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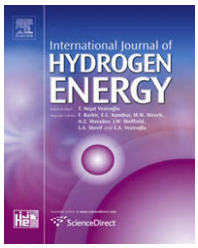

An integrated approach to hydrogen economy in Sicilian islands

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ARTICLE INFO

Article history:
Received 23 November 2007
Received in revised form
12 September 2008
Accepted 20 September 2008
Available online 25 November 2008

Keywords:
PEFC
Hybrid
Ships
Island
Communities
Renewable
Hydrogen
Fuel cell
Electric vehicle

ABSTRACT

CNR–ITAE is developing several hydrogen and fuel cell demonstration and research projects, each intended to be part of a larger strategy for hydrogen communities settling in small Sicilian islands. These projects involve vehicle design, hydrogen production from renewable energy sources and methane, as well as implementation strategies to develop a hydrogen and renewable energy economy. These zero emission lightweight vehicles feature regenerative braking and advanced power electronics to increase efficiency. Moreover, to achieve a very easy-to-use technology, a very simple interface between driver and the system is under development, including fault-recovery strategies and GPS positioning for car-rental fleets. Also marine applications have been included, with tests on PEFC applied on passenger ships and luxury yacht as power system for on-board loads. In marine application, it is under study also an electrolysis hydrogen generator system using seawater as hydrogen carrier. For stationary and automotive applications, the project includes a hydrogen refuelling station powered by renewable energy (wind or/and solar) and test on fuel processors fed with methane, in order to make the power generation self-sufficient, as well as to test the technology and increase public awareness toward clean energy sources.

1. Introduction

The forecast growth in fuel consumption by road transport has been identified as a major policy challenge in the European Union (EU) [1]. This can be explained by concerns about fuel consumption-related emissions of greenhouses gases (GHGs) and the increasing dependence on imported oil [2]. In this context, it is generally agreed that actions are needed to curb GHG emissions [3,4]. Thus, strong interest has arisen in the last decade for fuel cell-powered vehicles. Also marine application may benefit from this technology and further research and testing are needed to assess its potential. Polymer electrolyte fuel cells (PEFCs) are very promising power sources for future residential, mobile and automobile applications [5–7,23]. They are actually considered as well one of the best solution for automotive applications. This is due to criteria related to large flexibility, fast start-up [8], small dimensions and high efficiency [9].

2. The Sicilan islands scenario

In recent years minor islands have attracted major attention, with several European and national programs addressed to

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doi:10.1016/j.ijhydene.2008.09.107

Fig. 1 – Sicilian islands layout.

the development and protection of these areas. Minor Sicilian islands, recently acknowledged as mankind heritage, include large portions of protected areas; thus, they represent a good opportunity for sustainable development solutions [10].

The 14 Sicilian islands (Fig. 1), organized in eight municipalities, extend from 3 to 38 km^2, with a significant height above sea level (refer Table 1). Often, during wintertime, they remain isolated due to atmospheric and sea conditions. Main supplies, such as potable water and fuel, are provided by bulk carriers from the mainland, excepting some islands where potable water is produced by desalination of seawater. Power is locally produced by diesel generators connected to the local grid. The main human activities are agriculture, with valuable typical products, fishing and tourism. Although tourism infrastructures are not everywhere adequate, population grows roughly 5 times during summer holidays.

Vehicles are generally not allowed during summer for non-residents. However, the most used transportation system is gasoline cars or smoky and noisy two/four strokes small vehicles. Furthermore, during tourist season, several ships and motorboats fill the coastline and the small ports in the islands. In order to preserve the marine environment it is strongly desirable equipping ships with environment-friendly engines and propellers.

3. Microcar design

In small islands, the main use of vehicles includes rent cars for tourists, taxi and shuttle service, with no particular requirements in terms of top speed and a very limited average speed. Despite that, these vehicles must be able to overcome steep slopes even at full load, and should be noiseless and smokeless [11].

The electric traction, today based on conventional batteries, is currently preferred from an environmental point of view, but it has strong limitations due to short operating range and long recharging time [12]. A disadvantage of current electric vehicle technologies is that the energy supply required to power the vehicle needs to be stored as electricity on board the vehicle. The batteries that are needed for this purpose are expensive, have a limited cycle lifetime and a limited energy storage capacity. The range of an electric vehicle is therefore much shorter compared to vehicles fuelled with gasoline or diesel. Although several models of battery-powered light vehicles are commercially available, most of them are not suitable for these applications. Very steep slopes require a high torque motor (or a motor coupled with a reduction gearbox) and a large amount of energy stored on board. In case of battery-powered vehicles, this would require a large number of batteries installed on-board with serious limitations in terms of weight and volume. The increased weight would dramatically reduce acceleration performance of the vehicle as well as increase the need of an oversized braking system. On-board storage capacity for goods or luggage would be also sacrificed. Moreover, battery disposal would rapidly become a problem without an adequate and efficient policy of waste battery management. Recharge is another critical issue

Table 1 – Area and height above sea level of minor Sicilian islands

Island	Municipality	District	Area, km^2	Height (min–max), m
Lampedusa	Lampedusa e Linosa	AG	20.2	0–193
Linosa and Lampione			5.3 and 1.2	0–195
Lipari	Lipari	ME	37.6	0–924
Vulcano			21	0–500
Stromboli and Strombolicchio			12.6	0–926
Filicudi			9.5	0–775
Alicudi			5.2	0–675
Panarea and surrounding rocks			3.3	0–421
Salina	S. Marina di Salina	ME	27	0–962
	Malfa			0–860
	Leni			0–962
Ustica	Ustica	PA	8.65	0–248
Favignana	Favignana	TP	19	0–686
Marettimo			12	0–984
Levanzo			10	0–278
Pantelleria	Pantelleria	TP	83	0–836