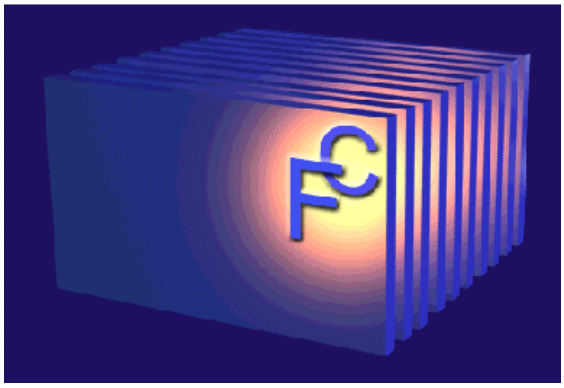


IEA Advanced Fuel Cells

Implementing Agreement

Annual Report 2006

May 2007

INTERNATIONAL ENERGY AGENCY

This Annual Report has been prepared by the Operating Agents and the Secretariat of the Executive Committee, who also acted as Editor.

Extra copies can be obtained from the programme's web site at www.ieafuelcell.com or from:

Mrs Heather Haydock
Secretary, IEA Advanced Fuel Cells Executive Committee
The Gemini Building
Fermi Avenue
Harwell
Didcot, OX11 0QR
United Kingdom

Distribution List

- Executive Committee
- IEA Secretariat
- All Operating Agents and Proposed Operating Agents
- Other Participants (on request)

1. INTRODUCTION

1.1 GENERAL

The Implementing Agreement for a programme of research, development and demonstration on advanced fuel cells was signed by seven countries in Paris on April 2nd, 1990. Since that time, a further thirteen countries have signed the Implementing Agreement and two countries (Spain and New Zealand) have left the Agreement. The current participants are Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Italy, Japan, Korea, Mexico, Netherlands, Norway, Sweden, Switzerland, UK and USA.

The aim of the IEA Advanced Fuel Cells programme is to advance the state of understanding of all Contracting Parties in the field of advanced fuel cells. It achieves this through a co-ordinated programme of research, technology development and system analysis on Molten Carbonate (MCFC), Solid Oxide (SOFC) and Polymer Electrolyte Fuel Cell (PEFC) systems. There is a strong emphasis on information exchange through Task meetings, workshops and reports. The work is undertaken on a task-sharing basis with each participating country providing an agreed level of effort over the period of the Task.

The IEA's Committee on Energy Research and Technology (CERT) approved a five-year extension to the Advanced Fuel Cells Implementing Agreement in November 2003. The extension is underway and will run from 2004 until the end of December 2008. The Implementing Agreement covers fuel cell technology and its potential applications in stationary power generation, portable power applications and transport.

This report gives an overview of the status, progress and future plans of the programme, summarising the activities and decisions of the Executive Committee as well as of each of the Tasks.

1.2 PARTICIPANTS

The following eighteen IEA-member countries participated in this Implementing Agreement during 2006. Spain and New Zealand were previously Participants but left the Implementing Agreement before 1999.

Country	Signatory Party	Date of Signature
Australia	Ceramic Fuel Cells Limited (CFCL)	November 1995
Austria	Austrian Energy Agency (EVA)	September 2004
Belgium	Vlaamse Instelling voor Technologisch Onderzoek (VITO)	November 2002
Canada	Delegation to the OECD	November 1991
Denmark	Riso National Laboratory	September 2004

France	Commissariat à l'Energie Atomique (CEA),	May 2005
Finland	Finnish National Technology Agency (TEKES)	May 2002
Germany	Forschungszentrum Jülich	December 1992
Italy	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente (ENEA)	April 1990
Japan	New Energy and Industrial Technology Development Organisation (NEDO)	April 1990
Korea	The Korea Electric Power Corporation (KEPCO)	April 1998
Netherlands	Netherlands Energy Research Foundation (ECN) (from October 1999, previously Netherlands Agency for Energy and the Environment (NOVEM)	April 1990
Mexico	Electrical Research Institute	June 2006
Norway	Research Council for Norway (from October 1994, previously the Norwegian Council for Scientific and Industrial Research)	April 1990
Sweden	The Swedish Energy Agency (from December 1998, previously NUTEK)	April 1990
Switzerland	Office Féderale de l'Energie (OFEN)	April 1990
United Kingdom	Department of Trade and Industry (from April 1992, previously the Department of Energy)	September 1990
United States	Department of Energy	May 1995

The Executive Committee meets twice a year under the Chairmanship of Prof Lars Sjunnesson (E.ON Sverige, Sweden). The Vice-Chairman is Prof Detlef Stolten and the Secretariat consists of Mrs Heather Haydock, Ms Claire Handley (until May 2006) and Mrs Grace Gordon (all AEA Technology, UK). The IEA/OECD representative during 2006 was Mr Jeppe Bjerg from the Energy Technology Policy Division.

The following table lists all the Executive Committee Members their Alternates and the Operating Agents of the different Annexes at the end of 2006. Addresses and contact numbers are given in Appendix 1 to this report.

Country	Ex Co Member	Alternate Member	Operating Agent	Annex No.
Australia		K Foger		
Austria	G Simader	V Hacker		
Belgium	G van Bogaert			
Canada	V Scepanovic	E Andrukaitis		
Denmark	Inger Pihl Byriel	S Linderoth		

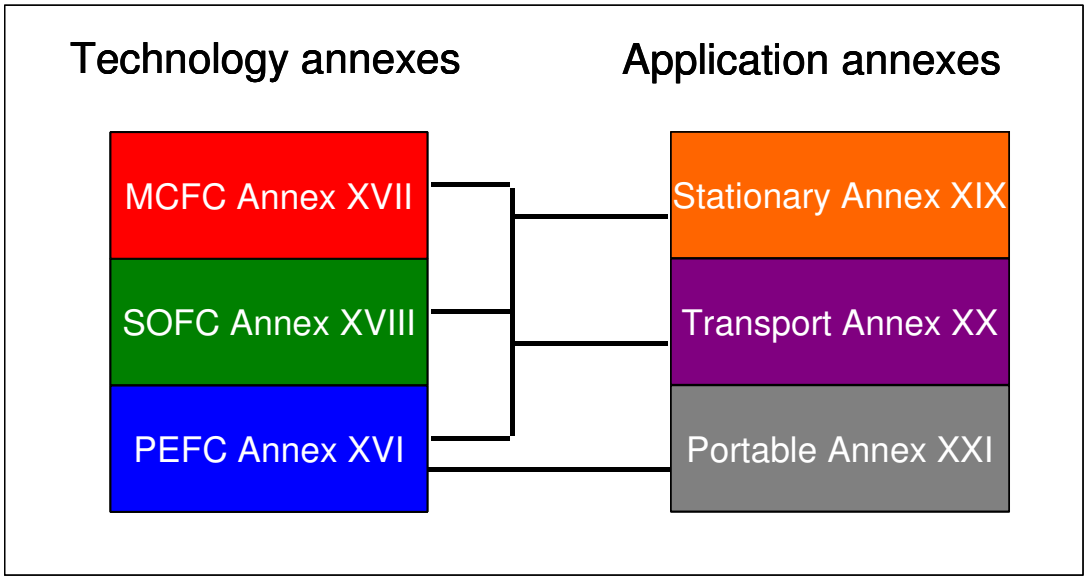
Finland	H Kotila	R Rosenberg		
France	N Bardi			
Germany	D Stolten	H Nabielek	H Dohle	XXI
			G Erdmann	XX
Italy	R Vellone	A Moreno		
Japan	K Terao	M Tabuchil		
Korea	H-C Lim	T-H Lim	T H Lim	XVII
Mexico	J Huacuz	U Castillo		
Netherlands	F de Bruijn			
Norway	R Hildrum	R Aaberg		
Sweden	L Sjunnesson	B Gustafsson	B Ridell	XIX
Switzerland	A Hintermann			
UK	R Eaton	G Vaughan		
USA	N Garland	M Williams	D Myers	XVI
			S Singhal	XVIII

1.3 CURRENT AND FUTURE ANNEXES

Six Annexes were approved and commenced in 2004:

Annex XVI	Polymer Electrolyte Fuel Cells.
Annex XVII	Molten Carbonate
Annex XVIII	Solid Oxide Fuel Cells.
Annex XIX	Fuel Cells Fuel Cells for Stationary Applications.
Annex XX	Fuel Cells for Transportation.
Annex XXI	Fuel Cells for Portable Applications

Together these six annexes form an integrated programme of work for 2004 to 2008, comprising three technology-based annexes (MCFC, SOFC and PEFC) and three application-based annexes (stationary, transportation and portable applications), as shown below.



The programme places a greater emphasis on application- and market-orientated issues than previously, whilst continuing to address technology development and information management. The scope and timing of the programme are shown below.

Scope of the programme for 2005-2008

Information Management Internal and external network	**Implementation and Application Issues** Reduction of barriers	**Technology Development** Stationary, Mobile, Portable **MCFC, SOFC, PEFC**
Co-ordination within the Implementing Agreement Co-ordination with other Implementing Agreements Public awareness and education	Market issues Environmental issues Non-technical barriers (e.g. standards, regulations) User requirements and evaluation of demonstrations	Cell and stack - cost and performance - endurance - materials - modelling - test procedures - minimise size of stack Balance of Plant - tools - availability - data base Fuel processing Power conditioning Safety analysis

Timescales

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008
MCFC	Annex VI				Annex XIV				Annex XVII				
SOFC	Annex VII			Annex XIII					Annex XVIII				
PEFC	Annex VIII			Annex XI					Annex XVI				
Stationary	Annex IX			Annex XII					Annex XIX				
Transport		Annex X				Annex XV			Annex XX				
Portable									Annex XXI				

2. EXECUTIVE COMMITTEE REPORT

2.1 MEMBERSHIP AND PARTICIPATION

Mexico joined the agreement as of 19 June 2006. The Executive Committee Members are Dr Jorge Huacuz (Member) and Dr Ulises Cano Castillo (Alternate Member) from the Electrical Research Institute.

There were changes in the Executive Committee membership in 2006 for Denmark:- Fritz Luxhoi (Member) was replaced by Mrs. Inger Pihl Byriel of Energinet.

Switzerland:- Alphons Hintermann (Member) was replaced by Dr Andreas Gut, Swiss Federal Office of Energy

Japan:- Nobuhiro Kuriyama (Member) and Tomohiko Ikeya (Alternate Member) were replaced by Mr. Katsuhiro TERAO (Member) and Dr. Mitsuharu TABUCHI (Alternate Member) NEDO.

Six Operating Agents continued to run the Annexes initiated in 2004. Dr Debbie Myers continued her role as Operating Agent for the PEMFC activities under the Annex XVI. Dr Tae Hoon Lim held a second year as Annex XVII Operating Agent. Paul van den Oosterkamp of ECN replaced Professor Georg Erdmann for Annex XX. Operating agent for Annex XXI is Dr Hendrik Dohle. Bengt Ridell continued his management of Stationary fuel cell activities as Operating Agent for Annex XIX. Finally, Subhash Singhal was Overall Operating Agent for Annex XVIII, though this position is rotated and the Interim Operating Agent for 2006 was Dr Jari Kiviaho.

2.2 ACTIVITIES AND DECISIONS

2.2.1 Activities

Two Executive Committee meetings were held. The 32nd Executive Committee meeting was held in Mol Belgium 20/21 April 2006 and the 33rd meeting was held in Oslo, Norway 2-3 November 2006.

The web site for ExCo members was updated during 2006. The members' section of the web site now comprises a section for ExCo members and sections for each of the 6 annexes, each accessed using a different user name and password. The annex sections will allow experts participating in an annex to upload and download papers themselves.

This is in addition to the public web site (www.ieafuelcell.com), which provides information on the programme, downloadable publications, contact details and links to other fuel cell organisations.

The 2005 Annual Report was prepared and distributed.

The Executive Committee continued to co-ordinate its activities with other relevant IEA Implementing Agreements. This has included cross-representation on the Executive Committees of the Hydrogen Implementing Agreement.

2.2.2 Decisions

In November 2006 the IEA AFC ExCo proposed to change Operating Agent from Germany (TU Berlin, Prof. Erdmann) to The Netherlands (ECN, Paul van den Oosterkamp). ECN agreed to take up this task and a re-start meeting of Annex XX was scheduled for the first quarter of 2007.

2.2.3 Financing and Procedures

All activities under the Annexes of the Implementing Agreement are task shared. The only cost shared activity is the Common Fund, which provides funding for the Executive Committee Secretariat.

There were no changes to the procedural guidelines for the programme during this year.

2.2.4 Future Plans

Information exchange with other Implementing Agreements will continue to be encouraged, building on links already in place with the Hydrogen and Hybrid Electric Vehicle Implementing Agreements.

The two Executive Committee meetings will be held in 2007. The first will be held in Amsterdam in the Netherlands 19-20 April 2007. The second meeting will be held in Japan in November.

Continued implementation of the approved work programme for six new Annexes and an accompanying programme of cross-cutting workshops and other activities. The six Annexes comprise three technology-specific annexes on PEFC, SOFC and MCFC, and three application-specific annexes on stationary, transportation and portable applications.

3. KEY ACHIEVEMENTS

This section of the Annual Report summarises the key achievements of the programme during the year.

3.1 ACHIEVEMENTS OF ANNEX XVI PEFC

There have been a number of important technical achievements for Annex XVI, as detailed in section 4.1.

3.2 ACHIEVEMENTS OF ANNEX XVII MCFC

The latest R&D data on stack technology and new materials for longer life and higher performance at lower cost were discussed at the first meeting of Annex XVII. The latest findings, particularly fuel options and the requirements for fuel from the operational experiences of several field test systems, were presented at the meeting. The progress in system updating and optimization by each member country was introduced. These topics will be continuously dealt with at future annual meetings.

During the second meeting, an interesting new observation on volatilization of molten carbonate from electrodes was reported, which showed much faster volatilization from anode than cathode. A test result of bi-functional anode, capable of electrolyte reservoir as well as electrode, verified the possibility of solving the problem of electrolyte depletion.

A lifetime estimation method was suggested by analyzing a 40,000-hour single cell operation. The estimation model was found to be in good agreement with long-term operation results.

Outstanding operation results of various demonstration sites in Europe, USA, and Japan were reported. Some of them succeeded in achieving more than 20,000-hour operation without having any serious problems. However, to be competitive in the market, further improvement is required, particularly in terms of durability and cost. These topics will be on the agenda of future meetings.

In the third meeting, new materials and fabrication methods for components, such as cathode, matrix, and anode were reported. These new components enhanced cell performance significantly and also, reduced manufacturing cost.

New balance of plant was also reported in the meeting. These new BOP's, such as container and heat exchanger, were reported to be cost effective.

Increased numbers of systems were operated for demonstration in Europe, USA, Japan and Korea. These demonstration systems were installed in various application fields, such as hotel, hospital, university, manufacturing, and so on and were operated using various fuels, such as natural gas, propane and biogas.

Interestingly, one of these demonstration systems, 1 MW class, was operated using both digester gas and natural gas successfully. In this system the fuel can be switched from one to the other when it is needed.

3.3 ACHIEVEMENTS OF ANNEX XVIII SOFC

Annex XVIII held a very successful workshop in June 2006. Twenty participants from, Canada, Finland, France, Germany, Japan, Korea, Netherlands, Sweden, Switzerland, United Kingdom, and United States attended the Workshop. Presentations included review of SOFC development activities in member countries in addition to several topical technical reports.

3.4 ACHIEVEMENTS OF ANNEX XIX FUEL CELLS FOR STATIONARY APPLICATIONS

Annex XIX 'Fuel Cells for Stationary Applications' the subtasks are well defined and the work is now running at full pace. Outlines of the subtask reports have been presented and some of the subtasks have already achieved important results.

Some findings and achievements that can be reported.

- Natural gas is no longer the obvious fuel for stationary fuel cells. The use of alternative fuels, waste and renewables can be very important for the introduction of high temperature fuel cells. There is a vast market of alternative locally produced fuels that can be used in an efficient way in stationary fuel cells. The high efficiency of the fuel cells also for smaller sizes is a major advantage in comparison with other technologies. These fuels are very important to solve the issue of decreasing the dependency on imports of foreign fossil fuels.
- Coal can be one important fuel for larger stationary fuel cells plants. Some countries that today are heavily dependent on important fuels like USA and China have abundant amount of domestic coal. In USA there are plans to include SOFC in the Future-Gen clean coal power plant process. A new type of fuel cell called direct carbon fuel cell is under development in the USA.
- many of the important balance of plant components in fuel cell systems are still far from commercial. For most fuel cell projects the components are still custom made. For a commercial market introduction all components have to be designed for mass production. A harmonisation and standardisation of the design of the balance of plant components will lower the costs and increase the reliability and thus speed up the commercialisation of fuel cells systems. It has unfortunately been found that the issue is very sensitive among the developers as they see a risk to reveal their proprietary system design to their competitors.
- The existing Codes and standards have to be adjusted to facilitate the introduction of a large number of stationary fuel cells. This work has now started in Japan and several of the codes and standards have been modified to ensure practical installations of fuel cell systems in houses.

3.5 ACHIEVEMENTS OF ANNEX XX FUEL CELL SYSTEMS FOR TRANSPORTATION

In November 2006 the IEA AFC ExCo proposed to change Operating Agent from Germany (TU Berlin, Prof. Erdmann) to The Netherlands (ECN, Paul van den Oosterkamp). ECN agreed to take up this task and a re-start meeting of Annex XX was scheduled for the first quarter of 2007. There was no technical progress on this annex during the year.

3.6 ACHIEVEMENTS OF ANNEX XXI PORTABLE FUEL CELLS

There have been a number of important technical achievements for Annex XXI, as detailed in Section 4.6.

4. TASK REPORTS

4.1 REPORT TASK XVI
POLYMER ELECTROLYTE FUEL CELLS

4.1.1 Duration

This Annex, Task XVI, entered into force on January 1, 2004, and is scheduled to remain in force until December 31, 2008.

4.1.2 Operating Agent

Argonne National Laboratory, Contractor, for the United States Department of Energy

4.1.3 Participants

Agencies from fifteen countries were involved in this Annex during the year 2006:

Austria:	Graz University of Technology
Belgium:	Flemish Institute for Technological Research, Vito
Canada:	The Government of Canada
Denmark:	IRD Fuel Cells A/S
Finland:	VTT Processes
Germany:	Forschungszentrum-Jülich GmbH ICT Fraunhofer
Italy:	Ente per le Nuove Technologie, l'Energia e l'Ambient, ENEA
Japan:	New Energy and Industrial Technology Development Organisation, NEDO
Korea:	Korea Institute of Energy Research
Mexico:	Instituto de Electricas
Netherlands:	Netherlands Energy Research Foundation (ECN)
Norway:	Norwegian Technical University, NTNU
Sweden:	Swedish National Energy Administration (STEM)
United Kingdom:	Secretary of State for Industry
United States:	The Department of Energy of the U. S. Government.

4.1.4 Objective

The objective of this Task is to contribute to the identification and development of techniques to reduce the cost and improve the performance of polymer electrolyte fuel cells (PEFCs) as well as PEFC systems.

4.1.5 Task Description

This Task consists of three subtasks:

Subtask 1. New Stack Materials

Research in this subtask aims to develop improved, lower-cost membranes, electrode catalysts and structures, membrane-electrode assemblies (MEAs), bipolar plates and other stack materials and designs. The effort includes:

- composite and high-temperature membranes
- membranes that conduct protons without external humidification
- reduced precious metal loadings in electrodes
- non-precious metal cathode and anode catalysts
- anode catalysts and electrode layer configurations with enhanced tolerance to carbon monoxide
- higher-activity cathodes
- lower-cost bipolar plates and other stack materials
- lower-cost, continuous fabrication techniques for MEAs
- stack materials for stacks operating at higher temperatures (>100°C)

Subtask 2. System and Balance-of-Plant Issues

This subtask addresses system-level and balance-of-plant issues in PEFC systems. This subtask involves development, engineering, modelling, testing, and standardization of test procedures involving:

- fuel processors, fuel processing catalysts, and supports
- gas purification membranes
- compact fuel reformers and micro-structured reactors
- the effect of contaminants, operating environments, duty cycles, and operating temperatures including temperatures below 0°C
- system designs offering efficiency and dynamic response while maintaining costs, weights, and volumes within target values
- the reliability, durability, rapid-start, and dynamic behaviour of PEFC systems

Subtask 3. Direct Fuel Polymer Electrolyte Fuel Cells

The objective of this subtask is to improve the performance and lifetime of direct fuel polymer electrolyte fuel cells, including direct methanol and direct sodium borohydride fuel cells. This subtask involves identification and development of improved:

- anode and cathode catalysts
- electrode/electrolyte structures
- fuel impermeable membrane electrolytes
- anion-conducting membranes
- concepts in stack materials and designs

4.1.6 Progress Summary

4.1.6.1 Background

This Annex continues the work previously conducted under Annex XI Phase II, Annex XI, Annex VIII, and Annex IV. Austria, Denmark, Finland, and Mexico are the four countries that did not participate in Annex XI Phase II, but are participating in this Annex XVI.

4.1.6.2 Activities

The Annex XVI working group met at ECN, Petten, Netherlands on June 8-9, 2006 and at Forschungszentrum-Jülich GmbH in Jülich, Germany on November 27-28, 2006. Discussions at these workshops indicate that progress is being made in all subtasks of the Annex, as highlighted in the next section.

4.1.7 Technical Accomplishments

Subtask 1: New Stack Materials

- Developing and characterizing carbon nanofiber-based fuel cell electrodes. (Austria)
- Received a patent on reversible gas diffusion electrodes. (Belgium)
- Understanding the relationship between structure, phase separation, and properties of solid polymer electrolytes as a proton-conducting medium in fuel cell membranes and gas diffusion electrodes. (Canada)
- Developing cathode electrocatalysts, platinum-chromium, platinum-cobalt, platinum-iridium, and platinum-cobalt-chromium, and platinum-cobalt-iridium. Alloying platinum with cobalt and chromium improved its oxygen reduction activity. (Finland)
- Developed new electrocatalysts, electrocatalyst supports, and techniques for forming electrocatalyst nanoparticles which to reduce the loading of precious metal electrocatalyst. (France-observer)
- Improved the low relative humidity performance of Nafion by forming composites with oxides and other polymers. (Italy)
- Developing proton-conducting membrane electrolyte operating at elevated temperatures (>100°C). A conductivity of 5 x 10^{-2} S/cm has been achieved at 180°C with an imidazole-phosphonic acid, polyphosphoric acid-derivatized polymer, exceeding the conductivity of the standard electrolyte membrane. (Netherlands)
- Mitigating the degradation of catalyst supports by using alternative forms of carbon. The thermal stability of the support is enhanced (by 150°C) by using carbon nanofibers as opposed to Vulcan XC72 for support of platinum nanoparticles. (Norway)
- Exploring various techniques for depositing platinum nanoparticles on carbon nanofibers for use in the electrodes of high-temperature polymer electrolyte fuel cells. (Norway)
- Developing non-metallic functionalized carbon cathode electrocatalysts. Oxygen reduction activity of 40 mA/m² at 100 mV was observed. (United Kingdom)
- Investigating particle size and support effects on the electrocatalytic activity of gold and platinum. Found that there is a strong size effect on the catalytic activity of the platinum and gold centers for oxygen reduction. Loss of activity is observed for very small centers with diameters below 2.5 nm for gold and the trend implies that centers below 1 nm are totally inactive. (United Kingdom)
- Developing polymer electrolytes that use hydroxide-ion-conducting membrane rather than a proton-conducting membrane. Achieved a maximum power density of 55 mW/cm² at 50°C on hydrogen and oxygen using Pt/C catalysts. The maximum power density for a cell with Ag/C catalysts was 45 mW/cm². (United Kingdom)

Subtask 2: System and Balance-of-Plant Issues

- Developing a technique, total harmonic distortion analysis, that can detect a defect or critical condition in one or a few cells out of a multi-cell stack. This technique a two-channel measurement system rather than a complicated wiring system to each cell and expensive multiplexing. (Austria)
- Further developed a low cost, high-speed current voltage monitoring system for PEFC stacks. (Belgium)
- Developed fuel cell stacks, stack components, and auxiliary devices for stationary CHP (0.5 to 2 kW), back-up power, and industrial specialty vehicles. (Finland)
- Developing and integrating PEFC systems for automotive applications. (France-observer)
- Understanding the impact of the time evolution of electrode microstructure on PEFC performance. (France-observer)
- Developing magnetic tomography techniques to determine the current density distribution in PEFC single cells and stacks. (Germany)
- Designing and manufacturing low-pressure (<50 mbar) 500 W stacks. Stable operation was obtained only at temperatures <50°C. (Italy)
- Establishing accelerated durability tests and testing the strength of carbon-polymer molded bipolar plates provided by various vendors. Found that the slope of a log-log plot of strength vs. stress may be a good measure of the durability of molded bipolar plates. (Japan)
- Evaluating data from residential demonstration PEFCs systems. The average primary energy reduction rate per system was 15.8%, the average energy reduction amount 2010 MJ, the average CO_2 reduction rate 28.2%, and the average CO_2 reduction amount 229 kg. (Japan)
- Determined the influence of clamping pressure on pore characteristics of the gas diffusion layer. (Korea)
- Found that freeze-thaw cycling of a membrane-electrode assembly from -25°C to 80°C did not cause significant property changes in the membrane, altered the hydrophobicity of the gas diffusion layer, and caused delamination of the electrodes from the membrane. (Korea)
- Developing an understanding of water flooding of PEFCs using electrochemical impedance spectroscopy (EIS). Found that EIS can reproduce the effect of flooding on polarization curve data. (Mexico)
- Developing an emulator of PEFC stationary and dynamic response to aid in the development of power electronics. (Mexico)
- Found that the potentiostatic dissolution rate of platinum increases approximately 100-fold with an increase in potential from 0.85 and 1.15 V and 1000-fold with an increase in temperature from 60 to 80°C. (Netherlands)
- Integrating systems and developing components for PEFCs. (Turkey-observer)
- Modeling gas and liquid flow and pressure losses in a PEFC stack. Concluded that the pressure losses are larger for the cathode loop than for the anode loop due to higher fluid viscosity, the pressure drop along the cathode flow-field is as much as 31 kPa, and that the anode and cathode loops are highly coupled by transport through the membrane-electrode assembly. (United Kingdom)
- Determined that the potential cycling dissolution rate for nanoparticle platinum electrocatalysts is five times higher than for bulk platinum and that dissolution-

related degradation is no worse for potential cycling conditions than for constant potential conditions at voltages below 1.0 V. (United States)

Subtask 3: Direct Fuel Polymer Electrolyte Fuel Cells

- Determined that modifying the polymer membrane to decrease the partition coefficient of methanol may be a more effective strategy for reducing methanol crossover than attempting to control the water content. (Canada)
- Achieved direct methanol fuel cell volumetric and gravimetric power densities of <10 L/kW and <8 kg/kW, respectively, by optimization of the bipolar plate design and using a composite end-cap. (Denmark)
- Studying catalysts for direct ethanol fuel cells and evaluating direct borohydride fuel cell configurations and materials. (France)
- Proved that hydrogen can be generated, in an energy-consuming reaction, in areas or under conditions of oxygen depletion on the cathode of direct methanol fuel cells. (Germany)
- Decreased the methanol crossover through Nafion by forming composites with oxides and other polymers. (Italy)
- Developing direct sodium borohydride fuel cell components and systems and constructing a 100W stack. (Turkey-observer)
- Found that the performance of direct methanol and direct borohydride fuel cells are greatly influenced by operating conditions and that both are suitable candidates for portable applications. (United Kingdom)
- Determined that carbonate formation does not negatively impact the performance of alkaline anion-exchange membranes for direct methanol, ethanol, or ethylene glycol fuel cells. (United Kingdom)
- Exploring Pt, PtRu, PtRuW, and PtRuSn supported on titanium mesh as the anode for direct ethanol fuel cells. Achieved a maximum power density of 16 mW/cm² using a PtRu/Ti anode (1 M ethanol, 90°C). (United Kingdom)
- Developing microbial fuel cells that use beer factory wastewater as the fuel and sewage bacteria as the anode catalyst. They achieved a maximum power density of 23.4 mW/m² using bacteria colonized on a carbon cloth as the anode and platinum deposited on titanium mesh as the cathode catalyst. (United Kingdom)
- Developing polymer electrolyte membrane methanol fuel cells that use a hydroxide-ion-conducting membrane rather than a proton-conducting membrane. The maximum power density achieved for the methanol/oxygen fuel cell was 8.5 mW/cm² at 80°C with 2 Molar methanol and PtRu/C and Pt black electrodes. The alkaline membranes were found to be less permeable to ethanol and methanol than Nafion 115. (United Kingdom)

4.1.8 Work Plan for Next Year

As indicated in previous reports of this series, each participating country is working from a broad program plan rather than more specific task plans. The areas of active R&D for this Annex are improved membrane-electrode assemblies, materials, and stack components, reduced catalyst loadings and cost, improved catalyst durability, increased CO tolerance, compact fuel processors, system design and analysis, and improved direct fuel fuel cells and

stacks. The general research areas of the participating countries are summarized below.

Austria:	Improved materials for hydrogen-air and direct methanol fuel cells, fuel cell stack and cell model, and fuel cell power system modeling
Belgium:	Fuel cell, stack, and component testing, system integration and testing, determination of technical feasibility of using ammonia as a distributed fuel for fuel cells
Canada:	Membrane, electrode, and bipolar plate development, characterisation, and modelling
Denmark:	Direct methanol and hydrogen-air fuel cell systems
Finland:	Direct methanol fuel cells for micro-power applications, electrocatalyst development, stack construction and testing, and MEA development
Germany:	Direct methanol and hydrogen-air fuel cells, materials, and systems
Italy:	MEAs, catalysts, membranes, fuel cell stack and system testing and analysis
Japan:	Stack materials and component designs, MEAs, bipolar plates, effects of ambient air contaminants, codes and standards, and demonstrations of fuel cell electric vehicles, fuelling stations, and stationary systems
Korea:	Stack development and testing, MEA fabrication development and performance characterisation, system integration and testing, control system development, and micro direct methanol fuel cells for consumer applications
Mexico:	Membrane-electrode assembly, stack, and electronics characterization and development
The Netherlands:	Materials characterization and development, system and cell modelling
Norway:	High temperature polymer electrolyte fuel cell development, electrocatalysts and electrocatalyst supports, hydrogen-chlorine fuel cells, and the integration of a methanol reformer and a high temperature fuel cell
Sweden:	Fuel processing, fuel cell materials and designs

United Kingdom: CO tolerance, electrocatalyst development, systems analysis, direct methanol fuel cells with alkaline membrane electrolyte, bipolar plates, direct methanol fuel cells, and microbial fuel cells

United States: Modelling and systems analysis, high-temperature polymer electrolytes, non-platinum electrocatalysts, and direct methanol fuel cells

4.2 REPORT TASK XVII MOLTEN CARBONATE FUEL CELLS TOWARDS COMMERCIALIZATION

4.2.1 Duration

Original period: January 1, 2004 to December 31, 2008.

4.2.2 Operating Agent

Korea Institute of Science and Technology (KIST) of Korea.

4.2.3 Participants

Original Participants:

Germany	Forschungszentrum Jülich GmbH (KFA) through Motoren und Turbinen Union Friedrichshafen GmbH (MTU)
Italy	Ente Nazionale per le Nuove Tecnologie l'Energia e l'Ambiente (ENEA)
Japan	New Energy and Industrial Technology Development Organization (NEDO)
Korea	Ministry of Commerce, Industry and Energy (MOCIE) through Korea Institute of Science and Technology (KIST)
United States	US Department of Energy (DOE) through Fuel Cell Energy (FCE)

Future Participants:

Turkey	Marmara Research Center of Scientific and Technological Research Council of Turkey

4.2.4 Objective

The objective shall be to provide for further international collaboration in the research and development of certain aspects of MCFC technology, in order to realize commercialization of the MCFC system. These aspects shall include:

(a) Improvement of performance, endurance, and cost effectiveness, for stacks and BOP.
(b) Development and standardisation of effective test-procedures for materials, cells and stacks.
(c) Identification of present and envisaged problems to be solved for commercialisation.

4.2.5 Task Description

(a) Subtask A: Stack and New-material Technology for Longer Life, Higher Performance and Lower Cost.
Subtask-leader: KIST(Korea).

In this subtask, a basic analysis is made of stack performance improvements needed for commercial systems. Discussion focuses on the following topics.

(1) Survey of alternative materials for cell components
(2) Survey of long lifetime stack
(3) Survey of high performance stack
(4) Survey of low cost stack

(b) Subtask B: Operating experiences and fuels for MCFC
Subtask-leader: MTU(Germany)

In this subtask, information and experiences from various demonstrations of each participant country regarding "Operating experiences and Fuel for MCFC" are exchanged and discussed in order to accelerate the commercialization of MCFC systems.

(1) Sharing and discussion of operation data, stack problems and BOP and their countermeasures, etc.
(2) Discussion on characteristics of fuels from various sources
(3) Standardization of fuel processing for MCFC

(c) Subtask C: System updating and optimization
Subtask-leader: ENEA (Italy).

In this subtask, technical reviews will be made, aimed at the realisation of effective MCFC systems. Discussion will be carried out on performance, reliability, cost, operability, etc. Activities will be carried out on the following items. Items (1) through (2) will be discussed at every meeting to share up-to-date information of the participants' experiences.

(1) Survey of system configuration and BOP components
(total efficiency, control, site space, improvement of components, etc.)
(2) Operation experiences of BOP
(operating data, problems and their countermeasures, etc.)
(3) Possibility of more effective systems in the future
(higher efficiencies, utilisation of coal gas, CO_2 recovery, etc.)
(4) Solutions towards commercialisation
(cost, market, operability, etc.).

4.2.6 Progress Summary

4.2.6.1 Background

The attractions of the Molten Carbonate Fuel Cell (MCFC) as a power source have been understood for quite some time. However, it has also been realized that a number of problems, mainly related to endurance and cost, have to be overcome or overridden before commercialization of MCFC technology can come within sight. By the end of 1991, initiatives were taken for collaborative work in this respect, within the IEA Programme on Advanced Fuel Cells. After canvassing interest during a workshop in June 1992 at ECN in The Netherlands, Annex III "MCFC Materials and Electrochemistry" was started in May 1993 with the participation of Germany, Italy, Japan, the Netherlands and Sweden. The Annex remained active to the end of 1995, dealing with the endurance problems connected to corrosion of the bi-polar plate, dissolution of the cathode, and the electrolyte inventory of MCFC stacks. Apart from an extensive data-exchange and fruitful expert discussions, the main result of the Annex was a consensus on the relative importance of the endurance limitations mentioned. In addition, life-time estimations were made relating to the eventual mal-functioning of cells and stacks caused by the phenomena studied.

At the finalisation of Annex III it was recognised that, for further progress in endurance improvement and cost reduction, better quantitative studies would be necessary. Such studies should, in addition to estimates for endurance limitations by malfunctioning, analyse the rate of gradual degradations of stack performance and assess its contributions. Subsequently, ways to reduce the various degradation contributions should be identified.

From another Annex under the Advanced Fuel Cell Program, Annex I “MCFC BOP Analysis” it became clear that further work would be necessary to reveal possibilities for Balance-of-Plant (BOP) technology with improved reliability and reduced cost. Also, the study of BOP provides for interfacing between system-user requirements and stack operational windows, and the resulting consequences for performance and endurance.

In the course of the work performed in Annex III, frequently data was encountered without proper description of the used methods or procedures, or obtained with methods not allowing for easy comparison. The demand was felt for the development and standardisation of effective test-procedures for MCFC materials, cells and stacks.

In the second phase of the IEA Programme on Advanced Fuel Cells, the various Annexes were divided in fuel-cell-type oriented Annexes, concerning materials, cell, stack and Balance-of-Plant aspect, and Annexes regarding system aspects, applications, and user requirements. In this manner, Annex VI “MCFC under Real Operating Conditions” concentrated on the manufacturer’s capabilities to improve MCFC technology, frequently communicating with Annex IX “Fuel Cell Systems for Stationary Applications” about the conditions set by applications and users.

The final meeting of Annex VI was held on April 15-16,1999 in Petten, and the Annex concluded at the end of 1999. The purpose of Annex VI activities had been accomplished and the final report was submitted and approved at the 19th ExCo Meeting.

During the period of Annex VI, several operation tests with large-scale stacks have been carried out: a 280kW system test by MTU, a 100kW system test by ENEL/Ansaldo, a 1,000kW system test by MCFCRA of Japan, a 250kW system test by M-C Power, etc. Encouraged by a series of successful tests, Annex XIV "MCFC towards demonstration" came into action in 2000. During its 3-year period, this Annex concentrated on further cooperative work to pursue demonstration of MCFC system, sharing technical information and experiences to support demonstration programs in each member country.

There have been many successful MCFC system demonstrations worldwide in various applications; nevertheless, several issues related to lifetime, system optimization and cost reduction are yet to be solved for practical market entry. Annex XVII, scheduled to be active between 2004 and 2008, concentrates on solving technical and the economic issues by sharing information and experiences from RD&D programs of each participant country.

4.2.6.2 Activities

The first meeting was held on October 18-20, 2004 in Kawasaki, Japan hosted by NEDO. All participants except Italy attended the meeting. The activities for each Subtask were discussed at the meeting and agreed by the participants.

The objectives of the first meeting were as follows:

Subtask-A: Survey of alternative materials for cell components
Subtask-B: Sharing and discussion of operation data and problems with stack and BOP
Subtask-C: Survey of system configuration and BOP components.

4.2.6.3 Technical Accomplishments

First meeting

Subtask A: Survey of alternative materials for cell components

In this subtask, participants made presentations on their efforts on finding alternative materials which would enable MCFC systems to have a longer lifetime at lower cost. The latest R&D data from each country's developers were provided and discussed. Presentations were as follows:

A-1 Improvement of lifetime of MCFC by Y. Mugikura (CRIEPI)
A-2 Bi-functional anode for MCFC by S.P. Yoon (KIST)
A-3 Stack and new-material technology by M. Bischoff (MTU CFC Solutions)
A-4 Materials technology status for direct fuel cells by H. Maru (FCE)

Subtask B: Sharing and discussion of operation data and problems with stack and BOP

In this subtask, participants made presentations on their experiences in demonstration system operation, analysis of operating data and fuel options in particular. Presentations were as follows:

B-1 Operating experience and fuels for MCFC by M. Bischoff (MTU CFC Solutions)
B-2 Direct fuel cell operating experience updating by H. Maru (FCE)

Subtask C: Survey of system configuration and BOP components

In this subtask, participants made presentations on stacks, BOP, systems and operational test experience. Presentations were as follows:

C-1 100kW MCFC system preparation and short stack test results in Korea by H. Lim (KEPRI)
C-2 Development of high performance module by M. Tooi (IHI)
C-3 Compact system operation and high performance module in Kawagoe test station by F. Yoshiba (MCFCRA)
C-4 System updating and optimization by M. Bischoff (MTU CFC Solutions)

Second meeting

Subtask A: Survey of alternative materials for cell components

In this subtask, participants made presentations on their efforts on finding alternative materials which would enable MCFC systems to have a longer lifetime at lower cost. The latest R&D data from each country's developers were provided and discussed. Presentations were as follows:

A-1 Long-term operation test and acceleration test for nickel shorting by Y. Izaki (CRIEPI)
A-2 Volatilization of molten carbonate in MCFC by K. Tanimoto (AIST)
A-3 Developments of new components in KIST by S. Yoon (KIST)
A-4 Stack and new materials for long life, high performance and low cost by A. Moreno (ENEA)

Subtask B: Sharing and discussion of operation data and problems with stack and BOP

In this subtask, participants made presentations on their experiences in demonstration system operation, analysis of operating data and fuel options in particular. Presentations were as follows:

B-1 HotModule field test experience and various gas application by M. Bischoff (MTU CFC Solutions)
B-2 MCFC demonstration in EXPO 2005 Aichi, Japan by M. Tooi (IHI)
B-3 Development of MCFC in Korea by J. Han (KIST)

B-4 Development and demonstration of MCFC in AFCo by B. Marenaro (AFCo)
B-5 Direct Fuel Cell: renewable fuel experience by M. Farooque (FCE)

Subtask C: Survey of system configuration and BOP components

In this subtask, participants made presentations on stacks, BOP, systems and operational test experience. Presentations were as follows:

C-1 GenCell MCFC design highlight by M. Connors (GenCell)
C-2 Development MCFC in Japan by M. Tooi (IHI)
C-3 System updating and optimization by A. Moreno (ENEA)
C-4 Cost reduction: media supply by M. Bischoff (MTU CFC Solutions)

Third meeting

Subtask A: Survey of high performance stack

In this subtask, participants made presentations on their recent finding of new cost effective components which would enhance performance and life time of MCFC systems. The latest R&D data from each country's developers were provided and discussed. Presentations were as follows:

A-1 Development of New Components at KIST by S.P. Yoon (KIST)
A-2 Comparison of Adsorber, Matrix and Cathode by M. Bischoff (MTU CFC)
A-3 Development of Lifetime Estimation Method for an MCFC Stack by Y. Mugikura (CRIEPI)
C-5 FCE DFC: About Fuels by M. Farooque (FCE)

Subtask B: Discussion on characteristics of fuels from various sources

In this subtask, participants made presentations on their experiences in demonstration system operation, analysis of operating data and fuel options in particular. Presentations were as follows:

B-1 HotModule Operation & Reliability Experience by M. Bischoff (MTU CFC)
B-2 Direct FuelCell Products Commercialization Progress by M. Farooque (FCE)
Subtask C: Possibility of more effective system in the future

In this subtask, participants made presentations on stacks, BOP, systems and operational test experience. Presentations were as follows:

C-1 System Developed & Demonstration in Korea by B.-J. Kim (KEPRI)
C-2 Status of MCFC at CRIEPI and in Japan by Y. Mugikura (CRIEPI)
C-3 Fuel Cell at CESI RICERCA by M. Scagliotti (CESI)
C-4 MTU BOP Cost Reduction Progress by M. Bischoff (MTU CFC)

4.2.7 Work Plan for Task XVII

It was agreed unanimously that Annex XVII would have a meeting once a year. The topics of the scheduled meetings are listed in following table.

Year	2004	2005	2006	2007	2008
Subtask A	Survey of alternative materials for cell components	Survey of long lifetime stack	Survey of high performance stack	Survey of low cost stack	Summary of cell and stack technology
Subtask B	Sharing and discussion of operation data, troubles in stack and BOP,	Sharing and discussion of countermeasure for troubles	Discussion on characteristics of fuels from various sources.	Standardization of fuel processing for MCFC	Summary of operating experiences and fuels for MCFC
Subtask C	Survey of system configuration and BOP components	Operation experiences of BOP	Possibility of more effective system in the future	Solution towards commercialisation	Summary of BOP updating and optimisation

Turkey expressed their wish to join in Annex 17 from next year and will present their R&D activity in the 4th meeting held in Korea. Turkey's participation will be decided by original participant countries in the forth meeting

4.3 REPORT TASK XVIII

4.3.1 Duration

January 2004 – December 2008.

4.3.2 Operating Agent

The overall Operating Agent of the Annex XVIII is Dr. S. C. Singhal, Pacific Northwest National Laboratory, Richland, WA, USA. The Overall Operating Agent is responsible for reporting to the Executive Committee.

There will be annual Interim Operating Agents responsible for the preparation, execution and documentation of the annual workshops, including the production and dissemination of the proceedings. The Interim Operating Agent for 2004 was Dr. S. C. Singhal, for 2005 Dr. Brian Borglum, Versa Power Systems, Calgary, Canada, and for 2006 Jari Kiviaho, VTT Processes, Finland. The interim Operating Agent for 2007 will be Dr. K. Yokomoto, NEDO, Japan.

4.3.3. Participants

Ceramic Fuel Cells Ltd (Australia)
Natural Resources Canada (Canada)
Risø National Laboratory (Denmark)
VTT Processes (Finland)
ADEME (France)
Forschungszentrum Jülich (Germany)
The New Energy and Industrial Technology Development Organisation, NEDO (Japan)
Korea Institute for Energy Research, KIER, (Korea)
ECN (Netherlands)
Swedish National Energy Administration (Sweden)
Swiss Federal Office of Energy (Switzerland)
DTI (UK)
US DOE (USA)

4.3.4. Objective

To organise a series of annual workshops, each to be organised by and in a different country. Each workshop will be organized over one or two days, with discussions on general progress and/or selected SOFC topics. Where possible, these workshops will be linked to other relevant conferences, in order to minimise travelling costs. The workshops should lead to open discussions relating to common problems and should have realizable and achievable aims.

4.3.5 Task Description

Representatives from 11 countries (see participants list) participated in the Annex XVIII Workshop on June 30, 2006 at Suomenlinna island, just off the coast of, Helsinki, Finland. The annual Interim Operating Agent "system" is working well and will be continued. Annex XVIII comprises a series of workshops, each organized by and in a different country. The provisional list of workshops is as follows:

Year	Interim Operating Agent (country/organization/representative)	Workshop in connection with:
2004	USA/PNNL/Subhash Singhal	2004 Fuel Cell Seminar, San Antonio, Texas, USA; November 1, 2004
2005	Canada/Versa Power Systems/Brian Borglum	SOFC IX, Quebec City; May 2005
2006	Finland /VTT/Jari Kiviaho	7th European SOFC Forum, Lucerne, Switzerland; July, 2006
2007	Japan / K. Yokomoto / NEDO	SOFC X, Japan; June 2007
2008	Switzerland / Olivier Bucheli/ HTCeramix	8th European SOFC Forum, Lucerne, Switzerland; July 2008

4.3.6 Progress Summary

4.3.6.1 Overview

During the Annex XIII last workshop in Jülich, Germany in September 2003, a new annex on solid oxide fuel cells for the period 2004-2008 was discussed among the representatives present. The *modus operandi* for the Annex XIII, with an Interim Operating Agent alternating each year among participating countries, was found to be very successful and it was recommended that the Executive Committee adopt this modus for the new period. Also none of the participating countries was willing to fulfill this task for the whole duration of the new period. Later at the request of the Executive Committee, this modus was modified to have a permanent Overall Operating Agent (Dr Subhash Singhal, Pacific Northwest National Laboratory, USA) for the whole duration of the Annex with Interim Operating Agents organizing annual workshops.

The aim of this new annex, Annex XVIII, is the continuation and intensification of the open information exchange to accelerate the development of SOFC towards commercialization. The mechanism proposed to reach this aim is via annual workshops, each year organized by an Interim Operating Agent, where representatives from the participating countries present the status of SOFC Research, Development and Demonstration in their respective countries, in addition to discussing a selected topic.

4.3.6.2 Administration in 2006

The Overall Operating Agent (Dr Subhash Singhal) prepared status reports on Annex XVIII for the ExCo meetings.

4.3.6.3 Activities in 2006

Preparations were made for the 2006 Workshop which was held on June 30, 2006 at Suomenlinna island, just off the coast of, Helsinki, Finland.. The workshop was attended by twenty representatives of eleven of the participating countries; Canada, Finland, France, Germany, Japan, Korea, the Netherlands, Sweden, Switzerland, UK and the USA. They either presented the status of SOFC R, D&D in their respective country or gave a technical presentation.

4.3.6.4 Technical Accomplishments in 2006

During the workshop, 12 presentations were made by experts from participating countries dealing with SOFC research, development and demonstration. The presentations showed that in the recent years a real progress has been made toward manufacturing and commercialisation of SOFCs.

4.3.6.5 Future Plans

The Workshop for 2007 will be held in Nara, Japan and will be organized and chaired by Dr. K. Yokomoto, NEDO, Japan. This Workshop is being held just before the Tenth International Symposium on Solid Oxide Fuel Cells (SOFC-X), also in Nara, Japan, to minimize travel expenses. Each expert will speak on a selected SOFC topic and a discussion will be held to explore avenues for collaboration among the Annex members.

4.3.6.6 Conclusion

The system of an Overall Operating Agent and annual Interim Operating Agents and the organisation by these Interim Operating Agents of workshops linked to other large, international SOFC conferences has so far turned out to be a successful concept. The openness of discussions, the open exchange of technical know-how and the intimate atmosphere of such workshops, are highly appreciated by the participants of the workshops.

The Executive Committee is invited to note the satisfactory progress achieved and to endorse the future plans presented.

4.4 REPORT TASK XIX FUEL CELL SYSTEMS FOR STATIONARY APPLICATIONS

4.4.1 Duration

The Annex entered into force in 1 May 2004 and shall remain in force until 31 December 2008.

4.4.2 Operating Agent

The Swedish Energy Agency acting through E.ON Sverige AB, Sweden.

4.4.3 Participants

The Contracting Parties, which are the Participants in the Task are:

Forschungszentrum Jülich GmbH (Germany)
Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, ENEA (Italy)
The New Energy and Industrial Technology Development Organisation, NEDO (Japan)
The Swedish Energy Agency(Sweden)
Energinet.dk, (Denmark)
Vlaamse Instelling voor Technologisch Onderzoek, VITO, (Belgium)
L'Agence de l'Environment et de la Maitrise de l'Energie, ADEME (France)
Ceramic Fuel Cells Ltd (Australia)
Energieonderzoek Centrum Nederland ECN (The Netherlands)
United States of America Department of Energy (USA)
Swiss Federal Office of Energy (Switzerland)

Technical Research Centre of Finland, VTT (Finland)
Austrian Energy Agency (Austria)

A full list of participating experts is provided in appendix 7 to this report.

4.4.4 Objective

The main objective of the work in Annex XIX is to receive a better understanding the possibilities for all kinds of stationary fuel cells to reach the market. The vision of the Annex is:

"Among experts from leading regions in the world create and define a wise and efficient way to deploy stationary fuel cells on the market"

All fuel cell technologies under development suitable for stationary fuel cells and sizes will be considered for the analysis in Annex XIX.

4.4.5 Task Description

The work in the Annex will focus on the following objectives:

- to describe the market conditions from all aspects for stationary fuel cells and to analyse the present situation.

- to identify the commercial niche applications for the early introduction of stationary fuel cells and the market applications for the broad use of stationary fuel cells.

- to analyse opportunities and obstacles for stationary fuel cells to reach the market

The Task has been fulfilled by work undertaken in five different sub-tasks. The sub-tasks are described more in detail below. It has been important for the success of the Task that all participants have been active in (all) the different sub-tasks.

Subtask I Market outlook for stationary fuel cells

The work in this task shall be to identify potential customers and different business concepts for stationary fuel cells. A SWOT-analysis will be performed (Strength Weaknesses Opportunities and Threats).

A part of the subtask will be to collect and analyse the latest available information regarding the development of and the market conditions for stationary fuel cells. Information will be collected from the participating countries through questionnaires and discussion during experts meetings.

Subtask II The effect of a large number of fuel cells connected to the power grid

What will be effect on the existing infrastructure if a large number of stationary fuel cells are connected to the local power distribution grid? In the subtask, the influence on several aspects will be analysed, including the electrical grid, fuel distribution, codes and standards, safety issues, economic considerations etc. Different alternatives for the control of the operation of the fuel cells will be discussed.

Subtask III Fuels for stationary fuel cells

There are several different kinds of fuels that can be used in stationary fuel cells. Natural gas is the most common fuel to choose depending on the existing infrastructure. Hydrogen is also an obvious choice for future use as it can be produced locally in many different ways including the use of renewable energy. There are many other fuels existing today, for example, waste gas can be used in stationary high temperature fuel cells. That can be gases from chemical industry plant like purge gas, synthesis gas or other process gases. It can also be gasification of biomass or sewage gas etc. The subtask will investigate and describe the availability of different gases and the possibilities and consequences to use them as fuels for stationary fuel cells.

Subtask IV Balance of plant for stationary fuel cells

Today, the balance of plant represents about two thirds of the cost for a complete fuel cells system. Most of failures in demonstration plants for stationary fuel cells are related to the balance of plant. System auxiliary components are in general selected from existing suppliers standard components. It is difficult for the suppliers to develop components designed for fuel cells, as the market for the foreseeable future is very limited. The effort of this subtask will be to interest the suppliers for larger markets and analyse the consequences for the balance of plant in a large fuel cell market. Some components to be mentioned are equipment for desulphurisation, reformers, and inverters

Subtask V Market and technology status for stationary fuel cells

The work in this subtask will be to collect and present the information regarding the development of the technology and the market conditions for stationary fuel cells. Information will be collected from the participating countries.

4.4.6 Task Results

Some examples of critical issues have been found

- The possibilities to use alternative and sustainable fuels can be one important driver for high temperature fuel cells. The different biogases from anaerobic digester plants and gasification plants can be used in high temperature fuel cells with high efficiency for production of electricity and heat.
- Codes and standards must be ready before a major market introduction. That is one important lesson learned from the great demonstration project in Japan.
- A standardisation of balance of plant components could be an important factor to speed up the commercialisation of fuel cells but the fuel cell system suppliers are very reluctant to share information.
- It is important to find early adopters of niche applications so that the fuel cell system suppliers can start with volume production.
- The interest for stationary fuel cells and the public support is growing significantly in many regions of the world. The strong drivers are security of supply of energy products, the building up of new export industries and the concern of the local and global environment.

4.4.7 Work Plan for Year 2007

The work in the five subtasks will continue and draft subtask reports will be produced.

The three questionnaires on fuels for fuel cells, market issues and the issues regarding implementation of a large number of fuel cells into the power grid will be completed.

Two experts meetings will be organised during the year 2007. The spring meeting will be held in Jülich, Germany and hosted by FZJ. The autumn meeting will be held in the USA in connection with the Fuel Cell Seminar in San Antonio, Texas and hosted by the DOE and EPRI.

4.5 REPORT TASK XX FUEL CELL SYSTEMS FOR TRANSPORTATION

No technical progress was made in this Annex during the year, and no meetings held. In November 2006 the IEA AFC ExCo proposed to change Operating Agent from Germany (TU Berlin, Prof. Erdmann) to The Netherlands (ECN, Paul van den Oosterkamp). ECN agreed to take up this task and a re-start meeting of Annex XX was scheduled for the first quarter of 2007.. Readers are referred to the 2004 Annual Report, available from www.ieafuelcell.com, for an overview of this Annex

4.6 REPORT TASK XXI PORTABLE FUEL CELLS

4.6.1 Duration

This Annex entered into force on April 1, 2004. The kick-off meeting was held on July 5-6, 2004 at Forschungszentrum Jülich GmbH, Germany. The annex is due to run until December 2008.

4.6.2 Operating Agent

Forschungszentrum Jülich GmbH, Germany

4.6.3 Participants

Agencies from nine countries participate in this Annex:

Austria:	Energieverwertungsagentur
Canada:	The Government of Canada
Denmark:	Risø National Laboratory
Finland:	VTT Technical Research Center of Finland
Germany:	Forschungszentrum-Jülich GmbH
Italy:	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, ENEA
Korea:	Korea Institute of Science and Technology
Mexico:	Electrical Research Institute *(observer)*
Netherlands:	Netherlands Energy Research Foundation (ECN)

A full list of participating experts is provided in Appendix 7 to this report.

4.6.4 Objective

The main objective of this application oriented task is to assist - through international cooperation - the development of portable fuel cells towards commercialisation through:

- the exchange of information to tackle complex problems in stack and systems design and operation;
- the consideration of end-user requirements on portable fuel cell operation with the goal to minimize size and costs of cells and systems;
  the study of alternative materials in case traditional concepts are too expensive or are too short-lived.

4.6.5 Task Description

This Task consists of three subtasks:

Subtask 1. System Analysis for Portable Fuel Cells
Tackle complex problems in stack and systems by modelling of mass and energy flows. Performing system analysis for portable applications, e.g. analysis of energy demand of the auxiliary components, water- and heat management, etc. Collect information about rules and regulations concerning the operation and e.g.

the storage and the transport of portable fuel cells. Regarding safety aspects as refilling, transport, etc

Subtask 2. System, Stack and Cell Development for Portable Fuel Cells
Test of operation concepts for portable systems, e.g. cold start concepts, dynamic load following, etc. Evaluation of design goals for portable systems, e.g. comparison with existing techniques as Li-Ion accumulators or batteries, deriving of specifications for stacks and systems. Evaluating fuel storage concepts suitable for the specific demands of portable applications. Design of systems for portable applications, e.g. DMFC systems with a liquid anode feed or micro-reformer systems with small PEFC systems. Design of stacks for portable applications, e.g. small and suitable for mass production.

Subtask 3. Materials under Operating Conditions / Materials Innovation
Stack and system testing with regard to the power output, the efficiency and lifetime. Cost aspects, e.g. use of cheap and easy to manufacture materials.

4.6.6 Progress Summary

4.6.6.1 Background

The annex entered into force on April 1, 2004. As the market for portable applications is expected to be the first market for fuel cells this new annex should bundle the forces and concentrate on the specific research demands and technical conditions for portable fuel cells.

4.6.6.2 Activities

The kick-off meeting was held on July 5-6, 2004 at Forschungszentrum Jülich GmbH, Germany. The annual status meeting 2005 was held on May 30-31 at ITAE in Messina, Italy. The annual status meeting 2006 was held on September 4-5 at the Technical University of Graz, Austria.

4.6.6.3 Technical Accomplishments

System Analysis for Portable Fuel Cells

- Portable DMFC systems as a replacement for lead-acid batteries in the 100 W to kW class were presented. A special focus was put on testing the stacks at varying operating conditions. (Germany)

- Design of a complete fuel cell system with a nominal power of 15 W including peripheral components, tank and electronics. Demonstration of this power unit for a DVD reader. (Italy)

- Investigation of air-breathing systems for hydrogen powered wheelchairs (Italy).

- An important topic to be solved before introducing methanol into the market are safety tests for system and stack components such as cartridge tests, vibration

tests, drop tests, etc. National and international rules and regulations were presented (Japan).

System, Stack and Cell Development for Portable Fuel Cells

- New stacks (micro fuel cells) based on diffusion effects and new materials have been shown. An example for surface mount packaging on electronic boards has been give. Further more, miniaturised stacks based on SOFC have been developed. (Canada)

- Components for a 1 kW stack have been demonstrated based on graphite epoxy materials. (Finland)

- 2 kW and 100 W stacks have been developed; both are based on carbon materials. (Germany)

- The newly developed PEFC stack consists of 10-20 cells with a cell area of 25 cm^2 each. The effect of clamping on the power has been shown. The stack is designed for air breathing operation. (Italy)

- A flat 10 W stack has been developed consisting of 24 cells with an area of 20 cm^2 each. In addition, a small 0.5 W stack has been demonstrated. (Italy)

Materials under Operating Conditions / Materials Innovation

- New catalysts based on nanotubes have been demonstrated. (Canada)

- The single cell performance of MEAs prepared in-house was presented. The maximum power density in air breathing PEFC operation was 81 mW/cm^2 (Italy)

4.6.7 Work Plan for Next Year

The work will be continued in the above mentioned subtasks.

APPENDICES

Appendix 1 Membership of the Executive Committee

1.1 Members and Alternate Members

Australia	Dr K Foger Ceramic Fuel Cells Ltd 170 Browns Road Noble Park Victoria 3174	Tel: (+) 61-3-9554-2311 Fax: (+) 61-3-9790-5600
Austria	Mr G Simader EVA Otto-Bauer-Gasse 6 1060 Vienna	Tel: (+) 43-1-5861524-24 Fax: (+) 43-1-5861524-40
	Dr Viktor Hacker Steyrergasse 21 A-8010 Graz	Tel: (+) 43-316-873-8780 Fax: (+) 43-316-873-8782
Belgium	Mr G van Bogaert VITO Boeretang 200 B-2400 Mol	Tel: (+) 32-14-335911 Fax: (+) 32-14-321185
Canada	Dr V Scepanovic NRCan 580 Booth St. Ottawa ONTARIO K1A 0E4	Tel: (+) 1-613-996-5965 Fax: (+) 1-613-996-9416
	Dr E Andrukaitis Department of National Defence, Canada National Defence Headquarters Constitution Building 305 Rideau Street, 8th Floor Ottawa Ontario KIA 0K2	Tel: (+)1-613-990-0638 Fax: (+)1-613-993-4095

Denmark	Mrs. Inger Pihl Byriel Energinet.dk Fjordvejen 1-11 DK-7000 Fredericia	Tel: (+)45 7624 4416
	Mr S Linderoth Riso National Laboratory Bygning 228 Postboks 49 Roskilde	Tel: (+)45-4677-5797
Finland	Mr H Kotila National Technology Agency (TEKES) PO Box 69 FIN-00101 Helsinki	Tel: (+)358-10-521-5874
	Dr Rolf Rosenberg VTT Processes PO Box 1601 FIN-02044 VTT	Tel: (+)358-9-456-6342 Fax: (+)358-9-460 493
France	Mr Nicolas Bardi CEA CEA/DRT/LITEN Route de Panorama – BP 6 F – 92265 Fonteany-aux-roses Cedex	Tel: (+)33-1-46-54-93-70 Fax: (+)33-1-46-54-82-32
Germany	Prof D Stolten Forschungszentrum Jülich IWV-3: Energy Process Engineering D-52425 Jülich	Tel: (+)49-2461-613076 Fax: (+)49-2461-613385
	Dr H Nabielek Forschungszentrum Jülich PBZ: Project Fuel Cells D-52425 Jülich	Tel: (+)49-2461-613271 Fax: (+)49-2461-618162
Italy	Dr R Vellone CRE-Casaccia Via Anguillarese 301 00060 S. Maria di Galeria ROME	Tel: (+)39-06-3048-3126 Fax: (+)39-06-3048-3795
	Dr A Moreno CRE-Casaccia Via Anguillarese 301 00060 S. Maria di Galeria ROME	Tel (+)39-06-304 84298 Fax: (+)39-06-3048-6306

Japan	Mr Katsuhiro Terao 1310 Ohmiya-cho Saiwai-ku Kawasaki-shi KANAGAWA 212-8554	teraokhr@nedo.go.jp
	Dr Mitsuharu Tabuchi tabuchimth@nedo.go.jp 1310 Ohmiya-cho Saiwai-ku Kawasaki-shi KANAGAWA 212-8554	
Korea	Mr H-C Lim KEPRI 103-16 Munji-dong Yusong-ku Taejon 305-380	Tel: (+)82 42 865 7540 Fax: (+)82 42 865 5304/5374
	Dr T-H Lim KIST 39-1 Hawolkog-dong Sungbuk-ku Seoul 136-791	Tel: (+)82 2 958 5273 Fax: (+)82 2 958 5199
Netherlands	Dr F de Bruijn ECN P O Box 1 1755 ZG PETTEN	
Mexico	Dr Jorge M Huacuz Electrical Research Institute Av. Reforma 113. Col Palmira Cuernavaca Mor. 62490 Mexico Cuernavaca	Tel: +52 777 362 3806
	Dr Ulises Cano Castillo Electrical Research Institute Av. Reforma 113. Col Palmira Cuernavaca Mor. 62490 Mexico Cuernavaca	Tel: +52 777 3183811

Norway	Ms R Hildrum Statkraft SF PO Box 200 Lilleaker NO-0216 Oslo Norway	Tel: (+)47-24-06-74-35 Fax: (+)47-24-06-70-80
	Mr R J Aaberg Statkraft SF PO Box 200 Lilleaker NO-0216 Oslo Norway	Tel: (+)47 24 06 82 01 Fax: (+)47 24 06 70 80
Sweden	Prof L Sjunnesson Sydkraft AB SE-20509 MALMO	Tel: (+)46-40-255600 Fax: (+)46-40-6115184
	Dr B Gustafsson Swedish Energy Agency Box 310 SE-63104 Eskilstuna	Tel: (+)46-16-544-2085 Fax: (+)46-16-544-2099
Switzerland	Dr A Hintermann Swiss Federal Office of Energy CH-3003 BERNE	Tel: (+)41-31-3225654 Fax: (+)41-31-3232500
United Kingdom	Mr R Eaton DTI 1-19 Victoria Street LONDON SW1H OET	Tel: (+)44-20-7215-2650 Fax: (+)44-20-7215-2840
	Mr G Vaughan DTI 1-19 Victoria Street LONDON SW1H OET	Fax: (+)44-20-7215-2840
USA	Dr N Garland USDOE 1000 Independence Ave EE 32, 5G-023 Washington DC 20585-0121	Tel: (+)1-202-586- Fax: (+)1-202-586-
	Mr Wayne Surdoval US DOE National Energy Tech. Lab. 626 Cochrans Mill Road P.O. Box 10940 Pittsburgh, PA 15236-0940	Tel: (+)1-412-386-6002 Fax: (+)1-412-386-5917

1.2 Operating Agents

Annex XVI	Dr D Myers Argonne National Lab. 9700 South Cass Ave. Argonne IL 60439 USA	Tel: (+)1-630-252-4261 Fax: (+)1-630-252-4176
Annex XVII	Dr T-H Lim KIST 39-1 Hawolkog-dong Sungbuk-ku Seoul 136-791 Korea	Tel: (+)82 2 958 5273 Fax: (+)82 2 958 5199
Annex XVIII	Dr S Singhal Pacific Northwest National Laboratory 902 Battelle Boulevard PO Box 999 Richland WA 99352 USA	Tel: (+)1 509 375 6738 Fax: (+)1 509 375 4300
Annex XIX	Mr B Ridell Grontmij SE-20509 Malmo Sweden	Tel: (+)46-40-255996 Fax: (+)46-40-256017
Annex XX P.O. Box 1	Paul van der Oosterkamp ECN 1755 ZG Petten The Netherlands	vandenoosterkamp@ecn.nl
Annex XXI	Dr H Dohle Institut IWV-3 Forischungszentrum Julich GmbH 52425 Jülich	Tel: (+)49-2461 616884 Fax: (+)49-2461-616695

1.3 Secretariat

IEA Secretariat	Mr J Bjerg Energy Technology Policy Division International Energy Agency 9, rue de la Fédération 75739 Paris Cedex 15 France	Tel: (+)33-1-4057-6677 Fax: (+)33-1-4057-6759

ExCo Secretariat
Mrs H Haydock
AEA Technology
The Gemini Building
Fermi Avenue
Harwell International Business Centre
Didcot, OX11 0QR
United Kingdom
Tel: (+)44-870 190 6487
Fax: (+)44-870 190 6318

ExCo Secretariat
Mrs G Gordon
AEA Technology
The Gemini Building
Fermi Avenue
Harwell International Business Centre
Didcot, OX11 0QR
United Kingdom
Tel: (+)44-870 190 6482
Fax: (+)44-870 190 6616

Appendix 2 Executive Committee Meetings to Date

1st meeting	April 2, 1990, Paris, France.
2nd	November 25, 1990, Phoenix, Arizona, USA.
3rd	June 27-28, 1991, Petten, The Netherlands
4th	February 7, 1992, Makuhari, Japan
5th	September 24-25, 1992, Malmo, Sweden
6th	March 15, 1993, Rome, Italy
7th	September 28, 1993, London, United Kingdom
8th	March 15, 1994, Zürich, Switzerland.
9th	October 11, 1994, Jülich, Germany
10th	May 11-12, 1995, Oslo, Norway
11th	September 18th, 1995, Loughborough, United Kingdom
12th	February 1-2, 1996, Tokyo, Japan
13th	September 17-18, 1996, Roskilde, Denmark
14th	April 15-16, 1997, Vancouver, Canada
15th	September 18-19, 1997, Amsterdam, The Netherlands
16th	March 19-20, 1998, Santa Fe, USA
17th	October 1-2, 1998, Melbourne, Australia
18th	April 13-14, 1999, Jülich, Germany
19th	September 20-21, 1999, London, UK
20th	April 10-11, 2000, Malmö, Sweden
21st	November 4, 2000, Portland, Oregon, USA
22nd	May 3-4, 2001, Capri, Italy
23rd	September 5-6, 2001, Basel, Switzerland
24th	May 30-31, 2002, Paris, France
25th	November 22-23, 2002, Palm Springs, California, USA
26th	May 8 , Espoo, Helsinki, Finland
27th	October 23-24, 2003, Dusseldorf, Germany
28th	April 1-2, 2004, Vienna, Austria
29th	October 13-14, 2004, Seoul, Korea
30th	April 28-29, 2005, Copenhagen, Denmark

31st	November 18, 2005, Palm Springs, California, USA
32nd	April 20-21, 2006, Mol, Belgium
33rd	November 2-3, 2006, Oslo, Norway

Appendix 3 Task Proposals Under Consideration

There are currently no task proposals under consideration as the six new Annexes were approved in 2004 and comprise three technology-specific annexes on PEFC, SOFC and MCFC, and three application-specific annexes on stationary, transportation and portable applications.

Appendix 4 Executive Committee Reports and Publications

The following reports have been issued:

- Minutes of 33 Executive Committee Meetings since initiation (1990).
- Annual Reports 1990-2006.
- Contribution on the Advanced Fuel Cells Implementing Agreement for the 2003/2006 Implementing Agreement Highlights IEA publication (2006)
- Contribution on the Advanced Fuel Cells Implementing Agreement for the EUWP Autumn Status Report on Transport related Implementing Agreements (2006)
- Strategy and Procedural Guidelines for the IEA Advanced Fuel Cells Programme, Utrecht, The Netherlands (1992).
- Revised Procedural Guidelines for the IEA Advanced Fuel Cells Programme (1998)
- Updated Implementing Agreement (1998).
- Strategy for the IEA Advanced Fuel Cells Programme 1999-2003 (1998).
- "International Co-operation of Fuel Cell R&D via the International Agency", K Joon, H Barten, paper presented at the 1994 Fuel Cell Seminar, San Diego, USA.
- "The IEA Advanced Fuel Cells Programme", K Joon, invited paper presented at the 2nd International Fuel Cell Conference, Kobe, Japan, February 1996.
- End of Term Reports to the IEA in September 1995, September 1998 and October 2003.
- "Progress in Fuel Cell Development through Co-operation in the Framework of the International Energy Agency", K Joon, L Sjunnesson, invited paper presented at the 3rd International Fuel Cell Conference, Nagoya, Japan, December 1999.
- Summary Final Report of the IEA Advanced Fuel Cells Programme 1996-1999.

In addition, verbal presentations have been given by the Chairman and Secretary to the IEA Working Party on End Use Technologies, the Committee on Energy Research and Technology, the Working Party on Fossil Fuels and the IEA Hydrogen Executive Committee.

Appendix 5 Workshops and Task Meetings

This section lists meetings and workshops held to date and planned for 2007, for those tasks that were active during the year.

5.1 Task XVI: Polymer Electrolyte Fuel Cells

5.1.1 Workshops and Meetings Held to Date

Annex XVI Working Group November 27-28, 2006, Forschungszentrum-Jülich GmbH, Jülich, Germany

Annex XVI Working Group, June 8-9, 2006, ECN, Petten, Netherlands

Annex XVI Working Group, June 1-2, 2005, VITO-Energy Technology, Mol, Belgium

Annex XVI Working Group, November 30-December 1, 2005, Loughborough, United Kingdom

5.1.2 Workshops and Meetings Planned for Next Year

Annex XVI Working Group, June 7-8, 2007, VTT Processes, Helsinki, Finland

Annex XVI Working Group, November/December, 2007, specific dates and venue yet to be determined

5.2 Task XVII: Molten Carbonate Fuel Cells

5.2.1 Workshops and Meetings Held to Date

The first meeting was held on October 18-20, 2004 in Kawasaki, Japan hosted by NEDO.
The second meeting was held on November 12-13 in Palm Springs, U.S.A. hosted by FCE.

The third meeting was held on November 15 in Milan, Italy hosted by CESI Ricerca.

5.2.2 Workshops and Meetings Planned for Next Year

The third meeting of Annex XVII is scheduled to be held in Italy in September 2006 hosted by ENEA.

The forth meeting of Annex XVII is scheduled to be held in Korea in September, 2007 hosted by KIST.

5.3 Task XVIII: Solid Oxide Fuel Cells

5.3.1 Workshops and Meetings Held to Date

The first Workshop of Annex XVIII was held on November 1, 2004 in San Antonio, Texas, USA. The workshop was attended by twenty representatives of

ten of the participating countries; Australia, Canada, Finland, France, Germany, Japan, the Netherlands, Sweden, Switzerland and the USA. They all presented the status of SOFC R, D&D in their respective country. Not able to attend the workshop was any representative from the United Kingdom. During the workshop, 13 presentations were made by experts from participating countries. The presentations showed that in the recent years, a real progress has been made toward the commercialization of SOFCs.

The second Workshop was held in Quebec City, Canada on May 14, 2005 and it was organized and chaired by Dr. Brian Borglum, Versa Power Systems, Calgary, Canada. This Workshop was held just before the Ninth International Symposium on Solid Oxide Fuel Cells (SOFC-IX) in Quebec City to minimize travel expenses. Also, this Workshop was held in conjunction with IPHE SOFC. Each expert spoke on a selected SOFC topic and a discussion was held to explore avenues for collaboration among the Annex members.

The third Workshop was held in Helsinki, Finland, on Friday, June 30 and was organized and chaired by Dr. Jari Kiviaho, VTT Processes, Finland. This Workshopwas held just before the Seventh European SOFC Forum, July 3-7, 2006, in Lucerne, Switzerland. For this meeting, each member country's representative was asked to present a technical presentation in the area of advanced SOFC systems or another technical topic.

5.3.2 Workshops and Meetings Planned for Next Year

The Workshop for 2007 will be held in Nara, Japan, on Saturday, June 2 and will be organized and chaired by Dr. K. Yokomoto, NEDO, Japan. This Workshop is being held just before the Tenth International Symposium on Solid Oxide Fuel Cells (SOFC-X), also in Nara, Japan. For this meeting, each member country's representative is being asked to present a technical presentation in the area of advanced SOFC systems or another technical topic

5.4 Task XIX: Fuel Cell Systems for Stationary Applications

5.4.1 Workshops and Meetings Held to Date

First meeting in Annex XIX, April 29 – 30, 2004, Rome, Italy hosted by ENEA

Second experts' meeting November 1, 2004, San Antonio, Texas, USA hosted by DOE

Third experts' meeting April 4-5, 2005, Petten, The Netherlands hosted by ECN

Fourth experts' meeting November 14, 2005, Palm Springs, California, USA hosted by DOE

The fifth experts' meeting April 4-5, 2006 in Linz, Austria hosted by Energie AG Oberösterreich

The sixth experts' meeting October 10-11, 2006 in Rome Italy hosted by ENEA.

5.4.2 Workshops and Meetings Planned for Next Year

The seventh experts meeting will be held March 19-20, 2007, Jülich, Germany hosted by FZJ The eighth experts' meeting will be held October 15, 2007 in San Antonio, Texas, USA hosted by DOE and EPRI.

Two members from Annex XIX have participated in a workshop.

5.5 Task XX: Fuel Cells for Transportation

5.5.1 Workshops and Meetings Held to Date

The Annex XX working group met in Stuttgart, Germany for a one day Kick-Off Meeting on 28 September 2004.

5.5.2 Workshops and Meetings Planned for Next Year

No information available.

5.6 Task XXI: Portable Fuel Cells

5.6.1 Workshops and Meetings Held to Date

July 5-6, 2004, Juelich, Germany, kick-off meeting, hosted by Juelich Research Center.

May 30-31, 2005, Juelich, Germany, annual meeting, hosted by ITAE, Messina, Italy.

September 4-5, 2006, Graz, Austria, annual meeting, hosted by Technische Universität Graz.

5.6.2 Workshops and Meetings Planned for Next Year

Annex meeting 24th September 2007 in Stuttgart, Germany

Appendix 6 Task Reports and Publications

This section lists task reports and publications produced to date for those tasks which were active during the year. These publications are classified according to the following system.

Level	Classification	Report Type	Distribution
1a	Restricted - sub-task participants only	Working papers	Distribution limited to those experts participating in the specific sub-task.
1b	Restricted - annex participants only	Sub-task reports, detailed technical reports	Distribution limited to those experts participating in the annex.
2a	Restricted - annex participants and Ex Co members only	Summary technical reports	As above + Ex Co members from countries participating in annex for personal reference and approvals.
2b	Restricted - countries participating in annex only	Summary technical reports, summary final reports	As above + Ex Co members from countries participating in annex may distribute report to organisations in that country not participating in the annex
2c	Restricted - IA signatory countries only	Summary final reports	Distribution to any organisation in a country participating in the IA
3a	Unrestricted within IEA	Annual reports; summary final reports	Open distribution to all countries in IEA.
3b	Unrestricted	Annual reports; summary final reports	Open distribution including countries not in IEA. To publicise and inform about IEA programme.

Some of the reports are classified according to an earlier system which only used three levels:
Level 1: Experts participating in relevant Sub-task only.
Level 2: Participating Countries and all Executive Committee Members.
Level 3: Unrestricted.

6.1 Task XVI: Polymer Electrolyte Fuel Cells

6.1.1 Reports, Papers and Abstracts Published to Date (level 3b)

Krishnan, P; Park, JS; Yang, TH; Lee, WY; Kim, CS. 2006. Sulfonated poly(ether ether ketone)-based composite membrane for polymer electrolyte membrane fuel cells. *JOURNAL OF POWER SOURCES* 163 (1): 2-8, Sp. Iss. SI.

Kim, M; Park, JN; Kim, H; Song, S; Lee, WH. 2006. The preparation of Pt/C catalysts using various carbon materials for the cathode of PEMFC. *JOURNAL OF POWER SOURCES* 163 (1): 93-97, Sp. Iss. SI.

Yuan, W; Scott, K; Cheng, H. 2006. Fabrication and evaluation of Pt-Fe alloys as methanol tolerant cathode materials for direct methanol fuel cells. *JOURNAL OF POWER SOURCES* 163 (1): 323-329, Sp. Iss. SI.

Brace, KM; Hayden, BE; Russell, AE; Owen, JR. 2006. A parallel optical screen for the rapid combinatorial electrochromic analysis of electrochemical materials. *ADVANCED MATERIALS* 18 (24): 3253-+.

Cheng, H; Scott, K. 2006. Investigation of Ti mesh-supported anodes for direct borohydride fuel cells. *JOURNAL OF APPLIED ELECTROCHEMISTRY* 36 (12): 1361-1366.

Cheng, H; Yuan, W; Scott, K. 2006. The influence of a new fabrication procedure on the catalytic activity of ruthenium-selenium catalysts. *ELECTROCHIMICA ACTA* 52 (2): 466-473.

Every, HA; Janssen, GJM; Sitters, EF; Mendes, E; Picken, SJ. 2006. Performance analysis of sulfonated PPTA polymers as potential fuel cell membranes. *JOURNAL OF POWER SOURCES* 162 (1): 380-387.

Scott, K; Jackson, C; Argyropoulos, P. 2006. A semi empirical model of the direct methanol fuel cell. Part II. Parametric analysis. *JOURNAL OF POWER SOURCES* 161 (2): 885-892.

Cheng, H; Scott, K; Lovell, K. 2006. Material aspects of the design and operation of direct borohydride fuel cells. *FUEL CELLS* 6 (5): 367-375.

Zhang, JL; Xie, Z; Zhang, JJ; Tanga, YH; Song, CJ; Navessin, T; Shi, ZQ; Song, DT; Wang, HJ; Wilkinson, DP; Liu, ZS; Holdcroft, S. 2006. High temperature PEM fuel cells. *JOURNAL OF POWER SOURCES* 160 (2): 872-891, Sp. Iss. SI.

Lim, C; Allen, RG; Scott, K. 2006. Effect of dispersion methods of an unsupported Pt-Ru black anode catalyst on the power performance of a direct methanol fuel cell. *JOURNAL OF POWER SOURCES* 161 (1): 11-18.

Fraser, SD; Monsberger, M; Hacker, V. 2006. A thermodynamic analysis of the reformer sponge iron cycle. *JOURNAL OF POWER SOURCES* 161 (1): 420-431.

Varcoe, JR; Slade, RCT; Wright, GL; Chen, YL. 2006. Steady-state dc and impedance investigations of H-2/O-2 alkaline membrane fuel cells with commercial Pt/C, Ag/C, and Au/C cathodes. *JOURNAL OF PHYSICAL CHEMISTRY B* 110 (42): 21041-21049.

Cheng, H; Scott, K. 2006. Influence of operation conditions on direct borohydride fuel cell performance. *JOURNAL OF POWER SOURCES* 160 (1): 407-412.

Cheng, H; Scott, K. 2006. Investigation of non-platinum cathode catalysts for direct borohydride fuel cells. *JOURNAL OF ELECTROANALYTICAL CHEMISTRY* 596 (2): 117-123.

Norsten, TB; Guiver, MD; Murphy, J; Astill, T; Navessin, T; Holdcroft, S; Frankamp, BL; Rotello, VM; Ding, JF. 2006. Highly fluorinated comb-shaped copolymers as proton exchange membranes (PEMs): Improving PEM properties through rational design. *ADVANCED FUNCTIONAL MATERIALS* 16 (14): 1814-1822.

Liu, BJ; Robertson, GP; Guiver, MD; Shi, ZQ; Navessin, T; Holdcroft, S. 2006. Fluorinated poly(aryl ether) containing a 4-bromophenyl pendant group and its phosphonated derivative. *MACROMOLECULAR RAPID COMMUNICATIONS* 27 (17): 1411-1417.

Rama, P; Chen, R; Thring, R. 2006. Polymer electrolyte fuel cell transport mechanisms: a universal modelling framework from fundamental theory. *PROCEEDINGS OF THE INSTITUTION OF MECHANICAL ENGINEERS PART A-JOURNAL OF POWER AND ENERGY* 220 (A6): 535-550.

Shivhare, MR; Allen, RG; Scott, K; Morris, AJ; Martin, EB. 2006. A kinetic model for the direct methanol fuel cell anode based on surface coverage. *JOURNAL OF ELECTROANALYTICAL CHEMISTRY* 595 (2): 145-151.

Guerin, S; Hayden, BE; Pletcher, D; Rendall, ME; Suchsland, JP. 2006. A combinatorial approach to the study of particle size effects on supported electrocatalysts: Oxygen reduction on gold. *JOURNAL OF COMBINATORIAL CHEMISTRY* 8 (5): 679-686.

Guerin, S; Hayden, BE; Pletcher, D; Rendall, ME; Suchsland, JP; Williams, LJ. 2006. Combinatorial approach to the study of particle size effects in electrocatalysis: Synthesis of supported gold nanoparticles. *JOURNAL OF COMBINATORIAL CHEMISTRY* 8 (5): 791-798.

Komanicky, V; Chang, KC; Menzel, A; Markovic, NM; You, H; Wang, X; Myers, D. 2006. Stability and dissolution of platinum surfaces in perchloric acid. *JOURNAL OF THE ELECTROCHEMICAL SOCIETY* 153 (10): B446-B451.

Xie, Z; Song, CJ; Andreaus, B; Navessin, T; Shi, ZQ; Zhang, JJ; Holdcroft, S. 2006. Discrepancies in the measurement of ionic conductivity of PEMs using two- and four-probe AC impedance Spectroscopy. *JOURNAL OF THE ELECTROCHEMICAL SOCIETY* 153 (10): E173-E178.

Ghosh, PC; Wuster, T; Dohle, H; Kimiaie, N; Mergel, J; Stolten, D. 2006. Analysis of single PEM fuel cell performances based on current density distribution measurement. *JOURNAL OF FUEL CELL SCIENCE AND TECHNOLOGY* 3 (3): 351-357.

Siu, A; Pivovar, B; Horsfall, J; Lovell, KV; Holdcroft, S. 2006. Dependence of methanol permeability on the nature of water and the morphology of graft copolymer proton exchange membranes. *JOURNAL OF POLYMER SCIENCE PART B-POLYMER PHYSICS* 44 (16): 2240-2252.

Mattu, J; Johansson, T; Holdcroft, S; Leach, GW. 2006. Highly ordered polymer films of amphiphilic, regioregular polythiophene derivatives. *JOURNAL OF PHYSICAL CHEMISTRY B* 110 (31): 15328-15337.

Guerin, S; Hayden, BE; Lee, CE; Mormiche, C; Russell, AE. 2006. High-throughput synthesis and screening of ternary metal alloys for electrocatalysis. *JOURNAL OF PHYSICAL CHEMISTRY B* 110 (29): 14355-14362.

Thomassen, M; Borresen, B; Scott, K; Tunold, R. 2006. A computational simulation of a hydrogen/chlorine single fuel cell. *JOURNAL OF POWER SOURCES* 157 (1): 271-283.

Lobato, J; Rodrigo, MA; Linares, JJ; Scott, K. 2006. Effect of the catalytic ink preparation method on the performance of high temperature polymer electrolyte membrane fuel cells. *JOURNAL OF POWER SOURCES* 157 (1): 284-292.

Ramschak, E; Peinecke, V; Prenninger, P; Schaffer, T; Hacker, V. 2006. Detection of fuel cell critical status by stack voltage analysis. *JOURNAL OF POWER SOURCES* 157 (2): 837-840, Sp. Iss. SI.

Shimpalee, S; Lee, WK; Van Zee, JW; Naseri-Neshat, H. 2006. Predicting the transient response of a serpentine flow-field PEMFC I. Excess to normal fuel and air. *JOURNAL OF POWER SOURCES* 156 (2): 355-368.

Shimpalee, S; Lee, WK; Zee, JW; Naseri-Neshat, H. 2006. Predicting the transient response of a serpentine flow-field PEMFC II: Normal to minimal fuel and AIR. *JOURNAL OF POWER SOURCES* 156 (2): 369-374.

Rodgers, M; Yang, YS; Holdcroft, S. 2006. A study of linear versus angled rigid rod polymers for proton conducting membranes using sulfonated polyimides. *EUROPEAN POLYMER JOURNAL* 42 (5): 1075-1085.

Kulikovsky, AA; SchrnitZ, H; Wippermann, K; Mergel, J; Fricke, B; Sanders, T; Sauer, DU. 2006. DMFC: galvanic or electrolytic cell?. *ELECTROCHEMISTRY COMMUNICATIONS* 8 (5): 754-760.

Varcoe, JR; Slade, RCT. 2006. An electron-beam-grafted ETFE alkaline anion-exchange membrane in metal-cation-free solid-state alkaline fuel cells. *ELECTROCHEMISTRY COMMUNICATIONS* 8 (5): 839-843.

Cheng, H; Scott, K. 2006. Determination of kinetic parameters for borohydride oxidation on a rotating Au disk electrode. *ELECTROCHIMICA ACTA* 51 (17): 3429-3433.

Rimbu, GA; Jackson, CL; Scott, K. 2006. Platinum/carbon/polyaniline based nanocomposites as catalysts for fuel cell technology. *JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS* 8 (2): 611-616.

Rimbu, GA; Stamatin, I; Jackson, CL; Scott, K. 2006. The morphology control of polyaniline as conducting polymer in fuel cell technology. *JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS* 8 (2): 670-674.

Schaffer, T; Tschinder, T; Hacker, V; Besenhard, JO. 2006. Determination of methanol diffusion and electroosmotic drag coefficients in proton-exchange-membranes for DMFC. *JOURNAL OF POWER SOURCES* 153 (2): 210-216.

Schaffer, T; Hacker, V; Besenhard, JO. 2006. Innovative system designs for DMFC. *JOURNAL OF POWER SOURCES* 153 (2): 217-227.

Siu, A; Schmeisser, J; Holdcroft, S. 2006. Effect of water on the low temperature conductivity of polymer electrolytes. *JOURNAL OF PHYSICAL CHEMISTRY B* 110 (12): 6072-6080.

Ghosh, PC; Wuster, T; Dohle, H; Kimiaie, N; Mergel, J; Stolten, D. 2006. In situ approach for current distribution measurement in fuel cells. *JOURNAL OF POWER SOURCES* 154 (1): 184-191.

Wang, XP; Kumar, R; Myers, DJ. 2006. Effect of voltage on platinum dissolution relevance to polymer electrolyte fuel cells. *ELECTROCHEMICAL AND SOLID STATE LETTERS* 9 (5): A225-A227.

Varcoe, JR; Slade, RCT; Lam How Yee, E. 2006. An alkaline polymer electrochemical interface: a breakthrough in application of alkaline anion-exchange membranes in fuel cells. *CHEMICAL COMMUNICATIONS* (13): 1428-1429.

Rubatat, L; Shi, ZQ; Diat, O; Holdcroft, S; Frisken, BJ. 2006. Structural study of proton-conducting fluorous block copolymer membranes. *MACROMOLECULES* 39 (2): 720-730.

Guerin, S; Hayden, BE. 2006. Physical vapor deposition method for the high-throughput synthesis of solid-state material libraries. *JOURNAL OF COMBINATORIAL CHEMISTRY* 8 (1): 66-73.

Yu, EH; Scott, K; Reeve, RW. 2006. Application of sodium conducting membranes in direct methanol alkaline fuel cells. *JOURNAL OF APPLIED ELECTROCHEMISTRY* 36 (1): 25-32.

3 x (3)R30°", JOURNAL OF MOLECULAR CATALYSIS A-CHEMICAL 228 (1-2): 55-65 Sp. Iss. SI, MAR 16 2005.

Reports (Level 2b)

- Summary Report on Annex XVI Workshop, June 8-9, 2006, ECN, Petten, Netherlands
- Status Report on Annex XVI: Collaborative Research on Polymer Electrolyte Fuel Cells, Spring, 2006
- Status Report on Annex XVI: Collaborative Research on Polymer Electrolyte Fuel Cells, Fall, 2006

6.1.2 Reports Planned for Next Year

Meeting, Status, and Annual Reports for the Polymer Electrolyte Fuel Cell Task, Level 2.

6.4 Task XVII: Molten Carbonate Fuel Cells

6.4.1 Reports Published to Date

- The annual report of Annex XVII was published in January 2005.

6.4.2 Reports Planned for Next Year

- Annual report for 2006

6.2 Task XVIII: Solid Oxide Fuel Cells

6.3.1 Reports Published to Date

- Proceedings of the Workshop in San Antonio, Texas on November 1, 2004, by Subhash Singhal (Editor), November 2004.
- Proceedings of the Workshop in Quebec City, Canada on May 14, 2005, by Brian Borglum (Editor), May 2005.
- Proceedings of the Workshop in Helsinki, Finland on June 30, 2006, by Jari Kiviaho (Editor), June 2006.

6.3.2 Reports Planned for Next Year

- Meeting, Status, and Annual Reports for the Solid Oxide Fuel Cells Annex XVIII.
- Proceedings of the Workshop in Nara, Japan on June 2, 2007, by K. Yokomoto (Editor), June 2007.

6.2 Task XIX: Fuel Cell Systems for Stationary Applications

6.2.1 Reports Published to Date

- Minutes from Expert's meetings, Status Reports, two per year, and Annual Reports for Annex XIX.
- Final reports from Annex XII stationary fuel cells
  - The official summary report is published
  - A full version final report has been distributed to all members of Annex XII including all subtask reports and as selection of special reports

6.2.2 Reports Planned for Next Year, Annex XIX

- Meeting, Status and Annual reports
- Draft reports from subtasks

6.5 Task XX: Fuel Cell Systems for Transportation

No information available

6.6 Task XXI: Portable Fuel Cells

6.6.1 Reports Published to Date

- Annual report of Annex XXI: Portable Fuel Cells, Dec 14, 2004.
- Annual report Annex XXI: Portable Fuel Cells 2005.

6.6.2 Reports Planned for Next Year

- Status and Annual Reports for Annex XXI

Appendix 7 Task Experts

This section lists the Operating Agents and the other experts who have participated in those tasks that were active during the year. Each organisation is categorised as government or government agency (G), research institution (R), industry (I) or academic (A).

7.1 Task XVI: Polymer Electrolyte Fuel Cells

Operating Agent: Deborah Myers, Argonne National Laboratory, USA (R)

Experts:

Viktor Hacker	Graz University of Technology (A)	Austria
Gilbert Van Bogaert	Vito - Energy Technology (R)	Belgium
Steven Holdcroft	Simon Fraser University (A)	Canada
Brant Peppley	Royal Military College of Canada (A)	Canada
Jorgen Lundsgaard	IRD Fuel Cells A/S (R)	Denmark
Matti Valkiainen	VTT Processes (R)	Finland
Jürgen Mergel	Forschungszentrum Juelich GmbH (R)	Germany
Torsten Schwarz	ICT Fraunhofer (R)	Germany
Marco Brocco	Italian National Agency for New Technologies, Energy and Environment (ENEA) (R)	Italy
Tomohiko Ikeya	New Energy and Industrial Technology Development Organization□NEDO□ (G)	Japan
Ulises Cano-Castillo	Instituto de Electricas	Mexico
Gaby Janssen	ECN- Fuel Cell Technology (R)	Netherlands
Børre Børresen	Norwegian University of Science and Technology (NTNU) (A)	Norway
Lars Pettersson	Royal Institute of Technology, KTH (A)	Sweden

Rob Thring Rui Chen	Loughborough University (A)	United Kingdom
Keith Scott	University of Newcastle upon Tyne (A)	United Kingdom
Brian Hayden	University of Southampton (A)	United Kingdom
John Varcoe	University of Surrey (A)	United Kingdom
Deborah Myers	Argonne National Laboratory (R)	United States
Piotr Zelenay	Los Alamos National Laboratory (R)	United States

R = research institution, A = academic institution, G = government

7.4 Task XVII: Molten Carbonate Fuel Cells

Operating Agent: Tae-Hoon Lim, KIST, Korea (R)

Experts:

1	Manfred M.Bischoff	MTU (I)	Germany
2	Angelo Moreno	ENEA (G)	Italy
3	B. Marcenaro	Ansaldo(I)	"
4	Yoshiyuki Izaki	CRIEPI (R)	Japan
5	Y. Mugikura	"	"
6	M. Yoshikawa	"	"
7	Masaaki Tooi	IHI(I)	"
8	K. Tanimoto	AIST(R)	"
9	Tae-Hoon Lim	KIST (R)	Korea
10	Jonghee Han	"	"
11	Sung-Pil Yoon	"	"
12	Hee Chun Lim	KEPRI (R)	"
13	Joong Hwan Jun	RIST (I)	"
14	Hans Maru	FCE (I)	U. S. A.
15	Mohammad Farooque	"	"
16	D. Connor	GenCell(I)	"

7.3 Task XVIII: Solid Oxide Fuel Cells

Overall Operating Agent: Subhash C. Singhal, Pacific Northwest National Laboratory, USA

2006 Interim Operating Agent: Jari Kiviaho, VTT, Finland

Participants of the 2006 Workshop held June 30, 2006, Helsinki, Finland:

1	Brian Borglum	Versa Power Systems (R)	Canada
2	Tony Petric	McMaster University (I)	Canada
3	Erkko Fontell	Wartsila Corporation (I)	Finland
4	Jari Kiviaho	VTT Processes (R)	Finland
5	Laurent Antoni	CEA (R)	France
6	Robert Steinberger-Wilckens	Forschungszentrum Jülich (R)	Germany
7	Takashi Ujiie	NEDO (G)	Japan
8	Harumi Yokokawa	AIST (I)	Japan
9	Rak-Hyun Song	KIER (R)	Korea
10	Bert Rietveld	Energie Onderzoekscentrum Nederland (R)	Netherlands
11	Mohsen Assadi	Lund Institute of Technology	Sweden
12	Olivier Bucheli	HTceramix (R)	Switzerland
13	Mark Ormerod	Keele University (I)	UK
14	Stephen Skinner	Imperial College (I)	UK
20	Subhash Singhal	Pacific Northwest National Laboratory (R)	USA

7.2 Task XIX: Fuel Cell Systems for Stationary Applications

Operating Agent: Bengt Ridell. Grontmij AB, Sweden

Experts:

1	Karl Föger	CFCL (I)	Australia
2	Antoine Aslanides	EDF(I)	France
	Ludmilla Gautier	EDF(I)	France
3	Ulf Birnbaum	FZJ (R)	Germany
4	Gerhard Huppmann	MTU (I)	Germany
5	John Bøgild Hansen	HTAS(I)	Denmark
6	Adwin Martens	VITO(R)	Belgium
7	Rolf Rosenberg	VTT(G)	Finland
	Jari Kiviaho	VTT(G)	Finland
8	Timo Kivisaari	Wärtsilä(I)	Finland
9	Kazuhito Hato	NEDO (G)	Japan
10			
11	Peter vander Laag	ECN (R)	The Netherlands
	Paul van den Oosterkamp	ECN (R)	The Netherlands
12	Angelo Moreno	ENEA (G)	Italy
13	Bengt Ridell	Grontmij (I)	Sweden
14			
15	Dan Rastler	EPRI (I)	USA
16	Stephan Renz	Thoma & Renz (I)	Switzerland
17	Günther Simader	E.V.A. (G)	Austria
	Georg Trnka	E.V.A. (G)	Austria
18	Heinrich Wilk	Energie AG OÖ(I)	Austria

7.5 Task XX: Fuel Cell Systems for Transportation

Operating Agent: Prof Dr. Georg Erdmann

No information available

7.5 Task XXI: Portable Fuel Cells

Operating Agent: Hendrik Dohle, Juelich Research Center, Germany

EXPERTS

1	Ed Andrukaitis	Def. Research and Development	Canada
2	Vincenzo Antonucci	ITAE	Italy
3	Ulises Cano Castillo	Electrical Research Institute	Mexico
4	Hendrik Dohle	Forschungszentrum Jülich	Germany
5	Alexander Dyck	CEAG AG	Germany
6	Viktor Hacker	Technische Universität Graz	Austria
7	Holger Janssen	Forschungszentrum Jülich	Germany
8	Doo-Hwan Jung	KIER	Korea
9	Soren Lundsgaard	IRD	Denmark
10	Erik Middelmann	Nedstack fuel cell technology	NL
11	Ralf Peters	Forschungszentrum Jülich	Germany
12	Rolf Rosenberg	VTT	Finland
13	Thomas Schaffer	Technische Universität Graz	Austria
14	Günter R. Simader	Energieverwertungsagentur EVA	Austria
15	Gaetano Squadrito	ITAE	Italy
16	Matti Valkiainen	VTT	Finland
17	Ad Verhage	Nedstack fuel cell technology	NL