ΡΥΘΜΙΣΤΙΚΗ ΑΡΧΗ ΑΠΟΒΛΗΤΩΝ, ΕΝΕΡΓΕΙΑΣ & ΥΔΑΤΩΝ
REGULATORY AUTHORITY FOR ENERGY, WASTE & WATER

Regulatory Authority for Energy, Waste & Water

«Regulatory Framework and Hybrid Stations in Non Interconnected Islands - Greece»

Dr. Dionysios Papachristou
Electrical Engineer NTUA, Scientific Expert
Director of Communication Office
Regulatory Authority for Energy, Waste & Water

On line, 10.11.2023

Contents

The structure & characteristics of the electrical systems in Islands

GREECE

The Greek electrical Systems

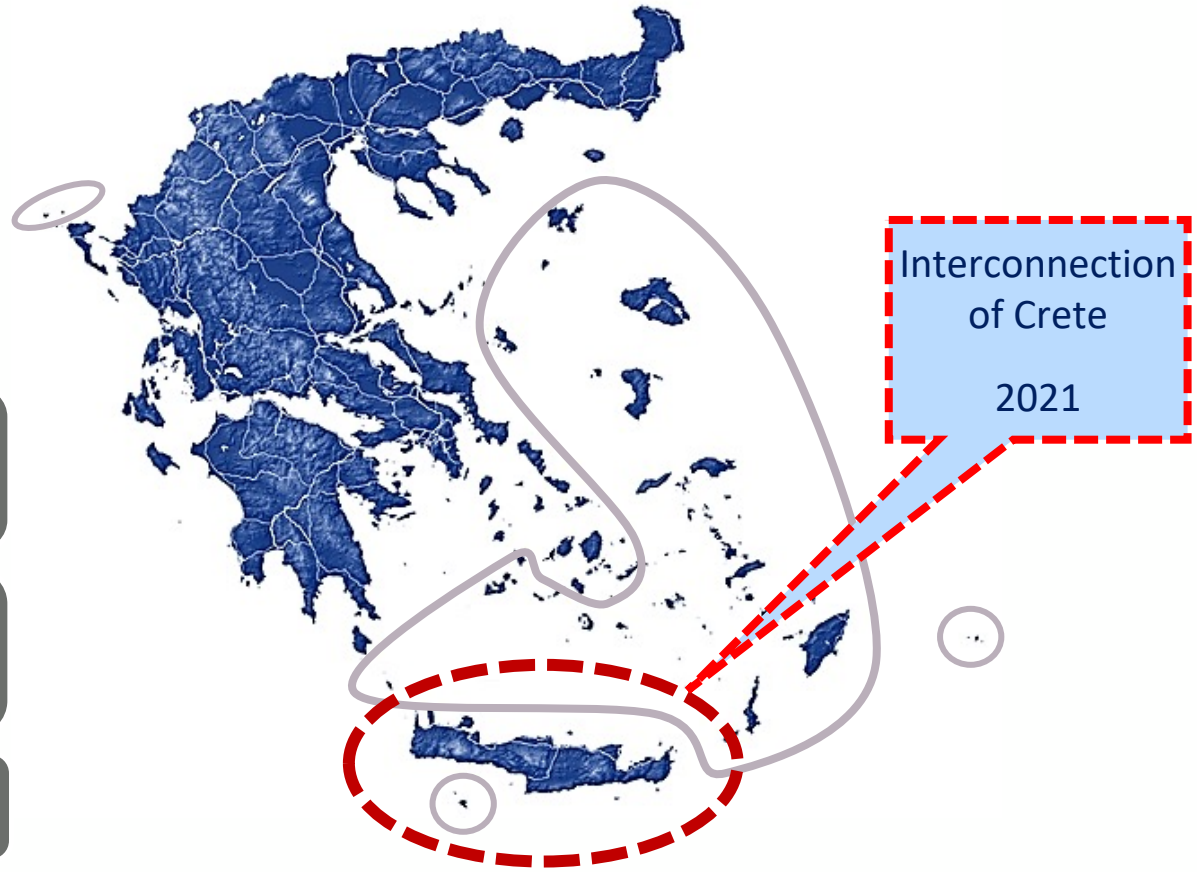
- **1 Mainland Electrical Systems (ES)**

- **46 Islands**
- **28 Electrical Systems (ES)**

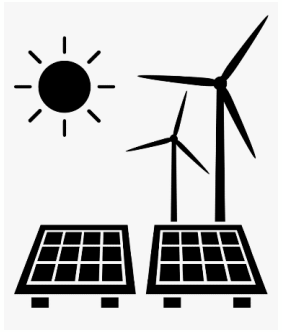
1 Big (With peakload above 100 MW, Rhode)

11 Medium (With peak load between 5MW and 100 MW)

16 Small (with peak load bellow 5MW)



30 Thermal Stations (1.012 MW)

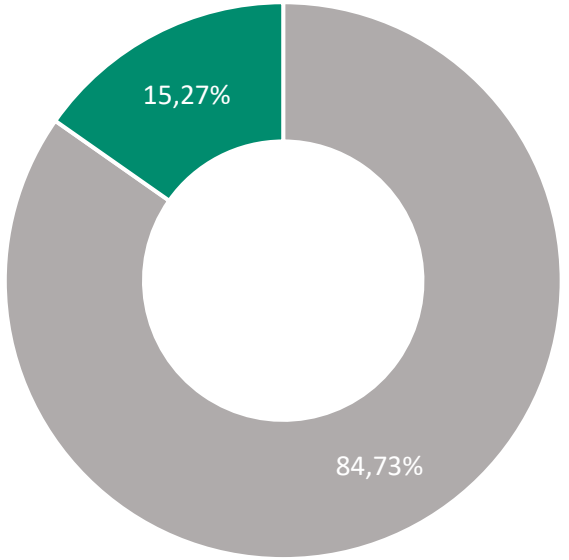


691 RES stations (162,47 MW)

- 53 Wind stations (108,06 MW)
- 641 PV Stations (51,46 MW)
- 2 Hybrid Stations (2,95 MW)

Autoproducers (5,84 MW)

- 959 PV Roof (4,67 MW)
- 106 PV net metering (1,17 MW)



1 Mainland Electrical Systems (ES)

28 Isolated Electrical Systems (ES)

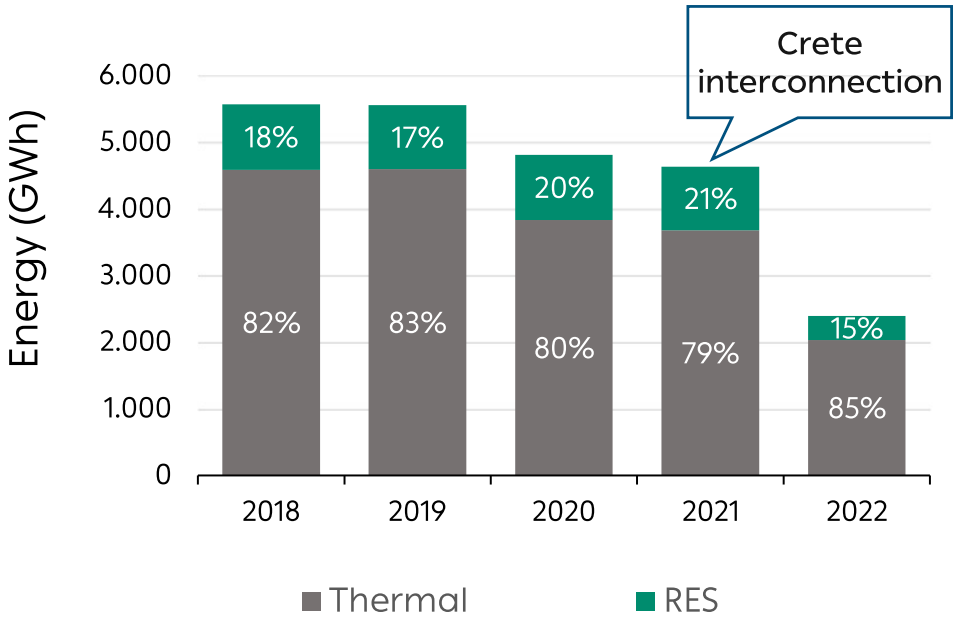
Electrical System	Installed Capacity (MW)
Rhodes	320,45
Agios Efstratios	0,84
Agathonisi	0,639
Amorgos	6,2
Anafi	1,152
Antikithira	0,413
Arkioi	0,405
Astypalaia	5,1
Gavdos	0,83
Donousa	0,99
Ereikousa	1,165
Thira	80,187
Ikaria	20,0224
Karpathos	19,054
Kythnos	7,195
Kos-Kalumnos	213,688
Lesvos	102,595
Limnos	26,153
Megisti	2,22
Milos	25,5
Othonoi	0,662
Patmos	8,925
Samos	49,63
Serifos	9,215
Sifnos	12,725
Skyros	8,9
Simi	9,875
Chios	77,782
TOTAL	1.012

28 Isolated Electrical Systems (ES)

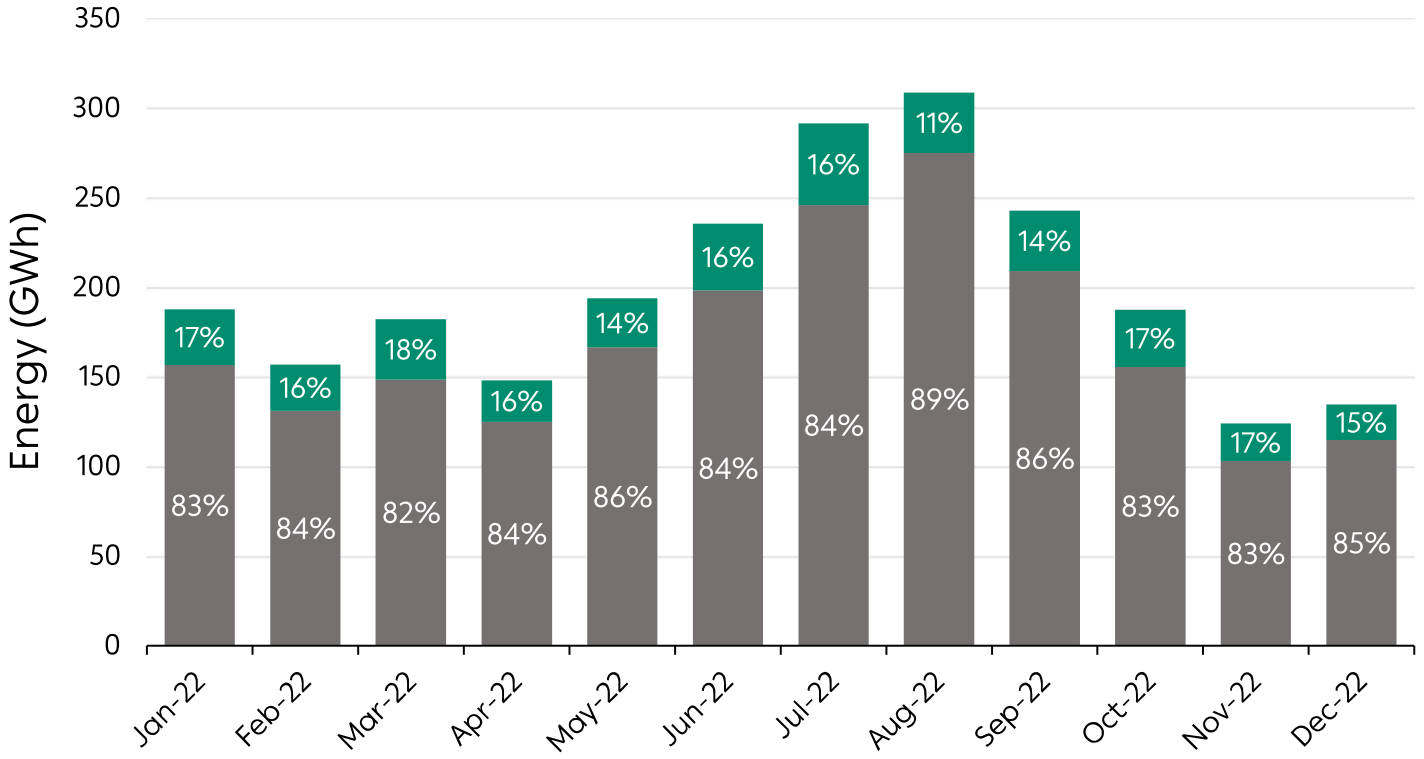
Region	Electrical System	Island
South Aegen	Agathonisi	Agathonisi
	Amorgos	Amorgos
	Anafi	Anafi
	Antikithira	Antikithira
	Arkioi	Arkioi
	Astypalea	Astypalea
	Gavdos	Gavdos
	Donousa	Donousa
	Ereikousa	Ereikousa
	Thira	Thira
		Thirasia
	Karpathos	Karpathos
		Kasos
	Kithnos	Kithnos
	Kos	Kos
		Pserimos
		Giali
		Kalimnos
		Leros
		Lipsoi
		Tenedos
		Nisiros
		Tilos
	Megisti	Megisti
	Milos	Milos
		Kimolos
	Othonoi	Othonoi
	Patmos	Patmos
	Rhodes	Rhodes
		Chalki
	Serifos	Serifos
	Sifnos	Sifnos
	Skyros	Skyros
	Simi	Simi
North Aegean	Agios Efstratios	Agios Efstratios
	Limnos	Limnos
	Lesvos	Lesvos
		Megalonisi
	Chios	Chios
		Oinouses
		Psara
	Ikaria	Ikaria
	Samos	Samos
		Fournoi
		Thimaina

Annual Production (years 2018-2022)

	Thermal	RES
	GWh	GWh
2018	4.586,12	986,08
2019	4.594,66	960,76
2020	3.831,72	978,19
2021	3.676,97	954,01
2022	2.030,19	363,79

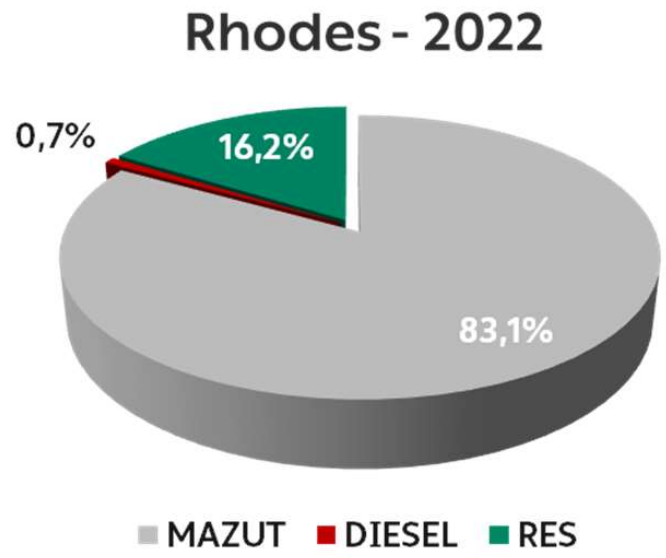


Monthly Production in year 2022

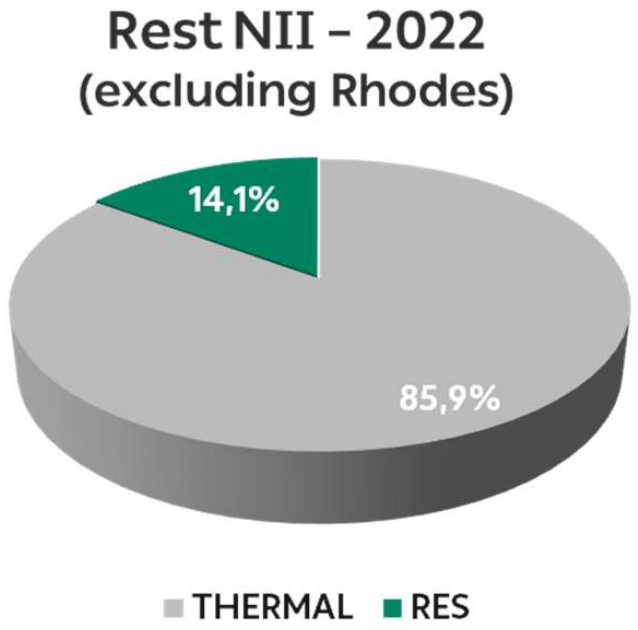


Source: HEDNO

2022 NII Energy Balance (Demand: 2.392 GWh, RES Generation: 356 GWh)



Demand: 846 GWh, RES Generation: 137 GWh



Demand: 1.546 GWh, RES Generation: 219 GWh

Source: HEDNO

The National Energy & Climate Plan (Greece)

1 New NECP for NII / Interconnections

The goal of eliminating the operation of thermal units with liquid fuel is the completion of the interconnection of all islands with the interconnected system (Mainland), a goal of the previous NECP that is already successfully implemented and further expanded in the present NECP. The island interconnection project includes:

- Interconnection of Crete with Mainland (Phase II)
- Phace D Interconnection of Cyclades (South and West)
- Interconnection of Dodecanes with Mainland
- Interconnection of North-East with Mainland

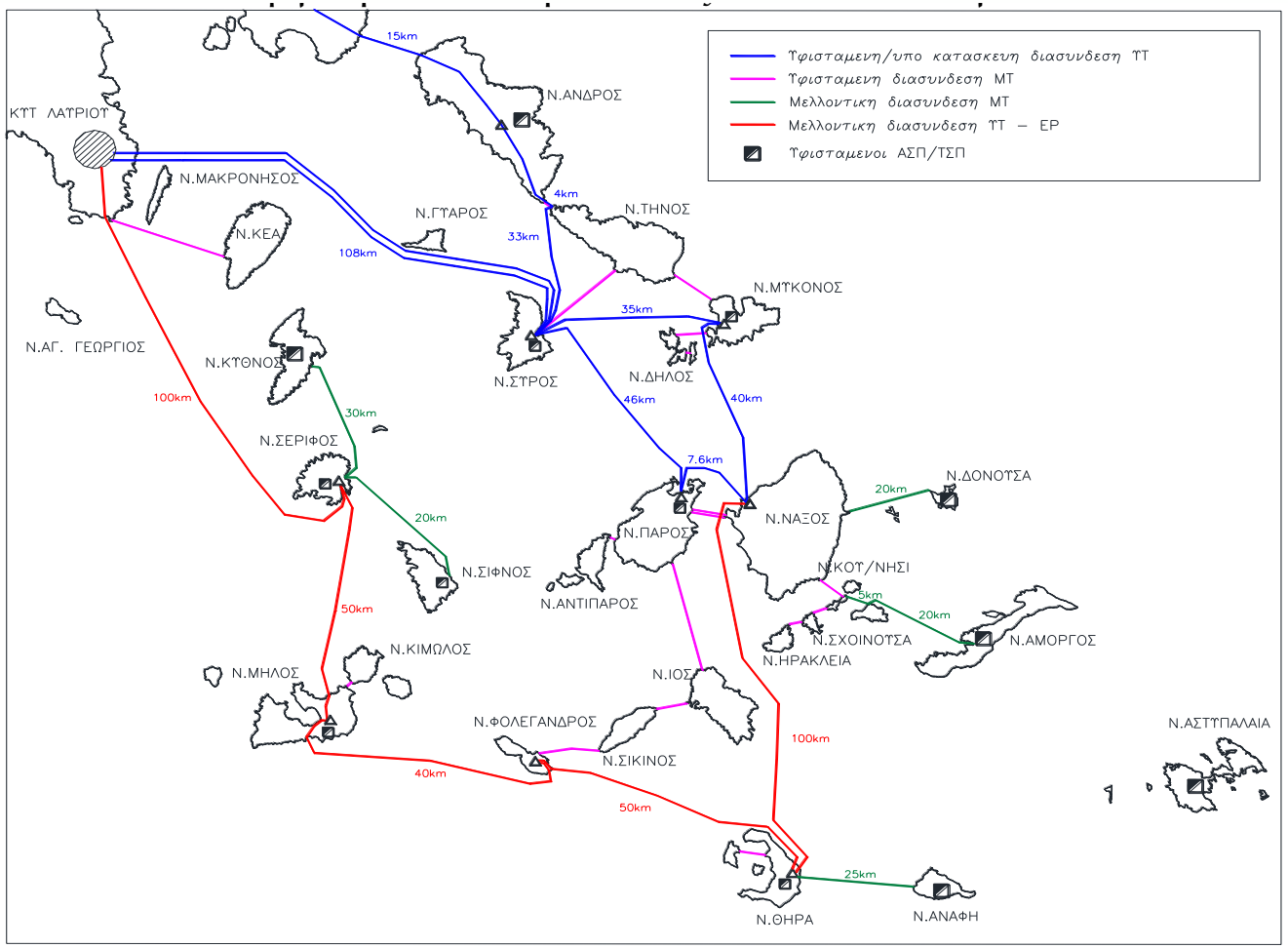
Interconnections of Cyclades

Phase D (on process)

Connection Paros (or Naxos) - Thira

To be completed in 2023

Thira to Folegandros
Folegandros to Milos
Milos to Serifos
Serifos to Attika

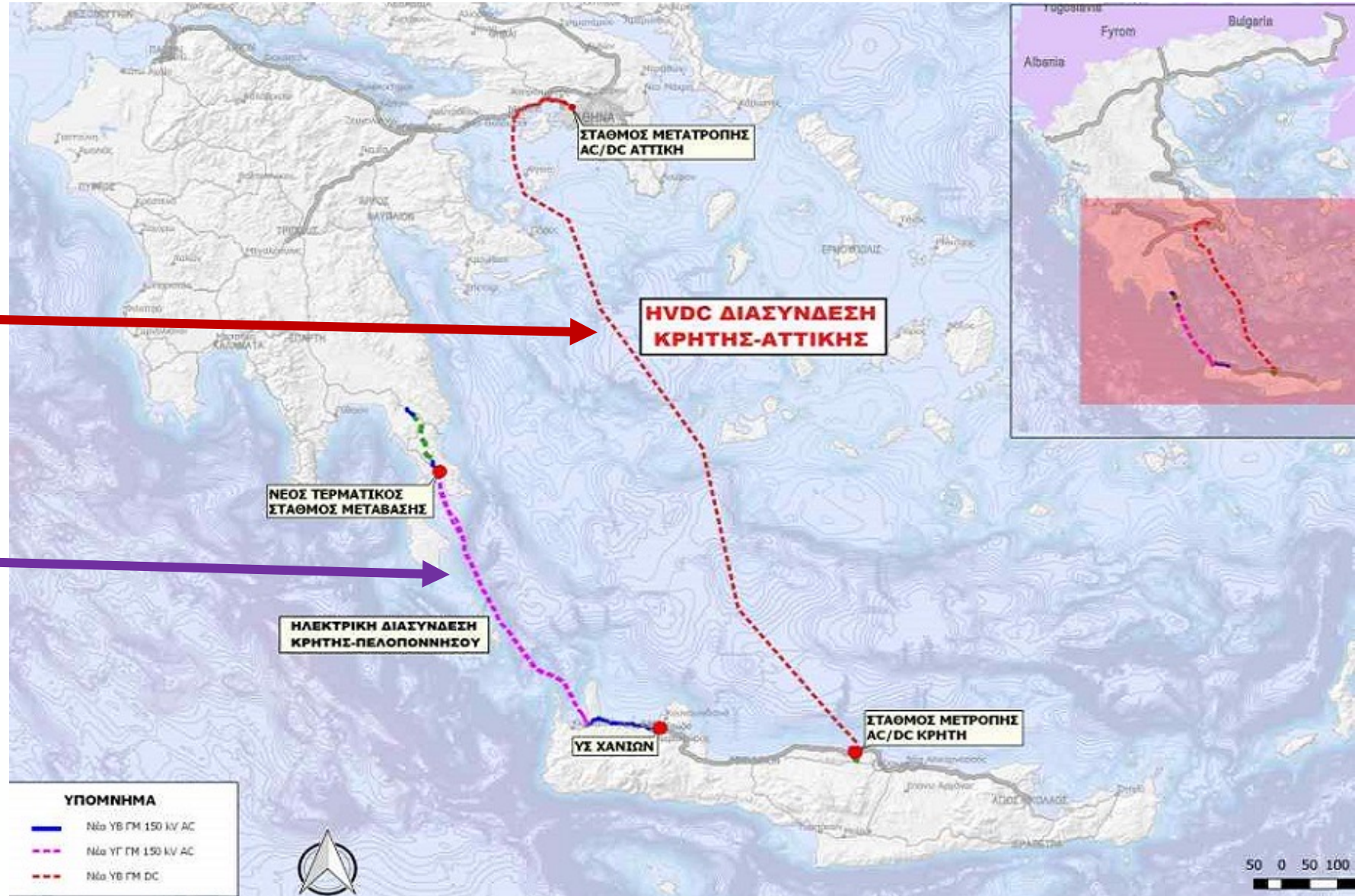


Interconnection of Crete with Mainland (Phase II)

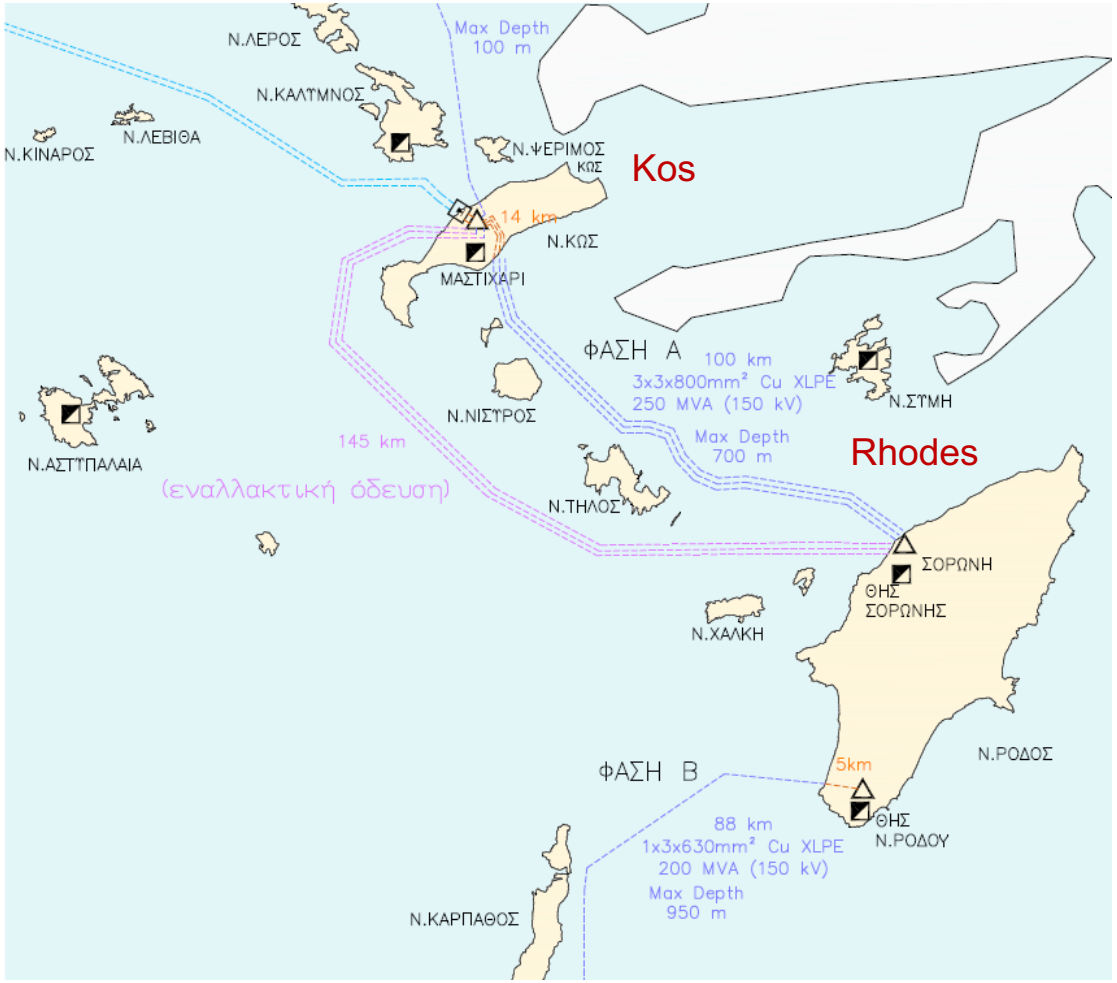
Interconnections of Crete

To be completed in 2024

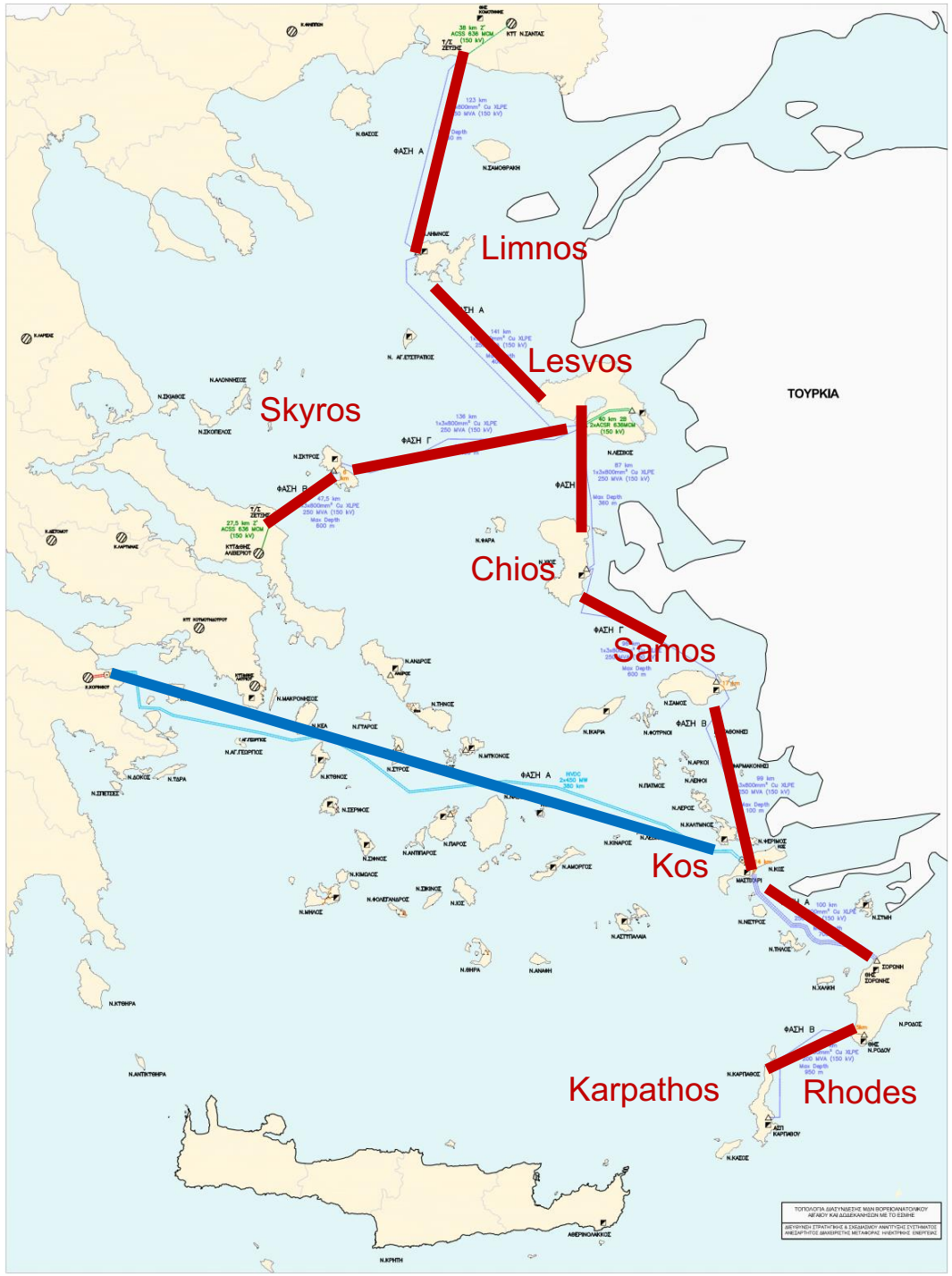
The first cable is **already in operation since 2021**



Interconnection of Dodecanes with Mainlnd



Different ways of connection Rhodes-Kos



2 New NECP for NII / Hybrid stations

3 measures

3 New NECP for NII / GR-eco Islands

The implementation of the GR-eco Islands Program aims to transform the islands of Greece into models of green economy, energy self-sufficiency, digital innovations and sustainable mobility. It started from Halki and using European funds it is planned to expand to dozens of other small Greek islands such as:

Simi, Agathonisi, Megisti, Arkoi, Marathi, Kasos, Chalki, Pserimos, Yiali, Lipsi, Telendos, Nisiors, Megalonisi, Oinouses, Psara, Fournoi, Thimaina, Amorgos, Anafi, Donousa, Heraklia, Antiparos, Schoinousa, Ios, Sikinos, Koufonisi, Folegandros, Thirasia, Kithnos, Kimolos, Serifos, Sifnos and Kea.

3 New NECP for NII / GR-eco Islands

In order for an island to be selected and participate in the actions that will be found in the GR-eco Islands, it should meet some criteria, such as:

- To have a low population (from 3,000 to 5,000 people).
- Interconnection with Mainland after 2030 or never
- The resources from the Decarbonisation Fund for the Greek Islands, which exceed €1 billion, are of decisive importance for the implementation of the above and the minimization of the carbon footprint of the NIIs.

The Regulatory Framework for Hybrid stations in Non-Interconnected Islands

National Legal basis | National Regulatory Framework

- Law 3468/2006 (in particular its articles 6, 10);
- Law 4414/2016 on a new support scheme for renewable energy sources and high efficiency combined heat and power installations - Provisions concerning the legal and administrative unbundling of natural gas supply and distribution and miscellaneous provisions (in particular its articles 13, 21);
- Law 4643/2019 on the liberalization of the energy market, modernization of PPC, privatization of DEPA and support of RES and other provisions (in particular its article 22);
- **Law 5037/2023 (FEK B' 78/28.03.2023) – article 114, par. 1 & 3.**
- Regulation 304 on NIIs published on 11 February 2014.

Regulatory Framework approved by EU

State aid SA.58482 (2021/N) – Greece

Remuneration scheme of Hybrid Power Stations in NIIs of Greece until 2026

The first main objective of the notified scheme is **to increase the level of RES in the energy mix** of the NIIs in Greece, currently estimated to around **20 %** of the annual electricity demand **to levels of up to 50 %** of the annual electrical energy demand on each NII. In this way, the notified scheme will incentivise electricity production from RES in order to contribute to the achievement of the targets set by Directive (EU) 2018/2001 on the promotion of the use of energy from renewable sources (the "RED II")21 and Regulation (EU) 2018/1999 on the Governance of the Energy Union and Climate Action (the "Governance Regulation").

According to Greece, the design of the notified scheme for the establishment of HPS projects in the NIIs takes into account the new circumstances in the NIIs.

Greece has notified the following types of measures under the notified scheme, broken down as follows:

Measure 1:

Support granted for HPSs in six small NIIs that will not be interconnected (Agios Efstratios, Antikithira, Gavdos, Megisti (Aegean sea) | Ereikousa, Othonoi (Ionian sea);

Measure 2:

Support granted without a call for tenders to HPSs in Crete;

Measure 3:

Support granted in calls for tender to HPSs in the remaining 22 NIIs.

Measure 1:

According to the legislation framework there is a competitive procedure for the islands, such as already implemented for the island Astypalaia:

Ministers Decision with the basic parameters

Anouncment of the tender by Regulator

Submission of Applications (Folder A – technical data | Folder B – Economic proposal)

Results with the best economic proposal.

Measure 2:

Greece submits that there are currently four mature projects in Crete that received their Cetrification Production and the environmental permits and could apply for immediate support under the notified scheme, once it has been approved by the Commission. The main characteristics of these four mature HPS projects in Crete are:

a) The Amari HPS project combines a 78 MW wind farm with pumped hydro storage of a guaranteed capacity of 50 MW (installed capacity of hydro turbines (2+1)x25 MW). The developer of the pumped-hydro HPS project has already obtained the rights to exploit the existing irrigation and water supply dam (Potamoi Dam) at Amari as the lower reservoir of the pumping station, through a competitive tender procedure held by the Organization for the Development of Crete in 2011. The HPS facilities will utilize the existing Potamoi Dam as a lower water reservoir, along with a purpose-built upper reservoir of 1.15 hm3 total volume, ensuring a nominal energy capacity of 1,236 MWh.

b) The Plakakia HPS project combines a 60.5 MW wind farm with battery storage of 27.5 MW guaranteed capacity /220 MWh installed storage capacity. Initially it was conceived with pumped-hydro storage facilities of larger capacity, now converted to battery storage.

c) The Stavros HPS project combines a 4.725 MW wind farm with battery storage of 1.95 MW guaranteed capacity/16 MWh installed storage capacity.

d) The Kissos HPS project combines a 10.5 MW wind farm with battery energy storage of 5 MW guaranteed capacity/ 40.8 MWh installed storage capacity.

In total, the four projects represent a guaranteed capacity of 84.45 MW.

Measure 3:

For the remaining 22 NIIs

	Two step continuous bidding format	Single step- static auction
Participation & awarding	In two phases: a) submission of relevant documentation and guarantees after 1-2 month period final list of participants (codified names) with total participating capacity b) Conduct of a descending continuous electronic bidding process (30 min), where the participants can change their bids to lower prices.	Single phase. Simultaneously electronic submission of relevant documents and of the unique economic bid per proposal in encrypted format.

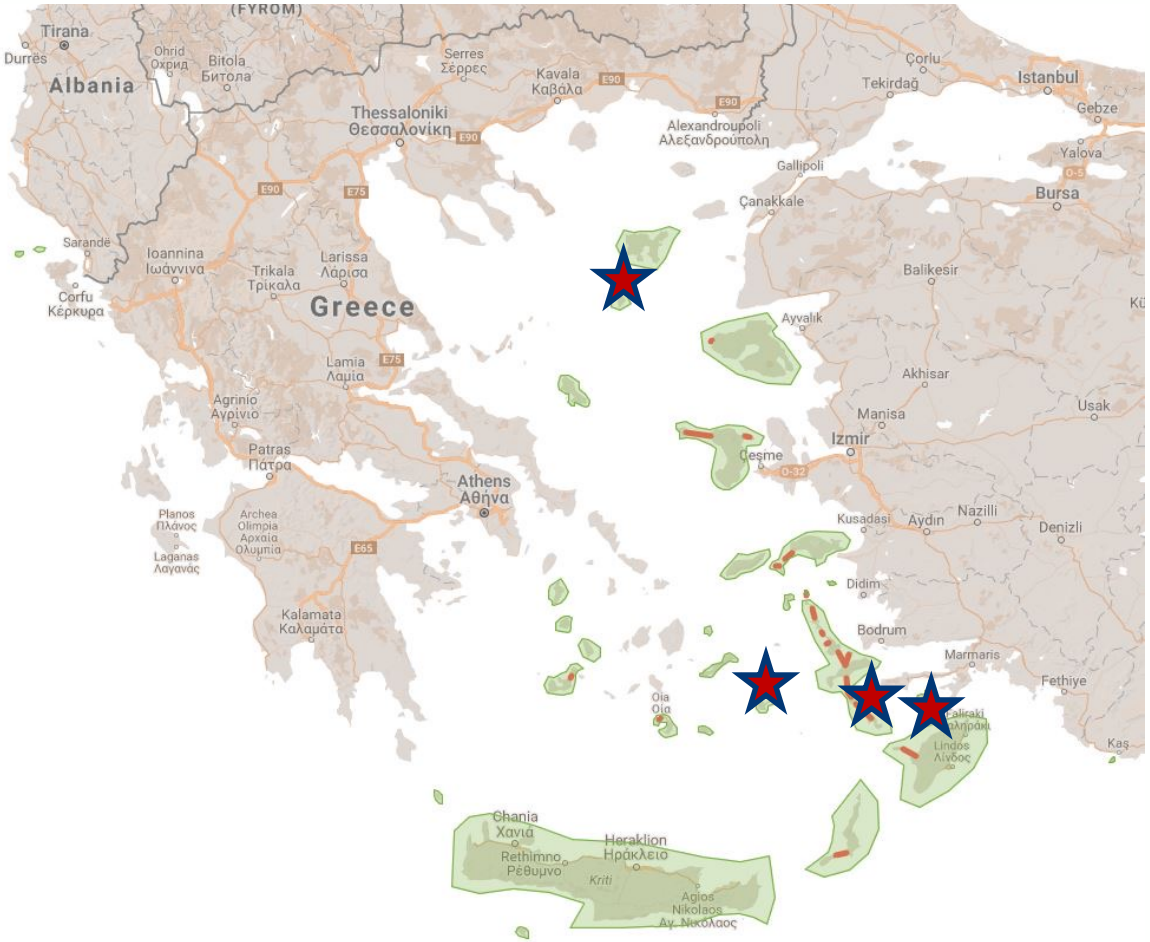
4

The Innovative Hybrid Projects in Non-Interconnected Islands

Greece

Innovative Projects in Islands, GREECE

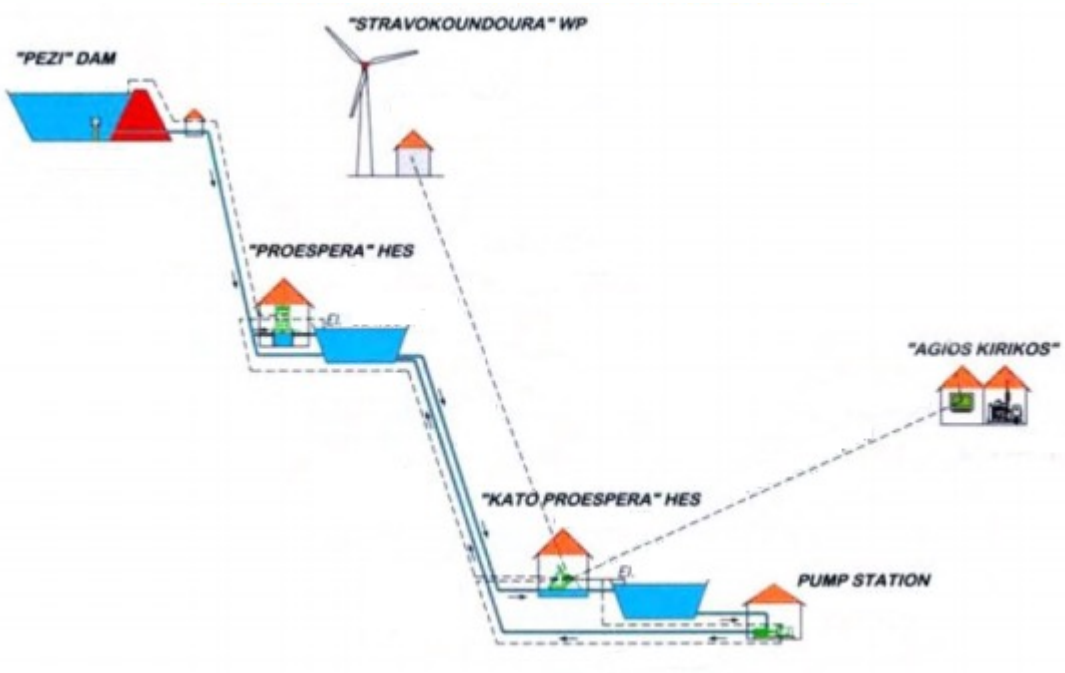
- ✓Ikaria
- ✓Tilos
- ✓Agios Efstratios
- ✓Astypalea



★ Islands with Innovative Projects

Ikaria

- The project combines **Hydro Electric** power and **Wind** power and its **guaranteed power** is **2,55 MW**, when the **5-year Average Peak Demand** of Ikaria is **7,3 MW**.
- The whole project consists of **two hydro power plants** (1 MW & 3 MW) with two reservoirs that exploit water that comes from a dam and a **wind park** (2,7 MW) which provides energy to the **water pumps** (3 MW).



- It is expected that the Hybrid plant will cover **30% of the energy needs of the island.**

in operation

Ikaria

in operation

Ikaria – Hybrid station prices

According to the Hybrid Regulatory Framework (2010)

- Decision of the Board of RAE 1334/2010 *«Special Terms of Production License from hybrid station on the Non-Interconnected Islands»*
- 1146/2011*«Determination of electricity pricing energy from hybrid plants for the island of Ikaria»*
- Production License for the Hybrid station in Ikaria (Decision 1147/2011

The following parameters where determined :

a) The Price for the Available Capacity for the supply of guaranteed Capacity from the controlled units output of the hybrid plant is defined at 188 €/kW/year

b) The sale price of energy to the grid from its controlled production units hybrid plant is set at 295 €/MWh

c) The price of the energy from the network to upload the water to the upper tank (as a storage system) of the hybrid station is set to 109€/MWh

Tilos

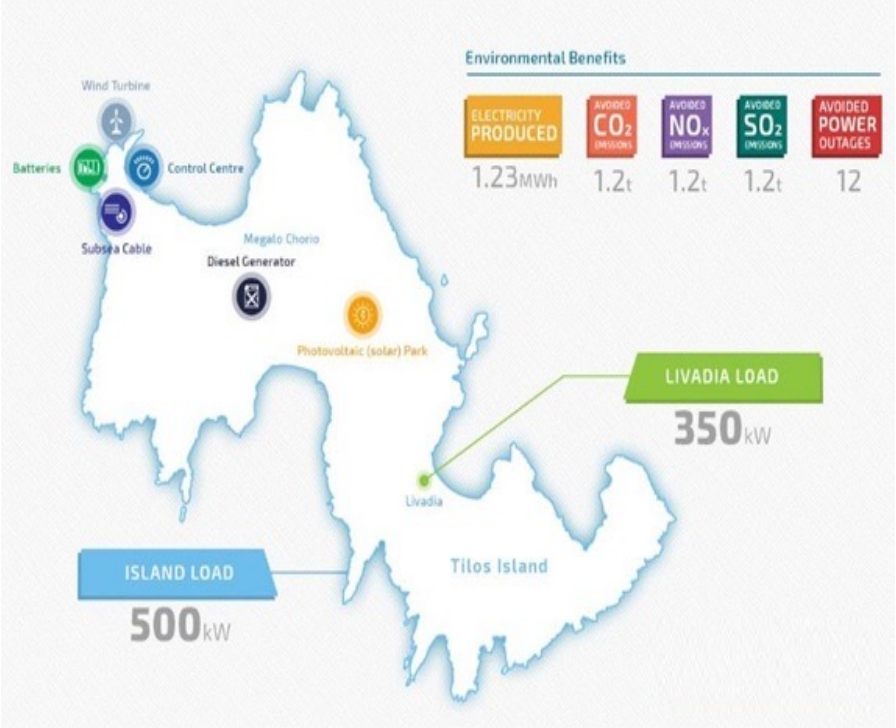
TILOS project is a **Horizon 2020 EU funded project** located in the island of Tilos.

Tilos is an island of the Dodecanese complex. It is **interconnected with Kos** and it is one of the 9 islands of the **ES of Kos-Kalymnos**, The **5-year Average Peak Demand** of the **Kos-Kalymnos ES** is **94,8 MW**.

The **main objective of TILOS** project, is the development and operation of a **prototype battery system** based on $NaNiCl_2$ batteries (2,88MWh) with Wind turbines (800 kW) and PVs (160 kW), provided with an **optimum, real-environment smart grid control system** and coping with the challenge of supporting multiple tasks including:

- Micro grid energy management
- Maximization of RES penetration
- Grid stability
- Export of guaranteed energy
- Ancillary services to the main grid of Kos

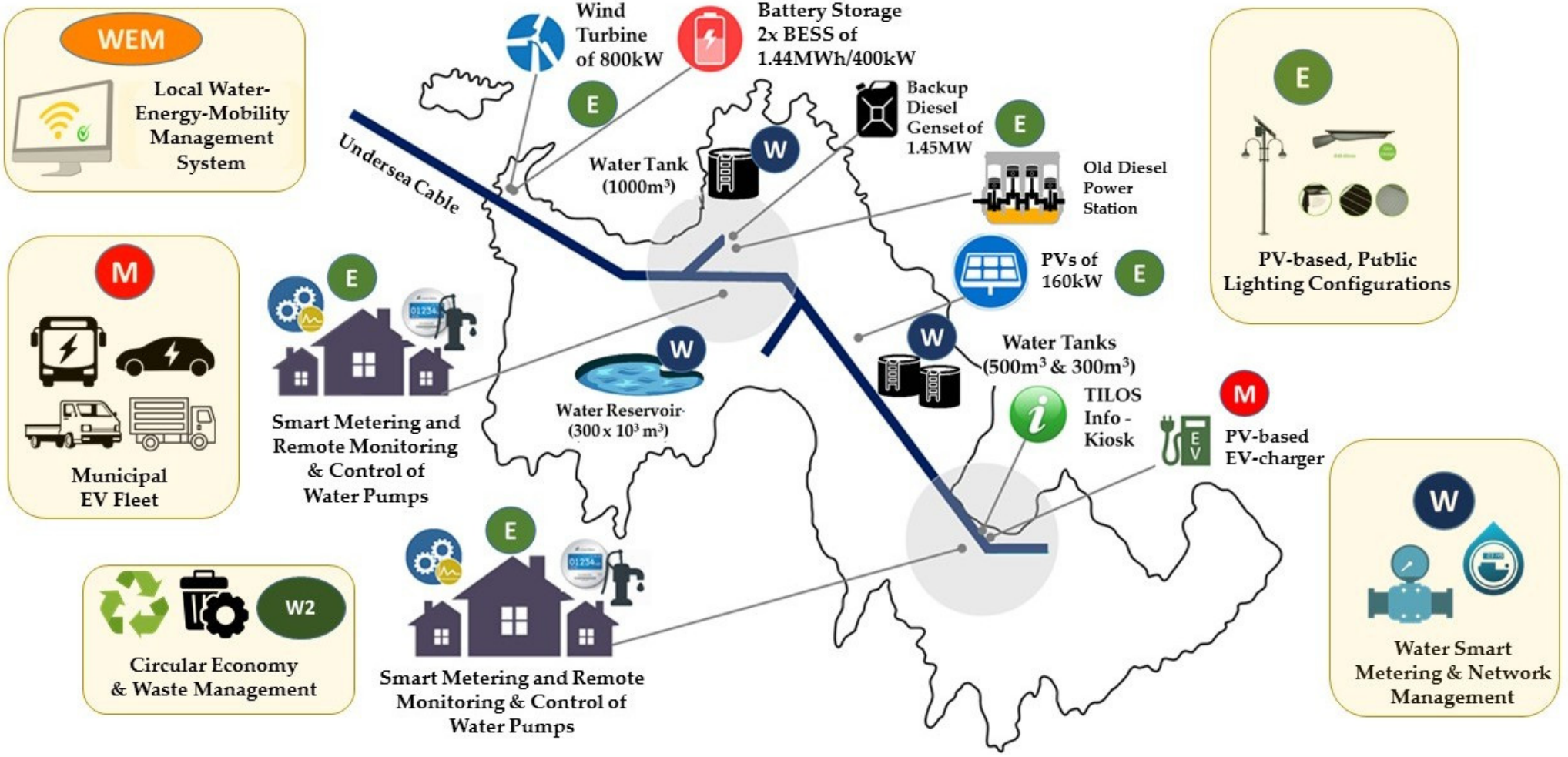
The **project's guaranteed power** is **0,4 MW** and it is in **operation.**



- The TILOS project won **two European Sustainable Energy Week (EUSEW) Awards** in Brussels in 2017. The first ever **Energy Islands award** and the **Citizen's Award**.

in operation

Tilos



in operation

Tilos

- 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 ~**2GWh** (<30% CF), equal to **~65%** of Tilos island annual electricity demand

- 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

in operation

Tilos

- 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
- TILOS SM & DSM Microgrid Platform is a **hardware / software platform** supporting **metering and control** of both community and individual, end-consumer loads
- Installation of **100 panels** integrating 3 loads per household and including **8 pumping stations (water-energy nexus)**
- 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**
- Enables **improved RES penetration**, **operation** and also **provision of grid-supporting service**

in operation

Tilos – Hybrid station prices

According to the Hybrid Regulatory Framework (2010) the Regulator

- 1334/2010 *«Special Terms of Production License from hybrid station on the Non-Interconnected Islands»*
- 125/2016 Determine the pricing of electricity from Hybrid plants in Kos- Kalimnos and
- 126/2016 Production License for the Hybrid station in Tilos

the following parameters where determined :

a) The Price for the available Capacity for the supply of guaranteed Capacity from the controlled units output of the hybrid plant is defined at 165 €/kW/year
b) The sale price of energy to the grid from its controlled production units is set at 165 €/MWh
c) The purchase price of the energy from the network to fill the storage system is set at 103€/MWh

Agios Efstratios

Hybrid system for the production of electricity & heat from RES

- PROJECT PREAMBLE

Beneficiary: Municipality of Agios Efstratios

Implementation: Centre for Renewable Energy Sources (CRES)

Program: National Strategic Reference Framework 2014-2020

Funding: European Regional Development Fund (ERDF)

Main target: > 85% RES penetration in electricity/heating

under construction

Agios Efstratios

Hybrid system for the production of electricity & heat from RES

Agios Efstratios village

Population of 250

PPC Station

Public Power Corporation

Diesel generators, 840 kW

under construction

Agios Efstratios

Hybrid system for the production of electricity & heat from RES

THE PROJECT – HYBRID POWER PLANT (HPP)

① Renewable Energy Sources (RES) Station

Wind Turbine Generator (WTG) 0,9 MW
Photovoltaic Station (PV) 0,23 MW
Collector Substation

② Main Station

Battery Energy Storage System (BESS) 2.560 kWh
Interconnection Substation
Operation & Maintenance (O&M) Facilities
District Heating Plant (DHP) 1.050 kW
Hot Water Storage Tanks 500 m^3

③ District Heating Network

Distribution Heat Network
Customers Heat Network

under construction

Agios Efstratios

Hybrid system for the production of electricity & heat from RES

- THE PROJECT – other works from HEDNO *(Hellenic Electricity Distribution Network Operator S.A.)*

④ Transmission Line

Collector Substation to Interconnection Substation connection

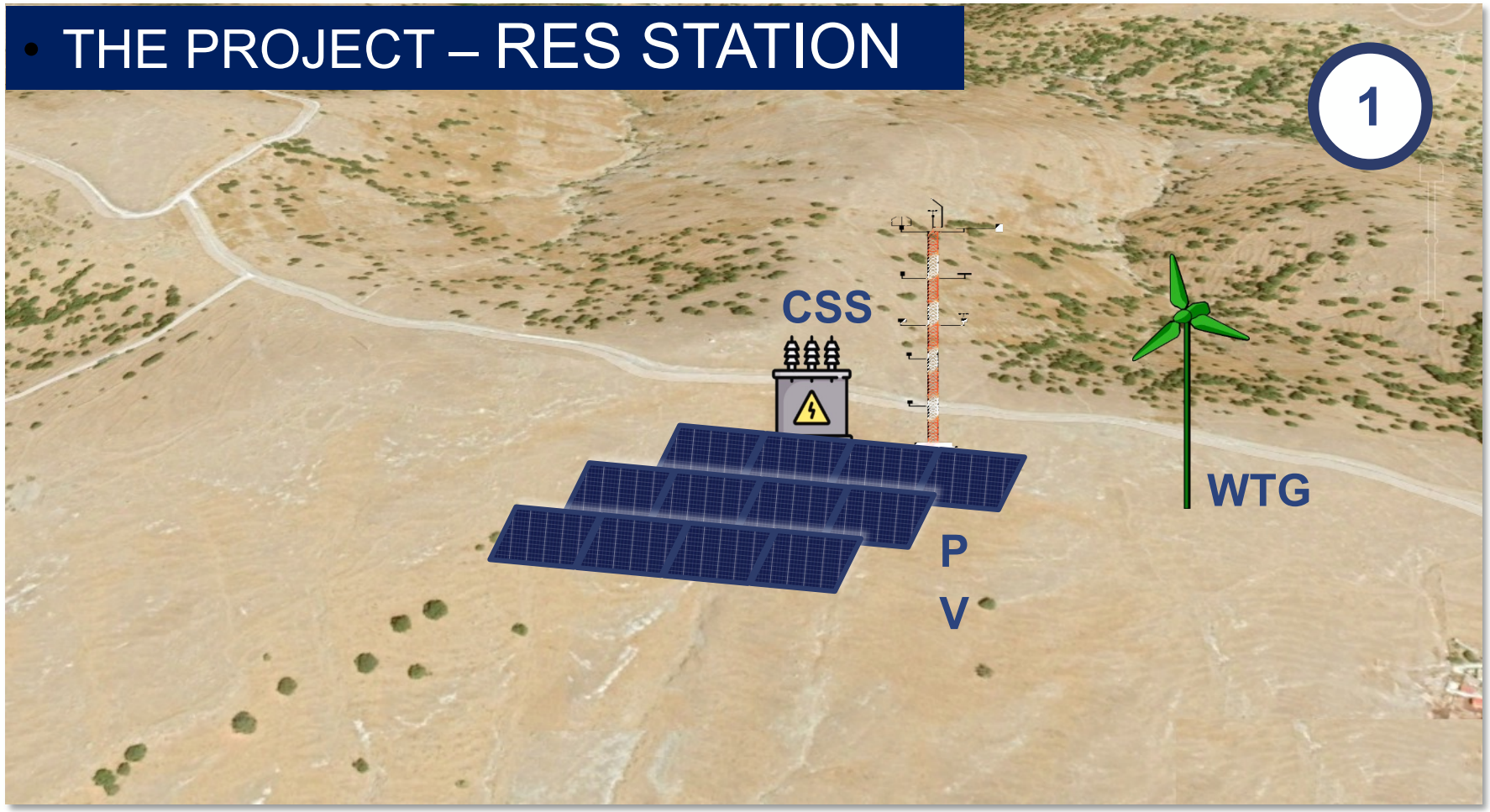
⑤ PPC Station Upgrades

PPC Station and Interconnection Substation equipment specifications alignment

under construction

Agios Efstratios

Hybrid system for the production of electricity & heat from RES

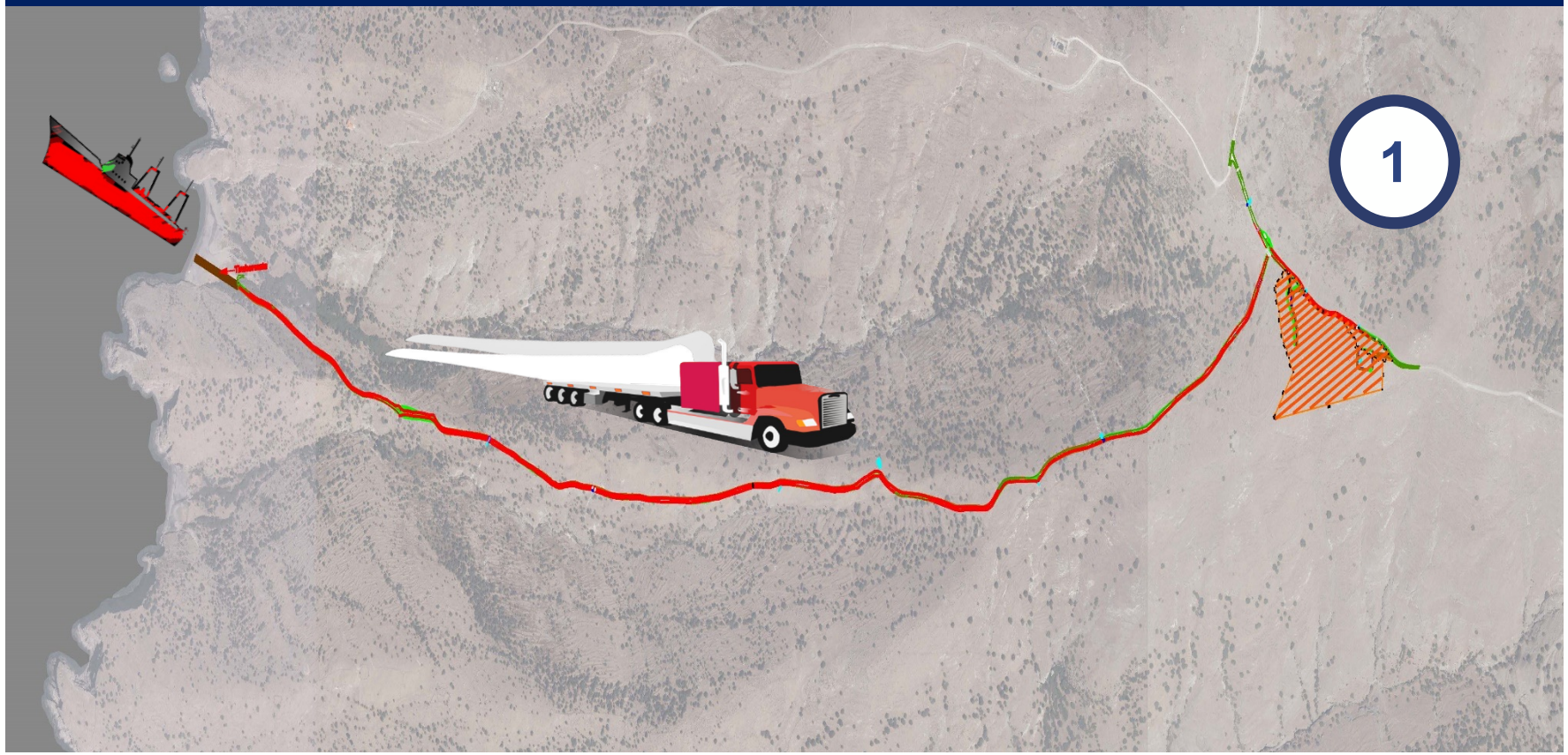


under construction

Agios Efstratios

Hybrid system for the production of electricity & heat from RES

- THE PROJECT – WTG LANDING AND TRANSPORT



under construction

Agios Efstratios

Hybrid system for the production of electricity & heat from RES

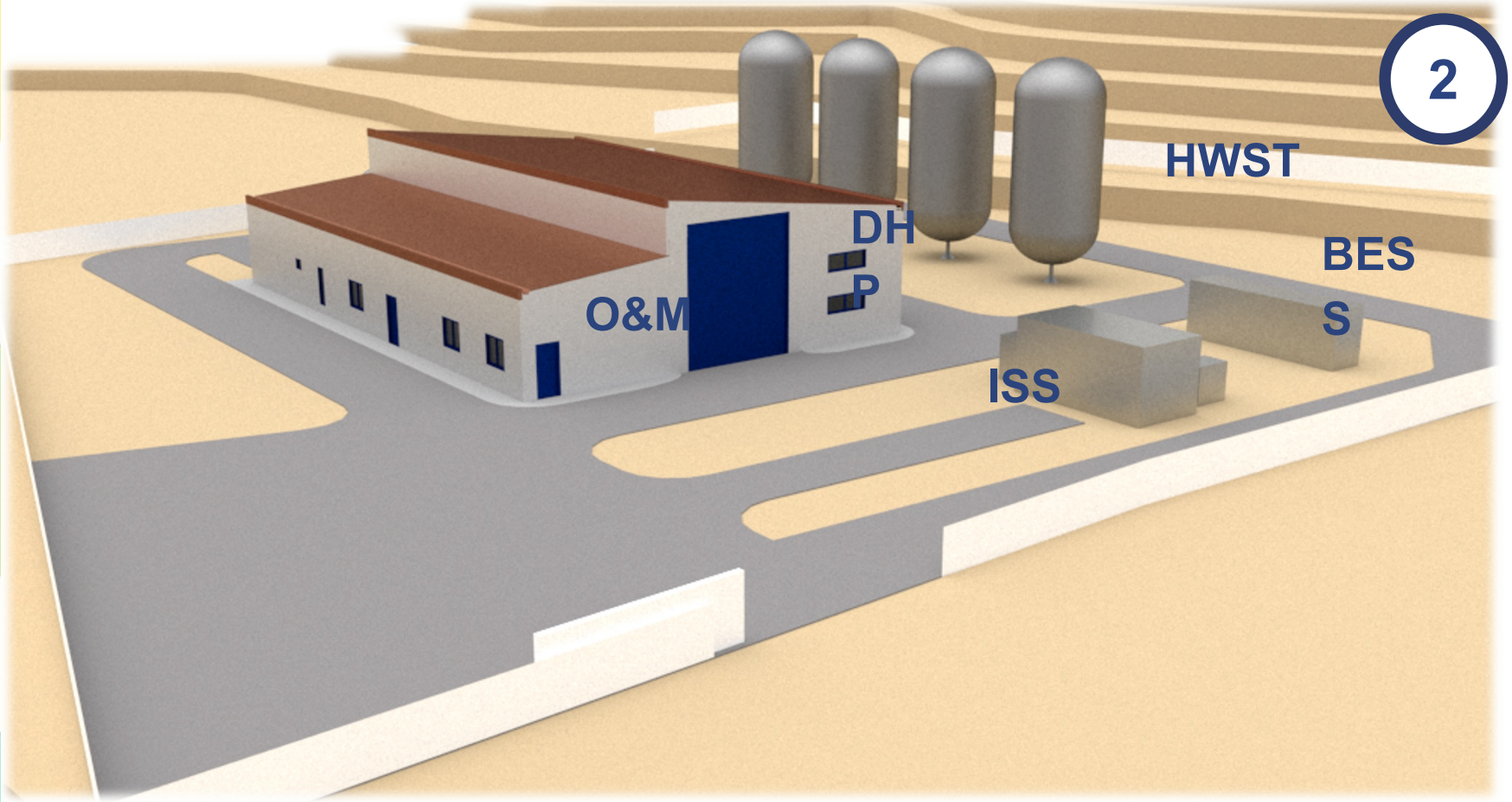
- THE PROJECT – WTG LANDING AND TRANSPORT

1

under construction

Agios Efstratios

Hybrid system for the production of electricity & heat from RES



• THE PROJECT – **MAIN STATION**

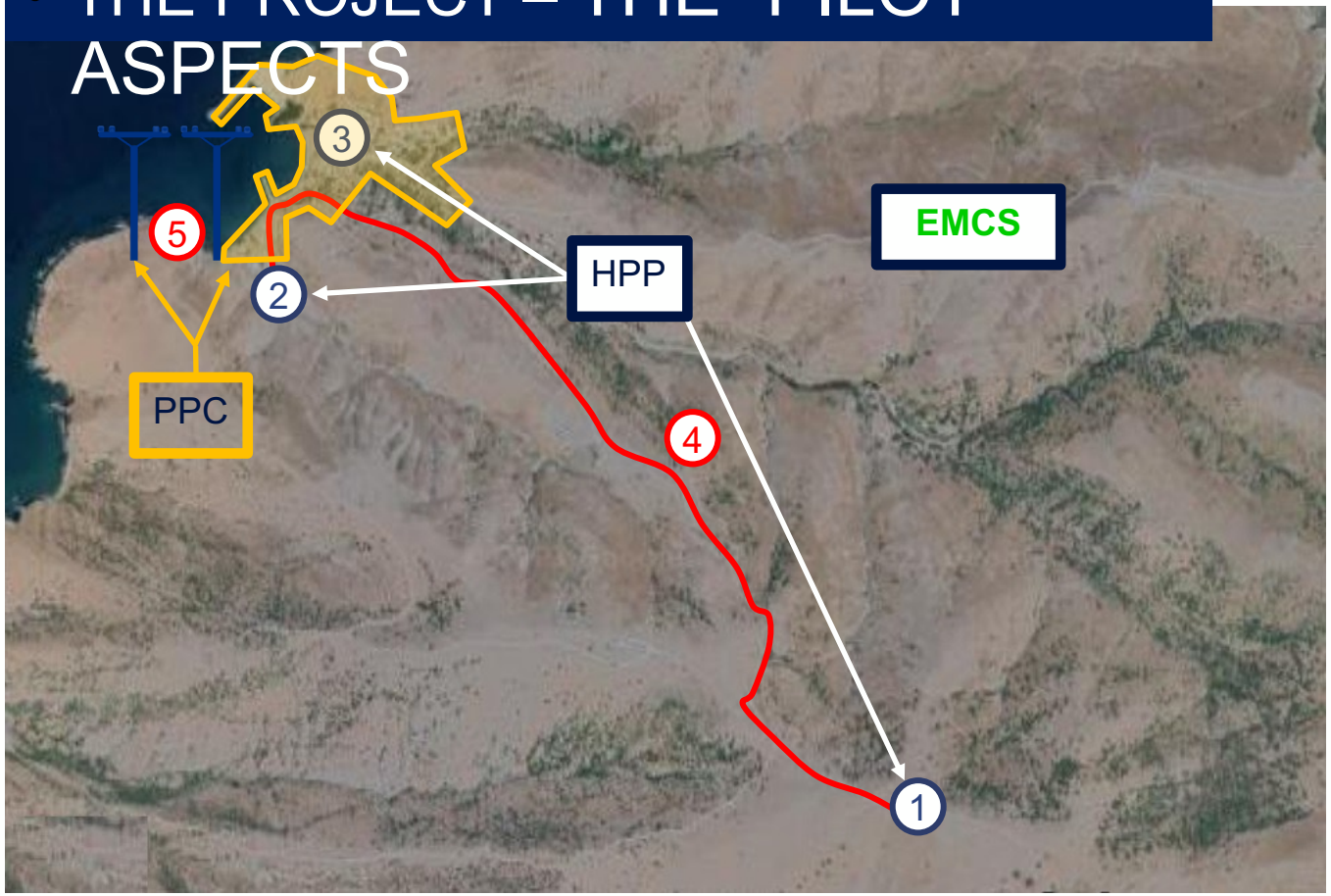
- Battery Energy Storage System (BESS) 2.560 kWh
- Interconnection Substation (ISS)
- Operation & Maintenance (O&M)
- Facilities District Heating Plant (DHP) 1.050 kW
- Hot Water Storage Tanks (HWST) 500 m3

under construction

Agios Efstratios

Hybrid system for the production of electricity & heat from RES

- THE PROJECT – THE "PILOT" ASPECTS



Current Sole Generation Entity

Public Power Corporation Plant

New Additional Generation Entity

Pilot Aspects

PPC & HPP to operate as <u>one</u> Generator

An Energy Management Control System (EMCS) will be developed to:

- combine the different technologies,
- satisfy the Non Interconnected Islands Electric Code as it has been modified by the Regularity Authority for Energy (RAE) for this project, and
- **satisfy the Project requirement for RES penetration >85%**

under construction

Agios Efstratios

Hybrid system for the production of electricity & heat from RES

3

- THE PROJECT – DISTRICT HEATING NETWORK

5.000 m, Distribution Network

90 buildings already subscribed

under construction

Agios Efstratios

Hybrid system for the production of electricity & heat from RES

1 Renewable Energy Sources (RES) Station

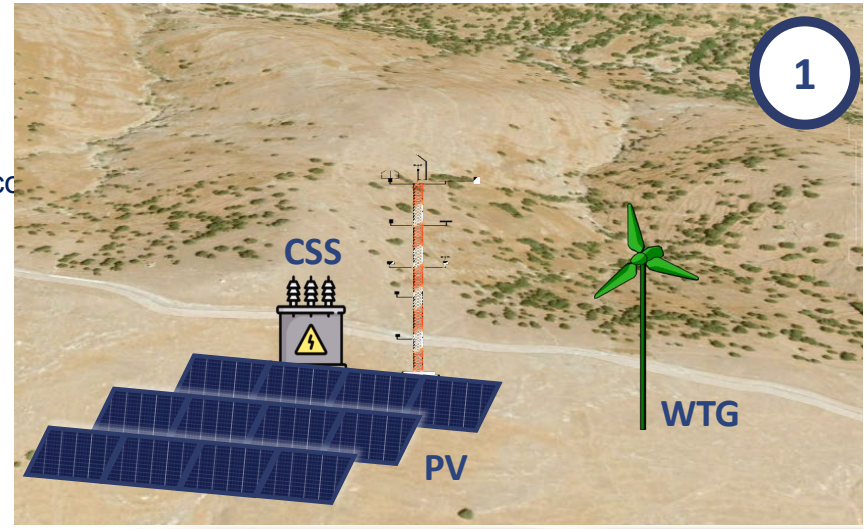
- Wind Turbine Generator (WTG) 0,9 MW Photovoltaic Station (PV) 0,23 MW Collector Substation

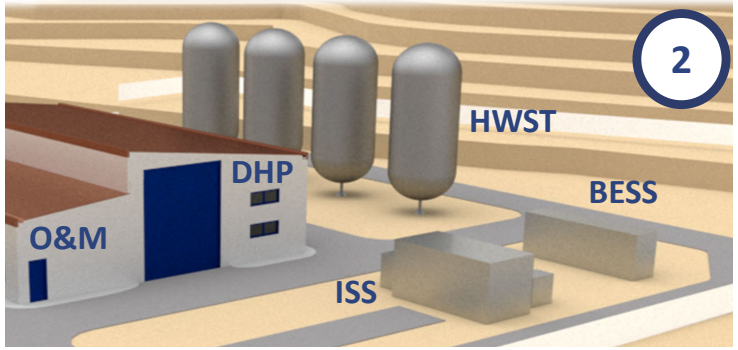
2 Main Station

- Battery Energy Storage System (BESS) 2.560 kWh Interconnection Substation Operation & Maintenance (O&M) Facilities District Heating Plant (DHP) 1.050 kW
- Hot Water Storage Tanks 500 m3

3 District Heating Network

- Distribution Heat Network Customers Heat Network (5.000 m distribution network / 90 buldings)





under construction

Agios Efstratios – Hybrid station prices

According to the Specific Regulatory Framework:

- Decision of the Board of RAE (429/2020): «*Definition of a special framework for the operation and management of the research-demonstration hybrid station and the electrical system of the island of Agios Efstratios, derogation from the Management Code of Non-Interconnected Islands (Government Gazette B΄ 304/11.2.2014), in accordance with the provisions of article 152 of Law 4495/2017*»

- Opinion of the Board of RAE (4/2021): «*Redefining the Weighted Energy Cost of the electrical and thermal subsystem of the island of Agios Efstrati for the research-demonstration hybrid station and the district heating system on the above island by updating the RAE Opinion under no. 15/2020, in accordance with the provisions of article 152 of Law 4495/2017*»

- Ministers Decision (O.G. B'- 2354/16.06.2020: «*Special framework for implementation and operation of the research demonstration project on the island Agios Efstratios according to article 152 thereof Law 4495/2017 (A΄ 167), as applicable*»

Agios Efstratios – Hybrid station prices

The following parameters are determined :

a) The sale price of energy to the grid from its controlled production units hybrid plant is set at 130 €/MWh. This price is 78% lower than full Production Cost of the local conventional station, and 47% lower from the corresponding Variable Production Cost.
b) The compensation price of thermal energy that will be injected from the district heating system to the consumers is configured at 51 €/MWh (fifty one euro per megawatt hour).

“Smart Island” pilot projects

- During the last 10 years, significant efforts have been made to further **enhance RES and Storage integration** in the Non Interconnected islands.
- Law 4495/2017 & Law 4546/2018 authorize the Ministry of Energy, RAE and HEDNO to take all necessary actions for the implementation of “Smart Island” pilot projects in 3 Greek islands (**Astypalea,** Symi, Megisti/Kastelorizo).
- Each pilot project will consist of new RES units in combination with storage units controlled by a smart management system.

The target of the “Smart Island” pilot projects is to **increase RES penetration**, while **ensuring the supply of demand** and **the secure operation of the power systems in a cost efficient way**.

The “Smart Island” pilot projects will be implemented by investors who will have to participate in **tenders** held by the Regulatory Authority for Energy.

Astypalea

Development of the Astypalea hybrid system aims to:

Showcase an innovative technical and commercial mechanism to match electric vehicle charging with renewable energy

Reduce energy costs by at least 25 %

Reduce CO2 emissions of the island's energy system by 50% in1st phase and by 70% in 2nd phase.

Project to serve as a pilot for greening energy production in non-interconnected islands in Greece

Increase energy security and resilience of Astypalea's energy system, while reducing dependence on fossil fuels.

Astypalea

Vehicle electrification

Switching from the existing fleet of combustion vehicles to electric ones.

Smart mobility

Public transportation will operate on demand, taking us wherever we wish, whenever we need to.

Charging & energy

A hybrid energy system will replace the existing diesel generators.

Autonomous driving

Future option: It will be tested on the island, given the available technology.

e-astypalea

Greek islands go electric

Astypalea

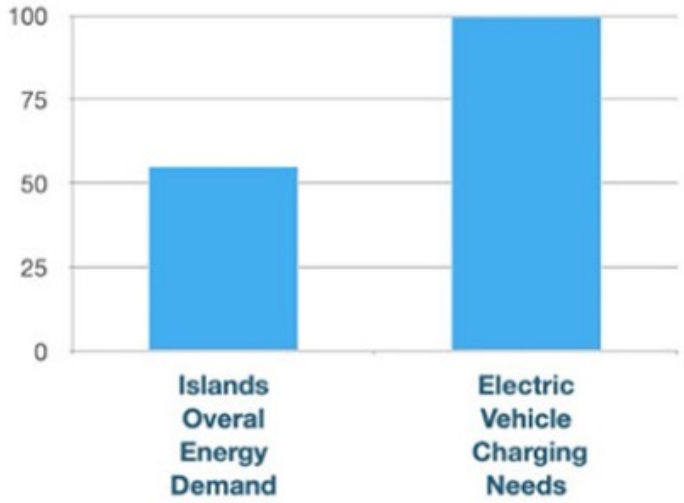
1st phase (by 2023)

3 MWh Photovoltaic (PV) Plant

+

7 MWh Battery System

will cover



Astypalea

2nd phase (by 2026)

The hybrid system will be expanded (potential addition of wind turbine)

will cover

More than 80% of the island's overall demand

Results of the tender for Astypalea

Decision E-29/2023 by RAEWW (Energy sector)

A/A	Περιγραφή	Μονάδες	Απαίτηση Προκήρυξης/Υ.Α.	Προσφερόμενη τιμή
1	Εγγυημένη ισχύς του ΥΒΣ ΕΠΕ	MW	≥3,000	3,000
2	Εγκατεστημένη ισχύς μονάδων ΑΠΕ του ΥΒΣ ΕΠΕ	MW	≥ 3,000	3,531
3	Εγγυημένη ωφέλιμη χωρητικότητα των συστημάτων αποθήκευσης του ΥΒΣ ΕΠΕ (στο σημείο σύνδεσης με το δίκτυο ΜΤ)	MWh	≥ 7,200	9,111
4	Εγγυημένη ενέργεια προσφορών του ΥΒΣ ΕΠΕ στον ΚΗΕΠ (E_{off})	MWh/έτος	≥ 4.900	6.552
5	Reference price for the compensation of the energy injected into the network by the YBS EPE units (C_{off})	€/MWh	≤ 200,0	**164,5**
6	Συνολική διείσδυση ΑΠΕ μετά την ένταξη του προσφερόμενου ΥΒΣ ΕΠΕ (συμπεριλαμβανομένων των υφιστάμενων σταθμών ΑΠΕ του νησιού)	%	≥ 50	61,2
7	Κάλυψη της ζήτησης για φόρτιση των Η/Ο	-	Κατά προτεραιότητα	Κάλυψη κατά 100% από τον προσφερόμενο ΥΒΣ ΕΠΕ
8	Δήλωση ετοιμότητας για ενεργοποίηση της σύνδεσης του ΥΒΣ με το Δίκτυο (από τη χορήγηση Βεβαίωσης Παραγωγού)	μήνες	≤ 20	19
9	Ονοματεπώνυμο Συμμετέχοντα (φυσικό πρόσωπο) / Επωνυμία Νομικού Προσώπου	PPC Renewables		

Ikaria

Hybrid System

Small Hydro & Pump storage - Wind

operating

30%

Tilos

Hybrid System

PV – Wind
Batteries

operating

75%

Kythnos

Microgrid
PV – Battery
(Diesel/backup)

under con.

100%

Agios Efstratios

Hybrid System

Wind - PV – Battery
District Heating Plant
Hot Water Storage Tanks
Distribution Heat Network

under construction

>85%

Astypalea

Vehicle Electrification

PV
Charging points
Smarty mobility

tender: on process

>85%

Chalki

Energy Community

PV
Net-metering

operating

100%

Thank you for your attention

132 Pireos str, 118 54, Athens
Tel.: +30 210 3727400
E-mail: info@rae.gr

ΡΥΘΜΙΣΤΙΚΗ ΑΡΧΗ ΑΠΟΒΛΗΤΩΝ, ΕΝΕΡΓΕΙΑΣ & ΥΔΑΤΩΝ
REGULATORY AUTHORITY FOR ENERGY, WASTE & WATER

Dr. Dionysios Papachristou
Electrical Engineer-NTUA, Scientific Expert
Director, Communication Office
Regulatory Authority for Energy, Waste & Water

Tel.: *+30 210 3727409*
E-mail: *papachristou@rae.gr*