

Country	1997	1998	1999	2000	2001	2002
Germany	529	812	1586	1665	2627	3247
U.S.	29	577	477	165	1635	410
Spain	116	368	932	1024	1050	1493
Denmark	200	310	325	603	115	497

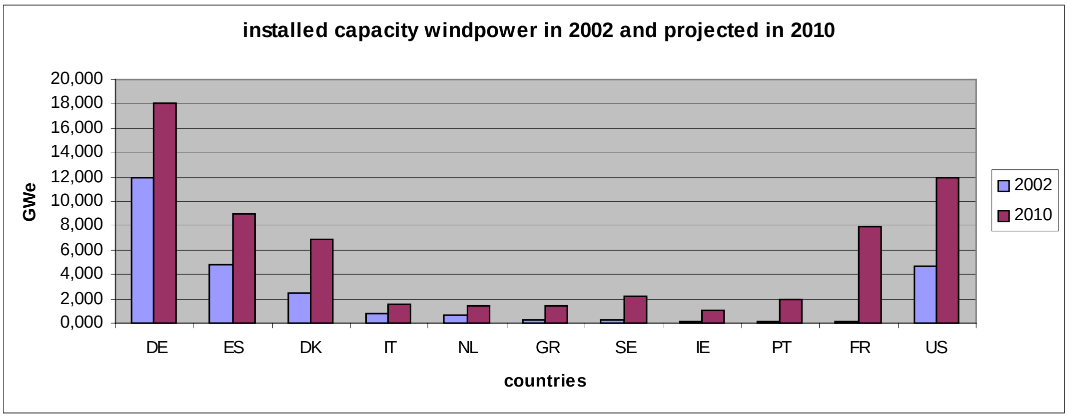
Source: BTM consult, AWEA and EWEA.

The future of wind power in the different countries is difficult to forecast. It depends, among others, on the market strategies of the actors involved and especially on the policies implemented. Within the European Union, some countries have introduced new policies. In France, for example, it can be expected that the introduction of the fixed deed-in-tariff scheme will lead to an expansion of wind power. For the U.S., one crucial point will be the nation-wide implementation of the Renewable Portfolio Standard.

Some indications about a likely outcome for the year 2010 are shown in Figure 4.3-3. The numbers for the European countries are based on the forecasts performed in the EU project PRETIR (2002), assuming that the policies listed in Table 4.1-1 are implemented. The numbers for the U.S. were forecasted from the U.S. Energy Information Service (2003) calculating the effects of a nation-wide 10 % Renewable

Portfolio Standard to be phased in until 2020. The numbers quoted apply for the year 2010.

Figure 4.3-3: Projections of installed wind power for different countries



source: data from AWEA, EWEA, PRETIR, EIA

The results from the forecasts seem to imply some catching up of countries which have implemented new policies, such as France. However no substantial change in the lead of the EU over the U.S. can be observed. Nevertheless, the development of the past 25 years has shown that reversals in the world leadership of wind power are possible to achieve. Thus, it will take additional efforts to continue the European success story of the last 15 years in the long run. There are indications that the role of the U.S. in the world market might become more important. The take-over of the German producer Tacke by GE Wind has formed an important German-American player. A law suit pending before U.S. patent courts between GE Wind and its competitors can also be interpreted as an attempt to close the growing American market for the European companies. Perhaps most important, however, are the indications from the long-term R&D policy. If the U.S. is successful in linking basic research and application as stated in their R&D programmes, they might be better suited to tackle some of the key challenges lying ahead. This could substantially improve their relative technological competitiveness, unless the European countries are travelling the same road.

5 Summary and Conclusions

With the economic slowdown of the early 2000s, the analysis of the interaction between regulation and innovation has become even more important than before. Clearly, environmental problems are one of the most prominent causes for regulation. Thus, the question arises what was the role of environmental regulation was in shaping new markets with new innovations.

There are different starting points for such an analysis. Environmental regulation, in almost every country, predominantly took the form of command and control policies. It is argued that such a policy design is rather harmful to innovations, compared to market-based instruments such as emission taxes or tradable certificates. Thus, in that view, the relationship between innovation and regulation depends on the policy design. However, there are other approaches which play down the importance of the design of policy instruments. They are based on the concept of innovation systems and the importance of so-called soft context factors such as the existence of long-term policy goals or the style of regulation. Here the functioning of the system, consisting of all relevant players from R&D institutions over suppliers and users of technology until the end consumers, and their interactions among each other, decides on the level of innovation.

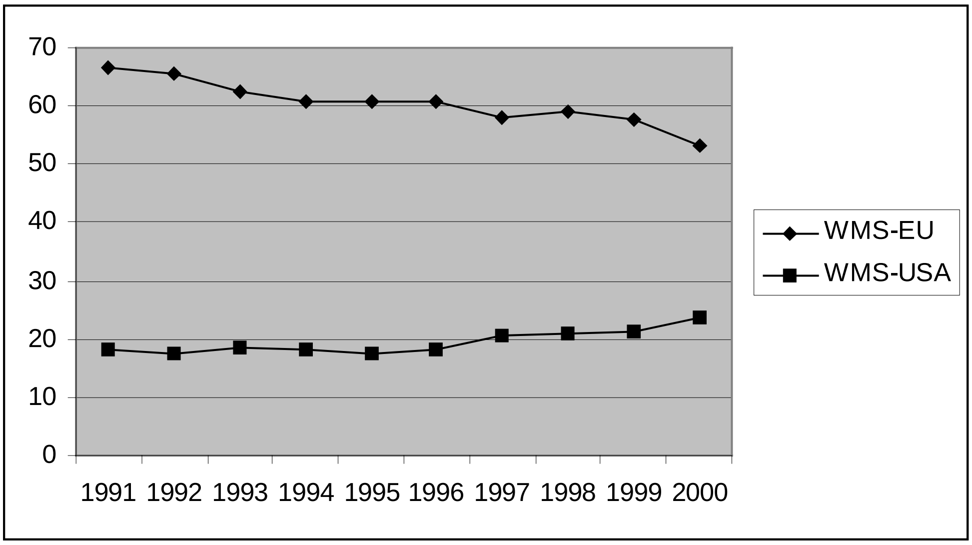
In this report, starting from an overview about the environmental regulatory regime, the relationship between regulation and innovation has been analysed for the two cases water policy and wind power. In order to broaden the analysis, the EU perspective was contrasted with the U.S. perspective. For the European perspective, a special reference to Germany was made.

The environmental regulation in the U.S., Europe and Germany shows various similarities. The increase in environmental regulation in the 1970-1980s was caused in both countries by an increasing public awareness in several fields of environmental protection. In addition, general environmental statutes and regulations applicable to all areas of environmental protection were passed since the late 1980s onwards, concerning environmental impact assessment, environmental liability, or the availability of environmental information. Furthermore, market-based instruments are gaining more importance. Nevertheless, most countries were and still are emphasising command and control policies to counteract environmental problems. However, there are some differences in the emphasis of the different approaches available. In Germany, application of the concept of "best available technology" (BAT) has been widely used. Together with a certain flexibility about how to interpret BAT by the decentralised bodies implementing the regulation, this allows a continuous increase in requirements if technological progress occurs. In the U.S., however, the legislation focuses more on emission limits which gives less flexibility to the government body implementing the regulation.

Comparing the innovations which have been taking place requires the use of innovation indicators such as patents and output indicators (e. g. world market shares, Revealed Comparative Advantage). The analysis of environmental patents shows two important characteristics. First, in contrast to the U.S., Japan and Italy, which have below average patents in environmental technology, Germany, Sweden and Canada have been specialising in environmental technologies. Other important European suppliers of environmental technology such as France, UK, and the Netherlands do not show a clear specialisation pattern. Second, for the U.S. and Germany, the specialisation in environmental technologies has been substantially lower in the second half of the 1990s than in the first half reflecting that the share of environmental patent applications out of all European patent applications decreased about 20 % after a peak in the early 1990s.

The data on the world market shares show that the U.S. with 23.6 % and Germany with 16 % were the leading countries. In sum, the EU accounted for 53.2 %. The data on the Revealed Comparative Advantage show that the U.S., and some EU countries such as Spain, Germany, UK, Italy, and Denmark have been specialising in environmental technologies. However, interpreting the data on innovation output, the change over the years also is important. Here, it is interesting to see that the position of Germany as world leader of environmental exports at the end of the 1980s has been somewhat diminished during the 1990s, even though the relative specialisation has remained about the same. Furthermore, the world market share of all EU countries has been reduced from 1991 to 2000.

Figure 5-1: World Market Shares for environmental technologies for European Countries and the U.S.



Source: data from Legler et al. 2002

To sum up the arguments, environmental regulation has been established in Europe and the U.S. following the increasing pressure on the environment and its perception by the public during the 1960s and 1970s. Together with making regulations stricter in the 1980s, this has worked towards an increase in environmental innovations, as indicated by various innovation indicators. However, taking both the development of the patents and the output innovation indicators since the late 1980s together, two possible lines of arguments can be deducted.

- The reduction of the patent specialisation for both Germany and the U.S. in the late 1990s can be interpreted as a reduced innovation dynamics of environmental technologies. Thus, after the establishment of new regulations in the 1980s had led to comparatively high innovation dynamics, the lessening of additional requirements in the 1990s led to comparatively lower efforts in the 1990s. Nevertheless, this also supports a positive relationship between environmental regulation and innovation.
- Another line of argument is based on the changes in environmental strategies. During the 1990s, the so-called integrated environmental technologies have become much more important, partially replacing end-of-pipe technologies. However, the innovation indicators mainly reflect changes in end-of-pipe technologies. Indeed, the reduction in patent specialisation for Germany and the U.S., and also in overall world market shares in environmental technology for the EU countries might reflect a switch to new paradigms of environmental policy, which do not typically fall under the heading of conventional environmental technology.

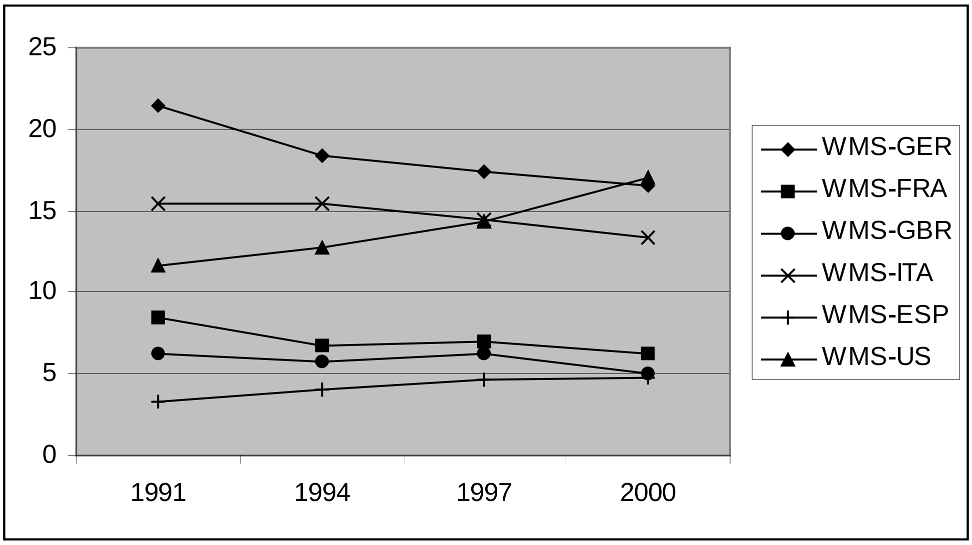
The water sector can be characterised as a sector with environmental technologies which are until now rather typical for conventional environmental technologies. Thus, the relationship between environmental regulation and innovation at wastewater treatment plants is typical for incremental innovations along an existing technological paradigm, which are covered rather well with the existing data on innovation indicators.

The German Federal Water Act and the U.S. Clean Water Act form the basis of water policy in the respective country. Both were enhanced and amended in the 1970s and 1980s. In 1977 U.S. industries had to install "best practicable control technology" (BPT) to clean up wastewater discharges and U.S. municipal wastewater treatment plants were required to meet an equivalent goal, i. e. secondary (biological) treatment. In 1989 the industry had already to use the economically achievable best available technology (BAT), because the act required now a greater pollutant cleanup than BPT. In Germany, an amendment of § 7 a Federal Water Act in 1986 intensified the standards, especially for hazardous substances.

To sum up the argument, in both countries the foundations of the environmental regulation in the water sector were developed in the 1970s and made stricter in the 1980s. Thus, the broad development of environmental regulation of the water sector was rather similar between the two countries. The German and the U.S. innovation system are also influenced by R&D policies, with a number of government programmes existing in both countries.

Both countries were important exporters of wastewater treatment technologies at the end of the 1980s. The World Market Share shows the share in exports of water technology of a country out of the exports of all OECD countries. With a little over 20 %, Germany's world market share in wastewater treatment technologies was about equal to its overall share in environmental technologies. For the U.S., the share of 10 % of wastewater treatment technologies was a little bit lower than its share in all technologies. Germany, France, Great Britain and Italy lost World Market Shares, whereas Spain and the U.S. enhanced their World Market Shares in water technologies.
(16)

Figure 5-2: World Market Shares of water protection technologies of selected European Countries and the U.S.



This strong position clearly was influenced by the environmental regulation. The development of environmental patents in the 1980s for Germany clearly shows a strong increase in the 1980s. However, it was not only the regulation with command and control policies which pushed this development. The German emission charge on wastewater, with increasing tax rates until the early 1990s, also contributed to that effect. Furthermore, long-term policy goals were also very important in Germany providing continuous guidance for the development of water protection technologies.

For Germany, the innovation indicators in the 1990s still show a high specialisation for wastewater treatment, but the figures have been decreasing. The detailed analysis has also shown that most of the innovation challenges can be traced back to the national regulations during the 1980s. Thus, with few exceptions, the requirements from the EU Urban Waste Water Treatment Directive did not lead to a new strong impulse from regulation. The technological basis, R&D policies, the need to increase water quality in East Germany, plus the elaboration of regulations along existing technological trajectories were strong enough to allow continuity of specialisation at wastewater treatment technologies, but rather with somewhat declining specialisation. Definitely German industry was not able to fully participate in the diffusion of wastewater treatment technology in other countries during the 1990s. Thus, in the 1990s, Germany was not able to fully exploit the role as lead market of wastewater technologies it had acquired during the 1980s. The U.S. in contrast, was able to increase its world market share during the 1990s, even though it did not specialise on patenting in this area.

In Chapter 1, it has been argued that innovation is a complex process which does not follow simple stimulus response mechanisms. Indeed, the following arguments in particular are important to explain the innovation process in the water sector in addition to the development of environmental regulation:

- The water sector has been traditionally viewed as a natural monopoly; public ownership, protection of service areas, and price regulation are important aspects which are sometimes associated with lower competitive pressure on innovations.
- Particularly for Germany, the standardisation organisations in the wastewater sector form very important bodies for R&D spillovers. Nevertheless, it also has been shown that the innovators from the machinery and appliances industries are less integrated in the standardisation process than the rather traditional experts from civil engineering.
- In Germany and the U.S., the wastewater treatment institutions are usually locally based, and even restricted to local activities. Thus, they have little incentive or even possibility to engage in the world market.
- Taken together, these aspects help to explain why there is an excellent technological basis in Germany on the one hand, which is, however, not fully reflected in the world market on the other.
- Furthermore, it has to be kept in mind that the innovations discussed so far have been mainly along the traditional trajectory of wastewater treatment. Indeed, there are some new challenges arising from the EU Water Framework Directive which might go beyond the traditional technological path, e. g. with regard to the development of new products and technologies in order to tackle new immission paths not previously considered. Furthermore, new concepts of the water sector employing decentralised technologies and leading towards a new paradigm are getting more and more attention (Hiessl et al. 2003). The strategy of a decentral-

ised water sector not only poses new challenges for the development of innovative technologies, but also opens up the perspective of supplying the world market with concepts also appropriate for developing countries, which will form an important part of the world market demand for wastewater concepts in the future. It remains to be seen whether or not EU countries will be among the first movers seizing these opportunities.

Wind power can be interpreted as a new technological paradigm competing with conventional electricity generation. At the same time, even though these changes are motivated also from the environmental side, they are very different from the environmental technologies such as scrubbers which were used at power stations in the 1980s and which have been covered by the innovation indicators under the heading of air pollution.

The comparative analysis of the regulatory policies reveals some differences and similarities within the EU in general and between Germany and the U.S. in particular. Both countries used the instrument of R&D policies to spur innovation in the early phase of experimentation. However, the U.S. scaled down its effort by about 90 % in the 1980s, marking a substantial break in the continuity of the policy. Furthermore, a substantial part of the California wind energy boom in the 1980s was supplied by Danish firms. Thus, at the beginning of the 1990s, no national wind supply industry existed in the U.S. powerful enough to participate in the world-wide boom to come in the 1990s. In Germany, however, the R&D policy evolved constantly over time. Even though the strength of the many German actors was rather weak at the beginning of the 1990s, an innovation system for wind energy with a considerable variety and a substantial accumulation of knowledge existed.

This different starting point on the supply side at the beginning of the 1990s was supplemented by different policies to foster diffusion. In the U.S., the primary policy was a subsidy in form of a tax credit, supplemented by a tradable quota system and state subsidies. In Germany, like in other European countries, the main instrument used were fixed feed-in tariffs above the avoided costs of utilities. It is difficult to compare the intensity of subsidisation between the countries. The difference between feed-in tariffs and avoided costs in Germany seems to be larger than the tax credit per kWh granted in the U.S. However, for a more complete comparison, the effects of the tradable quota system and the state subsidies would have to be included on the U.S. side. Thus, it can be argued that the intensity of subsidisation will narrow down substantially in a more complete analysis.

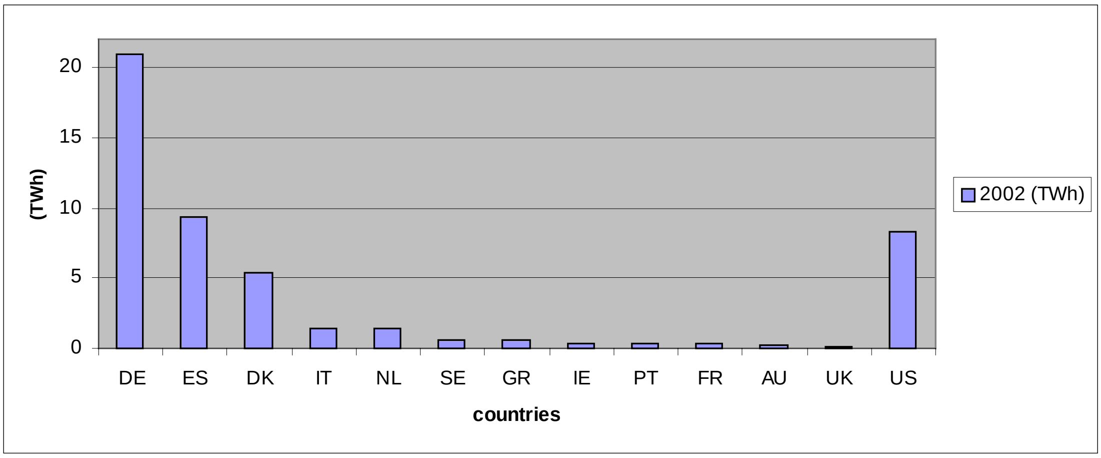
The comparison of the innovation process reveals the importance of both the differences in the functioning of the innovation system from the 1980s onwards and the effects of the regulation. Compared to Germany with a mere of 20 MW installed at the end of 1989, the U.S. clearly seemed to have the lead in the diffusion of wind power in the 1980s. However, the situation changed dramatically in the 1990s. The

U.S. did not participate in the take-off of wind power as much as some European countries. Germany, in contrast, had an enormous take-off in the 1990s, taking the lead in world installations. Indeed, Germany already installed more than 10,000 MW leading the world in total MW of wind power installed. Given the difference in the size of the countries, it can be argued that the U.S. at present is lagging substantially behind. The German success was achieved by fixed feed-in tariffs, which were adjusted to the market trends and needs over time (e. g. levelling out between electric utilities, degression of feed-in tariff). In general, the analysis indicates that the predictability of fixed feed-in tariffs used for example in Germany, Spain and for a long time in Denmark stimulates market growth more than the alternative instruments of direct subsidisation and quota systems used for example in the United States and the UK.

The phase of market expansion in Germany led to virtuous circles which let German producers catch up with the Danish ones. Furthermore, the relatively high political weight attributed to environmental issues such as global warming increased the legitimacy of wind power and gave additional guidance for the direction of research. In sum, the German innovation system of wind power had a high functionality during the take-off phase in the 1990s. The result was that, at the beginning of this century, the German companies together with the Danish and Spanish ones emerged as key players in wind turbine supply.

The generation of electricity from wind power has been steadily increasing in the past. In 2002, Germany was leading generation followed by Spain, the U.S., and Denmark. The future of wind power in the different countries is difficult to forecast. It depends, among others, on the market strategies of the actors involved and especially on the policies implemented. Within the European Union, some countries such as France have introduced new policies most likely leading to an expansion of wind power. For the U.S., one crucial point will be the nation-wide implementation of the Renewable Portfolio Standard. The results from forecasts for the year 2010 seem to imply some catching up of countries newly implementing policies. However, in the short run, no substantial change in the lead of the EU and even Germany alone over the U.S. is likely to occur according to these forecasts.

Figure 5-3: Generation of electricity from wind power in 2002



generation calculated with normalised wind velocity

However, the development of the past 25 years has shown that reversals in the world leadership of wind power are possible to achieve. Thus, it will take additional efforts to continue the European success story in the medium to long run. The development of the last few years indicate that wind power is expanding in the U.S. too. Furthermore, there are indications such as take-overs and strategies to protect the North American market which indicate that the role of the U.S. in the world market might become more important. Perhaps most important, however, are the indications from the long-term R&D policy. If the U.S. is successful in linking basic research and application as stated in their R&D programmes, they might be better suited to tackle some of the key challenges lying ahead. This could substantially improve their relative technological competitiveness, unless the European countries are moving into the same direction.

Reflecting on the results of the analysis performed, several conclusions can be drawn:

- The results indicate that environmental regulation indeed has fostered environmental innovations. The analysis also demonstrates that the technological lead can change in rather short time frames. In the field of traditional water technologies, in the 1990s Germany lost some of the technological advantage it had acquired at the end of the 1980s. However, in the field of wind power, Germany has caught up with the leading Danish firms at the same time and leads world development right now.
- Integrated environmental technologies, decentralised water systems technologies, and renewable forms of electricity supply form new technological paradigms which differ from incremental innovations along existing technological paths such as conventional wastewater treatment or conventional power stations.

In order to reach or keep world leader status in environmental technologies, it is necessary to establish lead market positions at these new paradigms. This emphasises the need for R&D policies and transition management policies, which in the early phases of technology development create variety among technological solutions and strategic technological niches, and for environmental regulations which help form a mass market in the later stages.

- Various aspects proved to be very influential in deciding on the innovative effects of environmental regulation: the existence and performance of economic regulation, the institutional processes which determine the interaction between R&D institutions, suppliers of technology and users to create knowledge spillovers, or the existence of long-term policy goals such as water quality class II in Germany or the doubling of renewable electricity supply in the EU, which help to guide the search processes. Thus, the analysis clearly supports the approach to analyse innovation processes within a systems approach.
- The design of instruments matters for the effects on innovation in various ways: within the design of command and control policies (e. g. mechanisms to increase the requirements), within the design of economic instruments (e. g. the importance of fixed feed-in tariffs), and between the different forms of instruments (e. g. the supportive function the German emission charge on wastewater had). However, there is no easy solution favouring one instrument design only.

In general, the analysis emphasises the need to investigate possibilities for regulatory improvement (Fischbeck/Farrow 2001). However, with different instruments used in parallel, this task gets even more complicated because the different interaction effects between the instruments must be accounted for (Gunningham/Grabosky 1998). There is a certain path dependency of policy-making, which constrains the implementation of new instruments, and which makes it necessary to search for transition strategies (Walz/Betz 2003). Perhaps the approach of innovation systems and the debate on transition management of large technological systems – e.g. the creation of technological niches – could also give interesting input into the future analysis of policy instrument innovations and regulatory improvements.

References

Angerer, G. et al. (1996): Einflüsse der Forschungsförderung auf Gesetzgebung und Normenbildung im Umweltschutz, Heidelberg, Physica.

ATV (1991): Arbeitsblatt A 131. Bemessung von einstufigen Belebungsverfahren ab 5,000 Einwohnerwerten, St. Augustin: Gesellschaft zur Förderung der Abwassertechnik e. V. (GFA).

ATV (1992): Arbeitsblatt A 202. Verfahren zur Elimination von Phosphor aus Abwasser, St. Augustin: Gesellschaft zur Förderung der Abwassertechnik e. V. (GFA).

Barde, J. P. (1992): Economique et Politique de l'Environnement, Paris: Presses Universitaires de France.

Barde, J. P. (1995): Environmental Policy and Policy Instruments, in: Folmer H., Gabel L. and H. Opschoor (eds), Principles of Environmental and Resource Economics. A Guide for Students and Decision Makers, Cheltenham, UK and Lyme USA: Edward Elgar, p. 201-227.

Bergek, A.; Jacobsson, S. (2003): The Emergence of a Growth Industry: A Comparative Analysis of the German, Dutch and Swedish Wind Turbine Industries, in: Metcalf, S; Cantner, U. (eds): Change, Transformation and Development. Physica-Verlag: Heidelberg, pp. 197-227.

BMU (2000a): The ecological tax reform. URL: http://www.bmu.de/english/fset 800. htm, loaded 14 August 2001.

BMU (2000b): Act on Granting Priority to Renewable Energy Sources (Renewable Energy Sources Act), EEG.

Böhm, E., Hiessl, H., Hillenbrand, T. (1998): Effektivität und Effizienz technischer Normen und Standards für kommunale Umweltschutzaufgaben am Beispiel der kommunalen Abwasserentsorgung.

Brauch, H. G. (1996): Forschung, Entwicklung, Markteinführung und Exportförderung für erneuerbare Energien in den USA, in: Brauch, H. G. (ed.): Energiepolitik. Springer: Heidelberg 1997, 15, pp. 221-242.

Carlsson, B. et al. (2002): Innovation systems: analytical and methodological issues, in: Research Policy, Vol. 31.2002, S. 233-245.

Carlsson, B.; Stankiewicz, R. (1995): On the Nature, Function and Composition of Technological Systems, in: B. Carlsson (ed): Technological Systems and Economic Performance: The Case od Factory Automation. Dordrecht: Kluwer Academic Publishers.

Copeland, C. (1999): Clean Water Act. Summaries of Environmental Laws Administered by the EPA. Washington, DC: National Council for Science and the Environment.

Durstewitz, M (2003): ISET. EXTOOL – EXCETP 6 – Workshop, January 2003: Experience Curves for Wind and Observed Cost Reductions. Paris: International Energy Agency [pdf].

Edquist, Ch.; McKelvey, M. (eds) (2000): Systems of Innovation. Growth, Competitiveness and Employment, Cheltenham: Elgar Reference Collection.

Ender, C. (2002a): Wind energy use in Germany – Status 30.06.2002, in: DEWI Magazin no. 21 August 2002, pp. 10-23.

Ender, C. (2002b): International Development of Wind Energy Use – Status 31.12.2001, in: DEWI Magazin no. 21 August 2002, pp. 24-30.

Environmental Law Institute (1997): The United States Experience With Economic Incentives in the Environmental Pollution Control Policy, Washington, DC.

European Commission (2003): Integrated Product Policy; Commission outlines its strategy to stimulate greener products, IP/03/858, Brussels, 18 June 2003.

EPA (2000): Project XL: Encouraging Innovation, Delivering Results, United States Environmental Protection Agency, Office of Policy, Economics, and Innovation EPA100-K-00-001.

Fachgruppe Wasserchemie (1978): Hauptausschuss "Phosphate und Wasser": Phosphor-Wege und Verbleib in der Bundesrepublik Deutschland, Weinheim: Verlag Chemie.

Fischbeck, P. S.; Farrow, R. S. (eds) (2001): Improving Regulation. Cases in Environment, Health and Safety, Resources for the Future Press, Washington D.C.

FME – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, (2001a): Water Resources Management in Germany – Part 1 Fundamentals, Wuppertal, October 2001.

FME – Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, (2001b), The German Water Sector – Policies and Experiences, Berlin, Bonn and Witten, October 2001.

Georgia Department of Natural Resources Environmental Protection Division (2002): Rules and Regulations for Water Quality Control, Atlanta, Georgia.

Goldstein, A. (1999): EPA gets tough on states' dirty waters", Washington Post, August 15, 1999.

Grupp, H. (1999): Umweltfreundliche Innovation durch Preissignale oder Regulation? Eine empirische Analyse für Deutschland, in: Jahrbücher für Nationalökonomie und Statistik, No. 5/6, pp. 611-631.

Gunningham, N: Gabrosky, P. (1998): Smart Regulation: Designing Environmental Policy, Oxford, U.K.: Clarendon Press.

Gutermann, P. E., Quigley, D. H. (2001): Drowning in a Sea of Clean Water Act Regulation, The Metropolitan Corporate Counsel.

Hansen, W., Kahlenborn, W., Kraemer, A. R. (2000): National Case Study on Policy Networks and the Implementation of the Urban Waste Water Treatment Directive 91/271/EEC in Germany. Berlin: Ecologic – Centre for International and European Environmental Research.

Hansen, W., Kraemer, A. R. (2000): Development and Requirements of the Urban Waste Water Treatment Directive (91/271/EEC). Berlin: Ecologic – Centre for International and European Environmental Research.

Heaton, G. R. (1998): Technology and Environmental Performance: Leveraging Growth and Sustainability. Worcester, MA: Worcester Polytechnic Institute.

Hemmelskamp, J. (1998): Wind Energy Policy and Their Impact on Innovation – An International Comparison. Seville, Spain: Institute for Prospective Technology Studies.

Hiessl, H. et al. (2003): Alternativen der kommunalen Wasserversorgung und Abwasserentsorgung: AKWA 2100. Technik, Wirtschaft und Politik, Heidelberg: Physica-Verlag.

Hohmeyer, O. (2002): Vergleich externer Kosten der Stromerzeugung in Bezug auf das Erneuerbare Energien Gesetz, Texte des Umweltbundesamts Nr. 06/02, Berlin.

http://www.accepta.com/default.asp. Accessed 5 April 2003.

http://www.epa.gov/safewater/consumer/contam_timeline.pdf. 13 February 2001.

http://www.waterportfolio.com/index.asp Accessed 5 April 2003.

http://www.web4water.co.uk/default.phtml Accessed 5 April 2003.

Industrial Economics Inc. (2000): Preliminary Health Risk Reduction and Cost Analysis, Revised National Primary Drinking Water Standards for Radionuclides, Cambridge, MA.

ISI (1998): Effektivität und Effizienz technischer Normen und Standards für kommunale Umweltschutzaufgaben am Beispiel der kommunalen Abwasserentsorgung. Karlsruhe: ISI Research Reports Volume 33-1998

Jaffe, A. B. et al. (1995): Environmental regulation and the competitiveness of U.S. manufacturing: What does the evidence tell us? In: Journal of Economic Literature, Vol. 33.1995, pp. 132-163.

Jarass, H. D., DiMento, J. (1993): German environmental law in comparison to U.S. environmental law, Zeitschrift für vergleichende Rechtswissenschaft, Vol. 92, p. 420-422.

Johnson, A. (1998): Functions in Innovation System Approaches. Mimeo, Department of Industrial Dynamics, Sweden: Chalmers University of Technology.

Johnson, A.; Jacobsson, S. (2000): Inducement and Blocking Mechanisms in the Development of a New Industry, in: Coombs R, Green K, Walsh V, Richards A (eds) Technology and the Market: Demand, Users and Innovation. Cheltenham, U.K. and Northhampton, MA, USA: Edward Elgar.

Karadeloglou, P., Ikwue, T., Skea, J. (1995): Environmental Policy in the European Union, in: Folmer H., Gabel L. and H. Opschoor (eds), Principles of Environmental and Resource Economics. A guide for Students and Decision Makers. Cheltenham, UK and Lyme USA: Edward Elgar, p. 276-296.

Kemp, R. (1997): Environmental Policy and Technical Change, Cheltenham, U.K.: Edward Elgar.

Kemp, R., Smith, A. (2000): The implementation and technological impact of the Urban Waste Water Treatment Directive (91/271/EEC) in Germany, the Netherlands, Spain, England and Wales. Synthesis report for TEP, SPRU, University of Sussex, UK.

Klemmer, P. (ed.) (1999): Innovation and the Environment, Berlin: Analytica.

Lange, J., Otterpohl, R. (2000): Abwasser. Handbuch zu einer zukunftsfähigen Wasserwirtschaft. Donaueschingen-Pfohren: Mall-Beton-Verlag.

Legler, H., Grupp, H., Gehrke, B., Schasse, U. (1992): Innovationspotential und Hochtechnologie. Technologische Position Deutschlands im internationalen Wettbewerb, Heidelberg: Physica.

Legler, H., Schmoch, U., Gehrke, B., Krawczyk, O. (2002): Innovationsindikatoren zur Umweltwirtschaft, Studien zum deutschen Innovationssystem Nr. 2-2003. Hannover: Niedersächsisches Institut für Wirtschaftsforschung, Karlsruhe: Fraunhofer-Institut für Systemtechnik und Innovationsforschung.

Lemke, M., Wackerbauer J. (2000): Handbuch der Umweltschutzwirtschaft: Definitionen – Marktstudien – Potentialanalysen. München, Wien: Oldenbourg.

Leone, R., Hemmelskamp, J. (2000): The Impact of EU Regulation on Innovation of European Industry. Heidelberg: Physica.

Lewis J., The Birth of EPA, http://www.epa.gov/history/topics/epa/15c.htm.

Lichtenberg E., Penn, T. M., (2003): Prevention versus treatment under precautionary regulation: A case study of groundwater contamination under uncertainty, American Journal of Agricultural Economics, Vol. 84, No. 6.

Lozan, A. (2001): Environmental Policy in the United States – Best Models and Practices For Countries in Transition, Internet Access Training Program (IATP), www.iatp.md.

Lübbe, E. (2002): Jahresbericht der Wasserwirtschaft. Gemeinsamer Bericht der mit der Wasserwirtschaft befassten Bundesministerien – Haushaltsjahr 2001. In: *Wasser & Boden 54, 7/8*, p. 5-13.

Microbial Regulations – Georgia EPD surface-water regulations http://ga.water.usgs.gov/projects/chatm/regsstreams.html, 27 May 1999.

Microbial Regulations-Georgia EPD drinking-water regulations, http://ga.water.usgs.gov/projects/chatm/regsgadrinking.html, 27 May 1999.

National Environmental Education & Training Foundation: Drinking Water Safety and Regulation, What's In the Water?, www.neetf.org, 2003.

Neij, L. (2003): The use of experience curves for assessing energy policy programmes, Environmental and Energy Systems Studies, Lund University. [pdf]

Nelson, R.R. (1994): The co-evolution of technology, industrial structure, and supporting institutions. Industrial and Corporate Change, vol. 3, no. 1, pp.47-63.

New Lab Pinpoints Water Quality Problems 2001, http://www.forestry.uga.edu/warnell, 18 January 2001.

OECD, (1999): Technology and Environment Towards Policy Integration, Paris: OECD.

Office of Water, Environmental Protection Agency, www.epa.gov/ow, accessed 5 April 2003.

Okun D. A. (2002): Water reuse introduces the need to integrate both water supply and wastewater management at local and regulatory levels, Water Science and Technology, vol. 46, No. 6-7.

PRETIR (2002): Implementation of Renewable Energy in the European Union Until 2010, Project executued within the ALTENER Programme, Utrecht/Brussels, May 2002.

Porter, M. E., Linde, van C. (1995): Towards a new conception of the environment competitiveness relationship, Journal of Economic Perspectives, 9 (4), p. 97-118.

Skea, J. (1995): Environmental Technology, in: Folmer H., Gabel L. and H. Opschoor (eds), Principles of Environmental and Resource Economics. A Guide for Students and Decision Makers, Cheltenham, U.K. and Lyme, USA: Edward Elgar, p. 389-412.

Small Business Innovation Research Programme, http://es.epa.gov/ncer/sbir/, accessed 5 April 2003.

State of Georgia (1996), Department of Natural Resources, Environmental Protection Division, Public Water System, compliance report.

StBa – Statistisches Bundesamt (1999): Fachserie 19, Reihe 2.1, Öffentliche Wasserversorgung und Abwasserbeseitigung 1995. Stuttgart: Metzler-Poeschel.

Stern, A. (1995): Water in Europe. What to Expect From the EU Policy Review, for the Conference organised by the Club of Bruxelles on 22 and 23 November 1995.

The Cadmus Group Inc. (2000): Regulatory Impact Analysis for the Proposed Ground Water Rule, Arlington, VA.

Tullo, A. H. (2002): Turning on the tap, Chemical and Engineering News, Vol. 80, No. 46.

Union of Concerned Scientists (2003): Clean Energy: The Renewable Portfolio Standard, http://www.ucsusa.org/clean_energy/renewable_energy/page.cfm?

U.S. Energy Information Administration (2003): Analysis of a 10-percent Renewable Portfolio standard, Washington, D.C., May 2003.

Utterback JM (1994): Mastering the Dynamics of Innovation: How Companies Can Seize Opportunities in the Face of Technological Change. Boston, MA: Harvard Business School Press.

Voice, T. C. (2003): Environmental Health and Regulation in the United States, Michigan State University, presentation.

Walsh, J., Singer, J. M. (1999): Incentives for Environmental Innovation: Federal Programmes that Reward Innovative Environmental Protection, Pepper Hamilton, LLP.

Walz, R. (1995): Structural reforms in the electric utility industry: A comparison between Germany and the USA, in: ENER Bulletin (1995), No.15, pp.53-71.

Walz, R.: Productivity effects of technology diffusion induced by an energy tax, in: Energy and Environment 10 (1999), No. 2, pp. 169-180.

Walz, R.; Betz, R. (2003): Interaction of the EU Directive with German climate policy instruments, research report within the EU project "Interaction in EU Climate Policy". Karlsruhe: FhG-ISI, May 2003.

Water Supply & Water Resources, http://www.epa.gov/ORD/NRMRL/wswrd/ index.html, 2003.

Web Site of AWEA/ EWEA: http://www.awea.org.

Web Site of the European Commission: http://europa.eu.int/comm/environment/ipp/ Accessed 22 July 2003.

Web Site of Energy Information Administration: http://www.eia.doe.gov/neic/ historic/helectricity.htm.

Web Site of The Bundesverband Windenergie e. V.: http://www.wind-energie.de/ suchen-und-finden/suchen.htm (Marktentwickung der Windkraftanlagen; Zahlen Europa).

Żylicz, T. (1995): Goals, Principles and Constraints in Environmental Policies, in: Folmer H., Gabel L. and H. Opschoor (eds), Principles of Environmental and Resource Economics. A Guide for Students and Decision Makers. Cheltenham, U.K. and Lyme, USA: Edward Elgar, 1995, p. 155-176.