Economic impact of hybrid systems

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Agenda

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Summary and outlook

Greece has 32 electrical island complexes with 1.6 GW of diesel generator capacity

- Overall subsidy for electricity on the islands amounted to € 720 mill. In 2016
- Cost of electricity generation on the islands is linked to the oil price and ranged from € 75 – 365 / MWh in 2017

Source:
HEDNO (DEDDIE) production data 2017, Hatziargyriou N. et al., Non-interconnected Island Systems: The Greek Case, IEEE Electrification Magazine, 2017

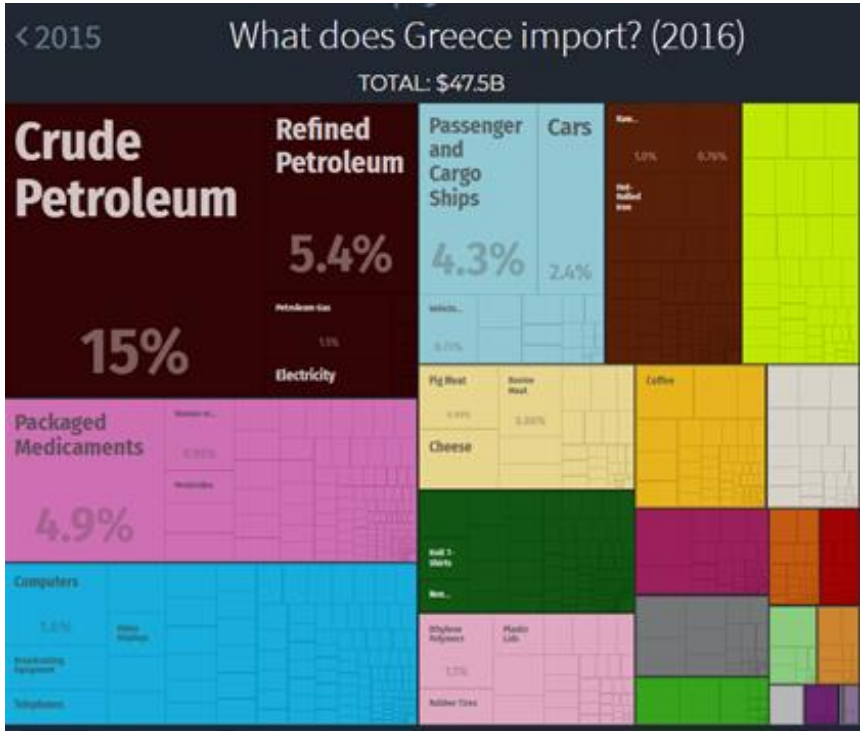
The Greek economy has contracted significantly and oil imports account for a large share of trade deficit

Gross domestic product and unemployment

- Greece has suffered the most severe economic crises of any EU country since WWII
- GDP reduction of 45%:
  - US$ 354.5 bn in'08 vs. US$ 196.6 bn in'16
- Unemployment levels in 2017:
  - >20% overall
  - >45% for the youth

Trade deficit

- US$ 19.7 bn in 2015
- Of US$ 47.5 bn imported goods, crude and refined petroleum account for 20.4%, which equals US$ 9.5 bn,

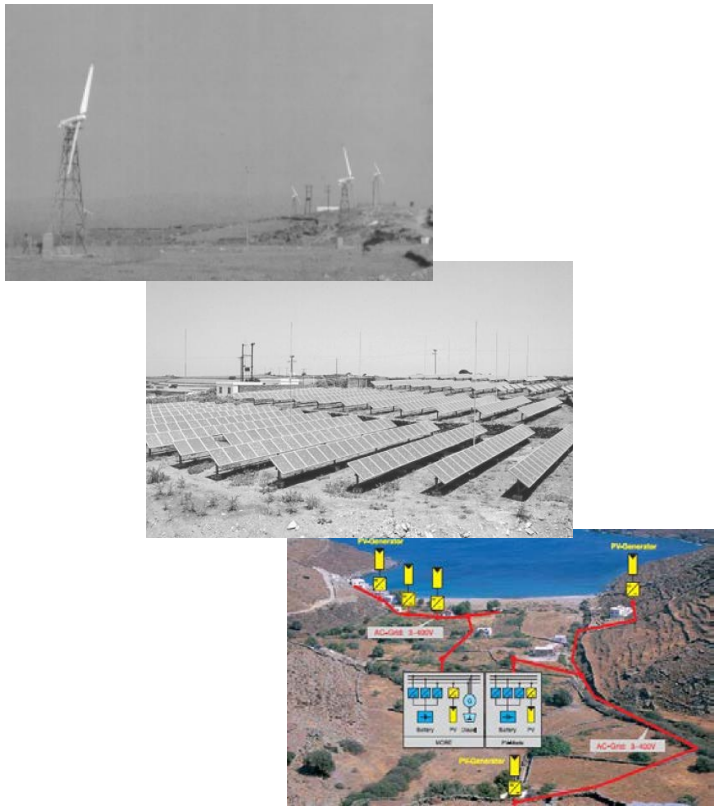


7% of petroleum imports related to electricity generation and negatively impact Greek GDP

Source:
Trading Economics, OECD Data, MIT Media Lab Macro Connections Group

Greece is a first mover for RE on islands and is building experience since 1982

Expertise and first mover advantage in Greece: Example Kythnos, Cycladic islands



- 1982: 100 first windfarm in Europe (100 kW)
- 1983: 100 kW PV farm with storage added
- 2000: Automated hybrid (500 kW wind/battery each)
- 2001: Microgrid - 12 homes with load control
- 2003: Adv. control for high RES penetration (Crete)

Knowledge-hub around Greek universities

- Built significant expertise in hybrid systems for islands collaborating with the local utility & DSO
- Established as leading hybrid research institutions

Source:
J. Reekers, G.Cramer, P. Strauß, et. All., „Inselnetzte mit hohem Anteil Erneuerbarer Energien auf der griechischen Insel Kythnos“, ISET Symposium Kassel, 2000

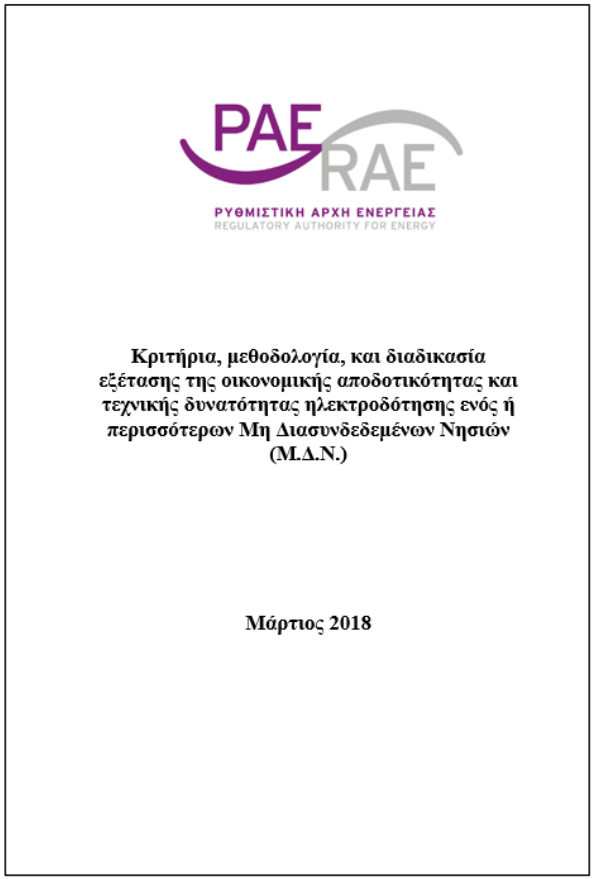
RAE, the Greek regulatory authority, suggested a frame-work for the evaluation of island connection & hybrids

Suggested framework for economic impact evaluation

- Centered on the interconnection of an island to the mainland Hellenic Electricity Transmission System (HETS)
- Benchmark for any hybrid considerations

Key criteria considered

- Electricity production cost, consisting of
  - energy demand
  - fuel prices
  - regulatory framework
  - national targets for renewable energy sources (RES)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REGULATORY AUTHORITY FOR ENERGY

Κριτήρια, μεθοδολογία, και διαδικασία εξέτασης της οικονομικής αποδοτικότητας και τεχνικής δυνατότητας ηλεκτροδότησης ενός ή περισσότερων Μη Διασυνδεδεμένων Νησιών (Μ.Δ.Ν.)

Μάρτιος 2018

Source:
The Greek Regulatory Authority for Electricity (RAE)

The framework focuses mainly on quantitative factors, but also considers qualitative aspects

Quantitative factors considered

- Security of supply
  - Expected losses of load in MWh
- Socio-economic welfare
  - Reduction in energy cost / redispatch cost
- RES integration cost
  - Avoided RES curtailment in MWh
- Power loss difference before and after
  - Long distance transmission losses in MWh
- CO_2 emmissions difference
  - Reduction in CO_2 emissions before and after

Qualitative factors considered

- Technical resilience
  - i.e. scenario: cable loss during maintenance
- Flexibility
  - Option to modify or adapt system in the future
- Environmental impact
  - Effect of construction, etc.
- Social impact
  - Effect on local community

Source:
The Greek Regulatory Authority for Electricity (RAE)

The project evaluation tries to take all factors into account, but ultimately focuses on the ENPV as deciding indicator

Project evaluation

- Economic Net Present Value (ENPV), based on the estimated cost savings compared to the total cost consisting of

$$ENPV = \sum_{t=f}^{t=T} \frac{R_t - C_t}{(1+i)^{(t-n)}}$$

  - capital costs for engineering, procurement, installation and commissioning, financing costs, costs for temporary solutions
  - environmental costs, equipment replacement costs, decommissioning costs etc.
  - operation and maintenance
- Economic Internal Rate of Return (EIRR) expresses the socio-economic attractiveness
- Economic Benefit / Cost ratio (EB/C)

ENPV is the main deciding indicator

- The two complementary indicators serve for comparative analysis

Source:
The Greek Regulatory Authority for Electricity (RAE)

Many islands, particularly smaller one's, are fragile economic systems with declining populations

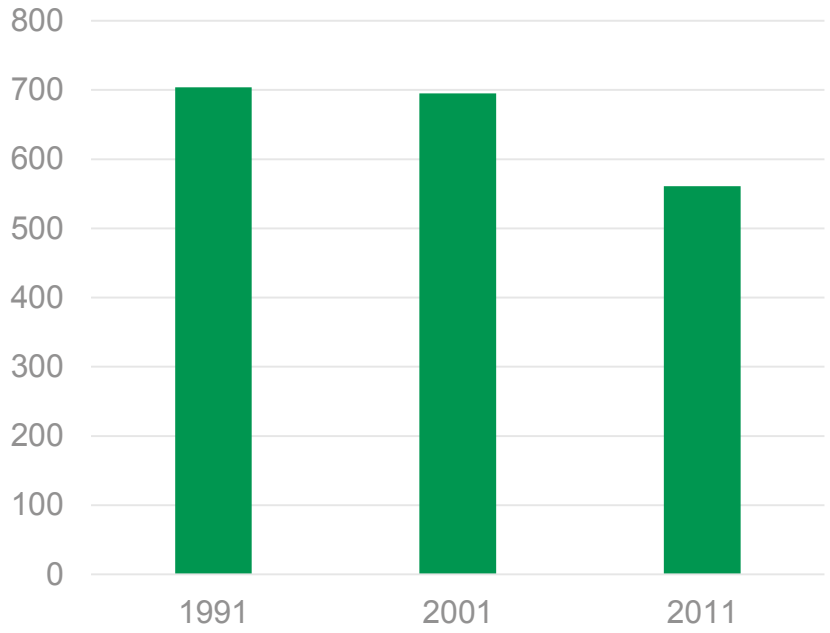
Economic situation on the islands

- Islands, particularly, when small are fragile economic systems
- Tourism is a major source of income
- Very seasonal in nature and does not provide income year round

Shrinking populations

- Example of Kythnos, Cycladic islands
- 20% reduction in permanent population from 1991 to 2011

Permanent employment, Kythnos, 1991 - 2011



Any measures with a direct impact on permanent employment on the islands should be considered

Source:
City Population – Population of Kythnos

Impact of electrification scenarios differ by islands with smaller islands typically experiencing a stronger effect

	Large islands	Small islands
	Operation and maintenance	***Operation and maintenance***
High RE	▪ Increase in employment	▪ Increase in employment – diesel O&M stays
Connection	▪ Reduction in employment/same with high RE	▪ Reduction in employment
	Fuel transport to the island	***Fuel transport to the island***
High RE	▪ Same employment	▪ Same employment
Connection	▪ Significantly reduced employment	▪ Significantly reduced employment
	Construction, installation & upgrades	***Construction, installation & upgrades***
High RE	▪ Temporary increase in employment	▪ Temporary increase in employment
Connection	▪ Temporary increase in employment	▪ Temporary increase in employment

Island specific

Island specific

Depending on specific island situation, with smaller islands more likely to be negatively impacted

Source:
OneShore analysis

Effects on the trade deficit, of export opportunities and economies of scope should also be taken into account

Impact on trade deficit

- Dependent on the local value creation of RE project implementation and mainland grid connection
- Components for solar plants make up approx. 50% of value, for wind projects probably more
- Sourcing other critical project features such as project development and financing could be local or external

Export of services and expertise

- Once expertise is established, it can be exported to other markets (e.g. PV knowledge to Middle East)
- Globally > 65 mill. people live on islands with less than 1 mill. inhabitants
- There are approx. 2,000 islands with between 1,000 and 100,000 inhabitants => island mini-grids

Effect of a pipeline of larger projects

- Economies of scale would exist if a larger pipeline of projects would be executed in parallel
- Reduction in component, installation and financing cost would lead to significant cost reductions

Source:
OneShore analysis, P. Blechinger „Mini-Grids for Off-Grid Energy Supply […], Leicester, 11 July 2013

Electrification scenarios can have a significant economic impact and should be studied case by case

Economic Net Present Value

- RAE suggests ENPV as main deciding factor
- Potential savings are certainly very important

Impact on local employment

- Impact on local employment is not considered
- For overall evaluation, it should play a significant part

Case by case analysis

- Each island case, each RE expansion and each mainland grid connection scenario is different
- Hence, individual cases should be analysed in order to obtain a full picture

Large vs. small islands

- The size of the island plays a significant role in determining the economic impact
- Large islands with a more stable local economy are more likely to be able to compensate job losses
- Smaller islands have fewer permanent jobs and are suffering from a reduction in population

The impact on local employment should be seriously considered for different electrification scenarios, particularly for smaller islands where permanent local jobs are scarce.


Our Vision
Driving unsubsidised renewable energy generation for isolated grids.
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