Annex 32: Solid Oxide Fuel Cells

Fuel cells and hydrogen have a potential for reducing emissions of greenhouse gases and air pollutants, facilitating the increased use of renewable energy sources, raising overall efficiencies of conversion. Thus a sustainable energy system becomes possible with zero or minimal impact on global climate. Solid oxide fuel cells (SOFCs) are considered an advantageous technology in energy production having many advantages over conventional power trains, such as combustion engines, including:

- High efficiency, especially at small scale
- Fuel flexibility
- Insignificant NO_x, SO_x and particulate emissions, reduced CO_2 emissions
- Silent and vibration-free operation

High operating temperatures make SOFCs well suited for combined heat and power production (CHP) or for hybrid systems where the SOFC stacks are coupled to a gas turbine. Fuel processor design is simplified compared to low temperature fuel cell types thanks to the possibility of direct oxidation of carbon monoxide and the use of hydrocarbon fuels via internal reforming reactions. SOFCs can be utilized for various applications with different power scales e.g. auxiliary power units for cars and trucks, residential combined heat and power production (CHP), distributed CHP or stationary power production. In particular, the most promising areas where pioneering companies and product development are looking at are:

- Mobile, military and strategic (< 1 kW)
- Auxiliary Power Units (APU) and back-up power (1 - 250 kW)
- Residential combined heat and power (1 - 5 kW)
- Stationary medium-large scale (20 kW - 10 MW)

Whereas record fuel efficiency is proven, long lifetime of fuel cell systems under real-life operation is a challenge for the durability of both fuel cell stacks and system components. Significant improvements in this respect have been achieved in the last 7 years: robust designs and more stable materials have been developed in laboratories worldwide, but these need to be engineered and assembled into end-use products with sometimes aggressive utilization profiles. This poses a challenge both to the fuel cell stacks as well as the other components of SOFC systems. An operating lifetime of at least 40 000 hours in the case of small-scale systems and even more for large-scale systems is required, which calls for better overall designs, given by real operational feedback. At the same time, investment costs related to the deployment of SOFC systems has to be decreased as much as possible in order to enable breakthrough on the commercial energy markets and thereby generate this operational experience.

When compared to established technologies for energy production, e.g. engines or gas turbines, widespread commercialization of the SOFC technology is hindered by a relatively

high cost of the SOFC-specific system components and limited availability of products, again due to the absence of developed markets and production.

Therefore, **reduction of cost**, **long lifetime** and **availability** are the high-level objectives for the SOFC technology in general, and for the AFC IA – Annex 32 in particular. These are prerequisites for a SOFC system for both stationary and micro CHP applications and the targets that the Annex wishes to clarify, bring closer and help the community to strike.

The inherent voltage degradation phenomena of SOFC stacks is the most important factor that affects the durability and lifetime of a SOFC system. For stationary applications, voltage degradation rates below 0.25 %/kh have to be achieved to ensure lifetimes long enough for the products. In addition to the SOFC stack, also the other components of the system, and the system as a whole, must endure years of continuous operation without unreasonable performance degradation or component failures. With the advent of large scale, standardized production of dedicated components and peripherals for SOFC systems, the lifetime and performance of system components can be better established, predicted and improved.

The means Annex 32 intends to employ to reach these overall objectives are:

- The continuation and intensification of the open information exchange to focus and accelerate the development of SOFC towards commercialization.
- The organisation of a series of annual workshops 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.
- Where possible, these workshops will be linked to other relevant conferences, in order to maximize scientific impact and minimise travelling costs. The workshops lead to open discussions relating to common problems and will be organized to have realizable and achievable aims.

Active partners of Annex 32 are Denmark, Finland, France, Germany, Italy, Japan, Korea, Sweden, Switzerland, United States and Netherlands.

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