THE WORLD ENERGY OUTLOOK AND THE ROLE OF INTERNATIONAL ENERGY TECHNOLOGY CO-OPERATION

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ABSTRACT

The IEA was established after the 1973 oil shock as an independent international organisation to safeguard energy supplies through collective actions between countries. One of the most important tools doing this is the IEA technology programme which currently includes some 40 multilateral collaboration projects, called Implementing Agreements, covering most relevant technology aspects of energy supply and end use.

Present IEA World Energy Outlook forecasts a continued growth in world energy demand and in a continued dependence on fossil fuels as the primary fuels. Projected green house gas emissions in 2010 are thus 35-50 per cent above the 1990 level. Increased use of Renewables will be necessary to change this negative trend and to reach the long term goal of a sustainable energy system. The developments of many Renewables are promising but R&D-efforts and market experiments must continue in order to increase their shares of total energy supply.

Geothermal energy[1] plays an increasingly significant role in many countries. However, there is still huge untapped potential in both developed and developing countries. The new IEA Implementing Agreement on Geothermal Energy Research will be a vital new tool strengthening the international cooperation in geothermal energy research and thus in the development of geothermal energy as a commercial environmentally sound energy source.

[1] Geothermal energy is in this paper included in the Renewable Energy concept, even if geothermal resources strictly speaking are not renewable on a human time scale.

1. INTRODUCTION

During the last couple of years there has been a growing awareness of the need to change today's fossil fuelled-based economy into one which mainly relies on more environmentally sustainable energy sources. This will be a long term process and encompass a multitude of actions concerning supply and use of energy.

As in every large scale societal change technology will be a key driver for this process. But technology does not develop in a vacuum. It develops because the people, the knowledge, the sufficient money - and most important- the determination to succeed is there. In some cases this can be an entire market driven process. This is typically the case for less radical technological development. In other, typically where the risks are higher or where there are externalities which the market price mechanism does not take into account, there is a need for public support to the R&D-process.

The overall objective of this paper is to show how the new IEA international collaboration project on Geothermal energy research and technology will provide a means to accelerate the progress of geothermal energy technologies. Doing this, it focuses on three topics:

- The operations of the International Energy Agency and its multilateral technology programme
- Renewable energy technologies' role in the future world energy supplies
- The importance of Geothermal energy research and development

2. The Operations of the International Energy Agency and its Multilateral Technology Programme

The International Energy Agency

The International Energy Agency is an international governmental organisation which was created in 1974. The IEA is the energy forum for 23 industrialised countries, including the USA, Japan, all 15 European Union Member Countries, three other European countries, Turkey, Australia and New Zealand. The IEA is also to an increasing degree giving attention to issues in non-member countries as their importance in world energy supply and demand issues is increasing.

The establishment of the IEA was in response to the first oil shock to ensure its Members' collective energy security. At that time, the essence of energy security was seen as an uninterrupted oil supply. Attention focused primarily on developing emergency preparedness measures to respond to a major disruption in the international flow of crude oil, and on promoting long-term cooperation and research and development activities among Members to reduce their dependence on imported oil.

While these activities continue today as fundamental elements of the Agency's work, they have been complemented in recent years by increasing awareness of the significance, for energy policy and for energy security, of two further factors: concern over the environmental impact of energy-related activities, and the growing globalization of energy issues, as different countries' economies and energy markets become increasingly interdependent. This includes international collaboration on environmental impacts of energy-related activities and co-operation with non-IEA countries.

Some of the more noticeable outputs of the IEA include:

- reviews of member and non-member countries' energy policies
- policy studies on important energy policy relevant topics
- production of energy statistics and a monthly oil market report, both regarded as the landmark in their areas
- fostering international collaboration in energy technology.

The IEA energy technology collaboration has three cornerstones:

- annual reviews of national energy technology policies and R&D-programmes

The IEA experts review the effectiveness of present policy programmes and suggest improvements. To increase the impact the work is done in close co-operation with the government in the reviewed country.

- sponsoring of state-of-the art reviews and conferences on promising energy technologies

This include a multitude of activities often done in parallel including publication of reports, preparations of conferences,

presentations and suggestions for further actions from involved parties.

- providing a framework and secretariat legal and administrative support for international collaboration on energy technology research, development and demonstration, or the exchange of information.

The IEA role is to identify areas of co-operation and then support the researchers in the establishment and management of the research co-operation. The IEA also manages a review process of the agreements to increase the effectiveness of the co-operation.

The IEA Energy Technology Collaboration Programme

The IEA Energy Technology Collaboration Programme provides a framework for experts to work co-operatively and share results. Each project is set up under an Implementing Agreement which provides the legal contractual mechanism for establishing the objectives of the projects and the rights and commitments of its participants.

There are presently around 40 active IEA Implementing agreements, each with between three and twenty countries participating. As an average there are 10 Participants in Each Agreement, and thus in total around 400 participants, directly coordinating research expenditures of more than USD 100 million per annum. Thus, the Implementing Agreement provide very substantial leveraging of domestic expenditures.

There has been a strong emphasis over the last five years to strengthen the participation of Non-Member countries and it is with great delight that we see the Republic of Korea, the Russian Federation, China, Brazil and many more participating in implementing agreements. Almost half of the implementing agreements now have participants from non-IEA member countries.

The types of benefits from participating in an Implementing Agreement typically include sharing costs, pooling resources, and avoiding unproductive research paths. Further, participants are able to spread the risks associated with the choice of research priorities. These outcomes of collaboration enable the research and development objectives of national energy technology programmes to be better achieved at lower cost. International collaboration also has important benefits for technology demonstration and diffusion, disseminating information about the latest technological developments and their commercial utilisation.

The success of the Technology Collaboration programme is shown by the fact that the number of Implementing agreements as well as the number of participants and projects constantly grows. Since 1991 the number of participants has for instance increased by 40 per cent.

3. Renewable Energy Technologies' Role in the Future World Energy Supplies

The world energy outlook

The IEA annually publishes its perspective on Global Energy Demand and Energy Supply issues in its World Energy Outlook (WEO). The 1996 edition tells a rather clear story of energy growth and increasing carbon dioxide emission from now to 2010.

Prognosticating the future is an insecure activity and therefore the IEA uses two cases in its energy forecast. The Capacity Constraints case is based on historical trends in energy-use improvement and on increasing energy prices. The Energy Savings case combines high efficiency in energy use with flat energy prices. Here follow some highlights from the outlook:

- World primary energy demand is expected to continue to grow. Between 1993 and 2010 the growth is projected to be between 34 and 46 per cent.

- Fossil fuels will continue to be the word's primary fuel and will account for nearly 90 per cent of total primary energy demand in 2010.

- The main growth-area will be China and South-East Asia where the energy demand could more than double by 2010. Coal -- the most carbon intensive of all conventional fossil fuels -- will continue to be the major fuel in this high-growth area.

- World oil demand is projected to rise from 70 million barrels per day at present to between 92 and 97 million barrels

per day in 2010. Furthermore, OECD oil import dependence will continue to rise from 50 to around 60 per cent.

The implications for increasing greenhouse gas emissions from this development are clear:

- By 2010, world carbon emissions could be between 36 and 49 per cent above their 1990 level.
- CO_2 emissions in Rest of the World countries are likely to have overtaken those in the OECD countries by 2010.
- The increase in China alone will be of the same magnitude as for the whole OECD-region.

The scope for renewables

The picture presented above may look a bit bleak in terms of meeting the goals set out for instance in the UN Framework Convention on Climate Change. But there is also a good side of the World Energy outlook in the context of Renewable energy. With a primary energy demand expected to nearly double over the next fifteen to twenty years there is ample room for technologies that become competitive.

And further, a lot of interesting things are happening out there right now. We are seeing growth in the contributions of renewables to commercial energy supplies. Renewables, mostly in forms of hydropower and biomass, contribute about 18% to the world's electricity needs today. Excluding large-scale hydro and biomass use, the current contribution of all other renewables is about 2%.

Recent case studies on renewables applications across OECD countries indicate that the cost of delivered energy from renewable energy plants are generally falling and, already today, many technologies can be economic in selected markets and selected regions.

- According to *World Energy Outlook* energy produced from new renewable energy sources is expected to grow at an annual average rate of almost 10 per cent until 2010 in IEA countries.
- The *World Energy Council* predicts that by 2020 the contribution of renewables to world energy supplies will rise to over 20 per cent under current policies; they suggest that under ecologically driven policies the renewables contribution to energy supplies could even rise to almost 30 per cent by 2020.
- Even stronger growth is predicted by the *UN* in its 'Blue Book' which assumes that renewable's share of world electricity production could be 60 per cent by 2050.

Key Issues for Renewables

How the development and market deployment of Renewable energy technologies can be enhanced is discussed in the forthcoming IEA-publication *Renewable Energy Technologies: Key Issues In Developing Their Potential.* This report argues that there are clear motives why an increased deployment of Renewables will be possible as they have additional benefits which are being increasingly recognised at both the national and the local level.

- Renewables' modularity makes it possible to tailor them to particular needs and circumstances, making them particularly valuable for niche markets, where the energy requirements are small and therefore the costs of conventional electricity supply, either through grid extension or by diesel-generator sets, are high.
- Production and end-use of renewable technologies can offer prospects of increased employment opportunities particularly in non-urban areas and can offset energy imports.
- And of course there are various environmental benefits associated with the use of renewables, in particular with respect to global warming and acid rains.

However, there are also several, mainly economic, barriers to enhanced use of renewables

- Lack of market confidence: By building up a substantial track record some renewable energy technologies are starting to prove their cost-effectiveness and reliability in the commercial market.
- Limited utility interest and involvement in integrating renewables into supply networks on an appropriate timescale.

- Limited industrial and manufacturing industry interest in development and demonstration programmes.

- Limited financing options for Renewables projects. Some characteristics of Renewables deter investors: Renewables installation costs (initial costs) are higher per kilowatt than those of fossil fuel sources - even when lower operating costs make the Renewables sources cost competitive on a life cycle basis.

The Way Ahead

If Renewable energy technologies are to make an increasing impact in the world energy markets then considerably more effort will be required to effectively bring them to the market place as competitive options for current and emerging energy supplies. But this will not happen if we work in isolation, we must continue to strive to work together on these tasks and challenges so that we can share the tasks and efforts, duplication of efforts and learn from each other's experiences. The IEA will continue to play a role in this process, both through its mechanisms for policy dialogue and for technology collaboration.

Leadership will need to come from government and industry. Governments have a clear responsibility to provide the framework for sustainable economic development, but many of the decisions to apply specific technologies fall to industry, utilities and individuals.

At this point I must add a few words of caution.

- In real terms, many government energy technology R&D budgets have declined since 1985.

IEA Government Energy R&D Budgets (million US dollars at 1995 prices)

Country	1985	1995	% change 1985 to last available year
United States	3214	2915	-9
Germany	1589	406	-74
Italy	1137	290	-75
Sweden	156	64	-59
Switzerland	138	182	+32
United Kingdom	708	83	- 88
Denmark	17	147	+183

Source: country submissions and *OECD Economic Outlook*

- Furthermore, initial responses from IEA Member countries suggest that private sector energy R&D spending has also declined in many countries and that nearer term R&D is increasingly favoured. It also appears that increasing competition in the electricity sector, at least in the short run, may be resulting in significant decreases in energy technology R&D budgets in the United States and the United Kingdom, and in a focus on shorter term energy technology R&D.

Private industry prefers to invest in energy technology that is either near to commercialisation or required by environmental or other regulations and standards. In several IEA countries, corporate R&D expenditures are being reoriented, as we have seen, towards shorter-term, quicker-payback projects, as a reaction to corporate restructuring and financial market pressures. Longer-term, higher-risk and more uncertain energy projects are thus less likely to be undertaken in the private sector. As will be discussed in a forthcoming IEA-report on *Capital stock turnover* in the energy industry the slowed renewal of the capital stock resulting from competition can also act as a hinder towards the fast diffusion of new environmentally friendly technologies.

These trends may very well be overreactions from governments and companies as the market changes from one regulatory regime to a different one and my comments should not be interpreted as if I resist increased competition in the energy

industry. On the contrary, the empirical evidence that competition in the long run promotes technological advances mainly through a more efficient use of resources is devastating. But, it is vital that this radical change does not mean a 5-10 year stop in the long term energy R&D leading to slowed down developments and lost competence as research teams are being separated.

In this context I would also like to mention our recent study *Enhancing the Market Deployment of Energy Technology: A Survey of Eight Technologies* which, as the title indicates discusses key issues in relation to the market deployment of new energy technologies.

4. Current and Future Role of Geothermal Energy

Geothermal energy is the thermal energy stored in rocks and fluids within the earth. It is estimated that approximately 10% of the world's land mass contains accessible hydrogeothermal resources that could theoretically provide hundreds of thousands of megawatts of energy for many decades.

Presently, Geothermal energy plays a significant role in some OECD countries, such as Japan, the western parts of the United States, Mexico and New Zealand. In Iceland nearly all buildings are heated using geothermal energy, and at present geothermal energy provides about a third of the electrical power needs of El Salvador and the Philippines.

On the whole the current use is however just a fraction of the potential and also limited compared with the most important Renewable energy sources that is hydro and bio energy.

Technology Shares in OECD Electricity Capacity

Technology	Share (per cent)
Conventional steam	52 per cent
Hydroelectric	22 per cent
Nuclear	16 per cent
Gas turbine	5.1 per cent
Combined cycle	3.4 per cent
Internal combustion	0.8 per cent
Renewables	0.5 per cent
Geothermal	0.3 per cent
Other thermal	0.2 per cent

Source: OECD/IEA statistics (1994 data).

See also, *OECD Experience and Perspective on Electricity Generation Technologies,* paper presented by John Paffenbarger, IEA, at Seminar-Workshop on ASEAN 2020, Bandung, Indonesia, 11-13 June 1996.

As you all know, geothermal resources are strictly speaking not Renewable on a human time scale. Reservoirs can become depleted in a matter of decades and thus require careful phasing, conservation and reservoir management policies. On the other hand, geothermal resources do not share the intermittent quality of many Renewable energy sources and can deliver energy as required. However, the environmental characteristics of Geothermal energy makes it relevant from a policy point of view to group it with Renewable energy sources.

Geothermal energy is used in two ways - for electricity generation or direct use as heat. The temperature of the extracted fluids greatly influences the use to which the resource is put. High-temperature fields can favourably be used for electricity generation and low-to-medium temperature resources, which are more plentiful than high-temperature resources, are commonly used for direct-heat applications.

Geothermal energy has had a long history of use in applications as therapeutic hot baths, space and water heating, and agricultural growth stimulation. Even as a source for generating electricity its history is more than 90 years. However, there remain a multitude of important R&D-issues in order to increase the use of this attractive energy source.

About two years ago the IEA therefore started to scan the interest between its member countries to set up a collaborative project in the form of an Implementing Agreement on Geothermal energy research and technology. The response has been quite strong with 16 countries having expressed interest in the implementing agreement and with eight possible research areas defined. So far five countries, United Kingdom, New Zealand, Japan, US, Switzerland, as well as the European Union have decided to join the Implementing Agreement and there are more countries considering participating. Three of the research areas, formally called annexes, have been approved;

- Environmental Impacts of Geothermal Energy Development
- Hot dry rock
- Deep Geothermal resources

We expect several others research proposals to be developed and approved within short.

5. Concluding Remarks

Available forecasts for world energy supply and demand indicate a development which will lead to increased stress on our common environment and a continued dependence on fossils fuels as the worlds' primary fuels. In the long run the dependence on fossil fuels has to be reduced and the share of more environmentally sustainable energy sources, such as geothermal energy, has to increase.

This will not happen by accident, but only if we devote the necessary intellectual and financial resources and take the necessary decisions to develop the alternatives and give them a reasonable competitive situation. Leadership will need to come from government and industry as well as from the research society.

Intensified international collaboration can provide a means to accelerate progress effectively and to develop new and improved energy technologies by sharing limited financial and human resources, and by broadening the prospects of market deployment in all countries. It is therefore with great pleasure I welcome that a new Implementing Agreement on Geothermal Energy research and technology is added to the increasingly long list of energy technology areas with a functioning IEA Implementing Agreement and I wish present and future participants in the collaboration projects success in the accomplishment of their tasks.