



Advanced Fuel Cells

Implementing Agreement

ANNUAL REPORT 2007

August 2008

This Annual Report has been prepared by the Operating Agents and the Secretariat of the Executive Committee, who also acted as Editor. Copies can be obtained from the programme's web site at www.ieafuelcell.com or from:

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1. Introduction

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

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

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

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

Participants

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

Denmark

Signatory Party: Riso National Laboratory
Date of Signature: September 2004

Belgium

Signatory Party: Vlaamse Instelling voor
Technologisch Onderzoek (VITO)
Date of Signature: November 2002

Netherlands

Signatory Party: Netherlands Energy
Research Foundation (ECN) (from October
1999, previously Netherlands Agency for
Energy and the Environment (NOVEM)
Date of Signature: April 1990

Canada

Signatory Party: Delegation to the OECD
Date of Signature: November 1991

United States

Signatory Party: Department of Energy
Date of Signature: May 1995

United Kingdom

Signatory Party: Department of Trade and
Industry (from April 1992, previously the
Department of Energy)
Date of Signature: September 1990

Mexico

Signatory Party: Electrical
Research Institute
Date of Signature: June 2006

France

Signatory Party: Commissariat à l'Énergie
Atomique (CEA)
Date of Signature: May 2005

Italy

Signatory Party: Ente per le Nuove
Tecnologie, l'Energia e l'Ambiente (ENEA)
Date of Signature: April 1990





Norway
 Signatory Party: Research Council for Norway
 (from October 1994, previously the Norwegian
 Council for Scientific and Industrial Research)
 Date of Signature: April 1990

Sweden
 Signatory Party: The Swedish Energy Agency
 (from December 1998, previously NUTEK)
 Date of Signature: April 1990

Finland
 Signatory Party: Finnish National Technology
 Agency (TEKES)
 Date of Signature: May 2002

Germany
 Signatory Party: Forschungszentrum Jülich
 Date of Signature: December 1992

Switzerland
 Signatory Party: Office Fédérale de l'Energie
 (OFEN)
 Date of Signature: April 1990

Austria
 Signatory Party: Austrian Energy Agency (EVA)
 Date of Signature: September 2004

Turkey
 Signatory Party: Tübitak Marmara Research
 Center Energy Institute
 Date of Signature: June 2007

Korea
 Signatory Party: The Korea Electric Power
 Corporation (KEPCO)
 Date of Signature: April 1998

Japan
 Signatory Party: New Energy and Industrial
 Technology Development Organisation (NEDO)
 Date of Signature: April 1990

Australia
 Signatory Party: Ceramic Fuel Cells Limited
 (CFCL)
 Date of Signature: November 1995

The Executive Committee meets twice a year under the Chairmanship of Prof Lars Sjunnesson (E.ON Sverige, Sweden). The Vice-Chairman is Prof Detlef Stolten and the Secretariat consists of Mrs Heather Haydock and Mrs Grace Gordon (both AEA, UK). The IEA/OECD representative during 2007 was initially Mr Jeppe Bjerg and subsequently Ms Carrie Pottinger, both from the Energy Technology Policy Division.

The following table lists all the Executive Committee Members their Alternates and the Operating Agents of the different Annexes at the end of 2007. Addresses and contact numbers are given in Appendix 1 to this report.

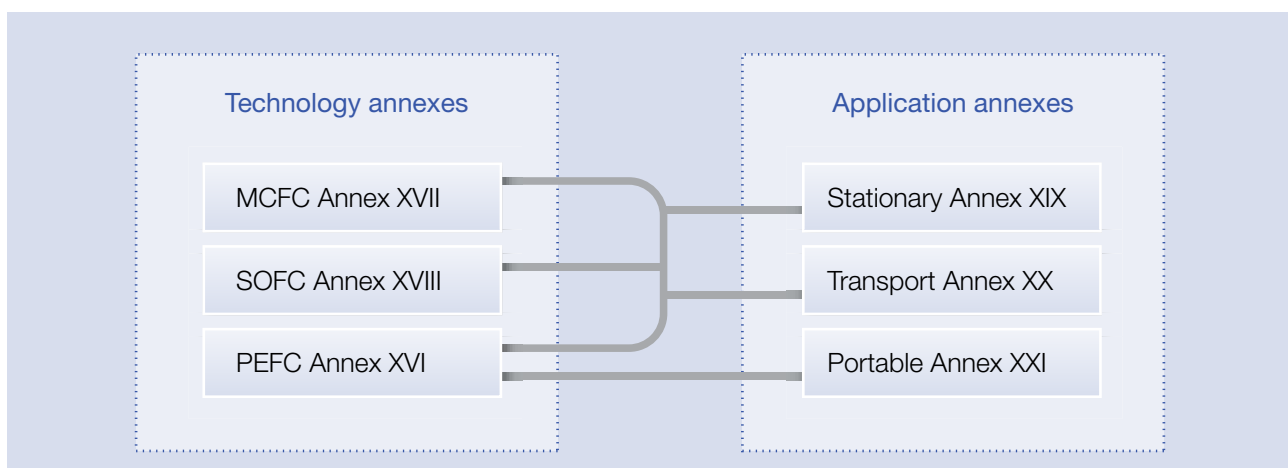
Country	Ex Co Member	Alternate Member	Operating Agent	Annex No
Australia	K Foger			
Austria	G Simader	V Hacker		
Belgium	G van Bogaert			
Canada	V Scepanovic	E Andrukaitis		
Denmark	Inger Pihl Byriel	S Linderoth		
Finland	H Kotila	R Rosenberg		
France	T Priem			
Germany	D Stolten	Z Pors	H Dohle	XXI
Italy	R Vellone	A Moreno		
Japan	T Itomi			
Korea	H-C Lim	T-H Lim	T-H Lim	XVII
Mexico	J Huacuz		U Castillo	
Netherlands	F de Bruijn		P van den Oosterkamp	XX
Norway	TH Tronstad			
Sweden	L Sjunnesson	B Gustafsson	B Ridell	XIX
Switzerland	S Oberholzer			
Turkey	E Gunen			
UK	R Eaton	G Vaughan		
USA	N Garland	W Surdoval	X Wang S Singhal	XVI XVIII

CURRENT AND FUTURE ANNEXES

Six Annexes were approved and commenced in 2004:

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



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	Market issues	Cell and stack
Co-ordination with other Implementing Agreements	Environmental issues	<ul style="list-style-type: none"> • cost and performance • endurance • materials • modelling
Public awareness and education	Non-technical barriers (e.g. standards, regulations)	<ul style="list-style-type: none"> • test procedures • minimise size of stack
	User requirements and evaluation of demonstrations	Balance of Plant
		<ul style="list-style-type: none"> • tools • availability • data base
		Fuel processing
		Power conditioning
		Safety analysis

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

Scope of the programme for 2005-2008

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



Turkey joined the agreement in June 2007. The executive Committee Member is Dr Evren Gunen of Tubitak Marmara Research Centre Energy Institute.



2. Executive Committee Report

MEMBERSHIP AND PARTICIPATION

Turkey joined the agreement in June 2007. The Executive Committee Member is Dr Evren Gunen of Tübitak Marmara Research Center Energy Institute.

There were changes in the Executive Committee membership in 2007 for Switzerland, Germany and Japan.

- Dr Andreas Gut (Member, Switzerland) was replaced by Dr Stefan Oberholzer, Swiss Federal Office of Energy.
- Dr Heinz Nabelek (Alternate Member, Germany) was replaced by Dr Z Pors.
- Mr. Katsuhiko Terao (Member, Japan) and Dr. Mitsuharu Tabuchi (Alternate Member, Japan) left the Executive Committee.
- Mr Terao was replaced by Mr Tatsuo Itomi from NEDO.

Six Operating Agents continued to run the Annexes initiated in 2004.

- Dr Xiaoping Wang replaced Dr Debbie Myers as Operating Agent for the PEMFC activities under the Annex XVI towards the end of the year.
- Dr Tae Hoon Lim held a third year as Annex XVII Operating Agent.
- Paul van den Oosterkamp of ECN had replaced Professor Georg Erdmann for Annex XX in late 2006.
- The Operating Agent for Annex XXI was Dr Hendrik Dohle but he has now left Juelich and will be replaced as Operating Agent in early 2008.
- Bengt Ridell continued his management of stationary fuel cell activities as Operating Agent for Annex XIX.
- Finally, Subhash Singhal was Overall Operating Agent for Annex XVIII, though this position is rotated and the Interim Operating Agent for 2007 was Dr K Yokomoto of NEDO.

ACTIVITIES AND DECISIONS

Activities

- Two Executive Committee meetings were held. The 34th Executive Committee meeting was held in Amsterdam, the Netherlands on 19th April 2007 and the 35th meeting was held in San Antonio, USA 19th October 2007.
- The 2006 Annual Report was prepared and distributed.
- The Executive Committee continued to co-ordinate its activities with other relevant IEA Implementing Agreements. This has included cross-representation on the Executive Committees of the Hydrogen Implementing Agreement.
- The Secretary and members of the ExCo contributed comments to the IEA on its publications “IEA Energy Technology Essentials” and “Energy Technology Perspectives (ETP)”.
- A poster was prepared and displayed at the IEA Ministerial Fair in May.

Decisions

ExCo Members unanimously approved the re-appointment of Lars Sjunnesson and Detlef Stolten as ExCo Chairman and Vice Chairman respectively, for a further two years.

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.



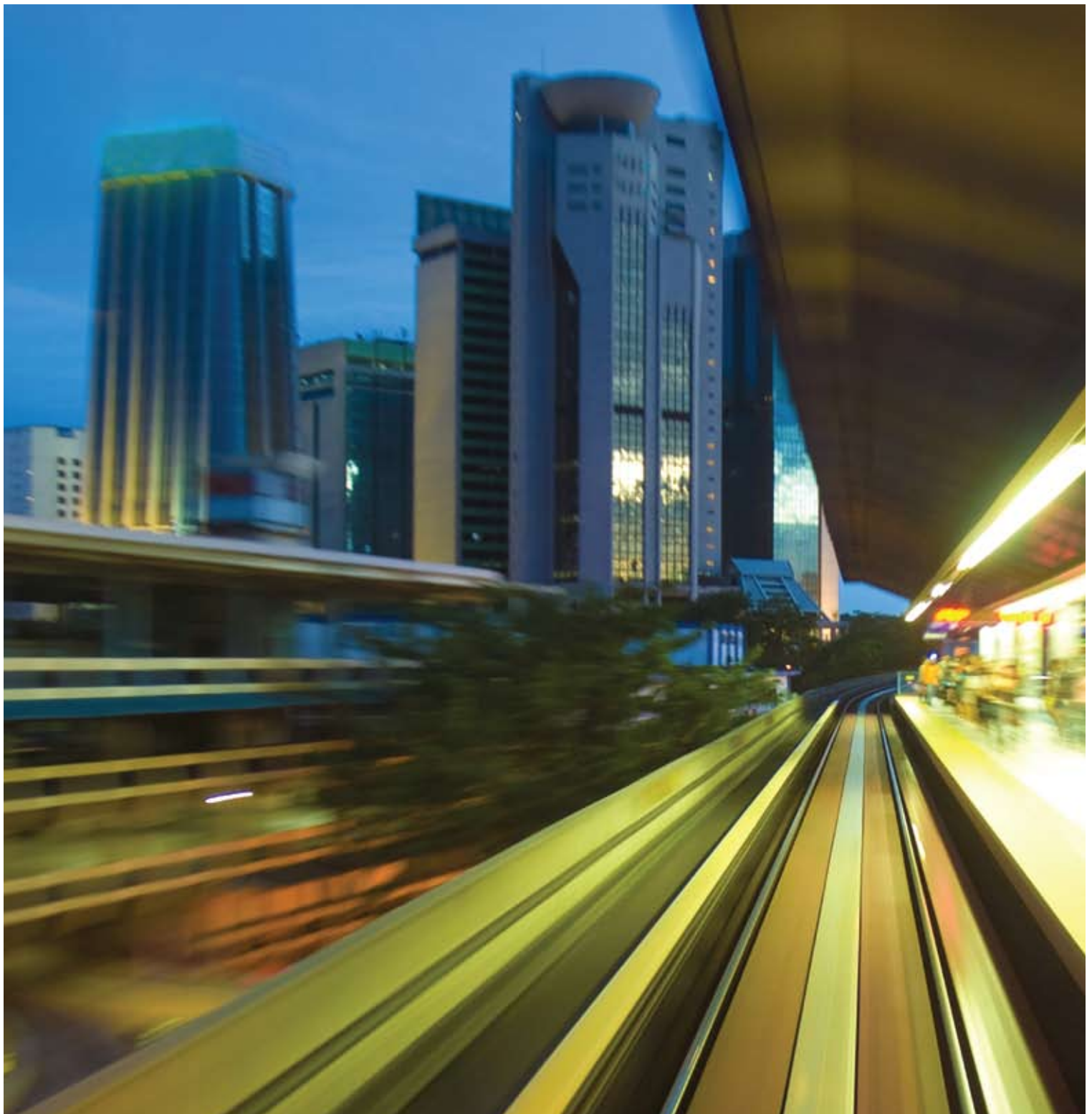
Future Plans

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 2008. The first will be held in Tokyo, Japan on 25/26 February 2008. The second meeting will be held in conjunction with the US Fuel Cells Seminar in October/November. Continued implementation of the approved work programme for six new Annexes and an accompanying

programme of cross-cutting workshops and other activities. The six Annexes comprise three technology-specific annexes on PEFC, SOFC and MCFC, and three application-specific annexes on stationary, transportation and portable applications.

Preparation of an end of term report (2005-2008) and extension request for the Implementing Agreement, subject to a positive decision by the Executive Committee at its first meeting in 2007.



Technical achievements include the development of an 80kW system for fuel cell locomotives.



3. Key Achievements

This section of the Annual Report summarises the key achievements of the programme during the year. Further details are given in Section 4.

ACHIEVEMENTS OF ANNEX XVI PEFC

Technical achievements in Annex XVI have included:

- new methods for making lower-cost, higher durability platinum electrodes,
- the development of an ammonia-fuelled PEFC,
- the development of an 80kW system for fuel cell locomotives,
- improved understanding of the degradation mechanisms involved when cells are started up and shut down, and when they are exposed to sub zero temperatures,
- the development of a PEFC stack simulator for system studies,
- studies on the effect of air impurities on the performance of cell components,
- the performance modelling of high temperature PEFCs.

ACHIEVEMENTS OF ANNEX XVII MCFC

The latest R&D data on MCFC stack and system performance were presented and discussed at the 2007 annual workshop. Discussions centred on reducing stack degradation rates and costs through better design and improved materials. Technical achievements reported by participants included the demonstration of an MCFC system under real operating conditions for over 25,000 hours and bench-scale cell tests of over 60,000 hours.

ACHIEVEMENTS OF ANNEX XVIII SOFC

Annex XVIII held a very successful workshop in June 2007. Twenty four participants from, Canada, Denmark, France, Germany, Japan, Korea, Netherlands, Switzerland, United Kingdom, and United States attended the Workshop. Presentations included reviews of SOFC development activities in member countries in addition to several topical technical reports around the topic of Advanced SOFC Systems and Performance.

ACHIEVEMENTS OF ANNEX XIX

FUEL CELLS FOR STATIONARY APPLICATIONS

A study has been completed on the market prospects for fuel cells in different countries based on the latest available information regarding the development of and the market conditions for stationary fuel cell systems. Annex XIX has also studied the obstacles for the introduction of a large number of stationary fuel cells connected to the low-voltage distribution network, including the differences between countries. This has addressed issues such as power quality, safety problems and codes and standards. Information has been exchanged on fuels for fuel cells; analysis undertaken suggests that there is good potential for anaerobic fermentation and thermal gasification/pyrolysis products from biomass and waste. Some progress has been made in specifying balance of plant items, and estimating their likely costs, although this has been difficult because fuel cell developers often consider this information proprietary. Cost estimates for a 1kW PEMFC system have been developed, based on information from Japan.

ACHIEVEMENTS OF ANNEX XX

Information has been shared on targets, status and projections for automotive fuel cell systems, including results from a study of the cost breakdown of components of a PEMFC stack. A review has been undertaken of hydrogen storage options and their status, characteristics and challenges. Information has been exchanged on the progress and future plans of fuel cell vehicle development programmes in participant countries. This Annex has made slower progress than originally hoped because the original Operating Agent was unable to fulfil his obligations. This has now been resolved and the Annex is active once more.

ACHIEVEMENTS OF ANNEX XXI

PORTABLE FUEL CELLS

No achievements this year as work has been suspended – see Section 4 for further explanation.



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. Task Reports

REPORT TASK XVI

POLYMER ELECTROLYTE FUEL CELLS

Duration

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

Operating Agent

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

Participants

Agencies from fifteen countries were involved in this Annex during the year 2007:

Austria	Graz University of Technology
Belgium	Flemish Institute for Technological Research, Vito
Canada	The Government of Canada
Denmark	IRD Fuel Cells A/S
Finland	VTT Processes
France	CEA
Germany	Forschungszentrum-Jülich GmbH ICT Fraunhofer
Italy	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, ENEA
Japan	New Energy and Industrial Technology Development Organisation, NEDO
Korea	Korea Institute of Energy Research
Mexico	Instituto de Electricas
Netherlands	Netherlands Energy Research Foundation (ECN)

Norway	Norwegian Technical University, NTNU
Sweden	Swedish National Energy Administration (STEM)
Turkey	TUBITAK
UK	Secretary of State for Industry
United States	The Department of Energy of the US Government.

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.

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

PROGRESS SUMMARY

Background

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

Activities

The Annex XVI working group met in Helsinki, Finland on June 7-8, 2007 and at the Technical University of Graz on November 22-23, 2007. Discussions at these workshops indicate that progress is being made in all subtasks of the Annex, as highlighted in the next section.

Technical Accomplishments

Subtask 1: New Stack Materials

- Development of composite polymer-carbon bipolar plates for high temperature PEFCs. (Germany)
- Exploration of various carbon supports and catalyst deposition methods and determination of the impacts of freeze-thaw cycles on membrane electrode assembly (MEA) properties. (Netherlands)
- Fabrication of carbon-coated aluminium bipolar plates. (Norway)
- Development of palladium bimetallic cathode electrocatalysts. (United States)

Subtask 2: System and Balance-of-Plant Issues

- Development of a software tool to provide expert fuel cell modelling knowledge to scientist, system developers and application engineers. (Austria)
- Development of a multi single cell for testing multiple MEAs simultaneously and under identical conditions. (Finland)
- Performing a thorough mechanical and structural study of Nafion in order to understand the effects of aging. (France)
- Studying water distribution in PEFC cathode flow field channels. (Korea)

Subtask 3: Direct Fuel Polymer Electrolyte Fuel Cells

- Improving the performance of direct methanol fuel cells by optimising electrode pore structure. (Denmark)
- Developing bi- and tri- metallic alloys of platinum as ethanol electro-oxidation catalysts. (United Kingdom)
- Developing alkaline PEMFC methanol and borohydride fuels, mesh-supported fuel cells and methanol-tolerant cathode catalysts for DMFC. (United Kingdom)
- Developing alkaline anion-exchange membrane hydrogen-air and liquid fuel-air fuel cells; demonstrating that carbonate formation does not

Work Plan for Next Year

As indicated in previous reports of this series, each participating country is working from a broad program plan rather than more specific task plans.

The areas of active R&D for this Annex are improved membrane-electrode assemblies, materials, and stack components, reduced catalyst loadings and cost, improved catalyst durability, increased CO tolerance, compact fuel processors, system design and analysis, and improved direct fuel fuel cells and stacks. The general research areas of the participating countries are summarized below.

Austria Improved materials for hydrogen-air and direct methanol fuel cells, degradation studies, fuel cell stack and cell model, and fuel cell power system modeling

Belgium Fuel cell, stack, and component testing, system integration and testing, determination of technical feasibility of using ammonia as a distributed fuel for fuel cells

Canada Membrane, electrode, and bipolar plate development, characterisation, and modelling

Denmark Direct methanol and hydrogen-air fuel cell systems

Finland Direct methanol fuel cells for micro-power applications, electrocatalyst development, stack construction and testing, and MEA development

France MEA development, characterisation and modelling; system development for locomotive applications

Germany	Direct methanol and hydrogen-air fuel cells, materials, and systems; development of fuel cell scooter.	Sweden	Fuel processing, fuel cell materials and designs
Italy	MEAs, catalysts, membranes, fuel cell stack and system testing and analysis	Turkey	Integration of systems and component development
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	UK	CO tolerance, electrocatalyst development, systems analysis, direct methanol fuel cells with alkaline membrane electrolyte, bipolar plates, direct methanol fuel cells, and microbial fuel cells
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	United States	Modelling and systems analysis, high-temperature polymer electrolytes, non-platinum electrocatalysts, and direct methanol fuel cells
Mexico	Membrane-electrode assembly, stack, and electronics characterization and development		
The Netherlands	Materials characterization and development, system and cell modelling		
Norway	High temperature polymer electrolyte fuel cell development, electrocatalysts and electrocatalyst supports, hydrogen-chlorine fuel cells, and the integration of a methanol reformer and a high temperature fuel cell		

The objective shall be to provide for further international collaboration in the research and development of certain aspects of MCFC technology, in order to realise commercialisation of the MCFC system.

REPORT TASK XVII

MOLTEN CARBONATE FUEL CELLS TOWARDS COMMERCIALIZATION

Duration

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

Operating Agent

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

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)
Turkey	Marmara Research Center of Scientific and Technological Research Council of Turkey [from June 2007]

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:

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

Task Description

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.

- Survey of alternative materials for cell components
- Survey of long lifetime stack
- Survey of high performance stack
- Survey of low cost stack

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.

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

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.

- Survey of system configuration and BOP components (total efficiency, control, site space, improvement of components, etc.)
- Operation experiences of BOP (operating data, problems and their countermeasures, etc.)
- Possibility of more effective systems in the future (higher efficiencies, utilisation of coal gas, CO₂ recovery, etc.)
- Solutions towards commercialisation (cost, market, operability, etc.).

PROGRESS SUMMARY

Background

The attractions of the Molten Carbonate Fuel Cell (MCFC) as a power source have been understood for quite some time. However, it has also been realized that a number of problems, mainly related to endurance and cost, have to be overcome or overridden before commercialization of MCFC technology can come within sight. By the end of 1991, initiatives were taken for collaborative work in this respect, within the IEA Programme on Advanced Fuel Cells. After canvassing interest during a workshop in June 1992 at ECN in The Netherlands, Annex III "MCFC Materials and Electrochemistry" was started in May 1993 with the participation of Germany, Italy, Japan, the Netherlands and Sweden.

The Annex remained active to the end of 1995, dealing with the endurance problems connected to corrosion of the bi-polar plate, dissolution of the cathode, and the electrolyte inventory of MCFC stacks. Apart from an extensive data-exchange and fruitful expert discussions, the main result of the Annex was a consensus on the relative importance of the endurance limitations mentioned.

In addition, life-time estimations were made relating to the eventual mal-functioning of cells and stacks caused by the phenomena studied.

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

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

In the course of the work performed in Annex III, frequently data was encountered without proper

description of the used methods or procedures, or obtained with methods not allowing for easy comparison. The demand was felt for the development and standardisation of effective test-procedures for MCFC materials, cells and stacks.

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

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

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

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

Activities

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

The objectives of the first meeting were as follows:

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

Technical Accomplishments

First meeting

Subtask A: Survey of alternative materials for cell components

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

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

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

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

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

Subtask C: Survey of system configuration and BOP components

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

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

Second meeting

Subtask A: Survey of alternative materials for cell components

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

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

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

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

- B-1 HotModule field test experience and various gas application by M. Bischoff (MTU CFC Solutions)
- B-2 MCFC demonstration in EXPO 2005 Aichi, Japan by M. Tooi (IHI)
- B-3 Development of MCFC in Korea by J. Han (KIST)
- B-4 Development and demonstration of MCFC in AFCo by B. Marenaro (AFCo)

B-5 Direct Fuel Cell: renewable fuel experience by M. Farooque (FCE)

Subtask C: Survey of system configuration and BOP components

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

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

Third meeting

Subtask A: Survey of high performance stack

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

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

Subtask B: Discussion on characteristics of fuels from various sources

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

- B-1 HotModule Operation & Reliability Experience by M. Bischoff (MTU CFC)
- B-2 Direct FuelCell Products Commercialization Progress by M. Farooque (FCE)

Subtask C: Possibility of more effective system in the future

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

- C-1 System Developed & Demonstration in Korea by B.-J. Kim (KEPRI)
- C-2 Status of MCFC at CRIEPI and in Japan by Y. Mugikura (CRIEPI)
- C-3 Fuel Cell at CESI RICERCA by M. Scagliotti (CESI)
- C-4 MTU BOP Cost Reduction Progress by M. Bischoff (MTU CFC)
- C-5 FCE DFC: About Fuels by M. Farooque (FCE)

Fourth meeting		Korea	250kW system development by KEPRI; RD&D programmes including a 250kW external reforming system and 300kW internal reforming system; cell development by KIST; factory being set up capable of producing 15MW per year (orders in place for 5MW already)
The following technical highlights were presented at the fourth meeting:			
Germany	degradation over 25,000 operation; sulphur tolerance; commercialisation efforts		
Italy	AFCo demonstrations and activities at ENEA (single cell testing; system analysis)	USA	experience and product evolution; cost reduction; market trends analysis
Japan	degradation over 60,000 bench-scale cell tests at CRIEPI; activities at AIST	Sweden	activities at KTH on component materials and simulation
		Turkey	Activities at MAM including the NAV plant (ship application) and MC-WAP projects

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	Summary of BOP updating and optimisation



The objective of this task is to organise a series of annual workshops, each to be organised by and in a different country.



REPORT TASK XVIII

Duration

January 2004 – December 2008.

Operating Agent

The overall Operating Agent of the Annex XVIII is Dr. S. C. Singhal, Pacific Northwest National Laboratory, Richland, WA, USA. The Overall Operating Agent is responsible for reporting to the Executive Committee. There will be annual Interim Operating Agents responsible for the preparation, execution and documentation of the annual workshops, including the production and dissemination of the proceedings. The Interim Operating Agent for 2004 was Dr. S. C. Singhal, for 2005 Dr. Brian Borglum, Versa Power Systems, Calgary, Canada, for 2006 Jari Kiviaho, VTT Processes, Finland and for 2007 Dr. K. Yokomoto, NEDO, Japan.

Participants

Australia	Ceramic Fuel Cells Ltd
Canada	Natural Resources Canada
Denmark	Risø National Laboratory
Finland	VTT Processes
France	ADEME
Germany	Forschungszentrum Jülich
Japan	The New Energy and Industrial

Technology Development Organisation, NEDO

Korea	Korea Institute for Energy Research, KIER
Netherlands	ECN
Sweden	Swedish National Energy Administration
Switzerland	Swiss Federal Office of Energy
UK	BERR (previously known as DTI)
USA	US DOE

Objective

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

Task Description

Representatives from 11 countries (see participants list) participated in the Annex XVIII Workshop on June 2, 2007 in Nara, Japan. The annual Interim Operating Agent “system” is working well and will be continued for the remainder of the current phase. Annex XVIII comprises a series of workshops, each organized by and in a different country. The list of workshops is as follows:

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

PROGRESS SUMMARY

Overview

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

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

Administration in 2007

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

Activities in 2007

Preparations were made for the 2006 Workshop which was held on June 2, 2007 in Nara, Japan. The workshop was attended by twenty-four representatives of eleven of the participating countries; Australia, Canada, Denmark, France, Germany, Japan, Korea, the Netherlands, Switzerland, UK and the USA. They either presented the status of SOFC R, D&D in their respective country or gave a technical presentation.

Technical Accomplishments in 2007

During the workshop, 15 presentations were made by experts from participating countries dealing with SOFC research, development and demonstration. The presentations showed that in the recent years a real progress has been made toward manufacturing and commercialisation of SOFCs.

Future Plans

The Workshop for 2008 will be held in Lucerne, Switzerland in June and will be organized and chaired by Dr. Olivier Bucheli, HT Ceramix, Switzerland. This Workshop is being held in conjunction with the 8th European SOFC Forum.

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 objective of this task is to receive a better understanding of the possibilities for all kinds of stationary fuel cells to reach the market.



REPORT TASK XIX

FUEL CELL SYSTEMS FOR STATIONARY APPLICATIONS

Duration

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

Operating Agent

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

Participants

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

Australia	Ceramic Fuel Cells Ltd
Austria	Austrian Energy Agency
Belgium	Vlaamse Instelling voor Technologisch Onderzoek, VITO
Denmark	Energinet.dk
France	L'Agence de l'Environnement et de la Maitrise de l'Energie, ADEME
Finland	Technical Research Centre of Finland, VTT
Germany	Forschungszentrum Jülich GmbH
Italy	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, ENEA
Japan	The New Energy and Industrial Technology Development Organisation, NEDO
Netherlands	Energieonderzoek Centrum Nederland ECN
Sweden	The Swedish Energy Agency(Sweden)

Switzerland Swiss Federal Office of Energy

USA United States of America Department of Energy

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

Objective

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

The vision of the Annex is:

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

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

Task Description

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

- to describe the market conditions from all aspects for stationary fuel cells and to analyse the present situation.
- to identify the commercial niche applications for the early introduction of stationary fuel cells and the market applications for the broad use of stationary fuel cells.
- to analyse opportunities and obstacles for stationary fuel cells to reach the market

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

Subtask I: Market outlook for stationary fuel cells

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

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

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

What will be effect on the existing infrastructure if a large number of stationary fuel cells are connected to the local power distribution grid?

In the subtask, the influence on several aspects will be analysed, including the electrical grid, fuel distribution, codes and standards, safety issues, economic considerations etc. Different alternatives for the control of the operation of the fuel cells will be discussed.

Subtask III: Fuels for stationary fuel cells

There are several different kinds of fuels that can be used in stationary fuel cells. Natural gas is the most common fuel to choose depending on the existing infrastructure. Hydrogen is also an obvious choice for future use as it can be produced locally in many different ways including the use of renewable energy.

There are many other fuels existing today, for example, waste gas can be used in stationary high temperature fuel cells. That can be gases from chemical industry plant like purge gas, synthesis gas or other process gases. It can

also be gasification of biomass or sewage gas etc. The subtask will investigate and describe the availability of different gases and the possibilities and consequences to use them as fuels for stationary fuel cells.

Subtask IV: Balance of plant for stationary fuel cells

Today, the balance of plant represents about two thirds of the cost for a complete fuel cells system. Most of failures in demonstration plants for stationary fuel cells are related to the balance of plant.

System auxiliary components are in general selected from existing suppliers standard components. It is difficult for the suppliers to develop components designed for fuel cells, as the market for the foreseeable future is very limited. The effort of this subtask will be to interest the suppliers for larger markets and analyse the consequences for the balance of plant in a large fuel cell market. Some components to be mentioned are equipment for desulphurisation, reformers, and inverters

Subtask V: Market and technology status for stationary fuel cells

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

Task Results

Some examples of critical issues have been found

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

Work Plan for Year 2008

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

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

Two experts meetings will be organised during the year 2008. The spring meeting will be held in Helsinki, Finland on 10-11 March and hosted by VTT. The autumn meeting will be held in Venice, Italy in September and hosted by ENEA.



The objective of this task is to develop the understanding of fuel cells with their particular properties, applications, and fuel requirements.



REPORT TASK XX

FUEL CELL SYSTEMS FOR TRANSPORTATION

Duration

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

Operating Agent

ECN, Netherlands (previously Technical University of Berlin)

Participants

Agencies from nine countries participate in this Annex:

Austria	Austrian Energy Agency
Denmark	Danish Energy Agency
Finland	Finnish Agency for Technology & Innovation (TEKES)
Germany	Forschungszentrum-Jülich GmbH
Italy	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, ENEA
Korea	Korea Institute of Science and Technology (KIST)
Netherlands	Netherlands Energy Research Foundation (ECN)
Sweden	Swedish Energy Agency (STEM)
United States	US Department of Energy (DOE)

A full list of participating experts is provided in Appendix 7 to this report. These include several representatives of the automotive industry.

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 review 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.

Task Description

This Task consists of four subtasks:

Subtask A. Advanced Fuel Cell Systems for Transportation

This subtask will focus on the fuel cell module (fuel cell, peripherals and reformer, if applicable). It will prepare an inventory of markets and a summary of gaps and barriers.

Subtask B. On-board Hydrogen Storage Systems

This subtask will focus on the market readiness of storage materials for different market segments, including the definition of efficiency targets.

Subtask C. Hydrogen infrastructure

This subtask will evaluate hydrogen production methods, considering production efficiency and hydrogen purity features. It will also examine the status of hydrogen network activities.

Subtask D. Technology Validation and Economics

This subtask will exchange and compare cost models and assess the economic gap of fuel cells in transport.

PROGRESS SUMMARY

Background

This Annex is the successor to Annex XV that ran from May 1, 2001 and ended on December 31, 2003. The current annex entered into force on January 1, 2004.

Activities

The Annex XX working group met in Stuttgart, Germany for a one day Kick-Off Meeting on 28 September 2004. A second expert meeting was held in Lucerne, Switzerland in 2005. Thereafter there was no activity until the new Operating Agent took over in late 2006, at the instigation of the Executive Committee. The work of the Annex has now been re-started and two expert meetings were held in 2007 – one in the Netherlands in May and the other in Italy in December.

Technical Accomplishments

Automotive Fuel Cell Systems

Information was shared on the status and likely future performance and costs of automotive fuel cell systems. The current status is that attention has focussed on hydrogen as the fuel and PEFC as the fuel cell type. The largest fuel cell companies involved in this work are Ballard and UTC; both have active co-operations with auto companies. Fuel cell cars are still at the demonstration stage while some buses

are operating in real world applications, e.g. the Thor buses with UTC Power fuel cells in California. Most experts believe initial market penetration will start in 2015 with commercial products by 2020.

Hydrogen Storage

Information was shared on the status of hydrogen storage development and future R&D needs. There are a number of storage technologies at the R&D stage but their possible applications are unclear and there has been a lack of real-life experimentation. Technologies in the applied phase include high pressure gas storage in cylinders, cryogenic liquid hydrogen storage and solid state LaNi₅ storage. Each option has been assessed in terms of its cyclability, energy density, energy/efficiency losses (for liquid hydrogen), complexity, costs and safety implications. Promising metal hydride materials have been assessed in detail against the application requirements. One of the existing options for hydrogen storage are considered to meet long-term goals for the technology.

Hydrogen Infrastructure

Energy chain analysis was used to compare the costs of hydrogen produced from different sources with conventional (taxed and untaxed) gasoline and diesel in EU markets.

Information was exchanged on regional hydrogen projects including the EC Zero Regio project, the Scandinavian hydrogen partnership and a feasibility study on hydrogen networks in the Netherlands.

Costs are seen to be the biggest barrier to further uptake of hydrogen infrastructure with real market introduction unlikely before 2015-2020. The need for deployment policies was highlighted, both for hydrogen cars and hydrogen infrastructure.

Technology Validation and Economics

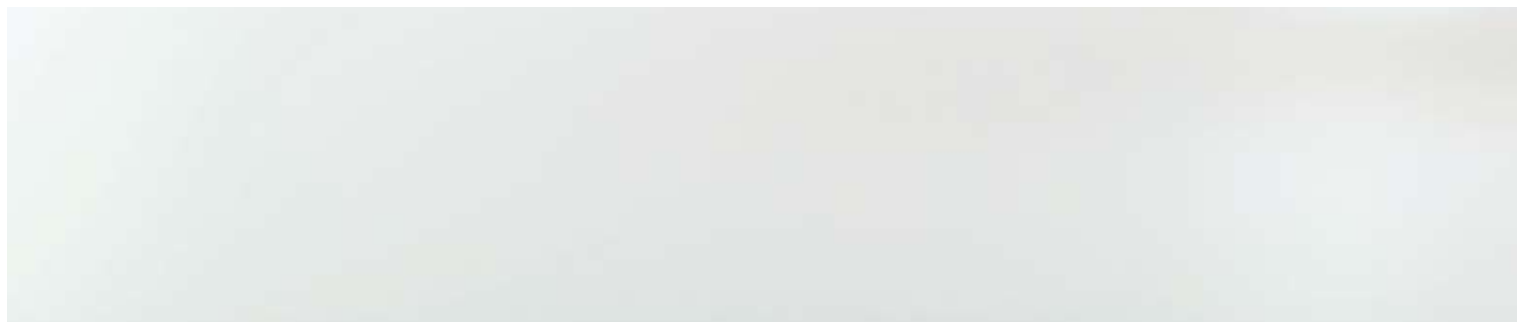
Presentations were given a TIAX study on the projected cost of PEFC for transport applications in volume manufacture. The headline cost was 108 \$/kW; the stack represented 63% of the system cost and the dominant component of this was the electrodes, due to high platinum loadings. Further reduction of platinum loadings or a switch to alternative electrode materials is therefore an R&S priority.

Work Plan for Next Year

All sub-tasks will proceed during 2008. The experts participating in the Annex will also prepare a work programme for the period 2008+ when the current phase ends.



The objective of this task is to assist - through international co-operation - the development of portable fuel cells towards commercialisation.



REPORT TASK XXI

PORTABLE FUEL CELLS

Duration

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

Operating Agent

Forschungszentrum Jülich GmbH, Germany

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
Netherlands	Netherlands Energy Research Foundation (ECN)

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

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.

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.

PROGRESS SUMMARY

Background

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

Activities

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

At the ExCo meeting in October 2007 the German ExCo Member announced that Dr Hendrik Dohle had left the Forschungszentrum Juelich and was no longer able to carry out his duties as Operating Agent.

He also explained that there had been no activity on this Annex during the year as the proposed Annex meeting scheduled for had to be cancelled due to lack of participation.

Juelich will appoint a new Operating Agent to take on this Annex and ExCo members will be asked to confirm whether they wish to continue with the Annex. If there is interest in continuing then an Annex meeting will be held in Spring/Summer 2008.

The technical achievements described below are therefore taken from the 2006 Annual Report.

Technical Accomplishments

System Analysis for Portable Fuel Cells

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

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

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

Japan An important topic to be solved before introducing methanol into the market are safety tests for system and stack components such as cartridge tests, vibration tests, drop tests, etc. National and international rules and regulations were presented.

System, Stack and Cell Development for Portable Fuel Cells

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

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

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

Italy The newly developed PEFC stack consists of 10-20 cells with a cell area of 25 cm² each. The effect of clamping on the power has been shown. The stack is designed for air breathing operation. (Italy)

Italy A flat 10 W stack has been developed consisting of 24 cells with an area of 20 cm² each. In addition, a small 0.5 W stack has been demonstrated.

Materials under Operating Conditions /

Materials Innovation

- New catalysts based on nanotubes have been demonstrated. (Canada)
- The single cell performance of MEAs prepared in-house was presented. The maximum power density in air breathing PEFC operation was 81 mW/cm² (Italy)

Work Plan for Next Year

To be determined at annex meeting (if held).



Appendix 1: Membership of the Executive Committee

Appendix 2: Executive Committee meetings to date

Appendix 3: Task proposals under consideration

Appendix 4: Executive Committee reports and publications

Appendix 5: Workshops and task meetings

Appendix 6: Task Reports and publications

Appendix 7: Task Experts

Appendix 1

MEMBERSHIP OF THE EXECUTIVE COMMITTEE

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Appendix 2

EXECUTIVE COMMITTEE MEETINGS TO DATE

Meeting	Date	Place
1	2 April 1990	Paris, France
2	25 November 1990	Phoenix, Arizona, USA
3	27-28 June 1991	Petten, The Netherlands
4	7 February 1992	Makuhari, Japan
5	24-25 September 1992	Malmo, Sweden
6	15 March 1993	Rome, Italy
7	28 September 1993	London, United Kingdom
8	15 March 1994	Zürich, Switzerland
9	11 October 1994	Jülich, Germany
10	11-12 May 1995	Oslo, Norway
11	18 September 1995	Loughborough, United Kingdom
12	1-2 February 1996	Tokyo, Japan
13	17-18 September 1996	Roskilde, Denmark
14	15-16 April 1997	Vancouver, Canada
15	18-19 September 1997	Amsterdam, The Netherlands
16	19-20 March 1998	Santa Fe, USA
17	1-2 October 1998	Melbourne, Australia
18	13-14 April 1999	Jülich, Germany
19	20-21 September 1999	London, UK
20	10-11 April 2000	Malmö, Sweden
21	4 November 2000	Portland, Oregon, USA
22	3-4 May 2001	Capri, Italy
23	5-6 September 2001	Basel, Switzerland
24	30-31 May 2002	Paris, France
25	22-23 November 2002	Palm Springs, California, USA
26	8 May	Espoo, Helsinki, Finland
27	23-24 October 2003	Dusseldorf, Germany
28	1-2 April 2004	Vienna, Austria
29	13-14 October 2004	Seoul, Korea
30	28-29 April 2005	Copenhagen, Denmark
31	18 November 2005	Palm Springs, California, USA
32	20-21 April 2006	Mol, Belgium
33	2-3 November 2006	Oslo, Norway
34	19 April 2007	Amsterdam, the Netherlands
35	19 October 2007	San Antonio, Texas, USA

Appendices 3&4

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

In addition, verbal presentations have been given by the Chairman and Secretary to the IEA Working Party on:

- End Use Technologies,
- the Committee on Energy Research and Technology
- the Working Party on Fossil Fuels
- the IEA Hydrogen Executive Committee.

Appendix 5

WORKSHOPS AND TASK MEETINGS

This section lists meetings and workshops held to date and planned for 2008, for those tasks that were active during the year.

TASK XVI: POLYMER ELECTROLYTE FUEL CELLS

Annex Working Group	Date	Place	Country
Workshops and meetings held to date			
XVI	22-23 November 2007	Technical University of Graz	Austria
XVI	7-8 June 2007	VTT Processes	Helsinki, Finland
XVI	27-28 November 2006	Forschungszentrum-Jülich GmbH	Jülich, Germany
XVI	8-9 June 2006	ECN	Petten, Netherlands
XVI	1-2 June 2005	VITO-Energy Technology	Mol, Belgium
XVI	30 November - 1 December 2005	Loughborough	United Kingdom
Workshops and meetings planned for next year			
XVI	29-30 May 2008	IRD	Svenborg, Denmark
XVI	Autumn 2008, specific dates tbc	tbc	tbc

TASK XVII: MOLTEN CARBONATE FUEL CELLS

Meeting No.	Date	Hosted by	Country
Workshops and meetings held to date			
1	18-20 October 2004	NEDO	Kawasaki, Japan
2	12-13 November	FCE	Palm Springs, USA
3	15 November	CESI Ricerca	Milan, Italy
4	14-16 September 2007	KIST	Korea
Workshops and meetings planned for next year			
5	April/May 2008	TUBITAK	Turkey

TASK XVIII: SOLID OXIDE FUEL CELLS

Workshops and Meetings Held to Date

The first Workshop of Annex XVIII was held on November 1, 2004 in San Antonio, Texas, USA. The workshop was attended by twenty representatives of ten of the participating countries; Australia, Canada, Finland, France, Germany, Japan, the Netherlands, Sweden, Switzerland and the USA. They all presented the status of SOFC R, D&D in their respective country.

Not able to attend the workshop was any representative from the United Kingdom. During the workshop, 13 presentations were made by experts from participating countries. The presentations showed that in the recent years, a real progress has been made toward the commercialization of SOFCs.

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

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

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

Workshops and Meetings Planned for Next Year

The Workshop for 2008 will be held on 30 June in Lucerne, Switzerland in conjunction with 8th European SOFC Forum. It will be organised and chaired by Dr Olivier Bucheli of HT Ceramix.

TASK XIX: FUEL CELL SYSTEMS FOR STATIONARY APPLICATIONS

Meeting No.	Date	Hosted by	Country
Workshops and meetings held to date			
1	29-30 April 2004	ENEA	Rome, Italy
2	1 November 2004	DOE	San Antonio, Texas, USA
3	4-5 April 2005	ECN	Petten, The Netherlands
4	14 November 2005	DOE	Palm Springs, California, USA
5	4-5 April 2006	Energie AG Oberösterreich	Linz, Austria
6	10-11 October 2006	ENEA	Rome, Italy
7	19-20 March 2007	FZJ	Jülich, Germany
8	15 October 2007	DOE and EPRI	San Antonio, Texas, USA
Workshops and meetings planned for next year			
9	10-11 March 2008	VTT, in association with the annual Finnish Fuel Cell Seminar	Helsinki, Finland
10	September	ENEA	Venice, Italy

TASK XX: FUEL CELLS FOR TRANSPORTATION

Annex Working Group	Date	Type of Meeting	Country
Workshops and meetings held to date			
XX	28 September 2004	One-day kick-off meeting	Stuttgart, Germany
XX	2005	Working group meeting	Lucerne, Switzerland
XX	May 2007	working group meeting	Petten, The Netherlands
XX	December 2007	working group meeting	Rome, Italy
Workshops and meetings planned for next year			
XX	Spring 2008	working group meeting	Europe
XX	October 2008	working group meeting	US

TASK XXI: PORTABLE FUEL CELLS

Annex Working Group	Date	Type of Meeting	Hosted by	Country
Workshops and meetings held to date				
XXI	5-6 July 2004	kick-off meeting	Juelich Research Center	Juelich, Germany
XXI	30-31 May 2005	annual meeting	ITAE	Messina, Italy
XXI	4-5 September 2006	annual meeting	Technische Universität Graz	Graz, Austria
XXI	24 September 2007	annual meeting	cancelled*	Stuttgart, Germany
Workshops and meetings planned for next year				
XXI	tbc	tbc	tbc	tbc

*Annex meeting planned for 24th September 2007 in Stuttgart, Germany was cancelled due to lack of participation.

Appendix 6

TASK REPORTS AND PUBLICATIONS

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

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

Some of the reports are classified according to an earlier system which only used three levels:

1	Experts participating in relevant Sub-task only.		
2	Participating Countries and all Executive Committee Members.		
3	Unrestricted.		

**TASK XVI: POLYMER ELECTROLYTE FUEL CELLS
REPORTS, PAPERS AND ABSTRACTS PUBLISHED
TO DATE (LEVEL 3B)**

Krishnan, P; Park, JS; Yang, TH; Lee, WY; Kim, CS. 2006.

Sulfonated poly(ether ether ketone)-based composite membrane for polymer electrolyte membrane fuel cells. *JOURNAL OF POWER SOURCES* 163 (1): 2-8, Sp. Iss. SI.

Kim, M; Park, JN; Kim, H; Song, S; Lee, WH. 2006.

The preparation of Pt/C catalysts using various carbon materials for the cathode of PEMFC. *JOURNAL OF POWER SOURCES* 163 (1): 93-97, Sp. Iss. SI.

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

Brace, KM; Hayden, BE; Russell, AE; Owen, JR. 2006.

A parallel optical screen for the rapid combinatorial electrochromic analysis of electrochemical materials. *ADVANCED MATERIALS* 18 (24): 3253-+.

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

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

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

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

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

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

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

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

Varcoe, JR; Slade, RCT; Wright, GL; Chen, YL. 2006. Steady-state dc and impedance investigations of H₂/O₂-2 alkaline membrane fuel cells with commercial Pt/C, Ag/C, and Au/C cathodes. *JOURNAL OF PHYSICAL CHEMISTRY B* 110 (42): 21041-21049.

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

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

- Norsten, TB; Guiver, MD; Murphy, J; Astill, T; Navessin, T; Holdcroft, S; Frankamp, BL; Rotello, VM; Ding, JF. 2006. Highly fluorinated comb-shaped copolymers as proton exchange membranes (PEMs): Improving PEM properties through rational design. *ADVANCED FUNCTIONAL MATERIALS* 16 (14): 1814-1822.
- Liu, BJ; Robertson, GP; Guiver, MD; Shi, ZQ; Navessin, T; Holdcroft, S. 2006. Fluorinated poly(aryl ether) containing a 4-bromophenyl pendant group and its phosphonated derivative. *MACROMOLECULAR RAPID COMMUNICATIONS* 27 (17): 1411-1417.
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- Shivhare, MR; Allen, RG; Scott, K; Morris, AJ; Martin, EB. 2006. A kinetic model for the direct methanol fuel cell anode based on surface coverage. *JOURNAL OF ELECTROANALYTICAL CHEMISTRY* 595 (2): 145-151.
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- Guerin, S; Hayden, BE; Pletcher, D; Rendall, ME; Suchsland, JP; Williams, LJ. 2006. Combinatorial approach to the study of particle size effects in electrocatalysis: Synthesis of supported gold nanoparticles. *JOURNAL OF COMBINATORIAL CHEMISTRY* 8 (5): 791-798.
- Komanicky, V; Chang, KC; Menzel, A; Markovic, NM; You, H; Wang, X; Myers, D. 2006. Stability and dissolution of platinum surfaces in perchloric acid. *JOURNAL OF THE ELECTROCHEMICAL SOCIETY* 153 (10): B446-B451.
- Xie, Z; Song, CJ; Andreaus, B; Navessin, T; Shi, ZQ; Zhang, JJ; Holdcroft, S. 2006. Discrepancies in the measurement of ionic conductivity of PEMs using two- and four-probe AC impedance Spectroscopy. *JOURNAL OF THE ELECTROCHEMICAL SOCIETY* 153 (10): E173-E178.
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- Siu, A; Pivovar, B; Horsfall, J; Lovell, KV; Holdcroft, S. 2006. Dependence of methanol permeability on the nature of water and the morphology of graft copolymer proton exchange membranes. *JOURNAL OF POLYMER SCIENCE PART B-POLYMER PHYSICS* 44 (16): 2240-2252.
- Mattu, J; Johansson, T; Holdcroft, S; Leach, GW. 2006. Highly ordered polymer films of amphiphilic, regioregular polythiophene derivatives. *JOURNAL OF PHYSICAL CHEMISTRY B* 110 (31): 15328-15337.
- Guerin, S; Hayden, BE; Lee, CE; Mormiche, C; Russell, AE. 2006. High-throughput synthesis and screening of ternary metal alloys for electrocatalysis. *JOURNAL OF PHYSICAL CHEMISTRY B* 110 (29): 14355-14362.
- Thomassen, M; Borresen, B; Scott, K; Tunold, R. 2006. A computational simulation of a hydrogen/chlorine single fuel cell. *JOURNAL OF POWER SOURCES* 157 (1): 271-283.

- Lobato, J; Rodrigo, MA; Linares, JJ; Scott, K. 2006. Effect of the catalytic ink preparation method on the performance of high temperature polymer electrolyte membrane fuel cells. JOURNAL OF POWER SOURCES 157 (1): 284-292.
- Ramschak, E; Peinecke, V; Prenninger, P; Schaffer, T; Hacker, V. 2006. Detection of fuel cell critical status by stack voltage analysis. JOURNAL OF POWER SOURCES 157 (2): 837-840, Sp. Iss. SI.
- Shimpalee, S; Lee, WK; Van Zee, JW; Naseri-Neshat, H. 2006. Predicting the transient response of a serpentine flow-field PEMFC I. Excess to normal fuel and air. JOURNAL OF POWER SOURCES 156 (2): 355-368.
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- Rodgers, M; Yang, YS; Holdcroft, S. 2006. A study of linear versus angled rigid rod polymers for proton conducting membranes using sulfonated polyimides. EUROPEAN POLYMER JOURNAL 42 (5): 1075-1085.
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- Varcoe, JR; Slade, RCT. 2006. An electron-beam-grafted ETFE alkaline anion-exchange membrane in metal-cation-free solid-state alkaline fuel cells. ELECTROCHEMISTRY COMMUNICATIONS 8 (5): 839-843.
- Cheng, H; Scott, K. 2006. Determination of kinetic parameters for borohydride oxidation on a rotating Au disk electrode. ELECTROCHIMICA ACTA 51 (17): 3429-3433.
- Rimbu, GA; Jackson, CL; Scott, K. 2006. Platinum/carbon/polyaniline based nanocomposites as catalysts for fuel cell technology. JOURNAL OF OPTOELECTRONICS AND ADVANCED MATERIALS 8 (2): 611-616.
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- Schaffer, T; Tschinder, T; Hacker, V; Besenhard, JO. 2006. Determination of methanol diffusion and electroosmotic drag coefficients in proton-exchange-membranes for DMFC. JOURNAL OF POWER SOURCES 153 (2): 210-216.
- Schaffer, T; Hacker, V; Besenhard, JO. 2006. Innovative system designs for DMFC. JOURNAL OF POWER SOURCES 153 (2): 217-227.
- Siu, A; Schmeisser, J; Holdcroft, S. 2006. Effect of water on the low temperature conductivity of polymer electrolytes. JOURNAL OF PHYSICAL CHEMISTRY B 110 (12): 6072-6080.
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- Wang, XP; Kumar, R; Myers, DJ. 2006. Effect of voltage on platinum dissolution relevance to polymer electrolyte fuel cells. ELECTROCHEMICAL AND SOLID STATE LETTERS 9 (5): A225-A227.
- Varcoe, JR; Slade, RCT; Lam How Yee, E. 2006. An alkaline polymer electrochemical interface: a breakthrough in application of alkaline anion-exchange membranes in fuel cells. CHEMICAL COMMUNICATIONS (13): 1428-1429.

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

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

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

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

Reports (Level 2b)

- Summary Report on Annex XVI Workshop, June 7-8, 2007, VTT Processes, Helsinki, Finland
- Summary Report on Annex XVI Workshop, Graz, Austria on Nov. 22-23, 2007
- Status Report on Annex XVI: Collaborative Research on Polymer Electrolyte Fuel Cells, Spring, 2007
- Status Report on Annex XVI: Collaborative Research on Polymer Electrolyte Fuel Cells, Fall, 2007

Reports Planned for Next Year

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

Reports published to date	Reports planned for next year
TASK XVII: MOLTEN CARBONATE FUEL CELLS	
<ul style="list-style-type: none"> The annual report of Annex XVII was published in January 2007. 	<ul style="list-style-type: none"> Annual report for 2007.
TASK XVIII: SOLID OXIDE FUEL CELLS	
<ul style="list-style-type: none"> Proceedings of the Workshop in San Antonio, Texas on November 1, 2004, by Subhash Singhal (Editor), November 2004. Proceedings of the Workshop in Quebec City, Canada on May 14, 2005, by Brian Borglum (Editor), May 2005. Proceedings of the Workshop in Helsinki, Finland on June 30, 2006, by Jari Kiviaho (Editor), June 2006. Proceedings of the Workshop in Nara, Japan on June 2, 2007, by K Yokomoto (Editor), June 2007. 	<ul style="list-style-type: none"> Meeting, Status, and Annual Reports for the Solid Oxide Fuel Cells Annex XVIII. Proceedings of the Workshop in Lucerne, Switzerland on June 30, 2008, by Olivier Bucheli (Editor), July 2007.
TASK XIX: FUEL CELL SYSTEMS FOR STATIONARY APPLICATIONS	
<ul style="list-style-type: none"> Minutes from Expert's meetings, Status Reports, two per year, and Annual Reports for Annex XIX. 	<ul style="list-style-type: none"> Meeting, Status and Annual reports Reports from subtasks
TASK XX: FUEL CELL SYSTEMS FOR TRANSPORTATION	
<ul style="list-style-type: none"> Annual report of Annex XX 2004. Annual report Annex XX 2005. Annual report Annex XX 2007. 	<ul style="list-style-type: none"> Status and Annual Reports for Annex XX
TASK XXI: PORTABLE FUEL CELLS	

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).

Expert	Organisation	Categorisation	Country
TASK XVI: POLYMER ELECTROLYTE FUEL CELLS			
OPERATING AGENT: XIAOPING WANG, ARGONNE NATIONAL LABORATORY, USA (R)			
Viktor Hacker	Graz University of Technology	A	Austria
Gilbert Van Bogaert	Vito - Energy Technology	R	Belgium
Steven Holdcroft	Simon Fraser University	A	Canada
Brant Peppley	Royal Military College of Canada	A	Canada
Jorgen Lundsgaard	IRD Fuel Cells A/S	R	Denmark
Matti Valkiainen	VTT Processes	R	Finland
Jürgen Mergel	Forschungszentrum Juelich GmbH	R	Germany
Torsten Schwarz	ICT Fraunhofer	R	Germany
Marco Brocco	Italian National Agency for New Technologies, Energy and Environment (ENEA)	R	Italy
Tomohiko Ikeya	New Energy and Industrial Technology Development Organization (NEDO)	G	Japan
Ulises Cano-Castillo	Instituto de Electricas	R	Mexico
Gaby Janssen	ECN- Fuel Cell Technology	R	Netherlands
Børre Børresen	Norwegian University of Science and Technology (NTNU)	A	Norway
Lars Pettersson	Royal Institute of Technology, KTH	A	Sweden
Rob Thring	Loughborough University	A	United Kingdom

Expert	Organisation	Categorisation	Country
Rui Chen	Loughborough University	A	United Kingdom
Keith Scott	University of Newcastle upon Tyne	A	United Kingdom
Brian Hayden	University of Southampton	A	United Kingdom
John Varcoe	University of Surrey	A	United Kingdom
Xiaoping Wang	Argonne National Laboratory	R	United States
Deborah Myers	Argonne National Laboratory	R	United States
Piotr Zelenay	Los Alamos National Laboratory	R	United States

TASK XVII: MOLTEN CARBONATE FUEL CELLS
OPERATING AGENT: TAE-HOON LIN, KIST, KOREA (R)

Manfred M.Bischoff	MTU	I	Germany
Angelo Moreno	ENEA	G	Italy
B. Marcenaro	Ansaldo	I	Italy
Yoshiyuki Izaki	CRIEPI	R	Japan
Y. Mugikura	CRIEPI	R	Japan
M. Yoshikawa	CRIEPI	R	Japan
Masaaki Tooi	IHI	I	Japan
K. Tanimoto	AIST	R	Japan
Tae-Hoon Lim	KIST	R	Korea
Jonghee Han	KIST	R	Korea
Sung-Pil Yoon	KIST	R	Korea
Hee Chun Lim	KEPRI	R	Korea
Joong Hwan Jun	RIST	I	Korea
Hans Maru	FCE	I	USA
Mohammad Farooque	FCE	I	USA
D. Connor	Gencell	I	USA

Participant	Organisation	Categorisation	Country
TASK XVIII: SOLID OXIDE FUEL CELLS OVERALL OPERATING AGENT: SUBHASH C. SINGHAL, PACIFIC NORTHWEST NATIONAL LABORATORY, USA 2007 INTERIM OPERATING AGENT: K YOKOMOTO Participants of the 2006 workshop:			
Brian Borglum	Versa Power Systems	R	Canada
Tony Petric	McMaster University	I	Canada
Erkko Fontell	Wartsila Corporation	I	Finland
Jari Kiviaho	VTT Processes	R	Finland
Laurent Antoni	CEA	R	France
Robert Steinberger-Wilckens	Forschungszentrum Jülich	R	Germany
Takashi Ujiie	NEDO	G	Japan
Harumi Yokokawa	AIST	I	Japan
Rak-Hyun Song	KIER	R	Korea
Bert Rietveld	Energie Onderzoekscentrum Nederland	R	Netherlands
Mohsen Assadi	Lund Institute of Technology		Sweden
Olivier Bucheli	HTceramix	R	Switzerland
Mark Ormerod	Keele University	I	UK
Stephen Skinner	Imperial College	I	UK
Subhash Singhal	Pacific Northwest National Laboratory	R	USA

Expert	Organisation	Categorisation	Country
TASK XIX: FUEL CELL SYSTEMS FOR STATIONARY APPLICATIONS			
OPERATING AGENT: BENGT RIDELL. GRONTMIJ AB, SWEDEN			
Karl Föger	CFCL	I	Australia
Antoine Aslanides	EDF	I	France
Ludmilla Gautier	EDF	I	France
Ulf Birnbaum	FZJ	R	Germany
Gerhard Huppmann	MTU	I	Germany
John Bøgild Hansen	HTAS	I	Denmark
Adwin Martens	VITO	R	Belgium
Rolf Rosenberg	VTT	G	Finland
Jari Kiviaho	VTT	G	Finland
Timo Kivisaari	Wärtsilä	I	Finland
Kazuhito Hato	NEDO	G	Japan
Peter vander Laag	ECN	R	The Netherlands
Paul van den Oosterkamp	ECN	R	The Netherlands
Angelo Moreno	ENEA	G	Italy
Bengt Ridell	Grontmij	I	Sweden
Dan Rastler	EPRI	I	USA
Stephan Renz	Thoma & Renz	I	Switzerland
Günther Simader	E.V.A.	G	Austria
Georg Trnka	E.V.A.	G	Austria
Heinrich Wilk	Energie AG OÖ	I	Austria

Expert	Organisation	Categorisation	Country
TASK XX: FUEL CELL SYSTEMS FOR TRANSPORTATION			
OPERATING AGENT: DR PAUL VAN DEN OOSTERKAMP			
No information available			
TASK XXI: PORTABLE FUEL CELLS			
OPERATING AGENT: JUELICH RESEARCH CENTER, GERMANY			
Ed Andrukaitis	Def. Research and Development	G	Canada
Vincenzo Antonucci	ITAE	R	Italy
Ulises Cano Castillo	Electrical Research Institute	R	Mexico
Hendrik Dohle	Forschungszentrum Jülich	R	Germany
Alexander Dyck	CEAG AG	I	Germany
Viktor Hacker	Technische Universität Graz	A	Austria
Holger Janssen	Forschungszentrum Jülich	R	Germany
Doo-Hwan Jung	KIER	R	Korea
Soren Lundsgaard	IRD	I	Denmark
Erik Middelmann	Nedstack fuel cell technology	I	NL
Ralf Peters	Forschungszentrum Jülich	R	Germany
Rolf Rosenberg	VTT	R	Finland
Thomas Schaffer	Technische Universität Graz	A	Austria
Günter R. Simader	Energieverwertungsagentur EVA	G	Austria
Gaetano Squadrito	ITAE	R	Italy
Matti Valkiainen	VTT	R	Finland
Ad Verhage	Nedstack fuel cell technology	I	NL

