Integration of Hydro-Wind Power Generation on El Hierro Island

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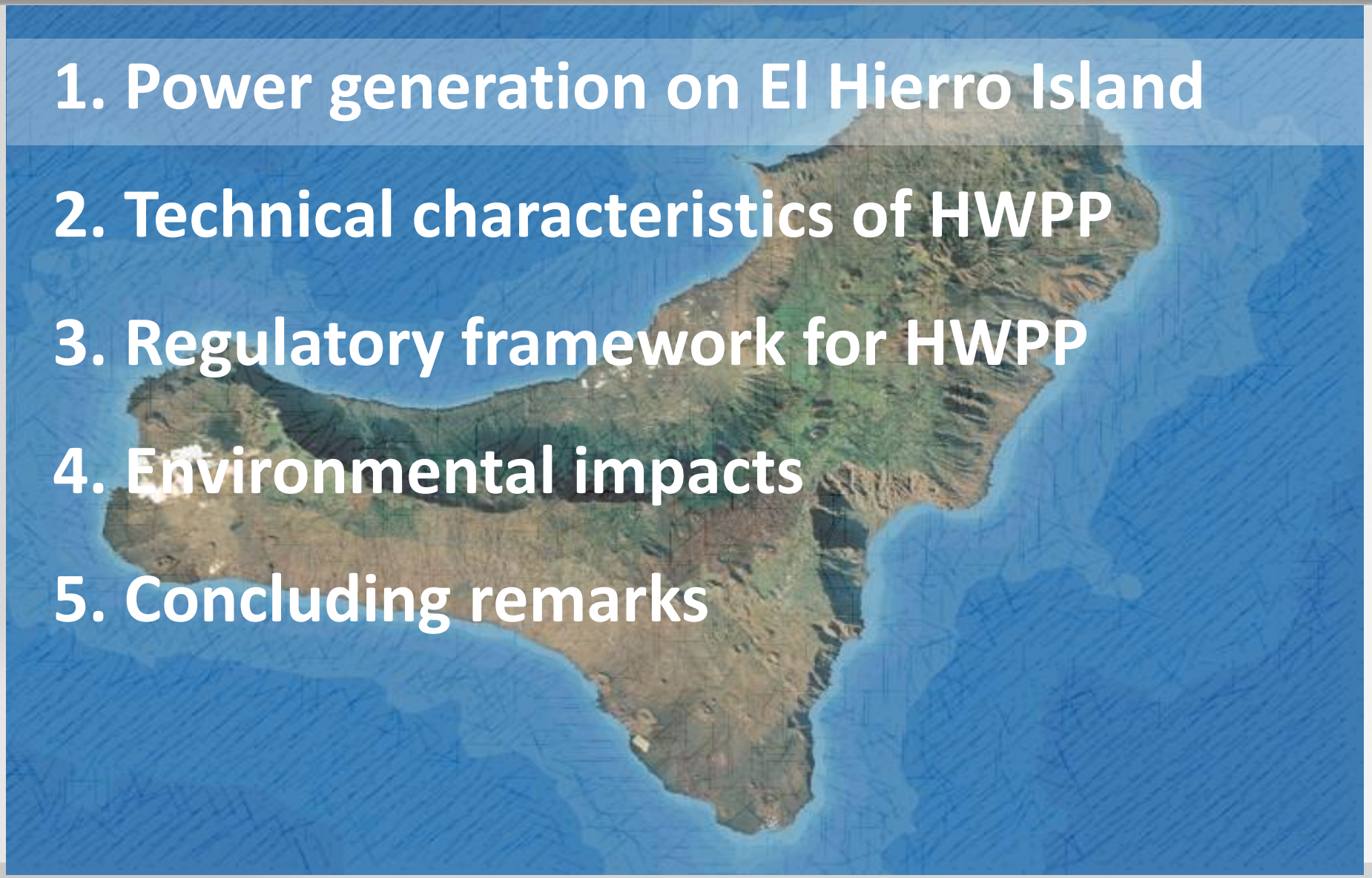
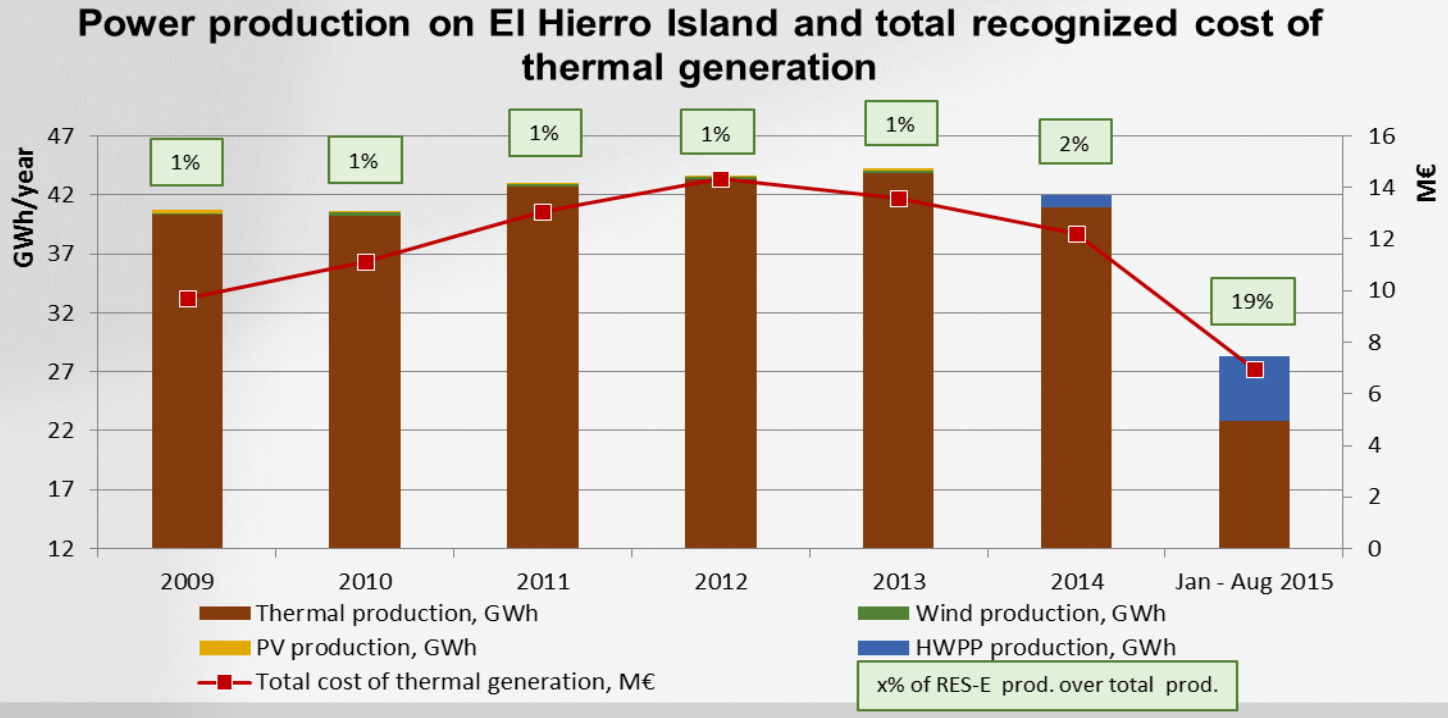
OUTLINE



1. Power generation on El Hierro Island
2. Technical characteristics of HWPP
3. Regulatory framework for HWPP
4. Environmental impacts
5. Concluding remarks

Power generation on El Hierro Island

- 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



Power generation on El Hierro Island

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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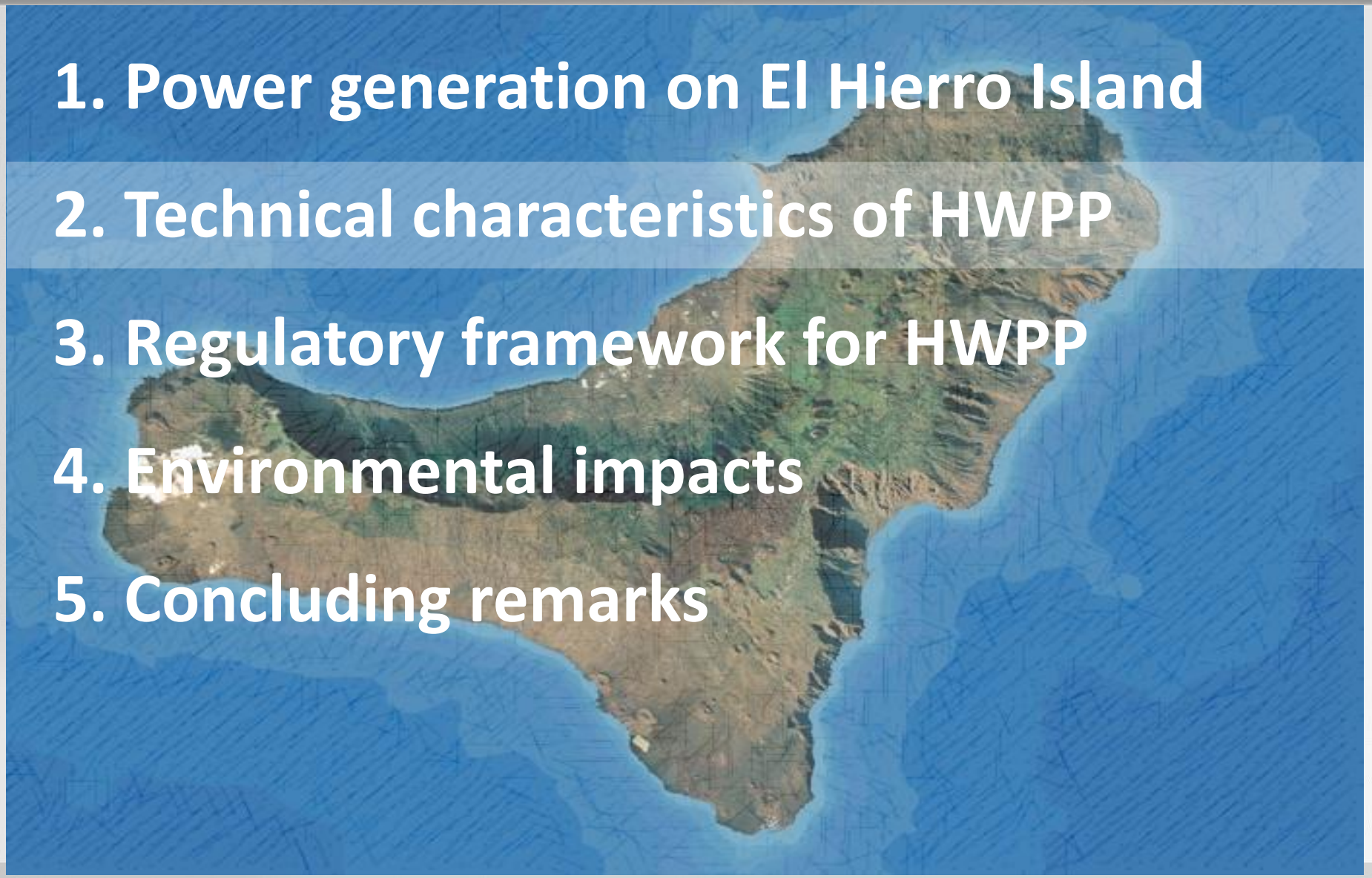

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Characteristics of HWPP

Technical characteristics

- Upper reservoir: 556,000 m^3
- Lower reservoir: 150,000 m^3
- Windmills (11.5 MW) with lifetime = 20 years
- Turbines (11.32 MW) [65 years]
- Pumping (6 MW) [65 years]

Ownership structure (Consorcium)

- 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

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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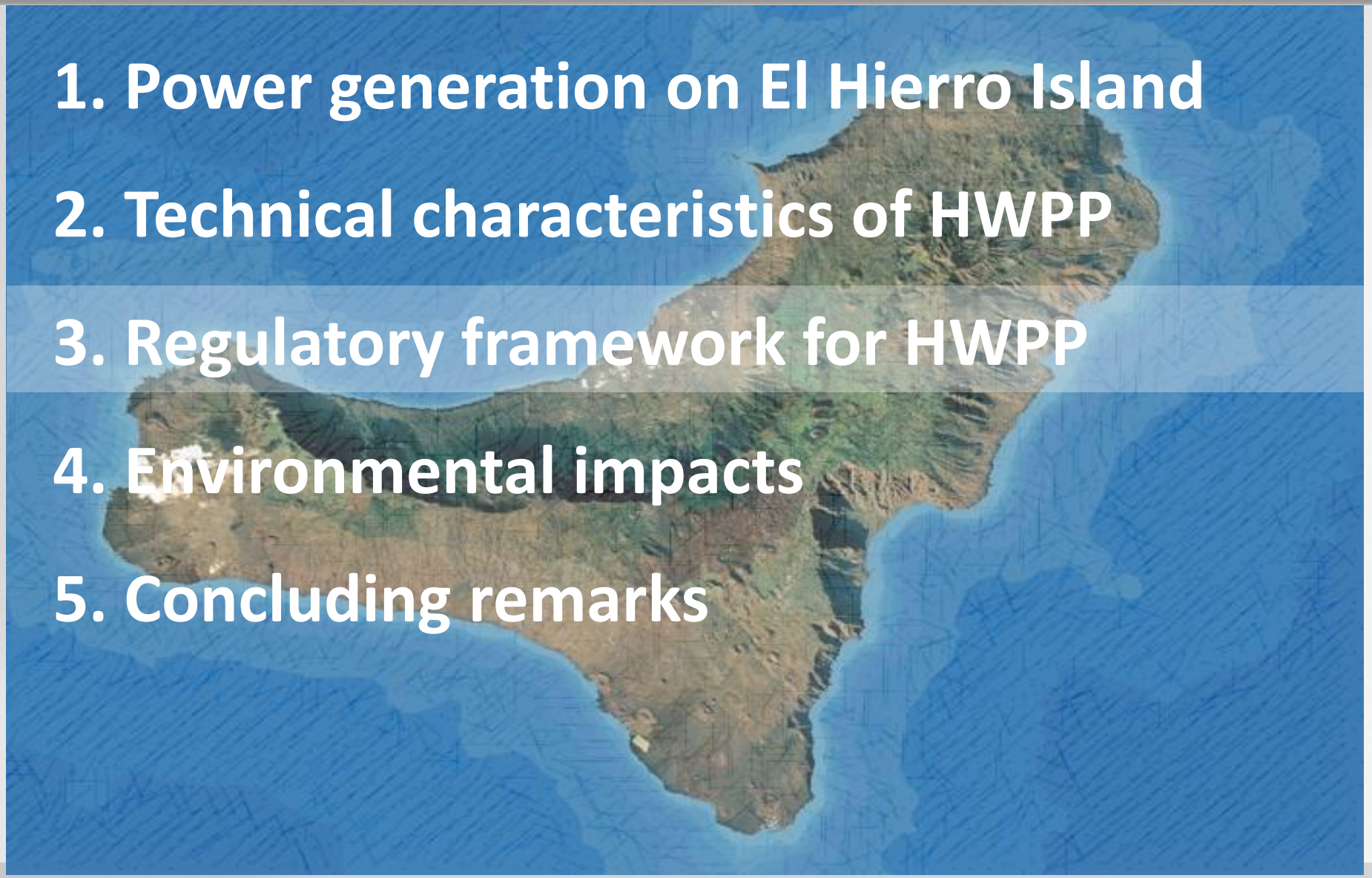

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Regulatory comparison

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

RETAIL PRICE

RES-E

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

Power generation in SIPSS

Conventional generation (thermal) and hydro-wind power station

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

$FC = INV + COMT_F + GRLL + RA$

$VC = C_{fuel} + C_{start\text{-}up} + C_{res} + C_{om} + C_{reg}$

  - 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_{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 ($0.55*VC_{system}$) > $VC_{RES\text{-}E\_unit}$**

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

Remuneration of HWPP

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

$$FC = INV + COMT_F + GRLL + RA$$

  - 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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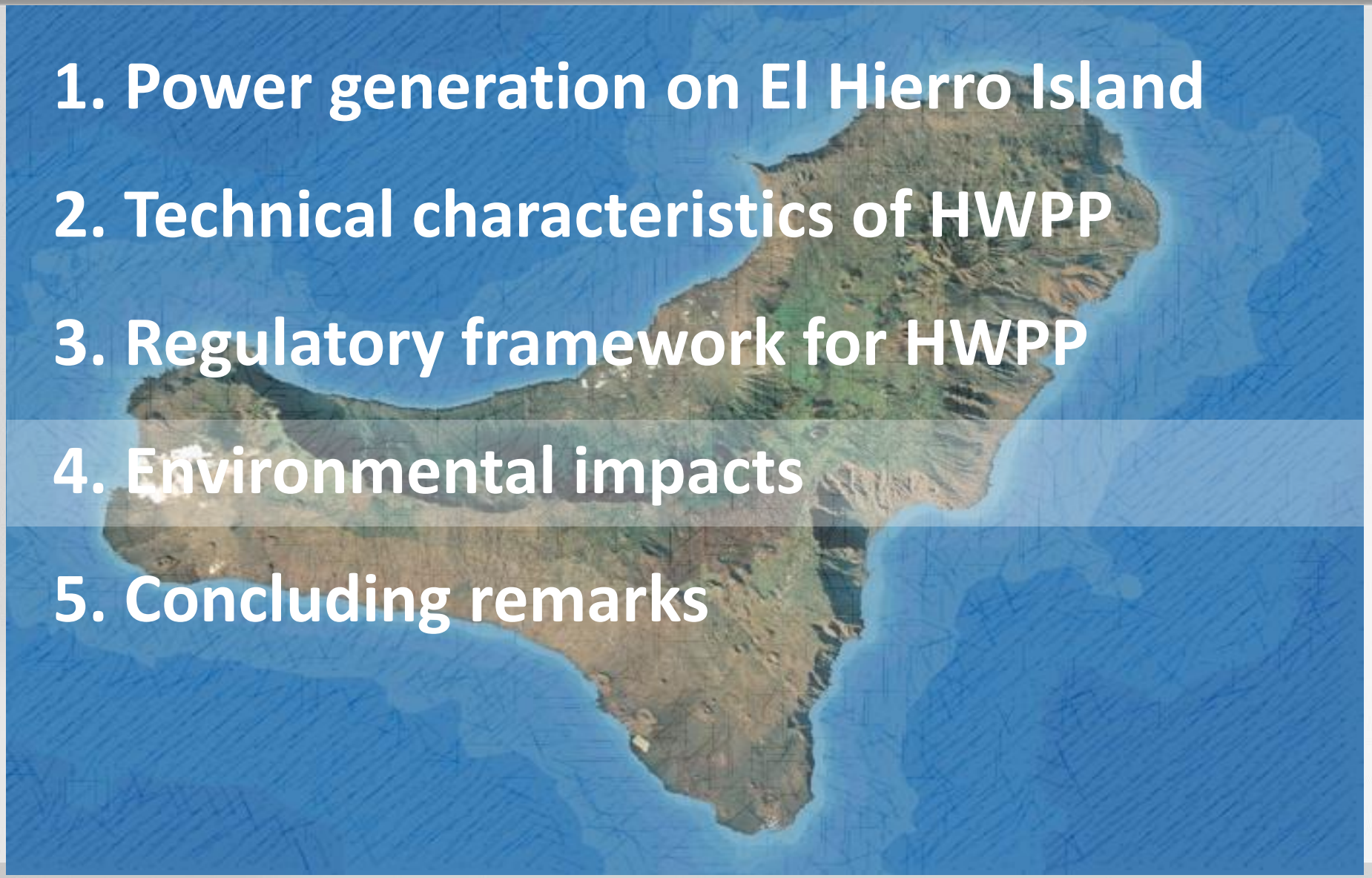

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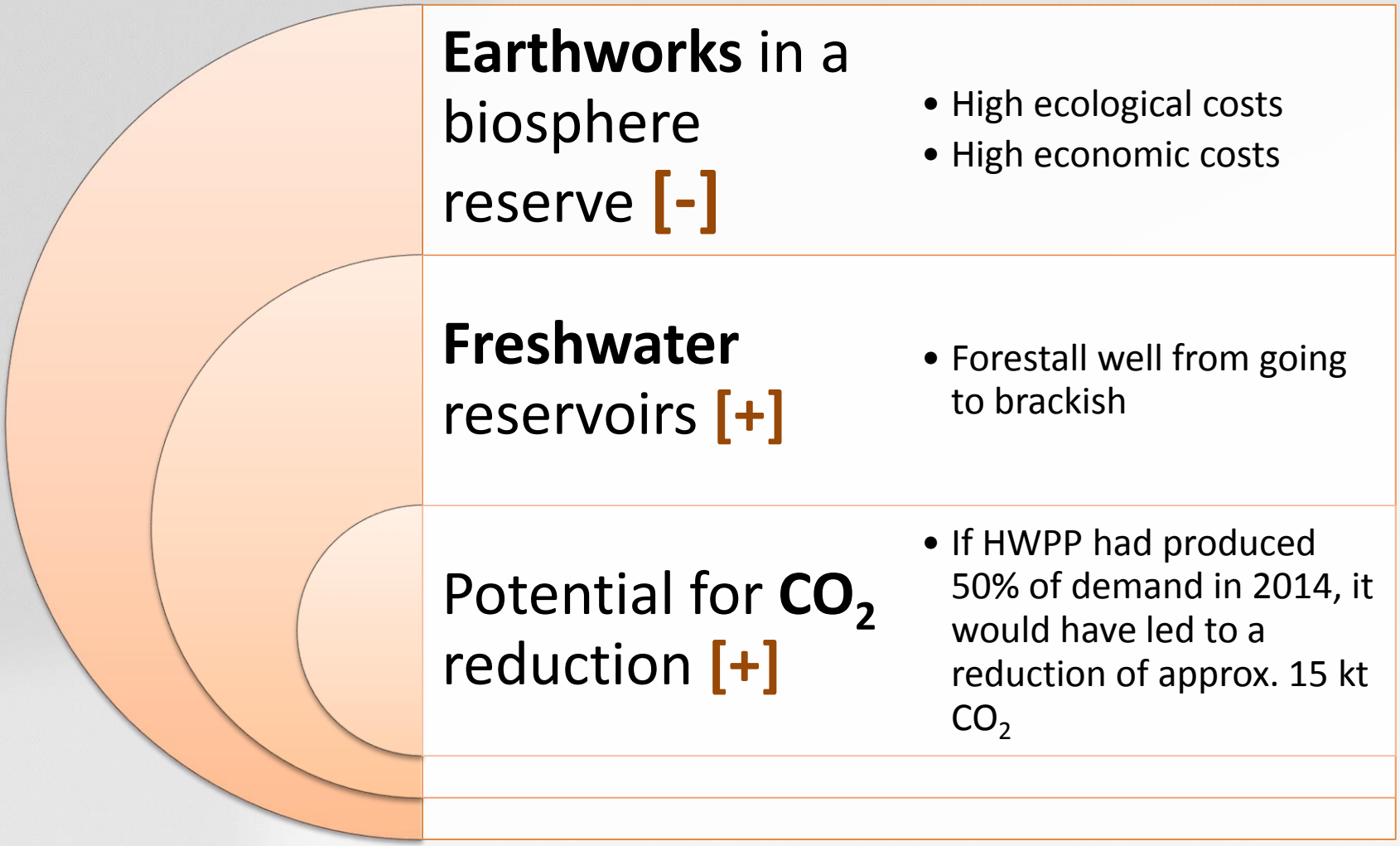
Environmental impacts



Earthworks in a biosphere reserve **[-]**	• High ecological costs • High economic costs
Freshwater reservoirs **[+]**	• Forestall well from going to brackish
Potential for **CO_2** reduction **[+]**	• If HWPP had produced 50% of demand in 2014, it would have led to a reduction of approx. 15 kt CO_2

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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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