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Impacts of Fleet Electrification on Grid Infrastructure

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SUMMARY

The transportation sector is the largest source of greenhouse gas emissions in the United States. The transition to electric vehicles will be an essential element of our path forward to meet climate goals. While much attention has focused on passenger vehicles, the electrification of fleet vehicles such as trucks, delivery vans, and buses presents a huge opportunity to reduce emissions. These medium- and heavy-duty vehicles (MHDVs) can emit up to 30 times the amount of carbon dioxide as a typical passenger vehicle and 150 times more particulate matter. Electrifying fleets will reduce air and noise pollution, particularly in environmental justice communities near industrial or high-traffic areas.

National Grid and Hitachi ABB Power Grids conducted an analysis to understand the grid impacts of electrifying fleet vehicles, focusing on a top 100 metro region in the United States. The resulting study seeks to provide an understanding of how differences in fleet locations, usage patterns, charging patterns, and other factors impact specific portions of distribution or transmission systems.

Impacts will vary substantially at different parts of the electric grid because fleets are often "clustered" in specific geographic areas. For instance, the analysis identified two distribution feeders (the electric circuit to commercial or residential customers) which might eventually need to support more than 400 vehicles. Where fleets are clustered as this, new electric load from electric MHDVs could eventually exceed the electric grid's current capabilities, meaning that upgrades will be needed to fully enable fleet electrification. These potential impacts suggest that there is an immediate need to collaborate across industry and proactively plan for infrastructure upgrades or other solutions to meet these needs.

KEYWORDS

Electric Vehicles, EV, Charging, Medium-Duty Vehicles, Heavy-Duty Vehicles, MHDV, Fleet, Grid Impacts, Planning, Distribution, Transmission

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Introduction: The Importance of Fleet Electrification

The transportation sector has overtaken electric generation as the United States' largest source of greenhouse gas emissions [1]. Movement to more sustainable fuel sources, such as electricity, is one path forward in mitigating transportation emissions. The electrification of fleets presents a major opportunity: medium- and heavy-duty vehicles (MHDVs) accounted for almost a quarter of U.S. transportation emissions in 2019 [2]. Addressing transportation emissions will be critical to meeting climate, environmental, and equitable transportation goals.

Policymakers are adopting strong targets to decarbonize fleets, and for good reason: fleets offer a substantial return on investment when it comes to decarbonization. While cargo trucks and buses account for a small proportion of total vehicles and miles traveled, they represent a far greater share of fuel use and emissions [3]. Converting fleets will take heavier polluters off the road – and when fleets make bulk purchases of electric vehicles, this conversion can have large, immediate benefits for pollution and health.

The shift to electric fleets may appear slow compared to passenger vehicles, but commercial EV adoption is expected to accelerate quickly. Total cost of ownership is approaching (or has reached) parity in many EV models, including fleet vehicles. The North American Council for Freight Efficiency (NACFE) has studied medium-duty (Class 3-6) and heavy-duty (Class 7-8) electric vehicles against their internal combustion engine counterparts and found that many medium-duty vehicles have already reached cost parity, with heavy-duty soon to follow [4]. Bloomberg New Energy Finance (BNEF) projects a >150x increase in electric buses and commercial fleet vehicles from 2020 to 2025, compared to a 4x increase in electric passenger vehicles [5]. This could result in step-changes in electric load at operators' sites, compared to steadier growth in residential and other commercial areas. Quantifying how and where fully electric fleets might impact the grid will be critical to enable fleet electrification at scale while minimizing costs for fleets and other customers.

National Grid and Hitachi ABB Power Grids undertook a case study of actual fleets in an area of National Grid's U.S. service territory. This study considers two key questions: What are the impacts of fully electrifying a given fleet? And what are the impacts of multiple fleets in an area fully electrifying at once? It provides a foundation for future analysis, which would refine assumptions on fleet usage and timelines, analyze broader system needs and solutions, and identify policy considerations.

This analysis provides valuable insight for utilities, fleet operators, regulators and policymakers, communities, suppliers, and other stakeholders committed to the decarbonization of commercial transportation. While several implications are identified herein, this study is intended to open the door for further collaboration across the public and private sectors to accelerate the electrification of MHDVs.

Case Study: Large-Scale Fleet Electrification's Impact to the Electric Grid

<u>Context, Assumptions, and Data Collection</u>

As EV fleets scale up, their collective and long-term impacts will necessitate larger upgrades to meet customer needs. This study offers a framework to evaluate the large-scale electrification loads of multiple fleets in a specific area of National Grid's distribution network. The framework was implemented to identify the impact of 100% fleet electrification in a top-100 metro area in National Grid's U.S. service territory. The analysis considers six factors to generate charging scenarios for the fleets in the study area:

1. *Fleet locations:* 51 major fleet operators were manually identified in the study area through online map services and satellite imagery.
    a. The analysis assumes that fleet vehicles would only be charging at the depot.
    b. The analysis focuses on large companies with easily identifiable fleets, so small commercial sites and geographically dispersed fleets that may also electrify are not included in this study.

2. *Fleet vehicle count:* The number of vehicles in individual fleets was estimated based on facility and parking lot sizes, number of parking spots available, and visible vehicles at fleet locations.
3. *Fleet vehicle class:* The vehicles at each site were assigned to vehicle classes, depending on available data. The overall fleet composition for the study area is summarized in *Table 1*.

Table 1: Study area fleet summary

Fleet Vehicle Type	Total Vehicles
Medium-Duty (Box Trucks, Step Vans, Bucket Trucks, etc.)	1,577
Heavy-Duty (Regional Freight Trucks)	781
School Buses	311
Total	**2,669**

4. *Electric vehicle characteristics:* Extensive literature review was performed based on the projected EV models available for each EV fleet vehicle category.
    a. The area of the study experiences cold winters, with low temperatures in January averaging 15 degrees Fahrenheit. Extremely cold ambient temperatures can significantly affect battery capacity, so the impact of temperature on battery efficiency that is, total miles/kWh) was separately considered for winter and summer scenarios for each vehicle type [6].
    b. The total charging requirement of the battery is determined from the trip mileage and the battery efficiency of each vehicle category.
5. *Driving pattern:* The National Renewable Energy Laboratory's (NREL) Fleet DNA dataset informed assumptions for the driving pattern of the fleet operators.[1]
    a. Regardless of the category of the fleet vehicle, more than 50% of all trips are <70 miles, and more than 90% of trips are <100 miles for all categories but freight trucks.
6. *Charging infrastructure.* Charger ratings are determined by: 1) average dwell time of vehicles and 2) the vehicle's total energy demand for its operating profile. Charger ratings were determined so a vehicle's battery would fully charge during its dwell time. This analysis assumes that the average fleet owner has two vehicles per charger, which in practice could vary by fleet and use case.[2] The charger rating estimates and 2:1 vehicle-to-EVSE ratio assumptions used in this analysis are meant to provide a "right-sized" estimate of EVSE needs for customers.

Modeling Methodology & Analysis

Once these data and assumptions were identified, the analysis followed this process (at a high level):
1. The analysis uses a Monte Carlo simulation to evaluate probabilistic distributions of fleet schedules in order to develop reasonable boundaries of potential charging profiles.
2. The analysis then uses that simulation to develop fleet charging profiles in winter and summer conditions. Charging profiles were further developed for two different charging strategies:
    a. "Full Charging with Right-Sized Infrastructure" – This strategy assumes that fleet vehicles charge at the full charger nameplate rating upon returning to the facility (or a charger becoming available).
    b. "Minimum Charging with Right-Sized Infrastructure" – This strategy assumes that total facility charging needs are met at the lowest peak rate possible to fully charge vehicles before they are scheduled to leave the next day.[3] That is, even if a vehicle is using a 150 kW-rated charger, it may charge at less than 150 kW as long as that lower rate allows it to fully charge before it departs the depot. The optimization routine manages the charging schedule of the

[1] See http://www.nrel.gov/fleetdna. Fleet DNA has been used in other vehicle electrification studies for estimating charging and transportation attributes.
[2] A recent report by Rocky Mountain Institute estimates 1 to 2.5 vehicles per charger [7]. IEA's outlook assumes 3.8 trucks per charger with an average of 480 kW, or ~125 kW per vehicle, and 7.7 buses per charger with an average of 190 kW, or ~25 kW per vehicle [8].
[3] "Minimum Charging" charging strategy does not consider any reduction in charger efficiency vs "Full-Sized" charging strategy, i.e. whether the vehicle charges less efficiently. Each strategy in this analysis assumes 85% charger efficiency.

parked vehicles and adjusts the rate of charging of the fleet to meet vehicles' overall charging requirement during their dwell time at the lowest charging peak at the facility. Vehicles could charge at their full nameplate rating for a period of time and then a lower rating as more vehicles return to the depot.

3. The analysis then considers where fleets are located on the distribution system and assigns them to the nearest distribution feeder. The analysis then aggregates the load across multiple fleets to understand total impacts of multiple fleets electrifying.
   a. Understanding impacts at the feeder level is critical because utilities plan distribution infrastructure upgrades based on available capacity at the feeder level.
   b. The analysis adds this aggregated load over a "baseline" load (forecasted winter or summer peak load) to find if the feeder can accommodate the new load from fleet electrification.
   c. The analysis aggregates the load up to the substation level and considers how residential and public charging load in a "100% electrification" scenario might also affect available capacity.

Monte Carlo is a scenario generation technique, used to model scenarios based on the probability of their occurrence. The Monte Carlo-based framework for fleet schedule generation is shown in Figure 1, in which three steps are performed to generate fleet schedule scenarios, using school buses as an example:

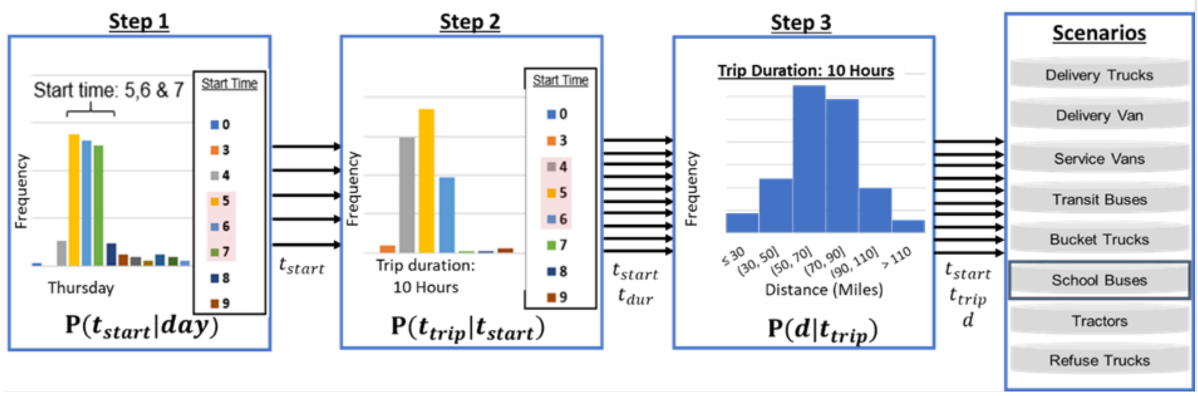


Figure 1: Monte-Carlo based framework for fleet schedule generation

Step 1: Start times for a given fleet type on a given day.
Step 2: Trip length information for a given start time and day
Step 3: Distance covered during the trip for a given trip duration

At the end of Step 3, scenarios were generated (based on probability of occurrence with sample data from the Fleet DNA database) with the following variables:

- Day of week
- Hour of trip start
- Total duration of trip in hours
- Distance travelled during the trip

A database is created for every class and category of fleet vehicle, with 1,000 different scenarios developed for every working day. These scenarios are used to determine the potential charging load for each of the 51 fleets.

<u>Estimation of Fleet Load Profiles</u>

For a given day and the type of fleet vehicles, these scenarios are then used to generate schedules for the fleet in question;[4] when is a fleet vehicle out on a trip, and when is it parked at the depot? This analysis provides a probabilistic view of how many vehicles are likely to be parked at a fleet depot at

[4] A number of scenarios, equal to the number of vehicles in the fleet, are randomly selected from the set. These sets of scenarios indicate typical workday schedules for fleet operators. For any workday, a unique $C(1000, N_v)$ combinations/workday schedule can be extracted from the scenario database for a fleet with N_v vehicles.

any given hour of the day – and thus, how many vehicles might be able to charge at any given hour of the day. Charging requirements are aggregated across all vehicles in a given fleet to calculate the total charging requirement for the fleet as a whole.[5] Charging requirements are estimated at every hour for each fleet.[6] The charging profiles for a school bus example are presented in Figure 3, showing the variations in the charging load profile due to weather. The analysis considers a "Full Charging" strategy: buses charge at the charger's maximum rating when they return to the depot or when a charger becomes available.

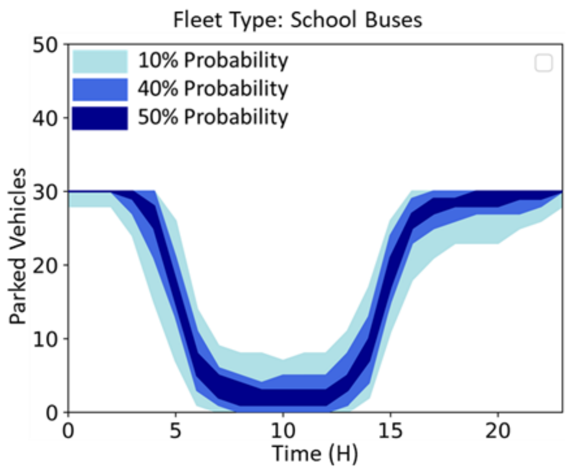
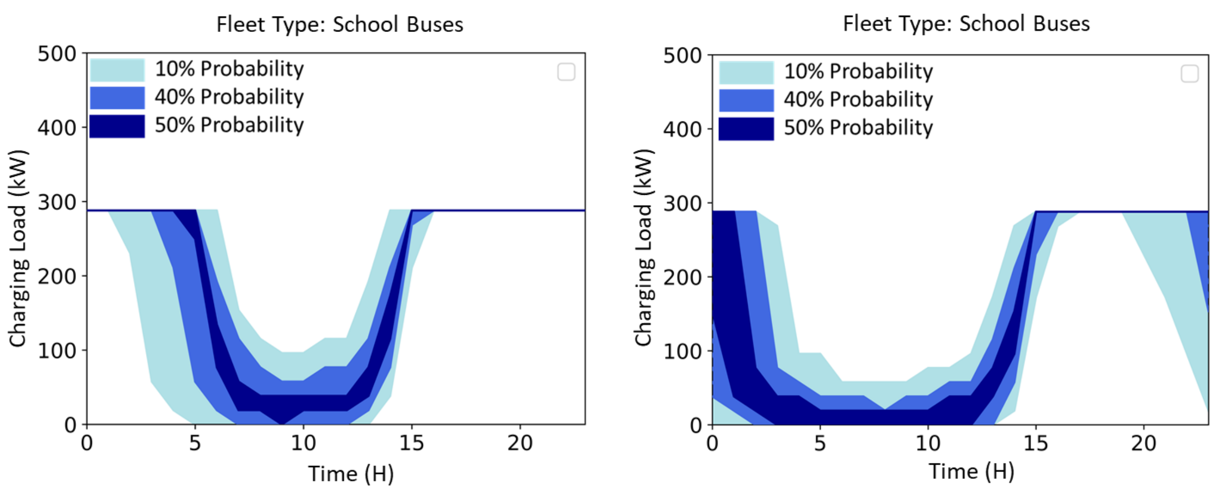


Figure 2: Parking scenarios for School Buses

Figure 3(a) shows 1,000 charging scenarios for a fleet of 30 school buses in the winter. The charging requirement for the fleet is facilitated by 15 chargers rated at 19.2 kW each. The school buses generally start trips in the morning between 5:00-7:00 am, and return to the depot between 3:00-6:00 pm, with an average dwell time between 13-16 hours. Figure 3(b) shows the analysis for the same fleet of school buses during the summer. Buses have higher efficiency in warmer temperatures and need to charge 35-40% less than they would during colder conditions.[7] In the winter, each bus needs about 8-9 hours to charge; in the summer, each bus needs about 5-6 hours. In either season, the bus fleet will need to maximize its available charging capacity overnight.



(a) Winter- Full Charging Strategy

(b) Summer- Full Charging Strategy

Figure 3: Charging scenarios for a fleet of 30 school buses

[5] Fleet charging is limited by the number of vehicles available for charging, the aggregate charging requirement for all vehicles based on usage, charging efficiency, vehicle battery efficiency, individual charger rating or limit (defined in kW), and the number of chargers available for a fleet (assuming 1 charger for every 2 vehicles).

[6] $\min\ (i = 1, 24)\ \Sigma\ w^j(i)*kW^j_{charge}(i)$ represents the ideal charging requirement at each hour. GEKKO, a python-based machine learning, and optimization suite, was used to estimate the charging requirements at every hour for each fleet. The priority coefficient (w) can be used to further prioritize charging during specific hours of the day.

[7] The miles per kWh for school buses is assumed to be 0.44 during winter and 0.70 during summer. Efficiency figures for each vehicle category are defined from manufacturer specifications, compiled from the Zero-Emission Technology Inventory (ZETI) tool by CALSTART [9].

System Impacts of Fleet Electrification

To understand overall impacts on the grid, utilities need to understand the impacts of electrifying all of the fleets in a given area. Thus, after developing charging profiles for each fleet in the study area, the analysis then assigns those fleets to a specific feeder on National Grid's electric distribution system in the study area and aggregates the total hourly load associated with full electrification of those fleets.

51 major fleets were identified in the study area and mapped to 19 distribution feeders. Out of those 19 feeders, 5 feeders hosted "clusters" of 4 or more fleets as seen in Figure 4. Several feeders host multiple, large fleets; more than 400 fleet vehicles were mapped to Feeders 10 and 18. The geographical concentration of these large fleets means that more load would be seen on these feeders as a result of fleet electrification. The aggregate charging load for every fleet operator was added to the corresponding feeder's summer and winter peak profiles to get the overall impact of fleet electrification on the feeder.

Figure 5(a) shows the daily peak load profile for Feeder 18 in winter. Currently, 2 MW of load is expected in peak winter conditions, based on forecasts through 2024. Feeder 18 is rated to support 8.2 MW, which is more than enough capacity to meet the existing load. However, more than 400 fleet vehicles were identified in the area of Feeder 18; if these vehicles fully electrify under these assumptions, the peak load would exceed the feeder rating by over 3 times the rated load in the overnight charging period. This is a remarkable increase in load – nearly 25 MW – though the logic is straightforward:

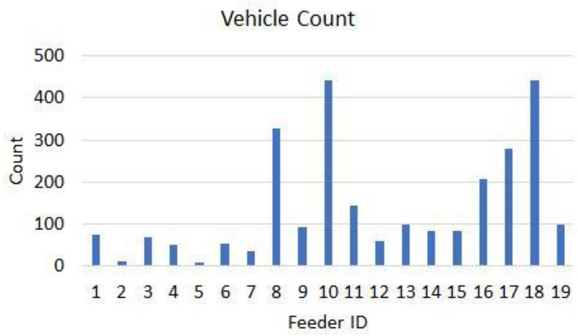
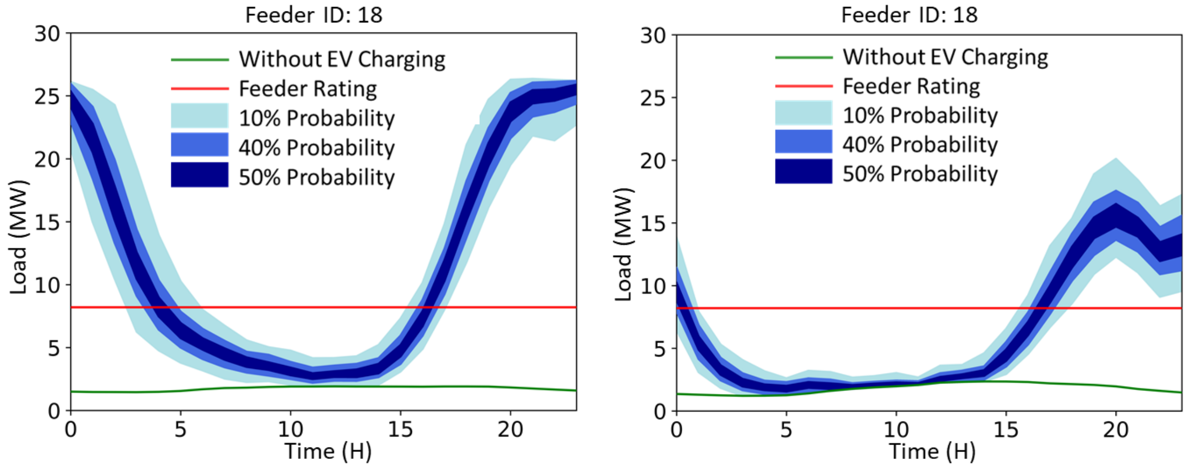


Figure 4: Total Vehicles Supported by the Feeders

- 400+ fleet vehicles associated with Feeder 18, 67% of which come from freight vehicles
- 200+ vehicles charging at peak hours overnight (assuming a 2:1 vehicle to EVSE ratio)
- Vehicles charging at an average rate of ~120 kW (due to freight fleets "clustered" at this feeder)

As Figure 5(b) shows, the effects would be moderated in summer conditions, though night-time load would still exceed the feeder rating. Charging strategies could possibly be implemented to help mitigate these overload scenarios, given the capacity available for much of a day.



(a) Winter-Full Charging Strategy (b) Summer-Full Charging Strategy

Figure 5: Load profiles for Feeder 18 with fleet charging

Figure 6 summarizes the impact of fleet electrification on the 19 feeders supporting fleets in the study area. Impacts of fleet electrification are magnified in winter conditions, when battery efficiency is lower. Hence, for the feeders experiencing higher electrification, the peak load is observed during winter. Of the 19 distribution feeders studied, over 68% of them (13 feeders) would eventually be overloaded or at risk of overloading when nearby fleets fully electrify.

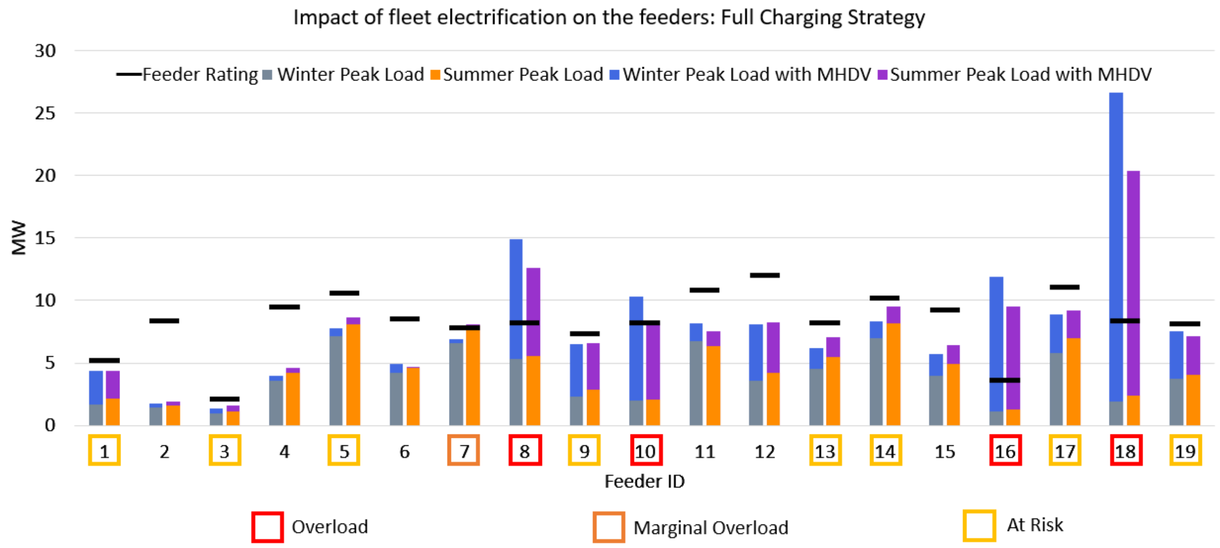


Figure 6: Impact of fleet electrification on the feeders during winter and summer peak load with Full Charging Strategy[8]

For four feeders – Feeders 8, 10, 16, and 18 – the peak load imposed by fleet electrification would exceed the feeder rating capacity in both summer and winter conditions. As previously discussed, Feeder 18 faces substantial impacts from the electrification of over 400 fleet vehicles (many of which are regional freight vehicles with chargers rated at 150 kW); Feeder 16 supports just over 200 vehicles, though has a lower feeder voltage.

Impacts are not limited to these four feeders with high fleet penetration. For another 9 feeders, full fleet electrification would either cause the feeder to exceed available capacity in one season, or to exceed 80% of the current feeder capacity. These impacts only reflect electrification of fleet load, not further light-duty passenger load or load from smaller fleets. The potential load from full electrification, and the system needs resulting from that load, should be kept in mind as decarbonization efforts progress. While these feeders are each able to meet current peak loads, this analysis demonstrates that the loads associated with long-term, large-scale fleet electrification will require upgrades, especially where “clusters” of fleets with many vehicles, or with large vehicles, electrify on similar timeframes.

Broader Electrification and Substation Impacts

Just as fleets are electrifying, so too will light-duty passenger vehicles (cars, SUVs, minivans, etc.). The simultaneous electrification of MHDVs and light-duty vehicles has the potential to magnify the impacts of vehicle electrification.[9] The next step of this analysis aggregates fleet load at the substation level, and considers the load associated with “100% electrification” scenarios for two categories of light-duty EV charging:

1) Residential Charging – defined in this paper as the charging performed “at home” by EVs privately owned by individuals and driven for personal use.
2) Public Charging – typically includes the on-street charging facilities located at commercial locations, workplace, or parking lots.[10]

[8] “At Risk” = over 80% of rated load in one season.
[9] National Grid and other utilities have begun incorporating LDV loads into load forecasts.
[10] The study does not include highway charging loads, though the study area is adjacent to several interstates.

Figure 7 evaluates potential substation impacts for a specific substation, which serves 7 feeders including Feeder 17 and Feeder 18 (the freight-heavy feeder with the largest absolute impacts from fleet electrification).

- The substation's forecasted peak load, including existing near-term forecasts of residential and public charging, was first assessed for each hour of a winter or summer day. [11]
- The analysis then added the load associated with a "100% electrification" scenario for residential and public charging, for light-duty vehicles. This was done by extracting the per vehicle load profile used by the National Renewable Energy Laboratory's Electric Vehicle Infrastructure Projection Tool (EVI-PRO) Lite, and applying it to EV adoption forecasts made using Bayesian analysis of each census block group's demographics [10].
- The analysis finally adds in the load associated with fully electrified MHDV fleets served by the substation, as previously described.
- The analysis considers these fleet loads on a peak summer and a peak winter day.
- Finally, the analysis considers the same Full Charging strategy used for prior analysis of fleet impacts. It also assesses a Minimum Charging strategy, in which fleets would charge their vehicles at the lowest possible rate to reach full charge, which could mitigate impacts from fleet load.

The substation has two transformers serving three and four feeders each; as a result, the load is not shared equally between the two. One of the substation transformers may become overloaded, even if the combined station capacity appears suitable, and other substation equipment and devices could have specific constraints that would lower the actual available capacity.

The Minimum Charging Strategy previously mentioned could reduce charging load from fleets, but the peak reduction achieved from this minimum charging strategy depends on the overall charging demand, dwell time of fleet vehicles, and the chargers' capacity. Figure 7 compares the effect of a minimum charging strategy versus a full charging strategy for fleet vehicles on the overall demand experienced by the substation during summer and winter. Winter charging needs are higher, with a minimum charging strategy for fleets reducing peak load of the studied substation by approximately 10 MW.

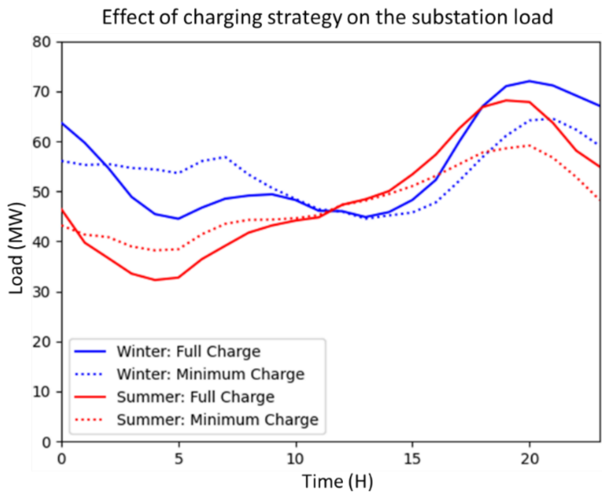


Figure 7: Impact of Fleet Charging Strategy (Full vs Minimum Charging) on substation loading[12]

Additional alternatives like energy storage should also be considered to address peaks through shifting or smoothing strategies. This analysis suggests that specific distribution feeders will feel the impact of fleet electrification, and those impacts could travel up the distribution system to the transmission system.

<u>Conclusions of Analysis and Further Considerations</u>

This analysis demonstrates that:

- Full fleet electrification could have substantial impacts at the feeder and substation levels, especially around large, heavy-duty fleet clusters. The results indicate that 4 distribution feeders exceed their ratings in both winter and summer seasons as fleets electrify, with 9 additional feeders exceeding or reaching 80%+ of feeder rating in either winter or summer conditions.

[11] National Grid's base feeder forecasts used in this analysis currently include a small amount of residential and public EV load that was accounted for in the analysis.
[12] Load includes residential, public, and fleet estimates.

  - The load from fully electric fleets increases winter load on Feeder 18 to more than 300% of the feeder rating, suggesting that even intermediate stages of fleet electrification would begin to substantially impact portions of the electric grid.
  - The results show that many feeders associated with large fleets (13 of 19 identified) face future overloads or are at risk of future overloading. This finding is especially noteworthy considering that only the fleet loads are compared to the feeder ratings.
  - The "Full Charging" scenario presented should be viewed as a reasonable case for fleet operations that mitigates worst-case outcomes with right-sizing of chargers, not a worst-case where vehicles are all charged at their fastest rating.. For example, school bus fleets are assumed to use 19 kW Level 2 chargers; in practice, buses are capable of charging faster, and the chargers could be rated several times above that.
  - Many fleets were not included in this analysis. The results here are for the largest, most impactful fleets that could be identified, but there are many smaller fleet operators that would add additional load upon electrification.
  - At the substation considered in this analysis (which serves Feeder 18), full fleet electrification could increase winter peak load by approximately 60%.
- Additionally, as residential and public premises install their own electric charging, the aggregate loads could have further impacts at the substation level.
  - High levels of residential and public charging could increase peak load by approximately 20% at the substation considered in this analysis.
- Charging patterns and load profiles will vary by fleet. Potential impacts on the electric system could be estimated using methods similar to those employed in this case study, but more accurate estimates require more granular data from fleet operators.

While this study reviews the impacts of full-scale electrification, early movers could soon begin causing electric grid impacts. There are a number of sensitivities that could affect the results and lead to higher or lower levels of EV load and system impact. Below is a discussion of some of the larger drivers that could affect results and should be monitored over time:

Table 2: Summary of Impact Analysis Sensitivities

	<u>Higher Grid Impact</u>	<u>Lower Grid Impact</u>
Fleet Operations	• Faster charging at higher rates is preferred for operations, or required for peak periods • Charging is not able to be optimized due to vehicle schedules	• Lower daily mileage • Vehicles charge on-route, reducing concentrated loads • Vehicle dwell times are longer than estimated • Battery efficiency increases substantially more than expected
Fleet Location	• Additional fleets not identified in the study electrify • New fleets move to constrained areas or existing fleets expand	• Fleets relocate over time to more accessible parts of the electric network ("headroom hunting")
Fleet Vehicle Types and Numbers	• More vehicles than estimated • Fleets have a higher heavy-duty vehicle ratio than estimated • Fleets relocate vehicles to serve seasonal needs	• Fewer vehicles than estimated • Fleets have a higher light-duty vehicle ratio than estimated

	Higher Grid Impact	Lower Grid Impact
Charging Infrastructure	• Fleets install more fast-charging ports or higher power chargers than anticipated[13] • Fleets install more charging ports to allow more vehicles to be charged at the same time	• Fleets install fewer fast-charging ports than anticipated. • Fleets have fewer charging ports for simultaneous charging (increasing EV:EVSE ratio)[14]
Temperature Impact	• Fleets install more charging ports to compensate for lower battery efficiencies at lower temperatures	• Fleets require less time to fully charge due to higher battery efficiency at higher temperatures • Advances in battery technology improve cold weather efficiency
Other Technologies	• Electrification of heating, such as electric heat pumps, accelerates and adds additional electric load	• Hydrogen (or natural gas or diesel) takes larger share of MHDVs[15] • Energy storage and other DERs improve in performance and cost • Managed charging meaningfully reduces peaks across many fleet types and use cases

Implications: Preparing the Electric Grid for Large-Scale Fleet Electrification

This analysis demonstrates the scale of full fleet electrification and its impact on portions of the electric distribution network. It is intended to support more comprehensive planning for long-term, large-scale electrification needs. National Grid and Hitachi ABB Power Grids intend to build from these insights and further study potential system impacts and interconnection options. Utilities and policymakers can act now to understand the implications of fleet electrification and hot to prepare the grid for this impact.

Significant impacts from fleet electrification should be anticipated – especially where several large fleets are fully electrifying in the same area – and could manifest abruptly where fleet operators switch over large portions of their vehicles, such as a transit agency making a bulk procurement of electric buses.

Traditionally, utilities only invest in upgrades when a specific customer has made a request for service. However, the electrification of multiple neighboring fleets could impose large loads that stress this reactive service to load process and delay interconnection timelines. Further, this process could lead to a "who pays" dilemma, which may cause the first fleet that requests service to pay the cost of the upgrade. As this study demonstrates, fleets might be concentrated in certain areas of the distribution or transmission systems. Only considering fleets on a case-by-case basis misses the "clustering" effect and makes it impossible to plan for the most cost-effective solutions.

By planning for high electrification scenarios, utilities could direct investments to ensure fleet operators do not need to wait for infrastructure upgrades to install chargers and put their new vehicles to work. Without this proactive planning, fleet electrification could also come at higher cost, as multiple, piecemeal upgrades are made to enable one fleet at a time when one, larger upgrade would have provided for multiple fleets at once. Streamlining and updating supportive interconnection

[13] A fast charging port in this study is defined as DCFC with maximum charging rate at 150 kW while a Level 2 charging port is at 19 kW. It is expected that DCFC charging power may increase to 400 kW [11].
[14] Charging port is an individual charger with a defined maximum charging capacity. A charger may have multiple dispensers to connect to multiple vehicles to allow partial charging or scheduled charging without moving these vehicles. These dispensers can only charge at the maximum of their connected charging port.
[15] Hydrogen could have separate grid impacts, e.g. to support electrolysis.

processes could reduce costs, address fleet pain points, and accelerate progress toward decarbonization goals.

Using actual operational data will be necessary when conducting long-term system planning studies. Individual fleets will have drastically different routes, use profiles, and vehicle mixes. This study shows the potential impacts and system constraints for one specific area, but a similarly sized group of fleets in another area may have different energy requirements and impacts on the grid.

<u>We Need an End-to-End Analytical Approach: Solutions Should Include Transmission, Distribution, Distributed Energy Resources, and Charging Infrastructure Programs</u>

The scale of charging loads indicates that distribution upgrades (and/or DERs) may not always be sufficient to meet electrification needs. Substantial spot loads could require a connection to higher-voltage portions of the electric system: for instance, in National Grid's service territory, at a common distribution voltage (13.2 kV), the maximum individual customer load would typically be limited to 2,500 kVA (which at most would equal 2.5 MW) for delivery of secondary voltage (e.g. 277/480V) [12]. Where customer load exceeds those thresholds, fleets may either need DERs to reduce their peak demand or to connect directly to the transmission or sub-transmission networks, which offer higher capacity than distribution networks.

Even where distribution upgrades are sufficient to meet near-term needs, future analysis will evaluate whether one right-sized, upfront investment could reduce long-term costs and quicken the pace of fleet electrification. A new substation could serve a significant load from the transmission network and last for decades. By contrast, making incremental minimum upgrades might be less expensive upfront, but more expensive in the long-term. This could potentially cause electrification delays while infrastructure is upgraded and even cause electrifying fleets to move locations to offload to another feeder. Where full electrification of multiple fleets may be difficult on the distribution system, solutions could take advantage of nearby transmission lines, which present an opportunity for high capacity charging for multiple fleets.

In addition to traditional infrastructure investment, managed charging will have a role to play in supporting EV adoption. This analysis demonstrates that differences in charging strategy can reduce the magnitude and duration of peak loads associated with fleet charging. Utilities should work with customers to manage charging impacts across *all* fleets in a given area to reduce impact on specific feeders, which will help reduce systemwide costs and address system needs as electric fleets scale up. Implications or benefits of "vehicle-to-grid" (V2G) capabilities for clustered fleets also merit study.

<u>Fleet Electrification Needs Can Be Addressed in Conjunction with Other Investments</u>

National Grid and other utilities continuously invest in maintaining and upgrading electric networks. As utilities plan for mandatory asset condition or aging infrastructure investments, they should consider the impacts of transportation electrification and how investments could be accelerated, targeted, or right-sized to address multiple needs at once.

National Grid's Multi-Value Transmission framework, as well as the New York Joint Utilities' "Phase 1" investment plans for 2030 state climate goals, could serve as a valuable case study.[16] Addressing electric transportation needs simultaneously with other investments will minimize costs and accelerate adoption by proactively addressing network constraints. These investment plans should also consider how grid-enhancing technologies can allow for better utilization of existing systems, further reducing costs (and increasing reliability) of serving fleets' and other vehicles' electric load.

[16] See NY Public Service Commission Case 20-E-0197, *Proceeding on Motion of the Commission to Implement Transmission Planning Pursuant to the Accelerated Renewable Energy Growth and Community Benefit Act*

Taking a more holistic approach will also be necessary to plan for generation capacity as the electrification of transport drives substantial increases in electric load, potentially at the same time as other applications (e.g., electric heating or hydrogen production). New planning processes will be needed to support this. Instead of studying the system impacts of each customer service request, utilities could study the anticipated needs for all fleets in a given area, which could be more easily incorporated into system forecasting and planning processes.

The Road from Here: Actions to Accelerate Fleet Electrification

This study begins to answer a pressing question: what impacts could large-scale MHDV fleet electrification have on the electric grid? This is the first step to developing strategies and policies in support of electrifying these fleets. Further analysis will provide additional insight on system impacts, interconnection options, and actions needed to enable and accelerate full electrification. Electrifying MHDVs presents a major opportunity, which will require a broad coalition to be fully realized, including:

Fleet Owners and Operators: Provide comprehensive data on fleet sizes, locations, implementation schedules, and operational requirements.	Fleet operators can partner with companies like Hitachi ABB Power Grids and National Grid to refine and expand the analysis presented in this study. High-quality data on fleet locations, fleet vehicle count, and vehicle use is limited. By working with their utility or charging providers, system integration challenges can be addressed proactively to meet electrification goals at lowest cost.
Policymakers: Utilize studies such as this one to inform policies needed to accelerate fleet electrification at lowest cost.	Legislators, regulators, and other policymakers are taking action to support near-term MHDV electrification. This study shows what will be needed to meet medium- and long-term MHDV electrification goals. Future policy attention could focus on: 1) Planning for the needs of multiple fleets in an area, versus one fleet at a time (holistic vs. "piecemeal" approach). 2) Supporting individual fleets with large loads. 3) Proactively and efficiently investing in fleet electrification.
Communities: Identify additional community needs, goals, and constraints with regard to fleet electrification.	As discussed above, particulate and other emissions from trucks significantly impact local air quality. Eliminating tailpipe emissions from fleet vehicles will be critical to addressing environmental justice concerns. Further analysis can identify fleet depots in Environmental Justice Communities (EJCs) and the infrastructure needed to help those facilities electrify.
Suppliers: Use insights from this study to develop services, systems, and products to support fleet electrification.	Electric fleet service and product suppliers can support electrification requirements by understanding the operational constraints for solutions to meet various market needs. Integrated solutions with standard interoperability will be needed to foster technology adaptations. Accelerating MHDV electrification requires collaborations among suppliers and market participants to provide end-to-end solutions with seamless integration.

Collaboration will lead to a faster, better coordinated, and lower cost transition to electric vehicles. National Grid and Hitachi ABB Power Grids look forward to partnering with all interested stakeholders to support the decarbonization of medium- and heavy-duty transportation. The insights offered by this case study, as well as the implications and next steps identified above, provide an early vision of what that partnership should seek to accomplish.

Proper system and investment planning can identify and alleviate roadblocks for fleet operators and pull forward fleet EV adoption, so that the environmental and public health benefits are realized years or decades sooner than currently forecasted. Proactively addressing the impacts of new load associated with fleet electrification is key to ensuring the transition to zero-emission medium- and heavy-duty vehicles is as fast, efficient, and equitable as possible.

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[17] https://ngrid.com/fleet-electrification-study
[18] https://search.abb.com/library/Download.aspx?DocumentID=9AKK107992A5322&LanguageCode=en&DocumentPartId=&Action=Launch

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