Status of fuel cell R&D programme and perspectives for commercialization in Italy

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Abstract

In order to promote the development and commercialization of different fuel cell technologies a national programme, coordinated by ENEA, was begun in 1985, with the collaboration of industries, utilities and research facilities. In the framework of this programme, phosphoric acid fuel cell plants of different sizes and for different applications (from a few kW to 1 MW) will be built and tested; R&D activities are being carried out in the field of advanced fuel cells (molten carbonate, solid oxide, solid polymer) to develop cell and stack technology. The status of programme activities, together with the perspectives for commercialization in Italy, are presented and described.

Introduction

The potential advantages of fuel cells (high efficiency, low polluting emissions, easy co-generation, siting and fuel flexibility) make them very attractive for electric power generation in the Italian energy system. Market opportunities could be quite attractive in future in a variety of applications, such as dispersed-type power plants for electric utilities, industrial and residential co-generation, and electric transportation.

Fuel cells in the Italian energy system

The Italian energy system is heavily dependent on imported fuel, mainly oil. A reduction of this dependence, by saving energy and diversifying energy sources, has been established in the National Energy Plan, defined in 1988, after the referendum which decided against nuclear plants. Forecasts of different sources contributions for the years 1995 and 2000 are shown in Tables 1 (total energy supply) and 2 (electric energy production).

According to this plan, a considerable increase in coal and natural gas use is foreseen. The growing opposition to large coal plants, however, makes it difficult to extend the expected use of coal; therefore natural gas will play a more important role.

For power generation, which is state controlled by ENEL (the National Board for Electric Energy), the main targets are:

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TABLE 1

Prospects of total energy consumption in Italy

	1995		2000	
	Mtoe[a]	(%)	Mtoe[a]	(%)
Oil	87.5	(51)	81	(45)
Natural gas	42	(25)	50	(28)
Coal	22.5	(13)	29	(16)
Hydro-geo	12.5	(7.5)	14	(8)
Other sources	1.5	(1)	3	(1.5)
Elec. energy import	4	(2.5)	3	(1.5)
Total	170	(100)	180	(100)

[a]Mtoe: 10^6 ton oil equivalent.

TABLE 2

Prospects of electric energy production in Italy

	1995		2000	
	Mtoe[a]	(%)	Mtoe[a]	(%)
Oil	18.5	(29)	16.5	(22)
Natural gas	13	(20.5)	18	(24.5)
Coal	15	(23.5)	21	(28.5)
Hydro-geo & other sources	13	(20.5)	15.5	(21)
Elec. energy import	4	(6.5)	3	(4)
Total	63.5	(100)	74	(100)

[a]Mtoe: 10^6 ton oil equivalent.

- to reduce environmental impact
- to reduce dependence on oil
- to increase the contribution of industrial self-producers and municipal utilities

In this context, the development and commercialization of a new power generation technology, such as fuel cells, which are efficient and environmentally benign, is of great importance for the evolution of the Italian energy system.

The potential market in different applications has been estimated in the past and the results are described elsewhere [1]. According to these studies, the economically feasible market size could vary from a minimum value of 4000 MW to a maximum of 15 000 MW by the year 2010. Evolution of the Italian energy scenario in recent years seems to confirm the more optimistic figures reported in ref. 1.

In fact, new stringent emission standards and availability of a well-expanded natural gas network promote the introduction of dispersed type generators in the range 1–50 MW, located near end-users. In this hypothesis, fuel cell systems can fully benefit by their modularity, high efficiency, low environmental impact and co-generation possibility.

Therefore ENEL interest in fuel cells is rapidly increasing. A feasibility study for a phosphoric acid power plant (5–10 MW) has been made in cooperation with Ansaldo and a decision about the construction of a prototype plant is expected in the near

future. According to ENEL [2], in the Italian electric system fuel cell dispersed generators could be installed in the HV/MV transforming stations, providing electric power and heat for district heating inside urban areas.

The present Government's policy, in accordance with the National Energy Plan, supports the growth of municipal electric utilities and stimulates industries to self produce electric energy and to use co-generation. The prospects for fuel cells in this field look very promising, if they can compete with other technologies in terms of reliability and costs. In industrial co-generation, for instance, new plants to the extent of about 1500 MW will be installed before the year 2000.

The use of on-site fuel cell systems (25–1000 kW) in commercial and residential co-generation should represent the first step in market introduction in Italy. The increasing interest of potential users has recently induced Ansaldo to sign an agreement with International Fuel Cell Co. (IFC) for the production and commercialization of 200 kW plants.

Besides the stationary applications previously examined, special attention is devoted to the use of fuel cells in transportation. In fact, fuel cell powered vehicles could improve the efficiency of fossil fuel utilization and reduce air and noise pollution, particularly in urban areas. They represent an effective alternative to the internal combustion engine vehicles, with comparable performance, range and refueling time.

The potential market for fuel cell powered vehicles could be very large in the long term in Italy (almost half of the whole fuel cell market), particularly in applications like public transportation, delivery vans and forklift trucks. The need to reduce pollution in urban areas and new regulations, like the restriction of combustion engine traffic in the historical centres of cities, are encouraging the introduction of electric and hybrid vehicles. In this situation the interest in developing fuel cell systems for transportation is rapidly increasing both in industries (FIAT, Breda) and potential users.

Status of research and development programme

Phosphoric acid fuel cells (PAFC)

PAFC demonstration plants play a role of primary importance in promoting the introduction of fuel cell systems into the market place and in developing the industrial experience in the construction of fuel cell plants.

The main effort in this field is represented by the 1 MW PAFC power plant designed and built in Milan by Ansaldo, in the framework of a cooperation with Aem (Milan Municipal Energy Authority) and ENEA. The plant, installed inside the Milan urban area (Bicocca), uses fuel cell stacks supplied by IFC and a methane reforming system supplied by Haldor Topsøe. The design of the plant was begun by Ansaldo in 1988 and the site preparation and construction of the building in June 1990 by Aem; assembly of the plant, started last spring, will be completed by the end of the year. Process and control (PAC) tests will be carried out during the first half of 1992; then the fuel cell stack assemblies will be installed and the plant will go into operation, connected to the Aem network, by the end of 1992.

The experience gained by Ansaldo in designing and constructing the plant and the results that will be obtained by Aem during its operation are essential to prepare for the introduction of fuel cell plants into the Italian electric system.

In the field of on-site generation, three projects are being carried out in order to evaluate the performance and durability of the plants and to gain experience in their operation and maintenance.

A 25 kW plant, constructed by Kinetics Technology International with Fuji cell stacks, has been installed at ENEA Energy Research Center in Casaccia, near Rome; an extended evaluation of the plant and its components will be carried out beginning next autumn. At almost the same time, testing of a 50 kW plant, supplied to Eniricerche by Fuji and installed near Milan, will begin. A 200 kW IFC system, supplied by Ansaldo as part of an agreement with IFC, will be field tested in Bologna at the city Municipal Energy Authority (ACOSER), starting from 1992; the programme is conducted in cooperation with ENEA and the Commission of the European Communities (THERMIE programme).

Other projects in this field are likely to start in the near future: several users are evaluating the possibility of testing Fuji or IFC plants.

As far as small portable generators are concerned, an R&D programme, jointly established by ENEA and the Ministry of Defence, is being carried out with the participation of industries and research organizations. In this context, Ansaldo and Tecnars are working to design, construct and test compact 1 and 5 kW generators; the TAE Institute of CNR (National Research Council) (Messina) has developed and successfully tested (1990) a 1 kW stack, made entirely with proprietary components and engineering.

The PAFC projects previously described are summarized in Table 3.

Molten carbonate fuel cells

The features of molten carbonate fuel cells (efficiency, cost, co-generation capabilities, low sensitivity to fuel impurities) make them more promising than phosphoric acid ones for the Italian energy system. The aim of the programme in this field is the development of both stack technology and systems.

Research activities promoted by ENEA and carried out by industry (Ansaldo) and research organizations (Institutes of CNR, CISE, Universities) in the second half of the 1980s have generated experience in all the critical aspects of the technology.

Ansaldo has developed production techniques for components (tape casting scaled up to 900 cm^2) and has designed, constructed and tested cells and stacks (a 1 kW stack was tested in 1990), with satisfactory performance. An agreement has been recently signed with IFC to carry out a cooperative effort aimed at developing and demonstrating molten carbonate fuel cell power plants. The first step of this programme is the construction and testing of a 100 kW plant by 1994.

TABLE 3

Phosphoric acid fuel cell projects in Italy

Project	Organizations involved	Operation
1 MW	Aem, Ansaldo, ENEA, CEC	1992
200 kW IFC	Ansaldo, ACOSER, ENEA, CEC	1993
50 kW Fuji	Eniricerche	1991
25 kW KTI-Fuji	ENEA	1991
1–5 kW	Ansaldo, ENEA, CNR-TAE, Ministry of Defense, Tecnars	1990

The programme will be sponsored by ENEA and the Ministry of Industry. Besides Ansaldo, ENEA's laboratories (testing and characterization of components, cells and stacks) and Fabbricazioni Nucleari, a small company controlled by ENEA (fabrication of cell components), will take part in the activity.

To improve cell technology in terms of power density, life and cost, basic research activities on materials and components will continue, with the participation of public and private organizations and in cooperation with the Commission of the European Communities (JOULE programme).

Ginatta, another Italian industry, has recently started a project in the molten carbonate fuel cell field. On the basis of its experience in electrochemical plants working with molten salts, the aim of Ginatta is to build and operate a demonstration plant with internal methane reforming in the medium term. The project is financially supported by the Ministry of Industry, in the context of legislative measures for energy saving.

Solid oxide fuel cells

In consideration of the progress and the growing interest in this technology, an R&D programme was established by Eniricerche in 1989 with the aim of developing flat plate cells and constructing a 1 kW stack with internal methane reforming. At present, the main effort is devoted to developing processes for the production of ceramic powders and fabrication techniques for components. Collaborations with European partners in the framework of JOULE and BRITE programmes are planned.

Other research activities on materials and components are being carried out by the Institutes of CNR (TAE of Messina and CSTE of Pavia, in the JOULE programme) CISE and ENEA. Moreover, CNR-TAE is cooperating with the Institute of Electrochemistry of Sverdlovsk (USSR) and will test a 100 W stack supplied by this institute.

Solid polymer fuel cells and fuel cell systems for transportation

Recent progress in solid polymer fuel cells makes this technology very attractive for transportation applications. To develop cell and stack technology a cooperation was established in 1988 between ENEA and De Nora. At present, cells with Nafion and Dow membranes have been built and tested with very promising results; the design and construction of stacks is continuing, the goal being a 10 kW stack at the end of 1992.

Besides this development programme, ENEA is going to test a 4 kW stack supplied by Ballard under its hydrogen project.

Market and system studies indicate that, with future stringent emission standards, a hybrid system with solid polymer fuel cells and methanol fuel has the potential of becoming competitive with internal combustion engines. A great effort is required, however, to develop and demonstrate this new propulsion system for vehicular applications.

To this end, a three year programme, sponsored by ENEA and the Ministry of Industry, is starting now. The objectives are the development and laboratory testing of critical components (methanol reformer and stack) and power source system, the design of a system for automative applications and its integration with vehicle drivetrain components.

A second phase of the programme will include system optimization and building and testing of an experimental vehicle.

Conclusions

Fuel cells have a great potential for different applications (dispersed power plants, co-generation, transportation) in the Italian energy system. However, a considerable effort is required to develop the technology and bring it into the market place, in competition with other advanced systems.

For this purpose an extensive programme is being carried out in Italy, with the participation of public organizations, industries, users and research institutes and in cooperation with the Commission of the European Communities and international partners. In this framework, phosphoric acid fuel cell plants of different size and for different applications (from a few kW to 1 MW) will be built and tested; R&D activities are being carried out in the field of advanced fuel cells (molten carbonate, solid oxide, solid polymer) to develop cell and stack technology.

References

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