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FUEL CELLS IN ITALY

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Introduction

Since the beginning of the seventies, scattered research activities on fuel cells were conducted in Italy producing a source of basic knowledge. In 1983 ENEA gathered all the potential operators (industries, utilities, users, research structures) into a working group aimed at verifying the feasibility of a national research and development (R&D) programme. The working group conducted a thorough evaluation of the potential benefits of FC technology in the Italian energy system; thus, in 1984 the 'Progetto VOLTA' was launched which established the guidelines for Italian activities in this field.

Starting from these guidelines, the Italian programme has been developed in the last five years: the up-to-date status is presented here.

Italian interests in fuel cells

The well known advantages of fuel cell plants (high efficiency, low polluting emissions, multi-fuel supply possibility) can fit the future needs of the Italian energy system: the strong dependence on imported fuels, mainly oil, is going to be reduced by saving energy and diversifying fuel sources. The growing energy demand in the densely populated urban areas could be better satisfied by dispersed-type power plants with acceptable environmental impact.

Market studies [1] allow quantification of the potential energy saving projected to 2010: according to a pure extrapolation of the present Italian energy scenario, 1 Mtoe/year could be saved. Introducing some hypotheses about the evolution of the energy scenario such as: (a) the government promotes industrial self-production of electricity by means of an adequate price policy, (b) FC plant cost is reduced to 700 $/kW, (c) combustion engine traffic is restricted in urban areas of historic interest, then the fuel

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cell potential market increases and the figure of energy saving in 2010 goes up to 3.5 Mtoe.

The estimated market is illustrated in Table 1, for the 'extrapolative' scenario and for the 'evolutive' scenario. Accordingly, fuel cell technology is going to be an attractive industrial business so that another goal of the Italian programme is to encourage national industries to enter this field.

TABLE 1

Potential Italian market of fuel cell systems in 2010 [1]

Application	Installed power (MW)	
	Extrapolative scenario	Evolutive scenario
Power plants (1 - 100 MW)		
Electric utilities	1500	2500
Industrial self-producers		6200
On-site generators (20 - 200 kW)	200	500
Small generators (1 - 10 kW)	100	200
Electric vehicles	2500	6000
Total	4300	15400

Italian R&D activities

Phosphoric acid FC

The world leaders (U.S.A. and Japanese manufacturers) have reached a quite satisfactory stage of development in phosphoric acid stack technology, so that it has been decided to cease competing in this field, except for very small generators. However, PAFC demonstration plants are very important in the national programme strategy, because they are essential to promote both the internal market and the industrial experience in building up fuel cell plants.

The main effort in this strategy is represented by the 1 MW PAFC power plant to be installed in Milan. The plant will be designed and built up by Ansaldo, then AEM (Milan Municipal Energy Authority) will take charge in the operational phase, scheduled for 1991.

The electrochemical section (two 670 kW fuel cell stacks) is supplied by the International Fuel Cell Co. (U.S.A.) and the methane reforming section by Haldor Topsøe (DK). The conceptional design activity is nearly completed and Ansaldo is approaching the detailed design phase. The work undertaken so far has permitted the acquisition of very useful experience

in the fuel cell system. Meanwhile, AEM is involved in the site preparation and licensing; all the relevant problems should be solved in a short time.

We are confident of a successful experiment for this first European FC power plant; this could be very favourable toward the commercialization of fuel cells.

Application of FC systems is on-site generation (20 - 200 kW) is very promising and should represent the first step in market penetration. Italy participates in the CEC 25 kW programme: one plant will be installed in 1990 and tested in Bologna at the city Municipal Energy Authority (ACOSER). The installation of a similar 25 kW plant, also constructed by KTI with Fuji cell stacks, is underway at ENEA Energy Research Center in Casaccia, near Rome. This prototype is a breadboard unit that will permit an extended characterization of the plant and its components.

An on-site demonstration programme is likely to be enhanced by testing one or more IFC 200 kW plants: some utilities are evaluating this opportunity.

The small portable generators programme, jointly established by ENEA and the Ministry of Defence, includes two different R&D aspects: (a) the cell stack development and (b) the system design, construction and test. The latter aspect is carried out by Ansaldo and Tecnars, and is aimed at manufacturing some compact generators of 1 and 5 kW equipped with cell stacks produced by a foreign supplier. Meanwhile, the Institute CNR-TAE of Messina is at an advanced stage in the development of a 1 kW stack entirely made with proprietary components and engineering. By now, the performance and endurance of monocells and 100 W stacks have been shown to be state-of-the-art. In a second phase of the programme, these two R&D aspects should be linked together to construct a portable generator equipped with the Italian stack.

Molten carbonate FC

A major goal of the Italian fuel cell programme is to develop molten carbonate FC stack technology, which is more promising than PAFC for several reasons (efficiency, cost, cogeneration capabilities, low sensitivity to fuel impurities).

In order to meet this goal the 'Progetto VOLTA' negotiated an international agreement with an experienced partner to acquire up-to-date knowhow and to carry out a joint development programme. Unfortunately, several problems have delayed this step, but we are very confident that a satisfactory collaboration will be arranged by the end of this year.

Notwithstanding, Italian activities in this field have grown considerably in the last five years, with contributions from industries and research centres.

Ansaldo have developed production techniques on a laboratory scale for both conventional and advanced components. Furthermore, Ansaldo bult and tested small cells up to 100 cm^2; performances were quite satisfactory and endurance tests lasted up to 2000 h. Studies of mechanisms of hot

corrosion for metallic components were carried out by Ansaldo in collaboration with the Politechnic of Milan.

CNR-TAE of Messina accumulated an overall 30 000 h of endurance tests of components in 100 cm^2 IGT monocells with emphasis on modeling and investigation of the behaviour in the lowest temperature range (600 - 650 °C). This work, coupled with in depth post-mortem analysis of all components, has clearly indicated that extended endurance under lower T conditions will outweigh inherent losses in power. A catalyst suitable for internal reforming has been developed and prepared for extensive in-cell experimentation.

CISE's activities have been focused on the development of novel cathodes through studies of the mechanisms of their dissolution under simulated conditions.

Part of the activities of Ansaldo, CNR-TAE and CISE are carried out within the framework of a CEC research programme in this field. The University of Genoa developed mathermatical models for components, cell and stack. ENEA used a three electrode cell in order to carry out the electrochemical characterization of components and small cells. The use of molten carbonate fuel cells in coal power plants was studied by CRITA, from both the technical and economic point of view, with reference to the Italian energy system.

All these activities have generated experiences which are very useful for the larger programme that is going to start shortly.

Solid polymer electrolyte FC

In consideration of the recent progress and the growing interest for this technology, an R&D programme was established in 1988 within the framework of cooperation between ENEA and De Nora. The goal of this programme is the construction and characterization of a 10 kW stack in 1990.

Solid oxide FC

Basic research activities on materials and fabrication techniques of components were carried out in the past by CISE and CNR-IRTEC (Ceramic Research Institute), in order to investigate the critical problems of this technology.

A larger project is starting now, in close connection with the CEC programmes in this field and with the objective of building and evaluating cells and small stacks. A variety of materials and fabrication procedures will be investigated in order to develop systems made by processes easily amenable to mass production and that at the same time guarantee as high efficiency and power density as possible.

The main organizations involved are CISE, ENEA, Eniricerche, Milano Ricerche and National Research Council (CNR, with its Institutes TAE, IRTEC and CSTE).

FC system for transportation

The application of fuel cell technology for transportation is very promising; an integrated programme in this field is under evaluation. It will include the complete development of both the fuel cell generator and the electric vehicle, involving users and diverse industrial expertise.

Costs and sources of financing

Table 2 reports the distribution of funds among the various activities of the Italian programme.

The main share of these funds is devoted to design, bulding and testing of the Milan 1 MW PAFC plant; the necessary 40 billion Lire (about 28.5

TABLE 2

Total funds in the Italian fuel cell programme (values in million Italian Lire)

	Appropriation of funds until 1988	Expenditures until 1988	Funds to be engaged in 1989 - 1992
Phosphoric acid FC			
1 MW demonstration plant	40625	2764	
Small transportable generators	7500	1610	1000
On-site generators	3980	600	2500
Molten carbonate FC	7482	4860	27000
Solid oxide FC	715	565	5000
Polymeric electrolyte FC	1972	220	2000
FC systems for transportation			4000
Market and application studies	682	540	1000
Total	62956	11159	42500

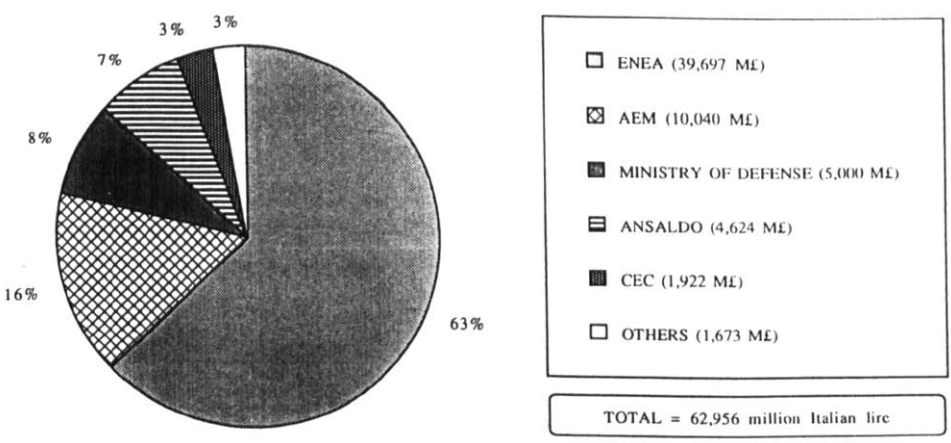

Fig. 1. Funds engaged until 1988.

million US$) are financed by ENEA (≈63%), AEM (≈25%), Ansaldo (≈10%), CEC (≈2%).

Another point to be emphasised is that future appropriation should mainly concern molten carbonate FC technology.

The distribution of all funds committed until 1988 among financial sources is shown in Fig. 1.

Reference

1 TESI, Institute Ricerche Breda, AEM, under ENEA contract.