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# H2 for intermittent energy storage The Porto Santo Pilot Project

ISR – University of Coimbra 27 of May 2008

Coimbra, 27 de Maio de 2008



# OBJECTIVES

- To show a model optimising hydrogen storage integration with renewable energy sources
- To show a way to increase RES penetration
- To show a way for increasing security of energy supply for islands
- To show a path for sustainable development of islands



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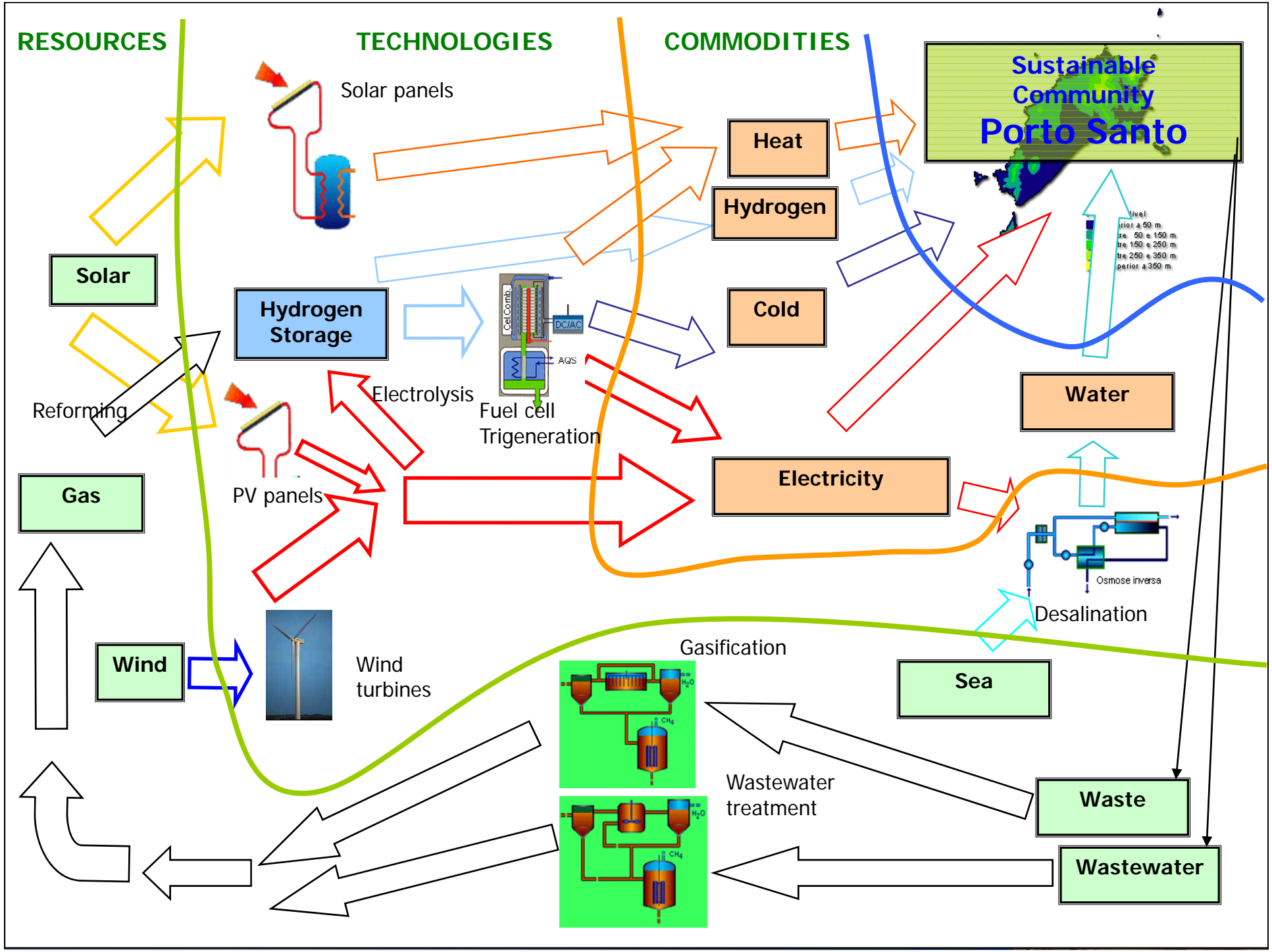
# Problems in Islands

- Isolation
- Small local markets
- Higher costs of energy, transport and communication
- No economies of scale
- Security of supply



# Islands Advantages

- **Renewable sources have better economic viability due to depending less on size and fuel handling infrastructure**
- **Usually good renewable resources**
- **Renewable energy appeal to high quality tourists**





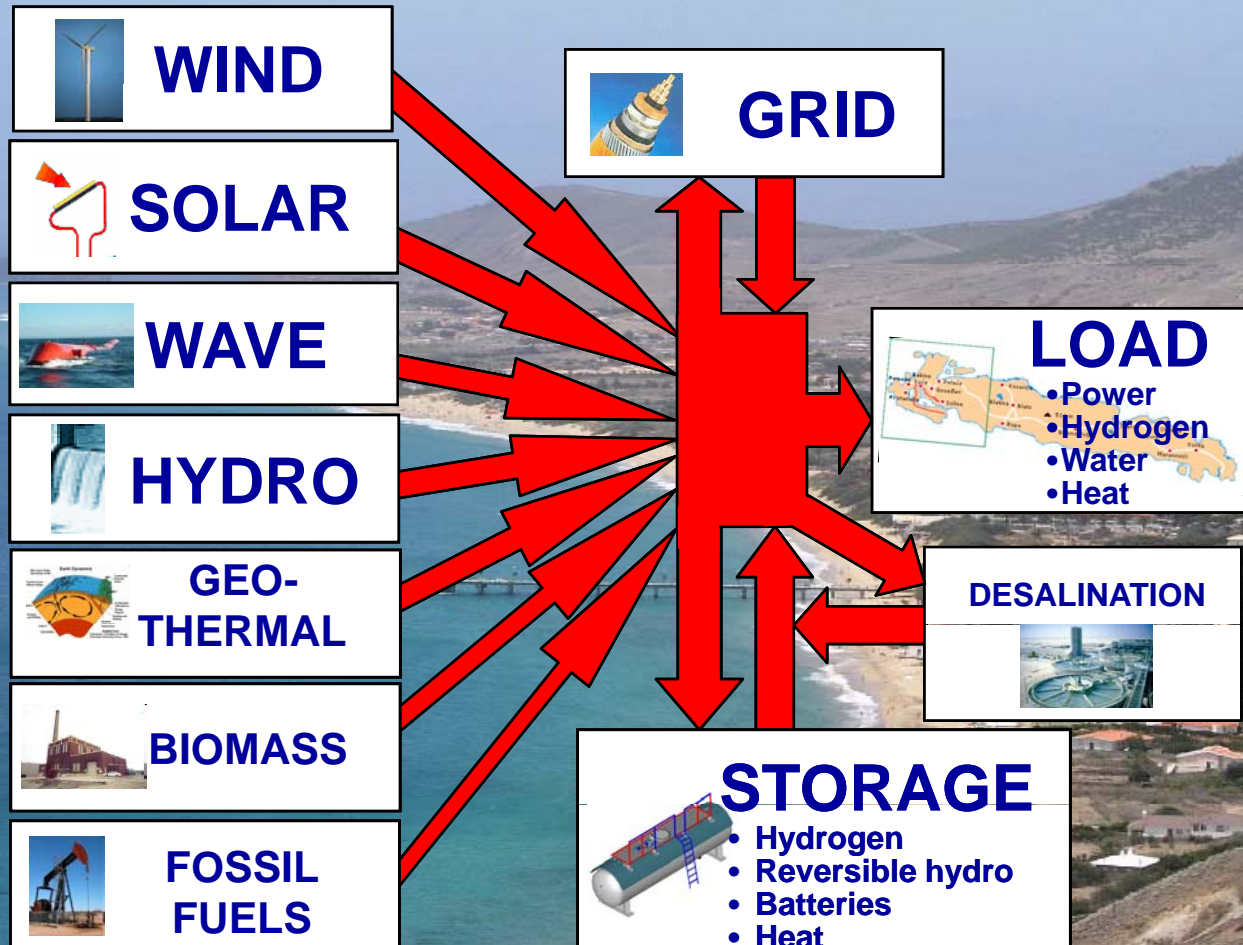
# H<sub>2</sub>RES MODEL

- **Energy planning tool**
  - **Small and medium power systems**
  - **Higher penetration of renewables**
  - **Integration of energy storage**
  - **Electricity dump: desalination or other**
- **Need to use time series instead of usual approach**



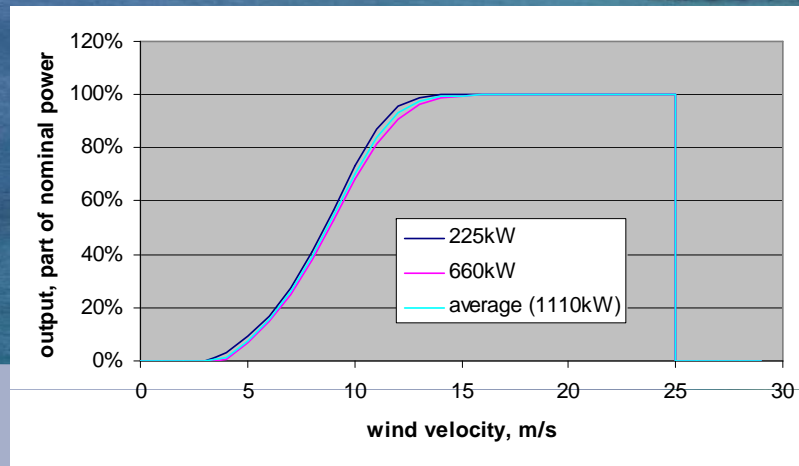
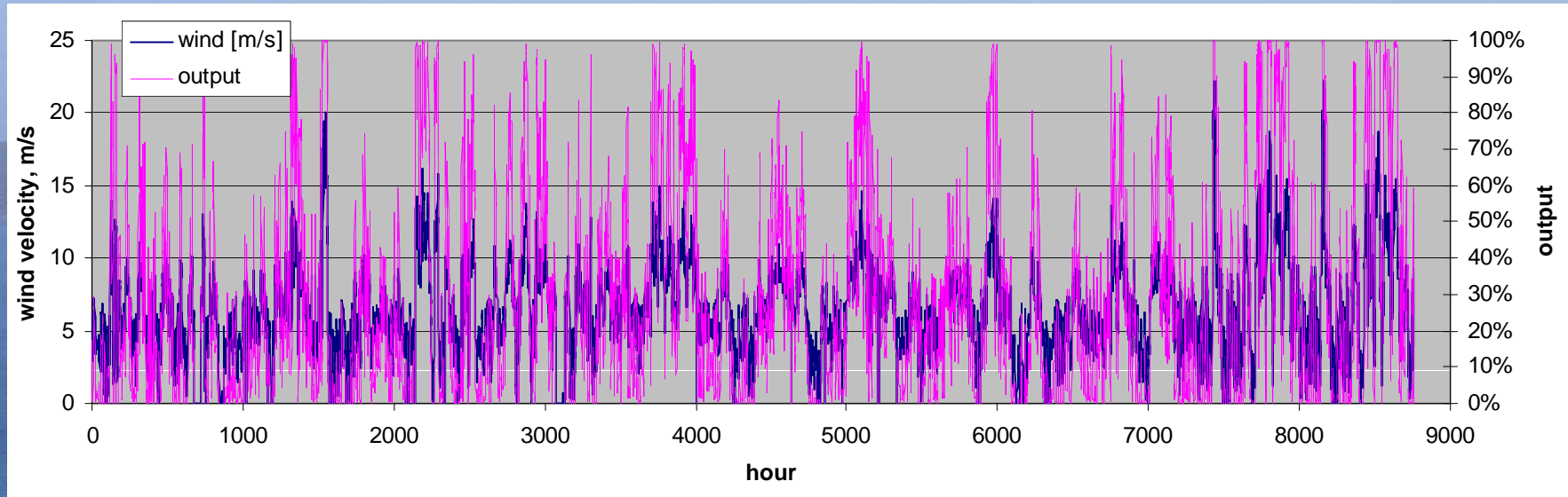
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# H<sub>2</sub>RES MODULES





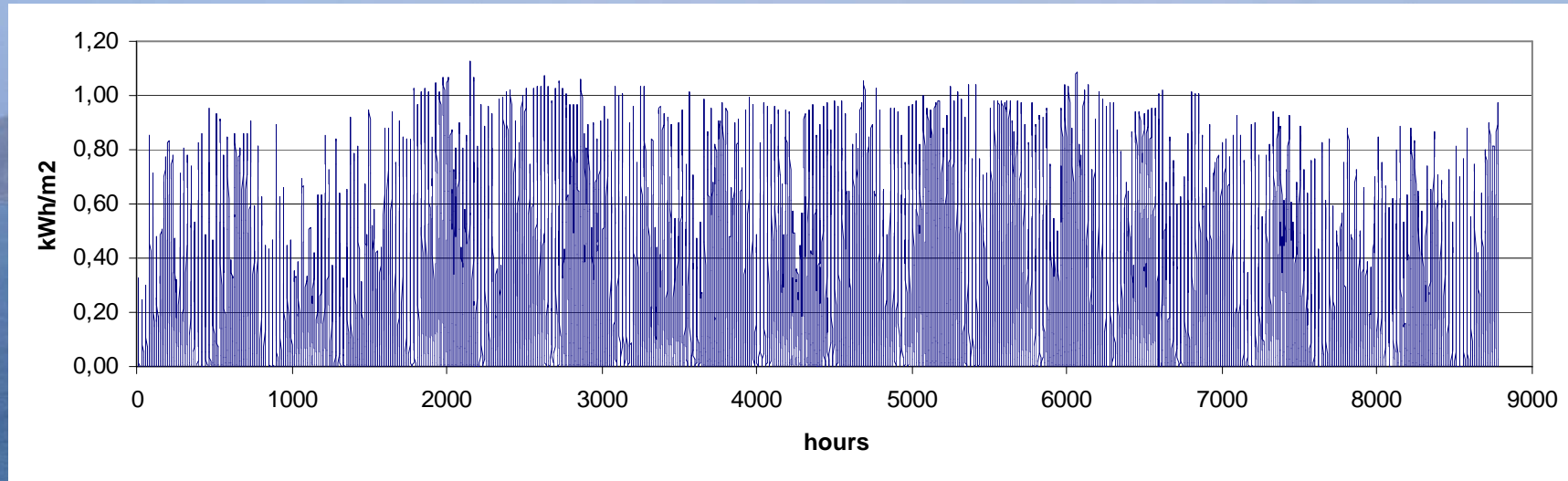
# H<sub>2</sub>RES – WIND MODULE



- Hourly wind velocity data obtained
- Converted into hourly potential output



# H<sub>2</sub>RES – SOLAR MODULE

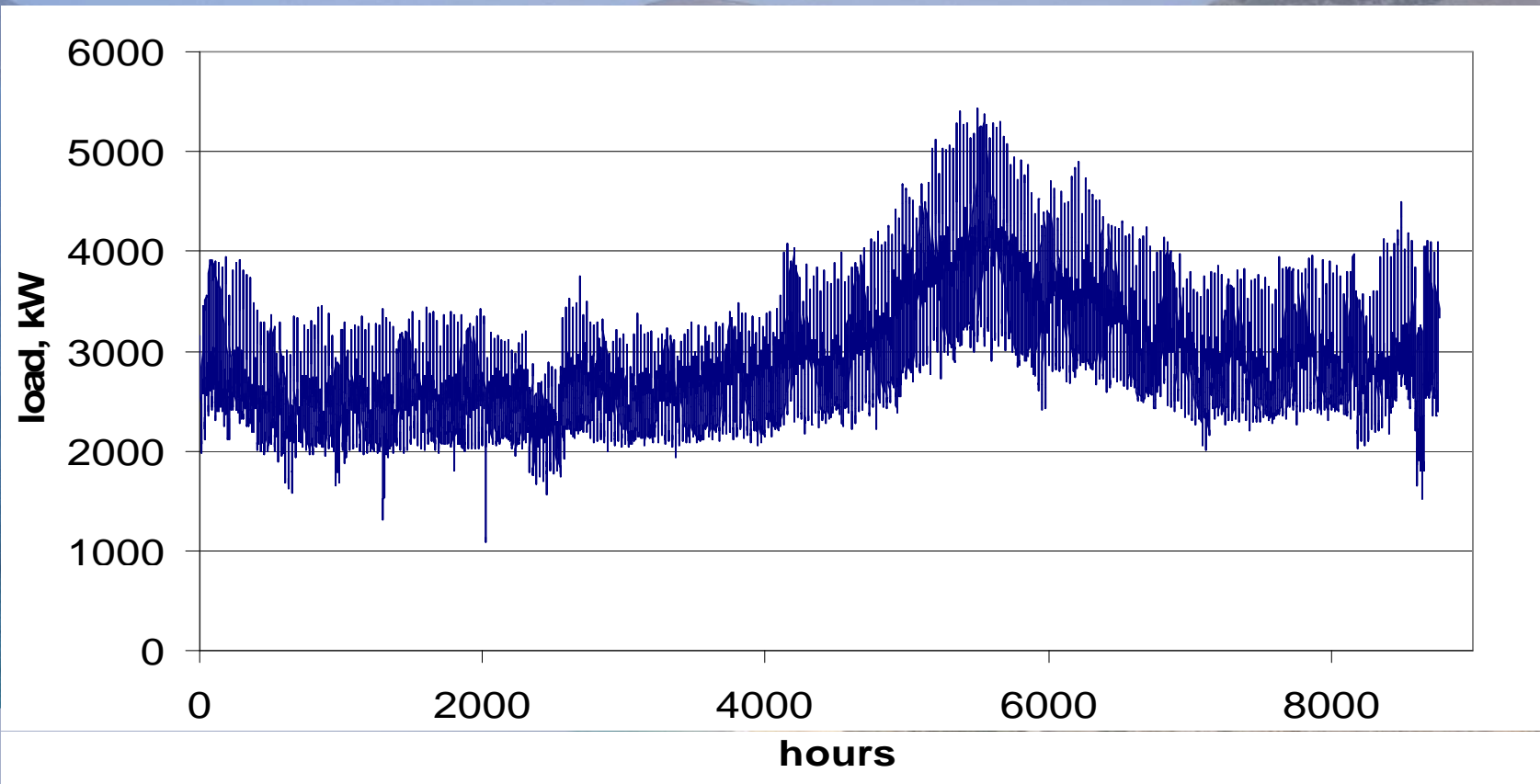


- Hourly total radiation on horizontal surface obtained and adjusted to the inclined surface (RETSCREEN)
- Converted into hourly potential output by efficiency provided from supplier



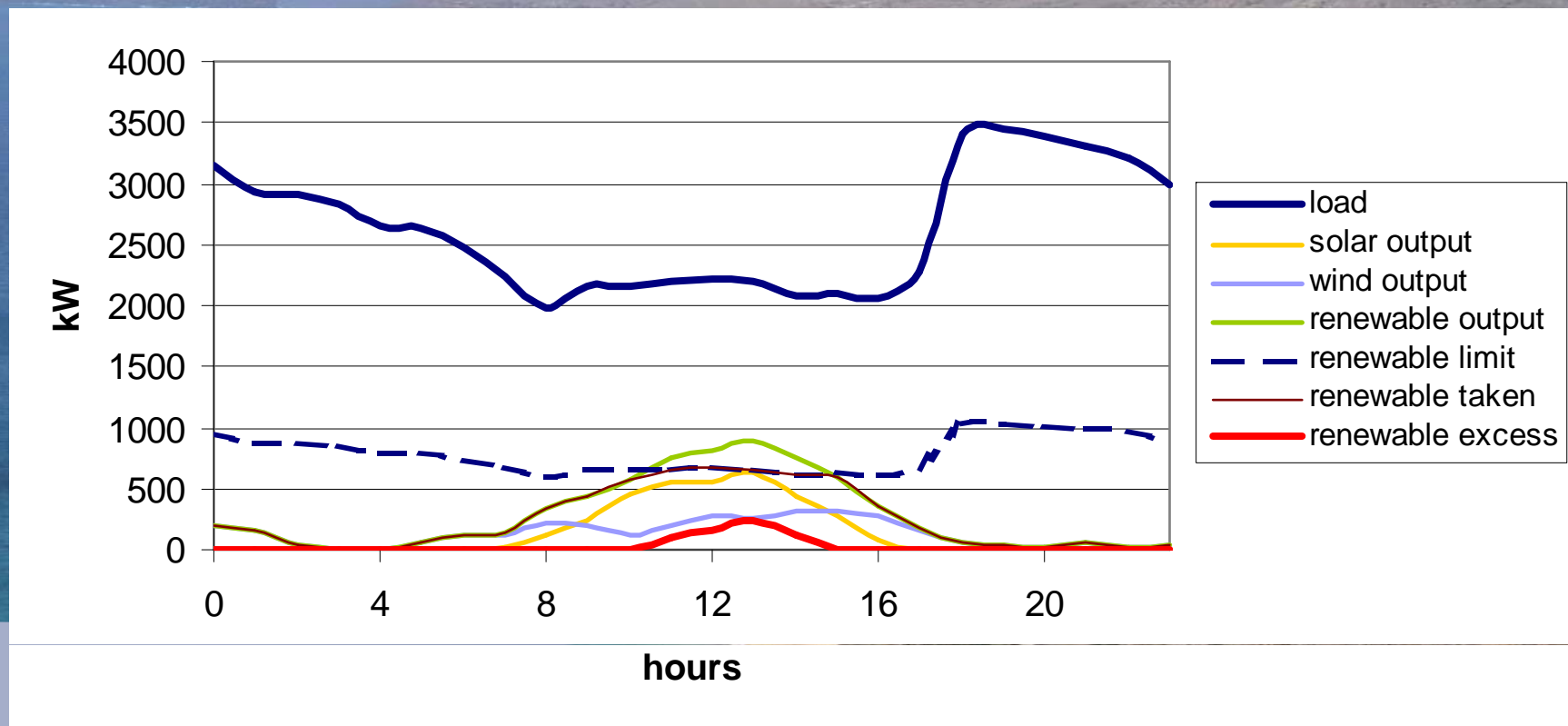
# H<sub>2</sub>RES – LOAD MODULE

- Hourly load of power system obtained



# H<sub>2</sub>RES – LOAD MODULE

- Limit to renewable intake
- Excess renewable rejected



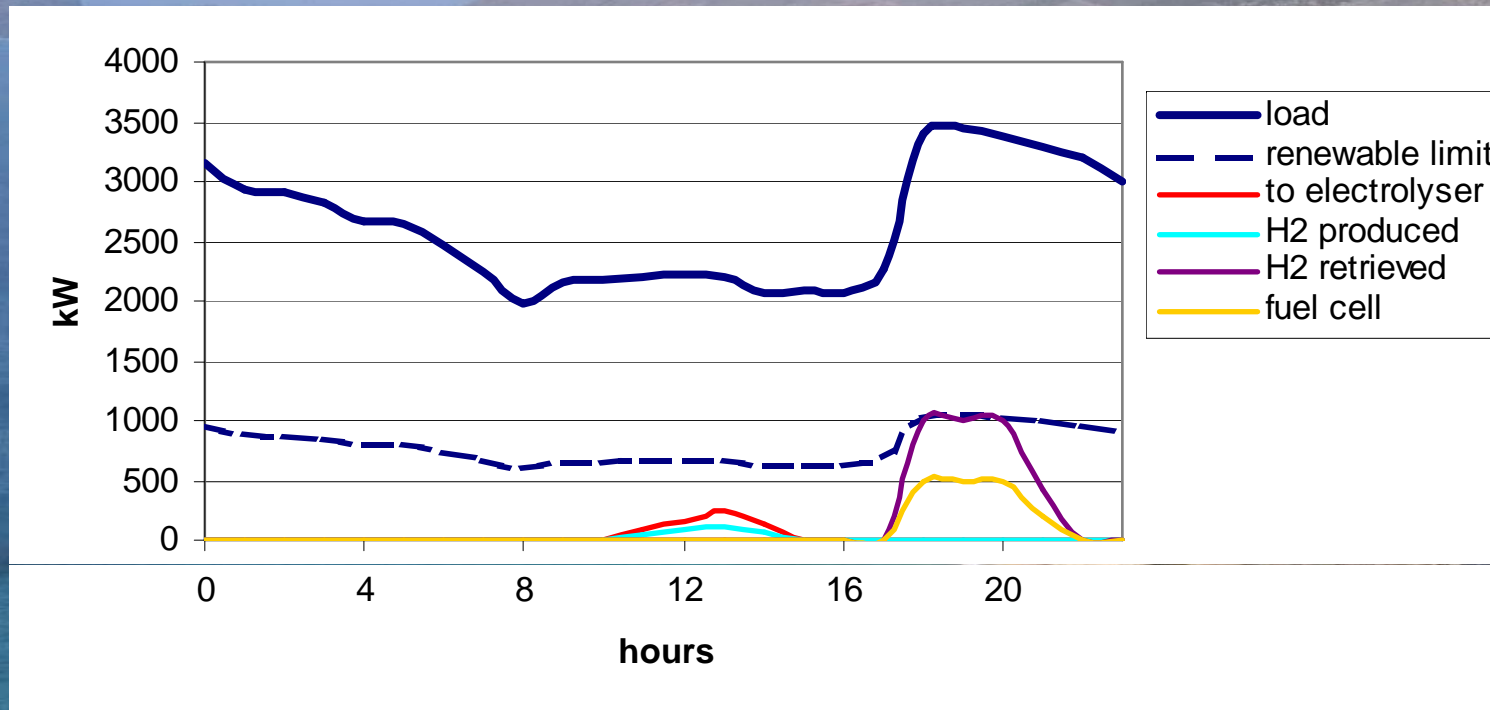
# H<sub>2</sub>RES – STORAGE MODULE – FILLING

- **Excess renewable taken to electrolyser**
  - **If less than electrolyser capacity**
  - **If hydrogen tank not full**
- **The rest rejected – taken to desalination or other electricity dump**



# H<sub>2</sub>RES – STORAGE MODULE – H<sub>2</sub> USED

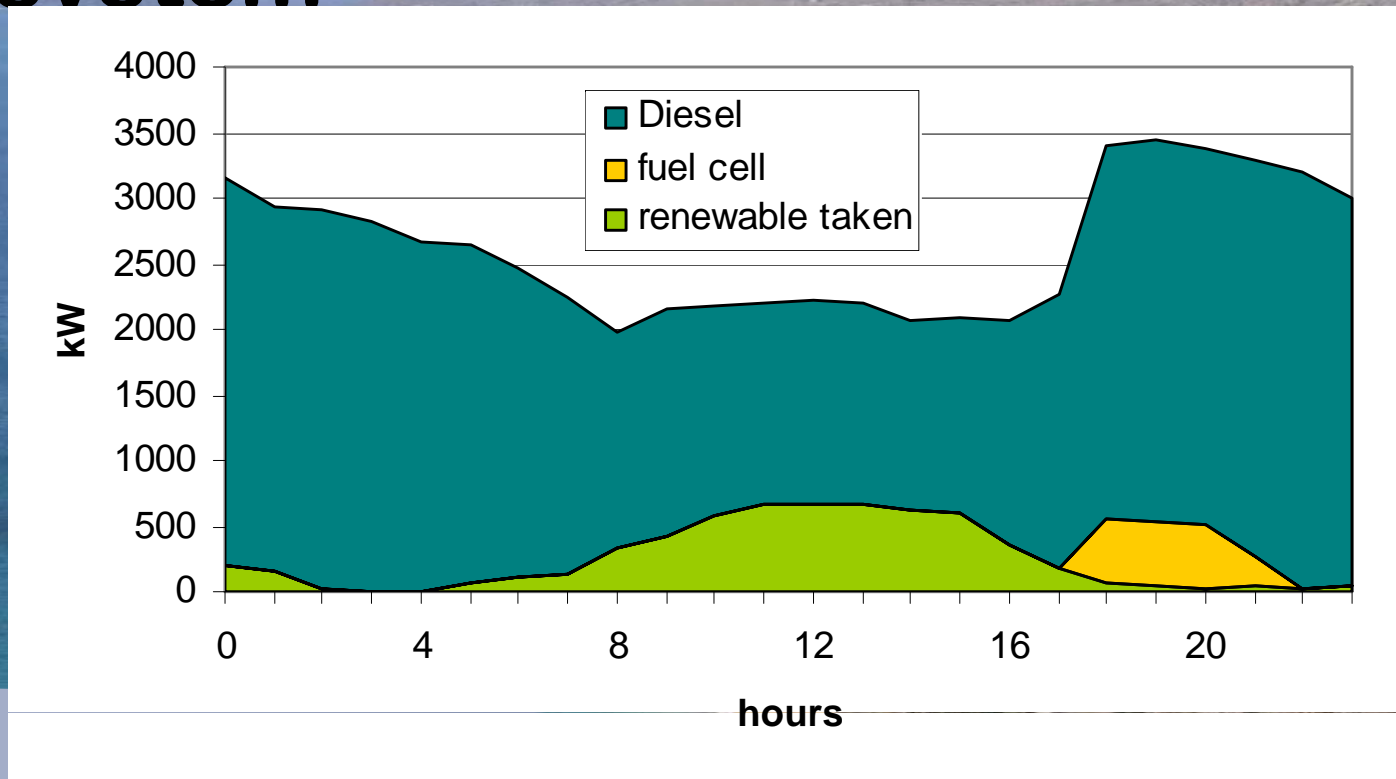
- During peak hours (various definition) **fuel cell** is turned on using hydrogen stored until tank is empty





# H<sub>2</sub>RES MODEL

- Electricity delivered to power system





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# PORTO SANTO

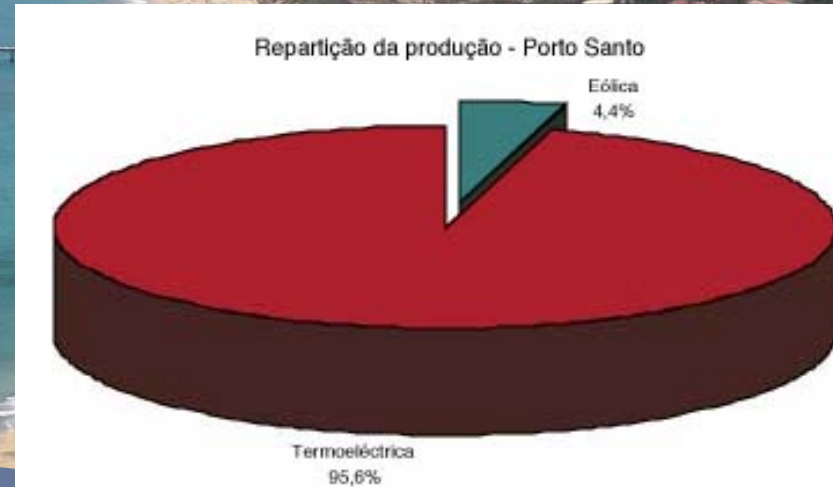
- Population:  
5000 in winter  $\Rightarrow$  **20000** in summer





# PORTO SANTO

- **Power system (2000):**
  - 13.8 MW thermal + 1.1 MW wind
  - 24.1 GWh thermal + 1.1 GWh wind
  - 5.6 MW peak, 2 MW base, 20% growth



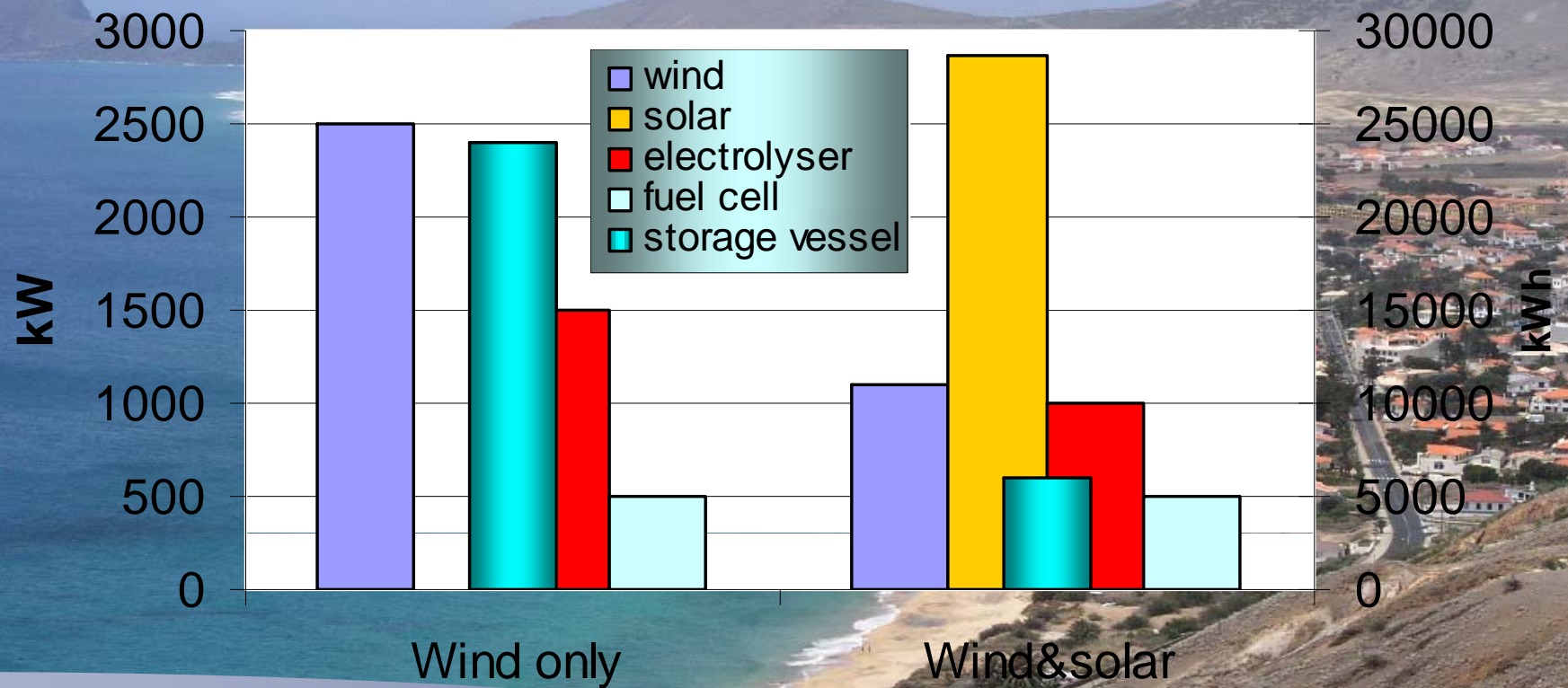


# PEAK SHAVING SCENARIA

- **Scenaria**
  1. **Wind only**
  2. **Wind as installed + solar**
- **Up to 30% renewable at any time can be taken by power system**
- **Excess to electrolyser**
- **Fuel cell for peak shaving, optimised at 1.8% of electricity delivered**

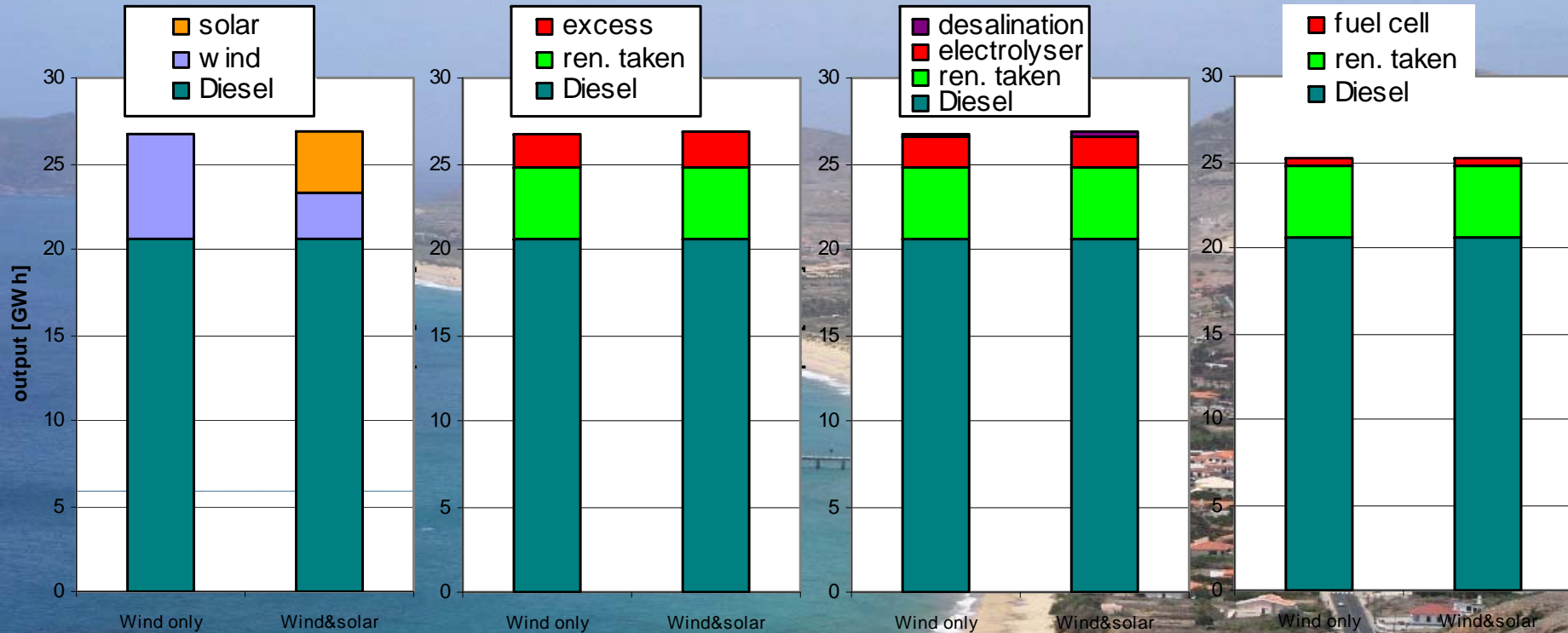


# PEAK SHAVING SCENARIO





# PEAK SHAVING SCENARIO



|            | peak serving time |
|------------|-------------------|
| Wind only  | 53%               |
| Wind&solar | 62%               |



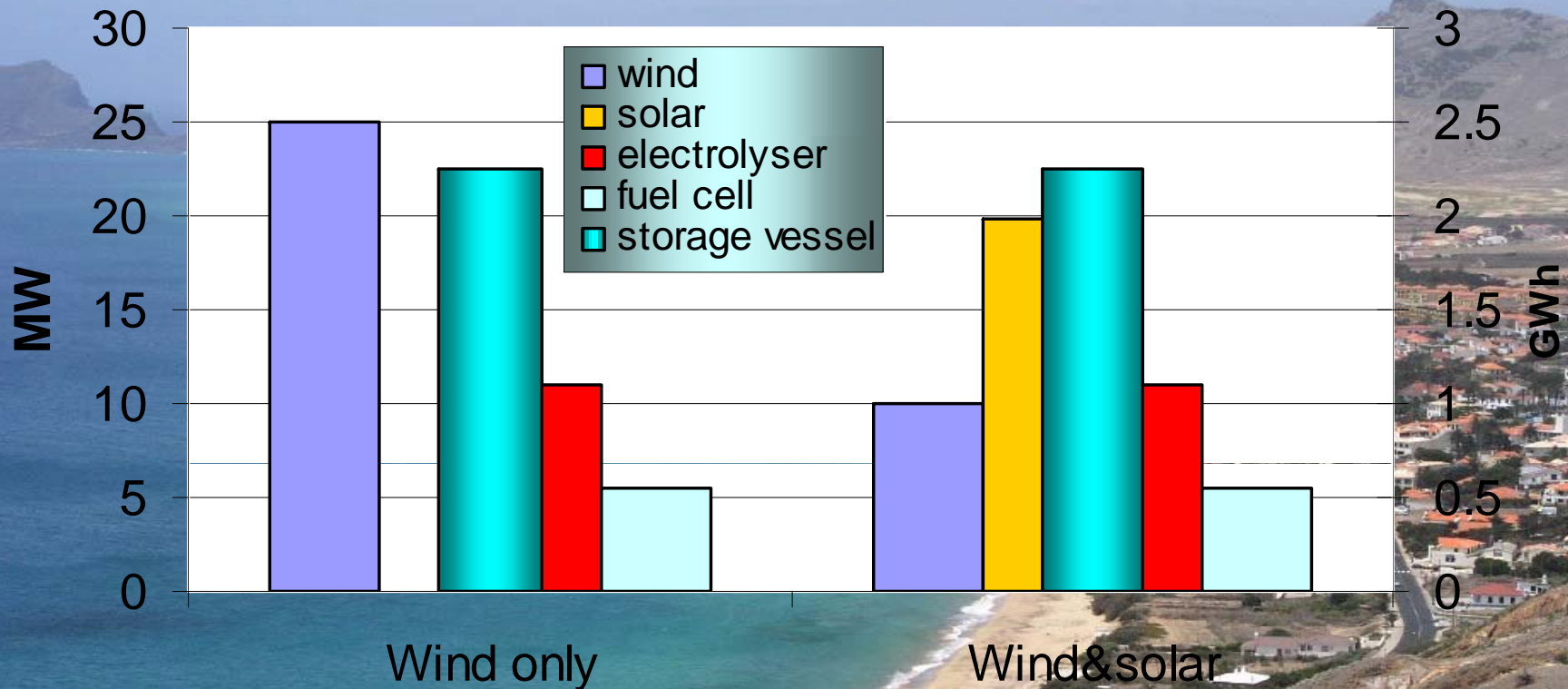
# 100% RENEWABLE SCENARIA

- **Scenaria**
  1. **Wind only**
  2. **Wind + solar**
- **Up to 100% renewable at any time can be taken by power system**
- **Excess to electrolyser + desalination**
- **Fuel cell to cover load when no renewable available**
- **Optimised on no Diesel**



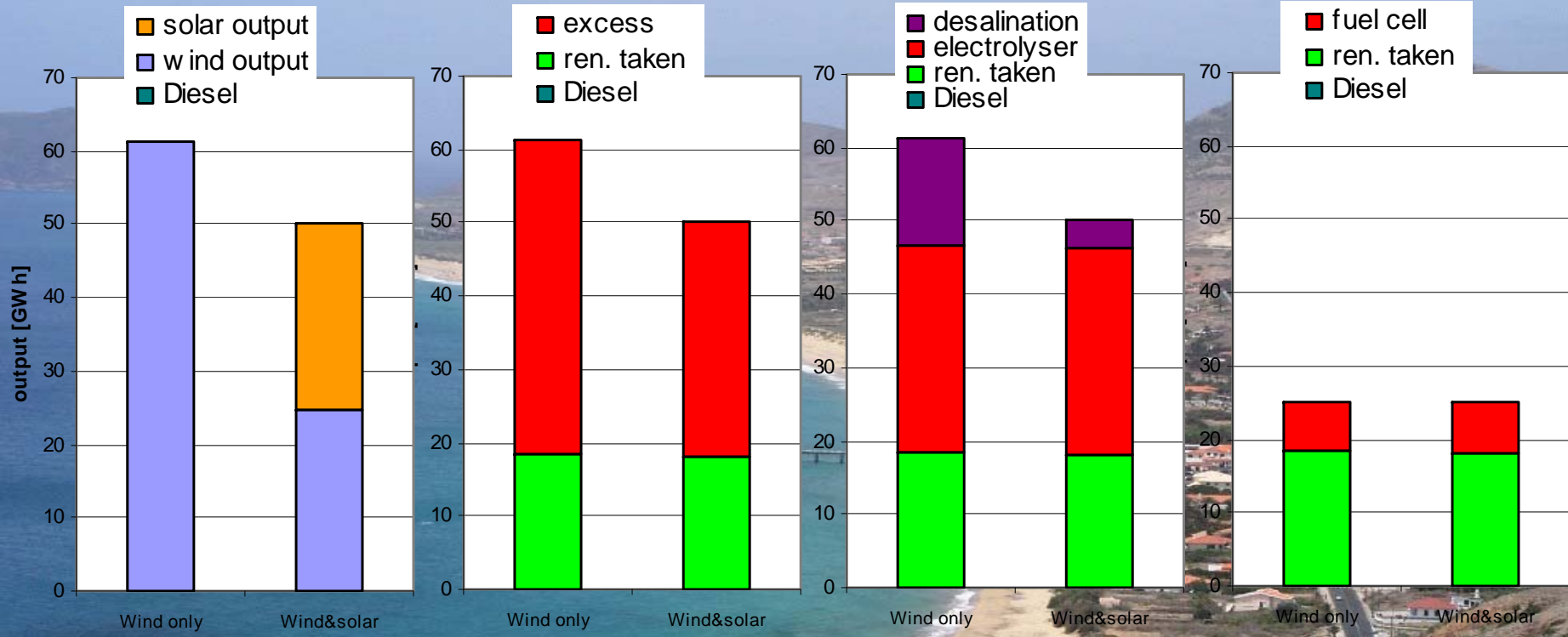
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# 100% RENEWABLE SCENARIA





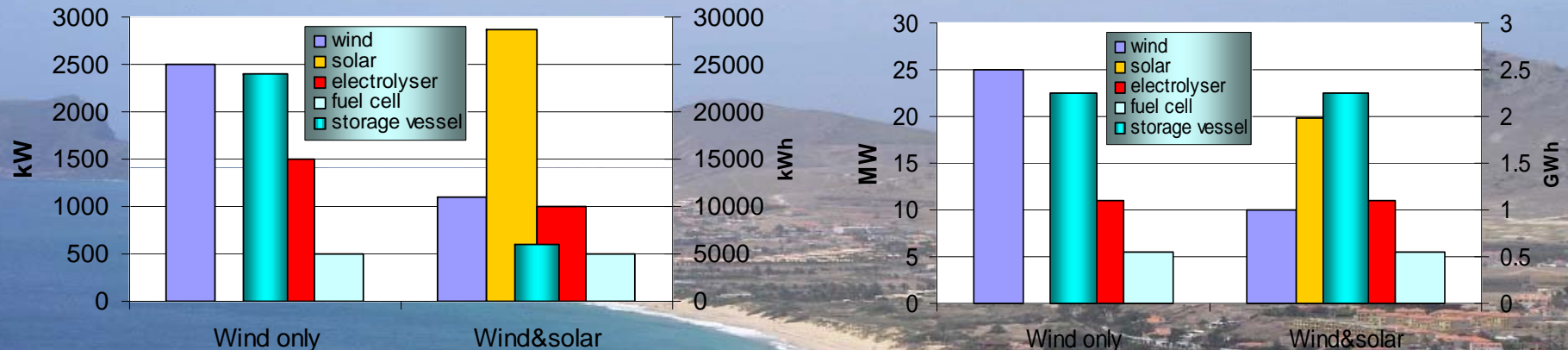
# 100% RENEWABLE SCENARIO



|            | fuel cell serving time |
|------------|------------------------|
| Wind only  | 37%                    |
| Wind&solar | 41%                    |



# H<sub>2</sub>RES CONCLUSIONS



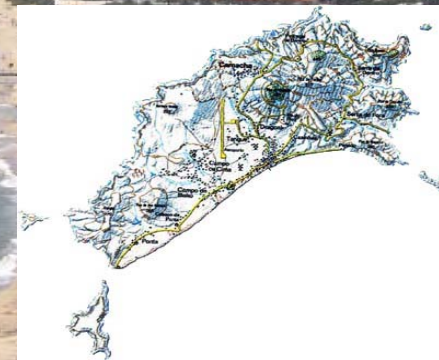
- For peak shaving wind&solar takes smaller storage and electrolyser
- For 100% renewable better wind only



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# PORTO SANTO

- Porto Santo Island
- Location: Madeira Archipelago
- Area: 42 km<sup>2</sup>
- Population: 5500 (winter) up to 15000 (summer)
- Climate: average temperature 18.4 °C, semi-arid, oceanic
- Main economic activity: tourism





# PORTO SANTO ENERGY SYSTEM

- **Thermal Power Plant with 2 groups of 3,5 MW diesel engines, 3 diesel engine groups of 4 MW and a windmill park of 1,1 MW.**
- **Wind contributes to almost 4,4% of total electricity consumption**



# OBJECTIVES

- **Demonstration of hydrogen potential as energy storage for intermittent sources**
- **Installation of a 7,5 kW Fuel Cell**
- **Electricity of the windmill park (1.1 MW) is used to produce hydrogen by electrolysis**



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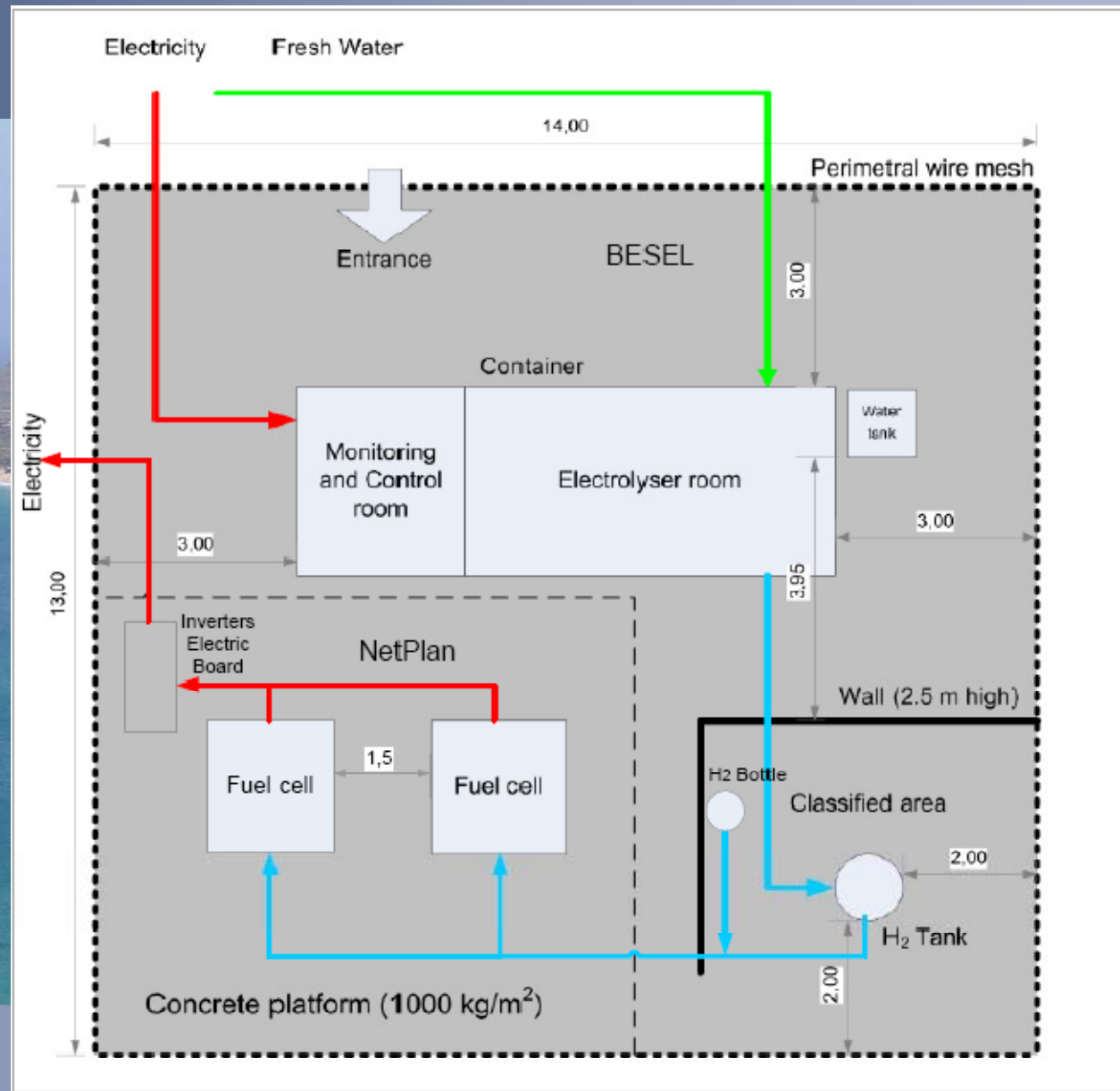
# LAYOUT SCHEME

- **Main Equipment:**
  - Fuel Cell (PEM) of 7,5 kW
  - PEM Electrolyser with a production rate of 2 m<sup>3</sup>N/h of H<sub>2</sub>
  - Water Deionizer with a production capacity of 50 l of deionised water per day
  - Storage vessel for H<sub>2</sub> with a 55 m<sup>3</sup>N capacity
  - Monitoring and Control System for the complete system



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# LAYOUT SCHEME



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# FUEL CELLS

- 2 x Gencore 5U48FG
- 5 kW module
- Consumption of 75 l of H<sub>2</sub>/min
- Adjustable operation voltage 46 – 56 V
- Connection ethernet





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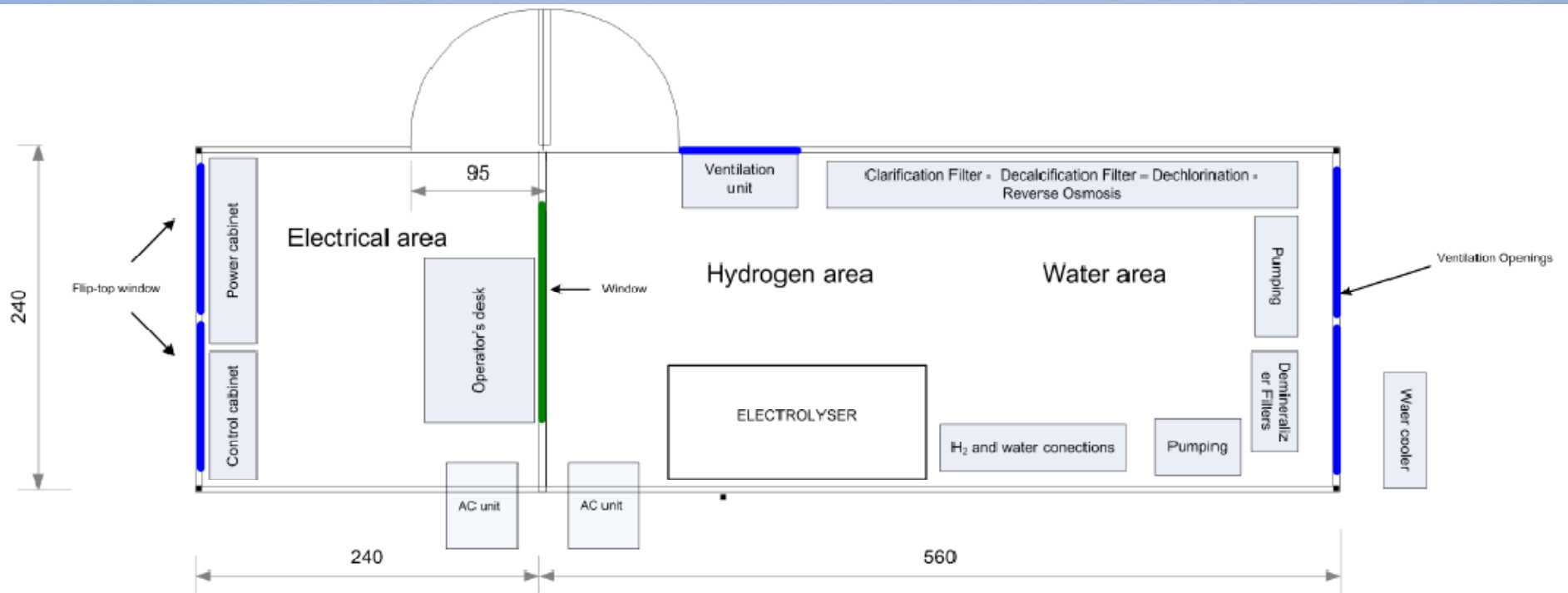
# ELECTOLYSER

- **HOGEN H2**
- **Production:  $2\text{m}^3\text{N/h}$  of  $\text{H}_2$**
- **30 bar**
- **99,99% purity**
- **Container**





# ELECTROLYSER





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# HYDROGEN SYSTEM



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An aerial photograph of a coastal town and beach. The town is built on a hillside overlooking a sandy beach and the ocean. A pier extends into the water. The background shows rolling hills and mountains under a clear sky.

# THANKS

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