TP Mise à Niveau
Project: Analyze a local hybrid energy system
Zhongliang LI Rachid OUTFIB
2019 Sep.

1 Introduction
In the TP project, a hybrid energy system installed in an industrial factory will be analyzed, including the energy aspect and the economic aspect. The project will be realized by programming in Python. Two or three persons per group.

2 System structure
The structure of the studied photovoltaic (PV) panels and wind turbines (WT) hybrid energy system is shown in Fig. 1. The system is designed to compensate the local electricity consumption. The system is designed to compensate the local electricity consumption. The number of PV panels is 44, and the WT number is 4.

3 PV and WT models
The power generated by a single PV $P_{PV}(t)$ panel at time $t$ is modeled as a simple function of solar radiation $G$, as

$$P_{PV}(t) = G(t) A_{PV} \eta_{PV}$$  \hspace{1cm} (1)

where $G(t)$ is the solar radiation, $A_{PV}$ is the surface of the PV panel, $\eta_{PV}$ is the efficiency of the PV system.

The power generated by a single WT $P_{WT}(t)$ is calculated as a piece-wise function of the wind speed $v(t)$ as follows $[2]$:

$$P_{WT}(t) = \begin{cases} 0, & v(t) < v_c \\ P_r \frac{v(t)^3 - v_c^3}{v_r^3 - v_c^3}, & v_c < v(t) < v_r \\ P_r, & v_r < v(t) < v_{max} \\ 0, & v(t) > v_{max} \end{cases}$$  \hspace{1cm} (2)
where $v_c$, $v_r$, and $v_{max}$ are respectively so-called cut-in, nominal and cut-off speeds, which are dependent on the WT power level.

The technical parameters of used PV and WT are summarized in the following table.

<table>
<thead>
<tr>
<th>Technical parameters</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$A_{PV}$</td>
<td>1.64 m²</td>
</tr>
<tr>
<td>$\eta_{PV}$</td>
<td>0.17</td>
</tr>
<tr>
<td>$v_c$</td>
<td>10 m/s</td>
</tr>
<tr>
<td>$v_r$</td>
<td>12.5 m/s</td>
</tr>
<tr>
<td>$v_{max}$</td>
<td>20 m/s</td>
</tr>
<tr>
<td>$P_r$</td>
<td>4 kW</td>
</tr>
</tbody>
</table>

The data of solar radiation $G(t)$ and wind speed $v(t)$ in the location of system have been provided by MeteoFrance. They are provided in the file named `meteo.csv`. 

Figure 1: Diagram of the PV/WT hybrid energy system.
4 Load power

The consumed power of the industrial factory has been measured during one year. The measured data have been saved in the file named load.csv.

5 Power balance

The power generated by the PV/WT hybrid energy system $P_{\text{gen}}(t)$ is calculated as

$$P_{\text{gen}}(t) = N_{PV}P_{PV}(t) + N_{WT}P_{WT}(t) \quad (3)$$

In this study, the power generated by the local installed hybrid energy system will not be fed to the transmission grid, but only used to compensate the local consumption. To guarantee the power balance, the power provided by the transmission grid can be calculated as

$$P_{\text{grid}}(t) = \begin{cases} P_{\text{load}}(t) - P_{\text{gen}}(t), & P_{\text{load}}(t) > P_{\text{gen}}(t) \\ 0, & P_{\text{load}}(t) \leq P_{\text{gen}}(t) \end{cases} \quad (4)$$

where $P_{\text{load}}$ is the load power.

6 Tasks

1. Calculate the power of a single PV during one year, plot the power curve, find the maximum power and minimum power pint, calculate the total energy generated by the PV.

2. Calculate the power of single WT during one year, plot the power curve, find the maximum power and minimum power pint, calculate the total energy generated by the WT.

3. Calculate the power of the PV/WT hybrid energy system $P_{\text{gen}}(t)$ during one year, plot the power curve, find the maximum power and minimum power pint, calculate the total energy generated by the system.

4. Calculate the power provided by the transmission grid $P_{\text{grid}}(t)$ during one year, plot the power curve, find the maximum power and minimum power pint, calculate the total energy provided by the grid.

5. The average price of EDF is 0.065 €/kWh. How much it takes to pay to EDF for one year? If there is no local hybrid power system, how much more to pay?
References
