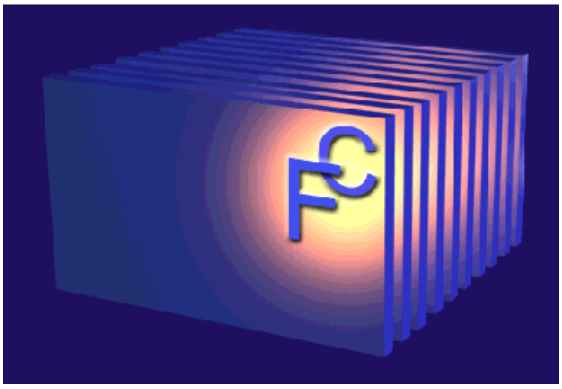


IEA Advanced Fuel Cells

Implementing Agreement

Annual Report 2004

April 2005

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
AEA Technology Environment
B154 Harwell
Didcot
Oxfordshire OX11 OQJ
United Kingdom

Distribution List

- Executive Committee (1 copy each)
- IEA Secretariat (100 copies)
- 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 twelve 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, 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 now 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 seventeen IEA-member countries participated in this Implementing Agreement during 2004. 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	L'Agence de l'Environnement et de	August 1996

	La Maîtrise de l'Energie (ADEME)	
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
Norway	Research Council for Norway (from October 1994, previously the Norwegian Council for Scientific and Industrial Research)	April 1990
Sweden	The Swedish National Energy Administration (STEM) (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 (Sydkraft, Sweden). The Vice-Chairman is Prof Detlef Stolten and the Secretariat consists of Mrs H Haydock, Ms C Handley and Mrs G Gordon (all AEA Technology, UK). The IEA/OECD representative during 2004 was Mr Jeppe Bjerg from the Energy Technology Policy Division.

The following table lists all the Executive Committee Members at the end of 2004, their Alternates and the Operating Agents of the different Annexes. 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	S Linderoth	F Luxhoi		
Finland	H Kotila	R Rosenberg		
France	G Chaumain	N Thybaud		
Germany	D Stolten	H Nabielek	H Dohle	XXI
			G Erdmann	XX

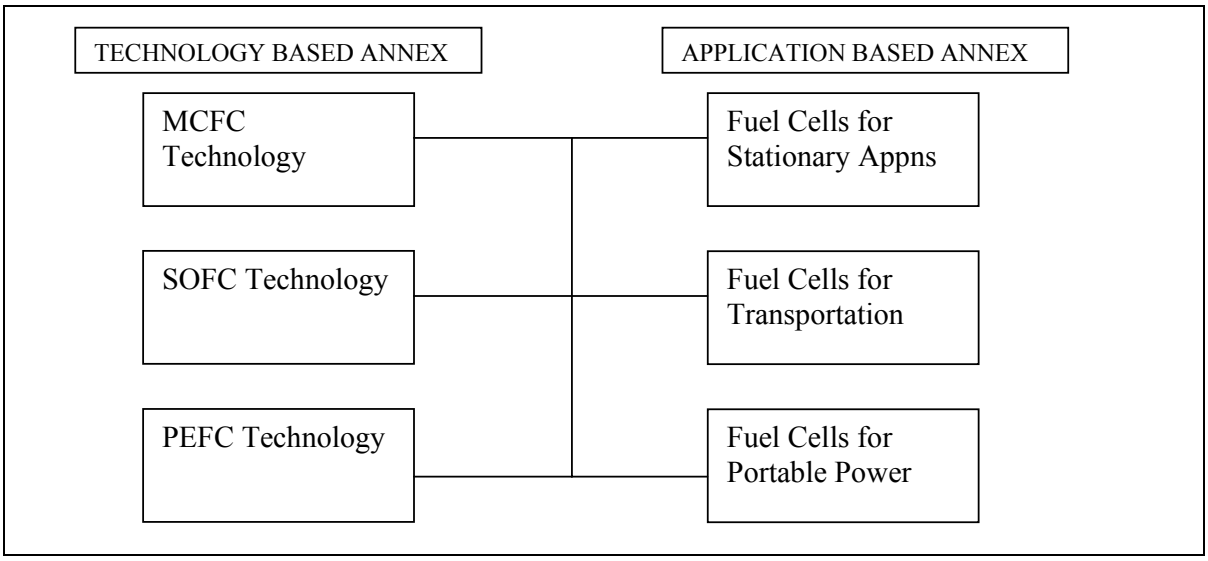
Italy	R Vellone	A Moreno		
Japan	N Kuriyama	T Ikeya		
Korea	H-C Lim	T-H Lim	T H Lim	XVII
Netherlands	S van der Molen			
Norway	R Hildrum	R Aaberg		
Sweden	L Sjunnesson	B Gustafsson		B Ridell XIX
Switzerland	A Hintermann			
UK	R Eaton	M Heffernan		
USA	N Garland	M Williams	D Myers	XVI
			S Singhal	XVIII

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.

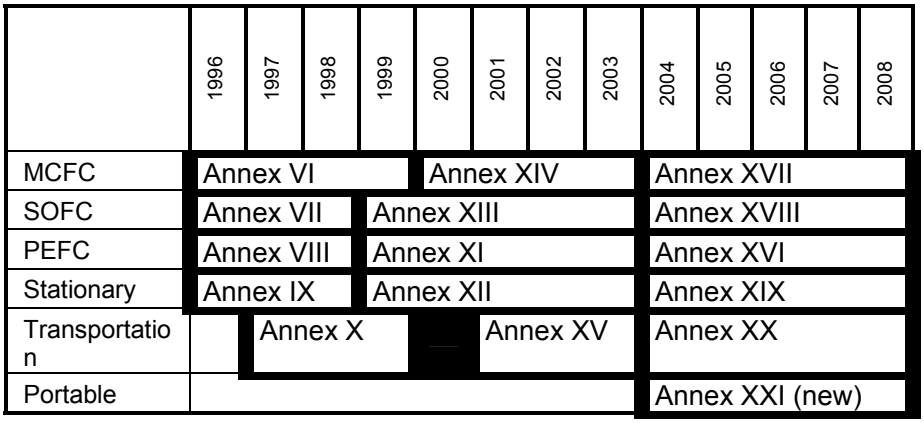


The programme places a greater emphasis on application- and market-orientated issues than previously, whilst continuing to address technology development and information management. The scope and timing of the programme are shown below.

Scope of the programme for 2004-2005

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



2. EXECUTIVE COMMITTEE REPORT

2.1 MEMBERSHIP AND PARTICIPATION

Two new countries, Austria and Denmark, joined the Executive Committee as members in 2004. Mr Günter Simader is the Member for Austria and Dr Viktor Hacker the Alternate. For Denmark, Mr Fritz Luxhoi is the Member and Mr Soren Linderoth the Alternate.

There were changes in the Executive Committee membership in 2004 for Finland, Japan and the USA. Mr Heikki Kotila (TEKES) replaced Mr Jerri Laine (TEKES) as member for Finland. Nobuhiro Kuriyama (NEDO) replaced Mr Fujio Shouji (NEDO) and Mr Tomohiko Ikeya (NEDO) as Member for Japan. Dr Nancy Garland replaced Jo-Ann Milliken as Member for the USA

Six Operating Agents were assigned to the new Annexes initiated in 2004. Dr Debbie Myers continued her role as Operating Agent for the PEMFC activities under the new Annex XVI. Dr Tee Hoon Lim was appointed as Annex XVII Operating Agent. Two German operating agents were assigned; Professor Georg Erdmann to Annex XX and Dr Hendrik Dohle to Annex XXI. Bengt Ridell will continue his management of Stationary fuel cell activities as operating Agent for Annex XIX. Finally, Subhash Singhal was assigned as Operating Agent for Annex XVIII, and this position will be rotated.

2.2 ACTIVITIES AND DECISIONS

2.2.1 Activities

Two Executive Committee meetings were held. The 28th Executive Committee meeting was held in Vienna, Austria in April and the 29th meeting was held in Seoul, Korea in October.

The web site for ExCo members was updated during 2004, providing details of meetings and downloadable papers and reports. 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 2003 Annual Report was prepared and distributed.

Each of the Operating Agents for the six new Annexes prepared an Annex Text for presentation at the Executive Committee meetings. Four Annex Texts were approved at ExCo 28 for Annexes XVI (PEFC), XVII (MCFC), XIX (Stationary) and XXI (Portable). The remaining Annex Texts, for Annex XVIII (SOFC and Annex XX (Transportation) were approved at ExCo 29. The Annexes will run from the date of approval until the end of December 2008

On behalf of the ExCo, the Secretary prepared a contribution on the Advanced Fuel Cells Implementing Agreement for the 2003/2004 Implementing Agreement Highlights publication. The Highlights publication will be presented to the IEA Ministers at their bi-annual meeting in late April 2005 in Paris. On behalf of the ExCo, the Secretary has recently prepared a contribution on the Advanced Fuel Cells Implementing Agreement for the EUWP Autumn Status Report on Transport related Implementing Agreements.

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. The ExCo Chairman attended the 3rd Meeting of the Hydrogen Co-ordination Group at the IEA in Paris in June 2004 and an update on HCG activities was presented at the ExCo29 meeting.

2.2.2 Decisions

Following presentations at the 28th and 29th ExCo meetings, the ExCo unanimously approved the new Annex Texts outlining the Programme of Work for the six Annexes.

Austria officially became a member of the AFC Implementing Agreement in 2004. The Executive Committee unanimously approved the applications of Denmark and Mexico to join the Implementing Agreement, on condition that they join at least one active Annex with the approval of its Operating Agent and participating experts. Denmark has subsequently joined the new Annex XIX on stationary applications and officially became a Member in 2004. Mexico was invited to attend the Annex XVI PEFC in Italy in November 2004, but was not able to make it. Mexico still intends to join Annex XVI.

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 2005. The first will be held in Copenhagen, Denmark on 28-29 April. The second meeting will be held in Palm Springs, USA, in the second week of November (provisional dates).

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 FUEL CELLS 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 the following annual meetings.

3.3 ACHIEVEMENTS OF ANNEX XVIII SOFC

Annex XVIII held a very successful workshop in November 2004. The workshop was attended by twenty representatives from ten participating countries who exchanged information on their research activities and gave technical presentations on issues relating to SOFC fabrication.

3.4 ACHIEVEMENTS OF ANNEX XIX FUEL CELL SYSTEMS FOR STATIONARY APPLICATIONS

Annex XIX is still at the early stage of planning and starting up work in the different subtasks. During the first year the subtasks were planned in detail and a work plan was agreed. Draft outlines of the subtask reports were presented.

Some preliminary findings can be reported.

- The existing Codes and standards have to be adjusted to facilitate the introduction of a large number of stationary fuel cells
- The balance of plant components in fuel cell systems are still far from commercial and thus too expensive for a commercial product. They have to be prepared for volume production
- There is a vast market of alternative locally produced fuels that can be used in an efficient way in stationary fuel cells

3.5 ACHIEVEMENTS OF ANNEX XX FUEL CELL SYSTEMS FOR TRANSPORTATION

A number of significant technical achievements were reported by the experts participating in Annex XX and are summarized below.

Jörg Wind from DaimlerChrysler reported from the CEP project in Berlin:
The Clean Energy Partnership (CEP) is a consortium comprising the following companies: Aral, BMW Group, Berlin Public Transport (Berliner Verkehrsbetriebe – BVG), DaimlerChrysler, Ford, GM/Opel, Hydro/GHW, Linde and Vattenfall Europe. From the end of 2004, CEP will run a demonstration project with the aim of proving the everyday suitability of hydrogen for transportation purposes. Different methods of hydrogen production will be demonstrated and hydrogen technologies for vehicles developed with a view to series production.

A public hydrogen filling station has been installed at the Berlin Messedamm. Gaseous hydrogen is to be produced on site via electrolysis and stored in compressed form, while super-cooled liquid hydrogen will be delivered by truck and stored in a cryogenic tank. The hydrogen will be used either by vehicles with modified internal combustion engines or by fuel cell vehicles.

The CEP project is planned to run for a period of five years and is supported by the German Federal Government as part of its national sustainability strategy. The federal strategy has been devised to demonstrate future-oriented technologies and thereby indicate the technical and financial prerequisites for the use of alternative fuels in road transportation. One essential point is the realization of favourable effects on the environment. As far as possible, the hydrogen is therefore produced from renewable energy sources such as hydroelectric and wind power. With renewable energy there will be practically no harmful emissions and also no greenhouse gas emissions emanating from hydrogen production and use.
Source: www.cep-berlin.de

The experts reported, which new insights concerning well to wheel studies have been achieved since 2002.
Bob Wimmer (TOYOTA) proposed to shift the focus from the Full Energy chain to the Life Cycle Assessment (LCA) which integrates the manufacturing emissions of plants and vehicles into the analysis.

The debate about the choice between conventional hybrids and FCEV hybrids is open. But FC projects of the automobile industry represent still the largest development effort. Thus the promise of Hybrid ICE vehicle market entry has no negative impact on FCEV development yet.

3.6 ACHIEVEMENTS OF ANNEX XXI FUEL CELL SYSTEMS FOR PORTABLE APPLICATIONS

A number of significant technical achievements were reported by the experts participating in Annex XXI and are summarized in Section 4.1.

The world-market for handheld applications such as mobile phones or PDA is appr. 550 million devices, for portable applications like notebooks the demand is 40 million, and for small traction (wheel chairs, e-bikes) it is 400,000. One important goal is the integration of system components and the reduction of the total number of necessary system components to become competitive against conventional energy storage systems such as batteries. Studies for the use of DMFC in Laptops and mobile phones show that they are technically competitive against Li-Ion batteries if pure methanol can be used which depends on the water management. An important issue is the design of the system architecture. Systems with a monodirectional DC/DC converter allow a smaller stack sizing and an easier load following management, whereas the use of a bidirectional DC/DC converter is combined with higher costs.

Water management will remain an important challenge for portable fuel cells and also for DMFC. Simulation studies show that the exhaust gas air must be cooled to appr. 45°C to ensure water–autonomous operation at ambient pressure for a stoichiometric air flow rate of 4 which is necessary for DMFC operation. If this exhaust temperature cannot be reached, additional water must be fed into the system by using a highly concentrated methanol/water mixture (e.g. 50% of methanol) or by a separate water tank. A new principle for operating a Direct-Methanol-Fuel-Cell with liquid electrolytes was presented. The polymer membrane consists of two halfs with sulfuric acid in between. By pumping the sulfuric acid through the membrane the methanol permeation can be minimized. Furthermore the electrolyte can carry pecursor products out of the cell. Measurements were performed at moderate operating conditions (50°C, ambient pressure) which are suitable for portable applications. A hydrogen generator combined with a portable fuel cell system of the 500 W class was demonstrated. The hydrogen is generated from a sodium borohydride subsystem. For typical cell phone applications a fuel cell system based on metal hydride storage (storage capacity 20 Wh) was tested. The maximum power demand is 4.3 W, the average power is 1 W. A 3 W air breathing PEFC system is superior to Li-Ion batteries at an energy content greater than 12 Wh. The hydrogen storage is the current handicap with regards to further miniaturization.

4. TASK REPORTS

4.1 REPORT TASK XVI PHASE 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 thirteen countries were involved in this Annex during the year 2004:

Austria:	Graz University of Technology
Belgium:	Flemish Institute for Technological Research, Vito
Canada:	The Government of Canada
Finland:	VTT Processes
Germany:	Forschungszentrum-Jülich GmbH
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 Science and Technology
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 and Finland are two 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 Newcastle University, Newcastle upon the Tyne, United Kingdom, on May 6-7, 2004 for the spring meeting, and at ENEA headquarters, Rome, Italy, on November 18-19, 2004 for the fall meeting. Discussions at these workshops indicate that progress is being made in all subtasks of the Annex, as highlighted in the next section.

4.1.6.3 Technical Accomplishments

Subtask 1: New Stack Materials

- Using modelling and electrochemical impedance spectroscopy, concluded that mass transport in the cathode electrocatalyst layer is dominant near open circuit potential and under high polarization. Under moderate polarization both charge transfer and mass transfer impedance are significant. (Canada)
- Assembled stacks from commercially purchased membrane-electrode assemblies and using them for constructing power packs (POWERPEM project). Energetics of oxygen adsorption on different platinum crystal faces are being determined via molecular modeling. Based on the modeling work, an alloy of Pt, Co, and Cr was studied experimentally. (Finland)
- Developed Pt-Mo/Pt-Ru bilayer anodes for reformate tolerance, optimized the cathode catalyst ink by adding stabilizers to improve viscosity and sodium carbonate to form pores, and developed membrane electrolytes based on functionalized imidazole for use at high temperatures (120-150ºC). (Netherlands)
- Developed high-temperature polymer membrane fuel cells with polybenzimidazole-phosphoric acid electrolyte and hydrogen/chlorine fuel cells for co-generation of HCl and electric power. (Norway)
- Identified binary and ternary alloy compositions with oxygen reduction activity comparable to Pt using rapid fabrication and screening methods. (United Kingdom)

Subtask 2: System and Balance-of-Plant Issues

- Developed a fast fuel cell stack model, conducting fuel cell power system modeling for the European Space Agency (ESA), developing a power system simulation tool for ESA, and conducting mechanistic CFD modeling of polymer electrolyte membrane fuel cells. (Austria)
- Determined the feasibility of ammonia as a fuel for polymer electrolyte or solid oxide fuel cells (European ACCEPT program). The project involves ammonia polymer electrolyte membrane fuel cell sensitivity analysis, ammonia cracker adaptation, system integration, testing, and model verification. Constructed test benches for alkaline and polymer electrolyte fuel cell stacks up to 20 kW_e, requiring specialized gas humidifying equipment. (Belgium)
- Designed and constructed a 15 kW_e polymer electrolyte fuel cell stack test system. Constructed a natural gas fuel processor with partial oxidation, water-gas shift, and preferential oxidizer stages. (Italy)
- Developed control algorithms based on “fuzzy logic” for fuel cell/battery hybrid systems. Designed and fabricated a micro methanol fuel processor and fuel vaporizer. (Korea)
- Conducted a theoretical study on membrane humidification effects on PEFCs for automotive and aeronautical applications. Determined that membrane humidification and thickness affect not only the membrane resistance, but also the cathode over-voltage via water content of this layer. (United Kingdom)

- Determined that the maximum sodium borohydride concentration for the efficient hydrolysis reaction for hydrogen production is about a half of the $NaBH_4$ saturated solution using a semi-empirical dissolution model. (United Kingdom)
- Modeled the effects of higher operating temperature (120ºC) and low relative humidity on the size of an automotive hydrogen-fueled polymer electrolyte fuel cell system. Determined that it is desirable to operate under dry conditions or with <15% RH, depending on the humidification scheme (i.e., condenser-humidifier or enthalpy wheel). (United States)

Subtask 3: Direct Fuel Polymer Electrolyte Fuel Cells

- Developed direct methanol fuel cells (DMFCs) with liquid electrolyte, maximum power density obtained thus far is ~200 mW/cm^2. An active methanol oxidation electrocatalyst of 10% tin and 90% platinum was developed using combinatorial techniques. (Austria)
- Developed DMFCs with reduced methanol crossover for micro-power applications. (Finland)
- Automating membrane-electrode assembly fabrication for DMFCs. Inert inorganic particles (silica, graphite) added to the catalyst inks improve the electrode performance by altering the electrode hydrophilicity. Achieved a DMFC performance of 125 mW/cm^2 at 80ºC. Presented a DMFC-powered vehicle at the Fuel Cell Seminar. (Germany)
- Developed DMFCs with an alkaline polymer electrolyte membrane with performance comparable to proton-conducting cells. (United Kingdom)

4.1.7 Work Plan For Next Year

The general consensus of the Working Group is that, due to the rapid advances being made in the development of polymer electrolyte fuel cells, it is difficult, and perhaps inappropriate, to develop a detailed work plan for any significant length of time. Instead, each participant is working from a generic program plan that identifies the tasks and areas of effort. These are summarised below, by participating country.

Austria:	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
Finland:	Direct methanol fuel cells for micro-power applications, electrocatalyst development, stack construction and testing, and MEA development
Germany:	Direct methanol fuel cells, materials, and systems

Italy:	MEAs, catalysts, 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
The Netherlands:	CO tolerance, low humidity membranes, and system and cell modeling
Norway:	High temperature polymer electrolyte fuel cell development, 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, and direct methanol fuel cells
United States:	Modelling and systems analysis, automotive reformer development, high-temperature polymer electrolytes, non-platinum electrocatalysts, and direct methanol fuel cells

4.2 REPORT TASK XVII MOLTEN CARBONATE FUEL CELLS

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)

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, problems with the stack, 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 mal-functioning, 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 the 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 troubles in 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 troubles in 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)

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 commercialization	Summary of BOP updating and optimization

4.3 REPORT TASK XVIII SOLID OXIDE FUEL CELLS

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. The Interim Operating Agent for 2005 is Dr. Brian Borglum, Versa Power Systems, Calgary, Canada.

4.3.3. Participants

Ceramic Fuel Cells Ltd (Australia)
Natural Resources Canada (Canada)
ADEME (France)
Forschungszentrum Jülich (Germany)

The New Energy and Industrial Technology Development Organisation, NEDO (Japan)
ECN (Netherlands)
Swedish National Energy Administration (Sweden)
Swiss Federal Office of Energy (Switzerland)
DTI (UK)
US DOE (USA).
VTT Processes (Finland)

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 into relevant conferences, in order to minimise travelling costs. The workshops should lead to open discussions relating to common problems and have realizable and achievable aims.

4.3.5 Task Description

Representatives from 11 countries (see above participants list) participated in the Annex XVIII Workshop on November 1, 2004 in San Antonio, Texas, USA. The experts attending the meeting agreed on the objectives of the Annex described above and agreed on an Interim Operating Agent "system" as described above. It was decided that the Annex XVIII would comprise a series of workshops, each to be 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/FuelCell Energy/Brian Borglum	SOFC IX, Quebec City; May 2005
2006	Finland /VTT/Jari Kiviaho	7th European SOFC Forum, Lucerne, Switzerland; July, 2006
2007	Japan / NEDO / tbd	SOFC X, Japan; Summer 2007
2008	Switzerland / tbd / tbd	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 C. 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 2004

The Interim Operating Agent for 2004 prepared status reports on Annex XVIII for the ExCo meetings.

The Interim Operating Agent prepared a concept work plan for the new Annex XVIII on SOFC for the period from 2004 to 2008 and presented it at the ExCo meeting.

4.3.6.3 Activities in 2004

Preparations were made for the 2004 Workshop which 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 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

4.3.6.4 Technical Accomplishments in 2004

During the workshop, 13 presentations were made by experts from participating countries dealing with the SOFC research, development and demonstration in their respective countries. The presentations showed that in the recent years a real progress has been made toward manufacturing and commercialization of SOFCs

4.3.6.5 Future Plans

The Workshop for 2005 will be held in Quebec City, Canada on May 14, 2005 and will be organized and chaired by Dr. Brian Borglum, Versa Power Systems, Calgary, Canada. This Workshop is being held just before the Ninth International Symposium on Solid Oxide Fuel Cells (SOFC-IX) in Quebec City 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 National Energy Administration acting through Sydkraft 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 National Energy Administration
Eltra, (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)

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

4.4.3 Objective

The main objective of the work in Annex XIX is to receive a better understanding of 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 have 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? The subtask will cover the influence on several aspects and will analyse 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 fuels to choose depending on the existing infrastructure. Hydrogen is also an obvious choice for future use as it can be produced locally on many different ways including the use of renewable energy. There are many other fuels existing that today in several cases are considered as waste that can be used in stationary high temperature fuel cells. Gases can come from chemical industry

plant like purge gas, synthesis gas or other process gases. They can also be produced by gasification of, for instance, biomass or sewage gas. 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

Currently, 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 lager 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

The work in Annex XIX has recently started and there are not yet any major results published.
It can be mentioned that as the stationary fuel cells are now developed at a faster pace it is a very important issue to prepare and understand the market. Some examples of critical issues have been found

- It is important to find early adopters niche applications
- The possibilities to use alternative and sustainable fuels can be one important driver for high temperature fuel cells
- Codes and standards must be ready before a major market introduction

4.4.7 Work Plan for Year 2005

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

Two experts meetings are planned for the year 2005.

4.5 REPORT TASK XX
FUEL CELL SYSTEMS FOR TRANSPORTATION

4.5.1 Duration

This Annex entered into force on March 2004 and ends on December 2008.

4.5.2 Operating Agent

Prof. Dr. Georg Erdmann, TU Berlin.

4.5.3 Participants

Agencies from the countries participated in this Annex during the year 2004:

Canada: Natural Resources of Canada (NRC)
Germany: Forschungszentrum-Jülich GmbH
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 Science and Technology (KIST)
Netherlands: Netherlands Energy Research Foundation (ECN)
Sweden: Swedish Energy Agency
United States: The Department of Energy of the U. S. Government (USDOE)

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

4.5.4 Objective

The overall objective of ANNEX XX is to develop the understanding of fuel cells with their particular properties, applications, and fuel requirements. The specific objectives are to:

- Improve the common understanding of state of the art fuel cell systems, on board fuel storage systems, technology development directions, cost reduction approaches.
- Improve the concepts for alternative fuels by discussing manufacturing technologies, required infrastructure for storage and distribution, efficiencies and emissions during fuel production
- Leverage the emissions work being carried out in Participants' organizations
- Jointly reviewing the ongoing work on practices and procedures relevant to alternative fuels and fuel cell vehicles, and help identify their niche applications
- Accelerate the market entry of advanced fuel cell systems by identifying open development issues of common interest, but also contradictory views and recommendations on private and government strategies.

4.5.5 Task Description

This Task consists of the following subtasks:

Subtask A: Fuel Cell electrical vehicles
This subtask will analyze the technology progress of fuel cells for generating traction power and auxiliary power. The systems to be considered include polymer electrolyte fuel cells (PEFC) and solid oxide fuel cells (SOFC). The subtask will emphasize transportation applications related to road traffic (passenger automobiles, trucks and mass transit), railroads and waterways. It will compile and review the results of recent field tests in different countries as well as experimental data on regulated emissions (carbon monoxide, nitrogen oxides, sulfur dioxide, volatile organic compounds and particulates) from different fuel cell systems operating with conventional and alternative fuels.

Subtask B : Fuel infrastructure
This subtask will update the ongoing work on efficient production, transportation and distribution of low-cost hydrogen from diverse sources including fossil, nuclear and renewable energies. It will also include the comparison of liquid versus gaseous hydrogen as a fuel for fuel cell electrical vehicles. Other alternative fuels such as methanol, ethanol and Fischer-Tropsch-liquids are likewise assessed. Field data on stationary production of hydrogen, fuel economy of passenger vehicles, LDVs and busses are assessed.

Subtask C: System analysis and comparison of fuel cells and hybrid electrical vehicles
The comparison includes fuel economies (well-to-wheel analysis; life cycle analysis)
environmental impacts (regulated emissions, greenhouse gases), fuel resource requirements (incl. supply diversity, supply security) and costs (total cost of ownership; Life Cycle Costs). The subtask shall also identify the pros and cons as well as differences in the assessment of the two electric vehicle options.

4.5.6 Progress Summary

4.5.6.1 Background

This Annex is the successor to Annex XV that ran from May 1, 2001 and ended on December 31, 2003.

4.5.6.2 Activities

The Annex XX working group met in Stuttgart, Germany for a one day Kick-Off Meeting on 28 September 2004. A report on the meeting was prepared and released in October 2004.

4.5.6.3 Technical Accomplishments

The participating experts will not meet in traditional workshops and listen to prepared
papers of other experts but shall come together in “brainstorming type” meetings towards exchanging experiences and discussing views and recommendations. Each of the semi-annual meetings should focus on one or – at most – two commonly agreed themes that correspond with the subtasks. The Kick-off meeting concentrates on the question: System analysis and comparison of fuel cells and hybrid electrical vehicles. The results from the meeting are summarised below.

Well-To-Tank / Well-To-Wheel aspects

Beyond the FCEV technology, there is a (too) broad spectrum of candidates for fuels (liquid or gaseous hydrogen, methanol, ethanol, FTD,…). Also the feedstocks have a wide variety from coal and nuclear to biomass and photovoltaics. The fuel production technologies such as electrolysis, steam reforming, liquefaction, compression have a different status of technological maturity. The location of the fuel production plants (remote, central, local, at the filling station) has a significant impact on ecological and economical parameters. Until now the description of fuel logistics (vessel, pipeline, truck) is based on uncertain assumptions.

A decision among this manifold of options may rely on at least the following criteria

- fuel cost at the filling station:
- total cost of ownership (taking the vehicle price and performance into consideration)
- unit costs of carbon emission reductions over the full energy chain
- feedstock availability / security of supply (WTW fuel efficiency)
- local environment (zero emission vehicle ZEV; external costs)
- risk and social acceptance

As the decision criteria vary on a short, mid and long term scale, the overall assessment becomes not easier.

Hybridization

Hybridization means that electric batteries may assist the Fuel Cell in meeting the vehicle power demand under certain driving conditions. The following questions and aspects related to FCEV hybridization were largely discussed by the experts.

FCEVs will have at the beginning some degree of hybridization
Hybridization reduces the FC power requirement (up to 50 %)
Hybridization reduces FCEV fuel consumption by 10-20 % (depending on the drive cycle)
Operational strategy of the hybrid FCS is crucial (but depends on the drive cycle)

Present development of gasoline/diesel hybrids will help FCEV
Many hybrid components are similar and favour FCEV development
The development of hybrid operating strategies are likewise useful for

FCEV (example: Impact of the energy management on the battery life)
The fuel cell use as an auxiliary power unit (APU) will have similar advantages
Recuperative breaking will have a greater advantage with FCEV than with standard hybrid vehicles

The counterarguments

Gasoline/diesel hybrids are market ready
Market penetration of gasoline/diesel hybrid may lock-out competing technologies
Gasoline/diesel hybrids may become the baseline technology for comparing FCEV
State of the art gasoline hybrid vehicles have an GHG advantage over hydrogen FCEV if the hydrogen is produced from natural gas (steam reforming)
Barring technological breakthroughs, FC and ICE vehicle efficiencies will improve at similar rates

4.5.7 Work Plan for Next Year

The activities of Annex XX will work in four sub-tasks.

- Subtask A: Hydrogen infrastructure
- Subtask B: Advanced fuel cell systems
- Subtask C: Technology validation
- Subtask D: Assessment and Economics

4.6 REPORT TASK XXI FUEL CELL SYSTEMS FOR PORTABLE APPLICATIONS

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.

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 combine 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.

4.6.6.3 Technical Accomplishments

System Analysis for Portable Fuel Cells

- The driving force for the use of fuel cells in portable applications is the decreased size and the decreased weight of fuel cell based systems compared to conventional energy storage devices such as batteries. For hydrogen fuel cells a system analysis for hydrogen storage both on metal hydrides and chemical hydrides was carried out. The energy density for chemical hydrides ($LiBH_4$, NaBH) is in the range of 1-4 kWh/L (Canada).
- An important topic is the system integration of fuel cells, electronic control in hybrid with batteries for the support of different applications in the sub-kW range. The world-market for handheld applications such as mobile phones or PDA is appr. 550 million devices, for portable applications like notebooks the demand is 40 million, and for small traction (wheel chairs, e-bikes) it is 400,000. For these applications the customer´s demands are derived and fuel cell systems are designed and tested (Germany).
- A specific topic in DMFC systems is water management. Simulation studies show that the exhaust gas air must be cooled to appr. 45°C to ensure water–autonomous operation at ambient pressure for a stoichiometric air flow rate of 4 which is necessary for DMFC operation (Germany).
- Studies for the use of DMFC in Laptops and mobile phones show that they are competitive against Li-Ion batteries if pure methanol can be used. An important issue is the design of the system architecture. Systems with a monodirectional DC/DC converter allow a smaller stack sizing and an easier load following management, whereas the use of a bidirectional DC/DC converter is combined with higher costs (Italy).

System, Stack and Cell Development for Portable Fuel Cells

- A new principle for operating a Direct-Methanol-Fuel-Cell with liquid electrolytes was presented. The polymer membrane consists of two halfs with sulfuric acid in between. By pumping the sulfuric acid through the membrane the methanol permeation can be minimized. Furthermore the electrolyte can carry pecursor products out of the cell. Measurements were performed at

moderate operating conditions (50°C, ambient pressure) which are suitable for portable applications (Austria).

- A hydrogen generator combined with a portable fuel cell system of the 500 W class was demonstrated. The hydrogen is generated from a sodium borohydride subsystem (Canada).
- A 1 kW PEMFC-Stack for the PEM power pack with low-price composite bipolar plates has been designed. On specific topic to be investigated is the influence of impurities of cathode air impurities on the performance (Finland).
- The focus of CEAG in the field of fuel cells is the development of systems, especially the controller units. For typical cell phone applications a fuel cell system based on metal hydride storage (storage capacity 20 Wh) was tested. The maximum power demand is 4.3 W, the average power is 1 W. A 3 W air breathing PEFC system is superior to Li-ion batteries at an energy content greater than 12 Wh. The hydrogen storage is the handicap in the moment with regards to further miniaturization (Germany).
- A new DMFC system with an electrical power output of 1 kW has been developed. The specific power density is 15 W/kg respectively 6 W/l. The relatively complex system of a 2 kW DMFC system (y.o.c. 2002) has been simplified by system integration. The external heat exchanger for the liquids has been replaced by a condenser/cooler unit.
- In the field of reformer development and testing a 3 kW autothermal diesel reformer has been characterized. The conversion rate of sulfur-poor diesel is higher than 98% (Germany).
- A specification for a fuel cell system designed for operation in a laptop is in progress. The volume of the system will be 50% for the electronic and 50% for the fuel cell and its cartridge. The use of pure methanol is essential for achieving a compact system design and to be competitive with Li-ion batteries. The aim of the project is to achieve 40 mW/cm² @ 0.3 V. 12 cells will be used with a total area of 240 cm². The voltage of 3.6 V will be converted to 10.8 V by means of a DC/DC converter (Italy).
- Different DMFC-stacks in a power range of 10-200 W have been tested. An air-breathing stack with a maximum power of 65 W using a 2 M methanol solution running at ambient conditions was used to demonstrate the operation of mobile TV. The stack of the 200 W class operates at a voltage of 12.8 V and a current of 15 A. The cell consists of 39 cells with an active area of 138 cm² each. The endplates have the dimensions of 140 x 124 mm. This system was successfully demonstrated as a power source for a vacuum cleaner (Korea).
- Another 1 kW hydrogen based fuel cell system is in development. The system is a hybrid system with a battery. An important topic is the dynamic evaluation of fuel cells (transient response) with regard to the development of power electronics and control systems (Mexico).
- NedStack produces PEFC and DMFC stacks in the range from sub-kW to the 200 kW class. For portable units, a DMFC stack with a nominal power of 100 W and a stack volume of 1.2 L (without endplates) has been designed. The stack consists of 36 cells with an active area of 56 cm² each producing a current density of 143 mA/cm² at a cell voltage of 0.35 V. Cooling is effected by MeOH circulation and heat-exchanger (The Netherlands).

Materials under Operating Conditions / Materials Innovation

- New high temperature membranes based on non-woven polymer coated with a porous ceramic layer made of oxides of alumina, zirconia and silica have been successfully tested. The pore size is in the range of 80-240 nm. With regard to the temperature the chemical and thermal stability has been proven up to 210°C. Further tests are in progress (Austria).
- Membrane development, catalyst development and MEA development are in the scope of this subtask. The performance of recast Nafion-membranes (53 µm, 88 µm) with inorganic compounds is comparable to a Nafion 112 (60 µm) using hydrogen and air at ambient pressure and ambient temperature. The performance of non perfluoronated polysulfonate membranes is lower compared to Nafion 112 at high current densities (132 mW/cm² vs. 150 mW/cm² at 0.6 V), but superior at partial load (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: (+) 43-1-5861524-1 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	Mr F Luxhoi Eltra	Tel: (+)45-7622-4000

	Fjordvejen 1-11 7000 Fredericia	
	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	Dr G Chaumain ADEME 2 square Lafayette BP406 49004 ANGERS Cedex 01	Tel: (+)33-1-41-91-4017 Fax: (+)33-1-41-91-4002
	Ms N Thybaud ADEME 2 square Lafayette BP406 49004 ANGERS Cedex 01	Tel: (+)33-2-41-91-4028 Fax: (+)33-2-41-91-4002
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 N Kuriyama NEDO 11310 Ohmiya-cho Saiwai-ku Kawasaki-shi KANAGAWA 212-8554	Tel: (+)81-44-520-5261 Fax: (+)81-44-520-5263
	Mr T Ikeya NEDO 11310 Ohmiya-cho Saiwai-ku Kawasaki-shi KANAGAWA 212-8554	Tel: (+)81-44-520-5261 Fax: (+)81-44-520-5263
Korea 5304/5374	Mr H-C Lim KEPRI 103-16 Munji-dong Yusong-ku Taejon 305-380	Tel: (+)82 42 865 7540 Fax: (+)82 42 865
	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 S van der Molen ECN P O Box 1 1755 ZG PETTEN	Tel: (+)31-224-56-4380 Fax: (+)31-224-56-3489
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: (+)44-20-7215-2674
	Mr M Heffernan DTI 1-19 Victoria Street LONDON SW1H OET	Tel: (+)44-20-7215-2627 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-
	Dr M Williams USDOE NETL PO Box 880 Morgantown WV 26505	Tel: (+)1-304-285-4747 Fax: (+)1-304-285-4292

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	Mr H-C Lim KEPRI	Tel: (+)82 42 865 7540 Fax: (+)82 42 865

5304/5374

	103-16 Munji-dong Yusong-ku Taejon 305-380 Korea	
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 Carl Bro Energikonsult AB SE-20509 Malmo Sweden	Tel: (+)46-40-255996 Fax: (+)46-40-256017
Annex XX	Prof G Erdmann TU Berlin Einsteinufer 25 (TA8) D-10597 Berlin	Tel: (+)49 30 314-246-56 Fax: (+)49 30 314 269 08
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 B154 Harwell Didcot Oxfordshire OX11 OQJ United Kingdom	Tel: (+)44-870 190 6487 Fax: (+)44-870 190 6615
ExCo Secretariat	Ms C Handley AEA Technology	Tel: (+)44-870 190 6132 Fax: (+)44-870 190 6327

B154 Harwell
Didcot
Oxfordshire
OX11 OQJ
United Kingdom

ExCo Secretariat
Mrs G Gordon
AEA Technology
B329/J Wing
Harwell
Didcot
Oxfordshire
OX11 OQJ
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, Vienna, Austria
29th	October 13-14, Seoul, Korea

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 29 Executive Committee Meetings since initiation (1990).
- Annual Reports 1990-2003.
- Contribution on the Advanced Fuel Cells Implementing Agreement for the 2003/2004 Implementing Agreement Highlights IEA publication (2004)

- Contribution on the Advanced Fuel Cells Implementing Agreement for the EUWP Autumn Status Report on Transport related Implementing Agreements (2004)
- 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 2004, 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, May 6-7, 2004, Newcastle upon the Tyne, UK
Annex XVI Working Group, November 18-19, 2004, Rome, Italy

5.1.2 Workshops and Meetings Planned for Next Year

Annex XVI Working Group, June 2-3, 2005, Mol, Belgium
Annex XVI Working Group, October/November 2005, 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

First meeting was held on October 18-20, 2004 in Kawasaki, Japan hosted by NEDO.

5.2.2 Workshops and Meetings Planned for Next Year

The second meeting of Annex XVII is scheduled to be held in USA in November 2005 hosted by FCE.

5.3 Task XVIII: Solid Oxide Fuel Cells

5.3.1 Workshops and Meetings Held to Date

The first Workshop of the new 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

5.3.2 Workshops and Meetings Planned for Next Year

The Workshop for 2005 will be held in Quebec City, Canada on May 14, 2005 and will be organized and chaired by Dr. Brian Borglum, Versa Power Systems, Calgary, Canada. This Workshop is being held just before the Ninth International Symposium on Solid Oxide Fuel Cells (SOFC-IX) in Quebec City 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.

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

5.4.2 Workshops and Meetings Planned for Next Year

The third expert is planned to take place in April 5-6, 2005 at ECN, Petten in the Netherlands

5.5 Task XX:

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

Further meetings on transportation fuel cells will be in 2005.

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.

5.6.2 Workshops and Meetings Planned for Next Year

Two status meetings are planned for 2005.

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	Open distribution to all countries in IEA.

		reports	
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)

- Q.P. Wang, D.T. Song, T. Navessin, S. Holdcroft, and A.S. Liu, “A mathematical model and optimization of the cathode catalyst layer structure in PEM fuel cells”, ELECTROCHIMICA ACTA, 50 (2-3): 725-730 Sp. Iss. SI NOV 30 2004
- Z. Xie and S. Holdcroft, “Polarization-dependent mass transport parameters for orr in perfluorosulfonic acid ionomer membranes: an EIS study using microelectrodes”, JOURNAL OF ELECTROANALYTICAL CHEMISTRY, 568 (1-2): 247-260 JUL 1 2004
- P. Piela, C. Eickes, E. Brosha, F. Garzon, P. Zelenay, “Ruthenium crossover in direct methanol fuel cell with Pt-Ru black anode”, JOURNAL OF THE ELECTROCHEMICAL SOCIETY, 151 (12): A2053-A2059 2004
- S. Guerin, B.E. Hayden, C.E. Lee, C. Mormiche, J.R. Owen, A.E. Russell, B. Theobald, D. Thompsett, “Combinatorial electrochemical screening of fuel cell electrocatalysts” JOURNAL OF COMBINATORIAL CHEMISTRY, 6 (1): 149-158 JAN-FEB 2004
- G.J.M. Janssen, “Modelling study of CO_2 poisoning on PEMFC anodes”, Journal of Power Sources vol.136, no.1 : 45-54 , 10 Sept. 2004
- G. Pede, A. Iacobazzi, S. Passerini, A. Bobbio, G. Botto, “FC vehicle hybridisation: an affordable solution for an energy-efficient FC powered drive train”, JOURNAL OF POWER SOURCES 125 (2): 280-291 JAN 14 2004
- R.K. Ahluwalia, X. Wang, A. Rousseau, R. Kumar, “Fuel economy of hydrogen fuel cell vehicles”, JOURNAL OF POWER SOURCES 130 (1-2): 192-201 MAY 3 2004
- E.H. Yu and K. Scott, “Development of direct methanol alkaline fuel cells using anion exchange membranes”, JOURNAL OF POWER SOURCES 137 (2): 248-256 OCT 29 2004
- L.X. Yang, R.G. Allen, K. Scott, P. Christenson, and S. Roy, “A comparative study of PtRu and PtRuSn thermally formed on titanium mesh for methanol electro-oxidation”, JOURNAL OF POWER SOURCES 137 (2): 257-263 OCT 29 2004

Reports (Level 2b)

- Summary Report on Annex XVI Workshop, May 6-7, 2004 Newcastle University, Newcastle upon the Tyne, United Kingdom.
- Status Report on Annex XVI: Collaborative Research on Polymer Electrolyte Fuel Cells, Fall, 2004

6.1.2 Reports Planned for Next Year

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

6.2 Task XVII: Molten Carbonate Fuel Cells

6.2.1 Reports Published to Date

- Meeting, Status and Annual Reports for Task XIV.
  First meeting was held on October 18-20,2004 in Kawasaki, Japan hosted by NEDO.
  The annual report of Annex XVII was published in January, 2005.

6.2.2 Reports Planned for Next Year

- Meeting, Status and Annual Reports for Annex XIV.
  The second meeting is scheduled to be held in November 2005 in USA hosted by FCE

6.3 Task XVIII: Solid Oxide Fuel Cells

6.3.1 Reports Published to Date

- Proceedings of the Workshop in San Antonio, Texas, USA on November 1, 2004, by S. C. Singhal (Editor), November 2004.

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 Quebec City, Canada, on May 14, 2005 by Brian Borglum (Editor), May 2005.

6.4 Task XIX: Fuel Cell Systems for Stationary Applications

6.4.1 Reports Published to Date

- Meeting, Status 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

6.4.2 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

6.5.1 Reports Published to Date

- Minutes of the Kick-off meeting of the IEA Annex XX Fuel Cells for Transportation, 28 September 2004

6.5.2 Reports Planned for Next Year

- Meeting, Status and Annual Reports for Annex XX

The next Annex XX meeting will be held in spring 2005 (May, 26-27th), Washington D.C. USA two-day meeting) with two full day sessions on:

- Economics of hydrogen production and infrastructure

- On-board hydrogen storage systems

Each brainstorming session will be started b a 45 minutes introductory speech highlighting the state of the art, the challenges and perspectives followed by shorter presentations and statements of the experts.

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.

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
Simon Fraser	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
Matti Valkiainen	VTT Processes (R)	Finland
Jürgen Mergel	Forschungszentrum Juelich GmbH (R)	Germany
Agostino Iacobazzi	Italian National Agency for New Technologies, Energy and Environment (ENEA) (R)	Italy
Tomohiko Ikeya	New Energy and Industrial Technology Development Organization□NEDO□ (G)	Japan
Won-Yong Lee	Korea Institute of Energy Reserch (KIER)	Korea
Gaby Janssen	ECN- Fuel Cell Technology (R)	The Netherlands
Børre Børresen	Norwegian University of Science and Technology (NTNU) (A)	Norway
Lars Pettersson	Royal Institute of Technology, KTH (A)	Sweden
Clayton Barnes	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
Piotr Zelenay	Los Alamos National Laboratory (R)	United States

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

7.2 Task XVII: Molten Carbonate Fuel Cells

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

Experts:

Manfred M.Bischoff	MTU (I)	Germany
Angelo Moreno	ENEA (G)	Italy
Biagio Passalacqua	Ansaldo(I)	"
Paolo Capobianco	"	"
Kazuhiro Satoh	NEDO (G)	Japan
Toru Shimizu	MCFC Research Association (R)	"
Hideaki Andoh	"	"
Masaaki Tooi	IHI(I)	"
Yoshiyuki Izaki	CRIEPI (R)	"
Tae-Hoon Lim	KIST (R)	Korea
Jonghee Han	"	"
Hee Chun Lim	KEPRI (R)	"
Joong Hwan Jun	RIST (I)	"
Hans Maru	FCE (I)	U. S. A.
Mohammad Farooque	"	"

7.3 Task XVIII: Solid Oxide Fuel Cells

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

Participants of the 2004 Workshop held November 1, 2004, San Antonio, Texas, USA

Karl Foger	Ceramic Fuel Cells Ltd. (R)	Australia
Brian Borglum	Versa Power Systems (R)	Canada
Scott Thompson	Versa Power Systems (I)	Canada
Jari Kiviaho	VTT Processes (R)	Finland
Laurent Antoni	CEA (R)	France
Robert Steinberger-Wilckens	Forschungszentrum Jülich (R)	Germany
Takashi Ujiie	NEDO (G)	Japan
Kenji Horiuchi	Tokyo Gas (I)	Japan
Harumi Yokokawa	AIST (I)	Japan
Bert Rietveld	Energie Onderzoekscentrum Nederland (R)	the Netherlands
Azra Selimovic	Lund Institute of Technology	Sweden
Olivier Bucheli	HTceramix (R)	Switzerland
Tad Armstrong	MSRI (I)	USA
Richard Goettler	SOFCo (I)	USA
Dan Rastler	EPRI (I)	USA
Subhash Singhal	Pacific Northwest National Laboratory (R)	USA
Jeffry Stevenson	Pacific Northwest National Laboratory (I)	USA
Anil Virkar	University of Utah (I)	USA
Mark Williams	U.S. DOE (G)	USA

7.4 Task XIX: Fuel Cell Systems for Stationary Applications

Operating Agent: Bengt Ridell. Carl Bro Energikonsult AB, Sweden

Experts:

Karl Föger	CFCL (I)	Australia
Philippe Stevens	EDF(I)	France
Ulf Birnbaum	FZJ (R)	Germany
Gerhard Huppmann	MTU (I)	Germany
Søren Linderoth	Risø(R)	Denmark
John Bøgild Hansen	HTAS(I)	Denmark
Adwin Martens	VITO(R)	Belgium
Rolf Rosenberg	VTT(G)	Finland
Erkko Fontell	Wärtsilä(I)	Finland
Tomohiko Ikeya	NEDO (G)	Japan
Peter vander Laag	ECN (R)	The Netherlands
Angelo Moreno	ENEA (G)	Italy
Bengt Ridell	Carl Bro (I)	Sweden
Mark Williams	DoE (G)	USA
Dan Rastler	EPRI (I)	USA
Stephan Renz	Thoma & Renz (I)	Switzerland

7.5 Task XX: Fuel Cell Systems for Transportation

Operating Agent: Prof Dr. Georg Erdmann

EXPERTS

1	Kerry-Ann Adamson	Technische Universität Berlin	Germany
2	Rajesh K. Ahluwalia	Argonne National Laboratory	U.S.A.
3	Peter Ahlvik	Ecotraffic AB	Sweden
4	Per Alvfors	Royal Institute of Technology	Sweden
5	Fabrizio	ENEA	Italy
6	Donald Anton	United Technologies Research	U.S.A.
7	Jan-Welm Biermann	RWTH Aachen	Germany
8	Rod Borup	Los Alamos National Laboratory	U.S.A.
9	Karen Campbell	Air Products and Chemicals	U.S.A.
	Joe Cargnelli	Hydrogenics	Canada
	Eric Carlson	TIAX, LLC	U.S.A.
	Mario Conte	ENEA	Italy
	Roger Cracknell	Shell Global Solutions	U.K.
	Robert Dempsey	ChevronTexaco Technology	U.S.A.
	Catherine	California Fuel Cell Partnership	U.S.A.

	Erich K. Erdle	DaimlerChrysler Corporate R&T	Germany
	Georg Erdmann	Technische Universität Berlin	Germany
18	Per Ekdunge	AB Volvo	Sweden
19	Anders Folkesson	Royal Institute of Technology	Sweden
20	David Frank	Hydrogenics	Canada
21	James Grieve	Delphi Automotive Systems	U.S.A.
22	Thomas Grube	Forschungszentrum Jülich	Germany
23	Pede Giovanni	ENEA	Italy
24	Mark Grist	Methanex Corporation	Canada
25	Adam Gromis	California Fuel Cell Partnership	
26	Jeffery Harrison	Chevron Texaco Technologies	U.S.A.
27	Shinichi Hirano	Ford Motor Company	U.S.A.
28	Bernd Höhlein	Forschungszentrum Jülich	Germany
29	Thomas Hülshorst	FEV Motorentechnik GmbH	Germany
30	Inchul Hwang	Hyundai Motor Company	Korea
31	Agostino Iacobazzi	ENEA	Italy
32	Magnus Karlström	Chalmers Institute of Technology	Sweden
33	Sae Hoom Kim	Hyundai Motor Company	Korea
34	John Kopasz	Argonne National Laboratory	U.S.A.
35	Ken Koyama	California Fuel Cell Partnership	U.S.A.
36	Ravi Kumar	GE – EER	U.S.A.
37	Oliver Lang	FEV Motortechnik	Germany
38	Jim Larkins	Georgetown University	U.S.A.
39	Tae Won Lim	Hyundai Motor Company	Korea
40	Göran Lindbergh	Royal Institute of Technology	Sweden
41	Magnus Karlström	Chalmers University of	Sweden
42	Reinhard Leithner	Technische Universität	Germany
43	Catherine Lentz	California Fuel Cell Partnership	U.S.A.
45	Tae-Won Lim	Hyundai Motor Company	Korea
46	William Liss	Gas Technology Institute	U.S.A.
47	Ronald Mallant	ECN	Netherlands
48	Subhasish Mukerjee	Delphi Automotive Systems	U.S.A.
49	Hyung-Seuk Oh	Hyundai Motor Company	Korea
50	Bertil Osterlind	Fortum Energy Solutions	Sweden
51	Jürgen Ogrzewalla	FEV Motorentechnik GmbH	Germany
52	Catherine E. Padro	National Renewable Energy	U.S.A.
53	Giovanni Pede	ENEA	Italy
54	Brant Peppley	Royal Military college	Canada
55	Lars Pettersson	Royal Institute of Technology	Sweden
56	Stefan Pischinger	VKA/RWTH Aachen	Germany
57	Jaco Reijerkerk	Linde Gas	Germany
58	Ludmilla Schlecht	Technische Universität Berlin	Germany
59	Torsten Schwarz	Frauenhofer ICT	Germany
60	Edward R. van	ECN	Netherlands

61	Per Sjöbom	Fortum Energy Solutions	Sweden
62	Jan Teuben	Shell Global Solutions	Netherlands
63	Stefan Unnasch	TIAX, LLC	U.S.A.
64	Gerald Voecks	General Motors Corp. (GAPC)	U.S.A.
65	Manfred Waidhas	Siemens AG	Germany
66	Michael Wang	Argonne National Laboratory	U.S.A.
67	Robert Wimmer	Toyota Motor Company	U.S.A.
68	Jörg Wind	DaimlerChrysler R&T	Germany
69	Dardas Zissis	United Technologies Research	U.S.A.

7.6 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