International Benchmark Study on Renewable Energy

Final report

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Preface

At the end of 1995, the Minister of Economic Affairs of the Netherlands published the Third White Paper on Energy Policy. This document has two key themes: increased competition and a larger share of renewable energy in overall energy supply. The Third White Paper states that by 2020, the share of renewable energy in the Netherlands must rise to 10%. Based partly on ECN calculations, it concludes that this 10% target can be achieved, provided that certain conditions are met.

At the request of Parliament, the policy for achieving this target was further elaborated in the action programme ‘Renewable Energy - Advancing Power’ (March 1997). This action programme states - and the ECN has warned - that only about half this target will be met unless the government prescribes a specific share of renewable energy in overall energy consumption. These revised expectations are based on higher economic growth forecasts and substantially lower fossil fuel prices than anticipated in the Third White Paper on Energy Policy.

This has prompted the following question: do these trends mean that Dutch policy instruments do not go far enough or that the 10% target is too ambitious? We felt this question could only be answered by comparing the policy of the Netherlands with that of other countries.

This study, which was carried out by CEA, looked at policy to stimulate renewable energy in 17 countries and evaluated the cost of exploiting the renewable options available to them. Based on this comparison, CEA concluded that the Dutch technical potential is small and the costs of realising it are high. The number of options being stimulated by the Dutch government is extensive and its range of instruments is broader compared with the other countries surveyed. It also emerged that apart from the Netherlands, very few countries apply an explicit target or a specific set of instruments for the long-term stimulation of renewable energy.

The European Union Member States are currently working on an EU incentives policy for renewable energy. The aim is to double the existing share of renewable energy from 6% to 12% by the year 2010. In my view, this study supports the view that Dutch policy is making an ambitious contribution to that goal.

In the light of these efforts, CEA ‘s conclusion that an international approach to the application of renewable energy would yield significant cost benefits is particularly well timed.

I therefore warmly recommend this study.

C.W.M. Dessens
Director-General for Energy

Foreword

Hardly a day goes by without newspaper headlines announcing some growing threat from the greenhouse effect. Rising sea levels, El Niño, the increasing frequency of flooding: all these natural phenomena are - rightly or wrongly - blamed on a structural deterioration in the global climate. The need to curb greenhouse gases and other harmful emissions released as by-products of energy production is universally accepted. In addition to reducing demand for energy and encouraging greater energy efficiency, energy from renewable sources offers a very realistic alternative to conventional energy generation, especially in the medium to long term.

At present, only a small proportion of the Dutch energy requirement is met by renewable energy. Over the next 25 years or so, the Dutch government therefore plans to multiply the share of renewable energy by a factor of roughly 10. This study examines how ambitious this goal is compared with the targets set by other EU Member States.

The study was carried out under considerable pressure of time. A large number of countries were visited in a very short space of time and a detailed exchange of views was held with leading policy-makers in the field of renewable energy. The study could not have been completed without their co-operation or the help of dozens of their immediate colleagues. We are therefore extremely grateful to them.

Messrs H. Koenen and B. Roukens supervised this study on behalf of the Ministry of Economic Affairs. Consultations with these two individuals led to a series of in-depth discussions and forced a rethink of various issues. We are convinced that this contributed both to the quality and the depth of the study, and therefore also hope that, by providing an insight into the renewable energy situation in other countries, it provides the reader with sufficient material to reflect on the situation in the Netherlands.

Finally, we would like to thank all staff at CEA who assisted us in producing this study: Marco Tieleman, who made countless international telephone calls, Patricia Arts for assistance with the calculations, Marianne de Groene for managing the exponentially growing archive and for organising the trips, and Corina van Geemert and Ingrid Kok for their secretarial support.

Rotterdam, January 1998

Summary

Background

The Dutch government has formulated a series of policy goals on renewable energy. Opinions are divided about the level of ambition reflected in these goals. Some feel they are over-optimistic, some believe that more could be done and still others regard the policy as ambitious yet feasible.

The Dutch Ministry of Economic Affairs therefore commissioned a survey to compare the targets set by the Netherlands with those in other countries. The survey covered the EU Member States, Norway, Japan and the United States of America. It was carried out by CEA, Consultants on energy and the environment.

Questions posed by the survey

A country's level of ambition regarding renewable energy is defined by its combined goals and the associated policy instruments. The survey primarily sought answers to four questions that strongly determine the different levels of ambition within each individual country:

1. What is defined as renewable energy? Not all options are equally 'renewable' in all countries.
2. What renewable options are available? To what extent can they be exploited and what would it cost to exploit them further? Natural conditions create major disparities between countries in this regard.
3. What rationale and policy goals are applied to the use of renewable energy? These differences could have a major influence on the activities carried out in different countries.
4. What instruments are used to achieve these goals?

Approach

As a rule, two institutions were approached in each country: the Ministry responsible, to obtain information about policy on renewable energy, and the national energy agency, to obtain more detailed information on energy potential, cost prices, the deployment of instruments, the practical experience gained and so on.

The survey used the so-called 'cost diagram' system developed by CEA for the Dutch energy sector. This system is also used in the National Environmental Action Plan (MAP) and in the Integrated Environmental Plan for the Energy Industry (IMES). The definition of 'primary energy' was taken from the Eurostat Convention; this definition has major benefits for international comparisons over and above the 'substitution principle' more commonly applied in the Netherlands. Current cost levels were used. The cost diagrams for each country gave a broadly quantitative idea of where in Europe relatively low and relatively high costs must be incurred to exploit renewable energy.

In addition to the cost diagrams, the individual country reports also describe the energy situation (including the status of renewable energy), energy policy and how that policy is implemented, the relevant renewable energy options in the country concerned and the deployment of policy instruments. Information was gathered and interviews were conducted with policy-makers and implementing authorities, mainly in the autumn of 1997. The findings of this study are therefore linked to a specific point in time.

Countries

A brief summary of policy on renewable energy in each country is given below. The reader is assumed to be familiar with policy in the Netherlands.

Belgium

In Belgium, the regional authorities are responsible for promoting renewable energy. Policy in Flanders is administered by the Ministry of the Flemish Community and in Wallonia by the Ministère de la Région Wallone. Wallonia does not have an official policy-based target for renewable energy. However, Flanders is working to achieve a 5% share of renewable energy within the total energy supply by the year 2020 (compared with roughly 0.5% at present). Most of the emphasis lies on options involving electricity. The 'Flanders Renewable Energy Plan' will seek to meet this target through a technology push combined with measures to remove legal, institutional and financial obstacles. The plan is currently being drafted and will require approval.

Denmark

In Denmark, energy and environment policy are integrated in a single Ministry, the Ministry of Environment and Energy. The Danish Energy Agency (DEA) is part of this Ministry. The national policy goal is to achieve a 12-14% share of renewable energy within overall energy consumption by 2005, rising to 35% by 2030. This will be achieved by promoting energy efficiency and by expressly encouraging a number of renewable energy options, notably wind energy and biomass. The policy is divided into a national and a regional component. At national level, agreements have been made with the power companies to establish offshore wind farms and to convert coal-fired urban power plants to biomass. The regions will be encouraged to take their own initiatives within the context of Local Agenda 21 and other programmes.

Germany

In Germany, various ministries are involved in the development and promotion of renewable energy. The Ministry of Economic Affairs (BMWi) co-ordinates federal policy on renewable energy while the Ministry of Education, Science, Research and Technology (BMb+f) is closely involved in its development and stimulation. In fact, this Ministry makes a larger financial contribution to renewable energy than the BMWi. The Länder pursue their own supplementary policies for stimulating renewable energy. Germany has no overall quantitative targets for renewable energy. A substantial proportion of investments made within the 250 MW wind energy programme ('Breitentest') are subsidised, as are investments in the '1,000 roof' programme to promote photovoltaics. An important financial incentive for the private sector is the 'Strom-EinspeisungsGesetz', which involves the payment of substantial compensation for the generation of electricity from wind turbines, photovoltaics, small-scale hydropower, biomass and gas from landfill waste.

Finland

Energy policy in Finland is the responsibility of the Ministry of Trade and Industry. The body directly responsible for promoting renewable energy is VTT Energy. Finland is just beginning to draft a national policy on renewable energy. Policy and demonstration projects are being prepared with assistance from the European Commission. However, no overall policy goals have been formulated as yet. The programme focuses primarily on encouraging the utilisation of biomass. To promote renewable energy, Finland is working towards the internalisation of external costs in energy prices. Due to the problems this creates for international trade (especially where electrical energy is concerned), the government is now introducing tax incentives to alleviate these difficulties as far as it can.

France

The Ministry for Industry is responsible for energy policy in France. Policy proposals are submitted and implemented by the ADEME agency. Renewable energy policy concentrates on options that are already profitable, and especially on the removal of administrative obstacles. Measures also focus on near-profitable options (encouraging lower cost prices). Sectors covered include hydropower, geothermal energy, biomass (residual wood) and wind energy. There are no overall quantitative policy-based targets, although there are short-term market launch programmes based on subsidiary targets. The government believes that it is up to the private sector to encourage the growth of renewable energy.

Greece

The Ministry for (Industrial) Development is primarily responsible for policy on renewable energy, which is part of the National Operational Energy Programme. There is no quantitative target for renewable energy. In 1994 the government introduced a law allowing independent electricity companies to generate electricity for third parties. This law guarantees the power company a certain level of compensation for the redistribution of this energy for at least 10 years. Tax incentives for private individuals have also proved highly successful. A large proportion of investments in renewable energy (75%) is tax-deductible. This instrument underlies the success of thermal solar energy, which has given Greece a lead in this field.

United Kingdom

The Department of Trade and Industry (DTI) is responsible for policy on renewable energy. The current aim is to achieve a 1,500 MW share of 'renewable' electricity capacity by the year 2000 (this represents less than 1% of energy consumption in 1995). Efforts to stimulate renewable energy focus on electricity generating options that are economically viable within the foreseeable future (wind energy, waste incineration and landfill gas). The UK's Non-Fossil Fuel Obligation obliges the regional energy distribution companies to purchase a certain amount of non-fossil fuels. Competitive tendering (bidding combined with cost-price ranking) exposes energy providers to market forces (competition). These instruments are designed to improve price-performance ratios and at the same time to encourage market penetration. The new Labour government is currently reviewing the UK's policy on renewable energy.

Ireland

The Department of Public Enterprise is responsible for renewable energy policy, much of which it also implements. One of Ireland's main reasons for promoting renewable energy is the likelihood of increased dependency on foreign energy sources following the exhaustion of the country's own energy stocks coupled with rising demand for energy. The (modest) target for 2010 is to achieve a 1% level of renewable energy. Emphasis is given to options that generate electricity. Ireland is currently the only EU Member State investigating the possibilities for wave energy. The total estimated potential is relatively low (approximately 10% of current energy demand). In Ireland, competitive tendering (Alternative Energy Requirement Competition) is used to stimulate cost-effective power-generation from renewable sources. Projects that are sufficiently competitive are awarded the asking price per kWh for a 15-year period.

Italy

The Ministry of Industry and Trade is primarily responsible for policy on renewable energy. However, both policy preparation and implementation are largely the preserve of the national energy agency. In addition to central government, the regional authorities in Italy are also actively involved in developing renewable energy. There is no quantitative goal for renewable energy. In 1988 the government drew up a national energy plan which included measures to stimulate renewable energy. The plan allowed independent power companies to redistribute electricity from renewable sources to the national grid at a high tariff. Following agreements made under the privatisation of the state-owned electricity company, new projects no longer qualify for these high tariffs. The introduction of a new incentives policy was thought likely at the end of 1997.

Japan

Energy policy is administered by the Ministry for International Trade and Industry (MITI). Since 1980 Japan has been actively working on new forms of energy, including renewable energy. This led in 1980 to the creation of NEDO (New Energy Development Organisation). In addition to renewable energy, New Energy also includes new coal technology and nuclear power. Subsidiary targets have been drawn up for certain policy components (for capacities to be achieved by 2010); together they are designed to achieve approximately a 3% share of renewable energy in total energy demand. There is no overall quantitative target for renewable energy. The instruments deployed include promotion, deregulation, standardisation and specific technology development.

Luxembourg

The Energy Ministry is responsible for policy on renewable energy, assisted by the national energy agency. One of the main reasons for stimulating renewable energy is the need to diversify. Another is the need to reduce harmful emissions. There is no quantitative goal for renewable energy. Renewable energy is stimulated by high tariffs for electricity sold to the grid, and by subsidies. These incentive schemes are now also attracting interest from investors in Germany and Belgium.

Norway

Energy policy is the responsibility of the Ministry for Petroleum and Energy. Policy is drafted by the Norwegian Water Sources and Energy Administration (NVE). Norway does not have quantitative long-term policy goals for renewable energy. Interest in renewable energy, especially biomass, has increased substantially in recent years, partly as a result of two dry summers (leading to a shortage of hydropower and the need to import electricity). Biomass can be flexibly deployed and also generates additional employment. Possibilities for wind energy and the expansion of hydroelectric capacity (for which there is only limited scope in Norway, however) are also being explored.

Austria

The Austrian Ministry of Economic Affairs is responsible for federal policy on renewable energy. The Bundesländer also determine much of this policy. There is no overall quantitative target for renewable energy. Biomass and large-scale hydropower projects are relatively cost-effective options in Austria and also have a reasonably high technical potential. Half of Austria is covered by forest. Residual wood and forestry cuttings in the form of biomass already account for a substantial share of energy supply. The potential for extensive hydropower (> 10 MW) has now largely been tapped. To stimulate renewable energy, annual tenders are issued, projects are ranked, evaluated and awarded according to a minimum subsidy for a maximum energy supply. The country's largest power producer is legally obliged to deliver a certain (stepped) percentage of the total electricity supplied in the form of wind and solar energy and biomass energy. The goal is to achieve 1% by 1999, rising to 3% by 2003.

Portugal

The Ministry for Industry and Energy and the Directorate-General for Energy (DGE) are jointly responsible for formulating policy on renewable energy. There are no quantitative goals. Portugal uses renewable energy to diversify its energy supply (it is currently highly dependent on oil), to improve its energy infrastructure and to generate additional employment. A series of demonstration projects on biomass have been launched (creation of a complete local infrastructure). The Directorate-General for Energy awards subsidies and interest-free loans for the establishment of renewable energy projects.

Spain

Energy policy falls under the responsibility of the Ministry for Industry and Energy. However, it is drafted and implemented by the Institutio para la Diversification y Ahorro de la Energia (IDEA). The Spanish government has set itself the goal of doubling the existing share (approximately 6%) of renewable energy in the overall energy supply by the year 2010. The main options are the utilisation of hydropower and biomass. In practice, the award of subsidies and Third Party Financing have proved to be the most effective way of stimulating renewable energy and the associated development of industry. These instruments are therefore central to Spain's existing policy on encouraging renewable energy.

United States of America

Energy policy is the responsibility of the Department of Energy. The United States have no quantitative national renewable energy targets. Hydropower makes by far the biggest contribution to the existing share of renewable energy, although the share of biomass is increasing. Geothermal energy, wind and solar (high temperature) power are also being given increased attention. Laboratories are used to support technology development and marketing (mainly by private companies). Most of the individual measures are drawn up by individual states. California, which is beginning to deregulate its electricity market, is taking the lead in this field. The US government is now considering the possibility of extending the Californian model (wires charge) to the rest of the country or opting for a compulsory share of renewable energy - with a fixed portfolio of options - within the output of electricity companies.

Sweden

Energy policy is the responsibility of the Ministry of Industry and Commerce, assisted by NUTEK, the Swedish National Board for Industrial and Technical Development. Sweden currently has the largest share of renewable energy within the EU. The main reason for further stimulating renewable energy is to enhance industrial development (for the international market). There is no quantitative policy goal on renewable energy in Sweden. Renewable energy is a key element in Sweden's energy policy due to the need to reduce the consumption of electrical heating and increase energy efficiency. Biomass and related technological developments are being given the most attention.

Comparison

The situations in each country were compared using the country reports. Particular attention was given to the positioning of the Netherlands vis-à-vis the other countries. The sections below follow the order of the four questions listed above.

What is defined as renewable energy?

The definition of renewable energy is not always the same for each country, and opinions differ even within individual countries. The definition used by each national government has therefore been taken as a yardstick for each country in the country reviews. Hydropower, wind energy, solar energy, tidal energy, wave energy and geothermal energy are all generally included under the term 'renewable energy'. Biomass and waste incineration are regarded as semi-renewable sources (in so far as 'renewability' involves a minimal impact on the environment).
In France, waste incineration and gas from landfill sites are not regarded as forms of renewable energy, although in the other countries they are. None of the countries surveyed had clear

guidelines as to what was and was not defined as renewable energy. The use of heat pumps and energy storage tend to be seen as energy-saving options rather than as renewable energy. Eurostat does not include these options in its definition of renewable energy for statistical publications. The same applies to passive thermal solar energy. However, the issue here is simply one of classification; none of the countries surveyed questions the positive environmental effects of these options.

Cost curves

A cost curve comparison of each country clearly shows that the costs to the Netherlands of meeting its renewable energy target are high by comparison. It will cost the Netherlands as much per capita to achieve this target as it would to achieve a level of approximately 35% in Austria and Germany, and almost 80% in Norway. These countries are likely to remain well below these percentages by the year 2020. The cost curve comparison also shows that the Dutch per capita expenditure could be used to achieve a 20% level of renewable energy in Denmark, 13% in Spain and approximately 2% in Belgium. The targets in these three countries are either at or substantially above these levels (5% in Flanders, 35% in Denmark). Only two of the countries surveyed therefore operate more ambitious targets than the Netherlands. Only Denmark deploys a specific set of instruments geared to meeting its renewable energy target. Unlike the larger European countries, whose technical capacity (in the form of hydropower, biomass, etc) is substantial by comparison, the Dutch goal is ambitious, given the conditions prevailing in this country. Clearly, realising this goal will require a significant level of commitment, including financial.

Rationale and policy goals

Apart from technical potential and cost price, other factors shown to be important during the survey were also examined. The first of these was each country's existing national fuel mix. Renewable energy targets are often linked to climate goals. The supply of energy in the Netherlands has already shifted from coal to natural gas in recent decades. Since natural gas releases fewer specific CO_2 emissions than coal during combustion, the Netherlands has already managed to reduce its CO_2 emissions by increasing the proportion of natural gas in the national fuel mix. Despite this, however, emission levels per head of the population remain quite high. Countries like Belgium, Denmark and Germany have similar per capita emission levels. Yet because their national fuel mix is largely coal-based, these countries will obtain a greater proportional reduction in emissions through the application of renewable energy.

A second factor is that the Dutch energy sector is undergoing a process of liberalisation and restructuring in line with EU Directives. Both the European Union and the United States recognise that restructuring and liberalisation will present threats as well as opportunities to renewable energy. The main threat is that in a purely commercially-driven energy supply market, companies will not want to invest in more 'costly' renewable energy. On the other hand, they will respond more readily to market requests for renewable energy; individual producers of renewable energy will also be able to supply or redistribute energy through the 'third party access' principle.
How much money each country spends on developing renewable energy depends largely on the local availability of relevant R&D capacity and experts. The results of R&D should be regarded more in terms of how they can boost industry, employment and exports rather than in terms of how they can directly stimulate renewable energy on a national scale. Many countries therefore see the creation of a domestic market for renewable energy as part of their policy of technology innovation.

Instruments deployed

It is difficult to assess the effectiveness of individual instruments since the end result (realising renewable energy) is often a combination of many factors. In Denmark and Germany the government's fixed redistribution allowance has certainly led to a massive growth of the home market. The bidding system used in the UK, Ireland and France is another effective instrument, since planned capacity is effectively guaranteed because suppliers are paid their asking price. The competition element also makes this a cost-effective instrument.

The relationship between the government and the energy companies in the Netherlands is unique compared with that in other countries. Because the energy distribution companies themselves fix the remuneration for electricity supplied to the public grid and the conditions for connection to the grid, they occupy a key position in the development of electrical - that is, grid-based - renewable energy options. In other countries, this interaction is much less direct, unless of course the companies are state-owned.

It is rare for governments to negotiate a fixed percentage of renewable energy with energy distribution companies. Apart from the Netherlands, only Austria has set a target for renewable energy within the overall supply of electricity.

Developments surrounding the marketability of renewable energy in the Netherlands are also unique. In the lead-up to a single European energy market, the experience gained in the Netherlands could be used to assist a European debate on opportunities for importing and exporting renewable energy.

The Netherlands uses an exceptionally broad range of instruments to stimulate renewable energy. Many countries, however, prefer to concentrate on only a few instruments and options. Notable examples include Sweden, with its strong emphasis on the development of industry based on biomass, and Denmark, which is doing the same in the case of offshore wind energy and co-firing using biomass coupled with energy conservation in order to boost the relative share of renewable energy in its energy output.

Conclusions

The cost diagram method provides a useful basis for comparing the renewable energy situations in the various countries. A comparison of the cost curves (cumulative cost diagrams) broadly shows the differences between national potential and between the costs associated with the further expansion of this potential.

Compared with other countries, the Dutch technical potential is small and the costs of opening it up are high. Hence the number of options being stimulated in the Netherlands by the Dutch government is extensive compared with the other countries surveyed. The range of instruments is also broader. Dutch policy covers all the options that are currently profitable or near-profitable. In some of these options, the target is very close to the technical potential (waste, biomass, hydrocombined heat and power pumps). Dutch policy is also looking at options that will not be commercially viable for many years to come (photovoltaics and heat pumps). The definition of renewable energy in the Netherlands is very broad.

Apart from the Netherlands, very few countries operate specific long-term goals for renewable energy. Unlike the larger European countries, whose technical capacity (in the form of hydropower, biomass, etc) is substantial by comparison, the Dutch goal is ambitious. In countries where such goals have been formulated (Denmark, Ireland, Spain, Flanders), they must be regarded as at least as ambitious as that of the Netherlands (except for Ireland). So far, only Denmark has developed a set of instruments specifically targeted at renewable energy. Clearly, realising the Dutch renewable energy target will require a substantial level of commitment, including financial. An international approach to developing renewable energy could have major cost benefits. However, an approach of this kind would be complicated by a variety of national definitions, conventions, motives (e.g. national industry or infrastructure development) and regulations. The Netherlands could, however, play a leading role in boosting international trade in renewable energy.

Terms, Definitions and Abbreviations used

Primary energy	The energy content of a specific energy source calculated back to its initial usable form.
Reference price	The price of the conventional fuel alternative.
Single Buyer	System within a liberalised energy market in which there is only one buyer for the electricity generated by an independent producer; this is usually the former state-owned company.
Technical potential	The utilisable share of a renewable energy option, disregarding any economic constraints.
Third Party Access	System within a liberalised energy market in which independent producers are afforded access to the energy infrastructure. Direct sale to consumers is usually permitted.

AB	Assembly Bill
ADEME	Agence de l'Environnement et de la Maîtrise de l'Energie
AEL	Agence de l'Energie de Luxembourg (Luxembourg national energy agency)
Altener	European Union Programme of Assistance for Renewable Energy
BEO	Projektträger für Biologie, Energie, Ökologie; Organisation responsible for managing Germany's renewable energy programme
BML	Bundesministerium für Landwirtschaft
BMwA	Bundesministerium für wirtschaftlichen Angelegenheiten; AustrianMinistry of Economic Affairs
BMb+f	Bundesministerium für Bildung, Wissenschaft, Forschung und Technologie
BMU	Bundesministerium für Umwelt
BMWi	Bundesministerium für Wirtschaft
BMZ	Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung
CCE	Centre for Energy Conservation
CEC	Californian Energy Commission
C.R.E.S.	Centre for Renewable Energy Sources: Greek national energy agency
DEA	Danish Energy Agency
DEV	Flanders Renewable Energy Plan
DGE	Directorate-General for Energy
DTI	UK Department of Trade and Industry
EdF	Electricité de France
ELWOG	Elektrizitätswirtschafts- und -organisationsgesetz: Austrian electricity sector act (1997)
ENEA	Ente per le Nuove tecnologie, l'Energia e l'Ambiente (Italian energy agency for new technology, energy and the environment)
ENEL	Ente Nazionale per l'Energia Elettrica (Italian national electricity company)
ETSU	Energy Technology Support Unit
Eurostat	European Statistical Bureau
EU	European Union
E.V.A.	Energie Verwertungsagentur: Austrian energy agency
EVU	Elektrizitätsversorgungsunternehmen: Austrian electricity production and transport company

EWEA	European Wind Energy Association
IDAE	Instituto para la Diversification y Ahorro de la Energia: Spanish energy agency
IEA	International Energy Agency
IMES	Integrated Environmental Plan for the Energy Industry
MAP	Environmental Action Plan
MITI	Ministry of International Trade and Industry
NEDO	New Energy Development Organisation
NFFO	Non-Fossil Fuel Obligation
NOPE	Greek National Operational Programme for Energy
NVE	Norwegian Water Sources and Energy Administration
P.E.N.	Plan Energia Nazionale: Italian national energy plan
PPC	Public Power Corporation: Greek electricity company
SERURE	Service des Energies Renouvables et de l'Utilisation Rationelle de l'Energie: works for the Ministries of Industry, Environment and Research
StrEG	Strom-EinspeisungsGesetz (German energy resupply act)
TPEC	Total Primary Energy Consumption
TPA	Third Party Access

1 Introduction

1.1 Context

The Third White Paper on Energy Policy sets out the Dutch policy on renewable energy [1]. It specifies that by the year 2000, 3% of energy consumption in the Netherlands must come from renewable sources and that by 2020 this share must have risen to 10%. The policy paper ‘Renewable Energy - Advancing Power’ contains an action programme for the next four years which translates this policy into practice [2].

Opinions are divided about the level of ambition reflected in these goals. Some feel they are over-optimistic; others believe that more could be done. Yet others regard the policy as ambitious yet feasible. In its paper ‘Energy for the future: renewable sources of energy’, the European Commission emphasises that opportunities for the application of the various forms of renewable energy differ widely for each country due to their prevailing natural conditions. Norway, for example, can generate more hydropower than the Netherlands, which in turn has greater access to wind energy than, say, Luxembourg.

The Dutch Ministry of Economic Affairs therefore commissioned a survey to compare the targets set by the Netherlands with those of other countries in the light of these international disparities. The survey covers the European Union Member States and one or two other countries that must be regarded as relevant in this context. The survey was carried out by CEA, Consultants on energy and the environment. CEA applied a framework to the survey that allowed a succinct account to be compiled of the policies and level of ambition in each country. This framework was developed by McKinsey and further refined by CEA; it was previously successfully used by the MAP for the energy distribution companies and the IMES.

1.2 Aim of the survey

The main aim of the survey was to assess the relative ambition of the Dutch target for renewable energy compared with those of other countries, especially other EU Member States. The survey therefore primarily sought answers to the following questions:

1. What is defined as renewable energy? Not all options are equally ‘renewable’ in all countries.
2. What renewable options are available? To what extent can they be exploited and what would it cost to exploit them further? Natural conditions create major disparities between countries in this regard.
3. What rationale and policy goals are applied to the use of renewable energy? These differences could have a major influence on the activities carried out in different countries.
4. What instruments are used to achieve these goals? And are the goals themselves realistic in the light of the instruments deployed?

1.3 Chapter guide

Chapter 2 describes the method used to conduct the survey and explains the terms of reference used in the comparison. Chapter 3 gives an account of each of the countries surveyed. As well as describing the opportunities for exploiting renewable energy in each country and the measures taken, it also examines the link between policy and practice. Chapter 4 compares policy on renewable energy in each country, focusing on where the Netherlands stands in comparison to the other countries. This is consequently the key chapter. Chapter 5 presents the report's conclusions.

2 Method used

2.1 Level of ambition

The level of ambition of a country with regard to renewable energy is defined by its national target for renewable energy and the funding it is willing to set aside to meet that target. These targets are not 'free-standing' - they must relate to what can reasonably be achieved in a particular country (i.e. its technical potential). A target that only covers a limited proportion of a country's technical potential cannot be regarded as ambitious. Conversely, a target that comes close to maximising that potential must be seen as highly ambitious. Since renewable energy is often relatively new and thus more expensive than energy derived from conventional fossil fuels, meeting these targets will be costly. The viability of a target can be tested by comparing it with the funding that is to be set aside for it. An ambitious target that is not matched by the appropriate resources cannot be regarded as realistic.

The cost price of renewable energy is not the same in every country. In the Netherlands, where average wind speeds are higher than in Austria, wind energy can be generated more cheaply. Even if both countries were to adopt the same target for wind energy and had the same reference costs for electricity generation, Austria would still be more ambitious than the Netherlands, at least if it were to deploy an adequate set of instruments to meet this target. Levels of ambition indicate the - public - will to deploy financial resources and/or other policy instruments in order to meet a specific target. Deployment of other policy instruments (such as statutory prescriptions) can also reflect what a particular country wishes to achieve.

2.2 Cost diagram

During the survey, it emerged that other than the Netherlands, very few countries operate an overall quantitative target for renewable energy. This removed the direct basis for a comparison of levels of ambition in terms of targets. Yet since the survey charted the costs for each country as a function of the technical potential to be opened up, it was nevertheless possible to draw conclusions about how the Dutch government's efforts compare with those of other countries.

This is because it is possible to compare the costs of realising a specific share of renewable energy in each country. This can be illustrated using so-called cost diagrams. The method employed for these cost diagrams was developed within the energy sector and was previously used by EnergieNed, SEP and Gasunie for their MAP and IMES plans. Figure 2.1 shows an example of a cost diagram.

The horizontal axis of the cost diagram indicates the cumulative potential of renewable energy. The vertical axis indicates the surplus costs attached to each option. These surplus costs are obtained by calculating the difference between the cost price of a specific renewable energy option (per GJ of primary energy) and what it would cost a potential commercial operator to purchase a conventional or fossil fuel-based alternative (reference price). Financially viable options will therefore lie on or below the horizontal axis. This diagram can also be used to indicate the target for renewable energy. If a country has a quantitative target, this is indicated in the diagram by a vertical broken line together with the year by which the target must be met.

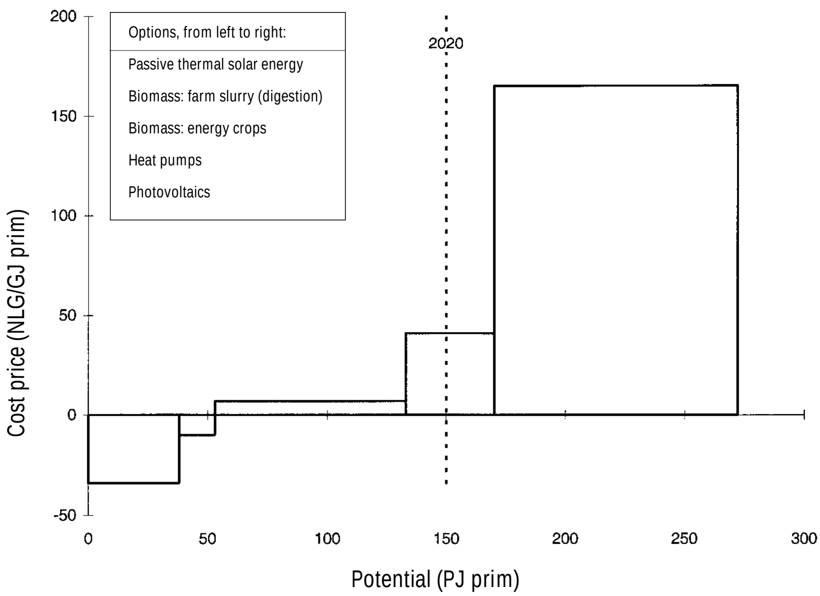


Figure 2.1 Theoretical cost diagram

The combined cost diagrams for all the countries surveyed provide a - broadly - quantitative review of where in Europe relatively low and relatively high costs must be incurred in order to open up renewable energy options. This is useful information, especially in the light of the European perspective of open frontiers and a liberalised market.

However, due to the nature of the data and the way in which they were gathered, no absolute value should be ascribed to these figures. It is difficult for example to accurately assess technical potential; definitions of what is meant by technical potential are not precisely the same for each country. Some definitions lean more towards a theoretical potential while others tend to emphasise a more practically (and thus more economically) viable potential. And even if precisely the same definitions were to be used, estimates of technical potential could still diverge widely.

Cost indicators also diverge widely, largely due to the substantial differences in energy revenues and/or potential connection costs. Even in a small country like the Netherlands, the difference between the best and worst projects within a particular option can easily be a factor of two. While this does not yield any firm conclusions about the total surplus costs of opening up (part of) a country’s technical potential, the approach used is nevertheless accurate enough to allow a comparison of each country’s efforts and ambitions relating to renewable energy.

The decision to adopt only one price level per option is, as mentioned earlier, a simplification of the actual situation. In fact, several cost prices can be identified within the various options. This may be due to differences in yield (favourable and less favourable locations) or in forms of commercial exploitation leading to disparities in the reference price. So instead of showing a single bar for each renewable energy option (a), the cost diagram will in this case show several smaller bars (b) as illustrated in Figure 2.2. Ranking these bars in line with their cost price (c) clearly shows that new priorities have arisen; the cheapest wind energy option (1) then becomes cheaper than e.g. the most expensive solar option (2).

If cost price figures are available for the various individual bars, this also gives a better picture of the real average cost price level of an option. Cost prices based on figures derived from limited practical experience are sometimes coupled to overall technical potentials due to a shortage of more accurate data. As a result, the average weighted cost price of the individual bars together could differ from the prices obtained in this survey using less accurate data.

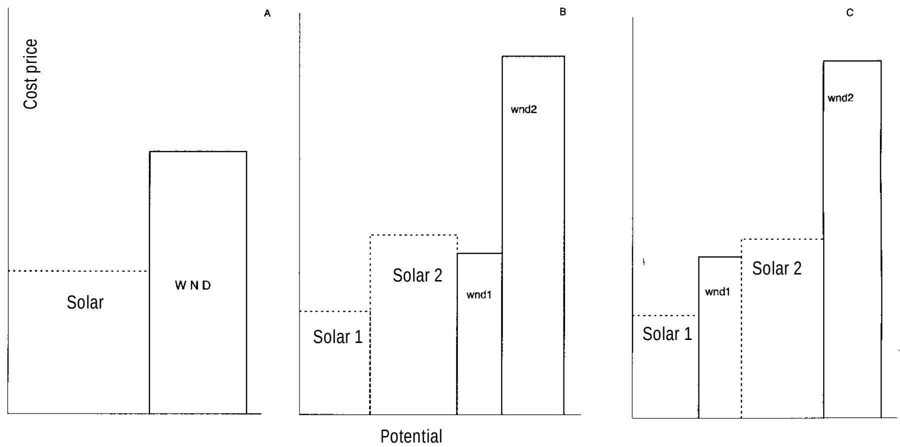


Figure 2.2 Effect of working with a single price level instead of several price levels

2.3 Country-by-country review

The renewable energy situation in the countries surveyed was charted in two phases. The first phase consisted largely of desk research, which was used to obtain a general review for each country. During the second phase, this information was checked and refined by means of interviews. The gathering of information and the interviews with policy-makers took place mainly during autumn 1997. The findings of the survey are therefore linked to a specific point in time.

2.3.1 General country reviews

The general country reviews were based on literature, notably 'The Renewable Energy Study' (TERES II) which charts the options for renewable energy within Europe [3]. Although many of the options in this study are examined together, the evaluation of the technical potential of each option proved a useful starting point.

The production figures were taken from Eurostat surveys, the most recent of which gives figures for 1994 [4]. However, Eurostat also agreed to provide as yet unpublished data for 1995 [a].

During this phase, the survey consulted the IEA and EU reviews of the various options to obtain a general account of the energy situation and the instruments deployed [5], [6], [7], [8], [9] and [10].

During the preparatory phase, questionnaires were sent out to the responsible ministries, energy agencies, electricity companies and energy umbrella organisations such as EWEA. The World Wide Web was also used to track down relevant organisations, individuals and information.

2.3.2 Interviews

The information outlined above provided an overall picture from which interviews could be prepared for each country. Draft reports were compiled per country based on the desk research. These reports were largely figure-based and discussed the production levels, targets, potential and costs of the relevant renewable energy options. The interviews had two aims:

1. to gain insight into national policy, the deployment of instruments, the practical experience gained and the main players in the field of renewable energy, all obviously in the context of a specific country (characteristic energy supply, natural resources).
2. to check and supplement the figures obtained.

Two types of organisation were generally approached in each country: the Ministry responsible, to gain insight into policy on renewable energy, and the national energy agency, to obtain more information on potentials, costs, the deployment of instruments, practical experience gained and so on. Annex A contains a list of the interviewees and the organisations they represent. In some cases, only one organisation needed to be contacted; for instance the Danish energy agency and the Ministry responsible are practically one and the same.

The survey often found - sometimes widely - divergent figures for the technical potential of a specific option. The various information sources also yielded widely differing cost prices. Since this survey compared different government policies, it was decided to opt for authoritative sources, in this case sources provided or approved by the relevant policy officials. The added advantage of this approach is that it yielded commercially sensitive information - albeit indirectly - on the so-called reference price of a specific renewable option, even from countries with extensively privatised energy sectors.

The calculation of cost prices was complicated by the fact that many economic factors are dependent on nationally prevailing market conditions (interest, inflation, and depreciation terms). By using data originating from a particular country, it was possible to make allowances for the differences in market conditions in an automatic and natural way.

The question of exactly which options are regarded as renewable should be approached in much the same way. Hence the survey accepted as ‘renewable’ those options designated as such by the authorities in a particular country, even though there may be some disagreement about the eligibility of some of these options. The definition used by each national government has therefore been taken as a yardstick for each country in the country reviews. However, the comparison between the countries only looked at options that were defined as renewable in all the countries surveyed. The overall technical potential of each country was calculated on the basis of the existing options within that country. Hence when compiling the national cost diagrams, the survey did not take into consideration the import and export of renewable energy. However, international trade was included as part of the international comparison of costs versus options.

Due to differences in the conventions, currencies and categorisations used, the source data were submitted to the interviewees for verification.

2.4 Comparison between countries

The information collected on each country allowed them to be compared in terms of renewable energy, based primarily on a comparison of all the cost diagrams. The various national policies and policy instruments were also compared.

2.4.1 Cost curves

As mentioned earlier, the cost diagrams show how much a country has to spend to realise a certain renewable energy potential. In order to be able to compare the consequences of the cost diagrams for each country, cost curves were produced showing the cumulative costs as a function of the technical potential to be opened up. Figure 2.3 shows how a cumulative cost curve is derived from the individual bars of a cost diagram. The cumulative cost curve reflects the total surface area of the cost bar (i.e. the sum of the product of the specific cost price and the potential for each option). The height of each bar indicates the specific cost price of a specific option (NLG/GJ). The width of the bar indicates the technical potential of the option (PJ). The product of both (surface = length x width) indicates the cost of fully exploiting the option concerned. The cumulative cost curve is obtained by adding together the surface areas of the bars from left to right. Because the options are ranked according to a rising specific cost price, the cumulative curve has an exponential character.

In the rest of this report, therefore, the costs are presented on a logarithmic scale since otherwise the figures would be unreadable, especially the figures for relatively inexpensive and thus more interesting options.

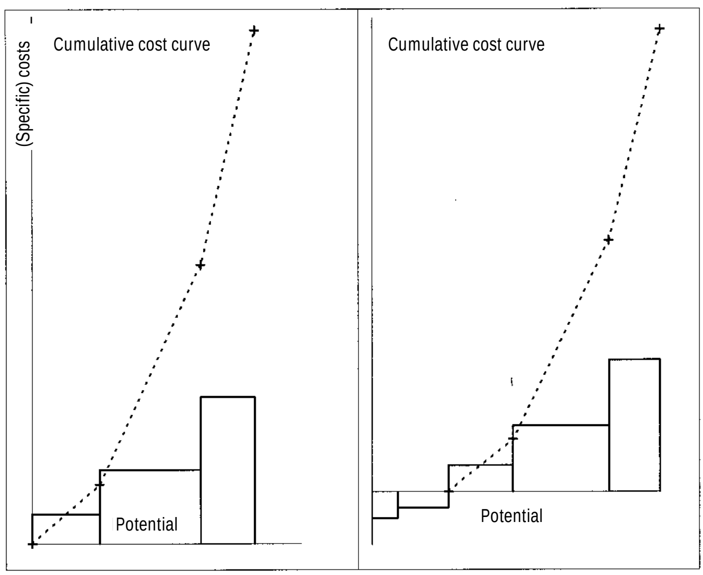


Figure 2.3 Deriving a cumulative cost curve from a cost diagram

Profitable options (i.e. those with a negative specific cost price) were not included in the cumulative costs, since it is investors and not society at large who will benefit from these options. This revenue will not therefore compensate for the ‘deficit’ created by exploiting unprofitable options. Figure 2.4 illustrates theoretical cost curves for two countries (country A and country B).

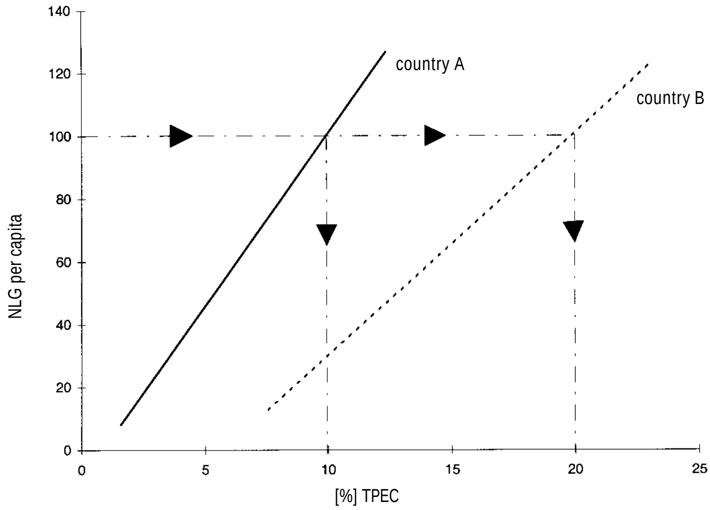


Figure 2.4 The cost of renewable energy as a function of relative cumulative technical potential (theoretical cost curves)

The horizontal axis illustrates the country's cumulative technical potential. This potential is shown relative to the total primary energy consumption (TPEC) of a particular country. It is theoretically possible for the technical potential of renewable energy to be greater than the TPEC and for it to therefore rise above 100%. The vertical axis shows the costs to society of exploiting this technical potential, expressed in guilders per capita.

These curves make it easy to compare the level of ambition of one country with that of others. Country A, for example, has a renewable energy target of 10% of its total primary energy consumption. Figure 2.4 shows how much this will cost - in this case, approximately NLG 100 per capita. The same chart also shows how much renewable energy country B could realise with an identical budget. If it realises more, country A's target can be regarded as ambitious compared with country B. If it realises less, its level of ambition will be regarded as lower. Hence in the example in Figure 2.4, the policy on renewable energy in country A is more ambitious than in country B.

2.4.2 Policy and policy instruments

Policy on renewable energy was compared and analysed using various cross-sections. The instruments deployed were examined partly in terms of their rationale (why is a particular country generating renewable energy?). In some countries, climatic factors (such as the need to reduce CO_2 emissions) play a crucial role while in others the need to create or preserve jobs can be an important reason for opening up a renewable option. Instruments designed to achieve a specific target were compared in the light of this and their effectiveness was assessed wherever possible.

2.5 Agreements and conventions

The results of the survey are presented in terms of primary energy, in accordance with the figures contained in the action programme 'Renewable Energy - Advancing Power' [2]. However, the conversion of consumed or consumable energy into primary energy is not straightforward, especially when international comparisons are involved. In the aforementioned action programme, the Netherlands uses the 'substitution principle' to obtain this conversion. The substitution principle expresses the quantity of consumable renewable energy in terms of the primary energy that would have been required to generate the same energy by conventional means. So if a (fossil fuel-based) power plant has an output of roughly 40%, then according to the substitution principle, one unit of wind energy would be needed to replace 100%/40% = 2.5 units of primary energy.

This quantity of primary energy is directly linked to the fuel consumed by the power plant. And this fuel consumption is in turn directly proportional to the level of CO_2 emissions. Hence the link between renewable energy targets and climate goals is practically one to one.

However, calculated in this way, primary energy is clearly highly dependent on the ‘fuel mix’ of the conventional (fossil fuel-based) energy generating option. A country like Austria obtains most of its electricity requirement from hydropower. Consequently, one Austrian unit of wind energy will be equivalent to approximately one unit of primary energy. This makes it difficult to compare primary energy consumption between different countries using the substitution principle.

Furthermore, the conventional fuel option is not fixed. The composition of the fuel package is changing all the time and technology is also constantly moving forward. Hence a planned power plant could have a proposed electrical output of approximately 55% compared with a 40% output on average from an existing plant. As long as conventional power plants continue to improve their efficiency, the quantity of primary energy replaced by renewable energy will continue to decline, measured according to the substitution principle.

Eurostat and many national statistical offices therefore use another definition of the term primary energy. Primary energy is defined as the quantity of energy initially released in a useable form from a conversion process (combustion, decomposition, flow, radiation). In the case of wind energy or hydropower, the quantity of primary energy is therefore equal to the electricity generated; in the case of biomass or waste incineration, the calorific value of the ‘fuel’ is the unit of measurement used; in the case of an active solar heating system it is the energy transferred to the heat conductor. Within this definition, one Dutch unit of wind energy would be equal to one Austrian unit. Changes in the composition and technology used in conventional energy generating options do not therefore affect the quantity of primary energy generated.

The ‘Eurostat’ Convention on primary energy involves clear benefits for international comparisons over and above the substitution principle. Precisely because a comparison (of national ambitions) was one of its aims, the survey adopted this convention. However, to help make technical potential, targets and cost price figures more easily identifiable, the Dutch cost diagram was presented according to the substitution principle as well as the Eurostat Convention.

Existing costs were used as guidelines. Anticipated developments were therefore not taken into account. The cost diagrams therefore illustrate how much it would cost today to exploit a specific proportion of a country’s technical potential. Clearly, this approach would not give an accurate picture of options which are not yet commercially viable and for which substantial reductions in cost price can still be expected. It is assumed that this development will run more or less parallel in all countries and will have largely the same impact.

The reference costs do not give any real indication of how things are likely to progress. Ongoing liberalisation may push down costs. On the other hand, there are signs of an increasing tendency to include external effects in the prices of fossil fuels (as in the Dutch regulatory energy tax). However, in the context of this survey, which aims to compare current levels of national ambition, the effects of cost and price scenarios are not of decisive significance.

3 Individual country reviews

This chapter gives separate accounts of each of the countries surveyed. Each review centres chiefly on the cost diagram; the rest of the information is designed to provide a rapid and more or less general review. When policies and instruments are being compared, certain situations, notably those that differ markedly from that in the Netherlands, will be explored more fully. The following topics will be discussed for each country:

1 The energy situation. Production figures for renewable energy (1995) will be compared with total energy consumption. Both total energy consumption and the production figures for renewable energy will be expressed in per capita terms. This indicator is influenced by industrial activity, efficiency of energy supply, climate and level of prosperity, among other factors. The figures for one country are compared with those of others by means of a graph. This provides a review of that country's relative energy intensity and of the quantity of renewable energy it has already exploited (expressed in per capita terms).
2 Policy and organisation. Who is responsible for policy on renewable energy, the rationale underlying policy-making and the main players involved.
3 Renewable energy options. The relevant renewable energy options for each country are listed in a table. Options are regarded as relevant if they have been designated as such by national policy-makers, in which case their targets or technical potentials will be known. The table specifically includes all possible options other than the import and export of renewable energy. Opportunities for international trade in renewable energy are discussed in more detail in the comparison of cost curves in chapter 4. There is however no international consensus about what should and should not be defined as 'renewable energy'. If a country specifically excludes a particular option, this is also indicated in the table.
4 Cost diagram. See section 2.2. The underlying calculation figures for a few countries are given in annex B. Much of these data were supplied confidentially; reference costs in particular are regarded as sensitive data in privatisation processes and are therefore omitted.
5 Instruments.

3.1 The Netherlands

3.1.1 Energy situation

Domestic energy consumption in the Netherlands totalled 3,145 PJ in 1995, which is equivalent to approximately 205 GJ per capita. The share of renewable energy in this total was around 1.4% (see Figure 3.1.1).

Per capita energy consumption in the Netherlands lies between that of its neighbours Germany and Belgium. This makes the Netherlands one of the more energy-intensive countries in the EU. The share of renewable energy generated (again per capita) is minimal however, with only Belgium and the United Kingdom achieving lower scores. Waste incineration, biomass - and to a lesser extent wind energy - are the main renewable energy options in the Netherlands.

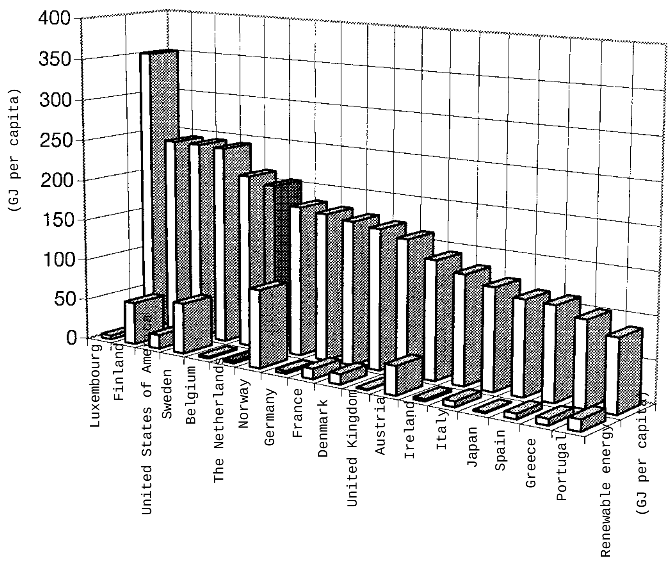


Figure 3.1.1 Energy consumption per capita, including the share of renewable energy.
Source: Eurostat [b].

3.1.2 Policy and organisation

In the Netherlands, the Energy Conservation and Renewable Energy Directorate of the Ministry of Economic Affairs formulate policy on renewable energy. Policy is set out in the form of energy policy documents. At the request of parliament, the most recent of these documents has been developed into an action programme: ‘Renewable Energy - Advancing Power’ [2]. This specifies that by 2020, 10% of the energy consumed in the Netherlands must be obtained from renewable sources. The Dutch government is therefore taking an active approach to the development of policy on renewable energy, which is part of a wider policy to secure a reliable, affordable and clean supply of energy in the long term. This positive attitude to renewable energy is dictated largely by long term environmental and economic considerations, namely the need to reduce emissions (clean supply) and to find an alternative to exhaustible fossil fuel stocks (long term affordability and reliability).

The national energy agency Novem plays a key role in implementing this policy and oversees research, development and demonstration programmes. The Renewable Energy Project Office was recently set up to improve the co-ordination of initiatives for projects and to boost public support for renewable energy. The energy companies play a leading role in generating renewable energy in the Netherlands. Renewable energy is also an important element in the Environmental Action Plans of the energy distribution companies. The energy sector has set itself the target of generating 3.2% of all electricity and 0.1% of all gas consumed from renewable sources by the year 2000 [11].

Within certain constraints, electricity companies in the Netherlands enjoy a fairly a high level of autonomy. Although the government has some input in price-fixing, much of this is the responsibility of the electricity distribution companies themselves (notably fixing reimbursements for the sale of electricity to the grid). The new Electricity Bill will however allow the government to fix the reimbursement for protected customers up to the year 2007.

3.1.3 Renewable energy options

The table below lists the renewable energy options that the Dutch government sees as relevant.

Table 3.1 Options for renewable energy in the Netherlands

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics	X	
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)	X	
Active solar energy	X	
Passive solar energy	X	
Geothermal energy	X	
Heat pumps	X	
Energy storage	X	

Almost all the possible options are seen as relevant in the Netherlands. The fact that in a small and densely-populated country like the Netherlands these options are limited, is obviously relevant.

3.1.4 Technical potential, targets and costs

Figure 3.1.2a illustrates the cost diagram for the Netherlands.

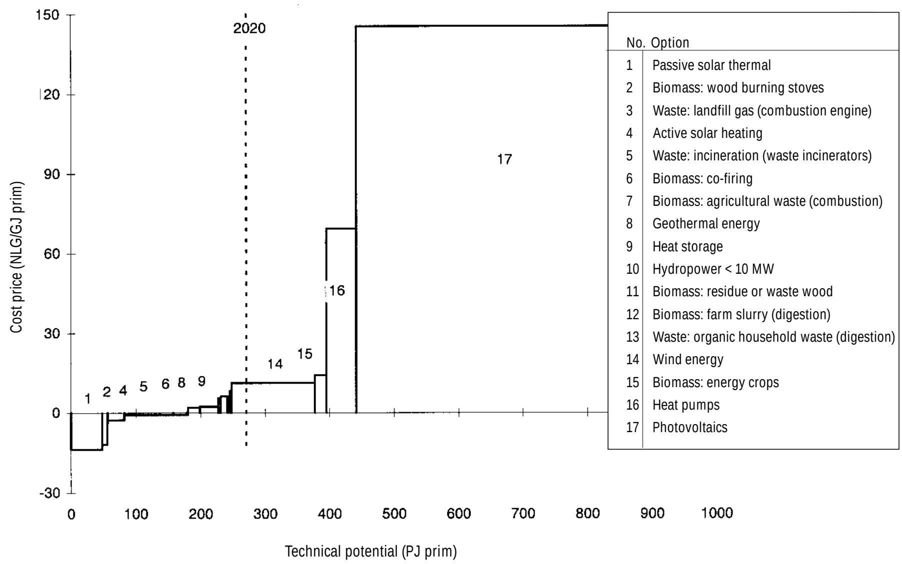


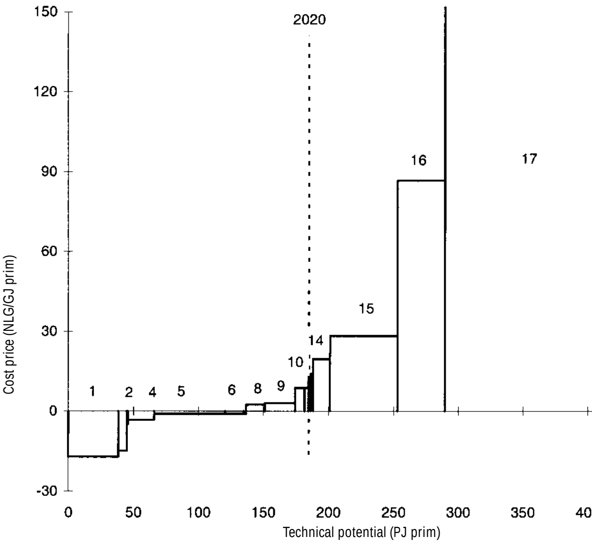
Figure 3.1.2a Cost diagram for the Netherlands (primary energy according to the substitution principle)[1]

The Netherlands is, as mentioned, one of the few countries with a quantitative target for renewable energy. This target specifies that by 2020, 10% of all energy consumed must be obtained from renewable sources. In the above diagram, this target (which excludes imported hydropower from Norway) is shown as a broken line (270 PJ prim). Within the existing parameters, a substantial proportion of this target can already be met at no extra cost through solar heat (active and passive solar thermal), biomass (wood burning stoves, co-firing and digestion) and waste (landfill gas and waste incinerators). Exploiting options such as heat pumps and photovoltaics involves quite high costs.

Figure 3.1.2a illustrates the primary energy situation according to the substitution principle[2]. However, in order to be able to compare the cost diagrams of the various countries, primary energy must be expressed according to the method used by Eurostat and the various national statistical offices. Figure 3.1.2b therefore illustrates the cost diagram according to the so-called Eurostat Convention. The 10% target according to the substitution principle is equal to roughly 7% measured by the Eurostat Convention (185 PJ prim).

1 Excluding imported hydropower from Norway (18 PJ).

2 In the case of combined heat and power options, the conversion to primary energy according to the substitution principle is not wholly accurate since the energy generated has been calculated on the basis of the electrical output of conventional power stations. Strictly speaking, the electrical and thermal output of a combined heat and power unit should be used instead.



No.	Option
1	Passive solar thermal
2	Biomass: wood burning stoves
3	Waste: landfill gas (combustion engine)
4	Active solar heating
5	Waste: incineration (waste incinerators)
6	Biomass: co-firing
7	Biomass: agriculture waste (combustion)
8	Geothermal energy
9	Heat storage
10	Biomass: residue or waste wood
11	Biomass: farm slurry (digestion)
12	Waste: organic household waste (digestion)
13	Hydropower < 10 MW
14	Biomass: energy crops
15	Wind energy
16	Heat pumps
17	Photovoltaics

Figure 3.1.2b Cost diagram for the Netherlands (primary energy according to the Eurostat Convention)

The action programme includes potential contributions for all the relevant options. For some options, this supposed contribution is almost the same as the technical potential itself (namely for waste, biomass, hydrocombined heat and power pumps).

3.1.5. Instruments

Measures for implementing policy on renewable energy are grouped under three themes:

1. Improving price-performance ratio (mainly through R&D);
2. Stimulating market penetration (e.g. through tax incentives);
3. Lowering administrative barriers (for example, by adapting a national agreement on wind energy to local level).

The first of these themes is supported by Research, Development and Demonstration programmes. This is especially crucial for options which are currently much more expensive than conventional, fossil fuel-based alternatives. Once the cost price of an option begins to approach that of the conventional alternative, market penetration will be encouraged.

The government's main strategy for encouraging market penetration is to partially offset the costs of unprofitable renewable energy options through tax incentives designed to boost the attractiveness of investments in and/or the commercial exploitation of renewable energy. A typical example is the regulatory energy tax, which is collected from domestic consumers by the energy companies and passed on to the government in the form of tax revenue. However, the share of energy obtained from renewable sources is tax-exempt and thus ultimately assists the growth of renewable energy. A second major source of funding for unprofitable elements are the contributions made by the energy distribution sector in the context their National Environmental Action Plan. These allocations will be used to meet the sector's targets for the year 2000.

An interesting related development is the introduction of certificates for renewable energy (the so-called green labels). The green label indicates the clean nature of the renewable energy generated.

The availability of green labels is not evenly spread throughout the Netherlands. Some energy distribution companies have shortages while others have a surplus. In other words, a market involving supply and demand is being created. Since trade in these labels is permitted, this market can be served.

This system effectively anticipates the new Electricity Act, which will allow the Minister to specify a minimum share of renewable energy in the end supply. Consumers will then be expected to demonstrate by means of certificates that they have bought an adequate share of renewable energy.

The Ministry of Economic Affairs has set aside over NLG 100 million per annum for renewable energy in its budget up to and including the year 2000. This does not take into account the reduction in tax revenue from the many investment schemes designed to promote renewable energy. Most of this funding will be targeted at long-term programmes for the various renewable options. Financial support will focus largely on research, development and demonstration projects and on removing (administrative) bottlenecks. Taxes or surcharges on top of energy tariffs will be used to finance instruments that promote the commercial exploitation of renewable options. In one instance, this will involve a shift in costs (the extra regulatory energy tax will be offset by a reduction in income tax). Existing fiscal, financial instruments will not be enough to finance the unprofitable elements of renewable options [2]. However, if end users are legally obliged to buy a specific share of their energy from renewable sources or to generate it renewably themselves, this will on balance create a market for renewable energy which will at least give some prospect of these targets being met. See [2] for a more detailed account of these instruments.

3.2 Belgium

3.2.1 Energy situation

Domestic energy consumption in the Belgium totalled 2,145 PJ in 1995, which is equivalent to approximately 212 GJ per capita. The share of renewable energy in this total was around 1% (see Figure 3.2.1).

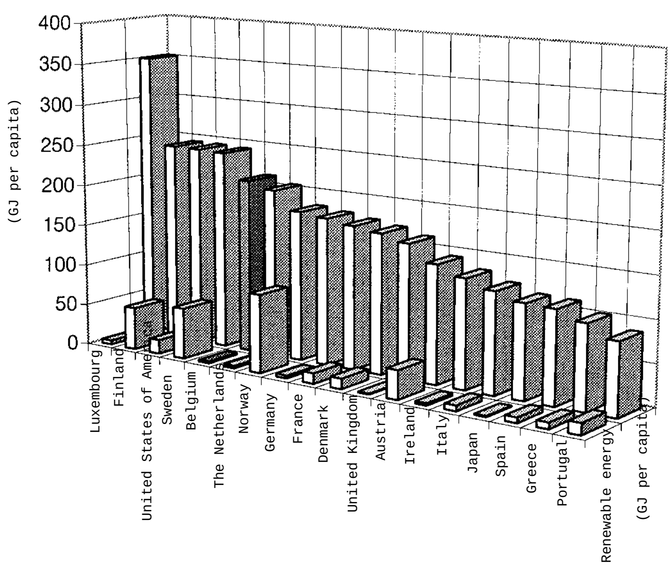


Figure 3.2.1 Energy consumption per capita, including the share of renewable energy. Source: Eurostat [b].

Biomass and organic waste account for the highest proportion of renewable energy consumption. Belgium also exploits hydropower, notably in the Ardennes. At present, the contribution made by other options is almost zero.

3.2.2 Policy and organisation

In Belgium, promoting renewable energy is seen as a regional responsibility. In Flanders, the Ministry of the Flemish Community (Energy Unit of the Department of Natural Resources and Energy) handles policy on renewable energy. In Wallonia it is the responsibility of the Direction Générale des Technologies de la Recherche et de l'Energie of the Ministère de la Région Wallonne. Energy supplies (sales to the grid, etc) are priced at the national level.

Energy policy in Belgium is targeted more at energy efficiency than at renewable energy. Most of the emphasis within renewable energy is directed at the electrical options, partly due to the fact that the electricity producer Electrabel - also the country's main electricity distributor - recently commissioned a series of studies on electricity potential.

Flanders is working towards a 5% share of renewable energy in the total energy supply by the year 2020 (the current share is approximately 0.5%). Wallonia does not have an official policy-based target. The main rationale for exploiting renewable energy at national level is the need to diversify, reduce CO2 emissions and encourage the development of industry.

3.2.3 Renewable energy options

The table below shows which energy options the Belgian government defines as renewable.

Table 3.2 Options for renewable energy in Belgium

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics	X	
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)	X	
Active solar energy	X	
Passive solar energy		
Geothermal energy		
Heat pumps		
Energy storage		

As mentioned, most of the emphasis in Belgium currently focuses on the opportunities presented by the electrical options.

3.2.4 Technical potential, targets and costs

Figure 3.2.2 illustrates the cost diagram for Belgium.

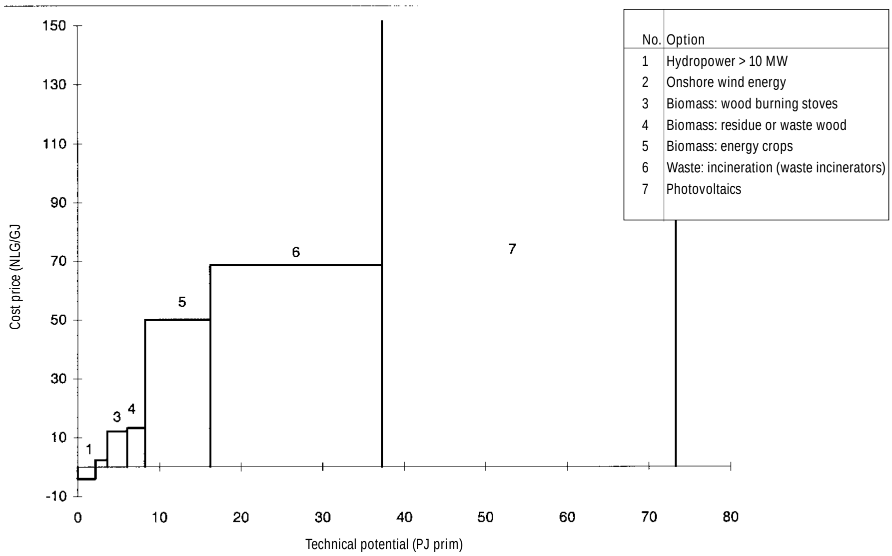


Figure 3.2.2 Cost diagram for Belgium (primary energy according to the Eurostat Convention)

Most of the large-scale hydroelectric potential in Belgium (namely in the Ardennes) has already been exploited. Pump accumulation (total capacity 1,300 MWe) is now taken into account in surveys of renewable energy. There is still some potential for small-scale hydroelectric options (approximately 0.3 TWh/year). Wind energy is only seen as viable in a small number of (coastal) locations (total potential 0.2-0.4 TWh/year).

There is considerable potential in Belgium for the combustion/digestion of wood. Long-term developments in the price of wood are an uncertain factor, however. The potential for the co-firing and digestion of waste materials is also considerable (approximately 4 TWh/year), and it is thought that competitive price levels can probably be sustained. Although solar thermal energy and photovoltaics have considerable potential, they are (too) costly.

The report ‘Potential of renewable energy sources for electricity generation in Belgium, by J. de Ruyk, Free University of Brussels, 1996’ provides a good review of the existing potential for renewable energy in Belgium. Although the report is not publicly available, there is a useful summary of its findings in the journal Energie & Milieu, Merksem, Belgium, July-August 1997.

3.2.5 Instruments

The Flanders Renewable Energy Plan (DEV) is currently being drafted to help meet Flanders’ target of a 5% share of renewable energy by the year 2020. This plan has yet to be presented to the Flemish parliament. Whether or not the DEV is ultimately adopted and implemented will depend on what is achieved in the interim. The minister responsible has announced that in addition to providing a ‘technology push’, the DEV will also seek to remove institutional and financial barriers to renewable energy. The plan will focus on administrative procedures (licenses), pricing, conditions governing connection, information supply, etc. The Flemish government and the electricity production sector (Electrabel) have recently signed a memorandum of understanding in which the sector has agreed to negotiate clear agreements and support the attainment of the specified renewable energy target.

A financial incentive of BEF 1/kWh is also offered for each kWh of electricity generated from renewable sources. This is paid out through Electrabel and has national coverage. There are also regional subsidies for demonstration projects. Although it is up to the regions to translate instruments into concrete measures - which could give rise to significant differences between regions - the policies of Flanders and Wallonia are in fact closely co-ordinated.

3.3 Denmark

3.3.1 Energy situation

Domestic energy consumption in Denmark totalled 880 PJ in 1995, which is equivalent to approximately 170 GJ per capita. The share of renewable energy in this total was around 7.3% (see Figure 3.3.1).

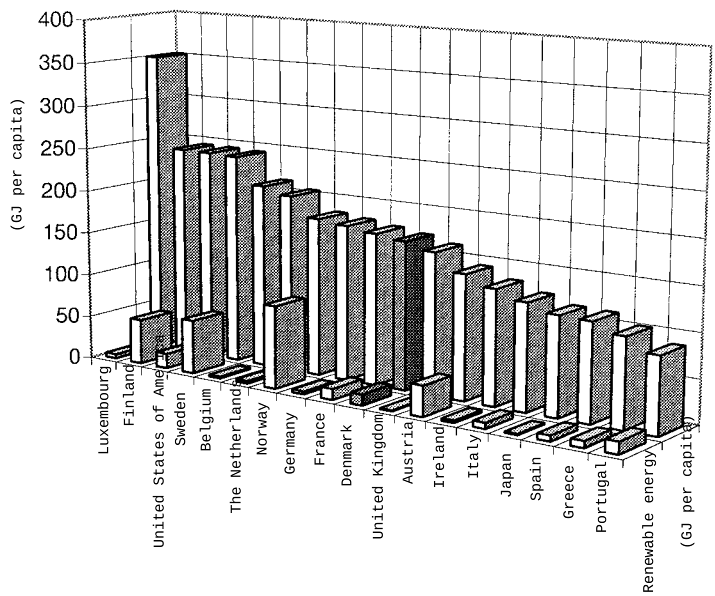


Figure 3.3.1 Energy consumption per capita, including the share of renewable energy. Source: Eurostat [b].

Wind energy, biomass and organic waste represent the largest fractions in the share of renewable energy. At present, the contribution made by other options is almost zero.

3.3.2 Policy and organisation

Energy and environment policy in Denmark have been integrated into a single Ministry, the Ministry of Environment and Energy. The Danish Energy Agency (DEA) is part of this Ministry. Policy and the implementation of policy are thus closely interwoven. The national policy goal is to achieve a 12-14% share of renewable energy within overall energy consumption by 2005, rising to 35% by 2030. This is being achieved largely by promoting energy efficiency, leading to an overall reduction in energy consumption. This will increase the share of renewable energy on balance. A number of renewable energy options - notably wind energy and biomass - are being specifically encouraged. The main rationale for exploiting renewable energy in Denmark is the need to reduce CO_2 emissions, diversify (reducing dependency on fossil fuels) and create more jobs.

3.3.3 Renewable energy options

The table below shows which renewable energy options are relevant for Denmark.

Table 3.3 Options for renewable energy in Denmark

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower		
Photovoltaics	X	
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)		
Active solar energy	X	
Passive solar energy		
Geothermal energy	X	
Heat pumps		
Energy storage		

3.3.4 Technical potential, targets and costs

Figure 3.3.2 illustrates the cost diagram for Denmark.

There is no potential in Denmark for hydropower since the country is flat and has no large rivers. There is still some limited potential for exploiting land-based wind energy and a substantial offshore potential (15-18 TWh/year).

Biomass (waste and energy crops) is seen as a cost-effective option with a fairly considerable potential (150-200 PJ/year), especially for co-firing in coal-fired power stations. Although Denmark's long and rugged coastline affords considerable potential for tidal energy, this is seen as cost-prohibitive. Photovoltaic conversion of solar energy is also extremely costly but is being studied for its possible export potential.

Reference costs - that is, the cost of coal-based electricity production - are low in Denmark compared with other countries. Partly for this reason, all the relevant renewable energy options have a (moderately) positive cost level.

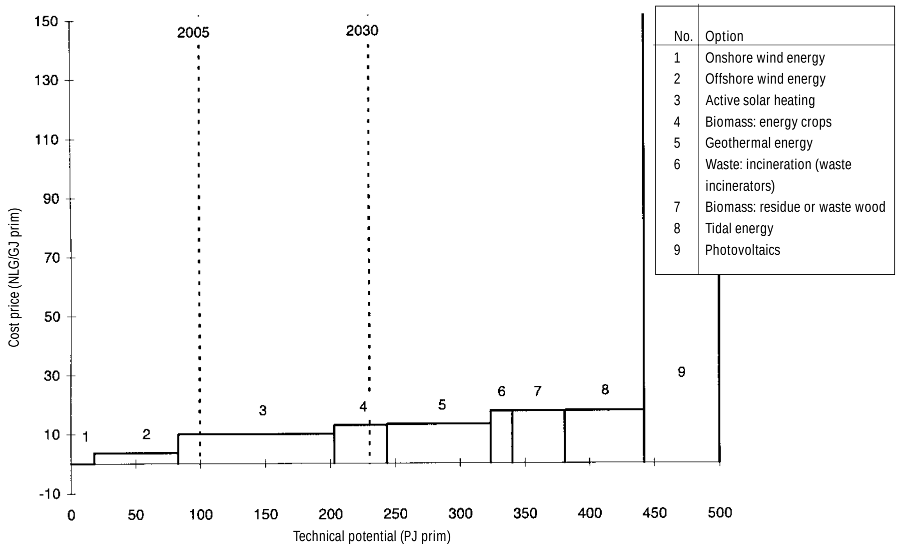


Figure 3.3.2 Cost diagram for Denmark (primary energy according to the Eurostat Convention)

3.3.5 Instruments

In spring 1996 the Danish government published its Energy 21 plan. In addition to supporting research and development and awarding investment subsidies to demonstration projects, the plan contains tax measures and targeted information campaigns for renewable energy. It also contains national initiatives (subsidies, CO_2 taxes, covenants with energy companies) and supports regional initiatives (regional heat planning, regional funds, etc).

Of the various financial instruments at its disposal, the Danish government favours subsidies for production rather than subsidies for investment, with the exception of subsidies for demonstration projects in biomass and photovoltaics. A demonstration project in which a local community (e.g. an island) will obtain all its energy from renewable sources (Renewable Energy Island) is currently being prepared in the form of a national initiative.

The information campaigns are being drawn up in partnership with local and regional authorities. These campaigns are specifically designed to focus on particular target groups and phases in the decision-making process. They also try to encourage co-operation between local and regional authorities, energy companies and environmental organisations, tying in with the activities being implemented under the Agenda 21 programme.

Different regions are launching their own initiatives, chiefly to assist the commercialisation of renewable energy. At present these initiatives are focusing chiefly on biomass linked to combined heat and power.

As mentioned, Denmark's national Energy 21 plan stresses energy efficiency rather than renewable energy. Wind energy and biomass are the main options being studied at national level.

In mid-1997 the Danish government signed contracts with the electricity production companies ELSAM and ELKRAFT to realise 750 MW in offshore wind capacity within 10 years. The government had concluded earlier agreements with these companies to convert a series of coal-fired district heating plants to biomass utilisation. Agreements have also been made with local authorities to introduce biomass in regions heavily reliant on natural gas; demonstration and development programmes on energy crops have also been launched.

The energy distribution companies are legally obliged to assist the supply of energy from renewable production units to the national grid. This involves allowing connections to be made to the grid (70% of the costs of which are borne by the energy distribution company itself) and providing a guaranteed reimbursement for sales to the grid of 85% of the price charged to domestic consumers, as well as a tax incentive.

3.4 Germany

3.4.1 Energy situation

Domestic energy consumption in Germany totalled 14,500 PJ in 1995, which is equivalent to approximately 180 GJ per capita. The share of renewable energy in this total was around 1.9% (see Figure 3.4.1).

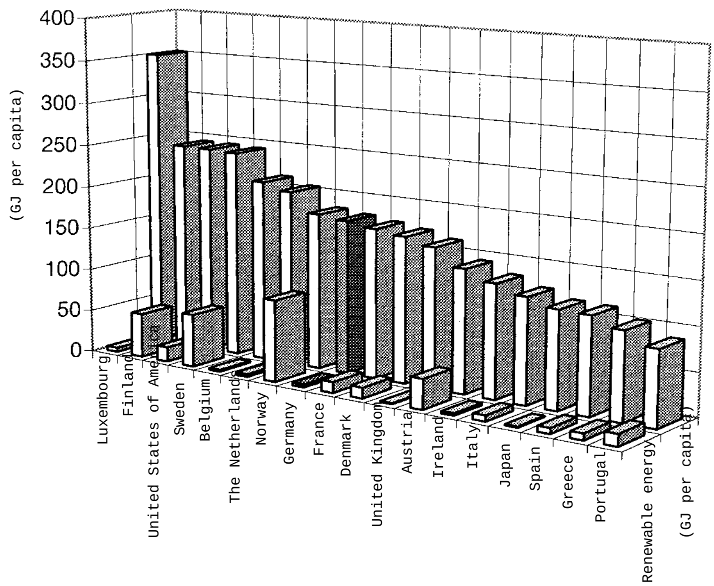


Figure 3.4.1 Energy consumption per capita, including the share of renewable energy. Source: Eurostat [b].

Waste, biomass and hydropower are the main forms of renewable energy that have been exploited so far.

3.4.2 Policy and organisation

In Germany, five ministries are involved with renewable energy in one way or another. The Ministry of Economic Affairs (BMWi) co-ordinates federal policy on renewable energy while the Ministry of Education, Science, Research and Technology (BMb+f) is closely involved in its development and stimulation. In financial terms, this Ministry in fact makes a bigger financial contribution to renewable energy than the BMWi. In recent years, the budget for renewable energy within the relevant energy research programmes has been just under NLG 200 million. However, the term 'research' should in this case be broadly interpreted. A large proportion of the investments made in the 250 MW wind energy 'Breitentest' programme are subsidised (20%), as are investments in the '1,000 roof' programme to promote photovoltaics. The BEO (Projektträger Biologie, Energie, Ökologie) is responsible for overseeing the management and implementation of programmes. The Ministry of the Environment (BMU), which is responsible for realising Germany's climate target, is also involved in policy on renewable energy. The Ministry for Development Co-operation (BMZ) runs programmes to encourage the application of renewable energy in the developing world. Finally, the Ministry of Agriculture (BML) allocates funding to renewable energy, mainly to promote the use of biomass.

Germany is a federal state divided into 'Länder'. These Länder have a relatively large measure of autonomy and many therefore pursue their own - supplementary - policies to stimulate renewable energy. The policies of these federal states are not analysed further in this survey. Most of the energy companies are tied to local or regional authorities (Stadtwerke) and are thus relatively small-scale. There are around 800 energy companies in Germany. Production and distribution are not separated by law.

3.4.3 Renewable energy options

The table below shows which renewable energy options are relevant for Germany.

Table 3.4 Options for renewable energy in Germany

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics	X	
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stoves)		
Active solar energy	X	
Passive solar energy		X
Geothermal energy	X	
Heat pumps	X	
Energy storage		X

The passive solar thermal and energy storage options are classified as energy conservation measures.

3.3.4 Technical potential, targets and costs

Figure 3.4.2 illustrates the cost diagram for Germany.

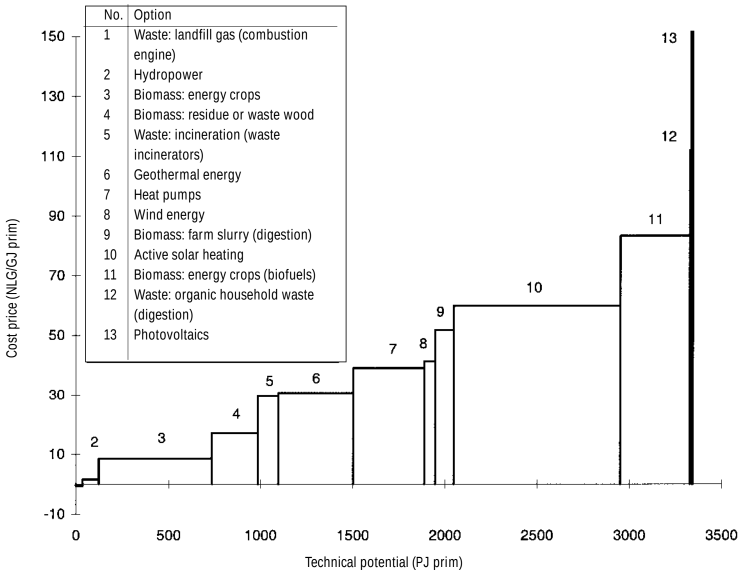


Figure 3.4.2 Cost diagram for Germany (primary energy according to the

Germany has no renewable energy targets. Landfill gas and hydropower can be exploited further at no substantial extra cost. However, their technical potential is fairly limited. Geothermal energy, heat pumps and active solar heating (domestic solar hot water systems) have considerable potential. Photovoltaics is extremely costly and has a very low potential, due in this case to a somewhat non-standard interpretation of technical potential. The BMWi has issued figures for the potential it believes could be opened up by 2020. The extremely high cost involved is consequently a limiting factor.

3.4.5 Instruments

During 1996 the federal government spent DEM 230 million on R&D to promote renewable energy. It is estimated that the budget for renewable energy could be doubled by the contributions from the various Länder. One important financial instrument designed to stimulate the creation of a domestic market in renewable energy is the so-called 'Strom-EinspeisungsGesetz' (StrEG), which requires energy companies to pay a high subsidy for electricity from wind turbines, photovoltaic systems, small-scale hydropower, biomass and landfill gas. This subsidy varies from 90% to 65% of the price charged to domestic consumers. Proposals have been made in the Bundestag to withdraw this measure since the relevant renewable energy options would still be financially viable even without the StrEG.
Investment subsidies are also available to encourage market penetration (DEM 110 million for 1994-1998).

Like the Netherlands, Germany offers tax incentives such as the accelerated depreciation of investments in renewable energy. For example, households are being awarded soft loans as part of a 50,000 solar roofs programme (thermal solar). There are also tax incentives for biofuels, residual wood and electric cars (exemption from excise duties, lower VAT).

3.5 Finland

3.5.1 Energy situation

Domestic energy consumption in Finland totalled 1,243 PJ in 1995, which is equivalent to approximately 244 GJ per capita. The share of renewable energy in this total was around 21.3% (see Figure 3.5.1).

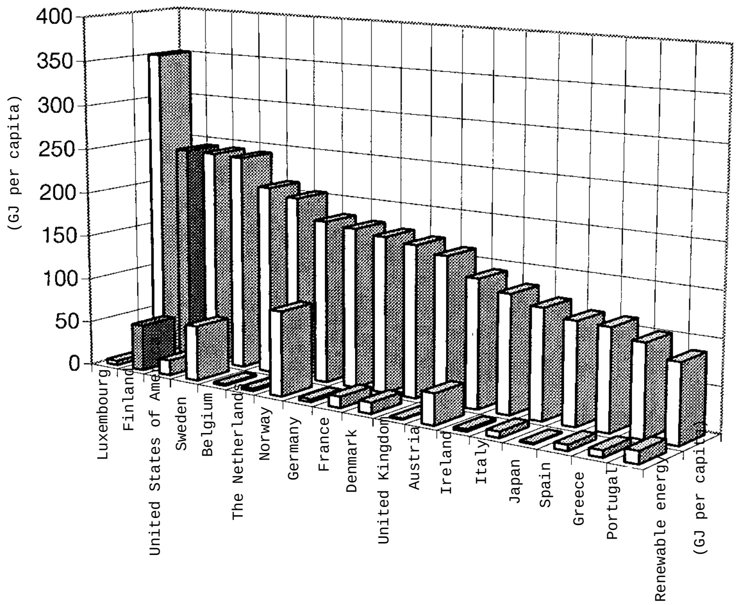


Figure 3.5.1 Energy consumption per capita, including the share of renewable energy. Source: Eurostat [b].

The current share of renewable energy in Finland consists mainly of biomass (peat) and hydropower for electricity generation. At present, the contribution made by other renewable energy options is almost zero.

3.5.2 Policy and organisation

Finland is just beginning to draft its own policy on renewable energy. However, no policy-based targets have been formulated as yet. Energy policy in Finland is the responsibility of the Ministry of Trade and Industry (Department of Energy). The body directly responsible for promoting renewable energy is VTT Energy, which oversees research and market development for new energy techniques. Strictly speaking, VTT Energy is an independent body, though in practice it is essentially part of the Ministry. VTT seeks - largely assisted by funding from Brussels - to initiate structured policy-making and demonstration projects. Where it is commercially viable, renewable energy is already part of the policies of industrial operators and energy companies. The main rationale for exploiting renewable energy is to reduce CO_2 emissions (international agreements), develop industry and create jobs (wood/peat industry). Finland has no quantitative targets for renewable energy consumption.

3.5.3 Renewable energy options

Table 3.5 Options for renewable energy in Finland

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics		
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)	X	
Active solar energy		
Passive solar energy		
Geothermal energy		
Heat pumps		X
Energy storage		X

3.5.4 Technical potential, targets and costs

Figure 3.5.2 illustrates the cost diagram for Finland.

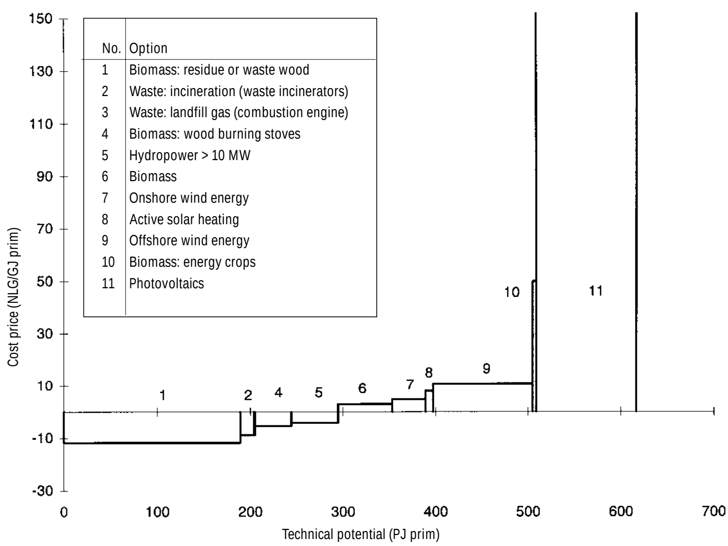


Figure 3.5.2 Cost diagram for Finland (primary energy according to the Eurostat Convention)

The renewable energy potential that has been exploited so far consists mainly of biomass (180 PJ/year), chiefly in the form of waste (wood) and peat. More efficient conversion processes and the increased use of peat as a fuel could almost double this figure to around 300 PJ/year.

Hydroelectric potential is limited since Finland is a relatively flat country, and existing potential has already been fully utilised. There is still considerable potential for wind energy, especially offshore (approximately 30 TWh/year). Potential for onshore wind energy is however limited due to the low wind speeds. Solar (thermal and photovoltaic conversion) is only sporadically applied since is regarded as too costly to be included as a structural element within national policy.

3.5.5 Instruments

Finland is working towards internalising external costs in energy prices as a way of boosting the consumption of renewable energy. This process has not yet been implemented (it has even to some extent been reversed) due to problems in the international trade of electrical energy in particular. Since suppliers from countries where costs are not internalised are supplying electricity more cheaply, the Finnish government is now trying to use tax measures to create a more level playing field. The tax that was initially levied on primary fuels has therefore now been converted into a tax on the end product, electricity. This has increased the reference costs, resulting in a cost benefit to companies generating their own electricity. The CO_2 tax is still levied on fuels used for generating heat.

The government is currently giving specific financial assistance to demonstration projects involving biomass: peat, slurry, industrial, agricultural and forestry waste. Practical experience is being acquired in the integrated implementation of these biomass projects through a regional approach. This regional approach encourages collaboration between local power generators and job creation. The projects also stimulate technological know-how. The existing projects will be expected to show that the utilisation of biomass is both feasible and potentially (economically) viable. The support provided consists of financial aid, information supply and training.

No instruments have been developed as yet to utilise wind potential.

3.5.6 Additional remarks

The IEA does not regard energy obtained from peat as ‘renewable’.

3.6 France

3.6.1 Energy situation

Domestic energy consumption in France totalled 10,050 PJ in 1995, which is equivalent to approximately 175 GJ per capita. The share of renewable energy in this total was around 7.1% (see Figure 3.6.1).

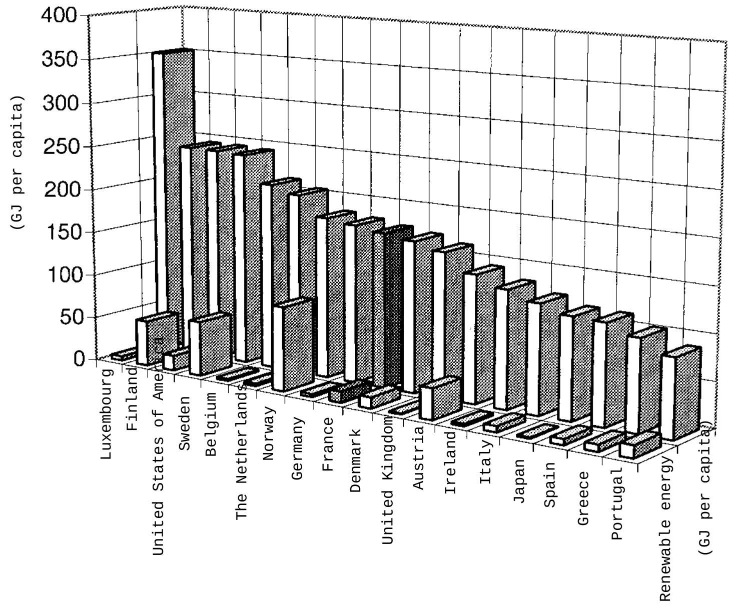


Figure 3.6.1 Energy consumption per capita, including the share of renewable energy.

Hydropower makes a major contribution to renewable energy in France. France's utilisation of renewable energy is average compared with the rest of the European Union.

3.6.2 Policy and organisation

The Ministry for Industry is responsible for energy policy in France, and co-ordinates this policy with the Ministries of the Environment and Agriculture (biomass). Proposals for policy on energy efficiency are submitted and implemented by the agency ADEME.

French policy focuses on forms of renewable energy that are already profitable (removing (social) obstacles) or near-profitable (stimulating the market to bring down cost prices). The government specifically does not encourage options that are still far from profitable. France does not have any overall quantitative policy goals (this is left to the market). However, there are short-term goals in certain sub-sectors.

The French government will need to decide the future of nuclear power by the year 2005. By then, the Ministry would like to see levels of renewable energy high enough to avoid it having to build any new nuclear power stations. The left-of-centre government which came to power in 1997 is now working to achieve a substantially higher level of renewable energy than had previously been planned, and is currently drafting new policy to that end.

The main rationale for exploiting renewable energy is to reduce costs, in the short term by applying or demonstrating renewable energy options in the most favourable locations (high yield or high reference costs, e.g. wind energy and solar energy in the French overseas territories). In the longer term, these options will need to be competitive throughout France. Job creation is also a factor where biomass is concerned (this policy is the responsibility of the Ministry of Agriculture). France has no problem with CO_2 emissions: levels are low, largely due to the use of nuclear power to generate electricity.

3.6.3 Renewable energy options

The table below shows which renewable energy options are relevant in France.

Table 3.6 Options for renewable energy in France

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics		
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste		X
Biomass	X	
HEAT		
Biomass (wood burning stove)		
Active solar energy	X	
Passive solar energy		
Geothermal energy	X	
Heat pumps		X
Energy storage		X

Ambient heat (heat pumps) and energy storage are not regarded as renewable energy options in France; nor is waste incineration.

3.6.4 Technical potential, targets and costs

Figure 3.6.2 illustrates the cost diagram for France.

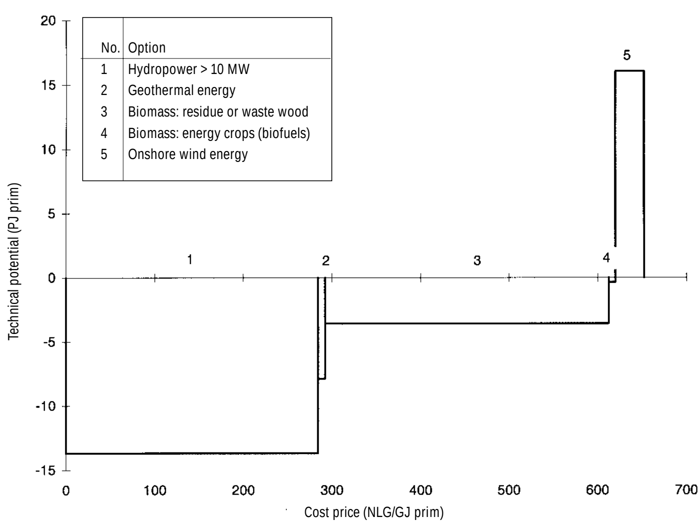


Figure 3.5.2 Cost diagram for France (primary energy according to the Eurostat Convention)

The potential for large-scale hydropower has been almost fully exploited, although there are smaller-scale opportunities that could probably still be utilised. However, no figures are available to quantify this potential. The potential for biomass in the form of wood has also largely been fully exploited, although its energy output can be improved. Biomass in the form of energy crops is more expensive but it is being studied due to its potential for generating employment. The Ministry of Agriculture is responsible for formulating policy for this option.

There is some technical potential for geothermal energy - an option that is also in many cases economically attractive. There is considerable potential for tidal energy, but this option is not regarded as socially acceptable since it would interfere with the interests of the tourist sector.

The technical potential of wind energy is limited and the associated costs are NLG 15 and 20/GJ prim higher than the reference price. In favourable locations - notably the French overseas territories (Martinique and Guadeloupe) - wind energy can be profitably exploited. Approximately 20% of the existing planned capacity is being realised overseas and this is expected to be by far the most profitable share. Solar thermal power is - with one or two exceptions - seen as economically unattractive. Photovoltaics is still too expensive to qualify for government subsidies.

3.6.5 Instruments

The French government uses two lines of approach when deploying its instruments.

The first line of approach is to remove administrative bottlenecks (on an ad hoc basis) which stand in the way of renewable energy options that could otherwise be profitably exploited. These bottlenecks may include lack of co-operation from local authorities, apparently due to a lack of information, or friction in the administrative decision-making process surrounding the formulation of general rules at local level. At national level, measures are being taken to encourage standardisation and the dissemination of information. Precisely how local bottlenecks are tackled depends very much on the specific measures taken by regional players.

The regional authorities and energy agencies play a key role here. ADEME has regional offices that facilitate local processes and report the experience gained at local level to national policy-makers.

The second line of approach is to improve price-performance ratio for near-profitable options. One of the ways in which this is done is by demonstrating these options in relatively favourable locations. In the case of wind energy (EOLE 2005, one of the most recent programmes) the bidding system is systematically applied. This system is outlined in annex C. Under this system, EdF pays a bonus on the price per kWh over a 15-year period (based on a ‘voluntary’ agreement between it and the French State). ADEME supervises this process.

Government support for the cultivation of crops used to produce liquid fuels for vehicles is linked to its employment policy. This aid falls under the responsibility of the Ministry of Agriculture and is not part of the policy on renewable energy.

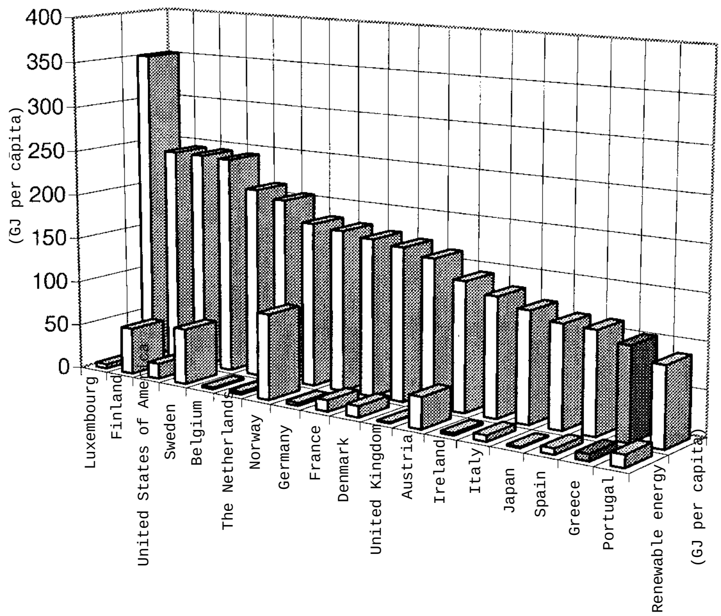


Figure 3.7.1 Energy consumption per capita, including the share of renewable energy. Source: Eurostat [b].

3.7 Greece

3.7.1 Energy situation

Domestic energy consumption in Greece totalled 1,060 PJ in 1995, which is equivalent to approximately 100 GJ per capita. The share of renewable energy in this total was around 7.4% (see Figure 3.7.1).

Specific energy consumption in Greece is among the lowest in the European Union. This is partly due to low demand for energy to heat buildings. Greece's share of renewable energy is higher than the EU average. The main options which have been exploited to date are biomass, hydropower and - to a lesser extent - active solar heating systems.

3.7.2 Policy and organisation

The Ministry of (Industrial) Development is primarily responsible for policy on renewable energy, which is an integral part of Greece's National Operational Energy Programme (NOPE). The Centre for Renewable Energy Sources (C.R.E.S.) is the national co-ordination centre for renewable energy. Another of its specific tasks is to promote the efficient use of energy and boost energy conservation. Alongside programme management and the transfer of knowledge, C.R.E.S. also carried out practical research and sets up pilot projects. The main reason for stimulating renewable energy in Greece is to reduce emission levels; activities relating to renewable energy are therefore also part of 'Climate Change, the Greek Action Plan'. Renewable energy will therefore play a key role in policy to cut CO_2 emissions, together with the replacement of lignite by natural gas and the use of more efficient generating technologies, especially in the medium term.

In the short term, domestic solar hot water systems are expected to make the biggest contribution to renewable energy in Greece. One of the country's problems is the rapid rise in demand for electricity, partly due to the relatively low price of electricity.

The state-owned electricity company PPC (Public Power Corporation) dominates the production, transmission and distribution of electricity. It also mines lignite and is thus the country's largest energy company. Greece has opted for the 'single buyer' model in its move towards a liberalised energy market. Under certain circumstances, self-generation or independent generation are allowed; however, the energy produced must always subsequently be sold to PPC.

3.7.3 Renewable energy options

The table below shows which energy options are regarded as renewable by the Greek government.

Table 3.7 Options for renewable energy in Greece

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics	X	
Active solar energy	X	
Wave energy		
COMBINED HEAT & POWER		
Waste		
Biomass		
HEAT		
Biomass (wood burning stove)		
Active solar energy	X	
Passive solar energy	X	
Geothermal energy	X	
Heat pumps		X
Energy storage		

Thanks to Greece's subtropical climate, solar thermal energy can also be used to generate electricity through steam production. Although the use of heat pumps is not regarded as a renewable option, it is encouraged in programmes for energy conservation and increased energy efficiency.

3.7.4 Technical potential, targets and costs

Figure 3.7.2 illustrates the cost diagram for Greece.

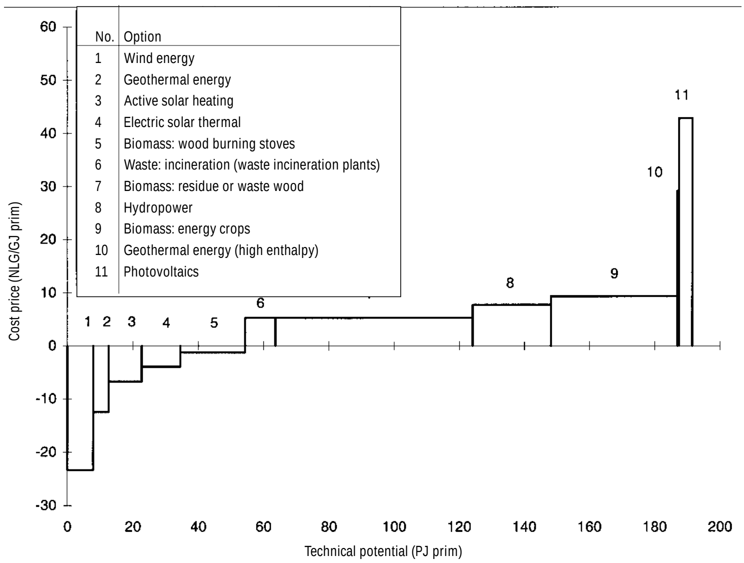


Figure 3.7.2 Cost diagram for Greece (primary energy according to the Eurostat Convention)

The Greek government has not formulated an explicit quantitative target for renewable energy. Due to the high reference costs for electricity in Greece, especially on the outlying islands, wind energy and electric solar thermal energy can be profitably generated. Domestic solar hot water systems also appear to be economically viable, partly due to the long hours of sunlight and the relatively low cost price involved. The combined biomass options also have a relatively high technical potential.

3.7.5 Instruments

A key instrument for stimulating renewable energy in Greece is Act 2244/94, which sets out the rules governing the generation of electricity from renewable sources. The Act came into force in 1994 and allows independent companies to generate electricity. However, they are subsequently obliged to sell what they produce to PPC. The Act guarantees power companies a certain level of compensation for the redistribution of this energy for at least 10 years.

The National Operational Energy Programme also awards subsidies for investments in renewable energy and for the replacement of lignite by natural gas. In 1997 investments in renewable energy totalled approximately NLG 270 million. The Greek government and the European Union supplied 45% of these investments.

The award of tax incentives to private individuals has also proved a highly successful measure. A large proportion of private investments in renewable energy (75%) are tax-deductible. This strategy underlies the success of solar thermal energy, in which Greece has now acquired a lead in Europe. By 1995 over 2 million square metres of collector surface had been installed, compared with approximately 170,000 square metres in the Netherlands at the end of 1996.

3.8.1 Energy situation

Domestic energy consumption in the United Kingdom totalled 9,430 PJ in 1995, which is equivalent to approximately 160 GJ per capita. The share of renewable energy in this total was around 0.7% (see Figure 3.8.1).

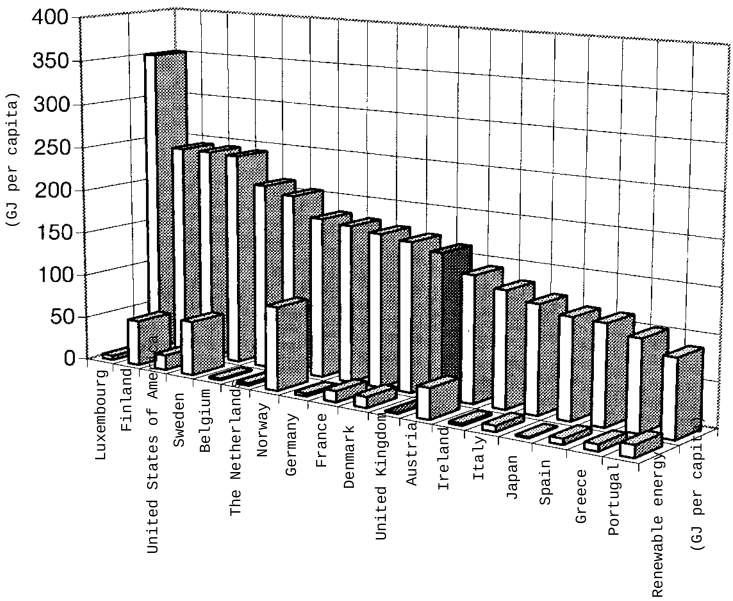


Figure 3.8.1 Energy consumption per capita, including the share of renewable energy. Source: Eurostat [b].

Energy intensity in the United Kingdom is thus significantly lower than in Germany, the Netherlands and Sweden. The share of renewable energy in the UK is the lowest in the European Union. Most of the UK's renewable energy is generated by hydropower, waste incineration and biogas (landfill gas and gas from sewerage slurry).

3.8.2 Policy and organisation

The Department of Trade and Industry (DTI) is responsible for policy on renewable energy. The implementation of this policy is contracted out to the energy agency ETSU. Most of the UK's energy sector is privatised and its energy market is highly liberalised. There is a clear distinction between production, transport and distribution, and in this respect the UK is well ahead of the rest of Europe. Domestic gas consumers are for example already able to 'shop around'. The UK energy sector has little interest in relatively high-cost sources of renewable energy.

The UK government's current aim is to achieve a 1,500 MW share of 'renewable' electricity capacity by the year 2000. However, it sees this target more as a declaration of intent than as a firm commitment. The government is stimulating renewable energy primarily through an anticipated reduction in cost price, and is therefore concentrating solely on those options which are likely to be economically viable within the foreseeable future (approximately 5 years). Another stated aim is to develop a renewable energy industry in the UK, to increase self-sufficiency and to prevent harmful emissions. The new Labour government is currently reviewing policy on renewable energy. While some of the programmes launched by the previous government may be continued, a significant change of course is likely to be announced soon in favour of renewable energy.

3.8.3 Renewable energy options

The table below shows the renewable energy options that are relevant to the United Kingdom.

Table 3.7 Options for renewable energy in the United Kingdom

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics	X	
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)		
Active solar energy		
Passive solar energy	X	
Geothermal energy	X	
Heat pumps		
Energy storage		

Although studies have been carried out on the potential of typical 'heat' options, most of the emphasis is focused on 'electrical' options.

3.8.4 Technical potential, targets and costs

Figure 3.8.2 illustrates the cost diagram for the United Kingdom.

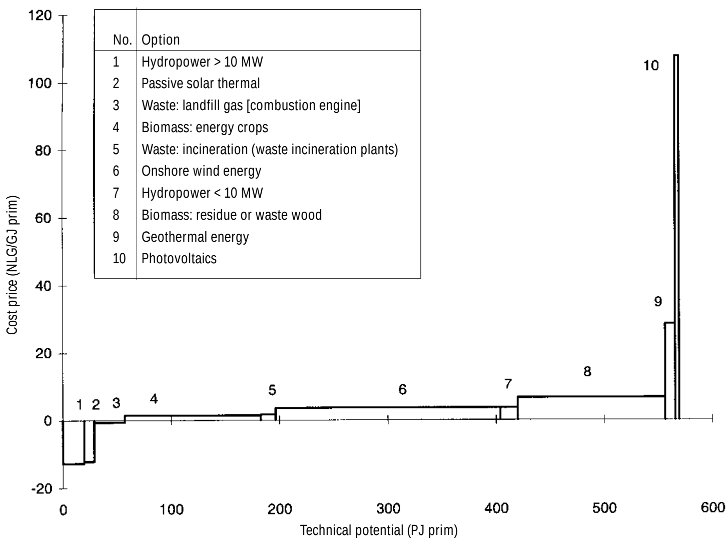


Figure 3.8.2 Cost diagram for the United Kingdom (primary energy according to the Eurostat Convention)

Small-scale hydropower, passive solar thermal energy and landfill gas all appear to be economically viable options for the UK. Their combined potential is approximately 100 PJ. The biomass energy crops and waste incineration plant options also appear to be relatively cost-effective. Due to the UK's wind-rich climate, almost 200 PJ in wind energy can be generated relatively cost-efficiently. The geothermal and photovoltaic conversion options are highly costly. Like Germany, the UK applies a slightly different definition of technical potential to other countries, based on the concept of 'accessible resources' which stipulates that renewable energy should not involve overly high costs [12], [13]. The most expensive options in the UK are therefore regarded as having a negligible 'technical' potential.

3.8.5 Instruments

The two main lines along which policy is formulated are as follows:

1. Stimulating the market for electricity from renewable sources to meet the aforementioned 1,500 MW renewable energy target.
2. A backup programme carried out by ETSU.

3.8.5.1 Stimulating the market for electricity from renewable sources

Measures to stimulate the market for electricity from renewable sources are carried out with help from the 'Non-Fossil Fuel Obligation' (NFFO). This instrument has a legal status and obliges the regional electricity distribution companies to buy up a specific volume of non-fossil fuels. In a progressively liberalised energy market, this is a necessary instrument for maintaining and/or promoting capital-intensive, non-flexible (nuclear power), relatively costly and uncertain forms of renewable energy. Renewable energy technologies are however exposed to the rigors of the market through competitive tendering (bidding combined with ranking according to cost price).

These price competitions appear to be highly effective. Three competitive tenders (orders) have already reduced the price per kWh by half. The cost price for wind energy, waste incineration plants and landfill gas is now roughly equal to the pool price. This system is described in more detail in annex C.

3.8.5.2 Backup programme

The purpose of this programme is to carry out research, development and demonstration programmes, to remove institutional obstacles, to accelerate the local planning process and to support the marketing of renewable energy. The programme's goals - especially those of its R&D component - were ambitious and are regarded by the responsible implementing authorities as unrealistic due to substantial cutbacks in the corresponding financial resources.

The planning process has been accelerated by extensive studies on potential (both technical and economic) which also examined the administrative and legal bottlenecks for each option [12]. The figures obtained by this study are regularly updated [13].

3.9 Ireland

3.9.1 Energy situation

Domestic energy consumption in Ireland totalled 470 PJ in 1995, which is equivalent to over 170 GJ per capita. The share of renewable energy in this total was around 2.1% (see Figure 3.9.1).

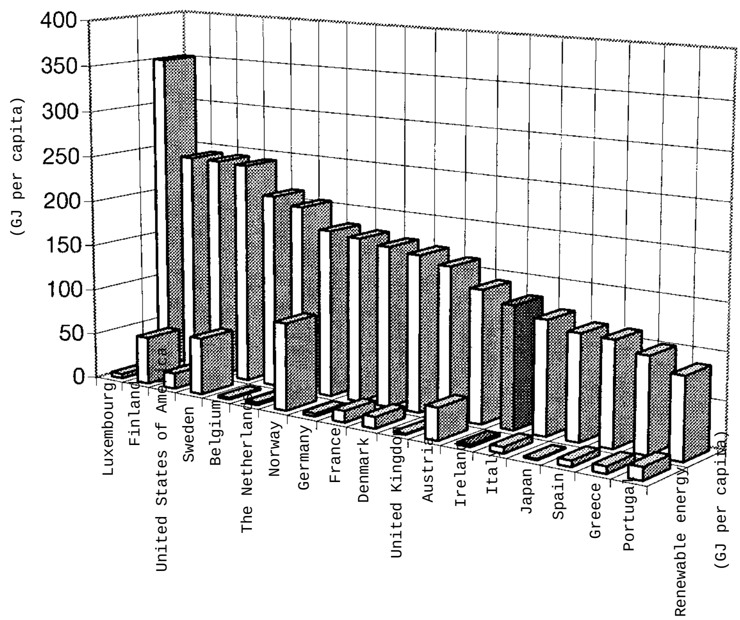


Figure 3.9.1 Energy consumption per capita, including the share of renewable energy.
Source: Eurostat [b].

Ireland's energy intensity is roughly equivalent to the EU average. The share of renewable energy in this total is below average. This percentage is moreover being squeezed due to the rapidly rising demand for energy in Ireland (by a rate of 25% per annum). Renewable energy is generated mainly through biomass and hydropower.

3.9.2 Policy and organisation

The Department of Public Enterprise (formerly the Department of Transport, Energy and Communications) is responsible for policy on renewable energy, much of which it also implements. One of Ireland's main reasons for promoting renewable energy is the likelihood of growing dependency on foreign energy sources following the exhaustion of its own peat stocks. This is important partly because Ireland is an island, and this will complicate its energy supply. The need to reduce emissions and to contribute to the EU's CO_2 reduction target are other important factors. The Renewable Energy Information Office (REIO), which is part of the Irish Energy Centre, has been created to support government policy. Its main tasks are to distribute information and provide regional support.

The energy companies in Ireland (Electricity Supply Board, ESB, the Irish Peat Board, the gas company and the Irish National Petroleum Corporation) are state-owned. The government is currently working on the liberalisation of the electricity market and is transferring production, network management and sales activities to independent subsidiaries or operating units.

3.9.3 Renewable energy options

The table below shows which renewable energy options are relevant to Ireland.

Table 3.9 Options for renewable energy in Ireland

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics		
Tidal energy		
Wave energy	X	
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)		
Active solar energy		
Passive solar energy		
Geothermal energy	X	
Heat pumps		X
Energy storage		X

Emphasis is given to options that generate electricity. One reason for this is that there is no real market for heating supply in Ireland. Buyers of energy satisfy demand for heat themselves through fuel conversion. Moreover, the market for fuel is divided (oil, coal, peat and gas). The Irish government does not regard peat as a renewable source of energy.

3.9.4 Technical potential, targets and costs

Figure 3.9.2 illustrates the cost diagram for Ireland.

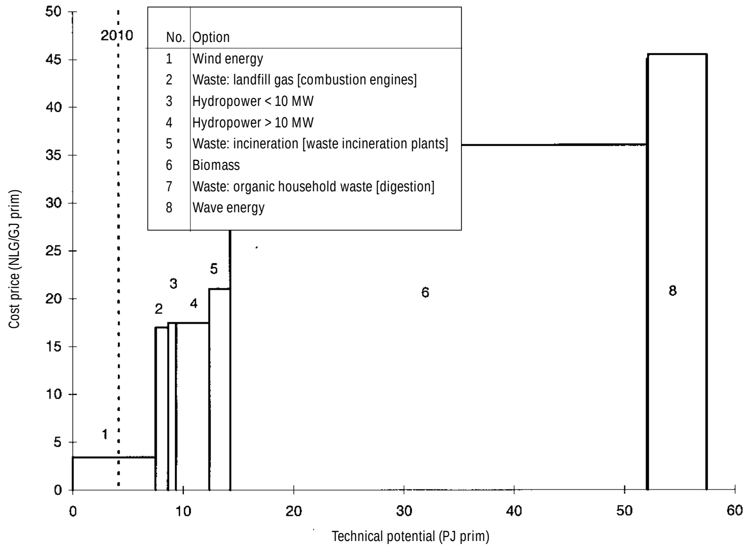


Figure 3.9.2 Cost diagram for Ireland (primary energy according to the Eurostat Convention)

Ireland's aim is for 14% of its existing electrical production capacity (Declared Net Capacity) to be obtained from renewable sources by 2010. Due to the relatively low operating hours of renewable production capacity and the comparatively limited share of electricity in the overall supply of energy, this equates to only around 1% of energy consumption in 1995.

None of the options are profitable due to the low reference prices for electricity in Ireland. Relatively few extra costs are involved in the exploitation of wind energy, however. Biomass has the greatest technical potential in Ireland. There is some potential for wave energy on the Irish coast; Ireland is currently the only EU Member State that is seriously investigating the possibilities for wave energy (through a pilot project).

3.9.5 Instruments

One of the most important instruments in Ireland is competitive bidding within the relevant options (Alternative Energy Requirement Competition, AER). This instrument is largely the same as the one operated in the United Kingdom under the NFFO. See annex C for a more detailed account of this instrument. Three competitive bids have now been organised in Ireland; together, they have generated almost 200 MW in renewable energy capacity. A substantial extra subsidy was provided during the first round[3]. However, the competition element proved so effective that no applications were made for this extra subsidy. The ESB pays the mandatory asking price to the project developer for a period of 15 years (Power Purchase Agreement, PPA). The difference between the asking price and the production costs saved by ESB are offset by a small increase in the price of electricity. The subsidies within the AERs are provided by the European Renewable Development Fund (ERDF). During the last round, these totalled approximately NLG 175/kWe. The ERDF is part of the Economic Infrastructure Operational Programme. Ireland's wave energy project is also subsidised by the European Union. Competition is open to all. A consortium between the ESB and a major US company was recently chosen to set up a project for the extraction of energy from waste.

3 IEP 15 million, including a grant for combined heat and power.

Third party access (TPA) is permitted in principle for the supply of electricity from renewable sources to end-users. This option has not yet been exercised.

3.10 Italy

3.10.1 Energy situation

Domestic energy consumption in Italy totalled 6,970 PJ in 1995, which is equivalent to approximately 121 GJ per capita. The share of renewable energy in this total was around 5.6% (see Figure 3.10.1).

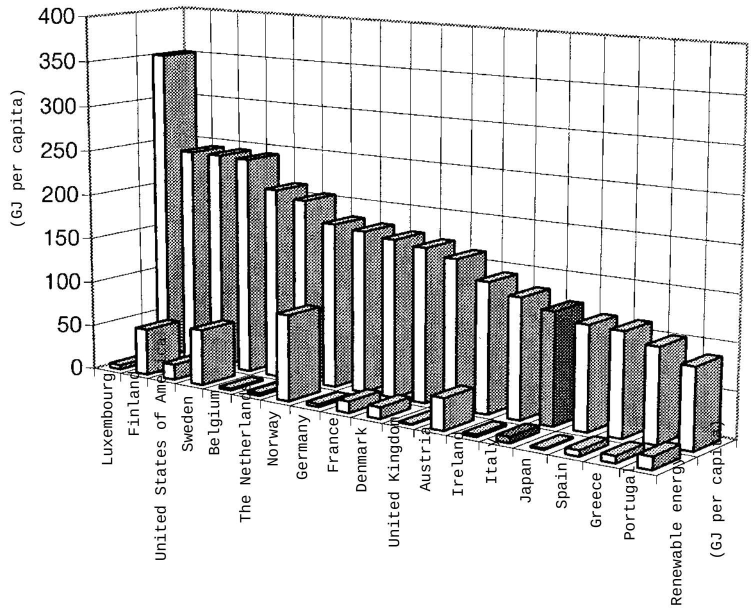


Figure 3.10.1 Energy consumption per capita, including the share of renewable energy. Source: Eurostat [b].

Italy has a relatively low energy intensity compared to other EU Member States. Italy's share of renewable energy is substantially higher than that of the Netherlands and is roughly equal to the EU average. Renewable energy is currently generated through hydropower, biomass and geothermal energy, the latter being used to generate electricity.

3.10.2 Policy and organisation

The Ministry of Industry and Trade bears prime responsibility for policy on renewable energy. Policy preparation and implementation are handled mainly by the national energy agency (ENEA). The main reasons for promoting renewable energy in Italy are diversification, job creation and the reduction of emissions. Apart from central government, the regional authorities in Italy are also actively involved in developing renewable energy.

ENEL is the country's leading electricity company. There is no distinction between production, distribution and planning. ENEL was previously wholly state-owned, but it is now being semi-privatised.

The Italian government drew up a national energy plan in 1988 - the Plan Energia Nazionale (P.E.N.) - which included measures to stimulate renewable energy. This led to a series of subsidy schemes and favourable rates for sales to the grid (Comitato Intermisteriale Prezzi No. 6, 1992, CIP6/92). Under certain conditions, independent generators of renewable energy and combined heat and power are given access to the national grid. Once ENEL has been privatised, these favourable buying rates will be withdrawn. The government is currently considering how this can be compensated.

3.10.3 Renewable energy options

The table below shows the energy options that the Italian government regards as relevant.

Table 3.10 Options for renewable energy in Italy

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics	X	
Geothermal energy	X	
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)		
Active solar energy	X	
Passive solar energy		
Geothermal energy	X	
Heat pumps		
Energy storage		

High temperature geothermal energy is present in various locations throughout Italy. It can also be used to generate electricity.

3.10.4 Technical potential, targets and costs

Figure 3.10.2 illustrates the cost diagram for Italy.

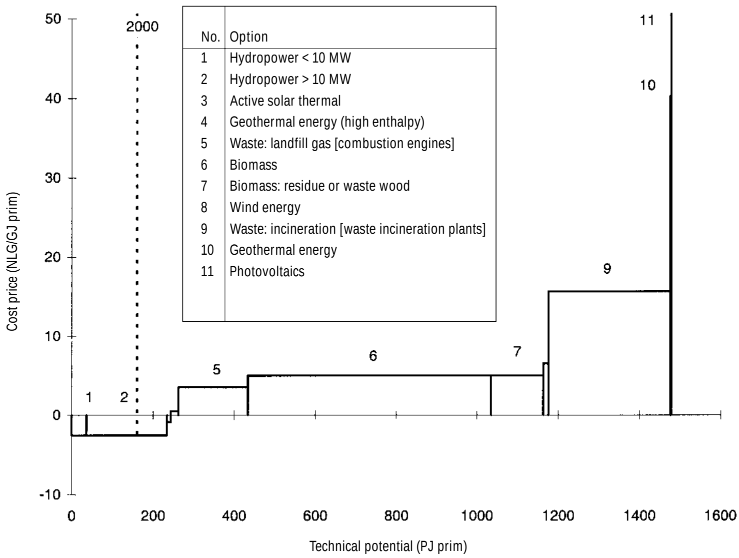


Figure 3.10.2 Cost diagram for Italy (primary energy according to the Eurostat Convention)

Large and small-scale hydropower appears to be the most viable option. Italy also has a large volume of waste and biomass, although their exploitation would involve surplus costs.

The 1988 national energy plan (P.E.N.) indicated the general targets that would need to be met for each option by the year 2000. Taking into account all the relevant options, this would result in a total capacity of approximately 175 PJprim or 2.5% of TPEC. Although little of this capacity has been realised so far, substantial progress is expected over the coming years. Only 70 MW in wind capacity has been exploited to date, but project proposals totalling more than 1,100 MW had been submitted by 1996. 700 MW of this should be realised over the next three years.

3.10.5 Instruments

CIP6/92 reduced ENEL's monopoly by giving self-generators a legal right to supply electricity from renewable sources to the national grid at a high tariff. In 1996 the rates for wind energy and hydropower were approximately 20 cents per kWh, and 10 cents per kWh higher for photovoltaics, biomass and waste. These favourable rates are paid during the first eight years of the life cycle of the option, after which the rate changes to approximately 10 cents per kWh. The premium for electricity from renewable sources is financed by a small increase in the price per kWh for end-users. Once ENEL has been privatised, these high rates will be abolished. They are likely to be replaced in the near future by a new incentives policy.

In addition to assistance from central government, there is also renewable energy is also given substantial financial support by the regions. Apulia, for example, recently contributed over NLG 40 million to investments in the construction of a large wind farm.

Most R&D is carried out by ENEA, although some is also carried out by ENEL. Research on photovoltaics is being given high priority, with relatively large plants being built (MW scale). So far, 16 MWp of capacity has been connected to the national grid. Trade and industry play a key role in this development. A large number of demonstration projects are also being set up in liquid biofuels and biomass. As well as benefiting the environment, this is also seen as a useful way of using fallow agricultural land.

3.11 Japan

3.11.1 Energy situation

Domestic energy consumption in Japan totalled 14.137 PJ in 1994, representing about 113 GJ per capita. The share of renewable energy in this total was around 1% (see Figure 3.11.1).

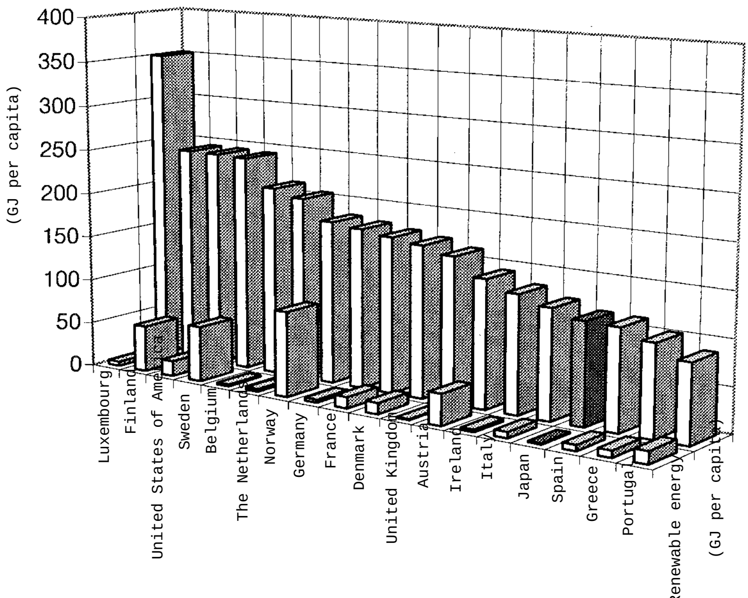


Figure 3.11.1 Energy concumption per capita, including the share of renewable energy
Souce:Eurostat [b]

The main renewable energy options currently being exploited in Japan are hydropower, geothermal energy and waste.

3.11.2 Policy and organisation

Energy policy is the responsibility of the Ministry for International Trade and Industry (MITI). Since 1980 (Law concerning the promotion of development and introduction of oil-alternative energy), Japan has been actively working on new forms of energy, including renewable energy. This led in 1980 to the creation of NEDO (New Energy Development Organisation). Apart from renewable energy, New Energy also covers innovative coal-based technologies and nuclear power. These options are also jointly referred to as 'alternative energy'.

The rationale underlying Japan's policy to promote 'New Energy' is based on the need to reduce dependency on oil, to boost the development of industrial technology and to generate more employment. Targets have been set for certain policy components (for capacities to be achieved by 2010). Together they amount to only a small percentage (approximately 3%) of the total energy supply. There is no integrated policy goal. One argument used to justify this is that since the electricity market is being liberalised, it would not be appropriate for the government to set targets for the open market.

3.11.3 Renewable energy options

Table 3.11 Options for renewable energy in Japan

	Relevant	Non-renewable
ELECTRICITY		
Wind energy		
Hydropower	X	
Photovoltaics	X	
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)		
Active solar energy		
Passive solar energy		
Geothermal energy	X	
Heat pumps		
Energy storage		

Japan has considerable experience in exploiting hydropower, geothermal energy and waste (combined heat and power). There is still some technical potential for expanding these options. Japan also has potential, though less experience, in exploiting solar energy (photovoltaic conversion) and liquid biofuels for vehicles. There is little potential for wind energy in Japan.

3.11.4 Instruments

The Japanese government is concentrating its support for research and development on photovoltaic conversion (New Sunshine Programme) and on the development of clean cars and associated liquid biofuels. The development of technology is central to these activities. For the other options that are relevant to Japan (hydropower, geothermal energy and the utilisation of waste and biomass), instruments are primarily used to improve market conditions (familiarity, safety requirements, etc) for the market launch and improvement of existing designs.

In the case of technology that is more or less proven, the government's role is restricted to promotion, deregulation and standardisation. Its promotional efforts are geared towards familiarising companies and the general public with solar energy options. Its deregulation and standardisation tasks involve clarifying and where possible relaxing requirements governing the safety and integration into the national grid and operating installations of photovoltaic cells, waste incineration plants and combined heat and power units based on biomass and waste, and streamlining the relevant license-granting procedures. The government also grants subsidies, awards tax concessions and issues low interest loans for renewable energy applications.

3.12 Luxembourg

3.12.1 Energy situation

Domestic energy consumption in Luxembourg totalled 143 PJ in 1995, which is equivalent to around 350 GJ per capita. The share of renewable energy in this total was around 1.4% (see Figure 3.12.1).

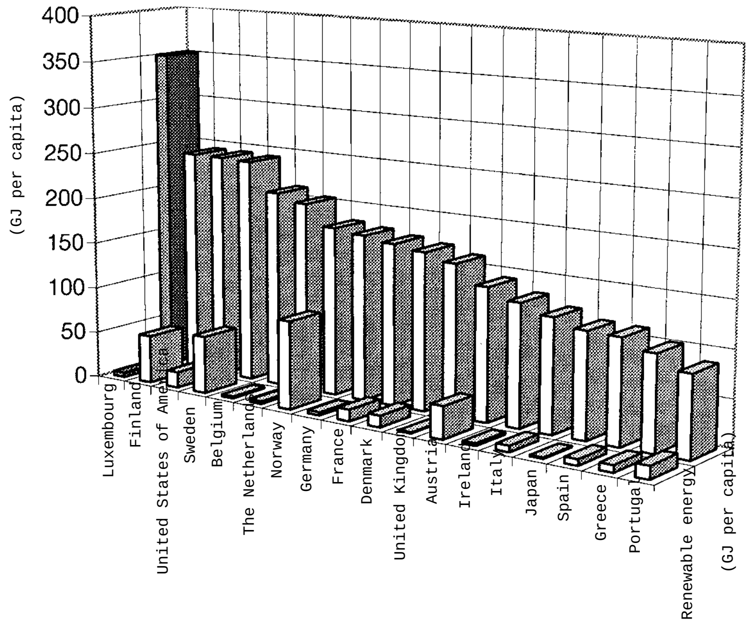


Figure 3.12.1 Energy consumption per capita, including the share of renewable energy. Source: Eurostat [b].

Luxembourg's energy intensity is the highest in the European Union. This is due to the high energy consumption of the steel industry and the country's small population (approximately 400,000). The share of renewable energy in total energy consumption is relatively low and much of it is generated through waste incineration and hydropower.

3.12.2 Policy and organisation

The Ministère de l'Energie is responsible for policy on renewable energy. The energy agency AEL (l'Agence de l'Energie de Luxembourg) is officially responsible for stimulating renewable energy. AEL concentrates on filling gaps in the implementation process and on providing information and advice to regional and local authorities. One of the main reasons for stimulating renewable energy in Luxembourg is diversification. The desire for self-sufficiency is not a motive. The country's central location and its relative scarcity of (natural) resources and minerals means that it will inevitably be forced to rely on energy imports. The rationale underlying diversification is the need for a varied 'fuel mix' as a basis for energy supply. A second reason for promoting renewable energy is to reduce harmful emissions (CO_2 and acid emissions). Compliance with EU policy is a further - political - reason for Luxembourg's increased interest in renewable energy.

Due to Luxembourg's limited 'natural' resources (no coastline, no major contours), its 'environmental' policy concentrates on reducing fuel consumption and conserving energy. Natural gas will increasingly replace oil as a fuel for domestic heating. Due to its relatively high dependence on imported fuel, especially for electricity production, it is particularly difficult to ascribe a precise volume of emissions saved to Luxembourg. Combined heat and power occupies a key role in Luxembourg's energy and environment policy due to the environmental gains involved. However, if the electricity generated by combined heat and power plants replaces electricity imported from Belgium or Germany, Luxembourg's emissions will increase. On the other hand, Luxembourg can make substantial national reductions in CO_2 emissions by converting the steel industry's fossil fuel-fired ovens to electrical ovens fed by imported electricity.

A large proportion of Luxembourg's energy sector is state-owned (30-50%). This is regarded as essential for an effective energy policy.

3.12.3 Renewable energy options

The table below shows the relevant renewable energy options for Luxembourg.

Table 3.12 Options for renewable energy in Luxembourg

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics	X	
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)		
Active solar energy	X	
Passive solar energy		
Geothermal energy		
Heat pumps		X
Energy storage		

Heat pumps are classified as energy conservation options rather than as renewable energy.

3.12.4 Technical potential, targets and costs

Figure 3.12.2 illustrates the cost diagram for Luxembourg.

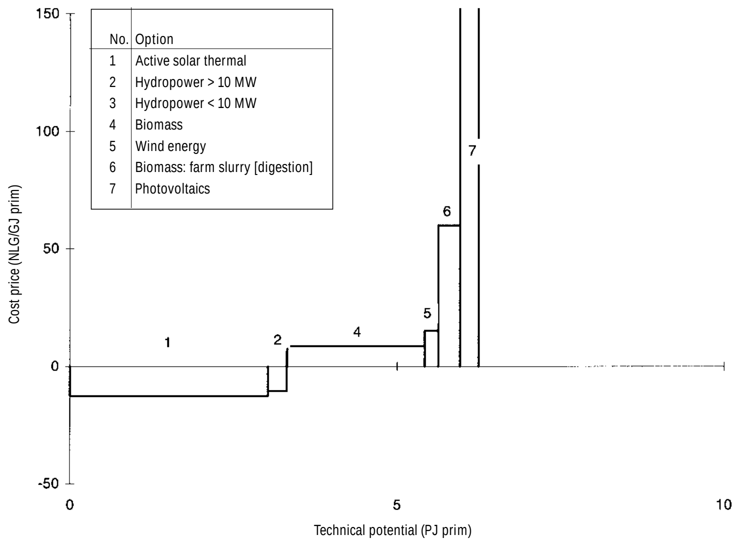


Figure 3.12.2 Cost diagram for Luxembourg (primary energy according to the Eurostat Convention)

Renewable energy can only make a modest contribution to energy supply in Luxembourg. The potential for hydropower and waste incineration has already been fully unlocked. Only solar thermal energy and large-scale hydropower are cost-effective. Biomass, wind energy and photovoltaic conversion have a modest development potential.

3.12.5 Instruments

Electricity companies are obliged to buy power from renewable sources at a favourable fixed rate. The reimbursement for capacities of up to 500 kW is approximately 15 cents/kWh. Investors in solar energy (thermal and photovoltaic) or in installations for upgrading biomass qualify for an additional 25% subsidy. A subsidy of NLG 325/kWel is issued for wind energy. These incentive schemes are even attracting interest from outside Luxembourg.

The Luxembourg government is mainly using covenants and long-term agreements to boost energy and environmental awareness in the private sector (industry, the utility companies). Companies whose energy consumption exceeds a certain level are obliged to conduct energy audits that specifically examine the possibilities for renewable energy options. Companies investing in renewable energy can deduct 60% of the investment costs from their (pre-tax) company profits.

The transport sector is still growing and is a major contributor to CO_2 emissions. To curb these emissions, the government is encouraging the use of biofuels, which are tax-exempt. There are currently 10 buses in the capital city running on bio-diesel.

National, regional and local authorities are obliged to draft so-called energy plans. These plans include:

- a description of the existing energy situation;

- an assessment of the economic viability of various energy options;
- an indication of priority areas for combined heat and power or natural gas;
- measures to improve the economic viability of renewable options;
- an indication of the contribution made by renewable sources;
- an evaluation of the costs of exploiting these sources.

Central government co-funds these energy plans and the AEL provides practical support. The government also helps fund local public information and awareness campaigns and makes a practical contribution through its own media campaigns. These campaigns are also of course largely geared towards energy conservation and efficient energy consumption.

3.13 Norway

3.13.1 Energy situation

Domestic energy consumption in Norway totalled 781 PJ in 1995, which is equivalent to around 182 GJ per capita. The share of renewable energy in this total was approximately 52% (see Figure 3.13.1).

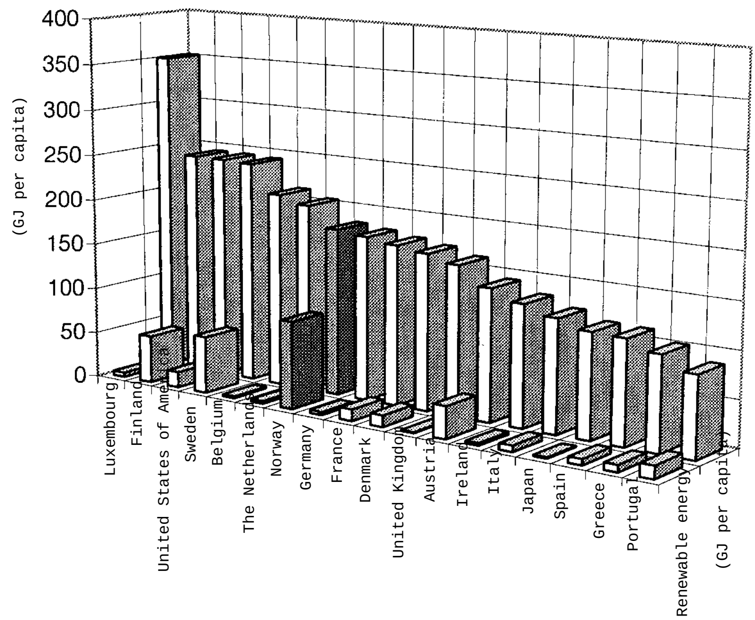


Figure 3.13.1 Energy consumption per capita, including the share of renewable energy. Source: Eurostat [b].

Norway has the biggest share of renewable energy among the countries surveyed. At present, this share consists primarily of large-scale hydropower. Utilisation of biomass and waste is growing but is still relatively limited.

3.13.2 Policy and organisation

Energy policy in Norway is the responsibility of the Ministry for Petroleum and Energy. It is implemented by NVE (Norwegian Water Sources and Energy Administration), which is a government agency. The name of this agency reflects the importance of hydropower within the Norwegian energy supply. The NVE promotes and supervises the responsible and efficient use of water resources (annual spread) and electricity production.

Interest in other forms of renewable energy than hydropower has increased substantially in recent years, partly as a result of two dry summers (leading to a shortage of hydropower and the need to import electricity). Biomass occupies a key role in Norway's existing renewable energy policy due to the fact that it can be flexibly deployed (it can be stored and used when convenient) and because it generates additional employment.

The electricity sector in Norway is highly liberalised and production tariffs for electricity are unregulated. Market prices vary widely throughout the year (a factor of 4 between low and peak periods is not uncommon). Due to price fluctuations, the cost of deploying renewable energy is highly variable. The market itself is expected to regulate the progressive phasing in of renewable energy; government policy is merely designed to promote free and fair competition.

The main reasons for exploiting renewable energy in Norway are the need for (flexible) diversification and additional employment.

3.12.3 Renewable energy options

The table below shows the relevant renewable energy options for Norway.

Table 3.13 Options for renewable energy in Norway

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics		
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)	X	
Active solar energy		
Passive solar energy	X	
Geothermal energy		
Heat pumps		X
Energy storage		X

3.13.4 Technical potential, targets and costs

Figure 3.13.2 illustrates the cost diagram for Norway.

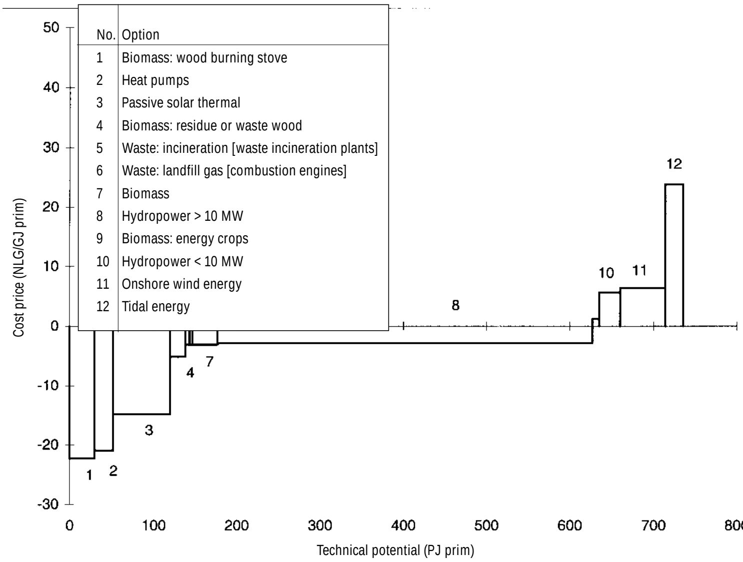


Figure 3.13.2 Cost diagram for Norway (primary energy according to the Eurostat Convention)

Biomass, which has considerable potential (approximately 50 PJ/year), will be a key option for the coming years (waste wood and energy crops). Although hydropower has greater technical potential (approximately 35 TWh/year), exploiting it would be socially sensitive due to a conflict with tourism.

Wind energy still has considerable utilisable potential (approximately 20 TWh/year) which can be exploited fairly cost-effectively. Solar thermal energy is relatively costly but can sometimes be useful since it reduces the need for electrical heating (Norway is trying to reduce domestic electricity consumption so that it can divert the electrical energy that becomes available elsewhere). The potential for doing so is considerable (estimated at approximately 70 PJ/year). Photovoltaic conversion is regarded as too costly to justify central government funding, although it is applied on a decentral level in more remote areas.

3.13.5 Instruments

Norway has almost no instruments specifically designed to promote renewable energy, although it does provide short-term research budgets, usually for just a year. A series of demonstration projects has been launched on biomass: these cover all aspects of local infrastructure. The purpose of these projects is to demonstrate the viability and attractiveness of biomass as energy input. These projects will probably be reproduced throughout the country. The liberalised energy market will be expected to regulate these developments.

The government levies a carbon and sulphur tax on fossil fuels and on electricity generated from these fuels. For domestic consumers, this tax is around 10% of the total energy price. Due to differences between regional economies, a reduced rate applies to certain parts of the country. Some sectors of industry are exempted from the eco-tax. The government is negotiating voluntary emission reduction agreements with these industrial consumers.

3.14 Austria

3.14.1 Energy situation

Domestic energy consumption in Austria totalled 1,140 PJ in 1995, which is equivalent to around 140 GJ per capita. The share of renewable energy in this total was around 24% (see Figure 3.14.1).

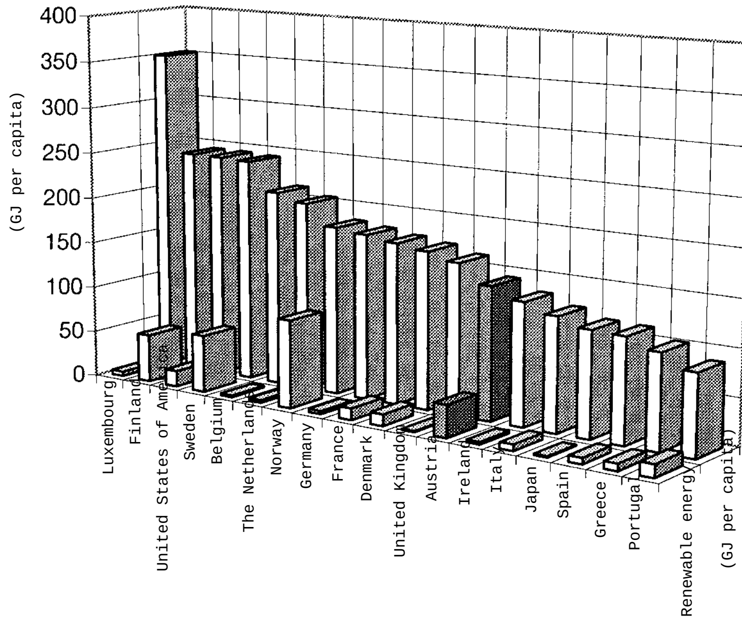


Figure 3.14.1 Energy consumption per capita, including the share of renewable energy.
Source: Eurostat [b].

Specific energy consumption in Austria is relatively low. Austria has an energy-extensive industry. The share of renewable energy is high, mainly due to the use of hydropower and biomass. Almost 70% of electricity is generated using hydropower.

3.14.2 Policy and organisation

The BMwA is responsible for federal policy on renewable energy, assisted by the Austrian energy agency E.V.A. (Energie Verwertungsagentur). Much of Austria's policy on renewable energy is implemented by the 11 Bundesländer. This study however only covers policy at federal level. Key reasons for stimulating renewable energy include the need to reduce dependency on energy imports, curb CO_2 emissions and generate (local) employment.

The electricity sector is divided into national power companies (large-scale) and regional distribution companies (Landesgesellschaften) which are also allowed to generate their own electricity. The electricity sector is currently beginning the process of liberalisation required for the internal European market.

3.14.3 Renewable energy options

The table below shows the relevant renewable energy options for Austria.

Table 3.13 Options for renewable energy in Austria

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics	X	
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)		
Active solar energy	X	
Passive solar energy	X	
Geothermal energy	X	
Heat pumps	X	
Energy storage		

3.14.4 Technical potential, targets and costs

Figure 3.14.2 illustrates the cost diagram for Austria.

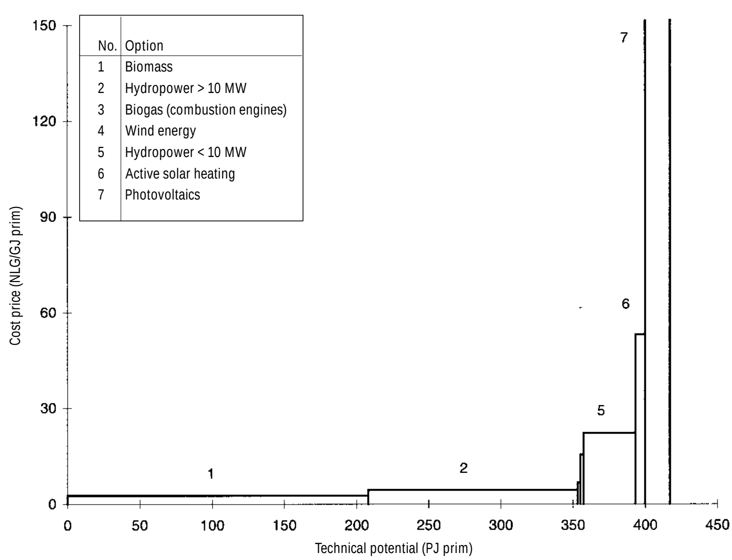


Figure 3.14.2 Cost diagram for Austria (primary energy according to the Eurostat Convention)

4 No cost price figures are available fir waste incineration, heat pumps or geothermal energy despite the considerable technical potential of these options.

Biomass and large-scale hydroelectric projects are relatively cost-effective options in Austria and also have a reasonably high technical potential. Half of Austria is covered by forest. Residual wood and forestry cuttings in the form of biomass already account for a substantial share of energy generation. The potential for large-scale hydropower (> 10 MW) has largely been tapped. The price for large-scale hydropower is slightly above the reference price, although one or two projects have achieved a cost price below it. One factor limiting the development of further potential is the risk of environmental damage.

Austria has no quantitative target for renewable energy. However, the targets specified by the Toronto Climate Change Convention - a 20% reduction in CO_2 emissions by 2005 compared with 1988 levels - have been incorporated into Austria's environment policy.

3.14.5 Instruments

In mid-1997 the electricity company EVU and the BMwA signed an agreement to promote electricity generation using biomass, solar energy and wind energy. This agreement lays down the rates for electricity supplied to the grid and for connections to the grid. However, these do not in themselves encourage the use of electricity from renewable sources. The real financial incentive is provided by an annual fund of ATS 80 million (approximately NLG 13 million). The shortfall for each project is made up by a subsidy based on an internal yield of 7%; 50% of this is paid out when the project has been realised and the rest in five-yearly instalments of 10% each. The programme is designed to reduce the cost price of the aforesaid options. Within this framework, annual competitions are announced. The submitted project proposals are classified and evaluated against a 'minimum subsidy, maximum energy supply' requirement. Due to the limited funds available, only a small number of projects can be implemented.

Electricity companies are obliged by law (ELWOG) to deliver a certain (stepped) percentage of the total electricity supply in the form of wind and solar energy (photovoltaic cells) and biomass energy. The goal is to achieve 1% by 1999, rising to 3% by 2003. Failure to meet this obligation will mean the electricity companies having to pay a level of compensation equivalent to the price difference between average purchase costs and the costs of generating electricity using the aforesaid renewable options.

Austria levies an energy tax on fossil fuels. Energy from renewable sources is tax-exempt, however. An increase in this tax is planned for the year 2000 and will be compensated by a reduction in the tax on labour.

The success of biomass as a source of renewable energy will depend on how effectively it is encouraged at Land and municipal level. Use of biomass is also being stimulated through EU funding within the context of the 'set aside' policy for agricultural land. Solar energy (active thermal and photovoltaic cells) and more generally heat options such as heat pumps are being promoted at decentralised level in particular. This is being tied in with processes and regulations governing the construction of housing, e.g. new residential development and urban regeneration. By the end of 1994 Austria had a collector surface of more than a million square metres for thermal solar energy, 1 MWp of photovoltaic cells, 124,000 heat pumps and 1,600 MWth of biomass.

In 1997, the budget for R&D totalled over ATS 100 million (approximately NLG 17 million), with particular attention being given to setting up demonstration projects rather than to detailed basic research.

3.15 Portugal

3.15.1 Energy situation

Domestic energy consumption in Portugal totalled 861 PJ in 1995, which is equivalent to around 87 GJ per capita, the lowest value among the countries surveyed. The share of renewable energy in this total was around 15.7% (see Figure 3.15.1).

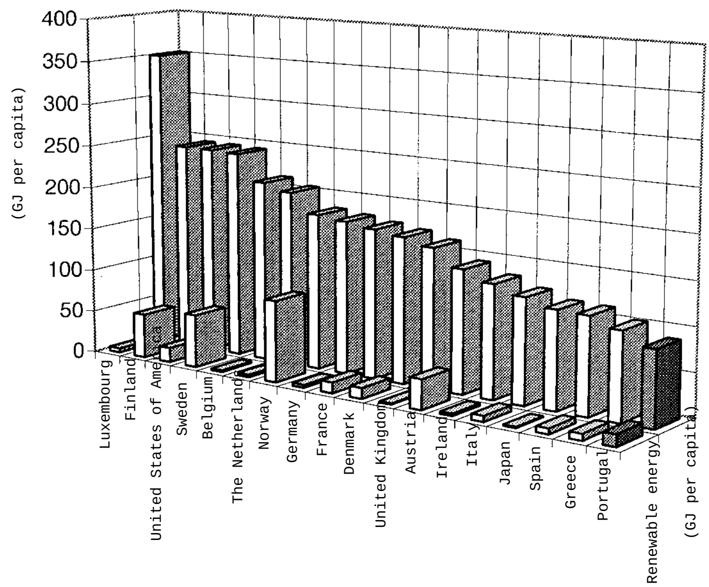


Figure 3.15.1 Energy consumption per capita, including the share of renewable energy.
Source: Eurostat [b].

The share of renewable energy in energy supply in Portugal is currently dominated by large-scale hydropower and to a lesser extent by biomass (e.g. in the form of domestic firewood).

3.15.2 Policy and organisation

The Ministry for Industry and Energy and the Directorate-General for Energy (DGE) are jointly responsible for formulating policy on renewable energy. DGE plays a key role in the allocation and payment of financial assistance. There is no official energy agency in Portugal, although the Centre for Energy Conservation (CCE) to some extent fulfils this role. The policy of the Portuguese government is strongly geared towards improving the overall energy infrastructure and concentrates on options that generate electricity.

The main reasons for exploiting renewable energy in Portugal are diversification (Portugal is very heavily reliant on oil) and employment (collecting, transporting and processing biomass material from forests).

3.15.3 Renewable energy options

Table 3.15 Options for renewable energy in Portugal

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics		
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)	X	
Active solar energy		
Passive solar energy	X	
Geothermal energy		
Heat pumps		X
Energy storage		X

3.15.4 Technical potential, targets and costs

Figure 3.15.2 illustrates the cost diagram for Portugal.

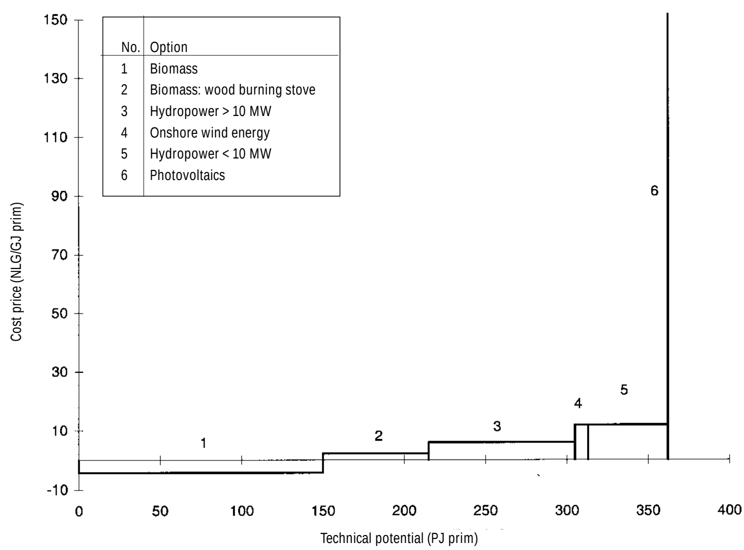


Figure 3.15.2 Cost diagram for Portugal (primary energy according to the Eurostat Convention)

Portugal has some potential for expanding the utilisation of hydropower. However, to do so would be controversial (problems of land ownership, the risk of undermining the value of tourist locations). The Portuguese government has set itself the task of developing 70 MW of wind energy capacity over the next few years. Although the technical potential of wind energy is inherently much greater, there are no indicators to quantify it.

Biomass has the biggest technical potential in Portugal, mainly in the form of residual wood from forests that must be cleared to reduce the danger of forest fires. Although the government has not formulated any specific targets to this end, policy on renewable energy will clearly need to centre on biomass.

The potential for solar thermal energy and photovoltaic cells is considerable. However, the costs involved are regarded as too high to permit an active strategy to be pursued.

3.15.5 Instruments

The energy company EDP is legally required to buy electricity from renewable sources at the prevailing electricity price for customers connected to the national grid (mostly industrial consumers). This scheme is guaranteed for eight years from the start of the project.

Subsidies and interest-free loans are key instruments used by the government. Up to 60 and 55% respectively of the total costs of biomass and wind energy projects can be borrowed free of interest. These subsidies are intended for relatively small projects. The procedures governing the award of subsidies and loans in Portugal are complex. The DGE is responsible both for applying the rules and for evaluating applications.

A series of demonstration projects on biomass has been launched (creation of a complete local infrastructure). These are likely to be reproduced throughout the country.

Apart from the aforementioned reimbursement for the EDP, renewable energy is not stimulated on an actual yield basis.

3.15.6 Additional remarks

All the electricity produced by installations built with government (and EU) funding must be fed into the national grid. Such projects can therefore be regarded as improvements to the public infrastructure, which is one of the conditions for major components of financial assistance from Brussels.

3.16 Spain

3.16.1 Energy situation

Domestic energy consumption in Spain totalled 4,385 PJ in 1995, which is equivalent to around 112 GJ per capita. The share of renewable energy in this total was approximately 6.4% (see Figure 3.16.1).

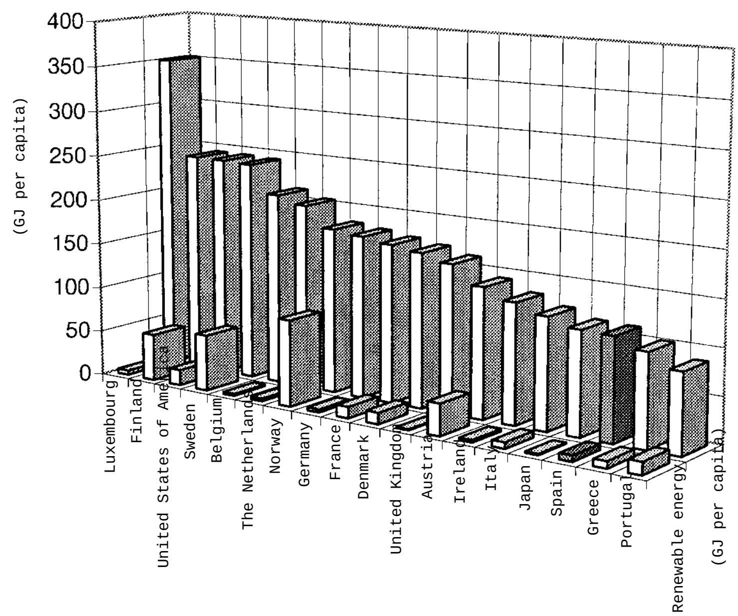


Figure 3.16.1 Energy consumption per capita, including the share of renewable energy.
Source: Eurostat [b].

At present, almost all the renewable energy in Spain is generated by hydropower. Reasonable contributions are made by the utilisation of biomass and waste and the application of wind energy. The active exploitation of solar energy is still minimal.

3.16.2 Policy and organisation

Energy policy falls under the responsibility of the Ministry for Industry and Energy, although it is drafted and implemented by IDAE. IDAE is officially unattached to the Ministry, yet in practice they are closely interrelated. For example, the President of IDAE is also Secretary to the Minister.

The Spanish government has set itself the target of doubling the existing share (approximately 6%) of renewable energy in the overall supply of energy by the year 2010. This ties in with the overall goals in the European Commission's Green Paper. The main reasons why Spain is exploiting renewable energy is to help curb CO_2 emissions, diversify energy supply and promote industrial development (export promotion).

3.16.3 Renewable energy options

Table 3.16 Options for renewable energy in Spain

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics	X	
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)	X	
Active solar energy	X	
Passive solar energy		
Geothermal energy	X	
Heat pumps		X
Energy storage		X

3.16.4 Technical potential, targets and costs

Figure 3.16.2 illustrates the cost diagram for Spain.

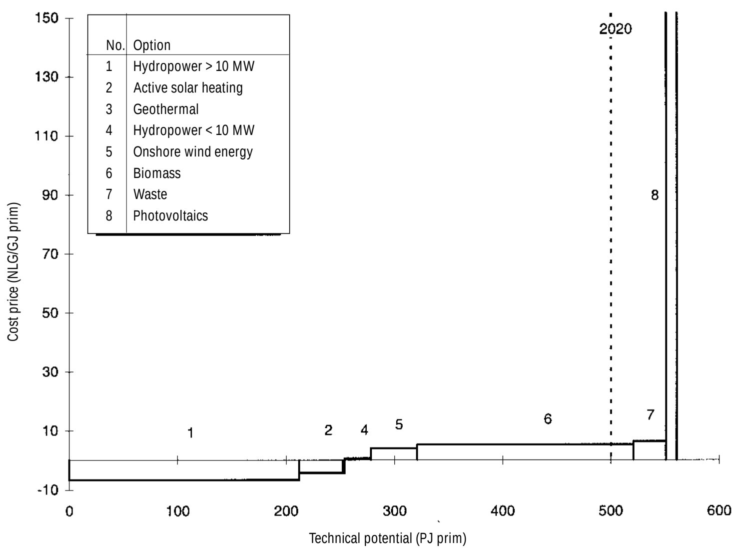


Figure 3.16.2 Cost diagram for Spain (primary energy according to the Eurostat Convention)

Biomass and hydropower are the main options within the existing supply of renewable energy, accounting for over 95% of this supply. Biomass in Spain involves the utilisation of forestry and agricultural products, organic household and industrial waste and landfill gas. Almost all the biomass in Spain is used to generate heat. The existing utilised potential for biomass can be deployed in a more energy efficient way. There is also an additional technical potential. The existing potential for waste incineration and digestion has been almost fully exploited. The same is true of the potential for large-scale hydropower. There is however almost certainly considerable extra potential for small-scale hydropower, wind energy, Photovoltaics and solar thermal energy. However, no reliable national studies of this potential have yet been produced. There is some technical potential for geothermal energy, but in so far as it is relevant it has already been exploited.

3.16.5 Instruments

The state-owned electricity company ENDESA (which is soon to be privatised) is obliged to pay a relatively high rate for electricity from renewable sources. This rate has been set at approximately 15 cents per kWh for hydropower, wind energy and photovoltaic conversion and over a cent less per kWh for the utilisation of biomass and organic household waste.

The remaining state aid is concentrated in investment subsidies for demonstration projects and third party financing. In the case of third party financing, IDAE awards funding - under favourable conditions (fixed for each project) - to initiators of renewable energy projects who lack the necessary resources (mainly government agencies). IDAE plays a key role in evaluating the feasibility of proposals and in contract negotiations concerning the award of subsidies and participating interests. IDAE has a participating interest in 11 companies that exploit renewable energy. This stake never exceeds 49%.

3.17 United States of America

3.17.1 Energy situation

Domestic energy consumption in the United States totalled 62,832 PJ in 1994, which is equivalent to around 244 GJ per capita. The share of renewable energy in this total was around 7% (see figure 3.17.1).

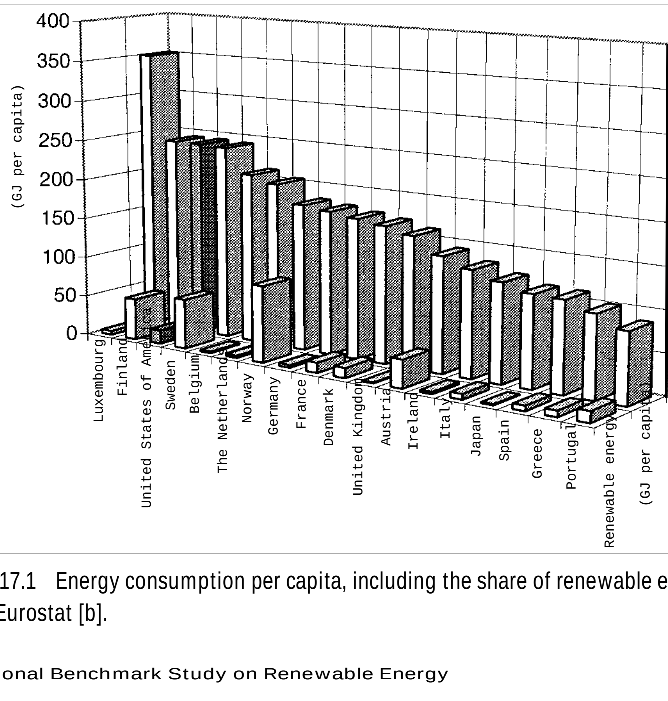


Figure 3.17.1 Energy consumption per capita, including the share of renewable energy. Source: Eurostat [b].

Hydropower makes by far the biggest contribution to the existing share of renewable energy, although the share of biomass is increasing. Geothermal, wind and (high temperature) solar energy are also being studied.

3.17.2 Policy and organisation

Policy on renewable energy is the responsibility of the Department of Energy. The United States has no quantitative renewable energy targets.

Policy analyses and studies are carried out mainly by laboratories. Four of these are actively engaged in research on renewable energy. Policy on renewable energy is translated into practice by the energy companies and the private sector. The government concludes agreements with the private sector - via the laboratories - on projects and development goals, and the laboratories also sometimes share in the financial costs and benefits. Agreements of this kind are not concluded with the energy companies since they have their own research institute, EPRI.

Most of the measures are drawn up by individual states. Senior government officials recognise the need to stimulate renewable energy. Obvious reasons for doing so include compliance with international environmental agreements, the need for the United States to set an example in this regard and the international significance of US policy (impact on climate, price developments). However, Congress rarely supports policy measures to promote renewable energy, especially where these lead to an increase in the cost of conventional options.

3.17.3 Renewable energy options

Table 3.17 Options for renewable energy in the United States

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics	X	
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)	X	
Active solar energy	X	
Passive solar energy		
Geothermal energy	X	
Heat pumps		X
Energy storage		X

3.17.4 Instruments

48 US states are now taking steps to restructure their electricity supply. 22 of these states are devoting specific attention to the role of renewable energy in a deregulated market.

The furthest advanced is California, where a fully liberalised market began operating on 1 January 1998. The Assembly Bill (AB 1890) on deregulation has created a USD 540 million fund which will be paid for by customers of the existing private electricity companies in the form of a ‘wires charge’ on their electricity bills. The Californian Energy Commission (CEC) will use the revenue obtained to stimulate existing and projected forms of renewable energy in line with specific rules. Over 90% of the funds channelled to specific projects are linked to production yield (in the form of a reimbursement per kWh paid to the producer and/or buyer). In 1996 the CEC invited the shareholders of relevant companies to submit proposals on how to award funding. The rules for the allocation of this funding - as specified in AB 1890 - were laid down following a series of meetings and workshops.

The federal government now believes that the ongoing process of deregulation coupled with low energy prices has reduced interest in renewable energy.

This is not only true of buyers in general - with the exception of a handful of niche markets - but also and especially applies to research and development on the more costly options by the energy companies. The government therefore feels it must play a stronger role in guiding long-term research. The federal government also wants to introduce a mandatory renewable energy target for each state.

It can do so in one of two ways. The first option is a so-called ‘federal wires charge’ based on the Californian model. The second option is to work with a standard portfolio of obligatory shares for the various forms of renewable energy. This option is being developed by a number of other states and proposals to this effect have already been submitted by members of Congress.

The federal administration also increasingly recognises the importance of raising awareness of renewable energy in schools and universities. Various projects have been launched to this end, e.g. energy management role-play and the supply of information on disk and CD-ROM.

The United States operates many different forms of ‘green pricing’, in which consumers fund renewable energy projects through a surcharge on their electricity bills. These surcharges can vary between roughly USD 2 and 30 per month. The higher amounts are usually linked to direct participation by consumers in the development and exploitation of renewable energy units (e.g. photovoltaic cells on house roofs). In California, consumption of renewable energy is encouraged by giving consumers who buy more than half their energy from renewable sources priority access to the liberalised electricity market.

3.18 Sweden

3.18.1 Energy situation

Domestic energy consumption in Sweden totalled 2,135 PJ in 1995, which is equivalent to around 242 GJ per capita. The share of renewable energy in this total was around 26 % (see Figure 3.18.1).

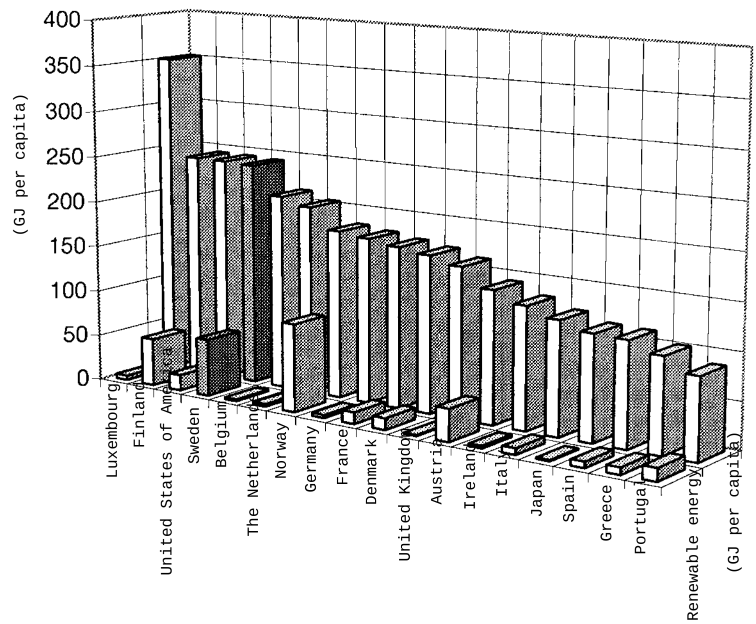


Figure 3.18.1 Energy consumption per capita, including the share of renewable energy.
Source: Eurostat [b].

Sweden is one of the three most energy-intensive countries in the European Union. Energy intensity is however reduced to some extent by the relatively high proportion of hydropower in the energy balance (hydropower involves no heat loss). Sweden currently has the largest share of renewable energy in the EU.

After hydropower, biomass is also widely used as a form of renewable energy. The contribution made by other renewable options is almost zero.

3.18.2 Policy and organisation

Policy on renewable energy in Sweden is the responsibility of the Ministry of Industry and Commerce, which has a very small energy division. The Ministry therefore relies heavily on NUTEK, the Swedish National Council for Industry and Technological Development. Until recently, NUTEK also supervised the liberalisation of the Swedish electricity market. This task will be transferred to a newly established Central Energy Authority at the beginning of 1998. Sweden's energy policy is drawn up in conjunction with the Ministries of Economic Affairs and the Environment.

The main reasons for stimulating renewable energy in Sweden are to enhance industrial development (for the international market; export promotion), encourage sustainable development (a very real goal in Sweden) and curb CO_2 emissions (international covenants).

3.18.3 Renewable energy options

The table below shows the relevant renewable energy options for Sweden.

Table 3.18 Options for renewable energy in Sweden

	Relevant	Non-renewable
ELECTRICITY		
Wind energy	X	
Hydropower	X	
Photovoltaics		
Tidal energy		
Wave energy		
COMBINED HEAT & POWER		
Waste	X	
Biomass	X	
HEAT		
Biomass (wood burning stove)	X	
Active solar energy		
Passive solar energy	X	
Geothermal energy		
Heat pumps		
Energy storage		

3.18.4 Technical potential, targets and costs

Figure 3.18.2 illustrates the cost diagram for Sweden.

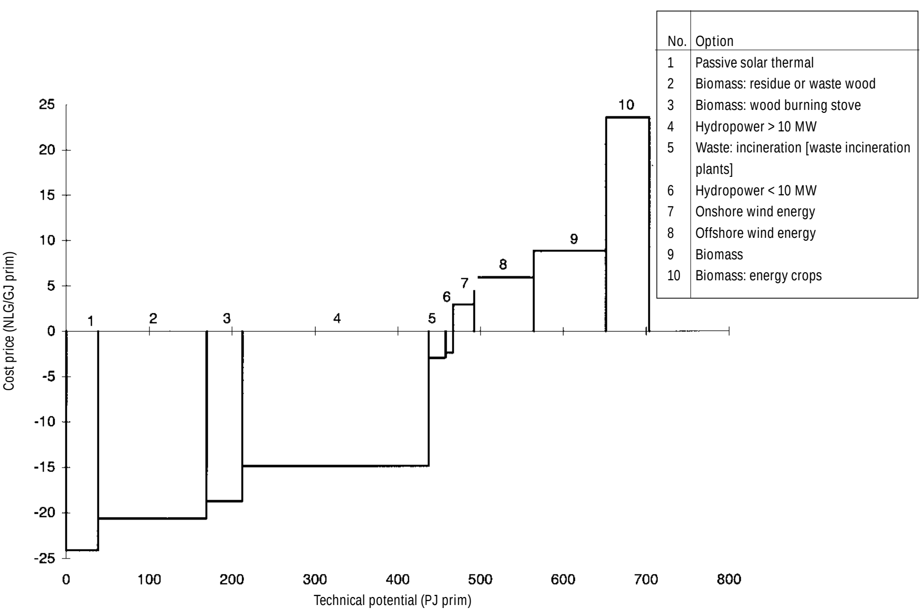


Figure 3.18.2 Cost diagram for Sweden (primary energy according to the Eurostat Convention)

Sweden has considerable technical potential (450 PJ) which can be viably exploited. Much of it has already been developed in the form of passive solar thermal energy, biomass (residual wood, peat and slurry), hydropower and waste incineration plants.

The potential for hydropower has been almost fully exploited; however, the remaining potential has been politically blocked. The potential for land-based wind energy in particular is ultimately restricted by low wind speeds or extreme cold. Sweden's biomass potential has already largely been exploited, although significant efficiency improvements are still possible. As in the other Scandinavian countries, solar thermal energy is costly; occasionally, however, it can be an interesting option since it reduces demand for electrical heating. Photovoltaic conversion of solar energy is regarded as too costly to justify a specific policy-based strategy, although it is applied at decentralised level.

The reference price in Sweden is expected to rise over the coming years following the decommissioning of the country's nuclear power stations.

3.18.5 Instruments

The main thrust within overall energy policy in Sweden is to reduce the consumption of electrical heating, increase energy efficiency and further exploit renewable energy.

The application of renewable energy is primarily encouraged through the award of investment grants. Biomass and related technological developments are being given particular attention. Sweden is working closely in this regard with Eastern Europe, partly because this part of Europe is seen as an important market for biomass technology. Subsidies can reach a maximum of 25% of the total investment. The Swedish government is aiming for a rise in electricity production using biomass-fired units of 0.75 TWh per year over a period of five years. The price per kWh for electricity generated by these units is kept relatively low by the 'heat crediting' principle, i.e. attributing a substantial proportion of the total costs to the heat generated.

Since mid-1997, an investment subsidy has been available for wind energy (levels of more than 200 kW) and small-scale hydropower (up to 1,500 kW). This subsidy can total a maximum of 15% of the investment costs. The aim is to increase electricity production from wind turbines by 0.5 TWh (approximately 250 MW) and that of small-scale hydropower by 0.25 TWh. SEK 300 and 150 million respectively (approximately NLG 75 and 37.5 million) has been set aside for this over the five-year period. The extra reimbursement for electricity delivered to the national grid from this type of installation is equivalent to roughly 3.5 cents per kWh.

On 1 January 1998, SEK 100 million was allocated over a five-year period to develop technical know-how to improve energy efficient equipment and renewable energy options. This is a substantially higher amount than has been allocated in previous years. Cost effectiveness is also being improved by NUTEK, which is contracting out the operation of 15 9MW installations (series effect).

A carbon and sulphur tax is currently levied on fossil fuels. However, if they are used in electricity production, these fuels are tax-exempt. As a result, the most heavily taxed fuels tend to be used for conventional electricity production. Sweden is currently reviewing its tax regime for energy supply. The Swedish government believes that only international regulations will provide a truly satisfactory environmental solution.

4 Comparison

This chapter compares the renewable energy situation in the countries surveyed, with specific attention for the position of the Netherlands vis-à-vis these other countries. The comparison will provide answers to the four questions posed in the situation analysis at the beginning of this survey, namely:

1. What is defined as renewable energy?
2. What renewable options are available? To what degree are they available and what would it cost to increase their availability (cost curves)?
3. What rationale and policy goals are applied to the use of renewable energy?
4. What instruments are used to achieve these goals?

The sections below are classified according to these four questions.

4.1 What is defined as renewable energy?

Opinions about what constitutes renewable energy often differ between - and even within - individual countries. The individual country reviews therefore take the definition employed by each national government as the yardstick for each country. This section compares the standpoints of each national government and uses this comparison to draw a number of general conclusions.

Some options are regarded as renewable by almost every country. These are: hydropower, wind energy, solar energy and, where applicable, tidal energy and geothermal energy. Although wave energy is not being studied as an option in any of the countries surveyed, it is still regarded as a renewable option.

Other options lie at the edge of what can be defined as renewable (in the sense that they cause some limited environmental damage). This is especially true of the ‘broad’ energy options from biomass and waste, where many different processing methods are used. All countries define energy obtained from organic household waste, wood residues (from the forestry sector and industry) and energy crops as renewable. In Finland and Sweden, peat-burning is regarded as a source of renewable energy, while in Ireland it is not. The IEA also excludes peat as a renewable resource since it takes too long to replenish itself naturally. In France, waste incineration and landfill gas are not regarded as forms of renewable energy. However, in the other countries surveyed, waste incineration is classified as renewable, although in many cases it is only the organic fraction that is seen as relevant.

Some countries regard the use of heat pumps and energy storage as forms of energy efficiency rather than as renewable energy, and classify them as energy conservation tools for industry and the built environment. The same applies to passive solar thermal energy. However, this is merely a question of classification; the clean nature of these options is not an issue.

None of the countries operates clear guidelines as to what is and is not defined as renewable energy.

Many countries devote a far greater proportion of their efforts to options that generate electricity rather than to those which generate heat. One important reason for this is that as a rule, the market for heat production is less highly organised and centralised than the electricity sector. As a result, less research is conducted into new activities and interests are comparatively less well represented. Although heat grids do exist in urban agglomerations, they are few and far between compared to the electricity infrastructure. Opinions about the electrical options and the extent to which they are renewable are therefore more fully developed than opinions about the heat options.

4.2 Cost curves

To obtain a ‘pure’ comparison of cost curves, the survey only looked at options that were defined as renewable in all the countries surveyed. In specific terms, this meant that the heat pump, energy storage and passive solar thermal options were not included in the compilation of the set curves. Strictly speaking, waste incineration should also have been omitted. However, only France excludes it as a renewable option. Furthermore, the technical potential for waste incineration accounts for over 25% of the Dutch long-term target. For these reasons, it was decided to include the waste incineration option in the cost curves. Since this distorted the direct comparison between the Netherlands and France, the survey examined whether leaving this option out of the cost curves would substantially affect the overall comparison. In fact it made almost no difference to the final result. The curves presented below can therefore be regarded as a sound basis for a comparison between the countries surveyed.

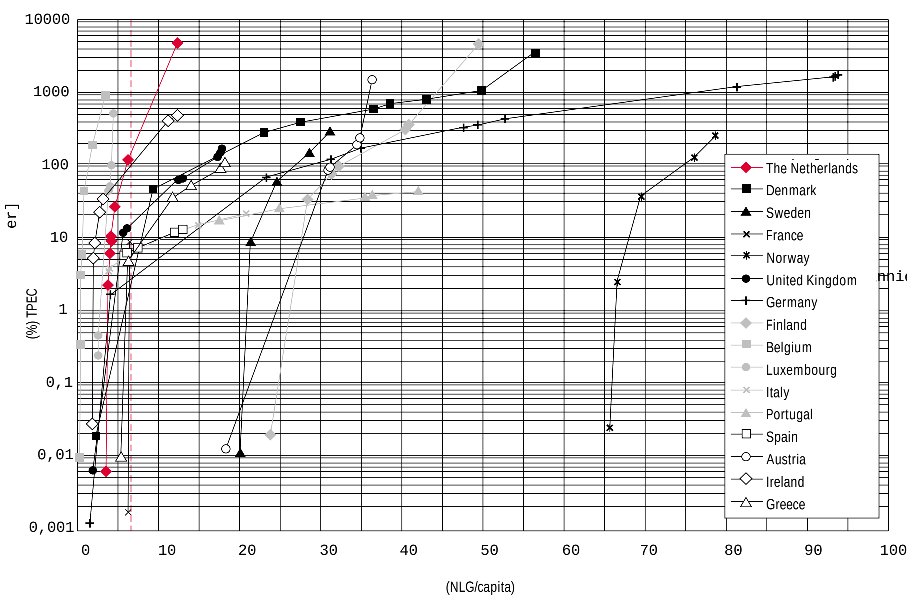


Figure 4.1 Cost curves for EU Member States Norway (primary energy according to the Eurostat Convention)

Cost curves were compiled for each EU Member State plus Norway. The method used to calculate the cost curves for the various countries from cost diagrams is described in section 2.4. The curves are based on figures calculated using the Eurostat Convention. This procedure is explained in section 2.5. Figure 4.1 illustrates the curve for the Netherlands vis-à-vis those for all the other countries. The Dutch 10% renewable energy target obtained using the substitution principle is roughly equivalent to 7% using the Eurostat Convention applied here. This is depicted on the graph as a vertical broken line. Although the results of the survey are too general to allow any conclusions to be drawn about the absolute values of cost levels, they do enable clear comparisons between the various countries.

A cost curve comparison of each country clearly shows that the costs to the Netherlands of meeting its renewable energy target are proportionally high. It will cost the Netherlands as much per capita to achieve this target as it would to achieve a level of approximately 35% in Austria and Germany, and almost 80% in Norway. These countries are likely to remain well below these percentages, including by the year 2020. The cost curve comparison also shows that Dutch per capita expenditure could be used to achieve a 20% level of renewable energy in Denmark, 13% in Spain and approximately 2% in Belgium. The targets in these three countries are either at or substantially above these levels (5% in Flanders, 35% in Denmark). Only two of the countries surveyed therefore operate more ambitious targets than the Netherlands. However, it should be pointed out that the instruments for Flanders are still at the planning stage and that the 'Flanders Renewable Energy Plan' still requires approval by parliament.

Figure 4.2a illustrates the cost curves for the Netherlands and the other Benelux countries. Among the Benelux countries, the Netherlands appears to have the best physical conditions for renewable energy. By comparison, neither Belgium nor Luxembourg have many opportunities for renewable energy (not much wind, limited hydropower). Moreover, those opportunities that are available are costly. Luxembourg also has a high level of energy consumption (it has the highest energy intensity in the EU), which means that it has to generate far more renewable energy in absolute terms to realise a specific percentage of renewable energy.

Figure 4.2b compares the cost curve for the Netherlands with those of six key countries for renewable energy. These countries are:

1. Denmark (model country)
2. Germany and ..
3. France as examples of large prosperous nations and as key European powers (axis countries)
4. the United Kingdom (Anglo-Saxon country)
5. Spain (a typical southern European state)
6. Sweden representing the large Scandinavian countries (Finland, Norway).

Countries with hydropower and biomass as natural resources can realise a substantial proportion of their energy supply renewably and at relatively low cost. France's cost curve effectively reflects a policy of maintaining the status quo. Denmark's cost curve (which is similar to that of the Netherlands in terms of size and location) is notable in being more favourable than that of the Netherlands. This is because its estimated technical potentials are higher (due to a longer coastline) and its costs lower (a more wind-rich country). It may also be that Denmark has taken a lead in the cost price learning curve with regard to the wind and biomass options.

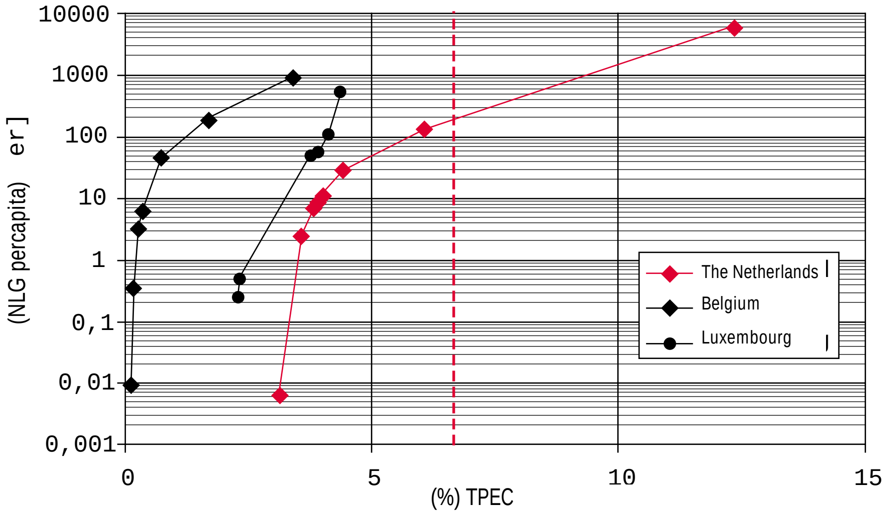


Figure 4.2a Cost curves for the Benelux countries (primary energy according to the Eurostat Convention)

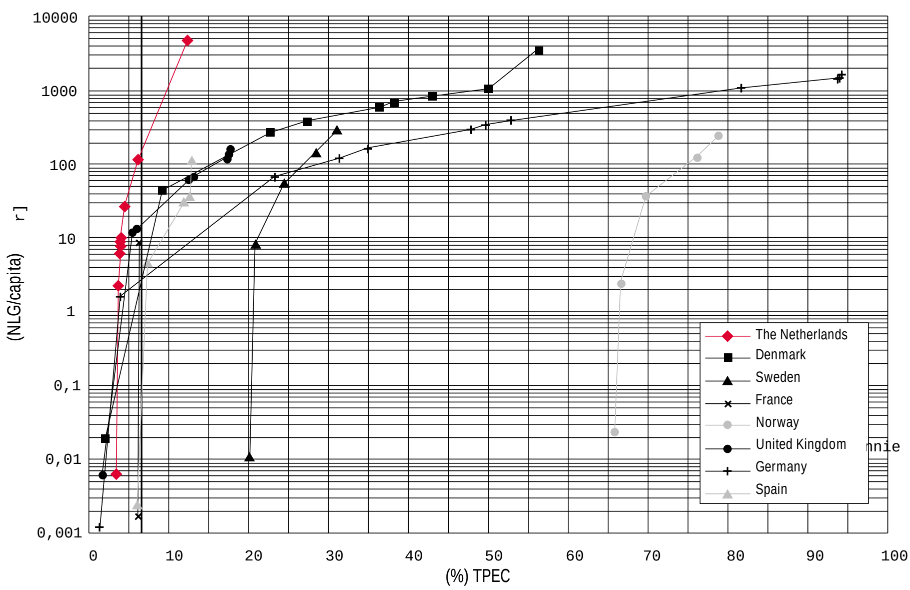


Figure 4.2b Cost curves for the Netherlands and six European key countries (primary energy according to the Eurostat Convention)

The cost curves clearly show that an international approach to the application of renewable energy would yield significant cost benefits. However, an international approach linked to imports and exports of renewable energy would be complicated by differences in the definitions, conventions, motives (e.g. development of national industry or infrastructure) and legislation employed in each country.

4.3 Motives and policy goals

There are many reasons why national governments want to stimulate renewable energy. The relative importance of these reasons differs markedly, including between the various countries. Table 4.1 shows the weighting given to these motives by each country.

Table 4.1 Key motives for stimulating renewable energy in the countries surveyed

	Belgium	Denmark	Germany	Finland	France	Greece	United Kingdom	Ireland	Italy	Japan	Luxembourg	The Netherlands	Norway	Austria	Portugal	Spain	United States of America	Sweden
Anticipated cost reduction				++	+++	++	++						+	+				
Diversification/security of supply/self-sufficiency		+					+	++	++	+	++	+	+	++	+++	++	+	
Sustainable development	+							+			+	+					++	+
Curbing emissions	+	++	++	++		++	+	++	+		+	+		++		+	+	+
Industrial development	+	+	+++	+	+	++	++	+		+		+	+			+++	++	+++
Employment (agriculture/forestry)			+	+++	++				++	+	+		+++	+	+++			
Keeping pace with EU partners						+		+			+							

This table lists the main motives cited during the interviews, although this is not to suggest that these are the only ones. In many countries, all the reasons are applicable. The scores give a picture of the weighting ascribed to specific motives by each country. Motives are usually reflected in measures, programmes or effects. This is clearly visible in Denmark and Sweden, where the motive of industrial development is underpinned by a wide range of export promotion activities and is also actually creating a strong position in the global wind energy and biomass market. Section 4.4 (deployment of instruments) discusses this in more detail.

Apart from technical potential and costs, the survey revealed one or two other factors that have a clear influence on national motives and policy goals. These factors and the way they interrelate are illustrated below and in Figure 4.3.

1. 'Conventional' fuel supply
2. The market and public acceptance of renewable energy
3. The restructuring of the electricity market
4. R&D capacity/expertise in the field of renewable energy.

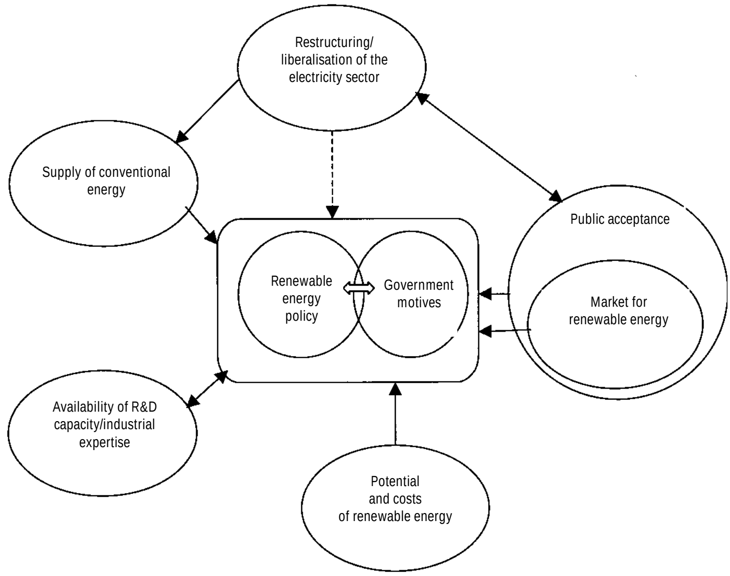


Figure 4.3 Factors influencing motives and policy

4.3.1 CO_2 emissions from 'conventional' fossil fuels

Renewable energy has to 'compete' with existing energy carriers. As well as providing a cost reference, these existing energy sources also provide a reference for CO_2 emissions. Renewable energy targets are often linked to climate goals (i.e. curbing CO_2 emissions). Levels of CO_2 emissions in each country vary widely, as illustrated in table 4.1.

A country's CO_2 emissions are defined by its energy intensity and fuel mix. In the Netherlands, there has been a shift away from coal in favour of natural gas in recent years. The CO_2 reduction arising from this shift has therefore already been exploited. Despite this, the level of emissions per head of the population is still relatively high (11.6 tonnes compared to the EU average of 8.6). Countries like Belgium, Denmark and Germany have similar emission levels. Yet due to their local fuel mix, they will achieve a greater proportional reduction in emissions though the deployment of renewable energy than the Netherlands. Denmark's electricity supply is heavily reliant on coal (see Figure 4.4) while Belgium and Germany consume a high percentage of oil and coal to generate heat (see Figure 4.5).

Table 4.2 Per capita CO_2 emissions (tonnes per annum). Source: IEA.

Country	1990	1995
Luxembourg	28.4	21.8
Denmark	10.4	11.6
The Netherlands	10.8	11.6
Belgium	11.0	11.6
Germany	12.4	10.8
Finland	10.8	10.7
Ireland	9.5	9.7
United Kingdom	10.2	9.6
Austria	7.7	7.5
Italy	7.2	7.4
Greece	7.1	7.3
Sweden	6.2	6.4
Spain	5.6	6.3
France	6.7	6.2
Portugal	4.2	5.1
EU average	8.8	8.6
United States of America	19.6	19.9
Japan	8.5	9.2
Norway	7.4	7.8

If the Dutch renewable energy target is met by 2020, it will manage to curb emissions by approximately 1 tonne of CO_2 per head of the population. Denmark's target for 2030 is equivalent to a reduction of more than 2 tonnes of CO_2 per capita, based on key indicators for the Netherlands (composition of the target, reduction in CO_2 emissions per unit of renewable energy). In view of the national fuel mix involved, Denmark will actually achieve a bigger reduction in emissions.

Countries with a high proportion of hydropower (such as Norway and Austria) tend to have low emission levels. In Norway, electricity (generated using hydropower) is used for indoor heating, among other things. Norway's natural gas stocks could however be used for local indoor heating instead and the unused electricity exported to countries with a high proportion of fossil fuels in their energy production systems. Internationally, this would lead to a reduction in CO_2 emissions, although in Norway itself emissions would rise.

Portugal has the lowest emission levels among the countries surveyed, despite being heavily reliant on oil. However, per capita energy consumption in Portugal is also low. Renewable energy can therefore be used as an environmentally sound alternative for growing energy demand linked to ongoing economic growth. CO_2 emissions in France are low due to its relatively low energy intensity and use of nuclear power.

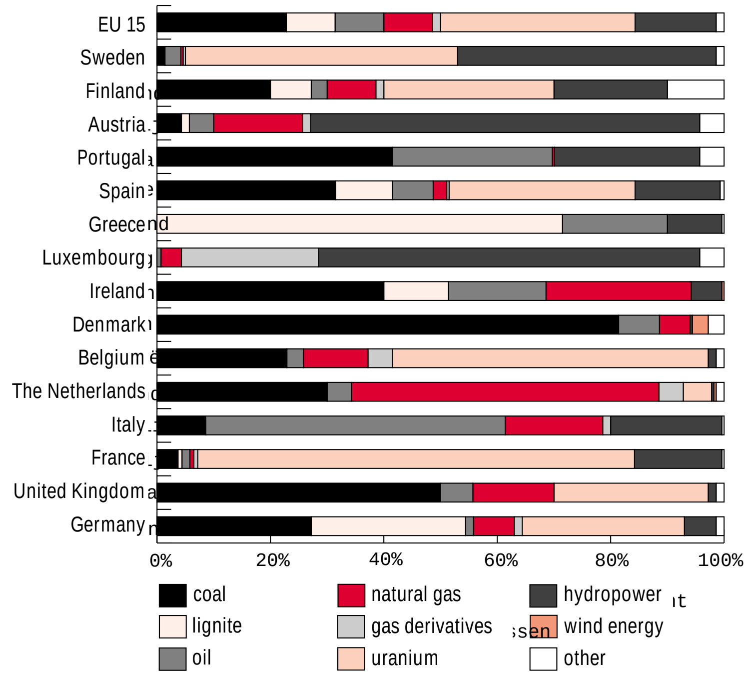


Figure 4.4 Fuel mix of the EU Member States (total electricity production for 1995)[5] [14]

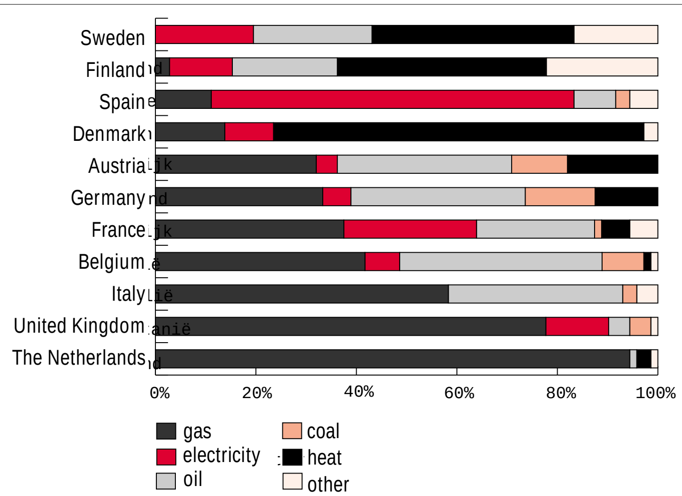


Figure 4.5 Energy carriers used for heating in Europe. Source: [15]

5 In Ireland, peat is included under lignite

4.3.2 The market for renewable energy and public acceptance of renewable energy

The positive environmental effects of renewable energy do not necessarily mean that it will be accepted either by potential consumers or by other, less directly involved players (governments, contractors, and local residents). In practice, public acceptance of renewable energy is complicated by the relatively high costs involved, lack of familiarity, the local nuisance factor and the negative impact of renewable energy options on the natural environment and landscape.

The perception that renewable energy projects damage the natural and physical environment and thus undermine tourism is significantly reducing its potential in several countries. Clear examples include Norway and Sweden (hydroelectric projects) and France (tidal energy in Normandy). Public opinion is one of the reasons why Denmark is concentrating its policy on offshore wind energy and biomass, since these options are regarded as less sensitive. Norway, Finland and Portugal have deliberately opted for demonstration projects using biomass, which are designed to provide experience of the entire implementation process through a region-based approach. This regional approach promotes co-operation between local players and local employment. Part of the purpose of these projects is to show that biomass utilisation can be an attractive option for the regional economy in order to increase public support for follow-up projects. These demonstration projects are therefore deliberately being carried out in regions with a relatively weak economy so as to maximise their chances of local acceptance.

Evidence from the Netherlands, Germany and the United States shows that consumers are prepared to pay more for electricity obtained from renewable sources ('green pricing') and to invest in renewable energy projects. Political support for, and social acceptance of tax incentives favouring renewable energy over fossil fuels is high in most of the countries surveyed. The successful application of domestic solar hot water systems in Greece is largely attributable to tax incentives. In the United States, tax measures relating to energy have so far been firmly resisted by Congress.

Energy companies can play an active role as initiators and promoters of renewable energy, as illustrated by the implementation of the MAP in the Netherlands. In many countries, the role of the energy distribution companies is limited to an obligation to buy electricity obtained from renewable sources at a fixed price.

One specific way of increasing public acceptance of renewable energy is the bidding system applied in the United Kingdom, Ireland and France. Under this system, initiators of renewable energy projects are themselves responsible for encouraging local acceptance and also integrate the associated costs into their prices.

4.3.3 Restructuring of the electricity market

The energy sector in the Netherlands is undergoing a process of liberalisation and restructuring to bring it into line with EU Directives. Some countries are further advanced in this process than others. Energy supply in the United Kingdom, Ireland, Norway (non-EU), Sweden and Finland in particular has been almost fully liberalised. Scandinavia operates the so-called 'Nordic market' which allows free international trade in electricity. The United States and Japan are also restructuring their electricity sectors. However, the EU's southern Member States are still far from liberalisation.

It is acknowledged not only in the European Union but also in the United States that restructuring and liberalisation will create both opportunities and threats for renewable energy. The main danger is that in a purely commercial energy supply market, companies will no longer be interested in research or in the higher cost renewable energy options. This will force the government to take a bigger role in supporting R&D and in creating a separate market for renewable energy. On the other hand, companies are likely to respond more readily to requests for renewable energy and individual producers of renewable energy will be able to act as (through) suppliers of renewable energy to the national grid via the 'third party access' principle.

4.3.4 Availability of R&D

The amount spent by national governments on developing renewable energy depends very largely on whether or not they have a national industry and an associated home-grown R&D capacity. In most countries, the biggest proportion of the renewable energy budget is spent on R&D due to its importance for industrial development, exports and jobs. Percentages of between 80 and 90% are not uncommon.

The results attached to this spending should primarily be viewed in terms of industrial, employment and export policy and less directly in terms of national efforts to stimulate renewable energy. The results of research, in the form of improved price-performance ratios, are of international significance.

The Californian Energy Commission only pays out 10% of the resources aimed at improving price-performance ratio and promoting R&D in the form of investment subsidies; the remaining 90% is paid out on a kWh basis.

4.4 Deployment of instruments

This section discusses the similarities and differences between the various countries in their choice of instruments for stimulating renewable energy. They are linked to the motives and policy goals covered in section 4.3.

The Dutch government has classified its measures to increase the proportion of renewable energy in overall energy supply under three themes:

1. improving price-performance ratio
2. stimulating market penetration
3. tackling administrative obstacles

Measures under the first theme focus on industrial technological development. Other countries give a more specific role to measures aimed at improving price-performance ratio in their market penetration strategies. In the United Kingdom, Ireland, France and Austria, for example, improvement of price-performance ratio is also encouraged through public calls to tender.

The other two themes aim to reduce the unprofitable aspects of renewable energy and create favourable market conditions. The Netherlands focuses more attention on the market, public acceptance and the removal of administrative obstacles than many other countries.

Table 4.3 illustrates the weightings given to the various instruments deployed in the different countries, as cited in the interviews. The themes listed are those cited for the Dutch context.

The effectiveness of the individual instruments is difficult to evaluate since their ultimate purpose (to generate renewable energy) is often a combination of many factors. It can however be concluded that the high reimbursement in Denmark and Germany for electricity sold to the grid has led to a spectacular growth in the domestic market. The bidding system in the United Kingdom, Ireland and France is also a particularly effective instrument, since because suppliers are paid their asking price, the planned capacity is effectively guaranteed. Under this system, improvement of the price-performance ratio and market penetration are very directly linked. The bidding system is described in annex C.

The Netherlands deploys a much broader range of instruments than any other country in the survey. However, breadth and effectiveness are not necessarily linked. Many countries prefer to concentrate their instruments on only one or two options, notable examples being Sweden (which has a strong accent on industrial development based on biomass energy) and Denmark (for which the same applies to wind energy and biomass (co-)firing linked to energy conservation).

Table 4.3 Instruments deployed in the countries surveyed

	Belgium	Denmark	Germany	Finland	France	Greece	United Kingdom	Ireland	Italy	Japan	Luxembourg	Netherlands	Norway	Austria	Portugal	Spain	United States	Sweden
Improved price-performance ratio																		
Long-term basic research	+		+	+					+	+		+					+	+
European research programmes	+					+		+			+	+						+
Long-term research contracts												+					+	
Competition							+	+						+				
Encouraging market penetration																		
Investment subsidies/loans			+			+		+		+	+	+		+	+	+		
Bid price allowance					+		+	+						+				+
Subsidies for commercial operationalisation		+	+		+				+		+	+				+	+	
Tax incentives	+			+	+	+				+	+	+						+
(Co)funding of demonstration projects	+	+	+	+		+			+				+	+		+	+	+
Liberalisation of the market						+	+						+					+
Long-term agreements governing implementation		+			+						+	+			+	+	+	
Information campaigns	+			+			+	+		+	+	+		+			+	
Provision of training/awareness-raising				+		+		+				+	+					
Legislation			+			+						+						
'Green' power			+									+					+	
Energy taxes												+		+				
Tackling administrative obstacles																		
Standardisation		+			+	+			+	+		+	+					
Certification					+	+						+						
Legislation						+				+		+				+		
Consultations on mega-locations												+						
Compiling location plans/resource assessments								+			+	+				+		

The various national governments and energy agencies use information and awareness-raising campaigns to increase public support for renewable energy, to correct preconceptions and to familiarise the public with the concept of renewable energy. This is done partly by drawing attention to the economic benefits (job creation, etc) and environmental gains associated with renewable energy. Efforts to remove administrative obstacles and promote market penetration are more highly structured in the Netherlands than in most other countries. This may be partly due to the fact that certain obstacles (lack of space, few economically viable options) are more pressing in the Netherlands than they are elsewhere. Norway, Austria, the United States and Japan have also given specific attention to boosting public support for renewable energy, though more recently and in a less structured way than the Netherlands.

The relationship between the government and energy companies in the Netherlands is unique. Dutch energy distribution companies play a key role in the development of renewable energy, especially the electricity options, in that they set the rates for sales of electricity to the grid and the conditions governing connection. In other countries, the government exercises greater control, either through state ownership (as in Ireland and France) or through legislation (as in Belgium, Germany, the United Kingdom, Italy, Portugal, the United States and Sweden). The Danish government has concluded agreements with the energy companies based on discussions about the feasibility of various options.

There is however scope for private initiative even in countries with strong government control. This effectively reduces the monopoly of the electricity producers and is generally yielding positive results (market penetration linked to cost price reduction and increased public support).

Like the Dutch government, the Austrian authorities have also concluded an agreement with the energy companies for a fixed percentage of renewable energy within the overall energy supply. The fixing of this percentage has sharpened discussion in the Netherlands about what precisely can be defined as renewable energy (are waste incineration plants as ‘green’ as wind turbines?) and about how trade in renewable energy can be structured and supervised. The Netherlands has unique experience in this regard. In the lead-up to a single European energy market, this experience could be used to guide a European debate on how to exploit opportunities for importing and exporting renewable energy.

Most R&D activities are funded by national governments, with some assistance from energy producers. All the countries have their own strategies for promoting R&D. Efforts to promote renewable energy in industrial R&D are of more than average importance in Sweden, Spain and the United States, however.

In almost all the countries surveyed, the unprofitable parts of near-profitable options are paid for by consumers and taxpayers. Relatively poor countries like Portugal, Ireland and Greece make substantial use of EU funding to pay for their development needs. Revenue from consumers takes the form of a surcharge on, or increase in, the energy price. The Netherlands uses the MAP system, in which consumers contribute to a fund via a surcharge on the energy price. This fund is used to finance energy conservation measures and renewable energy projects. A similar system is used in California by the California Energy Commission. The main differences between the systems used in the Netherlands and in California are that in California, all consumers contribute to the fund, the system is targeted solely at promoting renewable energy and the CEC involves the main implementing agents in the disbursement plan. In many countries, the energy distribution companies are obliged to buy electricity from renewable sources at a relatively favourable rate.

5 Conclusions

This report examines how the level of ambition of the Dutch policy on renewable energy compares with that of other countries.

The international comparison used in this report was based on the so-called cost diagram system (costs versus utilisable potential) developed by CEA for the Dutch energy sector and applied to the MAP and the IMES. This system provided a reliable basis for a positioning of the renewable energy situation in each country. The combined cost curves gave a broad quantitative review of where in Europe relatively low and relatively high costs must be incurred to exploit renewable energy options.

The definition of 'primary energy' was taken from the Eurostat Convention; this Convention has major benefits for international comparisons over and above the 'substitution principle' more commonly applied in the Netherlands. The 10% target according to the substitution principle is roughly equal to 7% measured by the Eurostat Convention. During the compilation of the cost diagrams, the actual situation was simplified by adopting an average price level for each option. This proved a highly workable approach for a comparative study of this kind. Studies that focus on the absolute cost of renewable energy at national or international level would need to conduct a more in-depth examination of the various cost levels per option.

Opinions about what constitutes renewable energy frequently differ from country to country. Most countries regard hydropower, wind energy, solar energy and, where applicable, tidal energy, wave energy and geothermal energy as renewable. 'Renewable' in this sense has two meanings: inexhaustible and releasing no harmful emissions. All the other options are open to discussion at the very least. The definition of renewable energy applied by the Netherlands is broad in that it includes options such as heat pumps, energy storage, waste incineration plants and open wood burning stoves. Although these are inexhaustible, they nevertheless involve some environmental load (they are therefore 'grey-green' as opposed to 'green'). None of the countries surveyed operates clear guidelines as to what can and cannot be defined as renewable energy. With the exception of France, energy from waste incineration is classified as renewable in all the countries surveyed. Many countries regard heat pumps and energy storage as forms of energy conservation rather than as renewable energy. The Eurostat statistics also exclude these options. The same applies to passive solar thermal energy. However, this is merely a question of classification; the clean nature of these options is not at issue.

Most of the countries surveyed do not have quantitative long-term targets for renewable energy. This makes it difficult to compare levels of ambition based on relative targets (Denmark, Ireland, Spain and Flanders).

The cost curve comparison of each country clearly shows that the costs to the Netherlands of meeting its renewable energy target are proportionally high. It will cost the Netherlands as much per capita to achieve a 7% renewable energy target as it would to achieve a level of approximately 35% in Austria and Germany, and almost 80% in Norway. These countries are therefore likely to remain below these percentages, including by the year 2020.

The cost curve comparison also shows that the Dutch per capita expenditure could be used to achieve a 20% level of renewable energy in Denmark, 13% in Spain, approximately 8% in Ireland

and roughly 2% in Belgium. The actual target for Ireland is below this (1% by 2010). In Spain, the target lies more or less at the level indicated (12% by 2010). The targets for Belgium and Denmark are however substantially higher than the percentage indicated (5% in Flanders by 2020 and 35% for Denmark by 2030). Only two of the countries surveyed therefore operate more ambitious targets than the Netherlands. However, it should be pointed out that the Flemish action plan on which this target is based is still awaiting approval by parliament. The fact remains, however, that the Netherlands is almost unique in formulating and setting quantitative targets.

Renewable energy targets are often linked to climate targets. The volume of CO_2 emissions reduced through the deployment of renewable energy is defined by the mix of conventional fuels it replaces. The Netherlands has a high share of natural gas in its energy supply. Combustion of natural gas releases fewer CO_2 emissions than the burning of coal or oil. This means that compared with other countries (which have a large share of coal and/or oil in their energy supply), the Netherlands has to generate a relatively large volume of renewable energy to achieve its proposed emission reduction.

Compared with other countries, the Dutch technical potential is small and the costs of opening it up are high. Hence the number of options being stimulated by the Dutch government is extensive compared with the other countries surveyed - as indeed they must be in order to meet the targets set. The Dutch government is investigating all options that are currently profitable or near-profitable. In some of these options, the target lies very close to the technical potential (waste, biomass, hydrocombined heat and power pumps). In the case of other options, the gap between the target and the technical potential is wider (notably wind energy and photovoltaic conversion). The Netherlands is also looking at options that will not be commercially viable for many years to come (photovoltaics and heat pumps).

The cost curves also clearly show that an international approach to the application of renewable energy would yield significant cost benefits. However, such an approach would be complicated by differences in the definitions, conventions, motives (e.g. development of national industry or infrastructure) and legislation employed by each country. In Norway, for example, electricity (generated using hydropower) is used for indoor heating, among other things. Norway also has natural gas reserves. If these reserves were to be used for local indoor heating instead, the unused electricity could be exported to countries with a high proportion of fossil fuels in their energy supply systems. Internationally, this would result in a reduction in CO_2 emissions, although in Norway itself emissions would rise.

An internal EU energy market will generate demand for trade in renewable energy. The experience currently being gained with the trade in green labels and ultimately perhaps also with renewable certificates will give the Netherlands a head start within the European Union.

The Netherlands deploys a much wider range of types of instrument than any other country. However, breadth and effectiveness are not necessarily linked. Many countries prefer to concentrate their instruments on only one or two options, notably Sweden (which has a strong emphasis on industrial development based on biomass energy) and Denmark (for which the same applies to offshore wind energy, biomass (co-) firing and energy conservation).

In the Netherlands, efforts to improve price-performance ratio are focusing mainly on industrial technological development. In other countries, measures to improve price-performance ratio and market penetration are sometimes linked. In the United Kingdom, Ireland, France, Austria and the United States, price-performance ratio is boosted through competitive calls for tender by or on behalf of the government (bidding system).

The effectiveness of the individual instruments is difficult to assess since their ultimate purpose (to generate renewable energy) is often a combination of many factors. Certainly, though, the high reimbursement for sales to the grid in Denmark and Germany has led to a spectacular growth in the domestic market. The bidding system is also a particularly effective instrument, since because suppliers are paid their asking price, the planned capacity is effectively guaranteed.

It is acknowledged not only in the European Union but also in the United States that the restructuring and liberalisation of markets will create both opportunities and threats for renewable energy. The main danger is that in a purely commercial energy supply market, companies will no longer be interested in research or in the more ‘costly’ renewable energy options. This will force the government to play a bigger role in supporting R&D and in creating a separate market for renewable energy. On the plus side, however, companies are likely to respond more readily to requests for renewable energy and individual producers of renewable energy will be able to act as suppliers of renewable energy to the national grid via the ‘third party access’ principle.

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Belgium	Ministry of the Flemish Community Department of Natural Resources and Energy J. Vereecke	
	Ministère de la Région Wallonne Direction Générale des Technologies de la Recherche et de l'Energie S. Switten	
Denmark	Ministry of Environment and Energy Danish Energy Agency O. Odgaard	
Germany	Bundesministerium für Wirtschaft M. Schulz	Forschungszentrum Juelich Gmbh, BEO H.J. Neef
Finland	Ministry of Trade and Industry Energy Department A. Aalto	VTT Energy P. Pirila, H. Holttinen, E. Alakangas
France	Ministère de l'Industrie J.P. Leteurtrois (head of SERURE)	ADEME J.L. Bal, B. Chabot
Greece	Ministry of Development A. Papathanassopoulos	C.R.E.S. Centre for Renewable Energy Sources M. Simantoni
United Kingdom	Department of Trade and Industry Energy Technologies G. Bevan	ETSU Renewable Energy Enquiries Bureau A. Brown, G. Staunton
Ireland	Department of Public Enterprise P. O'Neill, M. Crosbie	Renewable Energy Information Office Dr E. Mckeogh
Italy	Ministry of Industry and Trade General Directorate Energy Sources and Base Industry Dr A. Rega	Italian National Agency for New Technology, Energy and Environment Dr M. Garozzo
Japan	Ministry of International Trade and Industry New Energy Policy Division T. Makino	New Energy and Technology Industrial Development Organisation K. Yoshino
Luxembourg	Ministère de l'Energie M. Hoffman	Agence de l'Energie de Luxembourg J. Offerman
Norway	Ministry for Petroleum and Energy S. Roar Brunborg	NVE Norwegian Water Sources and Energy Administration H. Birkeland, KanEnergie, F. Salvesen

Austria	Bundesministerium für wirtschaftlichen Angelegenheiten O. Zach	Energie verwertungsagentur M. Heindler, M. Cerveny
Portugal	Ministry of Industry and Energy M.A. Ribeiro Paulo Directorate General for Energy J. Penaforte Costa	CCE M. Collares Pereira PhD
Spain	Ministerio de Industria y Energia, IDAE Departamento de Energias Renovables J. Donoso, B. Benavides	
United States	US Department of Energy Dr A.R. Hoffman	National Renewable Energy Laboratory E.C. Boes PhD, W.D. Short, B.G. Swezey
Sweden	Ministry of Industry and Commerce A. Axenbom	NUTEK, National Board for Industrial and Technical Development L. Tegnier

Annex B Data for cost diagrams

The Netherlands

			Substitution convention	
Options	Target 2020	Tech. pot.	Average costs	Ref. price
	[PJprim]	[PJprim]	[NLG/GJprim]	[NLG/GJprim]
Power production				
Wind energy	45	130	20	9
Wind energy: onshore				
Wind energy: offshore				
Hydropower: < 10 MW	3	4	14	9
Hydropower: > 10 MW				
Photovoltaics	10	497	167	21
Solar thermal electric				
Tidal energy				
Wave energy				
Potential combined heat and power				
Waste				
Waste: incineration [waste incineration plants]	45	75	8	9
Waste: organic household waste [digestion]	7	3	25	17
Waste: landfill gas [combustion engines]	1	1	5	9
Biomass	57		18	9
Biomass: residue or waste wood		10	15	9
Biomass: co-firing		20	8	9
Biomass: farm slurry (digestion)		4	15	9
Biomass: agricultural waste [combustion]		3	8	9
Biomass: energy crops		18	23	9
Heat production				
Active solar thermal	10	25	11	14
Passive solar thermal	2	48		14
Geothermal	2	18	8	6
Biomass: wood burning stove	8	8		12
Heat pumps	65	46	75	6
Heat storage	15	29	9	6
Total	270	939		

Options	Target 2020	Tech. pot.	Eurostat convention Average costs	Eurostat convention Ref. price
	[PJprim]	[PJprim]	[NLG/GJprim]	[NLG/GJprim]
Power production				
Wind energy	18	52	50	22
Wind energy: onshore				
Wind energy: offshore				
Hydropower: < 10 MW	1	2	36	22
Hydropower: > 10 MW				
Photovoltaics	4	199	417	53
Solar thermal electric				
Tidal energy				
Wave energy				
Potential combined heat and power				
Waste				
Waste: incineration [waste incineration plants]	33	55	11	12
Waste: organic household waste [digestion]	5	2	34	23
Waste: landfill gas [combustion engines]	1	1	7	12
Biomass	41		24	12
Biomass: residue or waste wood		7	21	12
Biomass: co-firing		15	11	12
Biomass: farm slurry [digestion]		3	21	12
Biomass: agricultural waste [combustion]		2	11	12
Biomass: energy crops		13	32	12
Heat production				
Active solar thermal	8	20	14	17
Passive solar thermal	2	38	17	
Geothermal	2	14	10	8
Biomass: wood burning stove	6	6		15
Heat pumps	52	37	94	8
Heat storage	12	23	11	8
Total	185	489		

Options	Target 2020	Tech. pot.	Substitution convention Average costs	Ref. price
	[PJprim]	[PJprim]	[NLG/GJprim]	[NLG/GJprim]
Power production				
Wind energy				
Wind energy: onshore		1	36	24
Wind energy: offshore				
Hydropower				
Hydropower:< 10 MW			30	24
Hydropower:> 10 MW		2	30	24
Photovoltaics		36	366	24
Solar thermal electric				
Tidal energy				10
Wave energy				
Potential combined heat and power				
Waste				
Waste: incineration [waste incineration plants]		21	115	24
Waste: organic household waste [digestion]				
Waste: landfill gas [combustion engines]				
Biomass		5		
Biomass: residue or waste wood		2	63	24
Biomass: farm slurry [digestion]				
Biomass: energy crops		8	74	24
Biomass: energy crops [biofuels]				
Heat production				
Active solar thermal			29	21
Passive solar thermal				
Geothermal				
Biomass: wood burning stove		2	58	21
Heat pumps				
Heat storage				
Total		77		

			Substitution convention	
Options	Target 2020	Tech. pot.	Average costs	Ref. price
	[PJprim]	[PJprim]	[NLG/GJprim]	[NLG/GJprim]
Power production				
Wind energy				
Wind energy: onshore	3	18	62	24
Wind energy: offshore	14	65	64	24
Hydropower				
Hydropower:< 10 MW			53	24
Hydropower:> 10 MW				
Photovoltaics		58	336	24
Solar thermal electric				24
Tidal energy		61	71	24
Wave energy				
Potential combined heat and power				
Waste				
Waste: incineration [waste incineration plants]	23	17	55	10
Waste: organic household waste [digestion]				
Waste: landfill gas [combustion engines]				
Biomass				
Biomass: residue or waste wood	51	41	55	10
Biomass: farm slurry [digestion]				
Biomass: energy crops	9	41	45	10
Biomass: energy crops [biofuels]				
Heat production				
Active solar thermal		120	40	25
Passive solar thermal				
Geothermal		80	42	10
Biomass: wood burning stove				
Heat pumps				
Heat storage				
Total	100	501		

Options	Target 2020	Tech. pot.	Substitution convention Average costs	 Ref. price
	[PJprim]	[PJprim]	[NLG/GJprim]	[NLG/GJprim]
Power production				
Wind energy				
Wind energy: onshore		54	30	18
Wind energy: offshore				
Hydropower				
Hydropower:< 10 MW		25	23	18
Hydropower:> 10 MW	515	450	15	18
Photovoltaics				
Solar thermal electric				
Tidal energy				
Wave energy		22	59	18
Potential combined heat and power				
Waste				
Waste: incineration [waste incineration plants]		5	21	25
Waste: organic household waste [digestion]				
Waste: landfill gas [combustion engines]		4	21	25
Biomass		30	21	25
Biomass: residue or waste wood		18	19	25
Biomass: farm slurry [digestion]				
Biomass: energy crops		8	26	25
Biomass: energy crops [biofuels]				
Heat production				
Active solar thermal				
Passive solar thermal		68	63	45
Geothermal				
Biomass: wood burning stove		30	22	45
Heat pumps		22	24	45
Heat storage				
Total	515	736		

Options	Target 2020	Tech. pot.	Substitution convention: Average costs	Ref. price
	[PJprim]	[PJprim]	[NLG/GJprim]	[NLG/GJprim]
Power production				
Wind energy				
Wind energy: onshore	25	25	21	18
Wind energy: offshore		72	10	18
Hydropower				
Hydropower:< 10 MW	9	9	15	18
Hydropower:> 10 MW	225	225	3	18
Photovoltaics			3	
Solar thermal electric				
Tidal energy				
Wave energy				
Potential combined heat and power				
Waste				
Waste: incineration [waste incineration plants]	18	20	29	32
Waste: organic household waste [digestion]				
Waste: landfill gas [combustion engines]				
Biomass	73	87	41	32
Biomass: residue or waste wood	131	131	12	32
Biomass: farm slurry [digestion]				
Biomass: energy crops		52	56	32
Biomass: energy crops [biofuels]				
Heat production				
Active solar thermal				
Passive solar thermal		38	32	56
Geothermal				
Biomass: wood-fired burners	43	43	37	56
Heat pumps				
Heat storage				
Total	524	702		

Annex C Bidding system

The United Kingdom, Ireland and France currently use the bidding system as a financial incentive to boost renewable energy. The following description is based on the system in the UK, although it is also broadly similar to that in the other two countries. The UK's bidding system is based on the 1989 Electricity Act, which authorises the Secretary of State to instruct regional energy companies (RECs) to buy a fixed proportion of their electricity from non fossil-based sources. This is known as the Non-Fossil Fuel Obligation (NFFO). The leading non fossil-based fuels in the UK are nuclear power and electricity from renewable sources. The NFFO effectively (temporarily) shields these renewable sources from the liberalised energy market. In Ireland and France, the bidding system applies only to renewable energy options.

The NFFO

The Non-Fossil Fuel Obligation effectively creates a market for options which would not otherwise be viable. The ultimate purpose of the NFFO is to allow the renewable options to compete with fossil fuel-based options. To this end, the government issues calls to tender at fixed intervals under the NFFO. The bidding process begins with a government Order specifying a purchasing obligation for the RECs (NFFO [sequence no]). These RECs have joined together to form a Non-Fossil Purchasing Agency (NFPA) for the purpose. The NFPA negotiates contracts with generators of electricity from renewable energy.

Competition

To speed up the marketability of renewable options, a competitive bid is organised during each NFFO round. Invitations to tender are issued to would-be generators of renewable energy. Each government Order specifies the quantity of renewable energy (in MW) that must be purchased. Once the various project proposals have been assessed in terms of their technical, administrative and financial viability, they are ranked according to their price per kWh. The lowest bidders are awarded a contract. The bids are analysed and evaluated in detail by the electricity regulator (Office of Electricity Regulations, OFFER).

Contracts (Power Purchase Agreement)

The contracts with producers of energy from renewable sources cover a period of 15 years. The main element in these contracts is an indexed, guaranteed price for electricity from renewable sources. This price is equal to the bid price submitted by the generating company. The difference between this price and the actual price is financed by adding a surplus to the price per kWh charged to consumers. This levy is collected by the RECs. The surplus charge is fixed by OFFER. The DG for Electricity Supply is responsible for regulating the tasks carried out by OFFER.

Participants

In principle, any organisation can submit a bid. When the NFFO was first established, most of these bids were submitted by ideological organisations that had links with the environmental movement. Now, however, an increasing number are professional, commercially-based companies. The RECs themselves may also submit bids, which they increasingly do either directly or through subsidiaries. A subsidiary of National Power (National Wind Power) is currently tendering for the latest contract.

These bids have led to spectacular cost reductions (see Figure C.1).

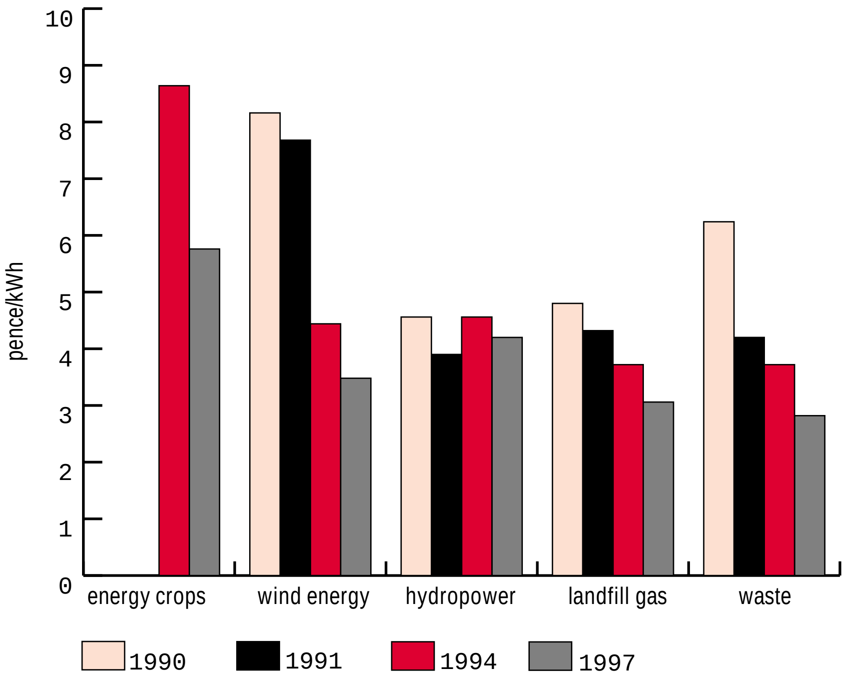

Figure C.1 Cost price movements in the United Kingdom following NFFO bids

During the last round (NFFO-4), bid prices were submitted for wind energy which were close to the market prices for energy from fossil fuel-based sources (wholesale contract price for generators). One gratifying side-effect of this rather unexpectedly large fall in prices is that a higher volume of renewable energy can be contracted for the same budget (that is, revenue from the surplus charge on consumers).

The Directorate-General for Energy (DGE) regularly commissions research to evaluate and underpin government policy. The purpose of these Energy Policy Studies is to communicate the results of this research to a wider audience. The series includes other publications with relevance to energy policy in the Netherlands.

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