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Green Electricity Market Development
Lessons from Europe and the U.S. and Implications for Norway

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Tittel: Markedsutvikling for grønn elektrisitet: erfaringer fra Europa og USA og implikasjoner for Norge
Forfattere: Lin Gan, Gunnar S. Eskeland, Hans H. Kolshus, Harald Birkeland, Sascha van Rooijen, Mark van Wees

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Sammendrag: Ulike fremgangsmåter for å fremme grønn elektrisitet ble analysert ved å se på landene Tyskland, Nederland, Sverige og USA. Case-studiene har vurdert utviklingen av markedet for grønn elektrisitet og drivkreftene bak utviklingen. Denne rapporten trekker sammen funn av relevans for Norge, spesielt med hensyn til fornybare energikilder, produksjon av elektrisitet, potensial for grønn elektrisitet, relevante politiske tiltak og hovedbarrierer for fremtidig markedsutvikling. Et sett med virkemidler blir diskutert for Norge, inkludert innmatingsavgifter, grønne sertifikater med kvoteplikt, og subsidier til forskning og utviking.
Alle virkemidlene har sine styrker og svakheter, men rapporten argumenter for å hjelpe dagens tilgjengelige teknologier – slik som vind – må et valg tas mellom grønne sertifikater med kvoteplikt og innmatingsavgifter. Begge virkemidlene vil implisitt skattelegge ikke-grønn for å subsidiere grønn elektrisitet. Det tyske studiet viser at innmatingsavgifter har fordeler som effektivitet, sikkert investeringsmiljø, fleksibilitet og enkel administrasjon. Sverige har et grønt sertifikatsystem for elektrisitet og dersom EU også går i den retning vil dette styrke argumentasjonen for grønne sertifikater. Rapporten konkluderer at målsetningene for tiltakene må være klare og konsistente, uavhengig av valg av virkemiddel. Det er en også rolle for forskning og utvikling for å hjelpe fremtidens teknologier.

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Abstract: Various approaches to promoting green electricity were analyzed through the cases of Germany, the Netherlands, Sweden and the United States. How has green electricity market penetration evolved, and what were the main driving forces? The findings from the case studies are synthesized and analyzed with respect to their relevance for Norway, particularly in terms of energy resources, production, potential, relevant policies and barriers. Potential policy instruments for Norway include feed-in tariffs, green certificates under quota obligations, and subsidies for research and development, and are discussed in terms of their strengths and weaknesses. The report argues that to assist technologies feasible today – such as wind power – a choice must be made between green certificates based on obligatory quotas and a feed-in tariff system. Both effectively tax non-green electricity to subsidize green electricity. As shown by the German case study, feed-in tariffs have advantages in terms of effectiveness, providing a suitable investment climate, flexibility and ease of administration. Sweden has a system of green electricity certificates, and if EU also goes in this direction, this will provide an opposing argument, in favor of green certificates. The report concludes that a clear and consistent policy design is crucial, regardless of the particular instruments chosen. It also argues that there is a role for R&D support to help the technologies of the future.

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Abbreviations

AWEA	American Wind Energy Association
CHP	combined heat and power
CIAB	Coal Industry Advisory Board
EEG	German Renewable Energy Act
EIA	Energy Information Administration
EREC	European Renewable Energy Council
EU	European Union
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
GCS	Green Certificate System
GE	green electricity
GHG	greenhouse gases
GW/GWh	gigawatt/gigawatt hour
GWP	Global Warming Potential
kW/kWh	kilowatt/kilowatt hour
MEA	Ministry of Economic Affairs
MW/MWh	megawatt/megawatt hour
NGO	non-governmental organization
NOK	Norwegian kroner
NVE	Norwegian Water Resources and Energy Directorate
OECD	Organisation for Economic Co-operation and Development
PJ	petajoule
PURPA	Public Utilities Regulatory Policies Act
PV	photovoltaic
R&D	research and development
RD&D	research, development and demonstration
RECS	Renewable Energy Certificate System
ROCS	Renewable Obligation Certificates
RPS	Renewable Portfolio Standards
SEA	Swedish Energy Agency
SEK	Swedish kroner
SFT	State Pollution Authority
SSNC	Swedish Society for Nature Conservation
TW/TWh	terrawatt/terrawatt hour
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
VAT	value added tax
WCED	World Commission on Environment and Development
WEC	World Energy Council
WWF	World Wide Fund for Nature

Executive summary

Case studies in Germany, the Netherlands, Sweden and the United States have examined how green electricity market penetration has evolved and the main driving forces behind its development. Over the past few decades, all of the countries studied have employed a mix of policy instruments to support renewable energy and have had one or more shifts in policy focus. The 1970s focused primarily on R&D stimulus, followed by investment subsidies in the 1980s, consumers' support in the 1990s and producers' support at present. Most case-study countries support renewable energy with financial incentives. The quota system in Sweden and the renewable portfolio standard of the United States are presently the only non-financial instruments applied. Countries do not stimulate different renewable technologies neutrally. Germany and the Netherlands, for example, differentiate their feed-in tariffs by technology. The Swedish quota system, however, does not differentiate between renewable energy technologies. Because the quota system sets targets for the share of renewables as a whole, it is likely selects the least-cost among technologies presently available.

The lessons from the case studies are applied to the case of Norway, a country where virtually all current electricity needs are satisfied by large-scale hydroelectric power, but where additional capacity will be needed in the future. A lesson to emerge from the case studies is the importance of a clear, consistent, and coherent policy as investors require long term stability. For a country to develop a clear and consistent policy on green electricity, with the appropriate resources allocated to its implementation, it must place green electricity high on the political agenda. In addition, consistent and cohesive policy design requires a careful consideration of the policy options available. These policy options include feed-in tariffs, green certificates under quota obligations, and subsidies for research and development as well as for adoption. The report concludes that feed-in tariffs have important advantages with respect to flexibility and ease of implementation. Sweden has, however, already opted for a green certificates scheme, and this – together with potential developments in EU in the same direction – could potentially be important enough for Norway to choose such a system. Another dimension important in green electricity development is research on new technologies. Here, the report recommends a scheme with publicly funded research, perhaps funded with resources raised from energy and electricity consumption, though the source of funding is less important. Finally, once a policy is designed, its success depends on the extent to which it is implemented, which, in turn, depends greatly on existing implementation capacity and efforts to strengthen implementation capacity.

1 Introduction

Renewable energy development has evolved differently in national and regional settings in the past decades. Interest in renewable energy began with increased environmental awareness in the 1960s and in debates concerning the relative merits of nuclear power versus fossil fuels for meeting increasing demand for electricity. In the mid-1970s and 1980s, interest in renewable energy surged as a result of the "energy crisis" caused by the disruption of oil supplies and the rising prices of oil and other fossil fuels. From the early 1990s, interest in renewable energy continued to grow because of widespread interest in sustainable development following the report "Our Common Future" (World Commission on Environment and Development 1987). In the 1990s, debates on renewable energy got an extra stimulus from international environmental actions, such as the UN Framework on Climate Change in Rio (1992) and the Kyoto Protocol (1997). Interest intensified over the past several years because of the need to implement cost-effective greenhouse gas (GHG) mitigation policies, concerns for energy security, reduction of local environmental impacts of fossil fuels burning, global integration and liberalization of the energy market.[1] Recently, attention stems from the adoption of EU's RES-Directive and the Political Declaration and the International Action Programme at the International Renewable Energy Conference in Bonn (2004), which has indicated a new trend of development on renewable power generation, and even more is expected at the Bonn follow-up ministerial conference to be held in Beijing in November 2005.

Agencies such as the Organization for Economic Cooperation and Development (OECD) and the International Energy Agency (IEA) have focused their attention on the issue, and interest has intensified because of the need to implement cost-effective GHG mitigation policies, increase global integration and liberalize energy markets throughout the world.[2] Politicians and business leaders are increasingly concerned about speeding up the development of renewable energy technologies and their market adaptation. Government regulations and incentive policies play a critical role in promoting renewable energy. There is also a growing interest in developing and using cleaner energy from environmentally-concerned industries, including electric utilities. Consumers increasingly demand more flexible systems, more choices, stricter environmental standards and higher quality electricity supply and services. Quite possibly, the 21st century will be seen as a critical time for the development and large-scale market dissemination of electricity from renewable energy sources.

The terms "green energy" and "green electricity" are evocative, popular terms, with a variety of meanings at best relating to a blend of objectives. One avenue towards clarification is to distinguish between the ultimate services that energy consumption provides. IEA (2002) identifies the four main energy services as transport, stationary services, electrical uses and fuel inputs to power generation. This report focuses on electricity,[3] and further differentiates electricity according to how it is produced. Green electricity is produced from wind, solar, biomass, geothermal, hydropower[4] and wave/tidal sources.

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[1] A recent driver in Europe is the implementation of the EU Directive 2001/77/EC on renewable energy sources, known as the "RES-Directive" (EU 2001).

[2] OECD 1998, 2001.

[3] The production of heat from renewable energy sources is discussed in the Norwegian case but is not included in the other case-study countries.

[4] The EU (2001) RES Directive on the promotion of electricity produced from renewable energy sources does not distinguish between large-scale and small-scale hydropower. However, earlier EU

The interest in green energy – and more specifically green electricity – can be related to policy objectives, including energy security, environmental protection and climate change mitigation. As a practical matter for this report, allowing for several underlying policy objectives, *we assume that these are operationalized as increasing the share of renewable energy sources in electricity production*. It is increasingly recognized that green electricity becomes a very important component in electricity production as worldwide demand for electricity increases. Thus, it is important to review policies designed to increase utilization of renewable energy sources. Alongside instruments such as Europe's emission trading system (2005-2007) and the Kyoto quota market (2008-2012) that are designed to reduce CO_2 emissions, green electricity development adds a new dimension to electric power production and consumption. In general terms, a policy intervention either taxes non-green electricity and/or subsidizes green electricity. This allows renewable energy technologies to compete when they otherwise could not, potentially allowing them to develop and become more competitive. Specific policy instruments vary widely (see chapter 3), and include such options as using quotas rather than price instruments, influencing research rather than expanding the use of existing technologies.

This report reviews the development of green electricity markets in Germany, the Netherlands, Sweden, and the United States (see Wüstenhagen and Bilharz 2004; van Rooijen and van Wees 2003; Wang 2004; Menz 2004; and Menz and Vachon 2004). These case-studies compare how the countries differ in terms of resource endowments, energy politics, energy industry structures, regulatory policies, energy prices, citizen attitudes, and the mass media involvement. They examine how green electricity market penetration has evolved, and the main driving forces behind its development. This report presents the main findings of the case studies and discusses how the findings may be relevant for potential green electricity policy and market development in Norway. While virtually all of Norway's current electricity needs are satisfied by large-scale hydroelectric power, additional capacity will be needed in the relatively near future. Identifying policy options for Norway is therefore important because of the increasing role that green electricity could play in providing sustainable and secure energy supplies in the future. This report describes potential impediments, existing public policies, and possible measures for increasing production and use of green electricity in Norway.

The report is organized as follows: Chapter 2 focuses on driving forces for and barriers against green electricity market development, and the status and outlook for green electricity in the case-study countries. Chapter 3 discusses the policy objectives, categorizes policy instruments, addresses the institutional aspects of policy development and analyses the instruments applied in the four case-study countries. Chapter 4 analyzes resources, supply and demand for electricity, and the green electricity market development in Norway. In conclusion, Chapter 5 makes the policy recommendations for Norway on its future development of green electricity.

2 Green Electricity Market Development

How important are renewable energy sources for electricity production today? The IEA (2002) estimates that 39 percent of the global production of electricity in 2000 was supplied by coal, while gas, nuclear and hydropower all supplied 17 percent each. The remaining electricity production was from oil (8%) and other renewables (2%). The mixture varies across regions; for example, hydropower supplied 68 percent of the electricity in Latin

documents define large hydro as projects above 10 MW installed capacity. A strict definition of green electricity should exclude electricity produced from large hydropower because of its environmental and social impacts. See sections 3.1 and 4.4 for more details on the RES Directive.

America but only 12 percent in Europe. The share of other renewables did not exceed 3 percent in any region for 2000. The country-specific statistics (IEA 2001a) in **Table 2.1** show that there are significant variations across countries in terms of the fuel mix for electricity production.

Table 2.1 Electricity Production by Energy Carrier in Major Countries*, 2001 (percent)

Country	Fossil fuels	Nuclear	Waste	Hydro	Biomass	Geothermal	Other**
Australia	91.5	0.0	0.0	7.7	0.6	0.0	0.1
Canada	29.1	13.0	0.0	56.7	1.2	0.0	0.1
China	79.8	1.2	0.0	18.9	0.1	0.0	0.0
France	8.6	76.5	0.3	14.3	0.3	0.0	0.1
Germany	62.5	29.4	1.8	4.0	0.5	0.0	1.8
India	83.1	3.4	0.0	12.8	0.3	0.0	0.3
Italy	77.4	0.0	0.6	19.3	0.3	1.6	0.7
Japan	58.7	30.7	0.5	9.0	0.7	0.3	0.0
Netherlands	90.7	4.2	2.7	0.1	1.0	0.0	1.1
Norway	0.4	0.0	0.0	99.3	0.2	0.0	0.0
Russia	64.6	15.4	0.3	19.7	0.0	0.0	0.0
Sweden	4.0	44.6	0.3	49.0	1.9	0.0	0.3
UK	73.5	23.4	0.4	1.7	0.9	0.0	0.3
USA	71.0	20.8	0.6	5.7	1.2	0.4	0.2

Source: IEA 2001a

*   Norway is included for comparison.

** Includes solar and wind.

2.1 Main Driving Forces

A way to examine the cross-sectional patterns of electricity production as shown in **Table 2.1** is to look at key driving forces: resource availability, and political, environmental, technological and economic factors. These are, of course, not independent of one another, but one can argue that in the cross-sectional pattern, there is an almost hierarchical order. First, nature itself exercises a heavy hand through the natural resource base. Countries are to a varying extent endowed with resources such as hydropower, geothermal energy and coal, which for reasons of transportation costs allow country-specific cost advantages for those energy sources. Second, there are political driving forces. These are related to other driving forces, perhaps particularly environmental and economic, and their traces are also heavy, in particular for nuclear power. The economics or technology of nuclear power depends less on the natural resource base than political factors (some of those concerns are environmental), so the main characteristic of France is that the country combines (or perhaps responds to) a scarcity of other energy sources with politics that have allowed nuclear power development. Environmental concerns have had influence beyond nuclear power, in particular for the point at which countries stop further development of their hydropower resources (in Norway, for instance). For coal combustion, environmental concerns have been important in making coal combustion cleaner, switching to cleaner coal, and to some extent replacing coal with other sources of energy. Nevertheless in the USA and Europe, coal-fired power plants have retained their competitiveness, even for new plants, while the pressure on emissions has grown.

2.1.1 The Natural Resource Base

The fuel mix of a country's electricity production can to a large extent reflect its given natural resources. Some countries (such as Norway, Canada and Sweden) have significant water resources, while others (such as Australia, China, Germany and the USA) have significant coal resources. Increased use of renewable energy resources could be driven by the limited availability of fossil fuels. Assessments of fossil fuel availability usually focus on conventional hydrocarbon reserves, i.e. those occurrences that can be exploited with current technologies and market conditions. Rogner (1997) finds that the focus on reserves underestimates long-term global hydrocarbon availability. But the potential accessibility of fossil fuels increases dramatically if the vast unconventional hydrocarbons are included in the resource estimates. This is based on the application of historically observed rates of technology change and long-term production costs that are not significantly higher than present market prices.

Nevertheless, fossil fuels will become scarcer over time, and renewable energy sources could play a larger role in energy markets. Globally, there are vast amounts of renewable energy resources that could be utilized for electricity production. This is shown in an assessment by the Intergovernmental Panel on Climate Change (IPCC 2001). The global technical potential of hydropower is estimated at 14,000 TWh/year, while the economic potential is limited to 6,900-8,700 TWh/year. The largest potentials are in Latin America, Asia and the former Soviet Republic countries. Globally, biomass has a technical energy potential of 396 EJ/year, with the largest potential for development in South America and Africa. The global theoretical wind potential is estimated at 480,000 TWh/year, but 20,000 TWh[5] is given as a more realistic potential. When it comes to solar energy, even the lowest estimates of technical potential exceed current global energy use by a factor of four.

Many scenarios have been developed to help project future energy supply and demand. The IEA (2002) estimates that electricity production from both hydropower and other renewables will increase towards 2020. The increase in production of electricity from hydropower will mainly take place in developing countries where there still is a large potential. However, hydropower's share of global production will be reduced to 15 percent. Most of the growth in electricity production from other renewables will take place in OECD countries, and its share of global production will increase to 3 percent. Biomass and wind power will account for most of the projected growth, but it is expected that geothermal, solar and other power sources will contribute more after 2020. Other studies also project the extent to which renewable resources will meet the demand for energy and electricity. The IPCC developed a set of scenarios until 2100, and these were presented in a Special Report on Emission Scenarios (IPCC 2000). Although the study does not project the fuel mix for electricity production, it does project the share of renewables of primary energy. For 2020, this share varies from 5 to 19 percent in the marker scenarios, while the share in 2100 varies from 14 to 80 percent. The wide range reflects the differences in the driving forces for the scenarios, such as demographic change, economic growth rates and technological change. The US Energy Information Administration[6] (EIA 2004b) projects that global electricity production from hydropower and other renewables will increase by 57 percent from 2001 to 2025, but its share of total electricity production will remain at the current level of 20 percent.

[5] Technical potential assumes that 27 percent of the earth's surface is exposed to a mean annual wind speed higher than 5.1 m/s at 10 meters above ground. The realistic potential assumes that just 4 percent of that land area could be used.

[6] The official energy statistics from the US Government

2.1.2 Political Interests and Pressure

Although there was interest in renewable energies in the 1960s and 1970s, the first major political boost came when the UN World Commission on Environment and Development (WCED) brought the concept of sustainable development to the political agenda with the report Our Common Future (WCED 1987). The report tried to strike a balance between environment and development, North and South, and between the present and the future. In terms of energy, the WCED recommended reducing resource- and energy-intensive activities, using resources and energy more efficiently, and changing production and consumption patterns. As a follow up to the WCED report, the UN General Assembly decided to hold regional conferences and a global conference. Thus, the UN Conference on Environment and Development (UNCED) took place in Rio de Janeiro in 1992. The conference adopted Agenda 21, a comprehensive, international plan of action to achieve more sustainable patterns of development. Agenda 21 reached the conclusion that the energy course was unsustainable and recommended a series of concrete actions to promote sustainable energy production and use (UNDP 1997).

Greenhouse gas emissions and the issue of climate change were dealt with extensively at the 1992 Rio Conference, and the UN Framework Convention on Climate Change (UNFCCC) was signed at the conference. Although the UNFCCC does not include stabilization commitments, quantified targets or timetables, it laid the basis for the development of the Kyoto Protocol in 1997. The Kyoto Protocol requires most developed countries to reduce their GHG emissions by 5.2 percent relative to 1990 levels in the period 2008-2012. The development of renewable energy sources should benefit from the implementation of the Kyoto Protocol, as the GHG emissions from electricity produced from fossil fuels would incur an additional cost. As a follow-up to the Rio conference, the World Summit on Sustainable Development took place in Johannesburg in 2002. In June 2004, the World Renewable Energy Conference in Bonn was held as a response to the call of the Johannesburg summit for the global development of renewable energies. The central issue was how to increase the share of renewable energy technologies for power generation in industrialized and developing countries. This should be done in ways that better exploited their relative strengths and capacities to meet the future needs of consumers. The current preparation for the follow-up of the Bonn conference is to hold a ministerial renewable conference in Beijing in November 2005. It is expected that further political commitments could be made through this event.

It is clear that political leaders have been inspired by these major events but also from public opinion and NGO involvement. The trend for sustainable energy development has become mainstreamed in political agendas also at the national level, in both developed and developing countries. At the World Renewable Energy Conference in Bonn, a number of concrete actions and commitments towards renewable energy were put forward by a large number of governments, international organizations and stakeholders from civil society and the private sector, known as the International Action Programme.[7]

2.1.3 Concerns about the Natural Environment

The most obvious driver for renewable energy from the environmental perspective is the concern about increased concentrations of GHG and the resulting climate change effects. Fossil fuel combustion is the primary source of CO2 emissions, and the resulting global warming represents a major challenge to human society and global eco-systems. However, the combustion of fossil fuels has also consequences for local and regional pollution, as it

[7] China pledged to significantly increase renewable energy power generation so that it will account for 10 percent of its generating capacity by 2010. Countries such as Germany, Denmark, Egypt, and the Philippines also made significant commitments.

emits sulfur and nitrogen oxides, carbon monoxide and suspended particulate matter. At the local level, fossil fuel combustion is a major contributor to urban air pollution, which is thought to contribute to millions of illness- and mortality incidents around the world. Coal mining activities result in soil erosion, pollution and often in the loss of human lives due to mine accidents. At the regional level, soil acidification is causing significant damage to natural systems, crops, and human-made structures. These pollutants are shown to cause considerable health and other ecological damages in Europe, the USA, and China (WWF China 2003). Using renewable energy sources would result in significantly less negative environmental and health impacts, especially by replacing electricity produced from coal (Goldemberg 2004, Aunan et al. 2004).

2.1.4 Technology Development

The high costs of R&D but generally also the costs per kWh, combined with an insufficient scale of development are often seen as the principal constraints on the growth of renewable energy technologies. But substantial technological development and cost reductions have made several renewable energy technologies more competitive. Despite these gains, renewable energy sources so far make only a modest contribution to the global production of electricity (IEA 2002). In a study by McVeigh et al. 1999, the actual performance of renewable energy technologies in the USA over three decades was compared against stated projections. The study found that, in general, renewable technologies failed to meet expectations with respect to market penetration. However, they succeeded in meeting or exceeding expectations with respect to their costs. The small market share of renewables appears to have more to do with changes outside their own development, principally regulatory reform and changes in conventional technologies (declining real prices of fossil based power), than with their technological performance.

Neuhoff (2004) distinguishes between three distinct generations of renewable energy technologies, each presenting different, complex challenges to expansion of their markets. The mature generation (hydropower, biomass combustion, wind power, solar thermal utilization and geothermal technologies) are already cost-competitive, provided the renewable plants are located in high quality resource areas. The emerging generation (advanced bioenergy, and solar PV) are proven technically, but still need substantial cost reduction through market expansion. Concentrated solar power, thin-film technology, ocean energy, and even more advanced bioenergy will require substantial R&D in order for these technologies prove themselves at the market scale and to begin entry into commercial markets applications.

With a larger market dissemination and increased cumulative installed capacity of renewable energies, economies of scale could lower costs and accelerate demand. Predicting the future costs of electricity from renewable energy sources is difficult, but there are estimates. **Table 2.2** combines Turkenburg's assessment of current costs and IEA's assessment of likely cost reductions. Although the estimates can vary depending on site conditions, the study reports cost reductions of 10-15 percent for bioenergy, 15-30 percent for onshore and offshore wind energy, 30-50 percent for solar PV energy, and 10 percent for geothermal and hydropower by 2020.

Countries that have the political will and willingness of the industry have been able to build up industries for renewable energy technologies. Such examples are Denmark and Germany for wind technologies, Sweden and Finland for biomass CHP, Japan, Germany and to some extent USA for solar PV application in buildings. This has led to social benefits, e.g. employment, but also brings economic benefits as shown by the export of wind turbines from Denmark and Germany.

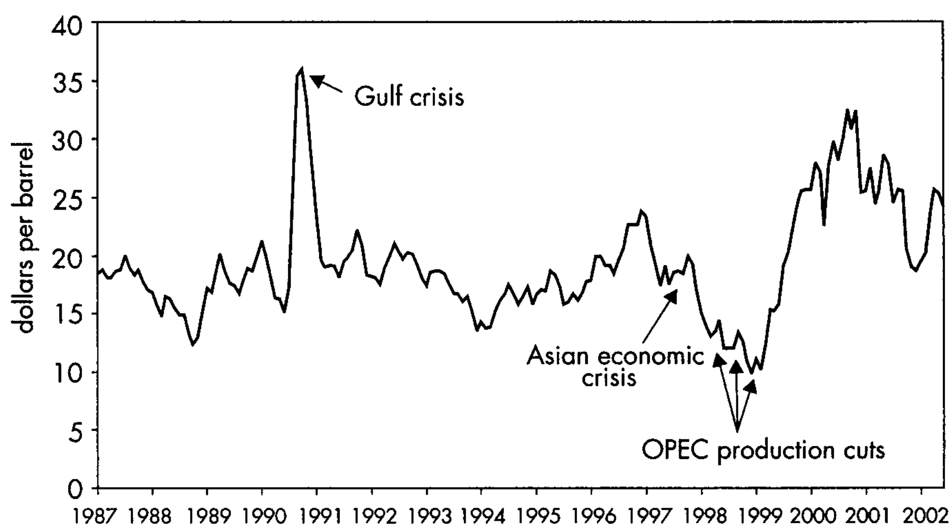
Table 2.2 Current and Potential Future Costs of Electricity from Renewable Energy

	Current cost[8]	Cost reductions by 2020
Biomass	3-12 ¢kWh	10-15%
Wind	4-8 ¢kWh	15-30%
Solar PV	25-160 ¢kWh	30-50%
Geothermal	2-10 ¢kWh	10%
Hydro	2-12 ¢kWh	10%

Source: Turkenburg 2001, IEA 2001b

2.1.5 Economic Driver

Energy prices are important considerations for energy supply and demand. The costs of renewable energies are not fully comparable to conventional energies because of the latters' externalities, but it is clear that the price of conventional energies affect the demand for electricity from renewable energy sources. An early sign of this is the disruption of oil supplies and consequently the rising prices of oil and other fossil fuels in the mid-1970s and 1980s that stimulated the interest in renewable energies. **Figure 2.1** shows that crude oil prices have become much more volatile since the mid-1990s.



Source: IEA 2002.

Figure 2.1 Monthly Average Spot Price of Brent Blend Crude Oil (1987-2002)

From 1987 to 1996, the monthly average spot price of Brent Blend crude oil fluctuated between US$13 and US$22 per barrel in nominal terms. The exception is 1996, when the price reached about US$35 per barrel as a result of the first Gulf War. Since 1996, the monthly average spot prices have fluctuated over a wider range, from a low of under US$10 in February 1999 to a high of US$33 in the autumn of 2000 (IEA 2002). Since then, the monthly average spot price gradually fluctuated down to about US$20 in early 2002 but has increased to reach US$50 in the autumn of 2004.[9] IEA finds that unless surplus capacity in

[8] Euro cent

[9] There were days when the spot price reached US$52 per barrel (EIA 2004a).

crude oil production and refining increases, markets will remain sensitive to actual or feared swings or disruptions in supply. Geopolitics and regional conflicts also affect oil prices.

Even though oil is the most important energy source, coal remains the most important fuel for electricity generation. Coal trade, especially seaborne trade in hard coal, has on average increased by around 4 percent a year since 1970. The growth is dominated by the trade in steaming coal, which is used mainly for electricity generation. The main reason for coal's dominating role in the production of electricity has been its low and stable, even slightly decreasing prices and transportation costs (WEC 2004). Between 1995 and 2002, many new mines were developed specifically for the export market and resulted in a upward pressure on prices due to strong market demand. With lower growth in production capacity and more transparent coal markets, price cycles have become more frequent. A large part of the recent price increases for steam coal have been driven by freight cost increases (CIAB 2004). Long-term price projection for coal is very difficult, and forecasts tend to be inaccurate (Gawlick 2004). Nevertheless, if the current high oil and coal prices prevail, it will stimulate the development of alternative energy sources.

2.2 Major Barriers to Market Development

Although there are certain driving forces that would seem to encourage the production of energy from renewable energy sources, Table 2.1 shows that renewable energy still accounts for only a small share of total electricity production. Cost is widely seen as the main barrier for the development of renewable energy sources (see section 2.1), but in the following section we briefly discuss some of the other major barriers to green electricity policy and market development.

2.2.1 Deregulation and Lower Electricity Prices

The deregulation of electricity markets has led to increased competition in the market both because producers have to compete for market shares and because consumers have the opportunity to choose their source of electricity. Increased competition in electricity markets may, however, have a negative effect on green electricity development and on the environment, as the fossil fuel prices become lower. While there is evidence that consumers in the USA are willing to pay a premium to obtain electricity produced from renewable sources, customers with the opportunity to choose their source of electricity may choose among sources according to price and environmental externalities. Utilities facing competitive pressures have an incentive to turn to the cheapest source of electricity generation consistent with pollution control regulations. Since electricity costs do not typically reflect all environmental costs, sources that offer the lowest cost could be those that result in the most pollution. To the extent that prices for electricity produced from renewable technologies more fully capture external costs than prices for electricity from conventional sources, cleaner renewable electricity technologies would be at a disadvantage relative to conventional technologies in restructured, competitive markets. Furthermore, renewable electricity technologies are generally characterized by relatively high capital costs and low operation and maintenance costs, making them more attractive over long time horizons and less attractive to firms facing short-term competitive pressures (Menz 2004).

2.2.2 Potential Conflict Between Policy Instruments

The review of the case studies shows that there are numerous policy instruments, both financial and non-financial, that can be used to promote the development of green electricity. However, mixing policy instruments can lead to different incentives working in different directions with respect to the chosen technologies.

2.2.3 Lack of Political Will and Institutional Arrangements

It has been widely recognized that strong political will from concerned governments on green power development is key to the successful development of renewables. Political will has played an important role in Germany, for instance, where wind power has become mainstreamed in industrial sectors, and substantial production capacity in wind turbines power plants has been built in some 10 years. This would be unthinkable without strong political comments and associated policy support. It can be generalized that political willingness to support green power development is a precondition for green power industrial development. Agreements are needed among key parties, including agreements on visions for long-term development, and on concrete regulatory and incentive policies. Thus, institutional arrangements also need to be in place to facilitate such agreements, resolve disputes and implement policies. It appears that central government coordination is important for the decision-making and policy implementation processes. Substantial human resources arrangements are also critical.

2.2.4 Stochastic Supply, Grid Capacity and Access

Hydropower without storage, wind power, and various forms of solar and wave energy are by nature stochastic and result in an uncertain electricity production. This creates difficulty in ensuring electricity supply. There will therefore be a need for a back up (spinning reserve), but this increases the cost. Because of the intermittent nature of, for example, wind resources, it is better suited to supplement rather than replace the more traditional forms of power production (coal, natural gas and nuclear). Transmission policies that impose stringent scheduling requirements or otherwise fail to accommodate the characteristics of the generation resources may result in implicit discrimination against non-traditional resources such as wind (AWEA 2002).

The lack of capacity and access to the electricity grid can also limit green electricity market development. Taking wind power as an example, transporting electricity produced from a large offshore wind farm to land is economically feasible only where sufficient electricity grid capacity is available. Since wind resources are typically remote from load centers, the development of wind generation requires development of associated long-distance transmission lines that reach those locations (AWEA 2002). But it is not only a question of grid capacity. Electric utilities often maintain monopoly rights to produce, transmit and distribute electricity. High costs or a lack of standards for connection and transmission hence discourage the penetration of renewable energy sources in electricity markets. Renewable energy sources in distributed generation involve the use of small, modular electricity generation units close to the point of resource consumption location. Unfortunately, utilities have limited experience in connecting numerous small-scale generation units to their distribution networks, and the possible level of renewables penetration depends strongly on the existing electrical infrastructure (EREC 2004).

2.2.5 Resistance from Fossil Fuel Based Industries

Commercial utilization of fossil fuels has been the main source of power supply from the time of modern history, particularly from the Industrial Revolution. Coal became the main source of fuel in the 17th century, and was joined by oil and natural gas in the 20th century. Consequently, industrial infrastructure (coal mines, oil fields, power plants, transmission lines, oil and gas pipe lines, machinery production, and transportation systems) are all built to serve the needs of the fossil fuel industries. Fossil fuel and related technologies are mature and inexpensive due to large quantities in production, and stakes are high for producers along the value chain in those industries. As fossil fuel prices are still cheap in the world markets, these industries have been able to develop a strong power base and lobbying power to governments in major industrialized countries[10] and key developing countries such as China and India. Their vested interests mean that certain policy reforms can be met by strong opposition. Many small stakeholders can participate in the development of green power generation, and they tend to be decentralized and fulfill local demands. Decentralized renewable power generation is certainly not in the interest of major fossil fuel power industries,[11] as it can reshape the structure of the conventional power industry.

2.2.6 Weak Consumer Awareness and Support

Renewable energy sources are often supported by the public. But even though consumers now have a better opportunity to choose their source of electricity, weak consumer awareness and inability to purchase green electricity may pose barriers. Experience from the United States shows that consumers who have purchased green products through financial incentive programs generally have a long-standing interest in renewable energy and are strongly motivated by non-economic factors, including environmental concerns, a desire to reduce dependence on utilities, and national security threats. Until recently, most US electricity customers have not been able to participate in green electricity markets, and currently that opportunity is limited to electricity customers in about 30 states (Menz 2004). An important factor influencing consumer interest is naturally the price of green electricity but also the focus on this in the mass media. An analysis of utility market research studies (Farhar 1999) shows that across the studies examined, majorities of 52 to 95 percent said they were willing to pay at least a modest amount more per month on their electric bills for power from renewable sources. Polls show that customers' willingness to pay increases when customers are educated about utility energy options. Information and education are important, and the media can play an important role.

2.2.7 Lack of NGO Involvement

Environmental NGOs can play an active role in promoting green electricity market development. In Sweden, the Swedish Society for Nature Conservation (SSNC) was instrumental in initiating a number of environmental schemes and guidelines. The aim of their labeling scheme was to speed up the conversion from nuclear power and fossil fuels to renewable energy sources and to prevent the continued expansion of hydroelectric power stations (Wang 2004). In the Netherlands, WWF has been instrumental in mobilizing the support from the mass media in the green electricity campaign. Similarly, German NGOs have been active in launching three competing eco-labeling schemes.[12] However, there is still a lack of strong NGO presence and influence in green power development. Many environmental NGOs are limited by their expertise, financial constraints and lobbying power. There are few incentive mechanisms to encourage their participation from the government's side.

[10] For example, the oil and coal industries have been successful in lobbying the U.S. government to block the progress of the Kyoto Protocol, and have prevented the government from making any commitment on CO_2 emissions reduction in the U.S.

[11] This has been the case in the formation process of the Renewable Energy Law in China. Major power companies tried to block the discussion on quota obligations for renewable energy production.

[12] Eco-labelling does not appear to be a strong positive driver for green electricity marketing in Germany so far. This is because competing eco-labels counteract the basic function of an eco-label to reduce complexity and give guidance to consumers, and because they have a high level of sophistication in distinguishing green power from EEG-supported electricity.

2.3 Status and Outlook in the Case-study Countries

The status of green electricity in the case-study countries is summarized in **Table 2.3**. Including hydropower, almost half of Sweden's electricity production in 2002 came from renewables, while the other countries' share of renewables ranged from 4 to 9 percent. Excluding hydropower reduces the share of renewables to 2-4 percent in all four countries. More details are found in the following sections.

Table 2.3 Share of Green Electricity Production in the Case Study Countries (2002)

	percent green electricity		
Country	**with hydro**	**without hydro**	**Energy source ranked by importance**
Germany	7.8	3.8	Hydro, wind, biomass, solar
Netherlands[13]	4.0	3.9	Biomass, wind, hydro, solar
Sweden	49.0	3.0	Hydro, biomass, wind, solar
USA	8.8	2.2	Hydro, biomass, wind, thermal, solar

Sources: Wüstenhagen and Bilharz 2004; Eurostat 2004; Dutch Government 2003; Wang 2004; Menz 2004.

2.3.1 Germany

Germany relies heavily on coal and nuclear power, which account for 50.6 percent and 28.3 percent of electricity production, respectively, in 2002. Natural gas makes up 9.3 percent, and the share of renewables in electricity generation has almost tripled from 2.8 percent (15 TWh) in 1991 to 7.8 percent (46 TWh) in 2002. Hydropower is currently the most important energy source for green electricity consumption in Germany, as it accounted for about 4 percent in 2002. Growth in hydropower has been relatively limited in recent years, and the number of large hydropower plants has been stable over the past few decades. A number of small hydropower plants (< 5 MW) were decommissioned throughout the 20th century, but the trend has been reversed due to the introduction of the feed-in law in 1991. Refurbishment of existing hydropower plants with careful environmental impact management looks like the most promising option in terms of increasing electricity production with hydropower (Wüstenhagen and Bilharz 2004).

Three percent of the electricity consumption in 2002 came from wind power. Starting from only 27 MW installed capacity in 1989, wind power has seen an almost 60 percent compound annual growth rate for 13 consecutive years. In 2002, the installed capacity for wind power in Germany exceeded 12,000 MW, representing about half of the capacity in Europe and more than one third worldwide. Biomass accounted for less than 1 percent of electricity consumption in 2002. However, biomass CHP has become a high priority from 2004. Several players have announced plans to build new power plants using solid biomass. Identifying a continuous flow of resources within a useful proximity is crucial for competitive operation of larger biomass plants (5-20 MW). Photovoltaics (PV) have a small market share in Germany with about 0.03 percent of electricity consumption in 2002. However, growth rates have been very high, about 50 percent annually, throughout the decade. In terms of installed capacity, Germany ranked second behind Japan at the end of 2003. Geothermal energy has so far only been used for heat supply and not for electricity generation.[14] Eight pilot and demonstration plants are currently being planned, and geothermal electricity generation has a technical

[13] Statistics from Eurostat and the Dutch Government used instead of van Rooijen and van Wees (2003) as it does not report figures for 2002.

[14] Only exception is a small geothermal power plant in North-Eastern Germany.

potential that is comparable with PV and onshore wind energy (Wüstenhagen and Bilharz 2004).

Further growth is expected, particularly in wind energy, PV and biomass. A study commissioned by the German Ministry of Environment and Environmental Agency finds that wind (onshore and offshore) and solar energy have long-term technical potential to generate 250 TWh of electricity per year (more than 40 percent of German electricity consumption in 2002). In a scenario aiming at 80 percent CO_2 reduction by 2050, the Environmental Agency estimates that 63 percent of the electricity will be generated from renewable energy sources. It is expected that 46 percent will come from domestic generation, while 17 percent will be covered by imports (Wüstenhagen and Bilharz 2004).

The liberalization of the electricity market in 1998 is important, as it became possible for customers to directly influence the way their electricity is made. Initial price competition led to an erosion of profit margins and a wave of mergers and acquisitions. New green power marketers introduced products while incumbent utilities repositioned their programs for the newly competitive market environment (Bird et al. 2002). Today, more than 135 marketers supply 1,700 GWh of green power to an estimated 490,000 customers in Germany. This represents a market share of about 1.3 percent of residential customers. A survey (Wüstenhagen and Bilharz 2004) among German green power suppliers estimates that 127 MW of new capacity has been created as a result of green power demand between 1999 and 2003. They find that green power marketing driven by customer demand is growing but has had limited measurable impact so far. However, scenario analysis for the next ten years suggests that green power marketing could come close to driving half of the new capacity in 2013.

2.3.2 The Netherlands

The Dutch electricity sector has since the 1970s been dominated by natural gas, coal and oil. In 2002, these energy sources accounted for about 92 percent of the electricity production while nuclear energy accounted for 4 percent. Renewable energy sources accounted for 3,644 TWh or 4 percent of the Dutch electricity production in 2002. Green electricity production increased by 21 percent from 2001 and by 39 percent compared to 2000. Almost 70 percent of the green electricity production in 2002 came from biomass, accounting for 2,535 TWh and 2.8 percent of the total electricity production. One percent of the total electricity came from wind energy, while hydropower, PV and thermal energy accounted for only 0.14 percent, 0.06 percent and 0.02 percent, respectively. The Netherlands requires import to meet the demand for electricity. In 2002, electricity imports amounted to 20.9 TWh, and of this, 10.35 TWh were considered green. This represents a significant increase from the green electricity imports of 7.6 TWh in 2001 and 1.5 TWh in 2000 (van Damme and Zwart 2003). Taking import into account, green electricity accounted for 9.9 percent and 12.9 percent of the total electricity consumed in 2001 and 2002, respectively.

Installed onshore wind electricity capacity in the Netherlands amounted to 466 MW in 2000. A review of the literature for onshore wind potential shows that the technical potential could be as high as 6 GW, but most studies assume at least 2.5–3 GW. Given various constraints, 1.5–2.2 GW is considered a reasonable target for 2010. Offshore placement of wind turbines has recently become an important option. The long-term technical potential on the Dutch continental shelf has been estimated to be between 10 and 56 GW. A realizable potential for 2020 has been estimated at 6-10 GW, and the government target for 2020 is 6 GW (Junginger et al. 2004; de Noord et al. 2004).

The Dutch hydropower capacity in 2000 was 37 MW, consisting of 2 MW generated from small hydro plants and 35 MW from large hydro. The technical potential for hydropower in the Netherlands is small. Hydropower technology is fully mature, and minimal cost reductions and efficiency improvements are expected. The technical potential is estimated to be about 100 MW, while the economic potential is estimated at 53-56 MW (Junginger et al. 2004; de Noord et al. 2004). Electricity produced from domestic biomass and organic waste accounted in 2000 for 40 PJ_{th}.[15] In scenario studies for 2020, the range is 44-166 PJ_{th} while the best guess ranges from 65-75 PJ_{th} (Junginger et al. 2004). The installed PV capacity in the Netherlands was 20.5 MWp[16] in 2001. For 2020, the realizable potential is reported to range from 35 to 8,000 MWp (de Noord et al. 2004) and from 16 to 2,000 MWp with a best guess at 580 MWp (Junginger et al. 2004).

Green electricity entered the Dutch electricity system during the 1990s, with the strongest increase in the second half of the 1990s (Dinica and Arentsen 2003). Green electricity has then been offered by all 12 electricity distribution companies since 1999, and sales grew considerably in late 1999 with the help of a marketing and media campaign launched by the World Wide Fund for Nature (WWF). Just before the liberalization of the green consumer market in July 2001, there was heavy advertising by utilities hoping to increase customer loyalty. This, combined with tax exemptions for green electricity, fuelled the demand. Since 1996, the number of green consumers has increased from 16,000 to 1.4 million in 2003. This sharp increase in demand is the result of the financial support measures (for consumers, the price difference between green and conventional grey electricity was, in effect, zero), combined with market liberalization and the media campaign promoted by environmental NGOs. Anticipating future full liberalization of the electricity market, electricity companies have used green electricity as a marketing tool to attract new customers and retain existing ones.

Two main targets have been set for the green electricity market in the Netherlands. In its third white paper on energy from 1995, the Dutch government formulated a policy goal of 10 percent renewable energy of total energy supply in 2020. The main emphasis was put on electricity from renewable sources, and a target of 17 percent contribution to the domestic electricity consumption was set. In line with the target formulated in the EU directive on renewable electricity, the Dutch government formulated an intermediate target of 9 percent contribution to electricity consumption from renewables in 2010. Studies have indicated that these goals may not be reached by domestic production only, and that import of green electricity may be needed to reach the targets. Nonetheless, there is still a potential for increased production of green electricity in the Netherlands (Junginger et al. 2004).

2.3.3 Sweden

Electricity production in Sweden has been and still is dominated by hydropower and nuclear energy. In 2002, 46 percent of the total electricity produced came from hydropower, while nuclear energy accounted for 45.7 percent. The current share of renewable energy in Sweden remains small, and biomass and wind are the main renewable energy sources. Their contribution to the electricity production in 2002 is 2.6 percent and 0.4 percent respectively (Wang 2004).

Nuclear energy increased substantially after the first oil crisis in the early seventies, when the production was 1.4 TWh (or 2%, in 1972). Nuclear energy in production terms peaked in 1991 with 73.5 TWh, and its significance for electricity production peaked in 1996, accounting for 52.3 percent (SEA 2003). Nuclear power has been discussed in Sweden for decades, and political decisions have been made to decommission the nuclear power plants. Concern for industrial competitiveness has, however, hindered firm actions so far. To date there is still a lack of national consensus on the approach and timeframe of the phase-out of nuclear power. This dilemma has resulted in a lack of strong government commitment towards the development of renewable energy, which is reflected in the short-term nature of

[15] PJ heat production

[16] MW at peak power (PV functioning in optimal sunlight).

the subsidy programs for the renewable energy sources. In addition, CO_2 policies have not been an additional incentive for promoting renewables, as the Swedish energy sector is already almost carbon free (Wang 2004).

Hydropower has dominated the electricity production in Sweden, accounting for more than 75 percent in the early 1970s. Production in 1970 was 40.9 TWh; it peaked in 2000 with 77.8 TWh, and was 66.0 TWh in 2002 (SEA 2003). The majority of this is from large hydropower stations, but there are also around 1200 small hydropower stations that together generate around 1.5 TWh of electricity. Despite the fact that Sweden has rich water resources, future expansion of hydropower is, however, limited due to the legislated protection of the few remaining large rivers. Small hydropower is controversial because of environmental impacts in the small streams concerned. Thus biomass and wind power are clearly the most important renewable sources of energy in Sweden so far in terms of resources, policy efforts and impacts (Wang 2004).

The use of biomass (biofuels and peat) in conventional thermal power plants was 3.8 TWh, or 2.6 percent of the total electricity production in 2002. Sweden has the second largest peat resources in Western Europe (after Finland) as well as large forest resources. The largest sources of biofuels are wood fuels (logs, bark, chips and energy forest), black liquors in pulp mills, peat, refuse, straw and energy grasses. It is estimated that, by 2010, the potential for the use of biofuels in Sweden will be about 160 TWh (Wang 2004).

Sweden's first wind power plant with an installed capacity of 3 MW came in 1982. The number of wind power plants has steadily increased, and by 2002 there were 620 wind power plants with an installed capacity of 345 MW and a production of 609 GWh (0.4 % of the total electricity generation). Wind energy is the fastest growing renewable electricity resource in Sweden, as the installed capacity and the production nearly doubled from 1997 to 2002. Wind power is one of the main options for renewable electricity production for Sweden. In recent years, there has been more focus on identifying concrete sites for onshore and offshore wind power. The Swedish Energy Agency has suggested a target of 10 TWh of wind electricity by 2015, and concludes in a report that the potential may be around 100-200 TWh. A large share of the potential production will have to come from offshore installations, considering conflicts of interests for land-based wind power (Wang 2004).

Electricity production from solar PV is negligible in today's Swedish energy system. There have been some R&D programs for PV, but Sweden lacks market development initiatives and subsidy programs such as feed-in tariffs or roof-top programs that have led to a direct promotion of PV in countries such as Germany and Japan. However, the interest from the industry, architects and building companies to integrate solar PV systems in buildings are growing, and awareness of the advantage with PV system is increasing (Wang 2004).

Competition was introduced into the Swedish electricity market in January 1996. Since then, all end-users are free to choose their electricity suppliers. The liberalization of the Swedish electricity market provides straightforward access for small independent generators to be connected to the grid, and all consumers have access to green power. With the liberalized electricity market, the SSNC introduced a green label, called "Bra Miljöval" (Good Environmental Choice). SSNC, being Sweden's largest NGO, has been able to initiate a number of environmental schemes and guidelines in the past. The objective of the voluntary labeling scheme for green electricity was to speed up the shift from nuclear power and fossil fuels to renewable energy sources and to prevent the continued expansion of hydroelectric power stations. The labeling scheme gave customers the opportunity to pay a levy on their electric bill to cover the incremental cost of producing electricity from renewable sources. The labeling scheme has been successful. In 1996, the amount of environmentally labeled electricity sold already amounted to 3 percent of total generated electricity. The share of green electricity demand continued to grow to 10 percent in 2001 (Wang 2004). However, a significant portion of the sales is to non-residential customers, such as commercial and industrial customers and public agencies. There has been little interest among residential customers so far. Furthermore, very little new renewable capacity has been installed to meet demand. Most of the green products are from hydro projects installed before 1996, and only 5 percent of the power supplied is from new renewables (Bird et al. 2002).

2.3.4 USA

The United States relies heavily on non-renewable fossil fuels for most of its energy needs. Coal and nuclear power have been responsible for about two-thirds of net electricity generation for the last several decades. Coal is the principal energy source used for electricity production and has accounted for more than 50 percent since 1980. Given the abundance of coal reserves, the US Department of Energy expects coal to account for nearly 50 percent of net electric generation in 2025. Nuclear power generation increased by 35 percent between 1990 and 2002, and has consistently accounted for about 20 percent of total electricity generated over that period. Nuclear powers's share of total electricity production is expected to fall to less than 15 percent in 2025 because of the public concerns about the safety of nuclear power plants and difficulties in dealing with radioactive waste. Natural gas has been used to generate a steadily increasing share of net electricity since the late 1980s because it is both relatively abundant and cleaner than other fossil fuels for electricity production. Natural gas is expected to contribute nearly 30 percent of net electricity production in 2025 (Menz 2004).

The share of net electricity generation produced from renewable sources (including hydropower) declined from nearly 12 percent in 1990 to about 9 percent in 2002. The decline was mainly caused by a drop in hydroelectric production. The production of electricity from other renewable sources has been virtually constant in relative terms for the last several years, accounting for 2.2 percent of total electricity production in 2002. Electricity generation from non-hydropower renewable energy sources is expected to increase to 3.3 percent in 2025 (EIA 2003). Hydroelectric power is the major renewable source of electricity and was responsible for 6.6 percent of total electricity generation and about three-fourths of electricity produced from all renewable sources in 2002. More than 90 percent comes from conventional large-scale and pumped storage facilities operated by electric utilities. Because virtually all of the nation's hydropower capacity is currently utilized, the share of electricity generated by conventional hydroelectric facilities is expected to decline to 5.2 percent of total generation in 2025 (EIA 2003).

Biomass has been the second largest source of renewable electricity and was responsible for 17 percent of electricity from all renewable sources in 2002. Wood and agricultural waste currently make up more than two-thirds of biomass capacity. Electricity generation from biomass is expected to more than double between 2001 and 2025. Wind energy is the fastest growing renewable electricity resource in the United States. From 1997 to 2002, generation from wind sources increased from 3,288 million kilowatt hours (kWh) to 10,354 million kWh, and wind power accounted for 3.0 percent of electricity produced from all renewable sources in 2002. The amount of solar electricity produced in the United States increased slightly from 1997 to 2002, when it accounted for just 0.15 percent of electricity produced from renewable sources. The relatively high cost of solar energy remains a key impediment, particularly in grid-integrated applications. Geothermal electricity production in the United States has declined consistently since 1992, and accounted for 2.2 percent of electricity generated by renewable sources in 2002. Geothermal electricity generation is expected to increase and comprise 0.6 percent of total electricity generation by 2025.

In a recent study, the Union of Concerned Scientists estimates that major renewable resources excluding hydropower – wind, solar, biomass (excluding municipal solid waste), geothermal, and landfill gas – could potentially provide 5.6 times the total amount of electricity used in the country in 2001. Wind power has the greatest potential, and could have met over 400 percent of the nation's electricity needs in 2001. Estimated potentials for other renewable sources as a percentage of 2001 electricity sales were solar (photovoltaic), 71 percent; biomass (natural materials only), 24 percent; geothermal, 6 percent; and landfill gas, 1 percent (Menz 2004).

The development of renewables across the states is uneven. While hydropower is produced in almost every state of the country, the Pacific states (Washington, Oregon, and California) account for about 60 percent of total hydroelectric production in the United States. As of 2000, wind power's share of total electricity produced from renewable sources was greatest in Iowa (33 percent), Minnesota (24 percent), Texas (19 percent), and California (5.8 percent). States with the highest portion of their total renewable electricity from wood/wood waste are Mississippi, Louisiana, Virginia, Georgia, and Maine. Support at the state level is strong, but there is considerable variation among states in both their regulatory environments and the policies that have been implemented to promote green electricity (Menz 2004). The lack of political commitment on reducing GHG emissions in the USA seems to have become a major barrier to developing substantial federal policies.

3 Comparison of Green Electricity Policies

This chapter discusses government policies and policy instruments that can be used to promote green electricity development. Special attention will be given to effects of policies implemented in the case-study countries and the institutional dynamics of green electricity markets. Section 3.1 presents policy objectives; Section 3.2 presents categories of policies and policy instruments and the evaluation criteria. Section 3.3 addresses institutional aspects of policy development in the case-study countries; Section 3.4 analyses the policies and instruments applied in the four case-study countries and evaluates their effects in the policy implementation processes; Section 3.5 compares the policies and policy instruments and assesses their advantages and disadvantages in practical application.

3.1 Policy Objectives

What makes electricity "green" in a given context relates of course to policy objectives, and there is therefore scope for different answers. If the objective is strictly to mitigate global warming, for instance, then it would be natural to include nuclear power in the 'green' (or favored-policy) category. Similarly, from broad environmental objectives, many would exclude large hydropower facilities from the 'green' category. Sweeping references are typically made to two related but different policy objectives, namely greenhouse gas mitigation and energy security. A study by the IEA (2004) finds that little attention has traditionally been given to the possible connection between these two policy objectives. However, with climate change becoming an increasingly important factor, more attention has been paid to adopting an integrated approach in recent national energy policy plans. This trend is exemplified by the recent EU Directive 2001/77/EC on renewable energy sources, known as the "RES Directive".[17] The purpose of the RES Directive is to increase the contribution of renewable energy sources to electricity production. Promotion of renewable energy sources is seen as a priority measure given that their exploitation contributes to environmental protection and sustainable development. In addition, their exploitation can also create local employment, have a positive impact on social cohesion, contribute to energy security, and help meet the GHG emissions reduction requirements of the Kyoto Protocol.

[17] EU 2001. Other examples are: The National Energy Policy Development Group for the USA (the White House 2001), recent white papers on energy policy in both the UK (DTI 2003) and France (MINEFI 2003), as well as in other OECD countries and at EU level through the European Commission green paper on energy security (EU 2000).

Table 3.1 illustrates how the GHG mitigation and energy security objectives could translate into different policy instruments. A few lessons can be drawn from the table. The first is that the delimitations of both the activities to be addressed and the chosen policy instrument depend critically on the objective pursued. Second, neither of these objectives relate specifically to electricity production, but rather more broadly to activities in energy production, consumption, and even beyond. This means that the fundamentally interesting domain for intervention is broader than the electricity sector, but instruments applied specifically for the sector could, as a part of a broader package, of course be advisable for administrative or other reasons.

Table 3.1 Relation Between Policy Objective, Desired Influence, and Instrument[18]

Objective:	Textbook intervention point (example)	Ideal influence (roughly)	Textbook instrument	Observed instrument (example)	Main margin of influence (judgment)
GHG mitigation	Global emissions, according to Global Warming Potential (GWP)	Demand and supply behavior, sectoral balances, technology	Global and uniform GWP tax, or tradable quotas	Tradable CO_2 quotas and CO_2 tax, some sectors, some countries	Fuel substitution, energy conservation
Energy security	Develop national energy sources with uncorrelated risks. R&D and real investments for energy conservation	Demand: energy conservation. For Norway: non-rain energy, transmission; for US: non-Middle East, non-oil	US: Oil import tax; alternative energy subsidy. Norway: Hydro tax, non-hydro subsidy	Conservation subsidies, R&D subsidies, strategic oil reserves (US).	Home insulation, hydrogen and fusion technology, calm markets

Third, while the objective of GHG mitigation has a truly global ideal intervention point (broadly speaking, mitigation is equally valuable independent of where it happens),[19] energy security represents different desirable interventions in different parts of the world. Energy security for countries such as Norway would traditionally mean access to electricity in protracted periods (a year and longer) with low precipitation. But it could also mean increased transmission capacity with neighboring countries. For other countries like the USA and in continental Europe, nuclear, natural gas, coal and domestic oil (including reserves) can cushion their vulnerability to shortages in oil imports. Fourth, an instrument geared to pursue one objective is likely to be poorly suited to pursue another. Now, intervention with some policy instruments is quite costly – including administratively – so it could be that a strategy for an important objective does well enough in pursuing another.

As a practical interpretation for this report, we shall mainly understand the policy objective as increasing the share of renewable energy sources in electricity production. By focusing on production, a country would want to increase the share of renewables in electricity production

[18] Authors' illustration of how different objectives would lead to different interventions and effects. Instruments such as feed-in tariffs for green electricity (Germany) and green electricity certificates (Netherlands, Sweden, and proposed for Norway) are rarely motivated without referring at least to the two first of these objectives.

[19] Exceptions from this rule are starting to influence the scientific literature, see for instance Berntsen et al. 2004.

domestically. This is exemplified by German policies which represent a web of national and local policy initiatives, where the latter aim to have green electricity in many locations of Germany. A different interpretation could be to increase the share of renewable energy sources in electricity consumption. This interpretation assumes that the objective includes green electricity produced abroad. This could be either through regular import of electricity or through import of green certificates (see next section) so that foreign electricity production effectively is subsidized by domestic consumers. We shall therefore broadly allow for both interpretations.

3.2 Categorization of Policies and Policy Instruments

In broad terms, a policy intervention to increase the share of green electricity will tax non-green electricity and/or subsidizes green electricity. In **Figure 3.1**, a tax, *t*, shifts the marginal cost for non-green (MCN) upwards, and a subsidy to green, *s*, shifts the marginal cost (MCG) curve downwards. The intersection between the new dotted curves illustrates a share for green of 3 percent, which is about the average (categorizing hydro as non-green) in the case-study countries (the Netherlands, Germany, Sweden and USA, see table 2.3). When we exclude hydropower from the green category, cost considerations alone would have been responsible for keeping the share of green electricity to a minimum (less than 1 per cent) in most countries, were it not for policy interventions such as illustrated here.

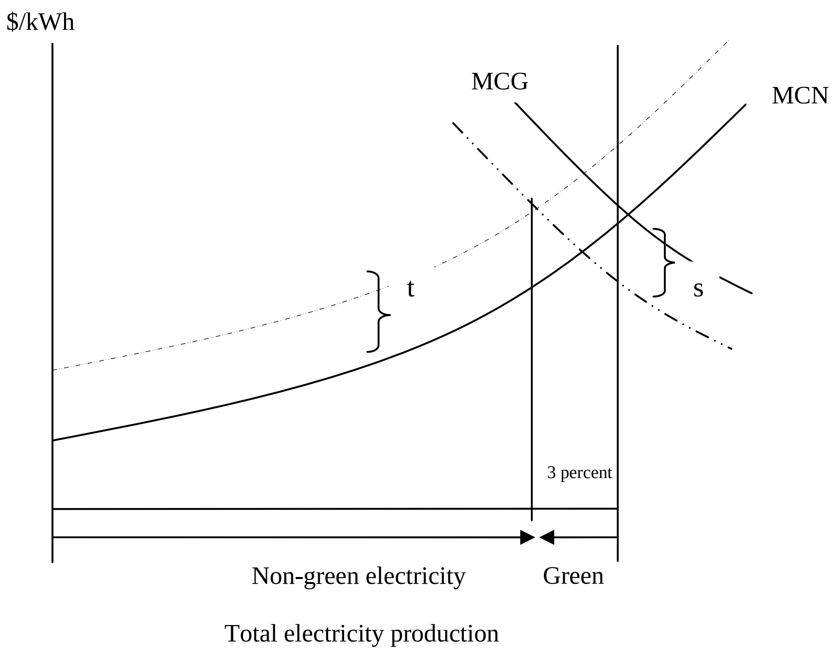


Figure 3.1 Share of green electricity supported by subsidy, and tax on non-green.[20]

[20] The horizontal axis represents total production of electricity (and consumption, if we assume a closed economy). From left to right, MCN represents the marginal cost curve, or the supply curve for non-green electricity. From right to left, MCG represents the supply curve for green electricity. The country's total energy consumption is produced most effectively where the two curves intersect, but in the figure this happens outside the graph, so the share of green electricity (excluding hydropower) without policy intervention is zero.

Governments can apply a wide range of policies and policy instruments to promote green electricity.[21] A rough distinction is made between 'command and control' regulatory instruments and market-based instruments, such as green electricity trading schemes. Van Dijk et al. 2003 have developed a typology of those policy instruments that directly support renewable energy development. A distinction is made between financial and non-financial measures, both of which can be used to stimulate research and development, investments, production and consumption of renewable energy. The various policy instruments are categorized in **Table 3.2** and discussed briefly below (based on de Vries et al. 2003).

Table 3.2 Categorization of Policy Instruments for Promotion of Renewable Energy

Policy area	Financial measures	Non-financial measures
RD&D	- Fixed government RD&D subsidy - Grant for demonstration, development, test facilities, etc. - Zero (or low) interest loans	- Negotiated agreements between producers and government
Investment	- Fixed government investment subsidy - Bidding system on investment subsidy/grant, or on long term feed-in tariff - Subsidy on switching to renewable energy production or on the replacement of old renewable energy installations - Zero (or low) interest loans - Tax advantage for renewable energy investments - Tax advantage on (interest on) loans for renewable energy investments	
Production	- Feed-in tariff at a fixed level set by authorities - Revenue side of green certificate scheme - Bidding system on feed-in tariffs necessary to operate on a profitable base - Tax advantage on the income generated by renewable energy	- Quota obligation on production (example: green certificates)
Consumption	- Tax advantage on the consumption of renewable energy - Tax on fossil fuels	- Quota obligation on consumption - Education and campaign

Source: van Dijk et al. 2003

Feed-in tariffs – a payment by the grid operator per kilowatt hour to the green electricity provider – are a commonly used policy instrument. The term is used both for a regulated minimum price per unit of green electricity and for a defined premium over market electricity prices. Regulatory measures are usually applied to impose an obligation on the general electricity utilities to pay the (independent) green power producer a price as specified by the

[21] The terms "renewable energy" and "renewable electricity" are used. Renewable electricity policies are a subset of renewable energy policies, which also include other forms of energy generated from renewable sources such as heat and gas. Many government policies, such as R&D subsidies, have a broad scope and target several types of renewable energy. Other policies, such as quota obligations on electricity production are restricted to renewable electricity only.

government. The tariff may be supplemented with subsidies from the state. The level of the tariff is commonly set for a number of years to give investors security on income for a substantial part of the project lifetime. Many different adaptations of the instrument are applied.

Green certificates in effect combine command and control (certification, and the quota obligation) with financial incentives from certificate sales. Certificates are issued to distinguish electricity produced from certain renewable sources. The 'green quality' is incorporated in the green certificate, which is issued at the moment of production, and which can be traded separately from the sale of electricity. This way, a producer of electricity from renewable sources can have greater revenues, selling both certificates and power. Quota obligations are used to impose a minimum production or consumption of electricity from renewable energy sources, thereby creating a demand for the certificates. The government sets the framework within which the market has to produce, sell, or distribute a certain amount of energy from renewable sources. The certificates provide an accounting system to register production, authenticate the source of electricity, and to verify whether demand has been met. Penalties that are applied if the demand obligation is not met will also serve as a 'safety valve' or 'maximum price'. In an alternative system, certificate demand is voluntary and based on the customer's willingness to pay for green electricity.

Subsidies can be to both investments and R&D. Investment subsidies can help overcome the barrier of a high initial investment cost. This type of subsidy is commonly used to stimulate investments in less economical renewable energy technologies. Investment subsidies are usually a given fraction, say 20-50 percent of eligible investment costs, but subsidized, low interest rate loans are also considered. Subsidies to R&D typically go through national research programs funded through the general government budget.

Fiscal measures can support green electricity. These schemes may take different forms, which range from rebates on general energy taxes or rebates from special emission motivated taxes, to proposals for lower value added tax (VAT) rates or tax exemption for green funds, to more generous depreciation schemes.

Bidding systems can be used to select beneficiaries and determine the level of investment support or production subsidies (and through feed-in-tariffs). Potential investors or producers have to compete through a competitive bidding system. The criteria for the evaluation of the bids are set before each bidding round. The government may for instance decide on the desired level of electricity from a group of renewable sources, and then let potential producers bid on the premium over market tariffs they require to provide a certain quantity for a given number of years. The premium may then be paid the producer by the network operator (as with a feed-in tariff system), who is reimbursed. Financing may be through a nondiscriminatory levy on all electricity consumption. In each bidding round, the most cost-effective offers will be selected. If desirable, the bidding may be differentiated in bands of different technologies and energy sources.

Policy instruments can be evaluated based on the following set of criteria: effectiveness, cost-efficiency, market certainty, transparency, and transaction costs.

To measure the **effectiveness** of policy instruments, policy objectives should be clearly defined. In most cases, renewable energy policies aim for an increased share of renewable electricity, and effectiveness then means ensuring that such a goal is met. In principle, but not always in practice, a quota system could be an effective instrument to ensure such an increased share. Due to the long time perspective required for electricity investments to be justified, a quota system with its uncertain premium need not be as effective a stimulus as is – for instance – a long-term guaranteed premium for green electricity. Instruments such as R&D subsidies, financial measures like zero- or low-interest loans, tax credits, or feed-in-tariffs all work at different margins and time horizons, but generally provide no guarantee for meeting a certain predefined market share.

Cost-efficiency of a policy instrument can be defined as the increase in green electricity divided by the cost of the instrument. In practice it is often difficult to assess cost-efficiency, due to uncertainty both in the incremental cost and in the resulting increase in green electricity provided. The cost-efficiency of a policy instrument also depends on the perspective of the stakeholder (van Dijk et al 2003). Government regulation could be efficient compared to subsidies, depending on how budgetary consequences are valued. Both investment incentives and feed-in tariffs may be inefficient if they do not create competition and incentives to reduce costs. Quota systems and bidding procedures are often regarded efficient as they use competitive forces to hold down costs.

Market certainty is an important element in promoting investments in renewable energy. Policy instruments have varying impacts on the level of market certainty (van Dijk et al, 2003). A primary requirement is of course that green producers must be guaranteed access to the grid for their output. Long-term fixed feed-in tariffs contribute significantly to market certainty as investor risks are minimized. A system with obligated quotas provides less market certainty, but price fluctuations and market dynamics can be partly influenced by the design of the regime. Financial support will generally reduce technical and market risks.

Transparency of policy instruments relates to implementation and monitoring, and to the costs for stakeholders of preparing a deal (van Dijk et al, 2003). The transparency of a feed-in tariff system is often considered high, and this is also the intention with trade-based instruments, such as certificates based on quota obligations.[22] Frequently, subsidies and fiscal measures are less transparent, which may lead to an increase in transaction costs, such as search, approval and monitoring costs.

In **Table 3.3**, five frequently used policy instruments in the case-study countries are evaluated based on the selected criteria described above (for evaluation of the policies implemented in the case-study countries, see section 3.3).

Table 3.3 Evaluation of Main Policy Instruments

	RD&D subsidies	**Investment subsidies**	**Feed-in tariffs**	**Production quota[23]**	**Tax credits**
Effectiveness	No guarantee	No guarantee	No guarantee	+?	No guarantee
Cost-efficiency	-	-	-/+	+	-/+
Contribution to market certainty	-/+	-/+	+	-/+	-/+
Transparency and transaction costs	-	-	+	+	-

There are important and intricate questions about exactly how policy instruments work, whether they be green certificates (with obligated shares of green in consumption or production) or feed-in tariffs. **Figure 3.2** illustrates the main logic behind any instrument driven by quota obligations, such as green certificate systems. The assumption is that there is cheap non-green electricity available (at a constant marginal cost, for simplicity, MCN), and

[22] There can be problems with the certificate trading system, with high requirements in terms of monitoring and verification (see Sweden, section 3.3).

[23] Quotas are often associated with effectiveness (assurance of meeting objectives), but non-compliance can happen, and likely would in Norway in a dry year.

there is costlier green electricity available at constant MCG. The government forces producers (or vendors, or consumers) to blend the two rather than to simply use the lower cost alternative first, yielding a 'blended' marginal cost curve, MCGC. Each non-green producer could, then, make sure to build a kilowatt hour (kWh) of green for each they build of non-green. But they can also buy certificates from green power producers. Green producers then get a 'subsidy' for their power production from the sale of certificates, so the MCGC curve gives a constant price blending of power stations at one price that equals MCG reduced by the subsidy and MCN raised by the cost of certificate purchases.

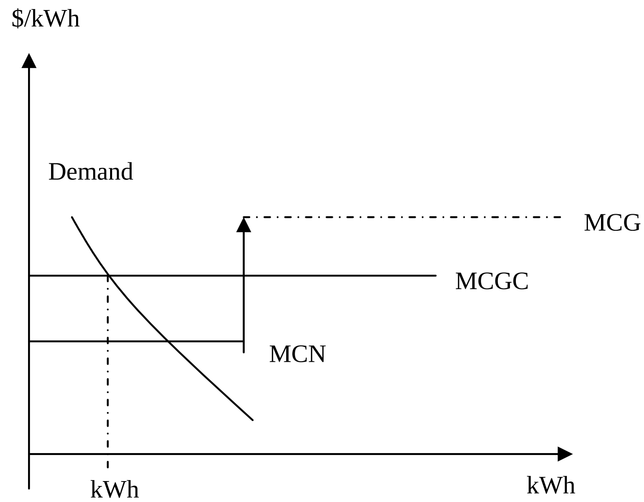


Figure 3.2 Supply curves of non-green and green electricity[24]

But it is important to acknowledge that there are alternative possible outcomes. One scenario to be aware of (see Bye et al. 2002a) is when the cost of green certificates gives no relevant increase to the marginal cost of non-green power, as will be the case in a market where most of the long-term costs are sunk costs (e.g. in hydropower markets). The market tariff may be dominated by a capacity constraint. In such a market, green certificates will not be able to force a substitution of green power for non-green power, so the market can only sell the green power by increasing the total amount of power produced, and the market price will for this reason be reduced as non-green producers accept the costs of the obligation.

The distinction between long-term and short-term marginal cost is an important one in power markets, not the least for nuclear and hydro, and it does create complications in how green certificates markets function. Briefly put, in a closed market, if an obligated share of green power is higher than the available capacity in a given year, a high certificate price would not help meet the obligation unless the total demand were dramatically suppressed. Then, most likely, a fee paid by those in violation of the obligated share will clear the market, and the market will work, but fail to 'meet the target'. Similarly, if the green capacity available is higher than the obligated share, the certificate price could be zero for that year,

[24] The horizontal segments MCN and MCG, are the supply curves for non-green and green electricity, respectively. MCGC is a supply curve blending the two, using obligated shares of green electricity and green certificates bring green production on stream even though it would be out of the market without intervention. This is the intended mechanism of green certificates, and consumption is both greener and lower than it would have been without intervention. The intervention can be represented as equivalent to taxes and subsidies, shown in **Figure 3.1**.

and green producers would experience losses, though possibly produce.[25] These complications can be reduced in large and open markets with jurisdictional borders (see the U.S. and Dutch case studies) or with long-term arbitration possibilities (a non-green producer may purchase certificates now which will put green capacity on the market in two years' time).

Nevertheless, these rigidities and complications are amongst the distinguishing features that can make other instruments more attractive. Others are the operation of registries to monitor certificate holders and trades, their compliance, and so on (see discussion in proposed law). The so-called feed-in tariffs, for instance can be used in more flexible ways. One is to subsidize long-term green power delivery by providing a contract upon construction, a model by which many problems are avoided.

3.3 Institutional Dynamics of Green Electricity Markets

This section addresses institutional aspects of policy development, focusing on the roles of various actors in the processes of designing, implementing and evaluating renewable electricity policies. The roles, positions and influence of key actors are discussed accordingly, emphasizing the German and Dutch cases for illustration. Different actors play different roles in the development of green electricity policies, with an important distinction between government actors and non-government stakeholders (see **Table 3.4**).

Table 3.4 Categorization of government and non-government actors

Government Actors	Non-government Actors
Federal/national/state government, including:	Fossil fuel based power industry
Ministry of Energy (or other ministry responsible for the energy sector)	Energy industry associations
Ministry of the Environment	Green industry (wind, solar, biomass, etc)
Ministry of Finance	Grey industry (steel, chemicals, cement, etc)
Parliament	Environmental NGOs
Implementing agencies	Consumers
Inter-government bodies, e.g. EU	Consumer associations
	Media groups

3.3.1 Roles and Positions of Policymakers

The main questions to be addressed are, who determines policy agenda? Who is directly or indirectly involved in policy-making? Who makes the final decisions on key policies? We first look at Germany and then the Netherlands. Germany has achieved the most success, compared with other EU member states, in establishing a domestic green electricity production capacity. The Netherlands has undergone a series of major policy shifts and has a strong domestic demand for green power, but has weak domestic production capacity.

In Germany, a broad coalition and a strongly involved parliament have been the key pushers behind renewable energy policy development. The feed-in law of 1991 (StrEG) was initially designed by a coalition of conservatives, greens and a few social democrats, and was further developed under a red-green government. Only the Liberal Party did not actively promote this policy, but eventually voted in favor of the law. The political process that

[25] Some of these difficulties are observed in the emerging Swedish green certificates market (see section 3.4.3).

resulted in the adoption of the Renewable Energy Law (EEG) in 2000 differed somewhat. As with the feed-in law in 1991, a parliamentary initiative acted as key catalyst. The EEG was partly driven by the coalition agreement of 1998, expressing the need for sustainable energy supply and reduction of CO_2 emissions. The Ministry of Economic Affairs (MEA) took responsibility for reforming the renewable energy policy. Members of the parliament from the two coalition parties soon criticized the Ministry for not being progressive enough and finally brought their own proposal for the law.

The all-party consensus leading to the adoption of EEG was new. The competition authority of the European Union was also involved in the policy process in 2000. The authority argued that the anticipated feed-in tariffs would distort market competition as the tariffs would excessively subsidize specific industries. This case was finally rejected by the European Court of Justice. The trend from all-party consensus towards a more polarized policy style has been accentuated under the drafting legislation for the EEG amendment of 2004. Support for the draft law mainly came from members of the coalitions, with MEA again in a rather conservative position. But with responsibility for renewable energy transferred to the Ministry of Environment, the MEA position had less impact on the process. The main opposition came from conservative and liberal parties, but had little impact since it was not appreciated by the general public.

In contrast to the German case dominated by a broad coalition, the Dutch study shows that a single actor can dominate the policy scene for a long time. The Dutch Ministry of Economic Affairs, responsible for renewable energy policy, has played a key role in the design and implementation of all renewable energy policies. The Ministry always advocated the importance of a voluntary market. Though this has not yet proven effective, the voluntary approach is in line with the traditional liberal markets perspectives in the Ministry of Economic Affairs. Mandatory obligations would not easily fit in the tradition of the ‘gentlemen’s agreements’ between government and industry, an approach which has long been advocated by the MEA. Renewable energy policy has also been influenced by another objective important to the Ministry, namely to avoid environmental legislation that might harm international competitiveness. Policy choices might have been different if energy had been the responsibility of another ministry, or if other stakeholders had played a stronger role. It is remarkable that other governmental actors, especially the Ministry of Environment, the Ministry of Finance and the Parliament, were unable to speed up the slow development of renewable energy, or to slow the mass outflow of government subsidies to other countries. On several occasions, the Ministry of Economic Affairs has overruled initiatives of other government departments and ignored advice both from parliamentary and special advisory bodies.

3.3.2 Position and Influence of Non-government Stakeholders

In Germany, both industry and the general public have directly or indirectly influenced policy decisions. From the beginning of the 1990s, the German Association of Small Hydro Generators played an important role in obtaining support from parliament, influencing the development of the feed-in law of 1991. In the end, however, wind energy became the main beneficiary of the law, and the electric utilities, including large utilities and the German Association of Electric Utilities, opposed it. The new law would replace a voluntary agreement with the utilities and would most likely reduce their influence. The sector argued that supporting small hydropower plants would be very costly. Ten years later, during the adoption of the renewable energy law (EEG), the lobby of electric utilities and industrial associations was much stronger. On the other hand, the lobby groups were more heterogeneous, as some members of industrial associations, such as wind manufacturers, benefited from the 1991 law. In general, industries are concerned about all support for renewable energy, as it is financed by all electricity consumers, and an extra burden for large industrial consumers was expected.

In Germany, the general public is very much in favor of renewable energy. The 'green' attitude is reflected in the relatively large support to the Green Party, and new laws have had even broader public support. In 2004, during the development of the EEG amendment, renewable energy manufacturers and their associations had become a relevant lobby group. The farmers' association became a new supporter for renewable energy policy due to the opportunities for its members in both biomass and wind energy. The electric utilities were again among the opponents of the EEG amendment, but their criticism had shifted to disagreement on details. This mild opposition might have been caused by the fact that utilities have seen that increasing customer prices doesn't automatically lead to commercial disadvantages. Some utilities had started to develop renewable energy projects and were potential beneficiaries of renewable energy support. The coal lobby, including the trade union of miners and the chemical industry, remained strong opponents.

In the Netherlands, non-governmental stakeholders have played a modest role in the design of renewable energy policies. An exception is the grey industry, mostly energy intensive industries and the energy sector companies. These have lobbied to oppose both energy taxes and obligated shares of renewable electricity. Different stakeholders, especially NGOs, energy distribution companies and the media have played a role in raising consumer awareness in the Netherlands between 1996 and 2002. NGOs in cooperation with energy distribution companies set up many information campaigns on renewable electricity. As a result, many consumers switched to renewable electricity. This shift was facilitated when the price difference between grey and green electricity disappeared as the result of the ecotax. Anticipating future electricity market liberalization, electricity companies have used green electricity to attract and retain customers.

3.3.3 Institutions and Actors in a Comparative Perspective

The German and Dutch studies show that institutional settings in policy development can differ significantly. In the Netherlands, a single player dominated the policy scene for a long period, while in Germany a broad number of stakeholders have been involved. These differences are due to culture, tradition, and the political environment.

The German case indicates that renewable energy policies can benefit from a broader support and early involvement of key stakeholders. Compared to Germany, Dutch policies have been developed and implemented by a small number of actors while input from others was limited. It is notable that renewable energy policies can benefit from strong and knowledgeable parliamentary participation, as the German Parliament gave an enormous stimulus to renewable energy policy development. Members of the Parliament have been well acquainted with the subject and have taken many initiatives over the last decade. The Dutch Parliament played a much weaker role, as it was seldom alert and did not initiate many new actions. The members of the Dutch parliament also failed in monitoring implementation, as illustrated by the fact that targets were never realized.

A pro-green attitude facilitates policy adoption. The environmental awareness in Germany is relatively high, which is reflected in the strong Green Party. The situation is different in the Netherlands. The country has many green electricity customers, but they became aware and supportive only after policies were implemented. The lobbying power industry can be very effective. In both countries, large industries were exempted from renewable electricity regulation after successful lobby activities. Politicians are frequently sensitive to arguments about international competitiveness. In Germany, a concern to help build the green electricity industry has caught on, but this seems not to be the case in the Netherlands so far.

3.4 Policies and Policy Instruments in the Case-Study Countries

This section presents a brief overview of the current and past policies and policy instruments applied in the case-study countries. It compares the policy instruments used in the four countries, and evaluates the policy effects.

3.4.1 Germany

The discussion on sustainable energy started in the early seventies, directly after the oil crisis in 1973. Although the debate primarily focused on the drawbacks of nuclear energy and the benefits of energy efficiency, renewable energy gained more and more attention over the years. The first energy research program was launched in 1974. The 1986 Chernobyl nuclear accident was another important trigger for seeking new ways to generate power. More recent factors are the Rio conference in 1992 with the adoption of the United Nations Convention on Climate Change (UNFCCC), followed by the Kyoto Protocol in 1997. Germany intends to become the world's leading country on renewable energy, as seen from the Bonn Conference in 2004.

The developments in public opinion were accompanied by technological change and the emergence of a renewable energy industry (mainly wind turbine technology). The development of wind turbines had two very different roots. First, there was an unsuccessful top-down approach by the government, where players in research and industry aim to build a very large wind turbine from scratch. Second, several smaller players started building smaller turbines in a bottom-up approach, then gradually increasing size and finally becoming commercial success. After years of support for technology development, the 1991 introduction of the Feed-in Law (StrEG) gave fixed tariffs for renewable electricity. This marked a shift from R&D funding to production incentives. The system guaranteed long-term fixed prices with a purchase obligation, thus minimizing commercial risks for investors and project developers. This resulted in a significant growth of new capacity, especially wind energy. To stimulate electricity generation from biomass, a separate law providing resources for biomass was introduced in 2001. This resulted in fast biomass CHP development. The key elements of renewable energy policy are the system of feed-in tariffs introduced in 1991, updated with the Renewable Energy Act (EEG) in 2000 and the EEG amendment in 2004.

Table 3.5 Milestones in Green Electricity Policy and Market in Germany

1974	Start of R&D programs
1970s – 1980s	Technological support (esp. wind technology) Industrial development (esp. wind sector)
1980s – 1990s	Changing public opinion in favor of renewables and against nuclear
1991 2000 2001 2004	Feed-in Law (StrEG) Renewable Energy Act (EEG) (update of StrEG) Biomass Law (closely linked to EEG) EEG mandate

The German renewable energy policy has delivered results. Between 1990 and 2002, 13,000 MW in new capacity came on stream. Germany has seen much stronger growth in renewables compared to EU average. Between 1991 and 2000, power generation from renewables grew by 142 percent, while over the same period other EU member countries experienced a growth of 25 percent. In the 1990s, the share of renewables almost doubled in Germany. In the EU as a whole, the share of renewables grew only by 13 percent. In addition, the costs of wind and solar power decreased by about 30 percent and 60 percent between 1990 and 2000.

The objective of the German renewable energy policy has, however, not always been clearly defined. Although not explicitly stated, the StrEG of 1991 aimed at promoting renewable energy technologies. The EEG of 2000 stated that the purpose of the law was to facilitate a sustainable development of energy supply in the interest of managing global warming and protecting the environment. To achieve this, the law aimed at achieving a substantial increase in the percentage of electricity supplied by renewables, at least doubling the share of renewable energy sources by 2010. The EEG also made explicit reference to corresponding EU objectives. The EEG Amendment of 2004 is even more explicit. While retaining the EEG objective of sustainable energy supply to protect the climate and the environment, the new law – according to the draft adopted by the government in December 2003 – also aims to

- Reduce the cost of energy to the national economy by internalizing external cost;
- Contribute to avoiding conflicts about allocation of fossil energy resources;
- Promote development of renewable energy technologies;
- Increase the share of renewable electricity supply to 12.5 percent by 2010 and 20 percent by 2020.

The feed-in tariff system provides no guarantee for achieving the policy objectives. The sharp increase in the share of renewables and the significant reduction of costs, however, lead to the conclusion that the policy instruments have been effective in the pursuit of these goals. In addition to increasing the share of renewables and reducing their costs, the policy also aimed to internalize the external costs. This objective has not been reached so far. Although no explicit targets for different technologies were set, the growth of other sources, especially biomass lagged behind.[26] In addition to the feed-in tariffs, a large number of dispersed federal, regional and local support programs were available to support investment in renewable energy generation by subsidies, tax incentives or soft loans. The stop-and-go element in these support schemes, in addition to the fragmentation, has reduced their combined effect.

3.4.2 The Netherlands

The Netherlands has gained considerable experience in the promotion of the green energy market. Over the last three decades, a variety of policy instruments have been applied, including direct investment subsidies, fiscal support, voluntary agreements, consumer subsidies and R&D programs.

Directly after the first oil crisis of the 1970s, the government started promoting R&D for renewable energy. In this period, industrial activities were set up to use wind and solar energy. These were often driven by personal idealism rather than long-term corporate strategy. In the 1980s, policies shifted to direct investment subsidies and financing for demonstration projects. The intention was to speed up market growth to facilitate cost reduction and further market expansion. In the early 1990s, international agreements on GHG mitigation gave renewable energy a new momentum.

In the early 1990s, the government negotiated voluntary agreements with the energy distribution sector. The latter committed to voluntary sales targets for renewables amounting to 3.2 percent of electricity sales and 0.7 percent of gas sales by the year 2000. These measures were expected to lead to a 2.7 Mt reduction in CO_2 emissions over the same period. Investments in green energy were financed by a general environmental levy. In 1996, the government introduced a regular energy tax (the "ecotax") for small- and medium-scale

[26] Recent developments in Germany indicate that industries invest heavily in biomass combined heat/power applications which have been driven by government policies and support programs.

energy users. This new tax system was made to stimulate green electricity consumption by exempting green electricity. In addition, production support was given to green suppliers. In 2002, total support to green electricity amounted to eight Euro Cents per kilowatt-hour (kWh) (six Euro Cents for consumer support and two Euro Cents for production support). In terms of cost, support for renewables amounted to €150 per ton of CO_2 (van Rooijen and van Wees 2004).

An informal, voluntary green label system was implemented by the energy sector in 1998. The green label system set a target for green electricity in the Netherlands, which was further specified for each of the participating companies. The green electricity price under the label system consisted of three components: i) a small feed-in price based on an agreement between Dutch distributors and renewable generators (later replaced by a pool price/guaranteed price), ii) the green label price (average of 2 Euro cents/kWh), and iii) a production subsidy. With the liberalization of the electricity market in 2001, a new mechanism for the voluntary trade of green certificates became operational, replacing the green label system. The goal was to stimulate the domestic production of green electricity. The green certificate system was linked to the energy tax exemption scheme and production subsidies (Dinica and Arentsen 2004). During 2001, imported green electricity was not eligible for the eco-tax exemption, but distribution companies lobbied for including imports. The argument was that domestic production capacity was insufficient to meet demand. As of January 2002, imports also became eligible (van Damme and Zwart 2003).

In July 2003, a new policy titled “environmental quality of electricity production” (MEP) was introduced. Two main objectives of the MEP were to reduce investment risks and to improve the cost-effectiveness of renewable electricity. Support is provided by means of a feed-in tariff combined with a partial exemption from the ecotax. The tariff is financed through an annual levy on household electricity connections. The ecotax exemption will be phased out. Thus, by 2005, the promotion of the Dutch green electricity market will be fully supply driven. **Table 3.6** shows the milestones for the Dutch policy approach.

Table 3.6 Milestones in Green Electricity Policy and Market in the Netherlands

1970s	RD&D policies, industrial development, especially wind and solar
1980s	Investor subsidies and demonstration projects
early 1990s	New momentum: CO_2 targets
early 1990s	Voluntary agreements between the government and energy distribution sector
1996	Regulatory energy tax (consumption stimulation)
1998	Introduction of voluntary green label system
2001	Liberalization of the energy market and introduction of green certificate system
2003	Introduction of environmental quality of electricity production (MEP), focusing on production stimulation

The voluntary agreement of the early 1990s can be seen as an important milestone, as it was the first time that the government intervened to set targets. The targets were, however, never met because the goals were not compulsory and the compliance regime was poor.

An evaluation of the effectiveness of the second phase (1996–2002) is difficult because policy objectives were not clearly stated. Since the mid-1990s, renewable energy policy matured, and more stakeholders became involved in the process. The government, however, did not choose between stimulating demand or supply. This resulted in a strange outcome where targets were mainly supply-driven (i.e. stimulate investments in renewable energy) while instruments primarily focused on promoting demand. The results were poor, as the steep increase in demand for renewable electricity could not be met by national production, and imports of green electricity increased rapidly. Criticism grew as Dutch taxpayers' money was spent on green electricity generated in other countries, generation that was not additional from the perspective of the Netherlands.

The green label system was unfortunately timed and only operational for two years. It was introduced towards the end of the voluntary environmental program of Dutch distributors, a commitment made under the old monopolistic regulatory scheme. A new electricity law promoted in 1998 launched a new regulatory context better matched to the gradually liberalizing electricity market. Contrary to the green label system, the tradable green certificate system introduced in 2001 has no specified supply/purchase obligation. Combined with a demand strongly dependent on the exemption from the eco-tax, this led to a highly uncertain market environment for potential investors (Dinica and Arentsen 2004).

Although the policy was quite effective in reducing administrative barriers, it is questionable whether the right barriers had been addressed. Only at a late stage did the government see the problem of an unstable investment climate, and did not succeed in creating a stable investment climate. Policies were diverse and complex and changed over time, as with subsidy conditions, eligibility of technologies for support, and the level of support. According to Dinica (2002), the Dutch government did not succeed in building investor confidence through stable policies, and failed to reduce market uncertainties. The lack of clear and consistent policy objectives, instruments, and enforcement procedures has hindered substantial investments. The notion of the unstable investment climate as a potential barrier was adopted late.

Although the effectiveness of Dutch green electricity policy between 1996 and 2002 has been limited, government strategy has had some positive effects. First, consumer awareness has increased, and renewable energy use has become part of the lifestyle of many households. Second, the liberalization of the green electricity market has paved the way for the broader liberalization of the energy market. The energy sector grew accustomed to the new market conditions and became used to launching marketing campaigns to attract new customers. Finally, the Netherlands has gotten attention as a front-runner in promoting consumer participation in green electricity campaigns.

The Netherlands is so far the only EU country that combines feed-in tariffs with a green certificate scheme. It has been hoped that the feed-in tariff would help secure substantive market certainty to investors. At this early stage of development, however, it is a bit early to evaluate the effects of this policy instrument.

3.4.3 Sweden

Renewable energy development in Sweden is very much related to nuclear power, which has been debated for decades. Political decisions have been made to decommission the nuclear power plants. The concern about the negative impacts on industrial competitiveness, however, has hindered firm actions so far. To date there is still a lack of national consensus on the approach and timeframe for phasing out of nuclear power. The result is a rather weak government commitment towards renewable energy, which is reflected in the short-term nature of the subsidy programs for the renewable energy sources. In addition, CO_2 policies have not given additional incentives for renewables, as the energy sector is already almost carbon free.

Since 1991, policies have been adopted to promote renewable energy. These measures include investment subsidies, tax relief for renewable energy and emission taxes. The taxation of fossil fuels has been gradually increased since its introduction in the early nineties. The carbon tax is, however, levied only on fossil fuels used in heating sectors, while power generation is exempted. Since 1994, small-scale electricity production based on renewable energy sources is (partly) exempted from the energy tax. This provides a tax benefit of 1–2 ct/kWh. Since the seventies, the government also promoted renewable energy by means of supporting research programs and technology demonstration. The 1997 Energy Act confirmed the energy policy guidelines of 1991, and formed the basis of the new energy policy program that became operational in 1998. The program had two main components: a seven-year extension of the energy research program and a five-year program of subsidies until the end of 2002.

Approved by the Swedish Parliament in 2002, the green certificates scheme[27] ('Elcertifikat'**)** came into force on May 1, 2003. The target is to increase the production of renewable electricity by 10 TWh from the 2002 level by the year 2010. A quota obligation is formally imposed on electricity users, increasing from 7.4 percent in 2003 to 16.9 percent in 2010.[28] The consumers can either let the electricity suppliers ensure that the consumers' quota obligation is met or, from 2004, voluntarily handle the quota obligation on their own. For the first five years a price guarantee will be offered to electricity generators to secure their market for certificates. The price guarantee decreases from SEK 60 per certificate in 2003 to SEK 20 per certificate in 2007. Several transition schemes for the period up to 2009 have been made so that the market actors will have some time to adjust to the new system. Only production that takes place within Sweden is eligible for certificates. However, the long-term intention is to also include production from other countries and be compatible with envisaged EU initiatives.

In 2004, the green certificate scheme was assessed by the Swedish Energy Agency (SEA) (SEA 2004a, 2004b). In its first year of operation, virtually no new production capacity was added but there was significant fuel switching from fossil fuels to biofuels in existing plants. The SEA Director General, Mr. Korsfeldt, stated that under the current condition, the target of an additional 10 TWh of renewable electricity by 2010 would not be achieved. The system does not constitute adequate support for technical development, and no major new investments were made as a result of the electricity certificate system in the first quota year. If the electricity certificate system is made permanent and the quota levels are made transparent for a period of 10–15 years, Mr. Korsfeldt finds it probable that the willingness to invest will be sufficient for the target. The SEA further stressed the importance of continued investments in research and technological development (SEA 2004c).

The average price of a green certificate in 2004 has been around 3 øre/kWh[29], a small increase from 2003. For a household using electricity for heating (20,000 kWh/year), the green certificates accounted for 2.4 percent (about 572 SEK) of the total cost of electricity. However, only 49 percent (or 650 million SEK) of what the consumers paid for the certificates in 2003 went to the producers of electricity from renewable energy sources. Seventeen percent went to cover the administrative costs and profits for the electricity suppliers. The government received 20 percent through value-added tax and another 14 percent through fines (as not enough certificates were bought, see SEA 2004b). The twin observations that little new capacity has been added and that less than half of what consumers pay for the certificates went to renewable energy sources could undermine support for the system. The effectiveness of the green certificate scheme has also been criticized by concerned NGOs.[30]

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[27] Including power from wind, solar, biomass (including peat), geothermal energy, tidal power, wave energy and hydropower. All new hydropower plants and a limited number of old ones due to the size will be included.

[28] Even though the scheme formally includes all energy consumers, it should be noted that the el-intensive industry does not have any required share."

[29] 1 øre = 1/100 krone

[30] The Swedish system for Renewable Obligation Certificates (ROCS) is not working in the right way, according to Johan Kling, project coordinator of the Swedish label Bra Miljöval and working on the eco-labeling of transport systems for the Swedish Society for Nature Conservation. "The system is not

The subsidies provided in the 1990s have proven insufficient to bridge the gap in costs to alternatives of hydro and nuclear. After the liberalization of the electricity market in 1996, the gap became even bigger as prices went down. It is expected that the quota system will result in a higher share of biomass-based electricity production. **Table 3.7** shows the major milestones in the Swedish policy approach.

Table 3.7 Milestones in Green Electricity Policy and Market in Sweden

1975	First energy research program (including renewables)
1991	Energy policy guidelines adopted by the parliament (introduction of direct investment subsidies for wind and biofuels and of environmental taxation)
1996	Liberalization of the energy market
1997	Energy act (extension of research program and subsidy measures)
2002	Approval of the green certificate scheme by parliament Elimination of investment subsidies
2003	Introduction of the green certificate system (based on obligated quotas)

For a long time, the Swedish renewable energy policy mainly consisted of supportive R&D programs and investment subsidies. Despite these policies, studies show that the Swedish efforts have had modest results. According to Åstrand and Neij (2004), the level of installed capacity per euro spent on market subsidies and R&D for wind energy is 2 to 5 times lower compared to Germany and Spain. The most recent evaluation also concludes that there has been too much faith in the possibilities of energy RD&D as a stimulus for the transition of the energy system (Arnold and Chesshire 2003).

Low performance could also be caused by a lack of continuity and coherence in the government policies on renewable energy. Subsidy schemes have lacked continuity; there were even intervals without any subsidies at all. Also, the long-term government intentions have not been clear. The lack of continuity and long-term commitment is mainly driven by the position of nuclear energy. During the last two decades, the deadlock on nuclear power issues has made it difficult for the government to have a consistent policy to promote renewables. The Swedish situation illustrates the importance of consensus on long-term objectives and strategy.

The lack of coordination between different parts of the government has also hindered the development of wind energy. As government commitment to promote wind power has not

efficient in stimulating investments in new production of renewable power", he says. Since May 2003 Sweden has a national obligation for renewables, imposed on all consumers. In practice, the obligation (a share of 7.4 percent in 2004, rising to 16.9 percent in 2010) is transferred to suppliers, who get paid extra money in meeting the obligation on behalf of their customers. "In the first year of the ROCS system only 40 million of the 130 million Euros paid extra by customers was invested in renewables", according to Kling. "The rest was spent on taxes, VAT, fines and administration costs. In the first year of ROCS almost half of all suppliers chose not to invest in renewable sources, but to pay fines for not meeting the obligation. Therefore the ROCS system is rather a masked tax system than a system for certifying the quality of electricity." At present Kling is discussing the certificates system with the Swedish Energy Agency and the government. "In the long run the obligation could lead to rising green energy production, but at present this is not the case. The criteria are very flexible." In Kling's opinion the system is also unsuitable to meet the European Directive on disclosure of information about the fuel mix of each supplier (mandatory as from July 1st 2005). "Full disclosure could be built on the ROCS, but for now there is not enough control. At present, it is possible to use the power coming from one wind power plant for both the renewable obligation and for export, thus double counting the economic value of wind power." (Source: Green Prices, Nov.30, 2004) had enough strength, the reaction of the regional and local governments, which are in charge of issuing the permits, is slow.

3.4.4 The United States

In the United States, governments and regulatory agencies at the federal, state, and local levels have adopted specific policies to support wind, solar, biomass, and other renewable energy sources. Deregulation, for example on the opening up of markets, has facilitated power generation from renewable sources. Deregulation in the United States started in late 1970s. At the federal level, the government has provided R&D funding, demonstration grants, and other financial incentives, including tax deductions and credits for electricity produced from wind, solar, geothermal and closed-loop biomass facilities. The federal renewable energy production incentive (also called the production tax credit), first enacted in 1992 as part of the Energy Policy Act, provides financial incentives for electricity produced from new, qualifying renewable energy facilities. The federal production tax credit has played an important role in the recent wind energy development. The federal government also allows accelerated depreciation for corporate investments in solar, geothermal, and wind facilities. The federal Public Utilities Regulatory Policies Act (PURPA) of 1978 has also played an important role in renewable energy development by requiring utilities to purchase electricity from small-scale production facilities.

At the state level, there is considerable variation both in the general regulatory environment and green electricity policies. Most states apply a wide range of financial incentives to promote renewable energy, including production incentives, personal and corporate tax credits, grants and loans or leasing programs. Also various rules and regulations vary, with examples including construction and design standards as well as green power purchasing requirements. In 2003, 15 states have adopted renewable portfolio standards (RPS), which require a gradually increasing percentage of an electricity provider's electricity sales to come from qualifying renewable energy sources. Some states allow retail electricity providers to use tradable renewable energy credits to satisfy the RPS requirement. Recently, a number of voluntary measures, such as educational and outreach programs, has been adopted. Most measures are still in the process of implementation. **Table 3.8** shows the major milestones in the US policy approach.

Table 3.8 Milestones in Green Electricity Policy and Market in the USA

1978	Start with restructuring of the electricity market (PURPA)
1992	Federal renewable energy production incentive (production tax credit) as part of the Energy Policy Act
90's-ongoing	Wide range of financial incentives, rules and regulation and voluntary measures applied by state or local governments
2003-ongoing	Adoption of RPS (state level)

While there has been interest in promoting the use of renewable energy in electricity production for a number of years in the United States, the market share of non-hydro renewable energy sources in electricity production has remained at about 2 percent over the past decade. An evaluation of policy instruments is difficult, because most measures are still in the early stage of implementation. Reliable data on program funding, cost, and energy savings from different types of policy measures are not yet available. In addition, the evaluation of the effectiveness of the policy instruments is difficult because objectives haven't always been clearly defined. The RPS of 2003 is the only instrument establishing specific targets for renewable electricity.

Of the instruments most widely applied, financial incentives used in conjunction with mandatory regulations such as net-metering and RPS appear to have been the most effective in promoting renewable energy technologies. Public benefits funds (supported by surcharges on electricity users) have also played a role in stimulating renewable energy technologies and in promoting green electricity products. Competition at the retail level in restructured markets and green-pricing programs offered by traditional utilities have also helped to develop green energy sources. In conjunction with green power education programs, these instruments may be critical for long-term development of the green electricity industry.

Despite all efforts, important impediments to green electricity remain. Barriers still not effectively addressed include the relatively high cost of electricity from renewable energy sources, price distortions from external costs or direct subsidies, lack of customer awareness on green power products, and the abundance of coal and other conventional energy sources. In the absence of significant increases in fossil fuel prices, much more stringent environmental regulations, or significant changes in electricity customer preferences, green electricity markets are likely to continue to develop slowly.

3.5 Comparison of Policies and Policy Instruments

The policies and policy instruments of the four countries show similarities as well as differences. In most countries, the initial debates on renewable energy started after the first oil crisis in 1973. Germany and the Netherlands immediately took action. In both countries, the 1970s and 1980s are characterized by a focus on R&D programs and industrial development. The situation is slightly different for Sweden, as the oil crisis there resulted in a shift to nuclear power. At a later stage the envisaged phase-out of nuclear plants has contributed to renewable energy policies. The United States is in important ways behind the other countries in developing a clear national policy framework for renewables, and most of the policy implementation happens at the state and local levels (see **Table 3.9**).

Table 3.9 Main Characteristics of the Policy Approach in the Case-Study Countries

Germany:
First discussions on renewables started directly after the first oil crisis in 1973 Initial activities on research, technology and industry development (R&D incentives) Important milestone: Feed-in Law in 1991 (production incentives) Significant increase in new capacity and cost reduction since the beginning of the 1990s
The Netherlands:
Thirty years of experience with a wide mix of policy instruments Many fundamental shifts in policy direction Present key instrument: feed-in tariff (production incentive) + green certificates
Sweden:
Discussion on renewables not stimulated by oil crisis and CO_2 targets but by the discussions on the phase out of nuclear power Late development of policy instruments compared to other countries Main policy instruments until 2003: investment subsidy and R&D Present policy: green certificate system base on quota obligation
The United States:
Wide mix of policy instruments applied at federal, state and local level Considerable variation among states Most instruments are in an early stage of implementation

In the 1990s, debates on renewable energy got an extra stimulus from international environmental actions, such as the UNFCCC and the Kyoto Protocol. Recently, the Political Declaration and the International Action Program at the International Renewable Energy Conference in Bonn (2004) has indicated a new trend of development on renewable power generation, which has encountered wider support from different stakeholders around the world.

Over the past few decades, all countries have employed a mix of policy instruments to support renewable energy. As indicated in **Table 3.10**, all countries have had one or more shifts in policy focus over the last three decades. Policies in general change from R&D support towards production incentives. Although R&D support is still present in all countries, it remained the key factor until recently only in Swedish RE policy. Most shifts in policy focus have occurred in the Netherlands. The 1970s focused primarily on R&D stimulus, followed by investment subsidies in the 1980s, consumer support in the 1990s, and producer support at present.

Table 3.10 Primary Focus of Policy Instruments

	Germany	**Netherlands**	**Sweden**	**United States**
RD&D	1970s–1980s	1970s	1970s–1990s	
Investments		1980s	1990s	
Production	1991–present	2003—present	2003–present	1992–present
Consumption		1996–2002		

Table 3.11 shows that most case-study countries support renewable energy by financial incentives. The quota system in Sweden and the RPS of the United States are presently the only non-financial instruments applied. Despite longstanding experience with renewable energy policies in many countries, various policies are still in an early stage of implementation, with Germany's Feed-in Law (1991) as a notable exception.

Table 3.11 Financial and Non-financial Policies for Renewable Energy

	Financial	**Non-financial**
R&D	Germany (1970s–1980s) Netherlands (1970s) Sweden (1970s–1990s) The United States (late 1970s–present)	
Investment	Netherlands (1980s) Sweden (1991–2002)	
Production	Feed-in tariff Germany (1991–present) Feed-in tariff Netherlands (2003–present) Production Tax Credit US (1992–present) Tax (exemption) Sweden (1990s)	Quota Sweden (2003–present) RPS US (2003–present)
Consumption	Ecotax Netherlands (1996–2002)	Voluntary agreement Netherlands (early 1990s)

It is clear that countries do not stimulate different renewable technologies neutrally. Germany and the Netherlands, for example, use differentiated feed-in tariffs for different technologies. The Swedish quota system, however, does not differentiate renewable energy technologies. As the quota system sets targets for the share of renewables as a whole, it is likely that least-cost technologies will develop more quickly.

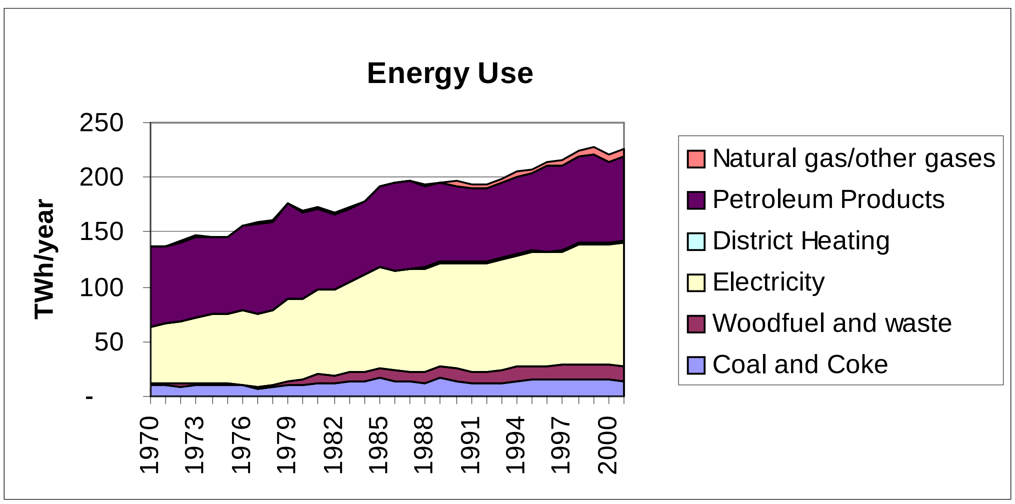
4 Green Electricity Market Development in Norway

The Norwegian energy sector is dominated by the high dependence on electricity consumption, as Norway has the highest per capita use of electricity in the world. This is partly explained by a high share of electricity-intensive industries in Norwegian manufacturing. However, even controlling for electricity use in manufacturing, Norway would rank high in terms of electricity use per capita (NVE 2000). Electricity has a high share in general energy use, including heating purposes. Hydropower completely dominates electricity production. Due to limited growth in production capacity and a slow and relatively constant growth in overall energy consumption, the nationwide energy balance has become increasingly dependent on imports. This chapter presents the energy sector[31] in Norway in terms of energy use and energy resources, the electricity market, policies and policy instruments in use, potentials for green electricity and the main barriers to green energy market development.

4.1 Energy Use and Resources

4.1.1 Energy Use

In the Norwegian energy system, electricity is mainly used for stationary energy consumption. Petroleum products are used in the transport sector, and coal, coke and gas are used as inputs for the industry.



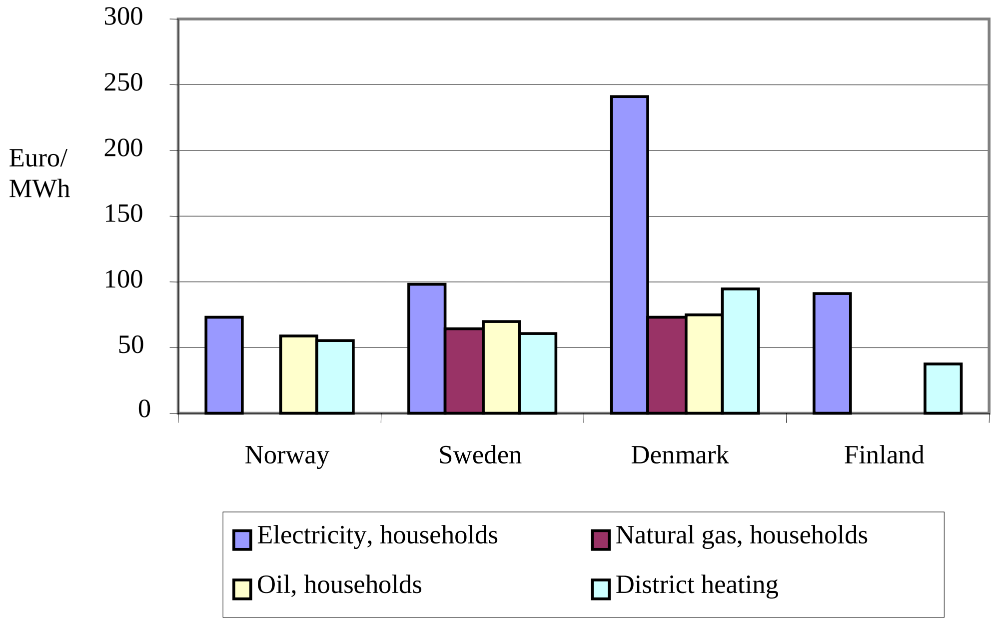
Source: NVE 2003

Figure 4.1. Energy Use by Energy Carriers (1970–2001)

[31] The chapter will, as in the case-study countries, focus mainly on electricity. However as one of the main energy policy targets in Norway the latest years has been to reduce the dependence on electricity, the discussion will also reflect alternative ways to obtain a more sustainable energy system more broadly.

Figure 4.1 shows the total annual energy consumption by the various energy carriers. As seen from this overview, the use of electricity has increased significantly from 1970 to 2001. Although the oil crisis in 1973 and 1979 did reduce the consumption of petroleum products, the overall consumption has been relatively stable.[32] The other carriers are relatively small in the overall energy mix, but bioenergy is becoming more important and the use of district heating[33] is not widespread.

Total stationary energy consumption has grown slowly the latest few years. The energy intensive industry and other parts of the private sector account for most of the increased energy use. The domestic housing sector has become highly dependent on electricity, as the use of oil has been drastically reduced since the 1980s. The use of fuel wood in the housing sector has increased somewhat since the mid 1990s.[34] **Figure 4.2** shows that the relative price of electricity is low in Norway compared to its Nordic neighbors. Compared with Norway, electricity is far more expensive than other heating resources in Sweden, Denmark and Finland. In Denmark, the price of electricity is prohibitively high for heating purposes. Thus almost every Danish consumer uses district heating or natural gas for heating.



Source: Espegren 2004.

Figure 4.2 Nordic Energy Prices Countries (2002)

4.1.2 Energy Resources

In 2003, Norway was the world's seventh largest producer and the third largest exporter of oil.35 The amount of crude oil produced annually has been fairly stable since the mid-1990s

[32] Note that this includes the energy use for transport, such as gasoline and diesel.

[33] District heating systems constitute a heating system transporting warm water (or steam) in pipes between buildings

[34] A difficult aspect considering domestic energy use is to quantify the amount of wood fuel used. It is estimated that as much as 70 percent of the fuel wood used is not traded commercially but cut by the end user, or traded privately without taxation.

[35] Including natural gas liquids (NGL) and condensates.

at approximately 150–160 million metric tons per year, of which about 130–140 million metric tons are exported. Natural gas production has increased significantly from about 42 billion Sm^3 in 1996 to about 75 billion Sm^3 in 2003, almost all exported (Statistics Norway 2004a).

Norway is also rich in renewable energy resources. During the last century a substantial amount of hydropower has been developed, with a total production capacity (in an average year) of 118.4 TWh/year. This is on average about 99.6 percent of the gross national electricity production. Most of the installed capacity comes from hydropower stations of above 10 MW, while 4.4 TWh comes from stations between 1–10 MW and 0.25 TWh from installations less than 1 MW. Due to variations in precipitation, the amount of electricity produced from hydropower can vary from 89 TWh in a dry year to 150 TWh in a wet year. The technical and economic potential for large hydropower has been estimated at 186.5 TWh/year, but of this 36.5 TWh is protected from development. Given current production capacity, the remaining technical and economical potential for large hydropower is about 30 TW (OED 2004). However, based on the public opinion and the political environment, not much of this is likely to be developed. Estimates show that there is a technical and economical potential for small hydropower of about 25 TWh/year (NVE 2004a).

Despite moderate support there has been a great interest in developing wind energy in Norway since 1997. In 2003, 65 wind turbines were operating at 14 locations along the coast. The total installed capacity is 97 MW, with capacities for each of these turbines ranging from 55 kW to 2 MW. The estimated annual production in 2003 was 219 GWh/year.[36] Additional capacity is being installed at Hitra (70 MW) and Smøla (stage 2 = 105 MW). The Norwegian Water Resources and Energy Directorate (NVE) has received plans to build up to 2,900 MW of capacity, producing a total of 8.8 TWh/year. NVE (2001) has estimated the physical potential for wind power at 480 TWh/year,[37] which is some four times the annual electricity produced from hydropower.

Bioenergy as a source of heat has earned a more important position in energy supply due to higher electricity prices. Bioenergy heating (not electricity production) is a competitive energy source when bioenergy or waste is available at low cost and close to the end user, when the project building or process has a piped (warm water or steam) heating system, and when the energy consumption is relatively high. NVE (2001) estimates that bioenergy production could increase from the current 15 TWh/year to about 35 TWh/year. In addition to the use of biomass for heating purposes, there are possibilities for electricity production (cogeneration). This is relevant in the wood processing industry, in conjunction with waste treatment plants, and for use in district heating systems. There are some existing smaller bioenergy electricity plants that use landfill gas or waste combustion, as well as some sludge processing plants. The present electricity production from bioenergy is approximately 160 GWh/year.

The use of active solar energy systems is not very common in Norway. Demonstration facilities have been installed, mainly with positive experience. Passive use of solar energy is closely linked to the construction of home exteriors, and many houses utilize passive solar heating, but without any estimates of the energy used or saved. Typical features of passive (solar energy) houses are high insulation values on the entire building exterior, optimum orientation, and location in the landscape. The use of grid connected photovoltaic systems (PV) is rather limited in Norway. There are some demonstration sites showing various types of PV panels, as well as building integrated installations. In summer houses and cabins, off-grid PV installations were common during the 1980s. NVE (2001) estimates that solar energy

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[36] Data for 2003 submitted to IEA.

[37] Assumes an average wind speed greater than 8 m/s at a height of 50 meters and with a wind turbine density of 15 MW/km^2.

could account for an additional 20 TWh/year through the use of active and passive solar energy.

A prototype tidal energy turbine of 300 kW made by Hammerfest Strøm AS was installed in Kvalsundet and connected to the grid in autumn 2003. There are also other on-going studies considering the use of tidal currents, especially in the counties of Troms and Finnmark. Studies are also undertaken on effects of the underwater turbines on sea life. The Norwegian government in the 1980s gave substantial financial support to the development of wave energy R&D. A range of demonstration installations was made. Recently, the state-owned foundation Enova has granted NOK 30 million as subsidy to a sea-wave driven power plant in Rogaland and test production will begin in December 2005.[38]

4.2 Electricity Sector Development

In this section, we focus on Norwegian electricity production, the deregulation of the Norwegian electricity market, electricity prices and the electricity balance.

4.2.1 Electricity Production

Table 4.1 shows the dominance of hydropower in electricity production in Norway. From 1991 to 2002, hydropower accounted on average for 99.6 percent of the total electricity production. Some electricity is produced in thermal power plants. Such power plants have a limited installed capacity and are often located close to and owned by industrial companies that use the heat and electricity themselves. The energy inputs are often fossil fuels and bioenergy (waste). This is a small but somewhat increasing niche. Although electricity production from wind is still small, there is an increasing development potential.

Table 4.1 Electricity Production in Norway, 1991–2002 (GWh)

Year	Hydropower	Wind power	Thermal power	Total	Share of non-hydro (percent)
2002	129,837	75	561	130,473	0.49
2000	142,289	31	496	142,817	0.37
1995	122,487	10	514	123,011	0.43
1991	110580	-	429	111,011	0.39

Source: Statistics Norway 2004b

The use of district heating in Norway must be seen in conjunction with electricity production. The use of district heating systems has gradually been developed since the early 1980s. Spurred by higher electricity prices and some financial support, a range of district heating systems have been established. From 1994 to 2000, heat production increased from about 1.8 TWh to 2.2 TWh. Several of these systems include advanced multi-fuel burners, so fuels can be switched continuously. The most important heating sources are waste, electricity, petroleum products, and industrial waste heat (the renewable share of the waste heat is considered renewable energy). Market conditions and price fluctuations explain changes in the energy mix from one year to another. The challenge with respect to increasing the use of biomass in these systems is the cost of fuel, collection, handling and transportation (NVE 2003).

[38] The Norway Post, Dec.24, 2004.

4.2.2 Deregulation and Electricity Prices

The Norwegian electricity market was deregulated in 1991 and is currently one of the most open in the world. The electricity market was formally opened for free competition in 1991, but real market access for all end-users was not established until 1995. All customers, including individual households, have access to competing suppliers. Border tariffs between Norway and Sweden have been abolished. Transmission tariffs are completely independent of trading agreements. The Nordic electricity exchange, Nord Pool, organizes an electricity spot-market and a futures market where it is possible to trade weekly contracts up to three years ahead. Prices in all markets, including bilateral contracts and the retail market, relate to the spot-market. Also in short-term operation of the network, the system-operators are obliged to use market operations as far as possible. All providers are free to negotiate bilateral physical contracts, but trade in the futures market is increasing rapidly. In Norway, all long-term contracts are financial, with physical electricity being traded in the spot-market.

Of the about 340 utility companies, there are many different types of energy utilities, and the extent of their involvement in electricity generation, trading and transmission varies widely. Important types include production companies, grid companies, vertically integrated utilities and industrial companies. Many energy utilities have in recent years been converted from municipally owned companies to limited share companies. As a consequence of the deregulation, utility companies were forced to deliver electricity at competitive prices. Increased competition has thus forced the utility companies to become more conscious of the cost of the energy development.

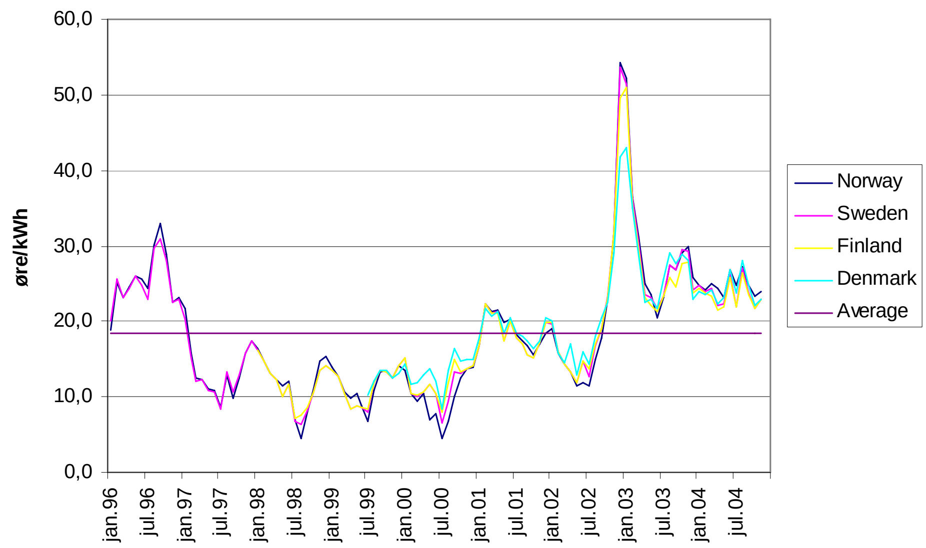
Prior to the deregulation in 1991, the official Statkraft prices were decided annually by the Parliament to ensure stable and acceptably low energy prices. During the first few years after the deregulation, the production capacity was still high relative to the demand, and the lower energy prices reduced interest in energy savings for many users. It also resulted in worse conditions for renewables to compete price-wise with direct electrical heating. Consumption in all sectors has been constantly rising since 1991. Since 1996, average production capacity has been about equal to or less than total energy demand, resulting in higher prices and the need for import of electricity.

Electricity spot prices have increased gradually, as seen by the higher prices in years 2001, 2002 and 2003 (**Figure 4.3**). In October 2002 the price rose quite dramatically, due to a very dry period in the fall, and the price remained high until the melting of snow in the spring of 2003. Even if Norway has transmission capacity to neighboring countries, the capacity is limited. The prices fluctuate, and deviate from those in neighboring countries mainly when peaks and troughs are encountered. Prices tend to be low throughout much of the year (summer and autumn) with occasional “spikes” in the autumn/winter, as in 2002/03.

This illustration is relevant in Norwegian energy policy. It clearly illustrates the vulnerability of being dependent on a sole source of energy that is not fully controllable, such as hydropower. Since the deregulation of the Norwegian electricity market, the highly variable spot price has also represented the typical buy-back price for wind energy (since the exact production from wind turbines is not fully predictable even the day before). In some cases, producers of wind energy have attempted to set up bilateral trade agreements at a slightly higher price than the market price. However, the amounts of power sold through these arrangements have been rather marginal.

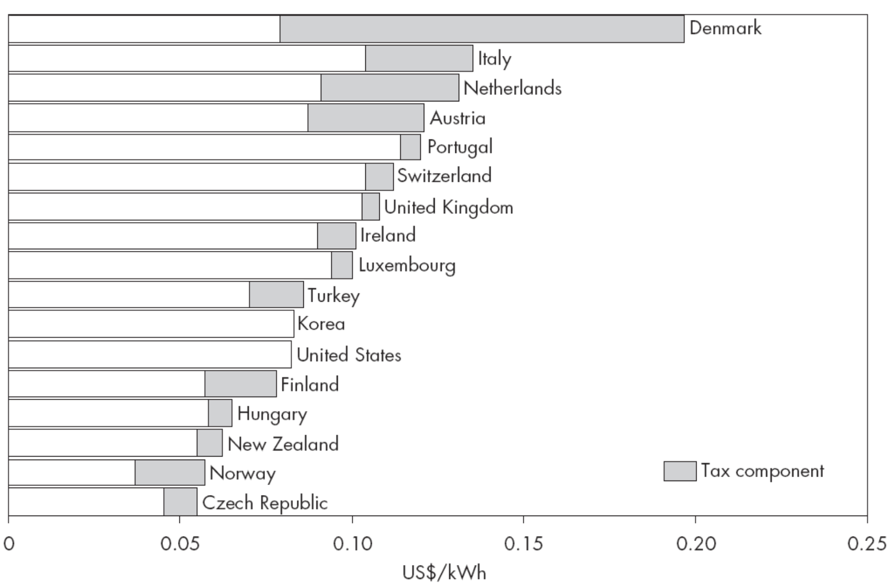
Figure 4.3 also shows how integrated the Nordic electricity markets have become with identical spot prices. Differences in spot prices can be explained by transmission capacity constraints, allowing spot prices to increase more in deficit areas and decrease more in surplus areas when the constraint is binding. Even though the electricity spot price is very similar, the end-user prices differ in the Nordic countries due to electricity tax, value-added tax and transmission tariffs. **Figure 4.4** compares the domestic (household) electricity prices in most

IEA countries in 2000.[39] It is clear that electricity prices to households in Norway are very low compared to the other countries. The fact that pretax prices are also low may in part be because hydropower is not affected by the CO_2 tax (IEA 2001d).



Source: www.nordpool.com

Figure 4.3 Monthly Average Spot Prices at the Nord Pool, 1996-2004[40]



Source: IEA 2001d

Figure 4.4 Domestic Electricity Prices in IEA countries, 2000.[41]

[39] Figures for Norway apparently exclude transmission tariffs. It is not clear from IEA whether comparability is ensured.

[40] Norwegian figure represents the average for Oslo, Bergen, Molde, Trondheim and Tromsø. The Danish figure represents the average of the DK-West and the DK-East system.

4.2.3 Electricity Balance

Over the last twenty years, electricity end-use has increased consistently. In the first part of this period, the production capacity was larger than the average total use, resulting in net exports. However the additional supply has been quite limited since the early 1990s, and during the 1990s Norway "on average" came closer to aggregate electricity balance (there is always export and import within a year, due to temporal variations). The total electricity exchange capacity is approximately 400–600 GWh/week. This implies that in some hypothetical, but not unlikely cases, there might be an electricity shortage, due to limited power and limited import capacities.[42] Transmission capacity is valuable not only during net import years but also for gross imports and exports during a zero net import year.

NVE (2002) has estimated the Norwegian electricity balance towards 2015. Due to the dominance of hydropower, the electricity balance depends largely on whether it is a wet, normal or dry year. Electricity consumption is based on a "steady growth" scenario with an annual 1.2 percent increase in consumption. This is lower than the observed average increase for the whole period 1991–2002, which was 1.5 percent. However, for the later part of this period (1996–2001), the increase was only 1 percent. The calculations further assume that higher electricity prices in a dry year would result in 5 TWh less electricity consumption as electric boilers are decoupled. These assumptions reflect natural variations in precipitation in Norway and Sweden. These countries also have the most use of electric boilers in multi-fuel heating systems. NVE projected that hydropower electricity could increase by 1 TWh by 2005, 2 TWh in 2010, and 4 TWh in 2015 in normal years. A dry year would only see half this production increase. Wind power is to increase to 1 TWh by 2005, 3 TWh in 2010 and 5 TWh in 2015.

Figure 4.5 shows that during normal years, it is estimated that Norway would have to import 7 TWh in 2005, 12 TWh in 2010 and 15 TWh in 2015. Under normal conditions, such import is not problematic, but contributes to uncertainty about supply security. The import level in 2015 would bring Norway closer to the import capacity level. The theoretical electricity import capacity is 30 TWh, but in reality, import levels cannot reach this level, in part because Sweden will be similarly short on electricity in a dry year. It has been estimated that a practically feasible level of electricity import can be around 20 TWh between 2005 and 2015. The estimated demand for electricity would in dry years exceed production and imports by 14 TWh in 2005, 18 TWh in 2010 and 19 TWh in 2015, so consumption would have to be reduced.[43] There are plans to improve the electricity exchange capacity. One example is the plan to have a cable between Norway and the Netherlands with capacity of 3–3.5 TWh/year.

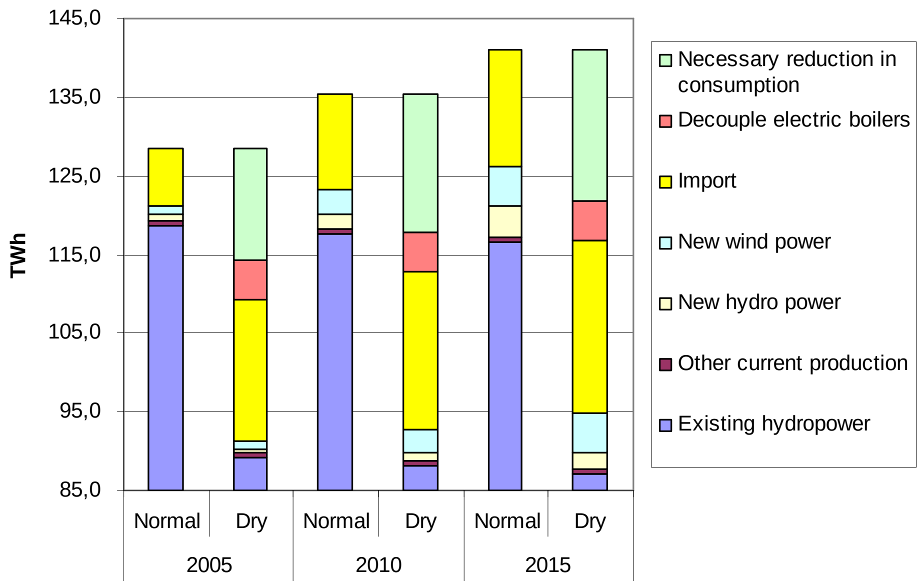
The calculations by NVE do not include any new natural gas-fired power plants. The issue of new gas fired power plants is a very 'hot' issue on the Norwegian political agenda. This was highlighted in 1999 when the Centrist government had to leave its position due to strong conflicts over its climate policy. The Centrist government wanted a stricter regulation of greenhouse gas emissions from new gas-fired power plants, but was defeated in Parliament, and a Labor party government took office. Licenses have been granted for three gas-fired power plants that could produce 12 TWh by 2007 and reduce the dependence on hydropower

[41] Ex-tax prices for the United States. Tax information not available for Korea. Data not available for Australia, Belgium, Canada, France, Germany, Greece, Japan, Spain and Sweden.

[42] Readers should be aware that this description is simplified and on a national level. Local and regional conditions within the Nordic countries vary somewhat, both with respect to production capacity and bottlenecks in the transmission system.

[43] A wet year would have the opposite effect. In 2010, 20 TWh could become available for export or increased consumption.

and imports.[44] These plants are allowed to be built without technologies that can clean the CO_2 content, but additional plants will need such technologies. These are power plants where CO_2 is extracted and treated and/or used for other means. One option considered is to use the excess CO_2 as injection gas into oil fields to increase extraction of oil from a given field. NVE (2004b) estimates that CO_2 cleaning adds 15-20 øre/kWh to the production costs compared to conventional natural gas-fired power plants, while Bolland et al. 2002 estimate the additional costs at 18-19 øre/kWh. This means that production costs nearly double, depending on the costs of natural gas. Gas-fired power plants will be subject to the permit requirements of the Norwegian emissions trading system for 2005–2007 (and the subsequent European system), confronting them with a cost of CO_2 emissions. It is still very uncertain whether these plants will be developed due to the current high price of natural gas, the relative low electricity prices, and uncertainty about CO_2 costs.



(Source: NVE 2002).

Figure 4.5 Electricity Balance in Norway toward 2015 (normal and dry year).

4.3 Potential for Green Electricity

Renewable energy sources other than hydropower do not currently account for any significant production of electricity in Norway. Thus a challenge remains to utilize the country's vast renewable energy resources if renewable energy sources are to play a role in meeting the future electricity demand. It is clear that wind power and hydropower account for most of the presently applicable potential. **Figure 4.6** shows the technical and economical potential for electricity production from hydro (large and small scale), wind and biomass, and their associated costs per kWh (NVE 2004a). The estimates show that at 20 øre/kWh, about 23 TWh could be built. At the cost of 30 øre/kWh, an additional 84 TWh could be built.

[44] Interview with Minister for Energy, Thorhild Widvey in Aftenposten 22.11.2004 http://www.aftenposten.no/nyheter/okonomi/article875510.ece

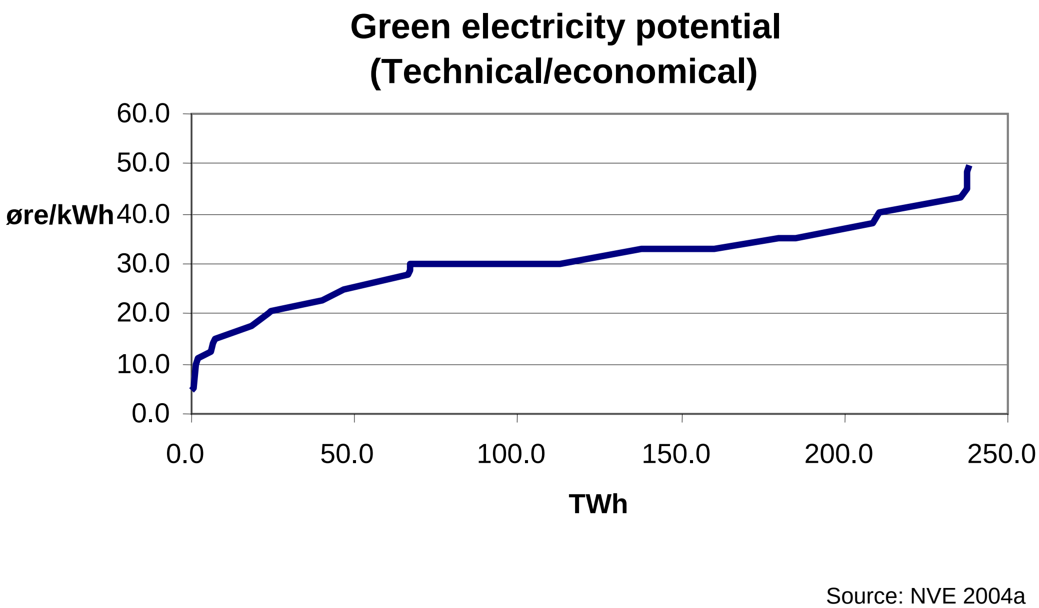


Figure 4.6 Technical/Economical Potential for Green Electricity in Norway

There is a technical and economical potential for new large-scale hydropower of 7 TWh (20 øre/kWh) and 20 TWh (30 øre/kWh) and 12 TWh from refurbishment and upgrading of existing plants. Of this, 3 TWh could be achieved within 10 years under the current conditions. The focus has also shifted towards small-scale hydropower (50 kW-10 MW). The technical and economical potential for small-scale hydropower is about 13 TWh (20 øre/kWh) and 20 TWh (30 øre/kWh).

The best wind resources in Norway are along the western coastline from the southernmost tip and east to the Russian border. There are also good resources in some mountain areas, but they are considered less likely to be exploited due to environmental concerns. The cost of wind power is in the range of 30–35 øre/kWh. At the cost of 30 øre/kWh, it is estimated that 40 TWh could be built. The installation costs are relatively stable per MW installed, thus the resulting energy production cost depends on mean wind speed. In some favorable cases, wind energy cost might come down to 25 øre/kWh. However, estimates by NVE show that the overall energy potential at such a low cost is rather moderate, i.e. less than 1 TWh. Local market conditions and existing transmission capacity matter, since the best wind locations will typically be far from important consuming regions.

The investment costs for biomass electricity generation is quite high, thus the resulting electricity price is very high. Estimates on the use of domestic biofuels indicate that some 0.5 TWh/year from biomass is possible, however at a price range of 20 to 100 øre/kWh. Norway's topography with its many mountains and hills makes it difficult to collect large quantities of bioenergy at a low cost.

4.4 Policies and Policy Instruments

There are two main factors influencing the development of renewable energy in Norway: energy policy and climate policy. Norway's energy policy is mainly defined in the following documents: St. meld. nr 29 (1998-1999), St. meld nr 9 (2002-2003), the"Sem Declaration" of the Government, St. meld. 18 (2003-2004) and St.meld. 47 (2003-2004). National targets for renewable energy are that (i) by 2010, Norway should have 3 TWh/year from wind energy, and (ii) the use of heat from renewable energy sources (reducing direct electrical heating) should be increased by 4 TWh/year. Additionally, the government aims to reduce energy use by 4 TWh/year within 2010 compared to a given growth scenario[45] (Enova 2004).

The main stated objective of the Norwegian climate strategy is to comply with the Kyoto Protocol, which limits Norway's quota for greenhouse gas emissions in the period 2008–2012 to 1 percent higher than in 1990[46]. Estimates by the Norwegian Pollution Control Authority (SFT) and the Norwegian Ministry of Finance indicate that the total GHG emissions in Norway in 2010 could be 24 percent higher than the 1990 emissions if no measures were taken (SFT 2000), with the implication that Norway must combine emission reductions with quota purchases abroad. The development in the energy sector will have a great impact on Norway's abilities to meet its commitments. Renewable fuels, and generally increased use of renewable energy sources, can reduce GHG emissions.

The Norwegian authorities have used a range of means to promote renewable energy during the last decades. The most important mechanisms have been financial support, tax incentives and normative measures.

4.4.1 Financial Support

During the 1980s support was mainly focused on R&D. During 1992–2001, NVE was in charge of the implementation of the public programs promoting energy efficiency and increased use of renewable energy, and recently also natural gas. **Figure 4.7** shows the financial support from the Research Council of Norway and from NVE (before Enova was established) for renewable energy sources-technologies. This includes support to R&D, prototype installations and investment support (non-prototype). Funding from NVE was not specified for each energy technology, but some limits were defined, as for a scheme for heating from renewables and another for wind energy. The funding from the Research Council has been subject to competition through applications, and with limited earmarked funding for each technology.

During the 1980s and 1990s, public programs were quite specific with respect to which technologies should be supported. **Figure 4.7** shows a clear increase in the financial support from 1997 when a major subsidy scheme for renewable energy sources was launched. This "heating system subsidy scheme" from 1997 to 2001 included bioenergy, waste, industrial waste heat and solar energy for heating, and support mechanisms for other types of heating rather than the use of direct electricity heating. This subsidy scheme introduced more flexibility for market actors to choose between various renewable energy technologies.

In mid 2001, a new state-owned company, Enova, was established in Trondheim.[47] Enova is the national agency charged with using public funds to promote renewable energy sources and rational use of energy (RUE). In 2003, the Energy fund had NOK 539 million at its disposal. NOK 259 million came from the national budget, while NOK 192 million came from a surcharge of 0.3 øre/kWh on the transmission tariff. In 2004, the surcharge was increased to 0.8 øre/kWh, increasing this funding to about NOK 460 million, combined with funding over the national budget of NOK 130 million.

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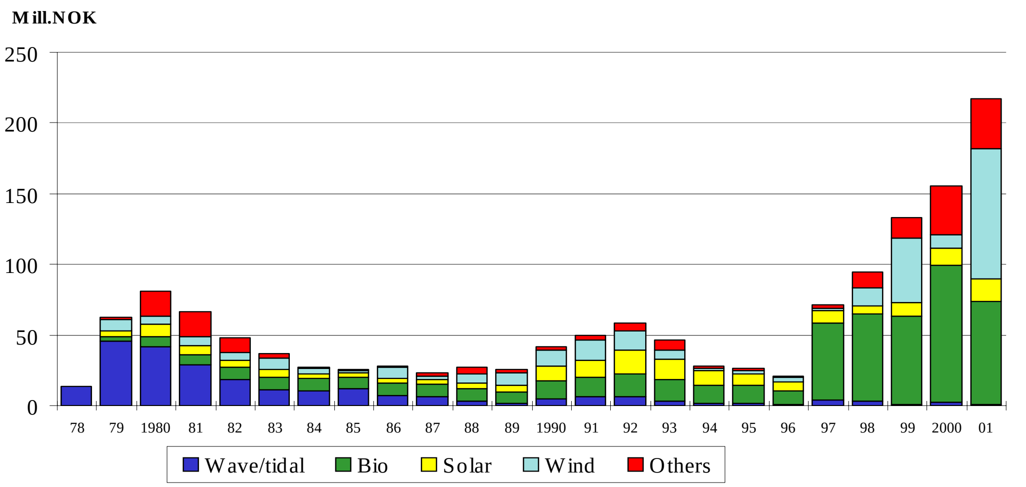
[45] Assumes an annual 1.6 percent growth up to 2005 and 1 percent from 2005 to 2020.

[46] Quota purchases are also allowed.

[47] Enova aims at working in a targeted and result-oriented manner close to the energy market actors. It focuses on developing incentive schemes and new markets for energy services and products. It will not be operative in the market itself, but make use of organisations/institutions/enterprises (operating agents) that should compete for assignments and tasks. Furthermore, Enova will offer a nationwide public information and guidance service.



Source: NVE 2001

Figure 4.7 Introductory Support to Renewable Energy Technologies

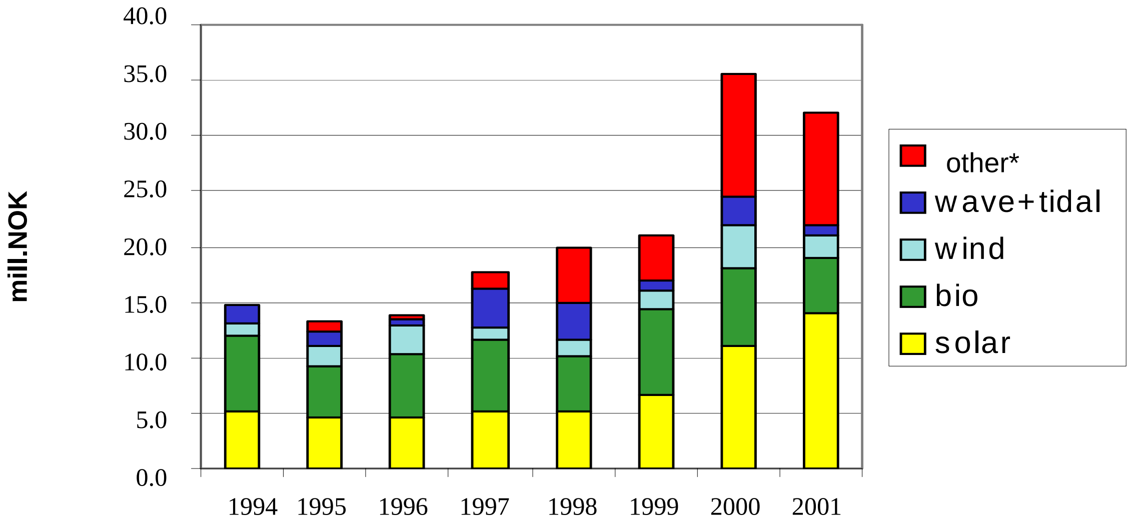
Table 4.2 summarizes Enova's use of resources. In 2003, Enova distributed a total of NOK 283 million in support for five main areas, while the similar figures for 2002 were 235 million. Enova established contracts with those receiving the investment support and the contracts resulted in aggregate energy results of 921 GWh in 2002 and 1827 GWh in 2003. In 2002, each kWh required 26 øre while the similar figure for 2003 was 16 øre. With project lifetimes of 20 years for wind and heat and 10 years for energy use, the investment support per kWh over the lifetimes amount to 0.5, 1.0, and 2.4 øre for wind, heat, and energy use respectively. NOK 92 million was given to support wind energy in 2003, a total of 1.3 TWh of wind energy was contracted in 2003 for the period 2003–2005. The energy result is divided over three years depending on when the investment support will be given. Production support amounting to 725,000 NOK (equal to 4.75 øre/kWh) was given to wind energy in 2003, but no funds are available for 2004 and onwards.

Table 4.2 Enova Support in 2002 and 2003

Area of focus	Support (øre/kWh)	Mill NOK	GWh
Wind	20	127	530
Heat	10	181	1,343
Energy use	24	216	874
Other renewables	-	3	1
Natural gas	-	1	0
Total		529	2,748

Source: Enova 2004

Figure 4.8 shows R&D-related funding to renewable energy sources. Also the R&D funding has changed from initially technology specific to a more competitive basis. Funding for wind energy R&D is rather moderate, whereas solar and bioenergy have received most of the funding. The funding of R&D-related solar energy projects has mainly been support to integrated active solar heating systems on roofs, and to Norwegian PV-module production, now supplying the world market.



* hydrogen, and salt gradient

Source: Research Council of Norway (unpublished).

Figure 4.8 R&D Funding for Renewable Energy

Table 4.3 compares Norwegian government energy R&D expenditures in 1999 with the case-study countries. The renewables' share in Norway's total energy R&D expenditures was similar to the share of the USA (10–11 percent), but far lower than the shares in the Netherlands and in Germany. However, government renewable energy R&D expenditures per capita in Norway are higher than in Germany and the USA.

Table 4.3 Government Energy R&D expenditures* in 1999

Country	Total energy expenditures (US$ million)	Total renewables expenditures (US$ million)	Renewables share (percent)	Renewables expenditures ($)/capita
Germany	106.8	62.7	58.7	0.8
Netherlands	133.2	39.5	29.6	2.5
Sweden	64.9	12.2	18.8	1.4
USA	2342.0	264.2	11.3	1.0
Norway	49.0	4.9	10.1	1.1

* At 2000 prices and exchange rates

Source: IEA 2001c

R&D in technologies rarely results directly in commercial technologies. However the intermediate stage – often characterized by prototype or demonstrations – has been partly supported by NVE, and partly co-financed by the Research Council. "Innovation Norge" (previously SND) has also provided funding to the intermediate stage between R&D and commercialized products, and to development of commercialization/business adaptation of products, including some energy-related products. Other sources of funding include the Ministry of the Environment for renewable energy, and the Ministry of Agriculture for bioenergy.

An initiative that slows the development of renewable energy sources and energy efficiency is the R&D concerning natural gas fired power plants with CO_2-cleaning. A focus on the development of CO_2-cleaning technologies has led to the less focus on renewables. Actual funding over the years has increased from 6 million NOK in 2000, while the Research Council now allocates about 50 million NOK annually for research in CO_2-cleaning. There is a strong and wide political willingness to promote R&D-activities by substantial funding. In 2002, the government decided that a public innovation centre should be established in Grenland. This national gas technology program will push for environment-friendly use of gas for energy purposes, including CO_2 capture and storage. The innovation centre called Gassnova was established in January 2005 and it will manage the interests from the fund for environment-friendly gas technologies established July 2004. With a capital fund of 2 billion NOK, the resources available in 2005 will be about 46 million NOK and from 2006, the annual resources will amount to about 92 million NOK. Gassnova will finance the development aspect of these technologies while the Research Council will still finance the research aspect.

4.4.2 Tax Incentives

Norway has a range of taxes on various kinds of energy use, and some of these taxes have an environmental basis, established to enhance lower consumption and use of fossil fuels. **Table 4.4** summarizes energy related taxes by the second half of 2004. The conversion to specific price per kWh disregards the actual coefficient of performance.

Table 4.4 Overview of Current Energy-related Taxes in Norway

Type of tax	Tax level	Typical cost (øre[48]/kWh)	Comments
Mineral Oil			
CO_2 Tax (øre/l)	52	4.6	Heavy Fuel Oil*
Sulphur Tax (øre/l pr 0.25 percent S)	7	2.5	Heavy Fuel Oil 1percent S
Base Tax (øre/l)	40.5	3.7	Heavy Fuel Oil*
Waste			
CO_2 (kr/ton waste)	39.70	1.4	**
Polluting fumes (kr/ton waste)	65-100	2.3-3.4	***
Electricity tax (user)			VAT is added on for the end-user, but not in all counties.
General electricity tax		9.67	
Electricity tax in industry and district heating		0.45	

Source: Compiled by Norsk Energi November 2004

* Pulp and paper does not pay Base Tax, and pays only about half of the CO_2 tax

** Non-fossil waste is exempted

*** Indicative values

Traditional oil for fuel purposes has three different taxes. The CO_2 tax is environmental or climate-related tax. The sectors/activities foreign shipping, fishing and external aviation are exempted from the CO_2 tax. The sectors/activities pulp and paper industry, fishmeal industry, domestic aviation, domestic shipping of goods and the supply fleet on the continental shelf face a reduced CO_2 tax rate. The sulphur tax is also an environmental tax, scaled according to every 0.25 percent of sulphur in the oil. Various reductions in the tax are achieved through the installation and use of appropriate fume gas cleaning. The base tax is a fiscal tax from which several energy intensive industrial branches are exempted. There is now no energy or environmental tax on gas, coal or biofuels. For coal, apart from in non-fuel process usages (which had and have tax exemptions), there were no more users. There is a set of taxes on various types of waste to be incinerated. In addition there is a CO_2 tax per ton of waste. Non-fossil waste is not charged the CO_2 tax. Energy production facilities in the industry based on waste derived fuels are also exempted, according to certain specifications, and on the condition that they get permission from the Norwegian Pollution Control Authority (SFT).

Electricity supplied to industry, industrial processes and district heating faces a reduced electricity tax compared to other end-users. Some specific industrial processes[49] are exempted from the electricity tax. In addition, consumers in Finnmark and some counties in Northern Troms are exempted from the electricity tax, and consumers in Finnmark, Troms and Nordland are exempted from VAT on electricity.

In general, it is politically difficult to add new taxes. Nevertheless, the electricity tax doubled from 1997 to 2001, leading to more general awareness of the tax. During 2001 there was a tremendous public (and political) debate over the electricity tax, and the result was a small reduction (it is also very hard to reduce already established taxes). In the late 1990s, there was an initiative to remove the investment tax on investments related to the use of renewable energy sources. However, the entire investment tax was soon thereafter removed in all sectors, thus resetting the competition baseline for renewable versus conventional fuels. Traditionally, since the early 1980s, the use of direct economic subsidies have been the major measure to prompt energy efficiency and increased use of renewable energy sources. In addition to direct investment subsidies, a production support on wind-energy based electricity was introduced in 1999. However the production support was abolished by Enova in 2003.

4.4.3 The EU RES Directive and Norwegian Green Certificate System

The EU's RES Directive 2001/77/EC on the promotion of electricity produced from renewable energy sources in the internal electricity market became effective from October 2001. The purpose of the RES Directive is to increase the share of power produced by renewable energy sources in the EU common market. This is seen as important for reasons of security and diversification of energy supply, environmental protection, and social and economic cohesion. The directive states that the increased use of electricity produced from renewable energy sources constitutes an important part of the package of measures needed to comply with the Kyoto Protocol. The specific goals are to increase the share of renewable energy in gross national energy consumption from 6 percent (1997) to 12 percent (2010), while the share of electricity produced from renewables shall increase from 13.9 percent (1997) to 22.1 percent (2010). Under the RES Directive, all countries are obliged to have a system in place for 'Guarantees of Origin' for all renewable energy production by October 2003. These Guarantees of Origin do not have to be tradable, but may in such a case function as green certificates. In countries with a green certificate system already in place, it is likely that the system will be used for Guarantees of Origin (van Dijk et. al 2003).[50]

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[49](i) Electricity supplied to chemical reduction, electrolyses, metallurgical or mineralogical processes, (ii) electricity supplied to the pulp and paper industry (on the condition of participation in programs on energy efficiency), (iii) electricity produced in energy recovery systems and supplied directly to the end user, (iv) electricity produced in backpressure systems, and (v) electricity supplied to greenhouses.

[50] A prototype green certificate and trading system for Europe has already been established: RECS (Renewable Energy Certificate Trading System) independent from the 'Guarantees of Origin' and from governments. This system has members ranging from utilities to power brokers and wind turbine

The RES Directive does not specify the policy instruments that the member countries should use to reach the given targets. However, green certificates were suggested as a common policy instrument during the preparation of the directive. But since there was uncertainty whether this was the most effective policy instrument, no agreement was reached on having a compulsory common system of green certificates. Instead, the RES Directive requires countries to ensure that the origin of electricity produced from renewable energy sources can be guaranteed (NVE 2004a). The intermediate progress at the end of 2002 showed a progress much less than anticipated, thus EU has signaled increased pressure on the member states to increase implementation. The Commission shall, not later than 27 October 2005, present a report on the experience gained from the application and coexistence of different policy instruments. If necessary, the report may be accompanied by a proposal for a Community framework with regard to support schemes for electricity produced from renewable energy sources. It is perceived that green certificates may be part of such a Community framework.

The RES Directive is important for Norway since Norway is governed by the same basic rules as the 25 EU member countries. The RES Directive will therefore also be implemented in Norway. The directive requires each country to submit progress reports on the development of increased percentage of electricity, but the indicators of renewable electricity shares will be determined by each country for itself.[51]

In 2000, the Norwegian Parliament (Stortinget) commissioned a report on a green certificate system (GCS) adapted to Norwegian and Nordic conditions. The background for this request was the on-going work on green certificates in the EU (Budsjettinnst. S.nr. 9 (2000-2001)). As a follow-up to this request, the Ministry of Petroleum and Energy commissioned three reports[52] in 2001 and another three in 2002 to consider using green certificates for promoting electricity produced by renewable energy sources. In the White Paper on Natural Gas (St.meld.nr. 9 (2002-2003)), the Ministry of Petroleum and Energy concluded that a national GCS would not function as intended. There would, especially in the initial phase, be a limited amount of green electricity that could be included in a GCS. This was due to long permit processes and construction time. Additionally, it was felt that a national GCS would add to the lack of continuity in Norwegian energy policies since Enova had just been established and since an international GCS potentially could arise. The Ministry therefore recommended continuing with the current practice of promoting renewable energy through Enova. At the same time, the Ministry was positive to establishing an international GCS and recommended that Norway should participate in such a system. The Ministry therefore decided to continue working on establishing a GCS, which could be adapted to an international certificate system.

Then, in conjunction with the passing of St.meld.nr. 9 (2002-2003) March 2003, the Norwegian Parliament decided to "…request that the government to take the initiative to establish a preferably joint Swedish/Norwegian mandatory Green Certificate Market that eventually can be coordinated with an international trading scheme, and a proposed implementation plan should be presented for the Storting no later than Spring 2004"

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owners' associations. So far, national groups within RECS have been established in Denmark, Norway, the Netherlands, Germany, Italy, Belgium, Austria and France.

[51] Another EU directive, of May 5, 2001, COM (2001) 226, "Proposal for a Directive of the European Parliament and of the Council on the Energy Performance of Buildings", could also have implications for Norway. The main features are a common European methodology describing the measurement of energy use, minimum standards to buildings on energy performance, energy certificates on buildings and increased use of inspection of boilers and HVAC equipment in buildings.

[52] See: http://odin.dep.no/oed/norsk/dok/026021-220005/dok-bn.html (in Norwegian); Bye et al. 2002a, 2002b; ECON 2002; Eldegard 2002; Kristiansen 2002a, 2002b.

(Author's translation). In St.meld. nr. 18 (2003-2004), a common Norwegian-Swedish GCS was one of the ten recommended actions to reduce the electricity production's vulnerability to reduced precipitation. In St.meld. nr. 47 (2003-2004), the Ministry proposed to establish a Norwegian-Swedish GCS. The Government presented a draft law-proposal regarding a mandatory certificate scheme in November 2004, but has not yet specified the level (amount) of renewable energy to be mandatory. The Government aimed to introduce a GCS consistent and linked with Sweden's from January 1, 2006, but this has now been delayed by a year.[53]

4.5 Barriers to Market Development

Despite a constant development both in industrial installations and technological development, the label "alternative" energy is still associated with the renewable energy sources, apart from hydropower. However, with the remaining higher electricity prices in the last two years, the interest in energy issues has increased. With the strong seasonal changes in the energy prices, it takes a long time before the average (increasing) price is apparent to the general public. It seems that the concern about the energy costs attracts more attention than environmental concerns. In a survey on electricity prices made for Enova, it is reported that "*Norwegian consumers have an almost senseless attitude toward their personal electricity consumption and show little willingness to reduce the use of energy*".[54]

A large portion of the population lives along the coast where the electrical grid supplying the coast often is quite weak. As wind power is becoming more relevant, grid limitations will prohibit large-scale wind power. Additionally, larger buildings used to be equipped with piped heating systems, and it is a good basis for the fuel switch from oil to biofuel. In the 1970s the steadily increasing use of direct electrical heating virtually eliminated the boiler room. The all-electric installations also prohibit a relatively easy change of fuel. The use of district heating exists in larger towns and cities, but these systems are still lacking in many towns.

The use of renewable energy sources might be considered problematic, at least in terms of learning. There is often a fear that new technology is more demanding to use or will be of lower quality. Low electricity prices combined with demanding requirements for low payback (pay-off) time on investments have been the major barriers to the use of upfront relatively more expensive equipment. Many still regard low electricity prices as something they are entitled to as citizens of a country rich in natural resources, and manufacturing (often cornerstone industries) often benefits from favorable electricity contracts.

Barriers against hydropower. Public opinion on hydropower seems to be quite divided. Those favoring may have economic interests, while opposing may be affected directly by either hydropower plants or the regulation of rivers, as with fishermen and individuals with conservation interests. During the 1950s and 1960s, hydropower utilization and power station development was closely linked to the industrialization of Norway. However by the late 1960s the attitude had changed, and some of the first major protests arose in Mardøla and Nordmarka (hydropower development and power line demonstrations). The construction of the Alta dam sparked significant controversy in the late 1970s and early 1980s. Later, the political signals have been not to expand large hydropower. In his New Year's speech in 2001, Prime Minister Jens Stoltenberg stated that the time for new large hydropower was over.

[53] Press release from the Ministry of Petroleum and Energy, Feb. 14, 2005.

[54] The Norway Post, Dec.2, 2002.
(http://www.norwaypost.no/content.asp?cluster_id=21312&folder_id=5)

Barriers against wind energy. It has been debated how high the development density should be to limit the assumed environmental impact of wind energy. Also, grid limitations pose a substantial hurdle to large-scale wind power development. The economic responsibility for associated transmission projects has not yet been clarified. Naturally the very proximity between wind turbines and the end user is technically positive (as it can reduce grid transmission costs and losses, and also limit the impact on the wilderness). However, large-scale wind turbines, up to 100 meters high, have been considered environmentally negative in several cases along the Norwegian coastline. Some reviews have been made concerning the impact of wind farms on wildlife, which mostly show positive results.[55]

Barriers against Bioenergy. The use of bioenergy has both positive and negative aspects. The positive effects are reduced CO_2 emissions compared to the use of fossil fuels. At the same time, the use of bioenergy may or may not reduce the other emissions to air that have regional and local impacts, and may or may not increase transportation activities locally and nationally. However, the use of local biofuel leads to a safer energy supply locally. The challenges and barriers against the increased use of bioenergy are mainly the high investment cost of the equipment, fuel collection cost, the need for piped heating systems, etc. There is also a greater need for maintenance to biofuel equipment than oil burners. For these reasons, support for and installation of biofuels systems mainly concentrates on larger scale users, not single households.

5 Lessons learned for policy development

While the experiences of the four case study countries have been quite different, some clear lessons emerge. This section reviews the main lessons learned from the case study countries, and their implications for Norway about agenda setting, policy design, and implementation. It concludes with some specific policy recommendations for Norway.

5.1 Objectives and Agenda Setting

One of the clearest lessons to emerge from the case studies is the importance of a clear, consistent, and coherent policy. Germany, which has had consistent support in the electorate, has consistently devoted resources and has had consistently impressive results. The Netherlands, Sweden, and Norway, on the other hand, have had inconsistent and changing policies, which have resulted in little success in terms of deployment. For a country to develop a clear and consistent policy on green electricity, with the appropriate resources allocated to its implementation, it must place green electricity high on the political agenda.

In Europe, green electricity development is gaining priority on the political agenda. The EU is committed to reducing CO_2 emissions within its member states, and some EU countries have set ambitious targets for their renewable energy production and consumption by 2010 and 2020 respectively (International Action Programme 2004). Among the motivating factors are the greenhouse gas issue, a desire to reduce fossil fuel burning due to pollution problems (local and regional); the view that decentralized renewable energy sources can help energy security and reduce risks in the electricity sector; and finally that developing renewable energy sources can provide new jobs and other social benefits.

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[55] A behavior test on reindeer was performed by Nord-Trøndelag Elektrisitetverk. This study showed no significant behavior change of the reindeer. Swedish reviews conducted by SEA have shown little or no impact on most animals and birds. However a recent study has shown some effects on bats, which fly into turbines at night. Objections by the Norwegian military defense against possible wind farms are based on a claim that the wind turbines obstruct the radars.

As in most other countries, green electricity policy in Norway is motivated by a blend of two major underlying policy objectives: energy security and greenhouse gas emission reductions. For both of these objectives, consistency across European countries is a relevant question. For energy security, scenarios of risk will differ across countries. Whether solutions for Europe are relevant for Norway will depend *inter alia* on the extent to which Norway's risks are comparable to those in other European countries and on transmission capacity. For Norway, extended periods of low rainfall is an important scenario behind shortage of electricity. This is to some extent also the case for Sweden, and those rainfall scenarios move together. Since for most other countries, including in Northern Europe, energy security relates to totally different risk scenarios, renewables should not be portrayed as playing the same role in energy security in Norway as they do in the rest of Europe, even in Sweden. For greenhouse gas mitigation, solutions outside Norway are relevant to the global problem, but Norway's international obligations depend on emission reductions in Norway or quota purchases, and neither of these are ensured through transnational instruments such as an envisaged transnational green electricity certificates system.

The passage of the RES Directive suggests that Europe might edge towards a common green certificates market and related policies. Norway needs to consider carefully its own situation and policy options to stimulate green electricity in the future. Without such stimulus, electricity demand will be met either by imports or by – it seems – domestic natural gas-fired power plants (with or without carbon capture and storage). Natural gas-fired power plants with carbon capture and storage represent an interesting combination of fossil fuels with zero contribution to greenhouse gas warming, but have yet to prove competitive in terms of costs. Imports, on the other hand, contribute to global GHG emissions (since the imported electricity typically will originate from coal fired plants), even though they do not add to Norway's emissions in the context of the country's Kyoto commitments.

Norway's commitment to reducing greenhouse gas emissions now will be guided to a great extent by the European emission trading system until 2007, and by trading under the Kyoto Protocol until 2012. The Norwegian commitment (International Action Programme 2004) at the Bonn International Renewable Energy Conference indicates political will to support green electricity generation in Norway.

5.2 Policy Design

In addition to a high placement on the political agenda, a clear, consistent, and cohesive policy design requires a careful consideration of the policy options available. For Norway, the policy instruments employed so far are funds for research and the Enova funding mechanism (for renewables as well as energy conservation). At this point, the main focus when looking ahead is on the proposed introduction of a joint green certificate scheme with Sweden in June 2006. The proposed joint green certificate system has been open for public consultation and will be submitted to Parliament in 2005.

The challenge for Norway will be to choose one or more policy instruments to create a more complete and coherent policy design. Below, we briefly describe the features of the main policy instruments used in the case-study countries and their significance for Norway. (See **table 5.1** for an overview.)

Table 5.1 Policy Instruments: Objectives, Advantages/Disadvantages in Implementation

Policy Instruments	**Objectives & Characteristics**	**Advantages**	**Disadvantages**
Feed-in tariffs	Financial scheme ensuring a premium payment to the verified production from eligible electricity sources (investments, typically)	Can ensure long-term return, relatively simple to implement (but laws may need to be defined), flexible (different technologies can be provided with different tariffs, contract lengths, etc.), low administrative costs.	May not ensure long-term target. Requires good management. Transparency needed. Not cost-effective.
Green certificate scheme	Combines obligation for consumers to use a share of green electricity, with certification of green electricity production.	Encourages competition and cost effectiveness. Relies on market mechanism for resource utilization and (within green) technology choice	May not do much for high cost technologies. Transaction costs can be high. Transparency and verification systems needed May not meet quantitative target.
Renewable energy fund	Financial instrument to support GE, either in R&D or in application, from general revenue or through surcharge on electricity use.	Can potentially use government subsidy, private funds and through surcharges.	Reliance on subsidies if not financed by surcharge on electricity use, requires good management, tight objectives, transparency needed. Not cost-effective. Subsidy on energy use. No guarantee for meeting quantitative target.
Tax incentives	Fiscal instrument to reduce costs for GE consumers or producers.	Consumers and producers' interest in GE can be better mobilized. Low administrative costs.	Potential limit of tax benefits. Transparency complicated. Not cost-effective. Subsidy on energy use. No guarantee for meeting quantitative target.
Voluntary green electricity scheme	Mobilize consumer's interest in GE. Provide flexibility and equity to GE consumers for their support	Encourage wider consumers' participation and generate additional fund from consumers. Low administrative costs.	Effectiveness depends on electricity prices and consumers' access to information. Not cost-effective. No guarantee for meeting quantitative target.

5.2.1 Feed-in Tariffs

Feed-in tariffs pay green electricity producers according to the kilowatt hours they 'feed' into the grid. The feed-in tariff can provide the producer either a guaranteed price per kilowatt hour of green electricity, or a guaranteed premium. The tariff may be financed by subsidies from the state. However, mobilizing the funds via surcharges on electric power in general is meaningful both in terms of political communication and as a solid (but not compelling) public finance principle. Promoting green electricity production through feed-in tariffs can be both transparent and flexible. Feed-in tariffs have proven effective in Germany, particularly in mobilizing producers/investors' interest and participation. They have helped to substantially increase the market share of key renewable energy technologies such as wind and solar PV in the past decade. This instrument is flexible in allowing different technologies to be given different tariffs.[56] However, it should be noted that Germany's results must be seen in connection with the high feed-in tariff levels applied. In 2001, German electricity customers spent 1,540 million Euro for renewables under the EEG, which equals a cost of 0.18-0.26 Eurocents/kWh. Thus the impressive results could perhaps be attributed more to the high funding level for each kWh output than to the particular choice of instrument.

5.2.2 A Green Certificate Scheme with Obligated Green Electricity Shares

A green certificate scheme defines a certain set of technologies as green, and certifies electricity from eligible producers. It is often accompanied by a quota system that obligates the producer or consumer to a certain share of green electricity. The government will most often define the mandatory quotas, and decide on principles of certification of green production, issue certificates, and facilitate and monitor a market for those certificates. The system is in principle similar to the feed-in tariff system, in the sense that it combines 'a tax' on non-green electricity (the cost of the quota obligation) with subsidies on green electricity production. Green certificates provide a strong incentive for market competition and cost reduction. It escapes the tax concept, but of course uses government authority both in the quota obligation and in the choice of green technologies and their certification.

A quota system, combined with green certificates, is currently being implemented or is planned in a number of EU Member States (Belgium, the Netherlands, Italy, Sweden and the UK). Being 'mainstream' or prepared for these developments is thus a potential argument for quota-based certificates (as are presently being proposed in Norway). A common EU system for green electricity certificates would have strong similarities to a CO_2 emissions trading system in that it would take advantage of cost differences across countries. Such a system presumably would result in expanding the production of hydro- and wind power in Norway and bioenergy in Sweden, assuming that they prove competitive within the defined realm of green technologies in Europe. But there are several reasons to be more tentative, and perhaps move forward slowly. First, an integrated system allows Norwegian resources to support green electricity production abroad, which may not be consistent with Norwegian policy objectives, neither for energy security nor for Kyoto obligations. Second, as chapter 3 reports, the quota and certificate system in Sweden seems to involve high administration costs and has run into implementation challenges (though it may be too early to judge the system).[57] Third, it is not certain that EU will, in the end, support a green certificates system, nor what shape it would take, so the value of Norway's being ahead rather than prepared is not proven.

5.2.3 A Renewable Energy Fund and Other 'General Revenue' Schemes

A national Renewable Energy Fund could be an effective tool to manage and use the money accrued from different sources. It resembles the fund of resources collected through a feed-in tariff system, but differs in its broader or more general revenue base, and in the predictability of the fund structure. Renewable energy funds may be private or semiprivate, as would be natural should revenue come from voluntary green certificates markets (e.g. not driven by obligated shares), from surcharges on energy (like today's Enova), from contributions within

[56] One can invite bidders to offer renewable energy for a fixed subsidy over a twenty year period, for instance, if desirable in different auctions for different technologies.

[57] It now appears the target of increasing green electricity production in Sweden will not likely be achieved, but changes are being made. Slow progress may be due to teething problems, and the long lead times for large projects.

a specific industry seeking to solve its own problems technologically, or from private donations. A proposal to use a dedicated share of the Norwegian National Petroleum Fund (Gan 2001) should be treated in line with using general tax revenue, and be consistent with the institutional framework for the Fund's resources (which it presently would not be). A renewable energy fund could be used to support R&D, demonstration, and even public campaigns and NGOs' participation. The advantages of operating such a fund are its flexibility to receive and channel funds from different sources, and using the money in accordance with public interest and policy objectives.

5.2.4 Tax Incentives

Tax incentives are another subsidy-like way of reducing the cost burden for green electricity producers or investors. They have the disadvantage of requiring an administrative machinery for tax collection also to handle aspects of a green electricity policy. Tax incentives are used as instruments in Norway in areas such as the encouragement of general R&D within businesses. A principal feature of this instrument is that, in contrast to subsidies, it works effectively only on firms and individuals in taxable position. As with incentives through subsidies, tax incentives could potentially be set at different levels to support those technologies desirable by government policy objectives.

5.2.5 A Voluntary Green Electricity Scheme

Voluntary green electricity schemes can be found in many European countries (Austria, Germany, Finland, Ireland, the Netherlands, Sweden, Switzerland and UK) but also in the United States, Canada, Japan and Australia. Electricity companies are offering green electricity as an additional strategy to both keep their current customers and attract new ones (Business Insights 2002). Government or non-government bodies can then be involved in certifying green production (government, in the RES Directive), facilitating the channeling of a potential interest from environmentally concerned consumers. Such a scheme is an alternative (or possibly a supplement) to a green electricity scheme based on obligatory quotas, and as such uses less government power, relies more on consumer motivation, and in most settings will achieve a lower penetration. A voluntary system can even allow consumers to demand specific types of power (e.g. wind) if the power is labeled to allow this. This can be done if a specific producer advertises its share of wind in its production, and thereby sells at a premium directly to consumers.

5.3 Policy Implementation

Once a policy is designed, its success depends on the extent to which it is implemented. Implementation, in turn, depends greatly on existing capacity and efforts to build capacity.

The role of investors and project developers is important in realizing the policy objectives. This means that policy makers have to understand the main driving forces of the private sector, and both risks and profit margins mainly determine investment decisions. These indicators are more important compared to short-term financial incentives. In general terms, the effectiveness of policies to stimulate renewable energy is best guaranteed if objectives and policies are stable and predictable, allowing confidence and a long time horizon among key stakeholders. Market uncertainties need to be minimized, and stakeholders should feel secure about future developments in policy. The effectiveness of instruments such as subsidies and tax incentives could decrease if these instruments are applied in a 'stop-and-go' manner. All case-study countries have experienced this with promotion schemes when conditions changed frequently during implementation.

Participation of a wide range of stakeholders provides a good basis for renewable electricity policy development. The German case shows that involvement of a wide set of stakeholders has many advantages, and the Dutch case shows the importance of effective coordination between national and local governments. If different levels of authorities have different objectives or interests, the implementation process could be severely hindered.

Environmental NGOs and the media can play critical roles in bridging the gap between general public and government authorities and concerned industries. They also function as "watchdogs" to generate social debate and attempt to keep governmental policies moving in the right direction. The media can also help ensure effective monitoring of policy implementation at different levels in society.

Competence building among customers, consulting engineers, renewable energy experts, architects, and other professionals is generally important to increased use of renewable energy sources. It may be costly to acquire the interdisciplinary qualifications that are needed in the planning of complex projects. Conservatism in the power and building sectors, as well as time constraints, often result in the use of familiar solutions. Courses and education have been and will still be a positive initiative, including both information integrated in professional education, as well as post-qualifying education. Information about advantages, possible savings, tender rules, and purchasing process and rules is important to increase the consciousness about renewable energy sources and purchase options.

5.4 Overall recommendations for Norway

Norway has a stated goal of increasing the use of renewable energy technologies, such as wind, wave, tidal, and solar power, as well as bioenergy and hydropower (in case of the latter, perhaps limited to small-scale plants). The European Union also shares the objective of increasing the share of green electricity in production/consumption. These objectives are reflected in Norway's recently proposed law on green electricity certificates and in the EU's RES Directive.

The modest penetration of these renewable technologies (with the exception of hydropower) can be largely ascribed to their high cost relative to alternatives, and market prices. There is an obvious potential for government intervention to help reduce the costs of renewable sources of energy, thus increasing their market share. A carefully designed policy framework can assist the use of green electricity in Norway, in the sense of alternatives to hydropower, CO_2-emitting natural gas plants, and imports, which otherwise represent plausible expansion paths. Key challenges are to ensure consistency with underlying policy objectives as well as with potential conflicts between key instruments, and to minimize implementation costs.

To expand the share of green electricity in the short term, two instruments in particular stand out as being potentially attractive for Norway: green certificates and feed-in tariffs. Both of these instruments combine the equivalent of a tax on non-green electricity with a subsidy on green electricity. From a theoretical perspective they are fairly similar, but in practice there are reasons to see the feed-in tariffs as combining lower administrative costs with very attractive flexibility in terms of policy goals. However, if Sweden and the EU implement a certificates system in ways fairly consistent with Norwegian policy objectives, then this provides one argument for Norway to go along with a similar, consistent certificate system. While Norway's goals in areas such as climate policy and energy security will not be entirely equivalent to those of the neighboring countries, the value of implementing instruments jointly with other countries might be important enough for Norway to adjust its strategy accordingly.

For either of these instruments to be successful in the long run, they must succeed in making green electricity more competitive, i.e. bringing down the costs that will prevail absent government intervention. While increased adoption of renewables can do an important job, this suggests that an overall policy design could include strategies for investment in R&D. R&D can be stimulated in the early phases with basic research subsidies, provided there are other systems (green certificates or feed-in tariffs) to create markets for solutions. The applied end of RD&D should then be left to the private sector.

There are other instruments that may also fit well in a general policy design package, but the focus should be on consistency, and instruments should compensate for each others' weaknesses. It is also important to consider the costs of administration, which may very well increase disproportionately as more policy instruments are added. Finally, as the case studies illustrate, great emphasis should be placed on communication, stability and credibility: stop-and-go measures, reversals and confusion will generally have high costs.

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