VEHICLE-TO-GRID (V2G): OPPORTUNITIES AND CHALLENGES

Francisco Sayu

Emerging Technology Director

Personal Vision: to live, work, and play in a world of optimized energy systems that maximize resiliency, affordability, and justice

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RENEW Wisconsin is a nonprofit organization dedicated to building a stronger, healthier, more vibrant Wisconsin through the advancement of renewable energy. We work on policies and programs that support solar power, wind power, biogas, local hydropower, geothermal energy, and **electric vehicles**.

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AGENDA

- Why Electric Vehicles?
- EV Infrastructure Updates: Bipartisan Infrastructure Law (BIL)
- Vehicle Electrification Trends
- EV charging basics
- Vehicle-to-Grid (V2G)
  - Benefits
  - Challenges
  - Business case
- Case Studies
- Discussion (Q&A)

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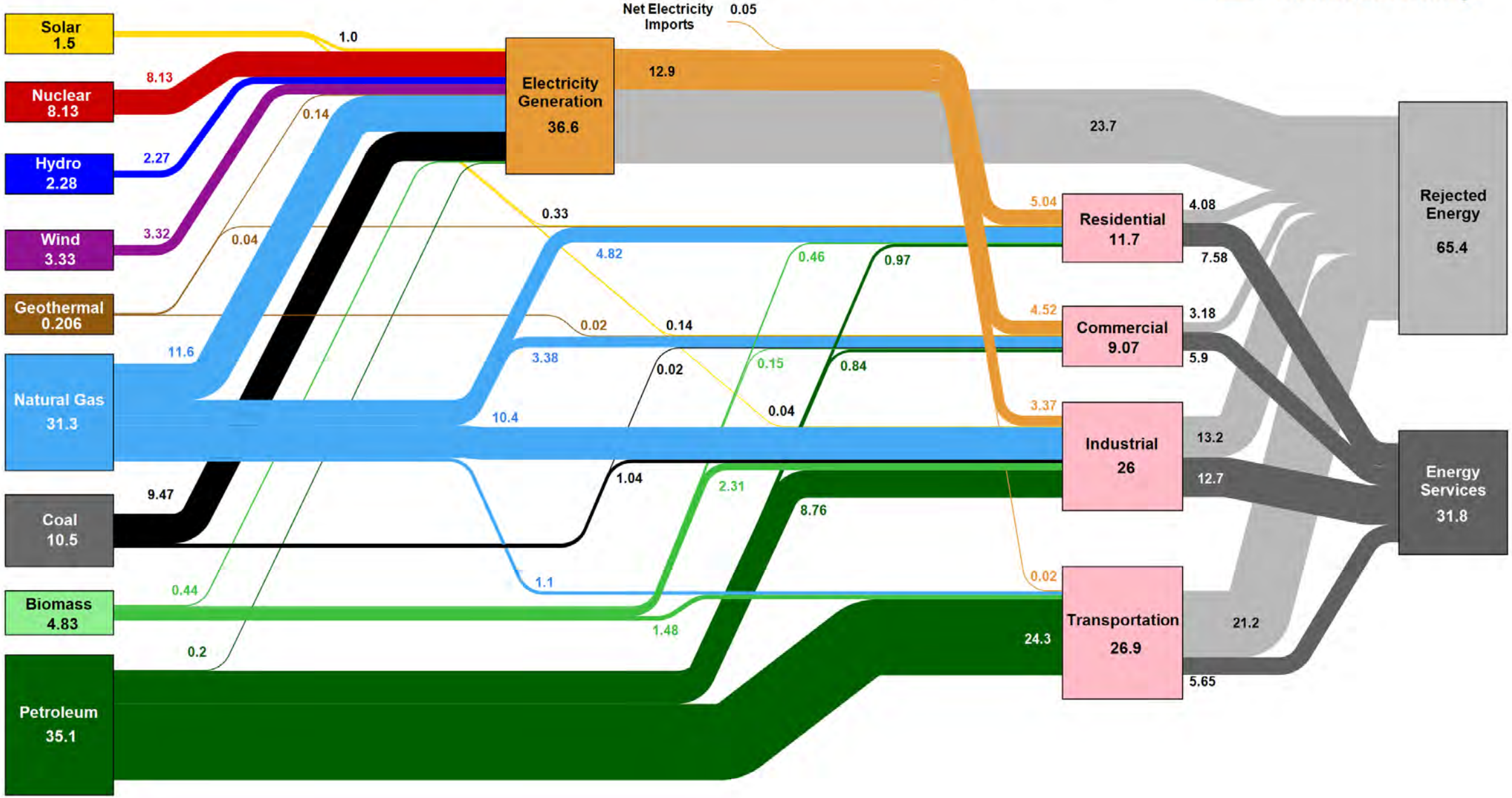
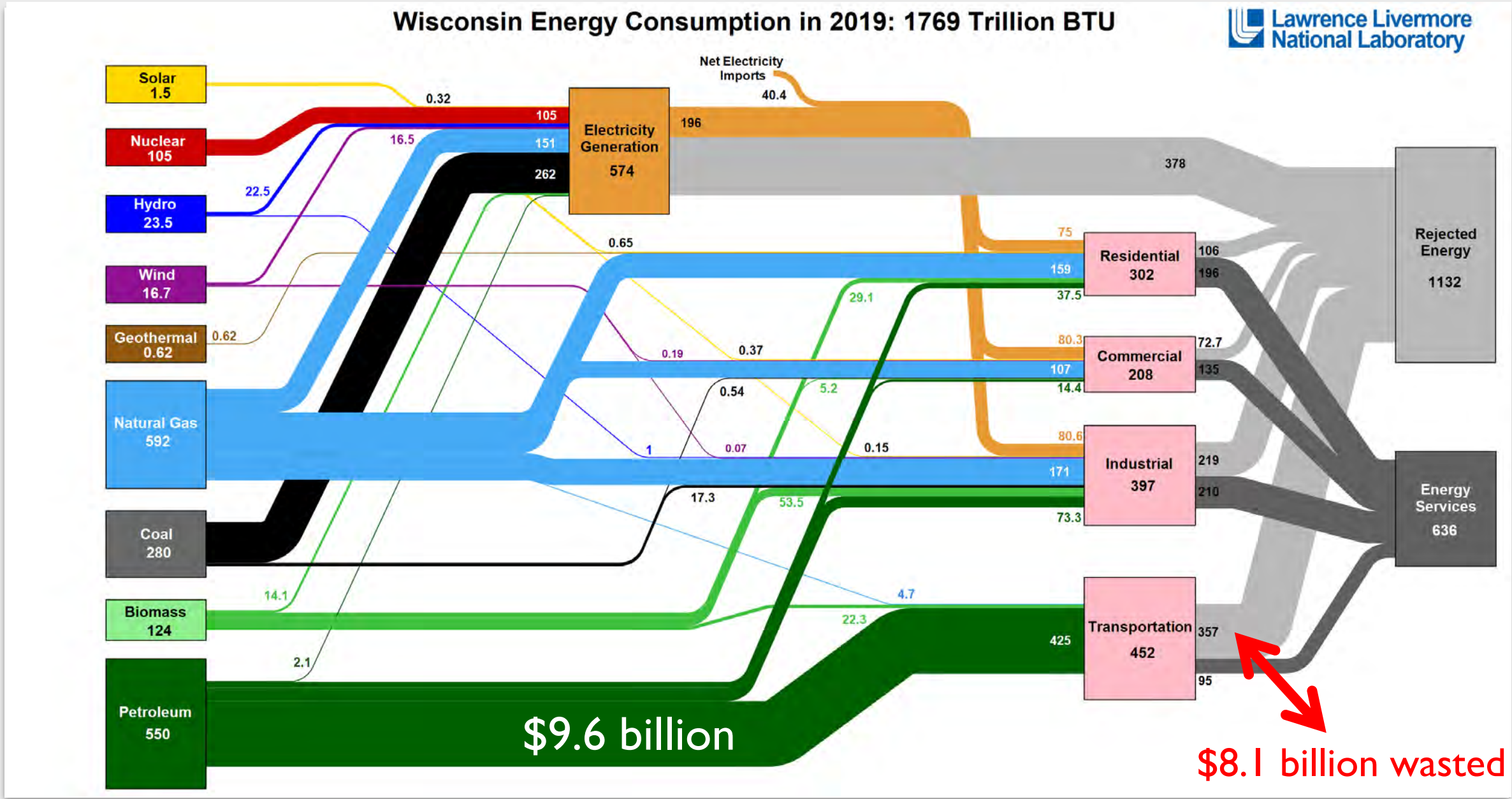
Estimated U.S. Energy Consumption in 2021: 97.3 Quads

Lawrence Livermore National Laboratory




Wisconsin Energy Consumption in 2019: 1769 Trillion BTU
Lawrence Livermore National Laboratory
Solar 1.5
Nuclear 105
Hydro 23.5
Wind 16.7
Geothermal 0.62
Natural Gas 592
Coal 280
Biomass 124
Petroleum 550
Net Electricity Imports
40.4
Electricity Generation 574
196
378
Residential 302
Commercial 208
Industrial 397
Transportation 452
Rejected Energy 1132
Energy Services 636
0.32
105
16.5
151
262
22.5
0.65
0.62
0.19
0.37
0.54
1
0.07
0.15
17.3
14.1
2.1
29.1
5.2
53.5
4.7
22.3
75
159
37.5
80.3
107
14.4
80.6
171
73.3
425
106
196
72.7
135
219
210
357
95
$9.6 billion
$8.1 billion wasted

Electrification of transportation must be a priority because the transportation sector wastes over 21 Quads of energy per year – that's 22% of the total energy in the economy or 14 times the total amount of solar power generated in 2021

Quad = 293 billion kWh
183 million barrels of petroleum
38.5 million tons of coal

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But there is hope…

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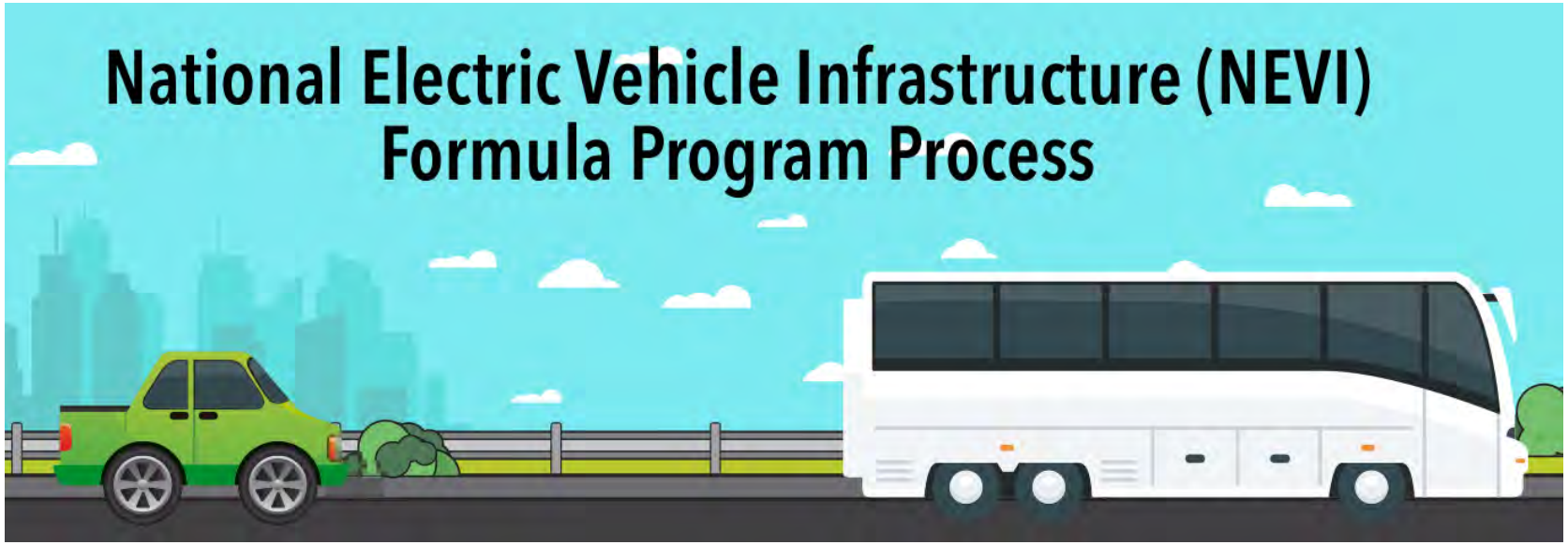
PRE-WORKSHOP UPDATE: BIPARTISAN INFRASTRUCTURE LAW (BIL)
NATIONAL ELECTRIC VEHICLE INFRASTRUCTURE (NEVI)

- Invest $7.5 billion in EV chargers by 2030
- National Electric Vehicle Infrastructure (NEVI) Formula Program provides up to $79 million for WI
- NEVI Plan due August 1 (WisDOT)
- Discretionary Grant Program $2.5 billion – Guidance TBD



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PRE-WORKSHOP UPDATE: BIPARTISAN INFRASTRUCTURE LAW (BIL)
CLEAN SCHOOL BUS PROGRAM

- Invest $5 billion to replace existing school buses with zero-emission and low-emission models
- The first $500 million will be awarded as lottery rebates
- 200 WI school districts are on the priority list
- Up to $375,000 rebate per school bus (up to 25 buses per district) and $20,000 for EV chargers
- **Applications** due August 19

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DISCLAIMER

Implementation of the **Vehicle-to-Grid (V2G)** technologies discussed in this workshop has legal/regulatory implications that go far beyond the scope of this workshop. This workshop address V2G technological potential only. The workshop is does not explore regulatory, policy or legislative issues related to V2G

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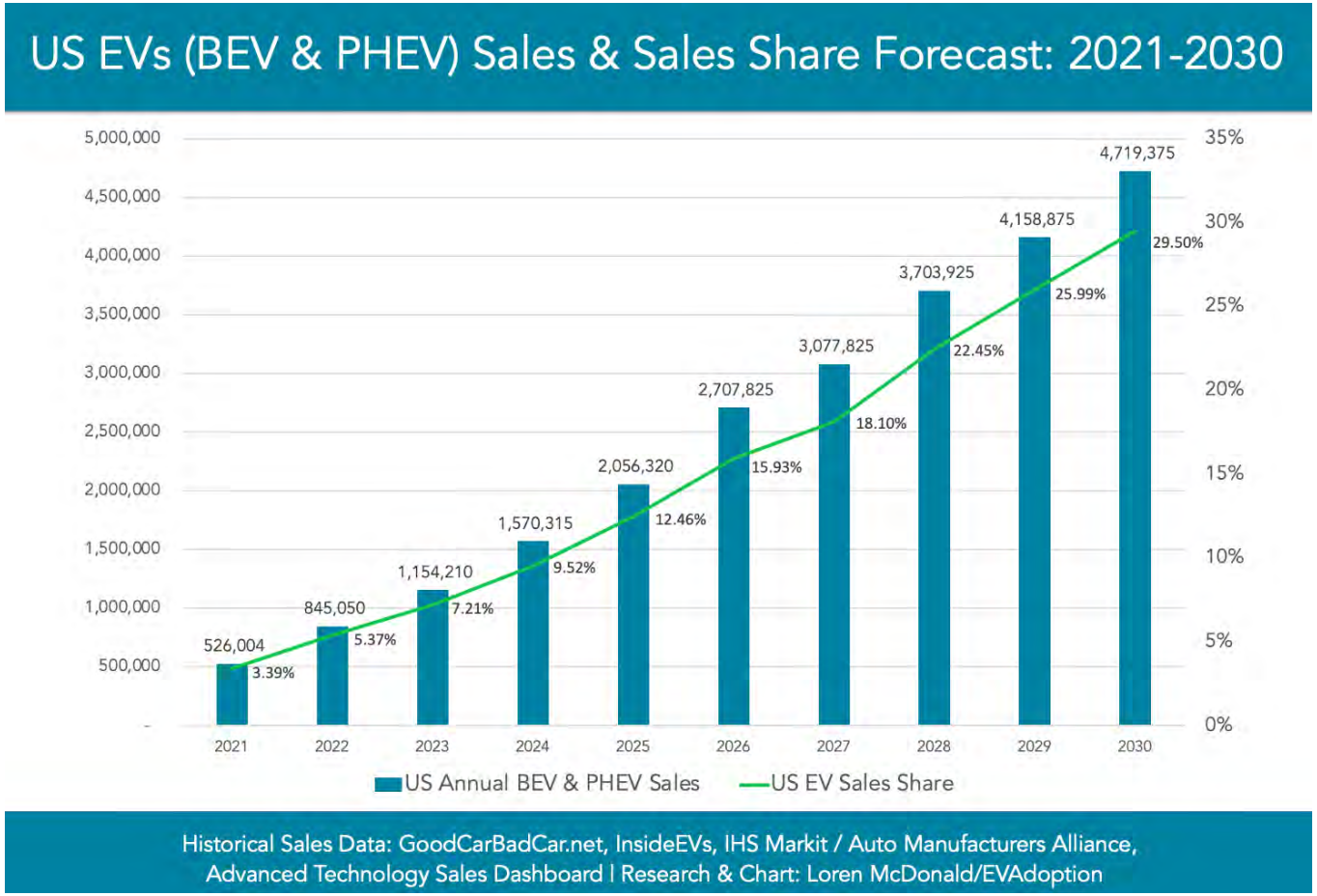
VEHICLE ELECTRIFICATION TRENDS

- As of December 2021, cumulative sales in the U.S. totaled 2.32 million Battery Electric Vehicles (BEV) & Plug-in Hybrid Electric Vehicles (PHEV)
- U.S. EV sales expected to reach approximately 30% of all new car sales in 2030
- 2022 "the year of the EV trucks"
  - Rivian R1T
  - Hummer EV
  - Ford F-150 Lightning
- **Until 15% of the vehicles on the road go electric, there won't be any real impact on the grid**



Source: https://evadoption.com/ev-sales/ev-sales-forecasts

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ELECTRIC VEHICLE (EV) CHARGING

- **Level 1:** Your regular 120V outlet
- **Level 2:** Most public charging stations and 240V outlets
- **Level 3:** DC fast chargers
- **Bidirectional charging:** Advanced EV charger capable of charging and discharging energy from an EV

LEVEL 1 CHARGING

Level 1 or "Trickle charging" uses standard 120V electrical outlet

- 1.5 kW
- 4 miles/hour
- Limited options for managed EV charging
- Convenient - plug into almost any outlet!

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LEVEL 2 CHARGING

Level 2 chargers use 240V electrical circuits or dedicated charging stations

- 4 – 17 kW
- 12 - 30 miles/hour
- Can purchase for $300 - $700 + Installation
- Available through utility managed changing programs/pilots

2 EV charging at EnTech's Microgrid in Madison, WI

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LEVEL 3 CHARGING

Level 3 Direct Current (DC) fast chargers use 480V electrical circuits at public charging stations

- 50 – 350 kW
- 5 - 45 minutes to 80%
- Example: Alternative Fuel Corridor of the **NEVI** Program (Bipartisan Infrastructure Law (BIL)

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BIDIRECTIONAL CHARGING

Advanced EV chargers capable of charging and discharging energy from an EV

- Vehicle-to-Home (V2H)
- Vehicle-to-Building (V2B)
- **Vehicle-to-Grid (V2G)**

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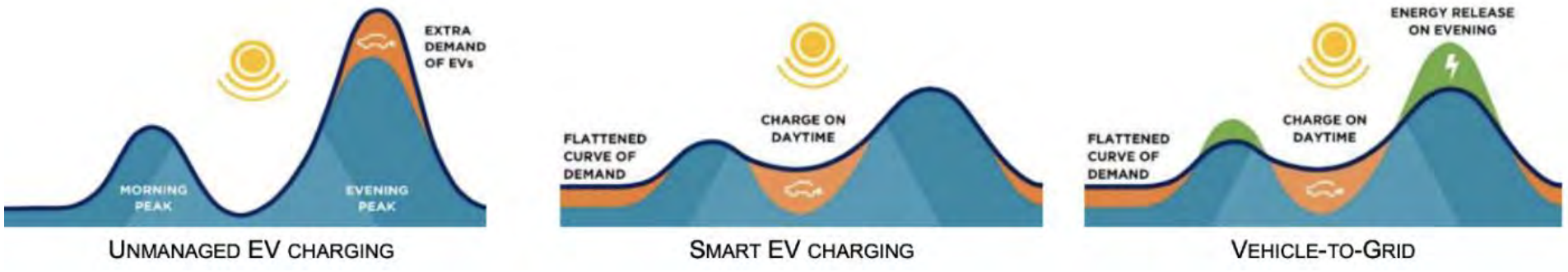
VEHICLE-TO-GRID (V2G)

The goal of V2G technology is to fully integrate electric vehicles into the power grid

- In charging mode, power flows from the grid to the vehicle
- In discharge mode, power flows from the vehicle to the grid
- The direct-current (DC) battery output must be converted to alternating-current (AC) to match the grid
- DC is converted to AC using an inverter built into the vehicle or the charging station



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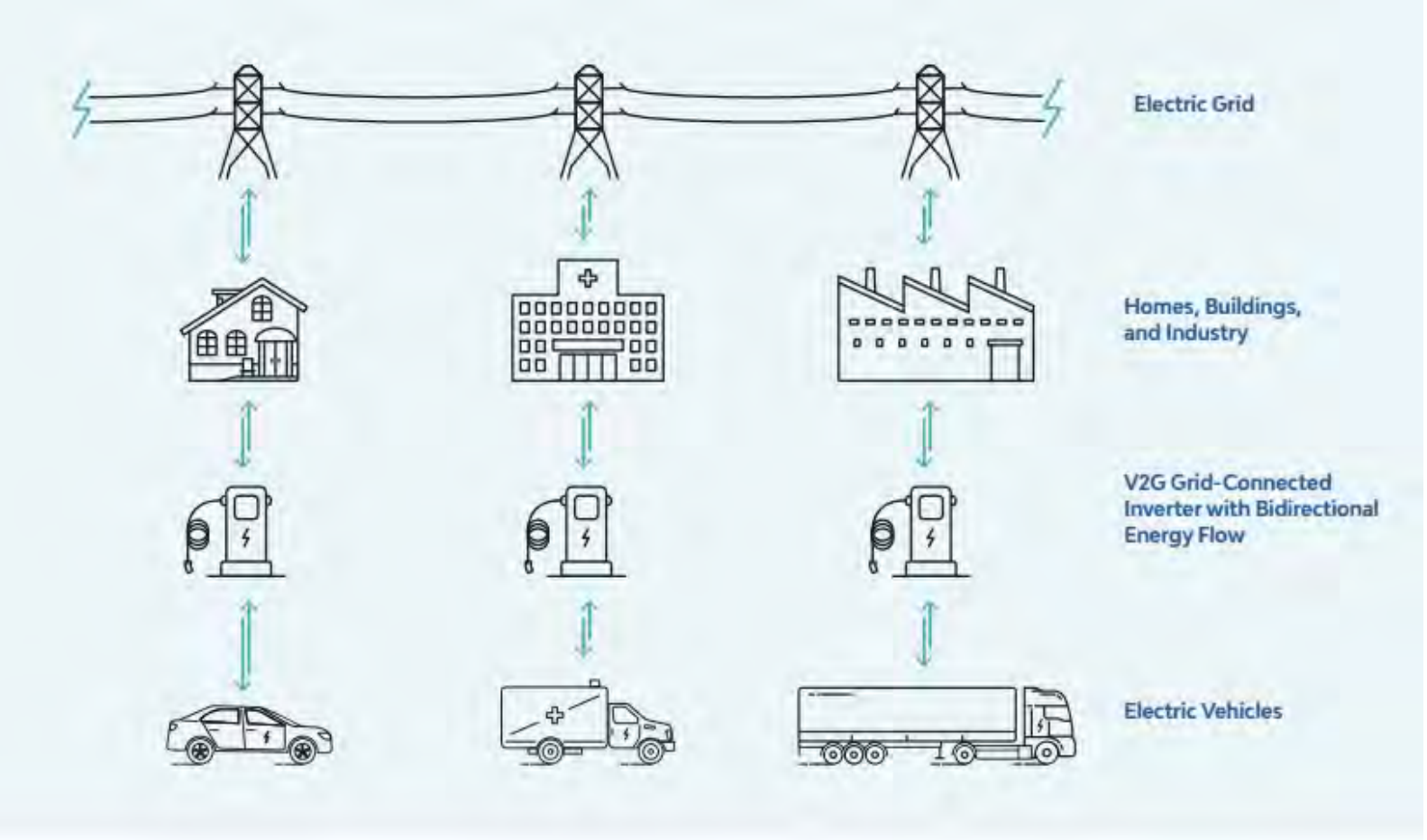
Source: Magnum Cap CHAdeMo V2G Webinar https://www.chademo.com/wp2016/wp-content/uploads/2021/05/CHAdeMO_V2G_Magnum_Cap.pdf

VEHICLE-TO-GRID (V2G)

V2G requires communication and algorithms to sense grid status

- Determine if EVs should be providing or drawing electricity at any given time
- Availability of vehicles for providing the services needed
- Track the services provided by vehicles so owners can be paid for making their vehicles available



https://www.electrificationcoalition.org/wp-content/uploads/2022/06/Advancing-V2G-Technology-Adoption.pdf

VEHICLE-TO-GRID (V2G) APPLICATIONS

Transmission System Operator (TSO)

- ✓ Ancillary services
  - Frequency regulation
  - Power reserve
  - Inertia

Distribution System Operators (DSO)

- ✓ Transformer upgrade deferral
- ✓ Congestion management
- ✓ Renewable energy integration

Facility Operators (Behind the Meter)

- ✓ Demand charge management
- ✓ Tarif optimization
- ✓ Emergency backup

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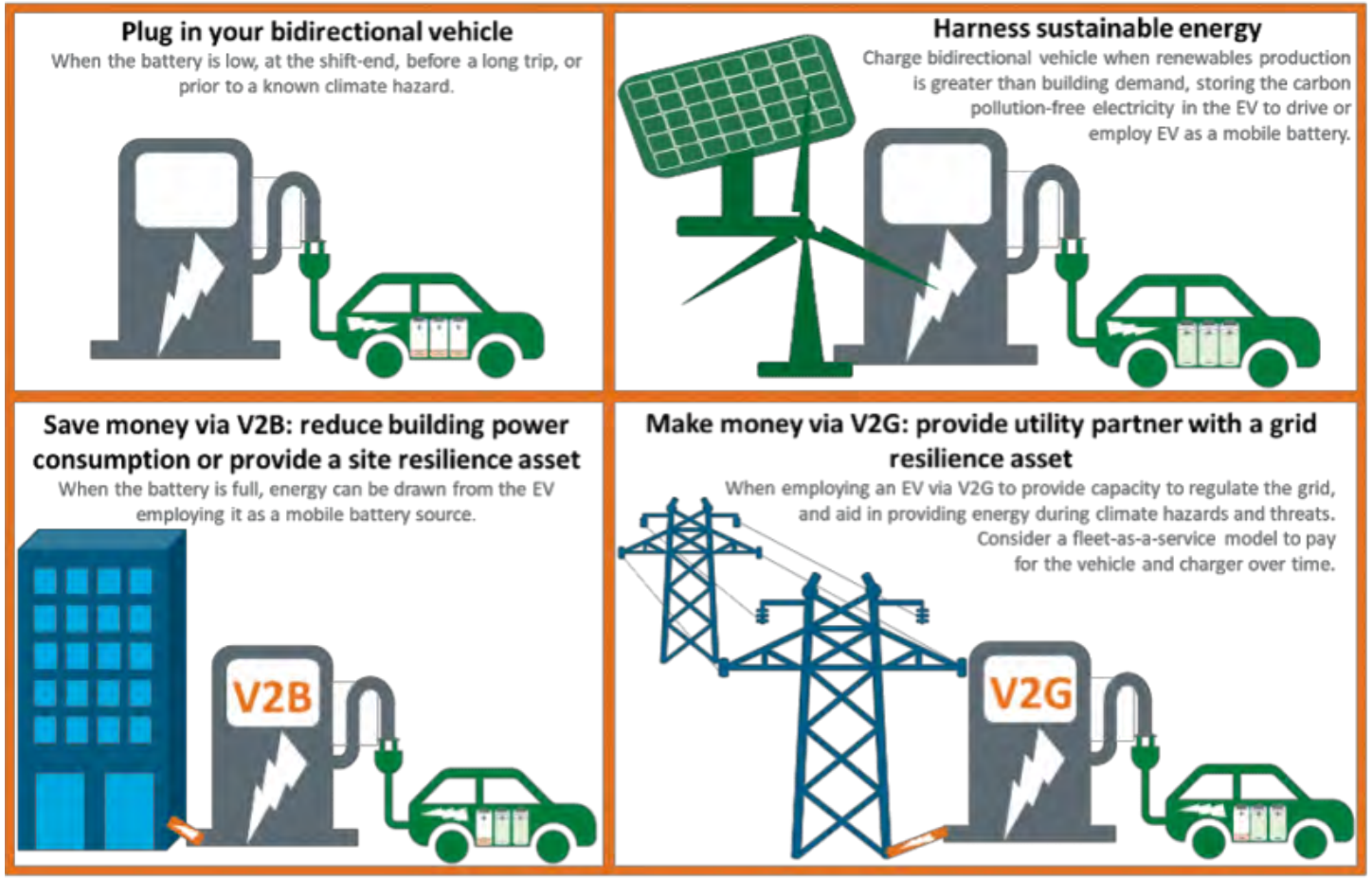
Takeaway: V2G can turn EVs into distributed energy resources, harness renewable energy, save money, and generate additional revenue



Source: Office of Energy Efficiency and Renewable energy, https://www.energy.gov/eere/femp/bidirectional-charging-and-electric-vehicles-mobile-storage

CONCERNS RELATED TO V2G

- V2G **potentially** increase battery wear and shorten battery life **(TBC)**
- Communications and management for an extensive network of charge points, vehicles, and customer information have security and privacy implications
- Public perception "the inconvenience factor"
- Limited V2G capable vehicles
- Safety (delivering power back to the grid safely)
- Regulatory framework necessary

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THE BUSINESS CASE FOR V2G

V2G-capable vehicles could provide Four primary services:

- Bulk energy storage
- Peak shaving
- Operating reserves
- Frequency regulation

Example: Electric school busses:

"By delivering stored clean energy back to the grid when it's needed most, electric school buses can help create a more resilient local power system and reduce the dependence on expensive fossil fuel power plants"

Gareth Joyce, President of Proterra

V2G-equipped electric school bus delivers power to grid for 50 hours

Posted October 20, 2021 by Charles Morris & filed under Fleets and Infrastructure, Newswire, The Infrastructure.

Source: EV industry insiders, https://chargedevs.com/newswire/v2g-equipped-electric-school-bus-delivers-power-to-grid-for-50-hours/

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CASE STUDY: KALUZA-ENABLED V2G CHARGING (UK)

Collaboration between OVO Energy, Kaluza, Nissan, Cenex, Indra Renewable Technology, and the UK's Department for Business Energy and Industrial Strategy (BEIS)

Roll out V2G across UK homes, showcasing the significant economic, environmental and societal value of the technology

Source: electrive.com https://www.electrive.com/2020/11/24/electric-nation-installs-100-v2g-chargers-in-the-uk/

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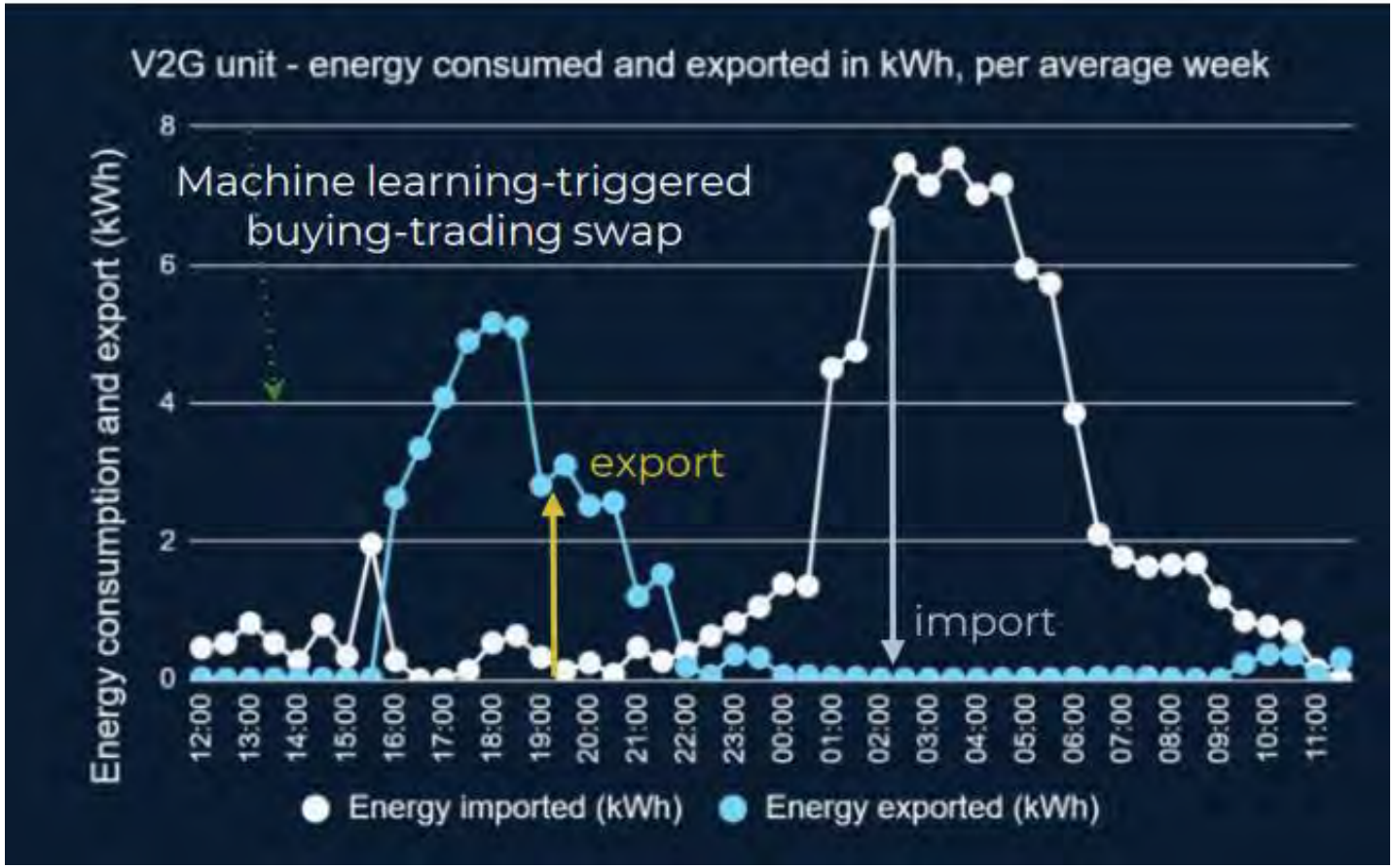
CASE STUDY: KALUZA-ENABLED V2G CHARGING (UK)

V2G is optimized to charge at the cheapest times, and export at the most profitable times

- Average customer imports 11.4 kWh and exports 6.8 kWh per day
- Participants earn £60 - 130/month
- Customers plug in to charge on average 18 times per month
- 319 connected EVs provide 0.4 MW of capacity to support the grid at peak times



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Source V2G: Democratizing the energy system, Tom Pakenham OVO Energy, :https://www.cenex.co.uk/app/uploads/2021/03/Merged-Slides-OVO-Indra-Nissan.pdf

CASE STUDY: ROANOKE ELECTRIC COOPERATIVE V2G PILOT PROJECT

Type of Vehicle: Nissan Leaf

Project: Roanoke Electric Cooperative, Clean Energy Works, and Fermata Energy V2G pilot (North Carolina) using Fermata Energy's bidirectional charger.

Objective: determine the additional financial value of using the EV batteries when the car is parked at home

Photo credit: Fermata Energy. Photo is of Electronic Instrumentations Technology (EIT), Fermata testbed, Danville, VA (2019).

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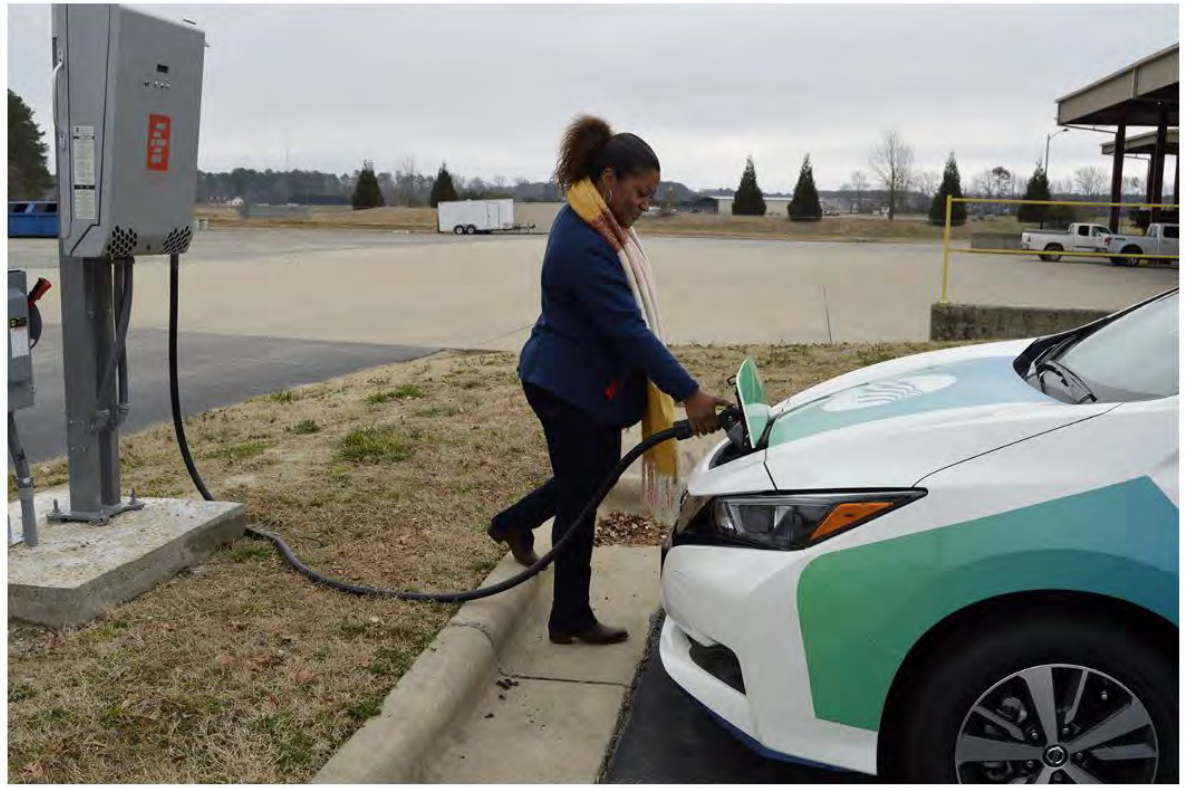
CASE STUDY: ROANOKE ELECTRIC COOPERATIVE V2G PILOT PROJECT

Key Results:

- Peak shaving
  - 4 kW December ($36 in avoided demand charges)
  - 11 kW January ($105)
- Total Utility savings of more than $2,600 per year
- Enhance resilience by providing backup power to Roanoke Electric's microgrid during the times when it was islanded from the grid



Early results from the first electric cooperative test of an electric-vehicle-to-grid charger show promise that such systems can help reduce peak demand and save members money.

Photo credit: Fermata Energy. Photo is of Electronic Instrumentations Technology (EIT), Fermata testbed, Danville, VA (2019).

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CASE STUDY: CITY OF UTRECHT, THE NETHERLANDS

"for the energy transition to go well, and to be effective without a huge investment by grid operators and other storage facilities, really the way forward is to combine [the growth of renewable energy generation and electric vehicles]. And to basically enable the batteries and cars to be a buffer for renewable energy to balance the system."

Robin Berg, the director of We Drive Solar

Utrecht wants to be the first city to use its electric car fleet as a giant battery

What it could mean to be a "bidirectional" city.

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Source: Fast Company Magazine, https://www.fastcompany.com/90705832/utrecht-wants-to-be-the-first-city-to-use-its-electric-car-fleet-as-a-giant-battery

CASE STUDY: CITY OF UTRECHT, THE NETHERLANDS

- Office building + Solar garage with 250 Bidirectional charging stations
- Car sharing system (150 Ioniq 5s with V2G technology)
- Currently 1,400+ Bidirectional charging stations installed the city
- Plans to install 10,000 Bidirectional charging stations to balance the whole city (less than 10% of the city's car fleet)

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EVs WITH BIDIRECTIONAL CHARGING CAPABILITY

Vehicle	size (kWh)	Days storage	Port	V2L	V2G	V2H	Availability
Nissan Leaf (ZE1)	36-62	1.7-3	Chademo	✗	✓	✓	Yes
Mitsubishi Outlander (plug-in)	13.8	0.7	Chademo	✓	✓	✓	Yes
Ford F-150 Lightning	98-130	4.7-6.2	CCS	✓	✓	✓	July 2022 (US)
Hyundai Ioniq 5	54-77.4	2.6-3.7	CCS	✓	TBC	TBC	Yes
Kia EV6	54-77.4	2.6-3.7	CCS	✓	TBC	TBC	Yes
BYD Atto 3	50.1-60.4	2.4-2.9	CCS	✓	TBC	TBC	July 2022 (Aus)
MG ZS EV (2022)	49-68	2.3-3.2	CCS	✓	TBC	TBC	July 2022 (UK)
Porsche Taycan	71-83.7	3.3-3.9	CCS	TBC	TBC	TBC	TBC

Source: Datawrapper, https://zecar.com/

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WHAT'S NEXT…

V2G technology is available today, and now is the time to deploy it. We need political will and leadership to advance policies to bring the benefits of this technology to our homes and businesses. Our electric grid faces increasing natural and human-caused threats; V2G technology can help stabilize the grid, boost renewable energy development, and make electric vehicles more affordable. We can accomplish all this if we work together. **Let's do it!**

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QUESTIONS?

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THANK YOU!

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www.renewwisconsin.org