Customized Energy Solutions

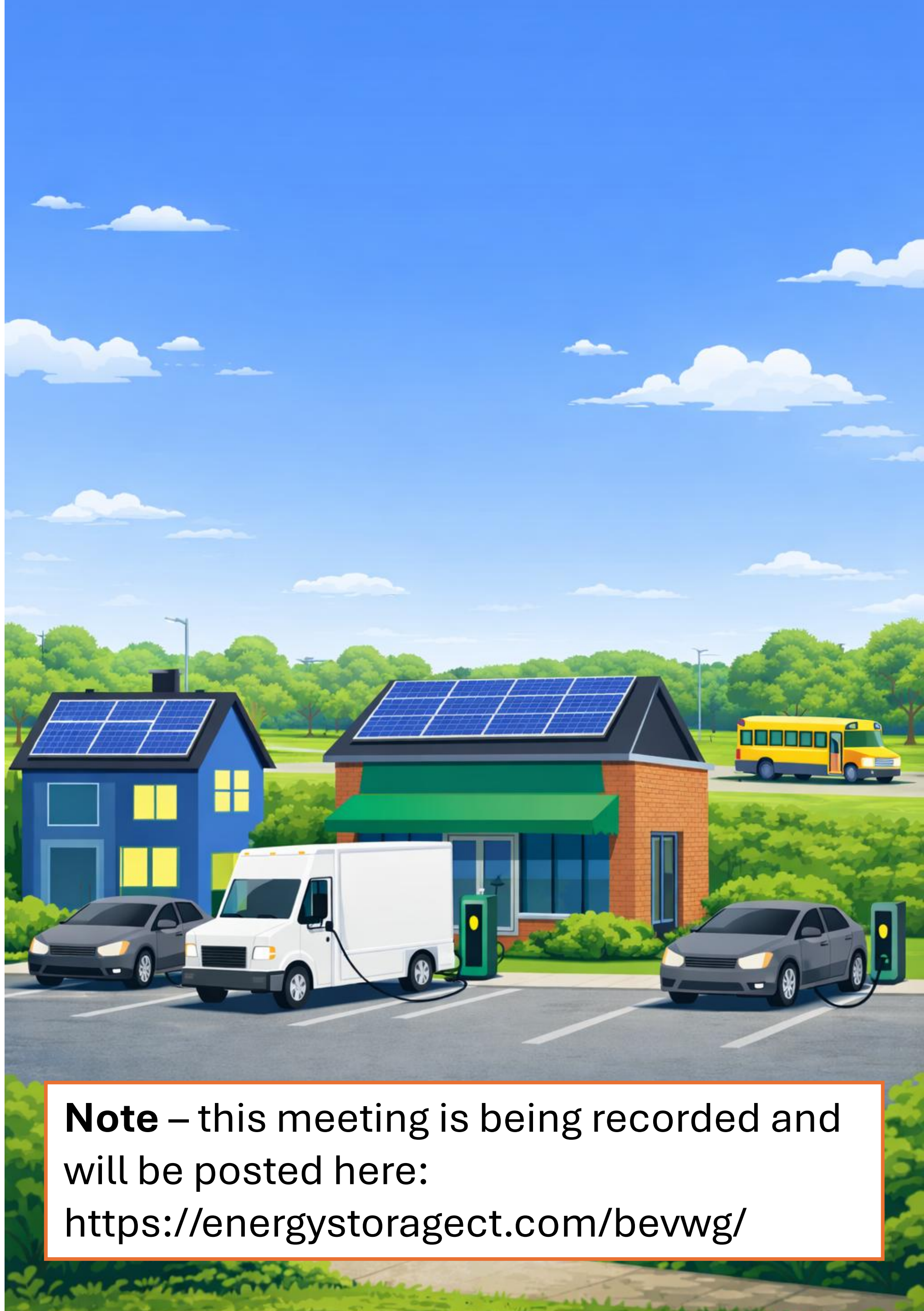
Bidirectional EV Working Group

Meeting #2: Vehicle Class Implications

energy storage SOLUTIONS

CONNECTICUT GREEN BANK | EVERSOURCE | UI An AVANGRID Company

March 31st, 2026



Note – this meeting is being recorded and will be posted here: https://energystoragect.com/bevwg/

Meeting Agenda – Meeting #2: Vehicle Class Implications

Agenda

1. Welcome & Overview
2. Vehicle Class – Definitions, Key Differences, and Relevance for ESS
3. Market Maturity and ESS Participation Thresholds
4. Deeper Dives: Participation/Enrollment Pathways and AC- vs. DC-Coupled Systems
5. Wrap-Up & Next Steps

Objectives

- Review definition of light-duty (LD) vs. medium/heavy duty (MHD) EVs for the purposes of the Working Group
- Introduce key differentiating characteristics across vehicle class
- Identify ways that different vehicle class characteristics may influence the integration of bidirectional EVs into the Energy Storage Solutions (ESS) program
- Identify potential gating criteria that would identify when vehicle/vehicle class would be eligible to participate in ESS

Logistics

- For clarifying comments and questions, please use hand raise function.
- There will be discussion periods during each section

Additional Information

- The WG Charter, meeting notes, slides, presentations and other resources are accessible at: https://energystoragect.com/bevwg/

Context: Key Vehicle Class Distinctions and Relevance for ESS

Background: Why Are We Discussing Vehicle Classes?

Customized Energy Solutions

PURA Order

- Explicitly specified that the report must address "differentiated requirements or recommendations for MHD vehicles compared to LD EVs"

Relevant drivers of program implementation

- Reviewing unique characteristics of LDs vs. MHDs may help identify program design elements that are sufficiently flexible to accommodate multiple classes and/or areas where distinct design is required for different classes (e.g., approach to enrollment)

Understand vehicle class maturity/potential for program participation

- Possibility that different levels of potential program participation/readiness to participate in ESS could inform timing, approach to incorporating into the program

Provide context for future discussion on incentives

- Is there a rationale to have distinct incentive levels and design for different vehicle classes?

Throughout: ensure discussion considers both present state and anticipated changes (e.g., trends in AC- vs. DC-coupled bidirectional EVs)

ESS Definition of Light Duty vs. Medium/Heavy Duty

Customized Energy Solutions

*Definition: **LD** – up to 8,500 Gross Vehicle Weight Rating (GVWR); **MHD**: GVWR of 8,501 and above*

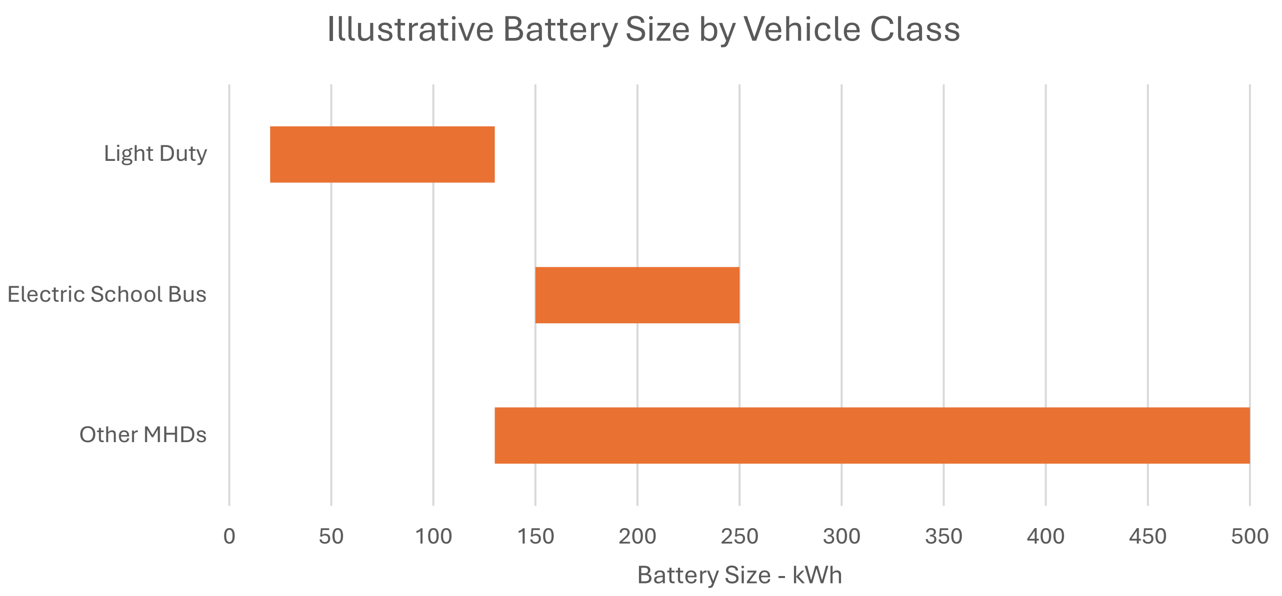
- Rationale: this definition is used in other relevant contexts, including:
  - Environmental Protection Agency definition
  - California Air Resource Board (CARB)
  - Brief summary of other CT programs for EVs, noting LD vs. MHD distinctions
- Other CT EV program eligibility:
  - **Managed Charging Program –** same definition, though this definition is referenced for the Light-Duty fleet program, not the Residential Program (see program manual)
  - **MHD charging service tariff** offered by Eversource and UI in CT (Eversource example tariff) – same definition
  - **'CHEAPR (vehicle incentive)** – doesn't specify LD vs. MHD. Primary criteria are: 1) purchased by resident, 2) from a dealer, 3) with MSRP of $50,000 or below. Doesn't specify LD vs. MHD. In practice, current list of eligible vehicles appears to have no vehicles with GVWR above 8,500.

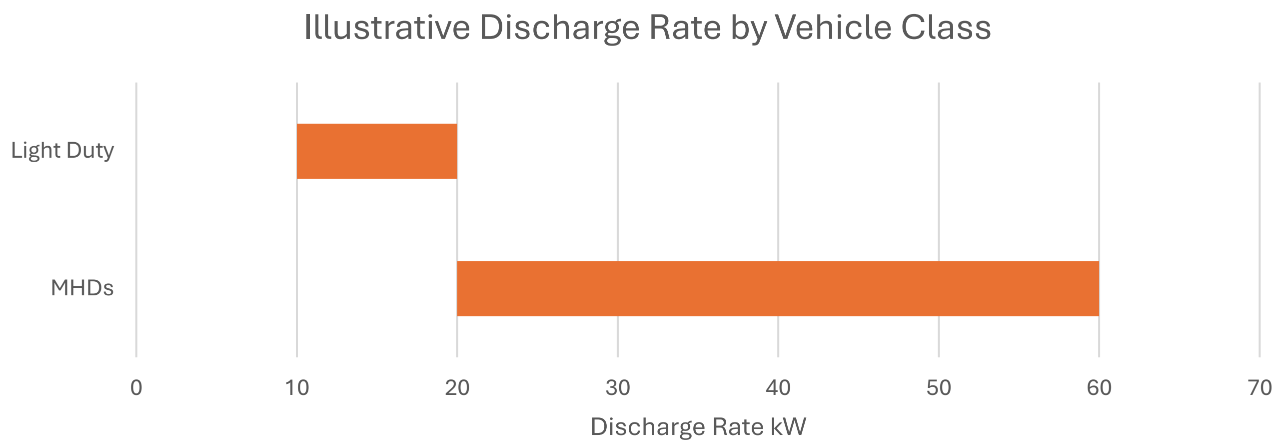
- Examples of important scenarios/considerations arising with this definition:
  - EVs used primarily as personal transportation that may be >8,500 GVWR; examples:
    - Tesla Cybertruck
    - Some Ford Lightning Configurations
    - Chevrolet Silverado EV
    - Most Rivians
  - LDs – personal vs. fleet use
  - MHDs – very different types of vehicles with distinct use profiles (e.g., school buses, refuse trucks, delivery vans, long-haul trucks, etc.)

Given the above, WG may consider differentiating incentives or other program requirements based on other criteria, e.g., whether the electric account is residential or commercial.

Battery Size

- Battery size and discharge rate (along with vehicle availability) determine potential discharge during ESS events, which will dictate:
  - Potential compensation
  - Potential system benefits
- There is significant variation in battery size (kWh) and potential discharge range (kW) across all vehicle classes
- Still MHDs have significantly larger (kWh) batteries and are capable at discharging at higher rates (kW)
  - Note – discharge rate limit is generally set by the inverter, which may be in the EVSE or the vehicle (see next slide)
  - Electrical service may also set the limit





Usage Patterns and Vehicle Availability

- In addition to battery availability, potential performance in the ESS program would be impacted by:
  - **Vehicle availability** (i.e., is the vehicle plugged in in a place where it can discharge during ESS events?)
  - **Vehicle state of charge** (i.e., does the vehicle have sufficient energy at the beginning of ESS events to discharge during the events?)
- **LDs**: heterogeneous usage, fairly specific to individual vehicles
- **MHDs**: heterogenous usage, but patterns for some vehicle/fleet types may be more predictable (e.g., electric school buses)

Examples of Use Patterns for School Buses

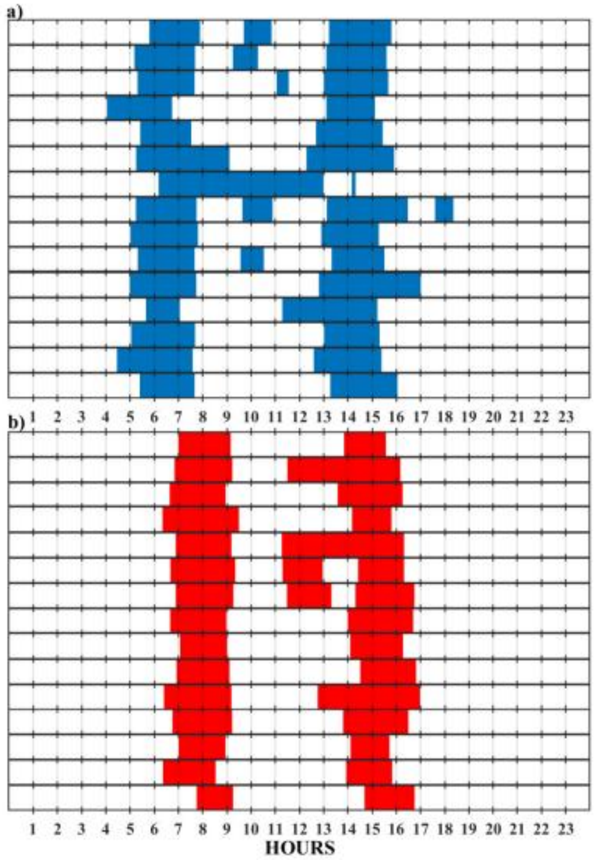
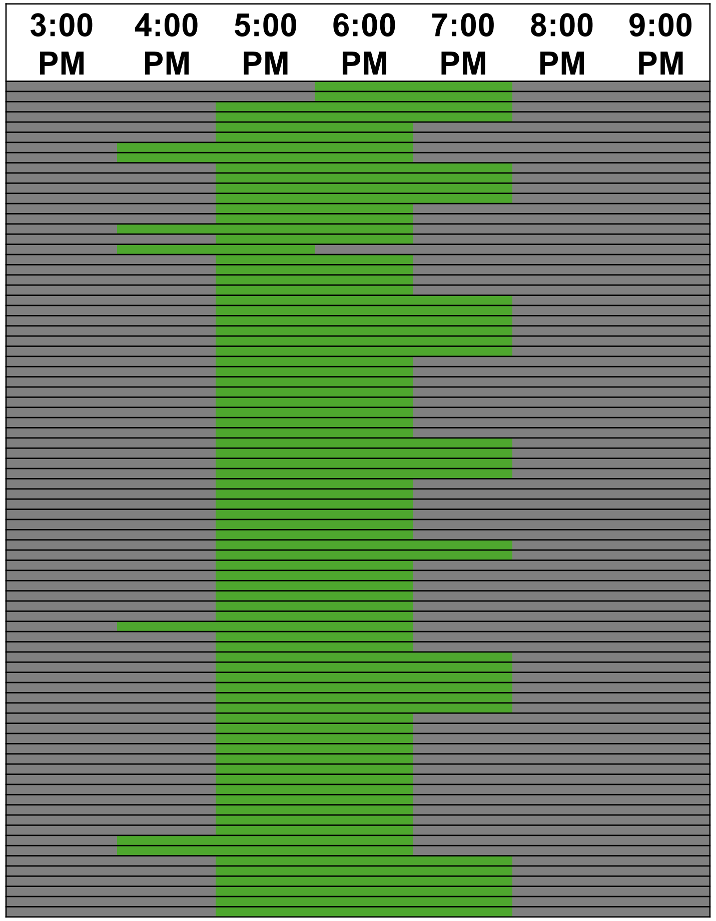


Figure 5: Bus-level operating times (Monday) for a) Fleet 40 (CO) and b) Fleet 41 (WA), respectively.

https://docs.nrel.gov/docs/fy24osti/87322.pdf

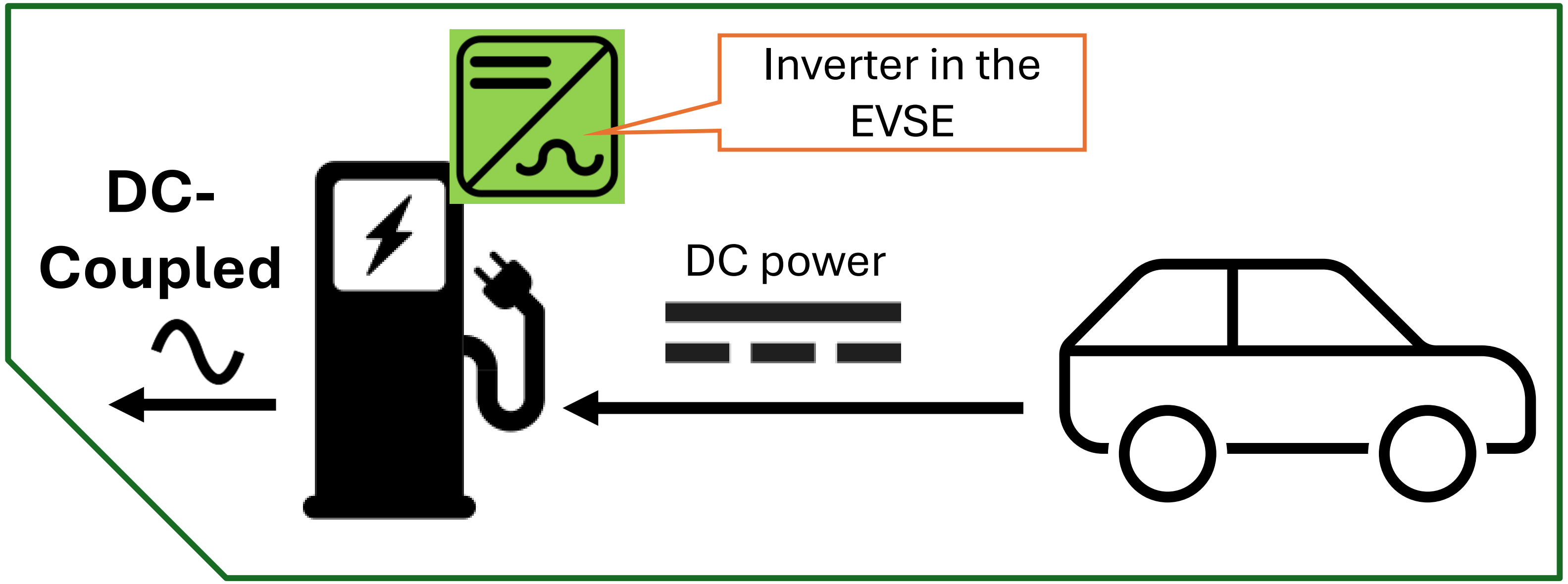
ESS Summer 2025 Active Events

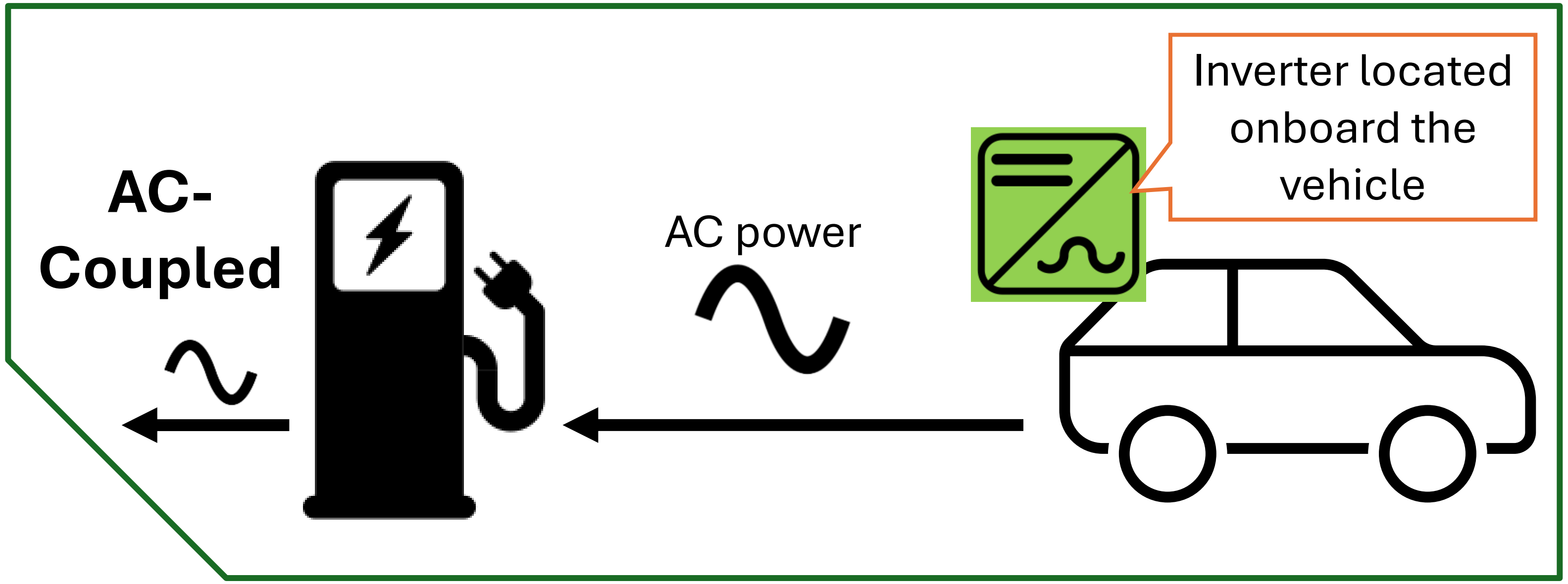


Summer 2025 ESS active event hours. Times represent the beginning of the hour (i.e., if 6 and 7:00pm columns are filled it, event was 2 hours long, starting at 6:00pm). Each line represents an event for a given EDC (i.e., two lines for a given date if each EDC called an event on that date)

AC- vs. DC-Coupling for Bidirectional EVs

- Two main types of bidirectional power flows: AC- and DC-coupled
  - More details later on
- Implications for:
  - Applicable standards
  - Approach to eligible equipment lists, registration, interconnection etc.
- Distinction by LD vs. MHD; *In general*:
  - **MHDs**: historically DC-coupled, anticipate to continue to be dominated by DC-coupled
  - **LDs**: to date (and for most announced products), primarily DC-coupled; AC-coupled systems could become more common, but there are barriers (more challenging interconnection, standards, etc.)





Ownership and Operations

- Vehicles may be owned and used in a variety ways, e.g., personal use, leased fleet vehicles, owned/operated fleet vehicles, etc.
- **In general**, LDs are more likely to be personal vehicles while MHDs are more likely to be fleet vehicles. Examples of exceptions:
  - Personal vehicles that are classified as MHDs (e.g., Rivians, Cybertrucks, etc.)
  - LD vehicles used in commercial fleets
- **Relevance**
  - **Primary value of bidirectional EV.** Examples:
    - Personal – primary value may be backup power or environmental preference
    - Fleet vehicle – ESG goals, sustainability mandates (e.g., Public Act 22-55 requirement for 100% of school buses to be zero-emission by 2040)
  - **Economic considerations.** Individuals and businesses/fleet operators and residents may evaluate the economics of pursuing a bidirectional EV differently.
  - **Buying power.** Fleet operators may be better positioned to use buying power to improve economics and influence EV and EVSE OEMs (e.g., pushing to adopt a specific communication protocol, addressing warranty concerns, etc.)
  - **Technical sophistication.** Fleet operators may be more capable of addressing technical issues that may arise.
  - **Depot charging/discharging**. While centralized depots may present certain efficiencies, they may also create interconnection challenges.

Why These Distinctions Matter

- Considerations above may influence level of participation/performance by vehicle class
- Why do we care about level of participation?
  - ESS pivot to primarily performance-based incentives – should limited performance matter?
  - Potential reasons for seeking some minimum level of performance/participation:
    - Justification of program administrative costs: experience with ESS has demonstrated that administrative costs can be non-negligible; furthermore, integration challenges, working with many different partners is labor-intensive, can shift attention away from other valuable program efforts
    - Energy Storage Solutions program currently limited to **580 MW**, while program is far from this overall goal, as it approaches it, preference for ensuring that those MW are associated with resources that are robust participants, providing benefits to CT residents and businesses

Examples of characteristics that may influence participation and performance:

- Vehicle availability/usage patterns/customer preferences
- % of time asset is plugged in
- Dispatch flexibility
- OEM battery warranty
- Battery size/discharge capacity
- Maturity of ecosystem needed to aggregate/facilitate enrollment in ESS
- Incentive level available

Implications of LD vs. MHD for ESS Integration

- Program elements that might differ for LDs vs. MHDs:
  - Eligible equipment (applicable standards, eligible equipment lists, etc.)
  - Enrollment pathway (e.g., individual customer, bulk enrollment through OEM, charging management service provider, fleet operator, etc.)
  - Approach to dispatch and providing telemetry data
  - Incentive, compensation structure
  - Other details that would need to be addressed in the ESS Program Manual

Discussion:

- *What are the other important implications of LDs vs. MHDs for the ESS and the Bidirectional EV WG's work?*
- *For these items, what can be addressed during this meeting vs. future meeting vs. outside of this Working Group?*

Market Readiness Snapshot

Connecticut EV Market Share

73,156	+20.94%	3.17%	~12%
Total EVs Registered in CT, including plug-in hybrid EVs	Year-over-Year Growth, 2024-205	EVs as % of Total Vehicles Registered	EVs as % of Total LD Vehicle Sales Q1-Q3 2025

- Note – YoY growth likely influenced by temporary increase in EV sales with expiration of federal tax credit for EVs
- Values above are for *all EVs* including plug-ins; few of the above are currently bidirectional capable
- Of the numbers above 277 were vehicles weighing 10,000 pounds or more

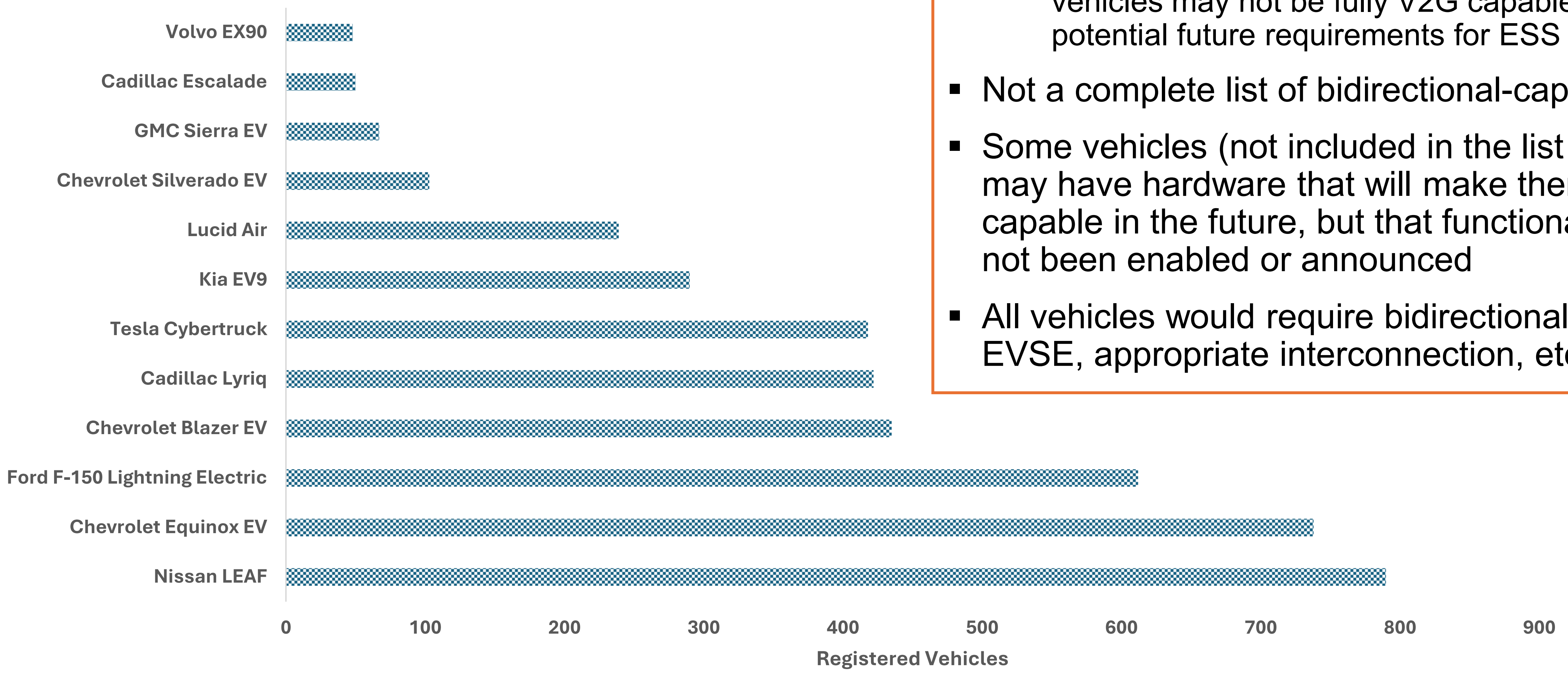
- Significantly more EV adoption for LDs than MHDs; this does not necessarily translate into potential for ESS participation

Sources: https://portal.ct.gov/-/media/deep/air/mobile/cheapr/ev-reg-fact-sheet.pdf. https://www.autosinnovate.org/posts/papers-reports/get-connected-ev-quarterly-2025-q3. Unless otherwise noted, data as of 12/31/2025.

Customized Energy Solutions

Top Bidirectional-Capable EVs in Connecticut

Numbers of EVs Registered as of 12/31/2025



- Based on models with announced or demonstrated V2H/V2G capabilities
  - Note – this is an illustrative list – some of these vehicles may not be fully V2G capable or meet potential future requirements for ESS integration
- Not a complete list of bidirectional-capable EVs
- Some vehicles (not included in the list to left) may have hardware that will make them V2G capable in the future, but that functionality has not been enabled or announced
- All vehicles would require bidirectional-capable EVSE, appropriate interconnection, etc.

Source *- CT Electric Vehicle Registration Data: [Link]*

EV/EVSE Interoperability

- **Relevance of interoperability**: will an EV owner/operator that purchases a given EV and EVSE be required to purchase a new EVSE if they move to a different EV (or vice versa)? Would a fleet operator be effectively locked into a specific EV OEM once they install a specific EVSE?
- Interoperability of EV and EVSE has many layers:

Layer	Light-Duty (LD)	Medium / Heavy-Duty (MHD)
Connector / Interface	- **AC**: J1772 (ubiquitous) - **DC**: CCS / NACS (standardizing) - Bidirectional capability varies by OEM	- **DC**: CCS (today), MCS (emerging) - More standardized within fleet deployments - Less fragmentation in practice
Certification & Interconnection	- **DC:** EVSE certified via UL 1741 SB - **AC:** Mixed and evolving pathways. For AC, UL 9741 + UL 1741 certification pathway *explicitly based on pairing of specific vehicle with specific EVSE equipment*	- EVSE almost always certified as DER (UL 1741 SB) - Aligns with IEEE 1547-2018 - More consistent, utility-aligned processes
Vehicle–EVSE Communication	- ISO 15118-2 (current baseline) - Transition to ISO 15118-20 underway - OEM-specific implementations common	- Increasing use of ISO 15118 (especially for DC) – may be integrated with fleet energy management systems - Less emphasis on plug-and-play interoperability. *See challenges experienced in GridEdge IES pilot*.
Aggregation & Control	- Fragmented: OEM controls vehicle dispatch - EVSE vendor + aggregator integration varies	- Centralized fleet control: Single operator manages vehicles + chargers – In theory, easier integration with aggregators / utilities -

Takeaways:

For both LD and MHD– interoperability of EV and EVSE for V2G is (and will likely continue to be for some time) limited.

LDs:

- Currently, bidirectional capability often explicitly limited within a given OEM for LDs (e.g., Tesla, GM, Ford); other pairings (e.g., EV9 and Wallbox Quasar 2) are currently specific to given EVSE and OEM
- For DC, maturing standards could make interoperability more feasible, but OEMs may continue to choose to keep environments closed; for AC, interoperability more challenging

MHDs:

- Interoperability still currently limited (e.g., by vehicles using ISO 15118-2 or proprietary protocols that preceded standards vs. 15118-20)
- Consolidation on DC architecture removes some potential barriers to interoperability
- Fleet operators more sophisticated, may be better able to understand (and potentially address) interoperability issues

AC vs. DC Coupling

- Implications of coupling for maturity/potential integration into ESS:
  - Differences in **interconnection:**
    - **DC**: Generally, DC-connected systems can be treated much like stationary storage, requiring relatively few modifications to interconnection processes, as DC-connected EVSE uses many of the same relevant certifications used by solar and stationary BESS inverters, e.g., UL 1741 SB
    - **AC**: Multiple potential pathways (e.g., Maryland supporting either EVSE certified to UL 1741 SC with SAE J3072 EV or paired EV/EVSE certified to UL 1741 SB as composite system); generally, more likely to require changes in interconnection standards
  - Differences in **certifications:**
    - **DC:** As noted above, use of 1741 SB standard for DC systems is widespread
    - **AC:** An evolving space; UL 1741 SC expected to be finalized this year
    - **Note** - other important standards and certifications also apply, e.g. ISO 15118-20 which is a communication protocol between the EV and the EVSE addressing items such as charge/discharge setpoints.
- **Takeaways**:
  - **In general,** DC-coupled architecture is more mature, with a more established certification pathway. Finalization of relevant certifications and changes to interconnection processes to better accommodate AC-coupled bidirectional EVs, however, could yield significant advancement for AC-coupled systems in the near future.
  - **MHDs:** Almost exclusively DC-coupled, not likely to change
  - **LDs:** Currently effectively all DC-coupled, but AC-coupled systems could become more available in the near future

Customized Energy Solutions

Discussion:

- *Are there specific **gating criteria** that we should consider before vehicles are ready to be integrated?*
  - *This could be completing standards, work that the PAs need to do to make the program ready for it, interconnection criteria, etc.*
  - *Should we consider integrating certain classes of vehicles initially through a limited offering?*

Deeper Dives

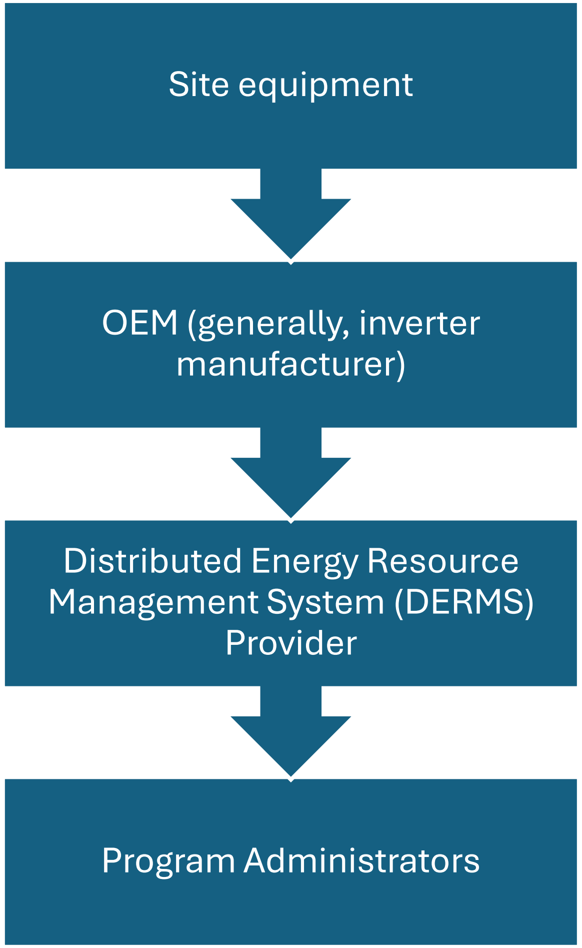
Enrollment and Participation Pathways

- ESS has an existing process for enrolling customers, gathering telemetry data, and making payments
- Primary options for **enrollment**:
  - Through Contractor, Third-Party Owner (TPO) or Aggregator, who submit application on behalf of customer
  - Customer self-enrollment, through web or app interface provided by BESS Operator, BESS Aggregator, or OEM
  - Contractors, TPOs, Aggregators, as well as self-enrollment platforms must be approved by Program Administrators
- **Payments**:
  - Performance payments can be made directly to customer or to another party the customer designates (e.g., TPO, OEM, etc.)
  - Some OEMs/Aggregators charge a "vendor fee" or keep some of the performance incentive – a charge for operating a BESS in the program

Discussion:

- Do these types of parties (contractors, TPOs, Aggregators, etc.) map well onto the Bidirectional EV space?
- How might the processes described above need to differ for EVs? What does this look like for MHDs vs. LDs?

Typical, High Level Telemetry Data Flow



Wrap-Up & Next Steps

Review of Meeting Topics

Meeting	Theme	Key Questions & Focus Areas
2	**Bidirectional EV Technology Requirements by Vehicle Class**	• Technical characteristics of bidirectional EVs by vehicle class; ESS participation readiness. • Vehicle, charger, and site-level requirements for bidirectional operation. • Integration of IES pilot early lessons. • Potential for phased inclusion of bidirectional EVs into ESS by vehicle class
3	**Technical Integration of Bidirectional EVs into ESS**	• How ESS technical requirements must adapt for bidirectional EVs; data, telemetry, and verification needs. • DERMS capabilities, constraints, and potential workarounds. • Privacy, cybersecurity, and data access considerations.
4	**Cross-Program Participation**	• Overlap between ESS Program and other state EV programs, particularly managed charging. • Distinguishing load reduction vs. energy discharge across programs. • Considerations across programs to avoid double-counting. • Identification of relevant tariffs (enabling and/or potential conflicts)
5	**Bidirectional EV Incentives**	• Appropriate incentive structure for bidirectional EV participation in ESS. • Upfront versus performance-based incentives. • Incentives tied to EVSE, vehicles, or integrated systems.
6	**Draft Recommendations Review**	• Present draft findings; identify consensus vs. minority views; confirm alignment with PURA's five directives. • Document consensus positions and non-consensus items. • Alignment with Interconnection Working Group recommendations.

Meeting Schedule

Meeting	Topic	Date
1	Kickoff & Framing	Friday, March 6th: 9:00-10:30AM ET
2	Bidirectional EV Technology Requirements by Vehicle Class	Tuesday, March 31st: 9:00-10:30AM ET
3	Technical Integration of Bidirectional EVs into ESS	Thursday, April 16th: 9:00-10:30AM ET
4	Cross-Program Participation	Thursday, May 7th: 9:00-10:30AM ET
5	Bidirectional EV Incentives	Friday, May 29th: 9:00-10:30AM ET
6	Draft Recommendations Review	Friday, June 12th: 9:00-11:30AM ET