Available online at www.sciencedirect.com

ScienceDirect

Energy Procedia 143 (2017) 39–46

Energy Procedia

www.elsevier.com/locate/procedia

World Engineers Summit – Applied Energy Symposium & Forum: Low Carbon Cities & Urban Energy Joint Conference, WES-CUE 2017, 19–21 July 2017, Singapore

Development of a multi-purpose infrastructure for sustainable mobility. A case study in a smart cities application

G. Dispenza[a], V. Antonucci[a]*, F. Sergi[a], G. Napoli[a], L. Andaloro[a]*

[a]*Institute of Advanced Energy Technologies "Nicola Giordano", National Research Council of Italy, Salita S. Lucia sopra Contesse, 5, Messina, Italy*

Abstract

Research in smart cities is characterised by different needs: decrease of polluting emissions, improvement of energy efficiency, optimization of production and consumption of energy are the main action required. According to the last European directives, alternative fuels can play a fundamental role in the future of transportation [1]. In the framework of an Italian research project, called i-NEXT (innovation for greeN Energy and eXchange in Trasportation), CNR-ITAE has developed a microgrid able to receive, as input, the solar energy and to deliver, as output, hydrogen and electricity for electric and hydrogen vehicles [2-6]. A 100 kW photovoltaic plant, installed on the roof of a shed for vehicles recovering, represents the energy source. An electrochemical energy storage of 100 kW and 300 kWh, equipped with 16 sodium nickel chloride high temperature batteries, balances the energy production from PV plant in order to guarantee the energy self-sufficiency of the whole system. Electricity produced supplies both an on-site hydrogen production (by electrolysis), compression and distribution system and an electric charging station needed for Electric Vehicles (EV), Fuel Cell Electric Vehicle (FCEV) and Fuel Cell Hybrid Electric Vehicle (FCHEV). The hydrogen produced supplies two FCE bikes and a FCHE minibus developed in the framework of the project while a last mile delivery van (EV) is fed through a fast charging station. An ICT platform allows to monitor, control and connect plants and vehicles in order to manage energy flows, fault and warning events. The paper reports the results of the research activities regarding both infrastructures and vehicles development.

Peer-review under responsibility of the scientific committee of the World Engineers Summit – Applied Energy Symposium & Forum: Low Carbon Cities & Urban Energy Joint Conference.

Keywords: Smart vehicles, Smart grid, Hydrogen, Energy storage system

* Corresponding author. Tel.: +39 090 624234; fax: +39 090 624247.
E-mail address: vincenzo.antonucci@itae.cnr.it

1876-6102
Peer-review under responsibility of the scientific committee of the World Engineers Summit – Applied Energy Symposium & Forum: Low Carbon Cities & Urban Energy Joint Conference.
10.1016/j.egypro.2017.12.645

1. Introduction

A key issue for achieving the EU climate change objectives [7] but also to contribute to its innovation, jobs and growth agenda is to accelerate the development and deployment of cost-effective low-carbon technologies.
This is the main aim of the EC Strategic Energy Technology Plan [8] (SET-Plan) that, in the short term (2020), foresees the use in Member States of low-carbon technologies available today or in the final stages of development, lowering their costs and improving performance as well as promoting pro-active support measures [9].

Smart city definition is not univocal and often refers to the use of information and communication technology (ICT) in different sectors: infrastructure, transport and logistics, energy and security. According to Giffinger et al. [10] 'a Smart City is a city well performing in a forward-looking way in six characteristics (Smart Economy, People, Governance, Mobility, Environment, Smart Living), built on the ''smart'' combination of endowments and activities of self-decisive, independent and aware citizens'.

Focusing attention on urban transport sector, information accuracy and decision-making speed are of paramount importance in managing today's mobility of goods and people inside the city. Intelligent Transport Systems (ITS) can provide road users with updated information and forecasts on both traffic and weather conditions. The result is a higher efficiency in the use of resources and a better management of physical flows [11]. Moreover electric and hybrid electric vehicles can contribute to the realization of more sustainable mobility systems for smart city. In this context the i-NEXT project represents the first initiative developed in Sicily in the smart city sector; the aim of the project is to realize a easily adaptable platform able to be replicated and improved in other cities also.

Nomenclature

EV	Electric Vehicles	HPPM	Hydrogen Production and Purification Section
FC	Fuel	HSM	Hydrogen Storage Section
FCEV	Fuel Cell Electric Vehicle	HRM	Hydrogen Refueling Section
FCHEV	Fuel Cell Hybrid Electric Vehicle	CPP	Critical Peak Pricing
PV	Photovoltaic	DSO	Distribution System Operator
BESS	Battery Energy Storage System	EMS	Energy Management System
ITS	Intelligent Transport System	PCC	Point of Common Coupling (Interface of the micro-energy district to the power grid)
ICT	Information Communication Technology		
HCM	Hydrogen Compression Section	SDs	Smart Devices

2. The Smart City platform

The smart city platform, realized within the i-NEXT project in the Capo d'Orlando municipality (Sicily-Italy), proposes to introduce and integrate new technologies in urban context with the aim to improve mobility services for citizens that are final users. The energetic independence of the platform is a fundamental element taken in to account during design and size phases of the plants, so a micro-grid dedicated to the platform is realized. With this aim, in order to reduce as much as possible the amount of energy from national electric grid, a photovoltaic (PV) plant, linked with a battery energy storage system (BESS), is realized. The BESS role is to offset uncertainty and unpredictability of solar renewable energy. The smart city platform is shown in figure 1. Solar energy coming from PV and energy stored in BESS is enough to fed electrolyser, compressor and recharge infrastructures for vehicles (EV, FCEV and FCHEV) developed in the same project. In order to meet the different needs of urban mobility three kinds of vehicle are developed: a fuel cell hybrid electric minibus for urban transport of people, two fuel cell bikes for bike sharing service in tourism sector and finally an electric delivery van for distribution of goods in last mile.

The amount of hydrogen produced by electrolysis is compatible with daily consumption of minibus and bikes so the whole smart city platform is able to guarantee mobility services by using self-production of energy. Production and use of energy (supply and demand) are managed and controlled by using an ICT platform implemented for this specific application. Logic of platform operating uses an algorithm that optimizes the self-consumption and the production of hydrogen when solar source is available.