MW Resource Assessment Model for a Hybrid Energy Conversion System With Wind and Solar Resources

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Identification of Candidate Wind-Solar Sites, HECS ID Tool

- Desired Locations should have
  - Highest complementarity
  - Least distance

- HECS ID Tool automatically computes & creates a pairing of sites locations to form hybrid locations.

Correlations between individual wind farms and solar radiation stations

Sample Results & Applications of MWRAM

- Parameters Variation
- Wind (Onshore & Offshore) & Solar (Concentrating & Photovoltaic) Resource of USA

Proven Impact of Intermittent Gene

Wind-Solar MW Resource Assessment Model (MWRAM)²

- Wind Power: $P_w = f_w(v_w)$
- Solar Power: $P_s = f_s(g)$

Mathematical Formulation

- **Wind Model**
  \[ f_w(v_w) = \frac{1}{\lambda} \left( \frac{v_w}{\lambda} \right)^{\beta-1} e^{-\left( \frac{v_w}{\lambda} \right)^{\beta}} \]

- **Solar Model**
  \[ f_s(g) = \frac{C_r A_r}{P_{net}} \left( \frac{g}{G_{max}} \right)^{\alpha} \exp(-\frac{g}{G_{max}}) \]

Locations and Cases Studied

- Locations of USA

Mathematical Formulation

- Integrated Hybrid Model
  \[ E(P_{net}) = E(P_w) + E(P_s) \]
  \[ \text{if } 0 \leq E(P_w) \leq E(P_{net_{max}}) \text{ & } 0 \leq E(P_s) \leq E(P_{net_{max}}) \]
  \[ \text{& } 0 \leq (E(P_I) \leq E(P_{net_{max}} + P_{net_{max}}) \]

- Annual Average Capacity Factors for Sites A, B, C

- CF = Rated Power of Plant (MW)/Hours in Interval (h)

- For preferred case selected, the CF allows ranking the shortlisted locations in terms of resource potential.

Challenges in Grid Integration of Renewable Energy

- Dealing with intermittency of Power output from renewable energy sources.
- Increasing the renewable energy penetration without hampering grid stability and reliability.
- Addressing adverse effect of output fluctuations on power grid frequencies, voltages & transient performance.

Taking Advantage of Hybrid Wind-Solar Generation

- Complementary solar and wind plant profiles when considered in aggregate can be a good match to the load profile.
- As compared to stand-alone plants, the hybrid plant would require less storage or reserve capacity.
- Reduction in emissions, generation of additional jobs, security of supply etc.

Schematic of Wind & Solar Hybrid Energy Conversion System (HECS)

- California Average wind and solar output, along with net demand – July 2001 & Jan 2002 (scaled to 2010 levels)

Motivation

- Reducing renewable resource intermittency impact on the power system

Mathematical Formulation

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