Energy policy after 2020

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Economic arguments to pursue energy policy for non-climate related reasons

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Table of contents

Table of contents i

Summary i

1 Introduction 1

2 Market failures: a general description 5
- 2.1 What are market failures? 5
- 2.2 Public goods 5
- 2.3 External effects 6
- 2.4 Asymmetric information 7
- 2.5 Market power 7
- 2.6 Economic development 10
- 2.7 Other reasons for government intervention 10

3 Market failures and the objectives of energy policy 13
- 3.1 Introduction 13
- 3.2 Sustainability 13
- 3.3 Energy supply security 19
- 3.4 Affordability of energy 26
- 3.5 Conclusion 31

4 Instruments 35
- 4.1 Introduction 35
- 4.2 Sustainability 35
- 4.3 Energy security 46
- 4.4 Affordability 51
- 4.5 Interaction between instruments 56

5 Energy policy after 2020 59

Literature 63

Summary

This research investigates the contribution of sustainable energy policy and energy saving policy to the public goals of energy policy in the Netherlands. Not surprisingly current discussion about sustainable energy policy mainly focus on the contribution of energy policy to the goals of climate policy, i.e. the mitigation of climate damage as a result of the production and consumption of energy. This overshadows many other effects of sustainable energy and energy saving, which may also form a proper scope for energy policy. This study intends to highlight these other objectives for sustainable energy policy and energy saving. What are these objectives? What is their quantitative impact? Can they be used as an economic rationale for policy intervention?

To address this set of questions, a thought experiment is needed. We need to distinguish between the climate-related objectives of energy and the other motivations for sustainable energy and energy saving policy. This study examines the public goals of energy policy for non-climate related reasons through the lens of market failures. What are the market failures supporting these non-climate related goals as a public objective for energy policy? The main conclusions and policy recommendations from this thought experiment are summarized in the table below.

Table S.1 Non-climate related objectives shift the agenda for energy policy

Energy efficiency	Energy efficiency policies are a robust element of energy policies because of information and behavioral failures.
	Energy savings policies in transport are also important to improve air quality.
Renewable energy	Renewable energy primarily plays a role in climate change policies, however it might also be significant in longer term air pollution policies. Additional support for renewable energy at an early stage can be optimal in order to realize the benefits of lower future costs
Biomass	Biomass co-firing is not attractive if there is no climate policy because of the detrimental effects on air quality.
Security of supply policies	Sustainable energy is not a cost-effective option to further this goal. Market specific tools, trade policies and economic diplomacy are better instruments. Energy savings may prove a cost-effective option to increase security of supply.
Affordability	In addition to market regulation, innovation with respect to energy efficiency can also increase affordability.

Below, we discuss the results from our study in more detail for the three different domains of energy policy: sustainability, security of supply and affordability.

Air pollution as the main target for sustainability

Alongside climate change policy, the main market failure related to the sustainability objective is air pollution caused by emissions such as SO_2, NO_x and particulate matters (PM). Currently, emission reduction targets are being negotiated in Europe for air pollutants for 2020. These targets will replace the 2010 national ceilings on emissions from the NEC-directive. For those targets, end-of-pipe measures are a cost-effective option. Studies by IIASA, PBL and ECN show that renewable energy and energy efficiency only play a limited role in achieving these targets in a

cost-effective way. From the point of view of market failures related to the public goal of sustainable energy, therefore, there would be little reason to continue with the deployment of renewable energy such as the SDE+ and the biomass co-firing obligation. Innovation failures such as learning-by-doing (LBD) would also not be relevant for renewable energy policy, because these technologies have no role to play in reducing air pollutant emissions. There are reasons to continue with energy efficiency policies, because of market failures such as information and behavioural failures, as long as the benefits of these policies in terms of reduced energy costs outweigh the costs of these policies.

The 2020 targets for air pollutants however are not necessarily the optimal emission reduction targets which maximise welfare. Furthermore, optimal policies might require further reductions beyond 2020, for which renewable energy might be a cost-effective option. In contrast to climate change policies, long-term emission targets for air pollutants have not been formulated so far and cost-benefit studies on long-term air pollution are rare. The limited evidence that is available on welfare maximizing long-term air pollution policy indicate that renewable energy and energy efficiency technologies are important to achieve the optimal emission reduction targets in a cost-effective way, both for 2020 and beyond. The important role which both renewable and energy saving technologies will have in optimal air pollution abatement is a main driver for policies which address innovation failures. Addressing these innovation failures such as knowledge spillovers related to LBD can substantially reduce the future costs of emission abatement.

The optimal policies aimed at reducing air pollutant emissions will be a mix of market-based instruments such as emission trading, aimed at reducing emission from large stationary sources such as power plants, and deposit refund systems, standards such as emission standards for cars and local measures aimed at preventing the occurrence of local hot spots with high air pollution concentrations. This mix of policies will ensure that the necessary emission reductions are achieved in a cost-effective way. Furthermore, pricing will increase the costs of polluting technologies such as fossil energy production, which will make it more attractive to use clean technologies such as renewable energy and to increase energy efficiency. However, given the occurrence of information and behavioural failures such as, for example, asymmetric information and split incentives, which hamper the deployment of energy saving technologies, there will also be a need for flanking policy measures which address these information failures. Examples of such policies are information programs, labeling and appliance standards. Compared to the current policy mix addressed at energy efficiency, a policy context without climate change objectives will see a shift in energy saving policies towards energy savings which contribute most to the reduction of air pollutants such as, for example, energy efficiency improvements in traffic and transport.

Pricing of air pollutants instead of CO2 causes a shift in the deployment of renewable energy technologies. The use of biomass will not be an option because air pollutant emissions tend to increase when biomass is used. Instead, clean technologies such as wind, solar and geothermic energy will be used.

To reduce future costs of air pollutant emission abatement, policies are necessary to address innovation spillovers. Given the important role of clean renewable energy technologies and energy efficiency for long-term air pollutant emission abatement, innovation policies need to be addressed at those technologies. These policies will include R&D subsidies, prizes for clean innovations and deployment subsidies for clean technologies and energy efficiency measures. Given the current state of knowledge on optimal innovation policies and the uncertainty regarding learning rates for specific technologies and the role of learning-by-doing (LBD) versus learning-by-research (LBR), it is not possible to be more specific about optimal innovation policies. Given this uncertainty, it will be optimal to keep a large number of technology options open in order to be able to learn from future knowledge on promising technologies. An important difference with current deployment policies such as the SDE+ and the biomass co-firing obligation is that biomass based technologies will probably not play a role and therefore should not be included in R&D and deployment policies.

Security of supply

Security of supply in energy markets involves the capacity of the market system to adequately supply the demand for energy, now and in the future. Instruments promoting energy security come in many guises and serve not only economic but also political and strategic goals. This makes it virtually impossible to assess the optimal policy mix for the security of supply in quantitative terms. One may even ask what optimal means in this context as it is almost impossible to distinguish between first best and second best policy options. This is a field for which political and institutional preconditions matter.

This study focuses on the economic rationale for improving security of supply, acknowledging the importance of the political and institutional context. From the economic point of view an optimal policy would directly remedy the market failure causing security of supply problems. This would suggest employing general economic policies such as trade policy: the negative externality involved is a macroeconomic cost and not a market failure specific to the energy market. Social cost-benefit analyses such as De Joode et al (2004) demonstrate that market specific solutions such as building extra reserve capacity for oil and natural gas can be second best options. But the impact of these instruments is only felt for short term supply shocks. It does nothing to improve security of supply in the long term. For this aspect the other instruments are better suited. Investing in interconnection is such an instrument, but unfortunately a quantification of the impact of interconnection investments on security of supply is unavailable. Economic diplomacy and building international institutions for good governance in the energy markets also fall into this category.

Sustainable energy policy addresses the market failures accompanying security of supply indirectly. This policy option generates insufficient benefits in terms of improvements in the security of supply to warrant the costs. These policy tools are far too expensive, if the security of supply is treated as an isolated policy goal. Energy saving may be a no-regret option in this regard, given the fact it incurs negative social costs in some cases and simultaneously reduces import dependency.

For the security of delivery – indicating the quality and availability of energy services – first best policy options are regulatory schemes which incentivize network operators on the basis of estimates of the 'value of lost load' (VOLL). Q-factor regulation is an example of this approach. In principle this type regulation can fully accommodate the market failure associated with the security of delivery. Sustainable energy policy often causes additional network problems and therefore conflicts with the security of delivery as a policy goal. For energy saving this is different.

In principle energy saving creates excess capacity or reduces scarcity on existing energy infrastructures. It thereby improves the security of delivery. The development of smart grids may help to improve the cost efficiency of network operators by linking energy saving and energy use to capacity management on power lines.

Affordability of energy
Sustainable energy policy may have an impact on affordability as a policy goal, but this impact is only felt over the long term. It requires innovation and LBD, which means that the costs are generally incurred before the benefits can be reaped in terms of improved cost effectiveness. It is unlikely that sustainable energy contributes to the affordability of energy even for the period after 2020. For the short term (pre 2020) sustainable energy has a negative impact on energy prices and is therefore in conflict with affordability as a policy goal.

Energy saving is in many cases a no-regret option for households and firms. It improves affordability in a direct way by reducing the volume of energy consumed. This effect can be substantial. Larger increases in energy saving require more expensive technologies, which are not cost efficient and therefore decrease rather than increase purchasing power. In the long run innovation may improve the cost efficiency of these technologies. From this perspective promoting innovation for energy efficiency technologies should be on the agenda of energy policy for the period before and after 2020.

First best options to improve the affordability of energy are sectorspecific regulation and general competition policies. These policies directly address market power as a market failure.

A second best policy option is sector specific price regulation. This policy option only addresses the symptom and not the disease, which is a lack of competitive market pressure. But is is able to directly control the cost of energy to consumers by means of a price cap. Very likely the economic benefit of price regulation on affordability as a policy goal is modest.

General conclusion
The general conclusion of this study is that sustainability, energy security and affordability of energy only partially supports a case for sustainable energy if we ignore the case for climate change as a thought experiment. After 2020 air pollution is the most important reason to promote sustainable energy as a public goal of energy policy. For energy security and affordability the impact of sustainable energy may in fact be negative. Energy saving does contribute to sustainability, energy security and affordability of energy as public goals and achieves a positive contribution in a cost effective way.

1 Introduction

This research investigates the contribution of sustainable energy policy and energy saving policy to the public goals of energy policy in the Netherlands. Not surprisingly current discussions about sustainable energy policy mainly focus on the contribution of energy policy to the goals of climate policy, i.e. the mitigation of climate damage as a result of the production and consumption of energy. This overshadows many other effects of sustainable energy and energy saving, which may also form a proper scope for energy policy. This study intends to highlight these other objectives for sustainable energy policy and energy saving. What are these objectives? What is their quantitative impact? Can they be used as an economic rationale for policy intervention?

To address this set of questions, a thought experiment is needed. We need to distinguish between the climate-related objectives of energy and the other motivations for sustainable energy and energy saving policy. The study focuses on the second set of objectives and assumes that goals related to climate policy play no role. Why this deliberate ignorance of the factor that so dominates the current policy debate in energy? This allows us to employ the sharp analytical framework that economists use to discuss the rationale for government policy. This analytical framework is the theory of market failures. This study examines which market failures are involved in the non-climate related policy goals for sustainable energy and energy saving. In addition it assesses the design and effectiveness of the instruments falling in this category.

In order not to disrupt current policy discourse, this thought experiment focusses on energy policy after 2020. This offers a time frame suited to temporarily 'freeze' our concerns for the global climate and study other perspectives on sustainable energy and energy conservation, such as the affordability of energy to households and firms and the issue of energy security, as seen from a national perspective.

The end result of this report will be an advice on the policy objectives for and instruments of sustainable energy and energy saving policy alongside the domain of climate policy. This advice looks at policy from an economic perspective, but, needless to say, economic rationale is only part of the policy perspective on the energy market. The redistribution of welfare is a case in point. These other policy perspectives are mentioned, but do not form the core of this study. So our policy advice comes with an important disclaimer: there is more that rules the energy market than economic incentives.

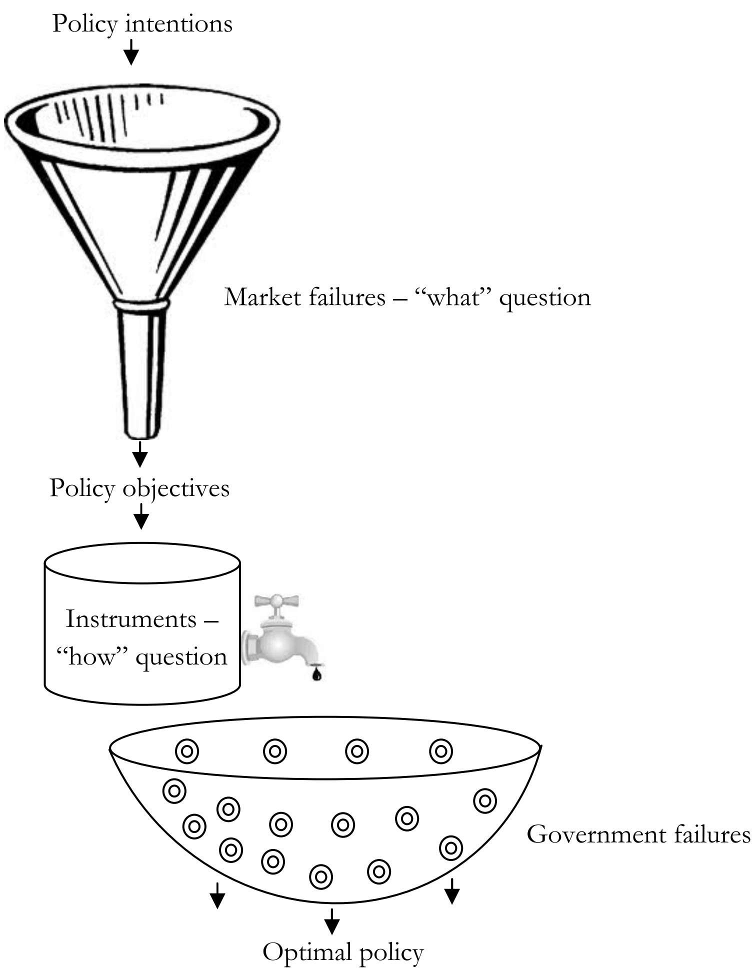
This study consists of four steps:

1. The analysis of market failures that support sustainability, energy security and affordable energy as the public goals of energy policy;
2. The analysis of instruments that can employed to remedy the market failures investigated in step 1;
3. The analysis of the effectiveness and efficiency of policy instruments investigated in step 2;
4. A discussion of the optimal policy mix for sustainable energy policy and energy saving policy when 'climate' is assumed to play no role in the policy process;

To address these issues this report first regards the "what" questions of a potential government intervention: Does any problem exists in energy markets and if so, why is that a problem? What are the public interests? What is the role of the government in achieving them? Furthermore, this study makes a link to the "how" question: Which instruments are in use that address market failures? Figure 1.1 demonstrates this process, with market failures acting as a funnel for policy objectives.

The starting point in the analysis is a thought experiment which assumes away the government: the market is left unregulated and no government intervention takes place. The "what" questions can then be reformulated: Are there problems that cannot be solved by market mechanisms (i.e. there are market failures)? What is the role for government intervention in correcting market failures? The underlying idea behind analyzing a fictive case is that if market failures exist and remain uncorrected, market processes will typically not result in welfare-optimal choices of prices, quality, or capacity. In these cases, policy intervention may be desirable.

Figure 1.1 The process of distilling an optimal policy mix



Optimal policies are ideally suited to redress market failures. However, the government does not operate in isolation. Inevitably government intervention has an impact on markets as well. This impact is described as a government failure indicating that policy actions are not costless to society. Ideally if the costs of policy intervention are lower than the benefits of diminished market failures, the policy in question contributes positively to economic welfare. The instrument with the lowest cost-benefit ratio may be termed optimal. The cost-benefit calculation acts as the final sieve to separate cost effective from less optimal policy instruments, as illustrated in Figure 1.1.

Beyond correcting for market failures, the government may also redistribute welfare. The question that arises in this context is not how much welfare should be redistributed, because this is by nature a political question. Nevertheless, economists can show whether there are reasons for redistribution via the energy market and whether it can be done in an efficient way. Another cause of government action can be paternalism, i.e., if the government believes that economic agents do not make decisions that are aligned with their own interest.

Chapter 2 describes the types of market failures that should answer the “what” question. Market failures come in many guises and shapes and have a different impact on the energy market. Chapter 3 therefore gives a quantitative estimate of the most dominant market failures in the energy market. This is done on the basis of existing data. The quantitative size of a market failure indicates the potential gain in welfare if government policy succeeds in reducing this market failure. This brings the “how” question into scope.

Chapter 4 lists and analyzes instruments that aim at correcting for the market failures in the energy market. This study does not review all types of economic policy, but focuses only on those instruments which fall under the scope of sustainable energy and energy saving policy. Comparing the effectiveness of those instruments and their costs of implementation to their potential impact on reducing market failures, demonstrates the effect on economic welfare. A positive impact indicates that this type of policy should be on the agenda for energy policies after 2020 for independent reasons and alongside the more familiar arguments related to climate change. A negative impact indicates that energy policy after 2020 should ignore this particular type of instrument. This is a conclusion based on economic argumentation. A negative cost-benefit ratio does not exclude political arguments to pursue policy goal such as energy security via economic diplomacy or income equality through the energy bill.

When analyzing the effects of instruments, it needs to be recognized that instruments are accompanied by government failures, as shown in Figure 1.1. A complete analysis of government failures is, however, beyond the scope of this research. Nonetheless, it needs to be taken into consideration that government intervention in other markets (such as patent protection) may negatively influence the efficiency of energy markets with respect to the three policy goals. We will consider these types of government failures under institutional barriers.

Chapter 5 concludes this study by answering the question what the scope is for sustainable energy and energy saving policy on the basis of non-climate related objectives.

2 Market failures: a general description

2.1 What are market failures?

From a welfare perspective, it is desirable that tasks are performed efficiently. Efficiency can be distinguished in the short- and long-term. *Static efficiency* is defined in the standard economics literature as the condition in which the short-term combined welfare of consumers and producers is maximized with production taking place at the lowest cost (cost-efficiency).[1] Static efficiency is the level at which resources are optimally allocated within the economy (i.e. allocative efficiency) and all firms are on their production possibility frontier (i.e. productive efficiency). *Dynamic efficiency* is defined as the extent of maximization of the present value of the consumers' and producers' static utility flow over the long term. More reliable products (i.e. increased capacity in electricity production and in the network) and improved production technologies (e.g. the presence of clean technologies) positively affect the expected future revenues. Unlike static efficiency, dynamic efficiency is realized as a result of innovation and investments.[2]

If markets cannot perform tasks efficiently, market failures are present. Four types of market failures can be distinguished: [3]

- public goods,
- positive or negative external effects,
- information asymmetry, and
- market power.

This chapter defines these market market failures as they occur in the energy market. The next chapter links them with the goals of energy policy and describes their quantitative impact on the energy market.

2.2 Public goods

Public goods are products or services that are both non-excludable and non-rivalrous. It implies that producing public goods by the market is not possible as no party may be excluded from the benefits and use of these goods (non-excludability) and usage by one consumer may not occur at the cost of the consumption of other consumers (non-rivalry). As a consequence, public goods are often linked with free riding behavior: consumers can benefit from the usage of public goods without contributing to (paying for) it. Examples of public goods are military defense or dikes.

1 Kocsis et al. (2009).
2 Promoting short-term goals may suppress long-term goals and vice versa. Such trade-offs manifest themselves in the form of the trade-off between static and dynamic efficiency. Theoretical and empirical literature widely point out the existence of this trade-off, claiming that in many situations achieving a high level of static and dynamic efficiency simultaneously is not possible. In case of low (high) static efficiency and high (low) dynamic efficiency, consumer prices are relatively high (low) and investments are also high (low).
3 For an overview of market failures see e.g. Baarsma & De Nooij (2006), Saline (2000).

As a commodity energy does not comply to the definition of pure public goods. In the first place, it is rivalrous. Depending on its source, energy is a scarce commodity. Worldwide resources of fossil energy are scarce by definition. Sustainable energy sources like wind are generated by a virtually unlimited power source. But that does not make energy a free commodity. At any point of time a heavy load at source A does decrease the consumption possibilities at source B when generation cannot deliver this peak demand. In addition the energy infrastructure has limited capacity and so generates scarcity in energy delivery.

Secondly, consumers can be excluded from the use of energy. A significant part of the world population lacks access to a proper source of energy. In developed markets people can be cut off from energy delivery by the network operator when energy bills are left unpaid. Free-riding is possible and in some countries like South-Africa appears endemic, but only occurs as the product of illegal behavior and not as the natural outcome of regular market operation.

2.3 External effects

It may occur that the production of goods and services has effects beyond that particular market (for instance on other markets or on the environment) and market players do not take these effects into consideration in their costs and benefits when making market decisions. These effects are called external effects or externalities. External effects have no market and thus no price. Therefore, the social costs or benefits that include these external effects are higher than the private costs or benefits, respectively. External effects can be negative or positive:

- *Negative externalities*: External effects are negative if the social costs of an activity are higher than the private costs of the same activity. A typical example is environmental externalities. A factory that is located next to a river may release polluting substances into the river without taking into consideration its negative effects on the population and the environment located next to the river. Consequently, environmental damage reduces consumers' welfare in the short- and long-term.
- *Positive externalities*: External effects are positive if the social benefits of an activity are higher than its private benefits and the market cannot internalize these benefits. An example is knowledge spillovers in the innovation process. If knowledge spillovers are not internalized, less innovation may occur than would be socially desirable. Knowledge spillovers lead to externalities if firms cannot pick all the fruits of their investments in knowledge and innovation because other firms use this knowledge without paying the full price for that. The reason behind this lies in the shortcomings of the patent system: it is not always possible to ask patent protection, and in case it is possible, it can be expensive to do so. Also, the period and the breadth of ideas, over which patents protect innovators, are limited. Consequently, the incentives to innovate become lower and a lower than socially optimal level of innovation may occur, thus reducing long-term welfare.

2.4 Asymmetric information

If one party in the market has more or better information than another party, there is a chance of suboptimal choices of price, quantity, or quality. Incomplete information can relate to prices (or demand), costs, risks, and quality. Two situations can be distinguished:

- *Moral hazard*:[4] The basic situation of moral hazard is the following. An actor (principal; less informed party) assigns a task to another actor (agent; more informed party). The agent receives compensation for completing the task. The principal eventually only sees the result. If the result is not sufficient, the principal cannot observe or verify the effort that the agent exerted in completing the task. In other words, the result can be influenced by random factors, but also by the risk-taking behavior of the agent, and ex post the principal cannot prove which one caused the failure. By knowing this, the agent may exert less effort or take more risks, and the outcome will then be less efficient. An example is a contract between a shareholder of a firm as a principal and the manager as an agent. To keep his job or reputation, the manager may take higher risks in the hope of achieving a higher profit, but at the same time, the chance of failure also increases. After observing the result, the shareholder cannot verify if failure had occurred due to the risk-taking behavior of the manager. For the same reason, the manager may put less effort into achieving the expected result.
- *Adverse selection*:[5] A condition for adverse selection is that an important characteristic of a product or the firm is only known by the firm ex ante, before contracts are signed. This characteristic can be for instance the quality of a product or service. Consumers are willing to pay for better quality, but they cannot observe it ex ante. Producers of a worse quality product will set a low price. Producers of a higher quality product would like to charge a higher price, but as consumers will not pay that higher price if they are not able to observe the increase in product quality. Consequently, the product with high quality is excluded from the market and only the worst quality (and cheap) product survives.

2.5 Market power

Market power reduces the pressure for competition. As market power increases, prices get higher, the quantity produced and sold may fall, and firms may invest less in innovation, quality and capacity. The end result of market power is a decrease in economic welfare, as the 'deadweight loss' increases. This is the sum of the loss in consumer welfare that emerges as a result of market power and the possible gain in producer surplus caused by market power. Competition becomes less intense in the presence of barriers to entry. There are several forms of entry barriers that are relevant to the energy market:[6]

Economies of scale

Economies of scale refers to the reduction in unit costs as the capacity or the production of a firm increases. In these markets, investments are often lumpy, involving large (sunk) investment costs. Due to economies of scale, only few firms may be able to grow and survive in the market, which is also the socially desirable market outcome. If economies of scale lead to market power,

4 E.g. Holmström (1979).
5 Akerlof (1970).
6 See e.g. Motta (2004).

then firms can charge a price above the efficient level or invest less than it would be socially desirable.

In energy markets economies of scale occur as a result of the cost structure of the industry. The network operators form natural monopolies, given that the duplication of the energy infrastructure is not viable from an economic perspective. The lumpiness of investments in energy generation likewise generate economies of scale and may therefore foster market power. Such problems multiply when energy firms are vertically integrated. In energy markets without government intervention, it is beneficial (it delivers efficiency gains) to vertically integrate some levels of energy supply: e.g. production and transport, supply and distribution, or production and supply. For instance, before ownership unbundling of energy distribution took place in 2005 in the Netherlands, the production, delivery, and distribution of energy had been in the hands of a few companies with large market shares. These companies had a (regional) monopoly position. Vertical integration may then lead to the exclusion of the suppliers of alternative (renewable) energy sources (i.e., producers do not get access to the distribution network).[7]

A second element of scale economies in energy markets is related to innovation. The innovation process of electricity generation and energy efficiency technologies requires investments in physical and human capital. Therefore, innovations are characterized by economies of scale. It implies that only a limited number of firms can effectively innovate in these markets, thus leading to the concentration of R&D firms. On the one hand, scale effects are welfare increasing as they lower the costs and increase the efficiency of these technologies. On the other hand, scale effects may lead to market power if firms' products are differentiated or the market continues to concentrate, due to entry barriers. In this case, the price may rise above the efficient level.

Switching cost

Consumers that intend to buy energy-efficient products or install devices for distributed generation may face high searching costs. To a less extent, learning new devices also causes costs for consumers. Therefore, consumers will adopt less energy-saving products or distributed generation devices, which may be an obstacle for energy conservation. Producers of 'dirty' products or technologies might then be left with a dominant position.

Cartels

A cartel is an agreement between competing firms about setting prices, quantities or market shares together in order to reduce competition and, as a result, gain a higher profit. Collusion of this kind occurs in any kind of industry and is therefore relevant to the energy market as well. There are no examples of price fixing or market division since the liberalization of the Dutch energy market in 2004, but anti-competitive behavior is a constant threat in any market.

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7 A network firm (e.g. telecommunication network operator) with integrated services in the downstream market may have incentives to exclude its downstream competitor (e.g. Internet service providers) from the market by charging a high access price for using its network or applying non-price discrimination. An upstream firm has such incentives if the gains in its downstream revenue are higher because of reduced competition than the potential gains of providing access to the network. A vertically integrated firm with upstream monopoly always has such incentives. See e.g. Bijlsma et al. (2008).

Mergers and acquisitions

The purchase of a competing firm or another firm in the vertical chain may deliver efficiency gains to the acquiring or merging firms. As a negative consequence, a horizontal market becomes more concentrated and prices increase. Instead, these firms may first also charge a lower price, with which they can exclude competing firms from the market, thus further increasing concentration. In the presence of entry barriers, firms raise prices above the efficient level. In the Dutch energy market Eneco in 2011 acquired Oxxio – one of the most successful new players in the market, which again increased the concentration ratio in the market. Concentration only slowly declined since liberalization in 2004 demonstrating the difficulty for new energy suppliers to quickly acquire sufficient market share.

Path dependency

Some markets are characterized by *path dependency and technological superiority*.[8] Often as a result of a historical development that is influenced by the accumulation of knowledge in R&D, technological development follows a pattern, called path dependency. Examples are innovations in the software industry. Consequently, the market gets locked-in in existing technologies or platforms and new and potentially superior products or technologies are not invented. Path dependency has influence on environmental externalities, knowledge spillovers, and network externalities but above all on market power: it creates a barrier to entry for competing technologies and suppliers. In the energy sector new developments in sustainable energy experience this barrier. Developments in fuel cell technology and electric cars is a case in point. The lack of loading infrastructure impedes the market introduction of these new technologies and 'locks' the market into the track of fossil energy based transporation systems.

Institutional barriers – patent system:[9]

The patent system aims at protecting the innovation of firms and providing the possibility for innovators to recoup R&D expenditure via a license fee. The license fee is a cost element for subsequent innovators. There are several reasons why a license fee supports market power.

- *The extent of license fee*: The nature of patents is that firms that hold patents have market power over their innovations. Therefore, a firm can charge a high license fee for the buyers of that innovation and impedes the entry of new innovations that are based on these first inventions. Examples are innovations for energy-efficiency and clean electricity generation. Also, it reduces complementary innovations with the ability to reduce CO2 emissions of 'dirty' technologies, such as carbon capture and storage.
- *First-mover advantage*: Firms that first asked patent protection have established a strong position over patents. First movers have a stronger market position toward new innovators.
- *Patent pool and cross-licensing*: Innovations in electricity generation technologies are sequential, that is, a new development may contain several earlier innovations of other companies. Larger R&D companies may have incentives to agree with each other about exchanging licenses at a lower fee or for free. Consequently, companies may form patent pools, within which they cross-license each other. This lowers the R&D costs of participating firms and put non-member firms into a disadvantageous position, potentially excluding them from the market.

[8] See e.g. Arthur (1989).
[9] Aalbers et al. (forthcoming).

2.6 Economic development

Support for innovation policies and industrial policies is often found in the argument that such policies promote economic development. This can be interpreted in a broad manner. Economic development can include different targets, such as higher economic growth, improved competitiveness or the creation of employment. Energy policies are also affected by this line of thinking. A case in point is the goal of the *Energierapport 2011* to simultaneously boost economic growth and clean energy ('groen en groei'). The question is: is there a market failure involved and can economic development therefore be seen as a proper public goal in the energy market? Needless to say economic development can be a proper public goal for other reasons and for other markets, such as the aim to boost employment, which remains one of the corner stones of Dutch labour market policies.

A relevant factor for this analysis is that economic development is only partially determined by the energy market. Economic growth depends on structural parameters such as labour productivity and labour supply. If there are bottlenecks impeding economic growth, the relevant market failures generally fall outside the scope of the energy market proper, such as knowledge spillovers or market power impacting on the innovation process. Take the example of employment. An investment program for the energy market creates new jobs in this sector. But the price mechanism secures that this new employment replaces employment elsewhere in the economy. The net effect on employment is therefore limited. A proper plan to boost employment should focus on market failures in the labour market directly. Economic development is therefore at most a side-effect of energy policy, but cannot be a main target, if we judge this public goal in terms of market failures. Again there may be other reasons to justify the effort to boost economic development.

2.7 Other reasons for government intervention

So far, we have discussed economic rationales for policy intervention in the energy market. In addition to these economic arguments, there exist political reasons. For example, a too large dependency on oil imports from Middle-Eastern countries might be viewed as undesirable because it can restrict foreign policy vis-à-vis these countries. Energy policies reducing the share of imports from these countries also helps to reduce the polical dependency. The following political arguments may support government intervention in the energy market.

Paternalism

Paternalism arises in the case of consumer, rather than market failure. Compulsory use of safety belts may be an example of this. Consumers may tend to underestimate the risk of being involved in a car accident, the consequences of this, or the extra safety that a belt supplies. Therefore, they may use safety belts less often than is good for their *own* welfare. Providing information or making the use of seat belts obligatory may be a government response to such a consumer choice.

A question is whether consumer failure arises on energy markets. An example may be energy saving actions *that pay off to consumers*, but which are nonetheless not undertaken. It is an empirical question whether such behavior actually occurs. It does *not* refer to a conscious decision of a consumer *not* to invest in energy savings despite knowing that such an investment pays off. It does refer to unconscious 'decisions' (inactions) or an unconscious lack of efforts to obtain information. If such type of behavior occurs, it may have implications for sustainability, security, and affordability.

Welfare (re)distribution

Redistribution always occurs against some cost: the cost of collecting taxes, and the fact that it is practically impossible to devise a tax scheme that does not introduce market distortions. Given a social objective for redistribution of welfare and incomes, the question is how to achieve this against minimal cost. Taxes that are introduced to internalize negative external effects, for example, are welfare enhancing if they prove effective in curtailing emissions and simultaneously add to a government's budget, part of which is allocated to welfare distributions of some sort.

Directly influencing prices or quantities *with the objective of welfare redistribution* can only be efficient if the goods or services concerned are consumed *specifically* by the section of the population that a redistribution policy seeks to address. An example is the UK which sponsors energy conservation measures for lower income groups with the explicit goal to support the income position of these groups. This leaves open the question if redistribution goals are more efficiently achieved outside the energy market.

A specific form of redistribution concerns welfare redistribution *amongst generations*. In the energy market, depleting natural resources now, or emitting CO_2, may go at the cost of future generations. Actions like these that may lead to suboptimal social welfare over generations are in principle already covered by the market failure mechanism of *external effects*. However, from a government perspective it introduces the question of how to weigh effects over generations.

Second, regulation in a market may contribute to the occurrence of market failures, in particular to market power. Strictly speaking, these institutional barriers are government failures in other markets. However, they need to be considered here as they may amplify the effects of market failures. For instance, the patent system that aims at protecting the innovation of firms may increase the market power of firms that hold patents. By a patent, the firm gains a monopoly position over its innovation. Therefore, it can charge a high license fee for the buyers of that innovation.

3 Market failures and the objectives of energy policy

3.1 Introduction

Energy policy in the Netherlands sets three "public goals": sustainability, energy security, and affordability (Energierapport 2011). Even if energy policy disregards climate change as a negatieve externality, several other forms of market failure may occur in energy markets. This chapter discusses these market failures and relates them to the three policy goals. Further the quantitative impact of these market failures is analyzed indicating where the potential for welfare improving energy policies lies. The next chapter then investigates whether policies supporting sustainable energy and energy saving are effective instruments to remedy the market failures discussed below and reap the potential for welfare improvement.

3.2 Sustainability

The policy goal of sustainability aims at a transition to a cleaner supply of energy, with the ultimate goal of achieving a CO_2-free economy by 2050. The concept of sustainability is, however, broader than only avoiding climate change. It also includes tackling other environmental problems, such as air pollution. In that sense, negative environmental externalities are still the dominating market failure.

Two developments in the energy market are considered as important contributors to the reduction of environmental problems and thus achieving sustainability: renewable energy and energy efficiency and conservation. However, these components are also bound to market failures that delay the effective use of newly developed technologies. What are the obstacles of the wide-spread use of renewable energy sources and energy efficient technologies and products? Currently, *clean electricity* can only be produced by expensive technologies, such as wind turbines and solar PVs. Consequently, these technologies are still rarely adopted in the Netherlands. The most relevant market failure, therefore, relates to the innovation process: knowledge spillovers are present, which are amplified by some imperfections of the patent system. To a lesser extent, the development of renewable energy technologies is also impeded by the imperfect capital market and market power.

The other driver of sustainability is *energy efficiency*. It can be defined as the amount of energy services (for instance, heating, lighting, or motion) provided by a unit energy input.[10] Energy efficiency increases if the same amount of energy input can produce more energy services. Energy efficiency is different from *energy conservation*. The latter term refers to a reduction of energy demand.[11] The relation of the two concepts is not straightforward as energy efficiency

10 Gillingham et al. (2009).

11 Insufficient energy conservation is mainly the result of behavioral (or consumer) failure (i.e., consumers do often not make informed choices). This aspect will be considered in the section on paternalism and welfare distribution.

does not necessarily lead to energy conservation, even though both contribute to sustainability. The markets for energy efficient technologies and products are primarily characterized by knowledge spillovers and to a lesser extent by imperfect capital markets. Energy conservation is bound to information problems and switching costs.

Below, we will discuss in more detail the main market failures in the domain of sustainability. These market failures are: negative and positive externalities, information failures and asymmetric information and behavioral failures. This chapter explains these market failures in more detail and offers examples.

3.2.1 Market failures related to sustainability

Negative environmental externalities
Environmental externalities occur when market players do not take the consequences of their actions on the environment into consideration. In the field of energy, the major environmental externality is climate change, caused by the emission of CO_2. This externality will *not* be taken into account in this analysis. The main other environmental externalities related to energy are air pollution, surface subsidence and other damage caused by mining activities, skyline pollution, noise, and loss of biodiversity.

Air pollution is the second major environmental externality caused by energy production and energy use next to climate change in terms of the costs it imposes on society. Air pollution causes both health hazards and biodiversity loss. Local air pollution consists of high concentrations of particulate matter (PM) and tropospheric ozone. This affects people's health and results in premature deaths. Local air pollution is caused by emissions of NO_2 and of PM. These are to a large extent the result of the use of fossil fuels in transport and electricity generation. In addition to local air quality, air pollution can also lead to acidification of lakes and forests. Energy use contributes to these problems through the emissions of SO_2 and NO_x. In contrast to local air quality, where emissions mainly affect the direct neighborhood, emissions of SO_2 and NO_x can affect regions far away. For example, emissions in the UK cause acidification of Swedish lakes. Therefore, there are European ceilings for each member state for the emissions of SO_2 and NO_x.

Other negative environmental externalities are increased costs from damage to buildings due to the subsidence of the surface caused by the extraction of gas in for example the Slochteren area[12], damage from mining activities such as oil spills and the discharge of cooling water from power plants in nearby rivers, causing eutrophication and therefore reducing biodiversity.

Generation of renewable energy, intended to reduce negative externalities such as polluting emissions from the use of fossil fuels, can also give rise to other negative externalities. Wind turbines can cause noise nuisance, fatalities to birds (and bats), and wind farms are often perceived as skyline pollution.

12 However, to what extent this is a negative externality is questionable since people encountering damage to their buildings can inform the company extracting gas from the Slochteren gas fields to apply for a compensation (NAM, Provincie Groningen, Provincie Drenthe, 2004)

Positive knowledge spillovers

The market for innovation can be characterized by knowledge spillovers. If users of an accumulated knowledge do not pay for the use of this knowledge, developers cannot gain the fruits of their effort. Then external effects exist. Is this the case in energy markets? An important characteristic of innovations in electricity generation and energy efficient technologies is that knowledge spillovers in each technology type (e.g., clean and dirty) are both sequential and complementary. Sequential means that each innovation builds on the preceding innovation in the same technology type, i.e. innovators "stand on the shoulders of giants". Complementary means that knowledge spills over between firms within the same (either clean or dirty) technology type, but not between these types. Currently, innovations in these technologies are protected by patents. Since patents are rather restrictive (too long and broad) and can be used at an arbitrarily high license fee charged by the patent holder, less follow-on innovations may be developed than it would be socially desirable.[13]

Learning-by-doing and learning-by-research: The knowledge accumulation in the innovation process is influenced by how fast the market 'learns' new technologies. Learning depends on the costs and benefits that the developing firm can make. These costs and benefits are related to the production and the installed capacity of these technologies (scale effects; *learning-by-doing LBD*), and the extent of R&D expenditure (*learning-by-research, LBR*). The further a technology is in its learning process, the cheaper it becomes and the more consumers will adopt it (Figure 3.1). For instance, carbon-based technologies are far in their learning process and thus cheap. Clean technologies are in an earlier stage of learning and rather expensive.[14] Besides, clean technologies differ in their costs. For instance, solar PVs produce electricity more expensively than onshore wind turbines (see Table 3.1).

Figure 3.1 Different energy related technologie are in different stages of maturity

Stage of Technology Development	Early R&D, Proof of Concept	Demonstration & Scale-Up	Commercial Roll-Out	Diffusion & Maturity
Examples of Clean Energy Sectors	• Advanced battery chemistries • Algal biofuels • Artificial photosynthesis • Fuel cells (automotive) • Hydrogen storage • Integrated biorefineries • Material science • Next-generation solar • Osmotic power • Synthetic genomics	• Carbon Capture & Storage • Cellulosic biofuels • Enhanced geothermal power • Floating offshore wind • Fuel cells (distributed generation) • Grid-scale power storage • Marine (wave, tide) • Plug-in hybrids • Solar Thermal Electricity Generation • Smart grid	• Biodigestors • Coal-bed methane • Fuel Cells (UPS) • Heat pumps • Hybrids • Industrial energy efficiency • LED lighting • Offshore wind • Solar photovoltaics • Small-scale hydro • Smart meters	• Building insulation • Bicycles • Compact Fluorescent Lights • Condensing boilers • Large-scale hydro • Municipal solid waste • Onshore wind • Public transport • Sugar-cane based ethanol • Traditional geothermal power • Waste methane capture

Source: WEF (2010, p. 35)

[13] See Aalbers et al. (forthcoming) for an overview that is based on Acemoglu et al. (2012).
[14] Lindman & Soderholm (2012).

Table 3.1 The most expensive technology, solar PV, has the fastest learning process, while the relatively cheap onshore wind has a slower learning rate

Technology	Average cost between 2010-2020 $2009/MWh	Learning rate[15]
Onshore wind	85	7%
Biomass	131	5%
CSP	207	10%
Solar PV (large scale)	280	17%

Source: World Energy Outlook 2010[16]

Both LBD and LBR will be subject to the knowledge spillovers described above. The knowledge acquired through learning, either by research or by deploying a new technology, cannot be fully appropriated by the firm which develops the knowledge, part of it will spill over to other firms. Consequently, the level of knowledge creation will be less than optimal.

Path dependency: In the market for innovation in electricity generation technologies, there is enormous knowledge accumulated in carbon-based generation. For historical reasons, path dependency of 'dirty' technologies exists. As a consequence, the economy may get locked in dirty technologies.[17] In general, innovation in electricity generation is characterized by sequential and complementary innovations. Therefore, not only the market for dirty technologies, but also the market for green technologies is prone to path dependency.[18]

Asymmetric information

Information asymmetry between consumers and the firm:[19] Energy efficiency and conservation are currently considered as important components of achieving public goals in energy markets. Rational consumers are willing to buy products that consume less energy. Without obligations to label the energy use of products and houses, consumers may not have sufficient information about their quality. For instance, real estate agents have incentives not to reveal the energy efficiency of a large energy user house and set a high price for that. In this case, only cheap and less energy-efficient houses may remain in the market (adverse selection).

- *Institutional barriers – patent system*: [20] The patent system aims at protecting the innovation of firms and providing the possibility for innovators to recoup R&D expenditure via a license fee. The license fee is then a cost element for subsequent innovators. There are several reasons why a license fee can lead to market power.
- *The extent of license fee*: The nature of patents is that firms that hold patents have market power over their innovations. Therefore, a firm can charge a high license fee for the buyers of that innovation and may impede the entry of new innovations that are based on these first

15 The learning rate can be interpreted as how many percent the costs of a technology will reduce if the used capacity of this technology doubles.
16 http://www.iea.org/publications/freepublications/publication/weo2010.pdf
17 Theoretical evidence: Acemoglu et al. (2012), Unruh (2000). Empirical evidence: Noailly & Smeets (2012), Lanzi & Sue Wing (2010).
18 Empirical evidence: Noailly & Smeets (2012), Johnstone et al. (2010). Related article: Aghion et al. (2011).
19 Gillingham et al. (2009).
20 Aalbers et al. (forthcoming).

inventions. Examples are innovations for energy-efficiency and clean electricity generation. Also, it reduces complementary innovations to curtail the carbon emission of 'dirty' technologies, such as carbon capture and storage.

- *First-mover advantage*: Firms that first asked patent protection have established a strong position over patents. First movers have a stronger market position toward new innovators.
- *Patent pool and cross-licensing*: Innovations in electricity generation technologies are sequential, that is, a new development may contain several earlier innovations of other companies. Larger R&D companies may have incentives to agree with each other about exchanging licenses at a lower fee or for free. Consequently, companies may form patent pools, within which they cross-license each other. This lowers the R&D costs of participating firms and put non-member firms into a disadvantageous position, potentially excluding them from the market.

Behavioral failures

Next to market failures, behavioral failures might also constitute a reason to introduce policy measures. The concept of behavioral failures has emerged in the behavioral economics literature and has a strong foundation in psychology. Behavioral failures in the field of energy focus on systematic biases in consumer decision making that may be relevant to decisions regarding investment in energy efficiency. The main topics from behavioral economics which have been applied to energy consumption, are prospect theory and bounded rationality (Gillingham 2009 and Lavrijssen 2012). Prospect theory suggests that consumers do not value gains and losses on their own merits but relative to a reference point, which is often the status quo. Moreover, they can value losses different from gains, which will also distort optimal behavior. In the concept of bounded rationality, consumers can be cognitive constrained in their decision making, which can also lead to deviations from optimal utility maximization.

3.2.2 Quantification of market failures related to sustainability

In this section, we will focus on the level of air pollution for both current and optimal policy targets levels. Current target levels are the policy goals for emission reductions which are currently being negotiated within Europe. However, these reductions do not necessarily maximize welfare. There are indications in the economic literature on optimal emission reductions, which suggest that further emission reductions are warranted from a welfare point of view. The optimal scale for air pollution policy is the European level, given the dispersion of air pollutants over a wide area and the optimal level for some air quality policy instruments, such as standards for emissions from cars and trucks. In the air quality policies discussed in this report for the Netherlands we therefore assume that these policies will form part of comparable air quality policies in the rest of the EU.

The magnitude of innovation market failures and asymmetric information will be discussed together with policies to address these market failures in Chapter 4.2.3.

Current air pollution policy targets

Air pollution is the main environmental externality on which energy policies can have an effect next to climate change. Smeets (2012) and ECN (2011) provide an overview of the costs and benefits of different policy measures aimed at reducing air pollution. Three scenarios are analyzed, Low*, Mid and High*, which are increasing in emission reduction and therefore in abatement costs and benefits. The major benefits of reducing air pollution are health effects through reduced early deaths. In addition, air pollution damages the natural environment through eutrophication and acidification. The abatement costs for the three scenarios in 2020 are €35 million, € 85 million and € 165 million respectively. These are the additional costs of emission reductions in addition to emission abatement realized with the policy measures implemented up to 2010. The costs of these measures are estimated at € 3 billion in 2020.

In the PBL study (Smeets 2012), the value of the benefits have been estimated based on the health effects of reduced emissions, the benefits of reduced damage to the natural environment have not been monetized because a reliable method to value these benefits is currently lacking, according to the study. Lower concentrations of $PM_{2,5}$ and ozone will increase the average life-expectancy in the Netherlands, because of reduced emissions. In terms of early deaths, the years of life lost (YOLL) because of one year of exposure to air pollution will be reduced with circa 50.000 in the Baseline scenario, which includes policies implemented up to 2010. Further emission abatement realizes a further gain of reduced YOLL of 3600 in the LOW* scenario up to 9200 in the HIGH* scenario. In addition, the number of days in which the Dutch population is ill because of exposure to air pollution will also be reduced, with circa 0,3 or 0,4 million days in the LOW* scenario up to 0,9 million days in the HIGH* scenario.

Table 3.2 Costs and benefits of air pollution abatement in 2020 relative to the baseline scenario (million euro)

	Low*	Mid	High*
Costs	35	85	165
Health benefits	155-300	255-485	395-755
Net benefits	120-265	170-400	230-590

Estimating a value for the health effects requires an estimate of the value of a lost life year. In EU air pollution studies, a Value of a Life Year (VOLY) is used of € 54,000. This is based on studies in which the willingness to pay for increased life expectancy because of reduced air pollution has been determined through large scale polls. The VOLY knows large uncertainties, there are also studies which arrive at a VOLY of €20,000 (NEEDS 2007). Following Smeets (2012), we will therefore use both these values in order to provide a range of estimates for the benefits of air pollution abatement. Furthermore, the benefits of reduced days of illness are taken into account. Table 3.2 provides an overview of the total health benefits realized in the baseline and the other scenarios and of the abatement costs mentioned above.

In all scenarios, the benefits outweigh the costs in 2020. Therefore all cost-effective policies aimed at realizing the emission abatement in the High* scenario should be undertaken from a welfare point of view. Smeets (2012) and ECN (2011) provide an overview of these policies. The main measures in the High* scenario are in the agriculture, consumers and industry/energy sectors. In the industry and energy sector, measures are undertaken to reduce NMVOS, $PM_{2,5}$ and SO_2 and NOx emissions. These are mainly end-of-pipe measures, renewable energy does not play a role.

Muller et al. (2011) determine the damage of air pollution per industry for the United States. They conclude that for a number of industries damages from air pollution are larger - and sometimes cosiderably larger - then value added in these industries, one of which is coal-fired electricity. This implies that these industries should lower their emissions (considerably). Whether they would need to be shut down and replaced by other energy technologies such as renewable energy sources depends on the shape of the marginal benefit and cost curves for end-of-pipe technologies on the one hand and the costs of renewable energy on the other. Nordhaus et al. do not address these questions.

Optimal air pollution policy targets

The policy goals which are currently discussed in the negotiations on new air pollutant emission targets in Europe are based on what is politically achievable, they are not necessarily welfare optimal in terms of costs and benefits. Recent studies suggest that the health effects air quality can also be large at relatively low concentration levels (see Chay and Greenstone 2003). If this would be taken into account, more ambitious targets for air pollution reduction would possibly be warranted. Bollen and Brink (2012, earlier version 2011) have studied a scenario with more ambitious air pollutant emission targets for 2020, based on cost-benefit considerations. In this study, emission reductions are 62% compared to 2000 emissions while in the scenario proposed in the current EC proposal on air pollutants the reduction level is 55% (based on a weighted sum of air pollutants, see Bollen and Brink 2011, Table 2).

In addition, air pollutant policy so far has mainly focused on 2020 and longer-term targets for air pollution have not been taken into account. Bollen et al. (2009) have studied optimal policies for air pollutants and climate change up to 2050, again based on cost-benefit considerations. Air pollutant emission reductions in these scenarios are considerably higher than in 2020. PM emissions are reduced by more than 90% relative to 2000 emissions, compared to the 55% emission reductions in 2020 in the current EC proposals and 62% for the welfare optimal policy for a weigthed sum of air pollutant emissions. This will also have consequences for current optimal policies, see Chapter 4.2.3 below.

3.3 Energy supply security

One of the goals of Dutch energy policy is to provide for a secure energy supply. This will require a diversified energy supply, which includes both renewable energy and fossil fuels (Energierapport 2011). Two types of energy security can be distinguished. The first type is security of supply (in Dutch: "voorzieningszekerheid"), which requires sufficiently available energy sources to meet energy demand (Correljé and van der Linde 2004). The main focus of this type of energy security is on the availability of energy from sources in other countries, such as oil and gas imports. The second type of energy security is security of delivery (in Dutch: "leveringszekerheid"), which requires sufficiently available energy infrastructure such as power generation and network capacity to guarantee an adequate supply to consumers.

This chapter discusses the market failures making energy supply security an objective for public policy. In addition energy supply security is a field strongly affected geopolitical concerns. CIEP

(2004) recommends that energy must become an integral part of EU external trade and foreign policy to secure future security of supply.[21]

3.3.1 Market failures related to security of supply

The major potential market failure related to security of supply is the negative externality. Another market failure which affects the security of supply is market power.

Short term and long term security of supply

Energy security can be defined as a short term and a long term issue (Correljé and van der Linde 2006). As a *short term* issue it points to the ability of world energy markets to accomodate temporary production losses or sudden surges in demand. This notion covers the impact of sudden disruptions of regional or world energy markets and points to the importance of maintaining spare capacity and strategic stocks. Over the *longer term* energy security is much more an issue of maintaining investments in production and transportation facilities in order to match the supply and demand for energy in a sustainable manner. This points to the dynamics of the entire supply chain involving geological analysis, exploration and creation of reserves and the development of production and transportation capacity. Long term dynamics in the energy supply chain is driven by a complex set of forces including the outlook of demand and prices, the investment climate in production countries (including political and economic stability), technological development and the comparative advantage of production countries.

Currently fossil energy still dominates world energy markets, which means that energy security is mainly an issue of securing the supply of fossil energy like oil and natural gas (IEA 2012).[22] The general opinion seems to be that for long term energy security it is not the level of production and reserves that forms a threat – by and large reserves for both oil and natural gas seem adequate to meet world demand for a main part of the 21ste century (Constantini, Gracceva et al 2007, p. 212). It is the location of reserves that causes problems of long term energy security. They are unevenly distributed and only a few countries and regions will remain surplus exporting countries in the future (Bielecki 2002).[23] As a consequence, the large consuming areas such as the US, the EU and Japan will become dependent on the same oil and gas resources.[24]

Macroeconomic adjustment costs as a negative externality

The economic cost associated with energy security is macroeconomic. A lack of energy security in the short term manifests itself in price volatility. Unanticipated supply interruptions generally

[21] See also AER (2005).

[22] IEA (2012) states that fossil fuels remain the principal sources of energy worldwide, though renewables grow rapidly. It is estimated that the demand for oil, gas and coal grows in absolute terms through 2035, but their combined share of the global energy mix falls from 81% to 75% during that period.

[23] OPEC oil will remain an import energy source in the coming decades. OPEC countries control about 70 percent of the proven reserves (IEA 2012, p. 98). Gas resereves are less concentrated, but Russia plus the Caspian Sea region and the Middle East account for about 60 percent of the total technically recoverable conventional gas reserves (IEA 2012, p. 139). To put the European dimension in context, in terms of import dependency the EU is currently the largest energy importer in the world. It imports more than half of the energy consumed in the EU. This percentage is expected to rise to 70 percent in 2030. See Europan Commission (2011a).

[24] However, the latest projections show that the tide in international energy markets may be turning. The *World Energy Outlook 2012* speaks of an "energy renaissance" in the United States. The Outlook expects the US to become all but self-sufficient in net terms by 2035 thanks to rising production of oil, shale gas and improved fuel efficiency in transport. See IEA (2012), pp. 74-76.

fuel inflation and unemployment as the supply shock upsets production and investment decisions. If uncertainty continues due to a lack of long term energy security, this may even decrease potential economic growth in a structural manner.[25] Hamilton (2009) demonstrates the negative long term impact of volatile energy prices on economic growth and employment.

The analytical framework of this study classifies this economic cost as a negative externality. This is the market failure associated with the lagged macroeconomic adjustment to price volatility caused by energy security problems. In practice this classification depends on the extent to which the market takes these effects into account. For example, an energy company can trade in futures markets to hedge against price risks. Or it can use dual fired capacity and switch between coal, biomass and gas in order to reduce the effect of supply disruptions for a specific energy source. The more markets anticipate the risk of sudden price shocks, the smaller the externality is and the less need there is for government intervention. This explains why in the *Markets and Institutions* scenario of Correljé and van der Linde (2006) energy security is a less pressing problem than in a scenario where national interests overrule market-based coordination in the global energy markets (see further below). However, in practice it is difficult to establish with any certainty whether private actors take the effects of possible macroeconomic disruptions into account.[26]

Energy security and the balance of payments

Imports and exports of energy may have an enormous impact on the balance of payments. Figure 3.2 presents the share of energy imports and exports in total imports and exports respectively. This share varies considerably over time from a maximum of almost 25 percent in the mid-1980s to a minimum of 6 percent in 1998. The most likely explanation of this pattern is the development of international oil prices, which closely matches that of the export and import pattern of energy.[27] Figure 3.2 shows that depending on price developments energy does indeed have an important impact on foreign trade relations.

However, the question is whether the impact of energy on the balance of payments can be seen as a market failure. With continuing global economic growth energy demand will increasingly deplete scarce fossil energy reserves. The result will be higher global energy prices. According to IEA (2012) in the 'current policies scenario' the global oil price peaks in 2035 at $ 145 per barrel compared to the current $ 108 per barrel.[28] Does this increase pose a threat to the balance of payments of the Netherlands, given its dependence on foreign sources of energy?

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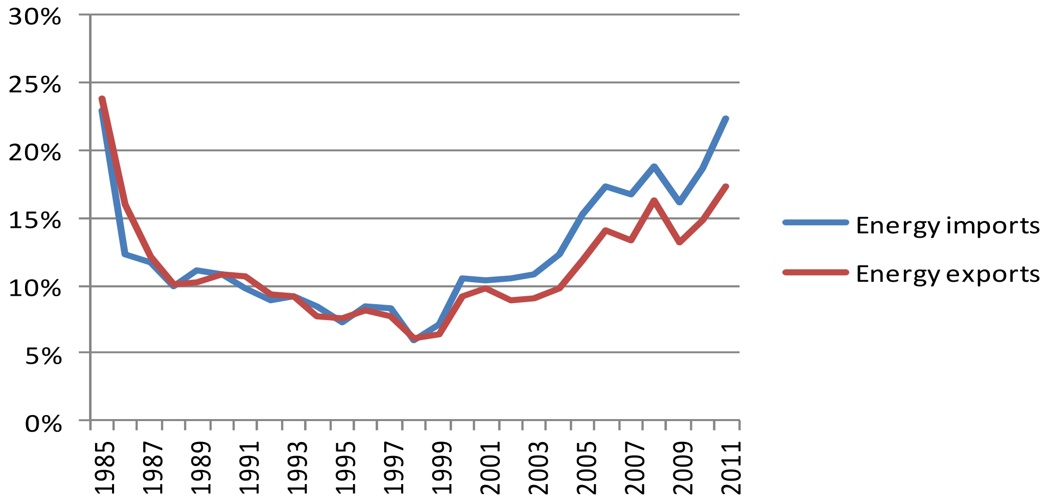
25 Bohi et al. (1996). See also the Netherlands Bureau for Economic Policy Analysis (CPB, 2004), Leiby (2007), and Hedesund (2008).

26 Leiby (2007).

27 See IEA (2012), p. 82 for a graphic description of the development of global oil market prices since 1980.

28 Please note that IEA calculates a real price. This is the nominal price corrected for the expected rate of inflation. The nominal price in 2035 will therefore be much higher than $ 145 per barrel. See IEA (2012), pp. 82-84.

Figure 3.2 Upward and downward shifts in energy imports and exports as share of total foreign trade



Source: CBS statline, SEO Economisch Onderzoek

Figure 3.2 demonstrates that the share of energy imports rises faster than the share of energy exports. The Netherlands exports natural gas and thus also profits from increasing global energy prices, which cushions the impact of rising energy prices on the balance of payments. But with the depletion of the Groningen field the level of gas exports will fall in the coming decades. The gap between energy imports and energy exports that we observe in Figure 3.2 is therefore expected to widen in the future. This makes our economy more vulnerable to price volatility on global energy markets.

However, an increasing share of energy imports on the balance of payments does not point to a specific market failure in energy markets. Ultimately comparative advantages and relative factor intensities determine international trade patterns. Energy intensive industries feel the impact of rising energy costs, but so do their foreign competitors. The economy as a whole only suffers if it embodies a relative large share of energy intensive industries. Intersectoral competition then favors more energy-efficient industries, but this is not a balance of payments effect.

There are two possible effects if the balance of payments worsens as a result of increasing energy imports. The first effect concerns the balance of trade.[29] From the national perspective imports are matched by exports. International trade theory demonstrates that it is impossible to engage in international trade and not have a comparative advantage in some sector of the economy.[30] Thus if imports rise, there is increased pressure to exploit comparative advantages in exporting sectors at the same time. The international price mechanism tends to iron out the impact of sectorspecific price shocks on the trade balance.

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29 The balance of payments consists of two components, the current account and the capital account. The current account is composed of the balance of trade, factor incomes (earnings on foreign investments minus payments made to foreign investors) and cash transfers.

30 A country may have the highest cost of production for all commodities and still command a comparative advantage in one of its sectors. This insight is the very essence of the notion of comparative advantage.

If this process fails, for example as a result of short term frictions, a second mechanism comes to the fore. A shortage on the current account is compensated by a surplus on the capital balance. If a country is a net importer of commodities, it turns into a net exporter of capital. At the end of the day the balance of payments of any country must reside in equilibrium.

In sum, the impact of increasing energy imports on the balance of payments points to the need for macroeconomic adjustments, as discussed above. This does not involve a market failure that is specific to energy markets, but to the adaptability of the economy in general. For energy policy this 'market failure' does not constitute a ground for policy intervention. This is the domain of international trade policies and general economic policies.

Other motives for energy security policy

This conclusion shows that energy security policy is pursued for reasons not strictly connected with market failures. The issue of general economic development is an example of this. The foreign relations aspect is another example. There are geopolicital arguments to reduce energy imports from countries considered to be a risk factor due to a lack of economic and political stability (CIEP 2004). For the EU the internal market is an important reason to put energy security on the agenda. Bilateral energy relations between individual member states and third suppliers or transit countries are said to result in fragmentation of the internal market rather than a strengthening of the EU's energy supply and competitivity (European Commission 2011b).

From a political perspective these are valid reasons for government intervention. The impact of the energy security policies in this category must be assessed on their own merits, as is extensively done in CIEP (2004) and IEA (2007).

3.3.2 Quantification of market failures related to energy security

Measuring security of supply

Given the geopolitical background of energy security issues, it is not surprising that CIEP (2004, p. 44) concludes that energy security cannot be easily translated into absolute numbers. The development of reliable indicators for energy security is an important bottleneck. Constantini, Gracceva et al (2007) use dependence and vulnerability indicators such as the share of European oil and gas imports as a percentage of total world oil and gas imports. The vulnerability on the supply side can be measured in terms of the degree of supply concentration in trade and production of oil and gas. On the demand side the share of oil used in transportation and the share of electricity produced with gas are relevenant indicators. But other indicators are possible and an overall indicator for energy security is lacking.

Even the economic impact of energy security is hard to determine. Some supply shocks create macroeconomic havoc, other shocks pass relatively unnoticed. In general the level of risk to a country is a function of the flexibility of its energy system and its economy to accommodate supply shocks and the tightness of the energy market concerned (CIEP 2004, ibid.). As Correljé and van der Linde (2006, p. 535) put it, "the *state of the world* does matter for what is – and will be – happening in the world oil and gas industry."

This remark points to the importance of scenario analysis as an instrument to assess projections about energy security. Correljé and van der Linde (2006) develop two scenario ("storylines" in their wording) to describe possible futures in the international energy markets.

The *Markets and Institutions* scenario puts international development and cooperation center stage. This scenario takes place in a world marked by further globalization of markets, culture and politics. The practical impact of this scenario is the development of the multilateral system that governs international relations and the liberalization of markets to accommodate the international flow of goods, persons and capital. This 'free' global market is facilitated by strong economic institutions such as the IMF, WTO, OPEC and IEA.

The *Regions and Empire* storyline involves a division of the world into countries and regions and is thereby much more pessimistic on the prospects for international cooperation and development. Political and military strategy, bilateralism and regionalism divide up the world into competing US, EU, Russian and Asian spheres of influence. As a corollary firms operate less internationally and operate from a more national perspective.

What do these storylines tell us about energy security as a political and economic risk factor? First the scenario's point to the pivotal role played by Russia in the international energy market. Russia exports both oil and gas to the EU. It is also not associated with OPEC and can thus be seen as an alternative source of oil. This poses a risk to the world market if Russia collapses as a major producer, but Correljé and van der Linde (2006) consider this risk very small for both scenario's. The main difference between the scenario's is that in a *Markets and Institutions* world Russia will become broader integrated in the EU market, in the *Regions and Empire* world Russia develops its own 'empire'.

Second the role for European policy differs in the scenario's. In the *Markets and Institutions* context the EU should focus on creating the right investment climate as a principal measure to safeguard energy security. Here import dependence is not seen as a major geopolitical or economic risk for the EU. In principle market incentives should be sufficient to prevent major problems of energy security. Liquid markets efficiently translate shifts in supply and demand into shifts in forward prices. This induces a re-allocation of supplies or investment in new production and transport capacity.

In contrast in a *Regions and Empire* world market coordination fails to secure energy security automatically, calling for the strategic use of a set of energy policy tools and the active use of foreign and security policies.

Quantification of market failures related to energy security

This still leaves unanswered the question what the quantitative size is of the negative externality related to energy security. Daniëls, Tieben e.a. (2012) developed a method to quantify this risk based on import dependence as a specific indicator. The result of this study must be qualified as partial, given that other indicators are not included, but at least it provides some insight in the magnitude of the market failure associated with energy security.

Daniëls, Tieben e.a. (2012) assume that higher import ratios for energy make a country more vulnerable to energy price shocks potentially impacting energy supply security. Based on macroeconometric estimations from the United States a risk premium was calculated to estimate this relationship. For 2020 this potential welfare loss in terms of energy security as a result of fossil energy use in the Netherlands is circa € 3,4 billion on a yearly basis (in euro's of 2020).[31] This is the price of the negative externality that from a social perspective should be included in the price of imported fossil energy. After 2020 this potential welfare loss increases due to the increased demand for energy and the fact that the Netherlands will increasingly start to import natural gas as the Slochteren field depletes. In 2030 the potential welfare loss in terms of energy security related to fossil energy use amounts to circa € 4,5 billion on a yearly basis (in euro's of 2030).

This welfare loss comprises several market failures. The negative externality of macroeconomic adjustments costs has already been mentioned. In addition market power on energy markets affects security of supply. For example, vertical integration between energy producers and suppliers creates barriers for (smaller scale) alternative energy sources. As a result, the share of fossil fuels in the energy mix will be larger, which may amplify the effect of price shocks on the economy. There is a close connection between the negative externality and market power as a market failure. In the international market, market power of for example oil producing countries is the ultimate source of the price shock causing the need for macroeconomic adjustment. Please note that in *Markets and Institutions* type of world, market incentives may be strong enough to sufficiently cushion price volatility in energy markets, even in times of geopolitical crises, and reduce the welfare loss of energy security problems to virtually zero. The calculation of the economic impact of the negative externality is approximate at best and should be considered an upper boundary for the real impact of suboptimal levels of energy security.

The next chapter discusses the possibilities to reduce this potential welfare loss by means of sustainable energy policies and energy saving policies.

3.3.3 Market failures related to security of delivery

The main market failures related to security of delivery are market power and asymmetric information.

Information asymmetry between consumers and the firm

Security of delivery is typically a problem related to the capacity and quality of energy network services. The information problem is that consumers have less knowledge of the quality of network services than the services operator. This applies to the problem of power or gas interruptions (black outs). The two relevant dimensions here are the frequency and duration of the service interruptions. Electricity has an additional voltage quality feature, such as voltage dips or transients. The fact that consumers and network operators do not directly negotiate about the price of network services, does not change the fact that an information asymmetry exists.

31 This figure is based on the market failure related to net oil and gas imports in the business-as-usual scenario used for Daniëls, Tieben e.a. (2012).

Market power
Energy networks are governed by economies of scale. As a result the market is dominated by natural monopolies. The market power of these monopolies causes a reduced incentive to accommodate the preferences of consumers with regard to the quality of energy supply. Put briefly, without regulation there is an incentive for operators to choose both the capacity and the quality of networks lower than it would be socially desirable.

Market power in times of peak demand
There is a second source of market power affecting the electricity market. Due to the domestic trade on several trading platforms and the emerging intraday platforms between countries, energy producers with different scales and of different countries are able to compete with prices. Some producers have large market shares (e.g. large power plants), but they cannot abuse their market power when demand and supply are relatively balanced in the electricity market. However, generally these producers have an obligation to build up stand-by capacities. Consequently, they have market power in case of emergency situations and can charge high prices. In other words, market power has an impact on prices when peak demand occurs.[32]

If regulation aims to curtail this market power, a missing money problem may occur. The marginal costs of stand-by capacity are very high and the peak price may be insufficient for the costs of stand-by capacity. If this occurs the market may lack sufficient stand-by capacity, which increases the risk of outages in situations of peak demand. This can be classified as an institutional barrier, given that the obligation to maintain stand-by capacity is at the root of this problem.

3.3.4 Quantification of market failures related to security of delivery

Based on contingent valuation analysis Baarsma and Hop (2009) estimated the shadow price of power outages in the Netherlands. Their research indicates that the utility as a result of a power outage is on average €2,80 for households and €33,10 for SME firms.[33] Note that the price tag for SME firms is much higher than for households, which is mainly due to the higher opportunity costs for firms when power supply is interrupted. This brings the total cost of power outages to circa € 50 million per year.[34]

3.4 Affordability of energy

Affordable energy means that consumers are able to buy a product or service because their willingness to pay is above the marginal cost of production. Therefore, affordable energy can primarily be achieved by increasing cost-efficiency. In this research, cost-efficiency is considered

32 See Stoft (2002), p. 349.

33 This price tag is a composite of the price tag for the *frequency* of power interruptions and the cost of the *duration* of power interruptions. The average duration of power outages in the Netherlands in 2011 was 21 minutes. For gas the average duration of supply interruptions in 2011 was 43 seconds. See NMa (2012b).

34 Please note that the interruptions of gas supply are not included in this cost calculation. The total social cost of the security of delivery is therefore higher than € 50 million. The number of interruptions per year for the natural gas supply is much lower than for electricity (see above), but reliable Dutch estimates of the 'value of lost load' (VOLL) for gas are lacking. British research indicates a VOLL for gas for residential consumers of circa € 15,5 per day for a reduction in the frequency of gas outages from once in 20 years to once in 50 years. For SME firms this figure is € 45,3. See London Economics (2011).

in the light of the two other policy goals, sustainability and energy security. It can immediately be seen that these public goals can only be obtained by large investment costs in sustainability (e.g. innovations in renewable energy and energy efficiency) and more reliable energy supply and networks. This is the trade-off between short-term effects (cost-efficiency or static efficiency) and long-term effects (innovations and investments or dynamic efficiency). Therefore, the question is not how cost-efficiency in general can be achieved[35] but how the long-term effects due to sustainability and energy efficiency can be achieved at the lowest costs.[36]

On the one hand, given energy demand, efficiency is determined by the costs related to the production, transmission, and distribution of energy. Within that, the costs of production are affected by the availability and costs of energy sources. On the other hand, efficiency is influenced by the energy consumption and in that respect, the availability and costs of energy efficient technologies. In that line, four markets can be distinguished with respect to affordability: energy efficient technologies, clean energy production technologies, energy production, and energy networks.

3.4.1 Market failures related to affordable energy

In each of the above mentioned markets, several questions arise. With respect to *energy efficiency*, are energy-efficient technologies available and affordable for consumers? Is there a source of market power that increases prices of these technologies?

Due to knowledge spillovers, first-mover advantage, and some limitation of the patent system, the developers of energy efficient technologies may have market power. Market power may be amplified by the presence of switching costs: new devices and technologies need to be found, installed, and learned by users. Without policy intervention, the initial high costs and the potential market power of (first mover) patent holders will keep the price of new energy efficient technologies high.

Regarding *clean technologies*, the following questions can be formulated. What are the dominant technologies in the current market? What are the potential alternatives? Can alternative energy technologies enter the market? If not, what types of barriers to entry exist?

Currently, carbon-based electricity generation technologies dominate the market as they are much cheaper than clean technologies. Therefore, a question is whether and how clean technologies can become cheaper and be more extensively adopted in electricity production. Clean technologies are at the moment in the beginning of their learning curves, which can be characterized by high costs. Any further cost reduction depends on the development (learning by research) and adoption (learning by doing) of innovations. Further knowledge accumulation in clean electricity generation technologies are linked to the limitation of the patent system, the path dependency of dirty technologies, and the relatively slow learning process through adoption. These characteristics of the innovation process constitute barriers to entry for clean electricity generation. Consequently, clean technologies may remain only to a limited extent available and

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35 As it is done, for instance, by carbon-based electricity generation technologies.

36 This study does not question the relevance of the public goals themselves. Affordability as a public goal belongs to the domain of goals determined by egalitarian motives.

adopted and the electricity produced by them will be expensive. Fossil-based fuel, such as shale gas or drilling in deep sea, may become another source of energy in the future. In comparison to the costs of clean technologies, newly explored fossil-based resources can become cheaper alternatives of carbon-based energy.

The following questions arise with respect to *energy* generation. Are the available energy sources priced at the efficient cost level? Or are there reasons to believe that market failures exist in energy production and therefore that the price of energy is high? As energy markets in Europe have become more integrated, trading and transporting energy takes place in an international market– with an increasing frequency. Do players in the Dutch market have efficiency advantages in comparison to players abroad? If efficiency differences exist, how is it reflected in energy prices?

Traditional forms of energy production, such as power plants, are characterized by economies of scale. As such types of energy production are technology and capital intensive, larger energy producers gain efficiency by their size. Furthermore, until the late 90s, production was vertically integrated with the transport of electricity. Economies of scale and vertical integration lead to a concentrated market of energy producers. These companies were also publicly owned by municipalities and provinces, keeping the electricity price low. The privatization of these public utilities and the ownership unbundling of transport and production may have caused higher prices. However, competition has intensified in two directions. First, distributed generation by large energy consumers (such as greenhouses) and to a lesser extent by households supplies own electricity consumption in some regions. The excess production is traded in several trading platforms, including the APX/ENDEX. According to London Economics (2007), the Dutch market of energy producers is still concentrated, but there is no sign of the abuse of market power (see the relatively low price-cost markup in Table 3.3). Second, interconnectors and international trading platforms have recently opened, which stimulate cheaper (and often green) energy to enter the Dutch market.[37] For these reasons, the price of electricity may become competitive. A market segment where market power still exists is electricity produced by stand-by capacities. Only large generators have obligations to build up stand-by capacities. Therefore, in the case of emergence, these companies are able to charge a high price for electricity.

[37] For instance, the recently allowed intraday market between Norway and the Netherlands may let cheap hydro-energy in the water-rich seasons in Norway to flow into the Dutch market. In exchange, Dutch gas-fired electricity can flow into the Norwegian market in the drier seasons.

Table 3.3 Producers in the Netherlands have a relatively low market concentration

Country	HHI[38]	CR(n), in %[39]	Price-cost markup, in %[40]
Belgium	7694<<8843	(1): 86,4<<93,7	38,0
France	8592	(1): 90,9<<94,8	N/A
Germany	1914<<2158	(2): 54,0	51,0
The Netherlands	2153	(2): 54,5	14,4
Spain	2813	(2): 71,8	20,8
Great Britain	1072	(2): 31,2	21,5

Source: London Economics (2007)

The production of gas depends on geological conditions and is in practice dominated by state-owned firms. In the Netherlands, the *Nederlandse Aardolie Maatschappij B.V.* (NAM) dominates the market with its market share of 80 percent.[41] Prices in this market are largely determined by international market conditions. The introduction of LNG and bio-gas only slowly changes this situation and currently has no impact on the price. Shale-gas is widely recognized as a development, which in the long run may have a dampening effect on gas prices.[42] For the Netherlands the depletion of the Slochteren field is an important development. This means that supply of natural gas in the market will increasingly depend on the price of imported gas.[43]

Relating to the *transport of energy*, one may ask the following questions. Are network operators efficient in transmitting and distributing energy? How does market power in transport and distribution affect energy prices (without government intervention)?

Building up an infrastructure that transports energy requires large lumpy investments. Therefore distribution and transmission networks are natural monopolies. Without government intervention, these infrastructure companies have little incentive to manage their networks efficiently. On top of that, due to their monopoly position, they can charge monopoly tariffs for transporting energy. However, these tariffs need to be allowed to reflect investments in networks, which are important for the security of delivery.

The isolation of these four markets with an impact on the affordability of energy demonstrates that basically all market failures discussed earlier may play a role.

38 The Herfindahl-Hirschman Index (HHI) is the sum of the squares of market shares of all fimrs in a market. If the HHI is between 1,000 and 1,800, then the market has a moderate concentration. In the range above 1,800 is the market highly concentrated.
39 The concentration-ratio CR(n) indicates the combined market share of the n largest firm.
40 The price-cost-markup is the difference between the market price and the marginal costs of firms, given in a percentage form. The marginal costs are calculated as marginal average costs, that is, they contain fixed costs that are necessary for starting up a new and maintaining an existing production facility. The larger the markup, the larger the market concentration.
41 Based on production quantities of the total of onshore and continental shelf. Source: NL Olie en Gasportaal.
42 Market surveys indicate that in the United States this impact is already felt.
43 For an economic analysis, see van Foreest (2010).

- Knowledge spillovers impede the development of energy-efficient appliances and clean energy technologies, which in the long run may increase the costs of devices and energy supply;
- Information asymmetries impede both the development of energy-efficient appliances and the investment of all types of energy sources. Both increase the price of devices and energy supply;
- Market power has an impact in several sectors of the energy production, transmission and distribution chain and causes higher prices. Economies of scale are the most relevant explanatory factor behind this market failure.

3.4.2 Quantification of market failures related to affordable energy

In the market for *energy efficient* appliances and *clean electricity generation* technologies, affordability is closely related to the costs of innovative developments. The costs of new innovative products and technologies are primarily determined by their learning through the R&D process (learning-by-research) and the adoption of new technologies (learning-by-doing). For instance, clean energy generation technologies are in different phases regarding their maturity (see Figure 3.1), which is reflected also in their cost-development (see Table 3.1). On the contrary, carbon-based technologies are very mature and therefore able to produce electricity at a low cost. In that sense, knowledge spillovers and path dependency in carbon-based technologies are in favor of cost-efficiency. An optimal energy mix that is achieved at the lowest possible costs needs to take this cost development of energy generation technologies into consideration. As it has already been discussed in Chapter 3.2, most of the clean technologies remain expensive compared to carbon-based technologies until 2020, even in the presence of carbon-taxes.

With respect to energy production and the transport of energy, market power is the most relevant market failure that determines prices. As these markets are (or were formally) characterized by natural monopolies, network operators and producers have been subject to some form of price regulation. Therefore, measuring the size market power in an imagery situation without policy intervention is not possible. The data that is presented below, therefore, measures the size of market power in the presence of tariff regulation. The real size of market failure without government intervention is then, of course, larger.

In the market of *energy production*, producers in the Netherlands have relatively low market shares in comparison to other European counties. Despite this fact, market power influences wholesale prices. An approximation of this effect can be calculated based on the markup, price, and volume data of electricity production (Table 3.4). According to these estimates, producers together earned approximately half a billion euro per year in 2003-2005 by charging a wholesale electricity price above their marginal average costs.[44]

[44] Marginal average costs contain the fixed costs that a new or existing production facility entails.

Table 3.4 Producers earned yearly approximately half billion euro above their marginal costs

	2003	2004	2005
Average base load price (APX; €/MWh)*	46,36	31,59	52,65
Produced volume (GWh)**	96.695	100.725	100.424
PCMU (%)***	14,4	14,4	14,4
Total due to markup (million €)****	564,3	400,5	665,5

Source: *Website of APX; **CBS Statline; ***London Economics (2007); ****Inclusive investments

The NMa studied the effect of market power of *energy networks* by analyzing their profits. In the case of regional network operators, the NMa analyzed the profitability of the four largest network operators – Eneco Holding N.V., Essent N.V., N.V. Nuon, and Delta N.V. – in both electricity and gas markets (NMa, 2007).[45] The NMa calculated separately the profits that are the result of regulated activities and of activities on the free market segments. In their study, they concluded that approximately half of the profits originated in regulated activities, although the size of these profits did not change over the years. Between 2003 and 2005, this amount summed up to yearly 393 million euro. This means approximately 15 euro per year for each electricity or gas connection.

As the transmission network operator TenneT only provides regulated services, its profit is corrected after every regulatory period (the so called *nacalculatie*).[46] Therefore, in principle it is not possible for TenneT to make a profit above its costs. However, the allowed income that TenneT can realize takes investments in network capacity into consideration, which verifies a somewhat positive profit in the long term (Mulder, 2010).

3.5 Conclusion

Table 3.5 provides an overview of all the relevant market failures related to the realization of the three goals of energy policy. This chapter demonstrates that in quantitative terms air pollution represents the most important public goal for energy policy, if the economic analysis focuses on motivations that generally fall outside the scope of policy discussions due to the importance of climate change. The environmental externality represents a relatively large welfare loss, which justifies policy measure to remedy this market failure. Other market failures related to sustainability as a policy goal are less supported in empirical analyses of the energy market.

The second most important policy goals is the security of energy supply. The negative externality underlying this policy objective represents a maximum welfare loss of circa € 3,4 billion on a yearly basis. This outcome crucially depends on the political and institutional setting. Appropriate institutional and market processes may reduce the welfare loss to zero, demonstrating that the market is quite able to sufficiently secure energy security and that government intervention for this purpose is not needed. The welfare loss of the security of delivery amounts to circa € 50 million per year.

45 Please note that after 2007 the companies were legally obliged to separate their network operation from their other businesses. There are currently 11 regional network operators active in the Netherlands.

46 NMa (2010, 2012a)

The market failures related to the affordability of energy are much more difficult to estimate in a quantitative sense. There are indications that market failures such as market power cause economic costs to society. A rough estimate is that energy producers earn an excess profit of circa € 500 million per year. Please note that this profit represents a shift of welfare from consumers to producers and not a loss of aggregate welfare per se ('deadweight loss'). Shifting market conditions may quickly eradicate this excess profit for producers making predictions about the future size of this market failure a hazardous undertaking. Tariff regulation controls the profits of network operators and should in principle prevent excess profits. However, in practice excess profits may occur. Problems in this category should be classified as an institutional barrier, given that regulation insufficiently controls the market power that forms a 'natural' aspect of network operation.

Table 3.5 Effects of market failures on achieving policy goals

Market failures	Sustainability	Security of supply	Security of delivery	Affordable energy
External effects				
Environmental externalities	E.g. air pollution, destruction of the landscape			
Knowledge spillovers incl. path dependency and learning curves (adoption)	Less green innovation; less energy-efficient technologies	Little amount of green energy in the energy mix		Expensive green technology and energy-efficient devices
Asymmetric information				
Imperfect capital market	Suboptimal investments in clean and energy-efficient technologies (innovation and adoption)		Suboptimal investments in network capacity => lower quality	Expensive green technology and energy-efficient devices
Between consumers and firms	Less adoption of energy-efficient technologies (adverse selection)		More quality problems (moral hazard)	Expensive energy-efficient appliances
Market power				
Economies of scale	Barriers to entry for less efficient production technologies such as green		Market power in networks => suboptimal investments in network capacity	High prices of clean energy; potentially high of dirty Expensive transport of energy in the absence of regulation
Mergers/acquisition	Vertical integration leads to exclusion of (smaller scale) alternative energy sources	Vertical integration leads to exclusion of (smaller scale) alternative energy sources and – in the absence of regulation – alternative energy suppliers	Cross-border investment may reduce due to mergers	Exclusion of alternative suppliers may increase prices Cross-border mergers may increase international energy prices (in the absence of regulation)
Switching costs	Less adoption of energy-efficient products and distributed generation			Expensive energy-efficient products and distributed generation technologies
Institutional barriers: Obligations			No market for standby capacity => insufficient supply	No market for standby capacity => high prices in case of emergency
Institutional barriers: Patent system	Less innovation in energy-efficient products and clean energy generation, less complementary innovations (CCS)	Lower level of green in energy mix Less energy-efficient devices => more energy consumption		More expensive energy-eff. devices and green and complementary technologies

4 Instruments

4.1 Introduction

This chapter discusses the instruments related to the tree policy goals for the energy market. The aim is to link these instruments to the market failures they seek to remedy and to estimate the economic impact of the instruments in a quantitative sense. This should provide input into the discussion about an optimal policy mix for the energy market, assuming that climate change plays no role. [47]

4.2 Sustainability

4.2.1 Types of instruments

The main policy instruments in the field of sustainable energy and energy saving can be categorized as follows:

1. Market-based instruments
2. Command and control regulation
3. Subsidies
4. Voluntary agreements and information

Market-based instruments provide economic incentives which influence an actor's behavior. They provide actors with flexibility, for example on when and how to reduce their emissions in case of an emission charge, because they have the option to either reduce emissions or pay the charge. Market-based instruments are in theory cost-effective because actors can choose options with the lowest costs to reduce their emissions.

The main market-based instruments are taxes, tradable emission permits, and tradable certificates, such as renewable energy certificates and white certificates for energy savings. Taxes and charges are used extensively within the Netherlands, environmental taxes currently providing a substantive amount of revenue for the treasury. The main energy related tax in the Netherlands is the Energy Tax, which rests predominantly on gas and electricity consumption of households and small businesses. Gas used in power plants is exempted from the tax. Other energy related taxes are excises on oil and motor fuels. In 2013, a charge will be introduced on electricity consumption. This revenue will be used to finance subsidies for renewable energy.

The EU ETS is the main example in Europe of an emission trading scheme, which limits CO_2 emissions of large energy consumers and the electricity generation sector. In a number of countries in the EU, a renewable energy obligation is combined with tradable renewable energy certificates (for example, in the UK, and a combined scheme in Norway and Sweden). In the

[47] There is a large literature on the effectiveness and efficiency of different policy instruments. In this paper, the main focus is on the rationale for renewable energy and energy savings policies in general in the absence of climate change policy, not on the choice and design of optimal instruments. Therefore we will limit ourselves to a general overview of the main instruments used in the different areas of energy policy.

Netherlands, a tradable renewable energy obligation has not been introduced yet, although it is being discussed.

Other instruments that provide economic incentives are deposit-refund systems and liability payments. Deposit refund systems are well known in the case of bottles, they can however also be used in combinations of taxation and subsidy. For example, the BPM in the Netherlands (a tax on new bought cars) is differentiated: cars with high polluting emissions must pay a higher tax than clean cars, which can be exempt from the BPM. The obligation to pay liability payments provides an incentive to limit damage. An example is the compensation for damage from surface subsidence due to the extraction of gas in the Slochteren area or compensations paid by oil companies for damage costs due to oil spills.

Table 4.1 Energy policy instruments related to sustainability

Instruments	Examples in the Netherlands and the EU
Market-based instruments	
Taxes	Energy tax
	Coal tax
	Excise on oil and motor fuels
Tradable emission permits	EU ETS
Renewable energy obligations	Applied in e.g. the UK, Sweden and Norway
White certificates	Energy savings obligation combined with tradable energy savings certificates.
Liability payments	Compensation payments for damage due to gas exploration, legal obligation to pay compensation for damage caused by oil spills
Regulation (Command and control)	
Input standards	Requirements regarding the quality of motor fuels (e.g. no lead or sulfur)
	Obligation to include renewable energy in motor fuels (5.75% in 2010 and 10% in 2020)
	Co-firing of biomass in coal power plants obligation of 20% in 2015
Technology requirements	IPPC-directive, requirements regarding the use of best available technologies
Output standards	“Besluit emissie eisen stookinstallaties”
	“Besluit emissie eisen verbrandingsinstallaties”
	NEC-directive, ceilings on EU-member state emissions of SO2, NOx and PM
Appliance standards	Energy using products directive
Licenses	Environmental licenses for firms which fall under the IPCC-directive
Subsidies	
Direct subsidies	SDE+
	Subsidies for energy savings in the build environment
Fiscal subsidies	EIA, subsidy for investments in energy saving equipment
	MIA/VAMIL, subsidy for investment in clean technologies
	“Saldering”, exemption from energy tax for a limited amount of production of renewable energy
	WBSO, reduction of income tax for employees working in R&D
Information	
Labels	Energy-labels on household appliances
Voluntary agreements	
“Convenant energiebesparing Energie-Nederland en Ministerie van BZK”	
“Meerjarenafspraken energie-efficiency overhead en bedrijven”	

Command and control regulation is widely used in energy and environmental policy. According to the regulation, emission targets have to be met or specific technologies have to be implemented. They can take the form of input requirements, such as standards for the quality of fuels, technology requirements, such as BAT (Best Available Technology), or output controls, such as a maximum on specific emissions. Standards can either leave little room for flexibility, such as a standard which prescribes the use of a specific technology, or it can leave substantial room for different options, such as the EPC, the Dutch energy standard for new buildings which only sets an aggregate norm which can be met with a large number of different technologies.

Subsidies (both direct subsidies and tax reductions and tax exemptions) are used extensively in energy and environmental policy. Subsidies provide a financial incentive to undertake specific activities, such as emission reduction, investment in R&D, or in specific equipment, such as clean technologies. They are employed to reduce emissions, to stimulate the uptake and diffusion of clean technologies, and to promote R&D. Major examples of subsidies in the field of energy policy in the Netherlands are the SDE+, a subsidy for renewable energy production, and the EIA, a fiscal subsidy to stimulate investments in energy saving equipment.

Finally, instruments such as *voluntary agreements and information* (for example energy labels on appliances) do not coerce firms and households to change their behavior (either because of command or control regulation or an economic or financial incentive), but aim to change behavior through the provision of information or by making (non-binding) agreements.

Table 4.1 gives an overview of the different types of instruments and main examples of the application of these instruments within the Netherlands and the EU.

4.2.2 Impact on market failures

Market-based instruments such as taxes and emission trading reduce negative environmental externalities. If the quantity in an emission trading scheme or the level of a tax is set at the optimum level, firms and households will take the environmental damage resulting from their behavior into account in their decisions and pollution will be reduced to the optimal level. Leaving aside the ETS, the main market-based instruments in energy policy are the energy tax and excises on oil and motor fuels. They will reduce air pollution, the main environmental externality next to climate change and the one on which we will focus for now. However, they are based on the volume of energy used and not on the SO_2, NO_x, and PM emissions. Moreover, they do not take into account the locality of emissions, which can be relevant for the environmental damage caused by air pollution. Therefore, they are not optimally designed from the point of view of reducing air pollution. In addition, the level of the energy tax may either be too low or too high given the environmental damage of air pollution. The same holds for the excises on oil and motor fuels. Pricing can in principle be an optimal instrument to correct for negative environmental externalities such as air pollution, such as, for example, the SO2 emission trading scheme in the United States. However, for those air pollutant emissions where locality is an important element in the damage caused by these emissions market based instruments will be less suitable in as far they do not take into account the locality of the emissions. Furthermore, transaction costs of pricing air pollution for mobile sources such as vehicles will be high. Hence, other types of pricing come into the picture including deposit refund systems in which the price of cars without air pollution reducing measures is increased at the expense of clean cars, who are subsidized.

Pricing instruments do not have an effect on other market failures. They will induce more innovation on clean technologies, however, pricing instruments alone are not sufficient to address knowledge spillovers. The pricing of the negative environmental externalities ensures that innovation on clean technologies becomes attractive. The level, however, is still suboptimal because of knowledge spillovers. This also holds for learning-by-doing. Given an optimal price, firms and households will still invest less (or later) than optimal in clean technologies because part of the benefits of cost reductions realized through learning-by-doing will spill over to others.

Tradable renewable energy obligations increase the costs of all energy use and reduce the costs of clean energy sources. Therefore, they contribute to reducing environmental externalities. However, they are not as effective and efficient as price instruments. The price increase due to the obligation to acquire renewable energy certificates is in general related to the volume of energy used and not based on the level of polluting emissions. Moreover, the choice of specific technologies (such as wind energy, solar energy and biomass) is not necessarily the most effective and efficient choice for reducing emissions. An emission trading scheme which caps the polluting emissions themselves leaves it to the market to decide which abatements options to use (from end-of-pipe to renewable energy), which will be more effective and efficient than tradable renewable energy obligations. In fact, the levels of air polluting emission from biomass combustion are high compared to gas powered electricity generation. Therefore, the inclusion of biomass in a renewable energy obligation scheme would be counterproductive for reducing air pollution. Consequently, tradable renewable energy obligations are not an optimal instrument to address environmental externalities.

Tradable renewable energy obligations can address learning-by-doing. They provide a financial incentive to deploy specific technologies. Given optimal pollution prices, the obligation can be set at such a level that the additional benefits of selling obligations compensates for knowledge spillovers related to learning-by-doing. Such an optimal level would also take into account the optimal timing of deployment policies and the relation between learning-by-doing and learning-by-research.

Command and control regulation in the form of input, technology, or output standards corrects for environmental externalities. Either directly or indirectly (through technologies or inputs), they reduce polluting emissions and thus the environmental damage. Technology requirements can reduce the externality of learning-by-doing, because it requires the deployment of specific technologies and thereby can ensure that the benefits of lower costs through learning-by-doing are realized even though they are not fully appropriated by those who install the new technologies.

Appliance standards may solve asymmetric information problems such as adverse selection, because consumers are automatically informed about the true energy efficiency of a product. However, they can also be economic inefficient when consumers have heterogeneous preference regarding energy efficiency, in which case some consumers are forced to incur costs for an efficiency which they do not value enough to outweigh the costs they have to make (Hausman and Joskow 1982).

Subsidies are a widely used instrument in energy policy. The major subsidy in terms of financial outlay is the SDE+, which is used to stimulate the deployment of renewable energy technologies. A subsidy is not an optimal instrument to address negative environmental externalities. A pricing instrument not only provides an incentive to use cleaner technologies, it also raises the price of energy and thereby reduces energy use and emissions. A subsidy does provide an incentive to use clean technology but there is no incentive to reduce energy use. Consequently, the cost of realizing a specific emission target will be higher with a subsidy.

Subsidies for specific technologies, such as the SDE+ will address the knowledge externality related to learning-by-doing, comparable to the effect of tradable renewable energy obligations. The level of subsidy provided by the SDE+ however is considerably higher than the size of the externality (see Fischer and Newell 2008 and Koutstaal 2011). Other technology subsidies, such as the EIA, the MIA, and VAMIL can also contribute to reducing the knowledge externality related to learning-by-doing.

General R&D subsidies, such as the WBSO will address knowledge spillovers in R&D. However, they do not address path dependency in energy R&D. Addressing path dependency requires specific subsidies or prizes for clean energy technologies and disincentives for innovation in environmental harmful technologies (Acemoglu et al. 2012, Aalbers et al. (forthcoming)). The problem of path dependency is related to the existence of negative environmental externalities. If for the sake of this thought experiment the climate change externality is left outside of the analysis, the problem of path dependency may well be more limited and therefore the required policy intervention for the development of clean technologies may also be less forceful. Whether this is the case, depends on the fact if an optimal level of clear air requires deployment of renewables or whether end-of-pipe measures are sufficient. End-of-pipe measures are complementary to fossil fuel technologies. If these technologies are sufficient, path dependency will not be an issue.

Direct subsidies can also address the problem of liquidity constraints caused by imperfect capital markets. This may either take the form of a financial grant or of a loan with favorable interest rates.

*Information,*such as labels on household appliances can address the problem of information failures such as adverse selection, because buyers are informed about the energy efficiency of different products. Information campaigns can help consumers to make better decisions by providing more reliable information on the energy efficiency of applications and savings measures.

4.2.3 Quantitative assessment

In order to assess the quantitative impact of the main policy instruments on the market failures related to sustainability, we will focus on the main policy areas, sustainable energy and energy efficiency. It is difficult to determine the effects of individual policy instruments on, for example, air pollution emissions, given the large number of policy instruments used in the field of energy and climate. Therefore a more aggregated approach is needed. Where possible, we will provide insights in the main policy instruments applied within these policy areas.

Renewable energy policy

The policy target of renewable energy policy in the Netherlands is to realize a share of 16% in total energy consumption in 2020. Policies implemented so far will realize a level of about 8% (Verdonk and Wetzels 2012), therefore the current policy target will increase the renewable energy share with about 8%-point. The main instruments used to realize this target are the SDE+, the implicit subsidy of netting ("saldering") and the recently introduced co-firing obligation. The main market failures affected by renewable energy policy next to climate change are air pollution, and innovation related market failures such as knowledge spillovers (political dependence and security of supply is discussed in Chapter 3.3).

Current policies and air pollution

Smeets (2012) and ECN (2011) have studied the impact on air pollution if policies would be introduced to realize a renewable energy target of 14%.[48] Table 4.2 shows he effects on emission pollution from increasing renewable energy use from ca. 9% in the baseline up to 14%. It has been assumed that the renewable energy target is realized in the most cost-effective way. This reflects the way the current subsidy in the Netherlands, the SDE+, is set up. With the exception of SO_2, increasing the renewable energy target will increase air polluting emissions. A main reason for this effect is the increased use of biomass in smaller installations for electricity and/or heat production. As regards air pollution, achieving the renewable energy target in a cost-effective way such as the SDE+ is a counterproductive policy instrument.

Table 4.2 Air pollutant emission effects of renewable energy policies

Emissions	2020 reductions compared to baseline scenario (Kiloton)
SO_2	1,6
NO_x	-0,8
NH_3	-0,4
NMVOS	-1,9
$PM_{2,5}$	-0,4

The co-firing obligation which has recently been proposed in the Netherlands will also increase air pollution, therefore this is not a viable policy to abate air pollution either.

The air pollution targets currently under discussion within Europe for 2020 can largely be met by end-of-pipe measures (Smeets 2012). Renewable energy is not a cost-effective option and can even be counterproductive.

Optimal policies and air pollution

Although current policies such as the SDE+ and the biomass co-firing obligation will not be optimal from an air pollution perspective, this is not to say that renewable energy cannot contribute cost-effectively to air pollution abatement. Increasing the share of renewable energy technologies such as wind energy, geothermal heat and solar energy will have a positive impact on air pollution emissions. Bollen and Brink (2011) have studied a scenario with more ambitious air pollutant emission targets for 2020, based on cost-benefit considerations (see Chapter 3.2.2).

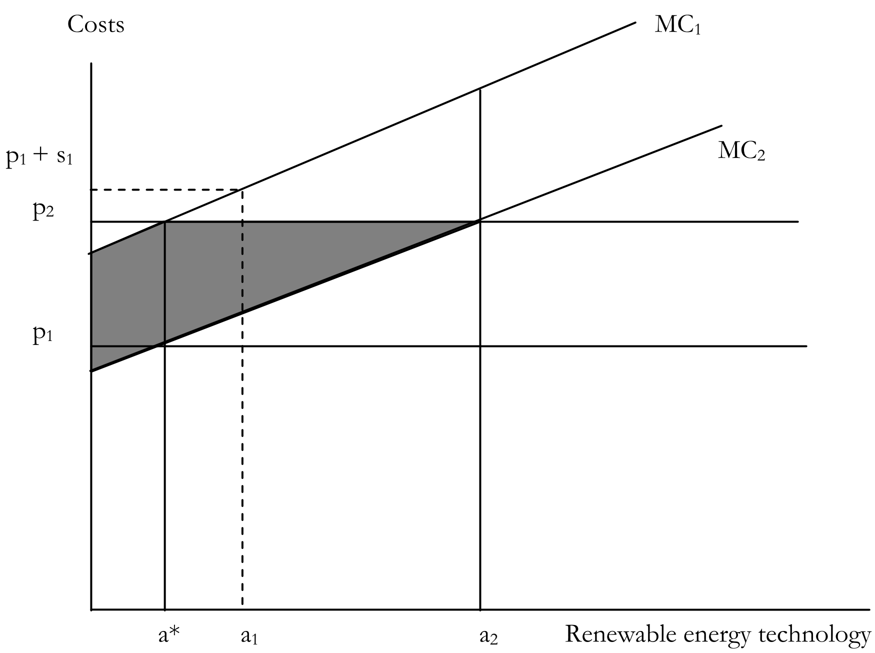
48 14% was the renewable energy target of the past government. Recently this target has been increased to a renewable energy share of 16%.

This scenario shows an increase in the production from non-fossil fuel energy sources compared to the baseline, which consists specifically of solar and wind energy. Moreover, longer-term targets for air pollution have not been taken into account in the studies mentioned above. Welfare optimization will require further emission reductions after 2020 (see Bollen et al. 2009 on long-term emission targets for air pollutants) for which renewable energy will probably be cost-effective as well.

Innovation

Stimulating the deployment of renewable energy policies can also have an impact on innovation market failures, especially on the knowledge spillovers associated with learning-by-doing. Speeding up learning in the deployment of new technologies will reduce their costs, for example because production techniques become more efficient or because new energy technologies become more efficient. This cost reduction is the benefit of the diminished innovation market failure. This is illustrated for a simple two period model in Figure 4.1.

Figure 4.1 Benefits of innovation



The horizontal axis shows the deployment of an electricity generating renewable energy technology, the vertical axis the costs and price of electricity. MC_1 are the marginal costs of the technology in the first period. Let the price of electricity in a first period be P_1. Without a subsidy or other incentive scheme, this technology will not be deployed. A subsidy of S_1 will induce deployment of this technology of a_1. Because of learning by doing, marginal costs decline to MC_2 in the second period. With an electricity price in the second period of P_2, the renewable technology will be used up to a_2. Without the first period subsidy, marginal costs would have remained MC_1, and second period deployment would have been a*. The grey area equals the gross welfare benefits in terms of lower second period costs realized by subsidizing the technology in the first period. Part of this gain will accrue to those who have realized this cost reduction through LBD. However, part of it will spill over to others, therefore policy intervention might be warranted to realize the cost reduction. Whether the subsidy has a net benefit depends on the costs of the first period deployment. This is equal to the subsidy needed to deploy the technology, s_1 times the deployment level a_1. In Figure 4.1, the benefits as represented by the grey area will be larger than the square $a_1 * s_1$, suggesting that there will be net benefits.

The benefits from addressing knowledge spillovers depends strongly on the future price of conventional energy sources. If in a subsequent period the price remains too low for the technology to be implemented, there will be no benefits at all. In an optimal policy, the price of conventional energy sources should include the full social costs, including the damage from CO_2 emissions and air pollution. CPB (2011) investigates the additional policies (policies aimed at LBD and LBR) which would be optimal in two climate change policy scenarios in which 2050 GHG emissions are reduced with 51% relative to 1990 (Global Action scenario) and 10% (Fragmented Action scenario). These additional policies are policies in addition to a CO_2 price which are aimed at LBD and LBR, such as investment- and R&D-subsidies, prizes for innovation and product standards[49]. Given the uncertainty about learning rates, Monte Carlo simulations are run with different learning rates. For each simulation, the optimal level of support in the EU in 2020 for renewable energy technologies is determined. This yields a distribution of different support levels for different assumptions regarding the learning rate. In the majority of the simulations, solar PV receives additional policy support between \$24 and \$90 per MWh in the Global Action scenario.[50] In the Fragmented Action scenario, the support level is lower, between \$0 and \$70 per MWh. The budgets spend within the EU on additional policies for renewable energy technologies will depend on the relative size of the learning effects for different technologies (CPB 2011, p.19).

An important message from this study for our analysis is that additional support for renewable energy at an early stage can be optimal in order to realize the benefits of lower future costs. Whether this is the case will depend on future prices, including the social costs of polluting emissions, as has been shown above. In the CPB study, the costs of carbon are internalized in the price through the emission reduction objective for 2050. In our analysis, climate change policy is not included and future prices will not rise because of climate change policies. Instead, the social costs of air pollution might provide a rationale for deploying cost-effective technologies that reduce air pollution in order to minimize future abatement costs. With the policy targets currently under discussion in Europe for 2020, there is no role for renewable energy in reducing air pollution in a cost-effective way. If we assume that extension of current air pollution emission reduction targets beyond 2020 could also be met in a cost-effective way without renewable energy, there would also be no reason to reduce the costs of these technologies through LBD and LBR.

However, reducing emission further in order to maximize welfare will already in 2020 entail the use of renewable energy, as has been described above. Reducing the future costs of renewable energy through addressing knowledge spillovers related to LBD will then be a cost-effective

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49 In the CPB study, no distinction is made between LBD and LBR, in effect only learning-by-doing is modelled.

50 The spillover rates assumed in the CPB study are 100% (personal communication with Johannes Bollen). While there is limited empirical evidence on knowledge spillovers (see Fischer and Newell 2008), presumably part of the benefits of LBD will be appropriated by firms themselves.

strategy to abate air pollution, comparable to the role of additional policies in GHG emission reduction scenarios as explored in CPB (2011).

Renewable energy policy instruments

The main policy instruments in renewable energy policy in the Netherlands are currently the SDE+, biomass co-firing and, considerably smaller in realized volumes of renewable energy generation, netting ("saldering"). In a policy context without climate change, the main market failures which would warrant renewable energy policies are air pollution and innovation market failures such as knowledge spillovers associated with LBD. The current SDE+ and the biomass co-firing obligation are counterproductive for air pollution abatement, because biomass use tends to increase air pollutant emissions rather than decrease them. Moreover, current emission eduction targets for air pollution for 2020 under discussion in Europe consist mainly of end-of-pipe measures, renewable energy policies are not cost-effective. If instead policy targets would be based on welfare maximalisation, it might be optimal to use renewable energy sources such as wind and solar in the electricity generation mix in 2020 in order to limit air pollutants emissions sufficiently. Furthermore, long-term air pollution emission targets can provide a rationale for stimulating deployment of renewable in order to benefit from lower future costs through LBD.

The current literature does not provide quantitative estimates of the optimal volume of renewable energy in the generation mix. Moreover, there is insufficient knowledge on learning rates and knowledge spillovers to make meaningful estimates of the level of investment support that would be optimal to address knowledge spillovers associated with LBD. In the context of this research project, therefore, we have to limit ourselves to the observation that, even without taking the climate change externality into account, there can be reasons to continue with policies aimed at the deployment of and innovation in renewable energy. In terms of optimal policy, these policies would include internalizing the social costs of air pollution (for example, through pricing such as a tax or tradable emission permits[51]), deployment policies such as subsidies or renewable energy obligations and innovation policies to address knowledge spillovers in LBD and LBR[52].

Energy efficiency policies

In contrast to renewable energy policy, there is no specific target for energy efficiency, although a directive on energy efficiency is at the moment under discussion within the EU on energy efficiency (EC, 2012). Energy efficiency improvements are about 1,1 % per year in the period 2004-2008 (Daniëls and Elzenga 2010). Whether additional energy efficiency policies are welfare improving will depend on the direct costs and benefits of these measures and on the extent to which market failures are reduced by additional policies.

Direct costs and benefits of energy saving

Energy savings policy not only yields benefits through reduced market failures such as less air pollution and more innovation, it also reduces costs because of saved energy expenditures. ECN (forthcoming) gives an overview of the net direct costs (costs minus saved energy expenditures) of energy savings in various sectors. For households, there are only limited possibilities for energy savings measures which show a net benefit in terms of direct costs. Moreover, it is hardly

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51 There is a large literature on optimal policy design for air pollutant emissions. In this study, we will not go into the details of designing specific policy instruments for air pollution.

52 See Aalbers et al. (2012) for a detailed analysis of innovation policy design in the power sector.

possible to focus policy at the cost-effective measures, because heating behavior to a large extent determines whether a measure is cost-effective or not (ECN, forthcoming).

In the power sector, energy saving options are linked to the building of new plants with higher efficiencies in energy conversion. Construction of new plants in the Netherlands is not expected before the early 2020's, given the large investment in new generation capacity of recent years. Whenever new capacity will be build, firms will have a strong incentive to build the most efficient plants and no policies will be needed. Replacing existing plants before they are fully depreciated is very costly, given the large capital costs of investments in power plants.

In utility buildings, there is more room for cost-effective energy savings, up to 70 PJ primary energy use, at negative net costs. As discussed in Chapter 2, in principle these efficiency measures should be undertaken without further policies, because they are profitable in themselves. One of the reasons why utility building might not implement these effieciency measures, is the existence of market failures such as information problems. This will be discussed below.

Air pollution and energy efficiency
Energy efficiency measures are an important part of cost effective climate change policies.[53] Without climate change policies, the rationale for energy efficiency policy will have to be found in air pollution policies.

Up to 2020, with the air pollution emission targets such as formulated in the scenarios currently in discussion in Europe (see Chapter 3.2.2) energy saving only plays a limited role. The cost-effective measures for air pollution abatement identified in PBL (2012) and ECN (2011) include mainly end-of-pipe measures. However, with the more ambitious policy targets based on cost-benefit considerations, energy efficiency contributes significantly to emission abatement. Bollen and Brink (2011) show that primary energy demand in the EU is reduced by more than 15%. Moreover, beyond 2020 further efficiency improvements will probably be needed to reduce air pollutant emissions, given the emission reduction needed (see Chapter 3.2.2). Substantial efficiency improvements will therefore be needed both in the short- and the long-term to reduce air pollutant emissions in a cost-effective way.

Innovation failures
Comparable to renewable energy policy, cost reductions in energy savings technologies through LBD will also be subject to knowledge spillovers. However, empirical information concerning knowledge spillovers and learning rates in energy savings technologies is scarce. It is therefore difficult to quantify the effects of energy savings policy on knowledge spillovers related to learning-by-doing. Weis et al. (2010) find learning rates between 9 percent and 27 percent for energy demand technologies. Energy savings policies which provide an incentive for the deployment of energy savings technologies can therefore also have a net positive welfare effect. The extent to which these policies will be positive will depend on the cost reduction which can be realized for given technologies and the net costs of stimulating these technologies. As argued above, the benefits will depend on the extent to which external costs such as the damage from air pollution are reflected in the price of energy. When these costs are included in the costs of

53 See for example Daniëls, Tieben et al. (2012) on the importance of energy efficiency measures in cost-effective climate change emission reductions in 2050.

energy, lowering the costs of energy demand technologies through LBD will probably be welfare increasing, given the need for future emission reductions (Bollen et al. 2009).

Information problems

Information problems such as asymmetric information or split-incentives may be one of the reasons why cost-effective energy savings such as the estimated 70 PJ in utility buildings are not adopted. They can be addressed by programs which provide information about potential energy savings or examples of energy savings. There is some evidence on the impact of information programmes such as labeling and industrial energy audits which indicates that they can be effective in increasing energy efficiency (Gillingham et al. 2009). However, as Gillingham et al. (2009) note, data on the cost-effectiveness of such programs is not readily available.

Other options are the use of standards such as appliance standards or building standards such as the Dutch EPC for new houses and of financial incentives such as subsidies or tax credits. They address information problems through proscribing a minimum level of energy efficiency.

Lack of insights in the extent to which information problems hinder the adoption of energy efficiency measures and in the cost-effectiveness of instruments used to address these problems, prohibit clear conclusions on the optimal use of different instruments used for addressing information problems.[54]

Energy efficiency instruments

The main market failures which should be addressed by energy efficiency problems in a policy context without climate policy are air pollution, innovation failures and information problems. The optimal instruments required to address these market failures will be comparable to those for renewable energy policies: internalizing the social costs of air pollution through pricing or quantitative targets, innovation policies directed at energy saving technologies such as R&D subsidies and deployment incentives and policies such as labels and standards which address information problems.

On an aggregate level, energy efficiency policies in the Netherlands in the period 1995-2007 have not been successful (Algemene Rekenkamer 2011) and realized energy savings have remained behind the levels expected ex-ante. This is explained by a choice of less effective instruments, such as instruments with a less obligatory character in the energy-intensive industry in the years 2000-2007 compared to earlier years and policies which were mainly oriented at reducing costs of investments in energy efficiency measures while other barriers have apparently played a larger role in limiting the uptake of energy saving measures such as the timing of investment decisions and lack of information and knowledge.

Other non-binding policy instruments also appear to be less effective than previsaged. The voluntary agreement on energy savings in the build environment performed considerably less than planned, with an estimated 23 PJ of energy saved in 2020 instead of the foreseen 100 PJ (Daniëls & Elzenga, 2010, pp. 40-41). Limited participation because of the non-binding character and limited financial support are mentioned as reasons for this underperformance of the instrument.

54 See, for example, the ex-post evaluation of the EIA in Aalbers et al. (2007) on the problems of evaluating a single instrument such as the EIA.

In this study, the focus is on the aggregate level of energy savings which would be optimal in a policy context without climate change policies and not on specific policy design. However, it is clear from recent evaluations of Dutch energy efficiency policies that improving the current policy mix would be needed to make it more effective.

In contrast to the abundance of studies on climate change policies, considerable less work has been done on quantifying optimal policies for air pollution control in Europe after 2020. Consequently, no meaningful estimates can be given of, for example, the level of support needed to address knowledge spillovers in LBD. However, given the importance of energy efficiency improvements for post-2020 air pollution abatement, continued support for energy efficiency will be optimal.

With a focus on air pollution instead of on reducing CO_2 emissions, it will be necessary to redirect energy efficiency policy towards energy savings which contribute most to the reduction of air pollutants. In general, energy savings will have an effect on air quality, but the effect can differ considerably between sectors. For example, energy savings in traffic and transport will have a direct impact on air polluting emissions, while the effect on air pollution of the reduction of electricity demand will to a large extent depend on the effect of reduced demand on the generation mix. The consequences of energy savings on air quality are therefore not necessarily large or proportional to the amount of energy saved. Consequently, policies aimed at reducing air pollution through increased energy efficiency should optimally be focused on those energy saving measures which contribute most to air pollutant emission reductions.

4.3 Energy security

4.3.1 Types of instruments

Security of supply

Security of supply plays a role in virtually all parts of the energy market: oil, gas, electricity, and networks. The range of instruments that can be linked with this goal is therefore long. Correljé and van der Linde (2006) classify energy security instruments in the following categories: prevention, deterrence, containment and crisis management. Geopolitical strategies best fit under the heading of prevention, deterrence and crisis management; economic instruments seem more concentrated in the containment section. This involves diversification to source and origin, stand-by contracts, storage, energy system flexibility, energy saving and the stimulation of domestic production. But this division is not clear cut, as energy system flexibility may also play a role in crisis management. Just consider the positive impact of dual firing capacity in electricity generation as a rational alternative to strategic gas reserves.

Sustainable energy promotes the diversification of energy production and often forms a domestic source of energy. This makes sustainable energy a possible instrument to improve energy security. Similarly network investment may improve energy security by connecting markets and bringing alternative sources of supply into purview. This is a relevant factor for both electricity and gas markets. On the demand side smart grids may help to better match supply and demand, which also facilitates energy security seen as a short term phenomenon.

Table 4.3 provides an overview of instruments to be considered for security of supply as a policy goal. This overview is organized according to market segments within the energy sector to highlight the market specific nature of some of the tools.

Geopolitics is a tool potentially covering all energy markets. In the Netherlands the dependence on importation is greatest for oil and gas, which are traditionally the focal point for foreign policies aiming to secure security of supply of energy. CIEP (2004) advocates that security of supply should become an integral part of EU external trade and foreign and security policy making. Ikkonikova and Zwart (2010) promote the adoption of EU trade quotas to increase buying power and counteract the market power of large suppliers like Algiers and Russia in the European gas market. Such quotas should be implemented bilaterally to encourage supply diversification generating a positive externality for other EU member states through improved buyer power. For the national agenda energy diplomacy and maintaining good international relations in the energy field is of the utmost importance, as described in CIEP (2011).

Promotion of domestic production, for example via local energy markets, is an instrument that also falls in this category. Several regions in the Netherlands aim to achieve energy neutrality relying on local sources of production. The ultimate consequence of energy neutrality may be uncoupling of the regional energy grids from the national grid. In such cases energy security becomes a regional issue.

Security of delivery

As a policy goal security of delivery is closely connected to capacity investment in energy networks. Increase in capacity will generally reduce the risk of a black out. First best policies therefore fall in the category of market-based instruments and command and control. An example of the former is regulation to counter to negative impact of natural monopolies on capacity investments. A rate of return type of regulation provides the strongest incentive for capacity investment, but generates negative incentives for cost efficiency. The optimal regulatory instrument therefore seeks a balance between cost efficiency and capacity investments, such as q-factor regulation or a menu approach.[55] Alternatives are input requirements in the Netcode prescribing the network operators to maintain a specific quality of their network services. This applies to both gas and electricity networks. For natural gas, additional issues play a role, such as maintaining the quality of biogas when it is distributed via the natural gas infrastructure. This calls for quality standards.

55 For an overview of these regulatory approaches, see Tieben et al. (2012).

Table 4.3 Instruments improving security of supply

Market	Market specific	Sustainable energy	Energy saving
Oil	Expanding emergency oil stocks	Promoting biofuels and bio-feedstock by means	Increasing energy efficiency in transport sector and industrial sectors
		Promoting sustainable transport technologies (electric cars)	
Natural gas	Introducing a cap on Groningen production	Promoting biogas	Energy saving for households and in utility sector
	Gas storage	Substituting gas-fired electricity capacity	
Electricity	Raising the tax of electricity	Promoting sustainable electricity	Energy saving for households and in utility sector, energy efficiency in industrial sectors
	Decentralized production; "virtual" power plants		
Networks	Interconnection investments (natural gas and electricity)		Smart grids enabling demand management
	Investing in LNG terminals		
All markets	Geopolitics Trade quotas Energy system flexibility Stimulation of domestic production, i.e. in local energy markets		

Source: SEO Economisch Onderzoek

Security of delivery is generally seen as negatively impacted by the introduction of sustainable energy. Sustainable sources, such as solar PV and wind energy are intermittent sources, which makes it more difficult to maintain the power balance in the electricity grid. For energy saving this is different. In principle energy saving creates excess capacity or reduces scarcity on existing energy infrastructures. It thereby improves the security of delivery. The development of smart grids may help to improve the cost efficiency of network operators by linking energy saving and energy use to capacity management on power lines.[56]

Interconnection may also be seen as an instrument to improve the security of delivery. However, current market circumstances also demonstrate potentially negative effect of interconnection. Increased penetration of renewables push peak prices in the direction of off-peak prices and this problem is partly exported to the Netherlands. As a consequence it is no longer profitable to run gas-fired capacity as prices are almost always lower than marginal costs of this capacity. But gas-fired capacity is needed as a back-up facility. Interconnection so creates potentially security of delivery problems, necessitating regulation to solve the 'missing money' problem.

56 By implication, network operators may postpone or cancel network expansions, which may reduce the security of delivery to its former level. See Blom, Bles et al (2012).

4.3.2 Impact on market failures

Security of supply

Instruments promoting energy security come in many guises and serve not only economic but also political and strategic goals. This makes it virtually impossible to assess the optimal policy mix in quantitative terms. One may even ask what optimal means in this context as it is impossible to distinguish between first best and second best policy options. This is a field probably better served by institutional and political analysis as demonstrated by CIEP (2004). Here the objectives of a strictly economic analysis should be modest.

There are studies linking energy security to sustainable energy such as Turton and Barreto (2006), but these studies generally address sustainable energy in terms of its contribution to the prevention of climate change. Daniëls, Tieben et al (2012) also falls in this category but this study can be used to give some notion of the economic impact of sustainable energy policy and energy saving on security of supply as a policy goal. This estimation is based on a risk premium which measures the negative externatility of macroeconomic adjustment costs in case of violent price swings in energy markets. This risk premium implies that a reduction of fossil energy imports improves energy supply security. Hence as energy from sustainable sources substitutes imported fossil based energy, energy supply security improves. But this does not occur for all sustainable sources. For example, as a substitute the price of biomass responds to changes in the prices of natural gas and oil. Moreover the importation of biomass makes the economy depended on the price changes in foreign markets, such as is the case for fossil energy like natural gas and oil. For coal this problem does not exist, given the diversity of producing countries.

Daniëls, Tieben et al (2012) show that an ambitious agenda for sustainable energy and energy saving has important benefits in terms of improvements of security of supply. In economic terms the aggregate benefit is circa € 7,6 billion for the period 2020-2050. On a yearly basis the benefit is on average € 520 million from 2020 onwards.[57] This is the impact of a broad policy agenda comprising both sustainable energy and energy saving. The data do not allow an assessment of the impact of more specific policy measures.[58]

The improvement of the security of supply is not a free lunch. It requires enormous investments which far outrun the benefit of improved security of supply. The yearly costs of the policy mix in Daniëls, Tieben et al is circa € 10 billion. Additionally there are economic costs of the policy measures taken to boost this amount of investments. This can vary from circa € 1,4 billion to circa € 3,7 billion per year depending on the type of policy instruments.[59]

To put this result in context it is useful to refer to a cost-benefit analysis of the CPB focused on security of supply in energy markets as a policy goal (De Joode et al 2004). This study covered existing and potential policy options. The study concludes that “security of supply policy is hardly ever beneficial to society” (De Joode et al 2004, p. 139). The market specific tools are aimed at

57 The bandwith around this estimate minimal € 260 million per year to a maximum of € 1.400 million per year. Please note that Daniëls, Tieben et al (2012) only report net present values. For the purpose of this study costs and benefits are expressed on a yearly basis in current prices.

58 In principle, this would be possible but requires additional model runs, which were not carried out for this study.

59 In general market based policies generate comparatively the lowest loss of economic welfare. Subsidies are the most expensive in terms of ‘deadweight loss’.

decreasing the negative externality of supply shocks. This generates opportunity costs in terms of setting aside potentially productive assets like natural gas and oil. But such measures leave the market relatively unharmed; they leave scope for allocative efficiency which makes them a better option than the alternative, sustainable energy and energy saving. Instruments aiming at sustainable energy and energy saving do impede the market by either affecting demand or supply generating higher economic costs in terms of welfare losses.

There is a specific tool in this policy field which acts upon *market power* as a market failure. This is investment in interconnection for both the gas market and the power market. New gas grids throughout Europe, such as Nabucco, may allow the EU to source gas from the Caspian region and the Middle East, bypassing Russia. LNG terminals offer a similar channel to supply gas in case of contractions elsewhere in the market. On a policy level building a roundabout for natural gas may fall under this heading, given that it aims to increase interconnection in the North-West European market (Brattle 2010). Similarly interconnection in the North-West power market improves the security of supply of power. The extent to which interconnection investments improves the security of supply has not been quantified in the literature.[60]

What can geopolitics contribute to the diminishing of market failures causing security of supply problems? This relationship has been extensively described, for example by CIEP publications, but a quantification of the economic impact is lacking.[61]

Security of delivery

There are several regulatory instruments to improve the security of delivery. The most interesting schemes are market-based. They generate an incentive for network operators to improve the security of delivery by including the social cost of the security of delivery in their tariff schemes.[62] This is done by means of a q-factor which internalizes this cost in the price of network services. By improving the quality of network services in terms of supply interruption the network operators are able to add the 'q' to their tariffs, which generates extra revenues and thus provides the incentive to invest in extra quality. In the Netherlands q-factor regulation is integrated in the system of yardstick competition. In principle, the q-factor is able to fully internalize the social cost of supply interruptions and thus offers a first best solution for the market failures causing the security of delivery issues.[63]

Sustainable energy policy often causes additional network problems and therefore conflicts with the security of delivery as a policy goal. For energy saving this is different. In principle energy saving creates excess capacity or reduces scarcity on existing energy infrastructures. It thereby improves the security of delivery. The development of smart grids may help to improve the cost

60 In fact Brattle (2010) concludes that the Netherlands already enjoys an excellent degree of security of supply in the gas market. It easily passes the N-1 test with a surplus production of 30 percent. A system passes the N-1 test if it can still meet demand after the largest source of gas supply is removed. The point is: if current production already sufficiently secures security of supply, the added value of the gas roundabout in this respect will be limited. Unfortunately Brattle (2010) does not estimate this relationship.

61 An exception is the social cost benefit analysis of economic diplomacy of Van den Berg, De Nooij et al (2008). This social cost benefit analysis shows that economic diplomacy can have major economic benefits, but the authors do not include security of supply of energy as one of the possible benefits.

62 For an overview see Joskow (2007) and Poort and Tieben (2010).

63 For example in the Netherlands the determination of the q-factor is directly based on estimates of VOLL.

efficiency of network operators by linking energy saving and energy use to capacity management on power lines. There are no calculations to indicate the extent to which energy saving improves the security of delivery.

4.3.3 Conclusion

What is first and second best if we evaluate the policy instruments under this heading? First best options remedy a market failure directly, such as building extra reserve capacity for oil and natural gas. But this impact is only felt for short term supply shocks. It does nothing to improve security of supply in the long term. For this aspect the other instruments are better suited. Investing in interconnection is such an instrument, but unfortunately a quantification of the impact of interconnection investments on security of supply is unavailable and strongly depends on the nature of the connection. A interconnection between Belgium and the Netherlands will have a different impact on energy security than an interconnection between our country and Norway.

Sustainable energy policy and energy saving also address the market failures accompanying security of supply directly. However, these policy options generate insufficient benefits in terms of improvements in the security of supply to warrant the costs. These policy tools are far too expensive for the security of supply as an isolated policy goal.

For the security of delivery first best policy options are regulatory schemes which incentivize network operators on the basis of estimates of VOLL. Q-factor regulation is an example of this approach. In principle this type regulation can fully accommodate the market failure associated with the security of delivery. Sustainable energy policy often causes additional network problems and therefore conflicts with the security of delivery as a policy goal. For energy saving this is different. In principle energy saving creates excess capacity or reduces scarcity on existing energy infrastructures. It thereby improves the security of delivery. The development of smart grids may help to improve the cost efficiency of network operators by linking energy saving and energy use to capacity management on power lines.

4.4 Affordability

As it has been noted earlier, achieving sustainability and energy security may be accompanied by large investment costs that make energy more expensive for consumers at the short run but cheaper and more reliable in the long run. Consequently, instruments that aim at sustainability and energy security may reduce short-term welfare. Or conversely, instruments that aim at lowering the current prices for consumers may erode investment incentives for firms and therefore reduce long-term welfare.

With respect to affordable energy, two groups of instruments can be distinguished: one that targets more cost-efficient solutions for sustainability and energy security via new innovative product and technologies and another that targets market power. In Table 4.4, the currently available instruments and their static (short-term) and dynamic (long-term) effects are summarized.

4.4.1 Type of instruments

First, the volume and the composition of energy are components, which have an impact on the purchasing power of energy consumers. Ceteris paribus, an increase in energy efficiency means a reduction of the energy bill for end users. This brings into purview the entire range of instruments linked to energy saving (see Table 4.4). Furthermore, the energy mix can also influence the energy bill of consumers. Currently, an energy mix that consists of fossil-based sources has the lowest costs for consumers. However, over the longer term this situation may change. Boosting sustainable energy for instance by subsidizing clean energy sources (see also Table 4.4) can make these technologies a competitor for fossil-based energy. By subsidizing the R&D process, more efficient clean technologies can be developed. By subsidizing the adoption of clean technologies, a larger deployment of renewable energy can be achieved that eventually lowers energy prices. The question is on what term this decrease in the price of energy can be expected. Current estimates show that this process can take decades (Schoots 2010).

Second, instruments that target more affordable energy aim to increase cost-efficiency by reducing market power. On the one hand, cost-efficiency can be achieved by increasing competition. For instance, competition plays a role downstream in the wholesale and retail energy markets. The government can stimulate competition by stimulating market integration, for instance by providing a framework for national and international trading platforms or cross-border investments. On the other hand, where competition cannot be achieved for instance due to economies of scale, competitive conditions are stimulated by sector-specific regulation, generally based on European legislation. Such measures are the vertical separation of the transport and production of energy, which eventually opened downstream competition, and the tariff regulation of regional and national networks.[64] In the case of tariff regulation, so far the major goal has been stimulating cost-efficiency. Recently, however, dynamic efficiency has also been seen as a relevant public goal: to increase downstream competition, sufficiently large and reliable networks are required. Therefore, tariff regulation needs to provide sufficient incentives for network operators to invest in network renewals and expansions. Currently, in the Netherlands regional network operators are regulated based on a yardstick competition, while in the case of TenneT revenue-cap regulation applies. Finally, there is a general instrument, namely competition policy that provides an ex post remedy in the case of the abuse of market power.

Affordability is also a clear example of a policy goal that is affected by political considerations. In times of quickly rising retail prices for energy political debates focus on the impact of higher energy prices on purchasing power. The price cap on energy retail prices is a clear example of political interference. The original proposal for the liberalized energy market did not contain a price cap. The introduction of the price cap was the result of a political compromise in parliament. The aim was to protect energy consumers in case competition failed to curtail retail price increases.[65]

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64 See e.g. http://ec.europa.eu/competition/sectors/energy/inquiry/index.html.

65 Proposal for an amendment of the Energy Act, Crone and van Walsem, 15 november 2000, Tweede Kamer, 27250, nr. 30.

Table 4.4 Instruments for more affordable energy and effects on static and dynamic efficiency

Market	Instrument	Effect on static efficiency (short term: price)	Effect on dynamic efficiency (long term: innovation, investment)
Energy efficient appliances	Carbon tax, ETS	? (0)	0
	Subsidies		
	- R&D subsidies in NL	? (0/+)	+
	- Deployment subsidies (EIA)	? (+)	+
	Appliance standards	? (-)	+
Clean generation technology	Carbon tax, ETS	? (-)	+
	Subsidies		
	- R&D subsidies in NL	? (0)	0/+
	- Deployment subsidies (SDE+)	? (+)	?
	Standards	? (-)	? (+)
Energy production	Tariff regulation	+	+/-
	Competition policy	+	-
	Market integration	+	-
Networks	Tariff regulation	+	+/-

4.4.2 Impact on market failures

Instruments that target the innovation of energy efficient appliances and clean energy production technologies (Table 4.4) are more likely to have a positive impact in the long run than in the short run as they involve large investment costs that firms may include in their prices. Innovations are determined by instruments that target directly knowledge spillovers, such as subsidies, but also by instruments that aim at the reduction of CO2-emission, such as carbon taxes. However, there are hardly any studies to evaluate the exact impact of these instruments on innovation and indirectly on prices.

The effects of instruments targeting innovations in energy efficient appliances in the housing market is analyzed by two recent CPB studies (Noailly, 2010 and Noailly et al., 2010). These studies estimated the effects of carbon taxes, standards, and government R&D subsidies on the patenting activities in seven EU countries, including the Netherlands. Patent counts were taken into consideration in building insulation, high-efficiency boilers, and energy efficient lightning. Particularly in the last group, the Dutch company Philips is very innovative, but Dutch firms are also active in the market of high-efficiency boilers.[66] The studies showed that setting a standard has a significant positive effect on innovations, while government subsidies have a small and carbon taxes have no significant effect on innovative activities.

[66] In other fields, such as insulation or solar boilers, Germany, Austria and Scandinavian countries are more active than the Netherlands.

With respect to the R&D in the clean sector, the Netherlands is relatively small compared to other countries, such as Japan, the USA or Germany.[67] Therefore, subsidizing clean technologies specifically in the Netherlands is unlikely to have an impact on knowledge spillovers and thus on clean technology prices.[68]

In an SEO-report from 2007, the effects of a deployment subsidy (*energie-investeringsafterk*, EIA) on energy saving is analyzed (Aalbers et al., 2007). The study concluded a positive effect on the energy saving of eight technologies. Investments, in which firms used EIA, reduced energy usage by an amount between 3230 TJ and 10352 TJ (19 and 62 percent of total energy saving). In terms of cost-efficiency, it implies a reduction between 59 MJ/euro and 6569 MJ/euro. However, the effectiveness of EIA depends strongly on which other instruments it is used in combination with.

Instruments that subsidize the deployment of renewable energy generation, such as SDE+, may lead to somewhat lower costs and thus lower prices in the short term. However, a substantially larger volume of renewable capacity is necessary to spur the cost reduction of clean technologies that make these technologies competitive with dirty technologies (learning-by-doing). As discussed in Chapter 4.2, this capacity is likely to involve higher costs than its potential benefits are in terms of cost reduction (Koutstaal, 2011).

The blue map scenarios of the IEA demonstrate the importance of the competition between clean and dirty technologies.[69] An ambitious program to increase sustainable energy worldwide will have to decrease long-term fossil-based energy prices by more than 50 percent. It means circa 70 US dollar per barrel of crude oil in 2050 in a blue map world (sustainable scenario) versus 160 US dollar per barrel of crude oil in a business as usual scenario (low share of production for sustainable energy). This generates a considerable increase in purchasing power for the consumers of fossil-based energy of circa € 10 billion viewed over the period to 2050.[70] This equals a yearly purchasing power benefit of circa € 700 million.

However, this price effect occurs on global energy markets. A Dutch agenda to boost sustainable energy, which is not followed by other countries, will have no impact on energy prices determined on the global market. There, Dutch players are price takers and international cooperation is necessary to lower prices. The Dutch policy aimed at establishing this international cooperation can be seen as one that aims to improve the long-run affordability of energy.

Note that the calculation of the large increase in purchasing power does not discrimate between sustainable energy and energy saving. In many cases investment in energy saving has a positive business case indicating that energy saving improves the purchasing power of energy consumers. This result applies to households and firms. Energy saving is often a no-regret option.

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67 See UNCTAD (2011). Japan has been published most of the patents on climate change mitigation technologies between 1988 and 2007, followed by the USA and Germany. Smaller countries are also active in specific technologies. For instance Denmark in wind, Finland in clean coal, and Israel in geothermal energy.

68 In countries that are active in clean innovations, subsidies and carbon taxes have a significant positive effect on innovations. See e.g. Aghion et al. (2011).

69 See IEA (2010). Please note that these are real prices, corrected for the rate of inflation.

70 See Daniëls et al. (2012), pp. 98-99.

Instruments that address the market power of producers and network operators primarily aim at the increase of short-term effects, that is cost efficiency and lower energy prices. The vertical separation of transport and production induced downstream competition on the wholesale and retail level. For retail markets there is a price cap in operation to control retail prices and remedy the effect of a somewhat concentrated retail market. Moselle (2009) estimated that the gross benefit of this price cap is circa € 350 million to € 700 million per year. With € 650 thousand per year the direct costs of implementing the price cap stand in no comparison to this benefit.[71] However, the joint market share of the three incumbents is still above 80% and falling slowly, in spite of more than thirty competing firms in the retail market. Therefore, additional instruments, such as transparency, may be necessary to stimulate the conscious supplier choice of consumers. On the wholesale market, trading platforms can effectively reduce wholesale prices. In that, market integration and thus international platforms can play an additional role. On the down side, lower wholesale prices may reduce the incentives of electricity producers to invest in production capacity. In particular, the effect of lower prices on building up stand-by capacity, over which a few companies have market power, may be crucial.

For network operators tariff regulation applies. A recent SEO-report has analyzed the effectiveness of the current regulatory regime in the Netherlands (Tieben et al., 2012). An important conclusion of the study is that regulation needs to find a balance between guaranteeing low prices for consumers and sufficient investment in capacity. Germany and the UK have already made adjustments in their regulation in that respect. In Germany, network operators can for instance socialize investment costs by charging a tariff for energy producers. In the UK, a menu of sliding scale regulation is applied, which is in particular applicable for transport networks. For capacity investments, cross-border lines are going to play an increasingly important role in the future. International cooperation within the EU is relevant for that.

As a final note, competition policies address market power ex post. Competition law remains an ultimate and effective remedy when firms may exercise market power either in the vertical chain of the energy market or for end consumers.

4.4.3 Conclusion

Sustainable energy policy may have an impact on affordability as a policy goal, but this impact is only felt over the long term. For the short term sustainable energy has a negative impact on energy prices and is therefore in conflict with affordability as a policy goal.

Energy saving is in many cases a no-regret option for households and firms. It improves affordability in a direct way by reducing the volume of energy consumend. This effect can be substantial. Larger increases in energy saving require more expensive technologies, which are not cost efficient and therefore decrease rather than increase purchasing power. In the long run innovation may improve the cost efficiency of these technologies.

[71] Note that this cost calculation does not include indirect costs such as the welfare loss caused by the intervention of the regulation in the price mechanism. The Dutch regulator for energy NMa estimates the benefit of its oversight on retail tariffs to be € 1 million per year. The difference with the estimate of Moselle (2009) is considerable. See NMa (2012c).

First best options to improve the affordability of energy are sectorspecific and general competition policies. These policies directly address market power as a market failure.

A second best policy option is sector specific price regulation. This policy option only addresses the symptom and not the disease, which is a lack of competitive market pressure. But is is able to directly control the cost of energy to consumers by means of a price cap. Very likely the economic benefit of price regulation on affordability as a policy goal is modest.

4.5 Interaction between instruments

This chapter discusses the three policy goals for the energy market in isolation. This ignores the interaction between the instruments addressing the market failures related to the policy goals. Instruments in sustainable energy policy and energy saving serve multiple purposes. There are two types of interaction between the instruments, negative and positive.

It is clear that there are market failures which support multiple policy goals. This is most notably the case for knowledge spillovers and market power. This overlap implies that instruments addressing these market failures are able to further multiple policy goals. In this case addressing knowledge spillovers by means of innovation policies may help reduce pollution, strengthen energy security and improve the affordability of energy at the same time. However, this confluence is not as straight forward as it appears. There is first of all the *issue of timing*. This chapter stressed that before 2020 sustainable energy cannot be seen as a cost effective measure to reduce pollution. End-of-pipe technologies meet the same goal much cheaper. After 2020 sustainable energy may become a cost effective instrument to improve pollution, but this requires innovation through LBD. This can be a long drawn process during which the costs of sustainable energy supply are higher than those of alternative sources of energy. In this phase there is inevitably a negative trade-off between the goals of pollution and the affordability of energy.

By the same token the confluence of policy goals depends on the *nature of the sustainable energy technology* employed. In the current market biomass co-firing is seen as a cost effective measure to meet the sustainable energy targets for 2020, but this technology worsens rather than aids pollution abatement. Wind energy and solar PV should be preferred in this respect, but these technologies are intermittent sources. Their intermittency may pose a risk to the stability of the electricity networks in the absence of supporting measures. The impact of sustainable energy can already be felt in the Dutch energy market through the coupling of the Germen energy market, which supplies a considerable volume of sustainable energy. This pushes peak prices to a level below the marginal costs of gas-fired capacity: these sources are pushed out of the merit order, while their role is considered increasingly important to maintain balance in a network with a larger supply of intermittent sources. This clearly shows that as policy goals sustainability and energy security are not automatically in unison. Supporting measures such as regulation of stand-by capacity are indispensable.

Table 4.5 reviews the positive and negative trade-offs. The table concludes that positive trade-offs are more likely for energy conservation instruments than for the promotion of sustainable energy. The most important problems concern the type of technology and the time required to go through the process of LBD (innovation). This is a typical economic phenomenon: costs go before benefits making it hard to connect sustainability and energy security in a positive way with affordability as a policy goal. This may perhaps be achieved in the long run and is more a likelihood for the 2030-2040 period than for the 2020-2030 period.

It is important to stress that as a policy goals energy security may also be internally inconsistent. As a domestic production source, sustainable energy may further the security of supply, but poses a challenge to the security of delivery through its intermittent character. This makes it important to distinguish between the security of supply and the security of delivery as different policy goals.

Table 4.5 Policy goals for sustainable energy and energy conservation are not automatically in unison

	Sustainability	**Energy security**	**Affordability**
Positive trade-off	Unlikely for *sustainable energy*. Only under ideal circumstances (post 2020). For *energy conservation* a positive trade-off is much more likely. Strongest link between pollution and affordability.	Chance for trade-off is greatest for energy conservation. Sustainable energy fosters domestic production and may therefore also improve energy security. Effect depends on the technology. Biomass furthers neither pollution nor energy security.	Unlikely for *sustainable energy*. Only under ideal circumstances, requires LBD (innovation). For *energy conservation* a positive trade-off is much more likely. Strongest link with pollution.
Negative trade-off	Depends on energy technology. Trade-off most likely with affordability due to a lack of cost effectiveness (pre 2020). Increased share of sustainable energy may pose a risk to security of delivery.	Importation of sustainable energy may depress prices, but pushes stand-by capacity out of the merit order. Causes trade-off with affordability. Also goals of security of delivery is not supported by increased share of intermittent source.	Importation of sustainable energy may depress prices, but pushes stand-by capacity out of the merit order. Causes trade-off with security of delivery.

Source: ECN and SEO Economisch Onderzoek

Suppose that instruments promoting sustainable energy and energy conservation meet the ideal situation and comply to the three policy goals simultaneously. This would mean that the social benefits related to these instruments should be added to calculate the total impact on economic welfare. This would certainly improve the social business case for these instruments, but a positive outcome is not guaranteed. The literature does not provide many social cost-benefit analyses of pollution abatement instruments, which makes it difficult to assess the impact of instruments furthering this goal. Daniëls, Tieben e.a. (2012) show that the benefits of reduced CO2-emissions are a crucial factor in a social cost-benefit calculation of sustainable energy. In our thought experiment this benefit does not count, making investment in sustainable energy an unprofitable affair for society, even for the period after 2020. But this comparison is not entirely fair, given that the cost abatement curve for pollution differs from that for CO2.

Based on Daniëls, Tieben e.a. (2012) the result for pollution is not entirely known, but likely to be negative given the high impact of CO2-emission as a negative externality on the outcome of the social cost-benefit analysis.[72]

The results of the social cost-benefit analysis of De Joode et al (2004) support this conclusion, because it demonstrates that a confluence of goals for sustainability and energy security is unlikely. This automatically depresses the social business case for sustainable energy as a policy goals to be pursued for reasons independent of the concerns for climate change. For energy conservation this result is different. Energy conservation very likely has a positive social business case, given that it simultaneously decreases import dependency.

72 To meet the CO2-goal in Daniëls, Tieben e.a. (2012) virtually all abatement options are required, making this goal very expensive from a social point of view. For pollution a cost effective mix of instruments could perhaps avoid the most expensive options leading to a better social business case. Unfortunately without a cost abatement curve for pollution this claim remains unproven.

5 Energy policy after 2020

Air pollution as the main target for sustainability

In the absence of climate change policy, the main market failure related to the sustainability objective is air pollution. Currently, emission reduction targets are being negotiated in Europe for air pollutants for 2020. These targets will replace the 2010 national ceilings on emissions from the NEC-directive. For those targets, end-of-pipe measures are a cost-effective option. Studies by IIASA, PBL and ECN show that renewable energy and energy efficiency only play a limited role in achieving these targets in a cost-effective way. From the point of view of market failures related to the public goal of sustainable energy, therefore, there would be little reason to continue with the deployment of renewable energy such as the SDE+ and the biomass co-firing obligation. Innovation failures such as LBD would also not be relevant for renewable energy policy, because these technologies have no role to play in reducing air pollutant emissions. There are reasons to continue with energy efficiency policies, because of market failures such as information and behavioural failures, as long as the benefits of these policies in terms of reduced energy costs outweigh the costs of these policies.

The 2020 targets for air pollutants, however, are not necessarily the optimal emission reduction targets which maximize welfare. Furthermore, optimal policies might require further reductions beyond 2020, for which renewable energy might be a cost-effective option. In contrast to climate change policies, long-term emission targets for air pollutants have not been formulated so far and cost-benefit studies on long-term air pollution are rare. The limited evidence that is available on welfare maximizing long-term air pollution policy indicate that renewable energy and energy efficiency technologies are essential to achieve the optimal emission reduction targets in a cost-effective way, both for 2020 and beyond. The important role which both renewable and energy saving technologies will have in optimal air pollution abatement is a main driver for policies which address innovation failures. Addressing these innovation failures such as knowledge spillovers related to LBD can substantially reduce the future costs of emission abatement.

Comparable to the optimal policy mix for climate change policies as described in CPB (2011), the optimal policy mix needed to realize these emission targets consists of both ‘carrots’ and ‘sticks’. While prices, emission caps and emission standards for air pollutants (‘the sticks’) will reduce emissions and reduce the price gap between fossil and renewable energy technologies, policies aimed at innovation failures (‘the carrots’) will ensure that future costs of renewable energy technologies and energy efficiency measures will fall sufficiently fast.

The optimal policies aimed at reducing air pollutant emissions will be a mix of market-based instruments such as emission trading, aimed at reducing emission from large stationary sources such as power plants, and deposit refund systems, standards such as emission standards for cars and local measures aimed at preventing the occurrence of local hot spots with high air pollution concentrations. This mix of policies will ensure that the necessary emission reductions are achieved in a cost-effective way. Furthermore, pricing will increase the costs of polluting technologies such as fossil energy production, which will make it more attractive to use clean technologies such as renewable energy and to increase energy efficiency. However, given the occurrence of information and behavioural failures such as, for example, asymmetric information and split incentives, which hamper the deployment of energy saving technologies, there will also be a need for flanking policy measures which address these information failures. Examples of such policies are information programs, labeling and appliance standards. Compared to the current policy mix addressed at energy efficiency, a policy context without climate change objectives will see a shift in energy saving policies towards energy savings which contribute most to the reduction of air pollutants such as, for example, energy efficiency improvements in traffic and transport.

Pricing of air pollutants instead of CO2 will also see a shift in the deployment of renewable energy technologies. The use of biomass will not be an option because air pollutant emissions tend to increase when biomass is used. Instead, clean technologies such as wind, solar and geothermic energy will be used.

To reduce future costs of air pollutant emission abatement, policies are necessary to address innovation spillovers. Given the important role of clean renewable energy technologies and energy efficiency for long-term air pollutant emission abatement, innovation policies need to be addressed at those technologies. These policies will include R&D subsidies, prizes for clean innovations and deployment subsidies for clean technologies and energy efficiency measures. Given the current state of knowledge on optimal innovation policies and the uncertainty regarding learning rates for specific technologies and the role of LBD versus LBR, it is not possible to be more specific about optimal innovation policies. Given this uncertainty, it will be optimal to keep a large number of technology options open in order to be able to learn from future knowledge on promising technologies. An important difference with current deployment policies such as the SDE+ and the biomass co-firing obligation is that biomass based technologies will probably not play a role and therefore should not be included in R&D and deployment policies.

Security of supply
What is first best and second best if we evaluate the policy instruments under this heading? First best options remedy a market failure directly, which in this case suggests employing general economic policies such as trade policy: the negative externality involved is a macroeconomic cost and not a market failure specific to the energy market. Social cost-benefit analyses such as De Joode et al (2004) demonstrate that market specific solutions such as building extra reserve capacity for oil and natural gas can be second best options. But the impact of these instruments is only felt for short term supply shocks. It does nothing to improve security of supply in the long term. For this aspect the other instruments are better suited. Investing in interconnection is such an instrument, but unfortunately a quantification of the impact of interconnection investments on security of supply is unavailable. Economic diplomacy and building international institutions for good governance in the energy markets also fall into this category.

Sustainable energy policy addresses the market failures accompanying security of supply indirectly. This policy option generates insufficient benefits in terms of improvements in the security of supply to warrant the costs. This policy tool is far too expensive for the security of supply as an independent policy goal. Energy saving may be a no-regret option in this regard, given the fact it incurs negative social costs in some cases and simultaneously reduces import dependency.

For the security of delivery first policy options are regulatory schemes which incentivize network operators on the basis of estimates of VOLL. Q-factor regulation is an example of this approach. In principle this type regulation can fully accommodate the market failure associated with the security of delivery. Sustainable energy policy often causes additional network problems and therefore conflicts with the security of delivery as a policy goal. For energy saving this is different. In principle energy saving creates excess capacity or reduces scarcity on existing energy infrastructures. It thereby improves the security of delivery. The development of smart grids may help to improve the cost efficiency of network operators by linking energy saving and energy use to capacity management on power lines.

Affordability of energy

Sustainable energy policy may have an impact on affordability as a policy goal, but this impact is only felt over the long term. It requires innovation and LBD, which means that the costs are incurred before the benefits can be reaped in terms of improved cost effectiveness. It is unlikely that sustainable energy contributes to the affordability of energy even for the period after 2020. For the short term (pre 2020) sustainable energy has a negative impact on energy prices and is therefore in conflict with affordability as a policy goal.

Energy saving is in many cases a no-regret option for households and firms. It improves affordability in a direct way by reducing the volume of energy consumed. This effect can be substantial. Larger increases in energy saving require more expensive technologies, which are not cost efficient and therefore decrease rather than increase purchasing power. In the long run innovation may improve the cost efficiency of these technologies. From this perspective energy saving should be on the agenda of energy policy for the period before and after 2020.

First best options to improve the affordability of energy are sectorspecific regulation and general competition policies. These policies directly address market power as a market failure.

A second best policy option is sector specific price regulation. This policy option only addresses the symptom and not the disease, which is a lack of competitive market pressure. But is is able to directly control the cost of energy to consumers by means of a price cap. Very likely the economic benefit of price regulation on affordability as a policy goal is modest.

General conclusion

The general conclusion of this study is that sustainability, energy security and affordability of energy only partially support a case for sustainable energy if we ignore the case for climate change as a thought experiment. After 2020 air pollution is the most important reason to promote sustainable energy as a public goal of energy policy. For energy security and affordability the impact of sustainable energy may in fact be negative. Energy saving does contribute to sustainability, energy security and affordability of energy as public goals and achieves a positive contribution in a cost effective way. Table 5.1 explains the results of this thought experiment comparing the agenda for energy policy after 2020 independently of climate change, and the climate driven agenda for the period up to 2020.

Table 5.1 Robust elements of energy policies supporting non-climate change related objectives

	Current energy policy targets for 2020	Optimized air quality targets 2020 and beyond
Sustainable energy	Focus on a sustainable energy target promoted by SDE+, bio-mass co-firing obligation et cetera	Deployment policies aimed at emission reduction and innovation failures for renewables such as wind and sun No biomass support (such as co-firing obligation)
	Climate objective (CO2) dominates over pollution targets Energy efficiency policies addressed at information and behavioral failures which yield positive net benefits because of savings on energy spending	Energy saving policies yielding net benefits including social costs of air pollution
Security of supply	Sustainable energy is seen as a positive but unintended byproduct improving energy security. Focus is on other instruments such as international relations and maintaining emergency stocks.	Sustainable energy cannot independently support energy security as a policy goal: for this goal it is not cost effective. Policy agenda does not change in a world which ignores climate as a thought experiment.
	Energy efficiency promotes reduced import dependency of oil and natural gas. .	Energy saving policies yielding net benefits including social costs of improved energy security.
Affordability	Plays no role as an argument to support sustainable energy. Costs are simply too high compared to conventional sources of supply.	This conclusion does not change in the post 2020 period. Over the longer term (> 2030) innovation may change this result. But this implies an intertemporal tradeoff: currently higher energy prices for end-users to profit from lower prices in the future (costs of innovation go before benefits)
	Only energy efficiency policies addressed at information and behavioral failures which yield positive net benefits because of savings on energy spending	Energy saving comes much stronger to the fore as a policy yielding net benefits including social costs of improved affordability

Source: ECN and SEO Economisch Onderzoek

Literature

Aalbers, R. (2001). Blijft het licht in Nederland branden?, ESB, 30 maart 2001, 293-295.

Aalbers, R., B. Baarsma, P. Berkhout, S. Bremer, M. Gerritsen & M. de Nooij (2007). Ex-post evaluatie Energie Investeringsaftrek (EIA). SEO-report nr. 999, Amsterdam.

Aalbers, R., V. Kocsis & V. Shestalova (forthcoming). Directed technical change in electricity generation technologies, CPB Discussion Paper, Den Haag.

Acemoglu, D., P. Aghion, L. Bursztyn & D. Hemous (2012). The Environment and Directed Technical Change. *American Economic Review*, 102(1): 131–66.

AER (2005), *Energiek buitenlands beleid: energie: voorzieningszekerheid als nieuwe hoofddoelstelling*, Den Haag.

Aghion, P., A. Dechezlepretre, D. Hemous, R. Martin & J. Van Reenen (2011). Carbon taxes, Path Dependency and Directed Technical Change: Evidence from the Auto Industry. Working paper.

Akerlof, G. (1970). The Market for "Lemons": Quality Uncertainty and the Market Mechanism, Quarterly Journal of Economics, 83(4): 488-500.

Algemene Rekenkamer (2011), *Energiebesparing: Ambities en Resultaten*, Den Haag.

Arthur, B. (1989). Competing Technologies, Increasing Returns, and Lock-In by Historical Events, Economic Journal 99: 116-131.

Baarsma, B. & M. de Nooij (2006). Calculus van het publiek belang op de elektriciteitsmarkt, SEO-rapport nr. 885, Amsterdam.

Baarsma, B. and P. Hop (2009), Power outages in the Netherland, *Energy*, vol. 34(9), pp. 1378-1386.

Bielecki, J. (2002), Energy security: is the wolf at the door?, *Quarterly Review of Economics and Finance*, vol. 42, pp. 235-250.

Bijlsma, M., V. Kocsis, V. Shestalova & G. Zwart (2008). Vertical foreclosure: a policy framework. CPB Document 157, Den Haag.

Blom, M., M. Bles, C. Leguijt. F. Rooijers, R. van Gerven, D. van Hameren en F. Verheij (2012), *Maatschappelijke kosten-baten analyse intelligente netten*, Delf/Arnhem: CE Delft en KEMA.

Bohi, D.R. & M.A. Toman (1996). *The Economics of Energy Security*, Kluwer Academic Publishers, Boston.

Bollen, J. & C. Brink (2011). *The Economic Impacts of Air Pollution Policies in the EU*, CPB Achtergronddocument.

Bollen, J. & C. Brink (2012). *Air Pollution Policy in Europe: Quantifying the Interaction with Greenhouse Gases and Climate Change Policies*, CPB Discussion Paper 220.

Bollen, J, B. van der Zwaan, C. Brink & H. Eerens (2009). Local air pollution and global climate change: A combined cost-benefit analysis, *Resource and Energy Economics*, 31, 161–181.

Brattle Group (2010), *Economic Impact of the Dutch Gas Hub Strategy*, London.

Chay, K. & M. Greenstone (2003). Air Quality, Infant Mortality, and the Clean Air Act of 1970, MIT Department of Economics Working Paper No. 04-08

CIEP (2004), *Study on Energy Supply Security and Geopolitics*, Den Haag: Clingendael International Energy Programme (CIEP).

CIEP (2011), *Het Internationale Energiebestuurssysteem: Hoe navigeert Nederland naar betaalbaar, duurzaam- en voorzieningszekerheid in een onzekere wereld?*, Clingendael: Den Haag.

Correljé, A. and C. van der Linde (2006), Energy supply security and geopolitics: A European perspective, *Energy Policy*, vol. 34, pp. 532-543.

Constantini, V., F. Gracceva, A. Markandya and G. Vicini (2007), Security of supply: Comparing scenarios from a European perspective, *Energy Policy*, vol. 35, pp. 210-226.

CPB (2011). *Analyse routekaart 2050*, CPB Notitie, Den Haag.

Daniëls, B., B. Tieben, J. Weda, M. Hekkenberg, K. Smekens & P. Vethman. (2012*), Kosten en baten van CO2-emissiereductie maatregelen*, ECN-E--12-008/SEO 2012-32, Amsterdam: ECN en SEO Economisch Onderzoek.

Daniëls, B.W., Elzenga, H.E., Beurskens, L.W.M., Geilenkirchen, G., Hanschke, C.B., Hoen, A., Kieboom, S., Lensink, S.M., Menkveld, M., Kroon, P., Peek, K., Roeterdink, W.G., Schijndel, M. van, Seebregts, A.J., Sipma, J.M., Tigchelaar, C., Verdonk, M., Vethman, P., Volkers, C.H., Wetzels, W., (2010). *Aanvullende beleidsopties Schoon en Zuinig*, ECN-E--10-015.

ECN (2011), *Actualisatie Optiedocument 2010 RR2010-SV en NREAP*, ECN-E--11-023, Petten.

ECN en PBL (2010) Referentieraming energie en emissies 2010-2020. Energieonderzoek Centrum Nederland en Planbureau voor de Leefomgeving. ECN rapport ECN-E--10-004, Petten en Bilthoven.

ECN (forthcoming). *Energy efficiency measures*, Petten.

European Commission (2011). Proposal for a Directive on energy efficiency and repealing Directives 2004/8/EC and 2006/32/EC [COM/2011/370].

European Commission (2011a), *Key facts and figures on the external dimension of the EU energy policy*, Commission staff working paper, COM (2011) 539, Brussels.

European Commission (2011b), On security of energy supply and international cooperation - "The EU Energy policy engaging with partners beyond our borders", Communication from the Commission, Brussels.

Energierapport (2011). Ministry of Economic Affairs, Agriculture and Innovation, The Hague.

Gillingham, K., R.G. Newell & K. Palmer (2009). Energy efficiency economics and policy, RFF Discussion paper 09-13.

Fischer, C., Newell, R., 2008. Environmental and technology policies for climate mitigation. *Journal of Environmental Economics and Management* 55:142–162.

Foreest, F. van (2010), *The Role of Natural Gas in the Dutch Energy Transition*, Oxford Institute for Energy Studies, WP NG 39, Oxford.

Hausman JA, Joskow PL. 1982. Evaluating the costs and benefits of appliance efficiency standards. *Am. Econ. Rev.* 72:220–25.

Hedesund, F. (2008). Energy security policies in EU-25 - the expected cost of oil supply disruptions. Paper presented at the 2008 EAERE conference. Bron: www.webmeets.com/files/papers/EAERE/2008/241/241.pdf.

Holmström, B. (1979), Moral Hazard and Observability. *Bell Journal of Economics*, 10: 324-340.

IEA (2007), *Energy security and climate policy: assessing interactions*, Paris.

Ikkonikova, S. & Zwart, G. (2010). Reinforcing buyer power: Trade quotas and supply diversification in the EU natural gas market. CPB Discussion Paper 147, The Hague.

Johnstone, N., I. Hascic & D. Popp (2010). Renewable energy policies and technological innovations: evidence based on patent counts, *Environmental Resource Economics*, 45, 133-155.

Joode, J. de, D. Kingma, M. Lijesen, M. Mulder and V. Shestalova (2004), *Energy policies and risks on energy markets: a cost benefit analysis*, The Hague: CPB.

Joskow, P.L. (2007), *Incentive regulation in theory and practice: electricity distribution and transmission networks*, NBER working paper.

Kocsis, V., R. Lukach, B. Minne, V. Shestalova, N. Zubanov & H. van der Wiel (2009). Relation entry, exit and productivity: an overview of recent theoretical and empirical literature, CPB Document 180, Den Haag.

Koutstaal, P.R. 2011, Assessing the innovation benefits of climate and energy policy instruments, paper presented at the EAERE Conference, June 2011, Rome.

Lanzi, E. & I. Sue-Wing (2010). Directed technical change in the energy sector: an empirical test of induced directed innovation. Working paper.

Lavrijssen, S. (2012), *De verschillende gezichten van de energieconsument*, Wolf: Nijmegen.

Leiby, P.N. (2007). Estimating the energy security benefit of reduced US oil imports. Oak Ridge National Laboratory, ORNL/TM-2007/028.

Lindman A. & P. Solderholm (2012). Wind power learning rates: A conceptual review and meta-analysis. Energy Economics, 34(3): 754-761.

London Economics (2007). Structure and Performance of Six European Wholesale Electricity Markets in 2003, 2004 and 2005. London.

London Economics (2011), *Estimating Value of lost load (Voll)*, London.

Moselle, B. (2009), *Assessment of the effects of tariff regulation on the Dutch residential retail markets for energy*, The Brattle Group.

Motta, M. (2004). Competition Policy. Cambridge University Press, New York.

Mulder, M. (2010). Tariff regulation and profitability of energy networks. A model analysis for TenneT TSO. NMa Working Papers No 3, The Hague.

Muller, N., R. Mendelsohn & W. Nordhaus (2011), *Environmental Accounting for Pollution in the United States Economy*, American Economic Review, 101 (August 2011): 1649–1675.

NEEDS (2007), *New Energy Externalities Developments for Sustainability*, Final report on the monetary valuation of mortality and morbidity risks from air pollution, Université Paris.

NMa (2007). Onderzoeksrapport inzake de winsten van energiebedrijven. Netherlands Competition Authority, The Hague.

NMa (2010). Onderzoek winsten en financiële positie TenneT periode 2005-2009. Netherlands Competition Authority, The Hague.

NMa (2012a). Onderzoek winsten TenneT 2010. Netherlands Competition Authority, The Hague.

NMa (2012b), *Factsheet Kwaliteit 2011 Regionaal Netbeheer Elektriciteitsnetten & Gastransportnetten*, Den Haag.

NMa (2012c), *Outcome van NMa optreden: resultaten voor 2011*, The Hague: NMa.

Noailly, J. (2010). Improving the energy efficiency of buildings: The impact of environmental policy on technological innovation. CPB Discussion Paper No. 137, The Hague.

Noailly, J., S. Batrakova & R. Lukach (2010). Home, green home – A case study of inducing energy-efficient innovations in the Dutch building sector. CPB Document No. 198, The Hague.

Noailly, J. & R. Smeets (forthcoming). Directing Technical Change from Fossil-Fuel to Renewable Energy Innovation: An Empirical Investigation Using Patent data, CPB Discussion paper, The Hague.

Poort, J. & B. Tieben (2010), Van maatstaf naar maatwerk. Een korte geschiedenis van economische regulering, *Tijdschrift voor Toezicht*, vol. 1(4), pp. 27-44.

Saline, B. (2000). Microeconomics of Market Failures. MIT, USA.

Schoots, K. (2010), *Innovatie en leercurven*, ECN 10-038, ECN: Petten.

Smeets, W. (2012). Kosten en baten van strengere emissieplafonds voor luchtverontreinigende stiffen Nationale evaluatie voor de herziening van het Gothenburg Protocol, PBL.

Stoft, S. (2002), *Power system economics*, Wiley.

Tieben, B., R. van der Noll, N. Rosenboom en V. Kocsis (2012), *Efficiënt en effectief reguleren: Advies over de efficiëntie en effectiviteit van het tariefreguleringsproces van het netbeheer in de energiemarkt,* in opdracht van de NMa, SEO-rapport 2012-04, Amsterdam.

Turton, H. and L. Barreto (2006), Long-term security of energy supply and climate change, *Energy Policy*, vol. 34, pp. 2232-2250.

UNCTAD (2011). Technology and Innovation Report 2011. Powering Development with Renewable Energy Technologies. United Nations Publications, UNCTAD/TIR/2011, Geneva.

Unruh, G. (2000). Understanding carbon lock-in. Energy Policy, 28: 817-830.

Van den Berg, M., M de Nooij, H. Garretsen and H. de Groot (2008), MKBA financieel buitenlandinstrumentarium. Een onderzoek naar de maatschappelijke kosten en baten van het

financieel buitenlandinstrumentarium van het Ministerie van Economische Zaken, SEO-report 2008-64, Amsterdam.

Verdonk & W. Wetzels (2012). *Referentieraming energie en emissies: actualisatie 2012; Energie en emissies in de jaren 2012, 2020 en 2030*, ECN en PBL.

Weiss, M., M. Junginger, M.K. Patel, K. Blok (2010). A review of experience curve analyses for energy demand technologies, *Technological Forecasting and Social Change*, 77(3), 411-428.

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