Early-Operation Evidence and Lessons Learnt from the First-ever Battery-based Hybrid Power Station in Greece on the Island of Tilos

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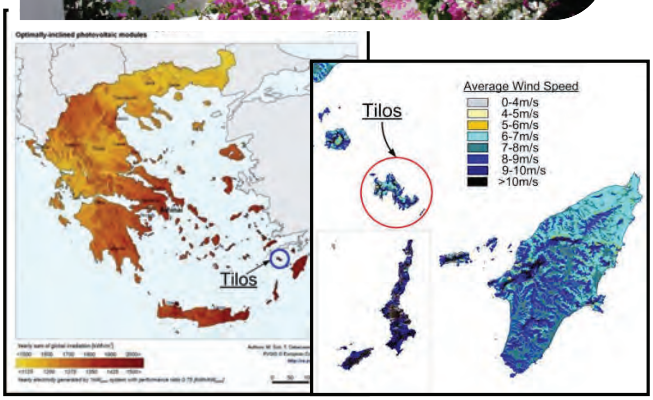
TILOS Project – General Info

- **Framework**: Horizon 2020
- **Call**: Local / small-scale storage-LCE-08-2014
- **Score/Ranking**: 14/15 (1st among 80 proposals)
- **Budget**: 15M€ (11 M€ funding)
- **Consortium:** 13 partners / 7 European countries
- **Duration**: 4 years (2/2015-2/2019)

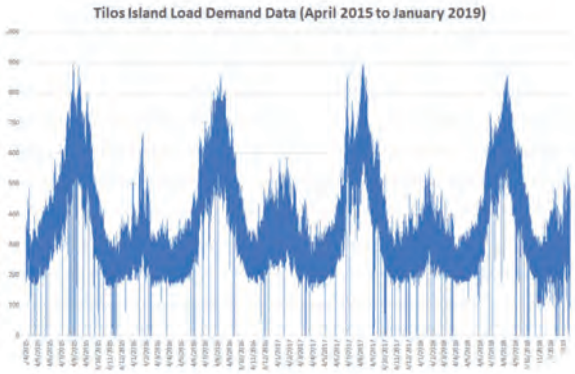
HORIZON 2020

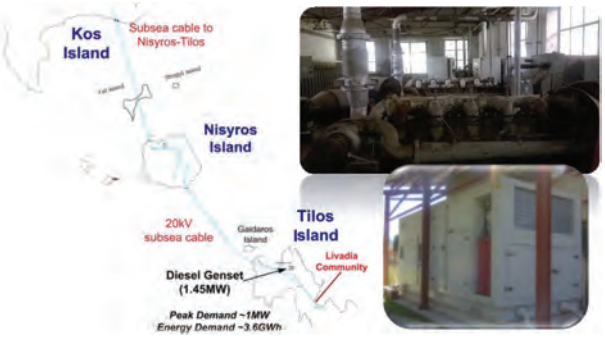
The Island of Tilos



- Small scale, remote Aegean Island; Belongs to the island complex of the Dodecanese
- Local population of ~**500 people**; More than **doubles** during the summer period
- Peaceful island with **environmentally-friendly** profile and culture
- **Medium-quality** wind potential – Average wind speed in the order of **6.5-7m/sec**
- **Excellent** solar potential; ~**1750kWh/m^2.a**

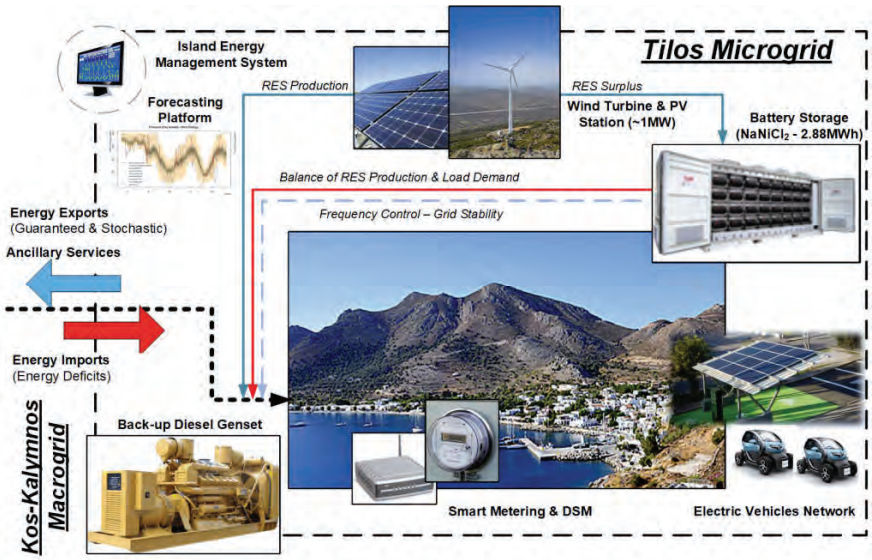
The Island of Tilos





- Peak demand of Tilos close to **1MW**; Annual electricity demand of ~**3GWh**
- The island belongs to the **Kos-Kalymnos** electricity system (~100MW system)
- **Subsea interconnection** with Kos through Nisyros island; Tilos last in line (mainly oil-based supply: 85% oil vs 15% RES)
- Occurrence of faults from time to time causes **power cuts** that may last for tens of minutes up to a few hours
- Emergency **diesel genset** of PPC; Activated manually in the case of severe power cuts

TILOS Microgrid / Main Components



TILOS HPS – Wind Turbine

- One of the main elements of the TILOS Hybrid Power Station is the **Enercon E-53 wind turbine** of **800kW**
- Installed in **July 2017**, the wind turbine is located on the north side of the island, next to the **subsea cable junction**
- Annual energy yield of ~**2.1GWh** (30% CF), equal to **70%** of Tilos island annual electricity demand
- Supports both **energy autonomy** of Tilos and clean **energy exports** to the electricity system of Kos

TILOS HPS – PV Station

- Small-scale **PV power station** of **160kW$_p$**, comprising of 592 solar panels of 270W$_p$ each @30 degrees tilt angle
- Located in the center of the island, between the villages of **Livadia** and **Megalo Chorio**
- Annual CF in the order of **19%**, expected to contribute with ~**265MWh** of clean energy on an annual basis, which is close to **9%** of Tilos island demand
- Offers a more "dispatchable" energy source that allows for better regulation of the overall Tilos system

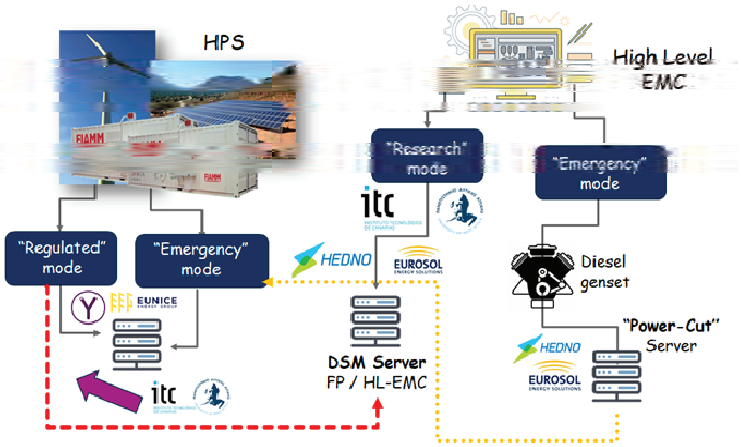
TILOS HPS – Battery Storage

- The **BESS** of TILOS comprises of the **FZSoNick NaNiCl$_2$ Battery** and **IDT Inverter**
- Together they comprise a **multifunctional configuration**, for both **island** and **grid-connected** applications
- Battery capacity of **2.88MWh** (80% useful) ~12h of autonomy for Tilos; nominal power of **800kW**, close to island peak
- Accurate forecasting allows for optimized battery operation through the better scheduling of **charging/discharging rates**

TILOS Smart Metering & DSM Network

- TILOS SM & DSM Microgrid Platform is a **hardware / software platform** supporting **metering and control** of both facility-level and individual end-consumer loads
- **150 end-users** (mainly residential consumers) and **8 pumping stations**; **Mesh wi-fi** communication & **2 main collection points**
- By exploiting an adequate **pool of customers (15% of loads)**, the platform is able to deploy **DSM strategies** at the local, end-user level, and also at the global, MG/aggregator level
- Forecasting enables provision channeling of **signals to local consumers** through the SM-DSM platform

TILOS High-Level Energy Management Centre



- Offers an **upper level entity** that could **govern all components**
- Supported the **unbundling of roles** between different partners and actors onsite
- Interfaces also the **local diesel genset**, deemed necessary in order to run island tests
- Commissioned in Jan 2019, **enabling isolated mode** of operation for Tilos

Demonstration / Trial Period

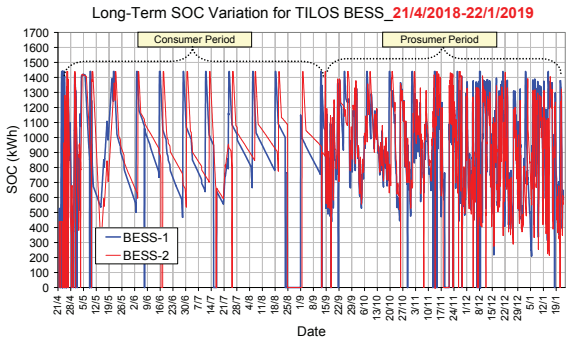
	2018									2019		
Activities	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**….**
BESS Commissioning												
HPS Consumer Mode												
Wind Turbine Commissioning												
PV Station Commissioning												
HPS Prosumer Mode												
HL-EMC Installation												
Island Testing in Berlin												
HPS Profile Testing												
HL-EMC Commissioning & Island Testing on Tilos												
Solar EV Station Commissioning												
HEDNO Commissioning Tests												
HPS Operational License												
HPS-only / Full-DSM Island Test												

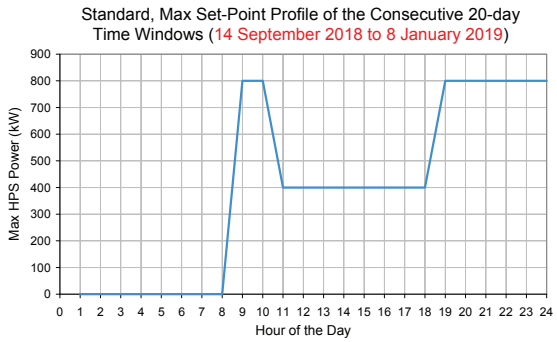
Trial Period Testing

- **PPA** issuance (Jan 2018)
- Two distinct periods: Consumer & Prosumer
- May-Sept 2018; Sept 2018-Jan 2019
- **Increased RES** penetration (daily, monthly…)

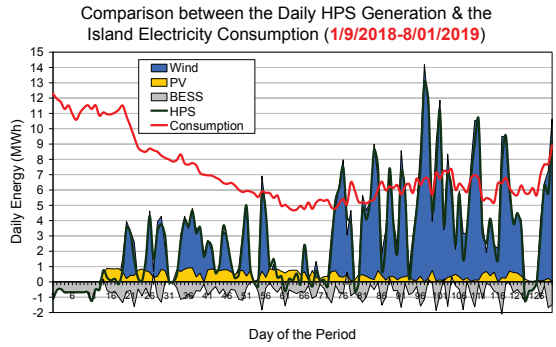
- **Profile Tests for the HPS** (day-ahead scheduling)
  - Std HEDNO profile
  - Island load-following
  - Island load-following + Exports
  - RES following

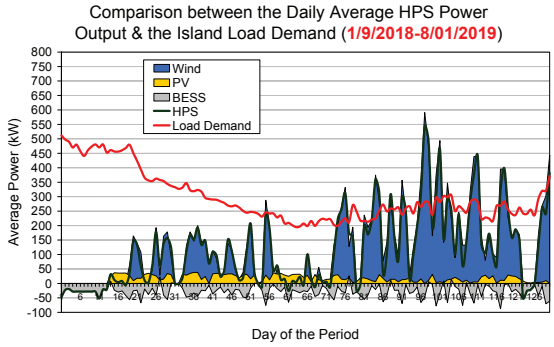
- **Island Tests** (isolated mode of operation)
  - Artificial black-out
  - Black-start with genset
  - Increased instantaneous RES shares
  - DSM contribution

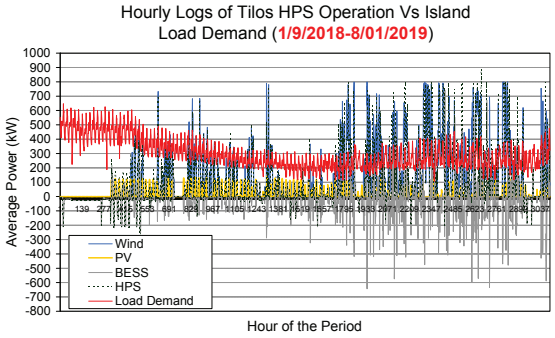


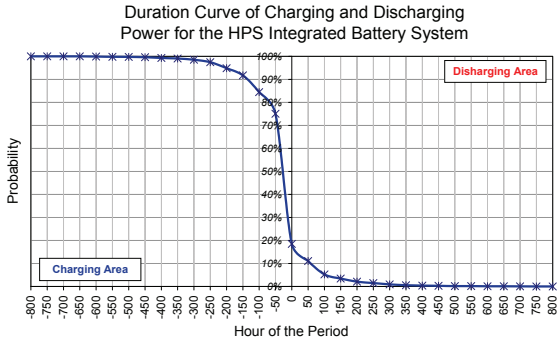


Default HEDNO Profile

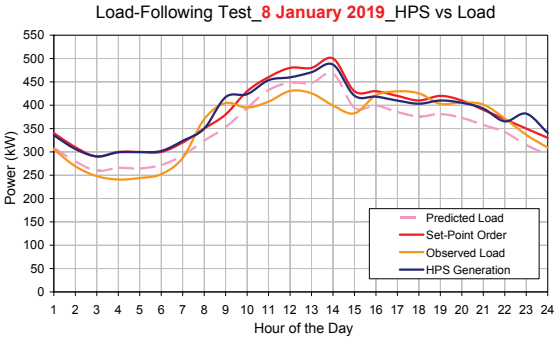


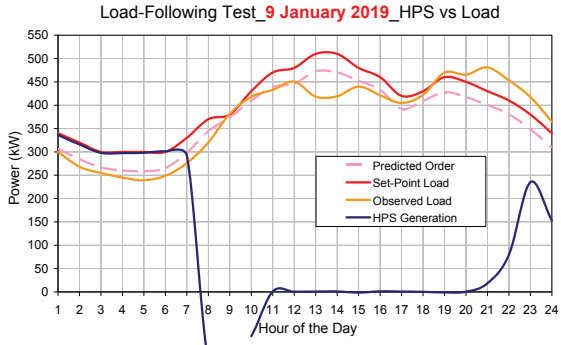


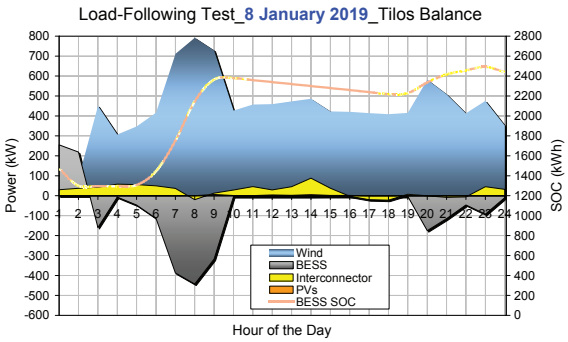


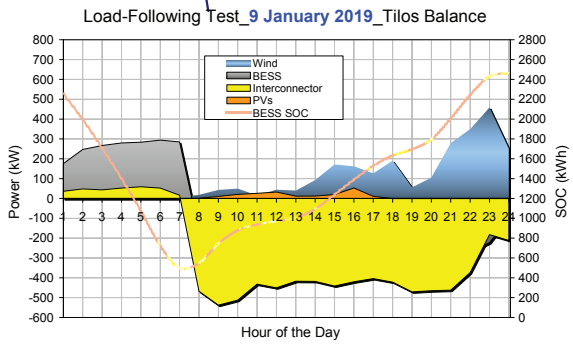


HPS Trial Period – Load-Following

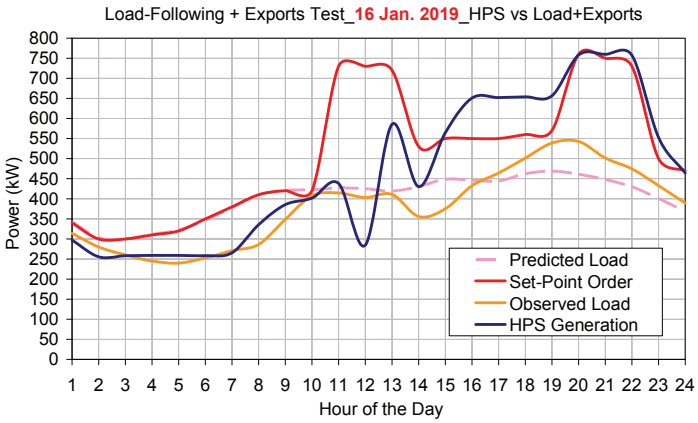


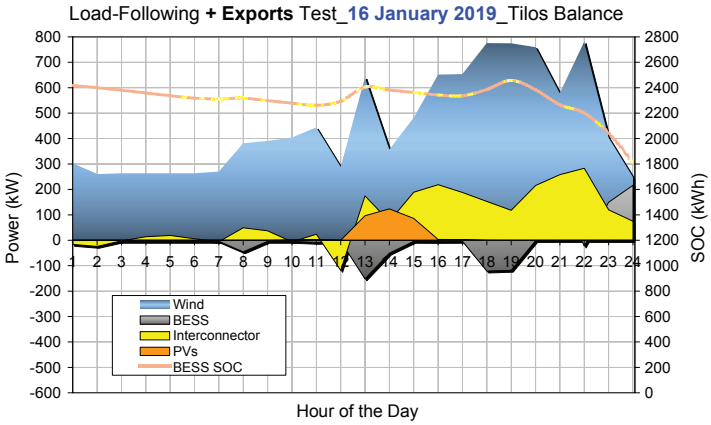






HPS Trial Period – Load-Following + Exports





DSM Commissioning & Trial Period

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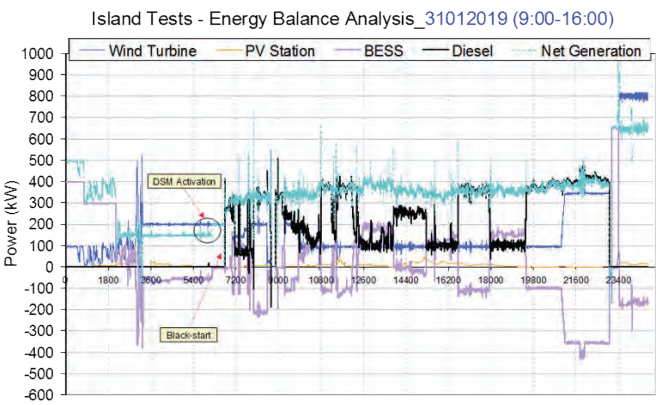
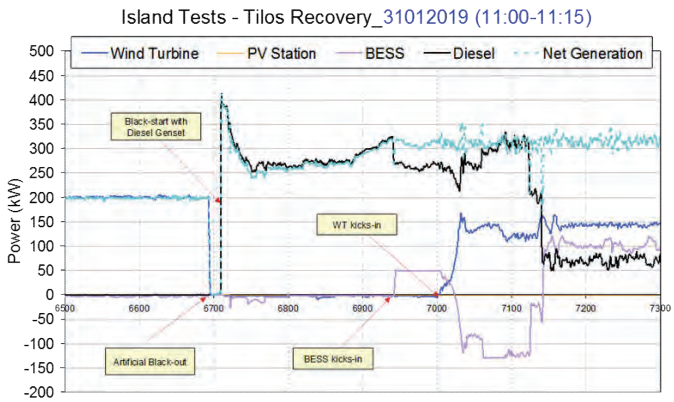
Island Tests





- Artificial **black-out and almost immediate recovery** via the diesel genset, followed by the introduction of the HPS, which received set points from the HL-EMC
- Instantaneous **RES shares >80%**
- Smooth continuous operation with the activation also of the DSM side during RES excess, designating **interoperability aspects** between the different components

Key Exploitable Results

1. The integrated prototype Battery Energy Storage System which comprises the core element of the Tilos HPS and smart microgrid, offering also a solution tailored to the Greek regulatory framework

2. The first-ever battery-based Hybrid Power Station in Greece and issuance of all relevant permits, including the first-ever PPA, which disrupted the local energy market and paved the way for system replication

3. The integrated, end-to-end, Smart metering & DSM platform and prototype DSM panel, and roll-out of 100 DSM panels in residential, commercial and community loads of Tilos

4. The first-ever, Solar-based EV Charging Station on a Greek island, introducing green electromobility in Tilos

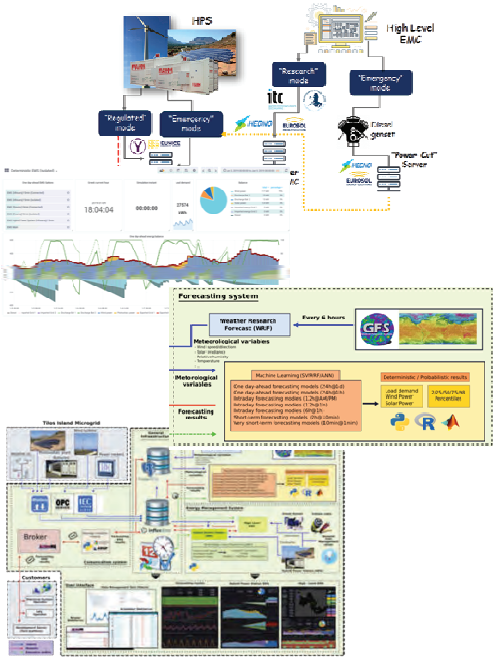
Key Exploitable Results

5. The High-Level Energy Management Centre governing all components of TILOS microgrid and comprising an expandable infrastructure that can incorporate additional vectors and modules

6. A multi-layer EMS which enables operation of the Tilos HPS in line with the Greek regulation framework, as a grid-forming entity for island system operation and as an HL-EMC-governed component

7. The advanced forecasting system, comprising different forecasting techniques and models for wind power generation, solar power generation and load demand

8. The Microgrid Management Platform comprising an advanced smart microgrid energy management platform, which incorporates also the forecasting platform of TILOS and which allows for the optimal dispatch of all agents of the Tilos microgrid



Key Exploitable Results

9. The Microgrid and Extended Microgrid Simulators of TILOS comprising two high-level energy balance analysis and sizing tools for RES-based storage configurations and microgrids

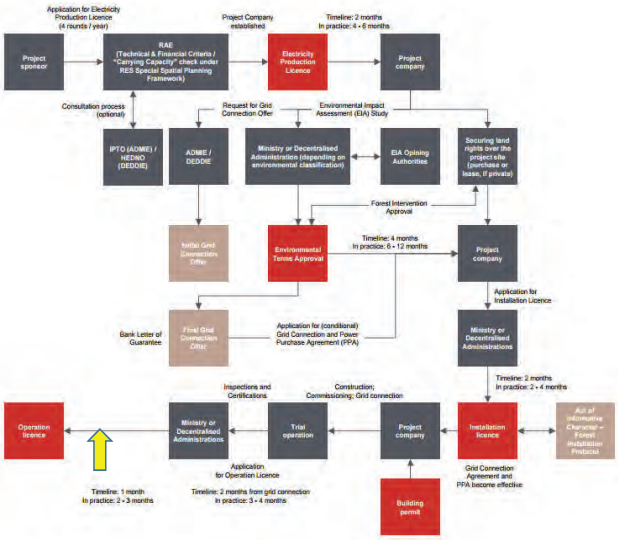
10. The Population Engagement Toolkit, including training material, set of questionnaires and surveys, dissemination actions, etc.

11. The Advancement of the Greek Regulation on HPSs through the introduction of battery-related features which reflects on the local market and facilitates new investments in the field

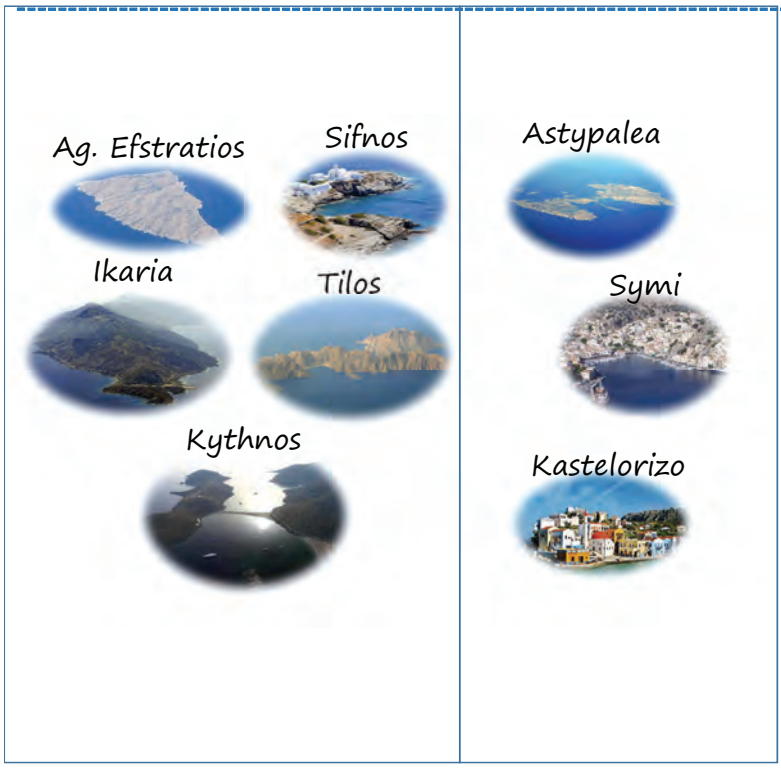
12. The TILOS Ecosystem itself, capturing all of the above aspects and offering an infrastructure that can further advance while also comprising a living lab and testbed for the application of new strategies, platforms and smart elements

Key Topics

- Different features of **battery storage (vs PHS)** introduce several challenges
- Topics to elaborate on:
  - Sizing principles
  - Dispatching principles
  - Ancillary services
  - Tariff schemes
  - Different scale islands
  - Demand response-end users
  - The microgrid entity



The Way Forward



- 15 Aegean islands
- >1000 respondents
- 8-25 September 2017

Key finding: **3/4** islanders encourage power supply from RES+Storage !!!

Thank you
for your Attention