Towards 100 % RES: The Experience of the Canary Islands

Canary Islands Institute of Technology (ITC)

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The Canary Islands (Spain)

- 2 million inhabitants, 12 million tourists/year
- Total energy dependence on external resources
- Electricity generation from fossil fuels (oil); low heat demand
- Isolated (insular) electrical systems
- Importance of water-energy binomial (desalination)
The Canary Islands

- > 2.5 GW installed power, approx. 9000 GWh total el. consumption
- 15% of electricity consumed in water cycle
- Abundant Renewable Energy Resources:
  - wind: ~ 4000 h.eq./y;
  - sun: ~ 2000 kWh/m²/y

Structure of internal fossil fuels market

- Electricity generation 55.6%
- Road Transport 29.9%
- Other (Industrial, Residential...) 12.1%
- Combined water-electricity production 2.4%

Seawater desalination plants
European Outermost Regions (OMRs)

OMRs are NATURAL LABORATORIES for developing, testing and demonstrating new technologies which will be implemented in continental regions (Europe and ROW), in insular regions worldwide, as well as in developing countries.

OMRs are the IDEAL PLATFORMS to showcase and transfer adapted technologies to regions of developing and emerging countries worldwide (and particularly of European neighbour regions).
The Canary Islands: Ideal Test Bench

Every island configurates one or several real laboratories for testing and demonstrating new technologies, especially emerging ones.
The Canary Islands are fully committed to the development and implementation of innovative energy, water and environmental protection technologies and policies, providing sound proof of concepts for the whole Europe and RoW.
The Canary Islands have been carrying out successful international cooperation projects (especially with West Africa and South America) for many years, developing and transferring adapted technology, for example in the energy, water, agriculture, fishing and public health sectors.

The Canary Islands Government is deploying technology parks specialized in adapting technologies for the developing world.
ITC is a technology center specialized in:

- Energy Saving/Efficiency, Renewable Energies
- Water Technologies
- Other emerging technological sectors

- International Cooperation
  (energy and water supply to peri-urban and remote areas)
The ITC

Contribution to maximization of RES penetration:

- Characterization of RE resources (mapping and prediction)
- Test platforms for RES systems and components (solar labs, distributed generation lab, etc.)
- Development of RES systems (with energy storage): hybrid systems, mini- microgrids, insular 100% RES models, electricity & water supply to remote African villages
- Grid stability studies
- Energy storage: wind-pumped hydro, RE-HYDROGEN, etc.
Surplus of Energy Supply: Potential on RES development

RES in Canary Islands are already cheaper than conventional sources for electricity.

Coste de la Energía Eléctrica en Canarias (c€/kWh)

Fuente: IUDR - FEDEA, extraído del Análisis de los sobrecostes de la Energía del Sistema Energético de Canarias de RICAM. Elaboración propia.
Obstacles for the Sustainable Energy Development in Islands

- Weak, isolated grids
- Fragile ecosystems (rich biodiversity, etc.)
- Lack of space for energy infrastructure placement
- Difficulties for the massive deployment of Renewable Energies

SiNGULAR
Smart and Sustainable Insular Electricity Grids Under Large-Scale Renewable Integration

SEVENTH FRAMEWORK PROGRAMME
MAXIMIZING PENETRATION OF RENEWABLE ENERGIES

The need for enacting policies to support renewable energy is often attributed to a variety of barriers that prevent investments from occurring.

Barriers to renewable energy penetration in Islands electric power systems

Strategy for maximizing RES penetration

- Grid stability studies
- Energy storage
- Forecasting of wind and sun
- Demand Management
- Distributed generation
(Renewable) ENERGY STORAGE

• Solutions allowing for storage of excess RES produced during valley hours of the electric demand curve, and feeding it back to the grid during peak consumption.
• Short term energy storage to manage RES variability and fluctuations
• Finding energy vectors for RES applications in Transport.
Maximizing RES Penetration in Insular Grids: Canary Islands

Several Storage Projects ongoing, promoted by the utility (ENDESA) and the TSO (Red Eléctrica de España): NaS, ZnBr, Supercaps, Flywheels

Pumped-Hydro Storage (Peak Shaving)
4 systems planned: Gran Canaria, Tenerife, La Palma, La Gomera
Technical Solutions (I)  HV/MV: Pumped Hydro (where possible)

- Upper Reservoir
- Hydro Power Station
- Lower Reservoir
- Pumping Station
- Wind Farm
- Desalination Plant
Technical Solutions (II)

- HV/MV:
  - Subsea electrical interconnections

Refuerzo del enlace submarino entre Lanzarote y Fuerteventura

Enlace submarino Gran Canaria y Fuerteventura:
Technical Solutions (III)

- MV/LV:
  - Distributed Generation, esp.:
  - Mini- & Microgrids with high renewable energy penetration, incl. energy storage, management of critical loads (e.g. seawater desalination) and electrical mobility
DEMAND MANAGEMENT: water desalination

20% of energy production goes to water desalination and water distribution.

Use of desalinated water

<table>
<thead>
<tr>
<th></th>
<th>374,000 m³/day</th>
<th>153 plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential &amp; touristic</td>
<td>374,000 m³/day</td>
<td>153 plants</td>
</tr>
<tr>
<td>Agriculture</td>
<td>146,000 m³/day</td>
<td>100 plants</td>
</tr>
</tbody>
</table>

Energy consumption for water desalination:

1Kgr fuel/ m³ of desalinated water.
- For 522,000 m³/day
- Import 150,000 Ton fuel /year.
DEMAND MANAGEMENT: Electric cars

30% of oil consumed in the internal market goes to the road transport sector.

Peak shaving: More than 1 million vehicles could charge at valley hours of the electric demand curve.
Waste to energy

Due to the complex topography of islands, lack of large farming areas, difficulties to implement extensive mechanization of agriculture and water shortages, it is not possible to develop energy crops efficiently in most islands. Therefore biomass energy available is limited to the different residues from which energy could be recovered.

Waste a renewable energy resource

Biomass energy complementary to other unmanageable RES such as wind and photovoltaic

Potentially usable waste as biomass energy

- Municipal Solid Waste, MSW
- Sewage sludge
- Animal farming
- Agricultural
- Forest residues

Energy recovery from waste is a key element in the fight to reduce the volumes of waste accumulating in landfills in island’s landfills.
ITC is behind key technological (clean energy and water) projects in the Canary Islands:
The ISLE-PACT Project (I)

GOALS:

- Achieve an overall objective of more than 20% CO2 emissions reduction by 2020
- Demonstrate islands’ political commitment to EU sustainable energy objectives by signing a BINDING DECLARATION, THE PACT OF ISLANDS
- Develop Island Sustainable Energy Action Plans (ISEAPs) as the means by which they will achieve the overall target of the project
- Develop methodologies and tools to monitor progress of implementation of ISEAPs as well as track progress in reducing CO2 emissions
- Assess environmental and socio-economic factors
- Produce a pipeline of priority bankable projects
- Propose a number of financing tools and mechanisms that will provide the financial resources needed by investors
- Launch a strong information dissemination campaign

Participating Regions (12):
- Azores, Madeira
- Islas Canarias, Baleares
- Creta
- Malta
- Chipre
- Cerdeña
- Gotland+ B7 Islands
- Samso
- Outer Hebrides of Scotland
The ISLE-PACT Project (II)

Projects for maximizing penetration of RES

- RES Systems
  - Technologies
  - Land availability
  - Resources (wind-sun etc)

- Sustainable Transport
  - Excess RES production
  - Mobility (H2 – EPV)
  - Grid stability

- Energy Storage
  - Rational use of energy

- Energy Efficiency
  - Restriction in transport infrastructures
  - Reduction in losses

- Distributed Generation

www.isle-pact.eu
IDENTIFYING POTENTIAL BANKABLE PROJECTS

Projects that will contribute to increase RES penetration in European Islands in all the energy value chain

- **Generation**
  - Wind, solar, Wave, Geothermal, Biomass, hybrid (wind-diesel)

- **Energy Storage**
  - Reversible pump-hydro
  - Batteries
  - Hydrogen

- **Distribution**
  - Microgrids, district heating and cooling, etc.

- **Energy Efficiency**
  - Primary sectors
  - Industry
  - Services
  - Residential

- **Final consumption**
  - Manageable loads: e.g. electric vehicles, Water desalination
The ISLE-PACT Project (III)

Criteria for prioritizing projects

- Compatibility with current framework and existing schemes for promoting RES
- Contribution to global strategy for maximizing RES penetration in the island
- Impact on the reduction in energy demand
- Performance on standard financial parameters (PAYBACK, IRR, NPV)
- Maximization of Green House Emissions reduction to necessary investment cost
- Capacity for local employment creation of the investment project
- Innovative aspect of the project
- Maximization of energy production per unit of occupied land

A list of aprox. 25 bankable projects will be compiled for the 12 participating European island regions
SMILEGOV

Enhancing effective implementation of sustainable energy action plans in European islands through reinforcement of smart multilevel governance

www.sustainableislands.eu

MULTILEVEL GOVERNANCE!!!
La Graciosa 100% RES

La Graciosa:
650 inhabitants
0.7 MW peak
2 GWh/y demand

Smart Microgrid with high RES penetration, energy storage (incl. desalination) and electric vehicles fleet
SMART METERS (already installed) + electric vehicles (planning phase)
Multimegawatt Wind Test Platform at Arinaga Port (Gran Canaria)
First Spanish off-shore wind turbine (GAMESA)
THE PARADIGM OF OUR VISION (Islands: Natural Laboratories)

- **El Hierro** Island Wind-Pumped Hydro Power Station (100 % Renewable Energy Supply)
El Hierro: 100% RES Island

Recently commissioned

- 278 km²
- 10,500 inhabitants
- 7 MW peak
- 40 GWh/y demand (Diesel)
100% renewable energy supply

- Design and construction of a Wind-Pumped Hydro Power Station
- Installation of solar collectors & PV systems
- Evaluation of biomass exploitation possibilities
- Transport. Sustainable Mobility
- Environmental Education
Wind-Hydro Power Station
El Hierro: 100% RES Island

Wind – Pumped Hydro Power Station

Upper Reservoir

Water Conductions

Lower Reservoir

Pumping Station

Hydro Station

Wind Farm
## Wind-Hydro Power Station

<table>
<thead>
<tr>
<th>Facility</th>
<th>Capacity</th>
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<tbody>
<tr>
<td>Wind Farm</td>
<td>11.5 MW</td>
</tr>
<tr>
<td>Hydroelectric Substation</td>
<td>11.3 MW</td>
</tr>
<tr>
<td>Pumping Station</td>
<td>6 MW</td>
</tr>
<tr>
<td>Upper Reservoir</td>
<td>400,000 m³</td>
</tr>
<tr>
<td>Lower Reservoir</td>
<td>150,000 m³</td>
</tr>
</tbody>
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Upper Reservoir