SYSTEM RAMPING AND RENEWABLE ABSORPTION CAPABILITIES PROVISION AGAINST ECONOMIC VALUE OF FLEXIBILITY RESOURCES

Julien ANCEL, Industrial Engineering Department, Centralesupelec, Université Paris-Saclay, julien.ancel@centralesupelec.fr
Olivier MASSOL, Industrial Engineering Department, Centralesupelec, Université Paris-Saclay, olivier.massol@centralesupelec.fr

Overview

With the rise in renewable capacities, power systems face increased needs for flexibility, understood as their ability to follow residual demand variations at all timescales. This flexibility is provided by resources such as batteries, pumped hydro storage and demand response, or by thermal peaking units at the expense of supplementary carbon emissions. Yet, due to power market failures such as missing money or to technical limitations, it is unclear wether revenues extracted from the existing day-ahead, intraday and reserve markets can cover capital expenditures corresponding to the different flexibility resources (Astier & Lambin, 2019). This is especially uncertain at high levels of renewable capacities as spot prices are expected to be close to zero or negative a larger portion of the year if flexibility resources are not yet present, and with inevitable spikes in tight hours when flexibility resources may be unavailable or may not perceive the full spike due to price caps.

To counter this effect and foster investment in flexibility providers, the EU has regulated that capacity mechanisms may be extended by Member States to flexibility resources. These instruments have to be sized up, and the opportunity of opening such mechanisms to flexibility resources has to be quantified. Hence, there is a need to assess simultaneously the contribution of different flexibility resources to the total flexibility of the system and their potential revenues without support schemes. We argue that such assessment, in a unified and technology neutral framework does not yet exist for all the flexibility providers mentioned above. Our contribution is to provide such assessment framework and a marginalist (i.e. for 1MW of each flexibility resource considered[1]) application on 2035 France.

Methods

Our methodology follows three steps:

1. We build a scalable technology-neutral model of flexibility resources and justify how simpler models tend either to value only one attribute of the resource (e.g., the value of controllability (Bruninx et al. 2018) or availability alone, or the gains from only one of the many markets (Pape 2018)) even though their total value depends on their fixed mix of attributes, or to overestimate the number of activations of these resources, the time-arbitrage they realize and hence their profits (Mier & Weissbart 2020). This model is inspired by hydropower modelling with up/downstream reservoirs but accounts also for minimum down times, energy recovery time constraints, and eventual contractual limit on the number of activations (see Figure 1 for a schematic representation).

2. We model a multisettlement dispatch accounting for day-ahead, intraday and reserve markets accounting for uncertainty of residual demand, day-ahead forecast errors regarding load and renewables using stochastic dual dynamic programming. The use of a decomposition technique for flexibility modelling is in itself a contribution (Motta et al., 2024). The model is validated on historical data, then calibrated on 2035 France.

3. For each considered flexibility resource, we calibrate our flexibility representation for a MW of the resource. Then we compute its total profits in the 2035 setting, the variation of the ramping needs of the system with and without the resource as defined in (ENSTOE, 2024), and the variation in renewable curtailment in a marginalist system as a proxy to measure how the flexibility resource may help absorbing more renewable capacities in the system.

Considered flexibility resources are a representative Li-ion battery and demand response stemming from residential and tertiary sector loads, and for reference a MW of ramp constrained OCGT.

[1] This choice avoids the impact of an eventual cannibalization coming from the co-existence with other new flexibility providers or the resource itself. If investment in flexibility providers as a whole is optimal however, such cannibalization should not prevent each invested resource to reach a zero profit equilibrium (in perfect markets). Modeling such investment decisions is possible with slight modifications of our framework but remains out of the scope of this paper for clarity.

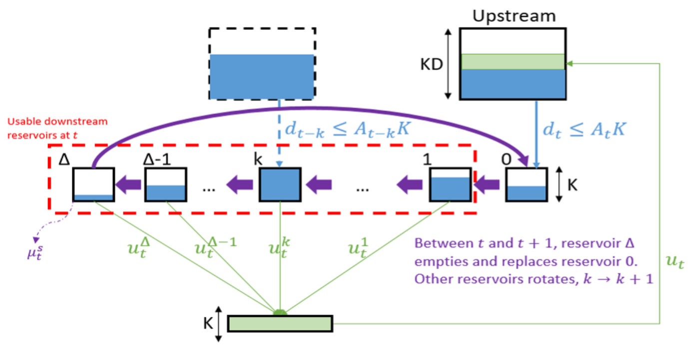

Figure 1 - Scheme of the flexibility resource model without minimum down time. *[Reading: d variables are upward flexibility decision (generation) and u ones are downward decisions (=pumping). K is a capacity, A an availability factor,Δ a maximum time to recover from d decisions, D the maximum duration of a flexibility event and N the maximum number of activations per year. A minimum down time can be added using a similar row of rolling reservoir before the energy can re-enter the upstream reservoir.]*

Results

As Figure 2 illustrates, our model is more conservative regarding the number of activations but the consideration of multiple markets allows to recover order of magnitudes of the yearly profits and risks of flexibility resources found in other assessments (10-30 k€/MW/y with high risks of low or zero profits).

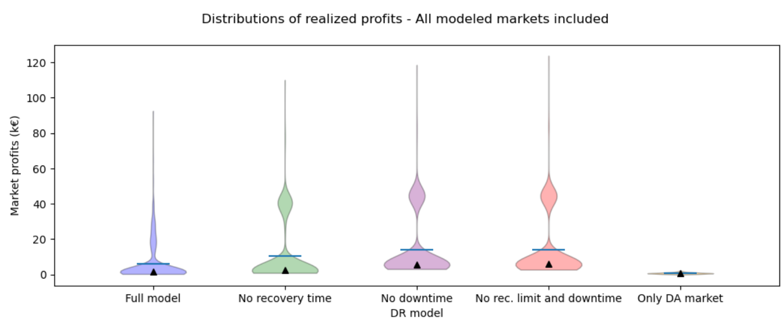

Figure 2 - Sensitivity of the modeling assumptions of flexibility from 1 MW of residential space heating.

Moreover, our SDDP based multi-settlement dispatch yields realistic dispatch and prices which are enough to draw insights in the considered prospective setting.
Results regarding the case study and the three criteria value assessment of flexibility resources are still forthcoming.

Conclusions

From our preliminary results, we can still only draw an insight for flexibility modelers in that 1) modelling flexibility, notably from the demand-side, only through an energy balance constraint severely overestimates potential activations and profits, and 2) our modelling framework provides a scalable way to give a more realistic view of flexibility resources.

References

Astier, N., & Lambin, X. (2019). Ensuring Capacity Adequacy in Liberalised Electricity Markets. The Energy Journal, 40(3), 227-242. https://doi.org/10.5547/01956574.40.3.nast
Bruninx, K., Dvorkin, Y., Delarue, E., D'haeseleer, W., Kirschen, D.S., 2018. Valuing Demand Response Controllability via Chance Constrained Programming. IEEE Transactions on Sustainable Energy 9, 178–187.
ENTSO-E, 2024. System Flexibility Needs for the Energy Transition.
Mier, M., Weissbart, C.. 2020. *Power markets in transition: Decarbonization, energy efficiency, and short-term demand response*. Energy Economics 86, 104644.
Motta, V.N., Anjos, M.F., Gendreau, M., 2024. *Survey of optimization models for power system operation and expansion planning with demand response*. European Journal of Operational Research 312, 401–412.
Müller, T., Möst, D., 2018. *Demand Response Potential: Available when Needed ?* Energy Policy 115, 181–198.
Pape, C. 2018. *The impact of intraday markets on the market value of flexibility - Decomposing effects on profile and the imbalance costs*. Energy Economics, 76, 186-201.