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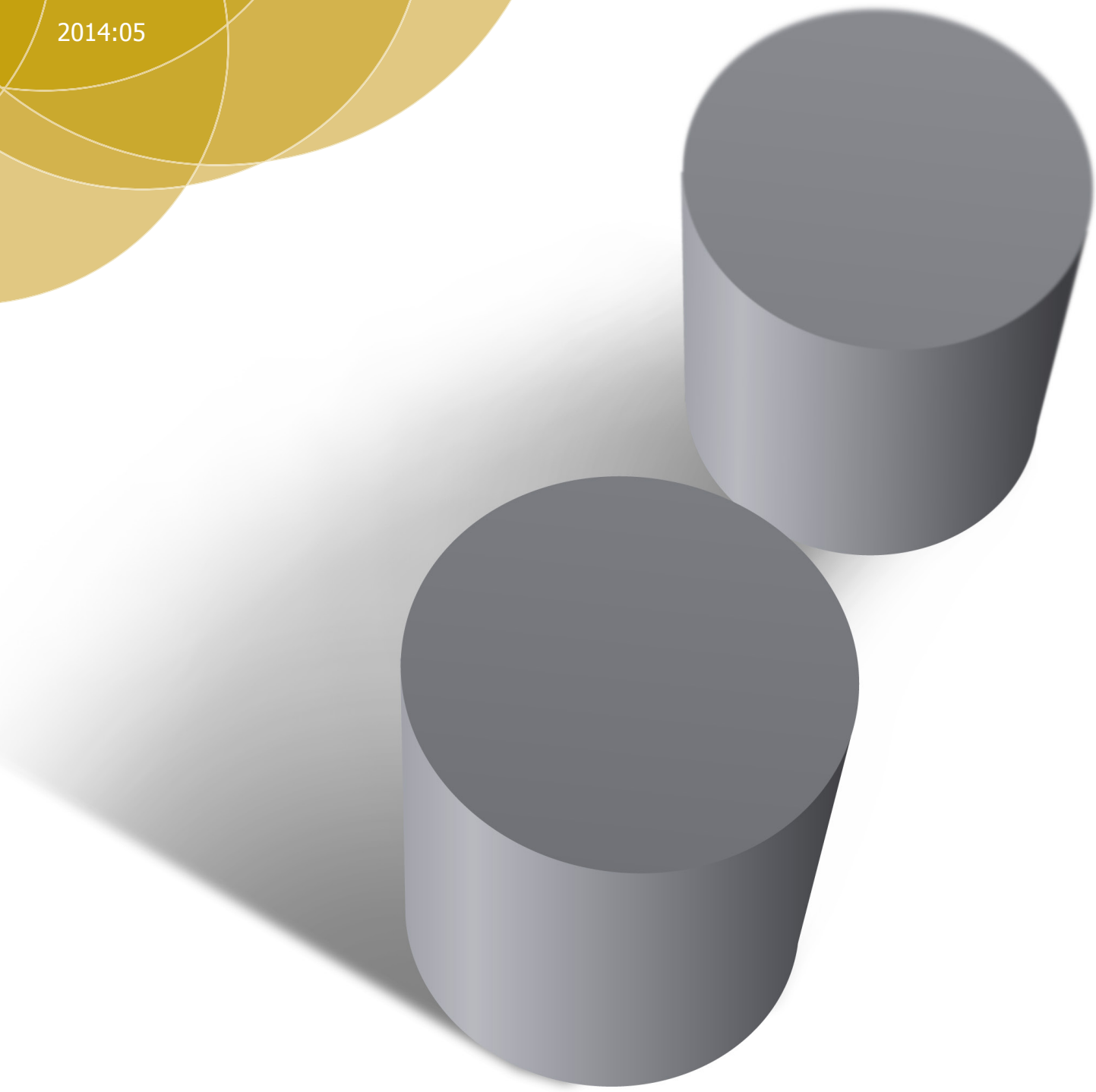

Policy for **energy systems of the future** – beyond 2020

An international survey

In this report Growth Analysis describes the overall trends in energy policy in a number of countries in Europe and beyond. The report is based on country studies that analyse broad national strategies as well as specific policies and instruments targeting different sectors and different parts of the innovation chain.

growth analysis

The Swedish Agency for Growth Policy Analysis has been commissioned by The Swedish Energy Agency to conduct this study on long term energy policies in a number of countries. The Swedish Energy Agency works for the use of renewable energy, improved technologies, a smarter end-use of energy, and mitigation of climate change. The mission is a sustainable energy system.
Read more at www.swedishenergyagency.se

Ref.no: 2013/164
The Swedish Agency for Growth Policy Analysis
Studentplan 3, 831 40 Östersund
Telephone: +46(0)10 447 44 00
Fax: +46(0)10 447 44 01
E-mail: info@tillvaxtanalys.se
www.tillvaxtanalys.se

For more information, please contact Martin Flack.
Telephone: +46 (0)10 -447 44 77
E-mail: martin.flack@tillvaxtanalys.se

Foreword

Sweden's energy policy rests on three cornerstones: secure energy supply, economic competitiveness and ecological sustainability. In an increasingly globalised world, where global value chains are becoming increasingly dominant, international factors are coming to play a growing role in the design of the energy system and the energy policy.

The Swedish Energy Agency is currently pursuing a development programme with the aim of finding solutions to the challenges that lie ahead as regards energy– beyond 2020. In conjunction with this, the agency commissioned Growth Analysis to draw up a basis that describes the general trends in the energy policy area in a number of countries in and outside Europe. Some central observations are:

- *The energy question is becoming increasingly complex and its importance is growing*. Energy policies are being influenced to a greater extent by a growing number of considerations such as for example the environment, competitiveness, innovation and technological development, security and geopolitical strategy. In order to understand developments in the energy area, any analysis must therefore be based on a broad perspective.
- *Energy prices are central driving force in the development of the policy.* In India, China and South Korea, steps are being taken to deregulate the energy markets and increase incentives for greater energy efficiency by means of market-based price signals. In Europe, the high energy prices are already a dominating factor in the energy debate in many countries and energy policy design at both EU level and in the individual countries will in all likelihood be coloured by this.
- *Selective policy measures dominate the policy mix,* but development in Europe is moving in the direction of a greater emphasis on cost-effectiveness and in Asia towards more market-oriented solutions. Experiences from over a decade of support for renewable energy have resulted in greater knowledge of what is effective and what is not – the transfer of this knowledge between countries contains great potential for greater cost-effectiveness and faster expansion of renewable energy.

The present report is a summarising analysis of the underlying reports that have been drawn up for the individual countries. It has been written by Martin Flack, who was also project leader for the study. The underlying reports drawn up for Denmark, Japan, China, Poland, South Korea and the USA were written by Growth Analysis' analysts at the agency's foreign offices. The others were written by Carina Weingaertner, Honorary Research Fellow, Civil Engineering, University of Birmingham (Brazil), Robin Jacobsson, Junior Consultant at Sweco Strategy (England and Germany) and Arati Davis, Consultant and part-owner of Damage Control Consultancy (India).

Stockholm, March 2014

Enrico Deiaco
Head of Department, Innovation and Global Meeting Places
Growth Analysis

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Summary

The present report is based on a number of studies that describe the development of energy policy in some of the countries that are considered to be most important as regards global development in the energy area, viz. Brazil, Denmark, India, Japan, China, Great Britain, South Korea, Germany and the USA. Each country study describes in detail both overarching long- and short-term strategies and specific interventions in different energy sectors and aimed at different parts of the innovation chain.

Our ambition is to relatively briefly summarise the main observations from the studies and present a cohesive analysis of the central driving forces, challenges and prerequisites for these countries' energy policies. Some of these observations concerning driving forces behind and the design of energy policy are presented below.

Driving forces behind the energy policy

The energy issue is becoming increasingly integrated with other policy areas, for example development and economic policy, environmental policy and foreign policy. The driving forces behind the countries' energy policies are therefore also different, in particular as regards emphasis on environmental and climate issues, depending, among other things, on their industry structure, economic growth, income level, access to domestic energy raw materials, among other things. A general observation is that environmental issues are emphasised more in countries with a high income level and when the environmental problems are perceived to be more urgent.

A further observation is that the majority of countries apply an "all-of-the-above" strategy, i.e. implement a broad set of energy solutions, ranging from traditional coal power to more modern renewable energy technologies. Research and development for future energy solutions are also part of this strategy. China and the USA are prominent examples of this; their energy policies span the whole spectrum of energy solutions, from advanced CSP (concentrating solar power) to shale gas and hydromethane.

In Europe, the picture is somewhat different with several countries pursuing a clearly defined policy for structural changes in the energy sector – phasing out fossil fuel in favour of renewable energy. Germany is perhaps the clearest example of this but the same perspective also predominates in Denmark. The impression given by Great Britain is a little more fragmented with both major investments in renewable sources and at the same time the highest subsidies in the world on fossil energy.

It must be emphasised that China, India and several other countries have an ambition to break their fossil fuel dependency in the long term but in practice it is the conventional fossil forms of energy that will predominate for the foreseeable future.

Energy efficiency is a high priority in all the countries and is considered to be a cost-effective solution that both promotes sustainable development and strengthens competitiveness. Japan is a world leader, above all in the industry sector and continues to invest large sums in the area. Smart grids and more energy-efficient buildings are two prioritised areas, which is also true of, for example, the USA.

Common to all countries is that the fundamental driving forces behind the energy policy are a safe, secure supply of energy and economic competitiveness. This is also the case in for example Germany and Denmark, but possibly with a more long-term view of the

energy issue. Higher energy costs are accepted today (within reasonable limits) because they are seen as an investment in future energy supply security and competitiveness.

Box 1 Greater harmonisation of the USA's energy policy.

The energy debate in the USA for obvious reasons mainly concerns developments in the gas market. Extraction of shale gas (and oil) has increased substantially and changed the United States' situation from one of dependency on imports to possible independence and even net exports in the long term. Energy prices, and gas prices in particular, have also decreased significantly, which strengthens industry's competitiveness relative to other countries. Against this background, the challenges that the USA faces have to do with how its energy system develops in the long term, i.e. beyond the present and next decades and include such issues as upgrading of the electricity grid and stability in a situation with a high degree of federal autonomy and very varying levels of ambition, aims and directions: future energy sources, beyond shale gas; greater energy efficiency in industry, homes and transportation and electrification of the vehicle fleet.

Against this background, the Department of Energy has taken the initiative for a recurrent review and strategy process to be made every four years, called the Quadrennial Energy Review. The aim is to harmonise the federal energy policy and steer more in the direction of handling specific challenges in the area of energy. In line with this, it is also possible to see a shift in the general direction of the energy policy, from basic research towards applied research and innovation measures. The current polarisation in Congress, however, makes any assessment of the future extremely precarious.

Policy measure mix in transformation

Regarding the design of the policy, a general trend seen in recent years has been increasing use of selective policy instruments and technology-specific interventions. This so-called "new soft industrial policy" has been the subject of intense debate among economists and many critical voices have been raised concerning the efficiency losses that the selective policy is assumed to entail. On the other hand, both economists and politicians emphasise that the general policy instruments that have been tried hitherto have not succeeded in driving technological development and innovation at the pace required to resolve the energy challenges many countries are facing. One conclusion is that a combination of different policy instruments is needed to attain the ambitions of the energy policy[1] and that several different parameters affect what mix of policy instruments is most appropriate.

The report also describes a number of currents in energy policy that illustrate this conclusion. These are summarised below.

Support for renewable energy leads to increased production

Several European countries have in recent decades introduced various more or less technology-specific policy instruments, primarily to promote demand for renewable energy. Germany has its FiT system, Great Britain both FiT and green certificates, known as renewable obligations, and Denmark also has similar support systems.

Considering the results of these different systems, we can see that production of renewable electricity has risen substantially in the three countries. Development has been most

[1] See for example Growth Analysis (2012) Report 2012:02, Miljödriven näringslivsutveckling – Några grundläggande utgångspunkter för en verksam, effektiv och lärande politik [Environment driven development of trade and industry – Some fundamental starting points for an operative, effective and learning policy]

dramatic in Germany, where production increased from 1.5 to 102 TWh between 1990 and 2011 and the share of renewable energy, mainly solar power, currently stands at over 12%. Detailed follow-ups that have been made[2] also show that the subsidy systems are responsible for much of this increase. It is, however, difficult to say exactly how great this positive impact has been, because estimates of what would have taken place without the subsidies are naturally mere guesses. Irrespective of this, regarding the goal of increased production of renewable energy both the input tariffs and the electricity certificates seem to be affecting matters in the right direction.

But the future is uncertain – the cost side is a central challenge

A further dimension of these support interventions is that according to responsible decision-makers and authorities they are to be socio-economically cost-effective and entail the smallest possible cost increases for the end consumer. Here the picture is less positive. In all countries, evaluations show that the systems have become more expensive than initially thought and that the cost curve is pointing upwards at a steep angle. Current assessments show for example that the cost of expanding renewable energy in Germany over the next twenty years may be as high as a thousand billion Euro (8,840 billion SEK at current exchange rates).[3] This bill will ultimately be paid by German households and the country already has one of the highest electricity prices in Europe.

In Great Britain, the cost of the country's renewable energy programme is increasing rapidly and towards levels where they are meeting strong resistance. According to the *Department of Energy and Climate Change*, the annual cost amounted to roughly 2 billion GBP in 2013, will increase to 2.5 billion in 2014 and just over 3 billion in 2015[4] and will then double by 2020. The accumulated cost is then expected to be in the region of 40 billion GBP (approx. 400 billion SEK at current exchange rates) and around 100 billion GBP by 2030 (approx. 1,000 billion SEK).[5]

Against this background, an increasingly lively debate has sprung up in both Germany and Great Britain about the future of support for renewable energy. After a prolonged period of drafting, Minister for Economics and Technology Philipp Rösler and Minister for the Environment Peter Altmaier presented a joint proposal for reducing the rising cost of the German input tariffs on 14 February 2013.[6] This also means that a process of yearly evaluations of costs and results achieved is to be devised to reduce the risk of runaway cost increases in the future.

A debate is also going on in Denmark about the cost of expansion, primarily of wind power, and the Danish Energy Agency has been criticised for not exercising sufficient control. One example that has been mentioned is the construction of solar cell installations on agricultural land, which receive the same subsidies as domestic solar panels. This led to

[2] See for example Lipp (2007), Lessons from Renewable Electricity Policy from Denmark, Germany and the United Kingdom, Energy Policy, 35: 5481-5495; European Commission (2008) The Support of Electricity from Renewable Sources, Commission Staff Working Document, COM (2008) 19 Final, Brussels 23.1.2008, SEC (2008) 57; Bergek and Jacobsson (2009) En kritisk granskning av det svenska elcertifikatsystemet [A critical review of the Swedish tradable green certificate scheme], RIDE/IMIT working paper no. 84426-027,
[3] http://www.faz.net/aktuell/wirtschaft/wirtschaftspolitik/energiepolitik/umweltminister-altmaier-energiewende-koennte-bis-zu-einer-billion-euro-kosten-12086525.html
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rapid expansion with substantial profits for investors. The cost of solar cells now risks delaying the expansion of the Kriegers Flak offshore wind farm since the total renewable energy budget may be exceeded.

The central issue here is how production of renewable energy can continue to be increased to replace coal, oil and gas in the long-term – ambitions remain largely unchanged – without the costs becoming impossible for politicians to justify. What policy measures are most effective as regards the implementation of existing technology to drive the technological development of future energy solutions and how can we strike a balance between these two necessities?

A reform of Europe's support systems towards greater cost-effectiveness has already begun but it is still to early to say what this will result in.

Asia moving towards deregulation and market-orientation

In India, Japan, China and South Korea the picture is different to the one in Europe. India and China are struggling to meet the rapidly growing demand for energy and are using all means available. In Japan and South Korea, the biggest challenge is to keep energy prices down to support domestic industry while at the same driving both greater energy efficiency and diversification away from fossil fuels, which are considered to pose both a financial and a supply security risk. All four countries, however, are currently changing their institutional regulatory frameworks into more market-oriented models.

China is shifting towards freer setting of energy prices, which was confirmed at the third plenum of the Central Committee in November 2013. Energy pricing was one of the main issues and decisions taken at the plenum strengthened development towards market-pricing of electricity, oil and gas. The background is that the artificially low prices have led to undesired effects such as overcapacity in the country's electricity-intensive industry, lack of incentives to increase energy efficiency and high energy intensity in the economy in general. Now that China both wants to climb higher in the global value chains (from cheap manufacturing to greater service content) and needs to increase energy efficiency as a matter of urgency, energy prices are seen as an important piece of the puzzle and gradually increasing energy prices can be expected for certain kinds of energy and in certain sectors.

The South Korean government also controls energy prices, which are kept artificially low to support the country's domestic industry. Just like in China, the shortcomings of this policy are becoming increasingly evident. The country has an energy intensity that is 30% higher than the OECD average at the same time as it is totally dependent on imported energy. South Korea is therefore extremely sensitivity to external factors and for this reason the government in Seoul has initiated a number of processes to change this state of affairs. Deregulation of the electricity market and more market-oriented pricing of energy are two important components of the package.

Similar processes are also under way in Japan and India. In Japan, deregulation of the electricity market is in important issue given the country's ambitions to increase energy supply security and at the same time complement the energy mix with renewable alternatives. In India, the state traditionally exercises very direct control of the energy sector as both regulator, producer and distributor. Some steps are being taken now, first and foremost in the renewable energy sectors, to shift towards a more indirect role for the state players and more market-based policy instruments.

Free pricing and a fully deregulated energy market are still a long way off in these countries, perhaps most of all in China. The examples above nonetheless show that they are moving in this direction. In the long term, this may have far-reaching consequences as regards energy prices and the countries' industry structure and their role in the international energy markets.

Box 2 Brazil in need of structural reforms

Like the USA, Brazil finds itself in a situation where energy production has the potential to increase substantially over the coming decades – even if many obstacles remain to be faced. The overall direction of the country's energy policy is determined by an ambition to ensure a secure and competitive energy supply, preferably from domestic resources. These resources are already extensive, not least as regards hydropower, and the discovery of very substantial oil and gas deposits off the south coast of the country (*Pre-sal*) has raised hopes for greatly increased energy production, lower prices and a more prominent role as a global player in the energy policy area.

These, however, remain hopes and the challenges of exploiting these deep-water deposits are many. Another of Brazil's central challenges is to build the necessary infrastructure, to be able to use not only oil and gas from Pre-sal but also the hydropower and bioenergy in the remote northern and north-western parts of the country.

In connection with this, it is also worth mentioning a specific challenge for Brazil, the so-called "*Custo Brasil*", the Brazil Cost, referring to the structural deficiencies in the country's institutions as a whole and which also affect the energy area. These deficiencies include excessive layers of bureaucracy, corruption, high rates of interest, underdeveloped infrastructure and a lack of trained manpower. Alongside the direct interventions to increase energy efficiency and capacity increases in both both hydropower and fossil energy this is one of the government's main focus areas.

1 Introduction: general global energy trends

The global energy market is currently undergoing substantial, and probably important, changes. Two fundamental factors lie behind these changes: a) the geographical displacement of demand from the USA, the EU and other developed economies towards the growing economies in first and foremost Asia and the Middle East, and b) new technological advances that are also leading to changes on the supply side, where the USA's gas revolution is perhaps the clearest example.

It is still too early to predict the ultimate outcome but it is already clear today that both the political and the economic balance in the world will change and that the energy question will play a defining role for the foreseeable future.

The price of energy, and in particular regional price differences, is a central factor to consider. Those regions that for various reasons enjoy relatively low energy prices also develop strongly as regards industrial production and economic growth. To summarise, electricity-intensive industries in Japan and Europe are losing competitiveness while China, India, the Middle East and the USA are showing positive development[7]. Despite hopes that greater energy efficiency can contribute to mitigate this competitive disadvantage for the EU, the situation appears in general to be permanent. How it should be handled, not least in Japan and the EU, will be a central component of national energy strategies in the coming years.

As regards the details of the energy system's development, most indications point to fossil forms of energy continuing to dominate for the foreseeable future. According to the IEA's latest forecasts, fossil forms of energy will constitute 75 percent of the energy mix in 2035, compared to today's 82 percent. Renewable energy is developing strongly but in most cases from a low level and comes up against technological, institutional and political barriers along the way.

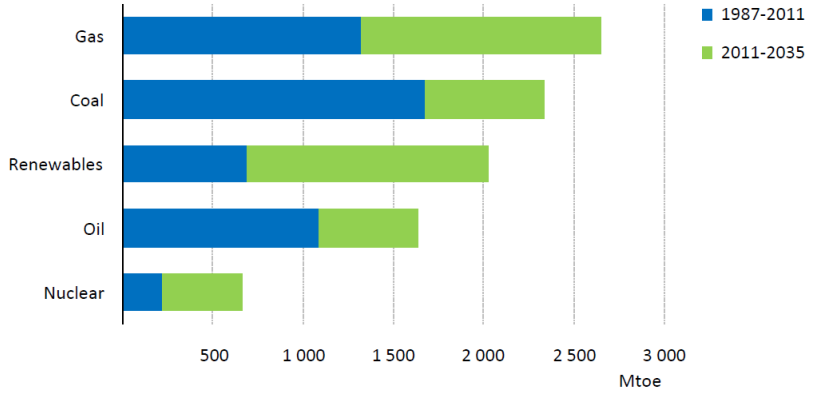


Figure 1 Growth in global energy demand, 1987-2011 and forecast to 2035

Source: IEA, World Energy Outlook 2013

An important message in Figur 1 above is also that all forms of energy actually increase over the years to 2035. 1.3 billion people still do not have access to electricity today and

[7] IEA, World Energy Outlook 2013

the growing middle classes around the world are consuming an increasing amount, which means that all the energy that it is possible to extract from known energy sources must be extracted to satisfy increasing demand in China, India and other relatively poor but fast-growing countries – also including a considerable increase in energy efficiency as industry undergoes structural change and modernisation.

To summarise, the brief reflection above indicates that the linkages between energy demand and other policy areas are growing stronger. Energy and climate are one such linkage to which great attention is already being devoted, energy and economic competitiveness another. In order to analyse and understand the development of the energy policy over the coming decades, it is therefore crucial to also understand these linkages and how they are transposed upwards in the political system. The next chapter contains an overview of this broad area and an attempt to summarise the central trends in the future energy policies of some of the leading countries in this respect.

2 Energy policy priorities; some general observations

This chapter gives a general picture of how the energy question and the challenges described above are being dealt with in a number of countries, including Brazil, India, Japan, China, the USA and a number of European countries. The survey is based on two perspectives or questions: a) what are perceived to be most important challenges as regards energy and b) what action is being taken to meet these challenges today and in the foreseeable future?

Not all aspects of of the energy landscape in each country will be touched upon; the focus lies instead on pointing out what is most fundamental to the development of the national energy policy and its possibilities to succeed.

2.1 Challenges

The challenge at the centre of the debate in all countries is how demand can be met securely, at a competitive price and with as little negative environmental impact as possible. It is important to underline that a secure energy supply means both a stable supply system without unplanned interruptions and a secure system, which is to say a system with a minimum of energy-related incidents (for example a melt-down in a nuclear reactor). Not only does the the emphasis between these different dimensions vary, however, but also the nature of both the problems and the solutions.

2.1.1 Energy policy for growth and competitiveness

One general pattern is not unexpectedly that the developing economies, of which China and India are good examples, emphasise the economic aspects more strongly while both security of supply and the environment are more in focus in the EU, Japan and to a certain degree also the USA. The explanation is that the latter countries have to a great extent already undergone an industrial development that briefly put has meant that energy intensity in their economies has fallen to such a low level that the total demand for energy is actually decreasing despite continued economic (although modest in some cases) growth.

By contrast, China, India and some other countries have both considerably higher economic growth and a considerably more energy-intensive economic structure. Since economic development and combating poverty are generally the number one priority, there is an urgent need to increase capacity.

Towards an increasingly globalised energy market

One aspect of the argument above, which is becoming increasingly important and which to a great extent is driving the development of the energy policy in the fast-growing countries, is that the expansion of capacity that is in fact taking place cannot match demand – resulting in a growing energy deficit and increased imports. *India* is a clear example of this, as Figur 2 below shows. The country's energy consumption has increased fivefold since 1980 and the forecast to 2030 is a further threefold increase compared to present levels. Domestic production over the same period has fallen a long way behind. This has had a serious impact on the trade balance and the problem is becoming increasingly acute as the energy deficit grows larger for every year that goes by. Dealing

with this challenge is therefore one of the Indian government's most important challenges. How they are going about this is discussed in more detail in the following section. The strategy can be briefly summarised as focusing strongly on most aspects – from energy efficiency, renewable energy and smart grids to more efficient coal power, new shale gas extraction and other unconventional forms of energy, for example methane hydrates.

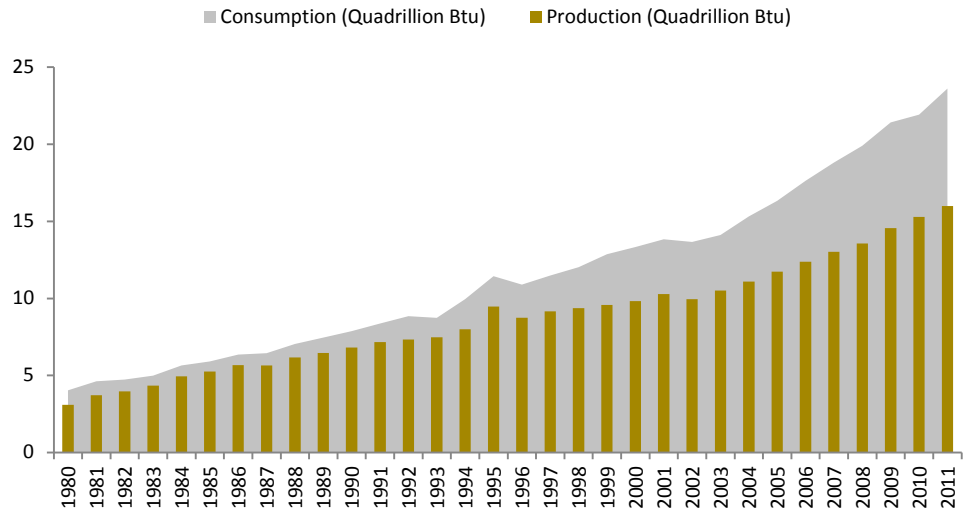


Figure 2 Total energy production and consumption in India, 1980-2011.

Source: EIA International Statistics, 2011

The picture in *China* is largely the same as in India. The country's energy consumption has been growing faster than production since the early 2000s and imports of oil, natural gas and coal are a growing headache for the government in Peking. The direct costs of importing energy and the burden this places on the economy are one side of the challenge; the other, and probably more important, is the geostrategic side. China is becoming increasingly dependent on the international markets and is influenced to a greater degree than before by the price variations in these markets. We can also see how major steps are being taken by Peking to avoid or moderate this dependency, partly by securing access to energy sources in other countries, not least in Central Asia and Africa, and partly by investing in domestic forms of energy and increased energy efficiency. China is for example already today the world's largest producer of solar panels and the targets for domestic energy production from the sun, wind and water are very ambitious. Regarding solar power, the aim is to increase solar energy capacity from today's 7 GW to 35GW by 2015 and at the same time reduce the cost of the electricity produced to more competitive prices compared to conventional forms of energy.[8]

Both China and India have extensive domestic energy resources; their foremost challenge is that demand is growing faster than capacity can be expanded. In *South Korea* and *Japan*, dependency on imports is also a central challenge, but their fundamental problem is a lack of energy sources of their own. Both countries import over 90% of their energy and this is coming to be increasingly seen as a burden on the economy and as a geostrategic risk.

[8] During the course of the 12th five-year plan, China intends to bring the cost of solar energy down to 0.8 yuan per kWh by 2015 and 0.6 yuan by 2020.

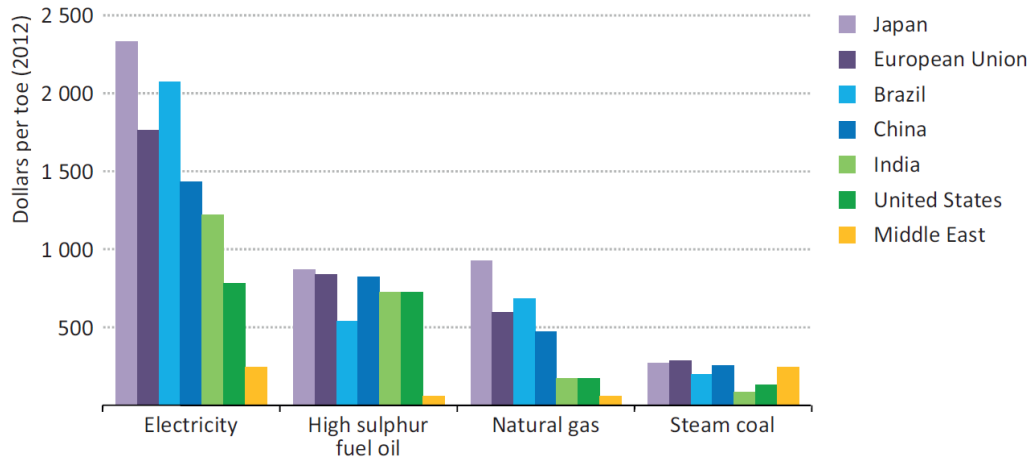
Japan has also been forced to deal with its loss of nuclear power, with the industry today largely at a standstill, which before the Fukushima disaster accounted for some 30% of the country's electricity production.

It also quite clear in this regard how availability of energy, regardless of its form, is prioritised in order to secure economic development and industry's competitiveness despite the environmental challenges that conventional forms of energy entail. Under prime minister Abe, Japan has rescinded its earlier pledges to reduce CO_2 emissions and will not be accepting any binding undertakings on these emissions for some time to come. The country's energy policy is focused on dealing with the post-Fukushima situation, which is still serious in some respects, through measures primarily focused on increased energy efficiency and restarting nuclear power plants as soon as safety regulations permit. One particular challenge as regards the expansion of renewable, and distributed, energy is the modernisation of both the power grid and the energy markets. The energy market is currently dominated by a small number of regional companies who with their status as monopolies control the entire chain from production to distribution, which is hampering the introduction of new forms of energy that require more flexibility.

The energy debate in *the USA* for obvious reasons mainly concerns developments in the gas market. Extraction of shale gas (and oil) has increased substantially and changed the United States' situation from one of dependency on imports to possible independence and even net exports in the long term. Energy prices, and gas prices in particular, have also fallen significantly, which strengthens industry's competitiveness relative to other countries (see Figur 3 below). Against this background, the challenges that the USA faces have to do with how its energy system develops in the long term, i.e. beyond the present and next decades and include such issues as upgrading of the electricity grid and stability in a situation with a high degree of federal autonomy and very varying levels of ambition, aims and directions: future energy sources (beyond shale gas) greater energy efficiency in industry, homes and transportation, and electrification of the vehicle fleet.

Like the USA, *Brazil* finds itself in a situation where energy exports have the potential to increase substantially over the coming decades – even if many obstacles remain to be overcome. The overall direction of the country's energy policy is determined by an ambition to ensure a secure and competitive energy supply, preferably from domestic resources. These resources are already extensive, not least as regards hydropower, and the discovery of very substantial oil and gas deposits off the south coast of the country (*Pre-sal*) has raised hopes for greatly increased energy production, lower prices and a more prominent role as a global player in the energy policy area. These, however, remain hopes and the challenges of exploiting these deep-water deposits are many. Another of Brazil's central challenges is to build the necessary infrastructure to be able to use not only oil and gas from Pre-sal but also the hydropower and bioenergy in the remote northern and north-western parts of the country.

The situation in Europe diverges in some respects from that in the rest of the world. European countries naturally share the challenges of ensuring a secure energy supply at as low a cost as possible and the cost aspect in particular has grown in importance as the price of other forms of energy has risen substantially in Europe compared to other countries, mainly the USA, in recent years (see Figur 3 on the following page). Prices, linked to industrial competitiveness, are also at the centre of the European Commission's coming energy policy package.



Note: toe = tonne of oil equivalent.

Figure 3 Industry's energy prices inclusive of taxes by fuel and region

Source: IEA, IEA, World Energy Outlook 2013

The environment: a new and increasingly important feature of the energy policy

Alongside the central issue and energy prices linked to industry's competitiveness, it is clear that the environment, and the climate challenge in particular, is given higher priority in Europe than in much of the rest of the world. The objectives of the the development of the energy system that steer the energy policy at EU level and in the individual member states strongly emphasise the introduction of renewable energy, reduced CO_2 emissions and greater energy efficiency. Trade in emission rights is also intended to lead to less use of fossil forms of energy in the economy in general, including the energy sector, even if results are at present only modest.

A further indication of the environment question's great importance in Europe is the prohibition introduced by many countries of prospecting for and extracting shale gas, despite the fact that an increase in the use of gas might contribute to lower energy prices and a stronger competitive situation for industry. The issue is far from being resolved and many players, countries like Poland and Great Britain for example, are also pushing for more permissive legislation and a clearer role for shale gas in the Commission's coming energy and climate package.

Against the background of the above discussion, it should be emphasised that *the environment and climate questions have in fact in practice become a more important factor in the design of the energy policy in many other countries outside Europe in recent years*. In China, and to a certain degree also in India, local environmental pollution of air and water has brought focus to bear on the negative external effects of fossil energy production – first and foremost coal power. The air in China's major cities is today so polluted that it is seen as an economic and political risk and thus something that needs to be dealt with. The government in Peking is also pursuing an active policy to mitigate the negative consequences of coal combustion, both by switching to other forms of energy and through more efficient combustion.

There are also historical examples of how the environment question has driven a transition in the energy sector. Air pollution and smog in the USA's major cities was for example a

central factor behind the policy-induced introduction of ethanol as vehicle fuel in the 1950s and 1960s.[9]

India is one country that deviates from this trend. Air pollution in the country's large cities, including Delhi, is at least as serious as in China's but in spite of this little attention is paid to the question in the public debate. This might possibly indicate that greater importance is attached to economic development in India than in present-day China and the USA in the 1950s and 1960s. One explanation might be that India still has a considerably lower level of income and that the country does not feel it can "afford" environmental considerations until it has the challenges associated with combating poverty under control.

Taken together what this means is that *environment questions are of importance for the design of the energy policy but not until the problems become acute* and are perceived to threaten economic development or political stability. A further aspect is that level of income is very important as regards emphasis on environmental issues, as the example from India illustrates.

The following section will discuss what different countries do to deal with their environmental and other energy policy related challenges. The review is divided into measures that concern management and development of the already established energy system based on mature technology and measures aimed at introducing and disseminating new technology that can in the long term lead to changes in the structure of the prevailing system.

2.2 Policy as a response to energy challenges

Policies to affect the supply of and demand for energy can be divided into different categories. An important parameter in this categorisation is technological maturity; a policy can be directed at anything from future energy solutions such as fusion reactors or expanding already established technology like conventional coal power faster or over a greater area. Between these two extremes there are many intermediate steps, for example wind farms, solar cells and fuel cells.

The most important observation in Figur 4 on the following page is that different degrees of technological maturity require different sets of policy instruments or combinations of policy instruments and not least different degrees of state involvement. One commonly accepted description of the role of the state in different phases of technological maturity is that the more mature the technology the less the need for direct state subsidies and the greater the role of technology-neutral policy instruments that influence consumers' and producers' incentives but do not reward a specific technological solution.

All the countries in the present study work actively to influence both the supply side and the demand side in the energy system and the choice of policy instruments is generally well in line with what can be expected against the background of the short introduction above. On the detailed level, there are however interesting similarities and differences between the countries and and in the following two sections we will present a summarised picture of the the energy policy's concrete implementation; first, those measures that aim to stimulate and steer development within the established sectors followed by the policy that is directed at promoting development and dissemination of new energy technology.

[9] A more detailed discussion can be found in Growth Analysis' report Policies for biofuels in Brazil and the US - An analysis of innovation strategies, actors and governance (WP/PM 2013:05)

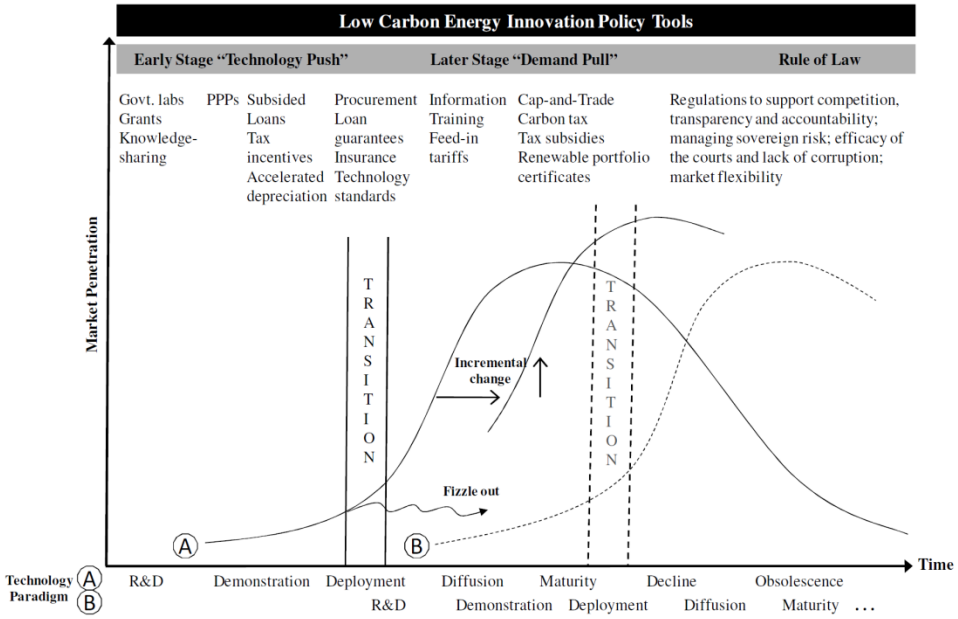


Figure 4 Examples of public support measures for energy technologies in different phases of maturity.

Source: E. Knight, N. Hogarth (2011)[10]

2.2.1 Management and development of today's energy systems

Regarding already established technology, such as conventional hydropower, coal power or nuclear power, the different countries' energy policies are largely a part of the current overarching institutional structure. For example, there is naturally a difference between centrally controlled China and decentralised America's way of promoting capacity expansion in such basic forms of power, while there are at the same time similarities between the countries, as a result of the player structure and the way the market functions also being influenced by common technological and financial prerequisites. These sectors are for example generally dominated by a small number of major players who control large production facilities and who maximise their profits by producing on a consistently high level. Technological development takes place as a rule incrementally, in small steps, and is largely both financed and implemented within the large organisations.

A policy that is intended to influence these players is therefore largely made up of general economic policy instruments, regulatory frameworks governing for example emissions, competition and anti-corruption.

Every country designs its set of measures in line with the overarching objectives of its energy policy. *China* has for example, as described earlier, set clearly defined goals to increase energy production in order to enable continued economic growth. In both the short and the medium term (up to 2035 for example), this means that mainly coal power but also oil and gas will increase substantially in absolute terms. Peking sets concrete production targets for the state-owned energy companies that are followed up with detailed checks and reviews. Failure to attain the goals is punished financially and through reduced possibilities for top managers to climb in the political hierarchy.

[10] E. Knight, N. Hogarth, Clean energy technology and the role of non-carbon price based policy: an evolutionary economics perspective (CCEP Working Paper 2, 2011)

China has at the same time a clear ambition to reduce dependency on fossil forms of energy, primarily coal, which are considered to lead to both environmental and security risks. To achieve this, Peking has in recent years included new objectives and various kinds of regulation to both increase productivity and reduce emissions. Concrete measures include financial support for increased efficiency in and modernisation of existing production facilities, higher taxes or tax discounts for those players who fail to attain or succeed in attaining the goals set, and forced closure of production units that do not live up to what is expected of them.

An indirect but central mechanism in these efforts is a transition to freer price-setting of electricity, which is expected to put increased pressure on general energy efficiency in the whole economy and drive efficiency efforts in the energy sector in particular. During the Central Committee's third plenum in November 2013, the focus was on the pricing of energy and decisions taken at the plenum strengthened development towards market pricing of electricity, oil and gas.

A further example of how regulation can be used to steer direction within the established energy system is the *USA*. The federal government has strictly limited control over the design of the energy system at the level of the individual states, which makes it difficult to implement an overall energy policy for the entire country – much of the energy policy is designed and implemented directly by the states themselves. And resistance in Congress towards new climate legislation makes matters even more complicated. One instrument at the government's disposal, however, is regulation of limits for emissions of hazardous particles to air, which is now being used actively to force a transition in the energy area. The Environmental Protection Agency (EPA) recently made the regulatory framework more stringent in order to reduce emissions of, among other things, CO_2, and this is expected to result in any new[11] coal power plants having to include technology for the capture and storage of CO_2 (CCS). This illustrates the discussion earlier in this chapter on how environmental policy and regulations enter the energy policy and influence development there.

Regulation of emissions from existing power stations, the single largest source of CO_2 emissions, is next in line. The vehicle industry also uses the so-called CAFE rules to drive development in the direction of more fuel-efficient vehicles are lower emissions.

In Japan, the energy discussion centres around the challenges in the nuclear power sector. Following the earthquake and tsunami that devastated the Fukushima nuclear power plant in spring 2011, all production of electricity at the country's approximately 50 nuclear power plants was brought to a halt in just a few months, resulting in the loss of one third of the country's total production capacity. This has since been compensated for through imports of liquid natural gas (LNG), oil and coal. The cost of the increased imports constitutes a heavy burden on Japan's already stretched budget and prime minister Abe has made it one of his prioritised issues to resolve this problem.

In both the short and the medium term Japan's energy policy centres around restarting nuclear power plants in order to quickly increase domestic production of energy. The security question is central in this and connected with it is the continuing negative opinion that nuclear power is facing from large parts of the population. As in China and the USA, the regulatory frameworks and institutional frameworks surrounding Japan's energy sector

[11] At present the USA's low gas prices mean that coal power is on the back burner and that new plants are not being planned anyway.

are currently undergoing reform in the direction of increased control and follow-up to reduce the perceived risks. In concrete terms, a new authority, the Nuclear Regulatory Authority (NRA) has for example been set up with a mandate to assess the safety of the nuclear power plants and prohibit plants that do not conform to the more stringent requirements from producing electricity. 14 plants are currently under review and decisions are expected in early 2014. This is a parallel to the example of regulation of air pollution in the USA and again shows how sustainability aspects, people's health in this case, can play a decisive role in the design of an energy policy.

Brazil is of particular interest as regards development in established energy sectors and the role of the policy in this development. Electricity production today consists of approximately 80% hydropower and the government has launched ambitious plans to further expand capacity to meet the rapidly growing demand; hydropower's theoretical potential is estimated to be in the region of 245 GW, only 83 GW of which is exploited today. An expansion of approximately 20 GW is currently under way, principally in Amazonas, largely financed by public investment. There are however many uncertainties concerning future development of hydropower. The lack of infrastructure is a serious bottleneck as is the fact that much of the theoretical potential lies in areas that for environmental reasons or social considerations are in practice not able to be exploited.

At the same time, non-renewable forms of energy, in particular oil and natural gas, are seeing strong development, not least due to the recently discovered Pre-sal oil field off the south coast of the country. In early 2013, the government launched a ten-year plan to increase oil production from approximately 2.7 million to over 5 million barrels a day by 2021. The plan also includes ambitious targets for exports of oil and the Brazilian government hopes that the country will become self-sufficient in oil over the coming decade.

Like China and India, Brazil clearly prioritises the need to increase (primarily domestic) energy production and uses all available forms of energy to ensure a secure supply of energy – both renewable and fossil. Unlike present-day China and the USA in the 1950s, the problems with local environmental pollution in Brazil are not related to fossil forms of energy. It is instead the expansion of large-scale hydropower, in Amazonas in particular, that is causing local environmental problems and social tensions. This poses a great challenge to future expansion of hydropower in Brazil and great efforts are being made to try to include the local population in the planning work and to develop sustainable solution for local development that will benefit them too. Al taken together, there is much to indicate that the strong environment related and security policy related driving forces away from fossil forms of energy – primarily coal – that we are currently seeing in China are not to be expected in Brazil over the course of the next few decades.

In conclusion, all of this can be compared with the situation in Europe, where the countries included in the present study (Denmark, Poland, Great Britain and Germany) all have different prerequisites and consequently different strategies. With the exception of Poland, the energy policy in all the countries is however primarily focused on phasing out fossil forms of energy, with a minor reservation as regards gas. A few examples are given below.

In Poland, coal is the most important source of energy as the country still has an abundant supply of both black and brown coal. The policy for renewable energy is not particularly well developed even though steps have recently been taken to accelerate the process. We shall return to this later in the report. The current energy discussion largely centres around possibilities to extract the shale gas that is thought to exist over a large area stretching from

the Baltic and through central and eastern Poland. The geological prerequisites have however proven to be less advantageous than was earlier hoped and many of the companies that had initially shown interest have now discontinued their prospecting. The government has however presented a bill concerning legislation to facilitate shale gas extraction and make it easier to prolong prospecting licences and to proceed to commercial production. It will be easier for the companies to use state-owned land around a drilling site and they will be able to drill deeper than 1,000 metres without needing to apply for a new licence.

By way of comparison, in *Denmark* a more active process of change is going on in the energy policy area. The country has also come a long way with regard to first and foremost the introduction of renewable energy and wind power in particular, which today accounts for 30% of electricity production. At the same time, oil production continues, although at a slower rate, and plans exist to exploit new gas fields over the coming years. Industry and the transport sector are relatively heavily dependent on oil and coal and the political ambition is to reduce this dependency dramatically over the coming decades. 35% of the final energy production is to come from renewable energy sources by 2020.

Many in the energy debate are of the opinion that these targets need to be reformulated. They say that natural gas should also have a place for a time after 2035 to compensate for varying production from the renewable sources. The IEA has sent a similar message: "*The use of natural gas as a flexible source of electricity supply in the medium term should be included as an important part of the analysis*", was the IEA's recommendation in its latest review of Denmark's energy policy[12].

One problem, however, is that gas prices are currently high compared to other fuels. This is partly a result of the terms and conditions of long-term contracts with Gazprom in Russia and partly a result of falling coal prices in the wake of the shale gas boom in the USA. Coal condensation in Germany is currently cheaper than Denmark's gas-fired power stations. This creates uncertainty about using gas in the future.

Germany is currently undergoing the most extensive energy transition in modern times, known as the Energiewende. The overarching ambition is to have completely phased out nuclear power, which today accounts for 16% of the country's electricity production, by 2022 and to have replaced it with renewable forms of energy, primarily solar and wind power. Energy efficiency is also a cornerstone of the Energiewende, as is electrification of the vehicle fleet. The policy in these areas will be described later in the report. Regarding nuclear power and fossil forms of energy, there will be a controlled phasing out with a political preference for keeping gas as a transitional fuel. Due among other things to the development of shale gas in the USA, which is forcing down the price of coal, this has proven to be more easily said than done. On a political level, the high costs to private individuals and to a certain degree also industry that today's energy policy entail are heavily criticised (although energy-intensive companies are exempt from taxes and charges). The government considers modern coal power to be an important piece of the puzzle to achieve economic growth and will constitute a substantial part of the energy mix until at least 2030.

In the same way as Denmark and Great Britain, *Great Britain* has staked out a long-term path to an energy system independent of fossil forms of energy. 90% of the energy consumed comes today from fossil forms of energy and 5% from nuclear power.

[12] IEA(2012) Energy Policies of IEA Member Countries- Denmark 2011 Review, p. 9

Renewable energy makes up 5%, most of which is bioenergy from waste combustion. In the climate area, the government has taken on a legally binding goal to reduce emissions of greenhouse gases by 80% compared to 1990 levels by 2050, which will only be possible by drastically changing the energy system, first and foremost in the direction of an increased share of renewable energy. At the same time, fossil energy, primarily offshore gas and oil, is heavily subsidised; according to the Overseas Development Institute, Great Britain ranks fifth in the world as regards these subsidies, with £2.6 billion on an annual basis. Shale gas also attracts great interest, even though the question is highly controversial, and the government has introduced a tax discount for companies wishing to prospect and extract the gas.

All taken together, opinions in Great Britain are divided, as they are in Europe as a whole and also in some other countries. On the one hand, ambitious efforts are under way to develop and disseminate the renewable energy that is considered to be sustainable in the long term, while on the other hand conventional energy is still economically advantageous and represented by strong pressure groups, which means that development is slow – both between sectors and between different countries.

A common challenge for the countries in the present study is thus how the established structures in the energy system can be reformed to allow broader dissemination of renewable energy. The present structure with a small number of vertically integrated players constitutes a barrier and distinct steps are being taken in many countries to change this. India, Japan, China and South Korea are working to increase the flexibility in their systems through deregulation and new policies concerning pricing and subsidies to established players, which will be discussed further in the following section.

2.2.2 Policy for future energy systems

The backbone of the policy for development and dissemination of new, low-carbon energy technologies consists of different kinds of research and development (R&D) efforts and financial support to make the often still relatively expensive alternatives competitive as regards price. The first category of measures are intended to create greater possibilities for new technologies to develop and demonstrate technological viability in relation to established alternatives while the second category is intended to create the prerequisites for dissemination to a greater number of users. There are many examples of these two categories from the studies upon which the present report is based. A few of them will be described here that illustrate different ways of looking at how innovation policy for new energy solutions can be designed.

Examples of policies for technology push

Rising prices and tougher competition for energy raw materials and growing concern about the environmental consequences of our present global energy systems, consisting of approximately 88% fossil forms of energy mean that investments in research and development (R&D) in the energy area are a very important question. For this reason, it is somewhat of a paradox that public investments in energy R&D are not only small in relation to other areas, health and defence for example (which it goes without saying are also highly important areas) while development over time has been as weak as it has (Figur 5).

It should be emphasised that it is primarily in OECD countries that the trend has been negative. In China for example, development has been much stronger, although exact

figures are difficult to confirm[13]. R&D generally has high priority on the political agenda due to the country's endeavours to climb in the global value chains and energy is one of the areas that are frequently emphasised as being central in this context. According to the IEA[14], China spent USD 4 billion on energy R&D in 2011, to be compared with slightly less than the 17 billion spent by the IEA's member countries, which include the USA, Japan, Great Britain and South Korea, together (Figur 6).

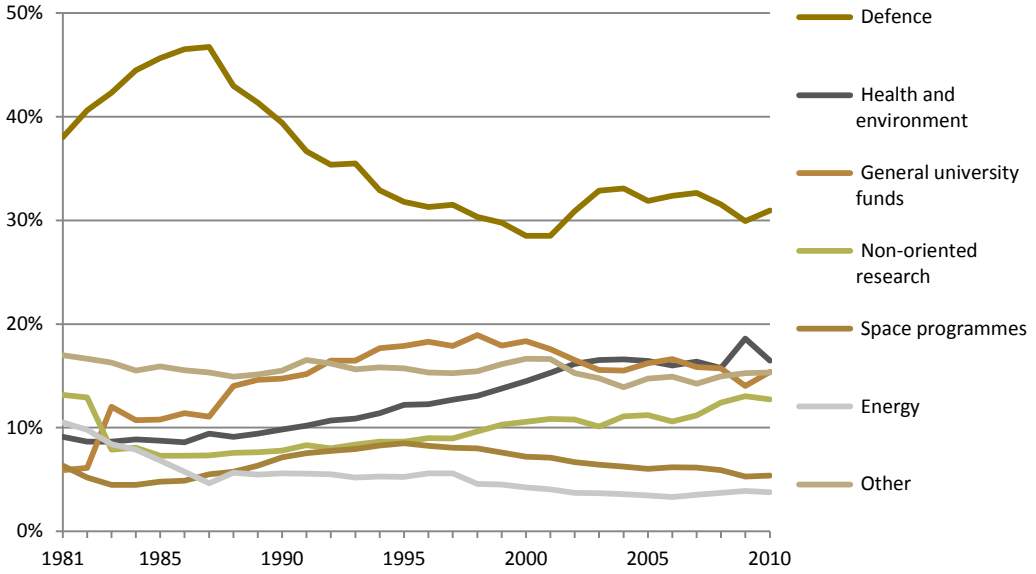


Figure 5 Distribution of the OECD countries' public R&D, share of total R&D budget

Source: IEA, Tracking Clean Energy Progress 2013

[13] China's official statistics should generally be viewed with caution and the energy area is no exception. Figures are adapted to the political rhetoric and do not always give a good picture of reality.
[14] IEA, Tracking Clean Energy Progress 2013

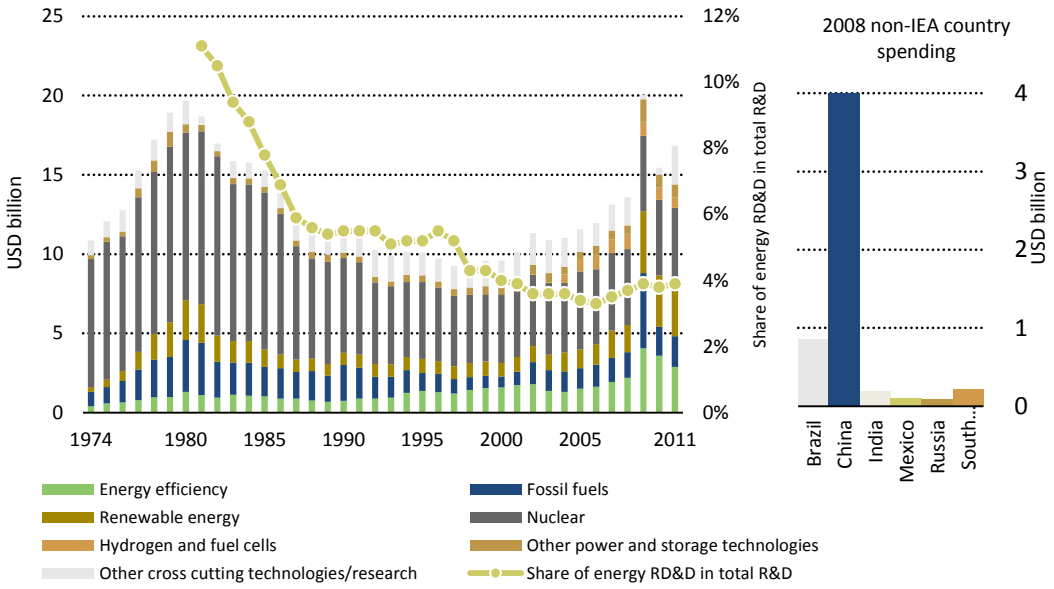


Figure 6 Public investments in energy R&D in IEA countries, by areas of technology.

Source: IEA, Tracking Clean Energy Progress 2013

A further observation from Figur 6 above is that approximately one quarter of the total investments in energy R&D are made in nuclear power, while a further just over 10% go to fossil forms of energy. Energy efficiency and renewable energy together account for approximately 38%. It may seem as if the share that goes to the fossil sector is small in relation to the energy forms' large share in the energy mix. The explanation for this is that the technology in the oil, gas and coal sectors is considerably more mature and therefore does not need the same level of investment in R&D as the new alternatives that are developing. Looking at investment in production capacity, the picture is also another – here the non-renewable forms of energy (fossil and nuclear power) are still predominant.

Future fossil energy technology – not only oil and coal

Earlier in the report we observed that fossil forms of energy will constitute most of the global energy mix for the foreseeable future. It is therefore no surprise that China, like Brazil, India, the USA and some other countries, devotes a considerable portion of itsR&D budget to developing cleaner, more efficient technology for these forms of energy. New super-critical coal power stations with considerably higher efficiency and lower emissions per energy unit produced are a central component in this, as is also technology to be able to exploit previously uneconomical energy reserves, for example shale gas and, further ahead, methane hydrates.

Compared to conventional fossil forms of energy, shale gas is relatively evenly distributed around the globe and the shale gas revolution in the USA has therefore also awakened hopes in many other countries of a growing supply of cheap domestic energy. At the same time, the extraction technology that has made the USA's progress possible, horizontal drilling and hydraulic cracking (fracking), probably involves considerable environmental

risks[15]. Continued investment in R&D to handle these risks and also to make the technology economically competitive under other geographical and topographical conditions is therefore an issue of priority for China for example, which is considered to have the greatest theoretical potential for shale gas extraction.[16]

Japan, South Korea, India and the USA also belong to those countries that at the same time are exploring possibilities to exploit the potentially very large reserves of fossil energy bound in the form of *methane hydrates* below the ocean floor (Figur 7).

This energy source is still relatively unexplored and substantial R&D investment will be needed before methane hydrates are economically competitive compared to both other fossil forms of energy and today's renewable energy technologies. A large number of R&D projects are also currently going in the above-mentioned countries. In the USA, for example, the DoE (Department of Energy) is funding at least some 30 projects at *The National Energy Technology Laboratory* in which major companies like Chevron and BP also participate as co-funders. The aim of these projects is to investigate possibilities and challenges associated with methane hydrates as a source of energy and the risk that large-scale extraction would mean for the environment and the climate.

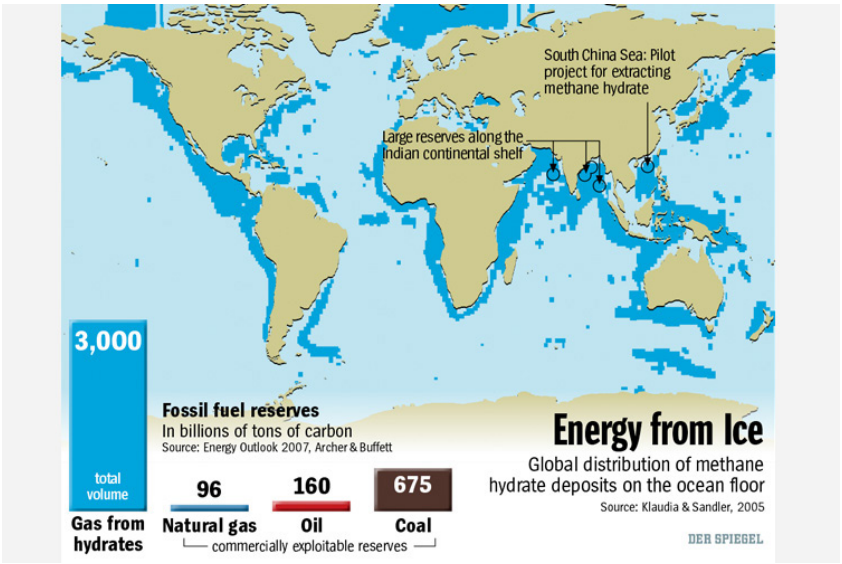


Figure 7 Global reserves of methane hydrates

Source: Der Spiegel Online[17]

In the light of the realisation that fossil forms of energy, albeit partly new guises, will play a significant role in both the short and the medium term, technological development to deal with the emissions of CO_2 that accompany this development is an important question. The IEA points to carbon capture and storage (CCS) as a necessary technology for the energy

[15] The environmental risks have not been thoroughly investigated but the very fact that the method requires enormous quantities of water renders it problematic in countries like China and India, where supplies of water are extremely limited and competition with other areas, not least food production, is tough.
[16] Read more about this in Growth Analysis' Svar Direkt 2013:11, Okonventionell gas och olja: En internationell utblick [Unconventional gas and oil; An international survey]
[17] Warning Signs on the Ocean Floor: China and India Exploit Icy Energy Reserves, article published 13 December 2007.

system's long-term sustainability. At present, however, the technology is far too costly to be commercially viable and according to the IEA substantial state R& D subsidies are needed in the form of measures to stimulate demand during a transitional period to bridge this cost disadvantage. One particularly important question is the pricing of CO2 emissions, through taxation or emission rights trading, to a greater extent than today. This, however, is still a controversial issue in most countries outside the EU, even though some small steps have for example been taken in China and some of the American states.

China is the only country to have an active policy for CCS, in the form of a comprehensive R&D programme to drive technological development forward. Among other things, Chinese authorities, led by the NDRC (the ministry for planning) and the MOST (the Ministry of Science and Technology), have built 11 pilot plants with the aim of reducing the costs that the technology still entails in the industrial processes where it is intended to be used. In the USA and a number of other countries, CCS is already in commercial use in industrial contexts, often in combination with oil extraction in order to increase production from oil wells that are in the process of drying up. The environmental benefits of this arrangement are burdened by increased oil production but the plants contribute to increase experience of CCS technology. The USA also pursues R&D and test operations with CCS, including a full-scale CCS programme for both industrial applications and coal power. A new coal-fired power station with CCS will be put into operation during 2014 and four more are in various stages of planning, albeit with somewhat uncertain prospects as regards their future.

Energy efficiency - a "no regrets policy"

One prioritised and in many ways uncontroversial area for public R&D investments is energy efficiency. All the countries in the study attach great importance to this as it is perceived to be a "no regrets policy", which is to say profitable also in relation to other priorities and courses chosen.

Japan has perhaps come furthest as regards energy efficiency, in particular in industry, which is the world leader in the area. Between 1973 and 2009, energy intensity (energy consumption per unit of GDP) in the economy fell by approximately 43% and is today half of that in the USA and one third of the international average. Historically, the role of the policy in achieving this has been partly to support technological development in cooperation with the major industrial players and partly, within the framework of the so-called Top Runner programme, to introduce mandatory standards for different sectors based on the principle of best available technology. Taxes and other financial policy instruments have been seen more rarely.

In the work on the future energy strategy, increased energy efficiency continues to be a prioritised area, in particular against the background of the competitive disadvantage that Japan's high energy prices entail for the country's industry. In addition to continuing the Top Runner programme, where homes and commercial properties will be given special priority, other, more extensive measures are under discussion. The government has for example presented plans to deregulate the electricity market and make it more efficient in order to enable greater flexibility with the help of new smart grid technology, the integration of nine regional power grids and a greater share of renewable energy.

In *Korea*, the government, in the same way as the Japanese government, views energy efficiency as an attractive way of securing the energy supply and strengthening industry's competitiveness. There is a great need for powerful measures. The country is 97%

dependent on imported energy but has a pricing model that does not create incentives for energy efficiency. On the contrary, energy consumption is heavily subsidised and energy intensity is consequently 30% higher than the OECD average. The power grid is also heavily loaded and power reserves were for example only 3.8% in 2012, clearly below the 4% that is considered to be a safe level[18].

Against this background, substantial efforts are being made in the area of R&D to develop and disseminate new technology for greater energy efficiency. The focus of these endeavours are seven areas of technology that are considered to have great potential and are already South Korea's areas of strength:

- Systems for energy-efficient buildings (BEMS)
- Solutions for efficiency in the energy sector
- Energy storage
- Green vehicles
- LED lighting
- Energy-intensive household appliances
- Six selected green household appliances

In parallel with the investments in R&D, several other measures are being applied to increase energy efficiency, for example a reform of the pricing system towards a more market-adapted model. This is discussed in the section on *Demand pull policies* below.

Both Japan and Korea are also focusing on R&D in smart grids as part of their efforts to increase energy efficiency in their economies. Korea is for example investing USD 25 billion up to 2030 to drive the development of smart grid technology and markets, among other things through investments in large-scale test-beds.[19]

In *the USA*, energy efficiency is also high on the political agenda. In the 2014 budget bill, president Obama proposes a goal of halving energy intensity in the American economy by 2030. The main focus would appear to be implementation of already existing technology, such as better insulation in homes and more fuel-efficient vehicles, which is discussed in the following section. In a long-term perspective, however, current technology will not be sufficient and R&D therefore plays an important role also in the USA. The Department of Energy (DoE) funds a large number of R&D programmes on for example advanced manufacturing and smart homes.

Renewable energy[20]

R&D investment in renewable energy is identified by the IEA, among others, but also by the national governments in all the countries in the study, as a central measure to attain the goals of the energy policy. The prerequisites and levels of ambition, however, vary widely. One general observation is that these investments to a great extent are motivated by industrial and growth policy forces, in addition to the purely energy policy motives for

[18] This can be compared to Sweden which had power reserves in the region of 10% in 2013.
[19] Read more in Growth Analysis' Svar Direkt: 2013:10 Smartare elnät för förnybar energi och ökad konsumentmakt [Smarter electricity grids for renewable energy and greater consumer power].
[20] This section is largely based on material from a parallel project that focused on processes for steering and prioritising public R&D investments in the energy area. This material is available for download on Growth Analysis' website.

greater supply security and environmental sustainability. The "green economy", based on new, developing environmental engineering companies, is viewed as potential future growth generator. Positioning oneself in the international competition for market shares is therefore an explicit priority in several of the countries studied.

This perspective is especially clear in South Korea, where the previous government's growth strategy was largely based on the development of environment-driven business development and competitiveness. Another, albeit somewhat contradictory, example is Brazil, that through its state-subsidised ethanol programme (PROÁLCOOL) has played a leading role in the development of biofuels in the transport sector.

In the USA, R&D in the energy area is funded by several players, both at federal level and state level. Interest in renewable energy has increased generally over time and the area today receives most of the non-defence related R&D investments (Figur 8). In the budget for 2014 negotiated in Congress, funding for the Office of Energy Efficiency and Renewable Energy, one of the principal players in the area, is increased from USD 1.8 billion to 1.9 billion, a considerably more modest increase than the roughly 1 billion proposed by the president.[21] ARPA-E, which funds high-risk projects with great commercial potential first and foremost in the renewable energy area, is given an additional 280 million dollars in the budget agreement.[22]

A new initiative is an instrument with a budget of USD 200 million that is intended to encourage the states to work more actively with energy efficiency and the development of smart grids. In the area of transport, a broad programme to develop vehicle technology for plug-in hybrids is proposed in order to force prices down and increase comfort in these vehicles to a comparable level with conventional vehicles by 2020.

[21] Read more about the budgetary consolidation on Growth Analysis' website: http://www.tillvaxtanalys.se/download/18.1224700513d6878e6cb370/1364216753396/Sequestration+20130320+RHED.pdf

[22] Read more about the budgetary consolidation on Growth Analysis' website: http://www.tillvaxtanalys.se/download/18.1224700513d6878e6cb370/1364216753396/Sequestration+20130320+RHED.pdf

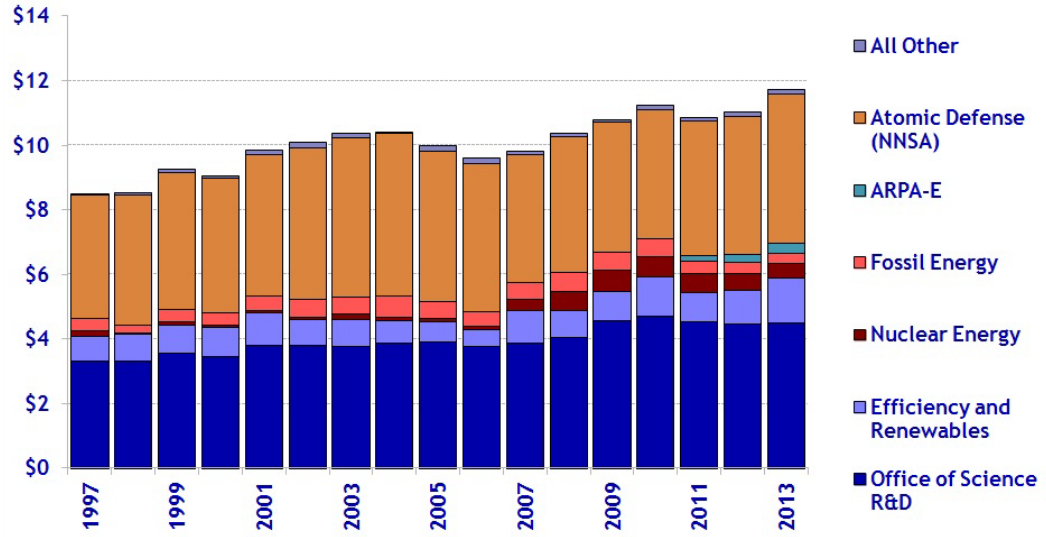


Figure 8 Development of Department of Energy R&D, 1997-2013, USD billions, fixed prices

Note: The Office of Science finances basic research in the energy area.

Source: AAAS Report: Research and Development [23]

Denmark has five principal public funding providers for energy research: The Danish Council for Strategic Research's development programme EUDP, ForskEL, ELFORSK, and the Danish National Advanced Technology Foundation. Investment in energy research has increased significantly over a number of years. The budget was doubled between 2006 and 2010 and the money goes to a great extent to development of renewable energy production and to technology for increased energy efficiency.

The boards of the five funders have today identified three areas of particular importance to attain the goal of switching Denmark's energy system to 100% renewable energy: energy renovation of existing buildings, smart power grids and energy storage.

In *Germany*, the priorities for R&D in the energy area are drawn up every four years in overarching programmes decided by the government. The current programme covers the period from 2011 until 2014 and comprises EUR 3.5 billion for investments in renewable energy, storage and grid technology related to energy efficiency. Compared to the previous programme period, this is an increase of 75%, which is to a large degree explained by the need to quickly develop these areas in order for the phasing out of nuclear power to match the country's climate goals.

The federal government presents a report on energy research every year. The latest edition of the "Bundesbericht Energieforschung" was published in September 2013 and states that support for R&D in renewable energy amounted to EUR 261 million of a total of EUR 708 million, or approximately one third, and that this is twice as much as in 2006.

The Federal Environment Ministry, BMU, is in charge of the subsidies for wind power, solar energy, geothermal energy and certain power system studies. The aim of the investments in research on solar energy is primarily to increase efficiency and reduce

[23] More detailed figures can be found on the AAAS' website:http://www.aaas.org/page/guide-rd-funding-data-%E2%80%93-historical-data

costs. Special efforts are made for low-energy solar collectors, cheaper solar cells and electricity from solar heat installations. Investments in wind power concentrate on technological prerequisites for offshore installations, reducing costs and converting older wind farms. The power system studies largely focus on the integration of renewable electricity.

Examples of policies for demand pull

The energy question, both in scope and focus, has political influence in all countries and in all energy areas. This section focuses on renewable energy and energy efficiency but an important observation that should be emphasised is that the public subsidies for consumption of fossil fuels at a global level are considerably higher than the corresponding subsidies for renewable energy. The IEA estimates that over USD 500,000 million goes to subsidies fossil energy of various kinds while the corresponding figure for renewable energy is just under a fifth of this.[24] It is often vehicle fuels such as petrol and diesel that are subsidised through the price being forced down by means of tax deductions and other subsidies. In some cases, such as in South Korea and Indonesia for example, the price in the consumer market is so low that it does not cover the production costs.

This naturally creates imbalances in the energy system and in these countries' economies, for example by reducing the incentives for energy efficiency, undermining the driving forces to invest in renewable energy and cementing the prevailing energy system. As the prices of fossil fuels have increased, the cost of the subsidy systems has also increased substantially in many countries and isnow so high that it constitutes a considerable burden on the national budget.

These facts, in particular the last, are well known but difficult to handle politically. Gradual steps are however now being taken in many countries, including China, South Korea and Japan, to reduce the subsidies and thereby redirect the incentives more towards attaining the goals of greater energy efficiency and production of renewable energy.

Energy efficiency

It was observed earlier that energy efficiency is generally viewed as a win-win solution and that R&D in the area has high priority in most countries. It is on the demand side, however, that most initiatives are taken and this section will describe some of these.

India has launched several major initiatives to reduce energy use both in industry, construction and homes and in the transport sector. As in most countries, there are established standards and certification marks, for example for buildings and home electronics. These are designed as a rule in close collaboration with industry representatives and are generally voluntary.

One particularly interesting initiative is the National Mission on Enhanced Energy Efficiency (NMEEE), launched in 2010. The purpose of the NMEEE is to save 23 tonnes of oil equivalents by 2015 by setting up a market for energy saving certificates for eight selected energy-intensive industries and 478 companies. For each sector and company, compulsory goals are set by the Bureau of Energy Efficiency (BEE), and those companies that manage to perform better than the goals can sell so-called E-Scerts at auction to companies that do not attain the goals.

[24] IEA, World Energy Outlook 2013

Brazil estimates that the potential for greater energy efficiency in the country corresponds to a capacity of approximately 40 TW on an annual basis. Just under half, 18 TW, of this potential is in the electricity sector where various forms of transfer losses are a major problem due to the antiquated power grid (but which nonetheless largely covers the entire country). A central challenge is that the institutional regulatory framework is characterised by fragmented and ineffective political decision-making and corruption. As long ago as 2011 the government launched a national roadmap for energy efficiency but little has happened since then and many of the initiatives that are launched, for example *Procel Edifica* that encourages energy-efficient solutions for building design, are non-mandatory.

Standards and various forms of voluntary marking are also common in *the USA*. Despite these instruments not being mandatory, the DoE estimates that the cumulative saving from all standards in the area of home electronics alone will amount to USD 1.7 trillion by 2030.

One challenge with energy efficiency measures is that the investment cost may often be difficult to justify for a household or a company from a private finances perspective, despite the potentially substantial long-term gains. An interesting initiative in the USA to deal with this investment threshold is Energy Performance Contracting (EPC), which allows investments to be financed through loans with the estimated energy saving as security. The service is offered by so-called Energy Service Companies (ESCOs) and makes energy efficiency measures possible for the user without capital input. Interest and amortisation are instead paid from the profits from energy saving.

As described earlier, the controlled pricing of various forms of energy in *Korea* has counteracted rather than encouraged energy efficiency for many years. The new National Energy Plan for 2013-2020 marks an important paradigm shift in that focus is brought to bear on demand instead of energy production. The most important measure, which will be introduced gradually, is to abandon subsidised electricity prices and instead allow the market to steer and even out peaks and valleys in demand and thus prevent power cuts. The technological measures to promote energy efficiency primarily concern energy storage systems (ESS) and smart ICT solutions. This is fully in line with president Park's vision of a "creative economy" based on South Korea's strong, advanced internet and telecom industry. Higher electricity prices will however be compensated in the industry by means of subsidising ESS and energy management systems. Low-income households will be given so-called energy checks.

Denmark sees energy efficiency as a crucial element in its transition to a sustainable energy system. The energy agreement of March 2013 contains a number of initiatives in the area. The goal is to reduce gross consumption of energy by 7.6% between 2010 and 2020. The Energy Saving Council was set up in 2010 to contribute to coordinating energy saving in Danish society. A new strategy is currently being designed and will be presented in early 2014.

Reducing energy consumption in existing buildings has high priority. Heating, ventilation and lighting in buildings account for between 30% and 40% of all energy consumption in Denmark. The requirements concerning energy housekeeping are among the most stringent in the world. Energy certification rules governing selling and leasing were introduced many years ago. Denmark has a policy to encourage people to build houses with very low energy consumption (passive houses and zero-energy houses). The requirements will be made more stringent over the next few years and the vision is for all houses eventually to produce more energy than they consume. The state is to set an example by making its

energy use more efficient. The government is bringing forward investments in the renovation of office and university buildings to 2014 and 2015 for this purpose.

Renewable energy

Development and dissemination of renewable energy is a central component in the transition to a more sustainable energy system. These forms of energy are still largely dependent on political support of various kinds to be able to compete with established alternatives and uncertainty about the development of the policy is the most important barrier to stable growth.

An important observation on the basis of the review below is also that the policy process in the case of renewable energy is largely characterised by unforeseen effects and consequences. The rate of expansion in Germany is for example higher than was predicted, the cost per KWh of wind power in Great Britain has not fallen at the rate hoped for and capacity utilisation of wind power in China is considerably lower than planned. The policy's costs have consequently in many cases been higher than was estimated, which will be one of the main challenges for these subsidy systems in the years ahead.

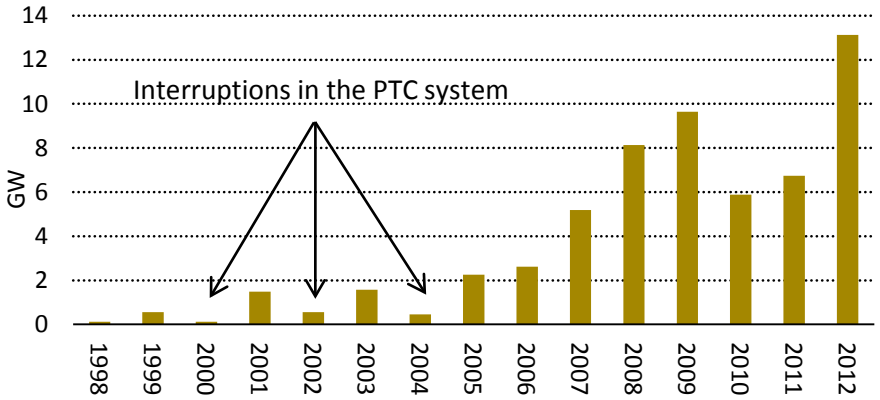


Figure 9 Total wind power capacity in the USA, 1998-2012, GW

Source: IEA, Tracking Clean Energy Progress 2013

The PTC (Production Tax Credit) subsidy system is one of the most important subsidy systems to support, among other things, expansion of renewable energy in the USA, and is based on producers of renewable energy being entitled to a tax deduction of between 11 and 22 USD/MWh depending on energy source. The system has been characterised by disjointedness and did not operate at all in 2000, 2002 and 2004. As Figur 9 shows, this led to no wind power installations being built during those years. In 2012, it was decided that the PTC system would be discontinued, but was prolonged at the last minute in 2013, albeit in modified form. PTC subsidies for wind power were discontinued at the end of 2013 and no decisions to prolong the system have yet been made. It is therefore difficult for the market's players to make decisions on long-term investments.

Other kinds of federal tax deductions and investment support also exist in the USA, among them a 30% subsidy of the investment cost in construction projects in the renewable energy area. This has hitherto primarily favoured the solar cell industry, even though other forms of energy are also eligible to apply for deductions.

At state level, the rules governing the requirements concerning the share of renewable energy in the energy mix, the Renewable Portfolio Standard, play a central role as regards demand for increased capacity. More than 30 states have today implemented such a system. Many states also have other policy instruments in place to strengthen demand for renewable energy. California for example introduced a trading system for emission rights in 2013 and among other things also has strict regulations concerning cars' fuel efficiency in order to steer towards increased demand for fuel-efficient plug-in hybrids.

Through its ambitious strategy for energy transition, die Energiewende, *Germany* has attracted great attention around the world. The overarching goal, as described earlier in the report, is to phase out nuclear power in favour of principally renewable forms of energy and energy efficiency. To achieve this, the government has launched a number of new policy instruments, including the controversial Feed in Tariff (TiF) system. The principle behind FiT is to guarantee producers of renewable energy a fixed price that makes production economically profitable for a relatively long period of time. The price varies depending on location, technology and the size of the installation, which makes the system complex. The price, or more correctly the subsidy, decreases over time to reflect the technological development that is going on continuously, bringing production costs down (Figur 10).

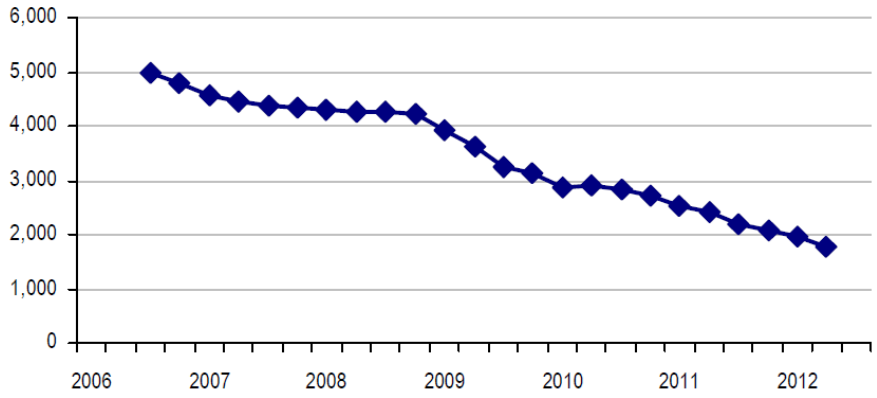


Figure 10 Average installation cost of solar cells for consumers, EUR/kW

Source: Hummer et al 2013[25]

Germany's policy has been generally successful, the county's rate of expansion of renewable energy is one of the highest in the world (Figur 11) and the installation cost per unit of energy is as said steadily falling. Two particularly important aspects of this development is that enterprise and employment in the renewable energy sector have also increased dramatically and that ownership of the production facilities is spread over a large number of private individuals rather than concentrated to a few industrial players as is the case in traditional energy sectors. Taken together, these factors to a large extent explain the broad support that the Energiewende has had among German people.

[25] Hummer, P., Lekander, P., Gandolfini, A., Hunt, S., Cossio, I. (2013) The unsubsidised solar revolution UBS Investment Research European Utilities. Published 15.01.2013

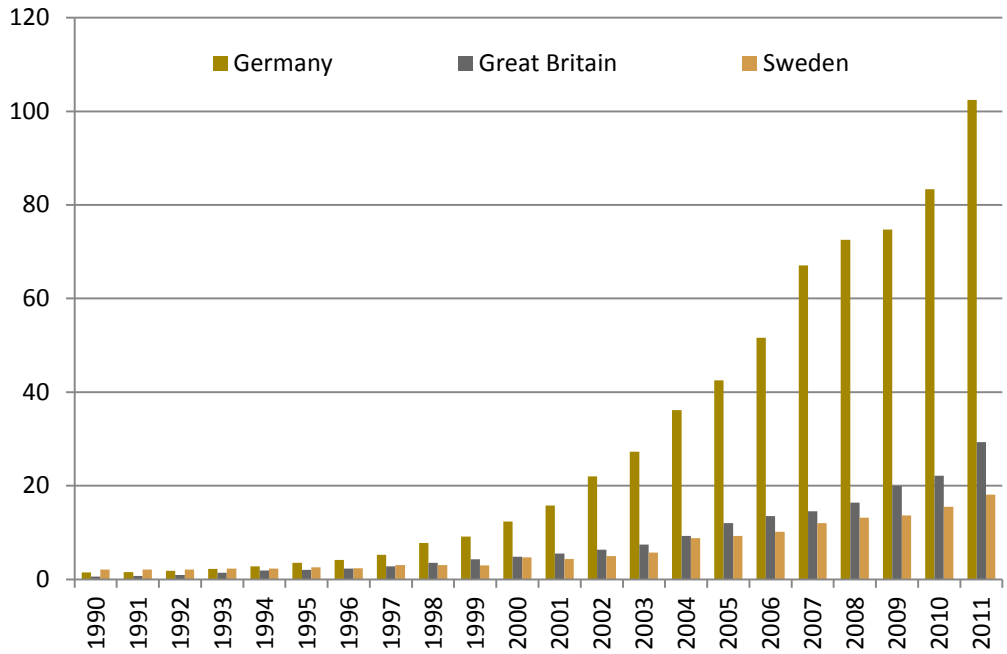


Figure 11 Production of renewable energy in Germany, Great Britain and Sweden, 1990-2011, TWh
Source: BP Statistical Review of World Energy June 2012

At the same time, an intense debate has sprung up in recent years about the FiT system's socio-economic cost, which has also increased dramatically as increasing numbers of solar and wind power installations have come into operation. Electricity prices in Germany are among the highest in the world and the FiT charge tangibly adds to this. Most Germans are still in favour of the system and the Energiewende in general, but support has fallen off as electricity prices have risen.

The German government has announced sweeping reforms of the system against a background of the public's failing support. These will probably mean that fewer companies will be exempted from paying FiT charges and possibly also a reduction in energy tax.

Regardless of these challenges, *Japan*, among others, has been inspired by Germany's example. An FiT system similar to the one in Germany but with even more generous subsidies was launched in 2012. Since then, installed capacity has increased by 18%, from 20.6 GW to 24.2 GW. Solar cells andland-based wind power dominate but offshore wind power, geothermal energy, bioenergy and small-scale hydropower are attracting increasing interest.

In autumn 2013, Japan's first offshore wind farm was completed off the Fukushima coast, probably a result of FiT payments during the year adjusted to reflect the additional cost associated with this technology.

Developing renewable energy has also been a central component in Denmark's strategy for many years. 35% of the final energy production is to come from renewable energy sources by 2020. This is 10% higher than today and above the level of 30% that applies for Denmark as decided by the EU.

Danish electricity consumers pay for the subsidies for renewable electricity through the so-called PSO charge on their electricity bills. The total revenue in 2012 was DKK 4.7 billion. The system is so constructed that the charge increases when prices in the electricity market fall. One of the occasions when this happened was in 2012, due to large imports of cheap hydropower from Norway and Sweden.

Subsidies are technology-dependent and it has therefore been possible to expand offshore wind power despite the costs being higher than for land-based installations. The technology-dependent subsidies have also been criticised, in particular subsidies for solar cells, which have led to costs far in excess of budgets and intense political debate. The economic terms and conditions are therefore now under review and the government intends to reduce subsidies to land-based wind power from 2015. The analysis is that technological development has advanced so far that the energy source should be able to manage on its own.

Many Danes have invested in solar cells. The "explosive" expansion, as the government calls this development, has forced it to make changes to state subsidies. The state will continue to favour installation of solar cells but the rules will be changed to make the subsidy more effective: among other things, the level of subsidy will be reduced to reflect the falling prices of solar cells.

As in Germany, the increase in the cost of the subsidy has caused intense political debate in Denmark. The Energy Board is criticised for not having had sufficient control. One example that has been mentioned is the construction of solar cell installations on agricultural land, which receive the same subsidies as domestic solar panels. This led to rapid expansion with substantial profits for investors. The cost of solar cells now risks delaying the expansion of the large Kriegers Flak wind farm, because the total budget for renewable energy will otherwise be exceeded.

Biogas is another prioritised area. There is a substantial state investment subsidy for biogas plants (DKK 260 million in 2012). Progress has nonetheless been slow. A certain amount of biogas is now produced from maize, which was not the intention from the outset. A special task force has now been assigned to secure the expansion of biogas. The question is how the fuel is to be used in the energy system. One possibility is to feed biogas into the natural gas network, but this would require a relatively costly quality upgrade of the biogas. In 2013, the European Commission gave the go-ahead for a new system of subsidies, which may accelerate the use of biogas in Denmark.

In 2012, *Poland* drew up an action plan to attain the goals of the EU directive on renewable energy. This action plan has later been updated.

The measures include a quota system of green electricity certificates to encourage production of renewable electricity. Companies that sell energy are obliged to purchase a certain number of certificates that prove they are producing from renewable sources.

There are also other policy instruments. Producers of renewable electricity have priority in the power grid. Electricity from such sources is exempt from energy tax. Small electricity producers (for example with wind and solar power) pay only half the normal charge for connection to the power grid. Individual households and small companies can receive help from special investment programmes. Poland's national environmental protection and water management fund has already subsidised a number of projects for, among other things, solar heating.

The system may be changed very soon. According to a proposal from the government, the current system of green certificates is to be replaced with auctions. In future, power producers will have to compete to offer renewable electricity at the lowest possible prices. The state will guarantee sales at a given price level for a period of 15 years for those producers who win the auctions.

Those companies that are already part of the green certificate system can choose when to switch to auctions but must do so by 2021 at the latest. Until then, the two systems will exist alongside each other. The new system is estimated to halve the state's costs, which is also the primary objective – rather than further subsidise the expansion of renewable energy.

To conclude, a few words about *China*, which in many ways is leading the development of renewable energy. The country has the largest total installed capacity of wind power and for the past four years has managed to maintain a capacity growth of over 10% a year. Wind energy is considered to have several advantages and has high priority, mainly because it it does not affect the country's limited water resources and is also an energy source that can be expanded on a large scale with the help of market forces. Expansion took off after China's law on renewable energy came into effect in 2005 and wind power capacity doubled every year between 2006 and 2009 and has since then continued to increase to about 70 GW today. By 2015, wind power capacity is expected to have increased to 100 GW, 50 GW of which will come from offshore wind farms according to China Energy Outlook.

Growth, however, has brought serious problems. Both China and the USA had approximately 47 GW installed and connected *capacity* in 2011. But while American power stations generated approximately 129 TWh, those in China generated only 74 TWh. The average capacity factor of American wind farms was 29% while in China it was only 20%. The reasons for the lower capacity utilisation in China's wind farms are many and in many ways indicative of the problems China has encountered in its rapid expansion of capacity for different energy sources. Among other things it has taken a long time to connect many wind power projects to the grid, as the expansion of the power grid has lagged far behind the construction of the wind farms.

In the solar energy area, China is today the biggest producer of solar panels, even if development has been accompanied in recent years by problems of over-capacity and insufficient profitability. Domestic production of solar energy is trailing wind power by a broad margin but the goal is to expand solar energy capacity from today's 7 GW to 35 GW by 2015. Peking has also presented the grid companies with demands to connect solar energy in their area to the grid. While there is much to indicate that growth will continue, there is a serious risk that similar problems to those that accompanied the expansion of wind power capacity will be encountered.

Hydropower is a third important area in China as regards renewable energy and the potential to expand capacity is judged to be very great. The 2012 White Book for the energy sector estimates a technically possible expansion of 542 GW, which is the highest in the world. Less than 30% of this is currently exploited, which means that continued expansion of hydropower is a priority. The enormous Three Rivers Dam project, the world's largest hydroelectric power station, put into operation in 2012, clearly shows the country's great intentions and that they have the technology for major projects. Hydropower is expected to account for half the goal of 15% of China's energy

consumption coming from new energy sources by 2020. Under the 12th five-year plan, rapid expansion of hydropower is planned and some sixty major projects will be begun.

In the same as for fossil energy sources, all new energy sources will be subsidised by the state by means of various tax deductions and direct investment subsidies. As in the other countries in the study, dependency on these subsidies is a critical point for the development of renewable energy in China. This is one of the areas discussed in the following chapter, which summarises the crucial policy challenges in the energy area based on the experiences and ambitions that have hitherto been presented.

3 Perspective on the future energy policy landscape – a summary

The observations presented above paint a divided picture of policy development in the energy area. On the one hand, it is clear that energy transition is a priority and that this is driving substantial investments in R&D, innovation and dissemination of new energy technologies, while on the other hand it is obvious that renewable energy constitutes only a minor part of the energy policy and that most countries pursue an "all of the above" strategy, i.e. they focus on developing all potential sources of energy regardless of whether they are renewable or not.

The overarching objective of the energy policy is a secure energy supply and economic competitiveness, followed by environmental sustainability. In some countries, including China as a prominent example, the environmental aspects are currently growing in importance. Environmental pollution, which is linked to fossil energy, has become so serious that is seen as a direct threat to economic growth and political stability, and countries also consider that they can afford to invest in new, cleaner technology to deal with it.

Energy efficiency considered attractive regardless of which sources of energy are used and is a central component of the energy policy in all countries, in particular in Asia.

Despite the countries in the study being very different, they share many challenges in the energy area and have a few common issues that must be dealt with sooner or later. This chapter describes a number of summarising arguments concerning important considerations and crucial issues for future energy policies, the focus naturally being on the prerequisites in the countries in the study but with general implications for the global energy markets and also for Sweden's prerequisites as regards its energy policy.

3.1 The role of the state and the industry policy's new guise

A general starting point for political measures for technological development, or innovation is that there is some form of market failure that it is the state's job to rectify by means of for example regulation or a tax that internalises a negative external effect in the companies' investment decisions. The reality, however, is often more complex and requires combinations of policy instruments rather than one for every target and goal set. The role of the state is therefore a question of values, morals and other soft factors and very much a result of historical and fundamental ideological factors.

In China in particular and to a certain extent in for example Japan and South Korea, the role of the state is by tradition a salient feature when it comes to technological development and planning of complex systems and the direction of economic development. As described above, these traditions are to a great extent still alive. The energy policy is designed in close collaboration between the state and trade and industry and is adapted to the domestic companies' needs rather than with cost-effectiveness in mind. National areas of strength are generally selected in advance and substantial investments are then made to stimulate these, both for the domestic market and to increase exports.

It should be emphasised that technological development in the energy area has generally been stringently steered by the government in most industrial countries. Sweden is one

example of where expansion of first large-scale hydroelectric power, then nuclear power and thereafter principally biofuel-based district heating have been clearly driven by the state – in collaboration with other public and private interests. Technological development in the energy area has been seen, and continues to be seen, as a prerequisite to secure industrial competitiveness through low electricity prices.[26]

Against the background of the financial and economic crisis that has characterised the world economy since the Lehman Brothers collapse of 2008, there has also been yet another shift in this direction in other, by tradition more market-oriented, countries and also in some new areas.

In the USA, the state has by means of both monetary policy and economic policy actively intervened to stimulate economic development. As discussed earlier, this policy is also directed at the energy area in the form of investment subsidies, production subsidies and various forms of R&D measures. One clear trend is that all the more of this is directed at the latter stages of the innovation chain and is becoming increasingly technology-specific.

We see a similar situation in Europe where for example Germany, Great Britain and Denmark adapt their subsidies to certain technological solutions. Brazil and India are on the same track but have not come as far as regards policy design and implementation. Taken together, this exemplifies what has come to be known as "*new soft industrial policy*"[27], which means that the state plays a facilitating, coordinating role in relation to private players with the ambition of among other things drawing up strategic goals, dealing with collaboration problems, enabling experimentation and ultimately increasing productivity in the economy. The term "soft" derives from the fact that it is not on the other hand a question of direct subsidies to industry or necessarily a question of technology-specific policy, unlike some historical industrial policies (Sweden's shipyard subsidy for example) that have been more direct.

What the long-term results will be and whether this proves to be a passing phase or a long-term trend is not yet clear. A key factor in the context is the industrial policy's net socio-economic gains, which are being questioned.

3.2 Policy reforms in the making – the same ambitions at lower prices

In Germany, Great Britain and Denmark, where a "soft" and generous policy has been pursued in the energy area for a number of years, the cost side has increasingly stood out in recent years. Depending on the design of the subsidy system, the costs arise either as a direct burden on the national budget or in the form of higher energy prices for households and companies – or both. Costs have risen considerably faster than was estimated in all three countries and have reached levels bordering on what is politically and economically tolerable.

In Germany, the total cost of the EEG fee (the additional charge on electricity bills that finances the feed in tariff and other associated costs) is estimated to have been roughly 20 billion EUR in 2013 alone. This is perceived by some parts of the government and trade

[26] Kaijser och Kander (2013) Framtida energiomställningar i ett historiskt perspektiv, Naturvårdsverket , Rapport 6550 [Future energy transitions in a historical perspective, Swedish Environmental Protection Agency, Report 6550], February 2013

[27] Read more about this phenomenon in the OECD's report Beyond Industrial Policy – Emerging Issues and New Trends. OECD Science, Technology and Industry Policy Papers No. 2 2013

and industry as too high a sum and an intense debate has been going on about the future of the subsidy system for a long time, not least during the run-up to the 2013 elections. Public support for the Energiewende is strong, but in recent opinion surveys has been lower than previously. This is largely because the cost is being felt more and more by individuals and companies (those not exempted from the EEG fee). Pressure on the government to act is therefore increasing.

It has still yet to be finally decided how the system will be reformed but it is clear that changes will be made to brake and reverse this cost development, for example by reducing the number of companies that are exempted from the EEG fee and possibly also reducing the energy tax. It is, however, clear that the renewable energy and energy efficiency targets will remain unchanged. Germany is also one of the countries that argue for higher ambitions and a stricter regulatory framework for the EU's energy and climate policy after 2020.

The picture is partly the same in Great Britain, even if there are also considerable differences. Rising energy costs were one of the most discussed political issues in the country in late 2013 and early 2014. Contrary to the government's goals, fuel poverty has,increased in recent years and more and more people are questioning the generous subsidies directed at both renewable energy and conventional energy. Considered in terms of cost per kWh, renewable energy is however considerably more expensive, in particular the offshore wind farms, and it is primarily this that is drawing criticism from several quarters.

An important component of the British example is that the pace of expansion, contrary to the situation in Germany, is not living up to expectations. This naturally provides the debate with more fuel for those who advocate lower subsidies. In December the British government also announced that the subsidy for certain forms of energy, first and foremost solar cells and land-based wind power, will be drastically reduced from and including 2015. At the same time, the subsidy for offshore wind farms will increase. This move is generally interpreted as a way of assuaging the criticism directed at the renewable energy subsidy but at the same time risks undermining the impact of the policy because every pound invested in offshore wind power generates only a small portion of the electricity that the corresponding investment in land-based wind or solar power does.

Regardless of this, the objectives of the energy policy in principle remain unchanged and it is therefore an urgent matter for the government to find a way forward that both drives development in the direction of more renewable energy and less dependence on fossil energy and can at the same time be accepted by much of the population. Of relevance in this context is a significant difference between the German and the British examples. Germany has always had an ambition to not only generate renewable energy but also create new jobs in the energy sector and has also been successful: today approximately 350,000 Germans work directly or indirectly with renewable energy. At the same time, the subsidy system is leading to a distributed private ownership of energy production itself; in 2013 there were 1.3 million registered producers. Taken together, these two factors are an important reason for the strong support that the policy still has.

In Denmark, the objectives of the energy policy have been ambitious and based on a broad political alliance. Changes are currently being made within the government and how this will affect the energy policy is naturally as yet unclear. Results, however, have hitherto fulfilled expectations. The share of renewable energy in Denmark has grown quickly over

the past decade and higher energy efficiency has enabled total consumption to be reduced despite relatively strong economic growth during the same period.

Public support for the energy policy is strong and the government puts great effort into maintaining local acceptance in order for this to continue. Just as in Germany, the energy policy is designed to give positive economic effects in the form of more jobs, more trade and more innovation at local level. Denmark also performs well in comparison with other countries, Sweden included, as regards innovation and "green" competitiveness.[28]

At the same time, the increase in the cost of subsidising solar cells has led to an intense political debate in Denmark. The Energy Board is criticised for not having had sufficient control. One example that has been mentioned is the construction of solar cell installations on agricultural land, which receive the same subsidies as domestic solar panels. This led to rapid expansion with substantial profits for investors. The cost of solar cells now risks delaying the expansion of the large Kriegers Flak wind farm, because the total budget for renewable energy will otherwise be exceeded.

The situation in China is in many ways unlike that in Europe and the USA but the question of how subsidies for technological development and innovation in the energy area can be designed better with regard to both results and cost-effectiveness is also under discussion here. China has encountered serious problems with low efficiency, in particular in the case of wind power, as a consequence of an unbalanced subsidy structure where capacity expansion was the primary objective and where infrastructure and technological maturity have lagged behind. In the solar cell industry, the policy has led to over-establishment and poor profitability, in particular after the financial crisis of 2008 when many countries cancelled or reduced their subsidies for expansion of solar power installations.

No dramatic change in China's energy policy is to be expected in the foreseeable future but the goals of a secure energy supply and economic competitiveness remain unchanged. A gradual reform is however taking place in some areas; pricing policy is one, where market adaptation has already begun.

In both India, South Korea and to a certain degree Japan, similar steps are being taken towards a more market-based pricing of energy and deregulation of the energy market in order to stimulate energy efficiency and give new forms of energy better possibilities to compete with the established forms of energy and players.

Closing remarks

All taken together, this report shows that energy policy in these important countries will be characterised by considerable uncertainties in the immediate future. The overarching long-term objectives, however, remain unchanged and there is also relatively strong public support for these objectives – given that the reforms now being planned are implemented in smart ways with people's need for energy and preferences for stability, independence and reasonable costs in mind.

Regarding Sweden, it will be important to both understand what happens in the international energy markets to be able to adapt the policy to the main global trends and learn from other countries' experiences in a structured fashion. This report is intended to

[28] Green competitiveness is defined here on the basis of green innovation activity, development of the export markets for green products and services and the current production value. Read more in Benchmarking green competitiveness - Internationell jämförelse av grön konkurrenskraft [Benchmarking green competitiveness - An international comparison of green competitiveness], Growth Analysis WP/PM 2013:18

contribute to both these processes but naturally needs to be complemented and followed up. Growth Analysis also intends to contribute to this through future projects with a focus on issues such as energy prices linked to industry's competitiveness, reform of the energy market and optimisation of selective energy policy instruments.

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Growth Analysis, Studentplan 3, S-831 40 Östersund
Phone: +46 10 447 44 00 | info@growthanalysis.se | www.growthanalysis.se