Assessing the impact and representativeness of Dunkelflaute events in long term energy system planning in TIMES Belgium model

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Agenda

- Why to assess a Dunfelflaute in TIMES-BE?
- Data gathering
- Weather years analysis
- Dunkelflaute analysis
- Time Slice tool + Dunkelflaute day
- DF day in TIMES – BE
- Conclusions

Why to assess a Dunfelflaute in TIMES-BE?

- As part of an Energy Transition Found project, the question was how the Belgian energy system can cope with the electrification of the demand in a scenario with high penetration of renewables.
- Additionally, in this new landscape the occurrence of extreme events of scarcity of clean electricity will have an impact on the topology of the power sector.
- Therefore, it was necessary to assess how a Dunkelfloute event could impact the future installed power capacity and how it will operate. Which will influence the design of future energy systems, considering the phase out of nuclear power plants after 2035.

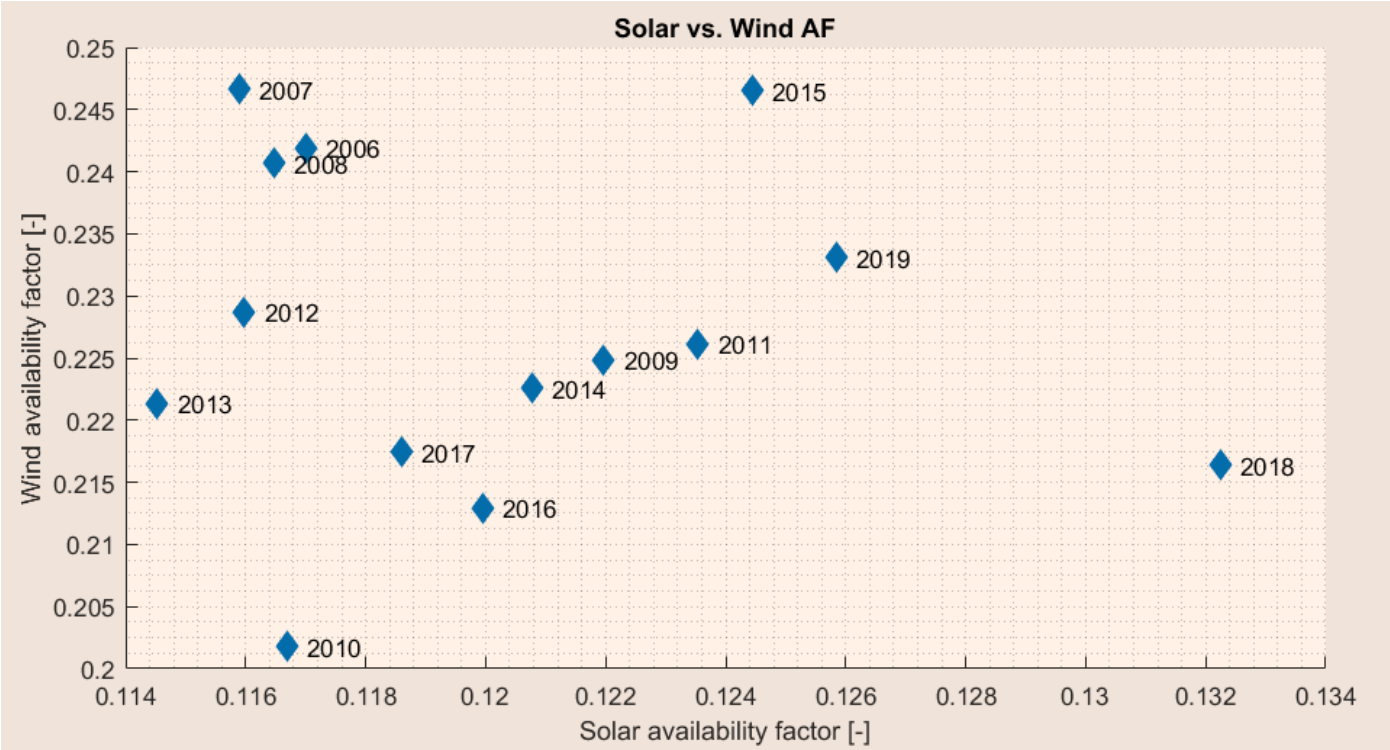
Data gathering

- Satellite information for 40 years from the Royal Meteorological Institute (KMI) database for wind and solar.
- Data was treated to compute the capacity factor of 14 years for PV and wind, differentiated for 11 provinces in Belgium.
- During the same process, the available roof area for commercial/industrial and residential PV was used to compute the maximum technical capacity.
- Available area was used to define the maximum capacity for wind onshore and ground PV.

Weather years analysis

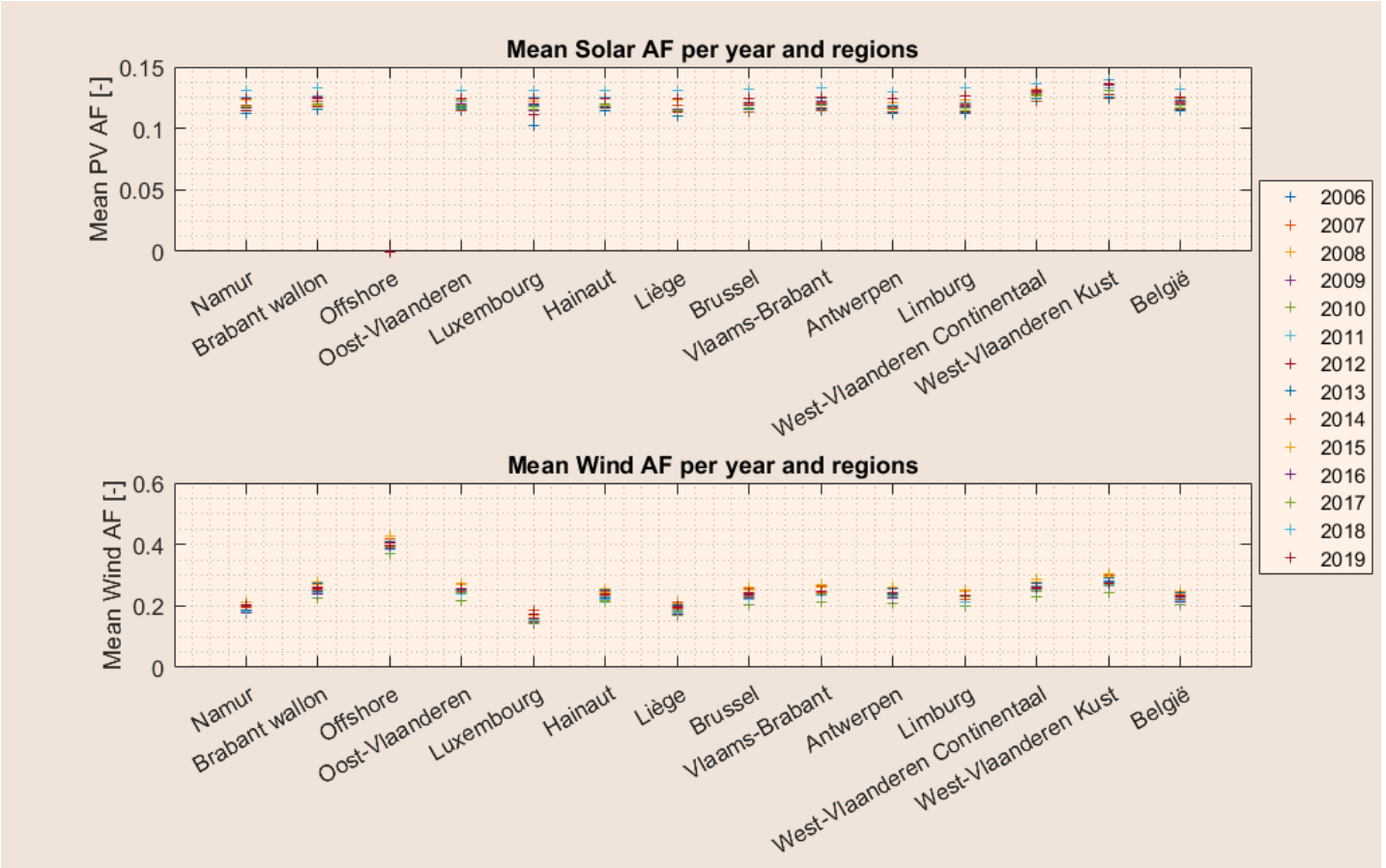
From the CF it is possible to identify:

1. The dispersion of CF for wind is higher than for solar.
2. PV generation in 2018 and 2019 was much higher than other years.



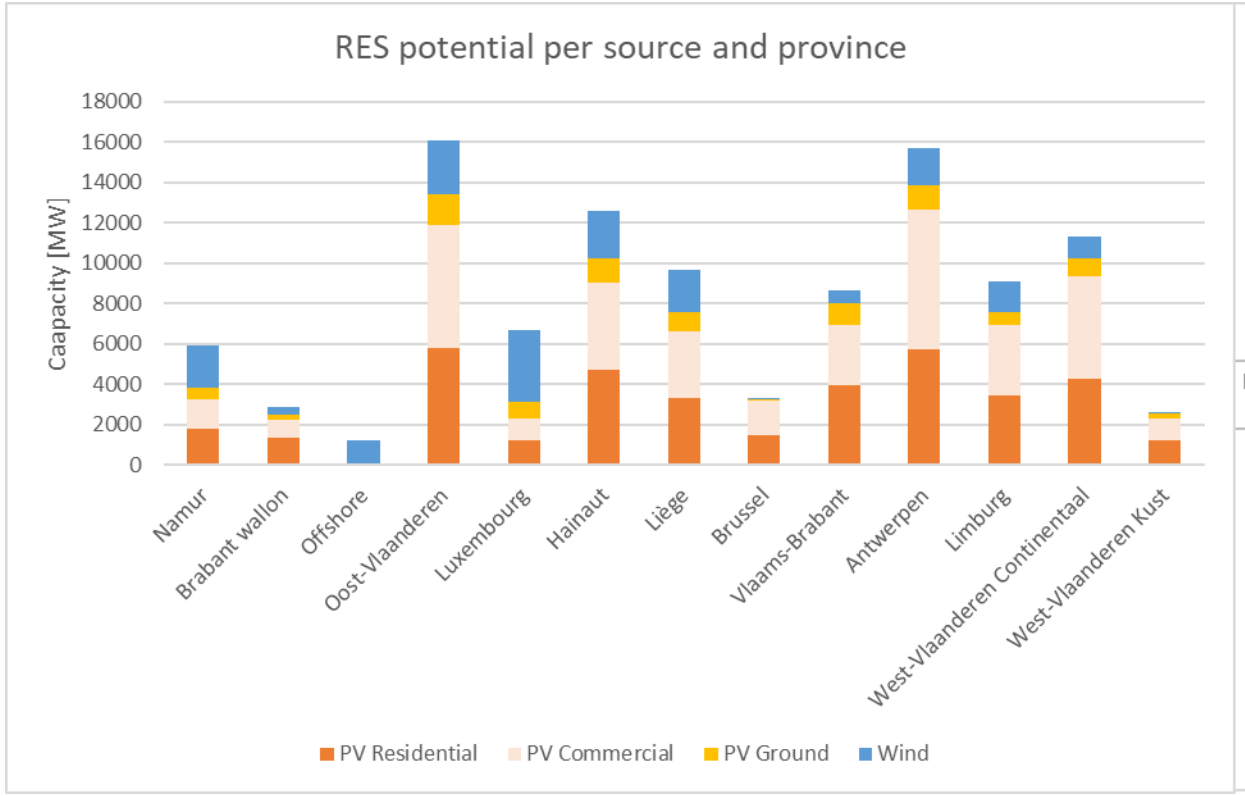
Weather years analysis

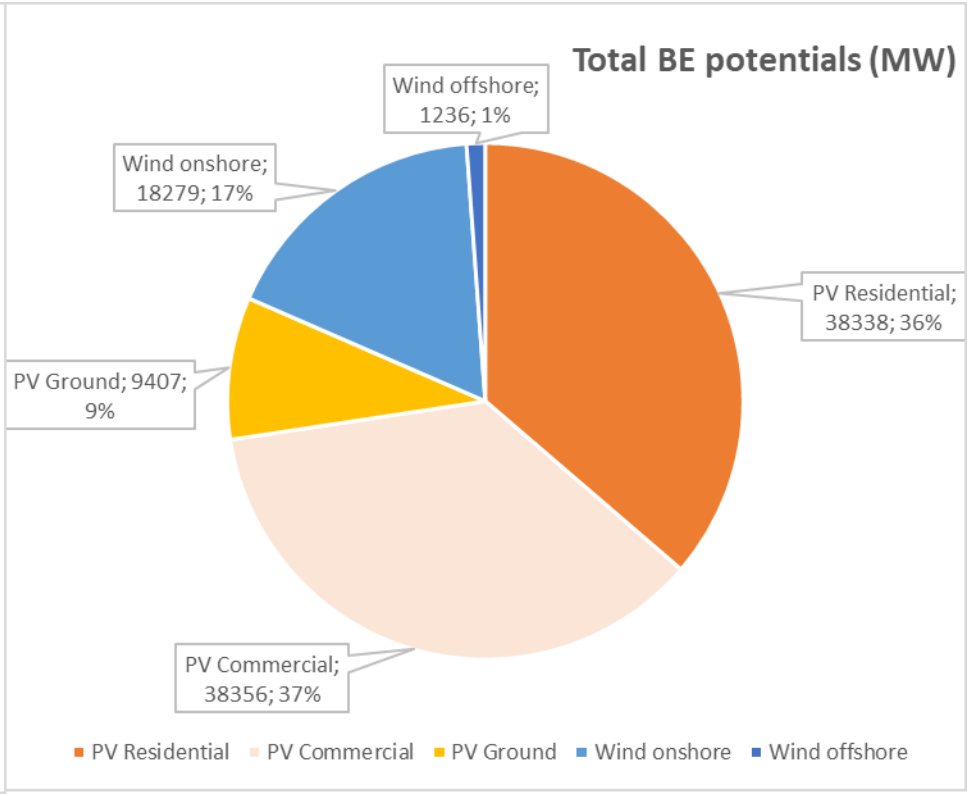
- Due to the size of the raw data, a MATLAB script was used to compute average CF per province per year.
- Since Belgium is not a big country, the CF are similar across provinces. Nonetheless, it is expected that in a national DF event there will be more renewable energy available in some parts of the country.



Data gathering

- Maximum theoretical potential assessed per province





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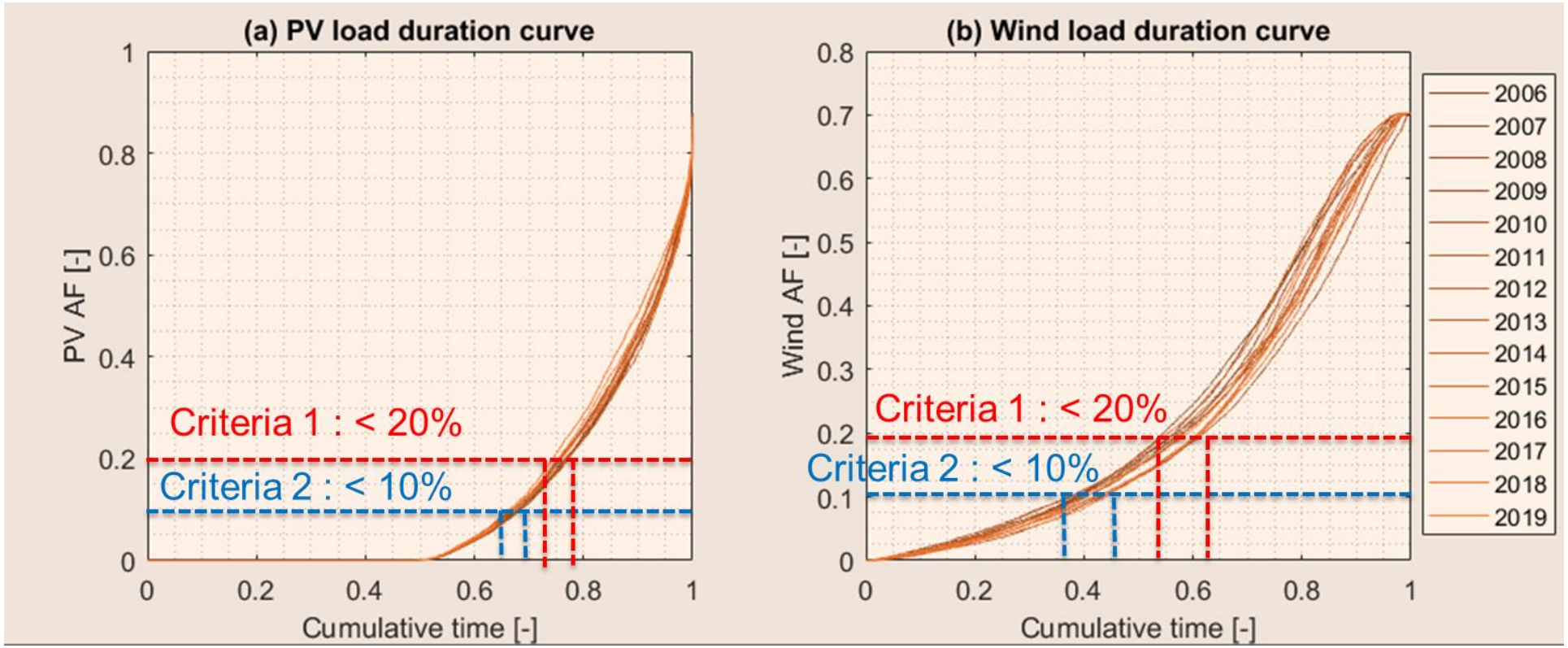
Dunkelflaute analysis

What's a Dunkelflaute ?

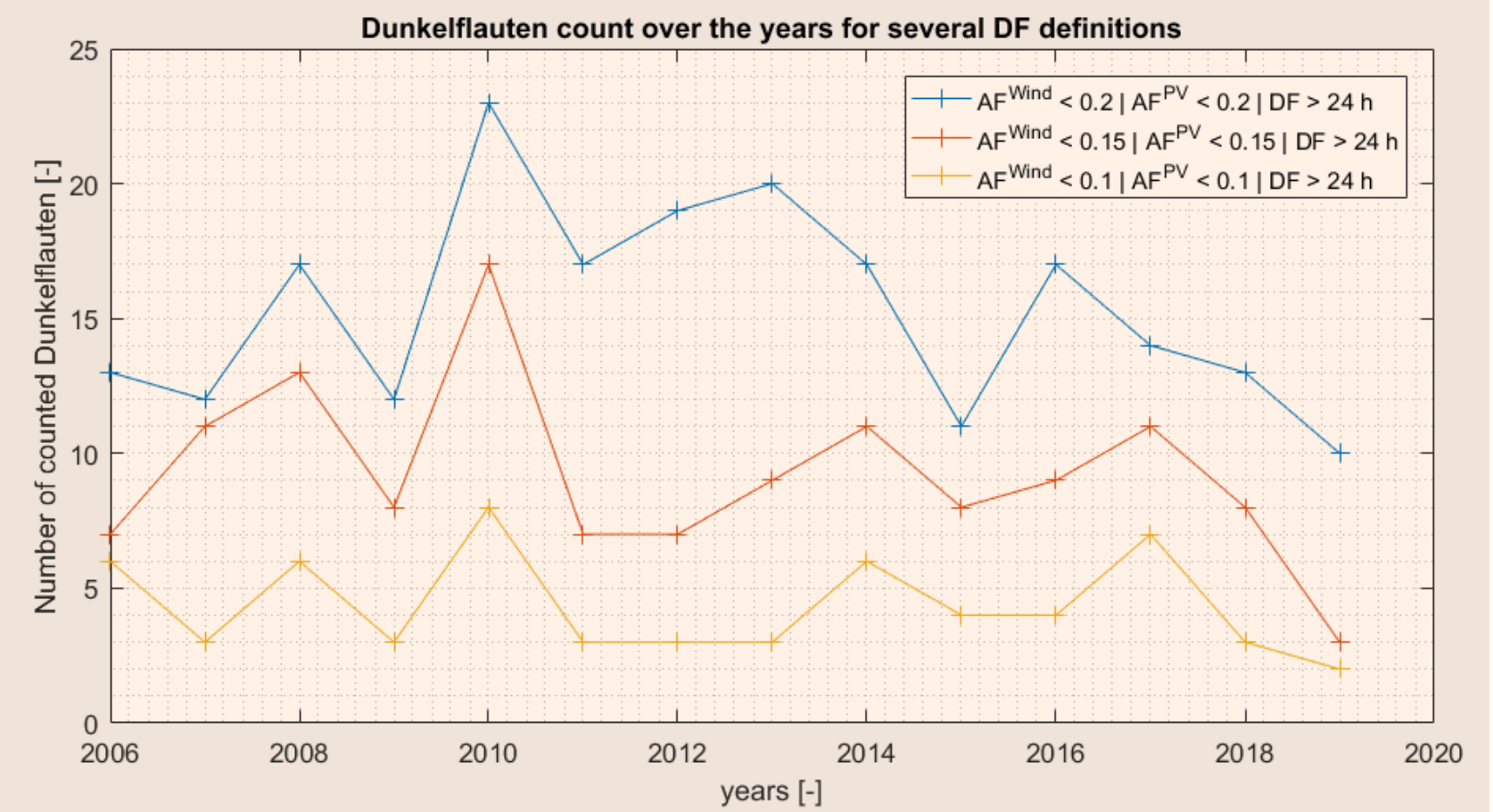
- Interpreted as a period of a certain length where wind and solar availability is under a given threshold.
- Therefore, there are 3 "variables" that characterize a DF
  - PV CF threshold/criteria
  - Wind CF threshold/criteria
  - Dunkelflaute length/duration
- Nevertheless, there is not common definition of these 3 variables.

Dunkelflaute analysis

- The stricter the criteria on CF, the less Dunkelflaute events will be encountered.



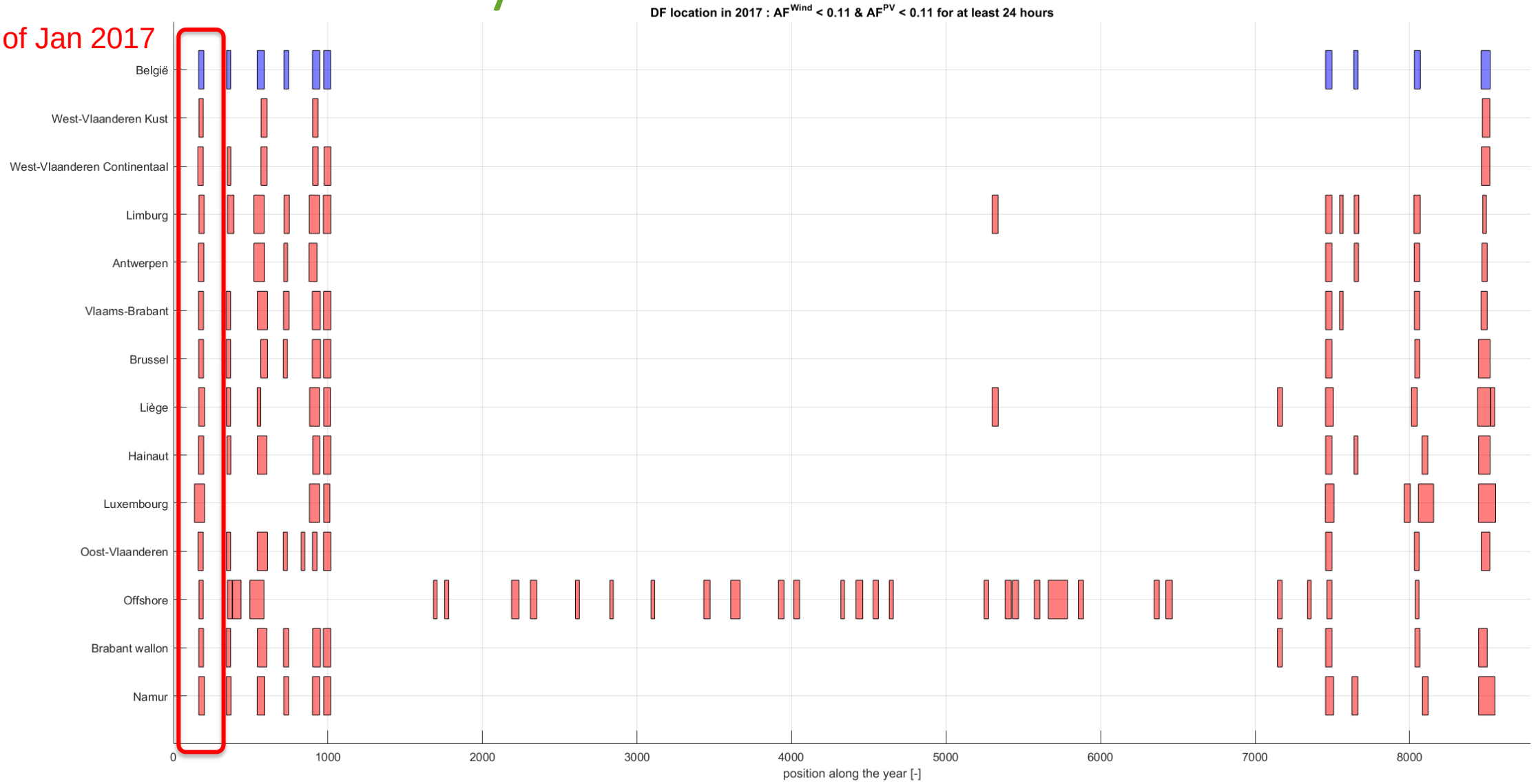
Dunkelflaute analysis



- We defined the Dunkelflaute event as a period of 24 hours where the CF for both wind and solar is below 0.11 simultaneously in all provinces.

Dunkelflaute analysis

8th of Jan 2017

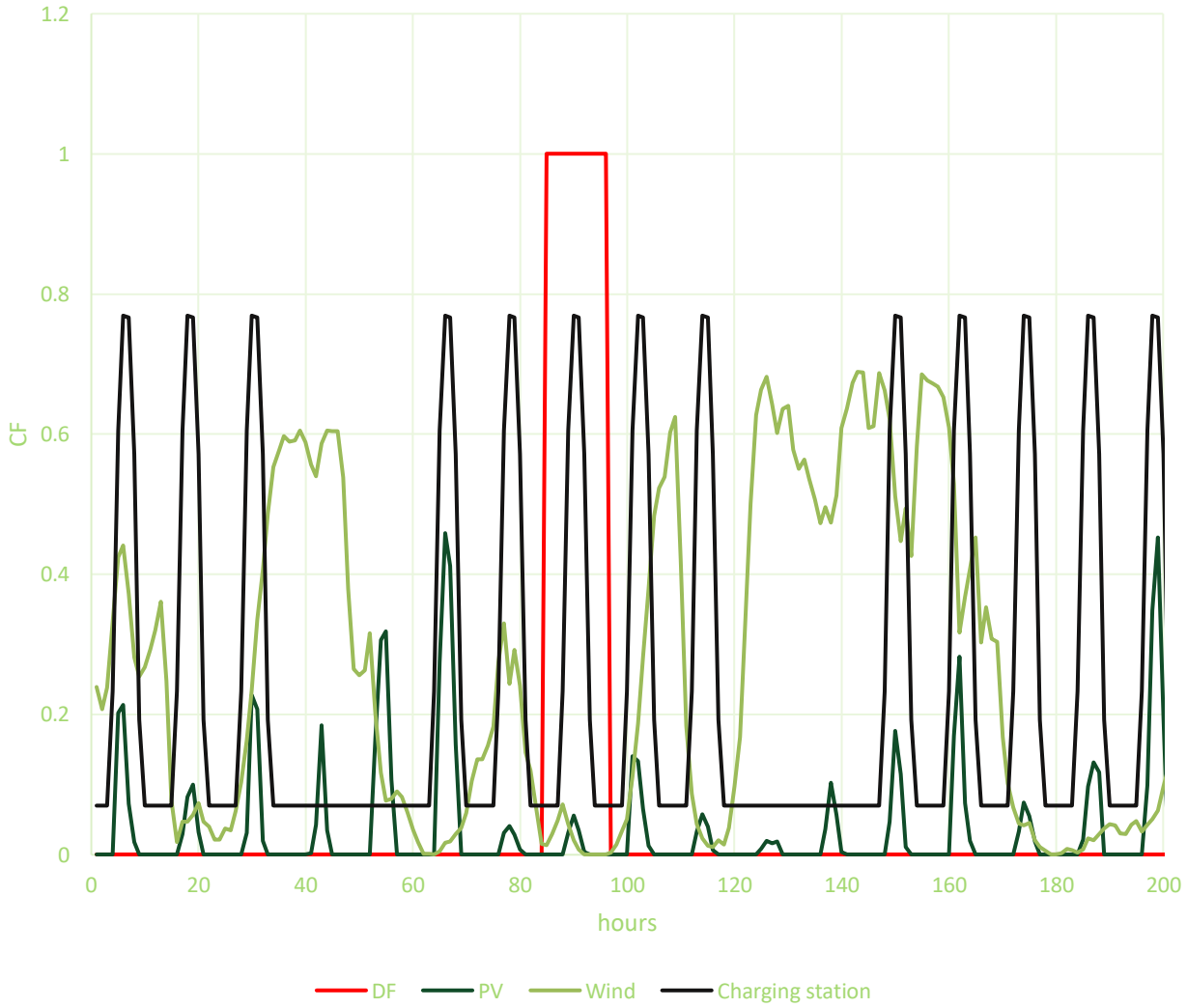


Dunkelflaute analysis - takeaways

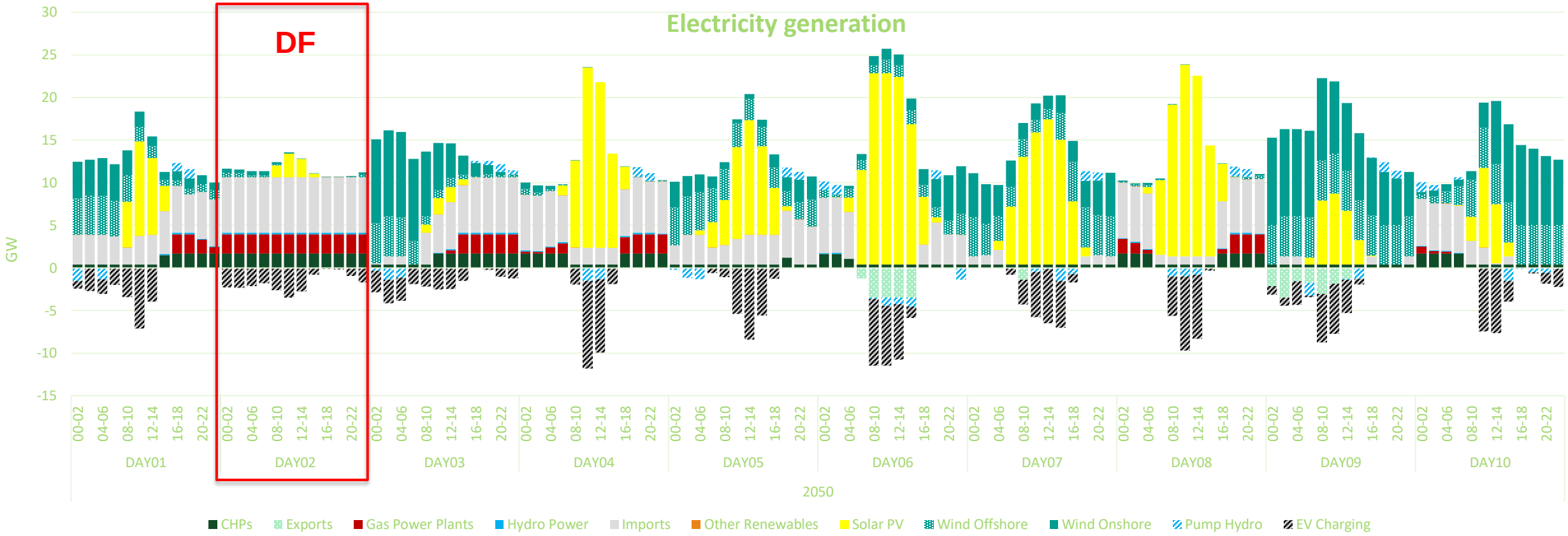
- If DF definition is too strict, less DF events are counted.
- Provincial simultaneity is a very strict criteria!
- We decided to use 2017 as a single weather year and to include in the TS structure the 8th of January as a DF (all provincial CF below 11% for 24h)

Time Slice tool + Dunkelflaute day

- The time slice tool selects the most representative days given a specific number of time slices to define the granularity of time in TIMES.
- Since DF events rarely occur, the days when there is a DF won't be selected by the TS tool. It is not a representative day.
- Therefore, it was necessary to "force" the TS tool to select the chosen DF day. This was done by adding an artificial profile and allocating a high weight to it.



DF day in TIMES – BE



- In the DF day, the import works at maximum capacity through the entire day. CHPs and Gas power plants are used to compensate the low availability of wind and solar.

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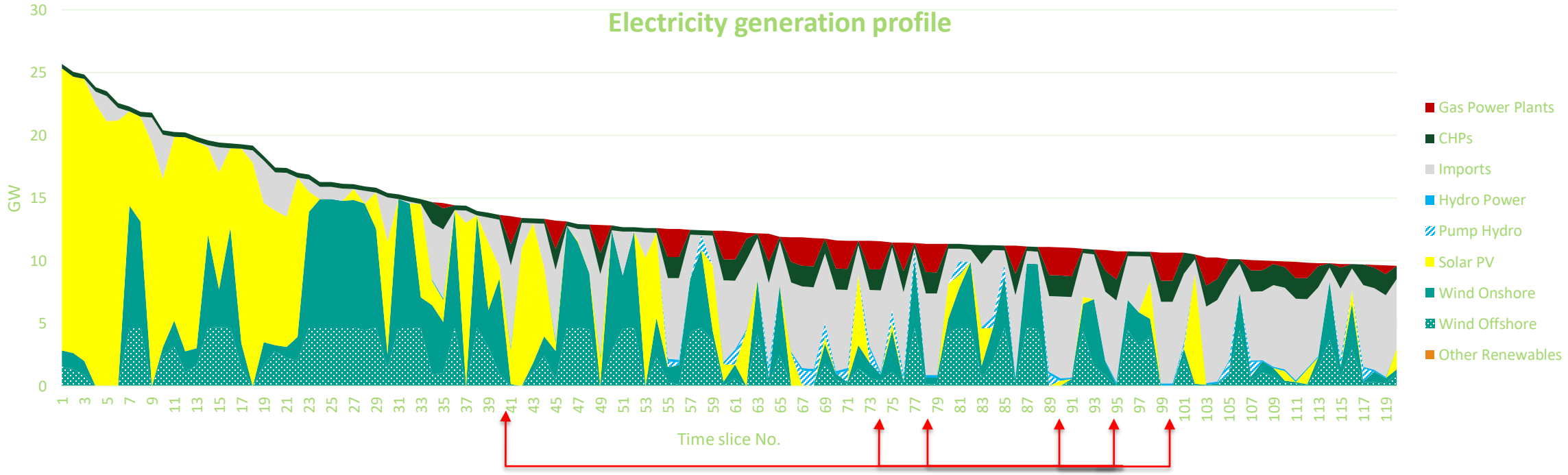
DF day in TIMES – BE



- The DF event does not happen in the periods of high electricity generation. This implies that the correct use of charging facilities and batteries could be managed to maintain the demand low.
- This might not be the case since TIMES assumes a rational behavior of the demand.

Conclusions

- Times is useful to provide insights but a more detail model is need to assess the impact of extreme events such as the DF defined in this case.
- Flexibility sources are becoming more relevant. In the case of DF, smart charging and use of batteries might help to cope with the scarcity of clean electricity.
- Including a DF into the TS structure might distort results since, in this way, it is assumed that the DF event is happening every year at the same time.
- The statistical analysis of the yearly occurrence of the defined DF is needed to support the meaning of the results. This is an ongoing process with KMI.
- The analysis should be complemented also varying the definition of DF in CF and duration.
- For future works, it would be interesting to explore other alternatives to assess DF events without modifying the TS structure.

Thanks!

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