Primary and Secondary Control in relation to Wind Power Plants

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Microcosm Model of Primary and Secondary Response

Energy balance model - includes
Governing - primary response
AGC - secondary response

Variable percentages of:

Conventional generation responsive to governing and automatic generation control

Wind generation - non responsive

Wind generation - transient boost capability based on rotor energy storage

Wind generation - operating below maximum output and responsive to frequency in accordance with governing droop

Six illustrative cases

Case A - approximately condition of WECC today
- 40% of conventional generation provides primary/secondary response

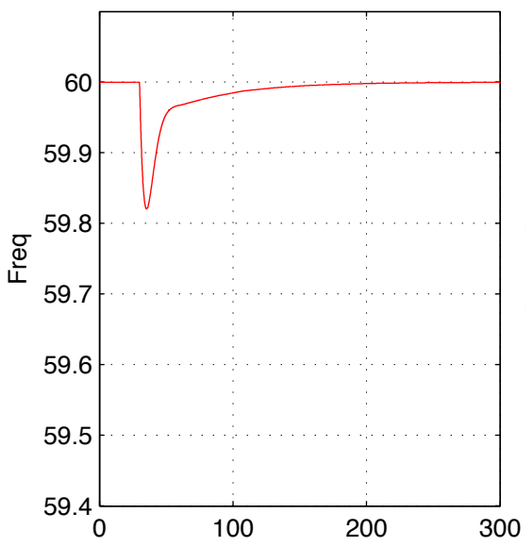
Case B - 30% wind production
- 40% conventional generation - responsive
- wind replaces non-responsive conventional capacity

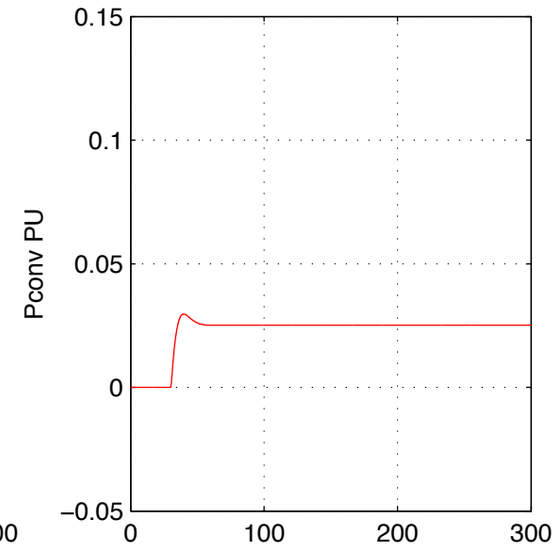
Case C - 30% wind production
- 10% conventional responsive - all wind capacity is non responsive

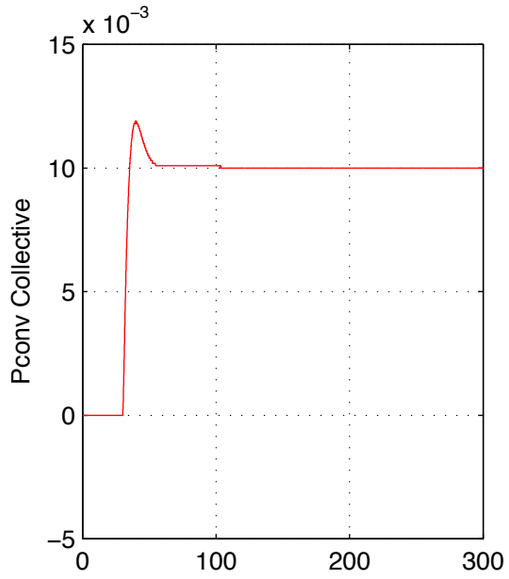
Case D - 30% wind production
- 10% conventional responsive - 2/3 of wind plants have transient boost capability

Case E - 30% wind production
- 10% conventional responsive
- 2/3 of wind plants operate below maximum output to provide up to 2% of their capacity as primary response

Case F - 30% wind production
- 20% conventional responsive -
- 2/3 of wind plants operate below maximum output to provide up to 2% of their capacity as primary response



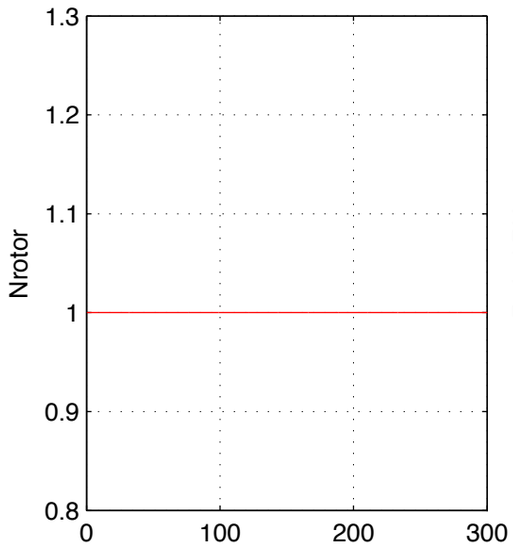


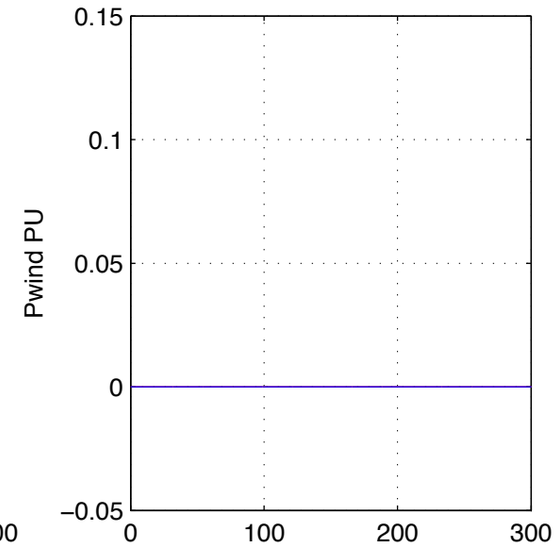


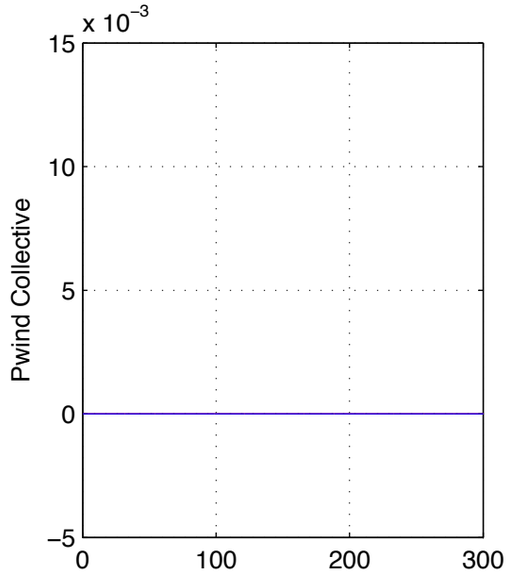
Case A
40% conventional regulating
No wind

Frequency dips to 59.82
Frequency restored in <2 min

This is approximately what WECC achieves at present







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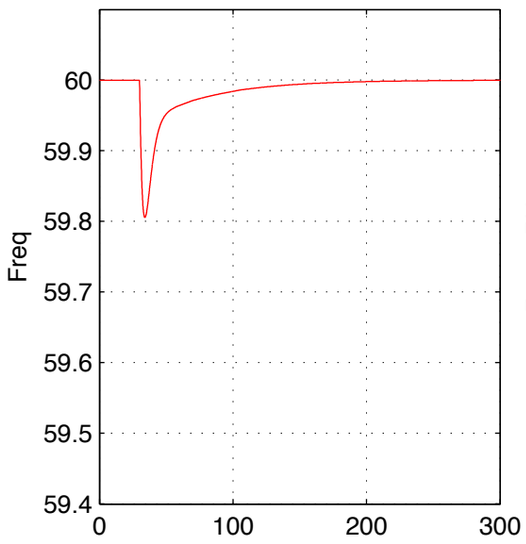
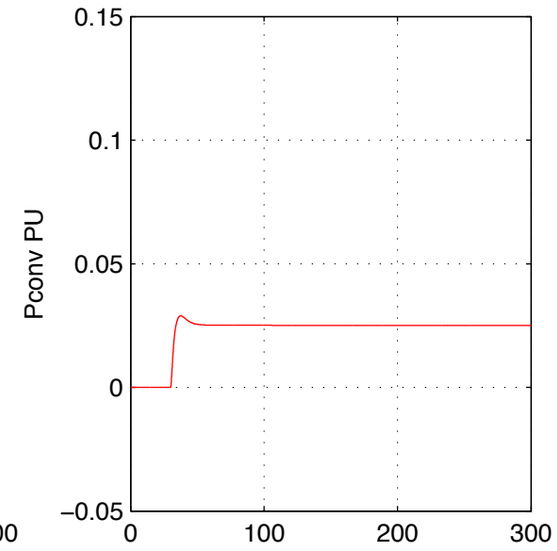
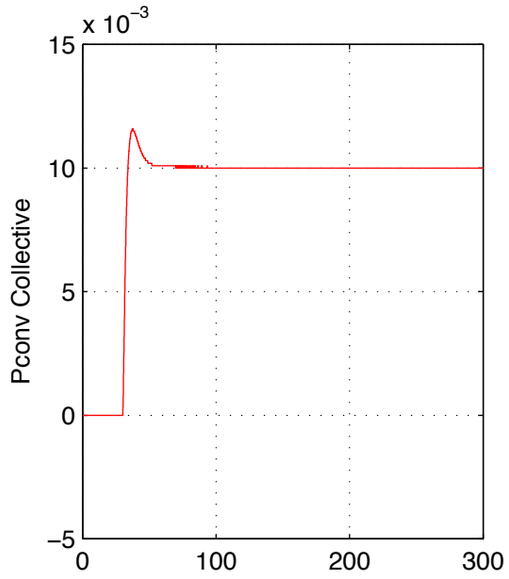


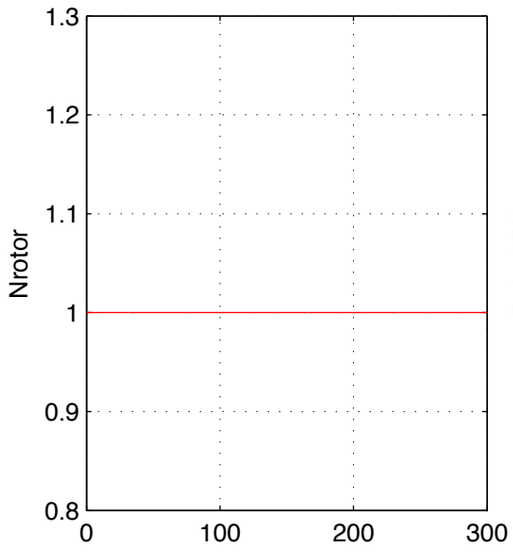


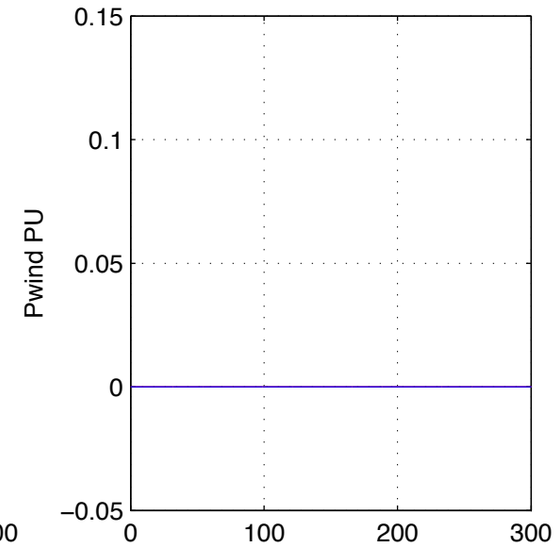


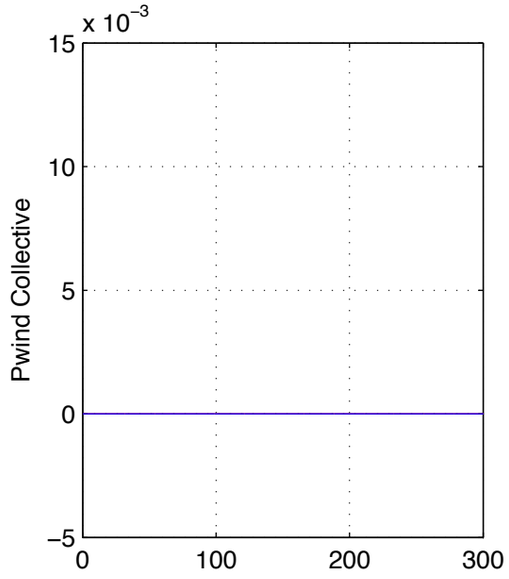
Case B
40% conventional regulating
30% nonresponsive wind

Wind capacity reduces system effective inertia constant

Frequency dips to 59.81
Frequency restored in ~2 min







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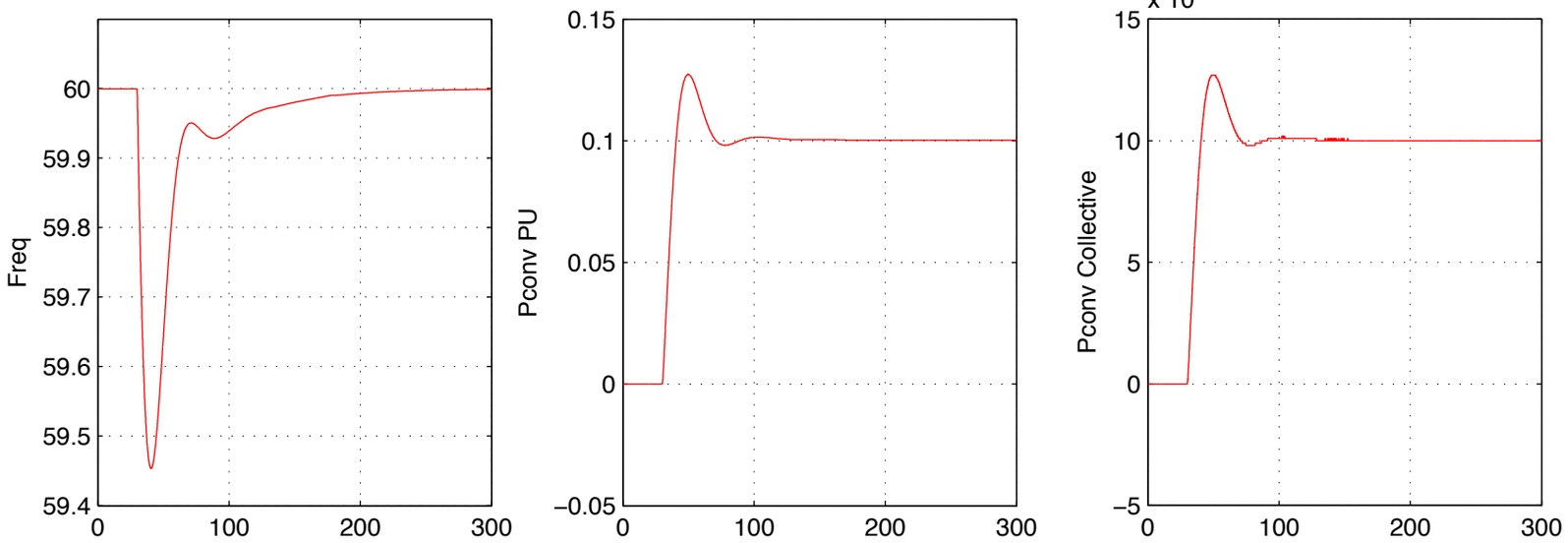
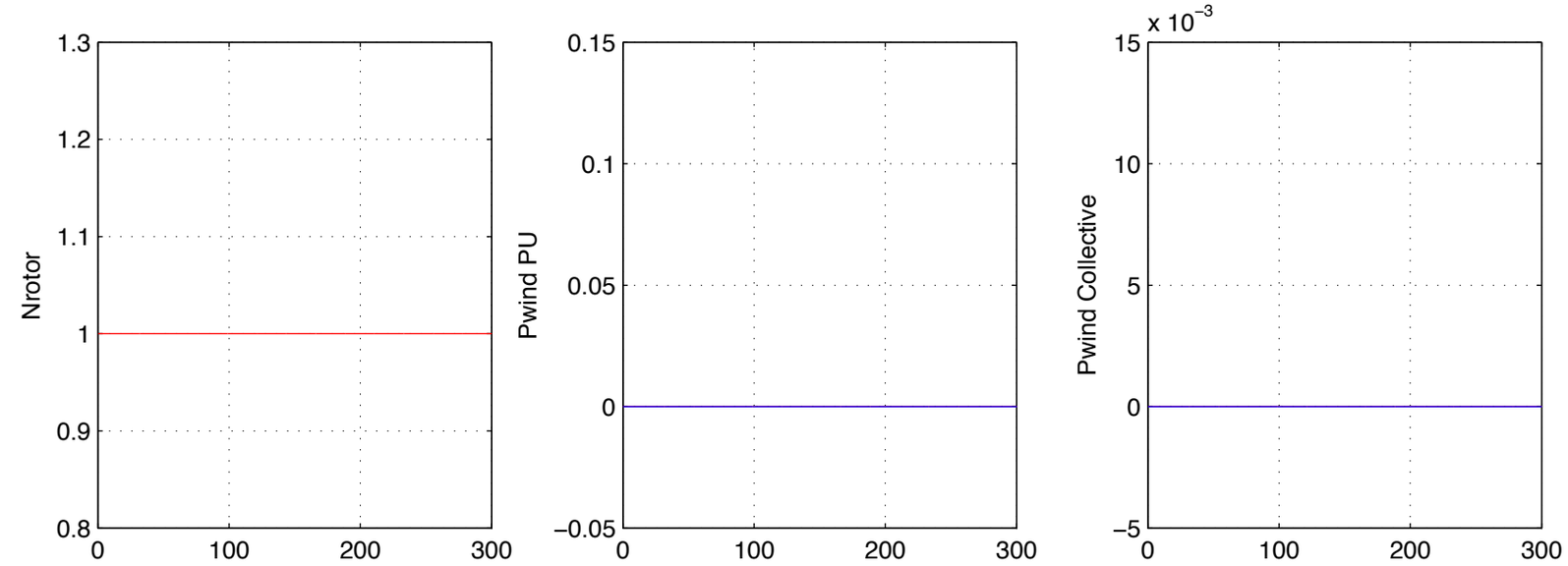
Effect of electronically coupled generation on system inertia is not a critical issue



Case C
10% conventional regulating
30% nonresponsive wind

Frequency dips to 59.46
Frequency restored in ~2 min

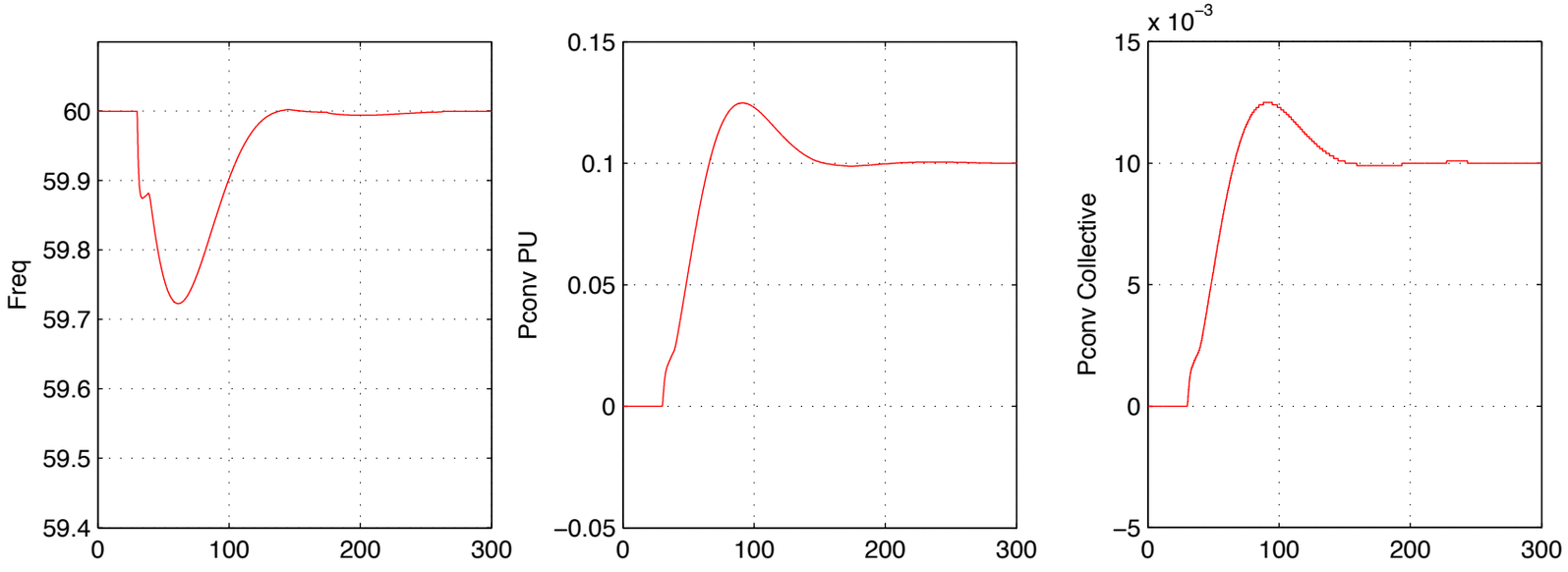
Requires units providing FRR to produce 12% reponse (each unit) in 20 sec



This scale of per-unit primary response:

is not a realistic expectation in technical terms

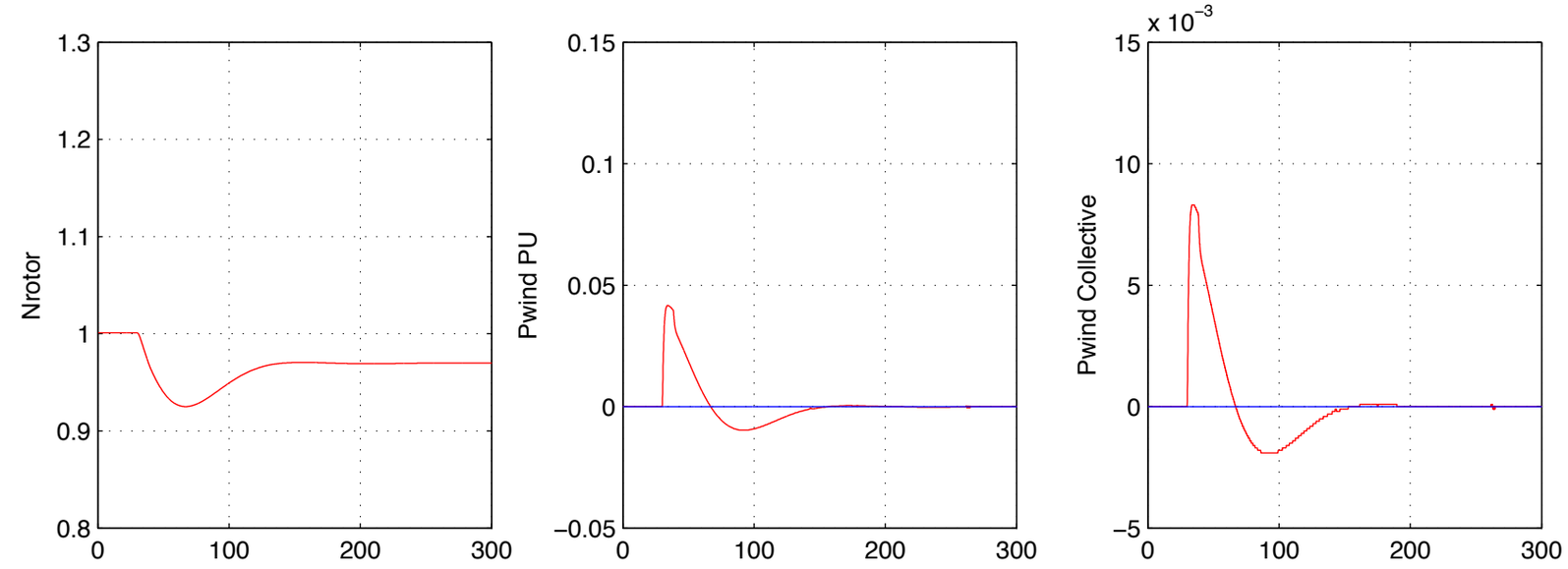
requires the plants providing primary reserve to be ‘turned-down’ by an unduly large amount in commercial terms



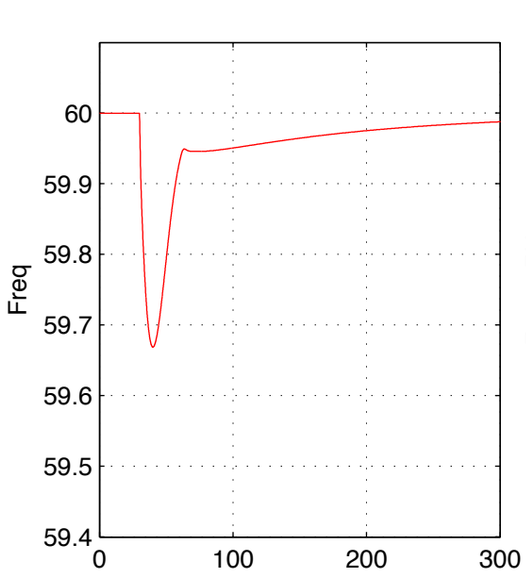
Case D
10% conventional regulating
10% nonresponsive wind
20% wind giving transient boost

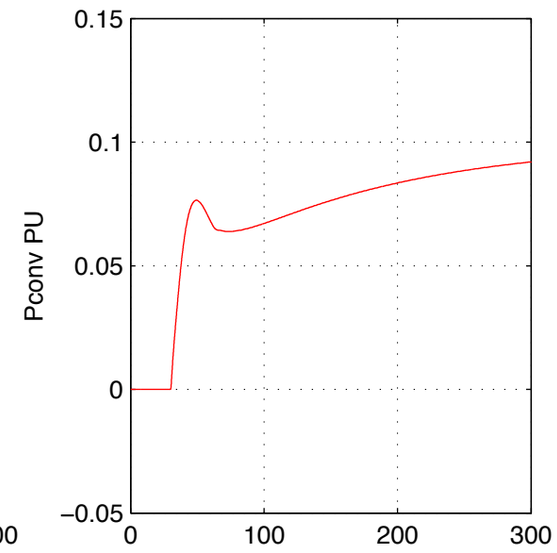
Frequency dips to 59.72
Frequency restored in ~2 min

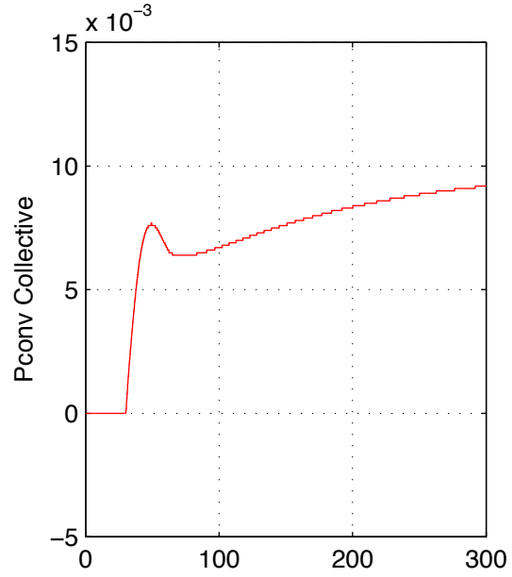
Extends time for 12% reponse to 55 sec



This is still an unrealistic expectation regarding primary response from conventional plants and still a burdensone commercial requirement regarding reduction of output







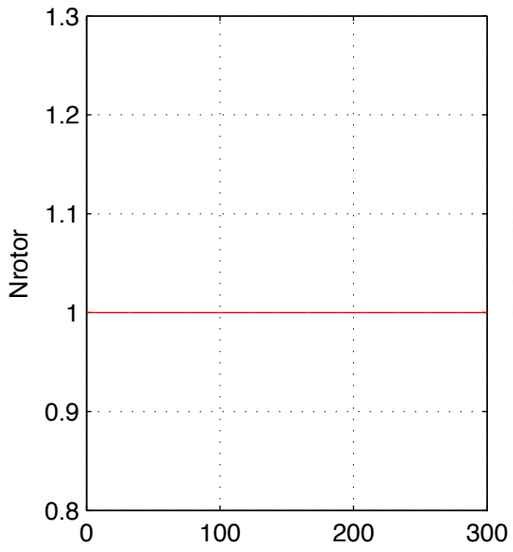
Case E

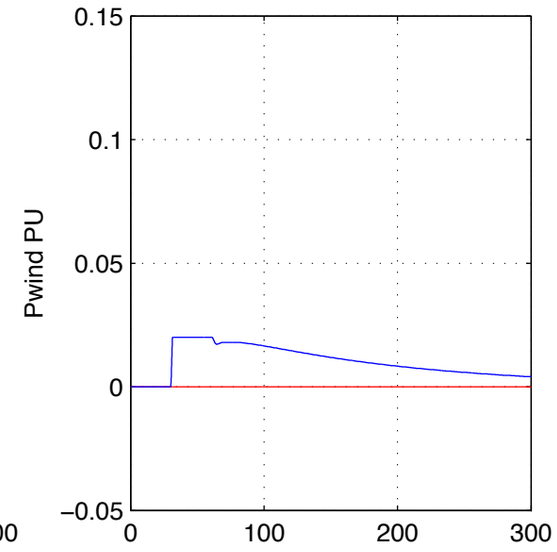
10% conventional regulating

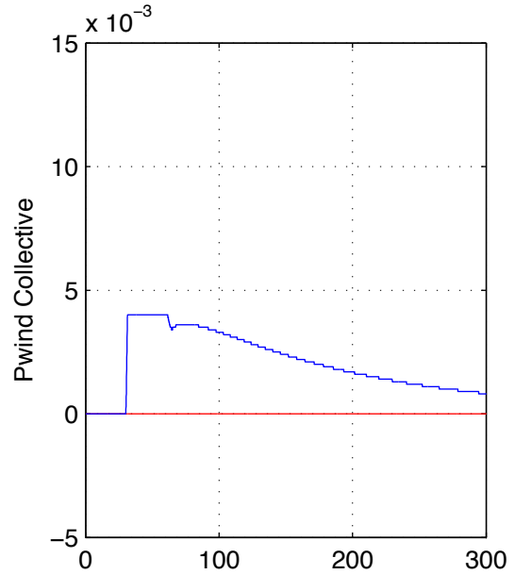
10% nonresponsive wind

20% wind operating below maximum and capable of sustained primary response (2%)

Frequency dips to 59.67







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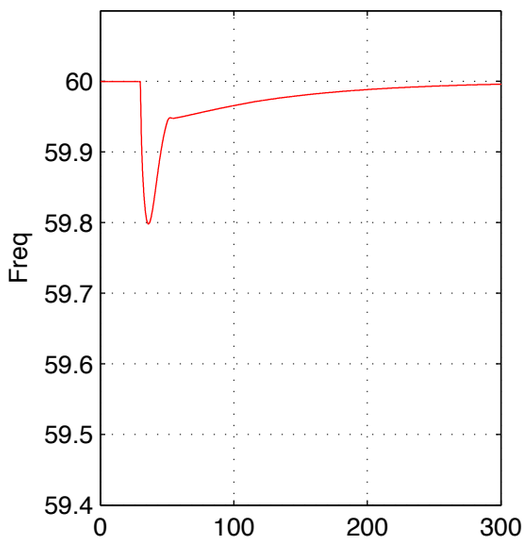
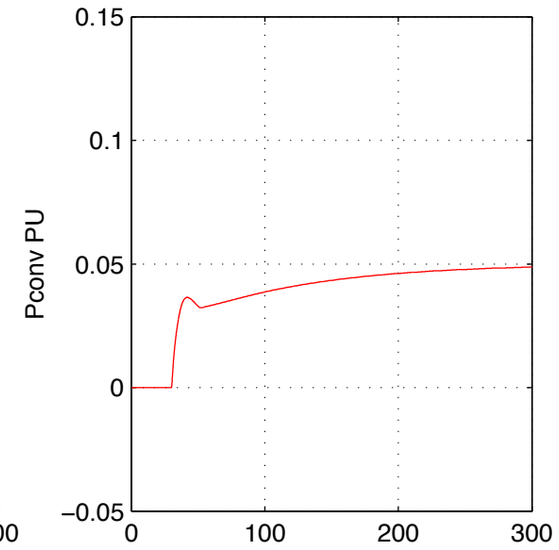
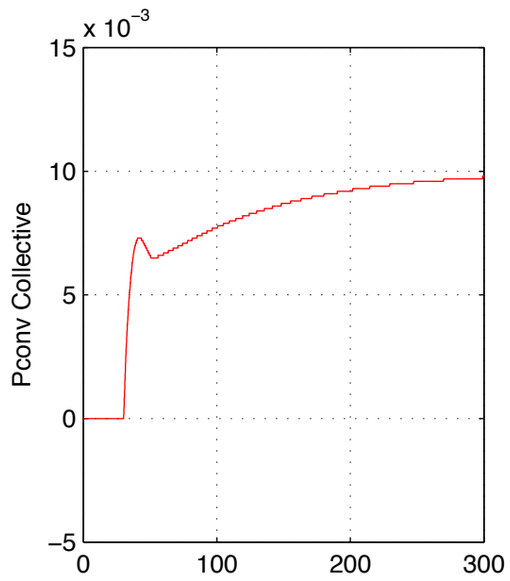
Requires units providing FRR to produce 7% (each unit) in 20 sec

This is better - but -

This level of primary and secondary response would be achievable only if ‘everything in every conventional plant worked perfectly’







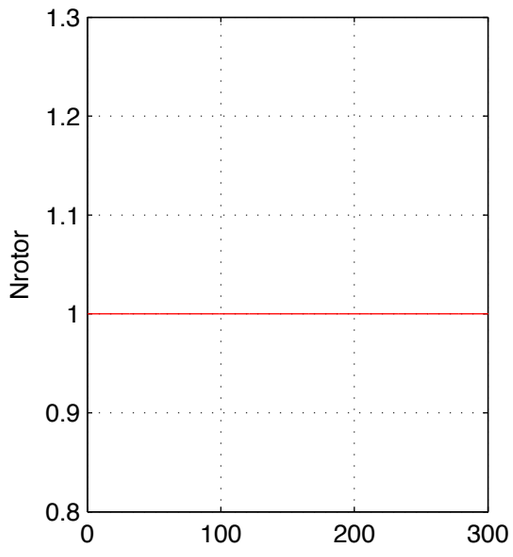
Case F

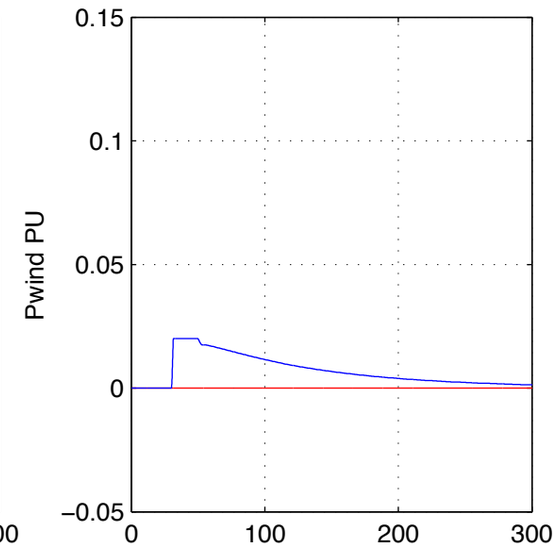
20% conventional regulating

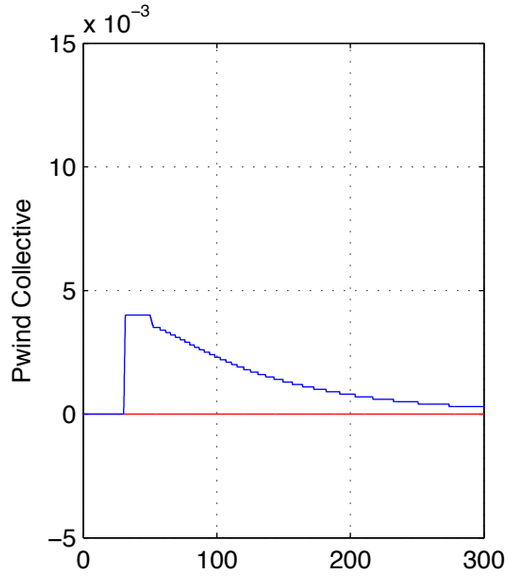
10% nonresponsive wind

20% wind operating below maximum and capable of sustained primary response (2%)

Frequency dips to 59.80





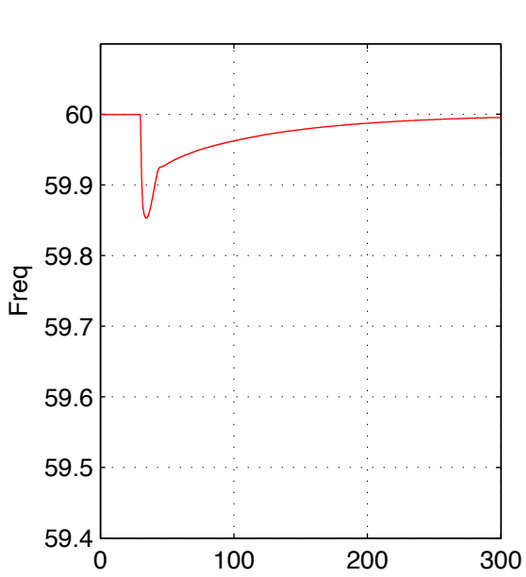


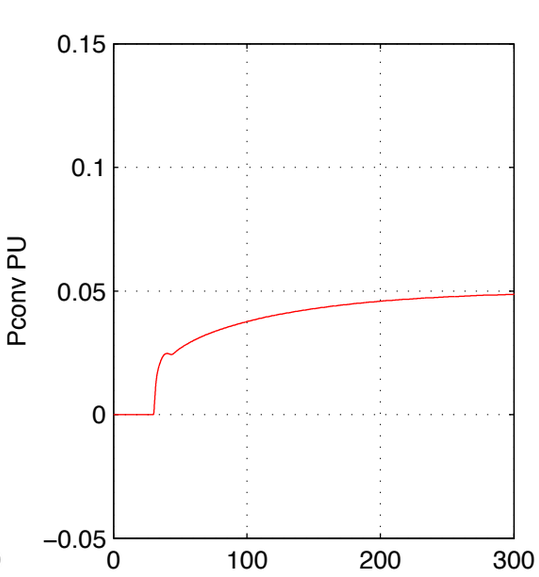
c2w021x2

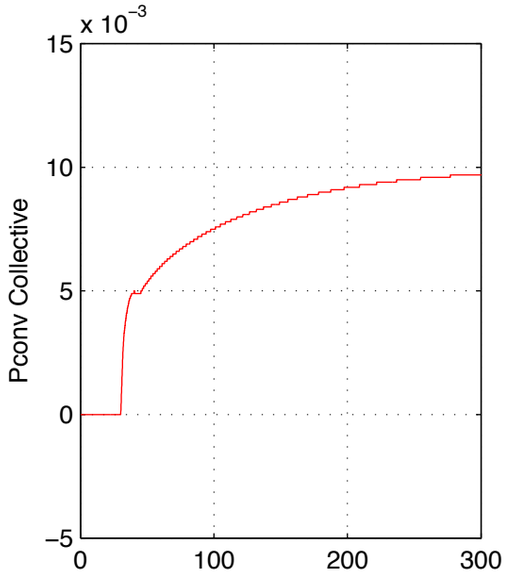
Requires units providing FRR to produce 3.6% (each unit) in 12 sec

This level of primary and secondary response would require diligence on the part of conventional plants and system dispatchers

Would need current-design governors in hydro plants to achieve this







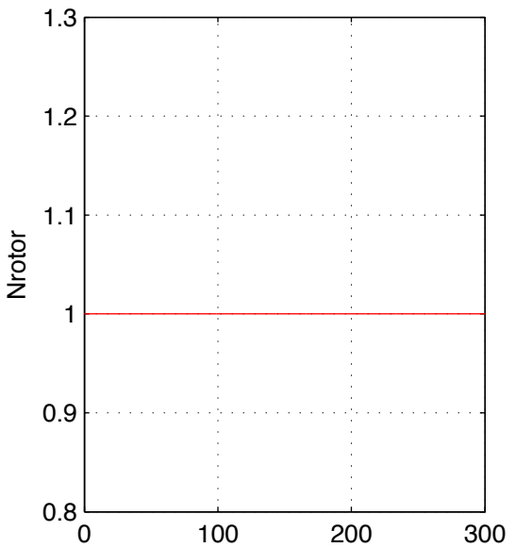
Case G

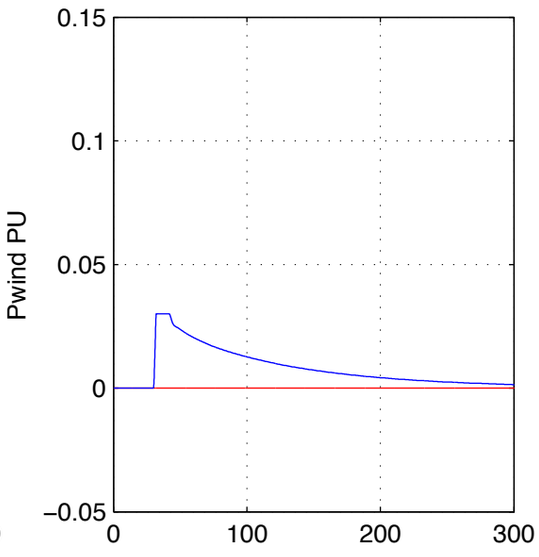
20% conventional regulating

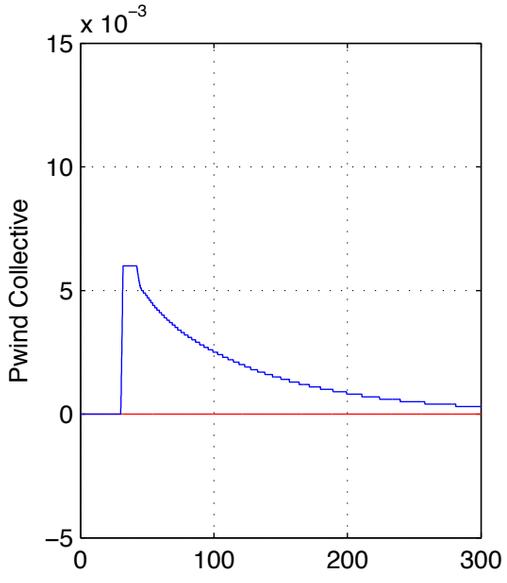
10% nonresponsive wind

20% wind operating below maximum and capable of sustained primary response (3%)

Frequency dips to 59.85







Response required of conventional plant is very manageable

c2w021x3

Indications at the Grid-wide Level

Inertia constant effect is visible but is not severe

Transient boost of output in lieu of sustainable primary response

- is essentially the same in grid terms as conventional plants with aggressive local load controllers
- benefit in primary response terms is at the cost of increasing demand on conventional plant for sustained primary response and secondary response

Sustainable primary response is necessary

- requires wind plant to operate normally below maximum output with headroom to sustain initial response
- or coordinated use of substantial energy storage (3-5% for 15 minutes)
- procurement of coordinated sustainable response from other sources

Typical requirement is for primary response to be sustained for 15 minutes

All/most plants should have demonstrated capability for sustainable primary response

- grid dispatch process must be able to call on plant to operate in sustainable response mode, as necessary