International Symposium
Renewables Integration into the Japanese Power Grid by 2030
A Frequency Stability and Load Flow Analysis

!7th Dec. 2018

Power Systems with large amount of Renewables (Distribution Generations)

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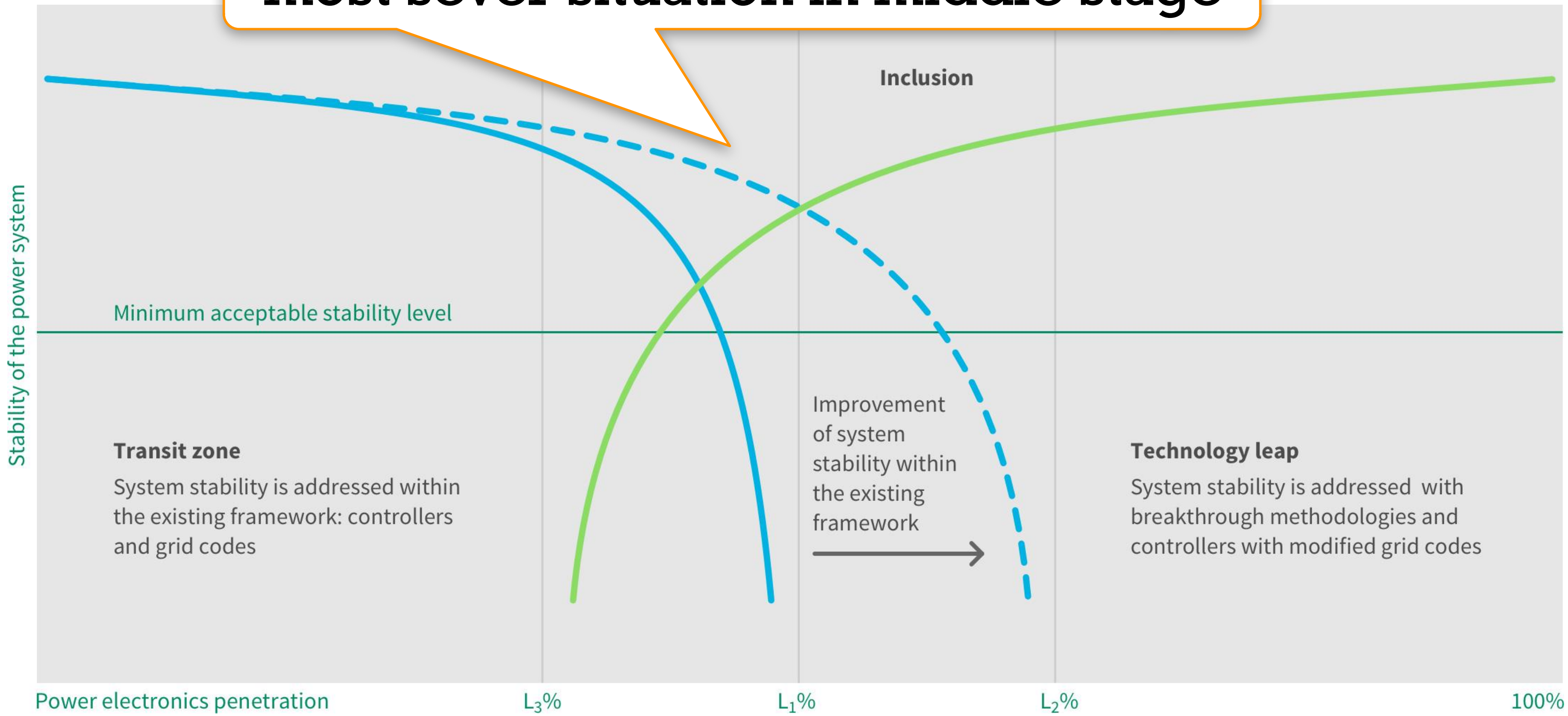
Myth and Misunderstanding about Renewables

- "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 sever situation in middle stage



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

Fundamental Equation of Turbine Generator

Inertia Moment

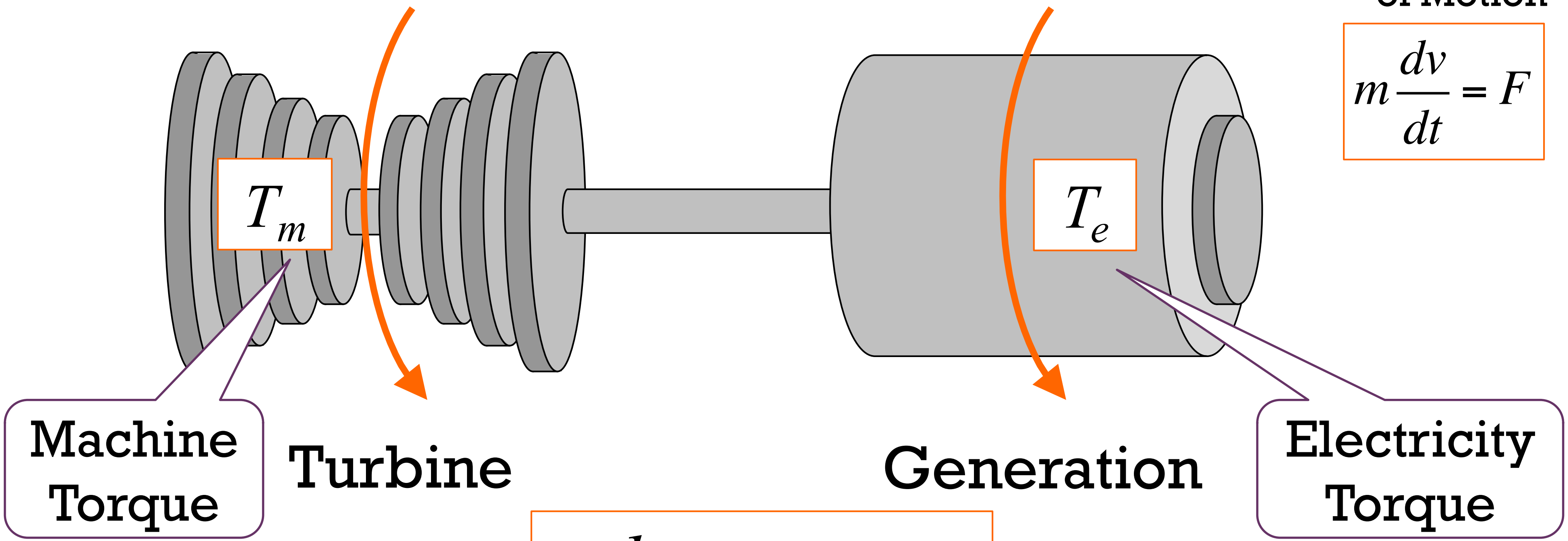
$$J\frac{d\omega}{dt} = T$$

Angle Frequency

Torque

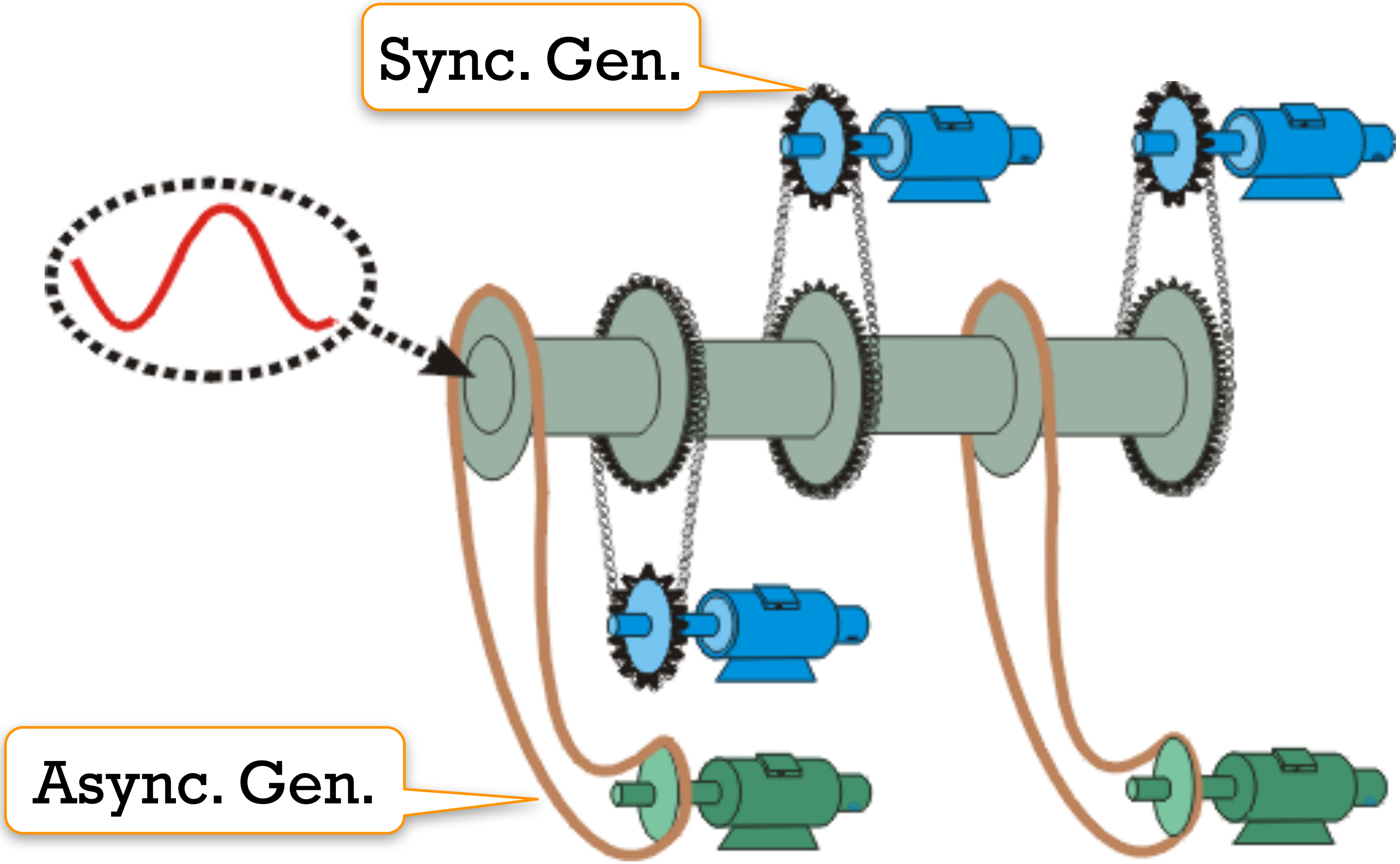
Similar as Equation of Motion

$$m\frac{dv}{dt} = F$$



$$J\frac{d\omega}{dt} = T_m - T_e$$

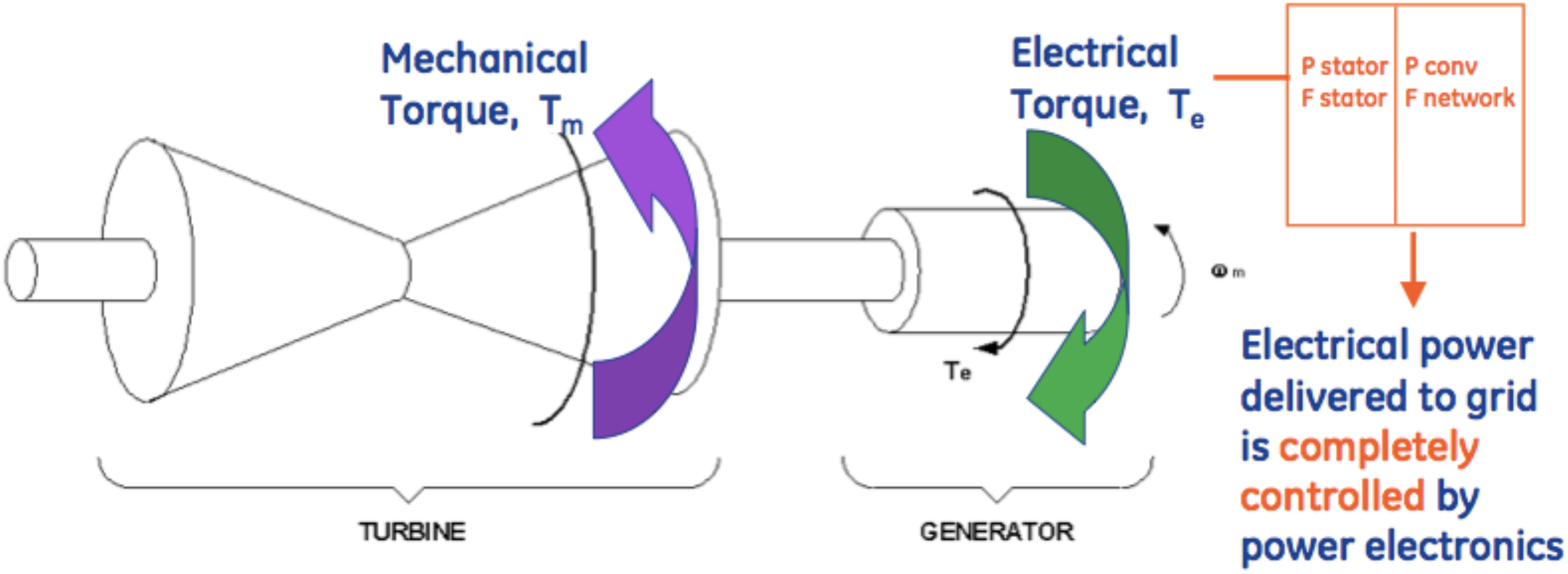
Synchronous and Asynchronous Generators



(source) Mark O'Malley: Wind Integration in Ireland: a National Effort with International Consequences, JWEA Wind Integration Workshop (2012)

Vertual Inertia (GE Energy)

How does it work?

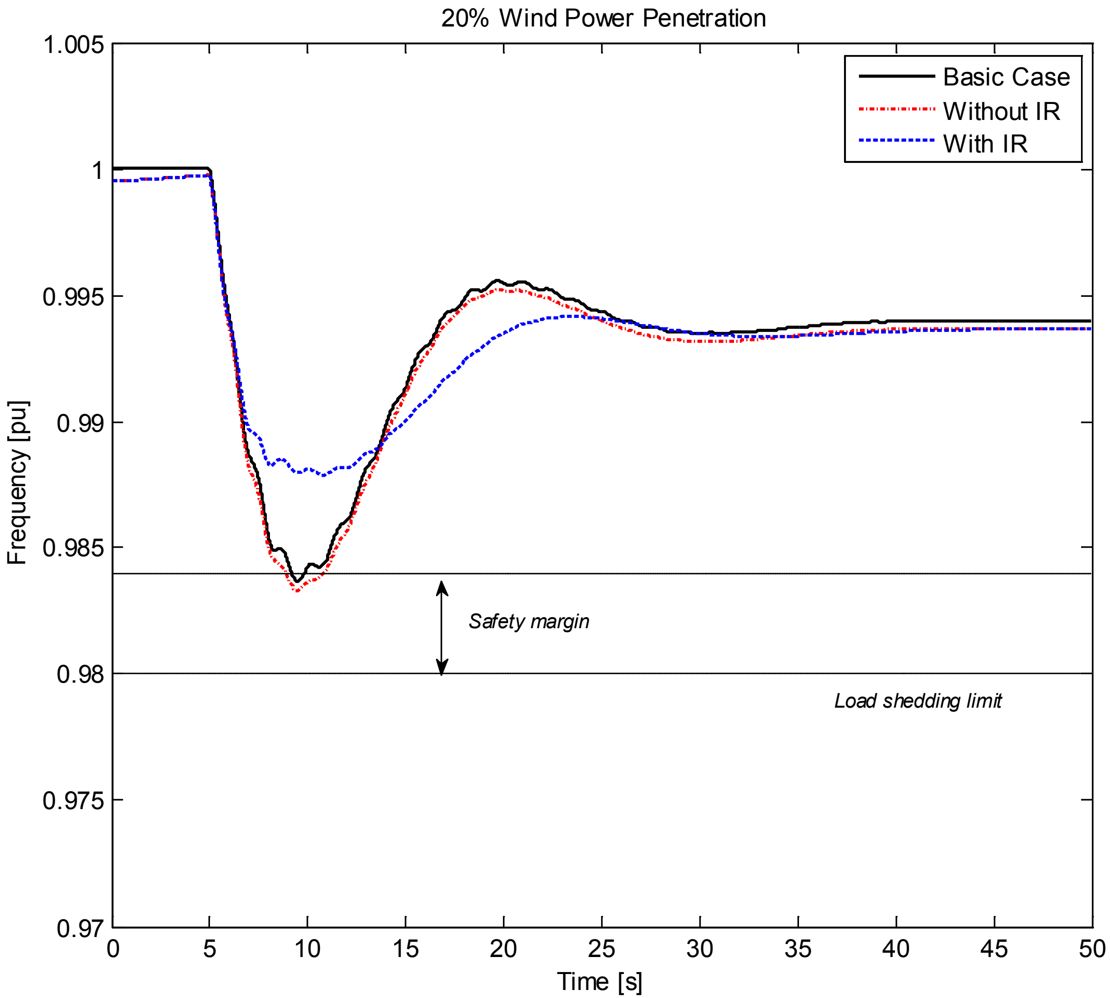


- In steady-state, torques must be balanced
- When electrical torque is greater than mechanical torque, the rotation slows extracting stored inertial energy from the rotating mass

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

(souce) N. Miller: "Impact of frequency responsive wind plant controls of grid performance, GE Energy (2010)

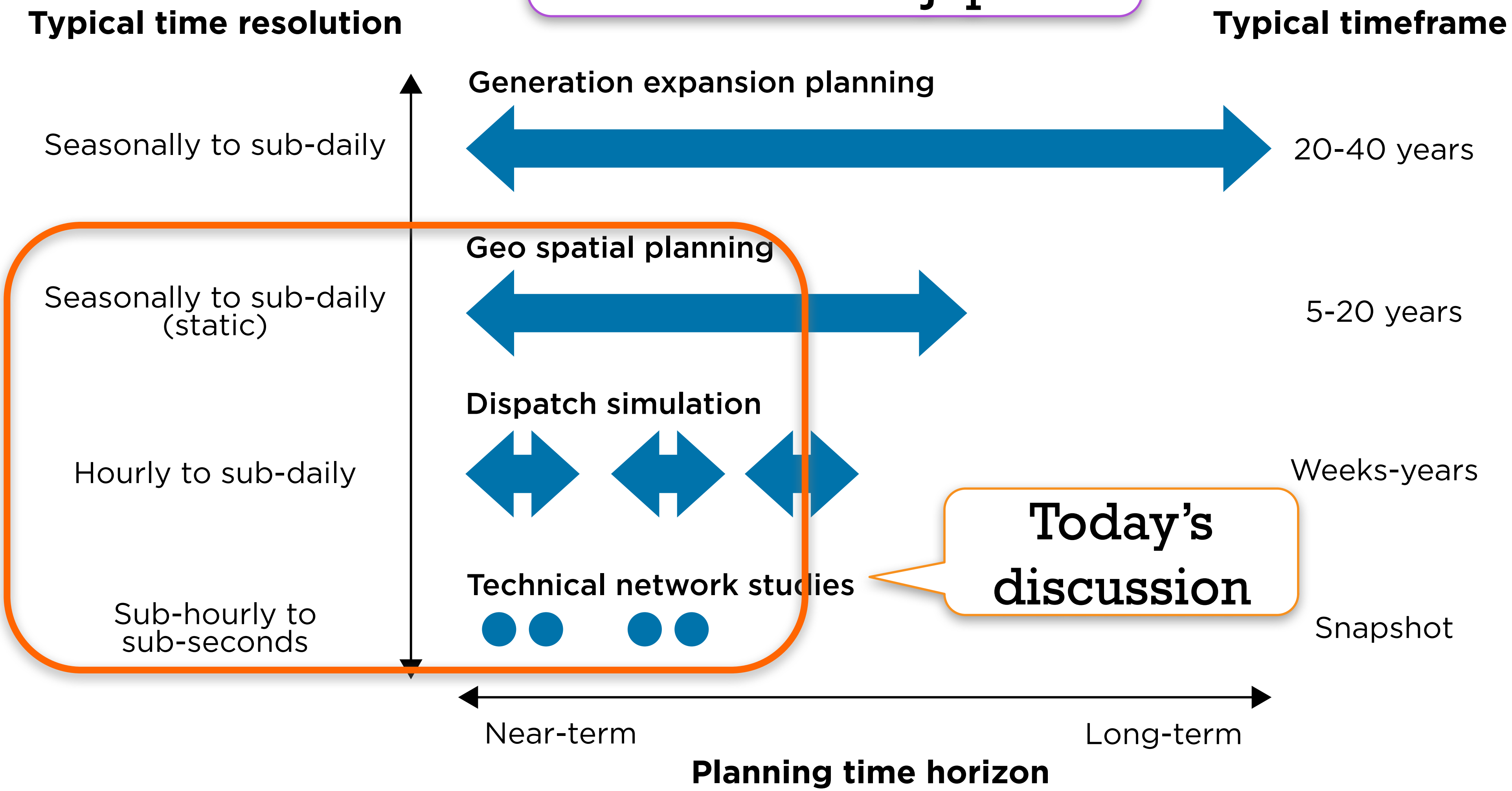
Vertual Inertia (Risø-DTU)



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

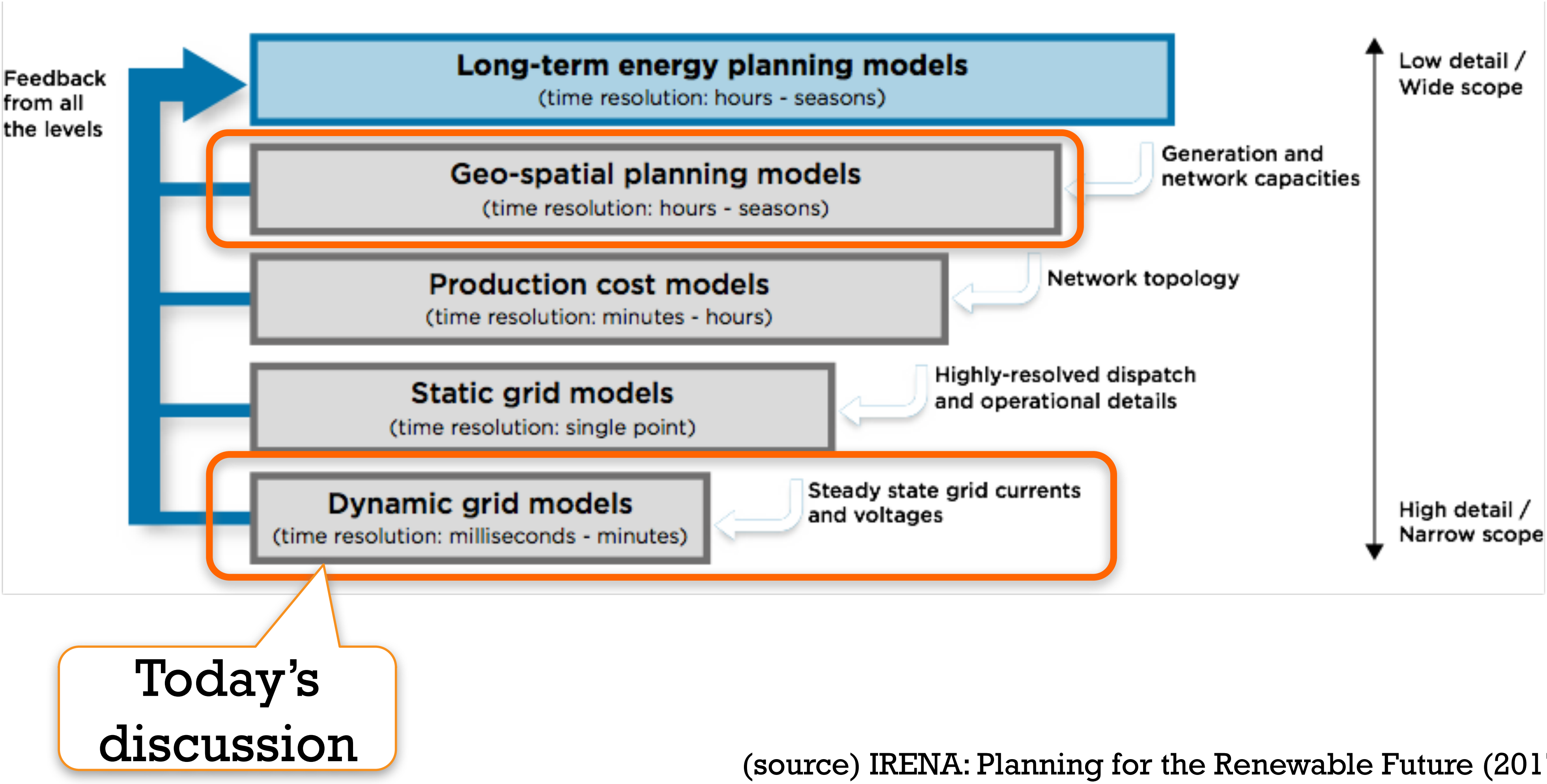
Power System Analysis

Very active worldwide.
How about in Japan?



(source) IRENA: Planning for the Renewable Future (2017)

Power System Analysis



(source) IRENA: Planning for the Renewable Future (2017)