2023/2024 Load Power Factor Audit Results

Revision 1

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ISO-NE OPERATIONS SUPPORT SERVICES

Overview

- ISO-NE is responsible for administering the New England's Load Power Factor (LPF) Program as defined by Operating Procedure No. 17 Load Power Factor and System Assessment (OP-17)
  - This year's audit is being performed in accordance with the current effective OP-17
- The program has undergone some logistical changes over time; however, the overall objective remains the same:
  - During light load periods, the distribution system must *avoid injecting VARs* to the transmission system
  - During heavy load periods, the distribution system must *avoid excessively consuming VARs* from the transmission system
- This presentation will briefly review:
  - How the LPF is measured and the major components of the program
  - MVAR deficiencies based on each area LPF standard

“Load” Definition

- OP-17 LPF Program considers “load” to be the *net* load as seen from the transmission system

New England Transmission System Voltage	
Transmission System	Distribution System
Transmission Generator’s Voltage Control	Distribution Generator’s Voltage Control
Dynamic & shunt reactive devices	Automatic & manual shunt reactive devices
Bulk transformer taps	Load serving transformer taps
	Load power factor

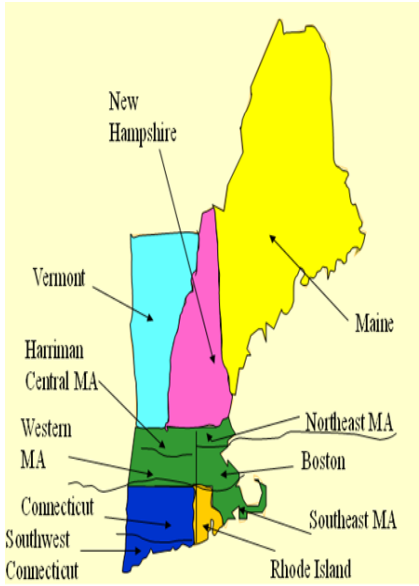
Surveyed LPF

Balancing Act:
Transmission & distribution system together determine system voltage

"Load" Definition, cont'd

- Based on data available to ISO-NE, it is not possible to delineate actual "load" from devices on the distribution system
- This means that we cannot determine whether:
  - The overnight load itself is *increasingly capacitive*, or
  - The overnight load itself is simply *less inductive*, resulting in over-compensation with distribution capacitors
- Rooftop PV systems can generate VARs overnight
  - *E.g.*, 11.2 kW rooftop system was found to be generating 0.8 kVARs at night (unknown if inductive or capacitive, expected to be capacitive from filters)

About the OP-17 LPF Program

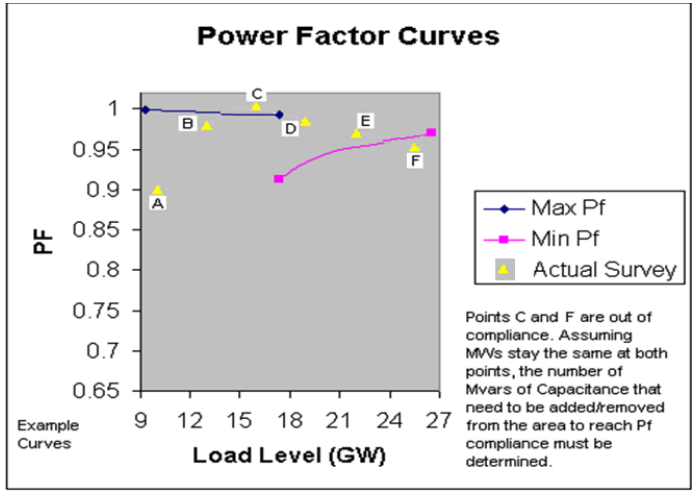


- LPF standard development:
  - The ISO/Voltage Task Force (VTF) performs area studies to determine standards
  - Points that define the LPF standard are based on the voltage criteria from each area
- The ISO conducts surveys to:
  - Verify compliance with standards
  - Reduce data gathering burden on Transmission Customers (TCs)
- 2023 and 2024 Audits are ISO's 5th and 6th years examining hourly performance
- Compliance enforcement
  - Tier 1 – LPF performance is found to be outside of the area's standards
    - Information sharing; TCs receive letter establishing non-compliance
  - Tier 2 – LPF performance is found to be outside of the area's standards and caused an operating issue
    - Verification of performance, potential mitigation plan, potential use of additional compliance mechanisms depending on the cause and severity of the issue

About the 2023/2024 LPF Audit

- The ISO analyzed area LPF from 1/1/2023 – 12/31/2024 on an hourly basis

- The ISO collects and plots a year's worth of each area's performance data for each hour
  - Distribution transformers' **high side flow** (MW & MVAR) is surveyed
  - An area's distribution transformers' **high side flow** is aggregated
  - An area's LPF is calculated based on the aggregate **high side flow**



Changes to the 2023/2024 Audit

- Prior discussions with the Transmission Owners related to audit results and OP-17 revisions indicated that audit results are best shown in MVARs, rather than power factor
- Starting with this survey, non-compliant load power factor points will be measured in terms of the quantity of MVARs that need "correction" to become compliant
  - The ISO will use the current method that determines the quantity of MVARs needed to correct non-compliant LPFs hour-by-hour (shown as the average MVAR surplus and the Max MVAR surplus in the following tables)
  - Two measured values will be supplied to each non-compliant entity:
    - Average quantity of MVARs needing correction over all hours when non-compliant
    - Maximum quantity of MVARs needing correction at worst hour of non-compliance
  - Additional revisions to OP-17 were introduced to the RC in Q3 2024
    - Discussion on the proposed revisions paused during Q4 2024, but will resume at the RC in Q2 2025

Area Performance Tables

- Two sets of standards are included on the following slides:
  - The “Max” standard refers to a maximum load power factor for light load, high voltage conditions
    - Non-compliance with this standard exposes the system to pre- or post-contingent high voltage
  - The “Min” standard refers to a minimum load power factor for peak load, low voltage conditions
    - Non-compliance with this standard exposes the system to pre- or post-contingent low voltage
  - Both tables note compliance or non-compliance by LPF area
    - Note that LPF areas do not necessarily correspond directly with an individual Transmission Owner or distribution provider
  - Non-compliant areas show their non-compliance in terms of MVARs and hours of exposure to non-compliant conditions
- Note: There was very little change in compliant/non-complaint status for 2022, 2023, or 2024 for each area

Revisions to LCC Performance Tables

- A few substations were found to have sign issues with data used and have been corrected
- As a result, one LCC area changed from non-compliant to compliant: RI for the Max (light load) standard
- All of the changes were limited to the Max standard table
  - No changes occurred in the Min standard table

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Area Performance – Max Standard

Max Standard

	2023 data					2024 data				
Zone	Compliant Max Standard (2022 &2023)	Average MVAR Surplus	Max MVAR Surplus	Percent of Hours Non-Compliant (Max Standard)	Percent of Hours Non-Compliant at < 9GW NE Load (Max Standard)	Compliant Max Standard (2024)	Average MVAR Surplus	Max MVAR Surplus	Percent of Hours Non-Compliant (Max Standard)	Percent of Hours Non-Compliant at < 9GW NE Load (Max Standard)
ME	Yes	---	---	---	---	Yes	---	---	---	---
NH	Yes	---	---	---	---	Yes	---	---	---	---
VT	Yes	---	---	---	---	Yes	---	---	---	---
NEMA	No	7.4	47.2	5.6%	21.2%	No	9.1	41.1	7.7%	12.2%
BOST	No	96.2	212.4	79.0%	96.2%	No	107.8	206.7	78.5%	98.0%
SEMA	No	17.8	64.4	2.3%	30.8%	No	7.1	18.1	0.5%	2.0%
RI	No	1.9	5.6	0.1%	---	Yes	---	---	---	---
CMAH	No	12.0	53.3	14.8%	35.3%	No	6.7	22.0	3.8%	8.8%
WMA	No	13.0	48.5	7.4%	37.8%	No	9.7	38.8	4.6%	15.7%
CT	No	40.0	152.2	7.1%	56.4%	No	23.5	96.5	1.3%	8.8%
SWCT	Yes	---	---	---	---	Yes	---	---	---	---
Total	---	188.3	583.5	---	---	---	163.8	423.0	---	---

Area Performance – Min Standard

Min Standard

		2023 data				2024 data			
Zone	Compliant Min Standard (2022, 2023, 2024)	Average MVAR Deficiency	Max MVAR Deficiency	Percent of Hours Non-Compliant (Min Standard)	Percent of Hours Non-Compliant > 18GW NE Load (Min Standard)	Average MVAR Deficiency	Max MVAR Deficiency	Percent of Hours Non-Compliant (Min Standard)	Percent of Hours Non-Compliant > 18GW NE Load (Min Standard)
ME	Yes	---	---	---	---	---	---	---	---
NH	Yes	---	---	---	---	---	---	---	---
VT	Yes	---	---	---	---	---	---	---	---
NEMA	Yes	---	---	---	---	---	---	---	---
BOST	Yes	---	---	---	---	---	---	---	---
SEMA	Yes	---	---	---	---	---	---	---	---
RI	Yes	---	---	---	---	---	---	---	---
CMAH	No	6.57	23.13	0.15%	5.06%	6.86	11.55	0.03%	0.90%
WMA	Yes	---	---	---	---	---	---	---	---
CT	Yes	---	---	---	---	---	---	---	---
SWCT	Yes	---	---	---	---	---	---	---	---
Total	---	6.57	23.13	---	---	6.86	11.55	---	---

Conclusions Drawn from Area Performance

- Six areas were non-complaint for the Max condition (light load, high voltage) in 2023 and 2024
  - All six areas (NEMA, Boston, SEMA, CMAH [Central MA/Harriman], WMA, CT) had significant exposure, with Boston being by far the poorest performing area
- Only one area was non-compliant for the Min condition (peak load, low voltage) in 2023 and 2024
  - The CMAH area had modest exposure to non-compliance for this condition
- Some improvement in non-compliant exposure magnitude and duration was observed from 2023 to 2024

2024 LPF AUDIT RESULTS – TRANSMISSION CUSTOMERS

LPF Data Overview

- In the interest of understanding how each area was meeting, or failing to meet, the LPF requirements, individual Transformer Owner distribution load MW and MVAR values were summed to create individual LPFs for each zone
  - These individual LPFs were then broken down by Transmission Owner / Distribution Owner (TO/DO) to better identify violations that are embedded within the LPF zones
- Based on these breakdowns, plots and tabulations were created for each individual TO/DO
  - These TO-specific data collections are indicative of individual company performance and form the basis of whether each company meets the LPF requirements in each area
    - The ISO will work with any entity wishing to understand the details of the information used in this effort
  - The results are noted in tabular form for ease of review
  - Since OP-17 does not specify that audit results are to be shown in terms of MVARs, compliance status is only noted in the tables (as done historically) and MVAR data will be shared only with the individual TO/DO

TO/DO Performance Tables

- Tables broken down by Transmission or Distribution Owner (TO/DO)
- Only compliant/non-complaint status is noted
  - Data specifics will be shared only with the specific TO/DO
- Municipal utilities are not included due to data availability issues
  - Some municipal co-ops (*e.g.*, CMEEC) are noted as belonging to the co-op and not the individual members and have been reported that way
- TO/DO entries are grouped by area, with an abbreviated name, a longer name, and the compliance status for Max and Min standards

Revisions to the TO / DO Performance Tables

- As noted for the LCC data, a revision to the signs for some errant data was found and resulted in RI becoming compliant for the Max standard in 2024
- A number of Massachusetts municipal utilities had their performance broken out from their interconnecting transmission providers due to their ownership of the distribution transformers serving their load directly from the transmission system
  - These municipal utilities were not identified in the data source used and required manual effort to separate their data from that of their transmission providers

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TO Performance – Max Standard

2024 LPF Survey							
Zone / Load Abbreviation	LPF Zone Name	Company Name	Compliant Max Standard	Zone / Load Abbreviation	LPF Zone Name	Company Name	Compliant Max Standard
BOST_EVRSRCE	Boston	Eversource	No	NH_CMP	New Hampshire	Central Maine Power	No
CMAH_AMLP	Central MA / Harriman	Ashburnham Municipal Light Dept	No	NH_NEP	-	National Grid	No
CMAH_FGE	-	Fitchburg Gas & Electric	No	NH_PSNH	-	Eversource	Yes
CMAH_HUDSON	-	Hudson Light & Power Dept	No	RI_NEC	Rhode Island	Rhode Island Energy	Yes
CMAH_NEP	-	National Grid	No	SEMA_BELD	Southeast MA	Braintree Electric Light Dept	Yes
CMAH_NU	-	Eversource	No	SEMA_EVRSRCE	-	Eversource	No
CMAH_PMLD	-	Paxton Municipal Light Dept	No	SEMA_HNGM	-	Hingham Municipal Light Plant	No
CMAH_SHREW	-	Shrewsbury Electric & Cable	No	SEMA_MANSFD	-	Manfield Municipal Electric	Yes
CMAH_SMLD	-	Sterling Municipal Light Dept	No	SEMA_MDLBOR	-	Middleborough Gas & Electric	No
CMAH_VELCO	-	VELCO	No	SEMA_NAED	-	North Attleborough Electric Dept	No
CMAH_WBMLP	-	West Boylston Municipal Light Plant	No	SEMA_NGRID	-	National Grid	No
CT_CMEEC	Connecticut	Connecticut Municipal Electric Energy Coop	No	SEMA_TMLP	-	Taunton Municipal Light Plant	No
CT_NU	-	Eversource	No	SWCT_NU	Southwest CT	Eversource	Yes
CT_UI	-	United Illuminating	No	SWCT_UI	-	United Illuminating	Yes
ME_BHE	Maine	Versant	Yes	VT_NEP	Vermont	National Grid	No
ME_CMP	-	Central Maine Power	Yes	VT_VELCO	-	VELCO	Yes
NEMA_LELWD	NE Massachusetts	Littleton Electric Light and Water Dept	No	WMA_CMLP	Western MA	Chicopee Electric Light	Yes
NEMA_MDLTN	-	Middleton Electric Light Dept	No	WMA_HGE	-	Holyoke Gas & Electric	No
NEMA_NEP	-	National Grid	No	WMA_NEP	-	National Grid	No
NEMA_PBDY	-	Peabody Municipal Light Plant	No	WMA_NU	-	Eversource	No
NEMA_RMLD	-	Reading Municipal Light Dept	Yes	WMA_SHELD	-	South Hadley Electric Light Dept	No
NEMA_SDANV	-	Danvers Electric	No				
NEMA_WAKEFD	-	Wakefield Municipal Gas & Light	No				

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TO Performance – Min Standard

2024 LPF Survey							
Zone / Load Abbreviation	LPF Zone Name	Company Name	Compliant Min Standard	Zone / Load Abbreviation	LPF Zone Name	Company Name	Compliant Min Standard
BOST_EVRSRCE	Boston	Eversource	Yes	NH_CMP	New Hampshire	Central Maine Power	Yes
CMAH_AMLP	Central MA / Harriman	Ashburnham Municipal Light Dept	No	NH_NEP	-	National Grid	No
CMAH_FGE	-	Fitchburg Gas & Electric	Yes	NH_PSNH	-	Eversource	Yes
CMAH_HUDSON	-	Hudson Light & Power Dept	No	RI_NEC	Rhode Island	Rhode Island Energy	Yes
CMAH_NEP	-	National Grid	No	SEMA_BELD	Southeast MA	Braintree Electric Light Dept	Yes
CMAH_NU	-	Eversource	No	SEMA_EVRSRCE	-	Eversource	Yes
CMAH_PMLD	-	Paxton Municipal Light Dept	Yes	SEMA_HNGM	-	Hingham Municipal Light Plant	Yes
CMAH_SHREW	-	Shrewsbury Electric & Cable	Yes	SEMA_MANSFD	-	Manfield Municipal Electric	Yes
CMAH_SMLD	-	Sterling Municipal Light Dept	Yes	SEMA_MDLBOR	-	Middleborough Gas & Electric	Yes
CMAH_VELCO	-	VELCO	No	SEMA_NAED	-	North Attleborough Electric Dept	Yes
CMAH_WBMLP	-	West Boylston Municipal Light Plant	No	SEMA_NGRID	-	National Grid	Yes
CT_CMEEC	Connecticut	Connecticut Municipal Electric Energy Coop	No	SEMA_TMLP	-	Taunton Municipal Light Plant	Yes
CT_NU	-	Eversource	Yes	SWCT_NU	Southwest CT	Eversource	Yes
CT_UI	-	United Illuminating	Yes	SWCT_UI	-	United Illuminating	Yes
ME_BHE	Maine	Versant	Yes	VT_NEP	Vermont	National Grid	Yes
ME_CMP	-	Central Maine Power	Yes	VT_VELCO	-	VELCO	Yes
NEMA_LELWD	NE Massachusetts	Littleton Electric Light and Water Dept	Yes	WMA_CMLP	Western MA	Chicopee Electric Light	Yes
NEMA_MDLTN	-	Middleton Electric Light Dept	No	WMA_HGE	-	Holyoke Gas & Electric	No
NEMA_NEP	-	National Grid	Yes	WMA_NEP	-	National Grid	No
NEMA_PBDY	-	Peabody Municipal Light Plant	Yes	WMA_NU	-	Eversource	Yes
NEMA_RMLD	-	Reading Municipal Light Dept	No	WMA_SHELD	-	South Hadley Electric Light Dept	Yes
NEMA_SDANV	-	Danvers Electric	Yes				
NEMA_WAKEFD	-	Wakefield Municipal Gas & Light	No				

Conclusions Drawn from TO/DO Performance

- This data shows entities that are non-complaint within an otherwise compliant area (*e.g.*, NH-NEP in New Hampshire)
  - Shows the value of indicating compliance on a company basis within an area
- This data further shows that the non-compliance picture seems worse than that just for the areas
  - There are a number of non-compliant entities in compliant areas
- The critical information determining the type of corrective actions required to become compliant is found in the detailed data
  - For example, frequent vs. infrequent non-compliance and significant vs. modest values of MVAR non-compliance

Conclusions

- LPF compliance remains a challenge
  - Most zones are not compliant for the light load/high voltage curve
  - No significant improvement year-over-year in LPF zone compliance
  - Visibility into what TOs/distribution providers are doing within each zone should help focus efforts on where compliance improvements within a zone are needed the most
    - This information will be shared directly with individual entities

Questions