International Energy Agency (IEA) Advanced Fuel Cells

Implementing Agreement

ANNUAL REPORT 2009

June 2010

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.

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 three countries (New Zealand, Spain and the UK) 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 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 February 2009. The extension is underway and will run until February 2014. 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 2009.

Spain and New Zealand were previously Participants but have since left the Implementing Agreement.

The UK left the Agreement during 2009.

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
(left April 2009)

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

France
Signatory Party: Commissariat à l'Energie 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 Féderale 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 Secretary is Mrs Heather Haydock (AEA, UK). The IEA/OECD representatives during 2009 were Carrie Pottinger followed by François Cuenot.

The following table lists all the Executive Committee Members, their Alternates and the Operating Agents of the different Annexes at the end of 2009. Addresses and contact numbers are given in Appendix 1 to this report.

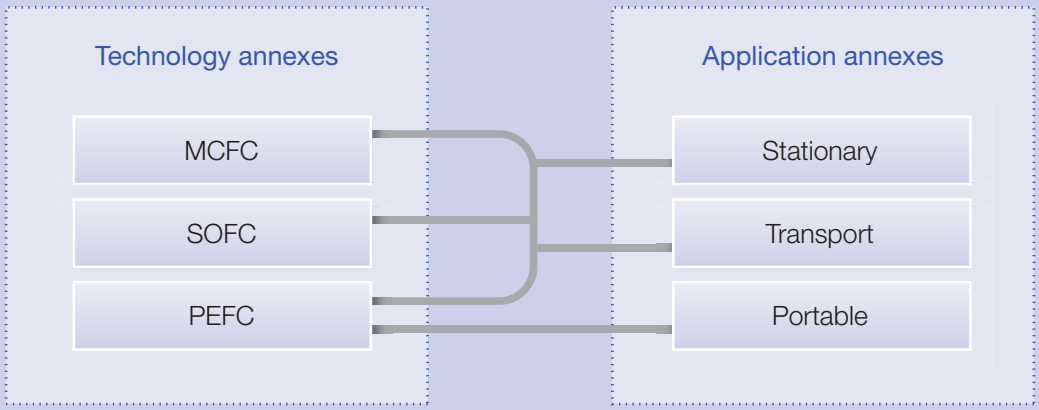
Country	Ex Co Member	Ex Co Alternative	Operating Agent	Annex Number
Australia	K Foger			
Austria	G Simader	V Hacker		
Belgium	G van Bogaert			
Canada	V Scepanovic	E Andrukaitis		
Denmark	I Pihl Byriel	S Linderoth		
Finland	H Kotila	R Rosenberg	J Kiviaho	24
France	T Priem			
Germany	D Stolten	R Samsun	M Müller	27
Italy	A Moreno			
Japan	T Itomi			
Korea	H-C Lim	T-H Lim	T-H Lim	23
Mexico	J Huacuz	U Cano Castillo		
Netherlands	F de Bruijn		P Van Oosterkamp	26
Norway	T Tronstad			
Sweden	L Sjunnesson	B Gustafsson	B Ridell	25
Switzerland	S Oberholzer			
Turkey	E Gunen	B Erdor		
USA	N Garland	W Surdoval	X Wang	22

CURRENT AND FUTURE ANNEXES

Six Annexes were approved and commenced in 2009:

Annex	Title
Annex 22	Polymer Electrolyte Fuel Cells
Annex 23	Molten Carbonate
Annex 24	Solid Oxide Fuel Cells
Annex 25	Fuel Cells for Stationary Applications
Annex 26	Fuel Cells for Transportation
Annex 27	Fuel Cells for Portable Applications

Together these six annexes form an integrated programme of work for February 2009 to February 2014, 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 2009-2014

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

Timescales

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
MCFC	Annex VI				Annex XIV				Annex XVII					Annex 22				
SOFC	Annex VII			Annex XIII					Annex XVIII					Annex 23				
PEFC	Annex VIII			Annex XI					Annex XVI					Annex 24				
Stationary	Annex IX			Annex XII					Annex XIX					Annex 25				
Transport		Annex X				Annex XV			Annex XX					Annex 26				
Portable									Annex XXI					Annex 27				

2. Executive Committee Report

2.1 MEMBERSHIP AND PARTICIPATION

The UK left the Agreement in April 2009. No new member countries joined.

There were changes in the Executive Committee membership in 2009 for Germany and Italy. Dr Remzi Samsun took over from Dr Z Pors as Alternate Member for Germany. Dr Angelo Moreno replaced Dr Raffaele Vellone as ExCo Member for Italy.

Jari Kivalho took over from Subhash SInghal as Operating Agent for the solid oxide fuel cell annex, Annex 24 (previously XVIII). Similarly, Martin Muller took over from Hendrick Dohle as Operating Agent for the portable systems annex, Annex 27 (previously XXI). Paul van den Oosterkamp resigned as Operating Agent for the transportation annex, Annex 26 (previously XX) and no new Operating Agent has yet been appointed. As a result, there was very little activity under Annex 26 during 2009.

The other three Operating Agents continued to run the Annexes as they transitioned into the new phase of work: Dr Xiaoping Wang for the PEMFC activities under the Annex 22 (previously XVI); Dr Tae Hoon Lim for Annex 23 (previously XVII) and Bengt Ridell for stationary fuel cell systems under Annex 26 (previously XIX).

François Cuenot replaced Carrie Pottinger as IEA Desk Officer.

2.2 ACTIVITIES AND DECISIONS

2.2.1 Activities

Two Executive Committee meetings were held. The 38th meeting was held in Istanbul, Turkey in April 2009 and the 39th Executive Committee meeting was held in Copenhagen, Denmark on November 26, 2009.

An End-of-Term report and updated Strategic Plan were produced in late 2008/early 2009 to support a request to extend the Implementing Agreement.

The Chairman presented the Executive Committee's proposal to extend the Implementing Agreement to the IEA Committee on Energy Research and Technology (CERT) in Paris in February 2009. The proposal was well received and the extension was approved unanimously.

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 web site of the Implementing Agreement (www.ieafuelcell.com) was substantially improved and updated.

2.2.2 Decisions

ExCo Members unanimously approved the re-appointment of Lars Sjunnesson and Detlef Stolten as ExCo Chairman and Vice Chair respectively, for a further two years from April 2009. Nancy Garland was also elected as a Vice Chair for the same period.

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.

Two Executive Committee meetings will be held in 2010. The 40th meeting will be held in Essen, Germany on 21 May 2010, along with a joint ExCo meeting with the Hydrogen Implementing Agreement. The 41st meeting will be held at the IEA, Paris on 4-5 October 2010.

Continued implementation of the approved work programme for six new Annexes is planned. There may also be additional 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. Further details are given in Section 4.

3.1 ACHIEVEMENTS OF ANNEX 22 POLYMER ELECTROLYTE FUEL CELLS

- Alternative cathode catalyst supports, such as doped SnO2, carbon nanotubes/nanofibres, and ordered mesoporous carbon, were shown to be better supports than traditional carbon black, as they rendered the catalyst with either better stability or/and better mass transport properties, while allowing low loadings of platinum (Pt).
- Low temperature polymer electrolyte membrane (PEM) micro-combined heat and power (CHP) of about 2 kWe rating units were built and put in field test in residential demonstrations.
- Alternative preparation methods for electrocatalysts and non-Pt and non-Pt-Group metal catalysts were developed to address the cost issue of PEFC catalysts.
- A study of different forms of carbon as gas diffusion layers (GDL) under sub-freezing conditions identified better GDL materials and designs of gas flow fields.
- Investigation of the cold start behavior of membrane electrolyte assemblies (MEAs), cells, and stacks provided useful data to enable the development of cold start strategies for PEFC systems.
- Better in-situ characterisation tools were developed to visualise the changes of catalysts oxidation state, and distribution of current density and product water.
- Potential fuels, ethanol/ethylene glycol and acetate/ wastewater, were identified for direct fuel PEFCs and Direct Methanol Fuel Cells (DMFCs), respectively.
- Pilot–scale coating technology was developed for DMFC MEA fabrications to optimize homogeneity, porosity, and hydrophobicity of crack-free layers and contacts between layers for better performance and stability.

3.2 ACHIEVEMENTS OF ANNEX 23 MOLTEN CARBONATE FUEL CELLS

Highlights included a MCFC-gas turbine system design from CRIEPI that gives over 70% efficiency and a 50kW demonstration system for MCFC combined with carbon capture (concentration/separation) and storage (CCS), also in Japan. Over 95 MW of MCFC systems are installed or on order worldwide, with 72 MW of this in Japan and Korea and 15 MW in California and the west coast of the United States. Grid support is the main application, accounting for 69 MW of the total.

3.3 ACHIEVEMENTS OF ANNEX 24 SOLID OXIDE FUEL CELLS

The key highlight from Annex 24 was the strong SOFC demonstration programme in Japan. During the programme, 27 residential units were installed (2007) and 36 residential units were installed in 2008. All units were operating during 2009 without serious problem.

3.4 ACHIEVEMENTS OF ANNEX 25 STATIONARY FUEL CELLS

Key achievements of Annex 25 included the impressive update from the stationary fuel cells programme in Japan. There was also an interesting presentation from Germany of high temperature fuel cells in combination with gas turbines. An annex report was produced and published on the subject of fuels for fuel cells.

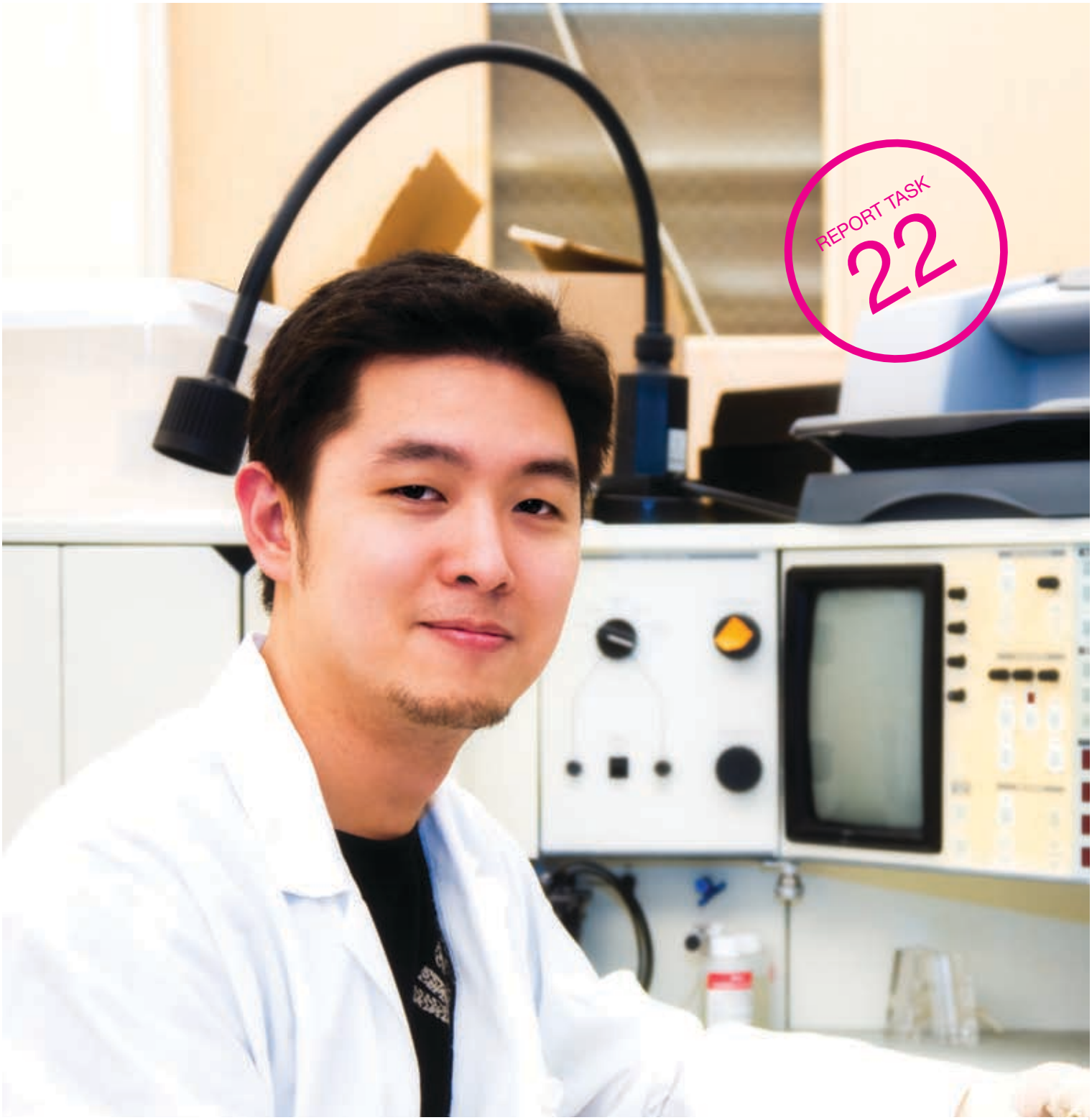
3.5 ACHIEVEMENTS OF ANNEX 26 FUEL CELLS FOR TRANSPORTATION

Annex 26 was dormant during the 2009 reporting period in the absence of an operating agent.

3.6 ACHIEVEMENTS OF ANNEX 27 FUEL CELLS FOR PORTABLE APPLICATIONS & LIGHT TRACTION

Key achievements of Annex 27 were:

- DMFC-Scooter with >32 % efficiency (Japan).
- DMFC System as battery replacement in warehouse trucks (Germany).
- DMFC 2,300 h test of hydrocarbon MEA (Japan).
- DMFC -6.46 µV/h degradation rate after 4000 h operation (Korea).
- PEFC durability studies depending on operation conditions (Austria).



The objective of this task is to contribute to the development of techniques to reduce the cost and improve the performance and durability of polymer electrolyte fuel cells, direct fuel polymer electrolyte fuel cells, and corresponding fuel cell systems.

4. Task Reports

4.1 REPORT TASK 22

POLYMER ELECTROLYTE FUEL CELLS

4.1.1 Duration

February 2009 until February 2014 (five years).

4.1.2 Operating Agent

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

4.1.3 Participants

Agencies from fourteen countries were involved in this Annex during the year 2009:

Austria	Graz University of Technology
Belgium	VITO
Denmark	IRD Fuel Cell A/S
Finland	VTT
France	CEA
Germany	Jülich and ICT Fraunhofer
Italy	ENEA
Japan	Kyushu University
Korea	KIER
Mexico	Instituto de Electricas
The Netherlands	ECN
Switzerland (observer)	Paul Scherrer Institute
Turkey	Tübitak Marmara Research Center Energy Institute
USA	ANL

4.1.4 Objective

The objective of Annex 22 is to contribute to the identification and development of techniques to reduce the cost and improve the performance and durability of polymer electrolyte fuel cells (PEFCs), direct fuel polymer electrolyte fuel cells, and corresponding fuel cell systems. Major applications are in the automotive, portable power, auxiliary power, and stationary power (residential, commercial), and combined heat and power sectors.

4.1.5 Task Description

This Task consists of three subtasks:

Subtask 1: Stack Materials

- Use of carbon nano-fibers as Pt catalyst support and in gas diffusion layers (GDLs) to improve cell performance at high current densities and improve cell durability (Austria).
- Air cathode and ion permeable membrane for microbial fuel cells (MFCs) to improve cell performance and reduce cost (Belgium).
- Electro-deposition of platinum on multi-wall carbon nanotube (MWCNT)-based gas diffusion layer for PEFCs electrodes to reduce cost and improve durability (Italy).
- Carbon-free catalyst supports and nanostructured electrocatalysts with improved durability and thermochemical and geometrical stability (Japan).
- High-temperature water-free composite membranes for high temperature (>90°C) anhydrous PEFCs to mitigate carbon monoxide poisoning and improve system efficiency (Korea).
- Gas diffusion layers in sub-zero temperatures and multiple freeze-thaw cycles (Korea).
- Ordered mesoporous carbon (OMC) as catalyst support for cathodes (Netherlands).
- Fe-polyaniline-derived non-Pt cathode electrocatalysts for the oxygen reduction reaction, ORR (USA).

- Structure, activity, and stability of Pd-Cu non-Pt ORR catalysts and carbon nanotubes doped with nitrogen and transition metals for enhanced ORR (USA).
- Aligned carbon nanotubes (ACNTs) as cathode supports to enhance electrode mass transfer and durability (USA).

Subtask 2: System, Component, and Balance-of-Plant

- Early market demonstrations projects for hydrogen, including hydrogen production and applications (Belgium).
- Low temperature PEM μCHP (~2 kWe) field test and demonstration project (Denmark).
- Fuel cell stacks, balance-of-plant components, and control system, testing equipment, characterization methods or protocols, and durability knowledge towards developing a 10-kW power pack (Finland).
- Cold start mechanisms, behavior, and effects in Nafion membranes, single fuel cells, and short stacks (France).
- LPG fuel processor for small-scale (1 kWe) power generation (Italy).
- Power electronics for 1 kWe fuel cell power supply (Mexico).
- A micro-cogeneration system (5 kWe) for stationary application (Turkey).

Subtask 3: Direct Fuel Polymer Electrolyte Fuel Cells

- Kinetics and mechanisms of electro-oxidation behavior of ethanol and ethylene glycol on model electrocatalyst surfaces (polycrystalline Pt) in acidic and alkaline media (Germany).
- Coating technology for DMFC MEA fabrication to optimize homogeneity, porosity, and hydrophobicity of crack-free layers and contacts between layers for better performance and improved stability (Germany).
- Water management in DMFC systems and distribution of water, CO2, and current density in DMFCs (Germany).

4.1.6 Progress Summary

4.1.6.1 Background

This Annex continues the work previously conducted under Annex XVI with the same participating countries except for the UK who withdrew from the Implementing Agreement in early 2009.

4.1.6.2 Activities

During 2009 two meetings of this Annex were held, one on June 3-4, 2009, at CEA, Grenoble, France, and the other on November 12–13, 2009, at Argonne National Laboratory, Argonne, Illinois, USA. The participants decided to continue the various Subtasks of the Annex during the new phase of the Implementing Agreement. Potential host sites for the 2010 Annex meetings were discussed.

4.1.7 Technical Accomplishments

Subtask 1: Stack Materials for Improved Performance and Reduced Costs

- Researchers at Graz University (Austria) conducted research on fabrication and characterization membrane electrode assemblies (MEAs) with carbon nano-fibres (CNFs) as supports for Pt in the electrodes and in the gas diffusion layers (GDLs). Compared to a conventional MEA, the MEA with optimized CNFs showed a higher current density and power output (1300 mA/cm2 vs. 1000 mA/cm2 and ~380 mW/cm2 vs. 290 mW/cm2) with a lower platinum loading (anode: 0.1 mgPt/cm2, cathode: 0.4 mgPt/cm2). Also, the CNF-based MEA showed a lower power density loss than a commercial MEA over 200 h of potentiostatic operation.

- Researchers at VITO (Belgium) developed low-cost electrodes and membrane materials for Microbial Fuel Cells (MFCs). The MFCs offer the promise of renewable energy production simultaneously with wastewater treatment.
- Researchers at ENEA (Italy) are studied nano-structured Pt electrodeposited on multi-wall carbon nanotubes (Pt/MWCNTs) as PEFC electrodes. The test results in a half cell configuration showed that performance comparable to that of commercial Pt/C catalyst at comparable Pt loadings was obtained.
- Fuel cell research at Kyushu University (Japan) included materials synthesis, cell preparation and testing, and electrochemical and materials characterizations.
- Researchers at the Korea Institute for Energy Research (KIER, Korea) investigated alternative polymer electrolyte membranes for high temperature, low humidity operations for CO-tolerant PEFC systems, thereby eliminating preferential oxidation (PrOx) units in reformers.
- Researchers at KIER showed the importance of GDL properties for successful operation of fuel cells under sub-freezing conditions.
- Researchers at ECN (the Netherlands) investigated ordered mesoporous carbon (OMC) as an alternative to conventional carbon black as catalyst support. MEA testing indicated that mass transport properties for electron, proton, and oxygen of the OMC catalysts were poor, due to a water/Nafion blocking effect for oxygen transport, and the OMC's lower electronic conductivity. This research is ongoing.
- Research at the Paul Scherrer Institute (PSI, Switzerland) focused on the development of materials (catalysts, membranes) and advanced diagnostic methods (spatially resolved transient and steady state techniques, neutron radiography), stacks, and systems.
- Researchers at Argonne (USA) investigated non-Pt electrocatalysts based on palladium (Pd), ruthenium (Rh) and copper (Cu). The 1:1 Pd-Cu system showed the best oxygen reduction reaction (ORR) mass activity, nearly 75% that of commercial platinum/carbon catalysts. They have also characterized Non-precious metal cathode electrocatalysts derived from Fe-polyaniline developed at Los Alamos National Laboratory (LANL) using X-ray absorption spectroscopy to identify active sites for the ORR. Finally, in another task, researchers at Argonne have investigated aligned carbon nanotubes (ACNTs) as a potential catalyst support in PEFCs, where they offer several potential advantages over carbon black including better catalyst utilization, better support stability, better thermal and electrical conductivity, better water management and better mass transfer.

Subtask 2: System, Component, and Balance-of-Plant Issues

- An early market demonstration project on hydrogen is underway in Belgium for the region of Flanders to South-Netherlands from June 1, 2009, to May 31, 2012, with a budget of €14.1 million. The anticipated results by the end of the project include mobile hydrogen tank stations, 1 MW power plant operating on waste-hydrogen, hydrogen production via photo-electrolysis (1 m^2), roll-out scenarios for hydrogen infrastructure, applications of hydrogen in logistic, maritime, and intercity transport, and education/training programmes.
- Researchers at IRD Fuel Cells (Denmark) are working on a demonstration project for 1.5 kWAC µCHP (micro combined heat and power) units. The demonstration project includes low-temperature (LT) PEM µCHP units for east DK, and high-temperature (HT) PEM and SOFC µCHP units for south DK. The ultimate goal of the demonstration project is to direct future R&D, engineering, and field tests towards reliable and affordable µCHPs.

- Research activities at VTT (Finland) included PEFC system development as part of the “WorkingPEM 2007-2009” project, which had the goal of developing a 10-kW PEFC power pack.
- Researchers at CEA (France) investigated cold-start mechanisms, cold-start behaviour, and cold-start effects on its durability of a Nafion membrane and a single cell. Post-mortem analyses of the MEA after repeated cold start studies showed that there was no change in the anode, but cracks formed in cathode with delamination between membrane and cathode layer. It was not clear, however, if the changes were solely due to the cold start, since the fuel cell operates at rated conditions after each cold start.
- Researchers at ENEA (Italy) evaluated the performance of a 1-kWe LPG fuel processor for PEFCs in small-scale electric power generation. Although the performance of the fuel processor still needs to be improved, the experimental results showed the feasibility of the fuel processor concept and design.
- Examples of the commercialization activities of fuel cell technologies in Japan included the Honda FCVs, 1-kW residential PEFCs (ENE FARM), and portable DMFC devices, such as the Toshiba DynarioTM. To realize large-scale commercialization of these technologies, however, their costs and durability must be improved further. Many research centres have recently focused on, or new centres have been established to tackle, these issues. For example, the University of Yamanashi Fuel Cell Nanomaterials Centre was opened in 2008, a “Hydrogen Town” has been built with 150 stationary fuel cells installed in a new residential area in Fukuoka, a “Hydrogen Highway” has been constructed for refuelling FCVs, and Kyushu University is the home for the International Research Centre for Hydrogen Energy.
- Researchers at Instituto de Electrica (Mexico) compared a two-stage power conditioner architecture with an integrated power conditioner architecture for a 1-kW-PEFC-based power supply. The two-stage architecture was found to be suitable for fuel cell power conditioning as it exhibits a low input current ripple.
- Researchers at the TUBITAK Marmara Research Center (Turkey) are developing a natural gas fueled 5-kW PEFC micro-cogeneration system for stationary applications. Progress thus far includes optimal design of the PEFC, fabrication of bipolar plates and application of flow channels on the plates, MEA fabrication, assembly of a 5-kW PEFC module, identifying gas delivery and control, humidification, thermal and water management sub- systems, and performing system integration and performance tests.

Subtask 3: Direct Fuel Polymer Electrolyte Fuel Cells

- Researchers at Fraunhofer ICT (Germany) have been investigated the electrochemical oxidation of ethanol and ethylene glycol in alkaline solutions. Both fuels were identified to be more suitable fuels than methanol for direct fuel polymer electrolyte fuel cells.
- Researchers at Jülich (Germany) have been developing pilot-scale coating technology for DMFC MEA fabrication with optimum homogeneity, porosity, and hydrophobicity of crack-free layers and contact between layers for better performance and better stability. First results show that controlled changes in these properties alter the water transport and operational stability of the resulting MEAs at low air flow rates. Researchers at Jülich (Germany) have also investigated water management in DMFC systems under water-autonomous operation.

4.1.8 Work Plan for Next Year

During 2009, the areas of active R&D within the Annex addressed many of the critical technical barriers that have prevented PEFC technologies from achieving widespread commercialization. For both hydrogen PEFCs and direct fuel PEFCs, the R&D included cell and stack materials and components, improved MEAs, reduced catalyst costs, improved catalyst and support durability, and enhanced system design and analyses. Although significant progress has been made in many areas, there is still a need for further advancement. Thus, it is expected that these topic areas will continue to be active for R&D in future years. Recently, there has also been increased activity in fuel processor development for small-scale PEFC power plants, and in residential PEFC system development and demonstrations. Participants in this Annex are expected to contribute significantly to these developments.

The objective of this task is to provide for further international collaboration in the research and development of certain aspects of Molten Carbonate Fuel Cells technology, in order to realise commercialisation of the system.

4.2 REPORT TASK 23

MOLTEN CARBONATE FUEL CELLS AT THE BEGINNING OF MARKET PENETRATION

4.2.1 Duration

February 2009 until February 2014 (five years).

4.2.2 Operating Agent

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

4.2.3 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 Centre of Scientific and Technological Research Council of Turkey [from June 2007]

4.2.4 Objective

The objective of the Task is to provide for further international collaboration in the research and development of certain aspects of MCFC technology, in order to realise commercialization of the MCFC system. These aspects 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

There are three subtasks in Annex 23:

Subtask A:	R&D Issues for Longer Life, Higher Performance and Lower Cost
Subtask B:	Lessons Learned from Demos and Early Products
Subtask C:	Standardisation of stack and balance of plant (BoP)

4.2.6 Progress Summary

4.2.6.1 Background

This Annex continues work undertaken under Annex I "MCFC Balance of Plant Analysis", Annex III "MCFC Materials and Electrochemistry", Annex XIV "MCFC under Real Operating Conditions" and Annex XVII "MCFC towards Commercialisation".

4.2.6.2 Activities

The first meeting was held on November 16, 2009 and was hosted by DoE at The Courtyard by Marriott Palm Springs Hotel - CA, USA. There were six presentations at the meeting.

4.2.6.3 Technical Accomplishments

Highlights included a MCFC-gas turbine system design from CRIEPI that gives over 70% efficiency and a 50kW demonstration system for MCFC combined with carbon capture (concentration/separation) and storage (CCS), also in Japan. These are illustrated in the Figure 1 and Figure 2, below.

Figure 1 Ultra Highly Efficiency MCFC-GT Hybrid System

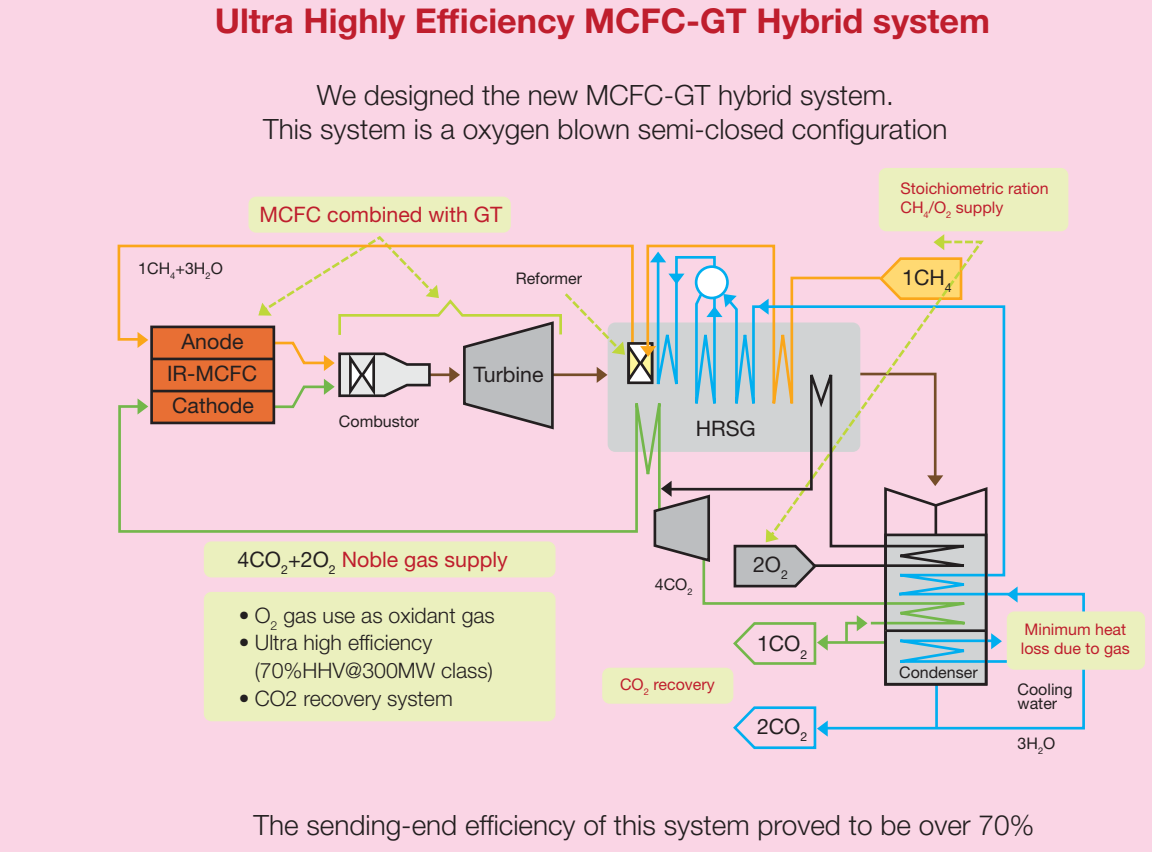
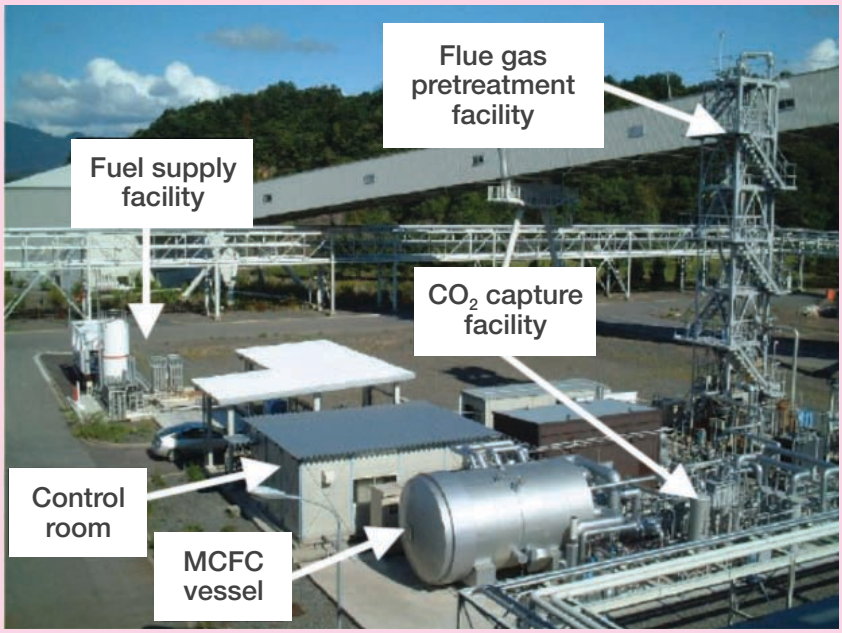


Figure 2 50kW-class system view at Misumi Power Station



Over 95 MW of MCFC systems are installed or on order worldwide, with 72 MW of this in Japan and Korea and 15 MW in California and the west coast of the United States. Grid support is the main application, accounting for 69 MW of the total.

Figure 3 Market potential and targeted applications

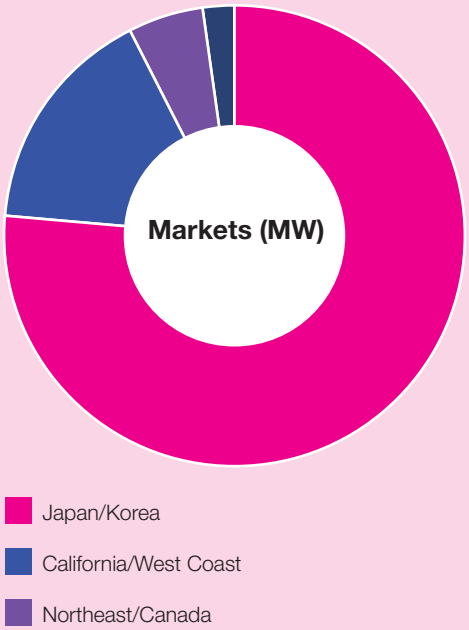
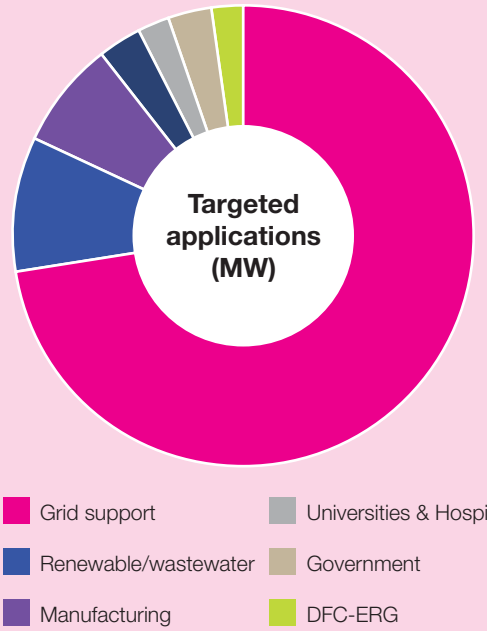


Figure 4 Targeted applications



Asia is adopting a distributed generation system. South Korea has declared that fuel cells are a key economic driver: to illustrate, POSCO Power ordered over 68MW and the latest 30MW order was worth $58 million. There are plans to build a facility to assemble stacks from FuelCell Energy components upon completion of new licensing agreement. The system is pending Korean Renewable Electricity Standard (RES) of 4.3% by 2015 and 11% by 2030.

4.2.6 Future Plans

The second meeting of Annex XXIII Working Group will be held on July 9 – 10, 2010 in Perugia. The meeting will be hosted by University of Perugia. Discussion topics will include:

- Presentations concerning the sub tasks
- Preparation of the new version of MCFC status of the art

The objective of this task is to organise a series of annual workshops to discuss selected Solid Oxide Fuel Cells topics.

4.3 REPORT TASK 24 SOLID OXIDE FUEL CELLS

4.3.1 Duration

February 2009 until February 2014 (five years).

4.3.2 Operating Agent

The overall Operating Agent of Annex 24 is Jari Kiviaho. The Overall Operating Agent is responsible for reporting to the Executive Committee.

4.3.3 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
United States	US DOE

4.3.4 Objective

The overall objective of Annex 24 is to organise a series of annual workshops, each to be organised by and in a different country. Each workshop will be organised over one or two days, with discussions on general progress and/or selected SOFC topics. Where possible, these workshops will be linked to other relevant conferences, in order to minimise travelling costs. The workshops should lead to open discussions relating to common problems and should have realizable and achievable aims.

4.3.5 Task Description

Annex 24 comprises a series of workshops, each to be organised by and in a different country. The list of workshops is as follows:

Year	Location	Workshop in connection with:
2009	Vienna, Austria	-
2010	Lucerne, Switzerland	European Fuel Cell Forum
2011	Canada	SOFC XII conference
2012	Italy	European Fuel Cell Forum
2013	Japan	SOFC XIII

4.3.6 Progress Summary

4.3.6.1 Overview

This Annex will build on the successful collaboration engendered during Annex XVIII and earlier SOFC annexes. The aim of this new annex, Annex 24, 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

The Operating Agent (Jari Kiviaho) prepared status reports on Annex 24 for the ExCo meetings.

4.3.6.3 Activities

The last meeting of Annex 24 was held in Vienna on October 4th 2009. There were 16 participants from 12 countries. Topics discussed included:

- How to organise Annex 24 work;
- Status of the US Solid state Energy Conversion Alliance (SECA) programme;
- Status of the Japan SOFC demonstration programme;
- EC Fuel Cells and Hydrogen Joint Undertaking - 1st and 2nd call;
- ECN decision to stop all SOFC activities.

The highlight of the meeting was the strong demonstration SOFC programme in Japan. During the program, 27 residential units were installed (2007) and 36 residential units were installed in 2008. All units were operating without serious problem.

Decisions were taken on the locations and timing of future workshops – see above for full list.

4.3.6.4 Technical Accomplishments

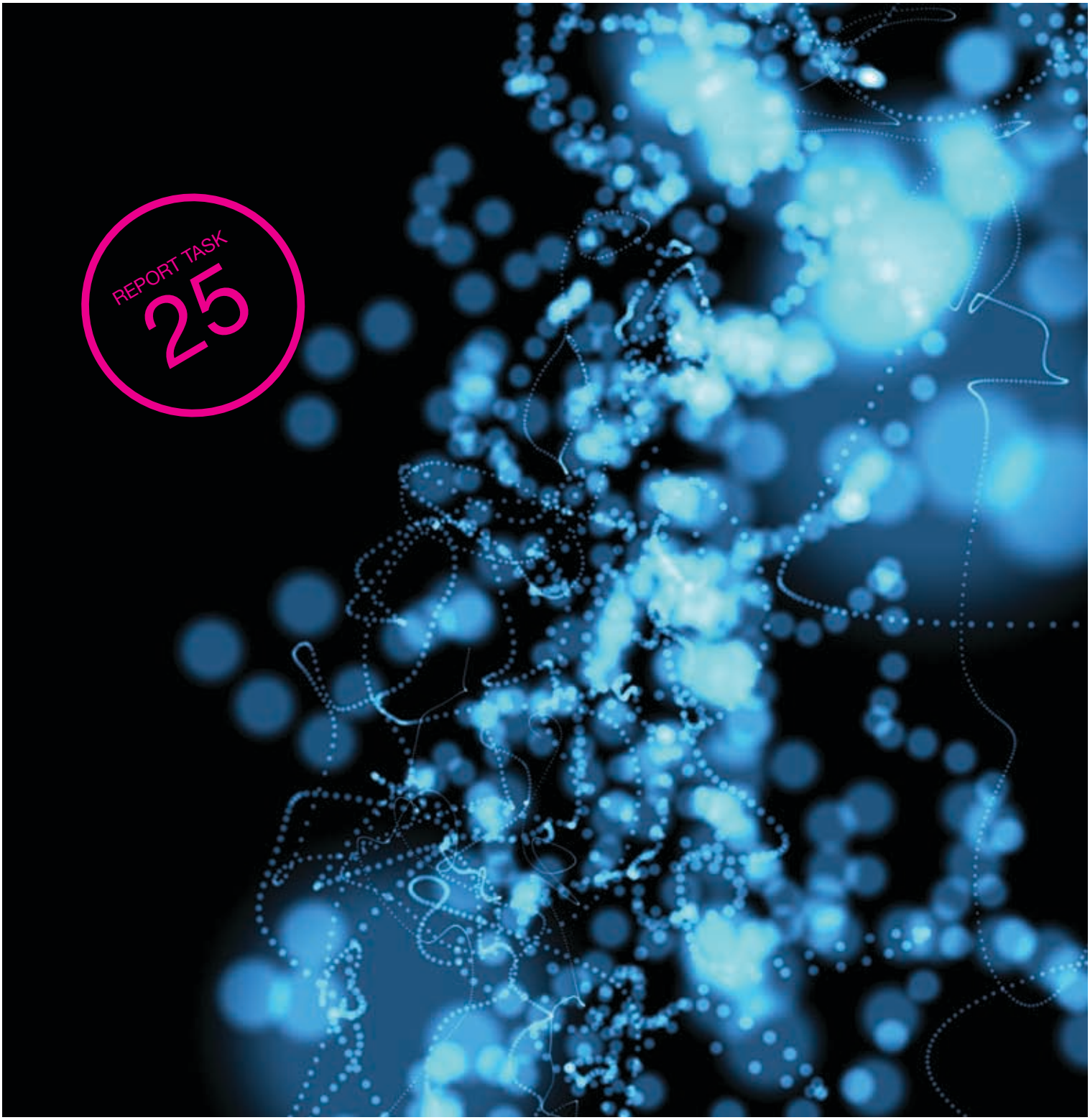
During the workshop, 15 presentations were made by experts from participating countries dealing with SOFC research, development and demonstration. The presentations showed that in the recent years a real progress has been made toward manufacturing and commercialisation of SOFCs.

4.3.6.5 Future Plans

In future, the main focus will be on the annual meetings. It was agreed that partners' motivation is necessary to move Annex 24 in the right direction and that support is needed from the ExCo Committee. Specifically, there must be orders based on needs, good instructions and templates and sufficient time to react.

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 objective of this task is to understand better how stationary fuel cell systems may be deployed in energy systems.

4.4 REPORT TASK 25

FUEL CELL SYSTEMS FOR STATIONARY APPLICATIONS

4.4.1 Duration

February 2009 until February 2014 (five years).

4.4.2 Operating Agent

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

4.4.3 Participants

The Contracting Parties, which are the Participants in Annex 25 are:

Austria	Austrian Energy Agency
Denmark	Haldor Topsoe
Finland	Technical Research Centre of Finland, VTT
Germany	MTU Onsite Energy and FZJ
Italy	Ente per le Nuove Tecnologie, l'Energia e l'Ambiente, ENEA
Japan	Technova
The Netherlands	Energieonderzoek Centrum Nederland ECN
Sweden	Grontmij
Switzerland	Thoma & Renz
USA	Sandia National Laboratories

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

4.4.4 Objective

The objective of Annex 25 is to understand better how stationary fuel cell systems may be deployed in energy systems. The work will focus the requirement from the market on fuel cells for stationary applications, both opportunities and obstacles that must be overcome will be investigated and discussed. The market development will be followed closely with a special focus on fuels, environment and competiveness.

4.4.5 Task Description

Subtask 1 Residential Fuel Cells

Subtask leader: Ulf Birnbaum, FZJ, Germany

Co-leader: Eneos Celltech, Japan

The main focus of this subtask is to evaluate conditions for the commercialisation of small residential fuel cells and examine fuel cells for use in larger residential buildings.

Subtask 2 Fuels for Fuel Cells

Subtask leader: Viviana Cigolotti of the ENEA, Italy.

This subtask will study the possibilities to use industrial surplus hydrogen as fuel.

Subtask 3 Fuel Cell Plants Components

Subtask leader: Rolf Rosenberg, VTT, Finland

This subtask will identify projects in which BoP components are developed and look at their approaches to what and how is developed and which the targets are. CHP and hybrid systems will be investigated. The technical requirements defined earlier in the task will be used a basis. Component developers will be approached to get their views on how realistic the cost estimates are and SOFC, MCFC and high temperature PEFC- systems will be addressed.

Subtask 4 Analysing design, operating and control strategies

Subtask leader: Whitney Collela, Sandia NL, USAThis subtask aims to identify optimal design, operating

and control strategies for fuel cells systems, CHP and trigeneration and hydrogen production. Annex 25 will follow the modelling work at Sandia and give feed-back.

Subtask 5 Follow up of demonstration projects

Subtask leader: Stephan Renz, Switzerland

This subtask will analyze demonstrations projects with the aim to study the real status of the technology. It will also analyse the different definitions of efficiency for energy conversion systems. Data and information about efficiencies of existing plants or systems (fuel cells, demonstration plants, competing technologies, the grid etc.) will be collected. The main differences will be explored and conclusions will be elaborated. Finally a common questionnaire will be developed for the analysis.

Subtask 6 Market status

Subtask leader: Bengt Ridell, Grontmij, Sweden

The aim of this subtask is to present and discuss the latest development in the area of stationary fuel cells for instance new technology break-through, major programmes, market development etc.

4.4.6 Progress Summary

4.4.6.1 Activities

The last Annex meeting was held on May 21st 2009 in Essen, Germany. Topics discussed included how to finalise the work in Annex XIX and decide which reports can be sent for publishing to the ExCo, and the new suggested subtasks in Annex 25 in the new Implementing Agreement.

The highlights of the meeting were the approval of reports from Subtasks 1 and 3, a presentation from Forschungszentrum Jülich on high temperature fuel cells in combination with gas turbines, and an impressive update from the stationary fuel cells programme in Japan.

4.4.7 Task Results

Subtask 1 Residential Fuel Cells

- The Callux project in Germany has started and 64 units have been installed: 30 SOFC and 34 PEFC. The total number in 2010 is expected to be 800 units. The vision is that the full commercial market in 2020 will have a volume of 72,000 units per year in Germany.
- In Annex 25 the conditions for that vision will be investigated and analysed.
- The new European Building Directive was presented and its influence on the fuel cell market was discussed. The heat demand will decrease significantly but the electricity demand will increase.
- The new European Building Directive was presented and its influence on the fuel cell market was discussed. The heat demand will decrease significantly but the electricity demand will increase.

Single family house with 121 qm living area*		
	Constructed 1990	Renovated 2010
Specific heat demand	170 kWh/m2	80 kWh/m2
Operation hours	1,800 h/a	1,800 h/a
Heat capacity	12 kW	6 kW
Boiler capacity	15,5 kW	(6 kW/0.92n) 6.5 kW

Subtask 2 Fuels for Fuel Cells

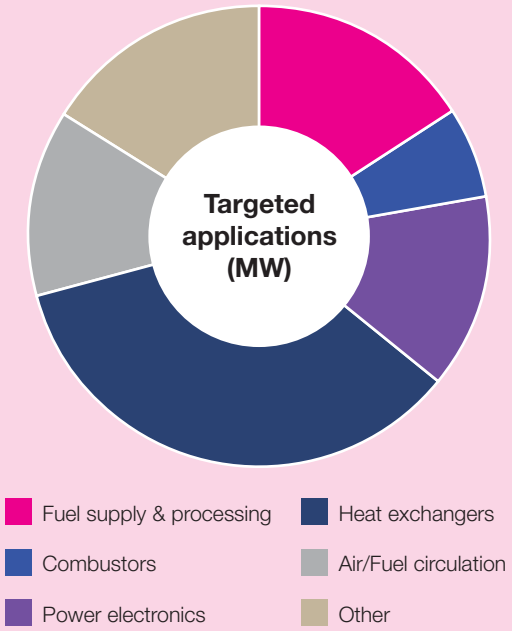
Current activities within Subtask 2 focus on:

- Renewable fuels.
- Fuel that do not compete with food production.

- Anaerobic digester plants.
- Waste from agriculture or food industry.
- Waste fuels other industries.

Figure 5 A fuel cell system in the brewing industry

Figure 6 Breakdown of costs of principal components and sub-systems for SOFC



Subtask 3 Fuel Cell Plants Components

The following findings were discussed during the Annex meeting:

- Balance of Plant (BOP) represents 50-67% of total cost and most failures occur in BOP components.
- There is a lack of dedicated components and few component developers.
- Components are too expensive and there is no incentive for lowering cost.
- Information about component requirements and the potential developers is needed.

Subtask 4 Analysing design, operating and control strategies

Combined cooling, heating and power (CHP) or tri-generative fuel cell systems (FCS) can convey electricity, recoverable heat, and chilled water and hydrogen as transport fuel to multiple buildings via networks, as shown in the Figure 7.

Subtask 5 Follow up of demonstration projects

No highlights to report.

Subtask 6 Market status

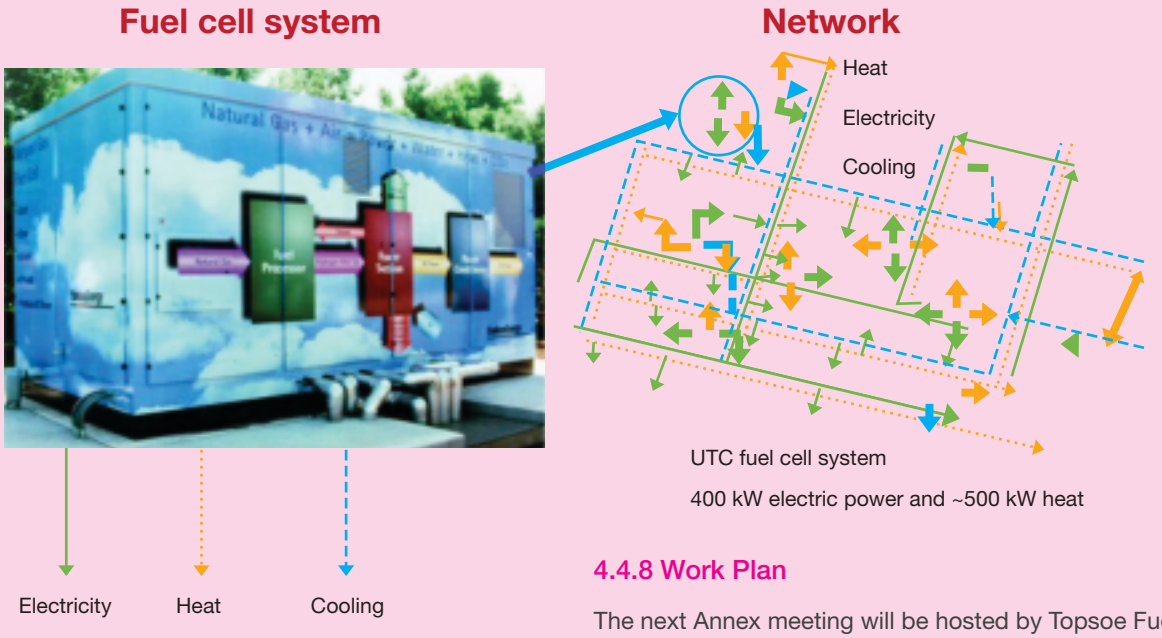
Highlights of subtask 6 include:

- The new company Dantherm Power owned by Ballard, Dantherm and Danfoss. was presented. There were sales of 400 x 2kWe systems on a commercial basis.
- EWZ presented a 240 kWe MCFC project in Zürich.
- Oliver Bücheli presented the latest news from HT-Ceramix and the new SOFC Power group in Italy.
- Wärtsilä, Finland presented their fuel cell programme.
- VTT Finland presented their SOFC programme. A special topic was the commissioning of a Versa Power 10 kWe power unit.
- Paul Scherrer Institute presented their fuel cell programme.
- ZHAW presented its modelling of the Hexis fuel cell.

Table 1 SOFC system component cost (Euros)

System cost	1500 €/kW	2000 €/kW	2500 €/kW	4000 €/kW
Fuel system	276	368	461	737
Air system	207	276	345	552
Automation & control.	161	215	269	430
Structural	151	202	252	404
Power conversion	120	159	199	319
Exhaust system	26	35	44	71
Purge system	22	29	36	57
Safety system	12	16	20	32
Start-up system	10	13	16	25
Assembly & testing	65	87	108	173
Stack	450	600	750	1200
Total	1500	2000	2500	4000

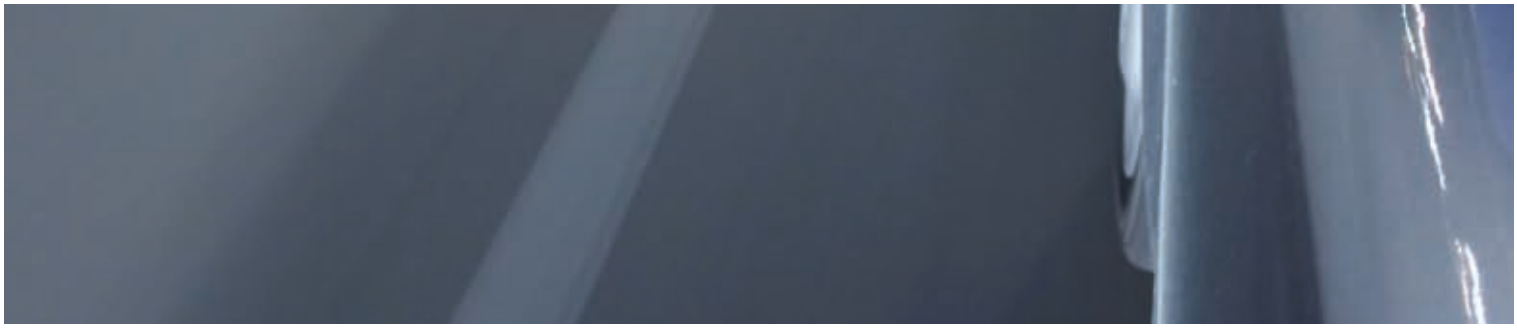
Figure 7 Tri-generative fuel cell system



4.4.8 Work Plan

The next Annex meeting will be hosted by Topsoe Fuel Cells in Denmark, October 2010. Part of this meeting will be held together with IEA Hydrogen Task 23 on Small Scale Reformers. The Spring meeting in 2011 will be hosted by WatersstofNet in Antwerp, Belgium.

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



4.5 REPORT TASK 26

FUEL CELL SYSTEMS FOR TRANSPORTATION

4.5.1 Duration

February 2009 until February 2014 (five years).

4.5.2 Operating Agent

ECN, Netherlands (previously Technical University of Berlin)

4.5.3 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.

4.5.4 Objective

The overall objective of Annex 26 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' organisations
- 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.

4.5.5 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.

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 and Annex XX that ran from 2004 to 2008.

4.5.6.2 Activities

No meetings were held during 2009.

4.5.6.3 Technical Accomplishments

No technical advances were seen during 2009.

4.5.7 Work Plan for Next Year

To be decided. The priority is to find a new Operating Agent for the Annex and then re-establish activities.

This annex is concerned with fuel cells and fuel cell systems for portable applications and light traction. Promising techniques for these applications are polymer electrolyte fuel cells operated with methanol or hydrogen.

4.6 REPORT TASK 27

PORTABLE FUEL CELLS

4.6.1 Duration

February 2009 until February 2014 (five years).

4.6.2 Operating Agent

Forschungszentrum Jülich GmbH, Germany

4.6.3 Participants

Agencies from nine countries participate in this Annex:

Canada	NRC
Germany	Fraunhofer Institut Chemische Technologien
Sweden	Intertek Semko
Austria	Technische Universität Graz
Korea	KIER
Japan	AIST
Germany	Forschungszentrum Jülich GmbH
Italy	CNR-ITAE
Austria	Technische Universität Graz

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

4.6.4 Objective

Annex 27 is concerned with fuel cells and fuel cell systems for portable applications and light traction. Promising techniques for these applications are polymer electrolyte fuel cells operated with methanol or hydrogen.

4.6.5 Task Description

Compared to batteries fuel cells offer advantages in powering portable and small mobile applications. The main advantage is the high power density of the fuel and the longer operating time of the device. Also the time that is necessary for recharging batteries is may be a problem that can be avoided by using fuel cells.

The direct methanol fuel cell (DMFC) that is often used in portable and small mobile devices offers the advantage of using a fuel with a volumetric energy density that is four times higher than the energy density of hydrogen at 350 bars. Yet the DMFC itself provides a much lower power density than the polymer fuel cell operated with hydrogen.

In most applications it is necessary to couple the fuel cell with a hybridization battery to cope with load peaks or energy recovery.

Key issues in developing MEAs are improving durability and performance. Also the operation at low air stoichiometry is necessary to achieve high operating temperatures and to close the water loop.

4.6.6 Progress Summary

4.6.6.1 Background

This annex follows on from Annex XXI on portable applications, which entered into force on April 1, 2004. As the market for portable applications is expected to be the first market for fuel cells. this annex focuses on the specific research demands and technical conditions for portable fuel cells.

4.6.6.2 Activities

The last Annex 27 meeting was held on September 1, 2009 in Graz, Austria. Countries who were in attendance are listed above.

At the meeting, the following topics were discussed:

- System, stack and cell development
- Lifetime enhancement
- System analysis and hybridization

The highlights of the meeting were as follows:

- DMFC-Scooter with >32 % efficiency (Japan)
- DMFC System as battery replacement in warehouse trucks (Germany)
- DMFC 2,300 h test of hydrocarbon MEA (Japan)
- DMFC -6.46 µV/h degradation rate after 4000 h operation (Korea)
- PEFC durability studies depending on operation conditions (Austria)

No decisions were taken at the meeting.

4.6.6.3 Technical Accomplishments

Stacks and systems for light traction

In this section, the activities in developing fuel cell systems in the range from 250 W up to several kW are shown. These systems are suitable for small mobile application respectively light traction.

DEVELOPMENT OF PEFC BICYCLE WITH ASSISTED PEDALING (ITAE; ITALY)

Max. power Output: 250 W

Voltage range: 13.2 V – 20.2 V UDC

H2 Consumption: 3.3 ln/min @ full load

Hydrogen pressure: 0.7 - 0.8 bar

Oxygen supply: air with ambient pressure

Cell number: 22 cells (31 cm^2 active area)

Hydrogen storage: solid state

Hydrogen capacity: 900 Sl @ 12 bar

DEVELOPMENT OF COMPACT HIGH EFFICIENT 1 KW DMFC STACK (YAMAHA; JAPAN)

Power density: 0.145 W/cm^2

Power density at maximum power output:

168 W/kg, 246 W/l

DEVELOPMENT OF DMFC SCOOTER (YAMAHA; JAPAN)

System efficiency: >32 %

Driving range: 125 km

Speed: 30 km/h

Fuel: methanol water solution (54 mass% methanol)

Hybridization: with battery

Durability: 1500 h

DEVELOPMENT OF PEMFC POWERED TRUCK (KANTO, TOKYO GAS, JFEC; JAPAN)

Fuel Cell System with 8 kW

Hydrogen storage at 35 MPa

Secondary battery

Total driving distance: 14.4 km

Total driving hours: 2.6

Total operation hours: 10.8

Hydrogen consumption rate (average): 1.66 Nm^3/h

Hydrogen consumption rate while driving: 3.12 Nm^3/h

DEVELOPMENT OF A DMFC SYSTEM AS BATTERY REPLACEMENT IN WAREHOUSE TRUCKS (FORSCHUNGSZENTRUM JÜLICH; GERMANY)

System power output: 7 kW peak; 0,8 kW average

Methanol consumption: ca. 1 l/h

Fuel: Pure methanol

Water autonomous up to 35 °C ambient temp.

Hybridization: with battery

DEVELOPMENT OF DMFC 800 W STACK FOR SCOOTERS (KIER; KOREA)

Specification: 2 sub-stacks (45 cells/sub-stack)

Active area: 102 X 151 mm^2

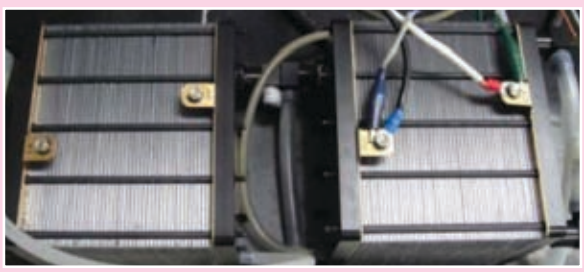
Cell pitch: 2.94 mm

Peak power: ~700 W/sub-stack

Normal power: ~500 W/sub-stack @ 18V

Dimensions: 120 X 190 X 175 mm^3 (4 l/sub stack)

Power density: 175 W/l



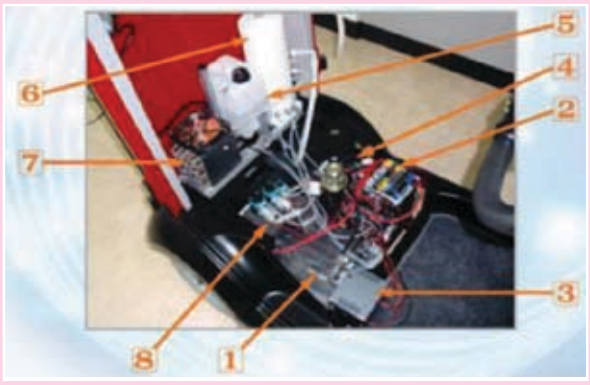
DEVELOPMENT OF DMFC SYSTEM FOR WHEEL CHAIR (KIER; KOREA)

Specification:

max. speed: 15 km/h

fuel cell: 500 W (750 Wpeak)

Lead acid battery



1: Stack (70 cells; 100 cm²; 500 Wnom)

2: Power converter

3: Air supply

4: Battery

5: Methanol tank

6: Fuel mixing tank

7: Heat exchanger

8: Fuel pump

STACK DEVELOPMENT PEFC 500 W (CNR-ITAE; ITALY)

Design, realization and test of a 500 W stack for medium temperature 120°C operating Stack, by using composite MEAs and a cell design totally developed and realized in CNR-IITAE labs.

2 Cells Stack

Working current: 50°

Voltage: 1.3-1.4 V

Rated Power - H2/air: 69 W

Rated Power with H2+100ppmCO/air: 66 W

Max Power in H2/aria: 88 W (80 A)

Max power in H2+100ppmCO/aria:74 W (80 A)

STACKS AND SYSTEMS FOR PORTABLES AND HANDHELDS

DEVELOPMENT OF FUEL CELL SYSTEM FOR RECHARGING PERSONAL HANDHELDS (MYFC; SWEDEN)

Fuel: Hydrogen

Prototype of charger: 2.5 W / 2.4 V

DEVELOPMENT OF FUEL CELL TECHNOLOGY TO REALIZE CORDLESS PERSONAL DEVICES (NEC JAPAN)

Targets:

- Development of thin /small stack (70W/L)
- Higher fuel efficiency 1.0Wh/cc by new fuel control method
- Reduction of Pt loading
- Solidification of fuel / fuel system (methanol?)
- Lower cost
- Higher safety
- Higher robustness

Development of a prototype FC pack of 30W/L for personal device as a result of the base technology development related to downsizing stacks

Specs:

Output: 3 W (max. 5 W)

Output voltage: 5 V (USB output terminal)

Energy: 10 Wh

External size: 110 mm x 45 mm x 20 mm

FIVE WATT CLASS DMFC STACK FOR CELLULAR PHONE (KIER; KOREA)

Max. power: 8.9 W (108.6 mW/cm^2),

Cell No: 6 (BP t = 1.5&1.2mm) (ED t = 1.5mm)

Active area: 82 cm^2 (13.68 cm^2 x 6 cells),

Stack size: 50*48*16.5 mm^3, 106g

MEA-development

Research and development of membrane electrolyte assemblies has included:

- Investigation of the conductivity of different reinforced membrane materials at 80 °C and 100 % humidity by CNR-ITAE in Italy.
- Development o dry powders for MEA preparation using the stencil method y NRC, Canada.
- Coating techniques for large scale production of MEAs by Forschungszentrum Jülich in Germany.
- Direct ethanol fuel cell MEA development by ICT Fraunhofer in Germany.
- Long term durability tests by Hitachi, Japan and Kier, Korea.
- In situe PEMFC membrane degradation studies by TU Graz, Austria.

Hybridization of fuel cell systems

Work in this area has included:

- Tests of battery systems for DMFC systems in material handling applications by Forschungszentrum Jülich, Germany.
- Development and testing of Lithium-Ion and Ni-MeH batteries at ICT Fraunhofer, Germany.
- Battery testing in an accredited test laboratory by Intertek, Sweden.

4.7.7 Work Plan for Next Year

During the last year a lot of development work has been done. The phase of testing the systems under real operating conditions has now started and the aims for further development of Annex 27 are as follows:

FC STACK / MEA

- Improvement the power density
- Improvement of MEA performances and durability, and better quality control to minimize performance variation among cells
- Reduction of the platinum-loading and improvement of bipolar plate manufacturing.

POWER GENERATION SYSTEM INCLUDING BOP, SECONDARY BATTERIES AND CONTROLS

- Maximization of the system efficiency
- Maintaining of the water balance in the system
- Detoxification of in the emission gas
- Assurance of reliability

PRODUCT DEVELOPMENT

- Better product concepts and quality assurance to exceed customers expectations / requirement
- Assurance of fuel quality and establishment of fuel-supply network
- Cost reduction

Appendix 1

MEMBERSHIP OF THE EXECUTIVE COMMITTEE

1.1 MEMBERS AND ALTERNATE MEMBERS

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1.2 OPERATING AGENTS

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No Operating Agent currently

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Appendix 2

EXECUTIVE COMMITTEE MEETINGS TO DATE

Meeting	Date	Place
1	April 2, 1990	Paris, France.
2	November 25, 1990	Phoenix, Arizona, USA.
3	June 27-28, 1991	Petten, The Netherlands
4	February 7, 1992	Makuhari, Japan
5	September 24-25, 1992	Malmo, Sweden
6	March 15, 1993	Rome, Italy
7	September 28, 1993	London, United Kingdom
8	March 15, 1994	Zürich, Switzerland.
9	October 11, 1994	Jülich, Germany
10	May 11-12, 1995	Oslo, Norway
11	September 18th, 1995	Loughborough, United Kingdom
12	February 1-2, 1996	Tokyo, Japan
13	September 17-18, 1996	Roskilde, Denmark
14	April 15-16, 1997	Vancouver, Canada
15	September 18-19, 1997	Amsterdam, The Netherlands
16	March 19-20, 1998	Santa Fe, USA
17	October 1-2, 1998	Melbourne, Australia
18	April 13-14, 1999	Jülich, Germany
19	September 20-21	1999, London, UK

Meeting	Date	Place
20	April 10-11, 2000	Malmö, Sweden
21	November 4, 2000	Portland, Oregon, USA
22	May 3-4, 2001	Capri, Italy
23	September 5-6, 2001	Basel, Switzerland
24	May 30-31, 2002	Paris, France
25	November 22-23, 2002	Palm Springs, California, USA
26	May 8	Espoo, Helsinki, Finland
27	October 23-24, 2003	Dusseldorf, Germany
28	April 1-2, 2004	Vienna, Austria
29	October 13-14, 2004	Seoul, Korea
30	April 28-29, 2005	Copenhagen, Denmark
31	November 18, 2005	Palm Springs, California, USA
32	April 20-21, 2006	Mol, Belgium
33	November 2-3, 2006	Oslo, Norway
34	April 19, 2007	Amsterdam, the Netherlands
35	October 19, 2007	San Antonio, Texas, USA
36	February 25-26, 2008	Tokyo, Japan
37	October 27, 2008	Phoenix, Arizona, USA
38	April 15, 2009	Istanbul, Turkey
39	November 26, 2009	Copenhagen, Denmark

Appendix 3 and 4

APPENDIX 3

TASK PROPOSALS UNDER CONSIDERATION

There are currently no task proposals under consideration as the six new Annexes were approved in 2009 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 39 Executive Committee Meetings since initiation (1990).
- Annual Reports 1990-2007.
- Draft strategic plan, January 2009.
- End of term report on the phase 2004-2008, October 2008.
- Contribution on the Advanced Fuel Cells Implementing Agreement for the 2003/2006 Implementing Agreement Highlights IEA publication (2006)
- Regular contributions on the Advanced Fuel Cells Implementing Agreement for the EUWP Status Reports on Transport related Implementing Agreements
- Strategy and Procedural Guidelines for the IEA Advanced Fuel Cells Programme, (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 in 2009.

5.1 TASK 22:

June 3-4, 2009, CEA, Grenoble, France
November 12-13, 2009, Argonne National Laboratory, Argonne, Illinois, USA

5.2 TASK 23: MOLTEN CARBONATE FUEL CELLS

July 9-10, 2009, University of Perugia, Italy

5.3 TASK 24: SOLID OXIDE FUEL CELLS

October 4, 2009, Vienna, Austria

5.4 TASK 25: FUEL CELL SYSTEMS FOR STATIONARY APPLICATIONS

March 26-27, 2009, Vienna, Austria
November 16, Palm Springs, USA

5.5 TASK 26: FUEL CELLS FOR TRANSPORTATION

No meetings held

5.6 TASK 27: FUEL CELLS FOR PORTABLE APPLICATIONS & LIGHT TRACTION

September 1, 2009 in Graz, Austria

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	Level 3: Unrestricted.		

6.1 TASK 22: POLYMER ELECTROLYTE FUEL CELLS

Level 3b reports, papers and abstracts:

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Reports (Level 2b)

- Status reports to Executive Committee, twice each year.

6.4 TASK 23: MOLTEN CARBONATE FUEL CELLS

6.4.1 Reports Published to Date

- Annual reports.
- Book on International Status of MCFC – see http://www.ieafuelcell.com/documents/MCFC_international_status.pdf.

6.1 TASK 24: SOLID OXIDE FUEL CELLS

- 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.
- Proceedings of the Workshop in Lucerne, Switzerland on June 30, 2008, by Olivier Bucheli (Editor), July 2007.

6.2 TASK 25: FUEL CELL SYSTEMS FOR STATIONARY APPLICATIONS

- Short report on fuels for fuel cells see http://www.ieafuelcell.com/documents/Adv_Fuel_Cells_Annex_XIX_Summary_rpt.pdf
- Minutes from Expert's meetings, Status Reports, two per year, and Annual Reports for Annex 25 and predecessor annexes.

6.5 TASK 26: FUEL CELL SYSTEMS FOR TRANSPORTATION

- Annual and status reports.

6.6 TASK 27: PORTABLE FUEL CELLS

- Annual and status reports.

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 22: POLYMER ELECTROLYTE FUEL CELLS

Expert	Organisation	Categorisation	Country
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		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
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

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

7.2 TASK 23: MOLTEN CARBONATE FUEL CELLS

Expert	Organisation	Categorisation	Country
OPERATING AGENT: TAE-HOON LIM, KIST, KOREA (R))			
Manfred M.Bischoff	MTU	I	Germany
Angelo Moreno	ENEA	G	Italy
B. Marcenaro	Ansaldo	I	
Yoshiyuki Izaki	CRIEPI	R	Japan
Y. Mugikura	IRD Fuel Cells A/S	R	Denmark
M. Yoshikawa	VTT Processes	R	Finland
Masaaki Tooi	IHI	I	
K. Tanimoto	AIST	R	
Tae-Hoon Lim	KIST	R	Korea
Jonghee Han		G	Japan
Sung-Pil Yoon			Mexico
Hee Chun Lim	KEPRI	R	
Joong Hwan Jun	RIST	I	
Hans Maru	FCE	I	USA
Mohammad Farooque		R	United States
D. Connor	GenCell	I	
Piotr Zelenay	Los Alamos National Laboratory	R	United States

7.3 TASK 24: SOLID OXIDE FUEL CELLS

Expert	Organisation	Categorisation	Country
OPERATING AGENT: JARI KIVALHO, VTT, FINLAND (R)			
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
Subhash Singhal	Pacific Northwest National Laboratory	R	USA

7.4 TASK 25: FUEL CELL SYSTEMS FOR STATIONARY APPLICATIONS

Expert	Organisation	Categorisation	Country
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

7.5 TASK 26: FUEL CELL SYSTEMS FOR TRANSPORTATION

No information available

7.6 TASK 27: PORTABLE FUEL CELLS

Expert	Organisation	Categorisation	Country
OPERATING AGENT: MARTIN MÜLLER, JUELICH RESEARCH CENTRE, GERMANY			
Ed Andrukaitis Adamson	Def. Research and Development	-	Canada
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