

# Renewables for Azores Green Islands – How big can we go?

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## Assessing Large Penetration of Renewable Resources into Constrained Energy Systems

### MOTIVATION

- Islands represent a compelling case for renewable generation:
1. to displace expensive and polluting imported petroleum and
  2. to harness abundant wind, waves, sunshine, and in some cases including the Azores, geothermal.

In many cases there are plenty of resources. However, there are few tools that effectively model energy systems with very high penetration of renewable energy resources (IEA 2004, Morch 2005). Furthermore, due to the dynamic changes, complexity, uncertainty of environmental change and current unfavourable projections, there is an increased demand for scenario-based assessments, with focus on forward-looking assessments that are well-designed and supported by appropriate information systems, and fit well into existing policy-making processes (EEA, 2008).

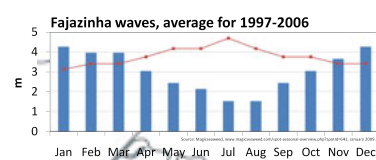
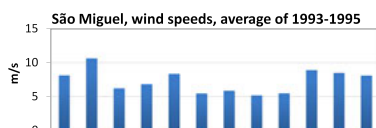
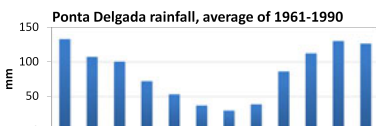
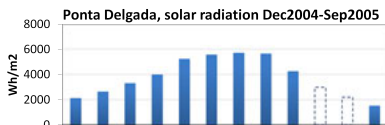
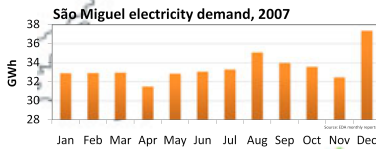
### RESEARCH QUESTIONS

•How should an energy system with a very high level of renewables be planned? Which are the key aspects in the resource dynamics that should be taken in to account?

•How may solar, wind and hydro resources change in the future due to natural or anthropogenic climate change?

•How can uncertainties and risks related to energy systems planning be evaluated & included in decisions?

### MONTHLY TRENDS



Long term wind trends show mid-day peak  
With early morning and summer fall off

Wind & Solar compliment load well

A peak in tourism corresponds to a peak in electricity demand – could eco-tourism shave this peak?

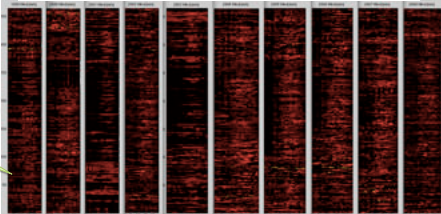
Complementary behaviour between solar radiation and rain – can we take advantage of this?

Wind & Solar are both concentrated in mid-day

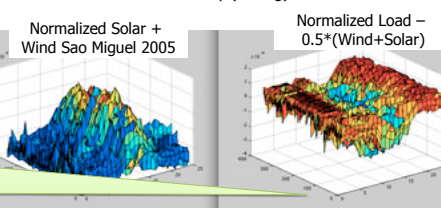
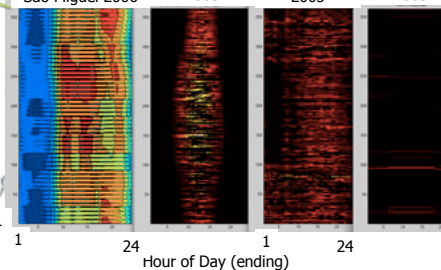
Subtracting 100% solar&Wind from load, shows a need for nighttime generation. Geothermal and/or storage would compliment well.

### HOURLY TRENDS

Measured Surface Wind speeds (m/s) Ponta Delgada



1999 Extrapolated Load São Miguel 2006  
Measured Insolation 2005  
Measured Wind Speed 2005  
2008 Precipitation



### FUTURE DIRECTIONS

- **Energy systems modelling:**
  - multicriteria optimization, simulation and/or system dynamics tools,
- **Uncertainty analysis:**
  - statistical tools
- **Decision support:**
  - decision analysis or options analysis
- **Power systems modeling:**
  - simplified dispatch and reliability

- Climatic trends for sun, rain and wind
- Optimal Resource mix and site selection
- Interactions with Demand
- Potential for storage
- System economics and dispatch
- System reliability

### OBJECTIVE

The research aims to understand the resource and load dynamics at various temporal and spatial scales, including the effects of global climate change. We are developing a tool for energy systems design based on the opportunities and challenges presented by these dynamics.

REFERENCES  
IEA (2005). Variability of wind power and other renewable: Management options and strategies.  
Morch, A. Z. (2005). *Software tools for energy planning: Overview and comparison*, SINTEF Energy Research, SINTEF, Norway.  
EEA (2008). Modelling environmental change in Europe: towards a model inventory (SEIS/Forward), EEA Technical report, No 11/2008, European Environment Agency (EEA).