Study Committee C6

Active Distribution Systems and DER

10712_2022

Two Years of Operation of Tilos Hybrid Power Station, Experiences and Lessons Learned

E. TSOUMAS[1], K. KAOUSIAS[2], G. PECHLIVANOGLOU[1], V. TSIMARAS[1], A. MOUSTAKIS[1], V. KALAVROUZIOTIS[1], A. KOURI[1], C. KOURELIS[2]

[1]Eunice Energy Group (Greece), [2]Hellenic Electricity Distribution Network Operator (Greece)

Motivation

- **Hybrid Power Stations (HPS),** achieving high RES penetration in combination with storage unit, formulate the appropriate means for feeding Non-Interconnected Island (NII) remote Power Systems.
- **Tilos Island** belongs in the Non-Interconnected Island (NII) System of Kos – Kalymnos and is a representative example of a remote island that simulates the operational characteristics of a Microgrid.
- **Characteristics & Problems:** Tilos is located at the end of the NII system and faced voltage stability and power quality issues for several years.
- **Tilos HPS development**, aims in optimizing local power system's operation by integrating local energy storage and is proven through the results of its operation since its initial commissioning in 2018.

Method/Approach

- Operation of HPS in grid connected scheme with the NII System. 100% Compliance with the regulations and operation protocols of HEDNO NII Grid Code.
- Participation in the specific day-ahead and intraday markets of the NII System of Kos – Kalymnos by following NII system's hourly setpoints through the R-DES.
- RES production is firstly used for the substitution of the scheduled production, then for storage and finally for direct injection via the surplus set-point.
- **Operation Modes:**
  - ✓ Steady State: HPS follows hourly production setpoints by optimally combining available RES production and stored energy.
  - ✓ Transient Response: HPS rapidly responds in transient modifications (≈1min) issued in case of NII system exceeding real time constraints.
  - ✓ Island Mode: HPS can achieve high levels of RES penetration (>70%) with the support of local backup diesel genset (e.g., in case of major faults in the submarine cable R-44). All test island mode operations so far have been deemed successful.

Objects of investigation

- **Reduction of thermal production in the NII:** The HPS combining RES and storage successfully substitutes production from gensets as fully dispatchable unit.
- **NaNiCl$_2$ Batteries:** Test of an EU prototype storage technology within the parameters of high temperatures and demanding environmental conditions.
- **Integration of RES in low power quality grid:** The HPS doesn't incorporate the stochastic nature and production volatility of RES-only units.

Experimental setup & test results

- **HPS – RES:** Wind Turbine 800kW
- **HPS – RES:** PV station 160kWp
- **HPS – BESS:** 2 x NaNiCl$_2$ Prototype Battery Energy Storage Systems (BESS) 400kW/1440kWh (each)
- **HPS – BESS:** 2x BESS Converters 500kVA
- **SCADA & EMS operation center:** Real Time Control & Supervision of all HPS components
- **Operation:** HPS Tilos was set in trial mode operation in 14.09.2018, while since 10.10.2019 it has started its commercial operation. It is the first and only HPS with PPA with the DSO (HEDNO) and an Operation License.

Discussion

- HPS BESS:
  - ✓ Enhances RES penetration.
  - ✓ Ensures optimal compliance of hourly setpoints and transient response instances.
  - ✓ Compensates any production fluctuation from WT and PV in a millisecond level.
- Provision of ancillary services :
  - ✓ P-Q operation
  - ✓ Q-U functionality
  - ✓ Frequency response
  - ✓ Primary & Secondary Reserve
- Voltage stability : Through daily absorbption or production of reactive power from HPS BESS converters, voltage stabilization is achieved for the the island of Tilos thereby eliminating Voltage Dips/Surges affecting household loads.
- Reduced rate of failure: Throughout it's operation so far, the HPS presents decreased rate of failure compared to NII systems thermal units (gensets).

Conclusion

- HPS BESS prototype achieves rapid response time (≈500msec) in any fluctuation occurred from internal dynamic RES production or external grid disturbances or necessary setpoints alterations.
- Operation results prove that HPS are profitable RES solutions under the necessary regulated operation framework that can actively support local microgrids and NII grids.
- Future HPS development: The overall experience gained assisted the DSO in further formulating and optimizing the operation framework for future HPS in various NII systems (Ikaria, Ag. Efstratios and Astypalaia).

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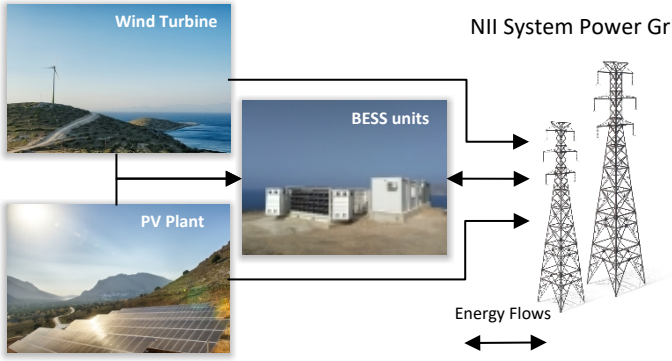
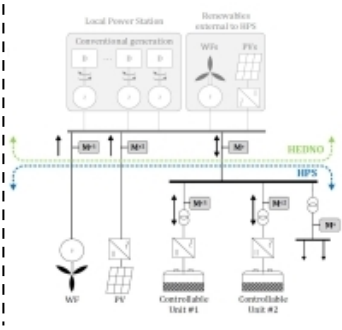
Energy Flows with Power Grid



HPS Tilos Components

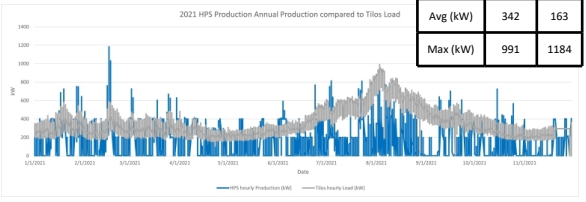
Overview SLD



Allocation of Microgrid Components

Tilos Hourly Load Curve - HPS Production 2021

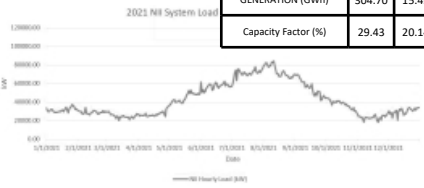
Tilos	Load	HPS
Avg (kW)	342	163
Max (kW)	991	1184



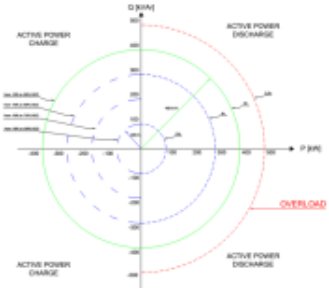
NII System Kos - Kalymnos

Kos – Kalymnos Power Plant Elements 2021

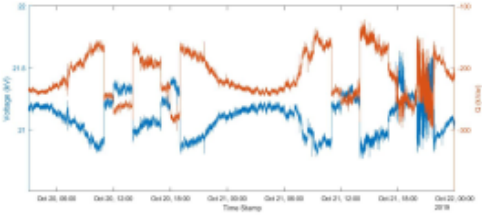
Generation Type	Thermal	PV	WP	TILOS HPS
INSTALLED(MW)	118.2	8.78	15.2	0.4
GENERATION (GWh)	304.70	15.49	40.14	1.405
Capacity Factor (%)	29.43	20.14	30.14	40. 1



P-Q Control



Q-U Droop Control



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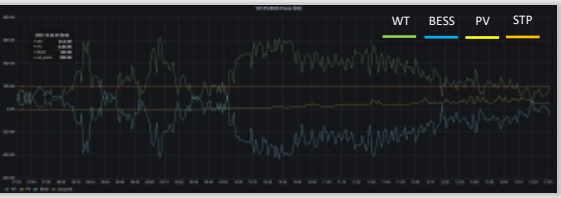
Steady State Operation (1)

- The HPS complies to a constant Power Command (Setpoint) of 200kW issued by the DSO.



Transient Response Operation

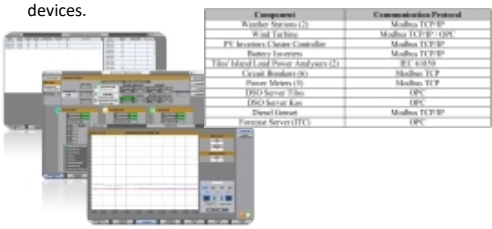
- The HPS adjusts its total output according to minute level modifications in the hourly Setpoint.

Steady State Operation (2)

- The HPS adjusts to hourly alterations of the Power Command from 0 kW to 200 kW to 400kW.

SCADA, Communication & Protocols

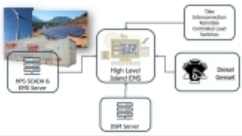
- **Fiber-optic Communication:** Fiber – optic and UTP cables were installed to ensure fast communication between the various components and measuring devices.

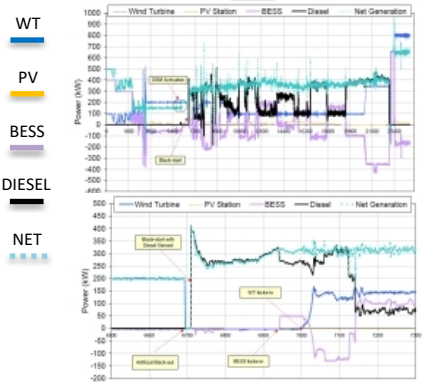


Component	Communication Protocol
Weather Stations (2)	Modbus TCP/IP
Wind Turbine	Modbus TCP/IP, OPC
PV Inverters Cluster Controller	Modbus TCP/IP
Battery Inverters	Modbus TCP/IP
Tilos Island Load Power Analysers (2)	IEC 61850
Circuit Breakers (8)	Modbus TCP
Power Meters (3)	Modbus TCP
DSO Server Tilos	OPC
DSO Server Kos	OPC
Diesel Genset	Modbus TCP/IP
Enercon Server (TEC)	OPC

Island Mode Operation

- Trial outage of Tilos R-44 submarine cable. Local genset operated in parallel with HPS.
- During Black-Start instance Energy Balance between diesel genset, HPS and island load.
- Achieved RES penetration of ~85%





Conclusion

- **HPS as VPP**: Tilos implemented the technology of a Virtual Power Plant (VPP) with high level SCADA, as it controls household heaters, A/C and the various local critical loads (water pumps). It provides an ideal testbed for various DSM practices from both the scopes of DSO and Producer.
- **Operation Framework:** The development and so far operation of the HPS provided experience on operation and pricing optimization methods for similar projects. The adoption of a single tariff, independent of the HPS component proves to be the sustainable method of operation.
- **Environment:** The positive environmental impact from RES production can be easily be introduced in NII systems and microgrids through the scheme of HPS.
- **Awards:** HPS Tilos has been distinguished with the following International Awards:
  - ✓ Energy Islands Award (2017),
  - ✓ Citizens' Award (2017
  - ✓ European Enterprise Promotion Award (2019)
  - ✓ RESponsible Islands 3rd Prize (2020).