Methodology memo on chapter " Indicators on the flexibility of the electricity system" in The state of renewable energies in Europe, 2016 edition, p. 245-251

Flexible Capacity

A first key factor for a flexible system is the availability of flexible resources at the supply and demand side. The term flexibility includes a time component. This time component is defined as availability of capacities within 15 min, i.e. all capacities that could be made available for generation or load adjustments within 15 min are included. Thus, it depicts the technically available flexibility of the system to adjust to a situation where generation and demand are in imbalance. In order to allow an unbiased comparison of different power systems or Member States, the **flexible capacity** is compared to the annual peak load (upper bound) and capacity of volatile renewable energies (vRE). The share with ramp-up capacities within 15 min (generation < load) is based on the following formula:

$$Flexible\ capacity\ _{GT,i,t} = \frac{C_{GT,i,t}}{C_{i,t}} \quad \text{and} \quad = \frac{C_{GT,i,t}}{C_{RET,i,t}}$$

$C_{GT,i,t} :=$ capacity $with\ ramp-up\ time\ of\ max.15\,min\ \ per\ country\ i,\ year\ t$

$C_{RET,i,t} :=\ volatile\ RE\ capacity\ \ per\ country\ i\ and\ year\ t$

$C_{i,t} :=\ peak\ load\ \ \ per\ country\ i\ and\ year\ t$

A high degree of flexibility is assumed for gas, oil and hydro (pump storage and reservoir) based electricity generation. In contrast biomass, coal, lignite and nuclear based generation is considered significantly less flexible. The ramp-up times are specified per energy source (fuel). The data on capacities are installed capacities by generation technologies provided by ENTSO-E (transparency platform), i.e. they comprise reliable available and unavailable generation capacities. Unavailable capacities within the EU range between 30-40% of net generating capacities and include scheduled and forced unavailability, system service reserves and non-usable capacities due to limited availability of resources, mothballing units, network constraints, etc. Non-usable capacities comprise the largest share of unavailable capacities – 40%-90% of unavailable capacities or 20%-26% of net generating capacity according to the Yearly Statistics and Adequacy Report 2014 – while system service reserves and outages show a constant profile across months, ranging around 3% of net generating capacities, respectively.

Between 2012 and 2014 system service reserves decreased in average, non-usable capacities increased mainly due to growing renewable capacities. For the flexibility indicator, PV and wind based non-usable capacities are excluded, but fossil fuel and nuclear powered plants as well as biomass and hydro-power are considered as flexible generation technologies. The flexible installed capacities are weighted by their technology specific share of availability within 15 min (warm start) and summed up. The available flexible capacities are depicted as part of peak load and as part of volatile RE capacity. The peak load refers to the highest hourly load within one year and the volatile RE capacities are based on installed wind and PV-capacities in the respective year. The peak load is chosen to compare generation flexibility with one of the most stressed hours during the year while the vRE reflects the flexibility need due to RES deployment.

The flexibility indicator shows how many times flexible generation is able to cover the peak load or the volatile RE. Thus, this indicator shows the maximum technically available flexibility under the given technology mix.

Data and information on flexible capacities and cross-border capacities are collected from the ENTSO_E Transparency Platform, data on load come from ACER Reports, data on ramp-up times, and in the later phase data on must-run capacities are based on different studies and reports and will be supplemented by expert talks and feedback rounds in the framework of workshops or project meetings in a later phase.

Flexible transmission:

Transmission capacities between countries allow balancing in times of shortfall or surplus generation due to a regional balancing of different RES generation characteristics and a regional optimization of flexibility resources. Further, a high cross-zonal transfer capacity contributes to an efficient dispatch and promotes the integration of national markets. Thus, high transmission capacities increase a system's flexibility. The transmission flexibility is captured by the forecasted day-ahead transfer capacities, which are compared to peak load and vRE per country.

$$\text{Transmission capacity share}_{\,i,t} = \frac{TC_{i,t}}{C_{i,t}} \quad \text{and} \quad \frac{TC_{i,t}}{C_{RE,i,t}}$$

$TC_{i,t} :=$ day − ahead forcasts of transfer capacities per country i and year t

$C_{RE,i,t} :=$ volatile RE capacity per country i and year

$C_{i,t} :=$ peak load per country i and year

The forecasted day-ahead transfer capacities are used to depict transmission capacities, because cross-zonal transmissions depend on actual tradable

capacities (commercial capacities), which in turn are based on physical capacities, so called "hardware", and market coupling mechanisms or regulations, so called "software". Changes in cross-zonal physical transfer capacities between 2014 and 2015 are due to investments into interconnectors such as between France and Spain, Sweden, Poland and Lithuania, Denmark and Norway. They have increased the cross-border transfer capacities in 2015. In addition, the introduction of the flow based market coupling (FBMC), i.e. changes in the software, in the Central-Western-European electricity market in 2015 should render more transfer capacities compared to the available transmission capacity method (ATM) applied in 2014. To calculate the annual transmission capacity, the average of the forecasted hourly day-ahead transfer capacities is calculated per country based on the control area. In 2014 and 2015 unidirectional transfer capacities are depicted, in the next reporting phase average of bidirectional cross-zonal transfer values will be applied.

The transmission capacities are depicted as part of peak load and as part of volatile RE capacity. The peak load refers to the highest hourly load within one year and the volatile RE capacities are based on installed wind and PV-capacities in the respective year. The peak load is chosen to compare transmission flexibility with one of the most stressed hours during the year while the vRE reflects the flexibility need due to RES deployment.

Data and information on flexible capacities and cross-border capacities are collected from the ENTSO_E Transparency Platform, data on load come from ACER Reports, data on ramp-up times, and in the later phase data on must-run capacities are based on different studies and reports and will be supplemented by expert talks and feedback rounds in the framework of workshops or project meetings in a later phase.