Sargent & Lundy
Electric Vehicles and Transportation

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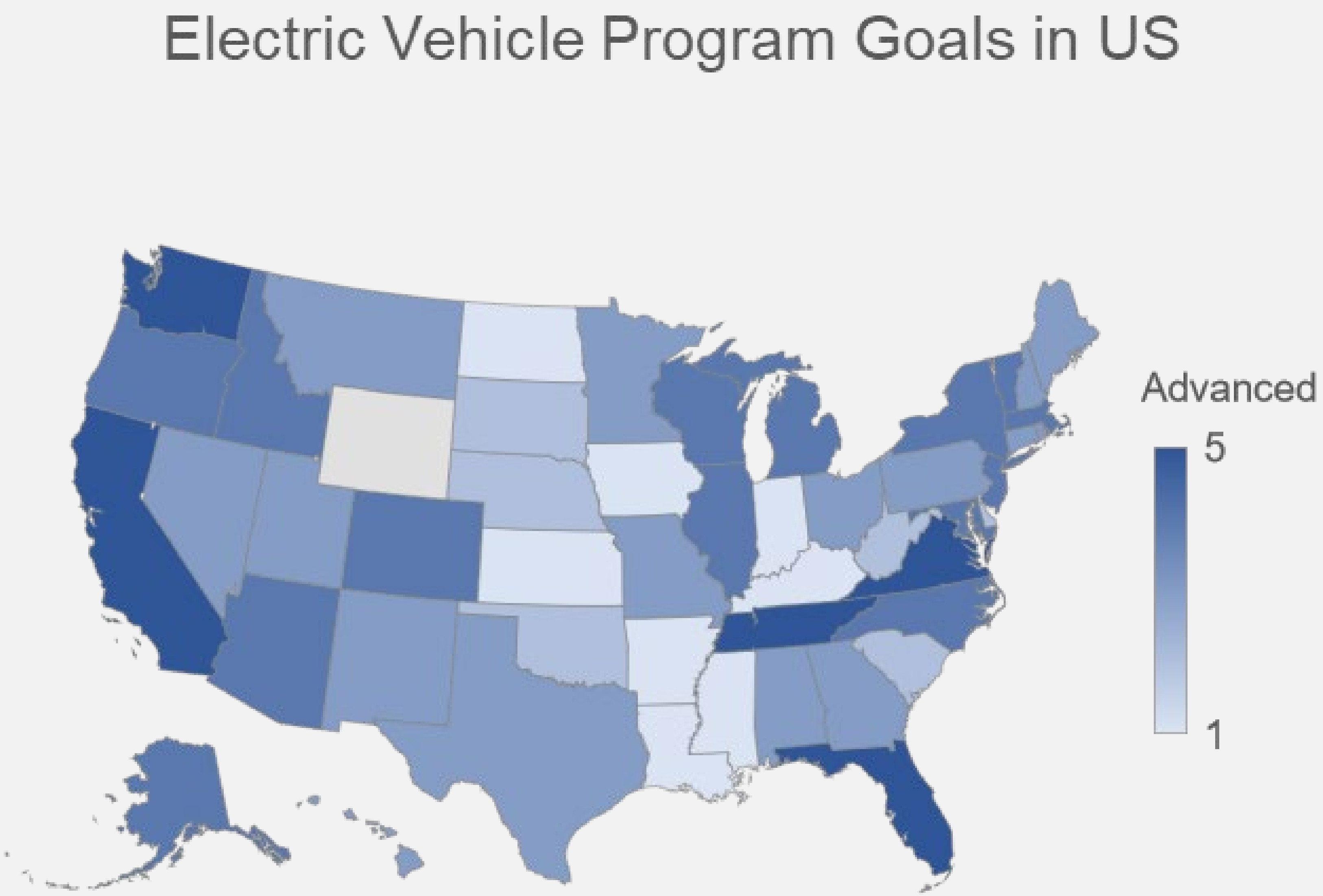
Agenda

- Federal and State policy review
- Growth in electric requirements and demand
- Need for Load side energy management
- Potential solutions for controlling BtM loads
- Innovative designs over time
- Utility connection standards for loads

Federal and State mandates for EV Adoption



- Executive Order establishing a target of half of new vehicles sold in 2030
- Maine and Idaho targeting all vehicles sold by 2030
- CA, VA, and WA target of all vehicles sold in 2035
- OR targeting 90% of vehicles sold in 2035
- All medium and Heavy duty trucks sold in NJ by 2050 and all transit buses by 2032
- Other states targets feature increasing the number of EV vehicles deployed

H.R. 3684 – Infrastructure Bill

Highway Trust Fund (other than the Mass Transit Account):

(C) Charging and fueling infrastructure grants.--To carry out section 151(f) of title 23, United States Code-- (i) $300,000,000 for fiscal year 2022; (ii) $400,000,000 for fiscal year 2023; (iii) $500,000,000 for fiscal year 2024; (iv) $600,000,000 for fiscal year 2025; and (v) $700,000,000 for fiscal year 2026.

SEC. 11109. SURFACE TRANSPORTATION BLOCK GRANT PROGRAM. (a) In General.--Section 133 of title 23, United States Code, is amended--

SEC. 11401. GRANTS FOR CHARGING AND FUELING INFRASTRUCTURE.

Maximum grant amount - $15,000,000

SEC. 25006. ELECTRIC VEHICLE WORKING GROUP

SEC. 25007. RISK AND SYSTEM RESILIENCE. (a) In General.--The Secretary, in consultation with appropriate Federal, State, and local agencies, shall develop a process for quantifying annual risk in order to increase system resilience with respect to the surface transportation system of the United States by measuring

SEC. 40107. DEPLOYMENT OF TECHNOLOGIES TO ENHANCE GRID FLEXIBILITY.

``(10) The ability to facilitate the aggregation or integration of distributed energy resources to serve as assets for the grid. ``(11) The ability to provide energy storage to meet fluctuating electricity demand, provide voltage support, and integrate intermittent generation sources, including vehicle-to- grid technologies.

``(14) The ability to facilitate the integration of renewable energy resources, electric vehicle charging infrastructure, and vehicle-to-grid technologies. ``(15) The ability to reliably meet increased demand from electric vehicles and the electrification of appliances and other sectors.''. (b) Authorization of Appropriations.--There is authorized to be appropriated to the Secretary to carry out the Smart Grid Investment Matching Grant Program established under section 1306(a) of the Energy Independence and Security Act of 2007 (42 U.S.C. 17386(a)) $3,000,000,000 for fiscal year 2022, to remain available through September 30, 2026

SEC. 40112. DEMONSTRATION OF ELECTRIC VEHICLE BATTERY SECOND-LIFE APPLICATIONS FOR GRID SERVICES.

SEC. 40208. ELECTRIC DRIVE VEHICLE BATTERY RECYCLING AND SECOND-LIFE APPLICATIONS PROGRAM.

SEC. 40414. DATA COLLECTION ON ELECTRIC VEHICLE INTEGRATION WITH THE ELECTRICITY GRIDS.

(a) In General.--Not later than 1 year after the date of enactment of this Act, the Administrator shall develop and implement measures to expand data collection with respect to electric vehicle integration with the electricity grids. (b) Sources of Data.--The sources of the data collected pursuant to subsection (a) may include-- (1) host-owned or charging-network-owned electric vehicle charging stations; (2) aggregators of charging-network electricity demand; (3) electric utilities offering managed-charging programs; (4) individual, corporate, or public owners of electric vehicles; and (5) balancing authority analyses of-- (A) transformer loading congestion; and (B) distribution-system congestion.

SEC. 40431. CONSIDERATION OF MEASURES TO PROMOTE GREATER ELECTRIFICATION OF THE TRANSPORTATION SECTOR. (a) In General.--Section 111(d) of the Public Utility Regulatory Policies Act of 1978 (16 U.S.C. 2621(d)) (as amended by section 40104(a)(1)) is amended by adding at the end the following: ``(21) Electric vehicle charging programs.--Each State shall consider measures to promote greater electrification of the transportation sector, including the establishment of rates that-- ``(A) promote affordable and equitable electric vehicle charging options for residential, commercial, and public electric vehicle charging infrastructure; ``(B) improve the customer experience associated with electric vehicle charging, including by reducing charging times for light-, medium-, and heavy-duty vehicles; ``(C) accelerate third-party investment in electric vehicle charging for light-, medium-, and heavy-duty vehicles; and ``(D) appropriately recover the marginal costs of delivering electricity to electric vehicles and electric vehicle charging infrastructure.''.

H.R. 3684 – Infrastructure Bill

TITLE XI--CLEAN SCHOOL BUSES AND FERRIES SEC. 71101. CLEAN SCHOOL BUS PROGRAM.

SEC. 71102. ELECTRIC OR LOW-EMITTING FERRY PILOT PROGRAM.

Federal Highway Administration

highway infrastructure program

For an additional amount for ``Highway Infrastructure Programs'', $47,272,000,000, to remain available until expended except as otherwise provided under this

(2) $5,000,000,000, to remain available until expended for amounts made available for each of fiscal years 2022 through 2026, shall be to carry out a National Electric Vehicle Formula Program (referred to in this paragraph in this Act as the ``Program'') to provide funding to States to strategically deploy electric vehicle charging infrastructure and to establish an interconnected network to facilitate data collection, access, and reliability: Provided, That funds made available under this paragraph in this Act shall be used for: (1) the acquisition and installation of electric vehicle charging infrastructure to serve as a catalyst for the deployment of such infrastructure and to connect it to a network to facilitate data collection, access, and reliability; (2) proper operation and maintenance of electric vehicle charging infrastructure; and (3) data sharing about electric vehicle charging infrastructure to ensure the long-term success of investments made under this paragraph in this Act

port infrastructure development program

For an additional amount for ``Port Infrastructure Development Program'', $2,250,000,000, to remain available until September 30, 2036:

(1) Port electrification or electrification master planning;

(6) Worker training to support electrification technology;

(8) Electric vehicle charge or hydrogen refueling infrastructure for drayage, and medium or heavy duty trucks and locomotives that service the port and related grid upgrades; or (9) Other related to port activities including charging infrastructure, electric rubber-tired gantry cranes, and anti- idling technologies:

International – COP26

Clean energy at COP26: Philanthropists and investors launch $100bn alliance as UK and India collaborate on green grids

2 November 2021, source edie newsroom

The Bezos Earth Fund, Ikea Foundation and Rockefeller Foundation have forged a major new alliance with central investment banks, aiming to mobilize $100bn for renewable energy, other low-carbon technologies and green jobs.

Funding and support will also be provided to microgrids and minigrids, in recognition of the fact that remote villages do not always have access to other connections, and to smart electric vehicle (EV) charging that can help balance the grid.

[Clean energy at COP26: Philanthropists and investors launch $100bn alliance as UK and India collaborate on green grids (edie.net)]

IL benchmarking to promote adoption

TABLE 1 Policies Promoting PEV Adoption in Illinois and the 12 ZEV States

State Policies/Programs	CA	CO	CT	IL	ME	MD	MA	NJ	NY	OR	RI	WA
ZEV program	Y	Y	Y		Y	Y	Y	Y	Y	Y		Y
PEV purchase subsidy	Y		Y		Y		Y	Y	Y	Y	Y	
PEV tax credit/sales tax exemption		Y				Y		Y				
Public fleet purchase subsidy	Y						Y		Y			
Truck/bus purchase incentive/tax exemption	Y					Y	Y		Y	Y		
State fee reduction or testing exemption		Y[a]	Y	Y[a]			Y		Y		Y	
Home EVSE incentive	Y	Y	Y			Y	Y	Y	Y	Y		Y
Public EVSE incentive	Y	Y		Y	Y	Y	Y	Y	Y			
Public fleet purchase requirement/guideline				Y								
Manufacturing incentive	Y											
EVSE permitting/building code regulation										Y		Y
HOV lane access	Y					Y		Y	Y			
Utility Programs												
Residential EVSE rebate	Y	Y	Y			Y	Y		Y	Y		
Non-residential EVSE rebate	Y	Y				Y	Y		Y	Y		
MUD and workplace EVSE rebate	Y					Y	Y					
PEV purchase/loan rebate	Y	Y	Y				Y[b]					
Charging rate reduction/incentive	Y					Y	Y		Y			

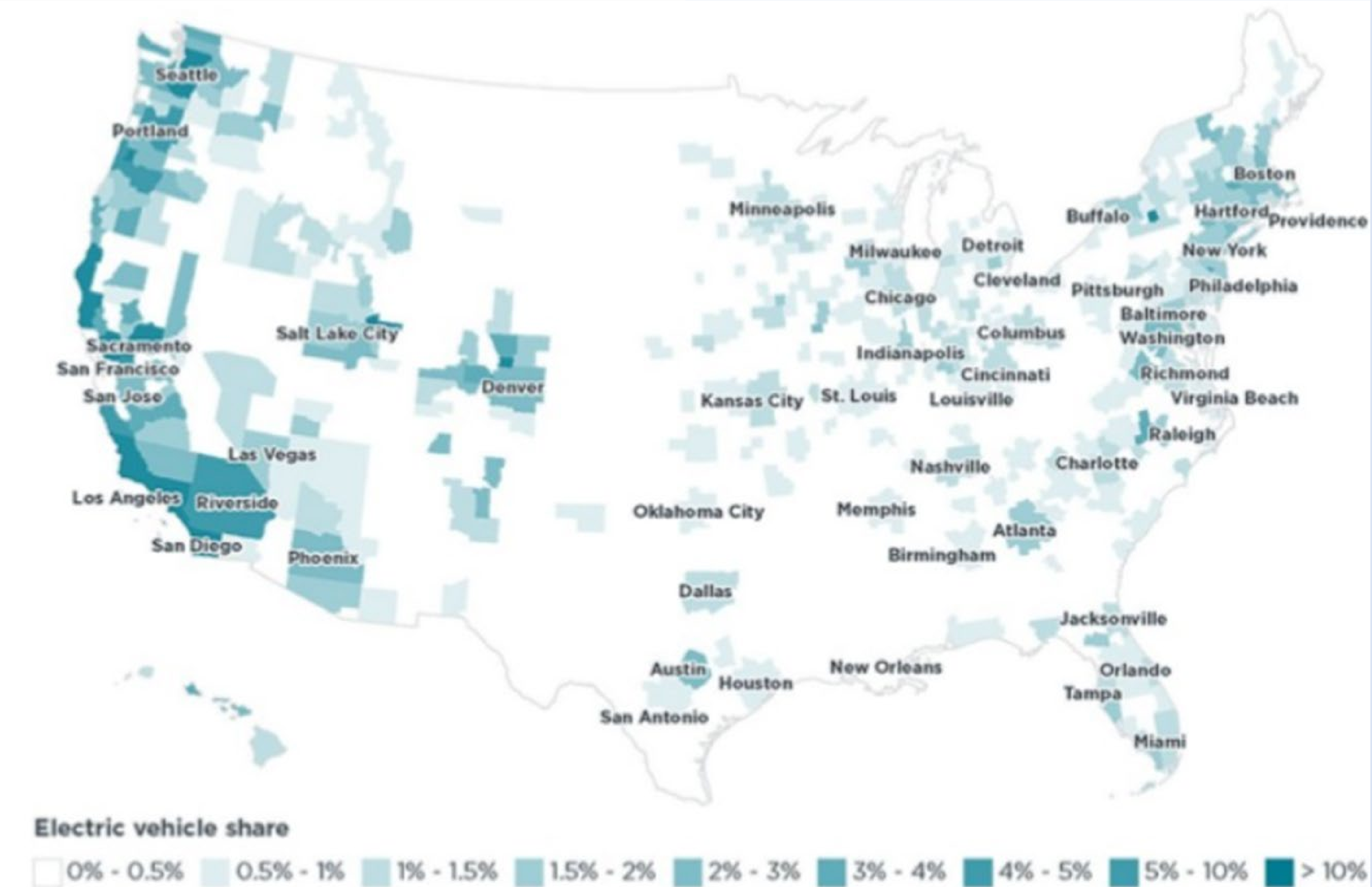
[a] Colorado, Illinois, Oregon, and Washington have an additional annual registration fee for PEVs, as do 24 other non-ZEV states.
[b] Massachusetts provides discounts on qualified PEVs purchased or leased from participating dealerships.
[c] Tacoma Public Utility provides an incentive for customers to report charging patterns.
Source: Adapted from AFDC (undated).

Electric Vehicle Market

Guide to Market Growth

EV Market share of Registered Vehicles

EV Market share less than 1% in almost all counties

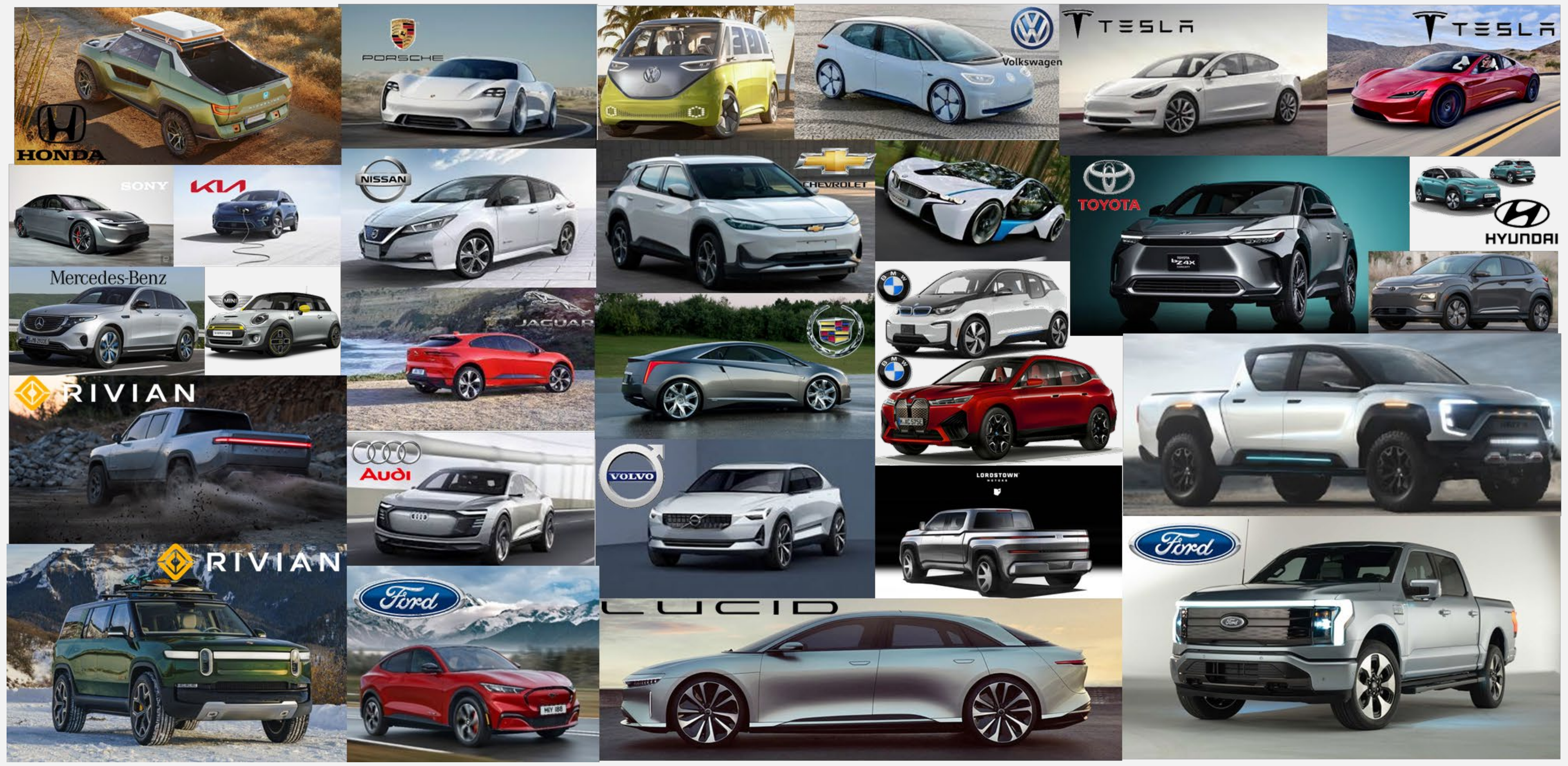


Select few counties have more than 5% registered EVs

New Electric Vehicles will drive consumer demand

Over 160 new models committed to by 2025

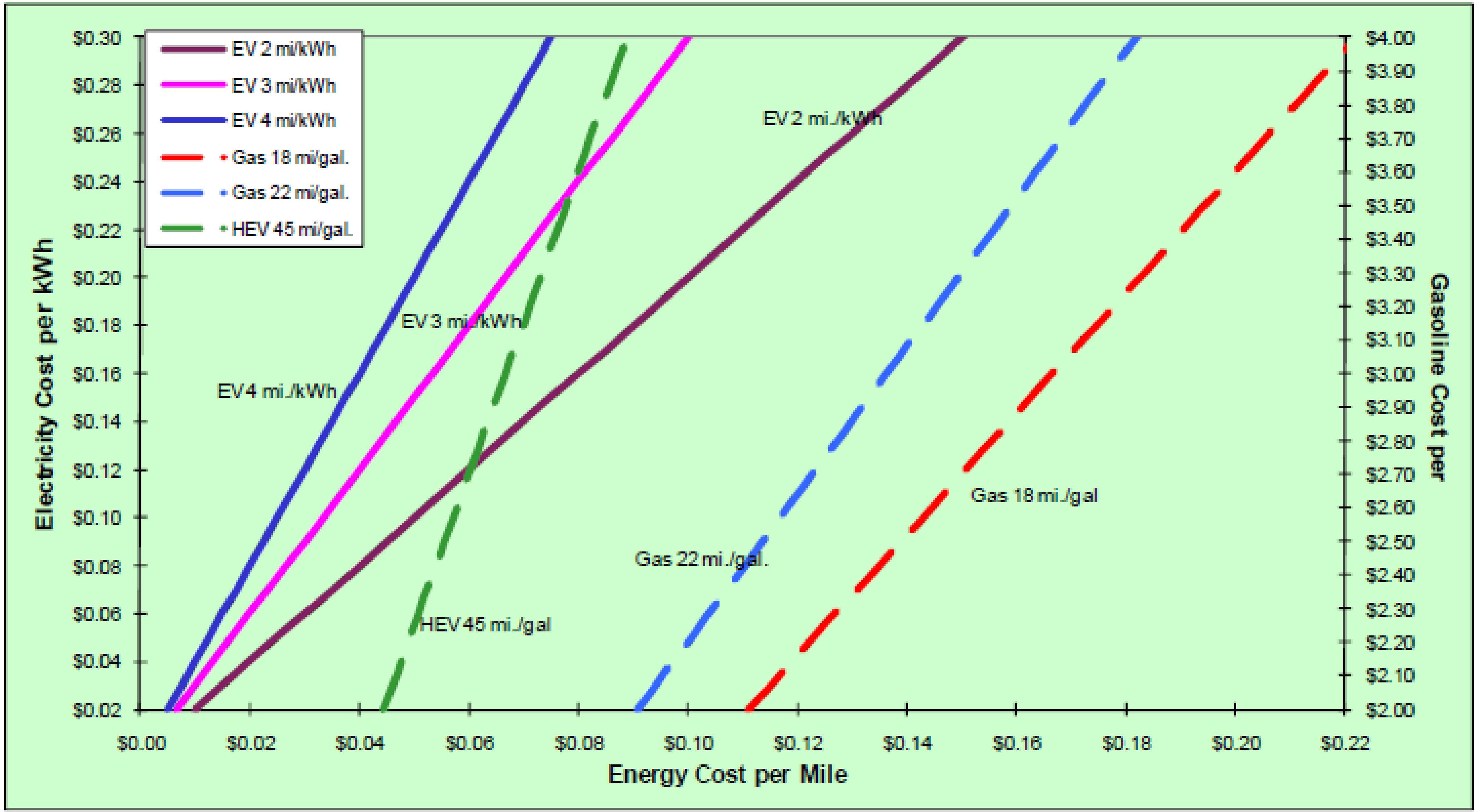
Majority of OEMs committed to stopping ICE production within this decade



The global **Electric Vehicle Charging Infrastructure market** size is expected to be worth around **US$ 150.20 billion** by 2030, according to a new report by Vision Research Reports.

The global Electric Vehicle Charging Infrastructure market size was valued at US$ 15.10 billion in 2020 and is anticipated to grow at a CAGR of 33.10% during forecast period 2021 to 2030

Electricity more cost competitive than fuel ICE Vehicles



Increasing Diesel and Gasoline Costs – As demand decreases from conversion, fuel costs will need to absorb additional refining costs over lower volume

State Revenue – Solution for substituting taxes associated for fuel needs to be developed. Models exist with low rate of deployment.

Source: Idaho National Laboratories, avt.inl.gov

Infrastructure Top Priority for Consumers

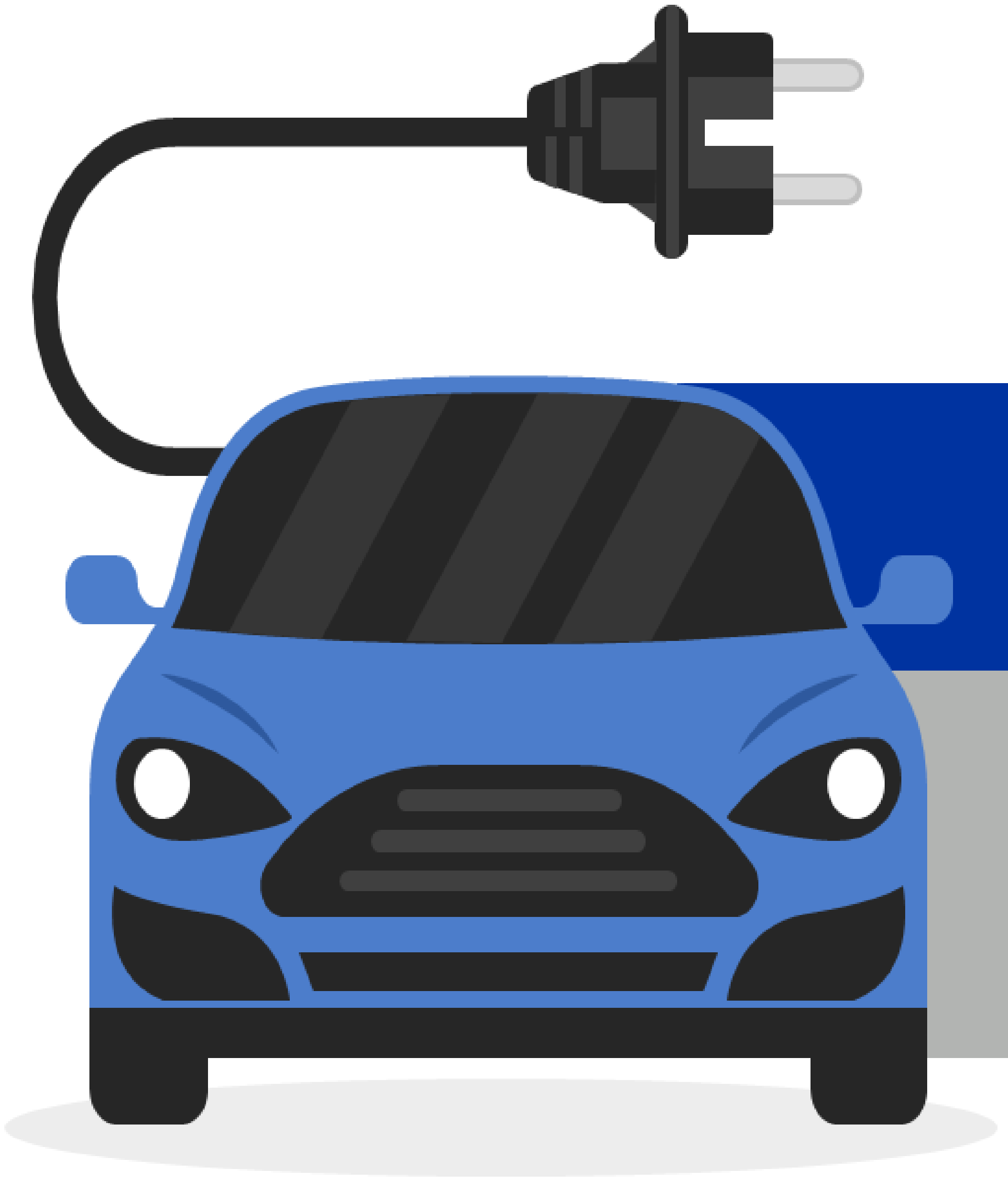
Consumer priorities for EV adoption, 2018 and 2020

Greater concerns are shown in orange.

2020 Global Auto Consumer Study	FRANCE		GERMANY		ITALY		UK		CHINA		US	
In your opinion, what is the greatest concern regarding all battery-powered electric vehicles?	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020	2018	2020
Driving range	31%	28%	35%	33%	4%	27%	26%	22%	25%	22%	24%	25%
Cost/price premium	32%	22%	22%	15%	19%	13%	24%	16%	9%	12%	26%	18%
Time required to charge	11%	15%	11%	14%	18%	16%	13%	16%	12%	15%	10%	14%
Lack of electric vehicle charging infrastructure	16%	22%	20%	25%	44%	32%	22%	33%	18%	20%	22%	29%
Safety concerns with battery technology	4%	11%	5%	10%	7%	10%	6%	12%	22%	31%	8%	13%
Others	6%	2%	7%	3%	8%	2%	9%	1%	14%	0%	10%	1%
Total	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Sample size	1,083	1,266	1,287	3,002	1,048	1,274	965	1,264	1,606	3,019	1,513	3,006

Source: Deloitte Global Auto Consumer Study[18]

EV conversion will have a major impact on the grid



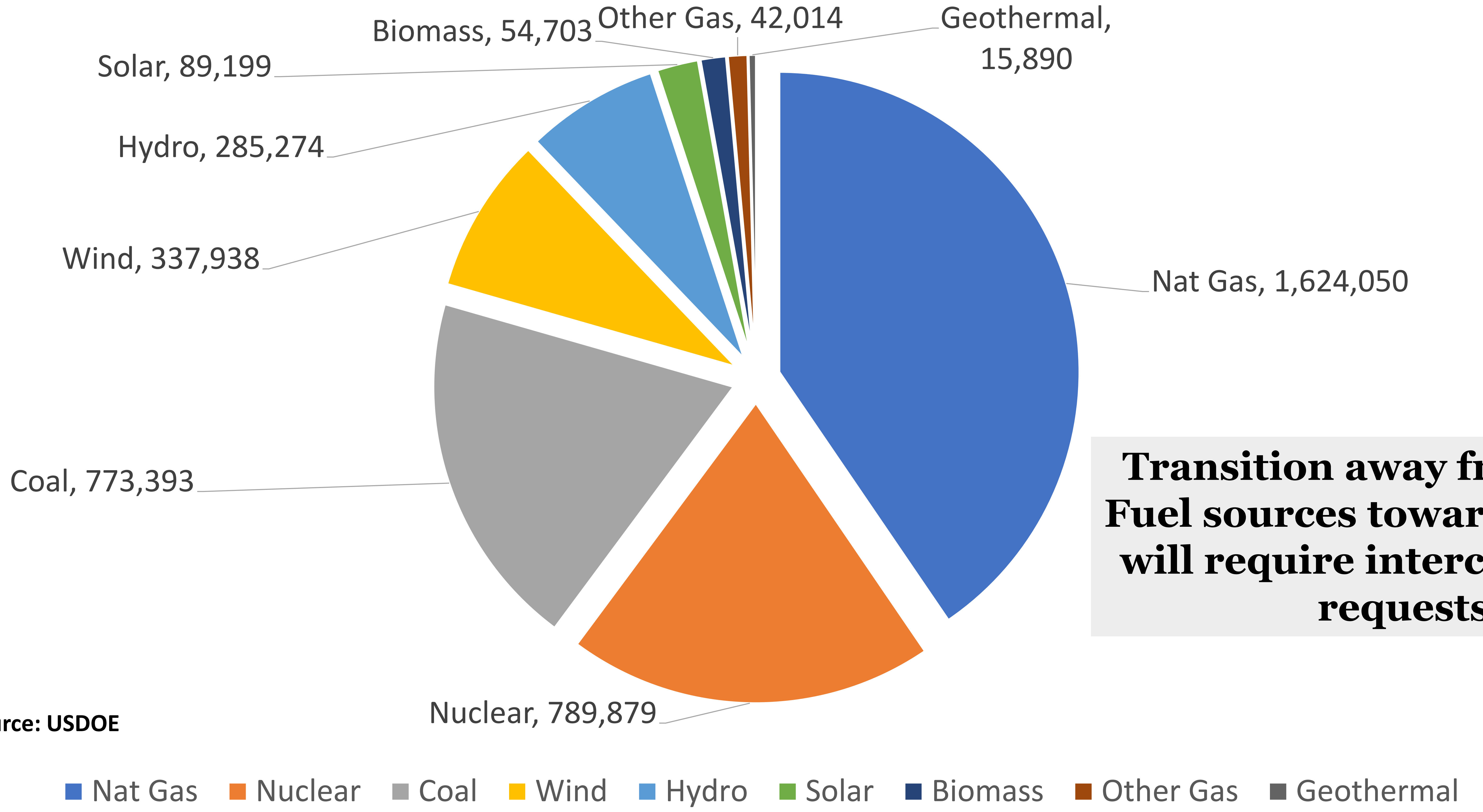
3.23 trillion miles are driven every year.

If these miles are converted into electric power, then it will be the equivalent **of 1 trillion kwh of new load** or 25% of all of the load that exists today.

Grid Expansion

Grid Complexity

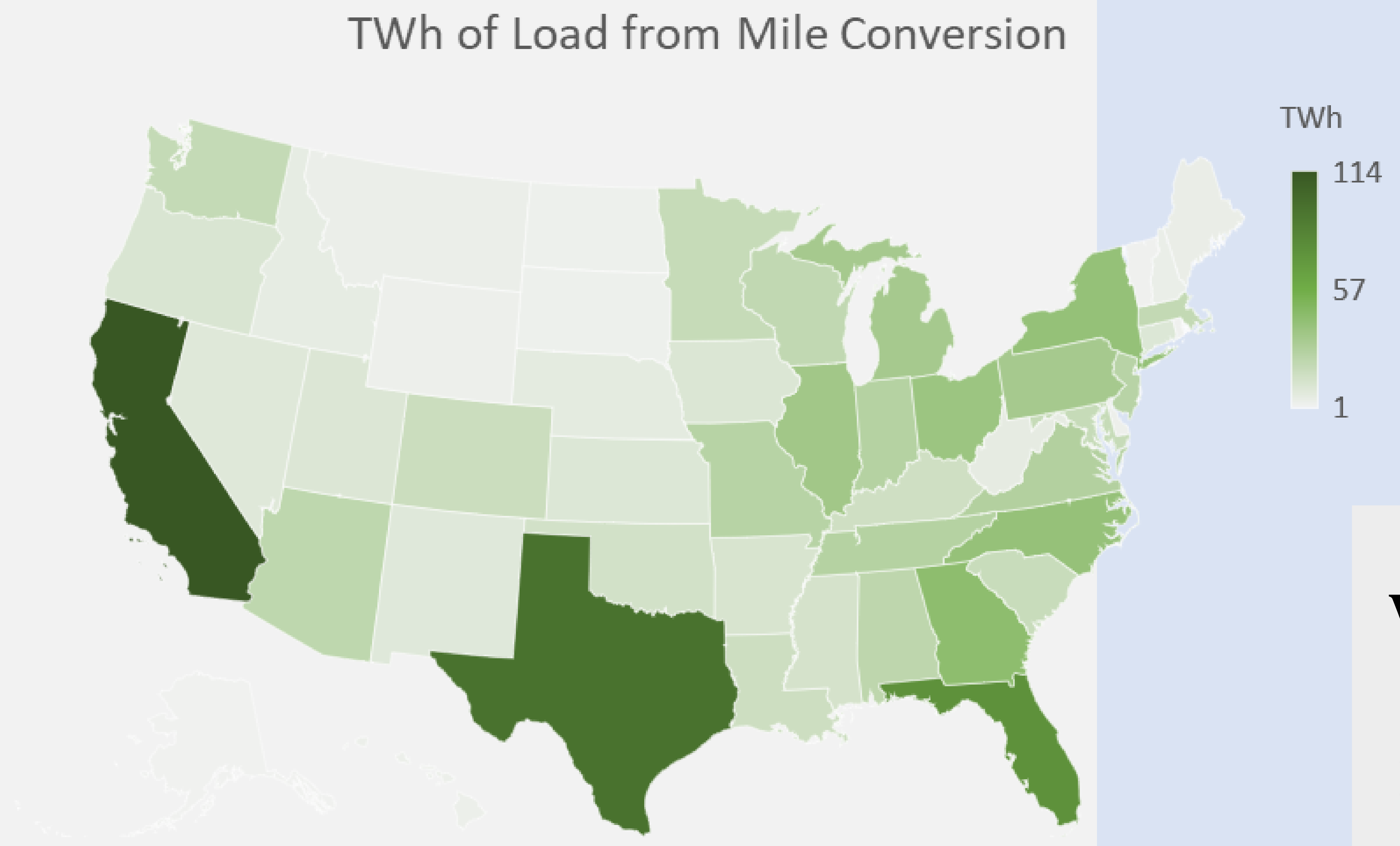
Electricity Generation US (2020 GWh)



Transition away from Fossil Fuel sources towards renewal will require interconnection requests

Source: USDOE

Electric Vehicle Increasing Demand on Grid

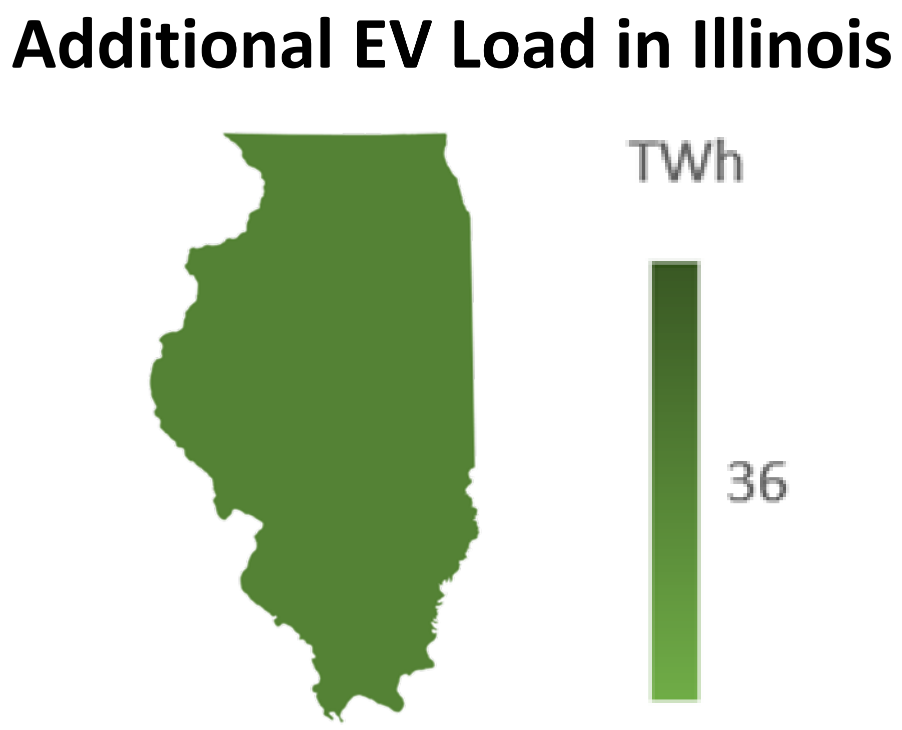


Miles converted to electricity will increase total load on grid by approximately 25%

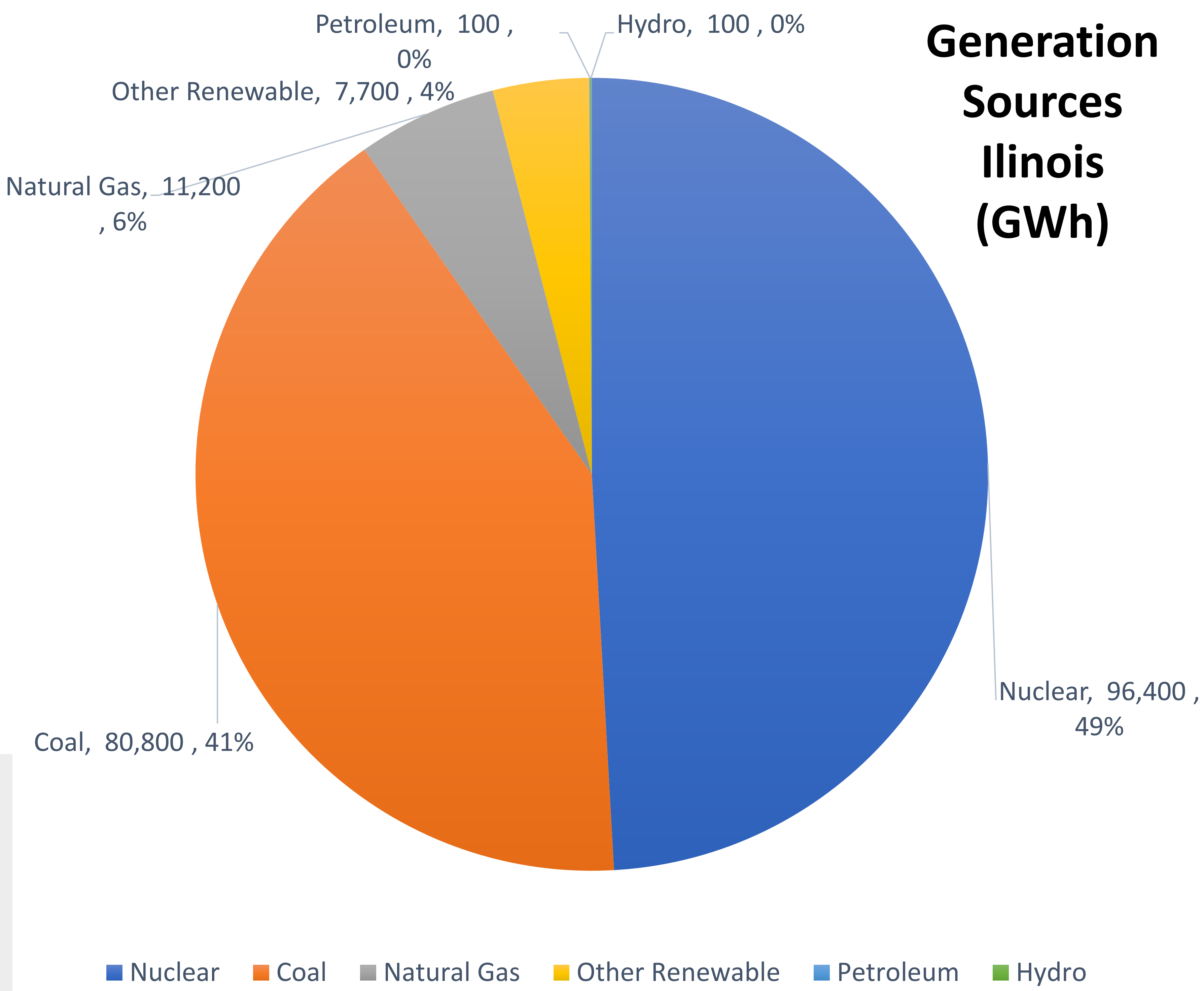
Key will be when and how the load will be distributed…

Source: USDOT Federal Highway Administration, Data based on mile conversion to electricity

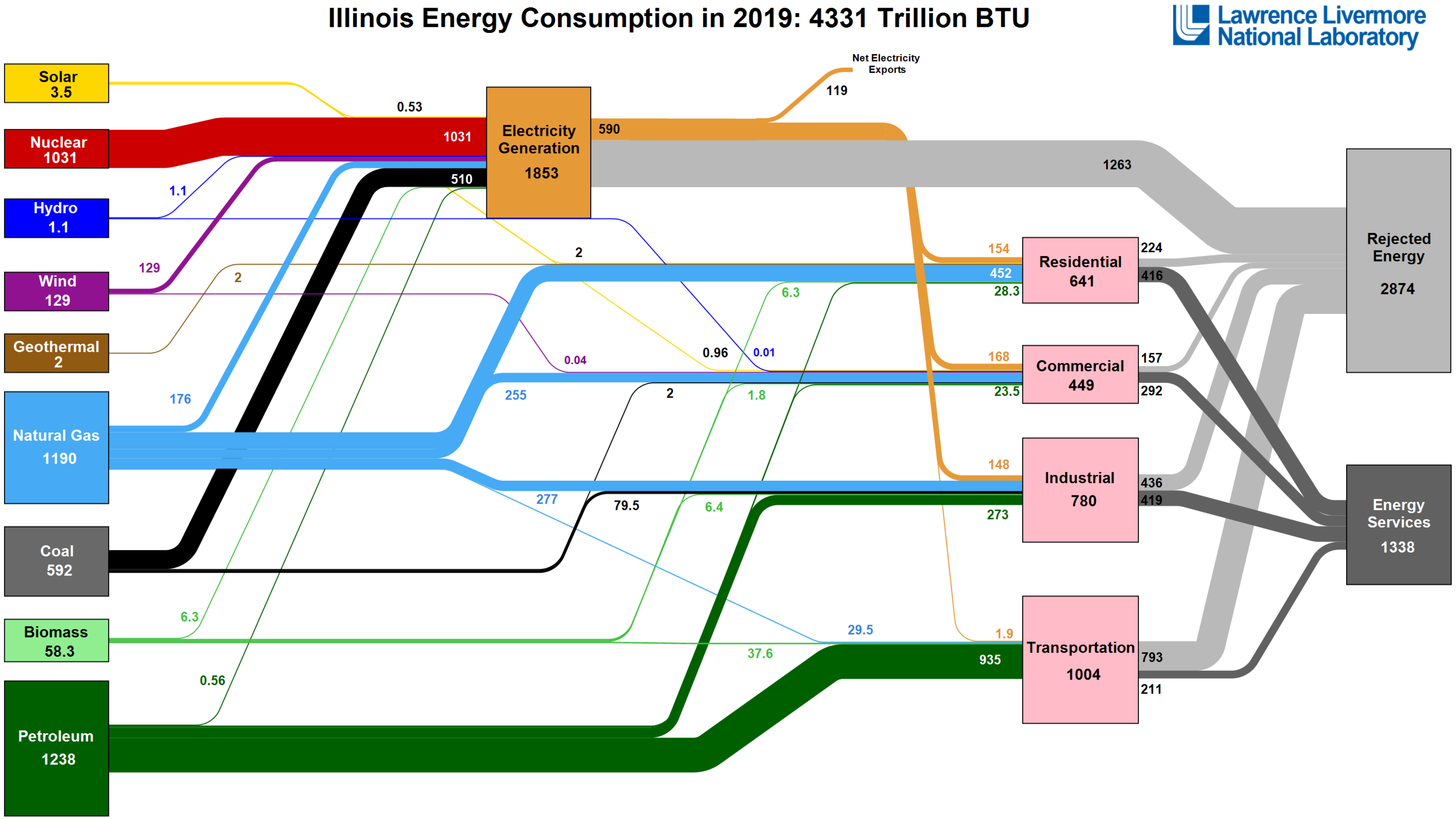
EV Load will further challenge IL Clean Energy goals



Electrification of vehicles and conversion of fossil fuel generation sources to renewable will create different challenges on the same grid



Energy view of power illustrates transition needed for transportation



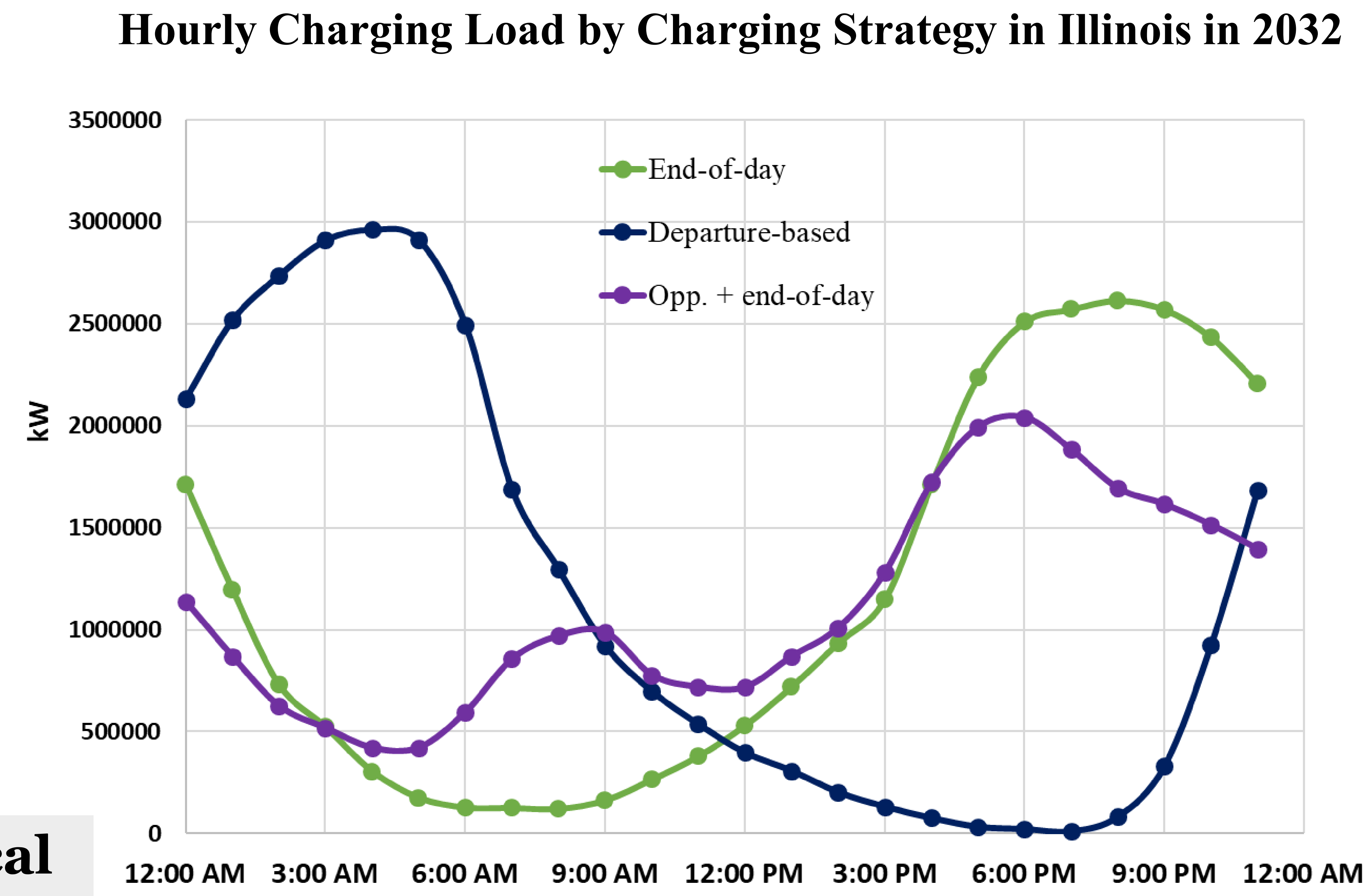
Source: LLNL August, 2021. Data is based on DOE/EIA SEDS (2019). If this information or a reproduction of it is used, credit must be given to the Lawrence Livermore National Laboratory and the Department of Energy, under whose auspices the work was performed. Distributed electricity represents only retail electricity sales and does not include self-generation. EIA reports consumption of renewable resources (i.e., hydro, wind, geothermal and solar) for electricity in BTU-equivalent values by assuming a typical fossil fuel plant heat rate. The efficiency of electricity production is calculated as the total retail electricity delivered divided by the primary energy input into electricity generation. End use efficiency is estimated as 0.65% for the residential sector, 0.65% for the commercial sector, 0.49% for the industrial sector, and 0.21% for the transportation sector. Totals may not equal sum of components due to independent Rounding. LLNL-MI-410527

Different charging strategies lead to varying solutions for the grid

Departure charging – EV penetration on residential distribution and workplace charging

End of Day charging – Time of Use tariffs to dissuade charging and adoption of this charging. This will also lead to more charging away from home.

Incentives and policies will be critical to minimize the additional infrastructure to handle the load on the grid



Source:
Electric Vehicle Adoption in Illinois ,
Yan Zhou, Marianne Mintz, Thomas Stephens, and Spencer Aeschliman
Energy Systems, Argonne National Laboratory ,
Charles Macal , Decision Infrastructure Sciences, Argonne National Laboratory ,
July 2020

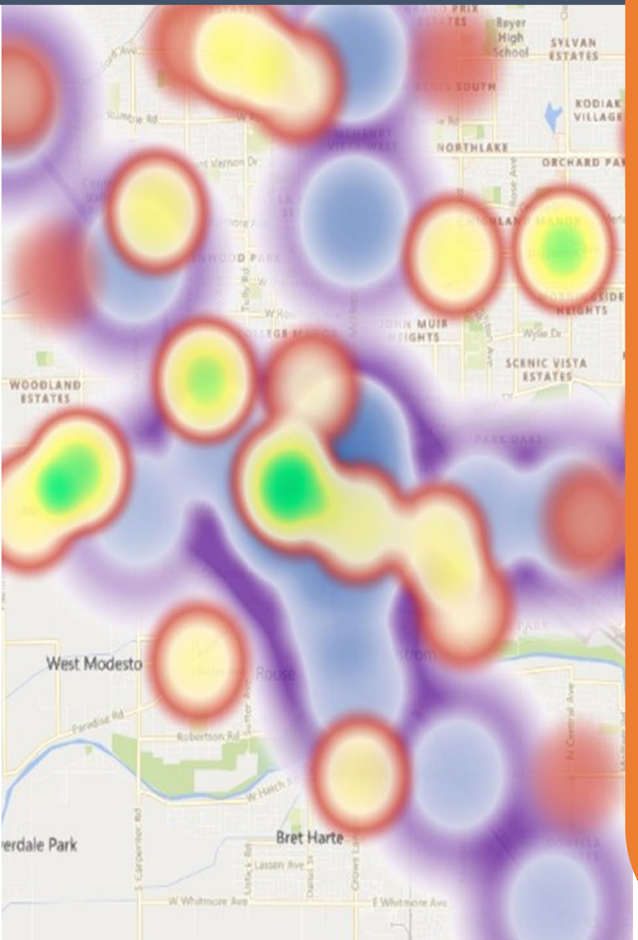
Additional Load will not be Homogeneous!

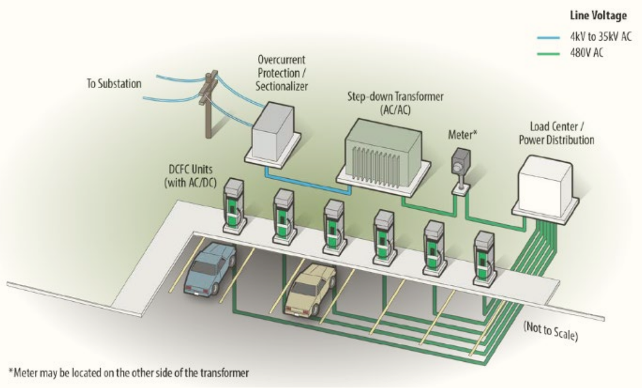
Significant Load Centers will create a challenge

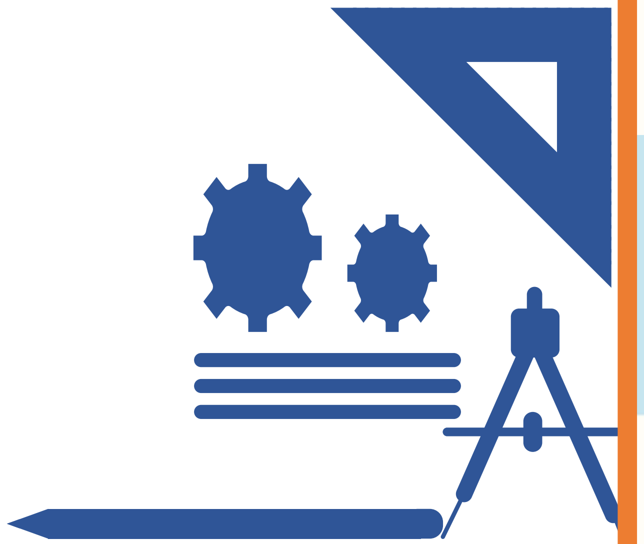
- Power and grid planning for significant load centers as a result of electrification of logistic centers
- An example of logistic centers within a sample quadrant in Bolingbrook, IL will create significant additional load
- Solution will require additional electric infrastructure (Utility and Customer Owned) to support additional load
- **First mover advantage** for grid real estate potentially more important than land

Electric Vehicle Challenges and Solutions

Where should charging stations be located to promote adoption?	What will be the impact of charging on the grid?	How will stations connect and interact with the grid?	How should stations be designed to minimize impact and maximize benefit?	How should fleet transitions be planned?
Network Model	Electric System Analysis for EV Penetration	EV Interconnect Standards Development	Innovative Microgrid EV Station Design	Fleet and Logistic Center Strategy and Planning







Infrastructure Assessment

Our team would work with yours to identify infrastructure options to support the technology for zero emission transportation including evaluation of electrical and civil requirements.

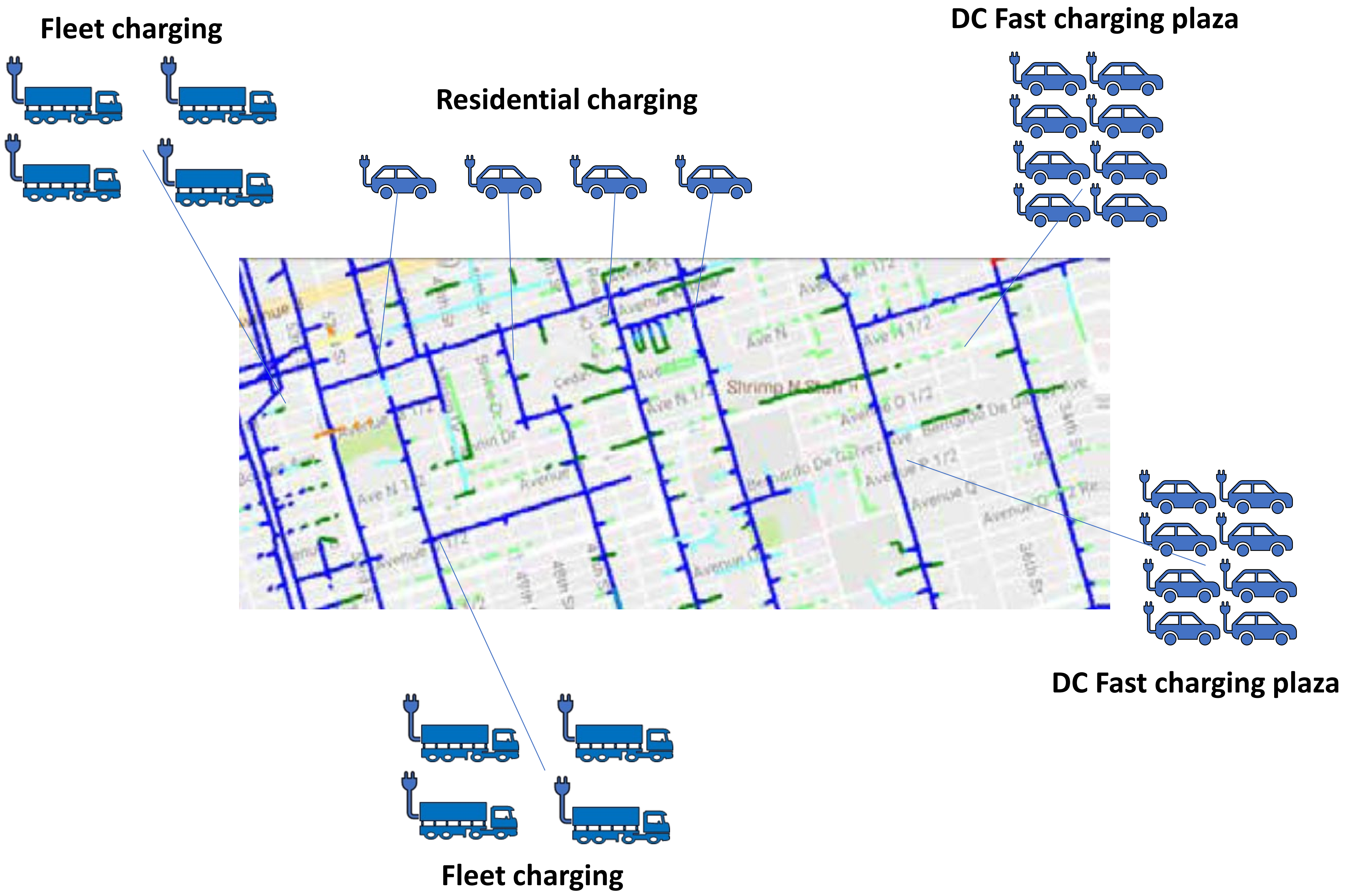
Multi Year Plan

We would design and deliver a multi-year phased plan with assessment points to address the plan and optimize the fleet conversion and deployment.

End to End Lifecycle planning

Our approach would be collaborative with all members of the operating team to ensure every part of the operation is covered with a solution and plan.

Electric Grid Analysis for EV Penetration



- Determine impact of various types of charging on the grid
  - Fleet charging
  - DC Fast charging plazas
  - Workplace charging
  - Residential charging
- Determine the current electric system strengths, weaknesses, and recommendations for future system planning
- Provide recommendations for the following:
  - Infrastructure upgrades
  - System protection
  - Timing for additional buildout
  - Availability and impact of DERs
  - Replacement or additional distribution transformers
  - Opportunity and value for battery energy storage

Electric Grid Analysis for EV Penetration

Inputs

Circuit information
- *Circuit maps*
- *Loading information*
- *Detail on infrastructure sizing on various circuits*

EV Penetration Levels
- *Utilizing leading industry tools such as EVI-Pro, EV penetration is modeled with various scenarios to inform loading profiles on the grid*

Electrical System Data
- *Types and sizes of transformers in the substation*

Loading Scenarios
- *Peak information and modeling*

Deliverables

Impact of Future Electric Vehicle and DER Penetration
Identify loading risks over time driven by increased penetration of EV and DERs

System Model Flow and Short Circuit Results

Scenario Planning
Multiple penetration scenarios to understand sensitivity of penetration and variables in model.

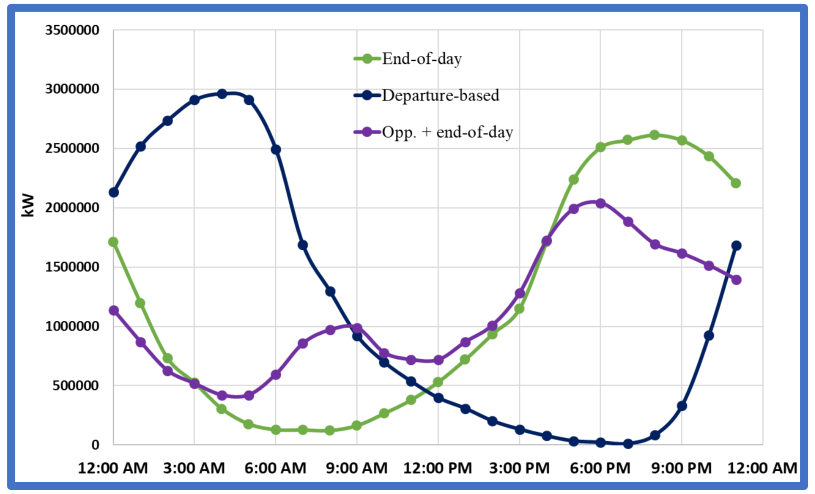
Asset Strategy Planning
Asset strategy plan over time for upgrade requirements.

Residential EV Charging Coordination

- Typical distribution circuit may have around 3000 metered customers
- Typical meter will need at least one additional 50 amp circuit for level 2 charging (average 10 kW)
- Worst case scenario, the circuit would require an additional 35 MVA transformer for just this line
- Realistically, the charging profile would look vary according to customer side load management
- Potential for charging coordination and software solutions for residential charging

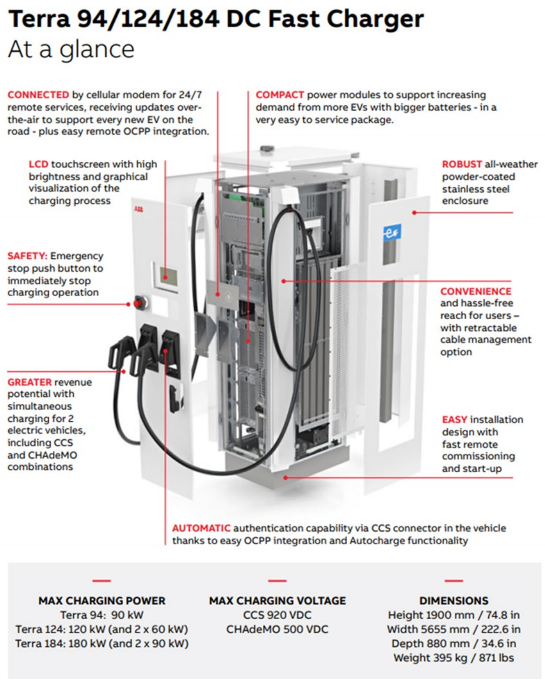
3000 Customers per distribution circuit

50 amp circuit per customer



DCFC Plazas

	DCFC Plaza
Number of Chargers	8
Charger Size (kW)	150
Input Power	153 amps, 128 kVA
Power Factor	>.96
Max (kVA)	1024

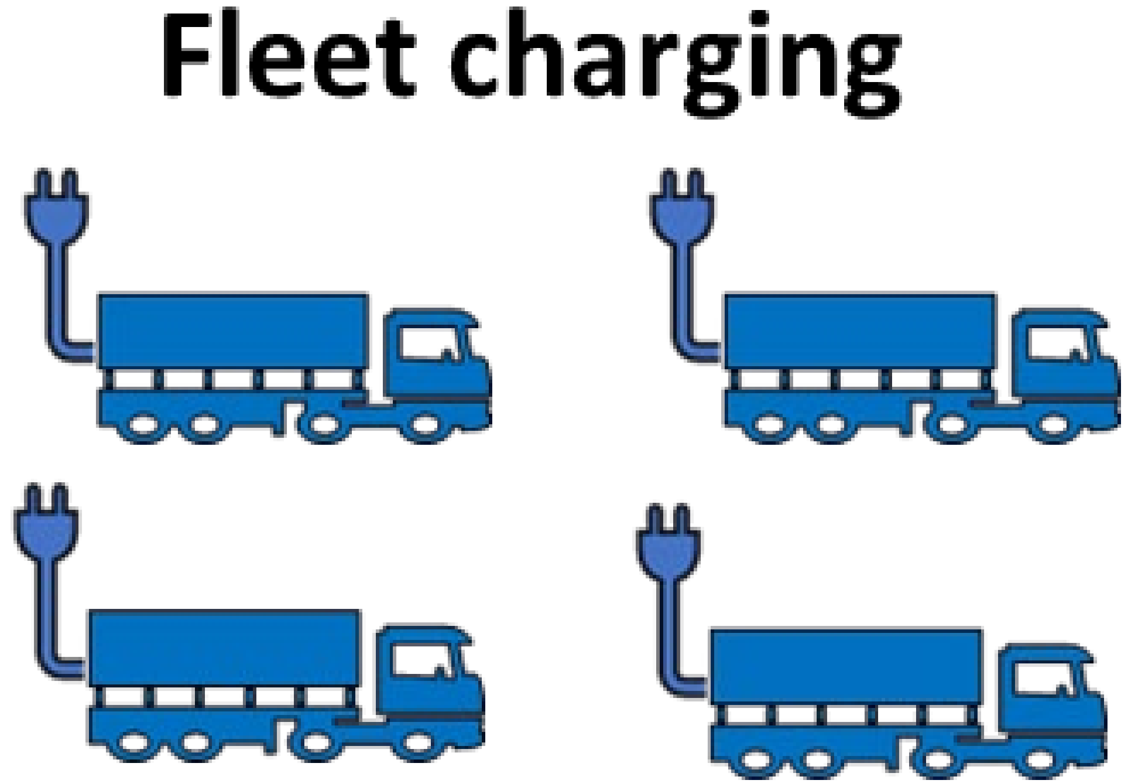


- Typical DCFC Plaza will add approximately 1 MVA per location
- Charging behavior will drive number and size of DCFC Plazas
- Trend is towards more chargers with higher rate of charging
- Multiple PE firms moving into this space
- Significant stock movement since infrastructure bill passed

Fleet Charging

- Fleet Charging use case will be main determinant for charging variables (rate and number)
  - Class 8 vs. Last mile van vs. Service group
  - Turnaround time requirements

- Trend towards Charging as a Service / Fleet as a Service / Energy as a Service
- Fleet charging load centers will vary from 1 MW up to 15+ MW



Innovative EV Station Design

- Collocate **Solar** renewable generation and **battery storage** with **EV charging stations**
- Minimize capital investment on utility infrastructure upgrade requirements through battery power offset
- 2020 CEC study determined “ES and PV collocation as the best option for minimum break-even price and highest profitability index1”
- Single interconnection point for multiple clean grid services
- Cost efficient power during peak demand minimizing O&M and energy costs
- Optimize station resiliency minimizing downtime
- Support utility storage objectives and participate in incentive programs

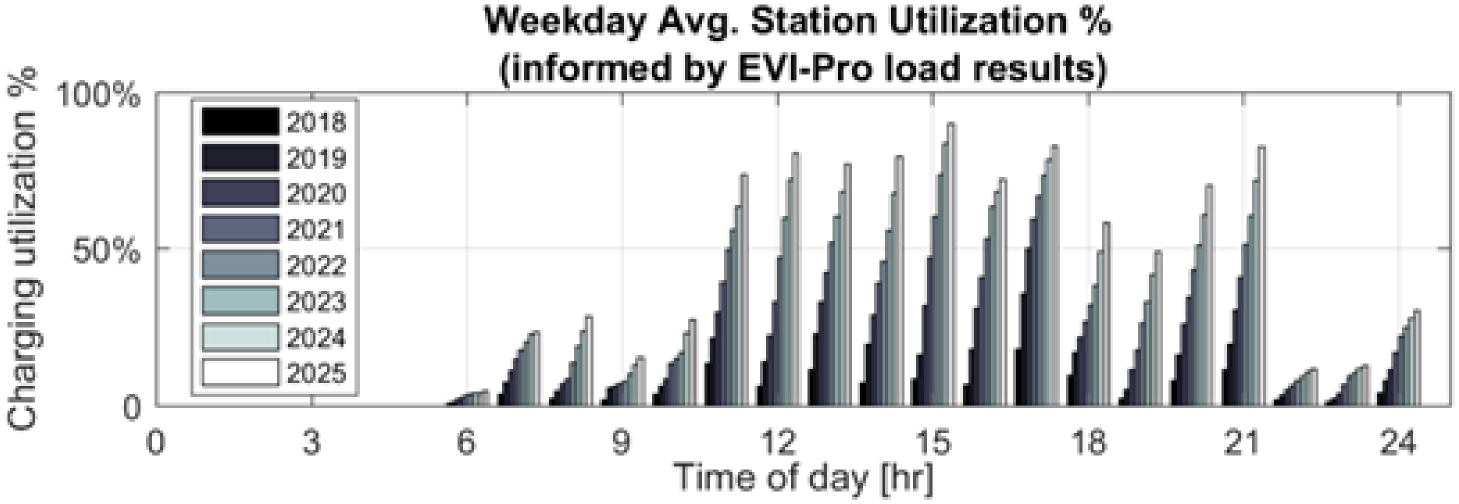
Eleftheria Kontou and Eric Wood, Financial Feasibility of High-Power Fast Charging Stations:
Case Study in San Diego California, July 2020, 17, 23

Innovative EV Station Design
Case Study: PV and Storage with EV

- An analysis of deploying various DC Fast Charging (DCFC) stations with variables such as number of ports and integration with renewable and storage
- Model utilized all current tools such as EVI Pro location modeling and E-FAST (Electric infrastructure Financial Analysis Scenario Tool)
- Conclusion: Deploying DCFC stations with an ability to scale and integrating with local PV and battery storage yields maximum utilization, lower operating costs, increased reliability, and higher IRR
- Note: IRR does not take into account ability to dispatch to grid

DC Fast Charging Station with 400kW Ports						
Economic Model	12 Plugs - DCFC 125kW		24 Plugs - DCFC 125kW		48 Plugs - DCFC 125kW	
Scenario	Break Even Price ($/KWh)	IRR	Break Even Price ($/KWh)	IRR	Break Even Price ($/KWh)	IRR
Base	0.5	4.36%	0.46	5.83%	0.42	8.61%
PV Only	0.49	3.72%	0.45	5.90%	0.4	9.84%
PV and Storage	**0.43**	**7.09%**	**0.42**	**6.52%**	**0.36**	**12.94%**

"This results in having alternative scenario 2 with ES and PV collocation as the best option for minimum break-even price and highest profitability index, no matter the number of plugs of the station. It suggests that the operational costs savings achieved warrant ES and PV collocation, despite the high capital and installation costs. Renewables integration can result in up to 15% break-even price reductions in this case."



Eleftheria Kontou and Eric Wood, Financial Feasibility of High-Power Fast Charging Stations:
Case Study in San Diego California, July 2020, 17, 23

Brookville Smart Energy Bus Depot

Brookville, MD

- 2 MW Solar
- 4.3 MWh Battery Energy Storage
- 2 MW charging capacity
- Onsite natural gas generators that will transition to carbon-neutral sources

https://microgridknowledge.com/brookville-bus-depot-microgrid/
https://microgridknowledge.com/bus-depot-microgrid-maryland-alphastruxure/

US Coast Guard Training Center - Petaluma

Petaluma, CA

- 5 MW Solar
- 11.6 MWh Battery Energy Storage

Coast Guard solar-storage-genset microgrid to include Ameresco energy efficiency upgrades - Power Engineering (power-eng.com)

Bergstrom Automotive

[Bergstrom Installs Microgrid-Based EV Charging Units in Wisconsin (environmentalleader.com)](environmentalleader.com)

Bergstrom Automotive in Neenah, Wisconsin

- 320 kWh storage
- 47 MWh solar annually
- Onsite natural gas generators
- System deployed to support F-150 and Ford Electric Vehicles

SACRT / SMUD / GiddyUp EV Microgrid

- Largest EV Station Deployment in North America
- Multiphase project that will incorporate 100 DC Fast Chargers, 150 kW carport solar, and 2MW battery energy storage facility

SacRT partners with SMUD, GiddyUp Ev on new high-speed charging hub coming to Power Inn Station | Mass Transit (masstransitmag.com)

SacRT, GiddyUp EV partner on electric vehicle charging station - Sacramento Business Journal (bizjournals.com)

Los Angeles Department of Transportation to Install Solar and Storage Microgrid and EV Charging To Power 100+ Electric Buses with Proterra and Apparent

LADOT will deploy
- 1.5 megawatts of rooftop and bus solar canopy
- 4.5MWh energy storage system provided by Apparent at the Washington Bus Yard
- Five Proterra 1.5-megawatt fleet chargers with 104 remote EV charging dispensers.

- Apparent's intelligent grid operating system (igOS™) platform will integrate Proterra Energy's charging infrastructure with energy generation to coordinate how and when the electric buses are charged with energy generated from solar, or drawn from storage or the utility.

[Los Angeles Department of Transportation to Install Solar and Storage Microgrid and EV Charging To Power 100+ Electric Buses with Proterra and Apparent (yahoo.com)]

Key Variables for Determining an EV Microgrid

Battery Size

Charging availability
Resiliency
Space constraints

PV Array

Dependent on space availability

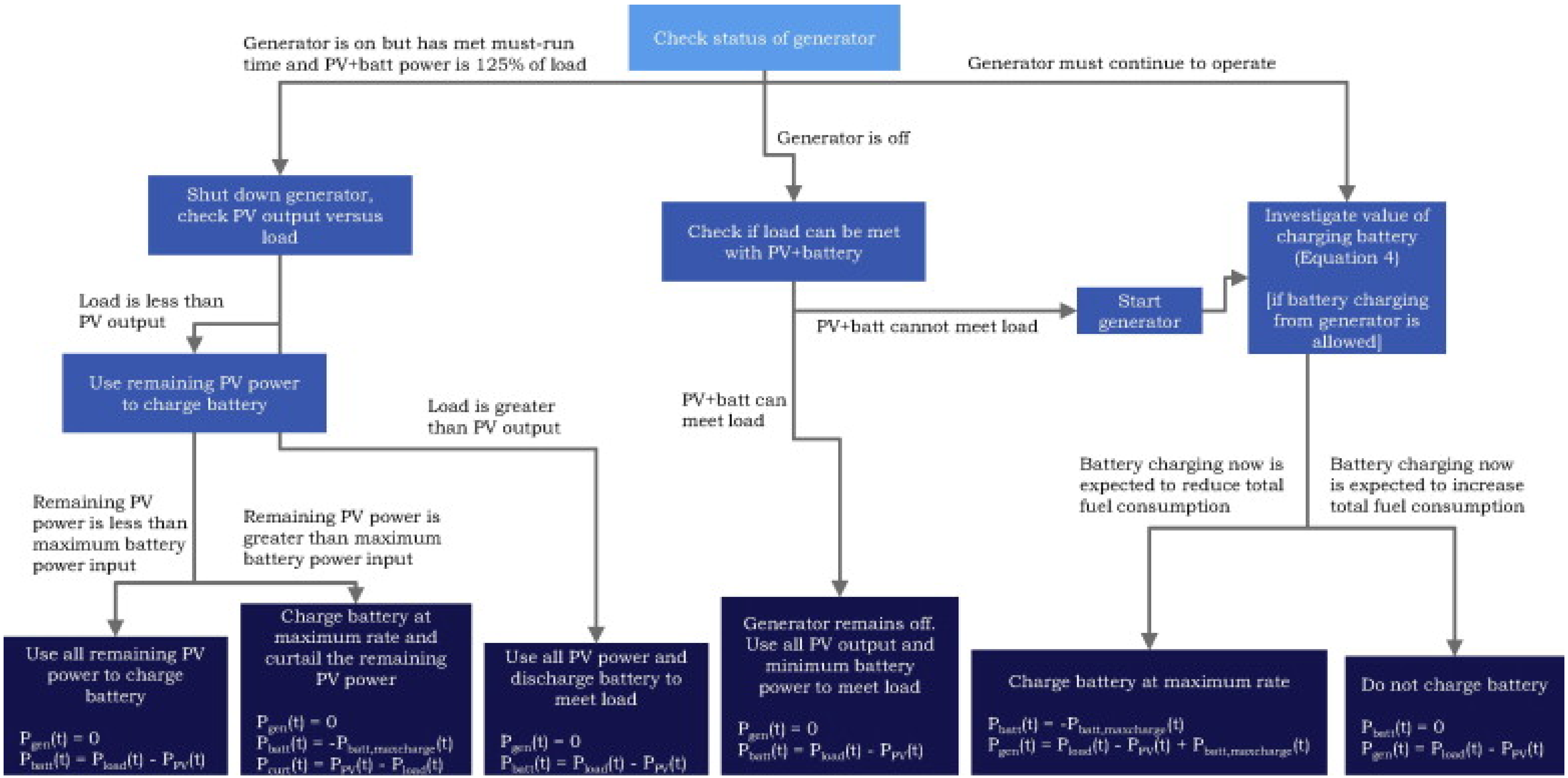
Diesel generator

Regulatory constraints

Charger utilization

Impact dispatch speed and quantity

Energy Systems Model for Microgrid Operation



Eric Hittinger, Ted Wiley, John Kluza , Jay Whitacre , Evaluating the value of batteries in microgrid electricity systems using an improved Energy Systems Model, Energy Conversion and Management 89 (2015) 458–472

Modeling key to sizing the system correctly

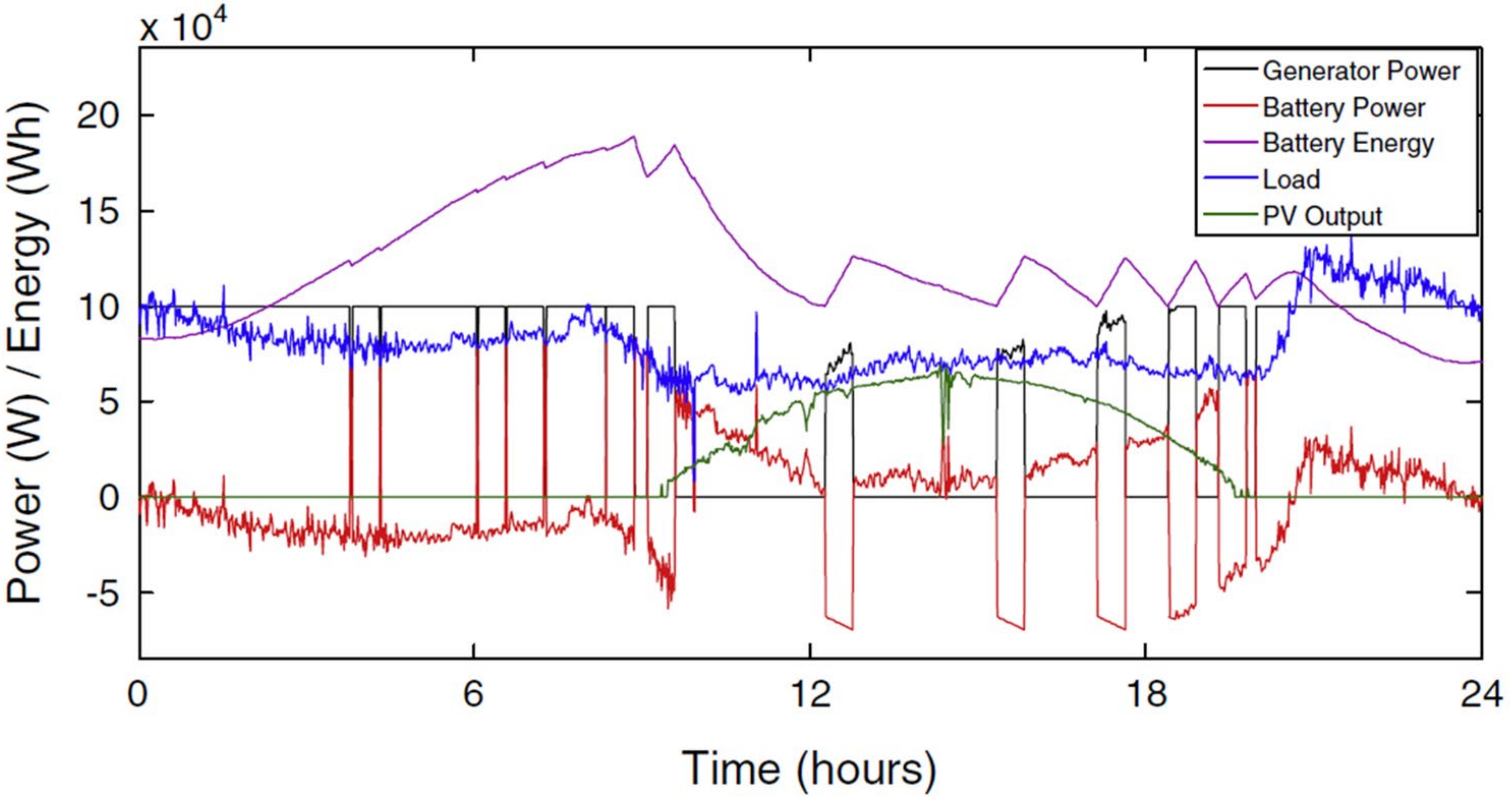


Illustration of an example output from the ESM

- 100 kW diesel generator,
- 200 kW h AHI battery
- 88 kW PV array

- 160 kW max/81 kW average load.

Eric Hittinger, Ted Wiley, John Kluza , Jay Whitacre , Evaluating the value of batteries in microgrid electricity systems using an improved Energy Systems Model, Energy Conversion and Management 89 (2015) 458–472

Develop Common Standards for Electric Vehicles and Behind the Meter Storage/Generation

DRIVERS

01 Increased EV and Microgrid deployment will require consistent interconnection and metering

02 Inspections will require a common understanding of the infrastructure

03 **Future locations may have the ability for bi-directional power flow that will need to be measured**

- Utilities must have a consistent mechanism for standard design and construction of facilities
- Important for safety through inspections
- Billing applications need to assure that all usage of grid is compensated

Sargent & Lundy

Thank You