Lessons Learned from DER Cluster Studies in New England

Presentation to the VT System Planning Committee

October 25, 2023

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ELECTRANIX

SPECIALISTS IN POWER SYSTEM STUDIES

Who is Electranix

Established in 2000, we offer power system consulting services for ISOs, TOs, GOs, and larger consultants, mainly in studies and simulation. We develop E-Tran, E-Tran Plus software, and primarily use PSCAD/EMTDC, PSS/E, PSLF and E-Tran. We are located in Winnipeg, Manitoba, Canada

Leadership Team

- Dennis Woodford – *Director, Founder*
- Garth Irwin – *President, Founder*
- Andrew Isaacs – *Vice-President*

Modelling and Studies Team

- Lukas Unruh – Study Engineer
- Jeremy Sneath M.Sc. – Study Engineer
- Anuradha Dissanayaka M.Sc. – Study Engineer
- Anuradha Kariyawasam Ph.D. – Study Engineer
- Francisco Gomez Ph.D. –Study Engineer
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- Amit Jindal Ph.D. – Study Engineer
- Kumara Mudunkotuwa Ph.D. – Study Engineer
- Kasun Samarawickrama M.Sc. – Study Engineer
- Alex Poersch – Study Specialist
- Mukesh Das Ph.D. – Study Engineer
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- Hang Li M.Sc. – Research Specialist
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Software Team

- Joel Dyck M.Sc. – Computer Scientist
- Nathan Kroeker – Computer Scientist
- Suren Dadallage M.Sc. – Electrical Engineer
- Pokyee Tsu – Computer Scientist
- Noah Wu – Computer Science Intern

Admin Team

- Crystal Isaacs M.Sc. – Admin and Finance Manager
- Camille Gao – Administrator
- Gagandeep Saini – Administrator

Electranix Experience in ISONE

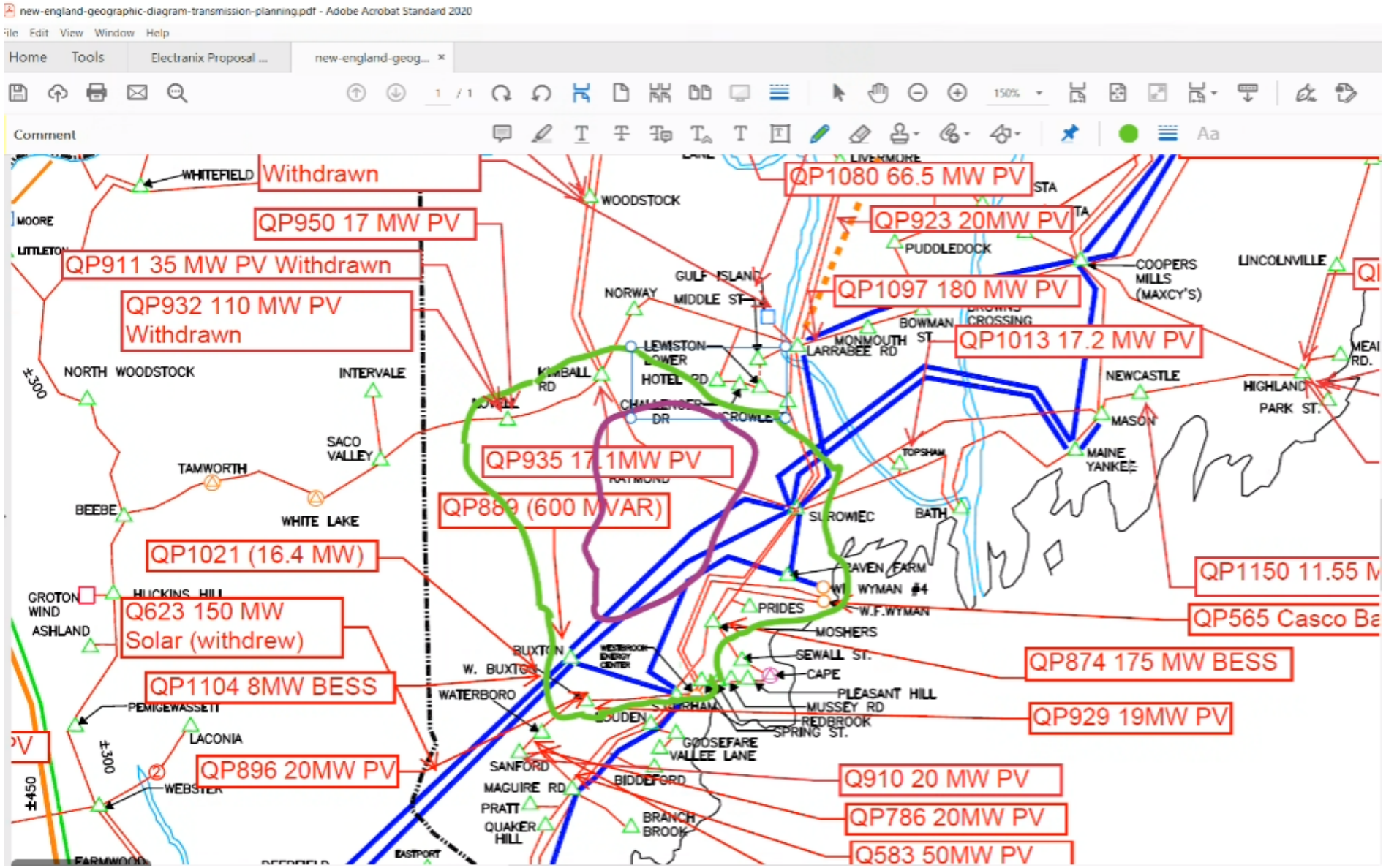
- ISONE
  - FERC queued project interconnection studies (since 2011)
  - Training and support for model development
- National Grid
  - DER Cluster studies (Mass, RI)
  - Training and support as NG moves to performing their own studies
- CMP
  - DER Cluster studies (Maine)
- Eversource
  - Training and support for performing DER cluster studies in house.

Why do this study in PSCAD?

- Concern that the limitations of PSS/E in “weak grids” would begin to become evident in high DER penetration scenarios as well.
  - Ride-through
  - Impact to nearby large transmission connected IBRs
  - Control interactions/instabilities
- Questions about the validity/correctness of the DER_A model as implemented in the ISONE system (generic model, generically parameterized)

Scoping a Cluster Study

- Requires dedicated effort to select
  - Study area and model extent
  - Which regions to cluster?
  - Impacted FERC generators
  - Aggregation of DER
  - Key disturbances (feed in from prior studies)
- First scoping is done internally (TO/Electranix), then discussed with ISONE groups
- Need to try and get real engagement and agreement at this stage!!

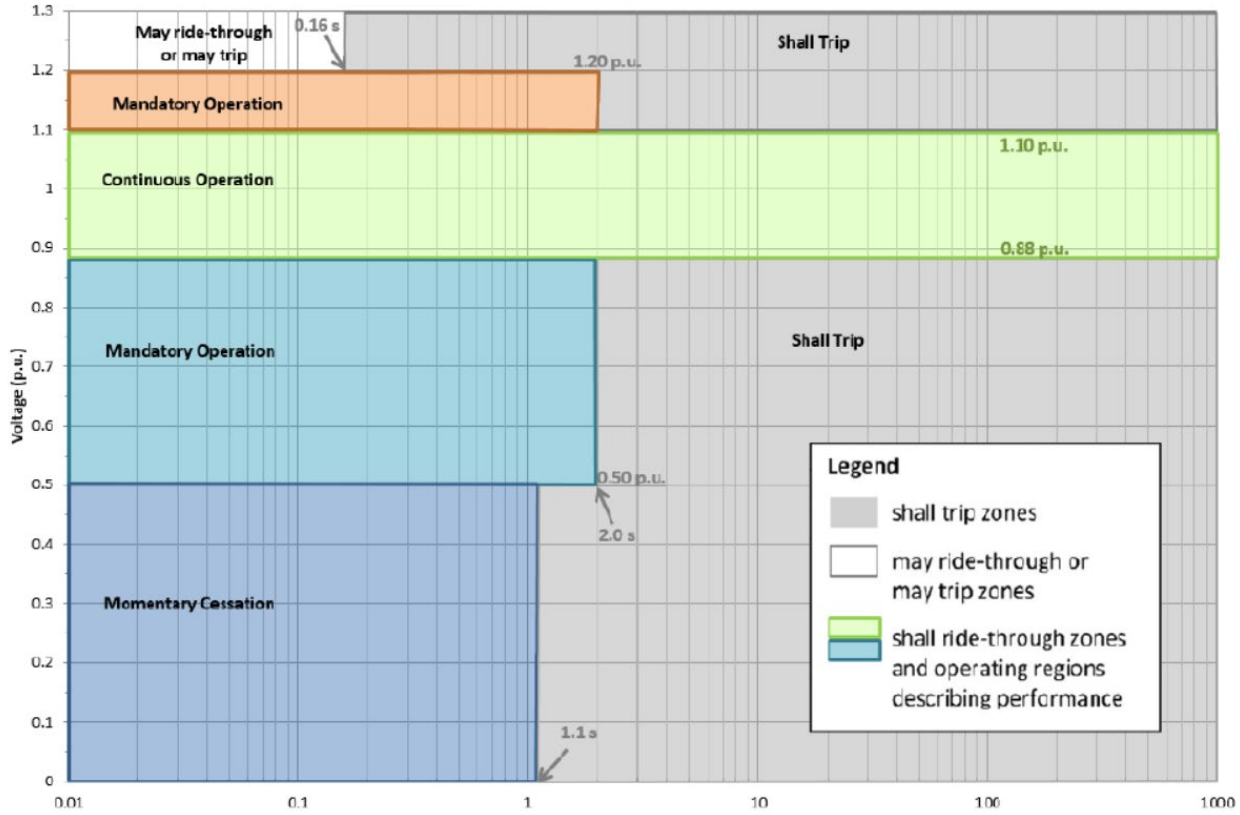

new-england-geographic-diagram-transmission-planning.pdf - Adobe Acrobat Standard 2020
Withdrawn
QP950 17 MW PV
QP911 35 MW PV Withdrawn
QP932 110 MW PV Withdrawn
QP1080 66.5 MW PV
QP923 20MW PV
QP1097 180 MW PV
QP1013 17.2 MW PV
QP935 17.1MW PV
QP889 (600 MVAR)
QP1021 (16.4 MW)
Q623 150 MW Solar (withdrew)
QP1104 8MW BESS
QP896 20MW PV
QP1150 11.55 M
QP565 Casco Ba
QP874 175 MW BESS
QP929 19MW PV
Q910 20 MW PV
QP786 20MW PV
Q583 50MW PV
WHITEFIELD
WOODSTOCK
PUDDLEDOCK
COOPERS MILLS (MAXCY'S)
LINCOLNVILLE
NORWAY
MIDDLE ST.
GULF ISLAND
BOWMAN ST.
MONMOUTH
LARRABEE RD
NEWCASTLE
HIGHLAND
PARK ST.
MASON
NORTH WOODSTOCK
INTERVALE
SACO VALLEY
TAMWORTH
BEEBE
WHITE LAKE
LEWISTON
HOTEL RD
KIMBALL RD
TOPSHAM
MAINE YANKEE
BATH
SUROWIEC
RAVEN FARM
WYMAN #4
W.F.WYMAN
PRIDES
MOSHERS
SEWALL ST.
CAPE
PLEASANT HILL
MUSSEY RD
REDBROOK
SPRING ST.
GOOSEFARE
VALLEE LANE
BIDDEFORD
SANFORD
MAGUIRE RD
PRATT
QUAKER HILL
BRANCH BROOK
WATERBORO
W. BUXTON
BUXTON
GROTON WIND
ASHLAND
HUCKINS HILL
PEMIGEWASSETT
LACONIA
WEBSTER
EASTPORT
FARMWOOD
±300
±450

Input data

- Secured powerflow and dynamic cases in PSS/E
- High quality, tested DER models
- Models (and permission to use) for relevant FERC projects
- Detailed description of disturbance scenarios
- SRD or requirements
- Scope assumptions

DER model testing

- DER models are <u>OEM specific black box models</u>
- Each DER PSCAD model tested for:
  - PSCAD study usability
    - Generic?
    - Small timestep?
    - Initialization?
    - ‘Stable’ Operation?
  - SRD ride-through requirements (similar to IEEE 1547)
    - Voltage envelope trip / no-trip regions
    - Momentary cessation / mandatory operation regions



New Electranix PSCAD model requirements & support docs:

PSCAD Model Requirements Rev. 12

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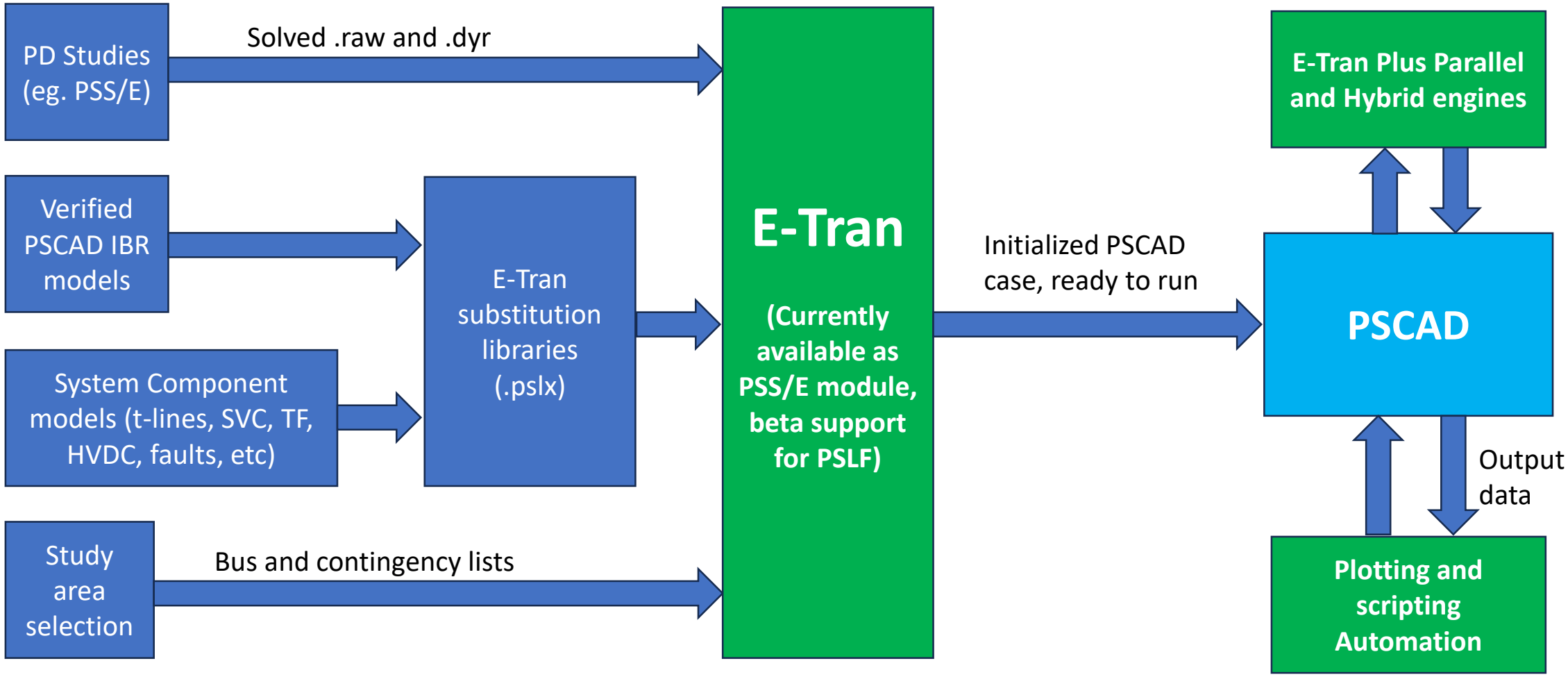
This document includes the following attachments:
Attachment #1: PSCAD Model Test Checklist for Reviewing Model Submissions
Attachment #2: PSCAD Model Requirements Supplier Checklist

Composite Model Construction



Example: PSCAD Model Vital Statistics

- 70 aggregated DG models, 2 transmission connected IBR models
- 403 3-phase AC busses
- 13 conventional generators with exciters & governors
- ZIP type load models
- 20 seconds of simulation time (one case) runs in 80 minutes on a 64-Core 128-Thread Threadripper PC
- 4 base cases
- 14 BES contingencies

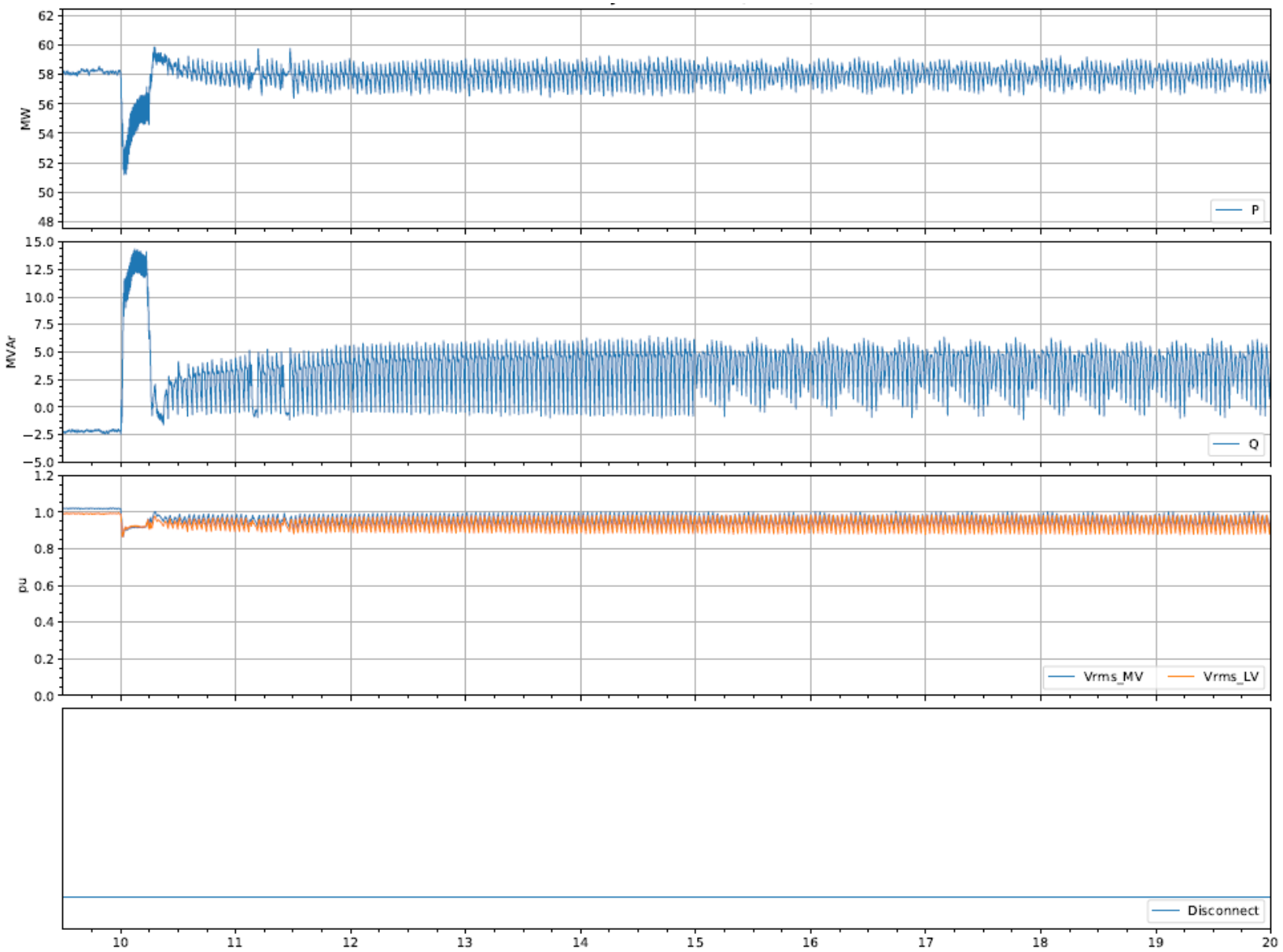
Analysis

- Massive amount of output makes *engineering* challenging. There are many things to see…
- Sensitive high level pass-fail criteria are applied automatically (first layer of analysis)
  - Automated tests for:
    - Ride-through failure, momentary cessation
    - Voltage recovery and stability
    - Very high or extended transient voltages
    - High or low steady state voltages
    - Undamped oscillations in P, Q, V
    - Harmonic content
    - Loss of synchronism or slipped poles
- Study engineer zooms in to key issues as required
- If issues are identified, iterative analysis between PSCAD and PSS/E is required

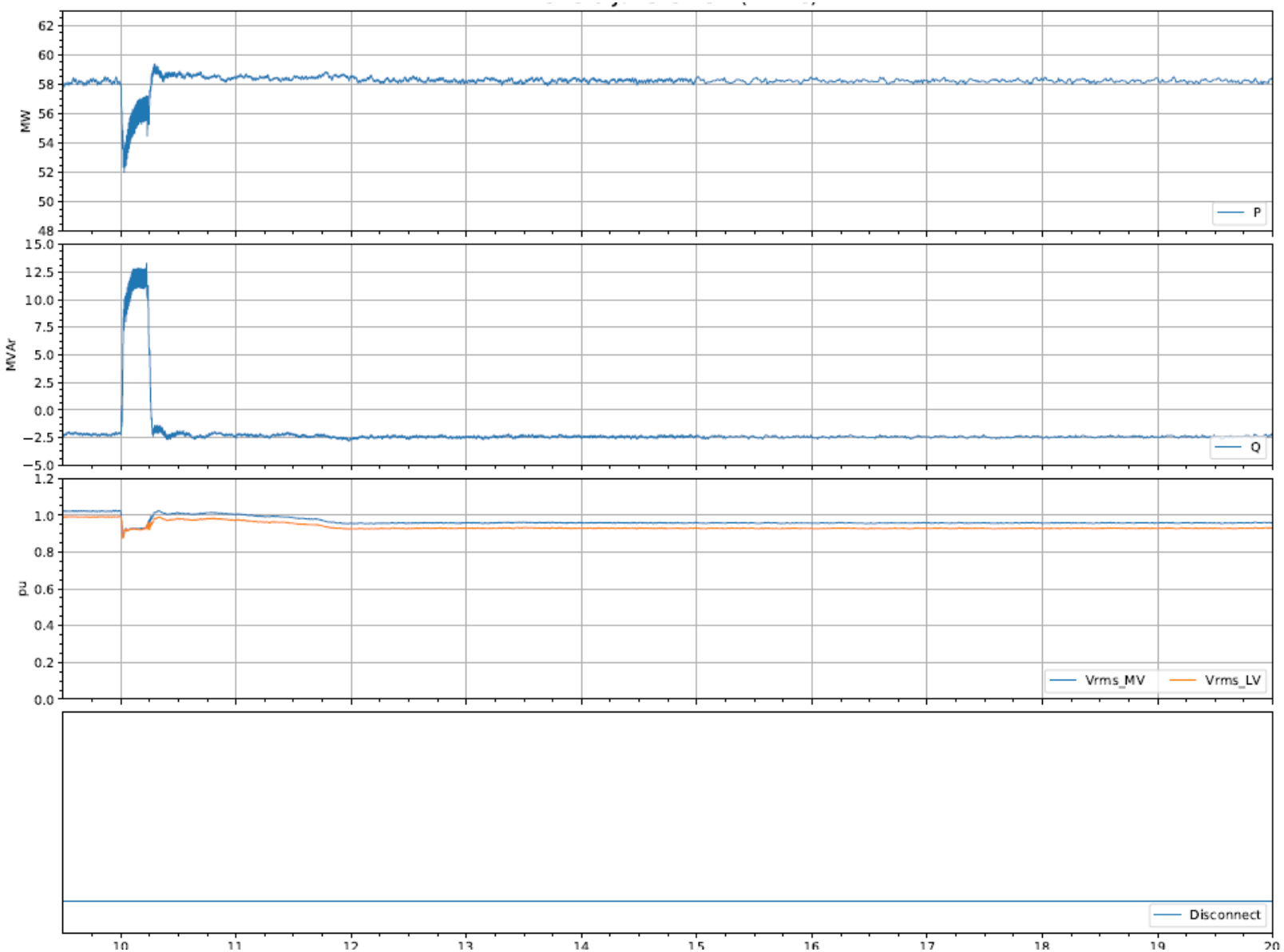
Example… problems identified!!

- Significant instability and tripping observed in PSCAD which were not evident in the corresponding PSS/E transient stability study.
- High MW connection pocket had control stability and ride-through issues. Notes:
  - Lack of voltage control from DER contributed to the issue, but dynamic var mitigation alone was not sufficient (eg. STATCOM).
  - Addition of synchronous condenser was used to both assist in stabilizing controls and in providing voltage support.
- Iterations were required in both PSCAD and PSS/E to mitigate the issues and ensure the models were trued up at the end of the study.

Undamped oscillations in inverter quantities, as well as inverter tripping (not shown here)…



…Fixed with 25 MVAr Synchronous Condenser!



Results summary table after sync condenser:

Contingency #	Pre - fault elements out	Acceptable Transmission Impact?			
		Light Load Case		Peak Load Case	
		Nearby Offshore Wind ON	Nearby Offshore Wind OFF	Nearby Offshore Wind ON	Nearby Offshore Wind OFF
1	All in	Yes	Yes	Yes	Yes
2		Yes	Yes	Yes	Yes
3		Yes	Yes	Yes	Yes
4		Yes	Yes	Yes	Yes
5		Yes	Yes	Yes	Yes
6		Yes	Yes	Yes	Yes
7		Yes	Yes	Yes	Yes
8		5.2 MW DER Trip	5.2 MW DER Trip	Yes	Yes
9	CCT 1 OOS	Yes	Yes	Yes	Yes
10		Yes	Yes	Yes	Yes
11	CCT 2 OOS	Yes	Yes	Yes	Yes
12		Yes	Yes	Yes	Yes
15		Yes	Yes	Yes	Yes
13	CCT 3 OOS	Yes	Yes	Yes	Yes

Lessons Learned (technical)

- PSCAD study can identify limitations in transmission system which were not evident using standard PSS/E planning models
- PSCAD study is significant in time, cost, and required expertise. If used for this purpose, basic design should be robust from a steady state and dynamic point of view prior to conducting the study.
- DER model acquisition and quality testing should be conducted early to avoid delays. (Think 3-6 months for first round… may be able to partner with other TOs)
- Scoping focus should be put on weakening the system, and in regions with voltage concerns… TOV tripping has been a going concern for DER
- Representative Modelling Approach .
  - Limited by state of the art modelling
  - Required for plant aggregation, inverter model assumptions, and collector/distribution feeder circuits

Lessons Learned (non-technical)

Interaction with ISONE

Involve ISONE early in scoping and keep them in the loop through the course of a study

Study Timelines

Pressure for studies to be faster, but there are factors that complicate this principle:

- Continually increasing volumes of FERC and State interconnections into the same areas
- A heightened complexity and potential need for additional study requirements for DER studies
- Coordination and dependency on other study outputs, including outputs compromised by developer attrition
- Timing of FERC queued projects entering and exiting study can be a huge head-ache

Stakeholder Communication

An ongoing informative and collaborative communication plan is the only sure way to:

- manage stakeholder expectations relative to the continually changing circumstances

Next Steps:

- Develop model intake process
- Begin developing PSCAD capability
  - Short term: Build understanding at a high level to be able to create processes, manage data and consultants, develop capability to intake models
  - Long term: Develop capability to perform studies

Questions?

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