Planning & Coordination

Distributed Generation Cluster Studies

Meg Sullivan, Manager, Transmission Planning
Central Maine Power

July 19, 2022

Contents

Contents

Solar Forecast

ISO New England's Forecast Report of Capacity, Energy, Loads, and Transmission (the CELT Report)

- 10-year projections used in power system planning and reliability studies.
- Includes the energy and peak load forecasts integrate state historical demand, economic and weather data, and the impacts of utility-sponsored conservation and peak-load management programs.

Forecasts Used in Transmission Planning

2019

Gross 90/10 Summer Peak Load Forecast [1]

Load Zone	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
CT	7,719	7,734	7,751	7,769	7,786	7,802	7,818	7,834	7,850	7,866
ME	**2,217**	**2,235**	**2,260**	**2,288**	**2,313**	**2,339**	**2,363**	**2,387**	**2,412**	**2,437**
NEMA	6,722	6,787	6,856	6,928	6,998	7,069	7,138	7,207	7,276	7,346
NH	2,572	2,587	2,604	2,622	2,638	2,654	2,671	2,688	2,706	2,724
RI	2,313	2,340	2,368	2,398	2,429	2,460	2,491	2,522	2,552	2,583
SEMA	4,119	4,151	4,186	4,222	4,257	4,292	4,327	4,361	4,396	4,430
VT	1,123	1,128	1,134	1,141	1,147	1,154	1,159	1,165	1,172	1,179
WCMA	4,047	4,088	4,130	4,175	4,218	4,261	4,304	4,347	4,389	4,433
MA (Sum of Load Zones	14,888	15,026	15,173	15,325	15,473	15,622	15,768	15,915	16,061	16,209
ISO-NE	**30,832**	**31,050**	**31,291**	**31,543**	**31,786**	**32,030**	**32,271**	**32,512**	**32,753**	**32,999**

PV Forecast [3,4,5] (June 1st Total Nameplate Capacity)

Load Zone	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028
CT	486	562	655	752	842	913	985	1,056	1,119	1,162
ME	**44**	**51**	**58**	**65**	**71**	**78**	**85**	**92**	**98**	**105**
NEMA	347	398	448	496	544	589	623	654	684	713
NH	88	101	113	125	137	149	161	173	185	197
RI	133	184	235	281	324	366	408	451	493	536
SEMA	714	820	923	1,022	1,121	1,212	1,283	1,346	1,408	1,467
VT	316	345	367	388	410	431	452	473	495	516
WCMA	903	1,036	1,166	1,291	1,416	1,531	1,621	1,701	1,779	1,854
MA (Sum of Load Zones	1,964	2,254	2,537	2,809	3,081	3,332	3,527	3,701	3,870	4,034
ISO-NE	**3,031**	**3,497**	**3,965**	**4,421**	**4,865**	**5,269**	**5,618**	**5,947**	**6,261**	**6,550**

FOOTNOTES:

(1) The "gross" load forecast is from a probabilistic distribution of forecast peak loads without reductions from EE and BTM PV. It represents the 90/10 peak demand forecast, which is a point on the distribution where the peak demand is expected to be exceeded 10% of summer seasons and not met 90% of summer seasons.

(3) This table includes SORs and Generators (per OP-14) that participate only in the energy market. Negative values in this category are due to the transfer of certain resources from energy-only PV to the Forward Capacity Market PV category.

(4) The forecasted nameplate PV that is expected to be in-service as of June 1st of the study year is used to represent the PV forecast in the summer peak load cases for that study year. For example, a summer 2021 peak load case will include a forecast of nameplate PV that is expected to be in-service as of June 1, 2021.

(5) Additional details on the modeling of PV forecast in transmission planning studies are available in the Transmission Planning Technical Guide, section 2.3.10. (https://www.iso-ne.com/static-assets/documents/2017/03/transmission_planning_techical_guide_rev4_1.pdf)

2022

Gross 90/10 Summer Peak Load Forecast [1]										
Load Zone	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
CT	7,603	7,621	7,641	7,662	7,696	7,730	7,769	7,813	7,865	7,923
ME	2,245	2,267	2,291	2,317	2,350	2,386	2,428	2,475	2,530	2,591
NEMA	6,184	6,211	6,243	6,279	6,324	6,366	6,411	6,457	6,504	6,553
NH	2,617	2,637	2,656	2,675	2,696	2,717	2,738	2,761	2,785	2,811
RI	2,175	2,188	2,202	2,216	2,234	2,252	2,273	2,295	2,319	2,345
SEMA	3,776	3,782	3,791	3,803	3,821	3,836	3,853	3,871	3,890	3,909
VT	1,070	1,074	1,079	1,088	1,105	1,122	1,142	1,165	1,189	1,214
WCMA	3,802	3,814	3,830	3,848	3,871	3,892	3,915	3,939	3,964	3,990
MA (Sum of Load Zones)	13,761	13,807	13,863	13,930	14,016	14,095	14,179	14,267	14,358	14,452
ISO-NE	**29,472**	**29,594**	**29,732**	**29,889**	**30,098**	**30,302**	**30,528**	**30,776**	**31,046**	**31,336**

PV Forecast [3,4,5] (June 1 Total Nameplate Capacity)										
Load Zone	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
CT	844	957	1,081	1,219	1,324	1,429	1,534	1,637	1,733	1,820
ME	158	302	523	738	960	1,121	1,147	1,172	1,198	1,223
NEMA	494	565	631	695	760	820	871	919	966	1,012
NH	166	196	224	250	277	304	331	358	384	411
RI	304	356	404	451	498	544	591	638	682	721
SEMA	1,072	1,225	1,370	1,509	1,648	1,780	1,891	1,994	2,095	2,195
VT	443	471	498	523	549	574	600	625	651	676
WCMA	1,526	1,744	1,950	2,149	2,347	2,534	2,692	2,839	2,983	3,125
MA (Sum of Load Zones)	3,092	3,534	3,951	4,353	4,755	5,134	5,455	5,752	6,044	6,331
ISO-NE	**5,008**	**5,815**	**6,681**	**7,535**	**8,362**	**9,106**	**9,656**	**10,182**	**10,692**	**11,184**

Footnotes for Section 6.2

1. The "gross" load forecast is from a probabilistic distribution of forecast peak loads without reductions resulting from energy efficiency and BTM PV. It represents the 90/10 peak demand forecast, which is a value within the distribution that peak demand has a 10% probability of exceeding in any summer period.
2. These values include an 8% gross-up to reflect avoided transmission and distribution losses.
3. The PV values reflected in this table are the sum of FCM PV, non-FCM PV, and Behind-the-Meter PV. Refer to Section 3.1 for the breakdown of total PV by category.
4. The forecast nameplate PV expected to be in service as of June 1 of the study year is used to represent the PV forecast in the summer peak load cases for that study year. For example, a summer 2023 peak load case will include a forecast of nameplate PV expected to be in service as of June 1, 2023.
5. Additional details on the modeling of the PV forecast in transmission planning studies are available in the Transmission Planning Technical Guide, Section 2.3.11.

Level of Interest

Chapter 324 Level 4 Interconnection Applications 2018-2020

2018					
Month Ending	Applications Submitted	Cumulative Total Current Year	Cumulative Total All Years	Percent Growth (Month over Month)	Percent Cummulative Growth (Per annum)
Jan	0	0	0		
Feb	0	0	0		
Mar	0	0	0		
Apr	0	0	0		
May	0	0	0		
Jun	0	0	0		
Jul	0	0	0		
Aug	3	3	3		
Sep	2	5	5	-33%	-
Oct	1	6	6	-50%	-
Nov	0	6	6	-100%	-
Dec	0	6	6	0%	-

2019					
Month Ending	Applications Submitted	Cumulative Total Current Year	Cumulative Total All Years	Percent Growth (Month over Month)	Percent Cummulative Growth (Per annum)
Jan	1	1	7	-	-
Feb	1	2	8	0%	-
Mar	2	4	10	100%	-
Apr	2	6	12	0%	-
May	7	13	19	250%	-
Jun	4	17	23	-43%	-
Jul	4	21	27	0%	-
Aug	33	54	60	725%	1700%
Sep	83	137	143	152%	2640%
Oct	89	226	232	7%	3667%
Nov	53	279	285	-40%	4550%
Dec	13	292	298	-75%	4767%

2020					
Month Ending	Applications Submitted	Cumulative Total Current Year	Cumulative Total All Years	Percent Growth (Month over Month)	Percent Cummulative Growth (Per annum)
Jan	40	40	338	208%	3900%
Feb	35	75	373	-13%	3650%
Mar	39	114	412	11%	2750%
Apr	37	151	449	-5%	2417%
May	30	181	479	-19%	1292%
Jun	19	200	498	-37%	1076%
Jul	25	225	523	32%	971%
Aug	16	241	539	-36%	346%
Sep	16	257	555	0%	88%
Oct	18	275	573	13%	22%
Nov	19	294	592	6%	5%
Dec	32	326	624	68%	12%

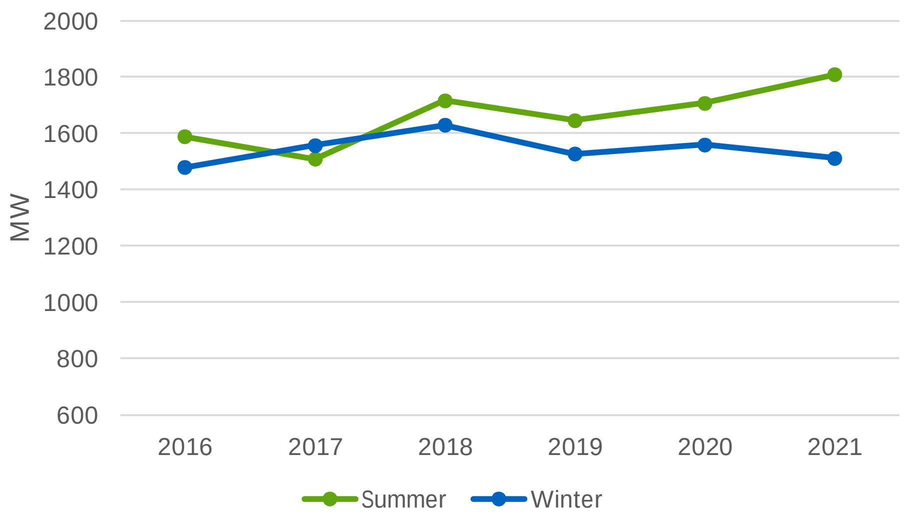
- Central Maine Power experienced more than 4,750% year over year growth in applications between 2019 and 2018.

CMP had approximately 2,000 MW in its Chpt. 324 Level 4 Interconnection queue in 2020

Solar & Load Profiles

CMP Peak Load

Adjusted Peak Load (without PTF losses)



CMP, a subsidiary of AVANGRID, serves approximately 646,000 electricity customers

We service an 11,000 square-mile service area in central and southern Maine

Our system is comprised of 25,000 miles of power lines and 280 substations

Solar & Load Profiles

High Penetration of Distributed Energy Resources

- Primarily solar photovoltaic (PV)
- Connecting to the low-voltage, distribution system
- Under 5 MW
- ISO-NE 2022 CELT forecasts 11,184 MW of PV resources by end of 2031
  - 1,223 MW of PV resources forecasted in Maine

Solar Characteristics

- PV is considered a clean, but intermittent resource
- High solar can occur during a mid-day summer peak or during a daytime light load such as mild spring weekend days
- Low solar can occur during a winter peak or summer evening peak

Result of Increased Solar DERs

- Decreasing load during mid-day periods
- Likely shift to winter peaking
- Reduction in synchronous generation

Level of Interest

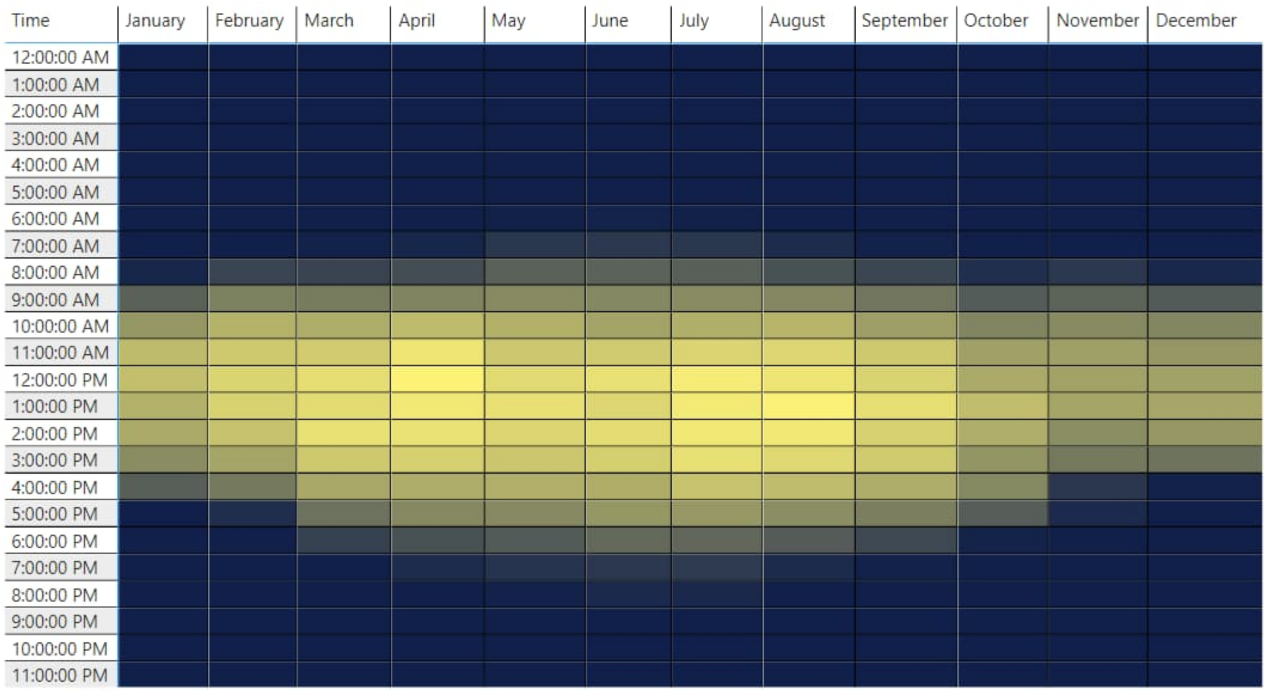
Today

- Central Maine Power has received over 730 applications for Chpt. 324 Level 4 interconnections
- There are nearly 1,800 MW in the CMP Level 4 Queue, excluding withdrawn projects
- Approx. 400 projects have an executed Interconnection Agreement
- Approx. 740 MW have both an executed Interconnection Agreement and ISO-NE approval to interconnect

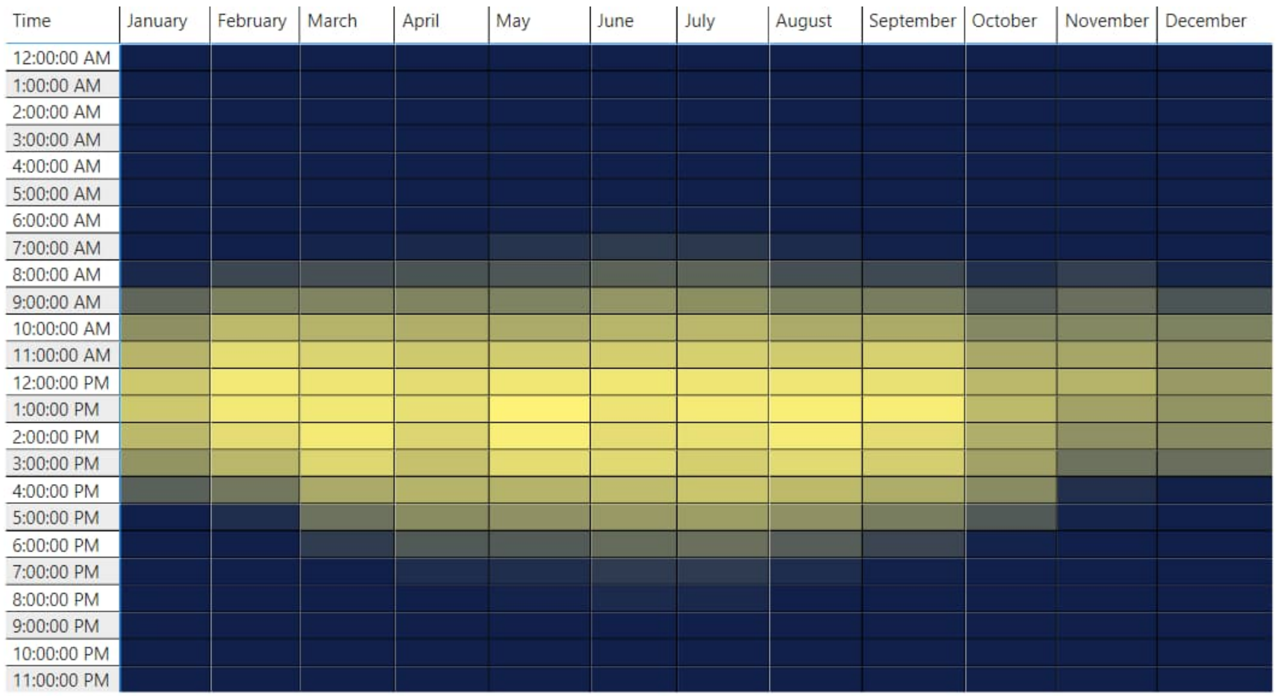
Solar & Load Profiles

Solar Profiles in Maine

Topsham



Waterville



Solar & Load Profiles

ISO-NE Analysis of Historical Load & Solar Conditions

Low load, high solar: daytime minimum load. Typically occurs between 12 and 2 PM on mild spring weekend days.

Low load, low solar: nighttime minimum load. Typically occurs between 2 and 5 AM on mild spring and fall weekend nights.

High load, relatively high solar: mid-day on a peak load day. Typically occurs between 12 and 3 PM on a hot summer weekday.

High load, low solar: evening on a peak load day. With increased solar penetration, will occur between 6 and 9 PM on a hot summer weekday. Note that power consumption is lower than during the midday hours – approximately 95% of the peak.

Source: *ISO-NE Transmission Planning for the Future Grid, PAC, Sept. 24, 2020*

Solar & Load Profiles

Masking the Load – Different System Behavior

- Current practice in transmission planning studies is to study net load levels.
  - Forecast Load – Energy Efficiency/Demand Resources – DER = Net Load

- Increased DER results in an artificial minimum load, during the day
  - 3 am on a mild spring night:
    8,000 MW – 0 MW DER = 8,000 MW net load
  - 1 pm on a mild sunny spring day:
    14,000 MW – 6,000 MW DER = 8,000 MW net load

Source: *ISO-NE Transmission Planning for the Future Grid, PAC, Sept. 24, 2020*

Contents

02 Cluster Studies

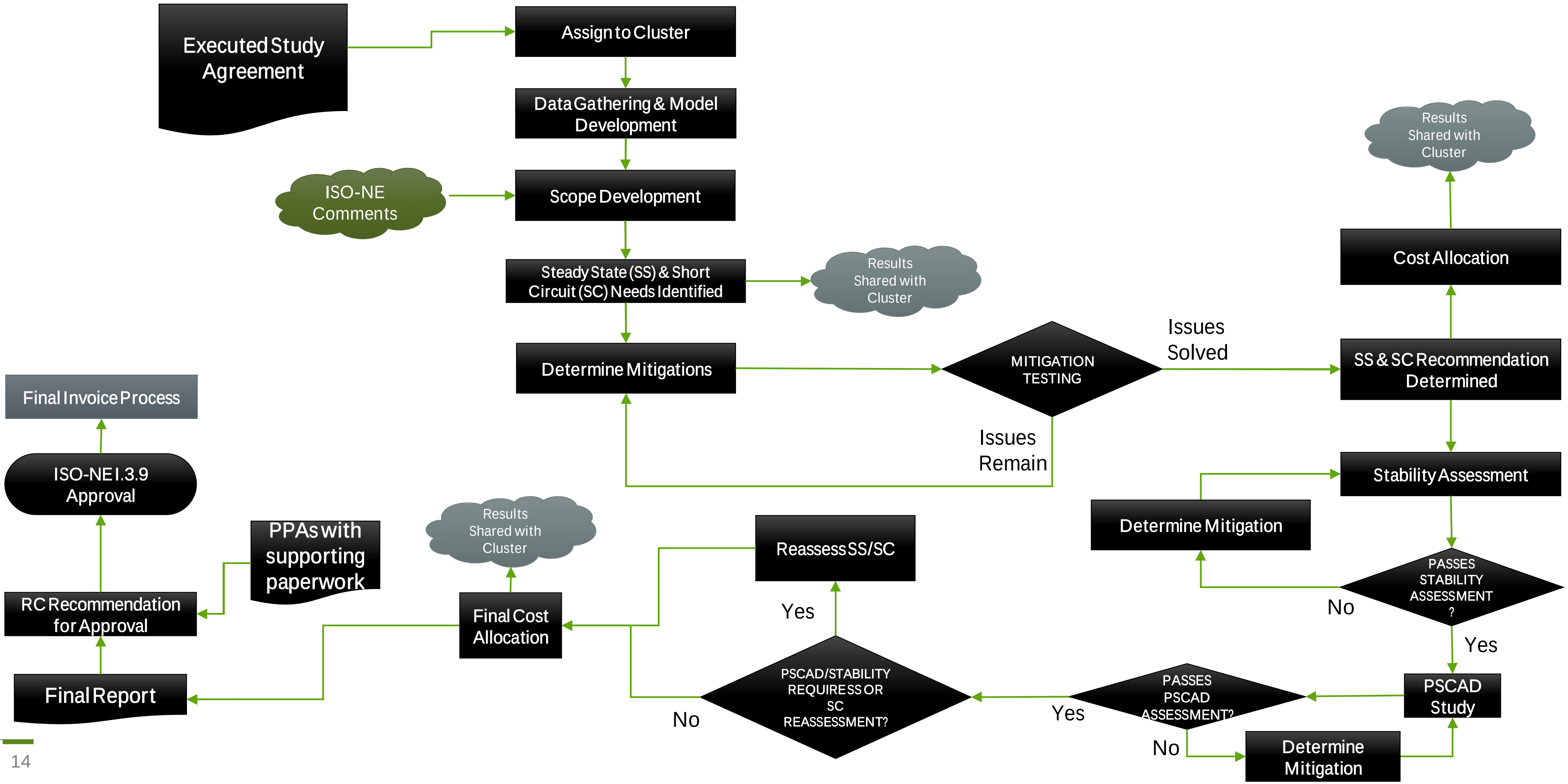
- Purpose & Background
- Cluster Study Results To-date

Purpose & Background

Transmission System Impact Study

- A transmission system impact study evaluates the effects of the proposed Distributed Generation (DG) interconnection on the operation and performance of the electric transmission system.
- The voltage level of the electric transmission system at CMP is 345 kV, 115 kV, and 34.5 kV.
- Historically, the reliability impacts of interconnections including DERs were assessed individually in a queue order of when they materialized. This sequential approach ensures that each project and its impacts were assessed in an orderly manner resulting in discreet incremental system model changes with each new DER which in turn became the basis for the start of the next DER study in the queue. This sequential approach works well for individual requests or gradual increases in DER penetrations; however, the timelines accompanying this approach quickly become impractical with high volumes of DERs seeking interconnections as has been experienced in Maine. DER projects are now assessed in “clusters.”
- The reliability performance of the system is assessed before and after the proposed DER projects.
- Each study must include a sufficiently broad range of system conditions including generation patterns (on/off-line scenarios), load levels (peak, shoulder, light, minimum), and system contingencies (unplanned outage events) to ensure a comprehensive assessment that minimizes the need for restudy or scope expansion at a later date.
- Study components include:
  - Load Flow
  - Short Circuit
  - Stability
  - Power-System Computer-Aided Design (PSCAD)
  - Mitigation, Challenge Work, & Cost Allocation

Purpose & Background



Purpose & Background

- DG projects are evaluated to determine if the interconnection or aggregate interconnections have a Significant Adverse Impact on the transmission system.
- “Significant Adverse Impact” is defined by ISO-NE
- On September 29, 2021, in Docket No. 2021-00262, CMP filed a summary document labeled the Cluster Study Whitepaper that describes the transmission cluster study process and its inherent complexities

Steady-State Load Flow

- A change to the transmission system that increases the flow in an Element by at least two percent (2%) of the Element’s rating and that causes that flow to exceed that Element’s appropriate thermal rating by more than two percent (2%). The appropriate thermal rating is the normal rating with all lines in service and the long-time emergency or short time emergency rating after a contingency.
- A change to the transmission system that causes at least a one percent (1%) change in a voltage and causes a voltage level that is higher or lower than the appropriate rating by more than one percent.

Short Circuit

- A change to the transmission system that causes at least a one percent (1%) change in the short circuit current experienced by an Element and that causes a short circuit stress that is higher than an Element’s interrupting or withstand capability.

Purpose & Background

Stability

- With due regard for the maximum operating capability of the affected systems, one or more of the following conditions arising from faults or disturbances, shall be deemed as having significant adverse impact: A fault or a disturbance that cause:
  - Any loss of synchronism or tripping of a generator
  - Unacceptable system dynamic response
  - Unacceptable equipment tripping: tripping of an un-faulted bulk power system element (element that has already been classified as Bulk Power System) under planned system configuration due to operation of a protection system in response to a stable power swing or operation of a Type I or Type II Special Protection System in response to a condition for which its operation is not required

Table I: Inverters' Voltage Trip Settings

Shall Trip – IEEE Std 1547-2018 (2nd ed.) Category II					
Shall Trip Function	Required Settings		Comparison to IEEE Std 1547-2018 (2nd ed.) default settings and ranges of allowable settings for Category II		
	Voltage (p.u. of nominal voltage)	Clearing Time(s)	Voltage	Clearing Time(s)	Within ranges of allowable settings?
OV2	1.20	0.16	Identical	Identical	Yes
OV1	1.10	2.0	Identical	Identical	Yes
UV1	0.88	2.0	Higher (default is 0.70 p.u.)	Much shorter (default is 10 s)	Yes
UV2	0.50	1.1	Slightly higher (default is 0.45 p.u.)	Much longer (default is 0.16 s)	Yes

PSCAD

- The increase in power electronic and inverter-based devices on the system has led to a concern that the typical stability analysis may be overlooking certain possible risks.
  - PSCAD models are much detailed than the simplified stability models.
  - Models are project-specific as opposed to generic (i.e. everything is "user-written").
  - Simulations are per-phase, as opposed to a simplified balanced system.
  - Allows for much smaller time steps (microseconds vs. milliseconds).
  - Simulations are very processing-intensive so models are generally equivalenced down to just a few buses away from the area of interest. Similarly, fault testing tends to be limited to a relatively short list of critical events.

Table II: Inverters' Frequency Trip Settings

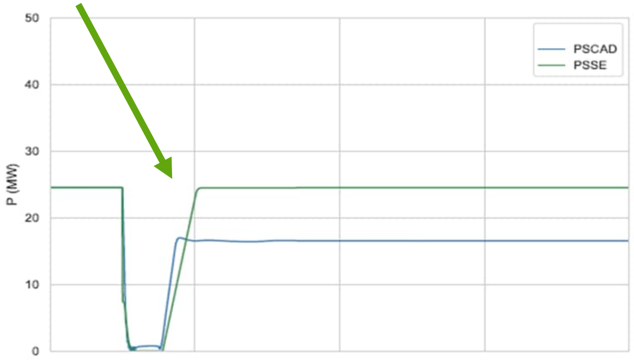
Shall Trip Function	Required Settings		Comparison to IEEE Std 1547-2018 (2nd ed.) default settings and ranges of allowable settings for Category I, Category II, and Category III		
	Frequency (Hz)	Clearing Time(s)	Frequency	Clearing Time(s)	Within ranges of allowable settings?
OF2	62.0	0.16	Identical	Identical	Yes
OF1	61.2	300.0	Identical	Identical	Yes
UF1	58.5	300.0	Identical	Identical	Yes
UF2	56.5	0.16	Identical	Identical	Yes

Purpose & Background

PSCAD Continued

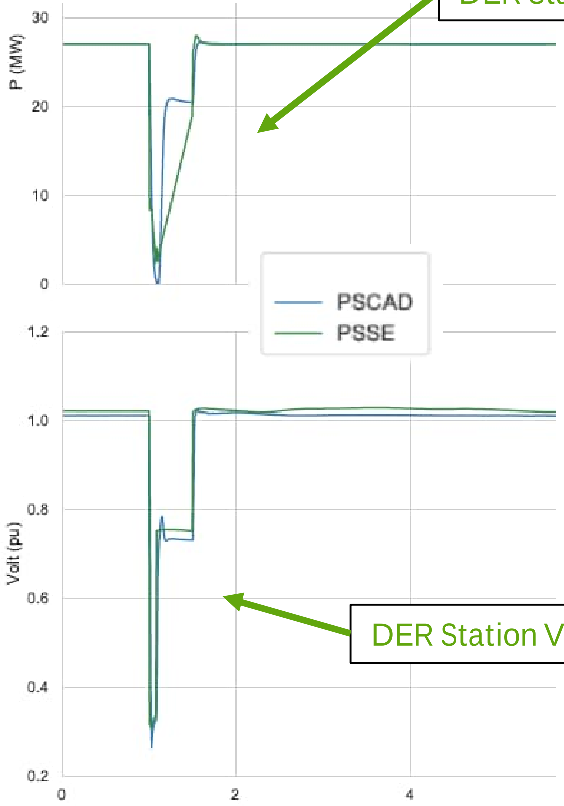
- Stability models are "benchmarked" against PSCAD models to demonstrate that they respond sufficiently similarly to the PSCAD model. This benchmarking is part of ISO-NE's stability model acceptance process.

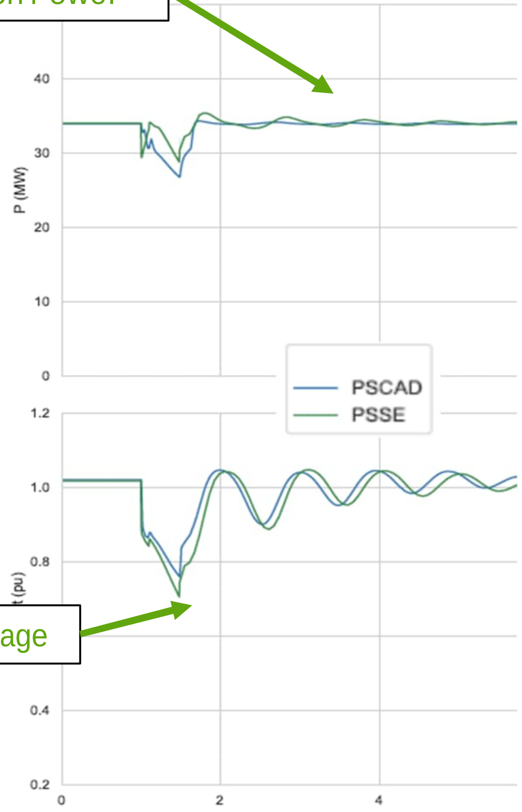
DER Station Power – tripping in PSCAD, no trip in typical stability study



PSCAD Benchmarking

DER Station Power





DER Station Voltage

Graph Source: *Electranix, ISO-NE 2020*

Purpose & Background

PSCAD Continued

- PSCAD analysis is testing for:
  - Weak grid control instability. Particularly at the end of long radial circuits, where available short circuit capacity may be relatively low, inverter-based generator controls are vulnerable to small signal instabilities and control issues.
  - Ride through capability. Following faults on the large lines in the connection area, the generators in the region are expected to recover full power. Inverter Based Resources (IBR) such as the DG being planned may trip for many reasons which may not be accurately represented in conventional transient stability tools.
  - Voltage control coordination. It is likely that the plants will have sufficient impedance between them to avoid voltage controller interactions, particularly since the majority of these DG plants are planned to be operated in constant power factor mode. However, if voltages throughout the distribution system vary significantly under various operating conditions, the individual plants may struggle to maintain their terminal voltages within acceptable ranges.

Local reactive power support to maintain system voltages is more critical in weak systems.

If the system is too weak and has insufficient voltage support, the system may experience post fault steady state voltage violations before the power plant voltage controller is able come into action (which may take 20 to 30 seconds depending on the time constants of these plant level controllers).

Tripping of a significant generator is more likely to result in undesirable poorly damped power oscillations in weak system compared to a strong system.

Source: *Panhandle and South Texas Stability and System Strength Assessment, Electranix, Mar. 28, 2018*

Purpose & Background

Mitigation, Challenge Work, & Cost Allocation

- If there are reliability criteria violations, mitigation is proposed and tested against all of the scenarios to ensure that proposed upgrades are sufficient.
- CMP has established "Challenge Sessions" for each cluster study that are designed to challenge the typical network upgrade approach and look for mitigation recommendations that may be both more cost-effective and facilitate more rapid interconnection of DG projects. Results of the Challenge Sessions are provided to cluster participants along with explanations as to why a challenge session mitigation recommendation was either accepted or deemed not a viable alternative.
- Once the pre- and post project mitigation measures are determined, the final step involves a weighted cost allocation analysis designed to determine each DER project's share of the required upgrade costs. A cost allocation methodology was developed by CMP in collaboration with a team of interested stakeholders as an approach that assigns network upgrade costs to projects in relation to their contribution to the need for the mitigation project. The result is that this methodology can identify projects with limited to no network upgrades that could proceed to interconnection with low-cost or no mitigation obligations. Additionally, it identifies projects that are substantial contributors to the required upgrade costs that can in turn make a determination as to whether they wish to withdraw from the interconnection queue.

Cluster Study Results To-date

Completed Cluster Projects			
Cluster Name	I.3.9 Approval Date	Study Projects	MW
Cluster 01 - Augusta - 1	1/4/2021	17	61
Cluster 02 - Winslow-County Rd-Lakewood -1	12/17/2021	20	65
Cluster 04 - Sanford-Quaker Hill - 1	6/27/2022	17	63
Total		54	189

Cluster Study Milestone	Clusters in Current Milestone	Sum of MW
Report Development	2	185.6
PSCAD	1	91.9
Mitigations Identified & Analysis Completed	9	236.7
Steady State & Short Circuit Needs Identified	0	0
Total	12	514.1

Active Cluster Projects								
Cluster Name	Cluster Entry Closed	Study Projects	Active Projects	MW	Active Project MW	Current Milestone	Overall Project Percent Complete	I.3.9 Approval Target
Cluster 03 - Kimball Rd-Lovell - 1	1/1/2021	26	25	92.5	91.9	5-PSCAD	80.00%	Sep-22
Cluster 05 - Lewiston Loop - 1	2/1/2021	24	23	83.1	82.1	6-Report Development	95.00%	Jul-22
Cluster 06 - Detroit-Guilford-Belfast - 1	2/1/2021	28	26	104.9	103.5	6-Report Development	95.00%	Aug-22
Cluster 07 - Raymond - 1	3/1/2021	13	13	51.1	51.1	4-Mitigations Identified & Analysis Completed	60.00%	Apr-23
Cluster 08 - Sturtevant-Leeds-Livermore-Ludden-Riley - 1	3/1/2021	7	7	22.6	22.6	4-Mitigations Identified & Analysis Completed	60.00%	Apr-23
Cluster 09 - Midcoast - 1	6/1/2021	16	16	50.6	50.6	4-Mitigations Identified & Analysis Completed	50.00%	Mar-23
Cluster 10 - Roxbury-Rumford-Woodstock - 1	5/1/2021	6	5	9.5	8.5	4-Mitigations Identified & Analysis Completed	60.00%	Apr-23
Cluster 11 - Augusta E-Puddledock-Bowman St - 2	6/1/2021	13	11	37.2	35.3	4-Mitigations Identified & Analysis Completed	60.00%	Apr-23
Cluster 12 - Winslow-County Rd-Lakewood - 2	7/1/2021	9	9	35.9	35.9	4-Mitigations Identified & Analysis Completed	60.00%	Apr-23
Cluster 13 - Kimball Rd-Lovell - 2	To Be Closed	7	5	13.9	12.5	Pending Cluster Entry Closure	5.00%	
Cluster 14 - Louden-Biddeford IP - 1	7/1/2021	4	3	12.3	11.4	4-Mitigations Identified & Analysis Completed	40.00%	May-23
Cluster 15 - Greater Portland - 1	8/1/2021	7	6	20.1	19.2	4-Mitigations Identified & Analysis Completed	40.00%	May-23
Cluster 16 - Wyman Area - 1	10/1/2021	3	1	4.0	2.0	4-Mitigations Identified & Analysis Completed	60.00%	Nov-22
Cluster 17 - Detroit Guilford Belfast - 2	To Be Closed	12	12	41.9	41.9	Pending Cluster Entry Closure	5.00%	
Cluster 18 - Lewiston Loop - 2	To Be Closed	10	9	26.4	25.4	Pending Cluster Entry Closure	5.00%	
Cluster 19 - Sanford-Quaker Hill - 2	To Be Closed	9	9	22.4	22.4	Pending Cluster Entry Closure	5.00%	
Total (Open Clusters):		156	145	524	514			

Contents

AVANGRID

03 Opportunities

- Anticipated Results
- Study Timelines
- Lessons Learned

Anticipated Results

Increasing study complexities

- Flows on the CMP sub-transmission system are shifting from load serving to exporting
- Studies must account for the large amount of DG approved to operate in addition to a number of scenarios to ensure system reliability under a variety of load conditions as well as a very active FERC generation queue.

Increasing impact from FERC-queued generation

- Throughout the lifecycle of a cluster study, ISO-NE is managing a queue of FERC-jurisdictional projects proposing to interconnect to CMP's transmission system. All FERC generator projects take precedence over DERs that do not yet have ISO New England Section I.3.9 approval, as mandated by the ISO New England process. The DER cluster studies must consider the impact of new proposed interconnections as they come under study in the ISO-NE queue.

Anticipate Network Upgrades

- As evidenced by recent cluster activity, depending on the interconnecting project's location and available system capacity, it is reasonable to anticipate network upgrades
- Some projects may not cause a significant adverse impact and those will be able to proceed with limited transmission upgrades
- Transmission network upgrades will impact a project's interconnection cost and timeline

Study Timelines

Cluster Name	Cluster Closed	Baseline Schedule Sept-2021[1,2]		Current Schedule July-2022[1,2]	
		Reliability Committee	I.3.9 Approval	Reliability Committee	I.3.9 Approval
Cluster 03 - Kimball Rd-Lovell - 1	1/1/21	22-Mar	22-Mar	22-Sep	22-Sep
Cluster 04 - Sanford-Quaker Hill - 1	2/1/21	22-Mar	22-Mar	22-Jun	22-Jun
Cluster 05 - Lewiston Loop - 1	2/1/21	22-Mar	22-Mar	22-Jul	22-Jul
Cluster 06 - Detroit-Guilford-Belfast - 1	2/1/21	22-Mar	22-Mar	22-Aug	22-Aug
Cluster 07 - Raymond - 1	3/1/21	22-Jul	22-Jul	23-Apr	23-Apr
Cluster 08 - Sturtevant-Leeds-Livermore-Ludden-Riley - 1	3/1/21	22-Jul	22-Jul	23-Apr	23-Apr
Cluster 09 - Midcoast - 1	5/1/21	22-Sep	22-Sep	23-Mar	23-Mar
Cluster 10 - Roxbury-Rumford-Woodstock - 1	4-6/1/21	22-Jul	22-Jul	23-Apr	23-Apr
Cluster 11 - Augusta E-Puddledock-Bowman St - 2	6/1/21	22-Aug	22-Aug	23-Apr	23-Apr
Cluster 12 - Winslow-County Rd-Lakewood - 2	7/1/21	22-Sep	22-Sep	23-Apr	23-Apr
Cluster 13 - Kimball Rd-Lovell - 2	7/1/21	22-Nov	22-Nov	23-Jun	23-Jun
Cluster 14 - Louden-Biddeford IP - 1	7/1/21	22-Aug	22-Aug	23-May	23-May
Cluster 15 - Greater Portland - 1	8/1/21	22-Aug	22-Aug	23-May	23-May
Cluster 16 - Wyman Area - 1	10/1/21	22-Sep	22-Sep	22-Nov	22-Nov
Cluster 17 - Detroit-Guilford-Belfast - 2	TBD	22-Nov	22-Nov	23-Apr	23-Apr
Cluster 18 - Lewiston Loop - 2	TBD	22-Nov	22-Nov	23-Apr	23-Apr
Cluster 19 - Sanford-Quaker Hill - 2	TBD			23-Mar	23-Mar

(1) This current view represents experience to date and results from the development of a detailed schedule for each cluster. It excludes unforeseen risks and unknowns (e.g. exceptionally complex mitigation [pre or post PSCAD analysis], ISO-NE queued project triggers re-assessment)

(2) Schedule excludes a period for an attrition window, subsequent attrition, and resulting study if necessary for Clusters 03-06

Lessons Learned

Increased Communications

- Executed NDAs provide projects with access to CEII results for each cluster for which the project developer has at least one participating project and allow CMP to increase communication throughout the study process
- Cluster-specific meetings scheduled to discuss results as they become available and communicate cluster-specific updates
- CMP updates and publishes cluster study schedules on a biweekly basis in order to keep cluster participants actively informed. In addition, CMP hosts monthly transmission study webinars

Challenge Session Improvements

- Using Challenge Sessions to determine any curtailment opportunities
- Incorporating previous Challenge Sessions into proposed standard mitigation

Terms & Conditions

- Benefits of Incorporating the T&Cs (Docket No. 2021-00277)
  - Document the currently undocumented process of conducting required transmission system impact studies to provide for increased schedule certainty
  - Implements a number of process improvements designed to streamline the study process
  - Require timely responses from cluster participants
  - Facilitate the attrition of projects as studies progress which improves network upgrade cost and schedule firmness for impacted DG
  - Equitably allocate the costs of both the studies and any resulting transmission system upgrades
  - Provide for a new “Conceptual Engineering Study” for projects with network upgrades to improve upon the +200/-50% cost estimates

Innovative & Traditional Network Upgrades

- Operate new PV at non-unity power factor
  - New PV consumes reactive power and helps reduce voltage constraints
  - Non-unity PF applications often accompanied by shunt capacitors to address voltage flicker.
  - Net result: new DG appears as unity to the transmission system
- Dynamic Reactive Devices
  - Deploy dynamic reactive compensation to targeted substations to manage voltage constraints
- PV+BESS Coupling
  - Co-locate batteries with large new PV
  - Must be part of the application
- Large BESS
  - Deploy large batteries to targeted substations to manage constraints
  - Today, BESS as a solution must be studied as its own generator interconnection as well
- Traditional Upgrades
  - Line and substation upgrades targeted toward transmission lines and substation capacity constraints
- Active Network Management / Curtailment
  - Regulate power production of PV in real-time to match available capacity and manage constraints

Active Network Management

Active Network Management (ANM)

- The management of DER via control systems to keep system parameters within predetermined limits.
- Provides for real time monitoring and control of the electric system
- If a system constraint is approaching an operational limit, then ANM can act upon the DER asset to ensure the operational limit is not breached
  - Limits can be thermal, voltage or other

Benefits

- Manage system constraints
- Increase hosting capacity
- Reduce interconnection costs
- Reduce time to interconnect