



7th International Conference and Trade Show Solar Energy Industry in Central and Eastern Europe

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The Greek Electrical Systems



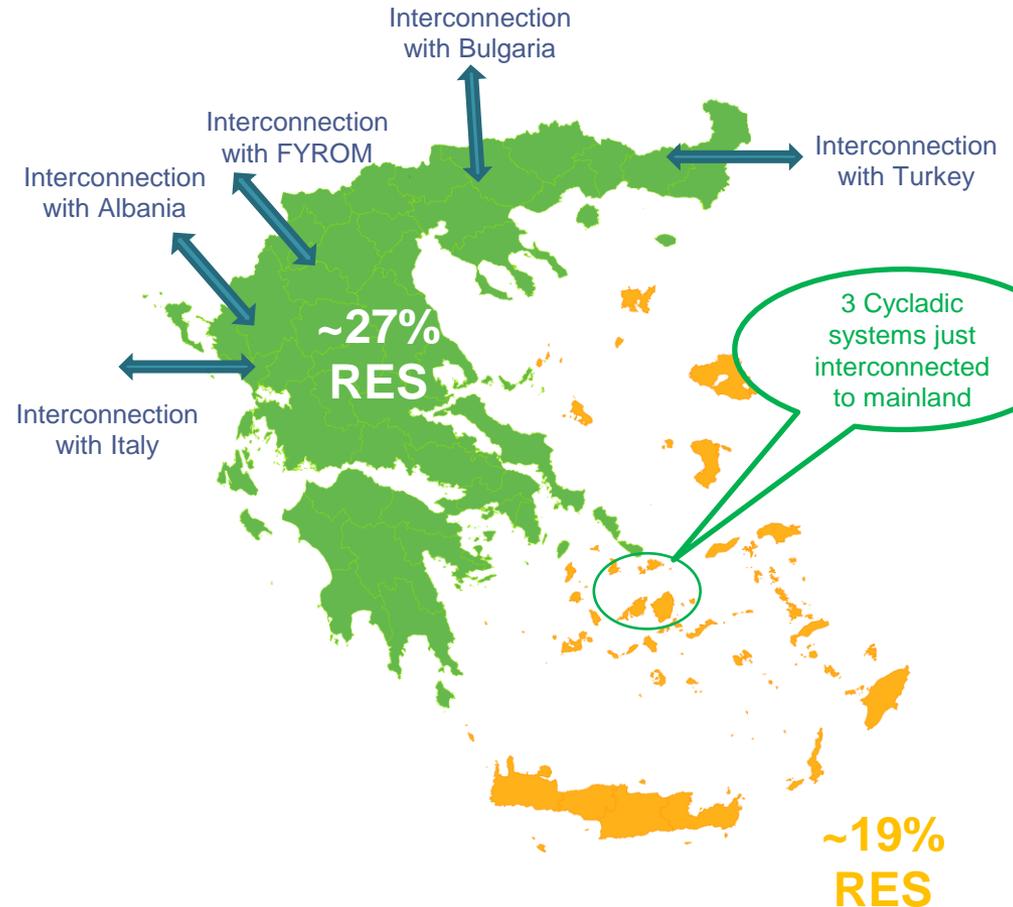
~52 TWh
electricity
demand

1 mainland system
including Ionian Islands,
interconnected with other
European (Italy, Albania,
FYROM, Bulgaria) and
neighbor (Turkey)
Countries



29 non interconnected to
mainland electrical
systems that cover Aegean
islands plus Crete

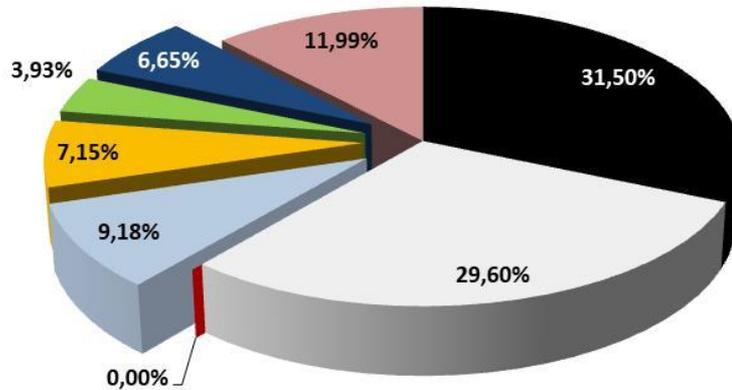
~5.6 TWh
electricity
demand



RES penetration % shares in electricity demand in Greece - 2017 (GWh)



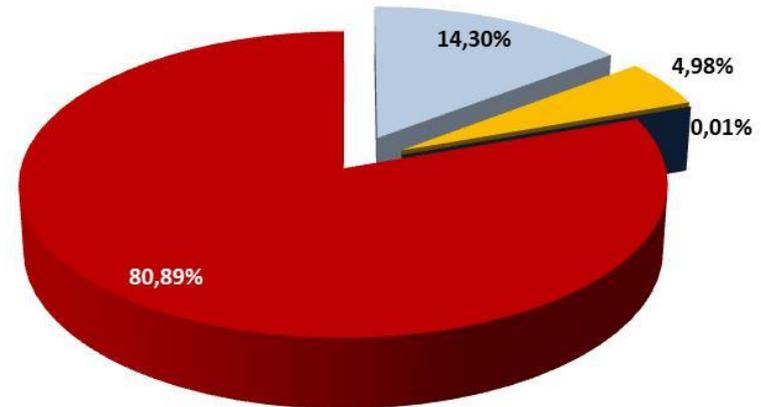
Mainland ~27%



- Lignite
- Natural Gas
- Oil
- Wind
- PV
- Other RES & COGEN
- Large Hydro
- Interconnections

	Share	GWh
Lignite	31,50%	16.387
Natural Gas	29,60%	15.397
Oil	0,00%	0
Wind	9,18%	4.777
PV	7,15%	3.718
Other RES & COGEN	3,93%	2.042
Large Hydro	6,65%	3.457
Interconnections	11,99%	6.237
	100%	52.015

Non Inter/ted Islands ~19%



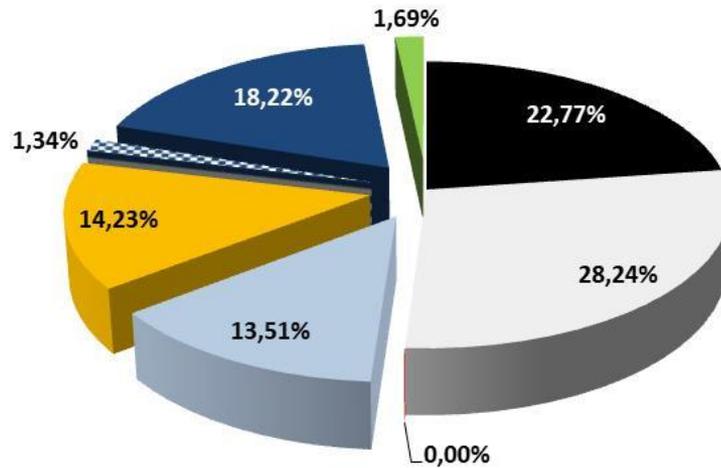
- Wind
- PV
- Small Hydro
- Oil

	Share	GWh
Wind	14,55%	815
PV	4,98%	279
Small Hydro	0,01%	0,475
Oil	80,46%	4505,525
	100,00%	5600

Thermal and RES Installed Operational Capacity MW in Greece - 2018



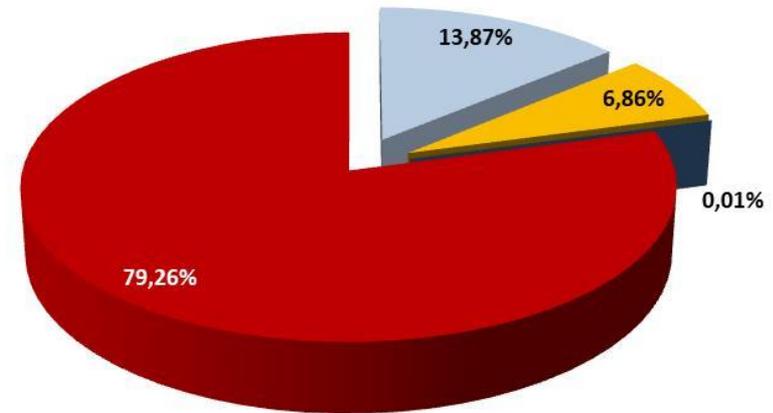
Mainland



- Lignite
- Oil
- PV
- Large Hydro
- Natural Gas
- Wind
- Small Hydro
- Other RES & COGEN

	Share	MW
Lignite	22,77%	3.912
Natural Gas	28,24%	4.853
Oil	0,00%	0
Wind	13,51%	2.322
PV	14,23%	2.445
Small Hydro	1,34%	231
Large Hydro	18,22%	3.131
Other RES & COGEN	1,69%	290
	100,00%	17.184

Non Inter/ted Islands



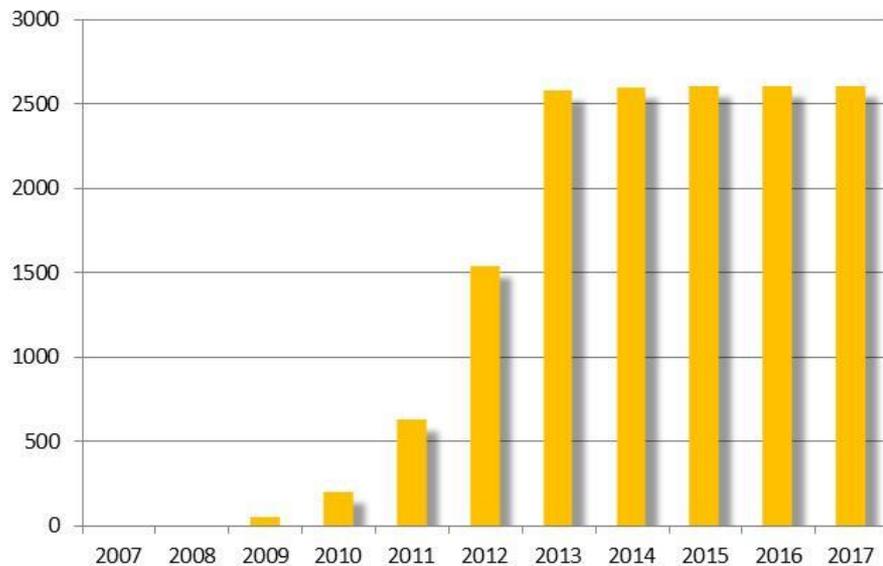
- Wind
- PV
- Small Hydro
- Oil

	Share	MW
Wind	13,87%	322,83
PV	6,86%	159,71
Small Hydro	0,01%	0,30
Oil	79,26%	1.845,30
	100,00%	2.328,14

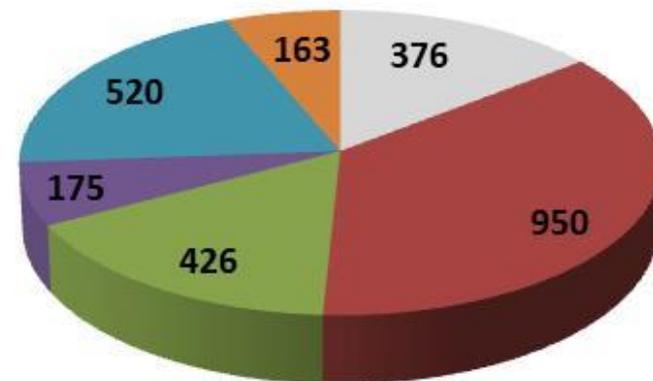
Profile of PV installations in Greece



PV installed capacity in MWp



MWp per Category



- <10 kWp
- 10-100 kWp
- 100-500 kWp
- 500-1000 kWp
- 1000-5000 kWp
- >5000 kWp

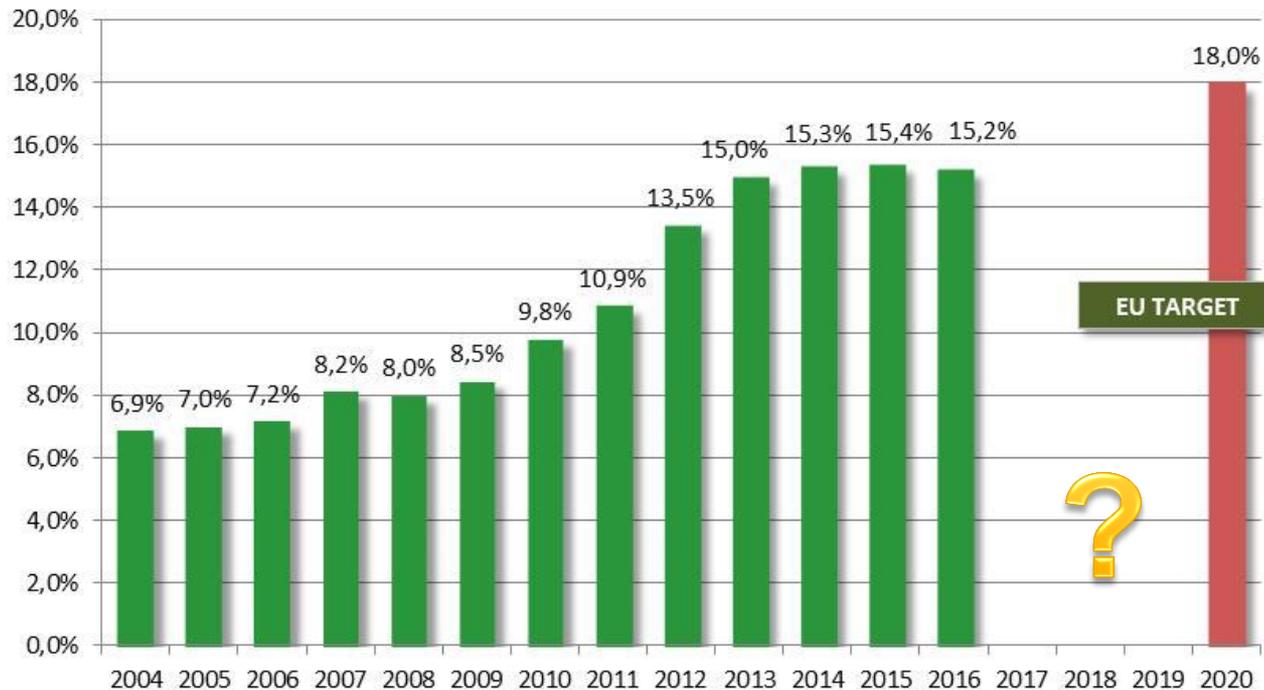
2020 National and EU RES Target for Greece



RES National Targets in MW for electricity production	2014	2020	Present Capacity
Wind	4.000	7.500	2.625
PV	1.500	2.200	2.605
Hydro	3.700	4.650	3.362
Biomass	200	350	61
Solar thermal for electricity	120	250	0
Total	11.534	16.970	8.653

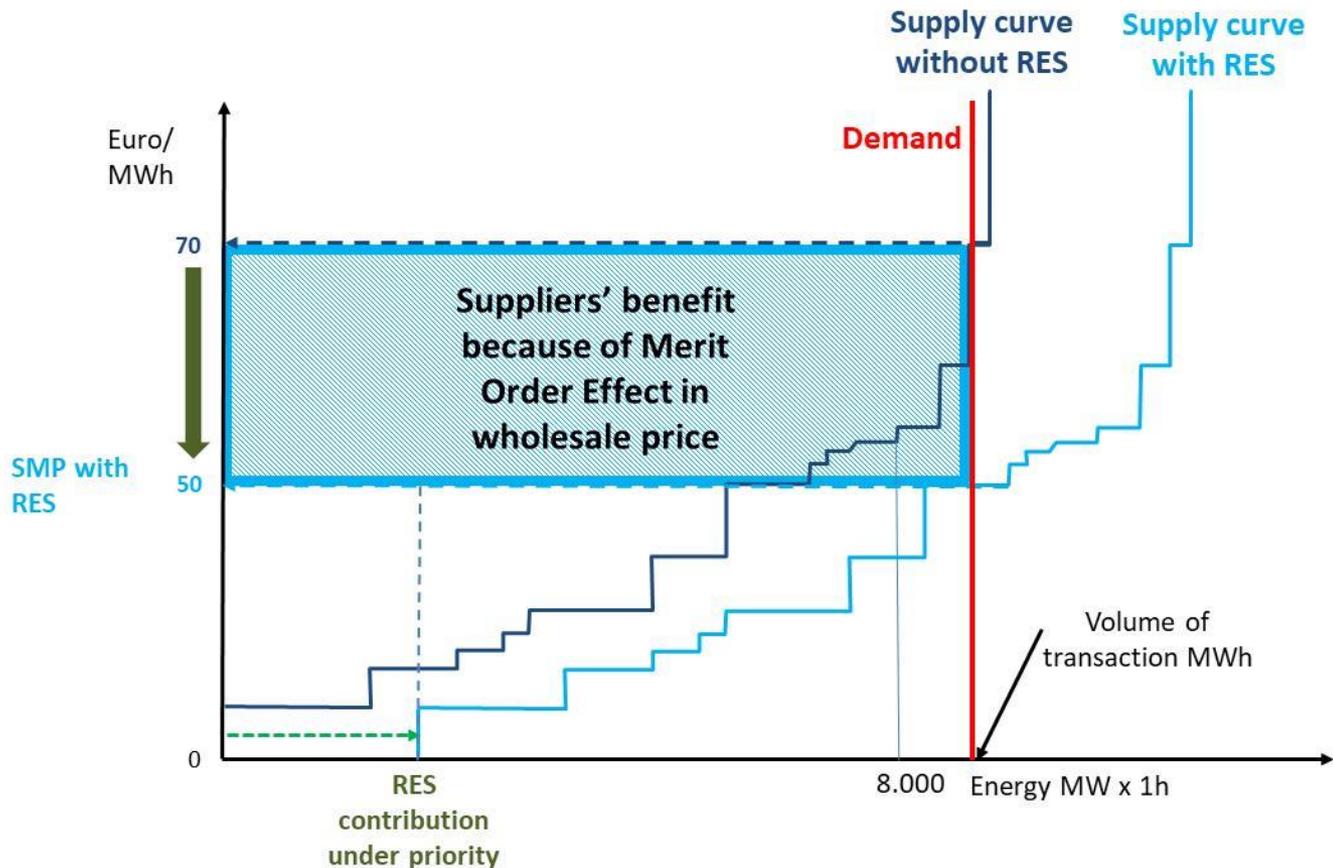
**STATE'S AIM IS
+2,7 GW NEW RES
UNTIL 2020 OUT OF WHICH
~1 GW PV**

% RES Share in total energy consumption



Merit Order Effect due to RES in wholesale market

Hourly
market
clearance



Merit Order Effect: RES penetration under priority displaces high cost thermal units that would commit otherwise and hence wholesale marginal price is strongly reduced. Consequently suppliers (retailers) benefit due to this price reduction for the whole volume of electricity they buy from the market.

Merit Order Effect distortion removed in Greece



Since law 4414/2016 wholesale electricity market is in parallel per hour resolved without RES and a second Virtual SMP (System Marginal Price or wholesale price) is produced.

For each hour the difference of this Virtual SMP from the main SMP (that is produced with RES calculated in the market), multiplied by the volume of electricity each supplier bought from the market, consists a special charge for each Supplier, that is driven to RES account and hence RES levy is retained at the appropriate fair level.

This way, increase in RES penetration does not over-increase RES levy due to the continuous decline of SMP they cause. Hence RES account and levy is stabilized.

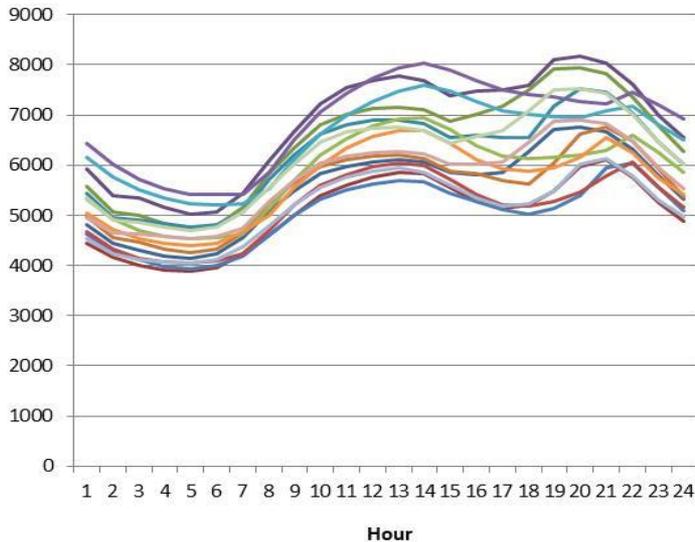
Following charts show the elaboration of law 4414 and the level of this Special Charge to Suppliers every hour.

No problem with Market Coupling between different countries. Market Coupling does not merge Day Ahead Markets but exploits the flow of electricity among them at the limit of their Available Transmission Capacity (ATC) while ensuring that the physical limits of the grid are respected, in order SMPs to converge as much as possible (see chart).

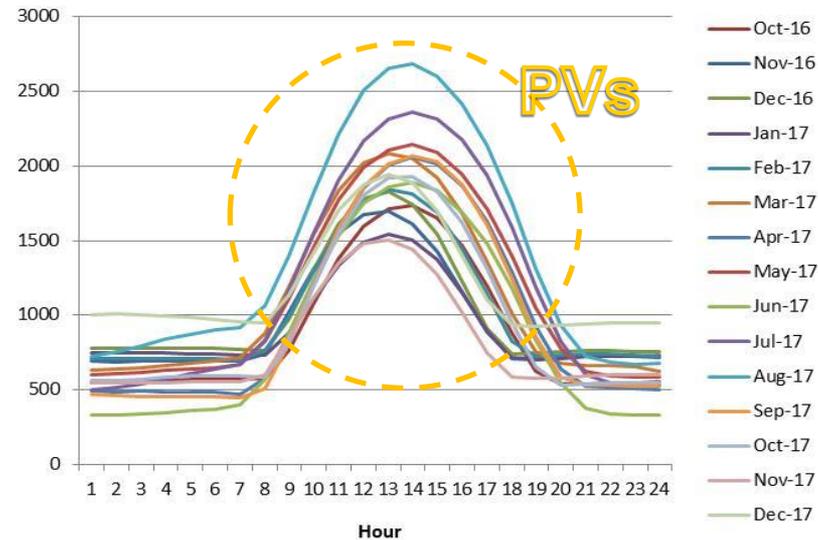
Wholesale market price reduction due to RES at Greek mainland system



True consumption in MWh/h

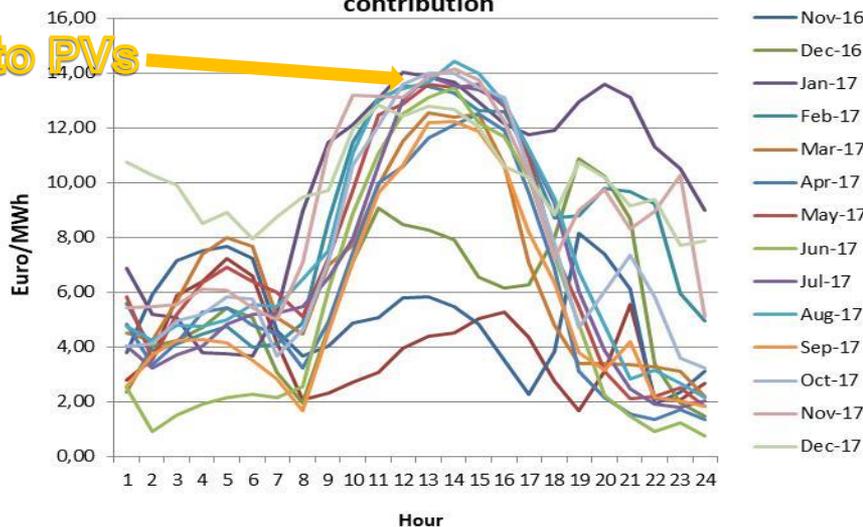


RES contribution to consumption in MWh/h



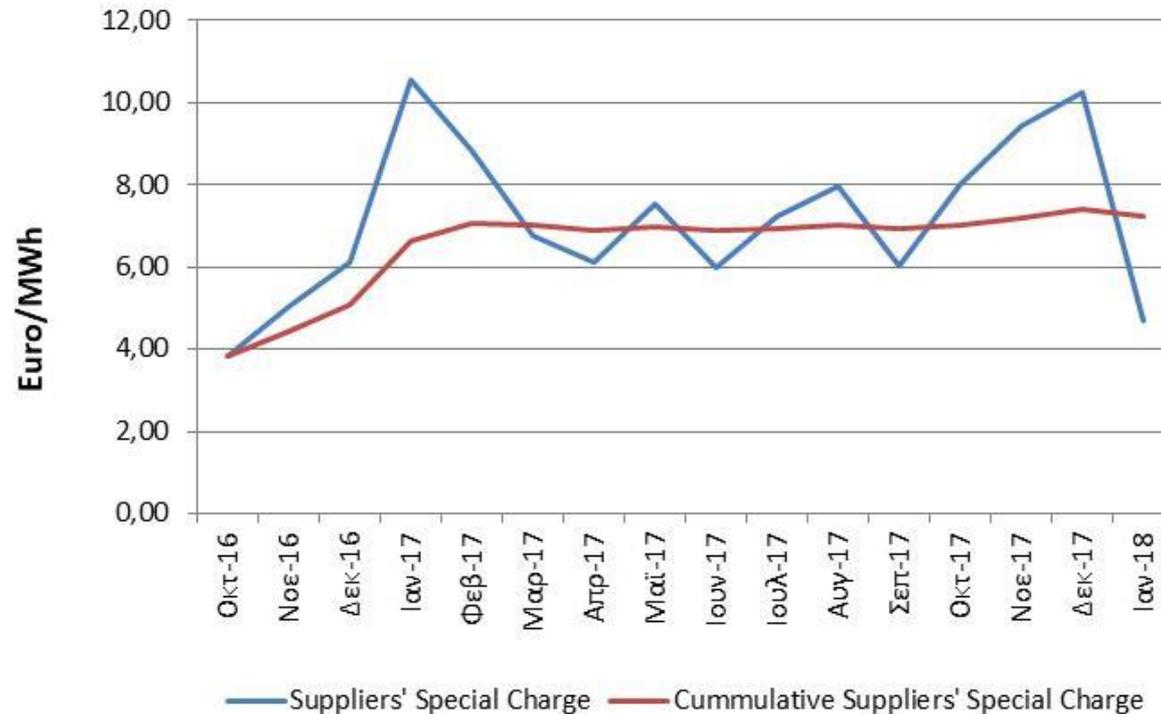
Reduction of wholesale elec. price due to RES contribution

Due to PVs



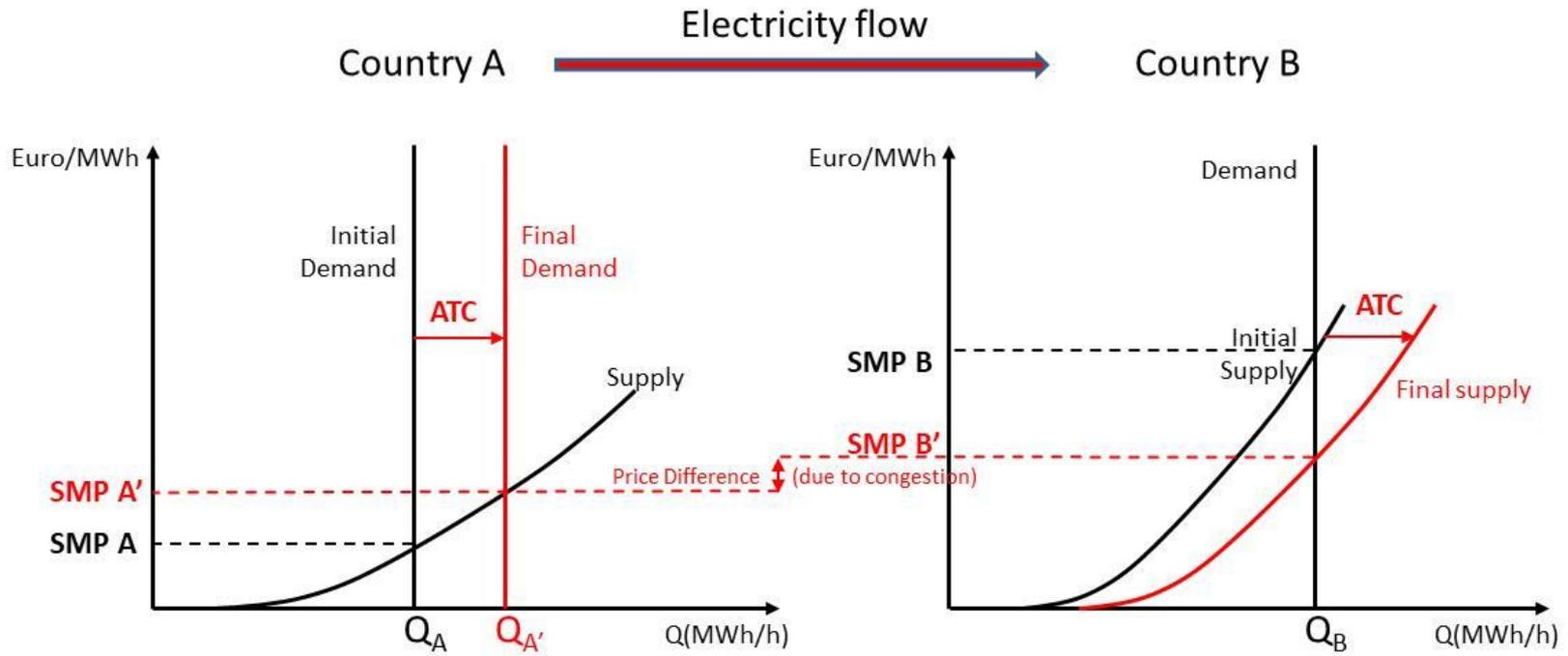
Suppliers' (retailers) Special Charge that is driven to RES account, reflects their market benefit due to RES and Merit Order Effect.

Suppliers' (retailers) Special Charge at a monthly level



Suppliers' (retailers) Special Charge was introduced with law 4414/2016 in order to lift the distortion of Merit Order Effect and retain RES levy at fair levels.

Market Coupling between different Day Ahead Markets



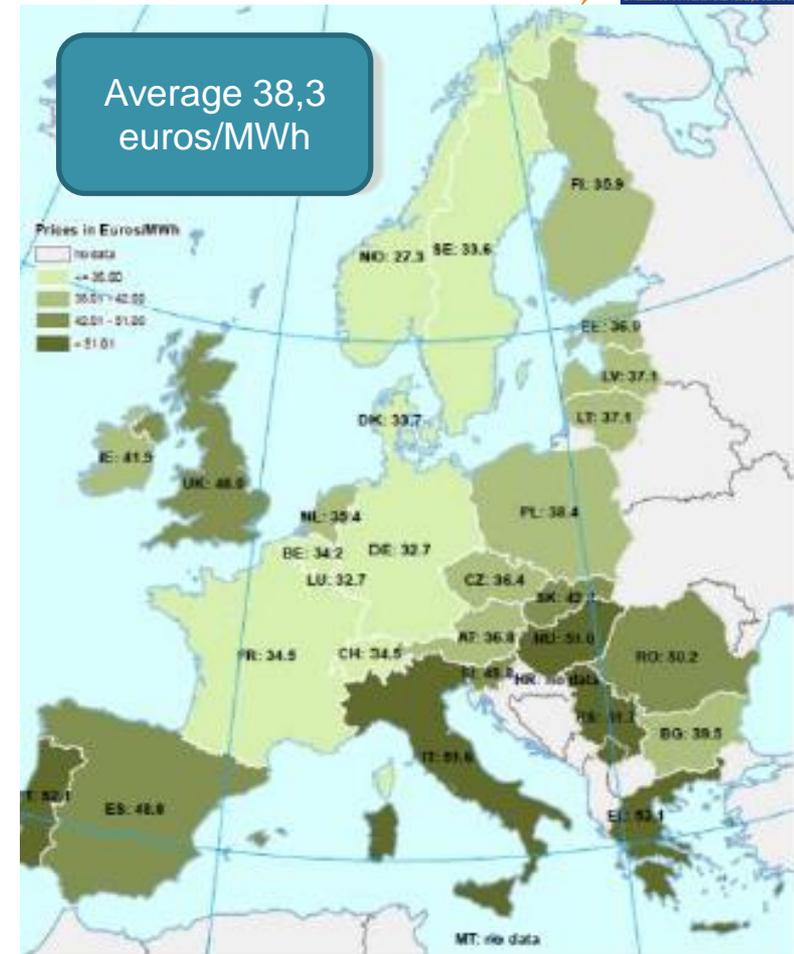
Different Day Ahead Markets

*Flow Based Market Coupling: Market Coupling optimizes the efficiency of power trading by allocating cross-border transmission capacity **between the different coupled spot markets**, while ensuring that the physical limits of the grid are respected. In so doing, market coupling narrows price spreads **between national power markets** and increases social welfare for the involved countries.*

Wholesale electricity prices among different markets some of which Market Coupled



4th quarter of 2016



3rd quarter of 2017

CWE (Central west Europe) cluster includes Germany, France, Belgium, Netherlands

NWE (Northwest Europe) region includes CWE, Denmark, Norway, Sweden, Finland, UK

NWE was coupled with **SWE** (Southwest Europe) in 2014 reaching up to Portugal.

Feed In Premium (FIP) and direct market participation



New Context

Potential removal of market priority for new RES projects based on FIP scheme according to law 4414/2016 or later directly participating to the market (Target Model).

Balancing responsibilities for new RES projects (> 500 kWp for PVs) based on FIP scheme according to law 4414/2016 or later directly participating to the market.

Auctions for “gaining” a FIP reference price.

Challenges on new RES projects

Possible not full absorption of production. Consequently new RES project's Levelized Cost of Energy (LCOE) will tend to rise, unless technology maturity could absorb it.

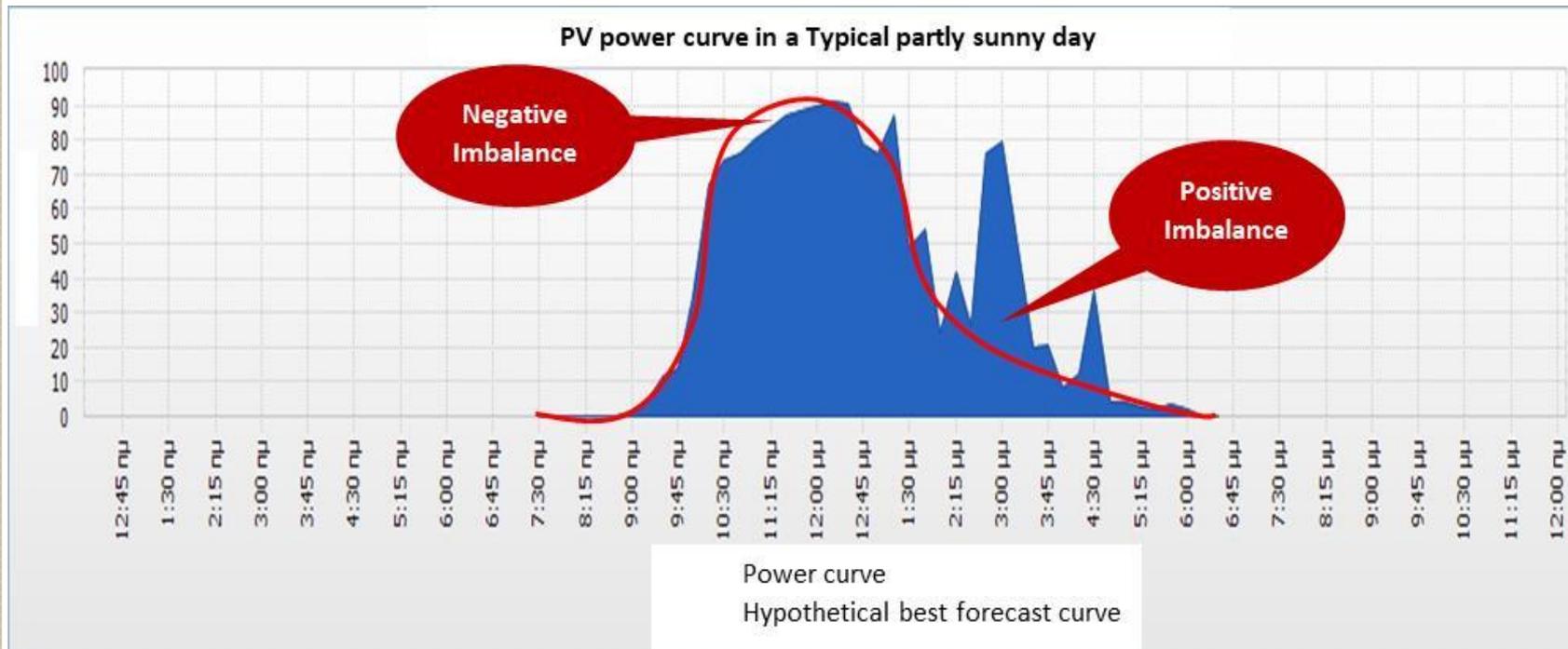
Clearing of imbalances due to balancing responsibilities for new RES projects will cost grossly more than 10% of their turnover or even more and make their net remuneration derogate significantly from FIP reference price gained in auction.

Economically competitive and efficient storage solutions will be a “must” for future RES projects in order to compete fossil fuels.

Balancing Cost and clearing of Imbalances

The cost of a negative imbalance will reflect the remuneration that a Balancing Services Provider (BSP) would ask, in order to increase his production and fill the gap.

The cost of a positive imbalance will reflect the remuneration that a BSP would ask to keep, in order to reduce his production compared to his prepaid position in Day Ahead Market and hence counteract the spike. The money that he will be willing to give back in order to reduce his production, will correspond to the extra remuneration (beyond Day Ahead Market) the PV producer will receive for the extra energy he injected to the grid during the spike.



Conclusion



Renewables and of course PVs need further decline in their equipment and hence installation costs.

In parallel they need economically effective, competitive and cheap decentralized storage solutions (i.e. batteries) in order to compete fossil fuels directly in electricity wholesale markets, without needing subsidies.

Only decentralized storage solutions (i.e. batteries) can eliminate expensive balancing costs per RES unit and restore full absorption of its renewable production potential.

ETS (Emission Trading System) and CO₂ prices per ton should reflect the true external environmental cost of fossil fuels. Although CO₂ prices have risen, they are way behind appropriate levels of >30 euros / ton.

It should be noted however that even high prices of CO₂ in ETS, cannot restore the damage of fossil fuels on the environment and climate change.

Depending on how fast all the above can be met, RES participation to wholesale markets remains a challenge for investors and of course the achievement of European targets for RES penetration.



THANK YOU !

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