Renewable energy integration in Small and Isolated Power Systems in Spain (SIPSS). Case study of the hydro-wind power station on El Hierro Island

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| Outline |
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| | • Regulatory comparison: mainland vs SIPSS |
| **2. Regulatory framework of SIPSS** | • Framework for generation  
| | • On-going reforms in SIPSS |
| **3. Gorona: Hydro-wind power plant (HWPP) on El Hierro Island** | • Technical characteristics  
| | • Main regulatory goals  
| | • Operation & remuneration scheme |
| **4. Lessons learned in SIPSS** |
Mainland Spain
Balearic Islands:
- Mallorca – Menorca
- Ibiza – Formentera

Canary Islands:
- Gran Canaria
- Tenerife
- Lanzarote – Fuerteventura
- La Palma
- La Gomera
- El Hierro

Ceuta & Melilla

<table>
<thead>
<tr>
<th>Macroeconomic measures, 2014</th>
<th>Mainland Spain</th>
<th>SIPSS</th>
<th>Balearic Islands</th>
<th>Canary Islands</th>
<th>Ceuta &amp; Melilla</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (MM)</td>
<td>43</td>
<td>3</td>
<td>1</td>
<td>2</td>
<td>0.165</td>
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<tr>
<td>GDP/cap (k€)</td>
<td>23</td>
<td>21</td>
<td>24</td>
<td>20</td>
<td>18</td>
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<tr>
<td>Unemploy. (% active pop.)</td>
<td>24%</td>
<td>27%</td>
<td>19%</td>
<td>31%</td>
<td>33%</td>
</tr>
</tbody>
</table>

Source: INE
Mainland Spain vs SIPSS in figures

Power sector: Gross power generation, 2014

Mainland Spain (260 TWh)

RES-E: 43%

- Nuclear: 22%
- Coal: 17%
- CCGT: 8%
- Wind: 19%
- Big hydro: 14%
- Fuel/gas: 0%
- Small hydro: 3%
- CSP: 2%
- RES thermal: 1%
- Cogen: 10%
- PV: 3%

Source: REE

Balearic Islands (4.6 TWh)

RES-E: 3%

- Wind: 3%
- CCGT: 10%
- PV: 3%
- RES thermal: 1%
- Cogen: 6%
- Coal: 53%

Canary Islands (9 TWh)

RES-E: 8%

- Wind: 5%
- Small hydro: 0%
- PV: 3%
- RES thermal: 1%
- CCGT: 38%
- Fuel/gas: 54%
Mainland Spain vs SIPSS in figures

Power sector: Consumption by segments, 2014

Mainland Spain (219 TWh)
- Domestic 32%
- Industrial 47%
- SME 21%

Balearic Islands (5 TWh)
- Domestic 45%
- Industrial 18%
- SME 37%

Canary Islands (8 TWh)
- Industrial 30%
- Domestic 41%
- SME 29%

SIPSS:
- Domestic consumption with higher share
- Industrial consumption significantly lower

Source: CNMC
Some regulatory features

Mainland Spain

Liberalization 1998

Markets processes (MIBEL):
- Forward contracts
- **Day ahead market (D-1)**
- Intraday market (D)
- Balancing market (TSO)
- Bilateral contracts

Common aspects

- TSO
- DSO
- Supply

SIPSS

- Traditionally Rate of Return Regulation
- Effective unbundling since 2007
  - *Cost Plus* regulation with incentives (IPC-X)
- NO MARKET & No bilateral contracts
- TSO: owns and controls network \( \geq 66 \) kV and establishes hourly power dispatching

Compensation for generation

- RETAIL PRICE
- RES-E
Power generation in SIPSS

Conventional generation (thermal) and hydro-wind power station

- Cost plus regulation with standardized two-part tariffs (FC + VC)
  
  \[ FC = INV + COMT_F + GRLL + RA \]
  \[ VC = C_{\text{fuel}} + C_{\text{start-up}} + C_{\text{res}} + C_{\text{om}} + C_{\text{reg}} \]

  - Fuel cost updated every 6 months
  - Annual indexation (IPC-X or IPRI-X) on fuel logistic costs, start-up cost, COMT\(_F\) & C\(_{\text{om}}\)
  - Useful life of installations: 25 years, in case of hydro: 65 years (linear depreciation)
  - Rate of Investment return: 10 year State bonds + 200 bp

- Costs covered by: Mainland MP\(_{D-1}\) + Compensation

Non-controllable RES-E generation: Same on Mainland & SIPSS (priority access)

- Feed-in Tariff & Feed-in Premium until June 2013
- New framework (Royal Decree 413/2013):
  - Additional payments linked to INVESTMENT of each INSTALLATION TYPE (1,500) defined according to technology, age, power system, installed capacity
  - Regulatory period of 6 years; current rate of return = 7.398%
  - Future installations to be decided via tenders / auctions
Power generation in SIPSS

Major regulatory concern #1

- HIGH exploitation cost & compensation

Total generation costs in SIPSS in two parts [M€] & unitary compensation [€/MWh]

Mayor drivers of high costs:

- Dependence on petrol
- Rigid standardised cost system
- Low penetration of RES-E
- Dispatching of TSO
  - Criteria #1: min ENS
  - Criteria #2: min cost
- Final consumers dominantly residential
- Environmental restrictions

Source: CNMC
Major regulatory concern #2

- Low level of RES-E penetration despite of lower cost

Remuneration of thermal plants in Balearic and Canary Islands vs wind installations in Spain, €/MWh

Source: CNMC
On-going reforms in SIPSS

- **New regulatory differentiation of power plants**
  - Controllable generation
  - Intermittent generation
  - Hydro pumping stations (for system security)

- **Improve productive efficiency & Reduce exploitation costs**
  - Stricter control over operation of plants
  - Penalisation of thermal plants if availability <30%
  - Possible curtailment of RES-E for economic reasons
  - **New price signals in final consumer tariff reflecting system costs**
  - **Additional payments for PV & wind if (0.55*V_{c_{system}}) > V_{C_{system}}**

- **Market elements**
  - **Tenders / Auctions** for new PV and Wind capacity
  - **Tenders / Auctions** for fuel supply of thermal plants

- **Strengthened role for TSO**
  - Demand forecast for all time frames
  - Proposing necessary new capacity (technology & location)
  - Ownership of pumping stations for balancing purposes
Population of the island: 11 thousand inhabitants

Power generation on El Hierro Island is based on diesel:

- Thermal plant: Llanos Blancos (11 MW: 9 units with 0.7 – 2 MW)
- Renewable: Wind (280 kW) & PV (≈5kW)
- HWPP (6 MW + 11 MW), starting operation in June 2014
**Technical characteristics**

- Windmills (11.5 MW) with lifetime = 20 years
- Turbination (11.32 MW) [65 years]
- Pumping (6 MW) [65 years]
- One connection point with the network: joint operation & remuneration of windmills and pumping – turbination.

**Ownership structure (Consortium)**

- Cabildo (Insular Authority) 60%
- Endesa 30%
- Instituto Tecnológico de Canarias 10%

**Financing**

- Total Investment ≈ 80 M€
- State aid: 35 M€
Main regulatory goals:

- Improve economic and energetic efficiency of power generation on the island
- Integration of RES-E: storage of wind energy
- Control for electrical network frequency and stability
- Reduction of GHG emissions
- Less dependency on petrol products (volatility)
- Lower overall exploitation costs of the island
- Store excess wind energy for pumping
- HWPP absorbs reserve capacity requirements, thus allowing for more efficient exploitation of the thermal plant
**Operation of HWPP**

- **Integrated operation of HWPP**
  - Windmills exploited jointly with pumping station

- **TSO: operates the whole power system on El Hierro.**
  - Given storage capacity, HWPP is dispatched according to:
    - Relationship between instantaneous demand & wind generation
    - Reservoir levels

- **Diesel plant (Llanos Blancos) cannot be used for pumping**
  - The upper reservoir can only be filled up by wind energy.

- **Currently, pumping covers 2 days of demand in a month**
  - Due to technical problems, reduced operation in the first year.
Remuneration

Although HWPP is a renewable plant, its remuneration is similar to that of a thermal plant.

- Fixed payment on the basis of net hydro capacity

\[ FC = INV + \text{COMT}_F + \text{GRLL} + \text{RA} \]

- GRLL = cost of filling the reservoir for the first time
- RA = additional payment (max. 122,079 €/MW\text{hydro})
- Audited values of investment and fixed O&M costs should be evaluated \textit{ex-post} due to lack of experience in this kind of installations.

- Established variable cost = 15,57 €/MWh
- Rate of return: state bonds + 200 bp (7.398%)
- Due to integrated exploitation of hydro & wind parts, the internal energy consumption of HWPP used for pumping is not remunerated (directly).
Key aspects of regulation:

Pumping exclusively with wind energy

- The diesel plant cannot be used for pumping, neither for security reasons is it permitted.
- If diesel plant were allowed to pump, it would imply paying twice for the corresponding turbined energy.
- This setup allows for maximising REE-E integration.

Efficiency factor of pumping station

- Its variation can have a significant effect on variable costs and on the hours of operation.

Min. # hours of operation for pumping station

- Established at 2,688 h/year
- In case it is too low, the remuneration could be excessively high.
Lessons learned in SIPSS

Singularity of SIPSS
- Adopt measures that recognise the singularity of each and every power system.
- Operation and retribution should not necessarily be linked to Mainland Spain.

Foster RES-E penetration through tendering
- Given abundant resources and in order to avoid economic distortions, instead of direct subsidies for RES-E, it is preferable to apply competitive tendering. Key issue: DEMAND FORECAST
- In order to alliviate potential risks of “over-remuneration”, competitive auctions or tendering can adjust better to future incurred costs.

Administrative ease
- Urgent need for accelerating burocratic paperwork / cut the redtape

End-user prices should reflect generation costs
- Efficient price signals can foster penetration of new technologies and distributed generation.
Thank you

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