MEASURES AND BARRIERS TOWARDS A SUSTAINABLE ENERGY SYSTEM

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Abstract

Energy is essential for our whole society. Associated with the intense use of fossil fuels environmental pollution increased and caused effects like climate change. Although the proved reserves of fossil fuels are going to last for at least the next five decades, they are limited. We therefore have to rethink our worldwide energy system in terms of sustainability. Establishing such a new energy system needs a number of different measures, which require strong and clear legislative actions. The measures should be technically purposeful and economically appropriate and will affect every stage of our energy supply chain. The real innovation of selected measures is often hindered by many different technical and non-technical barriers, which have to be identified and solved. The approach has to be situative, because each country has different basic conditions in terms of e.g. geography, culture, religion, reserves of fossil fuels and potentials of renewable energies or the political system. To solve the pending problems we need a local (e.g. single states, federal states, municipalities) but also a global approach, because global problems can only be solved through global actions (e.g. Kyoto-protocol). The time for action towards a sustainable energy system is now, because changes in energy systems need time due to the massive investments needed.

Keywords: energy policy, energy efficiency, renewable energy, barriers, energy innovation

1 Introduction

Energy is essential for our economy and is going to gain in importance due to the fast changing environment.

Especially through the rapid growth of the world population energy-related issues become increasingly urgent. Although the projections of the different international institutes like UNO[1] or IIASA[2] show a big variety of scenarios, we can assume that the world population will grow up to approximately 9 billion inhabitants until 2050. The growth will be very different depending on the region. The share of the world population in developing countries will rise from 76% in the year 2000 to 81% in 2030. Most of these people are going to live in the big cities.

The income per capita in the developing countries will rise faster than in the past, but will still remain below the level of the industrialised countries. One major task of the future will be to assure the right of everybody to have a similar living standard around the world and therefore avoid hunger and poverty.

This means that due to the predicted growth of the world population and a higher living standard also the energy demand will rise. Still fossil fuels like oil, gas or coal and nuclear energy are the most important part of today's energy systems, although great efforts must be made to intensify the use of renewable energies.

[1] United Nations Population Division, Department of Economic and Social Affairs, http://www.un.org/esa/population/publications/longrange/longrange.htm

[2] International Institute for Applied Systems Analysis (IIASA), http://www.iiasa.ac.at/Research/POP

The worldwide geographical distribution of fossil fuels varies a lot. Most of the reserves are located in so called "politically sensible" regions like Iraq or Saudi Arabia.

In the short-term the intense use of fossil fuels cannot be avoided, but this goal has to be pursued in the long run. Even if fossil reserves are going to be available another approximately 50 years (especially oil and gas) they are finite.

Inseparably associated with the intense use of fossil fuels is the environmental pollution. This problem has a local (e.g. domestic fuel) and a global dimension (e.g. climate change).

The European Union (EU) has only poor fossil reserves, which results in an energy import dependency from abroad because most of the needed fuels have to be imported. The EU forecasts that in a business-as-usual scenario the energy import dependency will rise from today approximately 50% to 70% in the next decades, which would result in a politically inacceptable situation.[3]

Legislation in the EU therefore tries to avoid an increasing energy dependency from abroad and further environmental pollution by particularly forcing renewable energy sources and energy efficiency measures. Until 2010 the share of renewable energies should reach a level of 22%, which is indeed a challenging target. For Austria this means that the present high level of renewable energy use (nearly 70% of the electricity is produced from hydropower) must still be increased to 78,1%. The EU therefore must consider all possible options, which means not only the supply (electricity and heating) but also the demand side.

One major challenge will be to reduce the yearly demand growth, which is at the moment approximately 2%/year for electricity. In order to do this, the EU will have to concentrate also on energy services and efficient use of energy by all people (perhaps a new definition of quality of life is necessary).

2 Path towards a sustainable Energy System

One major future challenge is to find a path towards a sustainable energy system. The most important factors in sustainable energy development are the prospects for economic growth and investment, improved energy accessibility for the poor, security of supply and the local, regional or global emissions resulting from energy production and use.[4] On the way towards a sustainable energy system a great number of different measures in nearly every sector of our society need to be realised, which needs of course clear and strong political basic conditions. Figure 1 shows a theoretical process for the realisation of measures in the energy sector.

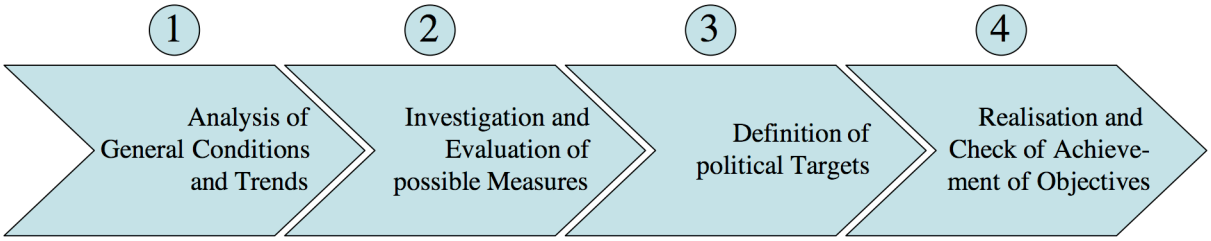

Figure 1: Theoretical process for the realisation of energy-related measures

The starting point is a detailed analysis of the general conditions and major trends. Regarding the identified directions of the development the time horizon (short-, medium- and long-term) and the most important parameters (e.g. demographic, energetic, economic or ecological parameters) have to be considered.

The investigation and evaluation of possible measures should be done as objectively as possible and therefore especially universities and other independent research facilities should be integrated in this process in the sense of a political consultancy. The underlying parameters for the assessment could be of different nature like feasibility or economical effects and should show important effects of the discussed scenarios. Possible barriers and how to overcome them should also be investigated in this stage of the process.

[3] European Comission: Green Book COM(2000)769 of 29. November 2000 - Towards a European Strategy for Energy

[4] World Energy Council (2004)

Based on the evaluation of possible measures clear political targets should be stated and also a way how to reach the targets in terms of implementation (transparent communication to the people).

The realisation and check of achievement of objectives is the last important step, in order to evaluate the success of the measures implemented.

This theoretical process of course needs to be adapted to the country-specific situation concerning e.g. the political system or cultural questions.

3 Possible general and sectoral Measures

In order to meet the challenge of realising a sustainable energy system all possibilities have to be considered. Nevertheless a few principles have to be regarded. Measures have to be divided into short-, medium- and long-term perspectives and strategies and the economic principle has to be the most important basis for decisions.

We have to define clear political guidelines especially regarding the topics energy and environment. The problem is that political targets often point in different directions, meaning that approaching one target (e.g. reduction of energy-import dependency) hinders achievement of another target (e.g. use of often more expensive domestic reserves which results in higher costs of energy supply).

The current situation in the EU is an example for this area of conflict. On one hand the EU wants to reduce the energy import dependency as postulated in the corresponding green book[5] and resulted in a second directive for forcing renewable energies[6]. On the other hand directives for environment protection have been published of which one deals especially with the quality of the European rivers[7]. The implementation of the directives in national law creates difficulty because due to the postulated protection and improvement of the quality of the rivers electricity production from hydropower is highly affected. Up to now only estimates exist but the values show that there could be a reduction of electricity from hydropower in the order of 5 to 10% in Austria. These directives thus are of considerable importance for Austria, where the share of hydroelectricity is about 70%. Additionally the EU launched a EU-wide emission trading[8], regardless of whether the Kyoto-protocol becomes operative or not.

Very important for energy innovations is the political framework.[9] The aim is to achieve the political targets through coordinated legislative measures. Those measures pertain to different parts of the energy supply chain and a few sectoral measures are shown by way of example.

3.1 Energy Supply

On the energy supply side a wide variety of technically and economically reasonable measures are possible and should be realised. In this sense not only electricity generation but also supply of heat and cooling energy based on of renewable energies should be pursued.

Where economically and technically possible the efficiency of existing energy conversion devices should be increased by using the best available technique. This includes for instance revitalisation and refurbishment of small-scale hydroelectric power plants, which represent a substantial option of making renewable energy useful. The utilisation of the non-used resources of waterpower by means of revitalisation and refurbishment of existing water power plants extensively avoids a detrimental intervention in the ecology and the water resources of lakes and rivers.

In electricity generation and heat production forced use of renewable energy sources (e.g. biomass co-firing in existing large-scale power plants[10] or substitution of fossil fuels with renewable energy

[5] European Comission: Green Book COM(2000)769 of 29 November 2000 - Towards a European Strategy for Energy

[6] European Comission: Directive 2001/77/EC for promotion of electricity produced from renewable sources in the internal electricity market

[7] European Comission: Directive 2000/60/EC of 23 October 2000 establishing a framework for Community action in the field of water policy, Official Journal L 327, 22/12/2000 P. 0001 – 0073

8 Directive 2003/87/EC of the European Parliament and of the Council of 13 October 2003 establishing a scheme for greenhouse gas emission allowance trading within the Community and amending Council Directive 96/61/EC (Text with EEA relevance), Official Journal L 275 , 25/10/2003 P. 0032 – 0046

[9] Sagar A.D. et al. (2002)

[10] Bachhiesl U. (2000)

sources) is recommended. Additionally cogeneration (combined heat and electricity production) should be applied wherever possible.

The local authorities and administration should be supported with regard to the establishment of municipal energy concepts. Such concepts are suitable as objective planning basics for a long-term development of the local energy consumption. The measures cover the reduction of energy input by means of thermal upgrading of buildings, modified heating installations, improved energy management and user behaviour as well as measures in the traffic sector including area development intervention.

With the increased application of local district heating from biomass heat plants, the emissions of the area heat supply can be reduced. By increasing the quota of biomass in energy supply, the regional forestry division is called on to intensify and expand the fuel logistics to an efficient service performance instrument.

The creation of an offer for a voluntary inspection of the energy generation plants in the stages of rough analysis and proposals for immediate and medium-term measures leads to a higher awareness for measures with reference to energy economising and in this way supports the operative plant optimisation.

3.2 Households and small-scale Customers

In the households and small-scale consumer sector, an improved situation is to be expected regarding thermal quality of the building enclosures and also with an increase of the efficiency of various power-consuming equipment and appliances. However, the desire for comfort and the reduction of the household size is increasing. If a significant change in awareness towards energy saving fails to be achieved, the requirement for energy (both in the heating/cooling sector as well as for electric power) will continue to grow at an increased rate.

Measures in this sector cover e.g. thermal situation of houses especially in cold regions but also in warm regions (avoids cooling) with respect to insulation and windows, more efficient electric devices, better information of the public, forced use of renewable energies (e.g. thermal solar collectors for hot water supply and heating or heat pumps[11]), efficient lighting and improvements in heating control.

3.3 Public Sector

Especially in the public sector “good practice” projects should be forced as a showcase for the public. Measures should of course be technically purposeful and economically appropriate compared to alternative solutions.

Renewable energy sources are to be applied for the air-conditioning of rooms as well as for the supply of room heat and warm water. For a high plant capacity utilisation throughout the year, corresponding measures for the realisation of co-generation are to be taken.

Energy accounting should be applied wherever possible because it provides a database for the comparison of the energy consumption with average values. Proposals for energy savings can be derived from this. Experience has shown that using this measure approximately 10% to 20% of the energy otherwise required can be saved for the buildings in question even without investments.

Although there is no broad consensus about how to consider external costs, an approach towards taking them into account should be done, because this would point out the real costs of the different fuel options.

The public sector should commit itself to use energy in such a way that a waste is avoided particularly where renewable energy sources are concerned and especially in order to reduce the negative environmental impact.

The already existing efforts in the sectors information, motivation, consultation and training for the various consumer groups are to be continued and expanded.

The electric power consumption and the emissions should be reduced with the use of power-saving equipment. New household appliances use up to 40% less power compared with old equipment and appliances. Therefore procurement directives for electrical equipment and plants/installations should be introduced or expanded.

[11] Bachhiesl U. (2004)

3.4 Industry

There is also potential for efficient energy use in the industrial sector. Different measures should make it possible to completely avoid increased energy consumption or keep it to a minimum by achieving higher productivity at the same time. Not only permanent technical progress and innovation but also additional measures like the following support this development.

Voluntary agreements should be examined and offered if possible. Energy benchmarking as an instrument should be applied for improving the competitiveness of energy-intensive production units.

A reduction of the specific energy application in trade and industry is to be expected by means of an intensified energy advisory service and training of those persons with responsibility with regard to energy.

Based on the climate-relevance of CO_2 emissions, these are to be reduced. The extent of the reduction should be orientated on international commitments, on the regional basic situation as well as on the regional possibilities for taking action.

Within the framework of the planning of new heat supply systems, existing waste heat potentials are to be identified and given due consideration as far as possible. By additionally using the thermal energy, the overall efficiency of the plant is substantially increased and the reduction potential expanded with regard to CO_2 emissions.

Pilot plants should be realised for the development and demonstration of innovative and efficient energy technologies.

3.5 Transport Sector

Efficiency improvements of the engines alone will not be sufficient to solve the pending problems in the sector of transport. Many of those improvements have been outweighed by higher vehicle weights, climatisation, car electronics and vehicle safety measures.

Short-term targets especially focus on the use of the car, which means that the individual and collective behaviour plays an important role in achieving reasonable user behaviour. This includes a generally reduced use of the car (e.g. avoid driving short distances to the next shop) or not using it altogether by walking, using the bicycle or public transport instead. This could be supported by establishing e.g. networks of bicycle paths in cities and forcing public transport in all fields, which means urban traffic and overland traffic (railways).

Regional plans for transport should be established in order to shorten transport distances.

Introduction of an energy efficiency labelling for passenger cars and connected measures (e.g. 4WD in cities) could lead to lower average fuel consumption.

With the introduction of programmes for calculation and illustration of energy characteristic figures on transport occurrence and by the implementation into the company cost calculation, the fuel consumption will be reduced and this will lead to a substantial decrease in fuel costs and emissions in the sector of freight and passenger transport.

The change from classic fuels like gasoline or diesel to bio fuels like bio diesel should be envisaged as a medium-term measure.

Long-term measures could include a complete switch to another fuel, which would also need a different supply infrastructure (e.g. hydrogen, methanol[12] or ammonia[13] in combination with fuel cells[14]). In this case of course the production of hydrogen has to be managed in a sustainable way.

4 Barriers to the Implementation of Measures

Often even well-developed energy technologies suffer from non-technical barriers and do not make their way into the market.[15] For this reason, successful energy innovations need integrated and systemic considerations. (See Figure 2)

[12] Kordesch K., Hacker V., Bachhiesl U. (2001)

[13] Gutschi C., Stigler H., Bachhiesl U. (2004)

[14] Enzinger P., Todem C., Bachhiesl U., Stigler H. et al. (2002)

[15] Shove Elisabeth (1998)

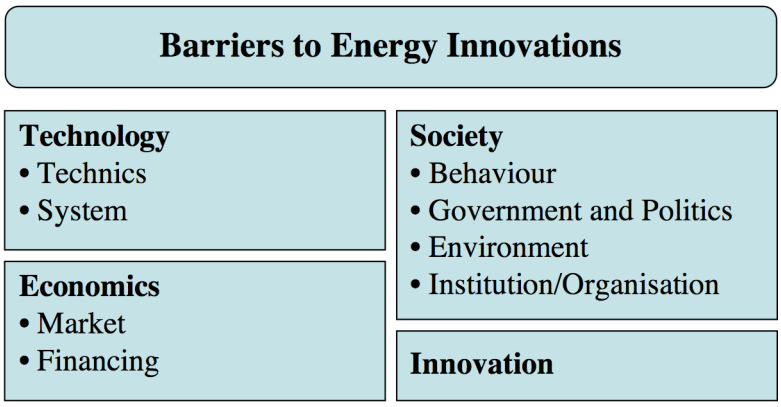

Figure 2: Barriers to energy innovations[16]

The EU realised the problems in this field and initiated an according project[17] and also the U.S. Department of Energy[18] deals with this topic. The following selected barriers of each category are presented. Of course not all barriers are relevant for every country, because of different stages of development of the country.

4.1 Technological Barriers

Typically, most renewable energy sources are not storable (e.g. wind, solar), i.e. you cannot generate the energy when needed, but only when the resource is available (e.g. when the wind blows). This causes problems in terms of the network management, because there is relatively high uncertainty about the availability of the generated energy, although the forecast methods are improving.

There are technical solutions not yet ready-to-market (e.g. electricity generation from biomass in small-scale power plants) or suffer from poor efficiencies (e.g. photovoltaic).

A poor degree of standardisation can cause incompatibilities within different systems.[19]

Also poor infrastructure like missing network or transport infrastructure could hinder the intense use of renewable energy sources. [20]

4.2 Economical Barriers

Energy markets are not always already fully established and therefore market barriers could hinder the market entrance of new generation capacity.[21]

If no external costs are considered, especially renewable energy sources are more expensive than classical fossil fuels. In combination with high initial investments, poor amortisation and higher risks massive financial barriers occur for renewable energy sources.[22]

4.3 Social Barriers

Changes in our energy system affect our whole society, which means more or less every human being. Therefore one big challenge will be not only to invent new energy technologies, but also to bring this technology to the people, so that they accept and use it. In this highly non-technical field[23] many barriers can be found, especially regarding behaviour, institutions and organisations, environment and government/policy.

[16] Bachhiesl U. (2002)

[17] European Comission: „ATLAS-Study“, http://europa.eu.int/comm/energy_transport/atlas

[18] U.S. Department of Energy, http://www.uit.doe.gov/inventions

[19] Painuly J.P. (2001)

[20] Isoard Stéphane at al. (2001)

[21] Sanstad Alan H. (1995)

[22] Stigler H., Bachhiesl U., Gamsjäger G., Stubenvoll K. (2003)

[23] Rösch Christine et al. (1999)

Contrary to standardised economic models managers do not always make optimal decisions in real life. Especially lack of time and/or information lead to wrong decisions, which often prevent e.g. new energy efficient products from being installed.[24]

Buying decisions of human beings are inseparably associated with faith in the vendor. Absence can result in a lack of information and following to a wrong (e.g. not the most efficient) buy.[25]

The acceptance of the population concerning new energy-related projects is often very low, even if renewable energy using facilities (e.g. wind power) are concerned. Prejudices often arise due to lack of information. On the part of the builder the population should be more involved in the project from the very first.[26]

4.4 Innovational Barriers

In the educational sector there is a lack of innovation-oriented research. This means that there has to be a closer connection between research institutes and the economy, which would also overcome problems concerning the knowledge transfer to applications in real life.[27]

In order to realise energy innovations financial support is needed. Because of the innovative character of such projects they are inseparably associated with relatively high risks and investors try to avoid these risks. The situation in Europe concerning risk capital is improving but compared to the United States still not so well developed (e.g. in Europe there is no high-tech and innovation oriented stock exchange like NASDAQ in the USA).[28]

As compared to Japan or USA, innovations in Europe are also often hindered by undue bureaucracy. One indicator for innovations is the number of patents filed which, as compared to Japan and the USA, shows a declining trend, also due to inappropriate basic conditions in the field of patenting.

5 Summary and Outlook

Our modern society faces major problems in terms of huge social differences, climate change and unlimited fossil fuels. Therefore a shift towards a sustainable society and especially towards a sustainable energy supply is indispensable.

Generally, global problems need global solutions, but we have to consider that we need - because of the differences between our world regions and countries in terms of e.g. geography, culture, religion, reserves, political system - a situative approach.

It is not to be expected that a radical new invention will be made in the next decades and therefore various small steps lead towards a sustainable energy system. Although fossil fuel reserves are going to last for at least five more decades (oil and gas but not coal), they are finite. We will therefore inevitably be confronted with higher energy prices.

One important basic principle should not be neglected – the economic principle. With the available financial resources we must try to get the highest output we can get. This means we should use the best potentials first. The situation in the EU is a good example. Thanks to the relevant directive, a EU-wide target for electricity from renewable energy sources has been defined. Those target values have been adapted to the level of each member state. What happens is that each member state tries to reach the target within its own country. Compared to an EU-wide solution the best locations having the lowest electricity production costs would be used and the costs for the same amount of electricity would be lower, thus economically more reasonable. The resulting cost difference could be used to build additional power plants. Although the EU aims at a single European electricity market, this vision is not reality now. For Europe it is one of the most important challenges for the near future to really establish this market.

The time for action is now, because a change in the present energy system takes several decades because of the huge investments needed. In Europe, for instance, we must install approximately

[24] DeCanio Stephen (1998)

[25] Weber, Lukas (1997)

[26] Menanteau Philippe et al. (2000)

[27] Sorell Steve et al. (2000)

[28] Darmstadter J. (2001)

600 GW[29] of new generation capacity, thus replacing 300 GW of existing capacity and 300 GW of new capacity due to the still increase in energy consumption (app. 2%/year electricity).

In order to meet our future challenges (especially energy security and emission goals) we have to keep all energy options open (including nuclear and large hydro power). It will also be very important to embank the energy demand grow rates, which will only be reached through a contribution of everybody.

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The author, Dr. Udo Bachhiesl, was born in Klagenfurt/Austria. After finishing school he studied "Mechanical Engineering/Economics" at Graz University of Technology[30] with a focus on "Energy and Environmental Management Technology" and finished his studies with his diploma thesis "Techno-economic Analysis of Biomass Co-combustion in large-scale Power Plants". He then submitted his doctoral thesis at the faculty for Electrical Engineering/Institute of Electricity Management and Energy Innovation at Graz University of Technology with the title "Successful Energy Innovation Processes - Framework and Methodology based on a detailed Analysis of Barriers and Success Factors". Dr. Bachhiesl assists currently the development of a new energy plan for Styria (federal state of Austria).

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