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Application of a scaling down method to study long term effects of wind and solar on the French TSO tariff

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Contextualization
A lot of articles and reports study national prospective electricity mixes ...

Articles and reports study electricity mixes and the consequences for the power system.
Two different ways to geographically allocate solar panels

The geographical allocation of a national capacity can be done in several ways.

The choice of the allocation will impact:
- Power flow
- Dimensioning
- Flexibility
- Environment
- ...
... for the substations of a TSO

Substations are the interface between the TSO and its clients.

Those clients can be DSO or important factories.

Substations are nodes of the high voltage power grid: knowing the residual load curves of each substation is useful for the grid exploitation.

\[
\text{Residual load curves} = \text{Local load} - \text{Local production}
\]

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Model and data
National prospective studies are scaled down to the substations of the French TSO

The model uses national prospective studies as input

It scales separately the national load and production to calculate the residual load curves of the substations

The load is scaled down using data from the French TSO

The production is scaled down using socioeconomic and grid data
Scaling down of the production

The model uses two inputs:

- National wind and solar capacities
- Rooftop vs ground based panel parameter

Then the production sites are geographically allocated:

- Rooftop panels: Socio economic hypothesis are used
- Onshore wind production & Ground based panels: method used in the French TSO network development plan
The geographical allocation of onshore wind farms & Ground based panels rely on three allocation keys:

The model sets capacities in high potential areas while taking into account the trend of installation.

<table>
<thead>
<tr>
<th>Step</th>
<th>Allocation Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>From national to regional</td>
</tr>
<tr>
<td></td>
<td>National capacity is allocated</td>
</tr>
<tr>
<td></td>
<td>according to the potential estimated</td>
</tr>
<tr>
<td></td>
<td>by the producers</td>
</tr>
<tr>
<td>2</td>
<td>From regional to departmental</td>
</tr>
<tr>
<td></td>
<td>Allocation according to the</td>
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<tr>
<td></td>
<td>last year installed capacity</td>
</tr>
<tr>
<td>3</td>
<td>From departmental to substations</td>
</tr>
<tr>
<td></td>
<td>Repartition according to capacity</td>
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<tr>
<td></td>
<td>reserved for the implementation of the</td>
</tr>
<tr>
<td></td>
<td>DER defined by the S3REnR</td>
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</tbody>
</table>
We evaluate the consequences of DER on the French TSO using two elements

Variables of interest

We calculate indicators of the residual load curves for each substation:

- Withdrawn energy
- Subscribed power
- Injected energy
- Injected power
- Dimensioning power

Cost model

We calculate the transformer reinforcement cost induced by DER at each substation:

- We assume a linear relation between transformer reinforcement cost and dimensioning power

It is to note that this model only represents a fraction of the grid reinforcement cost
Results

3
The article studies the impact of DER on the French TSO substations by 2030

Two parameters will vary:

- **The national wind and solar production**
  - **BAU scenario:**
    - Solar capacity: 18.5 GW
    - Wind capacity: 26.7 GW
  - **PPE scenario:**
    - Solar capacity: 47 GW
    - Wind capacity: 36.4 GW

- **The rooftop vs ground panel parameter** referred as T in percentage
  - Ex: a value of 0% means that all the new solar capacities will be ground panel
The rise of DER will impact the dimensioning power of the substations

The effect of DER on dimensioning power are heterogeneous:

- For most of the substations, the dimensioning power slightly decreases.
- For a little number of substations, the dimensioning power increases a lot.

For the PPE capacities, almost 10% of the substations have a dimensioning power increase of more than 20 MW.
The rooftop vs ground panel parameter has more effect with higher solar capacity

PPE 2030
Solar: 47 GW
Wind: 36.4 GW

BAU 2030
Solar: 18.5 GW
Wind: 26.7 GW

! The cost model only represents a small portion of the cost of the TSO
Substations with important rise of reinforcement cost also see their tariff bill diminishes.

The figure shows two things:

- The raise of tariff mostly impact the substations with a decrease of cost.
- Most of the substations with a raise of reinforcement cost also sees their tariff bill decrease.

DER impact differently the variables of interest which will affect the future tariff design.
Conclusion
The scaling down method allows us to evaluate the impact of DER on the French TSO substations.

DER will have heterogeneous impact on the dimensioning power of the different substations.

The total installed capacity and their location that also depend on social and political factors highly impact the result.

With the current tariff structure, the raise of cost at a substation induced by DER will not necessary induced a raise of tariff for this substation.

Further work will study the distributive impacts of the diffusion of DER.
The substations that are the most affected are the ones with the smallest population density.

The impact on dimensioning power are higher for low area with a low population density.

They are the substations with more local production regarding their local consumption.

The rooftop vs ground panel parameter impact the dimensioning power because it impact the nearness between consumption and production sites.