

Evolution of the Greek PV market in a Stagnating Electricity Demand Environment



Istanbul, 25 April 2024

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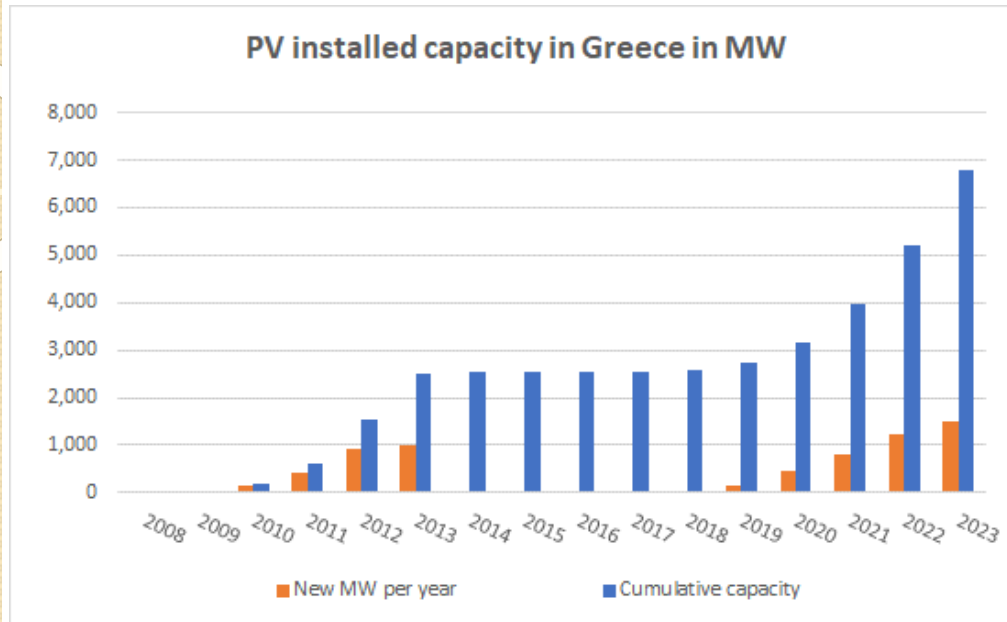
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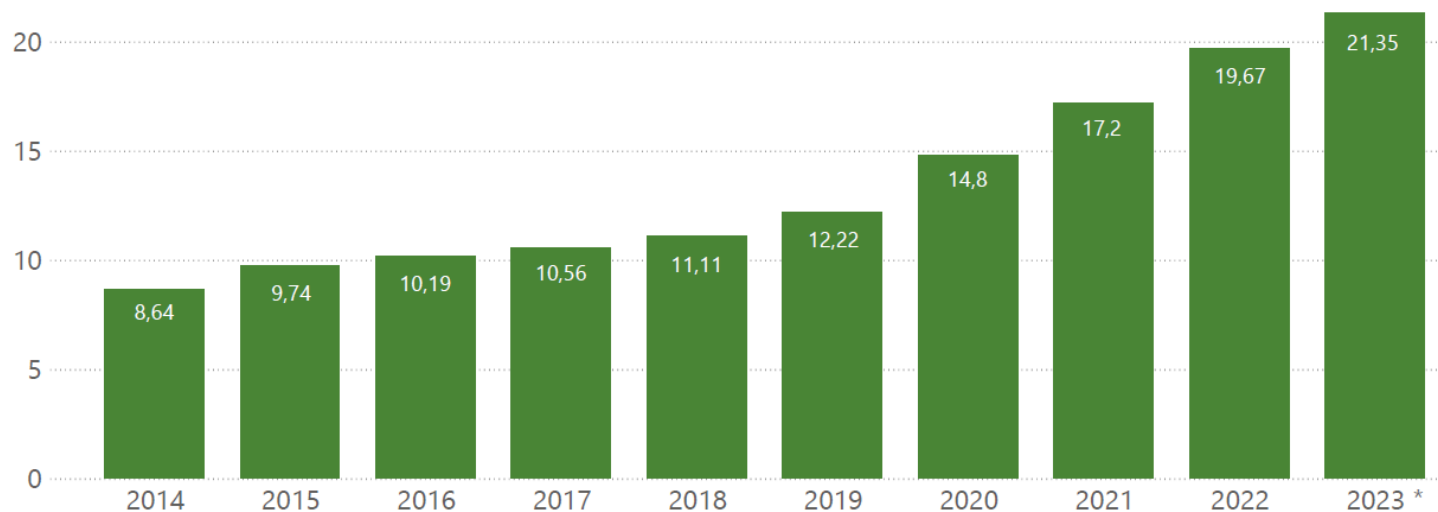
PVs and RES in Greece



	TODAY		2023	
	MW	%	GWh	%
WIND	5,130	40.1%	10,791	52.2%
PV	6,613	51.7%	7,850	38.0%
PV RESID	371	2.9%	451	2.2%
SMALL HYDRO	291	2.3%	689	3.3%
BIO	137	1.1%	565	2.7%
COGEN	256	2.0%	322	1.6%
Total	12,797		20,668	

Source: DAPEEP

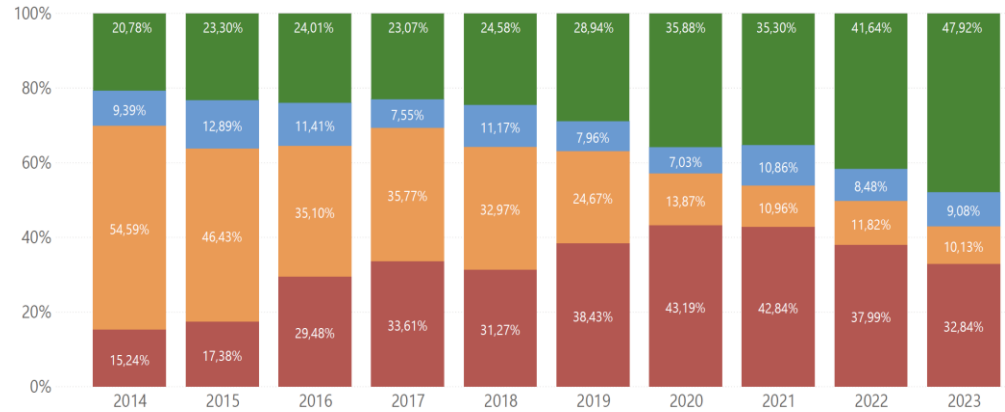
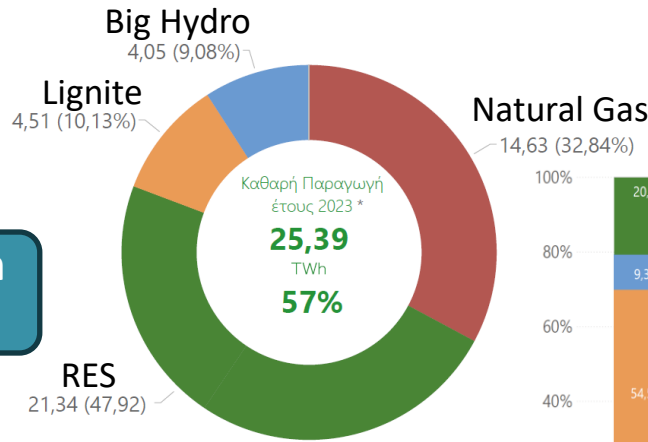
RES production in Greece (TWh)



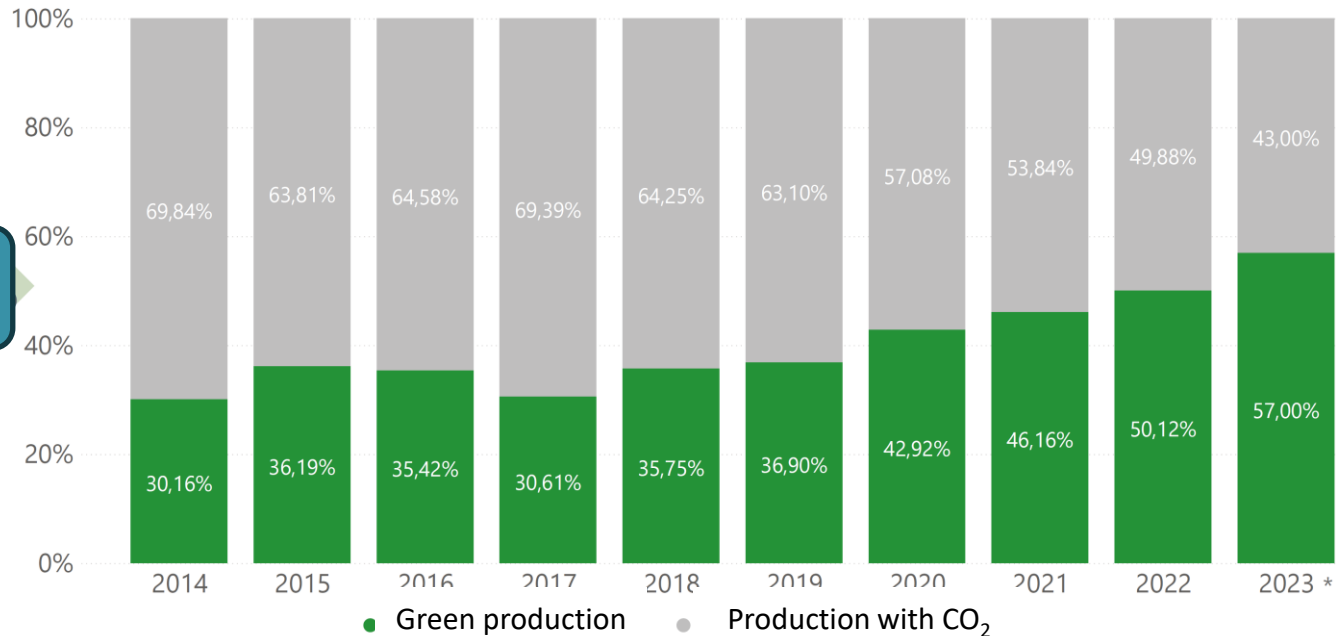
Source: IPTO

Electricity production (TWh) and % mix in Greece

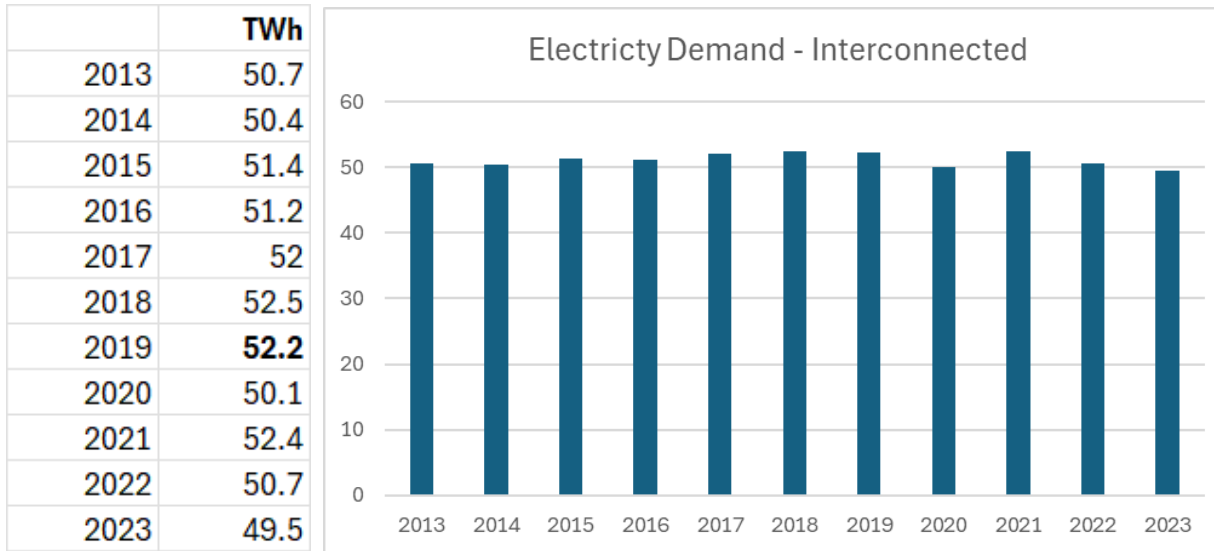
2023 share in production



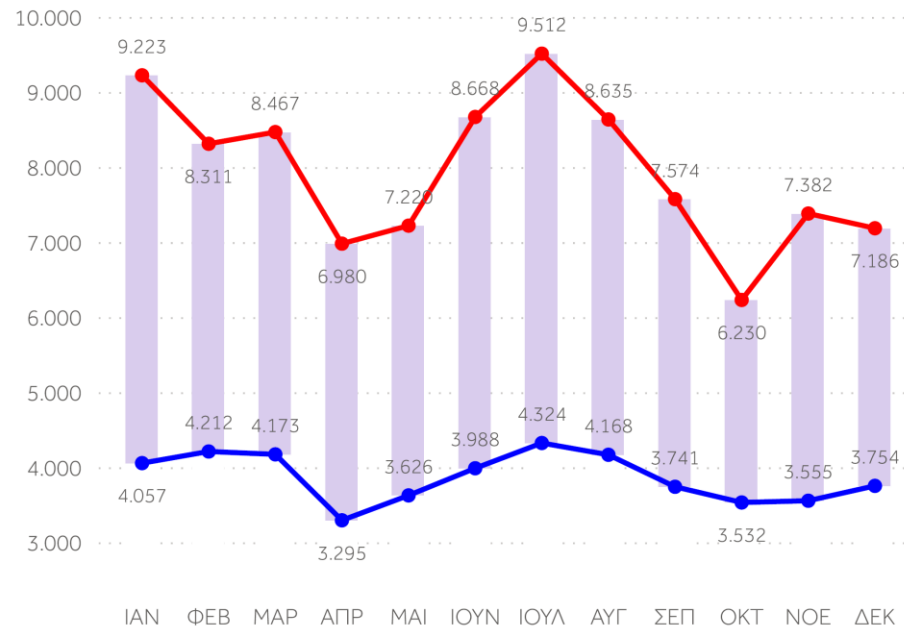
Share Evolution



Stagnating Electricity and Load Demand in Interconnected Grid since 2008



Electricity Demand (TWh) 2012 - 2023

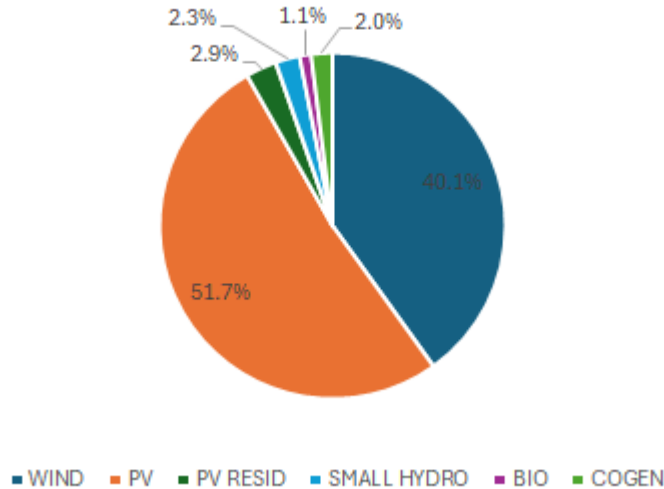


2023 Load Demand (MW)

RES Capacity and Energy Shares in Greece



RES Capacity (MW) in Greek Interconnected Grid - TODAY



~13 GW RES capacity in operation + 3.8 GW Big Hydro

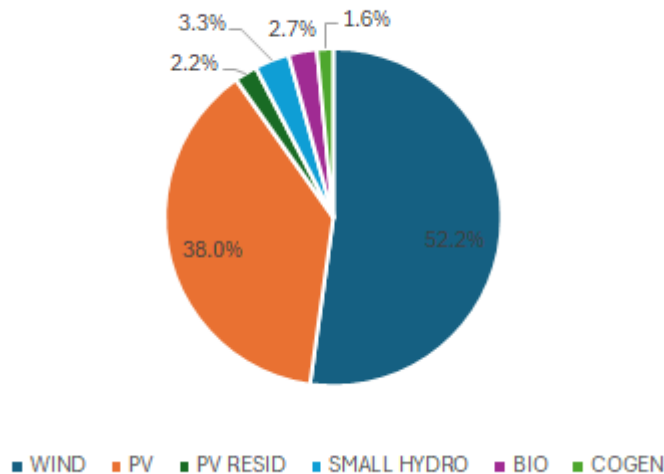
~21 TWh of RES production + 4 TWh of Big Hydro = 25 TWh in 2023

Plus, another ~15 GW in issued connection terms for new RES Projects

Plus, another ~40 GW of RES waiting for connection terms

Plus, a program of 2 GW of offshore Wind Farms plus new residential PVs

RES Production (GWh) in Greek Interconnected Grid - 2023



In terms of energy, RES + Big Hydro in Greece has reached ~51% of electricity consumption in Greece and 57% of production in 2023. Power demand in real time terms in Greece is approx. between 6 -9 GW.

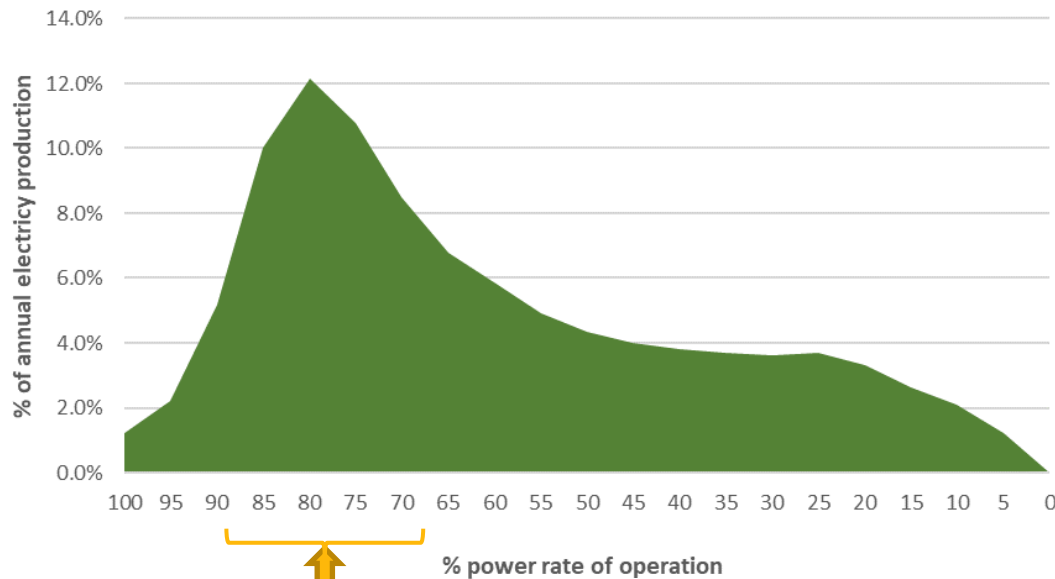
According to new NECP the RES target for 2030 is 23.5 GW plus 3.8 GW Big Hydro.

Today's RES + Con. Terms + Offshore Wind + resid. PVs = ~34 GW > NECP 2030 Target (27 GW) and also expected consumption

PV electricity production distribution Vs operation % rate (SPEF Study)



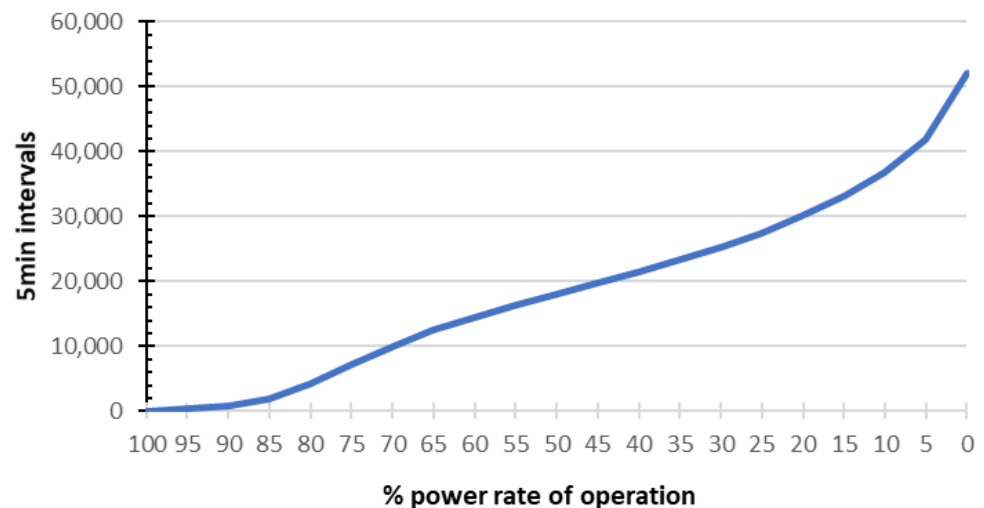
Typical PV electricity production



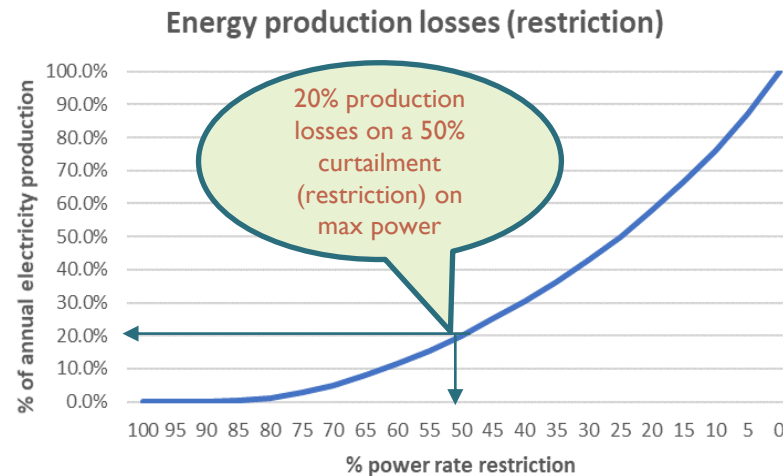
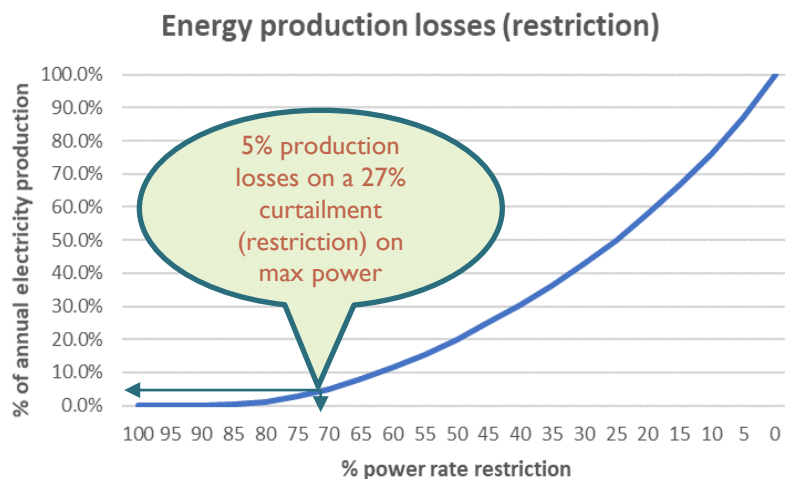
Most of annual electricity production of a typical PV plant*.

*Typical PV plant means fixed basis, 25° inclination and 1,500 MWh/MW specific annual production

Number of 5 minute intervals of typical PV operation



Energy production losses Vs % power rate restriction (curtailment) in a typical PV plant in central Greece



Blue curves are from a SPEF study based on real production data of PV plants in Central Greece and represent energy production losses at different restriction rates varying from 0 – 100%.

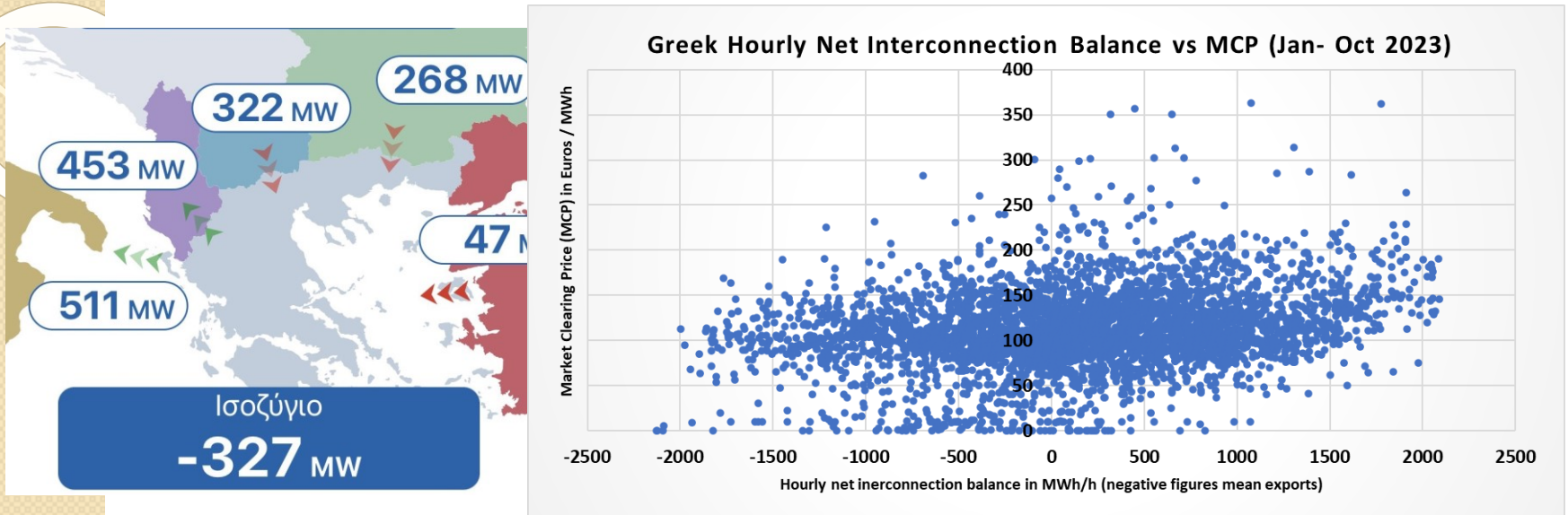
The Ministry of Energy aiming to exploit electrical space in the grids, has introduced -for new connection terms issued after law 4951/2022, a restriction (static curtailments) of PV operation at -27% of its maximum, leading to an annual energy losses of 5%.

The Ministry of Energy has announced that for new connection terms in PV plants restriction rate (static curtailments) may increase up to 50%, leading to an annual energy production loss of 20%.

Moreover dynamic curtailments have occurred since last spring leading to further production losses.

The main scenario tends to be that from now on for new projects a BESS (battery storage) unit of at least 2-hours capacity should be combined to save the energy losses.

Can electricity exports be the way to go for overcapacity



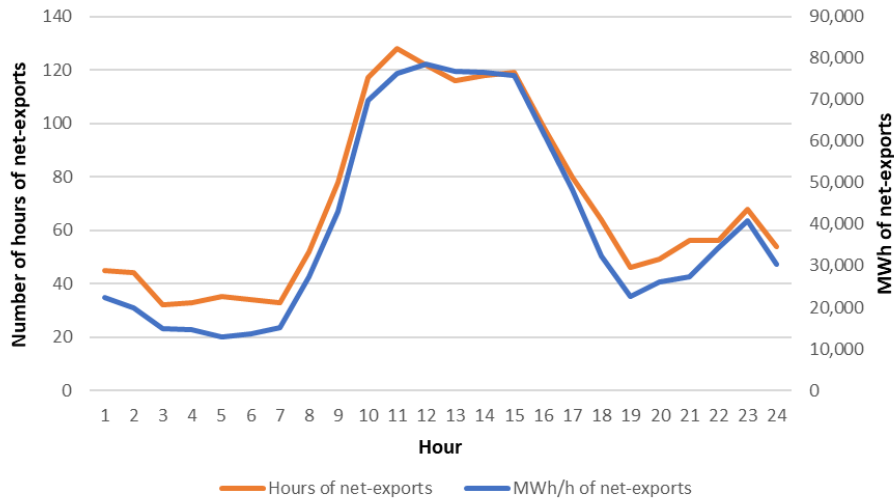
SPEF study

1. During Jan-Oct 2023 Greece, by processing the hourly data from the IPTO database, Greece showed a net export balance of interconnections within 175 days out of a total of 304 in the period and in this case in 1,678 of them.
2. For the sake of completeness, the diagram also shows the net import hours during these 175 days.

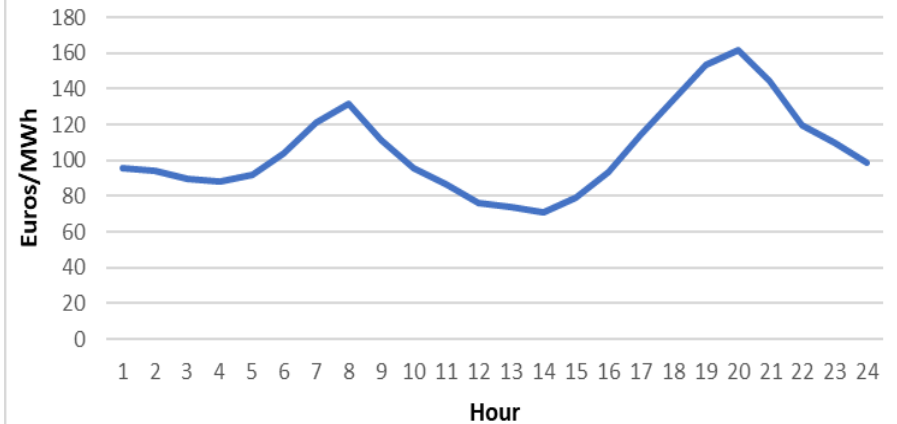
The profile of Greek net-exports Jan-Oct 2023 (SPEF study)



Hourly Net-Exports Profile Jan - Oct 2023

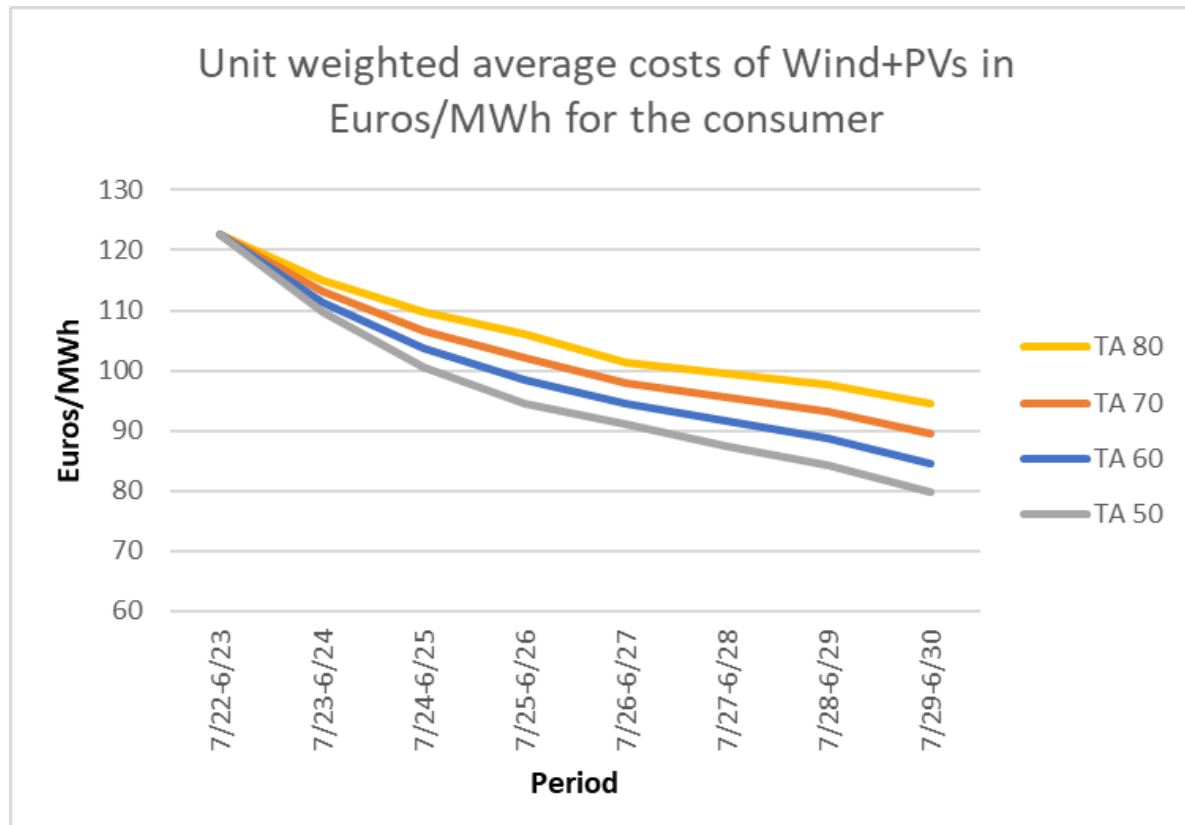


Hourly weighted average unit price per MWh of net-exports



Jan - Oct 2023	Hourly net-exports
Total net-exports MWh	962,125
Value of total net-exports	94,669,431
Weighted average unit price of net-exports in Euros/MWh	98.40

Evolution of unit cost of Wind+PV for the consumer

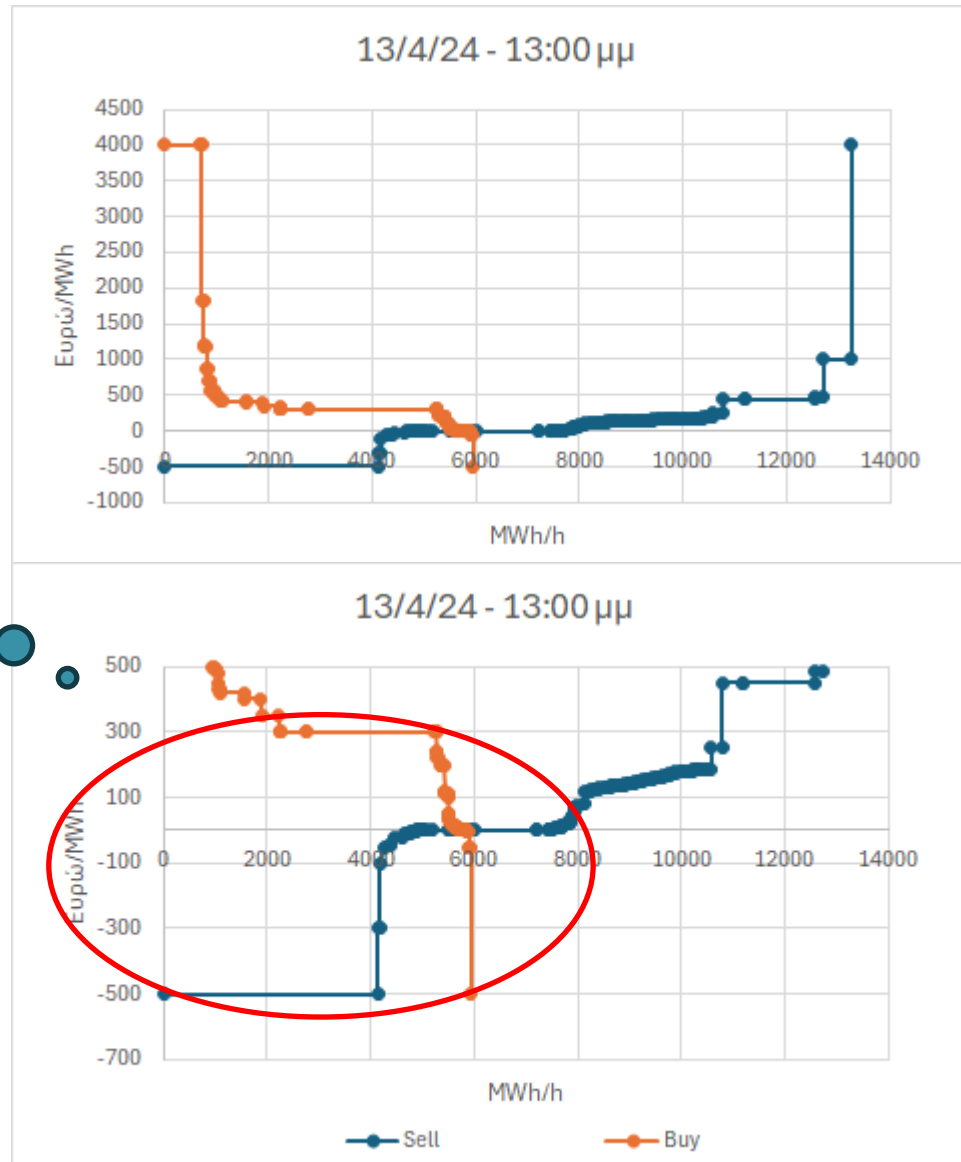


According to NECP plan for 13.4 GW totally PVs plus 9.5 GW totally Wind farms in 2030 and for different scenarios of remuneration prices (TA) for new entrants.

Higher remuneration tariff (TA) scenarios incorporate curtailment cost or BESS.

The situation of overcapacity has become even worse in spring 2024

Almost 8 GW of sell offers at negative or almost zero prices



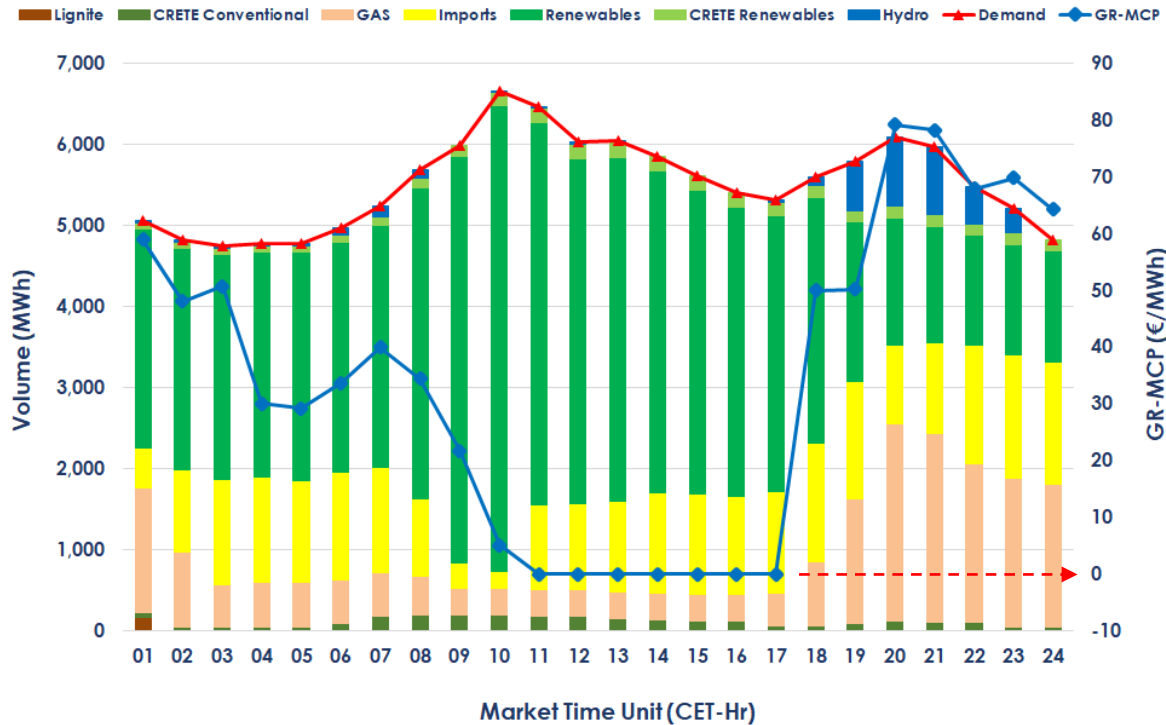
(zoom in)

Saturday, 13 April, 2024	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
Market Clearing Price																									
Greece Mainland	58.86	48.00	50.67	30.00	29.20	33.66	40.00	34.45	21.74	5.12	0.02	0.00	0.00	-0.01	0.00	0.02	0.03	49.99	50.19	79.15	78.17	67.84	69.74	64.25	33.80

Lots of hours zero prices in Day Ahead Market (DAM)



13/4/24 – Day Ahead Market



Saturday, 13 April, 2024	01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	TOTAL
Market Clearing Price																									
Greece Mainland	58.86	48.00	50.67	30.00	29.20	33.66	40.00	34.45	21.74	-12	0.02	0.00	0.00	-0.01	0.00	0.02	0.03	49.99	50.19	79.15	78.17	67.84	69.74	64.25	33.80

In Bulgaria that we are coupled, situation is even worse with negative prices in DAM



6/4/24

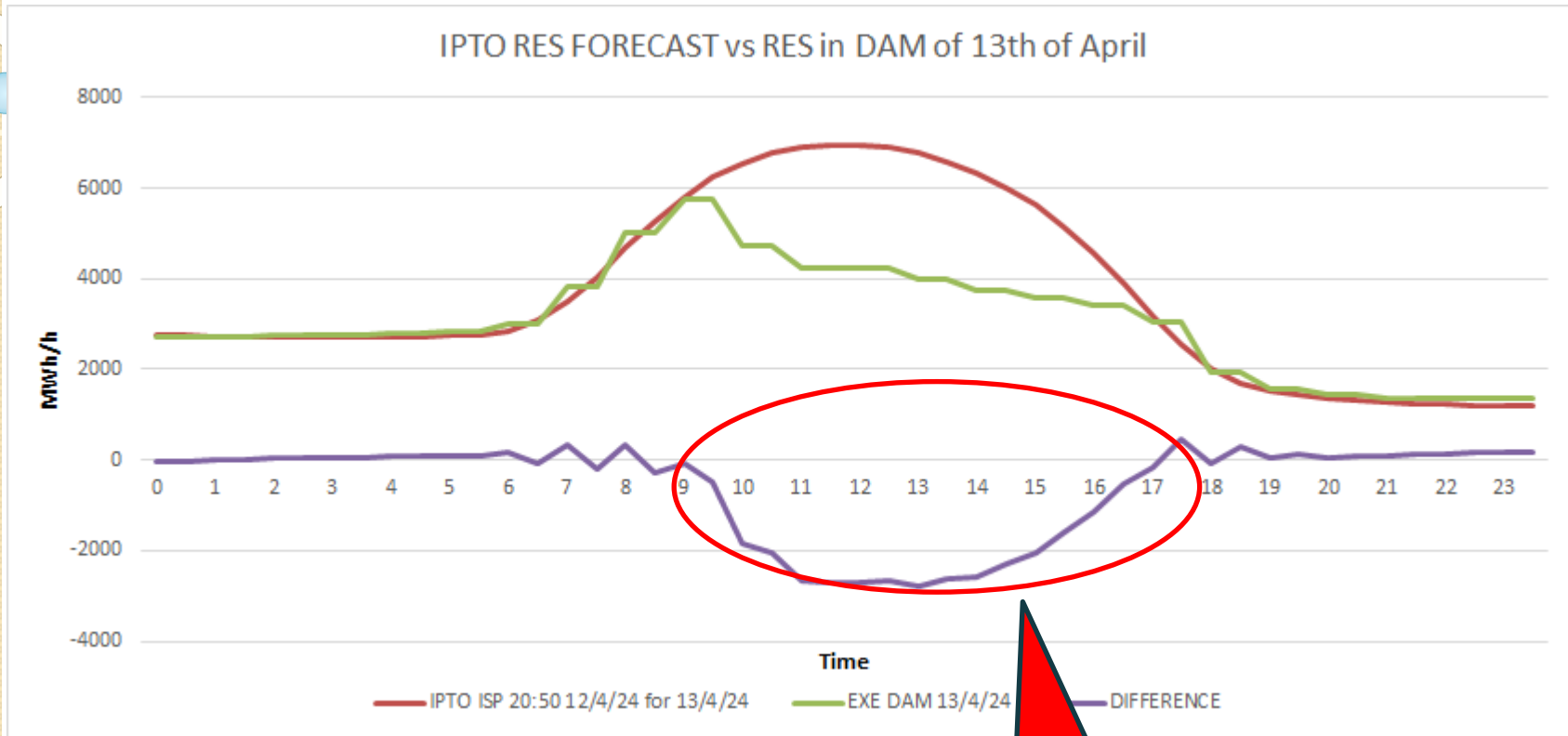
Date	Hour	Price(EUR)
6/4/2024	0:00:00	60.347781
6/4/2024	1:00:00	44.692023
6/4/2024	2:00:00	47.621726
6/4/2024	3:00:00	48.010308
6/4/2024	4:00:00	50.469622
6/4/2024	5:00:00	52.371627
6/4/2024	6:00:00	55.352459
6/4/2024	7:00:00	55.909767
6/4/2024	8:00:00	54.549731
6/4/2024	9:00:00	44.308554
6/4/2024	10:00:00	24.54201
6/4/2024	11:00:00	7.751185
6/4/2024	12:00:00	-0.511292
6/4/2024	13:00:00	-1.012358
6/4/2024	14:00:00	-0.501066
6/4/2024	15:00:00	-0.010226
6/4/2024	16:00:00	0
6/4/2024	17:00:00	40.760189
6/4/2024	18:00:00	75.170132
6/4/2024	19:00:00	90.319711
6/4/2024	20:00:00	84.102402
6/4/2024	21:00:00	76.729573
6/4/2024	22:00:00	62.709949
6/4/2024	23:00:00	46.757643

13/4/24

Date	Hour	Price(EUR)
13/4/2024	0:00:00	58.859921
13/4/2024	1:00:00	48.000082
13/4/2024	2:00:00	24.168767
13/4/2024	3:00:00	19.19901
13/4/2024	4:00:00	19.761431
13/4/2024	5:00:00	26.167918
13/4/2024	6:00:00	30.871804
13/4/2024	7:00:00	34.450847
13/4/2024	8:00:00	21.740131
13/4/2024	9:00:00	5.118032
13/4/2024	10:00:00	0
13/4/2024	11:00:00	-0.501066
13/4/2024	12:00:00	-25.181125
13/4/2024	13:00:00	-44.998798
13/4/2024	14:00:00	-41.931047
13/4/2024	15:00:00	-20.047755
13/4/2024	16:00:00	0
13/4/2024	17:00:00	9.857707
13/4/2024	18:00:00	46.379287
13/4/2024	19:00:00	79.147983
13/4/2024	20:00:00	78.171416
13/4/2024	21:00:00	58.711647
13/4/2024	22:00:00	51.51777
13/4/2024	23:00:00	44.998798



Dynamic RES curtailments i.e. in 13/4/24

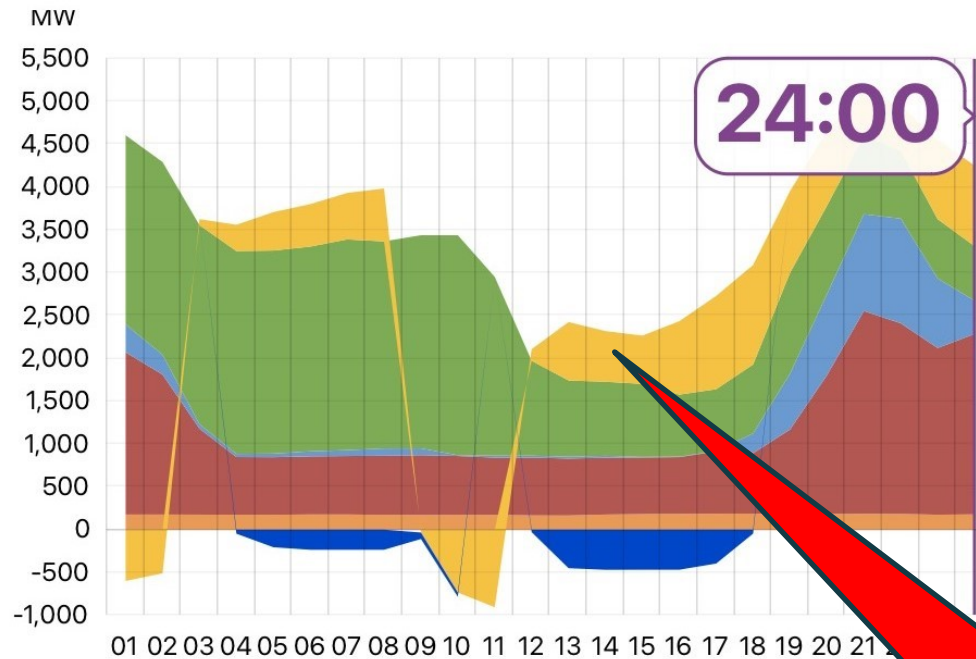


MCP in Bulgaria has reached -45 euros/MWh during noon hours

Dynamic RES curtailments

And instead of exports we had imports and increased RES curtailments i.e. in 13/4/24

▲ ▼ Ημερήσια



179
MW



2,108
MW



390
MW



637
MW



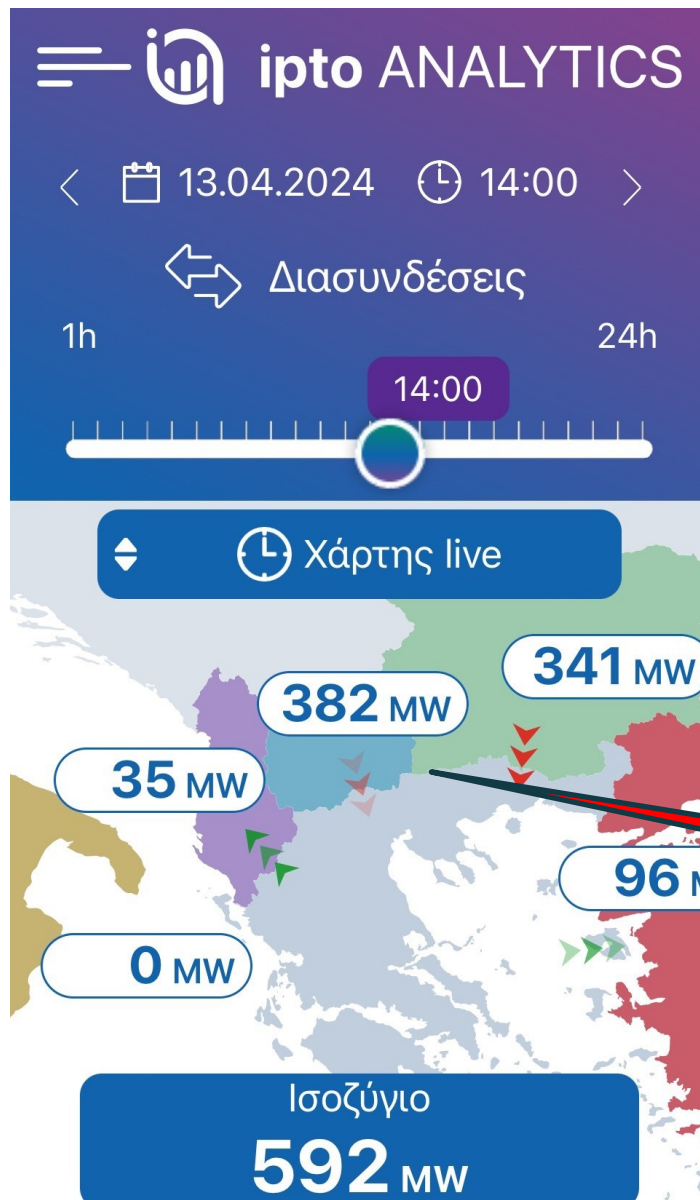
943
MW



0
MW

Imports

Imports and increased RES curtailments instead of exports i.e. in 13/4/24



Imports

Challenges and opportunities

- In most of the cases a battery storage (BESS) system of an adequate capacity (i.e. 2 hours capacity at the nominal power of the PV plant), doubles the cost of the overall installation CAPEX. This means that at operational level and if there is no state aid for the CAPEX of the BESS, a need for doubling the Tariffs arises (at least for non vertical players).
- Electricity exports constitute a policy of national and energy independence, However, economic conditions are crucial for their mid to long-term sustainability and benefit of the relative investments.
- Net exports of the period Jan – Oct 2023 with an average income of 98.4 euros/MWh do not appear to cover the fundamental costs of the period's electricity generation from RES (122 Euros/MWh) nor from conventional electricity from thermal units (>150 euros/MWh).
- Merit-Order-Effect with the “zero” pricing in the wholesale market of RES operating under FIT, FIP, CfD or PPA schemes will continue to cannibalize market clearing prices, more aggressively compared to the reducing cost of RES, posing this way barriers to exports and RES.
- The mismatch between the actual cost of electricity production and prices in the wholesale markets due to RES, is a European regulatory challenge and not only Greek. Storage facilities can help mitigating it, presumed that there won't be overcapacity and overproduction in the neighborhood in energy terms.
- In the neighboring countries and especially in Bulgaria, with which we are coupled, MCP zeroes out or becomes negative, so cross-border trade for our country turns into an import at the peak of RES production and thus the cuts in their production are further intensified due to even less free demand.

Challenges and opportunities

- So, it seems that the "strategy" of making a country an exporter of RES electricity with the existing pan-European model of marginal pricing and coupling is coming to a dead end, at least without adequate storage.
- The natural brake of the market is none other than the zero or negative MCPs that suspend the compensation in most of the RES projects (the ones with CfDs) and make curtailments economically neutral. In other words, if a project is not going to be paid for, it doesn't matter if it will be curtailed, and ultimately its development-construction is discouraged from the beginning.
- Electricity exports do not receive RES levy from their destination state, therefore the difference of MCP from the Reference Price of the RES projects of origin of the exported energy is paid by local RES Account. That is, in such cases of exports, the exporting country subsidizes the consumers of the importing country.
- Vertical players combining production and retail at a balanced mixture, enjoy best protection against wholesale market risks (curtailments, negative prices etc), since they practically sell their electricity production to final consumers at retail prices, that are offering much higher margins and the ability of extra income if needed through bill increases.
- Vertical players are neutral against negative wholesale prices (they just reverse a cashflow that in any case equals to zero when the mixture between production and retail is balanced), while for simple producers consist the ultimate barrier that oblige them to stay out of the market.



IENE

**1ST GREEK-TURKISH
ENERGY FORUM**

Thursday, April 25, 2024 | Istanbul

Thank you!

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