Integration of Hydro-Wind Power Generation on El Hierro Island

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IEA EGRD Workshop:
ISLANDS ENERGY – STATUS AND PERSPECTIVES
Tokyo, October 5-6, 2015
1. Power generation on El Hierro Island
2. Technical characteristics of HWPP
3. Regulatory framework for HWPP
4. Environmental impacts
5. Concluding remarks
Population of El Hierro: 11 thousand inhabitants

Power generation on El Hierro Island has traditionally been based on diesel, in the future HWPP might imply a share of RES-E higher than 50%:

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

**Offer a technical solution for RES-E integration**
- Store excess of wind energy by pumping.
- Control for electrical network frequency and stability.

**Improve energetic efficiency of power generation on the island**
- HWPP provides reserve capacity allowing for a more efficient operation of the thermal plant

**Reduce overall exploitation cost of the island**
- Unforeseen increase of budget due to: 1) tectonically complex soil & 2) simultaneous operation mode of pumping and turbines

**Reduce GHG emissions**

**Reduce dependence on oil products with volatile prices**
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**Characteristics of HWPP**

**Technical characteristics**
- Upper reservoir: 556,000 m³
- Lower reservoir: 150,000 m³
- Windmills (11.5 MW) with lifetime = 20 years
- Turbines (11.32 MW) [65 years]
- Pumping (6 MW) [65 years]

**Ownership structure (Consortium)**
- Cabildo (Insular Authority): 60%
- Endesa: 30%
- Technological Institute of Canary Islands: 10%

**Financing**
- Total Investment ≈ 80 M€ including State aid of 35 M€
Operation of HWPP

Integrated operation of HWPP

- HWPP has only one connection point to network: Windmills exploited jointly with pumping station with possibility of simultaneous pumping & turbine modes
- Operating modes: 1) supplying demand; 2) storing excess of wind energy.
- Minimum hours of operation for pumping: established at 2,688 h/year

Diesel plant (Llanos Blancos) cannot be used for pumping

- The upper reservoir can only be filled up by wind energy.

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
- Storage capacity considered currently for 2 days due to lack of reliable data of operation
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Some regulatory features

Mainland Spain

- Liberalization 1998
- Market processes (MIBEL)
  - Forward contracts
  - Day ahead (D-1)
  - Intraday (D)
  - Balancing (TSO)
  - Bilateral contracts

Common aspects

- TSO
- DSOs
- Supply

SIPSS

(Small & Isolated Power Systems of Spain: Balearic Islands, Canary Islands, Ceuta & Melilla)

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

Compensation for generation

UNMARKET & No bilateral contracts

RES-E
Power generation in SIPSS

Conventional generation (thermal) and hydro-wind power station

- Cost plus regulation with standardized two-part tariffs (FC + VC)

\[
FC = \text{INV} + \text{COMT}_F + \text{GRLL} + \text{RA} \\
VC = C_{\text{fuel}} + C_{\text{start-up}} + C_{\text{res}} + C_{\text{om}} + C_{\text{reg}}
\]

- Fuel cost updated every 6 months
- Annual indexation (IPC-X or IPRI-X) on fuel logistic costs, start-up cost, COMTF & Com
- Useful life of installations: 25 years, in case of hydro: 65 years (lineal depreciation)
- Rate of Investment return: 10 year State bonds + 200 bp

- Costs covered by: Mainland MP\textsubscript{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 in tenders / auction
On-going reforms in SIPSS

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

Improve productive efficiency & Reduce exploitation costs
- Stricter control over operation of plants
- Penalization 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 \times V_{C_{\text{system}}}) > V_{C_{\text{RES-E}}_{\text{unit}}})

Market elements
- Auction for new PV and Wind capacity
- Auction 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
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

\[ FC = INV + COMT_F + GRLL + RA \]

- GRLL = cost of filling the reservoir for the first time
- RA = additional payment (max. 122,079 €/MW_{hydro})
- Audited values of investment and fixed O&M costs should be evaluated *ex-post* due to lack of experience in this kind of installations. However, fixed O&M is established also *a priori* at 21,600 €/MW.

- Established variable cost = 15.57 €/MWh
- Rate of return: 10 year 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).
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<th>Environmental impacts</th>
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<td><strong>Earthworks in a biosphere reserve</strong> [-]</td>
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<td>- High ecological costs</td>
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<td>- High economic costs</td>
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| **Freshwater reservoirs** [+]
| - Forestall well from going to brackish |
| **Potential for CO₂ reduction** [+]
| - If HWPP had produced 50% of demand in 2014, it would have led to a reduction of approx. 15 kt CO₂ |
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Concluding remarks

Reducing overall exploitation costs on islands

- Unbundling on islands, where possibility of market conditions is reduced, might not lead to cost reduction.
- Smart grid elements, like distributed generation and storage, might improve cost efficiency and foster integration of intermittent generation in the future.

Islands vs Cities

- **Similarities:**
  - Space limitations that encourage rooftop generation
  - Densely populated areas: island >> mainland; cities >> countryside
  - Difficult and expensive development of distribution network: permits & authorizations
- **Differences:**
  - Islands usually lack interconnections via backbone transmission networks, while large cities are typically surrounded by high-voltage transmission rings
  - Islands tend to have regulated conditions, while cities market conditions
Thank you for your attention!

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