International Energy Agency

Energy Technology Initiatives 2013

Implementation through Multilateral Co-operation

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Implementation through Multilateral Co-operation

Ensuring energy security and addressing climate change cost-effectively are key global challenges. Tackling these issues will require efforts from stakeholders worldwide. To find solutions, the public and private sectors must work together, sharing burdens and resources, while at the same time multiplying results and outcomes.

Through its broad range of multilateral technology initiatives (Implementing Agreements), the IEA enables member and non-member countries, businesses, industries, international organisations and non-governmental organisations to share research on breakthrough technologies, to fill existing research gaps, to build pilot plants and to carry out deployment or demonstration programmes across the energy sector. In short, their work can comprise any technology-related activity that supports energy security, economic growth, environmental protection and engagement worldwide.

Some 40 Implementing Agreements carry out programmes in the areas of energy efficiency (buildings, electricity, industry, and transport), fossil fuels (clean coal, enhanced oil recovery, carbon capture and storage), fusion power (tokamaks, materials, technologies, safety, alternate concepts) and renewable energy technologies, and cross-cutting topics (technology transfer, research databases, and modeling).

This publication highlights the most significant recent achievements of the IEA Implementing Agreements. The core of the IEA Energy Technology Network, these initiatives are a fundamental building block for facilitating the entry of new and improved energy technologies into the marketplace.

iea Energy Technology Network

International
Energy Agency

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its primary mandate was – and is – two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply, and provide authoritative research and analysis on ways to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA carries out a comprehensive programme of energy co-operation among its member countries, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency's aims include the following objectives:

- Secure member countries' access to reliable and ample supplies of all forms of energy; in particular, through maintaining effective emergency response capabilities in case of oil supply disruptions.
- Promote sustainable energy policies that spur economic growth and environmental protection in a global context – particularly in terms of reducing greenhouse-gas emissions that contribute to climate change.
- Improve transparency of international markets through collection and analysis of energy data.
- Support global collaboration on energy technology to secure future energy supplies and mitigate their environmental impact, including through improved energy efficiency and development and deployment of low-carbon technologies.
- Find solutions to global energy challenges through engagement and dialogue with non-member countries, industry, international organisations and other stakeholders.

IEA member countries:

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Austria
Belgium
Canada
Czech Republic
Denmark
Finland
France
Germany
Greece
Hungary
Ireland
Italy
Japan
Korea (Republic of)
Luxembourg
Netherlands
New Zealand
Norway
Poland
Portugal
Slovak Republic
Spain
Sweden
Switzerland
Turkey
United Kingdom
United States

The European Commission also participates in the work of the IEA.

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FOREWORD

Current trends in energy supply and use are simply unsustainable – economically, environmentally and socially. Without decisive action, energy-related greenhouse-gas (GHG) emissions will more than double by 2050. In addition, increased fossil energy demand will heighten concerns over the security of supplies.

We can and must change our current path, but this will take an energy revolution and low-carbon energy technologies will have a crucial role to play. Energy efficiency, renewable energy sources, carbon capture and storage (CCS), nuclear power and new or improved technologies for cleaner, more efficient power generation, industrial processes or vehicles will require widespread deployment if we are to reduce greenhouse-gas emissions and meet energy demand. The task is urgent if we are to ensure that investment decisions made now do not lock us into decades of suboptimal technologies. More must be done to push forward the development and deployment of the technologies we need today - and will need in the future.

Unfortunately, the technologies with the greatest potential for energy and GHG emissions savings are often unable to reach markets. Favourable policy frameworks are an important first step. Increased co-operation between industries, businesses and governments is also necessary. Lastly, further research to improve the reliability of these technologies, reduce costs and accelerate deployment is also vital.

The multilateral technology initiatives, or Implementing Agreements (IAs), are supported by the IEA and a time-proven, flexible, effective mechanism for energy technology collaboration, research and analysis. Since the IA mechanism was created in 1975, participants have examined more than 1 400 topics in the energy field through applied research, testing, expert networks, databases, workshops and scientist exchanges. Organisations from 46 countries, 58 businesses, and four international organisations worldwide are working together to further research and share information on the latest developments in energy technologies through the IAs.

There are currently 40 IAs working in the areas of efficient end-use, fossil fuels, fusion and renewables (40 as of December 2012, the end of the period covered by this publication). Key recent outcomes designed to advance energy technologies include setting international standards; developing recycling models; carrying out life-cycle assessments; analysing case studies of energy technology efforts; preparing technology policy or research and development (R&D) best practice guidebooks and manuals; gathering important data; building pilot or demonstration projects; and crafting policy recommendations on areas pertinent to certain energy technologies.

During 2010-12, more than 300 topics were examined, with the final results of 86 collaborative studies published. The significant recent achievements and activities of these groups over that period are the focus of this book. The IAs are at the core of a network that co-ordinates and promotes the research, development and demonstration (RD&D) of technologies to meet challenges in the energy sector for IEA member countries and partner countries: the IEA Energy Technology Network.

I strongly encourage those who are engaged in energy issues, whether in government or in the private sector, to transform dialogue into action, in particular through collaboration in the IEA Implementing Agreements.

This publication is produced under my authority as Executive Director of the IEA.

Maria van der Hoeven
Executive Director
International Energy Agency

ACKNOWLEDGEMENTS

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INTRODUCTION

Accelerating research, development and deployment (RD&D) of energy technologies and systems is a crucial component of resolving key global challenges, such as promoting efficient use and production of energy, and ensuring energy security. To provide a platform for IEA member countries to address these challenges and facilitate collaboration with other partners, the IEA established a mechanism in 1975 for developing multilateral technology initiatives (formally known as Implementing Agreements [IAs]) in 1975.

IAs provide a flexible mechanism for governments, industries and businesses, and international and non-governmental organisations from IEA member and partner countries (non-IEA countries) to leverage resources and multiply the results of research into energy technologies and related issues. Through these initiatives, governments partner with industry and other organisations to pursue energy technology research, forming a cost-effective, global energy technology network.

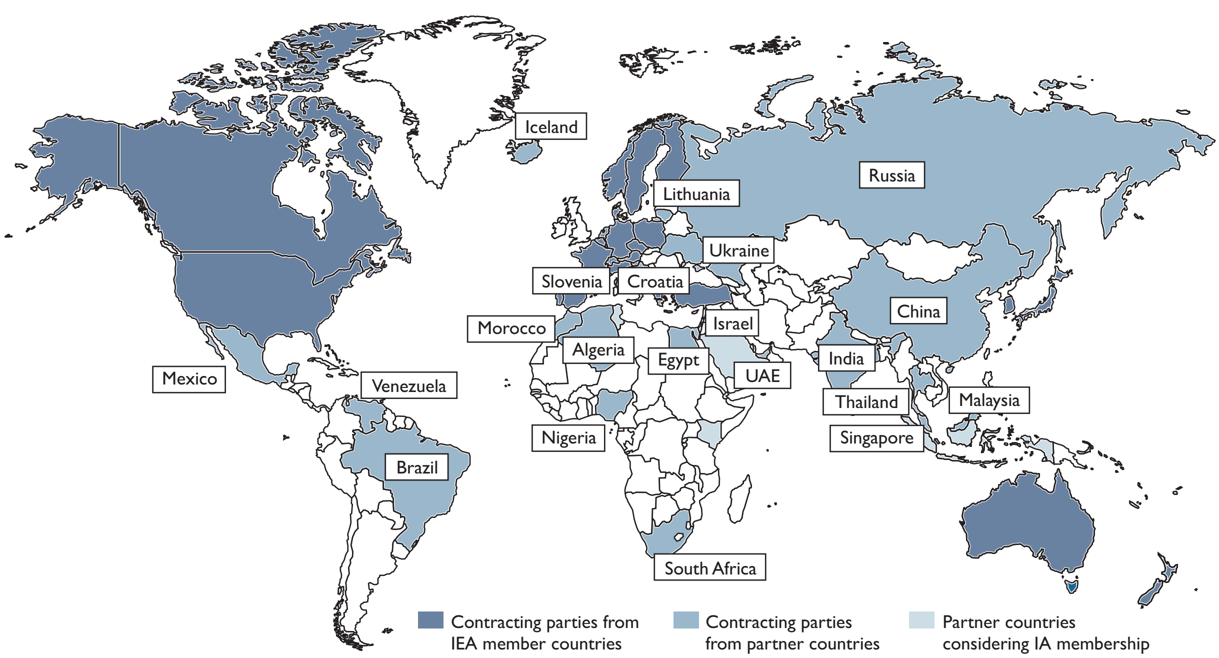
As of December 2012, there were 40 IAs working in the following areas:

- efficient end-use technologies (buildings, electricity, industry, transport);
- fossil fuels (greenhouse-gas mitigation, supply, transformation);
- renewable energies and hydrogen (technologies and deployment) and fusion power (international experiments); and
- cross-cutting issues (information exchange, modelling, technology transfer).

Cross-cutting initiatives provide tools and mechanisms that enable participants to implement technology programmes. The ETDE IA[1] allows access to its extensive database of scientific information to more than 90 partner countries. The CTI IA engages with IEA partner countries individually and through regional events in order to share best practices, build capacity, and facilitate technology transfer and financing. An example of this is the Clean Energy Project Development Initiative for India and the Asia Forum for Clean Energy Financing. Through energy models, the ETSAP IA provides energy stakeholders with the tools necessary to improve national energy plans, making them more reliable and realistic.

Improving end-use energy efficiency, whether in buildings and commercial services, electricity, industry or transport sectors, is crucial for the environment and energy security. Fourteen IAs currently research various aspects of these end-

1. IAs are referred in their abbreviated form in the text. The full formal names are provided in the section For More Information.



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use sectors. One recently created IA co-ordinates policies, promotes standards and analyses issues related to energy efficient electrical equipment (4E IA).

Fossil fuels are at the core of energy demand in the transport and electricity generation sectors and will continue to be for many more years to come. The work of six IAs focuses on finding ways to build on existing resources, while at the same time getting the most from every barrel of oil or tonne of coal while reducing costs and improving efficiency. Key areas of interest include enhanced oil recovery, carbon capture and storage (CCS), science and technologies for clean coal-fired power generation, fluidised bed conversion technologies and multiphase flow applications.

Renewable energy technologies provide clean, flexible, standalone or grid-connected electricity and heating or cooling. Ten IAs deal with renewable energy technologies (including deployment), bioenergy, geothermal, hydrogen, hydropower, ocean systems, solar (concentrated power, heating and cooling, photovoltaic), and wind.

Eight IAs co-ordinate national and regional fusion power programmes in both IEA member and partner countries and share experimental results on safety and materials, tokamaks, and alternate concept devices and physics.

IEA IMPLEMENTING AGREEMENTS

Quiet Achievers in International Energy Technology Collaboration

Cross-Cutting Activities

End-Use Technologies

Fossil Fuels

Fusion Power

Renewable Energies and Hydrogen

QUIET ACHIEVERS IN INTERNATIONAL ENERGY TECHNOLOGY COLLABORATION

The effectiveness of the Implementing Agreement mechanism

In existence for longer than many other international energy technology initiatives, the IEA Implementing Agreement (IA) mechanism is increasingly being recognised as a time-proven, flexible, and effective means of international collaboration on energy technology and science, beyond IEA member countries.

A new IA may be created at any time to respond to the needs of IEA Member country governments. Since 1975, 81 IAs have been created, while 40 have either ceased activities or merged their activities with another IA. Each IA is allowed a maximum term of five years, which is renewable.

Since the last edition of *Energy Technology Initiatives* (2010), the IA mechanism has been the subject of two separate studies conducted independently by the Organisation for Economic Co-operation and Development (OECD)[1]. The first study examines best practice with regard to international science and technology collaborative mechanisms. Seven initiatives or organisations, including the IA mechanism[2], were compared according to five criteria: priority-setting; funding and spending; knowledge sharing and intellectual property; putting science and technological innovation into practice; and capacity building for research and innovation.

By comparing the IA mechanism to other initiatives, this report highlights key advantages of the IA mechanism: the flexible governance structure; the chance for participation by the private sector; equal sharing rights (*i.e.* intellectual property); the creation and strengthening of networks to increase knowledge sharing; and, the participation of partner countries. The second study found a positive correlation for some countries between participating in an IA and patents registered by two or more of the IA participating countries, or co-invention[3].

Of note, the IA mechanism and its related IEA Framework for International Energy Technology Collaboration (see chapter: For more information) informed creation of the United Nations Framework for a Climate Change Convention (UNFCCC) technology mechanism, established in 2010.

Below is a brief summary of some key outcomes over 2010-12, along with important features of this unique technology collaboration tool.

Activities and outcomes

Analysis

IAs remain a mechanism for joint research and analysis. Over 2010-12, more than 300 topics were examined, with the final results of 86 collaborative studies published. The full list of topics addressed is included in the Statistics section of this report.

Lending expertise to the IEA

The strong expertise collected in the IAs is not only applied to their own activities. A frequently overlooked feature of the IA mechanism has been the opportunity it has provided for IA participants to contribute to IEA technology analyses. Such contributions take many forms, including providing comprehensive analyses, reliable data on technologies for models, co-authoring studies, serving as experts in stakeholder consultations and undertaking peer reviews of draft analyses. Over 2010-12, such efforts contributed to 11 technology roadmaps: *Bioenergy for Heat and Power; Biofuels for Transport; Carbon Capture and Storage (CCS) in Industrial Applications; Electric and Plug-in Hybrid Electric Vehicles; Energy Efficient Buildings: Heating and Cooling Equipment; Fuel Economy of Road Vehicles; Geothermal Heat and Power; High-Efficiency, Low-Emissions, Coal-Fired Power Plants; Hydropower; Smart Grids;* and *Solar Heating and Cooling*. In addition, IA data and findings fed into important IEA analytical studies, such as the *World Energy Outlook 2012, Energy Technology Perspectives 2012; Medium-Term Renewable Energy Market Report 2012; Electric Vehicle City Casebook; Carbon Capture and Storage Legal and Regulatory Review (3rd edition)*; and *CCS Retrofit: Analysis of the Global Installed Power Plant Fleet*.

IAs also lent expertise to a range of IEA workshops and collaborative efforts during 2010-12, such as those organised under the auspices of the Experts' Group on R&D Priority-Setting and Evaluation, and those related to energy efficiency policies. IA participants also provided expertise to the workshops of the IEA International Low-Carbon Energy Technology Platform, designed to foster engagement with partner countries and assist with national technology roadmap development. Recent examples include IA participation in workshops on bioenergy in Russia and on technology financing in Stockholm, as well as three regional workshops to develop the IEA *How2Guide: Smart Grids in Distribution Networks: a guidebook for roadmap development and implementation*.

IEA and the IAs: a win-win situation

IA activities enable the IEA to collaborate with government agencies, research institutions, multinational enterprises, industries, universities and international organisations. This increases the visibility of the Agency's work, while at the same time lending credibility to IAs. This in turn helps to attract respectable partners to the energy technology network: over 2010-12, 32 organisations joined an IA for the first time.

Links to international processes

An important aspect of the IA mechanism is its contribution to a number of high-level international initiatives. One longstanding example is the CTI IA, which holds side events at every Conference of the Parties (COP) to the United Nations Framework Convention on Climate Change (UNFCCC) and also participates in the activities of its Subsidiary Body for Scientific and Technological Advice (SBSTA).

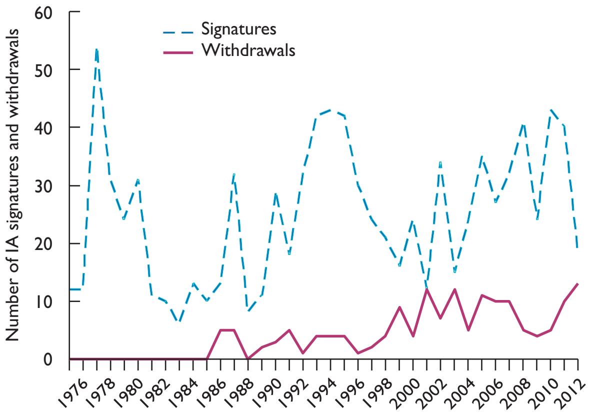
There have been two notable developments in this field since the last edition of this publication. In April 2011, a new IA was established (ISGAN IA) to serve as a managerial framework for the Clean Energy Ministerial (CEM) initiative on smart grids. In the second, a close collaboration was developed between the CEM Electric Vehicles Initiative, created in 2011, and the IA focusing on hybrid and electric vehicles (HEV IA).

Membership

IA participation builds connections between national governments and industries, creates networks of experts and expands national research capacities. To date, more than 414 entities have become signatories to IAs. The magnitude of membership in an IA underlines the strategic importance given to that topic by governments and private sector entities. Similarly, new participation in IAs – as well as withdrawals – reflects changes in priorities and budgets. New participation (signatures) in, and withdrawals from, IAs have varied significantly over time.

In 2012, 18 organisations (either governments, known as contracting parties, or non-government entities, known as sponsors) joined an IA and 13 organisations withdrew, resulting in the third lowest net participation (signatures less withdrawals) in the history of the IA mechanism. Table 1 represents the number of signatures and withdrawals over time, with peaks illustrating years when one or more IAs were created. Since the 2010 edition of *Energy Technology Initiatives*, two new IAs have been created – on smart grids, and gas and oil technologies (ISGAN IA and GOT IA) – while two others have closed (relating to clean coal science and electricity network R&D).[4]

Figure 1 • Signatures and withdrawals



Unless otherwise indicated all figure sources are IEA.

IEA member country governments continue to represent the majority of participants in IAs (75%), led by the United States (38 of 40 IAs as of December 2012), Canada (32) and Japan (31). Since 1983, these three countries have more than doubled their participation. Korea has had the largest growth, from no participation in IAs in 1993 to joining 28 IAs by 2012, placing fourth among all IEA member countries. In terms of leadership in the Executive Committee of an IA, the United States (five), Japan (four) and Italy (four) are Chairs of the greatest number of IAs, while Austria, Germany and Switzerland are each Chairs of three IAs .

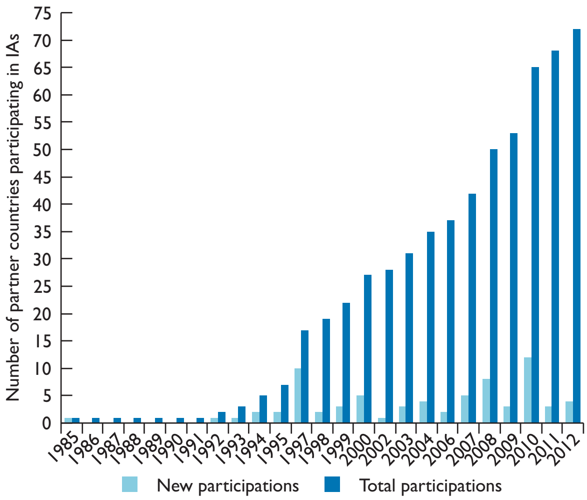
Since 2010, participation in IAs has grown from 575 to 600; this includes a 38% increase in partner country participation. To address global challenges through science and technology co-operation, increasing the participation of partner countries continues to be a priority. A total of 19 partner countries now account for 12% of total participation in all IAs. As of 31 December 2012, China was participating in 15 IAs, a greater number than six IEA member countries. Two countries have recently joined IAs: Morocco (2011) and Slovenia (2012).

Indonesia, Kenya, the Philippines, Qatar, Saudi Arabia and Tunisia may also be considering becoming IA members.[5]

The IEA Committee on Energy Research and Technology (CERT) engages with partner countries through its regular evaluation of each IA. As IA membership continues to expand beyond IEA member countries, opportunities for capacity building and technology transfer to partner countries through IAs continues to increase. Indeed, the IAs that address cross-cutting issues explicitly provide a framework for engaging with countries with fewer resources. Moreover, technology development in emerging economies contributes greatly to the work of the IAs. Much

![Figure 2]

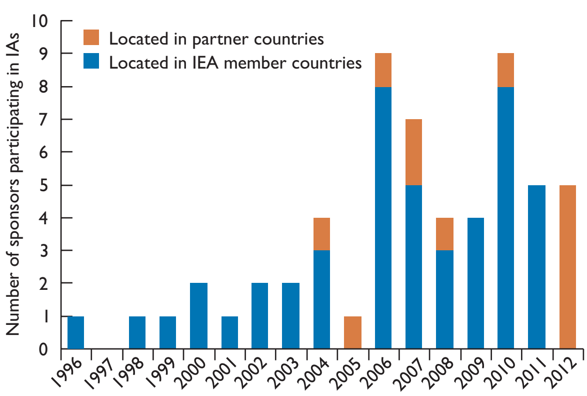
Figure 2 • Partner country participation



can and is being learned from partner country experiences. One IA has an equal number of IEA member country and partner country participants (concentrating solar power, or SolarPACES).

Given the importance of links among the private sector, academia and government in fostering successful research activities, another important feature of IAs is that they allow for participation beyond IEA member governments. Non-governmental entities, formally known as sponsors, currently represent 10% of all participation in IAs.

Figure 3 • Sponsor participation



Over 2010-12, 18 new sponsors became participants in IAs, the vast majority of which were in IAs relating to fossil fuels and renewable energies. This included multinational enterprises, industry associations and private research consortia. Six of the 16 new sponsors are located in partner countries, including: Petrobras (Brazil); the Economic Community of West African States (Cape Verde Islands); the Chinese Wind Energy Association and the Electrical Power Planning and Engineering Institute (China); the Instituto de Investigaciones Eléctricas (Mexico); and, Masdar Carbon (United Arab Emirates). In 2012, all new sponsors in IAs were located in partner countries.

The full list of companies participating in IAs as sponsors is shown in the Statistics section of this publication. However, data will not represent those cases where governments ask industry to represent them on the Executive Committee of an IA, nor do the figures cover instances where industry is consulted informally or participates in an IA project. Currently, more than 500 companies are informally engaged in IAs, either as participants or consultants.

Important international organisations also participate in IAs. The European Commission participates in 13 IAs in a broad range of areas, and the European Atomic Energy Community (EURATOM) participates in seven of the eight IAs relating to fusion. In 2012, the ITER International Fusion Energy Organisation joined the fusion IA related to tokamaks, bringing the number of international organisations participating in IAs to five. The Organisation for Petroleum Exporting Countries (OPEC) participates in the IA relating to CCS (GHG IA) and the United Nations Industrial Development Organisation (UNIDO) participates in an IA that focuses on hydrogen (Hydrogen IA). This is consistent with recent IEA efforts to encourage synergies between international organisations working in the field of energy. Indeed, international organisation participation could be encouraged further in the coming years.

Conclusion

Given significant energy and sustainability challenges worldwide, IAs will continue to play a role in facilitating international collaboration on energy technology. The knowledge gained from the large number of highly specialised topics addressed over 2010-12 is substantial. This includes new areas of work: using concentrated solar power to create high-temperature steam for electricity; driving desalination plants in arid regions; and, facilitating approval of CCS as a project type under the Clean Development Mechanism of the UNFCCC.

The value of IA participation is capturing attention beyond IEA member country governments as shown by the increased involvement of non-governmental entities and partner countries. This is a testament to the flexible and effective structure of IAs as a form of international collaboration on energy technology, and is particularly important given the global nature of today's energy challenges and the shift in energy demand to non-IEA countries.

More work must be done. There are considerable opportunities for partner countries to expand their participation in IAs. There also remains a pressing need for many IAs to better communicate their impressive research findings to decision makers in government and industry. This publication represents one small part of that effort.

Notes

1. OECD (2012), *Meeting Global Challenges through Better Governance: International Co-operation in Science, Technology and Innovation*, pp. 131-150, OECD, Paris.

2. The Consultative Group on International Agricultural Research, the Bill and Melinda Gates Foundation, the Group on Earth Observations, the International Atomic Energy Agency, the Inter-American Institute for Global Change Research, the Implementing Agreements, and the European Joint Programming Initiatives. Two mini-case studies were also carried out on the Global Carbon Capture and Storage Institute and the International Arabidopsis Genome Research Project.

3. OECD (2012), *Energy and Climate Policy: Bending the Technological Trajectory, OECD Studies on Environmental Innovation*, OECD, Paris.

4. The Implementing Agreement for a Programme of Research, Development and Demonstration on Clean Coal Sciences and the Implementing Agreement on Electricity Networks Analysis, Research and Development.

5. The full list of IA participants representing governments and intergovernmental organisations (Contracting Parties) is referenced in the Statistics chapter.

Climate Technology Initiative

Energy Technology Data Exchange

Energy Technology Systems Analysis Programme

CROSS-CUTTING ACTIVITIES

PROJECT FINANCIERS MEET PARTNERS

Policy context

According to the IEA *World Energy Outlook*, the share of global energy demand in OECD non-member countries is expected to rise by over one-third before 2035, underpinned by rising living standards in China, India and the Middle East.[1] The need for electricity in emerging economies will drive a 70% increase in worldwide demand, as 1.3 billion people still lack access to electricity. As a result, emerging economies will hold an increasing share of the worldwide burden to build an environmentally sound future. Efforts to share best practice, knowledge, tools and financing options with emerging economies is an important step to accelerating development and diffusion of clean technologies.

Background

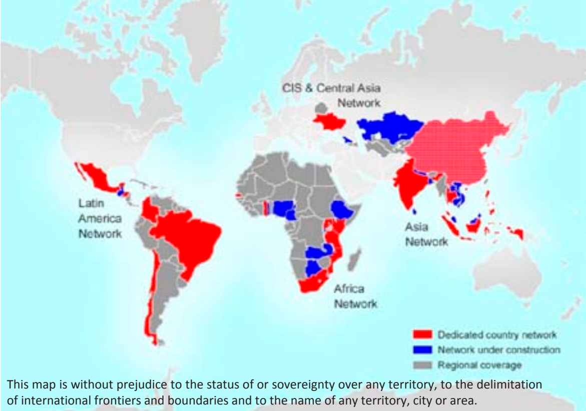
In co-operation with partner countries, international organisations, private business and financing communities, the Implementing Agreement for the Climate Technology Initiative (CTI IA) provides a framework for governments to carry out technology needs assessments; training; access to project financing; targeted capacity building; and exchanges of experts. The CTI IA anticipates working closely with the Technology Executive Committee and the Climate Technology Centre and Network of the United Nations Framework Convention on Climate Change (UNFCCC). There are 11 Contracting Parties.

Spotlight

The CTI IA Private Financing Advisory Network (CTI PFAN) is a global, multilateral initiative dedicated to reducing greenhouse gas emissions by bridging the gap between investors and clean energy projects in need of financing. It achieves this by identifying promising projects at an early stage of development, providing professional support and assistance through preparation of a financially sound business plan and by introducing mature projects to investors from the PFAN global network of investors and financiers.

Over the last two years the CTI PFAN Network has expanded, including four new regions: East Africa; West Africa; Central America and the Caribbean; the Commonwealth of Independent States (CIS); and Central Asia. Projects receiving CTI PFAN support have increased significantly.

By the end of 2012, CTI PFAN projects in the pipeline (proposals being processed) had increased to 164, compared to 69 in 2010. These projects represent USD 5 billion of total investments and have the potential to reduce CO_2 emissions by 7.1 million tonnes per year (t/yr).



▲ Dedicated national or regional financing networks form hubs for CTI IA activities and operations.[2]

In addition, some 30 projects have reached financial closure, bringing the total amount of financing raised to USD 432 million, representing 310 MW of clean generation capacity and 1.9 million tonnes of CO_2 (t/CO_2) emissions mitigation potential per year.

The large majority of projects reaching financial closure by the end of 2012 focussed on biomass, energy efficiency, hydropower, and biofuels (67%), while most were located in Southeast Asia, China, and eastern and southern Africa (82%).

The CTI PFAN network of consultants, investors and resource partners (regional development banks, small power producer collectives, competence centres and green initiatives) has grown to over 100 members.

CURRENT PROJECTS

- Capacity building
- Clean technology business network
- Exchange of experts
- Financing adaptation
- Innovations for a climate friendly building sector
- Joint activities with the UNFCCC
- Private Financing Advisory Network (PFAN)
- Regional clean energy financing forums
- Technology needs assessments

REFERENCES

1. World Energy Outlook 2012, *IEA, Paris.*

2. *This map is without prejudice to the status or sovereignty over any territory, to the delimitation of international frontiers and boundaries, and to the name of any territory, city or area.*

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POPULAR TOPICS, POLICIES AND PATENTS

Policy context

Energy planners and policy makers around the world need key research information to inform decision-making. Researchers need access to targeted, international energy research results in order to accelerate deployment of energy technologies. Industries need access to recent laboratory and academic research results, patents and policy briefs in order to keep track of recent trends and calculate risks of investments. The energy-specific research database, ETDEWEB, responds to these needs.

Background

The aim of the Implementing Agreement for the Establishment of the IEA Energy Technology Data Exchange (ETDE IA) is to provide governments, industry and the research community with access to the widest range of information on energy research, science and technology. The ETDE IA World Energy Base, or ETDEWEB, is the largest single resource for energy-related scientific, technical and policy information worldwide. Through the ETDEWEB, the ETDE IA provides free access to more than 90 Partner countries. There are 13 Contracting Parties, including Brazil, Mexico and South Africa.

Spotlight

The ETDEWEB is comprised of energy research results of the ETDE IA members, and many other relevant sources. It is designed for researchers eager to receive precise information in the shortest amount of time.

ETDEWEB includes over 4.8 million research literature citations, over 1 million citations with relevant links to other sources, and 472 000 links to full research documents. With over 60 000 searches per month, the ETDEWEB is continually demonstrating relevance in energy research efforts worldwide.

A study carried out in June 2010 demonstrated that, from 15 topics in the study, ETDEWEB provided unique search results not shown by Google or Google Scholar in 86.7% of cases.[1]

In particular, ETDEWEB search results often include the achievements of many of the IEA Implementing Agreements; the International Energy Agency; the European esp@cenet (patents from Japan, the European Patent Office, and the World Intellectual Property Organisation, and others); as well as major national energy organisations in Denmark, France, and the United States, and in scientific journals worldwide. This demonstrates that the ETDEWEB goes well beyond web-based search engines that quickly provide a multitude of results which then must be sorted and categorised before analysis.

Category	Subcategory	Share
Basic and applied science	Materials science, environmental science, engineering and non-radiation chemistry	38%
Nuclear technology	Radiology and nuclear medicine, nuclear reactors	17%
Renewables	Biomass, solar and wind	14%
Fossil fuels	Coal, lignite, peat and petroleum	12%
Conservation, conversion, distribution	Energy conservation, power transmission	11%
Policy	Policy	5%
Other	Defence, other	3%

▲ The most popular research topics 2010–12.

The information in the ETDEWEB is useful for research and development priority-setting, investment firms and manufacturers. In addition to linking to patents through the federated search, the "popular topics" option highlights the topics most frequently included in ETDEWEB search requests. In July 2012, topics included solar cells with amorphous or titanium materials; zero- and low-energy buildings; and carbon capture and storage, including carbon sequestration.

Though the majority of ETDEWEB records have English abstracts, it is not uncommon that some documents are in the native language. To help users from non-English speaking countries gauge interest, ETDEWEB includes a tool that will translate search results and citations into other languages. Lastly, ETDEWEB recently developed a search app for mobile phones.

CURRENT PROJECTS

ETDEWEB online research database:

- **Expanding coverage**
- **Adding search aids**
- **Developing a mobile phone application**
- **Broadening access to partner countries**

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1. ETDE-OA–237, ETDEWEB Versus the World-Wide-Web: a Specific Database/Web Comparison.

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SUCCINCT AND INSIGHTFUL

Policy context

Access to high-quality data and models provide energy planners and strategists with the tools they need to explore the potential impact of energy policy decisions made today. Quantifying and visualising the possible effects of framework policies, regulation, incentives, financial and fiscal measures, investments in infrastructure or R&D, enable informed decisions. Balancing short-term issues against these long-term effects is challenging, but without a long-term vision – and a view into that future – sustainable economic growth and environmental protection are unattainable.

Background

The aims of the Implementing Agreement for a Programme of Energy Technology Systems Analysis (ETSAP IA) are to assist decision makers in assessing the current energy technologies and markets that will meet the future challenges of energy supply, economic development, and environmental protection. The ETSAP IA research program has continually developed the MARKAL model generator and has recently designed an enhanced model, the Integrated MARKAL-EFOM System (TIMES). To date, more than 250 institutions in over 70 countries have used ETSAP models, including the Energy Research Institute of the National Development and Reform Commission (China). There are 20 Contracting Parties, including Russia and the European Commission.

Spotlight

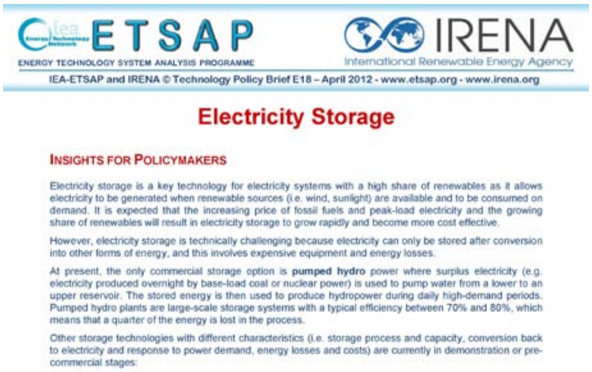
The IEA Technology Essentials series,[1] conceived in 2006, was designed to provide concise profiles on current energy technologies for producing, transporting and using energy.

In 2009, the ETSAP IA began compiling Energy Technology Data Source briefs (E-TechDS) that build on this basic concept. Each five- to ten-page E-TechDS brief provides basic information on process, status, performance, costs, data projections, market potential, barriers and policies for key energy technology clusters. Each is presented in a standardised manner, allowing easy comparison between technologies.

During 2010-12, 50 briefs were prepared, with another 30 in preparation or planned. A series of E-TechDS briefs on renewable sources and technologies are in preparation with the IEA and the International Renewable Energy Agency (IRENA).

Over the same period, several important policy-relevant enhancements have been integrated into the model. The element of risk is difficult to model accurately. As a result, using both a portfolio approach and limited resources approach, the TIMES model was revised to include hedging strategies for managing risk to price volatility and for coping with recurring uncertainties.

In addition, policy instruments such as feed-in tariffs, emissions trading, building regulations, and financial measures have been integrated into the TIMES model. Lastly, travel time and budgets were incorporated as measures of mobility modal choice between private car, buses and trains.


ETSAP
ENERGY TECHNOLOGY SYSTEM ANALYSIS PROGRAMME
IRENA
International Renewable Energy Agency
IEA-ETSAP and IRENA © Technology Policy Brief E18 – April 2012 - www.etsap.org - www.irena.org

Electricity Storage

INSIGHTS FOR POLICYMAKERS

Electricity storage is a key technology for electricity systems with a high share of renewables as it allows electricity to be generated when renewable sources (i.e. wind, sunlight) are available and to be consumed on demand. It is expected that the increasing price of fossil fuels and peak-load electricity and the growing share of renewables will result in electricity storage to grow rapidly and become more cost effective.

However, electricity storage is technically challenging because electricity can only be stored after conversion into other forms of energy, and this involves expensive equipment and energy losses.

At present, the only commercial storage option is **pumped hydro** power where surplus electricity (e.g. electricity produced overnight by base-load coal or nuclear power) is used to pump water from a lower to an upper reservoir. The stored energy is then used to produce hydropower during daily high-demand periods. Pumped hydro plants are large-scale storage systems with a typical efficiency between 70% and 80%, which means that a quarter of the energy is lost in the process.

Other storage technologies with different characteristics (i.e. storage process and capacity, conversion back to electricity and response to power demand, energy losses and costs) are currently in demonstration or pre-commercial stages:

▲ Example of an ETSAP IA Energy Technology Brief (E-TechDS).

CURRENT PROJECTS

Energy Technology Data Source briefs (E-TechDS)

Global, multi-regional ETSAP-TIAM model

Advancing the TIMES/MARKAL modelling tools:

- Prices: managing price volatility and uncertainties
- Transport: modes of transport, travel time and budgets
- Electricity generation: wide-scale integration of renewables
- Policies/measures: integrating policy instruments and financial measures
- Capacity-building: energy systems analysis

REFERENCES

1. Accessible under the free publications on the IEA website www.iea.org/publications/freepublications/.

www.iea-etsap.org

END-USE TECHNOLOGIES

Buildings

Buildings and Communities

District Heating and Cooling

Energy Efficient Electrical Equipment

Energy Storage

Heat Pumping Technologies

Electricity

Demand-Side Management

High-Temperature Superconductivity

Smart Grids

Industry

Emissions Reduction in Combustion

Industrial Technologies and Systems

Transport

Advanced Fuel Cells

Advanced Motor Fuels

Advanced Transport Materials

Hybrid and Electric Vehicles

REAL SAVINGS WITH RETROFITS

Policy context

Near-zero energy consumption in new – and existing – buildings and communities is possible. Designing a carefully chosen research and development (R&D) strategy will enable the building industries to move from incremental – to substantial – energy savings and reductions in greenhouse gas emissions.

Background

The aim of the Implementing Agreement for a Programme of Research and Development on Energy in Buildings and Communities (EBC IA) is to take advantage of energy-saving opportunities to remove technical obstacles to market penetration of new energy conservation technologies for community systems and residential, commercial, and office buildings. To implement this strategy, EBC IA activities focus on dissemination, decision-making and building systems. There currently 27 Contracting Parties, including China and Israel.

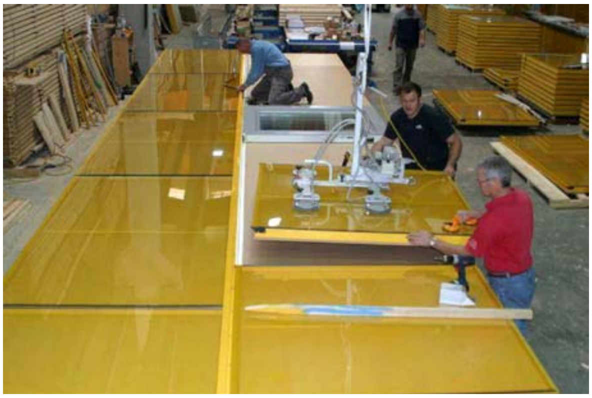
Spotlight

The main challenge to achieving energy conservation in the buildings sector is designing technologies and systems for existing buildings — approximately 80% of all buildings in OECD countries.

Some energy savings can be achieved through renovating building components such as windows, roofs, facades or heating systems. However, full building retrofits achieve substantial energy savings.

The EBC IA project, Prefabricated Systems for Low Energy Renovation of Residential Buildings, investigated the effectiveness of building renovation through the use of large, prefabricated renovation modules for both façades and roofs.

The study demonstrated that substantial energy savings are possible in typical apartment buildings that represent approximately 40% of European dwellings. Retrofits of 350 apartments measured as part of the study demonstrated energy savings between 80% to 90% or 30 kilowatt hours per square metre per year (kWh/m^2/yr) to 50kWh/m^2/yr. The prefabricated modules can be applied to many types of existing buildings and allow for larger window sizes, and ventilation systems integrated into the façade. Retrofits in the study were found to extend living space, for example, by incorporating balconies into apartments or by creating new rooftop apartments.



▲ Factory assembling of a large, prefabricated façade module (Austria).

Retrofits also present advantages compared to demolition and rebuilding. This includes, for example, reduction in construction cost, time and local disturbance, minimal waste and long-term reduction in CO_2 emissions.

CURRENT PROJECTS

- Air infiltration and ventilation centre
- Development and demonstration of financial and technical concepts for deep energy retrofits
- Energy-efficient communities
- Evaluation of embodied energy and CO_2 emissions for building construction
- High-temperature cooling, micro-generation and cost-effective energy and CO_2 emissions optimisation in building renovation
- Low temperature heating in buildings
- New generation computational tools
- Related energy technologies in buildings
- Reliable building energy performance characterisation based on full-scale dynamic measurements
- Reliability of energy efficient building retrofitting
- Towards net zero energy solar buildings
- Total energy use in buildings: analysis and evaluation methods

REFERENCES

Photo courtesy of Gap-solution GmbH (Austria).

www.iea-ebc.org

BE THE FIRST ON YOUR BLOCK

Policy context

The fundamental idea of district heating and cooling (DHC) 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 plants, biomass or biomass/coal co-firing, capturing geothermal heat and natural sources of heating and cooling, or recuperating industrial waste heat. Policies and measures to promote DHC include financial and fiscal support, utility supply obligations, local infrastructure and heat planning, emissions trading, interconnection measures and capacity building.

▲ Through innovative municipal planning, this new suburban housing development is linked to a district heating network (Neidonkallio, Finland).

Background

The Implementing Agreement for a Programme of Research, Development and Demonstration on District Heating and Cooling, including the Integration of Combined Heat and Power (DHC IA) examines district heating, cooling and power; energy efficient supply, notably combined heat and power (CHP); cost reductions through improved heating pipes and substations; efficient end-use through efficient customer connections and demand side management; and reducing the gap between supply and demand through thermal storage and system optimisation. There are currently nine Contracting Parties.

Spotlight

The overall objective of one recent DHC IA study, Policies and Barriers for District Heating and Cooling outside European Countries, was to identify and review key institutional barriers to DHC development and review best practice in 13 countries (Canada, China, Korea, Russia, the United States and selected European neighbouring countries). In China and Russia, some 200 million people are served by DHC systems.

The District Heating Technology Platform supported by the European Commission addressed these issues for 14 European countries. Working together, the two studies covered 95% of DHC networks worldwide.

Case studies for each country focussed on the current situation, the policy framework, as well as highlighting barriers to further deployment. Cross-country comparisons and analysis highlighted best practice in sustainable development of DHC systems.

Another DHC IA study, District Heating for Energy Efficient Building Areas, aims to understand cost effectiveness of installations, particularly as district heating networks are very location- and case-specific. In northern Europe, district heating networks reach 80% to 90% of central urban dwellers where heat demand is highest. Yet only 10% to 15% of outlying areas (e.g. suburban communities with a majority of single-family dwellings) are connected to DHC systems as they were not previously considered to be economical.

DHC system installation is considered to be cost effective when it achieves 1 Megawatt hour (MWh) per metre per year (MWh/m/yr). This ‘benchmark’ is based on DHC systems for multi-family dwellings located in densely-populated urban areas. The study found that installing DHC systems can also be cost-effective in outlying areas, despite the lower heat demand density of 0.5 MWh/m/yr. In outlying areas there are far fewer design and construction constraints related to existing infrastructure (telecommunications or sewage systems) and lengthy approval processes. In addition, the piping design for low heat density areas is simpler and can be made from lighter, cheaper materials.

CURRENT PROJECTS

Improved maintenance strategies for district heating pipe-lines

Integrating renewable energy and waste heat with district energy systems: economic and design optimisation

Towards fourth generation district heating: experiences with, and potential of, low-temperature district heating

REFERENCES

Photo courtesy of Kari Sipila.

www.iea-dhc.org

THE POWER OF POLICIES

Policy context

Many governments have a portfolio of successful energy efficiency policies for buildings, major appliances and industry. However, the wide variety of electrical equipment and their growing complexity pose new challenges for policy makers. As international trade in electrical equipment grows, international co-operation enables countries to develop policy approaches more effectively than acting alone.

Background

The Implementing Agreement for a Co-operative Programme on Energy Efficient Electrical Equipment (4E IA) supports sound policy development in the field of energy efficient appliances and equipment. It provides a forum for governments and other stakeholders to understand effective approaches to policies that will improve efficiencies of electrical equipment. There are currently 12 Contracting Parties.

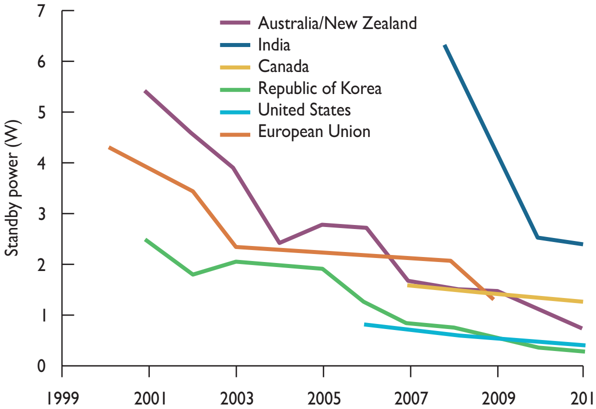
Spotlight

High-level international commitments can have real and lasting impacts on policy and carbon emissions. The mapping and benchmarking work stream of the 4E IA tracks the effect of policy interventions on product performance.

One recent 4E IA report, *Benchmarking of the Standby Power Performance of Domestic Appliances*, shows conclusively and for the first time that the IEA 1-Watt plan to reduce standby power[1], adopted by G8 ministers in 2005, has been effective.

The majority of devices are now well on course to meet this target, as illustrated by this figure showing the progress on reducing electricity consumption of standby use in televisions. These gains were made possible by policies enacted since 2001. This includes measures such as minimum efficiency performance standards, or MEPS (Korea, Canada); voluntary labelling (United States), and voluntary commitments (European Union).

The 4E IA analysis concludes that regulatory policies appear to deliver significant gains more quickly than other policy measures. Additionally, early signalling and delivery of a comprehensive policy plan in Korea was particularly successful – driving markets further and faster than could have been achieved through commercial development. The study developed methodologies to assist in the collection and analysis of standby power data to facilitate international comparisons. Six products were tested. For televisions (TVs), nearly 9 519 measurements were collected on over 6 000 TVs[2] in six countries or regions, representing approximately 45% of global TV sales in 2011.



▲ As a result of government policies, energy consumption for standby power for televisions has declined in many countries since 2001.

As well as demonstrating the success of policies designed to address conventional standby power, this analysis highlights the emerging threat of 'network standby', when devices connected to networks consume excessive power; while developing policy solutions to tackle these problems.

Similarly, comprehensive and detailed analysis by the 4E IA of refrigerators, air conditioners, computers, washing machines and lights have been used to formulate national and regional energy efficiency policies in Europe, North America and the Asia Pacific region.

CURRENT PROJECTS

- Electric motor systems
- Mapping and benchmarking
- Monitoring, verification and enforcement
- Policy driven innovation
- Smart metering infrastructure
- Solid state lighting
- Standby power

REFERENCES

1. In 1999 the IEA proposed the 1-Watt Plan, i.e. that all countries harmonise energy policies to reduce standby power use to no more than one watt per device.

2. Including cathode ray tubes (CRT), liquid-crystal displays (LCD) (representing 83% of world markets), and others.

www.iea-4e.org

WASTE HEAT, WANT HEAT

Policy context

Energy storage technologies bridge the gap between the energy at the source and the time and place that the consumer may need it. Recuperating the temperature from the ground, air, or water significantly reduces heating/cooling demand. Electrical storage combined with intermittent renewable sources has the potential to balance the electricity network. Energy storage enables policy makers and industries to reconcile energy, environmental and economic goals. However, further research will be needed to move energy storage technologies to widespread market deployment.

Background

The objectives of the Implementing Agreement for a Programme of Research and Development on Energy Conservation through Energy Storage (ECES IA) are to develop and demonstrate advanced thermal and electrical energy storage technologies for applications within a wide range of energy systems, and to encourage their use as standard engineering design options. Activities include case studies, demonstration plants, deployment, *in situ* measurements and design tools. There are currently 17 Contracting Parties and three sponsors.

Spotlight

Many of the processes in the industry sector are energy intensive as raw materials must be heated to high temperatures. Once used, much of the heat from these processes is vented into the atmosphere as waste heat: an inefficient and costly method.

As a result, the focus of one recent ECES IA study, Transportation of Energy by Utilisation of Thermal Energy Storage Technology, was to examine the technical and economical feasibility of recuperating this waste heat and transporting it to other industries and district heating networks.

The objectives of the project were to develop high-capacity storage materials and high thermal power charging and discharging technologies, for transporting waste heat. Using a systems analysis approach, aspects such as the potential costs and effects, matching supply with demand, and best practice in co-ordinating activities in the field were considered.

The study concluded that recuperating waste heat is not only technically possible, it is also economically feasible for transportation using truck, train or boat. However, this depends very much on the particular conditions as determined by the energy system under investigation.

▲ Heat recuperated from a waste incinerator is transferred to an industrial drying processor using a thermo-chemical storage tank.

A high number of journeys between the point of supply and consumption is necessary to achieve a return on investment. Therefore industries within close proximity should be favoured. The market price for the heat at the point of consumption is also an important factor to consider. Under favorable conditions - 250 degree Celsius (°C) with 1 000 transport cycles per year - the price for heat could be competitive at EUR40/MWh.

As a result of the study, in September 2012, the first mobile sorption storage (a high-capacity, high-efficiency thermal energy storage tank) began test operations in Germany. Further applications include recuperating waste heat from vehicles where presently 80% of fuel heating value is emitted as waste heat through exhaust.

CURRENT PROJECTS

- Applying energy storage in ultra-low energy buildings
- Electric energy storage: future energy storage demand
- Material research and development for improved thermal energy storage systems
- Surplus heat management using advanced thermal energy storage for CO_2 mitigation
- Thermal response test for underground thermal energy storage

REFERENCES

Photo courtesy of MVA Hamm Betreiber GmbH.

www.energy-storage.org

MULTIFUNCTIONAL HEATING AND COOLING

Policy context

By using the heat in the air, earth and water, heat pumps have the potential to significantly reduce consumption of fossil fuels and CO_2 emissions. Recent policies enacted in Europe, Japan, and the United States aim to reduce carbon dioxide (CO_2) emissions through accelerated deployment of clean technologies including heat pumps. These strategies will play an important role in reducing barriers to deployment.

Background

The aims of the Implementing Agreement for a Programme of Research and Development on Heat Pumping Technologies (HPT IA) are to quantify and publicise the energy saving potential and environmental benefits (local and global) of heat pumping technologies; develop and deliver information to support deployment of appropriate HP technologies; promote and foster international collaboration to develop knowledge, systems and practices in HP technologies through further research, development, demonstration and deployment; provide an effective flow of information among stakeholders and other relevant entities; and significantly improve the visibility and status of the Programme. There are currently 14 Contracting Parties.

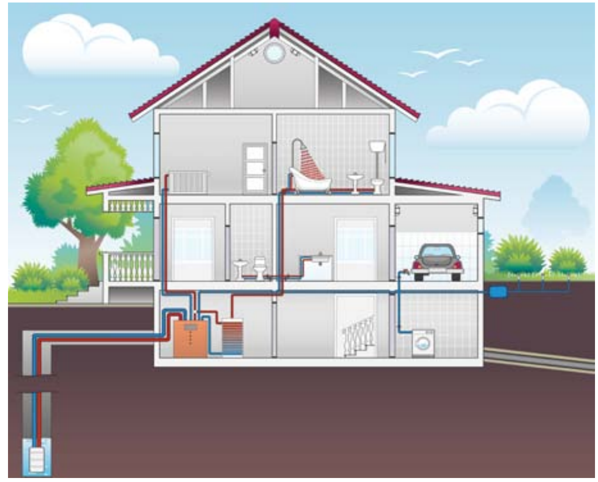
Spotlight

Low-energy houses are now integrated into current building practice and represent a growing share of new home designs. Integrating multifunctional heat pump concepts into low-energy house designs is an efficient way to treat several building functions simultaneously. Despite having been introduced to the market, the market share for heat pumps remains low. As a result, data from operational experiences are rare.

One recent HPT IA project, Economical Heating and Cooling Systems for Low-Energy Houses, brought to light new information on the cost-efficiency of heat pump concepts in low-energy houses.

Seven multifunctional heat pump prototypes were developed, lab tested, and field proven in countries participating in the study.[1] Best practices in systems design were identified, leading to industry recommendations.

Some of the heat pump concepts developed within the project proved to be so efficient that they are now commercially available in North America. More of the developed prototypes are currently being field-tested. The results of this study are summarised in best-practice sheets, systems concept sheets, and a final report (executive summary, market overview, systems developed, and field monitoring).



▲ Heat pumps are an efficient way to cover all building energy needs, including dehumidification.

CURRENT PROJECTS

- Applications of industrial heat pumps
- Cold climate heat pumps (improving low ambient temperature performance of air-source heat pumps)
- Common methods for testing and rating residential heat pumps and air conditioning for annual or seasonal performance
- Field measurements on heat pump systems in buildings – good examples with modern technologies
- Heat pump concepts for near-zero energy buildings
- Quality installation and maintenance
- Systems using solar thermal energy in combination with heat pumps
- Thermally driven heat pumps for heating and cooling

REFERENCES

1. Austria, Canada, France, Germany, Japan, the Netherlands, Norway, Sweden, Switzerland and the United States.

Schema courtesy of Istockphoto.

www.heatpumpcentre.org

SAVING MONEY AND EMISSIONS

Policy context

Energy efficiency offers near-term solutions to the issues of energy security and climate change. Energy efficiency improvements have a significant impact on system performance, the environment and employment. Demand-side management is one way to achieve large-scale energy efficiency improvements through targeted policies, managing electricity demand and market transformation.

Background

The Implementing Agreement for Co-operation on Technologies and Programmes for Demand-Side Management (DSM IA) focuses on electricity load shaping and load levelling, as well as cross-cutting issues such as resource planning, the role of municipalities, market transformation and technology procurement. There are 15 Contracting Parties, including India, and one Sponsor.

Spotlight

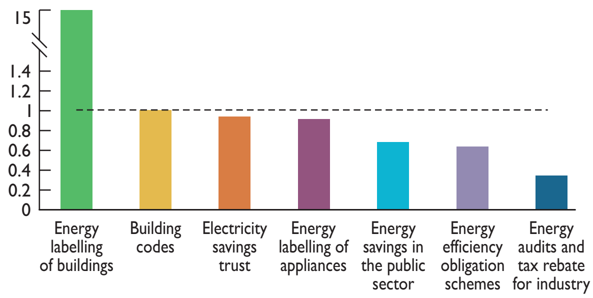
There are many types of policy instruments for achieving energy efficiency savings. Energy efficiency obligations[1] (EEO) require parties to meet quantitative energy savings targets by delivering or procuring eligible energy savings.

The final report from the recent DSM IA study, *Best Practices in Designing and Implementing Energy Efficiency Obligations Schemes*, examines experiences with energy efficiency obligation schemes in 19 jurisdictions in 11 countries within Asia, Europe and North America.

Experiences in individual jurisdictions were examined across 15 design parameters: policy objectives; legal authority; fuel coverage; sector and facility coverage; energy savings targets; sub-targets and portfolio requirements; compliance regimes; penalties; performance incentives; eligible energy savings; eligible energy efficiency measures; measurement, verification and reporting; trading of energy savings; and funding.

The study identified three broad types of energy efficiency obligation schemes for achieving quantitative energy savings targets: those established relatively independently (often with their own enabling legislation); those that were integrated components of resource planning and acquisition by the obligated energy provider; and those established principally by governments as integral components of government policies.

Each of the three types of schemes is the product of quite different ways of thinking about how to use energy providers to deliver energy efficiency. For the first time, information about the three different types of schemes has been systematically classified into categories that apply to all the schemes.



▲ Experiences in 19 jurisdictions were analysed, including this cost comparison of policy instruments in Denmark.

Through a comparative analysis of this information, the report identifies best practices in designing and implementing an EEO scheme. Adopting these best practices when designing new schemes (or when updating existing schemes) should deliver cost effective energy efficiency schemes.

CURRENT PROJECTS

- Behaviour change in demand-side management: from theory to policies and practice
- Branding of energy efficiency
- Competitive energy services
- Integration of demand-side management, energy efficiency, distributed generation and renewable energy sources
- Standardising energy savings calculations
- The role of customers in delivering effective smart grids

REFERENCES

1. Also referred to as energy efficiency portfolio standards, energy efficiency resource standards, energy efficiency commitments or energy supplier obligations.

Data courtesy of the Danish Energy Agency.

www.ieadsm.org

LOWERING RISKS AND REDUCING INFRASTRUCTURE

Policy context

Electricity demand continues to rise worldwide. Utilities are challenged to find economical, sustainable solutions. Losses due to fault current limitation are common. Nearly 50% of the electrical losses between generators and end-users occur in transformers. High-temperature superconducting (HTS) cables can transport current with low losses and a very high power density. Incorporating HTS into electrical generators and equipment increases system efficiency, reliability and safety. Policies and measures to enable HTS to become commercially available include continued support for R&D and sustained public and private research partnerships.

Background

The aim of the Implementing Agreement for a Co-operative Programme for Assessing the Impacts of High-Temperature Superconductivity on the Electric Power Sector (HTS IA) is to identify and evaluate the potential benefits of superconductivity and the barriers to achieving these benefits. HTS IA participants keep abreast of the state-of-the-art and industry standards regarding HTS component manufacturers, cryogenics research, laboratories and trade organisations. There are 13 Contracting Parties, including Israel, and two sponsors.

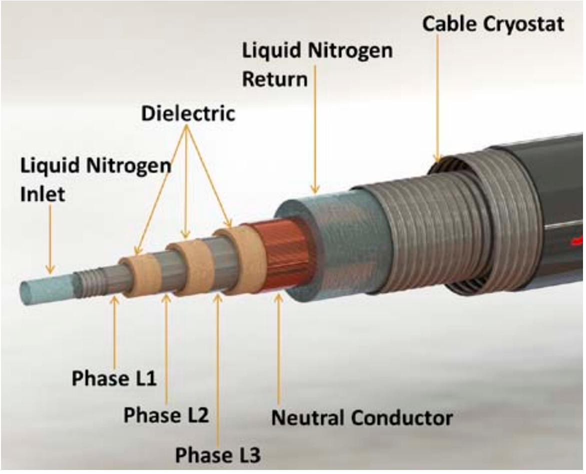
Spotlight

HTS cables have clear benefits for the electric power sector. They reduce space in urban environments, and when cooled to -200°C, HTS cables can transport nearly three times more electric power than conventional copper cables with much fewer transmission losses and without generating magnetic fields.

The HTS IA works actively to identify new applications and projects using this promising technology. In Essen, Germany (a Contracting Party to the HTS IA), a two-year "AmpaCity" project is testing a resistive HTS fault current limiter and the world's longest HTS cable - 1 kilometre (km).

The HTS cable is laid between two 10-kilovolt (kV) urban substations. Power is transformed from the high-voltage line (110 kV) to a 10 kV current limiter, then transmitted by HTS cable to the city centre. This eliminates the need for a MV substation.

Type testing has recently been completed. A two-year study found that despite needing a flow of liquid nitrogen to cool the HTS cables, it is actually more cost effective to install the cables and operate over a 40-year period than to install conventional high voltage lines, which require high levels of maintenance and additional network infrastructure. The



▲ A cross-section of a high-temperature superconducting cable used in the AmpaCity project (Essen, Germany).

smaller space needed for the cables enabled the distribution company to develop a simplified network configuration, further reducing the amount of land used. A 2012 study conducted by the AmpaCity partners found that a typical urban network including 20 transformers could be reduced to 15 using HTS cables, significantly reducing costs.

Project sponsors include the German Federal Ministry of Economics and Technology, the Karlsruhe Institute for Technology (KIT) and the project sponsor Jülich (PTJ), and Nexans, as manufacturer of cables and cable systems. Installation will be completed third quarter 2013.

CURRENT PROJECTS

- Alternating current losses
- Fault current limiters
- High-temperature superconducting rotors
- High-temperature superconducting rotating machines
- Roadmap for superconductors
- Simulating HTS using electromagnetic transient programmes
- High-temperature superconducting motors

REFERENCES

Photo courtesy of Nexans.

www.superconductivityiea.org

INCREASING CAPACITY AND RELIABILITY

Policy context

A safe, reliable supply of electricity drives economic growth. Unfortunately, most electricity networks were built more than 100 years ago, while others are unable to handle the considerable increase in demand. In addition, the sources - and uses - of electricity are becoming more complex. Integrating "smart grid" technologies such as advanced information, sensing, communications, control, and energy technologies and systems can significantly improve electricity network reliability while at the same time enable demand-side management. Policies and measures to support smart grids include framework policies oriented to a systems approach, targets, international standards, and continued support for R&D.

Background

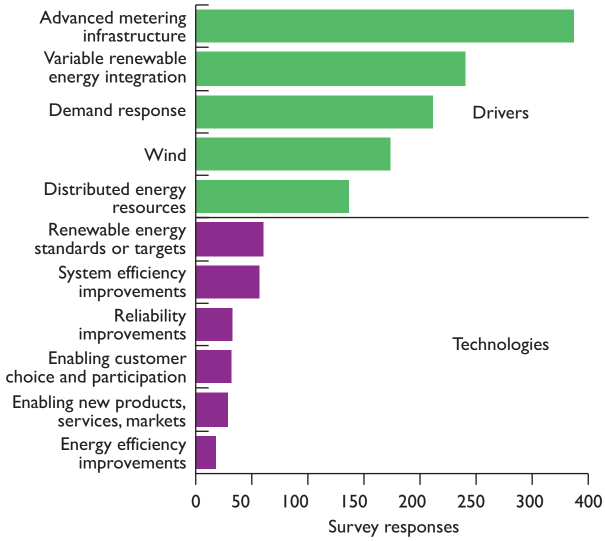
The International Smart Grid Action Network was launched in July 2010 under the Clean Energy Ministerial.[1] Formally organised under the Implementing Agreement for a Co-operative Programme on Smart Grids (ISGAN), the goals are to spur the accelerated development and deployment of smart grid solutions worldwide through activities to develop a better global understanding of smart grids, address gaps in knowledge and tools, and foster improved knowledge sharing and project collaboration. There are 22 Contracting Parties including China, India, Mexico and Russia.

Spotlight

Given the new area of study that smart grids represents, the ISGAN IA set out to create an inventory of the smart grid motivating drivers and technology priorities of each of the participants. The inventory outlines common interests and serves as the basis for the programme of work.

Data were collected from 19 participating countries. Motivating drivers include the driving forces for goal-oriented actions (*e.g.* planning, strategy development or strategic directions and implementation). Technologies are those that will develop or be deployed to support the driver. The top six motivating drivers from the study include renewable energy standards or targets; systems efficiency improvements; reliability improvements; enabling customer choice and participation; enabling new products, services, and markets; and energy efficiency improvements. The top-ranking technology priorities included advanced metering infrastructure[2], integrating large-sized variable renewables, demand response, wind, and distributed energy resources.

These top-ranked drivers and technologies are largely consistent across the range of continents though there are differences between world regions, as well as between developed and emerging economies.



▲ A ranking of the main survey results showing the main drivers and technology priorities among ISGAN IA participants.

Developed economies responding to the survey emphasised drivers and technologies that enable integration of new products, services, and clean energy sources. On the other hand, emerging economies prioritised elements that improve the reliable and cost-effective operation of the existing electricity network.

CURRENT PROJECTS

- Global smart grid inventory
- Smart grid case studies
- Benefit-cost analyses and toolkits
- Power transmission and distribution systems
- Synthesis of insights for decision makers
- Smart grid international research facility network

REFERENCES

1. A high-level global forum to promote policies and programs that advance clean energy technology, to share lessons learned and best practices, and to encourage the transition to a global clean energy economy.

2. Electricity meters that use two-way communication to collect electricity usage and related information from customers and to deliver information to customers.

www.iea-isgan.org

SHEDDING LIGHT ON EMISSIONS

Policy context

Nearly three-quarters of atmospheric CO_2 emissions in the transport sector result from fuels used for transport, accounting for one-fourth of carbon emissions worldwide. Given the worldwide projected demand, combustion engines will continue to play an important role for years to come. Therefore it is imperative that governments continue to support R&D to improve engine efficiencies. Accelerated, concerted efforts between the public and private sectors will also be needed.

Background

The aims of the Implementing Agreement for a Programme of Research, Development and Demonstration on Energy Conservation and Emissions Reduction in Combustion (ERC IA) are to carry out research projects related to advanced piston technology; furnaces and combustors; and fundamental research. Each project is carried out in parallel by the members in their national research laboratories or university science or engineering departments. In addition, each project benefits from close collaboration with industry to ensure market relevance. There are 12 Contracting Parties.

Spotlight

Despite diesel particulate filters (DPF), vehicles burning diesel create particulate emissions such as airborne black carbon. Black carbon can affect air quality and open-air water sources, resulting in health issues. Measuring these low levels of black carbon on the road and in real time requires sensitive new diagnostic tools

Until now, most tests of these particulate emissions were carried out in laboratories but not in on-road conditions. The ERC IA member from Canada, in consultation with the ERC IA ExCo and with two industries[1], has developed and commercialised an instrument that enables extremely precise measurements in on-road, real time conditions.

The laser-induced Incandescence Instrument (LII) is an optical technique that measures the system efficiency of emissions control by sampling and reporting levels of black carbon concentration (parts per billion and milligrams per cubic metre), surface area, and particulate diameter from either the direct exhaust or from a dilution tunnel facility. It can be applied to evaluate the system efficiency of emissions control of solid particulate matter. As a result, the LII enables the further development of diesel engines that are emissions compliant, with efficient and effective black-carbon management and strategies for diesel particulate filters, effective engine calibrations for reducing levels of particulate matter at different engine conditions and emissions compliant engine products.

▲ This innovative optical instrument measures concentrations of black carbon in diesel engines.

The optical system includes a computer-controlled automated laser beam, energy detection and adjustment system that maintains constant laser fluence[2] in a wide range of environmental conditions. Other applications include emissions from petrol/gasoline, aircraft engines, gas turbines, and urban air quality atmospheric measurements of black carbon.

CURRENT PROJECTS

- Advanced hydrogen-fuelled internal combustion engines
- Alternative fuels
- Hydrogen-enriched lean premixed combustion for ultra low emission gas turbine combustors
- Individual contributor tasks
- Internal combustion engine sprays
- Homogeneous charge compression ignition
- Nano-particle diagnostics

REFERENCES

1. A consortium between Natural Research Council (NRC) of Canada, Artium Technologies and Cummins. NRC holds the patent for the device.

2. The amount of laser energy delivered with each pulse.

Photo courtesy of Artium Technologies, Inc.

www.ieacombustion.net

ZOOMING IN ON HEAVY INDUSTRY

Policy context

The industry sector currently accounts for 27.3% of the world's energy use and is thus responsible for a significant share of global CO_2 emissions (22.6%). Improving industrial energy efficiency offers the most cost-efficient measure to reduce greenhouse gas emissions. Energy efficiency improvements are possible in heavy industries such as iron and steel, cement, petrochemicals, chemicals, pulp and paper, aluminium, and food processing. Raising awareness of the financial and environmental benefits of these improvements must be balanced against the additional investments required to implement changes. Fiscal and financial policies and measures designed to support heavy industry are an important first step.

Background

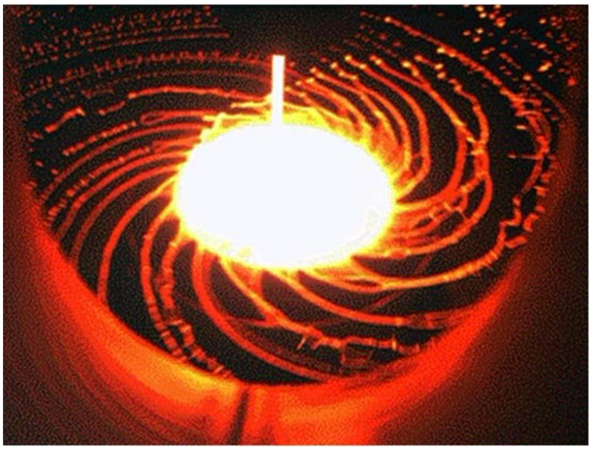
The aims of the Implementing Agreement on Industrial Energy-Related Technologies and Systems (IETS IA) are to accelerate the research and share the results of cost-effective new industrial technologies and system configurations that increase productivity and product quality while improving energy efficiency and sustainability. The IETS IA currently focuses on the energy-intensive process industries and technologies, but is moving to expand research into other industrial sectors and to facilitate cooperation between different industrial research disciplines. There are nine Contracting Parties.

Spotlight

Integrated steelmaking is complex, involving a series of industrial processes and producing a number of by-products, including excess process gases which are used to create electricity. Gaining a better understanding of the complex processes and energy intensity of the steel industry will improve efficiencies and reduce greenhouse emissions, currently responsible for 6% to 7% of CO_2 emissions worldwide.

The aims of the IETS IA project, Development and Use of Process Integration in the Iron and Steel Industry, are to advance the application of process integration[1] as a method to reduce energy consumption and lower greenhouse gas emissions in the steel sector. Applying process integration in the steel industry is a relatively novel approach that is rapidly evolving.

As a result, communicating the methods and results to industry stakeholders who are unfamiliar with the advantages of the approach will be a challenge. For this reason, the IETS IA holds workshops to bring together a cross-section of steel companies, research institutes and universities.



▲ Video observation of the dry slag granulation process in a pilot reactor.

One example of process integration includes the relationship between fluid dynamics and energy recovery. One particular pilot reactor includes a high-speed video camera that provides insight into the rate of dry slag granulation in the steelmaking process.

Outcomes of the project include a network of experts in the sector, a database of proven technologies, and a guidebook.

CURRENT PROJECTS

- Application of industrial heat pumps
- Development and use of process integration in the iron and steel industry
- Energy efficiency in SMEs
- Energy efficient separations systems: methodological aspects, demonstration and economics
- Energy efficient drying and dewatering technologies
- Industrial excess heat recovery
- Industry-based biorefineries
- Membrane technologies

REFERENCES:

1. Process integration refers to system-oriented methods and integrated approaches to complex industrial process plant design.

Photo courtesy of Commonwealth Scientific and Industrial Research Organisation (Australia).

www.iea-industry.org/

ALL ON BOARD THE CLEAN MACHINES

Policy context

Fuel cells are devices that use a chemical reaction to generate electricity. Fuel cells are polyvalent: they can use many types of fuels including primary or secondary fossil fuels, synthetic gases, and renewable sources such as biofuels and hydrogen. Fuel cells may be used as small batteries, electrical power plants as electrical propulsion for vehicles. Fuel cell pilot and demonstration programmes provide much-needed information to further improve the energy output from fuel cells, reduce investment risk and reduce production costs. Further support for research will be needed to fully capitalise on the fuel cell principle.

▲ One of 20 buses powered by hydrogen fuel cells as part of a demonstration project launched for the 2010 Winter Olympics Games (Vancouver, British Columbia).

Background

The Implementing Agreement for a Programme of Research, Development and Demonstration on Advanced Fuel Cells (AFC IA) advances understanding in the field of advanced fuel cells through a coordinated programme of research, technology development and systems analysis. This includes expert networks that enable specialists to share research, development and demonstration results; defining measurement and monitoring techniques; exchanging information on cell, stack and system performance; collaborating on the development of new procedures and models; and sharing information on application requirements. There are currently 15 Contracting Parties, including Mexico and Israel.

Spotlight

To gain understanding of how fuel cells may be deployed in transportation applications, one AFC IA project, Fuel Cells for Transport, reviewed the state-of-the-art of the rapidly developing fuel cell technologies for buses.

The specific objectives of this task are to improve the understanding of fuel cell systems, on-board hydrogen storage systems, directions of recent technology development activities, approaches for cost reduction, and field data from large-scale demonstration projects. Data related to performance, reliability, and cost were gathered, with a view to identifying and quantifying potential improvements needed to match national targets.

Compared to traditional diesel or newer diesel-battery hybrid systems, zero-emissions, hydrogen fuel cell-powered buses could provide operational as well as environmental benefits. The report found that the reliability (availability, stack lifetime and miles between road calls) of fuel cell buses is increasing. In many instances, availability has been limited by failures of control and other electric components rather than the fuel cell stack. In addition, the recent generation of fuel cell buses has consistently shown fuel economies twice as great (eight miles per diesel gallon equivalent) as conventional buses powered by diesel and compressed natural gas engines.

Many fuel cell bus demonstration projects have been carried out around the world, including Brazil, Canada, China, Europe, Korea and the United States. A programme with 20 hydrogen fuel cell buses funded by the Canadian national and local governments inaugurated during the 2010 Olympic Games, is still operating. The bus fleet has already logged over 1 million kilometres, demonstrating that the life span of fuel cell vehicles is approaching that of gasoline engines. Challenges remain for full commercialisation of fuel cell buses, primarily in achieving durability and reducing costs. Further analysis will focus on the economy of fuel cell vehicles combined with hydrogen production facilities.

CURRENT PROJECTS

Fuel cell systems for stationary applications

Fuel cells for portable applications

Fuel cells for transportation

Molten carbonate fuel cells

Polymer electrolyte fuel cells

Solid oxide fuel cells

Systems analysis of fuel cells

REFERENCES

Photo courtesy of Chris Cassidy, BusShots www.flickr.com/photos/chsscassidy/4661941919/.

www.ieafuelcell.com

BALANCING COSTS AND EMISSIONS

Policy context

Countries worldwide need to improve the fuel economy and reduce greenhouse emissions of road vehicles. Significant improvements in fuel economy can be achieved in the next five to ten years if countries implement the necessary policies. Policy packages composed of fuel economy labelling; standards and fiscal measures have proven to be effective in meeting targets. Renewable energy contributes to CO_2 emission reductions. For example, in Europe, 10% of energy in transport must be from renewable sources (*e.g.* biofuels and renewable electricity).

Background

The primary focus of the Implementing Agreement for a Programme on Research and Demonstration on Advanced Motor Fuels (AMF IA) is to facilitate the market introduction of advanced motor fuels and related vehicle technologies. The AMF IA provides a neutral platform for fuel analyses and reporting, drawing on the multifaceted expertise of its participants, industrial partners and networks. There are 16 Contracting Parties, including China and Thailand.

Spotlight

Most public transport systems worldwide include a majority of buses. Transport officials must balance key considerations such as the initial investments required and fleet maintenance costs with the need to reduce greenhouse gas emissions as well as local emissions (mainly particulates, oxides of nitrogen).

One recent AMF IA project – Fuel and Technology Alternatives for Buses – set out to address how vehicle technology and fuel used affect emissions and fuel consumption. Altogether 11 national laboratories and international agencies participated in the study, sharing existing data and jointly carrying out new measurements in laboratory conditions and on the road.

The study included measurements of fuel consumption, greenhouse gases and regulated emissions in a variety of driving cycles. A large number of fuels were examined, including conventional, synthetic and bio-based diesel fuels as well as alternative fuels for dedicated vehicles.

Lifecycle, or well-to-wheel analysis was carried out for energy consumption and greenhouse gas emissions. The results show that while burning clean fuels such as methane, ethanol and dimethyl ether can provide advantages over diesel in reducing regulated emissions such as particulates or airborne soot, the regulated emissions are first and foremost determined by the sophistication of the engine and the exhaust control system. Greenhouse emissions, on the other hand, are determined by efficiency and the carbon intensity of the fuel.

▲ Public transport planners must balance investment and maintenance costs with reducing greenhouse gas emissions.

Lastly, a cost assessment of both direct (purchase, operation and maintenance) and indirect costs (related to the effects on health and the environment) was carried out. The detailed report provides insights for municipal and community transport planning and implementation.

CURRENT PROJECTS

- Alcohol applications
- Alternative fuels for marine applications
- Enhanced emission performance and fuel efficiency for heavy duty methane engines
- Environmental impact of biodiesel vehicles in real traffic conditions
- Exhaust gas toxicity and particulates from internal combustion engines
- Particulate measurements of ethanol and butanol in diesel injection engines
- Performance evaluation of passenger car fuel and power plant options
- Research on unregulated pollutants emissions of vehicles fuelled with alcohol alternative fuels
- Synthesis, characterisation and use of hydro-treated oils and fats in engines

REFERENCES

Photo courtesy of VTT Technical Research Centre of Finland.

www.iea-amf.org

ROUND-ROBIN TESTING PRODUCES RESULTS

Policy context

Substituting steel in transport vehicles with lighter alternatives has the potential to reduce fuel consumption by 10%. Together with improvements in energy and component efficiencies, a 50% reduction in fuel consumption and CO_2 emissions of new vehicles is achievable by 2030. Policies and measures that benefit both the consumer and industry and that are in place over the long-term are important elements of successful transport efficiency strategies.

Background

The goals of the Implementing Agreement for a Programme of Research and Development on Advanced Materials for Transportation Applications (AMT IA) are to reduce weight to improve fuel efficiency without compromising safety, durability, and comfort; surface engineering including texturing coupled with advanced thin films and lubricant chemistry to reduce friction and improve durability; coating systems to manage heating and cooling, wear and greenhouse gas emission; and nano-materials to reduce weight and improve performance. There are eight Contracting Parties, including China and Israel.

Spotlight

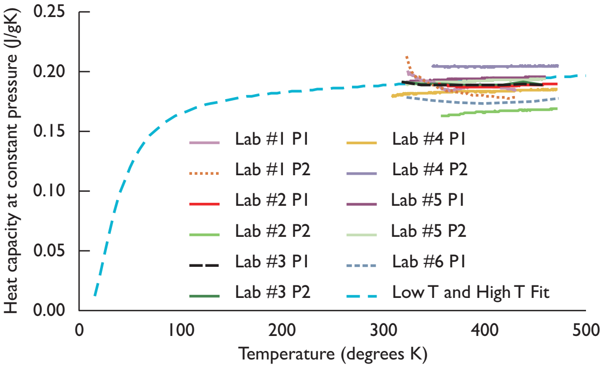
Much automotive industry research in recent years has focused on developing thermoelectric (TE) materials able to convert heat into electricity (or reversing the process to cool down). Application of TE materials in vehicles includes cabin air conditioning, electricity generation from exhaust heat, and battery thermal management.

The temperature benchmark achievable from TE materials averages between 1 and 1.5. Finding materials with a benchmark greater than 1.5 could significantly increase the efficiency and cost-competitiveness of materials. However, precise characterisation of materials is needed.

For this reason, the AMT IA project, Development of Thermoelectric Materials for Waste Heat Recovery in Transportation Industries, aims to develop standard testing methods and procedures for TE materials and to characterise key TE properties for transportation applications.

Two international round-robin tests of TE properties were carried out in seven national and private sector laboratories. Each lab was provided with two sets of specimens and asked to measure and record the thermal diffusivity, specific heat, density, the Seebeck coefficient,[1] and electrical resistivity.

Not surprisingly, as illustrated in the chart above, the laboratory results showed variances of between 4% and 9%. The significance of these results underlines the need for more rigorous measurement methods in order to correctly measure benchmarks and to advance TE materials discovery and development.



▲ Results of round-robin testing of materials samples in seven laboratories show a variance of between 4% and 9%.

As a result, the AMT IA study outlined procedures to eliminate operator and systems errors, and developed standard procedures for future testing. Other applications for TE materials include photovoltaics, fuel cells and remote power generation in space stations and satellites.

CURRENT PROJECTS

Advanced coatings to improve engine durability and efficiency

Integrated surface technology to reduce friction in engines

Low-cost carbon fibre measurement standards assessment

Magnesium alloy corrosion protection and durability for light-weighting of vehicles

Nano-materials testing and characterization for quality control

Thermoelectric materials characterisation measurement improvement and standard development

REFERENCES

1. *The conversion of temperature differences directly into electricity.*

www.iea-ia-amt.org

CHARGING AHEAD WITH ELECTRIC VEHICLES

Policy context

Fully electric and hybrid electric vehicles could significantly reduce CO_2 emissions in the transport sector. In addition, electric vehicles have the capacity to enable intelligent electricity grid management by filling the gap between electricity produced from intermittent renewable sources and consumer demand. Framework policies aimed at providing incentives for automobile manufacturers, consumers, municipalities and electricity networks, combined with continued R&D to reduce the costs of batteries will lead to successful deployment of electric vehicles.

Background

The aim of the Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (HEV IA) is to 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. This is accomplished through collaborative, pre-competitive research projects and related topics and to investigate the need for further research in promising areas. There are currently 17 Contracting Parties.

Spotlight

Widespread acceptance of battery and plug-in hybrid electric vehicles (EVs) will require overcoming several obstacles. Infrastructure investments, charging interoperability and urban planning are key issues. Achieving successful implementation will require cooperation between public and private stakeholders in a multitude of sectors. And one size will not fit all.

While longer recharging is a prerequisite for plug-in hybrid electric vehicles (PHEV), for EVs there is a greater need for public infrastructure to recharge away from work places and residences, and interoperability at all charge points, including quick-charging.

As a result, three recent studies are addressing these important challenges: Plug-in Hybrid Electric Vehicles (PHEV), a study of the HEV IA; Quick Charging Technology, a study of the HEV IA; and the *EV City Casebook*, an Electric Vehicles Initiative study to which the HEV IA provided significant contributions.

The PHEV study underlines the important role of fuel prices to the business case for EVs. However, further R&D is needed to develop the next generation of batteries and lower production costs. Plug-in hybrid electric vehicles with ranges of 15 km to 50 km were found to be the most cost-effective in terms of converting electricity to kilometres travelled.

Case studies of electric vehicle deployment compare the networks, charging points and the incentives used to expand EV networks in 13 cities and three regions worldwide. The report concludes that increasing industry participation, cross-border standardisation, interoperability between charging stations and data collection will be needed. The Treaty of Vaals[1] is highlighted as best practice in this regard.

▲ Charging station for public access, short-term hire of electric vehicles (Paris, France).

A new HEV IA study, E-Mobility and Business Models, will examine the drivers of growth in EV markets and charging infrastructure, and the role of investments in EVs and infrastructure in creating opportunities for economic growth. The Paris public service plan for short-term EV hire, Autolib, is leading the way. The plan has expanded to many cities in the Paris region.

CURRENT PROJECTS

- Accelerated testing procedures for lithium-ion battery ageing
- E-mobility business models
- Electrochemical systems
- Electric vehicle ecosystems
- Life-cycle assessments
- Market deployment of hybrid and electric vehicles: lessons learned
- Plug-in hybrid electric vehicles
- Quick charging technology
- System optimisation and vehicle integration

REFERENCES

1. A collaboration agreement between seven European organisations that allows "e-roaming" between countries and regions.

Photo courtesy of Creative Commons. Appeared p.34 IEA Journal No 4, www.flickr.com/photos/30998987@N03/7681129342/.

www.ieahev.org

Clean Coal Centre

Enhanced Oil Recovery

Fluidised Bed Conversion

Greenhouse Gas R&D

MINIMISING MERCURY EMISSIONS

Policy context

Coal is an inexpensive fuel and current world reserves could provide supply for another 150 years. Yet coal combustion accounts for 29.5% of greenhouse gas emissions worldwide. Retrofitting existing coal-fired power plants with cost-effective flue-gas treatments or replacing ageing plants with high-efficiency plants is urgently needed yet both require investments that industries and plant owners are not always willing to make. Policies and measures that include both regulation and incentives, such as technology or efficiency standards, fiscal and financial incentives, and emissions trading can be successful in prompting these investments.

Background

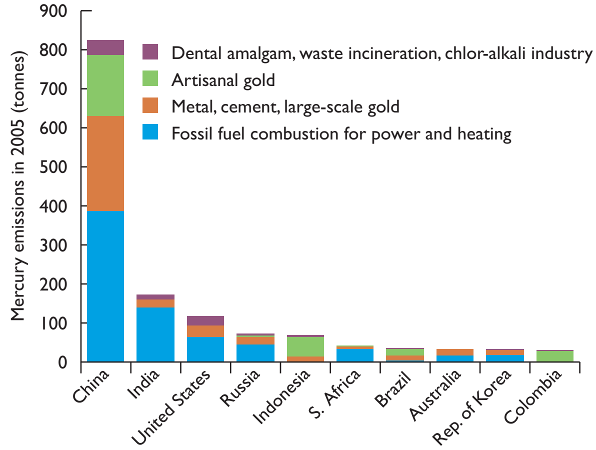
The goals of the Implementing Agreement for the IEA Clean Coal Centre (CCC IA) are to gather, assess and distribute knowledge on the energy efficient and environmentally sustainable use of coal. This includes conducting in-depth studies on topics of special interest; technical, economic and environmental performance assessments; balanced, objective reports that highlight opportunities for technology transfer; and research and development (R&D) gaps analysis. There are 12 Contracting Parties, including South Africa, and 12 sponsors, six of which are located in IEA partner countries.

Spotlight

Burning coal accounts for 46% of total global mercury emissions. Mercury is highly toxic to human health. Recent efforts of the CCC IA aim to reduce these harmful emissions.

The CCC IA report, *Legislation, Standards and Methods for Mercury Emissions Control*, summarises the current and impending global and regional standards for mercury emissions from large-scale, coal-fired power plants. There are numerous options for mercury control. The highest levels of control are achieved with fabric filters fitted for particulate removal. In plants equipped with a full range of flue gas treatment systems with no additional equipment for mercury removal, it is possible to reduce mercury emissions to less than 3 microns per cubic metre. Blending sub-bituminous coal with bituminous coal can also significantly reduce mercury concentrations.

As mercury emissions from coal vary widely depending on the quality of the coal and the age of the plant, selecting the most appropriate control option will require expert guidance. For this reason, together with the United Nations Environment Programme (UNEP), the CCC IA has published the *Process Optimisation Guidance Document* and designed an Interactive Mercury Emission Calculation Tool which simulates emissions-control technologies based on the plant. These tools are available as free downloads from the UNEP and CCC IA websites. In January 2013, the Minamata Convention, a global legally binding instrument on mercury was signed by 140 countries. The CCC IA was instrumental in providing unbiased information that led to the agreement. Other CCC IA work on mercurcy emissions includes *Economics of Mercury Control* and the annual conference on Mercury Emissions.



▲ Global anthropogenic emissions of air-borne mercury particulates in the 10 largest emitting countries (2005).

CURRENT PROJECTS

- CO_2 mitigation
- Coal properties and analysis
- Combustion
- Conversion and industrial use of coal
- Country studies and coal markets
- Emissions and control
- Environmental policy and legislation
- Gasification
- Mining, production and preparation
- Residues and management
- Pollution control technologies
- Power generation

REFERENCES

Source of the graph: Global Mercury Assessment 2013: Sources, Emissions, Releases and Environmental Transport. United Nations Environmental Programme Chemical Branch, Geneva, Switzerland.

www.iea-coal.org.uk

LOWER SALT INTAKE: INCREASE OUTPUT

Policy context

Global energy demand is expected to rise by over one-third in the period to 2035, underpinned by rising living standards in China, India and current energy policies in the Middle East. Yet by 2030, the majority of oil reserves will be produced from fields yet to be developed, fields yet to be found and additional enhanced oil recovery techniques. In most fields, less than 50% of oil is recoverable using conventional technology. Worldwide, only 30% to 35% of the oil underground will be produced according to present plans and technologies. Advanced techniques and technologies exist but in many cases they are not cost efficient. Given the significant additional amounts of oil recoverable and the need to meet future demand, policies and measures designed to provide incentives to industries and continued support for public R&D in this area will be needed.

Background

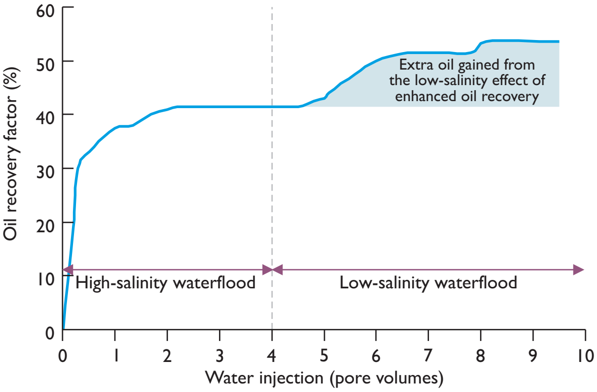
The objectives of the Implementing Agreement for a programme of Research, Development and Demonstration on Enhanced Oil Recovery (EOR IA) are to stimulate national efforts to continue to develop less costly EOR technologies as well as to research new technologies. This is achieved through an open forum for information and knowledge exchange. There are currently 11 Contracting Parties, including Russia and Venezuela.

Spotlight

The EOR IA plays an important role for the international R&D community by organising international symposiums that assess state-of-the-art technical capabilities of oil exploration engineering which lay the groundwork for practical applications of enhanced oil recovery. The EOR IA Workshop and Symposium of 2010 focussed on the Enhanced Oil Recovery Technique of Low-salinity Waterflooding.

Injecting high-saline water (seawater) into oil reservoirs maintains the pressure and drives the crude oil towards the producer wells. However, as salt is a conductor of electricity, it creates electrical charges that react with the rock reservoir walls, resulting in a magnetic effect. As oil adheres to the rock walls, the quantity of oil that can be recovered is reduced. However, by using low-salinity water the amount of electrical charge is lowered. The oil is then more easily liberated from the rock, allowing ever more oil to be recovered.

It is estimated that using the low-salinity technique will make it possible to recover an additional 6 billion barrels of crude oil from mature fields in the North Sea, equivalent to 42 million barrels of oil more than could otherwise be obtained from seawater flooding. Considerable further potentials may exist in other mature oil fields worldwide.



▲ Effects of low-salinity enhanced oil recovery in a sandstone core.

The 2010 EOR IA workshop acted as a catalyst, raising much interest among oil and gas multinational enterprises and government, which ultimately led to creation of a public-private partnership in the North Sea.

The 2011 EOR IA Symposium focused on "Enhanced oil recovery at USD 80+ per barrel", while the 2012 EOR IA workshop and symposium looked at "CO_2-enhanced oil recovery techniques".

CURRENT PROJECTS

Development of gas flooding techniques

Thermal recovery

Dynamic reservoir characterisation

Emerging technologies

Fundamental research on surfactants and polymers

Studies of fluids and interfaces in porous media

REFERENCES

Graph courtesy of Jonathan Thomas.

http://iea-eor.ptrc.ca/

FUEL FLEXIBILITY AND FEWER EMISSIONS

Policy context

A fluidised bed is a unique reactor where the fuel that is burned is maintained in motion, circulating in a fluid motion in order to burn thoroughly. This process increases the efficiency of the reactor, and, more importantly, reduces the total greenhouse gas and particulate emissions. Burning coal with biomass in a fluidised bed reduces harmful emissions from the combustion of these fuels separately while at the same time reduces the greenhouse gas emissions from the coal. This technology has gradually improved and is now deployed on a commercial basis. However, continued R&D in this field is needed to further improve fuel combustion efficiency, maintaining high fuel flexibility at stringent greenhouse gas limits. Co-operation between researchers, industrial representatives and governmental programmes accelerates the knowledge base and technology deployment.

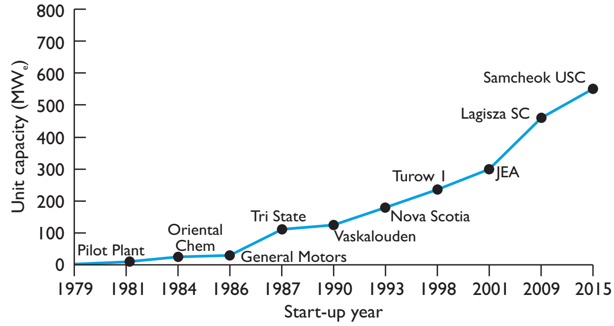
Background

The goals of the Implementing Agreement for Co-operation in the Field of Fluidised Bed Conversion of Fuels Applied to Clean Energy Production (FBC IA) are to advance the knowledge of national experts and industry professionals by sharing research results through regular symposia. There are currently 16 Contracting Parties, including China and Russia, and one Sponsor.

Spotlight

The mechanisms to exhibit FBC IA outcomes are the spring and fall conferences that highlight issues of importance to both academia and industry. These conferences provide an opportunity for technology transfer and knowledge exchange by developing the technology through industrial demonstration or by solving technical issues; improving environmental performance by substantially reducing emissions associated with conversion of coal, biomass and waste; networking with researchers and developers working in the field worldwide; and accelerating national research programmes through lessons learned.

The 2012 FBC IA conference focused on 'Renewable Energy and Energy Recovery from Waste'. Reports at the 2012 conference underline recent interest in FBC technologies as a cost-effective way to tightly control CO_2 emissions, nitrogen oxides and sulphur dioxide emissions. This avoids additional engineering, procurement and construction capital costs. As illustrated through expert reports at the annual FBC conferences 2010-12, FBC plant capacities have increased ten-fold between 1985 and 2010, moving from robust small-scale industrial boilers



▲ Increase in the capacity of fluidised beds, from pilot scale to commercial scale.

to commercialisation of the world's largest circulating fluidised bed boiler (CFB) in Poland (460 Megawatts of electricity [MW_e]). Today, more than 70 CFB units rated above 300 MWe are operating worldwide, with a 600 MW_e CFB beginning operations in China. An 800 MW_e model is also now commercially available.

FBC and CFB technology is cost-competitive and could challenge traditional pulverised coal-fired power plants. The benefits include improved fuel burning efficiency, reduced emissions, and high fuel flexibility. FBC and CFB plants can accommodate all types of coal, peat or biomass (sludge, municipal waste, agricultural waste and wood chips), alone or in combination, offering long-term fuel security and market flexibility. The world's largest (190 MW_e) CFB boiler burning pure biomass, *e.g.* wood residues and agricultural waste, is beginning operation in Poland.

In addition, existing units have been successfully used for the disposal of contaminated wastes, oil remediation and the elimination of low-calorific wastes.

CURRENT PROJECTS

- Co-firing and ash problems
- Energy crops and fluidised bed conversion
- Fluidised bed design aspects
- Mathematical, three-dimensional modelling
- Recent trends in participating countries
- Sewage sludge conversion

REFERENCES

Data courtesy of Foster Wheeler Global Power Group.

www.iea-fbc.org

CO_2 STORAGE CAPTURES DURBAN

Policy context

Coal-fired power plants and heavy industries such as cement and iron/steel are responsible for the majority of greenhouse gas and particulate emissions worldwide. Combining these processes with carbon capture and storage (CCS) can significantly reduce greenhouse gas emissions. Despite the advantages, successful implementation of CCS is dependent on geographical, environmental, legal and cost considerations. Successful deployment of CCS is critically dependent on comprehensive policy support. A policy approach focussing on funding, costs and risks, subsidies/penalties, and technology support will move CCS from the pilot stage to widespread deployment.

▲ Delegates at the UNFCCC Conference of the Parties huddle to resolve outstanding issues (Durban, South Africa).

Background

The aim of the Implementing Agreement for a Co-operative Programme on Technologies Relating to Greenhouse Gases Derived from Fossil Fuel Use (GHG IA) is to assess the technical viability and technology progress that can reduce greenhouse gas (GHG) emissions derived from fossil-fuel use. Activities include unbiased technology assessments for GHG mitigation, in particular CCS; facilitating implementation of potential mitigation options through demonstration projects; facilitating international collaboration through expert networks and summer schools; and disseminating results. There are currently 21 Contracting Parties (including India, South Africa and two intergovernmental organisations) and 26 sponsors.

Spotlight

Since 2005, the question of whether CCS should be approved as a clean development mechanism (CDM) under the Kyoto Protocol led by the United Nations Framework for a Climate Change Convention (UNFCCC) had been debated and negotiated.

The GHG IA has worked actively to provide unbiased, expert information to inform the ongoing discussions. Three GHG IA analytical reports relating to CCS for CDM have been published. GHG IA experts contributed to the UNFCCC experts' report, *Implications of the Inclusion of Geological Carbon Dioxide Capture and Storage as CDM Project Activities*. In addition, experts from three GHG IA expert networks (Modelling; Montitoring; and Risk Assessment) discussed the CDM-related issues and made balanced recommendations. These recommendations were shared at a dedicated CCS technical and legal meeting leading up to COP 17 in Durban, South Africa.

In addition, the GHG IA held a side-event during COP 17 to inform negotiators and offer an opportunity for valid concerns to be raised. GHG assessments and analysis led to a greater understanding of CCS potentials and a higher level of technical discussion during the negotiations.

After 32 hours of intense negotiations, on 9 December 2011, the parties agreed and adopted the modalities and procudures to allow CCS projects under the CDM[1], ending a six-year impasse. The information provided by the GHG IA contributed to this final agreement.

CURRENT PROJECTS

- Conferences
- Expert networks
- Information papers
- Modelling and databases
- Summer school and student mentoring
- Technical evaluations and reports
- Technical workshops

REFERENCES

1. See Decision 10/CMP.7, United Nations Framework for a Climate Change Convention (FCC/KP/CMP/2011/10/Add.2).

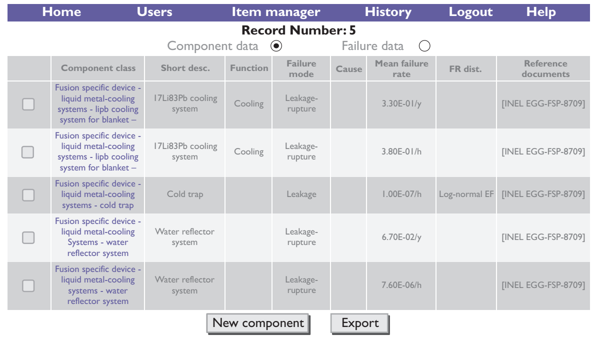
Photo courtesy of Leila Mead, Earth Negotiations Bulletin, International Institute for Sustainable Development.

www.ieaghg.org

TRACKING COMPONENT TESTS

Policy context

Fusion energy has the potential to be a safe, environmentally attractive and inexhaustible source of power. A significant amount of research must still be accomplished. While the understanding of fusion science advances, developing and demonstrating the safety and economic viability of fusion is equally important. The knowledge gained must be made available to both the regulator and the public in order to fully appreciate the potentials and challenges of fusion power. Further governmental support for this work is needed.


Home | Users | Item manager | History | Logout | Help

Record Number: 5

Component data ◉ Failure data ○

	Component class	Short desc.	Function	Failure mode	Cause	Mean failure rate	FR dist.	Reference documents
☐	Fusion specific device - liquid metal-cooling systems - lipb cooling system for blanket –	17Li83Pb cooling system	Cooling	Leakage-rupture		3.30E-01/y		[INEL EGG-FSP-8709]
☐	Fusion specific device - liquid metal-cooling systems - lipb cooling system for blanket –	17Li83Pb cooling system	Cooling	Leakage-rupture		3.80E-01/h		[INEL EGG-FSP-8709]
☐	Fusion specific device - liquid metal-cooling systems - cold trap	Cold trap		Leakage		1.00E-07/h	Log-normal EF	[INEL EGG-FSP-8709]
☐	Fusion specific device - liquid metal-cooling Systems - water reflector system	Water reflector system		Leakage-rupture		6.70E-02/y		[INEL EGG-FSP-8709]
☐	Fusion specific device - liquid metal-cooling systems - water reflector system	Water reflector system		Leakage-rupture		7.60E-06/h		[INEL EGG-FSP-8709]

New component | Export

▲ A sample query from the failure rate database.

Background

The aims of the Implementing Agreement on a Co-operative Program of Research on Environmental, Safety and Economic Aspects of Fusion Power (ESEFP IA) are to conduct research and to perform physical tests to determine the nature of materials and to benchmark the analytical tools that are necessary to demonstrate the safety and economy of fusion. This includes development, validation, and establishment of data requirements of environmental and safety analysis models and computer codes and supporting research; development of safety methodologies for use by designers of fusion facilities; and system studies of future fusion facilities to determine their environmental, safety and economic characteristics. There are six Contracting Parties, including Russia and China.

Spotlight

Failure rates of fusion device components are used to predict maintenance schedules, and are key elements in any safety analysis for fusion reactors. Therefore an important ongoing activity of the ESEFP IA involves developing and maintaining a failure rate database that covers tritium facilities and tokamak experiments worldwide.

This information is important to demonstrate the safety and reliability of fusion power. These data also support the industries' design components for fusion devices. These fusion-specific data are valuable to ascertain the reliability, availability, maintainability and inspectability (RAMI), the operations support, and quantification of the probabilistic safety assessment (PSA). Regulatory agencies rely on this information to license fusion power plants. Where possible, database entries have been validated against independent data and double-checked for accuracy. This includes data from nuclear fission reactors, but also the chemical industry, aerospace industry, particle accelerator datasets, military datasets, the offshore oil industry, and other industries with data applicable to fusion research.

The database now contains over 830 failure rate values of mechanical, electrical and electronic components such as compressors, condensors, circuit breakers, conductors, fans, heaters, magnets (both cryogenic and superconducting) piping (both cryogenic and superconducting), pressurisers, pumps, vacuum pumps and valves. An additional 460 values are in the process of validation.

Given the significance of this database in support of safety and reliability, at the end of 2012 the database (residing at the Italian National agency for new technologies, Energy and Sustainable Economic Development) was made available to the International Thermonuclear Experimental Reactor (ITER) project.

CURRENT PROJECTS

- Activation products source terms
- Failure-rate database
- In-vessel tritium source term
- Magnet safety
- Power plant studies
- Radioactive waste studies
- Socio-economic aspects
- Transient thermo-fluid modelling, validation tests

REFERENCES

The ESEFP IA website is under development. An overview of the collaborative activities may be consulted on the IEA website:

www.iea.org/techno/technologies/fusion.asp

TRAPPING BUBBLES AVOIDS LARGE VOIDS

Policy context

In magnetic-confinement fusion reactors, the plasma is heated to temperatures of more than 100 million degrees Celsius (°C) to enable fusion of the deuterium and tritium fuel. The main challenges for fusion power science are finding materials that can resist extreme heat radiating from the plasma as well as the effects of irradiation from the neutron bombardment. Other important challenges include identifying those materials that are able to provide safe, reliable and predictable performance, and a long service life at elevated temperatures, with minimum radioactivity in end-of-life components for simplified recycling or disposal. Studying the effects of irradiation in fusion devices presents a particularly difficult challenge, as fully suitable test beds are not available. Materials research is a strategic priority in many IEA member countries. Given the potential of fusion power and the applications to other high-potential energy options, continued efforts in this area will be needed.

Background

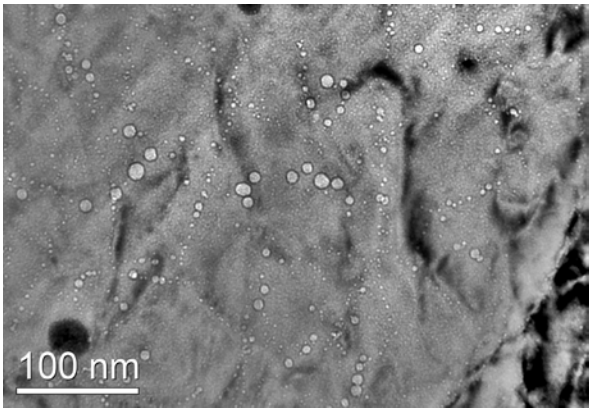
The focus of co-ordinated research under the Implementing Agreement for a Programme of Research and Development on Radiation Damage in Fusion Materials (FM IA) is to develop materials for the first wall and blanket of a power plant that will operate under high temperatures and survive the high flux of neutrons and charged particles produced in the plasma chamber. This work also includes developing protocols for measuring material production processes, joining methods and design properties. Research underway includes materials irradiation in fission reactors, ion beams, and computational simulation. The theories are paired with experiments and modelling efforts to represent true fusion conditions and lifetimes. There are nine Contracting Parties, including China, India and Russia.

Spotlight

A unique aspect of the fusion reaction is the substantial production of gases that affect the mechanical and physical properties of the materials.

One such gas, helium, is produced in significant quantities. As helium gas is not soluble, it forms 'bubbles' which accumulate to form voids in the materials, affecting its integrity and structure. It is essential to quantify these effects to develop safe and reliable fusion systems. As a result, helium bubbles are a topic of much research worldwide, and a focus of the FM IA. Currently it is difficult to explore the effects of helium under prototypical conditions due to a lack of appropriate neutron irradiation sources.

The large number of small bubbles and the few, large voids are significant. Growth in the number and size of the voids could cause premature failure of the steel.



▲ Helium bubbles in a steel specimen produced during neutron irradiation.

Novel experimental techniques combined with multi-scale modelling are being used in the activities of the FM IA to reveal the micro-level effects of helium on typical structural materials such as the reduced-activation ferritic or martensitic (RAFM) and advanced oxide dispersion strengthened (ODS) steels.

One strategy for managing high levels of helium is to provide many places for bubbles to form so that they do not transform into voids. This is one reason for the resurgence of interest in ODS steels. The high number of small oxide particles in ODS steels provides many places to 'trap' the helium, increasing resistance to unexpected structural failure.

CURRENT PROJECTS

- Diagnostics and control insulating ceramics modelling, computer simulation and validation
- Fundamental studies of irradiation effects
- Irradiation facilities and post-irradiation tests
- Reduced activation and advanced ferritic steels
- Silicon carbide composite materials
- Tungsten and tungsten alloys
- Vanadium base alloys

REFERENCES

Photo courtesy of Battelle Memorial Institute.

www.frascati.enea.it/ifmif

FEEDING RESULTS INTO ITER

Policy context

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 in order to generate electricity. Technology plays a critical role in our ability to accomplish this important task. Support for further research will be necessary to reap the rewards of fusion: large-scale electricity generation without greenhouse gas emissions.

Background

The goals of the Implementing Agreement for a Co-operative Programme on Nuclear Technology of Fusion Reactors (NTFR IA) are to conduct research experiments on key components of fusion power plants and associated technologies, in particular those operating close to the fusion burning plasma, or plasma-facing components. In particular, the NTFR IA works to develop effective, reliable, functioning components with prolonged lifetimes under the conditions expected to occur in a commercial fusion power plant. This is crucial to the economic performance and environmental and safety acceptability of fusion power. There are eight Contracting Parties, including China, India and Russia.

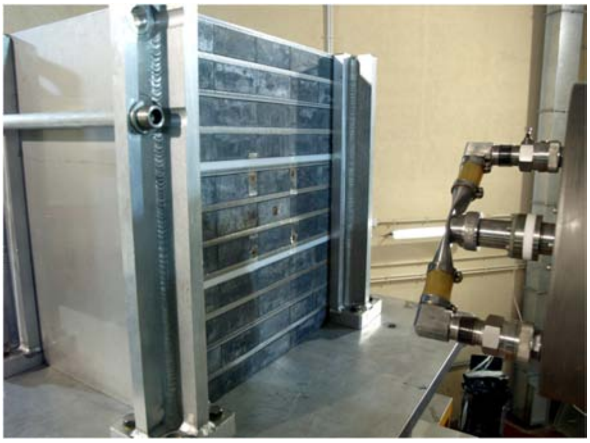
Spotlight

Two isotopes of hydrogen are used to fuel the fusion reaction – deuterium and tritium. Deuterium can be extracted from seawater but the worldwide supply of tritium is currently estimated at 20 kilograms. Yet when neutrons escaping the fusion plasma interact with lithium contained in the blanket, tritium is produced. This concept of 'breeding' tritium during the fusion reaction is an important one for the future needs of a large-scale fusion power plant.

Mock-ups of devices to extract the tritium, called Test Blanket Modules (TBM), simulate tritium breeding in a real fusion environment. The TBM shield the chamber walls from the high temperatures and the high-energy neutrons. In the blanket, the neutrons are slowed down so their kinetic energy can be transformed into heat, which will in turn be used to create electricity.

Testing plasma-facing components such as TBM is one of six research areas of the NTFR IA. Important recent progress was made in two main areas of R&D related to the ITER TBM Programme, neutron irradiation and tritium production.

The NTFR IA recently completed neutron irradiation tests on ceramic breeder pebbles. These pebbles have been irradiated by neutrons over several years in order to achieve conditions relevant to the post-ITER power plant, DEMO. The test results will be used to improve the design of both the ITER TBM programme and the DEMO blanket.



▲ Direct measurement of tritium production in irradiated lead-lithium walls.

In the blanket design, evaluation of tritium production and recovery are critical. However, experimental data of tritium production are lacking. To improve this situation, NTFR IA members carried out fusion neutron irradiation tests at a level of 14 megaelectron volts (MeV) on lead-lithium liquid breeder materials and ceramic breeder pebbles.

These measurements are important to establish benchmarks. Data from these experiments will be collected and shared via the data bank of the OECD Nuclear Energy Agency.

CURRENT PROJECTS

- Liquid breeding blankets
- Neutronics
- Plasma-facing components
- Plasma surface interactions
- Solid breeding blankets
- Tritium processing

REFERENCES

Photo courtesy of the Italian National Agency for New Technologies.

The NTFR IA website is under development. An overview of the collaborative activities may be consulted on the IEA website: www.iea.org/techno/technologies/fusion.asp.

KEEPING COOL UNDER THE BLANKET

Policy context

Materials that line the fusion chamber walls must withstand extreme temperatures of more than 100 million degrees and be robust enough to maintain structural homogeneity when coming into contact, or interaction, with the plasma. The effect of the plasma on the wall components, or plasma wall interaction (PWI), is an important focus of fusion research. While some progress has been made, continued support for research and development (R&D) will be needed to ensure that a solution is found in time for the operational period of the ITER experiment.

Background

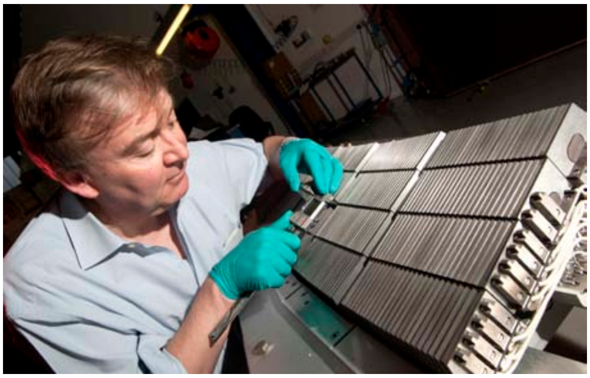
The co-operative research experiments conducted under the auspices of the Implementing Agreement for a Programme of Research and Development on Plasma Wall Interaction in TEXTOR (PWIT IA) seek to understand the PWI phenomena and to identify materials. Specifically, this includes erosion and deposition behaviour of wall materials; fuel recycling, retention and removal from deposited material layers; control techniques to limit peak heat loads; transport physics; modelling the transport in the edge plasma within three-dimensional magnetic structures; and development of plasma wall diagnostics relevant to the ITER project. There are currently three Contracting Parties.

Spotlight

Wall components made of tungsten will play a central role in future fusion reactors as it is the element with the highest melting point (3 422 °C). Most importantly, tungsten wall materials retain much less fuel gas compared with graphitic wall components. Nevertheless, tungsten interacts with the plasma and creates impurities that need to be minimised.

The chamber wall design for the ITER device includes tungsten tiles covered by a special magnetic field configuration known as the divertor. The divertor removes the outer boundary layer of the plasma away from the hot core and deposits it on collector plates, removing impurities which would have otherwise reacted with the walls of the vessel and resulted in structural damage.

TEXTOR[1] is a highly specialised tokamak device that served as a test facility for the PWIT IA to run experiments on the plasma wall phenomena. On the basis of these experiments, a bulk tungsten divertor was designed for the Joint European Torus (JET). The JET divertor replicates the design of the ITER wall and is in the second important phase of testing. The JET tungsten divertor has been successfully in operation since August 2011, performing closely to the design specifications for ITER.



▲ Last verification of the bulk tungsten assembly before it is installed in the remote handling unit of the Joint European Torus (JET).

The JET experimental campaign showed that oxygen and residual carbon were greatly reduced. The erosion of tungsten from the new wall structure was found to be substantially lower than traditional wall component materials such as graphite. Despite the absence of active cooling, the solid tungsten tiles were able to withstand a power density of 7 megawatts per square metre (MW/m^2) to 10 MW/m^2 and a total deposited energy of 60 megajoules per square metre (MJ/m^2) in spite of the absence of cooling.

These results show a positive experience with the ITER wall, an important step forward for a successful operation of ITER.

CURRENT PROJECTS

Design and construction of new test devices with linear plasmas and electron/ion beams for plasma-wall interactions under realistic conditions

Diagnostic developments for ITER

Modelling of erosion, migration and deposition of wall materials in ITER

Tritium retention and removal studies

REFERENCES

1. The Tokamak Experiment for Technology Oriented Research (TEXTOR), operated by Forschungszentrum Jülich (Germany).

Photo courtesy of the European Fusion Development Agency Joint European Torus.

www.fz-juelich.de/fusion

POSSIBLE PLASMA PATHWAYS

Policy context

The most highly developed approach to fusion power, the tokamak, confines hot plasmas through the use of large, superconducting magnets that create a powerful magnetic field. However, the coils are applied on the outside of the chamber, creating physics challenges that must be overcome. In the reversed field pinch (RFP) approach, the current in the plasma generates almost all of the magnetic field, "pinching" the plasma in place without the need for coils to create a magnetic field. This results in a higher efficiency between kinetic and magnetic pressure and a greater density of the magnetic field. Continued R&D focussing on alternative approaches to plasma confinement such as RFP is needed in order to contribute to knowledge of fusion science and accelerate the realisation of fusion power.

Background

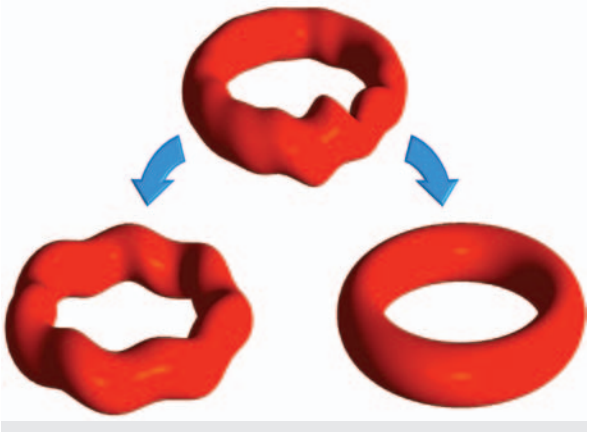
The main objective of the Implementing Agreement for a Programme of Research and Development on Reversed Field Pinches (RFP IA) is to share instrumentation, joint experiments and common development of theory and models of RFP. Research activities include assessing the potentials of the reactor configuration; determining plasma confinement scaling; providing state-of-the-art facilities for developing active feedback control of magneto-hydrodynamic stability; exploring inaccessible fusion parameter ranges in order to enhance fusion predictive capabilities; and creating techniques to either sustain steady-state plasma or find a pulsed reactor scenario. There are currently three Contracting Parties.

Spotlight

A key challenge to advancing the RFP approach is to reduce instabilities that cause distortion of the plasma shape. Under the RFP IA, substantial progress has recently been made on two potential paths to reduce these irregularities.

One option seeks to optimise the plasma's own tendency to form a simple helical symmetry, called the quasi-single-helicity regime. Based on recent results, an improved understanding of the quasi-single-helicity phase transition is emerging. Good progress has been made in the RFX[1] device to achieve high plasma current and density by coating the plasma-facing carbon wall with lithium. These optimal plasma conditions have also been obtained in the MST[2] device though with a lower plasma current than the RFX.

The second path to improved RFP involves controlling the current profile in order to bring the plasma as close as possible to pure toroidal symmetry by reducing twists and tears. Record confinement and plasma density have been achieved using this approach. New measurements in the MST device show that confining ion impurities attains the lowest value possible, the so-called "classical confinement".



▲ Illustration of the two pathways for RFP development: self-organised, quasi-single-helicity (left) and profile control twists or tears (right). The distortions have been exaggerated to emphasise the phenomena.

These results strengthen the validity of RFP research and the relevance for other fusion devices and experiments worldwide. Examples include the new RFP program at the University of Science and Technology of China (USTC), in Hefei, People's Republic of China.

CURRENT PROJECTS

Co-ordinated experiments on the following devices:

- EXTRAP T2-R (Sweden)
- Madison Symmetric Torus (United States)
- TPE-RX (Japan)
- Reversed Field Experiment (Italy)

REFERENCES

1. Refers to the Reversed Field Experiment device operated by the Consorzio RFX (Italy).

2. Refers to the Madison Symmetric Torus device at the University of Wisconsin (United States).

Schema courtesy of David Terranova.

The RFP IA website is under development. An overview of the collaborative activities may be consulted on the IEA website www.iea.org/techno/technologies/fusion.asp.

CREATING WAVES

Policy context

Fusion science is still in the exploratory phase. While much research focuses on devices in the shape of a torus (doughnut), called tokamaks, spherical torus machines have recently emerged as an innovative example of fusion confinement. Spherical tori, smaller than conventional devices (tokamaks), offer particular advantages. For example, the construction and operating costs are lower and the physics parameters are more easily controlled. This leads to greater understanding of plasma behaviours, in particular with regard to the crucial issue of plasma stability, steady-state, and other aspects. Continued R&D focussing on alternative approaches such as spherical torus (ST) devices is needed in order to accelerate knowledge of fusion science and realisation of fusion power.

Background

The aim of the Implementing Agreement for Co-operation on Spherical Tori (ST IA) is to contribute to the scientific and technology knowledge of plasma confinement by strengthening co-operation among spherical torus research programmes and facilities worldwide. This information serves to broaden the understanding of fusion science for all devices worldwide. There are currently three Contracting Parties.

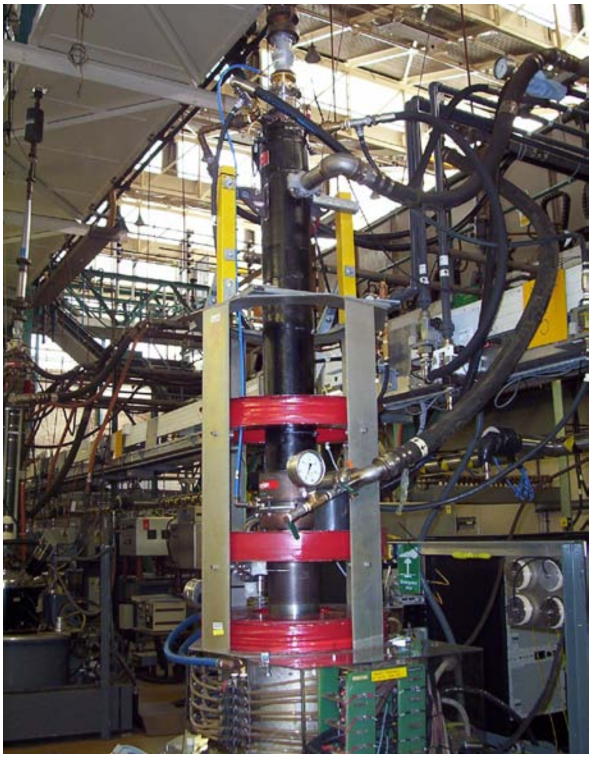
Spotlight

Due to the improved stability of an ST device, as compared to conventional tokamaks, the plasma has a higher pressure relative to the magnetic field pressure. For this reason, parameters for starting and maintaining the plasma will be different than for tokamak devices.

The aim of one current ST IA collaborative experiment, Science and R&D of Spherical Tori, is to increase understanding of the plasma start-up using the electron Bernstein wave (EBW).

The electron Bernstein wave (EBW) is a quasi-electrostatic wave that is typically used by spherical tori devices to heat the plasma and drive the current. In an ST, the plasma current that is needed to confine the plasma is driven by solenoid induction. Demonstrating ST operation without solenoid induction is one of the most important issues for the future of ST devices. The ST IA chose the MAST1 device to run collaborative experiments.

The MAST[1] device was upgraded to include a high-power gyrotron[2] capable of delivering up to 350 kilowatts (kW) of microwave power at 28 gigahertz (GHz) for 300 milliseconds. First tests to inject power into the plasma were limited by arcing between the gyrotron and the MAST device, limiting the pulse lengths.



▲ The 28 GHz gyrotron on the MAST spherical torus device for use in the plasma start-up experiments.

This difficulty was remedied by adding several transmission line components such as corrugated waveguides and transitions. After installation and final verifications of the gyrotron performance, the EBW start-up experiments on MAST under this IA collaboration will resume in 2013.

CURRENT PROJECTS

Physics and technology of future spherical torus devices

Science and R&D of spherical tori devices

Steady state operation of fusion devices

REFERENCES

1. Refers to the Mega Amp Spherical Tokamak device (United Kingdom).

2. The gyrotron was provided by the Oakridge National Laboratory (United States).

Photo courtesy of Culham Centre for Fusion Energy.

The STI IA website is under development. An overview of the collaborative activities may be consulted on the IEA website: www.iea.org/techno/technologies/fusion.asp.

DENSITIES, DYNAMICS AND 3-D PHYSICS

Policy context

A stellarator-heliotron[1] is a unique class of magnetic fusion devices without net currents in the plasma. Stellarator-heliotrons have demonstrated plasma in uninterrupted equilibrium, or a steady-state, which is a necessary prerequisite for fusion power plants. As there is no need for additional electrical current to 'drive' the plasma in stellarator-heliotrons, engineering needs can be significantly reduced. Continued R&D focusing on alternative approaches to plasma confinement is needed in order to accelerate knowledge of fusion science and realisation of fusion power.

Background

The aims of the Implementing Agreement for Co-operation in Development of the Stellarator-Heliotron Concept (SH IA) are to improve the understanding of physics and to develop the stellarator-heliotron concept of fusion reactors. This includes increasing the understanding of three-dimensional physics by conducting collaborative experiments, exploring theoretical issues and reactor design. The co-ordinated working group meetings and the international stellarator-heliotron workshops assess recent progress among SH IA participants. There are currently six Contracting Parties, including Russia and the Ukraine.

Spotlight

Under the auspices of the SH IA, joint planning and scientist exchanges between the national partners have accelerated plasma performance and the comprehensive understanding of physics of toroidal shaped plasmas.

The Large Helical Device (LHD) in Japan is the largest experimental platform for exploring the stellarator heliotron (SH) concept. The LHD has provided many opportunities for international collaborations which have in turn led to steady progress in experimental parameters. In particular, high-density plasmas have reached high temperatures without collision, exceeding 7 keV in the central ions.

In 2011, a helical divertor on the LHD was installed and came into operation. Compared to the open divertor, a helical divertor can increase the neutral gas pressure by a factor of ten. In 2012, eight new experimental campaign periods were added, including a cryogenic pump. Progress has also been made on the flexible helical device TJ-II (Spain). Using lithium-coated chamber walls, characterisation of plasmas is continuing. Results include a wider range of operational density and the ability to routinely reach the highest mode of plasma characteristics, or H-mode. Fast ion confinement properties have also been investigated, in particular low frequency waves and the dynamics of the fast ions.

▲ The Wendelstein 7-X will be the first stellarator to combine improved confinement with plasma equilibrium and stability. The first plasmas are expected by 2015.

Other devices that play important complementary roles in deepening the understanding of SH plasmas among the Contracting Parties include the Heliotron J (Japan), HSX (USA), H-1NF (Australia) and the Uragan 2M and 3M devices (Ukraine). Scientific advances from research carried out on all stellerator-heliotron devices have led to breakthroughs for other areas of fusion science. Three-dimensional physics, resonant magnetic perturbation, and stochastization of magnetic fields, once only considered relevant to SH plasmas, are now a focus among conventional tokamak experiments as well. The Wendelstein 7-X device[2] presently under construction (Germany) will be the first stellarator design to combine improved confinement with equilibrium and stability.

CURRENT PROJECT

Confinement and profile database

Demo assessment based on SH concepts

Integration of high-performance, steady-state plasma confinement for reactor-relevant regimes

International SH joint experiments

Model validations

Numerical code verifications

REFERENCES

1. A fusion containment device invented by the astrophysicist Lyman Spitzer (United States). The name stellarator signifies a "star machine". The origin of the name heliotron is "Helios" (the Sun in Greek).

2. The name Wendelstein makes reference to a mountain in the Bavarian Alps (1 838 metres).

Photo courtesy of Glen Wurden, Max-Planck-Institut für Plasmaphysik.

http://iea-shc.nifs.ac.jp/

JETTING INTO THE ERA OF ITER

Policy context

To date, tokamak[1] fusion reactors are the most successful and promising fusion confinement devices. Much tokamak research focuses on maintaining the plasma in equilibrium and finding suitable materials to withstand the extreme temperatures. Co-ordinated experiments, theory and diagnostics are needed to understand and master this complex science. Continued R&D is needed in order to accelerate knowledge of fusion science and realisation of fusion power through the ITER project.[2]

Background

The aim of the Implementing Agreement for Co-operation on Tokamak Programmes (CTP IA) is to enhance the scientific and technological co-operation across different tokamak devices through collaborative research activities. This includes real-time control of plasma profiles and instabilities that aims to maintain good plasma confinement and the development of advanced modes of operation towards steady-state and material erosion studies. An important outcome of this co-operation is the joint publication of research results and the sharing of information through workshops and co-ordinated working groups. There are currently six Contracting Parties, including India and ITER.

Spotlight

The CTP IA provides the framework for co-ordinating joint experiments with related research groups and the International Tokamak Physics Activities (ITPA).[3] This is ensured through scientist exchanges and personnel assignments. Highlights of recent experiments are as follows.

At the ASDEX-upgrade device (Germany), experiments showed progress with controlling plasma instabilities while the Tore-Supra (France) studied new techniques to mitigate the impact of instabilities. At the TCV device (Switzerland), prediction and pacing of plasma disruption was achieved.

In the United States, the Alcator C-Mod facility focussed on extending the operating modes at near steady state conditions. A neutral beam line was installed and successfully commissioned in the DIII-D device, while the first, successful simulations of nonlinear, micro- tearing were carried out for the NSTX device. In Japan, the 2011 earthquake and tsunami did not result in serious damages to the JT-60SA device and facilities (Japan). In Korea, experiments on the KSTAR machine studied the control of outer edge plasma conditions using several disruptive methods. In India, the repair and refurbishment of the SST-1 device is complete.

▲ The chamber wall of the Joint European Torus (JET) device was designed to replicate ITER specifications, providing a platform for ITER-relevant experiments.

In Europe, the new plasma-facing components of the Joint European Torus (JET) (United Kingdom) are made of tungsten and beryllium, the same materials foreseen for ITER. An independent panel set up by the European Commission ("Horizon 2020") recognised that JET is a key facility for the success of ITER, and recommended that the ITER-like wall of JET should be used to test conditions similar to ITER's deuterium-tritium phase of operations.

CURRENT PROJECTS

- Confinement database and modelling
- Edge and pedestal physics
- Magnetohydrodynamics, disruptions and control
- Sol and divertor physics
- Steady state operation
- Transport and internal transport barrier physics
- Tritium and remote-handling technologies

REFERENCES

1. The term tokamak is a transliteration of the Russian term for a toroidal chamber with magnetic coils (toroidal'naya kamera v magnitnykh katushkakh).

2. The International Thermonuclear Experimental Reactor (ITER) is a project to build the world's largest experimental tokamak reactor.

3. The ITPA operates under the auspices of ITER to provide a framework for internationally coordinated fusion research activities.

Photo courtesy of the European Fusion Development Agency Joint European Torus.

http://ctp.jet.efda.org/lt

RENEWABLE ENERGIES AND HYDROGEN

Bioenergy
Concentrating Solar Power
Deployment
Geothermal
Hydrogen
Hydropower
Ocean
Photovoltaics
Solar Heating and Cooling
Wind

PLEASE PASS THE PELLETS

Policy context

Bioenergies (biomass and biofuels) currently account for 10% of global primary energy supply. Bioenergies provide sustainable, socio-economic solutions to energy challenges, whether for electricity generation or transport. A variety of bio-based fuels can be used: wastes, agricultural and forestry residues, as well as crops grown specifically for energy purposes. Policies and measures to deploy bioenergy include incentives such as renewable energy certifications, supporting research and development (R&D) to ensure lower life-cycle greenhouse gas (GHG) emissions, and aligning bioenergy policies with agriculture, forestry and rural development.

Background

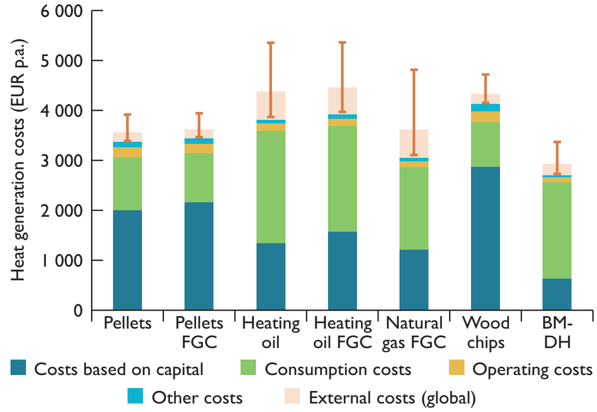
The vision of the Implementing Agreement for a Programme of Research, Development and Demonstration on Bioenergy (Bioenergy IA) is to make a substantial contribution to future global energy demand by accelerating the production and use of environmentally sound, socially acceptable and cost-competitive bioenergy. Activities include exchanging information on recent developments through studies and workshops; working with industry to develop handbooks and models; providing information for policy-makers and decision-makers; and compiling guidelines and standards on the use of bioenergy. There are currently 24 Contracting Parties, including Brazil, Croatia and South Africa.

Spotlight

Production, consumption and trade of wood pellets have grown strongly over the last decade. For these reasons one recent Bioenergy IA project, Biomass Combustion and Co-firing, examined the potentials and barriers of burning wood pellets, including supply chain, economic and environmental considerations.

Compared to other forms of biomass fuels, pellets are of consistent quality and burn efficiently. They are an ideal candidate for sustainable solutions as they can be made from many types of biomass such as sawdust from the milling industry or agricultural waste.

However, storing and burning pellets contribute to greenhouse gas emissions. When stored, pellets emit some carbon, and when burned, can create carbon and particulate emissions such as ash. Cost calculation comparisons were conducted using fossil fuel and biomass fuels for central heating systems in individual homes. Each fuel was also evaluated on the external costs, i.e. costs related to impacts such as health damage, environmental degradation, building damage and climate or safety issues.



▲ Costs of central heating systems including external costs based on global emissions.

The study showed that a district heating network linked to a biomass-fired boiler was found to be the most economical and environmentally sustainable option.

Considering the price of oil and natural gas, the pellet central heating system was found to be the next best option. Full results of this analysis can be found in *The Pellet Handbook.*

CURRENT PROJECTS

- Biomass combustion and co-firing
- Biomass feedstocks for energy markets
- Biorefining: sustainable processing of biomass into a spectrum of marketable bio-based products and bioenergy
- Climate change impacts of biomass and bioenergy systems
- Commercialisation of conventional and advanced liquid biofuels from biomass
- Energy from biogas
- Integrating energy recovery into solid waste management
- Pyrolysis of biomass
- Sustainable bioenergy markets and international trade: securing supply and demand
- Thermal gasification of biomass

REFERENCES

Source of the graph: Bios Bioenergiesystems GmbH, Graz, Austria.

www.ieabioenergy.com

CONCENTRATING ON CLEAN WATER

Policy context

Concentrated solar power (CSP) technologies use large, sun-tracking mirrors to concentrate sunlight. Combined with high-temperature thermal storage for backup supply, CSP plants can provide flexible, baseload electricity production as well as produce high-temperature heat for industrial processes or to purify or desalinate water. Despite the higher investment cost, CSP plants use many available technologies such as steam turbines, and electricity from CSP can be produced at a competitive cost per kilowatt-hour. Policies and measures to capitalise on this potential include long-term funding for additional research, development and demonstration (RD&D), financial incentives, proper planning and environmental assessments, and streamlining the permitting process for new plants.

Background

The aim of the Implementing Agreement for Solar Power and Chemical Energy Systems (SolarPACES IA) is to facilitate technology development, market deployment and energy partnerships for sustainable, reliable, efficient and cost-competitive concentrating solar technologies by providing leadership as the international network of independent experts. There are 19 Contracting Parties (including Algeria, Brazil, China, Egypt, Israel, Mexico, Morocco, South Africa, and the United Arab Emirates) and one Sponsor.

Spotlight

Many countries and regions with the most hours of annual sunlight also have a shortage of fresh water resources. For this reason, the SolarPACES IA project "Solar Energy and Water Process and Applications" aims to combine the benefit of high-temperature steam and electricity from CSP plants to purify waste or standing water and drive processes to desalinate seawater. Despite recent advances in energy efficiency, desalination plants are energy intensive and often operate using fossil fuels. Using exhaust steam from CSP plants would not only improve overall efficiencies but would also significantly reduce greenhouse gas emissions.

For these reasons, the SolarPACES IA subtask, Concentrated Solar Power and Desalination Plants, set out to examine cases of CSP plants combined with desalination in arid countries. Participants examined CSP-desalination demonstration projects in Egypt, Jordan, Israel and Spain. Detailed comparisons of systems configurations, components, materials and operating regimes were made. Salt concentrations and the location of the plant were also considered.

Two cases were examined in the Mediterranean region, the first focussing on a combined CSP desalination plant (using reverse osmosis) located on the shore, and a second focused on a CSP plant located inland, transmitting electricity to a coastal desalination plant (multi-effect distillation). Much of the coastal land is occupied and the amount of annual sun is somewhat lower due to cloud cover. However, it was found possible to generate 10.4 gigawatts (GW) of power and to desalinate 8.3 million cubic metres per day of water on the combined coastlines of Egypt, the Red Sea and the Persian Gulf.

▲ Example of a combined concentrating solar-desalination plant (Almeira, Spain).

The second case examined CSP plants located further inland, where electricity was transmitted to the coastal desalination plant. This configuration was not always possible due to the state of the electricity grid, and where it was possible, it resulted in transmission losses between the CSP installation and the desalination plant. However, the net result was found to be beneficial, as the multi-effect distillation process of desalination was found to be thermodynamically more efficient, requiring a smaller solar CSP plant to produce the same amount of electricity.

CURRENT PROJECTS

- Solar chemistry research
- Solar energy and water processes and applications
- Solar resource knowledge management
- Solar technologies and advanced applications
- Solar thermal electric systems

REFERENCES

Photo courtesy of CIEMAT.

www.solarpaces.org

RENEWABLES DEPLOYMENT INCREASES EMPLOYMENT

Policy context

Security of supply and the need for long-term, stable energy prices could be alleviated through greater deployment of renewable energy technologies. Heat and electricity from renewable sources can reduce health and environmental impacts as well as greenhouse gas emissions. However, increased understanding of the socio-economic issues related to renewables is needed. Policies and measures to support deployment of renewable energy sources include a stable policy framework, financial and fiscal incentives, continued R&D to lower costs, educational programmes for professionals and the trades, and consumer information campaigns.

Background

The goals of the Implementing Agreement for Renewable Energy Technology Deployment (RETD IA) are to identify the main barriers to deployment and provide advice and best practice guidance to policy makers and the private sector. This includes identifying barriers to deployment and providing best-practice solutions to remove them; offering guidance to the private sector and policy makers on innovative business strategies and projects, for example by fostering public-private partnerships; and facilitating ongoing international dialogue and public awareness of renewable energy deployment through concrete examples of deployment solutions. There are currently nine Contracting Parties.

Spotlight

The understanding of the economics of large-scale deployment of renewable energy technologies and the impacts on sectors of the economy is based on differing objectives and analytical tools. For this reason, the RETD IA set out to create a more structural approach aimed at gathering case studies of policy frameworks and methodologies used to estimate the effects of renewable energy use on employment.

The RETD IA EMPLOY project developed a set of coherent, consistent methodological guidelines for estimating the employment impacts of renewable energy. The main body of the report includes an overview of assessment approaches, while guidelines and case studies for each RETD IA participating country and Tunisia were synthesised in an annex to the report.

The study provided a consistent, reliable framework in which to measure employment effects from renewable energy deployment, which may be replicated from one country to another.

	Persons employed			Share of national employment
	Direct	*Indirect*	*Total*	*Total*
Canada	32 000	21 700	53 700	0.32%
Denmark	27 200	21 700	48 900	1.71%
France	29 800	19 100	48 900	0.18%
Germany	150 100	120 500	270 600	0.67%
Ireland	2 600	700	3 300	0.17%
Japan	27 600	33 000	60 600	0.09%
Netherlands	9 200	11 600	20 800	0.24%
Norway	10 200	6 200	16 400	0.63%
United Kingdom	16 200	11 000	27 200	0.09%

▲ Preliminary results of the Gross IO modelling approach, one of the models used to analyse the link between renewables deployment and employment.

Policy makers are guided in their choice for the most suitable approach, depending on the policy goals to be achieved, the data availability and budget allocation. Guidelines were prepared for four different methodological approaches. The report provides insight into the basics of the methods used, the methodological issues, advantages and disadvantages of various methods, data requirements and procedures to collect the data.

Although results are difficult to compare across countries, renewable energy technologies have been shown to have a positive effect on both jobs and the economy. Based on these results, the report includes recommendations for policy makers. This project was executed in collaboration with the International Renewable Energy Agency (IRENA).

CURRENT PROJECTS

Communication techniques and experiences to communicate about renewable energies

Crucial assumptions and methodological issues of energy scenarios

Next generation of renewable energy policy instruments for electricity generation

Policies and incentives along the innovation chain

Policy instruments to support renewable energy industrial value chain development

'True' costs for fossil, nuclear and renewable energy

REFERENCES

www.iea-retd.org

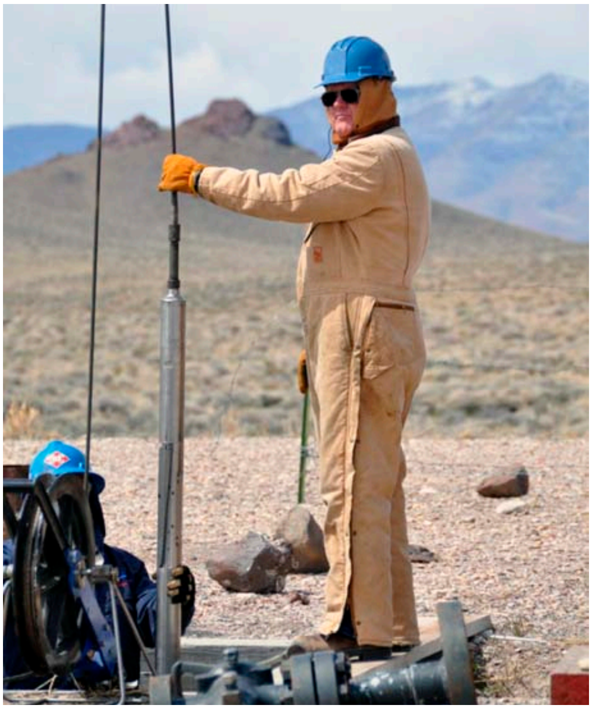
DRILLING DOWN GEOTHERMAL COSTS

Policy context

Electricity generation from high-temperature geothermal heat is the only renewable energy source that can provide continuous, base-load power for many years with no fuel costs and with minimal environmental impact. Geothermal steam can be used in district heating networks or for industrial processes, and the lower-temperature heat from the ground can be used for building heating and cooling. Policies and measures to support geothermal include economic incentives such as feed-in tariffs, tax incentives and renewable portfolio standards.

Background

The goal of the Implementing Agreement for the Co-operative Programme on Geothermal Energy Research and Technology (Geothermal IA) is to provide a framework for international co-operation on R&D. Activities include information sharing; developing best practice on the use of technologies and techniques; exploration, development and utilisation of geothermal; and producing and disseminating authoritative analysis and databases. There are currently 15 Contracting Parties, including Iceland and Mexico, as well as five sponsors.



▲ Participants in the GIA study logging (testing) a geothermal well to determine how to reduce costs.

Spotlight

Geothermal wells are more expensive to drill than oil and gas wells, and these costs increase according to the depth. These costs can represent more than half of the capital cost for a deep geothermal power project. Therefore reducing these costs is a primary focus for the industry.

The goal of one Geothermal IA project, Advanced Geothermal Drilling and Logging Technologies, is to develop a better understanding of these complex processes in order to identify opportunities for reducing these costs.

Geothermal drilling practices for wells destined for direct use (low temperature) and electricity generation (high temperature) require careful planning and design to reduce the time to full exploitation.

Technical challenges due to siting, water or steam quality and composition, and equipment; physical constraints such as the large diameter of the wells; and the unique character of each well, even wells in close proximity, are also important factors to consider. The project also considered indirect costs relating to the need to re inject fluids to maintain pressure. Optimal design criteria were established for a number of parameters, including drilling and completion programmes; drilling practices for cost avoidance; problem diagnosis and remediation during slim-hole drilling; trouble avoidance, well testing; geophysical logging; and preserving the wellbore.

Costs and risks of emerging technologies, in particular deep drilling, were explored. Drilling with casing was highlighted as a best practice as it reduces time spent and has been used successfully to drill through unstable formations. Expandable tubes and feedback processes were also examined. The results of the project, including case studies, are compiled in the *Handbook of Best Practices for Geothermal Drilling*, available free from the GIA website.

CURRENT PROJECTS

- Advanced geothermal drilling and logging technologies
- Direct use of geothermal energy
- Data collection and information
- Environmental impacts of geothermal development
- Enhanced geothermal systems
- Induced seismicity

REFERENCES

Photo courtesy of Sandia National Laboratories.

www.iea-gia.org

REFORMING HYDROGEN SUPPLY

Policy context

Supply of hydrogen is virtually limitless as it is the most abundant element in the universe. Yet on earth it must be extracted by splitting the hydrogen from the primary source such as fossil fuels. Hydrogen produced from nuclear power plants, renewable energy sources, or by splitting water through electrolysis result in a fuel with minimal environmental effects. And hydrogen fuel cells can be used for a wide range of applications in the residential, industrial and transport sectors. Despite these potentials, barriers related to storage and safety must be addressed. Reducing costs of production will also be needed. Policies and measures to support deployment of hydrogen include continued R&D for suitable materials and to address safety concerns; support for demonstration and pilot projects; fiscal, financial and regulatory measures; and developing international codes and standards to support commercial development.

Background

The aims of the Implementing Agreement for a Programme of Research and Development on the Production and Utilisation of Hydrogen (Hydrogen IA) are to accelerate hydrogen implementation and widespread utilisation to optimise environmental protection; improve energy security; and promote economic development internationally while establishing it as a premier global resource for expertise. There are currently 23 Contracting Parties, including Iceland, Lithuania and two intergovernmental organisations.

Spotlight

Provided storage and safety issues can be addressed, the potential for hydrogen to replace traditional fossil fuels in the transport sector is considerable and the benefits to energy security and environmental protection would be great. However, due to the costs and complexities of building new supply infrastructure from the site of production to the site of consumption (*i.e.* petrol stations), other options need to be considered.

For these reasons, the Hydrogen IA set out to analyse ways in which hydrogen can be produced on the site of consumption using steam to 'reform' natural gas. The objective of a recent five-year HIA study, *Small-Scale Reformers for on-site Hydrogen Supply,* was to work towards harmonisation of technology for on-site production of hydrogen from both fossil and renewable fuels and to explore challenges related to systems, markets and costs. Issues examined in the study include industrial harmonisation, remaining R&D challenges, safety, standards, emerging technologies, sustainability and resource issues (including bio-based fuels, combining carbon capture and storage with hydrogen production from fossil-based fuels, and new technologies), and cost calculations.

▲ This on-site, small-scale reformer provides hydrogen produced from natural gas to 10-12 customers per day (Long Beach, California).

Fifteen companies (reformer suppliers and gas companies) and institutes in ten countries participated in the evaluations. Demonstration projects with on-site production units at petrol stations are underway in Europe, Japan and the United States. By the end of 2011, 24 stations equipped with hydrogen reforming were operating in Germany. The study has contributed to developing a basis for safe and harmonised technology for on-site reformers. The final report is expected to serve as a global market guide for on-site hydrogen reforming.

CURRENT PROJECTS

- Bio-hydrogen
- Distributed and community hydrogen
- Fundamental and applied hydrogen storage materials development
- Global hydrogen systems analysis
- Hydrogen-based energy storage
- Hydrogen safety
- Large-scale delivery infrastructure
- Small-scale reformers for on-site hydrogen
- Water photolysis

REFERENCES

Photo courtesy of the Fiedler Group, a Los Angeles alternative fuels design firm.

www.ieahia.org

GETTING TO THE BOTTOM OF EMISSIONS

Policy context

Hydropower represents 17% of total electricity generation worldwide, compared to less than 2% for all other renewable sources combined. Hydropower is a proven technology, and it is reliable and efficient, with low operating and maintenance costs. Pumped storage can help electricity networks balance the variability of integrating other renewable energy sources. There is considerable potential for hydropower, especially in Africa, Asia and Latin America. However, many environmental impact issues must be addressed such as methane emissions from hydropower reservoirs. Due to the high capital investments required for new hydropower projects, policies and measures aimed at providing financial incentives, innovative financing schemes, and market design reforms will alleviate risks for investors and accelerate deployment.

Background

The objectives of the Implementing Agreement for a Co-operative Programme on Hydropower Technologies and Programmes (Hydropower IA) are to encourage awareness, knowledge and support for the sustainable use of water resources for the development and management of hydropower. This includes applying an interdisciplinary approach to hydropower research; increasing knowledge of a broad range of issues relating to hydropower; exploring areas of common interest among international organisations; disseminating balanced, unbiased information on hydropower; and encouraging hydropower deployment. There are seven Contracting Parties, including Brazil and China.

Spotlight

Due to uncertainties and diverging positions regarding GHG emissions from hydropower reservoirs, there is a lack of unbiased information feeding into energy policies, legislations and regulations. Under the project, Hydropower and the Environment: Managing the Carbon Balance in Freshwater Reservoirs, Hydropower IA members carried out a comprehensive study of the processes connected to reservoir GHG emissions. The goal was to establish best practice guidelines for planning studies on the carbon balance in reservoirs and to standardise GHG evaluation methods. The results of this study are synthesised in the *Guidelines for Quantitative Analysis of Net GHG Emissions from Reservoirs*. The *Guidelines* provide a methodology for performing quantitative analysis of net GHG emissions from man-made reservoirs, including advice and recommended procedures for performing *in-situ* measurements, data analysis and modelling.

▲ Researchers retrieving a methane trap from a hydropower reservoir (Wohlen, Switzerland).

The model comprises five stages of measurements: inundation area; reservoir; upstream watershed; reservoir outflow facilities; and downstream reach. General procedures for calculating estimates of net GHG emissions at each stage are outlined, including evaluations of uncertainties.

Advice on planning and executing measurement campaigns and calculating estimates of post-impoundment emissions (uncertainties for existing reservoirs) and pre-impoundment emissions (for both existing and planned reservoirs).

The *Guidelines* will be useful for hydropower plant operators, local or national GHG trading schemes, environmental impact assessments, and national GHG accounting.

CURRENT PROJECTS

- Hydropower and the environment
- Hydropower services
- Hydropower upgrading
- Renewal and upgrading of hydropower plants
- Small-scale hydropower

REFERENCES

Photo courtesy of Eawag, Switzerland.

www.ieahydro.org

PILOTS, PROJECTS AND POTENTIALS

Policy context

Current world electricity demand is 17 500 TWh. There is the potential to develop 20 000 TWh to 80 000 TWh of electricity generated by changes in ocean temperatures, salt content, movements of tides, currents, waves and swells. These technologies are proven. However, there are siting and environmental issues. Ports, coastal waters, and the open sea are divided into fishing permit areas and shipping routes. To capitalise on this energy source, international collaboration is necessary. Policies and measures to support deployment of ocean energy include financial support for continued research, financial and market incentives, and schemes to support development of industry supply chains.

Background

The aims of the Implementing Agreement for a Co-operative Programme on Ocean Energy Systems (OES IA) are to accelerate the viability, uptake and acceptance of ocean energy systems in an environmentally acceptable way. This includes unbiased, quality analysis of technologies to generate electricity from ocean movements (waves, swells, tides, currents), temperature differences or salt concentrations; as well as technologies related to desalination. There are currently 19 Contracting Parties, including China, Mexico and South Africa.

Spotlight

Multiple types of learning are needed for ocean energy technologies: adaptation, or applying lessons learned from other technologies or industries to ocean energy; gathering experiences with technologies already deployed; and innovation spurred by ongoing research and development.

In order to take advantage of potentials and projects for electricity generation from the ocean, the OES IA has recently prepared worldwide inventories of resource endowments, and experiences with demonstration projects and innovative processes.

First, the group established global maps of ocean energy resources: wave, tidal, thermal, and salinity gradients. These maps, together with technology developments, cost reductions, synergies with other industries, markets, policies, and challenges for ocean energy have been synthesised in *An International Vision for Ocean Energy*. This vision includes a goal of installing 337 GW of capacity, creating 1.2 million jobs and reducing 1 billion tonnes of CO_2 emissions by 2050.

Second, through the OES IA work on environmental issues, seven participating countries collaborated to create a searchable, publically available database of research and demonstration projects (Tethys).

▲ Tidal stream converter under development (Strangford Narrows, Northern Ireland).

The Tethys database collates results of environmental monitoring and research efforts on wave, tidal and current energy development worldwide. Developed through a partnership with the OES IA, Tethys drives an interactive map of ocean energy environmental monitoring and research projects, process status, key environmental issues, the status of environmental impact assessments, the name of the project developer, the technology type, scale of the project, total installed capacity and a description of the installation. A photo of the installation completes each case study.

These *in situ* data document the interactions among wave, tidal, and current devices, marine wildlife, and physical oceans systems. Taken together, the world resource maps and database of projects worldwide enable policy makers, investors, industry and ocean technology developers to more accurately gauge the potentials of ocean energy worldwide.

CURRENT PROJECTS

- Environmental effects and monitoring efforts
- Exchange and assessment of project information
- Grid integration
- Guidelines for development and testing

REFERENCES

Photo courtesy of Marine Current Turbines.

www.iea-oceans.org

INTEGRATING SMALL CELLS IN A BIG WAY

Policy context

Photovoltaic (PV) cells directly convert solar energy into electricity. Solar photovoltaic cells are a commercially available and reliable technology with a significant potential for growth in nearly all world regions. There are a wide range of PV cells on the market, and installations can be designed for individual urban or rural residences or large fields for power generation. Policies and measures to support further deployment of solar PV include fiscal and financial incentives; standards and codes for buildings and electricity network interconnections; increasing funding for R&D to further accelerate cost reductions and efficiency gains; and educating and training a skilled workforce.

▲ A large-scale (10 MW) array of photovoltaic panels (YangBaJing, Tibet).

Background

The aim of the Implementing Agreement for a Co-operative Programme on Photovoltaic Power Systems (PVPS IA) is to enhance the international collaborative efforts that facilitate the role of photovoltaic solar energy as a cornerstone in the transition to sustainable energy systems. This 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. There are currently twenty four Contracting Parties, including China, Israel and Mexico and three sponsors.

Spotlight

As electricity from PV cell installations continues to increase, it becomes increasingly important to understand – and address – the effects of this variable source on electricity network reliability and stability. This is the underlying rationale for the PVPS IA project, High Penetration of PV in Electricity Grids. The objectives are to review and document cases of successful high penetration of PV; identify technical barriers and develop technical requirements; and facilitate energy management and system control of electricity grids through greater deployment of PV.

Until now common definitions or scenarios including high-penetration of PV have been lacking. This is largely due to the broad range of PV technologies and the size of the installations. Coupled with varying voltage and system configurations of national or regional electricity networks, much is yet to be defined.

National workshops have been held with utilities, industry, and other stakeholders in China, Europe and the United States, to develop the necessary methods to enable distributed grid-connected PV technologies, in particular, protection requirements for PV inverters, control, safety and their impact on different applications, connection levels and network topologies.

This information will be synthesised into definitions of performance, operating ranges and utility compatibility with a high penetration of PV. The group has investigated the use of tools to forecast and monitor optimum weather conditions and the effect on the networks. The effects of a changing policy framework on the number of new, large-scale projects and the price of electricity are also considered. These efforts have resulted in case studies focusing on energy management using PV, overall power systems and distribution. Fourteen models of PV forecasting have been developed for Europe, Japan and the United States. The final report is designed for use by electricity network planners, specialists for PV systems and inverters, power system simulation engineers, utility engineers concerned with interconnection of distributed energy resources, and equipment manufacturers.

CURRENT PROJECTS

- Deploying PV services for regional development
- High penetration of PV in electricity grids
- Hybrid systems within mini-grids
- PV services for developing countries
- PV environmental health and safety activities
- Large-scale PV power generation systems
- Performance and reliability of PV systems

REFERENCES

Photo courtesy of the Institute of Electrical Engineering, Chinese Academy of Science.

www.iea-pvps.org

WEATHER FORECASTS AND SATELLITE IMAGES

Policy context

Solar heating and cooling (SHC) technologies can be used for a wide range of applications, from residential domestic hot water and space heating and cooling to industrial and agricultural processes. Combined with energy storage, SHC technologies can provide continuous energy supply. Policies and measures to support deployment of SHC technologies include fiscal incentives such as feed-in tariffs, renewable portfolio standards for commercial heat and subsidies, or consumer tax incentives. Regulatory approaches such as solar obligations or building regulations are also effective. Training for trade and building professionals and consumer awareness campaigns should also be considered.

Background

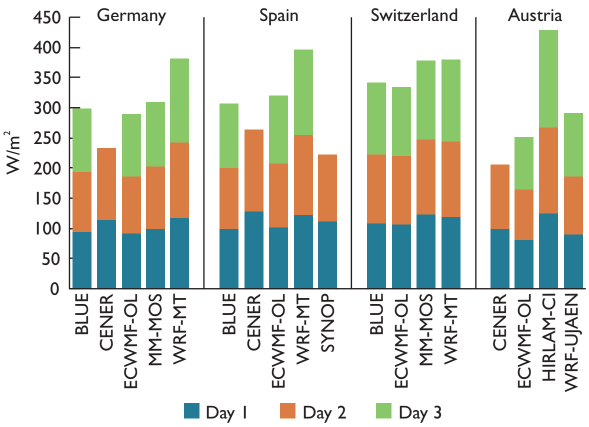
The aims of the Implementing Agreement for a Programme to Develop and Test Solar Heating and Cooling Systems (SHC IA) are to overcome barriers and increase the solar global market share through research, development and testing of hardware, materials and design tools; expand the solar thermal market; and raise awareness of policy makers and consumers. There are currently 21 Contracting Parties, including China, Mexico, Singapore and South Africa.

Spotlight

Knowledge of solar energy resources is critical when designing, building and operating successful solar systems. High penetration of electricity from solar technologies will require more precise forecasting techniques to meet fluctuations in both weather and demand.

For these reasons the SHC IA project, Solar Resource Assessment and Forecasting, aims to improve validation procedures of existing solar resource data so as to gain a clearer understanding of the accuracy of various methods that forecast solar radiation from a few minutes to three days in advance. Preliminary results from the project show that for forecasts of less than one hour, critical for system operators seeking to match varying supply with varying demand, application of Total Sky Imagers or all sky cameras appears promising as they provide images of how the radiation will change over the next several minutes. Participants also investigated the reliability of forecasts derived from cloud motion vectors (CMV), based on a time series of cloud images from satellite observations.

Results show that the CMV model is most suitable for up to four-hour forecasts, while numerical weather prediction (NWP) models are more accurate for four- to six-hour forecasts.



▲ As weather forecast models show varying results, combining satellite images with radiation and wind field data yields more accurate forecasts.

However, synthesing results from a combination of both CMV and NWP models were found to be more accurate, whether over single sites or large regions. Another method consists of combining satellite images of cloud and radiation fields with wind fields from the weather research and forecasting (WRF) model. This was found to achieve optimum forecasting results compared to real weather conditions up to six hours in advance. The results provide best practices on solar energy resources to assist policymakers and project developers in advancing solar energy integration worldwide.

CURRENT PROJECTS

- Advanced lighting for retrofitting buildings
- Compact thermal energy storage
- Large-scale solar heating and cooling systems
- Polymeric materials
- Quality assurance and support measures for solar cooling systems
- Solar and heat pump systems
- Solar energy in urban planning
- Solar heat integration in industrial processes
- Solar rating and certification procedures
- Solar renovation of non-residential buildings
- Solar resource assessment and forecasting

REFERENCES

Source of the graph: Prediction of Solar Irradiance and Photovoltaic Power in Comprehensive Renewable Energy, Volume 1, pp239 - 292. DOI: 10.1002/pip.1224.

www.iea-shc.org

RECOMMENDED PRACTICES REDUCE RISKS

Policy context

Electricity from land-based wind is cost-competitive, particularly when emissions are factored into conventional fuel prices. Offshore wind projects have the potential to greatly increase wind's contribution if the cost can be reduced. To capture the potential of wind on land and offshore, electricity networks will need upgrading to accommodate the capacity and to manage the added variability. Increasing the contribution of wind requires R&D to reduce cost and increase performance. In particular, work is needed to understand the complex forces acting on offshore wind turbines, to improve wind modelling for design and integration of wind plants into the grid, and to explore new materials for turbines in offshore and cold environments.

Background

The mission of the Implementing Agreement for Co-operation in the Research, Development and Deployment of Wind Energy Systems (Wind IA) is to stimulate co-operation on wind energy R&D and to provide high-quality information and analysis to member governments and industry leaders. This is achieved by assessing recent technology developments, deployment best practice, market uptake, and policy instruments. There are 20 Contracting parties, including Mexico, and three sponsors.

Spotlight

The Wind IA Recommended Practices (RP) are pre-normative standards that quickly respond to needs in the wind sector. They are drafted by participants in the Wind IA research projects and widely reviewed by experts in the field. They guide R&D and deployment until official standards bodies are able to complete their work.

By 2010, 11 such RP were issued. The rigorous review and approval process for each RP addresses key issues using a common approach. As a result, the wind industry, researchers, governments, and policy makers find them very useful.

Since 2010, four new RP have been guiding R&D activities: consumer labelling of small wind turbines; wind energy projects in cold climates; public acceptance of wind energy projects; and the use of remote sensing for wind resource assessment.

For example, the RP for *Wind Energy Projects in Cold Climates* recommends that planners, operators, authorities, insurers, and investors use an established risk evaluation method to determine the kind of risks a wind turbine installation in colder climates will face and the take the necessary measures to avoid or decrease these risks.

▲ Wind IA Recommended Practices 13 recognises that installing wind turbines in extreme and cold climates requires special equipment, increased focus on personnel safety and expanded planning.

For example, the RP presents a classification system of icing conditions at wind energy sites that provides wind power developers with an early understanding of the severity and consequences of site selection.

Other RPs under development include conducting integration studies, estimating the cost of wind energy, and conducting model benchmark studies.

CURRENT PROJECTS

- Benchmarking wind farm flow models
- Comparing codes for offshore wind foundations
- Cost of wind energy
- Environmental monitoring, assessment
- Improving aerodynamic models
- Integrating wind into power systems
- Small wind turbine quality labelling
- Social acceptance of wind energy projects
- Standardising wind turbine reliability data
- Remote sensing technology for wind energy deployment
- Wind energy in cold climates

REFERENCES

Photo courtesy of Lars Tallhaug.

www.ieawind.org

STATISTICS

Topics Addressed 2010–12

Scope and Portfolios

Energy Sectors

Participation

TOPICS ADDRESSED 2010–12*

CROSS-CUTTING
Climate Technology Initiative
Capacity building
Clean technology business network
Exchange of experts
Financing adaptation
Innovations for a climate friendly building sector
Joint activities with the UNFCCC
Private Financing Advisory Network (PFAN)
Regional clean energy financing forums
Technology needs assessments
Energy Technology Data Exchange
ETDEWEB online research database:
Expanding coverage
Adding search aids
Developing a mobile phone application
Broadening access to partner countries
Energy Technology Systems Analysis
Energy Technology Data Source briefs (E-TechDS)
Global, multi-regional ETSAP-TIAM model
Advancing the TIMES/MARKAL modelling tools:
Prices: managing price volatility and uncertainties
Transport: modes of transport, travel time and budgets
Electricity generation: wide-scale integration of renewables
Policies/measures: integrating policy instruments and financial measures
Capacity-building: energy systems analysis
BUILDINGS
Buildings and Community Systems
Air infiltration and ventilation centre
Energy-efficient communities
Evaluation of embodied energy and CO_2 emissions for building construction
Financial and technical concepts for deep energy retrofits
High-temperature cooling, micro-generation and cost-effective energy and CO_2 emissions optimisation
Low-temperature heating in buildings
New generation computational tools
Related energy technologies in buildings
Reliable building energy performance characterisation based on full-scale dynamic measurements
Reliability of energy efficient building retrofitting
Towards net zero energy solar buildings
Total energy use in buildings: analysis and evaluation methods
District Heating and Cooling, Including Combined Heat and Power
Improved maintenance strategies for district heating pipe-lines
Integrating renewable energy and waste heat with DHC
Towards fourth generation, low-temperature DHC
Energy Storage
Applying energy storage in ultra-low energy buildings
Electric energy storage: future energy storage demand

** includes studies completed, begun and active during 2010-12.*

Material research and development for improved thermal energy storage systems
Surplus heat management using advanced thermal energy storage for CO_2 mitigation
Thermal response test for underground thermal energy storage
Efficient Electrical Equipment
Electric motor systems
Mapping and benchmarking
Monitoring, verification and enforcement
Policy driven innovation
Smart metering infrastructure
Solid state lighting
Standby power
Heat Pumps
Applications of industrial heat pumps
Cold climate heat pumps (improving low ambient temperature performance of air-source heat pumps)
Common methods for testing and rating heat pumps and air conditioning for annual or seasonal performance
Field measurements on heat pump systems in buildings: good examples with modern technologies
Heat pump concepts for near-zero energy buildings
Quality installation and maintenance
Systems using solar thermal energy in combination with heat pumps
Thermally driven heat pumps for heating and cooling
ELECTRICITY
Demand-Side Management
Behaviour change in demand-side management: from theory to policies and practice
Branding of energy efficiency
Competitive energy services
Integration of demand-side management, energy efficiency, distributed generation and renewable energies
Standardising energy savings calculations
The role of customers in delivering effective smart grids
High-Temperature Superconductivity
Alternating current losses
Fault current limiters
High-temperature superconducting rotors
High-temperature superconducting rotating machines
Roadmap for superconductors
Simulating hts using electromagnetic transient programmes
High-temperature superconducting motors
Smart Grids (ISGAN)
Global smart grid inventory
Smart grid case studies
Benefit-cost analyses and toolkits
Power transmission and distribution systems
Synthesis of insights for decision makers
Smart grid international research facility network
INDUSTRY
Emissions Reduction from Combustion
Advanced hydrogen-fuelled internal combustion engines
Alternative fuels
Hydrogen-enriched lean premixed combustion for ultra low emission gas turbine combustors
Individual contributor tasks

Internal combustion engine sprays
Homogeneous charge compression ignition
Nano-particle diagnostics
Industrial Technologies and Systems
Application of industrial heat pumps
Development and use of process integration in the iron and steel industry
Energy efficiency in small- and medium-sized enterprises
Energy efficient separations systems: methodological aspects, demonstration and economics
Energy efficient drying and dewatering technologies
Industrial excess heat recovery
Industry-based biorefineries
Membrane technologies
TRANSPORT
Advanced Fuel Cells
Fuel cell systems for stationary applications
Fuel cells for portable applications
Fuel cells for transportation
Molten carbonate fuel cells
Polymer electrolyte fuel cells
Solid oxide fuel cells
Systems analysis of fuel cells
Advanced Materials for Transportation
Advanced coatings to improve engine durability and efficiency
Integrated surface technology to reduce friction in engines
Low-cost carbon fibre measurement standards assessment
Magnesium alloy corrosion protection and durability for light-weighting of vehicles
Nano-materials testing and characterization for quality control
Thermoelectric materials characterisation measurement improvement and standard development
Advanced Motor Fuels
Alcohol applications
Alternative fuels for marine applications
Enhanced emission performance and fuel efficiency for heavy duty methane engines
Environmental impact of biodiesel vehicles in real traffic conditions
Exhaust gas toxicity and particulates from internal combustion engines
Life-cycle analysis of transportation fuel pathways
Particulate measurements of ethanol and butanol in diesel injection engines
Performance evaluation of passenger car fuel and power plant options
Research on unregulated pollutants emissions of vehicles fuelled with alcohol alternative fuels
Synthesis, characterisation and use of hydro-treated oils and fats in engines
Hybrid and Electric Vehicles
Accelerated testing procedures for lithium-ion battery ageing
E-mobility business models
Electrochemical systems
Electric vehicle ecosystems
Life-cycle assessments
Market deployment of hybrid and electric vehicles: lessons learned
Plug-in hybrid electric vehicles
Quick charging technology
System optimisation and vehicle integration

FOSSIL FUELS
Clean Coal
Ash utilisation: impac of recent changes in power generation practices
Carbon Capture and Storage: legal and regulatory framework
Carbon mitigation technologies for emerging economies
CCS challenges and opportunities for China
CO_2 abatement in the cement industry
CO_2 abatement in the iron and steel industry
CO_2 reductions from CCTs and CO_2 capture
Coal-fired CCS demonstration plants
Coal-to-oil, gas and chemicals in China
Co-firing high ratios of biomass with coal
Efficiency and emissions monitoring and reporting
Emissions from cofiring coal, biomass and sewage sludge
Expert systems and coal quality in power generation
Global perspective on the use of low quality coals
Hybrid carbon capture systems
Impacts of seaborn trad eon coal importing coutnries: Pacific Market
Impacts of seaborne trade on coal importing countries: Atlantic market
Impacts of seaborne trade on coal importing countries: global summary
Integrating intermittent renewable energy technologies with coal-fired power plant
Legislation, standards and methods for mercury emissions control
Low water FGD technologies
Next generation coal gasification technology
Non-greenhouse gas emissions from coal-fired power plants in China
Opportunities for fine coal utilisation
Pre-combustion capture of CO_2 in IGCC plants
Propensity of coal to self-heat
Prospects for coal and clean coal in Ukraine
Public attitudes to coal use in the context of global warming
Trace element emissions from coal
Understanding pulverised coal, biomass and waste combustion
Update on lignite firing
Utilisation of low rank coals
Enhanced Oil Recovery
Development of gas flooding techniques
Thermal recovery
Dynamic reservoir characterisation
Emerging technologies
Fundamental research on surfactants and polymers
Studies of fluids and interfaces in porous media
Fluidised Bed Conversion
Co-firing and ash problems
Energy crops and fluidised bed conversion
Fluidised bed design aspects
Mathematical, three-dimensional modelling
Recent trends in participating countries
Sewage sludge conversion

Greenhouse Gas from Fossil Fuels (Carbon Capture and Storage)
Addressing sulphur and mercury corrosion in oxyfuel combustion bioler and flue gas processing units
Barriers to implementation of ccs: capacity constraints
Caprock systems for CO_2 geological storage
Challenges and opportunities of CO_2 capture and storage for the iron and steel industry
CO_2 capture at gas fired power plants
Control of nitrosamine formation in CO_2 capture plant: report
Effects of impurities on geological storage of CO_2
Emissions of substances other than CO_2 from power plants with CCS
Feasibility of monitoring techniques for sbustances mobilised by CO_2 storage in geological formations
Gaseous emissions from amine based post combusion CO_2 capture processes and their deep removal
Global storage resources gap analysis for policy makers
Natural releases of CO_2: building knowledge for carbon storage enviornmental impact assessments
Operational demonstrations of CCS
Operating flexibility of power plants with CCS
Post combusion capture conference one
Potential for biomass and carbon dioxide capture and storage
Potential impacts on groundwater resources of geological storage
Quantificaiton techniques for CO_2 leakage
Retrofitting CO_2 capture to existing power plants
Rotating equipment for carbon dioxide capture and storage
Summary report of the 6th risk assessment network workshop
Wellbore integrity network summary report
FUSION
Environmental, Safety, Economy of Fusion
Activation products source terms
Failure-rate database
In-vessel tritium source term
Magnet safety
Power plant studies
Radioactive waste studies
Socio-economic aspects
Transient thermo-fluid modelling, validation tests
Fusion Materials
Diagnostics and control insulating ceramics modelling, computer simulation and validation
Fundamental studies of irradiation effects
Irradiation facilities and post-irradiation tests
Reduced activation and advanced ferritic steels
Silicon carbide composite materials
Tungsten and tungsten alloys
Vanadium base alloys
Nuclear Technology of Fusion Reactors
Liquid breeding blankets
Neutronics
Plasma-facing components
Plasma surface interactions
Solid breeding blankets
Tritium processing

Plasma Wall Interaction	
Design and construction of new test devices with linear plasmas and electron/ion beams	
Diagnostic developments for ITER	
Modelling of erosion, migration and deposition of wall materials in ITER	
Tritium retention and removal studies	
Reversed Field Pinches	
Co-ordinated experiments on the following devices:	
EXTRAP T2-R (Sweden)	
Madison Symmetric Torus (United States)	
TPE-RX (Japan)	
Reversed Field Experiment (Italy)	
Spherical Tori	
Physics and technology of future spherical torus devices	
Science and R&D of spherical tori devices	
Steady state operation of fusion devices	
Stellerator-Heliotron	
Confinement and profile database	
Demo assessment based on SH concepts	
Integration of high-performance, steady-state plasma confinement for reactor-relevant regimes	
International SH joint experiments	
Model validations	
Numerical code verifications	
Tokamaks	
Confinement database and modelling	
Edge and pedestal physics	
Magnetohydrodynamics, disruptions and control	
Sol and divertor physics	
Steady state operation	
Transport and internal transport barrier physics	
Tritium and remote-handling technologies	
RENEWABLES AND HYDROGEN	
Bioenergy	
Biomass combustion and co-firing	
Biomass feedstocks for energy markets	
Biorefining: sustainable processing of biomass for marketable bio-based products	
Climate change impacts of biomass and bioenergy systems	
Commercialisation of conventional and advanced liquid biofuels from biomass	
Energy from biogas	
Integrating energy recovery into solid waste management	
Pyrolysis of biomass	
Sustainable bioenergy markets and international trade: securing supply and demand	
Thermal gasification of biomass	
Concentrating Solar Power (SolarPACES)	
Solar chemistry research	
Solar energy and water processes and applications	
Solar resource knowledge management	
Solar technologies and advanced applications	
Solar thermal electric systems	

Deployment
Business models for renewable energy in the built environment
Renewable energies for remote areas and islands
Offshore renewable energy
RE in global energy scenarios
Risk quantification and risk management in renewable energy projects
Costs of inaction
Linking RE promotion policies with international carbon trade
Financing renewable energy: key challenges for large-scale deployment
Geothermal
Advanced geothermal drilling and logging technologies
Direct use of geothermal energy
Data collection and information
Environmental impacts of geothermal development
Enhanced geothermal systems
Induced seismicity
Hydropower
Hydropower and the environment
Hydropower services
Hydropower upgrading
Renewal and upgrading of hydropower plants
Small-scale hydropower
Hydrogen
Bio-hydrogen
Distributed and community hydrogen
Fundamental and applied hydrogen storage materials development
Global hydrogen systems analysis
Hydrogen-based energy storage
Hydrogen safety
Large-scale delivery infrastructure
Small-scale reformers for on-site hydrogen
Water photolysis
Ocean
Environmental effects and monitoring efforts
Exchange and assessment of project information
Grid integration
Guidelines for development and testing
Photovoltaic Power Systems
Deploying PV services for regional development
High penetration of PV in electricity grids
Hybrid systems within mini-grids
PV services for developing countries
PV environmental health and safety activities
Large-scale PV power generation systems
Performance and reliability of PV systems
Solar Heating and Cooling
Advanced lighting for retrofitting buildings
Compact thermal energy storage
Large-scale solar heating and cooling systems

Polymeric materials
Quality assurance and support measures for solar cooling systems
Solar and heat pump systems
Solar energy in urban planning
Solar heat integration in industrial processes
Solar rating and certification procedures
Solar renovation of non-residential buildings
Solar resource assessment and forecasting for net zero energy solar buildings
Wind Turbine Systems
Benchmarking wind farm flow models
Comparing codes for offshore wind foundations
Cost of wind energy
Environmental monitoring, assessment
Improving aerodynamic models
Integrating wind into power systems
Small wind turbine quality labelling
Social acceptance of wind energy projects
Standardising wind turbine reliability data
Remote sensing technology for wind energy deployment
Wind energy in cold climates

SCOPE AND PORTFOLIOS

		Basic science[1]	Applied science[2]	Demonstration and deployment[3]	Socio-economic issues[4]
Cross-cutting	Climate Technology Initiative			✓	✓
	Energy Technology Data Exchange			✓	✓
	Energy Technology Systems Analysis			✓	✓
End-use: buildings	Buildings and Communities		✓	✓	✓
	District Heating and Cooling		✓	✓	✓
	Energy Efficient Electrical Equipment		✓	✓	✓
	Energy Storage		✓	✓	✓
	Heat Pumping Technologies		✓	✓	✓
End-use: electricity	Demand-Side Management		✓	✓	✓
	High-temperature Superconductivity		✓	✓	✓
	Smart Grids		✓	✓	✓
End-use: industry	Emissions Reduction in Combustion	✓	✓	✓	✓
	Industrial Technologies and Systems		✓	✓	✓
End-use: transport	Advanced Fuel Cells		✓	✓	✓
	Advanced Motor Fuels		✓	✓	✓
	Advanced Transport Materials	✓	✓	✓	✓
	Hybrid and Electric Vehicles		✓	✓	✓
Fossil fuels	Clean Coal Centre		✓	✓	✓
	Enhanced Oil Recovery		✓	✓	
	Fluidized Bed Conversion		✓	✓	
	Greenhouse Gas R&D		✓	✓	✓
	Multiphase Flow Sciences	✓	✓	✓	
Fusion power	Environmental, Safety and Economy			✓	✓
	Fusion Materials	✓	✓		
	Nuclear Technology Fusion Reactors	✓	✓		
	Plasma Wall Interaction	✓	✓		
	Reversed Field Pinches	✓	✓		
	Spherical Tori	✓	✓		
	Stellarator-Heliotron Concept	✓	✓		
	Tokamaks	✓	✓		
Renewables and hydrogen	Bioenergy		✓	✓	✓
	Concentrating solar		✓	✓	
	Deployment		✓	✓	✓
	Geothermal		✓	✓	
	Hydrogen		✓	✓	
	Hydropower		✓	✓	
	Ocean		✓	✓	
	Photovoltaics		✓	✓	
	Solar Heating and Cooling		✓	✓	
	Wind Energy Systems		✓	✓	✓

1. Physics, chemistry, conversion processes, mechanics, commercial technologies and materials.
2. Characterisation, insitu testing, and literature reviews of existing technologies or energy sources.
3. Market introduction, sectoral analysis, technology and knowledge transfer.
4. Includes employment, social acceptance, trade, finance and other socio-economic issues related to use of the technology or energy source.

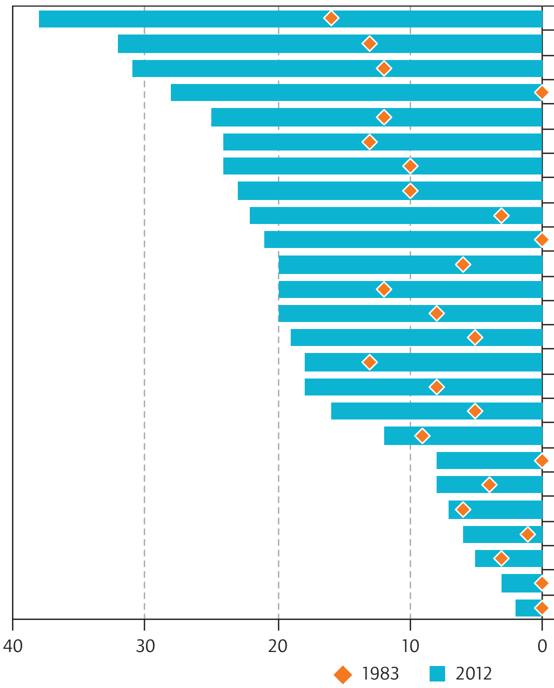
ENERGY SECTORS

		Supply	Transformation [1]	Demand
Cross-cutting	Climate Technology Initiative			✓
	Energy Technology Data Exchange	✓	✓	✓
	Energy Technology Systems Analysis	✓	✓	✓
End-use: buildings	Buildings and Communities		✓	✓
	District Heating and Cooling		✓	✓
	Energy Efficient Electrical Equipment		✓	✓
	Energy Storage		✓	✓
	Heat Pumping Technologies		✓	✓
End-use: electricity	Demand-Side Management		✓	✓
	High-temperature Superconductivity		✓	✓
	Smart Grids		✓	✓
End-use: industry	Emissions Reduction in Combustion		✓	✓
	Industrial Technologies and Systems		✓	✓
End-use: transport	Advanced Fuel Cells		✓	✓
	Advanced Motor Fuels	✓	✓	✓
	Advanced Transport Materials			✓
	Hybrid and Electric Vehicles	✓		✓
Fossil fuels	Clean Coal Centre	✓		
	Enhanced Oil Recovery	✓		
	Fluidized Bed Conversion	✓	✓	
	Greenhouse Gas R&D	✓	✓	
	Multiphase Flow Sciences	✓	✓	
Fusion power	Environmental, Safety and Economy	✓	✓	
	Fusion Materials	✓	✓	
	Nuclear Technology Fusion Reactors	✓	✓	
	Plasma Wall Interaction	✓	✓	
	Reversed Field Pinches	✓	✓	
	Spherical Tori	✓	✓	
	Stellarator-Heliotron Concept	✓	✓	
	Tokamaks	✓	✓	
Renewables and hydrogen	Bioenergy		✓	✓
	Concentrating solar	✓		✓
	Deployment	✓	✓	✓
	Geothermal	✓	✓	✓
	Hydrogen		✓	✓
	Hydropower	✓	✓	✓
	Ocean	✓	✓	✓
	Photovoltaics	✓	✓	✓
	Solar Heating and Cooling	✓	✓	✓
	Wind Energy Systems	✓	✓	✓

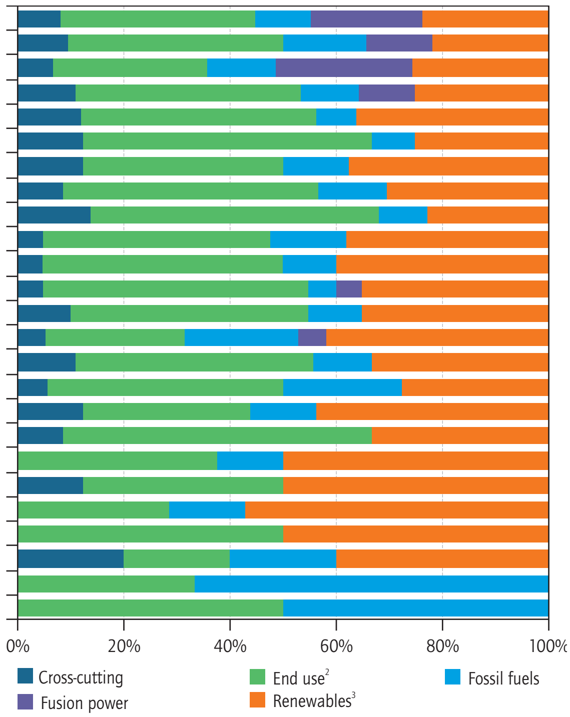
1. Electricity or heat generation and distribution, transformation from one state to another and combustion processes.

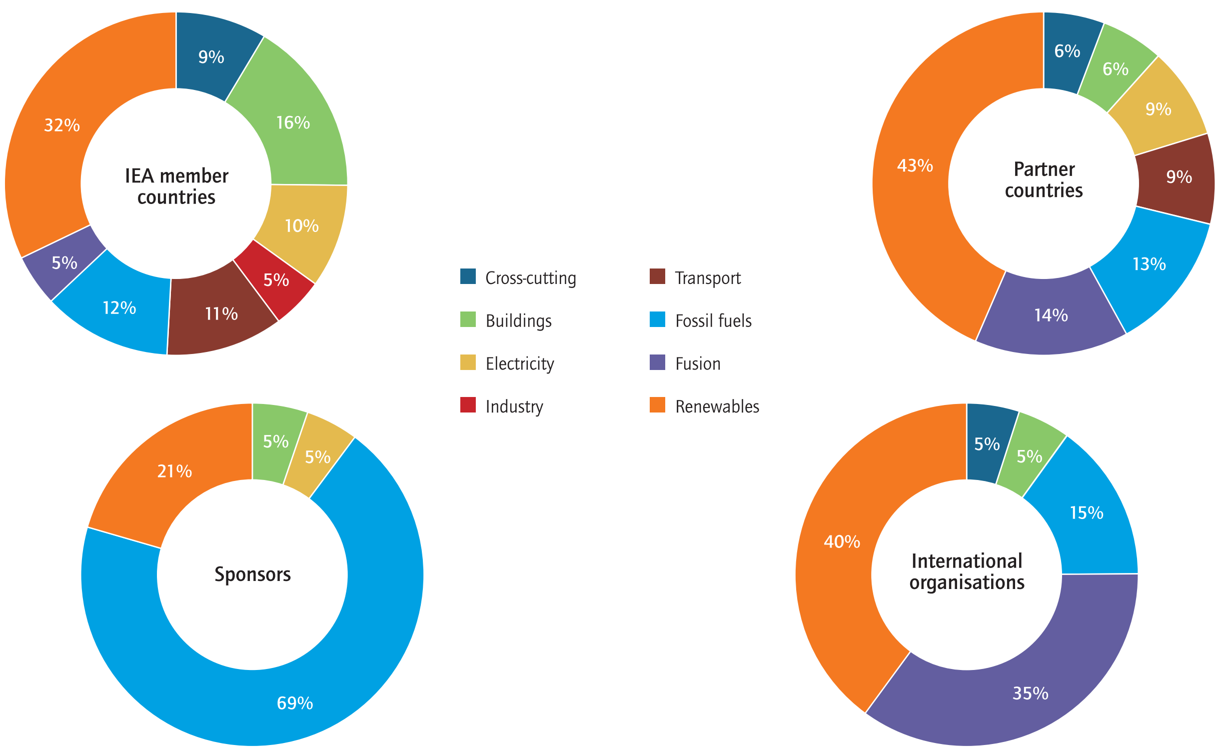
PARTICIPATION

Changes in participations, 1983-2012[1]



Share by sector, 2012





1. Countries that joined the IEA after 1983: the Czech Republic (2002), Finland and France (1992), Korea (2002) and Poland (2008). Hungary, Luxembourg and the Slovak Republic do not as yet participate in Implementing Agreements.
2. The end-use category includes buildings, electricity, industry and transport.
3. Renewables includes hydrogen.

ALL CATEGORIES

As of 31 December 2012

	Cross-cutting	End-Use				Fossil fuels	Fusion power	Renewables and hydrogen	TOTAL
		Buildings	Electricity	Industry	Transport				
Australia	1	2	1		2	4	1	8	**19**
Austria	1	3	2		3	4		5	**18**
Belgium	1	2	2	2	1			4	**12**
Canada	3	5	2	2	4	5	3	7	**32**
Czech Republic		1				1			**2**
Denmark	2	5		1	3	2		7	**20**
Finland	3	4	3	1	4	2		5	**22**
France	1	4	2		3	3		8	**21**
Germany	3	4	2	1	4	2		9	**25**
Greece	1	1				1		2	**5**
Ireland	1	1	1		1			4	**8**
Italy	1	3	3	1	3	2		8	**20**
Japan	2	4	2	1	2	4	8	8	**31**
Korea	3	5	3	2	2	3	3	7	**28**
Netherlands	2	3	3	1	1	2		6	**18**
New Zealand		1	1			1		4	**7**
Norway	3	4	3	2		3		9	**24**
Poland		1				2		0	**3**
Portugal		1		1	1	1		4	**8**
Spain	2	1	2		2	2		7	**16**
Sweden	3	5	3	2	3	2		6	**24**
Switzerland	1	3	3	1	3	1	1	7	**20**
Turkey		2			1			3	**6**
United Kingdom	2	5	3	1	2	3		7	**23**
United States	3	5	3	2	4	4	8	9	**38**
IEA member countries	**39**	**75**	**44**	**21**	**49**	**54**	**24**	**144**	**450**
Algeria								1	**1**
Brazil	1							3	**4**
China		2	1		2	2	3	5	**15**
Croatia								1	**1**
Egypt								1	**1**
Iceland								2	**2**
India			2			1	3		**6**
Israel		1	1					2	**6**
Lithuania								1	**1**
Malaysia								1	**1**
Mexico	1		1		1	1		6	**10**
Morocco								1	**1**
Russia	1		1			2	4		**8**
Singapore								1	**1**
Slovenia		1							**1**
South Africa	1					2		4	**7**
Thailand					1				**1**
Ukraine							1		**1**
United Arab Emirates								1	**1**
Venezuela						1			**1**
Partner countries	**4**	**4**	**6**		**6**	**9**	**11**	**30**	**70**
In IEA countries		3	3			30		10	**46**
In partner countries						10		2	**12**
Sponsors		**3**	**3**			**40**		**12**	**58**
EC	1	1				2	8	7	**18**
ITER							1		**1**
OPEC						1			**1**
UNIDO								1	**1**
Intl. organisations	**1**	**1**				**3**	**9**	**8**	**22**
TOTAL	**44**	**83**	**53**	**21**	**55**	**106**	**44**	**194**	**600**

EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).
Participations change frequently. For the most updated information, please consult www.iea.org/techinitiatives.

CROSS-CUTTING ACTIVITIES

As of 31 December 2012

	Climate Technology Initiative	Energy Technology Data Exchange	Energy Technology Systems Analysis	TOTAL
Australia	1			1
Austria	1			1
Belgium			1	1
Canada	1	1	1	3
Czech Republic				
Denmark		1	1	2
Finland	1	1	1	3
France			1	1
Germany	1	1	1	3
Greece			1	1
Ireland			1	1
Italy			1	1
Japan	1		1	2
Korea	1	1	1	3
Netherlands		1	1	2
New Zealand				
Norway	1	1	1	3
Poland				
Portugal				
Spain		1	1	2
Sweden	1	1	1	3
Switzerland			1	1
Turkey				
United Kingdom	1		1	2
United States	1	1	1	3
IEA member countries	11	10	18	39
Algeria				
Brazil		1		1
China				
Croatia				
Egypt				
Iceland				
India				
Israel				
Lithuania				
Malaysia				
Mexico		1		1
Morocco				
Russia			1	1
Singapore				
Slovenia				
South Africa		1		1
Thailand				
Ukraine				
United Arab Emirates				
Venezuela				
Partner countries		3	1	4
In IEA countries				
In partner countries				
Sponsors				
EC			1	1
ITER				
OPEC				
UNIDO				
Intl. organisations			1	1
TOTAL	11	13	20	44

EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).
Participations change frequently. For the most updated information, please consult www.iea.org/techinitiatives.

END-USE: BUILDINGS

As of 31 December 2012

	Buildings and community systems	District heating and cooling	Efficient electrical equipment	Energy storage	Heat pumping technologies	TOTAL
Australia	1		1			**2**
Austria	1		1		1	**3**
Belgium	1			1		**2**
Canada	1	1	1	1	1	**5**
Czech Republic	1					**1**
Denmark	1	1	1	1	1	**5**
Finland	1	1		1	1	**4**
France	1		1	1	1	**4**
Germany	1	1		1	1	**4**
Greece	1					**1**
Ireland	1					**1**
Italy	1			1	1	**3**
Japan	1		1	1	1	**4**
Korea	1	1	1	1	1	**5**
Netherlands	1		1		1	**3**
New Zealand	1					**1**
Norway	1	1		1	1	**4**
Poland	1					**1**
Portugal	1					**1**
Spain	1					**1**
Sweden	1	1	1	1	1	**5**
Switzerland	1		1		1	**3**
Turkey	1			1		**2**
United Kingdom	1	1	1	1	1	**5**
United States	1	1	1	1	1	**5**
IEA member countries	**25**	**9**	**12**	**14**	**15**	**75**
Algeria						
Brazil						
China	1			1		**2**
Croatia						
Egypt						
Iceland						
India						
Israel	1					**1**
Lithuania						
Malaysia						
Mexico						
Morocco						
Russia						
Singapore						
Slovenia				1		1
South Africa						
Thailand						
Ukraine						
United Arab Emirates						
Venezuela						
Partner countries	**2**			**2**		**4**
In IEA countries				3		3
In partner countries						
Sponsors				**3**		**3**
EC				1		**1**
ITER						
OPEC						
UNIDO						
Intl. organisations				**1**		**1**
TOTAL	**27**	**9**	**12**	**20**	**15**	**83**

EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation). Participations change frequently. For the most updated information, please consult www.iea.org/techinitiatives.

END-USE: ELECTRICITY AND INDUSTRY

As of 31 December 2012

	Electricity				Industry		
	Demand-side management	High-temperature superconductivity	Smart grids	TOTAL	Emissions reduction in combustion	Industrial technologies and systems	TOTAL
Australia			1	1			
Austria	1		1	2			
Belgium	1		1	2	1	1	2
Canada		1	1	2	1	1	2
Czech Republic							
Denmark						1	1
Finland	1	1	1	3	1		1
France	1		1	2			
Germany		1	1	2	1		1
Greece							
Ireland			1	1			
Italy	1	1	1	3	1		1
Japan		1	1	2	1		1
Korea	1	1	1	3	1	1	2
Netherlands	1	1	1	3		1	1
New Zealand	1			1			
Norway	1	1	1	3	1	1	2
Poland							
Portugal						1	1
Spain	1		1	2			
Sweden	1	1	1	3	1	1	2
Switzerland	1	1	1	3	1		1
Turkey							
United Kingdom	1	1	1	3	1		1
United States	1	1	1	3	1	1	2
IEA member countries	14	12	18	44	12	9	21
Algeria							
Brazil							
China			1	1			
Croatia							
Egypt							
Iceland							
India	1		1	2			
Israel		1		1			
Lithuania							
Malaysia							
Mexico			1	1			
Morocco							
Russia			1	1			
Singapore							
Slovenia							
South Africa							
Thailand							
Ukraine							
United Arab Emirates							
Venezuela							
Partner countries	1	1	4	6			
In IEA countries	1	2		3			
In partner countries							
Sponsors	1	2		3			
EC							
ITER							
OPEC							
UNIDO							
Intl. organisations							
TOTAL	16	15	22	53	12	9	21

EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation). Participations change frequently. For the most updated information, please consult www.iea.org/techinitiatives.

END-USE: TRANSPORT

As of 31 December 2012

	Advanced fuel cells	Advanced motor fuels	Advanced motor fuels	Hybrid and electric vehicles	TOTAL
Australia	1	1			2
Austria	1		1	1	3
Belgium				1	1
Canada	1	1	1	1	4
Czech Republic					
Denmark	1		1	1	3
Finland	1	1	1	1	4
France	1		1	1	3
Germany	1	1	1	1	4
Greece					
Ireland				1	1
Italy	1		1	1	3
Japan	1		1		2
Korea	1		1		2
Netherlands				1	1
New Zealand					
Norway					
Poland					
Portugal				1	1
Spain			1	1	2
Sweden	1		1	1	3
Switzerland	1		1	1	3
Turkey				1	1
United Kingdom		1		1	2
United States	1	1	1	1	4
IEA member countries	**13**	**6**	**13**	**17**	**49**
Algeria					
Brazil					
China		1	1		2
Croatia					
Egypt					
Iceland					
India					
Israel	1	1			2
Lithuania					
Malaysia					
Mexico	1				1
Morocco					
Russia					
Singapore					
Slovenia					
South Africa					
Thailand			1		1
Ukraine					
United Arab Emirates					
Venezuela					
Partner countries	**2**	**2**	**2**		**6**
In IEA countries					
In partner countries					
Sponsors					
EC					
ITER					
OPEC					
UNIDO					
Intl. organisations					
TOTAL	**15**	**8**	**15**	**17**	**55**

EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation). Participations change frequently. For the most updated information, please consult www.iea.org/techinitiatives.

FOSSIL FUELS

As of 31 December 2012

	Clean coal centre	Enhanced oil recovery	Fluidised bed conversion	Greenhouse gas R&D	Multiphase flow sciences	TOTAL
Australia	1	1		1	1	4
Austria	1	1	1	1		4
Belgium						
Canada	1	1	1	1	1	5
Czech Republic			1			1
Denmark		1		1		2
Finland			1	1		2
France		1	1	1		3
Germany	1			1		2
Greece			1			1
Ireland						
Italy	1		1			2
Japan	1	1	1	1		4
Korea	1		1	1		3
Netherlands				1		1
New Zealand				1		1
Norway		1		1	1	3
Poland	1		1			2
Portugal			1			1
Spain			1	1		2
Sweden			1	1		2
Switzerland				1		1
Turkey						
United Kingdom	1	1	1	1		4
United States	1	1		1	1	4
IEA member countries	10	9	14	17	4	54
Algeria						
Brazil						
China			1		1	2
Croatia						
Egypt						
Iceland						
India				1		1
Israel						
Lithuania						
Malaysia						
Mexico					1	1
Morocco						
Russia		1	1			2
Singapore						
Slovenia						
South Africa	1			1		2
Thailand						
Ukraine						
United Arab Emirates						
Venezuela		1				1
Partner countries	1	2	2	2	2	9
In IEA countries	6		1	23		30
In partner countries	7			3		10
Sponsors	13		1	26		40
EC	1			1		2
ITER						
OPEC				1		1
UNIDO						
Intl. organisations	1			2		3
TOTAL	25	11	17	47	6	106

EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).
Participations change frequently. For the most updated information, please consult www.iea.org/techinitiatives.

FUSION POWER

As of 31 December 2012

	Environment, safety, economy of fusion	Fusion materials	Nuclear technology	Plasma wall interaction	Reversed field pinches	Spherical tori	Stellarator concept	Tokamaks	TOTAL
Australia							1		**1**
Austria									
Belgium									
Canada	1	1	1						**3**
Czech Republic									
Denmark									
Finland									
France									
Germany									
Greece									
Ireland									
Italy									
Japan	1	1	1	1	1	1	1	1	**8**
Korea		1	1					1	**3**
Netherlands									
New Zealand									
Norway									
Poland									
Portugal									
Spain									
Sweden									
Switzerland		1							**1**
Turkey									
United Kingdom									
United States	1	1	1	1	1	1	1	1	**8**
IEA member countries	3	5	4	2	2	2	3	3	24
Algeria									
Brazil									
China	1	1	1						**3**
Croatia									
Egypt									
Iceland									
India		1	1					1	**3**
Israel									
Lithuania									
Malaysia									
Mexico									
Morocco									
Russia	1	1	1				1		**4**
Singapore									
Slovenia									
South Africa									
Thailand									
Ukraine							1		**1**
United Arab Emirates									
Venezuela									
Partner countries	2	3	3				2	1	11
In IEA countries									
In partner countries									
Sponsors									
EC	1	1	1	1	1	1	1	1	**8**
ITER								1	**1**
OPEC									
UNIDO									
Intl. organisations	1	1	1	1	1	1	1	2	9
TOTAL	6	9	8	3	3	3	6	6	44

EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation). Participations change frequently. For the most updated information, please consult www.iea.org/techinitiatives.

RENEWABLE ENERGIES AND HYDROGEN

As of 31 December 2012

	Bio-energy	Concen-trating solar power	Deploy-ment	Geo-thermal	Hydrogen	Hydro-power	Ocean Energy	Photo-voltaic	Solar heating and cooling	Wind	TOTAL
Australia	1	1		1	1		1	1	1	1	8
Austria	1	1						1	1	1	5
Belgium	1						1	1	1		4
Canada	1		1		1		1	1	1	1	7
Czech Republic											
Denmark	1		1		1		1	1	1	1	7
Finland	1				1	1			1	1	5
France	1	1	1	1	1	1		1	1		8
Germany	1	1	1	1	1		1	1	1	1	9
Greece					1					1	2
Ireland	1		1				1			1	4
Italy	1	1		1	1		1	1	1	1	8
Japan	1		1	1	1	1	1	1		1	8
Korea	1	1		1	1		1	1		1	7
Netherlands	1		1		1			1	1	1	6
New Zealand	1			1	1		1				4
Norway	1		1	1	1	1	1	1	1	1	9
Poland											
Portugal							1	1	1	1	4
Spain		1		1	1		1	1	1	1	7
Sweden	1				1		1	1	1	1	6
Switzerland	1	1		1	1			1	1	1	7
Turkey	1				1			1			3
United Kingdom	1		1	1	1		1	1		1	7
United States	1	1		1	1	1	1	1	1	1	9
IEA member countries	20	9	9	12	19	5	16	19	16	19	144
Algeria		1									1
Brazil	1	1				1					3
China		1				1	1	1	1		5
Croatia	1										1
Egypt		1									1
Iceland				1	1						2
India											
Israel		1						1			2
Lithuania					1						1
Malaysia								1			1
Mexico		1		1			1	1	1	1	6
Morocco		1									1
Russia											
Singapore									1		1
Slovenia											
South Africa	1	1					1		1		4
Thailand											
Ukraine											
United Arab Emirates		1									1
Venezuela											
Partner countries	3	9		2	2	2	3	4	4	1	30
In IEA countries		1		5				3		1	10
In partner countries									1	1	2
Sponsors		1		5				3	1	2	12
EC	1	1		1	1			1	1	1	7
ITER											
OPEC											
UNIDO					1						1
Intl. organisations	1	1		1	2			1	1	1	8
TOTAL	24	20	9	20	23	7	19	27	22	23	194

EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).
Participations change frequently. For the most updated information, please consult www.iea.org/techinitiatives.

SPONSORS

As of 31 December 2012

	Headquarters	Cross-cutting	End-use				Fossil fuels	Fusion power	Renewables and hydrogen	TOTAL
			Buildings	Electricity	Industry	Transport				
Alstom Power Technology AG	*France*						1			1
Babcock & Wilcox	*United States*						1			1
BG International	*United Kingdom*						1			1
BP International Ltd.	*United Kingdom*						1			1
Bruker HTSGmbH	*United States*			1						1
CanGEA	*Canada*								1	1
CEZ, a.s	*Czech Republic*						1			1
Chevron Corporation	*United States*						1			1
Coal Industry Advisory Board	*France*						1			1
Coal Association of New Zealand	*New Zealand*						1			1
Columbus Superconductors	*Italy*			1						1
Danish Power Group	*Denmark*						1			1
Doosan Power Systems Limited	*United Kingdom*						1			1
E.ON UK	*United Kingdom*						1			1
Electric Power Research Institute	*United States*						1			1
EnBW Kraftwerke AG	*Germany*						1			1
Enel Ingengeria e Innovazione SpA	*Italy*						1			1
European Photovoltaic Industry Ass.	*Belgium*								1	1
European Wind Energy Ass.	*Belgium*								1	1
ExxonMobil Corporation	*United States*						1			1
Geodynamics Ltd	*Australia*								1	1
Geothermal Group of APPA	*Spain*								1	1
Global CCS Insitute	*Australia*						1			1
Green Rock Energy Ltd	*Australia*								1	1
IF Technology b.v	*Netherlands*		1							1
JGC Corp.	*Japan*						1			1
Mitsubishi Corporation	*Japan*								1	1
ORMAT Technologies, Inc	*United States*								1	1
Regulatory Assistance Project	*United States*			1						1
Repsol YPF	*Spain*						1			1
RWE Aktiengesellschaft	*Germany*						1			1
Schlumberger Cambridge Research	*United States*						1			1
Schlumberger Carbon Services	*United States*						1			1
Scottish Power Generation Limited	*United Kingdom*						1			1
Shell International BV	*Netherlands*						1			1
Shaw Consultants, International, Inc.	*United States*						1			1
Solar Electric Power Association	*United States*								1	1
Solar Energy Industries Association	*United States*								1	1
Statkraft Development AS	*Norway*						1			1
Statoil	*Norway*						1			1
Total	*France*						1			1
University of Lleida	*Spain*		1							1
Vattenfall AB	*Sweden*						2			2
Warsaw University of Technology	*Poland*		1							1
Xstrata Coal	*Australia*						1			1
Located in IEA member countries			3	3			30		10	46
Anglo Coal	*South Africa*						1			1
Banpu Plc.	*Thailand*						1			1
Bharat Heavy Electricals Ltd.	*India*						1			1
Beijing Research Inst. Clean Coal	*China*						1			1
Chinese Wind Energy Association	*China*								1	1
Regional Centre for Renewable Energy & Energy Efficiency	*Cape Verde Islands*								1	1
Eletrobràs	*Brazil*						1			1
Electric Power Planning and Engineering Institute	*China*						1			1
Masdar Carbon	*United Arab Emirates*						1			1
Petrobras	*Brazil*						1			1
SUEK	*Russia*						1			1
Instituto de Investigaciones Eléctricas	*Mexico*						1			1
Located in partner countries							10		2	12
TOTAL SPONSORS			3	3			40		12	58

Note: This table represents participation by industries that are signatories to Implementing Agreements (sponsors). It does not include those cases where governments ask industry to represent them in the Agreements, nor does it include industry participation in the research tasks or in-kind contributions – estimated at well over 500 companies. Participations change frequently. For the most updated information, please consult www.iea.org/techinitiatives.

IEA ENERGY TECHNOLOGY ACTIVITIES

Technology Forecasting, Analysis and Strategies

Energy Technology Network

TECHNOLOGY FORECASTING, ANALYSIS AND STRATEGIES

This chapter provides a short overview of all IEA energy technology activities and highlights how the IAs fit within this wider programme.

Energy Technology Perspectives

The publication *Energy Technology Perspectives 2012 (ETP 2012)* is the IEA most ambitious analysis regarding current and expected developments in energy technology. It demonstrates how technologies can make a decisive difference in achieving the objective of limiting the global temperature rise to 2°C and enhancing energy security (the two-degree scenario, or "2DS"). The 2DS sets the target of cutting energy-related CO_2 emissions by more than half by 2050 (compared with 2009) and ensuring that they continue to fall thereafter. Since 2006, the *ETP* series aims to:

- guide short term action based on long-term analysis;
- outline the technological options for achieving deep cuts in carbon emissions over the next 50 years – and beyond;
- assess the state of progress in transforming the energy system;
- outline possible pathways to a more sustainable energy system;
- identify potential stumbling blocks and how to avoid them;
- provide guidance on which policies are best suited to bring about necessary changes at least cost and most effectively;
- assess benefits and costs associated with different scenarios.

ETP is the IEA most long-term outlook. Until now, the main results have been presented up to 2050. Forthcoming editions will focus on scenarios to 2075. Importantly for the purposes of this publication, *ETP* regularly draws on work carried out in some IEA IAs.

Technology roadmaps

At their meeting in June 2008 in Aomori, Japan, G8 leaders expressed a desire for the IEA to prepare roadmaps to advance innovative energy technologies. In response, the IEA has developed a series of global low-carbon energy technology roadmaps covering the most important technologies such as solar photovoltaics and electric vehicles, but also roadmaps for energy intensive sectors such as heating and cooling for buildings and the cement industry. All roadmaps are prepared in close consultation with governments, industry and the relevant IAs. The vision for each of the IEA roadmaps is based on the *ETP* 2DS mentioned above.

Each roadmap sets out milestones for technology development, legal/regulatory needs, investment requirements, public engagement and international collaboration in order for each technology or sector to fulfil its contribution to realise the 2DS by 2050. Importantly, several IAs have been instrumental in providing expertise to the technology roadmaps. Roadmaps published to date include:

- *Energy Technology Roadmaps: A Guide to Development and Implementation*
- *Bioenergy for Heat and Power*
- *Biofuels for Transport*
- *Carbon Capture and Storage*
- *Carbon Capture and Storage in Industrial Applications*
- *Cement*
- *Concentrating Solar Power*
- *Electric and Plug-in Hybrid Vehicles*
- *Energy Efficient Buildings: Heating and Cooling Equipment*
- *Fuel Economy of Road Vehicles*
- *Geothermal Heat and Power*
- *High-Efficiency, Low-Emissions Coal-Fired Power Generation*
- *Hydropower*
- *Low-Carbon Technology for the Indian Cement Industry*
- *Nuclear Energy*
- *Solar Photovoltaic Energy*
- *Smart Grids*
- *Solar Heating and Cooling*
- *Wind Energy*

Several of the roadmaps have been translated into languages other than English, including Arabic, Mandarin and Russian. Training workshops on the IEA technology roadmap methodology are regularly carried out in collaboration with the IEA Training and Capacity Building Programme. In addition, the "How2Guides" of the IEA International Low-Carbon Energy Technology Platform draw on the IEA methodology for global roadmaps to provide technology-specific policy and methodology guidance for roadmap development at the national level.

ENERGY TECHNOLOGY NETWORK

Under the oversight of the IEA Governing Board, the Committee on Energy Research and Technology (CERT) is responsible for implementing IEA priorities with regard to research, development, demonstration and deployment (RDD&D). It is supported in these efforts by four working parties and two informal experts' groups. Together with the IAs, these entities comprise what is known as the IEA energy technology network.

Committee on Energy Research and Technology (CERT)

Comprised of senior experts from IEA member governments, the CERT considers effective energy technology and policies to improve energy security, encourage environmental protection and maintain economic growth. Under the guidance of the IEA Governing Board, the CERT oversees the technology forecasting, analyses and RDD&D strategies of the IEA Secretariat, notably through its flagship publication, *ETP 2012*, and the series of energy technology roadmaps mentioned above.

The CERT also provides guidance to its working parties and experts' groups to examine topics that address current energy technology, or technology policy, issues. Through briefing papers and on the basis of presentations of selected external experts, including from IAs, CERT discussions in the last two years have focused on the following topics:

- "Rare Earth Minerals and Critical Materials" are essential for many technologies, including hybrid and electric vehicles and solar photovoltaics. This work increased the understanding of the needs for these minerals and the amount and location of global supply - an important elements for member countries to consider when formulating their respective policies in this area.
- Given recent gas finds and expansion of production of shale gas, the work on 'Gas Beyond 2020 Implications for Technology Policies and Technologies' examined the effect of lower gas prices on deployment of renewables for electricity generation.
- "Integrated Energy Systems of the Future" examined the advantages of a strategic, systems approach to national plans for heating and cooling, electricity (flexible production and delivery), and transport, including the role for energy storage.

Working Parties

There are four CERT working parties, each considering national policy developments and technology trends relating to their area of specialisation. They support and facilitate RDD&D co-operation among member countries, and, as appropriate, seek opportunities to collaborate with partner countries. They also regularly review the accomplishments of each IA in their relevant area of expertise and make a recommendation to the CERT for the continuation of each such IA. Working parties are comprised of programme managers and technology experts representing governmental agencies.

Working Party on Energy End-Use Technologies (EUWP)

The main objectives of the EUWP are to guide the work of the end-use technology IAs and to identify gaps in technologies and energy end-use systems. The EUWP builds relationships and engages with industry and partner countries through the work of the end-use IAs. The EUWP also follows closely the work of the Energy Efficiency Working Party (EEWP) and the International partnership for Energy Efficiency Co-operation (IPEEC). Recent workshops organised under the auspices of the EUWP, which generally involved experts from IAs, included:

- "Gaps in Technologies and Systems Analysis for the Industry and Transport Sectors:" examined the technologies and sectors with the greatest potential for energy savings. For industry, the iron/steel, cement, and petrochemical sectors were identified as priority areas. For transport, rethinking management of transport systems, for example more efficient logistics for shipping or better co-ordination between urban planning and transport planning, were recognised as important areas for further work.
- "From Buildings to Smart Cities" built further on the interconnection between energy efficiency improvements in community systems and transport. Participants highlighted the importance for municipal planners to consider, in parallel, smart grid technologies such as smart meters, together with new modes of transport such as electric vehicles.

Working Party on Fossil Fuels (WPFF)

The objectives of the WPFF are to encourage energy security and environmental protection by monitoring fossil fuel technology-related policies and trends of IEA member and key partner countries. The WPFF has been instrumental in bringing carbon capture and storage (CCS) and clean coal technologies to the forefront of policy debates. It works closely with the IEA Coal Industry Advisory Board, the Global Carbon Capture and Storage Institute and the Carbon Sequestration Leadership Forum. The WPFF also oversees the activities of the IAs operating in relevant technology fields. Recent topics examined under the auspices of the WPFF involving experts from IAs were as follows:

- "Next Generation Fossil Fuel Technologies" is a recurring theme in WPFF meetings. Recent issues examined include advances in technologies related to shale gas exploration, coal-fired power plants and processes to create crude oil from coal. For each area, national research programmes were measured against industrial perspectives, particularly with regard to improvements in treating environmental issues. The results of the discussions informed the IEA technology roadmap, *High-Efficiency, Low-Emissions Coal-Fired Power Plants*.
- The "High-Level Policy Dialogue on Implementation of Carbon Capture and Storage" was a roundtable reporting from IEA member country governments, China, and international initiatives of national priorities with regard to CCS. Despite a significant increase in pilot projects, participants shared current challenges relating to implementation, in particular relating to regulation, investments and infrastructure needs (in the cases where the geological formation is far from the origin of the CO_2). The need to review and revise policies and investment strategies to match technology evolution was cited.

Working Party on Renewable Energy Technologies (REWP)

The objectives of the REWP are to consider policies, market issues and technologies related to renewable energy sources and hydrogen. The REWP also co-ordinates the RD&D efforts of the renewable energy IAs, in particular with regard to deployment. The REWP also ensures government-private sector dialogue by monitoring the role of finance and markets through the Renewable Industry Advisory Board (RIAB), an informal body created by the CERT in June 2011. Finally, the REWP maintains close ties with the International Renewable Energy Agency (IRENA). Recent topics examined under the auspices of the REWP, again involving experts from IAs, are as follows:

- In collaboration with the Italian government and key international organisations and initiatives, 'From Mediterranean Plans to Renewable Energy Power Plants' reviewed initiatives to support major North African renewable deployment programmes. Given the global economic downturn, and despite a recent history of regional political instabilities, participants highlighted strategies to maintain attractiveness to investors in order to achieve the medium-term plan for these projects.
- "Renewables – Policy and Market Design Challenges" examined whether policy frameworks in IEA member countries were sufficient to maintain the strong growth in the renewables sector given lower natural gas prices. Participants agreed that in order to provide the optimal conditions under which investments – and employment – in renewables and other low-carbon technologies could be sustained; further governmental incentives would be needed.

Fusion Power Co-ordinating Committee (FPCC)

The objectives of the FPCC are to provide a forum to co-ordinate international science and research with regard to fusion: device-specific research (tokamaks and alternate concepts) and cross-cutting research (materials, safety and technologies). As with the other working parties, the FPCC also oversees the eight IAs operating in its area. Organisations and initiatives, such as the International Atomic Energy Agency and the ITER project, as well as key partner countries, regularly participate in FPCC meetings. Following the establishment of ITER in 2007, discussions in the FPCC have focused on rationalising international scientific programmes concerning fusion, including among the fusion-related IAs. One important recent action of the FPCC was the creation of a co-ordination group to examine "steady-state operations" in all fusion-related IAs. Steady-state operation, or maintaining the plasma in equilibrium, is one of the key challenges to successfully creating power from fusion devices.

Experts' and ad hoc groups

From time to time, IEA member countries establish informal experts groups to serve as focused, ad hoc or advisory bodies. In the case of CERT, two such bodies currently exist to advise the CERT and working parties by examining cross-cutting issues relevant to energy technology research through expert workshops and discussions.

Experts' Group on R&D Priority-Setting and Evaluation (EGRD)

The EGRD examines analytical approaches to energy technologies, policies, and R&D. The results and recommendations support the CERT, feed into IEA analysis, and enable a broad perspective of energy technology issues. Recent topics examined under the auspices of the EGRD involving experts from IAs included:

- "Energy Technology R&D Needs of Emerging Economies" provided an opportunity for partner countries, IEA member countries to report on national R&D strategies, to highlight common challenges and to identify opportunities for international collaboration. Drivers, needs, and opportunities for all participants, including the financial sector, were also considered. The workshop concluded that designing technology strategies that leverage international experience and fit with local energy systems and circumstances can facilitate societal benefits of clean energy technology deployment.
- "Developments in Energy Education: Reducing the Boundaries" focused on needs assessments of competencies and requirements for employment, the education value chain and capacity building as a global responsibility. Cross-border research institutes and programmes, cross-disciplinary engineering degree programmes, and extra-curricular university intensives organised by industries, were found to reduce barriers to technology implementation and accelerate innovation.

Renewable Industry Advisory Board (RIAB)

Created in 2011, the RIAB is composed of private sector entities located within OECD member countries. The RIAB informs the REWP and the IEA Secretariat of market-relevant information, industry advice and data. The first workshop organised under the auspices of the RIAB, "Renewables – Policy and Market Design Challenges", examined how the current market design is consistent with long-term policy goals, and provided an opportunity for industry majors to discuss changes needed, in particular regarding regulatory frameworks and infrastructure.

IEA ENGAGEMENT WORLDWIDE

International Low-Carbon Energy Technology Platform

Training and Capacity Building Programme

Bilateral Symposiums

Partnering with the Private Sector

In June 2012, the International Energy Agency (IEA) Governing Board adopted a global engagement strategy which guides co-operation with partner countries and international energy organisations. Together the IEA and its member countries have identified seven key partner countries – Brazil, China, India, Indonesia, Mexico, Russia and South Africa – with whom the IEA has benefitted from substantive bilateral co-operation on energy matters for many years. In addition, there are a range of further countries – among them, Kazakhstan, Thailand, Ukraine, Vietnam – and regions – Southeast Asia, the Caspian region, and Middle East/North Africa (MENA) – with which the IEA is seeking closer bilateral co-operation.

In the framework of this co-operation, the IEA typically agrees with partner countries on a time-bound work programme to outline concrete projects and areas where partners and the IEA consider that co-operation is mutually beneficial. This not only includes energy statistics and energy security, but also extends to projects that focus on energy technology. The development of technology focused national roadmaps, *e.g. Technology Roadmap: China Wind Energy Development 2050*, or *Technology Roadmap: Low-Carbon Technology for the Indian Cement Industry*, which should guide policy implementation in these areas, are recent examples. Increasingly, partner countries have sought greater participation in Implementing Agreements (IAs) as they offer an excellent opportunity to connect with peers and energy technology research networks that are at the forefront of research in their respective areas.

International Low-Carbon Energy Technology Platform

Created in 2010 in response to a request from the Group of Eight (G8) and IEA ministers, the International Low-Carbon Energy Technology Platform (Technology Platform) seeks to encourage the deployment and dissemination of low-carbon energy technologies. The aim of the technology platform is to facilitate joint projects on energy technology policies and analyses between IEA member and partner countries, international organisations and the private sector. Activities include focused, topical workshops (dialogue workshops), guidance on national roadmap development (How2Guides), and cross-cutting analysis (*e.g.* finance). The IAs regularly lend expertise to the Technology Platform. Recent activities of the Technology Platform include:

- How2Guides to support the development of national technology roadmaps;
- sustainable hydropower in Brazil;
- smart grids in Latin America, the Caribbean, Asia and South Africa;
- wind energy in Asia and South Africa ;
- efficient power generation in Russia (including cleaner coal and bioenergy);
- financing clean energy technologies; and
- deploying renewable energy in the Mediterranean region (focus on solar photovoltaics, heating and cooling, and concentrated solar power).

Training and Capacity Building programme

The IEA Training and Capacity Building programme (TCB) aims to strengthen the capacity of energy agencies in partner countries to formulate and implement effective, co-operative and transparent energy policies. The TCB regularly organises several training modules relating to energy technologies: energy technology policy and collaboration, energy technology roadmaps, carbon capture and storage (CCS), renewable energy sources and energy technology modelling. These sessions can be organised throughout the year based on funding. In addition, these teachings form part of the annual Energy Training Week held at the IEA. As an example, participants in the energy technology roadmap module learn how to devise a technology roadmap, focusing on national energy technology strategies, technology priorities and targets and building consensus among stakeholders. A sampling of recent events organised under the auspices of the TCB include:

- energy training week at the IEA (annual);
- energy statistics training (United Arab Emirates, Vietnam, Central Asia, Caspian Sea Region, West African and East African Community countries);
- emergency response exercise (Paris);
- energy technology modelling (Mexico);
- sustainable energy training (Latin America, Caribbean).

Bilateral symposiums

The IEA also hosts bilateral events in partner countries to enable a broad range of experts from the IEA Secretariat and the Energy Technology Network to share experiences on topics of particular interest such as energy efficiency policy pathways, roadmaps, modelling, and the IAs. Recent bilateral symposiums were held in Beijing (2012), Kazakhstan (2011), South Africa (2010), Singapore (2010) and New Delhi (2009).

Partnering with the private sector

To develop and deploy more secure and sustainable energy systems, business and governments must work together to share the burden of reducing greenhouse-gas emissions through deployment of low-carbon technologies. The IEA is uniquely placed to foster dialogue between policy makers and industry leaders and supports joint activities in diverse areas such as: transport and mobility modelling; long-range energy forecasting; CCS; emergency preparedness in the oil and gas sector; technology roadmaps; and policy recommendations. This market-relevant advice ensures that IEA publications encompass both regulatory and market considerations. A sample of recent activities involving the private sector includes:

- Energy Business Council;
- Coal Industry Advisory Board (CIAB);
- Energy technology roadmaps;
- Global Fuel Economy Initiative;
- Technology Platform;
- Energy efficiency policy pathways;
- Renewable Industry Advisory Board (RIAB);
- Chief Technology Officers roundtable; and
- Implementing Agreements.

FOR MORE INFORMATION

IEA Shared Goals

IEA Framework for International Energy Technology Co-operation

Frequently asked Questions

How to Become a Participant

Acronyms

Glossary of Terms

Implementing Agreement Websites

IEA Information

IEA "SHARED GOALS"[1]

The member countries of the International Energy Agency (IEA) seek to create conditions in which the energy sectors of their economies can make the fullest possible contribution to sustainable economic development and to the well-being of their people and of the environment. In formulating energy policies, the establishment of free and open markets is a fundamental point of departure, though energy security and environmental protection need to be given particular emphasis by governments. IEA countries recognise the significance of increasing global interdependence in energy. They therefore seek to promote the effective operation of international energy markets and encourage dialogue with all participants.

In order to secure their objectives, member countries therefore aim to create a policy framework consistent with the following goals:

Diversity, efficiency and flexibility within the energy sector are basic conditions for longer-term energy security: the fuels used within and across sectors and the sources of those fuels should be as diverse as practicable. Non-fossil fuels, particularly nuclear and hydro power, make a substantial contribution to the energy supply diversity of IEA countries as a group.

Energy systems should have the ability to respond promptly and flexibly to energy emergencies. In some cases this requires collective mechanisms and action: IEA countries co-operate through the Agency in responding jointly to oil supply emergencies.

The environmentally sustainable provision and use of energy are central to the achievement of these shared goals. Decision makers should seek to minimise the adverse environmental impacts of energy activities, just as environmental decisions should take account of the energy consequences. Government interventions should respect the Polluter Pays Principle where practicable.

More environmentally acceptable energy sources need to be encouraged and developed. Clean and efficient use of fossil fuels is essential. The development of economic non-fossil sources is also a priority. A number of IEA member countries wish to retain and improve the nuclear option for the future, at the highest available safety standards, because nuclear energy does not emit carbon dioxide. Renewable sources will also have an increasingly important contribution to make.

Improved energy efficiency can promote both environmental protection and energy security in a cost-effective manner. There are significant opportunities for greater energy efficiency at all stages of the energy cycle from production to consumption. Strong efforts by governments and all energy users are needed to realise these opportunities.

Continued research, development and market deployment of new and improved energy technologies make a critical contribution to achieving the objectives outlined above. 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.

Undistorted energy prices enable markets to work efficiently. Energy prices should not be held artificially below the costs of supply to promote social or industrial goals. To the extent necessary and practicable, the environmental costs of energy production and use should be reflected in prices.

Free and open trade and a secure framework for investment contribute to efficient energy markets and energy security. Distortions to energy trade and investment should be avoided.

Co-operation among all energy market participants helps to improve information and understanding, and encourages the development of efficient, environmentally acceptable and flexible energy systems and markets worldwide. These are needed to help promote the investment, trade and confidence necessary to achieve global energy security and environmental objectives.

1. The Shared Goals were adopted by IEA Ministers at their 4 June 1993 meeting in 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 an Implementing Agreement?

Implementing Agreements, or IAs, are multilateral technology initiatives that enable experts from governments and industry to work together to carry out programmes and projects on energy technology research, development and deployment (RD&D). These initiatives form contracts based on the principle of equitable sharing of rights and obligations. There are currently 40 IAs working in the areas of:

- cross-cutting activities;
- end-use (buildings, electricity, industry, transport);
- fossil fuels;
- fusion power;
- renewable energies and hydrogen.

Who can participate?

Participation is open to any public or private organisation from IEA member or non-member countries, as well as international and non-governmental organisations, academia and industry. The work of each Agreement is governed by an Executive Committee comprised of representatives designated by each member.

What are the benefits of participation?

International energy technology RD&D collaboration offers numerous advantages including:

- reduced cost and duplication of work;
- greater project scale;
- information sharing and networking;
- linking IEA member and non-member countries;
- linking research, industry and policy;
- accelerated development and deployment;
- harmonised technical standards;
- strengthened national RD&D capabilities.

How are the programmes structured?

The scope and strategy of each IA is in keeping with the IEA shared goals of energy security, environmental protection and economic growth, as well as engagement worldwide. Typically, the work includes:

- basic and applied research, technology development and pilot plants;
- technology assessment, feasibility studies, environmental impact studies, market analysis, policy implications;
- information exchange of research results and programmes;
- scientist exchanges;
- databases, modelling and systems analysis;
- expert networks.

How are IA projects financed?

Each IA is self financed by the participants. The research may be carried out on a cost- or task-shared basis, or a combination of both, as long as all signatories agree. Task-sharing works best when there are a number of different concepts under investigation by different participants in parallel. Cost-sharing is practical when funding joint activities or experiments. Some IAs cover the cost of central administration with a common fund, while the research projects are task-shared. Others rely entirely on task sharing, which implies a detailed definition of each signatory's participation.

What is the IEA framework?

The IEA Framework for International Technology Co-operation specifies the minimum legal and management requirements for IAs including the mandate, the nature of agreements, participation and withdrawal, copyright, length of term, reporting requirements and specific provisions concerning the structure of each programme.

What is the role of the IEA in the Implementing Agreements?

The IEA Committee on Energy Research and Technology (CERT) and the working parties (WPs) regularly review and rate IAs according to the following criteria:

- strategic direction;
- scope;
- contractual and management requirements;
- contribution to technology evolution;
- contribution to technology deployment / market facilitation;
- policy relevance;
- contribution to environmental protection;
- information dissemination;
- outreach to partner countries;
- added value.

In addition, the IEA Secretariat provides support by providing legal advice, acting as conduit between IAs and policy makers, and promoting IA outcomes through *Energy Technology Initiatives*, the *OPEN Bulletin*, IEA website and at international events. The IEA does not provide direct support to IAs through funding, as a signatory or as a programme manager (Operating Agent).

How are new IAs created?

A new Implementing Agreement may 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 shared goals of the IEA;
- the IEA Committee on Energy Research and Technology and the IEA Governing Board have approved.

HOW TO BECOME A PARTICIPANT OF AN IMPLEMENTING AGREEMENT[1]

Can my organisation participate?

Participate as a Contracting Party	*Participate as a Sponsor*
Contracting Parties are participants that are: • Governments of both OECD member countries or partner countries[2]; • The European Union; • Inter-governmental organisations. This includes any national agency, public organisation, private corporation or other entity designated by the government of the country wishing to become a CP.	Sponsors are participants that are: • Entities of an OECD member country or partner country that are not designated by its government to participate in the Implementing Agreement; • Non-governmental international entities. Sponsors are not eligible to be elected as Chair or Vice-Chair. A government-owned or controlled entity can become a Sponsor, provided the government does not object to the entity participating as a Sponsor rather than a Contracting Party.

What is the process to follow?

Contact the Chair

Contracting Party	Sponsor
1. My organisation contacts the Chair of the Implementing Agreement to discuss potential benefits of working together. 2. If there is mutual interest, then terms and conditions of participation are discussed. 3. If there is agreement, then the formal process may begin (unanimous vote, letters of invitation and acceptance).	1. My organisation contacts the Chair of the Implementing Agreement to discuss potential benefits of working together. 2. If there is mutual interest, then terms and conditions of participation are discussed. 3. If there is agreement, then the formal process may begin (unanimous vote, letters of invitation and acceptance).

Unanimous Vote and Letter of Invitation

Contracting Party	Sponsor
1. The Executive Committee (ExCo) votes unanimously to invite my organisation to become a participant as a CP, specifying mutually agreed terms and conditions. 2. The ExCo Chair or his/her representative sends a formal letter of invitation to my organisation, specifying the terms and conditions of participation.	1. The Executive Committee (ExCo) votes unanimously to invite my organisation to become a participant as a Sponsor, specifying mutually agreed terms and conditions. 2. The ExCo Chair or his/her representative sends a formal letter of invitation to my organisation, specifying the terms and conditions of participation.

Formal Letter of Acceptance

Contracting Party	Sponsor
1. If my organisation is a government ministry, office or department that intends to participate directly in the ETI, a letter of acceptance is sent to the IEA Executive Director, naming the individual(s) who will sign the Agreement on its behalf. 2. If my organisation is a government entity that intends to designate another entity to participate on its behalf, my organisation sends a letter of designation to the IEA Executive Director and names the individual(s) who will sign the Agreement on its behalf. The designated entity also sends a letter of acceptance to the IEA Executive Director.	1. If my organisation intends to participate directly a letter of acceptance is sent to the IEA Executive Director, naming the individual(s) who will sign the Agreement on its behalf. 2. If my organisation intends to designate a separate entity to participate on its behalf, it sends a letter of designation to the IEA Executive Director and names the individual(s) who will sign the Agreement on its behalf. The designated entity also sends a letter of acceptance to the IEA Executive Director.

Formal Approval by the Committee on Energy Research and Technology (CERT)

Contracting Party	Sponsor
If my organisation represents a partner country or intergovernmental organisation that has never participated in any other Implementing Agreement, then the IEA Committee on Energy Research and Technology (CERT) must review and approve my organisation's participation.	If my organisation has never participated in any other Implementing Agreement as a Sponsor then the CERT must review and approve my organisation's participation.

When does participation actually begin?

Contracting Party	Sponsor
The IEA Secretariat in Paris sends a signature page to the individual named in the letter of acceptance. Formal participation begins on the date of signature of the Agreement text.	The IEA Secretariat in Paris sends a signature page to the individual named in the letter of acceptance. Formal participation begins on the date of signature of the Agreement text.

1. The information in this table draws on the IEA Framework for International Energy Technology Collaboration.

2. OECD refers to the Organisation for Economic Co-operation and Development. A partner country is defined as a sovereign nation that is recognised as such by the United Nations. Economies that have been declared as protectorates of another state are not sovereign nations and therefore cannot participate in IAs.

ACRONYMS

ACRONYM	REPRESENTING
CERT	IEA Committee on Energy Research and Technology
EGRD	IEA Experts' Group on R&D Priority Setting and Evaluation
GB	IEA Governing Board
WP	IEA Working Party
EUWP	IEA End-Use Working Party
FPCC	IEA Fusion Power Co-ordinating Committee
REWP	IEA Renewable Energy Working Party
WPFF	IEA Working Party on Fossil Fuels
IA	Implementing Agreement
4E IA	IA for a Co-operative Programme on Energy Efficient Electrical Equipment
AFC IA	IA for a Programme of Research, Development and Demonstration on Advanced Fuel Cells
AMF IA	IA for a Programme of Research and Demonstration on Advanced Motor Fuels
AMT IA	IA for a Programme of Research and Demonstration on Advanced Materials for Transportation Applications
BIOENERGY IA	IA for a Programme of Research, Development and Demonstration on Bioenergy
CCC IA	IA for the IEA Clean Coal Centre
COMBUSTION IA	IA for a Programme of Research, Development and Demonstration on Energy Conservation and Emissions Reduction in Combustion
CTI IA	IA for Climate Technology Initiative
CTP IA	IA for Co-operation on Tokamak Programmes
DHC IA	IA for a Programme of Research, Development and Demonstration on District Heating and Cooling, including the Integration of Combined Heat and Power
DSM IA	IA for Co-operation on Technologies and Programmes for Demand Side Management
EBC IA	for a Programme of Research and Development on Energy in Buildings and Communities
ECES IA	IA for a Programme of Research and Development on Energy Conservation through Energy Storage
EOR IA	IA for a Programme of Research, Development and Demonstration on Enhanced Oil Recovery
ESEFP IA	IA on a Co-operative Programme on Environmental, Safety and Economic Aspects of Fusion Power
ETDE IA	IA for the Establishment of the IEA Energy Technology Data Exchange
ETSAP IA	IA for a Programme of Energy Technology Systems Analysis
FBC IA	IA for Co-operation in the Field of Fluidised Bed Conversion of Fuels Applied to Clean Energy Production
FM IA	IA for a Programme of Research and Development on Fusion Materials
GEOTHERMAL IA	IA for a Co-operative Programme on Geothermal Energy Research and Technology

GHG IA	IA for a Co-operative Programme on Technologies Relating to Greenhouse Gases Derived from Fossil Fuel Use
HEV IA	IA for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes
HYDROGEN IA	IA for a Programme of Research and Development on the Production and Utilization of Hydrogen
HPT IA	IA for a Programme of Research, Development, Demonstration and Promotion of Heat Pumping Technologies
HYDROPOWER IA	IA for a Co-operative Programme on Hydropower Technologies and Programmes
HTS IA	IA for a Co-operative Programme for Assessing the Impacts of High-Temperature Superconductivity on the Electric Power Sector
IETS IA	IA on Industrial Energy-Related Technologies and Systems
ISGAN IA	IA for a Co-operative Programme on Smart Grids
MFS IA	IA for a Programme of Research on Fossil Fuel Multiphase Flow Sciences
NTFR IA	IA on a Co-operative Programme on Nuclear Technology of Fusion Reactors
OES IA	IA for a Co-operative Programme on Ocean Energy Systems
PVPS IA	IA for a Co-operative Programme on Photovoltaic Power Systems
PWI IA	IA for a Programme of Research and Development on Plasma Wall Interaction
RETD IA	IA for Renewable Energy Technology Deployment
RFP IA	IA for a Programme of Research and Development on Reversed Field Pinches
SH IA	IA for Co-operation in Development of the Stellarator-Heliotron Concept
SHC IA	IA for a Programme to Develop and Test Solar Heating and Cooling Systems
SolarPACES IA	IA for the Establishment of a Project on Solar Power and Chemical Energy Systems (SolarPACES)
ST IA	IA for Co-operation on Spherical Tori
WIND IA	IA for Co-operation in the Research, Development, and Deployment of Wind Energy Systems
CP	Contracting Party
ExCo	Executive Committee
OA	Operating Agent
MTI	Multilateral technology initiatives
R&D	Research and development
RD&D	Research, development and demonstration

GLOSSARY

TERM	DEFINITION
Organisation for Economic Co-operation and Development (OECD)	The mission of the OECD is to promote policies that will improve the economic and social well-being of people around the world. The IEA is an autonomous agency of the OECD. In addition to IEA member countries, OECD Member countries include Chile, Estonia, Iceland, Israel, Mexico, and Slovenia.
International Energy Agency (IEA)	An autonomous organisation which works to ensure reliable, affordable and clean energy for its 28 member countries and beyond. The IEA's four main areas of focus are: energy security, economic development, environmental awareness, and engagement worldwide.
Governing Board (GB)	The Governing Board is the main decision-making body of the IEA and is composed of energy ministers or their senior representatives from each IEA member country.
Member countries	There are 28 member countries of the IEA: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Luxembourg, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, the United Kingdom, and the United States. The following OECD member countries are not member countries of the IEA: Chile, Estonia, Iceland, Israel, Mexico and Slovenia.
Partner countries	Partner countries include those with which the IEA seeks enhanced engagement as part of the Engagement Strategy as well as countries that are neither an IEA member country nor a partner country. By definition, a partner country is a sovereign nation that is recognised as such by the United Nations. Economies that have been declared as protectorates of another state are not sovereign nations and therefore cannot participate in IAs. Any country that has not previously participated in an IA must seek approval of the CERT, and, in some cases, Governing Board approval is required.
Framework	The Framework for International Energy Technology Co-operation, adopted by the Governing Board in 2003, outlines who may participate in an IA and the principal responsibilities of the participants. The Framework also provides the minimum requirements of information and reports that each IA is to transmit to the IEA Secretariat.
Committee on Energy Research and Technology (CERT)	Established in 1975, the CERT is the senior technology committee of the IEA and reports directly to the Governing Board. The CERT is responsible for identifying the IEA strategy for energy research and development (R&D) and for overseeing the implementation of this strategy. It also reviews national energy R&D programmes and those of the IAs.
Energy Technology Network	Comprises the CERT, the working parties, ad hoc or experts' groups, and the IAs.
Working Parties (WPs)	Working parties provide advice and support the CERT in carrying out its mandate, and to the IEA on issues relevant to each working party. The WPs support and facilitate co operation among IEA member countries in research, development, demonstration and deployment of the respective technologies. WPs also seek to expand collaboration with Partner countries. Each WP regularly reviews the accomplishments of the IAs and makes a recommendation to the CERT concerning the request for extension of the IA mandate.

Fusion Power Co-ordinating Committee (FPCC)	Established in 1975, the objective of the FPCC is to enhance fusion research and development activities worldwide, promoting, initiating and coordinate international co-operation on fusion activities.
Working Party on Energy End-Use Technologies (EUWP)	Established in 1981, the EUWP provides advice to the CERT and other IEA bodies on trends and policies relating to energy end use technologies.
Working Party on Renewable Energy Technologies (REWP)	Established in 1981, the REWP provides advice to the CERT and other IEA bodies on trends and policies relating to renewable energies and hydrogen.
Working Party on Fossil Fuels (WPFF)	Established in 1981, the WPFF provides advice to the CERT and the IEA on fossil fuel technology related policies, trends, projects, programmes and strategies which address priority environmental protection and energy security interests, including adequate, flexible, and reliable supply of power and electrical service of member countries.
Experts' Group on R&D Priority Setting and Evaluation (EGRD)	The EGRD promotes development and refinement of analytical approaches to energy technology analysis; to R&D priority setting; and to assessment of benefits from R&D activities. The results and recommendations support CERT, feed into IEA analysis, providing a global perspective to national R&D efforts.
Implementing Agreements (IAs)	International agreements that enable experts from governments and industry to work together to carry-out programmes and projects related to energy technology research, development and deployment (RD&D).
Executive Committee (ExCo)	The decision-making body of the IA which supervises the work. It is comprised of representatives from each of the IA signatories.
Participants	Signatories to an IA, including both Contracting Parties (representing governments or intergovernmental organisations), or sponsors (entities not representing governments and non-governmental organisations).
Contracting Party (CP)	IA participants that have been mandated to represent governments of OECD member countries or Partner countries, the European Union; and inter-governmental organisations. This includes national agencies, public organisations, or private corporations.
Sponsors	IA participants that have been given the mandate to represent entities of an OECD member country or Partner country that are not designated by its government to participate in the Implementing Agreement and non-governmental international organisations. Sponsors are not eligible to be elected as an IA Chair or Vice-Chair.
Project (annex or task)	A specific project or programme carried out under the auspices of the IA. In some cases the term Annex refers to each subsequent term of the IA approved by the CERT.
Operating Agent (OA)	The individual or organisation responsible for administering an IA project or activity (referred to as tasks or annexes).

IMPLEMENTING AGREEMENT WEBSITES[1]

Cross-cutting activities	Climate Technology Initiative	*www.climatetech.net*
	Energy Technology Data Exchange	*www.etde.org*
	Energy Technology Systems Analysis	*www.iea-etsap.org*
End-use: buildings	Buildings and Communities	*www.iea-ebc.org/*
	District Heating and Cooling	*www.iea-dhc.org*
	Efficient Electrical End-Use Equipment	*www.iea-4e.org*
	Energy Storage	*www.iea-eces.org*
	Heat Pumping Technologies	*www.heatpumpcentre.org*
End-use: electricity	Demand-Side Management	*www.ieadsm.org*
	High-Temperature Superconductivity	*www.superconductivityIEA.org*
	ISGAN (Smart Grids)	*www.iea-isgan.org*
End-use: industry	Emissions Reduction in Combustion	*http://ieacombustion.com*
	Industrial Energy-Related Technology Systems	*www.iea-industry.org*
End-use: transport	Advanced Fuel Cells	*www.ieafuelcell.com*
	Advanced Materials for Transportation	*www.iea-ia-amt.org*
	Advanced Motor Fuels	*www.iea-amf.org*
	Hybrid and Electric Vehicles	*www.ieahev.org*
Fossil fuels[2]	Clean Coal Centre	*www.iea-coal.org.uk*
	Enhanced Oil Recovery	*http://iea-eor.ptrc.ca*
	Fluidised Bed Conversion	*www.iea-fbc.org*
	Greenhouse Gas	*www.ieaghg.org*
Fusion power	Environment, Safety, Economy of Fusion	[3]
	Fusion Materials	*www.frascati.enea.it/ifmif/*
	Nuclear Technology of Fusion Reactors	[3]
	Plasma Wall Interaction	*www.pwi-ia.org*
	Reversed Field Pinches	[3]
	Spherical Tori	[3]
	Stellerator-Heliotron Concept	*http://iea-shc.nifs.ac.jp/*
	Tokamaks	*http://ctp.jet.efda.org/lt*
Renewable energies and hydrogen	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 (concentrating solar power)	*www.solarpaces.org*
	Wind Turbine Systems	*www.ieawind.org*

1. The Implementing Agreements function within a framework created by the IEA in Paris. Views, findings, and publications of the IAs do not necessarily represent the views or policies of the IEA or of all of its individual member countries.
2. This publication does not include information for two IAs. The Implementing Agreement for a Programme of Research on Fossil Fuel Multiphase Flow Sciences is expected to expire on 30 November 2014. The Implementing Agreement for Gas and Oil Technologies, created 22 March 2013 has not been included as this publication covers the period up to 31 December 2012
3. This IA website is under development. An overview of the collaborative activities may be consulted on the IEA website www.iea.org/techinitiatives.

IEA INFORMATION

This publication was prepared by the IEA to raise awareness of the valuable work that is being carried out by the Implementing Agreements (IAs). For more information on the activities of the IEA Secretariat in Paris, see www.iea.org. A selected list of relevant IEA web pages is provided below for easy reference.

IEA energy technology network

www.iea.org/aboutus/faqs/organisationandstructure/

Committee on Energy Research and Technology

- www.iea.org/aboutus/standinggroupsandcommittees/

Working parties

Working Party on Energy End-Use Technologies

- www.iea.org/aboutus/standinggroupsandcommittees/euwp/

Working Party on Fossil Fuels

- www.iea.org/aboutus/standinggroupsandcommittees/wpff/

Working Party on Renewable Energy

- www.iea.org/aboutus/standinggroupsandcommittees/rewp/

Fusion Power Co-ordinating Committee

- www.iea.org/aboutus/standinggroupsandcommittees/fpcc/

Experts' Group on R&D Priority-Setting and Evaluation

- www.iea.org/aboutus/standinggroupsandcommittees/egrd/

Implementing Agreements

- www.iea.org/techinitiatives

IEA engagement worldwide

www.iea.org/countries/non-membercountries/

International Low-Carbon Energy Technology Platform

- www.iea.org/aboutus/affiliatedgroups/low-carbonenergytechnologyplatform/

Training and capacity building

- www.iea.org/training/

IEA *OPEN Energy Technology Bulletin*

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