NATF Planning and Modeling Practices Group Update

April 25, 2019

NERC SAMS Meeting

Ed Ernst- NATF Program Manager

Activity Update

- Documents update (www.natf.net)
  - POSTED
    - NATF Reference Document: Relay Performance During Stable Power Swings(PRC-026-1) Evaluation Tools Reference Document
  - IN DEVELOPMENT
    - Facility Ratings (FAC-008-3) Reference Document
    - Resiliency and Transmission Planning Reference Document
- 2019 Joint NATF-NERC-EPRI Planning and Modeling workshop
  - Dates: June 18-19, 2019
  - Host: ITC
  - Location: Novi, MI (Detroit area)
  - Registration: Sold out. Waiting list formed
- April 3-4, 2019 NATF,ERPI,NERC Transmission Resiliency Development
  - 200+ attendees
  - Working with NERC to post presentations on NERC.com site
  - Key take-aways:
    - Collaboration is key to advancing on Resiliency - Between utilities, sectors, industry-government, etc.
    - Must think about coordinated attacks vs. threats in silos
    - Keys to success: Partnerships and collaboration; Information sharing; Documentation; Drills and training; Resilient communications must be a top priority; Research and Development

Coordination between NATF and NERC

- Document development
- Jointly Sponsored Modeling Workshops
  - June 2017 - Exelon(Com Ed) in Chicago
  - June 2018 - AEP in New Albany, Ohio (Columbus, Ohio area)
  - June 2019 - ITC in Novi, Michigan (Detroit area)
- Joint EPRI/NATF/NERC/UVIG Inverter-Based Resources webinar series
- Regular NATF-NERC meetings at CEO level to coordinate efforts
- Ryan Quint of NERC staff has standing slot on Monthly NATF Practice Group calls to cover topics as needed
- Ed Ernst has standing slots on SAMS calls to cover topics as needed

NATF Planning and Modeling Practices Group Update

Questions?

NERC
NORTH AMERICAN ELECTRIC
RELIABILITY CORPORATION

Node-Breaker Modeling Group Report

System Analysis and Modeling Subcommittee Meeting

Evan Shuvo and Neeraj Lal

April 24-25, 2019

RELIABILITY | ACCOUNTABILITY




Phase II Scope Overview

Purpose

- The Node Breaker Modeling Group (NBMG) shall update an Eastern Interconnection wide planning model to include node breaker representation and report experiences to and as guided by NERC System Analysis and Modeling Subcommittee (SAMS) using PSS®E software by PTI Siemens.

Responsibilities and Activities

- Check established case creation metrics or data quality checks to identify any issues in the node breaker representation
- Compare the node breaker representation conditions with the bus branch conditions (e.g., line flows, bus voltage magnitudes, etc.)
- If applicable, try conversion between software programs (e.g., PSLF to PSS/E)
- Contingency analysis
- Transient stability analysis

- Phase II - Contingency Analysis Progress
  - ACCC Issues and Observations
    - The default for the command to run all NB contingencies is to look for the next breaker up to 4 levels away (10 levels is the maximum)
    - PSSE V34.5.1 has an automatic command to use node-breaker information to create breaker to breaker contingencies.
      - ACCC produces duplicate results for branches with non-breakered taps/nodes.
      - Erroneous feedback messages in V34.5.1 – fixed in V34.6 – testing required
    - PSSE V34.5.1 does not have an automatic command to enforce monitoring node-breaker nodes. The monitoring of each node must be specified in the Monitored Element file in both forward and reverse directions.
    - Bus-branch and node-breaker thermal loading results for some substations with breaker-and-a-half configurations do not match.
      - Fixed in V34.6 – testing required

- SPP Activities
  - Doug Bowman

- NERC 2013 Node-Breaker Proposal
  - Dated November 12, 2013
  - Approved by Planning Committee on December 10, 2013
  - Dates of implementation originally developed by SAMS
  - Transition to the use of node-breaker models for off-line studies
    - From Page 2: “Initially the interconnection-wide cases could continue to be developed using the current bus-branch level of detail, with the node-breaker detail maintained by the Planning Coordinators. In that way, a user of the interconnection-wide case could “cut in” the node-breaker details of its own system for use in their studies, while the rest of the system retains a bus-branch level of detail. It should be noted that the node-breaker data for the entire interconnection will eventually need to be developed and maintained by interconnection model developers.”

Next Steps

- NBMG Recommendations to SAMS
  - NBMG will continue with planned activities
  - Recommend NERC SAMS consider reviewing 2013 Proposal
    - As a group or,
    - Develop a sub-team independent of NBMG
    - Review with a focus on current state of industry and technology
  - NBMG has prepared scenarios for consideration
    - Available to share with SAMS or sub-team
  - Provide recommendation at next SAMS meeting
    - Should 2013 proposal be modified?

Questions and Answers

Renewable Integration Impact Assessment

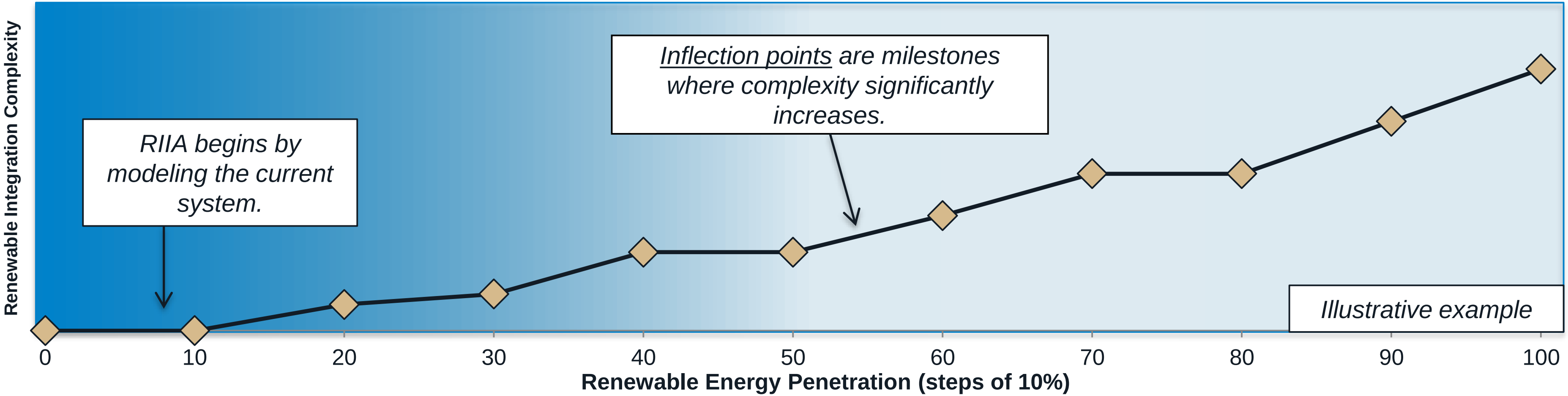
Finding integration inflection points of increasing renewable energy

NERC SAMS Meeting
April 24-25, 2019

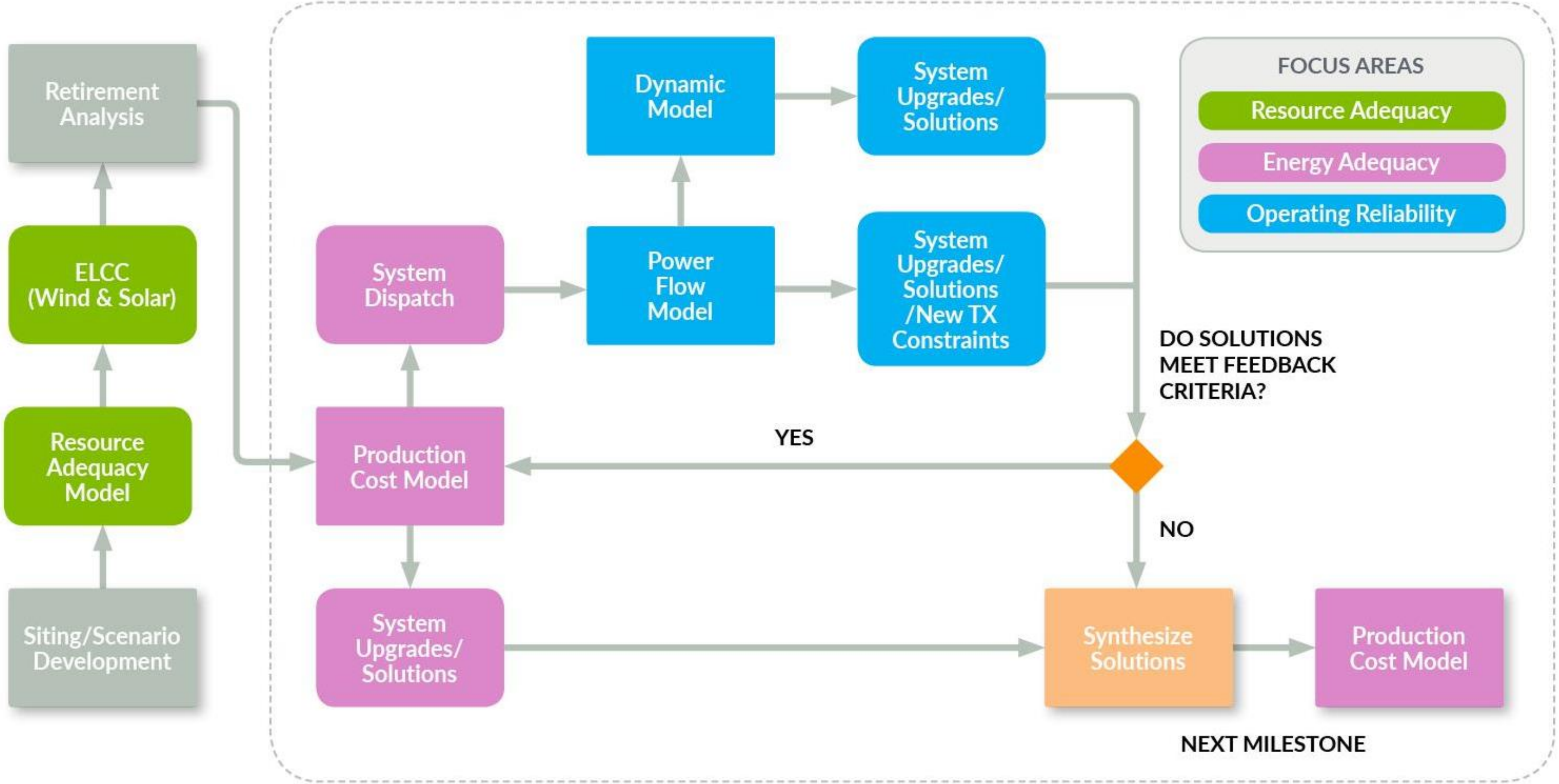
Objective

- MISO is conducting Renewable Integration Impact Assessment (RIIA) to find inflection points of renewable integration complexity
- First round of results were presented at NERC SAMS meeting on Nov 08, 2018
- Update the group on results for penetration up to 40% (energy-wise) with focus on frequency response.

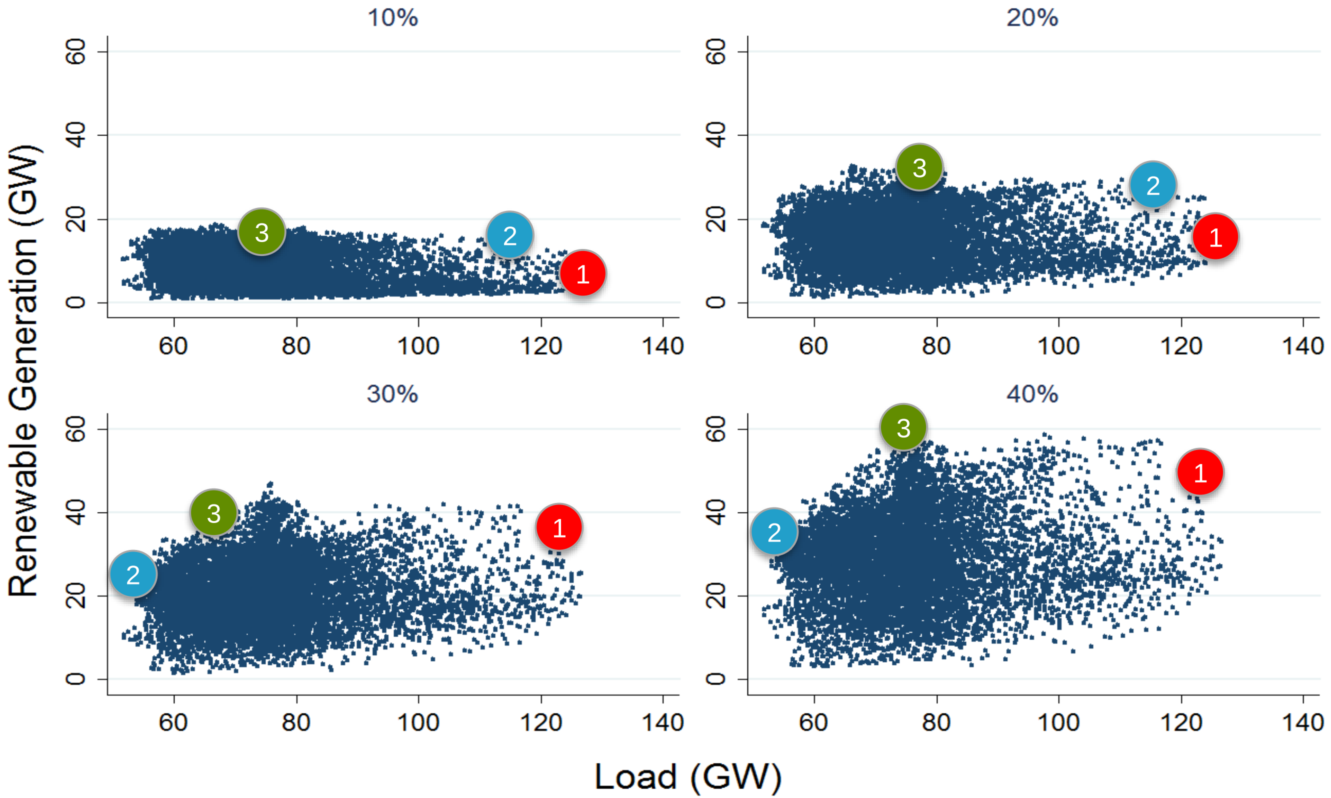
Renewable Integration Impact Assessment (RIIA) seeks to find inflection points of renewable integration complexity



Results are driven by a robust assessment process



Traditional points of transmission stress are changing as renewable penetration grows



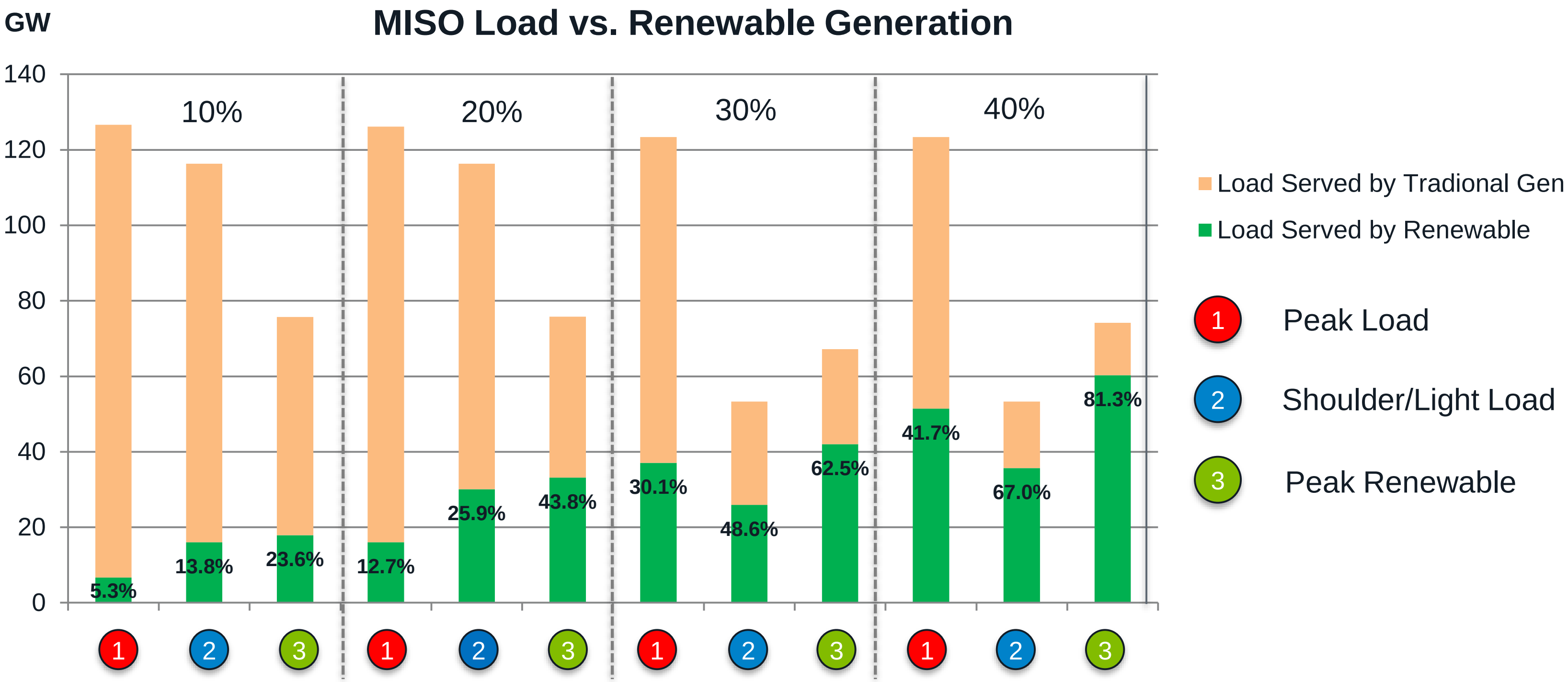
1 **Peak Load:**
Peak load with highest renewables

2 **Shoulder/Light Load:**
Shoulder load for 10%-20% milestone.
Lowest load with highest renewables for 30-40%.

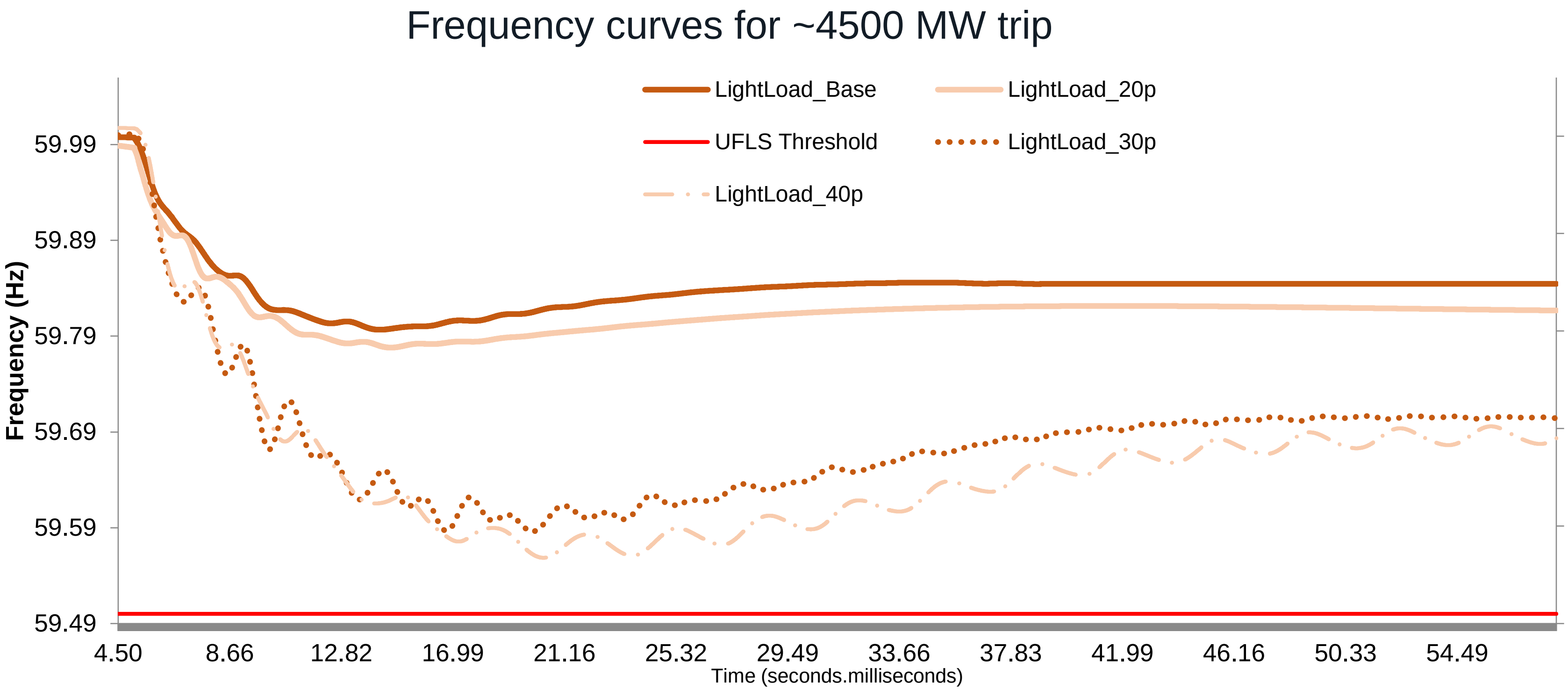
3 **Peak Renewable**
Highest renewables with lowest load

MISO

Operating Reliability analysis was conducted on instantaneous renewable penetration snapshots from 5% to 82%

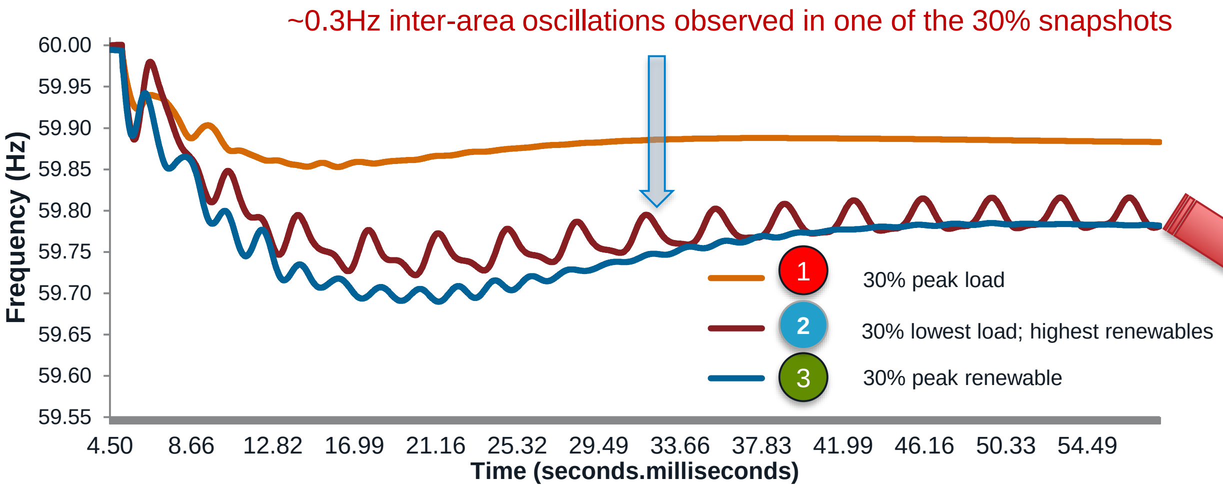


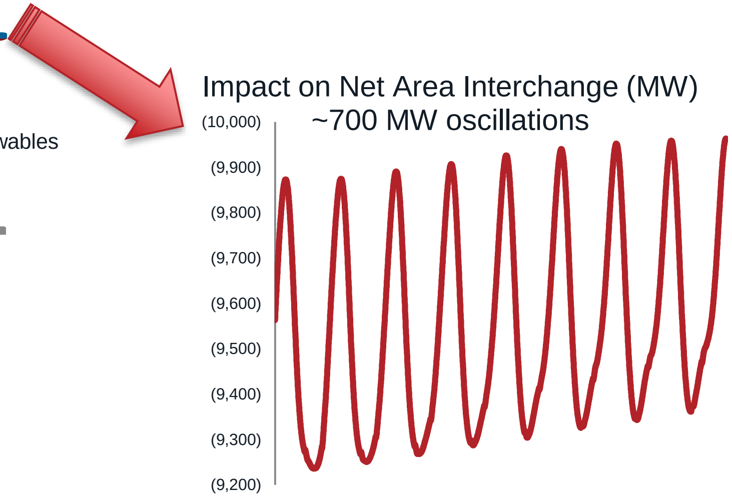
Frequency response declines as the renewable penetration increase, but system remains stable for large generator disturbance



**No headroom on renewable resources assumed*

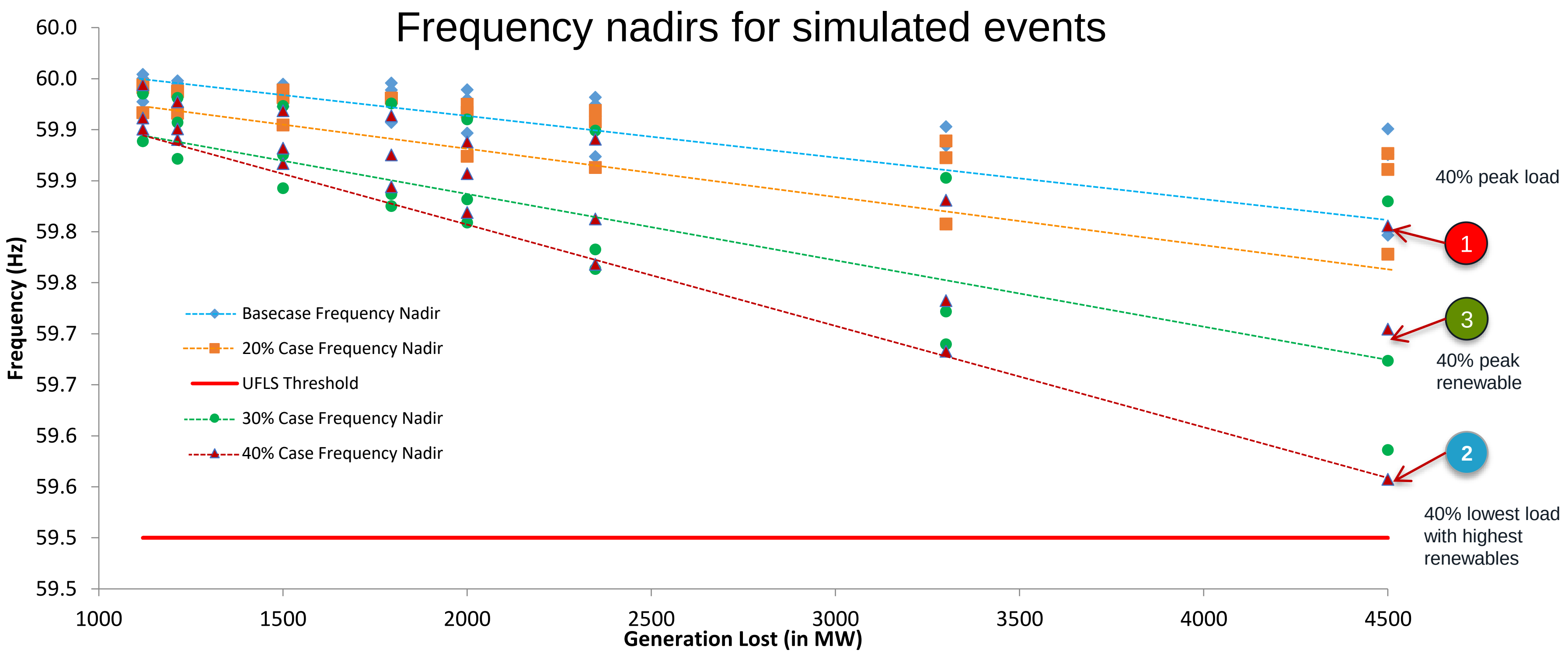
Large scale stability issues may occur due to Unit commitment and dispatch variation





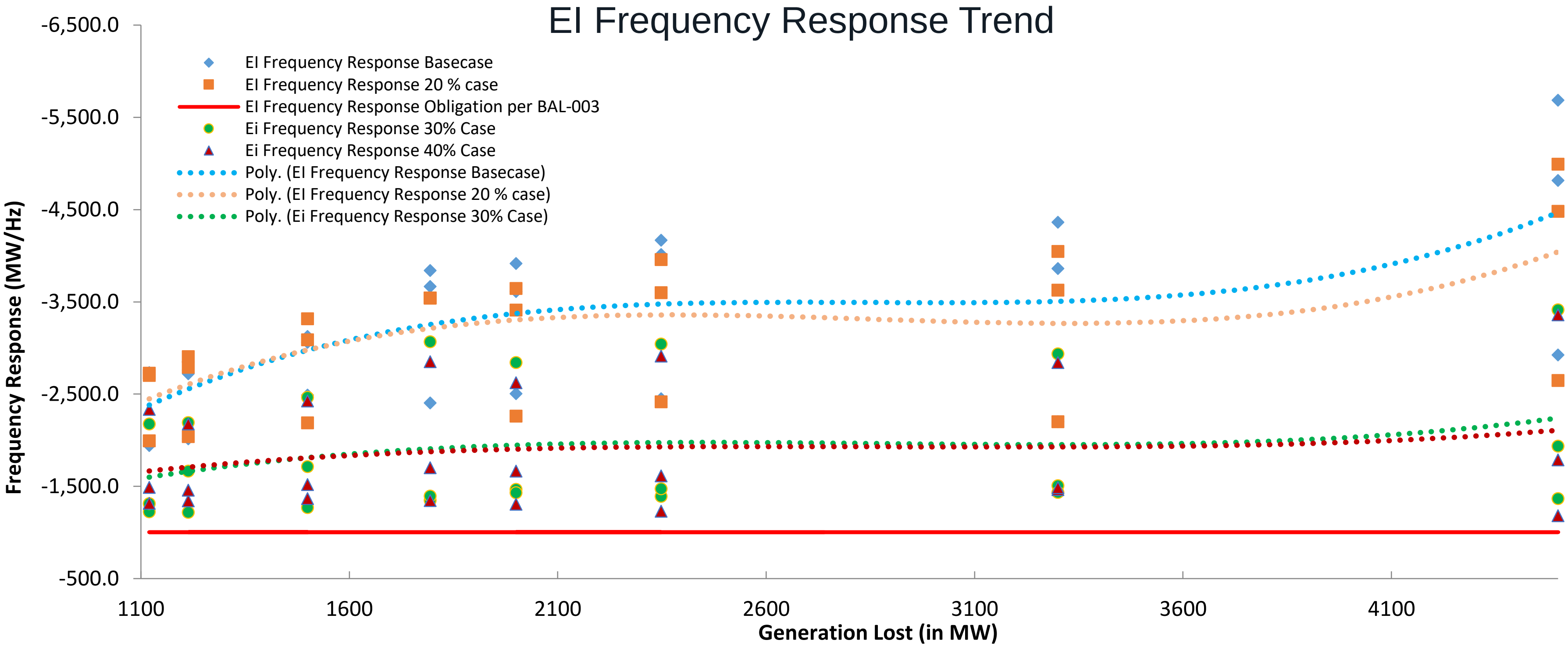
Power system stabilizer may be required to reliably operate the system

Hours of high renewable penetration during lowest load become significantly important for frequency stability



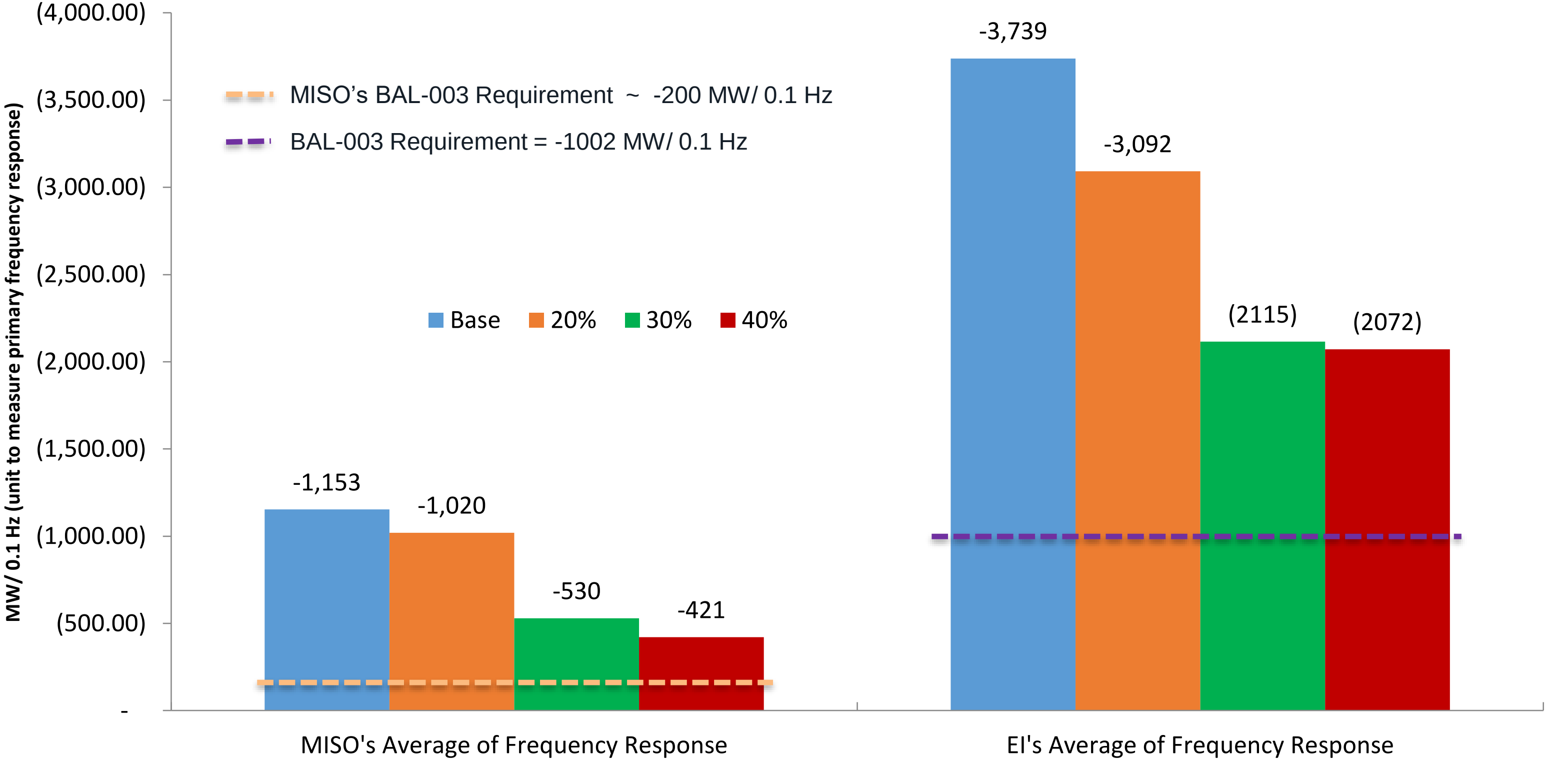
**No headroom on renewable resources assumed*

Primary frequency response significantly decreases with higher penetration of renewables*

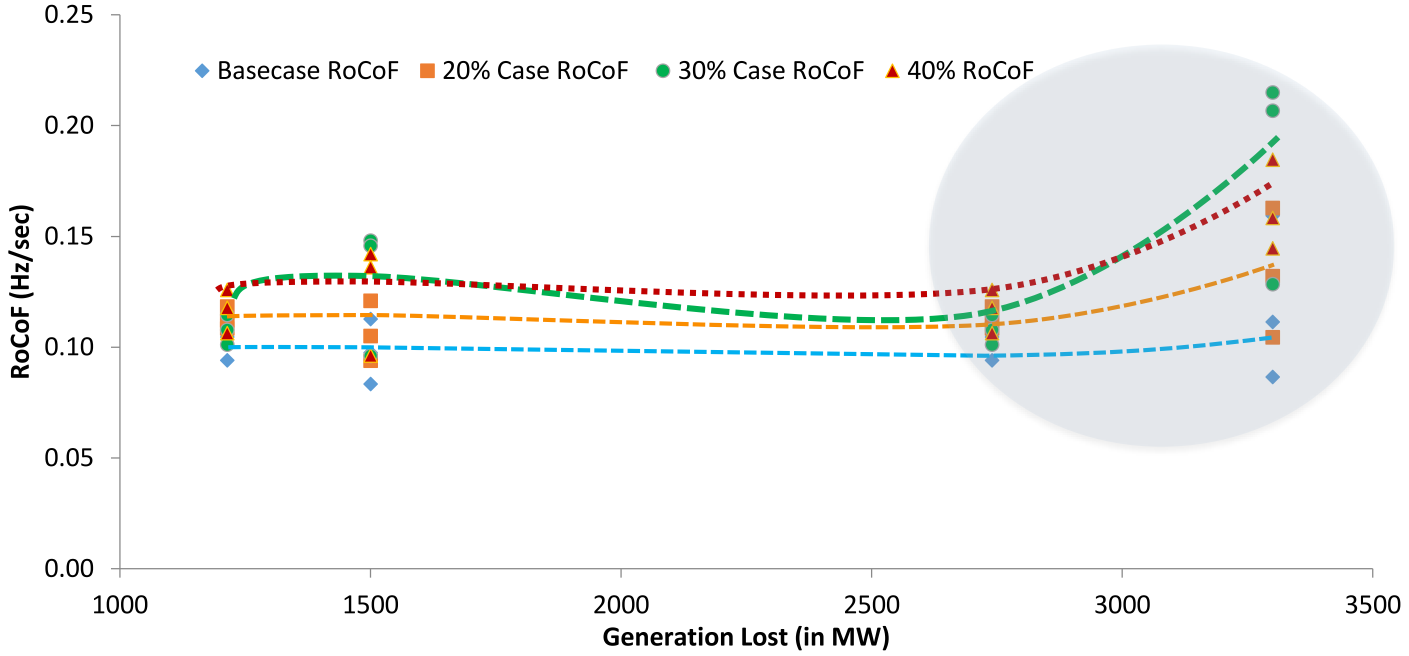


*No headroom on renewable resources assumed

Average primary frequency response for MISO's and Eastern Interconnection is acceptable up to 40%

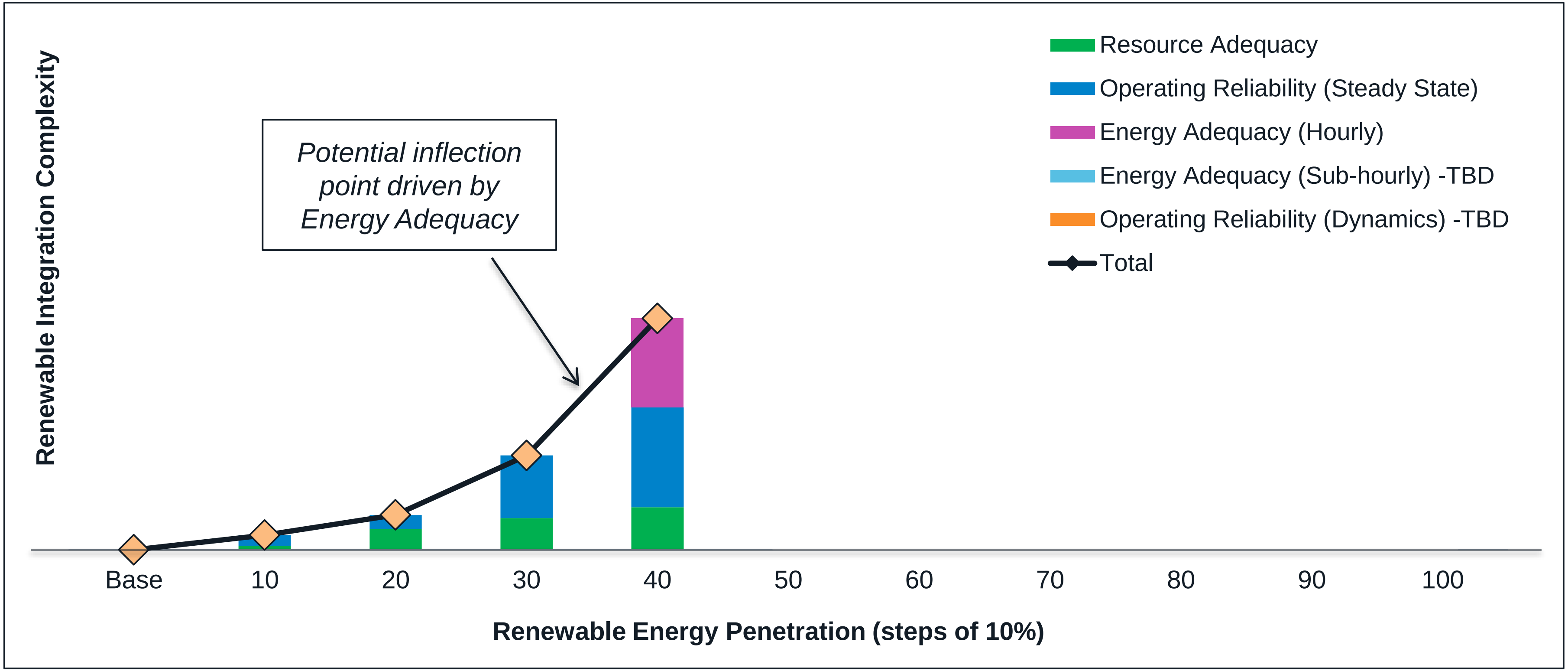


Large events occurring during high renewable penetration demonstrate a non-linear behavior of RoCoF metric

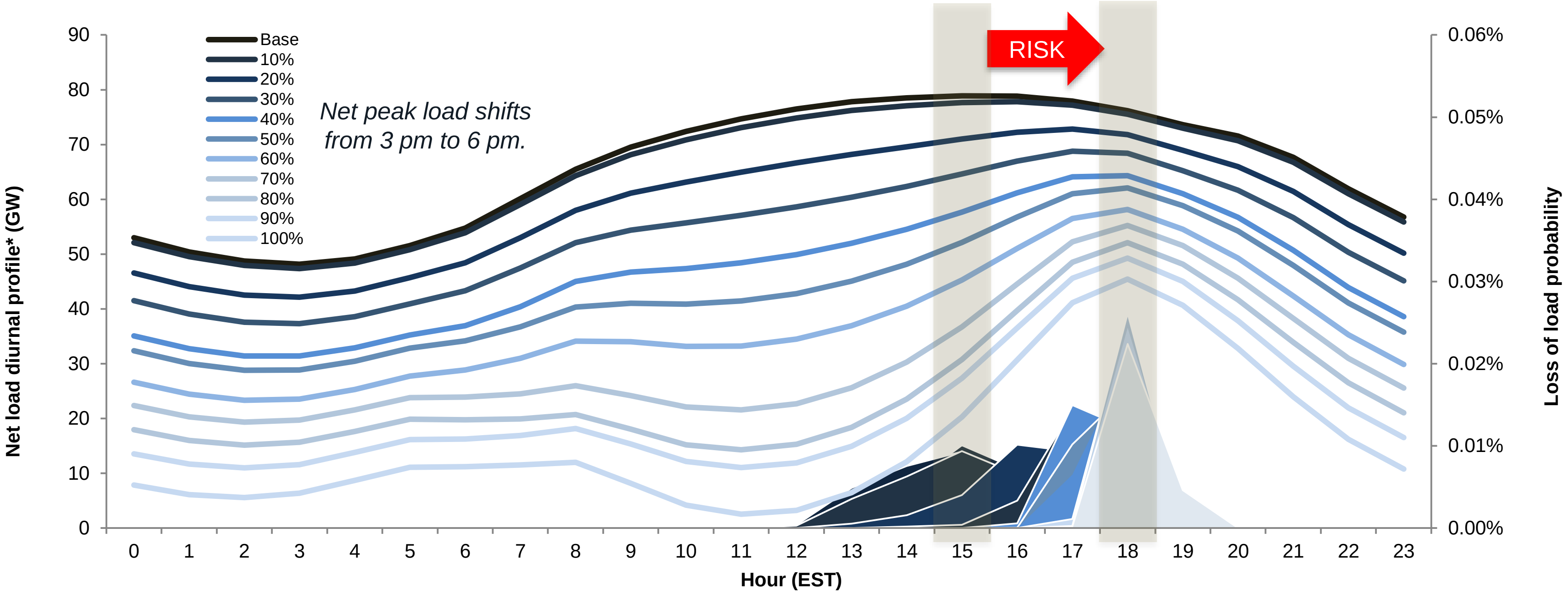


OTHER FINDINGS OF THE ASSESSMENT

Interim results indicate integration complexity increasing sharply from 30 - 40% renewable penetration



As renewable penetration increases, the risk of losing load shifts and compresses to a smaller number of hours



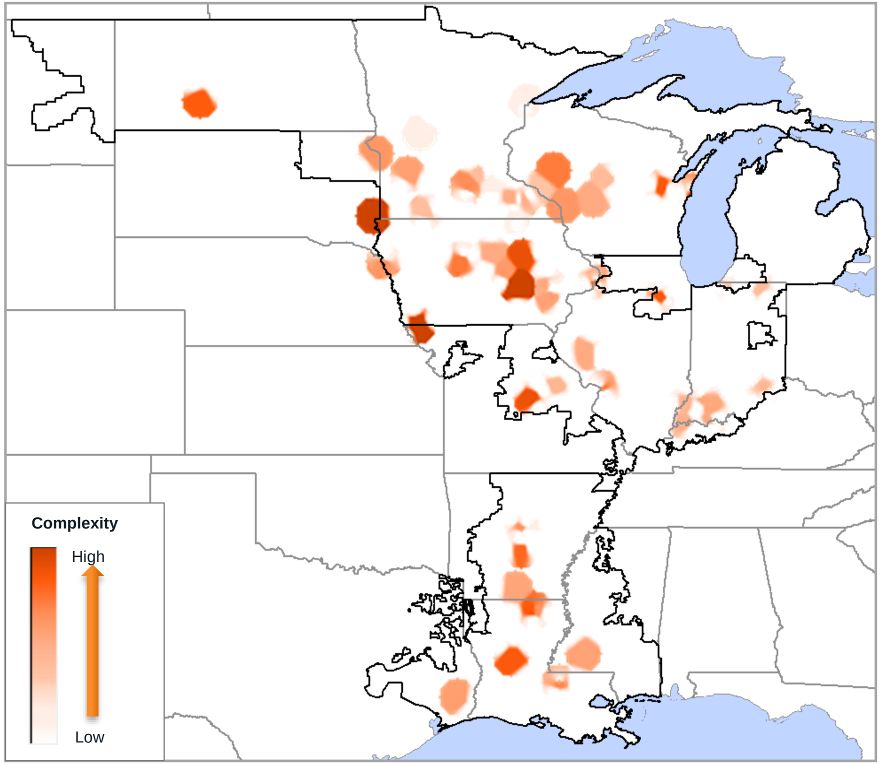
- Probability of losing load is targeted at one day in ten years over all penetration levels.
- While aggregate risk remains constant, the risk in particular hours increases.

*Profile shapes represent hourly averages across all days of the 6 study years.

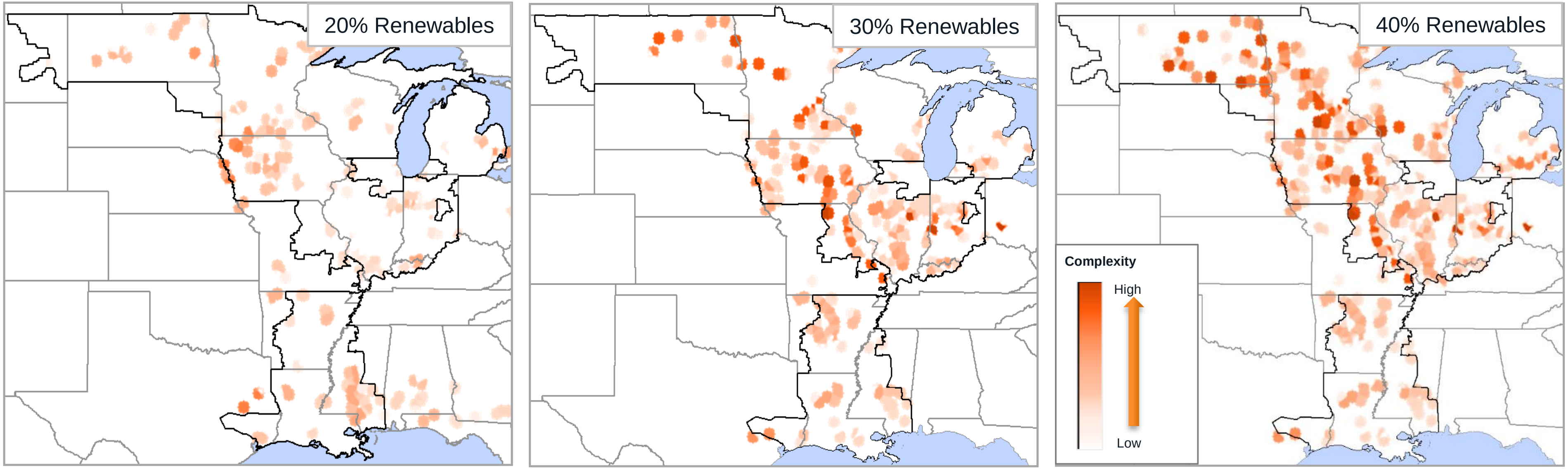
Energy adequacy solutions are needed at the 40% milestone to utilize the diverse variable resources across the footprint

- Introduced new transmission expansion optimization technique to develop solutions
- Evaluated 11,300 transmission candidates in MISO and selected ~80 cost effective solutions

Renewable Energy Curtailment			
	Base	w/ EA* solutions	w/ EA and OR** solutions
40%	18.2%	9.6%	9.2%
Renewable Energy Penetration			
40%	34.7%	38.4%	38.5%

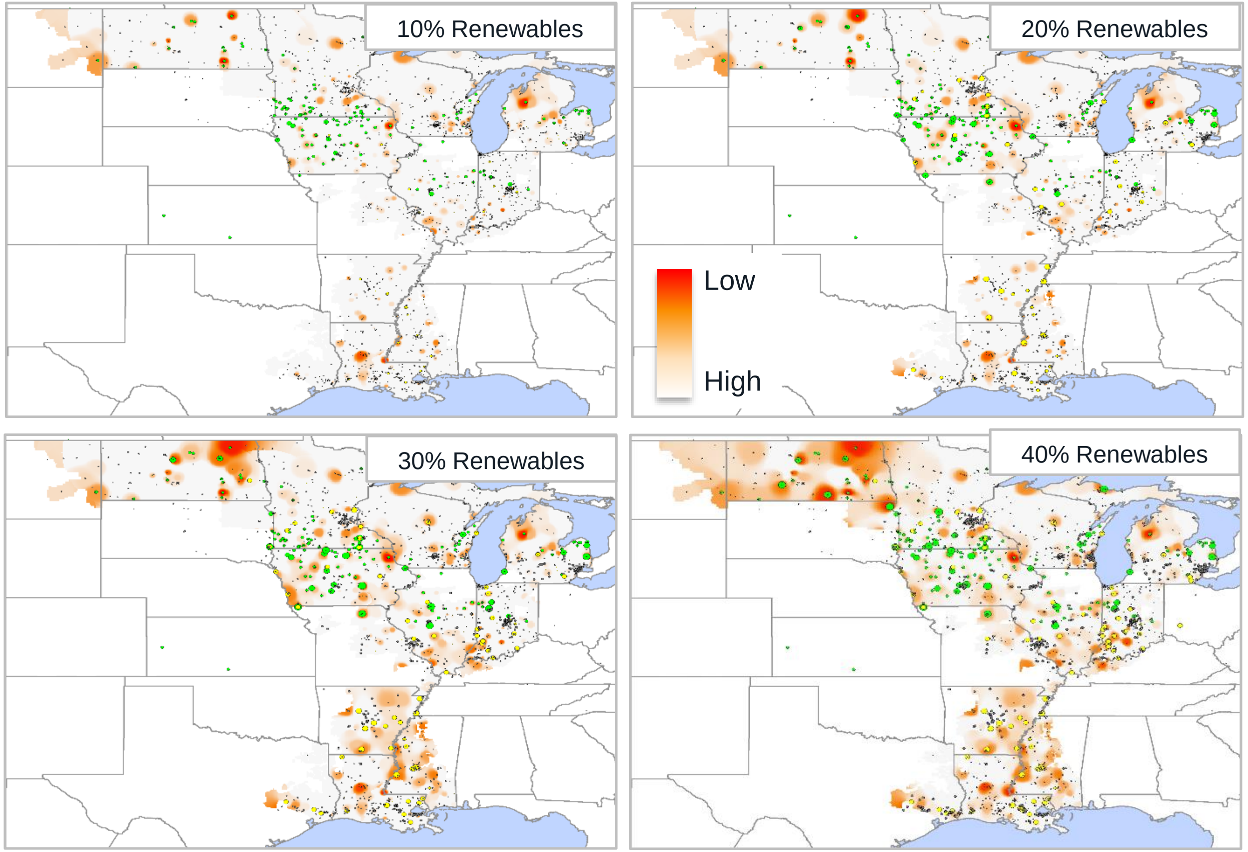


Steady state solution complexity increases with penetration level



- Integration complexity is measured as the approximate cost of the transmission fixes needed for steady state reliability issues
- The majority of the integration cost is from fixes for transmission thermal violations
- Represents cumulative expansion over the penetration levels

Potential system stability issues greatly increase at 40% penetration



- Heat map shows Short Circuit Ratio (SCR), which is an indicator of the system's strength to deal with disturbances
- RIIA uses a Weighted Short Circuit Ratio (WSCR) as it better captures systems with higher renewable penetrations

By examining increasing penetrations of renewables, several key takeaways have been thus far found

1. Risk of losing load compresses into a small number of hours and shifts to later in the day
2. Energy adequacy solutions are needed at the 40% milestone to utilize the diverse variable resources across the MISO footprint
3. Primary frequency response decreases significantly, but remains acceptable up to 40% renewable penetration
4. A host of steady-state, dynamic issues will need to be resolved to achieve higher penetration of renewables

Questions?

All RIIA-related documents can be found on MISO's web page.
Home > Planning > Transmission Planning Studies and Reports > Renewable Integration Impact Assessment

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PSSE – PSCAD Comparison Case Study

NERC SAMS Meeting

4-25-2019

Rob O'Keefe & Kiril Andov

Reason for PSCAD Benchmark of PSSE

Assurance of proper evaluation of

- **Stability**
- **Ride-through**

in view of unavoidable simplifying assumptions in a positive sequence simulation platform

August – October 2017 SSO Events

2018 CIGRE GOTF Paper:

Simulation of 2017 Wind Farms into Series Capacitor Sub-Synchronous Oscillation Events

R. O'Keefe, E. Rezaei, K. Andov, Y. Gong

American Electric Power

USA

Y. Cheng, J. Rose

Electric Reliability Council of Texas

USA

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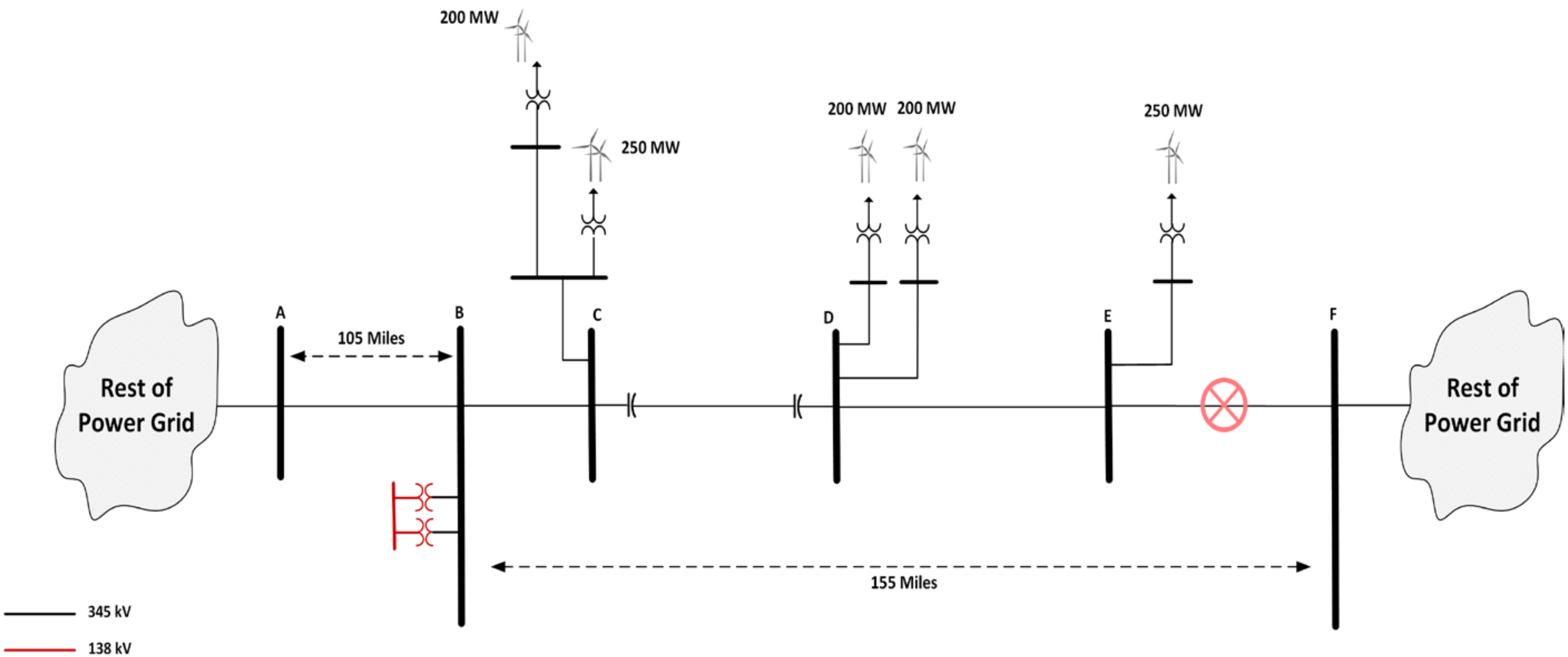
November 5, 2018 SSO Event



Phase-ground fault-trip line E–F

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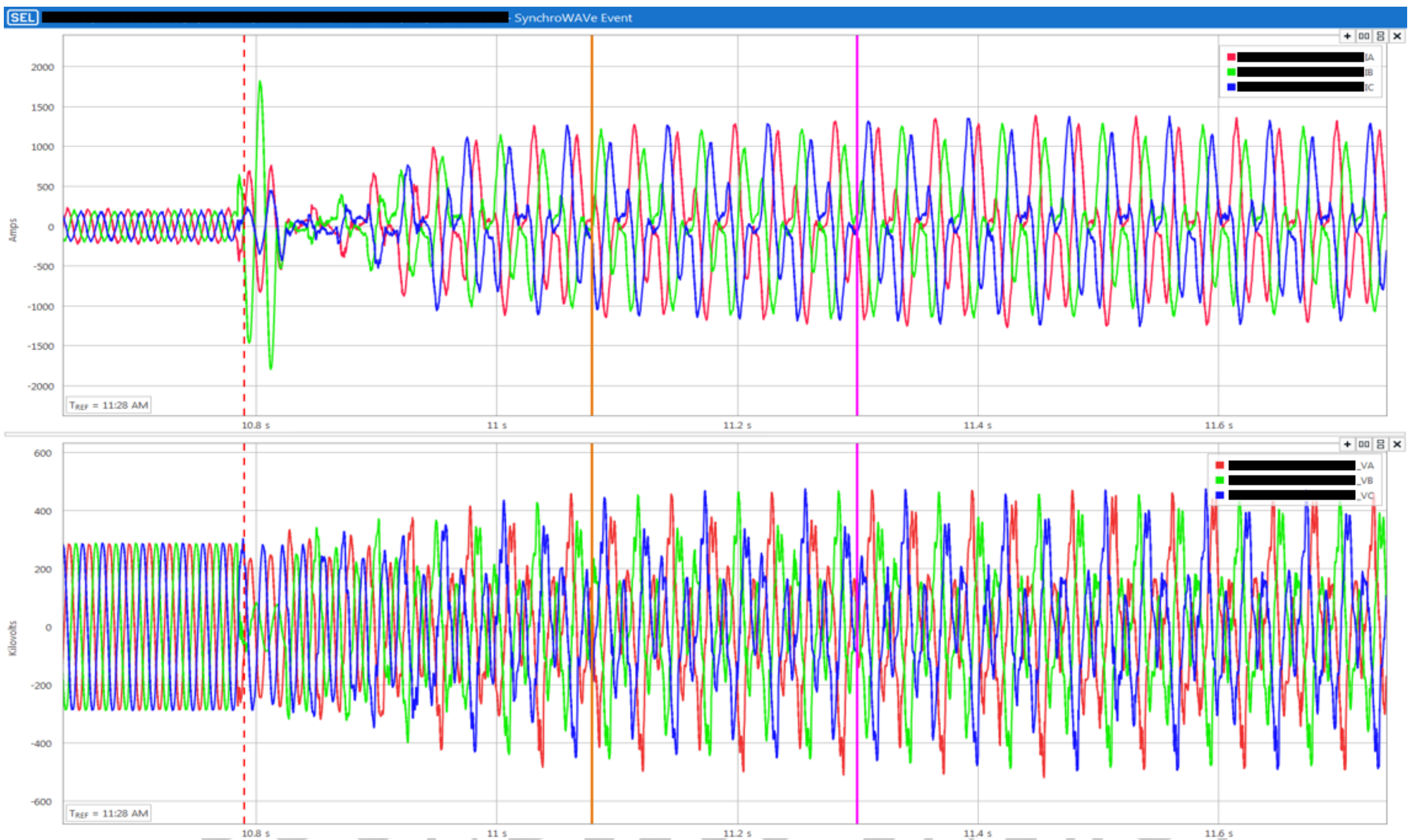
November 5, 2018 SSO Event

Station E to WF 3-phase currents / WF POI 3-phase voltage



November 5, 2018 SSO Event

Latest PSCAD model packages not showing any indication of SSCI

Wind machine control software updates made early 2019

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Comparison Details

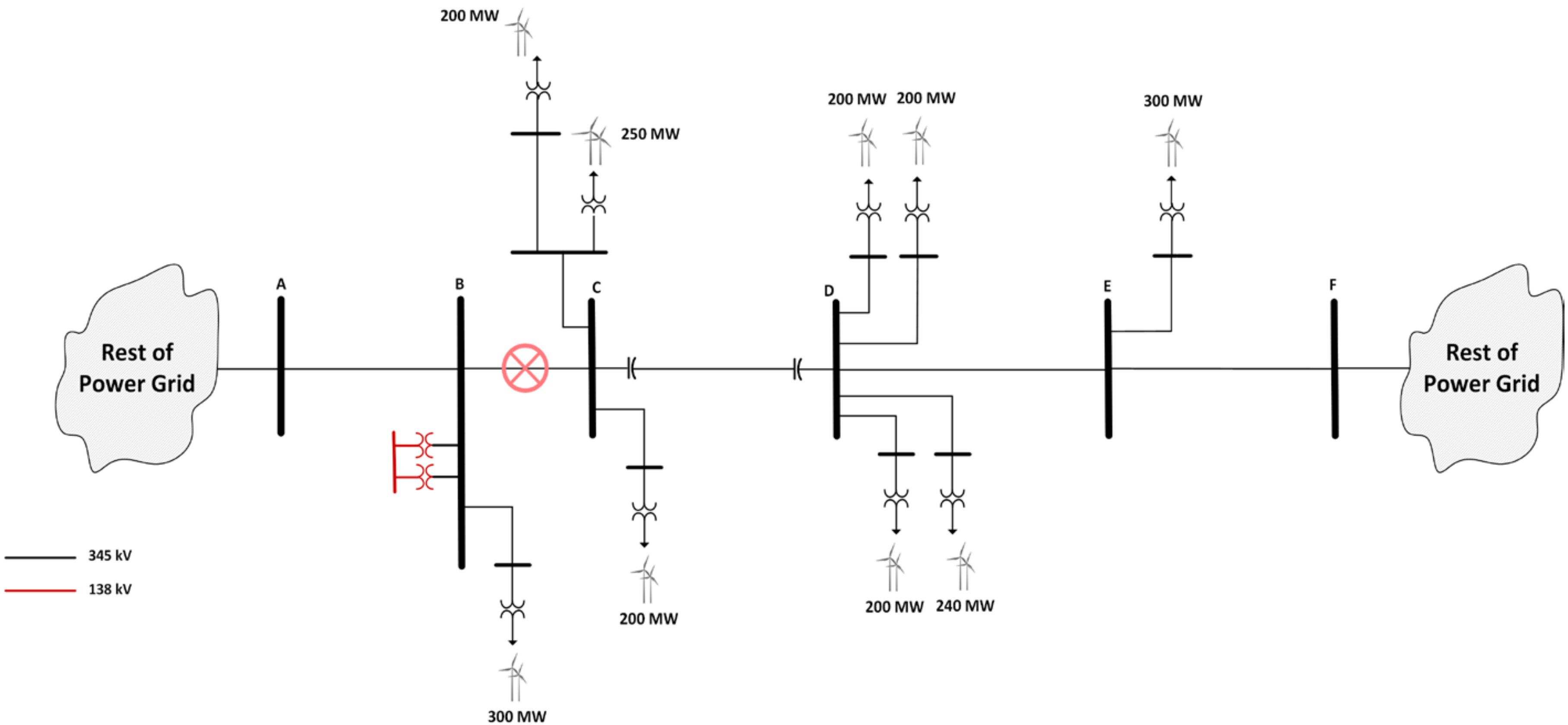
PSSE

- ~7900 bus interconnection dynamics case
- Vendor supplied user-defined WF modeling

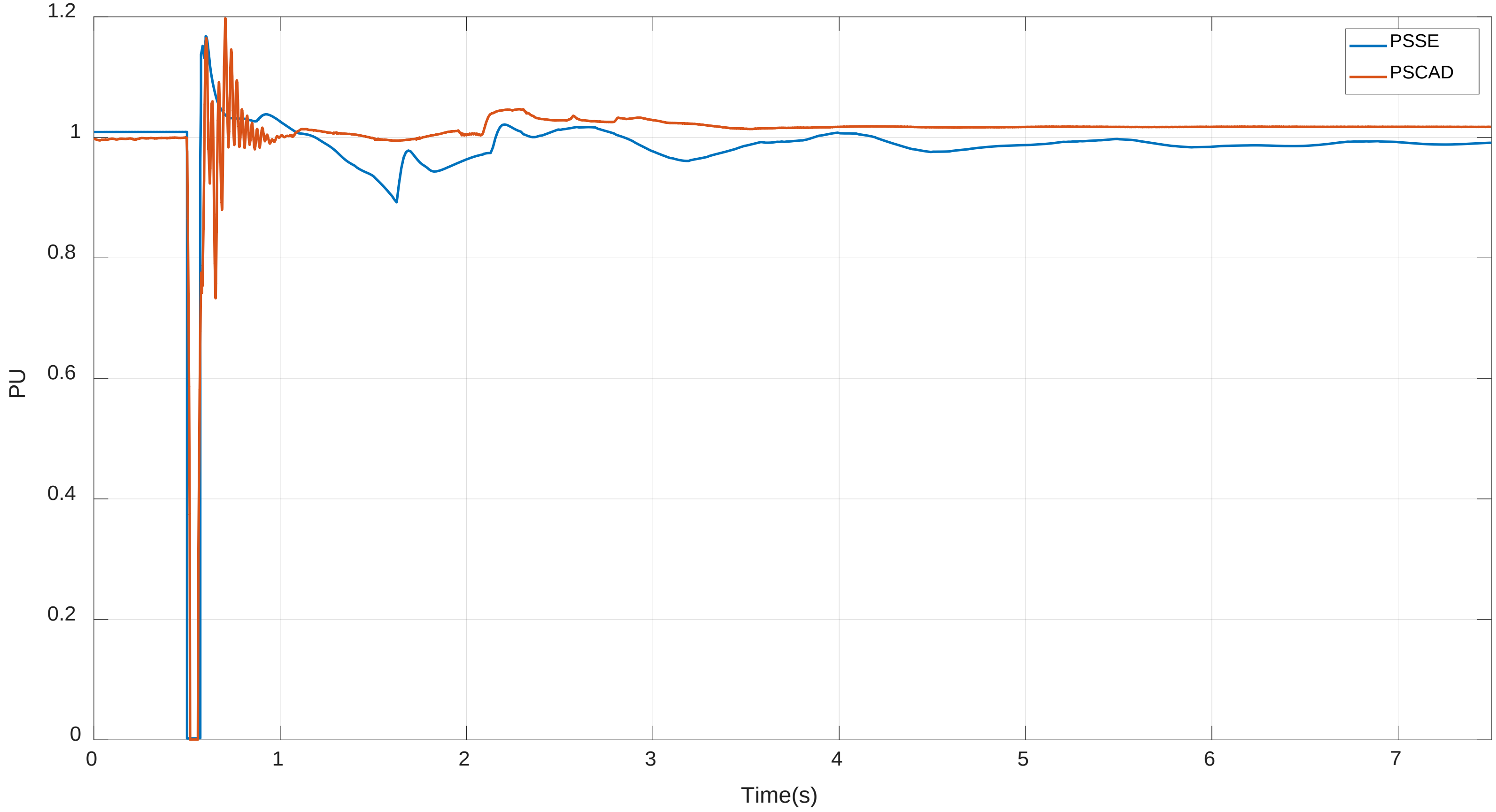
PSCAD

- 125 system and network equivalent buses
- Network converted directly from PSSE case via E-TRAN
- Vendor supplied WF modeling merged via E-TRAN substitution library

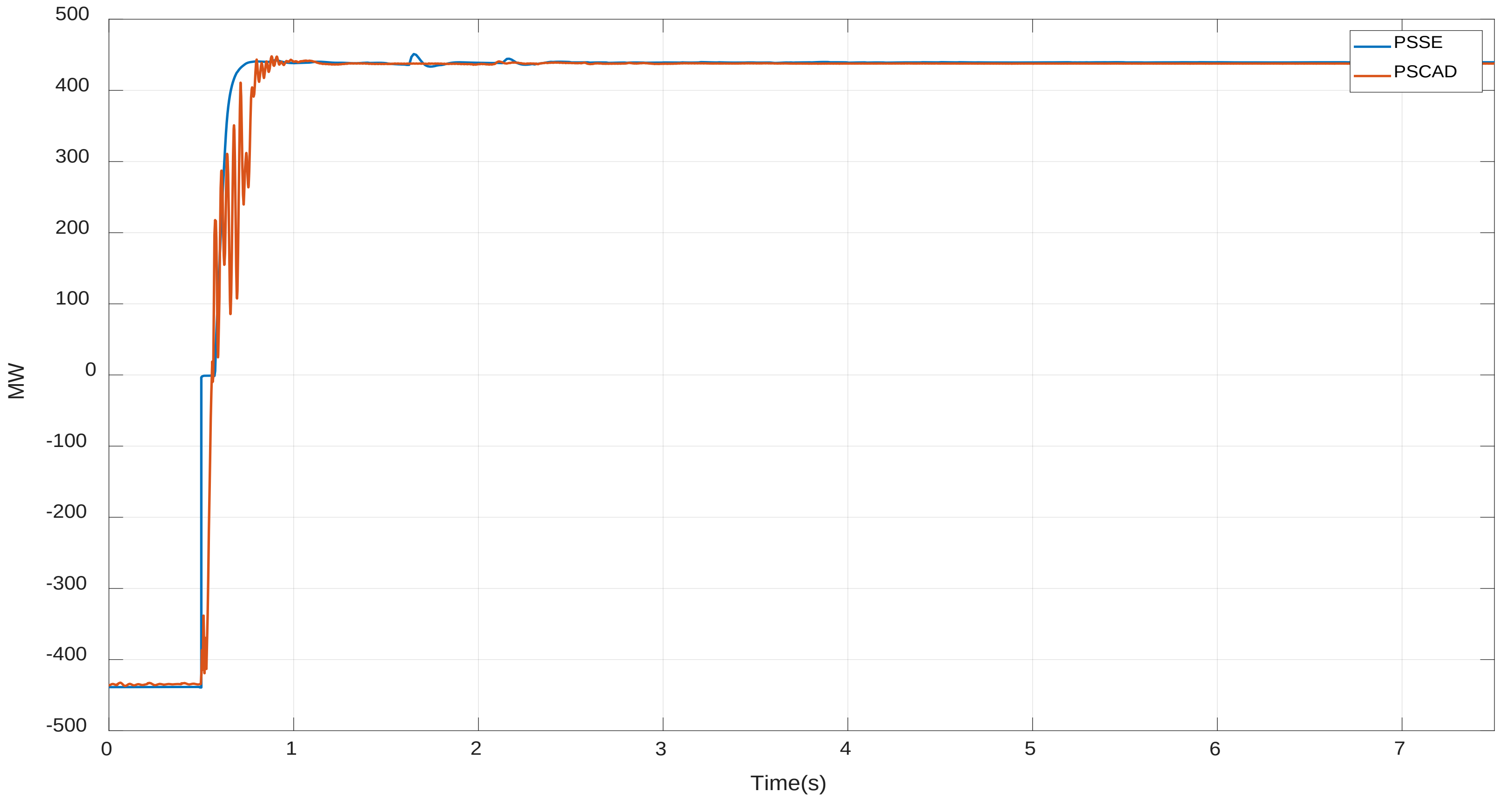
Case 1 – B-C 3-phase fault-trip 450 MW of wind generation through 2 series caps



Station C per unit RMS V



Station C to Station D MW



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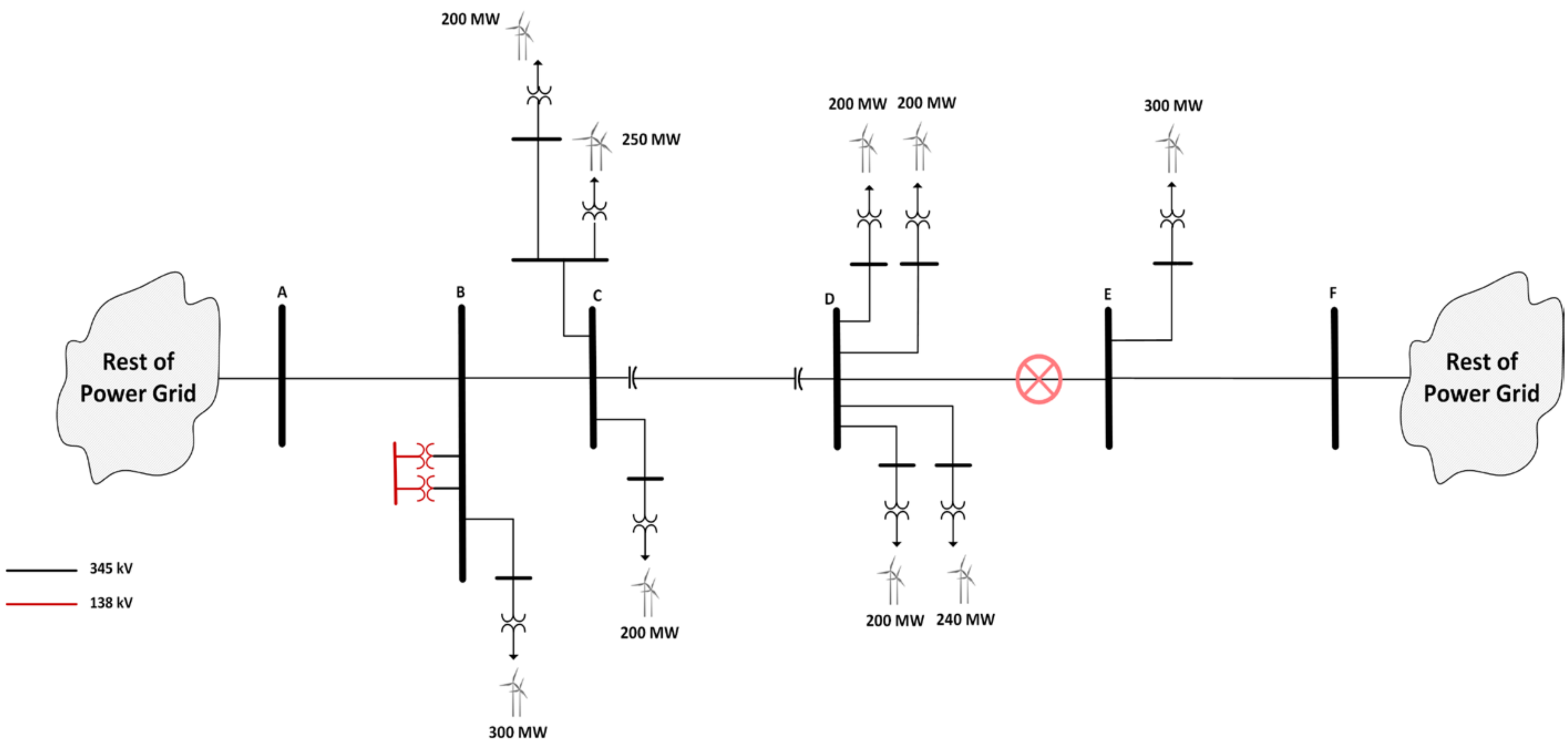
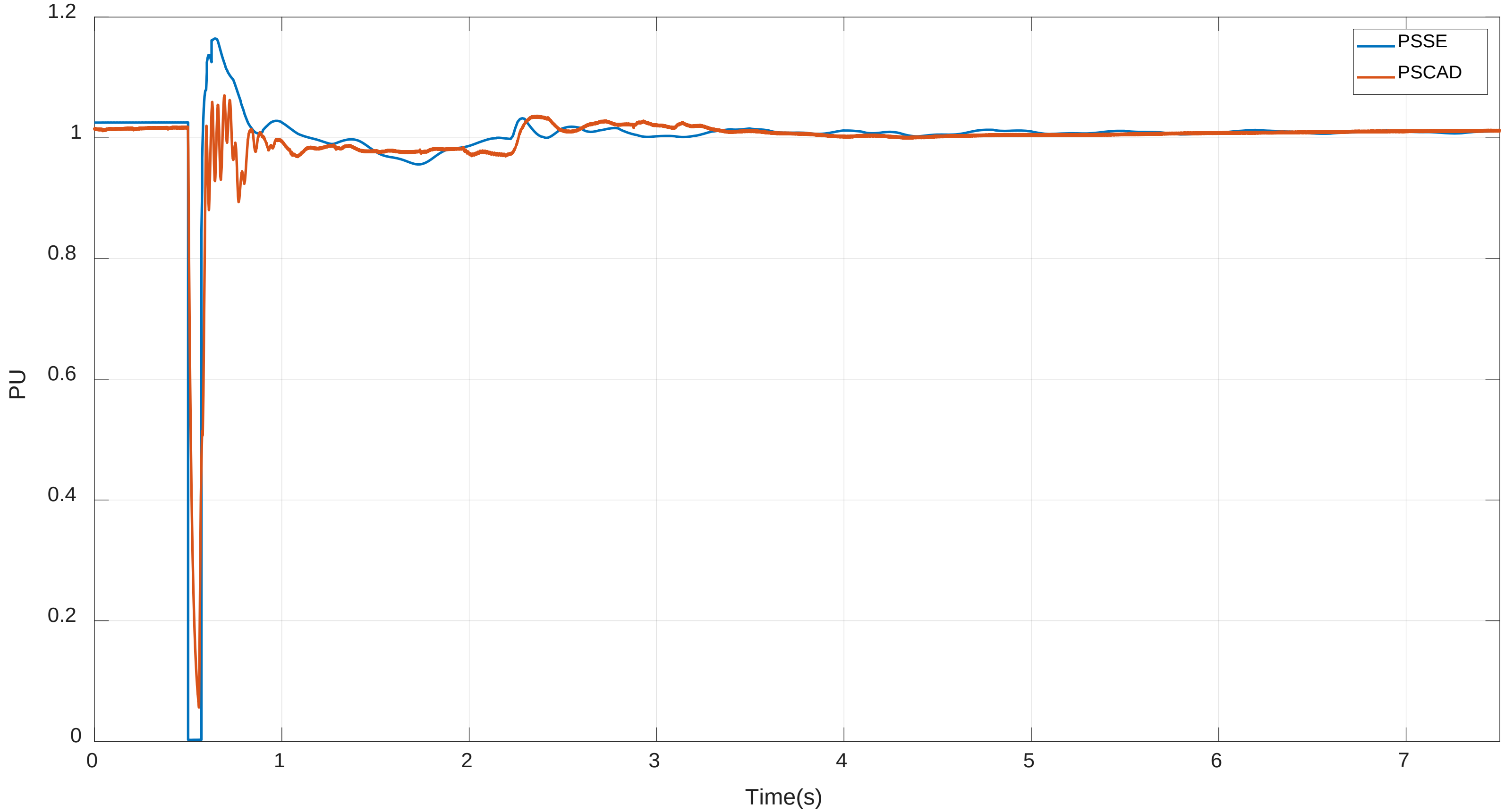
Case 2 – D-E 3-phase fault-trip 837 MW of wind generation through two series caps



Station D per unit RMS V



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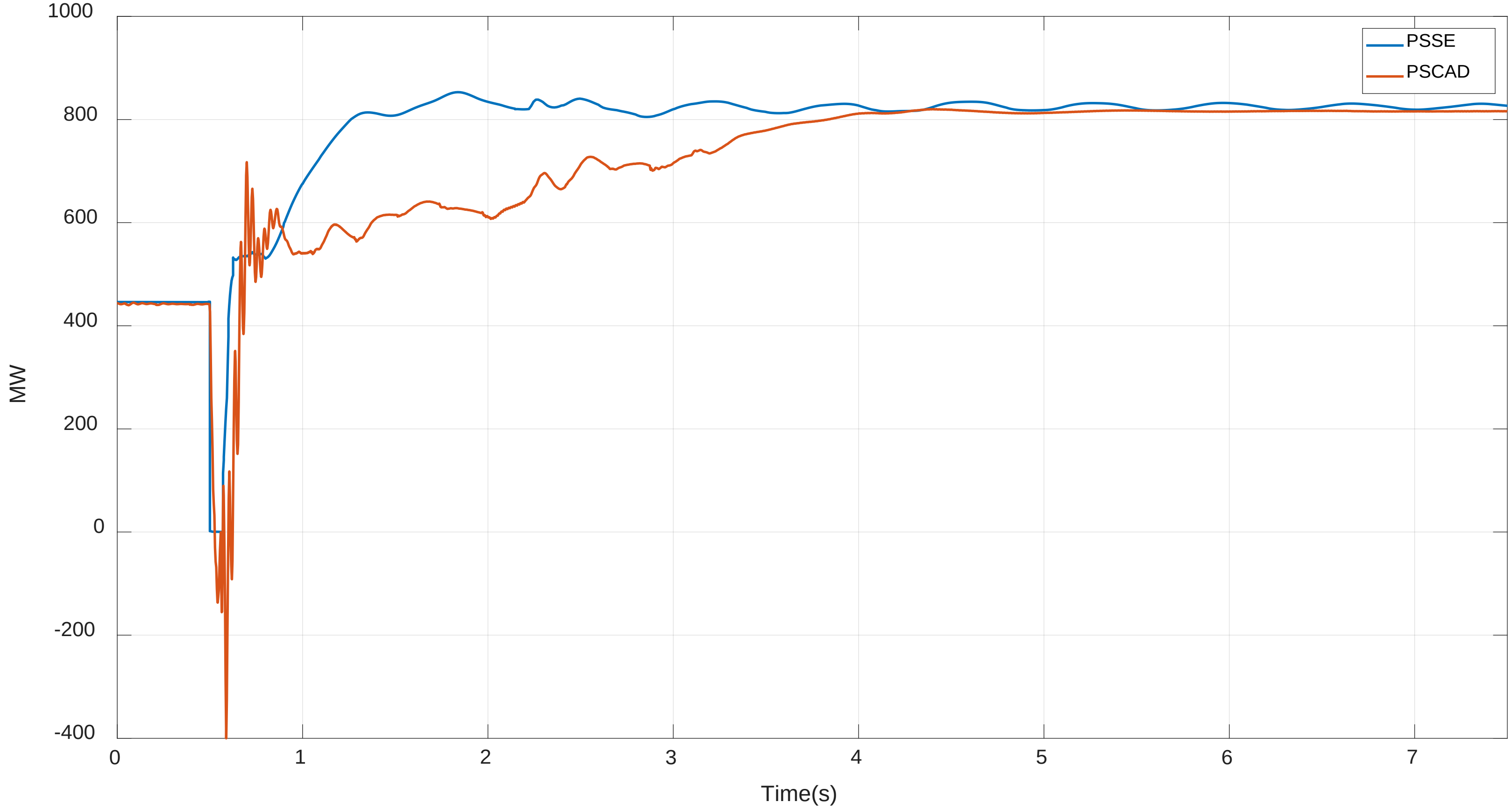
Station D to Station C MW



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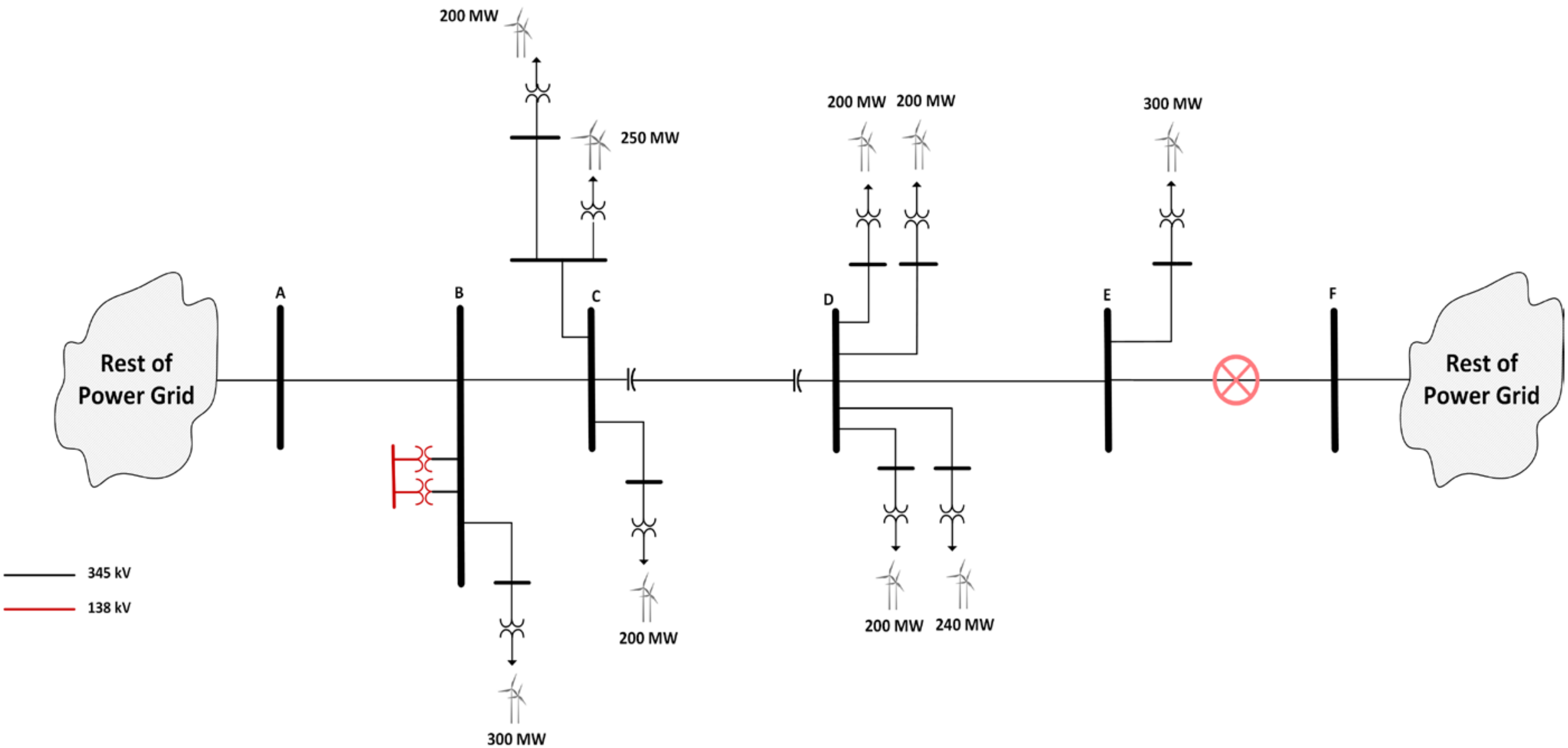
Case 3 – E-F 3-phase fault-trip 1137 MW of wind generation through the series caps



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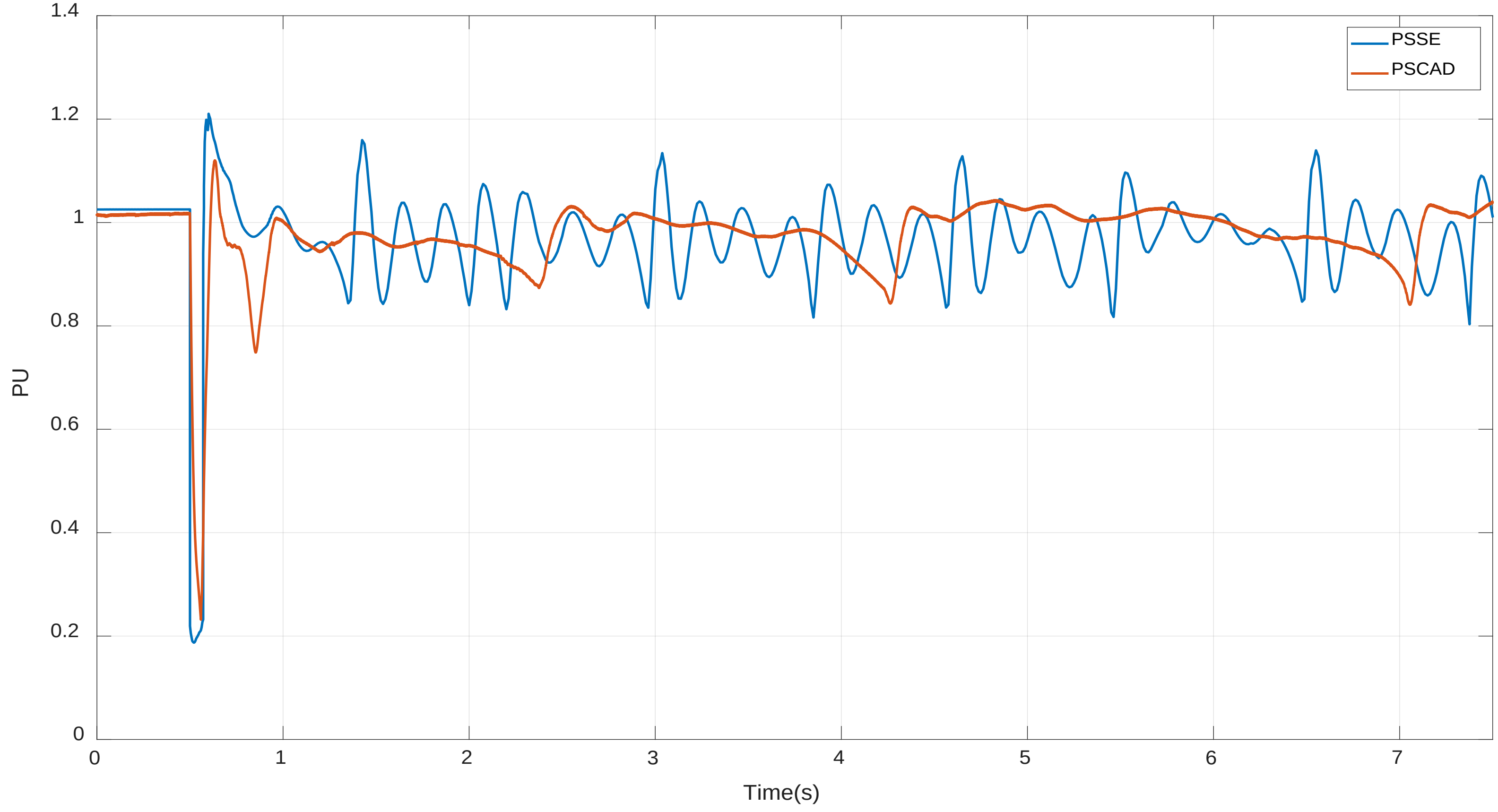
Station D per unit RMS V
100% Wind



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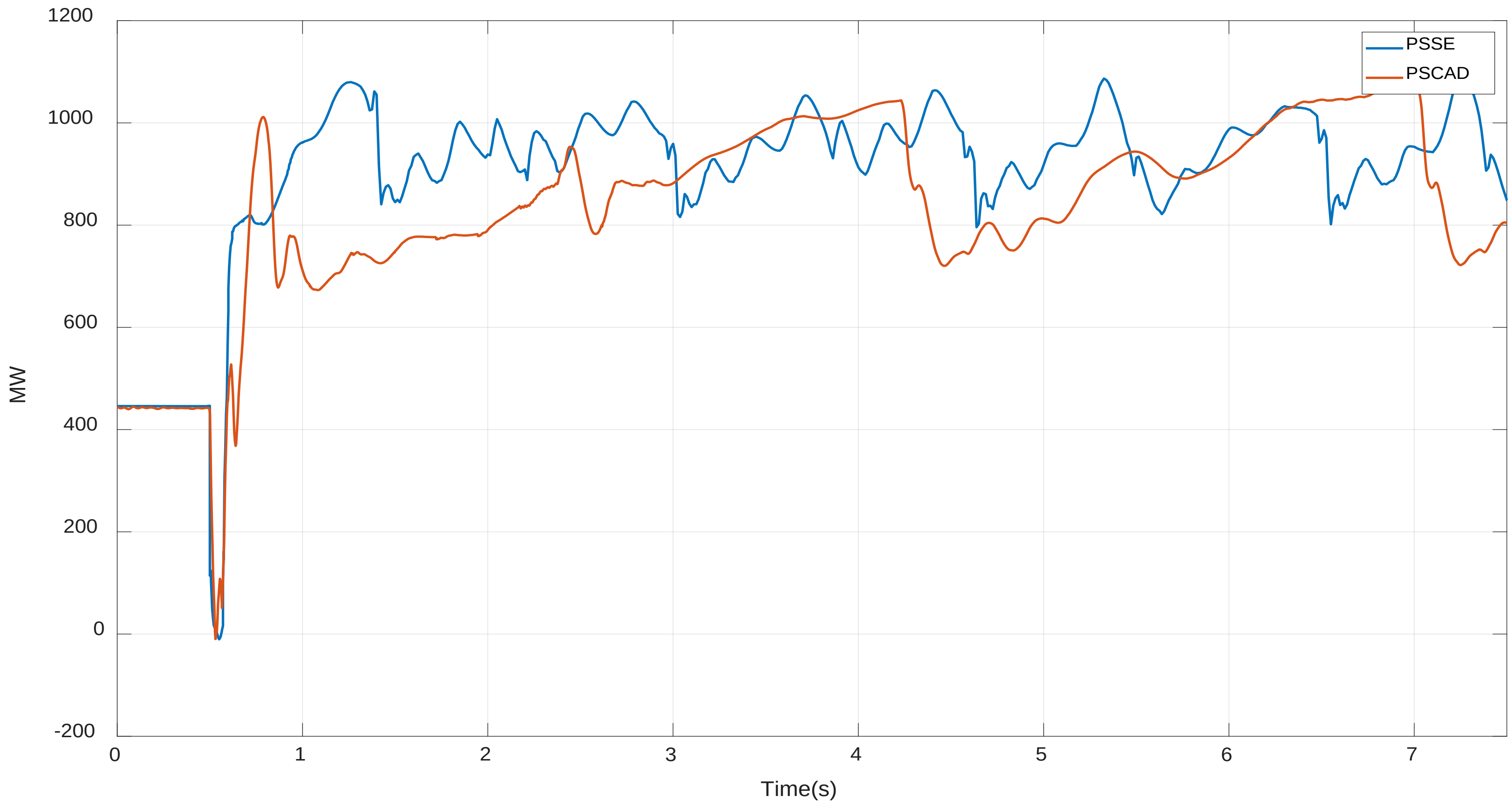
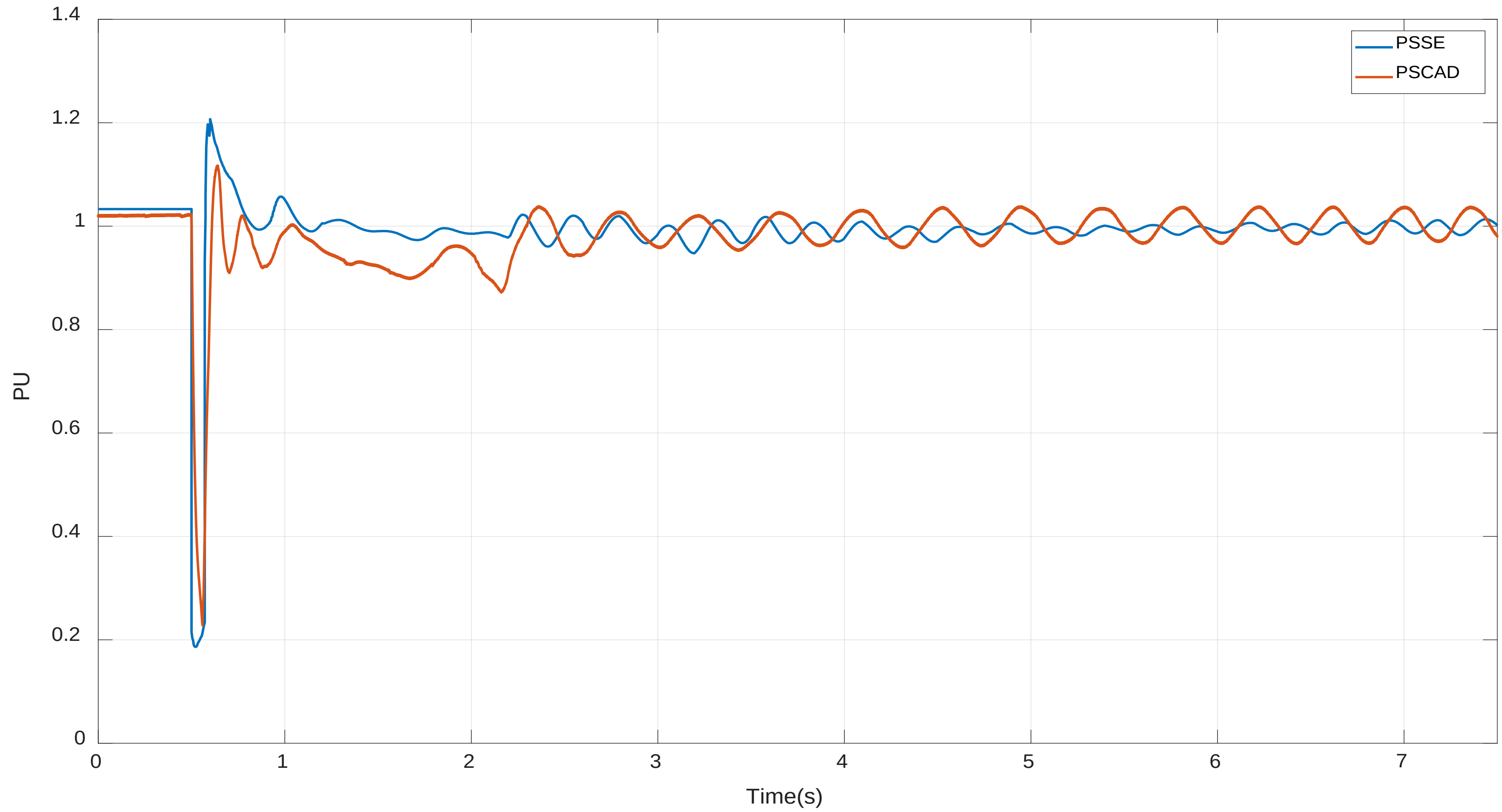
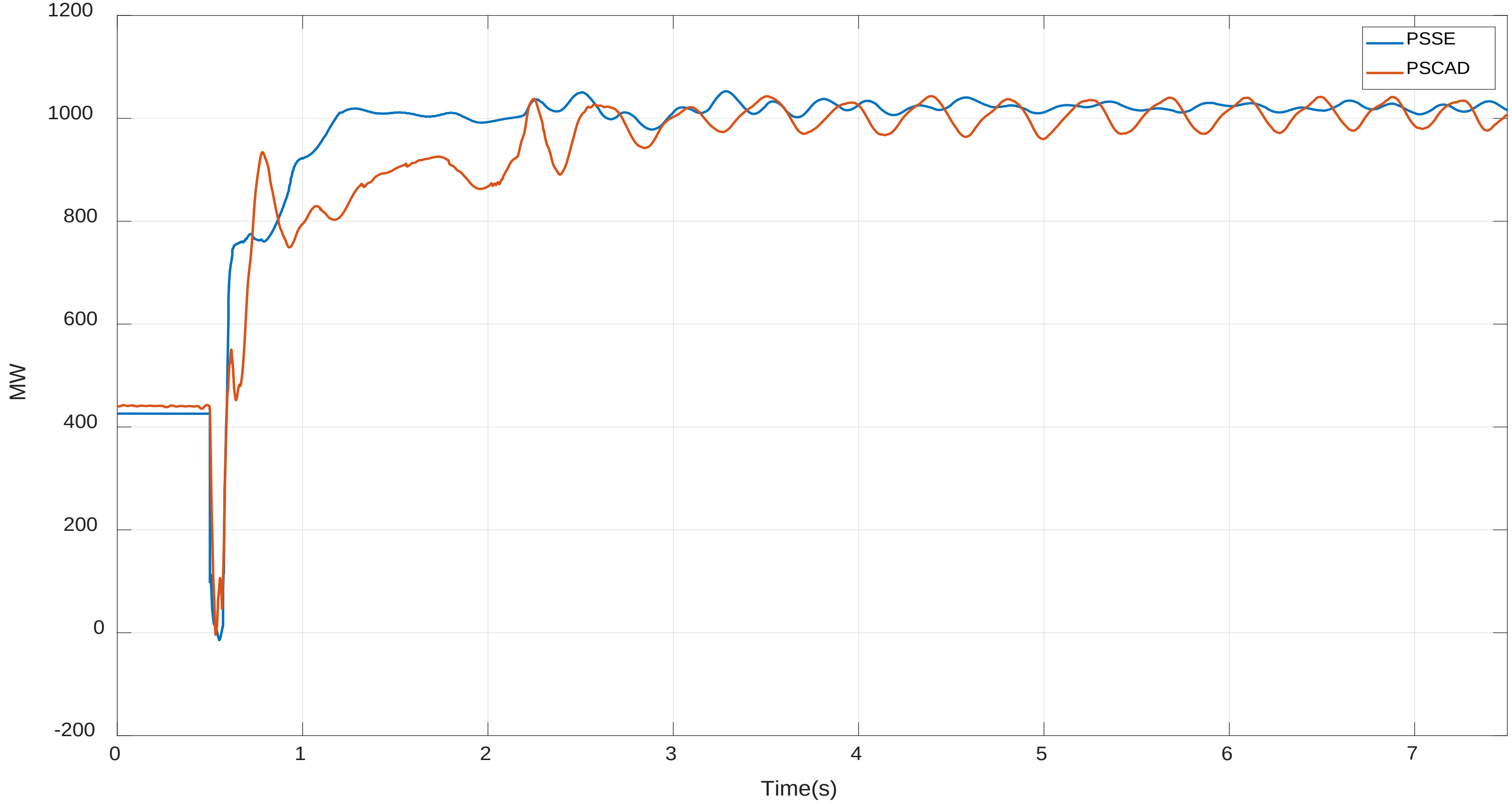
Station D to Station C MW 100% Wind



Station D per unit RMS V
90% Wind



Station D to Station C MW
90% Wind



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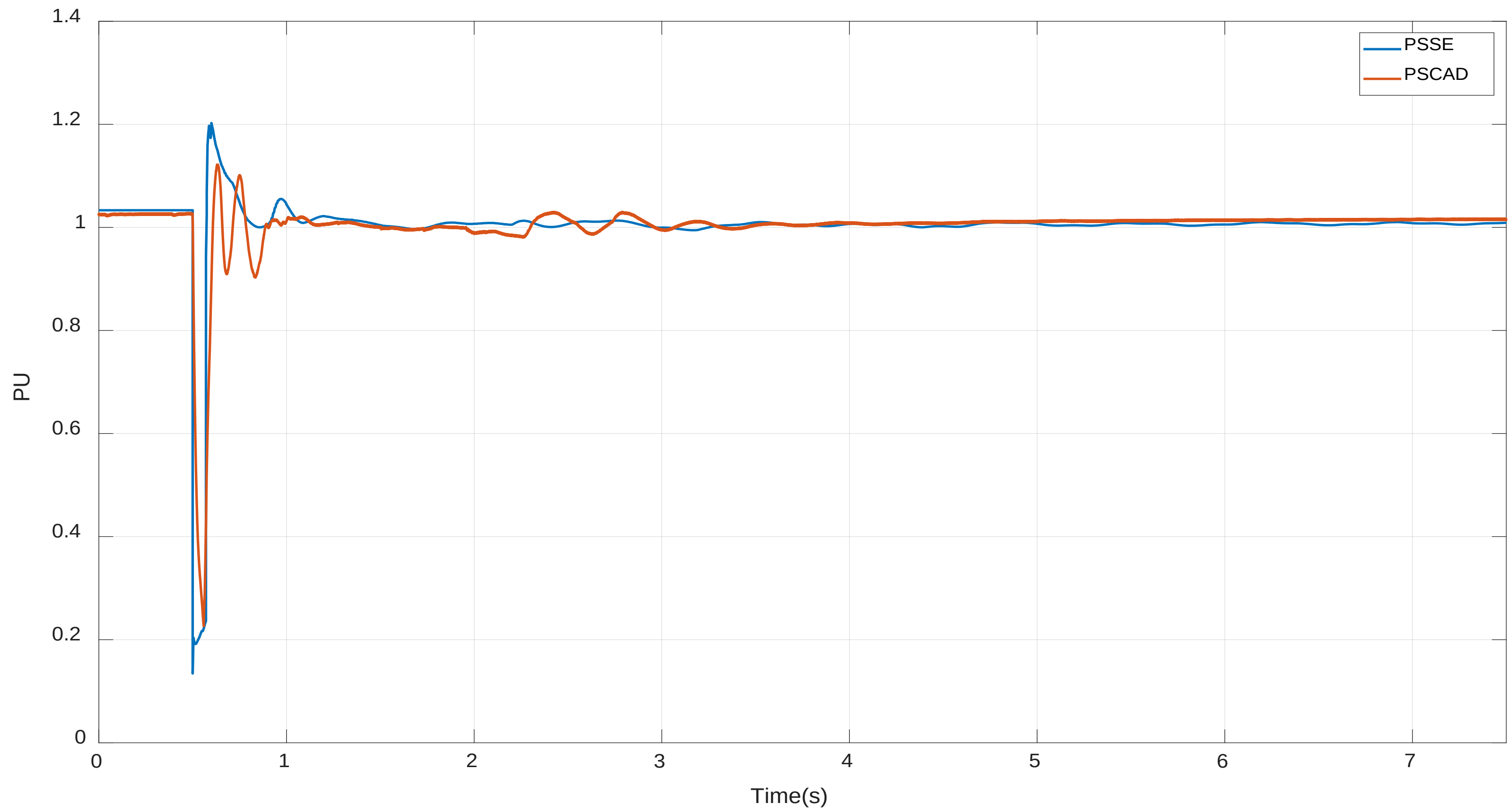
Station D per unit RMS V
85% Wind



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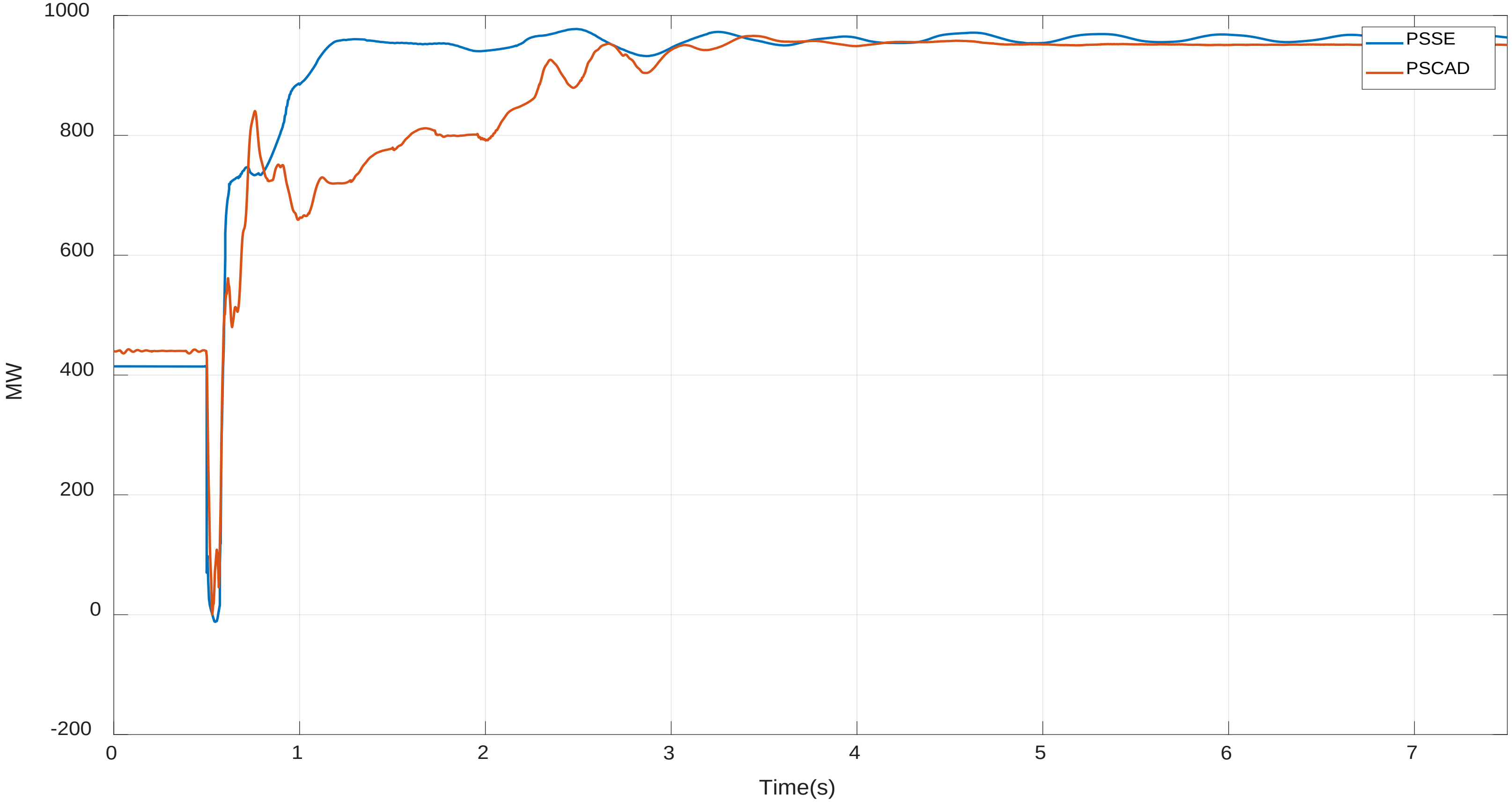
Station D to Station C MW
85% Wind



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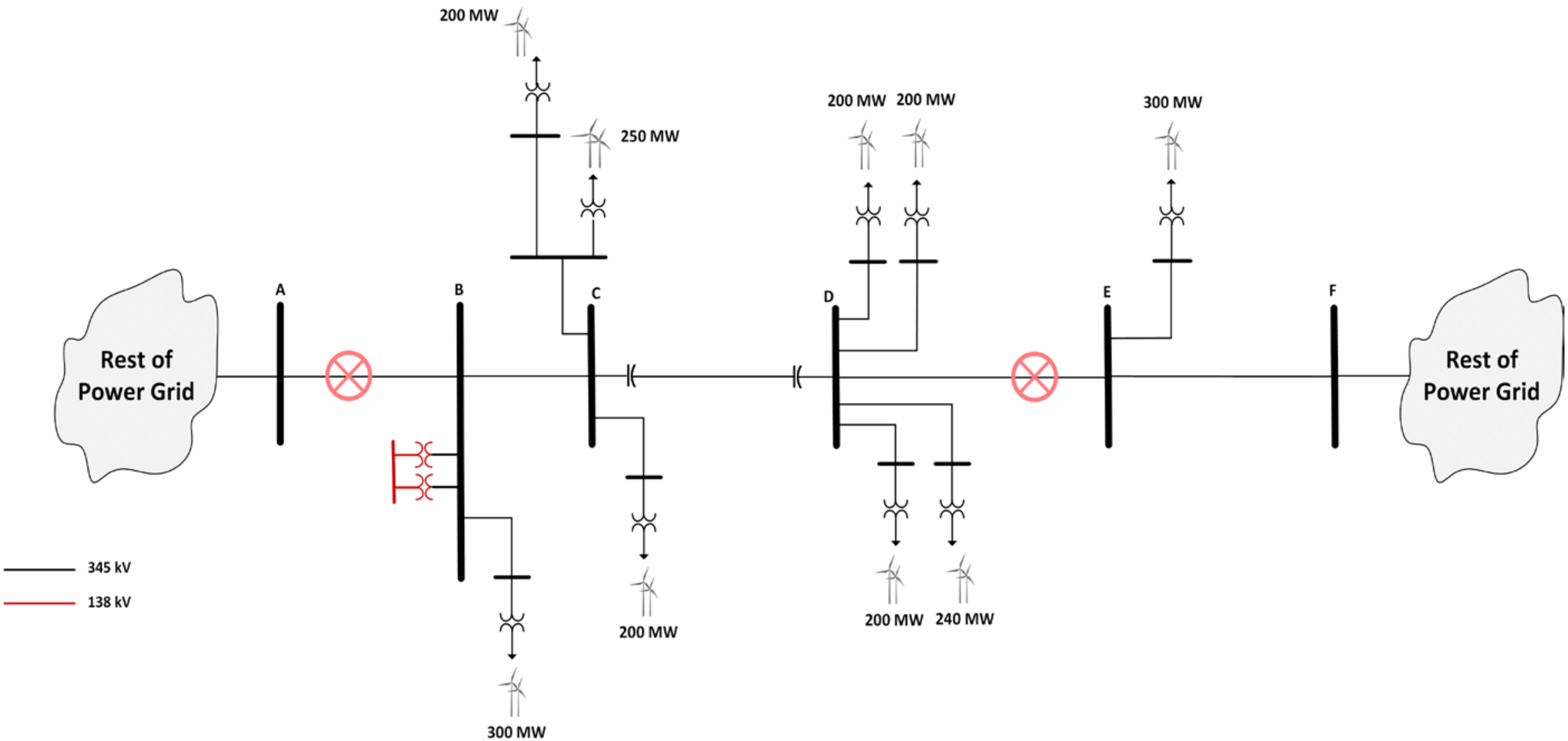
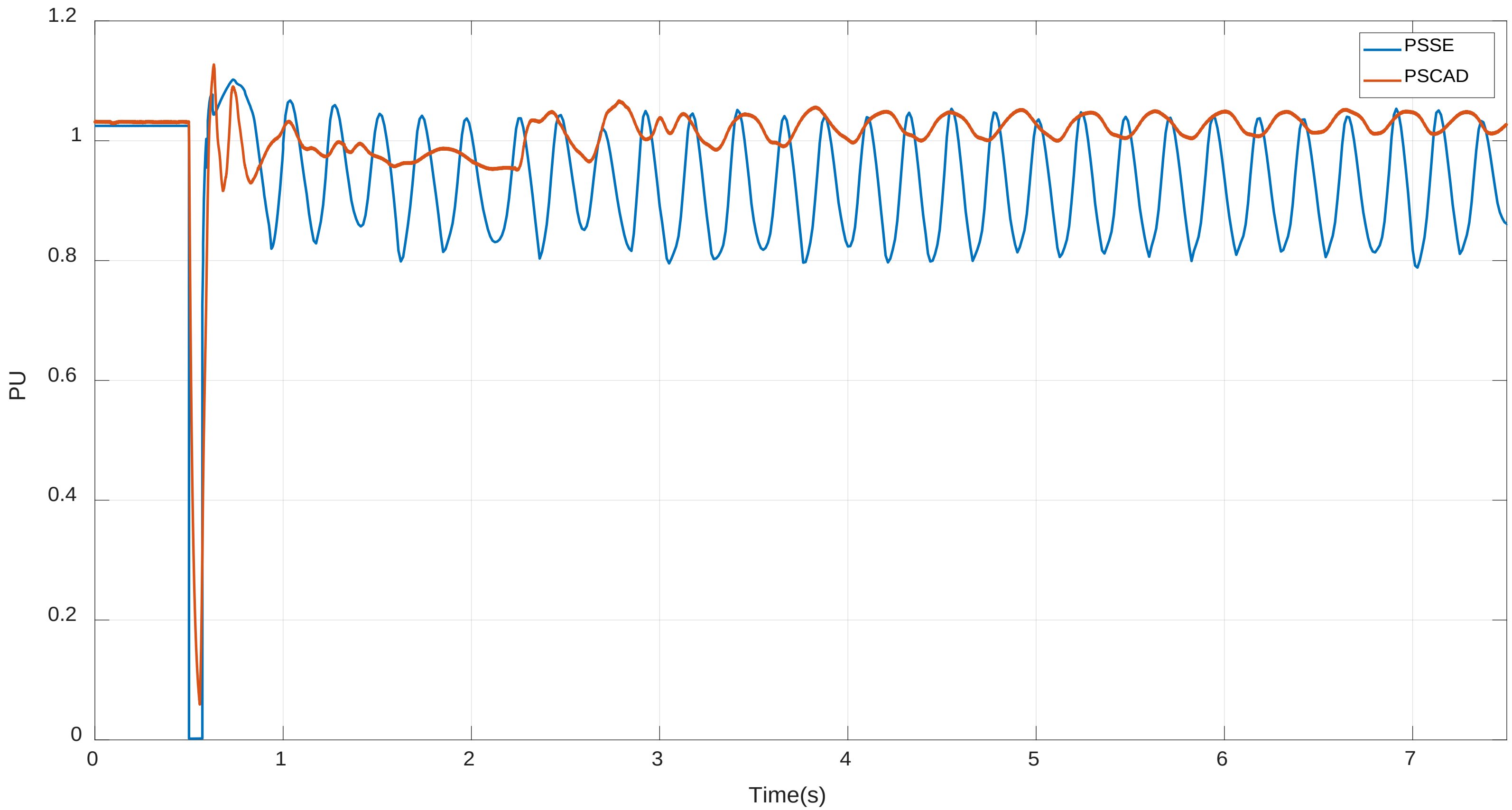
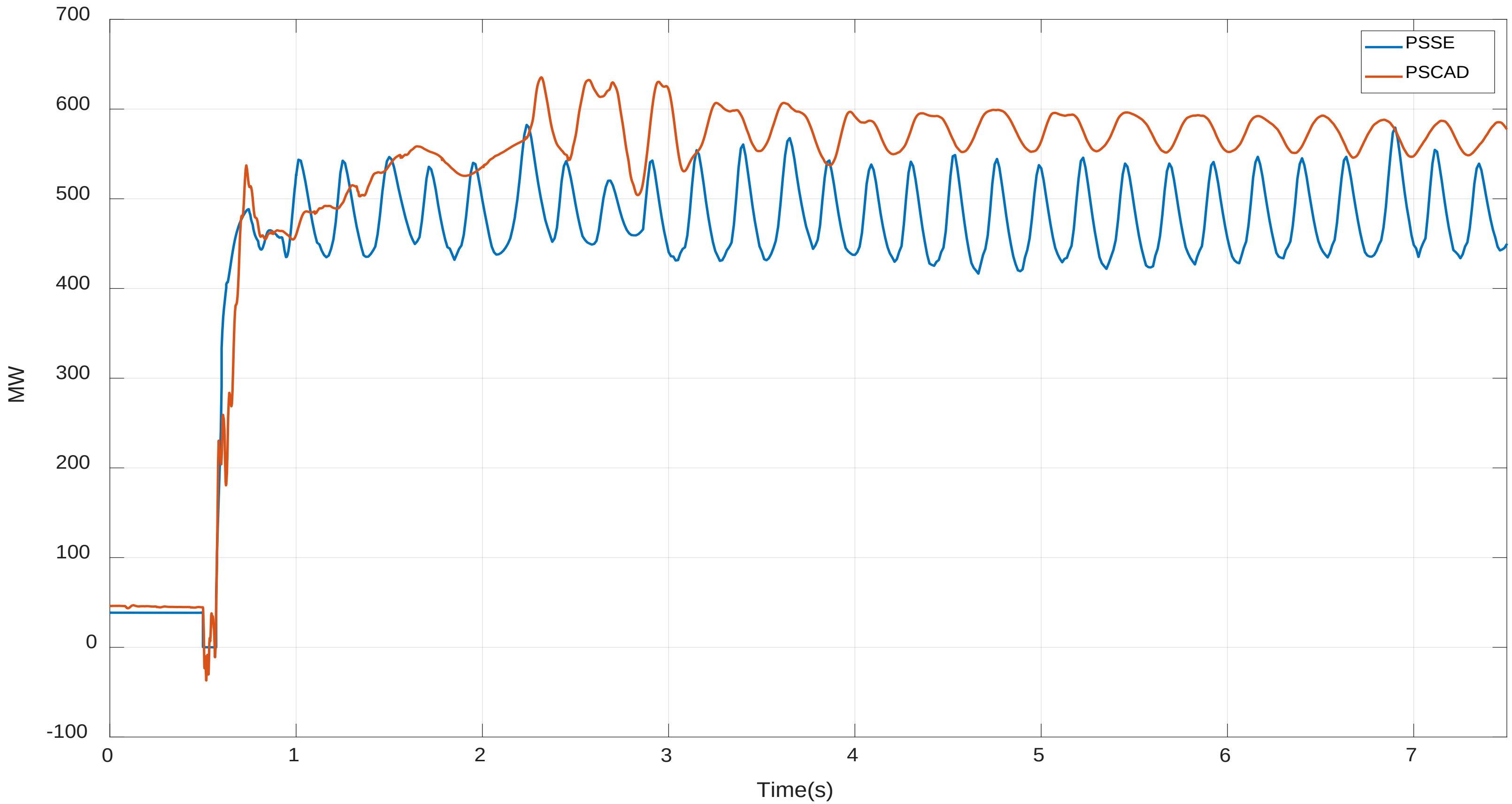
Case 4 – Pre-outage A–B D–E 3-phase fault-trip



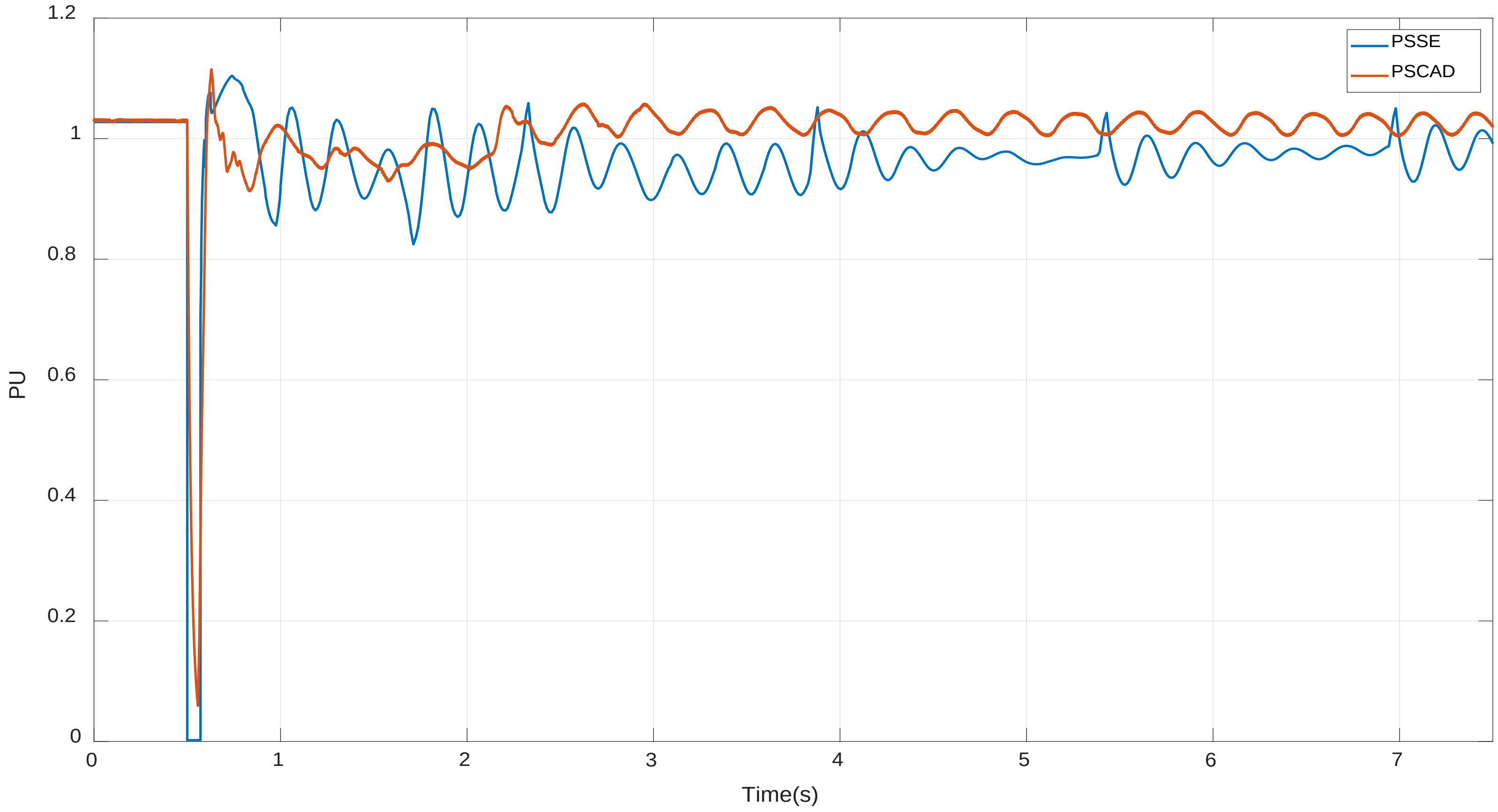
Station D per unit RMS V
70% Wind



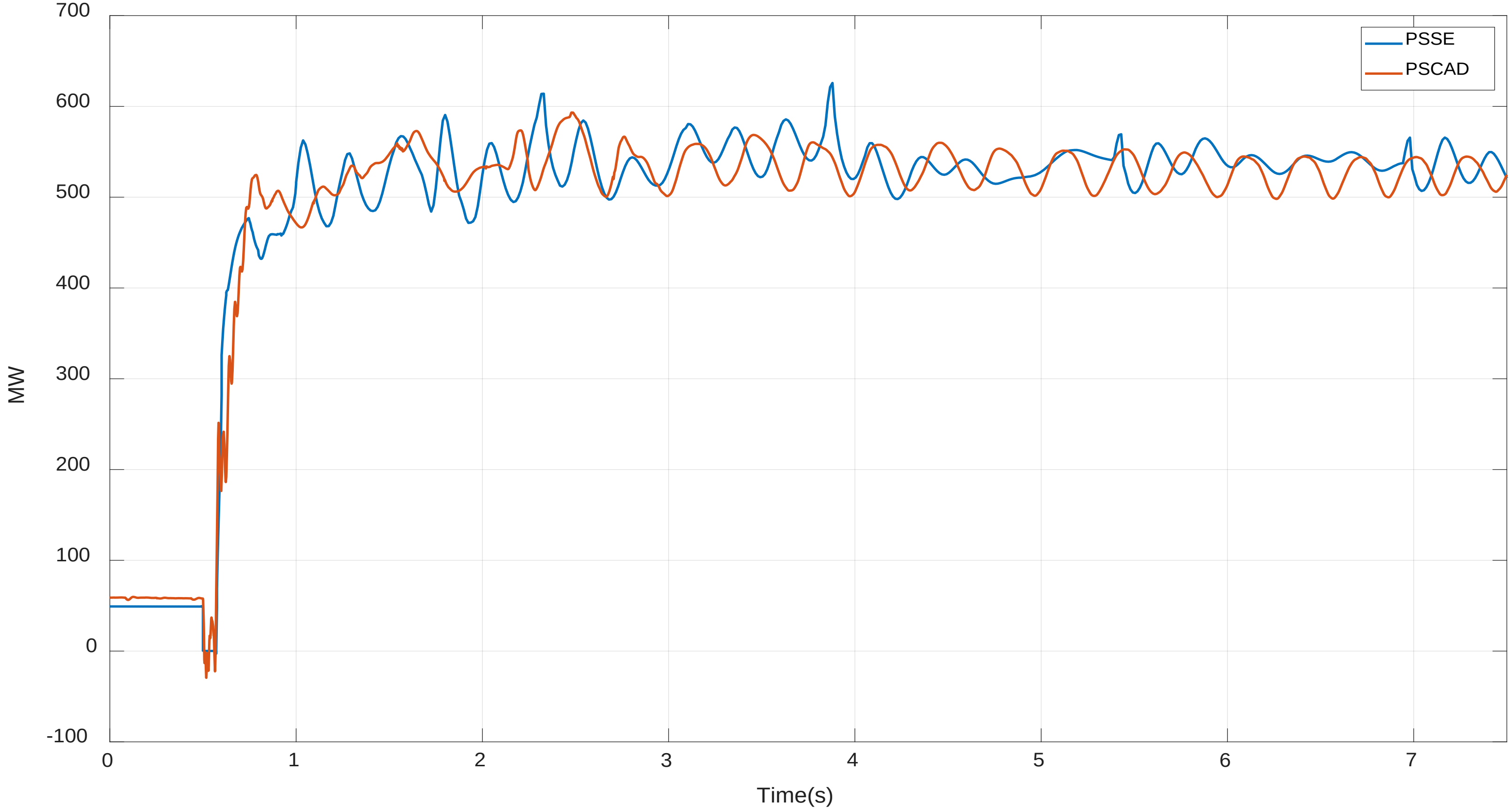
Station D to Station C MW
70% Wind



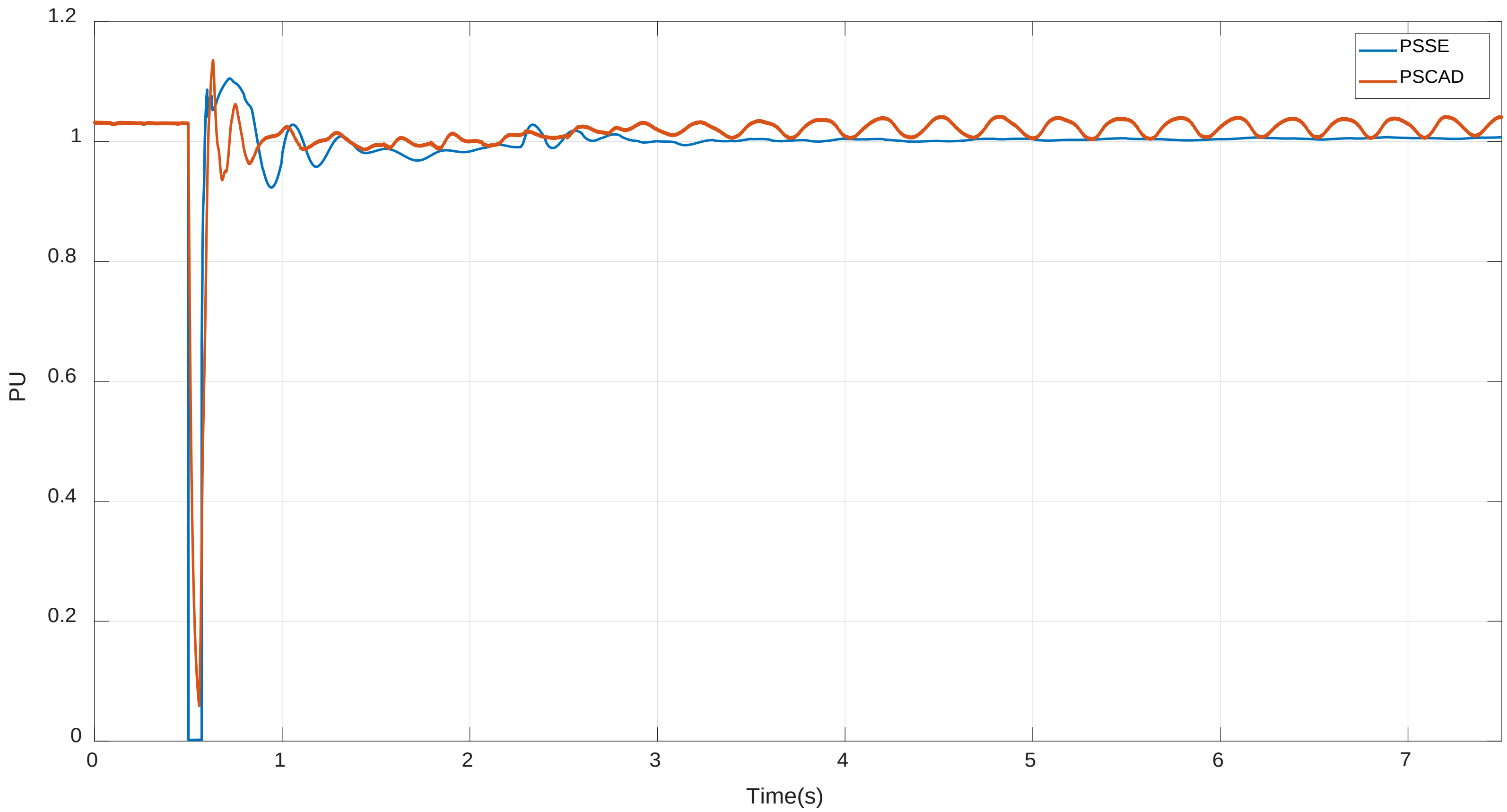
Station D per unit RMS V
65% Wind



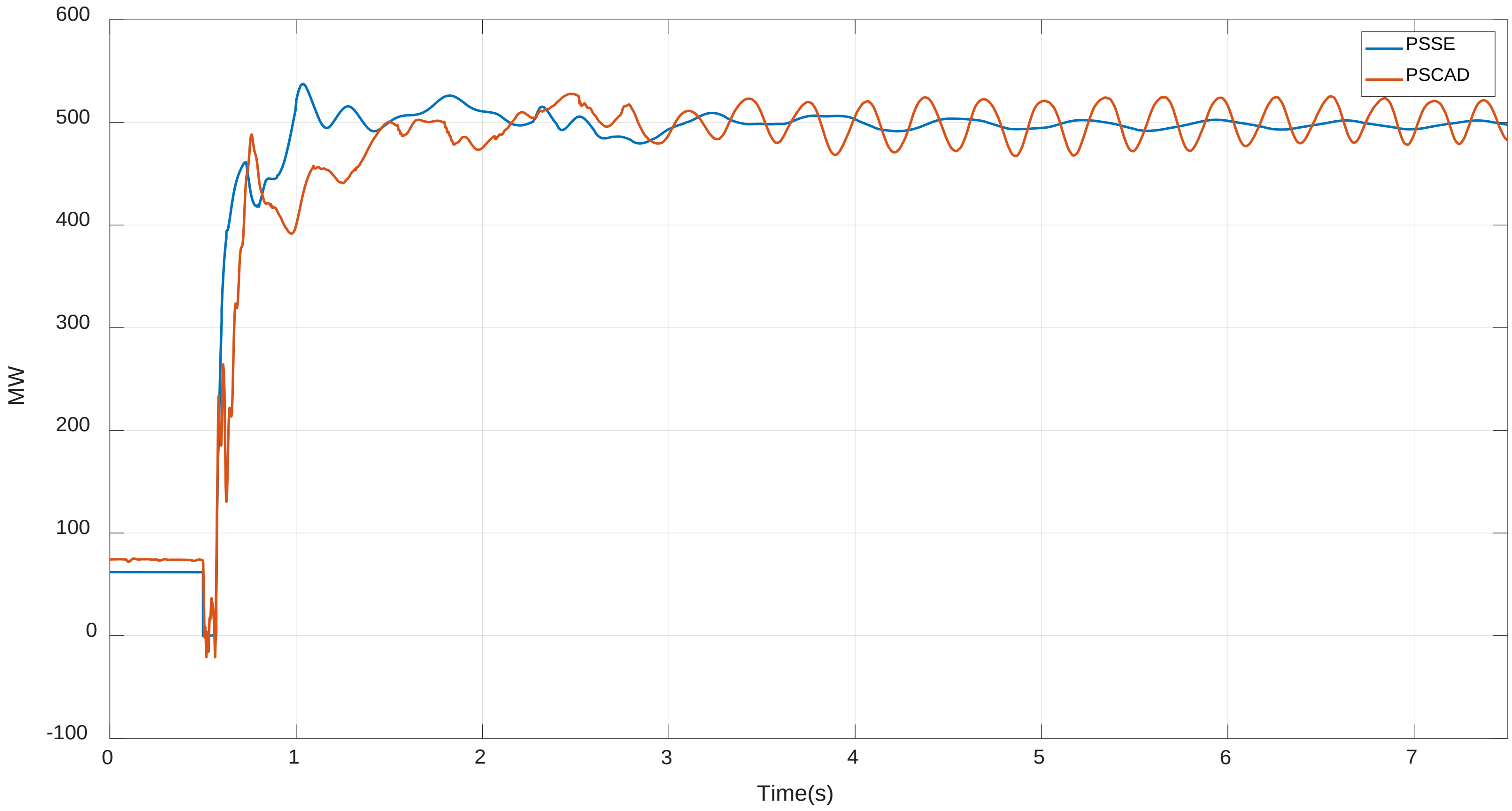
Station D to Station C MW
65% Wind



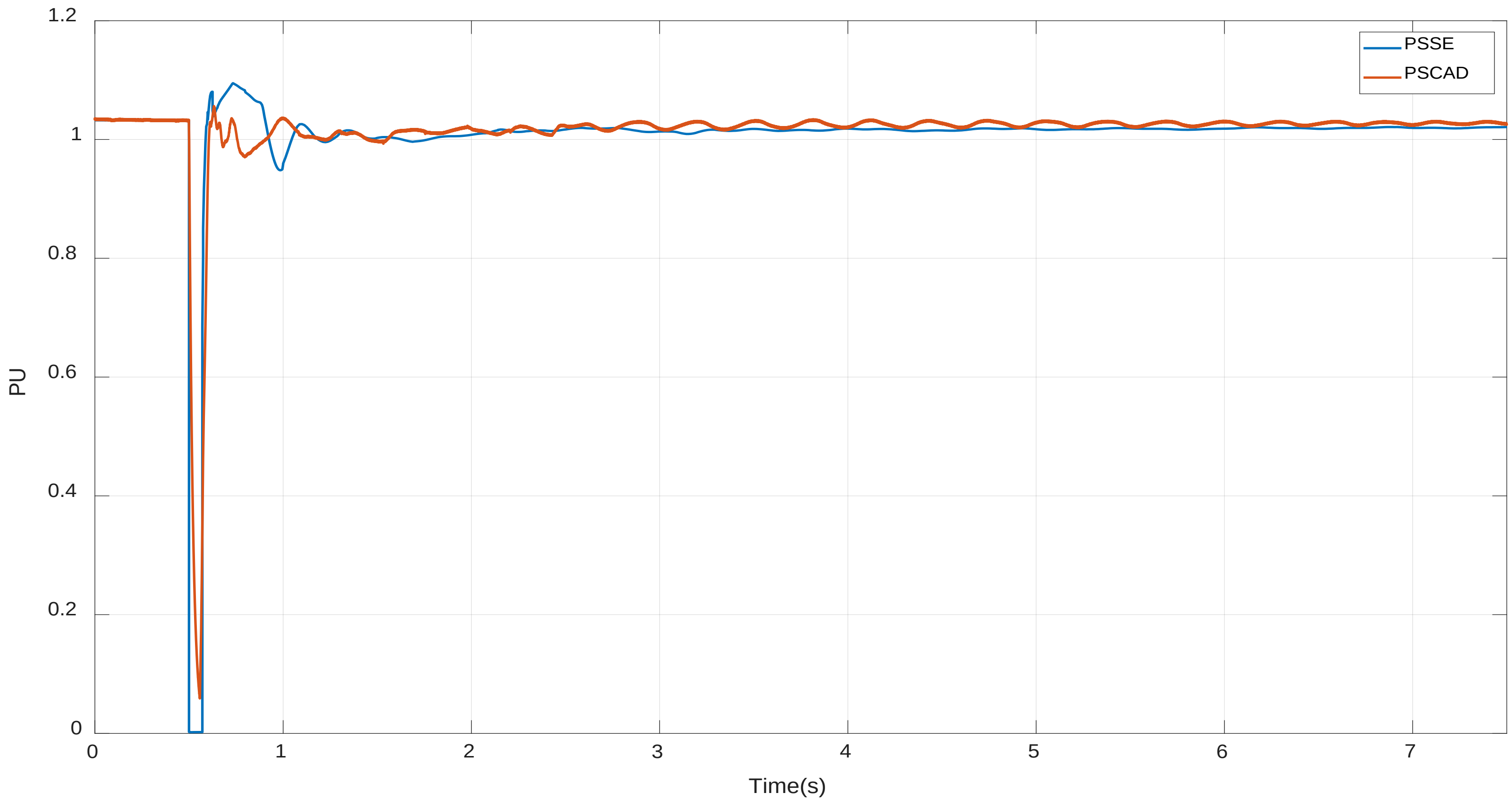
Station D per unit RMS V
60% Wind



Station D to Station C MW
60% Wind



Station D per unit RMS V 55% Wind



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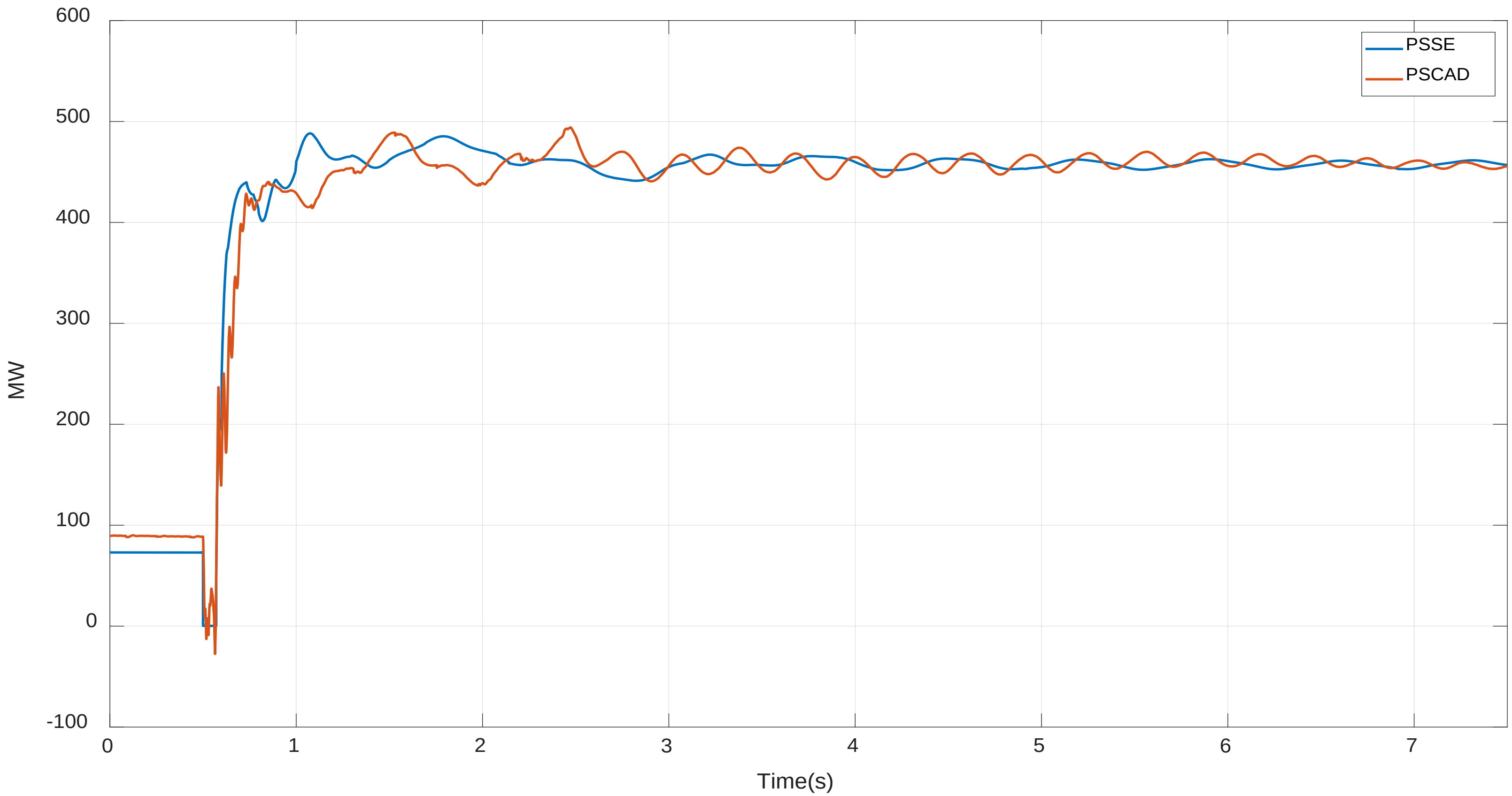
Station D to Station C MW
55% Wind



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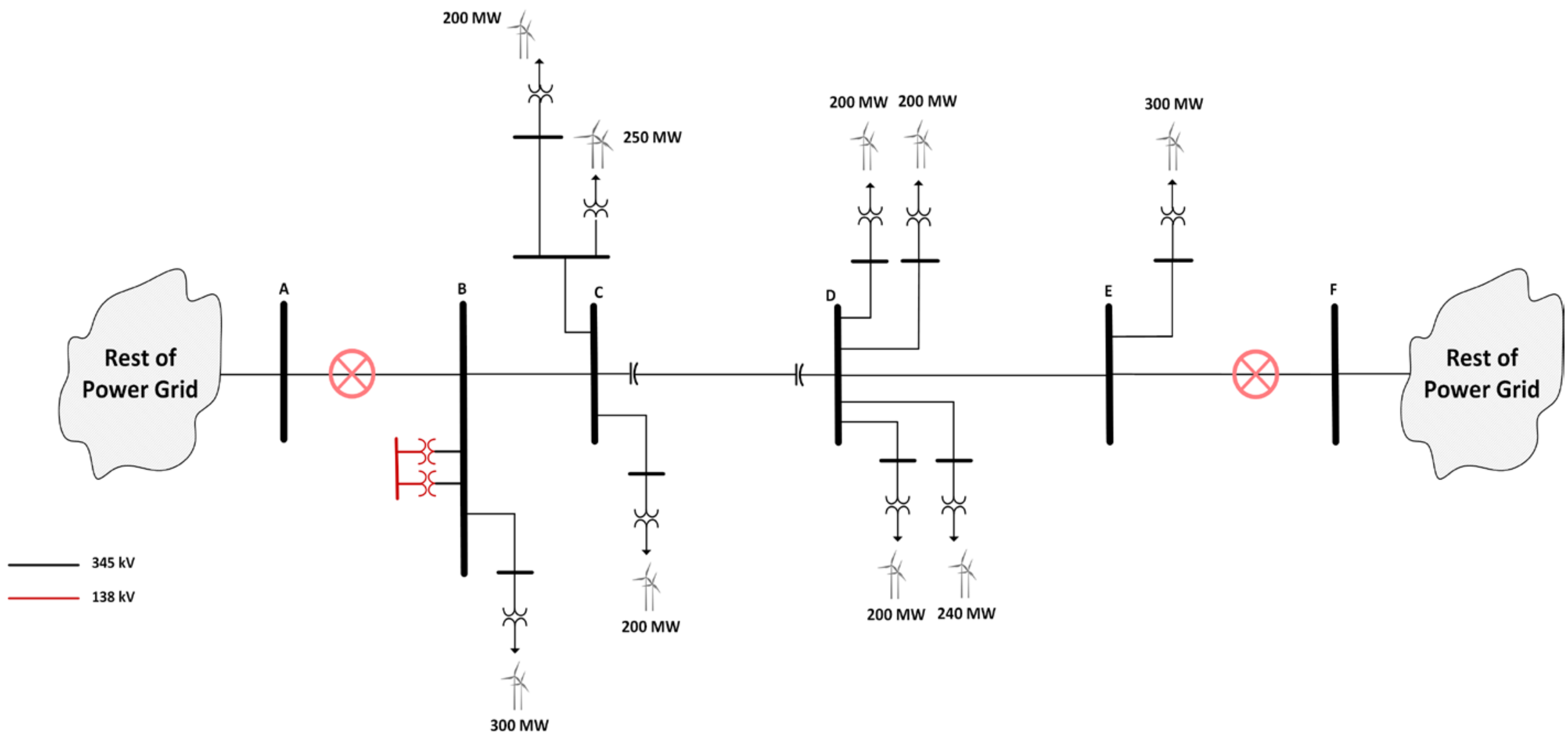
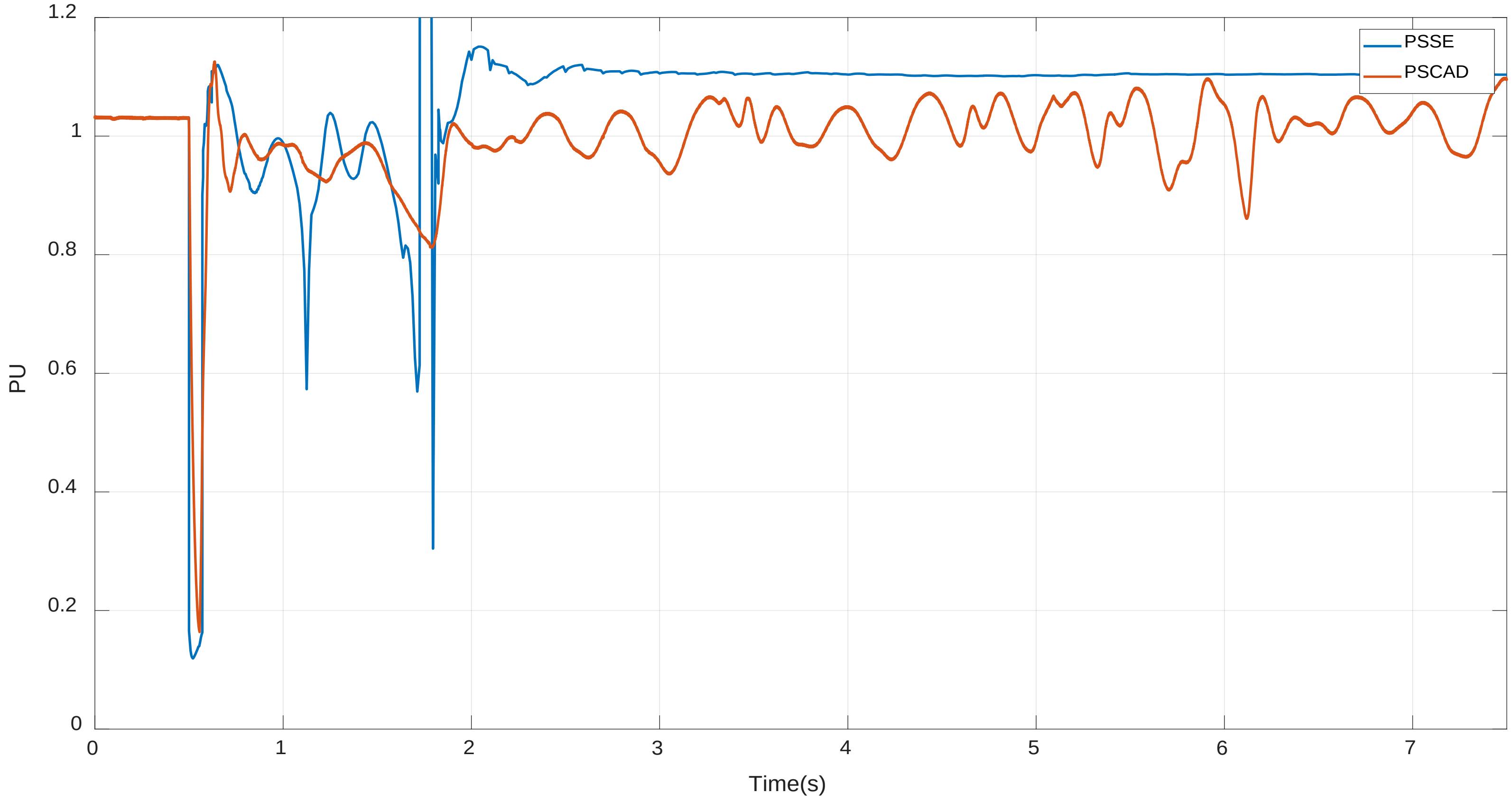
Case 5 – Pre-outage A–B E–F 3-phase fault-trip



Station D per unit RMS V
60% Wind



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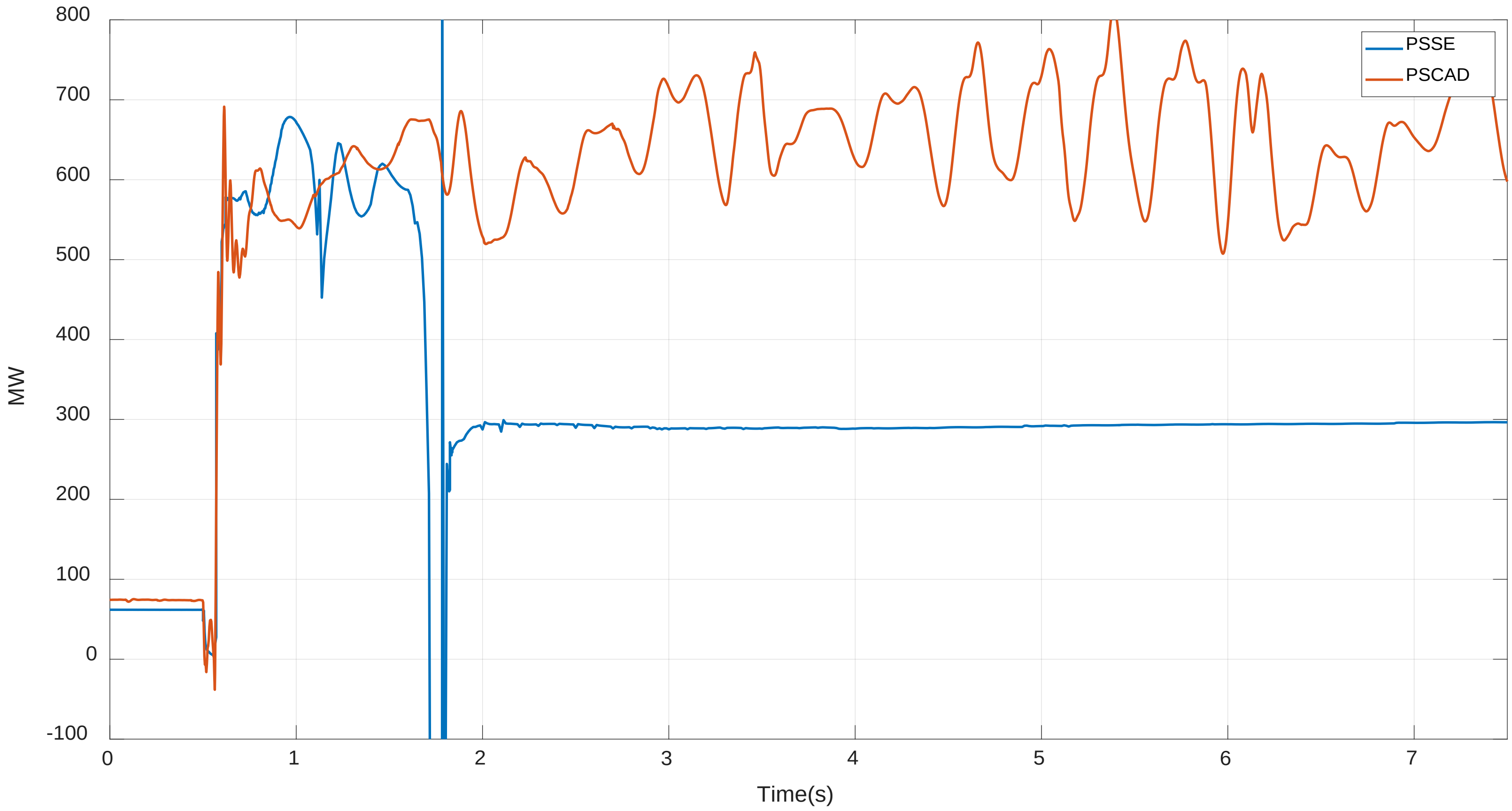
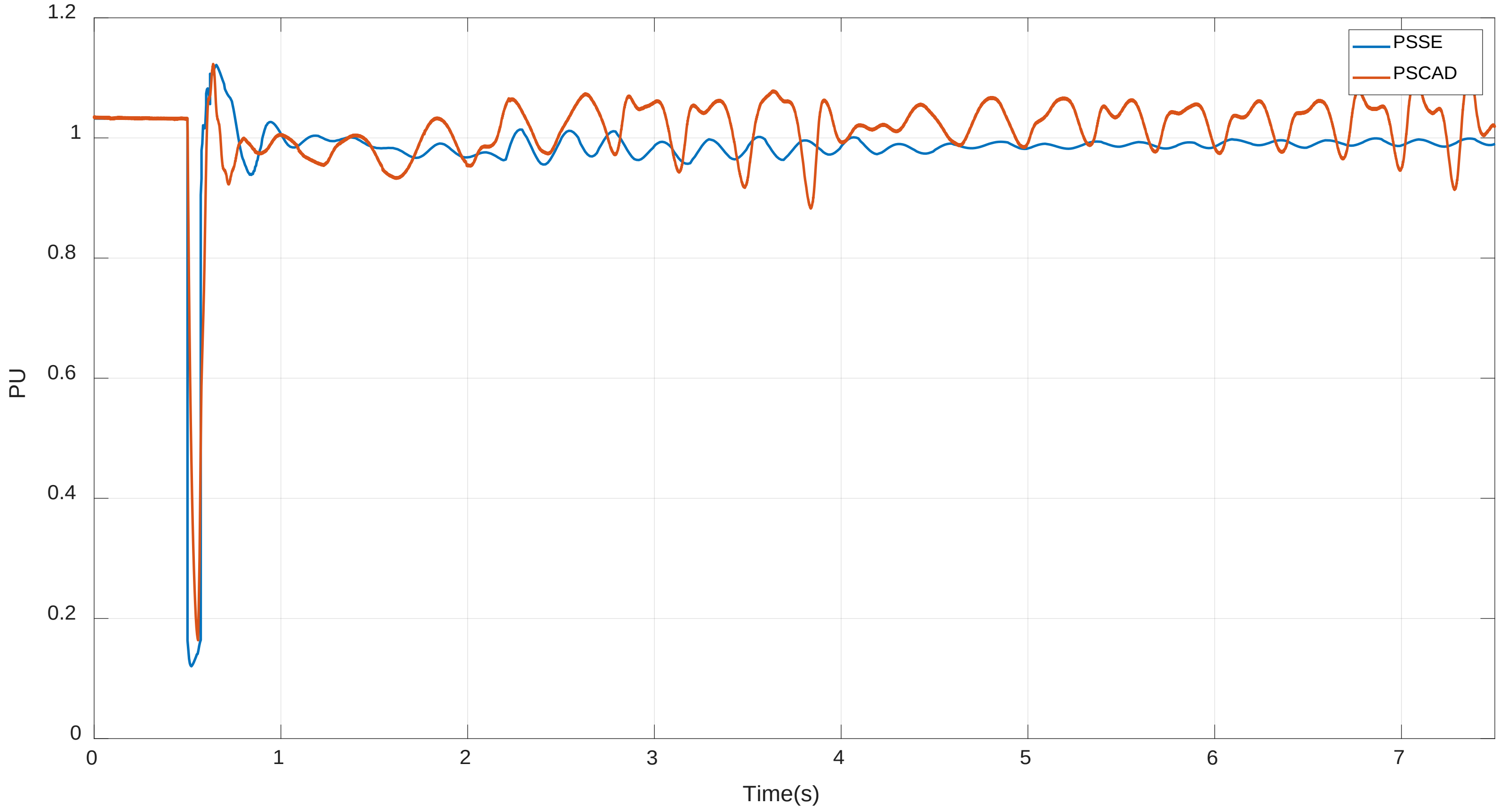
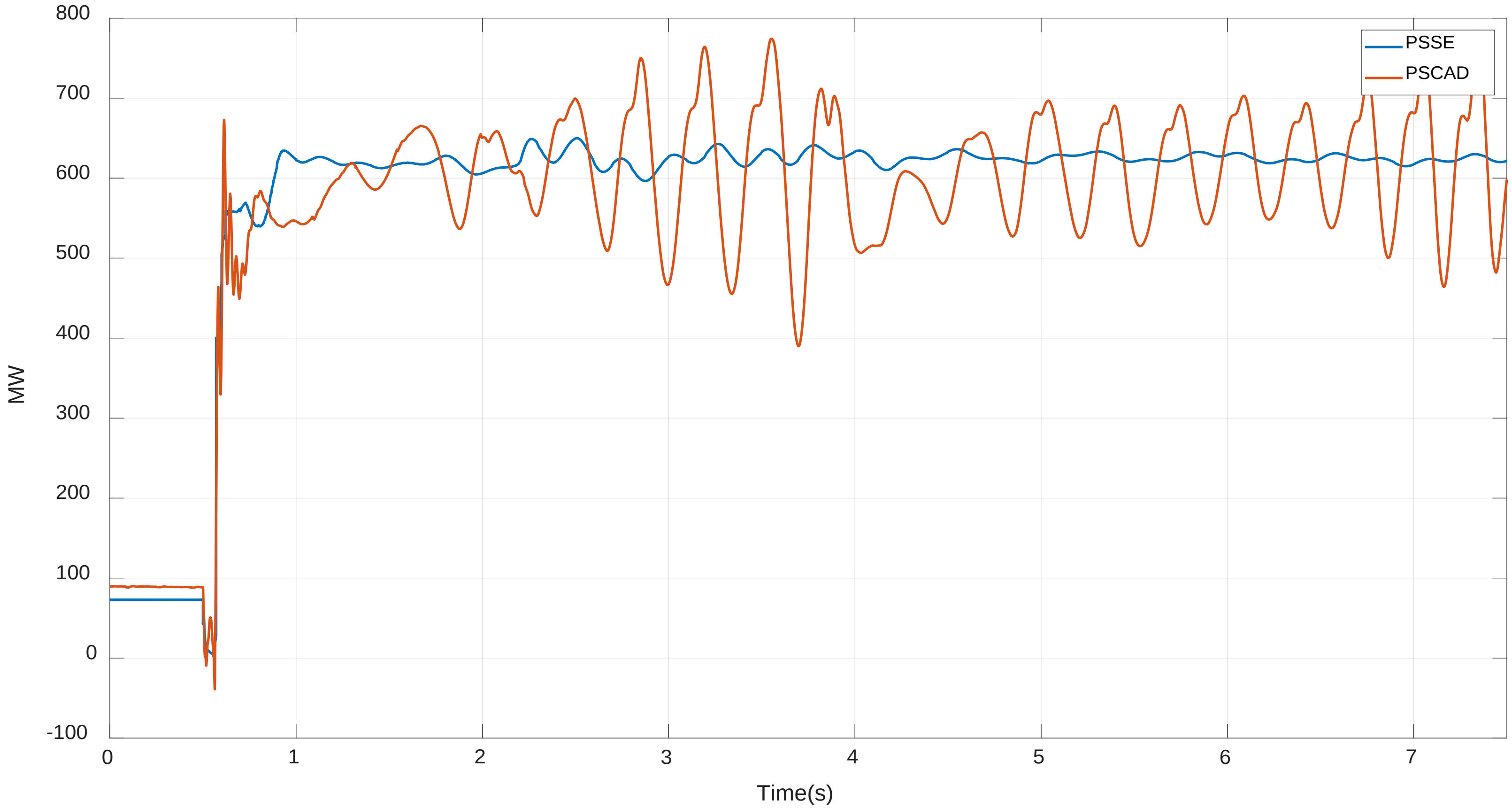
Station D to Station C MW
60% Wind



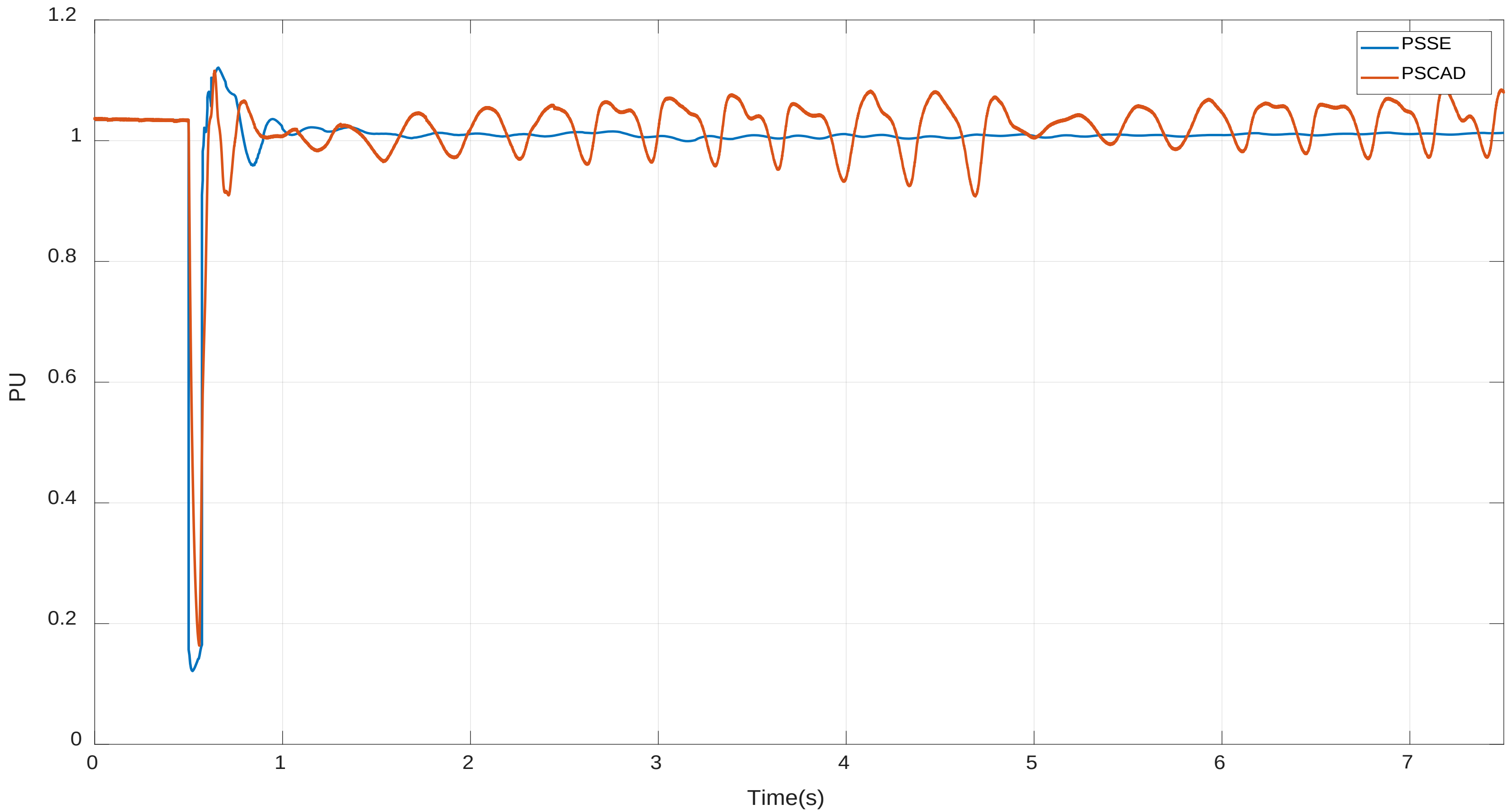
Station D per unit RMS V
55% Wind



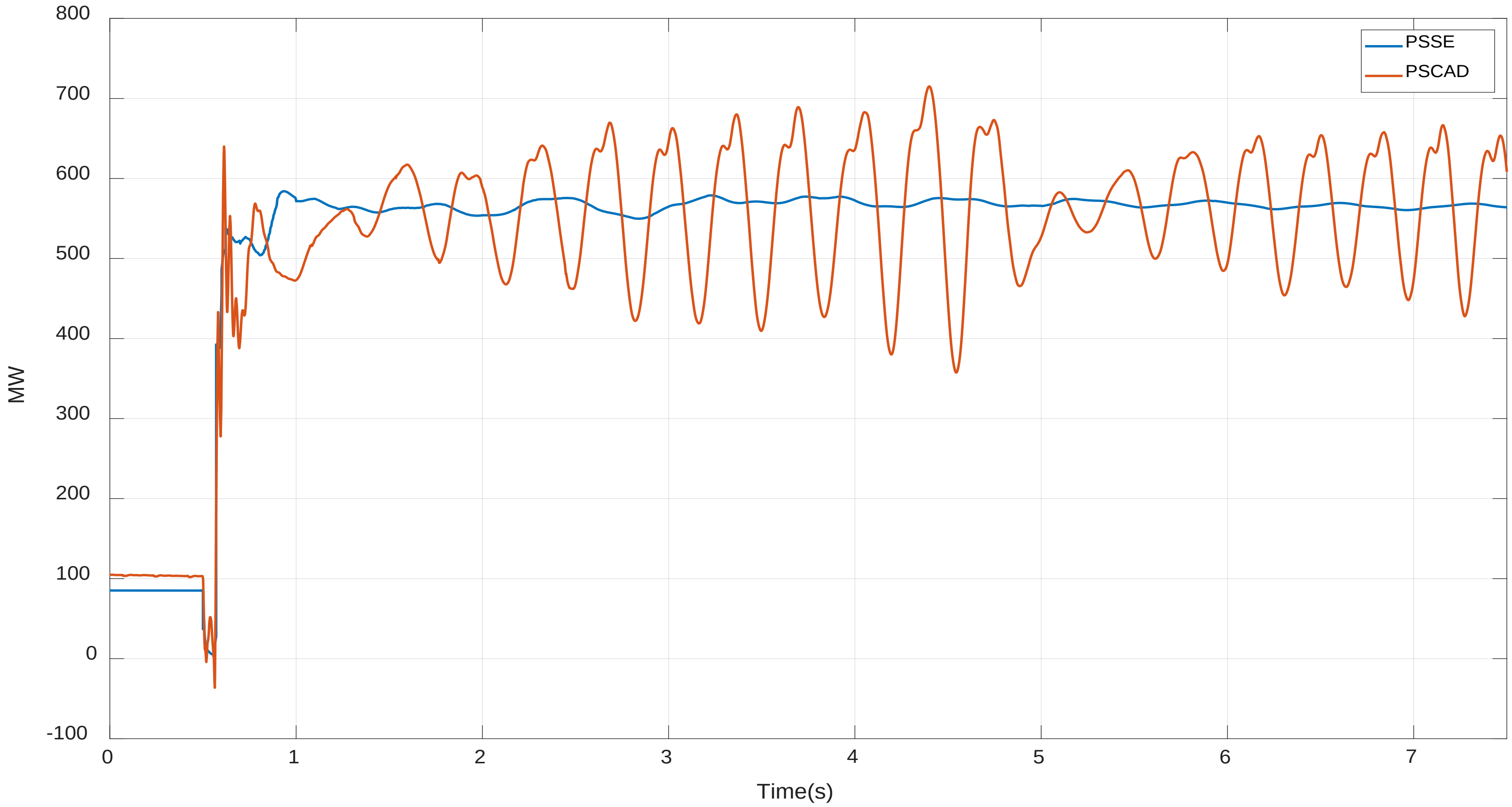
Station D to Station C MW
55% Wind



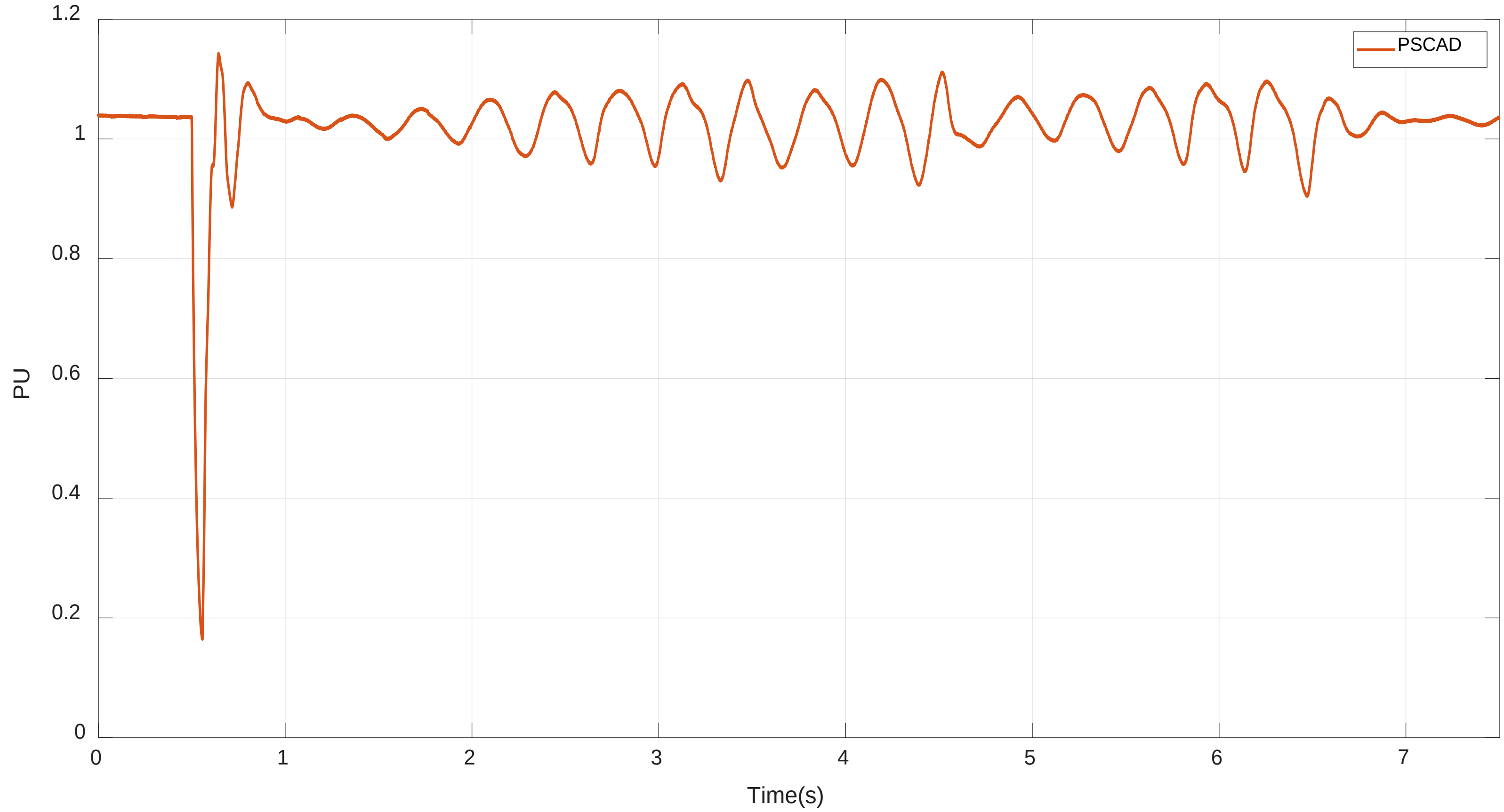
Station D per unit RMS V
50% Wind



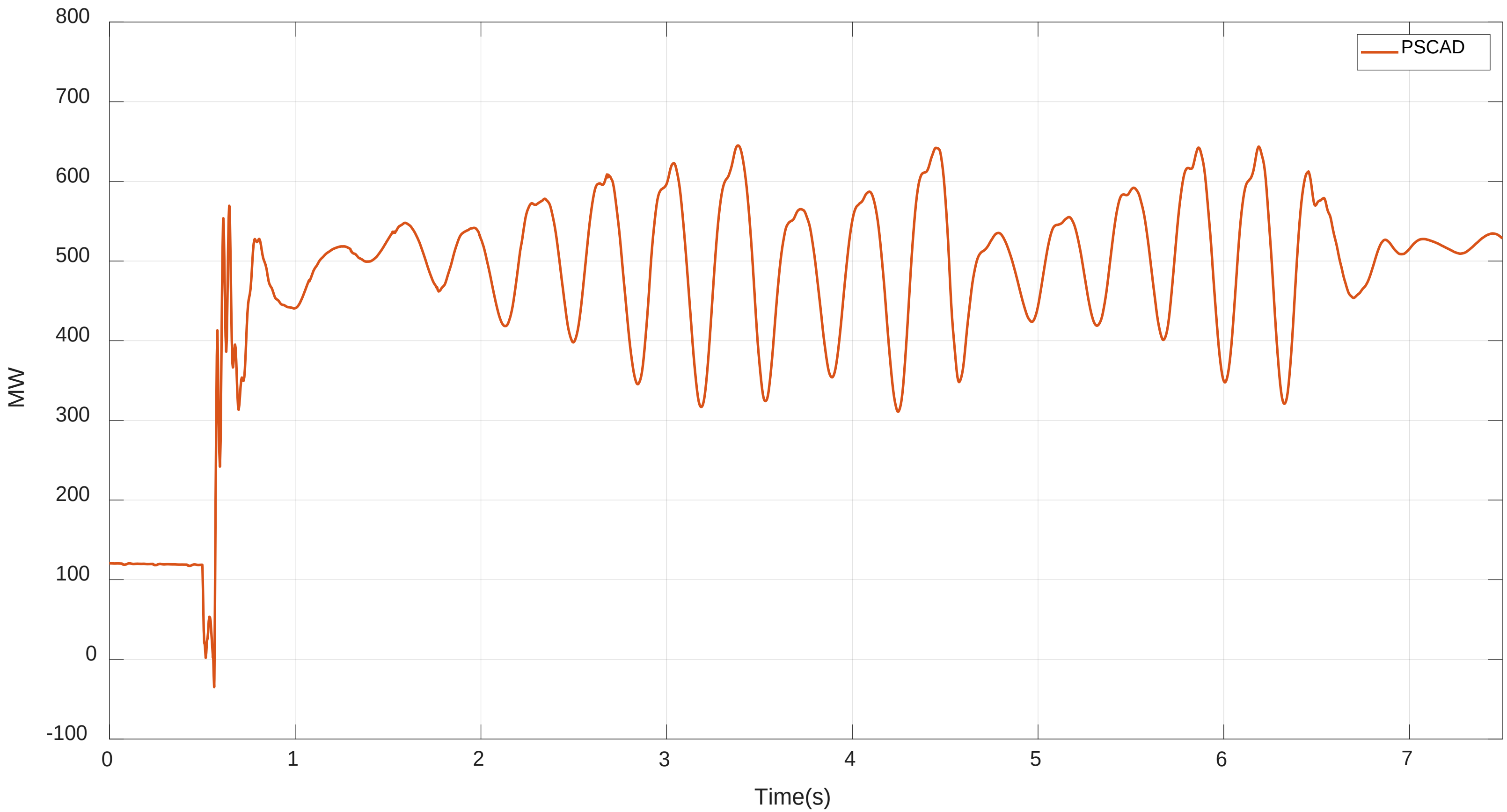
Station D to Station C MW
50% Wind



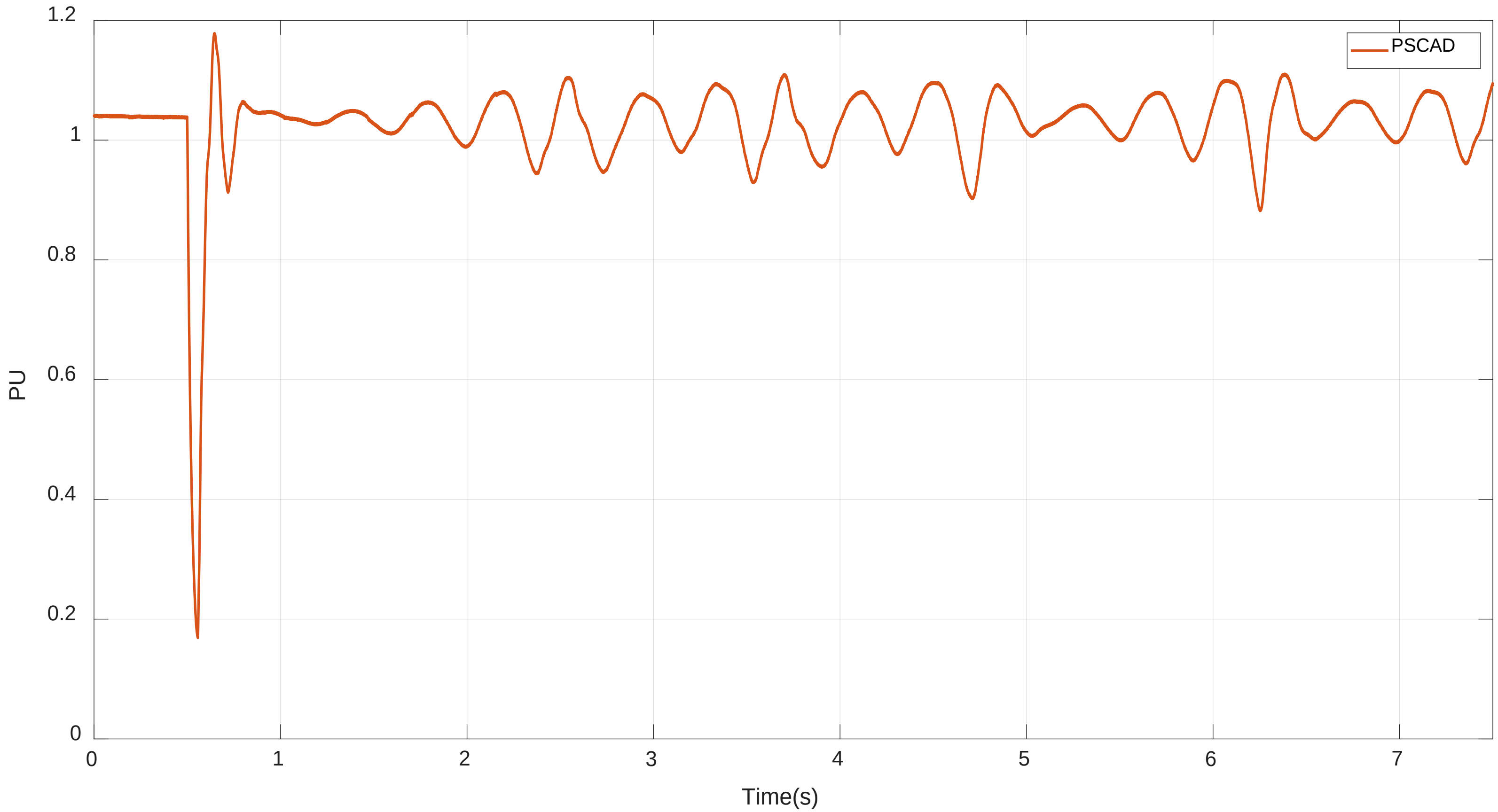
Station D per unit RMS V
45% Wind



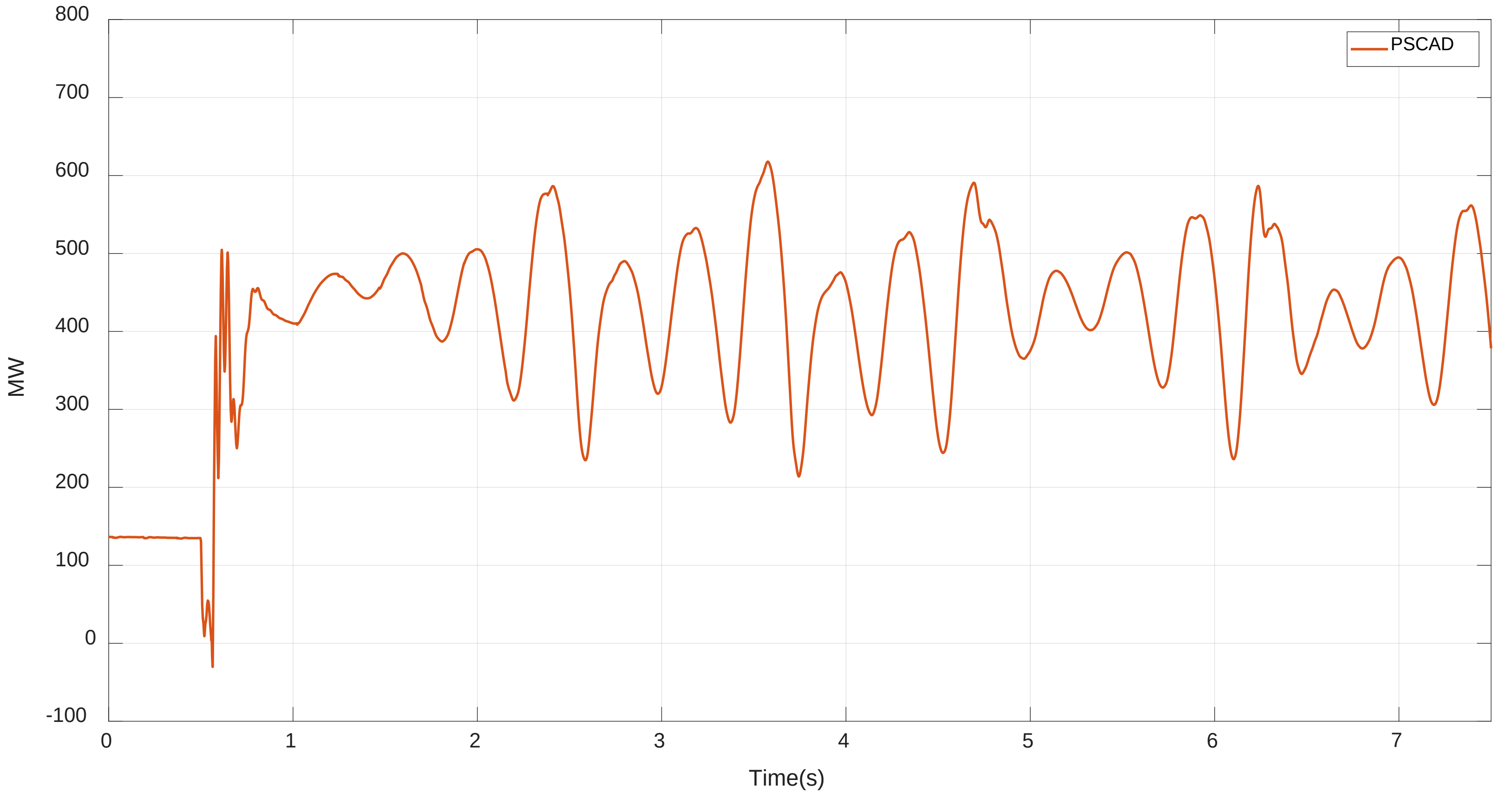
Station D to Station C MW
45% Wind



Station D per unit RMS V
40% Wind



Station D to Station C MW
40% Wind



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Case 5 – Pre-outage A–B E–F 3-phase fault-trip

- PSSE simulation stabilizes at 55%
- PSCAD not stabilizing even down to 40%

PSCAD case 138 kV network equivalent could be the cause of difference in Case 5

PSSE-PSCAD Comparison Summary

Case	PSSE	PSCAD
1 B-C outage	Stable	Stable
2 D-E outage	Stable	Stable
3 E-F outage	Unstable Decrease to 85% to stabilize	Unstable Decrease to 85% to stabilize
4 A-B / D-E outages	Unstable Decrease to 60% to stabilize	Unstable Decrease to 55% to stabilize
5 A-B / E-F outages	Unstable Decrease to 55% to stabilize	Unstable Decrease to ?% to stabilize

Summary

- As concentrations of wind and solar generation increase, so also the need for reliable indication of stability and ride-through performance
- This effort intended to compare positive sequence and EMT platforms: PSSE and PSCAD
- The specific results here are preliminary and no universal conclusions can be drawn
- More case studies are planned to further compare the two platforms
- A hybrid PSSE-PSCAD simulation tool will also be explored