

# Sustainable Mobility Models for the Island of Ventotene

F. Calenne, G. Fabbri, F. M. F. Mascioli, S. Valentini

POMOS - Pole for Sustainable Mobility  
INFOCOM Department – “Sapienza” University of Rome  
Via Eudossiana 18, 00184, Rome, Italy  
e-mail: gianluca.fabbri@uniroma1.it

## ABSTRACT

This paper illustrates the first results of the Phase 2 of the “Ventotene Zero Emission Island” program aimed at supporting the integration of Renewable Energy Sources (RES) as well as Sustainable Mobility actions on the small island of Ventotene in Italy. An experimental Automatic Vehicle Location and Monitoring system was developed and implemented in order to study and analyze advanced methods of transport information and management. Detailed description of the whole system and infrastructures and of the main results is provided.

**Keywords:** Sustainable Mobility, Fleet Management, Automatic Vehicle Monitoring and Location System.

## 1. INTRODUCTION

New transport technologies currently offer a wide selection of low-impact solutions with regard to emissions and noises. Hybrid and electric powered vehicles have the potential to enrich islands’ tourist resorts and cities in the future [1]-[2]. These technologies will reach their maximum efficiency in combination with advanced methods of transport information and management and with the use of RES [3]-[4]. Initiatives that could be completed by effective traffic restraint and integration of the different forms of transport, favouring pedestrian areas, primacy of public transport and incentives for the inhabitants to buy electric cars [5]-[6]. Cars, and the automotive sector in general, consume almost half of the world petroleum production and are one of the main direct causes of the urban pollution. Various options are being used around the world to reduce this problem: reduction of the use of private vehicles in urban areas, increasing efficiency to reduce consumption, use of new energy systems such as Fuel Cells or Electric Vehicles (EVs) and their integration with RES. The use of EVs can contribute significantly to the reduction of the environmental pollution in 21st century. Despite the history of EVs being as old as the internal combustion engines, the recent technological evolution can make the electric transport competitive with respect to conventional transport. Nevertheless, an effort should be made by the

industry and governments to protect the environment, through economical incentives to develop and acquire EVs. In this paper we will describe the first results of the second phase of a project developed on the island of Ventotene in Italy. The main purpose of this project is to study pathways that lead to sustainable energy systems for the island. The project looks into several aspects such as renewable energy penetration, efficient energy use, clean transportation options, monitoring and fleet management. The identified objectives were divided into two phases:

*Phase 1: Energy saving and rational use of energy, energy production based on renewable sources (installation of photovoltaic plants);*

*Phase 2: Sustainable Mobility actions (implementation of a local sustainable mobility programme).*

Phase 2 was developed by the Pole for Sustainable Mobility (POMOS) and some of the results of the first 3 months experimental period are presented in this work. The main goals of Phase 2 were to implement sustainable mobility models on the island through the introduction and development of the following systems:

1. *An Electric Vehicles fleet;*
2. *Experimental on board systems for the telemetry and the control of the vehicles;*
3. *An environmental monitoring system;*
4. *A Wireless communication system;*
5. *Intelligent charging systems.*

The project kicked-off on July 2009 and the installation of the main infrastructures and the arrival on the island of the first electric vehicles to be used by the Municipality started on that date. The project aims to develop and test an Automatic Vehicle Monitoring and Location System in order to determine geographic positioning and provide information about the vehicles and transmitting them to a remotely located server. Automatic Vehicle Monitoring (AVM) and Automatic Vehicle Location (AVL) systems are an electronic means of gathering data and performing commands and control over a land vehicle fleet [7]. While data on vehicle location are required for effective control, such systems are totally dependent upon reliable dedicated communications systems. *Figure 1* illustrates

the general architecture of the system. The vehicle's location is determined using GPS; after collecting positioning and monitoring data, these are transmitted using a wireless communications systems.

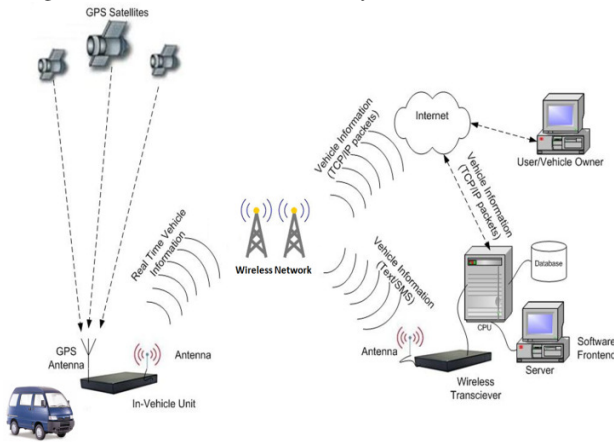


Figure 1: Automatic Vehicle Location and Monitoring system architecture.

The design and implementation of the system includes acquisition and transmission of a vehicle's location information along with on board apparatus status information to the monitoring server. Additionally, the system also provides a web based interface to display all transmitted information to the end user along with the location of the vehicle on a map. All the information is available to authorized users of the system via a website on the internet.

## 2. THE ISLAND OF VENTOTENE

The island of Ventotene is located in the Tyrrhenian Sea, and is part of the Pontine Islands, Italy (see Figure 2). The area of the island is 1.247 km<sup>2</sup> with a maximum length of 2.7 km and a maximum width of about 800 m. The weather is typically Mediterranean, with high temperatures in the summer time and mild winters [8]. The island has about 700 permanent residents inhabitants. During summertime, this number increases up to about 2500 due to the fact that many tourists each year choose the island as the venue for their holidays, thus resulting in a considerable increase in energy and mobility needs. The island is not connected to the electric grid on the mainland, and electricity is locally produced by means of a diesel power plant, with a considerable impact on the environment (i.e. pollutant emissions, noise and oil transport) and high generation costs [9]. Due to this reason, the Municipality of Ventotene participated in a project named "Ventotene Zero Emission Island" and financed by the Municipality of Lazio Regional Government aimed at supporting the integration of RES as well as Sustainable Mobility actions on the island. Through the activities planned in *Phase 2* of the project, POMOS wants to stimulate the penetration of Sustainable Mobility Models by means of pilot demonstrations performed with the help of local administrations, trying to

improve the citizens trust by increasing the number of electric vehicles and creating the system infrastructures.

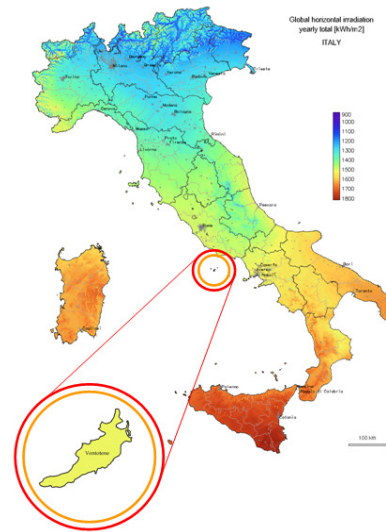


Figure 2: The island of Ventotene in Italy.

## 3. DESCRIPTION OF THE ACTIVITIES

### Electric vehicles fleet.

Due to the limited energy densities of the current commercially available battery packs, the performance of EVs are restrained as neighborhood vehicles, with limitations in terms of low speed, short battery life, and heavy battery packs. The island of Ventotene represents an ideal location to use and experiment EVs. The first activity was add seven 100% electric vans to Municipal fleet. These are commercial Porter Piaggios using a pure electric drive train which only consumes electric energy. The Van (see Figure 3) uses a 10.5 kW electric motor and uses 14 heavy-duty lead-acid battery packs (6V-180A) as sources of energy.

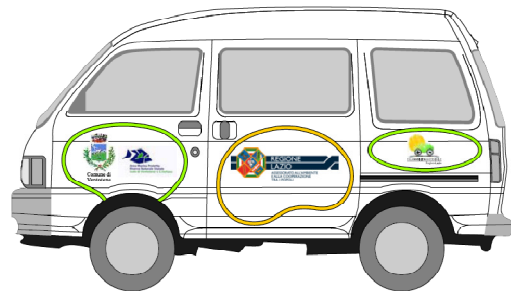


Figure 3: The Piaggio electric van to be used by the Municipality of the Island.

Two on-board battery chargers (high-frequency with control microprocessors) make it possible to recharge the batteries in 8 hours (10A - 200/230V - 50Hz) ; a fast 2 hours recharge is also possible using an external battery charger. Even though they are the auto industry's prime batteries, lead-acid (PbA) batteries are out of favour for EVs applications, because of their low energy density. In comparison, the nickel-metal hydride (Ni-MH) battery is preferred, because of its higher energy density, shorter

charging time, and long life cycle, but it has an immature recycling system. The lithium-ion (Li-Ion) battery chemistry is considered as a definite future trend, but compared to the other 2 candidates, it has lower durability, which is an issue that needs to be focused upon. Different battery chemistries and their typical charging times are summarized in *Table 1*.

Battery	PbA	Ni-MH	Li-Ion	Unit
Charging Time	8 - 10	6 - 14	5 - 7	Hours
Energy Density	60	80	180	Wh/kg

Table 1. Typical charging time and energy density of popular battery candidate for EVs.

The van can be used in two different driving modes, fast and economic, and it can reach a maximum speed of 57/52 kmph according to the selected mode. It has an autonomy of 110/137 km in suburban roads and of 90/112 km on city roads depending on the driving mode. To completely charge the battery pack 18.4 kWh are needed. The maximum slope gradient is 18%. The vans will be mainly used during the touristic season (May-September) for transportations from the port to the centre of the island with an estimated average of 15 daily kilometers traveled on the island for each vehicle. The vans will be also used to test the on board systems. Moreover a selection of other commercial electric and hybrid vehicles and prototypes developed by POMOS will be also tested on the island as well as the use of different kind of batteries.



Figure 3: Main mask of the realized multimedia software.

### On board system.

The fleet was equipped with on board telemetric device to locate the vehicles, and send that data over a wireless network. Direct connection of the device to the vehicle diagnostic bus can allows the automatic collection of vehicle performance data to support preventive maintenance. The on board system also includes a PC with a touch screen that is used to show data and information. A multimedia software was developed to provide to the drivers and the travelers with a series of audio and video messages according to the position of the vehicle. *Figure 3* shows the main mask of the multimedia software. The system calculates the real-time location of any vehicle, then data are transmitted to a central server

situated in the City Hall building and can be used immediately for daily operations and archived for further analysis too.

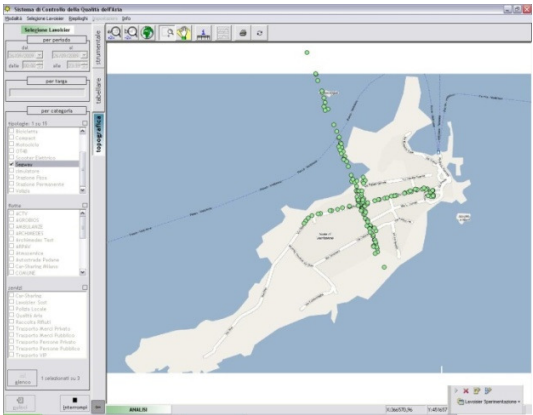


Figure 4: Location of a vehicle moving on the island.

Figure 4 shows the real time graphical location of a vehicle moving on the 2 main roads of the island. The system can be used to monitor on-time performance and can be used for service planning, safety and security, traveler information and entertainment, vehicle component monitoring, and data collection.

### Environmental monitoring system.

The use of a compact air pollution analyzer was planned for environmental monitoring. The analyzer has an air quality sensors module for several kind of gaseous pollutants (CO, NO2, SO2, O3). It can be easily installed either on outdoor fixed emplacements or onboard of any kind of mobile vehicle (car, van, scooter, bicycle, segway) and operated both as a kinematic and static units to create an air quality monitoring control network. The air pollution analyzer is made to operate under software control by an external controller unit dealing with satellite positioning and data transmission to a remote control centre. Data are sent to the server and displayed and analyzed using a software tool. Results of the measurements can be displayed and monitored using the tool a shown in *Figure 5*.

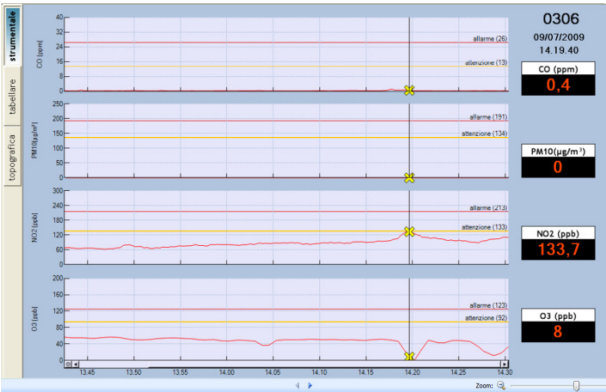


Figure 5: Measurements of gaseous pollutants.

### Wireless communication system.

An outdoor Wireless Mesh Network (WMN) was designed and created to cover most of the territory of the island. WMNs are dynamically self-organized and self-configured, with the nodes in the network automatically establishing an ad hoc network and maintaining the mesh connectivity. They have many advantages such as low up-front cost, easy network maintenance, robustness, reliable service coverage, etc [10]. Therefore, in addition to being widely accepted in the traditional application sectors of ad hoc networks, WMNs are undergoing rapid commercialization in many other application scenarios such as broadband home networking, building automation, high speed metropolitan area networks, community networking and enterprise networking, small islands networks. The network is set up by a “mesh” composed of various devices, operating as Network Universal Gateway and Network Universal Patcher, which creates an optimal coverage. The result is the creation of a digital ecosystem that, while fully covering the area of the touristic port and of the center of the island, can also reach nearby areas. The installation of additional devices on other selected sites extends and optimizes the wireless coverage. The geographical mesh network is illustrated in Figure 6.

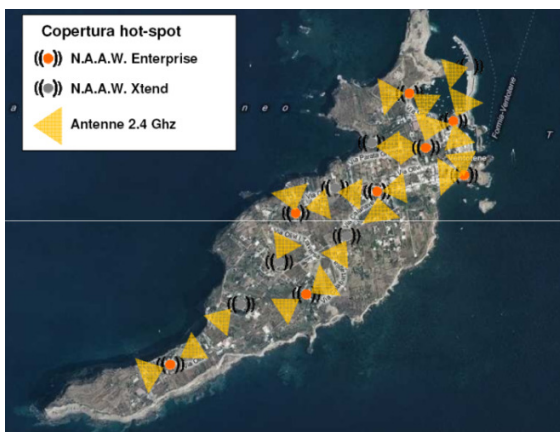


Figure 6: Geographical mesh network.

The image shows the coverage of the wireless network on the island and the strategic sites where the devices have been installed. Two kinds of devices were installed for the local coverage, the hot spot service and the link towards other nodes: the NAAW Enterprise and the NAAW Extend. The network automatically extends itself simply by adding new devices and auto-configures itself in real time: thanks to this solution each individual network user acts as a node contributing in improving the overall service, contrary to what happens in traditional networks. It is also possible to provide a new way to make requests for traditional touristic services with this wireless network. Users connecting with their laptop can access a special portal where they can select the desired services. The access portal can also be used to promote commercial activities on the island using promotional spaces. The system will be also used for video surveillance of specific

areas of the island using wireless video cameras that can be installed to monitor the areas transmitting images to the video surveillance network.

### Intelligent Networked Charging Infrastructure for EVs.

Charging stations will be installed at selected sites on the island to create a small Intelligent Networked Charging Infrastructure for EVs. The charging stations keep track of charging times and other data to allow remote monitoring of their utilization and correct functioning. The power supply management system is the core design of the Charging power station and includes the managements of the information of identifying the user, energy metering, self-management of pricing and accounts settling and warnings to the user. The charging parameters, including charge power, charge energy, and charge times, have been established by evaluating typical daily vehicle trips and daily vehicle kilometers traveled on the island. The project foresees the installation of a main charging station located in the night deposit of the vehicles and of a public network of three charging stations integrated with photovoltaic generators (PV). The charging stations will be used during the experimental phases of the project to charge the Municipal electric fleets and the experimental prototypes. In the future citizens with plug-in electric vehicles will be also able to charge their cars or scooters at these stations, located at convenient places around the island. The Public charging stations also include an access control system using a radio frequency identification - RFID technology, which not only restricts access to previously approved users or electric vehicle owners, but also tracks data related to who, when, and where people are using these public stations. The Charging Stations have been designed to provide the following functionalities:

- Communication with networked charging stations to provide access control, monitoring, management, and remote upgrades of individual stations;
- Supports of multiple Web-based applications that provide a rich set of features and functions for drivers, municipalities, citizens, tourists, installers, fleet operators and utility companies;
- Open charging infrastructure to all citizens;
- Remote monitoring and diagnostics for superior quality of service;
- Integration with Renewable Energy Sources for utility load management and with future Distributed Generation and Smart Grid capabilities;
- Reduced Green House Gas emissions per driver and per fleet;
- Fleet vehicle management.

All the experimental results and data coming from the charging infrastructure will be used to learn more about what is needed to support electric vehicles as they become more common on the island. The increased use of electric vehicles will impact electric utilities and the infrastructure



for providing electricity to customers. The installation and the utilization of the Charging Stations will help to understanding of things such as how this infrastructure works, how consumers want to use it, driving and charging patterns, and interconnection with the electricity grid and with RES.

#### 4. INTEGRATION WITH RES

One of the objectives of this project is to promote the use of EV recharged with renewable energy, avoiding increases in electricity generation with conventional sources and using the electrical grid as general energy storage. For this reason the charging stations will be integrated with photovoltaic generators with the general objective to study and promote the use of PV energy to charge EVs on the island territory. A first integrated PV station has been designed, built and installed for charging the electrical vehicles and other two stations will be installed before summer 2010. *Figure 7* shows the first installed Charging Station integrated with the PV generator.



*Figure 7: The first PV Integrated Charging station installed on the island.*

	PV Plant Producibility (kWh/kWp)	Total Monthly Energy (kWh)	Total Monthly Distance (km)	Van Monthly Trip (km)	Van Daily Trip (km)
<b>Jan</b>	71,07	136,45	814,28	271,43	8,76
<b>Feb</b>	81,31	156,12	931,60	310,53	11,09
<b>Mar</b>	112,77	216,52	1292,05	430,68	13,89
<b>Apr</b>	130,13	249,85	1490,95	496,98	16,57
<b>May</b>	153,04	293,84	1753,44	584,48	18,85
<b>Jun</b>	156,89	301,23	1797,55	599,18	19,97
<b>Jul</b>	183,55	352,42	2103,00	701,00	22,61
<b>Aug</b>	164,55	315,94	1885,31	628,44	20,27
<b>Sep</b>	135,07	259,33	1547,55	515,85	17,20
<b>Oct</b>	118,31	227,16	1355,52	451,84	14,58
<b>Nov</b>	75,95	145,82	870,19	290,06	9,67
<b>Dec</b>	63,63	122,17	729,03	243,01	7,84
<b>Total</b>	1446,27	2776,84		<b>Average</b>	<b>15,11</b>

*Table II. Energy produced by the PV charging station and monthly and daily kilometres that can be travelled.*

The installation has a PV array of 1.92 kWp nominal power which consists of 8 high efficiency m-Si, 240 W

modules. The PV modules are placed on a parking structure specifically designed for this installation and with the possibility to optimize the tilt angle. The support structure has been specifically designed to be portable for fast assembly and dismantling; bearing in mind that the installation shown to promote the use of EVs with PV on other small islands. *Table II* shows the energy produced by the PV generator in one year and the monthly kilometers that can be traveled by one single Van assuming a 0.17 kWh/km energy consumption. Assuming an average autonomy for the van of 112 km between recharges, the installation is able to recharge the daily operation of 3 vans allowing for each of them an average daily traveled distance of about 15 km corresponding to 2.55 kWh.

	PV Plant Producibility (kWh/kWp)	Total Monthly Energy (kWh)	Total Monthly Distance (km)	Van Monthly Trip (km)	Van Daily Trip (km)
<b>Jan</b>	71,07	409,36	2442,83	348,98	11,26
<b>Feb</b>	81,31	468,35	2794,80	399,26	14,26
<b>Mar</b>	112,77	649,56	3876,15	553,74	17,86
<b>Apr</b>	130,13	749,55	4472,85	638,98	21,30
<b>May</b>	153,04	881,51	5260,32	751,47	24,24
<b>Jun</b>	156,89	903,69	5392,65	770,38	25,68
<b>Jul</b>	183,55	1057,25	6309,01	901,29	29,07
<b>Aug</b>	164,55	947,81	5655,94	807,99	26,06
<b>Sep</b>	135,07	778,00	4642,65	663,24	22,11
<b>Oct</b>	118,31	681,47	4066,57	580,94	18,74
<b>Nov</b>	75,95	437,47	2610,57	372,94	12,43
<b>Dec</b>	63,63	366,51	2187,10	312,44	10,08
<b>Total</b>	1446,27	8330,52		<b>Average</b>	<b>19,42</b>

*Table III. Energy produced by the PV charging station and monthly distance.*

An estimation of the energy production using 3 Charging Stations (total PV nominal power of 5.76 kW) to recharge all of the 7 vehicles of the fleet during the year has been performed. The estimation is based on the I-V curves of the PV array and on the used DC/AC inverter and maximum power point tracking efficiencies. Mismatch, dust and angular were also included. *Table III* shows the results of the simulation. The table shows that the 3 stations can be used to recharge all the 7 vehicles allowing them to drive an average daily distance of about 19 km. The 3 Stations can be then used to:

- Recharge the seven vehicles assuring average 15-19 km daily trips;
- Recharge the prototypes that will be tested on the island by POMOS;
- Recharge vehicles of private citizens.

The excess of PV generated energy not used for EVs charging can be fed into the electrical grid and, vice versa, when the PV generated power is not enough, EVs can be charged from the grid. Italian local tariffs for PV green energy are applied and a bidirectional counter is used in order to calculate the electricity price for the EVs users. *Figure 8* shows both the energy produced by the 1.92 kW station (green bar) and by the 5.76kW stations (blue bar). The same figure shows the monthly energy consumptions

in kWh of recharging three and seven vans (purple bar and green bar).

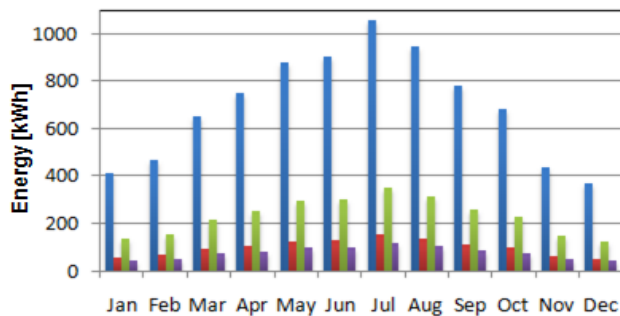


Table IV. Energy produced by the 1.92kW and 5.76kW charging stations and vehicles consumptions.

## 5. CONCLUSION

The characteristics of Ventotene are common in many islands of the Mediterranean area, especially Italy: no cable connection to the grid on the mainland, low efficiency, polluting diesel plants providing the only source of energy, significant population fluctuations due to the tourist stays during the summer, an absence of local sustainable mobility strategies. A roadmap for the introduction of sustainable transport systems on the island of Ventotene has been made.

Key elements of the project were:

- Introduction of electric transportation (commercial and prototypal vehicles);
- Installation of charging stations integrated with PV;
- Creation of a Vehicle Monitoring and Location system;
- Development of an integrated Georeferential platform for the telemetry and the environmental monitoring
- Development of a wireless communication infrastructure for fleet management;
- Integration of private transportation and public transportation;
- Educational activities and information.

The first three months of the project have shown that EVs are very appropriate for use on the island, both for daily transport from the port to the centre and small trips around the island. All the various aspects considered, lead to the conclusion that the Sustainable Mobility integration project on Ventotene is a good example that should be promoted on other similar islands. A documentary about the project has been made and various information and training events will be also staged such as the 3rd International School on Electric and Hybrid Vehicles (ISHEV2010) which is to be held in September 2010 and will involve experts and students discussing innovations in sustainable transportation. With this project Ventotene could become a model for the implementation of sustainable mobility policies at regional, national and international levels and for this reason it has been selected

by the PRESS4TRANSPORT [11] EU project as a pilot demonstration. More results will be provided in a future paper after the end of the summer. Future research work will also include remote vehicle's diagnostics. It will be provided through a vehicle on board diagnostic system, which helps in controlling the vehicle (e.g. doors, engine and other possible systems) from a remote location.

## 6. ACKNOWLEDGEMENTS

This project has been supported by the Department for the Environment of the Lazio Regional Government. The authors would like to acknowledge the helpful collaboration of all the persons involved in this project from Piaggio, Cnos-Fap, Aci Consult, Systeam and the Municipality of Ventotene.

## 7. REFERENCES

- [1] A. Pina, C.S. Ioakimidis, P. Ferrão, **Introduction of electric vehicles in an island as a driver to increase renewable energy penetration**, ICSET 2008
- [2] K. Bodek, J. Heywood, **Europe's Evolving Passenger Vehicle Fleet: Fuel Use and GHG Emissions Scenarios Through 2035**, Publication No. LFEE 2008-03 RP, March 2008.
- [3] G. Tondi, D. Chiamonti, A. Grassi, **Strategy for the implementation of RES on Pantelleria Island**, International conference RES for Island, Tourism and Water, Crete (GR), 26-28 May 2003.
- [4] D. Chiamonti, **RES utilisation in Pantelleria Island**, Presentation held at "Environmental Sustainability on minor islands" seminar, Pantelleria, 21-22 June 2002.
- [5] A. Grassi, L. Sardi, **The Pantelleria Island Project On Renewable Energies**, Book of proceedings "PV in Europe Conference", Rome, 17- 21 October 2002.
- [6] S. Iraci, **Sustainability on Island**, Graduation report, TU Delft, 2005, The Netherlands
- [7] S. Ritier, J. MC Coy, **Automatic Vehicle Location: An overview**, Vehicular Technology, IEEE Transactions, Vol. 26 Issue 1. Pp. 7-11, 1970.
- [8] Planistat Europe, Bradley Dunbar Ass. (March 2003), **Analysis of the island regions and outermost regions of the European Union**, Tech. Rep., [Online]. Available: <http://www.islenet.com>.
- [9] A. Corsini, M. Gamberale, and F. Rispoli, **Assessment of renewable energy solutions in an Italian small island energy system using a transient simulation model**, ASME Journal of Solar Energy Engineering, Vol.44, pp. 128:237, 2006.
- [10] I.F. Akyildiz, W. Xudong, **A survey on wireless mesh networks**, Communications Magazine, IEEE Volume: 43 , Issue: 9 Publication Year: 2005 , Page(s): S23 - S30.
- [11] [www.press4transport.eu](http://www.press4transport.eu), **Virtual Press Office to improve EU Sustainable Surface Transport research media visibility on a national and regional level**, [on line].