Policies for efficient energy use and renewable energy

There are numerous reasons to implement energy policies:

- Regulation of energy supply systems (especially for electricity and natural gas);
- Development of indigenous energy sources;
- Development of specific energy technologies (e.g., nuclear energy);
- Security of energy supply (especially limiting the dependency on oil);
- Conservation of energy sources;
- Limitation of environmental effects of the energy supply system;
- Liberalisation of the energy market; and
- Sustainable development.

Many governments consider energy conservation or improvement of the energy efficiency and the application of renewable energy sources as an important way to reach at least some of these targets.

This chapter is devoted to the types of policy instruments that can be used to improve energy efficiency and stimulate the application of renewable energy. Similar instruments can be used for a broader range of policy targets.

First, barriers to improving energy efficiency and implementing renewable energy will be discussed (15.1). Second, policy instruments will be discussed, first in general (15.2) and then with a focus on energy-related policies (15.3). Finally, ways of analysing the effectiveness of policy instruments is described (15.4).

15.1 Barriers for energy efficiency improvement

Various barriers to energy efficiency and renewables can lead an ‘actor’ (whether a company, institute, household or individual) not to pursue these options. These can be:

- Technical barriers. Options may not yet be available, or actors may consider options not sufficiently proven to be worth adopting.
- Knowledge barriers. Actors may not be informed about possibilities for energy efficiency improvement. Or they may know about certain technologies, but not be aware that the technology might be applicable to them.
- Economic barriers. The standard economic barrier is that a certain technology does not satisfy the profitability criteria set by firms. Another barrier can be the lack of
capital for investment. The fact that the old equipment is not yet depreciated can also be considered an economic barrier.

- Organisational barriers. Especially in non energy-intensive companies, there are no well-defined structures for choosing and carrying out energy efficiency investments.
- The landlord-tenant barrier. There is a group of barriers related to the fact that the one carrying out an investment in energy efficiency improvement (e.g., the owner of an office building) may not be the one who has the financial benefits (in this example, the user of the office building who pays the energy bill).
- Lack of interest. For the vast majority of actors, the costs of energy are so small compared to their total (production) costs that energy efficiency improvement is not even taken into consideration. The other barriers can then be considered as derived barriers: for instance, if energy costs are small, companies will not spend much effort learning about the options for energy cost reduction.

The use of the concept ‘barriers’ is common in energy analysis. Nevertheless, it has its limitations since it is based on the assumption that when enough barriers are taken away, measures will eventually be taken. However, even when all the barriers are removed, there may still be no real ‘drivers’ present for energy efficiency improvement, meaning that the associated measures are not adopted.

### 15.2 Policy instruments

Three basic mechanisms can be distinguished to influence the behaviour of an actor:

- Communication mechanisms: Transfer of information, providing knowledge. The basic assumption here is that people will change their behaviour when they are better informed.
- Economic mechanisms: Providing financial incentives to stimulate desired behaviour or financial penalties to discourage undesired behaviour. The basic idea here is that people will optimise their welfare.
- Normative mechanisms: Setting standards for what people are obliged to do or forbidding certain behaviour. The basic idea is that people will act on the basis of jointly adopted ideas about what is appropriate in certain situations.

Governments using these mechanisms to influence the behaviour of actors apply what we call policy instruments. In practice, policy instruments often use a combination of all three mechanisms. Of course, not only governments try to influence behaviour; other actors also try to influence each other’s behaviour. Approaches to policy evaluation that take into account all these influences are called network approaches.

Government policy making can be described in a simplified way as a three-phase process (so-called rational-analytical approach):
1. In the policy formulation phase the policy problem is defined, the policy targets are set and the policy instruments are selected; this is often done by government and parliament. In this phase, all kinds of interest groups can be involved and exercise influence.

2. In the policy implementation phase, a government-designated agency translates the selected policies to actions that influence the individual actors. Examples of such intermediary agency are a municipality that enforces a building code, or an energy agency that carries out a subsidy programme. There are also interactions in this phase, generally between the government agency and individual actor.

3. In the final phase, policy affects the behaviour of the targeted actors (or fails to). The success of this phase may depend on the degree of interaction for example between a company and the implementing agency.

### 15.3 Policy instruments in the area of energy

To improve energy efficiency, the following policy instruments can be considered:
- Energy or carbon taxation
- Investment subsidies or fiscal incentives
- Emission trading
- Energy efficiency standards
- Negotiated agreements
- Energy efficiency labelling
- R&D subsidies

To stimulate the production of energy from renewable sources, similar policies can be applied; the following can also be considered:
- Feed-in tariffs
- Renewable energy portfolio standards

We will now discuss these types of policy instruments in more detail.

In the case of an energy tax, energy users have to pay a levy on top of the market price when they purchase an energy carrier. When this levy is proportional to the carbon content of the energy carrier, the tax is called a carbon tax. Automotive fuels are taxed in most countries, but generally only small levies are placed on other energy carriers. Only a few countries in northwestern Europe have substantial carbon or energy taxes for fuels other than automotive fuels, and even in these countries, energy-intensive companies are generally exempted.

The appeal of a general tax is that it leads to an optimum outcome: if one wants to reach a specific aim (e.g., reduction of carbon dioxide emissions), taxation related to that aim (in this case, a carbon tax) will – at least in theory – produce the lowest possible costs for society as a whole. On the other hand, a serious disadvantage of an energy or carbon tax is that there may be negative effects for specific groups, in this case energy-intensive
companies (especially if the tax is only introduced in a few countries), as well as on low-income households. Furthermore, to achieve the desired results, taxation levels have to be fairly high. One specific application of a carbon or energy tax is to raise funds for subsidy schemes.

Subsidies are often provided to encourage investments in energy-efficient or renewable energy technology. Part of the investment is refunded, either directly or in the form of tax reduction (fiscal stimulation). Investment subsidies are in place or have been in place in many countries, often refunding a fixed fraction of the investment. Another form of subsidy is the rebate: purchasers of equipment that is more efficient than average (e.g. efficient refrigerators, compact fluorescent lamps) get a fixed amount of money back.

General investment subsidies, which provide a fixed percentage of the investment as a refund, have the disadvantage of so-called free-rider effects: part of the subsidies (which can amount to 50% or more of the investment) are given to actors that would have made the investment anyway. The free-rider effect is greater when the subsidy is generic, applying to all technologies, whether highly profitable or unprofitable; but the free-rider effect tends to be smaller when the subsidies are directed at specific technologies. Investment subsidies can be effective, but in general the costs for the government are higher than for other policy instruments.

In order to stimulate the development of renewable energy, special feed-in tariffs can be provided for electricity from renewable sources that are delivered to the public grid. Normally, the revenues for electricity fed into the grid depend on the prevailing market price of electricity, but the production costs of renewable electricity are still higher than the wholesale price of electricity in many cases. Feed-in tariffs can take various forms, but the most common is a fixed rate per kWh delivered. Feed-in systems for renewable energy sources are in place in various countries, including Denmark, Germany and Spain, and have contributed greatly to the growth of wind and solar electricity production in Europe. In most cases the feed-in tariffs are paid via a surcharge on the electricity price. In comparison to investment subsidies, an advantage of a feed-in scheme is that payment is strictly dependent on performance: if no electricity is delivered, nothing is paid.

In the case of emission trading, each actor (in this case, a company) gets a certain number of emission allowances. The company needs to keep its emissions below this ‘cap’, but the emission trading system allows the companies to buy or sell their emission allowances. There are different ways the initial allowances can be set: the allocation of allowances can be made by the government, for instance based on historic emissions (this is called grandfathering), but the allocations can also be sold at auction.

Until recently, emission trading systems were rare. The oldest system of any significance is the emission trading system for SO₂ from power plants in the USA. However, in 2005 a large CO₂ emission trading system was introduced in the European Union, covering about
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half of the Union’s emissions (including both power plants and large industrial energy users).

Like emission taxation, emission trading theoretically leads to the lowest possible costs of total emission reduction. Furthermore, total emissions can be tuned exactly to a predetermined level. The most important problem – apart from administrative issues – is making a fair initial allocation to the various companies.

Energy efficiency standards prescribe minimum technical requirements for energy conversion systems and energy end-use systems. Two main approaches are prescriptive standards, which impose requirements on specific components of equipment, and performance standards, which impose requirements on the overall level of (specific) energy use.

Most industrialised countries have standards for the energy efficiency of new buildings, both prescriptive (e.g., insulation values of walls and roofs) and performance standards. A number of countries (e.g., the USA and countries in South East Asia) have standards for the energy efficiency of household equipment. In 1975, the USA introduced the corporate-average-fuel-economy (CAFE) standard for passenger cars: the average specific fuel use of all new cars sold by a specific car company needs to meet a certain level.

Energy efficiency standards can be very effective in reducing or limiting energy use, but they are rigid and especially prescriptive standards do not allow much flexibility. Furthermore, legislative processes can take much time, and an adequate system of monitoring is necessary to enforce compliance. Finally, companies are not stimulated to go beyond the energy efficiency standards.

Renewable energy portfolio standards – also called renewable energy obligations – require that a certain part of the energy supplied originate from renewable sources. The obligation can be assigned to different parties, but in the case of electricity, the energy suppliers are often responsible (see Section 5.5). The suppliers are required to show that a certain percentage of the electricity they delivered to the final consumers comes from renewable sources. As there is only one grid, such a partial delivery is not possible in physical terms, so a system of certificates is introduced. When a unit of renewable electricity is produced, a certificate is created, which is redeemed when the electricity is delivered to the final consumer. This procedure avoids double-counting. In most systems, the certificates are tradable, and suppliers who do not comply, have to pay a penalty.

Renewable energy portfolio standards are in place in the UK and in several states in the USA. Though the instrument is still relatively young and experience is limited, it could induce more competition between technology suppliers and lead to lower costs; however, it also introduces more uncertainty for investors.
Negotiated agreements – or voluntary agreements – are agreements between governments and actors or groups of actors to limit or reduce energy use, usually specific energy consumption. Agreements can refer to the actors’ own energy use, or the energy use of the equipment they produce. Voluntary agreements on the energy efficiency of industrial processes are in place in a number of European countries. The European Union has made voluntary agreements with car manufacturers and with selected household appliance manufacturers. For companies, an advantage of such voluntary agreements is that they can be formulated in a way providing maximum flexibility. From the point-of-view of the government, the advantages are better cooperation on the part of the companies and a generally faster achievement than with energy efficiency standards. In order to attain ambitious voluntary agreements, the government needs to have a good negotiating position and it should actively support the process of implementing the desired energy-efficiency measures. Regular monitoring and independent verification are also necessary.

Energy efficiency labelling. Labelling is a way of informing the buyers or users of the equipment about its energy performance. For example, in the European Union, the energy use of electric appliances and cars is clearly marked. Labelling has some effect on purchasing behaviour, but the effect is limited, as is often the case with information tools. Nevertheless, labelling is an important first step in policy development, and its effect can be enhanced when it is combined with other policy instruments, such as subsidies.

Instead of stimulating the use of energy efficient equipment that is already available, governments can also stimulate the development of new renewable energy technologies and new energy-efficient technology. This is usually done by providing R&D subsidies. In the past, the development of nuclear technology received much support and currently many countries are also supporting the development of renewable energy technologies; only a few countries provide substantial funding for R&D on energy efficiency.

Other policy instruments to stimulate the development of new energy technology include:

- Cooperative technology agreements: agreements on technology development between governments and private actors. An example is the Partnership for a New Generation of Vehicles, an agreement in 1993 between the US administration and US car manufacturers to jointly work on prototype cars to be ready by 2005 that would consume only one third of the fuel of cars produced in the early nineties.
- Technology procurement programmes: a government sets certain requirements for the equipment it purchases. The supplier that meets these standards best is rewarded, for instance, through a guaranteed purchase. This was applied in Sweden and led to the development of cheaper and more efficient heat pumps.
- Technology-forcing standards: a government may set energy efficiency standards for the long-term that cannot be satisfied with existing technology and requires additional technological development. An example is a requirement in California to have a certain fraction of zero-emission vehicles on the road in the year 2010.
15.4 Energy policy evaluation

Policy instruments can be judged on a number of criteria:

- **Effectiveness.** To what extent does the policy instrument contribute to reaching a specific goal? Before we can answer this, we must first determine to what extent the pre-set goal was achieved. This does not answer the question of effectiveness yet, since autonomous developments, other policies, or external factors, may have contributed to achieving the goal. The effectiveness of a policy instrument is the degree to which the policy instrument itself contributed to the achievement of the goal: to determine this, we must compare the achievement reached with the policy in place, with what would have been achieved had the policy not been in place.

- **Efficiency.** The efficiency indicates the effectiveness of the means required to reach the effect. In general, the means can be expressed in financial terms, determined for i) the government, ii) for the target group (those targeted by the policy who may need to invest), or iii) for society as a whole.

- **Side-effects.** Various negative (but also positive) side-effects may occur, like effects on employment rates, effects on income distribution, and effects on the country’s balance of payments.

Policy evaluation can take place before a policy is implemented (ex ante evaluation) or after the policy has been implemented or has been in place for some time (ex post evaluation). Both types of evaluation have their own complexities:

- Ex ante evaluation generally requires two separate actions: to estimate what will happen if the policy is not introduced, and to estimate what will happen if it is introduced. The difference will represent the expected effect of the policy; of course, both estimates require some kind of modelling.

- In case of ex post evaluation, one is at least able to determine what has happened with the introduction of the policy instrument (although careful monitoring is required). In this case, though, an estimate needs to be made of what would have happened if the policy instruments had not been introduced.

Evaluating the effectiveness of energy efficiency improvement policies is more difficult than evaluating the effect of many other policies for two main reasons:

- First, autonomous developments and the effects of changes in energy prices can be very substantial. This makes the question "what would happen without the application of a policy instrument" difficult to answer, but highly relevant for the outcome of the evaluation.

- Second, the effects being measured are fairly small; in general, policies directed at energy efficiency improvement have an effect of one or at most a few percent per year. Especially when the policy is directed at a mix of options for energy efficiency improvement rather than individual technologies, it is difficult to measure the effects.
Ex ante policy evaluation can be done using the scenario building models discussed in Chapter 14. Some types of instruments, such as energy and carbon taxation, can be relatively easily simulated with these models, but the models are not always directly suitable for the evaluation of other policy instruments; then ad hoc assumptions have to be included in the analysis.

Two particular approaches for the ex-post analysis of the effectiveness and efficiency of policies can be mentioned, the first from economics, the second from policy science:

1. *Econometric approaches.* The effect of a policy instrument can be estimated by comparing situations with and without the policy instrument. These can be different periods in the same country, different regions within a country, or different countries. Ideally, econometric analysis will consider all the other relevant factors that can influence the development that the policy has targeted. Econometric analysis is especially strong in the case of economic instruments, but it can also be used for other instruments, for instance by introducing a variable that has a value 1 or 0 depending on whether the policy instrument is in place or not (a so-called dummy variable). Reliable econometric analysis is only possible when the available datasets are large enough.

2. *Theory-based evaluation.* Another useful approach is so-called theory-based programme evaluation. This assumes that policy instruments are based on an underlying ‘theory’ about how the policy is expected to work, or at least some implicit assumptions about the mechanisms of policy instruments. Theory-based evaluation does not only consider the outcomes, but also monitors the functioning of the underlying mechanisms. This monitoring can subsequently be used, not only to evaluate the policy instrument, but also to improve the understanding of actors’ behaviour, ultimately improving the ‘theory’ and engendering more effective policies.

*Examples of policy evaluation.* There are many examples of both ex ante and ex post policy evaluation. A combination of the two is often used, and some examples are presented in Figures 15.1-3.

Many policy evaluations are carried out on a rather ad hoc basis, often at the request of government and government agencies, and they do not always have a systematic character. Further methodological development is necessary to come to better and more reliable evaluations of the effectiveness and cost-effectiveness of policy instruments.

*Rebound and take-back effects.* In one way or the other, policy instruments have indirect effects that can partly offset the effect of the policy instrument. We can distinguish:

- The rebound-effect. Energy efficiency improvement may lead to savings, which may in turn be spent on other products or services that may generate additional use of energy.
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- The take-back effect (sometimes also indicated as rebound effect). If energy efficiency increases for a specific energy function, the costs of this energy function become lower. The lower price may lead to a higher use of the energy function. An example is the water-saving shower head. People with this equipment have lower costs for water and energy per unit of time, which may tempt them to shower longer or more often.

Take-back and rebound effects will be small, generally less than 10% of the intended energy conservation effect. Still, the effects may be substantial for specific types of equipment or specific sectors.

![Figure 15.1. Evaluation of various effects on the energy efficiency improvement of room air conditioners in the USA. The dots describe the actual development of the average efficiency of air conditioners sold in the USA, on the basis of market surveys. The government tried to influence the efficiency by setting standards. At the same time, electricity prices increased over time. The researchers had data available on 735 models of room air conditioners available on the US market, with information on a range of characteristics, including costs. They carried out econometric analysis on this data set to estimate the various effects: i.e., the relation between the characteristics of the room air conditioners and external factors, like time, energy prices and regulation. Next, these relations were used for the simulation depicted here. Though energy efficiency standards only came into effect in 1990, the authors allowed effects before that time in their analysis. Source: Newel et al., 1999.](image-url)
The researchers investigated which fraction of the conserved energy was induced by the voluntary agreements. They did this by category, using both expert estimates (the breakdown into categories was more detailed than that shown in the figure) and a survey among companies. The part of energy conservation that was induced through the voluntary agreements is shown in the shaded area of the bars. The rest is autonomous or caused by other policies (like the environmental action plans of the energy companies in the case of CHP stimulation). Source: Rietbergen et al., 2001.

Figure 15.3. Ex ante evaluation of the effect of various policies on the introduction of energy-efficient lighting in the Swedish service sector.
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In Figure 15.3, the researchers used a model simulating the adoption of technology by firms. This model represents the extent to which firms adopt new technologies, depending on the pay-back-period of the technologies. A vintage model is used to take into account the annual extension or replacement of part of the lighting systems. Energy-efficiency standards are simulated by assuming that full compliance occurs (or that undercompliance by some firms is compensated by overcompliance by others).

DSM = demand side management by the energy companies: the energy company provides the customer an incentive to invest in an energy efficiency measure, in exchange for a fraction of the energy savings paid via the electricity bill. Source: Swisher et al., 1994.

Further reading


Final achievement levels

After having studied Chapter 15 and the exercises, you should:
- be able to describe barriers for energy efficiency and renewable energy and be able to illustrate these with concrete examples;
- know the three basic mechanisms through which behaviour can be influenced;
- know the various policy instruments in the area of energy and be able to illustrate these with concrete examples;
- know the criteria for policy evaluation, know the various approaches to policy evaluation, and be able to apply these in a concrete situation; and
- be able to explain what rebound and take-back effects are.

Exercises chapter 15

15.1. Policy instruments and mechanisms
For each of the nine policy instruments (section 15.3), consider in what way communicative, economic and normative elements play an influencing role. Often more than one type may have an effect.

15.2. Ecotax
In the Netherlands, there is an energy tax in place. This tax was originally introduced to promote energy savings and the introduction of renewable energy. In 2005, the energy tax in the Netherlands for small users amounted for:
- Natural gas € 0.15/m³ (price without tax for small users is € 0.35/m³);
- Electricity € 0.07/kWh (price without tax is € 0.11/kWh);
a. Calculate the amount of tax in Euros per tonne CO₂;
b. What is the relation of the level of this tax compared to the external costs of energy use (with regard to climate change)?
c. Estimate the effect of the tax on the energy use of households (see Section 5.7).

15.3. Free-rider effect of subsidies
For a company, 15 measures to save energy are available. The investments are 4, 8, 12, 16, 20, …, 56 and 60 k€, respectively. They all save 1 TJ per year. Neglect costs for operation and maintenance. The energy price for the company is 7 €/GJ. The company uses a payback time criterion of 3 years.
a. Which investments will be done without subsidies?
b. Which investments will be done with a 25% subsidy?
c. What is the free-rider effect of the subsidy for this company (which part of the subsidy has no effect on the investment behaviour)?
d. Do the same for a subsidy of 50%. Is the efficiency of the subsidy (from the viewpoint of the government) higher now?

15.4. Effects of subsidies
A subsidy not only affects the cost-benefit analysis companies make, but can also have other effects. Think of three mechanisms through which a company, via a subsidy, can be stimulated to take energy efficient measures.
15.5. The choice of policy instruments
Consider the policy instruments mentioned in Section 15.3, and investigate in what way these instruments can be applied for the following concrete goals:
1. Promoting energy efficiency in industry; and
2. Promoting the use of heat pumps in industry.
Make a table in which you show each of the policy instruments, and judge these instruments with regard to effectiveness, efficiency and side-effects.

15.6. Replacement of the energy premium
As of the year 2000, the Netherlands’ government gave subsidies to buyers of energy-efficient electric appliances (refrigerators, freezers, washing machines, etc.). Each year 2 million of these appliances are sold. These appliances typically use 200 – 300 kWh per year (electricity costs for households are 0.20 Euro per kWh). The subsidy amounted to 50 Euro for equipment that is 15% better than what is sold without the subsidy. Under the subsidy scheme, about 80% of the people chose energy-efficient appliances (assume that there are only two types of equipment on the market: standard and energy-efficient).

a. Discuss why the measure has free-rider effects.
b. Discuss the take-back and rebound-effects associated with the measure.

In 2003, the subsidy scheme was stopped because of the increasing budget deficit of the Netherlands government. Despite the lack of resources, the Netherlands’ government wishes to continue with the stimulation of the market penetration of efficient appliances. You are asked to give advice to the Netherlands’ government. Consider alternative policy instruments that make use of each of the following mechanisms:
c. communicative
d. economic
e. normative

For each of these mechanisms, describe an alternative policy instrument that is based on the mechanism. Give an estimate of the expected effectiveness of each policy instrument. Be as quantitative as possible.