Temporary Rotor Inertial Control of Wind Turbine to Support the Grid Frequency Regulation

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This study focuses on variable speed wind turbine’s capability of providing inertia response to support the grid frequency regulation, especially for short-term frequency drop in low inertia grid.

What is inertia?

Inertia is the resistance of physical object to a change in its state of motion. *

Rotating objective inertia:

$J = m\ r^2$

$J_{wind\ turbine} = 40k * (37.5/3)^2$

$= 6.25 * 10^6\ Kg.m^2$

Energy stored in rotor mass:

$E = 0.5\ J\ \omega_m^2$

$E_{wind\ turbine} = 0.5\ J\ \omega_m^2$

$= 0.5 * J * 1.75^2$

$= 9.57 * 10^6\ J$ =

20 ton

@ 80km/h

Inertia Constant is defined as the kinetic energy stored in the rotor at rated speed divided by the VA base.

$H = E/S = 0.5\ J\ \omega_m^2 / S$

$H = E/S = 4.79\ s$

Similar as conventional power generation

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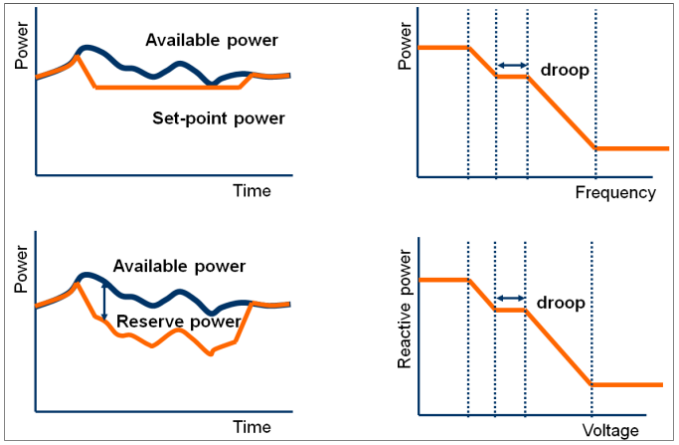
* From Wikipedia

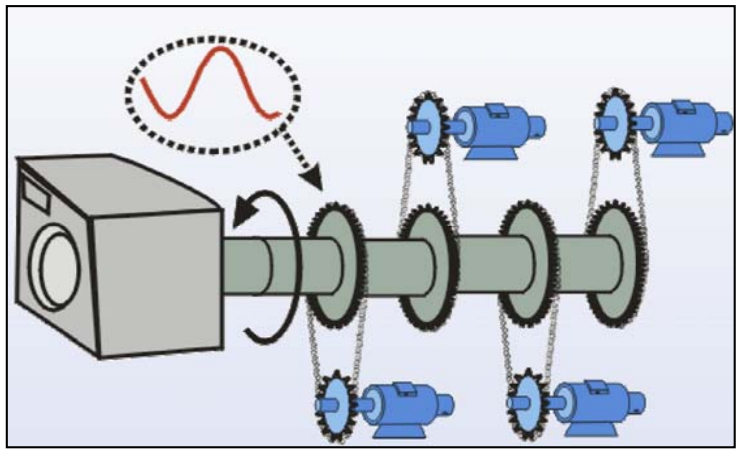
Why power system needs inertial control?

Frequency control by keeping balance between generation and consumption.

Long term balance : by power reservation



Short term balance : by rotating kinetic energy



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Frequency control requirements to wind turbines

Nordic Grid Code 2007:

Frequency control. Automatic control of the **wind turbine** active production as a function of the system frequency must be possible. The control function must be proportional to frequency deviations and must be provided with a dead-band. The detailed settings will be provided by the TSO.

Hydro-Québec requires **wind farm** to be able to contribute to reduce large (0.5 Hz), short-term (10 s) frequency deviation.*

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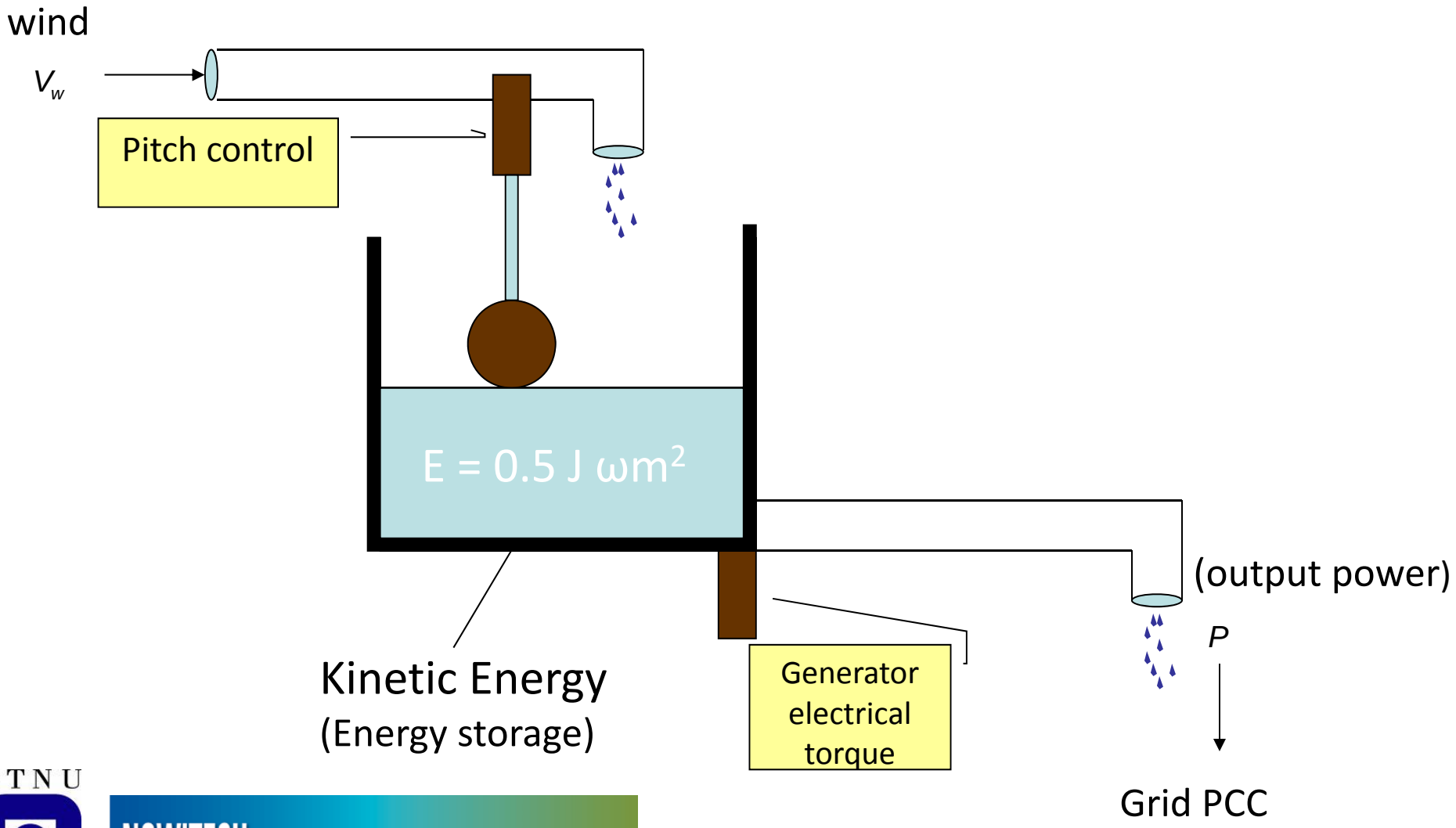
* Technical Requirements for the Connection of Generation Facilities to the Hydro-Québec Transmission System: Supplementary Requirements for Wind Generation, Hydro-Québec, Tech. Rep., May 2003, revised 2005.

Inertial Control is similar as Liquid Level System



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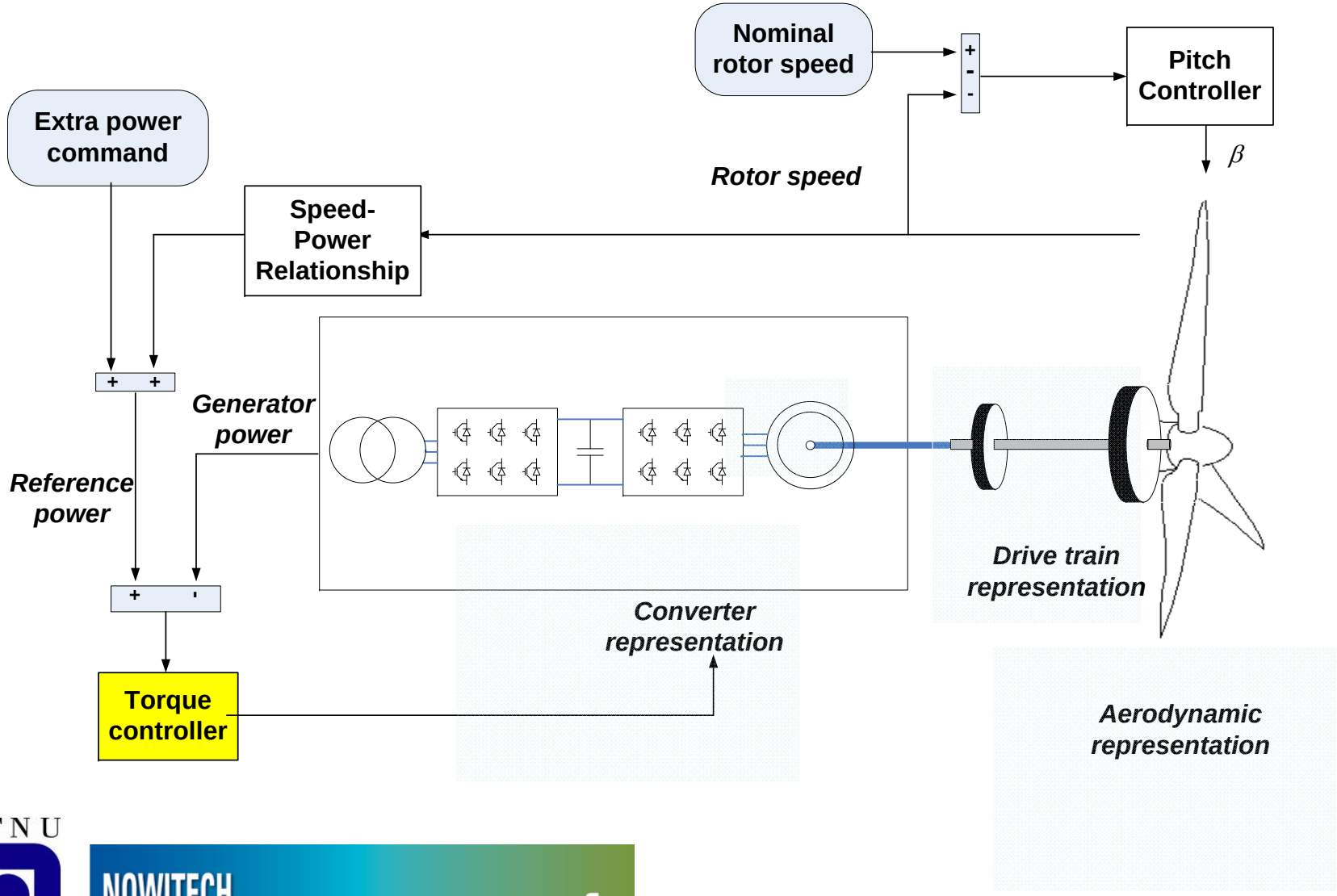
Wind turbine modeling for inertial control



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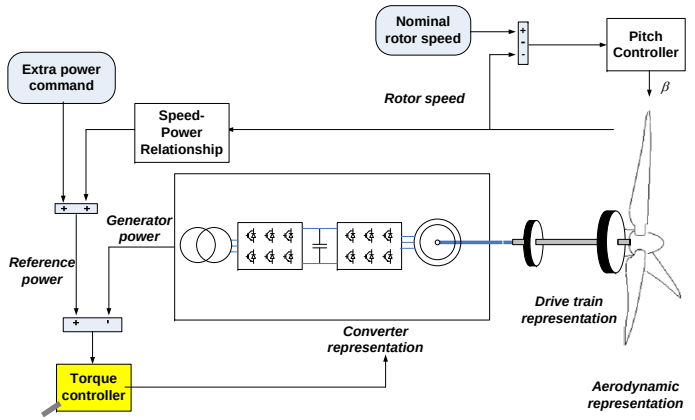
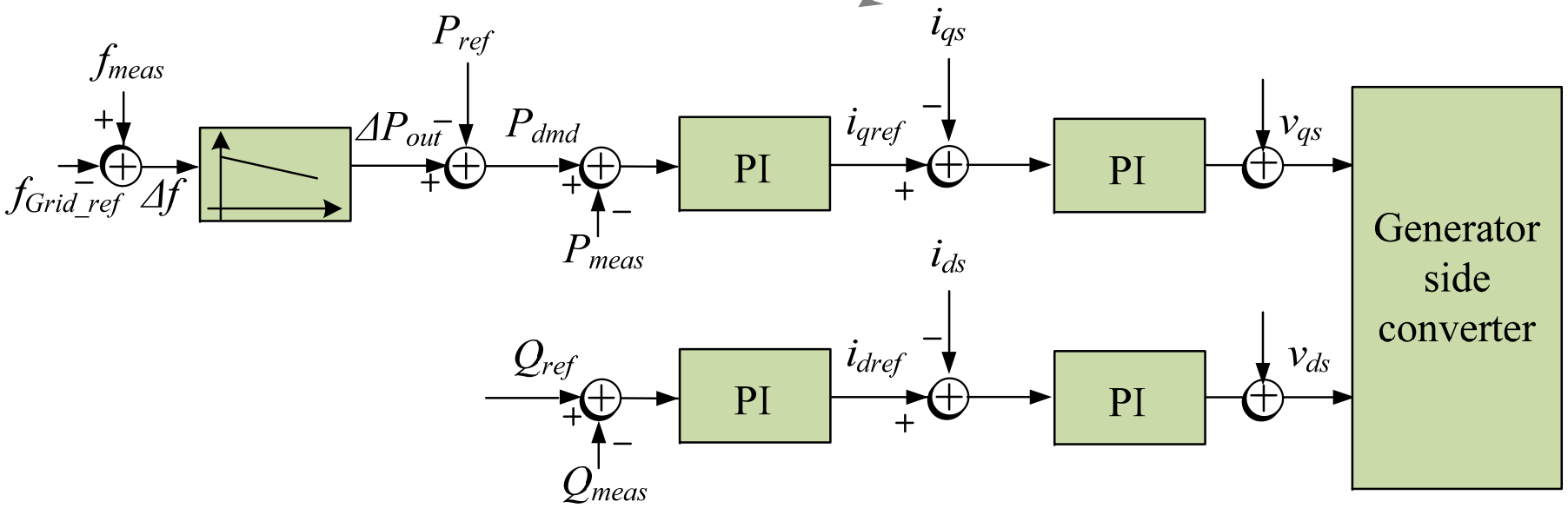
Vector Controller for generator side converter

-Torque Control executed in *q* axis.

-Faster than load angle control strategy*.





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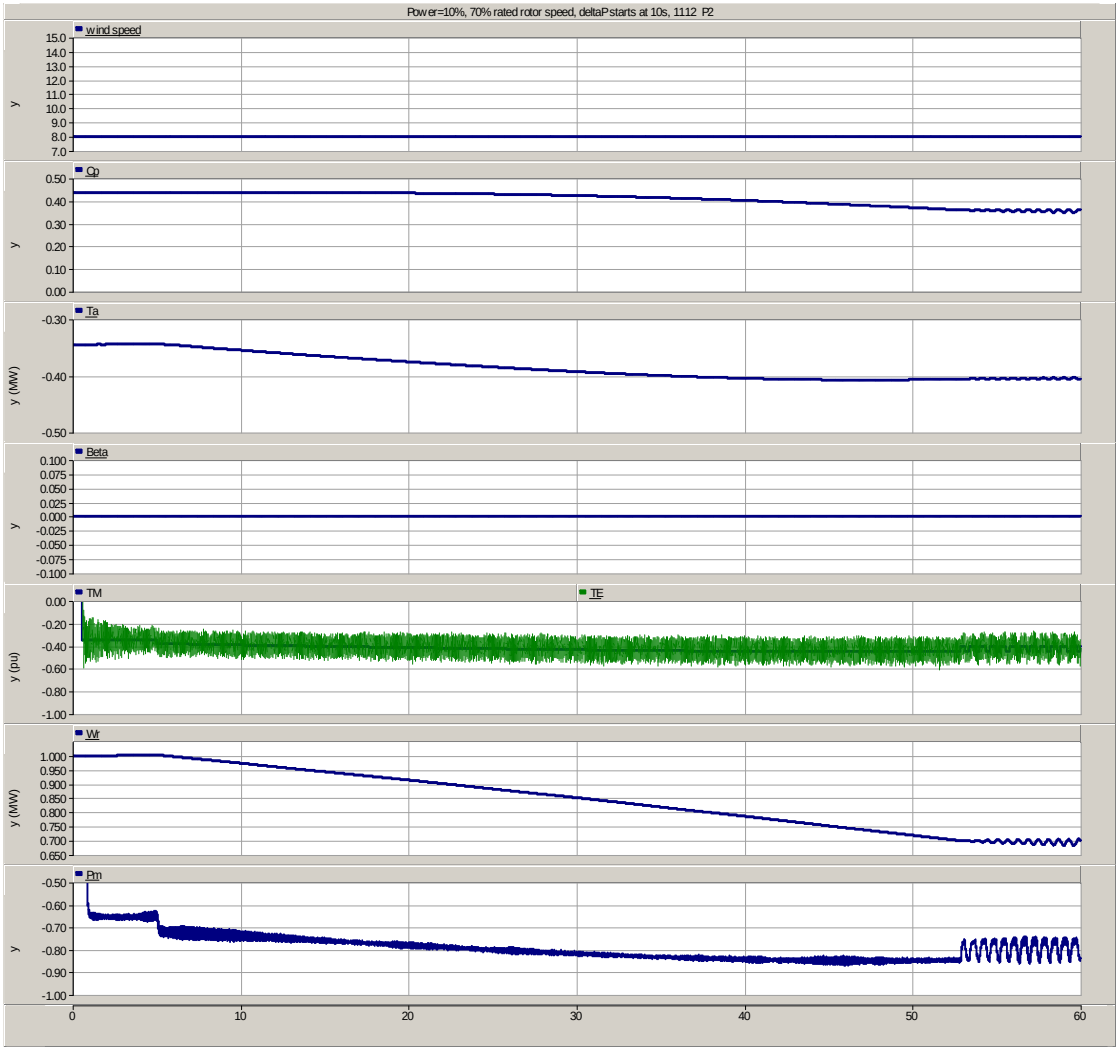
* P109, Wind Energy Generation: Model and Control, Olimpo A. et al.

Simulation: Wind turbine parameters when Power reference=110%, starts at 10s.



Wind speed (m/s)

Power co efficiency

Air dynamic torque (PU)

Pitch angle

Generator mechanic torque (PU)

Power output (MW)

Rotor speed (PU)

0 s

Time (s)

60 s

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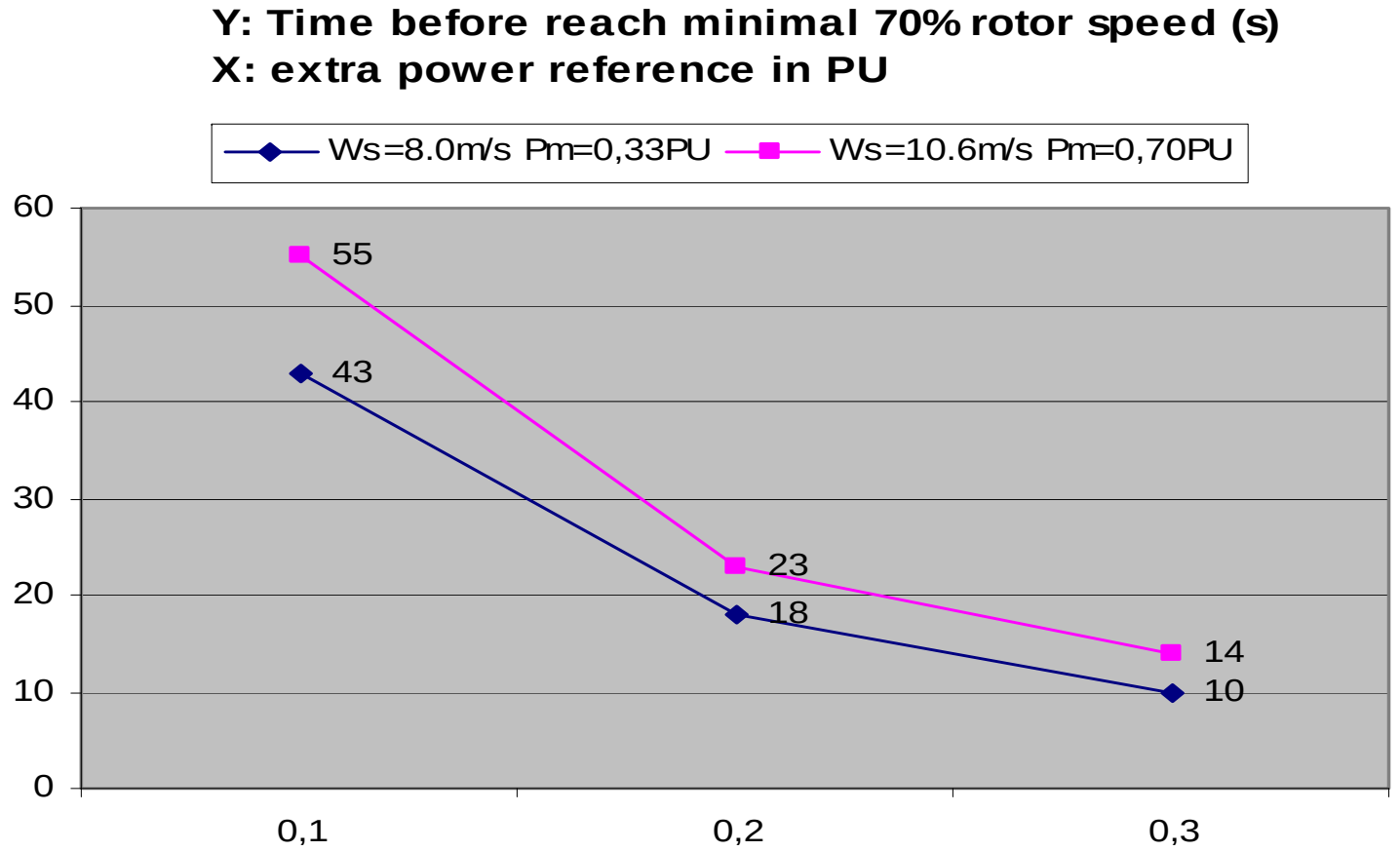
How is the inertial control ability?



WTG Rating	5 MW
Control	Variable Speed, collective Pitch
Rotor Diameter	126 m
Hub Height	90 m
Rated Tip speed	80 m/s

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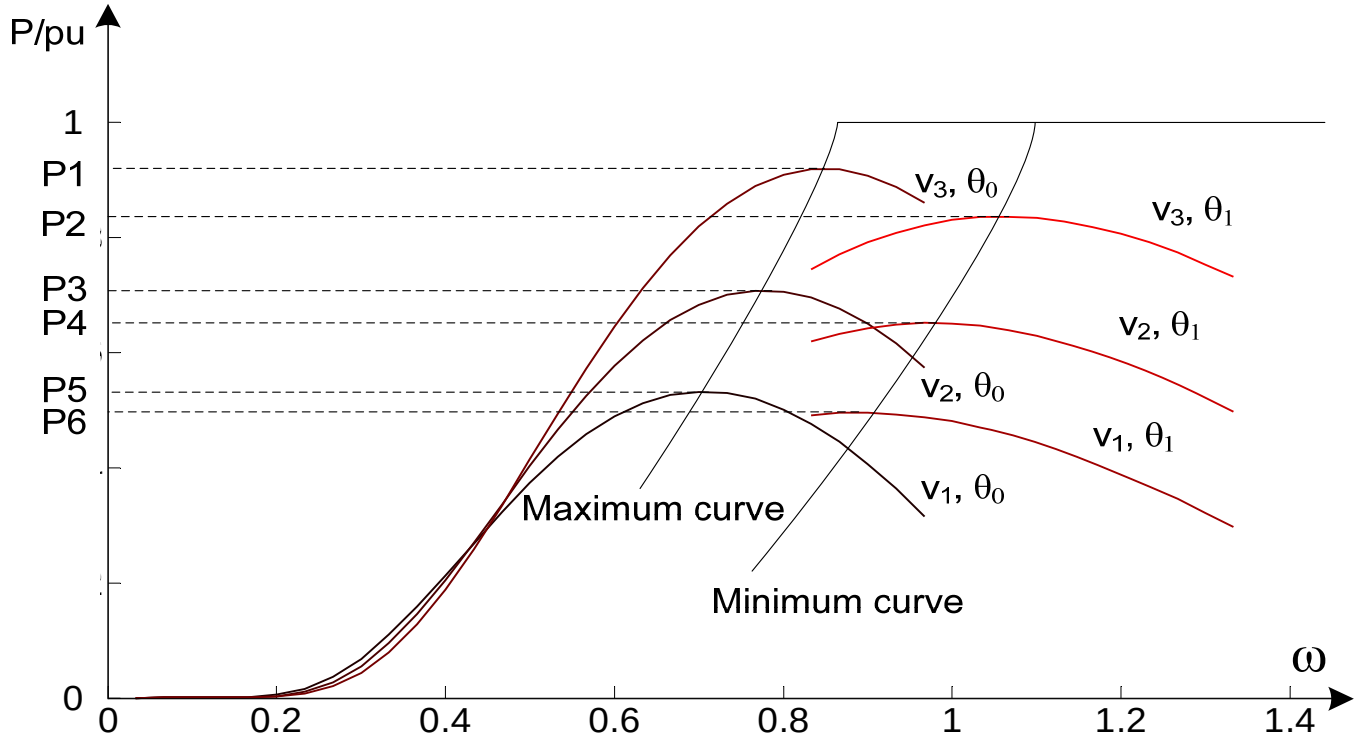
Power reservation by pitching for long-term frequency response



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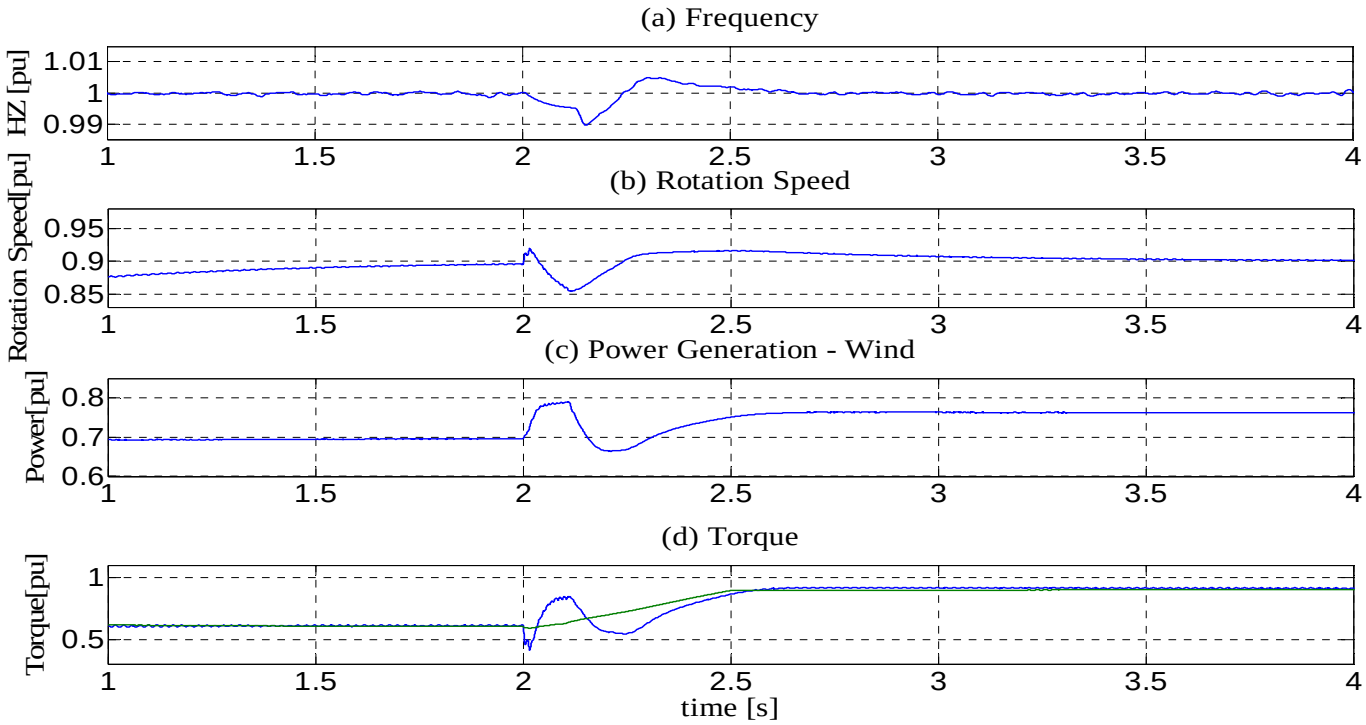
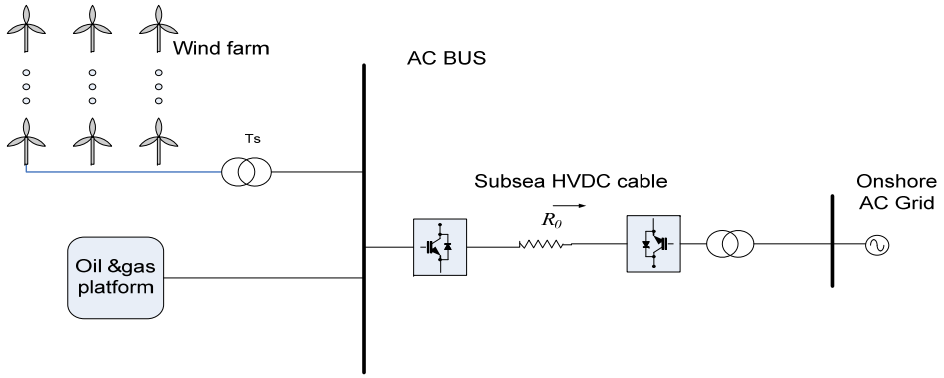
Frequency response with pitch control and inertial response control combined method implemented



Rated (base) apparent power	400 MVA	1.0 pu
Rated (base) voltage, offshore AC	115 kV	1.0 pu
Rated (base) voltage, HVDC link	120 kV	1.0 pu
System Frequency f_{ref}	50 HZ	1.0 pu
150-km dc transmission line		
Resistance per km	0.0217	
Inductance per km	0.792mH	



How to make wind parks “grid frequency friendly” ?

- ✓Wind parks need react to changes in grid frequency
- ✓Short-term inertial response capability is limited
- ✓Need to combine with long-term pitch control

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Thanks!
感謝！

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