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Hydrogen Applications for Small Islands

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ΚΑΠΕ CRES

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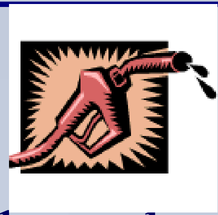
Is Hydrogen a Hype?



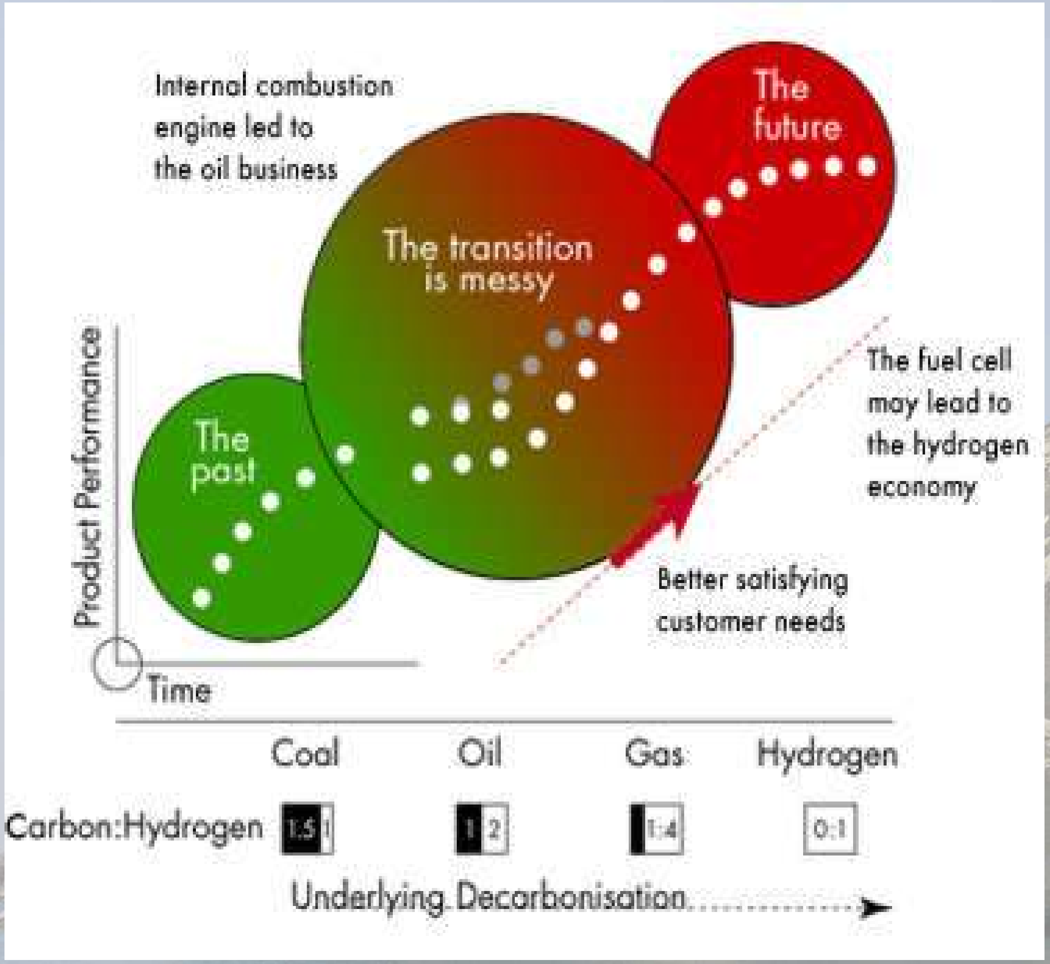
Reasons:

- Availability of fossil fuels
- Decrease environmental impact of hydrocarbons use
- Energy independence & security of supply

In the future 2 basic energy carriers will exist:

- **Electricity** (ligthing, informatics)
- **Hydrogen** (replacement of liquid & gaseous fuel in the transport sector, in autonomous stationary power systems and in the sector of heating)

Is Hydrogen a Hype?



Source:
Shell Hydrogen

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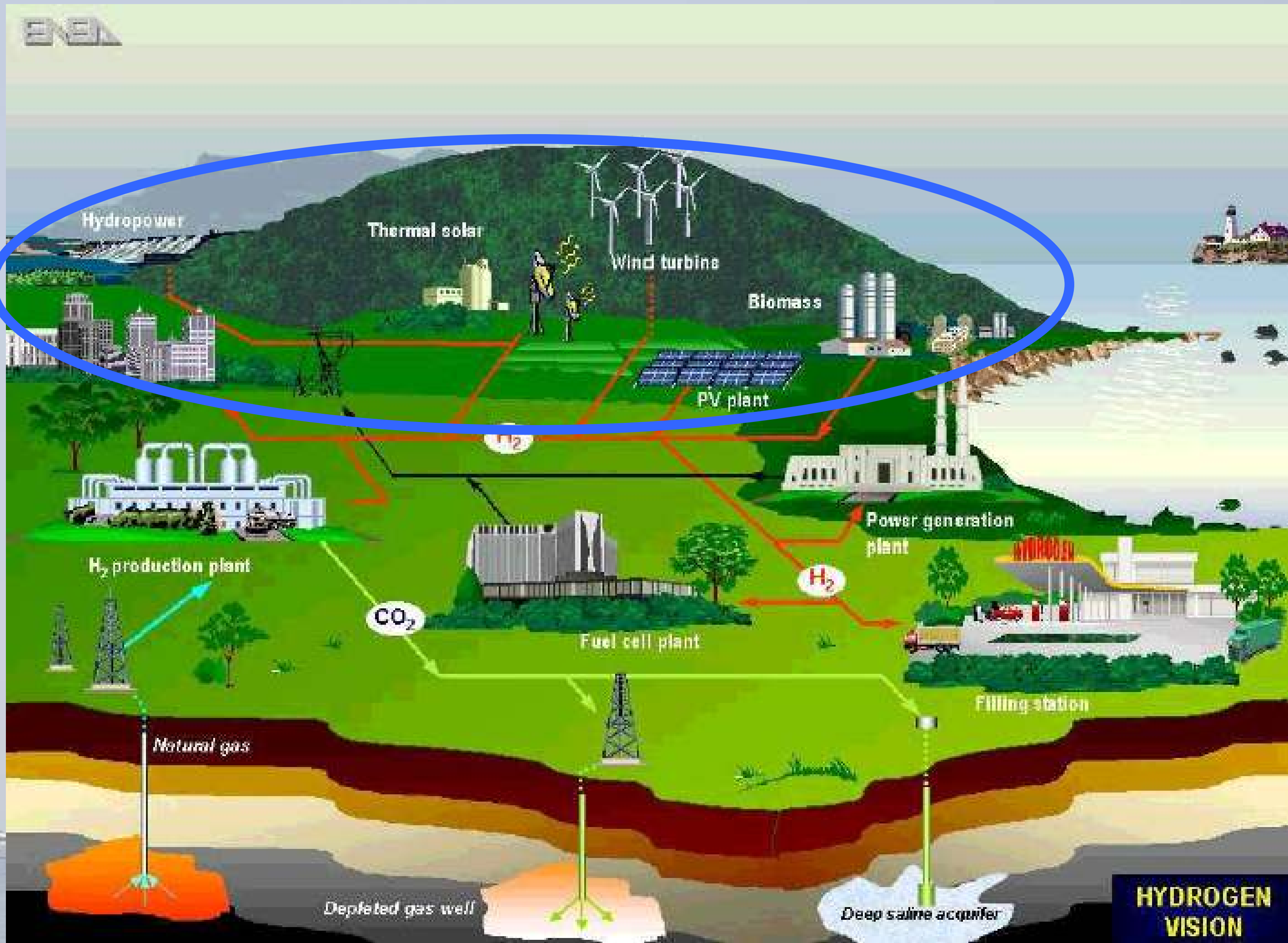
Role of RES



Source: HLG

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Role of RES

Characteristics:

- Confront the stochastic character of RES through energy storage in the form of hydrogen
- Potential of decentralised/ distributed hydrogen production, using local Renewable Energy Sources
- Decrease fossil fuel imports
- Penetration of RES in the Transport Sector

H2 applications in the transport sector

Applications in Marine Transport



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H2 applications in the transport sector

Applications in Road Transport

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Hydrogen Applications in the context of the Greek Green Island – Ai Stratis

Transport sector:

The objective of the project is to create the basic infrastructure for refueling hydrogen vehicles and electric vehicles through the development of :

H_2 production unit & vehicle filling station

There will be hydrogen vehicles on the island for demonstration purposes

Hydrogen Applications in the context of the Greek Green Island – Ai Stratis

BASIC EQUIPMENT INFO:

1) Hydrogen production unit through water electrolysis, driven only by RES, with a capacity of 60 - 100 kW, and hydrogen production capacity in the order of 10-20 Nm^3/hr
2) H2 gaseous storage tanks at medium pressure (30 kg), metal hydride tanks (1-2 kg), H2 gaseous storage tanks at high pressure (40 kg)
3) H2 compressor with a compression capacity of 10-20 Nm^3/hr, at a pressure of 220 bar
4) Hydrogen filling station for vehicles
5) Hydrogen ICE for stationary applications with a capacity of 90 kW (installed at the central power station of the island)

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Hydrogen Applications in the context of the Greek Green Island – Ai Stratis

Vehicles:

1) Hydrogen driven forklift
2) Small van or a sweeper driven by fuel cells
3) Fuel cell scooter
4) Replacement of diesel ICE with H2 ICE & integration in a fishing boat

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Hydrogen Applications in the context of the Greek Green Island – Ai Stratis

Autonomous stationary applications:

1) CHP applications based on Fuel Cells for 5 non-interconnected small farms
2) 2 UPS applications based on Fuel Cells (telecom applications)
3) Demonstration application based on Fuel Cells (Lighting of the municipality building)

The STORIES Project: "Addressing barriers to storage technologies for increasing the penetration of intermittent energy sources"

Scope:

To increase RES penetration in remote, or non-interconnected areas through the adoption of energy storage methods

Expected Results:

- Increase exploitation of RES in islands by identifying all suitable solutions to increase renewable energies penetration
- Assessment and mapping of the national regulatory and legislative framework of all EU Member States applying in remote regions
- Quantifications of the social, economic and environmental benefits of energy storage applications and grid control systems
- Estimation of economic aspects such as costs of power generation from conventional fuels in comparison to RES-energy storage power systems
- Results from different tariff schemes for combined RES-energy storage power systems in various islands/remote regions all over Europe
- Development of a Roadmap including list of recommendations for the adoption of hybrid RES-energy storage power systems
- Communication and dissemination throughout the project with the key target groups to increase public acceptance of RES-energy storage systems

Hydrogen Applications

Advantages

- Zero emissions
- Increased efficiency
- Applications in Transport
- Liberation of energy market

Disadvantages

- Increased capital cost
- High requirements for hydrogen purity
- Public acceptance

The case study of Milos

- Existing power system
- Proposed power system based on RES & H2 Technologies
- Subsidised power system based on RES & H2 technologies
- More info on **(http://www.storiesproject.eu/)**

Milos island

- South western Aegean Sea, Cyclades
- 86 miles from Piraeus
- Island Area: 151 km^2, Coast length: 125 km
- 5.000 permanent inhabitants
- 5 times increase of population during summer

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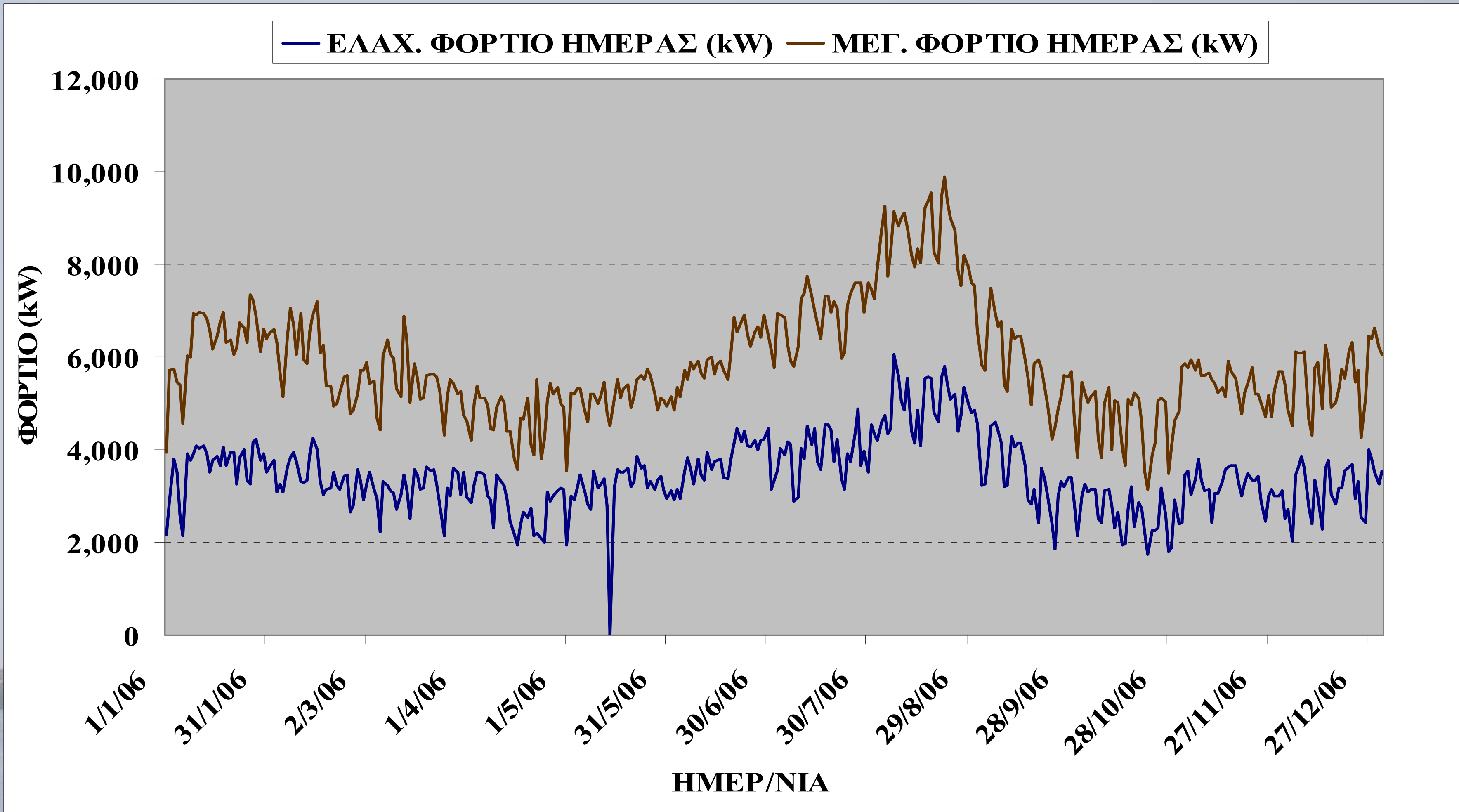
Milos Power Demand



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Milos: Architecture of the existing power system

- 8 Thermal Generator Sets

2 Sulzer 7TAF48 Units (1,75 MW, Heavy Oil)

3 MAN G9V30/45 Units (0,7 MW Heavy Oil)

1 CKD 12V27,5-B8S Unit (2 MW, Diesel)

1 CKD 12V27,5-B8S Unit (1,9 MW, Diesel)

1 FINCANTIERI BL230.12P Unit (1,75 MW, Diesel)

- 3 Wind turbines

2 Vestas V – 44 (0,6 MW)

1 Vestas V – 52 (0,85 MW)

Basic Simulation Inputs

- Heavy Oil: 0,34 €/L
- Diesel: 0,68 €/L
- Thermal generator sets: 250 – 300 €/kW
- Wind turbines: 1.200 €/kW
- Emission costs: 21 €/tn CO_2
- Project lifetime: 20 years

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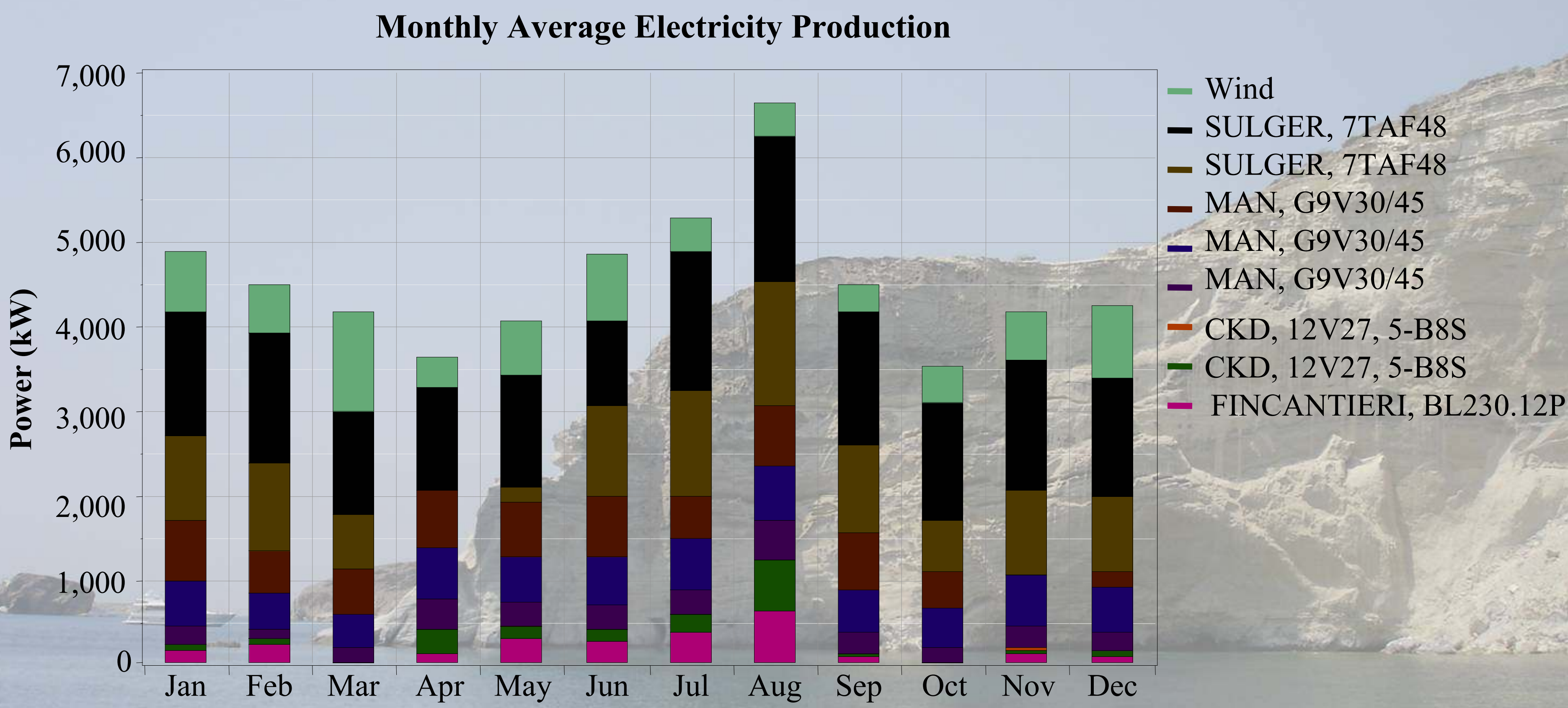
Simulation Results
Existing Power System



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Simulation Results
Existing Power System

- Cost of Energy Production (COE): 0,114 €/kWh
- Energy produced from Wind: 5.316.007 kWh/yr
- Renewable fraction: 0,134
- Heavy Oil: 8.128.720 L/yr
- Diesel: 704.548 L/yr

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Milos: Architecture of the proposed power system

- 4+1 Thermal Generator Sets

2 Sulzer 7TAF48 Units (1,75 MW Heavy Oil)

2 MAN G9V30/45 Units (0,7 MW Heavy Oil)

1 Rental Unit (1,032 MW, April-September)

- 30 Wind turbines

2 Vestas V – 44 (0,6 MW)

28 Vestas V – 52 (0,85 MW)

Electrolyser (2 MW)

Fuel Cell (PEM, 1 MW)

Hydrogen Tank (4.000 kg)

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Basic Simulation Inputs

- Heavy Oil: 0,34 €/L
- Diesel: 0,68 €/L
- Thermal generator sets: 250 – 300 €/kW
- Wind turbines: 1.200 €/kW
- Emission costs: 21 €/tn CO_2
- Electrolyser: 2.000 €/kW
- Fuel Cells: 3.000 €/kW
- Hydrogen tanks: 800 €/kg
- Project lifetime: 20 years

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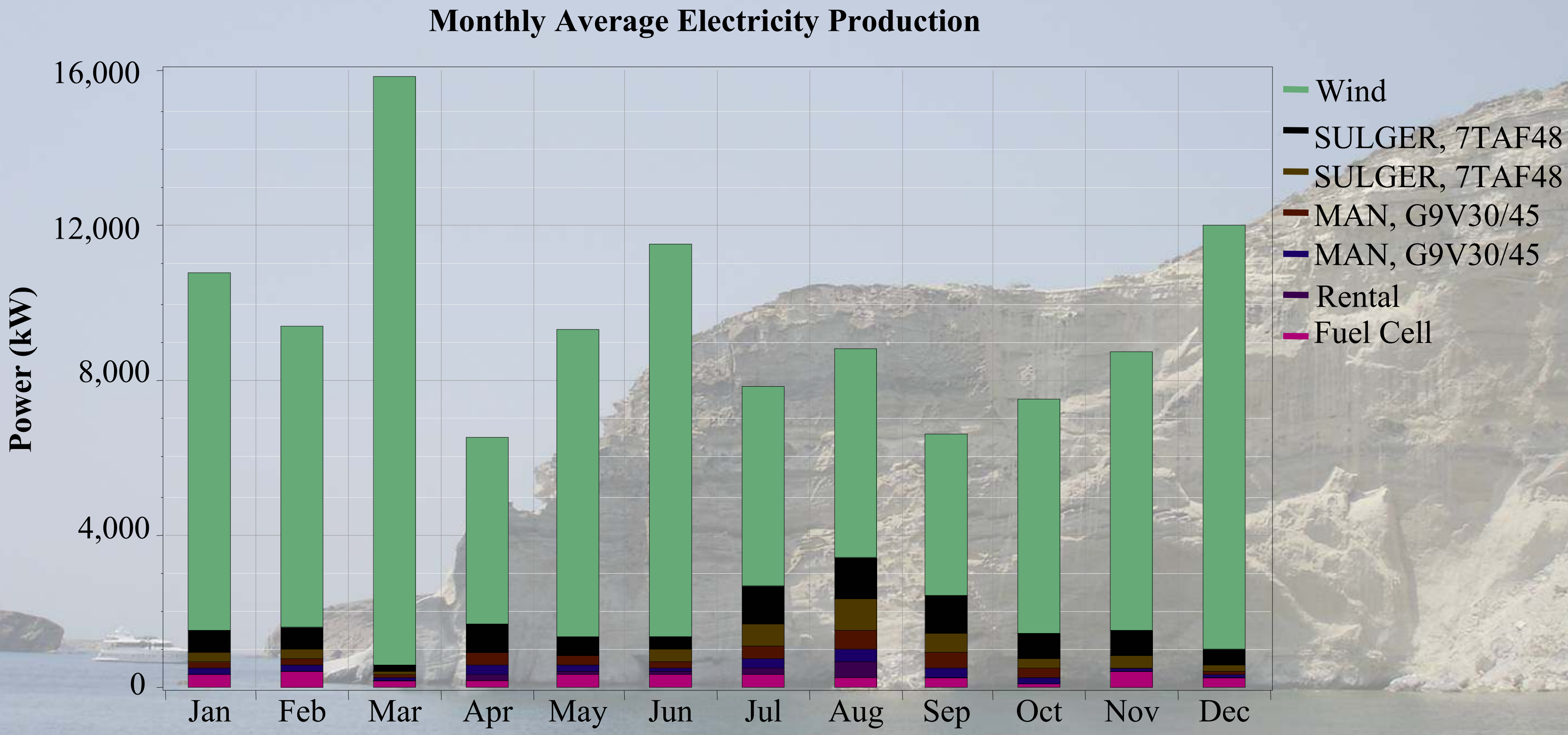
Simulation results
Proposed power system



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Simulation results
Proposed power system

- Cost of Energy production (COE): 0,144 €/kWh
- Energy produced from Wind: 69.124.688 kWh/yr
- Renewable fraction: 0,85
- Heavy Oil: 3.266.430 L/yr
- Diesel: 147.023 L/yr

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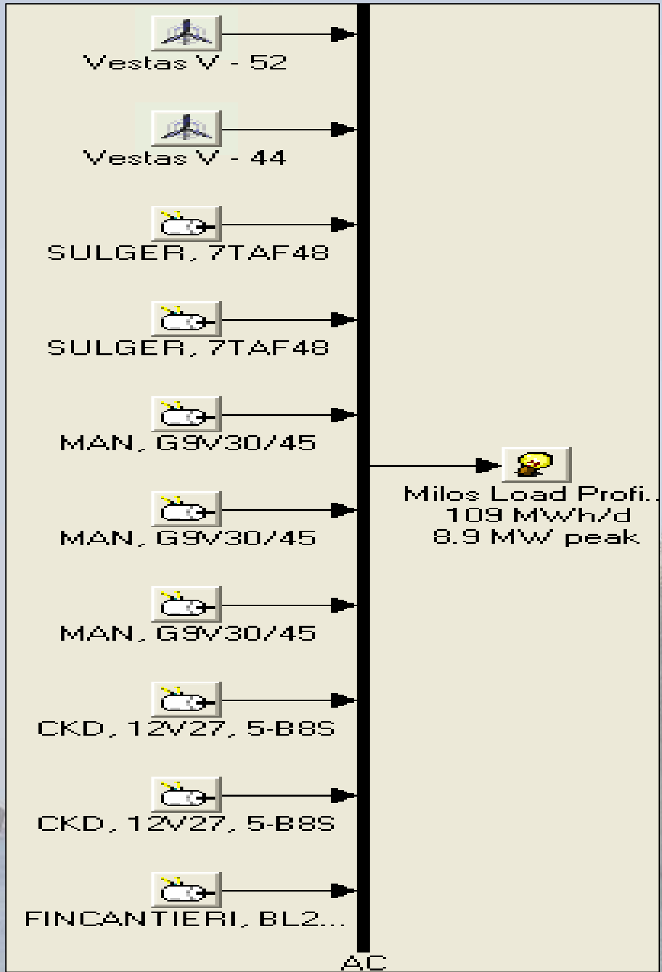
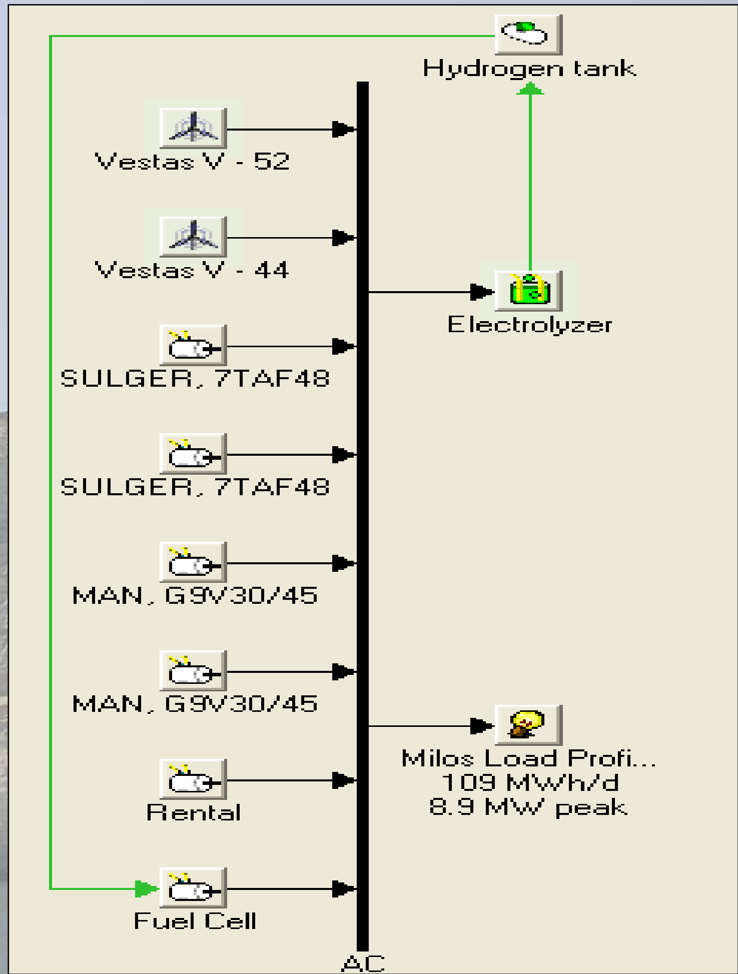
Basic Architecture of Systems





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Simulation Results

Parameters	Existing System	Proposed hybrid system without subsidies	Proposed hybrid system with subsidies (30% on WT & 50% on H2)
Cost of Energy (€/kWh)	0,114	0,144	0,112
RES penetration	13.4%	85%	85%
Number of Thermal Units	8	4+1	4+1
Wind turbines	3	30	30
Diesel (L/yr)	704.548	154.906	154.906
Heavy oil (L/yr)	8.128.720	3.054.863	3.054.863

Emissions (kg/yr)

Emissions	Existing System	Proposed hybrid system
CO_2	26,961,874	9,841,757
CO	57,416	21,809
Unburned H/C	6,360	2,416
Particulate matter	4,328	1,644
SO_2	525,409	196,873
NO_X	512,329	194,607

CONCLUSIONS

The introduction of hydrogen as energy storage method in Milos results in:

- relatively small increase in the power generation cost of the island (ca. 26%)
- huge increase on RE penetration on the island (from 13% to 85%)
- significant reduction in emissions produced (especially CO_2)
- further reduction on the cost of hydrogen energy equipment and the introduction of external costs makes the hydrogen-based system economically competitive to the existing one

GREEK H2 & FUEL CELLS TECHNOLOGY PLATFORM

- Established in 2006
- Similar structure to the European HFP
- 4 working Groups
    - Hydrogen production
    - Hydrogen storage & distribution
    - Hydrogen applications (stationary & transport)
    - Socio-economic issues
- Developed the Greek H2 and Fuel Cells Roadmap in 2007 (already submitted to Ministry of Development and the GSRT)

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PROPOSALS OF THE GREEK HFP

- **Inclusion of H2 & FC technologies in the national energy planning.**
- Call for a demonstration project where energy storage in the form of pump hydro, H2 & desalination for island power systems in combination with RES will be studied.
- Calls for proposal from GSRT for all fields of H2 & FC technologies.

PROPOSALS OF THE GREEK HFP

- **Introduction of a support framework for the development of H2 & FC applications.**

- Modifications to the existing Law (3468/2006) for RES & CHP.
- Subsidies on capital cost combined with promotional feed-in tariffs for autonomous power systems such as the islands.
- Support of 2 Lighthouse Projects (Milos & Ios).

THANK YOU !!