FLEXIBILITY AND ECONOMIC DISPATCH OF ISLAND POWER SYSTEMS WITH INTEGRATED THERMAL ENERGY STORAGE IN SMART GRIDS

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Atherinolakkos Power Station

Crete, Maximum Electrical Power Consumption: 700 MW

Crete, 3 X Thermal Power Stations: 708 MW

Crete, Wind Parks installed: 200 MW

Crete, PV Parks installed: 100 MW

Atherinolakkos Power Station
Annual Cost of Energy Production in Crete & TES-ORCs Optimal Scheduling

- Minimise:
  - Total Fuel Consumption: 177 M€
  - Start Up Cost of Local Units: 4.1 M€
  - Energy Not Supplied: 1.5 M€
ATHERINOLAKKOS - CRETE
50 MW POWER PLANT

NET ELECTRICAL EFFICIENCY: 36.6 %
GROSS ELECTRICAL EFFICIENCY: 39.2 %

BOILER
123 MW

HIGH PRESSURE
STEAM TURBINE
36 MW

T 530 °C/ 100 Bar

LOW PRESSURE
STEAM TURBINE
16 MW

T 198 °C/ 2.4 Bar

NET GENERATOR
OUTPUT
50 MW

ELECTRIC GENERATOR

COOLING TOWER

COMPRRESSED LIQUID:
T 239 °C/ 116 Bar

STEAM FLOW:
m=50.6 kg/s

CONDENSER
72 MW

CONDENSER
PUMP
0.74 MW

T 25 °C/ 0.03 Bars

FEEDWATER PUMP
0.88 MW

T 87 °C/ 0.03 Bar

Efficiency
39.2%
Thermal Input
123 MW
Electrical Power
50 MW
Efficiency: 10.6%
Thermal Input: 123 MW
Electrical Power: 13 MW
Oil-Fired Power Station Flexibility with and without TES-ORCs
Oil-Fired Electrical Energy Production & Electrical Energy Production using TES-ORCs
Derating Plant versus Steam Extraction

- DR [p.u.]

Steam Extraction Before the High Pressure Turbine [%]
Thermal Energy Storage versus Net Generator Output

- Power Station Output [MW]
- Thermal Energy Storage [MW]

TES and Power Station Output [MW]

Steam Extraction Before the High Pressure Turbine [%]
Heat Rate Input versus Steam Extraction

Heat Rate Input [MW]

Steam Extraction Before the High Pressure Turbine [%]
Rankine Cycle Efficiency versus Steam Extraction

Efficiency [%] vs. Extraction Steam Before the High Pressure Turbine [%]
Transmission Power System of Greece

Crete, Maximum Electrical Power Consumption: 700 MW

Crete, 3 Thermal Power Stations: 708 MW

AC Interconnection Athens-Crete: 150 MW

Crete, Wind Parks installed: 200 MW

Crete, PV Parks installed: 100 MW

Atherinolakkos Power Station
Unit Commitment – Economic Dispatch Optimisation of TES-ORCs

Interconnection
- 150 MW AC Interconnection
- Autonomous Operation

Fuel Cost
- Low Prices
- Baseline
- High Prices

Demand
- High
- Low

Storage Capacity
- 0
- 2 Hours
- 4 Hours
- 6 Hours
Typical Daily Operation of the Oil-Fired Power Station in Atherinolakkos

![Graph showing power unit and TES total generation over time with different storage capacities: 1h, 2h, and 3h. The graph illustrates the fluctuation in power output throughout the day.](image-url)
Average Annual Daily Operation of the Oil-Fired Power Station in Atherinolakkos

![Graph showing power unit and TES total generation over time with different storage capacities.](image-url)
TES-ORCs Optimal Scheduling in Atherinolakkos

- **No Storage**:
  - Fuel Cost: 177 mil. €
  - Start-Up Cost: 1.5 mil. €
  - ENS Cost: 4.1 mil. €

- **2 Hours**:
  - Fuel Cost: 175 mil. €
  - Start-Up Cost: 3.9 mil. €
  - ENS Cost: 1.1 mil. €

- **4 Hours**:
  - Fuel Cost: 175 mil. €
  - Start-Up Cost: 3.9 mil. €
  - ENS Cost: 1.1 mil. €

- **6 Hours**:
  - Start-Up Cost: 3.9 mil. €
  - ENS Cost: 1.1 mil. €
TES-ORCs Cost – Benefits Analysis

Installation cost: 20 M€ + 3.5 M€/Hour of Storage
TES-ORCs Discounted Payback Periods with Autonomous and Interconnected Transmission Power System of Crete

**ORC-TES Discounted Payback Period**

- **Autonomous**
  - 3.5 Years

- **With Interconnection**
  - 10 Years
Conclusions

- TES-ORCs can play an important role for increasing the **Flexibility** of Power Stations and to contribute to **Economic Dispatch**
- In Atherinolakkos Oil-Fired Power Station, the Flexibility increases from $27-50$ MW to $13-70$ MW
- $3.5$ years pay-back period for the Autonomous Power System of Crete
- $10$ years pay-back period for the interconnected Power System of Crete
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Thank you for your Attention!

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