RES Connection to the Grid: Current status & Challenges

Konstantinos Tsirekis
Strategy and System Planning Department

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ipto
INDEPENDENT POWER TRANSMISSION OPERATOR

RES Electrification and current Status

Electrified RES Connected to the Transmission System

Year	Number of RES Plants				Installed Power [MW]			
	Total	Wind	PV	Other	Total	Wind	PV	Other
Till 2012	36	32	0	4	**824**	780	0	44
2012	9	6	2	1	**108**	101	1	6
2013	11	3	8	0	**124**	73	51	0
2014	6	5	1	0	**110**	106	4	0
2015	5	5	0	0	**146**	146	0	0
2016	8	8	0	0	**215**	215	0	0
2017	12	12	0	0	**223**	223	0	0
2018	10	10	0	0	**175**	175	0	0
2019	37	37	0	0	**681**	681	0	0
2020	30	26	4	0	**530**	492	38	0
2021	30	23	7	0	**371**	299	69	3
2022	43	7	33	3	**582**	233	331	18
2023	81	25	54	2	**1098**	552	541	5
2024	989	10	979	0	**1740**	83	1657	0
Total	**1307**	**207**	**1090**	**10**	**6867**	**4094**	**2697**	**76**

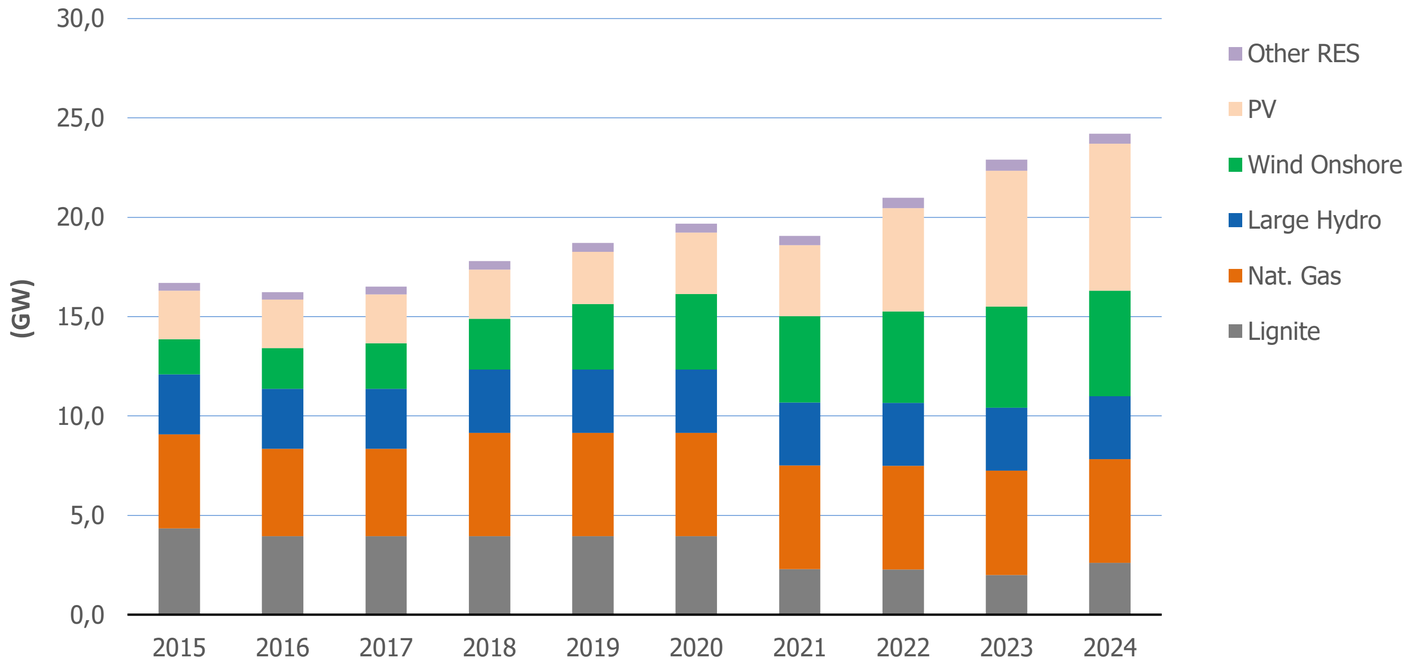
RES in Operation

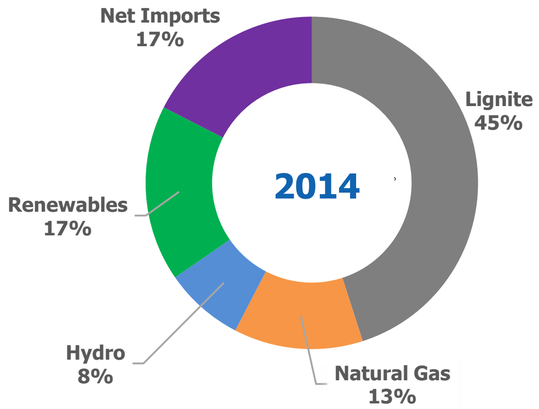
Category	Installed Power* [GW]			
	Total	Wind	PV	Other
Transmission (IPTO)	**6,8**	4,1	2,6	0,1
Distribution (HEDNO) Estimation	**8,4**	1,1	6,8	0,5
Total	**15,2**	**5,2**	**9,4**	**0,6**

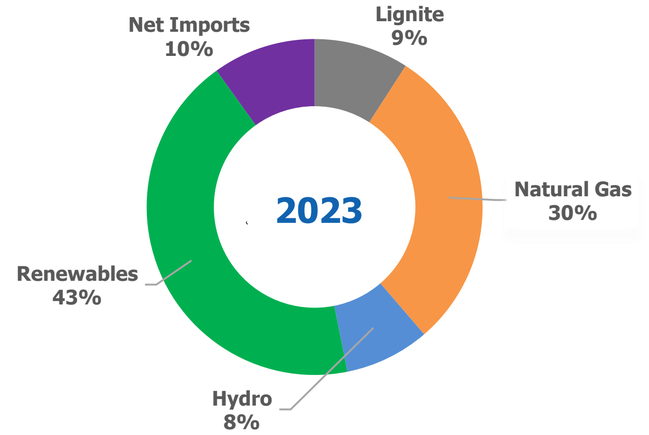
* Data by the end of Dec 2024

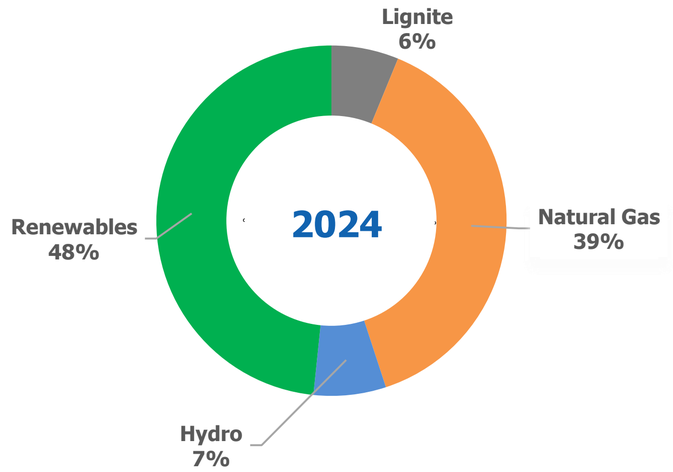
Historical data

Historical Evolution of Generation
(Capacity & Mix)

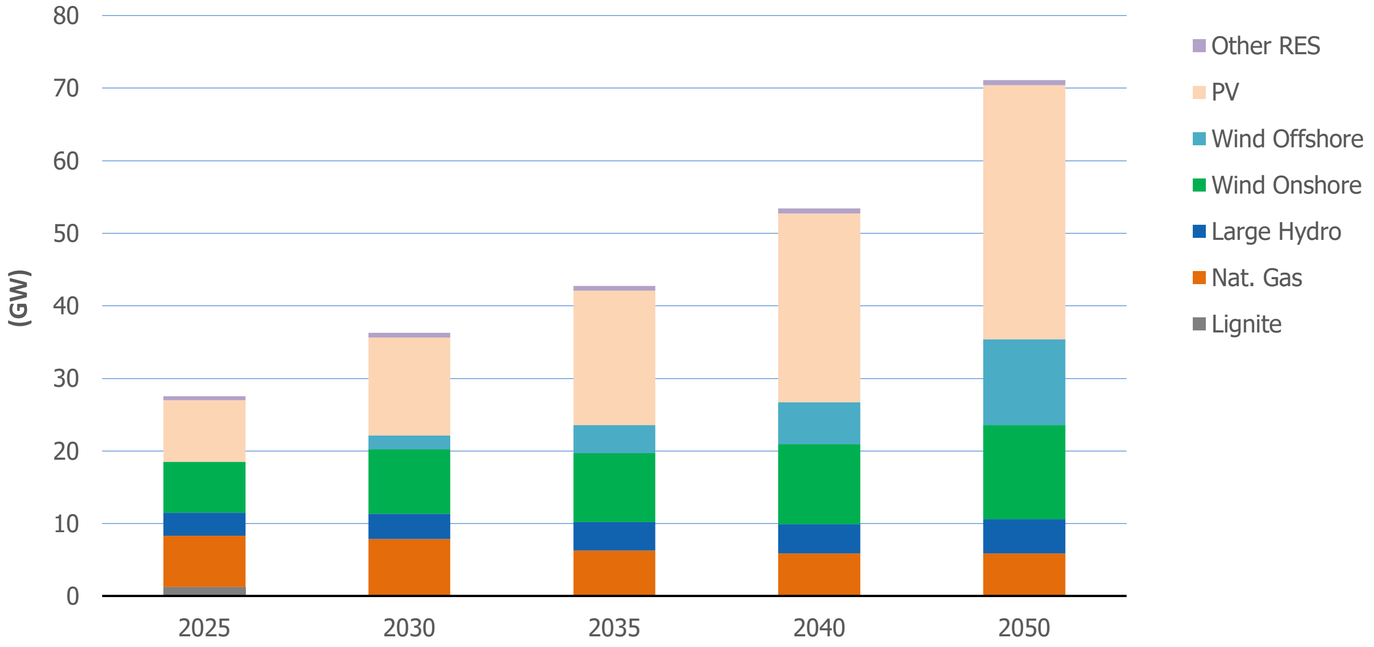


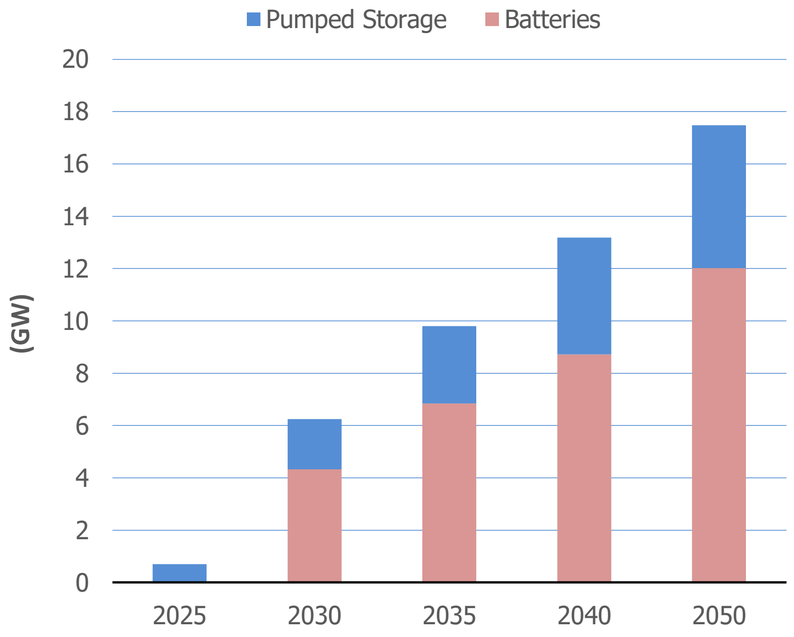






Generation Mix
Expected evolution of capacity (NECP Dec 2024)





Evolution of RES connection to the grid

RES Installed capacity	
Category	Installed capacity (estimation)
Reserved capacity In operation + Binding connection offers (IPTO/HEDNO)	~31 GW
Pending applications (IPTO)	~47 GW*
Reserved capacity for future RES Offshore wind + Crete	>3 GW
Total	**~81 GW**

* 6,7GW of which are combined with battery storage

- ~ 65 GW RES plants with production license from the Regulatory Authority
- 793 MW Binding connection offers for battery storage
- ~19,2 GW pending applications for battery storage

Total annual peak load **Maximum historical value**	**~11 GW**

Electric Energy balance Generation – Demand

Energy		
Category	2030 Estimation for RES 24,7 GW (NECP)	2030 Estimation for RES ~34GW
RES Generation*	+55 TWh	+75 TWh
Interconnections balance	+2 TWh	+2 TWh
Electric energy demand	-61 TWh	-61 TWh*
Electric energy balance	**-4 TWh**	**+16 TWh**

* IPTO estimations

- RES curtailments only due to low energy demand
- Power Balance (instantly)= (Generation + Imports) - (Demand + Exports) +/- Storage

  Energy Balance (time interval) = (Generation + Imports) - (Demand + Exports)
- Potential solutions:
  - Increase of energy demand → Electrification
  - Increase of storage penetration (whenever Energy Balance < 0)
  - International interconnections to countries with increased demand

IPTO invests ~6B€

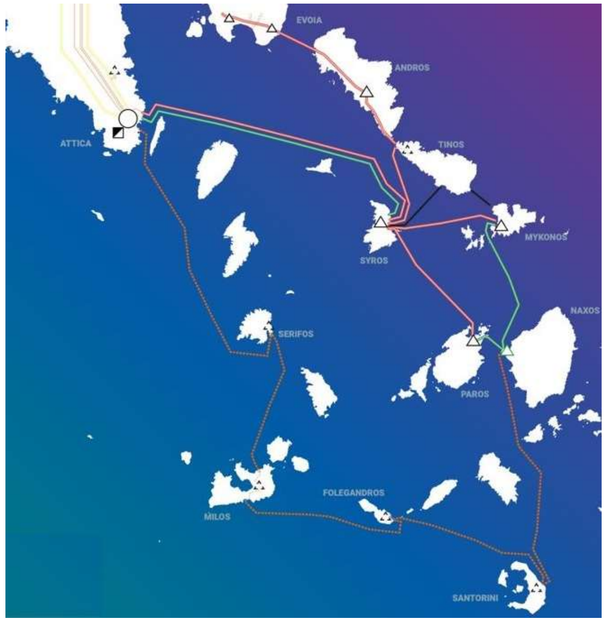
National Development Plan Major Internal Projects	
Project description	Expected commissioning
Dodecanese interconnection	2029
Crete - Attica interconnection	2025
Northeast Aegean interconnection	2029
Southern & Western Cyclades interconnection Santorini, Folegandros, Milos, Serifos	2026
2nd 400kV branch to Peloponnese	2025
EHV S/S Thesprotia and its connection to the 400kV System	2031

Offshore transmission network development:
Responsible for all stages of offshore transmission network assets for OWFs connection

Greek islands interconnections

Interconnection Crete-Peloponnese (completed 2021)

- The 1st phase of the interconnection of Crete with the HETS (150kV AC 2x200MVA)
- The longest AC submarine cable for island interconnection worldwide (135km each cable)
- The deepest HV submarine 3-pole XLPE cable worldwide (1,000m)
- Budget 372M€



Interconnection of Cyclades - phases A, B and C (completed 2020)

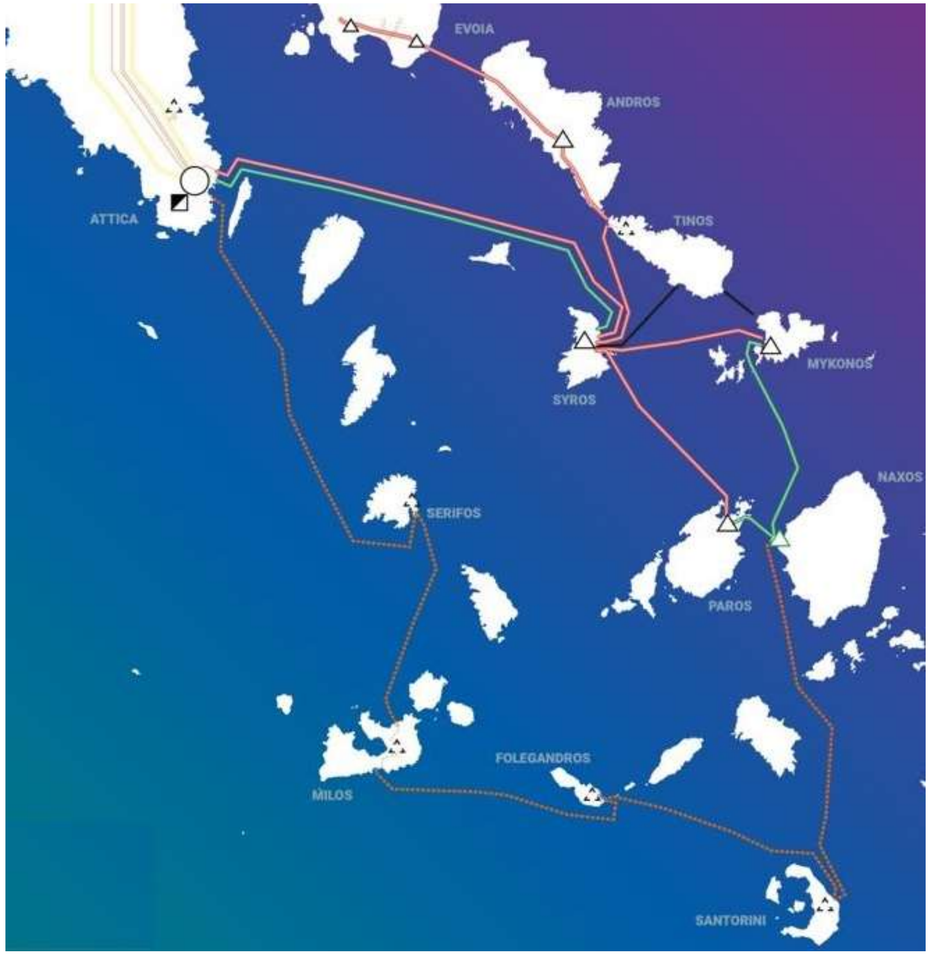
- The first 3 phases of the interconnection of Cyclades islands with the HETS
- Interconnected islands: Paros, Syros, Mykonos, Naxos, Andros, Tinos
- Budget 453M€

Greek islands interconnections

Interconnection Crete-Attica (expected 2025)

- The 2nd phase of the interconnection of Crete with the HETS (2x500MW HVDC ± 500kV)
- Ariadne Interconnection SPSA
- PMI
- Interoperability with Great Sea Interconnector
- The 1st of its kind in Mediterranean (500kV DC cables and VSC)
- Among the top 3 deepest interconnections worldwide (1,250m)
- Largest energy infrastructure ever in GR
- Budget 1.16B€

Greek islands interconnections



Interconnection of Cyclades - phase D (expected 2026)

- The 4th -and final- phase of the interconnection of Cyclades islands with the HETS
- Islands to be interconnected: Santorini, Folegandros, Milos, Serifos
- Budget: 523M€

Greek islands interconnections

Interconnection of Dodecanese islands (expected 2029)

- Islands to be interconnected with the HETS: Kos, Rhodes, Karpathos
- Budget 2.05B€

Interconnection of NE Aegean islands (expected 2029)

- Islands to be interconnected with the HETS: Skyros, Lesvos, Limnos, Chios, Samos
- Budget 1.25B€

Offshore transmission network development

- Responsible for all stages of offshore transmission network assets for OWFs connection

The map of interconnections to be completed by 2030

IPTO is aiming to gradually interconnect by 2030 all of the country's islands to the mainland system, to ensure reliable, cost-efficient and greener power supply.

Existing International Interconnections

Seven 400kV interconnections

Italy

- Submarine HVDC link, 500MW, Arachthos - Galatina

Albania

- 400kV OHL, 1,400MVA, Kardia - Zemblak

North Macedonia

- 400kV OHL, 1,400MVA, Meliti – Bitola
- 400kV OHL, 1,400MVA, Thessaloniki - Dubrovo

Bulgaria

- 400kV OHL, 1,400MVA, Thessaloniki – Blagoevgrad
- 400kV OHL, 2,000MVA, Nea Santa – Maritsa

Türkiye

- 400kV OHL, 2,000MVA, Nea Santa - Babaeski

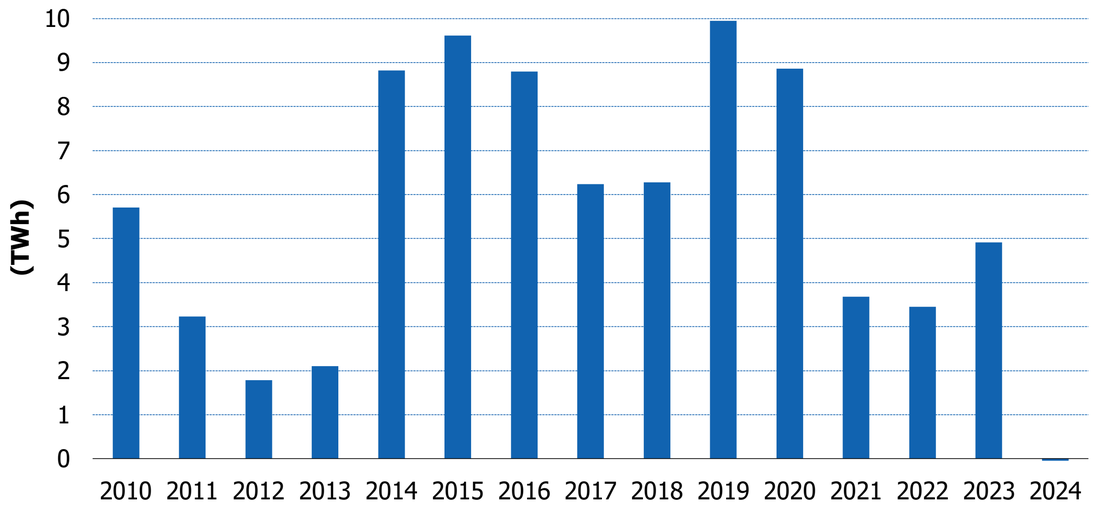
One 150kV interconnection

Albania

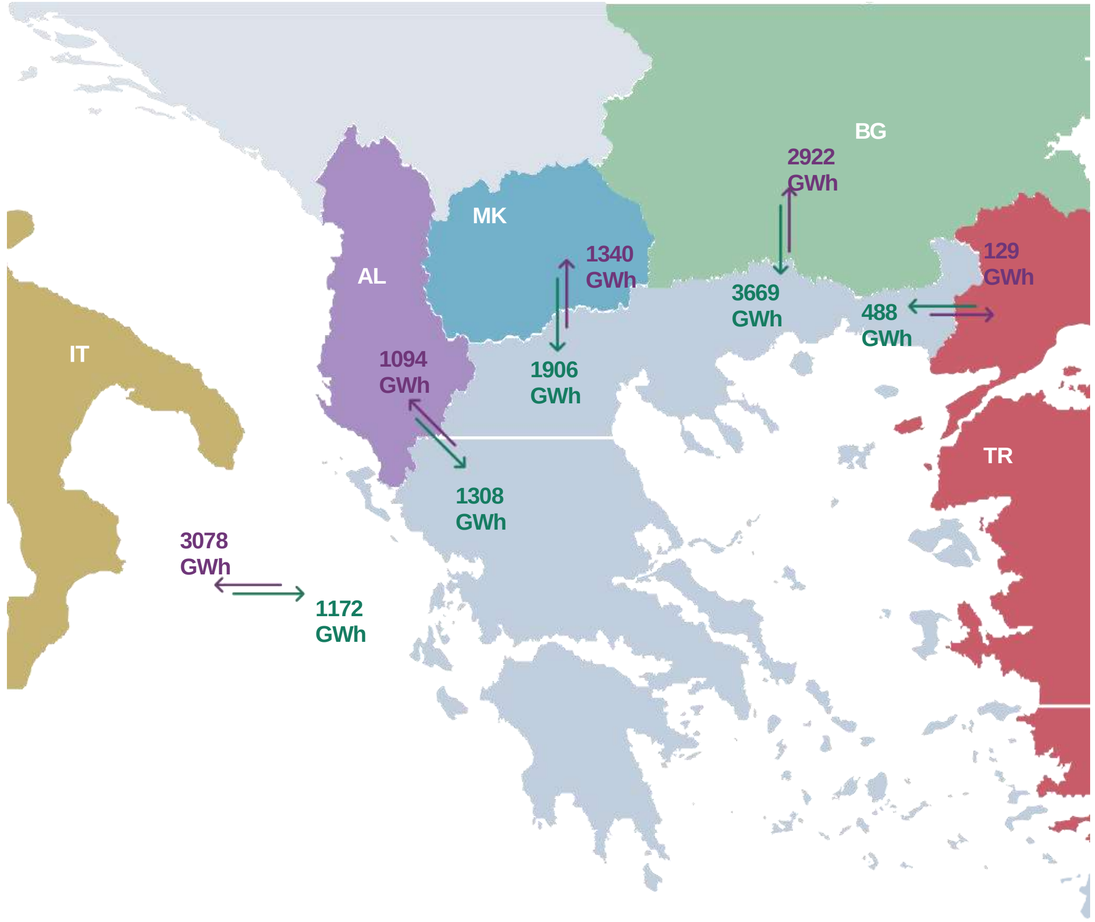
- 150kV OHL with Albania, 138MVA, Mourtos - Bistrica

Historical evolution of interconnection usage

Net flows



Commercial Schedules 2024



New International Interconnections

2nd 400kV Interconnection with Albania

- New 400kV OHL, 2000MVA, expected in 2031

2nd Interconnection with Italy

- New HVDC link 1000MW, expected in 2031

Great Sea Interconnector (GR – CY – IL)

- Phase 1: Submarine HVDC link 1000 MW between Greece and Cyprus, expected in 2031

2nd Interconnector with Türkiye

- New 400kV OHL, 2000MVA, expected in 2031

Under Consideration

GREGY Interconnector (ELICA S.A.)

- New submarine interconnection between Greece and Egypt, estimated capacity 3 GW

Saudi Greek Interconnection

- New interconnection between Greece and Saudia Arabia

Green Aegean Interconnector

- New HVDC interconnection with Germany, estimated capacity 3 GW (Stage 1)

Increase of NTC with North Macedonia

- Upgrade of existing400kV OHL Meliti (GR) - Bitola (NMK)

Connection constraints for new RES plants

- IPTO’s Ten-Year Development Plan meets the needs of the NECP
- No RES curtailment due to grid congestion exists now
- RES curtailments due to grid congestion are not expected in the upcoming years (except local level)
- Infinite grid → Total RES capacity > ~30GW may lead to excessive RES curtailments
- Prospects:
  - Electrification of energy demand
  - Increase of storage penetration (if Annual Energy Balance < 0)
  - International interconnections to countries with increased demand

Thank you!

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