International Energy Agency

Energy Technology Initiatives

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-government organisations to share research on breakthrough technologies, to fill existing research gaps, to build pilot plants and to carry out deployment or demonstration programmes. In short their work can comprise any technology-related activity that supports energy security, economic growth, environmental protection and engagement worldwide. A new initiative may be created at any time, provided at least two IEA member countries agree to work on it together.

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

In 2010, there are currently 42 Implementing Agreements in the areas of cross-cutting issues (technology transfer, research databases, modeling), energy efficiency (buildings, electricity, industry, transport), fossil fuels (clean coal, enhanced oil recovery, carbon capture and storage), fusion power (tokamaks, materials, technologies, safety, alternate concepts) and renewable energy technologies.

iea Energy Technology Network

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INTERNATIONAL ENERGY AGENCY

The International Energy Agency (IEA), an autonomous agency, was established in November 1974. Its mandate is two-fold: to promote energy security amongst its member countries through collective response to physical disruptions in oil supply and to advise member countries on sound energy policy.

The IEA carries out a comprehensive programme of energy co-operation among 28 advanced economies, each of which is obliged to hold oil stocks equivalent to 90 days of its net imports. The Agency aims to:

- 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:

Australia
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.

International Energy Agency

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FOREWORD

New technologies will be critical in addressing current global energy challenges such as energy security. More must be done, however, to push forward the development and deployment of the technologies we need today and will need in the future. Government leaders have repeatedly underlined the crucial role of industry and businesses in advancing energy technologies and the importance of strong collaboration among all stakeholders to accelerate technology advances.

In October 2009, Ministers from the 28 IEA member countries recognised the critical need for investment in energy technologies, adding that strong public-private partnerships are essential to overcome the global energy challenges we face. Ministers called for greater efforts to bolster public support for research, development and demonstration (RD&D) with a view to doubling cost-effective investment in low-carbon energy technologies by 2015 and urged the private sector to increase investment in these areas as well.

In addition, IEA Ministers agreed to accelerate the development and worldwide deployment of cleaner energy technologies and welcomed the development of an international low-carbon energy technology platform. This platform provides an international forum that enables countries to work together with industry and other international organisations to create country-specific, strategic energy technology plans drawing on the work of the IEA, the IEA global energy technology network and other ongoing initiatives.

Following the December 2009 Copenhagen Conference of the Parties (COP15), governments are looking for international collaborative mechanisms that can provide the means to translate dialogue into action and enhance energy technology development and deployment. Beginning with the year 2010, we are being offered a unique opportunity to make a difference and drive the transition to a low-carbon global economy.

To attain these goals, increased co-operation between industries, businesses and government energy technology research is indispensable. The public and private sectors must work together, share burdens and resources, while at the same time multiplying results and outcomes.

The 42 multilateral technology initiatives (Implementing Agreements) supported by the IEA are a flexible and effective framework for IEA member and non-member countries, businesses, industries, international organisations and non-government organisations to research breakthrough technologies, to fill existing research gaps, to build pilot plants, to carry out deployment or demonstration programmes – in short to encourage technology-related activities that support energy security, economic growth and environmental protection.

More than 6 000 specialists carry out a vast body of research through these various initiatives. To date, more than 1 000 projects have been completed. The significant recent achievements and activities of these Agreements are the focus of this book.

I strongly encourage those who may be engaged in energy issues, whether in government or in the private sector, to consider seeking participation in the IEA global energy technology network and the Implementing Agreements to transform dialogue into action for a secure energy future.

Nobuo Tanaka
Executive Director

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	Energy Technology Data Exchange	Debbie Cutler
	Energy Technology Systems Analysis	Giancarlo Tosato
End-Use: Buildings	Buildings and Community Systems	Malcom Orme
	District Heating and Cooling	Robin Wiltshire
	Efficient Electrical Equipment	Conrad Brunner
	Energy Storage	Andreas Hauer
	Heat Pumping Technologies	Roger Nordman
End-Use: Electricity	Demand-Side Management	Jan Bleyl
	Electricity Networks	John Baker
	High-Temperature Superconductivity	Alan Wolsky
End-Use: Industry	Emissions Reduction in Combustion	Bob Gallagher
	Industrial Technologies and Systems	Sara Boije
End-Use: Transport	Advanced Fuel Cells	Heather Haydock
	Advanced Motor Fuels	Jean-François Gagné
	Advanced Transport Materials	Stephen Hsu
	Hybrid and Electric Vehicles	Martijn van Walwijk
Fossil Fuels	Clean Coal Centre	Geoff Morrison
	Enhanced Oil Recovery	Erling Stenby
	Fluidised Bed Conversion	Juan Otero
	Greenhouse Gas RD Programme	John Gale
	Multiphase Flow Sciences	Chris Guenther
Fusion Power	Fusion Environment, Safety and Economy	Phil Sharpe
	Fusion Materials	Shiro Jitsukawa
	Large Tokamaks	Kensaku Kamiya
	Nuclear Technology of Fusion Reactors	Rainer Lässer
	Plasma Wall Interaction in TEXTOR	Ralph Schorn
	Reversed Field Pinches	Piero Martin
	Stellarator Concept	Hiroshi Yamada
	Spherical Tori	Brian Lloyd
	Tokamaks with Poloidal Field Divertors	Hartmut Zöhm
Renewable Energies and Hydrogen	Bioenergy	Adam Brown
	Deployment	Kristian Patrick
	Geothermal	Mike Mongillo
	Hydrogen	Mary-Rose de Valladares
	Hydropower	Niels Nielsen
	Ocean	John Huckerby
	Photovoltaic	Mary Brunisholz
	Solar Concentrated	Christoph Richter
	Solar Heating and Cooling	Pamela Murphy
	Wind	Patricia Weis-Taylor

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IEA GLOBAL ENERGY TECHNOLOGY NETWORK

Introduction

Committee on Energy Research and Technology

Working Parties

Experts' Groups

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INTRODUCTION

The IEA multilateral technology initiatives (Implementing Agreements) provide a flexible mechanism for governments, industries and businesses, international and non-governmental organisations from IEA member and non-member countries to leverage resources and multiply results through research of energy technologies and related issues. Through these initiatives, governments partner with industry and other organisations to form a cost-effective, global energy technology network to combine efforts.

More than 6 000 specialists carry out a vast body of research, development and deployment of energy technologies, systems and related issues. To date, more than 1 000 research projects, studies, and demonstrations have been carried out, not including workshops, networks, databases, models, manuals, scientist exchanges, and other tools and mechanisms. In April 2010 there were 42 Implementing Agreements (IAs) working in the following areas:

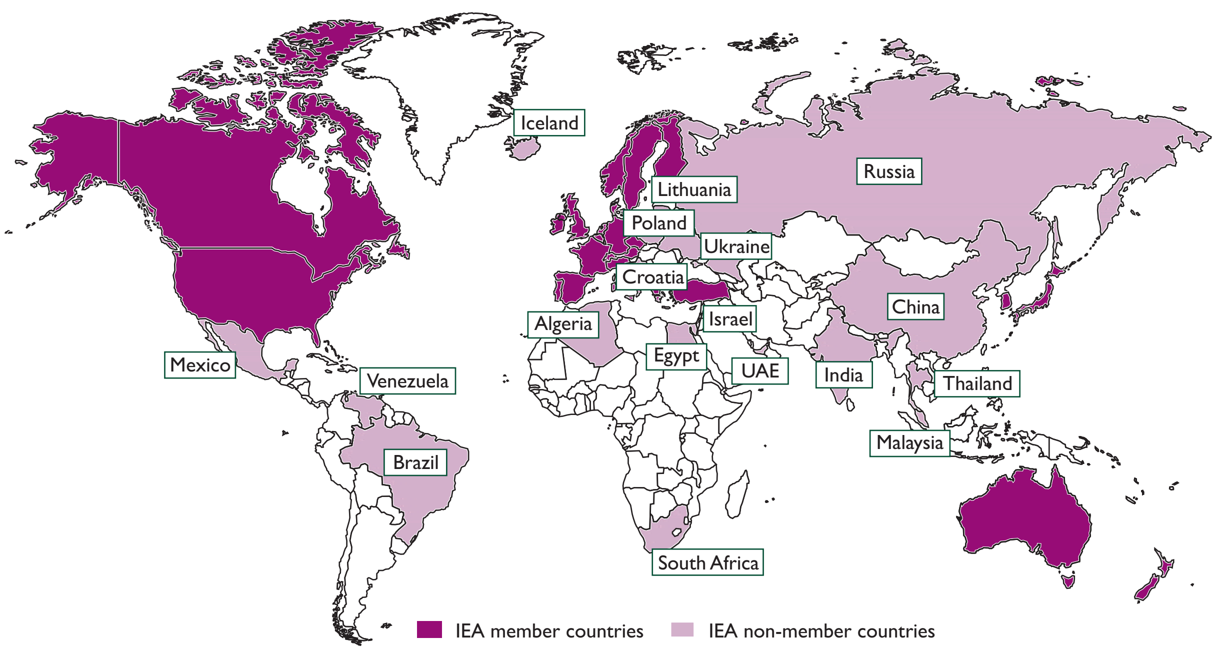
- cross-cutting issues (information exchange, modelling, technology transfer)
- efficient end-use technologies (buildings, electricity, industry, transport)
- fossil fuels (greenhouse-gas mitigation, supply, transformation)
- fusion power (international experiments)
- renewable energies and hydrogen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

Cross-cutting initiatives provide tools and mechanisms that empower countries. The Energy Technology Data Exchange allows access to their extensive database of scientific information to more than 60 IEA non-member countries. The Climate Technology Initiative engages with IEA non-member countries to share best practice, to build capacity, and to facilitate technology transfer and financing. Through energy models, the Energy Technology Systems Analysis IA provides countries with the tools necessary to devise national plans and strategies.

Improving end-use energy efficiency, whether in the buildings and commercial services, electricity, industry or transport sectors, is crucial for the environment and for energy security. Fourteen IAs currently research various aspects of these end-use sectors. One recently created Agreement coordinates policies, promotes standards and analyses issues related to energy efficient electrical equipment.

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, science and technologies for clean coal-fired power generation, fluidised bed conversion technologies and multiphase flow applications.

▶ IEA Global Energy Technology Network



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

Renewable energy technologies provide clean, flexible, stand-alone or grid-connected electricity sources, but they need the correct policy environment and collaboration with industry to facilitate deployment and to further reduce costs. Ten IAs deal with renewable energy technologies including deployment, bioenergy, geothermal, hydrogen, hydropower, ocean systems, solar (concentrated power, heating and cooling, photovoltaic), and wind.

The significant recent achievements, activities and operations of the IEA Implementing Agreements are the focus of this book.

These IAs are at the core of a network of senior experts. Consisting of the Comittee on Energy Research and Technology, four working parties and two expert groups.

A key role of the CERT is to provide leadership by guiding these groups to shape work programmes that address current energy issues productively, by regularly reviewing their accomplishments, and suggesting reinforced efforts where needed.

COMMITTEE ON ENERGY RESEARCH AND TECHNOLOGY

The IEA Governing Board created the Committee on Energy Research and Technology (CERT) in 1975 to examine and report on co-operative action in the conservation of energy, including co-operative programmes concerning:

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

The CERT Strategy Plan 2007-2011 outlines five strategic objectives:

Strategic Objective No. 1: Leadership and dialogue to support the CERT Working Parties

Strategic Objective No. 2: Stronger focus on the role of technology policy in developing cleaner, more efficient energy technologies and in deploying them, and on the role of policy in catalysing the scientific innovation needed to generate new energy technology approaches; constant efforts to distil for policy makers the important policy messages from work of the IEA energy technology network

Strategic Objective No. 3: Frequent, effective communication to policy makers of messages and perspectives extracted from analysis drawing on work and findings in the IEA's collaborative RD&D network, notably from the Implementing Agreements, Working Parties, expert and ad-hoc groups, and from associated private-sector players and financial institutions

Strategic Objective No. 4: More fruitful liaison within the IEA family – including joint activities with the Standing Group on Long-Term Co-operation and "hot-line" communication with the IEA Governing Board – and with the OECD

Strategic Objective No. 5: More vigorous collaboration with IEA non-member countries

CERT's Vision

Technology will have an increasingly decisive impact on progress in the worldwide quest for a globally clean, clever and competitive energy future.

CERT's Mission

To maximise energy technology's impact by optimising international collaborative RD&D* and deployment, by initiating timely technology assessment, analysis and scenarios, by engaging IEA non-member countries and, crucially, by delivering policy guidance that will make a difference. A key role of the CERT is to provide leadership for the Working Parties, expert groups and Implementing Agreements in the IEA energy technology network, to help them shape work programmes that address current energy issues productively, to support their efforts, regularly review coverage of mandates and suggest new efforts when needed.

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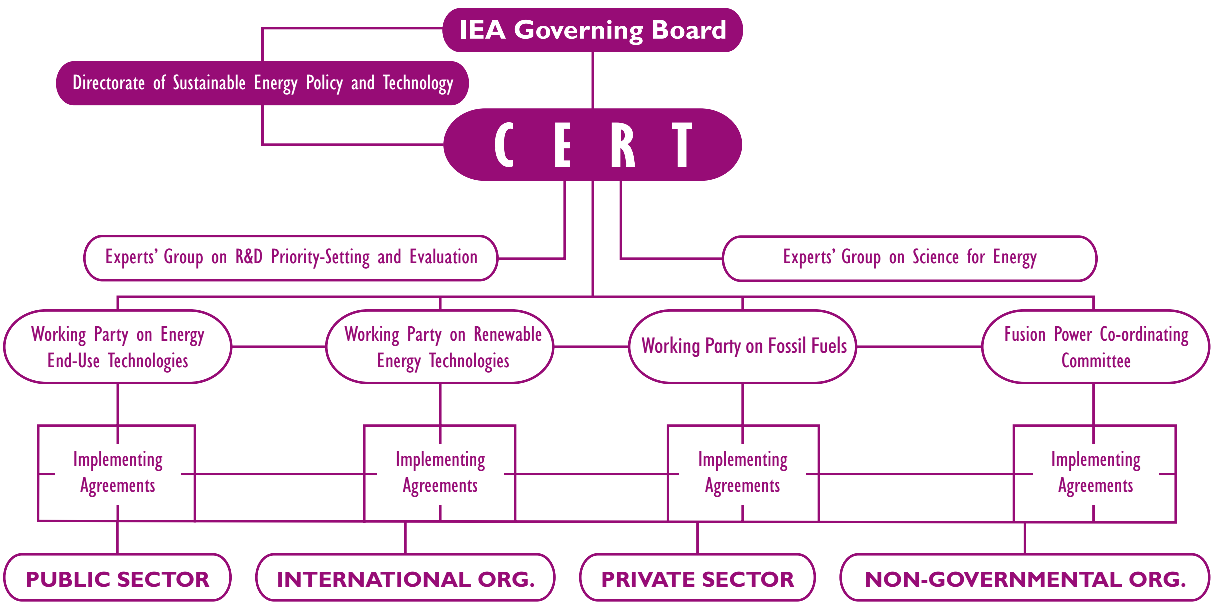
The CERT Working Parties provide advice and support to the CERT and other IEA standing bodies in their respective area of competence. They also guide the IEA Implementing Agreements by regularly reviewing their achievements. There are four Working Parties comprised of specialists in the following key areas:

- Energy End-Use Technologies
- Fossil Fuels
- Fusion Power Co-ordinating Committee
- Renewable Energy Technologies

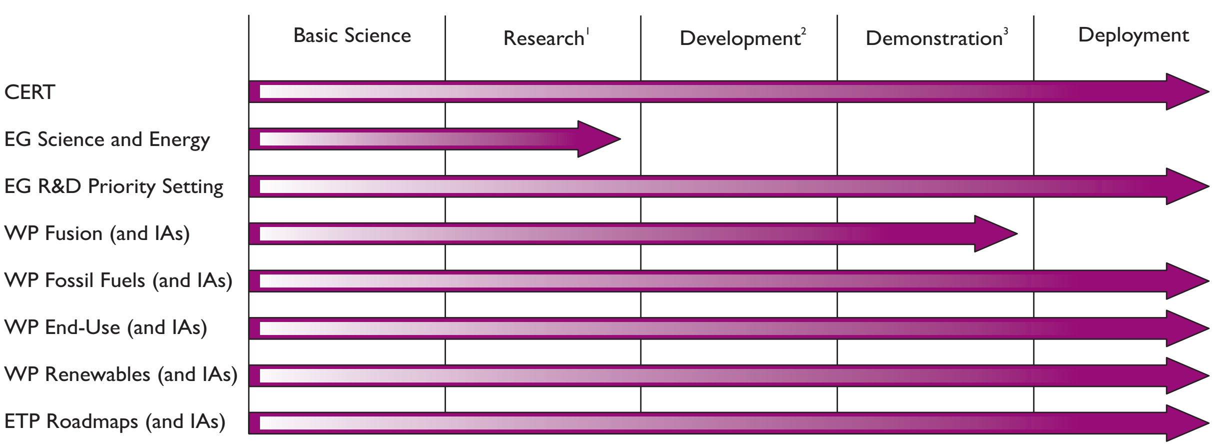
In addition, two Expert Groups provide advice to the CERT on priority-setting and cross-cutting issues, as well as highlighting ways to bridge gaps and reinforce links in the energy technology network research and innovation chain:

- R&D Priority Setting and Evaluation
- Science for Energy

Organisation Chart of the Global Technology Network



IEA Global Technology Network Research Portfolios



1. Includes modeling and technology assessment.
2. Includes research, advice and support for demonstration of the particular technology.
3. Includes market introduction and technology transfer.

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WORKING PARTIES

Energy End-Use Technologies

The Working Party on Energy End-Use Technologies (EUWP) is the principal advisory body to the CERT on all matters relating to energy end-use technologies and technology policies. The EUWP serves as a reference body for end-use technology issues within the IEA and represents the IEA to outside parties on these issues. Policy experts from member countries share experience in energy end-use technology and innovation and provide advice and support to the RD&D efforts of the Implementing Agreements.

The four strategic objectives of the EUWP are to ensure:

- strategic guidance on end-use technology RD&D;
- a well-functioning end-use Implementing Agreement network;
- effective communication with the CERT and IEA member Countries; and
- strengthened relations with IEA non-member countries.

Fossil Fuels

The Working Party on Fossil Fuels (WPFF) provides advice to the IEA on fossil fuel technology-related policies, trends, projects, and programmes. It supports strategies which address priority environmental protection and energy security interests, including adequate, flexible, and reliable supply of power and electrical service in IEA member countries. The WPFF carries out activities to meet those needs through international co-operation and collaboration facilitated by the IEA.

The objectives of the WPFF are to:

- identify fossil fuel technology-related priority interests, including electric power technologies, common to IEA member countries, including their integration with non-fossil fuel technologies;
- promote collaborative RD&D and technology deployment as well as electric power production, transmission, distribution and end-use efficiency, by arranging studies and technology information exchange on topics of common interest, conferences, workshops, and other activities;
- initiate, evaluate, and review Implementing Agreements and other international collaborative activities;
- co-ordinate with other sectoral bodies of the IEA which conduct fossil fuel-related studies, information exchanges and meetings relevant to the goals of the WPFF;
- review, evaluate, and participate in fossil fuel-related activities conducted by IEA bodies; and
- carry out technology co-operation activities with IEA non-member countries.

Fusion Power

The Fusion Power Co-ordinating Committee (FPCC) co-ordinates the IEA activities on fusion and advises the IEA CERT and other IEA bodies on fusion policy and technology issues. The FPCC provides advice and support to the fusion-related Implementing Agreements. The IEA fusion Agreements carry out RD&D activities in the areas of physics, technology, materials, safety, environmental and economic aspects, and social acceptance of fusion power. Their work is of direct relevance to ITER and the "beyond-ITER" programme (Demo reactor, fusion power plants, economic, environmental, safety and social aspects of fusion power).

The overall objectives of the FPCC are to:

- enhance fusion RD&D activities;
- assist in realising fusion energy in IEA member and non-member countries; and
- promote, initiate and co-ordinate international co-operative efforts on fusion research.

Renewable Energy Technologies

The Working Party on Renewable Energy Technologies (REWP) is the principal advisory body to the CERT on all matters relating to renewable energy. The REWP serves as the reference body for renewable energy issues within the IEA and represents the IEA to outside parties on these issues. The REWP provides advice and support to the RD&D efforts of the renewable energy Implementing Agreements and hydrogen.

The four strategic objectives of the REWP are to:

- continue to strengthen its role as a primary source of analysis and information on renewable energy technologies for IEA committees and offices, and non-IEA stakeholders;
- ensure the effectiveness of the renewable energy Implementing Agreements in developing and deploying renewable energy technologies;
- identify and describe the broad range of policies, technical, financial, regulatory, and other market related factors that affect market deployment of renewable energy technologies; and
- develop and implement recommendations for accelerated market deployment of renewable energy technologies in the global energy markets.

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EXPERTS' GROUPS

R&D Priority Setting and Evaluation

The Experts' Group on RD&D Priority Setting and Evaluation (EGRD) was created to provide guidance and advice to the CERT by developing and refining analytical approaches to energy technology R&D priority setting, identifying the steps necessary for implementation, and evaluating energy technology research programmes. The EGRD is comprised of senior experts engaged in national R&D efforts. Activities focus on international workshops, information exchange, networking and outreach. Results of these efforts feed into IEA analysis.

The current objectives of the EGRD are to:

- provide input and analysis for energy technology roadmaps;
- map R&D activities in IEA member countries;
- develop energy RD&D indicators; and
- evaluate the effectiveness of alternative approaches to technology development and deployment.

Science for Energy

The Experts' Group on Science for Energy (EGSE) assists the CERT in addressing energy technology challenges and barriers and identifying basic energy research opportunities by reinforcing the links between the basic science and applied energy research communities. The EGSE enables this interaction between senior experts through targeted activities such as international events, information exchange, networking and outreach to a wide range of stakeholders.

The current activities of the EGSE are to:

- map science for energy efforts, with a focus on identifying the network of researchers working in relevant topics in all countries;
- provide input and facilitate technology breakthroughs that follow on from IEA technology roadmaps;
- link science and energy research communities through futures workshops and other networking events; and
- communicate high-level messages regarding the necessary links between science and energy research.

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IEA IMPLEMENTING AGREEMENT PORTFOLIOS*

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

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

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IEA IMPLEMENTING AGREEMENT ENERGY SECTORS*

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

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

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IEA IMPLEMENTING AGREEMENTS

Recent Trends

Cross-Cutting Activities

End-Use Technologies

Fossil Fuels

Fusion Power

Renewable Energies and Hydrogen

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RECENT TRENDS: PARTNERING WITH INDUSTRY

Working in isolation, no one group of actors can find all the solutions. Partnerships between governments and industry bring together complementary strengths, skills and capacities. The private sector is a major source of capital and innovation. The public sector provides basic research and the regulatory framework that stimulates necessary energy-saving renovations or market penetration of cutting-edge technologies. Together, governments and industry are able to overcome the limitations of the other to tackle major issues such as improving energy security and reducing CO_2 emissions.

Despite a few exceptions, RD&D budgets of IEA member countries have declined in real terms since 1978. As a result governments rely increasingly on the private sector to become an active partner in accelerating energy technology research and deployment.

Despite the relative availability of capital in the private sector, industries in a particular sector may be too fragmented to fund significant research (*e.g.*, in the building sector), deployment time-frames may be too long or the investment risk may be too great for any one business to sustain. Lastly, competitive and financial market pressures make it increasingly difficult for the private sector to take full responsibility for long-term research.

Governments may therefore need to make ever more efforts to understand the needs of, and engage with, the private sector. And for this we need new forms of co-operation that go beyond traditional barriers. Increasingly governments are seeking input from industry in national policies. Innovative ways of moving technologies to the marketplace involve more joint public and private sector models and mechanisms.

Despite these efforts, energy technology innovation and diffusion is still a long process, generally taking two to three decades to reach full commercial deployment. The pace of innovation needs to accelerate.

The IEA would like to contribute to these efforts. Its ambition is to double cost-effective investments in low-carbon energy technologies by 2015, with the goal of accelerating the spread of technologies by:

- expanding private-sector participation in existing IEA activities through initiatives such as the low-carbon energy technology platform, the chief technology officers' roundtable, energy technology roadmaps, energy business council, sustainable transport modelling, energy efficiency analysis and the combined heat and power collaborative;
- sharing the financial burden; and
- raising awareness of time-proven, demand-driven, flexible multilateral technology initiatives that respond to changing policies and industry needs.

The sections below outline successful government and industry partnerships, whether on national energy technology policies or programmes, followed by an in-depth review of industry participation in multilateral technology initiatives – the IEA Implementing Agreements.

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THE ROLE OF INDUSTRY IN NATIONAL R&D POLICY PROCESSES

Industry is increasingly involved in the preparation, implementation and evaluation of public energy R&D policy. In some countries industry may be a driving force for energy R&D while in others it may be strongly driven by government initiatives.

Danish industries take part in strategy development via their representation in the Advisory Committee for Energy Research and consultation with Danish Energy Authority. In addition, there are programmes ("public service obligations") that are designed and implemented by Danish utilities (after approval of the Energy Agency). Industry is also involved in submitting and evaluating R&D proposals.

In **France**, R&D priorities for renewable energies are established together with industry. The *Institut Français du Pétrole* (IFP) ensures the link between private and public R&D for fossil-fuel research. A number of research networks in the area of fuel cells and transport R&D also include industrial partners.

In **Finland**, industry is consulted during the preparation of national energy research funding programmes.

Recently in **Germany** the high-technology research policy aims to increase co-operation between science and industry through cutting-edge clusters and networks, new incentives and to improve conditions for private investment in R&D to strengthen competitiveness.

Industries in **Ireland** are strongly represented in the main energy R&D funding agency and in particular, contribute to the preparation and implementation phase. Various industry-oriented research programmes are initiated in different areas of sustainable energy.

In **Japan**, energy R&D plays an important role and privately financed or publicly co-financed research institutions are common. The energy R&D and innovation system is largely based on R&D agencies financed by industrial corporations beyond public R&D institutes.

In **Korea**, industry played a majority role in developing 15 low-carbon technology roadmaps, followed by the research centres and universities. Direct government input only accounted for 3% of the roadmap development.

In the **Netherlands**, industry covers an important share of the overall non-nuclear energy R&D. However, it is not strongly involved in the priority setting process. Nevertheless, it was consulted for the current energy research strategy. Private industry R&D is supported by tax credit for research, and the voluntary agreement to reduce greenhouse-gas emissions between the government and various industrial sectors.

There is close co-operation between industry and public authorities in establishing energy R&D strategies in **Norway**. The 2007 strategy for energy R&D, Energi21, was authored by representatives from industry and academia and has been adopted as general guidelines for public energy R&D.

Industry associations and foundations in **Sweden** commission important parts of the R&D portfolio to universities and institutes.

Research in **Switzerland** is managed by the Federal Energy Research Commission (FERC) and the Swiss Federal Office of Energy (SFOE). The FERC is comprised of 15 representatives from enterprises of varying size, academia, policy makers, and the investment community. The FERC four-year master plan (2008-2011) includes 24 specific R&D areas. Each area has an advisory group which includes a variety of stakeholders including industry representatives. Through these advisory groups, the R&D efforts are strongly linked to industry needs.

The Engineering and Physical Science Research Council of the **United Kingdom** supports energy R&D projects. As half of its members are from industry, their influence is important.

The **United States** has a long history of involving many stakeholder groups in devising technology roadmaps, in which industry plays a central role.

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THE ROLE OF INDUSTRY IN NATIONAL R&D PROGRAMMES

Industry also participates in national R&D programmes. Participation may include co-operation, co-patenting and co-publishing between firms and research institutes, researcher mobility between industry and science, private funding of basic research, patenting by universities and public research institutes, or university spinoffs. A few examples are outlined below.

Australia: The National Research Flagships Programs are large-scale multidisciplinary research partnerships. Initiated in 2003, the National Research Flagships endeavour is one of the largest scientific research programmes ever undertaken in Australia, with the total investment to 2010-11 expected to be close to AUD 1.5 billion (approximately USD 1.15 billion). Flagships will focus on key technology areas including climate adaptation, food futures, light metals, minerals, manufacturing, preventative health, water, oceans, and energy.

On the demonstration side, **Australia** has multiple projects with significant funding. The Energy Innovation Fund provides AUD 150 million over five years to support the development of clean energy technologies. This amount includes AUD 100 million for solar thermal and solar photovoltaic technologies, including formation of the Australian Solar Institute, and AUD 50 million for the Clean Energy Program.

Denmark: There can be a close link between industry and universities for clearly defined technologies. An example is the Danish Research Consortium on Wind Energy which forms collaborations between five laboratories and universities.

France: The French *Pôles de Compétivités* (competitiveness clusters or centres of excellence) bring together industries, laboratories and universities based on the strengths of each region. They plan regional strategies and innovative projects. In addition to reducing costs, maximising outcomes, and networking, these centres of excellence provide a central point of contact for potential international partners. A large number of these clusters relate to energy.

Germany: The *Verbundprojekte* consortia are collaborations between universities and industrial partners that go beyond narrow thematic topics to aim to capture the broader field of energy research. For example the *Initiativkreis Ruhrgebiet*, or public-private partnership for energy research, brought together several Ruhr universities and three others. There are also a number of regional competency clusters, or *Kompetenznetze*, that provide opportunities for regional experts to network. Lastly, some research centres are funded jointly by universities and industry.

Korea: In 1994 Korea instituted public-private partnerships in 15 categories. Those relating to energy include electricity source facilities, gas supply facilities, collective energy facilities, and intelligent transportation systems. The government provides technical assistance, policy development, credit guarantees and tax and financial benefits to the industries involved.

Portugal: To bring to the fore innovative products, the national Innovation Agency (ADI) provides assistance to small- and medium-sized enterprises such as budgetary support and in some cases guaranteeing external financing provided by banks and credit institutions.

United Kingdom: The Energy Research Partnership is a high-level forum that brings together key funders of energy RDD&D in government, industry and academia, plus other interested bodies, to identify and work together towards shared goals. It is designed to give strategic direction to energy RDD&D in the context of the government's energy policy and especially with regard to the aim of increasing national research and development expenditure.

United States: Methane-to-Markets is a well-known example of an international partnership (14 countries, of which 9 are IEA non-member countries). The goals are to promote advanced energy technologies, innovations, transfer, industrial waste minimisation, recycling, re-use and energy sector reforms (*e.g.* energy laws, legal and regulatory initiatives).

Another example of such partnerships in the United States is the Energy Efficiency and Renewable Energy Industrial Technologies Program which brings together industry, state governments, associations, investors and other stakeholders to identify R&D opportunities with large potentials for energy savings to accelerate commercialisation of innovative technology solutions. It assists manufacturers to increase energy efficiency and carbon reduction in the value chain from extraction of raw materials to assembly of commercial products.

Europe: Project-based co-operation between industrial and public partners is fostered through, for example, the European Framework Programme for Research. The technology platforms provide a framework for stakeholders, led by industry, to define R&D priorities, timeframes and action plans. Following this model, a number of national technology platforms have been created (Austria, Belgium, Denmark, Germany, Greece, Italy, the Netherlands, Poland, Portugal, Spain and the United Kingdom).

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GOVERNMENTS AND INDUSTRY JOIN FORCES IN MULTILATERAL TECHNOLOGY INITIATIVES

There is a long history of fruitful collaboration between governments and industry in the IEA multilateral technology initiatives (Implementing Agreements). The first Implementing Agreement (IA) was created in 1975. By 1977, the first three companies began participating in IAs relating to renewable energy technologies: Electrolyser Corporation Ltd., Naamloze Venootschap DSM, and Faber Computer Operations. By 1979, the Austrian oil company OMV was designated to represent the government for a fossil fuel-related IA. Since then, industries have regularly participated in IAs in several ways, either by representing governments or through nationally owned energy companies (a total of 13 in 2002).

Adopted in June 2003, the Framework for International Energy Technology Co-operation allows non-governmental organisations to become signatories to IAs under the category of Sponsor. This official category allowed industry to have a seat at the table and vote on behalf of the company they represent. In addition, the Framework allows for equitable sharing of obligations, contributions, rights and benefits among all participants – whether government or industry.

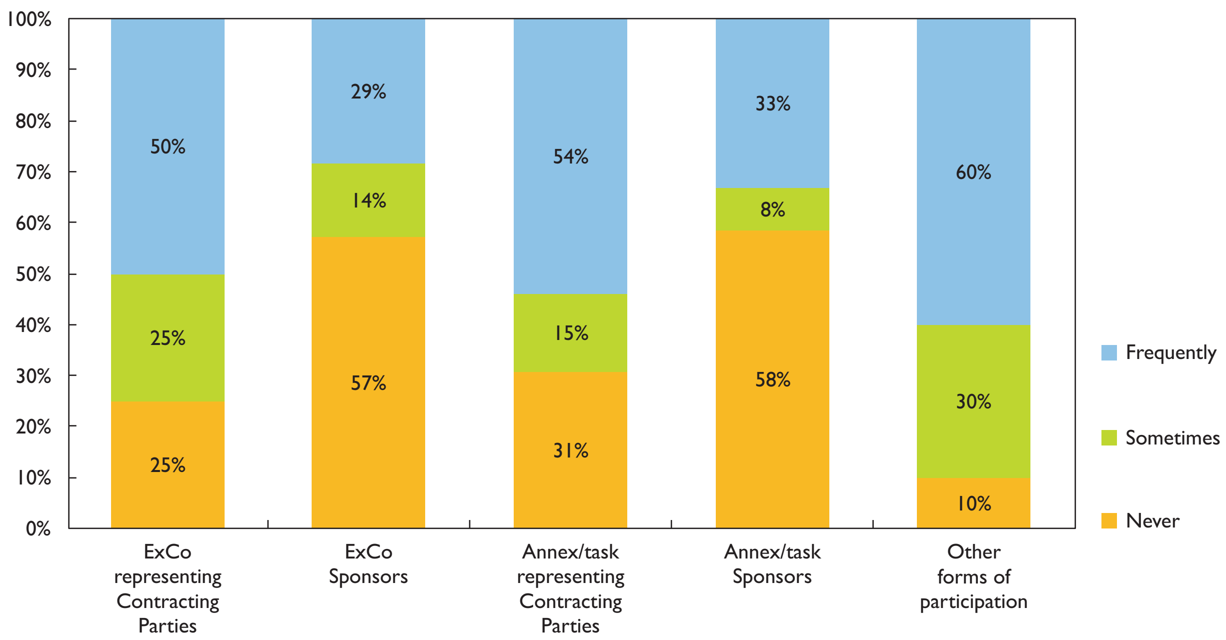
This has served to significantly increase the share of industry signatories in the Agreements. By 31 March 2010 there were 50 formal industry participations as Sponsors, the majority of which in the fossil fuels and renewables categories. Seven Sponsors were located in IEA non-member countries: Brazil, China, India, Russia, South Africa and Thailand. (See the Statistics chapter for the full list of companies currently participating as Sponsors.)

The majority of IAs regularly seek input, guidance and partnerships with industry. Perhaps the most important form of industry input to IAs is through informal communications based on long-standing relationships of trust, mutual benefit and information sharing. This is particularly true for those Agreements based on a task-shared (in-kind) funding mechanism rather than full-financing schemes.

Roles for Industry in Implementing Agreements

	Board of Directors (Executive Committee)	**Projects** (Annexes or Tasks)
Sponsor (signatory)	•	•
Representing government	•	•
In-kind contribution	•	•
Consultation	•	•

Figure 1 • Industry Participation in Implementing Agreements



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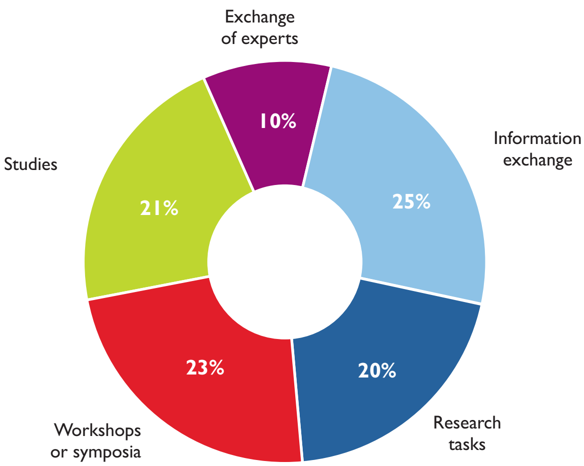
Overall, the nature of interactions with industry is related to the scope of the IA (see Figure 2). Those IAs that focus on collecting and sharing information frequently consult industries for data, while those concentrating their efforts on basic research may ask for industry input to identify applications and guide research while those Agreements that focus on areas with commercial applications have frequent interactions with industry research teams. This relationship may also be applicable for research projects carried out under the Agreement; for example, industry participation is more relevant for application-focused projects as of the technology or process is ready to be applied.

Figure 2 • Implementing Agreement Activities



Significant numbers of industries participate at the research project level where they represent governments or their own companies. Over 200 industries participate as Sponsors or representing governments in the projects of the renewable energy IAs. Those IAs concerning end-use in buildings and transport reported a high level of industry participation with over 100 for both sectors.

Industry may also be involved as end-users of the data generated by the IA or as co-hosts for symposia and workshops. Other industry participation includes information exchange, peer review, workshop participation, observers at board meetings, collaboration agreements, membership in trade association networks, as well as sponsoring conferences, team meetings, university summer schools, and research networks.

The IA mechanism can also be used to build pilot or demonstration plants. The United Kingdom, the Federal Republic of Germany and the United States created an IA to share equally the costs of building and operating an experimental pebble-bed, fluidised bed conversion (PBFC) facility at Grimethorpe (United Kingdom). The objectives of the project were to:

- provide a flexible facility to investigate combustion, heat transfer, corrosion, gas clean-up and energy recovery;
- carry out tests in a wide range of operating conditions; and
- provide data to assist design of large commercial plants.

Construction commenced in 1977 and experiments continued until 1984. As the terms of the Agreement had been fulfilled, it was not necessary to continue joint collaboration further.

Profit-generating technologies or processes resulting from the collaboration in an IA can be taken forward through separate contracts. When designed appropriately, technology standard agreements can accelerate innovation and protect the participants from patent infringement lawsuits from those outside the alliances. Once the basic research has reached the application stage, IAs may establish formal collaboration agreements such as memoranda of understanding with industry partners.

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What does each stakeholder group gain from increased co-operation?

Industry and business partners

- Linking research, technology and policy requirements
- Accelerating research results and regulated IPR issues
- Information sharing, knowledge transfer and networking to raise credibility
- Access to IEA non-member country markets and governments
- Harmonised benchmarking and standards
- Shared resources and risks leading to greater potential project scale
- Understanding government energy technology policy needs and input to priority-setting

IEA member and non-member country governments

- Understanding private sector needs and investment conditions in the short- and medium-term through closer collaboration with international business organisations
- Deploying low-carbon energy technologies at an accelerated pace and scale
- Sharing resources and risks
- Harmonising technical standards and intellectual property issues
- Strengthening national and localised research capabilities
- Strengthening existing linkages with other organisations and creating synergies to avoid gaps and overlaps

IEA multilateral technology initiatives (Implementing Agreements)

- Understanding private sector needs and investment conditions for technology uptake
- Accelerating results and knowledge transfer
- Shared resources and costs
- A strategic, harmonised and regulated approach to technology development and transfer, so that national regulation or ISO standards or similar is required
- Greater project scale
- Increased access to government and business

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CROSS-CUTTING ACTIVITIES

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BRIDGING THE GAP

Policy Brief

The objective of the Implementing Agreement for the Climate Technology Initiative (CTI IA) is to allow IEA member countries and IEA non-member countries to work together to foster international co-operation for accelerated development and diffusion of climate-friendly and environmentally sound technologies and practices. This is accomplished through assistance with technology needs assessments, training courses, project financing, targeted capacity building, and expert exchanges.

Background

The 11 Contracting Parties of the CTI IA undertake a broad range of co-operative activities in partnership with developing and transition countries and international organisations. The CTI works closely with the Secretariat of the United Nations Framework Convention on Climate Change and its Expert Group on Technology Transfer, relevant Implementing Agreements and other international organisations and initiatives.

Recognising their essential role in effective technology transfer, CTI IA ensures that representatives of the private business and financing communities participate on a regular basis in CTI IA regional activities in Africa, Asia, Eastern Europe, and South America. Topics include improved access to financing, application of low-carbon technologies, conducting technology needs assessments, and preparation of project financing proposals.

Spotlight

The CTI Private Financing Advisory Network (PFAN) was launched in 2006 in cooperation with the UNFCCC Expert Group on Technology Transfer. PFAN assists project developers in IEA non-member countries to develop, plan, finance and implement small- and medium-sized environmentally sound projects.

PFAN first identifies viable projects and provides developers with coaching and consultancy services. It then bridges the gap by bringing those developers in contact with private sector finance organisations through "match-making events", or Clean Energy Financing (CEF) fora. Thanks to the generous support of the CTI IA countries, the United States Agency for International Development, the Renewable Energy and Energy Efficiency Partnership, and many others, the PFAN activities have intensified in the last two years. The Asia Forum for CEF in Singapore showcased 33 projects where 400 project developers, investors, bankers and entrepreneurs gathered.

▲ Experts performing a thermal energy audit at the rolling mill cluster in Bhavnagar, Gujarat, India.

Based upon the success of this event, an Asian investor network was created and plans for regional networks are underway in Central Africa, South Africa and Latin America during 2010-11.

The last two years have also been highly productive for PFAN projects, with two projects guided to financial closure (USD 35 million):

- Mexico: run-of-river hydroelectric power station (5 MW)
- Brazil: bio-diesel refinery

Two further financial closings for PFAN projects in the Philippines include:

- Biomass plant (12 MW, USD 30 million)
- Waste-to-ethanol plant using biomass waste from the food processing industry (USD 1.1 million)

Both of these projects were identified and developed through the CTI IA CEF fora, clearly validating the concrete results of the concept. This brings the total of financing leveraged by PFAN to USD 71.1 million. Thirty-eight new projects have begun validation for review and processing, bringing the total projects under review to 46 (for a total estimated investment of USD 1.7 billion).

CURRENT PROJECTS

Capacity Building
Private Financing Advisory Network
Raising Awareness and Outreach
Technology Needs Assessments
Training Courses

REFERENCES

www.climatetech.net

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FASTER AND FURTHER

Policy Brief

Having access to key research information provides analysts with the tools necessary to draft appropriate policy documents. The Implementing Agreement for the Establishment of the IEA Energy Technology Data Exchange (ETDE) database is the largest single resource for energy-related scientific, technical and policy information worldwide. The ETDE online database, ETDEWEB, includes over 4.3 million research literature citations and hundreds of thousands of links to full research documents.

Background

The mission of the ETDE IA is to provide governments, industry and the research community in participating countries with access to the widest range of information on energy research, science and technology and to increase dissemination of this information to developing countries. The objectives of the 15 member countries of the ETDE IA (including Brazil, Mexico and South Africa) are to:

- compile and maintain a shared database on information related to energy research and technology;
- disseminate information related to energy research and technology; and
- explore, and where appropriate develop, other ways of collecting and disseminating information related to energy research and technology.

Spotlight

One of ETDE IA's strategic goals is to find ways to leverage new user interface technologies. Widgets are one of these new technologies. Part of the interactive Web 2.0 technology, widgets allow a website to serve as a platform, linking to other websites and platforms and vice-versa. A potential user (from an eligible country) can now start searching the database directly from the ETDE homepage or on another organisations' page[1].

The ETDE IA is also at the cutting edge of information technology. Database search speed now compares favourably with that of commercial systems, and thanks to several key initiatives usage has expanded dramatically.

In 2008 the ETDE database became accessible to search engines such as Google via site map technologies, significantly broadening visibility and outreach. ETDE has also implemented a new domain recognition authentication technology allowing users in approved countries immediate access. These improvements have resulted in substantial increases in ETDEWEB sessions. In 2007 requests totalled 33 253 and in 2009 reached 124 000. The portion of requests from non-member countries, only 465 in 2007, reached 9 967 in 2009.

The ETDE IA achieved two important milestones in the last two years including full-text, downloadable documents reaching more than 320 000. In addition, Digital Object Identifiers (DOI) on existing documents now total over 960 000, serving to protect intellectual property of the original source.

The new federated search feature allows users to simultaneously search ETDE and other worldwide research databases: the Danish Energy Agency, the European esp@cenet (patents from Japan, the European Patent Office, and the World Intellectual Property Organisation and others), l'Institut Français du Pétrole, the International Energy Agency, and the United States' scienc.gov, and Science Conference Proceedings portals.

Efforts continue to expand the ETDEWEB database. One project with the International Atomic Energy Agency INIS database will expand the full text totals significantly. In addition, special projects with Elsevier journals, co-operation with the World Energy Council, inclusion of Open Access journals, and information from other IEA agreements are also underway.

CURRENT PROJECTS

The ETDE IA provides free specialised information to the following developing countries:

Afghanistan, Albania, Algeria, Angola, Armenia, Azerbaijan, Bangladesh, Belize, Benin, Bhutan, Bolivia, Burkina Faso, Burundi, Cambodia, Cameroon, Cape Verde, Central African Republic, Chad, Colombia, Comoros, Congo, Congo (Dem. Rep.), Cote d'Ivoire, Djibouti, Ecuador, Egypt, El Salvador, Eritrea, Ethiopia, Gambia, Georgia, Ghana, Guatemala, Guinea, Guinea-Bissau, Guyana, Haiti, Honduras, Indonesia, Iraq, Jordan, Kenya, Kiribati, Kyrgyz Republic, Lao (PDR), Lesotho, Liberia, Macedonia (FYR), Madagascar, Maldives, Mali, Marshall Islands, Mauritania, Micronesia, Moldova, Mongolia, Morocco, Mozambique, Myanmar, Namibia, Nepal, Nicaragua, Niger, Nigeria, Pakistan, Papua New Guinea, Paraguay, Peru, Philippines, Rwanda, Samoa, Sao Tome and Principe, Senegal, Sierra Leone, Solomon Islands, Somalia, Sri Lanka, Swaziland, Tajikistan, Tanzania, Thailand, Timor-Leste, Togo, Tonga, Tunisia, Turkmenistan, Uganda, Ukraine, Uzbekistan, Vanuatu, Vietnam, Yemen, Zambia, and Zimbabwe.

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www.etde.org

1. ETDE widget script <script type="text/javascript" src="http://widgets.clearspring.com/o/499c7bb2b41caec0/4a900b0b93d5dd8b/4a4cc45cda112d74/4cc06de1/widget.js"></script>

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THE FOUNDATIONS OF POLICY MAKING

Policy Brief

Experts worldwide rely on tools such as the MARKAL and TIMES models to provide decision makers with quantitative evaluation of the impact of energy policies. Together with quality data on present energy markets and technologies, there tools are applied at the local, national, regional and global levels, facilitating design of more effective energy policies.

Background

The objective of the Implementing Agreement for a Programme of Energy Technology Systems Analysis (ETSAP IA) is to assist decision makers in the assessment of energy technologies and policies in meeting the challenges of energy supply, economic development, and greenhouse gas mitigation.

The ETSAP IA research programme has continually developed the MARKAL model generator and has recently designed an enhanced model, the Integrated MARKAL-EFOM System (TIMES). There are currently eight Contracting Parties to the Agreement. To date, more than 250 groups in over 70 countries have used ETSAP tools, including the Energy Research Institute of the National Development and Reform Commission (China).

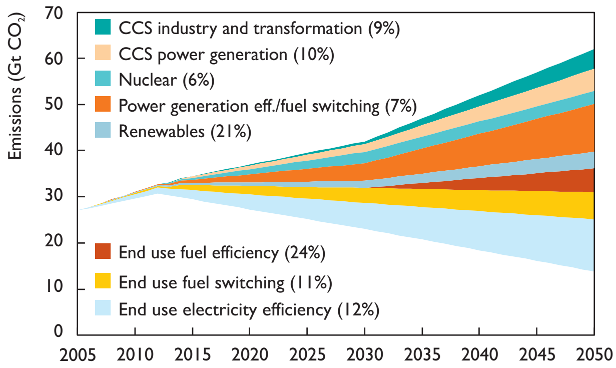
Spotlight

Fourteen Contracting Parties participated in the ETSAP IA project, Global Energy Systems and Common Analyses (GES), with additional input from over more than twenty-five universities and organisations worldwide. The main objectives of the GES project were to:

- carry out common global analysis
- implement a global/national modelling framework
- maintain and enhance existing capabilities

The report illustrates 50 or more models, studies and analyses carried out with ETSAP in tools. Among the many accomplishments achieved, two global model developments deserve special focus as they have raised the state-of-the-art for comprehensive energy system analysis to a new standard.

The IEA publication *Energy Technology Perspectives 2008* assesses possible routes to technology deployment and climate stabilisation and is based, among others, on a global multi-regional MARKAL model. The IEA study concludes that end-use efficiency and a virtually CO_2-free power sector can yield emissions stabilisation in 2050 at today's level (the accelerated technology scenario, or ACT).



▲ Contribution of emissions reductions options in the BLUE Map scenario between 2005 and 2050.

However, halving emissions would also require significant fuel switching, CO_2 capture and storage in end-use sectors and steps to ensure that rapidly growing emissions from transport are not just slowed, but reduced. The BLUE scenarios are therefore more challenging, require earlier and stronger action, and they will be much more costly. These important policy messages were designed based on a solid foundation of data such as the global MARKAL model.

Another model, the ETSAP TIMES Integrated Assessment Model (TIAM), is a detailed, technology-rich global model. The results of ETSAP-TIAM studies have become a trusted source for reputable climate mitigation policy groups such as the Intergovernmental Panel on Climate Change (IPCC). Making use of the stochastic version and the climate change module of the global multi-regional TIAM model, ETSAP contributed to identifying hedging strategies in the frame of the Energy Modelling Forum, working group 22.

CURRENT PROJECTS

IEA-ETP-Global MARKAL

ETSAP-TIAM for EMF-22

UK-Japan Low Carbon Society

EFDA-Global TIMES

EC-REACCESS

EC-REALISEGRID

US-EPA-MARKAL

US-NE-MARKAL

REFERENCES

www.etsap.org

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END-USE TECHNOLOGIES

Buildings

Electricity

Industry

Transport

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FROM INCREMENTAL TO SUBSTANTIAL

Policy Brief

The vision of the Implementing Agreement for a Programme of R&D on Energy Conservation in Buildings and Community Systems (ECBCS IA) is to find near-zero primary energy use solutions for buildings and communities. To achieve this, the ECBCS IA has designed a carefully chosen R&D strategy that will require changes to current design and construction practice and move from incremental to substantial "step" changes in IEA member countries.

Background

The strategy exploits opportunities to save energy in the buildings sector, and to remove obstacles to market penetration of new energy conservation technologies. It applies to R&D activities in residential, commercial, office buildings and community systems, in three focus areas:

- Dissemination
- Decision-making
- Building products and systems

There are currently 25 Contracting Parties to the Agreement, including China and Israel.

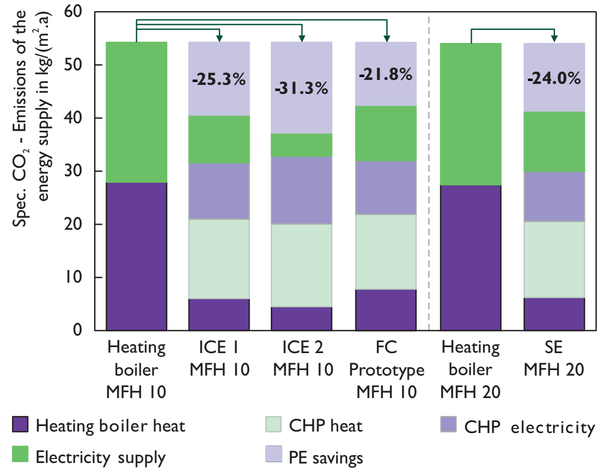
Spotlight

Co-generation (CG) recuperates waste heat from electricity generation, reducing consumption of fossil fuels and greenhouse-gas emissions. Until recently the use of CG systems in the residential sector was limited due to the lack of devices available on the market. Thanks to further developments by manufacturers and removal of many technical barriers, widespread market availability of CG is now becoming a reality.

One ECBCS IA project Simulation of Building-Integrated Fuel Cells and Other Cogeneration Systems generated a common approach to implementing residential-scale CG devices. Models were developed and integrated into existing whole-building simulation tools to examine the link between CG, other heating, ventilation and air conditioning components, and the building thermal and electrical demands.

Extensive experiments on 13 prototype and early-market, residential-scale CG devices were carried out. Data were collected and analysed on key occupant-driven electrical and hot water usage.

The results show substantial gains. Small-scale fuel cells and sterling and internal combustion devices showed steady-state electrical conversion efficiencies of 9% to 28%. Total energy conversion efficiencies (electrical plus thermal) ranged from 55% to as high as 100% for some devices. Team members also found that when coupled with ventilation and domestic hot water systems, CG reduces primary energy consumption by up to 33% and greenhouse-gas emissions by up to 23% compared to conventional condensing boilers, furnaces, domestic hot water heaters.



▲ CO_2 emissions from energy of the reference system and the residential CHP systems.

CURRENT PROJECTS

- Air Infiltration and Ventilation Centre
- Analysis of Microgeneration and Related Energy Technologies in Buildings
- Cost Effective Commissioning of Existing and Low Energy Buildings
- Energy Efficient Communities: Strategic Guidance for Urban Decision Makers
- Energy-Efficient Future Electric Lighting
- Heat Pumping and Reversible Air Conditioning
- Holistic Assessment Tool-kit: Energy Efficient Retrofit Measures for Government Buildings
- Integrating Environmentally Responsive Elements in Buildings
- Low Exergy Systems for High Performance Buildings and Communities
- Prefabricated Systems for Low Energy Renovation of Residential Buildings
- Reliability of Energy Efficient Building Retrofitting Performance and Cost
- Technical and Commercialisation Studies for Micro-generation Deployment in Buildings
- Total Energy Use in Buildings: Analysis & Evaluation Methods
- Towards Net Zero Energy Solar Buildings

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www.ecbcs.org

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COST-EFFECTIVE ALTERNATIVES

Policy Brief

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. Though barriers to the deployment of DHC schemes exist, they can be avoided through such measures as:

- internalising environmental benefits of DHC into emissions trading schemes;
- removing subsidies and guaranteeing a fair price for electricity and a fair balance between electricity and heat costs without cross-subsidies;
- urban energy foresight and planning.

Background

There are eight participants in the Implementing Agreement for a Programme of RD&D on District Heating and Cooling, including the Integration of Combined Heat and Power (DHC IA). The scope of the work encompasses:

- district heating, cooling and power, and their integration;
- energy efficient supply, notably combined heat and power;
- cost reduction through improved heating pipes and substations;
- efficient end-use through efficient customer connections and demand side management; and
- improving the relationship between supply and demand through thermal storage and system optimisation.

Spotlight

Northern European countries have well-developed district heating (DH) networks, where 80 to 90% of the central urban areas are equipped and 10 to 15 % of the areas with lower urban density (10 kWh/m^2/year) or heat demand (0.3 MWh/m^2/year).

One DHC IA project, District Heating Distribution in Areas with Low Heat Demand Density set out to examine ways in which DH could be a viable, cost-effective technology in low-density areas, which typically incurs high investments and often results in high heat losses. The team set out to identify cost savings through improved system design, new district heating pipes, and household applications.

New types of pipes that could potentially lead to significant cost reductions and environmental benefits were analysed.

▲ Plastic pipes ready to be installed in a new district heating and cooling network.

For example, triple pipes (two small supply pipes and one return pipe) were found to reduce heat loss by 45% compared to the standard pair of single pipes (one in each direction). And when compared to a circular twin pipe (the current state-of the-art) the triple pipe was found to reduce heat losses by 24%, resulting in a 20% reduction in costs.

Low-pressure, low-temperature systems connected directly to a radiator system in small local networks were also found to be cost-effective, as are new distribution methods using smaller service pipes with booster pumps or small pipes with heat storage units. One effective measure involves replacing the electricity consumed in household appliances (dishwashers, clothes washers or dryers) with heat.

In conclusion, numerous techniques and measures were found to reduce costs for heat distribution in areas with low heat demand. In many cases, it was found that careful planning leads to alternative solutions that are easily applied, save energy and reap financial rewards.

CURRENT PROJECTS

Distributed Solar Systems Interfaced with a District Heating System with Seasonal Storage

District Heating for Energy Efficient Building Areas

Interaction between District Energy and Future Buildings that have Storage and Intermittent Surplus Energy

Potential Increased Primary Energy Efficiency and Reduced CO_2 Emissions through DHC

REFERENCES

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TESTING AND TRADING KNOWLEDGE

Policy Brief

Improving energy efficiency is now recognised as the most cost-effective way to begin to address climate change and energy security concerns. A range of market barriers prevent consumers from investing in energy efficient equipment, requiring many governments to introduce well-targeted policy measures.

Most governments now 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. And as international trade in electrical equipment grows, increased international co-operation enables countries to develop policy approaches more effectively than acting alone.

▲ Downsizing and using variable frequency drive for partial load reduce annual electricity use of 50 kW pump motors by 50%.

Background

The Implementing Agreement for a Co-operative Programme on Energy Efficient Electrical Equipment (4E IA) provides an international forum for governments and other stakeholders to:

- share expertise and develop understanding of electrical equipment and policies; and
- facilitate co-ordination of international approaches to efficient electrical equipment.

There are 11 Contracting Parties to the Agreement, including South Africa.

Spotlight

Electric motors – drive pumps, fans, compressors, conveyors, and industrial equipment – are responsible for 40% of global electricity demand.

However, industry auditors worldwide continue to encounter outdated, inefficient motors in use. Oversized motors, systems with poorly integrated components or ill-adapted to changing loads are common, leading to large, unnecessary energy and financial losses. Energy efficiency improvements of 20%-30% have been attained by some industrial efficiency programmes. Successful pilot projects have illustrated potential efficiency gains with payback times of 1-3 years. Yet many barriers persist.

Suppliers, purchasers and regulators need to be confident that electric motors on the market fulfil energy performance claims. Introducing mandatory minimum energy efficiency standards for motors has increased the testing for compliance.

Coordinated efforts between both manufacturers and independent test centres are becoming a necessity. The goals of the 4E project on Electric Motor Systems (EMS) are to improve energy efficiency by promoting highly efficient electric motors systems in industrial and developing countries, disseminating best practice on technical and economical experience, and distilling lessons learned for coherent policies on minimum energy performance standards and labels (MEPS).

Harmonising testing standards and efficiency classifications is a major prerequisite for competitive global markets of premium products. The purpose of the EMS *Electric Motor MEPS Guide* is to provide information that will facilitate trade of highly efficient motors in global markets. Drawing on the 2008 International Electrotechnical Commission global standard (IEC 60034-30), the *MEPS Guide* includes new testing standards, efficiency classes, labels and minimum energy performance standards for three commercial levels of efficiency.

To stimulate exchange of efficient electric motor system technologies and policies, the EMS created the Global Motor Systems Network (GMSN). EMS experts participate in major international conferences to build momentum for the network, discuss issues with other experts in the field and extract relevant issues. At the 2009 EEMODS conference EMS experts presented the GMSN under the policies and programmes session, as well as conducting a Testing Centre workshop.

CURRENT PROJECTS

Electric Motor Systems

Mapping and Benchmarking

Standby Power

REFERENCES

www.iea-4e.org

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RECYLING VALUABLE WASTE HEAT

Policy Brief

Energy storage technologies can be used in a wide variety of applications. Domestic hot water and space heating/cooling are common examples of thermal energy storage. Combined with renewable technologies, energy storage saves the electricity or heat to be consumed when the sun is not shining or the wind is not blowing. Other energy storage applications include cooling for buildings taking advantage of low underground or water temperatures or heating by recuperating industrial waste heat and transporting it to other industries or to district heating networks.

Background

The overall objective of the Implementing Agreement for a Programme of R&D on Energy Conservation through Energy Storage (ECES IA) is 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. Currently 16 Contracting Parties and three Sponsors participate.

Spotlight

One recent ECES IA project, Sustainable Heating and Cooling with Underground Thermal Energy Storage, aims to optimise integration of thermal energy storage by demonstrating and evaluating the energy savings and CO_2 emissions reduction through technology development, design methods, feasibility studies and demonstration projects.

With the Oostelijke Handelskade project (Netherlands), the challenge was to design an environmentally sustainable, balanced heating and cooling system for a large-scale, multi-use building complex. It included an international passenger terminal for cruise ships, office buildings, a hotel, an arts centre and 130 residential apartments, each with different energy requirements and demand patterns. The energy system was developed and operated by a utility company.

Project planners chose a centralised aquifer thermal energy storage system combined with heat pumps in the dwellings and collective heat pumps in each office and public building. The goal was to balance thermal energy supply and demand within each building as well as between each of the buildings.

Surface water was used to balance the thermal demands, while surplus heat and cold could be stored seasonally using warm and cold wells with a total capacity 4.0 MW.

▲ Sustainable heating and cooling in the Oostelijke Handelskade complex (Netherlands).

Despite the elevated heat (8.2 MW) and cold demand (8.3 MW) for the complex, substantial savings were achieved:

- energy consumption was 50% lower than conventional heating and cooling systems (gas boilers and compression cooling machines);
- energy losses due to low-temperature heating and high-temperature cooling were reduced; and
- energy rates were in conformity with conventional systems.

ECES IA experts contributed to the project design phase, building on findings of previous ECES IA projects): just one example of how Implementing Agreement research directly supports technology demonstration and deployment.

CURRENT PROJECTS

- Applying Energy Storage in Buildings of the Future
- Compact Thermal Energy Storage Material Development and System Integration
- Cooling with Thermal Energy Storage
- Optimised Industrial Process Heat and Power Generation with Thermal Energy Storage
- Thermal Energy Storage Applications in Closed Greenhouses
- Thermal Response Testing
- Transporting Industrial Heat with Thermal Energy Storage Tanks

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www.energy-storage.org

Photo courtesy of IF Technology.

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ALL PUMPED UP TO SAVE EMISSIONS

Policy Brief

Heat pumps (HP) have the potential to significantly reduce both energy use and CO_2 emissions. A 30% market penetration of HP could generate savings of 1 500 million tonnes of CO_2 annually, or approximately 6% of current total global emissions. In addition, HP provide greater fuel flexibility, providing the potential to reduce infrastructure costs for supply networks in developing economies.

Recent policies enacted in Europe, Japan, and the United States aim to reduce CO_2 emissions through accelerated deployment of clean technologies including HP. These strategies will play an important role in reducing barriers to deployment.

▲ Field tests of residential heat pumps show good performance and considerable CO_2 emissions reduction.

Background

There are currently 13 Contracting Parties in the Implementing Agreement for a Programme of RD&D an Promotion of Heat Pumping Technologies (HPP IA). The five-year strategy aims to:

- quantify and publicise the energy saving potential and environmental benefits (local and global) of HP 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 Agreement.

Spotlight

The principal objectives of one HPP IA study, Economical Heating and Cooling Systems for Low Energy Houses, are to improve and further develop multifunctional HP system overall energy use, achievable comfort and costs, gather more field experience from real-world operation of HP systems, and derive design guidelines for multifunctional HP systems and their control. There are four subtasks:

- market and systems survey
- system assessment and comparison
- field testing of integrated HP systems
- system assessment and comparison

National activities of the participants focus on laboratory testing of prototypes of integrated HP systems including those using natural refrigerants such as CO_2.

Results of the national projects were translated into design recommendations, standard system solutions and best practice systems.

Preliminary conclusions underline the important role of regulation in leading low energy houses development (*e.g.* net zero energy building targets by 2020). Aggregated field test results show good performance of the most recent generation of HP, while field tests of new system layouts confirm considerable CO_2 emission reduction potentials compared to current systems.

Heat pumps were also found to improve low energy house efficiency of integrated systems through additional capacity range, simultaneous generation, and system integration. In addition, CO_2 heat pumps increased hot water temperature substantially.

CURRENT PROJECTS

Advanced Modelling and Tools for Analysis of Energy Use in Supermarkets

Compact Heat Exchangers in Heat Pumping Equipment

Economical Heating and Cooling Systems for Low Energy Houses

Ground-Source Heat Pumps: Overcoming Market and Technical Barriers

Retrofit Heat Pumps for Buildings

Thermally Driven Heat Pumps for Heating and Cooling

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www.heatpumpcentre.org

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INTEGRATING SAVINGS

Policy Brief

Energy efficiency is highlighted as offering near-term solutions. And energy efficiency improvements have a significant positive impact on system performance, the environment and employment. Demand side management (DSM) is one way to achieve large-scale programme improvements in energy efficiency. According to the IEA *World Energy Outlook*, investing USD 1 in demand side improvements offsets USD 2 of supply (generation, transmission and distribution). And the current financial crisis is undermining investment in low-carbon energy. There is therefore an urgent need for governments to respond decisively.

Background

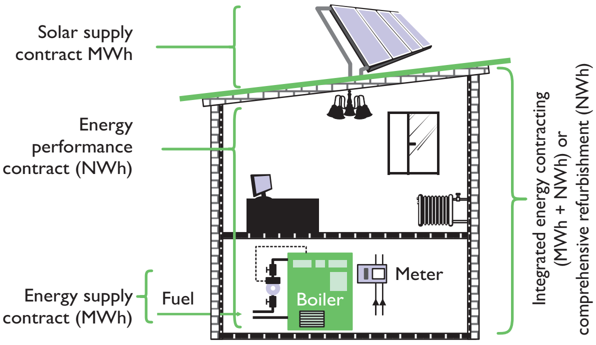
The scope of work of the Implementing Agreement for Co-operation on Technologies and Programmes for Demand Side Management Implementing Agreement (DSM IA) covers electricity load shape and load level. Load shaping ensures continuation of network operations in overload situations, by providing the opportunity to selectively switch loads instead of shutting down selected areas of supply completely. Load levelling typically involves storing excess electricity during periods of low demand for use during periods of high demand, by using energy efficient products, or through implementing energy-efficient measures. There are currently 19 Contracting Parties (including India) and one Sponsor.

Spotlight

Energy contracting is a cost-effective, multi-purpose-instrument that alleviates market barriers to energy efficiency measures. For this reason energy service companies (ESCO) have recently gained interest. The European Directive 2006/32/EC aims to improve energy end-use efficiency by:

- establishing indicative targets, incentives and the institutional, financial and legal frameworks needed to eliminate market barriers and imperfections which prevent efficient end use of energy; and
- creating the conditions for the development and promotion of a market for energy services and for the delivery of energy-saving programmes and other measures aimed at improving end-use energy efficiency.

Unfortunately proper design of control systems, HVAC systems, or electrical appliance demand is not widely understood by building sector professionals, consumers and public and private stakeholders. In addition, integrated planning tools that include life-cycle cost calculations, pay-back periods and procurement are not readily available.



▲ Comparing coverage of existing energy contracting models with the Integrated Energy Contracting Model.

Lastly, many existing building refurbishment models do not calculate the building envelope where substantial savings can be made.

The goal of the DSM IA project, Competitive Energy Services, is to increase accessibility to these tools by developing, testing and implementing comprehensive, innovative energy contracting models.

Project experts first adapted existing energy performance contracting models. Typical constraints such as baseline measurements and adaptations were substituted with quality assurance instruments for each measure implemented (*e.g.* thermo-graphs of individual performance measurements). Next the team extended the scope of the Energy Supply Contracting model to develop an Integrated Energy Contracting (IEC) model for the entire building.

Preliminary results are promising. After implementing the EIC model in a sample set of buildings in Austria, 40% energy savings were achieved with a 70% reduction in CO_2 emissions.

CURRENT PROJECTS

Branding of Energy Efficiency

Cooperation on Energy Standards

Competitive Energy Sources

DSM and Climate Change

Integration of DSM, Energy Efficiency, Distributed Generation and Renewables

Micro Demand Response and Energy Saving

Standardising Energy Savings Calculations

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www.ieadsm.org

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LOWERING RISKS AND RAISING RELIABILITY

Policy Brief

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

Background

The Implementing Agreement on Electricity Networks Analysis, Research and Development (ENARD) addresses the diverse issues involved in the development, design, operation and performance of electricity networks at the integrated system level.

ENARD's vision is to facilitate the uptake of new operating procedures, architectures, methodologies and technologies in electricity networks and to enhance their overall performance. ENARD provides comprehensive and unbiased information, data and advice to its four key stakeholder communities: governments, policy makers, power utilities, and power engineering equipment suppliers. There are currently 14 Contracting Parties, including South Africa.

Spotlight

According to the IEA *World Energy Outlook*, world energy demand is expected to increase by 45% by 2030. To meet this demand, USD 20 trillion cumulative investment in energy-supply infrastructure will be needed.

In Europe and North America, a large part of the infrastructure is near the end of its useful life and massive investment in assets will be needed to either replace or refurbish existing electricity network components. Asset management is one tool that utilities can use to address challenges such as ageing power transmission and distribution infrastructure, reliability and business risks.

There are six countries participating in the ENARD project Infrastructure Asset Management. The team has identified five asset groups for analysis and review: transformers, cables, overhead lines (including aerial bundled conductors, or ABC), switchgear protection and control. Phase 1 of the project, Distribution Systems, specifically addresses issues in relation to the distribution asset base. The goal is to gain a detailed understanding of risk-based definitions and methodologies and develop an authoritative, substantive, robust international information base.

▲ Transformer stations are just one asset to be managed by utilities.

Preliminary findings of the study show that due to the nature of assets that make up distribution systems, their diversity, the large numbers and the broad demographic spread, it is both impractical and totally uneconomic to undertake comprehensive, specific condition assessment for all assets. It is necessary to use generic knowledge and engineering experience of the assets as a major input to these systematic processes. Knowledge of end-of-life issues (expected lifetimes, ageing and degradation processes, and effective condition assessment techniques) was identified as essential prerequisites for successful asset management.

The final report will include significant benchmarks for asset managers attempting to build and use condition or risk-based processes to define the need and justify future investment programmes that enable economic renewal and continuation of satisfactory performance of distribution networks.

The team will continue to gather information on asset management and review case studies from around the world. Phase 2 of the project will examine the transmission asset base and further issues.

CURRENT PROJECTS

Distributed Generation System Integration and Infrastructure Asset Management

Information Collation and Dissemination

Transmission Systems

REFERENCES

www.iea-enard.org

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INCREASING CAPACITY AND RELIABILITY

Policy Brief

On all continents, continuously expanding demand for electricity places a burden on ageing electricity networks. Information technologies, population growth, economic welfare, efficiency requirements, system reliability and integrating renewables all contribute to the increasing strain.

Utilities are challenged to find economical, sustainable solutions. Nearly 50% of the electrical losses between generators and end-users occur in transformers. High-temperature superconductors (HTS) are electrical conductors that can transport current with low losses and a very high power density. Incorporating HTS into powerful electrical equipment increases system reliability and safety. Further, compact superconducting generators increase the yield from renewable sources such as hydro and wind.

To achieve abundant, inexpensive, safe electric power, and to move science and technology advances to the marketplace, sustained public and private R&D partnerships will be key.

Background

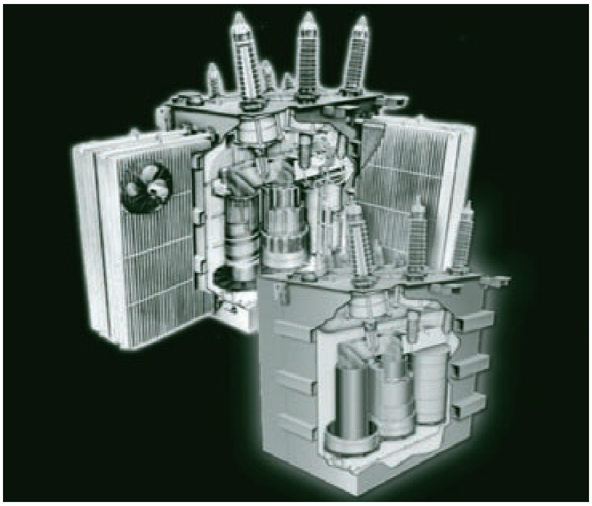
The aim of the Implementing Agreement for a Co-operative Programme for Assessing the Impacts of High-Temperature Superconductivity on the Electric Power Sector (HTS IA) is to identify and evaluate the potential benefits of HTS and barriers. This is accomplished by sharing experience and perspectives among experts while conducting focused inquiries into specific, relevant topics. There are currently 14 Contracting Parties, including Israel.

Spotlight

Early challenges of HTS included building robust, high-performance materials. The solution was a second-generation of HTS wires including both a superconducting layer and a flexible metallic substrate. Recently, several projects across the world have demonstrated that prototype HTS cable and rotating machines have considerable potential.

Despite these advances, two important barriers to widespread HTS deployment in electricity networks remain: conductor price and cryogenic system performance. In a recent report by the HTS IA, *AC Losses: Why they are Important and What Can be Done to Reduce them*, experts examined the potential role of AC, or current-dependent losses to reduce costs and improve performance.

Intended for R&D managers in government, electric utilities, private firms, and national laboratories, the report analyses the overall issues as well as the technical challenges of HTS transformers.



▲ Compared to traditional transformers (background), HTS transformers (foreground) are compact, more efficient, and present no fire hazard or threat to groundwater.

As refrigeration adds substantially to the capital cost of HTS equipment, reducing AC losses will lower the overall cost of the HTS cables and transformers. These promising results have stimulated HTS transformer demonstration projects in China, Japan, Korea and the United States.

HTS cables also continue to attract attention from utilities and developers worldwide. In the past two years, new cable projects have been announced in Korea, Japan, Spain and the United States. Of particular note is the 800-meter cable to be installed in Korea which will incorporate second-generation HTS wires. Other recent advances promise to significantly reduce costs of HTS cables. For example, the REBaCuO tape currently under intense development in Germany, Japan, Korea and the United States, offers increased critical current density and the promise of reduced costs.

CURRENT PROJECTS

- Alternating Current Losses and HTS
- Fault Current Limiters
- HTS Rotors
- HTS Rotating Machines
- Simulating HTS Using Electromagnetic Transients Programmes
- Superconducting Motors

REFERENCES

www.superconductivityiea.org

Illustration courtesy of Waukesha Electric Systems (United States).

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CAPTURING IMAGES OF FUEL DROPLETS

Policy Brief

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

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

Background

Each ERC IA research project is agreed among the 12 members, and then carried out in parallel in national research laboratories, enabling participants to leverage national resources and research funding. An ongoing dialogue with industry ensures economic relevance. All projects build on individual activities being carried out in participating countries.

Spotlight

For engine concepts, including diesel, direct-injection spark ignition, and balanced charge compression ignition engines, it is crucial to understand the characteristics of the fuel spray as it plays an essential role in the fuel-air mixture and resulting soot formation.

It is well known that soot may form within the spray core and the shear layer. At the Helsinki University of Technology in Finland, fundamental research, including large-eddy simulations (LESs) and experiments on fuel spray dynamics, is currently underway.

Under one recent ERC IA project, Advanced Piston Engine Technologies, subtopic Fuel-air Mixing, a collaborative project focusing on sprays in combustion was carried out by Finland, Italy and Japan. As a result of the collaboration, faculty from Keio and Chiba Universities (Japan) have developed a precision spray-measurement technique which can simultaneously measure the sizing and velocity vectors of individual droplet flights in dense spray. It uses an imaging method that studies the pattern of interference created by superposing two waves, together with some additional optical components and a newly developed software programme. The software was designed for easy handling and is now a commercially available system licensed to a manufacturer.

▲ Newly developed software programme using interferometric imaging renders thousands of data points as instantaneous images with information on the location, size, and velocity vectors of individual spray droplets in piston engines.

By using this interferometric imaging method, the sizing technique provides thousands of data points as instantaneous images with information on the location, size, and velocity vectors of individual droplets.

This novel system was applied to analyse fuel sprays and the resulting air flow by tracing the fine droplets involved in the spray.

One example of this application is an instantaneous picture of a swirl-type spray in a direct-injection gasoline engine with an injection pressure of 0.5 MPa. Another example is measurement data for a diesel hole–type nozzle with an injection pressure of 100 MPa under different ambient pressures.

CURRENT PROJECTS

- Advanced Furnace Technology Fundamentals
- Advanced Gas Turbine Technology
- Advanced Piston Engine Technologies
- Alternative Fuels
- Fundamentals of Turbulent Reacting Flows
- Homogeneous Charge Compression
- Hydrogen–Fuelled Internal Combustion Engines
- Ignition Combustion
- Internal Combustion Engine Sprays
- Nano-particle DiagnosticsTransfer

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http://ieacombustion.com

Photo courtesy of Kanomax Co., Ltd. (United States).

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CAPITALISING ON CONVENTIONAL PROCESSES

Policy Brief

Large, economically attractive reductions in fuel and electricity consumption are possible in industries such as iron and steel, cement, petrochemicals, chemicals, pulp and paper, aluminium and food processing. There is also a high potential of energy savings from increased efficiency of co-generation and combined heat and power.

As a result, there is a greater potential for reducing greenhouse-gas emissions at a lower cost than could be achieved in other sectors. Achieving significant CO_2 reductions in industry will require both a step change in policy implementation by governments and unprecedented investment in best practice and new technologies by industry. International co-operation and knowledge transfer of new equipment/system solutions and studies of future systems and technologies will be necessary for implementation.

Background

The mission of the Implementing Agreement for Industrial Energy-related Technologies and Systems (IETS IA) is to accelerate the research and share the results of cost-effective industrial technologies and system configurations that increase productivity and product quality while improving energy efficiency and sustainability.

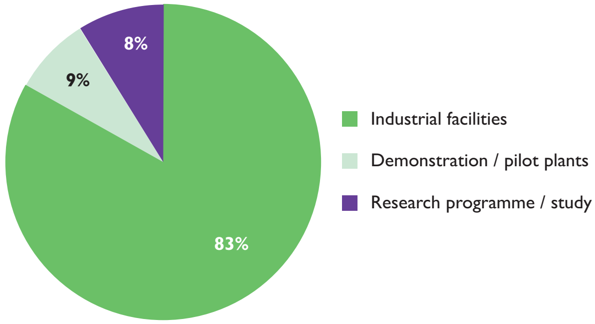
The IETS IA currently focuses on the energy-intensive process industries and technology areas, but is moving to expand research in other industrial sectors and to facilitate co-operation between different industrial RD&D disciplines. There are currently 11 participants, including Brazil.

Spotlight

The largest traditional industries produce and process chemicals, iron and steel, non-metallic materials, pulp and paper and non-ferrous metals. There has been recent interest and investment in biorefineries for conversion processes for heat and power generation simultaneously with biofuel production and chemicals.

Industry-based biorefineries involve several technological processes such as the biomass feedstock, biochemical platform, thermochemical platform, thermal energy, electrical energy and resulting biofuels, bioenergy and biomass-related by-products.

The overall objective of the IETS IA study, Industry-based Biorefineries, is to provide a sound basis for the integration of the biorefinery concept in different industrial sectors where biomass is used. This includes situations where biomass-based waste is readily available for fuel/energy production or where opportunities for bio-product generation could provide added value.



▲ Results of the inventory of 254 biomass projects or units in participating countries.

Activities of the study were divided into three areas of expertise:

- Bioenergy and biofuels
- Biochemicals and new fiber materials
- Sustainability of integrated systems

The first phase of the project was to create an inventory of R&D programmes and demonstration projects or industrial installations in participating countries with a view to defining the current state-of-the-art and benchmarking for biorefinery concept development.

Common areas of R&D in participating countries were identified for international projects:

- Catalysis
- Enzymes
- Pyrolysis
- Gasification
- Carbon fixation for biodiesel production using micro-algae

Results of the project will be published together with the Bioenergy IA work on Biorefineries: Co-production of Fuels, Chemicals, Power and Materials from Biomass.

CURRENT PROJECTS

Energy Efficient Separations Systems: Methodological Aspects, Demonstration and Economics

Energy Efficient Drying and Dewatering Technologies

Industry-based Biorefineries

Membrane Technologies

REFERENCE:

www.iea-iets.org

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FULL-SCALE POWER

Policy Brief

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

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

Background

The aim of the Implementing Agreement for a Programme of RD&D on Advanced Fuel Cells (AFC IA) is to advance understanding in the field of advanced fuel cells. The AFC IA operates a co-ordinated programme of research, technology development and system analysis, enabling specialists to:

- share RD&D results;
- define measurement and monitoring techniques;
- exchange information on cell, stack and system performance;
- collaborate on the development of new procedures and models; and
- share information on application requirements.

There are currently 19 Contracting Parties, including Mexico.

Spotlight

The work of the AFC IA encompasses polymer electrolyte, molten carbonate and solid oxide fuel cells and their applications (transportation, portable and stationary).

One task of the AFC IA aims to advance the commercial deployment of molten carbonate fuel cells (MCFC). There is growing interest in using renewable fuels such as biogas as a fuel for MCFCs.

In the project, leading industrial developers and research groups share information and results from national research and development activities. Regular workshops were held to discuss ways to improve component performance and durability and to reduce costs through efficient design and improved materials.

Technical achievements reported by participants have included the demonstration of an MCFC system under real operating conditions for over 25 000 hours and bench-scale cell tests of over 60 000 hours.

▲ This molten carbonate fuel cell plant produces 2.4 MW of electricity (Nowon, Korea).

Participants also share experiences of installing and operating pilot- and full-scale MCFC systems using different fuels, enabling fuel cell developers to accelerate their individual programmes.

Involvement in this task has also had spin-off benefits for some participants. For example, as a direct result of the two companies working together in this task, POSCO, a Korean steel maker, has started a new business venture with FCE, a fuel cell developer in the United States.

The 2.4 MW plant is capable of generating sufficient electricity to supply 3 200 households and enough hot water to heat 1 000 households. In addition, the project has obtained approval from the United Nations Framework to Climate Change Convention for a clean development mechanism (CDM) methodology.

A review of the major fuel cell demonstration plants worldwide is available in the study *International Status of Molten Carbonate Fuel Cell Technology*.

CURRENT PROJECTS

- Fuel Cells for Portable Applications
- Fuel Cell Systems for Stationary Applications
- Fuel Cells for Transportation
- Molten Carbonate Fuel Cells (MCFC)
- Polymer Electrolyte Fuel Cells (PEFC)
- Solid Oxide Fuel Cells (SOFC)

REFERENCES

www.ieafuelcell.com

Photo courtesy of POSCO Power (Korea).

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HOW GREEN ARE GREEN FUELS?

Policy Brief

Interest in alternative transport fuels, particularly biofuels, is growing rapidly. Advanced biofuels such as ligno-cellulosic ethanol[1] are capable of reducing greenhouse-gas emissions by 95% compared to traditional fossil-based fuels, while grain-based ethanol, the dominant biofuel in OECD countries, provides between 0-20% emissions reduction.

Realising the vast environmental potential, governments across the world have put in place regulations for a larger share of biofuels in the transport sector. By 2020 in Europe, 10% of transport energy must be from renewable energy sources – biofuels or electricity from renewable sources. In California and Europe, current regulations require a 10% reduction in carbon intensity of transport fuels by 2020.

Background

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

The AMF IA continues to provide 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 to the AMF IA, including China and Thailand.

Spotlight

Ethanol has rapidly become the most widespread biofuel produced and consumed in the world. Despite the strong position of ethanol, emissions testing of vehicles running on high concentrations of ethanol fuels has not been fully measured or calculated.

In addition to total hydrocarbon emissions and fuel consumption, many other parameters can affect measurement results that will require further evaluation and calibration methods: sampling line temperatures, sampling flow rates, quantity/quality of adsorbents, temperatures, and sample storage time.

One recent project of the AMF IA, Measurement Technologies for Emissions from Ethanol Fuelled Vehicles, aims to improve the analytical methods used for ethanol-fuelled vehicles and to make recommendations for ethanol vehicle emissions certifications.

There are three phases to the project: literature survey of measurement methodologies for alcohol-fuelled vehicles; measurement and correlation study of hydrocarbons and ethanol; and vehicle tests at different temperatures (as low as -7C).

▲ Researchers measuring biofuel exhaust emissions. Essential information is gathered to understand health effects of transport biofuels.

This work is both a cost- and task-shared activity. Government participants provide financing. The analytical work and the vehicle testing are carried out by AVL MTC in Sweden and by VTT in Finland. Two Industrial partners General Motors Powertrain and Volvo Car Corporation contribute on a task-shared basis.

A final report summarising the results, analysis and recommendations for improved procedures is imminent. In addition, an AMF IA manual *Ethanol as a Fuel for Road Transportation* is available for download on the AMF IA website.

CURRENT PROJECTS

- Biomass-Derived Diesel Fuels
- Ethanol as a Motor Fuel
- Fuel and Technology Alternatives for Buses
- Information Service
- Measurement Technologies for Emissions from Ethanol Fuelled Vehicles
- Particle Emissions of Two-stroke Scooters

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www.iea-amf.vtt.fi.com

1. Ligno-cellulosic ethanol is produced from wood residues (including sawmill and paper mill discards), municipal paper waste, agricultural residues (including corn stover and sugarcane bagasse), and dedicated energy crops (which are mostly composed of fast-growing tall, woody grasses).

Photo courtesy of VTT (Finland).

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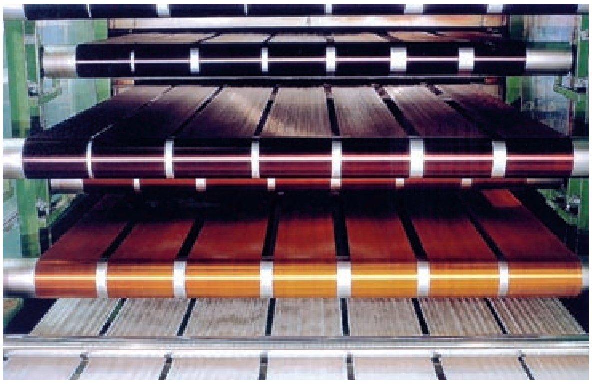
CARBON FIBRES REDUCE CARBON EMISSIONS

Policy Brief

Structural enhancements such as substituting steel in transport vehicles with lighter alternatives have the potential to reduce fuel consumption by 10%. Together with engine efficiency and other improvements, a 50% reduction in fuel consumption and CO_2 emissions of new vehicles is achievable by 2030.

Given the recent regulations and emissions-reductions targets in many IEA countries, developing engine efficiency and materials enhancements will be vital to achieving these goals.



Controlled stabilising and oxidisation of carbon fibres.

Background

The Implementing Agreement for a Programme of Research and Development on Advanced Materials for Transportation Applications (AMT IA) cooperates internationally to share information on recent advances in materials technologies. The primary research areas include friction reduction surface technologies and weight reduction technologies through the use of magnesium alloys, low-cost carbon fibres, and nano-composites.

There are currently five Contracting Parties to the AMT IA, including China.

Spotlight

One material that has received particular interest in materials science is carbon fibre. In terms of mechanical performance per unit weight, carbon fibre composites are unparalleled as a candidate to replace steel as they match the strength and solidity yet weigh only 20% of the weight of steel. Furthermore, carbon fibres possess excellent impact resistance. For example, Formula 1 racing cars are required to be constructed with carbon fibre composites.

The goal of one AMT IA project, Low-Cost Carbon Fibres, is to facilitate the introduction of low-cost carbon fibres (LCCF) into mass production of vehicle components.

Unfortunately there are two major barriers to widespread adoption of LCCF: cost and supply capacity. Current costs for carbon fibres are double the economically viable figure of USD 5-7/pound. The materials are traditionally prepared by the controlled stabilisation, oxidation and carbonisation of polyacrylonitrile (PAN) precursor fibres. Together with raw materials selection (*i.e.* precursor fibres) it is possible to lower costs at each stage of the process by a factor of 2.

Unfortunately the selection of precursor materials and associated manufacturing processes are commercially sensitive.

For this reason the AMT IA project concentrates on information-sharing and consensus-building in pre-competitive, non-commercial aspects of LCCF such as generating design data and test methodologies and standards.

AMT IA experts from the United Kingdom and the United States visited respective national laboratories and visited LCCF textile manufacturers. One company provided test samples for the project.

Two papers have resulted from the exchange, *FreedomCAR and Low-Cost Carbon Fibre for Automotive Applications*, and *Novel Materials and Approaches for Producing Carbon Fibre*. In addition, two national programmes, FreedomCAR (United States) and Foresight Vehicle (United Kingdom) have discussed aligning their national research programme agendas in this area.

There is also considerable potential for carbon fibre materials in other energy sectors such as renewables (wind turbine blades). Activated carbon fibre with metal-hydride particles on its surface is also a promising material for hydrogen storage.

CURRENT PROJECTS

Environmentally Friendly Corrosion Protection Technologies for Magnesium Alloys

Integrated Engineered Surface Technology to reduce Friction and Increase Durability

Low-Cost Carbon Fibres

REFERENCES

www.iea-amt.org

Photo courtesy of SGL Group.

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DEPLOYMENT: LESSONS LEARNED

Policy Brief

Electric vehicles and plug-in hybrid electric vehicles have received much attention recently from the automobile industry, governments and consumers.

Together with biofuels, battery electric vehicles (BEV) and plug-in hybrid electric vehicles (PHEV) could substantially increase the share of renewables consumed in the transport sector if the electricity is produced from renewable sources.

By using the vehicle storage capacity greater deployment of BEV and PHEV will assist electricity grid management and intelligent grids by filling the gap between production of electricity from intermittent renewable sources and consumer demand.

Background

The 14 Contracting Parties to the Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (HEV IA) share the following objectives:

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

Spotlight

The goal of one recent HEV IA study, Market Deployment of Hybrid and Electric Vehicles Lessons Learned, was to provide practical advice for utilities, local governments original equipment manufacturers (OEMs), small firms, regulators and others involved in deployment. Focused workshops were held in Europe, Japan, and the United States to bring together the experiences and perspectives from all concerned stakeholders: manufacturers, distribution, sales, charging infrastructure and market support from the utilities and governments involved in previous deployment campaigns.

Automakers shared a number of important lessons, including the need to protect EV R&D programmes from market fluctuations. They found that developing closer partnerships with power utilities was essential. As EV required greater consumer education than expected, OEMs needed to make better use of "pioneer" communities to assist in marketing efforts. Utilities over-marketed EVs early, leading to high consumer expectations. Utilities were also largely unaware of OEM concerns such as competition.

▲ Parking garages with electric vehicle recharging posts (Paris, France).

It was found that the cost of public recharging infrastructures far outweighed the deployment scale, adding little value to deployment while incurring high maintenance costs. Lastly, qualifying and installing recharging equipment in homes impaired sales and leasing processes, and home charging systems were over-subsidised.

Regulators in California found it difficult to justify the EV requirement given the minimal air quality gain of demonstrations and early markets. Regulatory and other EV deployment efforts resulted in research investments, particularly in battery research. EV regulation encouraged manufacturers to develop other technologies (*i.e.* zero-emission vehicles in California and hybrid vehicles) which had a large impact on emissions and efficiencies.

Lastly, providing reliable information on potential markets for EVs has been difficult, requiring innovations in market research methods and acceptance of uncertainty.

CURRENT PROJECTS

- Clean Vehicle Awards
- Electric Cycles
- Electrochemical Systems
- Fuel Cells for Vehicles
- Heavy-Duty Hybrid Vehicles
- Market Deployment of Hybrid and Electric Vehicles: Lessons Learned
- Outlook for Hydrid and Electric Vehicles
- Plug-in Hybrid Electric Vehicles

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www.ieahev.org

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FOSSIL FUELS

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

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UNRAVELING SUPPLY COSTS

Policy Brief

Coal is a reliable, abundant energy source. Current world reserves could supply coal for another 130 years. In addition, thanks to recent technological advances, coal can be used as a clean energy source.

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

Background

There are currently 12 Contracting Parties and 16 Sponsors from industry (9 within IEA countries and 7 in IEA non-member countries) in the Implementing Agreement for the IEA Clean Coal Centre (CCC IA).The goals of the CCC IA are to:

- gather, assess and distribute knowledge on the energy efficient and environmentally sustainable use of coal (including co-firing coal with waste or biomass);
- undertake in-depth studies on topics of special interest;
- assess technical, economic and environmental performance;
- identify where further RD&D is needed; and
- report balanced, objective findings that highlight opportunities for technology transfer worldwide.

Spotlight

Coal is produced in more than 50 countries and consumed in over 70 countries. A low unit price, a broad geopolitical distribution of reserves and a high reserves-to-production ratio have made coal an economic option. And rail or sea transport has ensured efficient and competitive functioning of the global coal market.

However, the 2008 price peak has led many to question whether these assumptions are still valid. One CCC IA study, *Future Coal Supply Prospects*, examines whether there are sufficient proven exploitable reserves to meet current and future demand, and that supplies will reach consumers at an affordable price. Between 1999 and 2006 coal volumes rose an average of 7% per year, from 357 million to 872 million tonnes. This acceleration is due to high growth in China and India, lower coal production in Europe, and particular consumers' requirements based on the quality of coal.

Seaborne trade accounts for 90% of volumes (10% traded by land). Transportation costs often account for 80% to 90% of the delivery price. The CCC IA study demonstrates that the 2008 price peak (up to USD 210 per tonne) was due to rail and shipping infrastructure limitations – not supply constraints.

▲ Major worldwide shipping routes for hard coal.

Though prices have returned to their historical average of USD 60-70 per tonne, further peaks due to transport issues are possible.

Looking forward, the CCC IA study concurs that demand is likely to increase until 2030 and beyond, and that current reserves will be inadequate. Together with a significant increase in coal production, research into further reserves will be required. As new supplies may be located in countries not currently on the export market, this will put additional strain on the existing transport infrastructure and shipping routes.

Ensuring timely delivery to consumers without raising costs will continue to be a challenge. And given the increased investments required for new reserves, strategic solutions will be needed.

CURRENT PROJECTS

- Capture and Storage of CO_2 with Other Air Pollutants
- Coal Use in China, India and South Africa
- Co-Gasification and Indirect Co-Firing of Coal and Biomass
- Developments in China's Coal-Fired Power Sector
- Performance and Risks of Advanced Pulverised Coal Plants
- Prospects for Clean Coal and CCTs in Indonesia
- Reporting and Inventories of Coal-Fired Power Plant Emissions
- Underground Coal Gasification

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www.iea-coal.org.uk

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STATE-OF-THE-ART INFORMATION

Policy Brief

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

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

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

Background

There are currently 11 countries participating in the Implementing Agreement for a programme of RD&D on Enhanced Oil Recovery (EOR IA), including Russia and Venezuela.

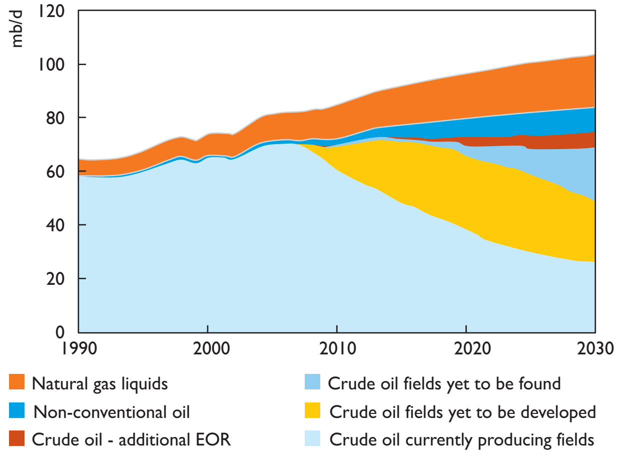
The aim of the EOR IA is to stimulate national efforts to continue to develop less costly EOR technologies as well as to research new technologies. This is achieved through an open forum for information and knowledge exchange.

Spotlight

The need for enhanced oil recovery R&D has increased over the years, particularly during periods of low oil prices. The United States Geological Survey reports that 900 billion barrels (Bbbl) were recoverable in 1996, and in 2007 1 300 Bbbl, with an additional 440 Bbbl possible (75% from higher recovery and 25% from new discoveries). And accoding to expert projections, this will increase.

By 2030, the majority of oil reserves will be from fields yet to be developed, fields yet to be found and additional enhanced oil techniques.

The role of the EOR IA is to serve as a toolbox for many types of unconventional hydrocarbon resources.



▲ Forecast of worldwide oil production to 2030.

It has been demonstrated that during investigation of advanced options, simpler and cheaper solutions are often discovered.

The EOR IA plays an important role for the international R&D community by providing opportunities for scientists to share and gain acccess to unbiased, state-of-the art information. Each year the EOR IA organises an international symposium to draw out the state-of-the-art technical capabilities of the oil exploration engineering. Speakers typically include representatives from multinational and national oil companies, engineering experts and trade associations.

The 2008 conference, Enhanced Oil Recovery Technology for Mature Oilfields, was held in China. At the 2009 Workshop and Symposium on Enhanced Oil Recovery, 33 presentations on results of applied research, experiments and studies were organised around the five themes of EOR IA research.

CURRENT PROJECTS

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

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

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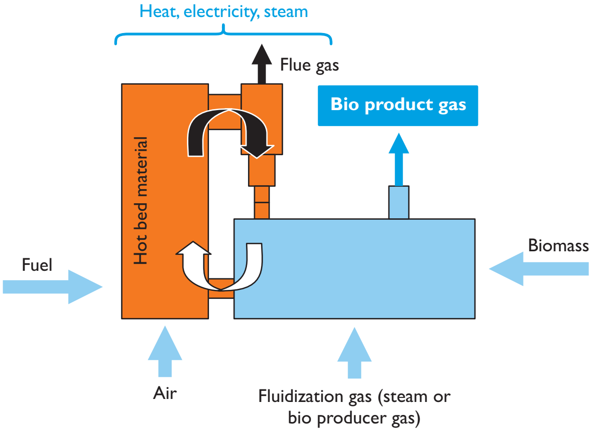
IMPROVING EFFICIENCY WHILE LOWERING CO_2

Policy Brief

A fluidised bed is a unique boiler where the fuel that is burned is maintained airborne, circulating in order to burn thoroughly. This increases the efficiency of the reactor, reduces volatile ash and greenhouse-gas emissions.

Burning biomass with coal in a fluidised bed reduces harmful gases and vapour from the biomass while at the same time reducing the greenhouse-gas emissions from the coal. This technology has gradually improved and is now deployed on a commercial basis.

Continued R&D in this field is needed to further improve fuel combustion efficiency. Co-operation between researchers, industrial representatives and governmental programmes accelerates the knowledge base and technology deployment.



▲ A circulating fluidised bed boiler combined with a biomass gasifier increases burning efficiency and reduces greenhouse-gas emissions.

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 operations professionals through shared research results and regular symposia.

There are currently 14 Contracting Parties and one sponsor. Industry also benefits from FBC IA developments through the annual expert conference.

Spotlight

The main outcome of the work of the FBC IA is the annual conference on issues of importance to both academia and industry (see current projects for the list of recent conferences). This provides 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 programme through lessons learned.

Research topics include coal combustion, conversion and co-firing (including gasification), biomass, wastes and other fuels. Other promising techniques under review include oxy-fuel[1] combustion and looping-cycle combustion, where important CO_2 reduction can be achieved.

One significant recent research topic includes co-firing biomass and wastes, particularly when co-fired with coal. Combustion behaviour, emissions, and ash problems are attracting increased attention, though more research is needed. New fields of research include:

- improving fuel efficiency in FBC for electricity generation to compete with pulverised coal;
- burning biomass with wastes at very high temperatures to reduce corrosion and deposits;
- replacing coal with biomass in co-combustion;
- oxy-fuel in FBC to facilitate CO_2 removal;
- looping cycle conversion with two coupled fluidised bed reactors to improve CO_2 removal;
- using limestone as a carrier medium; and
- three-dimensional modelling of gas/solid flows to understand the mechanisms of local solid concentration and heat transfer.

CURRENT PROJECTS

- Co-firing and Ash Problems
- Energy Crops and FBC Conversion
- Fluidised Bed Design Aspects
- Mathematical Modelling
- Recent Trends of FBC in Participating Countries
- Sewage Sludge Conversion

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www.iea-fbc.org

1. Oxy-fuel combustion uses pure oxygen with a gaseous fuel to increase burning efficiency by raising firing temperature.

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MONITORING AND VERIFICATION

Policy Brief

To achieve deep cuts in global CO_2 emissions it will be necessary to deploy a broad portfolio of mitigation options including energy efficiency, renewable sources, nuclear power and CO_2 capture and storage (CCS).

The technical viability of CCS technology has been demonstrated at five commercial-scale projects at oil and gas sites in Europe (Sleipner and Snohvit), Africa (In-Salah) and North America (Rangeley and Weyburn). In addition, large pipelines built to support these projects have demonstrated the ability to transport CO_2 safely over considerable distances. Demonstrations of CCS at fossil-fuel-fired power plant projects are under consideration and expect to be operational beginning 2014.

Background

There are currently 42 members of the Implementing Agreement for a Co-operative Programme on Technologies Relating to Greenhouse Gases Derived from Fossil Fuel Use (GHG IA). This includes 19 Contracting Parties (including India and South Africa) and 21 Sponsors drawn principally from the oil and gas and power sectors; the IEA Coal Industry Advisory Board; and two international organisations (the European Commission and the Organisation for the Petroleum Exporting Countries).

The aim of the GHG IA is to evaluate options and assess the progress of technologies that can reduce greenhouse-gas emissions derived from the use of fossil fuels. Activities include:

- evaluating technology options for greenhouse-gas mitigation from fossil fuels;
- facilitating implementation of potential mitigation options;
- facilitating international collaboration; and
- disseminating results as widely as possible.

Spotlight

The aim of one GHG IA project, CO_2 ReMoVe, is to develop innovative research and technologies for the monitoring and verification of CO_2 geological storage. ReMoVe is funded by the European Commission 6th Framework Progamme together with 10 industrial and 23 R&D partners, including the GHG IA and organisations from Argentina, India, and South Africa.

At the In Salah natural gas production facility, nearly 1 million tonnes of CO_2 per year are separated and injected into a sandstone formation 2 000 metres below the surface. Legacy datasets for In Salah have been gathered, including a full suite of reservoir management data (and also caprock logs and baseline seismic), and a model has been developed.

▲ CO_2 storage at the In Salah natural gas production facility (Algeria).

The data, interpretation studies, and modelling outcomes have undergone a systematic qualitative assessment. A complete description of the system has been developed and broken down by features, events and processes (FEP) relevant to performance. Two expert workshops were held to harmonise the FEPs and to develop scenarios for future site evolution. Recent analysis of satellite-based InSAR data has shown significant ground displacements at In Salah. As a result, additional focus will be placed on geomechanical studies going forward.

CURRENT PROJECTS

Research Networks

- Capture: Post combustion capture, oxy fuel and solid looping
- Geological storage: risk assessment, well-bore integrity; monitoring, modelling and environmental impacts.

Examples of recent studies

- Aquifer Storage Development Issues
- CCS Potential in the Cement Industry
- Effects of CCS on the CDM Market
- Fuel Cells for Combined Heat and Power
- Global Assessment of the CO_2 Storage Capacity in Oil and Gas Fields-Operating Flexibility of Power Plants with CCS

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Photo courtesy of British Petroleum (United Kingdom).

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MEASURING AND MODELLING CO_2

Policy Brief

Multiphase flow (MPF) combines two or more phases (gas-solid, liquid-solid, or gas-liquid-solid) such as oil, water, gas for oil production (well bores, risers, pipelines), flow to burners in coal-fired power plants, hydro transport of raw bitumen, or fluid catalytic cracking units and many other chemical reactors.

Processes involving multiphase flow are complex and require expertise from several different disciplines such as modelling, turbulence, experimental validation, surface chemistry, reaction kinetics, nucleation and growth, thermodynamics, as well as solver and algorithm development.

The science and technology of multiphase flow needs to continue to advance so that engineers can confidently design and scale-up production and processing facilities.

Background

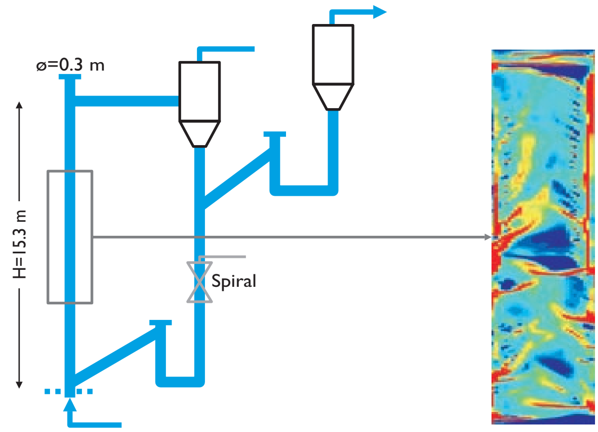
There are six Contracting Parties to the Implementing Agreement for a Programme of Research on Fossil Fuel Multiphase Flow Sciences (MPF IA), including China and Mexico. Activities are task-shared, *i.e.* each member undertakes research and the results are shared among all members through joint publications, conferences and expert exchanges. The objectives of the MPF IA are to:

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

Spotlight

Advanced gasification technology with carbon capture and storage can capture and permanently store at least 90% of CO_2 emissions. For this reason the focus of one MPF IA project, *In-situ* Synthetic Gas Sampling, CO_2 Capture, and CFD[1] Modelling for Entrained-flow Slagging Gasifier aims to set up a reliable *in-situ* sampling system to extract solids, liquids and gases at a variety of locations in a high-pressure, high-temperature slagging gasifier. It will compare and evaluate different CFD modelling approaches to deliver a validated CFD model for gasification research and clean-coal activities.

In-situ sampling will measure and evaluate the performance, new gasifier component designs and operating conditions. A test facility will approve the CO_2 capture of synthetic gas with a high-temperature, solid-sorbent looping process.



▲ Sampling CO_2 emissions in boilers.

Analysis of the samples and fundamental data will feed into the CFD model, which will aide the gasifier injector design and optimise gasifier operations. It is expected to improve performance and extend gasifier life while lowering development costs. Expected outputs from the project include:

- engineering design packages including *in-situ* sampling of solids, liquids and gases, suitable for a high-temperature, high-pressure slagging gasifiers and carbon capture from synthetic gas using solid sorbet looping technology at high temperatures and high pressure;
- experimental data sets for validating CFD models including a high-pressure, entrained-flow slagging gasifier and a high-temperature and high-pressure sorbent looping process for CO_2 capture; and
- validated CFD gasifier and carbon capture models suitable for gasification research and clean coal related activities.

CURRENT PROJECTS

CFD Model for Settling of Failings and Hydro-transport of Solids

Frictional Dense Granular Flows: Model Comparisons

***In-situ* Synthetic Gas Sampling, CO_2 Capture, and CFD Modelling for Entrained-Flow Slagging Gasifier**

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www.iea.org/techagr

1. High-fidelity numerical multiphase modelling.

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FUSION POWER

Fusion Environment, Safety and Economy

Fusion Materials

Large Tokamaks

Nuclear Technology of Fusion Reactors

Plasma Wall Interaction in TEXTOR

Reversed Field Pinches

Spherical Tori

Stellarator Concept

Tokamaks with Poloidal Field Divertors

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FULL-CYCLE ANALYSIS

Policy Brief

Fusion energy has the potential to be a safe, environmentally attractive and inexhaustible source of power. A significant amount of research must still be carried out including developing and demonstrating the safety aspects of various fusion systems to both the regulator and the public as well as determining the cost of future fusion power plants.

Background

There are four Contracting Parties (including Russia) to the Implementing Agreement on a Cooperative Program of Research on Environmental, Safety and Economic Aspects of Fusion Power (ESE IA). Under the ESE IA, each participant conducts research as well as develops the analytical tools that are necessary to demonstrate the safety aspects of fusion. The scope of the work encompasses:

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

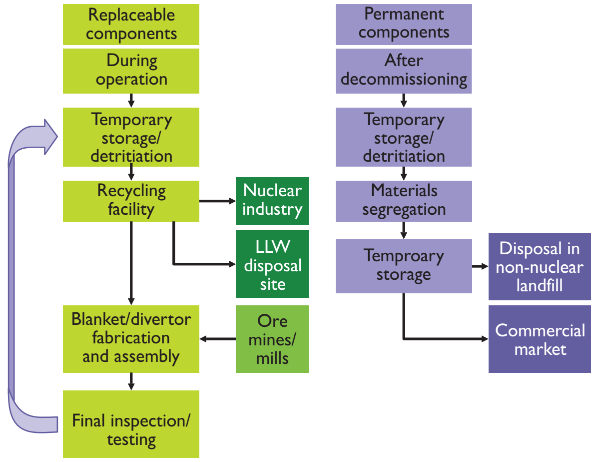
Spotlight

In order to maximise the environmental benefits of fusion power generation, it is important to clearly define the parameters governing the final stage of the materials cycle. Results of final-stage analysis from previous fusion power plant studies indicated that most materials could be cleared or recycled, and/or disposed of as low-level waste.

A fusion-specific approach is necessary and needs to be developed in order to handle the large amounts of low-level radiation waste. Recycling of materials and clearance (*i.e.* declassification to non-radioactive material) are the two recommended options for reducing the amount of fusion waste, while the disposal of low-level waste could be an alternative route for specific materials and components.

The ESE IA recently developed a comprehensive approach that considers the evacuation routes for the radioactive materials as well as the handling difficulties for recycling and clearance. Such an approach allows for a complete consideration of most of the parameters involved in such a complex materials management system. Also, it allows investigating different designs and materials compositions, in view of their impact on the environment.

Both recycling and clearance criteria have been recently revised by national and international institutions.



▲ Diagram of the fusion recycling and clearance process.

These revisions have consequences for fusion material management and have to be taken into account.

It is also important to define the various processes and routes to avoid generating large volumes of active waste from fusion. Two processes currently under development include:

- materials that will lead to low-activation levels, avoiding the generation of long-lived radio-nuclides through a strict control of the impurity content of materials; and
- suitable and reliable processes allowing either clearance of as much material as possible (potentially after adequate treatment) or recycling most of the remaining materials within the nuclear industry.[1]

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 and Validation Tests

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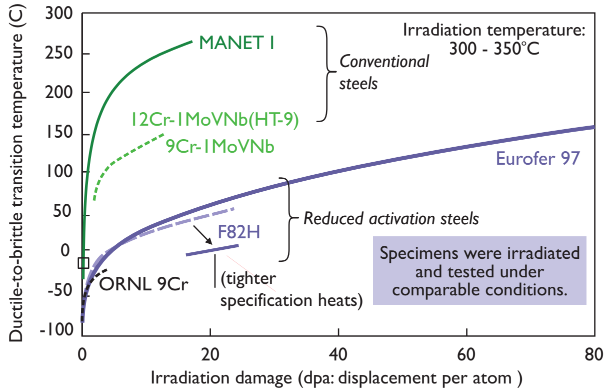
EXPERIMENTS LEAD TO RECORD LEVELS

Policy Brief

In fusion reactors the plasma is heated to temperatures more than 100 million °C by high-energy particle beams or radio-frequency waves. The main challenges for fusion power science are to find materials that can resist these extreme temperatures and the irradiation from the neutron bombardment.

Other important challenges include identifying those materials that are able to provide safe, reliable and predictable performance, long service life at elevated temperatures, with lower radioactivity in end-of-life components for simplified recycle or disposal.



▲ Irradiation exposure dependence of the ductile-to-brittle transition temperature (DBTT).

Background

There are seven Contracting parties to the Implementing Agreement for a Programme of Research and Development on Radiation Damage in Fusion Materials (FM IA), including China and Russia.

The focus of FM IA co-ordinated research is to develop materials for the first wall and blanket of a power plant. This work also includes development of material production and joining methods and measurement of design properties.

Investigations include materials irradiation in fission reactors, ion beams, and computational simulation. The strong, experimentally validated theory and modelling efforts make it easier to extrapolation data to true fusion conditions and lifetimes. FM IA participants also developed the conceptual design for an International Fusion Materials Irradiation Facility (IFMIF). IFMIF is now in the Engineering Validation and Engineering Design Activity (EVEDA) stage. This activity was planned by FM IA and is being conducted under the Broader Approach agreement.

Spotlight

One important research area of the FM IA is to develop an understanding of the effect of irradiation on the microstructure and mechanical properties of ferritic/martensitic steels used in the lining of the fusion reactor and test-blanket modules, and to apply the knowledge gained to develop steels with improved properties.[1,2]

FM IA research has led to the development of a new family of advanced steels known as reduced-activation ferritic/martensitic steels such as Eurofer97. These new steels surpass conventional steels (*e.g.* ferritic chromium-molybdenum steels) and have a lower ductile-to-brittle temperature (DBTT) making them more resistant to breakage, and with greater tensile strength.

Two FM IA teams carrying out research in this area recently achieved promising results. Using a Russian fast breeder reactor (BOR-60), European participants discovered they could achieve irradiation damage levels at a record high of 80 displacements per atom (dpa) with Eurofer97.

In collaborative experiments between participants from Japan and the United States, a lower post-irradiation DBTT for the martensitic steel F82H were observed in the High-Flux Isotope Reactor (United States) using more stringent specifications. Given these most promising results, follow-up investigations will be carried out in the coming months.

CURRENT PROJECTS

- Diagnostic and Control Insulating Materials
- Fundamental Studies of Irradiation Effects
- Irradiation Facilities and Post-Irradiation Test Methods
- Modelling and Computer Simulation
- Reduced Activation and Advanced Steels
- Refractory Metals, Mainly Tungsten Alloys
- Silicon Carbide Composite Materials
- Vanadium Base Alloys

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FEEDING RESULTS INTO ITER

Policy Brief

Tokamak[1] fusion reactors are the most successful and promising fusion confinement devices. ITER is an international project to design and build an experimental fusion reactor based on the tokamak concept.

The Implementing Agreement on Co-operation among Large Tokamak Facilities (LT IA) has been effective in investigating break-even conditions, in developing the necessary databases for ITER and a steady-state tokamak reactor, and providing leadership in coordinating International Tokamak Physics Activity (ITPA) joint experiments with other tokamak-related research groups.

Background

The objective of the LT IA is to enhance the scientific and technological achievements of tokamak reactors through co-operative research activities. Current experiments include:

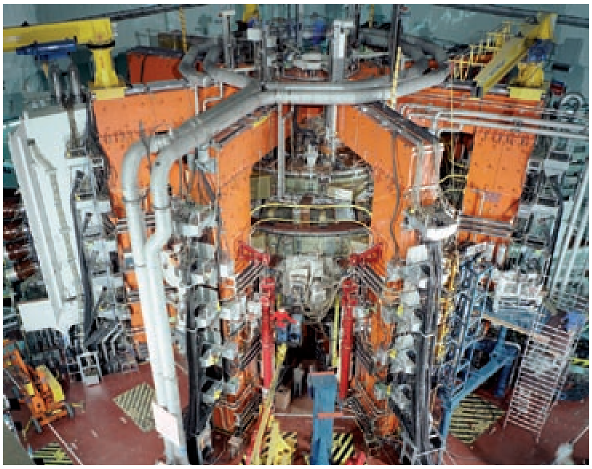
- energy confinement dependence on plasma pressure, collision and aspect ratio;
- controlling plasma instabilities (resistive wall modes, neoclassical tearing modes at high beta, edge localised modes, disruptions);
- material erosion, migration re-deposition and fuel retention;
- sustaining long, steady-state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

Spotlight

In Japan, experiments on the JT-60U device were completed in August 2008. Experiments were shifted to modification of the superconducting device JT-60SA, one of the joint programmes under the Broader Approach (BA) agreement between Japan and the European Union which contributes to ITER and DEMO construction.

In Europe, recent results of experiments on the Joint European Torus (JET) were integrated into the design of ITER components, the preparation of integrated operating scenarios and the physics necessary for efficient ITER exploitation. The focus of research activities includes:

- developing radio-frequency heating systems able to resist edge localised mode (ELM);



▲ The Joint European Torus (JET) machine, Culham (United Kingdom).

- optimising plasma shape and heating during the current rise phase; developing ITER baseline scenarios to high current (4.3MA) and advancing scenarios to high confinement and beta; and
- materials migration and fuel retention; cross-machine studies of plasma edge, toroidal field ripple and internal transport barriers.

In the United States, recent experiments on the C-Mod, DIII-D, and NSTX devices have provided input to the ITER design review including vertical position control, deuterium retention in metallic first-wall components and stabilising magneto-hydrodynamic instabilities including ELMs. Experiments have also addressed advanced tokamak long-pulse physics issues including dynamic control of error fields, non-inductive current drive using lower hybrid waves and operation at high normalised plasma pressure above the no-wall limit.

CURRENT PROJECTS

Confinement Database and Modelling
Edge and Pedestal Physics
MHD, Disruptions and Control
SOL and Divertor Physics
Steady State Operation
Transport and Internal Transport Barrier Physics
Tritium and Remote-Handling Technologies

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1. Tokamak machines are shaped like a ring (doughnut) and use magnetic coils to contain the plasma. The word tokamak is a transliteration of the Russian term for toroidal chamber and magnetic coil (toroidal'naya kamera v magnitnykh katushkakh).

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KEEPING COOL UNDER THE BLANKET

Policy Brief

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

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

Background

There are five Contracting Parties (including India and Russia) to the Implementing Agreement for a Co-operative Programme on Nuclear Technology of Fusion Reactors (NTFR IA).

Participants in the NTFR IA conduct R&D on key components of fusion power plants and their associated technologies, *i.e.* those operating close to the fusion burning plasma, and needing to handle large flows of energy.

The ultimate goal is to develop effective, reliable, functioning components with prolonged lifetimes under the conditions expected to occur in a commercial fusion power plant. This is crucial to the economic performance and environmental and safety acceptability of fusion power.

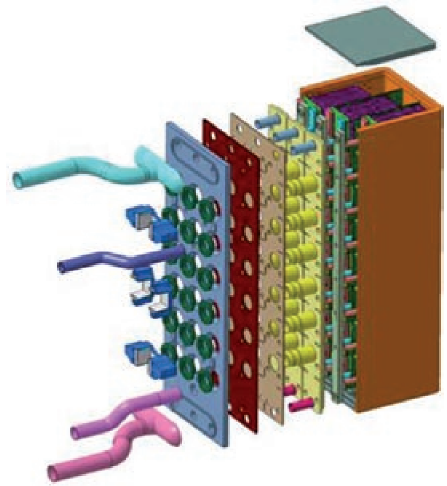
Spotlight

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

The second activity concerns the blankets, or the component which converts fusion energy (neutrons) into heat which can then be used to make electricity. The blanket uses either a solid or liquid lithium-based material. It must also be able to breed (create) tritium, one of the two elements necessary to maintain the fusion reaction, and, as necessary, provide tritium fuel to ignite reactions in other fusion power plants.

Though there are several types of breeder blanket compositions and designs, they all share common research issues:

- tritium recovery and control;
- magneto-hydrodynamic effects (MHD); and
- beryllium coating on the base material of the first wall.



▲ A helium-cooled, lithium-lead liquid breeder blanket (European design).

The objective the liquid breeder blankets (BB) research of the NTFR IA is to record the results from handling and processing of the liquid breeders and to enter them into an international database.

Following several years of gathering information on a broad range of blankets, in 2007, the project focus was narrowed to cover only dual-cooled, lithium-lead (DCLL) and helium-cooled, lithium-lead (HCLL) breeder blankets. During 2008 the R&D results of the HCLL breeders were critically reviewed and found to be insufficient to design a tritium recovery-control system for HCLL-based blankets. Early 2009, participants from Japan and the United States reported progress on tritium interaction with an HCLL breeder, though more research needs to be done.

The tritium recovery-control system may not be necessary for the liquid test blanket module in ITER, but carrying out systems verification will be useful for future reactors. For this reason, future NTFR IA research is expected to include tritium recovery, tritium solubility, corrosion, tritium permeation coating development, and MHD.

CURRENT PROJECTS

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

REFERENCES

www.iea.org/techagr

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REDIRECTING RUNAWAY ELECTRONS

Policy Brief

ITER seeks to demonstrate the possibility of generating 500 MW of electricity in pulsed operation.

Plasma wall interaction (PWI) is a crucial aspect for the construction of fusion reactors. Experiments to define the right conditions for the development of advantageous plasma configurations will have important implications for a steady-state (continuous) fusion power plant.

Background

TEXTOR[1] is a highly specialised tokamak designed to investigate PWI in a versatile test facility. PWI research benefits significantly from co-operation on joint experiments with other fusion devices and laboratory work which is based on well co-ordinated efforts with other fusion Implementing Agreements.

There are four Contracting Parties to the Implementing Agreement for a Programme of Research and Development on Plasma Wall Interaction in TEXTOR (PWIT IA). Research conducted focuses on urgent ITER issues:

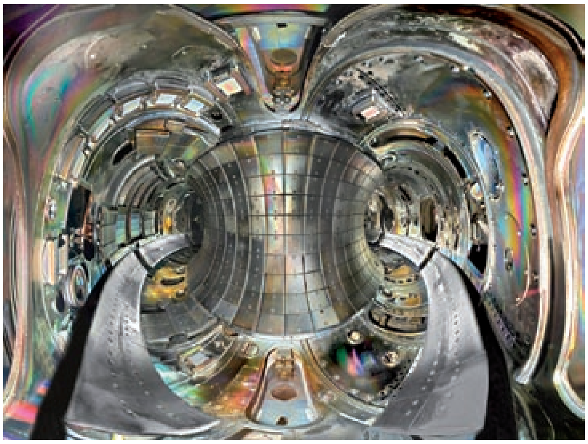
- longevity of the divertor target plates;
- tritium inventory build-up rates;
- strategies to improve and optimise the materials and concepts for plasma-facing components; and
- methods to suppress or avoid plasma instabilities and control the PWI.

Spotlight

PWI is relevant to ITER and beyond a cross-sectional research field as well as to the new generation of stellarator devices with capabilities for steady state operation. Specific topics addressed within the PWIT IA include:

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

During the instability phase of fusion plasma in a tokamak, highly energetic, or "runaway" electrons are generated.



▲ The burn chamber of the TEXTOR device. The magnetic perturbation coils of the dynamic ergodic divertor are placed behind graphite protection tiles in the centre.

Due to their size, ITER and future power plants may have massive amounts of runaway electrons. If these electrons hit plasma facing materials, extreme heat loads are expected – significantly reducing the lifetime of the wall elements. Suppressing runaway electrons is therefore an essential challenge for ITER. PWIT researchers have been able to mitigate runaway generation in TEXTOR by applying a dynamic ergodic divertor (DED). This subsystem directs suitable magnetic perturbation fields to the plasma edge.

These recent experiments based on external magnetic distortion fields have opened new horizons to plasma edge research with relevance for both tokamaks and stellarators on their way to a steady-state operation in later fusion power plants. This novel concept opens a wide domain of studies to control wall loads and plasma instabilities in the future.

CURRENT PROJECTS

Developing High-Z Wall Components for ITER-like Wall in JET

Modelling Erosion, Migration and Deposition of Wall Materials in ITER (cross-checked at TEXTOR)

Optimisation of Plasma Wall Interaction by External Magnetic Distortion Fields

Tritium Retention and Removal Studies

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1. Tokamak Experiment for Technology Oriented Research, Forschungszentrum Jülich (Germany).

Photo courtesy of Harry Reimer, Forschungszentrum Jülich.

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QUALITY IN CONFINEMENT

Policy Brief

The most highly developed approach to fusion power, the tokamak, confines hot plasmas at 100 million°C in extremely strong magnetic fields produced by large, superconducting magnets.

In the reversed field pinch (RFP) approach, the device exploits the plasma's self-organisation to generate a confining magnetic field. This results in a high efficiency ratio between kinetic and magnetic pressure, and therefore a high efficiency in the use of the magnetic field for confinement.

Compared to a tokamak, the RFP has smaller, simpler magnets and efficient internal plasma heating, and is approximately 10 times weaker. However, the weak magnetic field adds physics challenges that must be overcome. The Implementing Agreement for a Programme of Research and Development on Reversed Field Pinches (RFP IA) seeks to address these challenges.

Background

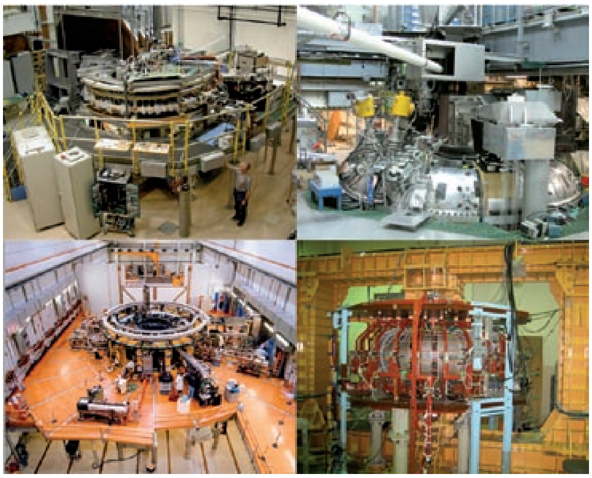
The main objective of the three Contracting Parties to the RFP IA is to share instrumentation, joint experiments and common development of theory and models. Research activities aim to:

- understand and optimise RFP plasma confinement to assess the configuration reactor potentials;
- determine confinement scaling laws towards reactor conditions;
- provide state-of-the-art facilities for developing active feedback control of magneto-hydrodynamic stability for ITER and other fusion devices;
- understand and advance fusion and plasma science by exploring fusion parameter ranges otherwise inaccessible and enhance the fusion predictive capabilities; and
- devise techniques to sustain steady-state plasma or find a pulsed reactor scenario.

Spotlight

Two transformational advances have been made in improving the quality of energy confinement in the RFP RFX[1] device.

The first occurred spontaneously when the plasma current was increased to a record level of 1.6 MA in helical equilibrium similar to the structure imposed by complicated magnets in stellarator devices. Magnetic turbulence is lower in the helical equilibrium, resulting in a substantial improvement in energy confinement.



▲ The four devices in the RFP IA (clockwise from top left: EXTRAP TZR,[2] MST, RELAX, and RFX-mod).

The second was made by using active control strategies in the MST[3] device. By programming the current drive for the plasma, the magnetic turbulence is reduced and the energy confinement improved to tokamak-like values. By injecting pea-sized pellets of frozen deuterium, the density in the hot plasma core increased while simultaneously applying current profile control and maintaining energy confinement. This resulted in a record plasma-pressure-to-magnetic-field-pressure ratio, or the value expected for a RFP-based fusion reactor.

A promising new low-aspect ratio RFP device, RELAX,[4] could stimulate the spontaneous helical equilibrium observed in RFX, as well as increase the generation of plasma current from the so-called bootstrap effect that occurs in the plasma from gradients in plasma thermal pressure.

CURRENT PROJECTS

EXTRAP T2-R (Sweden)

MST (United States)

RELAX (Japan)

RFX (Italy)

REFERENCES

www.iea.org/techagr

1. Reversed Field Experiment device, Consorzio RFX (Italy).

2. A medium-sized, reverse-field pinch device, Royal Institute of Technology (Sweden).

3. Madison Symmetric Torus device, University of Wisconsin (United States).

4. Reversed Field Pinch of Low-Aspect ratio Experiment device, Kyoto Institute of Technology (Japan).

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GYROTONS AND PLASMA PULSES

Policy Brief

The spherical torus (ST) machine has recently emerged as an innovative example of fusion confinement that could allow progress to be made in fusion energy development. Though ST devices have the capacity to operate at high temperatures (more than 10 million degrees centigrade), they are smaller in size than conventional tokamaks and therefore have lower construction and operating costs.

Although the ST plasmas are similar to the standard aspect ratio tokamak plasmas in many ways, the range of physics parameters can lead to important new plasma behaviours such as increased stability. In addition, creating plasma in a spherical torus reduces transport because of the flow shear and geometric configuration.

Background

There are currently three Contracting Parties to the Implementing Agreement for Co-operation on Spherical Tori (ST IA). Created in 2007, the aims of the ST IA are to enhance the effectiveness and productivity of fusion energy science and technology in preparation for ITER by:

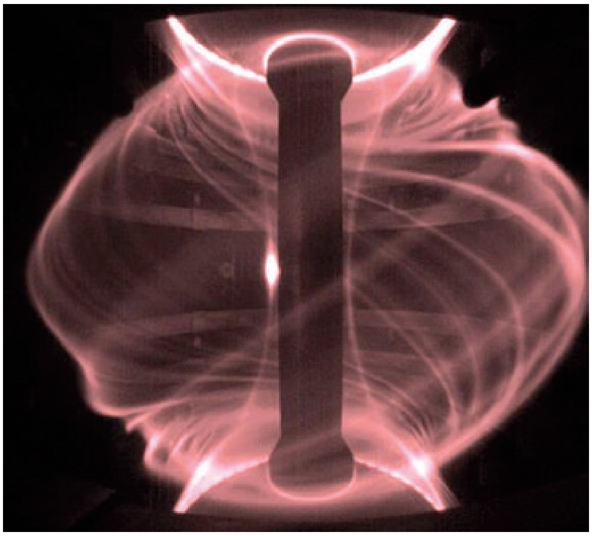
- strengthening co-operation among spherical torus research programmes and facilities;
- contributing to and extending the scientific and technology database of toroidal confinement concepts to the spherical torus physics regime; and
- providing a scientific and technological basis for the successful development of fusion power using the spherical torus.

Spotlight

ST research is important as it broadens the scientific understanding of tokamak physics. ST IA participants have made significant progress during their first term.

As part of collaborative efforts between the United States and the United Kingdom, a high-power gyrotron tube (up to 350 kW for 300 milliseconds) was recently installed on MAST[1] to study and understand the electron Bernstein wave (EBW) start-up experiment using zero or minimal solenoid induction.

After testing the first gyrotron, a second was successfully tested and reconditioned to high voltage short pulses. Two commissioning tests progressed rapidly, and it was found that the tube was able to consistently deliver 160 kW for 200 milliseconds arc-free. First attempts at coupling power into the plasma were limited by arcing between the gyrotron and the MAST device, with arc-free pulse lengths limited to 15-20 milliseconds.



▲ Colour photo of the plasma inside the mega amp spherical tokamak (MAST).

The first and second transverse electric mode converter relative to a second transverse electric bend was not ideal. As a result, the related waveguide components were inspected and cleaned. These corrections led to pulse lengths of 200 milliseconds at 100-150 kW with an improved arc-free pulse of 60-80 milliseconds.

Despite substantial EBW power modulation due to arcing, closed flux surfaces formed and solenoid-free plasma currents of up to 24 kA were achieved. Electron temperatures above 200 eV have also been measured.

The next phase of this collaborative experiment will focus on eliminating arcing, verifying the transmission line efficiency, and measuring and modelling the mode purity from the gyrotron, for example through mode convertors and waveguide transitions.

Results from the ST IA experiments are shared with fusion experts at the annual International ST Workshop and Collaboration Forum.

CURRENT PROJECT

Electron Bernstein Wave Start-up Proof of Principle Experiment

REFERENCES

www.iea.org/techagr

1. Mega Amp Spherical Tokamak device (United Kingdom).

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SUPER-DENSE CORES AND 3-D COMPUTATIONS

Policy Brief

A stellarator[1] is a class of magnetic confinement devices without net currents in the plasma that have demonstrated a variety of breakthroughs. Compared to a tokamak, a stellarator is disruption-free and operates in a steady-state. As there are no requirements for current drive, engineering needs are significantly reduced.

The Implementing Agreement for Co-Operation in Development of the Stellarator Concept (ST IA) improves the physics base and develops reactor design of the stellarator concept. Understanding three-dimensional physics in the stellarator also advances tokamak physics.

Background

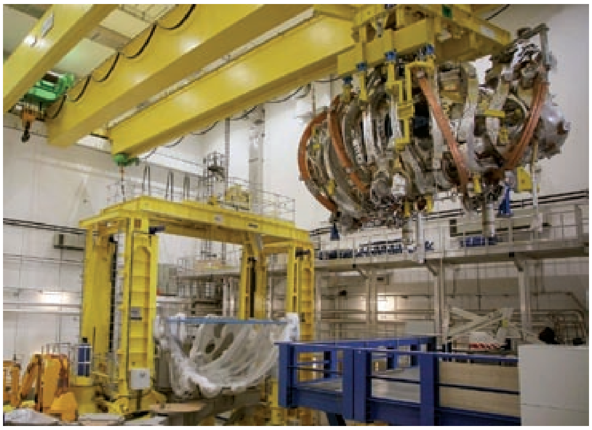
There are currently six Contracting Parties to the ST IA, including Russia and the Ukraine. Agreement participants cooperate and conduct diversified experiments on theory and reactor design. The bi-annual International Stellarator Workshop (ISW) assesses recent progress among ST IA participants.

Spotlight

Joint planning and co-ordination of national programmes and scientist exchanges and assignments under the auspices of the ST IA have accelerated both the performance envelope and the deep physical understanding of stellarator devices. The Large Helical Device (Japan) is the leading experimental platform for the stellarator/heliotron concept.

Significant recent advances in this area include an increase in the ratio of the plasma pressure to the pressure of the confinement magnetic field (5.1% with a range of 5% being maintained for longer than 100 times the energy confinement time). The high-density regime has been also extended to a range several times greater than standard fusion reactor requirements. This super-dense-core creates an innovative reactor scenario with relatively low temperatures (6-7 keV). Combined with the advantage that stellerators do not need current drive, this significantly lowers the engineering demands for fusion reactors.

The understanding of three-dimensional (3D) physics has progressed through development of simulation science and collaboration on computer code benchmarking. For example, a large-scale, gyro-kinetic simulation has revealed that enhanced zonal flows regulate turbulent eddies. The effects of resonant helical perturbation and 3-D magneto-hydrodynamic computations were also examined.



▲ The Wendelstein 7-X Stellerator device under construction (Germany).

Tokamak researchers will benefit from these experiments as they stabilise the regular, energetic bursts of energy and particles that escape from the magnetic field surrounding the plasma and cause energy losses.

Considerable improvement in plasma particle control has been observed in the TJ-II stellarator (Spain) by replacing boron-coated walls with lithium. High-density, neutral-beam injection was made possible during a lithium-hydrogen transition to an improved confinement regime. This lithium-hydrogen transition provides a unique opportunity to study the two-step process of edge-sheared flows in the plasma.

The Heliotron J (Japan), HSX (USA) and H-1 (Australia) devices also play an important complementary role in understanding stellarator physics and 3-D tokamak physics. The Coordinated Working Group reviews critical issues under the auspices of the ST IA. The first Wendelstein 7-X plasmas are foreseen for 2014.

CURRENT PROJECTS

Comparative Study: Confinement Improved Mode

Computer Code Benchmarking

Coordinated Working Group Meeting

Database: Stellarator/Heliotron Confinement

Database: Stellarator/Heliotron Profile

Joint Experiments: High-Beta and High-Density Operations

REFERENCES

www.iea.org/techagr

1. The name stellarator signifies a "star machine".

Photo courtesy of Max-Planck-Institut fuer Plasmaphysik (Germany).

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A STAR IS BORN

Policy Brief

Tokamaks with poloidal divertors are geometrically similar to the ITER tokamak but are much smaller, enabling plasma physics experiments on a smaller scale. Extrapolating results of these devices to ITER clarifies the physics aims while avoiding geometry effects. This prepares ITER operations for integrated tokamak operation scenarios.

Background

The experimental devices co-ordinated under the Implementing Agreement on a Co-operative Programme for the Investigation of Toroidal Physics in, and Plasma Technologies of, Tokamaks with Poloidal Field Divertors (PFD IA) play a strong role in guiding the design of ITER sub-systems.

The Tokamak PFD IA enables coordinated research between the three Contracting Parties through programmatic discussions, joint research programmes, and co-ordinated experiments. Examples of critical issues examined include:

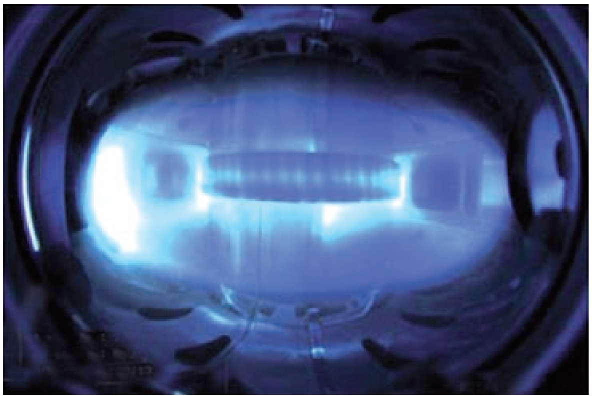
- development of hybrid scenarios for improved ITER operation;
- comparing the qualities of carbon and tungsten as plasma-facing components in next-step devices; and
- physics of performance-limiting instabilities and means for their stabilisation.

The International Tokamak Physics Activity (ITPA) identifies further critical issues by proposing joint experiments between research facilities on an international level. The PFD IA contributes largely to this activity through the experimental devices.

Spotlight

In 2008 the KSTAR[1] tokamak (Republic of Korea) was successfully commissioned. This device is comparable in size, plasma shape and parameters to the existing tokamaks ASDEX Upgrade[2] (Germany) and DIII-D[3] (United States), but is equipped with superconducting magnetic field coils that allow exploration of discharges on longer timescales. This includes the current redistribution time (in seconds) and is comparable to the discharge time in devices with normal conducting coils.

The ASDEX Upgrade tokamak successfully operated with all plasma facing components covered with tungsten. Though tungsten had not been used in tokamaks with the ITER-relevant shape, it is now regarded as the prime candidate for the first wall. The experiments demonstrated that the tungsten-covered wall components enabled high performance tokamak operation using standard and advanced operation modes, which are also foreseen for ITER.



▲ The first plasma of the KSTAR registered maximum plasma current of 133kA.

In 2009 the ASDEX Upgrade device was shut down for four months to install the clean tungsten wall. The start-up under these conditions was quite successful, with stable helium-mode discharges with auxiliary heating achieved after only six discharges. The 2009 experimental campaign operated for 72 days.

The new flywheel generator will enable experts to study raising the plasma parameters at longer pulse lengths. The goal is to extend the favourable improved helium-mode regime with a full tungsten wall, but it will also allow experts to re-examine regimes that need stronger shaping.

During the maintenance shutdown from mid-2009 to mid-2010, a new set of 2x4 in-vessel coils will be installed to study edge localised mode suppression with two static error fields. Ion cyclotron resonance heating antennae will be installed to study strong tungsten sputtering.

CURRENT PROJECTS

Alcator C-Mod (United States)

ASDEX Upgrade (Germany)

DIII-D (United States)

KSTAR Device (Korea)

NSTX (United States)

REFERENCES

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

1. Korea Superconducting Tokamak Advanced Research, National Fusion Research Institute (Republic of Korea).

2. AxialSymmetrisches DivertorEXperiment, Max-Planck-Institut für Plasmaphysik (Germany).

3. Doublet III device, General Atomics (United States).

Photo courtesy of National Fusion Research Institute (Republic of Korea).

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RENEWABLE ENERGIES AND HYDROGEN

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LOOKING AHEAD TO THE NEXT GENERATION

Policy Brief

Bioenergy currently provides 10% of global primary energy supply, 1.3% of electricity production, and 1.5% of transport fuels. A variety of conversion technologies are available, and a range of feedstocks can be used – wastes, agricultural and forestry residues, and crops grown specifically for energy purposes.

Background

The Implementing Agreement for a Programme of RD&D on Bioenergy (BIO IA) currently has 22 Contracting Parties, including Brazil, Croatia and South Africa. The goals of the Bioenergy IA are to:

- provide researchers with opportunities for international collaborative R&D;
- partner with industry on new RD&D projects; and
- assist policy makers to gain perspective on progress in bioenergy and deployment opportunities and establish standards.

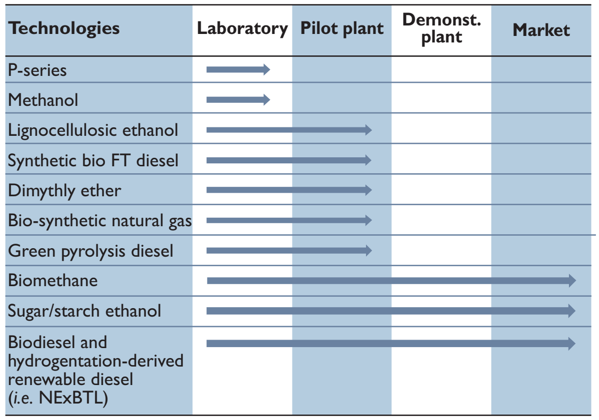
Spotlight

Driven by increasing concern over energy security and greenhouse-gas mitigation, global demand for liquid biofuels more than tripled between 2000 and 2007. Production costs are uncertain and vary with the feedstock available, but are currently estimated to be USD 0.80 – 1.00 per litre of gasoline equivalent. Most biofuels are currently produced from first-generation feedstocks (food crops).

These sources are generally limited in their ability to achieve oil-product substitution, climate change mitigation, and economic growth. Their sustainable production is under review due to undue competition for scarce land and water resources. These factors have lead to increasing interest in second-generation biofuels (produced from non-food biomass such as wood chips, switch grass, and residual non-food parts of food crops).

One recent study of the BIO IA reviewed technical challenges facing second-generation biofuels, evaluated their costs, and examined current policies to support their development. Although significant progress is being made, second-generation biofuels are still some way from commercial deployment. Considerable more investment is needed to ensure that future production can be undertaken sustainably. The study offers recommendations to overcome these constraints in the future.

Experts then found that the higher efficiencies of commercialised technologies such as biodiesel, sugar/starch ethanol, and bio-methane are the result of improvements in large-scale plants. In addition, efficiency improvement potentials are higher for second-generation biofuel technologies such as cellulose ethanol, P-Series fuels, synthetic bio FT diesel, and DME.



▲ Current development stages of biomass-to-biofuel conversion technologies

A complementary study evaluated the gaps in current research for production of second-generation biofuels. It concludes that the complexity of energy transformation, along with the investment risks of new technologies, are the reasons why second-generation biofuels are not yet fully commercialised. The main research gaps identified include catalysts and biocatalysts, feedstock preparation and processing, and systems integration.

CURRENT PROJECTS

Biomass Combustion and Co-firing

Biomass Feedstocks for Energy Markets

Biomass Production for Energy from Sustainable Forestry

Biorefineries

Commercialising First- and Second-Generation Liquid Biofuels from Biomass

Energy from Biogas

Greenhouse Gas Balances of Biomass and Bioenergy Systems

Integrating Energy Recovery into Solid Waste Management

Pyrolysis of Biomass

Socio-Economic Drivers in Implementing Bioenergy Projects

Sustainable International Bioenergy Trade

Thermal Gasification of Biomass

REFERENCES

www.ieabioenergy.com

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ANALYSING ALL COSTS

Policy Brief

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

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

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

Background

There are currently nine Contracting Parties to the RETD IA. The objectives of the Agreement are to:

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

Spotlight

National, local and regional plans for electricity generation frequently ignore the full set of costs and benefits of each energy source. Cost-benefit analyses typically include economic and financial costs such as initial investment, operations and maintenance, and payback time. However, it is equally important to take into account externalities such as the socio-economic impacts of the electricity generation.

The objective of one RETD IA project, Renewable Energy Costs and Benefits, is to provide full cost information. The interactive Renewable Energy Calculator enables analysts and planners to make financial and socio-economic comparisons between renewable and traditional energy sources for electricity generation.

The straightforward software features two basic costs: fuel price and discount rate. The fuel prices are based on forecasts to 2010 and 2025 from the IEA *World Energy Outlook*.[1] Discount rates are based on IEA *Energy Technology Perspectives*[2] rate of 5%.

▲ The Renewable Energy Calculator compares the financial and socio-economic costs of fuels and technologies.

Users may also choose to include any or all of the other costs: CO_2 emissions, environmental externalities (*e.g.* health consequences), security of fuel supply, system integration (infrastructure costs, balancing, power reserve, and capacity credit).

Fuel sources include natural gas combined-cycle, coal with or without CO_2 capture, coal combined heat and power, nuclear, waste incineration, wind (onshore or offshore), solar PV, concentrated solar, small or large hydropower, biomass gasification (small or centralised) and biomass with 20% coal co-firing.

A chart is immediately visible online and the data can be downloaded for further analysis. Definitions and methodologies for each parameter are also available for download.

CURRENT PROJECTS

Better Use of Biomass for Energy

Employment and Innovation through Renewable Energies

Non-Technical and Economic Barriers

Renewable Energy and Climate Change Abatement

Renewable Energy in Global Energy Scenarios

Renewable Energy in Transport

REFERENCES

www.iea-retd.org

1. IEA (2006), World Energy Outlook, Paris, 2006.

2. IEA (2006), Energy Technology Perspectives, Paris, 2006.

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KEEPING THE HEAT ON

Policy Brief

Geothermal heat is a sustainable energy source that has the potential to contribute significantly towards meeting current and future global energy demand.

Until recently, geothermal projects existed near tectonic plate boundaries (*e.g.* the Pacific Ring of Fire). Yet vast, deep heat resources exist within much of the rest of the world as well. Thanks to new techniques, geothermal foraging to recuperate the deep heat is planned or in operation in Australia, France, Germany, and Switzerland.

However, major barriers to recuperating the underground heat exist. These include lack of information on the technology, the potentials, the environmental and social benefits, and the lack of demonstration plants. Overcoming these obstacles will require concerted efforts by policy makers, the financial community and the public.

Background

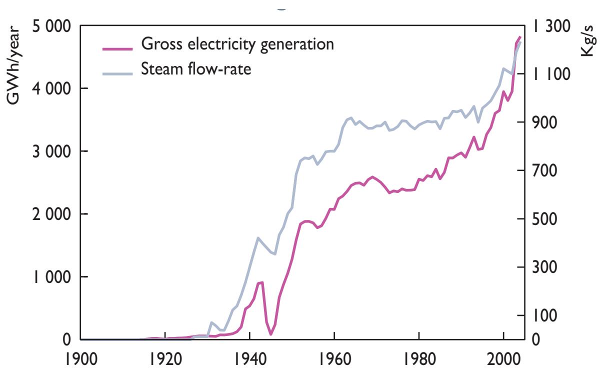
There are currently 13 Contracting Parties (including Iceland and Mexico) and six Sponsors participating in the Implementing Agreement for the Cooperative Programme on Geothermal Energy Research and Technology (GIA). The scope of GIA activities include:

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

Spotlight

Contrary to other sources of heat or power generation, geothermal resources (electricity production or direct use of heat) have the potential to sustain operations over long periods of time. This not only provides long-term environmental benefits, it ensures a full return on investment.

In the Philippines, four fields have been producing electricity for more than 25 years with installed capacity ranging from 190 to 430 MW. In New Zealand, the Wairakei field has been operating for more than 50 years allowing for an expanded re-development. However, by far the most spectacular longevity can be seen in the Lardarello field (Italy), which has been producing electricity for close to 100 years. For this reason, the GIA strategy 2007-2012 will focus on the long-term sustainability of geothermal resources.



▲ Electricity generation and steam flow rate in the Lardarello (Italy) geothermal field that has been operating for nearly 100 years.

One GIA study, Sustainable Geothermal Utilisation, carried out under the Environmental Impacts of Geothermal Energy Development project, was designed to inventory the longevity, recovery rates and cycle durations of geothermal projects around the world in order to more accurately model production.

In association with the 50th anniversary of the Wairakei geothermal power station, the GIA co-sponsored a workshop on sustainable geothermal modelling. Findings from the workshop will feed into further analysis in a significant GIA publication on the topic.

A recent joint International Geothermal Association-GIA workshop, Geothermal Energy: Global Development Potential & Contribution to Mitigation of Climate Change attracted over 60 participants from all major geothermal-resource producing countries. The objective was to provide input to the Intergovernmental Panel on Climate Change *Special Report on Renewable Energy Sources and Climate Change Mitigation*. Several GIA IEA experts are coordinating lead authors for the geothermal chapter of the report.

CURRENT PROJECTS

Advanced Geothermal Drilling Techniques

Direct Use of Geothermal Energy

Enhanced Geothermal Systems

Environmental Impacts of Geothermal Development

REFERENCES

www.iea-gia.org

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A POWERFUL PAIR

Policy Brief

Use of hydrogen as a fuel and an energy carrier enables a wide range of options that have the potential to alleviate energy security issues and offer significant CO_2 reduction possibilities.

For example, hydrogen fuel cells offer a wide array of applications such as electricity generation, combined heat and power and transportation. Future fuel cell powertrains have the potential to be twice as energy efficient as internal combustion engines in the mid term.

Coal gasification technologies offer opportunities for large-scale hydrogen production. When combined with carbon capture and storage, greenhouse-gas emissions are minimised. Hydrogen can also be used to store the electricity produced from renewables such as solar and wind.

Background

The strategy of the Implementing Agreement for a Programme of Research and Development on the Production and Utilisation of Hydrogen (HIA) is to facilitate, co-ordinate and maintain innovative RD&D activities through international co-operation and information exchange. There are currently 23 Contracting Parties to the HIA, including Iceland and Lithuania.

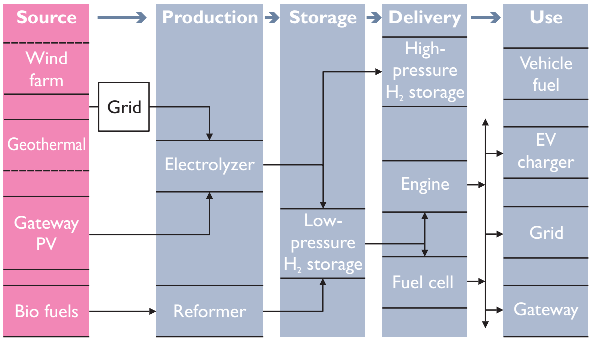
Spotlight

One recent project of the HIA, Wind Energy and Hydrogen Integration, examined the technical, economic, social, environmental, market and legal issues with producing electricity from wind and hydrogen by electrolysis. Applications for hydrogen storage and electrical conversion were also examined. The project has four subtasks:

- in-depth review of the current state-of-the-art;
- improve system integration technology development and system integration concepts;
- business concept development; and
- wind energy management applications.

The project provided a platform to demonstrate a renewable-hydrogen production system, gain operational experience, evaluate system performance and costs, optimise system integration and explore opportunities for system optimisations to increase performance and reduce costs.

Electricity produced from wind turbines was passed through an electrolyser to split water into hydrogen and oxygen. Each day 2-12 kg of hydrogen was produced and stored in steel tanks (up to 85 kg of hydrogen at 2 500 pounds per square inch) to be used for transport, fuel cells or to generate electricity.



▲ Combined renewables-hydrogen systems produce electricity from renewable sources, electrolyse water to create hydrogen, then store and use the hydrogen for transport, fuel cells or electricity generation.

Efficiency measurements from one project show that hydrogen production flow rates from one electrolyser to be about 20% lower than the manufacturer's rated flow rate. However, the maximum power point tracker electronic system which converts direct current to alternating current was found to produce 10-20% more energy than a direct-connect configuration.

In summary, matching the electrical characteristics of the renewable energy sources to the hydrogen-producing stacks further improves system efficiency and further lowers overall costs. This can be solved through systems-level design and integration and development of optimised power electronics packages that can maximise energy transfer, improve overall energy efficiency, reduce system complexity and lower costs. Another outcome of the study includes a simulations tool for wind-hydrogen system layouts.

CURRENT PROJECTS

- Advanced Materials for Water Photolysis
- Bio-hydrogen
- Fundamental and Applied Hydrogen Storage Materials Development
- High-Temperature Production of Hydrogen
- Hydrogen Safety
- Integrated Systems Evaluation
- Near-Term Market Routes to Hydrogen (Co-Utilisation of Biomass and Fossil Fuels)
- Small-Scale Reformers for On-Site Hydrogen
- Wind Energy and Hydrogen Integration

REFERENCES

www.ieahia.org

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FRESH RESERVOIRS AND RECOMMENDATIONS

Policy Brief

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

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

Background

The overall objective of the Implementing Agreement for a Co-operative Programme on Hydropower Technologies and Programmes (HTP IA) is to enhance the development of sustainable hydropower by carrying out research and programmes that disseminate balanced and objective information worldwide. The scope of work encompasses:

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

There are currently seven Contracting Parties, including Brazil and China.

Spotlight

Sustainable hydropower development continues to require government policies to ensure that proposed new hydro projects are environmentally and socially acceptable.

In pursuit of this goal, the HTP IA recently began a project on Hydropower and the Environment, led by the HTP IA's newest contracting party, Brazil. The project consists of two primary tasks, the first of which is Managing the Carbon Balance in Freshwater Reservoirs. The objectives of this task are to:

- increase knowledge of related processes;
- establish guidelines for planning studies on the carbon balance in reservoirs; and
- standardise greenhouse-gas flux evaluation methods.

The second primary task of the project will be to review, revise, and update the 2006 recommendations from the HTP IA report *Hydropower Good Practices: Environmental Mitigation and Benefits*, and the 2004 report, *The International Hydropower Association's Sustainability Guidelines*.

▲ The world's second largest hydropower dam with a capacity of 12 600 MW (Itaipu, Brazil).

The new documents will include updated recommendations relevant to government decision makers, regulators and other project approval agencies, financial institutions and government aid agencies on the five key areas initially reported:

- energy policy framework;
- decision-making process;
- comparison of hydropower project alternatives;
- improving environmental management of hydropower plants; and
- sharing benefits with local communities.

CURRENT PROJECTS

Hydropower Competence Network

Hydropower and the Environment

Hydropower Good Practice

Hydropower Upgrading

Integrating Wind Energy into Hydropower Systems

Public Awareness

Small-Scale Hydropower

REFERENCES

www.ieahydro.org

Photo courtesy of Itaipu Binacional.

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TAPPING INTO THE GRID

Policy Brief

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

Potential Global Electricity Production (TWh/year)	
Tidal current	>800
Salinity gradient	2 000
Ocean wave	8 000 - 80 000
Thermal energy	10 000

These figures compare to a total world electricity production from all sources of 17 450 TWh. The number of ocean energy technology concepts has increased to 100 known devices. A small number of ocean energy developers have produced full-scale prototypes, and few have completed testing or published results. For all ocean technologies deployment will not be possible without the proper market policies and support mechanisms.

Background

The Implementing Agreement for a Co-operative Programme on Ocean Energy Systems (OES IA) currently has 18 Contracting Parties, including Mexico and South Africa. The original focus of the OES IA concerned ocean, wave and tidal current technologies. Recently the scope of the OES IA has expanded to include ocean thermal energy conversion technologies, salinity power, as well as devices that use the energy extracted for purposes other than electricity generation, such as desalination.

Spotlight

Wave and tidal current conversion technologies are advancing to the commercial stage. Several pilot projects are now connected to electrical grids, and some large-scale projects are planned.

Development of appropriate interconnection guidelines, based on solid technical understanding of power outputs from the conversion devices and local grid constraints, is critical for market integration of ocean power. These frameworks not only accelerate the system design process, but also build confidence among network owners and operators.

In order to facilitate market integration, the OES IA launched a new project in 2007, Integration of Ocean Energy Plants into Distribution and Transmission Electrical Grids.

▲ An open-ring turbine prototype under test at the European Marine Energy Centre (United Kingdom).

Findings from the project are detailed in the report *Key Features and Identification of Needed Improvements to Existing Interconnection Guidelines for Facilitating Integration of Ocean Energy Pilot Projects*.

This report focuses on analysing existing interconnection guidelines, codes and standards. It identified areas where integration guidelines could be modified to develop a suitable marine energy interconnection guideline, and suggests that existing wind (onshore/offshore) energy standards, once revised in the marine energy context, will aid both small-scale pilot and large-scale commercial projects.

The report also notes that while some developers envision limited power generation for isolated communities, most are expecting to graduate into larger, full-scale commercial projects in the long term. As a result, effective pilot ocean energy interconnection guidelines will encourage early coordination between project developers and utilities.

CURRENT PROJECTS

Assessment of Environmental Effects and Monitoring Efforts for Ocean Wave, Tidal, and Current Energy Systems

Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems

Grid Connection of Ocean Energy Systems

Information Dissemination

REFERENCES

www.iea-oceans.org

Photo courtesy of Power Projects, Ltd. .

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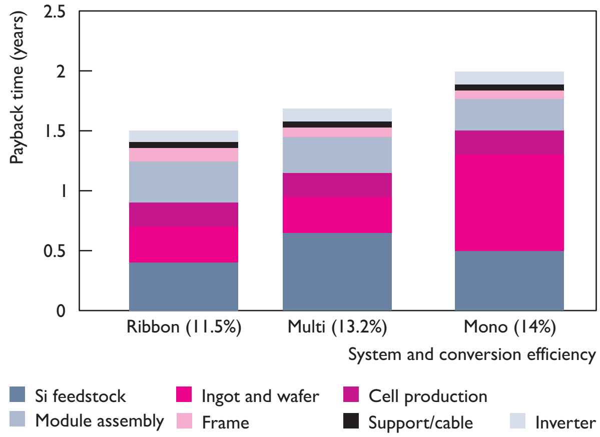
SETTING THE STANDARD

Policy Brief

Since 2000 cumulative installed photovoltaic (PV) capacity has increased by 40% per year. This impressive market growth is the result of the continued policy support for PV in an increasing number of countries.

In the next 10 years, PV is expected to achieve competitiveness with power grid retail prices in many regions. This will require a continued, strong and balanced policy effort to allow for optimal technology progress, cost reduction and ramp-up of industrial manufacturing for mass deployment.

PV also offers the ability to provide electricity to populations in remote locations, enhancing the quality of existing electricity supplies, and the quality of life.



▲ Energy pay-back time of crystalline silicon PV systems on a grid-connected, rooftop PV system in southern Europe.

Background

There are currently 22 Contracting Parties (including Israel and Mexico) to the Implementing Agreement for a Co-operative Programme on Photovoltaic Power Systems (PVPS IA), and one Sponsor. Most of the worldwide PV capacity (95%) is found in PVPS IA countries.

The PVPS IA conducts a variety of projects concerning the applications of converting solar energy from PV into electricity. This work contributes to the cost reduction of PV power applications, increases awareness of the potential and value of PV power systems, fosters the removal of both technical and non-technical barriers and enhances technology co-operation.

Spotlight

Despite the spectacular growth of the PV market, continued diligence on environmental, health and safety issues will be necessary. The PVPS IA Life Cycle Assessment project set out to quantify the environmental profile of electricity produced with PV systems (also compared to that of electricity from other sources of energy), to show the improvements in PV environmental profiles, and to assess the environmental profile of PV electricity with the help of external costs and other life cycle impact assessment methods.

Following in-depth review of technical and environmental characteristics of current PV systems, modelling approaches in life-cycle inventory analysis and life cycle impact assessments, PVPS IA experts chose to set the standard for others.

The *Methodology Guidelines on Life Cycle Assessment of Photovoltaic Electricity* demonstrates how to perform life cycle inventories based on ISO standards 14040 and 14044.

The *Guidelines* identify key parameters of life cycle assessments such as module efficiency, life expectancy, irradiation, degradation, back-up systems, system modelling, system boundaries, module recycling, and energy pay-back time.

Reporting results of payback times and mitigation potentials are equally important, as well as identifying the environmental impacts of the "background system" associated with PV plants – electricity production, or the production of glass, aluminium, plastics, steel.

The *Guidelines* also set the standard for life-cycle assessments and will serve to raise the quality of information available for the PV industry worldwide.

CURRENT PROJECTS

Exchange and Dissemination of Information on Photovoltaic Power Systems

Hybrid Systems within Mini-Grids

Photovoltaic Services for Developing Countries

Photovoltaic Environmental Health & Safety Activities

Urban Scale PV Applications

Very Large-Scale Photovoltaic Power System Generation System

REFERENCES

www.iea-pvps.org

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MORE POWER FROM CONCENTRATE

Policy Brief

The increasing demand peaks of summer air conditioning loads in hot, arid regions have made dispatchable concentrating solar power (CSP) an attractive option. With the engaged support and contributions of the countries participating in the Implementing Agreement for the Establishment of a Project on Solar Power and Chemical Energy Systems (SolarPACES) (SP IA), special feed-in tariffs and other financial incentives for CSP plants have been established in Algeria, Israel, Spain and the United States, boosting the development of new CSP projects by several thousand megawatts.

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

Background

There are currently 16 Contracting Parties in the SP IA, including Algeria, Egypt, Israel, Mexico, South Africa, and the United Arab Emirates. The aim of the SP IA is to solve the wide range of technical problems associated with commercialisation of CSP technology, including large-scale system tests and the development of advanced technologies, components, instrumentation, and systems analysis techniques. Market development and raising awareness of CSP potentials are also key elements of the SP IA.

Spotlight

Sunlight is the most abundant carbon-neutral energy resource. However, solar energy does not necessarily match the variations in demand. If it is to become a major contributor to our energy supply, some form of storage is necessary.

Solar electricity generated by CSP technology, followed by electrolysis of water, is a viable route for producing hydrogen. Hydrogen can be used to generate electricity in fuel cells and batteries to meet energy demands whenever and wherever required by the customers.

The SP IA is using a pilot plant in Spain to develop such an energy storage method by testing solar-heated, thermo-chemical processes that offer the potential of efficient large-scale hydrogen production.

▲ The SP IA is using a pilot plant in Spain to develop such an energy storage method by testing solar-heated, thermo-chemical processes that offer the potential of efficient large-scale hydrogen production.

The thermal behaviour and characteristics of the 100-kWth pilot plant were extensively tested, enabling optimisation of the process strategy while at the same time proving the feasibility of the control concept. SP IA researchers went on to carry out the first tests of hydrogen production by water splitting. The tests were successful – significant amounts of hydrogen were produced with steam conversion efficiency of up to 30%.

The recent SP IA report, *Solar Fuels from Concentrated Sunlight*, explains in more detail the potential value of hydrogen as a storage medium for solar energy. The report concludes with specific recommendations for an R&D strategy to further advance solar hydrogen production technologies.

CURRENT PROJECTS

Solar Chemistry Research

Solar Energy and Water Processes and Applications

Solar Heat for Industrial Applications

Solar Resource Knowledge Management

Solar Technologies and Advanced Applications

Solar Thermal Electric Systems

REFERENCES

www.solarpaces.org

Photo Courtesy of Platform Solar de Almeria (Spain).

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INDUSTRY WARMS TO SOLAR HEATING

Policy Brief

Space heating and cooling are applied throughout the world. In 2007, world solar hot water and heating capacity totalled 147 GW (63% of which in China). In the same year, 16 GW of capacity was added, 80% of which was in China.[1]

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

Background

The overall objectives 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, expanding the solar thermal market, and raising awareness of policy makers and consumers.

The SHC IA currently has 19 Contracting Parties, including Mexico. SHC IA participating countries collaborate with key players in the field, including solar industry associations.

Spotlight

The use of solar energy in commercial and industrial applications is relatively small compared to use in the residential sector. Most solar applications for industrial processes have been on a relatively small scale and are mostly experimental in nature.

However, given that the industrial sector consumes approximately 30% more energy than any other sector in OECD countries, there is considerable potential for using solar heat technologies in many industrial applications. To expand the market for solar thermal components in the industry sector, it will be necessary to more fully understand industry-specific requirements.

To help fill this gap, the SHC IA launched a collaborative research project that brought together experts and industries from the residential solar heating field and the high-temperature solar power field.

▲ A solar heating and cooling installation at a vineyard (Tunisia), one of 12 demonstration projects monitored under the SHC IA.

As part of this project, the report *The Potential for Solar Heat in Industrial Processes* surveyed and compared the key results and methodologies of several country-specific studies, and provides the following recommendations for policy makers:

- provide national economic incentives to encourage industry investment in solar thermal;
- conduct informational campaigns for industries to create greater awareness of solar thermal technologies;
- support further research and innovation to improve technical maturity and reduce costs; and
- sharing benefits with local communities.

CURRENT PROJECTS

Advanced Housing Renovation with Solar & Conservation

Compact Thermal Energy Storage

Polymeric Materials for Solar Thermal Applications

Photovoltaic and Thermal Systems

Solar Air-Conditioning and Refrigeration

Solar Energy and Architecture

Solar Rating & Certification Procedure

Solar Resource Knowledge Management

Towards Net Zero Energy Solar Buildings

REFERENCES

www.iea-shc.org

1. Data courtesy of IEA and the Renewable Energy Policy Network for the 21st Century.

Photo courtesy of Domain Neferis Winery, Tunisia.

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SYNCHRONISING FOR SUCCESS

Policy Brief

Countries around the world are turning increasingly to wind turbines for electricity generation. In 2008 wind energy generation capacity in 76 countries worldwide increased by 27 262 MW to 121 188 MW, totalling more than 1.5% of the global electricity consumption.

In Denmark the contribution of wind energy to total electricity supply reached 19% for the same year. In Portugal and Spain more than 11% of electricity demand is met by wind, nearly 9% in Ireland and more than 6% in Germany.

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. The Wind IA currently counts 20 Contracting Parties (including Mexico), and one Sponsor.

Spotlight

Integrating electricity produced from wind into power networks can be challenging due to the variability of wind and the variability of the electricity already in the grid (load) and consumer demand.

To address these challenges, one three-year project of the Wind IA, Power Systems with Large Amounts of Wind Power, evaluated various statistical methods that estimate short-term reserve allocation in power systems. The primary objective of the study was to facilitate the highest economically feasible wind energy penetration in electricity power systems worldwide.

A standard deviation of the variability of wind was combined with a standard deviation of the variability of the electricity network load to derive the incremental increase in variability. In 2009 the final report was published. The results show that several key factors influence the level of wind-power integration:

- Aggregating turbines over large areas increases the predictability of wind power forecasting and reduces costs by pooling resources.
- Intra-day and intra-hour trading between different balancing areas can reduce balancing service costs.
- Operating systems and electricity markets at less than day-ahead time scales can reduce wind-power forecasting errors that affect operating reserves.

▲ A wind turbine supplying power to the grid.

- Transmission quality is critical for maximising aggregation benefits, enhancing electricity markets, and increasing balancing areas.

Until now wind integration has primarily been studied at penetration levels of 10–20% of gross demand. What will happen at larger penetration levels, where wind becomes a more dominating part of power system, is not yet clear. Future studies that cover larger areas will be necessary to properly account for additional cross-border transmission issues.

CURRENT PROJECTS

Base Technology Information Exchange and Development of Recommended Practices

Cost of Wind Energy

Integration of Wind and Hydropower Systems

Offshore Wind Energy Development

Power Systems with Large Amounts of Wind Power

Small Wind Turbine Quality Labelling

Social Acceptance of Wind Energy Projects

Wind Energy in Cold Climates

Wind Tunnel Measurements and Improvement of Aerodynamic Models

REFERENCES

www.ieawind.org

Photo courtesy of Rick Hinrichs.

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STATISTICS

Implementing Agreement Participation

Government RD&D Budgets

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RECENT TRENDS

Implementing Agreements (IAs) have been a direct reflection of national priorities since their creation in 1975. In the 1980s, their main focus was on fossil fuels. In the 1990s, several IAs were created to address energy saving, greenhouse-gas emissions, climate change, technology transfer, and renewable energy. Most recently, IAs were launched in areas such as electricity networks, energy efficiency equipment and renewable technology deployment.

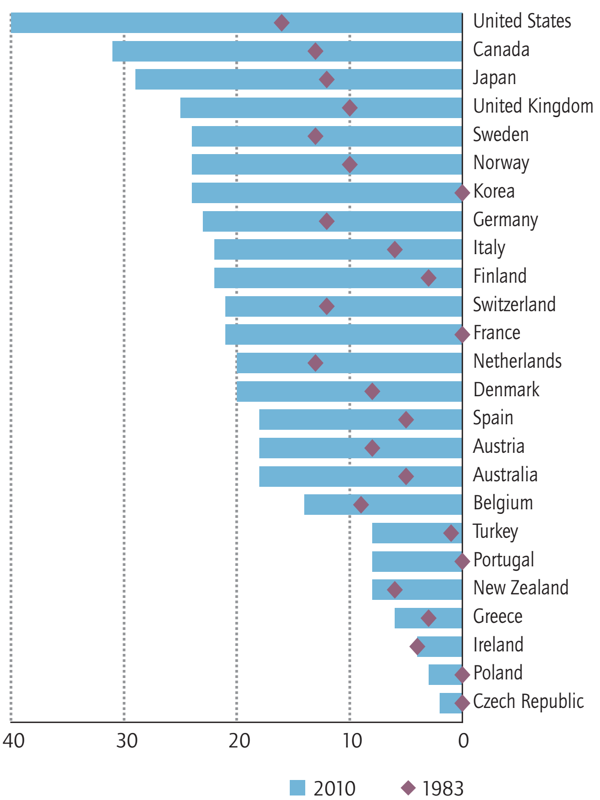
The United States participates in the largest number (40) of IAs, followed by Canada (31) and Japan (30). Since 1983, each of these three countries has more than doubled their participation. Korea has experienced the most spectacular growth, from no participations in 1993 to 24 in 2010.

Since 2007, participations[1] in Agreements grew from 446 to 575. This includes a 22% increase in IEA non-member country participations, particularly China and India.

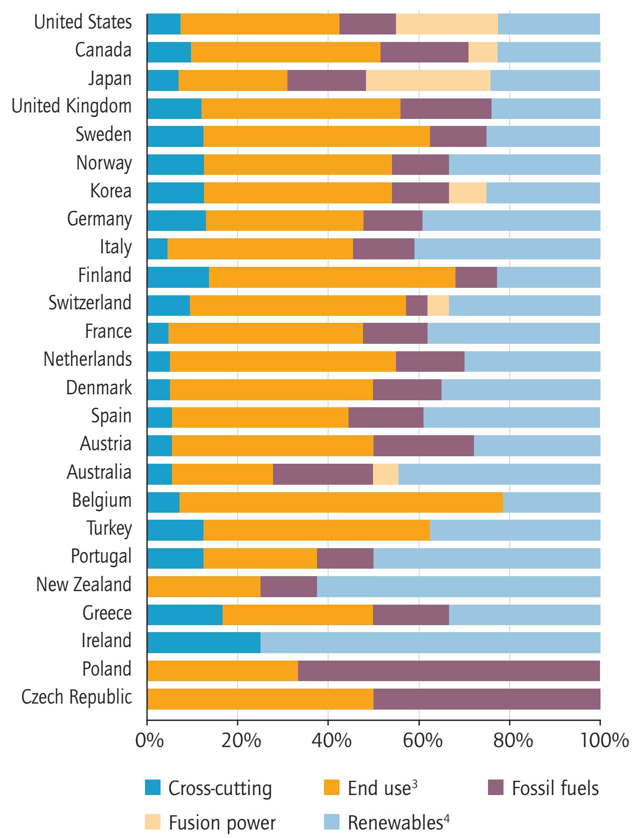
China participates in six IAs (buildings, transport, fusion, hydropower and clean fossil fuels), while India participates in three (energy efficiency, clean fossil fuels, fusion). Countries new to the IAs include Malaysia (2008), Thailand (2008) and the United Arab Emirates (2009).

During the same period, Sponsors (industries participating in the Executive Committee or board of directors) nearly doubled, from 26 in 2007 to 50 in 2010. The largest increase was seen in the clean fossil fuels and renewables sectors, which increased by 35% and 38%, respectively. The full list of companies participating in IAs as Sponsors is shown in the following tables. Note that the table 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 – currently estimated at more than 500 companies.

Changes in participation 1983-2010[2]



Share by sector 2010



1. Organisations multiplied by the number of initiatives in which they participate.

2. 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 IEA Implementing Agreements.

3. The end-use category includes buildings, electricity, industry and transport.

4. Renewables includes hydrogen.

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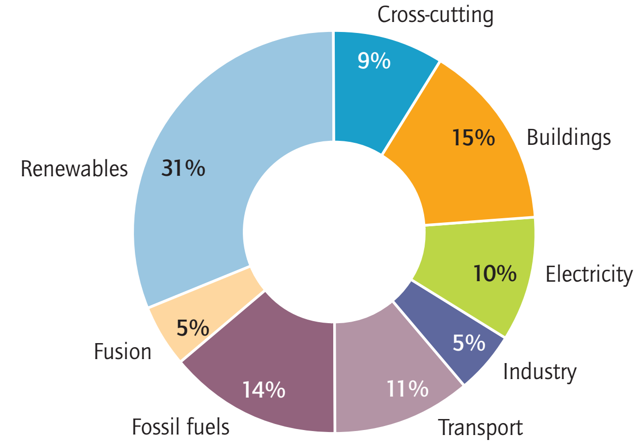
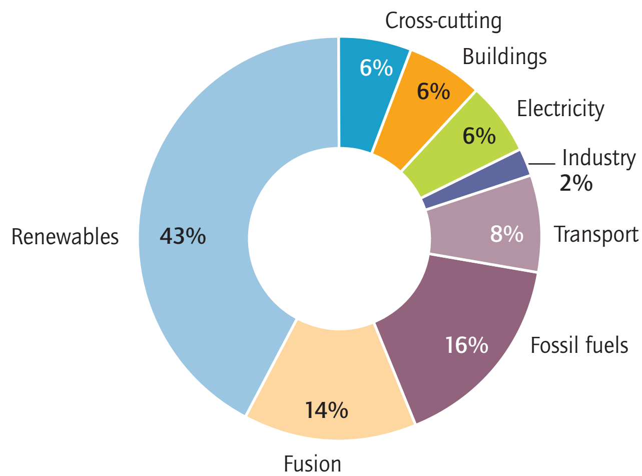
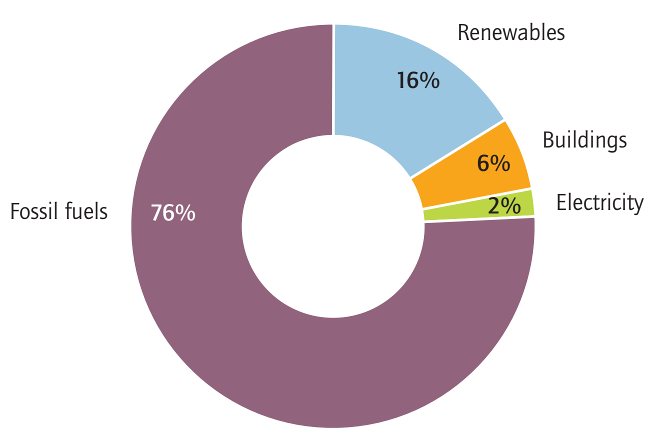
IEA member countries



IEA non-member countries



Sponsors



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ALL CATEGORIES

As of 31 March 2010

	Cross-Cutting	End-Use				Fossil Fuels	Fusion Power	Renewables and Hydrogen	TOTAL
		Buildings	Electricity	Industry	Transport				
Australia	1	1	1		2	4	1	8	**18**
Austria	1	3	2		3	4		5	**18**
Belgium	1	2	3	2	3			3	**14**
Canada	3	5	2	2	4	6	2	7	**31**
Czech Republic		1				1			**2**
Denmark	1	4	2	1	2	3		7	**20**
Finland	3	4	3	2	3	2		5	**22**
France	1	4	2		3	3		8	**21**
Germany	3	3	1	1	3	3		9	**23**
Greece	1	1	1			1		2	**6**
Ireland	1							3	**4**
Italy	1	2	3	1	3	3		9	**22**
Japan	2	3	1	1	2	5	8	7	**29**
Korea	3	5	2	2	1	3	2	6	**24**
Netherlands	1	4	3	1	2	3		6	**20**
New Zealand		1	1			1		5	**8**
Norway	3	4	3	2	1	3		8	**24**
Poland		1				2			**3**
Portugal	1	1		1		1		4	**8**
Spain	1	3	2		2	3		7	**18**
Sweden	3	4	3	2	3	3		6	**24**
Switzerland	2	3	3	1	3	1	1	7	**21**
Turkey	1	2			2			3	**8**
United Kingdom	3	3	3	1	4	5		6	**25**
United States	3	5	3	2	4	5	9	9	**40**
IEA members	**40**	**69**	**44**	**22**	**50**	**65**	**23**	**140**	**453**
Algeria								1	**1**
Brazil	1			1				2	**4**
China		1			2	1	1	1	**6**
Croatia								1	**1**
Egypt								1	**1**
Iceland								2	**2**
India			1			1	1		**3**
Israel		1	1					2	**4**
Lithuania								1	**1**
Malaysia								1	**1**
Mexico	1				1	2		6	**10**
Russia						1	4		**5**
South Africa	1	1	1			2		3	**8**
Thailand					1				**1**
Ukraine							1		**1**
UAE								1	**1**
Venezuela						1			**1**
IEA non-members	**3**	**3**	**3**	**1**	**4**	**8**	**7**	**22**	**51**
IEA members		3	1			31		8	**43**
IEA non-members						7			**7**
Sponsors		**3**	**1**			**38**		**8**	**50**
EC	1	1				2	9	6	**19**
OPEC						1			**1**
UNIDO								1	**1**
Intl. organisations	**1**	**1**				**3**	**9**	**7**	**21**
TOTAL	**44**	**76**	**48**	**23**	**54**	**114**	**39**	**177**	**575**

UAE (United Arab Emirates); EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).

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CROSS-CUTTING ACTIVITIES

As of 31 March 2010

	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
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
New Zealand				
Norway	1	1	1	3
Poland				
Portugal		1		1
Spain		1		1
Sweden	1	1	1	3
Switzerland		1	1	2
Turkey			1	1
United Kingdom	1	1	1	3
United States	1	1	1	3
IEA members	**11**	**12**	**17**	**40**
Algeria				
Brazil		1		1
China				
Croatia				
Egypt				
Iceland				
India				
Israel				
Lithuania				
Malaysia				
Mexico		1		1
Russia				
South Africa		1		1
Thailand				
Ukraine				
UAE				
Venezuela				
IEA non-members		**3**		**3**
IEA members				
IEA non-members				
Sponsors				
EC			1	1
OPEC				
UNIDO				
Intl. organisations			**1**	**1**
TOTAL	**11**	**15**	**18**	**44**

UAE (United Arab Emirates); EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).

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END-USE: BUILDINGS

As of 31 March 2010

	Buildings and Community Systems	District Heating and Cooling	Energy Storage	Efficient Electrical Equipment	Heat Pumping Technologies	TOTAL
Australia				1		1
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		4
Finland	1	1	1		1	4
France	1		1	1	1	4
Germany	1		1		1	3
Greece	1					1
Ireland						
Italy	1		1			2
Japan	1		1		1	3
Korea	1	1	1	1	1	5
Netherlands	1	1		1	1	4
New Zealand	1					1
Norway	1	1	1		1	4
Poland	1					1
Portugal	1					1
Spain	1		1		1	3
Sweden	1	1	1		1	4
Switzerland	1			1	1	3
Turkey	1		1			2
United Kingdom	1		1	1		3
United States	1	1	1	1	1	5
IEA members	23	8	15	10	13	69
Algeria						
Brazil						
China	1					1
Croatia						
Egypt						
Iceland						
India						
Israel	1					1
Lithuania						
Malaysia						
Mexico						
Russia						
South Africa				1		1
Thailand						
Ukraine						
UAE						
Venezuela						
IEA non-members	2			1		3
IEA members			3			3
IEA non-members						
Sponsors			3			3
EC			1			1
OPEC						
UNIDO						
Intl. organisations			1			1
TOTAL	25	8	19	11	13	76

UAE (United Arab Emirates); EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).

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END-USE: ELECTRICITY AND INDUSTRY

As of 31 March 2010

	Electricity				Industry		
	Demand Side Management	Electricity Networks	High-Temperature Superconductivity	TOTAL	Emissions Reduction in Combustion	Industrial Technologies and Systems	TOTAL
Australia	1			1			
Austria	1	1		2			
Belgium	1	1	1	3	1	1	2
Canada	1		1	2	1	1	2
Czech Republic							
Denmark	1	1		2		1	1
Finland	1	1	1	3	1	1	2
France	1	1		2			
Germany			1	1	1		1
Greece	1			1			
Ireland							
Italy	1	1	1	3	1		1
Japan			1	1	1		1
Korea	1		1	2	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 members	18	13	13	44	12	10	22
Algeria							
Brazil						1	1
China							
Croatia							
Egypt							
Iceland							
India	1			1			
Israel			1	1			
Lithuania							
Malaysia							
Mexico							
Russia							
South Africa		1		1			
Thailand							
Ukraine							
UAE							
Venezuela							
IEA non-members	1	1	1	3		1	1
IEA members	1			1			
IEA non-members							
Sponsors	1			1			
EC							
OPEC							
UNIDO							
Intl. organisations							
TOTAL	20	14	14	48	12	11	23

UAE (United Arab Emirates); EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).

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END-USE: TRANSPORT

As of 31 March 2010

	Advanced Fuel Cells	Advanced Motor Fuels	Advanced Transport Materials	Hybrid and Electric Vehicles	TOTAL
Australia	1	1			2
Austria	1	1		1	3
Belgium	1	1		1	3
Canada	1	1	1	1	4
Czech Republic					
Denmark	1			1	2
Finland	1	1		1	3
France	1	1		1	3
Germany	1	1	1		3
Greece					
Ireland					
Italy	1	1		1	3
Japan	1	1			2
Korea	1				1
Netherlands	1			1	2
New Zealand					
Norway	1				1
Poland					
Portugal					
Spain		1		1	2
Sweden	1	1		1	3
Switzerland	1	1		1	3
Turkey	1			1	2
United Kingdom	1	1	1	1	4
United States	1	1	1	1	4
IEA members	18	14	4	14	50
Algeria					
Brazil					
China		1	1		2
Croatia					
Egypt					
Iceland					
India					
Israel					
Lithuania					
Malaysia					
Mexico	1				1
Russia					
South Africa					
Thailand		1			1
Ukraine					
UAE					
Venezuela					
IEA non-members	1	2	1		4
IEA members					
IEA non-members					
Sponsors					
EC					
OPEC					
UNIDO					
Intl. organisations					
TOTAL	19	16	5	14	54

UAE (United Arab Emirates); EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).

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FOSSIL FUELS

As of 31 March 2010

	Clean Coal Centre	Clean Coal Science	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	1	6
Czech Republic				1			1
Denmark		1	1		1		3
Finland				1	1		2
France			1	1	1		3
Germany	1	1			1		3
Greece				1			1
Ireland							
Italy	1	1		1			3
Japan	1	1	1	1	1		5
Korea	1			1	1		3
Netherlands	1	1			1		3
New Zealand					1		1
Norway			1		1	1	3
Poland	1			1			2
Portugal				1			1
Spain	1			1	1		3
Sweden		1		1	1		3
Switzerland					1		1
Turkey							
United Kingdom	1	1	1	1	1		5
United States	1	1	1		1	1	5
IEA members	11	10	9	14	17	4	65
Algeria							
Brazil							
China						1	1
Croatia							
Egypt							
Iceland							
India					1		1
Israel							
Lithuania							
Malaysia							
Mexico		1				1	2
Russia			1				1
South Africa		1			1		2
Thailand							
Ukraine							
UAE							
Venezuela			1				1
IEA non-members		2	2		2	2	8
IEA members	9			1	21		31
IEA non-members	7						7
Sponsors	16			1	21		38
EC	1				1		2
OPEC					1		1
UNIDO							
Intl. organisations	1				2		3
TOTAL	**28**	**12**	**11**	**15**	**42**	**6**	**114**

UAE (United Arab Emirates); EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).

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FUSION POWER

As of 31 March 2010

	Fusion Environment, Safety, Economy	Fusion Materials	Large Tokamaks	Nuclear Tech. of Fusion Reactors	Plasma Wall Interaction TEXTOR	Reversed Field Pinches	Spherical Tori	Stellarator Concept	Tokamaks Poloidal Field Divertors	TOTAL
Australia								1		1
Austria										
Belgium										
Canada		1			1					2
Czech Republic										
Denmark										
Finland										
France										
Germany										
Greece										
Ireland										
Italy										
Japan	1	1	1	1	1	1	1	1		8
Korea			1						1	2
Netherlands										
New Zealand										
Norway										
Poland										
Portugal										
Spain										
Sweden										
Switzerland		1								1
Turkey										
United Kingdom										
United States	1	1	1	1	1	1	1	1	1	9
IEA members	2	4	3	2	3	2	2	3	2	23
Algeria										
Brazil										
China		1								1
Croatia										
Egypt										
Iceland										
India				1						1
Israel										
Lithuania										
Malaysia										
Mexico										
Russia	1	1		1				1		4
South Africa										
Thailand										
Ukraine								1		1
UAE										
Venezuela										
IEA non-members	1	2		2				2		7
IEA members										
IEA non-members										
Sponsors										
EC	1	1	1	1	1	1	1	1	1	9
OPEC										
UNIDO										
Intl. organisations	1	1	1	1	1	1	1	1	1	9
TOTAL	4	7	4	5	4	3	3	6	3	39

UAE (United Arab Emirates); EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).

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RENEWABLE ENERGIES AND HYDROGEN

As of 31 March 2010

	Bio-energy	Deploy-ment	Geo-thermal	Hydro-gen	Hydro-power	Ocean	Photo-voltaics	Solar Concen-trated	Solar Heating & Cooling	Wind	TOTAL
Australia	1		1	1		1	1	1	1	1	8
Austria	1						1	1	1	1	5
Belgium	1					1			1		3
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	3
Italy	1	1	1	1		1	1	1	1	1	9
Japan	1		1	1	1	1	1			1	7
Korea			1	1		1	1	1		1	6
Netherlands	1	1		1			1		1	1	6
New Zealand	1		1	1		1			1		5
Norway	1	1		1	1	1	1		1	1	8
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	6
United States	1		1	1	1	1	1	1	1	1	9
IEA members	**18**	**9**	**10**	**19**	**5**	**16**	**18**	**9**	**17**	**19**	**140**
Algeria								1			1
Brazil	1				1						2
China					1						1
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
Russia											
South Africa	1					1		1			3
Thailand											
Ukraine											
UAE								1			1
Venezuela											
IEA non-members	**3**		**2**	**2**	**2**	**2**	**3**	**6**	**1**	**1**	**22**
IEA members			6				1			1	8
IEA non-members											
Sponsors			**6**				**1**			**1**	**8**
EC	1		1	1			1	1	1		6
OPEC											
UNIDO				1							1
Intl. organisations	**1**		**1**	**2**			**1**	**1**	**1**		**7**
TOTAL	**22**	**9**	**19**	**23**	**7**	**18**	**23**	**16**	**19**	**21**	**177**

UAE (United Arab Emirates); EC (Commission of the European Communities); OPEC (Organisation for Petroleum Exporting Countries); UNIDO (United Nations Industrial Development Organisation).

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SPONSORS

As of 31 March 2010

	Headquarters	Cross-Cutting	End-Use				Fossil Fuels	Fusion Power	Renewables & Hydrogen	TOTAL
			Buildings	Electricity	Industry	Transport				
Alstom Power Technology AG	*France*						1			**1**
Australian Coal Industry Consortium	*Australia*						1			**1**
Babcock & Wilcox	*United States*						1			**1**
BG Advance	*United Kingdom*						1			**1**
BG International	*United Kingdom*						1			**1**
BP International Ltd.	*United Kingdom*						1			**1**
Canadian Electrical Ass.	*Canada*						1			**1**
CanGEA	*Canada*								1	**1**
ČEZ, 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**
Conoco-Phillips	*United States*						1			**1**
Danish Power Group	*Denmark*						1			**1**
E.ON UK	*United Kingdom*						1			**1**
Electric Power Research Institute	*United States*						1			**1**
Energesis Ingenieria	*Spain*		1							**1**
ENI Tecnologie ApA	*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**
Green Rock Energy Ltd	*Australia*								1	**1**
IF Technology b.v	*Netherlands*		1							**1**
Japan Facility Solutions	*Japan*			1						**1**
JGC Corp.	*Japan*						1			**1**
National Power	*United Kingdom*						1			**1**
NIG	*Netherlands*						1			**1**
ORMAT Technologies, Inc	*United States*								1	**1**
Orme Jeotermal	*Turkey*								1	**1**
PowerGen	*United Kingdom*						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**
Shell International BV	*Netherlands*						1			**1**
Shaw Consultants, Intl., Inc.	*United States*						1			**1**
Statkraft Development AS	*Norway*						1			**1**
Statoil	*Norway*						1			**1**
Total	*France*						1			**1**
Vattenfall AB	*Sweden*						1			**1**
Warsaw University of Technology	*Poland*		1							**1**
Located in IEA member countries			**3**	**1**			**31**		**8**	**43**
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**
EKSOM Holdings Ltd	*South Africa*						1			**1**
Eletrobràs	*Brazil*						1			**1**
SUEK	*Russia*						1			**1**
Located in IEA non-member countries							**7**			**7**
TOTAL			**3**	**1**			**38**		**8**	**50**

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.

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RECENT TRENDS

In 2007 the total public sector energy RD&D budgets (GBOARD) for the OECD amounted to USD 12 050 million (2008 prices). In the same year, the defence budget for R&D in OECD countries amounted to 33% of GDP while civil R&D accounted for 67% (of which only 9.5% for energy). Finland (2007) and Japan (2008) had the highest share of energy RD&D budgets per thousand units of GDP (0.8% and 0.79%, respectively).

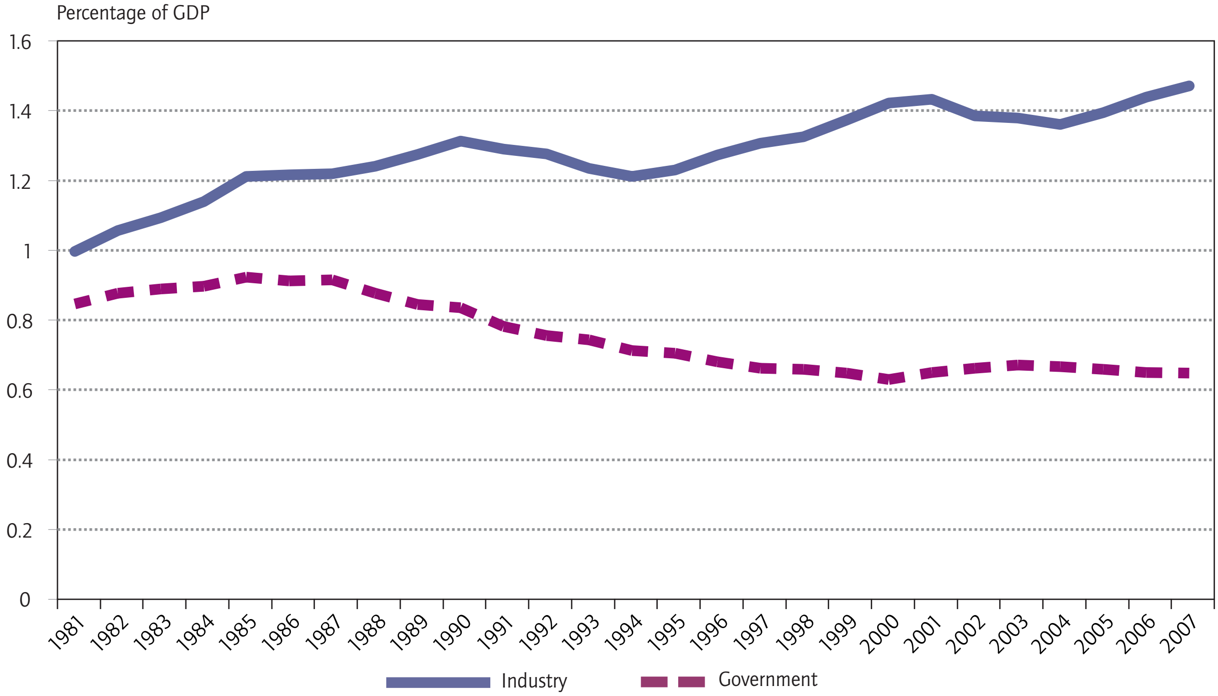
The general trend for government energy R&D budgets mirrors the trend for overall R&D. Though government RD&D budgets have steadily increased since 1997, in the last 35 years, total public sector energy RD&D budgets have declined in real terms, with 2008 nominal levels only slightly above 1976 budgeted amounts. Moreover, the relative share of energy in total RD&D has declined significantly in the last 27 years, from 12% in 1981 to 4% in 2008.

This downward trend is a reflection of national energy policies, global energy prices, and the increasing role of industry in research. In 2008, of the USD 889 931.5 million of the gross domestic expenditure on R&D (GERD) (all sectors), 64.2% was financed by industry, with 28.1% financed by government and other national sources.

This average masks large variations between member countries, where industry financing of GERD varied between 30.5% (Poland) and 77.7% (Japan).

Gross expenditure of R&D for all sectors represents actual outlays, while energy R&D budgets represent expected outlays. As the energy R&D figures are derived from the budget, they are more closely linked to policies, objectives or goals. As priorities evolve, so do the funds that are committed. The gap between budgets and expenditure may be explained by a variety of factors, including programme modifications or extensions, cost overruns, and differences in time of reporting, etc. Therefore individual data points may not be comparable.

Gross expenditure on R&D all sectors



Source: OECD, Main Science and Technology Indicators, December 2009.

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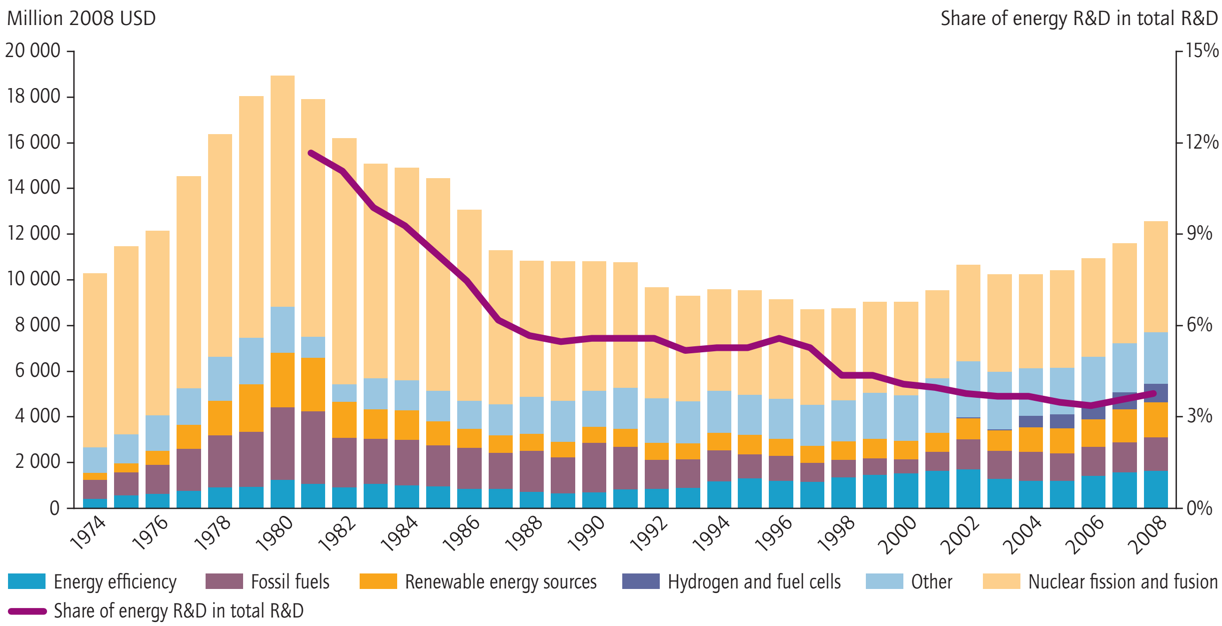
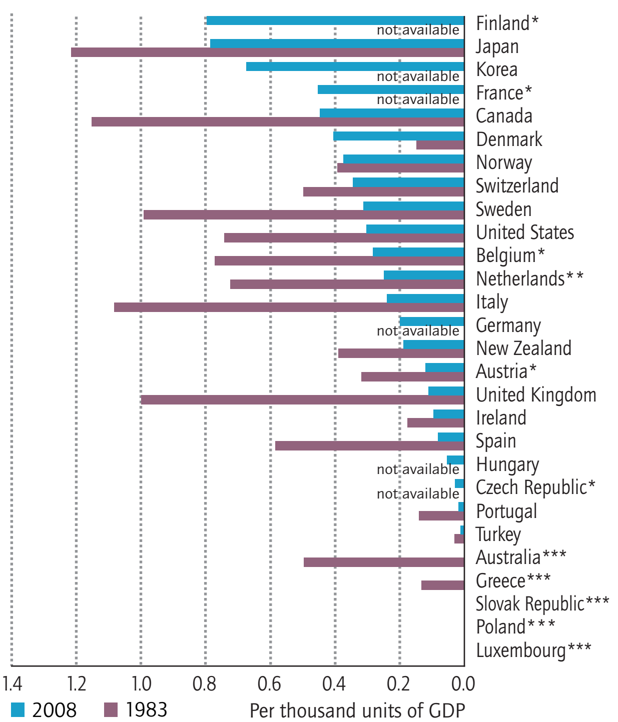
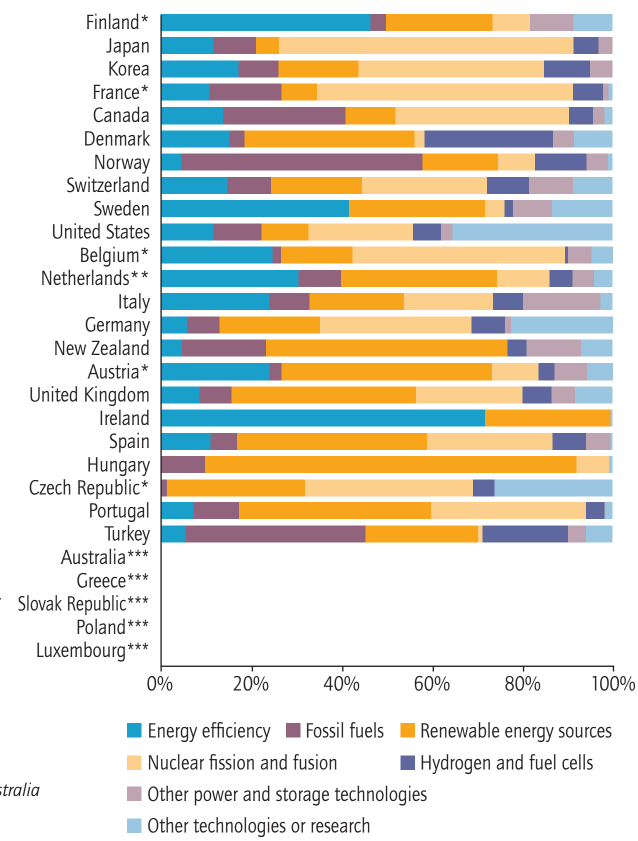
Public sector energy RD&D in IEA member countries



Energy RD&D budgets as share of GDP



RD&D shares by activity in 2008



** Data for Austria, Belgium, the Czech Republic, Finland and France are for 2007.*
*** Data for the Netherlands are for 2006.*
**** The most recent RD&D budgets received from Greece are for 2002 and from Australia for 2003. Very limited and incomplete information is available for Luxembourg and the Slovak Republic. No RD&D budgets have been submitted by Poland.*

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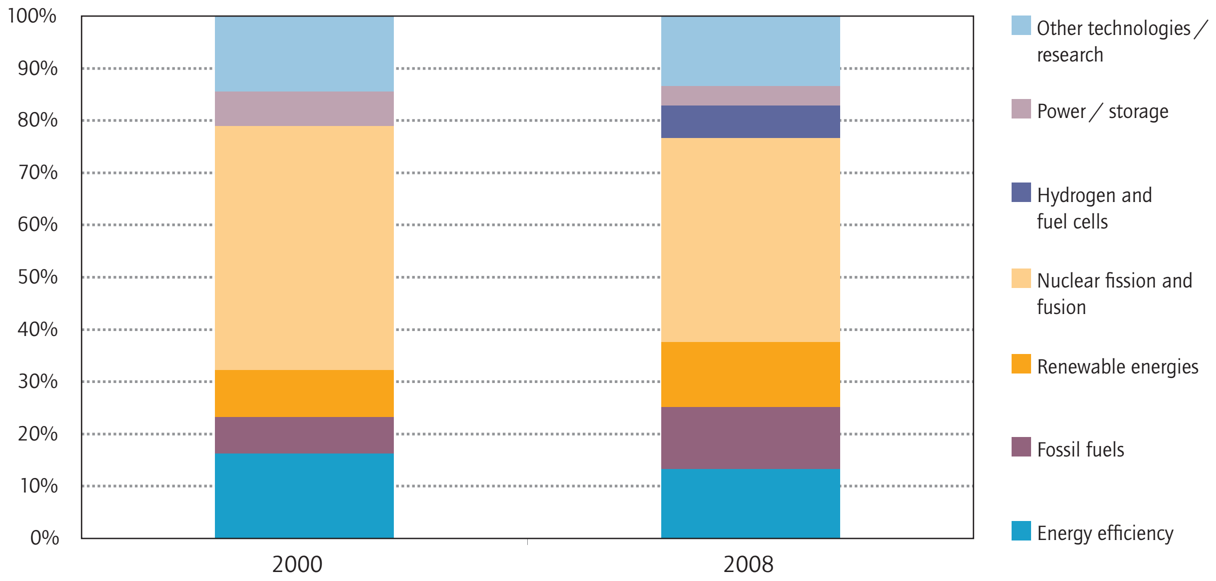
Estimated IEA total



Million USD, 2008 prices and exchange rates

	2000	2001	2002	2003	2004	2005	2006	2007	2008
Energy efficiency	1 674	1 815	1 897	1 456	1 359	1 364	1 609	1 779	1 862
Fossil fuels	726	893	1 492	1 390	1 421	1 378	1 484	1 507	1 658
Renewable energies	911	988	1 087	1 066	1 253	1 255	1 367	1 667	1 755
Nuclear fusion/fission	4 803	4 479	4 955	4 966	4 674	4 893	4 903	4 957	5 476
Hydrogen/fuel cells	..	..	35	42	574	660	802	832	885
Power/storage	674	746	632	624	516	432	588	532	519
Other tech./research	1 484	1 825	2 008	2 104	1 707	1 765	1 562	1 742	1 871
Total energy RD&D	**10 272**	**10 746**	**12 106**	**11 648**	**11 504**	**11 747**	**12 315**	**13 016**	**14 026**

Source: Estimated IEA total based on submissions to the IEA.

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FOR MORE INFORMATION

IEA Shared Goals

IEA Framework

Frequently Asked Questions

Acronyms and Glossary

Implementing Agreement Websites

Further Information

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IEA SHARED GOALS

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.

The "Shared Goals" were adopted by IEA Ministers at their 4 June 1993 meeting in Paris.

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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.

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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,

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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.

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FREQUENTLY ASKED QUESTIONS

What is an Implementing Agreement?

Implementing Agreements 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. They are contracts based on the principle of equitable sharing of rights and obligations. There are currently 42 Implementing Agreements (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?

Any public or private organisation within OECD member or non-member countries, international organisations, or non-governmental organisations may participate. Each IA signatory designates a representative to sit on the board of directors (Executive Committee) that governs the work of the Agreement as well as the joint projects.

What will my organisation gain by participating?

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

- reduced cost and duplication of work
- greater project scale
- information sharing and networking
- linking IEA member 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: energy security, environmental protection, economic growth and 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, modeling 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-shared basis, task-shared basis, or a combination of both, as long as the signatories agree. Task-sharing works well when there are a number of different concepts that are being investigated by different participants in parallel. Cost-sharing is practical when funding joint activities or experiments. Some Agreements cover the costs 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 (see page 94) 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 and the Working Parties regularly review and rate the 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 IEA non-member countries
- added value

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

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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 can my organisation participate?

If your organisation is interested in participating in an IA, the first step is to contact the Chair, the Operating Agent or the Executive Secretary and to discuss together the win-win of working together. Thereafter follows an exchange of letters with the final step being the signature of the Implementing Agreement.

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HOW TO JOIN IN AN IEA IMPLEMENTING AGREEMENT

Participation in an IA is based on mutual agreement between an interested newcomer (IN) and the Implementing Agreement (IA). Below is an outline of the steps involved for both.

	Interested Newcomer (IN)	*Implementing Agreement (IA)*
Let's Talk	The IN contacts the IA.	*The IA provides information on current activities and member contributions (fee-based or in-kind).*
	The IN provides information on what contribution (expertise) it can bring to the IA.	
	The IN and the IA agree to go to the next step.	
Let's Meet		*The IA invites IN to attend an Executive Committee (board of directors) meeting.*
	The IN attends an IA Executive Committee meeting.	
	The IN is interested in becoming a signatory to the IA.	*The IA is interested in having IN become a signatory.*
Let's Agree	The IA Executive Committee and the IN discuss the terms and conditions of participation.	
		The current IA members vote to invite the IN.
Let's Formalise		*The IA sends a letter of invitation to the IN outlining the agreed terms and conditions of participation.*
	The IN sends a letter of acceptance to the IEA Executive Director.	
		The IEA legal office sends a signature page to IN.
Let's Begin	IN's participation in the IA will begin on the date of actual signature.	

The information provided above is a schema of the steps involved to become a signatory to an IEA Implementing Agreement. There are two official categories of IA signatories, Contracting Parties (entities designated by governments or international organisations) and Sponsors (entities not designated by governments or non-governmental international organsations). If an IN is either a Sponsor or a Contracting Party of a government of a country that is not already participating in IAs, then an additional step is required before signature - approval by the IEA Committee on Energy Research and Technology.

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ACRONYMS

ACRONYM	REPRESENTING
CERT	Committee on Energy Research and Technology
EG	Expert Group
EGRD	Experts' Group on R&D Priority Setting and Evaluation
EGSE	Experts' Group on Science and Energy
WP	Working Party
EUWP	End-Use Working Party
FPCC	Fusion Power Co-ordinating Committee
REWP	Renewable Energy Working Party
WPFF	Working Party on Fossil Fuels
GB	Governing Board
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
BIO IA	IA for a Programme of Research, Development and Demonstration on Bioenergy
CCC IA	IA for the IEA Clean Coal Centre
CCS IA	IA for a Programme of Research, Development and Demonstration on Clean Coal Sciences
CTI IA	IA for Climate Technology Initiative
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
ECBCS IA	IA for a Programme of Research and Development on Energy Conservation in Buildings and Community Systems
ECES IA	IA for a Programme of Research and Development on Energy Conservation through Energy Storage
ENARD IA	IA on Electricity Networks Analysis, Research and Development
EOR IA	IA for a Programme of Research, Development and Demonstration on Enhanced Recovery of Oil
ERC IA	IA for a Programme of Research, Development and Demonstration on Energy Conservation and Emissions Reduction in Combustion
ESEA 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

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FM IA	IA for a Programme of Research and Development on Fusion Materials
GHG IA	IA for a Co-operative Programme on Technologies Relating to Greenhouse Gases Derived from Fossil Fuel Use
GIA	IA for a Co-operative Programme on Geothermal Energy Research and Technology
HEV IA	IA for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes
HIA	IA for a Programme of Research and Development on the Production and Utilization of Hydrogen
HPP IA	IA for a Programme of Research, Development, Demonstration and Promotion of Heat Pumping Technologies
HTP 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
LT IA	IA on Co-operation on the Large Tokamak Facilities
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
PFD IA	IA on a Co-operative Programme for the Investigation of Toroidal Physics in, and Plasma Technologies of, Tokamaks with Poloidal Field Divertors
PVPS IA	IA for a Co-operative Programme on Photovoltaic Power Systems
PWIT IA	IA for a Programme of Research and Development on Plasma Wall Interaction in Textor
RETD IA	IA for Renewable Energy Technology Deployment
RFP IA	IA for a Programme of Research and Development on Reversed Field Pinches
SC IA	IA for Co-operation in Development of the Stellarator Concept
SHC IA	IA for a Programme to Develop and Test Solar Heating and Cooling Systems
SP 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
R&D	Research and development
RD&D	Research, development and demonstration

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GLOSSARY

TERM	DEFINITION
Annex	An annex is a project carried out under an Implementing Agreement. In some cases it refers to subsequent each term of the Agreement approved by the CERT.
Committee on Energy Research and Technology	Established in 1975, the Committee on Energy Research and Technology (CERT) is the senior technology committee of the IEA and reports directly to the IEA 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 Implementing Agreements.
Contracting Party	Any participation in an IA which is a government of any country, the European Communities, an international organisation or 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.
Executive Committee	The decision-making body of the IA which supervises the work. It is comprised of representatives from each of the IA signatories.
Expert Group	Created by the CERT to provide advice on specific topics or issues.
Experts' Group on R&D Priority Setting and Evaluation	The IEA Experts' Group on R&D Priority Setting and Evaluation (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, feeds into IEA analysis, and provide a global perspective to national R&D efforts.
Experts' Group on Science and Energy	The Expert Group on Science and Energy (EGSE) provides advice to the CERT in addressing energy technology challenges and barriers and identifying basic energy research opportunities by reinforcing the links between the basic science and applied energy research communities.
Framework	Framework for International Energy Technology Co-operation, adopted by the IEA Governing Board in 2003, outlines who may participate in an IA and the principal responsibilities of the Participants and the various IEA bodies involved with IAs. The Framework also provides the minimum requirements of information and reports that each IA is to transmit to the IEA Secretariat.
Fusion Power Co-ordinating Committee	Established in 1975, the objective of the IEA Fusion Power Co-ordinating Committee (FPCC) is to enhance fusion research and development activities in both the IEA member countries and in non-member countries. The FPCC works to promote, initiate and co-ordinate international co-operation on fusion activities. The FPCC provides advice on fusion technology to the CERT and other IEA bodies and regularly reviews the fusion Implementing Agreements and makes recommendations to the CERT.
Governing Board	The highest ranking body of the International Energy Agency.
IEA Global Energy Technology Network	Comprised of the CERT, four working parties, two expert groups, and 42 IAs. The IAs encompass more than 6 000 experts worldwide from 42 countries, 50 industrial partners and three international organisations.

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IEA member countries	Australia, Austria, Belgium, Canada, 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, United Kingdom, United States. Iceland and Mexico are not IEA member countries.
IEA non-member countries	Any sovereign state that is not a member country of the IEA.
Implementing Agreement	A contractual relationship between at least two IEA member countries to carry out programmes and projects on energy technology research, development and deployment.
OECD	Organisation for Economic Co-operation and Development, of which the IEA is an autonomous agency. Member countries of the OECD include: Australia, Austria, Belgium, Canada, Chile, Czech Republic, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, Turkey, United Kingdom, United States.
Operating Agent	The individual or organisation responsible for administering an IA Executive Committee or one of the IA projects (also called tasks or annexes).
Participant	A signatory of an IA, whether a Contracting Party or a Sponsor.
Sponsor	A participant in an IA which is an entity in a country that is not designated by the government of that country to participate in an IA or a non-intergovernmental international entity in which one or more countries participate.
Task	A collaborative activity carried out within the IA's Programme of Work in which participants may choose to take part.
Working Party	Working parties provide advice and support to the CERT in carrying out its mandate and to the IEA on issues relevant to each working party.
Working Party on Energy End-Use Technologies	Established in 1981, the Working Party on Energy End-Use Technologies (EUWP) provides advice to the CERT and other IEA bodies on trends and policies relating to energy end-use technologies. The EUWP also supports and facilitates co-operation among member countries in research, development, demonstration and deployment of energy end-use technologies and, as appropriate, shall seek to expand collaboration with non-member countries. The EUWP also regularly reviews the buildings, electricity, industry and transport-related Implementing Agreements and makes recommendations to the CERT.
Working Party on Fossil Fuels	Established in 1981, the Working Party on Fossil Fuels (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. It also regularly reviews the fossil-fuel Implementing Agreements and makes recommendations to the CERT.
IEA Global Energy Technology Network	Comprised of the IEA Committee on Energy Research and Technology, four working parties, two expert groups, and 42 Implementing Agreements encompassing more than 6 000 experts worldwide from 42 countries, 50 industrial partners and three international organisations.

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IMPLEMENTING AGREEMENT WEBSITES

Implementing Agreement	Website
Cross-Cutting Activities	
Climate Technology Initiative	*www.climatetech.net*
Energy Technology Data Exchange	*www.etde.org*
Energy Technology Systems Analysis	*www.etsap.org*
Energy End-Use Technologies	
Buildings	
Buildings and Community Systems	*www.ecbcs.org*
District Heating and Cooling	*www.iea-dhc.org*
Efficient Electrical Equipment	*www.iea-4e.org*
Energy Storage	*www.energy-storage.org*
Heat Pumping Technologies	*www.heatpumpcentre.org*
Electricity	
Demand-Side Management	*www.ieadsm.org*
Electricity Networks	*www.iea-enard.org*
High-Temperature Superconductivity	*www.superconductivityiea.org*
Industry	
Emissions Reduction in Combustion	*http://ieacombustion.com/*
Industrial Technologies and Systems	*www.iea-iets.org*
Transport	
Advanced Fuel Cells	*www.ieafuelcell.com*
Advanced Motor Fuels	*www.iea-amf.vtt.fi*
Advanced Transport Materials	*www.iea-ia-amt.org*
Hybrid and Electric Vehicles	*www.ieahev.org*
Fossil Fuels	
Clean Coal Centre	*www.iea-coal.org.uk*
Clean Coal Sciences	*http://iea-ccs.fossil.energy.gov*
Enhanced Oil Recovery	*http://iea-eor.ptrc.ca/*
Fluidized Bed Conversion	*www.iea-fbc.org*
Greenhouse Gas RD Programme	*www.ieaghg.org*
Multiphase Flow Sciences	*www.iea.org/techagr*
Fusion Power	
Fusion Environment, Safety and Economy	*www.iea.org/Textbase/techno/iaresults.asp?id_ia=17*
Fusion Materials	*www.frascati.enea.it/ifmif/*
Large Tokamaks	*www-jt60.naka.jaea.go.jp/*
Nuclear Technology of Fusion Reactors	*www.iea.org/techagr*
Plasma Wall Interaction in TEXTOR	*www.iea.org/techagr*
Reversed Field Pinches	*www.iea.org/techagr*
Spherical Tori	*www.iea.org/techagr*
Stellarator Concept	*www.iea.org/techagr*
Tokamaks with Poloidal Field Divertors	*www.aug.ipp.mpg.de/iea-ia/*

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Renewable Energy Technologies

Bioenergy	*www.ieabioenergy.com*
Deployment	*www.iea-retd.org*
Geothermal	*www.iea-gia.org*
Hydrogen	*www.ieahia.org*
Hydropower	*www.ieahydro.org*
Ocean	*www.iea-oceans.org*
Photovoltaics	*www.iea-pvps.org*
Solar Concentrated	*www.solarpaces.org*
Solar Heating and Cooling	*www.iea-shc.org*
Wind	*www.ieawind.org*

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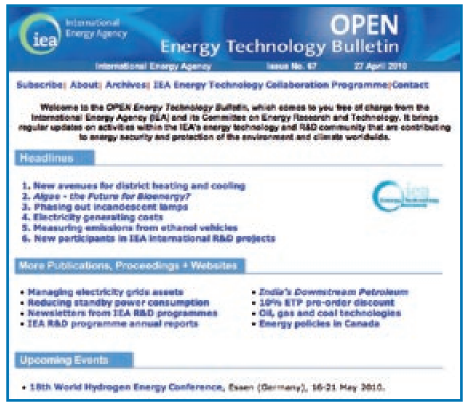
FURTHER INFORMATION

IEA *OPEN Energy Technology Bulletin*



The IEA online newsletter *OPEN Energy Technology Bulletin* reports the most recent findings of the IEA multilateral technology initiatives (Implementing Agreements) and analysis from the IEA Secretariat.

The *OPEN Bulletin* provides an easy way to stay informed of the IEA technology community's activities, publications and events.

Current OPEN Bulletin: www.iea.org/impagr/cip/index.htm

Archives: www.iea.org/impagr/cip/archived_bulletins/index.htm

To subscribe: http://mailing.iea.org/

Global Energy Technology Network

▼ **www.iea.org/techagr**

Here you'll find all you need to know about the actors and mechanisms of the IEA global energy technology network:

- IEA Committee on Energy Research and Technology, Working Parties and Expert Groups
- *Frequently Asked Questions* brochure (English, French, Mandarin, Portuguese, Russian and Spanish)
- IEA Framework for International Energy Technology Co-operation
- Implementing Agreement outreach events in non-member countries through the Networks of Expertise in Energy Technology (NEET)
- A brief overview of all Implementing Agreements and links to their websites

For More Information

For queries relating to IEA Implementing Agreements or energy technology RD&D activities at the IEA secretariat, do not hesitate to contact:

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