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The Roosevelt Project

Industrial Heartland Electric Vehicle Case Study Working Paper Series

Grid Impacts of the Electric Vehicle Transition in the Industrial Heartland

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by Christina Hajj

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The Roosevelt Project
A New Deal for Employment, Energy and Environment

About the Roosevelt Project

The Roosevelt Project takes an interdisciplinary approach to the transitional challenges associated with progress toward a deeply decarbonized economy. The project aims to chart a path forward through the transition that minimizes worker and community dislocations and enables at-risk communities to sustain employment levels by taking advantage of the economic opportunities present for regional economic development. The first phase of the project involved an analytical assessment of cross-cutting topics related to the transition. The second phase of the project assesses the transition through the lens of four regional Case, working with local partners on the ground in the Industrial Heartland, Southwest Pennsylvania, the Gulf Coast, and New Mexico. The project was initiated by former Secretary of Energy, Ernest J. Moniz, and engages a breadth of MIT and Harvard faculty and researchers across academic domains including Economics, Engineering, Sociology, Urban Studies and Planning, and Political Science.

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White Paper #7
Grid Impacts of the Electric Vehicle Transition in the Industrial Heartland

As the transportation sector decarbonizes, EV (Electric Vehicle) adoption will materially change both the economies of the Industrial Heartland and electric utility company operations in those communities where vehicle electrification occurs. The economies of the Industrial Heartland are very closely interconnected with the manufacturing sectors that support the ICE (Internal Combustion Engine) automotive industry. For example, in Michigan, 35% of GSP in 2019 was related to the automotive sector.[1] A transition to an electrified automotive industry will have clear challenges and opportunities over the next decade.

Congruent to the changes that will occur in the broader economy due to the transition to an electrified automotive industry, utility operations will need to adjust accordingly. Grid planning will need to be able to support additional load requirements due to vehicle charging. Charging patterns will need to be closely monitored to ensure reliability and peak demands are met. Generation will become increasingly flexible to meet the needs of changing market dynamics.

A well-managed transition to an electrified automotive industry can also help facilitate a transition to a cleaner economic future. The electric grid will help facilitate this transition as generation sources become increasingly clean, customer charging needs evolve, and the economy shifts to support an auto manufacturing economy focused on electric vehicles. Strong cross-sector partnerships across utilities, the auto sector, communities, and policymakers will be critical in ensuring successful planning and development of the evolving electrified economy.

Electric utility planning processes have been put in place to capture the needs and requirements of changing market dynamics on the electrical system. In the 1970s and 1980s, the adoption of central air conditioning had significant impacts on energy requirements. As a result, investments and upgrades were made to assure system reliability. Today, electric utilities regularly file long-term plans in support of continued infrastructure investments, including grid planning and integrated generation resource planning to assure future needs are met.

EV Forecasts and Grid Impacts

A key component of these planning activities is long-term load forecasting. Traditionally, load forecasting looked at economic activity such as customer growth rates and GDP growth to forecast energy consumption. However, with the growth of new technologies that impact energy efficiency, electric vehicles, solar generation and batteries, forecasting has become much more complex.

To accurately predict the impact electric vehicles will have on the distribution system, planners will need: (1) Knowledge of the penetration rate of these vehicles at a much more granular level (e.g. at the circuit, household or business/organization level), (2) knowledge of when customers will charge their vehicles (during the day or at night) and (3) what type of charging will be

[1] Detroit Regional Chamber. "MICHauto Finds Auto Industry Has $225 Billion Economic Contribution To Michigan." 28 May 2019. [MICHauto Finds Auto Industry has $225 Billion Economic Contribution to Michigan - Detroit Regional Chamber (detroitchamber.com)]

utilized (base charging, L2 fast charging or advanced L2 charging). While advanced metering infrastructure (e.g., smart meters) has enhanced forecasting capabilities at the hourly level, the adoption of electric vehicles is still in its infancy and much can change.

While there are differing opinions on the pace of EV adoption, one thing is clear, EV's are the future of the automotive industry. The majority of the world's vehicle manufacturers are committed to an EV future. New EV vehicle models are being announced and launched at a record pace with many manufacturers committing to an "all-electric" future product line up by as early as 2035. A sample of recent announcements is listed in Exhibit A[2]:

Exhibit A: EV Announcements

U.S. Light Duty Vehicle Sales, 2019 (millions of units)		Commitment	Announced
17.1			
2.9	Other OEMs	*Note: 216k from Tesla*	
1.3	NISSAN MOTOR CORPORATION	EV variant for all models by 2030	Jan 2021
1.3	HYUNDAI MOTOR GROUP	40% EV/PHEVs by 2030	Dec 2020
1.6	HONDA	100% ZEVs by 2040	Apr 2021
2.2	STELLANTIS	EV variant for all models by 2025	Jan 2021
2.4	TOYOTA	70% EV/PHEVs by 2030	Feb 2021
2.4	Ford	40% EVs by 2030	May 2021
2.9	gm	100% ZEVs by 2035	Jan 2021

Based on these announcements, vehicle forecasters such as Bloomberg, IHS Markit, McKinsey & Co., among others have been increasing their outlook for the EV market. By 2040, DTE is projecting that 1.3M electric vehicles will be operational in its service territory. Passenger electric vehicles are projected to reach total cost of ownership parity by 2026 with ICE vehicles, excluding subsidies. Interest in electrification of fleets is also growing, with companies such as Amazon, FedEx, and Uber committing to electrify their fleets.[3] As of April 2021, there were 48 medium-duty electrified models, 29 heavy-duty models, and 40 bus models available, and these options are expected to grow.[4] Government policy, both federal (viz. tax and incentives) and state (e.g., California Air Resource Board CARB), become the dominant drivers of adoption after

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[2] PHEV is a plug-in-hybrid-electric vehicle and ZEV is a zero-emissions-vehicle

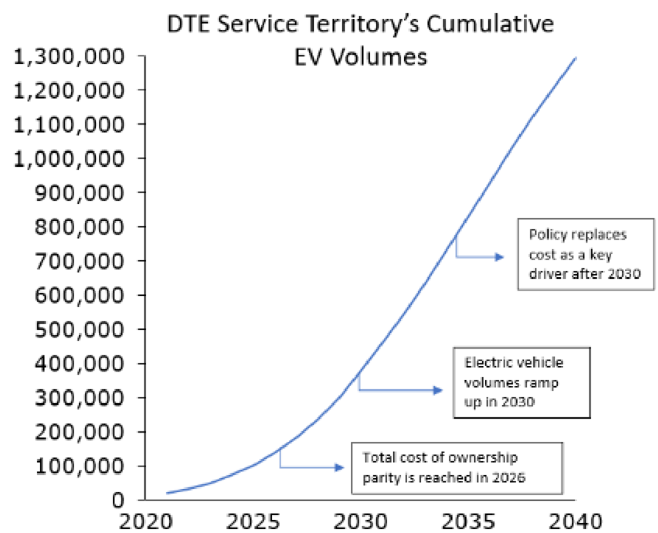
[3] See: https://sustainability.aboutamazon.com/; https://www.fedex.com/en-us/sustainability.html; https://www.uber.com/us/en/about/sustainability/

[4] MJ Bradley & Associates, "Electric Vehicle Market Status – Update," April 20201, https://www.mjbradley.com/sites/default/files/EDF_EV_Market_Report_April_2021_Update.pdf

2030. Government incentives and supportive policies are key assumptions of adoption, if incentives fade, so will adoption. The combination of these factors creates the market dynamic to drive up EV sales volumes exponentially. Of course, policy has the potential to change; therefore, planning must remain flexible so as to account for market and policy forces. DTE's current EV volume forecast is shown in Exhibit B.

For the purposes of the discussion on grid impacts of EV adoption, the time horizon of the forecast is broken into two-time frames: The next 5-10 years, roughly 2020-2030, and the next 10 years following, roughly 2030 -2040. The forecasting timeline is broken into two for a few reasons. From a distribution perspective, it is difficult to plan the infrastructure in any locational detail past a 10-year forecast horizon. Once beyond that point, the forecast is primarily based on trends and projections at a regional level, which drives broad estimates in costs rather than investments in specific infrastructure.

Exhibit B: DTE EV Forecast



Transition to EVs – 2020-2030:

In May 2020, DTE conducted a grid impact study of electric vehicle adoption. Based on analysis and modeling of a representative sample of DTE circuits, the study found:[5]

- "Up to 20% of EV penetration can be accommodated on many circuits without major upgrades, but clusters of early, high adoption will require localized investments."
- "Because the timing of widespread EV adoption is uncertain, the suitability of grid infrastructure, planning criteria, and standards should continue to be evaluated and incorporated into DTE's multi-year standards update cycle. For example, where applicable, running three-phase wires to more premises will help reduce phase imbalance, and deploying larger distribution transformers will mitigate unnecessary, expensive upgrade costs in the future."[6]
- "Continuing to pilot managed charging solutions and alternatives to infrastructure upgrades like battery storage will be important to minimize distribution system investment as EV penetration increases."

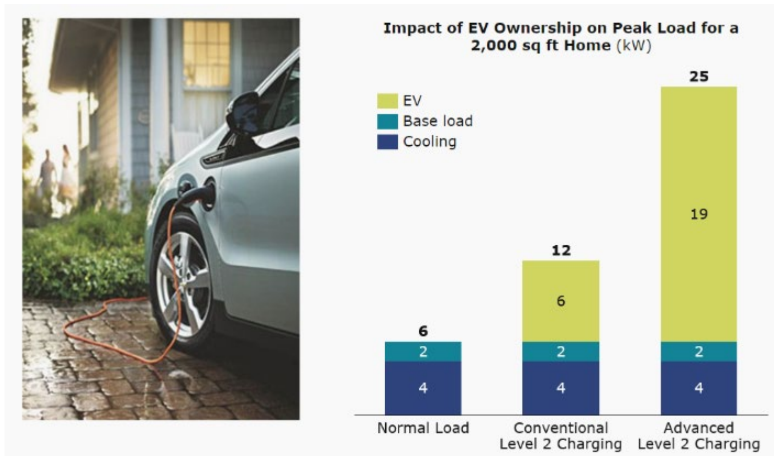
[5] Class 1-8 vehicles and charging up to 500 kW were considered for the study. EV impacts are extremely dependent on the specific circuit infrastructure and load allocation.

[6] This finding is specifically addressing that when a transformer needs to be replaced for other reasons, it may be replaced with a larger size to accommodate future EV utilization, thus eliminating the need for a second upgrade in the future

Studies from other regions have also highlighted the unique aspects of planning for fleet electrification. For example, a study from National Grid highlights the potential for usage patterns to vary widely across fleets and for fleet charging to be "clustered" in specific areas.[7] The report calls for collaboration between utilities and fleet operators to further quantify electrification needs and timelines, analyze system needs and solutions (including transmission, distribution, distributed energy resources and charging programs), and understand policy considerations to facilitate and expedite interconnection of electrified fleets.

In short, from an EV penetration perspective, the distribution system and subsequent planning processes will be impacted before penetration and customer behavior changes how the generation curve looks. Advanced charging technologies (i.e., High-Speed Charging) have the potential to significantly increase peak household load depending on time of charge. An example of how electric vehicle charging (Level 2 and Advanced Level 2 charging) impacts peak load for a 2,000 sq. ft home"[8] is shown in Exhibit C.

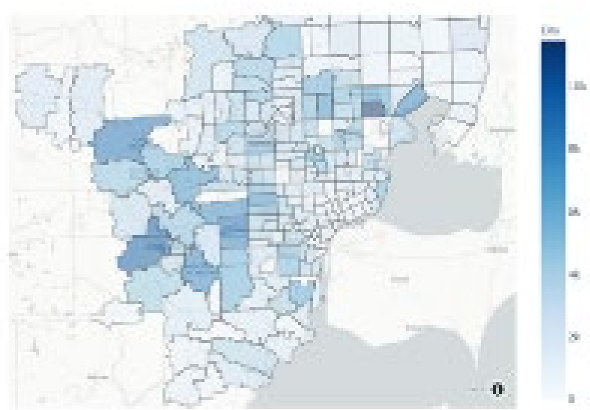
Exhibit C: Impact of EV Charging at a Household Level at Peak



Transition to EVs – 2030-2040:

Going forward, the impact on the distribution system resiliency will depend on EV penetration (Exhibit D) and clustering, or the concentration of EV adoption in a particular planning area. Beyond location of homes where EV owners may reside, it is difficult to predict exactly where vehicles will be charged. Having well-informed forecasting capabilities at the distribution level will provide insight into new construction planning for grid infrastructure. From a generation perspective, without utility-

Exhibit D: 2030 Penetration of EVs by Zip



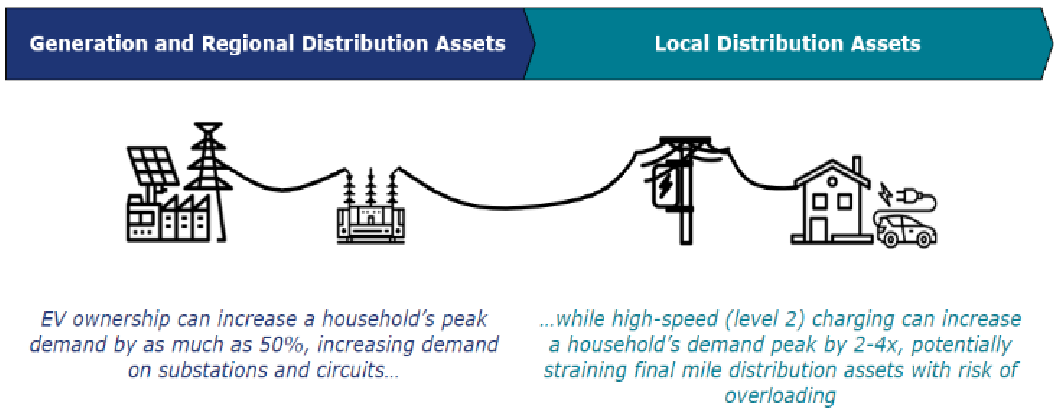
[7] National Grid and Hitachi ABB Power Grids, "The Road to Transportation Decarbonization: Understanding Grid Impacts of Electric Fleets," September 2021, https://www.nationalgridus.com/media/pdfs/microsites/ev-fleet-program/understandinggridimpactsofelectricfleets.pdf

[8] The 2,000 sq ft home size is just a point of reference, not a criterion.

controlled charging, generation needs are likely to be highly coupled to pricing signals, incentives, and convenience of charging behavior.

As the Industrial Heartland continues to transition its grid infrastructure to support EV adoption, the following Exhibit E highlights some central considerations that will impact potential system upgrades.

Exhibit E: EV adoption drives need for system



Example of changes that may be needed to support EV growth

- Additional generation capacity
- Distribution voltage level increases
- Upgraded distribution circuits and transformers
- Rate structures that incentivize optimal charging times

Changes in generation planning will largely depend on overall penetration of EV's while local distribution asset management will depend on charging patterns and charging technologies. Rate design and customer programs such as TOU (Time of Use) rates, or variable electric rates dependent on the time of energy use, could influence the shift of load to optimize charging time periods. This would reduce the need for additional generation capacity to be added based on current generation mix to meet peak demand. In other words, the existing generation assets could be optimized to meet charging needs if demand were shifted to off-peak times. Optimal charging times may shift over time as generation mixes change. For example, as solar penetration increases and there is a surplus of solar generation during specific times of the day, charging during those periods may be incentivized by adjusted TOU rates. Customer behavior and charging patterns are still unknown, and it is not yet proven that pricing signals alone will be enough to drive customer decisions relative to charging. These factors will need to be considered through regular forecasting, via electric utility planning processes, and various customer pilots and feedback mechanisms to improve and optimize long-term planning to meet customer needs.

Grid Planning Considerations:

Utilities will need to evolve the processes and standards that are fundamental to planning and investing to meet the changing customer needs that will come with an increased adoption of electric vehicles. Three core considerations in grid planning that may evolve are the integration of EV forecasts into planning, changes to standards, and the increased importance of grid reliability and resiliency.

Integrating EV Forecasts into Planning:

An accurate load forecast is fundamental to grid planning and to efficiently invest in grid infrastructure. Forecasting informs the need for upgrades to the grid such as new substation construction or expansion, circuit upgrades, or other area upgrades to support loading. There are multiple facets of EV loading that will make forecasting more complex, including initial localized adoption of vehicle purchases, timing of charging, and even location of charging (e.g., home vs workplace). All of these variables will impact the load forecast on a circuit or substation. The current state of forecasting may be primarily focused on peak load at a circuit or substation level. Integrating an EV forecast into the planning process will generate load data at a more granular level, both in time (hourly) and in higher spatial resolution (sections of circuits). This type of load forecast will help identify grid needs, which may be either localized high density loads at a location such as charging depot, or more distributed load increases due to broad adoption of home charging.

Electric Utility Planning Standards:

After understanding the potential loading impacts indicated by a forecast with integrated EV impact, utilities may need to make updates to standards to account for increased overall loading or increased loading density. As much of the grid infrastructure equipment has a lifespan of decades, prudent changes to upgrades today may prevent rework in the future. Some examples of upgraded planning standards may include upgrading components such as insulators, conductors and transformers, or enhancing circuit configuration to run three-phases throughout a larger area of the circuit and even to premises. Changes in standards or requirements may even be necessary at the building code level, requiring different service panels or other equipment in residences if customers desire the fastest charging capabilities that future EVs will be capable of. Finally, utilities may need to consider increasing the distribution voltage level to support the EV growth.

Grid Reliability and Resilience:

The increase in EV penetration has the potential to significantly increase load on the grid. One aspect of grid planning, which was previously discussed, is designing and upgrading the system to ensure there is sufficient capacity to support this new load. Another aspect of grid planning is improving reliability and resiliency of the grid. The concepts of reliability and resiliency are related but have some fundamental differences. Reliability is generally tied to traditional grid metrics such as SAIFI (System Average Interruption Frequency Index) (frequency of outages), and SAIDI (System Average Interruption Duration Index) (duration of outages). Resiliency is generally defined by Institute of Electrical and Electronics Engineers (IEEE) as the ability of the grid to withstand and recover from significant events that can impact the grid.

There are two key reasons that grid reliability and resiliency may increase in importance over the next 10-20 years as adoption of EVs increases. The first is the increased threat of extreme weather, potentially due to climate change. If the frequency and intensity of storms increase, the impact on customers and the outages they will experience could increase without additional measures to strengthen grid infrastructure. The second reason is the increased dependency on electricity to meet customer needs. Over the last couple of years, customers have come to depend on reliable electric service to not only keep their lights and appliances on, but also to enable remote work and remote schooling. Looking forward to a future where mobility is also tied to reliable electric service, customers will be even less likely to tolerate frequent or lengthy outages. As a result, typical metrics utilities look at to determine investment needs may expand to include data that measures where customers experience long duration outages (CELID) or frequent outages (CEMI) (Customers Experiencing Multiple Interruptions).

Investments to harden the system and reduce the frequency of outages typically include programs such as tree trimming, and hardening efforts that increase the strength of circuit equipment such as poles, crossarms and insulators. Additional investments can make the grid more flexible and resilient to potential disruptions. This can include a suite of upgrades that can detect and isolate faults and restore portions of the outage automatically and remotely. To implement this flexibility may require grid capabilities to physically isolate the fault, sufficient capacity on a neighboring circuit to transfer the load, and an overall technology and control platform to coordinate the operations. These types of investments go beyond the basic hardening and reliability programs but can limit the impact of any outage event that does occur.

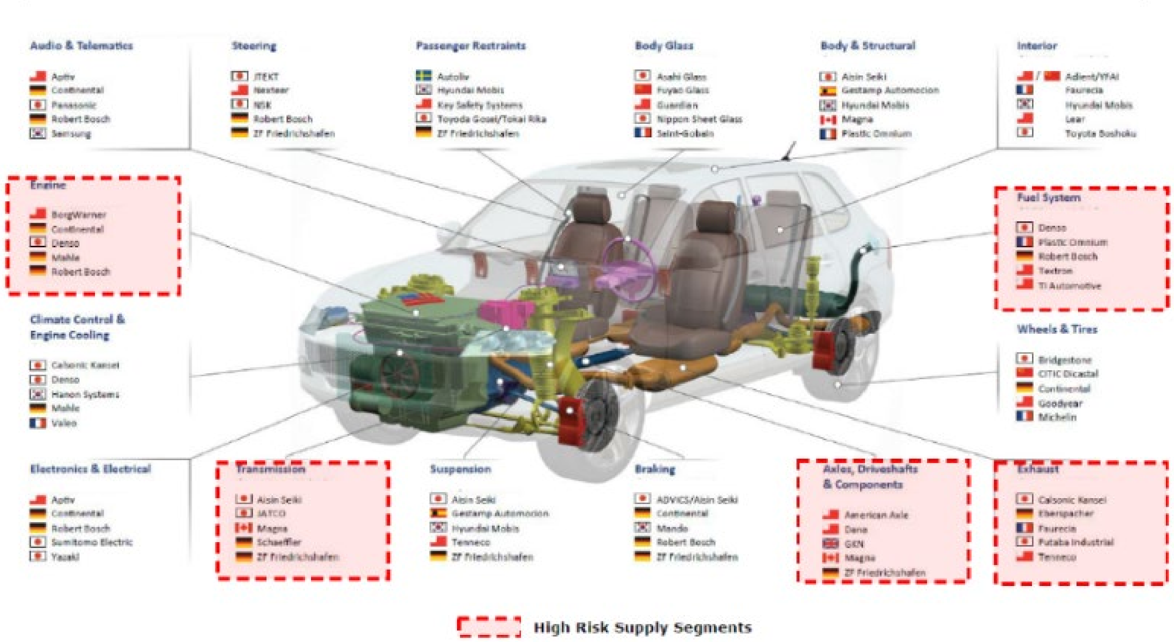
Economic impact of transition from ICE to EV manufacturing

The EV transition in the Industrial Heartland has impacts that extend beyond EV adoption and grid penetration. The current auto manufacturing sector and supply chain in the region would see shifts in the transition from internal combustion engine vehicles to electric vehicles. From a

Exhibit F: High Risk Supply Segments of an ICE Vehicle

manufacturing perspective, this region, particularly Southeast Michigan, has a large concentration of drivetrain and powertrain manufacturing. In addition to the ICE (Internal Combustion Engine) engine becoming obsolete in the transition to EV’s, traditional exhaust systems, fuel systems, drivetrain components (axles, driveshafts, etc.) and transmissions are at elevated risk for obsolescence (see Exhibit F below). In Michigan, powertrain and drivetrain manufacturing currently account for about 30,000 jobs and the three-state region of Michigan, Ohio and Indiana employ over 75,000 in the powertrain and drivetrain sectors.[9] This date drives the conclusion that a transition to an EV auto sector will eliminate the need for many vehicle components, specifically in the powertrain and drivetrain sectors, that will result in a loss of jobs

Total non-assembly components per ICE vehicle



Recommendations:

- Moving forward, the regulatory construct should continue to serve the goal of aligning stakeholders to meet changing energy needs while maintaining a clear focus on safety, reliability, affordability, a transition to cleaner energy, and innovation of the system and electric vehicle integration. Rate design should support customers in a smart and affordable way – it should align the costs of the grid with how customers use the grid, signaling the optimal approaches to integrating new technology. Flexible regulatory processes and approaches will help electric utilities manage for changes in technology, customer adoption, and grid enhancements in alignment with policymakers and stakeholders. Considerations should include:
    - Advanced rate design can signal the most efficient times for customers to charge their vehicles – continued advances in aligning grid costs with rate design, and an improved understanding the locational impacts of EV grid integration, will support smart and grid-efficient rate options for EV customers and other technology adopter

[9] U.S. Bureau of Labor Statistics 2019 - Quarterly Census of Employment and Wages, NAICS code 33631 (Motor vehicle gasoline and parts mfg.) and 33635 (Motor vehicle powertrain components mfg.)

- Flexible regulatory mechanisms which: 1) support changing customer and grid requirements and 2) align policymakers, electric utilities, industry, and other stakeholders
- Electric vehicle adoption will have a significant impact on overall electric sales, but equally important is how charging patterns will evolve. If charging (both L2 and advanced L2) occur during peak energy consumption times, it has the potential to stress the distribution system. TOU rates and other incentives to influence charging patterns optimized for utility planning purposes are going to be important elements in reducing this risk. Managed charging programs and smart grid charging solutions should be evaluated and included as potential solutions to reduce peak energy consumption and reduce the need for upgrades and investments in additional infrastructure.

- Electric vehicles require fewer components leading to simpler assembly and a smaller labor force. As the economies transition to an electric future, many supply chains and component manufacturing will be disrupted. A likely offset to some of these economic losses could include battery development and assembly, electronic components and electric motors. A comprehensive regional economic development policy for the Industrial Heartland should be put in place to address the loss of existing operations and the transition to an electrified manufacturing future. This policy ought to include plant re-purposing, employee re-education and general policy to support the development of an EV supply base in the region.

- Because building codes and standards may not account for charging infrastructure in their current condition, states may need to evaluate potential changes to those codes and standards for services in new homes or neighborhoods. Ensuring consistency across the state for building codes and standards will ensure safety in the deployment and continued build out of EV infrastructure planning and development, which eventually, will reduce the chance of overloading circuits in homes, businesses and garages. Additionally, planning for EV charging in new commercial installations and parking garages is necessary to increase access to charging in public spaces.

Additional policy recommendations for consideration are included in DTE's 2020 Grid Impact Study

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