



Low Carbon Ukraine

Policy advice on low-carbon policies for Ukraine

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Regulating curtailment

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Key Messages

- 1 Curtailment is a valuable system flexibility option and should be compensated
- 2 Curtailing and compensating RES can be cheaper than taking up 100% of RES electricity through investment into conventional plant park or transmission
- 3 Ukraine should start with a simple heuristic to estimate curtailed energy and later introduce a more precise method based on weather data

The two main technical reasons to curtail RES...

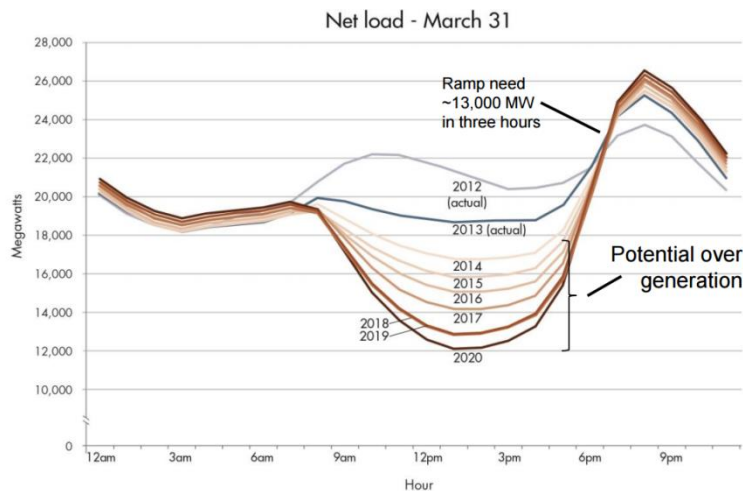
Flexibility constraints

- High RES generation, low demand & „Must-Run“ obligations
- Violation of system stability & system reserve requirements

Transmission Constraints

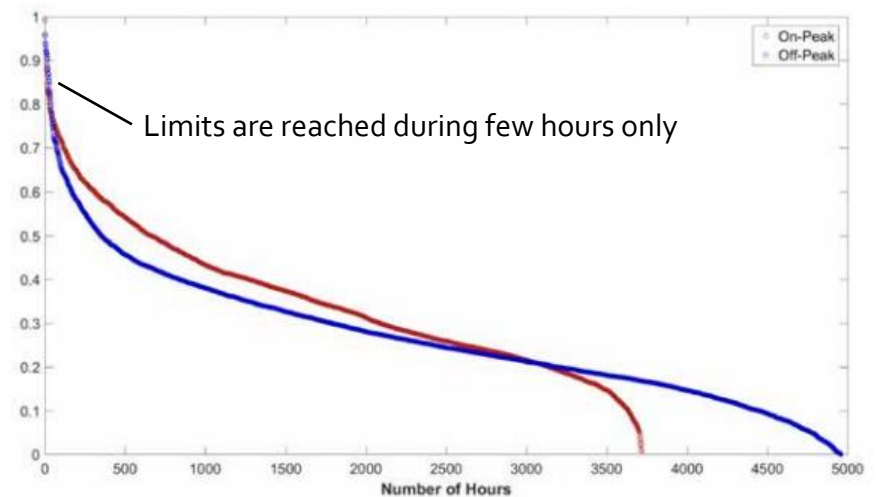
- Congestion (excess of carrying capacity) of the local network
- Lack of transmission access

California's „duck curve“



Source: CAISO 2013

Net flow as percentage of transmission limit



Source: Rojo 2017

...and their implied economic trade-offs

Flexibility constraints

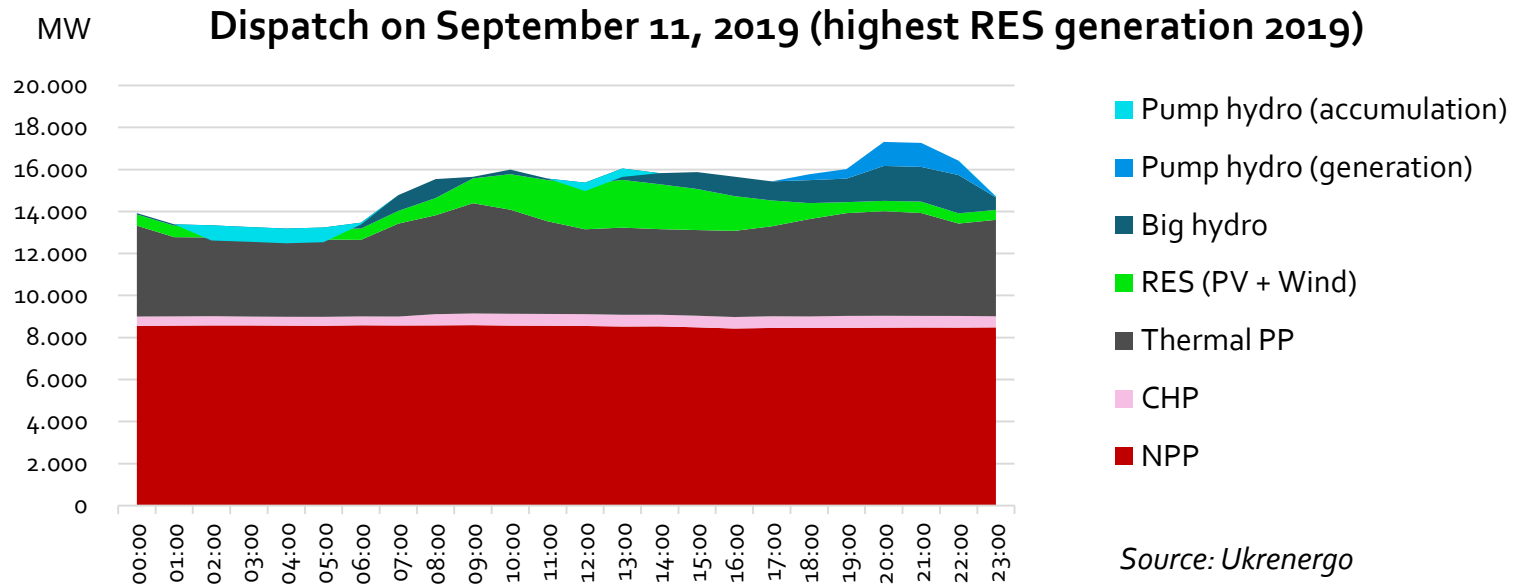
- Curtail RES or decrease minimum generation level?
 - Option 1: Compensate RES producers
 - Option 2: Invest in storage or flexible generation

Transmission Constraints

- Curtail RES or increase grid capacity?
 - Option 1: Compensate RES producers
 - Option 2: Build new transmission lines

➤ Curtailing and compensating RES can be **cheaper** than taking up the last kWh of RES electricity through **investment** into flexible generation or transmission

RES curtailment might become normality in 2020



- Due to higher RES generation, system operation has already changed in 2019
- **Pump hydro** was dispatched to consume solar electricity around noon
- Moreover, Ukrenergo has **occasionally curtailed** RES generation to maintain **system security**
- With RES capacities expected to reach **9 GW** by end 2020, curtailment is likely to take place **regularly**

Curtailment needs to be valued as a flexibility option

- Curtailed electricity should be compensated because
 1. Curtailment is a valuable system flexibility option
 2. Compensation reduces investment risk and uncertainty for RES producers – and could thus lead to lower prices at auctions
- But: Compensating less than 100% of curtailed electricity can be economically efficient
 - Setting incentives for investors to look for locations with better grid connection and/or uncorrelated wind (geographical smoothing) – and hence less curtailment

Regulation should be based on first principles

Simplicity

- How much energy was curtailed (MWh) and how to compensate (€)?
- Methodology to calculate curtailed energy as well as monetary compensation should be easy and comprehensive

Transparency

- TSO curtailment orders and compensation payments should be made public

Fairness

- No discrimination of bigger/smaller RES producers

The German methodology to estimate curtailed energy

- German RES producers get to decide every year between **two methodologies** for estimating curtailed energy
 - Here: focus on wind and PV
1. Estimate curtailed energy **using a heuristic** ("Pauschales Verfahren")
 - Last generation metering before curtailment used as heuristic for lump sum compensation
 2. Estimate curtailed energy **using actual weather data** ("Spitzabrechnungsverfahren")
 - Wind/solar conditions during curtailment used to estimate actual foregone generation
- Prerequisite for both approaches: **Metering** at RES plant installed

1. Using a heuristic to estimate curtailed energy: the t-1 approach

- Measure **average generation** for the last metered time interval before curtailment (P_0)
- Subtract actual/reduced generation during curtailment (P_a, P_{red}) from P_0
- Multiply by curtailment duration t to get curtailed energy W

$$W = (P_0 - \max(P_a, P_{red})) * t$$

- Potential issue: If PV generation around noon is curtailed, curtailed energy could be **underestimated** – average generation before curtailment is likely to be lower

2. Estimating the actual curtailed energy using weather data

- Estimate theoretical generation $P_{i,t}$ for every interval of curtailment duration as a function of **weather conditions** and **plant characteristics**
- Measure actual wind speed / solar irradiation directly at the RES plant
- Multiply with plant-specific **performance curves** and **efficiency factors**
- Subtract actual/reduced generation during curtailment ($P_{i,a}, P_{red}$) from $P_{i,t}$

$$W = (P_{i,t} - \max(P_{i,a}, P_{red})) * t$$

- Correct estimation of curtailed energy but some **important prerequisites**:
1. Certified performance curves for RES plants
 2. Certified measuring devices for wind speed / solar irradiation
 3. Automated data submission to TSO

German RES producers pay proportionate but capped deductible

- German RES producers are compensated for 95% of the lost revenues – i.e. the supported price determined through auction – due to curtailment
 - If lost revenues due to curtailment in one year exceed 1% of total revenues, they are compensated for 100% of lost revenues
- **FIT-based** compensation recommendable for Ukraine as market-based compensation (e.g. as in Spain) needs a **more mature** market

“If the feed-in of electricity from an installation to generate electricity from renewable energy sources, mine gas or CHP is reduced due to a grid system bottleneck, the grid system operator to whose grid system the installation is connected **must compensate the operators affected by the measure for 95 percent of the lost revenues** plus the additional expenses and minus the saved expenses. If the lost revenues in a year **exceed 1 percent of the revenues of that year**, the operators affected by the assumption of technical control **are to be given 100 percent compensation** from that point in time” (CEER 2018).

Conclusion and recommendations

- Curtailment needs to be valued as a flexibility option
- Regulation and compensation should be based on first principles
- Outlook: Need to discuss tariff design that incentivizes TSO to minimize curtailment

Recommendations

1. Introduce RES curtailment compensation for 100% of foregone revenue
2. Estimate curtailed energy by the t-1 heuristic in 2020 and 2021
3. Allow RES producers to change to exact, weather data-based methodology after 2023

Curtailement can also be a voluntary option for RES producers

- There are two approaches to RES curtailment
 - **Involuntary:** System operator curtails to maintain system security or relieve congestion
 - **Voluntary:** RES producers curtail to maximise profit (economic curtailment)

Involuntary curtailment

- Action taken by system operator manually or automatically to ensure system security / avoid grid congestion
- If there is compensation, it is either fixed (e.g. at FIT) or based on respective market price
- Done in: Germany, Italy

Voluntary curtailment

- Action taken by RES producers
- RES participating on balancing market by offering downwards reserve
- Remuneration always at market prices
- Done in: Spain, Denmark