DEMONSTRATION OF INNOVATIVE SOLUTIONS IN THE FRAMEWORK OF SMILE PROJECT

SMILE

DAFNI
Network of Sustainable Greek Islands

Duration
2017 - 2021

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14.000.000 €

Lead Partner
Rina Consulting S.p.A.

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Route Monkey LTD
Samsø Elektro ApS
Samsø Energiakademi
Samsø Kommune
New Energy Coalition
Sunamp Ltd
Teknologisk Institut
VCharge UK Limited

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Introduction

In order to facilitate the energy transition, the Smart Islands Energy Systems (SMILE) project has implemented three large-scale demonstrator projects in three European islands with different policies, regulations and energy markets. The objective is to test solutions while establishing mutual learning processes and providing best practice guidance for replication in other regions. The three demonstrators have tested different combinations of technological solutions according to local specificities and conditions and the existing infrastructure.

For each island, the aim was to demonstrate and develop the optimal operation of the system under stable and secure conditions. Each of the demonstrators brings a specific set of challenges, technology options and most importantly, energy market conditions. The sites are therefore effectively representative of the majority of the EU energy markets and offer excellent demonstration settings which will deliver maximum impact in terms of replicability at Greek islands.

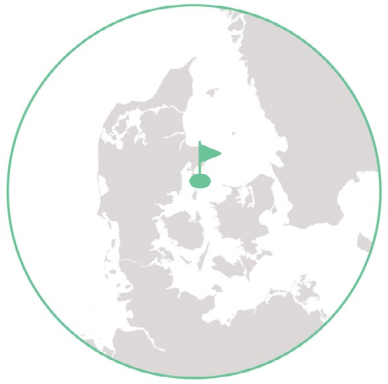
DAFNI's role in the project is to disseminate the knowledge generated to its members as well as to local island communities, actively contributing to the dialogue around the legislative, regulatory, technical and investment initiatives that must be taken for the implementation of sustainable energy projects in the island area.

In this direction, three representative Greek islands will be selected that have similar characteristics with the project pilot islands and will examine whether the technologies tested can be used in each island.

For each of the three islands that will be selected, the project's consortium will produce a feasibility study of the technologies under consideration considering the specific characteristics of each island.

Samsø, Denmark

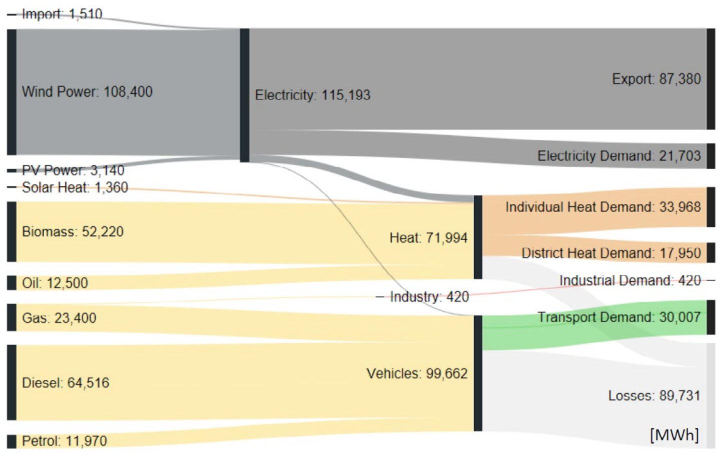
Area: 114 km^2
Population: 3.700 inhabitants
Electric system: Interconnected
RES Area: 60%



In 1997, Samsø was singled out by the Danish government as a role model for communities based on sustainable energy. Today, mainly through the installation of several renewable energy stations (wind turbines, photovoltaics, biomass) the island is CO^2 neutral regarding the energy sector in isolation (excluding agriculture and other sectors with emissions). The island produces more electricity than it consumes, while the inland electricity production is solely renewable.

The main production comes from onshore and offshore wind turbines. In addition, it is interconnected to the mainland, and there is an exchange of power both ways, but it is mostly exported. While the curtailment of renewable generation is not an issue in Samsø's energy system, there are several bottlenecks that present opportunities for better management of locally generated energy.

The current vision of making Samsø an island 'free of fossil fuels by 2030' has been introduced eliminating all the fossil fuels from the energy mix of the island. Several studied scenarios have revealed that is possible to make a 100% renewable energy system at Samsø by 2030, using only local electric power generation by wind turbines and PV systems together with the use of biomass resources. Associated costs will stay similar to current costs, and the system could additionally enhance the security of supply, while contributing to local job creation, considering that the island is already a destination for international energy tourism.



Sankey diagram of Samsø's reference model of the energy system for 2015

Figure 1: Sankey diagram of Samsø's energy system (2015) [1]

Smart marina

The largest marina on the Danish island of Samsø has been selected as a test marina for a pioneering solution aimed at helping island communities with limited power grids to increase the use of sustainable energy. The purpose was to test, how a "Smart Marina" is able to optimize its energy management by storing and managing energy from photovoltaics (PVs).

Therefore, the first innovative solution was introduced and implemented in Samso. The energy demand in the Ballen marina is very inconsistent as it is dominated by the demand from berthed yachts and associated tourism. This results not only in significant fluctuations on a daily basis but also in seasonal variations, as tourism has its peaks in the summer.

The solution integrates the following advanced technologies:

Installation of photovoltaics at the marina

PVs cover the electric power consumption of boats, electric vehicles and that of buildings on the marina. Due to the higher electricity consumption during the summer months, and low production during the winter, PVs power generation will end up covering approximately 1/2 of the yearly energy use at the marina.

Installation of a central battery energy storage system (BESS) at the marina.

The purpose is to level out fluctuations derived from the variable RES power generation and load peaks. Storage capacity should be sufficient to buffer the local day-to-day energy consumption. This way it will be possible to use electrical energy generated by PVs also during evening and night time where most boats are docked in the marina and energy consumption is high (it peaks around 23:00 during the high season). In other words, the battery stores energy for later use, so marina's consumers can make use of solar power even after sunset, while it ensures a stable power supply based on sustainable energy.

Installation of an intelligent power grid (smart control system).

This intelligent power grid is known as a Smart Grid system which is capable of balancing power production and consumption management. The fluctuations in power production, which are a natural consequence of using solar power, are managed accordingly minimizing their impact.
For example, tasks can be postponed that require a lot of power until a time when the battery state-of-charge is plentiful.

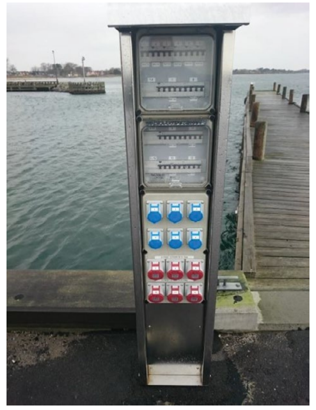
Installation of heat pumps or electric water heaters.

The heating energy in the harbor master's office is covered by a heat pump. Thus, the heating energy is partly replaced by solar energy.

Installation of power meters and vehicle sockets (plug-in).

New sockets are installed to provide electricity to each boat and plug-in cars. The meters measure accurately the amount of energy consumed by each socket. Consequently, a pattern of demand load is created which assists the energy management of the marina, predicting power consumption.

The mentioned technologies are depicted in the next pictures from the pilot Samso site.

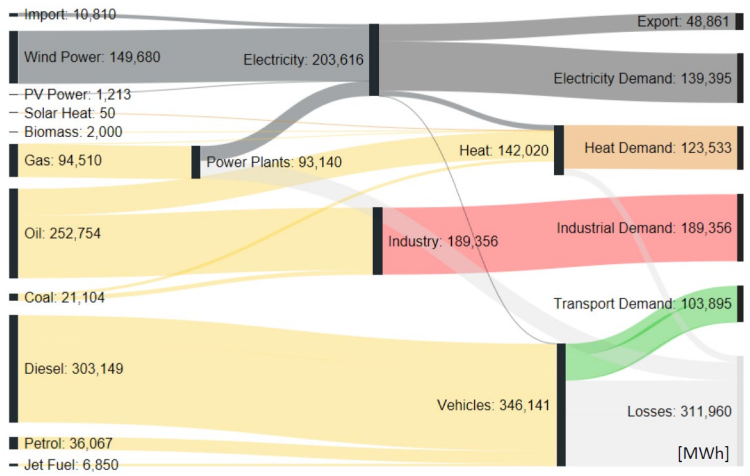


Orkney, United Kingdom

Area: 900 km^2
Population: 21.100 inhabitants
Electric system: Interconnected
RES share: 17%

The Orkney Islands have been home to renewable energy innovation for more than 60 years, with ground-breaking wind test sites located in the islands from the 1950s to the present day. In Orkney there are over 300 jobs related to renewables, over 700 individual energy producers and technology investors, while there are 12 large scale and numerous micro community-owned wind turbines providing clean energy and income locally.

As an archipelago of islands, Orkney is highly dependent on both ferry transport and imported fuel for farming, fisheries and land transportation. While the number of electrical vehicles (EVs) is increasing and alternative green fuel supply chains are being developed, there is currently no system for integrating smart charging with wider network conditions. Despite the high levels of renewable generation, many homes are heated by oil or coal. Combined with the northerly climate, poorly insulated housing stock and local income levels, Orkney has some of the highest recorded levels of 'fuel poverty' in the UK. Fuel poverty is defined as a household having to spend more than 10% of its income on heating. However, Orkney aims to reduce fuel poverty by supporting householders, as well as demonstrating leadership by adding low carbon housing improvement projects on its estate.



Sankey diagram of Orkney's reference model of the energy system for 2014

Figure 2: Sankey diagram of Orkney's energy system (2014) [1]

Heat Smart

At Orkney, different combinations of innovative technologies have been implemented in order to meet the energy needs of heating and domestic hot water by integrating Demand Side Management (DSM) system. This solution can provide intelligent control and aggregation of electric heating systems in homes and businesses, as well as EV charging points exploiting the excess electricity generated by wind turbines installed on the island which otherwise would be remained unexploited.
Four different solutions were applied to 45 households in total, which are descripted below:

House Type 1

Includes Phase Change Material (PCM) heat batteries with a combined rated capacity of 5.6 kW/ 12 kWh covering hot water needs during discharge.

House Type 2

Brings together five (PCM) heat batteries, with a combined capacity of 2.8 kWe/30kWh, with a 11, 14 or 16 kW (3.5-6 kWe) heat pump's significantly enhancing energy efficiency, as it performs 2.5 - 3 times better compared to an electric heater providing space heating and hot water too.

House Type 3

Consists of a 11, 14 or 16 kW (3.5-6 kWe) heat pump and a storage tank which stores energy in the form of hot water and injects it into the household heating system.

House Type 4

Connects a 11, 14 or 16 kW (3.5-6 kWe) heat pump, a hot water storage tank and a 3.5 kW/7.5 kWh lithium battery which discharges power proportionally behind the meter when the heat pump is operating. The net effect is reduced power drawn from the grid when the heat pump is providing heating and/or hot water.

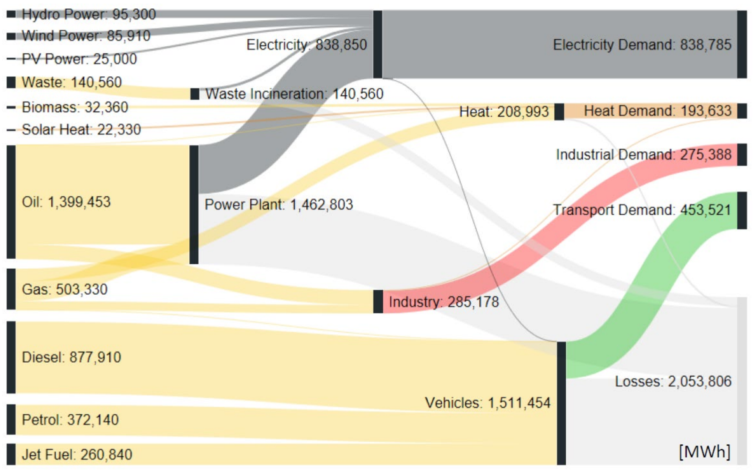
In addition, intelligent charging points for electric cars (7kW) have been installed, which serves residential, tourist, and commercial areas. Chargers for electric vehicles (EVs) are characterized as intelligent because their charging varies based on energy demand in each time period as well as the need to decongest or balance the electrical network.

Madeira, Portugal

Area: 801 km^2
Population: 270.000 inhabitants
Electric System: Non interconnected
RES share: 11%

Madeira is an autonomous energy island which means that it is not connected to any other landmass electrically. All energy consumed on the island must therefore be generated onsite. The local DSO – EEM, a publicly owned company (by the Regional Government), which is also fully responsible for transmission system operation (TSO) and energy commercialization.
EEM also operates the major generation assets, although in this sector has also private entities operating. This issue is becoming more prominent as the amount of solar energy generation on the island is increasing. The peaks in solar irradiation generally do not correspond with peaks in demand and the stochastic nature of this type of generation is difficult to manage on a small isolated grid with no current control systems. Frequency issues are therefore becoming an increasing challenge.

Madeira's electrical energy system is based on conventional thermal power plants and hydro plants, complemented by a solid amount of wind energy and steady growing solar energy production. Although renewable energies have been achieving considerable integration in the island's energy mix, it is still predominantly dominated by conventional thermal power plants. Namely, the electric grid in Madeira island is fed by five sources of energy: hydro, wind, photovoltaic, solid waste incineration, and thermal energy from burning fossil fuels like diesel and natural gas.



Sankey Diagram of Madeira's reference model of the energy system for 2014

Figure 3: Sankey diagram of Madeira's energy system (2014) [1]

Smart e-grid service

In Madeira, an intelligent control and automation system was implemented in the existing grid in order to provide for better management of the distribution network coupled with EV charging points. The implementation of grid balancing mechanisms decreases current strains on the grid and enhances its reliability and resilience. This, in combination with demand side management techniques (including market mechanisms such as time-of-use tariffs) and storage technologies, will help to address the increasing strain on the grid and will facilitate significant additional solar and other renewable generation in the future.

The solution can be applied from small scale (e.g., households, restaurants) to large scale (e.g., distribution network). Energy storage (battery) is the main component in both cases.
More specifically:

1. Small-scale batteries 3 kW / 8.6 kWh of power and capacity respectively, allow consumers to store excess electricity generated by their PVs when production is high while their consumption is low.
   This solution can function differently to consumers depending on their level of consumption. Regarding the domestic prosumers, the excess RES production is stored in a BESS, and consumed in the periods where the production from RES is lower or non-existent, maximizing self-consumption. On the contrary, for commercial prosumers, it is expected that all the energy production from solar PV will be consumed since there are normally high peaks of consumption when the solar production is also high. They can also benefit from BESS by doubling the batteries' utilization by pre-charging from off-peak periods (when the prices are the lowest) to cover early morning loads, and then re-charging from the sun to cover evening loads.
2. The larger battery provides 40 kW / 80 kWh of power and capacity respectively, is installed in a medium voltage substation to provide load-leveling (due to the high number of micro-producers) and voltage control services. The purpose is to improve the electric power supply Quality of Service, associated with low voltage distribution networks, with many dispersed production facilities, mainly PVs.v.
3. In parallel, smart chargers for electric vehicles were also installed to expand the provision of electricity services. Firstly, the electric vehicles can be fed with electricity originated from the local renewable energy systems depending on the availability of production. Secondly, the charging rate of EVs is controlled and adjusted according to the electricity grid conditions facilitating its stability and reliability.

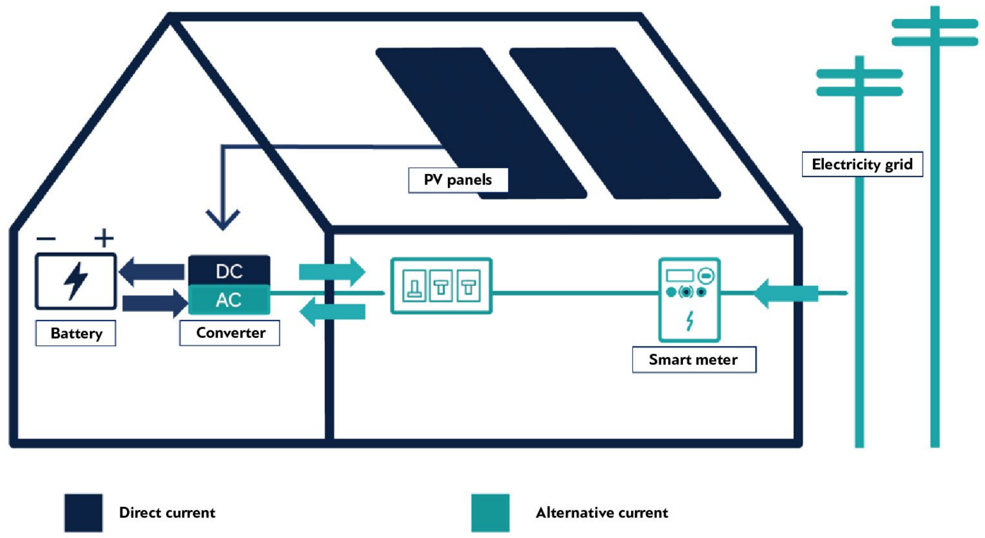


Figure 6: Small-scale residential solution

The backbone of the Madeira demonstrator is Energy Management System (EMS). It consists of a flexible data storage and querying system, which integrates all the solutions tested in Madeira within the scope of SMILE project.
Responsible for storing and handling all data collected from the pilot sites, the EMS provides the system administrator with access to the pilots' infrastructure and is intended to allow for the creation of products that give insight into energy consumption and production (or other pilot's data) to interested consumers (e.g., prosumers and EVs owners).

The main strengths of the EMS lie in its flexibility (it can be easily adapted and upgraded with new features) and interoperability. In fact, the EMS is an input-agnostic solution compatible with different third-party systems, like Battery Energy Storage Systems (BESS) or energy monitoring systems (i.e., it allows for integrating different data sources). All the data is made available through an API to entities that are properly authenticated.