



PLANNING FOR A MORE RESILIENT AND EQUITABLE FUTURE

Vermont System Planning Committee
Cost of Outages Model

October 25, 2023





Objective

To best approximate economic losses from outages
across VELCOs service territory

Bottom -Up Value -of-Lost Load Methodology

Quantifying VoLL for every utility customer using:

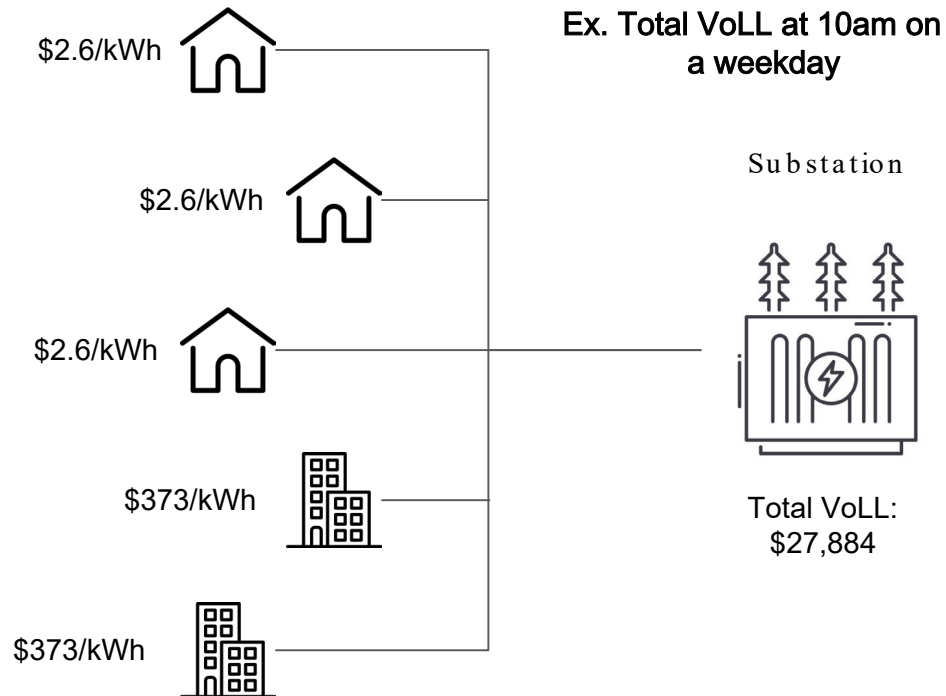
- Meter data
- Rate code
- VoLL survey data + Inflation

Verifying customers on each circuit using:

- Asset GIS

Account for:

- Net metered customers
- Battery storage customers
- Electrification



VoLL Calculation for Each Customer

$$VoLL(c) = C(d) \times L(c, h, w)$$

c = Specified customer

C = VoLL constant

d = duration of outage

L = Load

h = hour of the day

w = weekend of weekday

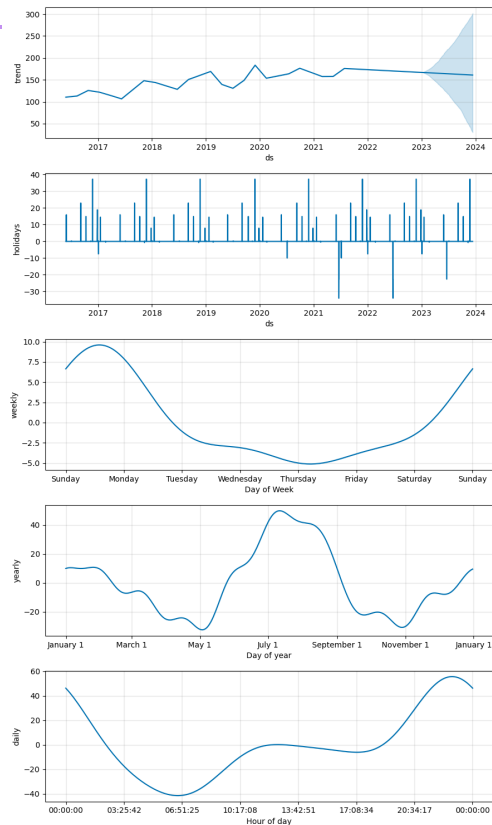
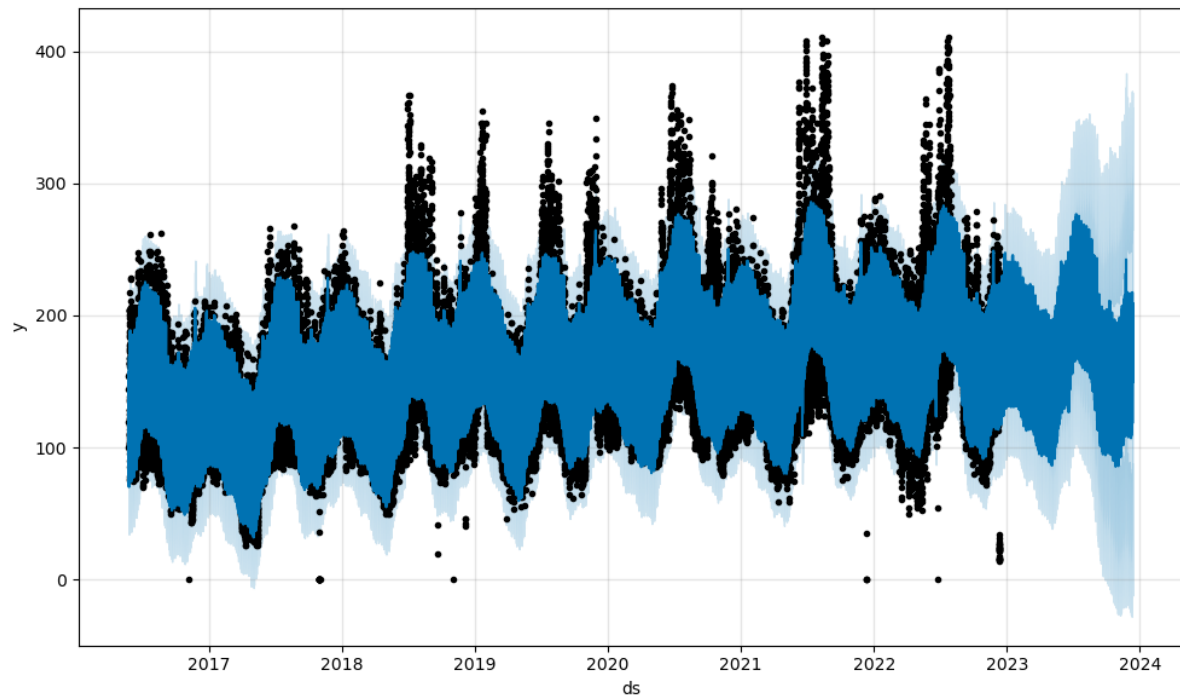
Table ES- 1. Estimated Average Electric Customer Interruption Costs US 2008\$ by Customer Type and Duration (Summer Weekday Afternoon)

Interruption Cost	Interruption Duration				
	Momentary	30 minutes	1 hour	4 hours	8 hours
Medium and Large C&I					
Cost Per Event	\$11,756	\$15,709	\$20,360	\$59,188	\$93,890
Cost Per Average kW	\$14.4	\$19.3	\$25.0	\$72.6	\$115.2
Cost Per Un-served kWh	\$173.1	\$38.5	\$25.0	\$18.2	\$14.4
Cost Per Annual kWh	\$1.65E-03	\$2.20E-03	\$2.85E-03	\$8.29E-03	\$1.31E-02
Small C&I					
Cost Per Event	\$439	\$610	\$818	\$2,696	\$4,768
Cost Per Average kW	\$200.1	\$278.1	\$373.1	\$1,229.2	\$2,173.8
Cost Per Un-served kWh	\$2,401.0	\$556.3	\$373.1	\$307.3	\$271.7
Cost Per Annual kWh	\$2.28E-02	\$3.18E-02	\$4.26E-02	\$0.1403	\$0.2482
Residential					
Cost Per Event	\$2.7	\$3.3	\$3.9	\$7.8	\$10.7
Cost Per Average kW	\$1.8	\$2.2	\$2.6	\$5.1	\$7.1
Cost Per Un-served kWh	\$21.6	\$4.4	\$2.6	\$1.3	\$0.9
Cost Per Annual kWh	\$2.06E-04	\$2.48E-04	\$2.94E-04	\$5.81E-04	\$8.05E-04

Methodology Steps

1. Forecast load for each customer for one year. Takes into account pattern changes, such as efficiency, EVs, and removes blips such as the pandemic.
2. Categorize each customer using their rate category. Using special treatment for solar customers and taking into account customers with battery storage.
3. Apply the VoLL formula for each customer. Using special treatment for solar customers and taking into account customers with battery storage.
4. Summarize VoLL across the following “buckets”:
 - a. Per substation
 - b. By every hour
 - c. Weekday/weekend
 - d. Only winter days

Historical & Predicted Residential Load for Substation 27



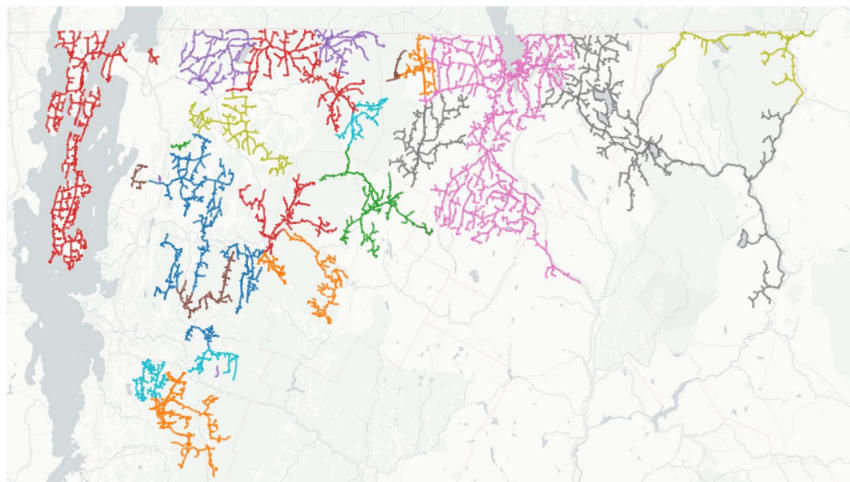
VoLL Results – VEC Territory – Substation 44

Average hourly VoLL in the Winter , varying for weekday vs. weekend

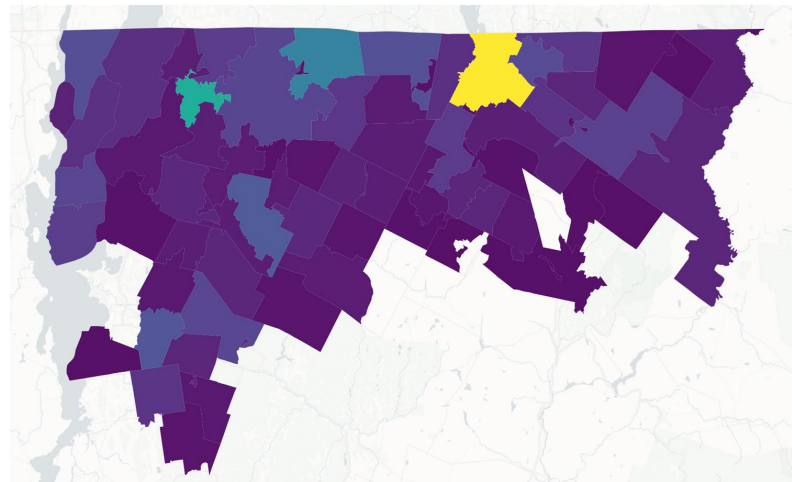
	Weekday			Weekday Total	Weekend			Weekend Total
hour	Medium and Large C&I	Residential	Small C&I		Medium and Large C&I	Residential	Small C&I	
0	\$70,128.31	\$5,201.38	\$392,690.62	\$468,020.31	\$55,759.10	\$5,322.66	\$340,200.63	\$401,282.39
1	\$68,373.33	\$4,837.07	\$390,487.39	\$463,697.79	\$53,347.71	\$4,969.75	\$335,320.85	\$393,638.31
2	\$67,119.02	\$4,592.65	\$391,820.03	\$463,531.70	\$51,468.43	\$4,736.71	\$334,098.28	\$390,303.42
3	\$67,614.03	\$4,560.62	\$394,602.87	\$466,777.52	\$51,372.97	\$4,716.00	\$334,459.80	\$390,548.78
4	\$70,966.41	\$4,804.87	\$402,652.34	\$478,423.62	\$54,172.37	\$4,971.46	\$340,233.95	\$399,377.78
5	\$77,027.33	\$5,276.22	\$422,544.22	\$504,847.76	\$59,720.60	\$5,453.87	\$358,008.05	\$423,182.52
6	\$84,084.81	\$5,821.58	\$456,444.63	\$546,351.02	\$66,308.36	\$6,010.09	\$389,959.23	\$462,277.68
7	\$89,817.04	\$6,279.85	\$497,580.17	\$593,677.05	\$71,616.33	\$6,478.98	\$429,324.30	\$507,419.62
8	\$92,815.30	\$6,574.55	\$533,106.73	\$632,496.58	\$74,238.09	\$6,784.03	\$463,268.68	\$544,290.80
9	\$93,412.70	\$6,723.76	\$552,537.59	\$652,674.05	\$74,508.82	\$6,943.24	\$481,314.28	\$562,766.34
10	\$93,128.28	\$6,776.04	\$554,737.25	\$654,641.56	\$73,949.40	\$7,005.16	\$482,333.30	\$563,287.86
11	\$93,252.21	\$6,753.91	\$547,656.44	\$647,662.56	\$73,851.61	\$6,992.25	\$474,283.23	\$555,127.09
12	\$93,829.44	\$6,667.67	\$541,386.99	\$641,884.10	\$74,261.71	\$6,914.77	\$467,261.60	\$548,438.07
13	\$93,874.33	\$6,574.94	\$540,759.20	\$641,208.46	\$74,195.14	\$6,830.30	\$466,103.31	\$547,128.75
14	\$92,492.30	\$6,599.68	\$543,470.07	\$642,562.04	\$72,758.10	\$6,862.77	\$468,508.88	\$548,129.76
15	\$89,795.35	\$6,858.69	\$544,203.15	\$640,857.19	\$70,063.07	\$7,128.96	\$469,164.20	\$546,356.22
16	\$86,790.59	\$7,344.15	\$539,893.68	\$634,028.43	\$67,117.36	\$7,620.98	\$465,005.64	\$539,743.99
17	\$84,451.29	\$7,874.41	\$531,143.49	\$623,469.19	\$64,894.15	\$8,157.19	\$456,635.00	\$529,686.34
18	\$82,924.33	\$8,180.25	\$519,426.91	\$610,531.48	\$63,539.90	\$8,468.32	\$445,525.38	\$517,533.60
19	\$81,596.73	\$8,074.37	\$504,130.97	\$593,802.07	\$62,440.96	\$8,367.06	\$431,061.38	\$501,869.40
20	\$79,837.27	\$7,570.82	\$483,190.34	\$570,598.43	\$60,965.10	\$7,867.44	\$411,174.02	\$480,006.56
21	\$77,591.75	\$6,858.28	\$456,692.62	\$541,142.65	\$59,056.88	\$7,158.11	\$385,946.14	\$452,161.13
22	\$75,263.54	\$6,156.38	\$429,184.09	\$510,604.01	\$57,118.09	\$6,458.70	\$359,918.10	\$423,494.89
23	\$73,134.87	\$5,581.76	\$407,495.16	\$486,211.78	\$55,429.15	\$5,885.86	\$339,913.30	\$401,228.30

Substations → Zip Codes

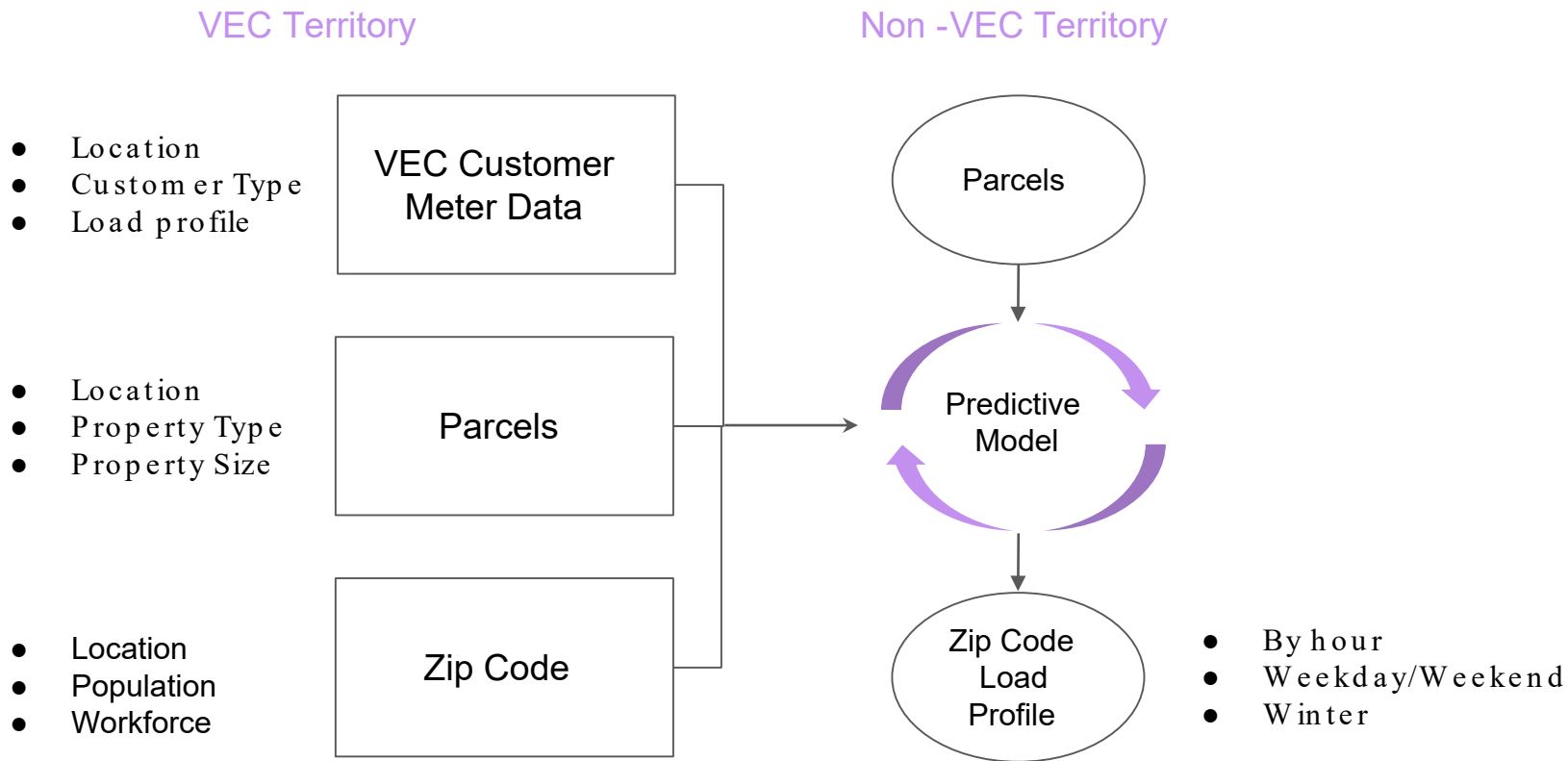
Substation Coverage View



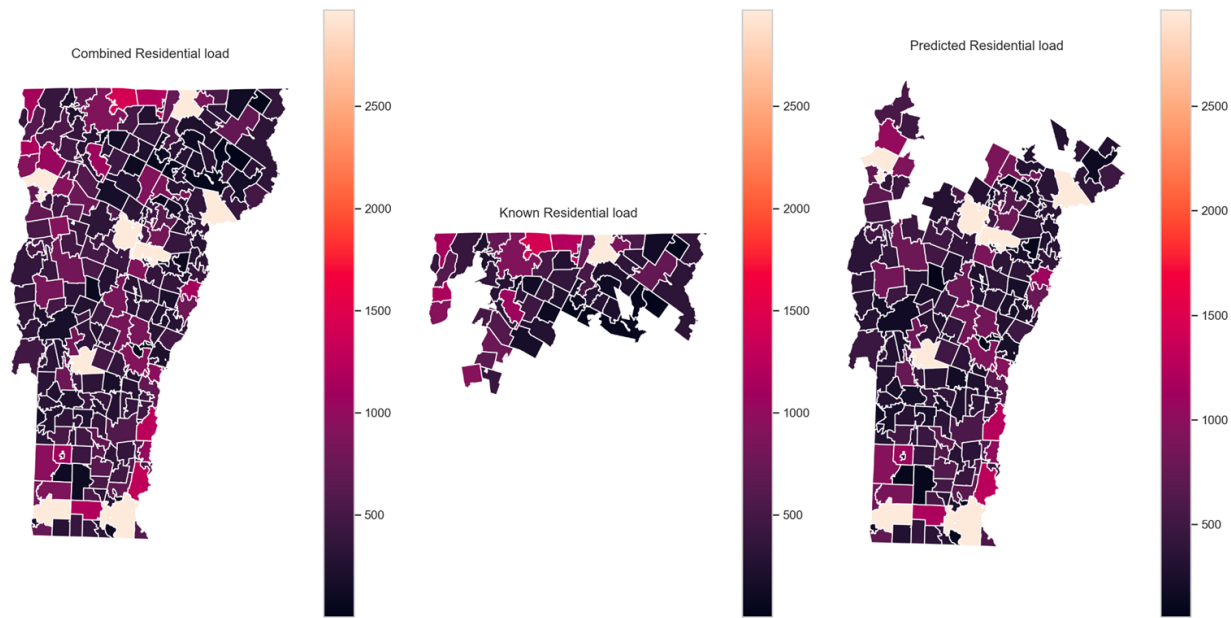
Zip Code View



Zip Code VoLL Prediction: Non -VEC Territory

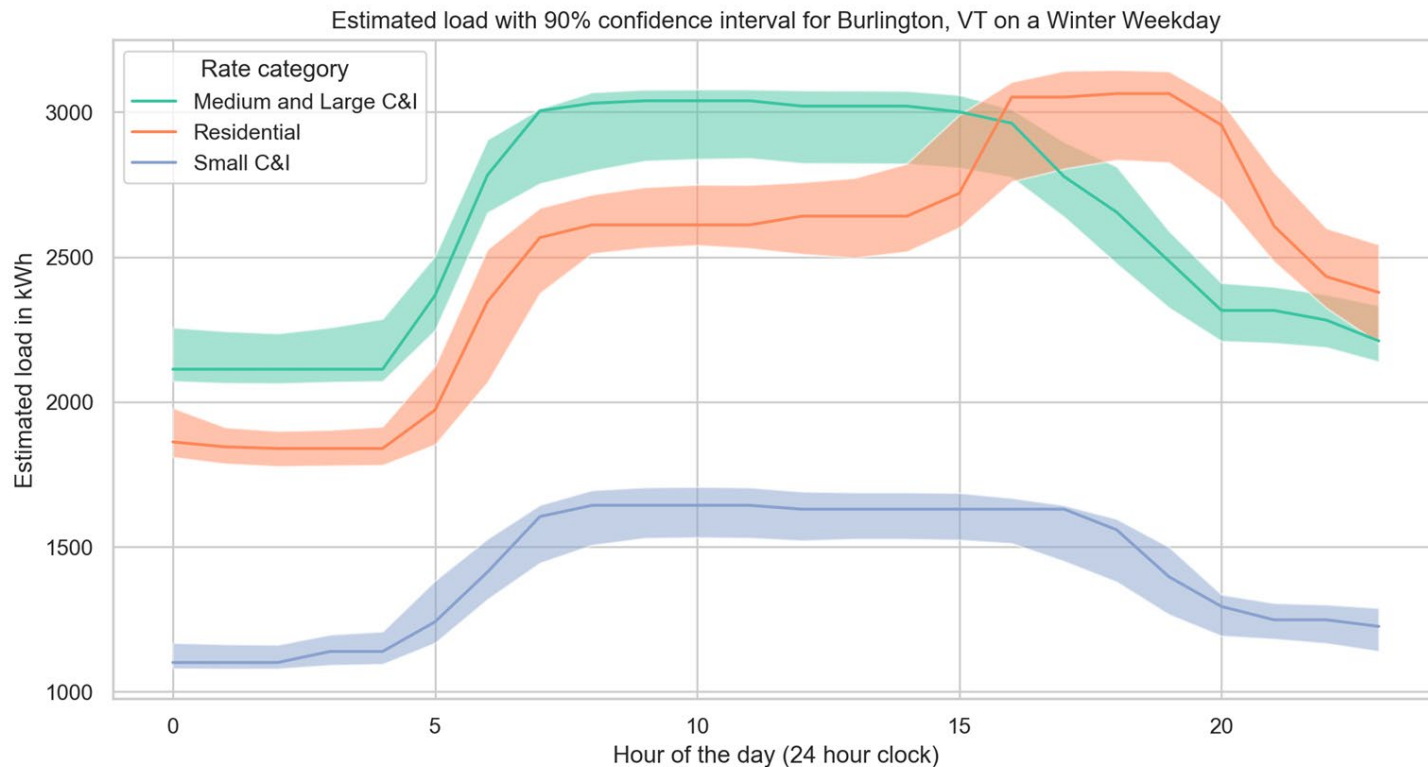


Forecasted load for each customer category in Zip Codes outside VEC service territory



Zip Code Hourly Load Prediction

– Non -VEC Territory



VoLL per Service Territory at 9am Winter Peak

Total VoLL for each Vermont electric utility service territory at peak load

<i>Service Territory</i>	Weekday Total	Weekend Total
Burlington Electric	\$ 1,920,288.06	\$ 1,516,428.82
Green Mountain Power	\$ 16,896,673.48	\$ 14,415,443.48
VEC	\$ 5,243,235.39	\$ 4,846,429.39
Other	\$ 1,543,104.77	\$ 1,344,540.27

VoLL – Non -VEC Territory – Zip Code 05401

Average hourly VoLL in the Winter , varying for weekday vs. weekend

	Weekday			Weekday Total	Weekend			Weekend Total
hour	Medium and Large C&I	Residential	Small C&I		Medium and Large C&I	Residential	Small C&I	
0	\$71,788.64	\$6,578.83	\$558,328.60	\$636,696.08	\$65,596.08	\$6,783.82	\$558,328.60	\$630,708.50
1	\$71,788.64	\$6,520.04	\$558,328.60	\$636,637.29	\$65,596.08	\$6,612.74	\$558,328.60	\$630,537.42
2	\$71,788.64	\$6,482.71	\$558,328.60	\$636,599.96	\$65,596.08	\$6,526.41	\$558,328.60	\$630,451.10
3	\$71,788.64	\$6,482.71	\$577,706.23	\$655,977.58	\$65,596.08	\$6,526.41	\$564,975.26	\$637,097.75
4	\$71,788.64	\$6,482.71	\$577,706.23	\$655,977.58	\$65,596.08	\$6,526.41	\$564,975.26	\$637,097.75
5	\$80,443.93	\$6,998.66	\$629,531.44	\$716,974.03	\$69,431.55	\$7,117.81	\$579,247.88	\$655,797.25
6	\$94,548.55	\$8,319.05	\$716,605.17	\$819,472.77	\$76,191.14	\$8,550.50	\$622,534.20	\$707,275.84
7	\$102,066.84	\$9,079.23	\$813,663.65	\$924,809.72	\$76,605.93	\$9,495.63	\$650,749.76	\$736,851.32
8	\$102,960.69	\$9,223.01	\$833,297.43	\$945,481.14	\$78,163.97	\$9,639.41	\$656,262.14	\$744,065.52
9	\$103,250.63	\$9,223.01	\$833,297.43	\$945,771.08	\$78,453.91	\$9,639.41	\$656,262.14	\$744,355.46
10	\$103,250.63	\$9,223.01	\$833,297.43	\$945,771.08	\$78,453.91	\$9,639.41	\$656,262.14	\$744,355.46
11	\$103,250.63	\$9,223.01	\$833,297.43	\$945,771.08	\$78,453.91	\$9,639.41	\$656,262.14	\$744,355.46
12	\$102,623.48	\$9,328.33	\$826,521.01	\$938,472.82	\$78,453.91	\$9,744.73	\$649,485.72	\$737,684.36
13	\$102,623.48	\$9,328.33	\$826,521.01	\$938,472.82	\$78,453.91	\$9,744.73	\$649,485.72	\$737,684.36
14	\$102,623.48	\$9,328.33	\$826,521.01	\$938,472.82	\$78,453.91	\$9,744.73	\$649,485.72	\$737,684.36
15	\$101,948.56	\$9,639.93	\$826,521.01	\$938,109.51	\$77,778.99	\$9,895.05	\$649,485.72	\$737,159.75
16	\$100,614.80	\$10,795.33	\$826,521.01	\$937,931.15	\$75,781.04	\$10,865.49	\$649,485.72	\$736,132.26
17	\$94,357.77	\$10,795.33	\$826,521.01	\$931,674.12	\$75,751.24	\$10,865.49	\$649,485.72	\$736,102.45
18	\$90,196.34	\$10,817.01	\$790,493.13	\$891,506.47	\$74,221.63	\$10,887.17	\$651,840.26	\$736,949.06
19	\$84,445.09	\$10,817.01	\$708,174.22	\$803,436.31	\$71,330.08	\$10,887.17	\$613,308.77	\$695,526.02
20	\$78,676.23	\$10,403.58	\$656,349.01	\$745,428.82	\$69,934.32	\$10,447.29	\$599,036.14	\$679,417.75
21	\$78,676.23	\$9,201.79	\$633,042.23	\$720,920.25	\$69,934.32	\$9,430.44	\$591,531.60	\$670,896.37
22	\$77,546.11	\$8,534.34	\$633,042.23	\$719,122.69	\$68,804.21	\$8,762.99	\$591,531.60	\$669,098.80
23	\$75,096.76	\$8,385.68	\$621,510.99	\$704,993.42	\$66,982.00	\$8,614.33	\$580,000.36	\$655,596.69

Questions.

The scientific approach to modeling climate risk on utility assets

