Comparison of Different Photovoltaic Models in a Capacity Credit Evaluation

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Comparison of Different Photovoltaic Models in a Capacity Credit Evaluation
1. Introduction

Comparison of Different Photovoltaic Models in a Capacity Credit Evaluation

Cost of electricity from utility-scale renewable technologies

Source: Renewable Power Generation Costs in 2014, IRENA
2. Methodology

Reliability Assessment
- In terms of adequacy
- SMC simulations (tool)
- LOLE and LOEE (reliability index)

Methods to assess reliability
- Deterministic
- Probabilistic
- Analytics
- Simulations (MC)
- Sequential
- Non-sequential

Credit Capacity Evaluations
- Equivalent load carrying capability (ELCC)

System Upgrade

Original System

\[ \text{LOLE}_{G+PV=D+\Delta D} = \text{LOLE}_{G=D} \]

\[ \text{ELCC} = \frac{\Delta D}{G_{PV}} \text{ (p.u.)} \]
### 3. PV Models descriptions

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</table>
3. PV Models descriptions

Step 3: Measured data

**Santos-Martin Model**
- Global horizontal irradiance measured (input)
- \((k_T)\) Hourly Clearness index
- \((k_d)\) Daily Clearness index
- Diffuse horizontal irradiance
  Beam normal irradiance

**Gafurov Model**
- \((k_d)\) Daily Clearness index (input)
- Synthetic hourly index generation
- \((k_T)\) Hourly Clearness index
- Diffuse horizontal irradiance
  Beam normal irradiance

**Advantage:**
Gafurov’s involves greater complexity than Santos-Martin \((k_T)\) data
3. PV Models descriptions

Step 6: Irradiance to power conversion

**Santos-Martin Model**

\[
E_{pu} = E / 800 \\
E_{pu,a} = \frac{R_{uc}}{1.05} E_{pu} \\
\Delta T = T_{amb} - 20 \\
P_g = S_{stc} \left[ 0.846E_{pu,a} - 0.106E_{pu,a}^2 - 0.00368E_{pu,a}\Delta T \right] \\
\eta_1 = \eta_{lo} - 0.005t_{age} \\
P_n = P_g [\eta_m \eta_w \eta_c \eta_1 \eta_{np}]
\]

- Energy Normalised at STC conditions
- Temperature correction
- Gross power output from PV array
- Net power delivered

**Gafurov Model**

\[
I_{eff} / I_{eff,stc} = I_T / I_{stc} \\
T_{pv} = T_{amb} + \left( NOCT - T_{amb,NOCT} \right) \left( 1 - \eta_{pv,src} / 0.9 \right) \frac{I_T}{I_{NOCT}} \\
P_{pv} = P_{pv,src} \frac{I_T}{I_{src}} \left[ 1 + \beta_{Voc} \left( T_{pv} - T_{pv,src} \right) \right] \\
P_{pv,net} = P_{pv} - PL_{pv}
\]

- Gross power output
- Net power delivered
- Temperature correction
- Energy Normalised at STC conditions

**Advantage:**

Gafurov’s power conversion needs physical PV array characteristics in contrast to Santos-Martin

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4. Results and Conclusions

System Characteristics

- IEEE-RTS System

<table>
<thead>
<tr>
<th>Unit size (MW)</th>
<th>Number of Units</th>
<th>Mean Time To Failure (MTTF) (h)</th>
<th>Mean Time To Repair (MTTR) (h)</th>
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</thead>
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<tr>
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</tr>
<tr>
<td>400</td>
<td>2</td>
<td>1100</td>
<td>150</td>
</tr>
</tbody>
</table>

Installed power: 3405 MW, Nº units: 32

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System Characteristics

Solar irradiance data

- Solar irradiance data from southern Spain
- 14 years of Solar data
- 18 different photovoltaics power plant localization

PV Penetration

\[
\text{PV Penetration} = \frac{\sum PV_{\text{generation}}}{\text{Total capacity}} \times 100 = \frac{\sum PV_{\text{generation}}}{\sum (PV_{\text{generation}} + \text{Thermal}_{\text{generation}})} \times 100(\%)
\]
4. Results and Conclusions

Credit Capacity Results

Conclusion:
Same credit capacity results are obtained with Santos-Martin Model and Gafurov Model.

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Thank you for your attention

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