Renewable Energy Technology Deployment - **RETD**

BARRIERS, CHALLENGES AND OPPORTUNITIES

A synthesis of various studies on barriers, challenges and opportunities for renewable energy deployment

May 2006

Prepared by Anders Kofoed-Wiuff, Kaare Sandholt and Catarina Marcus-Møller from Ea Energy Analyses for the IEA RETD Implementing Agreement

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Renewable Energy Technology Deployment (RETD)

- Barriers, Challenges and Opportunities

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Table of content

Abbreviations

APEC	Asia Pacific Economic Cooperation
BAU	Business As Usual
BIREC 2005	Beijing International Renewable Energy Conference 2005
BMU	Federal German Ministry for Environment, Natural Conservation and Nuclear Safety
CDM	Clean Development Mechanism
CERs	Certificates of Emission Reductions
CHP	Combined Heat and Power
CO2	Carbon Dioxide
CSD	Commission on Sustainable Development
DSO	Distribution System Operator
EEA	European Environment Agency
EPA	Environmental Protection Agency
ERU	Emission Reduction Units
EU	European Union
EU ETS	European Union Emissions Trading System/Scheme.
EWEA	European Wind Energy Association
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gases
GMI	Global Market Initiative
GNESD	Global Network on Energy for Sustainable Development
GREFF	Global Renewable Energy Fund of Funds
GVEP	Global Village Energy Partnership
GW	Gigawatts
IBRD	International Bank for Reconstruction and Development
IEA	International Energy Agency
IPP	Independent Power Purchase
JI	Joint Implementation
LPG	Liquefied Petroleum Gas
Mtoe	Million tons of oil equivalent
MW	Megawatt
NIMBY	Not In My Back Yard
NGO	Non-Government Organization
OECD	Organization for Economic Cooperation and Development
O&M	Operation and Maintenance
PEC	Photo Electro-Chemical
PPA	Power Purchase Agreements
PV	Photovoltaics
R&D	Research and Development
RD&D	Research, Development and Demonstration
RE	Renewable Energy
REEEP	Renewable Energy and Energy Efficiency Partnership
REIA	Renewable Energy in the Americas
REILP	Renewable Energy and International Law Project
REN21	Renewable Energy Policy Network for the 21st Century
Renewables 2004	Bonn International Renewable Energies Conference 2004
RETs	Renewable Energy Technologies
RETD	Renewable Energy Technology Deployment
TSO	Transmission System Operator
UN	United Nations
UNEP	United Nations Environment Programme

UNF	United Nations Foundation
UNFCCC	United Nations Framework Convention on Climate Change
UNIDO	United Nations Industrial Development Organization
VAT	Value Added Tax
WEO	World Energy Outlook
WSSD	World Summit on Sustainable Development
WTO	World Trade Organization

1 Executive summary

At the International Conference for Renewable Energies in Bonn (Germany) in June 2004, ministers and the Executive Director of the International Energy Agency (IEA) proposed to launch an IEA Implementing Agreement on Renewable Energy Technology Deployment (RETD). The agreement was one of the key outcomes and was included in the International Action Programme from the conference.

The purpose of RETD is to accelerate the deployment of renewable energy technologies. The agreement should supplement and build on the work of the nine existing technology-specific IEA implementing agreements on renewable energy. Focus is on breaking down barriers that are not country or technology-specific.

The activities within the agreement are financed by the participating countries and may possibly be supported by sponsors from the private sector in the future. Until now Canada, Denmark, France, Germany, Ireland, Italy, the Netherlands, Norway and the UK participate.

This report has been prepared as part of a process of identifying project activities to be included in an Implementation Plan for RETD for the period towards 2010 and a detailed Work Programme for 2006-2007.

The objective of this report is to synthesize relevant studies on barriers, challenges and opportunities for the deployment of renewable energy published in recent years.

The RETD Implementation Plan and the Work Programme include prioritised project activities aiming at breaking down barriers to renewable energy deployment and are based on a common understanding among key stakeholders of the current barriers and challenges for the deployment of renewable energy technologies.

A draft version of this report was presented at a Stakeholder Workshop on 22 March 2006, where approx. 40 representatives from the RE industry, energy market players and authorities convened to guide RETD on which areas to focus activities on. The present study reflects the input provided at the Stakeholder Workshop.

This report provides:

- A description of the drivers for renewables and important changes in global renewable energy framework;
- A brief status for the development of renewable energy technologies and their current utilization;
- An identification and description of barriers and opportunities for renewable energy deployment;
- A summary of the activities identified by the Executive Committee as relevant to pursue within the RETD mandate period running towards 2010.

Renewable energy status

Analyses show that the technical potential for utilization of renewable energy is almost 20 times as high as the current global energy demand. Analyses show that the technical potential for utilization of renewable energy is almost 20 times as high as the current global energy demand. Today, however, renewable energy only provides 17 % of the world's primary energy needs and traditional renewable energy use, i.e. biomass for cooking/heating and large hydro power, make up the greater share (9.0 % and 5.7 % respectively). New renewable technologies such as wind, solar and biomass power merely cover approximately 2 % of total global primary energy consumption (Martinot 2005).

This may seem a very low figure, but in some countries and markets renewable energy penetration is high:

- In Brazil almost as much **biofuel** (ethanol) as gasoline is used for automobile fuel
- In 2004 total wind power capacity increased to 47.3 GW. More than 70 % of the total **wind power** capacity was installed in only four countries: Germany, the US, Spain and Denmark. In Denmark wind power covers approx. 20 % of electricity consumption.
- By the end of 2005 total **photovoltaic** power capacity had grown to more than 5 GW. The capacity is concentrated in Japan, Germany and the US, which accounted for 86 % of the total capacity in 2002.
- In Israel there is close to 1 m^2 of **solar water heating** capacity per person.
- In Sweden **biomass** supplies more than 50 % of district heating needs and in Finland 11 % of the total electricity generation is based on biomass.

If countries learn from each other and best available practices are spread, the utilization of renewable energy technologies may increase considerably.

In fact statistics show that renewable energy utilization is already growing rapidly. In the five-year period from 2000 to 2004, grid-connected solar PV increased by 60 % per year on average, wind power by 28 %, biodiesel by 25 %, solar hot water/heating by 17 %, off-grid PV by 17 %, geothermal heat capacity by 13 % and ethanol by 11 % (Martinot 2005).

Probably the greatest challenge for renewable energy technologies is to become economically competitive with conventional technologies and in the longer term to be able to handle the issue of intermittency.

Figure 5 shows the long-run marginal costs (LRMC) of electricity production from different renewable technologies. The range of costs indicates that generation costs depend on the resource conditions in different countries or regions (in this case the EU member states). In some contexts renewable energy technologies are already competitive with conventional technologies, and R&D and market learning processes will increase the competitiveness of RE in the future. The cost of wind turbines for example was already reduced by a factor four (from 1981 to 1998) and, similarly, analyses show a cost decrease of 20 % every time the volume of photovoltaics produced is doubled. Compared to most other renewable energy technologies, generation costs for PV are still high however.

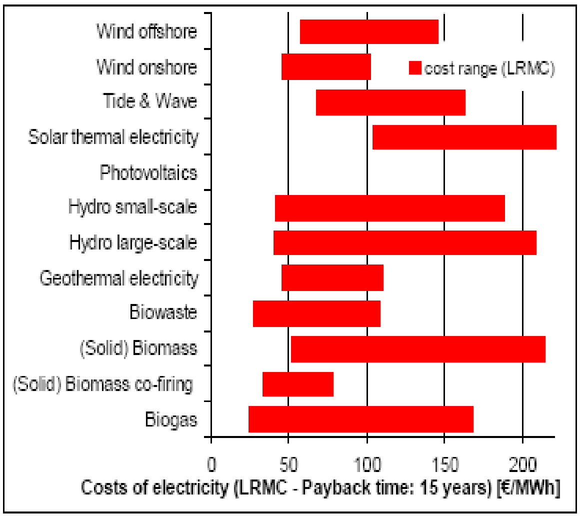

Figure 1: Electricity generation cost of renewable energy technologies (EU Commission 2005: 24, Support of electricity from RE sources). For comparison the long-run marginal cost of a new coal-fired plant is approx. 35 €/MWh, excluding externalities.[1]

If the externalities related to energy generation are incorporated into energy prices, this will also improve the competitiveness of renewable energy technologies since they are generally more environmentally friendly than conventional technologies. Renewable energy also provides a hedge against increasing fossil fuel prices resulting from the depletion of resources or geopolitical developments.

Support for renewable energy

To bring renewable technologies forward, a supporting framework is needed at different stages of technological development. In this regard it can be fruitful to consider the technological development process of new energy technologies to take place in four different phases. These are pioneer, introduction, market and competition (summarised in Table 5).

Phases	Description
Pioneer	The technology emerges as an independent technology. This phase is characterised by a small number of companies developing the technology primarily through radical innovations. The first barrier is to create a workable and reliable product. The greatest risk is technological.
Introduction	Introduction of the product on markets (most often niche markets). Known technology – many companies. Innovation becomes incremental. The greatest risk is financial.
Market	The technology has become reliable and standardised and established on the market. Competition has resulted in a smaller amount of companies. The greatest risk for investors is the market risk – i.e. achieving sufficient market share.
Competition	The product is mature and has the opportunity of competing on equal terms with conventional technologies. Few companies.

Table 1: Phases of the technological development process for RE technologies. For a more thorough description of the four phases, see Skytte et al. (2004)

[1] Solar PV is not included in the figure because its costs according to the communication from the EU is not within the indicated cost range (0-200 €/MWh) in a European context. According to the IEA (2006) the generation cost of PV may however in some countries, where the solar resource is great, come down to some 200 $/MWh – corresponding to approx. 160 €/MWh with the current exchange rate (1$=0,81€, 2006-04-04).

In the first phases, particularly in the pioneer phase, the technology push support is more important than market pull measures. This involves R&D for finding the right technology concept (basic research), support for demonstration plants (applied research) as well as initiatives which support networking between industry, research institutions and authorities to create synergies in product and process innovation.

In the later phases, market pull measures become important. In these phases innovation increasingly takes place incrementally and cost reduction is stimulated by learning-by-doing and learning-by-using processes. In the later phases, the structural integration also becomes very important. This involves physical planning for plants as well as grid connection and market and grid integration issues.

With continued expansion of renewable energy, the pattern of operation in the energy systems will change because the fluctuating nature of renewable energy sources will lead to price fluctuations in the market. These price fluctuations would signal a need for flexibility and regulation capacity of other plants and would require new measures, e.g. interconnections, storage capacity (heat/electricity) and new forms of demand response. Also it would be important to ensure efficient interaction between the electricity market, the heat market, the gas market and the markets for transport fuels.

Table 6 shows the importance of the different types of support in the various phases of technological development. Three stars refer to a great effect of support, two to a moderate effect and one to a little effect – a minus refers to an insignificant effect.

	Research and development (Technology push)			**Market development** (Demand pull)			**Structural integration**	
	Basic research	Applied research	Triple Helix[1]	Investment support	Price support	Separate markets[2]	Physical planning	Connection conditions
Pioneer	***	***	*	**	*	-	*	*
Introduction	**	**	***	***	**	*	**	**
Market	*	*	**	*	***	***	***	***
Competition	*	*	-	-	-	*	*	*

Table 2: Effect of support measures and plant conditions in the different phases (see Skytte et al., 2004: 99).
[1]Triple Helix: when industries, research institutions and authorities work dynamically together in order to generate synergies.
[2] For example renewable energy certificate markets or tenders for renewable energy capacity.

Drivers for renewable energy deployment

The following drivers are often mentioned as the most important in the promotion of renewable energy:

- Security of supply;
- Increasing/fluctuating fuel prices;
- Environmental concerns;
- Agricultural, rural and social policy issues;
- Technological development and business perspectives;
- Consumer support.

Drivers will vary from region to region and across countries, depending on issues such as access to renewables and other energy resources, state of industrial development, consumer demand considerations and possibly other considerations as well.

Three global developments in particular will change the market framework for the development and deployment of renewable energy technologies. These concern the liberalisation of energy markets, the international greenhouse gas regulation and the globalised markets for trade in renewable energy technologies and fuels.

These developments may create barriers as well as opportunities for renewable energy.

Barriers and opportunities for renewable energy

Table 3 provides a list of the most important barriers to renewable energy deployment divided into some generic categories. In addition, there is a number of examples of possible opportunities for overcoming the barriers, and relevant stakeholders are outlined. The table is based on the literature survey presented in chapter 5 and input from the Stakeholder Workshop on 22 March 2006.

Several discussions at the Stakeholder Workshop concerned information barriers at different levels. Often policy makers and energy planners are not aware of the benefits of renewable energy compared to fossil fuel technologies. This applies to the international and national level, but also to the local level (counties and local authorities) where many decisions on renewable energy are taken. Also private stakeholders and the general public do not have sufficient knowledge about renewable technologies and their benefits.

An issue related to the information barrier is the lack of market transparency and the fact that markets prices do not reflect the true costs of energy. At the Stakeholder Workshop it was pointed out that policy makers should be aware that renewable energy technologies are new entrants threatening vested interests of the conventional energy sector.

Decentralised renewable solutions face particular problems related to grid issues, local planning and NIMBY issues, which the participants of the workshop emphasised as important to deal with. Increased harmonisation of regulation (approval procedures, environmental impact assessments, spatial planning) through improved cooperation between different authorities was found to be an important measure. Also international cooperation between TSOs and authorities was encouraged as a means to deal with energy infrastructure issues (grid codes, grid access, interconnection between markets).

To significantly increase the share of renewables, many workshop participants called for politicians to (further) develop visions or targets for renewable energy deployment and to develop policy solutions which make investments in renewable energy technologies attractive to private stakeholders.

Barriers	Opportunities	Important stakeholders
There is no level playing field for renewable energy technologies	International cooperation on: - Phasing out subsidies for conventional technologies - Good practice for subsidies - Internalisation of externalities	National governments and international forums for cooperation (UN, EU, IEA, G8)
The incentives for governments and private companies to support renewable energy development are insufficient	- International agreements committing governments to demonstrate and deploy renewable energy technologies - Multilateral funds for RE deployment and demonstration – partnerships with the private sector	National, regional and local authorities, international forums for cooperation (IEA, G8), the RE industry, international financing institutions
Financing is unreasonably costly for renewable energy technologies	- Favourable loans for renewable energy projects through national or international institutions. Promote long-term power purchase agreements between consumers and RE generators - Initiatives to stimulate carbon financing of renewable energy projects; - Training and education of financiers	International/national financing institutions, national governments, CDM executive board, JI advisory committee, Asia-Pacific Partnership on Clean Development and Climate, energy producers, private financing institutions
Technology standards are lacking for (some) renewable energy technologies and fuels	- Develop standards for renewable energy technologies, components and fuels - Develop test facilities for renewable energy technologies	National and international standardisation organisations, the RE industry, industry associations, international trade organisations (WTO, NAFTA etc.)
Import tariffs and technical barriers impede trade in renewables	- International cooperation on removing duties and technical barriers to trade in renewable energy products	International and regional trade organisations (WTO, NAFTA etc.), international forums for cooperation (IEA, G8), the RE industry
Permits for new renewable energy plants are difficult to obtain	- Cooperation on best practice between national and local authorities from different countries - Developing internationally harmonized standard forms and requirements (to help RE project developers working internationally)	National and local authorities, the RE industry needs to adapt its products to meet requirements of authorities
Energy markets are not prepared for renewable energy	International cooperation on: - best practice for grid connection/access - removing market imperfections in relation to RE - new interconnectors - integration of intermittent RE sources - promoting demand response in energy markets	National authorities, transmission system operators, distributions system operators, energy regulators, energy traders
Renewable energy skills and awareness are insufficient	- Information and education on all educational levels at national level or through international programmes - Twinning between authorities and TSOs from countries with different experience and between operational personnel from different countries - International in-service training programmes - National and international awareness campaigns.	National and local authorities, NGOs, consumers, international forums for cooperation (IEA, G8), universities and technical colleges, operational personnel

Table 3: Summary of barriers to renewable energy and examples of opportunities and important stakeholders

Strategies

An important topic at the Stakeholder Workshop on 22 March 2006 was to identify focus areas or strategies for the RETD Implementing Agreement.

One of the focus areas identified at the workshop was benchmarking or provision of information on best practice policy measures. Benchmarking could for example be on support schemes for renewable energy, on internalising externalities or on grid connection issues.

Similarly, incentives to stimulate international cooperation between authorities and TSOs were pointed out as central, and public-private cooperation was emphasised as a means to deal with grid integration issues and problems related to approval procedures. This could for example be done by establishing international task forces with representatives from authorities, TSOs and utilities.

Provisions of unbiased quality information on renewable energy technologies (costs, performance of technologies, resource potentials, consensus-workshops etc.) were brought forward as another relevant focus area. It was discussed that this information should build on and take into consideration the existing work done within the IEA and the other implementing agreements concerned with renewable energy.

Information campaigns addressing issues such as the externalities (health impacts, climate change etc.), and the size of subsidies for conventional technologies and the benefits of renewable energy (rural development, employment, security of supply etc.) were also mentioned as a relevant activity for RETD. The target group for such activities could be market players as well as policy makers at all levels (international, national and local).

Furthermore it was pointed out that activities should take into consideration that renewable energy technologies are deployed at different markets (electricity, heat, fuel, gas), each with their own set of conditions and market barriers.

Activities related to education and training were found to be a possible RETD activity. Target groups for education initiatives could be energy planners, policy makers or technicians dealing with renewable energy.

Based on the input from the Stakeholder Workshop and the information provided in the present report, the RETD Executive Committee has selected more than twenty activities as possible activities within the framework of RETD. These activities are described in chapter 6 and in the Implementation Plan 2005-2010.

From the gross list of relevant activities the RETD Executive Committee has selected and bundled a number of high priority activities to be started as projects before the end of 2006. These projects are described in the outline of the Work Programme 2006-2007.

The projects concern:

A. Levelling the playing field for renewable energy;
B. Approval procedures and spatial planning;
C. Integration of renewable energy into energy systems and markets;
D. Renewable energy technologies in the heating and cooling markets;
E. Financing of renewable energy technologies;
F. Dissemination and communication strategy.

Once a permanent Operating Agent has been selected for RETD by mid-2006, the projects will be developed in such a detail that they can be launched without further elaboration.

Updated information about the RETD Implementing Agreement is available at www.iea-RETD.org

2 Introduction

In 2003 the IEA report "Renewable Energy into the mainstream" wrote:

"A policy framework must be created that will provide a more level playing field because rules, laws and systems have built up over the last century, based primarily on fossil-fuel based systems. For renewable energy markets to flourish, it is necessary to redress the imbalance of those traditional approaches. The policy framework must keep pace with the dynamic changes underway within the overall energy sector, as well as reflecting social, economic and environmental priorities." (IEA, 2003).

At the International Conference for Renewable Energies in Bonn (Germany) in June 2004 ministers and the IEA's Executive Director proposed to launch an IEA Implementing Agreement on Renewable Energy Technology Deployment (RETD). The agreement was one of the key outcomes from the conference and was included in the International Action Programme.

The RETD agreement focuses on ways to overcome barriers to market deployment of renewable energy technologies. Focus is on barriers that are not country or technology specific.

The RETD Implementing Agreement will include private companies as well as sub-national governments and NGOs.

Vision, mission and objectives of the new implementing agreement are presented below:

RETD Implementing Agreement

RETD Vision
Significantly higher utilization of renewable energy technologies will result from international cooperation encouraging more rapid and efficient deployment.

RETD Mission
- *To measurably improve cooperation between participating governments in identifying cross-cutting barriers to deployment and providing "best practice" solutions, thus strengthening international collaboration for technology deployment.*
- *To provide guidance to the private sector and policy makers on innovative business strategies and projects that encourages technology deployment by fostering public-private partnership projects.*
- *To inform and facilitate ongoing international dialogue and public awareness of renewable energy deployment by contributing concrete examples on deployment solutions.*

RETD Objectives
- *To elaborate and present options for "best practice" policy measures and mechanisms for cost reduction, enabling increased use of renewable energy in competitive energy markets through strengthened international collaboration.*
- *To elaborate and present options for innovative business strategies and projects that will encourage renewable technology deployment to public and private sector stakeholders.*
- *Building from the unique framework of the IEA, to disseminate information and enhance knowledge about renewable technology deployment, complementing other information programmes in supporting improved public and private sector decision making.*

The IEA has a long history of technology cooperation. The idea is that research and development of new technologies can be accelerated through cooperation and concerted actions. There are nine existing technology specific implementing agreements under the IEA Committee for Energy Research and Technology (CERT) (see Annex I). These implementing agreements have mainly focused on technical issues related to research and development within single technologies. Only in recent years activities have also to some extent been related to market dissemination.

The RETD Implementing Agreement will supplement and bring added value to the work of the nine existing technology specific implementing agreements. It is the purpose of the agreement to enhance technology development through strategies for overcoming barriers and facilitating growing and new markets.

The activities within the agreement will be financed by the participating countries and can possibly be supported by sponsors from the private sector in the future. Until now Canada, Denmark, France, Germany, Ireland, Italy, Netherlands, Norway and the UK have all showed commitment to the agreement.

2.1 Objective

This report has been prepared as part of a process of identifying project activities to be included in an Implementation Plan for the RETD agreement for the period towards 2010 [reference] and a detailed Work Programme for 2006-2007 [reference].

The objective of this report is to synthesise relevant studies on barriers, challenges and opportunities for the deployment of renewable energy, which has been published in recent years.

The RETD Implementation Plan and the Work Programme includes prioritised project activities aiming at breaking down barrriers to renewable energy deployment and are be based on a common understanding among key stakeholders of the current barriers and challenges for the deployment of renewable energy technologies.

A draft version of this report was presented at a Stakeholder Workshop on 22 March 2006, where approx. 40 representatives from the RE industry, energy market players and authorities were gathered to guide the RETD on which areas to focus activities on. The present study reflects the input provided at the Stakeholder Workshop.

Figure 1 illustrates the role of this study in developing programme activities for the RETD Implementing Agreement.

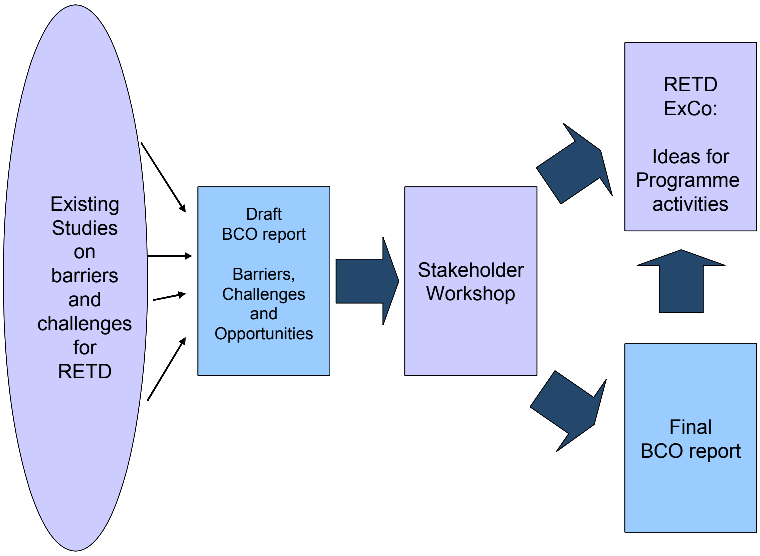

Figure 2: The role of the BCO report in developing programme activities for the RETD Implementing Agreement.

2.2 Methodology

Structure
The report is structured in the following way:

Chapter 3 describes driving forces and market framework. This is to set out the general context for renewable energy technology deployment and to provide a common understanding of the most important framework conditions and drivers.

Chapter 4 provides a brief status for the different renewable energy technologies that are available and elaborates on the needs for support during technological development. Some barriers are very specific to renewable technologies that produce electricity and heat, some to small-scale technologies and others to technologies which are traded on international markets etc.

Chapter 5 identifies barriers and opportunities for renewable energy technologies. Focus is on barriers that can be overcome through international collaboration on policies and business strategies and on barriers that are not technology specific. On the basis of the barriers identified opportunities and important stakeholders are pointed out.

Chapter 6 identifies possible strategies for renewable energy deployment to be pursued by the RETD.

In Annex I a preliminary survey of organisations and forums working with international renewable energy activities is presented.

Literature
The literature used for the study encompasses, among others:
- IEA papers. Please see the extensive library of papers available from the online bookshop of the IEA (www.iea.org/bookshop/b.aspx?new=5).
- Papers prepared for the RE conferences in Bonn in 2004 and in Beijing 2005
- Academic papers from Energy Policy and other relevant journals

- Policy papers from national authorities and from the EU

Fact sheets have been prepared, analysing most of the publications that have been used for the study. These highlight the barriers and solutions identified in the individual reports/paper. The fact sheets are included in Annex III.

Definition of renewable energy
By IEA definition, RE sources include combustible renewables and waste (solid biomass, charcoal, renewable municipal waste, gas from biomass and liquid biomass), hydro, solar, wind and tide energy (IEA 2005, Renewables Information 2005). Attention in this study has primarily been given to new renewable energy technologies, disregarding for instance large scale hydro.

Furthermore focus of the report is on barriers to RE deployment in IEA countries, though some of the problems described may also be of relevance to developing countries. Also issues related to cooperation between developed and developing countries are dealt with to some extent.

Author
The present report has been prepared by EA Energy Analyses in cooperation with the RETD Executive Committee[2]. Comments have been provided by Dr. Ole Langniss, Centre for Solar Energy and Hydrogen Research Baden-Württemberg.

[2]The RETD Executive Committee has representatives from the nine IEA countries supporting the RETD. Norbert Gorißen, BMU, Germany chairs the Executive Committee.

3 Driving forces and market framework

On a global scale at least 45 countries have developed national targets for renewable energy, including all 25 EU countries and 10 developing countries - among these China, India and Brazil. Although neither the United States nor Canada has a national target, 18 U.S. states and 3 Canadian provinces have targets based on renewables portfolio standards, and an additional 7 Canadian provinces have planning targets. Most national targets concern shares of electricity production, typically 5–30 percent (Martinot, 2005: 19).

This part of the report discusses driving forces and framework conditions for renewable energy sources with the aim to set out the general context for renewable energy technology deployment.

Drivers are interpreted in the broad term as reasons or rationales for market players as well as policy makers to develop and facilitate the deployment of renewable energy technologies.

Firstly the most important drivers for renewable energy deployment are described. Focus is on the drivers presented below, though acknowledging that in some contexts there may be other important drivers for RE utilization.

Drivers for renewable energy deployment:

- Security of supply
- Increasing/fluctuating fuel prices
- Environmental concerns
- Agricultural, rural and social policy issues
- Technological development and business perspectives
- Consumer support

Secondly the chapter deals with important changes in the international framework conditions for renewable:

- Liberalisation of energy markets
- International greenhouse gas obligations
- Globalisation

These changes may have a significant impact on renewable energy development, as well as on the measures used to promote RE technologies.

3.1 Drivers

Drivers for renewable energy are manifold. This section does not intend to give a comprehensive description, but to highlight some major drivers which are especially stimulating market growth in renewable energy. These issues have been addressed recently in publications from the conferences on renewable energy held in Bonn in June 2004 and Beijing in November 2005.

As explained by Sonntag-O'Brien and Usher in a background Paper for the International Conference for Renewable Energies in Bonn *"Though market and investment conditions vary according to technology (size, capacity, on or off grid, energy resource, etc) and region, the market drivers for RE are the same: improved economics (in some cases), energy security, global, regional and local environmental benefits, economic development, and* *consumer support."* (Sonntag-O'Brien & Usher, 2004 "Mobilising Finance For Renewable Energies").

Market drivers will vary from region to region and across countries, depending on issues such as access to renewables and other energy resources, state of industrial development, and consumer demand considerations and possibly other considerations as well.

Security of supply

Security of supply concerns may be grouped into three general categories.

The first category concerns the fact that, when using fossil fuels, we draw on limited geological resources. There is a risk that for instance oil production will peak within the next generation or two. This poses a physical risk for the energy supply.

The second concern deals with the vulnerability of supply and the geopolitical issues related to the fact that oil and gas resources are distributed very unevenly. Several countries have relatively high energy consumption and few or none indigenous fossil fuel resources. They are severely dependant on stable import of fossil fuels making them exposed to political developments in producer countries.

As the recent dispute over Ukrainian gas prices shows security of supply may indeed be vulnerable. That dispute also enlightens the dependency of EU on imported fossil fuels, a dependency that will probably grow in the future unless new indigenous resources are developed within the EU - an issue which is also stressed in the EU Green Paper: A European Strategy for Sustainable, Competitive and Secure Energy (European Commission, 2006).

To put some figures on this, in its green paper on security of supply from 2000 the European Commission estimated that the total proved oil reserves of the European Union would only be able to cover 8 years of consumption at the current level (European Commission, 2000: 19). The similar figure for the US is approx. 4 years[3].

The uneven distribution of resources primarily poses a political risk for the energy supply of consumer countries.

The latter concern deals with the economic disadvantage of depending on foreign resources beyond the risks associated with disruption of supplies. This primarily involves the negative effect on the balance of payment, which is of course dependent on the local resources and on the fuel price.

Renewable energies imply a high security of energy supply in the sense that they are generally based on utilization of local or indigenous energy resources. Furthermore, renewables contribute to a diversification of energy supply and some renewable energies may contribute to a decentralization of energy supply, which also may improve the local security of supply and preparedness of energy systems to deal with natural disasters, terrorist attacks and the like.

Increasing/fluctuating fuel prices

In it self increasing or high fossil fuel prices is of course a vital driver for the competitiveness and further utilization and of renewable energy sources. During the recent years fossil fuel

[3] Calculation based on statistics from BP Statistical Review of World Energy, 2005, www.bp.com, 2006-02-13.

prices have increased significantly, particularly the oil price which has more than doubled during the last two years (see Figure 3).

Though the IEA does not expect fuel prices to increase considerably during the coming 25 years, fluctuations in fuel prices are likely to increase. According to the IEA World Energy Outlook 2005 (IEA 2005, p. 63) the assumed developments in oil prices *"…should not be interpreted as a prediction of market stability, but rather as long-term trends around which prices will fluctuate. Indeed oil price may become more volatile in the future."*

Hedging against fuel price increases and fluctuations may provide an important driver for countries and companies to invest in renewable energy technologies. Variations in fuel prices however also involve an element of uncertainty for renewable energy developers and producers, because their investments are jeopardised if/when fossil fuel price turn low.

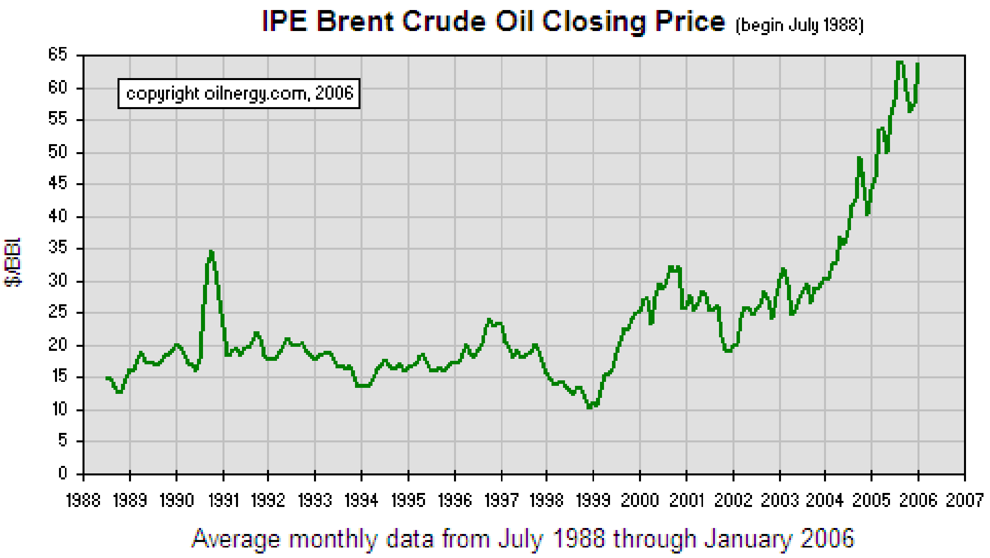

Figure 3: Development in oil prices since 1988 (www.oilnergy.com , 2006-02-13)

Environmental policies and concerns

The environmental impact from the lifecycle of renewable energy systems is generally very low compared to the lifecycle impact of fossil fuelled energy systems (see also chapter 5.2). Renewable energy can make a major contribution to reducing greenhouse gas emissions. in Germany for instance, renewable energy currently avoids 83 mill. tonnes CO2/year[4].

At the local and regional level renewable energy may lead to reductions in harmful pollutants such as SO2, NOx and dust.

It should be recognized in connection with the above that renewable energy technologies may also have negative impacts on the environment; examples concern the visual impacts from wind power and the problems caused by dams in hydro power projects. In some contexts environmental policies and concerns may therefore also pose a barrrier to further renewable energy deployment.

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[4] See the website of the German ministry of the environment, www.erneuerbare-energien.de/inhalt/36645/5466/, 27-02-2006

Agricultural, rural and social policies

Particularly for biomass technologies agricultural policies can be very important drivers for their utilization. Energy crops for instance provides a new market outlet for agriculture and at the same time contributes to rural development.

Also many organizations work towards getting electricity to the thinly populated regions of the world, with no energy infrastructure. The off-grid RETs have many advantages in these applications, as they do not need grid connection or fuel supply (wind/solar). As many of the thinly populated areas are situated in the developing countries the RET will be spread "*…particularly among the poorer and marginalized members of society -as a means of accelerating rural development and alleviating poverty."* (www.gvep.org/section/aboutus/ ,10-02-2006)

Technological development and business perspectives

Business perspectives of RE will probably become an increasingly important driver for national governments, industries and energy companies, and will imply further investments in development of RE technology.

Government support for RD&D in advanced technologies and knowledge based industries is by many analysts seen as essential if developed countries want to maintain competitiveness in global markets and increase employment. As stated by Foxon et al. (2005), *"Innovation is the principal source of economic growth and a key source of new employment opportunities and skills, as well as providing potential for realing environmental benefits.*

Consumer support

Many RE technologies are located at or near to the consumers and the deployment is often also driven by consumer engagement. Opinion polls show that consumers are generally positive toward supporting renewable energy technologies[5]. In some cases the attitude towards concrete RE plants have been negative from surrounding inhabitants and it is important to include population opinion in the planning of especially larger RE technology plant.

High support from consumers is a vital driver for RE and a high degree of information on the impact of RE technologies and plants can help maintaining and developing consumer support. Experience shows that consumer support is significantly enhanced where there is community involvement/ ownership.

3.2 Market framework

Three global developments (in particular) are changing the market framework for the development and deployment of renewable energy technologies:

- Liberalisation of energy markets
- International greenhouse gas reduction obligations
- Globalisation

[5] For example, in a recent analysis for the European Commission, Eurobarometer, asked Europeans, what measures national governments should choose to reduce dependency on imported energy resources. According to the study, *"Almost half of all Europeans (48%) support a Governmental focus on developing the use of solar power followed by promoting advanced research for new energy technologies (41%) and developing the use of wind power (31%). Regulation for the reduction of our dependence on oil (23%) and developing the use of nuclear power (12%) are less appreciated among the respondents."* (Eurobarometer 2006).

Their influence will be briefly described below.

Liberalisation of energy market

Energy markets around the world are being rapidly reformed. Following many years with structural immobility in electricity supply, governments around the world are allowing market forces to play an increasing role in the operation of energy systems and investments in new generating capacity. Most IEA countries have already introduced competition into their electricity systems or plan to do so (IEA 2002, IEA 2006).

The main goal of these changes is to improve the economic performance of electricity and gas supply.

The liberalisation of energy markets provides barriers as well as opportunities for renewable energy technologies:

On the one hand monopoly utilities are replaced by profit driven energy producers, which may be reluctant to develop and invest in alternative/renewable energy technologies. A market-based setup may particularly disfavour renewable energy technologies. Energy producers perceive them as high risk and they tend to be capital intensive and have long return time frames. This makes them highly exposed to the changing electricity prices in spot markets and costly to finance (Neuhoff 2005: 95).

On the other hand, the unbundling of gas and electricity utilities provides access to new actors and new technologies[6]. Beck and Martinot (2004: 16) explains; *"Wholesale power markets allow IPPs* [Independent Power Producers] *to bypass the biases against renewables that traditional utility monopolies have had."* Vertically integrated companies may have incentives to obstruct the entry of renewable technologies, because they take market share from their conventional generation assets (Neuhoff 2005: 95). Privatisation can promote renewables by introducing new sources of capital, and the drivers in the market to improve efficiency in order to be more competitive may make renewable energy technologies more attractive. Also distributed generation may gain more success because of its short lead time, its flexibility to install and because it may enhance efficiency of infrastructure investments[7].

The restructuring of energy markets has also changed the means of regulation used to promote renewable energy. In the traditional utility based systems voluntary agreements and control and command strategies were the primary means to achieve political objectives. For example requirements for utilities to apply a certain amount of biomass or install a certain number of wind power plants. In deregulated markets economic incentives such as taxes, feed-in-systems, quotas and certificate systems are often preferred in order to place all market players on an equal footing. This change of paradigm is important to bear in mind when barriers and opportunities for renewable energy deployment are considered.

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[6] The opening of natural gas markets creates opportunities for biogas whether from thermal gasification or from fermenters.

[7] Furthermore restructuring and liberalisation have raised the significance of customer value and choice as a new factor in energy supply systems. As put by the G8 Renewable Energy Task Force in 2001: "In most cases, the traditional model puts generation assets "behind the fence", and far removed from most local community involvement. This tends to limit public involvement in energy choices, previously the exclusive domain of energy companies and their regulators."(G8 2001: 35).

International greenhouse gas reduction obligations

With the coming into force of the Kyoto Protocol and the start up of the EU emissions trading system CO2 regulation has become international. A global market for CO2 allowances is established and a common price on CO2 is likely to emerge. The Kyoto Protocol encompasses the EU countries, countries with economies in transition (including Russia), Canada, Japan, and most developing countries, including large scale emitters like China and India. As of 18 January 2006 158 countries had ratified the Kyoto Protocol.

Among the large scale emitters the US and Australia have not ratified the protocol. However different incentives have emerged in some US States[8] resembling to some extent the EU system for emissions trading – and voluntary agreements on the reduction of CO2 emissions have been agreed by some US utilities (see for instance Point Carbon newsletter 2006-01-27).

Also the US and Australia are parties to the Asia Pacific Partnership on Clean Development and Climate[9]. The purpose of the new partnership is among others to *"develop, deploy and transfer cleaner, more efficient technologies and to meet national pollution reduction, energy security and climate change concerns, consistent with the principles of the U.N. Framework Convention on Climate Change (UNFCCC)"* (Asia Pacific Vision Statement, January 2006)[10].

By 2008-2012 the Kyoto protocol requires its industrialised parties to reduce their green house gas emissions by approx. 5 % (individual targets) compared to the 1990-level. Deployment of renewable energy technologies together with energy savings, energy efficiency and fuel switch measures (e.g. from coal to gas), will be key to achieve this objective.

The protocol also includes three international mechanisms, called flexible mechanisms, which aim to make it more cost-efficient for developed countries to reach the targets of the Kyoto Protocol.

Two of these mechanisms are intended to promote investment either in developing countries (through the Clean Development Mechanism), or in countries undergoing the transition to a market economy (through Joint Implementation). The third mechanism, emission trading, allows one country to sell parts of its emission quota to another country.

Through the flexible mechanisms the Kyoto-protocol provides global incentives for renewable energy deployment. Indeed many of the projects and methodologies, which have been proposed for the Clean Development Mechanism concern renewable energy technologies (UNEP 2006).

However, given the scheme's focus on cost efficiency, the international CO2 regulation will in particular provide incentives to renewable energy technologies, which are close to being competitive with conventional fossil fuel technologies. It will hardly act as catalyst for the development of more immature technologies.

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[8] See for instance the website of the Clean Energy States Alliance, www.cleanenergystates.org, 24-02-2006

[9] The Asia Pacific Partnership on Clean Development and Climate consists of Australia, China, India, Japan, the Republic of Korea and the United States.

[10] For further information on the visions of the Asia Pacific Partnership, please see http://www.dfat.gov.au/environment/climate/050728_final_vision_statement.html (22-02-2006).

With the adoption of the directive on emission trading in 2003, the responsibility for meeting the CO2 targets in the EU has to some extent been passed over to energy producers and energy intensive companies[11]. In a quota based system economic theory tells that the cost of emitting CO2 will be passed onto the cost of producing heat and electricity. In other words the EU ETS system means that the CO2 externality costs are (to some extent) internalised in heat and electricity prices.

In liberalised market the price increase will correspond to the CO2 costs of the marginal plant in each time segment[12]. This price increase will of course make it more attractive for energy producers to invest in renewable energy technologies.

A further implication of emissions trading between companies is that an EU country supporting deployment of renewable energy technologies (heat and electricity) will not benefit directly from reduced CO2 emissions in its Kyoto account. The reason for this is that the EU ETS in reality transfers the responsibility from the governments to the market players. Though new government supported renewable energy plants will reduce emissions from fossil fired power plants in that same country, the energy producers' emissions are fixed by a cap (settled by a national allocation plan). When a given power plant reduces its emissions, it will only allow the plant owner to sell surplus quotas to other companies covered by the scheme. This circumstance may reduce the incentives for governments to support renewable energy.

Also this change of responsibility means that players in the energy markets will become (even) more important than previously for developing and deploying renewable energy. The initiative is to a higher and higher extent left to the market players and measures and incentives should reflect this. Also it is important that supporting schemes for renewable energy are harmonised with international CO2 regulation.

Globalisation

Globalisation is a term often used to describe the changes in societies and the world economy that result from dramatically increased international trade and cultural exchange.

The OECD has produced a working definition of globalisation: *" Globalisation" is the growth, or more precisely the accelerated growth, of economic activity across national and regional political boundaries. It finds its expression in the increased movement of tangible and intangible goods and services, including ownership rights, via trade and investment, and often of people via migration. It can be and is often facilitated by a lowering of government impediments to that movement, and/or by technological progress, notably in transport and communications."* (Oman 1996, p.5) More broadly, globalisation is often referred to as the general integration, and resulting increase in interdependence between global actors (politically, economically etc.).

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[11] The EU emissions scheme started up already in 2005 and is planned to run during as well as after the first Kyoto-commitment period, 2008-2012. These companies are subject to a CO2 cap and trade system, covering over 11,500 energy-intensive installations across the EU and representing close to half of Europe's emissions of CO2. The installations include combustion plants, oil refineries, coke ovens, iron and steel plants, and factories producing cement, glass, lime, brick, ceramics, pulp and paper (EU Commission website).

[12] During the last 10 months CO2 quotas in the EU ETS have been traded at price of approx. 20-25 €/ton (a little higher the last two months). Assuming, for instance, that the marginal power plant is coal based and the electric efficiency some 40 %, the cost of electricity is due to increase by approximately 20 €/MWh (0.35 ton/MWh*22.5 €/ton*2.5).

In connection with renewable energy deployment globalisation offers barriers as well as opportunities.

On the one hand global competition between companies makes it important for governments to secure globally competitive energy prices for their national industries. This may be impediment to the deployment of renewable energy technologies, because these are generally more expensive than conventional fossil fuel technologies when externalities are not taken into account.

On the other hand globalisation opens up large markets for deployment of renewable energy in developed as well as developing countries. This will reduce the costs of technologies and provide benefits of economies of scale as international standards are developed for the different renewable energy technologies.

Furthermore global markets reduce the risks to renewable energy manufacturers because they are not dependent on market conditions in one region or country (Neuhoff 2005: 101). However, if the benefits from globalisation are to be fully exploited international solutions and cooperation will be needed within the context of renewable energy.

4 Renewable energy technologies

Renewable energy covers a wide range of different technologies used for variety of purposes: solar cells for pocket calculators, fuel wood for food preparation in Africa and off-shore wind power facilities for electricity generation and so on. Some produce heat others electricity (or combined heat and power) and some again bio-fuels for the transport sector. Some are incorporated into existing products, such as building-integrated PV-systems, where as others are separate installations.

The purpose of this chapter is to provide a brief status of the different renewable energy technologies that are available. Are the technologies fully matured? What are their costs? What are their developing potentials? How big are their resource potentials?

It is obvious that barriers, opportunities and challenges are not the same for all renewable energy technologies. Some are very specific to renewable technologies that produce electricity and heat, some to small-scale technologies and others to technologies which are traded on international markets etc.

Furthermore it is important to bear in mind that the focus of this study is on barriers to renewable energy *deployment*. Many renewable energy technologies have not (yet) matured technologically and economically to a point where deployment is relevant. For these technologies barriers are often more technology specific. The status for the different renewable energy technologies provided in this chapter will give a basis for pointing out, which barriers and which areas of action are more relevant for the different renewable energy technologies.

4.1 Status for the utilization of renewable energy

In 2004 new renewable technologies (that is excluding traditional biomass use for heating and cooking and large scale hydro) made up approx. 2 % of total global primary energy consumption (Martinot 2005).

This may not sound of much, but in some countries and markets renewable energy penetration is high:

- In Brazil almost as much biofuel (ethanol) as gasoline is used for automobile fuel
- In 2004 global wind power capacity increased to 47.3 GW. More than 70 % of the total wind power capacity was installed in only four countries: Germany, the United States, Spain and Denmark. In Denmark wind power makes up approx. 20 % of electricity consumption.
- By the end of 2005 total photovoltaic power capacity had grown to more than 5 GW. The capacity is concentrated in a Japan, Germany and the United States, who accounted for 86 % of the total capacity in 2002.
- In Israel there is close to 1 m2 of solar water heating capacity per person.
- In Sweden biomass supplies more than 50 % of district heating needs and in Finland 11 % of the total electricity generation is based on biomass.

If countries learn from each other and best available practices are spread the utilization of renewable energy technologies may increase considerably.

Statistics show that renewable energy utilization is already growing rapidly. In the five year period from 2000 to 2004 grid-connected solar PV has increased by 60 % per annum on average, wind power by 28 %,, biodiesel 25 %, solar hot water/heating 17 %, off-grid PV 17 %, geothermal heat capacity 13 % and ethanol 11 % (Martinot 2005: 7).

Table 4 supplies an overview of the utilization of renewable energy technologies by the end of 2004.

Indicator	Existing Capacity End of 2004	Comparison Indicators
Power generation	**(GW)**	
Large hydropower	720	World electric power capacity=3,800
Small hydropower	61	
Wind turbines	48	
Biomass power	39	
Geothermal power	8.9	
Solar PV, off-grid	2.2	
Solar PV, grid-connected	1.8	
Solar thermal power	0.4	
Ocean (tidal) power	0.3	
Total renewable power capacity (excluding large hydropower)	160	
Hot water/space heating	**(GWth)**	
Biomass heating	220	
Solar collectors for hot water/heating (glazed)	77	
Geothermal direct heating	13	
Geothermal heat pumps	15	
Households with solar hot water	40 million	Total households world-wide=1,600 million
Buildings with geothermal heat pumps	2 million	
Transport fuels	**(liters/yr)**	
Ethanol production	31 billion	Total gasoline production=1,200 billion
Biodiesel production	2.2 billion	
Rural (off-grid) energy		
Household-scale biogas digesters	16 million	Total households off-grid=360 million
Small-scale biomass gasifiers	n/a	
Household-scale solar PV systems	2 million	
Solar cookers	1 million	

Table 4: Renewable energy indicators (from Martinot, 2005: 7).

4.2 From research to market deployment

Some renewable energy technologies are at the beginning of the learning curve whereas others are commercial technologies, which are mass-produced. The purpose of this sub-chapter is to briefly explain the process of developing RE technologies and the different needs for support during these processes.

According to Skytte et al. (2004: 85) it can be fruitful to consider the technological development process of new energy technologies to take place in four different phases. These are pioneer, introduction, market and competition (summarised in Table 5)[13].

Phases	Description
Pioneer	The technology emerges as an independent technology. This phase is characterised by a small number of companies developing the technology primarily through radical innovations. The first barrier is to create a workable and reliable product. The greatest risk is technological.
Introduction	Introduction of the product on markets (most often niche markets). Known technology – many companies. Innovation becomes incremental. The greatest risk is financial.
Market	The technology has become reliable and standardised and established on the market. Competition has resulted in a smaller amount of companies. The greatest risk for investors is the market risk – i.e. achieving sufficient market share.
Competition	The product is mature and has the opportunity of competing on equal terms with conventional technologies. Few companies.

Table 5: Phases of the technological development process for RE technologies. For a more thorough description of the four phases see Skytte et al. (2004:85-91).

In each phase the technologies will have different needs for public support. Generally a distinction can be made between two types of support; technology *push* support and demand *pull* support. In the first phases, particularly in the pioneer phase, the technology push support is most important. This involves R&D for finding the right technology concept (basic research), support for demonstration plants (applied research) as well as so-called Triple Helix initiatives which support networking between industry, research institutions and authorities to create synergies in product and process innovation (Skytte et al. 2004: 81-82, see also Foxon et al., 2005: 2125).

In the later phases the market pull becomes the more important. In these phases innovation increasingly takes place incrementally and cost reduction is stimulated by learning-by-doing and learning-by-using processes. Market pull can take place as price or investment support or by establishing separate markets for new technologies, for example by RE certificate markets or through tendering procedures. In addition to these support forms the conditions for establishing new plants are important, this involves physical planning, and grid connection conditions (Skytte et al., 2004: 99-100).

One may criticise the approach of Skytte et al. for assuming that RE technologies must eventually become competitive with conventional technologies. Their model somewhat ignores that some RE technologies could be fully matured and industrialised, but still would require separate markets or subsidies to be able to compete with the conventional technologies (and that politicians may choose to support them in spite of this for security of supply or environmental reasons).

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[13] Foxon et al (2005) work with five stages of commercial maturity of renewable energy technologies: 1) basic and applied R&D, 2) Demonstration 3) Pre-commercial 4) Supported commercial 5) Commercial. Though the terms are different, the steps, which are described by Foxon, are very similar to those of Skytte et al (2004). The work by Foxon is based on a study undertaken for UK Department of Trade and Industry in 2003.

	Research and development (Technology push)			Market development (Demand pull)			Structural integration	
	Basic research	Applied research	Triple Helix[14]	Investment support	Price support	Separate markets[15]	Physical planning	Connection conditions
Pioneer	***	***	*	**	*	-	*	*
Introduction	**	**	***	***	**	*	**	**
Market	*	*	**	*	***	***	***	***
Competition	*	*	-	-	-	*	*	*

Table 6: Effect of support measures and plant conditions in the different phases (see Skytte et al., 2004: 99).

Table 6 shows how Skytte et al see the importance of the different support types in the different phases of technological development. Three stars refer to a great effect of support, two to a moderate effect and one to a little effect – a minus refers to an insignificant effect.

One may argue to the table that the structural integration may also play a great role in the dissemination of renewable energy technologies even in the final stage of technological development where they are assumed to be competitive with traditional technologies (competition phase). Dissemination of the wind power technology for instance is totally dependent on adequate planning framework, where potential conflicts of interests are handled. This is regardless of the plants' economic performances.

4.3 Renewable energy technology status

It is not the purpose of this report to go into detail with all renewable energy technologies. However it is useful to include a short status for the most important renewable energy technologies regarding technology development, resource potentials and economic performance.

Figure 1 gives a rough indication of how far different renewable energy technologies (or more precisely technology groups) have progressed using the terminology developed by Skytte et al. (2004).

It should be recognised that some technologies for instance photovoltaics cover a lot of different technologies and concepts. Photovoltaics include crystalline silicon technologies (single- and multi-crystalline) which are reliable commercial technologies that are mass produced and available for the market, as well thin film technologies and so-called third generation technologies like polymer and photo-electro chemical (PEC) cells, which are still being researched.

Many ocean power technologies are still at the pilot level, where basic and applied research (according to theory) are key elements to drive development further. New concepts are still being developed within these groups of technologies, because researchers and developers have not (yet) come-up with definitive solutions to intrinsic problems.

Other technologies like biomass gasification have developed to the introduction stage where triple-helix initiatives and support for niche markets are important.

[14] Triple Helix: when industries, research institutions and authorities work dynamically together in order to generate synergies.

[15] Such as renewable energy certificate markets.

Yet other technologies have developed to a level where they are reliable and established on the market. Depending on the resource potentials available some of these technologies like small-scale hydro power (in Norway) and geothermal power (in Iceland) are even competitive with conventional technologies, whereas for instance wind power and solar technologies need support in most markets to be competitive.

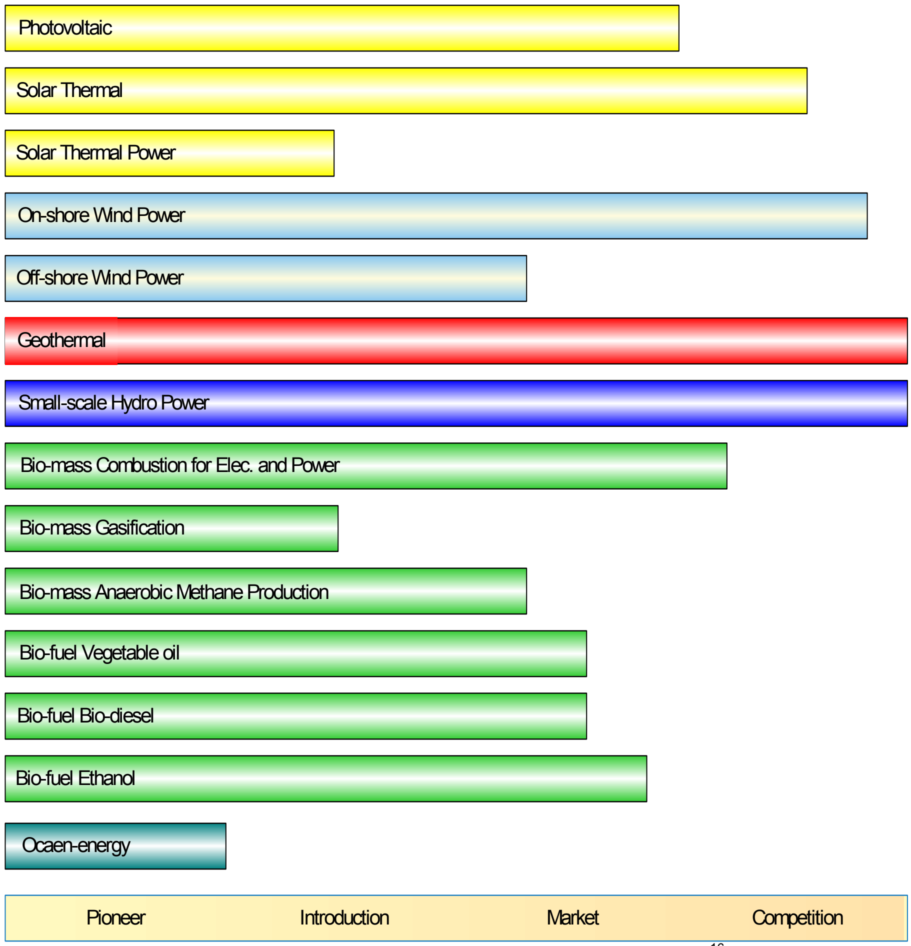

Figure 4: Development of renewable energy technologies – rough indication! [16]

In Table 7 the global resource potential from different renewable energy resources is outlined. The appraisal of the technical potential takes into account engineering and technological criteria.

For comparison the total global energy demand was approx. 425 Exajoules in 2002. It appears that the total technical potential of different forms of renewable energy exceed the current energy demand by manifolds.

[16] Developed by EA Energy Analyses on information from Martinot (2005) *Renewables 2005 – Global status report*, Skytte et al. (2004): *Support for renewable energy?*, IEA (2003) (*Renewable energy into the mainstream*) IEA, 2003 (*Renewables for power generation*) Beijing 2005 (*Increasing Global Renewable Energy Market Share: Recent Trends and Perspectives*.

In should be mentioned in this regard however, that renewable energy sources are not spread evenly on a global scale. Some regions may in surplus of renewable energy potential whereas others are in deficit.

Resource	Current use[a]	Technical potential	Theoretical potential
Hydropower	10.0	50	150
Biomass energy	50.0	>250	2,900
Solar energy	0.2	>1,600	3,900,000
Wind energy	0.2	600	6,000
Geothermal energy	2.0	5,000	140,000,000
Ocean energy	-	-	7,400
TOTAL	**62.4**	**>7,500**	**>143,000,000**

a. The current use of secondary energy carriers (electricity, heat and fuels) is converted to primary energy using conversion factors involved.

Table 7: Global renewable resource base (Exajoules per year) (Johansson et al, 2004).

Figure 5 shows the long-run marginal costs (LRMC) of electricity production for different renewable technologies. The cost-range indicates that generation cost depend on the resource conditions in different countries or regions (in this case the EU member states).

For many technologies the cost-range estimates are quite large and therefore it is difficult to make any definitive conclusion regarding which technologies are the most economic. This to a high degree depends on the resources available.

Nevertheless a conclusion can be made that ocean and solar technologies are still relative costly whereas wind, biomass and hydro power technologies are all close to being competitive with conventional generation technologies where the resources potential is good.

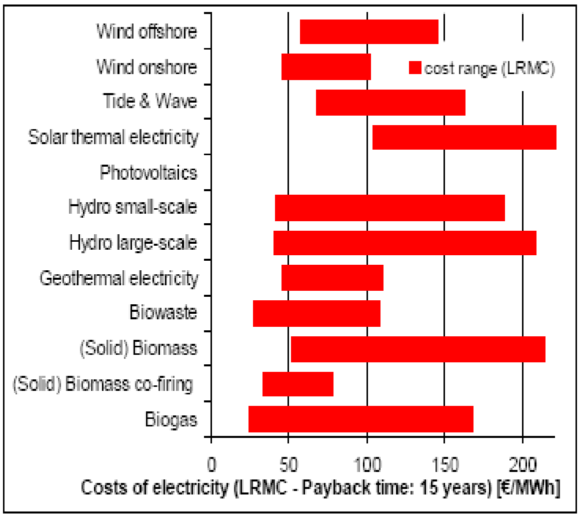

Figure 5: Cost of renewable energy technologies generation electricity (EU 2005: 24, renewable energy Comm.). For comparison the long-run marginal cost of new coal fired plant is approx. 35 €/MWh.[17]

[17] Solar PV is not included in the figure because its costs according to the communication from the EU is not within the indicated cost range (0-200 €/MWh) in a European context. According to the IEA (2006) the generation cost of

Annex II includes a more comprehensive description of the various renewable energy technologies.

PV may however in some countries, where the solar resource is great, come down to some 200 $/MWh – corresponding to approx. 160 €/MWh with the current exchange rate (1$=0,81€, 2006-04-04).

5 Barriers and opportunities for renewable energy

Based on the literature study it is the purpose of this chapter to identify barriers and opportunities for the further deployment of renewable energy technologies.

In the context of this study, only barriers that may be overcome by human actions are examined. That a specific technology is intrinsically not competitive is not in this study considered a relevant barrrier to its deployment. Similarly, barriers related to the lack of natural resources (no wind, no sun, no waves, no biomass etc.) in some regions of the world are not considered as relevant barriers in this study either.

It is the intention that the information provided in this chapter can form a basis for prioritising, which barriers and opportunities are the most relevant to deal with in the RETD context.

In order to facilitate the prioritising of barriers and opportunities three criteria of relevance are examined in this chapter:

1) Are the barriers cross-cutting from a technology point of view? Barriers that are very technology specific are of less importance for the RETD agreement, because such barriers are dealt with through the relevant RE technology Implementing Agreements.
2) Do the barriers pose a problem in several countries? Barriers that are specific to very few countries are of less relevance.
3) Will international cooperation make a difference to better overcome the barriers? The main focus of the RETD is on barriers that can be overcome through international collaboration on policies and business strategies

It is the intention that the barriers and opportunities identified in this chapter should provide a basis for identifying relevant activities to initiate within the framework of the RETD (see Chapter 6).

5.1 Identification of barriers

The following barriers to renewable energy deployment are dealt with in this chapter:

- There is not a level playing field for renewable energy technologies
    - Subsidies for conventional technologies
    - Externalities are not internalised in energy/fuel prices
- The incentives for governments and private companies to support renewable energy development are insufficient
- Financing is unreasonably costly for renewable energy technologies
- Technology standards are lacking for renewable energy technologies and fuels
- Import tariffs and technical barriers impede trade in renewables
- Permits for new renewable energy plants are difficult to obtain
    - Approval procedures are lengthy and troublesome
    - Lack of spatial planning for renewable energy
- Energy markets are not prepared for renewable energy
    - Integration of intermittent energy sources
    - Grid connection and access is not fairly provided
    - Other markets imperfections in energy markets
- Renewable energy skills and awareness is insufficient
    - Lack of knowledge and acceptance
    - Lack of training and education

In addition to the general description of the barriers the following questions are answered for each barrier category: Which stakeholders are important to deal with this barrier? Which renewable energy technologies face this barrier? Which countries face this barrier? And finally, will there be benefits of international cooperation to break down the barrier?

5.2 There is no level playing field for renewable energy technologies

Establishing a *level playing field* for renewable energy can be one of the strongest drivers for further deployment of RE technologies.

Providing a level playing field not only concerns the pricing of renewable energy technologies and competing technologies (fossil fuel and nuclear) but also trade barriers, and technical and administrative impediments and the provision of training and education, and accounting for all the benefits provided from RE (etc.).

In this chapter however the focus is on subsidies and external costs for conventional energies. Sub-chapters 5.6 and 5.7 will deal with the technical and administrative issues etc. that also are important to tackle in order to establish a level playing field for renewable energy.

Subsidies for conventional energy technologies

Direct and indirect financial support ("subsidies") to promote conventional energy supply skew the playing field against renewable sources of energy. This is a topic, which has been addressed in a variety of different papers and publications addressing barrriers to renewable energy technologies (see for example Beijing 2005, p. 10, STOA 2003: 60). Also energy subsidies may lead to generally lower energy prices for consumers (depending on how they are financed), thus masking the true energy price and inspiring higher energy use.

The WTO has defined energy subsidies as (i) a financial contribution (ii) by a government or any public body within the territory of a Member (iii) which confers a benefit. All three conditions must be satisfied in order for a subsidy to exist (referred by Pershing and Mackenzie 2004; 2).

According to the report "Removing subsidies – levelling the playing field for renewable energy technologies", by Pershing and Mackenzie, which was prepared for the renewable energy conference in Bonn in 2004, global subsidies for oil, coal gas and nuclear power total *"in the tens of billions of dollars annually. Subsidies take a variety of forms, including direct support to consumers, direct payments to investors in large and capital intensive projects, tax exemptions, price caps or ceilings and more subtle and indirect forms such as transmission grid support, regulatory hurdles for small and distributed power and agreements on formulas for risk calculation that emphasize volume of electricity rather than the security of fuel inputs."*(Pershing and Mackenzie, 2004: 3). Subsidies rarely benefit distributed technologies, but rather large scale technologies like hydro power dams and oil refineries (Pershing and Mackenzie, 2004: 4)

Similarly the European Environment Agency in 2004 synthesised data from a range of sources to estimate the size of support to the energy sector within the EU 15. Total subsidies (excluding external costs) were here estimated to be in the order of EUR 29 billion in 2001 for the electricity only. Approx. EUR 5.3 billion were allocated to renewable energy sources – and the remainder to fossil fuels (EUR 21.7 billion) and nuclear power (EUR 2.2 billion) (EEA 2004, Energy subsidies in the European Union – a brief overview, p. 14).

However, the rationales for adopting subsidies are manifold (see below) and similarly their consequences and the ways to reduce them are complex.

Pershing and Mackenzie (2004) has identified the following rationales for energy subsidies

- Protecting domestic industry and promoting jobs at home
- Reducing imports and improving national security
- Managing risk
- Making energy more affordable for specific social groups
- Protecting the environment.

According to the report "Increasing Global Renewable Energy Market Share" prepared for the Beijing International Renewable Energy Conference 2005, (Beijing, 2005:34) several countries have begun to reduce/eliminate fossil fuel subsidies. For example Germany is planning to reduce its coal subsidies after 2008.

Externalities are not internalised in energy/fuel prices

According to many economists the most economically sound approach to improve markets for renewable energy technologies lies in the "internalizing" of externalities. This means that price signals are provided to value damages caused by different technologies/fuels. This could be climate change costs, health impacts from dust and NOx emissions, costs of acid rain (corrosion of buildings, acidification of lakes…), visual impacts etc.

Within the international research project ExternE[18], the externalities associated with electricity production have been estimated. The study has proven that the cost of producing electricity from coal or oil would approximately double and the cost of electricity production from gas would increase by some 30% if external costs were taken into account.

Further details are given in the table below. Since externalities are site and plant specific they vary from country to country.

External cost figures for electricity production in the EU for existing technologies[1] (in € cent per kWh*)

Country	Coal & lignite	Peat	Oil	Gas	Nuclear	Biomass	Hydro	PV	Wind
AT				1-3		2-3	0.1		
BE	4-15			1-2	0.5				
DE	3-6		5-8	1-2	0.2	3		0.6	0.05
DK	4-7			2-3		1			0.1
ES	5-8			1-2		3-5**			0.2
FI	2-4	2-5				1			
FR	7-10		8-11	2-4	0.3	1	1		
GR	5-8		3-5	1		0-0.8	1		0.25
IE	6-8	3-4							
IT			3-6	2-3			0.3		
NL	3-4			1-2	0.7	0.5			
NO				1-2		0.2	0.2		0-0.25
PT	4-7			1-2		1-2	0.03		
SE	2-4					0.3	0-0.7		
UK	4-7		3-5	1-2	0.25	1			0.15

* sub-total of quantifiable externalities (such as global warming, public health, occupational health, material damage)
** biomass co-fired with lignites

Table 8: External costs for electricity production in the EU (in cent/kWh, PV = photovoltaics) (EU Commission 2003: External cost).

[18] ExternE is sponsored by the EU Commission. Researchers have participated from all EU member states and the United States of America. Further information on methodologies, result etc. can be found on the ExternE website: www.externe.info, 27-02-2006.

According to Pershing and Mackenzie (2004: 16) price signals to internalise externalities may be "*explicit (in the form of new taxes, user fees or surcharges), or implicit (e.g. in the form of caps on use). If designed in a sufficiently flexible manner, these tools can allow the market to implement the desired outcomes at the lowest cost"*.

One of the main barriers to an increased application of environmental taxes may be that governments are reluctant to introduce taxes on their domestic industries because (they fear that) the taxes will decrease competitiveness of the industry (se also STOA 2003: 72).

Opportunities

The following (general) opportunities will be relevant to pursue in the effort to dealing with the above mentioned barriers:

- International cooperation between governments on phasing out subsidies.
- International cooperation between governments on best/good practice for subsidies.
- International cooperation between governments on internalisation of externalities.

At present many adverse effects of energy use are not included in energy prices, although examples of good practice exist. As put by Beck and Martinot (2004:5), *"although environmental impacts and associated dollar costs are often included in economic comparisons between renewable and conventional energy, investors rarely include such environmental costs in the bottom line used to make decisions"*. One example of good practice is the EU emissions trading scheme, which is a cap and trade system, dealing with CO2 emissions from energy intensive installations. The system basically raises energy prices by the costs of the CO2 quotas, thereby benefiting the competitiveness of renewable energy technologies compared to fossil fuel technologies.

Also fossil fuel taxes are applied in many countries. According to the IEA database Renewable Energy Policies & Measures (http://library.iea.org/dbtw-wpd/textbase/pamsdb/re_webquery.htm, 02-02-2006) 19 countries within the IEA have applied fossil fuel taxes in some form.

Pershing and Mackenzie (2004) include the following main recommendations for a possible subsidy reform:

- *"create targeted, soundly based incentives that are practical, transparent, predictable and promote market competition.*
- *aim at all aspects of the system – including technical barriers, market impediments, administrative barriers and social and environmental constraints."*

Furthermore the report emphasises, that *"Internationally coordinated action can facilitate the process of removing environmentally damaging subsidies. However, unilateral actions may still be appropriate in the absence of international agreements.".* (Pershing and Mackenzie, 2004: 19).

The rationales for energy subsides are numerous. Often however protection of national industries is a key concern and therefore international cooperation is important (agreements of reciprocity) if energy subsidies are to be reduced. Also international cooperation on best practice is relevant since often energy subsidies are not the most effective means to achieve specific a policy goal (for example energy subsidies are sometimes used as a means to assist specific social groups though other measures such as income taxation might be more appropriate).

Similarly governments are often reluctant to introduce environmental taxes on energy products because they want to protect their national industry. International cooperation (mutual agreements) is therefore important to achieve progress on this issue. Through the United Nationals Climate Change Convention negotiations and actions are already taking place with regard to greenhouse gases. It may be relevant to initiate a similar cooperation on other substances (to the extent such initiatives have not been taken already).

Questions to be addressed

Which stakeholders are important to deal with these barriers?
National governments and international forums for cooperation (UN, EU, IEA, G8).

Which renewable energy technologies face these barriers?
Subsidies and lack of internalisation of externalities are principle problems to the development of all renewable energy technologies, although primarily to the technologies which are in phase of commercialisation/marketing (including many biomass technologies, wind power and solar technologies).

Which countries face these barriers?
These are general problems to many countries. However, the development of a carbon framework, for instance in the EU, provides an important contribution to deal with the issue of externalities.

Will there be benefits of international cooperation?
As discussed above international cooperation may be very important to phase out subsidies and to reach international agreements on pricing environmental externalities.

5.3 The incentives for governments and private companies to support renewable energy technology development are insufficient

Within a short time horizon renewable energy technologies may appear costly compared to conventional technologies. However, as experience accumulates costs are expected to decrease and depending on the framework conditions, for instance the costs of emitting CO2, and the development in fuel prices, they may eventually break even with fossil fuel technologies.

Case studies for various technologies and industries have shown that technologies exhibit a “learning ratio” that usually stays constant for a technology for large periods of time. This learning ratio is calculated by comparing production costs of a technology each time there is a doubling of manufacturing capacity. Typical learning ratios for energy technologies are between 10% and 20%. Therefore, each time installed capacity of a technology is doubled, the costs of energy produced with the technology fall by between 10% and 20%[19]. The concept of learning ratio is a heuristic concept, which does not identify the specific aspect where the improvement was or might be achieved, but observes that costs fall as experience with a technology is fed back into the manufacturing process and in research in better technology, operation, installation and maintenance (Neuhoff and Sellers, 2005; IEA 2000).

The cost curve in Figure 6 illustrates how technology learning through market experience may over time overcome the cost barriers and lead to profitable investments. Initially there is a need for support for the renewable energy technologies but following a certain period

[19] Further information about the theory of learning curves and empirical documentation may be found in the IEA report *Experience Curves for Energy Technology Policy* (IEA 2000).

renewable energy technologies are expected to generate a surplus compared to existing technologies.

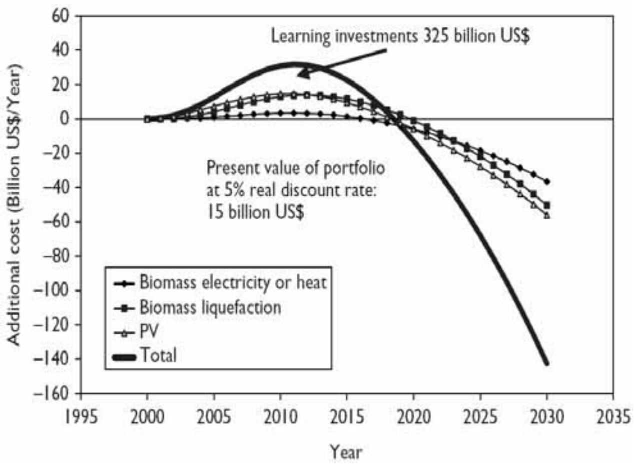

Figure 6: Additional annual costs for a portfolio of biomass and PV technologies (IEA 2000: 81, Experience Curves for Energy Technology Policy).

Individual companies and governments may however have incentives to free-ride and wait for other stakeholders to bring the technological development further.

Private companies cannot appropriate all the benefits of their innovation, product and process improvement. Therefore, it is widely accepted that governments need to support RD&D.

Similarly Barreto and Klaassen (2004) (p. 74) suggest that so-called learning spill-over could also result in a lack of incentives for individual countries to pay for the 'learning investments', because other countries could be free riding. It is not clear to what extent technology 'spill-over' prevents public investment into energy technologies. A strong motivation for national technology support programmes could be the benefits for national industry, especially as early adopters expect that early support will move their national industries into a leading position on international markets[20] (Neuhoff and Sellers, 2005). Concerning deployment, also the benefits to security of supply and environmental issues may prompt governments to support renewable energy (cf. chapter 3.1)

The above suggests that we need to align national interests with global interests. The example of the EU renewables objective offers some insights. Member states are committed to increasing the share of renewable technologies in their electricity supply by about 10 percentage points between 2003 and 2010 (to 21% by 2010) http://europa.eu.int/comm/energy/res/legislation/index_en.htm)[21]. While the process of coming to this agreement was difficult and the level of compliance and possible sanctions

[20] And in fact there is a barrier here too since there is no longer any such guarantee as 'national industries'. Governments may sink large funds into early mover advantages only to see the rewards moving elsewhere once the technology is developed.

[21] In this regard it should be mentioned the European Commission, according to the recent Green Paper "A European Strategy for Sustainable, Competitive and Secure Energy", will bring forward a Renewable Energy Road Map including *"consideration of which targets or objectives beyond 2010 are necessary, and the nature of such targets, in order to provide long term certainty for industry and investors"*.

are still being debated, the commitment was a driving force for the implementation and continuation of national support programmes (Neuhoff and Sellers, 2005).

Opportunities

The following (general) opportunities will be relevant to pursue in the effort to dealing with the above mentioned barriers:

- International agreements committing governments to demonstrate and deploy renewable energy technologies, including for example establishing international technology clubs for the promotion of specific technologies
- Establishing international (multilateral) funds for RE deployment and demonstration, including entering partnerships with RE industry and developers, and international financing institutions.

National politicians or administrations will be more successful in pursuing strategic deployment programmes if these programmes are consistent, with similar initiatives in other countries.[22] A joint public declaration or non-committing statement made by the Johannesburg Renewable Energy Coalition, the G-8[23], or any similar institution could express support for stretching targets for increases in research and development budgets or strategic deployment funding. This could provide a reference point for national policy debate and focus the attention of national administrations on energy technology policy (Seller and Neuhoff, 2005).

An international agreement that supports the strategic deployment of several renewable energy technologies would have the advantage that the nationally championed technology of each country could be included. This is likely to increase the number of participating countries. However, it would require a lengthy international process to foster such an agreement, as demonstrated by negotiations of the Kyoto Protocol (Neuhoff and Sellers, 2005).

Rather than fostering a broad agreement among many countries, one might consider developing ‘clubs’ of countries that support a new energy technology. A club of countries already covers a larger fraction of global population and industry than a single country. If the members decide jointly on their technology support programmes, they will internalise more of the positive externality and hence provide stronger support than if they were to make individually optimal decisions. This would be particularly successful if such a group of countries already represent a large fraction of the global natural resource-base for a technology, e.g. occupying the coastline with strong tidal streams. Another motivation for the formation of such a club could be that its members can capture a large share of the human, technological and financial resources required to advance a specific new energy technology (Neuhoff and Sellers, 2005).

For example, the Concentrating Solar Power Global Market Initiative (GMI) of several European, North American and North African countries aims at deploying 5GW of solar concentration in the next 10 years. Global commitment of sharing the learning costs of different technologies among countries by agreeing national targets on capacity and R&D budgets could be also an interesting approach.

[22] Barreto and Klaassen (2004) suggest forging sound international co-operation on research, development, demonstration and deployment activities for technologies that could contribute to mitigate greenhouse gas emissions.

[23] The G8 Renewable Energy Task Force (G8, 2001) provided a comprehensive set of policy recommendations.

A key question is whether governments will support international support programmes without knowing if the industry in their own country will benefit from the programme? In other words, how may a support programme be established ensuring that all countries get their share – and without compromising the efficiency of the scheme?

Questions to be addressed

Which stakeholders are important to deal with these barriers?
National, regional and local authorities, international forums for cooperation (IEA, G8), RE industry, international financing institutions.

Will there be benefits of international cooperation?
As discussed international cooperation and mutual agreements of reciprocity can be very important to provide the needed investments in renewable energy and to deal with the above mentioned free-rider problems.

Which renewable energy technologies face these barriers?
These barriers are general to all renewable energy technologies and to technologies at different technological levels.

Which countries face these barriers?
These barriers are general to all countries - particularly to small countries where the relative spill-over may be bigger.

5.4 Financing is unreasonably costly for renewable energy technologies

Compared to conventional fossil fuel technologies, renewable energy projects are generally more capital cost-intensive. Therefore weak capital markets not only create a problem of access to finance but also skew investment towards fossil fuel-based technologies. As explained in a recent report (Beijing 2005: 43) high interest rates, short maturities, and low debt-to equity gearing requirements increase the cost of renewable energy relative to conventional power.

Another barrier concerns lack of experience with renewable energy financing. Because *"financiers are typically averse to things that are new, the differences between RE and conventional energy systems and the risk perceptions they imply can become the most significant barriers to investment, even for RE technologies that are cost-competitive with conventional energy-supply options"* (Sonntag-O'Brien & Usher 2004: 2). Sonntag-O'Brien and Usher argue that financiers, as renewable energy technologies, must travel up a learning or experience curve.

Similarly in regulated markets special financing problems may exist if renewable energy generators are dependent on the goodwill of the dominating utility to finance their project: *"In some countries, power project developers have difficulty obtaining bank financing because of uncertainty as to whether utilities will continue to honour long-term power purchase agreements to buy the power"* (Beck and Martinot, 2004).

An additional financing issue concerns transaction costs, which are often disproportionately high for most renewable energy projects due to their small-scale nature. As stated by Sonntag-O'Brien & Usher (2004: 6), any *"investment requires initial feasibility and due-diligence work and the costs for this work do not vary significantly with project size. As a result, pre-investment costs, including legal and engineering fees, consultants, and permitting costs have a proportionately higher impact on the transaction costs of RE* *projects."* Still, as noticed by Beck and Martinot (2004: 5), higher transaction costs are not necessarily an economic distortion in the same way as some other barriers, *"but simply make renewables more expensive. However, in practice some transaction costs may be unnecessarily high, for example, overly burdensome utility interconnection requirements and high utility fees for engineering reviews and inspection."*. Some of these issues may be related to other barriers, which will be addressed in this chapter such as authorisation and planning procedures (including spatial planning).

As described in chapter 3.2 carbon credits may provide a new source of financing for renewable energy. Until now, however only a relatively few renewable projects have been carried through using the flexible mechanisms of the Kyoto Protocol [reference], perhaps because approval procedures are relatively complex. An important dilemma is to ensure a high environmental integrity of carbon projects without making approval procedures too complex.

Opportunities

One of the advantages of renewable energy, which is often not taken into account by financers, is the hedging benefits to energy companies existing technology portfolio; *"In liberalising markets, where power producers are forced to assume the fossil-fuel pricing risk, their typical approach has been to lock in the fuel supply with futures contracts. A growing body of work, however, is finding that fixed-cost RE can effectively hedge fossil price risk by diversifying a producer's energy portfolio away from fossil fuels."* (Sonntag-O'Brien & Usher 2004: 2)[24].

Also, in order for renewable energies to expand it will become increasingly important to expand the catalogue of financing sources and instruments. As put in Beijing report on increasing the market share of renewable energy; *"More creative leveraging of public and private sector resources will be needed to meet the financing requirements of the renewable energy industry, including official development assistance, the Global Environment Facility, and carbon financing."* (Beijing 2005: 3).

The following (general) opportunities will be relevant to pursue in the effort to dealing with the above mentioned barriers:

- Favourable loans for renewable energy projects through national or international institutions. Public private partnerships can be key to facilitate such products.
- Cooperation on best practice for subsidies. Comparisons of PROs and CONs of different financial support schemes for renewable energy technology. Focus on interaction with other environmental regulation (for example the international CO2 regulation).
- Promote long-term power purchase agreements between consumers and RE generators/project developers so as to reduce risks for both parties.
- Initiatives to stimulate carbon financing of renewable energy projects (for instance by developing methodologies for CDM and JI projects).
- Training and education of financiers so as better to understand values and risks associated with renewable energy technologies.
- Agreements between governments and utilities on deployment of renewable energy

[24] More information on portfolio analyses can be obtained from the website of Shimon Awerbuch, the University of Sussex, who is one of leading experts on the field (see www.awerbuch.com).

Questions to be addressed

Which stakeholders are important to deal with these barriers?
International finance institutions, national governments, CDM –executive board, JI- advisory committee, Asia-Pacific Partnership on Clean Development and Climate, Energy producers, private financing institutions

Will there be benefits of international cooperation?
As renewable energy technologies to a higher and higher extent are promoted on international markets, international cooperation on financing becomes more important, particular incentives which are related to global financing mechanisms such as carbon financing.

International cooperation on benchmarking and identification of best practice national measures will also be beneficial.

Which renewable energy technologies face these barriers?
Most of the new renewable energy technologies have high capital cost and relatively low operating costs. This makes them exposed to financial barriers.

Though many financing issues are likely to be technology specific, some of the barriers described above, for example the "portfolio benefit" of renewable energy technologies or carbon financing, may have common solutions.

Which countries face these barriers?
Though financial markets and financiers experience with renewable energy technologies may differ from one country to another, most financing issues will be country cross-cutting.

5.5 Technology standards are lacking for renewable energy technologies and fuels

As renewable energy technologies are increasingly sold on global markets standardisation of equipment is becoming an ever more important issue. This includes *"Expansion of the national standardization and quality assurance framework to include renewable energy systems and service delivery, as well as development of local standards to harmonize with international standards."* (Beijing 2005: 58). Issues of standardisation may particularly be a need in emerging economies.

Standardisation is relevant to technologies as well as components. *"One core aspect for the success of the model in the PC industry was development of platform standards to ensure compatibility of components from different producers. Platforms share interchangeable components, allowing customers and suppliers to benefit from the same technical advances, and advances can diffuse through such a market more rapidly. This has facilitated competition and innovation in component markets even where platform monopolies have developed (e.g. 'Wintel': Microsoft Windows and Intel)."* (Neuhoff and Sellers, 2005).

As a concrete example of a standardisation problem Neuhoff (2005) points to wind turbine manufacturers who face difficulties because their power electronic equipment has to satisfy different requirements in many markets. According to Neuhoff (2005) inspiration can be found in the telecoms sector where standardisation has allowed transfer of mobile equipment between most markets.

In the report prepared for the Beijing conference on renewable energy in 2005 expanded equipment standardisation, and harmonisation across countries has specifically been pointed out as an one the areas, where international cooperation would be beneficial.

According to the Beijing report the WTO may be a key player, when in the definition of standards for renewable energy technologies and equipment: *"How WTO rules on technical standards require that states base their regulations on "international standards. Thus, international standard setting will have a very significant impact on the WTO-compatibility of renewable energy measures. This includes any international standards that define what is a renewable energy source, and norms of reliability, safety, etc. for renewable energy technologies and operations."* (Beijing 2005, adopted from Renewable Energy and International Law Project (see www.reeep.org)).

An issue which is related to equipments standards is equipment and contractor certification in order to ensure uniform quality of equipment and installation. *"Contractor licensing requirements ensure that contractors have the necessary experience and knowledge to properly install systems. Equipment certifications, ensure that equipment meets certain minimum standards of performance or safety."* Beck and Martinot (2004)[25]

Opportunities

The following opportunities will be relevant to pursue in the effort to dealing with the above mentioned barriers:

- Develop standards for renewable energy technologies, components and fuels
- Develop test facilities for renewable energy technologies

Developing standards requires close cooperation between industry and standardisation organisation. The technology specific implementing agreements of the IEA could play important parts by pointing out areas/technologies/components of interest for standardisation. The IEA RETD could lead negotiations and create synergies for several technologies.

Test station facilities could become important to find reliable concepts for new renewable energy technologies. In Denmark for example the Test Station for Wind Turbines, established by RISØ National Laboratory in 1978, played an important role for the approval and standardisation of wind power turbines (Skytte et al 2004: 125).

It should be noticed in this regards that development of standards includes a risk that certain products are wrongly excluded from the market. Entry of new technologies may be blocked by the established industry which has chosen a particular standard. Therefore standards themselves can become an obstacle to renewable energy technologies becoming fully market competitive.

[25] Many organisations are involved in the standardisation of renewable energy technologies. These include among others:

- "European Committee for Standardisation"". In current CEN-projects specifications for fatty acid methyl esters in diesel and for ethanol in gasoline are being developed. Projects are also running, which deal with renewables in buildings (See, www.cenorm.be)
- ISO. International Organization for Standardization (www.iso.org)
- US DOE is working to develop and implement practices and procedures that will ensure safety in operating, handling, and using hydrogen and hydrogen systems. In addition, DOE is working with domestic and international organizations to identify the current gaps in the standards development process; facilitate the creation and adoption of model building codes and equipment standards for hydrogen systems in commercial, residential, and transportation applications; and provide technical resources to harmonize the development of international standards (www.eere.energy.gov/hydrogenandfuelcells/codes/).
- International Solar Energy Society / German Section Deutsche Gesellschaft für Sonnenenergie e.V. (DGS) is working on Quality Assurance Standards and Guidelines for Solar Technology
- The European Solar Thermal Industry Federation (ESTIF) is working on Standardisation (Solar Keymark**)** see http://www.estif.org/

Questions to be addressed

Which stakeholders are important to deal with these barriers?
National and international standardisation organisations, RE industry, industry associations, International trade organisations (WTO, NAFTA etc).

Will there be benefits of international cooperation?
International cooperation on standards, and for example on testing facilities, could be very relevant.

Which renewable energy technologies face these barriers?
On the face of it, this barrier is general to all renewable energy technologies, but standards need to be established for individual technologies/fuel/components. In this sense the barrier is not necessarily very technology cross-cutting.

Which countries face these barriers?
The barrier is international.

5.6 Import tariffs and technical barriers impede trade in renewables

Many studies have stressed the importance of eliminating barriers to trade in renewable energy sources and the technologies used to exploit them.

In the working paper "Liberalisation of trade in renewable-energy products and associated goods: Charcoal, solar photovoltaic system, and wind pumps and turbines" the OECD (Steenblik, 2005) has examined the implications of liberalising trade in renewable energy, focussing on renewable fuels as well as technologies.

According to the OECD the global estimate of the value of trade in renewable energy and related technologies sums up to approx. USD 4 billion a year. However, because statistics on world trade in renewables are quite imprecise the figures are surrounded by a high degree of uncertainty. OECD countries clearly dominate exports of high-tech renewable energy technologies, but in renewable-energy fuels, and relatively low-tech devices, for example solar water heaters, developing countries and countries in transition are major players, both as users and exporters (Steenblik 2005: 9).

According to the same report tariffs on renewable energy and associated goods are 15 pct. or higher on an ad valorem basis in many developing countries: *"Regarding import tariffs, preliminary analysis suggests that applied tariffs on wood and charcoal exceeding 25% are fairly common among developing countries, even those that use a lot of wood or charcoal for domestic cooking[…] Most striking are the tariffs on solar water heaters, which surpass 25% in a number of countries - including those whose sunny climates or dispersed rural populations would seem to be conducive to deployment of the technology.*" (Steenblik 2005: 10). Tariffs on hydraulic turbines, parts for hydraulic turbines, wind-powered generating sets and solar cells do only exceed 15% in 10 or fewer countries for each of the technologies.

For comparison according to Steenblik (2004) most OECD countries apply low tariffs on **non-renewable** energy products (duty free or a few %) and also tariffs on non-renewable energy products are generally low in developing countries (5-10 %) though some countries apply tariffs of up to 30 %.

In addition to the tariff-issue, non-tariff trade barriers exist as well, which may hinder the trade of renewable energy goods. These concern (Steenblik, 2004):

- Technical barriers to trade, such as certification and testing that are not required by, or that favour, domestic manufacturers
- Behaviour of state trading enterprises
- Subsidies favouring domestic suppliers.
- Non-competitive public procurement, or worse (influence pedalling, bribery and corruption)

It appears that also certification and testing of renewable energy technologies and equipment is pointed as trading barrier of interest (cf. chapter 5.5)

Steenblik also raises the problem of renewable energy subsidies favouring domestic suppliers. The case here is that it is important to ensure that renewable energy is promoted in a trade-friendly way. According to Ralf Dickel, from the Energy Charter Secretariat 2004 concern has been raised about renewable energy policies and trade distortions, because current renewable policies according to Dickel (2004):

1. *Might distort trade in energy*
2. *Often aim at boosting domestic production and reducing imports*
3. *Often include some elements of discrimination*
4. *Run counter to the general trend of electricity market opening*

A critical issue is whether WTO law can be used to challenge policies and measures favouring renewable energy technologies. It is important that those applying and interpreting international trade law understand that renewable energy is different from fossils fuels, both in terms of environmental effects and with regard to the promotion of energy security (www.reeep.org).

Opportunities

The following opportunities will be relevant to pursue in the effort to dealing with the above mentioned barriers:

- International cooperation between governments and through international trade organisations on removing duties and technical barriers to trade on renewable energy products
- Cooperation between governments on support schemes for RE technologies, which are not discriminative

The REEEP partnership is currently doing a project on Renewable Energy and International Law (REIL). Part of the project concerns removing unintended barriers to renewable energy which exist in international law and to capture the opportunities for using international law to expand the market further (www.reeep.org). An example of a concrete opportunity involves the possibility of using the international trade law administered by the World Trade Organization to promote renewable energy. This could for instance be done by using the so-called “green box” whereby member countries identify renewable energy subsidies that the other parties agree to not to challenge because of their positive environmental effects.

It should also be noticed that other IEA Implementing Agreements are also looking at trade barriers. For example, IEA Bioenergy (http://www.ieabioenergy.com/) is currently one year into a three-year project (Task 40) looking at “Sustainable International Bioenergy Trade: Securing Supply and Demand”

Questions to be addressed

Which stakeholders are important to deal with these barriers?

International and regional trade organisations (WTO, NAFTA etc.), international forums for cooperation (IEA, G8), RE industry

Will there be benefits of international cooperation?
Yes, obviously international cooperation is crucial to break down trade barriers.

Which renewable energy technologies face these barriers?
As described above analyses indicate that import tariffs primarily concerns RE fuels and solar thermal technologies. As regards technical barriers further analyses are needed to sort out which technologies are primarily affected.

Which countries face these barriers?
Analyses indicate that import tariffs on renewable energy fuels and technologies are primarily applied in developing countries. Further analyses are required to determine, where technical barriers pose a problem.

5.7 Permits for new renewable energy plants are difficult to obtain

The current legal and organisational framework has been optimised constantly over the years to the benefit of fossil and nuclear fuels.

Previously RE has been not considered as an option in spatial planning and in approving procedures. In many contexts it is therefore emphasised that approval procedures for renewable are lengthy, troublesome and costly, and furthermore that renewable energy plants are not taken sufficiently care of in spatial planning.

These barriers to renewable energy are dealt with in this chapter.

Lengthy and troublesome approval procedures

A large number of authorities are often involved when approvals for new renewable energy plants are to be issued and often coordination between the individual authorities is lacking.

According to the European commission (EU 2005, RE Comm., p.12-13) *“Requirements imposed by the numerous authorities involved (national, regional and municipal) often lead to delays, investment uncertainty, a multiplication of efforts and potentially greater demands for incentives by developers in order to offset investment risks or the initial capital intensity of the project”.* Often the lead times needed to obtain permits are unnecessarily long, for example for on-shore wind power projects authorisation procedures in some European countries may take up to seven years.

Of course it is important that permits for renewable energy plants are not rushed through on the expense of considerations for other environmental issues. Besides the direct environmental problems which this may create, it would also put renewable energy technologies in unfavourable light in the longer term. All relevant parties should be heard and Environmental Impact Assessments prepared when required.

Still however many studies have pointed out that there is scope for streamlining approval procedures. The EU Commission recommends appointing one-stop authorisation agencies, which are responsible for the co-ordination of several administrative procedures. As an example of a one-stop authorisation agency the EU commission (p. 13) refers to the German “Bundesamt für Seeschifffahrt und Hydrographie” for off-shore wind projects. Also the EU recommends different authorities to use standard forms and requirements.

Lighter procedures for small-scale renewable energy plants may also be relevant in order to speed-up processes and reduce transaction costs.

Conflicts related to spatial planning

An issue related to "approval procedures" concerns spatial planning for renewable energy plants.

As Neuhoff (2005: 96) explains administrative framework has been developed for existing technologies and is not yet tailored to the needs of renewables in many countries: *"While spatial planning traditionally envisages specific zones for industrial development, local plans must frequently be revised for the location of wind or bioenergy plants"*. Beck and Martinot sees similar problems (2004: 4): *"Urban planning departments or building inspectors may be unfamiliar with renewable energy technologies and may not have established procedures for dealing with siting and permitting."*

The European Commission (RE Comm., 2005: 13) has also identified inadequate spatial planning as an important barrier to renewable energy development. When renewable energy plants are not taken into account when spatial plans are drawn up, *"new spatial plans have to be adopted in order to allow for the implementation of an RES-E project in a specific area. This process can take a very long time."* According to the Commission obtaining the permits related to spatial planning accounts for the major part of the overall period needed for the project development.

In the process of spatial planning it is also important to observe the need to mitigate potential negative environmental impacts of renewable energy, for examples the loss of natural environment and agricultural diversity and potential water contamination stemming from the use of energy crops.

Opportunities

An interesting concept set out to deal with the problems related to spatial planning is so-called "pre-planning". As noticed by the EU: *"Where different levels of authorities are involved, a possible solution could be the preplanning carried out in Denmark and Germany where municipalities are required to assign locations that are available to project developers for a targeted level of renewable electricity generating capacity. In these pre-planned areas, the permit requirements are reduced and implemented faster. In Sweden, these areas are called 'areas of national interest for wind".* (EU Commission 2005: 13, RE Comm.)

At the RETD Stakeholder Workshop 22 March 2006 several participants argued for the benefits of combining the environmental planning, the spatial planning and the grid planning into one comprehensive planning procedure. This would reduce time consumption and thereby the risks associated with project development of renewable energy projects. Such procedures could be combined with public tenders for new renewable energy capacity.

Other opportunities which were also debated at the Stakeholder Workshop concern:

- Cooperation on best practice between national and local governments from different countries
- Developing international procedures for speeding up approval for renewable energy plants, including for example special procedures for small scale projects.
- Developing internationally harmonized standard forms and requirements (to help RE project developers that work internationally)
- Cooperation on good/best practice spatial planning between national and local governments from different countries (for instance pre-planning)
- Training and education of architects and spatial planners

- Improve awareness and acceptance of the public

Questions to be addressed

Which stakeholders are important to deal with these barriers?
National and local authorities. RE industry needs to adapt their products to meet requirements of authorities (for examples by reducing noise, odour, visual impact)

Will there be benefits of international cooperation?
International cooperation can be useful, particularly to exchange experiences between different countries.

Which renewable energy technologies face these barriers?
Approval procedures and conflicts related to spatial planning concern almost all renewable energy technologies. However, the concrete barriers, which the individual technologies face, are not necessarily the same. Wind power may often be rejected because of its visual impact, biogas plants because of the smell etc.

Further questions for discussion

- *Though international cooperation on spatial planning and approval procedures might be beneficial, why not do it technology by technology – using the existing technology specific implementing agreements?*
- *Is it practically possible to establish international activities that reach out to the planners in regional and municipal offices? How to make sure that such incentives will have an impact?*

5.8 Energy markets are not prepared for renewable energy

The existing energy infrastructure has been established in order to facilitate the best utilization of conventional energy sources – fossil fuel and nuclear. This regards the electricity infrastructure as well as the gas infrastructure and to some extent district heating systems.

Similarly the organisations, rules and regulation in energy markets have also been setup to support conventional technologies.

This section examines the barriers, which stem from the fact that energy markets are not prepared for renewable energy. Three issues are dealt with:

- Problems related to integration of intermitting energy sources
- That grid connection and access is not fairly provided
- Other markets imperfections in energy markets

Integration of intermitting energy sources

As renewable energy generation make up an increasing part of electricity consumption in some countries and markets the issue of integration into electricity systems becomes ever more important. The concerns particularly involve fluctuating energy sources such as wind power and solar power, which may change production rapidly as the weather develops.[26].

[26] Though practically all renewable energy technologies follow natural cycles solar, wind and tidal power are the only technologies following a time-scale of hours or minutes.

The focus of this sub-chapter is on barriers to wind power integration because solar and tidal power have not (yet) reached a similar level of penetration. However, the conclusions may be applied to other intermitting energy sources as well.

According to the IEA (2005: 15, Variability of wind power…), *"The two regions, where the natural variation of wind (often referred to as "intermittency") is currently most discussed in the context of changes to system operations are Western Denmark and Northern Germany, where wind power penetration has reached a considerable level, albeit a number of countries like the USA, UK, Portugal and Spain are investigating the demands on their grids as they expect wind to grow further in the near future."*.

Originally many experts believed that an only a small amount of intermitting energy sources could be integrated in energy systems without compromising system stability. *"However, with practical experience gathering, for example in the Western Danish region where over 20% of the yearly electricity load is covered with wind energy, this view has been refuted…"* (IEA 2005: 15, Variability of wind power…).

In Germany the "DENA Grid Study" has proved that the electricity from wind power can be integrated economically into the German electricity grid by 2015, even if renewable energy generation is increased to make up 20% of electricity generation (5% offshore-wind, 7.5% onshore-wind, and 7.5% other renewable sources). This only requires a moderate expansion of the grid (DENA 2005, BMU website[27]). Recent analyses by the Danish TSO Elkraft System (now Energinet.dk) show that it is even possible to cover up to 50 % of electricity demand with wind power at reasonable costs (Elkraft System, 2005[28]).

The main problems associated with wind power variations concern (IEA 2005, (Varialibility..) and Elkraft System 2005):

- Handling fluctuations in wind power generation. I.e. ensuring that the other players in the market are capable of adjusting their generation at a rate (MW per minute/hour) similar to the change in wind power output.
- Handling the unpredictability of wind power generation. The unpredictable fluctuations mean that the other market players would have to adapt at short notice. The size of the problem depends on the precision of the wind power forecasts and the possibility of adjusting production and consumption in the electricity system quickly.
- Ensuring sufficient power capacity in calm periods. Large scale wind power deployment in liberalised energy markets reduces electricity prices (because wind power capacity is bid at its marginal cost, which is approx. 0 €/MWh) and thereby the incentives for market players to invest in alternative power plants. For this reason ensuring sufficient capacity in calm periods may become an important issue for system operators in the longer term.
- Utilising wind power generation in windy periods. In markets with a very high degree of wind power capacity generation may in some periods exceed consumption. In these cases it may be necessary to curtail wind power generation unless the wind power can be exported to neighbouring systems or utilised for new purposes (increasing demand or storing).

[27] BMU, press release Berlin, 23.02.2005: Juergen Trittin: Pessimism about Expansion of Wind Power has no factual basis www.bmu.de/english/renewable_energy/press_statements_speeches/pm/35190.php

[28] Report available from the website of Energinet.dk (22-02-2006) : www.el-oest.energinet.dk/C1256AC3004D7084/About%20Elkraft%20System%20UK/11BE15B102792997C1256BD1004A448B?OpenDocument

- Provision of ancillary services (spinning reserves, reactive power etc.).

Grid connection and grid access

Two basic grid connection issues are often raised as barrriers to the deployment of renewable energy technologies:

1) That the energy infrastructure is not suited for renewable energy technologies
2) That grid owners (whether they be utilities or transmission system operators or distribution system operators) do not always provide fair access for renewable energy technologies.

For example the electricity infrastructure in most countries has been designed to allow large nuclear, coal or hydro power plants to be located near consumption centres, mines (coal), rivers (cooling water, large-scale hydro power) or the coast (cooling water). On the contrary renewable energy plants are often scattered over the countryside so as to utilise the dispersed energy resources of for example wind, biomass and solar power. Therefore renewable energy plants are often connected to the distribution grid, and prone to grid extensions and reinforcements in addition to grid connection investments (EU, 2005: 14, RE Comm.).

This is a fundamental problem which may increase the costs of implementing renewable energy technologies yet opens up for no simple solutions.

On the other hand priority access to the grid at a reasonable and transparent price is essential to the development of renewable electricity generation and a problem which may be dealt with if markets are regulated properly. According to Beck and Martinot (2004: 6):*"Individual home or commercial systems connected to utility grids can face burdensome, inconsistent, or unclear utility interconnection requirements. Lack of uniform requirements can add to transaction costs. Safety and power-quality risk from non-utility generation is a legitimate concern of utilities, but a utility may tend to set interconnection requirements that go beyond what is necessary or practical for small producers, in the absence of any incentive to set more reasonable but still technically sound requirements.".*

Grid access problems depend very much on the market setup in individual countries. In liberalised electricity markets transmissions system operators and distribution system operators should provide equal grid access to all market players based on fair and transparent rules for bearing and sharing grid investment costs. This is essential for the market model to work. In utility owned systems the situation can be more complex, because the grid owner will often have interests in existing as well as new generation facilities.

In Europe good practice on grid-connection can be found in countries such as Denmark, Finland, Germany and the Netherlands. According to the EU Commission (EU 2005: 15, RE Comm.), *"Transparent rules for bearing and sharing the necessary grid investment costs are necessary as many grid barriers result from a lack of such rules."* Rules vary considerably between EU Member States and much still need to be done on transparency for cost-sharing.

It is important that that rules deal with grid connection as well as grid enforcement, since in some systems grid congestions has been encountered the main bottleneck for further deployment of wind power.

Other imperfections in energy markets

Imperfection in energy markets cover a range of circumstances or factors that may cause private decision-making to produce less-than-optimal economic outcomes. In relation to renewable energy some of the most important imperfections in energy markets arise from the *"nonrivalry and nonexcludability of certain byproducts of energy consumption and production: so-called "environmental externalities," or side effects that have deleterious effects on health or welfare"* (Earth science study guide, website[29]). This question is dealt with in chapter 5.2.

In the following issues will be described relating to the lack-of competition between energy suppliers and imperfections concerning distribution and transmission of energy.

In several cases such imperfections may pose obstacles to renewable energy utilization. Examples are provided below.

- Access to sites for new power plants. Available sites for new power plants are often owned by existing energy companies and new sites for power plants are often costly and time consuming to develop – among others because of the NiMBY[30]-problem. This may impede the commissioning of for instance new biomass fired power plants.
- Availability of transmission capacity to market players. In some cases the available transmission capacity between different market areas are not fully utilized because the market framework has not been harmonized (interconnections between the Nordic countries and Germany provides an example). As a result the electricity system is operated inefficiently. Particularly this lack of utilization may be detrimental to the economy of wind power plants, because they are dependent on the availability of grid capacity to fully exploit their potential in windy periods. Also, because wind power generation may change unexpectedly due to variations in natural cycles, flexible use of interconnections becomes very important.
- Execution of market power in relation to the provision of balancing power. This may pose a problem particularly for wind energy producers. Due to the unpredictability of their generation they are more dependent on the provision of balancing services than conventional electricity producers
- Subsidies and energy tariffs. In some cases subsidies and fuel tariffs can make it more difficult to integrate wind power in electricity markets. One example is the Danish fuel tax reductions when energy plants produce combined heat and power. The purpose of this regulation has been to promote generation from CHP plants – which is generally positive from an environmental perspective. However, this regulation has also encouraged CHP plant owners to generate power in situations with much wind power where it would be more beneficial for thermal plants to produce only heat. This may lead to lower electricity prices than necessary (thereby impeding further installation of wind power plants) and to critical electricity surplus generation in extreme situations.

According to the EU Commission (2005, Communication on renewable energy, p. 9) *"Some countries are still characterised by the dominance of one or a few power companies, often vertically integrated. This might entail a monopoly-like situation, which could hamper the development of RES-E."*.

It should be recognised that renewable energy technologies challenge vested interests within the conventional energy supply chain. In countries with monopoly utilities or system

[29] www.bookrags.com/sciences/earthscience/market-imperfections-mee-02.html, 08-02-2006

[30] Not In My Back-Yard

operators, which have not been truly separated from energy generation, this may pose a serious obstacle to renewable energy deployment.

Opportunities

The following opportunities will be relevant to pursue to deal with the above mentioned barriers:

- Cooperation on new interconnectors between national governments and TSOs. This includes establishing modelling tools covering large geographical areas and in some contexts establishing new forums for cooperation.
- International cooperation on establishing best practice for grid connection
- International cooperation between authorities, energy traders and TSOs on utilization of interconnectors
- International cooperation between TSO and utilities on establishing best practice for charging balancing costs
- International research and development in technologies, which may increase the value of intermittent technologies (energy storage for example)
- International cooperation on experiences and best practice to promote demand response
- International cooperation on studies and development of tools to improve the prediction of RE resources
- Dissemination on best practice for integration of intermittent technologies at TSO level (operation) and government level (setting the framework)

Introducing large amounts of renewable energy generation increase the need for international collaboration on security of supply and preparedness and greater collaboration between the system operators.

To handle intermittency the following main options are often discussed (IEA 2005: 26, Variability of wind power…, Elkraft System 2005). For further details on these options, please see Annex IV.

- Power plants providing operational and capacity reserve, including from distributed generation.
- Increase interconnection with other grid systems.
- Develop demand response to energy prices.
- Increase electricity storages
- Improve the tools used to forecast wind power generation
- Curtail intermittent resource/technology

It also becomes important to create economic incentives in order to ensure efficient interaction between the electricity market, the heat market and the gas market. Heat storage facilities for example may play an important role as a form of indirect storage of electricity. This may entail changing the market design so as to make room and economy for the wind power.

Issues which are relevant to deal with concern the time of gate closure and the market framework for charging of balancing costs for intermittent energy sources. (EU 2005, RE comm.., p. 9-10). The closer gate closure is to the operating hour, the better intermittent RES-E technologies can predict how much electricity they will be able to deliver. (EU 2005, RE comm.., p. 9-10).

According to the IEA (2005, Variability of wind power and other renewables) two large scale projects in Europe are exploring large scale implementation of renewable energy sources in electricity systems. These are IRED-cluster and EU-DEEP. Other relevant projects are WILMAR (Wind power in Liberalised Electricity Markets) and SUPWIND.

Questions to be addressed

Which stakeholders are important to deal with these barriers?
National authorities (provide proper incentives for market players, promote competition and access to sites, develop demand response…)
Transmisssion system operators (grid enforcement, grid interconnection, develop demand response…)
Distributions system operators (grid connection)
Energy regulators (provide proper incentives for market players, promote demand response)
Energy traders (develop products which take into account the benefits of renewable energy – for example long-term power purchase agreements)

Will there be benefits of international cooperation?
Yes, though many of the solutions identified will have to be carried out at the national level, international cooperation will be important in many respects, for example to increase cooperation between national energy markets (electricity and gas) and to coordinate investments in interconnection capacity.

Which renewable energy technologies face these barriers?
Many of the market imperfections described in this subchapter concern all renewable energy technologies that have reached the market deployment level.

The problems related to intermittency primarily concern wind power at present, but may in the longer term also affect solar power and some ocean technologies like wave power.

Which countries face these barriers?
Many of the market imperfection issues are general problems, which are likely to be present to some extent in most countries.

The problems related to intermittency primarily concern countries with a high level of wind power such as Denmark, Germany and Spain. With the expansion of wind power this list of countries is however likely to grow.

5.9 Renewable energy skills and awareness are insufficient

Lack of public awareness of renewable energy technologies is frequently mentioned as a barrier to encourage wider uptake of renewable energy technologies. The fact is that renewable energy technologies can be the most economical solution in many cases, but the information barrier prevents such cases from being easily identified.

This subchapter deals with the following barriers to renewable energy deployment:

- Lack of knowledge and acceptance
- Lack of training and education

Lack of knowledge and acceptance

Besides sheer ignorance of renewable energy technologies and their benefits, cultural and psychological factors may pose a significant barrrier to the adoption of renewable energy.

Though people are generally positive towards renewable energy, as elaborated on in chapter 3.1, renewable energy challenges an existing system and this may create tensions.

According to Tsoutsos and Stamboulis (2005) it is relevant to highlight: *“the importance of institutional entrapment, especially in large, complex technical systems such as those of energy: economic, political and institutional commitments related to a long-term horizon form extremely high barriers to change and to entry. Interests vested in incumbent energy technologies and firms are immense, including the international power structure and world order.”*

Tsoutsos and Stamboulis (2005) identifies the following cultural and psychological factors, which have to be dealt with in a change of regime

- Social acceptance of renewable technologies is low because they have not been established as a reliable alternative
- The electricity- and oil-based civilization of everyday life is identified with comfort and ease
- Unfamiliarity with new technologies and possible failures or bad examples (broken or run-down wind turbines, poorly designed bioclimatic building, etc.) lead to scepticism
- Uncertainty that arises from the temporally variable nature of some renewable sources (sun, wind) put people off when comparing the alternatives with the perceived safety of electricity or oil

In Germany, for example, the *“establishment of social legitimacy of wind energy”* has been key for the relative success of the German wind power industry, according to Foxon et al (2005),

Futhermore Tsoutsos and Stamboulis (2005) mentions lack of risk-taking in governments as a barrier to renewable development: *“…governments do not risk change in the face of the political cost of vested interests in the political cost of vested interests”.*

Lack of training and education

According to a survey on new and renewable energy technologies made by Foxon et al. (2005) in the UK; *“Several technology and project developers pointed to a lack of necessary skills in the national workforce. This leads to some recruit internationally, while others devote significant resources to training. ”*

To secure sustainable commercial success, renewables must overcome a number of key barriers, including:

a) insufficient human and institutional infrastructure
b) limited capacity to support projects and markets, owing to a lack of experience and investment

(G8 Task Force Report)

Furthermore, often renewable energy plants are not successful because the operational personnel have not been given proper education and training to deal with the new technology. Therefore in-service training in private companies and education programmes at universities and technical colleges focusing on renewable energy technologies can be key to their further success.

Opportunities

Raising awareness is relevant on different levels because the renewable energy decision makers include consumers as well as public and (other) private decision-makers in the energy sector.

In 2005 the EU launched a public awareness campaign called Sustainable Energy Europe 2005-2008 (EU 2005, Sust. Campaign) focusing on intelligent sustainable energy production and use[31].

The objectives of the campaign are as follows:

- *"Raise the awareness of decision-makers at local, regional, national and European level*
- *Spread best-practice.*
- *Ensure a strong level of public awareness, understanding and support*
- *Stimulate the necessary trends towards an increase in private investment in sustainable energy technologies"*

In the Conference Issue Paper for the 2004 RE conference in Bonn it emphasised that information and advice to consumers should be neutral and free of commercial interests. Furthermore; *"Consumers should be informed via labels and receive advice about best practice examples of using renewables as well as energy-efficient technologies. This will necessitate the building up of institutional structures for consumer information and advice."* (Bonn 2004, Conference Issue Paper).

Building human capacity on renewable energy is also needed at several levels. Capacity building may be defined as *"the process of creating, mobilizing, and converting skills and institutions to achieve desired socio-economic results. It requires a long-term commitment, with activities focusing on individuals, institutions, and systems, and targeting public, private, and non-government organizations."* (Beijing 2005: 67).

As pointed out by Christensen (2004) in the report "Capacity Development Education and Training for the renewable energy conference in Bonn 2004, *"capacity development, education and training are generally recognised in the scientific literature, practical experience and political reality as cross cutting issues crucial to implement not only to promote renewable energy activities but also to move towards generally more sustainable development paths"*.

Capacity building is needed at the technological level as well as the institution level:

At the technological level:

- research, development, demonstration to increase technological skills
- develop capacity within the field of testing and licensing of renewable energy technologies.
- develop international resource and technology data on renewable energy sources in order to supplement existing measures (for instance the Solar and Wind Resource Assessment project carried out by UNEP/GEF)

At the institutional level:

- enhance capacity of energy planners and analyst to for example include full costs, including externalities when comparing different technological options

[31] See also the German Information Campaign on renewable energy (http://www.unendlich-viel-energie.de/)

- support governments to formulate, implement and enforce renewable energy policy programmes
- increase awareness among policy makers to better understand energy market distortions, their consequences and the opportunities of renewable energy technologies
- increase awareness and skills of international and national financial institutions, including enabling them to exploit the opportunities of carbon financing (using the international mechanisms JI, CDM and emissions trading)

Other possible opportunities to increase awareness and RE skills include:
- Information and education on all educational levels (basic school, high school, more advanced studies etc.) on national level or through international programmes
- In-service training of officials at local as well as national level
- Provision of incentives for the general population to take advantage of renewable energy deployment (tax deduction incentives etc.). Particularly this could be important to gain support from farmers and villagers.
- Twinning between authorities and TSO from countries with different experience
- International education programmes
- International in-service training programmes

Questions to be addressed

Which stakeholders are important to deal with these barriers?
National and local authorities, NGOs, consumers, international forums for cooperation (IEA, G8), Universities and technical colleges, operational personal.

Will there be benefits of international cooperation?
Yes, as described in chapter 4.1 the experience with and the utilization of renewable energy vary considerable between different countries and markets. Exchanging experiences between frontrunner countries and countries that have less experience can be important to improve human capacity. Also there may be benefits of international training programmes etc, as described above.

Which renewable energy technologies face these barriers?
As technologies mature awareness and acceptance increase. This barrier particularly concerns emerging technologies.

Which countries face these barriers?
This is not a country specific barrier although experience and acceptance of course vary from country to country.

5.10 Summary

Based on the literature survey Table 9 provides a general list of the most important barrriers to renewable energy deployment. In addition examples are provided of possible opportunities and relevant stakeholder.

Barriers	Opportunities	Important stakeholders
There is no level playing field for renewable energy technologies	International cooperation on: - Phasing out subsidies for conventional technologies - Good practice for subsidies - Internalisation of externalities	National governments and international forums for cooperation (UN, EU, IEA, G8)
The incentives for governments and private companies to support renewable energy development are insufficient	- International agreements committing governments to demonstrate and deploy renewable energy technologies - Multilateral funds for RE deployment and demonstration – partnerships with the private sector	National, regional and local authorities, international forums for cooperation (IEA, G8), the RE industry, international financing institutions
Financing is unreasonably costly for renewable energy technologies	- Favourable loans for renewable energy projects through national or international institutions. Promote long-term power purchase agreements between consumers and RE generators - Initiatives to stimulate carbon financing of renewable energy projects; - Training and education of financiers	International/national financing institutions, national governments, CDM executive board, JI advisory committee, Asia-Pacific Partnership on Clean Development and Climate, energy producers, private financing institutions
Technology standards are lacking for (some) renewable energy technologies and fuels	- Develop standards for renewable energy technologies, components and fuels - Develop test facilities for renewable energy technologies	National and international standardisation organisations, the RE industry, industry associations, international trade organisations (WTO, NAFTA etc.)
Import tariffs and technical barriers impede trade in renewables	- International cooperation on removing duties and technical barriers to trade in renewable energy products	International and regional trade organisations (WTO, NAFTA etc.), international forums for cooperation (IEA, G8), the RE industry
Permits for new renewable energy plants are difficult to obtain	- Cooperation on best practice between national and local authorities from different countries - Developing internationally harmonized standard forms and requirements (to help RE project developers working internationally)	National and local authorities, the RE industry needs to adapt its products to meet requirements of authorities
Energy markets are not prepared for renewable energy	International cooperation on: - best practice for grid connection/access - removing market imperfections in relation to RE - new interconnectors - integration of intermittent RE sources - promoting demand response in energy markets	National authorities, transmission system operators, distributions system operators, energy regulators, energy traders
Renewable energy skills and awareness are insufficient	- Information and education on all educational levels at national level or through international programmes - Twinning between authorities and TSOs from countries with different experience and between operational personnel from different countries - International in-service training programmes - National and international awareness campaigns.	National and local authorities, NGOs, consumers, international forums for cooperation (IEA, G8), universities and technical colleges, operational personnel

Table 9: Summary of barriers to renewable energy, and examples of opportunities and important stakeholders

6 Deployment strategies for renewable energy

This chapter describes the activities which have been identified by the Executive Committee as relevant to pursue within the RETD mandate period running towards 2010.

The activities are included in the RETD Implementation Plan 2006-2010 (outline) and some of them are described in more detail in the Work Programme 2006-2007 (outline). The Implementation Plan is a living document that will be revised based on periodic evaluation of the programme activities and upcoming relevant issues on the international agenda, whereas the Work Programme 2006-2007 includes a number of high priority activities to be started as projects before the end of 2006.

The Stakeholder Workshop on 22 March 2006 and the Roundtable Meeting on 6 April 2006 with representatives from the other renewable energy Implementing Agreements have provided important input for setting up the Implementation Plan and the Work Programme.

This chapter is structured around the following headlines: 1) Guidelines for selection of activities, 2) Relevant RETD activities and 3) Prioritised project to be started in 2006

6.1 Guidelines for selection of activities

In the course of identifying relevant activities for RETD, it was found relevant to establish some guidelines for the selection process.

The three objectives in the RETD Implementing Agreement set up the overall guideline for selection of activities in the Implementation Plan. According to the objectives, RETD should focus on:

1) Best practice policy measures
2) Public-private partnerships
3) Dissemination and training

(See chapter 2).

In order to prioritise the activities further, the characteristics described below should be taken into account.

RETD activities should preferably:

- **Lead to deployment of RE.** The focus of RETD is on activities related to deployment of RE (and not R&D issues for example).
- **Be executable.** It should be feasible to carry out activities within the organisational and financial framework of RETD.
- **Be technology crosscutting.** Activities that are very technology specific are not of importance for the RETD agreement, because such activities are carried out by the relevant IEA technology implementing agreements.
- **Be country crosscutting.** Activities addressing barriers that are specific to one or a very few countries are of less relevance. One of the strengths of RETD should be to harness the benefits of international cooperation.
- **Supplement and build on the work of existing Implementing Agreements.** It is a strength if activities proposed for RETD are synergetic to the activities carried out in the technology-specific Implementing Agreements

- **Reflect topicality.** It is preferable that activities relate to issues of topicality, including to relevant international events.
- **Deliver short-term Results.** To gain support for the implementing agreement activities that deliver short-term results are to be prioritised.
- **Bring added value to existing international processes and activities.** It is important that activities in the RETD do not duplicate existing work whether that be in the context of the IEA or other international forums/organisations.
- **Involve new actors into the field.** Particularly it will be important to encourage cooperation between public and private stakeholders, and to involve public stakeholders at all levels including the local level.
- **Benefit from IEA's reputation.** In some contexts using the IEA "name" as a platform to bring forward important messages will improve the power of penetration. Activities that enjoy this advantage should be prioritised.

6.2 Relevant RETD activities

Twenty activities in total have been selected as possible activities within the framework of the RETD Implementing Agreement. These activities are described in the Implementation Plan 2005-2010.

The activities have been grouped around the overall objectives of the Implementing Agreement (not disregarding that some activities may lead to the fulfilment of more than one objective of the RETD):

Objective 1

"To elaborate and present options for "best practice" policy measures and mechanisms for cost reduction, enabling increased use of renewable energy in competitive energy markets through strengthened international collaboration".

	Activity	Purpose	Outcome
Levelling the playing field	Externalities	Map the problem, increase awareness identify policy solutions.	Increased awareness of the problem at the national and international policy level.
	Subsidies for RE	Map the problem, increase awareness, identify policy solutions.	Increased awareness of the problem at the national and international policy level.
	Support schemes for RE	Examine what is the best way to support RE	Give understanding of good practice among politicians and other policy makers.
	Trade barriers to RE	Map the problem and develop input to relevant organisation and authorities.	Increased awareness of the problem at the national and international policy level and among international trade organisations.
Good	Approval procedure	Examine differences	Authorities have been

administra-tive practices		in administrative approval procedures in IEA/participating countries and guide on ideas for best practice.	supplied with information about best practice approval procedures.
	Physical planning	Identify activities that will improve local planning and encourage good practice. Guidelines for planners at national and local level (Standard Operating Procedure, SOP).	Planners at the local level have an improved understanding of the barriers to renewable energy and the tools (guidelines) available to deal with these.
	Task force for systematic removal of barriers in specific areas (geographical and/or markets)	To increase international cooperation between authorities at different levels.	An international coordination group has been established which has broken down important regulatory barriers and has the capacity to deal with up-coming barriers.
	Local energy planning	Focused information (road maps) for deployment of RET at local government/county level.	Local authorities/counties have available tools to develop plans for increased utilisation of renewable energy.
Facilitating policy strategies	Scenarios for RE	Illustrate the potentials of RE in the future energy supply. Develop scenarios at the regional level, in participating countries or globally.	Politicians and other policy makers are made aware of: - the fact that it is technically and economically feasible to obtain a very high level of RE in energy systems - measures and incentives required to increase RE deployment.

Objective 2

"To elaborate and present options for innovative business strategies and projects that will encourage renewable technology deployment to public and private sector stakeholders."

	Activity	Purpose	Outcome
Financing	International fund for demonstration of RE technologies	Develop innovative ideas for concerted public-private financing for overcoming the "valley of death".	Promote the idea of an international demonstration fund and lay the foundation for its establishment. Public and private support.
	Risk-hedging benefits of RE	Increase the awareness of portfolio theory and perform concrete analyses of energy systems.	Private energy producers and utilities are made aware that by increasing their utilisation of RE their risk profile will improve.
	Long-term contracts in energy markets	Examine how synergies can be created between energy consumers and RE generators in order to manage risks in energy markets.	Energy producers and energy consumers have the tools and are made aware of the benefits of entering long term contracts to reduce risk.
Standardisation and certification	Standards	Map where and how standards will benefit RE and enter into dialogue with standardisation organisations and industry organisations.	Recommendations for new standards are developed, enabling increased trade with renewable energy technologies and fuels.
	Test facilities	Examine the need for international RE test facilities (testing grounds) and certification systems.	The foundation has been provided (public-private support) for the commencement of one or more international test facilities for RE.
Twinning between public and private	Partnerships with utilities	Cooperation between authorities and utilities for identifying and breaking down "authority related" barriers to RE.	An international coordination group (with public and private participation) has been established which has broken down important regulatory barriers and has the capacity to deal with up-coming barriers.
	Integration of RE in energy systems	Improve cooperation between system operators and exchange of experience and best practice (grid codes, market setup etc.).	The human capacity of system operators has been improved through international cooperation enabling improved grid planning and grid access for RE technologies.

Objective 3

"Building from the unique framework of the IEA, to disseminate information and enhance knowledge about renewable technology deployment, complementing other information programs in supporting improved public and private sector decision making".

Activities under this program focus on diffusion of RETD information and its results.

	Activity	Purpose	Outcome
Dissemina-tion of information	RE internet portal	To develop a website with daily newsletter and up-to-date information about RE technologies, resources and policies.	Energy planners in public and private companies have improved access to state-of-the-art information on RE.
	Unbiased information about RE technologies	To provide a uniform, commonly accepted and up-to-date basis for energy planning activities in public and private organisations.	Energy planners in public and private companies have improved access to state-of-the-art, unbiased and transparent information on RE.
	Dissemination of information from the technology specific RE IAs	Achieve synergies by providing an umbrella for existing information initiatives of the relevant Implementating Agreements	The results and outcomes of RE related IAs reach a wider audience.
	Infrastructure	Dissemination of experience from the development of the technical infrastructure needed for deployment of RE. Summary of existing studies and provision of examples of good practice.	State-of-the-art information is supplied for grid planners on good/best practice for incorporation of RE.
Training	Train financiers of RE	Develop information material and arrange workshops/seminars about RE technologies.	Financiers' awareness and knowledge about the benefits of RE technologies is increased.
	Interactive education and training	To increase knowledge and awareness of RE through interactive learning aiming at in-service training and students.	The awareness and knowledge about the benefits of RE technologies is increased among - energy planners - coming energy planners - operational personnel.

6.3 Prioritised projects to be started in 2006

From the gross list of relevant activities the RETD Executive Committee has selected and bundled a number of high prioritised activities to be started as projects before the end of 2006. These projects are described in the outline of the Work Programme 2006-2007.

The projects concern:

A. Levelling the playing field for renewable energy;
B. Approval procedures and spatial planning;
C. Integration of renewable energy into energy systems and markets;
D. Renewable energy technologies in the heating and cooling markets;
E. Financing of renewable energy technologies;
F. Dissemination and communication strategy.

Once a permanent Operating Agent has been selected for RETD by mid-2006, the projects will be described in such a detail that they can be launched without further elaboration.

In the following sections, the rationales for commissioning the projects are described briefly.

6.4 Levelling the playing field for renewable energy

The purpose of the activities in this area is to create transparency of the real costs of energy services. The RETD stakeholder workshop on 22 March 2006 concluded that there is a need for a more clear understanding of the benefits of renewable energy. More precisely there is a need for information about the real costs of renewable energy technologies compared with the costs of conventional energy technologies. The target group is policy makers at all levels, and the results should be used at important international events such as the meeting in the Commission of Sustainable Development in 2007 (CSD 15).

The following activities should be considered:

- Summarizing and dissemination of studies and facts about external costs of energy production and subsidies to conventional energy technologies;
- Pricing of the benefits of renewable energy technologies such as environmental benefits (including CO_2 deduction), the creation of (local) jobs, technology development, security of supply and independency;
- Evaluation of the “real” prices of different energy generation technologies;
- Dissemination of the results through workshops and publications targeted at international events.

The activities should synthesize existing studies and the results should be disseminated in various ways. See also activity F on dissemination of results for the RETD implementing agreement.

6.5 Approval procedures and spatial planning

Most projects regarding technological infrastructure – renewable energy or not - must comply with administrative procedures such as permits under various sectors’ legislation and regional, municipal or local planning. Also Environmental Impact Assessments could put constraints on the implementation of the projects.

The current legal and organisational framework has in many cases been optimised over the years to the benefit of fossil and nuclear fuels. This could lead to unreasonably time-consuming and troublesome approval processes for projects for renewable energy. Lack of standards means that many projects must be approved individually; the authorities are not familiar with the new technologies etc. A large number of authorities are often involved when approvals for new renewable energy plants are to be issued and often coordination between the individual authorities is lacking.

On the other hand, well-coordinated efforts among central and local authorities, for instance clever use of spatial planning, could dramatically reduce the time spent on approval processes. Internationally, exchange of experience and learning from “best practice” could therefore contribute to reducing this barrier.

The activities in this area should stimulate international cooperation and best practice learning in efficietnt and streamlined approval procedures and procedures for spatial planning. They should also improve the understanding of the importance of good procedures among policy makers and relevant authorities.

Furthermore, the activities could illustrate how long-term transparent planning, with e.g. screening of possible conflicts of interest, with a good stakeholder dialogue and with reservation of areas for renewable energy structures, could promote renewable energy deployment.

6.6 Integration of renewable energy into energy systems and markets

The existing energy infrastructure has been established in order to facilitate optimal utilization of conventional energy sources – fossil fuels and nuclear power. This regards the electricity infrastructure as well as the gas infrastructure and to some extent district heating systems. Similarly, the organisations, rules and regulation in energy markets have also been set up to handle conventional technologies.

Activities in this area should aim to stimulate international cooperation on the integration of renewable energy into energy systems and markets. Relevant players are authorities, governments, energy traders, transmission system operators and utilities.

Possible action areas are:

- Grid connection;
- Grid access;
- Utilization of interconnectors;
- Charging of balancing costs;
- Promotion of demand response;
- Prediction of renewable energy resources;
- Integration of intermittent technologies.

6.7 Renewable energy technology in the heating and cooling markets

Renewable energy can easily replace fossil fuels in many applications for heating and cooling. Particularly favourable applications for renewable technologies are those that require low temperature heat, such as domestic hot water heating, space heating, drying processes, water processes for industrial heating and swimming pools. Renewable energy technologies can also meet cooling needs, where the demand and the supply - for example from solar-based technologies - are often well matched.

Activities in this area should concentrate on identifying actions which governments and local authorities could undertake to promote renewable energy for heating and cooling. Instruments should be explored for different relevant markets: stand-alone systems for households and industry as well as district heating technologies, including facilities for combined heat and power generation.

The following activities should be considered:

- A technology status for relevant renewable energy technologies, including for example solar water heating, biomass for heating and geothermal heating. The status should include information on current utilization, resource potential and technical and economic performance of the relevant technologies. It should build on existing literature and information from the relevant IEA implementing agreements.
- A policy status for the participating IEA countries and other countries if relevant. The policy status should account for relevant policy targets, measures and experience.
- Building on the policy status, innovative instruments for the promotion of renewable energy technologies in heating and cooling markets should be identified. Examples of good practice regulation from the different countries should be elaborated.

In addition, initiatives (workshops, networks, seminars etc.) should be carried out in order to exchange experience from the project with the relevant policy makers.

6.8 Financing of renewable energy technology

Compared to conventional fossil fuel technologies, renewable energy projects are generally more capital cost-intensive. Therefore weak capital markets not only create a problem of access to finance but also skew investment towards fossil fuel-based technologies. Another barrier concerns lack of experience with renewable energy financing. Similarly, in regulated markets special financing problems may exist if renewable energy generators are dependent on the goodwill of the dominating utility to finance their project. An additional financing issue concerns transaction costs, which are often disproportionately high for renewable energy projects due to their small-scale nature.

The activities in this area should analyse and help solving the various problems with financing of renewable energy technology. They should also facilitate international best practice learning on risk hedging, long-term contracts and other means to reduce transaction costs etc.

6.9 Dissemination and communication strategy

Dissemination of results from the RETD implementing agreement is a key activity in the Work Programme. The activity should ensure efficient and timely dissemination of the results, considering new tools (e.g. e-learning and other web-based tools) in order to reach the various target groups.

The activities in this area could also facilitate the dissemination of results from other implementing agreements on renewable energy if so desired from these implementing agreements. They could for instance supplement the technical work from a social science perspective (social, political and economical issues of RET).

As part of the dissemination efforts, a communication strategy should be evolved, looking at the different stakeholder groups and how to ensure an efficient and target oriented communication and dialogue. The communication strategy should consider the use of different tools for communication and dialogue, including establishing of Communities of Practices, e-learning, web-blogs etc.

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Annex I - International RE activities

What existing international measures, for instance within the IEA and the EU are focusing on breaking down for barrriers to renewable energy deployment. Where can this study make new contributions?

This annex provides an overview of some important existing renewable energy forums and activities. It is the intention that the information could be used, when defining activities for the RETD implementing agreement, so as to ensure that new activities supplement existing activities.

Information on the different forums and activities has primarily been obtained from relevant websites.

IEA – International Energy Agency
The IEA was founded during the oil crisis of 1973-74 and acts as energy policy advisor for its 26 member countries in their effort to ensure reliable, affordable and clean energy for their citizens.

When the IEA was founded in 1974, the main objective of its member countries was to reduce dependence on imported oil through the development of alternative sources while improving energy efficiency. More recently, concerns such as greenhouse gas emissions and globalisation have underlined the need for international co-operation.

To support these core issues, the IEA created a contract – Implementing Agreement – and a system of standard rules and regulations, allowing interested Member and non-Member governments to pool resources and research the development and deployment of particular technologies.

IEA currently have nine Implementing Agreements concerning Renewable Energy Technologies The Implementation Agreements deal with the following RETs, and they can be found at http://www.iea.org/Textbase/techno/index.asp:

The **Hydrogen** Agreement has a vision of a hydrogen future based on clean sustainable energy supply of global proportions that plays a key role in all sectors of the economy. IEA Hydrogen Program is to accelerate hydrogen implementation and widespread utilization by facilitating, coordinating and maintaining innovative research, development and demonstration activities, through international cooperation and information exchange. http://www.ieahia.org/

The implementing Agreement for **Bioenergy** aims to accelerate the use of environmentally sound and cost-competitive bioenergy on a sustainable basis, and thereby achieve a substantial contribution to future energy demands. http://www.ieabioenergy.com/

The **Geothermal** Agreement provides an important framework for wide-ranging international cooperation in geothermal R&D. Its activities presently cover five different task areas: Environmental Impacts of Geothermal Development, Enhanced Geothermal Systems, Deep Geothermal Resources, Advanced Geothermal Drilling Techniques and Direct Use of Geothermal Energy. http://www.iea-gia.org/default.asp

The **Hydropower** Agreement is a working group of governments and industry which aims to provide objective, balanced information about the advantages and disadvantages of hydropower.
http://www.ieahydro.org/

The **Ocean Energy** Agreement's mission is to enhance international collaboration to make ocean energy technologies a significant energy option in the mid-term future. Through the promotion of research, development, demonstration and information exchange and dissemination, the Agreement's objective is to lead to the deployment and commercialization of Ocean Energy Technologies. Current priorities are ocean waves and marine current systems.
http://www.iea-oceans.org/index1.htm

The **Photovoltaic Power** Systems Agreement, and conducting projects on the application of solar photovoltaic electricity. IEA PVPS operates worldwide via a network of national teams in member countries. http://www.iea-pvps.org/

The **Solar heating and cooling** Agreement deals with R&D and implementation of solar heating and cooling designs and technologies. http://www.iea-shc.org/

The **Solar PACES** Agreement concerns CSP technology. CSP is Concentrating Solar Power plants producing electric power by converting the sun's energy into high-temperature heat using various mirror configurations. The heat is then channelled through a conventional generator. The plants consist of two parts: one that collects solar energy and converts it to heat, and another that converts heat energy to electricity. http://www.solarpaces.org/

The **Wind** Agreement is contributing to the development of wind energy technology by sponsoring research tasks and creating a forum for discussion of research and development issues. http://www.ieawind.org/

G8 Renewable Energy Task Force
The G8 Renewable Energy Task Force was founded by the Leaders of the G8 countries and the President of the European Commission with a remit to identify actions that can be taken to promote a step change in the supply, distribution and use of renewable energy in developing countries.

Some of the activities of the Task Force is:
- Eugene – European Green Energy Network. The Eugene standard is to provide a trusted tool for ensuring that the green energy market delivers real benefits to the environment and communities.
- Climate scorecards http://assets.panda.org/downloads/g8scorecardsjun29light.pdf

REN 21 – Renewable Energy Policy Network for the 21st century
In the Political Declaration of the International Conference for Renewable Energies, Bonn 2004 (Renewables 2004), the establishment of a global policy network was embraced. REN 21 is now supported by a steering committee of 11 governments, five intergovernmental organizations, five non-governmental organizations, and several regional, local and private organizations. REN21 aims at providing a forum for international leadership on renewable energy with the goal: to allow a rapid expansion of renewable energies in developing and industrialised economies.

JREC – Johannesburg Renewable Energy Coalition

JREC Members have expressed their support for the JREC Declaration launched during the 2002 WSSD[32] in Johannesburg. As of June 2004, the national governments of 88 countries had joined the Coalition. The Coalition work for: *"with a sense of urgency, substantially increase the global share of renewable energy sources with the objective of increasing its contribution to total energy supply"*.

CSD – Commission on Sustainable Development
The fourteenth session of the UN Commission on Sustainable Development (CSD-14) will meet at UN Headquarters in New York from 1-12 May 2006. The CSD-14 will review progress in the following areas: Energy for Sustainable Development; Industrial Development; Air pollution/ Atmosphere; and Climate Change.

REEEP – Renewable Energy and Energy Efficiency Partnership
In June 2004, the REEEP was formally established as a legal entity in Austria with the status of an International NGO. The partnership actively structures policy initiatives for clean energy markets and facilitates financing mechanisms for sustainable energy projects. The aim of the organization is to accelerate and expand the global market for renewable energy and energy efficient technologies.

a) REIL – Renewable Energy International Law
   REIL is an international partnership working with industry, governments and NGOs to identify and evaluate legal issues that interact with the development of the market for renewable energy globally; and suggest ways to use law to promote and support the market; whether by removing barriers or by taking advantages of or developing opportunities

b) EESI – The Energy and Environment Security Initiative
   EESI is a project of the University of Colorado School of Law, designed to facilitate progress toward a global sustainable energy future through the innovative use of laws and policies.

c) ISEA – International Sustainable Energy Analyses
   Sponsored by REEEP, ISEA is a research project designed to identify and analyze the impact of international agreements on: Renewable energy technologies and markets; Markets, technologies and practices relevant to energy efficiency and conservation; and Conventional sources of energy, such as fossil fuels and nuclear power.

WEC – World Energy Council
The World Energy Council (WEC) is the foremost global multi-energy organisation in the world today. WEC has Member Committees in over 90 countries, including most of the largest energy-producing and energy consuming countries. The organisation covers all types of energy, including coal, oil, natural gas, nuclear, hydro, and renewables, and is UN-accredited, non-governmental, non-commercial and non-aligned. WEC's Mission is: *"To promote the sustainable supply and use of energy for the greatest benefit of all people"*.

Worldwatch Institute
The Worldwatch Institute is an independent research organization that works for an environmentally sustainable and socially just society, in which the needs of all people are met without threatening the health of the natural environment or the well-being of future

[32] The UN convened a World Summit on Sustainable Development (WSSD) in Johannesburg, South Africa in September 2002.

generations. Worldwatch focuses on the underlying causes of and practical solutions to the world's problems, in order to inspire people to demand new policies, investment patterns and lifestyle choices.

GEF – the Global Environment Facility
The Global Environment Facility (GEF) helps developing countries fund projects and programs that protect the global environment.

ECOSOC
The Economic and Social Council of the United Nations is an organ facilitating international cooperation on standards-making and problem-solving in economic and social issues.

MedREP – Mediterranean Renewable Energy Partnership
A partnership of the governments in different Mediterranean Countries with the Primary Themes: Climate change; Energy for sustainable development; Rural development and Poverty eradication. The World Bank and United Nations Environment Programme (UNEP/DTIE) are also members of the Partnership.

GVEP – Global Village for Energy Partnerships
GVEP is a voluntary Partnership that brings together developing and industrialized country governments, public and private organizations, multilateral institutions, consumers and others in an effort to ensure access to modern energy services by the poor.

GNESD – Global Network for Sustainable Development
The Global Network on Energy for Sustainable Development (GNESD) is a UNEP facilitated knowledge network of developing world Centres of Excellence and network partners, renowned for their work on energy, development, and environment issues.

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UNEP – United Nations Environment Programme
Promotes environmental understanding, and increases public knowledge about environmental factors and problems. The mission of the programme is: *"To provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations"*.

Financings programmes of the UNEP:

a) SEFI - UNEP Sustainable Energy Finance Initiative
SEFI is the UNEP Sustainable Energy Finance Initiative - a platform providing financiers with the tools, support, and global network needed to conceive and manage investments in the complex and rapidly changing marketplace for clean energy technologies.

b) RET/EE IAF - Renewable Energy Technology and Energy Efficiency Investment Advisory Facility

c) REED - Rural Energy Enterprise Development Initiative

UNDP – United Nations Development Programme

UNDP is the UN's global development network, advocating for change and connecting countries to knowledge, experience and resources to help people build a better life.

UN ECE – United Nations Economic Commission for Europe
UNECE strives to foster sustainable economic growth among its 55 member countries. To that end UNECE provides a forum for communication among States; brokers international legal instruments addressing trade, transport and the environment; and supplies statistics and economic and environmental analysis.

UN ECLAC - United Nations Economic Commission for Latin America and the Caribbean
UN ECLAC was founded for the purposes of contributing to the economic development of Latin America, coordinating actions directed towards this end, and reinforcing economic relationships among the countries and with the other nations of the world. The promotion of the region's social development was later included among its primary objectives.

National Council for Science and the Environment
The National Council for Science and the Environment (NCSE) has been working since 1990 to improve the scientific basis for environmental decisionmaking. The Council believes that comprehensive and integrated science can help society achieve its environmental goals in the most effective manner, recognizing economic, social, and security implications. The Council 's approach to science is embodied in the new phrase “sustainability science”.

Alliance to Save Energy (AS)
The Alliance to Save Energy promotes energy efficiency worldwide to achieve a healthier economy, a cleaner environment, and greater energy security.

IIIEE
Lund University's research and education institute with focus on preventative environmental strategies and cleaner production.

Intelligent Energy Europe (EU)
Intelligent Energy – Europe is an EU programme to boost energy efficiency and the use of renewables. With a total budget of €250 million, it co-finances activities, which support the objectives of the programme and hence EU energy policy.

Sustainable Energy Europe (EU)
Sustainable Energy Europe is a campaign to raise awareness and charge the landscape of energy, campaigning a more intelligent use and production of energy in Europe.

EBRD - European Bank for Reconstruction and Development
The EBRD uses the tools of investment to help build market economies and democracies in 27 countries from central Europe to central Asia.

EIB - European Investment Bank
The task of the European Investment Bank, the European Union's financing institution, is to contribute towards the integration, balanced development and economic and social cohesion of the Member Countries.
To this end, it raises on the markets substantial volumes of funds which it directs on the most favorable terms towards financing capital projects according with the objectives of the Union. Outside the Union the EIB implements the financial components of agreements concluded under European development aid and cooperation policies.

FAO – United Nations Food and Agriculture
FAO supports energy generation from biomass.

IAEA – International Atomic Energy Agency
The IAEA is the world's center of cooperation in the nuclear field. It was set up as the world's "Atoms for Peace" organization in 1957 within the United Nations family. The Agency works with its Member States and multiple partners worldwide to promote safe, secure and peaceful nuclear technologies.

IMF – International Monetary Fund
The IMF is an organization of 184 countries, working to foster global monetary cooperation, secure financial stability, facilitate international trade, promote high employment and sustainable economic growth, and reduce poverty.

UNIDO - United Nations Industrial Development Organization
The vision of UNIDO is to improve the living conditions of people and promote global prosperity through offering tailor-made solutions for the sustainable industrial development of developing countries and countries with economies in transition.

The World Bank Group Energy Program
The program helps developing countries achieve improved access to clean, modern and affordable energy services for their poor, and sustainability in the environmental, financial, and fiscal aspects of their energy sectors. The World Bank supports these objectives through targeted interventions and assistance across the full spectrum of public and private provision of energy services.

Some of the financing programs of the World Bank:

a) ASTAE - Asia Alternative Energy Program
Is to mainstream renewable energy and energy efficiency in Asia both politically, economically and regarding RD&D. ASTAE supports a broad portfolio of alternative energy projects and activities. While lending operations are funded primarily by the World Bank and the Global Environment Facility (GEF), ASTAE has relied on a number of donors and partners to support its work program.

b) ESMAP – Energy Sector Management Assistance Program
ESMAP is a global technical assistance program which helps build consensus and provides policy advice on sustainable energy development to governments of developing countries and economies in transition.

WHO - World Health Organization
The World Health Organization is the United Nations specialized agency for health. WHO's objective, as set out in its Constitution, is the attainment by all peoples of the highest possible level of health.

WMO - World Meteorological Organization
WMO is the UN system's authoritative voice on the state and behaviour of the Earth's atmosphere, its interaction with the oceans, the climate it produces and the resulting distribution of water resources.

UNFCCC - United Framework Convention on Climate Change
Consider what can be done to reduce global warming and to cope with whatever temperature increases are inevitable. UNFCCC supports the Kyoto Protocol which has more powerful (and legally binding) measures. UNFCCC supports all institutions involved in the climate change process, particularly the COP, the subsidiary bodies and their Bureau.

WSC - World Solar Commission
A part of UNESCO promoting solar energy as a cheap and effective replacement for traditional sources of energy. Solar energy does not harm the ecological balance and is free from the greenhouse effect.

GFSE - Global Forum on Sustainable Energy
GFSE orchestrates dialogues to facilitate decision-making on policy issues in the appropriate fora, foster public-private partnerships, and promote concrete cooperation endeavors in the field

PREP - Pacific Regional Energy Programme

BASE – Basel Agency for Sustainable Energy
BASE helps to build strategic partnerships between entrepreneurs and financiers to mobilize capital for sustainable energy in both developing and industrialized countries. BASE is a non-profit foundation and UNEP Collaborating Centre.

CURES - Citizens United for Renewable Energies and Sustainability
In order to bundle their proposals and to strengthen their position, NGOs from all over the world formed a new network: "Citizens United for Renewable Energies and Sustainability". The CURES-NGOs agreed to develop common strategies and demands and drew up a declaration: "The Future is Renewable", which at that point was signed by 38 organisations. The declaration calls for avoiding dangerous climate change and for the implementation of the Millennium Development Goals. It calls on all governments not to allow themselves to be blocked any longer by obstructive governments and lists many policies and measures, such as the phasing out of subsidies for fossil and nuclear energies and effective steps and frameworks for renewable energies.

Annex II – Status for renewable energy technologies

The table below gives a brief overview of different renewable energy technologies focusing on the following issues: energy product, brief description, resource potential, economy, commercialization and technological development and important research and development field.

For a more thorough description of the technologies the following papers we refer to the following papers: "Renewables 2005 – Global Status Report" a paper made for REN21 by the World Watch Institute and the Final Report prepared for the Beijing International Renewable Energy Conference 2005: "Increasing Global Renewable Energy Market Share: Recent Trends and Perspectives"

Technology	**Energy product**	**Brief description**	**Resource potential**	**Economy**	**Commercialization and technological development**	**Important R&D fields**
Photovoltaic (PV)	Electricity	Converts sunlight into electricity. Majority of the PV cells are made of crystalline silicon today.	Huge - particularly relevant in sunny regions. The global electricity need may be covered by PV.	5-10 times as expensive as conventional "on-grid" electricity generation. However there has been a significant reduction of costs since the first PV cells were introduced and more reductions is expected. Large demand and low production raised the prices in 2005.	Large markets for PV in Germany and Japan, because of subsidies. Large niche markets for off-grid application and electrical devices. The technology is mature but not yet competitive with on-grid electricity production.	Developing 3. generation PV technologies (e.g. PEC and polymer cells) with significantly lower generation cost and material consumption. Integration into buildings and products.
Solar thermal	Heating, cooling, desalination	Uses the energy of the sun to heat water.	Huge - particularly relevant in sunny regions.	Are considered competitive with conventional energy sources in countries with favourable climates	Large markets in many countries. The technologies are generally mature, though there is still a strong potential for cost reductions by large scale production.	Storage systems.
Solar thermal power[33]	Electricity, (hot water)	Concentrate solar power to produce electricity	Huge - particularly relevant in *very* sunny regions.	2-3 times as expensive as conventional "on-grid" electricity generation.	The technical feasibility of many systems has been proven.	Need for further demonstration activities.
On-shore Wind power	Electricity	Converts the energy of the wind into electricity. Most modern wind turbines are three-bladed designs with the rotor position maintained upwind.	Huge in windy regions. Estimates show that the global wind resource potential is greater global electricity demand.	On a levelled playing field (including CO2 costs) wind power may be competitive with conventional fossil based electricity production. Cost reduction is expected.	Large markets in many countries worldwide. Mature and competitive.	Up-scaling. Aerodynamics.

[33] To this group of technologies may also be added the so-called solar tower or chimney technology, which exploits the buoyancy of hot air to produce electricity (see www.enviromission.com.au) .

Off-shore wind power	Electricity	Converts the energy of the wind into electricity. Most modern wind turbines are three-bladed designs with the rotor position maintained upwind.	Huge see above – depends on water the water depths that may exploited.	On a levelled playing field (including CO2 costs) wind power may be competitive with conventional fossil based electricity production.	Markets in several countries are developing The technology is close to being mature.	Up-scaling. Aerodynamics. Maritime technologies and engineering. Environmental impacts.
Geothermal	Electricity and heat.	Heat in steam or water is accumulated. The steam is used for electricity production and the hot water for heating purposes.	Large potential for expanded electricity production	Competitive with conventional technologies in some regions. Very depending on the resource potential.	Mature technology. Could develop into competitive commercial technology through permeability enhancement.	Expanding the volume and productivity of geothermal resources. Improving drilling and energy conservation.
Small-scale hydro power	Electricity.	Water is led through turbines where there is height difference in the water run. Provides easy regulation and storage potential.	Large, only 25% of the reservoirs are used. Large potential in ship locks and weirs.	Need secure long term prices of REs.	Mature technology.	R&D in small flow low heads applications.
Bio-energy	Electricity and heat.	Combustion for heat and/or power production. Gasification creating gas for gas turbines or hydrogen production. Anaerobic methane production.	Large in both energy crops and waste.	Competitive in some regions and for some purposes.	Mature technology but small plants and low efficiency Large scale co-firing with coal show high efficiency and low cost. Starting to be commercialized. Mature but expensive.	Improvement of cook stoves reducing fuel input and toxic air pollution. Utilizing more difficult resources: waste, energy crops and grasses. Commercializatio n and demonstration needed Upgrading methane content
Bio-energy	Fuels	Vegetable oils in adapted engines. Fermented, hydrolyzed or thermally converted into biofuels such as biodiesel and ethanol.	Large in both energy crops and waste.	Competitive in some regions and for some purposes. Can be produced cheaper than petroleum fuels cost. (Brazil)	Mature Mature Mature and cheap	Biofuel production from waste material and energy crops instead of sugar ad starch.
Ocean-energy	Electricity	Electricity generation. Tidal barrage, wave energy, tidal/marine	Large Most relevant for coastal regions.	Ocean energy systems offer the promise of low cost reliable electricity, but have not yet	Most marine technologies are considered commercially immature	Ocean systems require demonstration and a protected entry market in order to thrive

		currents, ocean thermal energy conversion, salinity gradient/osmotic energy and marine biomass.		proven their economic competitiveness.		

Figure 7: Status for renewable energy technologies. References and further reading: IEA, 2003 (*Renewable energy into the mainstream*) IEA, 2003 (*Renewables for power generation*) Beijing 2005 (*Increasing Global Renewable Energy Market Share: Recent Trends and Perspectives*).

Annex III – Fact sheets

Fact sheets have been prepared for a great part of the publications that have been used for the study. These explain on the barriers and solutions identified in the individual reports/paper. The fact sheets are included in this annex.

Title	How to support renewable electricity in Europe? An assessment of the different support schemes
Year of publication	2005
Author	EU Commission
Literature source (journal)	EU Memo, see: http://europa.eu.int/comm/energy/res/biomass_action_plan/green_electricity_en.htm
Barriers identified	The paper identifies four types of barriers, which project developers face: • *Financial issues* • *Administrative issues.* Lack of coordination between different authorities. Long lead times to obtain permits. Insufficient spatial planning. • *Grid issues.* When pricing is unreasonable and not transparent, for example because of vertical integration and dominant utilities. • *Social issues*
Proposed solutions	Experiences with different support schemes (feed-in tariffs, green certificate markets, tendering and tax incentives) are discussed. To asses their performance two criteria are used: effectiveness (Are the RE technologies deployed?) and efficiency (deployment at lowest cost). No final or general conclusion is made on which system is the best - however feed-in shemes are praised for being effective and providing certainty for investors (low risk premium). In general the Commission finds that support schemes should be based on two pillars: 1) Cooperation between different national support, which should be the first step to towards a harmonisation in the long-term. 2) Optimisation of the national schemes. The optimisation should concern (among other things): - *Increasing legislative stability and reduction of investment risk,* for instance by avoiding systems with a stop-and-go nature. - *Streamlining of administrative procedures*, by using clear guidelines, one-stop authorisation agencies, pre-planning mechanisms. - *Grid issues and the transparency of connection conditions*, for instance by planning and developing transmission reinforcements in advance, and by making the principles of cost bearing and sharing fully transparent and non-discriminatory. Furthermore by making the grid operators cover the costs of infrastructure development - *Encouragement of technology diversity,* by making the support schemes flexible so as to support different technologies (for instance off-shore wind power although on-shore wind is more cost competitive) - Use the *possibilities of tax exemptions and reductions* which may be offered to RE under the directive on the taxation of energy products - Encourage local and regional benefits of RE (e.g. employment and rural development)

Relevant programme activities	Study on pros and cons of harmonising RE support schemes.
Other conclusions	-

Title	Barriers to renewable energy penetration; a framework for analysis
Year of publication	2001
Author	Painuly J.P., UNEP Collaborating Centre on Energy and Environment
Literature source (journal)	Renewable Energy 24 (2001), p. 73-89
Barriers identified	- Cost-effectiveness - Technical barriers - Market barriers, including inconsistent pricing structures institutional, political and regulatory barriers - Social - Environmental barriers Some barriers may be specific to a technology, while some may be specific to a country or a region. A comprehensive list of possible barriers may be found on pages 79-80.
Proposed solutions	The paper proposes a framework that may help in selection of renewable energy technologies and identifying all the important and relevant barrriers to a renewable energy technology in a specific country or region. The process of barrier identification starts with selection of RETs for the study of barriers through a literature survey on RETs and related projects in the country. The study of barriers and measures to overcome the barriers should be carried out using a literature survey, site visits and interaction with the stakeholders. The stakeholders include the RET industry (manufacturers of plant, equipment and appliances, owners of plant), consumers, NGOs, experts, policy makers (government), and professional associations. The response from stakeholders can be obtained through structured interviews or questionnaires. It is important that all the relevant barriers are considered and their dimensions are revealed during the interaction with the stakeholders. Barriers may be addressed directly at the micro level or indirectly at the macro level – creating conditions for the market to act. For example, setting up information centres, establishing codes and standards etc. address the barriers directly, whereas increasing energy prices through pollution taxation addresses the barriers indirectly.
Comments/ Other conclusions	The article notices that the Global Environment Facility set up an operational programme during execution of its second tranche to support projects for the removal of barriers to renewable energy in developing countries. It includes many relevant references to other reports and paper

Title	Effectiveness through risk reduction: a comparison of the renewable obligation in England and Wales and the feed-in system in Germany
Year of publication	2006
Author	Mitchell , Bauknecht D, Connor PM
Literature source (journal)	Energy Policy 34 (2006), p. 297–305
Barriers identified	The paper analyses two new renewable energy support mechanisms in detail: the England and Wales RO (Renewables Obligation) and the German EEG (Erneuerbare Energien Gesetz), with a particular focus on how they reduce risk for generators. Three kinds of risks are analysed: price, volume and balancing risk. Reducing risk for generators is important because risk has a price. Reducing risk can make a larger number of projects attractive, mainly because lowering risk reduces the cost of capital. For the same reason, risk reduction is also one way of increasing the efficiency of a support mechanism, and mitigating risk is an alternative to raising the level of compensation.
Proposed solutions	The paper argues that the German EEG is more effective at increasing the share of renewables than the England and Wales RO because it reduces risk for renewable energy generators more effectively. Furthermore although feed-in systems may still not be as efficient in the short term, they do provide long-term stability, incentives and resources for innovation leading to efficiency improvements in the long term (dynamic efficiency). Decreasing feed-in tariffs can be used to pass on some of the cost-savings resulting from these improvements to those who pay for the feed-in mechanism. The German system is found to be superior with regard to: 1) price risk (because renewable energy generators are guaranteed a fixed price) 2) volume risk (because the network operator is obliged to accept all renewably generated electricity) 3) balancing risk (because renewable energy generators are paid at a fixed rate irrespective of the load profile) The latter on the other hand may be a problem because the generators do not have incentives to act in the market for balancing power.

Comments/ Other conclusions	

Title	Renewable energy policies and barriers
Year of publication	2004
Author	Fred Beck and Eric Martinot
Literature source (journal)	Encyclopedia of Energy
Barriers identified	A wide range of barriers are identified in the paper – focusing particularly on utility owned system. Barriers are divided into three groups: *1) Cost and pricing.* Subsidies for competing fuels, the high initial capital costs of RE, environmental externalities, high transaction costs because RE projects are usually small. *2) Legal and regulatory issues.* Lack of framework for IPPs, siting and spatial planning, grid connection issues, liability issues of small generators 3) Market performance. Access to credit, risk issues of new technologies, lack of technical skills.
Proposed solutions	The paper describes experiences with different deployment strategies, but makes no actual recommendations. The paper explains experience with different RE promotion policies: US PURPA, Electricity feed in laws in Germany, the UK NFFO, renewable energy portfolio standards and green certificate markets. Different cost reduction policy initiatives are described: subsidies and rebates, different forms of tax relieve and loans and grants. Different market facilitation initiatives are described including building code standards, spatial planning, equipment standards, industrial locational incentives, education incentives. The significance of restructuring policies is explained. There are pros as well as cons of liberalising energy markets for renewable energy. Focus on costs and short time horizons of investments may decrease incentives to invest in RE, whereas privatisation may also provide new sources of financing Different policies aiming at increasing distributed energy generation may favour RE. These include net metering and real time pricing (benefiting for instance PV which produces in peak hours).
Relevant programme activities	Many of the barriers identified may be converted into programme activities aiming at overcoming these barriers, for example: - Spatial planning - sharing experiences of various countries with different technologies - Best practice on grid connection regulation of small scale (RE) technologies, ensuring fair conditions that

	the benefits of distributed energy generation are taken into accounts. - Equipment standards - Construction and design standards, including building code-standards (for example for PV) - Education incentives (international programmes)
Other conclusions/comments	The paper provides a good overview of the different barriers facing renewable energy deployment and a comprehensive description of experiences with different incentives (in the broad term) in different countries. Focus is primarily on barriers in regulated systems, which have not been unbundled/liberalised (utility). Lacks focus not the cost-effectiveness of different incentives.

Title	Financial measures by the state for the enhanced deployment of renewable energies
Year of publication	1998
Author	Gutermuth P
Literature source (journal)	Solar Energy
Barriers identified	Market prices in most cases do not reflect environmental harm or similar damage. Furthermore: - Subsidies for competing fossil fuel technologies - Renewable energy technologies usually have high investment cost making financing difficult
Proposed solutions	- Internalisation of environmental externalities in energy prices - Financial support schemes for RE - Removing subsidies for conventional technologies - Eliminate rates, charges and billing procedures which are not fair to renewable energy technologies - Preferential loans and guarantees. Low-interest loans and to small and medium sized companies using RE. Some fundamental principles for all types for subsidies are outlined: - subsidies should be temporary - but incentives should be spread over time to facilitate planning by producers and investors - elements of competition should be included - subsidies should be regularly reviewed to avoid windfall profits
Relevant activities	The paper concludes, that “it is useful to take account of information from the experience gained in a number of countries. In the interest of the greater use of RES, it would be highly constructive for information from such experiences to be systematically analysed and made available more so than is now the case.” On this background a relevant activity may be a knowledge sharing and dissemination within IEA countries focusing on experiences with different financial support mechanism – for instance leading to a common perception of best practice of financial support for RE.

Comments/ Other conclusions	Relevant question are raised in the article, but also questions which many other papers have dealt with before and since.

Title	EU Communication - The support of electricity from RE sources
Year of publication	2005
Author	EU Commission
Literature source (journal)	http://register.consilium.eu.int/pdf/en/05/st15/st15745.en05.pdf
Barriers identified	Monopolies (vertically integrated) may hamper the development of RE. Administrative barriers. - Large number of authoritites involved and lack of coordination between them (one-stop authorisation agencies would decrease this barrier) - Long lead times to obtain permits (clear guidelines for authorization procedures, lighter procedures for small projects) - RE insufficiently taken into account in spatial planning (pre-planning is recommended, i.e. preparing for RE plants) Grid access issues: - Rules for bearing and sharing grid investment cost are not transparent.
Proposed solutions	Well functioning liberalised and unbundled electricity markets are important for the promotion of RE. This includes: - Truly independent TSO and DSOs - Fair grid access to all producers - Developing network infrastructure according to long-term strategies, which take RE into account Measures for better integrating intermittent energy sources: - Better prediction of wind power - Time of gate closure (market) closer to the operating hour - Fair charging of balancing costs - Demand response (mentioned in annex 5) - Stronger interconnections between countries Transparent rules for bearing and sharing grid investment cost. Good practice can be found in Denmark, Finland, Germany and the Netherlands. Better planning and overall management of networks is needed (reference to the Trans-European Energy Network Programme) Harmonisation of RE support schemes among EU member countries may be useful for the promotion of renewable energy. However, there are also disadvantages of harmonisation, for example will member states which import RE-certificates to be

	unwilling to pay if they do not enjoy the benefits in the shape of The communication notices, that the EU directive on renewable electricity (2001) addresses some barriers by requiring member states to: - provide better grid access for RE technologies - streamline and facilitate authorisation procedures - establish a system of guarantees of origin
Relevant programme activities	Programme activities may be derived directly from the discussion of solutions in the paper. These may concern: - Cooperation between authorities on best practice in relation to unbundling: having truly independent TSO and DSOs, market setup (gate closure, balancing costs), grid cost sharing, transmission capacity planning. Could be carried through as a “RE policy road show”. Other activities of relevance: - Projects on better prediction of fluctuating energy sources (primarily wind power) (such projects are already being carried out). It is questionable if this in an obvious task for the RETD IA. - Providing publicly available data for analysing cross-national interconnections. Cooperation between energy authorities. - Activities promoting demand flexibility (such activities are already being carried out in other IEA projects) - Spatial planning – dissemination of best practice, including the idea of pre-planning for RE plants.
Other conclusions/comments	The communication is a response to the EU RE electricity directive from 2001, which requires the Commission to follow up on the experience gained with RE support schemes in the different member states. The report includes a comprehensive analysis of the effectiveness and efficiency of RE support schemes for different technologies and different EU countries. The communication lists the main benefits (drivers) for promoting RE: SOS, competitiveness of industry, GHG, local pollutants, economic/social/rural. The communication mentions that, the Commission in 2005 launched a public consultation process on how barriers were perceived by RE project developers and investors. The above mentioned barriers are based on this analysis.

Title	Increasing Global Renewable Energy Market Share: Recent Trends and Perspectives
Year of publication	2005, 1. November
Author	By an international Expert Group for the Beijing International Renewable Energy Conference 2005. Sponsors include UNDESA, New York, UNF and German Ministry of Environment
Literature source (journal)	-
Barriers identified	- higher relative cost of RE technologies in many applications - lack of mature markets, favourable policies and regulatory and legal framework - subsidies for fossil fuel technologies - inadequate institutional capacity with regards to design, development and implementation (potential activities) and skill and knowledge - financing (capital markets) - lack of awareness and understanding of benefits - spatial planning and grid connection - inadequate demonstration activities - high transaction costs (due to RE's small scale nature) - insufficient international cooperation and technology transfer
Proposed solutions	Experience with different forms of policy support is elaborated on (ch. 3) making use of concrete experiences from a variety of countries (more descriptive than analytic). A comprehensive description of RE financing mechanisms is given. Many sources and types of financing are available: carbon finance (CDM), SME finance, end-user finance, national government programmes, international & local financial institutions (commercial), multilateral development banks, bilateral development banks and international agencies (e.g. GEF and UNDP). Capacity building at different levels: - Technology level (*supposedly covered through the different RE IA's*) - Institutional level (formulation, implementation and enforcement of effective policies and programs) - Business level (business planning and support services) - Individual level (consumer awareness) International cooperation on: 1) Policy Development 2) Capacity building 3) Technology transfer 4) Joint R&D and demonstration 5) Financing 6) Reduction of trade barriers (themes from Bonn conference, see. P. 62)

Relevant programme activities	Capacity building at the institutional level (may be particularly relevant for developing countries). Capacity building could have different forms: road show, training/twinning, excursions to countries with best practice. Capacity building at business level. E.g. training programmes between different companies. Very important to ensure that the above activities are additional to existing programmes. Ch. 5.3 and 6.3 explain about (some?) of the many existing activities. Financing: Technical assistance and support targeting finance and banking sectors (particularly in developing countries). Common rules by the WTO on technical standards for RE equipment.
Other conclusions / comments	Includes an interesting chapter (2) on the status and perspectives of the most important RE technologies.

Title	Renewable Energy into the mainstream
Year of publication	2003
Author	IEA
Literature source (journal)	-
Barriers identified	
Proposed solutions	A five step strategy is outlined to increase RE penetration: - Accelerate technology development - Strengthen national policy framework (that reflect the values of RE) - Reduce market barriers and industry start-up costs (e.g. trade barriers) - Mobilise market investment (provde information on market opportunities) - Promote international cooperation
Relevant programme activities	
Other conclusions	Gives a compact description of the most relevant RE technologies. Good background info for a technology status chapter.

Title	Renewables for power generation
Year of publication	2003
Author	IEA
Literature source (journal)	-
Barriers identified	The report includes a comprehensive description of various RE technologies for power generation. For each technology "issues for further progress" are described: *Small-scale hydro power*: standardisation of turbine manufacturing, procedures for gaining permission, *Solar PV:* Standards and codes, planning and connection restrictions, lack of information and understanding of the technology, finance solutions and confidence building in the finance sector. *Concentrating solar power:* multiple projects in a "solar park" to reduce O&M, engineering and development costs, financing *Bio power:* standardises solid biofuels, analyses to assess public benefits, education and information *Geothermal power:* dissemination of information at various levels, Codes and standards should be developed with respect to grid access and connection. Local restrictions concerning permits and land use could be reduced by clear rules. *Wind power:* Internationally accepted requirements for power performance, safety, noise and other environment-related conditions should be developed in order to reduce trade barriers and administrative and installation costs. New locations, especially offshore and in non-surveyed terrain, should be mapped and assessed to reduce the visual impact on sensitive populations.
Proposed solutions	
Relevant programme activities	Standardisation, spatial planning, grid connection, financing, information to the public and to investors, international environmental requirements on safety and noise etc.
Other conclusions	Interesting table 1: *Focal Points for Policy Intervention in Renewable Energy Technologies,* showing the benefits of policy intervention for RE in the different development phases. Interesting maps showing the global potential of different technologies (p. 100-101)

Title	Market development (Wind energy – the facts – volume 5)
Year of publication	2004
Author	EWEA (European Wind Energy Association)
Literature source (journal)	EWEA website
Barriers identified	The benefits of wind power are taken sufficiently into account of in the current regulation of energy systems. Distribution and transmission grids in many countries are not robust enough to support large penetration of wind power.
Proposed solutions	Environmental taxes. Payment mechanisms (second best option) Voluntary systems and green markets (but they seldom have a noticeable impact). A precondition for a well-functioning internal market in renewable energy is that rules and regulations relating to wind turbine investments are harmonised. Harmonisation of rules and regulations, e.g. in relation to grid access conditions, tax treatment, safety standards, etc., the market will be distorted. Planning procedures and fair grid access at reasonable cost is of equal importance to the development of wind power and other renewable energy technologies Successful countries are characterised by substantial inward investment by suppliers who see a future market in that country, and who see the benefits of local supply.
Relevant programme activities	Activities aiming at harmonisation of rules and regulation, standards etc.
Other comments conclusions	Comprehensive analysis of pros and cons of different support schemes (tendering, certificate markets, price premium etc.)

Title	Large-scale deployment of Re for electricity generation
Year of publication	2005
Author	Karsten Neuhoff
Literature source (journal)	Oxford review of economic policy
Barriers identified	Mature technologies: high up-front costs and local site issues Emerging technologies: cost reduction through market experience R&D phase technologies: Public RD&D support Settlement systems for imbalances (wind and solar) and planning horizon (often approx. 24 hours) in liberalised markets. Inadequate internalisation of externalities in energy prices. Vertically integrated companies have incentives to obstruct the entry of RE if they take market shares from their conventional generation assets. In liberalised markets electricity producers are exposed to electricity prices risks inducing them to charge a risk premium on their capital. This particularly disfavours RE technologies which are often capital intensive. (This risk could be eliminated by long-term contracts between final consumers and generating companies). Inadequate spatial planning Mechanisms which expose investors to regulatory risk or uncertainty about future market design. Standardisation (e.g. of power electronic equipment for wind power plants).
Proposed solutions	Support for RE technologies (investment subsidies at first, later price support, for RE generators it is important with long-term guarantees). Demand side response (as response to fluctuation in generation) International agreements supporting strategic deployment of several RE technologies. Might be preferable to foster agreements for individual technologies. Partnerships with developing countries, for example facilitated by export credits guarantees for renewable energy tecgnologies.

Relevant programme activities	Financing: An activity examining the possibilities of consumers or consumer franchises making long-term electricity purchase agreements with renewable energy generators. Particularly relevant in liberalised energy markets to avoid unnecessary risk premiums stemming from uncertainty about future electricity prices.
Other conclusions	Interesting figure 1 showing the global potential of Re for electricity generation in a single graph.

Title	The sustainable diffusion of renewable energy technologies as an example of an innovation-focused policy
Year of publication	2005
Author	Theocharis D. Tsoutsos and Yeoryios A. Stamboulis
Literature source (journal)	Technovation 25 (2005) 753–761
Barriers identified	In the paper the following barriers to technological regime shift to renewable energy are recognised Technological factors - Technological immaturity - Interaction with exiting systems - Interfaces between subsystems - Learning and unlearning Government policy and regulatory framework - Unclear messages - Regulatory barriers to new technologies - No risk taking in the political cost of vested interests Cultural and psychological factors - Not established as a reliable alternative - The electricity- and oil-based culture is identified with comfort and ease - Unfamiliarity - Possible failures or bad examples lead to scepticism - The temporally variable nature of some renewable sources Demand factors - No specific expectations of the use and value of renewables - User demands adjusted to fit the new technologies - No willingness to trade comfort and low cost for reduced environmental impact Production factors - Devaluation of exiting facilities: from centralized to decentralized - Competencies in existing technologies would become obsolete Infrastructure and maintenance - Network incompatibility - Maintenance needs change - New agents enter the system - Sunk costs may be high Undesirable societal and environmental effects - Conflicts may arise over the deployment new installations Economic factors - Shift in economic rationale - “Sailing ship” effect

	- High initial investment - Slow take-off of new technologies
Proposed solutions	To ensure the diffusion of renewable energy it is important to view the RET's as a different system I respect to the conventional energy system. Niches in the energy markets are a good way to get the RET's started. Finding the right niches is the big challenge.
Relevant programme activities	
Other conclusions	

Title	Sektoranalyse for husdyrgødning og biomasseteknologi Analysis of the manure and biomass technology sector.
Year of publication	November 2005
Author	Kent Nielsen, Handelshøjskolen i Århus, Aarhus School of Business
Literature source (journal)	-
Barriers identified	
Proposed solutions	From experiences from other export technologies in Denmark, this report presents the importance of the following topics when setting off new technologies. - Critical mass ublic and private research - Plenty and highly educated labour and tailored educations offers - Entrepreneur culture – critical mass of new companies - Critical mass of companies – big companies as a motive power - Physical settings (science parks, innovation environments etc.) - Qualified venture capital - Advanced infrastructure - Advanced users - Development co-operation between private and public institutions - Challenging legislation
Relevant programme activities	
Other conclusions	

Title	Policy Recommendations for Renewable Energies
Year of publication	2004
Author	International Conference for Renewable Energies, Bonn, drafted by Thomas B. Johansson et.al.
Literature source (journal)	Report with conclusions from Conference
General assessment with respect to RETD project	The paper is of great importance to the RETD. The issues addressed are market framework and policy instruments that are essential to establish a level playing field for RE in the energy markets and to promote RE. The paper provides guidance for international organisations, national governments, financing bodies, local authorities, and other stakeholders.
Barriers identified	The paper discuss policies for RE markets based on a discussion of drivers, market barrriers to RE, and the need for including external costs and benefits, but does not address individual REs. A lot of market oriented barriers are mentioned in the paper. Examples: - subsidies to conventional energies - lack of accounting for external costs and benefits in market conditions
Proposed solutions	The report contains a large number of recommendations on policies to pursue at various levels of decision making. The report represents a catalogue of ideas for promoting RE. A comprehensive list of all the proposals (in head-lines) is listed below. Summary of "Policy Recommendations of Renewable Energies", Bonn 2004 (in bullets). I. Policy Background • Follow up to World Summit on Sustainable Development • Benefits of RE differs from country to country • RE can provide many energy services (7 mentioned) • Opportunity for orienting investments towards RE II. Policy Priorities for RE a. Establishing Policies for RE markets • Levelling the playing field by • removal of subsidies to conventional energies, and • including external costs and benefits in market conditions b. Expanding Financing Options for RE • Enact policies to reduce costs of RE through increasing cumulative investments and R&D in RE technologies • Feed-in tariffs (Pricing-systems) for RE • Renewable portfolio standards (quota systems)

	• Specialized funds/mechanisms – GEP, CERs, CDM etc • Micro-funding • Include RE in other sectors c. Developing Capacities for Increased Use of RE • Well-trained workforce • Coherent and functioning institutional framework • Provision of available, appropriate, and affordable RE III. The Role of National Governments a. Domestic Policy • Develop Energy Policy-emphasize on RE and sustainability • Clear goals and targets for RE • Transparent market conditions that encourage RE • Establish a level playing field (economic and legal means) • Address high costs of RE (subsidies) • Create temporary incentives (pricing and quota systems) • Integrate RE in non-energy policies and cross-section issues • Increase public awareness of potentials, costs and benefits of RE • Promote development of human capacity for RE • Develop enabling institutions • Use international organisations to set the agenda for RE • Utilize Kyoto Protocol mechanisms • Strengthen global cooperation in RE • Secure grid access for RE • Support RE for heating and cooling purposes b. Policy Options primarily related to Industrialized Countries • Increase funding for RE R&D&D • Focus development assistance on catalytic funding of RE • Promote RE through Export Credit Agencies • Utilize the power of public procurement c. Policy Options primarily related to Developing Countries • Provide access to cleaner cooking fuels • Provide access to electricity • New financing tools (i.e. micro-credit schemes etc.) IV. The Role of Intergovernmental Organisations • The UN system should define clear responsibilities for RE • WTO rules should promote RE • Include funding of RE in development cooperation programmes

- Increase leverage for RE investments through International Finance Institutions (IFIs) lending
- IFIs should
  - Establish clear objectives for RE
  - Provide dedicated funds to increase RE
  - Apply full cost accounting for IFI lending
- Increase transparency of RE activities
- Strengthen the Global Environment Facility's Portfolio
- Emphasize leadership role of regional organisations
- Straighten and enhance the cooperation for RE
- Strengthen institutional arrangements at international level

V. The Role of Local authorities, Private sector, Civil Society and Other Stakeholders

a. Local Authorities
- Establish local building codes
- Strengthen stakeholder involvement in licensing and siting
- Utilize the power of public procurement
- Establish private-public investment funds
- Address energy issues in other areas of local action

b. Business and Private Sector
- Incorporate corporate social responsibility into business
- Facilitate intra-firm technology transfer in RE solutions
- Specifically RE policies are important in three sectors:
  - Energy producers and traders
  - Finance and insurance
  - Energy customers/consumers
- Energy producers shall:
  - Pursue development of RE
  - Commit publicity to "green" energy
  - Help create incentives for RE
  - Invest in RE as a key industry strategy
- Finance and insurance shall:
  - Treat RE investments fairly
  - Provide finance for RE investments
  - Offer risk-hedging tools for RE investments
  - Pay attention to RE in developing countries
- Commercial and industrial energy consumers shall:
  - Recognize the range of benefits of using and marketing RE

c. Civil Society
- Use the power of consumers to develop and

	expand RE markets • Strengthen civil society's role in decision-making on sustainable energy solutions • Make use of the potential of NGOs • Increase awareness through the mass media d. Research and education • Focus curricula on new challenges (with respect to RE) • Strengthen RE research Although the list is long, not all questions of interest for RETD are addressed in the report or they are addressed in a superficial way. Enhancing deployment of RE by cross-boarder initiatives (i.e. EU) is addressed, but not very deeply. The report does not contain any list of literature
Relevant programme activities	The above list could be used as a kind of check-list for deployment activities to pursue. Another list of interest would be a mapping of IEA-activities performed so far on RE-deployment. RETD activities could include ("5 shots from the hip"): 1. Development of a level playing field for RE on energy markets 2. Best practice – assessment of the value of RE-demonstration 3. Economic and legal instruments for deployment of RE 4. Financing RE investments – risk-hedging tools 5. Non-member countries - providing assistance and support The proposals above should be perform together with various partners that are relevant for the study in question.
Other conclusions	It is of importance to include a study of the state-of-the-art of policy measures that have been implemented in various countries and to what extent they are active. IEA have a database about national policies, which might be useful.

Annex IV – Main options to handle intermittency

Introducing large amounts of renewable energy generation increase the need for international collaboration on security of supply and preparedness and greater collaboration between the system operators. To handle intermittency the following main options are often discussed (IEA 2005: 26, Variability of wind power and other renewables, Elkraft System 2005):

- Power plants providing operational and capacity reserve, including from distributed generation. When large amounts of wind power capacity are introduced in power systems the pattern of operation in the electricity system changes because the fluctuating nature of the wind leads to price fluctuations in the market. These price fluctuations will signal a need for flexibility and regulation capacity of other plants.
- Interconnection with other grid systems. The deployment of wind likely to increase the need for cross-border trade in power and stronger interconnectors (EU 2005, RE comm.., p. 9-10). Changing electricity prices will make it more attractive to invest in interconnection capacity between market areas.
- Demand response. Many literature sources have pointed out that there is a great potential for increasing demand response. At Nordic level, the potential for demand response is estimated at 12,000 MW corresponding to about 20% of peak-load consumption in the Nordic countries (Nordel, 2005). Also heat pumps and electric boilers would be of value to the electricity and heat system in the event of a significant expansion in the form of wind power because they could utilise the electricity production when electricity prices are low. Electric boilers and heat pumps will also be able to deliver cheap and fast regulating/balancing power. IT for metering, communication and dynamic optimisation will play a vital role to exploit the potential for demand response.
- Electricity storage. Obviously electricity storage technologies will be effective to even out wind generation. However batteries, compressed air storage technologies etc. are still relatively costly, primarily because of their high capital costs. In a long-term perspective, hydrogen is nominated as a storage alternative. Using hydro power plants for electricity storage – withholding generation when the wind is blowing and producing when it is calm – may on the other hand provide cheap and efficient electricity storage (when available). Also integration with the transport sector utilising the batteries in electric cars (possibly hybrid plug-in cars) could become interesting in the longer term.
- Improve the tools used to forecast wind power generation. In many countries with liberalised electricity markets renewable energy generators have to predict their production, just like other electricity producers. The more firm this prediction is, the greater the value of intermittent renewable energy sources. Better wind power prediction tools would give the other market players a longer notice time to adjust their generation and reduce the demand for balancing power for wind plant owner. Advanced tools have been developed for this purpose. There is however still scope for improvements (Elkraft System, 2005)
- Curtailment of intermittent technology. As a last resource it may be necessary to curtail wind power generation in situations with low demand and much wind.