Power Systems with large amount of Renewables (Distribution Generations)

Yo h Yasuda, Kyoto University
Myth and Misunderstanding about Renewables

- “More outages would occur as More Renewables!”
  - Outages could occur even with no renewables.
  - There are certain measures to avoid outages even with large amount of renewables.

- “Distribution generations can prevent blackouts!”
  - Is is fact that grid stability could become worse as more DG.
  - We should not be optimistic.
  - However, many measures have been proposed worldwide.

- Need for quantitative grid analysis
Challenging by large amount of Distribution Generations

“Inertia Problem” would be more severe in higher share of distribution generations

most severe situation in middle stage

(source) MIGRATE – Massive Integration of Power Electronic Devices, Stakeholder workshop, Brussels, 6 April 2017
Fundamental Equation of Turbine Generator

\[ J \frac{d\omega}{dt} = T \]

- Inertia Moment
- Angle Frequency
- Torque

Similar as Equation of Motion

\[ m \frac{dv}{dt} = F \]

- Machine Torque
- Turbine
- Generation
- Electricity Torque

\[ J \frac{d\omega}{dt} = T_m - T_e \]
Synchronous and Asynchronous Generators

Sync. Gen.

Async. Gen.

Virtual Inertia (GE Energy)

How does it work?

- In steady-state, torques must be balanced
- When electrical torque is greater than mechanical torque, the rotation slows extracting stored inertial energy from the rotating mass

WindINERTIA uses controls to increase electric power during the initial stages of a significant downward frequency event

Inertial response simulations – partial load case (0.86 pu wind speed)

Figure 6 illustrates the frequency excursion during the IR event defined in Table 1 both for the basic case (i.e. no wind power) and the case with 20% wind power penetration with and without activation of IR ancillary service inside WPPs. Since the conventional power plants are not replaced in 20% wind power scenario, there is not considerable difference between the basic case (0% wind power) and 20% wind power scenario without IR contribution.

Figure 7 compares the 50% wind power penetration case where no IR inside WPPs is activated with the cases where the IR is activated one by one first inside WPP1, then in WPP2 too and in the last also in WPP3 too.

Figure 6: System frequency excursion during IR event, 0.86 pu wind speed and 20% wind power penetration with and without inertial response from WPPs.

(souce) A. Hansen and M. Altin: Impact of advanced wind power ancillary services on power system, DTU Wind Energy Report 2015
Outlining planning components:

- Techno-economic assessments across planning time horizons
- Seasonally to sub-daily (static)
- Generation expansion planning
- 20-40 years
- 5-20 years
- Weeks-years
- Snapshot
- Typical time horizon
- Typical timeframe
- Hourly to sub-daily
- Sub-hourly to sub-seconds
- Near-term
- Long-term
- Geo spatial planning
- Dispatch simulation
- Technical network studies
- Four key planning components are defined in Figure 3. Although depicted as separate, some of these steps are often combined in the actual execution of techno-economic assessments, as discussed later. In the figure, three time dimensions also are distinguished: the planning time horizon, which refers to how far in the future the specific planning analysis is relevant; the timeframe, which refers to the overall period of time that is subject to techno-economic analysis; and the time resolution, which refers to the granularity, or level of detail, of analysis within the timeframe. The discussion below focuses on planning aspects in relation to the time horizon; the issues of timeframe and time resolution are discussed fully in Appendix 2, in relation to modelling tools for each planning step.

Thorough techno-economic assessments of possible pathways are critical in planning the transition to a power system with a high share of VRE, as they elucidate the implications of alternate policy choices. With that information, decision makers can take future actions more proactively and construct policies to meet multiple objectives that often are interrelated. Both near-term and long-term implications should be considered in the overall transition planning process, so as to understand and ensure the most cost-effective transition while meeting the non-techno-economic goals of a country’s energy policy. By building assessments on meaningful stakeholder consultation, decision makers also can ensure that a consensus is established around the legitimacy of results (NASEO, 2014; OLADE, n.d.; Wilson and Biewald, 2013).

Power System Analysis

Very active worldwide. How about in Japan?

Today’s discussion

Power System Analysis

Today's discussion