INTEGRATION OF RENEWABLE ENERGY SOURCES AND HYDROGEN STORAGE IN PORTO SANTO

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OBJECTIVES

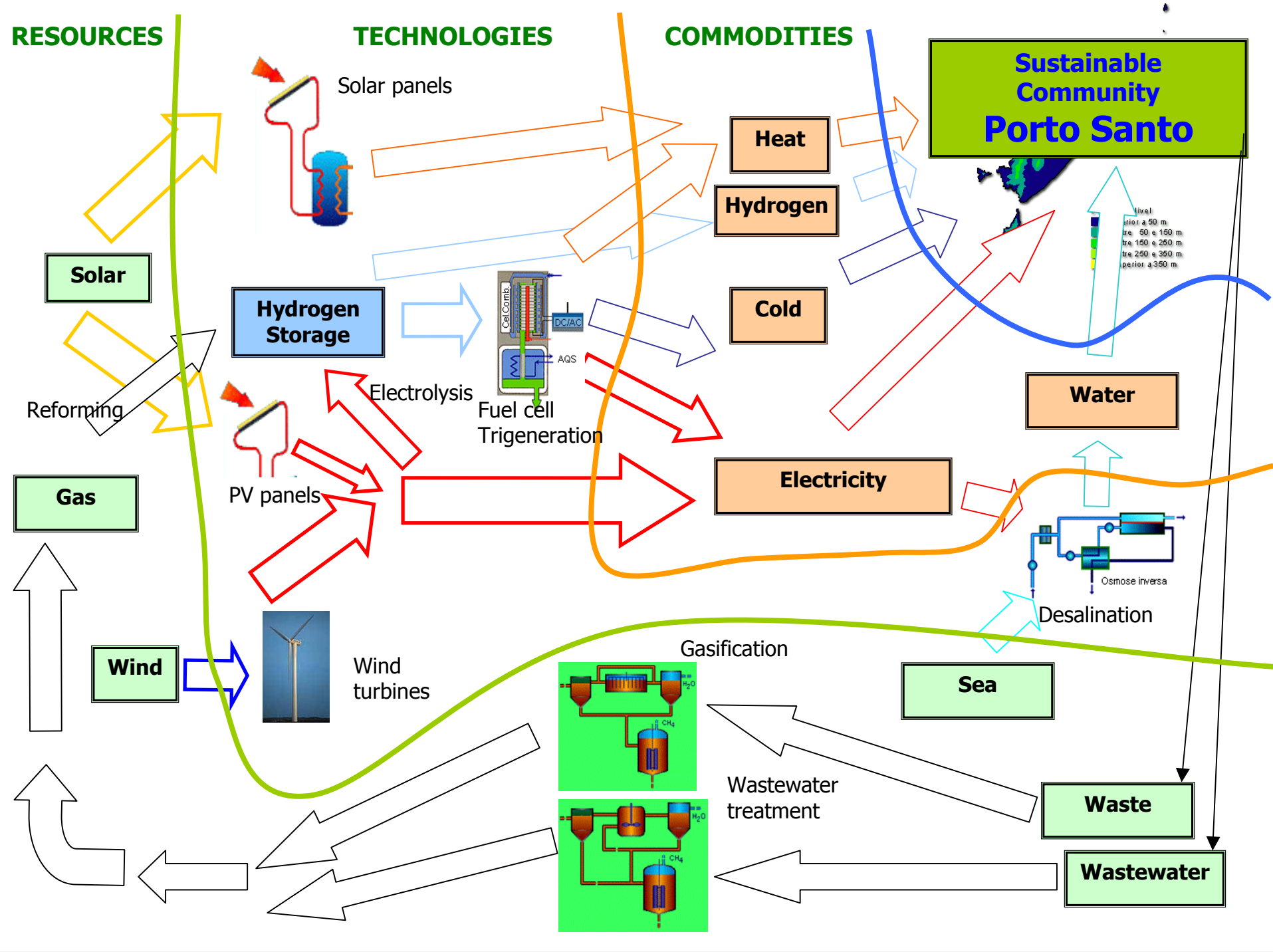
- To show a model optimising hydrogen storage integration with renewable energy sources
- To show a way to increase RES penetration
- To show a way for increasing security of energy supply for islands
- To show a path for sustainable development of islands

ISLANDS - PROBLEMS

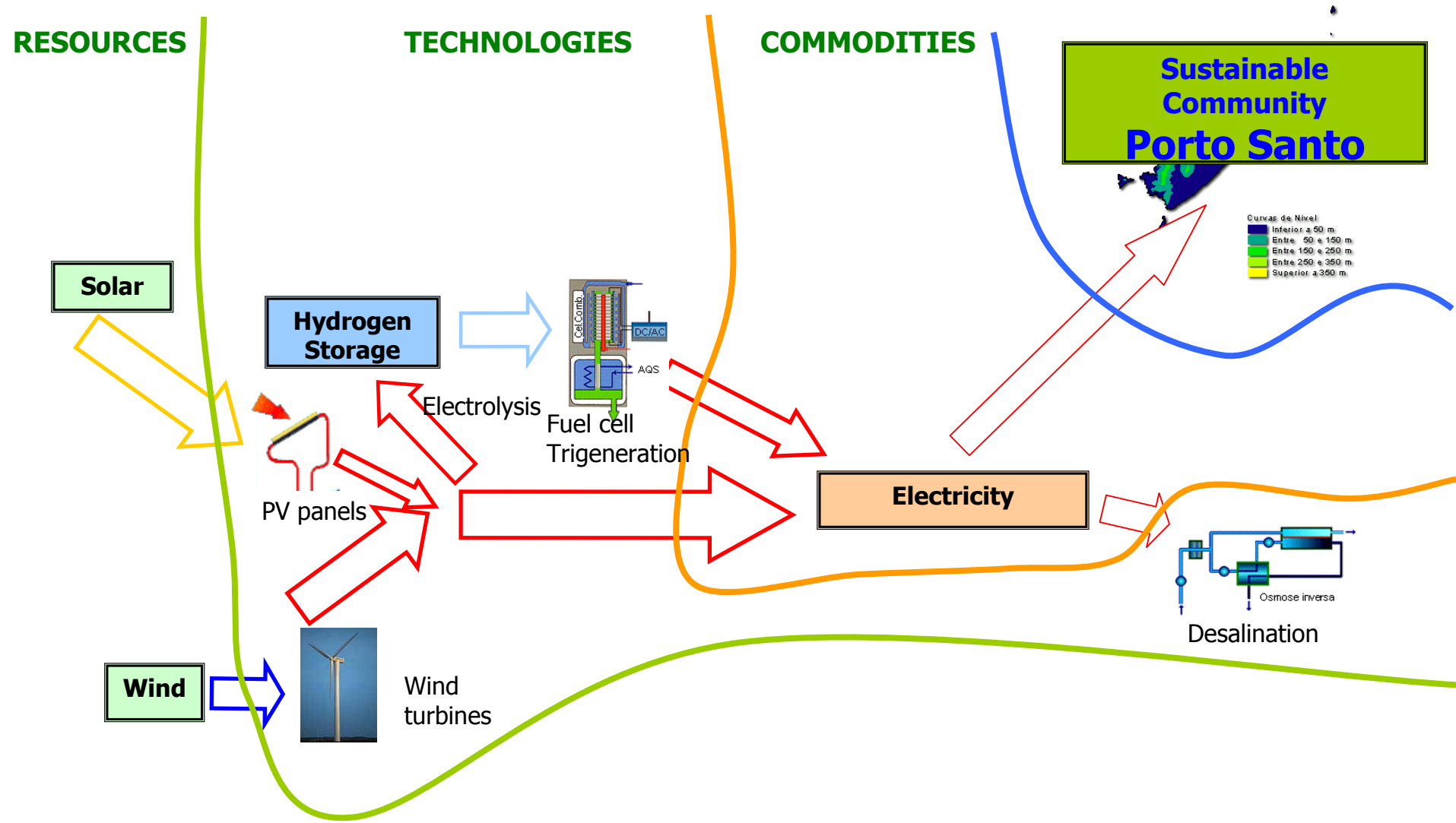
- Isolation
- Small local markets
- Higher costs of energy, transport and communication
- No economies of scale
- Security of supply problems
- High strain on energy, water, waste, environment and social systems

ISLANDS – ADVANTAGES

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


RESOURCES
TECHNOLOGIES
COMMODITIES
Sustainable Community
Porto Santo
Solar panels
Heat
Hydrogen
Solar
Hydrogen Storage
Cold
Electrolysis
Fuel cell Trigeneration
Reforming
Water
PV panels
Electricity
Gas
Osmose inversa
Desalination
Wind
Wind turbines
Gasification
Sea
Wastewater treatment
Waste
Wastewater

H_2RES MODEL


RESOURCES
TECHNOLOGIES
COMMODITIES
Sustainable Community
Porto Santo
Curvas de Nível
Inferior a 50 m
Entre 50 e 150 m
Entre 150 e 250 m
Entre 250 e 350 m
Superior a 350 m
Solar
Hydrogen Storage
Electrolysis
Cel.Comb.
DC/AC
AQS
Fuel cell
Trigeneration
PV panels
Electricity
Osmose inversa
Desalination
Wind
Wind turbines

H_2RES MODEL

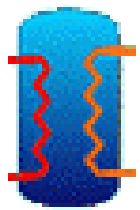
- Energy planning tool
  - Small and medium power systems
  - Higher penetration of renewables
  - Integration of energy storage
  - Electricity dump: desalination or other
- Need to use time series instead of usual approach (LDC, Weibull)

H_2RES MODULES

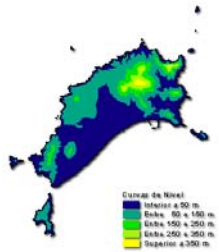
WIND

SOLAR

HYDRO



STORAGE

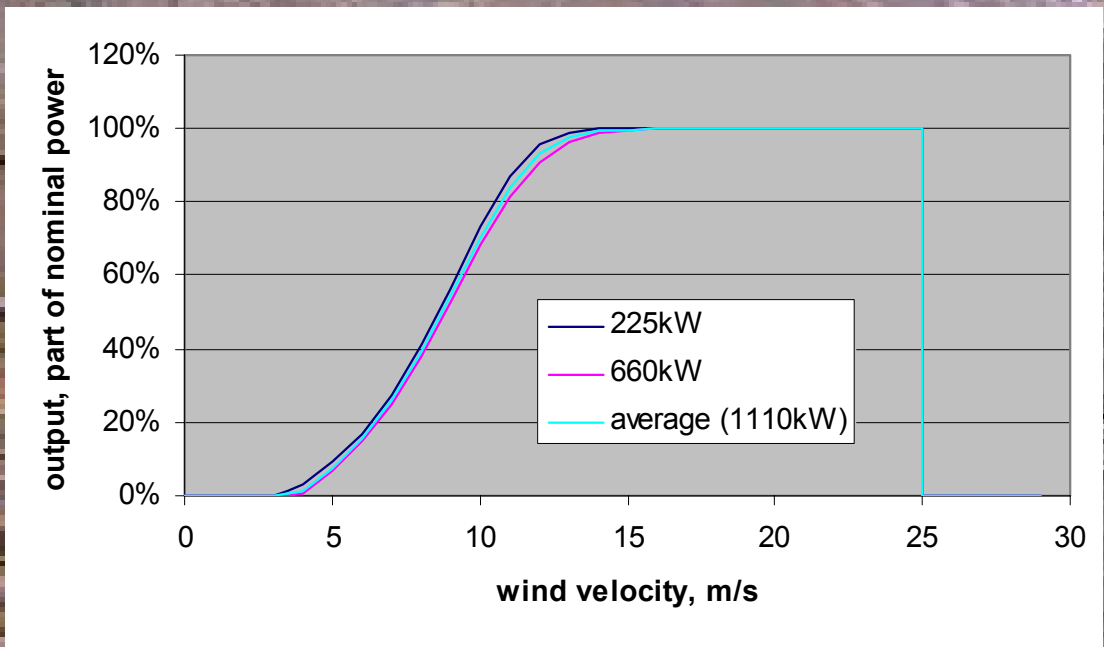


LOAD

H_2RES – WIND MODULE

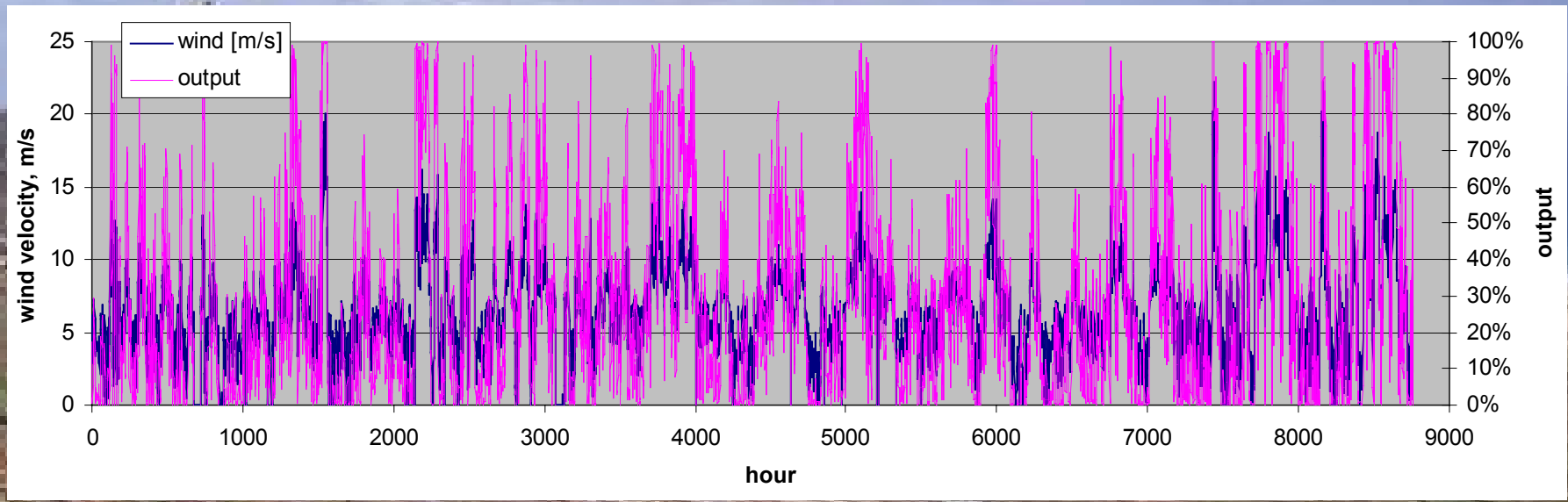
- Hourly **wind velocity** data obtained
- Adjusted to the **hub height**
- Converted into hourly potential **output**

$$v_z = v_{10}\left(\frac{z}{10}\right)^{0.14}$$



Example for VESTAS wind turbines, as installed on Porto Santo, Madeira, Portugal

H_2RES – WIND MODULE

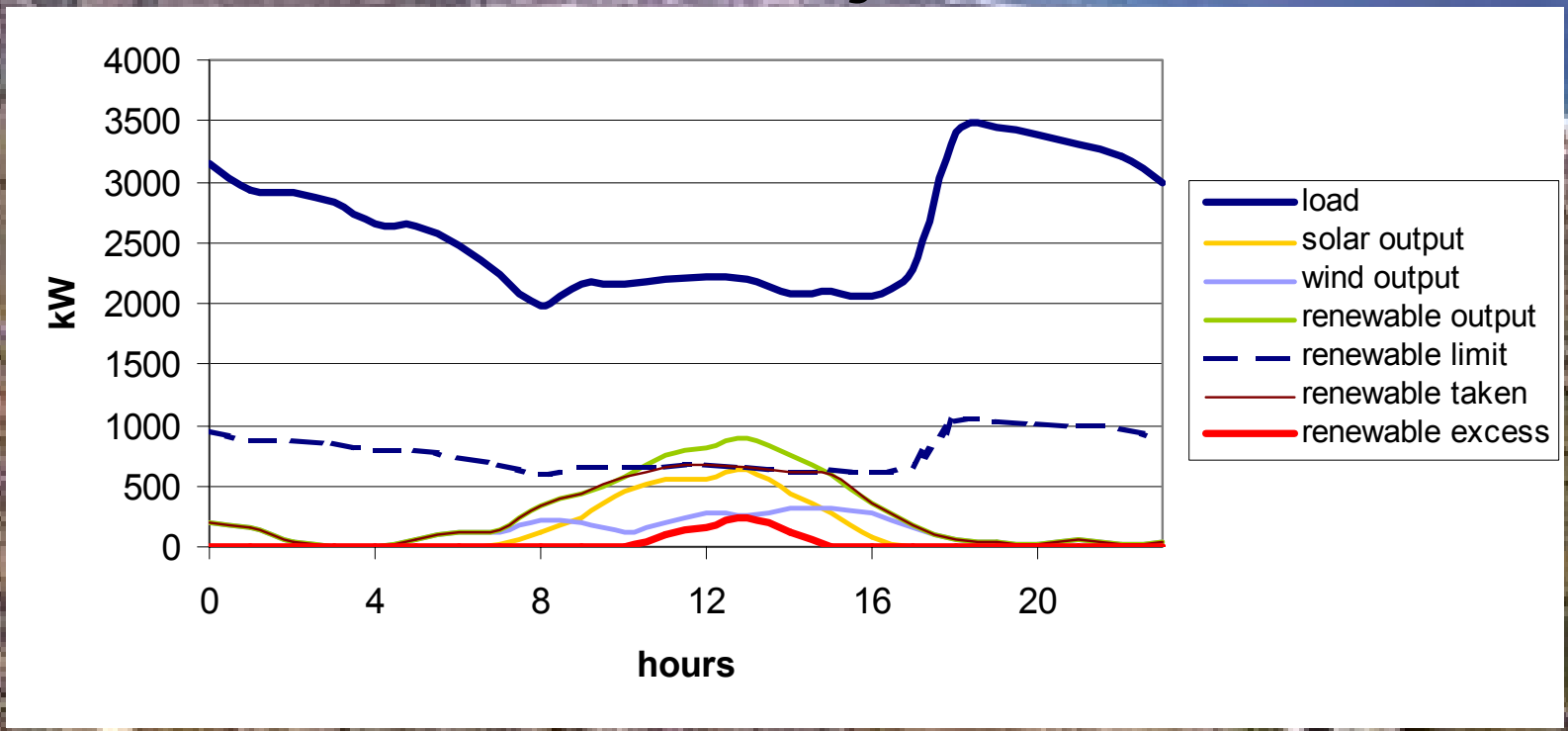


H_2RES – SOLAR MODULE

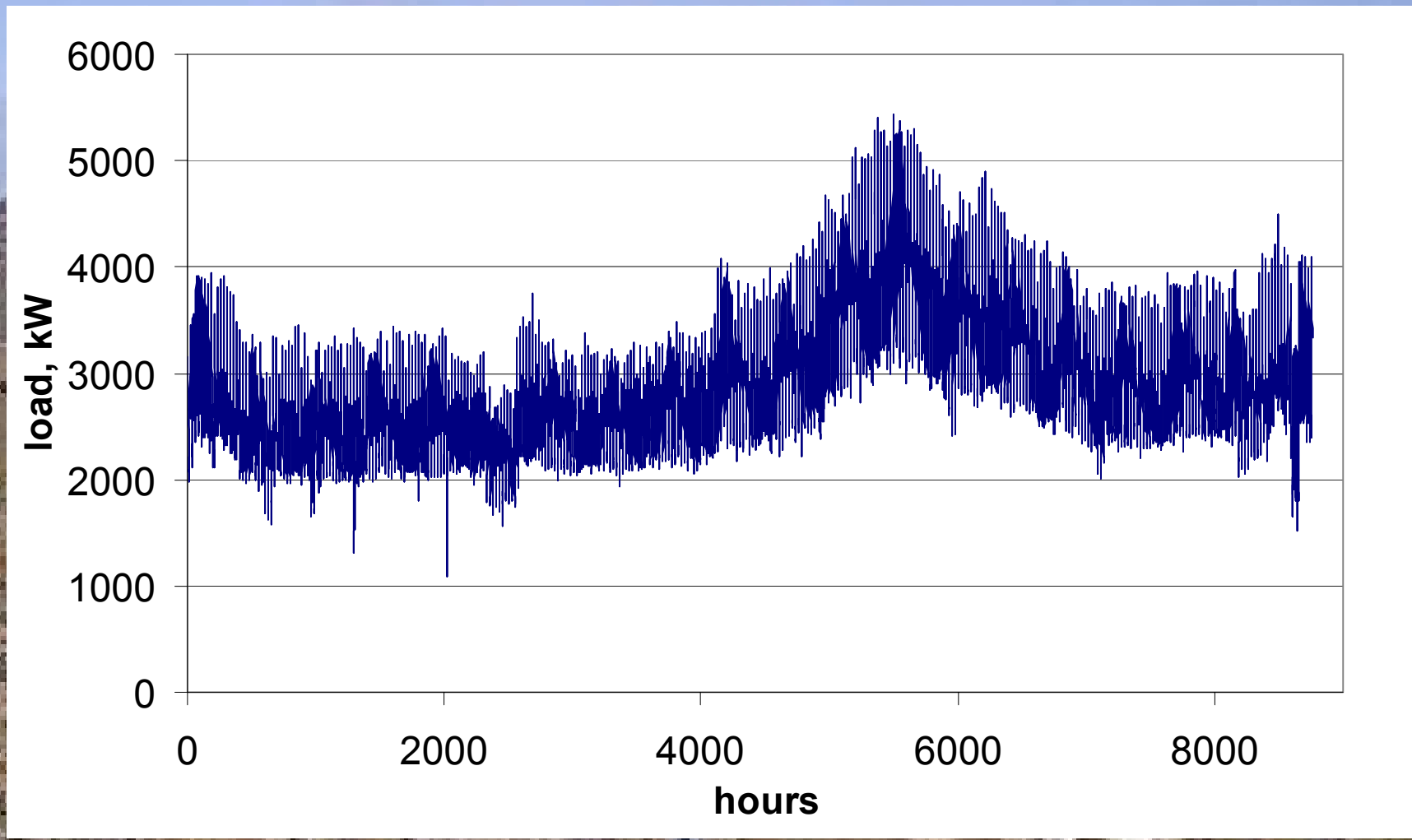
- Hourly total radiation on horizontal surface obtained
- Adjusted to the inclined surface (RETSCREEN)
- Converted into hourly potential output by efficiency provided from supplier

H_2RES – LOAD MODULE

- Hourly load of power system obtained
- Limit to renewable intake
- Excess renewable rejected



H_2RES – LOAD MODULE

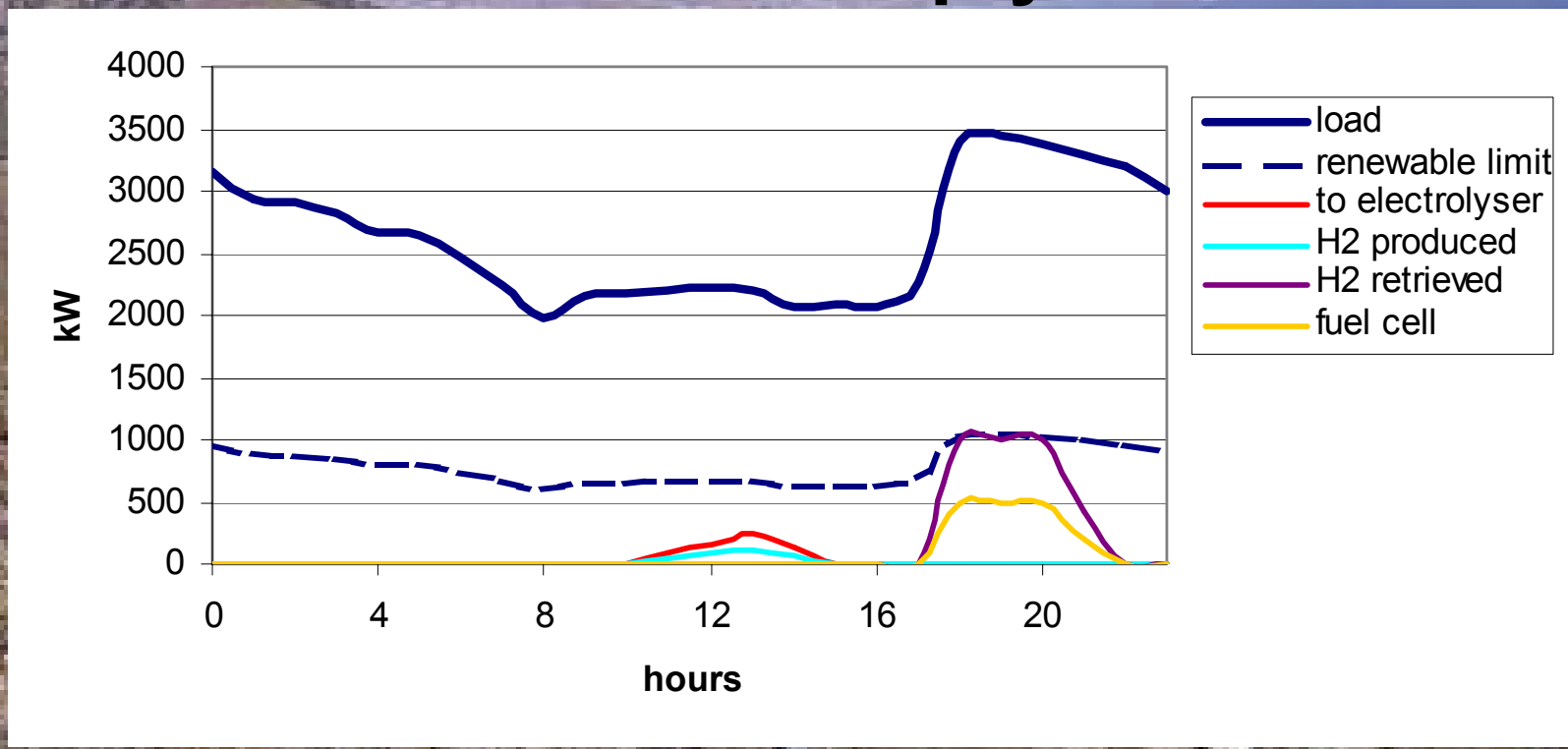


H_2RES – STORAGE MODULE – FILLING

- 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

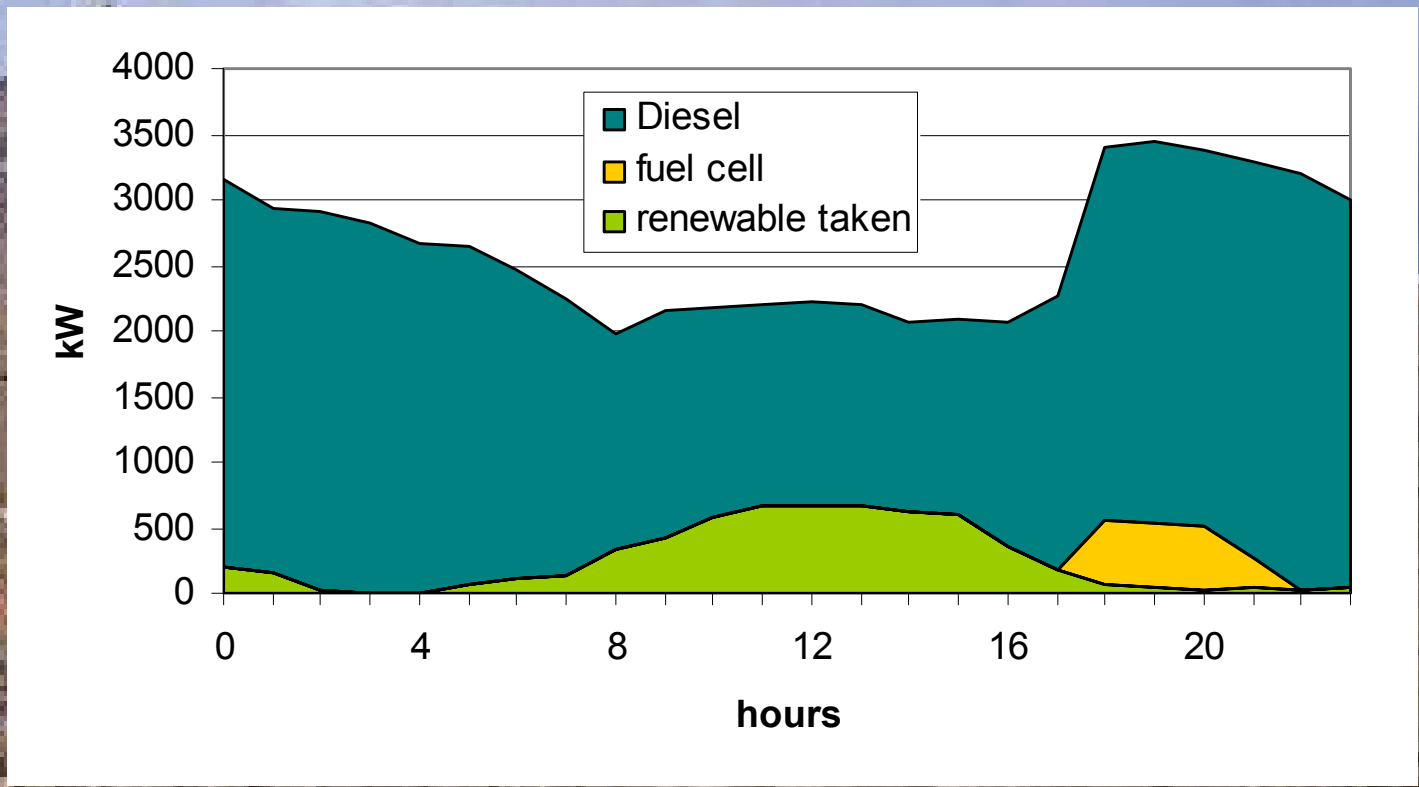
H_2RES – STORAGE MODULE – H_2 USED

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



H_2RES MODEL

- Electricity **delivered** to power system



PORTO SANTO

- **Population:**

  5000 in winter ⇒ 20000 in summer

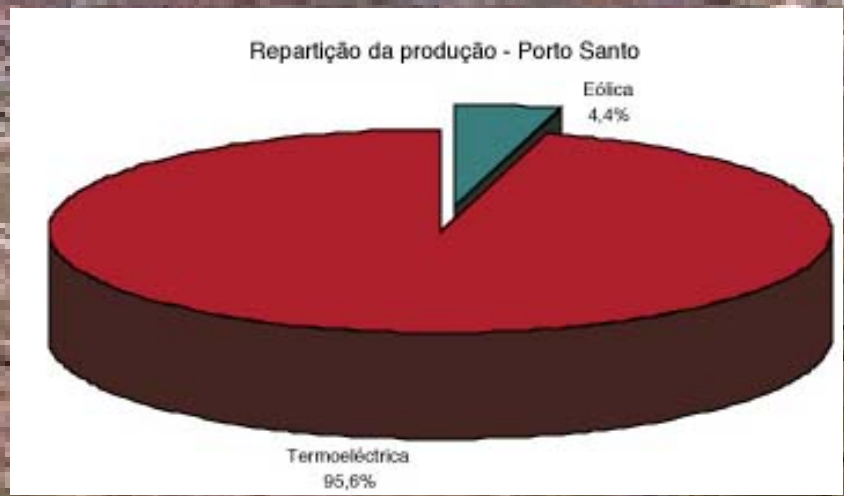
PORTO SANTO

- **Power system (2000):**

  13.8 MW thermal + 1.1 MW wind

  24.1 GWh thermal + 1.1 GWh wind

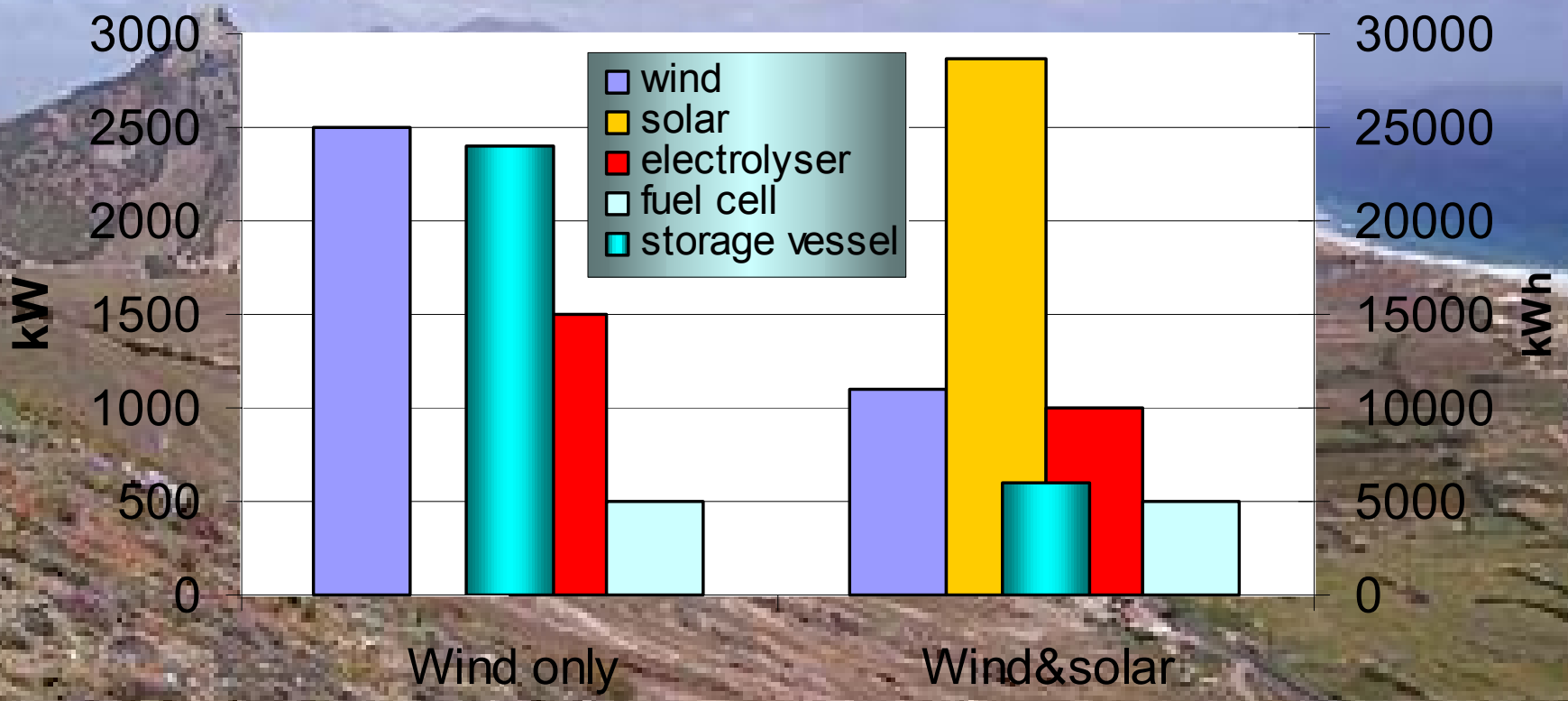
  5.6 MW peak, 2 MW base, 20% growth



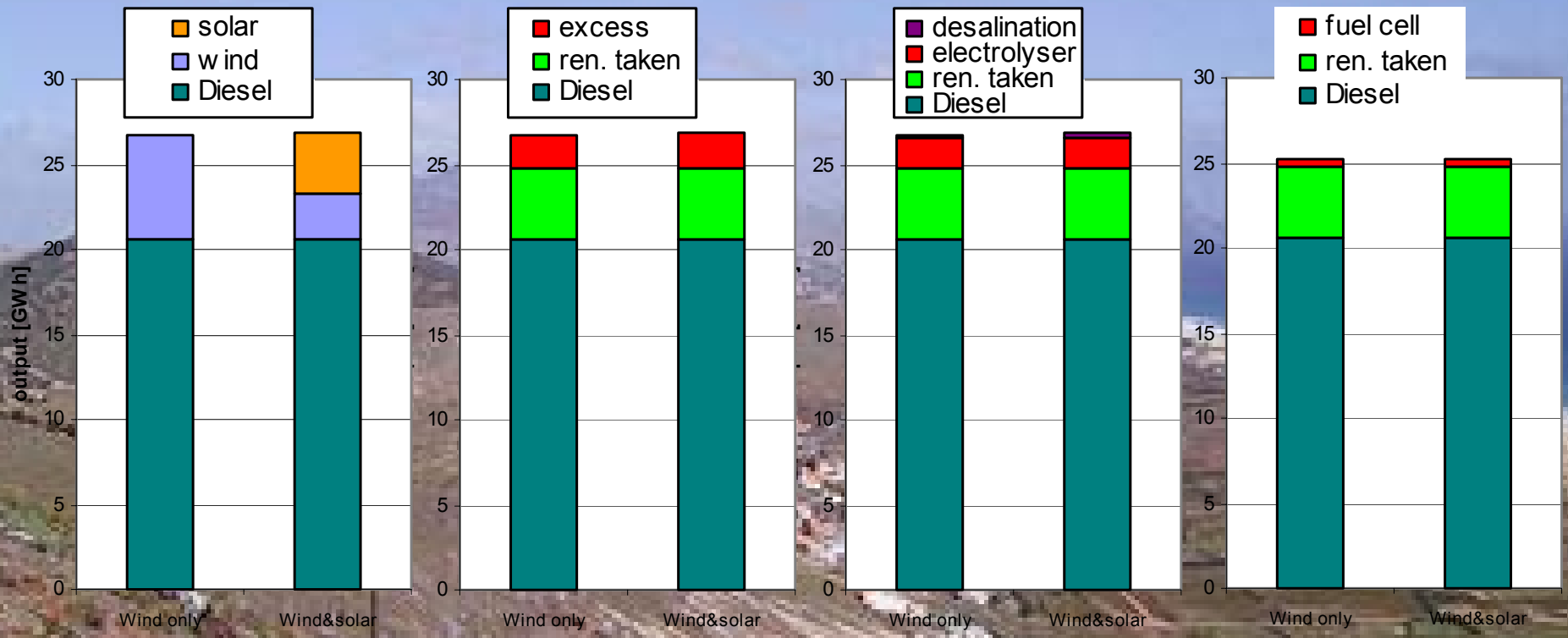
PEAK SHAVING SCENARIA

- 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 SCENARIA



PEAK SHAVING SCENARIA

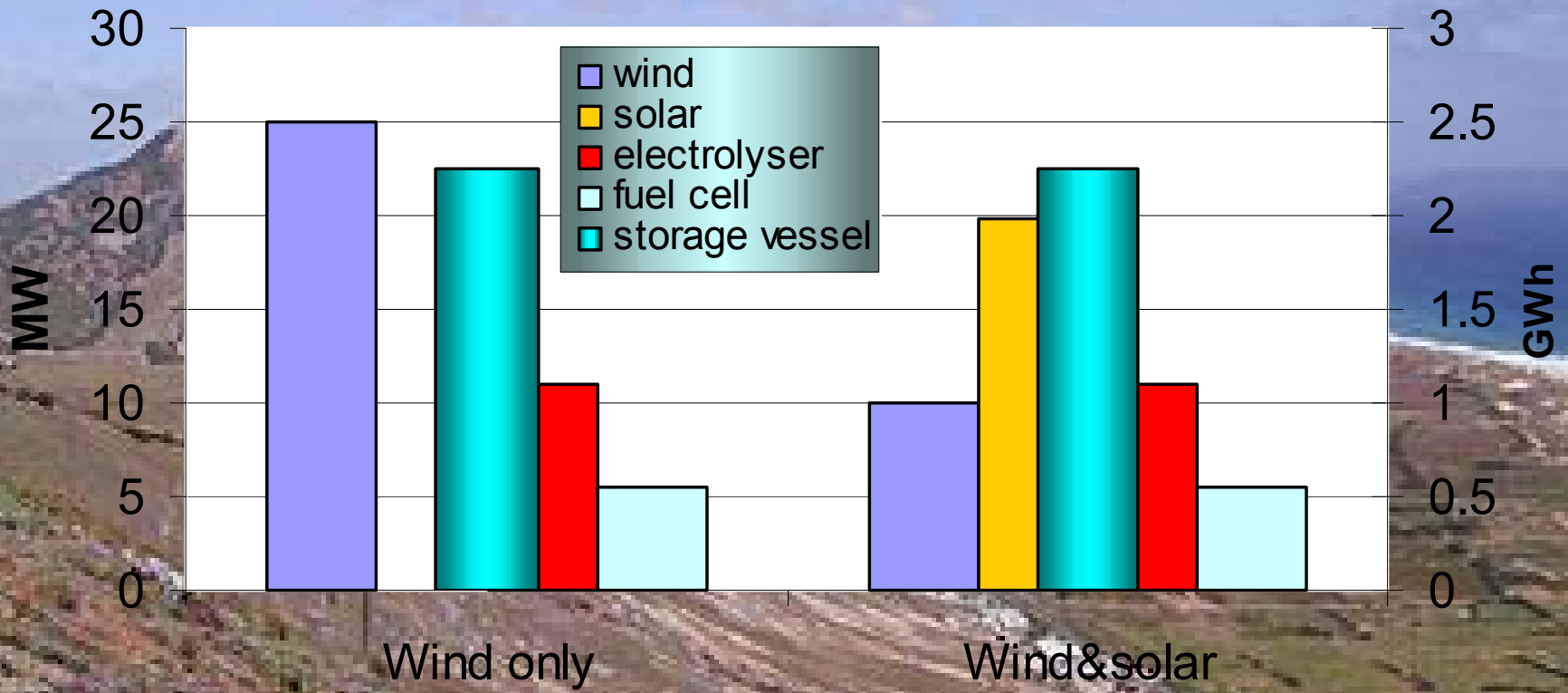


	peak serving time
Wind only	53%
Wind&solar	62%

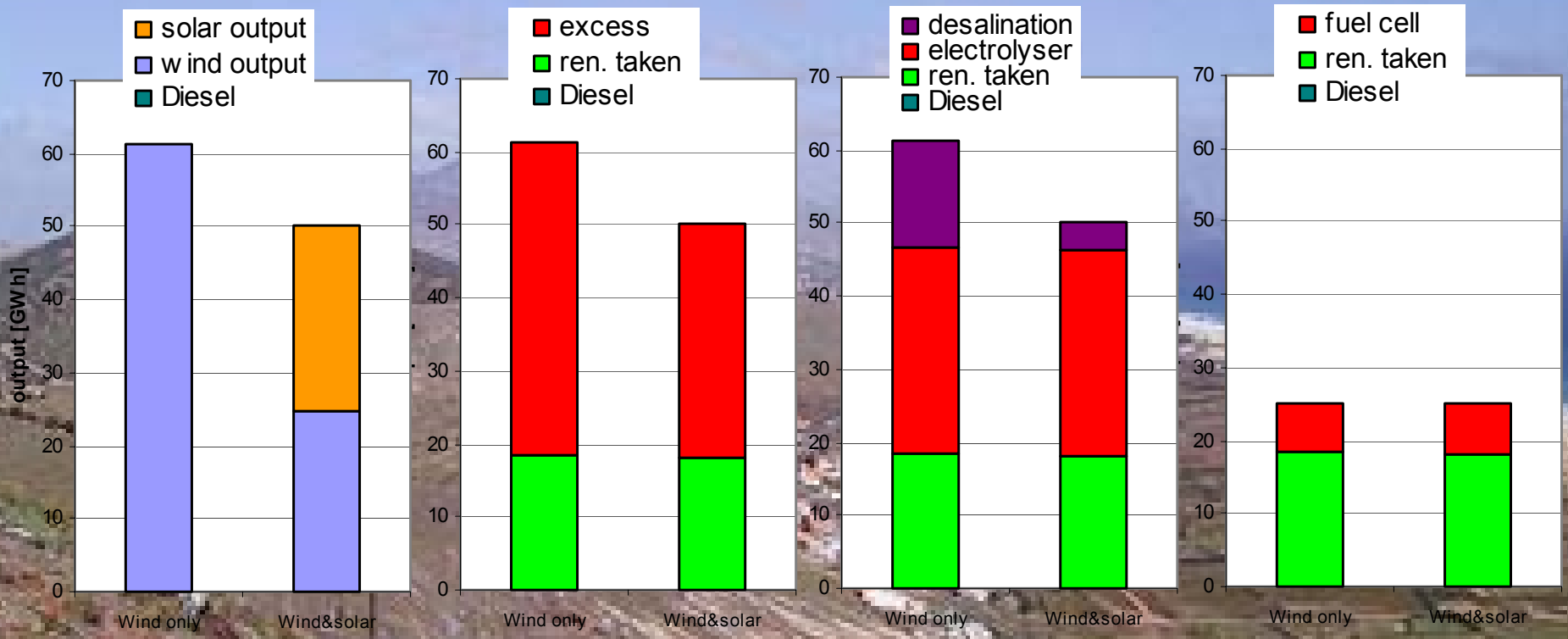
100% RENEWABLE SCENARIA

- 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

100% RENEWABLE SCENARIA

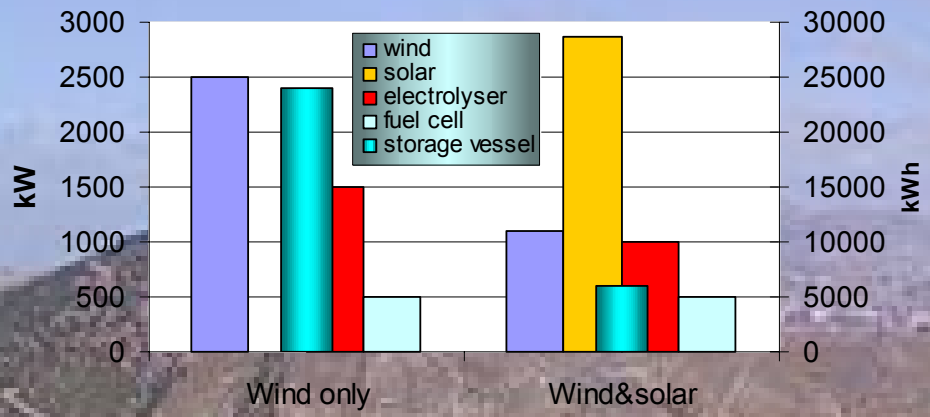


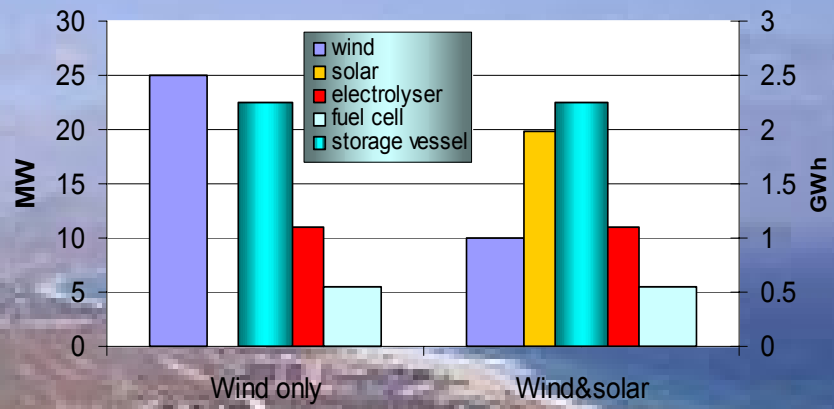
100% RENEWABLE SCENARIA



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

H_2RES CONCLUSIONS





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

CONCLUSIONS

- A model for optimising integration of hydrogen storage with intermittent renewable energy sources (wind and solar) was devised
- Storage module can work with batteries or pump storage
- The model was applied to Porto Santo
- The results were intriguing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