# Curtailments in RES energy in Greece and potential exploitation

As of July 25th, 2024, in 2024 alone, an estimate of over 526GWh of renewable energy have been curtailed from the Greek electricity system.

Regarding the current situation in the energy sector, curtailments can only be estimated, as most RES parks/plants do not have the necessary equipment providing accurate numbers of curtailed energy. The Greek Independent Power Transmission Operator (IPTO), responsible for deciding which parks and at which hours will be curtailed from the system, can accurately only provide the hours of the curtailments taking place.

A screenshot of a computer screen

Description automatically generated

Figure 1 Heatmap of the curtailed energy from the system

From the conducted estimate a heatmap is provided. Most curtails take place during the middle of the spring (mainly in April and the days close to April) and during the solar PV working hours. The reason of this picture is attributed to various factors.

Seasonality in electricity consumption. During the spring and autumn months usually, Greece has a lower electricity demand in the system, due to milder temperatures and lower tourist levels. During the summer months, especially in Jully, Greece has the biggest need in electricity supply, due to high temperatures and cooling devices (air-conditions), alongside high levels of tourism during the respective months. In the last years, winter also has become a season of high demand in electricity supply, as many homes have converted to electricity heating methods.

Figure 2 Electricity Net Load in MWh for the interconnected system in Greece

Seasonality does not only affect the load during the months of the year, but similar patterns can also be found during the course of the day, where the average load is significantly lower during the hours of 10:00am to 5:00pm (similar to the hours of office workers). After that high demand occurs from 6:00pm to 9:00pm affecting the net load during those hours and having a high volatility.

Figure 3 Average System Load in MWh during each hour of the day

In turn this high volatility affects the Day-Ahead wholesale Market (DAM) prices. The lowest prices for DAM can be found during the same hours where the system load is relatively low.

*Figure 4 Average hourly DAM Prices (€/MWh)*

While the “duck curve” is already visible in the average Day-Ahead prices, looking at the normalized prices makes this phenomenon even more prominent. The volatility in DAM prices is high, having the lowest average price at 12:00pm (peak hour of solar PV production) and peak price during 8:00pm.

Figure 5 Normalized hourly DAM (€/MWh)

Figure 6 Average hourly RES production (MWh)

In turn looking at the average patterns of RES production, a contrariwise picture is painted when compared both to DAM prices and the system load during the same hours.

Figure 7 Normalized hourly RES production

The same conclusions are drawn when considering the normalized curve of the RES production, giving special focus to the curve for 2024.

Figure 8 Normalized Average net load, RES and conventional production for 2024

Looking at the normalized RES production compared to the system load, the curves are completely opposite. conventional production follows the same pattern as the system load, as to account for needs that cannot be provided by renewable energy.

Considering these aspects the average curtailed energy is only rational to follow the same patterns as the renewable energy production, since Greece does not have considerable storage capacities, while the system cannot handle the residual production that is not needed for the system load, or even for other coupled markets (through Single Day-ahead Coupling – SDAC) at the given time unit.

Figure 9 Average hourly curtailed energy for 2024 (MWh)

Even though the hours during which the curtailments took place are on the spectrum of the lowest prices in DAM, the lost revenue is estimated to be surpassing the 5.5mil€ mark only for the current year (as of July 25th, 2024). Implementing storage technologies to store the curtailed renewable energy and sell it during peak price hours in DAM (during 18:00-21:00 CET) could bring an estimate of at least 40mil€ in the worst-case scenario. The difference in the two revenues discussed above is dramatic and maybe even hard to comprehend but is easy to understand when looking at the results in a graph form and keeping in mind the dramatic differences in DAM prices during the relevant hours.

Figure 10 Lost revenue from curtailed energy (€)

Figure 11 Pottential revenue of selling curtailed energy during peak price hours in DAM (€)

Figure 14 MCP for DAM in peak price hours (€/MWh)

Taking a look at a rather interesting day in July, specifically July 23rd 2024. The aggregation curves during the hours of 12:00pm and 8:00pm show two drastically different pictures of how the MCP is formulated at the respective hours. During 12:00pm the buy curve is easily satisfied by “cheap” energy sources, as it is peak renewable energy production hour. On the contrary, at 8:00pm, the buy curve is satisfied, using almost every production unit, since demand is higher, and the renewable energy production is on the lower side conventional technologies and big hydro technologies take place to cover the system demand bringing the MCP for DAM to almost 1000 €/MWh

Figure 12 Aggregation curves for 12:00pm (€/MWh)

Figure 13 Aggregation curves for 8:00pm (€/MWh)

Lastly, considering the potential that Greece has to offer in renewable energy production and the EU target toward a net-zero future, significant capacities of storage technologies should be included in the energy system. While the storage capacities will play a vast role in the improvement of the picture, the transmission capacities within the country are also a great matter that will affect the correct operation of the system. Storage technologies will not only make the energy system more efficient and resilient but also will offer lower energy prices during peak load hours, especially during the summer months where even though renewable energy production reaches its peak potential, electricity consumption is higher that in any other season of the year.

At the same time, an addition of storage capacities would also affect the structure of the wholesale energy market if used to cover imbalances in the system. In turn affecting MP selling their produced energy, by lowering balancing charges and non-compliance charges.