NYSERDA FutureGRID Challenge: Ithaca Electrification Study

Final Report | Report Number 24-05 | October 2023

NEW YORK STATE | NYSERDA

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NYSERDA FutureGRID Challenge: Ithaca Electrification Study

Final Report

Prepared for:

New York State Energy Research and Development Authority

Albany, NY

Christopher Cheng
Senior Project Manager

Prepared by:

Siemens PTI

Schenectady, NY

Christopher Matos
Project Manager

Holt Bradshaw
Project Director

Nidhi Desai
Senior Consultant

Hasala Dharmawardena
Senior Consultant

Michael Licata
Consultant

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Abstract

Siemens PTI conducted this NYSERDA FutureGrid electrification study to assess the technoeconomics of transitioning to electric vehicles (EVs), implementing building electrification, and adopting distributed solar photovoltaics (PV) in Ithaca. The study sought to quantify load growth from electrification and its impacts and mitigants on the individual substations and feeders serving Ithaca. Flat load growth, typical of the recent past, is no more, necessitating more geospatially granular and detailed load forecasting and engineering analysis to support planning and ensure continued system reliability. Siemens PTI developed building level load forecasts for EV charging, building electrification, and rooftop solar photovoltaic generation to the utility's base load forecast and quantified the engineering impacts to determine when, where, and to what degree new loads would impact the local distribution grid. We found that load in Ithaca would double by 2050 driven primarily by building electrification and to a lesser degree by EV charging as peak demand shifts from summer days to winter nights between 2030 and 2040 when distributed solar photovoltaics do little to offset that peak. Winter nighttime temperatures exacerbate the peak with increased heating demand and shortened EV range driving in increased charging. As a result, we expect from 13% to 22% of the total service transformers will have to be upgraded which will require early planning.

Keywords

electric vehicle forecast, building electrification forecast, rooftop solar PV forecast, utility system planning, distribution system impacts

Acknowledgments

Siemens PTI would like to acknowledge the entire team involved over the course of the project including Peter Berini and Juliette Do.

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Acronyms and Abbreviations

3D	Three dimensional
°F	Degrees Fahrenheit
AFDC	Alternative Fuels Data Center
ASHP	Air-sourced heat pump
BE	Break-even
BTU	British thermal unit
CAGR	Compound Annual Growth Rate
CEII	Critical energy/electric infrastructure information
CO_2	Carbon dioxide
COP	Coefficient of performance
DER	Distributed energy resources
DOE	Department of Energy
EPA	Environmental Protection Agency
EIA	Energy Information Agency
EV	Electric vehicle
EVI-Pro	Electric Vehicle Infrastructure—Projection tool
ft	Feet
GIS	Geographic information system
GHG	Greenhouse gas
GW	Gigawatt
GWh	Gigawatt hours
HVAC	Heating, ventilation, and air conditioning

IRA	Inflation Reduction Act of 2022
kWh	Kilowatt hours
LDV	Light-duty vehicle
LIDAR	Light detection and ranging
lbs.	Pounds
m2	Square meters
mi	Miles
MMBTU	Metric million British thermal unit
MOVES	Motor Vehicle Emission Simulator
MT	Metric tons
MW	Megawatts
MWh	Megawatt hours
NEEP	Northeast Energy Partnership
NFM	National Forecasting Model
NREL	National Renewable Energy Labs
NYISO	New York Independent System Operator, Inc.
NYS	New York State
NYSEG	New York State Electric and Gas
NYSERDA	New York State Energy Research and Development Authority
PV	Photovoltaic
SCADA	Supervisory control and data acquisition
T&D	Transmission and distribution
W	Watts
WNY	Western New York
ZIP code	Zone Improvement Plan code

Executive Summary

This NYSERDA FutureGRID electrification study for the city of Ithaca study (the study) was undertaken to provide a technoeconomic assessment of transitioning to electric vehicles (EVs), implementing building electrification, and adopting distributed solar photovoltaics (PV) in Ithaca. This study provides crucial insights for stakeholders, policymakers, and utilities involved in the electrification process.

Methodology: The study comprised five tasks encompassing comprehensive analysis of consumer behavior, economic incentives, load behaviors, and existing grid infrastructure. These tasks are:

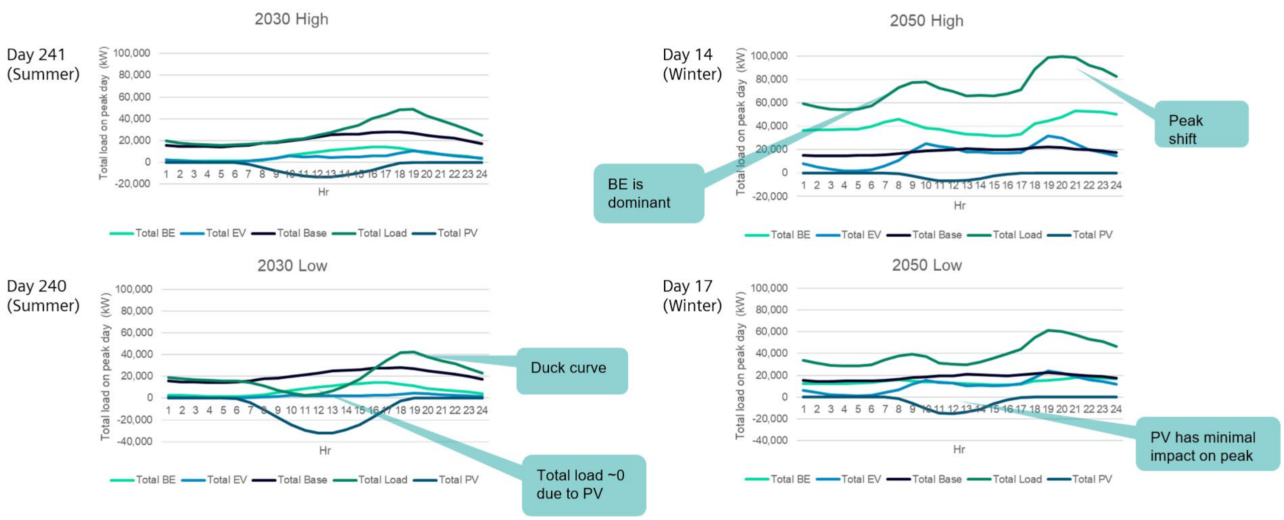
- Task 1: EV adoption and load forecast
- Task 2: Building electrification adoption and load forecast
- Task 3: Solar photovoltaic adoption and generation forecast
- Task 4: Circuit and feeder impact analysis
- Task 5: Geographic information system (GIS) mapping

Strategic findings: The study had five key findings:

1. **EV total load demand**: Projections indicate a substantial increase in EV total load demand, ranging from 80 gigawatt hours (GWhs) to 160 GWhs by 2050. The total load increase from EVs is low, but demand from EVs is highly coincident with the system peak.
2. **Building electrification**: Building electrification emerges as the primary driver for peak load shifting, leading to a shift in the city's peak demand from summer days to winter nights, primarily due to increased heating demand. Moreover, adopting heat pumps will exacerbate grid conditions in extreme cold weather when they have low operational efficiency.
3. **Distributed photovoltaics (PV)**: PV exhibits a relatively low overall impact on the grid, with minimal effects during peak hours due to nighttime operation. That said, high penetrations of PV can cause reverse system flow in the summer when solar irradiance is high.
4. **Rapid peak-load growth**: Users should anticipate a potential surge of 200%–1200% in peak load growth, contingent on specific feeders. Approximately 20% of transformers and 16% of feeders require upgrading and reconductoring, respectively.
5. **Distribution system upgrades**: The study underscores the necessity for early and substantial investments in distribution system upgrades to accommodate the rapid increase in electrification demand.

Figure ES-1. Changes in Hourly Load

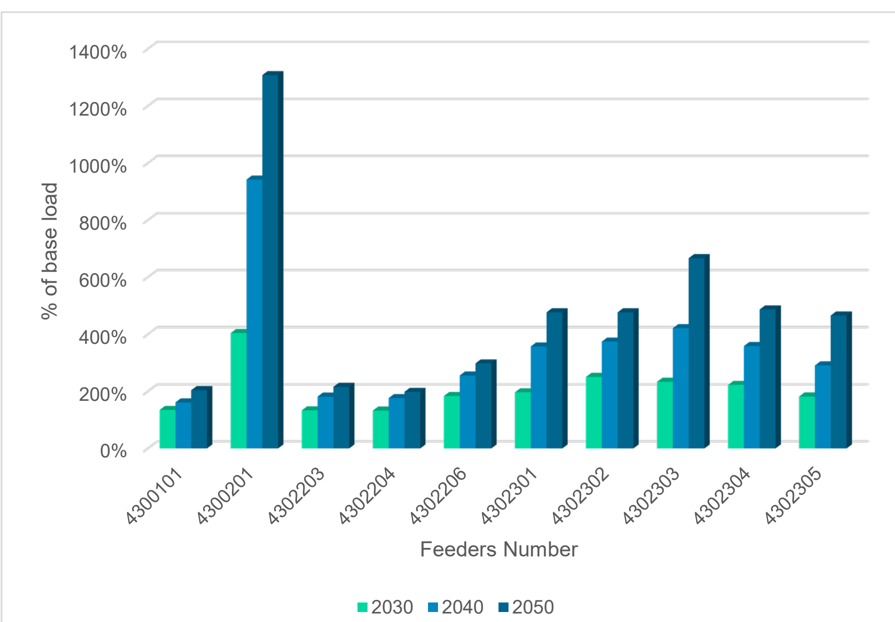
Source: Siemens PTI analysis.



The study emphasizes the shift from a summer peak to a winter peak and the substantial influence of cold temperatures on load modifiers, affecting the efficiency of both EVs and building electrification, thereby increasing demand. Furthermore, these temperature effects are not aligned with PV production cycles, mitigating the load reducing impact of PV during the peak, which will result in extreme peak-load growth for feeders in dense commercial and multiunit residential areas.

Figure ES-2. Peak-Load Circuit Impact as a Percentage of 2023 Base (Winter), High Load Scenario

Source: Siemens PTI analysis.



Finally, in addition to the five strategic takeaways, real gains exist in sustainability and environmental preservation. Electrification can realize real emissions reductions, particularly when coupled with other sustainability policies such as renewable energy goals. Our study projects 13–32 metric tons (MT) of emissions savings annually by 2050, contingent upon the future grid's overall carbon intensity.

This study's findings on electrification in Ithaca indicate a dynamic landscape in the shift toward electrification, emphasizing the critical need for proactive planning and investment in infrastructure.

1 Task 1: Electric Vehicle Adoption and Load Forecast

1.1 Objective

Siemens PTI forecasted the load impacts of future electric vehicle (EV) adoption in Ithaca by initially forecasting EV adoption trends across New York State and then segmenting those forecasts onto Ithaca. The team also developed forecasts for each vehicle segment and subsegment in Table 1 to quantify total EV impacts.

Table 1. Electric Vehicles Evaluated

Segment	Subsegment	Gross Vehicle Weight Rating[1]
Private Vehicles	Light-duty car (i.e., sedan)	<10,000 lbs.
	Light-duty trucks (i.e., pick-up truck)	<6,000 lbs.
Commercial Vehicles	Class 2b–3	8,500 lbs.–14,000 lbs.
	Class 4–8	14,000 lbs.–33,000 lbs.
	Class 7 tractors	26,000 lbs.–33,000 lbs.
	Class 8 tractors	>33,000 lbs.
Buses	Transit and school bus	>33,000 lbs.

1.2 Methodology and Data Sources

1.2.1 New York State Forecast

Siemens PTI forecasted vehicle sales for each segment and subsegment in New York State, using data on private and commercial vehicle sales forecasts from the 2022 Energy Information Agency (EIA) Annual Energy Outlook. Transit and school bus forecasts were based on the current transit bus fleet and scaled directly with population forecasts. When comparing forecasts for each vehicle segment and subsegment, other sources of information were considered. Siemens PTI forecasted EV sales by combining these vehicle and EV adoption forecasts as depicted in Figures 1, 2, and 3.

Figure 1. Private Vehicle Adoption Shapes, Percent of Sales

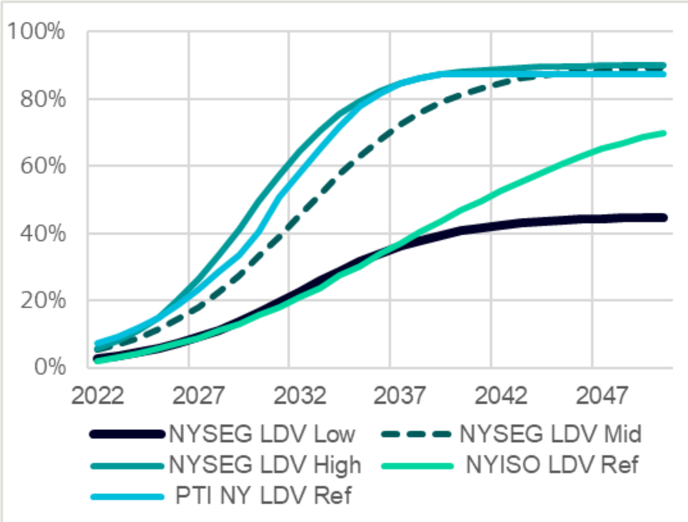


Figure 2. Commercial Vehicle Adoption Shapes, Percent of Sales

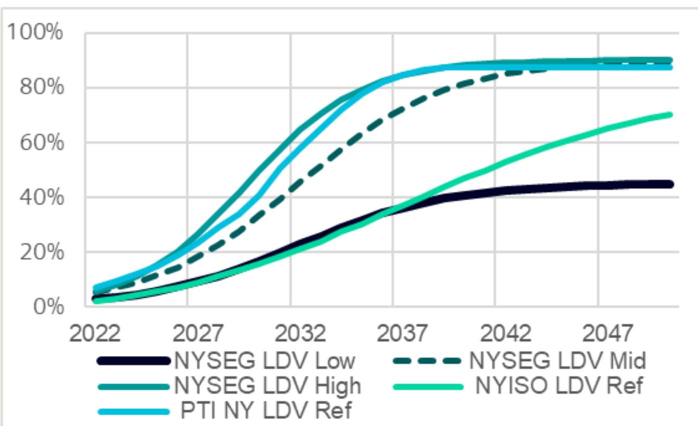
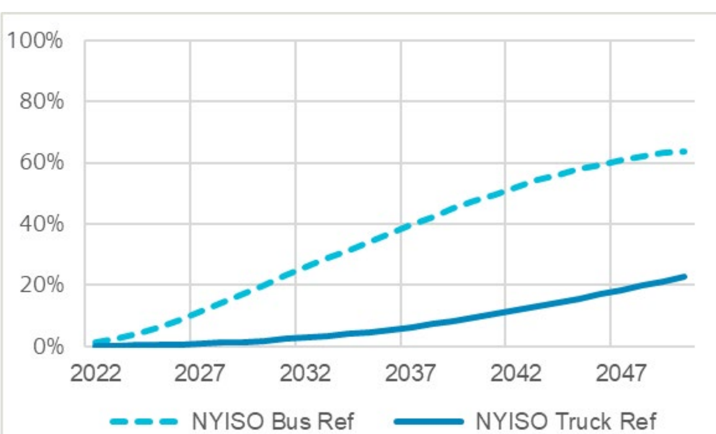


Figure 3. Truck and Bus Vehicle Adoption Shapes, Percent of Sales



The team then converted EV sales to registered EVs to determine the quantity and type of vehicles requiring charging in each year and to estimate how much each would need. Siemens PTI applied the Environmental Protection Agency (EPA) Motor Vehicle Emission Simulator (MOVES) 2 methodology to each subsegment, adjusting survival rates as needed to align with existing registered vehicles.

Siemens PTI then combined the estimated vehicle miles traveled and the per-mile energy consumption for each subsegment to forecast the annual energy requirement for each subsegment, providing the rated annual energy required. We considered four energy and load forecasts—reference, high, low, and 100% light-duty vehicle (LDV) and school bus—because varying degrees of EV adoption are possible.

Table 2. Electric Vehicle Adoption Scenario Definitions and Sources

Segment	Low	Reference	High	100% LDV and School Bus
Private	NYSEG Low	Siemens PTI	NYSEG High	NYS 100%
Commercial	Siemens PTI Low	Siemens PTI Reference	Siemens PTI High	Siemens PTI High
Buses—Transit	NYISO Low	NYISO Reference	NYISO High	NYISO High
Buses—School	NYISO Low	NYISO Reference	NYISO High	NYS School Bus 100%

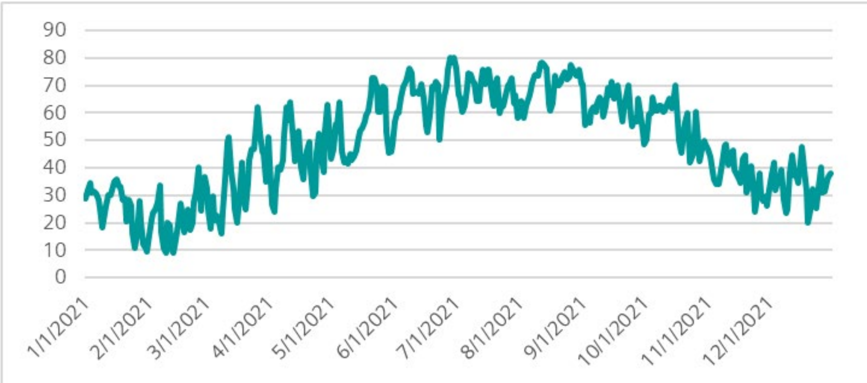
1.2.2 Ithaca Local Forecast

Siemens PTI developed a city-specific EV adoption curve for Ithaca because it displayed a higher-than-average adoption pace compared to other parts of the State. We backtested the forecast to ensure it aligned with actual registered EVs in Ithaca. The team used actual commercial EV registration data to estimate the city's commercial and bus adoption rates.

With EV sales forecast developed for the city, we used the same process detailed in the previous section to forecast EV stock, which we then used to calculate rated annual energy requirement. Siemens PTI also set out to understand the impacts of temperature on vehicle range and subsequent charging requirements. Based on the 2021 weather and temperature Cornell University reported, the minimum average temperature in Ithaca was 9 degrees Fahrenheit (°F) with maximum average of 80°F, illustrated in Figure 4.

Figure 4. Cornell University Average Daily Temperature Degrees Fahrenheit, 2021

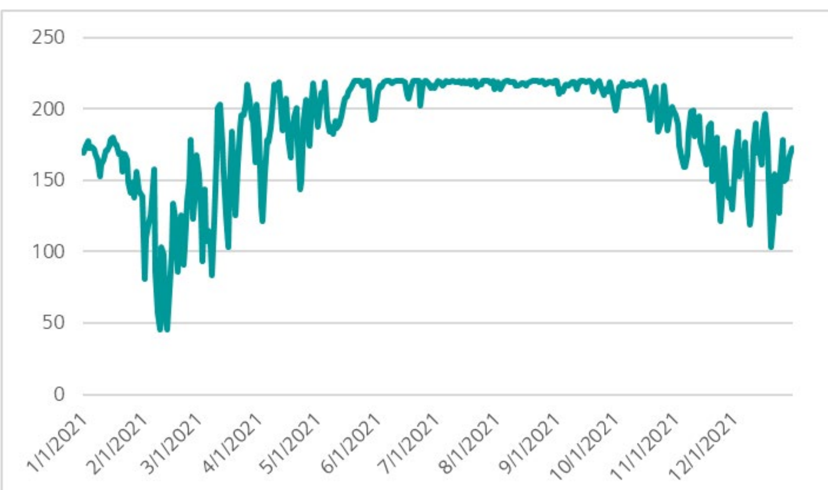
Source: Siemens PTI analysis.



A GEOTAB[2] analysis notes that 70°F is an ideal operating temperature ensuring the greatest range for EVs, and Siemens PTI used a 2019 Tesla 3 with a 54-kilowatt-hours (kWh) battery to evaluate temperature impacts. Using 2021 daily temperature data from the Cornell University weather station, the team evaluated the range for this Tesla model and then applied a regression-based formula to estimate the daily range impact, which Figure 5 illustrates.

Figure 5. Daily Range, 2019 Tesla Model 3 with 54-kWh Battery, Miles

Source: Siemens PTI analysis.



Siemens PTI confirmed that an EV operating in Ithaca for more than a year can expect a 15% range decrease from its manufacturing rating with the coldest days expected to dramatically reduce EV range. Additional analysis attempted to quantify the impacts of aging batteries on energy requirements. GEOTAB analyzed the battery health of 6,300 fleet and consumer EVs, representing 1.8 million days of data. Siemens PTI determined that EV batteries, on average, degrade at a rate of .17% per month and estimated that the average battery lifespan to be 4 years (48 months), corresponding to an average capacity loss of 8.1% of per EV over 4 years.

Siemens PTI used the National Renewable Energy Labs (NREL) Electric Vehicle Infrastructure–Projection (EVI-Pro) Lite tool for the Ithaca region to convert annual energy requirements into peak hour load to estimate the amount of charging infrastructure required in an area to meet peak demand. We conducted this process using two cases: one where charging was uncontrolled and EV owners charged whenever they pleased and the other when charging was delayed as much as possible (but still leaving the vehicle fully charged by 7:00 a.m.). We mapped the calculated energy and load forecasts to the New York State Electric and Gas (NYSEG) Ithaca circuits and conducted the analysis for each ZIP code in the Ithaca area.

1.2.3 Traffic Analysis

Siemens PTI used the Streetlight Data tool to consolidate and analyze traffic patterns in the city and evaluated the impact of vehicle volume with all other necessary traffic interactions.

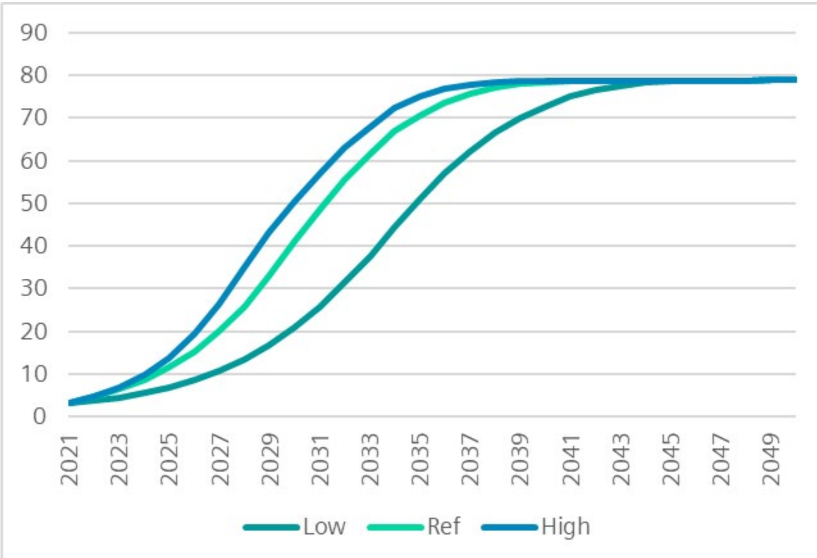
1.3 Results

1.3.1 Private Vehicle Load Impact

For the private vehicle market, energy requirements for the three EV energy scenarios (reference, low, and high) each displayed rapidly increasing energy requirements into the mid- to late 2030s, which Figure 6 illustrates.

Figure 6. Ithaca Electric Vehicle Temperature-Adjusted Energy Consumption for Private Vehicle, Gigawatt Hours

Source: Siemens PTI analysis.

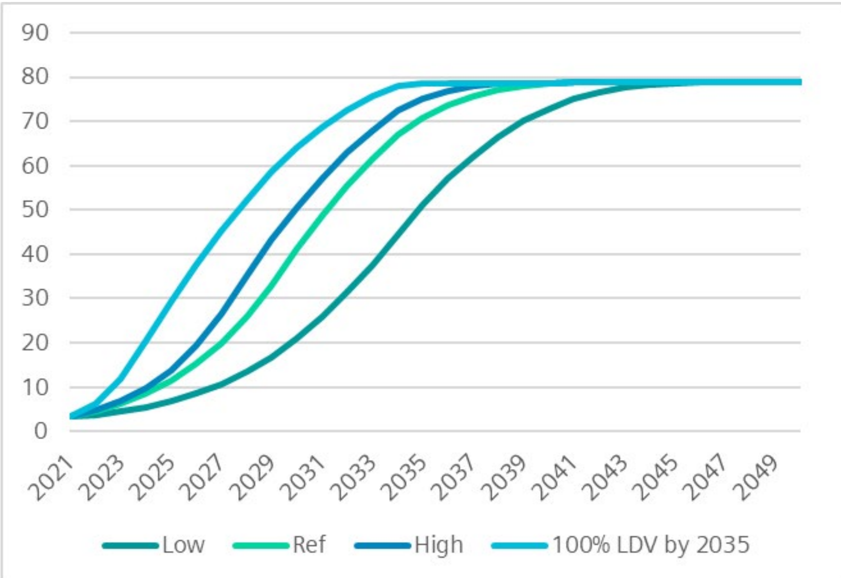


1.3.1.1 Special Scenario—100% Light-Duty Vehicle and School Bus by 2035 Load Impact

In September 2021, New York State passed legislation mandating that new LDVs and school buses sold in the State must be zero-emission by 2035 (i.e., 100% LDV and school bus by 2035 case). Because this legislation is estimated to have a higher energy requirement than the other three scenarios and a more aggressive timeline for EV adoption, we added this scenario to our study, which Figure 7 illustrates.

Figure 7. Ithaca Electric Vehicle Temperature-Adjusted Energy Consumption for 100% Light Duty Vehicle and School Bus, Gigawatt Hours

Source: Siemens PTI analysis.

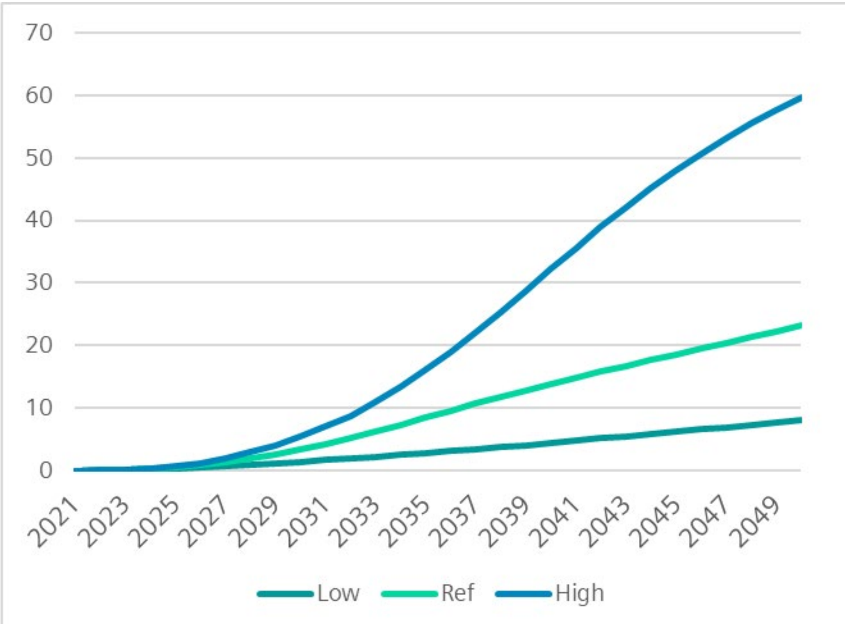


1.3.2 Commercial Vehicle Load Impact

Energy demands for the commercial vehicle market vary by scenario. The low case assumes that adoption is lower than other cases and the energy requirements increase slightly after 2030. The reference case sees a rapid increase in energy requirements from 2030 to 2050 corresponding to increased commercial vehicle adoption. The high case sees rapid and consistent growth after 2030 as commercial vehicle adoption increases beyond the reference case.

Figure 8. Ithaca Electric Vehicle Temperature-Adjusted Energy Consumption Commercial Vehicles, Gigawatt Hours

Source: Siemens PTI analysis.

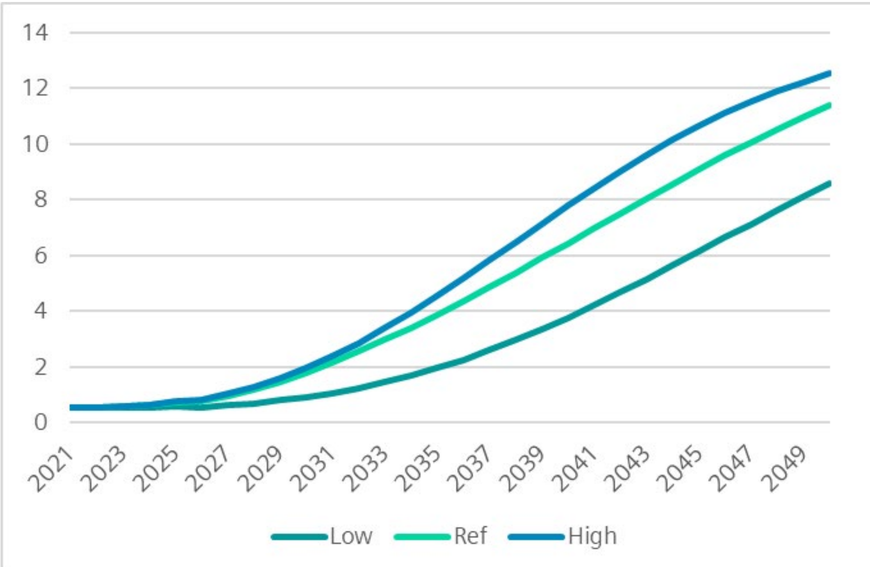


1.3.3 Trucks and Buses Load Impact

Energy requirements for trucks and buses indicate a similar growth across scenarios. Each scenario sees a rapid increase in the late 2020s and continuing through 2050.

Figure 9. Ithaca Electric Vehicle Temperature-Adjusted Energy Consumption for Trucks and Buses, Gigawatt Hours

Source: Siemens PTI analysis.

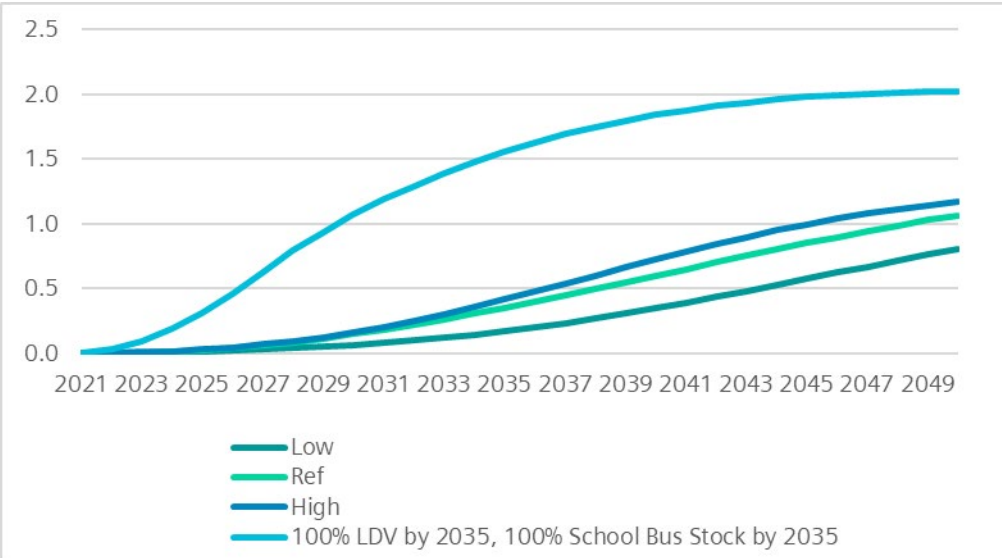


1.3.3.1 Special Scenario–100% Light Duty Vehicle and School Bus by 2035 Load Impact

The energy requirements for the 100% scenario accelerate rapidly in the early to late 2020s. This trend continues onward as bus vehicle adoption increases beyond reference.

Figure 10. Ithaca Electric Vehicle Temperature-Adjusted Energy Consumption for 100% School Bus, Gigawatt Hours

Source: Siemens PTI analysis.

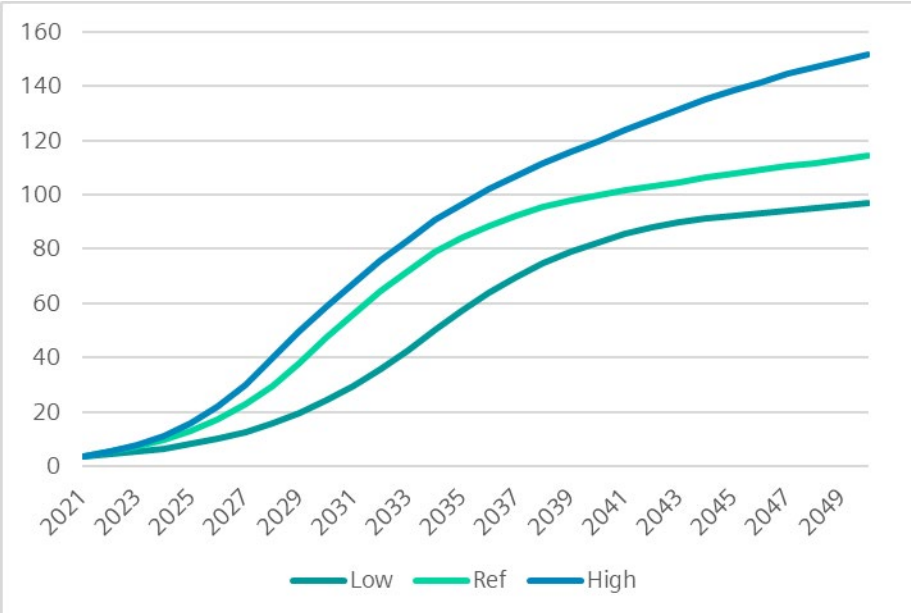


1.3.4 Total Load Impact

When considering total load impacts, the low case sees energy requirements accelerating into the mid- to late 2030s before slowing. The reference and high cases see growth begin to slow midway through the 2030s but continues growing until 2050.

Figure 11. Ithaca Electric Vehicle Temperature-Adjusted Total Load Impact, Gigawatt Hours

Source: Siemens PTI analysis.

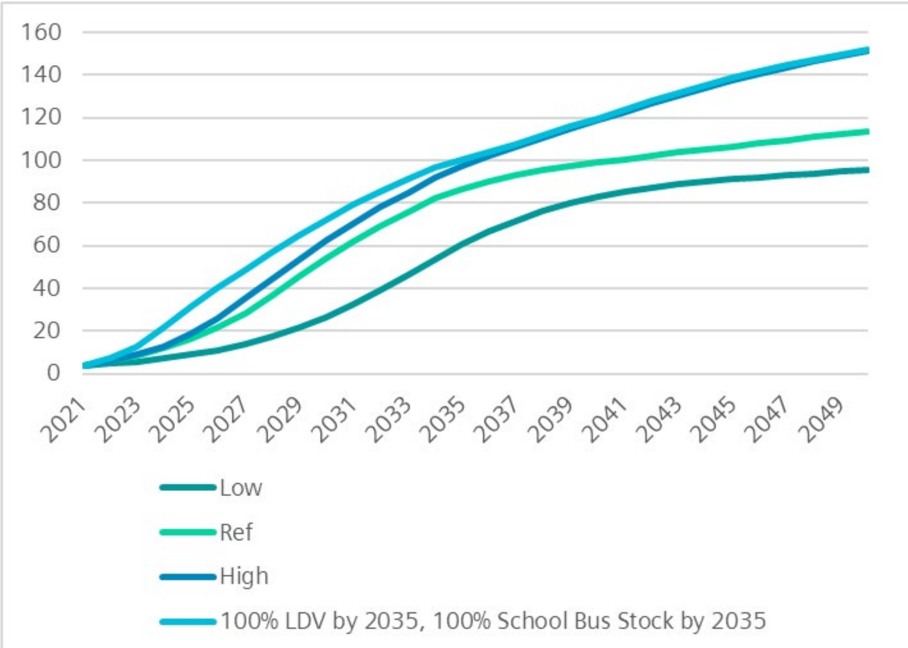


1.3.4.1 100% Light-Duty Vehicle and School Bus Stock by 2035

Under the 100% LDV and school bus case, energy requirements begin slowing in the late 2030s but continues to grow onward. This case, once again, sees more aggressive EV adoption and higher energy consumption than the other three cases. This case also outpaces the high case initially, but then maintains the same trend from 2035 until 2050.

Figure 12. Ithaca Electric Vehicle Temperature-Adjusted Total Load Impact, Gigawatt Hours

Source: Siemens PTI analysis.



1.3.5 Traffic Analysis

Siemens PTI evaluated traffic patterns based on four travel distinctions: volume distribution, trip length, trip duration, and trip type. Focusing on weekday and weekend traffic patterns, Siemens PTI evaluated volume distribution. Weekday traffic volume in Ithaca increases in line with rush hour morning and evening traffic. Weekend traffic volume peeks later in the day, around noon. Overall, daily volume is much higher during the week than on the weekends.

Figure 13. Traffic Volume Distributions (Number of Vehicles)

Source: Streetlight Data, Siemens PTI analysis.

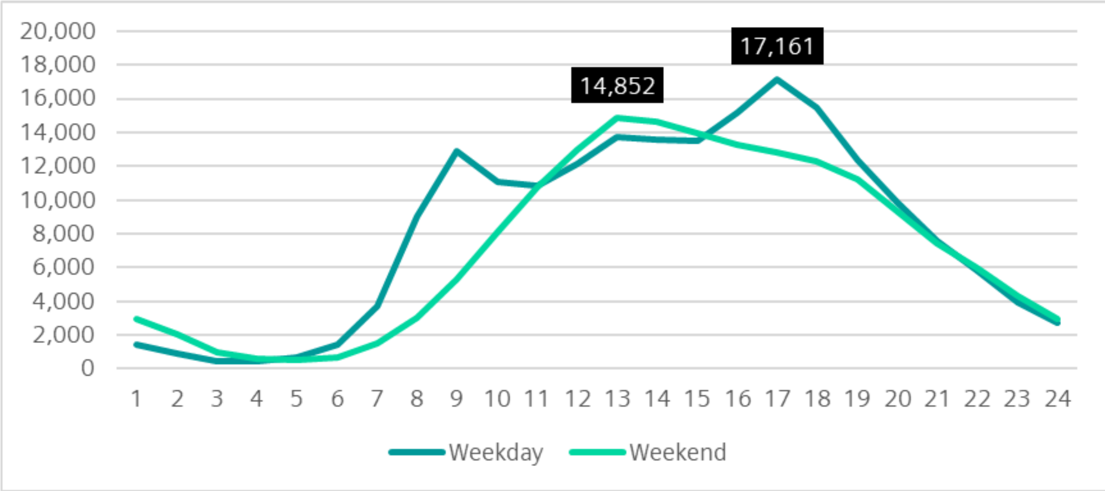
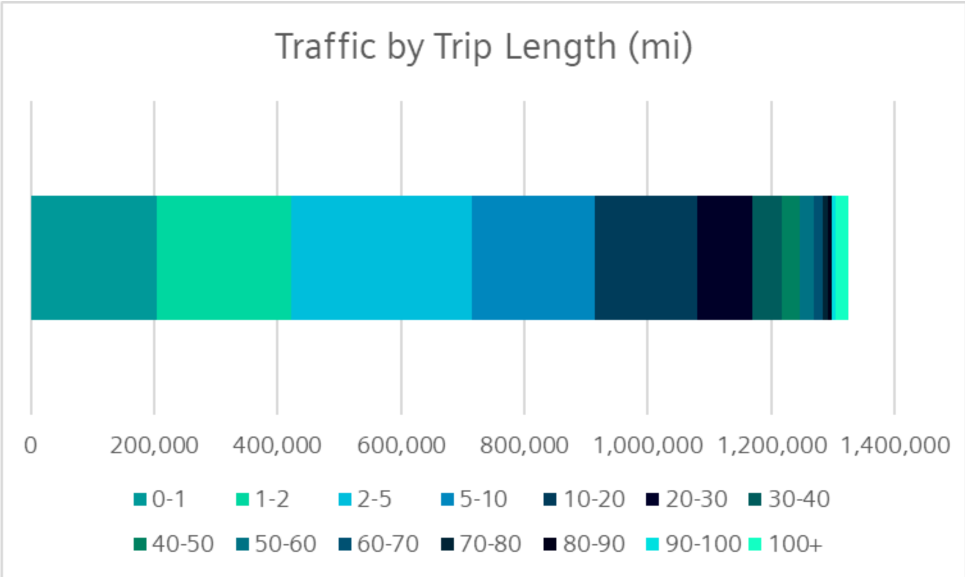


Figure 14. Traffic by Trip Length (Miles)

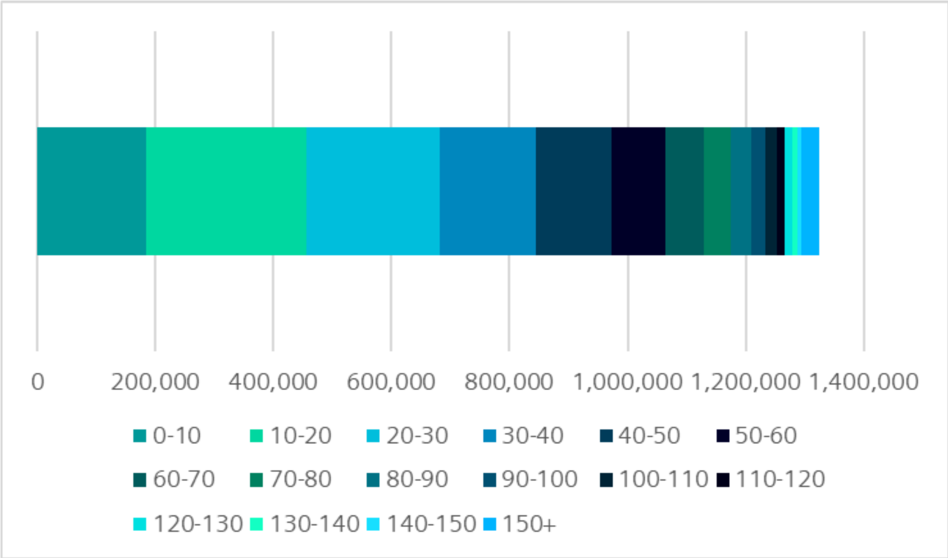
Source: Streetlight Data, Siemens PTI analysis.



Analyzing traffic by trip duration, Siemens PTI determined that most Ithaca drivers travel, on average, fewer than 40 minutes per trip, and a majority travel only between 10 to 20 minutes per trip.

Figure 15. Traffic by Trip Duration (Minutes)

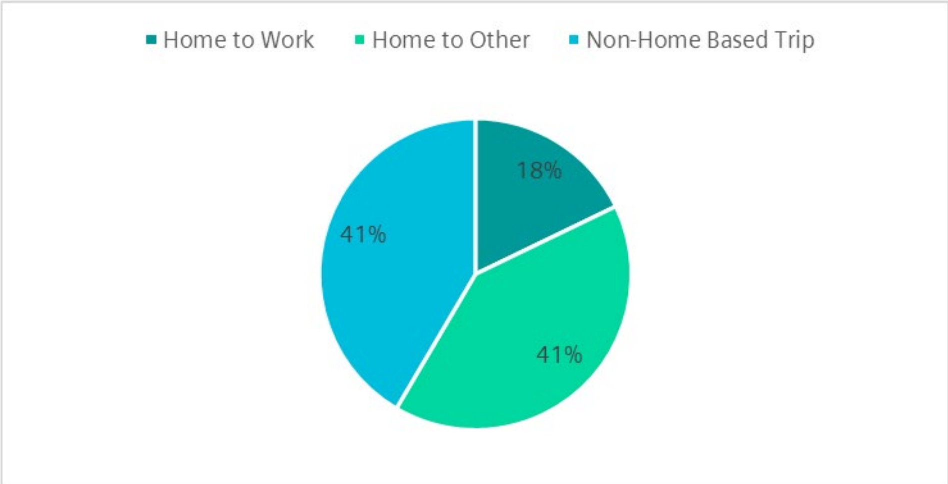
Source: Streetlight Data, Siemens PTI analysis.



Analyzing traffic by trip type, Siemens PTI concluded that most Ithaca drivers travel from home. Only 18% of drivers are commuting from a non-home–based location.

Figure 16. Traffic by Trip Type

Source: Streetlight Data, Siemens PTI analysis.



1.4 Analysis

For each adoption scenario, energy requirements accelerate into the mid- and late 2030s before slowing due to private market saturation. For the medium and high cases, energy requirement growth can be observed through 2050 as commercial vehicle, truck, and bus adoption increases beyond the reference case.

With the rapid adoption of EVs expected in Ithaca, additional energy supply is required during times of peak demand. This will require the utility to evaluate potential impacts more quickly, develop programs, and implement necessary solutions. In addition, utilities cannot consider EV charging impacts in isolation because the increased replacement of heating systems with electric alternatives and the deployment of distributed solar photovoltaic PV systems will impact the same electric feeders.

2 Task 2: Building Electrification Adoption and Load Forecast

2.1 Objective

Siemens PTI was tasked with developing a building electrification model that could forecast the potential electrification costs and load NYSEG would be managing as buildings convert from gas to electric energy use. Like most buildings in New York State, building gas consumption in Ithaca is primarily used for space heating. Consequently, Siemens PTI focused building electrification studies on the economics surrounding air-sourced heat pump (ASHP) adoption for buildings for which gas fuel was still the primary heating source. The study assumed that if switching from fossil gas heating to electric heating is economical for building owners, then they would convert all of their energy consumption to electricity.

2.2 Methodology, Data Sources, Scenarios

Siemens PTI electrification methodology used econometric modeling that based building electrification on a consumer's decision to adopt a heat pump to replace a gas heating system. A consumer's decision to replace the existing building gas heating system (reference building heating) is based on two conditions: (1) existing equipment failure, or (2) sufficient energy savings and incentives to justify early conversion. If the existing heating equipment fails in a given assessment year, the model compares the costs of installing an ASHP to a more efficient gas replacement (gas counterfactual).

Siemens PTI conducted this analysis at the building level, meaning several customers in one building could convert all at once. The team made this decision because many buildings in Ithaca have a single gas meter despite having multiple electric meters, suggesting users share gas bills and heating requirements. If a building converted to a heat pump solution, Siemens PTI assumes the entire building ceased using gas because of the high cost of gas interconnection relative to the low usage of gas for other end uses rather than heating.

2.2.1 Building Data and Energy Baseline Data

Building massing models are reconstructed using light detection and ranging (LIDAR) data output and clean building geometries. Ithaca's building data is then used to estimate building insulation properties where they are not known. We then carefully selected the Department of Energy (DOE) space-use templates and reference buildings and aligned them with city data. These data are then fed into a simulation model that generates an individual energy model for each building in the city.

2.2.2 Air-Sourced Heat Pump Technology Characteristics, Performance, and Cost Data

Because the city of Ithaca is located Climate Zone 5, a cold climate, Siemens PTI determined only Northeast Energy Partnership (NEEP) cold climate certified heat pumps[3] would be suitable for consumer adoption. NEEP categorizes ASHPs into four categories:

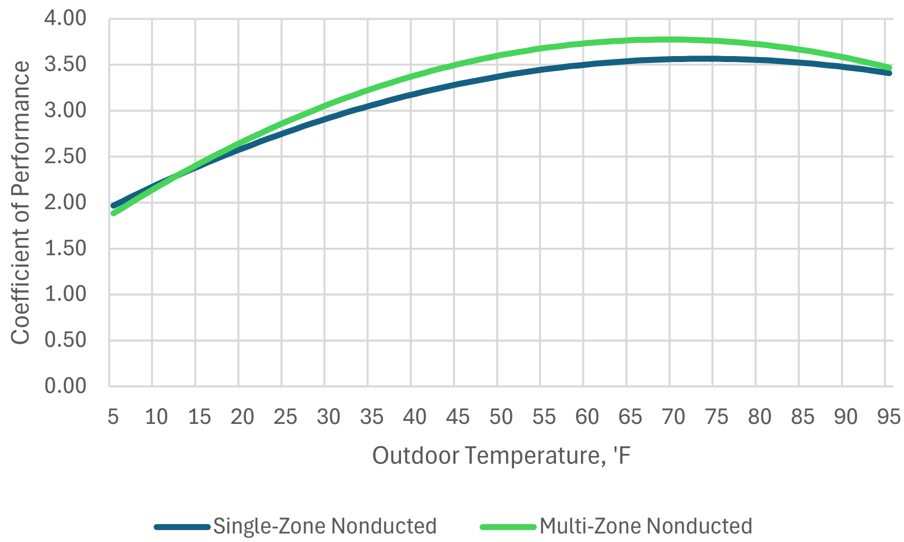
1. Single-zone, ducted
2. Single-zone, nonducted
3. Multizone, ducted
4. Multizone, nonducted

We selected the appropriate technology based on the presence of preexisting ductwork in the buildings.

ASHP performance is based on the delta between the ambient temperature outside and the ambient temperature inside a building. Siemens PTI developed ASHP coefficient of performance (COP) curve for each type of heat pump relative to the ambient outdoor temperature. Due to data limitations, Siemens PTI took a conservative approach, averaging the efficiency and consumption for winter months at 5°F. Siemens PTI currently expects the model's winter electric demand outputs are higher than actual outcomes.

Figure 17. Air-Sourced Heat Pump Coefficient of Performance Curves

Source: Northeast Energy Partnership (NEEP), Siemens PTI analysis.



The capital cost of converting heat pumps is tied to the sizing requirements of individual buildings. Heat pumps and the gas furnace counterfactuals used for this assessment are sized in British thermal units (BTUs). The larger the BTU capacity of a heating, ventilation, and air conditioning (HVAC) unit, the greater the cost tends to be. To size the units, Cornell University provided peak BTU HVAC needs for a single heating hour. We calculated the cost for ASHPs using EIA technology cost assumptions released in March 2023. The costs are provided for units sized at 36,000 or 90,000 BTUs. To scale the size and capital costs for each building individually, the team converted the EIA estimates from fixed prices per unit to dollar values per BTU of capacity for both equipment cost and for installation costs.

2.2.3 Rates and Variable Cost

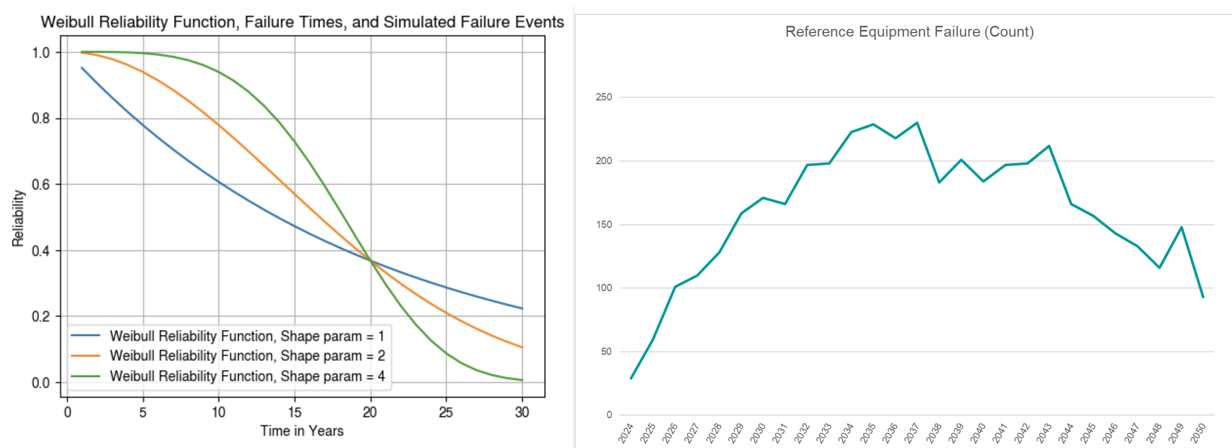
In addition to capital costs, consumers face variable costs derived from energy procurement and delivery activities. Rate classes conform to two groups, residential and commercial/industrial, and the retail rates are increased by a flat relative to the wholesale power prices applicable to Ithaca. Wholesale power and gas prices were sourced Siemens PTI's national forecast model, a forecasting tool Siemens PTI developed and used for developing state-of-the-market outlooks for resource planning.

2.2.4 Reference Equipment Failure

Failure of the reference equipment, relative to existing equipment installed, is an important dimension to consumer heat pump adoption. Siemens PTI lacked information regarding the age or condition of existing equipment in consumer homes. Consequently, Cornell University developed a failure curve using a Weibull distribution, a statistical method that leverages probability to model equipment time to failure.

Figure 18. Weibull Distribution and Reference Equipment Failure Count by Year

Source: Cornell, Siemens PTI analysis.



2.2.5 Scenarios

Siemens PTI developed three scenarios for analysis to reflect possible adoption outcomes based on incentives and market prices. Figure 10 summarizes the key variables adjusted for each scenario.

Figure 19. Heat Pump Adoption Scenarios

Input Adjusted	Low (Current Policy)	Medium	High
Incentive Levels	Incentive level cap at $2,000 federal tax credit available through 2032 and NYS $1,400 tax incentive for mini-splits.	Higher incentive caps at $12,000 for equipment and installation plus all IRA and NYS incentives.	Extends IRA level funds through in 2050, increases incentive cap to $25,000.
Demand Charges	Escalated as a percentage of system converting from gas to electric. CAGR=2%	Escalated as a percentage of system converting from gas to electric. CAGR=3.5%	Escalated as a percentage of system converting from gas to electric. CAGR=5%
Natural Gas Prices	Siemens PTI NFM at Dominion North Zone, WNY	Siemens PTI NFM at Dominion North Zone, WNY	Siemens PTI NFM at Dominion North Zone, WNY High Case

2.3 Results

Study findings indicate that under current conditions in the low scenario, slightly less than 50% of buildings in Ithaca will convert by 2050 without any further action being taken. This is largely due to equipment failing within the current Inflation Reduction Act of 2022 (IRA) incentives period and predicted normal increases in fossil gas costs over time. In middle scenario, the pressures from above-average gas costs will push greater economic adoption in the later years of the study period, with 54% of buildings converting from fossil gas heating to electricity. Finally, in the high case, Siemens PTI predicts building electrification could reach as high as 77% of existing buildings and a 57% reduction in fossil gas consumption. High natural gas costs coupled with prolonged incentives and increased incentive caps help drive economic decision-making and can encourage consumers to adopt before their equipment fails.

Figure 20. Buildings Electrified

Source: Cornell, Siemens PTI analysis.

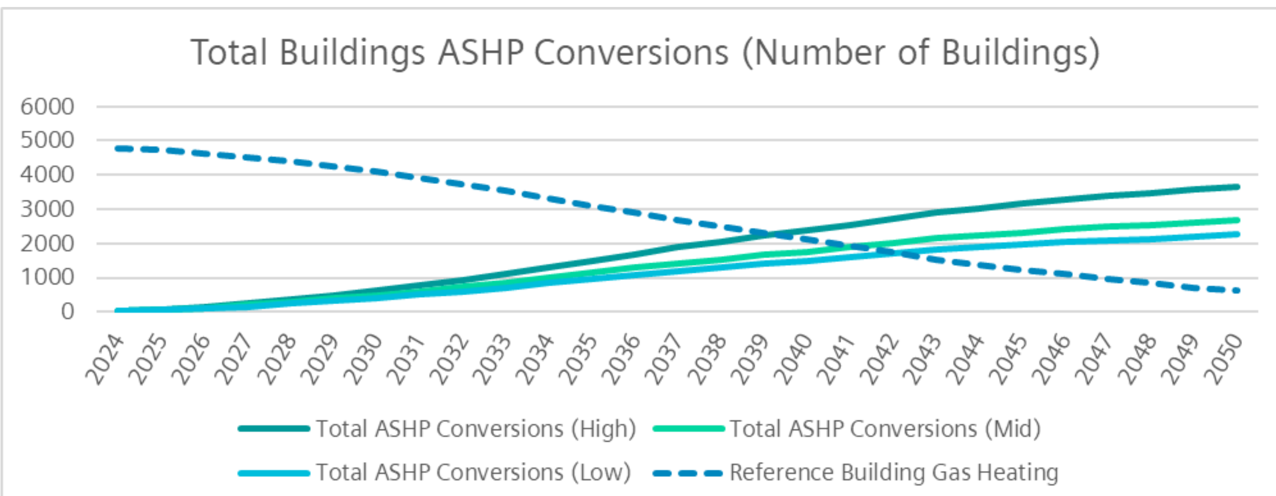


Table 3. Buildings Electrified by Scenario

Scenario (Buildings)	2024	2030	2040	2050	% of Total Buildings
High	21	636	2376	3671	74%
Mid	18	496	1765	2686	54%
Low	15	412	1494	2266	46%

Table 4. Change in Megawatt Hour Demand

Scenario	2024	2030	2040	2050	Net Change 2024–2050
High	137,137	143,578	158,556	168,746	23%
Mid	137,086	141,359	150,175	155,794	14%
Low	137,057	139,836	145,955	149,812	9%

Table 5. Change in Metric Million British Thermal Unit Demand

Source: Siemens PTI analysis.

Scenario	2024	2030	2040	2050	Net Change 2024–2050
High	1,203,603	1,060,131	737,710	514,805	-57%
Mid	1,204,684	1,105,583	901,298	766,544	-36%
Low	1,205,317	1,137,464	988,117	889,771	-26%

Table 6 illustrates the total subsidies required for each scenario to achieve the designated results. In the case of the low scenario, the $3.5 million in subsidies are already in place through federal tax incentives and New York State subsidies, and consumers can be expected to pay $5.5 million in costs. The medium scenario estimates total unsubsidized costs to be $14.0 million, requiring $6.4 million in subsidies and consumers bearing $7.6 million in costs. The high scenario requires approximately $23.1 million in subsidies with consumers bearing approximately $6.1 million in costs.

Table 6. Major Building Category Conversion Percentage

Source: Siemens PTI analysis.

Scenario	Increased MWh Demand (Sep-Mar Only)	Estimated Unsubsidized Total Adoption Costs	Subsidies Required	Total Subsidized Costs
High	31,608	$29,204,714	$23,127,512	$6,077,202
Medium	18,709	$14,020,007	$6,423,990	$7,596,016
Low	12,754	$8,999,341	$3,482,396	$5,516,945

2.4 Analysis

The results from this electrification study offer several insights regarding building electrification for Ithaca. First, at least some electrification is inevitable. Although the capital costs of heat pumps are unlikely to decrease because it is a mature technology, the energy savings from heat pumps coupled with existing incentives will encourage to consumers to electrify when the existing gas heating equipment fails.

Second, the influence of incentives is clear, not only the duration of those incentives, but also the amount. IRA incentives had a noticeable impact on consumer ASHP adoption rates before rolling off in 2032. After 2031 in the medium and low scenarios, consumer adoption of more efficient natural gas furnaces ticks up, despite the increased cost of gas in the medium scenario. However, in the high case, extending the duration IRA incentives through 2050 had a noticeable impact on ASHP adoption.

Third, subsidy timing is key. In general, consumers who can be attracted early in the incentive period are more likely to convert from fossil gas to an ASHP. Consumers are more likely to retain existing gas infrastructure if subsidies are not available. Moreover, if subsidies end too soon, gas prices may not be high enough to provide an economic incentive for conversion.

Electrification also can lead to substantial emissions reductions due to both efficiency gains from reduced energy consumption and using grid energy, which is projected to decarbonize over time. Gross emissions savings range from 4,500 MT in the low case to almost 10,000 MT in the high. Net savings, when accounting for grid emissions, vary greatly depending on the emissions factor. Using today's emissions factor, net emissions savings would fall just short of 1,000 MT annually. However, renewable energy policies are progressively decarbonizing electrical generation and reducing the emissions factors of electrical generation. Using NYSERDA data for Upstate New York, the 2030 emissions factor could realize 3,000–6,500 MT of emissions reductions in the low scenario.[4]

Table 7. Estimated Carbon Emissions Savings

Source: Siemens PTI analysis. [5]

Scenario	MMBTU Savings	Gross Annual Emissions Savings 2050 (MT, EIA)
High	688,798	36,444
Medium	438,140	23,182
Low	315,546	16,696

2.5 Forced Electrification Scenario

Siemens PTI was asked to estimate the costs of a scenario that forced 100% building conversion by 2050. Siemens PTI determined the best way to calculate these results was to remove subsides, force electrification, and provide the total equipment costs estimated to electrify the entire system. Siemens

PTI also maintained the same existing equipment failure curve, forcing the remaining 500 buildings to electrify in 2050 in accordance with a long-term forced electrification policy. By using this approach, Siemens PTI can provide policymakers with an unbiased projection of what is needed to electrify all city of Ithaca buildings.

Forced electrification resulted in a 75% increase of winter electric load and 44% increase in total load, exluding summer months potential load. The uneconomic forced electrification in the Ithaca footprint more than doubled the total costs. Forcing electrification resulted in nearly $70 million in equipment and installation costs, a $40 million increase from the high scenario.

Figure 21. Air-Sourced Heat Pump Conversions and Upgrades, Forced Adoption

Source: Cornell, Siemens PTI analysis.

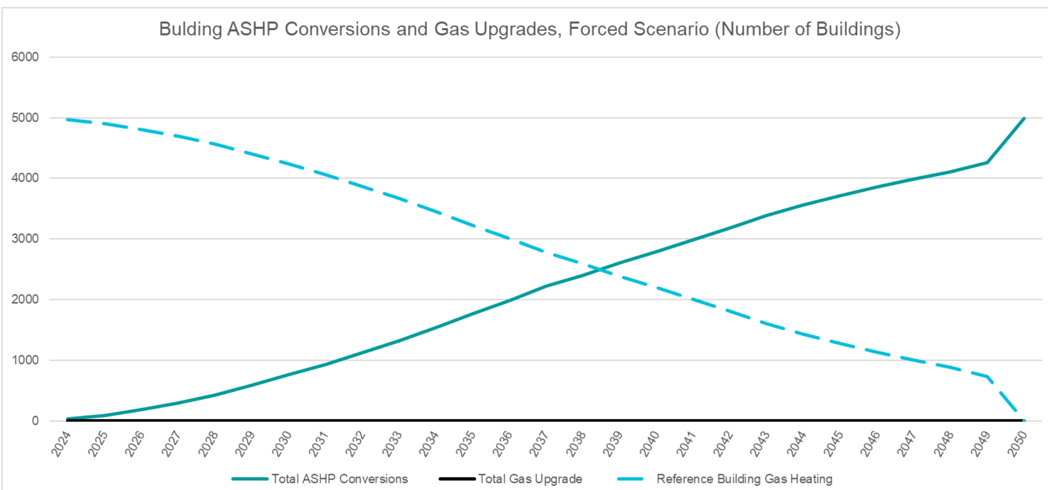


Figure 22. Change in Electric and Gas Consumption, Forced Adoption

Source: Cornell, Siemens PTI analysis.

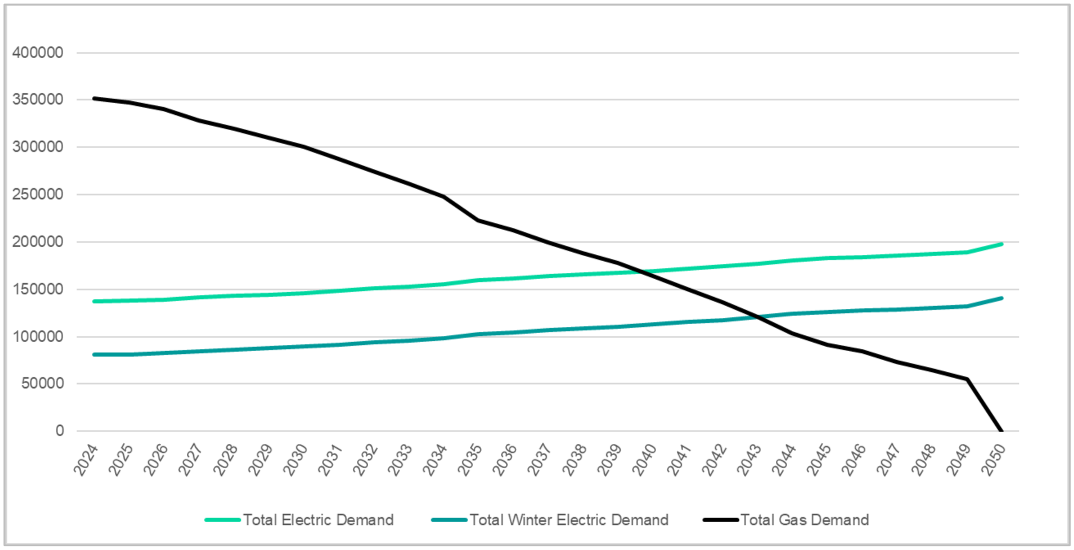


Table 8. Forced Adoption Scenario Impacts and Costs, 2030 and 2050

Source: Siemens PTI analysis.

	2030	**2050**
Total ASHP Conversions	15%	100%
Reference Building Gas Heating	85%	0%
Total Electric Demand	6%	44%
Total Winter Electric Demand	11%	75%
Total Gas Demand MMBTU	-14%	-100%
Total Estimated Cost	$ 69,411,056.18	

3 Task 3: Solar Photovoltaic Adoption and Generation Forecast

3.1 Objective

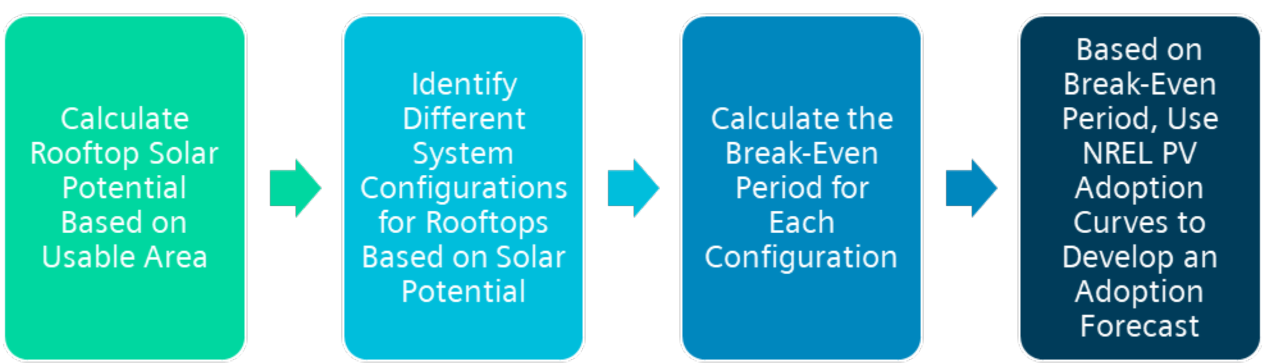
Task 3 investigated the impacts of distributed solar energy generation through photovoltaic technology and assessed the consequences of widespread distributed generation development. The research team employed innovative computational geometry, machine learning, and computer vision methodologies for urban three-dimensional (3D) reconstruction to analyze building rooftop renewable energy potential. The resulting data generated provided crucial insights for utility distribution grid planning.

3.2 Methodology and Data Sources

In collaboration with Cornell University, Siemens PTI analyzed 5,523 rooftops in Ithaca to assess the city's rooftop solar PV generation potential based on the amount usable rooftop area and solar irradiance. By conducting an economic analysis of each rooftop, Siemens PTI determined the BE or payback period for different system configurations. Using NREL research on solar PV adoption, Siemens PTI identified a relationship between a PV system's BE period and the percentage of customers willing to purchase a PV system.

Siemens PTI then separated low, medium, and high adoption scenarios based on the length of the identified BE periods, creating a PV adoption forecast reflecting these scenarios.

Figure 23. Photovoltaic Solar Adoption Methodology

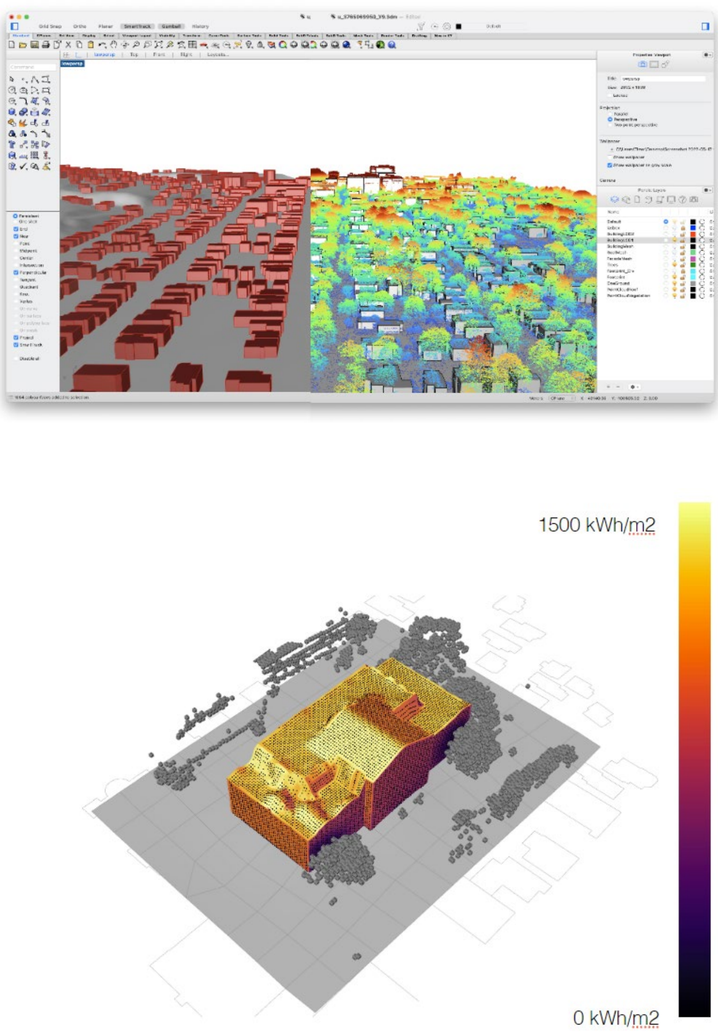


3.2.1 Rooftop Solar Potential and Technical Adoption Assessment

Cornell University used open-source building footprints that Microsoft provided and used LIDAR measurements to reconstruct each building’s 3D figure, reconstruct vegetation in the area, and then used a backward ray tracing approach to simulate incident radiation on rooftop sensors.

Figure 24. Photovoltaic Example Building Solar Potential

Source: Cornell University.



From the 5,523 assessed buildings, the team measured the hourly PV potential for the city on a by-building basis, and then annualized these measurements to create an annual PV potential estimate for Ithaca. In sum, these buildings offer a total rooftop area of 1,402,222 m^2.

3.2.2 Economic Adoption Assessment

Siemens PTI used the latest data available (February 2023) as assumptions for its economic assessment. This data included proxy panel dimensions and efficiencies, industry standards, and state and federal renewable incentives, among others.

Using Cornell University's analysis, the PTI team created an annualized assessment of each building's output potential. The team then segmented the accepted economic range of 800 kW/m2 to 1500 kW/m^2 potential into 100 kW/m^2 increments, and the team calculated the amount of available area on each rooftop that can produce the indicated degree of output potential. The team considered readings below 800 kWh/m2 uneconomic for solar development.

We estimated the total system size for each rooftop based on the amount available area that could produce at least 800 kW/m^2, and we based the calculations on a Siflab 370-watt panel with dimensions of 1.85 m^2 (~6' x 3.5') and an efficiency of approximately 20%. Once we determined the system size for each rooftop, we calculated the system cost (before incentives and other considerations) and the possible annual power generation.

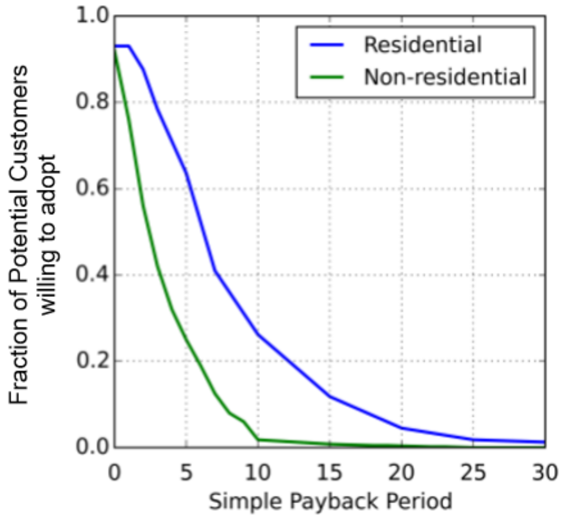
For each building's calculated system configuration, we calculated a BE period, which determined the amount of time recouping each system's initial investment would take. The team then identified three scenarios for the economic analysis each corresponding to different BE periods. The low case concerns rooftop PV configurations with estimated BE periods of 12 years or less; the medium, 15 years or less; and the high, 18 years or less.

3.2.3 Solar Photovoltaic Forecast Model

Using research from the National Energy Renewable Laboratory (NREL), Siemens PTI recognized a relationship between the BE period for a solar PV system and the percentage of potential customers willing to adopt a system given that BE period.

Figure 25. Customer Adoption as a Function of Payback or Break-even Period

Photovoltaics (Sigrin and Drury 2014), source for non-residential data: Rooftop photovoltaics market penetration scenarios (Paidipati et al. 2008).



The payback curve for residential solar served as a reference for each of the three scenarios, noting a maximum adoption rate of 20%, 11.8%, and 8% for the low, medium, and high scenarios, respectively. Based on the current and forecasted economic environment, the team created initial adoption curves, calculated a penetration rate for each year from 2022 to 2040, and applied each rate to the maximum generation potential for each scenario.

3.3 Results

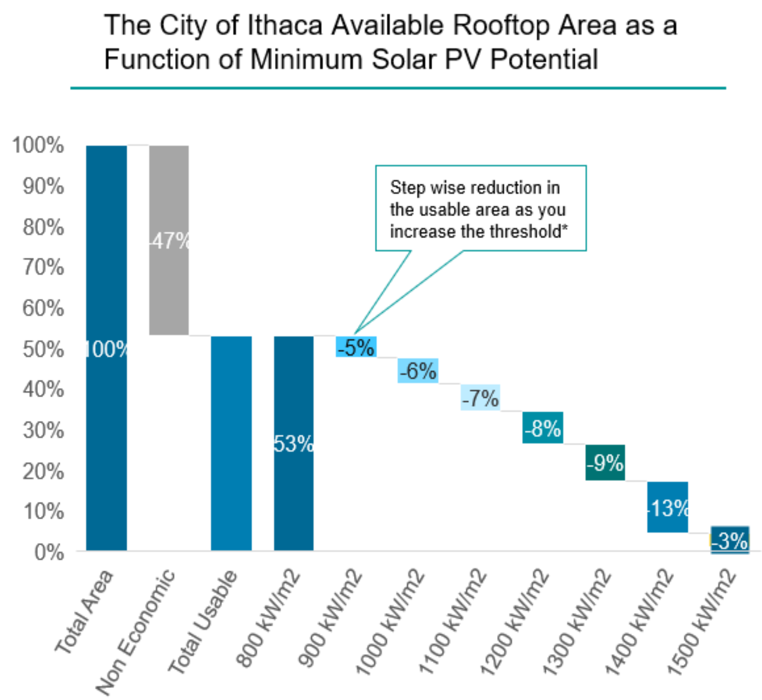
3.3.1 Technical Rooftop Solar Potential

Siemens PTI found that 47% of the city's total rooftop area offered less than 800 kW/m2 of solar generation potential. The remaining 53% offers PV potentials ranging from 800 kW/m2 to 1,500 kW/m^2. At each level of minimum solar intensity, the availability of viable and cost-effective opportunities decreased in increments ranging from 3% to 13%, with the largest drop occurring at 1,400 kW/m^2.

Figure 26. Waterfall Solar Photovoltaic Rooftop Area

Usable rooftop area at 900 kW/m2, 48%; at 1,000 kW/m2, 42%, etc.

Source: Cornell, Siemens PTI analysis.

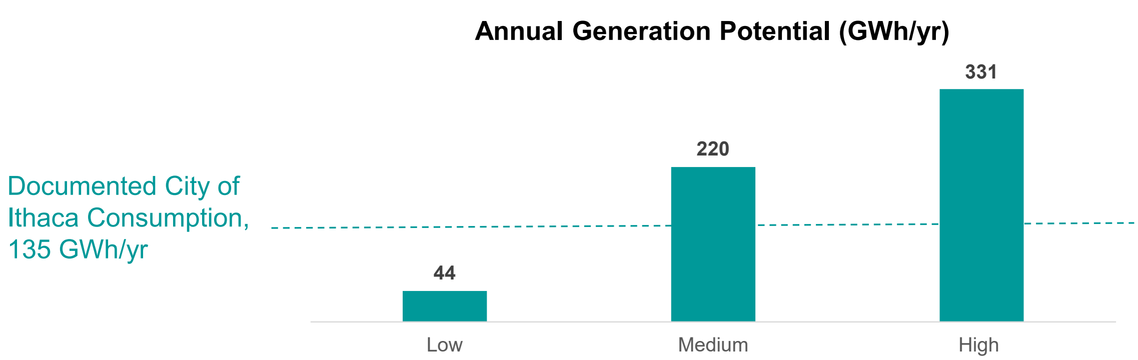


3.3.2 Economic Adoption Assessment

Using the economic BE criteria, Siemens PTI determined that the low scenario offers an annual generation potential of 44 GWh per year, 220 GWh for the medium scenario, and 331 GWh for the high scenario assuming that all economic available area is used for rooftop solar.

Figure 27. Solar Photovoltaic Generation Potential, Gigawatt Hours per Year

Source: Cornell, Siemens PTI analysis.



The team found that 78%, 91%, and 94% of measured buildings qualified for the low, medium, and high scenarios, respectively. Differences in the BE period corresponded to each scenario supporting different-sized system configurations.

Table 9. Solar Photovoltaic Adoption Results

Source: Cornell, Siemens PTI analysis.

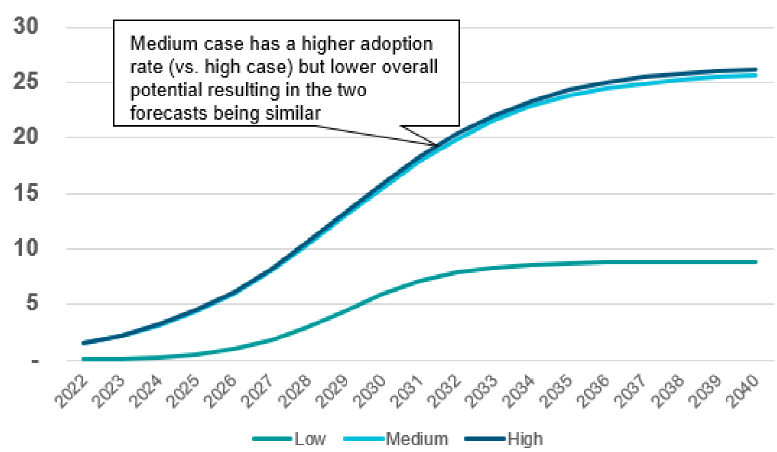
Scenario (BE Period)	Reference (≤12 years)	Medium (≤15 years)	High (≤18 years)
Number of Rooftops (%)	4,342 (78%)	5,039 (91%)	5,236 (94%)
Average System Size (kW)	7.2 kW	32.9 kW	50.4 kW

3.3.3 Photovoltaic Adoption Forecast

Using NREL's payback/adoption function, Siemens PTI identified a maximum annual generation potential of 8.83, 25.83, and 26.19 GWh for low, medium, and high scenarios, respectively.

Figure 28. Solar Photovoltaic Adoption Forecast, Gigawatt Hours per Year

Source: Cornell, Siemens PTI analysis.



Lower adoption rates correlated with high BE periods resulting in lower realized generation potential for each scenario, but especially the medium and high cases.

3.3.4 Avoided Emissions

Using EIA-published information, each scenario offers the annual greenhouse gas emission savings indicated in Table 10.

Table 10. Forecasted Emissions Reduction

Source: EIA.

GHG Emission Savings (Million lbs/yr CO_2)		
Year	**Low**	**Medium/High**
2030	1.3	3.5
2040	2	5.9

3.4 Analysis

The Cornell University team estimated that from 2018 to 2021 the average annual electricity demand for Ithaca was approximately 135 GWh per year. While Siemens PTI concluded that Ithaca has a generation potential in excess 331.4 GWh given the technical solar assessment, high BE periods make only ~26 GWh of generation is expected by 2040 in the high scenario. When considering the lower BE periods associated with the more feasible low scenario, only ~8.8 GWh is expected. Consequently, the low case only accounts for ~6% of the city's historic annual demand, whereas the medium and high scenarios account for ~19% each. These numbers are likely lower in practice because this study did not address the renter-owner dilemma: Rental properties comprise a large portion of the city's buildings, which would likely further restrict adoption than forecasted in this study because tenants have little incentive to invest in projects with long BE periods and owners realize little or no benefits from the energy generation.

Overall, Ithaca's solar PV adoption and installation will be limited due to economics as well as the high percentage of rental ownership. Consequently, citywide solar incentive programs may not be a cost-effective investment for NYSEG because of the city's inconsistent distribution of rooftops with optimal solar potential. However, Cornell University's electrification and DG solar potential models may identify areas where Siemen's PTI's distribution feeder analysis can be identified as high-value targets for DG solar when compared to the relative costs associated with needed grid investments.

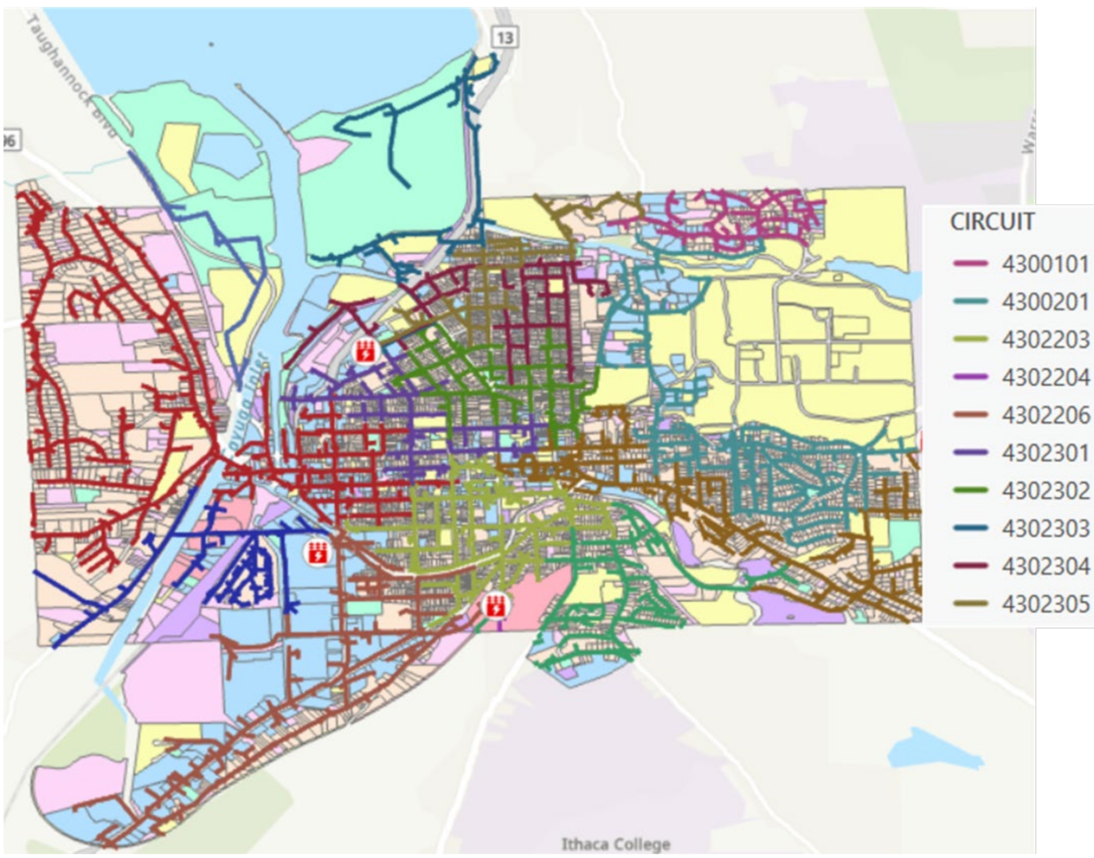
4 Task 4: Circuit and Feeder Impact

4.1 Objective

Task 4 set out to aggregate the results of tasks 1, 2, and 3 and model them on the existing NYSEG distribution and feeder system to see how electrification affects power balance and safe operation of the distribution system and suggest mitigation strategies and upgrades for planners.

Figure 29. Circuit Feeder Map

Source: NYSEG, Siemens PTI.

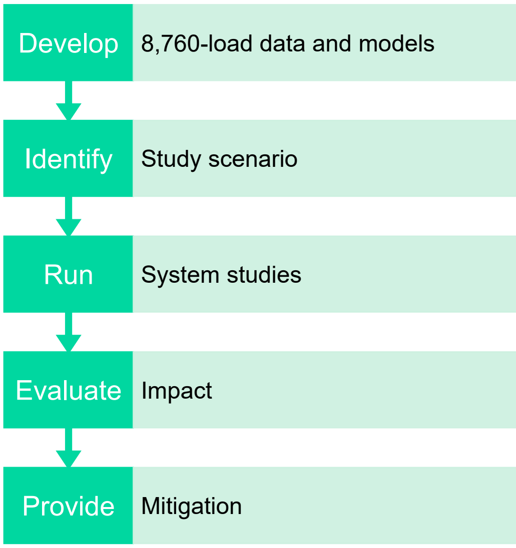


4.2 Methodology and Data Sources

The task 4 methodology consists of these five key steps:

1. Develop appropriate feeder models and data inputs to get the 8,760-load data
2. Based on this data, identify the appropriate study scenarios
3. Run system simulations for the selected study scenarios
4. Evaluate impacts
5. Provide mitigations to address any identified adverse impacts

Figure 30. Task 4 Methodology Steps



4.2.1 Grid Model

Siemens PTI assessed the accuracy of the T&D impact models by comparing modeled outputs with measured data from systems such as supervisory control and data acquisition (SCADA). Where measured data are unavailable, the team determined baselines based on equipment, expected load, and reasonable engineering judgment. This study used the following detailed approach to improve the accuracy of the feeder model:

- Evaluate model with available measurement sources
- Compare and tune the model based on measurements from sources with voltage and current measurements such as regulators, switched capacitors, and reclosers
- Add required control parameters to regulators and switched capacitors
- Include substation regulator and switched capacitors in the model
- Update source parameters (typically by using available short-circuit values for the substation and transformer banks)
- Update SCADA load data
- Unmask DER data by deducting it from feeder-head load measurement
- Run load allocation when model output diverges from available measurements (e.g., if kWh values are available for all loads, use a kWh-based load allocation method to align the feeder model with the SCADA data if possible)

This study did not require that models be developed anew because raw models were available for all the feeders studied. However, for future work, if detailed electrical engineering models of the distribution system do not exist, planners can develop raw distribution system models based on input data such as information already available in asset management, geographic information, and customer information systems. Once the raw models are developed, they can be tuned appropriately.

4.2.2 Input Data

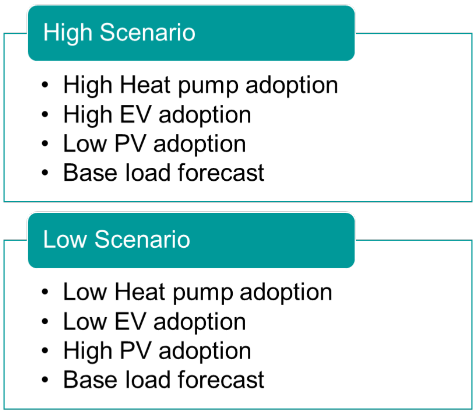
This study uses four input datasets: three load modifier datasets (EV, building electrification, and DER/PV based on tasks 1, 2, and 3), and one base load dataset. This section details how the team processed the raw data from these four datasets and used the results as inputs to the electric distribution feeder models:

- **EV forecast:** EV forecast was a mixed dataset with some 8,760 data provided at feeder level and at building level. This is the expected charging forecast from EVs.
- **BE forecasts:** This data was provided from the previous tasks and consists of building-level 8,760 datasets. This is the building-level electric demand forecast for buildings converted to heat pumps.
- **PV forecast:** This dataset is similar to the BE forecast, but the data is on the building-level rooftop photovoltaic energy production potential and 8,760 PV forecasts.
- **Base forecast:** This dataset was based on the node-peak load, New York State short-term forecast, and the load profile from historical 8,760 SCADA measurement of the feeder.

4.2.3 Scenarios and Load Aggregation

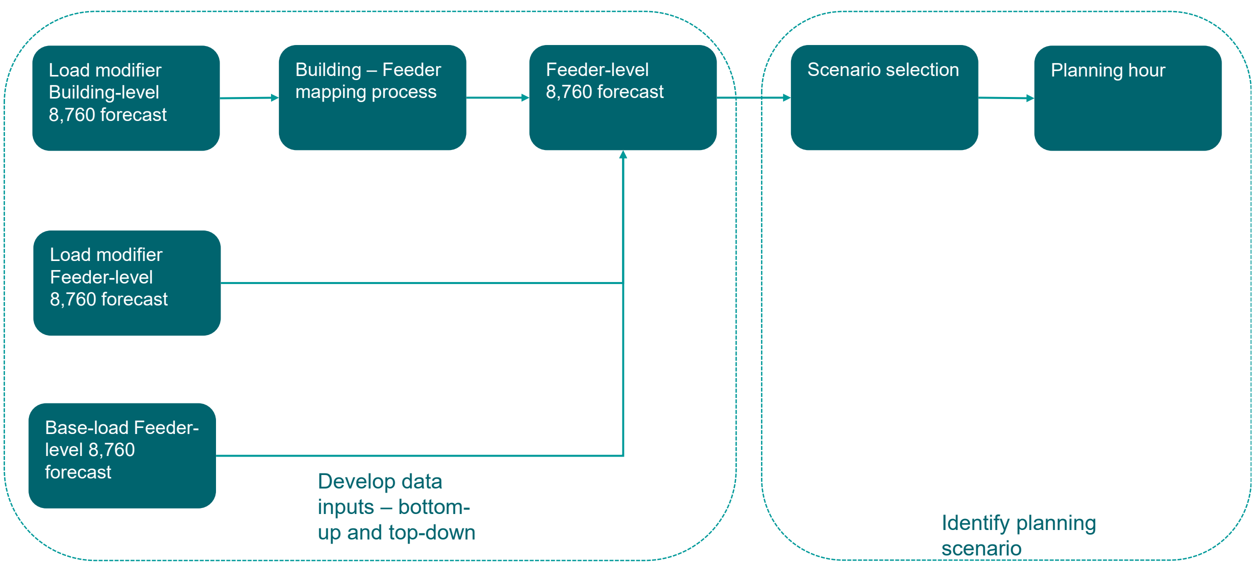
Two scenarios were considered, a high (maximum) and a low (minimum) feeder load forecast, based on EV, BE, and PV adoption from prior tasks in this study. However, scenario definitions for task 4 deviate from the scenarios defined in the past tasks since generation and load have opposing impact on the total feeder load. To create the high-load scenario, we combined the high BE and EV adoption forecasts with the low-adoption scenario for PV. Conversely, we created the low-load scenario by using the low BE and EV adoption forecasts with a high-adoption scenario for PV.

Figure 31. Clustering Load Modifiers to Develop the Two Scenarios



For each scenario, the team combined all the 8,760 datasets from feeder-level and building-level data sources to create the aggregate feeder-level 8,760 forecast. The aggregate 8,760-load forecast assumes all the loads are connected directly at the feeder, which is a reasonable assumption for the sake of identifying the peak planning snapshot(s) since losses are distributed across the network.

Figure 32. Process Flowchart for Planning Scenario Identification

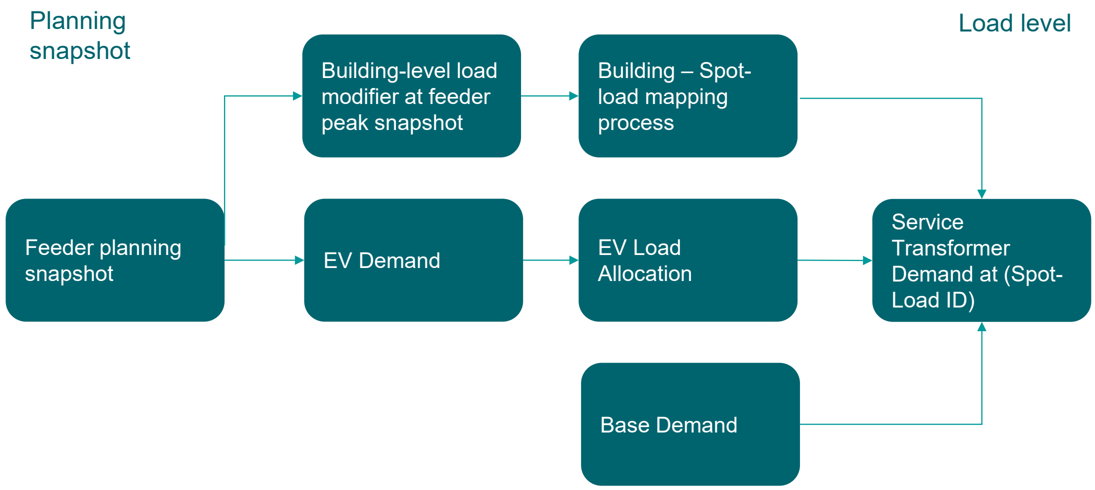


The data available on the building level is mapped to the feeder by mapping buildings to discrete, existing spot loads located on the feeder. If a building to spot load feeder map is not available, it can be developed by mapping utility customer/feeder data with city building data.

4.2.4 System Studies and Feeder Simulations

The first step in conducting system studies is simulating spot-load forecasts incorporated into the planning snapshot. To do this, start with extracting the load corresponding to the planning hour from all the 8,760 datasets.

Figure 33. Process to Develop Single-hour Planning Snapshot



In order to distinguish the upgrades resulting from electrification, the team forced the 2023 distribution system model to resolve any existing voltage or thermal overloading issues in the base model. With the base distribution model finalized, we then used it for conducting system studies to simulate the system impact of electrification load modifiers. The simulations must assess the effects of load modifiers on voltage and thermal limits on the system main distribution feeders and subsequent components. Therefore, we carried out an unbalanced power flow and saved the results for assessment.

4.2.5 Assessment

Three dimensions assess the results:

1. **Feeder assessment:** Assess the feeder based on thermal limits and node voltage limits
2. **Transformer impact:** Assess the service and feeder banks based on thermal limits
3. **Mitigation solutions:** Use industry-standard solutions to address thermal and voltage violations for each analysis year building on mitigation solutions from previous analysis years

4.3 Results

4.3.1 Citywide

The detail results of task 4 analysis are both too extensive for this document and subject to confidentiality. At a high level, due to HVAC electrification and EVs operating in Ithaca's cold weather conditions, the Ithaca grid peak will shift from summer period to winter, particularly in the high scenario.

Figure 34. Citywide Load Profile for Each Load Modifier on Corresponding Peak Day

Source: NYSEG, Siemens PTI analysis.

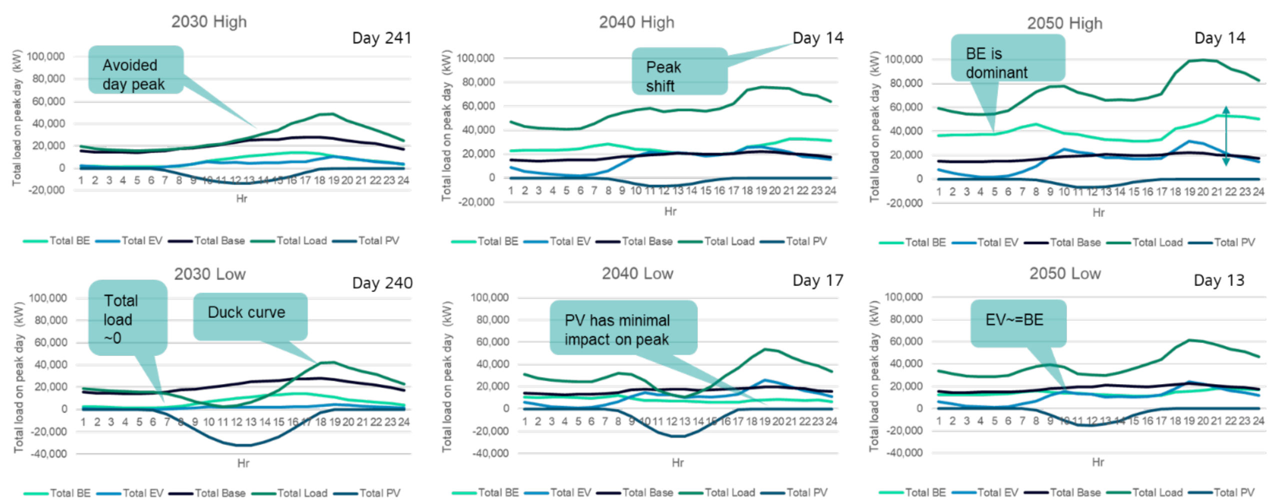


Figure 35. Annual Energy Forecast in Kilowatt Hours

Source: NYSEG, Siemens PTI analysis.

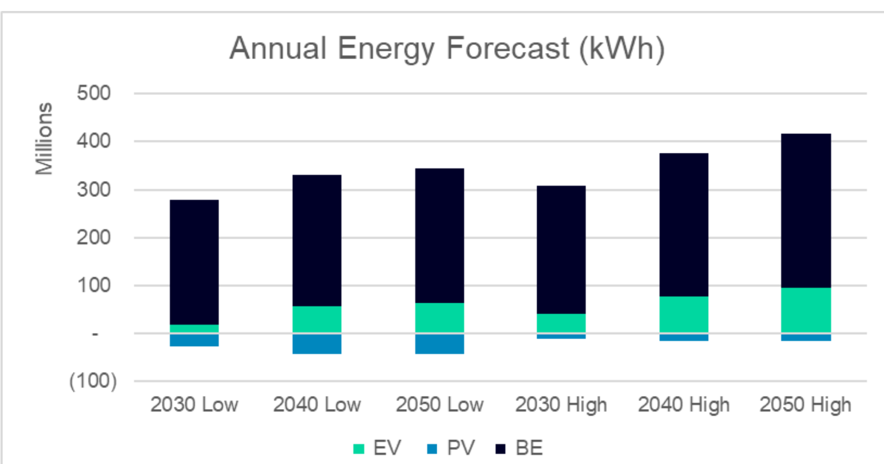
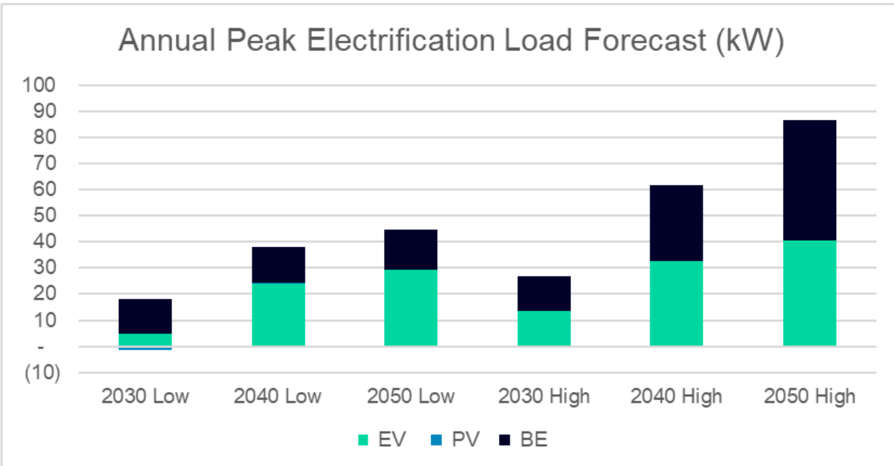


Figure 36. Citywide Load Profile for Each Load Modifier on Corresponding Peak Day in Kilowatt Hours

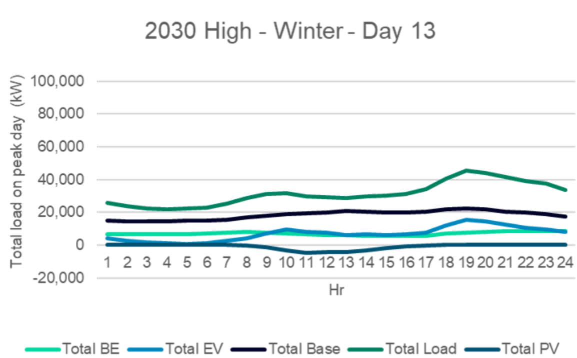
Source: NYSEG, Siemens PTI analysis.

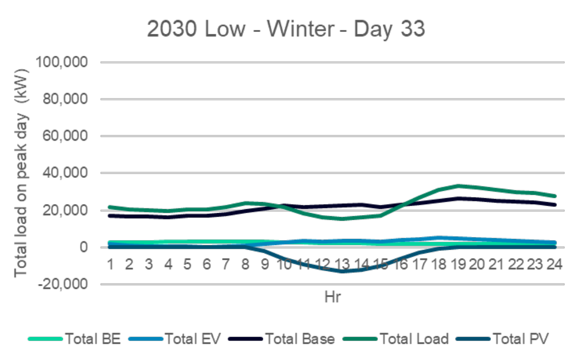


For the high scenario, the study results suggest that winter load will grow rapidly. The system will experience 100% load growth during the winter peak by 2030 and will likely convert to a winter peaking system by 2032.

Figure 37. 2030 Winter Peak

Source: NYSEG, Siemens PTI analysis.





4.3.2 Feeder Results

On average, the Ithaca feeders will experience load increases ranging anywhere from double to triple the current levels. However, in the city's central commercial districts, namely 4300201, the load could rise by as much as 1,200% by 2050 in the high scenario.

Figure 38. Total Impact of Load Modifiers by Feeder as a Percentage of Baseload, Low Scenario

Source: Siemens PTI analysis.

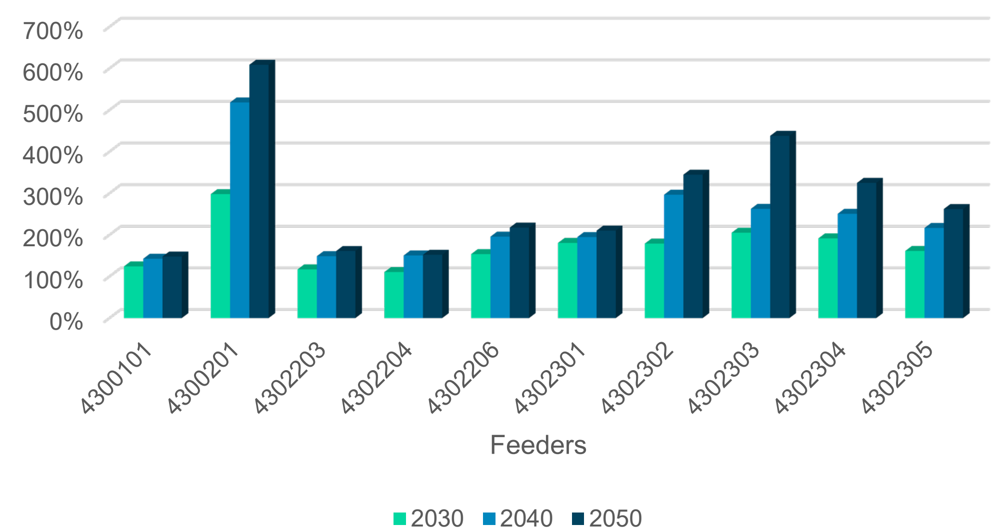
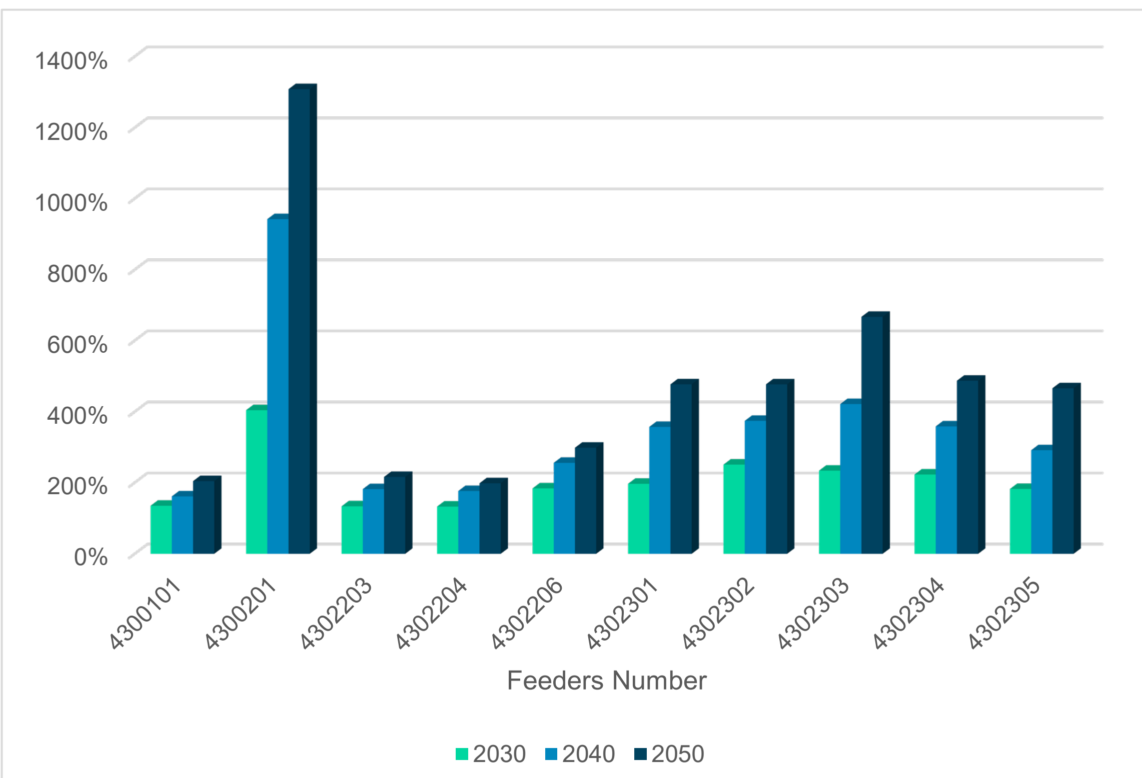


Figure 39. Total Impact of Load Modifiers by Feeder as a Percentage of Baseload, High Scenario

Source: Siemens PTI analysis.



4.4 Mitigation Assessment and Analysis

The key mitigations for this study are reconductoring service transformers and substation transformer upgrades. Table 11 summarizes the key mitigations.

Table 11. Length of Distribution Lines Needing Reconductoring

Source: Siemens PTI analysis.

Mitigation	Low	High
Total Reconductoring length 2030 (mi)	0.41	0.49
Total Reconductoring length 2040 (mi)	0.99	5.14
Total Reconductoring length 2050 (mi)	1.69	3.54

Figure 40. Reconductoring Requirements as Percentage of Total Feeder Backbone Length

Source: Siemens PTI analysis.

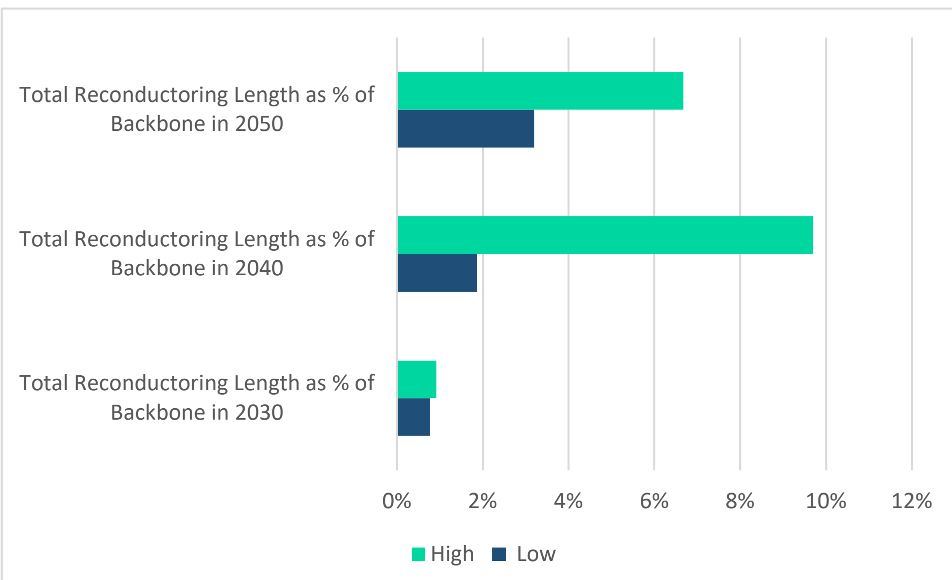


Table 12. Required Substation Upgrades for Planning Year

Source: Siemens PTI analysis.

Mitigation	Low	High
Total Substation Transformer Upgrades 2023–2030	0	0
Total Substation Transformer Upgrades 2030–2040	0	3
Total Substation Transformer Upgrades 2040–2050	0	1
Cumulative Secondary Transformer Upgrades 2030	93	159
Cumulative Secondary Transformer Upgrades 2040	187	286
Cumulative Secondary Transformer Upgrades 2050	211	349

Figure 41. Cumulative Service Transformer Upgrades for Mitigation

Source: Siemens PTI analysis.

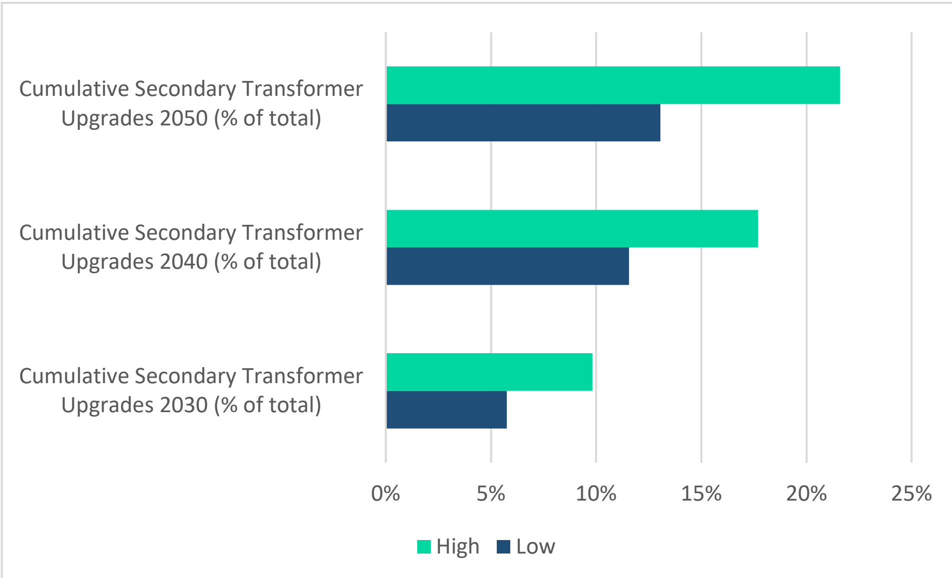
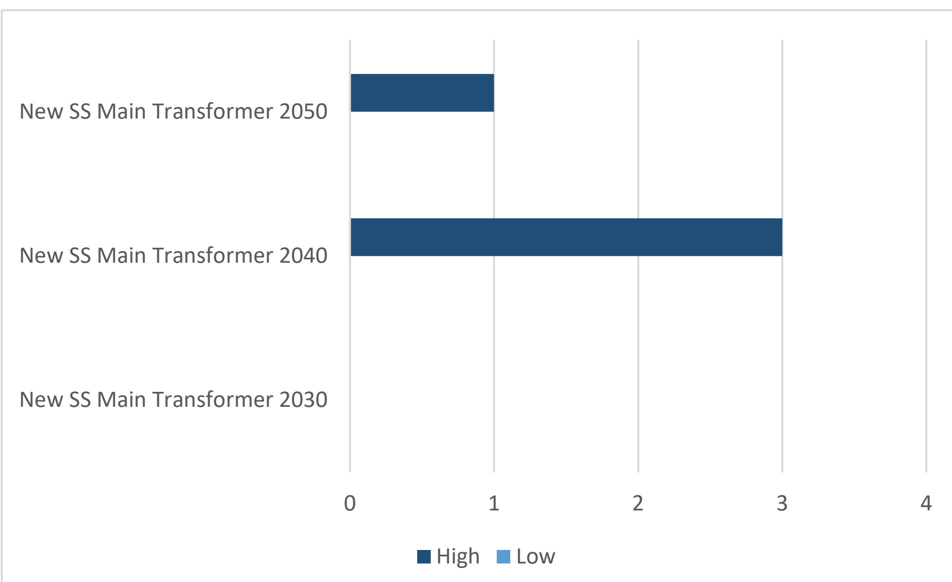


Figure 42. Substation Transformer Upgrades Required at Each Planning Year (75% Peak-Load Factor)

Source: Siemens PTI analysis.



4.5 Analysis

The main takeaways from the load profile and breakdown for the peak-load day for the city for different planning years and the energy forecast are:

- The peak power demand (1 hour) for Ithaca is expected to increase 3 to 5 times from 2023 to 2050, with the minimum demand increase observed with the low electrification peak-load scenario.
- The system peak shifts from a summer to a winter peak between 2030 and 2040 for all scenarios.
- The contribution of PV to decrease the absolute peak demand is negligible since it occurs at night.
- In 2030, the PV contributes to decreasing the day peak, resulting in the total load reaching close to 0 megawatts (MW) in the 2030 low scenario, but the relative impact of PV on the peak day decreases due to a combination of load growth and peak shift.
- From 2030 to 2050, in the high scenario, BE is more dominant, but for the low scenario, EV BE impact is approximately the same as EV impact.
- The EV has a lower load factor, whereas BE has a higher load factor.

The mitigations required for the adverse impacts show that from 13% to 22% of the total service transformers will have to be upgraded. Even with the low scenario (no change in existing policy), more than 13% of the service transformers will have to be upgraded due to an increase in load, causing thermal overloading.

The low scenario sees mitigation requirements increasing gradually, whereas in the high scenario, the majority of mitigation efforts are focused between 2030 and 2040. Therefore, infrastructure needs are expected to follow a similar pattern. Substantial investments are planned to enhance substation capacity. While this is unnecessary for the low scenario, four substation transformers must be added to the distribution system to accommodate the high scenario.

5 Task 5: Geographic Information System Mapping

5.1 Objective

Siemens PTI was tasked to develop an interactive layered map of Ithaca using Esri's ArcGIS Pro software, incorporating data from the previous tasks for public and private use. The ArcGIS Pro map includes multiple layers of data, ranging from EV plug-in charger locations to NYSEG substation circuit feeder data. Two maps were created: one map for public use and another for internal use, ensuring compliance with critical energy/electric infrastructure information (CEII) regulations. Siemens PTI used various sources, including publicly available geographic information system (GIS) maps and GIS maps directly from NYSEG to develop these maps.

5.2 Methodology and Data Sources

Siemens PTI developed an interactive GIS map for the city of the Ithaca. GIS is a tool that creates, manages, analyzes, and maps all types of data. The GIS connects data to a map, integrating location with descriptive data, which forms a foundation for mapping and analysis across several industries. GIS helps users understand patterns, relationships, and geographic context. The benefits include enhanced communication and efficiency, as well as improved management and decision making.

Siemens PTI used a variety of data sources and publicly available GIS maps to develop a functional GIS map for Ithaca. Some of the publicly available GIS maps included Ithaca tax parcel data from the city's website and the alternative fuel stations from the DOE Alternative Fuels Data Center (AFDC) website. Siemens PTI developed the substation and circuit feeder layers using GIS maps that NYSEG provided directly. They used these GIS maps as the foundation for developing the final product, using latitude and longitude coordinates to accurately map all datasets in the ArcGIS Pro software.

5.2.1 ArcGIS Map Layer 1: Tax Parcels

The tax parcel layer differentiates between property classes and better identifies locations for potential EV charging as well as load impacts on the system due to stressors. The team developed the tax parcels layer of the GIS map by downloading the tax parcel GIS map from the city of Ithaca's website and importing the map into ArcGIS Pro. The map included data such as addresses, property class, zoning, and locational information, enabling the display of different property classes that exist within the city.

5.2.2 ArcGIS Map Layer 2: Electric Vehicle Charging Stations

Siemens PTI added EV charging station locations to the map not only to display all existing EV charger locations within Ithaca County, but also to identify potential locations for future EV charging stations. A publicly available map of existing EV charger locations will help residents find and use public chargers more regularly. A map of potential EV charger locations helps the town and the local utility (NYSEG) identify areas for prioritizing the installation of charging stations, as well as applying for grants.

We created the existing EV charger locations layer of the GIS map by downloading the AFDC's alternative fueling station locator GIS map for Ithaca County and importing the map into ArcGIS Pro. The map included data such as station names, charger station addresses, charge type and plug quantity, accessibility, and locational information facilitating accurate mapping the charger locations within the city. The city provided a few charger locations that were not on the AFDC map, which we added manually.

We developed the potential EV charger locations layer of the GIS map using the existing EV charger locations layer as the foundation. The potential charger locations, and the charge type and plug quantity shown on the map, are a combination of Siemens PTI recommendations, based on the city's vision and criteria, and the city's recommendations for proposed locations and expansions for EV charging.

5.2.3 ArcGIS Map Layer 3: City of Ithaca Distribution Feeder Map

Siemens PTI displayed Ithaca's distribution feeder map to highlight the load and impacts of EV charging, distributed solar PV, and building electrification on the NYSEG electric system by scenario. We created the feeder map layer and sublayers using NYSEG's internal CEII protected substation and distribution circuit feeder GIS maps. The substation map included data such as substation names, addresses, and location information, facilitating the mapping of all substations connected to a circuit feeder within the city. The distribution circuit map had data such as circuit numbers, substation names, voltage details, and location information, enabling the mapping of all existing feeders within the city.

5.3 Results

Siemens PTI developed an informational and interactive GIS map of Ithaca comprising three layers and twelve sublayers that can be turned on and off as needed. The three main layers include tax parcels, EV charging stations, and the distribution feeder map. The EV charging stations layer has two sublayers:

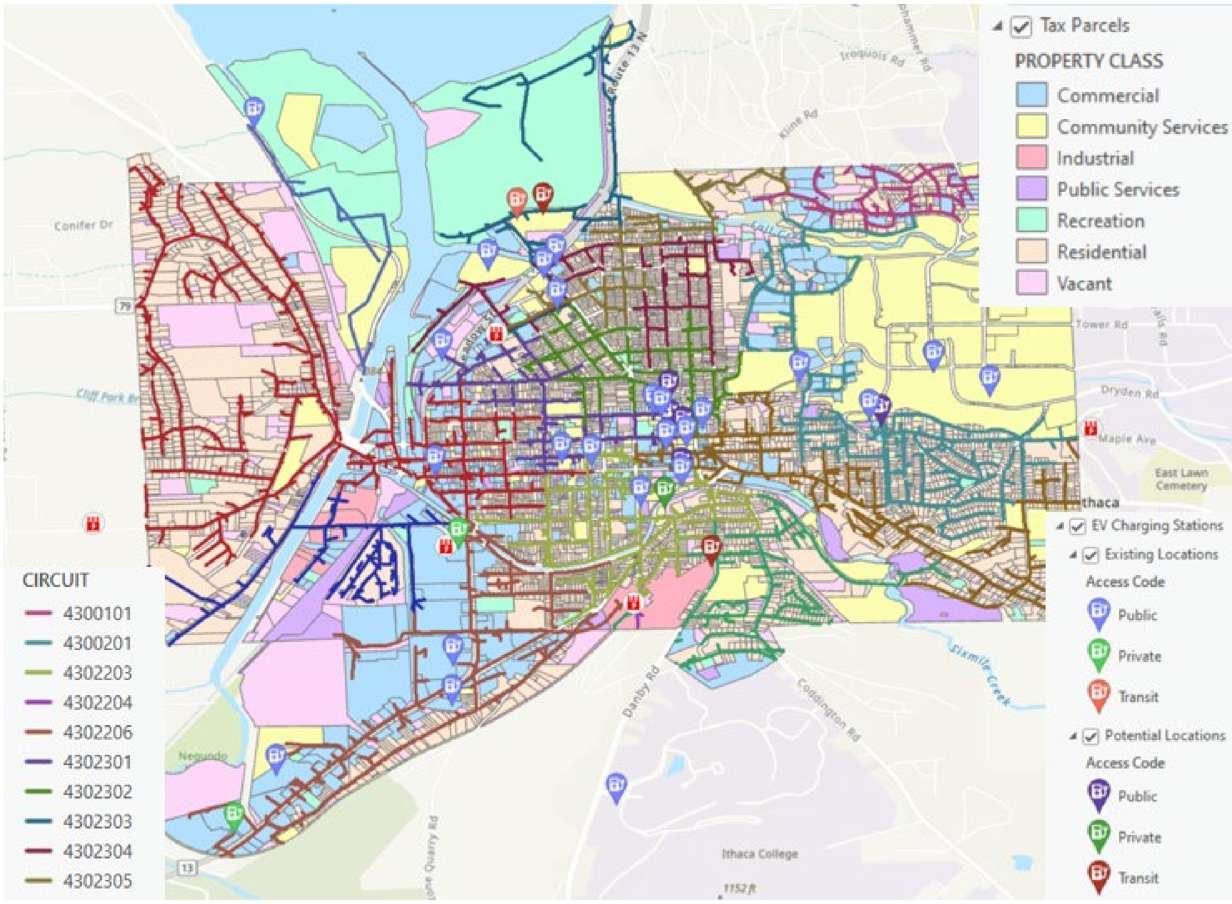
existing charger station locations and potential charger station locations. The distribution feeder layer is the most in-depth and informational layer with 10 sublayers, which include the substation datasets, the distribution feeder datasets, and the impacts on the load at the feeder level across different scenarios (low, reference, and high).

Siemens PTI identified 15 NYSEG distribution feeders located within Ithaca. For the circuit feeder layer, the attributes table includes the peak-load distribution of EV charging, distributed solar PV, and building electrification at the individual feeder level for the study years (2030, 2040, and 2050) and for all scenarios (low, reference and high).

In the previous task, Siemens PTI conducted a circuit load assessment on 10 of 15 distribution feeders in Ithaca. For the distribution feeder layer, the attributes table includes data for the feeder peaks, the base load, EV charging, distributed solar PV, and building electrification, as well as the peak day and peak hour for each of these 10 feeders for the study years (2030, 2040, and 2050) and for the low and high scenarios.

Figure 43. City of Ithaca Geographic Information System Map

Source: NYSEG, Siemens PTI.



6 Comprehensive Study Analysis

The NYSERDA FutureGRID study is a first-of-its-kind bottom-up approach to load forecasting and grid planning. Traditionally, zero-emission grid planning has only considered converting to electrical generation from fossil fuel powered resources to zero-emissions resources such as nuclear, wind, hydro, and solar. This study, however, guided the city of Ithaca's Green New Deal, envisions a future where fossil fuels are no longer the primary energy source; instead, electricity will serve as the primary energy for industrial processes, transportation, HVAC, and all facets of daily life. Moreover, this study contemplates the use of diffuse energy resources such as distributed PV solar panels in residential neighborhoods. While each of the five tasks and results mentioned earlier are enlightening, dimensions of this study can only be addressed from a holistic consideration of all tasks happening in tandem.

6.1 Rapid Peak-Load Growth

In a fully electric future, the difference between average load and peak load will increase. The average total energy requirements modeled in this study are lower than today's total energy requirements. However, converting from fossil-fuel–based energy to electric-only energy will cause greater hourly load fluctuations in different seasons. Ithaca is an excellent example of this shift. Not only will Ithaca convert from a system that peaks in the summer to one that peaks in the winter due to the conversion of heating from gas to electricity, but the inefficiency of electric heating during extreme cold weather events will also cause the peak to grow on some feeders by up to 1,200%, although the average load increases only between 1.5 and 2 times.

This is exacerbated by the fact distributed PV solar is not coincident with peak demand, particularly as electrification shifts to winter peaks. Consequently, this study found that distributed solar resources did not significantly mitigate Ithaca's demand or feeding back onto the system over the long term. However, this is not reflective of all jurisdictions or scenarios. If NYSEG or other planners need to account for high distributed PV solar, they will require a separate study that is secondary to the reliability planning undertaken here.

6.2 Early Infrastructure Planning

Electrification significantly affects utility planning and will likely accelerate load forecasts far faster than what conventional top-to-bottom load forecasting has projected. Across all tasks, a recurring theme emerges: the current system will need capital investments and upgrades. While not surprising, the planning process has slowed and systemic delays permeate the supply chain. Twenty years ago, transformer lead times were less than a year; five years ago, they were two years. Today, the lead times for transformers are in excess of 40 months. Similarly, generation interconnection requests are no longer routine. The average processing time for generation interconnection requests now exceed one year and are closer to two years. Planning decisions and investments have always been made years in advance, but the timelines have increased, and what once took three years for generation, now takes five, and what may have taken five years for transmission, now takes ten.

6.3 Commercial and Multiunit Residential High Priority

Dense mixed commercial areas, with different load shapes and uses for fossil gas being converted to electricity, will experience the greatest average and peak load growth. Feeders supplying these areas could experience growth exceeding 1,200% in a high electrification scenario. Utility planners must prioritize preemptive upgrades to these areas because electrification may occur rapidly and in substantial blocks (i.e., an entire apartment building or commercial load could electrify in less than a year). Ideally, planners and government officials would coordinate programs and incentives to facilitate planning and building the appropriate system upgrades to meet the intense new peak-load demands of these areas.

6.4 Extreme Weather Events Will Be More Extreme

This study was designed around the single coldest planning year; however, there is a difference between extreme events in planning and extreme events experienced in practice. In a fully electric future, no redundancy energy source provides power for daily life necessities. For Ithaca, extreme cold poses a serious risk to safe and reliable power operations. As the delta between the outdoor ambient temperature and the indoor ambient temperature increases, heat pumps lose their efficiency gains, potentially even dropping to an efficiency of <1. Furthermore, batteries lose efficiency in extreme cold weather, negatively impacting the chemical reactions that store and convert energy into electricity. This analysis reveals that some circuits in the city’s service area will experience a peak load growth exceeding 1,200% compared to today’s levels. This exceeds typical planning considerations, which considers factors such as local industry, the economy, and population growth.

Up to this point, grid planners have not needed to consider the implications of cold weather or extreme weather events when electricity is the sole energy source. By 2050, this will not be the case. While fuel alternatives such as hydrogen may exist, electric utilities such as NYSEG must plan for a future where electricity is the only energy and, consequently, the backbone of basic human needs. This study is a first step in assessing that future.

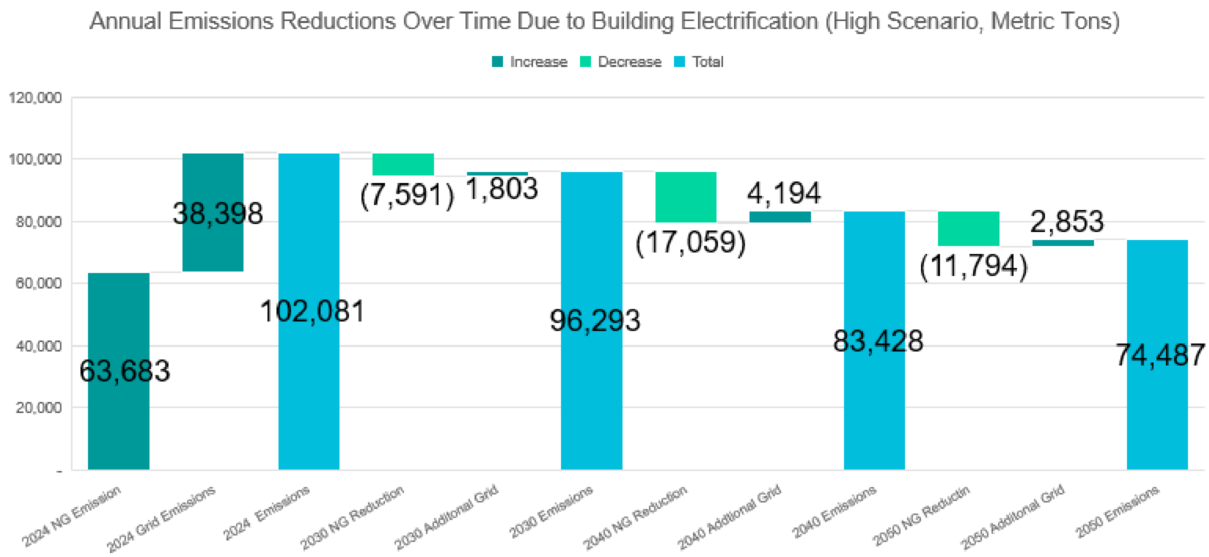
6.5 Emissions Reductions

Electrification will decrease emissions in Ithaca; however, accurately forecasting the extent of those reductions is difficult due to several ever-changing policy components. The switch to electricity does not entirely reduce carbon emissions. According to NYSERDA's emissions calculations, New York Independent System Operator, Inc. (NYISO), had a grid intensity of 0.28 MT/MWh in 2022.[6] If this is applied across the period of the study into 2050, Ithaca could realize an annual reduction of approximately 27,000 MT of carbon dioxide (CO_2) after accounting for net emissions from grid use.

Figure 44. Estimated Emissions Reductions from Break-even, High Scenario

Note: Emissions savings increase as the grid decarbonizes over time. This chart uses only a single emissions factor provided by the EIA.[7]

Source: Siemens PTI analysis.



However, electrification is not the only policy defining a sustainable future. Renewable energy policies currently in place continue to reduce the carbon intensity of electricity. Using NYSERDA's projected 2030 grid emissions factor of 0.115 MT/MWh, Ithaca could realize and additional 5,000 MT of emissions savings annually.

Table 13. Estimated Emissions Reductions from Break-even

Source: Siemens PTI analysis.

Scenario	MMBTU Savings	Gross Emissions Savings (MT, EIA)	Energy Load Increase (MWh)	Grid EF Today (MT/MWh, NYSERDA 2022)	New Electric Emissions (MT)	Net Savings EF Today (MT)	Grid EF 2030 (MT/MWh, NYSERDA 2022)	Annual Electric Emissions 2030 EF (MT)	Net EF Savings 2030 Grid (MT)
High	688,798	-3,644	31,608	.28	8,850	-27,593	.115	3,634	-32,809
Medium	438,139	-23,181	18,708	.28	5,238	-17,943	.115	2,151	21,030
Low	315,545	-16,695	12,754	.28	3,571	-12,124	.115	1,466	15,228

6.6 Areas of Future Analysis

6.6.1 Industry

Ithaca has a reasonable commercial presence but lacks significant heavy industry. Heavy industry loads usually have unique load impacts that must be assessed based on operational and metered data. As heavy industry increasingly starts transitioning to electricity, it will compound or exponentially increase real load management and power balance requirements. Areas with heavy industry will need actual consumption data and forecasts from industrial loads to determine future energy requirements.

6.6.2 Planning and Resiliency Criteria

This study did not consider changes to planning and resiliency criteria necessary for an energy future with decreasing energy diversification. Resiliency and planning criteria are based on values that require full studies to determine the balance among human equity, financial viability, and disaster probability.

7 Comprehensive Conclusion

The findings of this study underscore the urgency and complexity of electrification efforts. Effective planning and investment in grid infrastructure upgrades are paramount to accommodating the anticipated surge in demand. Building electrification, particularly in commercial and multiunit residential areas, emerges as a high priority. Moreover, understanding the interplay between load modifiers and climate conditions is crucial for optimizing electrification strategies. Following are five strategic conclusions and high-level recommendations for policymakers, city stakeholders, utility planners, and residents.

1. **EV load demand:** Projections indicate a substantial increase in EV total load demand, ranging from 80 GWhs to 160 GWhs by 2050. While EV load itself does not significantly increase system demand annually, it is does coincide with the system peak. Rate programs, partnerships with EV charging providers, and smart deployment systems can help reduce this coincidence and reduce the need for distribution upgrades.
2. **Building electrification:** Building electrification will be the single largest driver in load growth and peak demand, inevitably converting Ithaca from a summer peaking city to a winter peaking city sometime between 2030 and 2040. Incentives play an important role in increasing the speed and penetration of building electrification, not just in terms of amount but also in duration because of the importance of equipment failure on building conversion. Consumers are unlikely to incur costs for early electrification; however, they are more likely to convert if their equipment fails. Consequently, prolonged subsidies increase the likelihood that consumers will convert when equipment fails.
3. **PV impact:** PV will not provide significant peak savings in the long run as Ithaca's peak shifts to the winter. Although sunlight will be limited restricting the sun's availability to assist with peak shaving and demand will shift to nighttime, high solar penetration will still play a significant role in the summer. Under favorable economic conditions, high PV penetrations could lead to reverse flows, necessitating system adjustments.
4. **Rapid peak-load growth:** Electrification will cause rapid increases in peak-load growth propelled by EV growth, building electrification, and low solar peak shaving during periods of extreme cold when EV range is reduced, and heat pumps are less efficient. Some feeders may experience peak-load growth of 200%–1,200%, requiring upgrades or reconductoring for approximately 20% of distribution transformers and 16% of feeders.
5. **Early and thoughtful planning:** The rapid pace of electrification, coupled with supply chain constraints, may be exacerbated by other jurisdictions electrifying. This will require thoughtful planning and potentially the development of equipment reserves prior to their use.

In addition to these strategic takeaways, we offer an additional sustainability recommendation. Electrification can substantially reduce carbon emissions, particularly in a future grid powered by renewable energy. We project emissions reduction of 13–32 MT of solely from building electrification depending on the progress of renewable energy policies in New York State. Comprehensive plans that address environmental impacts from supply and demand promise to yield substantial emissions savings by 2050.

In summary, this study provides a vital roadmap for policymakers, utilities, and stakeholders navigating the intricate landscape of electrification in Ithaca. By carefully considering these findings, Ithaca and its stakeholders can forge a sustainable and efficient path toward a fully electrified future.

7.1 Lessons Learned

7.1.1 Data

Several data lessons emerged throughout the study. First, the study's required level of granularity required details electrical planners had not previously considered, which created challenges both in terms of collecting data that had never been collected before, as well as time delays in processing and cleaning up the new data, which required substantial resources.

Second, Siemens PTI lacked access to metered hourly data. Ideally, hourly meter data would have used to calibrate real building consumption and produce more accurate results. Rather, we relied on monthly billing data, which we weighted to develop hourly demand profiles.

Finally, Siemens PTI did not consider building envelope improvements for two reasons. First, electrifying a building does not guarantee that consumers are willing or are financially able to make the supporting building envelope improvements. Such improvements are not only costly, but they can also be invasive, sometimes requiring tenants to temporarily relocate. Second, no local engineering resources conducted building energy audits to determine which improvements were necessary or if they were possible. Rather than conducting audits to refine estimates, Siemens PTI took a more conservative approach to plan for extreme reliability events.

7.1.2 Load Modifier Adoption Methodologies

Econometric analysis requires developing probabilistic adoption curves using different adoption curves for different technologies. Some studies were readily available, such as NREL's Rooftop PV adoption methodology, which benchmarked probability of adoption based on a simple payback period. However, technologies such as EV and building electrification required different approaches. State policies on sales and available stocks primarily drove EV adoption, whereas equipment failure was the most likely driver for building electrification, coupled with a secondary economic and probabilistic layer. We deemed these approaches sufficient given the current economic, policy, and technological landscape. However, as these factors change over time, the study will need to be reassessed.

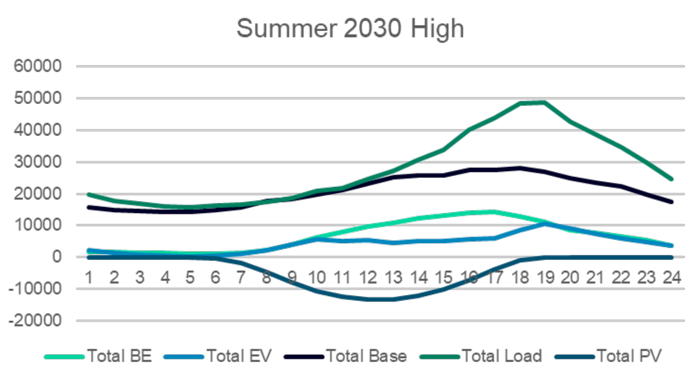
Appendix A. Additional Tables and Figures

A.1 Summer Peak Electrification Load Profiles

Based on the forecasts, the system peak shifts from a summer to a winter peak between 2030 and 2040. Consequently, we omitted the summer peak and its load modifier breakdown from the study.

Figure A-1. Summer 2030 High and Low Electrification Peak Load

Source: Siemens PTI analysis.



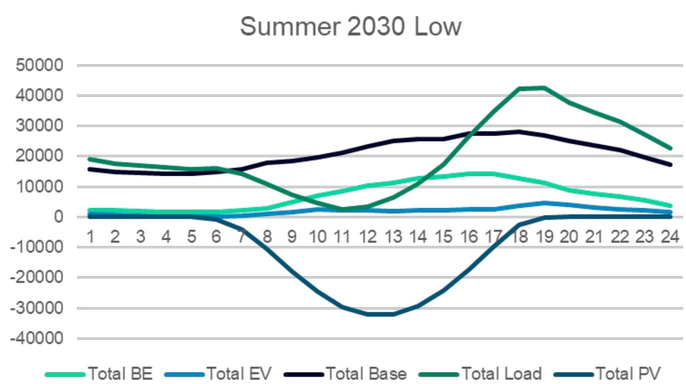


Figure A-2. Summer 2040 High and Low Electrification Peak Load

Source: Siemens PTI analysis.

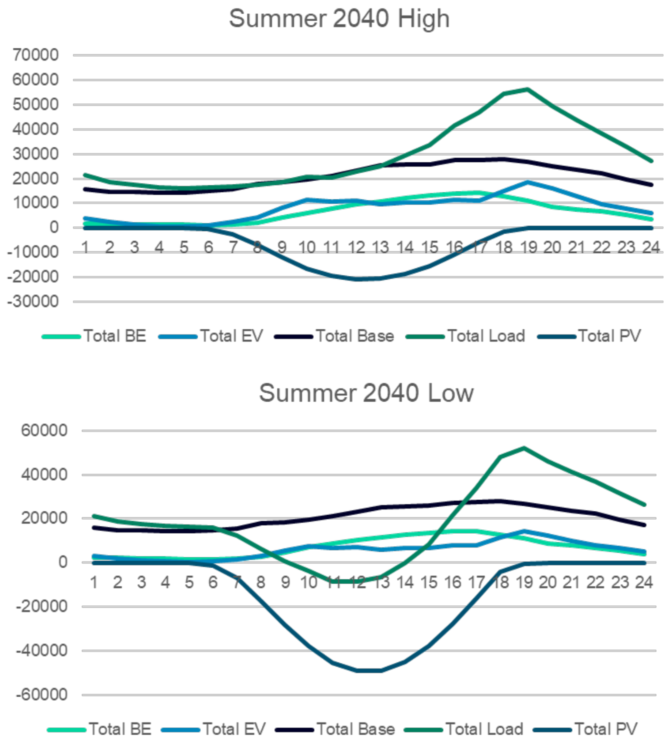
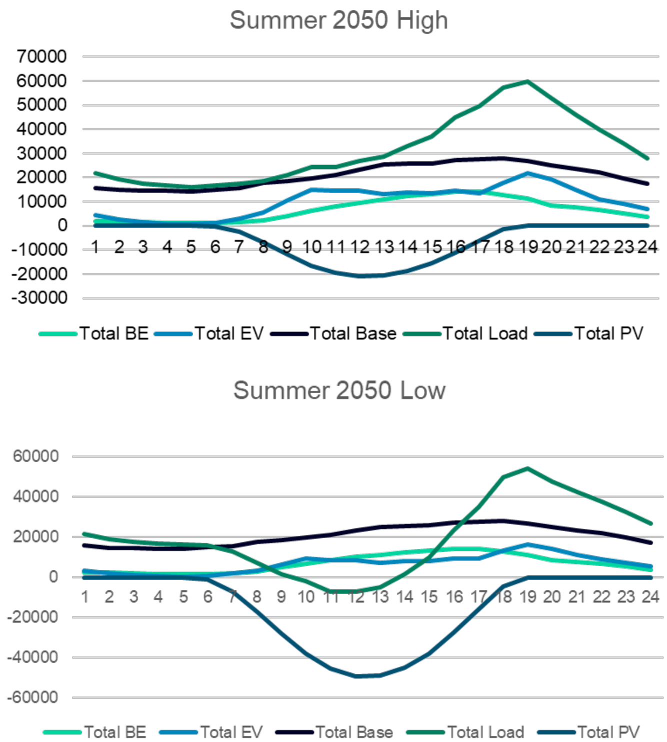


Figure A-3. Summer 2050 High and Low Electrification Peak Load

Source: Siemens PTI analysis.



A.2 Nodewide Results

Based on the results, multiple feeders exist without any mitigations or network grid code violations. Plots that do not convey any new information are omitted from the appendix for brevity.

A.2.1 Feeder 4302303

A.2.1.1 Impact Assessment

Figure A-4. Electrification Peak-Load Impact—4302303 Feeder High Scenario, 2030

Source: Siemens PTI analysis.

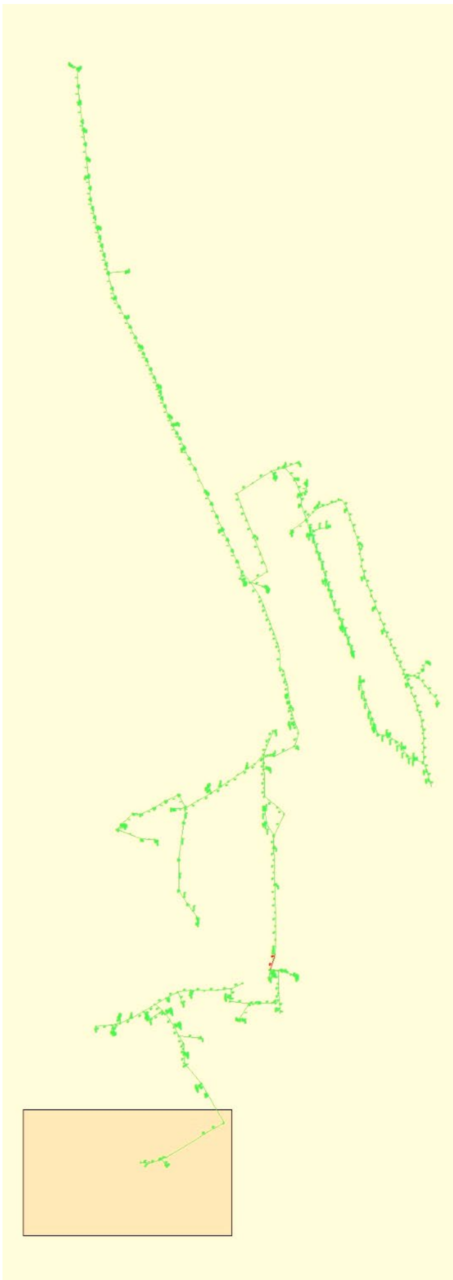


Figure A-5. Electrification Peak-Load Impact—4302303 Feeder High Scenario, 2040

Source: Siemens PTI analysis.

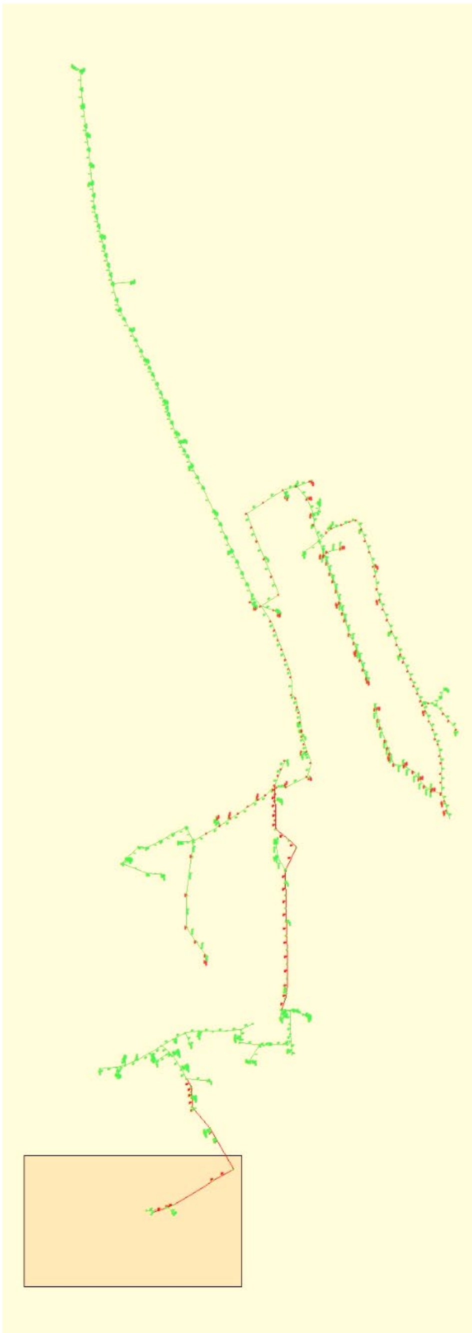


Figure A-6. Electrification Peak-Load Impact—4302303 Feeder High Scenario, 2050

Source: Siemens PTI analysis.

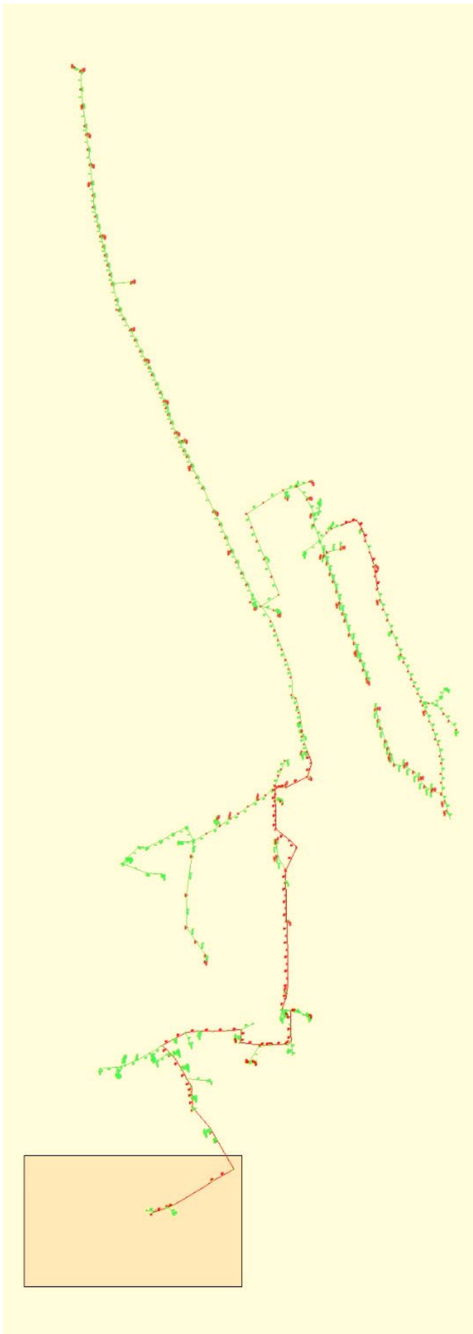


Figure A-7. Electrification Peak-Load Impact—4302303 Feeder Low Scenario, 2030

Source: Siemens PTI analysis.

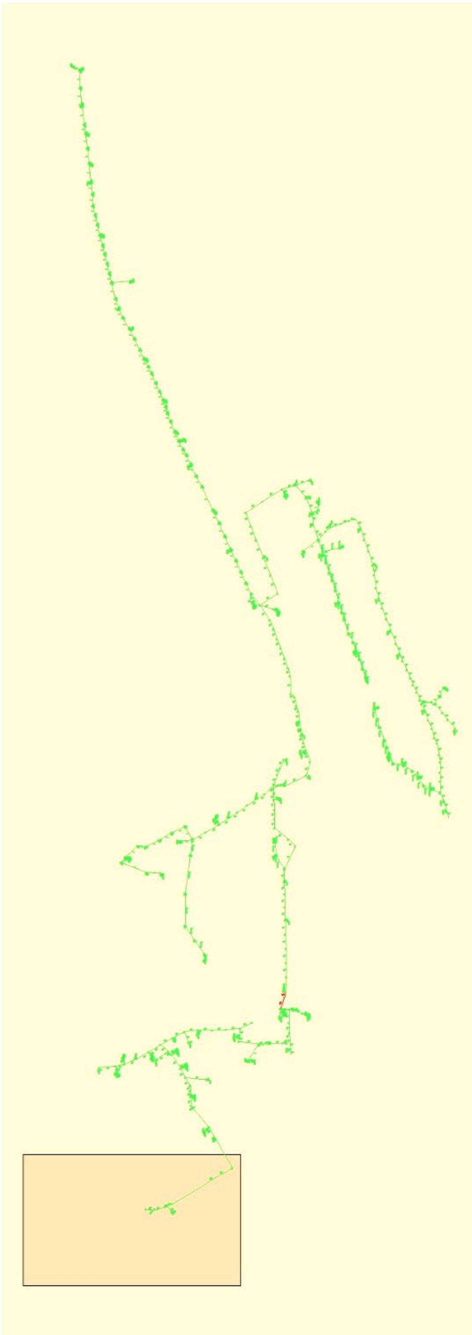


Figure A-8. Electrification Peak-Load Impact—4302303 Feeder Low Scenario, 2040

Source: Siemens PTI analysis.

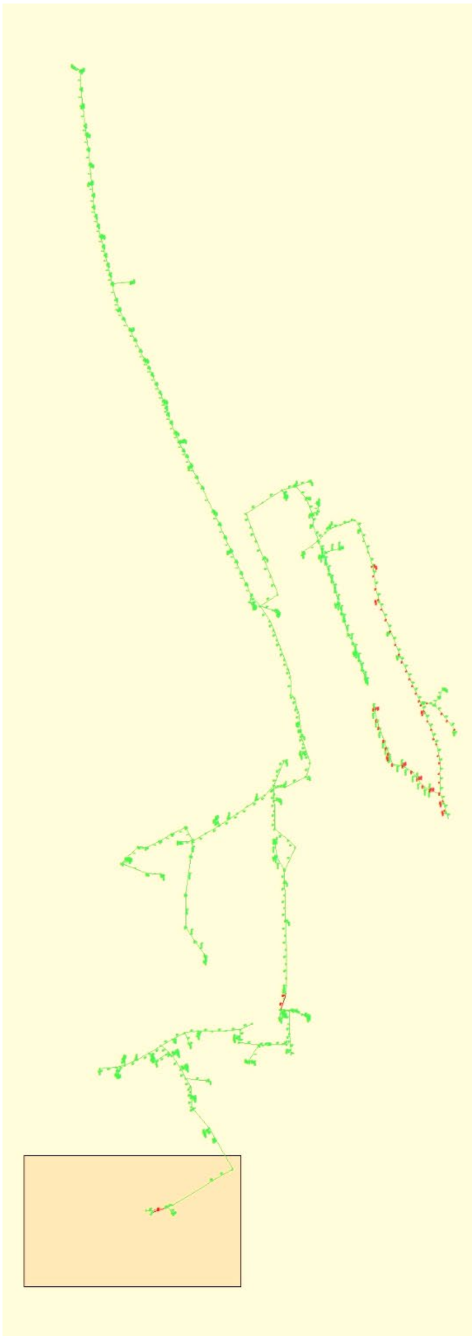
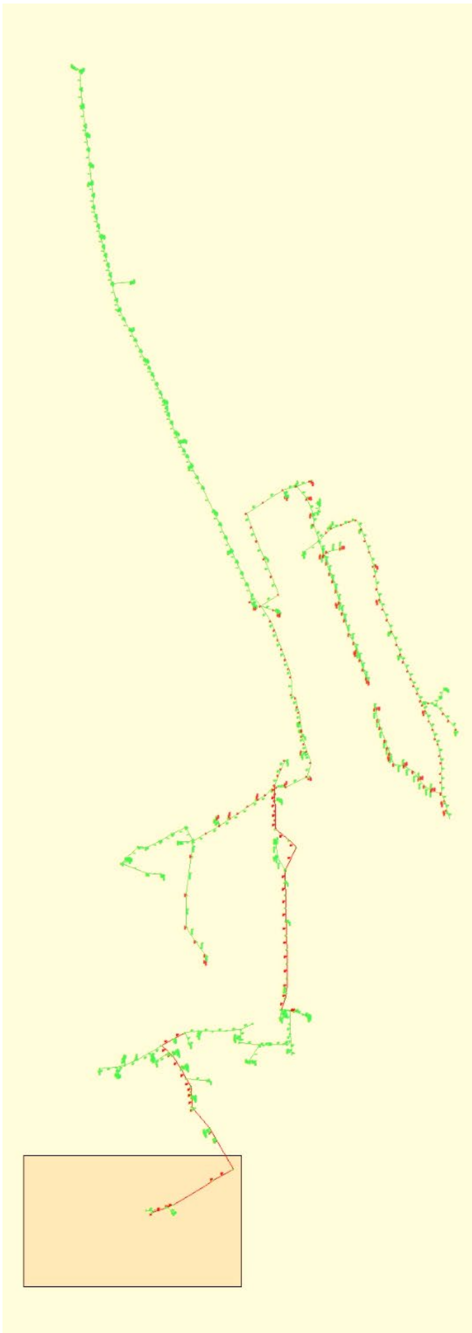


Figure A-9. Electrification Peak-Load Impact—4302303 Feeder Low Scenario, 2050

Source: Siemens PTI analysis.



A.2.1.2 Impact Mitigation

Table A-1. Impact Mitigation Summary—4302303

Source: Siemens PTI analysis.

Summary	High	Low
Total 3-Phase Feeder Backbone Length (mi)	5.73	
Total Secondary Transformers (no.)	121	
Total Reconductoring Length 2030 (mi)	0.05	0.00
Total Reconductoring Length 2040 (mi)	1.03	0.00
Total Reconductoring Length 2050 (mi)	0.94	1.23
Total Reconductoring Length (% of Backbone 2030)	1%	0%
Total Reconductoring Length (% of Backbone 2040)	18%	0%
Total Reconductoring Length (% of Backbone 2050)	16%	21%
Cumulative number of Secondary Transformer Upgrades in 2030 (no.).	7	0
Cumulative number of Secondary Transformer Upgrades 2040 (no.)	20	7
Cumulative number of Secondary Transformer Upgrades in 2050 (no.)	36	7
Cumulative Secondary Transformer Upgrades 2030 (% of Total)	6%	0%
Cumulative Secondary Transformer Upgrades 2040 (% of Total)	17%	6%
Cumulative Secondary Transformer Upgrades 2050 (% of Total)	30%	6%
Total Secondary Transformer Upgrades 2023–2030 (% of Total)	6%	0%
Total Secondary Transformer Upgrades 2030–2040 (% of Total)	11%	6%
Total Secondary Transformer Upgrades 2040–2050 (% of Total)	13%	0%
New Substation Main Transformer 2030 (no.)	0	0
New Substation Main Transformer 2040 (no.)	0	0
New Substation Main Transformer 2050 (no.)	1	0

A.2.2 Feeder 4302302

This feeder has no network violations for the study scenarios.

A.2.2.1 Impact Assessment

Figure A-10. Electrification Peak-Load Impact—4302302 Feeder High Scenario, 2050

Source: Siemens PTI analysis.

A.2.2.2 *Impact Mitigation*

Table A-2. Impact Mitigation Summary—4302302

Source: Siemens PTI analysis.

Summary	High	Low
Total 3-Phase Feeder Backbone Length (mi)	2.06	
Total Secondary Transformers (no.)	53	
Total Reconductoring Length 2030 (mi)	0.00	0.00
Total Reconductoring Length 2040 (mi)	0.00	0.00
Total Reconductoring Length 2050 (mi)	0.00	0.00
Total Reconductoring Length (% of Backbone 2030)	0%	0%
Total Reconductoring Length (% of Backbone 2040)	0%	0%
Total Reconductoring Length (% of Backbone 2050)	0%	0%
Cumulative number of Secondary Transformer Upgrades in 2030 (no.).	23	9
Cumulative number of Secondary Transformer Upgrades 2040 (no.)	30	26
Cumulative number of Secondary Transformer Upgrades in 2050 (no.)	30	26
Cumulative Secondary Transformer Upgrades 2030 (% of Total)	43%	17%
Cumulative Secondary Transformer Upgrades 2040 (% of Total)	57%	49%
Cumulative Secondary Transformer Upgrades 2050 (% of Total)	57%	49%
Total Secondary Transformer Upgrades 2023–2030 (% of Total)	43%	17%
Total Secondary Transformer Upgrades 2030–2040 (% of Total)	13%	32%
Total Secondary Transformer Upgrades 2040–2050 (% of Total)	0%	0%
New Substation Main Transformer 2030 (no.)	0	0
New Substation Main Transformer 2040 (no.)	0	0
New Substation Main Transformer 2050 (no.)	0	0

A.2.3 Feeder 4302203

A.2.3.1 Impact Assessment

Figure A-11. Electrification Peak-Load Impact—4302203 Feeder High Scenario, 2030

Source: Siemens PTI analysis.

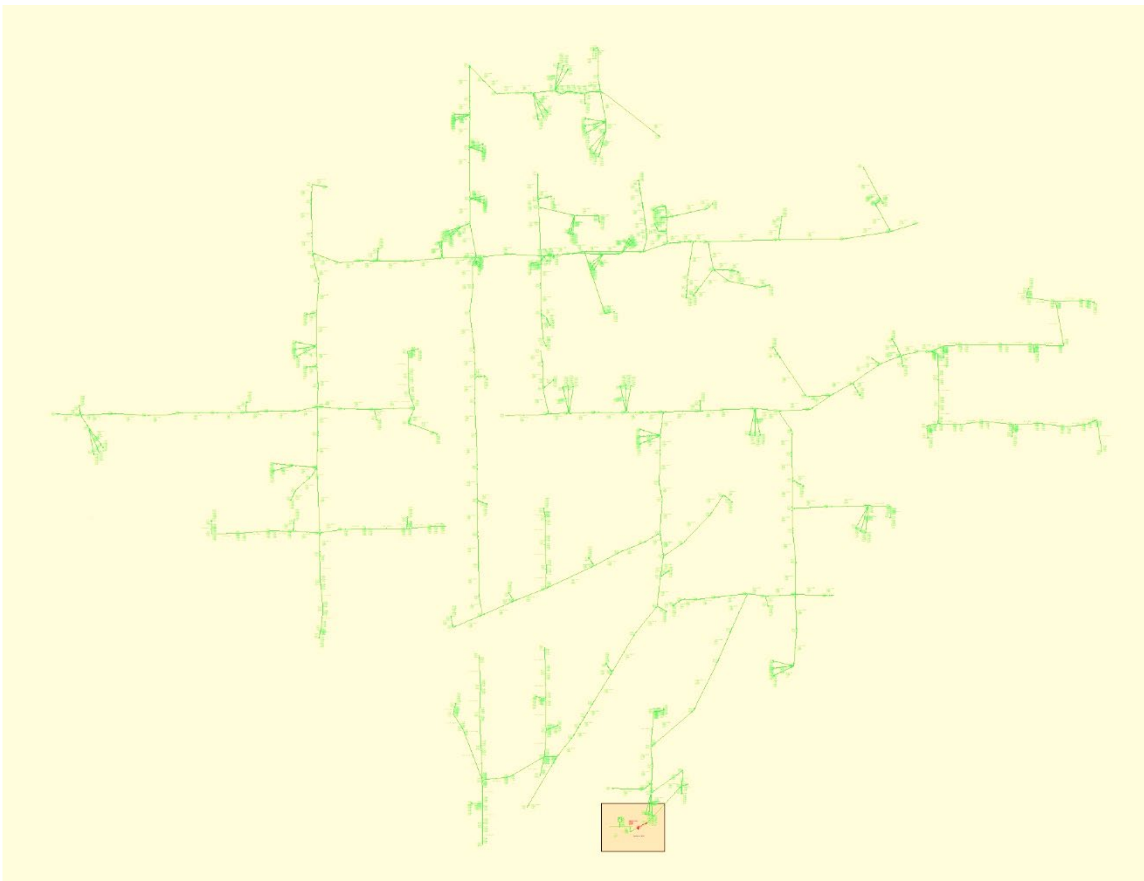


Figure A-12. Electrification Peak-Load Impact—4302203 Feeder High Scenario, 2040

Source: Siemens PTI analysis.

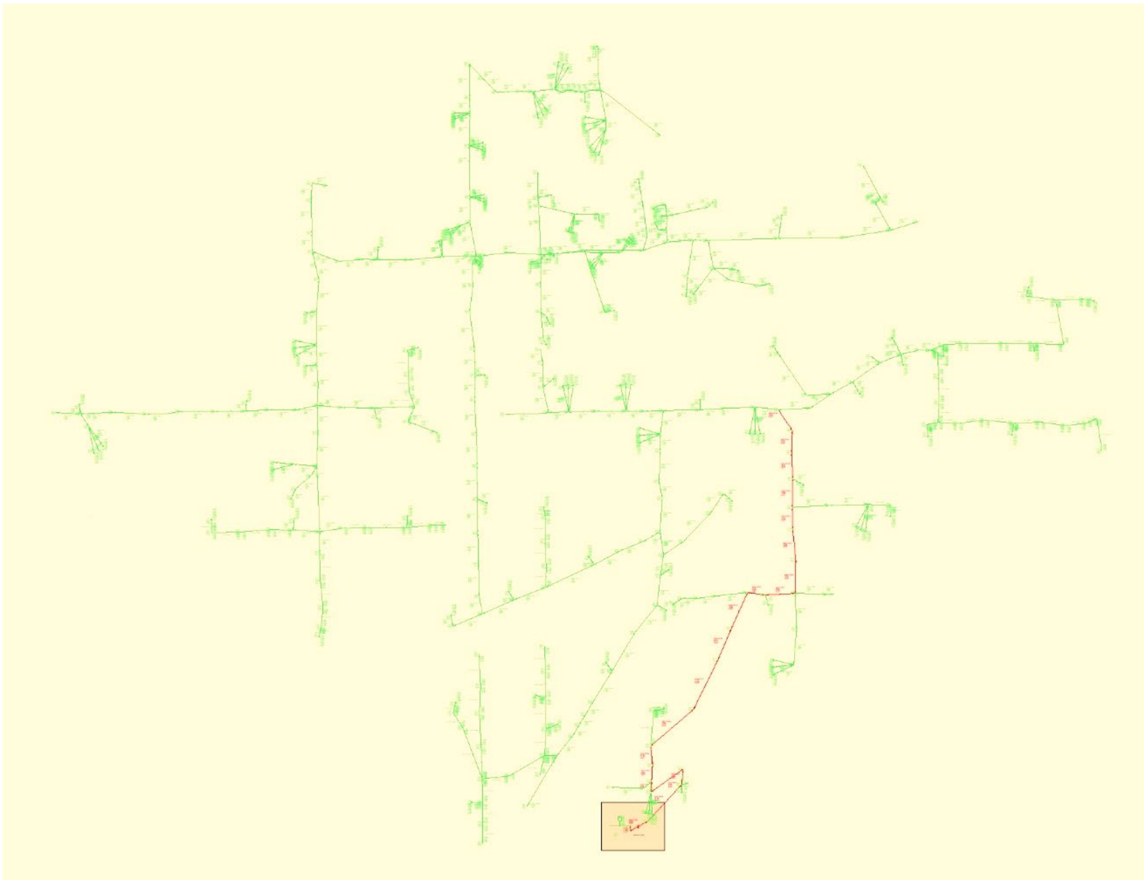


Figure A-13. Electrification Peak-Load Impact—4302203 Feeder High Scenario, 2050

Source: Siemens PTI analysis.

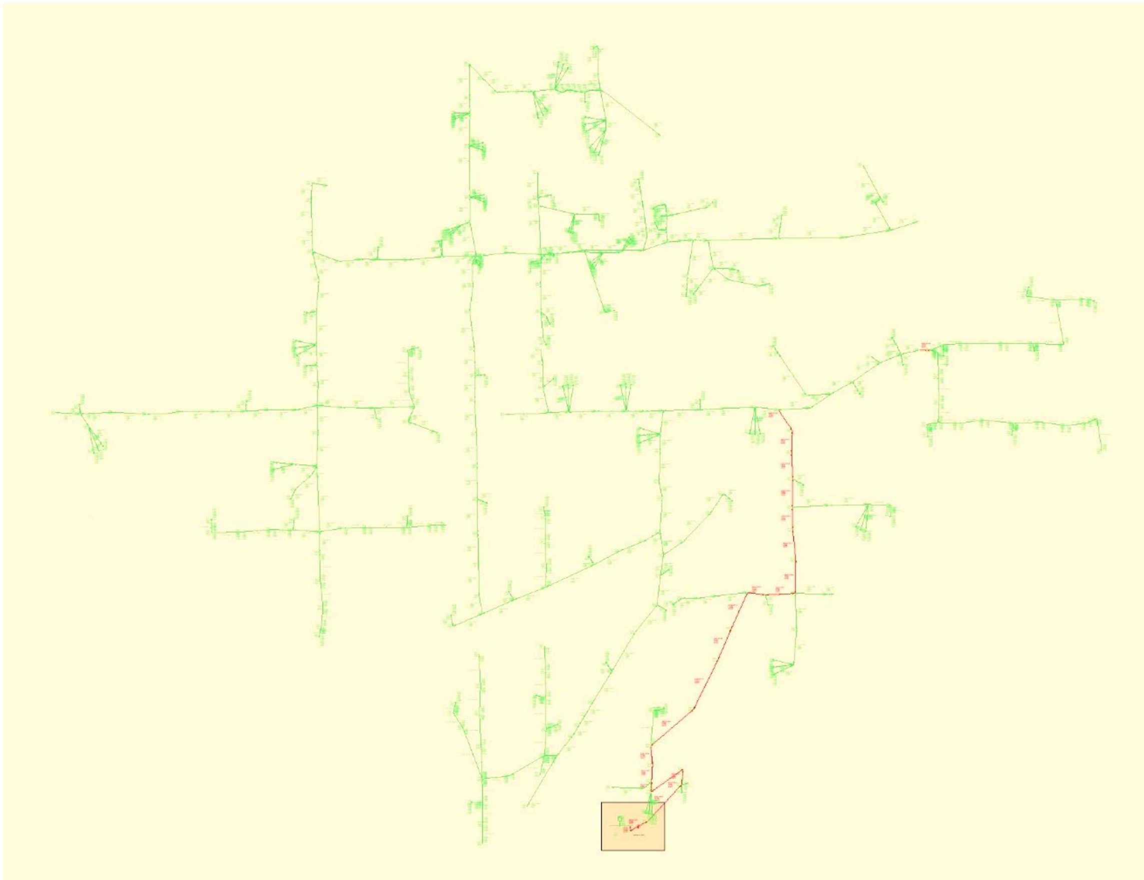


Figure A-14. Electrification Peak-Load Impact—4302203 Feeder Low Scenario, 2030

Source: Siemens PTI analysis.

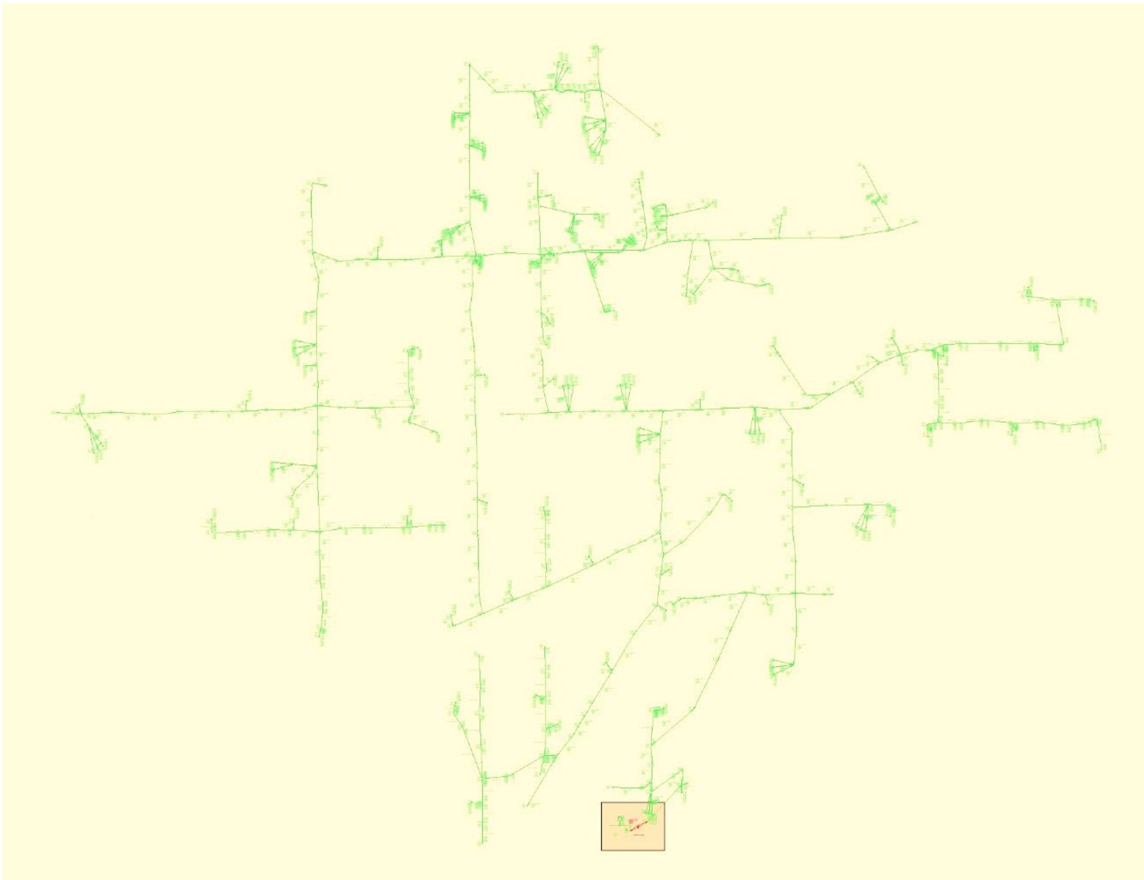


Figure A-15. Electrification Peak-Load Impact—4302203 Feeder Low Scenario, 2040

Source: Siemens PTI analysis.

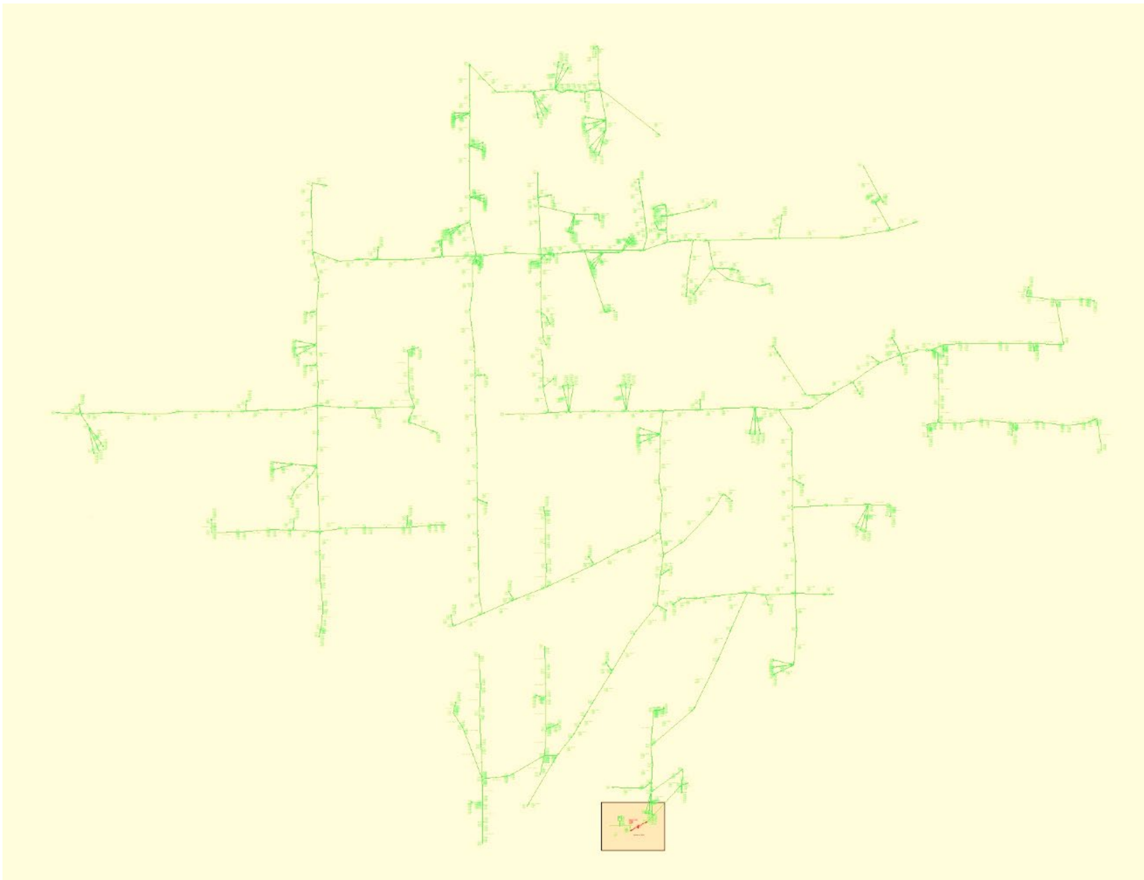
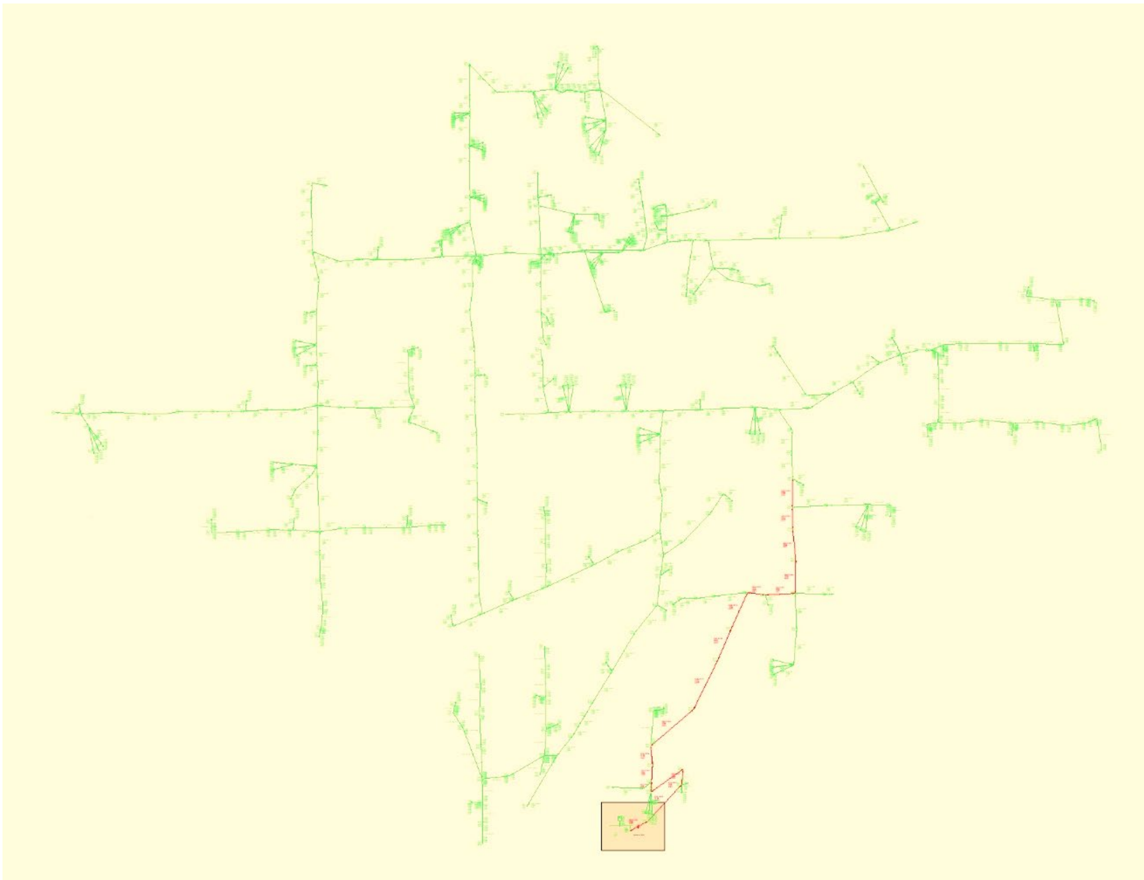


Figure A-16. Electrification Peak-Load Impact—4302203 Feeder Low Scenario, 2050

Source: Siemens PTI analysis.



A.2.3.1 Impact Mitigation

Table A-3. Impact Mitigation Summary—4302203

Source: Siemens PTI analysis.

Summary	High	Low
Total 3-Phase Feeder Backbone Length (mi)	4.08	
Total Secondary Transformers (no.)	132	
Total Reconductoring Length 2030 (mi)	0.22	0.20
Total Reconductoring Length 2040 (mi)	1.39	0.35
Total Reconductoring Length 2050 (mi)	0.67	-
Total Reconductoring Length (% of Backbone 2030)	5%	5%
Total Reconductoring Length (% of Backbone 2040)	34%	9%
Total Reconductoring Length (% of Backbone 2050)	16%	0%
Cumulative number of Secondary Transformer Upgrades in 2030 (no.).	16	14
Cumulative number of Secondary Transformer Upgrades 2040 (no.)	24	16
Cumulative number of Secondary Transformer Upgrades in 2050 (no.)	28	22
Cumulative Secondary Transformer Upgrades 2030 (% of Total)	12%	11%
Cumulative Secondary Transformer Upgrades 2040 (% of Total)	18%	12%
Cumulative Secondary Transformer Upgrades 2050 (% of Total)	21%	17%
Total Secondary Transformer Upgrades 2023–2030 (% of Total)	12%	11%
Total Secondary Transformer Upgrades 2030–2040 (% of Total)	6%	2%
Total Secondary Transformer Upgrades 2040–2050 (% of Total)	3%	5%
New Substation Main Transformer 2030 (no.)	0	0
New Substation Main Transformer 2040 (no.)	1	0
New Substation Main Transformer 2050 (no.)	0	0

A.2.4 Feeder 4302204

A.2.4.1 Impact Assessment

Figure A-17. Electrification Peak-Load Impact—4302204 Feeder Low Scenario, 2030

Source: Siemens PTI analysis.

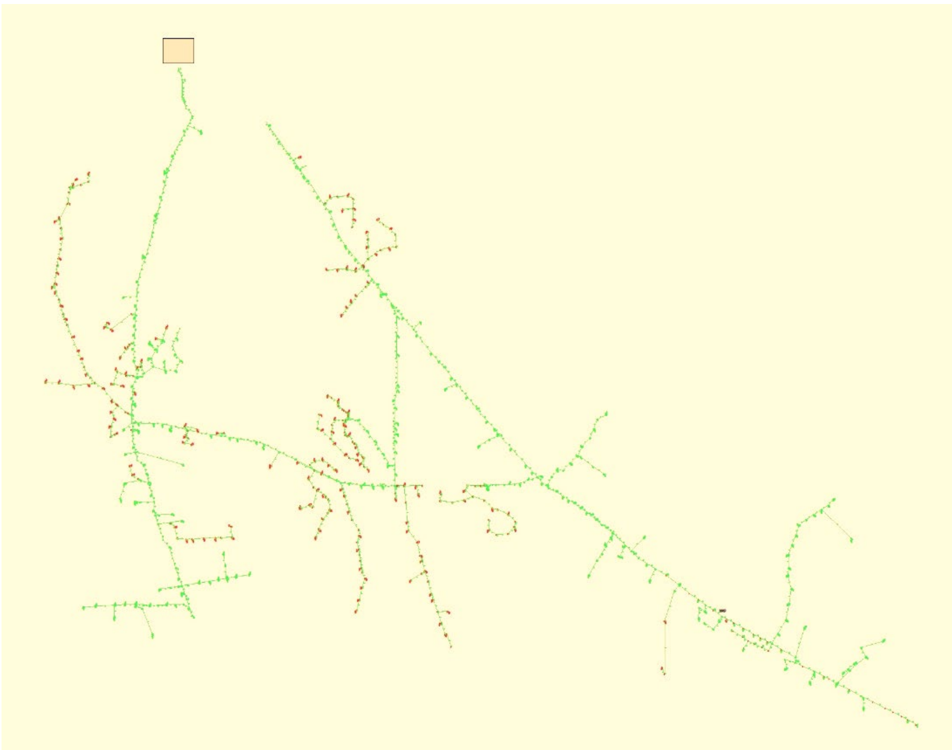


Figure A-18. Electrification Peak-Load Impact—4302204 Feeder Low Scenario, 2040

Source: Siemens PTI analysis.

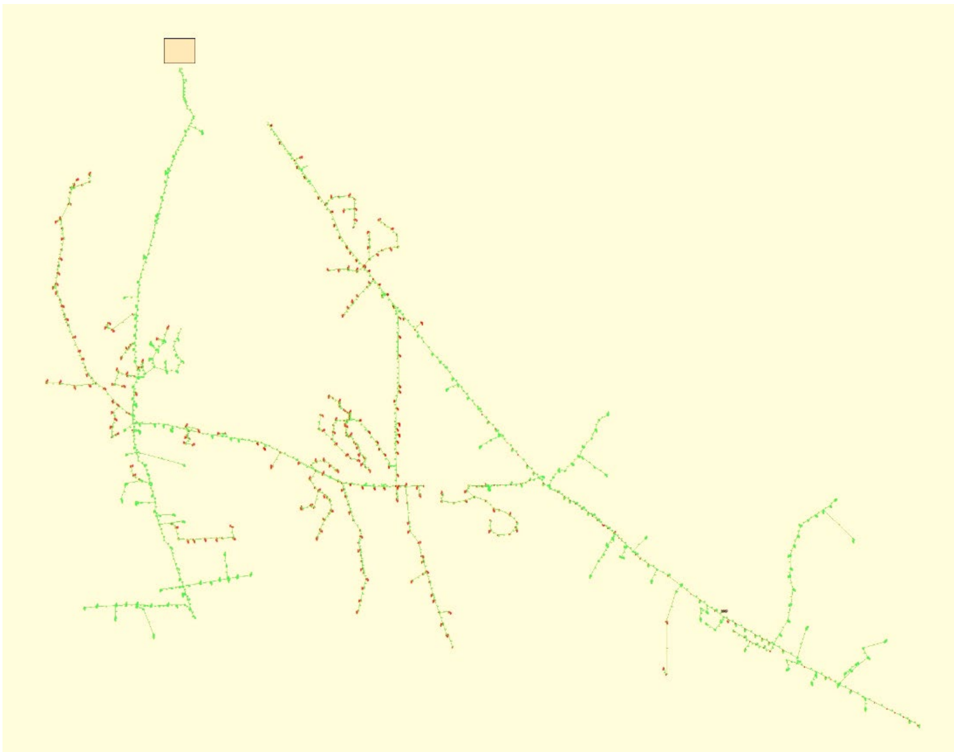
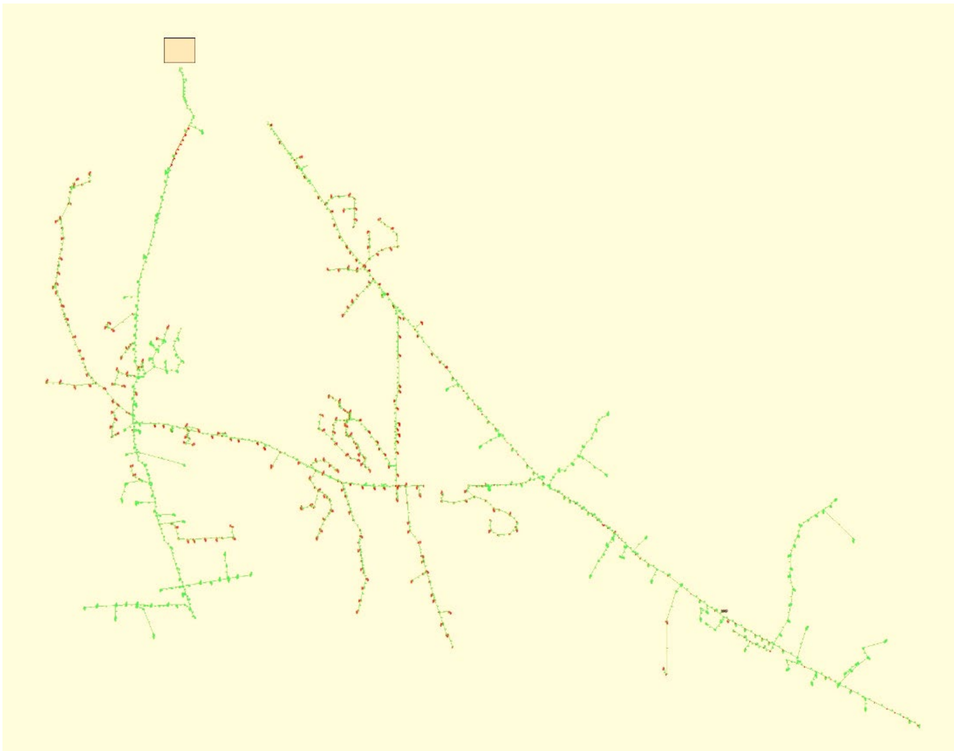


Figure A-19. Electrification Peak-Load Impact—4302204 Feeder Low Scenario, 2050

Source: Siemens PTI analysis.

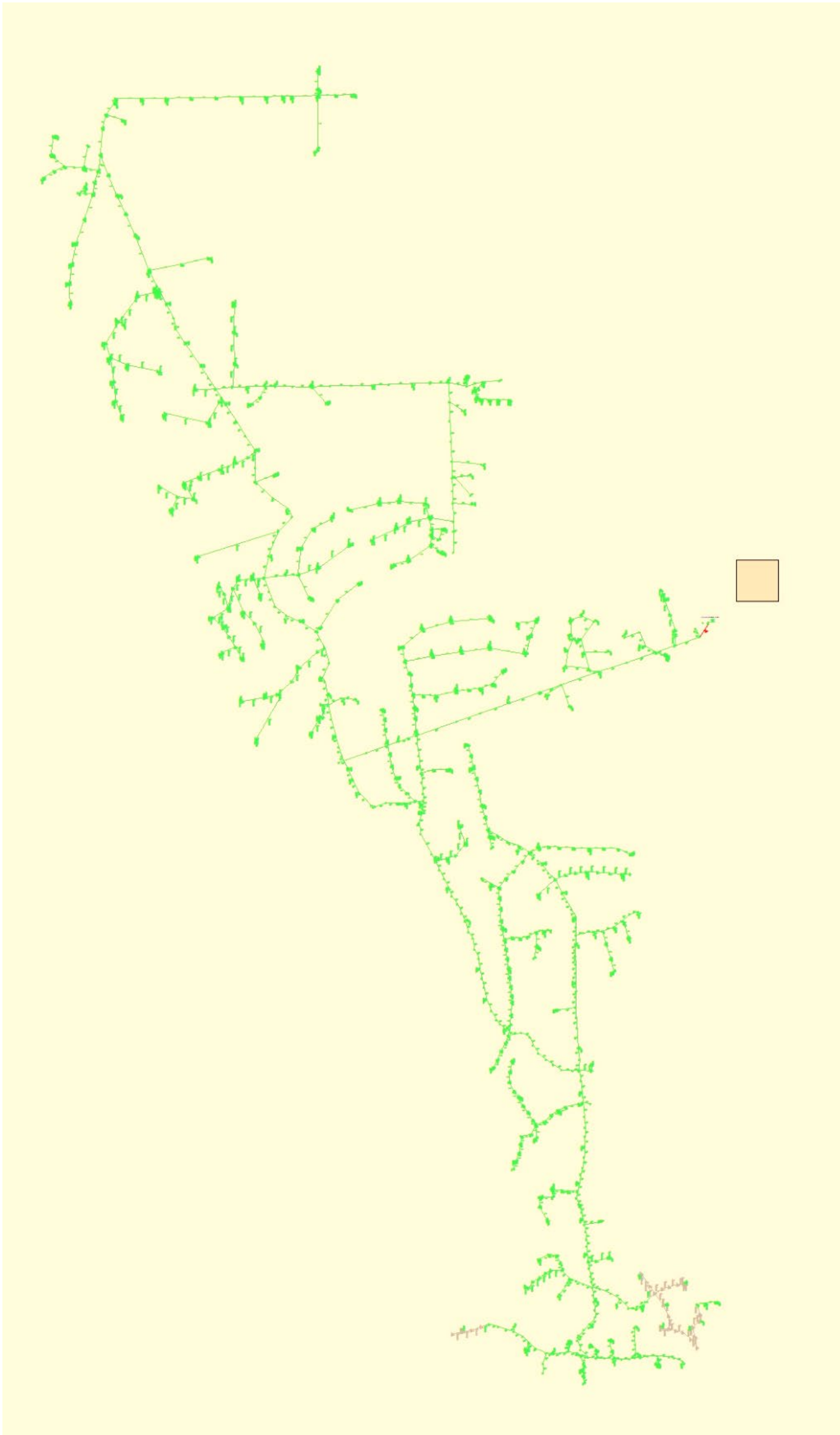


A.2.5 Feeder 4300101

A.2.5.1 Impact Assessment

Figure A-20. Electrification Peak-Load Impact—4300101 Feeder High Scenario, 2050

Source: Siemens PTI analysis.



A.2.5.2 Impact Mitigation

Table A-4. Impact Mitigation Summary—4300101

Source: Siemens PTI analysis.

Summary	High	Low
Total 3-Phase Feeder Backbone Length (mi)	8.35	
Total Secondary Transformers (no.)	270	
Total Reconductoring Length 2030 (mi)	0.00	0.00
Total Reconductoring Length 2040 (mi)	0.00	0.00
Total Reconductoring Length 2050 (mi)	0.00	0.00
Total Reconductoring Length (% of Backbone 2030)	0%	0%
Total Reconductoring Length (% of Backbone 2040)	0%	0%
Total Reconductoring Length (% of Backbone 2050)	0%	0%
Cumulative number of Secondary Transformer Upgrades in 2030 (no.).	12	9
Cumulative number of Secondary Transformer Upgrades 2040 (no.)	25	13
Cumulative number of Secondary Transformer Upgrades in 2050 (no.)	39	22
Cumulative Secondary Transformer Upgrades 2030 (% of Total)	4.4%	3.3%
Cumulative Secondary Transformer Upgrades 2040 (% of Total)	9.3%	4.8%
Cumulative Secondary Transformer Upgrades 2050 (% of Total)	14.4%	8.1%
Total Secondary Transformer Upgrades 2023–2030 (% of Total)	4.4%	3.3%
Total Secondary Transformer Upgrades 2030–2040 (% of Total)	4.8%	1.5%
Total Secondary Transformer Upgrades 2040–2050 (% of Total)	5.2%	3.3%
New Substation Main Transformer 2030 (no.)	0	0
New Substation Main Transformer 2040 (no.)	0	0
New Substation Main Transformer 2050 (no.)	0	0

A.2.6 Feeder 4302206

A.2.6.1 Impact Assessment

Figure A-21. Electrification Peak-Load Impact—4302206 Feeder High Scenario, 2040 and 2050

Source: Siemens PTI analysis.

Figure A-22. Electrification Peak-Load Impact—4302206 Feeder Low Scenario, 2030

Source: Siemens PTI analysis.

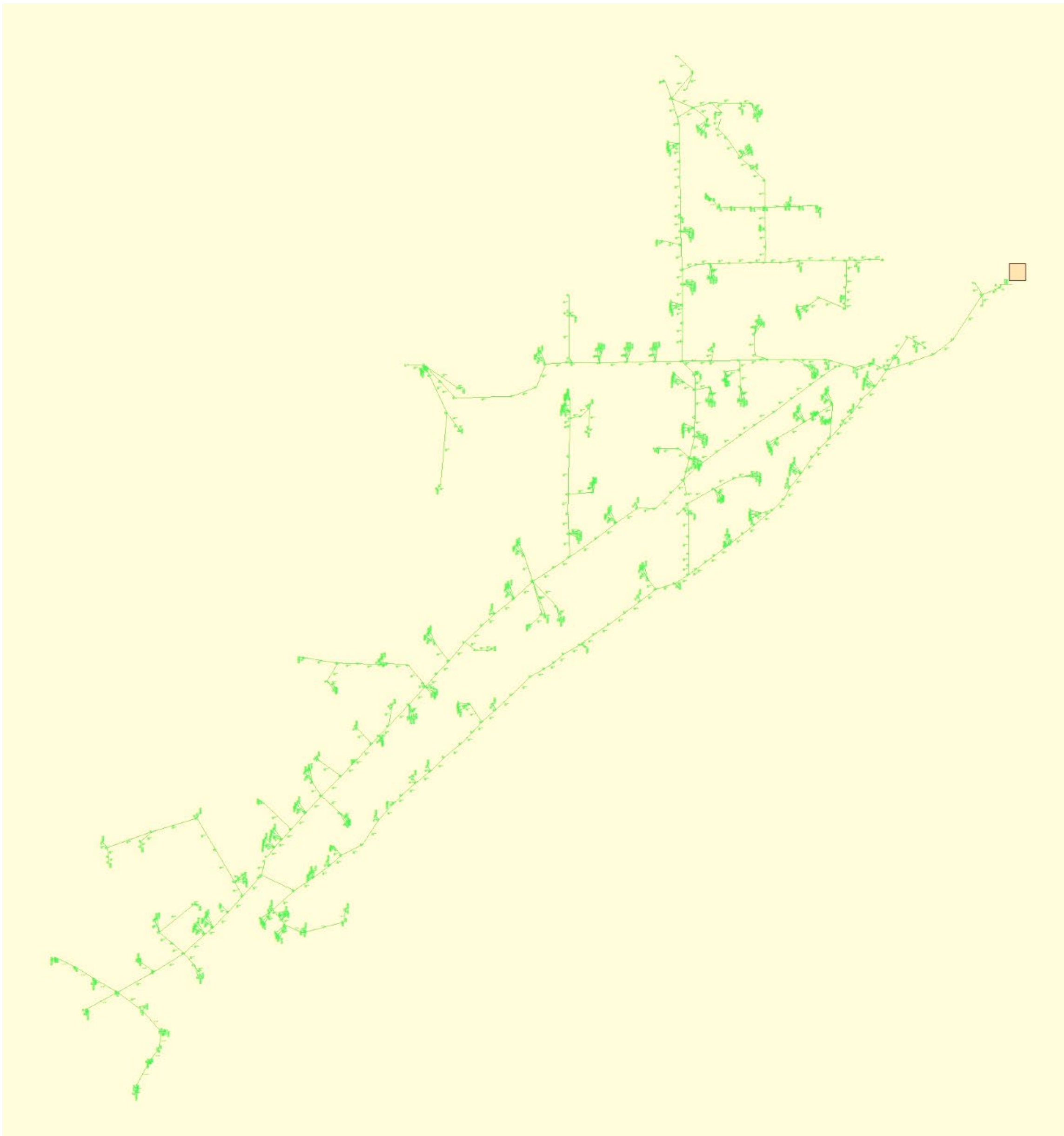


Figure A-23. Electrification Peak-Load Impact—4302206 Feeder Low Scenario, 2040

Source: Siemens PTI analysis.

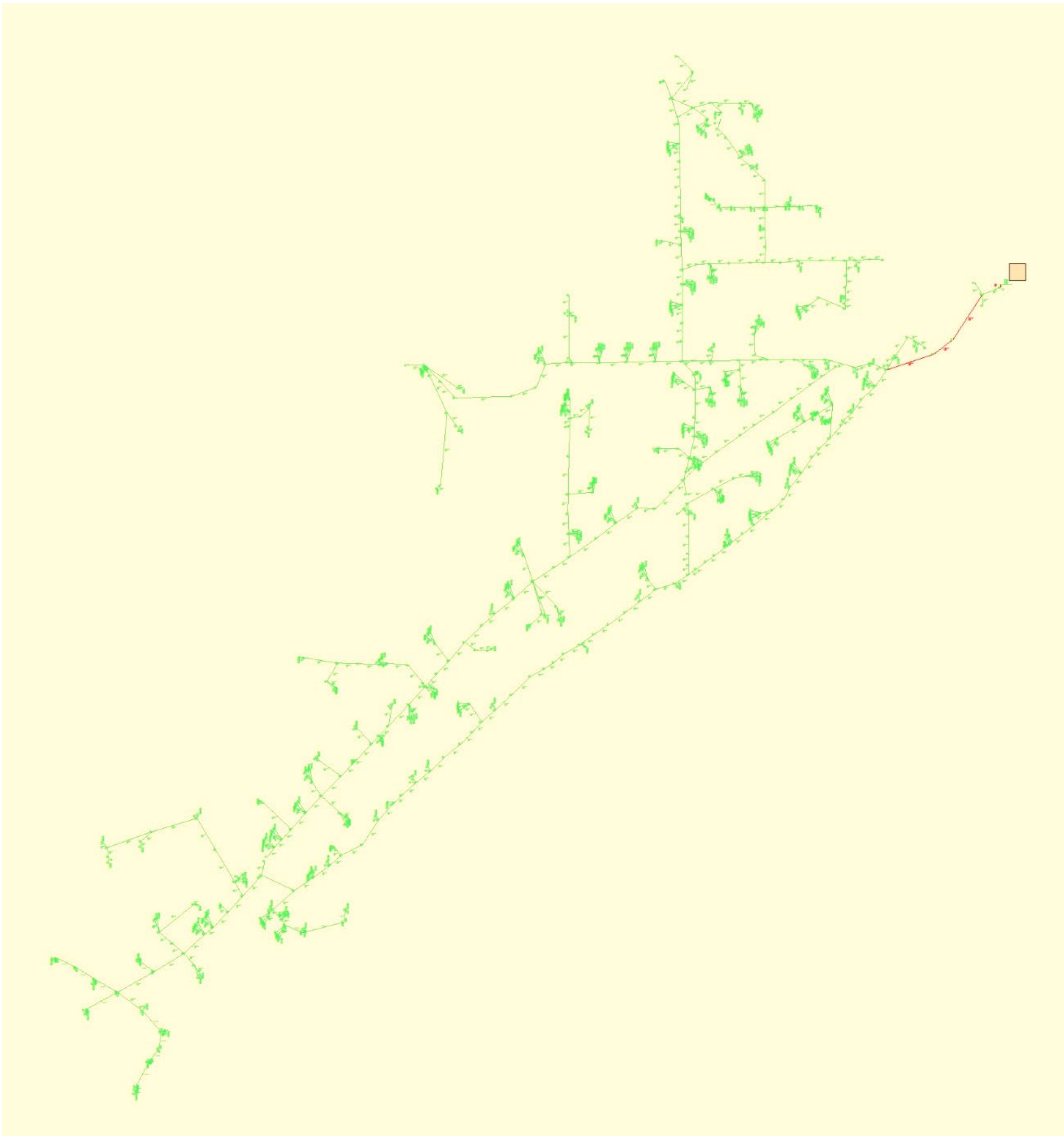
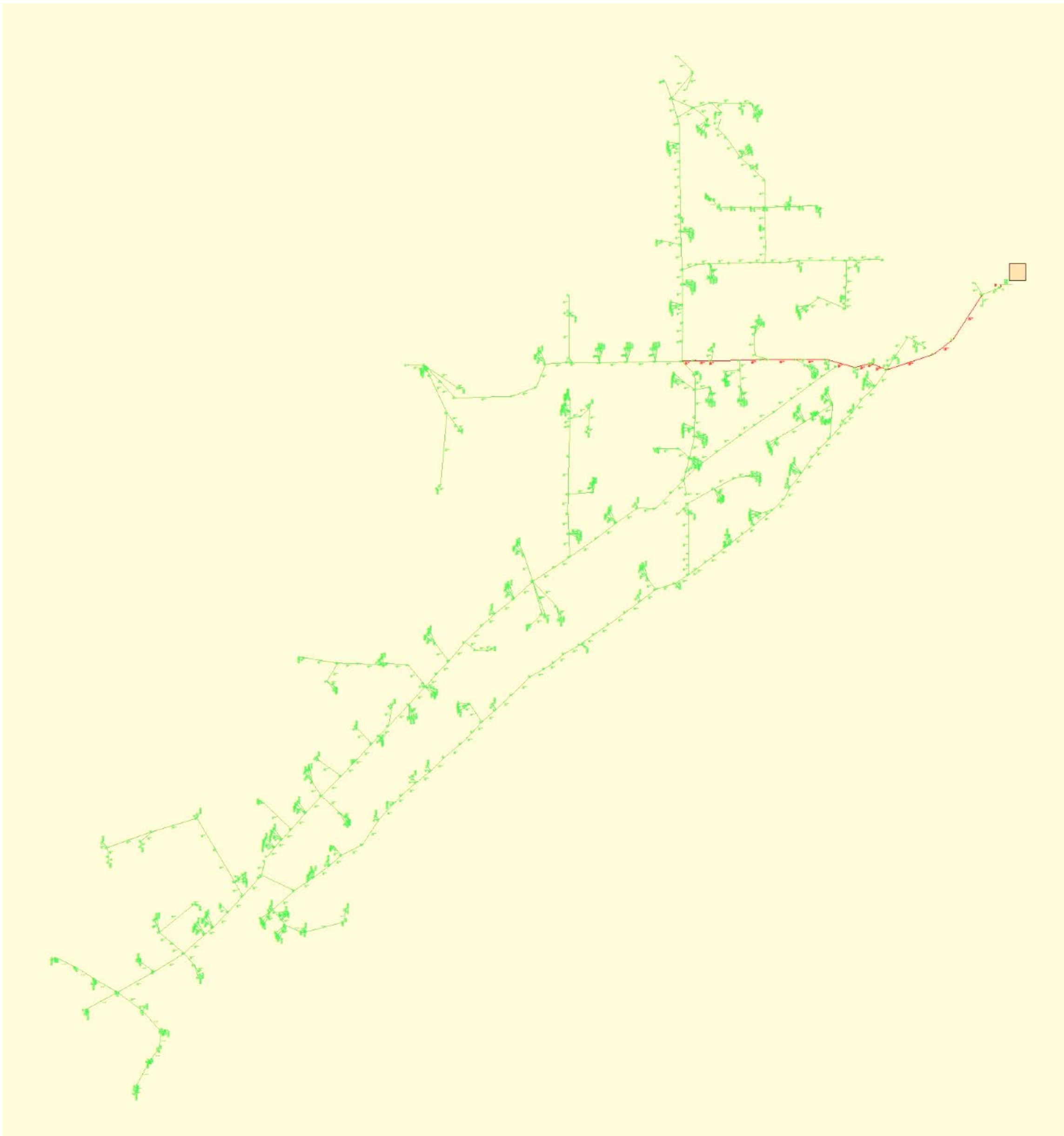


Figure A-24. Electrification Peak-Load Impact—4302206 Feeder Low Scenario, 2050

Source: Siemens PTI analysis.



A.2.6.1 Impact Mitigation

Table A-5. Impact Mitigation Summary—4302206

Source: Siemens PTI analysis.

Summary	High	Low
Total 3-Phase Feeder Backbone Length (mi)	10.74	
Total Secondary Transformers (no.)	246	
Total Reconductoring Length 2030 (mi)	0.00	0.00
Total Reconductoring Length 2040 (mi)	0.76	0.294
Total Reconductoring Length 2050 (mi)	0.00	0.469
Total Reconductoring Length (% of Backbone 2030)	0%	0%
Total Reconductoring Length (% of Backbone 2040)	7%	3%
Total Reconductoring Length (% of Backbone 2050)	0%	4%
Cumulative number of Secondary Transformer Upgrades in 2030 (no.).	18	5
Cumulative number of Secondary Transformer Upgrades 2040 (no.)	30	23
Cumulative number of Secondary Transformer Upgrades in 2050 (no.)	38	23
Cumulative Secondary Transformer Upgrades 2030 (% of Total)	7%	2%
Cumulative Secondary Transformer Upgrades 2040 (% of Total)	12%	9%
Cumulative Secondary Transformer Upgrades 2050 (% of Total)	15%	9%
Total Secondary Transformer Upgrades 2023–2030 (% of Total)	7%	2%
Total Secondary Transformer Upgrades 2030–2040 (% of Total)	5%	7%
Total Secondary Transformer Upgrades 2040–2050 (% of Total)	3%	0%
New Substation Main Transformer 2030 (no.)	0	0
New Substation Main Transformer 2040 (no.)	0	0
New Substation Main Transformer 2050 (no.)	0	0

A.2.7 Feeder 4300201

A.2.7.1 Impact Assessment

Figure A-25. Electrification Peak-Load Impact—4300201 Feeder High Scenario, 2030

Source: Siemens PTI analysis.

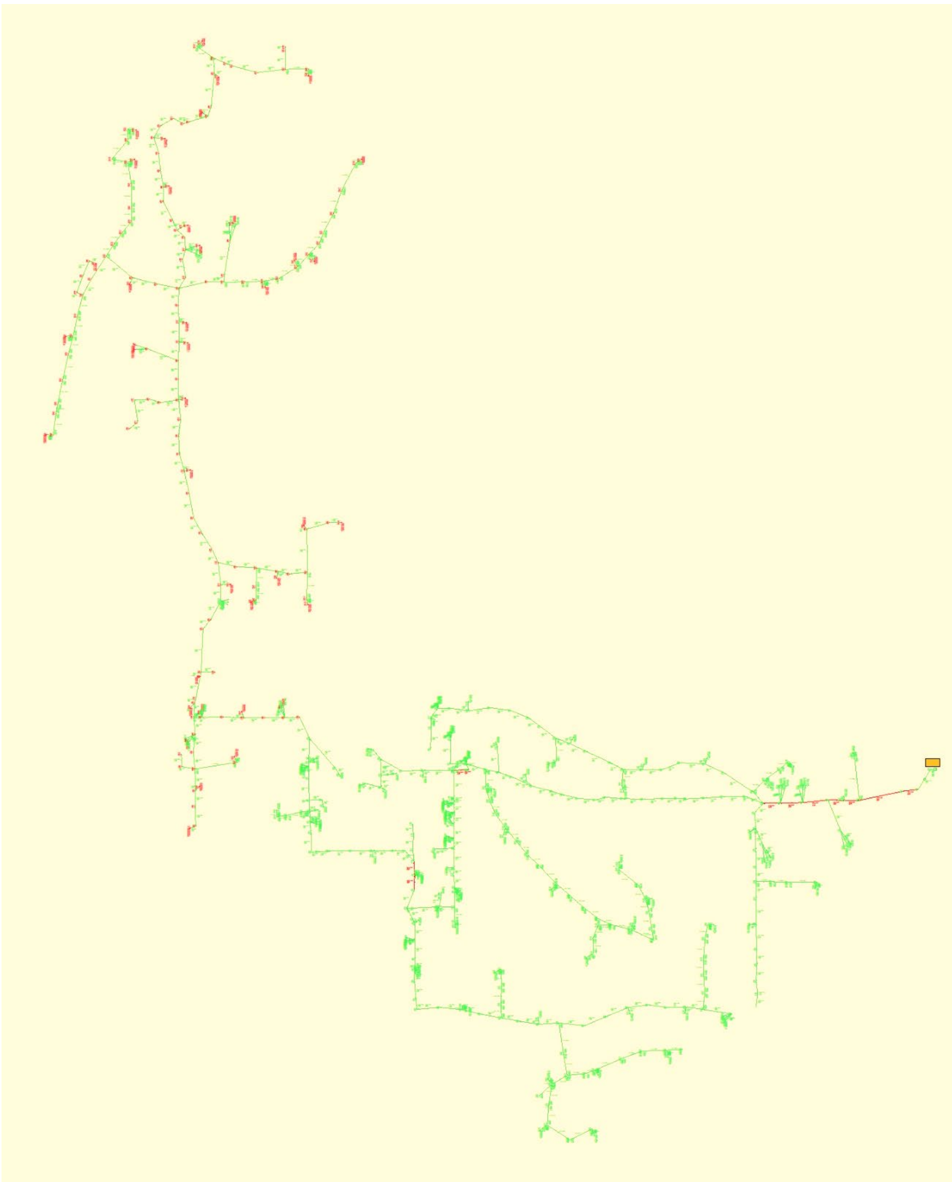


Figure A-26. Electrification Peak-Load Impact—4300201 Feeder High Scenario, 2040

Source: Siemens PTI analysis.

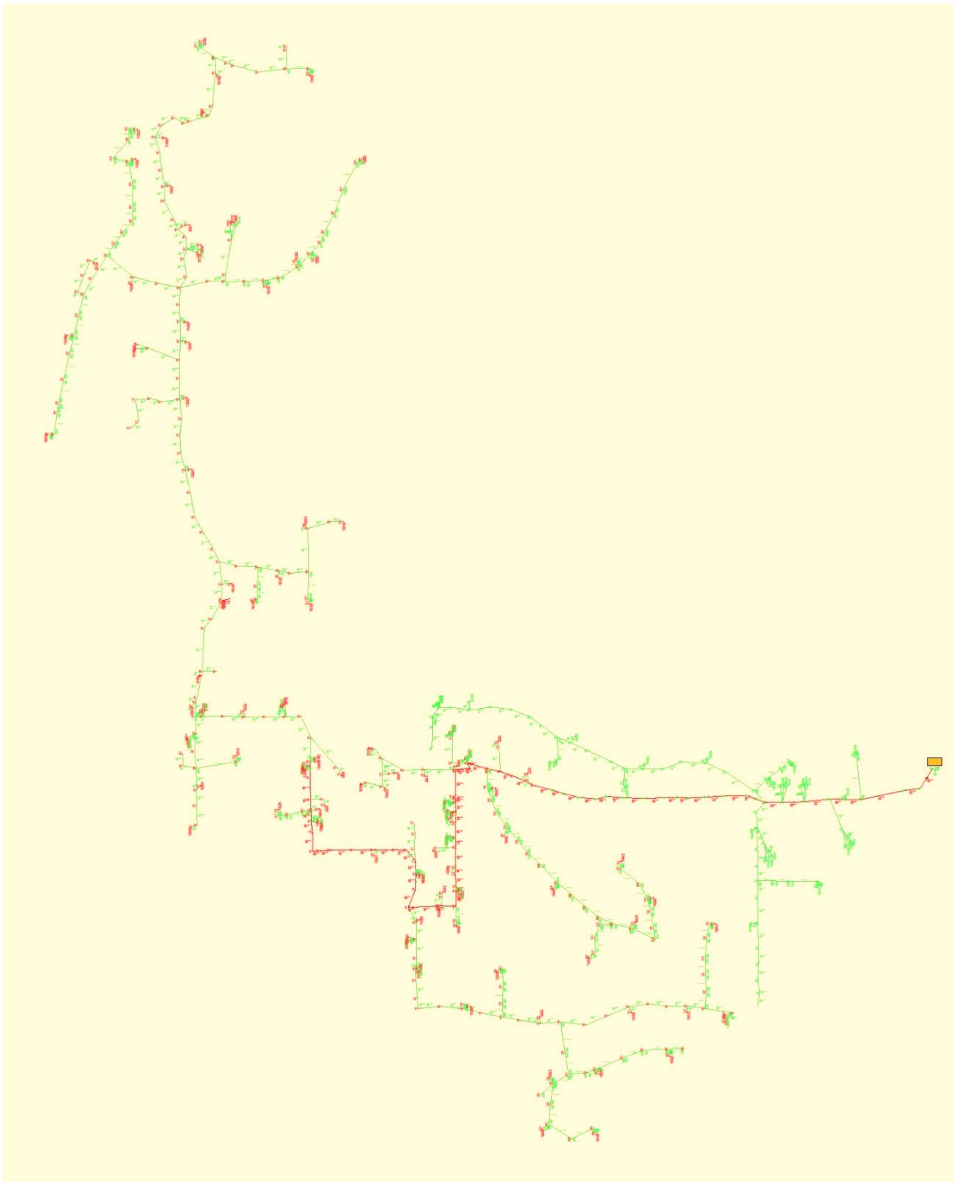


Figure A-27. Electrification Peak-Load Impact—4300201 Feeder High Scenario, 2050

Source: Siemens PTI analysis.

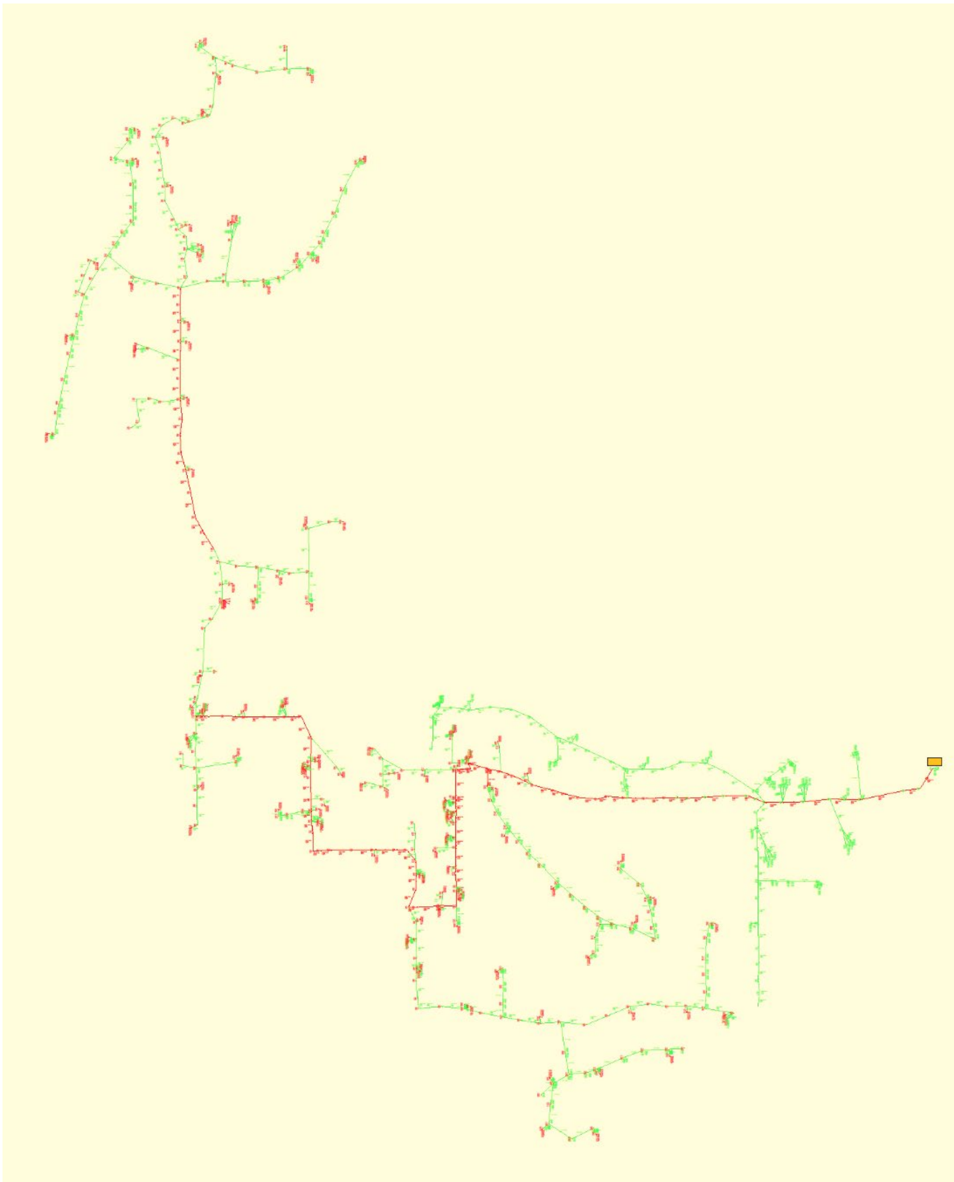


Figure A-28. Electrification Peak-Load Impact—4300201 Feeder Low Scenario, 2030

Source: Siemens PTI analysis.

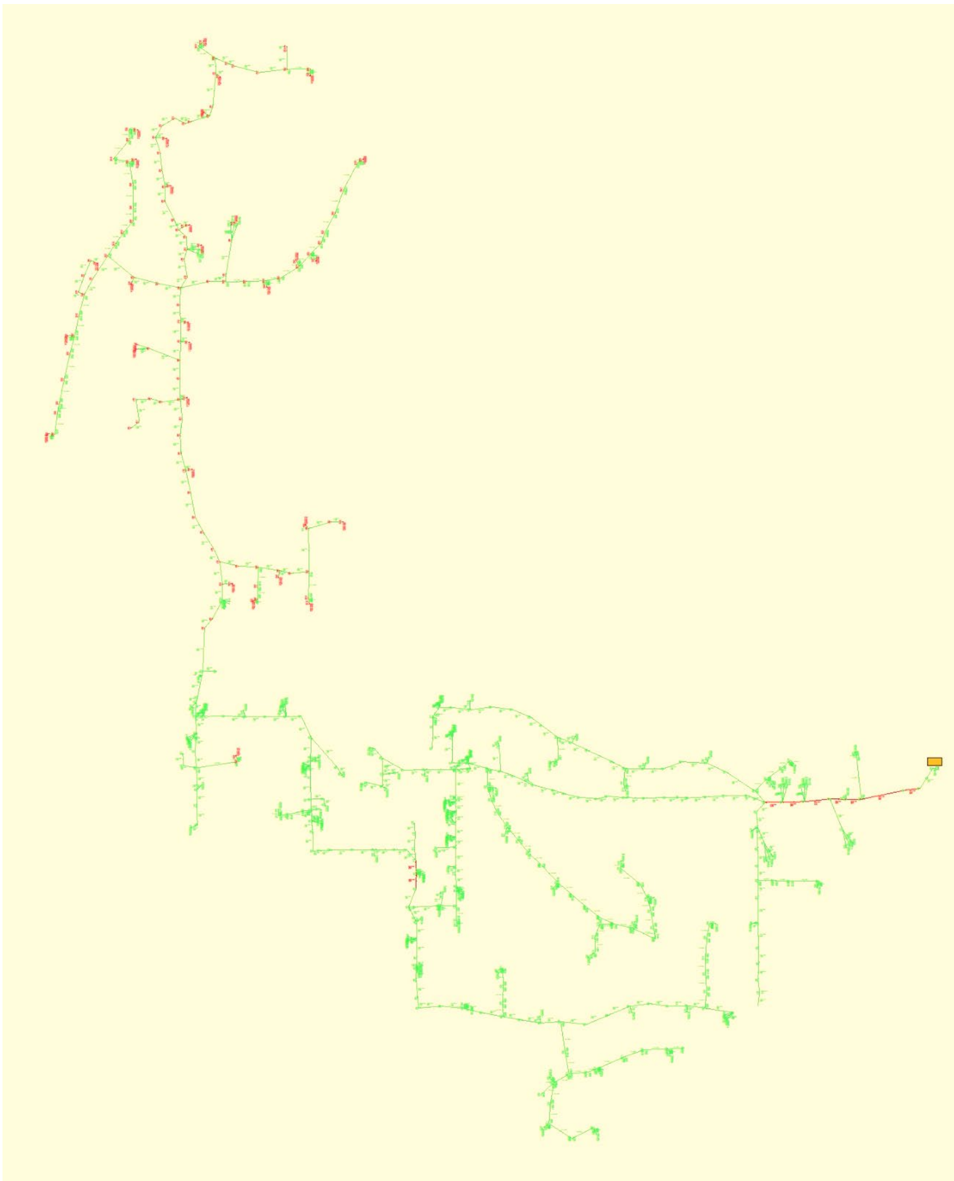


Figure A-29. Electrification Peak-Load Impact—4300201 Feeder Low Scenario, 2040

Source: Siemens PTI analysis.

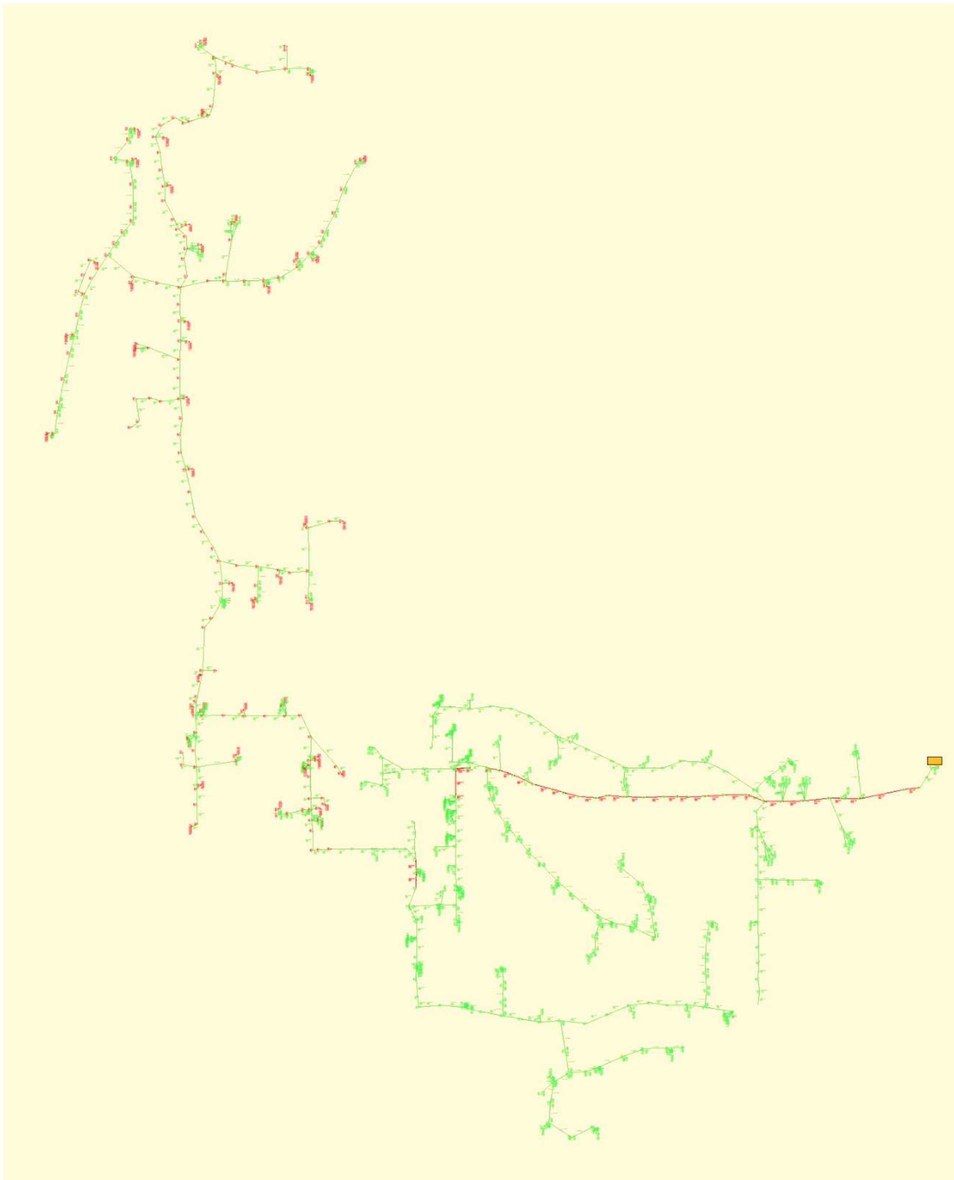
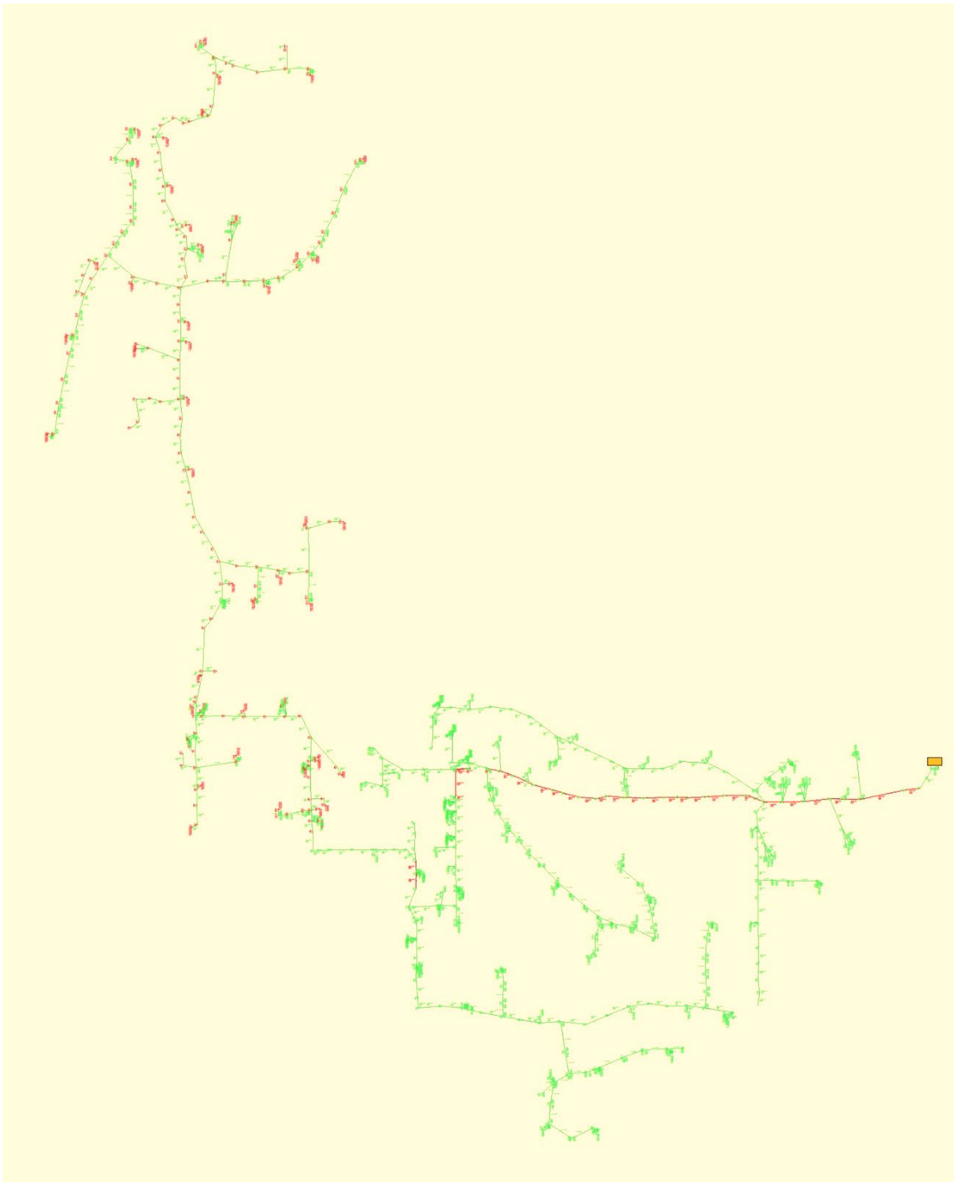


Figure A-30. Electrification Peak-Load Impact—4300201 Feeder Low Scenario, 2050

Source: Siemens PTI analysis.



A.2.7.2 *Impact Mitigation*

Table A-6. Impact Mitigation Summary—4300201

Source: Siemens PTI analysis.

Summary	High	Low
Total 3-Phase Feeder Backbone Length (mi)	2.09	
Total Secondary Transformers (no.)	157	
Total Reconductoring Length 2030 (mi)	0.22	0.20
Total Reconductoring Length 2040 (mi)	1.39	0.35
Total Reconductoring Length 2050 (mi)	0.67	-
Total Reconductoring Length (% of Backbone 2030)	11%	10%
Total Reconductoring Length (% of Backbone 2040)	66%	17%
Total Reconductoring Length (% of Backbone 2050)	32%	0%
Cumulative number of Secondary Transformer Upgrades in 2030 (no.).	22	22
Cumulative number of Secondary Transformer Upgrades 2040 (no.)	51	32
Cumulative number of Secondary Transformer Upgrades in 2050 (no.)	60	33
Cumulative Secondary Transformer Upgrades 2030 (% of Total)	14%	14%
Cumulative Secondary Transformer Upgrades 2040 (% of Total)	32%	20%
Cumulative Secondary Transformer Upgrades 2050 (% of Total)	38%	21%
Total Secondary Transformer Upgrades 2023–2030 (% of Total)	14%	14%
Total Secondary Transformer Upgrades 2030–2040 (% of Total)	18%	6%
Total Secondary Transformer Upgrades 2040–2050 (% of Total)	6%	1%
New Substation Main Transformer 2030 (no.)	0	0
New Substation Main Transformer 2040 (no.)	1	0
New Substation Main Transformer 2050 (no.)	0	0

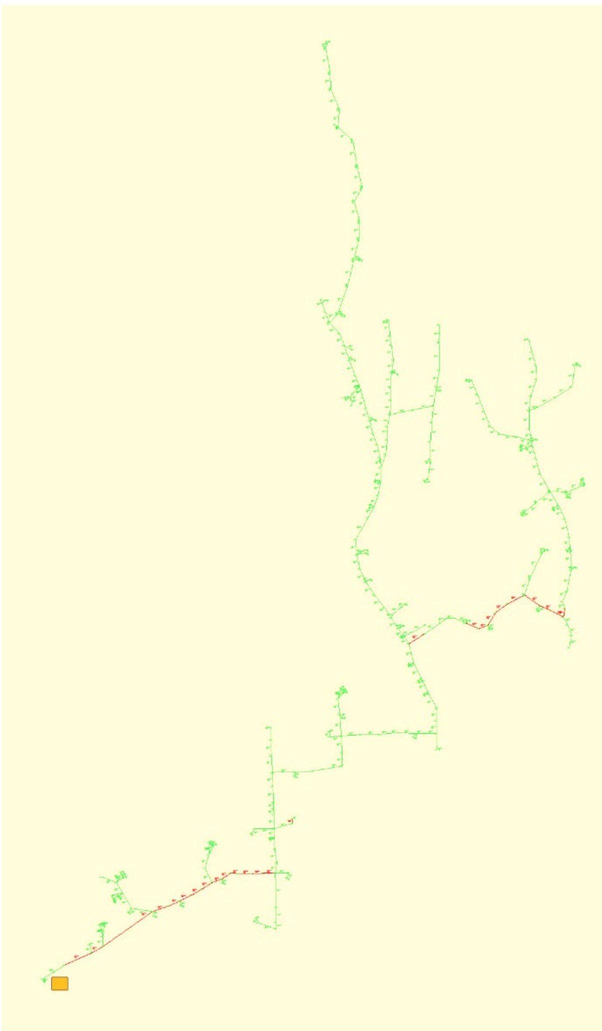
A.2.8 Feeder 4302305

A.2.8.1 Impact Assessment

No network violations occur until the high scenario, 2050.

Figure A-31. Electrification Peak-Load Impact—4302305 Feeder High Scenario, 2050

Source: Siemens PTI analysis.



A.2.8.2 Impact Mitigation

Table A-7. Impact Mitigation Summary—4302305

Source: Siemens PTI analysis.

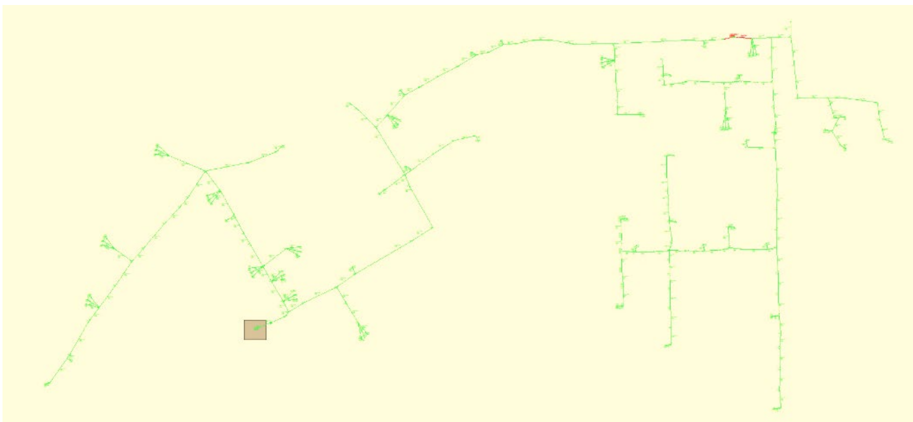
Summary	High	Low
Total 3-Phase Feeder Backbone Length (mi)	2.79	
Total Secondary Transformers (no.)	66	
Total Reconductoring Length 2030 (mi)	0.00	0.00
Total Reconductoring Length 2040 (mi)	0.00	0.00
Total Reconductoring Length 2050 (mi)	0.74	0.00
Total Reconductoring Length (% of Backbone 2030)	0%	0%
Total Reconductoring Length (% of Backbone 2040)	0%	0%
Total Reconductoring Length (% of Backbone 2050)	27%	0%
Cumulative number of Secondary Transformer Upgrades in 2030 (no.).	4	3
Cumulative number of Secondary Transformer Upgrades 2040 (no.)	14	8
Cumulative number of Secondary Transformer Upgrades in 2050 (no.)	15	11
Cumulative Secondary Transformer Upgrades 2030 (% of Total)	6%	5%
Cumulative Secondary Transformer Upgrades 2040 (% of Total)	21%	12%
Cumulative Secondary Transformer Upgrades 2050 (% of Total)	23%	17%
Total Secondary Transformer Upgrades 2023–2030 (% of Total)	6%	5%
Total Secondary Transformer Upgrades 2030–2040 (% of Total)	15%	8%
Total Secondary Transformer Upgrades 2040–2050 (% of Total)	2%	5%
New Substation Main Transformer 2030 (no.)	0	0
New Substation Main Transformer 2040 (no.)	0	0
New Substation Main Transformer 2050 (no.)	0	0

A.2.9 Feeder 4302304

A.2.9.1 Impact Assessment

Figure A-32. Electrification Peak-Load Impact—4302304 Feeder High Scenario, 2050

Source: Siemens PTI analysis.



A.2.9.2 Impact Mitigation

Table A-8. Impact Mitigation Summary—4302304

Source: Siemens PTI analysis.

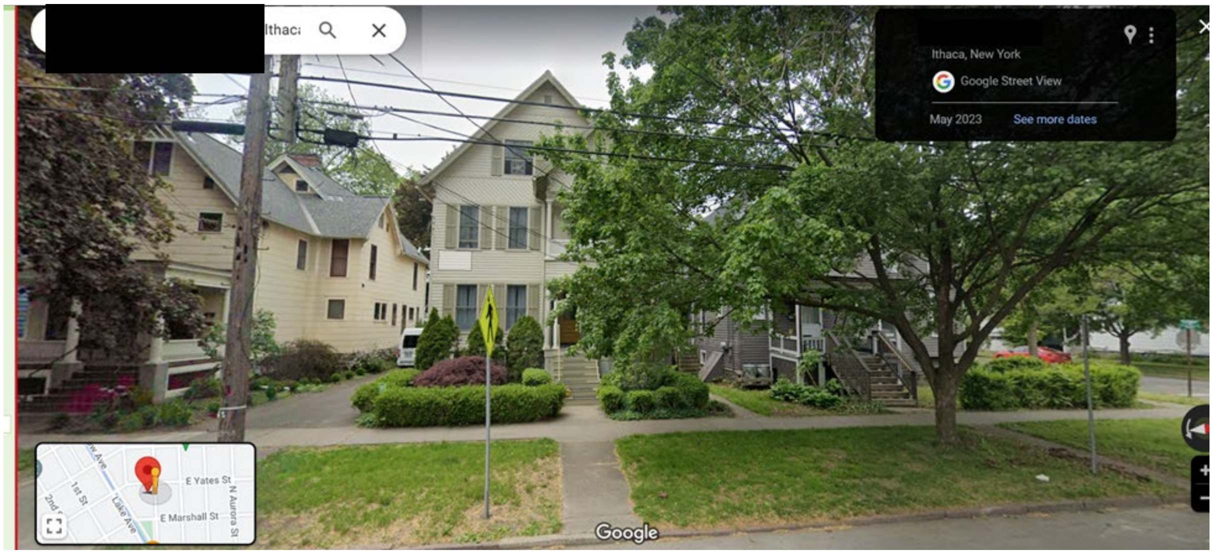
Summary	High	Low
Total 3-Phase Feeder Backbone Length (mi)	2.70	
Total Secondary Transformers (no.)	70	
Total Reconductoring Length 2030 (mi)	0.00	0.00
Total Reconductoring Length 2040 (mi)	0.00	0.00
Total Reconductoring Length 2050 (mi)	0.02	0.00
Total Reconductoring Length (% of Backbone 2030)	0%	0%
Total Reconductoring Length (% of Backbone 2040)	0%	0%
Total Reconductoring Length (% of Backbone 2050)	1%	0%
Cumulative number of Secondary Transformer Upgrades in 2030 (no.).	17	8
Cumulative number of Secondary Transformer Upgrades 2040 (no.)	23	20
Cumulative number of Secondary Transformer Upgrades in 2050 (no.)	23	20
Cumulative Secondary Transformer Upgrades 2030 (% of Total)	24%	11%
Cumulative Secondary Transformer Upgrades 2040 (% of Total)	33%	29%
Cumulative Secondary Transformer Upgrades 2050 (% of Total)	33%	29%
Total Secondary Transformer Upgrades 2023–2030 (% of Total)	24%	11%
Total Secondary Transformer Upgrades 2030–2040 (% of Total)	9%	17%
Total Secondary Transformer Upgrades 2040–2050 (% of Total)	0%	0%
New Substation Main Transformer 2030 (no.)	0	0
New Substation Main Transformer 2040 (no.)	0	0
New Substation Main Transformer 2050 (no.)	0	0

A.3 Winter Heat Pump Demand on a Sample Residential Building

The electrification impact on a typical residential building serves as an example to illustrate the impact of heat pump conversion on electric demand. The load could increase by up to 41 kW.

Figure A-33. A Typical Residential Building in Ithaca

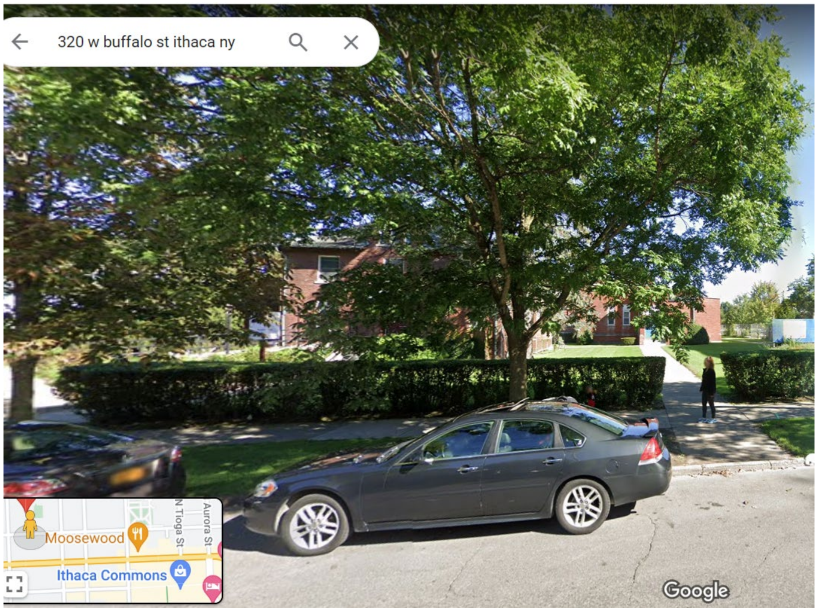
Source: Siemens PTI analysis.



A.4 Winter Heat Pump Demand on a Sample Commercial Building

The electrification impact on a typical commercial building illustrates the impact of heat pump conversion on electric demand. The load could increase by up to 358 kW.

Figure A-35. A Typical Commercial Building in Ithaca



Endnotes

[1] Alternative Fuels Data Center afdc.energy.gov/data/10380

[2] GEOTAB https://www.geotab.com/blog/ev-battery-health/

[3] NEEP's Cold Climate Air Source Heat Pump list: ashp.neep.org/#!/

[4] Projected Emission Factors for New York State Grid Electricity, August 2022 nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Energy-Analysis/22-18-Projected-Emission-Factors-for-New-York-Grid-Electricity.pdf

[5] Carbon Dioxide Emissions Coefficients by Fuel eia.gov/environment/emissions/co2_vol_mass.php

[6] Projected Emission Factors for New York State Grid Electricity, August 2022, nyserda.ny.gov/-/media/Project/Nyserda/Files/Publications/Energy-Analysis/22-18-Projected-Emission-Factors-for-New-York-Grid-Electricity.pdf

[7] Carbon Dioxide Emissions Coefficients by Fuel, eia.gov/environment/emissions/co2_vol_mass.php

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New York State Energy Research and Development Authority

17 Columbia Circle
Albany, NY 12203-6399

toll free: 866-NYSERDA
local: 518-862-1090
fax: 518-862-1091

info@nyserda.ny.gov
nyserda.ny.gov