INTERNATIONAL ENERGY AGENCY



energy technologies at the cutting edge

international energy technology collaboration IEA implementing agreements

2005



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

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

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

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

ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT

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

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

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FOREWORD

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

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

There are 40 Implementing Agreements, covering all the key new technologies of energy supply and end use (with the exception of nuclear fission, which has its own OECD Agency - the Nuclear Energy Agency). They cover clean and advanced fossil fuel technologies (including carbon capture and storage), an entire range of renewable energies (including biofuels), hydrogen and fuel cells, end-use technologies for transport, buildings and industry, fusion and cross-sectional activities.

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

Much of the work of these Agreements is, of course, highly specialised. But policy makers and others who are interested in energy technology need to be aware of them and to understand the nature of their work. The purpose of *Energy Technologies at the Cutting Edge* is to make this information available.

This publication provides a brief résumé of each Implementing Agreement, its recent achievements and ongoing activities, and the website address for those who want to know more.

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

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

Claude Mandil Executive Director

ACKNOWLEDGEMENTS

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

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

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INTRODUCTION

Energy Challenges

In the last 30 years, the world energy situation has confronted many challenges: oil supply disruptions have led to oil price fluctuations and shaken economies; increasing awareness of the environmental impacts of fossil fuels demands a decarbonisation of what was expected to be a fossil fuel future; and for the past six years abnormally high oil prices have reminded us again of the vulnerability of our economies to oil. Concern about the availability of fossil fuels may have abated, but many challenges must be overcome in mobilising the capital necessary to bring them on stream and now, actions must be taken to ensure that we can safely continue to use fossil fuels until other sources of energy can take over. The answers are not easy as policy makers grapple with politically difficult measures to curb greenhouse gas emissions, the relatively few conventional energy answers available to meet the challenges, and the difficulties inherent in bringing new technologies on stream quickly and ensuring their early uptake worldwide.

Even as governments have been responding to these challenges, world total primary energy supply and CO_2 emissions have relentlessly marched upward, increasing by 70% and 54%, respectively, since 1973. Despite efficiency gains, efforts at diversifying supply, RD&D expenditures and technology advances, energy security and environmental concerns continue to be as much of an issue today than they were 30 years ago, and in some respect more so. Not surprisingly, energy projections reveal increasing energy demand and CO_2 emissions in the short and medium-term if actions are not taken to change that future. The availability of new technologies will be crucial. But vigorous policy actions by governments will also be needed if these technologies are to realise their potential and address the energy challenges.

Technology Solutions

How can governments bridge the gap between energy demand, environmental goals and energy research? Obviously each country will chose those solutions that fit their specific energy situation, natural resources, political will and vision for the future. As government R&D budgets have declined in real terms since 1980, policy makers are hampered in finding the most efficient and effective way to meet the challenges. In addition to sufficient R&D budgets, governments have long concluded that greater progress can be made by combining technology efforts and sharing costs on an international level.

For more than 30 years, IEA international technology collaboration has offered a structure for governments to leverage and strengthen their national energy research and deployment efforts by:

- Bringing the abundance of existing technologies closer to commercial deployment through "technology learning" (i.e. clean fossil fuels, end-use, renewables);
- Identifying the challenges in bringing viable medium-term technologies forward (i.e. enhanced oil recovery, carbon capture and storage, hydrogen and fuel cells); and
- Offering a successful, cost-sharing structure for expensive exploratory research (i.e. fusion, gas hydrates).

As technologies approach maturity and the deployment stage, Implementing Agreements provide a forum for reaching out to the private sector. Industry will ultimately test the economic efficiency of technologies, taking forward those ready for the market and defining the next steps to prepare other technologies for cost-effective deployment.

In addition to providing an ideal connection between government and industry, IEA Implementing Agreements provide an ideal platform for IEA member countries to reach out to the rest of the World. *Energy Technologies at the Cutting Edge* reveals the recent achievements, success stories, case studies, current applications and future strategies of a large portfolio of vigorous international energy technology collaboration programmes - the IEA Implementing Agreements.



Participating countries in the IEA Energy Technology Collaboration programme.

IEA IMPLEMENTING AGREEMENTS: HIGHLIGHTS OF RECENT ACTIVITIES

Fossil Fuels

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

RELIABLE ELECTRICITY PRODUCTION

In 1971, coal contributed 40% to total world electricity supply. Thirty years later, coal contributes 39% of total world supply, more than double the amount of electricity generated from any other fuel source.



The IEA Clean Coal Centre (CCC) works for the continued development of coal as a reliable energy source and towards innovation in technologies that allow coal to be used as a clean energy source. This is achieved by gathering, assessing and distributing knowledge on the energy efficient and environmentally sustainable use of coal (including coal use with waste or biomass). In particular, this is done by undertaking indepth studies on topics of special interest; assessing the technical, economic and environmental performance; identifying where further research, development, demonstration and dissemination are needed; reporting the findings in a balanced and objective way without political or commercial bias and showing, where appropriate, the opportunities for technology transfer worldwide.

The following is a sample of recent CCC published works:

Understanding Pulverised Coal Combustion

 Premium Carbon Products and Organic Chemicals from Coal

Benefits and Barriers in Coal Ash Utilisation

 Utilisation of CFBC (Circulating Fluid Bed Combustion) and IGCC (Integrated Gasification Combined Cycle) Residues Air Pollution Control Technologies and their Interactions

- Understanding Coal-Fired Power Plant Steam Cycles
- Towards Zero Emission Power Plants
- Coal Full Life-Cycle Analysis
- Fuels for Biomass Co-Firing with Coal
- Financing Clean Coal Projects Under Kyoto
- Plant Life Extension
- Use of Coal in Areas of Water Shortage
- Halogen Chemistry in Coal Utilisation
- Coal-Bed Methane Emissions And Potential Future Sites

 Economic Retrofit Options for Low Emissions from Coal-Fired Power Plants

- Coal in China
- Clean Coal Technology Roadmaps
- Impact of Emissions Trading on the Coal Industry
- Summary of Canadian Clean Power Coalition Work on CO₂ Capture and Storage

During 2004, a topical report, *Coal in an Enlarged European Union* was issued. This report highlights the importance of coal in many of the accession countries and the effect this will have on the future production and use of coal in the European Union.

The Clean Coal Centre is also organising a second international conference "Clean Coal Technologies for Our Future" in Sardinia (Italy) in May 2005. This conference will cover current technology options and perspectives for future developments. The success of the first conference, attended by more than 200 participants, demonstrated strong interest in clean coal technologies among industries, governments and the local community.

The CCC also plays a key role in supporting the IEA Working Party on Fossil Fuel initiative on Zero Emissions Technologies, including the Asia Pacific Conference held in Queensland (Australia) in February 2004, co-hosted by the IEA member countries, the United Nations, the United States Department of Energy and the Australian and Queensland governments.

reference:

For detailed information on activities of the Clean Coal Centre, see www.iea-coal.org.uk.

MASSIVE UNTAPPED POTENTIAL

It is estimated that by using Enhanced Oil Recovery (EOR) techniques, 300 billion barrels of previously inaccessible crude oil (nearly two out of every three barrels of oil) from known reservoirs could be tapped. This is equivalent to the amount of proven reserves in Saudi Arabia - enormous potential, to say the least.

The IEA Collaborative Project on Enhanced Oil Recovery (EOR IA) examines the methods that will mobilise these untapped amounts of oil. The objectives of the EOR IA is to evaluate and disseminate the results of research and development and to undertake demonstration, laboratory and field tests in a tasksharing manner. The work program is largely one of basic research and laboratory investigations on EOR (often called tertiary recovery).

The goal of EOR is to increase the recovery of oil originally in place (OOIP) and therefore extend the economic life of the reservoir.

One technique used to recuperate OOIP is gas injection. As can be seen below, gas injection increases the mobility of oil. After gas/oil separation, the associated gas is re-injected into the reservoir at high pressure. As the reservoir pressures increases, the production flow rate increases.



CO2 injected into the oil reserve moves additional oil to the production well.

The work programme of the EOR IA centres on six main tasks:

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

Regular activities of the EOR IA include a two-day annual workshop where the participants present and discuss their contributions to the different Tasks. The following one-day Symposium focuses on a specific and relevant theme of Improved Oil Recovery (IOR). In addition to EOR, IOR techniques encompass many new technologies leading to lowered development costs and more effective drilling, production strategy, operating etc. The aim is to increase oil industry involvement through attendance, presentations and discussions with a view to bridging the gap between researchers and industry.

Symposium themes of last five-year term were as follows:

- 2000 Advances in Drilling, Completion, and Stimulation and their Impact on EOR (United Kingdom)
- 2001 Mature Fields: Chance and Challenge (Austria)
- 2002 Optimizing Recovery in High Pressure, High Temperature Reservoirs (Venezuela)
- 2003 Geological Storage of CO₂ (Canada)
- 2004 Improved Recovery from Chalk / Carbonate Reservoirs (Norway)

There are currently 11 Contracting Parties in the EOR IA: Australia, Austria, Canada, Denmark, France, Japan, Norway, Russia, the United Kingdom, the United States and Venezuela. In addition, China actively participates.

references:

Recovery estimate based on United States Geological Survey data and analysis by Chris Besson, IEA. Photo and image courtesy of Stanford University and the United States Department of Energy, Office of Fossil Fuels. For detailed information on the activities of the Enhanced Oil Recovery IA, see www.iea.org/eor.

EFFICIENT BURNING, LOWER EMISSIONS

Fluidized bed combustion (FBC) is a viable and versatile option for converting the energy in fuels into electric power, process steam and/or building heat. It can be used for a wide range of fuels, slurries, sludge, biomass, coal, coal rejects, refuse-derived fuels, or mixtures of these.

Burning in a fluidised bed offers the ability to burn a wide range of low-grade and difficult fuels, e.g. waste and biomass, as well as mixed fuels. Fluidised bed conversion technologies also offer advantages over conventional approaches, principally lower NOx emissions, in-process sulphur capture. Fluidised beds can be used to efficiently convert these fuels into heat and/or electricity. Utility-scale units operating with supercritical steam conditions offer the potential for power generation efficiencies as high as 45%.

A fluidised bed combustor is a vessel containing fine granular material that is held in suspension by air blown into the bottom of the vessel through uniformly distributed nozzles. The uniform upward flow of air keeps "bed" particles suspended in constant motion. Fuel fed into the vessel mixes uniformly throughout the "bed" (usually sand or limestone) of hot particles. This allows combustion of the fuel at lower temperatures than other furnaces leading to lower nitrogen oxide emissions. At FBC conditions limestone reacts directly with sulphur dioxide gas, therefore using limestone as the granular bed material allows in-bed removal of sulphur dioxide generated during combustion resulting in "clean" flue gas.



Artists' representation of the interior of a circulating fluidized bed combustor.

Circulating Fluidised Bed (CFB) boilers, introduced at utility scale in 1985, are now progressing steadily, with large coal-fired units in the 250-300 MWe range being installed worldwide. Italy, Mexico, Turkey, Puerto Rico, Australia, Poland, Finland, the Czech Republic, India, China and the United States have recently installed CFB boilers burning coal, coal washing residues, brown coal, petroleum coke or other fuels.

A 340 MW gross power CFB boiler is under construction in Sardinia, Italy to burn high-sulphur Sulcis coal. This boiler will be the largest of its type in the world with a production of I 026 tonnes/hour of superheat steam (at 565° C and 169 bar) and 836 tonnes/hour of reheat steam (at 580° C and 39 bar).

In Poland, the Turow power station is equipped with six CFB boilers for a total installed capacity of about 1 500 MW, and a supercritical CFB unit with a capacity of 460 MWe is planned in Lagisza. In China, more than 800 commercial CFB boilers have been put into operation since 1980. Currently, 15 CFB boilers (300 MWe) are in the planning or construction stages.

The main activities of the IEA Co-operation in the Field of Fluidised Bed Conversion of Fuels Applied to Clean Energy Production (FBC IA) are technical and information exchanges between research and operations professionals of local commercial FBC.

One such example was the technical session on "Future Challenges for Waste Combustion and Co-combustion in FBC" in Vienna (Austria), where 19 papers were presented. A site visit was organised to Vienna District Heating where a FBC burns a mixture of sewage sludge (approximately 7 tonnes/hour) and municipal solid waste (approximately 12 tonnes/hour).

At the technical session on "Combustion and Gasification in FBC" in Vaasa (Finland), 14 papers were presented including a presentation from Tsinghua University, China. The meeting included a site visit to the largest biomass power plant (CFB boiler) in the world (550 MWth).

references:

For detailed information on the activities of the Fluidised Bed Conversion IA, see www.iea.org/tech/fbc/index.html.

CARBON CAPTURE - THE NEW STRATEGY

The Greenhouse Gas R&D Programme (GHG) has now been operating for 13 years. It has produced over 100 studies on technologies for reducing greenhouse gas emissions. The main focus is on carbon dioxide capture and storage (CCS), but comparisons with other mitigation technologies and alternative energy carriers have also been assessed. Over this period, GHG has succeeded in helping to achieve general acceptance that CCS is technically feasible and could contribute to major reductions in CO₂ emissions.



CO2 capture technology at the Warrior Run plant (United States).

Phase 4 of GHG was completed in October 2004. During this phase CCS moved, from the realms of being a technical possibility, firmly onto the policy agenda. Consequently, activities have expanded to include: research facilitation, research networks, and communications initiatives. These activities are all aimed at confirming the credentials of CCS as a major option for climate change mitigation.

Sixteen Countries and the European Union, together with 10 major energy companies, have committed to **Phase 5**. India was welcomed as the most recent signatory. In addition to the benefits of shared costs and avoiding duplication, the GHG programme also provides members with a platform to disseminate the results of their own activities. During phase 5, progress towards the establishment of CCS technology is expected to accelerate in order to meet the IEA suggested target of one-third of global energy generation to be equipped with CCS by 2050. GHG IA is always supportive of initiatives contributing to the CCS field. Two initiatives, in particular, are worth noting. Firstly, the preparation of the Intergovernmental Panel on Climate Change (IPCC) Special Report on CO_2 Capture and Storage. Work on this report will be published in November 2005. Secondly, the GHG IA is assisting the Carbon Sequestration Leadership Forum (CSLF) by linking it to the GHG database of practical projects in CO_2 capture and storage.

Studies continue to be the foundation of GHG IA activities. Of particular interest during 2004 were studies examining CO_2 storage monitoring requirements and a study in a 'technology-stretch' series of post-combustion capture. CO_2 capture with solvent scrubbing of combustion flue gases is a leading near-commercial option. Other leading cost-effective CO_2 capture technology options are pre-combustion decarbonisation and oxy-fuel combustion. In both cases GHG IA participated in detailed cost-comparative engineering feasibility studies. One such example is the Canadian Clean Power Coalition Study of three technologies that produced detailed cost estimates for newly built plants.

The GHG IA also organises the global conference on greenhouse gas mitigation - the GHGT series. The "7th International Conference on Greenhouse Gas Control Technologies", held in Vancouver in September 2004 was the largest yet, with attendance of over 650 delegates from 35 different countries.

International experts actively participate in the GHG IA research networks. One such network focuses on power station CO_2 capture from flue gases using solvents. A CO_2 storage monitoring network is also well established. GHG IA helped establish a number of research projects, including two key monitoring projects, Sleipner and Weyburn. GHG IA helped participants monitor progress and redefine their goals through workshops, external expert reviews, and through participation in expert review panels. A new web site promotes knowledge of the research activities that are underway worldwide on CO_2 capture and storage. The database behind the web site contains 94 R&D project entries to date.

references:

For information on the new CO₂ sequestration website, see www.co2captureandstorage.info.

For detailed information on the activities of the greenhouse gas R&D programme, see www.ieagreen.org.uk.

COST-EFFECTIVE ENERGY APPLICATIONS

Multiphase flow is the flow of a mixture of two or more of solids, liquids or gasses (generally solid-liquid, solidgas and liquid-gas). As these mixtures behave in a different way than flows of ordinary liquids or gases, they are more difficult to predict and control.

If we can improve our knowledge and control of multiphase flow then it will be possible to achieve more efficient and cost-effective energy production, and fuel transport and use technologies.



Modelling of the shock wave developed during the flow of particles past an obstacle in a chute.

Multiphase flow has many applications within the fossil fuel energy sector. These include:

Discharging of a solid fuel such as coal from storage, its subsequent milling, classification and pneumatic storage to burners, and its combustion in a pulverised fuel flame;

■ Transport and deposition of ash and slag particles through the combustion chamber and convection section of a boiler;

- Particle separation from flue gasses in precipitators
- Transport of water and steam mixture on the steam side of the boiler;
- Production, transport and refining of oil and gas;

 Transport of solids (fuel or waste products) in slurry pipelines; and

 Injection of fuel and air as a spray into internal combustion engines and the subsequent production of exhaust gasses containing particulates Realising the importance of multiphase flow in the energy sector, the Implementing Agreement for Multiphase Flow Sciences (MFS IA) operates at both national and international levels to encourage collaboration amongst technology researchers and developers and to promote co-ordination of information exchange.

There have been numerous occasions where benefits from collaboration through the agreement have resulted in improved use of funding resources and research facilities. Various projects in Mexico, for example, have benefited from discussions with colleagues in Australia. Within Canada, participation within the Agreement has resulted in the formation of a national R&D programme and a network of researchers from universities and government laboratories. Additionally, within the United Kingdom, a technology status review of multiphase flow technologies relevant to coal-fired power plant has been completed and made available to other participants of the Agreement.

Since the commencement of the MFS IA, focus for collaboration between participants has varied. The current focus centres around:

- Non-intrusive sensors, including tomography;
- Computational Fluid Dynamics and experimental verification; and
- Granular flows.



One example of uses for multiphase flow - pouring concrete

reference:

For detailed information on the activities of the Multiphase Flow Science IA, see www.etsu.com/ieampf.

Renewable Energies S and Hydrogen

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

THE NEW LIQUID BIOFUEL AGE

The Implementing Agreement for a Programme of Research, Development and Demonstration on Bioenergy (Bioenergy IA) currently has 21 Contracting Parties, including Brazil, Croatia and South Africa. The scope of the work of the Bioenergy IA encompasses:

 Biomass resources such as conventional forestry, short-rotation forestry, agricultural crops and residues, oil bearing plants, municipal solid waste, industrial waste;

• Supply systems dealing with harvesting, collection, handling and storage;

• Conversion of biochemical, thermochemical, physical/chemical processes; and

• End products for transportation fuels, heat and electricity, solid fuels.

One important area of the Bioenergy IA is Task 39-Liquid Biofuels from Biomass. Due to high oil prices and uncertainty over fossil fuel resources, world production of bio-based ethanol increased dramatically in recent years, with current world production exceeding 30 billion litres/year.



This trend increases the likelihood that feedstocks such as wood and agricultural residue (lignocellulosic biomass) may soon become viable options for biofuels. In North America, petroleum additives from lignocellulosic biomass are receiving particular attention. They are compatible with existing distribution networks, blend easily with gasoline, have lower premiums than diesel or biodiesel under current tax policies, and supplies can support a relatively large biomass-to-ethanol sector.

Demonstration and pilot plants have recently been commissioned. The IOgen's facility Ottawa (Canada) produces 40 tonnes/day using wheat straw and poplar tree pulp. The Abengoa facility in Castilla y Leon (Spain) produces 200 million litres/year using agricultural residues for feedstock, as well as other plants in Canada, Sweden, and the United States.

In Europe the most likely alternative is biodiesel derived from oilseed plants (e.g. rapeseed), as close to 50% of new cars are diesel-powered, the tax structure is dieselfriendly, and the properties of rapeseed-based biodiesel (e.g. reduced emissions, improved lubrication). As liquid biofuels become a more important component of the transportation fuel supply, Task 39 collaboration has identified four key areas to address:

 Bio-based ethanol processes such as pre-treatment and enzymatic hydrolysis of lignocellulosic feedstocks and end uses for lignin;

• Potential volume and availability of liquid biofuels from the biomass industry;

Improved process economics (once feedstock availability and price are known); and

Standards and policies for improve deployment.

Each of the Bioenergy IA tasks is undertaken for three years: A full list of current tasks is as follows:

Task 29-Socio-Economic Drivers in Implementing Bioenergy Projects

Task 30-Short Rotation Crops

Task 31-Energy from Sustainable Forestry

Task 32-Biomass Combustion and Co-firing

Task 33-Thermal Gasification of Biomass

Task 34-Pyrolysis of Biomass

Task 36-Municipal Solid Waste

Task 37-Biogas and Landfill Gas

Task 38-Greenhouse Gas Balances of Biomass and Bioenergy Systems

Task 39-Liquid Biofuels from Biomass

Task 40-Security of Supply and Demand

Task 41-Bioenergy Systems Analysis

references:

Fulton, L. (2004), Biofuels for Transport: An International Perspective, report to IEA Bioenergy. Mabee, W.E. et al. (2004), Ethanol from Lignocellulosics, report to IEA Bioenergy Task 39. Worgetter, M. et al. (2003), A Worldwide Review on Biodiesel Production, report to IEA Bioenergy Task 39. For detailed information on the activities of the Bioenergy IA, see www.ieabioenergy.com.

ENERGY SAVINGS AND REDUCED CO₂ EMISSIONS

In 2004, the world geothermal electricity production reached 57 000 GWh while direct use of geothermal heat amounted to 261 420 TJ.



Geothermal Power Station, Nesjavellir (Iceland).

The use of geothermal power contributes both to energy savings (approximately 28 million tonnes of oil/year) and to CO_2 emissions reduction (91 million tonnes/year compared with equivalent oil-fuelled production). In addition, geothermal as an energy source reduces dependence on imported fuels, and offers greater security and diversity with no seasonal variability of supply.

The ten Contracting Parties in the IEA Cooperative Programme on Geothermal Energy Research and Technology (GIA) continued to advance and support the use of geothermal energy, addressing and analyzing the technical, economical and environmental issues that pose barriers to its development and deployment.

During 2003-2004, GIA participants actively contributed to geothermal and renewable international conferences and symposia, and more than 30 scientific papers and reports were published as a result of work undertaken in the GIA Annexes.

Recent work carried out under Annex I-Environmental Impacts of Geothermal Energy Development involved improvements in subsidence modelling, enabling a more reliable basis for forecasting and possible mitigation. A project investigating Enhanced Geothermal System (EGS) induced seismicity was initiated and a special issue of the newletter *Geothermics* was completed.

Excellent progress continued for Annex III-Enhanced Geothermal Systems on the Soultz (Europe) and Cooper Basin (Australia) EGS projects, with successful deep drilling (4 000-5 000 metres) and reservoir stimulation tests. The first version of a Project Management Decision Assistant handbook was completed which provides a synthesis of data and information to support successful EGS project planning and conduct. A significant compilation of data for EGS reservoir evaluation was also completed for the Hijiori (Japan) HDR experiment. A new study of EGS reservoir performance was also begun.

In Annex IV-Deep Geothermal Resources, a new computer code was developed and successfully tested (Mexico) that models the liquid-gas equilibrium and calculates thermodynamic properties of fluids. The model provides the basis for rigorous simulation of heat and mass transport in deep, high-temperature, high-gas reservoirs. Also, the first deep well (>4 000 metres) was drilled in Bad Urach (Germany), followed by successful reservoir stimulation.

As for Annex VII-Advanced Geothermal Drilling Techniques, the geothermal well drilling cost/ performance database was established and initial data entered, and the high-temperature section of Geothermal Drilling Best Practices Handbook was defined.

Several new projects to investigate the direct use of geothermal resources were initiated with the establishment of Annex VIII-Direct Use of Geothermal Energy.

At the end of 2004, an improved GIA website went online featuring GIA papers, reports, current projects and links to other noteworthy geothermal organisations.

references:

Bertani, R. (2005), World Geothermal Generation 2001-2005: State of the Art, proceedings from the World Geothermal Congress 2005. For detailed information on the activities of the Geothermal IA, see www.iea-gia.org.

SIZEABLE RENEWABLE ENERGY

Thanks to technological developments, hydropower is currently the fifth-largest supplier of world electricity, and by far the greatest supplier of electricity from renewable resources.

An average large hydropower plant supplies between 50 MW to 100 MW of electricity. In addition, due to the minimal CO_2 emissions, low operating costs and long plant life (roughly 100 years), it continues to be a vital component of electricity supply systems and is considered to be the most significant short- to medium-term renewable resource.

The Hydropower Implementing Agreement (Hydro IA) builds on past experience, examine what works, and disseminates balanced and objective information worldwide. There are currently seven Contracting Parties, including China. During Phase 2 (2003-2004), the work of the Hydro IA focused on the following topics.

Annex II-Small-Scale Hydropower addresses the technological, organisational and regulatory issues related to small hydro projects (<10MW). A comprehensive website was created that includes:

■ An interactive world map and map of installations, country briefs, programmes and activities, key contacts, affiliated organisations, and database search.

Planning, developing and operating information, including assessment tools and methodologies, financing, economic risk and sensitivity analysis.

Searchable library.

A typical small-scale hydropower plant can provide enough electricity for 800 people for 20-30 years.

The aim of Annex VI-Public Awareness is to increase understanding of the current and future role of hydropower in the global energy portfolio. A white paper on hydropower and other articles was prepared and an extensive database of technical information is available on the web site.

Following a needs-assessment survey, the participants in AnnexVII-Hydropower Competency Network prepared web-based teaching materials for universities and technical institutes worldwide. Workshops were held to familiarise educators.



Small-scale hydropower plant near Nice (France).

Annex VIII-Hydropower Good Practice collected over 70 studies illustrating examples of planning, operations and maintenance of hydropower installations. Training materials were developed making use of latest information technologies to disseminate results.

Despite the longevity of hydro plants and the high availability and reliability of power output, hydropower faces challenges such as public acceptance and the high initial cost and long payback period. The Hydro IA is developing a new programme to respond to these challenges:

 Integration of wind into hydropower systems (joint annex with Wind Energy Implementing Agreement);

- Safety and security of hydropower facilities;
- Best practice for hydropower performance;
- Hydropower innovations; and

 Development of hydropower in the developing world (where the greatest hydropower potential exists).

references:

For a direct link to the current work on small-scale hydropower, see www.small-hydro.com. For detailed information on the activities of the Hydropower IA, see www.ieahydro.org.

IN PURSUIT OF THE FUTURE

Fuelled by concerns about urban air pollution, energy security, and climate change, the notion of a "hydrogen economy" is moving beyond the realm of scientists and engineers and into the lexicon of political and business leaders. Hydrogen is the most abundant element in the universe, and already plays a critical role in the production of most fuels. It can be produced as a storable, clean fuel from solar, wind, hydro, biomass, geothermal, nuclear or tidal energy.

The role of the IEA Hydrogen Implementing Agreement (HIA) in providing impartial, expert technical advice is needed more than ever before. During 2004, HIA membership and activities grew, and two major milestones were achieved. The first was the launch of the report In Pursuit of the Future. This report provides an overview of hydrogen production, applications and opportunities as well as progress on HIA activities. The second milestone was establishment of the HIA Strategic Plan for 2004-2009. This "second generation" plan includes three major objectives:

- Assess the market environment;
- Advance science via pre-commercial R&D; and

• Outreach activities to accelerate hydrogen implementation and widespread utilisation.

After more than four years and 85 person-years of dedicated effort, conclusions on the key achievements of Task 14-Photoelectrolytic Production of Hydrogen were finalised. Outcomes include development of the world's first water-splitting catalyst; strong engineering progress with preparation and characterisation of WO3 and Fe2O3, pioneer-manufacture of demonstrator PEC water-splitting cells; and promising conceptual development of novel planar, multi-junction PEC water-splitting cells (WO3/TiO2).A follow-up project was launched in October, Task 20-Hydrogen From Water Photolysis.

Two major breakthroughs are associated with Task 15-Photobiological Production of Hydrogen, showcased at the 2004 World Hydrogen Energy Conference (Japan). The first is the identification of accessory genes needed for assembly of the Fe hydrogenase (where green algae produce hydrogen



Hydrogen refuelling station, Ariake (Japan).

from sunlight and water using photosynthesis). A second breakthrough is the advancement of hydrogen and methane fermentation systems.

Progress on subtasks of Task 16-Hydrogen from Carbon Containing Materials continues with extensive industry and government participation. Osaka Gas, a member of the subtask Small Stationary Reformers for Distributed Hydrogen Production, received an engineering excellence award from the Engineering Advancement Association of Japan. Work continues on subtask Hydrogen from Biomass., while the subtask Pre-combustion Decarbonisation will soon publish a final report.

The largest known collaboration on solid storage, Task 17-Solid and Liquid State Hydrogen Storage Materials, analyses 35 projects in the areas of hydride, carbon and combined hydride and carbon activities, and includes extensive databases on hydride materials, properties and applications.

Task 18-Integrated Systems Evaluation, identified nine modelling and analysis projects: the Fuel Cell Innovative Remote Systems for Telecommunications (FIRST) (Spain); the Malmö filling station and hythane-fueled buses (Sweden); and the EC Ecological City Transport System (ECTOS) and the Las Vegas Energy Station (United States).

Task 19-Hydrogen Safety investigates risk-assessment methodologies, a testing programme to evaluate the nature and consequences of safety related events, and targeted information packages for stakeholder groups.

references:

Photo courtesy of Japan Hydrogen and Fuel Cell Demonstration project (JHFC). For detailed information on the activities of the Hydrogen IA, see www.ieahia.org.

TESTING AND EVALUATION GUIDELINES



Offshore floating wave energy device, PELAMIS (United Kingdom).

Ocean energy systems are at the research and development and pre-commercial demonstration stage of technology development. A major challenge to developers and those supporting development in this area is that a number of different resource types exist for ocean energy systems (including waves, tides, tidal currents, salinity and thermal differentials). In addition, there are several different ways of extracting the energy from each resource type. Comparisons between systems is challenging due to the differing underlying assumptions of power production, generator capacity and cost statements.

The Implementing Agreement for Ocean Energy Systems (Ocean IA) was created in June 2001. The first major task of the Ocean IA is Task II-Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems. The aim of this task is to address this issue by setting guidelines for establishing standards of the theoretical, model and prototype testing, preliminary cost assessments, and presentations of results. The 2003 report, Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems, details the preliminary results.

The first section of the report provides an overview of model testing facilities currently available in a number of member countries to the Implementing Agreement and other European countries. The descriptions of facilities are provided on a consistent basis for comparability, such as: Wave tank dimensions;

■ Wave production capability (i.e., size, speed and dimensions); and

Current production capability.

Guidelines for the description of sea conditions and the means of determining the energy available in a given sea condition are provided in section two of the report. Recommended experiments for testing wave power converters include a number of recommended wave spectrum to investigate the sensitivities of a device concept to spectral shapes, wave periods, and directional spreading as well as survivability in extreme sea states. Methods for measuring absorbed power on a number of wave power converters are also included. Guidelines on results presentation and performance assessment are recommended in further sections of the report.

Further work scheduled under this Task are a workshop on prototype testing with representatives from a dedicated ocean energy systems test centre in the United Kingdom as well as other agencies involved in prototype testing. It is hoped that the work undertaken in Task II will provide the basis for meaningful analysis through common definitions, comparable data and results.



Offshore tidal current turbine, or Seaflow project (North Devon, United Kingdom).

references:

Nielsen, Kim (2003), Development of Recommended Practices for Testing and Evaluating Ocean Energy Systems. Photo of the Seaflow project courtesy of Marine Current Turbines Ltd. Photo of the Pelamis installation courtesy of Ocean Power Delivery Ltd. For detailed information on the activities of the Ocean Energy IA, see www.iea-oceans.org.

MORE POWER FOR LESS MONEY

Photovoltaic power systems provide sustainable energy solutions in the urban environment, costeffective off-grid electricity, and power for millions in developing countries.

The cost of producing one kilowatt of electricity from PV has decreased substantially since the early 1990s. Based on the historical trend shown below, it is reasonable to assume that more cost reductions will be achieved by reducing manufacturing costs, and, as manufacturing capacity increases, the cost of manufacturing will continue to decrease.



Highlights of activities during 2003 included the completion of Task 3 on stand-alone systems and quality assurance required for off-grid PV systems, projects and programmes. An international conference celebrating the 10th anniversary of IEA PVPS, Osaka (Japan), provided a unique opportunity to exchange information and views on PV policies and markets with worldwide stakeholders. Conference outcomes contributed to, and influenced, the development of IEA PVPS activities.

IEA PVPS currently focuses on work in a number of key areas:

International collaborative efforts to bring together architects, builders, financial experts, utility personnel, municipal planners, the PV industry and the educational sector to address the economic, institutional, and technical issues necessary to mainstream the use of PV in the urban environment, in the near to mid term (large-scale deployment of PV in urban environments).

■ The consequences of an estimated 1.64 billion people in developing countries without access to electricity in the foreseeable future and how renewable energy, in particular PV, can contribute directly to the targets of the Millennium Development Goals, agreed by the International Community, through the provision of electricity for basic services (PV services for developing countries).

Case studies and practical proposals for pilot systems of large-scale PV (suitable for selected desert regions), to provide general guidance for development of practical projects (studies on very large scale PV power generation systems).

Providing the technical information on PV operational performance, long-term reliability and other features of interest which are so important for an emerging technology (Performance, reliability and analysis of PV systems).

Current projects (tasks) of IEA PVPS include:

Task 1-Exchange and Dissemination of Information on PV Power Systems

Task 2-Operational Performance, Maintenance and Sizing of Photovoltaic Power Systems and Subsystems

Task 3-Use of Photovoltaic Power Systems in Stand-Alone and Island Applications

Task 5-Grid Interconnection of Building Integrated and Other Dispersed Photovoltaic Power Systems.

Task 7-Photovoltaics Power in the Built Environment

Task 8-Study on Very Large Scale Photovoltaics Power Generation Systems

Task 9-Deployment of Photovoltaic Technologies: Co-operation with Developing Countries

Task 10-Urban Scale PV Applications

reference:

For detailed information on the activities of the Photovoltaic IA, see www.iea-pvps.org.

GLOBAL CAPACITY EXCEEDS EXPECTATIONS

In 2004, the Implementing Agreement for a Programme to Develop and Test Solar Heating and Cooling Systems (SH&C IA) reached out to industry to increase the level of collaboration. Recognizing the importance of collaboration not only amongst countries, but also sectors, the Programme has established a Memorandum of Understanding with key solar thermal trade associations in Europe and North America. In addition to supporting their own objectives, an agreement was made to support activities that:

Share the vision that the solar thermal potential can provide 10-15% of the total energy demand in the OECD countries by 2025 (within the boundaries of a level playing field);

Increase the awareness of national and international government bodies and policy makers of this potential and therefore create a higher sense of urgency in its realisation; and

 Incorporate R&D results into new products and services by industry in order to open new applications and markets.

Global Installed Electric and Thermal Capacities, 2001



The first action undertaken in this collaboration was to address the underestimation of the capacity of solar thermal installations in many official statistics. This underestimation was largely due to the fact that solar thermal installations have traditionally been counted in square meters of collector area, a unit not comparable with other energy sources. At a meeting with major solar thermal trade associations from seven countries, a methodology was agreed upon to convert installed collector area into the thermal power equivalent (GWth) of installed capacity of solar collectors.

Using a factor of 0.7 kWth/m^2 to derive the nominal capacity from the area of installed collectors, the statistics show the global installed capacity to be 70 GWth (70 000 MWth), making solar thermal one of the leading sources of renewable energy world wide.

The worldwide contribution of solar thermal installations to meeting the thermal energy demand for applications such as hot water or space heating has been greatly underestimated in the past. This conversion will now make it possible to compare the installed capacity of solar thermal collectors with other renewable sources.

Current research Tasks of the SH&C IA include:

Task 27-Performance of Solar Fa ade Components

Task 28-Sustainable Solar Housing

Task 29-Solar Crop Drying

Task 31-Day-lighting in Buildings in the 21st Century

Task 32-Advanced Storage Concepts for Solar and Low Energy Buildings

Task 33-Solar Heat for Industrial Processes

Task 34-Testing and Validation of Building Energy Simulation Tools

Task 35-PV/Thermal Systems

references:

United Nations Development Programme (2004), World Energy Assessment: Overview 2004 Update. For detailed information on the activities of the Solar Heating & Cooling IA, see www.iea-shc.org.

GLOBAL MARKET INITIATIVE

The purpose of the Global Market Initiative (GMI) for Concentrated Solar Power (CSP) is to help create the conditions conducive for new plants and to expedite the building of 5 000 MWe of CSP worldwide over the next ten years through international collaborative efforts.

CSP technologies use large, sun-tracking mirrors to concentrate solar radiation. However, the final steps of generating electricity using CSP systems is similar to conventional electricity generation - the ultimate energy conversion process depends on the use of steam or gas to rotate turbines, or move a piston in a Stirling engine. In a CSP system, however, steam or hot gas is produced by the concentrated solar radiation. CSP technologies have been constructed in various sizes, from small multikW systems, to large power stations of several MW. These power stations have provided the cheapest electricity to be generated using solar power.

Two international executive conferences have been held to address the barriers to current and future CSP project opportunities and to expand the global market for CSP.

The First International Executive Conference on Concentrating Solar Power was held June 2002 in Berlin, Germany. Following the Berlin event, two regional working groups were formed to develop approaches to facilitate regional CSP markets. The Second International Executive Conference on Expanding the Market for Concentrating Solar Power was held in October 2003 in Palm Springs, at the invitation of the Governor of California. At this event, the California Energy Commission, the United States Department of Energy and the IEA SolarPACES Implementing Agreement joined the sponsors of the Berlin conference to finalise and launch the global initiative.

The conference participants mandated the IEA SolarPACES Implementing Agreement to act as a coordinating Secretariat for the GMI to prepare its presentation and endorsement at the Renewables 2004 conference in Bonn, Germany in June 2004 under guidance of the GMI interim management team. A GMI Action Proposal was formulated for the International Action Plan for Renewable Energies, discussed in several missions with the interested governments and a first draft presented at the preparatory Middle East and North Africa Renewable Energy Conference in Sanaa in April 2004. At the Renewable Energy 2004 conference in Bonn, the GMI Action Proposal was endorsed by ministers of the governments of Algeria, Egypt, Germany, Jordan, Israel, Italy, Morocco and Spain and included in the Actions and Commitments by Governments of the Renewables 2004 International Action Programme.

The countries participating in the GMI will cooperate in the deployment of CSP by setting market introduction targets, tariffs or appropriate financing mechanisms according to a country's specific situation to allow CSP plants to be financed. Adequate mechanisms, grid interconnections and fair tariff schemes for transnational power exchange shall be developed that allows to export solar electricity from countries with excellent solar radiation resources to the renewable electricity markets of developed countries with inferior solar resources. Multi- and bi-lateral financing institutions will be involved to make cross-country Clean Development Mechanism (CDM), Joint Implementation (JI) and related mechanisms bankable for CSP.

Current projects of the IEA SolarPaces Implementing Agreement include:

Annex 1-Concentrating Solar Electric Power Systems, involving the design, testing, demonstration, evaluation and application of solar thermal electric systems, including parabolic troughs, power towers and dish/engine system;

Annex 2-Solar Chemistry Research, covering development of engineering aspects of pre commercial and demonstrational solar chemical systems projects basic research on solar-specific chemical reactions and processes; and

Annex 3-Concentrating Solar Technology and Applications, where development/test solar components and subsystems; refine computation/ measurement techniques and facilities; advance specific solar technology areas.

references:

For more information on the "Renewables 2004 International Action Programme" at www.renewables2004.de.

For detailed information on the activities of the SolarPaces IA, see www.solarpaces.org.

AERODYNAMICS, CLIMATES AND MODELLING

In 2004, world-wide wind energy generating capacity increased to 47.6 GW. The vast majority of this generating capacity is located in the countries that participate in the IEA Implementing Agreement for Wind Energy. To mark the increasing importance of deployment issues, the agreement changed its name to the IEA Implementing Agreement for Co-operation in the Research, Development, and Deployment of Wind Energy Systems (Wind IA). Continuing to address research, development, and deployment issues to expand the use of wind generation, the Wind IA conducted a full schedule of work in 2003 and 2004.



An offshore wind farm using 3.6 MW turbines for an installed capacity of 25 MW, Arklow Bank (Ireland).

The ongoing Task XI-Base Technology Information Exchange, held topical expert meetings on "Integration of Wind and Hydropower Systems", "Acceptability in Implementation of Wind Turbines in Social Landscapes", "Critical Issues Regarding Offshore Technology and Deployment", and "System Integration of Wind Turbines". Under this task, the second Joint Action Symposium on Wind Forecasting Techniques was also held in 2004.

Work continued in Task XIX-Wind Energy in Cold Climates to pool information to enhance performance of wind turbines operating in cold regions. The results were published in the report Stateof-the-Art of Wind Energy in Cold Climates and is available on the Wind IA web site. Task XX-Horizontal Axis Wind Turbine Aerodynamics and Models from Wind Tunnel Measurements allows researchers in each country to share data from a full-scale wind turbine experiment in the NASA wind tunnel to improve aerodynamic models for wind turbine design. Participants are using the data to develop new models for aerodynamic predictions and integrating that understanding into models and validating models. Eleven organizations representing eight countries participate in this work.

Task XXI-Dynamic Models of Wind Farms for Power System Studies brings together the modelling experience of participants to predict the impact of wind farm generation on utility transmission and distribution systems. A database of wind farm site measurement data is being assembled and will be used for benchmark testing (procedures for which are under development) of dynamic models.

Two important new annexes were initiated in 2004, Task XXIII-Offshore Wind Energy Technology Development and Task XXIV-Integration of Wind and Hydropower Systems.

Task XXIII resulted from a topical experts meeting, which identified critical issues. Subtask One will review the experiences of participants with these critical issues and develop a detailed research agenda. Subtask Two will select technical research areas for foundations and structures, including those for waters deeper than 30 meters.

Also inspired by work at a topical experts meeting, Task XXIV is a joint project with the Hydropower Implementing Agreement. This area of research is important as altogether, the Wind IA participating countries have about 450 GW of hydropower capacity and more than 31 GW of wind generation. The annex work will explore the issues of integrating these types of generation through case studies conducted by the participants.

The Wind IA also maintains two important databases available to the research community, Task XVII_Wind Characteristics and Task XVIII-Enhanced Field Rotor Aerodynamics.

references:

Photo courtesy of Airtricity. For detailed information on the activities of the Wind IA, see www.ieawind.org.

End-use Technologies

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

Buildings Buildings and Community Systems Demand-side Management District Heating and Cooling Energy Storage Heat Pumping Technologies

Industry Emissions Reduction in Combustion High-temperature Superconductivity Process Integration in the Pulp and Paper Industry
Transport

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

FUEL CELLS AND SUSTAINABLE DEVELOPMENT

In recent years, fuel cell research has become a high priority in the R&D programmes and policies of the world's leading economies (United States, Japan, European Union). High expectations are expressed that fuel cell technology will contribute significantly to the goals of energy policy such as security of supply, economics and sustainability through transport and stationary power applications.



A 20 W power system with high-power density and a fuel cell stack height <5 cm.

The aim of the IEA Advanced Fuel Cells Implementing Agreement (AFC IA) is to increase knowledge in the research and development, demonstration and commercialisation of fuel cells. Participating countries work within expert groups on specific projects (annexes) to task-share R&D and exchange information.

Annex XIX-Stationary Fuel Cells investigates the market conditions and performance requirements of developing commercially viable fuel cell systems and applications. Potentially attractive niche markets for uninterruptible power supply and small stand-alone systems were identified, while single-house applications were found to be practical in remote locations. Medium-sized fuel cells (from 50 kW to I MW) operating in large buildings and industries have a large potential market once they become commercially competitive.

Interest in Annex XVIII-Natural Gas-Fuelled Solid Oxide Fuel Cells (SOFC) continued at a high level in 2004, primarily due to expansion of the U.S. Department of Energy's Solid State Energy Conversion Alliance (SECA) programme to six industrial teams; expansion of the European Union SOFC-related programs under Framework 6; and several new industrial NEDO programs in Japan. A Canadian company also produced several 5 kW distributed power generation systems built with tubular solid oxide fuel cells.

In Annex XVII-Molten Carbonate Fuel Cells (MCFC) for Distributed Power Generation, demonstration programs for MCFC between 250 kW and I MW are now operating in many countries. MCFC companies in the United States and Germany have successfully completed tests of MCFC with good results. Japan has developed a hybrid MCFC and gas turbine system, and Korea is currently constructing a 100 kW MCFC demonstration system.

Niche applications are also an AFC priority, such as polymer electrolyte fuel cell (PEFC) use for portable power. The work of **Annex XVI-PEFC** has encouraged significant milestones in PEFC development, particularly for methanol-powered fuel cells. Researchers in the United States have made a compact direct methanol fuel cell system for both 20 W and 80 W military power systems. Considerable progress has been made in improving the power density of these systems.

Two key challenges for fuel cell vehicles are performance and fuel infrastructure. Based on the findings of Annex XX-Fuel Cells for Transportation, fuel cell vehicles powered by alternative fuels could make a major contribution to energy security and a more sustainable transport sector. Initial results show that the fuel economy of hydrogen fuel cell vehicles can be three times greater than fuel economy of conventional internal combustion engine (ICE) vehicles. Compared to its conventional ICE counterpart, the Santa Fe fuel cell hybrid vehicle achieves 150% fuel economy on both the New European Drive Cycle and the Japanese driving schedule, and over 180% on the United States urban drive cycle.

For detailed information on the activities of the Advanced Fuel Cells IA, see www.ieafuelcell.com.

REACHING FOR TRANSPORTATION PERFORMANCE

The primary focus of the IEA Implementing Agreement for a Programme of Research and Development on Advanced Materials for Transportation Applications (IA-AMT) is to investigate promising new technologies that will increase efficiency of transport vehicles, reduce harmful emissions and maintain acceptable lifecycle costs. Current work of the IA-AMT focuses on the following research topics:

 Development of revolutionary materials (structural ceramics and ceramic matrix composites) for operation at higher temperatures and pressure

• Surface engineering to improve the resistance to wear and contact damage

 Development of durable coating systems for thermal, wear, and environmental management

Light weighting to improve fuel efficiency

Hard, wear-resistant, durable, and insulating ceramic coatings applied by physical vapour deposition (PVD), chemical vapour deposition (CVD), and thermal spray methods are an expanding technology for improving the durability, reliability, and efficiency of diesel and turbine engines for automotive and industrial power. As there are currently few widely accepted test standards for evaluating the baseline properties of ceramic coatings for engine applications, work on II-Co-Operative Programme Annex on Ceramics for Advanced Engines and Other **Conservation Applications**, sets out to assess those experimental methods that have the potential to quantify thin ceramic coating adherence.

The effects of subsurface damage (e.g. that results from component machining) on the rolling contact fatigue (RCF) performance of silicon nitride (Si3N4) is the primary theme of Annex III-Cooperative Programme on Contact Reliability of Advanced Engine Materials. The goal is to link RCF performances measured with each technique. Additionally, the generated subsurface damage in cylindrical rods and spheres machined under the "same" machining conditions will be compared to assess/verify sought equivalence. A detailed report on rolling contact fatigue (RCF) testing in each of the participating countries was completed in 2004.



An example of a valve in which the surface has been textured using micro-dimpling.

As friction loss is inherent in most mechanical systems, the ability to control it offers many opportunities for efficiency gains. Typically, materials, lubricants, and surface modifications have been used to reduce friction in automotive and diesel engines. Annex IV-Cooperative Programme on Integrated Engineered Surface Technology to Reduce Friction and Increase Durability explored the possibility that surface texture designs could reduce friction using thin films and coatings under a broad range of contact conditions. The aim is to develop design guidelines for technology implementation worldwide. In 2004 participants of Annex IV collaborated with COST 532 (European Cooperative Research Consortium on Triboscience and Tribotechnology), a consortium of 30 organisations from 14 European countries. In addition, China participated as an observer.

To further explore the scope in this area, IA-AMT launched a new project, Annex V-Light-Weight Materials. Materials under consideration include aluminium, high strength steels, magnesium, metal and polymer composites, titanium, inter-metallic alloys and other advanced materials.

For detailed information on the activities of the Advanced Materials for Transportation IA, see http://ia-amt.ornl.gov/.

THE NEED FOR NEW MOTOR FUELS

There is a growing need to replace diesel oil, gasoline and traditional alternative fuels with new alternatives. Most alternative fuels cost more to produce than conventional fuels, and enhancements such as reformulation, low-sulphur, low- benzene, low-aromatic qualities are growing rapidly, the need for other options is becoming a priority. Synthetic fuels such as paraffin (synthetic diesel oil) and alkylates (synthetic gasoline) are increasingly regarded as sustainable future alternative transport fuels. They can be produced from natural gas as well as from most types of gasified biomass including garbage and sewage sludge.

The vision of the IEA Implementing Agreement on Advanced Motor Fuels (AMF IA) is to achieve market penetration of advanced motor fuels and the widespread deployment of sustainable transport technologies to reduce emissions, improve energy efficiency and energy security. In 2004 the AMF, IA completed an End-of-Term Report for the period 1999-2004, a Strategic Plan for 2005-2009, finalisation of six annexes and preliminary work on six new annexes, as well as sponsoring the widely-attended "Windsor Workshop 2004 Transportation Technology & Fuels Forum", Toronto (Canada).

Standard emission certification methods for heavyduty applications are based on stand-alone engine tests on engine dynamometers. This method excludes important data on vehicle weight, drive train, body structure, etc., and results in emissions data that is difficult to convert. In addition, there is no universal standard for testing heavy-duty vehicles so it is difficult to compare and interpret results. The objectives of Annex XXIX-Evaluation of Duty Cycles for Heavy-Duty Urban Vehicles are to understand different duty cycles, produce a key for crossinterpretation of emission results generated with different cycles, study the interaction between vehicle and fuel technologies and test procedures and pinpoint international harmonisation in emission testing.

Annex XXX-Bio-safety Assessment: Animal Fat in Biodiesel evaluates the risk of using animal tallow derived from specified risk materials (SRM), dead stock, and downer animals as feedstock for the production of biodiesel. Given the presence diseases transmissible to humans, this study will determine what risks, if any, are present to animal and human health, and to address the existing knowledge gaps through experimental work.

The Fischer-Tropsch (FT) technique adjusts fuels to different types of engine requirements. FT-fuels are most promising for emissions reduction and engine performance, though the literature is not always accessible for the non-technician. The main objective of Annex XXXI-Production and Use of Synthetic Vehicle Fuels (Fischer-Tropsch Technique) is to present an analysis of the FT-Fuels role in future transportation system in layman's terms.

The objective of Annex XXXII-Future Fuels for Road Transport is to:

 Identify new engine concepts and improvements of today's engine technologies;

 Identify which demands that have to be put on the fuels to be used in these new engine concepts;

Examine which conventional fuels can be used in new engine concepts and which have to be disregarded; and

• Carry out a first economical assessment of production, distribution and use of the fuels that will have a possibility to be used in today's as well as tomorrow's engines.

Due to the widespread use of scooters in many congested city centres, Annex XXXIII-Particle Emissions of 2-S Scooters will endeavour to define:

 Composition of 2-S aerosol using different lube oils and fuels and different engine technology;

 Sampling and measuring procedures for particle counts and measures;

Improving exhaust gas after-treatment systems;

 Toxicity and new methods of health effects research;

New inputs for industrial partner products; and

New inputs for the legal authorities.

For detailed information on the activities of the Advanced Motor Fuels IA, see www.iea-amf.vtt.fi.

PROGRESS TOWARDS SUSTAINABLE TRANSPORT

Despite advances in fuel efficiency, fuel for road transport still accounts for 27% of total final energy consumption in OECD countries and 20% of world consumption. The need for sustainable transportation solutions is an important issue. Cities suffer from air quality problems, governmental policy makers are looking for measures to reduce emissions of greenhouse gases and many countries are trying to find ways to reduce their dependency on oil imports.

Hybrid and electric vehicles offer the possibility of reducing the dependence on oil while at the same time offering the potential to reduce adverse environmental impacts of burning fossil fuels. The use of hybrid drive systems incorporating an electric motor, together with another power source, may be the best way to capitalise on the potential benefits of electric traction systems.

The Implementing Agreement on Hybrid and Electric Vehicles (HEV IA) was created to address these problems, explore possible solutions and disseminate the results. This is done by fostering international collaboration in pre-competitive research and then disseminating objective information. The agreement has defined a scope of work tailored to the needs of those responsible for designing future transport policies. Current research tasks of the HEV IA treat the following topics:

• Annex I-Exchange of Information on Hybrid and Electric Vehicles

- Annex VII-Components for Hybrid Vehicles
- Annex VIII-Deployment Strategies

Annex IX-Clean City Vehicles (for Developing Countries)

Annex X-Fuel Cells, Vehicle Batteries and Super-Capacitors

Annex XI-Electric Two-Wheelers

All the vehicles currently being researched have in common the use of an electric motor in the propulsion system. In electric and in fuel cell vehicles, this is the motor that drives the wheels. Hybrid vehicles combine a combustion engine with an electric motor and battery. Depending on the driving pattern, a computer determines if the wheels of a hybrid vehicle are driven by the combustion engine and/or by the electric motor. This combination operates more efficiently. Compared to conventional combustion engine vehicles in city driving it may reduce fuel consumption by 60% (at a maximum) and air pollution by more than 60%. Hybrids capture braking energy and return it to the battery, which is called "regenerative braking." In addition, by combining gasoline with electric power, hybrids have the same or greater range than traditional combustion engines.

Electrical vehicles are zero-emissions vehicles. In addition, when the electricity for these vehicles is produced from renewables energy, and when hybrid vehicles consume only liquid biofuels, these vehicles can greatly reduce CO_2 emissions, lower the reliance on imported oil, and contribute to a truly sustainable transportation system.

Prototype fuel cell vehicles are currently being tested and the automotive industry is progressively making more hybrid vehicles available to the commercial market. Unprecedented changes to the automobile market may be expected during the coming decade and this will have major economic, environmental, and energy implications for all IEA member countries.



Example of a hybrid car that is successful on the market, the Toyota Prius.

references:

Photo courtesy of Toyota Motor Company.

For detailed information on the activities of the Hybrid & Electric IA, see www.ieahev.org.

Buildings

Buildings and Community Systems Demand-side Management District Heating and Cooling Energy Storage Heat Pumping Technologies

ENERGY EFFICIENCY ON THE MENU

Energy efficiency is often delivered at the local level. Together these local measures feed and build national programmes. However liberalization can have an impact on their role, for example, as competition throws into question the role of the municipal energy company. Lower prices make energy efficiency a less saleable commodity but an open market allows municipalities and citizens the possibility to choose. Combined, energy efficiency, dynamic pricing and demand response can considerably reduce consumption. Energy efficiency reduces energy consumption and capacity requirements through the use of more efficient appliances and equipment. Reliability demand response reduces load during peak periods, while dynamic pricing reduces load by offering customers market-based rates.

The Implementing Agreement for Co-operation on Technologies and Programmes for Demand-Side Management (IEA DSM) Task IX-Municipalities and Energy Efficiency in a Liberalised System (MEELS), set out to find ways for local authorities to respond to the challenges presented by competition. Task IX participants anticipated quickly finding a "best practice" that someone else had developed to solve the problem. Instead they found that continuity of current policies is of vital importance - the good ideas developed over the years are still good and still needed. The participants all examined their national situations, and made use of the United Kingdom's early experience of liberalization to provide some lessons to others. The team of experts identified good practice at the local level in a series of case studies in their own countries and elsewhere, and have used these to develop a set of 12 guidelines for local authorities to help them in preparing a strategy to meet the challenge of liberalisation.

Energy Performance Contracting (EPC) is a general term for mechanisms by which building owners can install and operate energy efficient plant and equipment using other people's capital funds. Task X-Energy Performance Contracting looks at the enormous potential energy savings from this practice, and has identified many projects within member countries where savings of 20-40% have been achieved. Although there are different approaches to EPC, the basic philosophy is the same. A building owner enters into a long-term contract with an Energy Service Company (ESCO), who undertakes to provide a specific level of service for an agreed regular payment. This payment usually represents a reduction in the client's previous outgoings, but contributes to the servicing of the capital costs of energy efficiency investments. These investments are funded by or through the ESCO, rather than the client, and lead to savings in energy costs which benefit both partners. At the end of the contract, all the savings revert to the client.

Financial advantages, particularly interesting to public sector clients, allows building owners to gain ESCO energy expertise and experience. Task X estimates the potential market for EPC in some countries to be up to ten times greater than at present. A number of opportunities and concrete actions to stimulate greater use of EPC were identified. The most important of these include raising awareness and credibility, demonstration projects, accreditation of ESCOs, process and procurement guidelines and templates, and performance guarantees.

The aim of Task VII-International Collaboration on Market Transformation, completed in 2004, was to encourage a greater market share for the most energy efficient appliances and products. It seeks to understand why energy efficiency is low in a consumer's hierarchy of needs. Why do some retailers and manufacturers shy away from selling the benefits of the energy efficiency of their products? Can we make 'energy efficiency', as a marketing concept, as popular or as strong as the brands of Coca-Cola, Adidas, or organic food? And how might we do this? As the demand for the most energy efficient products increases this approach has the capacity to put in motion the chain of market actors, from manufacturing to retail.

For detailed information on the activities of the Demand Side Management IA, see http://dsm.iea.org/.

COMING IN FROM THE COLD

Over 70% of total world district heating installations are found in Eastern Europe, otherwise known as the "transition economies". Far behind are China, (11% of installations), the European Union (9%) and the United States (3%). The future of district heating and its energy saving potential is a major focus among transition economy governments and largely undeveloped in most IEA countries.

To address this, members of the Implementing Agreement on District Heating and Cooling including integration of Combined Heat & Power (DHC/CHP IA) recently combined efforts with the IEA for the recent conference "District Heating Policy in Transition Economies". Discussions among the 100 participants from 27 countries focused on energy sector competition, district heating tariffs and regulation, ownership and management, reduction of emissions and facilitation of CHP. Outcomes from the conference fed directly into the IEA publication Coming in from the Cold: District Heating Policy in Transition Economies.



The current programme of the DHC/CHP IA covers a broad range of topics with the common theme of optimization and design of district heating networks integrating combined heat and power. One such study, Comparison of Distributed CHP/DH with Large-scale CHP/DH, evaluates economic and environmental impacts of a range of DHC/CHP size and technology approaches, including illustrations of different scales of actual systems using CHP installations from <1 MWe to >100 MWe.

Under Two-step Decision and Optimization Model for Centralized or Decentralized Thermal Storage in DH&C Systems, a model is being developed to determine if, and under what conditions (size, location), a thermal storage system(s) should be installed. The aim is to reduce production or distribution bottlenecks and peak load operation; improve waste heat or base load utilization; and minimize power demand and/or CHP power generation during times of highest power value.

In hot water district heating systems, the difference between a low return temperature and high supply/return temperature can maximize heating capacity and minimize pumping costs and distribution losses. Improvement of Operational Temperature Differences in District Heating Systems illustrates how low-return temperatures improve CHP operating conditions and efficiency, heat pumps and flue gas coolers. Another important related challenge is the broad spectrum of heat losses and related costs. Strategies to Manage Heat Losses-Technique and Economy focuses on improving technical knowledge to improve DH system design. Costs of measures for lowering heat losses are calculated for real situations with defined parameters. The outcome will be tools for network design (calculations, tables, and diagrams). Dynamic Heat Storage Optimization and Demand Side Management is developing recommendations based on dynamic supply temperature control and heat storage, analyzing the cost savings, CO₂ reduction and peak demands in gas and electric systems.

One side effect of hot water distribution is Biofouling and Microbiologically Influenced Corrosion in District Heating Networks. Biofouling (micro-organisms attaching to pipe and tank walls) and microbiologically influenced corrosion (MIC) can severely reduce system duration. Risk assessment is monitored in ten systems and will result in guidelines for monitoring, mitigation and control of biofouling and MIC.

The project Cellular Gas Influence on Insulation Properties of District Heating Pipes and Competitiveness of District Energy examines how the cellular gases replacing CFCs in heating network pipes influence insulation properties in the long term, calculate costs related to heat loss, and the use of vacuum as the cellular gas.

For detailed information on the activities of the District Heating & Cooling IA, see www.iea-dhc.org.

THE COMPREHENSIVE PERSPECTIVE

The mission of the Energy Conservation in Building and Community Systems (ECBCS) Programme is to facilitate and accelerate the introduction of energy conservation, and environmentally sustainable technologies into healthy buildings and community systems through innovation and research in decision-making, building assemblies and systems, and commercialisation.

In joining ECBCS, national governments and programmes enable their researchers and industry to take part in a well-established international programme, which each year collaboratively carries out over 65 person-years of work. This is achieved with an average workload of only approximately three person-years per country therefore offering greater leverage to national R&D approved programmes. There are currently 34 partner organisations from industry, mainly by direct participation in the project (annex) work programmes.

This year the Annex 5-Air Infiltration and Ventilation Centre (AIVC) is celebrating 25 years of leadership and excellence in the dissemination of reliable and effective information on ventilation. In 2004, six new ECBCS annexes were initiated, two were successfully completed, and another four are ongoing. The new Annexes that have been formally approved during 2004 cover the following topics:

Annex 41-Whole Building Heat, Air and Moisture Response

Annex 42-Simulation of Building-Integrated Fuel Cell and Other Cogeneration

Annex 43-Testing and Validation of Building Energy Simulation Tools

Annex 44-Integrating Environmentally Responsive Elements in Buildings

Annex 45-Energy-Efficient Electric Lighting for Buildings (described in detail below)

Annex 46-Holistic Assessment Toolkit on Energy Efficient Retrofit Measures for Government Buildings

During the same period, the work programmes of two annexes were successfully completed. The Energy Concept Adviser of Annex 36-Retrofitting of Educational Buildings is now being tested on real buildings. This electronic interactive source book includes design tools, inspirations, advice and decision tools. The objective of Annex 37-Low Exergy Systems for Heating and Cooling was to promote rational use of energy by facilitating and accelerating the use of lowvalued and environmentally sustainable energy sources for heating and cooling of buildings (exergy expresses the quality of an energy source and quantifies the useful work that may be done by a certain quantity of energy). This Annex, now completed, carried out the following sub-tasks:

 Exergy Analysis Tools for the Built Environment, which assessed and developed a set of tools of low exergy technologies;

 Low Exergy Concepts and Technologies - created a database of low exergy concepts;

• Case Studies and Market Potentials -collected practical experiences and analysed market potential.

Of the total electricity consumption, lighting consumption ranges from 5 to 15% in industrialised countries, and up to 86% in developing countries. Several components affect lighting energy use, including lighting equipment, performance targets and design, and control and integration. ECBCS therefore approved a new project, Annex 45-Energy-Efficient Electric Lighting for Buildings. This new annex will operate from 2004 to 2008 and intends to:

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

 Assess the technical performance of existing and future lighting technologies, and

 Assess barriers preventing the adoption of energy efficient technologies and propose means to resolve these barriers.

Several international conferences and workshops organised by ECBCS took place during 2004:

Energy-Efficient Building Operation (France)

 New Energy Systems for Domestic Dwellings (United Kingdom)

Energy-Efficient Lighting for Buildings (Finland)

 Better and Efficient Heat Pumps in Buildings (Belgium)

For detailed information on the activities of the Buildings & Community Systems IA, see www.ecbcs.org.

COOLING WITH PHASE CHANGE MATERIALS

Recently the operation of electric-driven chillers has caused severe shortage problems and even breakdowns of the electric grid in several countries. In the recent IEA symposium, "Cooling Buildings in a Warming Climate", several options were discussed to meet this increase in cooling demand.

Groundwater and the subsoil represent a substantial natural, low-temperature thermal store which can be used for cooling or heating of buildings. The cold can be extracted from the ground via wells, ducts, energy pillars etc. and used either directly, or indirectly using heat pumps. Underground Thermal Energy Storage (UTES) has been extensively investigated in several projects of the Implementing Agreement, most recently in Annex 13-Design, Construction and Maintenance of UTES Wells and Boreholes. Many large-scale pilot and demonstration plants have shown the technical feasibility and economical advantages of UTES. As a result, implementation has been growing rapidly in many countries, most notably in Belgium, Germany, the Netherlands and Sweden.

Another new and innovative thermal energy storage concept is based on the use of phase change materials (PCM) and thermo-chemical reactions. A phase change occurs when, as a result of heating or cooling, an element changes between the liquid, solid or gaseous states. PCM are often paraffin wax or salt hydrates, and are commonly used as hot or cold gel packs (i.e. transporting medication, laptop coolers, warm pizza boxes). Comprehensive R&D has been carried out under Annex 17-Advanced Thermal Energy Storage through Application of Phase Change Materials and Thermo-chemical Reactions-Case Studies and Demonstration Projects dealing with the basic material and technical aspects, as well as the demonstration of new technologies in pilot projects. Since this study was launched, considerable progress has been made on the feasibility of the concept and first steps towards market deployment.

Incorporation of micro-encapsulated PCM (paraffin wax) into the gypsum walls or plaster increases considerably the thermal mass and capacity of lightweight buildings. By night the PCM in the microcapsules cools and solidifies. During the day the warm air mixes with the cool walls, reducing the daily

temperature swing by several degrees, and thereby avoiding the need for electric chillers or, at a minimum, reducing the cooling requirements. Another application of active cooling systems is macroencapsulated salts that melt at an appropriate temperature. The PCM is stored in a building's air vent duct and the cold air is delivered via large-area ceiling and floor a/v systems.



Other thermo-chemical reactions like adsorption (the adhesion of a substance to the surface of another solid or liquid) of water vapour to silicagel or zeolites (naturally-occurring micro-porous crystalline solids made of aluminium, silicon and oxygen) can be used to generate heat and cold as well as regulate humidity. Of special importance in hot, humid climates or confined spaces where humidity levels are high, these open sorption systems use lithium chloride to cool water and zeolites to absorb ambient humidity.

Several industry workshops have been organised in conjunction with the regular semi-annual expert meetings. Two workshops were held during 2004: Arvika, Sweden and Beijing, P.R. China. The results of the work of Annex 17 will be published end-2005 and presented in a final workshop.

A comprehensive state of the art review of all thermal energy storage concepts and applications has been presented at the "9th International Conference on Thermal Energy Storage - FUTURESTOCK", Warsaw (Poland), September 2003. This well-attended conference was hosted by the Institute of Heat Engineering, Warsaw University of Technology.

For detailed information on the activities of the Energy Storage IA, see www.iea-eces.org/index.html.

MUCH MORE THAN HEAT

The formal title of the Heat Pump Programme (HPP) is the Implementing Agreement for Research, Development, Demonstration and Promotion of Heat Pumping Technology. However, the scope of the agreement is much wider than its name suggests - it actually includes heating, refrigeration, and air conditioning - all prominent energy efficient, cost-effective and climate-savings issues.

Policy in these areas is increasingly important for many IEA member (and non-member) countries, with the growth in the use of cooling and global warming each contributing to concerns about adequacy of peak electricity supply and increases in carbon emissions. In June 2004, the HPP was strongly involved in the workshop "Cooling Buildings in a Warming Climate" organised by the Future Buildings Forum. This workshop brought together several IEA buildingsrelated Implementing Agreements and a number of technical and policy experts. One important outcome of the event was that the key policy issues, especially in Europe, relate to regulatory measures - including the European Energy Performance of Buildings Directive. The workshop also generated timely suggestions for further policy-related studies and for technical and educational activities among the Implementing Agreements.

Environmental concerns over the use of harmful refrigerant liquids have prompted the HPP to examine this issue, and in particular in relation to carbon dioxide. The main objective of Annex 27-Selected Issues on CO_2 as Working Fluid in Compression Systems was to address the technical, safety and environmental matters associated with the use of CO_2 .

The technical and practical applications of using carbon dioxide as a working fluid needed to be addressed. Compact coolers, mobile space conditioning and heattransfer phenomena are some of the engineering challenges present in today's markets. Regarding safety, a major concern was the high operating pressure in supermarket refrigeration cases that are in close contact with people in the shopping area. Annex 27 successfully addressed and resolved all these issues, and the results were directly applied - technology using



Semi-hermetic compressor on a low-temperature supermarket refrigeration system with secondary fluid on both evaporator and condenser sides is integrated into the supermarket space heating system and works as a heat pump, Montreal (Canda).

CO₂ developed in Norway is now in use in Japan. A workshop and proceedings are available.

Supermarkets use large amounts of refrigeration equipment, both to cool the space and to store 26-Advanced Supermarket food. Annex Refrigeration/Heat Recovery Systems brought together European and American expertise to analyse the impact of energy use in supermarkets on global warming. This included theoretical and field studies on how to reduce global warming using advanced systems in individual countries. The results, presented at the International Institute of Refrigeration (IIR) Congress, demonstrate that energy savings of more than 10% can be achieved and reductions in global warming (Total Equivalent Warming Impact, or TEWI) of up to 60% are possible with low-charge refrigeration systems (compared to traditional designs). A final report and workshop proceedings are available.

The Heat Pump Programme's main ongoing activity deals with the crucial issues of test standards and calculation methods for seasonal efficiency. Annex 28-Test Procedures and Seasonal Performance, examines systems that provide both space heating and hot water. Annex 28 complements the work carried out by the European Committee for Standardisation (CEN) on heating-only applications. Nearly all the HPP participants are involved in the work of the CEN, with overlapping membership on standards committees.

For detailed information on the activities of the Heat Pumps IA, see www.heatpumpcentre.org.

Industry

Emissions Reduction in Combustion High-temperature Superconductivity Process Integration in the Pulp and Paper Industry

TARGETING COLLABORATION FOR SUCCESS

The work of ECERC IA is organised into five main areas.

Area 1-Advanced Piston Engine Technology, includes work on the induction processes, fuel-air mixing, ignition, flame processes, exhaust phenomena, spray and combustion in diesel engines, and combustion performance and characteristic of fuels.

As for Area 2-Advanced Furnace Technology Fundamentals, research concentrates on projects such as burner phenomena, gas flows, fuel-air mixing, flame processes, and post-flame process.

Turbulent reacting flows and physical and chemical processes are the subject of work in Area 3-Fundamentals, while Area 4-Advanced Gas Turbine Technology concentrates on combustion modelling and verification, emissions formation and control mechanisms, and injection and fuel-air mixing.

Lastly, Area 5-Supporting Activities deals with information exchange and distribution.

The II participants of the Implementing Agreement for a Programme of Research, Development and Demonstration on Energy Conservation and Emissions Reduction in Combustion (ECERC IA) have recently completed a two-year review of their research areas.As a result, several new research topics have been proposed in the following areas:

Particulates and the formation and mitigation of soot;

 Homogeneous Charge Compression Ignition (HCCI) that can provide diesel-like efficiencies and ultra-low NOx and PM emissions;

- Hydrogen Internal Combustion Engines that will reduce dependency on fossil fuels;
- Internal Combustion Engine Sprays to provide refined fuel injection; and

 Furnaces and Boilers leading to highly efficient heating systems.

These new project areas will build on efforts of individual countries, such as soot problems (Canada and the United States), HCCI (United States), fuel sprays (Japan), and furnace and boiler efficiency (Belgium). Each of these areas of national expertise will feed into an international "target collaboration", contributing towards a final solution.

One successful collaboration with industry at the national level has been maintained in the United States by Sandia National Laboratory Combustion Research Facility with a manufacturer of heavy-duty truck engines, using LII (Laser Induced Incandescence) to continuously log emissions levels on diesel-powered trucks The goal is to meet and satisfy the U.S. Environmental Agency Heavy-duty Federal Test Procedures. The Sandia-developed LII system was operational 24 hours/day for 7-1/2 continuous weeks using a dedicated operator to create data files and start and stop each test. Future plans include commercialising the test facility for wider use.



HCCI engine

For detailed information on the activities of the Emissions Reduction in Combustion IA, see www.im.na.cnr.it/IEA.

CABLE CHALLENGES AND OPPORTUNITIES



Yokosuka cable bridge. Japan's SuperAce Program is now testing a prototype 77 kV, AC HTS cable at CRIEPI's Yokosuka Laboratory. Portions of the cable's route are underground, near the ground and overhead.

Superconductors can transform several areas of industry through applications such as:

Current transport and energy storage with negligible loss;

Generation of very large magnetic fields through persistent currents, leading to magnetic levitation and suspension which enable the development of "frictionless" motors, bearings, flywheels and trains;

■ High performance resonators, filters and interconnecting passive devices which not only will have unsurpassed efficiency, but also will be dispersionless, a feature particularly useful in the microwave communication field;

Ultra sensitive magnetic field detectors which will transform the brain functions diagnostic, methods for early warning of seismic activities and for monitoring fluid flow in mining, as well as the detection of gravitational waves;

■ Josephson junction-based superconducting electronics in a form which combines this quantum effect and the quantisation of magnetic flux and could lead to the development of the very fast and low energy consumption digital devices. The IEA Implementing Agreement for a Co-Operative Programme for Assessing the Impacts of High-Temperature Superconductivity on the Electric Power Sector (HTS IA) considers, evaluates and disseminates the significance of research, development and demonstration activities throughout the world.

During 2004, the HTS IA completed work on the most comprehensive study HTS Cable: Status, Challenges and Opportunities. This application is at the forefront of High Tc development (temperature coefficient greater than 30°K), with 11 projects involving cable manufacturers (including the cryogenic part) and utilities across the world. For the first time, policy makers and R&D managers will have a detailed, unbiased source to consult about this topic. The 400page report was peer-reviewed by experts in Asia, Europe and North America.

In collaboration with the European SuperConductivity Network (SCENET), the HTS IA convened the first International Workshop concerned with Low-Temperature, High-Voltage Dielectrics. The subject was chosen for two reasons. First, it is vital to the success of the international effort in the development of applications of the high-temperature superconductors such as high power cables, motors and generators. Second, this subject has been largely over-looked to date. Thirty-three experts from eleven countries participated.

Another recent study published under the auspices of HTS IA, The Relation Between The Concern For Power Quality and Future Power Sector Equipment Incorporating Ceramic Superconductors discusses in detail an increasingly important aspect of network reliability and the role that future HTS equipment may have in working towards improvements in this area.

There are fifteen countries participating in the HTS IA: Belgium, Canada, Finland, Germany, Israel, Italy, Japan, Korea, the Netherlands, Norway, Sweden, Switzerland, Turkey, the United Kingdom, and the United States.

references:

Wolsky, A.M., (2004), HTS Cable: Status, Challenge and Opportunity.

Wolsky, A.M., (2003), The Relation Between The Concern For Power Quality and Future Power Sector Equipment Incorporating Ceramic Superconductors.

For detailed information on the activities of the High-Temperature Superconductivity IA, see http://spider.iea.org/tech/scond/scond.htm.

COMBINING RESEARCH EFFORTS LOWER COSTS

Process integration is the application of methodologies developed for system-oriented and integrated approaches to industrial process plant design for both new and retrofit applications. The methodologies can be mathematical, thermodynamic and economic models, methods and techniques, and may include artificial intelligence, hierarchical analysis, pinch analysis and mathematical programming. Process integration may benefit many industries through optimisation of design, increased energy efficiency, operability, flexibility, controllability, safety and yields, with lower capital investment and lower greenhouse gas emissions.

The processing of pulp and paper is one such industry. In an effort to further develop tools and methods for process integration and to increase resource efficiency within the pulp and paper industry, two Implementing Agreements combined research efforts. The Implementing Agreement for Advanced Energy-Related Technologies in the Pulp & Paper Industry, and the Implementing Agreement for a Co-operative Programme on Process Integration Technologies agreed to join efforts and share results under Annex XIII-Process Integration in the Pulp and Paper Industry. The objectives of this Annex XIII are to:

■ Increase efficient use of energy in the process industry through promotional activities such as education and awareness;

 Reduce greenhouse gases from energy use in the pulp and paper industry (it has been implemented in well over 100 mills); and

Evolve towards a wider process integration concept, taking into account process design as well as operation and long term process planning.

The results of Annex XIII will be designed for use by energy experts and decision-makers in the pulp and paper industry, consultant companies and the international research community, and will include:

- A final report consisting of background information;
- Descriptions and results from all case studies;

Brief descriptions of tools and methods used in the case studies;

 Identification of the need for further development of tools and methods for the pulp and paper industry;

• Comparisons and evaluations of the results from the case studies with emphasis on scope for improvements of the energy/environmental situation; and

• General conclusions and suggestions for further work within the IEA.



Cumulative Number of Process Integration Studies in the Pulp and Paper Industry Worldwide

In addition to the pulp and paper industry applications, process integration studies cover work in the areas of:

Short- and medium-term implementation, including studies aimed at identifying cost-efficient measures for increasing the resource efficiency of existing mills, and are constrained by current process design and installed process equipment. Efficiency improvements can be evaluated based on their own costs and savings, and recommended measures can be expected to be implemented in the short- to medium-term.

Strategic decision-making, which includes studies aimed at supporting decision-making in connection with design of new plants (or major up-rating exercises) or process development projects. Fewer process constraints are included and alternative design options are evaluated on equal terms. The implementation of recommended measures in this type of studies is directly linked to other strategic decisions.

references:

For detailed information on the activities of the activities of the Pulp and Paper IA, see www.ieapap.com. For detailed information on the activities of the activities of the Process Integration IA, see www.iea-pi.org.

Fusion Power

Environmental, Safety and Economic Aspects of Fusion Power Large Tokamaks Nuclear Technology of Fusion Reactors Plasma Wall Interaction in TEXTOR Reversed Field Pinches

INTEGRATING STUDIES

The Contracting Parties in the Environmental, Safety and Economic Aspects of Fusion Power Implementing Agreement are Japan, the European Union, the Russian Federation and the United States. For a number of years research groups in Japan, the United States and the European Union have collaborated in work on the individual technical aspects of the environmental, safety and economic aspects of fusion power. These studies showed good potential for viable economic performance, and for very favourable safety and environmental impacts stemming from inherent characteristics of the fusion process. Collaboration has also been fruitful in studies of designs of commercial fusion power plants. The technical aspects of fusion electricity generation are consistently integrated into overall designs of the plant and of the key individual components: these designs being constrained to preserve excellent safety and environmental characteristics whilst aiming for the best possible economic performance.

The parties have developed a variety of designs, differing in details. These differences arise from choices of different concepts for the key components and their constituting materials, and from varying assumptions relating to the projection of technical performance from the information gained in current research and development.

Regular workshops have been held to exchange information and ideas about design solutions and problems, and about analyses of component and overall plant performance. This has been very productive and has now produced a wide measure of agreement on the understanding of technical issues and on how different design choices lead to variations in the safety, environmental and economic characteristics of the plants.

The conclusions from this work are best illustrated by the results from a large European study that completed its work in 2004. Drawing heavily upon ideas stemming from work undertaken in the United States and Japan, this study developed and analysed four conceptual designs, all based on the main ("Tokamak") line of fusion development exemplified by the planned device ITER.

The main results, which are in conformity with results from Japanese and American studies, were as follows.

Irrespective of detailed design variations and material choices, the worst possible accidents would have only limited impact upon the public, and that the hazard from waste materials would fall relatively rapidly and would therefore not impose a management burden on future generations.

■ The costs of electricity generation are within the range of estimates for the future costs from other sources, the adoption of advanced materials and operating regimes naturally leading to the lowest costs. With a good understanding of these "standard models" now achieved, attention is now turning to other issues. In Europe and Japan, studies will focus on designs for DEMO. a power plant that will bridge the gap between ITER and the first generation of commercial power plants. In the United States, studies will focus on commercial power plant designs based on an alternative to the standard Tokamak concept, that has potential for further improved economic performance.



Bird's-eye view of a model fusion power plant.

For detailed information on the fusion power Implementing Agreements, see www.iea.org/techagr.

COORDINATING MULTI-MACHINE EXPERIMENTS

A Tokamak is the most successful device yet found for magnetic confinement of plasma. Its magnetic field is made up from helical lines of force on toroidal surfaces, and is generated both by external field coils and by the current in the plasma. The word tokamak comes from a Russian acronym for toroidal magnetic chamber.

Large Tokamaks, JT-60 and JET (Joint European Torus), reached equivalent break-even with an energy gain of I and has been making essential contributions to establish physics and the technological basis for ITER (ITER is the experimantal step between today's studies of plasma physics and tomorrow's electricity producing fusion power plants). This would demonstrate a sustained fusion burn of approximately 0.5 GW by the Tokamak concept.

Between June 2003 and September 2004, 50 scientist assignments were exchanged between the European (JET), Japanese (JET) and the United States Tokamak facilities, and four workshops were held as follows:

 Workshop 54:The Second IEA Large Tokamak
Workshop on "Implementation of the ITPA Coordinated Research Recommendations" (JT-60)

 Workshop 55: Physics Needs for High Beta Steady State Tokamak (JT-60)

■ Workshop 56: Physics of Current Hole (JT-60)

 Workshop 57:Heating and Control for long pulse operation in large Tokamaks (European Commission)
Highlights of activities during 2003-2004 include

increased participation from world Tokamak leaders at the IEA large Tokamak workshop on coordination of multi-machine experiments. A joint workshop among the Implementing Agreements on Large Tokamaks, PD and TEXTOR (Workshop 54) was held to coordinate implementation of ITPA coordinated research recommendations with Russia and China. In this workshop, almost all Tokamak facility leaders contributing to the International Tokamak Physics Activity (ITPA) were assembled and discussed results and plans of ITPA multi-machine experiments (JT-60, JET, DIII-D, AUG, C-MOD, NSTX, FTU, MAST, JFT-2M, TEXTOR, TCV, TS, T-10, T-11M, GLOBUS-M, TUMAN-3M, FT-2, HL-2A, HT-7).

Another important highlight is a joint investigation of new plasma configuration named "Current Hole" discovered in JT-60 and JET.A workshop was held at JT-60 to understand this configuration as a possible operation scenario of Tokamaks.



Diagram of a JAERI Tokamak 60 (JT-60).

To increase public visibility and information exchange, the Executive Committee of IEA Large Tokamak cooperation developed a homepage. The web site is organised in two parts: the free-access part for the general public and the restricted-access part for the Executive Committee members.

In the free-access part of the web site one can find the history of IEA Large Tokamak work, theory and simulations, explanations of atomic and molecular data, details of the JFT-2M and JT-60 programmes, annual reports, Executive Committee member contact information, task structure, and more.

For detailed information on the activities of Large Tokamaks IA, see www-jt60.naka.jaeri.go.jp.

ADVANCES TOWARDS A VIABLE ENERGY SOURCE

In order to make fusion achievable, we need to understand how to contain and maintain "hot" plasma and how to extract the energy from that plasma to generate electricity. The objective of the collaborative program on Nuclear Technology of Fusion Reactors (NTFR) is to conduct R&D on key fusion power plant components (those operating close to the fusion burning plasma that need to handle large flows of energy) and their associated technologies.

Despite the recent global focus on negotiations for ITER, NTFR has proven to be the most effective way to develop these technologies as they undergo integrated testing in ITER. The ultimate goal will be to develop effective, reliable, functioning components with prolonged lifetimes, in the conditions expected to occur in commercial fusion power plants. This is crucial to economic performance of fusion power.

The NTFR Implementing Agreement has two major activities (annexes). A number of fruitful collaborations took place during 2003-2004 on Annex 1-Tritium Breeding Blanket, Radiation Shielding & Tritium Processing Systems of Fusion Reactors. Work on this activity relates to the components known as "blankets", and their associated systems and technical issues. The blanket converts fusion energy (in the form of neutrons) into thermal energy (heat) which is used to produce electricity. The blanket is composed of a solid or liquid lithium-based material. It must also breed tritium, which, along with deuterium, is one of the two elements necessary to continue the fusion reaction. The blanket must also provide tritium fuel to activate other fusion power plants.

The second activity of NTFR, Annex 2-Plasma-Facing Components for Fusion Reactors, concerns the components immediately facing the plasma. These components experience a substantial amount of energetically charged particles, making it a very harsh and difficult environment in which to survive.

A significant amount of work has been accomplished in several technical areas essential to the development of solid breeding test blanket modules (TBM) for use in ITER. These include development of a solid breeding materials fabrication process, irradiation testing and experimental evaluation of thermo-mechanical properties of packed pebble bed. This work will be supported by modelling and development of a



A solid breeding blanket mock-up at Fusion Neutronics Source, JAERI (Japan).

common design database to help insure that the ITER TBM are all done on a common basis. Collaborative efforts are expected to continue in almost all of these areas for the near future. An international workshop in September 2004 on liquid breeding blankets succeeded in building a framework for active collaboration in five technical areas, with a goal to developing a liquid breeding TBM for ITER.

Extensive collaborative activities continued on a wide array of fusion neutronics projects, including: integral experiments on solid breeding blanket and materials to support the TBM development, experiments of induced radioactivity of low activation materials, improvement of fusion-relevant nuclear data, nuclear design studies and code development and calibration of the measuring techniques for tritium production rates in blankets. The mock-up assembly was composed of a tungsten armour, beryllium neutron multipliers layers, Li2TiO3 breeders layers, and a cooling water layers housed in a reduced activation ferritic steel (F82H) casing, and tritium breeding performances were examined by irradiating 14 MeV neutrons. Efforts have also been devoted to compilation of fusion neutronics experiments conducted in the SINBAD Radiation Shielding Experiments Database in collaboration with the Nuclear Energy Agency (NEA). Lastly, development and verification of a code to predict the behaviour of tritium released in a fusion facility, important for safety analysis, was recently completed.

For detailed information on the fusion power Implementing Agreements, see www.iea.org/techagr..

ITER-RELEVANT VERSATILE TEST FACILITY

Twenty percent of the thermal power of a fusion reactor has to be transferred from the hot plasma through the wall components of the burn chamber. This has to be achieved without overheating and excessive erosion of the plasma facing materials, without degrading the thermonuclear burn process by impurities released from the walls, and without burying too much tritium. Moreover, the helium ashes produced by the fusion processes have to be removed from the plasma with sufficient efficiency but without lowering the quality of thermal isolation of the fusion plasma.

The objective of the Implementing Agreement on Plasma Wall Interaction in TEXTOR (TEXTOR IA) is to study these processes, evaluate their relative importance and to develop methods for their control. This includes developing novel specific diagnostics and methods to condition the wall, to structure the wall and the magnetic field, and to influence the transport features of the confined plasma.

The TEXTOR IA is based on particularly strong and valuable collaboration between Canada, EURATOM, Japan and the United States. In the course of the world-wide research on fusion power, priority tasks for developing a long pulse reactor have emerged. These include heat removal, particle exhaust and the other objectives of TEXTOR IA, coupled with plasma confinement as a whole. A variety of approaches (e.g. materials, divertors, limiters) need to be developed, tested and evaluated. Medium-sized machines like TEXTOR have the particular mission of exploring new methods and concepts before transferring them to the large devices of reactor-grade performance.

The research programme is highly relevant for next generation machines, both on the Tokamak development path (ITER) and the Stellarator path (Wendelstein 7-X), and more generally for a stationary fusion reactor. Work under TEXTOR IA has contributed to solving problems concerning the interaction between the plasma and the reactor wall; including controlled heat transfer onto and through the wall, impurities released from the wall, retention of the nuclear fuel (tritium) in the wall and removal of the helium ashes produced by the fusion process. It has enabled the partners to make use of the TEXTOR facility to progress technology development and enabled the transfer of knowledge from TEXTOR to other research facilities, contributing to the total development process.



The TEXTOR tokamak being opened during an upgrade phase (Research Centre, Jülich, Germany).

An additional research area is now accessible with the recently commissioned Dynamic Ergodic Divertor (DED), the result of joint efforts of the European EURATOM Associations Research Centre Jülich (Germany), FOM Rijnhuizen (Netherlands) and ERM/KMS (Belgium), supported by CEA Cadarache (France) and the partners of the IEA Implementing Agreement on Plasma Wall Interaction in TEXTOR.

In combination with the versatile heating systems on TEXTOR, DED is a unique tool to excite, control or even suppress plasma instabilities, which is crucial for the burning fusion plasma experiment ITER. The goal of ITER is to demonstrate 500 MW of fusion power with a power amplification of 10. Although not all instabilities are detrimental, as they may provide mechanisms to control particle and energy exhaust, instabilities eventually limit the plasma pressure and thus the achievable fusion power.

First results show that magnetic perturbation fields of the DED reproducibly excite so-called "tearing modes" which allow the study of properties under controlled conditions. Heating by electron cyclotron waves at the mode location results in a complete suppression of the instability. This has a direct application to ITER where this technique may stabilize a related type of mode which is believed to be the major pressure limiting instability.

For detailed information on the fusion power Implementing Agreements, see www.iea.org/techagr.

MOVING BEYOND MAGNETIC CHAOS

Reversed Field Pinches (RFP) is a toroidal axisymmetric configuration, based on self-organised plasmas, similar to astrophysics. It is one of the possible magnetic confinement alternatives to the Tokamak concept, the most widely-researched fusion magnetic confinement option. The RFP concept offers potential advantages as an energy source, such as lower field and forces at the magnets and higher fusion power density in the reactor. The weaker magnetic field (ten times lower) may result in a significant advantage for fusion reactors, but reduces plasma stability and confinement.

The main activities of the Implementing Agreement for Research and Development of Reverse Field Pinches (RFP IA) are theoretical collaboration, diagnostic development and exchanges, joint experiments, data analysis and annual workshops. The objective is to improve the physics and technology base of RFP and enhance the effectiveness and productivity of R&D efforts in this area by strengthening co-operation among the Contracting Parties, European Atomic Energy Community (EURATOM), Japan, and the United States. In the last five years, the RFP IA produced significant scientific results (29 papers on refereed journals, plus many more at conferences). During the period 2000-2005, significant progress was made in the areas of:

Experimental study and modelling of MHD phenomena;

 Active control of plasma instabilities by fast amplifiers;

- Study of turbulence in the outer plasma region; and
- Specific technologies and spin-offs.

The strategy for the next five years is based on recent advances in understanding the physics underlying new régimes, and the new experimental capabilities of the projects RFX (Reversed Field Experiment), MST (Madison Symmetric Torus), and TPE-RX (Toroidal Pinch Experiment-RX). Key areas of collaborative development will be in the areas of confinement, current drive, resistive wall instabilities and beta limits.

Improvement of confinement is a major objective of the RFP IA. Ongoing research in this area concentrates

on inductive control of the current density profile (PPCD) and single-helicity (SH) states. The goal is to replace transient techniques by steady techniques. Elements of this work are shared among, and carried out by, each of the participants: RF wave injection (United States), neutral beam current drive (Japan), and oscillating magnetic fields, or LF (EURATOM). This work is relevant as, in addition to confinement, it advances understanding of **Current drive physics**. The objective of confinement research on single-helicity states is to shift from quasi single-helicity (QSH) states to pure SH states using the helical magnetic boundary to extend the parameter range. In addition to confinement, SH states would introduce all-new physics.



The diagram shows the effect of current density profile control in improving confinement.

Research on resistive wall instabilities (RWM) is particularly relevant to ITER, due to the long pulse and "advanced" regimes. Using 192 specific magnets and independent amplifiers, RFX has been modified to study RWM. Feedback control of RWM, if successful, will be easily exported to the Tokamak configuration. The goal is to demonstrate feedback stabilization of RWM using real-time control techniques. The RFP IA will develop the models and diagnostics (also for dynamo mode control).

The goal of research on **beta limits** is to determine the ultimate limit using auxiliary heating (RF and NB). Beta is a measure of efficiency of confinement by the magnetic field. The level is already higher than in Tokamaks, but the limit is, as yet, unknown. The RFP IA will co-ordinate this effort.

For detailed information on the fusion power Implementing Agreements, see www.iea.org/techagr.

Cross-sectional Activities

Climate Technology Initiative (CTI) Energy and Environmental Technologies Information Centres (EETIC) Energy Technology Data Exchange (ETDE) Energy Technology Systems Analysis Programme (ETSAP)

TECHNOLOGY TRANSFER, CAPACITY BUILDING

The Climate Technology Initiative (CTI) was established in 1995 at the first Conference of Parties to the United Nations Framework Convention on Climate Change (UNFCCC) by 23 countries and the European Commission. It began as a voluntary international initiative to strengthen the development and enhancement of technologies, practices and processes addressing climate change in both developed and developing countries. In July 2003, the CTI became an IEA Implementing Agreement.

A key objective of the CTI is information dissemination of climate-friendly and environmentally sound technologies and practices. This involves holding regional capacity building workshops and seminars in collaboration with the United Nations climate and development programs UNFCCC, UNIDO, UNEP, and UNIDO, as well as the IEA.

The CTI believes that effective transfer of technologies and development of a common understanding of the issues and possible actions will involve industry, academia and the financial sector. Efforts need to be made continuously to follow new technology developments and address rapidly changing international circumstances.

The objectives of CTI include advancing the development of coherent and integrated technology needs assessments among developing and transition countries. In collaboration with UNDP and UNEP, the CTI provides technical assistance to selected countries through technology needs assessment methods training and workshops. This includes developing and disseminating materials and information on lessons learned, such as development of a technology needs assessment handbook.

Over the past two years, the CTI facilitated technology needs assessment aiming to:

 Identify clean energy technology priority sectors (in partnership with developing countries);

 Implement targeted activities in selected priority sectors to foster market development and clean energy technology transfer;

Evaluate activities, and disseminating lessons learned, to inform market development and country activities in other regions and sectors; and



Participants in the CTI seminar "Energy Efficiency for Asian Countries", Yokkaichi (Japan).

 Develop strategies to eliminate barriers to technology transfer.

Training courses focus on the special requirements and circumstances of the target countries. Specific activities include:

 Capacity building for technology needs assessment, project planning and assessment, and the establishment of institutional arrangements;

Information dissemination of environmentally sound technologies and best practices appropriate to the region and circumstances of the target country;

 Identification of financing needs and alternative means of project financing;

• Exchange of experiences in the use of successful environment energy policy instruments;

Professional education and training;

 Initiation and strengthening of networking between institutions for energy efficiency and renewable energy; and,

 Facilitating interaction between governments, agencies, and other organizations.



Workshop on Technology Needs Assessment and Information for the Caribbean Region, Port of Spain (Trinidad and Tobago).

For detailed information on the activities of Climate Technology Initiative, see www.climatetech.net.

THREE MILLION CITATIONS: ONE SOURCE

Access to the Energy Technology Data Exchange (ETDE) Agreement information has grown significantly in recent months. To meet Energy Ministers goals of improving the deployment of sustainable technologies and capacity building, ETDE members began granting access to developing countries in April 2004. Thirtyseven developing countries were authorized for unconditional access during the first phase. And an additional 17 countries were for subsequent phases of access. By end-2004, the following countries had been granted access: Albania, Algeria, Armenia, Azerbaijan, Bangladesh, Bolivia, Bulgaria, Cameroon, Congo (Democratic Republic), Ecuador, Egypt, El Salvador, Ethiopia, Georgia, Ghana, Guatemala, Kazakhstan, Kenya, Madagascar, Mali, Moldova, Mongolia, Morocco, Myanmar, Nicaragua, Niger, Nigeria, Pakistan, Paraguay, Peru, Philippines, Romania, Russia, Senegal, Sri Lanka, Tajikistan, Thailand, Uganda, Ukraine, Uzbekistan, Vietnam, Yemen (Republic of), and Zambia.

ETDEWEB, the ETDE Internet version of the ETDE database, has seen significant positive changes during recent months. Previously, containing information from 1995 forward, ETDEWEB now includes historical information from 1987 onwards (ETDE Energy Database), and historical information from 1974 onwards (United States Department of Energy Office of Science and Technology Information Energy Citations database). The results is one database with over 3.4 million citations to energy-related research and literature. Since funding for various technologies ebbs and flows, the most current research in a technology area could be more than 10 years old. Users now have single-source access to historical information and current research. Beginning in September 2004, users also gained the ability to download ETDEWEB records - as many as 200 at once.

Based on 2003 usage data, a minimum of 1 000 unique users access ETDE information monthly through the commercially-based ETDE database products, while the ETDEWEB system showed close to 45 000 logins for the year. Additional access is also made through



country-specific systems in Brazil and Korea. Results of an updated user survey for ETDEWEB will be available in early 2005.

Access to full text information has also been a key focus during the reporting period. Members have made excellent progress to directly provide full text or to provide links to the full text for reports and for conferences. Journal literature, which makes up a significant segment of the database, has been more difficult, due to the copyrighted nature of the publications.

With the advent and increasing popularity of Digital Object Identifiers (DOI) to enable users to get to specific articles, 2004 saw ETDE joining the CrossRef organization and adding tens of thousands of DOI links to ETDEWEB by the end of 2004. The direct benefit to the researcher is that if their organization subscribes to the journal (or for those that are free), immediate access is possible. If no subscription is in place, most publishers are now offering single article availability, rather than requiring purchase of the whole journal issue.

The new 5-year strategic plan calls for ETDE to continue to look at ways to improve and expand on its services by looking at new technologies and broadening strategic partnerships. ETDE continues to strive to be 'best in class' regarding energy-related information.

references:

For direct access to the ETDE online database, ETDEWEB, see www.etde.org/ETDEWEB. For detailed information on the activities of the Energy Technology Data Exchange, see www.etde.org.

ENERGY TECHNOLOGY PROJECT HUBS

The Energy and Environmental Technologies Information Centres (EETIC) groups the CADDET and GREENTIE Centres, which operate in close collaboration.



The new EETIC logo.

The Centre for the Analysis and Dissemination of Demonstrated Energy Technologies (CADDET) exchanges information about demonstration projects on energy efficiency and renewable energy. CADDET works through a network of national teams, channelling new ideas to users. Its main product is the InfoStore, a searchable database with more than 1 600 case studies. InfoStore includes information on projects, including their technical details, energy and environmental impact and economics. Projects are classified by country, technology and sector but can also be searched by entering a keyword or words in the first field. A search for France, for example, will show the aims, summary of results, technical, energy, environmental, economic and contact details of 19 projects in the areas of both energy efficiency and renewables.

The Web site also houses a wide range of other publications, news and information. During 2003-2004 the CADDET site was expanded to include:

- Addition of 73 new InfoStore entries
- Publication of 5 new CADDET technical brochures

 Production of four InfoPoint newsletters and distribution of 9 000 copies per issue

During the same period, visitors to the CADDET site downloaded 1.5 million pages and products, of which over 100,000 PDF files.

During 2003 the two previous CADDET programmes, covering energy efficiency and renewable energy, were combined into a single programme, reflecting the close synergy between these two areas.

The two InfoPoint newsletters were combined into a single sixteen page issue and a combined CADDET web site was launched in November 2003. Streamlining carried out in recent years has enabled operational costs to be reduced, while new added-value web-based features have increased EETIC's value and penetration.

The Greenhouse Gas Technology Information Exchange (GREENTIE) is a network in 22 countries that exchange information on clean energy technologies and to bring know-how and experience to developing countries. At the heart of GREENTIE is the on-line directory of more than 6 000 suppliers of greenhouse gas mitigating goods and services, in the areas of efficiency, renewables or other (such as clean fossil fuel technologies or nuclear).

Co-operative activities between EETIC and the United Nations Environment Programme's Sustainable Alternatives Network (SANet) continued, with the launch of an Indian Local Desk in early 2004, hosted by India's National Productivity Council (NPC). EETIC provided training for the operators and a variety of marketing material, including a set of new EETIC fact sheets. During 2003-2004, visitors to the GREENTIE website downloaded close to 600 000 pages and products.

In a recent on-line survey, EETIC users gave a high level of customer satisfaction. In 2003 EETIC began exploring options for complementing funds from members with income from suppliers of information to the CADDET and GREENTIE databases, in particular from non-member countries. In 2004 EETIC began investigating a range of options to broaden membership through flexible financing with an aim to achieving greater involvement of market players.

reference:

For detailed information on EETIC, see www.eetic.org.

For detailed information on the activities of CADDET, see www.caddet.org.

For detailed information on the activities of GREENTIE, see www.greentie.org.

TECHNOLOGY MODELLING AND SCENARIOS

An integrated system view of the different energy markets and technologies is the focus of this agreement. From energy balances provided by the IEA statistical office and from information on the existing stock of energy technologies, the experts of the Energy Technology Systems Analysis Programme (ETSAP) reconstruct a modelling system for a country, region or worldwide. Taking advantage of the research carried out by the IEA implementing agreements on possible future developments and competitiveness of new supply and end-use technologies, they build long term scenarios where issues regarding energy security, economic sustainability, environment protection and climate mitigation are addressed and analysed.

The ETSAP strategy is twofold:

Establish, maintain and enhance the flexibility of consistent multi-country energy/economy/environment analytical tools and capability (MARKAL TIMES family of models); and

 Assist decision-makers and government officials in the assessment of new energy technologies and policies in meeting the challenges of energy needs, environmental concerns, and economic development.

ETSAP promotes the development and deployment of clean and advanced energy technologies through international networking, cooperation, collaboration, analysis and policy advice. ETSAP also continues to more clearly define and analyse energy technology issues and opportunities, and to enhance the development of analytical tools that inform and support policy and program development in member countries.

During 2003-2004, ETSAP contributed to the development and implementation of four global economic equilibrium models:

The Energy Technologies Perspective model (ETP) of the Energy Technology and R&D office of the IEA, which has been used to set up the alternative scenario of the World Energy Outlook 2004 and to evaluate potential impact of Carbon Capture and Sequestration technologies in future energy systems;

■ The System for the Analysis of Global Energy markets (SAGE), the modelling tool used by the United States Energy Information Administration's to prepare the projections of world energy consumption of the International Energy Outlook;

The European Fusion Development Agreement TIMES model to evaluate the conditions under which fusion power plants are useful to energy systems in the second half of the century; and

The Global MARKAL MACRO model used by the Paul Scherrer Institute to evaluate the impact of global learning on energy production and costs, considering factors such as research, practice and related spill-overs.



Projected Marginal Mitigation Cost

ETSAP tools have been used: in various European projects to evaluate the impact of new energy technologies and the potential for emission trading; in the United States to study different energy environment policies; in South East Asian countries to study the potential of regional gas pipelines: and in southern Africa to assess the benefits of interconnecting the electric grids of 14 countries.

The impacts of energy environmental policies, including green white and black certificates have been evaluated using ETSAP tools in several countries: China, Estonia, Finland, Germany, Italy, Japan, Korea, South Africa, Turkey, and the United States.

The ETSAP tools have improved substantially in the last two years. The Integrated Markal Efom System (the TIMES model generator) has now been documented and is already being used with its corresponding new VEDA interfaces. The MARKAL model generator, whose different variants have now been completely redocumented, now includes the climate equations and the damage functions, permitting to account for most externalities; the multi-regional capabilities of the ANSWER users' interface have been largely increased in its most recent version.

For detailed information on the activities of the Energy Technology Systems Analysis Programme, see www.etsap.org.

ANNEXES

Frequently Asked Questions IEA Framework for International Energy Technology Co-operation IEA Energy Technology Committee Structure IEA Secretariat Implementing Agreement Support Implementing Agreement Participation Implementing Agreement Web sites
FREQUENTLY ASKED QUESTIONS

What is IEA technology collaboration?

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

In 2005, there were 40 collaborative projects with several thousand participants from 58 countries, international organisations or companies working in the areas of:

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

Who can participate?

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

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

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

What are the benifits of participation?

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

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

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

- Flexibility
- Intellectual property rights protection

How is technology collaboration structured?

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

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

How is technology collaboration financed?

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

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

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

What is the IEA framework?

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

What is the role of the IEA?

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

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

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

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

How can my organisation participate?

If your organisation is interested in participating in the technology collaboration programme, the first step is to contact the Chair, Operating Agent or Executive Secretary of an Implementing Agreement to discuss and define together what form your participation might take.

Thereafter follows an exchange of letters (formal invitation, acceptance, and notification), with the final step being the signature of the actual contract (Implementing Agreement).

How are new Implementing Agreements established?

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

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

For more information

For more information on the energy technology collaboration programme, the Framework, or details on the activities of individual Implementing Agreements, please see the IEA website Technology Agreements pages at www.iea.org/techagr.

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

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IEA FRAMEWORK FOR INTERNATIONAL ENERGY TECHNOLOGY CO-OPERATION

I. General Principles

Article I Mandate

- 1.1 In fulfilment of Chapter VII of the Agreement on an International Energy Program and in light of the Shared Goals of the IEA, the IEA operates Implementing Agreements to enable IEA Member countries to carry out programmes and projects on energy technology research, development and deployment.
- 1.2 An Implementing Agreement is a contractual relationship established by at least two IEA Member countries, and approved by the Governing Board, for the purpose set out in Article 1.1.
- 1.3 Participants in an Implementing Agreement shall contribute as fully as possible to the achievement of its objectives and shall endeavour to secure, through public and private support, the necessary scientific, technical and financial resources for the programmes and projects carried out under such an Implementing Agreement.
- 1.4 Each Implementing Agreement shall have an Executive Committee composed of representatives of all participants.

Article 2 Nature of Implementing Agreements

- 2.1 The activities of an Implementing Agreement may include, inter alia:
 - (a) co-ordination and planning of specific energy technology research, development and deployment studies, works or experiments carried out at a national or international level, with subsequent exchange, joint evaluation and pooling of the scientific and technical results acquired through such activities;
 - (b) participation in the operation of special research or pilot facilities and equipment provided by a participant, or the joint design, construction and operation of such facilities and equipment;
 - (c) exchange of information on (i) national programmes and policies, (ii) scientific and technological developments and (iii) energy legislation, regulations and practices;
 - (d) exchanges of scientists, technicians or other experts;
 - (e) joint development of energy related technologies; and
 - (f) any other energy technology related activity.
- 2.2 Participation in an Implementing Agreement shall be based on equitable sharing of obligations, contributions, rights and benefits. Participants in an Implementing Agreement shall undertake to make constructive contributions, whether technical, financial or otherwise, as may be agreed by the Executive Committee.
- 2.3 Some or all of the participants in an Implementing Agreement may choose to execute specific projects and/or programmes through Annexes to the Implementing Agreement.

II. Rules Applicable to IEA Implementing Agreements

Article 3

Participation, Admission and Withdrawal

- 3.1 An Implementing Agreement can be established by two or more IEA Member countries subject to approval of the Committee on Energy Research and Technology (CERT) and of the Governing Board. There are two possible categories of participants in Implementing Agreements: Contracting Parties and Sponsors.
- 3.2 Contracting Parties may be
 - (a) the governments of both OECD member or OECD non-member countries;
 - (b) the European Communities;
 - (c) international organisations in which the governments of OECD member countries and/or OECD non-member countries participate; and
 - (d) any national agency, public organisation, private corporation or other entity designated by the government of an OECD member country or an OECD non-member country, or by the European Communities.
- 3.2.1 Participation in any Implementing Agreement for OECD non-member countries or for international organisations requires prior approval by the CERT. However, should the CERT consider a first time application by an OECD non-member country or an international organisation to be sensitive, it may refer the decision to the Governing Board as it deems appropriate.
- 3.2.2 Prior to CERT approval of participation of OECD non-member countries or international organisations in any Implementing Agreement, the Executive Committee shall:
 - (a) have voted in favour of the applicant to join the Implementing Agreement and provide evidence of the same to the CERT;
 - (b) provide the CERT with a copy of the terms and conditions of the applicant's participation in the Implementing Agreement; and
 - (c) provide the CERT with a letter from the applicant expressing the applicant's desire to join the Implementing Agreement and specifying which Annexes it wishes to join; its acceptance of the terms and conditions of the Implementing Agreement; the name of its designated entity if it is not the applicant itself; and the name of the entity that will sign the Implementing Agreement.
- 3.2.3 The terms and conditions for the admission, participation and withdrawal of Contracting Parties, including their rights and obligations, in Implementing Agreements and their Annexes, if any, shall be established by the Executive Committee of each Implementing Agreement.
- 3.2.4 Notwithstanding Article 3.2.3, no Contracting Party from an OECD non-member country or international organisation shall have greater rights or benefits than Contracting Parties from OECD member countries.
- 3.3 Sponsors may be
 - entities of OECD member countries or OECD non-member countries who are not designated by the governments of their respective countries to participate in a particular Implementing Agreement; and
 - (b) non-intergovernmental international entities in which one or more entities of OECD member countries or OECD non-member countries participate.
- 3.3.1 Participation of Sponsors in Implementing Agreements requires prior approval by the CERT.

- 3.3.2 Prior to CERT approval of Sponsor participation in any Implementing Agreement, the Executive Committee shall:
 - (a) have voted in favour of the applicant to join the Implementing Agreement and provide evidence of the same to the CERT;
 - (b) provide the CERT with a copy of the terms and conditions of the applicant's participation in the Implementing Agreement; and
 - (c) provide the CERT with a letter from the applicant expressing the applicant's desire to join the Implementing Agreement and specifying which Annexes it wishes to join; its acceptance of the terms and conditions of the Implementing Agreement; and the name of the entity that will sign the Implementing Agreement.
- 3.3.3 The terms and conditions for the admission, participation and withdrawal of Sponsors, including rights and obligations, in Implementing Agreements and their Annexes, if any, shall be established by the Executive Committee of each Implementing Agreement.
- 3.3.4 Notwithstanding Article 3.3.3, no Sponsor shall have greater rights or benefits than Contracting Parties from OECD non-member countries and no Sponsor shall be designated Chair or Vice-chair of an Implementing Agreement.
- 3.3.5 The CERT shall have the right to not approve participation of a Sponsor if the terms and conditions of such participation do not comply with this Framework, any Decisions of the CERT or the Governing Board and the Shared Goals of the IEA.

Article 4 Specific Provisions

- 4.1 Unless the CERT otherwise agrees, based on exceptional circumstance and sufficient justification, Implementing Agreements shall be for an initial term of up to, but no more than, five years.
- 4.2 An Implementing Agreement may be extended for such additional periods as may be determined by its Executive Committee, subject to approval of the CERT. Any single extension period shall not be greater than five years unless the CERT otherwise decides, based on exceptional circumstances and sufficient justification.
- 4.3 Notwithstanding Paragraph 4.2, should the duration of the programme of work of an Annex exceed the term of the Implementing Agreement to which it relates, the CERT shall not unreasonably withhold approval to extend the Implementing Agreement for such additional period to permit the conclusion of the work then being conducted under the Annex.
- 4.4 Either the Contracting Parties or the Executive Committee of each Implementing Agreement shall:
- 4.4.1 approve the programme activities and the annual programme of work and budget for the relevant Implementing Agreement;
- 4.4.2 establish the terms of the contribution for scientific and technical information, know-how and studies, manpower, capital investment or other forms of financing to be provided by each participant in the Implementing Agreement;
- 4.4.3 establish the necessary provisions on information and intellectual property and ensure the protection of IEA copyrights, logos and other intellectual property rights as established by the IEA;
- 4.4.4 assign the responsibility for the operational management of the programme or project to an entity accountable to the Executive Committee of the relevant Implementing Agreement;
- 4.4.5 establish the initial term of the Implementing Agreement and its Annexes;

- 4.4.6 approve amendments to the text of the Implementing Agreement and Annexes; and
- 4.4.7 invite a representative of the IEA Secretariat to its Executive Committee meetings in an advisory capacity and, sufficiently in advance of the meeting, provide the Secretariat with all documentation made available to the Executive Committee members for purposes of the meeting.

Article 5 Copyright

- 5.1 Notwithstanding the use of the IEA name in the title of Implementing Agreements, the Implementing Agreements, the Executive Committee or the entity responsible for the operational management of the programme or project may use the name, acronym and emblem of the IEA as notified to the World Intellectual Property Organisation (WIPO) only upon prior written authorisation of the IEA and solely for the purposes of executing the Implementing Agreements.
- 5.2 The IEA shall retain the copyright to all IEA deliverables and published or unpublished IEA material. Implementing Agreements wishing to use, copy or print such IEA deliverables and/or material shall submit a prior written request of authorisation to the IEA.

Article 6 Reports to the IEA

- 6.1 Each Executive Committee shall submit to the IEA:
- 6.1.1 as soon as such events occur, notifications of any admissions and withdrawals of Contracting Parties and Sponsors, any changes in the names or status of Contracting Parties or Sponsors, any changes in the Members of the Executive Committee or of the entity responsible for the operational management of the programme or project, or any amendments to an Implementing Agreement and Annex thereto;
- 6.1.2 annual reports on the progress of programmes and projects of the Implementing Agreement and any Annex;
- 6.1.3 notwithstanding Article 6.1.1, in addition to and with the Annual Report, annually provide the IEA with the following information:
 - (a) the names and contact details of all current Contracting Parties and Sponsors;
 - (b) the names and contact details of all Contracting Parties and Sponsors who may have withdrawn from the Implementing Agreement or any Annex in the year covered by the Annual Report;
 - (c) the names and contact details of all new Contracting Parties and Sponsors who may have joined the Implementing Agreement or any Annex in the year covered by the Annual Report;
 - (d) any changes in the names or status of any Contracting Parties or Sponsors;
 - (e) the names and contact details of the Executive Committee members and the entity responsible for the operational management of the programme or project; and
 - (f) any amendments to the text of an Implementing Agreement and any Annex thereto.
- 6.1.4 End of Term Reports, which shall include all the information and documentation required by Decisions of the CERT then in effect and relating thereto; and
- 6.1.5 at the request of the IEA, any other non-proprietary information as may be requested by the IEA in connection with the IEA's mandate.

Article 7 Effective Date

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

IEA ENERGY TECHNOLOGY COMMITEE STRUCTURE



IEA Committee on Energy Research and Technology (CERT)

Chair	Graham Campbell (Canada)
Secretary	Antonio Pflüger
WORKING PARTIES	
Working Party on Fossil Fuel Technology (FFW	P)
Chair	- Barbara McKee (Linited States)
Socratary	lacek Podkanski
Mockino Pacty on Renewable Energy Technolog	ov (REIIIP)
	קא (וובשו)
Chair	
Secretary	Rick Sellers
Working Party on End-Use Technology (EUWP)	
Chair	Peter Cunz (Switzerland)
Secretary	Jeppe Bjerg
Fusion Power Co-ordinating Comittee (FPCC)	
Chair	
Secretary	Giorgio Simbolotti

IEA SECRETARIAT IMPLEMENTING AGREEMENT SUPPORT

Cross-Cutting Issues	Antonio Pflüger	antonio.pflueger@iea.org
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Working Party on Fossil Fuels (WPFF)

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Clean Coal Centre	Jacek Podkanski	jacek.podkanski@iea.org
Clean Coal Science	Jacek Podkanski	jacek.podkanski@iea.org
Enhanced Recovery of Oil	Jacek Podkanski	jacek.podkanski@iea.org
Fluidised Bed Conversion	Jacek Podkanski	jacek.podkanski@iea.org
Multiphase Flow Sciences	Jacek Podkanski	jacek.podkanski@iea.org

Renewable Energy Working Party (REWP)

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Working Party on End-Use Technologies (EUWP)

EUWP Secretary	Jeppe Bjerg	jeppe.bjerg@iea.org
Transportation		
Advanced Fuel Cells	Jeppe Bjerg	jeppe.bjerg@iea.org
Advanced Materials for Transportation	Jeppe Bjerg	jeppe.bjerg@iea.org
Advanced Motor Fuels	Jeppe Bjerg	jeppe.bjerg@iea.org
Hybrid and Electric Vehicles	Jeppe Bjerg	jeppe.bjerg@iea.org
Buildings		
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District Heating and Cooling	Carrie Pottinger	carrie.pottinger@iea.org
Energy Storage	Carrie Pottinger	carrie.pottinger@iea.org
Heat Pumping Technologies	Carrie Pottinger	carrie.pottinger@iea.org

Industry

Emissions Reduction in Combustion Process Integration Pulp and Paper High Temperature Superconductivity Mitsuhide Hoshino Mitsuhide Hoshino Mitsuhide Hoshino Mitsuhide Hoshino mitsuhide.hoshino@iea.org mitsuhide.hoshino@iea.org mitsuhide.hoshino@iea.org mitsuhide.hoshino@iea.org

Fusion Power Co-ordinating Committee (FPCC)

FPCC Secretary	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Environmental, Safety and Economic		
Aspects of Fusion Power	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Fusion Materials	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Nuclear Technology Fusion Reactors	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Plasma Wall Interactions in TEXTOR	Giorgio Simbolotti	giorgio.simbolotti@iea.org
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Stellarator Concept	Giorgio Simbolotti	giorgio.simbolotti@iea.org
Large Tokamak Facilities	Giorgio Simbolotti	giorgio.simbolotti@iea.org
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Cross-Sectional Activities		
Climate Technology Initiative (CTI)	Carrie Pottinger	carrie.pottinger@iea.org
Energy Technology Data Exchange (ETDE)	Carrie Pottinger	carrie.pottinger@iea.org
Energy and Environmental Technologies		
Information Centres (EETIC)	Piotr Tulej	piotr.tulej@iea.org
Energy Technology Systems Analysis		
Programme (ETSAP)	Fridtjof Unander	fridtjof.unander@iea.org

IMPLEMENTING AGREEMENT PARTICIPATION

Summary

As of 31 March 2005, there were 40 Implementing Agreements with a total of 58 representatives (Contracting Parties) from: 26 IEA member countries, 14 non-member countries, 1 international organisation (the European Commission) and 16 Sponsors. During the period, the Committee on Energy Research and Technology (CERT) approved the extension of the standard 5-year term for 19 Implementing Agreements.

Recent Trends

Implementing Agreements

A new Implementing Agreement, the Climate Technology Initiative (CTI) was established in July 2003, with 7 original Contracting Parties. Two others subsequently joined.

The Implementing Agreement for Renewable Energy Technology Deployment (RETD) is near finalisation. As of 31 March 2005, 8 countries had expressed written interest in participating in this Implementing Agreement. The RETD programme of work and strategic plan were expected to be approved in June 2005.

Another possible Implementing Agreement, Electricity Transmission and Distribution, has established an outline proposal and in November 2004 a call for written express interest was sent.

The Implementing Agreement of a Programme of Research and Development on Heat Transfer and Heat Exchangers expired. The work on this Agreement will merge with two other industry-related Implementing Agreements, Process Integration and Pulp and Paper. In an effort to develop greater synergy, systems optimization and higher profile, while reducing expenses and facilitating cooperation on new activities, the work of these areas will merge to become one Implementing Agreement.

In contrast, during the pervious period, I January 2002 to 30 April 2003, no new Implementing Agreements were created, yet one closed (IEA Information Centre for Gas Technology Information).

Contracting Parties

From I May 2003 to 31 March 2005, 23 new Contracting Parties (CP) representing countries signed the following Implementing Agreements: Cross-Sectional (11), Renewables (6), Transport (4), Fossil Fuels (1) and Industry (1). Of the new signatories, 3 were from IEA non-member countries.

During the same period, 35 CP representing countries withdrew from the following Implementing Agreements: Cross-Sectional (10), Fossil Fuels (9), Renewables (9), Buildings (4), Fusion (2), and Industry (1). Of those having withdrawn, 4 were from IEA non-member countries.

During this time, CP representing international organisations did not sign any Implementing Agreements, while there was I withdrawal.

For comparison, during the previous period (January 2002-April 2003), 21 CP signed Implementing Agreements (4 of which from non-member countries), while 8 withdrew.

Sponsors

From I May 2003 to 31 March 2005, 7 Sponsors formalised participation in the following Implementing Agreements: Clean Coal Centre (4), Greenhouse Gas R&D (2), and Energy Conservation through Energy Storage (1). Of the new Sponsors, 4 are located in IEA non-member countries. No Sponsors withdrew during this time.

In contrast, during the previous period (January 2002-April 2003), 3 Sponsors joined while 1 Sponsor withdrew.

IMPLEMENTING AGREEMENT PARTICIPATION

as of 31 March 2005



IEA

Non-IEA



IMPLEMENTING AGREEMENT PARTICIPATION TOTAL ALL CATEGORIES

	Fossil Fuels	Renewa- bles and Hydrogen	End-use Transport	End-use Buildings	End-use Industry	Fusion Power	Cross- sectional	TOTAL
Australia	4	7		2				15
Austria	3	4	2	2			2	13
Belgium		2	4	3	2			12
Canada	6	7	3	5	4	4	4	33
Czech Republic								
Denmark	3	6		4			4	19
Finland	3	5	3	4	4		3	22
France	3	6	3	3				16
Germany	-	5	2	4	2		3	17
Greece				2				5
Ireland		3						4
Italy	3	6	3	3	2			18
lapan	5	7	4	4	2	7	2	31
Korea	2		2	2			3	12
Netherlands	3	5	2	4		•	2	17
New Zealand	-	3						5
Norway	3	6		5	3		4	22
Portugal		4						8
Spain		5		3			2	12
Sweden	3	6	4	5	4		2	24
Switzerland	-	7	3	2	2		2	18
Turkey		2		2				6
United Kingdom	6	6	2	5	2		3	24
United States	5	7	4	5	3	8	3	35
IEA Total	58	111	45	72	35	22	46	389
Algeria								
Brazil		2						4
China		1						2
Croatia								
Egypt								
lceland		2						2
India								
Israel		2						4
Lithuania								
Mexico	2	5						9
Poland								
Russia						4		5
South Africa		2						3
Ukraine								
Venezuela	2							2
Non-IEA Total	7	18		2	3	6	2	38
TOTAL	65	129	45	74	38	28	48	427
Sponsors	15			I				16
Eur. Comm.	2	8				8	2	20

IMPLEMENTING AGREEMENT PARTICIPATION FOSSIL FUELS

	Clean Coal Centre	Clean Coal Science	Enhanced Oil Recovery	Fluidised Bed Conversion	Greenhouse Gas R&D	Multiphase Flow Sciences	TOTAL
Australia							4
Austria							3
Belgium							
Canada							6
Czech Republic							
Denmark							3
Finland							3
France							3
Germany							
Greece							
Ireland							•
Italy							2
lanan							<u>5</u>
Japan Korea							
Notborlands							2
Now Zooland							<u> </u>
							2
Portugal							<u>_</u>
<u>Fortuga</u>							<u>I</u>
Syndon							<u>ו</u>
Sweden							
Switzenand							I
							1
United Kingdom							<u> </u>
United States			_			_	5
IEA Total	7	11	9	12	14	5	58
Algeria							
Brazil							
China							
Croatia							
Egypt							
Iceland							
India							I
Israel							
Lithuania							
Mexico							2
Poland							
Russia							I
South Africa							I
Ukraine							
Venezuela							2
Non-IEA Total		2	2		2	I	7
TOTAL	7	13	11	12	16	6	65
Sponsors	5				10		15
Eur. Comm.							2

IMPLEMENTING AGREEMENT PARTICIPATION RENEWABLE ENERGIES AND HYDROGEN

	Bio- energy	Geo- thermal	Hydrogen	Hydro- power	Photo- voltaic	Solar Heating & Cooling	Solar- PACES	Ocean Energy	Wind	TOTAL
Australia										7
Austria										4
Belgium										2
Canada										7
Czech Republic										
Denmark										6
Finland										5
France										6
Germany										5
Greece										<u> </u>
Ireland										3
Italy										6
Japan										7
Korea										
Netherlands										5
New Zealand										3
Norway										6
Portugal										4
Spain										5
Sweden										6
Switzerland										7
Turkey										2
United Kingdom										6
United States										7
IEA Total	17	7	15	6	19	17	6	6	18	111
Algeria										
Brazil										2
China										I
Croatia										I
Egypt										I
Iceland										2
India										
Israel										2
Lithuania										
Mexico										5
Poland										
Russia										
South Africa										2
Ukraine										
Venezuela										
Non-IEA Total	3	2	2	I	2		6		I	18
TOTAL	20	9	17	7	21	18	12	6	19	129
Sponsors										
Eur. Comm.										8

IMPLEMENTING AGREEMENT PARTICIPATION END-USE TECHNOLOGIES: TRANSPORT

	Advanced Fuel Cells	Advanced Motor Fuels	Hybrid & Electric Vehicles	Advanced Materials Transportation	TOTAL
Australia					I
Austria					2
Belgium					4
Canada					3
Czech Republic					
Denmark					1
Finland					3
France					3
Germany					2
Greece					
Ireland					
Italy					2
lapan					4
Korea					2
Notborlands					2
New Zeeland					<u> </u>
Dortugal					- 1
Contugal					
spain					
Sweden					4
Switzerland					3
Turkey					-
United Kingdom					2
United States					4
IEA Total	17	11	11	6	45
Algeria					
Brazil					
China					
Croatia					
Egypt					
Iceland					
India					
Israel					
Lithuania					
Mexico					
Poland					
Russia					
South Africa					
Ukraine					
Venezuela					
Non-IEA Total					
TOTAL	17	11	11	6	45
Sponsors					
Eur. Comm.					

IMPLEMENTING AGREEMENT PARTICIPATION END-USE TECHNOLOGIES: BUILDINGS

	Buildings & Community Systems	Demand Side Management	District Heating & Cooling	Energy Storage	Heat Pumps	TOTAL
Australia						2
Austria						2
Belgium						3
Canada						5
Czech Republic						I
Denmark						4
Finland						4
France						3
Germany						4
Greece						2
Ireland						
Italy						3
lapan						4
Korea						2
Netherlands						4
New Zealand						I
Norway						5
Portugal						I
Spain						3
Sweden						5
Switzerland						2
Turkey						2
United Kingdom						5
United States						5
IEA Total	20	17	10	13	12	72
Algeria						
Brazil						
China						
Croatia						
Egypt						
Iceland						
India						
Israel						I
Lithuania						
Mexico						
Poland						I
Russia						
South Africa						
Ukraine						
Venezuela						
Non-IEA Total	2					2
TOTAL	22	17	10	13	12	74
Sponsors						
Eur. Comm.						

IMPLEMENTING AGREEMENT PARTICIPATION END-USE TECHNOLOGIES: INDUSTRY

	Emissions Reduction in Combustion	Process Integration	Pulp and Paper	High-Temperature Superconductivity	TOTAL
Australia					
Austria					
Belgium					2
Canada					4
Czech Republic					
Denmark					
Finland					4
France					
Germany					2
Greece					
Ireland					
Italy					2
Japan					2
Korea					
Netherlands					
New Zealand					
Norway					3
Portugal					
Spain					
Sweden					4
Switzerland					2
Turkey					
United Kingdom					2
United States					3
IEA Total	11	5	5	14	35
Algeria					
Brazil					
China					
Croatia					
Egypt					
Iceland					
India					
Israel					
Lithuania					
Mexico					
Poland					
Russia					
South Africa					
Ukraine					
Venezuela					
Non-IEA Total		2		I	3
TOTAL	П	7	5	15	38
Sponsors					
Eur. Comm.					

IMPLEMENTING AGREEMENT PARTICIPATION FUSION POWER

	Environ- ment, Safety, Economy	Fusion Materials	Nuclear Tech- nology	TEXTOR	Reversed Field Pinches	Stellara- tor Concept	Large Tokamak	ASDEX Upgrade	TOTAL
Australia									
Austria									
Belgium									
Canada									4
Czech Republic									
Denmark									
Finland									
France									
Germany									
Greece									
Ireland									
Italy									
lapan									7
Korea									I
Netherlands									
New Zealand									
Norway									
Portugal									
Spain									
Sweden									
Switzerland									I
Turkey									
United Kingdom									
United States									8
IEA Total	3	4	3	3	2	3	2	2	22
Algeria									
Brazil									
China									
Croatia									
Egypt									
Iceland									
India									
Israel									
Lithuania									
Mexico									
Poland									
Russia									4
South Africa									
Ukraine									I
Venezuela									
Non-IEA Total		2				2			6
TOTAL	4	6	4	3	2	5	2	2	28
Sponsors									
Eur. Comm.									8

IMPLEMENTING AGREEMENT PARTICIPATION CROSS-SECTIONAL ACTIVITIES

	Climate Technology Initiative	Energy & Environment Information Centre	Energy Technology Data Exchange	Energy Technology Systems Analysis	TOTAL
Australia					
Austria					2
Belgium					I
Canada					4
Czech Republic					
Denmark					4
Finland					3
France					I
Germany					3
Greece					I
Ireland					I
Italy					I
Japan					2
Korea					3
Netherlands					2
New Zealand					
Norway					4
Portugal					I
Spain					2
Sweden					2
Switzerland					2
Turkey					I
United Kingdom					3
United States					3
IEA Total	9	4	14	19	46
Algeria					
Brazil					I
China					
Croatia					
Egypt					
Iceland					
India					
Israel					
Lithuania					
Mexico					
Poland					
Russia					
South Africa					
Ukraine					
Venezuela					
Non-IEA Total			2		2
TOTAL	9	4	16	19	48
Sponsors					
Eur. Comm.					2

IMPLEMENTING AGREEMENT PARTICIPATION



Large Tokamaks Workshop 54 participants from the European Union, Japan, the United States, Russia, and China.



Fluidized Bed Conversion site visit to the world's largest biomass plant (550 MWth CFB boiler), Vaasa (Finland).



Global Market Initiative endorsement at the Renewables 2004 conference by the German Minister for Environment, the Energy Ministers of Jordan, Egypt, and Monaco, and SolarPACES.



Heat Pump meeting in Montreal (Canada).



District Heating & Cooling meeting in New Orleans (United States).



Chinese delegation visits the Clean Coal Centre in London.



Advanced Fuel Cells meeting in Seoul (Korea).



Emissions Reduction in Combustion meeting in Espoo (Finland).



Energy Technology Systems Analysis (ETSAP) meeting.



I 2th SolarPACES International Symposium, Oaxaca (Mexico).



Energy Technology Data Exchange (ETDE) meeting in Ottawa (Canada).



Bioenergy meeting in Lucerne (Switzerland).

IMPLEMENTING AGREEMENT WEBSITES

Managed by the Implementing Agreements themselves, these websites are the first source of comprehensive information about the present and past activities of each programme. They provide details of participation, access to reports, technical updates, policy analysis and other publications, as well as notification of upcoming events. Many Implementing Agreements organise regular conferences and workshops and their websites offer proceedings and working papers on the specialised topics. Large volumes of technical information and links to other relevant websites make these Implementing Agreement websites a valuable source of current information on technology status and R&D approaches in more than 40 energy technology domains. In addition, many of the Implementing Agreements publish easily downloadable newsletters.

Fossil Fuels

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

Renewable Energies and Hydrogen

Bioenergy Geothermal Hydrogen Hydropower Ocean Energy Systems Photovoltaic Power System (PVPS) Hydrogen Solar Heating and Cooling SolarPACES Wind Turbine Systems

End-Use

Transport Advanced Fuel Cells Advanced Materials for Transportation Advanced Motor Fuels Hybrid and Electric Vehicles Buildings Buildings and Community Systems Demand-Side Management District Heating and Cooling Energy Storage Heat Pumping Technologies www.iea-coal.org.uk http://iea-ccs.fossil.energy.gov www.iea.org/eor www.iea.org/tech/fbc/index.html www.etsu.com/ieampf www.ieagreen.org.uk

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www.ieafuelcell.com http://ia-amt.ornl.gov www.iea-amf.vtt.fi www.ieahev.org

www.ecbcs.org http://dsm.iea.org www.iea-dhc.org/index.htm www.iea-eces.org www.heatpumpcentre.org

Industry

Emissions Reduction in Combustion	www.im.na.cnr.it/IEA
High-Temperature Superconductivity in the Electric Power Sector	http://spider.iea.org/tech/scond/scond.htm
Process Integration	www.iea-pi.org
Pulp and Paper	www.ieapap.com
Fusion	
Environmental, Safety and Economic Aspects Fusion Power	www.iea.org/techagr
Fusion Materials	www.iea.org/techagr
Large Tokamaks	www-jt60.naka.jaeri.go.jp/lt
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
Stellerator Concept	www.iea.org/techagr

www.iea.org/techagr

Toroidal Physics in, and Plasma Technologies of Tokamaks with Poloidal Field Divertors(ASDEX-Upgrade)

Cross-Sectional Activities

Climate Technology Initiative (CTI)	www.climatetech.net
Energy and Environmental Technologies	
Information Centres (EETIC)	www.eetic.org
Energy Technology Data Exchange (ETDE)	www.etde.org
Energy Technology Systems Analysis Programme (ETSAP)	www.etsap.org

FOR MORE INFORMATION

IEA Technology Web pages

The IEA Technology Agreements page of the IEA website (www.iea.org/techagr) includes a short description of each of the40 Implementing Agreements, a list of current projects, and links to their websites.

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

The following related information is available to download for free:

Energy Technology Collaboration: Frequently Asked Questions brochure (see also Annex I). IEA Framework for International Technology Co-operation brochure (see also Annex 2).

The publication Mobilising Energy Technology - Activities of the IEA Working Parties & Expert Groups.

IEA OPEN Energy Technology Bulletin



The IEA OPEN Bulletin reports regularly on developments within the IEA energy technology community and includes updates on current projects, upcoming workshops, and recent publications. The OPEN Bulletin currently has more than 5 000 subscribers worldwide.

Current issue http://spider.iea.org/impagr/cip/index.htm Past issues

http://spider.iea.org/impagr/cip/archived_bulletins/index.htm To subscribe http://weaver.iea.org/mailman/listinfo/open-mail

Contacts

For more information on the energy technology collaboration programme, the Framework, or details on the activities of individual Implementing Agreements, please see the IEA website Technology Agreements pages at www.iea.org/techagr, or by sending an email to impag@iea.org.

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

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