INTERNATIONAL ENERGY AGENCY

Energy Technologies at the Cutting Edge

International Energy Technology Collaboration
IEA Implementing Agreements

2007

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The International Energy Agency (IEA) is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy programme.

It carries out a comprehensive programme of energy co-operation among twenty-six of the OECD thirty member countries. The basic aims of the IEA are:

- To maintain and improve systems for coping with oil supply disruptions.
- To promote rational energy policies in a global context through co-operative relations with non-member countries, industry and international organisations.
- To operate a permanent information system on the international oil market.
- To improve the world's energy supply and demand structure by developing alternative energy sources and increasing the efficiency of energy use.
- To assist in the integration of environmental and energy policies.

The IEA member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. The Slovak Republic and Poland are likely to become member countries in 2007/2008. The European Commission also participates in the work of the IEA.

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

The OECD is a unique forum where the governments of thirty democracies work together to address the economic, social and environmental challenges of globalisation. The OECD is also at the forefront of efforts to understand and to help governments respond to new developments and concerns, such as corporate governance, the information economy and the challenges of an ageing population. The Organisation provides a setting where governments can compare policy experiences, seek answers to common problems, identify good practice and work to co-ordinate domestic and international policies.

The OECD member countries are: Australia, Austria, Belgium, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Republic of Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom and United States. The European Commission takes part in the work of the OECD.

FOREWORD

Now, more than ever, the international community is looking to technology to help meet the pressing challenges of energy security, environmental protection, economic growth, and the need for clean energy technologies. International co-operation is essential if we are to find solutions to these challenges.

The Implementing Agreements of the International Energy Agency provide the forum for this co-operation. Through these Agreements, several thousand scientists and experts from countries all over the world – IEA members and non-members, government and non-government participants – are working together. This is the engine room of international energy technology collaborative programmes.

There are 41 Implementing Agreements, covering all the key new technologies of energy supply and end use (with the exception of nuclear fission, which has its own OECD Agency – the Nuclear Energy Agency). They include clean and advanced fossil fuel technologies (including carbon capture and storage), an entire range of renewable energies (including biofuels), hydrogen and fuel cells, end-use technologies (buildings, electricity, industry, tranpsort), fusion and cross-cutting activities.

Implementing Agreements facilitate international co-operation and collaboration on research, development, deployment and demonstration. They engage in joint programmes and projects – making it possible to achieve better project definition, reduced costs, and enhanced international deployment prospects, as compared to national initiatives.

Policy makers and others who are interested in energy technology need to be aware of these Agreements to understand the nature of their work. The purpose of *Energy Technologies at the Cutting Edge* is to make this information available.

In response to requests from IEA Ministers, each résumé of Implementing Agreement activities in this publication now includes a policy brief. These outline some of the potentials of each of the technologies and possible barriers to implementation or deployment. It is hoped that this information will assist decision-makers in policy discussions and when setting priorities.

The framework for these Agreements is flexible, and the network is responding to current priorities. New agreements are being created to help governments to co-ordinate their efforts on key technology policy issues such as the deployment of renewables, flexible and reliable electricity networks, and efficient electrical appliances. In addition, through its outreach programme, Network of Experts in Energy Technologies (NEET), the IEA is promoting the full participation of key non-IEA countries.

I strongly encourage those who may be engaged in energy issues, whether in government or in the private sector, to consider seeking participation in the relevant Agreement to make your contribution and to share the benefits of collaboration.

I cannot emphasise too strongly the importance of the work of the Implementing Agreements in making a new energy future possible. I hope that this publication will make this goal more attainable.

Claude Mandil
Executive Director

ACKNOWLEDGEMENTS

This publication is based on core input from the Implementing Agreement Executive Committees. It was researched and edited by Carrie Pottinger, Energy Technology Co-ordinator. Neil Hirst, Director, IEA Office of Energy Technology and R&D, and Antonio Pflüger, Head of the Energy Technology Collaboration Division, reviewed and provided comments.

A special thanks once again to all the Implementing Agreement participants for their unrelenting commitment to the advancement of energy technologies.

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INTRODUCTION

IEA Implementing Agreements (IAs) provide the framework to advance the most efficient use of energy possible. Partnering with industry and non-member countries, the IEA Energy Technology Collaboration network is a cost-effective, global network.

Many Implementing Agreements include participants from non-member countries. The Energy Technology Data Exchange allows access to their extensive database of scientific information to more than 60 non-IEA countries. The Climate Technology Initiative engages with non-member countries to share best practice, to build capacity, to facilitate technology transfer and financing.

Improving energy efficiency, whether in the buildings and commercial services, electricity, industry or transport sectors is crucial for our environment and for energy security. Thirteen Implementing Agreements currently research various aspects of these end-use sectors. One recently created Agreement will analyse issues related to electricity transmission and distribution.

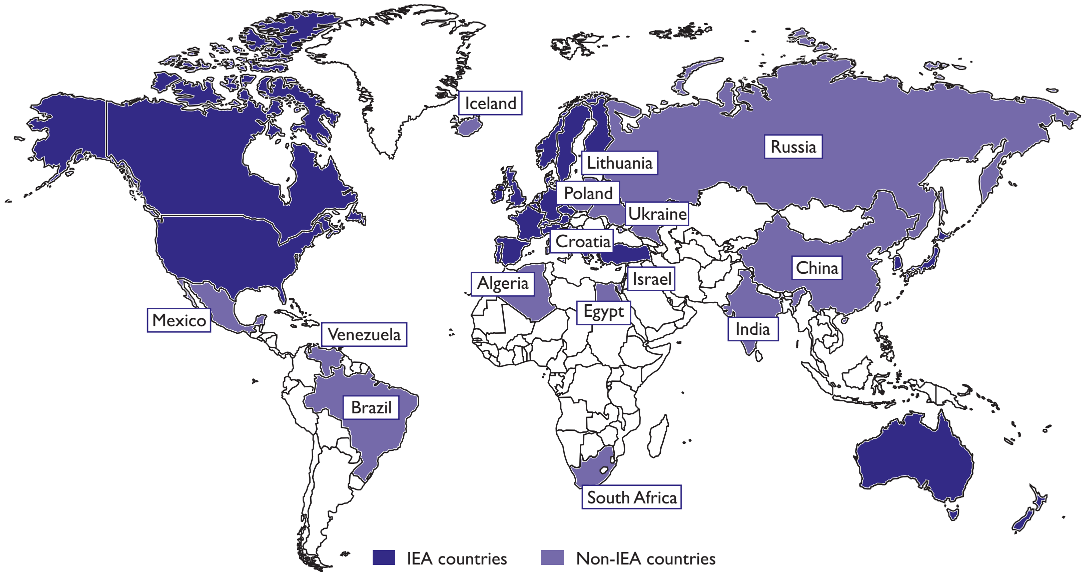
Fossil fuels are at the core of energy demand in the transport and electricity generation sectors and will be for many more years. The work of six IAs focuses on finding ways to make the most of existing resources, while at the same time getting the most from every barrel of oil or tonne of coal more cost- and energy-efficiently.

Fusion power has great potential for power generation though research in this area is costly. Nine IAs co-ordinate national and regional fusion programs and share experimental results to accelerate development.

Renewable energy technologies provide clean, flexible, stand-alone or grid-connected electricity sources, but they need the correct policy environment and public-private partnerships to facilitate deployment and to further reduce costs. Ten Implementing Agreements research renewable energy technologies. The focus of one new Implementing Agreement examines barriers and solutions to renewable technology deployment.

By combining efforts, Implementing Agreement participants save time and resources. Implementing Agreements largely respond to the goals of IEA countries: energy security, environmental protection and economic growth. The work of the Implementing Agreements covers the full range of R&D portfolios, working in all aspects of energy – supply, transformation and demand.

Global Energy Technology Network



The boundaries and names shown and the designations used on maps included in this publication do not imply official endorsement or acceptance by the IEA.

ACTIVITY PORTFOLIOS*

		Basic Science	R&D [1]	Demon-stration [2]	Deploy-ment [3]	Information Exchange
Cross-Cutting	Climate Technology Initiative				■	■
	Energy Technology Data Exchange					■
	Energy Technology Systems Analysis		■			■
End-Use *Buildings*	Buildings and Community Systems		■	■		■
	District Heating and Cooling		■	■		■
	Energy Storage		■	■		■
	Heat Pumping Technologies		■	■		■
Electricity	Electricity Networks		■	■		■
	Demand-Side Management		■	■	■	■
	High-Temperature Superconductivity	■	■	■		■
Industry	Emissions Reduction in Combustion	■	■	■		■
	Industrial Energy-Related Technology Systems		■	■		■
Transport	Advanced Fuel Cells	■	■	■	■	■
	Advanced Materials for Transportation	■	■	■		■
	Advanced Motor Fuels	■	■	■		■
	Hybrid and Electric Vehicles	■	■	■	■	■
Fossil Fuels	Clean Coal Centre		■	■	■	■
	Clean Coal Sciences	■	■			■
	Enhanced Oil Recovery	■	■			■
	Fluidized Bed Conversion	■	■	■		■
	Greenhouse Gas R&D Programme	■	■	■	■	■
	Multiphase Flow Sciences	■	■		■	■
Fusion	Environmental, Safety and Economic Aspects	■	■		■	■
	Fusion Materials	■	■			■
	Large Tokamaks	■	■			■
	Nuclear Technology of Fusion Reactors	■	■			■
	Plasma Wall Interaction TEXTOR	■	■			■
	Reversed Field Pinches	■	■			■
	Spherical Tori	■	■			■
	Stellarator Concept	■	■			■
	Tokamaks Poloidal Field Divertors	■	■			■
Renewables	Bioenergy	■	■	■		■
	Deployment				■	■
	Geothermal	■	■	■		■
	Hydrogen	■	■	■		■
	Hydropower		■	■		■
	Ocean Energy Systems		■	■		■
	Photovoltaic Power Systems		■	■	■	■
	Solar Heating and Cooling	■	■	■		■
	SolarPACES	■	■	■	■	■
	Wind Energy Systems		■	■		■

** Indicates primary focus, which does not exclude significant activities in other areas.*
1. Including modelling and technology assessment.
2. Including research, advice and support of demonstration of the particular technology.
3. Including market introduction and technology transfer.

ENERGY SECTORS*

		Supply	Transformation [1]	Demand [2]
Cross-Cutting	Climate Technology Initiative	■	■	■
	Energy Technology Data Exchange	■	■	■
	Energy Technology Systems Analysis	■	■	■
End-Use *Buildings*	Buildings and Community Systems		■	■
	District Heating and Cooling		■	■
	Energy Storage		■	■
	Heat Pumping Technologies		■	■
Electricity	Electricity Networks		■	■
	Demand-Side Management		■	■
	High-Temperature Superconductivity		■	■
Industry	Emissions Reduction in Combustion		■	■
	Industrial Energy-Related Technology Systems		■	■
Transport	Advanced Fuel Cells		■	■
	Advanced Materials for Transportation		■	■
	Advanced Motor Fuels		■	■
	Hybrid and Electric Vehicles		■	■
Fossil Fuels	Clean Coal Centre	■	■	
	Clean Coal Sciences	■	■	
	Enhanced Oil Recovery	■	■	
	Fluidized Bed Conversion		■	
	Greenhouse Gas R&D Programme		■	
	Multiphase Flow Sciences	■	■	
Fusion	Environmental, Safety and Economic Aspects	■	■	
	Fusion Materials	■	■	
	Large Tokamaks	■	■	
	Nuclear Technology of Fusion Reactors	■	■	
	Plasma Wall Interaction TEXTOR	■	■	
	Reversed Field Pinches	■	■	
	Spherical Tori	■	■	
	Stellarator Concept	■	■	
	Tokamaks Poloidal Field Divertors	■	■	
Renewables	Bioenergy	■	■	■
	Deployment	■		
	Geothermal	■	■	■
	Hydrogen	■	■	■
	Hydropower	■	■	■
	Ocean Energy Systems	■	■	
	Photovoltaic Power Systems	■	■	■
	Solar Heating and Cooling	■	■	■
	SolarPACES	■	■	■
	Wind Energy Systems	■	■	■

** Indicates primary focus, which does not exclude significant activities in other areas.*
1. Including electricity generation and distribution, industrial processes.
2. Including energy consumption and optimisation.

IEA IMPLEMENTING AGREEMENTS: RESPONSIVE, FLEXIBLE INSTRUMENTS

Since their creation in 1975, the vast body of research carried out under the Implementing Agreements (IAs) has consistently supported the overall objectives of the IEA Member countries in the field of energy research and development. Implementing Agreements provide a dynamic, flexible platform to explore short- and long-term solutions to problems at both the national and international level in areas such as climate change, the rising costs of fossil fuel exploration, demand-side management, and sustainable and secure energy supplies. They can be created at any time, provided that at least two IEA member countries become signatories, or Contracting Parties. Implementing Agreements can also shift their focus, merge with another IA, or be terminated, provided that all the Contracting Parties agree.

Table 1: Implementing Agreements, 1975 to 2007

	Created	Ended or Merged
Cross-Cutting	7	4
End-Use	23	10
Buildings	6	2
Electricity	3	0
Industry	9	8
Transport	5	0
Fossil Fuels	21	15
Fusion	11	2
Renewables	16	6
Total	**78**	**37**

Within the first 15 years of activity, 56 Implementing Agreements had been created, while 26 had ended. In the year 1989 alone, there were eight terminations, the most in the 30-year history of Implementing Agreements. As of 31 March 2007, nearly half of the Implementing Agreements created since 1975 had closed (47%): 41 remain active.

All but one of the first Agreements created in 1975 examined coal technologies and processes. By 1989, when energy priorities had shifted to environmental issues and climate change, all but one of these Agreements had either merged with others, had changed focus to take into account the new priorities, or had terminated. This shift in focus to environmental issues also led to the creation of the Greenhouse Gas R&D Implementing Agreement (1991), the Environmental, Safety and Economic Aspects of Fusion (1992), Hybrid and Electric Vehicles (1993), and Demand Side Management (1993). In the period 1991-2001, five IAs dealing with renewable energy technologies were created (Geothermal, Hydropower, Ocean Energy Systems, Photovoltaic, and SolarPACES).

At the first Conference of the Parties to the United Nations Framework Convention on Climate Change (UNFCCC) in 1995, 23 IEA/OECD countries and the European Commission launched the Climate Technology Initiative (CTI). The CTI was an autonomous body aimed at accelerating the development, application and diffusion of climate-friendly technologies and practices for all activities and greenhouse gases, cost-effective, environmentally-sound production and end-use technologies. In 2003, the CTI was transformed from an autonomous governmental body to an Implementing Agreement, a structure more closely adapted to the operations of this work.

More recently, the blackouts in North America and Europe triggered increased focus on transmission and distribution networks. Following a series of IEA workshops in 2004, the United Kingdom took the initiative to create an Implementing Agreement on Electricity Network Analysis and R&D.

Changing the name of an Agreement is one way to reflect changing priorities of IA participants. Some examples include: "Forestry" renamed "Bioenergy" renamed "District Heating" renamed "District Heating & Cooling" and yet again renamed to be "District Heating & Cooling (including CHP)". In another example, the increased concern over environmental issues such as CO_2 emissions and greenhouse gases in the early 1990s changed the scope of several Implementing Agreements. One example was "Coal Combustion Sciences", which was subsequently renamed "Clean Coal Sciences".

The scope of each Implementing Agreement is decided upon by the Contracting Parties to the Agreement. While the majority of the Implementing Agreement deal with research, development, collaboration and dissemination, examples exist of Agreements exploring the often more difficult aspects of collaboration – demonstration and deployment.

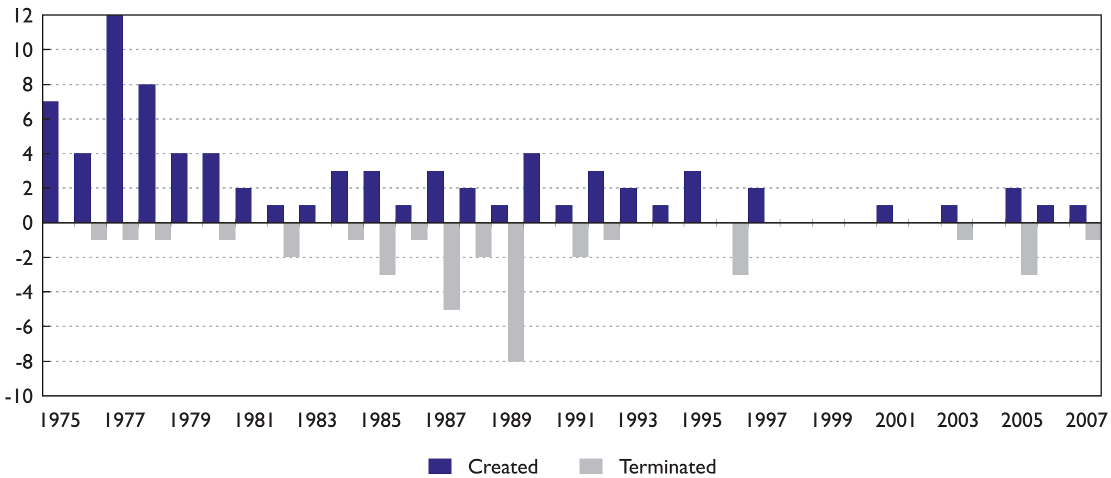
In 1975, an Implementing Agreement for a Project for Fluidized Coal Combustion made provisions for construction of a sizeable demonstration plant. The project consisted of four stages: Procurement of design study; Tendering for construction of the plant; Construction and acceptance; and Plant operation). The total cost of the project GBP 11.1 million (1975 prices) was shared equally among the three Contracting Parties (Germany, the United Kingdom and the United States).

While no provisions within the fusion power Implementing Agreements specify financing of demonstration machines, they do collectively input to, and share the results of, the multi-million dollar plants financed by participating countries and the European Commission. The very first deployment-focused Implementing Agreement, Renewable Energy Technology Deployment, was created in 2005.

Where there is a logical fit between two or more programmes, mergers can be a cost-effective way to continue research. There is a risk that the programme being merged will become too broad to produce significant results. Of course the inverse is also true, i.e. that countries that were not previously participating in either of the original IAs – for whom the original focus of either agreement would have been too narrow – become signatories. The most recent example is the Industrial Energy Technology Systems Implementing Agreement, a merger of the two Implementing Agreements – Process Integration and Pulp and Paper. In addition, this merged IA will continue the research on Heat Transfers and Heat Exchangers, an IA that closed in 2005, and will integrate work on Separations Technologies, a proposed Implementing Agreement that was never created. Following the merger, more countries are participating than had been in either IA previously.

However, nothing precludes short-term, one-off projects should participating countries agree. One example is the Implementing Agreement for a Construction of an Intense Neutron Source, created in 1976, ended in 1977.

Figure 1: Implementing Agreements Developments



Participation

Country participation in Implementing Agreements is one indication of national priorities and budget allocation. Table 2 on the following pages illustrates participation trends for each country by sector, from 1983 to 2007. While some countries have had relatively stable participation over time, latecomers such as Korea have quickly caught up to their European counterparts.

Comparing 1998 to 2007, total participation increased by 25% and the share of industry and non-member country participation increased from 7 to 14 % for the same period. In real terms, non-IEA country participations nearly doubled.

It is not surprising to see those countries with the greatest R&D expenditures to be those with the most IA participations (Canada, Germany, Japan, Italy, the United Kingdom, and United States). However, in 2007 it is interesting to note that Norway and Sweden are among the top five, and Denmark, Finland, Korea, the Netherlands and Switzerland are within the top 10.

Sponsor participation from industry was first approved by the Governing Board in 1993. As of 1998, there were five Sponsors participating in Implementing Agreements. By 31 March 2007, there were 26 Sponsors from IEA countries and 6 Sponsors from non-IEA countries. The large majority (75%) of Sponsors participate in Agreements dealing with fossil fuels.

Figure 2 and 3 compare participations of IEA and non-IEA countries. There is a marked focus of non-IEA country participation in renewable energy technology IAs, while end-use technologies are the prime focus of IEA countries. This could be due to the lack of RD&D budgets in non-member countries for the newer and more expensive technologies, while it would appear that through participation in Implementing Agreements, IEA countries have aimed to achieve demand restraint and energy efficiency – although the gap between end-use and renewable energy technologies is narrowing, particularly in most recent years.

It is not uncommon for Contracting Parties to periodically review the extent of activities within, and financial contribution to, the Implementing Agreements, particularly in terms of how well they match current national priorities. Since 2003, Austria, Australia, Finland, Netherlands, Sweden, Turkey and the United Kingdom have made such reviews and re-aligned participation in individual Agreements accordingly.

It is not uncommon for Contracting Parties to periodically review the extent of activities within, and financial contribution to, the Implementing Agreements, particularly in terms of how well they match current national priorities. Since 2003, Austria, Australia, Finland, Netherlands, Sweden, Turkey and the United Kingdom have made such reviews and re-aligned participation in individual Agreements accordingly.

Figure 2: Participation IEA Countries

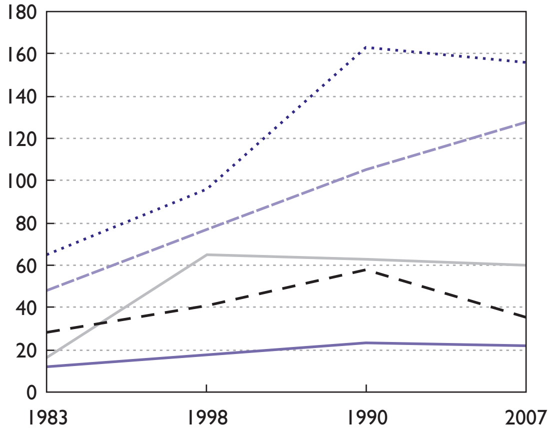
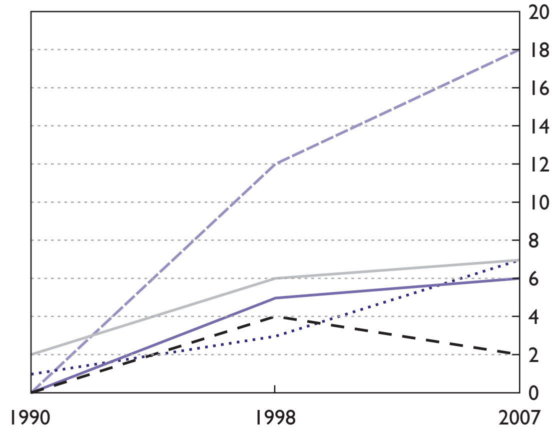


Figure 3: Participation non-IEA Countries



End-Use Renewables Cross-Cutting Fossil Fuels Fusion

Table 2: Developments in Participations by Sector

	1983						1990						1998						2007					
	Cross Cut.	End Use	Foss. Fuels	Fusion Power	Renew-ables	**Total**	Cross Cut.	End Use	Foss. Fuels	Fusion Power	Renew-ables	**Total**	Cross Cut.	End Use	Foss. Fuels	Fusion Power	Renew-ables	**Total**	Cross Cut.	End Use	Foss. Fuels	Fusion Power	Renew-ables	**Total**
Australia	2	2	-	-	1	**5**	2	1	2	-	1	**6**	2	3	5	-	5	**15**	-	3	4	1	7	**15**
Austria	2	2	1	-	3	**8**	1	-	2	-	4	**7**	1	3	2	1	4	**11**	1	6	4	-	4	**15**
Belgium	2	4	-	-	3	**9**	1	5	-	-	5	**11**	3	9	-	-	2	**14**	1	10	-	-	3	**14**
Canada	1	4	2	2	4	**13**	3	7	6	2	5	**23**	3	12	6	4	6	**31**	3	11	6	4	8	**32**
Czech Rep.	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	1	1	-	-	**2**
Denmark	1	3	1	-	3	**8**	2	5	5	-	4	**16**	4	8	4	-	4	**20**	1	7	4	-	7	**19**
Finland	-	2	-	-	1	**3**	3	6	2	-	4	**15**	2	9	4	-	5	**20**	3	11	1	-	5	**20**
France	-	-	-	-	-	**-**	1	-	2	-	-	**3**	2	5	2	-	5	**14**	-	7	3	-	8	**18**
Germany	2	6	1	-	3	**12**	2	7	2	-	5	**16**	3	10	1	-	5	**19**	3	7	3	-	9	**22**
Greece	1	1	-	-	1	**3**	-	1	-	-	1	**2**	1	1	-	-	3	**5**	1	2	1	-	1	**5**
Ireland	2	-	-	-	2	**4**	-	-	4	-	1	**5**	1	-	-	-	-	**1**	-	-	-	-	3	**3**
Italy	1	2	1	-	2	**6**	3	7	4	-	6	**20**	3	9	4	-	6	**22**	1	9	3	-	6	**19**
Japan	1	3	2	3	3	**12**	3	6	4	5	4	**22**	4	10	5	7	7	**33**	2	7	5	8	7	**29**
Korea	-	-	-	-	-	**-**	-	-	-	-	-	**-**	3	5	2	-	1	**11**	2	5	3	1	4	**15**
Netherlands	2	7	1	-	3	**13**	3	8	4	-	5	**20**	3	11	3	-	5	**22**	1	9	3	-	6	**19**
New Zealand	1	3	1	-	1	**6**	2	4	-	-	3	**9**	2	2	1	-	4	**9**	-	1	1	-	4	**6**
Norway	1	4	2	-	3	**10**	2	6	4	-	3	**15**	3	9	4	-	5	**21**	3	10	3	-	8	**24**
Portugal	-	-	-	-	-	**-**	-	-	1	-	-	**10**	1	2	1	-	1	**5**	1	2	-	-	4	**7**
Spain	2	2	-	-	1	**5**	2	1	3	-	4	**10**	3	3	3	-	6	**15**	1	4	2	-	5	**12**
Sweden	2	6	1	-	4	**13**	3	10	7	-	6	**26**	3	14	4	-	6	**27**	2	13	3	-	6	**24**
Switzerland	1	4	1	3	3	**12**	2	6	-	3	5	**16**	3	9	1	2	7	**22**	2	8	1	1	7	**19**
Turkey	-	-	-	1	-	**1**	-	2	-	1	-	**3**	1	3	-	1	3	**8**	1	2	-	-	2	**5**
United Kingdom	2	4	1	-	3	**10**	3	6	7	-	5	**21**	3	13	6	-	8	**30**	3	9	6	-	6	**24**
United States	2	6	1	3	4	**16**	3	8	6	7	6	**30**	4	13	5	8	7	**37**	3	12	5	9	8	**37**
TOTAL IEA	**28**	**65**	**16**	**12**	**48**	**169**	**41**	**96**	**65**	**18**	**77**	**297**	**58**	**163**	**63**	**23**	**105**	**412**	**35**	**156**	**62**	**24**	**128**	**405**

Table 2: Developments in Participations by Sector (cont.)

	1983						1990						1998						2007					
	Cross Cut.	End Use	Foss. Fuels	Fusion Power	Renew-ables	Total	Cross Cut.	End Use	Foss. Fuels	Fusion Power	Renew-ables	Total	Cross Cut.	End Use	Foss. Fuels	Fusion Power	Renew-ables	Total	Cross Cut.	End Use	Foss. Fuels	Fusion Power	Renew-ables	Total
Algeria	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	1	**1**
Brazil	-	-	-	-	-	**-**	-	-	-	-	-	**-**	1	-	-	-	2	**3**	1	1	-	-	1	**3**
China	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	1	1	**2**	-	-	1	1	1	**3**
Croatia	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	1	**1**	-	-	-	-	1	**1**
Egypt	-	-	-	-	-	**-**	-	-	1	-	-	**1**	-	-	-	-	1	**1**	-	-	-	-	1	**1**
Iceland	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	2	**2**
India	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	1	1	-	-	**2**
Israel	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	2	-	-	2	**4**	-	2	-	-	2	**4**
Lithuania	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	1	**1**
Mexico	-	-	-	-	-	**-**	-	-	-	-	-	**-**	1	-	2	-	4	**7**	1	2	2	-	6	**11**
Poland	-	-	-	-	-	**-**	-	-	-	-	-	**-**	1	1	2	-	-	**4**	-	1	-	-	-	**1**
Russia	-	-	-	-	-	**-**	-	-	-	-	-	**-**	1	-	1	4	1	**7**	-	-	1	4	-	**5**
South Africa	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	1	-	2	**3**
Ukraine	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	-	1	-	**1**
former Yugoslavia	-	-	-	-	-	**-**	-	-	1	-	-	**1**	-	-	-	-	-	**-**	-	-	-	-	-	**-**
Venezuela	-	-	-	-	-	**-**	-	-	-	-	-	**-**	-	-	1	-	-	**1**	-	-	1	-	-	**1**
TOTAL NON-IEA	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**-**	**2**	**-**	**-**	**2**	**4**	**3**	**6**	**5**	**12**	**30**	**2**	**7**	**7**	**6**	**18**	**40**
Sponsors IEA	-	-	-	-	-	-	-	-	-	-	-	-	2	-	3	-	-	**5**	-	2	*19*	-	5	**26**
Sponsors non-IEA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*	5	-	-	**6**
European Commission	*1*	*1*	-	3	2	**7**	2	2	*1*	7	5	**17**	3	*1*	2	8	7	**21**	*1*	*1*	2	9	8	**21**
TOTAL	**29**	**66**	**16**	**15**	**50**	**176**	**43**	**98**	**68**	**25**	**82**	**316**	**67**	**167**	**74**	**36**	**124**	**468**	**38**	**167**	**94**	**39**	**159**	**498**

Financing

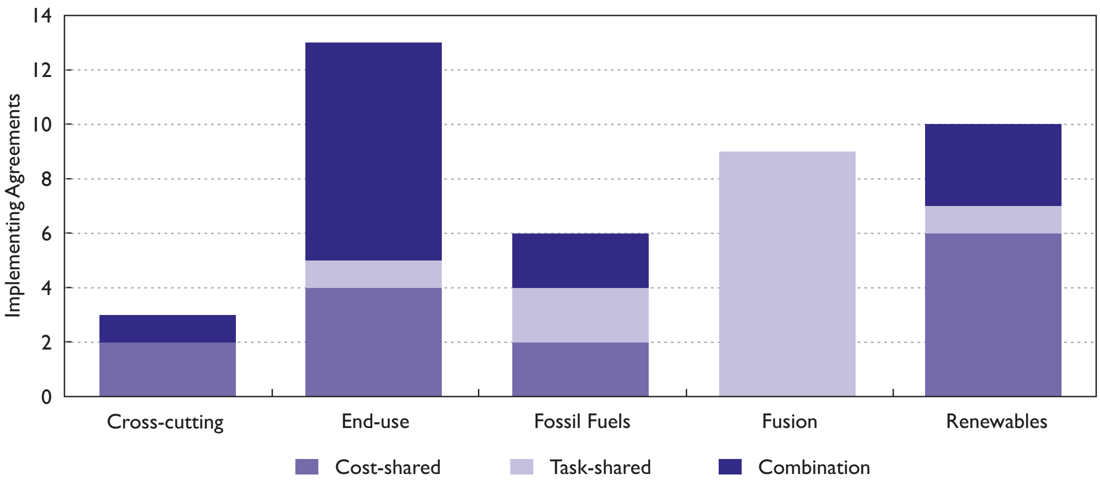
Covering the costs of collaborative research (administration and research projects) can take various forms. Each signatory is responsible for participating, either financially or in-kind, as set out in the Agreement. Each Agreement is responsible for establishing bank accounts, maintaining accounting systems, as well as collecting their annual fees and related costs, as the case may be. Though financing can take many forms, it generally falls within three main categories:

- Cost-sharing: Participants pay an annual fee to cover costs of administration and research projects (34% of Agreements operate under this type of financing modality).
- Task-sharing: Participants make no provision for either administrative or research funding and the workload (and output) is shared among the participants. The Contracting Parties define the level of commitment, usually in terms of person-years of effort to be dedicated to the work (32% of all current Agreements).
- Combination of cost- and task-sharing: This could include a cost-shared common fund with some (or all) of the research task-shared, or any combination thereof, as decided by the participants (34%).

Due to the task-sharing component of Implementing Agreements, actual annual expenditures are difficult to derive. In addition, despite that Implementing Agreements may be listed as entirely cost-sharing, there is always some element of task-sharing that is unaccounted for, implicitly underestimating total expenditures.

This is particularly true for the fusion Agreements, which represent the largest amount of collaborative efforts. Most, if not all, the global work in the area of fusion, estimated to amount to USD 715.2 million in IEA countries in 2005 (at 2005 prices and exchange rates), is a result of sharing experiences and co-ordinating activities that build on national and international programmes. Though direct costs are borne by each programme, including technical reports, materials investigation, test facilities, processes, personnel, and demonstration plants, they are possible largely as a result of the important collaboration within the Implementing Agreements.

Figure 4: Financing Modalities by Sector



Research Projects

The scope of each Implementing Agreement sets out the broad lines of the collaboration. In addition, most Implementing Agreements make provision for additional research to be carried out on specific aspects of the overall issue. These specific activities, called Annexes or Tasks, can be few or numerous, short-term or long-term. Each Contracting Party to the Agreement chooses the Annexes in which they will participate.

Article 2 of the IEA Framework outlines these activities of Implementing Agreements, which may include, *inter alia*:

(a) co-ordination and planning of specific energy technology research, development and deployment studies, works or experiments carried out at a national or international level, with subsequent exchange, joint evaluation and pooling of the scientific and technical results acquired through such activities;

(b) participation in the operation of special research or pilot facilities and equipment provided by a participant, or the joint design, construction and operation of such facilities and equipment;

(c) exchange of information on (i) national programmes and policies, (ii) scientific and technological developments and (iii) energy legislation, regulations and practices;

(d) exchanges of scientists, technicians or other experts;

(e) joint development of energy related technologies; and

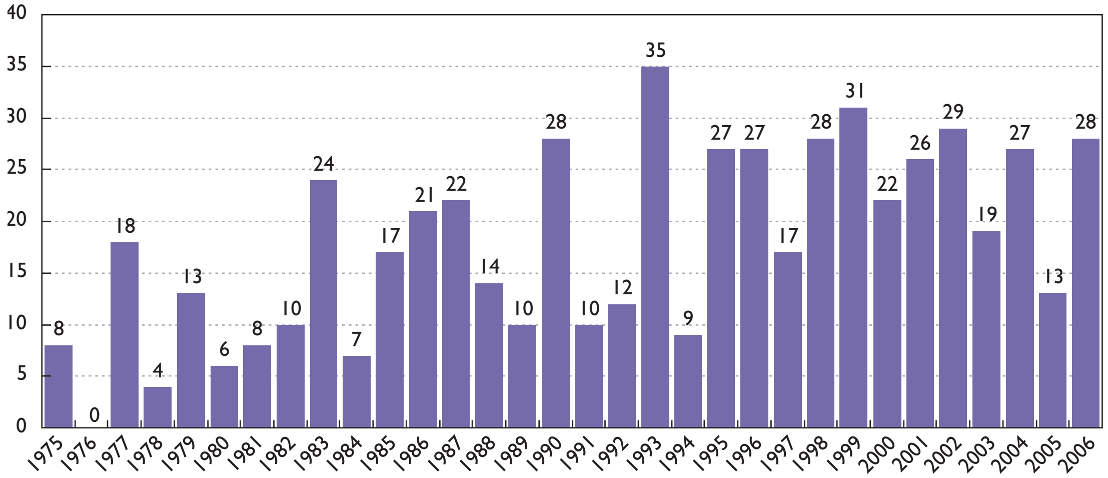
(f) any other energy technology related activity.

Other examples of IA projects include technology evaluations, developing and monitoring expert networks, data collection and analysis, modelling and publications. More recently, a proposed new IA on energy-efficient appliances is expected to have policy coordination as the primary focus.

Annexes are not the only measurement of work performed in IAs. They do not, for example, take account of the work of subtasks which can vary from one to 20 (or more) per research topic. Nor do Annexes reflect work of Implementing Agreements that are not project-specific but rather long-term (i.e., information exchange or co-ordination of national programmes), or where the scope does not lend itself to additional projects per se (i.e., some fusion IAs, Clean Coal Centre, Energy Technology Systems Analysis Programme). And in the case of the District Heating and Cooling IA, each extension period is called an Annex, within which several projects are carried out.

To the furthest extent possible, different Implementing Agreements identify and carry out common research tasks. Apart from the obvious inter-relationships between Implementing Agreements in the same sector, work on common Annexes has been performed between the buildings-related Implementing Agreements and the renewable energy IAs, and between the transport IAs and clean fossil fuels. In addition, the cross-cutting Implementing Agreements – Energy Technology Data Exchange (ETDE), Energy Technology Systems Analysis Programme (ETSAP), and the Climate Technology Initiative (CTI) – build on and feed into the work of all other Agreements. As new Agreements are created, further rationalisation and opportunities for common, horizontal projects will arise, broadening the base of potential applications.

Figure 5: Implementing Agreement Research Projects



R&D performed over a longer time period has several advantages. Firstly, it brings to bear a wide range of applications for existing technologies, enabling participating countries to explore a larger range of solutions that may have been overlooked under a shorter time frame. In addition, as technological advances such as increases in efficiency or reduced CO_2 emissions are incorporated into existing technologies, the range of technical possibilities evolves, resulting in ever more R&D for a given energy technology.

As can be seen from Figure 5, the number of research projects, or Annexes, has fluctuated greatly over the years. By 2007, research more than 570 projects had been carried out. This total does not include sub-tasks, the more than 200 studies of the Clean Coal Centre, the more than 100 studies of the Greenhouse Gas R&D IA, nor does it include the numerous workshops of the fusion power IAs.

As could be expected, those Implementing Agreements with the greatest number of research annexes are those in existence since the late 1970s. The following pages show the research Annexes carried out under seven Implementing Agreements.

SELECTED LIST OF RESEARCH PROJECTS

Implementing Agreement	Annex Title
Advanced Fuel Cells	Molten Carbonate Fuel Cell Balance-of-Plant Analysis
	Modelling and Evaluation of Advanced Solid Oxide Fuel Cell
	Molten Carbonate Fuel Cell Materials and Electrochemistry
	Collaborative Research on Polymer Electrolyte Fuel Cells
	Fuel Cell System Analysis
	Molten Carbonate Fuel Cells under Real Operating Conditions
	Solid Oxide Fuel Cells under Real Operating Conditions
	Polymer Electrolyte Fuel Cells
	Fuel Cells for Stationary Applications
	Fuel Cells Systems for Transportation
	Collaborative Research on Polymer Electrolyte Fuel Cells
	Fuel Cells for Stationary Applications – Demonstration and Implementation
	Solid Oxide Fuel Cells – Making Ready for Application
	MCFC Towards Demonstration
	Fuel Cell Systems for Transportation
	Polymer Electrolyte Fuel Cells (see Annex XI)
	MCFC Towards Demonstration
	Solid Oxide Fuel Cells – Making ready for Application
	Fuel Cells for Stationary Applications
	Fuel Cell Systems for Transportation
	Fuel Cells for Portable Applications
Advanced Motor Fuels	Common Study of Alcohol and Alcohol Blends as Motor Fuels
	Technology Information Exchange on Alternative Motor Alcohols
	Methanol Diesel Field Trials and Analysis
	Production of Alcohols and Other Oxygenates from Fossil Fuels and Renewables
	Performance Evaluation of Alternative Fuel/Engine Concepts
	State-of-the-Art on Natural Gas as a Motor Fuel
	Comparison of Environmental Impacts of Alternative Motor Fuels
	Heavy Duty Vehicles and Alternative Motor Fuels
	Automotive Fuels Information Service (AFIS)
	Characterisation of New Fuel Qualities
	Forecasting Planning Tools for AMF and Related Infrastructure
	Size and Compositional Analysis of Particulate Emissions Alternate-Fuelled Vehicles
	Emission Performance of Selected Biodiesel Fuels
	Investigation into the Feasibility of Diethyl Ether as a Fuel in Diesel Engines
	Implementation Barriers of Alternative Fuels
	Environmental and Economic Aspects of Biodegradable Lubricants in Vehicle Engines
	Real Impact of New Technologies for Heavy-Duty Vehicles
	Future Greener Diesel Fuels
	New Fuels for Homogenous Charge Compression Ignition (HCCI) Engines
	Dimethyl Ether as an Automotive Fuel II
	Deployment Strategies for Hybrid, Electric and Alternative Fuel Vehicles (Joint Annex with HEV IA)
	Particulate Emissions at Moderate and Cold Temperatures Using Different Fuels
	Cost-effectiveness of Advanced Motor Fuels
	Advanced Motor Fuel Information Exchange
	Fuel Effects on Emissions from Non-Road Engines
	Alcohols and Ethers as Oxygenates in Diesel Fuel
	Standardization of Alternate Fuels
	Information Service and Website
	Evaluation of Duty cycles for Heavy-Duty Urban Vehicles
	Bio-safety Assessment: Animal Fat in Biodiesel
	Production and use of Synthetic Vehicle Fuels Made by Fischer-Tropsch Technique
	Future Fuels for Road Transport
	Particle Emissions of 2-S Scooters
	Analysis of Biodiesel Options

Bioenergy	Integration of National Activities Concerning Forestry Energy Biomass Growth and Production Technology in Short Rotation Forestry for Energy Harvesting, Processing & Transport of Forest Biomass for Energy from Conventional Forests Methods for Converting Biomass Feedstocks into Usable Energy Forms Improvement of Energy-Dedicated Biomass Production Systems Biomass Supply from Conventional Forestry Improvement of Methods for Conversion of Biomass Feedstocks Efficient and Environmentally-Sound Biomass Production Systems Harvesting and Supply of Woody Biomass for Energy Biomass Utilization The Conversion of Municipal Solid Waste Feedstocks to Energy Biomass Production, Harvesting and Supply Biomass Utilisation Municipal Solid Waste Conversion to Energy Greenhouse Gas Balances Technology Assessment Studies – Converting Cellulosic Materials to Ethanol in Sweden Short Rotation Crops for Bioenergy Conventional Forestry Systems for Bioenergy Biomass Combustion Thermal Gasification of Biomass Pyrolysis of Biomass Techno-economic Assessments for Bioenergy Applications Energy from Thermal Conversion of MSW and RDF Energy from Biological Conversion of Organic Waste Greenhouse Gas Balances of Bioenergy Systems Biotechnology for the Conversion of Lignocellulosics to Ethanol Liquid Biofuels Solid biomass fuels standardisation and classification Socio-Economic Aspects of Bioenergy Short Rotation Crops for Bioenergy Biomass Production for Energy from Sustainable Forestry Biomass Combustion and Co-firing Thermal Gasification of Biomass Pyrolysis of Biomass Techno-economic Assessments for Bioenergy Applications Energy from Integrated Solid Waste Management Systems Energy from Biogas and Landfill Gas Greenhouse Gas Balances of Biomass and Bioenergy Systems Liquid Biofuels from Biomass Sustainable Bioenergy Trade Bioenergy Systems Analysis Bio-refineries
Buildings and Community Systems	Load/Energy Determination of Buildings Application of the Science of Ekistics and Advanced Community Systems Energy Conservation Measures for Heating of Residential Buildings Glasgow Commercial Buildings Monitoring Project Air Infiltration and Ventilation Centre Energy Systems and Design of Communities (ENSYDECO) Local Government Energy Projects Inhabitants Behaviour with Regard to Ventilation Minimum Ventilation Rates Systems Simulation Development of Tools for Energy Auditing of Buildings Windows and Fenestration Energy Management in Hospitals Condensation and Energy Energy Efficiency in Schools Building Energy Management Systems – User Guidance BEMS-2 – Evaluation and Emulation Techniques

Demand Controlled Ventilating Systems
Low-slope Roof Systems: The Effect of Adding Insulation on Roof Durability
Air Flow Patterns within Buildings
Calculation of Energy and Environmental Performance in Buildings
Design Methods for Energy-Efficient Communities
Multi-Zone Air Flow Modelling
Heat – Air – Moisture Transfer in New & Retro-fitted Insulated Envelope Parts
Real Time Simulation of HVAC-Systems
Energy-Efficient Ventilation of Large Enclosures
Evaluation and Demonstration of Domestic Ventilation Systems
Low Energy Cooling Systems
Daylighting in Buildings
Bringing Simulation to Application
Energy-Related Environmental Impacts of Buildings
Integral Building Envelope Performance Assessment
Advanced Local Energy Planning
Computer-Aided Fault Detection and Diagnosis
Control Strategies of Hybrid Ventilation
Retrofitting Educational Buildings
Low Exergy Systems for Heating and Cooling
Solar Sustainable Housing
High Performance Thermal Insulation Systems (HiPTI)
Commissioning of Building HVAC Systems for Improving Energy Performance
Whole Building Heat, Air and Moisture Response (MOIST-EN)
Simulation of Building-Integrated Fuel Cell and Other Cogeneration Systems (COGEN-SIM)
Testing and Validation of Building Energy Simulation Tools
Integrating Environmentally Responsive Elements in Buildings
Energy-Efficient Future Electric Lighting for Buildings
Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings
Efficient Retrofit Measures for Government Buildings
Cost-Effective Commissioning of Existing and Low-Energy Buildings
Heat Pumping and Reversible Air Conditioning
Low Exergy Systems for High-Performance Buildings and Communities
Prefabricated Systems for Low Energy Renovation of Residential Buildings

Heat Pumping Technologies

Common Study of Advanced Heat Pump Systems
Vertical Earth Heat Pump Systems
Heat Pump Systems Applied in Industry
IEA Heat Pump Centre
Integration of Large Heat Pumps into District Heating & Large Housing Blocks
Study of Working Fluid Mixtures and High-Temperature Working Fluids Compressor Systems
New Development of the Evaporator Part of Heat Pump Systems
Advanced Heat Exchange Technology for Heat Pump Systems
High Temperature Industrial Heat Pumps
Technical and Market Analysis of Advanced Heat Pumps
Stirling Engine Technology for Application in Buildings
Modelling Techniques for Simulation and Design of Compression Heat Pumps
State and Transport Properties of High Temperature Working Fluids and Non-azeotropic Mixtures
Working Fluids and Transport Phenomena in Advanced Absorption Heat Pumps
Heat Pump Systems with Direct Expansion Ground Coils
IEA Heat Pump Centre
Experiences with New Refrigerants in Evaporators
Thermo-physical Properties of the Environmentally Acceptable Refrigerants
Advanced Thermodynamics for Heat Pump Systems
Working Fluid Safety
Global Environment Benefits of Industrial Heat Pumps
Compression Systems with Natural Working Fluids
Heat Pump Systems for Single Room Applications
Absoption Machines for Heating and Cooling in Future Energy Systems
Year-round Residential Space Conditioning Systems Using Heat Pumps

	Advanced Supermarket Refrigeration/Heat Recovery Systems Selected Issues on CO2 as a Working Fluid in Compression Systems Test Procedures and Seasonal Performance Ground-Source Heat Pumps Overcoming Market and Technical Barriers Retrofit Heat Pumps for Buildings Advanced Modelling and Tools for Analysis of Energy Use in Supermarkets Economical Heating and Cooling Systems for Low Energy Houses Compact Heat Exchangers in Heat Pumping Equipment
Solar Heating and Cooling	Investigation of the Performance of Solar Heating and Cooling Systems Coordination of R&D on SHAC Components and Systems Performance Testing of Solar Collectors Development of an Insolation Handbook and Instrumentation Package Use of Existing Meteorological Information for Solar Energy Applications Performance of Solar Heating, Cooling and Hot Water Systems Using Evacuated Collectors Central Solar Heating Plants with Seasonal Storage Passive and Hybrid Solar Energy Buildings Solar Radiation and Pyranomentry Studies Research on Materials for SHAC Systems Passive and Hybrid Solar Commercial Buildings Building Energy Analyses and Design Tools for Solar Applications Advanced Solar Low Energy Buildings Advanced Active Solar Energy Systems Photovoltaics in Buildings Measuring and Modelling Spectral Radiation affecting Solar Systems and Buildings Advanced Glazing and Associated Materials for Solar and Building Applications Solar Air Systems Solar Energy in Building Renovation Daylight in Buildings Solar Building Energy Analysis Tools Optimisation of Solar Energy Use in Larger Buildings Solar Procurement Solar-Assisted Cooling Solar Combi-systems Performance Assessment of Solar Building Envelope Components Solar Sustainable Housing Solar Drying in Agriculture Solar Cities Whole Buildings Advanced Storage Concepts for Solar Thermal Systems in Low Energy Buildings Solar Heat for Industrial Process Testing and Validation of Building Energy Simulation Tools PV/Thermal Solar System Solar Resources Knowledge Management Advanced Housing Renovation with Solar and Conservation Solar Assisted Cooling Systems Polymeric Materials for Solar Thermal Applications
Wind Turbine Systems	Environmental and Meteorological Aspects of Wind Energy Conversion Systems Evaluation of Models for Wind Energy Siting Integration of Wind Power into National Electricity Supply Systems Investigation of Rotor Stressing and Smoothness of Operation of Large-Scale Wind Energy Study of Wake Effects behind Single Turbines and in Wind Turbine Parks Study of Local Wind Flow at Potential WECS Hill Sites Study of Offshore Wind Energy Conversion System Study of Decentralised Applications for Wind Energy Intensified Study of Wind Turbine Wake Effects Systems Interaction Base Technology Information Exchange Universal Wind Turbine for Experiments (UNIWEX)

Co-operation in the Development of Large Wind Turbine Systems
Field Rotor Aerodynamics
Annual Review of Progress in the Implementation of Wind Energy
Wind Turbine Round Robin Test Programme
Database on Wind Energy Characteristics
Enhanced Field Rotor Aerodynamics Database
Wind Energy in Cold Climates
Advanced Aerodynamic Modelling of Wind Turbines
Dynamic Models of Wind Farms for Power System Studies
Wind energy market acceleration
Offshore Wind Energy Technology Development
Integration of Wind and Power
Power System Operation with Large Amounts of Wind Power

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IEA IMPLEMENTING AGREEMENTS: HIGHLIGHTS OF RECENT ACTIVITIES

Cross-Cutting Activities

Climate Technology Initiative
Energy Technology Data Exchange
Energy Technology Systems Analysis Programme

INNOVATIVE FINANCING

Policy Brief

The objective of the Implementing Agreement for Climate Technology Initiative (CTI) is to encourage OECD member countries and non-Member countries to work together to foster international co-operation for accelerated development and diffusion of climate-friendly and environmentally sound technologies and practices. This can be advanced through properly conducted continuous technology needs assessments, training courses, creative financing, capacity building, and expert exchanges.

Background

The nine Contracting Parties of CTI undertake a broad range of co-operative activities in partnership with developing and transition countries and international organisations. The CTI works closely with the United Nations Framework Convention on Climate Change (UNFCCC) process, including its Secretariat and the Expert Group on Technology Transfer (EGTT), relevant IEA Implementing Agreements and other international organizations and initiatives. Industry, private business and financing communities participate on a regular basis in CTI activities. Seminars and symposia generally have a regional focus (Africa, Asia, Eastern Europe, South America) and cover such topics as energy efficiency, improved access to financing, climate development mechanisms, joint initiatives, technology transfer.

Spotlight

A recent initiative of the Climate Technology Initiative (CTI) in cooperation with the UNFCCC Expert Group on Technology Transfer (EGTT) explores innovative options for financing technology transfer, focusing on engaging the private financing community through a private financing advisory network (PFAN).

The aim of PFAN is to provide an interface between public sector policy goals and private sector commercial reality, and increase the number of bankable renewable energy projects and help bring them to financial closure.

To achieve this, PFAN provides coaching and technical assistance to project developers and other project proponents in developing countries and countries with economies in transition to assist them in the preparation of project financing proposals meeting the standards of the international financing community.

CTI side event "Broadening the Base of Financing for Technology Transfer" at the UNFCCC meeting, Bonn, Germany.

PFAN seeks to identify projects that may be suitable for private sector international finance at an early stage and then acts as a "free" project financing consultancy service to guide these projects to banking institutions through to financial closure. This includes assistance, advice and guidance on overall project and commercial structure and design, financing structure, sourcing and procurement of financing, and sourcing technical and engineering advice.

Seven projects are already receiving technical assistance through PFAN, including a biodiesel project in Brazil and a small-hydro project in Chile. Key selection criteria for further projects include a consistent regulatory framework, commercially and technically experienced project sponsors, a proven technology, risk sharing, repayment ability and adequate return. Though the economic elements of a project will be of primary importance, the environmental and social aspects will also be considered.

CURRENT PROJECTS

Raising Awareness and Outreach
Technology Needs Assessments
Training Courses
Capacity Building
Innovative Financing for Technology Transfer

reference:
www.climatetech.net

REACHING OUT WITH TECHNOLOGY INFORMATION

Policy Brief

Having access to key research information provides analysts with the tools necessary to draft appropriate policy documents. The Energy Technology Data Exchange (ETDE) database is the largest single resource for energy-related scientific, technical and policy information worldwide. The ETDE online database, ETDEWEB, includes over 3.8 million citations to literature and hundreds of thousands of links to full texts. The new distributed search feature allows users to pinpoint the results needed, while at the same time providing access to additional resource bases.

Background

The Energy Technology Data Exchange Implementing Agreement currently has 13 Contracting Parties, including Brazil and Mexico. The mission of ETDE is to provide governments, industry and the research community in participating countries with access to the widest range of information on energy research, science and technology and to increase dissemination of this information to developing countries. The objectives of ETDE are to:

- Compile and maintain a shared database on information related to energy research and technology
- Disseminate information related to energy research and technology
- Explore, and where appropriate develop, other ways of collecting and disseminating information related to energy research and technology

Spotlight

The ETDE recently enhanced its website and database, adding several new features. Registered users can set up a free e mail alert profile and receive information on a wide variety of energy-related research areas through the online interface, ETDEWEB.

The new ETDEWEB distributed search feature allows users to select all or one of the following additional sources to search at once Science.gov, Science Conferences, CORDIS projects, Danish Energy R&D Projects, IEA Energy Information Centre, and the Institut Français du Pétrole. ETDE will be adding more quality sources to the distributed search in the future.

The ETDE database includes research documents and full text abstracts on all aspects of energy: renewable energy technologies (e.g. solar, wind, biomass, geothermal, hydro and hydrogen), energy policy, efficiency and conservation, climate change, fossil fuels, nuclear (including waste management), materials and basic sciences R&D, and energy production, storage, and use (including environmental aspects and fuel cells).

Other recent activities and developments of ETDE include:

- Participating in the European Commission Expert Group on Energy Research and Technological Development (RTD)
- Launch of a project with the international publisher Elsevier to enhance timely coverage of over 45 key energy journals
- Membership options have been broadened to promote sponsorships and regional partnerships

CURRENT PROJECTS

In support of the G8 Plan of Action, ETDE continues to provide database access to developing countries. By 2007, more than 60 developing countries have been granted access to ETDE information:

Albania, Algeria, Armenia, Azerbaijan, Bangladesh, Belarus, Bolivia, Botswana, Brazil, Bulgaria, Burkina Faso, Cameroon, Central African Republic, China, Colombia, Congo (Dem. Rep.), Ecuador, Egypt, El Salvador, Ethiopia, Georgia, Ghana, Guatemala, Haiti, India, Indonesia, Iraq, Jordan, Kazakhstan, Kenya, Libya, Macedonia (FYR), Madagascar, Mali, Mauritius, Moldova, Mongolia, Morocco, Myanmar, Namibia, Nicaragua, Niger, Nigeria, Pakistan, Paraguay, Peru, Philippines, Qatar, Romania, Russia, Senegal, Serbia, Sri Lanka, Tajikistan, Tanzania, Thailand, Tunisia, Uganda, Ukraine, Uzbekistan, Vietnam, Yemen (Rep. of), and Zambia.

reference:
www.etde.org

MODELLING FUTURE TECHNOLOGY PROSPECTS

Policy Brief

Experts all over the world are using Energy Technology Systems Analysis Programme (ETSAP) tools such as the MARKAL and TIMES models to provide decision makers with quantitative evaluation of the impact of energy policies on energy security, economic sustainability, environment protection and climate mitigation.

ETSAP tools are used to train analysts worldwide and provide strong support for their evaluation activities. Together with quality data on present energy markets and technologies, the ETSAP tools are applied at the global, regional, national and local levels, resulting in the adoption of more effective energy policies.

Background

The purpose of ETSAP is to advise member countries on common energy RD&D and technology policies. For thirty years, ETSAP experts have developed tools, built models and evaluated energy related policies. The common research program of experts from 16 Contracting Parties has continually developed the MARKAL model generator and recently, the Integrated MARKAL-EFOM System (TIMES), an enhanced model that builds on MARKAL and the three decades of its use. The use of the model generators is simplified by the availability of two user interfaces, ANSWER and VEDA-FE/BE. To date, more than 200 groups in over 60 countries have used ETSAP tools, including the Energy Research Institute of the National Development and Reform Commission (China).

These methodologies have been continuously improved; models can now represent technological least-cost or partial and general economic equilibrium of local or global systems, projecting the future development of present energy systems from a few years to hundreds of years with myopic (limited foresight), clairvoyant (perfect foresight over the modelling time period) or stochastic (planning under uncertainty) points of view.

Spotlight

An important recent achievement using ETSAP tools has been the IEA publication, Energy Technology Perspectives. Scenarios and technology impact evaluations presented in this publication were calculated making use of a 15-region global MARKAL model. The same model was previously used to evaluate potentials for two other IEA studies, Prospects for *CO_2 Capture and Storage* and *Prospects for Hydrogen and Fuel Cells*. Other versions of similar global ETSAP models have been used by the United States Energy Information Administration for the International Energy Outlook (MARKAL-SAGE) and the by the European Fusion Development Agreement.

ACT Scenarios 2050

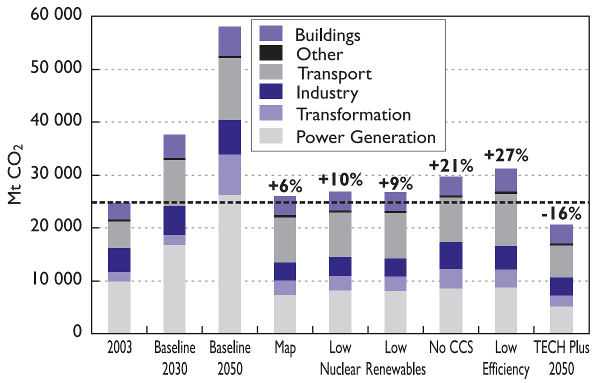


Figure 2.1 from Energy Technology Perspectives (IEA, 2006), based on results from the MARKAL model.

Through its common research program, ETSAP has developed the TIMES Integrated Assessment Model (ETSAP-TIAM). ETSAP-TIAM incorporates technology learning and international trade along with climate equations and a fully stochastic approach to climate sensitivity and other scenario parameters. With this model, in co-operation with institutes in Brazil, China, India and South Africa, ETSAP contributes to the study, *Hedging Strategies and Transition Policies*, of the Energy Modelling Forum working group 22.

CURRENT PROJECTS

EC-CASCADE-MINTS
EC-NEEDS
EC-RES2020
EC-TOCSIN
EnerKey
KAZAKHSTAN MARKAL-MACRO
US-NESCAUM NE12
USAID-SEE-REDP

reference:
www.etsap.org

End-Use Technologies

Buildings

Buildings and Community Systems
District Heating and Cooling
Energy Storage
Heat Pumping Technologies

Electricity

Demand Side Management
Electricity Networks
High-Temperature Superconductivity

Industry

Emissions Reduction in Combustion
Industrial Technologies and Systems

Transport

Advanced Fuel Cells
Advanced Materials for Transportation
Advanced Motor Fuels
Hybrid and Electric Vehicles

Buildings

Buildings and Community Systems

District Heating and Cooling

Energy Storage

Heat Pumping Technologies

BOOSTING BUILDING CODES AND STANDARDS

Policy Brief

Projects carried out within the Energy Conservation in Buildings and Community Systems Programme (ECBCS IA) directly support the technical basis of many national building codes, standards, and regulations. Current and former researchers from ECBCS IA projects use the knowledge they have gained from international collaboration to inform and improve their national approaches.

One example is the ASHRAE Standard (American Society of Heating, Refrigerating and Air-Conditioning Engineers), 'Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs'. This standard was underpinned by many collective years of work developing the BESTEST (Building Energy Simulation Test) approach to evaluating and verifying simulation tools within projects carried out by the ECBCS IA and the Solar Heating and Cooling Implementing Agreement.

Background

There are currently 23 Contracting Parties to the ECBCS IA, including Israel and Poland. Objectives of collaborative work are directly derived from the ongoing energy and environmental challenges facing IEA countries in the area of construction, energy markets and research. The ECBCS IA addresses these challenges and takes advantage of opportunities in the following areas:

- exploiting innovation and information technology;
- impact of energy measures on indoor health and use;
- integration of building energy measures and tools in response to changes in lifestyles, work environment alternatives, and business environments.

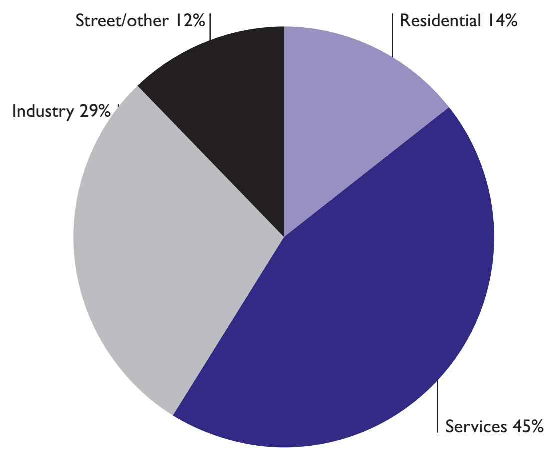
Spotlight

Wireless intelligent lighting controls and LEDs (light emitting diodes) are examples of existing technologies that, if applied more widely, could radically reduce lighting energy use. These technologies are now being studied by the ECBCS project, "Energy Efficient Electric Future Lighting for Buildings". The objectives of the project are to:

oidentify and accelerate the use of energy-efficient, high-quality lighting technologies and their integration with other building systems;

- assess and document the technical performance of existing and future lighting technologies;
- assess, document and propose solutions to the barriers to adoption of energy-efficient lighting technologies.

Global Electricity Consumption for Lighting by Sector



For industrialised countries, electricity consumption for lighting ranges from 5 to 15% of total electricity use, while in developing countries the value can be as high as 86%. More widespread deployment of LEDs, for example, could revolutionise lighting technology and decrease global lighting energy use by 50% by 2025.

CURRENT PROJECTS

Whole Building Heat, Air, Moisture
Simulation of Building-Integrated Fuel Cells and Other Cogeneration Systems
Testing and Validation of Building Energy Simulation Tools
Integrating Environmentally Responsive Elements in Buildings
Energy-Efficient Future Electric Lighting
Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings
Cost Effective Commissioning of Existing and Low Energy Buildings
Heat Pumps and Reversible Air Conditioning
Low-Exergy Systems for High-Performance Buildings and Communities
Prefabricated Systems for Low-Energy Renovation of Residential Buildings

references:
www.ecbcs.org
Source: IEA (2006), Light's Labour's Lost, IEA, Paris.

WHEN IS BIGGER BETTER?

Policy Brief

The fundamental idea of district heating and cooling (DH&C) is simple: connect multiple energy consumers to cost-effective, environmentally optimal heat sources through a piping network. Sources of the heat could include combined heat and power (CHP) plants, biomass or biomass/coal co-firing, capturing geothermal heat and natural sources of heating and cooling (e.g. underground or underwater), or recuperating industrial waste heat.

Yet barriers to the deployment of DH&C schemes exist. They can be avoided through such measures as:

- internalising environmental benefits of DH&C into emissions trading schemes;
- removing subsidies (e.g. gas prices for individual consumers) and guaranteeing a fair price for electricity and a fair allocation of cost between electricity and heat without cross-subsidies;
- effective urban energy planning.

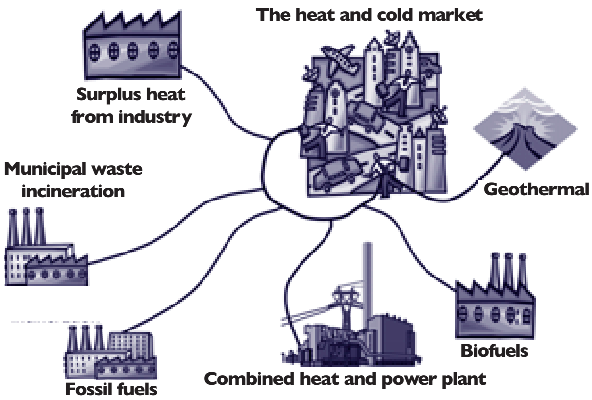
Background

There are currently eight Contracting Parties to the DHC IA. The scope of the work encompasses:

- district heating, cooling and power, and their integration;
- energy efficient supply, notably CHP;
- more economic distribution through improved heating pipes and substations;
- efficient end-use through efficient customer connections and optimisation of demand;
- improving the relationship between supply and demand through thermal storage and system optimisation;
- institutional issues.

Spotlight

A recent DHC IA study demonstrated that where there is a high heat demand, or density, large district heating networks from CHP plants offer greater economic and carbon savings than smaller networks. In addition, with the rapid growth in electricity consumption for air conditioning, DHC provides cooling with no additional investment.



However, new networks evolve slowly not only due to investment costs but also from an organisational perspective. They begin with a core high heat load, from which the network grows outward as customers realise the advantages for them to connect. But is DH&C justified in lower density areas where there are individual family houses and/or new-built areas with lower heat demand? This is a complex issue which the DHC IA research on the viability of district heating for lower density areas will begin to address.

Over the long term, DH&C offers key advantages that make it an investment in a sustainable future, offering fuel flexibility and security of supply, by using locally available low-carbon/renewable/heat that would otherwise be wasted.

CURRENT PROJECTS

Cost Benefits and Long-Term Behaviour of New All-Plastic Piping Systems

New Materials and Constructions for Improving the Quality and Lifetime of DH Heating Pipes and Joints

Assessing the Actual Energy Efficiency of Building-Scale Cooling Systems

Improved Cogeneration, Heat Utilisation DH Networks

District Heating Distribution in Areas with Low Heat Demand Density

reference:
www.iea-dhc.org

RECYLING VALUABLE WASTE HEAT

Policy Brief

Thermal energy storage (TES) technologies can be used in a wide variety of applications. Domestic hot water and space heating/cooling are common examples. Combined with intermittent energy supplies from renewable technologies, energy storage saves the electricity or heat to be consumed during peak demand periods. Recently, other applications of TES have been developed, such as cooling for buildings and recuperating and storing industrial waste heat, two ways to reduce energy demand and CO_2 emissions.

Integrating energy storage techniques and technologies into energy-producing systems is gaining momentum, but more can be done. The Energy Conservation through Energy Storage Implementing Agreement (ECES IA) continues to research new applications, and to raise awareness of TES potentials through the international EcoStock conferences.

Background

There are currently 15 Contracting Parties and two Sponsors (one from Poland) participating in the ECES IA. The overall objective of the ECES IA is to develop and demonstrate various advanced energy storage technologies for applications within a variety of energy systems, and to encourage their use as standard engineering design options. Other activities focus on case studies, demonstrations, deployment measures and design tools.

Spotlight

Two innovative applications of TES are currently being researched: recuperating industrial waste heat and transporting to consumers, and capturing and reusing high-temperature industrial waste steam or air for other processes.

Recuperating industrial waste heat and transporting by truck or train to consumer networks and office buildings up to 20 kilometres away is an economically feasible, flexible way to bring together producers and consumers without investing in new district heating and cooling systems or building on-site CHP. This work examines the advantages of the various types of storage used for the transport, whether phase change materials (chemical granules that store heat such as Zylite) or particular load and discharge capacities, as well as addressing issues such as consumer needs.

Capturing industrial waste heat and transporting to consumer networks is a new area of study.

It is possible to capture and storing high-temperature steam (120 300° C) from industrial processes such as pulp and paper, food processing, textiles, manufacturing of construction materials and drying. In the metallurgy industries, recovery and storage of flue gases and process air of 600° would make substantial energy gains possible in other areas of the process. The ECES IA plans to research the development and design of an efficient and economically optimized heat exchanger and innovative storage design that will allow manufacturers take full advantage of this wasted energy.

New power generation systems also create high temperature heat. In solar thermal power plants the temperature of solid-sensible materials range from 200 to 1 000° C, liquid-sensible materials from 200 500° C and phase-change materials from 200 500° C. Finding ways to recuperate this valuable heat, store it and use for other applications is another current project of the ECES IA.

CURRENT PROJECTS

Transportation of Energy by Utilization of Thermal Energy Storage Technologies

Optimised Industrial Process Heat and Power Generation with Thermal Energy Storage

Sustainable Cooling with Thermal Energy Storage

reference:

www.iea-eces.org

TESTING AND STANDARDS: KEYS TO DEPLOYMENT

Policy Brief

Heat pumping technology has the potential to significantly reduce both energy use and CO_2 emissions. A 30% market penetration of heat pumps could generate savings of 1 500 million tonnes of CO_2 annually, or approximately 6% of current total global emissions. Heat pumps can increase energy security by significantly decreasing energy consumption as well as energy imports. In addition, heat pumps provide greater fuel flexibility, providing the potential to reduce infrastructure costs for supply networks in developing economies.

Key barriers to market penetration of heat pumps include lack of awareness and the relatively high initial capital investment. Presently, heat pumps are cost-effective to society but not to all end-users. Policy instruments such as regulations, incentives, and the inclusion of environmental costing (e.g. C-based) are necessary to accelerate deployment. The Heat Pump Programme Implementing Agreement (HPP IA) is actively working to remove these barriers, mainly through international collaborative research projects.

Background

The HPP IA currently has 12 Contracting Parties. The scope of the work encompasses a full range of activities from R&D to market deployment. Strategic objectives of the Agreement are to:

- quantify and publicise the environmental and energy efficiency benefits of heat pumps;
- develop and disseminate information of heat pumping technologies to support appropriate deployment;
- maintain and develop international technical RD&D collaboration that furthers the environmental and market objectives;
- provide effective collaboration and flow of information to, from and between stakeholders and other relevant bodies.

Spotlight

Currently HPP IA activities focus on projects that increase confidence and awareness of the benefits of heat pumping technologies to industry, decision makers, and end-users. The scope of activities includes establishing performance standards and accreditation schemes for both installers and equipment, providing objective performance information and developing methods for life-cycle cost analyses.

A supermarket refrigerator case uses heat pumps to minimise loss.

For example, outcomes from a recently completed report, Test Procedures and Seasonal Performance Calculation of Residential Heat Pumps with Combined Space and Domestic Hot Water Heating included the following:

- data collection of overall Seasonal Performance Factor (SPF) of integrated heat pump systems;
- development of an easy-to-use calculation method of SPF;
- documenting the test procedure for repetition.

This methodology has already been integrated into a draft standard of the European standardisation organisation CEN (prEN 15316-4-2) in the framework of the European directive on energy performance of buildings (EPBD).

CURRENT PROJECTS

Ground Source Heat Pumps – Overcoming Market and Technical Barriers

Retrofit Heat Pumps for Buildings

Advanced Modelling and Tools for Analysis of Energy Use in Supermarkets

Economical Heating and Cooling Systems for Low Energy Houses

Compact Heat Exchangers in Heat Pumping Equipment

reference:

www.heatpumpcentre.org

Electricity

Demand Side Management

Electricity Networks

High-Temperature Superconductivity

BENEFITS OF MANAGING DEMAND

Policy Brief

Energy efficiency is an energy issue highlighted as offering near-term solutions. Energy efficiency improvements have a significant impact on system performance, the environment and employment.

Demand side management is one way to achieve large-scale program improvements in energy efficiency. The IEA *World Energy Outlook 2006* states that an investment of USD 1 on the demand side offsets USD 2 on the supply side (generation, transmission and distribution). The two cases below illustrate how regulatory modifications can improve conditions for market actors to use these effective mechanisms.

Background

The Implementing Agreement for a Programme on Demand-Side Management Technologies and Programmes (DSM IA) currently has 17 Contracting Parties (including India) and one Sponsor. The scope of the work is divided into two areas: electricity load shape and load level.

Load shaping ensures continuation of network operations in overload situations, or by providing the opportunity to selectively switch loads instead of shutting down selected areas of supply completely. Load levelling typically involves storing excess electricity during periods of low demand for use during periods of high demand, by using energy efficient products, or through implementing energy-efficient measures.

Spotlight

White Certificate schemes aim to create market incentives to reduce electricity demand and CO_2 emissions within a mandatory framework. The DSM IA work on White Certificate Trading addressed the following key issues:

- whether, and how, White Certificate trading is effective in attaining energy consumption reduction targets;
- possible formats of schemes;
- national and international implementation challenges;
- interaction with other energy efficiency policies.

Findings of the study show that the most effective and profitable applications of White Certificate schemes could be expected in the following policy environments:

- where energy taxation mechanisms are less effective;
- to replace investment subsidies and tax deduction options;
- together with/instead of detailed performance standards;
- in conjunction with voluntary agreements;
- in the presence of an intensive policy of support for energy audits.

Though all current White Certificate schemes allow some type of trading, whether cross-sectoral or cross-border, it is not their primary objective. Nevertheless, it was found that trading is an essential flexibility feature within instruments to reduce costs to comply with savings obligations.

In another area of research, the DSM IA "Demand Response Resources" project aims at sharing knowledge and best practices in planning and deploying effective, reliable demand response resources within participants' markets in several innovative ways.

An internet-based Demand Response Resources Portal allows participants to share information. The portal includes tools such as the demand response market potential calculator, which translates basic market demographic information into demand response market potential benchmarks. Another tool available on the portal is a database of country case studies. Yet another database stores nearly 100 strong-performance, innovative demand response products from Asia, Europe, and North America.

CURRENT PROJECTS

Time-of-Use Pricing and Energy Use for Demand

Demand Response Resources

Network-Driven DSM

Competitive Energy Services

Integration of DSM, Energy Efficiency, Distributed Generation and Renewable Energy Sources

reference:
http://dsm.iea.org

UNTANGLING THE NETWORKS

Policy Brief

The electricity industry worldwide is operating in a period of change and challenges. It has to respond to a series of often quite disparate external drivers, whilst maintaining, if not improving, overall service quality under ever more competitive market conditions. The successful development, design, configuration, operation and maintenance of its transmission and distribution (T&D) networks is an essential prerequisite of the industry's ability to respond to – and benefit from – such changes in the external environment.

The newly created IEA Implementing Agreement on Electricity Networks Analysis, Research and Development (ENARD IA) is working to address the diverse issues involved in the development, design, operation and performance of electricity networks at the integrated system level.

Background

The ENARD IA was created in 2006 to address the various issues involved in the development, design, operation and performance of electricity networks at the integrated system level.

The ENARD IA vision is to facilitate the uptake of new operating procedures, architectures, methodologies and technologies in electricity T&D networks, such as to enhance their overall performance in relation to the developing challenges of network renewal, renewable integration and network resilience. Currently with 10 Contracting Parties, the ENARD IA plans to provide comprehensive and unbiased information, data and advice to its four key stakeholder communities, namely:

- governments
- policymakers
- power utilities
- power engineering equipment suppliers

Spotlight

The first task of the ENARD IA is to gather information and assess the situation in participating countries with a view to identifying specific opportunities for further collaborative R&D. This work will be central to the

Agreement as a whole. It is principally led by the organisation and delivery of a series of topical experts' meetings and workshops, which aim to draw out key issues of common interest and which may be addressed further. These events are co-ordinated by an underlying programme of information and data collation to provide background material and shape the context of the future development of the work programme.

Early candidates for follow-on work include distribution system issues, transmission system issues, economic and regulatory aspects, micro-grids and electricity networks in the developing world.

The first projects will focus on the following topics:

- transmission systems
- distribution systems
- economic and regulatory issues

Consideration will also be given to the development of further projects in the areas of micro-grids and electricity networks in developing countries.

All work will begin with an expert meeting or workshop to define participating country needs and priorities. The first events will cover:

- distribution systems and end user aspects
- integration of distributed energy sources and new business models
- managing an ageing infrastructure
- economic and regulatory issues

CURRENT PROJECTS

Information Collation and Dissemination

reference:

www.iea-enard.org

INCREASING CAPACITY AND RELIABILITY

Policy Brief

The electric power sector is under increasing strain and the number of electricity outages, or faults, is increasing. In addition to providing electricity for light and power, utilities must now provide energy for the information economy and for communications including mobile phones, e-mail, and the Internet. In addition, following the deregulation and liberalisation of the power sector, networks are more vulnerable due to lack of maintenance.

The unusual electrical properties of superconducting materials accommodate very high power density with unusually low losses. Incorporating high-temperature superconductors (HTS) into powerful electrical equipment offers unusually compact, safe and environmentally benign equipment that can increase system reliability.

To achieve abundant, inexpensive, safe electric power, sustained public and private R&D partnerships as well as education of young scientists and engineers in the rapidly moving field of superconductivity will be needed. Moving recently discovered science and technology from the laboratory to marketplace is key.

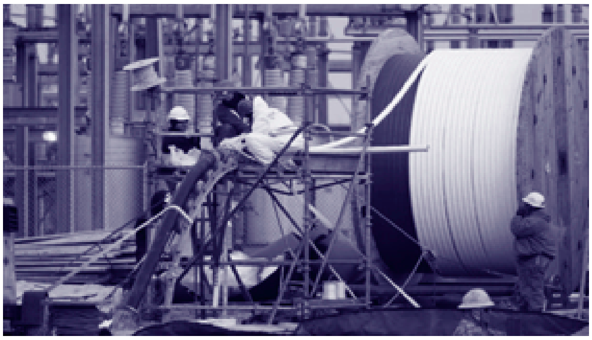
Background

The aim of the High-Temperature Superconductivity Implementing Agreement (HTS IA) is to identify and evaluate the potential benefits of superconductivity to the power sector and barriers to realising these benefits. This is accomplished by sharing experience and perspectives among experts while conducting focused inquiries into specific, relevant topics. There are currently 14 Contracting Parties to the HTS IA, including Israel.

Spotlight

In a recent study, *High-Temperature Superconductivity Rotating Machines — Challenges and Prospective Applications*, the HTS IA set out to examine in which conditions HTS motors and generators are better than conventional alternatives. The report surveys the state-of-the-art of HTS applications of 37 firms that manufacture powerful electric motors and 29 firms that manufacture electric generators.

Thanks to their magnetic-conducting capacity, HTS conductors can also yield significantly smaller, lighter motors. Reduced size and weight have financial value in a variety of circumstances.



A recent demonstration project of new HTS cable design enabling large amounts of power transmission through unusually small ducts.

Cost analysis of replacing the aluminium or copper coils on a rotor with HTS tape or cold coils shows that, in some cases, HTS increases generator efficiency by 33%. However, due to initial investments required to maintain the HTS at a constant operating temperature of 77 Kelvin the payback period can be up to 15 years, depending on whether the plant is running at 100% capacity.

It was found that the most advantageous applications for future motors or generators incorporating HTS generators for industry, airplanes, ships, and diesel-electric trains or trucks, oil and gas platforms, offshore wind turbines, and electricity generation in densely populated areas.

The most powerful wind turbines produce 5 MW of electricity. Replacing the magnetic poles in a gear box with HTS, a wind turbine generator would be much smaller, more efficient and more powerful, enabling more power per square kilometre of wind farm.

CURRENT PROJECTS

HTS Rotors

Superconducting Motors

HTS Rotating Machines

Alternating Current Losses and HTS

Fault Current Limiters

Simulating HTS

Using Electromagnetic Transients Programs

references:

http://spider.iea.org/tech/scond/scond.htm

Photo courtesy of Ultera, a joint US-European demonstration project (Southwire-NKT), Columbus, Ohio.

Industry

Emissions Reduction in Combustion

Industrial Technologies and Systems

HYDROGEN-POWERED ENGINES POSSIBLE

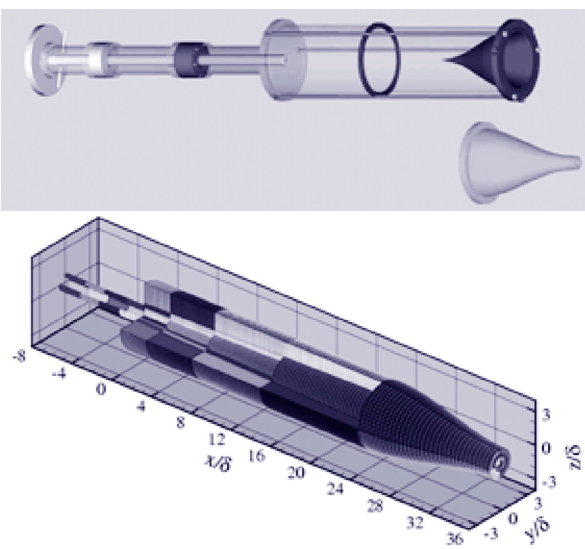
Policy Brief

Given the current and projected consumption for transport and power generation, combustion engines and boilers will continue to play an important role for years to come. Finding ways to burn the fuels more efficiently in turbines, boilers and piston engines is the goal of the Energy Conservation through Emissions Reduction in Combustion Implementing Agreement (ERC IA). Research conducted in the ERC IA reduces fuel consumption and greenhouse gas emissions.

Yet this valuable research is not sufficient. Accelerated, concerted efforts between the public and private sectors will be vital to extracting the most from combustion technologies.

Background

Eleven countries currently participate in the ERC IA. Each research project is chosen and carried out in parallel in national research laboratories, enabling participants to leverage research funding. An ongoing dialogue with industry ensures economic relevance. All projects build on individual activities already underway in participating countries.



A laboratory-scale combustion chamber (above) and a computerised version (below).

Spotlight

A common theme in these activities is an integrated experimental and computational program where the results of experiments in one or more participating countries are used to guide the development of computational tools of other countries. This approach has been used successfully in our work on hydrogen-enriched combustion for gas turbines.

A related area of much interest is internal combustion engines that operate on pure hydrogen or hydrogen-enriched hydrocarbon fuels. These are viewed as a near- to mid-term option for transportation in a hydrogen economy while fuel cells undergo continued development.

This research task focuses on advancing the development of hydrogen fuelled engines. A significant emphasis is placed on increasing efficiencies, reducing emissions, mitigation of undesired combustion (such as pre-ignition and knock), and increasing power densities.

Work will be carried out in two separate but complimentary programs:

- research related to engine operation with pure hydrogen;
- research related to engine operation with hydrogen-enriched hydrocarbon fuels.

As the hydrogen engine research community is small, much can be gained by collaborative efforts such as establishment of baseline engine operating conditions, instrumentation, diagnostics, and validation of models.

The benefits of a hydrogen economy for security, environment and energy sustainability are evident. Hydrogen and hydrogen-enriched-fuelled internal combustion engines are a critical transitional strategy towards development of a hydrogen infrastructure. Given the importance and complexity of the task, the program has been designed from the outset as a multinational effort, co-ordinated by a technical oversight committee. Additional countries may participate in this work following review and approval of the technical oversight committee.

CURRENT PROJECTS

Advanced Piston Engine Technologies
Advanced Furnace Tech. Fundamentals
Fundamentals of Turbulent Reactor Flows
Advanced Gas Turbine Technology
Homogeneous Charge Compression Ignition
Hydrogen Internal Combustion Engines
Internal Combustion Engine Sprays

reference:

www.ieacombustion.com

CAPITALISING ON CONVENTIONAL PROCESSES

Policy Brief

Large, economically attractive reductions in fuel and electricity consumption are possible in industries such as iron and steel, cement, petrochemicals, chemicals, pulp and paper, aluminium and food processing. There is also a high potential of energy savings from increased efficiency of cogeneration/combined heat and power. As a result, there is a greater potential for reducing greenhouse gas emissions at a lower cost than could be achieved in other sectors. By 2030, there is potential for CO_2 emission reductions in this sector of nearly 30%.

In order to facilitate implementation, further international cooperation and knowledge transfer regarding experiences of new equipment/system solutions and studies of future systems and technologies are necessary. These are the goals of the Industrial Energy Technologies and Systems Implementing Agreement (IETS IA).

Background

The IETS IA was established in 2005 as the result of merging, revising and extending activities formerly carried out under three separate Implementing Agreements. There are currently 10 Contracting Parties, including Brazil and Mexico.

The mission of the IETS IA is to accelerate the research and share the results of cost-effective new industrial technologies and system layouts that increase productivity and product quality while improving energy efficiency and sustainability.

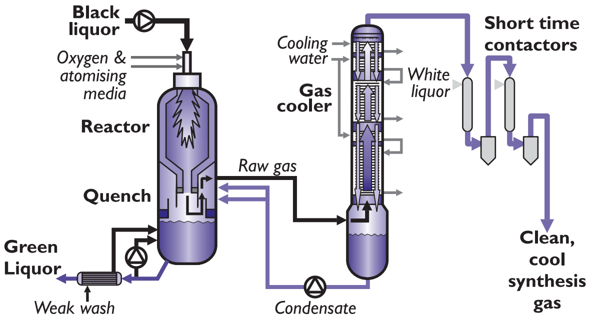
The IETS IA will initially focus on the energy-intensive process industries and technology areas, but will continuously evolve with the aim to include more industry sectors and to facilitate cooperation between different industrial RD&D disciplines.

Spotlight

After recovery of cellulose for paper making, the residual stream from the wood pulping process, known as black liquor, is burned in conventional boilers to recover the pulping chemicals while at the same time generating power from the biomass. Gasification of the black liquor, however, could substantially improve the efficiency of the process.

One research project of the IETS IA examines the ways to reduce technological barriers to successful commercial-scale operation of biomass and black liquor gasification technologies, particularly for refractory and metallic materials, fuels chemistry and mill integration. Gasifiers can separate sulphur and sodium and recycle these in the process while providing fuel for combined cycle gas turbines that generate enough electricity to make the plant a net power producer.

In addition, the black liquor gasification (BLG) process has several advantages compared to the traditional boilers. BLG makes it possible to make new, cost-effective products such as transportation fuels from the resulting synthesis gas. The estimated production cost for transportation fuels from BLG is close to the current price for gasoline and diesel. The potential for fuel production is significant in countries with large-scale pulp production.



A high-temperature black liquor gasification boiler.

Two BLG processes have been studied – a fluidised-bed process operating beneath the melting point of the inorganic content in the black liquor, and an entrained flow process operating above the melting point. Development of both processes has been accelerated as a result of the work of the IETS IA.

CURRENT PROJECTS

Gasification of Black Liquor and Biomass
Benchmarking in Pulp and Paper Industry
System Aspects of Separation Technologies

reference:
www.iea-iets.org

Transport

Advanced Fuel Cells

Advanced Materials Transportation

Advanced Motor Fuels

Hybrid and Electric Vehicles

SUSTAINABLE HEATING, TRANSPORT POSSIBLE

Policy Brief

High efficiency and the possibility of using locally produced, sustainable fuels for heating are among the key advantages of fuel cells and the main drivers to greater deployment in the future. Transport is also a sector where fuel cells have the potential to contribute significantly in the longer term.

Today, however, cost is a major barrier to the widespread deployment of fuel cell systems. Increasing the volume of fuel cells manufactured will be necessary to reduce costs. International cooperation helps to overcome this by sharing best practice of demonstration and deployment activities and accelerating research into cost-effective technologies.

Background

The aim of the IEA Advanced Fuel Cells Implementing Agreement (AFC IA) is to advance the state of understanding in the field of advanced fuel cells. The AFC IA operates a coordinated programme of research, technology development and system analysis. There are currently 18 Contracting Parties in the AFC IA, including Mexico. AFC IA expert networks enable specialists to share research, development and demonstration results; define measurement and monitoring techniques; exchange information on cell, stack and system performance; collaborate on the development of new procedures and models; and share information on application requirements.

Spotlight

The AFC IA researches all the main fuel cell types (polymer electrolyte fuel cells, molten carbonate, and solid oxide fuel cells), and applications (transportation, portable, and stationary). One project of the AFC IA examines fuel cell systems for stationary applications.

There are several different kinds of fuels that can be used in stationary fuel cells. Natural gas is the most common, though hydrogen is also versatile as it can be produced locally from many different fuels, including renewables. In addition, wastes such as purge gas from the chemical industry, or synthesis gas and process gases can be used in stationary high temperature fuel cells, as can biomass waste and waste-derived fuels, for example the CHRISSGAS project in Sweden using wood chips.

The market outlook for stationary fuel cells identifies potential customers and different business concepts for stationary fuel cells through a SWOT-analysis (Strength Weaknesses Opportunities and Threats). A comprehensive four-part questionnaire has been developed to analyse up-to-date information regarding market conditions in participating countries.

One issue this project addresses is the consequences of connecting a large number of small fuel cells to the distribution network both in terms of the quality of the electricity, fuel distribution, safety aspects, and economic considerations.

An example of a solid oxide fuel cell (SOFC) stationary power unit.

Most failures in demonstration plants for stationary fuel cells are related to the lack of system auxiliary components (desulphurisation, reformers, and inverters), also called balance of plant. Following a survey of major developers of high-temperature fuel cells, the AFC IA found that suppliers are reluctant to develop components designed for fuel cells as the market uptake is uncertain. Unfortunately the balance of plant costs for a stationary fuel cell contributes nearly two-thirds of the total system cost. Reducing these auxiliary costs will be vital to bringing fuel cells into the market.

CURRENT PROJECTS

Polymer Electrolyte Fuel Cells
Molten Carbonate Fuel Cells
Solid Oxide Fuel Cells
Fuel Cell Systems for Stationary Applications
Fuel Cells for Transportation
Fuel Cells for Portable Applications

references:

www.ieafuelcell.com

Photo courtesy of Siemens AG.

REDUCING FRICTION SAVES ENERGY

Policy Brief

Advanced materials are an important building block for modern technologies, particularly in the transport sector. Advanced materials testing and standards enable the development of energy efficient cars and trucks. This can be achieved through designing surface textures to reduce friction, testing and substituting lightweight frame materials that do not compromise safety, and testing effects of nano-materials and nano-structured coatings. By implementing these technologies, fuel consumption could be reduced by 10%.

Key barriers to achieving these goals are the lack of recognition that advanced materials technology requires a robust infrastructure: establishing standards, sophisticated materials-testing laboratories, and meeting fuel economy and pollution emission mandates. With the right policies, though, these can be overcome.

For example, the CAFÉ standard has played a significant role in improving fuel economy of cars in the United States. Through international co-operation in the Advanced Materials Transportation Implementing Agreement (AMT IA), research results of the materials testing and standards ensures simultaneous development in member countries.

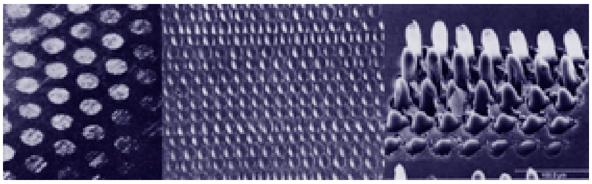
Background

Initially, the focus of research of the AMT IA was the use of ceramics for advanced diesel engine technology. Through sustained, joint efforts of the contracting parties, test methods, standards, and component technologies were developed that supported low heat rejection engine technologies. These results enabled the free flow of this advanced material worldwide.

Today the research of the AMT IA focuses on four areas: surface technologies, eco-materials (including weight reduction material substitution), coatings and thin films, and new emerging materials. There are currently five Contracting Parties in the AMT IA.

Spotlight

Surface properties such as topography, rigidity or elasticity, as well as operating conditions all influence the amount of friction. The AMT IA examine how modifying the surfaces can significantly decrease friction and increase automotive fuel efficiency. This is particularly true for heavy-duty truck engines, which are evolving rapidly to meet more stringent emissions standards. Surface textures such as those shown below are able to reduce friction by as much as 40%.



Examples of surface texture designs that reduce engine friction.

Another area of research of the AMT IA examines how to increase fuel efficiency through the use of lightweight materials for vehicle structural components such as the chassis. Magnesium alloys offer the same strength, while at the same time greatly reducing vehicle weight. A weight reduction of 100 kg represents approximately 1 mpg of savings (given average driving conditions) and approximately 5% reduction in emission levels.

However, there are many technical challenges facing the widespread use of this class of materials, including high fabrication costs, lack of corrosion resistance, and hardening while being handled.

For this reason, the AMT IA is also examining other materials to reduce weight and improve durability such as aluminium, titanium, carbon composites, and polymer composites.

CURRENT PROJECTS

Surface Texture Design Guidelines for Engine Components

3-D Descriptor of Textured Surfaces

Standard Testing Methods for Friction Measurement

Coatings for Magnesium Alloy Corrosion Protection

Nonmaterial Characterisation

Advanced Coating Evaluation Techniques

reference:
www.iea-ia-amt.org

NEW FUELS, NEW EMISSIONS RESULTS

Policy Brief

When choosing future fuel options one must understand not only the fuel chain – from feedstock to fuel processing to fuel distribution – but also the end-use sector. The potential environmental impacts and necessary vehicle/engine modifications are equally important.

The primary focus of the Advanced Motor Fuels Implementing Agreement (AMF IA) is to form policies and strategies to facilitate the market introduction of advanced motor fuels and related vehicle technologies in member countries.

Background

Eleven countries currently participate in the research of the AMF IA. The AMF IA continues to provide a neutral platform for fuel analyses and reporting, drawing on the multifaceted expertise of its participants, partners and networks.

Spotlight

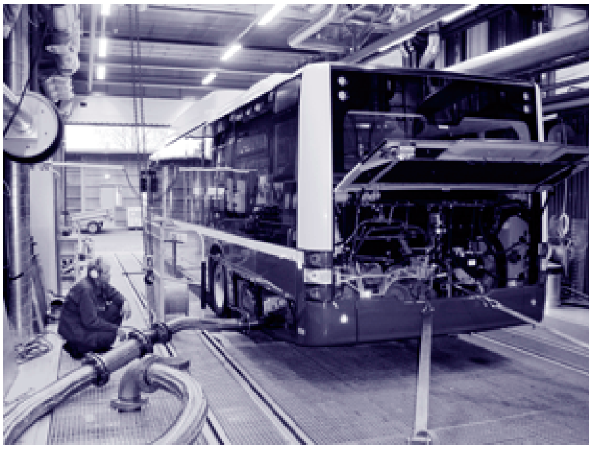
A new body of research of the AMF IA aims to forecast the future of the bio-diesel industry, analysing the various options for biomass-derived diesel fuels such as vegetable oil methyl esters (used today in growing volumes) and advanced diesel fuels extracted from biomass produced in second-generation bio-refineries.

The research will be carried out in three phases. First a review of the literature pertaining to the use of FAME (fatty acid methyl ester) as a diesel replacement fuel with a special emphasis on research results related to overcoming the technical barriers. Second, an in-depth investigation into the new concepts being proposed for flexible bio-refineries will be undertaken.

In addition to thoroughly understanding the chemical and thermal processes required by the concepts, the focus of this work is to understand how broadly we can reasonably extend the range of biomass feedstocks as well as fuel products from the conceptual bio-refineries.

Lastly, a critical technical assessment of the various concepts for bio-diesel will be carried out. Attention will be given to feedstock availability, efficiency of production, logistics, and the influence on greenhouse gases. Consideration is also given to the trends in engine development and fuel specifications to evaluate those biodiesel options with the potential of meeting future diesel fuel quality requirements.

Another research area of the AMF IA studies emissions of heavy-duty urban vehicles by comparing a number of duty cycles on several heavy-duty vehicles. New types of diesel, compressed natural gas (CNG), and hybrid buses were tested with three common test cycles in three different laboratories. Seven new buses have been run (three European and four North American models), using the seven best known duty cycles on chassis dynamometer. One key advantage of using complete vehicle testing is that emissions results are measured in grams/kilometre (or mile) rather than grams/kilowatt-hour, the standard measurement for engine testing.



A bus undergoes emissions testing.

A recently published, comprehensive AMF IA report, Outlook for Advanced Motor Fuels and Vehicles, examines the current state-of-the-art and offers projections for transportation energy, vehicle technologies and advanced and alternative fuels.

CURRENT PROJECTS

Evaluation of Heavy-Duty Vehicle Test Cycles

Production and Use of Synthetic Vehicle Fuels made by Fischer-Tropsch Technique

Particle Emissions of 2-S Scooters

Analysis of Biodiesel Options

references:

www.iea-amf.vtt.fi

Photo courtesy of Environment Canada.

EXPANDING MARKETS FOR HYBRIDS

Policy Brief

Surveys in America, Asia, and Europe have shown that many people drive their cars less than 50 km per day, and most people drive less than 100 km per day. Battery electric cars can meet the mobility needs of many urban households, but they usually do not meet consumer expectations.

In addition, electric vehicles are still a challenge for the automobile industry in terms of technology and marketing, and they are not currently the focus of policymakers. R&D support and developing adequate introduction strategies are needed to stimulate developments in this area. One of the most important objectives of Hybrid and Electric Vehicles Implementing Agreement (HEV IA) is to highlight the role electric vehicles can play in sustainable transportation and to bring electric vehicles back into the spotlight.

Background

The 10 Contracting Parties to the HEV IA share the following objectives:

- provide governments, local authorities, large users and industries with objective information on electric and hybrid vehicles and their effects on energy efficiency and the environment;
- collaborate on pre-competitive research projects and related topics and to investigate the need for further research in promising areas;
- collaborate with other transport-related Implementing Agreements and to collaborate with specific groups or committees with an interest in transportation, vehicles and fuels.

Spotlight

One new research project of the HEV IA investigates the available and emerging technologies for heavy-duty hybrid vehicles such as trucks, buses, dedicated heavy-duty vehicles, and possibly off-road mobile machinery such as forklifts, construction equipment or military equipment. The first task assesses the technical requirements, available technologies and characteristics and system integration requirements, focussing on power-train configurations, and power-train strategies for higher efficiency and lower emissions. The second task will be to examine the market situation, trends and potentials.

An example of a heavy-duty hybrid truck.

Another research project of the HEV IA examines the application of fuel cells for transport. The main focus will be on road vehicles, but other means of transport will be considered as well. Boats, airplanes and mining vehicles could be an interesting niche preparing the market introduction of fuel cell, electric and hybrid road vehicles. The use of fuel cells as APUs (auxiliary power units) might be the first economically viable niche for the introduction of fuel cells in vehicles following preliminary investigations of all types of fuel cells. Work will concentrate on PEM (polymer electrolyte membrane) fuel cells, though the potential of other fuel cells such as solid oxide fuel cells (SOFC) will also be examined.

Choosing the most suitable fuel and finding how to store it on board is probably the most important question for fuel cell vehicles. Hydrogen, methanol or even liquid fossil fuels for SOFC will be investigated.

Exotic fuels such as ammonia or other liquid or gaseous fuels will also be studied for their practical relevance as fuel for fuel cells. The HEV IA is investigating opportunities for common activities on mobile applications of fuel cells with the AFC IA.

CURRENT PROJECTS

Hybrid vehicles
Electrochemical Systems
Electric Cycles
Heavy-Duty Hybrid Vehicles
Fuel Cells for Vehicles

references:

www.ieahev.org

Photo courtesy of Nissan.

Fossil Fuels

Clean Coal Centre
Enhanced Oil Recovery
Fluidised Bed Conversion
Greenhouse Gas R&D
Multiphase Flow Science

CLEAN COAL PROJECTS

Policy Brief

Coal is a reliable, abundant energy source. Current world reserves could supply coal for another 180 years. In addition, thanks to recent technological advances, coal can be used as a clean energy source.

However, sustained research efforts are needed to ensure that industry and electricity generators continue to extract ever more from each tonne of coal.

Background

There are currently 11 Contracting Parties and 10 Sponsors from industry (5 within IEA countries and 5 located in non-IEA countries) in the Implementing Agreement for the IEA Clean Coal Centre (CCC IA). The goals of the CCC IA are to:

- gather, assess and distribute knowledge on the energy efficient and environmentally sustainable use of coal (including co-firing coal with waste or biomass);
- undertake in-depth studies on topics of special interest;
- assess technical, economic and environmental performance;
- identify where further RD&D is needed;
- report balanced, objective findings without political or commercial bias that highlight opportunities for technology transfer worldwide.

Spotlight

One recent CCC IA report, *Clean Coal Developments in Poland*, gives a concise overview of possibilities for clean coal technologies. Poland lacks significant reserves of oil and natural gas but possess large reserves of both lignite and hard coal, which supplies two-thirds of the country's primary energy demand and is used to produce most of its electricity.

Many conventional pulverised coal (PC) power plants have been modernised, and significant investment has been made to replace older plants with circulating fluidised bed combustion (CFBC) systems. Nearly 20 major CFBC units are operating for electricity generation or other industrial applications using subcritical steam conditions.

However, in Lagisza, a new supercritical (SC) 460 MWe plant is under construction, the first supercritical once-through CFBC boiler in the world. The plant will enable steam turbine net efficiencies to be higher than 43%. Developers are monitoring the results of the Lagisza plant with a view to building more supercritical CFBC projects.

Poland's largest lignite-fired power plant, the 4320 MW Belchatow station, burns 35 Mt/year of lignite.

Two SC lignite-fired, PC plants are currently under development. The first is Patnów, a 460 MWe SC, lignite-fired power plant. Patnów will be the largest, most efficient and most environmentally friendly lignite-fired power plant in Poland. The second project is taking place at Belchatów, where a new 833 MWe SC lignite-fired facility is being built. Once completed, the plant is expected to have a guaranteed gross efficiency of 44.2%. There are also plans to build a 900 MWe integrated gas combined cycle power plant elsewhere in Poland.

CURRENT PROJECTS

Prospects for Coal and Clean Coal Technologies in the Czech Republic and Poland

Ash Management for Power Generators

Public Attitudes to New Coal-Fired Plant

Trends in SO_2 Emissions

Use of PCI in Blast Furnaces

Management of FGD Residues

Power Projects Using Coal Mine Methane

G8 Global Database Coal-Fired Power Plants

references:

www.iea-coal.org.uk

Photo courtesy of Elektronia Belchatow S.A.

Source: BP Annual Report, 2006.

INCREASE OIL FIELD YIELDS AND REDUCE CO_2

Policy Brief

Despite measures taken to reduce CO_2 emissions and moves towards less dependency on oil and gas, global energy consumption is expected to continue to increase for several decades. Therefore a significant challenge is finding ways to stretch remaining resources and build a bridge of energy supply until more sustainable energy technologies are able to fully respond to energy demand.

Enhanced oil recovery (EOR) is one important way to achieve this. In most oil fields, less than 50% is recoverable using conventional technology. Worldwide, only 30 to 35% of the oil in ground will be produced according to present plans and technology. Advanced technologies have been developed to extract this additional oil, but in many cases they are not cost efficient to implement.

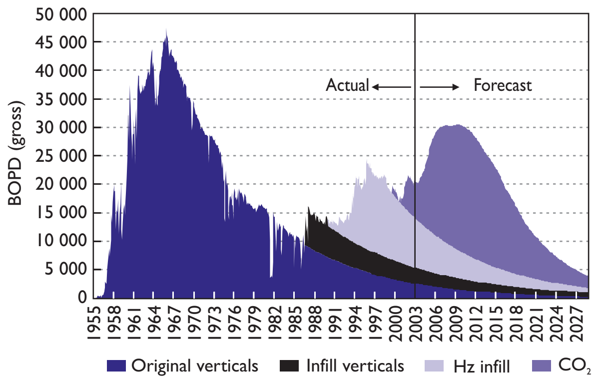
The main limitation to technology advances is the current lack of geoscientists and petroleum engineers. Greater public awareness of the need for oil for several more decades will be necessary to interest young people in choosing this profession. In addition, continued work in this area is important as public and private funded research related to oil recovery tends to follow the oil price, i.e. when oil prices are low many companies and governments reduce research expenditures.

Background

There are currently 11 countries participating in the Enhanced Oil Recovery Implementing Agreement (EOR IA), including Russia and Venezuela. The aim of the Agreement is to stimulate national efforts to continue to develop less costly EOR technologies as well as to research new technologies. This is achieved through an open forum for information and knowledge exchange.

Spotlight

One successful example of EOR technologies is the Weyburn field, which has become commercially viable through the use of enhanced oil recovery by CO_2 injection. Total oil recovery (prior to using CO_2 for enhanced oil recovery) would have been 154 million barrels. It is expected that an additional 67 million barrels will have been extracted through CO_2 injection. In addition, the Weyburn field has served as an important case study for the possibility of combining enhanced oil recovery by CO_2 injection with CO_2 sequestration: a win-win solution.



Production history of the Weyburn oil field (United States and Canada).

Each year the EOR IA organises an international symposium to draw out the state-of-the-art technical capabilities of the oil exploration engineering in each of the research areas of the Agreement listed below. Speakers typically include representatives from multinational and national oil companies, engineering experts and trade associations,

In 2006 the focus of the symposium was "Reservoir Management through Monitoring". This event addressed the recent technological progress in the use of reservoir characterisation, simulation and monitoring in order to optimise reservoir management, in particular of enhanced oil recovery processes. In 2005, the topic of the annual international symposium focused on "Advancement of Simulation Technologies for Improved Oil Recovery".

CURRENT PROJECTS

- **Studies of Fluids and Interfaces in Porous Media**
- **Fundamental Research on Surfactants and Polymers**
- **Development of Gas Flooding Techniques**
- **Thermal Recovery**
- **Dynamic Reservoir Characterization**
- **Emerging Technologies**

references:

www.iea.org/eor

Source: Petroleum Technology Research Centre, 2004.

STUDYING CO-CONVERSION CHEMISTRY

Policy Brief

A fluidised bed is a unique reactor that converts fuels such as coal and biofuels into heat or gas, and in turn to electricity or gaseous products. During the existence of this Implementing Agreement, the technology has gradually improved, and it is now commercial.

However, as new problems emerge, continued R&D in this field is required. The Fluidised Bed Conversion Implementing Agreement (FBC IA) allows regular co operation between researchers, industrial representatives and governmental officials to stay informed of technology advances in this area and use these advances to continually improve the technology base.

Background

There are currently 12 Contracting Parties to the FBC IA. The primary goals of this Agreement are to advance the knowledge of national experts and operations professionals through shared research results and regular symposia. Research areas include combustion, conversion and co-firing (including gasification) of coal, biomass, wastes and other fuels. Other promising techniques under review include oxy-fuel combustion and looping-cycle combustion, where important CO_2 reduction can be achieved.

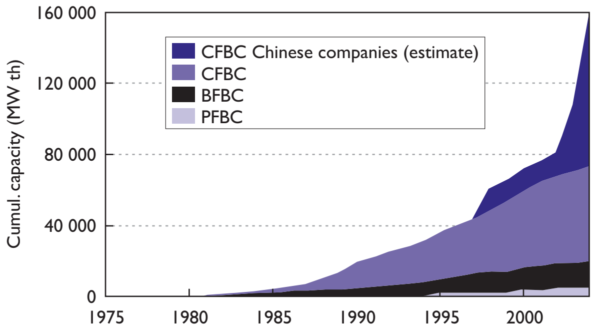
Spotlight

The recent focus of FBC IA research concerns the challenges and advantages of co-combustion. Co-conversion is possible in all types of converters. However, it was found that fluidised bed conversion is particularly useful when converting two fuels together. The proportions of each fuel are not important, as long as the heat balance of the bed permits.

This finding creates new possibilities for fuel conversion and demonstrates that there are benefits of using various fuels depending on the fuel properties (i.e. interaction of the mineral contents of the fuels). The goal of FBC IA research in this area is to find ways to mitigate or eliminate combinations that create negative fuel interactions and to take full advantage of the positive fuel interactions.

One example of a positive interaction is sulphur or aluminium silicates with potassium in ashes. This combination reduces the negative effects of free potassium in many biomasses that would otherwise deposit on heat transfer surfaces. Coal and biomass also show a positive interaction in this respect, but the most effective results are achieved by using sewage sludge as it virtually removes all deposits on tubes.

Fluidised Bed Devices Worldwide, 2004



However, a negative effect may result by co-converting biomass with high-chlorine content coal that could lead to severe deposits together with potassium from biofuels.

These results show that the composition of various fuels and their combinations should be investigated in order to find ways to predict the behaviour of a particular fuel or a particular combination of fuels with respect to deposits and subsequent corrosion of heat transfer surfaces, either in mono-conversion or in combination with another fuel.

CURRENT PROJECTS

- **Combustion of High Volatile Fuels in Circulating and Bubbling Beds**
- **Co-firing of Coal and Biomass**
- **Ash Behaviour and Utilisation of Ashes**
- **Large-Scale Fluidised Bed Boilers**
- **Behaviour of Difficult Fuels and Opportunity Fuels and Fuel Mixtures**
- **Fragmentation and Attrition of Fuels in the Fluidised Bed**

references:

www.iea.org/tech/fbc/index.html

Source: Boiler database, Åbo Akademi, Finland.

CAPTURE, STORE AND REDUCE CO_2

Policy Brief

There is no single global solution to maintaining energy security and economic growth while at the same time reducing greenhouse gas emissions.

Yet it is clear that carbon capture and storage is a feasible component in emissions-reduction strategies. The viability of CO_2 capture and storage (CCS) has already been successfully demonstrated. One CO_2 store under the seabed in the Norwegian section of the North Sea has been operating for more than 10 years.

Background

There are currently 18 Contracting Parties to the GHG IA, including India. In addition, industry partners play an active role in the work of the GHG IA. There are currently 14 multinational oil or technology companies participating as Sponsors. The aims of the IEA Greenhouse Gas R&D Implementing Agreement (GHG IA) are to achieve deep reductions in GHG emissions by:

- evaluating technologies aimed at reducing greenhouse gas emissions;
- facilitating RD&D activities;
- promoting and disseminating results of data and evaluation studies;
- facilitating technical and non-technical research networks.

Spotlight

The present RD&D status for CCS is very encouraging. Both government and industry are putting much effort into establishing CCS technology. The key targets are to:

- reduce the cost and energy penalties for CO_2 capture;
- build confidence that storage of CO_2 in underground formations is safe and effective.

There has been a recent surge of initiatives aimed at demonstrating the integrated operation of CO_2 capture at a power station with its storage deep underground. Unfortunately, such demonstrations are expensive – approximately USD 1 000 million – and securing funding for them is not easy.

Post-combustion carbon capture at an ammonia plant (Malaysia).

CURRENT PROJECTS

Research Networks:

-Well Bore Integrity (Storage)

-Risk Assessment (Storage)

-Measurement, Monitoring, and Verification (Storage)

-CO_2 Post-Combustion Capture

-Oxyfuel Combustion (Capture)

-Biofixation

Some Recent Studies:

-Safe Storage – Analogies with Natural Gas Industry

-Capture at Brown Coal Power Plants

-CCS Permitting Issues

-Trends in Cost of CO_2 Capture

-Monitoring Decision Support Tool

-Near-Zero Emissions Technologies

-Environmental Impacts of Solvent Scrubbing

-CCS and Power Plant Investment

references:

www.ieagreen.org.uk

www.co$_2$captureandstorage.info

Photo courtesy of Mitsubishi.

Sources: IPCC (2006), Special Report on Carbon Capture and Storage.

GOING WITH THE FLOW

Policy Brief

Multiphase flow science concerns the study of the movement of mixtures of fossil fuels for electricity generation (e.g. liquid-solids, gas-liquid, solids-gas, or liquid-gas). Such flows usually exhibit unique complex behaviour, unlike that of single-phase fluids. Due to particle erosion, flow blockage, and unreliable flow control techniques, the average plant operation is typically limited to less than 50% of design performance.

Improved knowledge in these phenomena will lead to more efficient and cost-effective energy production, transport and end-use technologies. For example, a recent study found that large-scale, solids-processing plants in the United States and Canada have an operating reliability of only 63% compared to 84% for plants processing liquids or gases.

Background

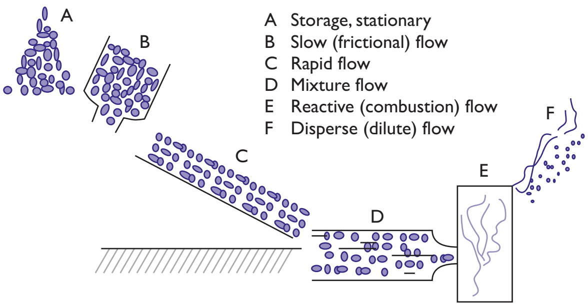
There are presently seven Contracting Parties to the Multiphase Flow Science Implementing Agreement (MPF IA), including China and Mexico. The MPF IA is task-shared, i.e. each participating country undertakes research and results are shared among all countries. The objectives of this Agreement are to:

- improve understanding of the fundamental behaviour and properties of multiphase flow through theoretical studies and experimentation;
- develop improved instrumentation for gathering fundamental information on multiphase flow;
- provide participants with access to advanced research apparatus and instrumentation not readily available in national programmes.

Spotlight

Recent research efforts of the MPF IA concentrate on two areas of multiphase flow: gas-solid reacting flows and gas-liquid-solids non-reacting flows.

Research in Australia, Canada, China and the United States focuses on gas-solid reacting flows in a coal gasification system for electricity production. In this system, fundamental measurements are being made to provide data and theory on various flow regimes that occur in a gasification process. These regimes range from frictional flow (hoppers, chutes and standpipes) to clustering core-annular flow (fast fluidised bed or transport reactor). The theory is being incorporated into Eularian-Eularian computational fluid dynamics (CFD) codes to predict system performance.



Multiphase flow can occur in any energy conversion process. This is an example an integrated gasification combined cycle (IGCC) plant.

Canada, Mexico and Norway are currently focusing on gas-liquid-solids non-reacting flows in various oil and gas extraction processes. This work provides a mechanistic understanding of these complex flow phenomena. Norway and Canada have exchanged researchers during the past year to share results of recent progress in understanding gas-liquid-solids flows.

Many MPF IA participating countries are studying problems that arise when moving and processing the solids. Based on the body of international scientific literature in this domain, many other countries are also interested in these challenges.

CURRENT PROJECTS

Pipeline Transport of Oil Sands, Oil-Gas Mixtures and Other Fossil Fuels

Multiphase Processes in Oil and Gas Recovery

Modelling of Reactive Flows in Fluidised Bed Conversion Reactors

Flow of Granular Materials Chutes, Bins and Hoppers

Biomass Materials Feeding and Handling

Experimental and Numerical Modelling of Circulating Fluidised Beds

references:

www.etsu.com/ieampf

Sources: Oil Shale Development in the United States: Prospects and Policy Issues, Rand Corporation, 2005.

Fusion Power

Environment, Safety, Economy of Fusion
Fusion Materials
Large Tokamaks
Nuclear Technology Fusion Reactors
Plasma Wall Interaction in TEXTOR
Reversed Field Pinches
Stellarator Concept
Tokamaks with Poloidal Field Divertors

FULFILLING THE PROMISE

Policy Brief

Fusion energy has the potential to be a very safe, environmentally attractive, cost-effective and inexhaustible source of power. To achieve this status, however, a significant amount of research must still be accomplished. Determining the costs and developing the safety aspects of various fusion systems and demonstrating them to regulators and the public are essential to the future of fusion power.

Background

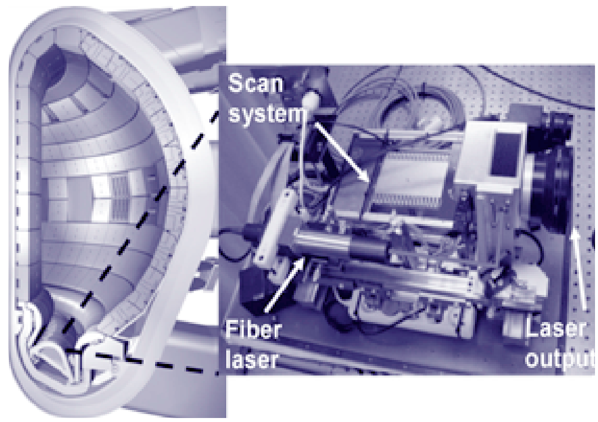
Five Contracting Parties, including Russia, participate in the Environmental, Safety and Economic Aspects of Fusion Power Implementing Agreement (ESE IA). Participants conduct research and develop the analytical tools necessary to demonstrate the safety aspects of fusion. The scope of the work encompasses:

- development, validation, and data requirements of environmental and safety analysis models and computer codes including supporting research;
- development of safety methodologies for use by designers of fusion facilities;
- system studies of future fusion facilities to determine their environmental, safety and economic characteristics.

Spotlight

Nuclear fusion releases or absorbs energy depending on the masses of the nuclei involved. Currently fusion fuel consists of deuterium, a stable isotope of hydrogen and tritium, a radioactive isotope of hydrogen. A key issue for safe fusion power plant operation is controlling, removing and recovering tritium trapped in material lining the reactor.

Some factors affecting tritium inventory control include complex structures within the reactor chamber, various types of materials selected for enhanced reactor performance, and continuous plant operation for economic power production. Several recovery techniques are presently under investigation by the international community participating in this ESEA IA. Recent advances have, for example, been achieved with laser ablation cleaning, flash-lamp deposit removal, and plasma torch heating. A few of these methods will be evaluated in JET, Tore Supra, and TEXTOR machines. These results will be valuable for ITER and other future fusion power plants.



The laser ablation tritium removal system using an Ytterbium-fibre laser.

One promising tritium removal method uses laser beams. Scanned over a surface, the beams rapidly heat and drive out the trapped tritium. Deployed on a remote manipulator and outfitted with mirrors, the system could treat surfaces at remote locations where excess tritium deposits are expected. A prototype of this system developed for JET has achieved sufficient material removal rates relevant for fusion reactors (see detail below).

CURRENT PROJECTS

In-vessel Tritium Source Term

Transient Thermo-fluid Modelling and Validation Tests

Activation Products Source Terms

Failure-Rate Database

Radioactive Waste Studies

Socio-Economic Aspects

Magnet Safety

Power Plant Studies

references:

www.iea.org/techagr

Schema courtesy of Idaho National Laboratory, United States.

INNOVATIVE MATERIALS RESEARCH

Policy Brief

The success of fusion energy requires employing a range of materials with properties that are superior to those used in more conventional energy systems. Materials are under development that will provide safe, reliable and predictable performance, long service life at elevated temperatures, and contain minimum radioactivity in end-of-life components for simplified recycle or disposal.

Studying the effects of irradiation from fusion systems presents a particularly difficult challenge, as fully suitable test beds are not available.

Background

There are seven Contracting Parties to the Fusion Materials Implementing Agreement (FM IA), including China and Russia. The focus of this co-ordinated research is development of materials for the first wall and blanket of a power plant that will operate under high temperatures and survive the high flux of neutrons and charged particles produced in the plasma chamber. This work also includes research on design properties, material production, and joining methods.

Investigations include materials irradiation in fission reactors, ion beams, and computational simulation. The strong, experimentally-validated theory and modelling effort supports data extrapolation to true fusion conditions and lifetimes.

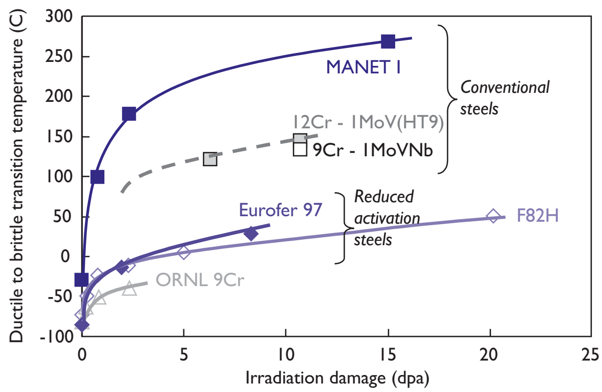
FM IA participants have also developed the conceptual design for an International Fusion Materials Irradiation Facility (IFMIF). IFMIF is now ready to move to the Engineering Validation and Engineering Design Activity (EVEDA) stage.

Spotlight

One important area of research under the FM IA is to find new steels capable of withstanding radiation bombardment. Radiation damage can produce large changes in structural materials. Conventional power systems are built with ferritic chromium-molybdenum steels. However, the molybdenum and some minor alloying elements are not acceptable for fusion power.

FM IA research has led to the development of a new family of advanced steels known as reduced-activation ferritic/martensitic steels. After exposure to neutrons (expressed as atom displacements) these new steels surpass properties of conventional steels, with a lower ductile-to-brittle transition temperature (DBTT) than conventional steels (i.e. they are more resistant to breakage yet have increased tensile strength).

Irradiations in Fission Test Reactors



* High-flux reactor or high-flux irradiation reactor at 300-400°C

More advanced versions of these steels, called oxide dispersion strengthened steels (ODS), hold even greater promise. Insoluble particles (a combination of yttrium, titanium and oxygen, or Y-Ti-O) provide an additional margin of strength at high temperatures. Higher operating temperatures allow higher thermal efficiency, thus lowering costs. These ODS steels are the focus of continuing investigations.

CURRENT PROJECTS

IFMIF Irradiation Facility
Reduced Activation and Advanced Steels
Vanadium Base Alloys
Silicon Carbide Composite Materials
Refractory Metals, mainly Tungsten Alloys
Diagnostic and Control Insulating Materials
Computer Modelling and Simulation
Fundamental Studies of Irradiation Effects

references:

www.frascati.enea.it/ifmif

Graph courtesy of Oak Ridge National Laboratory, United States.

EXPERIMENTS, THEORY AND MODELLING

Policy Brief

The Large Tokamak Implementing Agreement (LT IA) has been effective in developing Tokamak research to reach break-even conditions and in developing the necessary databases for the next-step device ITER, and a steady-state Tokamak reactor. This Agreement provides leadership in coordinating International Tokamak Physics Activity (ITPA) joint experiments with other Tokamak-related research groups.

Background

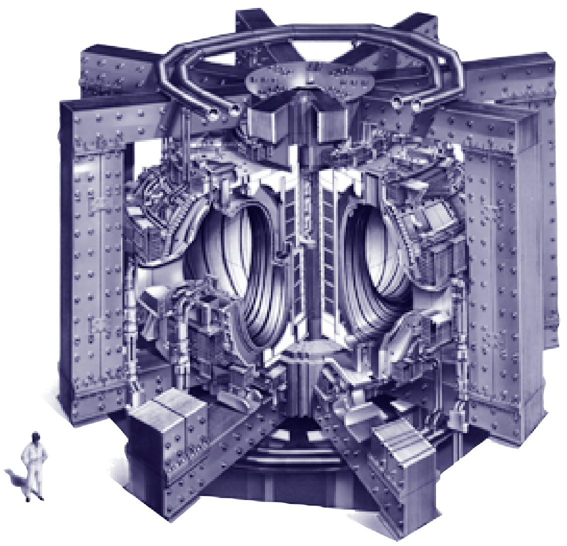
The objective of the LT IA is to enhance the scientific and technological achievements of large Tokamaks through co-operative research. The achievements of the LT IA have provided essential data and operating experience for ITER and the advancement of the Tokamak concept. There are three Contracting Parties to the LT IA. The current focus of LT IA experiments include:

- energy confinement dependence on plasma pressure, collision and aspect ratio;
- controlling plasma instabilities (resistive wall modes, neoclassical tearing modes at high beta, edge localised modes, disruptions);
- material erosion, migration re-deposition and fuel retention;
- sustaining long, steady-state high plasma pressure plasma discharges with reduced toroidal field ripple and high bootstrap currents;
- hybrid and other advanced modes;
- effect of q profile on triggering high confinement and fast-particle-induced magnetic-fluid dynamic (MHD) instabilities;
- real-time control of plasma profiles.

Spotlight

Recent experiments, theory and modelling of the LT IA were performed using the JET (European Union) and JT-60 (Japan), with contributions from operations of the DIII-D, CMOD and NSTX devices in the United States.

R&D is near completion and procurement packages put in place for major enhancements of high scientific value and strategic importance for the Joint European Torus (JET). These improvements focus on ITER scenarios with increased heating power and an ITER-like combination of first wall and divertor materials. ITER scenario development is also a major element of the DIII-D (United States) and the JT-60U (Japan).



Cross-section of a Joint European Torus (JET) machine.

One current focus of LT IA research is the development of negative-ion-source-based neutral beam injector (N-NBI) in JT-60U, tritium and remote handling in JET (including cleaning of plasma facing components using a flash lamp and a small plasma torch), as well as diagnostics improvements.

International workshops are regularly held to share results of the LT IA among participants and with other fusion-related Implementing Agreements. "Implementation of the ITPA Coordinated Research Recommendations", "Burning Plasma Physics and Simulation" and "Implementation of the ITPA Coordinated Research Recommendations" are three recent examples.

CURRENT PROJECTS

Transport and Internal Transport Barrier (ITB) Physics
Confinement Database and Modelling
Magneto-Hydrodynamic Models
Edge and Pedestal Physics
Scrape-Off Layer (SOL) and Divertor Physics
Steady State Operation
Tritium and Remote-Handling Technologies

references:
www-jt60.naka.jaea.go.jp/lt
Schema courtesy of EFDA-Jet.

CONVERTING AND CONTROLLING HOT PLASMA

Policy Brief

Developing fusion is an extremely difficult scientific and engineering challenge. For fusion to be achieved, we need to understand how to contain – and maintain – hot plasma. The next step will be to learn how to extract the energy from that plasma to generate electricity.

Technology plays a critical role in our ability to accomplish this important task, but it will not be easy. Even though a significant amount of research has been completed, more will be necessary to make fusion a viable option.

Background

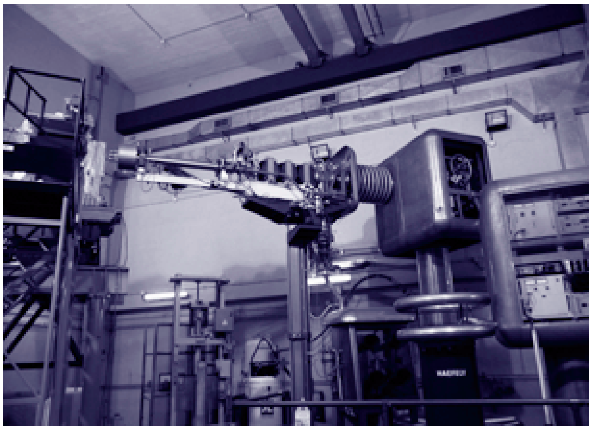
There are five Contracting Parties (including Russia) in the Nuclear Technology of Fusion Reactors Implementing Agreement (NTFR IA). The objective of this international collaborative program is to conduct research and development on certain key components of fusion power plants and their associated technologies, i.e. those operating close to the fusion burning plasma, and needing to handle large flows of energy. The ultimate goal is to develop effective, reliable, functioning components with prolonged lifetimes under the conditions expected to occur in a commercial fusion power plant. This is crucial not only to the economic performance of fusion power, but also its environmental and safety acceptability.

The NTFR IA has two major activities. The first activity relates to components known as blankets. The major function of the blanket is to convert fusion energy, which comes in the form of neutrons, into thermal energy or "heat' which can then be used to make electricity. The blanket uses either a solid or liquid lithium-based material. It must also breed tritium, one of the two elements necessary to maintain the fusion reaction, and, as necessary, provide tritium fuel to ignite reactions in other fusion power plants.

The second activity of the NTFR IA concerns the components that immediately face the hot plasma and accordingly experience a substantial amount of energetic charged particles which makes it a very harsh and difficult environment in which to survive. These components are important as they help to shape and control the plasma.

Spotlight

NTFR IA research has led to a significant amount of work being accomplished in a number of technical areas essential to the development of test blanket modules (TBM) for application to ITER. These included developing a fabrication process for the materials, testing the capacity to withstand irradiation, evaluating the thermo-mechanical properties of a packed pebble bed supported by modelling and developing a common design database to help insure that the TBM for ITER are all done on a common basis.



A 14-MeV fusion neutron irradiation facility, FNG (Frascati Neutron Generator), for the neutronics experiments of breeding blanket mock-ups.

In the neutronics area, there has been extensive collaboration on a wide array of fusion neutronics activities including integral experiments on solid breeding blanket and materials to support the TBM development, experiments of induced radioactivity of low activation materials, improvement of fusion relevant nuclear data, nuclear design studies and code development and calibration of the measuring techniques for tritium production rates in blankets.

CURRENT PROJECTS

Solid Breeding Blankets
Liquid Breeding Blankets
Neutronics
Tritium Processing
Plasma Facing Components
Plasma Surface Interactions

references:

www.iea.org/techagr

Photo courtesy of Italian National Agency for New Technologies, Energy and the Environment (ENEA).

PAVING THE WAY TO ITER

Policy Brief

ITER, the next step fusion device, will demonstrate the possibility of generating 500 million Watts of electricity from fusion power in pulsed operation.

The research field of plasma wall interaction (PWI) is crucial for the construction of such a fusion reactor. Experiments to define the right conditions for the development of advantageous plasma configurations will have important implications for a steady-state fusion power plant.

Background

There are four Contracting Parties to the Plasma Wall Interaction in TEXTOR Implementing Agreement (TEXTOR IA). The research conducted under the TEXTOR IA concentrates on urgent ITER issues:

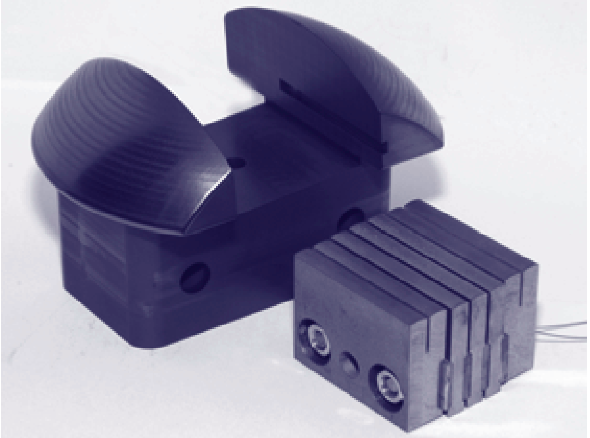
- lifetime expectations of the divertor target plates;
- tritium inventory build-up rates;
- strategies for improvements and optimisation of materials and concepts for plasma-facing components;
- methods to suppress or avoid plasma instabilities and control the plasma wall interaction.

TEXTOR is a highly specialised Tokamak designed to investigate PWI in a versatile test facility. It is operated by Forschungszentrum Jülich (Germany), with strong support from the partners ERM/KMS (Belgium), and FOM (Netherlands). Research in PWI significantly profits from co-operation based on joint experiments with other fusion devices and laboratory work which is based on well co-ordinated efforts with the other fusion-related Implementing Agreements.

Spotlight

As a cross-sectional research field, PWI is relevant to ITER and beyond as well as to the new generation of Stellarators with their intrinsic capability for steady state operation (i.e. the Japanese LHD, or W7-X, under construction in Germany). Specific topics addressed within the TEXTOR IA include:

- quantitative description of the erosion and deposition behaviour of wall materials;
- fuel (deuterium, tritium) recycling, retention and removal from deposited material layers;
- control techniques for limitation of peak heat loads, in particular with external distortion fields;
- transport physics, e.g. scrape-off layer (SOL) transport, stochastic plasmas, island divertor, turbulence, intermittency);
- modelling transport in the edge plasma within complex, three-dimensional magnetic structures;
- development of diagnostics relevant to ITER.



Test piece to the conceptual design of bulk tungsten divertor tiles for JET (lamellae) to be exposed to the TEXTOR plasma through a limiter lock.

All these aspects play a role in the development of tungsten divertor modules for JET in the frame of the ITER-like wall project. These are highly loaded, plasma-facing components at the outer strike point of high-beta, high-triangularity, ITER-relevant plasmas.

Recent experimentation with the Dynamic Ergodic Divertor has opened new horizons to plasma edge research with relevance to both Tokamaks and Stellarators. This novel concept, based on external distortion fields, opens a wide domain of studies to control wall loads and plasma instabilities.

CURRENT PROJECTS

Modelling of Erosion, Migration and Deposition of Wall Materials in ITER

Tritium Retention and Removal studies

Development of High-Z Wall Components for the ITER-like Wall in JET

PWI Optimisation through External Distortion Fields

references:

www.fz-juelich.de/ief/ief-4/en

Photo courtesy of Institute for Energy Research, Forschungszentrum J lich; Germany.

FEEDBACK STABILISATION AND ALPHA PARTICLES

Policy Brief

The most highly developed approach to fusion power, the Tokamak, confines hot plasmas at 100 million degrees Celsius in extremely strong magnetic fields produced by large, superconducting magnets. In the reversed field pinch (RFP) approach, the device uses the electromagnetic properties of the plasma itself to generate the confining magnetic fields. In RFP devices the magnetic field is approximately 10 times weaker, allowing for high plasma density.

However, the weak magnetic field adds physics challenges that must be overcome if the engineering advantage is to be realized. The research of the Reversed Field Pinches Implementing Agreement (RFP IA) is aimed at surmounting this set of physics challenges.

Background

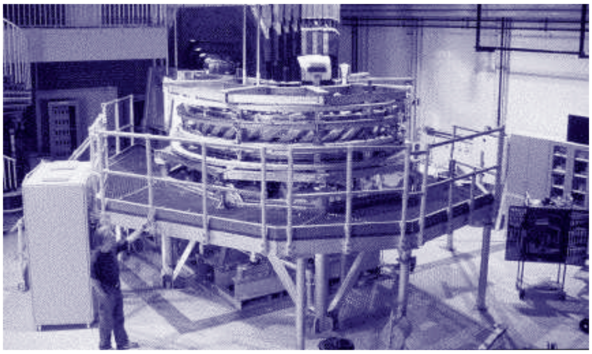
There are currently three Contracting Parties to the RFP IA. Research programs of each of the participants are coordinated and highly complementary. Taken as a whole, the international research addresses the key physics challenges of the RFP IA which are to:

- improve confinement of the plasma in the weak magnetic field;
- determine the maximal plasma pressure that can be confined;
- stabilise instabilities that arise when the plasma is not surrounded by a conducting shell;
- devise techniques to sustain the plasma in a steady state or to determine an attractive pulsed reactor scenario.

The main objective of the RFP IA is to cooperate on national experiments. Collaboration ranges from sharing of instrumentation to joint experiments and common development of theory and models. These goals would not be attainable without international cooperation through the RFP IA. Results are shared during annual international scientific workshops

Spotlight

Two notable advances emerged from recent research among RFP IA participants. Until now, most RFP experiments have operated with the plasma surrounded by a close-fitting conducting container to stabilise the plasma. It has long been known that without this shell a large number of instabilities, or growing waves, occur in the plasma. Unfortunately these waves degrade the ability of the magnetic field to confine the plasma, and over time, the conducting wall loses its stabilising ability. Experiments have now been operated in which the conducting shell is replaced by a set of actively controlled coils that stabilise instabilities through feedback. In the RFX (reversed field experiment) experiment in Padua, Italy and the T2 experiment (medium-sized reversed-field pinch) in Stockholm, Sweden, feedback has successfully stabilised the waves – as many as 20 at one time. This established that the conducting shell might not be necessary in an RFP fusion energy system. Feedback stabilisation is also highly relevant for use in advanced Tokamak devices such as ITER.



General view of an EXTRAP T2.

The second recent advance among RFP IA participants has been the demonstration that hot ions can be well-confined in the RFP plasma. In a fusion energy system, very energetic alpha particles produced in the fusion process must be confined by the magnetic field so that the energy can transfer to the background plasma and maintain the temperature. The presence of alpha particles can be simulated by injecting very energetic ions into the plasma. This has been accomplished in the MST (Madison Symmetric Torus) experiment in Madison, Wisconsin, United States. The results show that the ions are very well confined, even in the typically weak magnetic field of an RFP.

CURRENT PROJECTS

EXTRAP T2-R (Sweden)
MST (United States)
RFX (Italy)
TPE-RX (Japan)

references:

www.iea.org/techagr

Photo courtesy of the European Atomic Energy Community (Euratom), Stockholm, Sweden.

NEW OPTIMISATION SCENARIOS

Policy Brief

A Stellarator is a class of magnetic confinement concept without net currents in plasmas. Compared to a Tokamak, a Stellarator is disruption-free, with an intrinsic capability of steady-state operation. A Stellarator concept exploits these advantages and has demonstrated a variety of breakthroughs leading to optimisation of the fusion power plant.

The Implementing Agreement for Co-Operation in Development of the Stellarator Concept (Stellarator IA) strengthens co-operation among participating countries to improve the physics base of the Stellarator concept.

Background

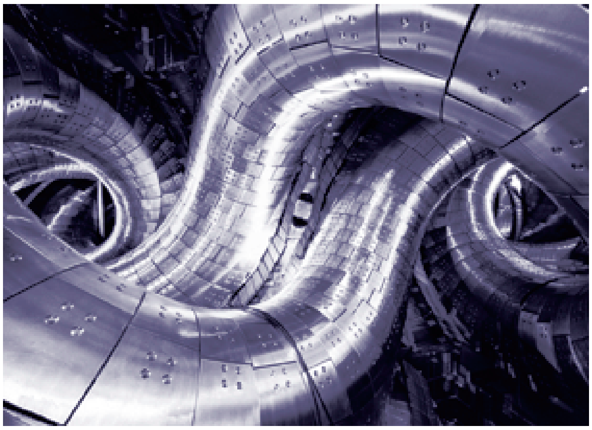
There are currently six Contracting Parties to the Stellerator IA, including Russia and the Ukraine. The Stellerator IA cooperates and conducts diversified experiments, theory and reactor design. The bi-annual International Stellarator Workshop (ISW) assesses recent progress among Stellerator IA participants.

Spotlight

Several recent experiments and discoveries have been accelerated by the joint planning and co-ordination of national programs, and assignment and exchange of specialists within the scope of the Stellarator IA. For example, new regimes in high beta (approximately 4.8%), long pulse (one hour) and high density (5x1020m-3) of plasma have been explored experimentally.

Together with the high density H-mode in the Wendelstein 7-AS (W7-AS) machine of the Max-Planck Institute for Plasma Physics (Germany), consistent confinement in the high-density regime has been clarified in a Stellarator. The recent discovery of an Internal Diffusion Barrier in the Large Helical Device (LHD) of the National Institute for Fusion Science (Japan) is making the possibility of a Super-Dense Core (SDC) reactor a reality. Unlike Tokamaks, a Stellarator does not require current drive and the high-density operation lowers plasma wall interaction. The SDC reactor has the potential to greatly reduce engineering demands. Experiments on the optimisation of high-beta operation in the LHD and the W7-AS have been characterised in terms of the flexibility of magnetic configurations. Both experiments show that concerned pressure driven MHD instabilities usually lead to weak confinement degradation and do not cause major disruption even in an unstable, linear regime.

These experimental observations create new optimisation scenarios and point to the need for a new physical model. They demonstrate that experiments under non-ideal conditions and with non-linearity are possible.



Inside view of the Large Helical Device (LHD).

Other coordinated activities of Stellarator IA participants include the International Stellarator Confinement Database, computer code benchmarking for transport, and reactor design and assessment. The database is comprised of the global scalar physical quantities of experimental devices such as the LHD, W7-AS, TJ-II (Spain), Heliotron J (Japan) and HSX (United States). The database will be expanded to include the 1-dimensional profile documentation to resolve key physical topics. Computer code benchmarking activities will be directly linked with upcoming quasi-symmetric devices, i.e., Wendelstein 7-X (Germany) and NCSX (United States).

CURRENT PROJECTS

High-Density Operations

High-Beta Experiments

International Stellarator Confinement Database

Computer Code Benchmarking

references:

www.iea.org/techagr

Photo courtesy of the National Institute for Fusion Science, Toki, Japan.

RESULTS IMPROVE FUSION FUTURE

Policy Brief

Tokamaks with a poloidal divertor are geometrically very similar to the international fusion power project ITER, allowing for exploration of relevant plasma physics on a smaller scale. Extrapolating these results to ITER avoids the need to account for geometry effects.

The set of experimental devices contributing to the Tokamaks with Poloidal Field Divertors Implementing Agreement (TPFD IA) play a strong role in guiding the design of ITER subsystems. They clarify the physics aims and prepare ITER operations in terms of integrated Tokamak operation scenarios.

Background

The TPFD IA enables coordination of research between experimental facilities among the three Contracting Parties through programmatic discussions, joint research programs, and coordinated experiments. Typical examples of critical issues examined include:

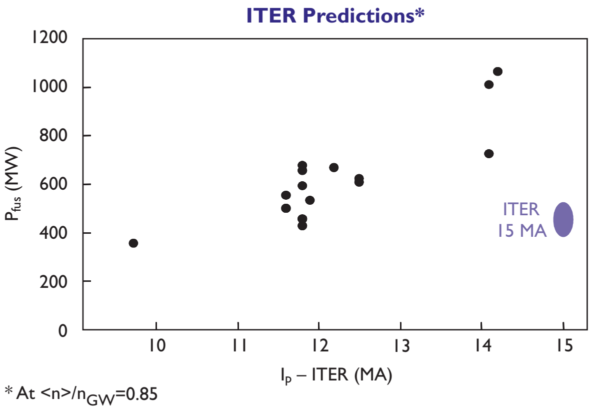
- development of hybrid scenarios for improved ITER operation;
- comparing the qualities of carbon and tungsten as plasma-facing components in next-step devices;
- physics of performance-limiting instabilities and means for their stabilisation.

Further critical issues are generally identified by the International Tokamak Physics Activity (ITPA), which proposes joint experiments involving several research facilities on an international level. The TPFD IA contributes largely to this activity through various experimental devices.

Spotlight

The results of two recent research areas demonstrate how progress achieved on devices of the TPFD IA directly impact – and improve- the ITER design and operational plan.

Stabilising the plasma is one of the great challenges of fusion power. Research experiments of the TPFD IA show that by applying microwaves at the electron cyclotron resonance frequency a localised current is created. This is suited to suppress a magneto-hydrodynamic (MHD) instability which limits the maximum achievable plasma pressure



Extrapolation of ASDEX Upgrade results applicable to ITER operations.

These results show that by operating the microwave heating system at this frequency, the fusion power can increase due to the increase in plasma pressure. This has strong implications for future fusion reactors based on the Tokamak principle and has led to a subsequent redesign and improvement of the ITER microwave heating system.

Confinement is another important aspect of fusion power research. By carefully tailoring the radial distribution of the toroidal (ring-shaped) plasma current under high-confinement (H-mode), the TPFD IA was able to enhance confinement quality and MHD stability in plasma discharges. This improved H mode could provide more fusion power or longer pulses in ITER without the need to use full plasma current capability. This would also increase the operational flexibility of the device with respect to the original planning.

CURRENT PROJECTS

Alcator C-Mod (United States)
ASDEX Upgrade (Germany)
DIII-D (United States)
KSTAR Device (Korea)
NSTX (United States)

references:

www.aug.ipp.mpg.de/iea-ia

Graph courtesy of Max-Planck Institute for Plasma Physics; Germany.

Renewable Energies and Hydrogen

Bionergy
Deployment
Geothermal
Hydrogen
Hydropower
Ocean Energy Systems
Photovoltaic Power Systems
Solar Heating and Cooling
SolarPACES
Wind Energy Systems

BIOMASS AND FOSSIL FUELS: GENERATING INTEREST

Policy Brief

Biomass currently provides 10% of world primary energy supply and 1.3% of electricity production. Co-firing biomass with fossil fuels could increase the share of biomass in electricity generation from 3 to 5% by 2050, while at the same time reducing CO_2 emissions.

Biomass co-firing with coal or oil in modern, large-scale, efficient power plants is cost-effective, requires moderate additional investment, reduces emissions and improves energy security.

Background

The Bioenergy Implementing Agreement (Bioenergy IA) currently has 20 Contracting Parties, including Brazil, Croatia and South Africa. The goals of the Bioenergy IA are to:

- provide researchers with opportunities for collaborative R&D through information exchange;
- partner with industry of new RD&D projects;
- assist policy-makers to gain perspective on progress in bioenergy and deployment opportunities and to set guidelines and standards.

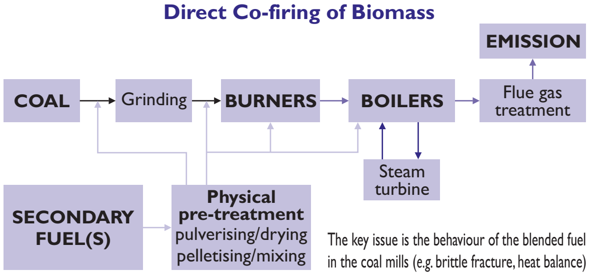
Spotlight

Co-firing fossil fuels with biomass has many advantages (e.g. existing infrastructure, higher efficiency); though a key issue is the behaviour of the blended fuel in the combustion process (e.g. brittle fracture, moisture content, heat balance). For example, wood pellets offer consistent burning quality yet they tend to be the most expensive. Aggregated biomass derived from other industries can be more cost-effective. Waste-derived fuels are more available and less expensive, but can be more challenging to burn.

Under this research task, the Bioenergy IA recently examined several relevant technical issues: catalyst performance, efficiency and emissions for different operation modes, small-scale systems, fuel flexibility and availability, and corrosion and deposit formation. In addition, several tools were created to assist experts in designing new co-firing systems or to make the most of existing co-firing plants:

- *The Handbook on Biomass Combustion and Co-firing* outlines the current R&D needs for biomass combustion, identifies possible applications, and conduct economic feasibility studies.

Direct Co-firing of Biomass



- "The fuelsim-average" spreadsheet calculates 15 different greenhouse gas emissions based on the mass, volume of the biomass burned.
- "The biobank", a set of databases covering the chemical composition of 1 000 types of biomass fuels, 560 types of ashes and 30 types of condensates from flue gas condensors in real-life installations.

CURRENT PROJECTS

Socio-economic Drivers in Bioenergy
Short Rotation Crops for Bioenergy
Biomass from Sustainable Forestry
Biomass Combustion and Co-firing
Thermal Gasification of Biomass
Pyrolysis of Biomass
Energy Recovery from Solid Waste
Energy from Biogas and Landfill Gas
GHG Balances
Liquid Biofuels from Biomass
Sustainable Bioenergy Trade
Bioenergy Systems Analysis
Bio-refineries

references:

www.ieabioenergy.com

Diagram courtesy of J. Koppejan, Netherlands.

Sources: IEA (2006), Energy Technology Perspectives, IEA, Paris.

IDENTIFYING BARRIERS, PROVIDING SOLUTIONS

Policy Brief

Security of supply, environmental concerns and the need for long-term, stable energy prices are all issues which could be alleviated through greater deployment of renewables.

R&D efforts have resulted in renewable energy technologies that are technically mature and are very close to being cost-competitive with conventional technologies. An intensified, internationally coordinated effort is necessary to strengthen deployment of these renewable energy technologies.

The Renewable Energy Technology Deployment Implementing Agreement (RETD IA) identifies the main barriers to deployment and provides advice and best practice to policy makers and the private sector.

Background

Created in 2005, the RETD IA currently has nine Contracting Parties. The goals of the RETD IA are to:

- identify and remove cross-cutting barriers to deployment and provide "best practice" solutions related to renewable technologies;
- provide guidance to the private sector and policy makers on innovative business strategies and projects, for example by fostering public-private partnerships;
- facilitate ongoing international dialogue and public awareness of renewable energy deployment by contributing concrete examples of deployment solutions.

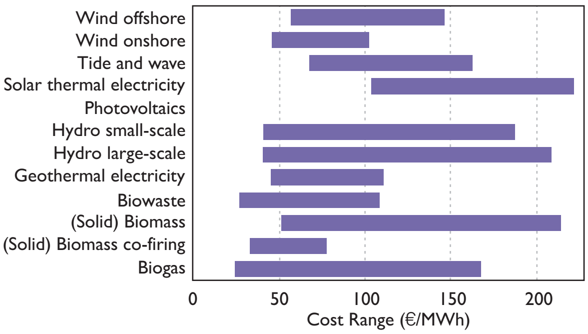
Spotlight

Several countries have extensive experience – and success – with deployment of renewable energy technologies:

- In Brazil ethanol from sugar cane currently supplies 40% of automotive fuel.
- Total world wind power capacity reached 74 GW in 2006, and is expected to reach 150 GW by 2010. More than 77% of the current capacity is installed in five countries: Denmark, Germany, India, Spain, and the United States.
- In 2005 total world grid-connected photovoltaic capacity grew to more than 3 GW, 87% of which is installed in only two countries: Germany and Japan.

Despite these success stories, new renewable energy sources currently supply only 2% of the global energy needs. If the proper policies are not enacted, and if industry does not accelerate manufacturing to reduce costs, the rate of energy consumption is expected to outgrow renewable energy supply within a few years.

Costs of Electricity*



* Long-run marginal cost payback time 15 years.

Europe-15 long-term marginal generation costs (2002).

Limited availability of reliable information is one of the main reasons for lack of deployment. In addition, lack of knowledge and awareness, energy market imperfection, unpredictable regulatory conditions and lack of standards are cited as some of the barriers to renewable energy technology deployment. In addition, many benefits from renewable energy sources are neglected or underestimated.

In 2006 the RETD IA published a comprehensive synthesis report *Renewable Energy Technology Deployment — Barriers, Challenges and Opportunities* and a short brochure, *Renewable Energy for Dummies*.

CURRENT PROJECTS

Approval Procedures and Spatial Planning

Integration of Renewable Energy into Energy Systems and Markets

Costs and Benefits of Renewable Energy to Society

Renewable Energy for Heating and Cooling

Financing of Renewable Energy

Renewable Energy for Transport

references:

www.iea-retd.org

Source: European Commission (2005), FORRES 2020: Analysis of Renewable Energy Sources' Evolution up to 2020.

TAPPING INTO VAST, UNUSED HEAT RESOURCES

Policy Brief

Geothermal energy has the potential to contribute significantly towards meeting current and future global energy demands. Geothermal power development has traditionally been restricted to areas near tectonic plate boundaries (e.g. the Pacific Ring of Fire). However, utilisation of the vast, deep heat resources is within reach over much of the rest of the world, for example in such 'non-traditional' locations as Australia, Germany, France and Switzerland.

However, major barriers to such development exist, such as lack of information on the technology, the potentials, and environmental and social benefits, as well as the lack of demonstration plants. Overcoming these obstacles will require increased understanding by policymakers, the financial community and the public.

Background

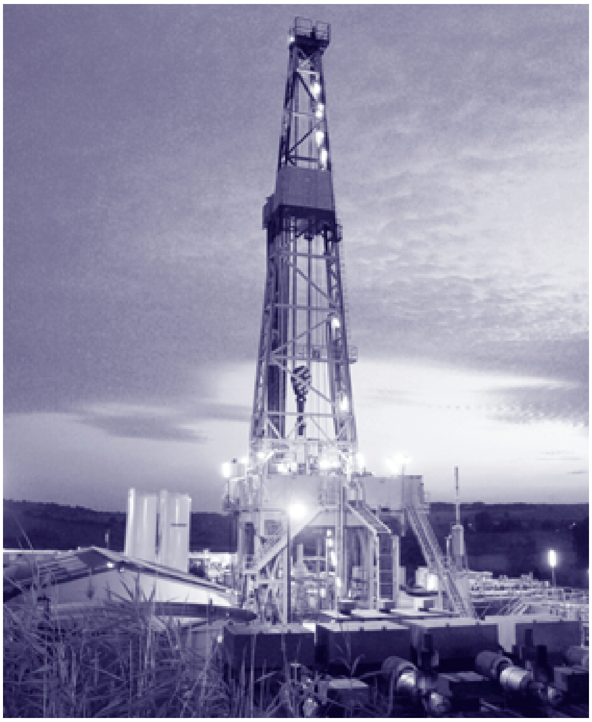
There are currently 12 Contracting Parties (including Iceland and Mexico) and three Sponsors participating in the Implementing Agreement for the Cooperative Programme on Geothermal Energy Research and Technology (GIA). The scope of GIA activities encompass:

- compilation and exchange of information on geothermal energy research and development worldwide;
- development of improved technologies for geothermal energy use;
- raising awareness of the environmental benefits of geothermal energy and researching ways to reduce its limitations.

Spotlight

Technologies for enhanced geothermal systems (EGS) were designed to extract the natural heat contained in high temperature, water-poor rocks in the earth's crust. Heat is extracted from rock formations that are either too dry or too impermeable to transmit available water at useful rates. Permeability can be enhanced through hydraulic fracturing or stimulation, which involves high-pressure injection of a fluid into the reservoir to crack the rock and/or to enlarge pre-existing openings.

The GIA work on EGS investigates new and improved technologies that can be used to artificially stimulate a



Drilling rig at the Soultz-sous-Forêts EGS site (Alsace, France).

geothermal resource to allow commercial heat extraction. This work largely concerns development and deployment through participation in the international pilot plant project at Soultz-sous-Forêts, France; the Cooper Basin project, Australia, and the Coso project in the United States. All projects have reached the stage of well production and are expected to be completed by 2009. Tasks of this research area include:

- application of conventional geothermal technology to enhanced geothermal systems;
- data acquisition and processing;
- reservoir evaluation;
- field studies of EGS reservoir performance.

CURRENT PROJECTS

Environmental Impacts of Geothermal Development

Enhanced Geothermal Systems

Advanced Geothermal Drilling Techniques

Direct Use of Geothermal Energy

references:

www.iea-gia.org

Photo courtesy of European Economic Interest Group Heat Mining.

MAPPING PRIORITIES AND GAPS

Policy Brief

Use of hydrogen as a fuel and an energy carrier is expected to enable a wide range of new technology options that could alleviate energy security issues while at the same time offering significant CO_2 reduction possibilities.

New technology options, such as fuel cells, offer a wide array of applications from power generation to combined heat and power (CHP) and transportation. Future fuel cell vehicles are expected to be four times more efficient than conventional internal combustion engines (ICE).

As an energy carrier, hydrogen offers an attractive option for storage of intermittent renewable technologies such as solar and wind. Moreover, production of hydrogen from fossil fuels can reduce emissions considerably when combined with carbon capture and sequestration.

Background

There are currently 21 Contracting Parties to the Hydrogen Implementing Agreement HIA, including Iceland and Lithuania. The goals of the HIA are to:

- promote acceptance of hydrogen as an energy;
- contribute to global energy security;
- exploit the environmental benefits of hydrogen;
- develop cost-effective hydrogen energy systems that can compete in global markets;
- identify and overcome barriers for hydrogen's penetration into the energy and fuel markets;
- promote deployment of hydrogen technologies with important local and global energy benefits.

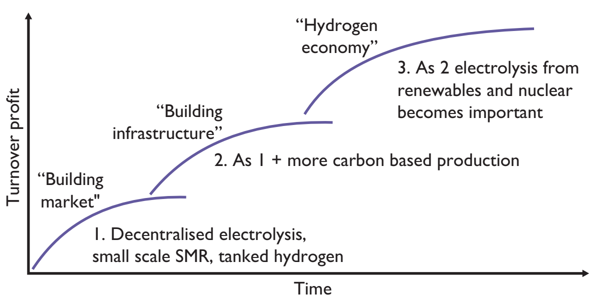
Spotlight

Though hydrogen is primarily produced from natural gas, it can be made from coal, biomass, solar, wind, hydro or nuclear power. A variety of processes (chemical, biological, electrolytic, photolytic and thermo-chemical) can also convert a feedstock into hydrogen.

A recent comprehensive report of the HIA, *Hydrogen Production and Storage: R&D Priorities and Gaps* examines the state of the art today and the mid-, to long-term prospects.

This report demonstrates that increased plant efficiency and lower capital cost will be necessary for all types of hydrogen processes. Taking into account the existing distributed power and natural gas infrastructure, water electrolysis and small-scale natural gas reformers are feasible near-term options for production. Medium- to long-term production options include hydrogen generation via centralised biomass- and fossil fuel-based plants combined with carbon capture and storage. Though promising, early stage photo-electrolysis and biological production processes as well as several high temperature processes for splitting water, are considered to be long-term options (2030 and beyond).

Main Hydrogen Pathways: The Long Term Perspective



Addressing the many technical issues associated with hydrogen storage will be vital. Solid or compressed hydrogen for vehicles is commercially available though costly due to transportation costs. C-fibre composite vessels are the most viable option. R&D issues include fracture mechanics, safety, compression energy and volume. Though already commercially available and used for laboratory research and aeronautics. To become fully cost-competitive, liquid hydrogen will require more R&D to increase liquefaction efficiency, reduce costs, improve insulated cryogenic flasks, automated boil-off capture (e.g., via hydrides) and re-liquefaction.

CURRENT PROJECTS

Integrated Systems

Hydrogen Safety

Hydrogen from Water Photolysis

Bio-hydrogen

Fundamental and Applied Hydrogen Storage Materials Development

Small-Scale Reformers for On-site Hydrogen Supply

Wind Energy and Hydrogen

reference:
www.ieahia.org

EVALUATING BEST PRACTICE

Policy Brief

Hydropower continues to be a vital component of electricity supply systems and is considered to be the most significant short- to medium-term renewable resource, with the potential to increase its contribution by over 50% during the next half century. Most of this potential is in China, India, Turkey, Brazil and other Asian and South American countries, as well as central Africa.

Key barriers to future large-scale development of hydropower are the huge capital requirements, water resource user conflicts, and environmental and social challenges. However, hydropower developments not only provide a sustainable, abundant source of low cost electricity, they can also enhance potable and irrigation water supply and provide flood control.

Background

The overall objective of the Hydropower Implementing Agreement (Hydro IA) to enhance the development of sustainable hydropower by carrying out research and programmes that disseminate balanced and objective information worldwide. There are currently seven Contracting Parties, including China. The scope of work of the Hydro IA encompasses:

- small hydro information and technology exchange, policy and innovative technical applications;
- documentation of examples of hydropower good practice;
- integration of wind energy into hydropower systems (with the Wind IA);
- increase public awareness of hydropower.

Spotlight

A recent comprehensive report of the Hydro IA, Hydropower Good Practices: Environmental Mitigation Measures and Benefits, presents 60 extensively documented case studies highlighting successful experiences with hydropower in 20 countries.

The process of selection and peer review of case histories was conducted through a series of expert meetings, international workshops and symposia. The principal objectives of the study were to document examples of good practice to:

- provide information to assist the design and planning of new projects;
- verify whether environmental impact assessments served their intended purpose;
- respond to regulatory and other governmental requirements;
- provide technical expertise for public hearings;
- respond to concerns expressed by opponents;
- make environmental conservation measures known;
- avoid negative environmental impacts and optimise positive outcomes.

Solbergfoss 110 MW hydro power plant operating since 1924 (Norway).

Measures to mitigate adverse impacts and the benefits associated with hydropower development were clearly demonstrated.

The report is suited for dissemination to a wide spectrum of stakeholders including developers who implement hydropower projects, governmental or non government organisations, investment institutions, and local communities.

CURRENT PROJECTS

Small-Scale Hydropower

Integrating Wind Energy into Hydropower Systems

Hydropower Good Practice: Additional Case Histories

reference:

www.ieahydro.org

TESTING THE WATERS

Policy Brief

The oceans contain a huge amount of energy. Changes in salinity, thermal gradients, tidal currents or ocean waves can be used to generate electricity using a range of different technologies currently in development. These could provide reliable, sustainable and cost-competitive energy. Capturing ocean energy could have substantial benefits.

Potential Global Electricity Production (TWh/year)

Tidal current	>800
Salinity gradient	2 000
Ocean wave	8 000 - 80 000
Thermal energy	10 000

These figures compare to a total world electricity production from all sources of 17 450 TWh. The number of ocean energy technology concepts has increased to 100 known devices. A small number of ocean energy developers have produced full-scale prototypes, and few have completed testing or published results. A wave farm demonstration plant needs to operate for several years to prove reliability, collect energy output data and reduce the perceived investment risk. Demonstration of large-scale systems such as shoreline-based oscillating water columns, large-scale thermal energy conversion systems or salinity gradient systems are implemented with less effort. For all ocean technologies deployment will not be possible without the proper market policies and support mechanisms.

Background

The IEA Ocean Energy Systems Implementing Agreement (OES IA) currently has 12 Contracting Parties, including Mexico. The original focus of the OES IA concerned ocean, wave and tidal current technologies. Recently the scope of the OES IA was expanded to include ocean thermal energy conversion technologies, salinity power, as well as devices that use the energy extracted for purposes other than electricity generation, for example, for desalination.

Spotlight

One research project of the OES IA aims to develop recommended practices for testing and evaluating ocean energy systems and, in this way, to improve the comparability of experimental results. This is done by collecting and analysing information on testing facilities and testing procedures. Guidelines for presentation of technical design and data, and for assessment of system performance, will be produced. This research area, which includes four subtasks:

- Establishing a database of existing testing facilities and test sites for ocean energy systems in the countries participating and other countries.
- Guidelines for testing wave energy systems are collected to form the basis for general standards on testing ocean energy systems.
- Standardisation of the presentation of test results on the performance and survivability of ocean energy systems. Definitions of the relevant ocean parameters and ocean energy converting systems parameters will be presented, and a standard format for the presentation of results will be proposed.
- The standardised presentation of the performance defined will be used to calculate the annual energy production of various ocean energy systems at different sites. For each system, the ratio between the energy production and the system volume, and the ratio between the energy production and the system weight will be produced.

Pelamis (wave) machines being assembled in Northern Portugal.

CURRENT PROJECTS

Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems

Grid Integration of Ocean Energy Systems

references:

www.iea-oceans.org

Photo courtesy of Ocean Power Delivery.

BRINGING POWER TO THE PEOPLE

Policy Brief

The annual growth rate of cumulative installed photovoltaic (PV) capacity has been relatively stable since 2000 at 40% per year. This impressive market growth is the result of the continued policy support for PV in an increasing number of countries.

As a result, it is expected that the development of PV technology will lead to a reduction of the price for solar electricity to lower than the price for peak-load power within a decade in a number of countries and, depending on the way retail electricity price tariffs are structured, this will be a significant milestone on the road to self-sustaining markets for grid-connected PV. Continuing political support for PV is thus required, both for research and development and for market deployment. The role that PV can play in developing countries continues to be highlighted. PV offers the ability to provide electricity to populations remote from electricity grids and also to enhance the quality of existing electricity supplies, and so the quality of life.

Background

There are currently 21 Contracting Parties to the Photovoltaic Power Systems Implementing Agreement (PVPS IA), including Israel, Mexico and one Sponsor. Most of the worldwide PV capacity (95%) is found in PVPS IA countries. The PVPS IA conducts a variety of projects concerning the applications of photovoltaic conversion of solar energy into electricity. This work contributes to the cost reduction of PV power applications, increases awareness of the potential and value of PV power systems, fosters the removal of both technical and non-technical barriers and enhances technology co-operation.

Spotlight

The focus of one recent research project of the PVPS IA concerns PV-based hybrid electricity generation and distribution systems. The mini-grid hybrid systems offer high-quality, reliable electrical power. They include energy generators, storage systems and loads that are interconnected by a stand-alone distribution network with relatively small rated power and limited geographical area. Potential applications of mini-grids range from remote village electrification to power parks for high-tech industrial customers. These systems can be complex, combining multiple energy sources, multiple electricity consumers, and operate in both island (stand-alone) and utility grid connected modes.

A PV hybrid (PV/propane generator/battery storage) provides electricity to a remote residence (Canada).

This project is a perfect example of public-private co-operation, with 10 countries and 14 companies participating. The first task was to survey the currently available guides, handbooks and software tools for design of PV hybrid systems and mini-grids to provide an overview of system architectures and to be able to evaluate and compare design methodologies and design tools.

A second task will be to carry out case studies of the social, political, economic, and environmental factors of successful implementation of PV hybrid power systems within mini-grids. Further analysis will focus on ways to maintain grid stability and optimise the contribution of all generation sources, highlighting existing methods while developing new, improved methods. Lastly, supervisory control parameters and strategies for mini-grids to evaluate the role of energy storage technologies in stabilising mini-grid operation will also be investigated.

CURRENT PROJECTS

Performance, Reliability and Analysis of PV Power Systems

Large-Scale PV Power Generation Systems

Photovoltaic Services for Developing Countries

Urban Scale Photovoltaic Applications

PV Hybrids for Mini-Grids

Environmental, Health, Safety Issues of PV

references:

www.iea-pvps.org

Photo courtesy of Xantrex Technology.

MOVING FROM R&D TO REALITY

Policy Brief

Solar thermal technologies for hot water heating, space heating and cooling are applied throughout the world. In 2005, world solar hot water/heating capacity totalled 88 GW (63% China, 13% Europe, 26% ROW). Another 13 GW of capacity was added in 2006, 77% of which was in China.

However, barriers to solar thermal technologies becoming a dominant energy source remain. These include cost competitiveness for certain technologies and a policy environment that benefits existing technologies and artificially low fossil fuel costs which do not include environmental costs. Ambitious policy objectives such as the Joint Declaration for a European Directive to Promote Renewable Heating and Cooling, calling for 25% of the EU heating and cooling to be supplied by renewables by 2020, is an important step in the right direction towards accelerating deployment.

Background

The Solar Heating and Cooling Systems Implementing Agreement (SHC IA) currently has 19 Contracting Parties, including Mexico. The SHC IA participating countries collaborate with key players in the field, including solar industry associations. The overall objectives of SHC IA participants are to overcome barriers and increase the solar global market share through research, development and testing of hardware, materials and design tools; expanding the solar thermal market; and raising awareness of policy makers and consumers.

Spotlight

The recent SHC IA research on daylighting for buildings focused on accelerating the development, application and market acceptance of high-performance daylighting systems. One aspect of this work was to demonstrate solutions which could be adapted to commercial and institutional buildings. The New York Times Building is an example of this approach.

Ultra clear, low-iron glass panels are draped in ceramic tubes to create a curtain wall that reflects light and changes colour depending on the time of day and weather conditions. To solve possible unforeseen technical issues with this innovative system, the Lawrence Berkeley National Laboratory (LBNL), a partner in the SHC IA research on daylighting, built a full-scale, one-story mock-up near the actual site of the new building.

Ceramic tubes adjust daylighting in the New York Times building.

This success has proven that integrated daylighting systems are reliable and robust and has repositioned daylighting applications from expensive niche-market applications to widespread, affordable solutions. Architects, engineers, builders and owners now have access to a technology that can be specified, installed, commissioned, operated, and maintained.

CURRENT PROJECTS

Advanced Storage Concepts for Solar and Low-Energy Buildings

Solar Heat for Industrial Processes

Testing and Validation of Building Energy Simulation Tools

PV/Thermal Solar Systems

Solar Resource Knowledge Management

Advanced Housing Renovation with Solar and Conservation

Solar Assisted Cooling Systems

Polymeric Materials for Solar Thermal Applications

references:

www.iea-shc.org

Photo: New York Times Building Architects: Renzo Piano Architects Workshop and Fox & Fowle; Mechanical, Electrical and Plumbing Engineers: Flack+Kurtz; Interior Architects: Gensler; Lighting: Susan Brady, Lawrence Berkeley National Laboratory.

Sources: REN21 (2006), Renewables Global Status Report: 2006 Update.

PRECISE LOCAL SOLAR FORECASTS

Policy Brief

The increasing demand peaks of summer air conditioning loads in prospering regions like southern Spain or the western United States have made dispatchable concentrating solar power (CSP) an attractive option. With the engaged support and contributions of the countries participating in the SolarPACES Implementing Agreement (SP IA), special feed-in tariffs and other financial incentives for CSP plants have been established in Algeria, Israel, Spain and United States, boosting the development new CSP projects by several thousand megawatts.

Behind these achievements lie many years of systems testing and project development in SP IA countries. Efforts on the technology front have been supported by policy recommendations to local, state and national governments from SP IA members and working groups. As a result of SP IA activities through the Global Market Initiative, it has been possible to align the policy/economic context with advances in technology development in SP IA countries, enabling full-scale, commercial projects.

Background

There are currently 12 Contracting Parties in the SP IA, including Algeria, Egypt, Israel, Mexico, and South Africa. The aims of SP IA participants are to solve the wide range of technical problems associated with commercialisation of concentrating solar technology, including large-scale system tests and the development of advanced technologies, components, instrumentation, and systems analysis techniques. In addition to technology development, market development and raising awareness of CSP potentials are key elements of the SP IA.

Spotlight

One recent initiative of the SP IA and the Solar Heating and Cooling IA concerns solar resource knowledge management and is carried out in collaboration with the Solar Heating and Cooling IA. The most efficient use of CSP requires detailed knowledge of 'fuel' availability, i.e. direct normal solar irradiance, or the fraction of the sunlight which can be concentrated. Direct irradiance shows much higher variability in space and time than global irradiance and is more sensitive to calculate. Accurate knowledge of solar resources for CSP must include high temporal – and spatial – resolution.

First commercial, 11 MW PS10 solar power tower plant (Seville, Spain).

A survey of solar thermal power plant planners found that 1% absolute accuracy is needed to establish long term averages. This is nearly impossible to achieve, even with premium-quality, daily measurements. However, new satellites offer more spectral channels that detect clouds with greater precision and produce high-quality images with greater temporal resolution (down to 15 min). This makes precise "now-casting" (weather forecasting a few hours ahead) possible. By extrapolating the solar radiation field from cloud motion, timely, reliable forecasts can be made 3-6 hours in advance. New local weather models used for short term forecasts (up to 48 hours) are the basis of solar yield forecasts. These yields allow more accurate predictions and therefore play an important role in achieving more precise market prices. In addition, more precise data on aerosol content will further improve forecast quality as it can play a significant role in certain solar-chemical reactions and satellite-derived solar irradiance values. Results of this work are shared with the Solar Heating and Cooling and Photovoltaic Implementing Agreements.

CURRENT PROJECTS

Concentrating Solar Power Systems

Solar Chemistry Research

Concentrating Solar Technology and Applications

Solar Heat for Industrial Processes

Solar Resource Knowledge Management

Global Market Initiative

reference:
www.solarpaces.org

PREDICTING THE UNPREDICTABLE

Policy Brief

The wind capacity of countries participating in the Wind Implementing Agreement (Wind IA) reached 51.3 GW in 2005. In Denmark, the contribution of wind energy to total electricity supply reached 18.5% for the same year.

This growing capacity has raised questions about the impact of large amounts of wind power on reliability and on efficiency (losses) of the distribution grid. To address these issues, the Wind IA endeavours to raise the quality of wind farm modelling and power system studies, to study the compatibility between hydro and wind generation, and carries out methodology assessments of system security and power capability in systems with large wind penetration.

Background

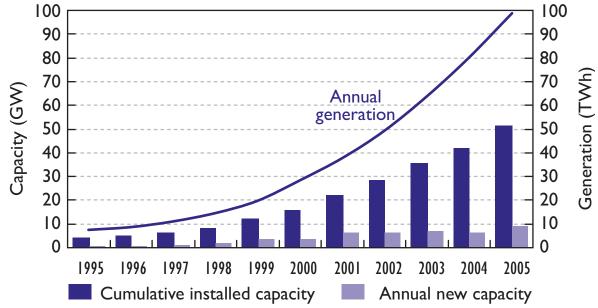
Currently there are 21 Contracting Parties (including Mexico) and one Sponsor in the Wind IA. The mission of the Wind IA is to stimulate co-operation on wind energy R&D and to provide high quality information and analysis to member governments and commercial sector leaders by addressing technology development and deployment and its benefits, markets, and policy instruments.

Spotlight

One research project of the Wind IA examines the design and operation of power systems with large amounts of wind power. This work aims to identify, refine and standardise methodologies to assess the impact of high wind penetration and contribute to power system efficiency. Case studies conducted in 10 countries addressed different aspects of power system operation and design such as reserve requirements, balancing and generation efficiency, capacity credit of wind power, efficient use of existing transmission capacity and requirements for new network investments, bottlenecks, cross-border trade, and system stability issues. In addition, the flexibility of the power system and how much this flexibility can be increased cost effectively is as important as the assessment of grid reinforcement externalities.

Costs associated with balancing the grid load following large-scale wind integration have been found to vary from 0.5 to 4 €/MWh. This amount is small when compared to the production cost of wind power (40-60 €/MWh) or with avoided fuel costs (20-30 €/MWh). The investment cost of reinforcing the grid range from 50 to 100 €/MWh depending on where the wind resource is located in relation to the load centres. The grid reinforcement costs are not continuous, i.e. there can be single, very high-cost reinforcements

Wind IA Member Countries, 2005



Recommended practise already derived from the case studies illustrate that:

- data used for forecasting should be based on several wind farms, meteorological towers or a synchronised weather simulation
- analysis of load variations must be correlated with wind variations
- operational simulations allow system response capture
- actual costs should be examined independent of tariff design structure

CURRENT PROJECTS

Base Technology Information Exchange

Wind Energy in Cold Climates

Horizontal Axis Wind Turbine Aerodynamics (HAWT) and Models from Wind Tunnel Measurements

Dynamic Models of Wind Farms for Power System Studies

Offshore Wind Energy Development

Wind and Hydropower Systems

Power System Operation with Large Amounts of Wind Power

reference:

www.ieawind.org

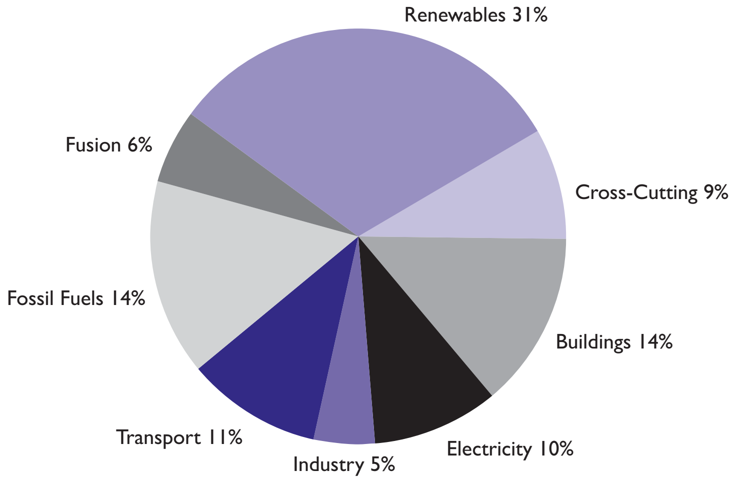
FOR MORE INFORMATION

Participation
IEA Energy Technology Network
IEA Secretariat Implementing Agreement Support
Background and Original Decisions
IEA Framework
Frequently Asked Questions
Implementing Agreement Websites
Further Information

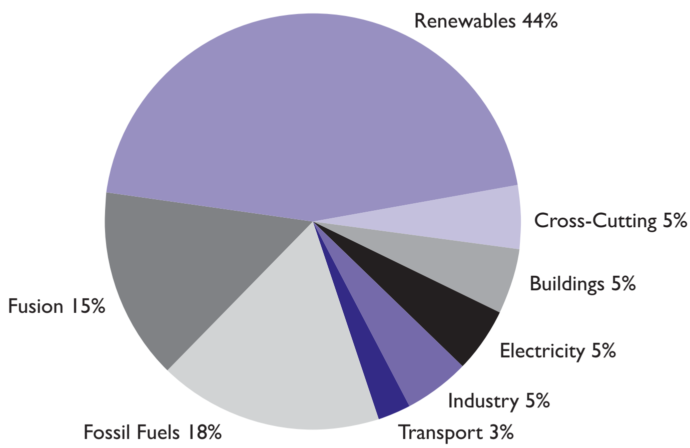
IMPLEMENTING AGREEMENT PARTICIPATION

31 March 2007

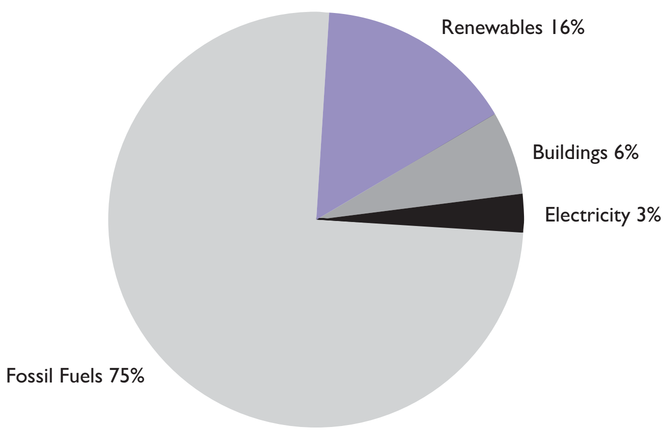
IEA Countries



Non-IEA Countries



Sponsors (IEA and non-IEA)



IMPLEMENTING AGREEMENT PARTICIPATION
ALL CATEGORIES

31 March 2007

	Cross-Cutting	End-Use				Fossil Fuels	Fusion Power	Renew-ables and Hydrogen	TOTAL
		Buildings	Electricity	Industry	Transport				
Australia		1	1		1	4	1	7	**15**
Austria	1	2	2		2	4		4	**15**
Belgium	1	2	3	1	4			3	**14**
Canada	3	4	2	2	3	6	4	8	**32**
Czech Republic		1				1			**2**
Denmark	1	3	2	1	1	4		7	**19**
Finland	3	3	3	2	3	1		5	**20**
France		3	1		3	3		8	**18**
Germany	3	3	1	1	2	3		9	**22**
Greece	1	1	1			1		1	**5**
Ireland								3	**3**
Italy	1	2	3	1	3	3		6	**19**
Japan	2	3	1	1	2	5	8	7	**29**
Korea	2	1	2		2	3	1	4	**15**
Netherlands	1	3	3	1	2	3		6	**19**
New Zealand		1				1		4	**6**
Norway	3	4	3	2	1	3		8	**24**
Portugal	1	1		1				4	**7**
Spain	1	2	1		1	2		5	**12**
Sweden	2	4	3	2	4	3		6	**24**
Switzerland	2	2	2	1	3	1	1	7	**19**
Turkey	1	2						2	**5**
United Kingdom	3	3	3	1	2	6		6	**24**
United States	3	4	2	2	4	5	9	8	**37**
IEA Total	**35**	**55**	**39**	**19**	**43**	**62**	**24**	**128**	**405**
Algeria								1	**1**
Brazil	1			1				1	**3**
China						1	1	1	**3**
Croatia								1	**1**
Egypt								1	**1**
Iceland								2	**2**
India			1			1			**2**
Israel		1	1					2	**4**
Lithuania								1	**1**
Mexico	1			1	1	2		6	**11**
Poland		1							**1**
Russia						1	4		**5**
South Africa						1		2	**3**
Ukraine							1		**1**
Venezuela						1			**1**
Non-IEA Total	**2**	**2**	**2**	**2**	**1**	**7**	**6**	**18**	**40**
TOTAL	**37**	**57**	**41**	**21**	**44**	**69**	**30**	**146**	**445**
Sponsors IEA		*1*	*1*			*19*		*5*	***26***
Sponsors non-IEA		*1*				*5*			***6***
Eur. Commission	*1*	*1*				*2*	*9*	*8*	***21***

IMPLEMENTING AGREEMENT PARTICIPATION CROSS-CUTTING ACTIVITIES

31 March 2007

	Climate Technology Initiative	Energy Technology Data Exchange	Energy Technology Systems Analysis Programme	TOTAL
Australia				
Austria				1
Belgium				1
Canada				3
Czech Republic				
Denmark				1
Finland				3
France				
Germany				3
Greece				1
Ireland				
Italy				1
Japan				2
Korea				2
Netherlands				1
New Zealand				
Norway				3
Portugal				1
Spain				1
Sweden				2
Switzerland				2
Turkey				1
United Kingdom				3
United States				3
IEA Total	**9**	**11**	**15**	**35**
Algeria				
Brazil				1
China				
Croatia				
Egypt				
Iceland				
India				
Israel				
Lithuania				
Mexico				1
Poland				
Russia				
South Africa				
Ukraine				
Venezuela				
Non-IEA Total		**2**		**2**
TOTAL	**9**	**13**	**15**	**37**
Sponsors IEA				
Sponsors non-IEA				
Eur. Commission				*1*

IMPLEMENTING AGREEMENT PARTICIPATION
END-USE: BUILDINGS

31 March 2007

	Buildings & Community Systems	District Heating & Cooling	Energy Storage	Heat Pumps	TOTAL
Australia	■				1
Austria	■			■	2
Belgium	■		■		2
Canada	■	■	■	■	4
Czech Republic	■				1
Denmark	■	■	■		3
Finland	■	■	■		3
France	■		■	■	3
Germany	■		■	■	3
Greece	■				1
Ireland					
Italy	■		■		2
Japan	■		■	■	3
Korea		■			1
Netherlands	■	■		■	3
New Zealand	■				1
Norway	■	■	■	■	4
Portugal	■				1
Spain			■	■	2
Sweden	■	■	■	■	4
Switzerland	■			■	2
Turkey	■		■		2
United Kingdom	■		■	■	3
United States	■	■	■	■	4
IEA Total	**21**	**8**	**14**	**12**	**55**
Algeria					
Brazil					
China					
Croatia					
Egypt					
Iceland					
India					
Israel	■				1
Lithuania					
Mexico					
Poland	■				1
Russia					
South Africa					
Ukraine					
Venezuela					
Non-IEA Total	**2**				**2**
TOTAL	**23**	**8**	**14**	**12**	**57**
Sponsors IEA			■		*1*
Sponsors non-IEA			■		*1*
Eur. Commission			■		*1*

IMPLEMENTING AGREEMENT PARTICIPATION
END-USE: ELECTRICITY AND INDUSTRY

31 March 2007

	Electricity				Industry		
	Demand Side Management	Electricity Networks	High-Temperature Superconductivity	TOTAL	Emissions Reduction in Combustion	Industrial Technologies & Systems	TOTAL
Australia	■			1			
Austria	■	■		2			
Belgium	■	■	■	3	■		1
Canada	■		■	2	■	■	2
Czech Republic							
Denmark	■	■		2		■	1
Finland	■	■	■	3	■	■	2
France	■			1			
Germany			■	1	■		1
Greece	■			1			
Ireland							
Italy	■	■	■	3	■		1
Japan			■	1	■		1
Korea	■		■	2			
Netherlands	■	■	■	3		■	1
New Zealand							
Norway	■	■	■	3	■	■	2
Portugal						■	1
Spain	■			1			
Sweden	■	■	■	3	■	■	2
Switzerland		■	■	2	■		1
Turkey							
United Kingdom	■	■	■	3	■		1
United States	■		■	2	■	■	2
IEA Total	**16**	**10**	**13**	**39**	**11**	**8**	**19**
Algeria							
Brazil						■ 1	1
China							
Croatia							
Egypt							
Iceland							
India	■			1			
Israel			■	1			
Lithuania							
Mexico						■	1
Poland							
Russia							
South Africa							
Ukraine							
Venezuela							
Non-IEA Total	**1**		**1**	**2**		**2**	**2**
TOTAL	**17**	**10**	**14**	**41**	**11**	**10**	**21**
Sponsors IEA	■			*1*			
Sponsors non-IEA							
Eur. Commission							

IMPLEMENTING AGREEMENT PARTICIPATION END-USE: TRANSPORT

31 March 2007

	Advanced Fuel Cells	Advanced Materials Transportation	Advanced Motor Fuels	Hybrid and Electric Vehicles	TOTAL
Australia					1
Austria					2
Belgium					4
Canada					3
Czech Republic					
Denmark					1
Finland					3
France					3
Germany					2
Greece					
Ireland					
Italy					3
Japan					2
Korea					2
Netherlands					2
New Zealand					
Norway					1
Portugal					
Spain					1
Sweden					4
Switzerland					3
Turkey					
United Kingdom					2
United States					4
IEA Total	**17**	**5**	**11**	**10**	**43**
Algeria					
Brazil					
China					
Croatia					
Egypt					
Iceland					
India					
Israel					
Lithuania					
Mexico					1
Poland					
Russia					
South Africa					
Ukraine					
Venezuela					
Non-IEA Total	**1**				**1**
TOTAL	**18**	**5**	**11**	**10**	**44**

Sponsors IEA					
Sponsors non-IEA					
Eur. Commission					

IMPLEMENTING AGREEMENT PARTICIPATION
FOSSIL FUELS

31 March 2007

	Clean Coal Centre	Clean Coal Science	Enhanced Oil Recovery	Fluidised Bed Conversion	Greenhouse Gas R&D	Multiphase Flow Sciences	TOTAL
Australia							**4**
Austria							**4**
Belgium							
Canada							**6**
Czech Republic							**1**
Denmark							**4**
Finland							**1**
France							**3**
Germany							**3**
Greece							**1**
Ireland							
Italy							**3**
Japan							**5**
Korea							**3**
Netherlands							**3**
New Zealand							**1**
Norway							**3**
Portugal							
Spain							**2**
Sweden							**3**
Switzerland							**1**
Turkey							
United Kingdom							**6**
United States							**5**
IEA Total	**10**	**10**	**9**	**12**	**16**	**5**	**62**
Algeria							
Brazil							
China							**1**
Croatia							
Egypt							
Iceland							
India							**1**
Israel							
Lithuania							
Mexico							**2**
Poland							
Russia							**1**
South Africa							**1**
Ukraine							
Venezuela							**1**
Non-IEA Total		**2**	**2**		**1**	**2**	**7**
TOTAL	**10**	**12**	**11**	**12**	**17**	**7**	**69**
Sponsors IEA	**5**				**14**		**19**
Sponsors non-IEA	**5**						**5**
Eur. Commission							**2**

IMPLEMENTING AGREEMENT PARTICIPATION
FUSION POWER

31 March 2007

	Environ-ment, Safety, Economy	Fusion Mate-rials	Large Toka-maks	Nuclear Tech-nology Fusion Reactors	Plasma Wall Inte-raction TEXTOR	Reversed Field Pinches	Spher-ical Tori	Stella-rator Concept	Tokamaks Poloidal Field Divertors	TOTAL
Australia								■		1
Austria										
Belgium										
Canada	■	■		■	■					4
Czech Republic										
Denmark										
Finland										
France										
Germany										
Greece										
Ireland										
Italy										
Japan	■	■	■	■	■	■	■	■		8
Korea									■	1
Netherlands										
New Zealand										
Norway										
Portugal										
Spain										
Sweden										
Switzerland		■								1
Turkey										
United Kingdom										
United States	■	■	■	■	■	■	■	■	■	9
IEA Total	**3**	**4**	**2**	**3**	**3**	**2**	**2**	**3**	**2**	**24**
Algeria										
Brazil										
China		■								1
Croatia										
Egypt										
Iceland										
India										
Israel										
Lithuania										
Mexico										
Poland										
Russia	■	■		■				■		4
South Africa										
Ukraine								■		1
Venezuela										
Non-IEA Total	**1**	**2**		**1**				**2**		**6**
TOTAL	**4**	**6**	**2**	**4**	**3**	**2**	**2**	**5**	**2**	**30**
Sponsors IEA										
Sponsors non-IEA										
Eur. Commission	■	■	■	■	■	■	■	■	■	9

IMPLEMENTING AGREEMENT PARTICIPATION RENEWABLE ENERGIES AND HYDROGEN

31 March 2007

	Bio-energy	Deploy-ment	Geo-thermal	Hydro-gen	Hydro-power	Ocean Energy	Photo-voltaic	Solar Heating & Cooling	Solar PACES	Wind	TOTAL
Australia											**7**
Austria											**4**
Belgium											**3**
Canada											**8**
Czech Republic											
Denmark											**7**
Finland											**5**
France											**8**
Germany											**9**
Greece											**1**
Ireland											**3**
Italy											**6**
Japan											**7**
Korea											**4**
Netherlands											**6**
New Zealand											**4**
Norway											**8**
Portugal											**4**
Spain											**5**
Sweden											**6**
Switzerland											**7**
Turkey											**2**
United Kingdom											**6**
United States											**8**
IEA Total	**16**	**9**	**9**	**18**	**6**	**10**	**18**	**17**	**6**	**19**	**128**
Algeria											**1**
Brazil											**1**
China											**1**
Croatia											**1**
Egypt											**1**
Iceland											**2**
India											
Israel											**2**
Lithuania											**1**
Mexico											**6**
Poland											
Russia											**1**
South Africa											**2**
Ukraine											
Venezuela											
Non-IEA Total	**3**		**2**	**2**	**1**	**1**	**2**	**1**	**5**	**1**	**18**
TOTAL	**19**	**9**	**11**	**20**	**7**	**11**	**20**	**18**	**11**	**20**	**146**
Sponsors IEA			*3*								***5***
Sponsors non-IEA											
Eur. Commission											***8***

IEA ENERGY TECHNOLOGY NETWORK

IEA Committee on Energy Research and Technology (CERT)

Chair . . . . Graham Campbell (Canada)

Secretary . . . . Antonio Pflüger

WORKING PARTIES

Working Party on End-Use Technologies (EUWP)

Chair. . . . . Peter Cunz (Switzerland)

Secretary . . . . Jeppe Bjerg

Working Party on Fossil Fuel Technology (WPFF)

Chair. . . . . Barbara McKee (United States)

Secretary . . . . Jacek Podkanski

Fusion Power Co-ordinating Comittee (FPCC)

Chair. . . . . Masahiro Seki (Japan)

Secretary. . . . . Giorgio Simbolotti

Renewable Energy Working Party (REWP)

Chair . . . . Roberto Vigotti (Italy)

Secretary . . . . Nobuyuki Hara

IEA SECRETARIAT IMPLEMENTING AGREEMENT SUPPORT

Cross-Cutting Issues	Antonio Pflüger	antonio.pflueger@iea.org
Co-ordination	Carrie Pottinger	carrie.pottinger@iea.org
Framework and Legal Issues	Andrea Nour	andrea nour@iea.org

Cross-Cutting Activities

Climate Technology Initiative	Carrie Pottinger	carrie.pottinger@iea.org
Energy Technology Data Exchange	Carrie Pottinger	carrie.pottinger@iea.org
Energy Technology Systems Analysis	Peter Taylor	peter.taylor@iea.org

Working Party on End-Use Technologies (EUWP)

EUWP Secretary	***Jeppe Bjerg***	***jeppe.bjerg@iea.org***
Buildings		
Buildings and Community Systems	Jeppe Bjerg	jeppe.bjerg@iea.org
District Heating and Cooling	Jeppe Bjerg	jeppe.bjerg@iea.org
Energy Storage	Jeppe Bjerg	jeppe.bjerg@iea.org
Electricity		
Demand Side Management	Carrie Pottinger	carrie.pottinger@iea.org
Electricity Networks	Debra Justus	debra.justus@iea.org
High Temperature Superconductivity	Debra Justus	debra.justus@iea.org
Industry		
Emissions Reduction in Combustion	Tom Kerr	thomas.kerr@iea.org
Industrial Technologies & Systems	Tom Kerr	thomas.kerr@iea.org
Transport		
Advanced Fuel Cells	Carrie Pottinger	carrie.pottinger@iea.org
Advanced Materials for Transportation	Carrie Pottinger	carrie.pottinger@iea.org
Advanced Motor Fuels	Carrie Pottinger	carrie.pottinger@iea.org
Hybrid and Electric Vehicles	Carrie Pottinger	carrie.pottinger@iea.org

Working Party on Fossil Fuels (WPFF)

WPFF Secretary	***Jacek Podkanski***	***jacek.podkanski@iea.org***
Clean Coal Centre	Jacek Podkanski	jacek.podkanski@iea.org
Clean Coal Science	Jacek Podkanski	jacek.podkanski@iea.org
Enhanced Recovery of Oil	Jacek Podkanski	jacek.podkanski@iea.org
Fluidised Bed Conversion	Jacek Podkanski	jacek.podkanski@iea.org
Greenhouse Gas R&D	Jacek Podkanski	jacek.podkanski@iea.org
Multiphase Flow Sciences	Jacek Podkanski	jacek.podkanski@iea.org

Fusion Power Co-ordinating Committee (FPCC)

FPCC Secretary	***Giorgio Simbolotti***	***giorgio.simbolotti@iea.org***
Environmental, Safety & Economy of Fusion	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Fusion Materials	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Large Tokamaks	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Nuclear Technology Fusion Reactors	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Plasma Wall Interaction TEXTOR	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Reversed Field Pinches	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Spherical Tori	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Stellerator Concept	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Large Tokamak Facilities	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Tokamaks Poloidal Field Divertors	Giorgio Simbolotti	giorgio.simbolotti@iea.org

Renewable Energy Working Party (REWP)

REWP Secretary	***Nobuyuki Hara***	***nobuyuki.hara@iea.org***
Bioenergy	Nobuyuki Hara	nobuyuki.hara@iea.org
Deployment	Nobuyuki Hara	nobuyuki.hara@iea.org
Geothermal	Nobuyuki Hara	nobuyuki.hara@iea.org
Hydrogen	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Hydropower	Nobuyuki Hara	nobuyuki.hara@iea.org
Ocean	Nobuyuki Hara	nobuyuki.hara@iea.org
Photovoltaics	Nobuyuki Hara	nobuyuki.hara@iea.org
Solar Heating & Cooling	Nobuyuki Hara	nobuyuki.hara@iea.org
SolarPACES	Nobuyuki Hara	nobuyuki.hara@iea.org
Wind	Nobuyuki Hara	nobuyuki.hara@iea.org

BACKGROUND AND ORIGINAL DECISIONS

The Agreement on an International Energy Programme (I.E.P. Agreement)

Following the geopolitical events of 1973 and the ensuing oil shortage and price increases, industrialised countries saw the need to create a co-operative international energy organisation. The Energy Co-ordination Group (ECG) was created within the framework of the OECD to define the scope and nature of this co-operation. This group met to discuss the terms, scope and activities of the Agreement on an International Energy Programme (I.E.P. Agreement), the underlying treaty which established the IEA. The ECG fully recognized "the significant role energy R&D including intensified international co-operation, can play in helping to solve energy problems".

While the top priority in 1974 was to secure sustainable supplies of oil through creation and sharing of a minimum amount of oil stocks, monitoring international oil markets, co-operation with oil companies and producer countries, the original signatory governments[1] also had the foresight to make provision for exploring alternative sources of energy and energy conservation measures through long-term co-operation. The overall goals of the I.E.P. Agreement (as amended 7th August 1992) state that Member countries are:

[ ] DETERMINED to reduce their dependence on imported oil by undertaking long-term co-operative efforts on conservation of energy, on accelerated development of alternative sources of energy, on research and development in the energy field and on uranium enrichment,

CONVINCED that these objectives can only be reached through continued co-operative efforts within effective organs, [ ]

Long-Term Co-operation on Energy

Chapter VII, Article 41 of the I.E.P. Agreement states

1. The Participating Countries are determined to reduce over the long term their dependence on imported oil for meeting their total energy requirements.

2. To this end the Participating Countries will undertake national programmes and promote the adoption of co-operative programmes, including, as appropriate, the sharing of means and efforts, while concerning national policies, in the areas set out in Article 42.

Article 42 makes provision for the Standing Group on Long Term Co-operation (SLT) to examine and report on co-operative action in the following areas in particular:

Conservation of energy, including co-operative programmes on

- *exchange of national experiences and information on energy conservation;*
- *ways and means for reducing the growth of energy consumption through conservation.*

Development of alternative sources of energy such as domestic oil, coal, natural gas, nuclear energy and hydro-electric power, including co-operative programmes on

- *exchange of information on such matters as resources, supply and demand, price and taxation;*
- *ways and means for reducing the growth of consumption of imported oil through the development of alternative sources of energy;*
- *concrete projects, including jointly financed projects;*
- *criteria, quality objectives and standards for environmental protection;*

Energy research and development, including as a matter of priority co-operative programmes on

- *coal technology;*
- *solar energy*

1. Original signatory countries of the I.E.P. Agreement included: Austria, Belgium, Canada, Denmark, Germany, Ireland, Italy, Japan, Luxembourg, Netherlands, Spain, Sweden, Switzerland, Turkey, United Kingdom, and United States. Subsequent acceding States (but not signatories as no provision was made for subsequent signatures) include Australia, Finland, France, Greece, New Zealand and Portugal, and later Korea, the Czech Republic and Hungary. Norway's participation is regulated by special arrangements.

- *radioactive waste management;*
- *controlled thermonuclear fusion;*
- *production of hydrogen from water;*
- *nuclear safety;*
- *waste heat utilisation;*
- *conservation of energy;*
- *municipal and industrial waste utilisation for energy conservation;*
- *overall energy system analysis and general studies.*

The I.E.P. Agreement conferred upon SLT the responsibility for examining and reporting on co-operative actions in the R&D sector as well as in other long-term policy areas. On R&D the Agreement provides for consideration of energy research and development, including as a matter of priority co-operative programmes on coal technology, solar energy, radioactive waste management, controlled thermonuclear fusion, production of hydrogen from water, nuclear safety, waste heat utilisation, conservation of energy, municipal and industrial waste utilisation, conservation, overall energy system analysis and general studies.

The I.E.P. Agreement also made provision for special expenses incurred from special activities (Chapter IX, Article 64):

> *2. Special expenses incurred in connection with special activities carried out pursuant to Article 65 shall be shared by the Participating Countries taking part in such special activities in such proportions as shall be determined by unanimous agreement between them.*

Article 65, Special Activities, states:

> *1. Any two or more Participating Countries may decide to carry out within the scope of this Agreement special activities, other than activities which are required to be carried out by all Participating Countries under Chapters I to V. Participating Countries which do not wish to take part in such special activities shall abstain from taking part in such decisions and shall not be bound by them. Participating Countries carrying out such activities shall keep the Governing Board informed thereof.*

Sub-Group on Energy R&D

At its first meeting, the SLT established the "Sub-group on Energy R&D" with a broad mandate to implement the ten programmes listed under 10(c) above, and to consider the full range of energy R&D projects, subject to SLT guidance, to ensure consistency "with the overall objectives and programmes of the Agency" [IEA/SLT/M(74)1, part IV].

The Sub-group embarked on an ambitious programme to develop a number of projects, which soon became the subject of the Agency's first Energy R&D Implementing Agreements.

In November 1975, the Governing Board conducted a special meeting on energy R&D in which Members were represented by their respective R&D principals. This was the only Board meeting to date so devoted to this sector, and it took a number of decisions on strategy and programmes. The Board endorsed the R&D work already accomplished and noted that five Implementing Agreements on coal technology and one on nuclear reactor safety had already been signed. The Board added R&D topics to those mentioned in the Long-Term Co-operation Programme (LTCP); it also adopted the Guidelines on Intellectual Property, advanced the R&D Chapter of the LTCP, and adopted its decision establishing the Committee on Energy Research and Development (CRD). In this way the Board endorsed the R&D policy assumptions of each of those actions, and chose to develop an IEA R&D strategy that would:

> *Provide guidance to Participating Countries as to the potential energy contributions and probable time scale associated with different technology options, leading in turn to energy policy options;*
>
> *Provide, in the course of its establishment and implementation, opportunities for periodic reviews of national programmes of energy R&D;*
>
> *Be closely co-ordinated with the other aspects of the Agency's Long-Term Programme;*
>
> *Provide guidance for the review of projects already undertaken in the Agency [IEA/GB(75)94, Item 3(a)].*

Committee on Energy Research and Development (CRD)

When it established the IEA Committee on Energy Research and Development (CRD) [IEA/GB(75)94, Item 7, Annex II], the Governing Board granted a more comprehensive and structured mandate than that of the SLT Committee. The CRD was required to:

Submit a strategy for energy research and development and to oversee the implementing of this strategy .

Ensure, through consultation and collaboration with the SLT, a close co-ordination between the R&D strategy and other aspects of the Long-Term Co-operation Programme.

Review periodically national R&D programmes in the light of the preparation and surveillance of the strategy.

Identify opportunities for collaboration among Members (within the R&D strategy and utilizing the national reviews), and promote such collaboration.

Continue the promotion and implementation of co-operation in energy R&D as decided by the Board on 21 November 1975.

Report to the Governing Board as appropriate (at least once each year) on the above subjects in conjunction with the SLT, and carry out such other functions as the Governing Board might delegate to it.

Beginning in the summer of 1976, this work was undertaken by two multinational teams proceeding in parallel in Brookhaven National Laboratory (United States), and at the Kernforschungsanglage, Jülich (Germany), under the direction of a Systems Analysis Steering Group established by the CRD. Preliminary reports were submitted in 1977 and 1979. IEA Ministers expressed their satisfaction with Group Strategy and the results of these reports for the policy direction they set for IEA activities. In effect, these reports "…stressed the high probability of a fundamental imbalance between energy supply and demand during the remainder of this century."

Committee on Energy Research and Technology (CERT)

Despite the Governing Board decision in March 1992 to change the name of the CRD to the Committee on Energy Research and Technology (CERT), the formal mandate of the Committee has remained unchanged since 1975. However, the Governing Board has on numerous occasions given instructions to the CRD/CERT to analyse specific programme questions. The focus of the CERT is thus in constant evolution [IEA/CERT(93)2/REV2].

The CERT Working Parties are to provide "advice to, and support the activities of, the Committee on Energy Research and Development and other IEA Standing Bodies" in the areas of the Working Parties' competence. Most of the mandates also provide for the Working Parties to identify priority interests common to Members and to promote collaboration by arranging studies, information exchange, conferences, workshops, and other activities. They are also to initiate, evaluate, and review Implementing Agreements and other collaborative activities, to co-ordinate their activities with other IEA sectoral bodies activities in related matters, and to review, evaluate and participate in related activities conducted by IEA bodies. In addition, each Working Party is to carry out particular functions based on its specialisation.

The IEA Secretariat plays a significant role in initiating, promoting, and implementing policy and operational actions; it supports each of the Agency bodies active in this as well as other sectors. Technology expertise and policy considerations are conveyed from the Working Parties to the CERT which in turn supports the work of the IEA Governing Board at both official and Ministerial levels, resulting in IEA feedback to each Member's R&D policy officials in capitals and to the administrators of the project Implementing Agreements and other IEA co-operative activities.

Legal Basis for Collaboration

In July 1975, the GB adopted the Guiding Principles for Co-operation in the Field of Energy Research and Development [IEA/GB(75)54]. The Guiding Principles made provision for four categories of participation:

- Governments of IEA member countries.
- National agencies, public organisations, private corporations, companies or other entities which have been designated by their governments as the vehicles of their participation.

- The European Communities.
- Other Members of the OECD, with the agreement of the Governing Board.

Following the evolution of participations in Implementing Agreements, a series of Amendments were made to the Guiding Principles. In 1976, the Governing Board approved participation of the first non-Member (Finland, not yet an IEA member country) to an Implementing Agreement (nuclear safety).

In 1991, the GB formalized the non-Member admission process by establishing the "Associate" participation, with rules adopted as amendments to the Guiding Principles.

In 1993, the "IEA Shared Goals" adopted by Ministers, stated that "Continued research, development and market development of new and improved energy technologies make a critical contribution. […] Energy technology policies should complement broader energy policies. International co-operation in the development and dissemination of energy technologies, including industry participation and co-operation with non-Member countries, should be encouraged" [IEA/GB(93)41].

In 1993, the Governing Board approved a new category of participant – "Sponsor" – and established the detailed procedures to be followed for participation [IEA/GB(93)32].

Seeking to incorporate these developments in Implementing Agreement participation since the creation of the Guiding Principles, the Governing Board voted to create the "IEA Framework for Energy Technology Co-operation" [IEA/GB(2003)6/REV2/ANN1]. The goals of the Framework set out to:

- permit broader participation by OECD non-member countries;
- permit broader participation by permitting "Sponsors" from non-OECD member countries;
- provide simple, common and binding rules for participation in Implementing Agreements, clearly setting out the responsibilities of Implementing Agreement participants and the CERT and Governing Board; and
- reduce the administrative burden, delay and any legal ambiguity for present and prospective participants in Implementing Agreements.

references:

Bamberger, C. (2004), IEA: The First 30 Years, Volume Four, Supplement to Volumes I, II and III, IEA, Paris.

IEA/GB(1975)54/ANN1, IEA Guiding Principles for Co-operation in the Field of Energy Research and Development, IEA, Paris.

IEA/GB(2003)6/REV2/ANN1, IEA Framework for International Energy Technology Co-operation, IEA, Paris.

OECD/IEA (1974), Agreement on an International Energy Programme (I.E.P. Agreement) (as amended).

Scott, R. (1995), IEA: the First 20 Years, Volume Two, Major Policies and Actions, IEA, Paris.

IEA FRAMEWORK FOR INTERNATIONAL ENERGY TECHNOLOGY CO-OPERATION

I. General Principles

Article 1
Mandate

1.1 In fulfilment of Chapter VII of the Agreement on an International Energy Program and in light of the Shared Goals of the IEA, the IEA operates Implementing Agreements to enable IEA Member countries to carry out programmes and projects on energy technology research, development and deployment.

1.2 An Implementing Agreement is a contractual relationship established by at least two IEA Member countries, and approved by the Governing Board, for the purpose set out in Article 1.1.

1.3 Participants in an Implementing Agreement shall contribute as fully as possible to the achievement of its objectives and shall endeavour to secure, through public and private support, the necessary scientific, technical and financial resources for the programmes and projects carried out under such an Implementing Agreement.

1.4 Each Implementing Agreement shall have an Executive Committee composed of representatives of all participants.

Article 2
Nature of Implementing Agreements

2.1 The activities of an Implementing Agreement may include, inter alia:

(a) co-ordination and planning of specific energy technology research, development and deployment studies, works or experiments carried out at a national or international level, with subsequent exchange, joint evaluation and pooling of the scientific and technical results acquired through such activities;

(b) participation in the operation of special research or pilot facilities and equipment provided by a participant, or the joint design, construction and operation of such facilities and equipment;

(c) exchange of information on (i) national programmes and policies, (ii) scientific and technological developments and (iii) energy legislation, regulations and practices;

(d) exchanges of scientists, technicians or other experts;

(e) joint development of energy related technologies; and

(f) any other energy technology related activity.

2.2 Participation in an Implementing Agreement shall be based on equitable sharing of obligations, contributions, rights and benefits. Participants in an Implementing Agreement shall undertake to make constructive contributions, whether technical, financial or otherwise, as may be agreed by the Executive Committee.

2.3 Some or all of the participants in an Implementing Agreement may choose to execute specific projects and/or programmes through Annexes to the Implementing Agreement.

II. Rules Applicable to IEA Implementing Agreements

Article 3
Participation, Admission and Withdrawal

3.1 An Implementing Agreement can be established by two or more IEA Member countries subject to approval of the Committee on Energy Research and Technology (CERT) and of the Governing Board. There are two possible categories of participants in Implementing Agreements: Contracting Parties and Sponsors.

3.2 Contracting Parties may be

(a) the governments of both OECD member or OECD non-member countries;

(b) the European Communities;

(c) international organisations in which the governments of OECD member countries and/or OECD non-member countries participate; and

(d) any national agency, public organisation, private corporation or other entity designated by the government of an OECD member country or an OECD non-member country, or by the European Communities.

3.2.1 Participation in any Implementing Agreement for OECD non-member countries or for international organisations requires prior approval by the CERT. However, should the CERT consider a first time application by an OECD non-member country or an international organisation to be sensitive, it may refer the decision to the Governing Board as it deems appropriate.

3.2.2 Prior to CERT approval of participation of OECD non-member countries or international organisations in any Implementing Agreement, the Executive Committee shall:

(a) have voted in favour of the applicant to join the Implementing Agreement and provide evidence of the same to the CERT;

(b) provide the CERT with a copy of the terms and conditions of the applicant's participation in the Implementing Agreement; and

(c) provide the CERT with a letter from the applicant expressing the applicant's desire to join the Implementing Agreement and specifying which Annexes it wishes to join; its acceptance of the terms and conditions of the Implementing Agreement; the name of its designated entity if it is not the applicant itself; and the name of the entity that will sign the Implementing Agreement.

3.2.3 The terms and conditions for the admission, participation and withdrawal of Contracting Parties, including their rights and obligations, in Implementing Agreements and their Annexes, if any, shall be established by the Executive Committee of each Implementing Agreement.

3.2.4 Notwithstanding Article 3.2.3, no Contracting Party from an OECD non-member country or international organisation shall have greater rights or benefits than Contracting Parties from OECD member countries.

3.3 Sponsors may be

(a) entities of OECD member countries or OECD non-member countries who are not designated by the governments of their respective countries to participate in a particular Implementing Agreement; and

(b) non-intergovernmental international entities in which one or more entities of OECD member countries or OECD non-member countries participate.

3.3.1 Participation of Sponsors in Implementing Agreements requires prior approval by the CERT.

3.3.2 Prior to CERT approval of Sponsor participation in any Implementing Agreement, the Executive Committee shall:

(a) have voted in favour of the applicant to join the Implementing Agreement and provide evidence of the same to the CERT;

(b) provide the CERT with a copy of the terms and conditions of the applicant's participation in the Implementing Agreement; and

(c) provide the CERT with a letter from the applicant expressing the applicant's desire to join the Implementing Agreement and specifying which Annexes it wishes to join; its acceptance of the terms and conditions of the Implementing Agreement; and the name of the entity that will sign the Implementing Agreement.

3.3.3 The terms and conditions for the admission, participation and withdrawal of Sponsors, including rights and obligations, in Implementing Agreements and their Annexes, if any, shall be established by the Executive Committee of each Implementing Agreement.

3.3.4 Notwithstanding Article 3.3.3, no Sponsor shall have greater rights or benefits than Contracting Parties from OECD non-member countries and no Sponsor shall be designated Chair or Vice-chair of an Implementing Agreement.

3.3.5 The CERT shall have the right to not approve participation of a Sponsor if the terms and conditions of such participation do not comply with this Framework, any Decisions of the CERT or the Governing Board and the Shared Goals of the IEA.

Article 4
Specific Provisions

4.1 Unless the CERT otherwise agrees, based on exceptional circumstance and sufficient justification, Implementing Agreements shall be for an initial term of up to, but no more than, five years.

4.2 An Implementing Agreement may be extended for such additional periods as may be determined by its Executive Committee, subject to approval of the CERT. Any single extension period shall not be greater than five years unless the CERT otherwise decides, based on exceptional circumstances and sufficient justification.

4.3 Notwithstanding Paragraph 4.2, should the duration of the programme of work of an Annex exceed the term of the Implementing Agreement to which it relates, the CERT shall not unreasonably withhold approval to extend the Implementing Agreement for such additional period to permit the conclusion of the work then being conducted under the Annex.

4.4 Either the Contracting Parties or the Executive Committee of each Implementing Agreement shall:

4.4.1 approve the programme activities and the annual programme of work and budget for the relevant Implementing Agreement;

4.4.2 establish the terms of the contribution for scientific and technical information, know-how and studies, manpower, capital investment or other forms of financing to be provided by each participant in the Implementing Agreement;

4.4.3 establish the necessary provisions on information and intellectual property and ensure the protection of IEA copyrights, logos and other intellectual property rights as established by the IEA;

4.4.4 assign the responsibility for the operational management of the programme or project to an entity accountable to the Executive Committee of the relevant Implementing Agreement;

4.4.5 establish the initial term of the Implementing Agreement and its Annexes;

4.4.6 approve amendments to the text of the Implementing Agreement and Annexes; and

4.4.7 invite a representative of the IEA Secretariat to its Executive Committee meetings in an advisory capacity and, sufficiently in advance of the meeting, provide the Secretariat with all documentation made available to the Executive Committee members for purposes of the meeting.

Article 5
Copyright

5.1 Notwithstanding the use of the IEA name in the title of Implementing Agreements, the Implementing Agreements, the Executive Committee or the entity responsible for the operational management of the programme or project may use the name, acronym and emblem of the IEA as notified to the World Intellectual Property Organisation (WIPO) only upon prior written authorisation of the IEA and solely for the purposes of executing the Implementing Agreements.

5.2 The IEA shall retain the copyright to all IEA deliverables and published or unpublished IEA material. Implementing Agreements wishing to use, copy or print such IEA deliverables and/or material shall submit a prior written request of authorisation to the IEA.

Article 6
Reports to the IEA

6.1 Each Executive Committee shall submit to the IEA:

6.1.1 as soon as such events occur, notifications of any admissions and withdrawals of Contracting Parties and Sponsors, any changes in the names or status of Contracting Parties or Sponsors, any changes in the Members of the Executive Committee or of the entity responsible for the operational management of the programme or project, or any amendments to an Implementing Agreement and Annex thereto;

6.1.2 annual reports on the progress of programmes and projects of the Implementing Agreement and any Annex;

6.1.3 notwithstanding Article 6.1.1, in addition to and with the Annual Report, annually provide the IEA with the following information:

(a) the names and contact details of all current Contracting Parties and Sponsors;

(b) the names and contact details of all Contracting Parties and Sponsors who may have withdrawn from the Implementing Agreement or any Annex in the year covered by the Annual Report;

(c) the names and contact details of all new Contracting Parties and Sponsors who may have joined the Implementing Agreement or any Annex in the year covered by the Annual Report;

(d) any changes in the names or status of any Contracting Parties or Sponsors;

(e) the names and contact details of the Executive Committee members and the entity responsible for the operational management of the programme or project; and

(f) any amendments to the text of an Implementing Agreement and any Annex thereto.

6.1.4 End of Term Reports, which shall include all the information and documentation required by Decisions of the CERT then in effect and relating thereto; and

6.1.5 at the request of the IEA, any other non-proprietary information as may be requested by the IEA in connection with the IEA's mandate.

Article 7
Effective Date

This Framework shall take effect and become binding on all participants in the Implementing Agreements and Annexes from the date of its approval as a decision by the Governing Board.

FREQUENTLY ASKED QUESTIONS

What is IEA technology collaboration?

Technology collaboration provides the basis for interested parties to undertake energy technology research, development and deployment activities.

In 2007, there were 41 collaborative projects with several thousand participants from 72 countries, international organisations or companies working in the areas of:

- Fossil Fuels
- Renewable Energies and Hydrogen
- End-Use (buildings, electricity, industry, transport)
- Fusion Power
- Cross-Sectional Activities

Who can participate?

The IEA technology collaboration programme is open to IEA member and non-Member countries. Typically, participants are:

- Governmental or energy technology entities representing governments;
- Research institutes and universities;
- Energy technology companies.

Each signatory designates a representative to an Executive Committee that governs and administrates the work.

What are the benefits of participation?

There are numerous advantages to international energy technology RD&D collaboration. Some examples include:

- Reduced cost and duplication of work
- Greater project scale
- Information sharing and networking
- Linking IEA member countries and non-member countries
- Linking research, industry and policy
- Accelerated development and deployment
- Harmonized technical standards
- Strengthened national RD&D capabilities

In addition, the IEA technology collaboration programme has a proven record of successful management that allows:

- Flexibility
- Intellectual property rights protection

How is technology collaboration structured?

The programme of work and strategy of each technology collaboration contract (Implementing Agreement) must fit into the IEA shared goals: energy security, environmental protection and economic growth. Typically, the work includes:

- Technology assessment, feasibility studies, environmental impact studies, market analysis, policy implications
- Research projects – from laboratory scale to pilot facility scale
- Information exchange of programs, policies, funding priorities, research, modeling
- Dissemination of results and experiences acquired

How is the work financed?

Technology collaboration can be financed on a cost-shared or task-shared basis, or a combination of both, as long as the signatories agree and as set out in the Implementing Agreement.

Task-sharing works well when there are a number of different concepts that can are being investigated by different participants in parallel, while cost-sharing is more appropriate for funding a single joint activity or experiment.

Some participants use common funds to cover the costs of central administration, leaving the project costs to be task-shared. Others may rely entirely on task-sharing, which reduces administrative burdens for accounting but implies a detailed definition of each participant's rights and obligations.

What is the IEA framework?

The IEA Framework for International Technology Co-operation, adopted by the Governing Board on 3 April 2003 to replace the IEA Guiding Principles for Co-operation in the Field of Energy Research and Development, sets forth minimum legal and management requirements for Implementing Agreements, including, e.g., who can participate, the process to become a participants, reports required by the IEA and the maximum initial term and manner of extension of Implementing Agreements. See Annex 2 for the full text of the Framework.

What is the role of the IEA?

The role of the IEA Secretariat in the energy technology collaboration programme is to:

- Provide legal advice and support;
- Identify areas of common interest between the IEA and the Implementing Agreements via workshops, publications and other collaborative efforts; and
- Report on energy technology collaboration activities via the IEA Web pages, the OPEN Bulletin, the Highlights publication and other material.

Every five years, the IEA Committee on Energy Research and Technology (CERT) and its Working Parties review the effectiveness, achievements and strategy of each Implementing Agreement. The CERT is also responsible for overseeing the energy R&D technology issues of all IEA member governments by:

- Analysing energy technology issues and recommending effective policy approaches based on Member country experiences;
- Tracking trends in energy technology RD&D; and
- Encouraging international co-operation on the research, demonstration, and deployment of energy technologies.

How can my organisation participate?

If your organisation is interested in participating in the technology collaboration programme, the first step is to contact the Chair, Operating Agent or Executive Secretary of an Implementing Agreement to discuss and define together what form your participation might take. Thereafter follows an exchange of letters (formal invitation, acceptance, and notification), with the final step being the signature of the Agreement.

How are new Implementing Agreements established?

A new Implementing Agreement can be created at any time, provided that:

- It is established by at least two IEA member countries
- The scope, strategic plan and work plan fit into the overall energy technology goals of the IEA member governments
- The IEA Committee on Energy Research and Technology and Governing Board have given their approval

IMPLEMENTING AGREEMENT WEBSITES

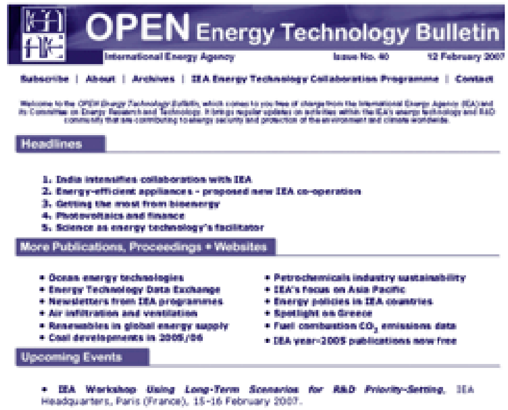
Implementing Agreement	Website
Cross-Cutting Activities	
Climate Technology Initiative	www.climatetech.net
Energy Technology Data Exchange	www.etde.org
Energy Technology Systems Analysis Programme	www.etsap.org
Energy End-Use Technologies	
Buildings	
Buildings and Community Systems	www.ecbcs.org
District Heating and Cooling	www.iea-dhc.org
Energy Storage	www.iea-eces.org
Heat Pumping Technologies	www.heatpumpcentre.org
Electricity	
Demand-Side Management	http://dsm.iea.org
Electricity Networks	www.iea-enard.org/
High-Temperature Superconductivity	http://spider.iea.org/tech/scond/scond.htm
Industry	
Emissions Reduction in Combustion	www.ieacombustion.com
Industrial Technologies and Systems	www.iea-iets.org
Transport	
Advanced Fuel Cells	www.ieafuelcell.com
Advanced Materials for Transportation	www.iea-ia-amt.org
Advanced Motor Fuels	www.iea-amf.vtt.fi
Hybrid and Electric Vehicles	www.ieahev.org
Fossil Fuels	
Clean Coal Sciences	www.iea-coal.org.uk
Enhanced Oil Recovery	http://iea-ccs.fossil.energy.gov
Fluidized Bed Conversion	www.iea.org/eor
IEA Clean Coal Centre	www.iea.org/tech/fbc/index.html
IEA Greenhouse Gas RD Programme	www.etsu.com/ieampf
Multiphase Flow Sciences	www.ieagreen.org.uk
Fusion Power	
Environmental, Safety, Economic Aspects Fusion Power	www.iea.org/techagr
Fusion Materials	www.frascati.enea.it/ifmif
Large Tokamaks	www-jt60.naka.jaea.go.jp/
Nuclear Technology of Fusion Reactors	www.iea.org/techagr
Plasma Wall Interaction in TEXTOR	www.fz-juelich.de/ief/ief-4/en
Reversed Field Pinches	www.iea.org/techagr
Stellarator Concept	www.iea.org/techagr
Toroidal Physics, Plasma Technologies of Tokamaks with	www.iea.org/techagr
Tokamaks with Poloidal Field Divertors	www.aug.ipp.mpg.de/iea-ia

Renewable Energy Technologies

Bioenergy	www.ieabioenergy.com
Deployment	www.iea-retd.org
Geothermal	www.iea-gia.org
Hydrogen	www.ieahia.org
Hydropower	www.ieahydro.org
Ocean Energy Systems	www.iea-oceans.org
Photovoltaic Power Systems	www.iea-pvps.org
Solar Heating and Cooling	www.iea-shc.org
SolarPACES	www.solarpaces.org
Wind Energy Systems	www.ieawind.org

FURTHER INFORMATION

IEA OPEN Energy Technology Bulletin



The IEA *OPEN Bulletin* reports regularly on developments within the IEA energy technology community and includes updates on current projects, upcoming workshops, and recent publications.

Current issue

http://spider.iea.org/impagr/cip/index.htm

Past issues

http://spider.iea.org/impagr/cip/archived_bulletins/index.htm

To subscribe

http://weaver.iea.org/mailman/listinfo/open-mail

IEA Technology Web pages

The IEA Technology Agreements page of the IEA website (www.iea.or/techagr) includes a short description of each of the Implementing Agreements, a list of current projects, and links to their websites.

The IEA website also includes detailed information on other energy technology activities of the IEA Secretariat including publications, papers, press releases, workshops, statistics, databases and ongoing work. For more information, see www.iea.org/Textbase/subjectqueries/keyresult.asp?KEYWORD_ID=4120.

Contacts

For specific queries relating to the IEA Energy Technology Collaboration Programme, or for information on related energy technology and R&D activities at the IEA, contact:

Carrie Pottinger
Energy Technology Co-ordinator
Office of Energy Technology and R&D
+33 (0) 1 40 57 67 61
Carrie.Pottinger@iea.org

For cross-cutting issues contact:

Antonio Pflüger
Head
Energy Technology Collaboration Division
+33 (0) 1 40 57 67 60
Antonio.Pflueger@iea.org

IEA Publications
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