Wednesday, October 28, 2020

FIRST ANNUAL SIDLEY BATTERY SCHOOL

Electric Vehicles: Technology, Law, and Policy

SPEAKERS

Kenneth W. Irvin • Justin A. Savage
Samina M. Bharmal • Joseph T. Zaleski
JT Guerin • David Garrett

SIDLEY

Wednesday, October 28, 2020

FIRST ANNUAL SIDLEY BATTERY SCHOOL

Electric Vehicles: Technology, Law, and Policy

Session 1: Technical School

SPEAKERS

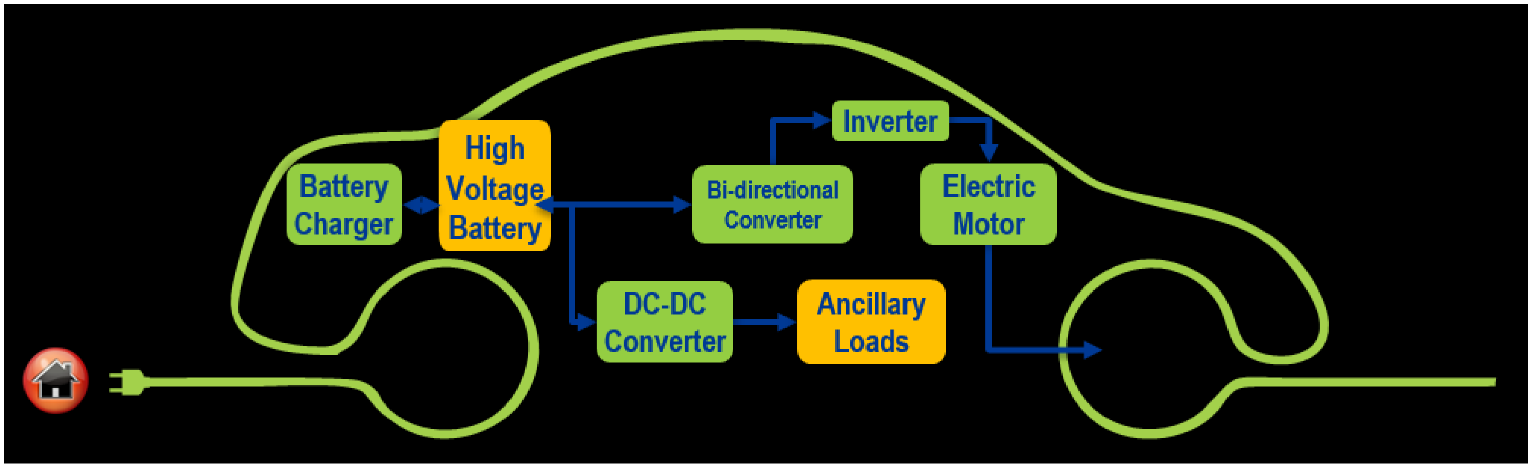
JT Guerin • David Garrett

SIDLEY

Agenda

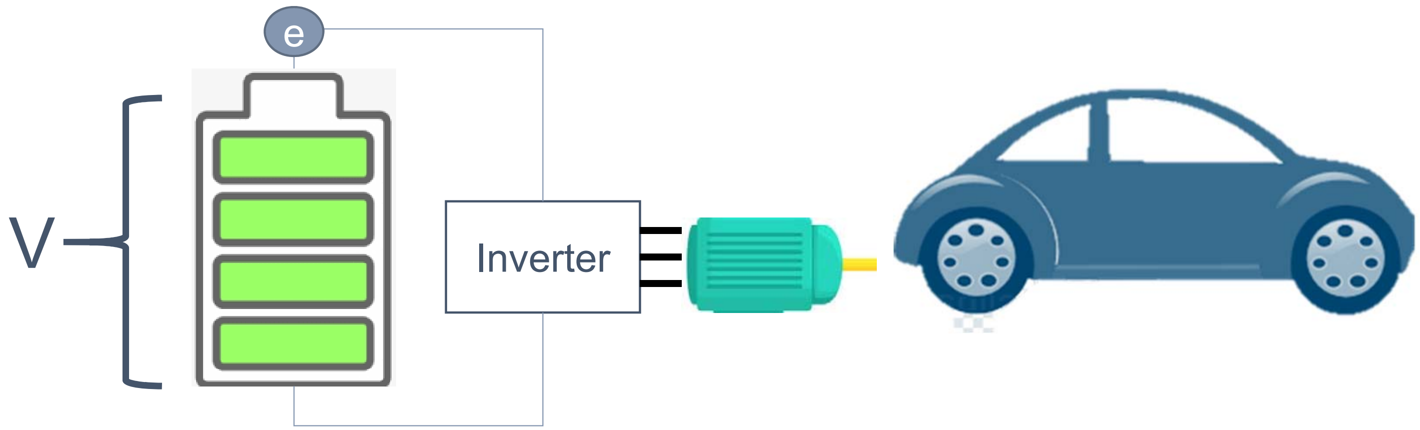
Electric Vehicle: Introduction

Electric Drive Systems



- High-voltage battery electrical energy storage (fuel tank)
- Bidirectional converter/inverter — DC to AC to drive electric motor
- Electric motor + single speed gear reduction — torque to wheels
- DC-DC Converter (high voltage to 12V) — vehicle electrical loads (lights, AC, power steering, etc.)
- Onboard charger — AC to DC Conversion to recharge battery

Battery Operation in the Vehicle



DEFINITIONS

Voltage (V): “force” required to move electric charge between two points

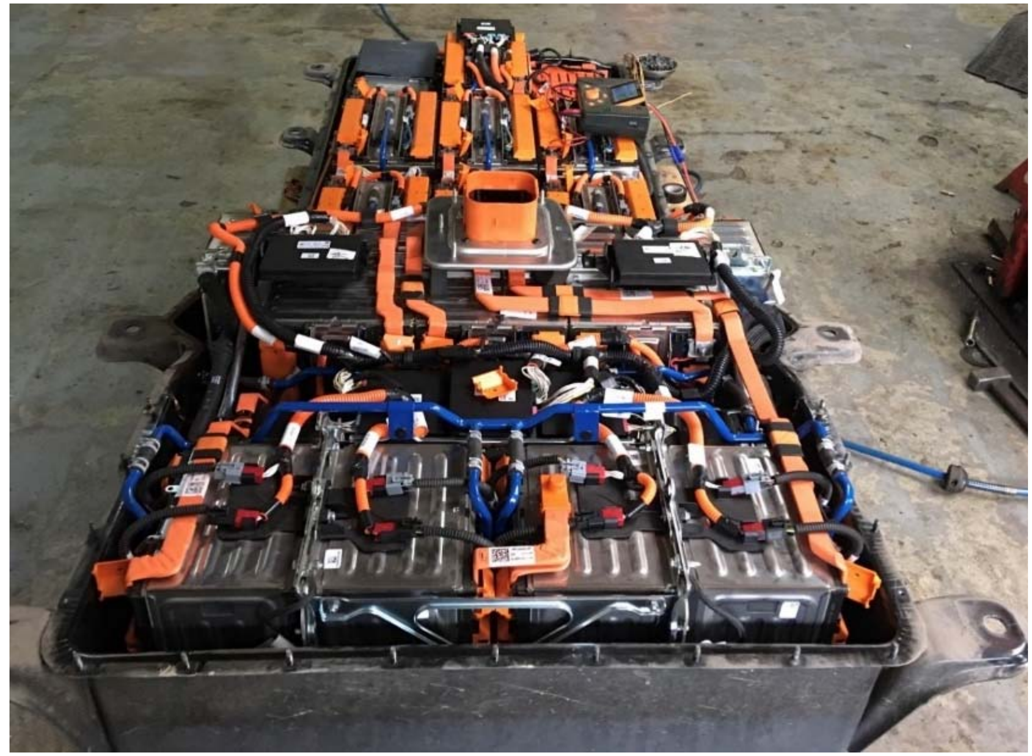
Amp (A): rate of charge flow

Amp Hour (Ah): unit of electric charge (rating for the capacity of cell)

Watt Hour (Wh): unit of Energy = V x Ah (defines how far the vehicle can go)

Watt (W): unit of Power = V x A (defines how fast the vehicle can go and how much mass it can move)

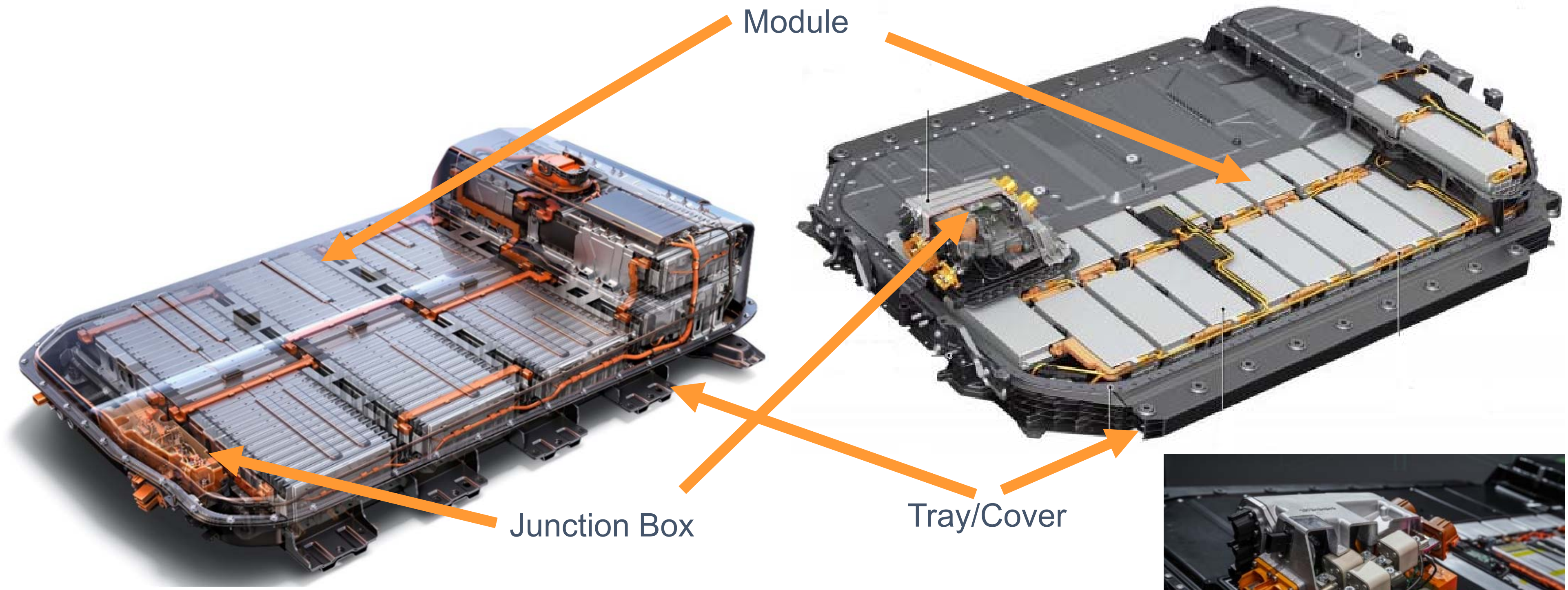
Battery Pack

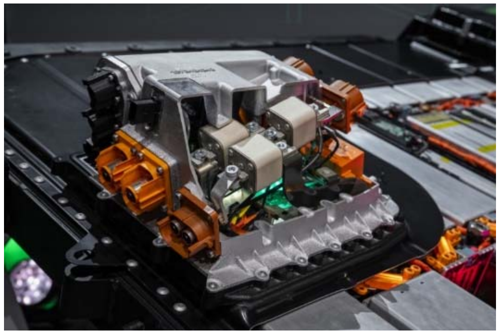


- **Cell** is a single electrochemical unit
- **Battery** is the assembly of cells for increased voltage and energy
- Battery (pack) assembly
  - Modules
  - Thermal management system
  - Electrical (junction box, contactors, fusing, wiring)
  - Battery management system (controller)
  - Tray/cover (sealing)

Battery Packs

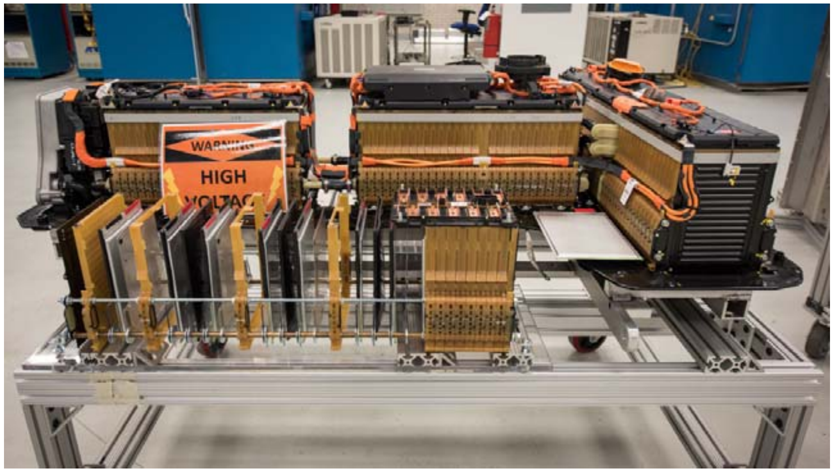
Battery Pack

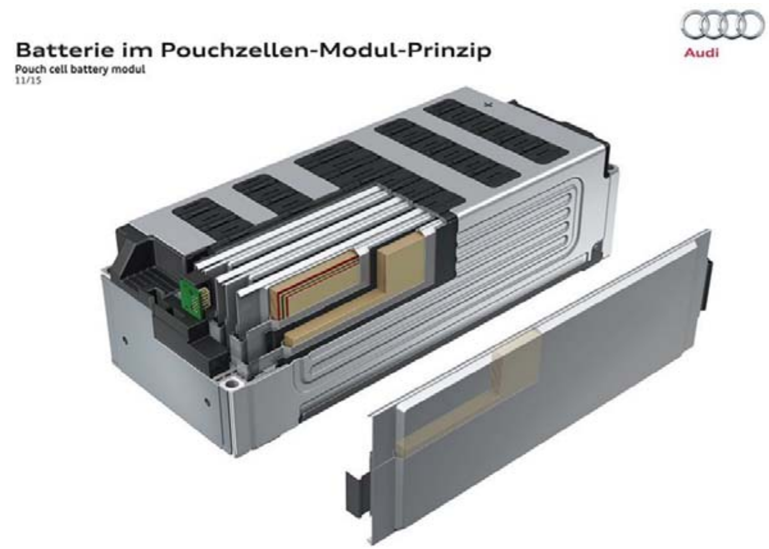




Volume efficiency 30%-40% all cells total volume to pack total volume
Mass efficiency 50%-65% all cells total mass to pack total mass

Battery Module





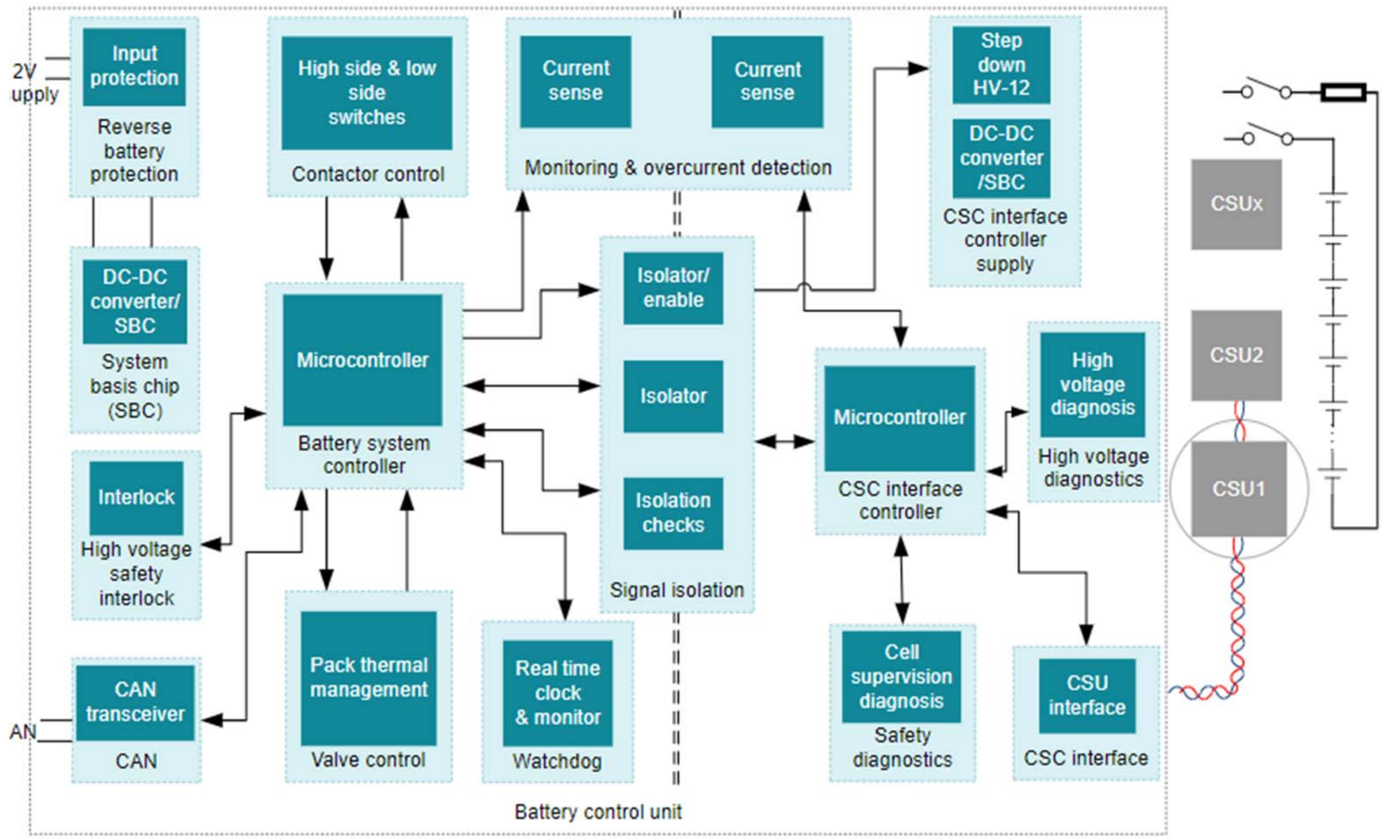
Functions of a module:

- Structure to hold and retain cells
- Cell-to-cell electrical connections
- Thermal management
- Cell electrical sensing

Modules designs vary significantly between manufacturers

Battery Management System (BMS)

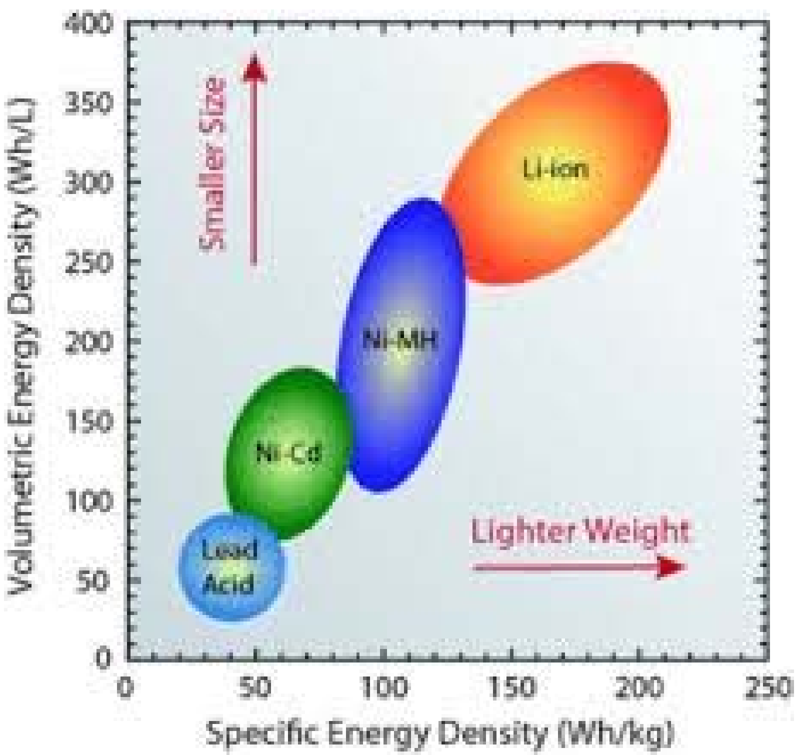
- BMS functions
  - Cell monitoring
  - Isolation detection
  - Balancing
  - State of charge
  - State of health/capacity
  - Diagnostics (OBD)
- Vehicle controls
- Charge control
- Functional safety
  - Functional safety process
  - ISO 26262 standard



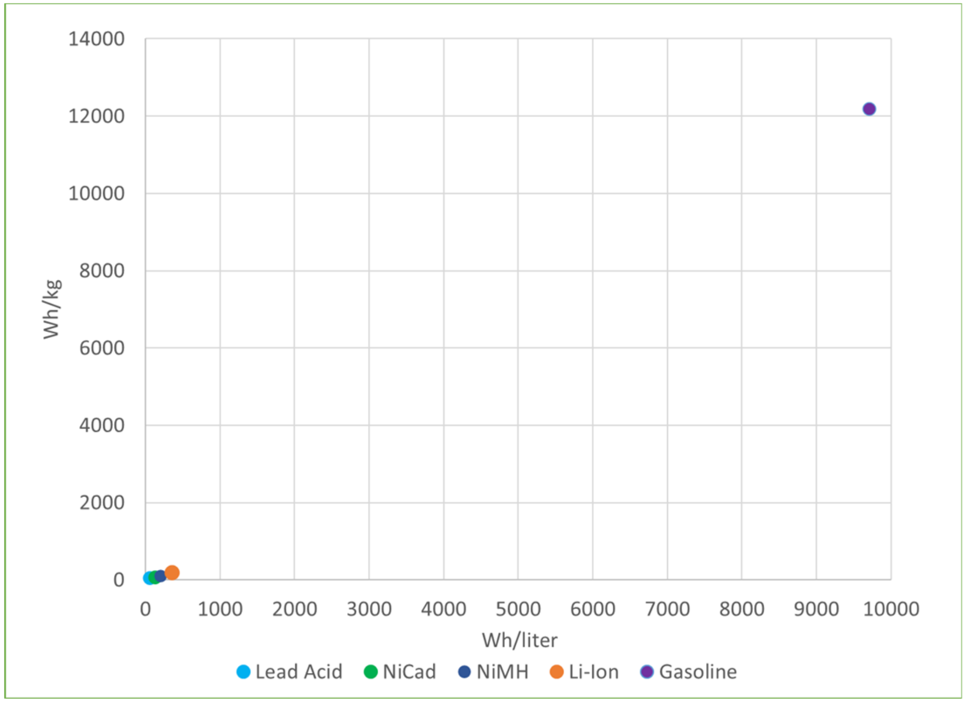
Source: Texas Instruments

Introduction to Lithium-Ion Cells

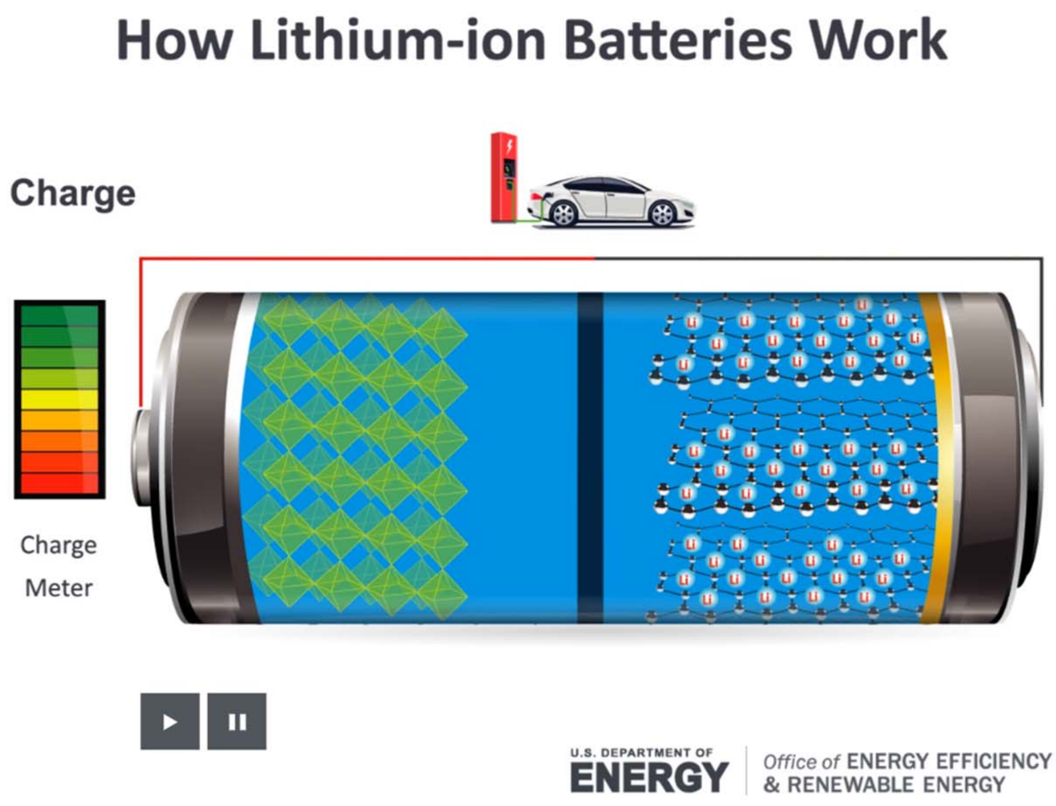
Lithium-Ion Battery Cells



Lithium-Ion (Present Status)
700-750 Wh/liter
250-265 Wh/kg

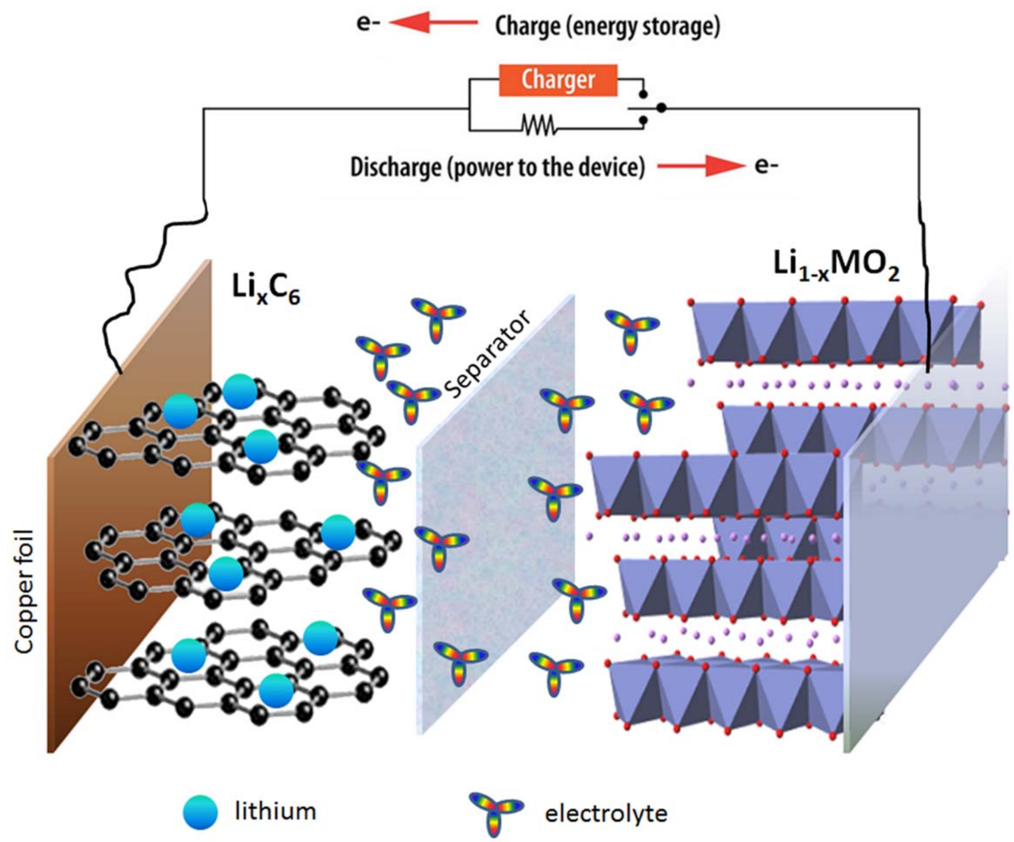


Lithium-Ion Battery Cell



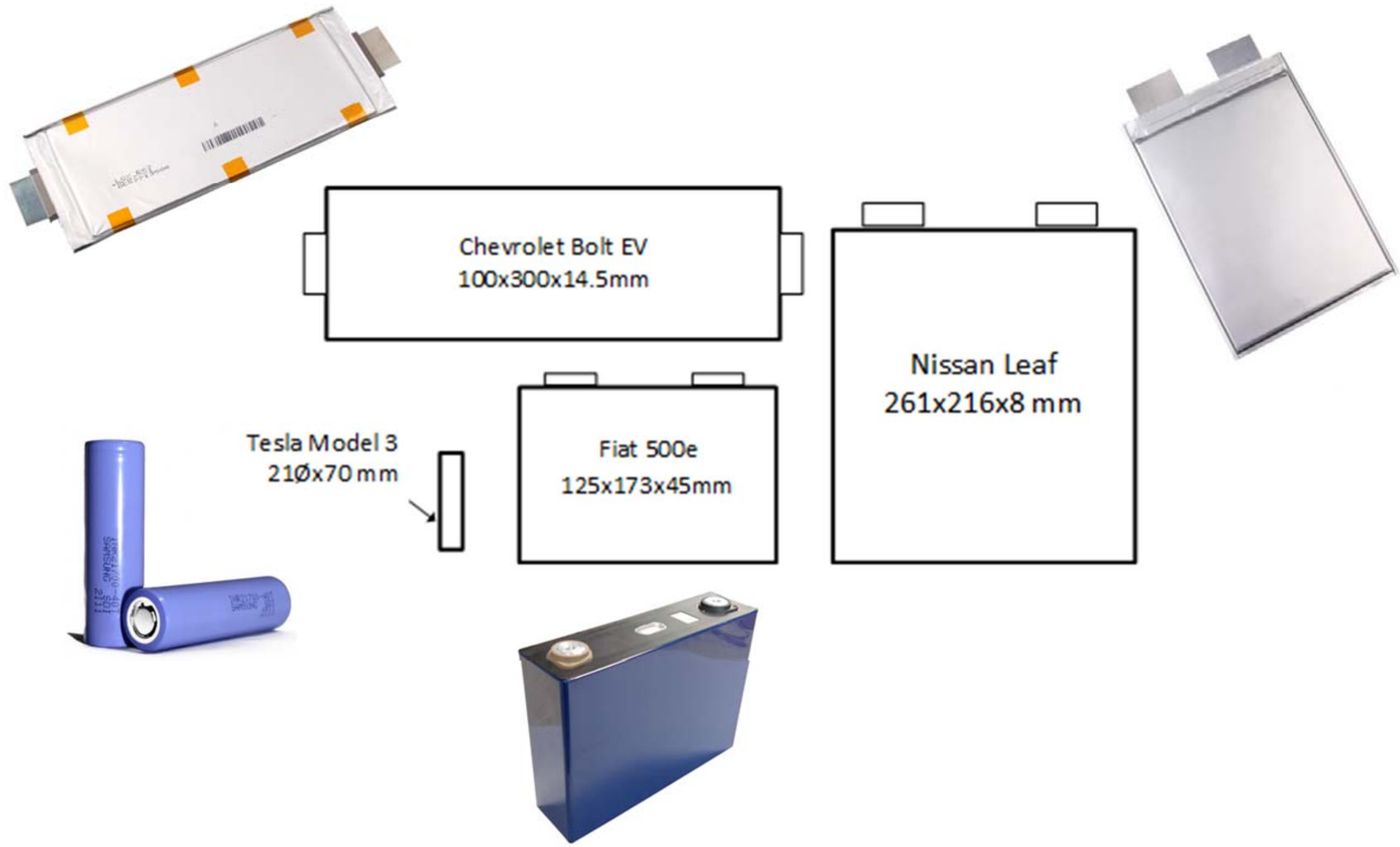
Lithium-Ion Battery Cells

- Voltage defined by the material used in cell
- Li-Ion cell ~3.6V/cell
- Ah capacity is function of the amount of Li



Formats

- Prismatic pouch
- Prismatic can
- Cylindrical can
  - 18650
  - 2170
  - 4860



Cell Design

- Winding
- Stacking
- Folding

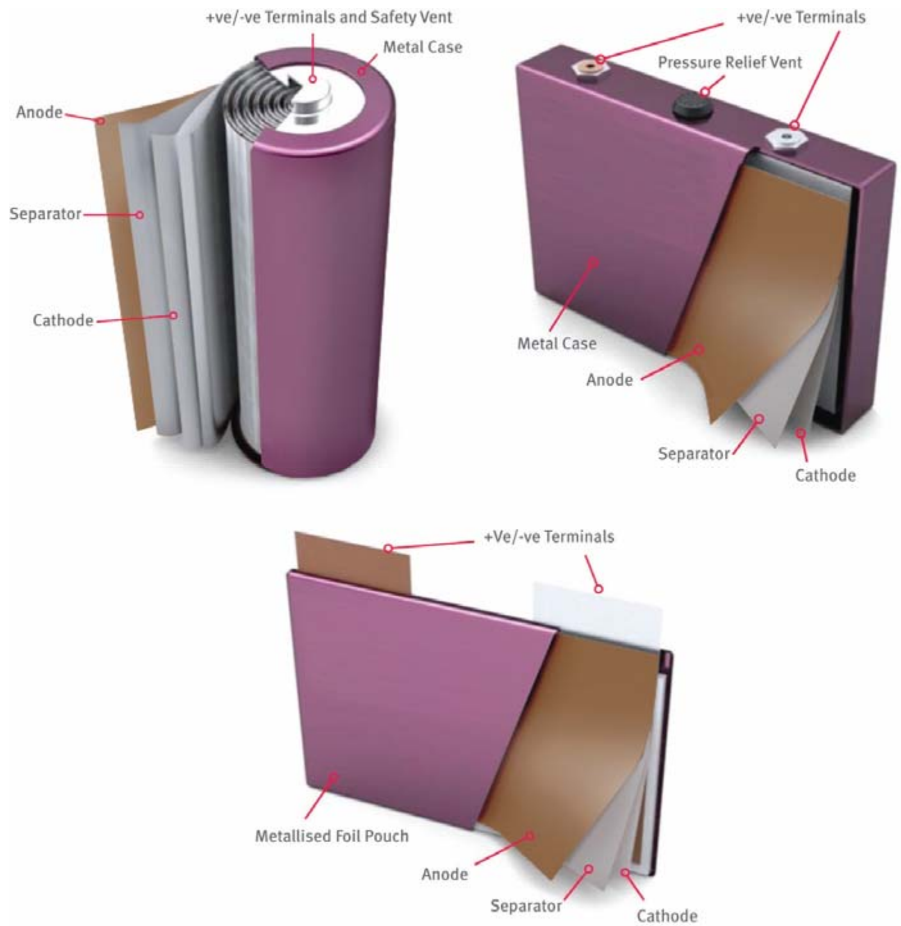
Copyright Foil

Anode (Neg Electrode)

Separator

Cathode (Pos Electrode)

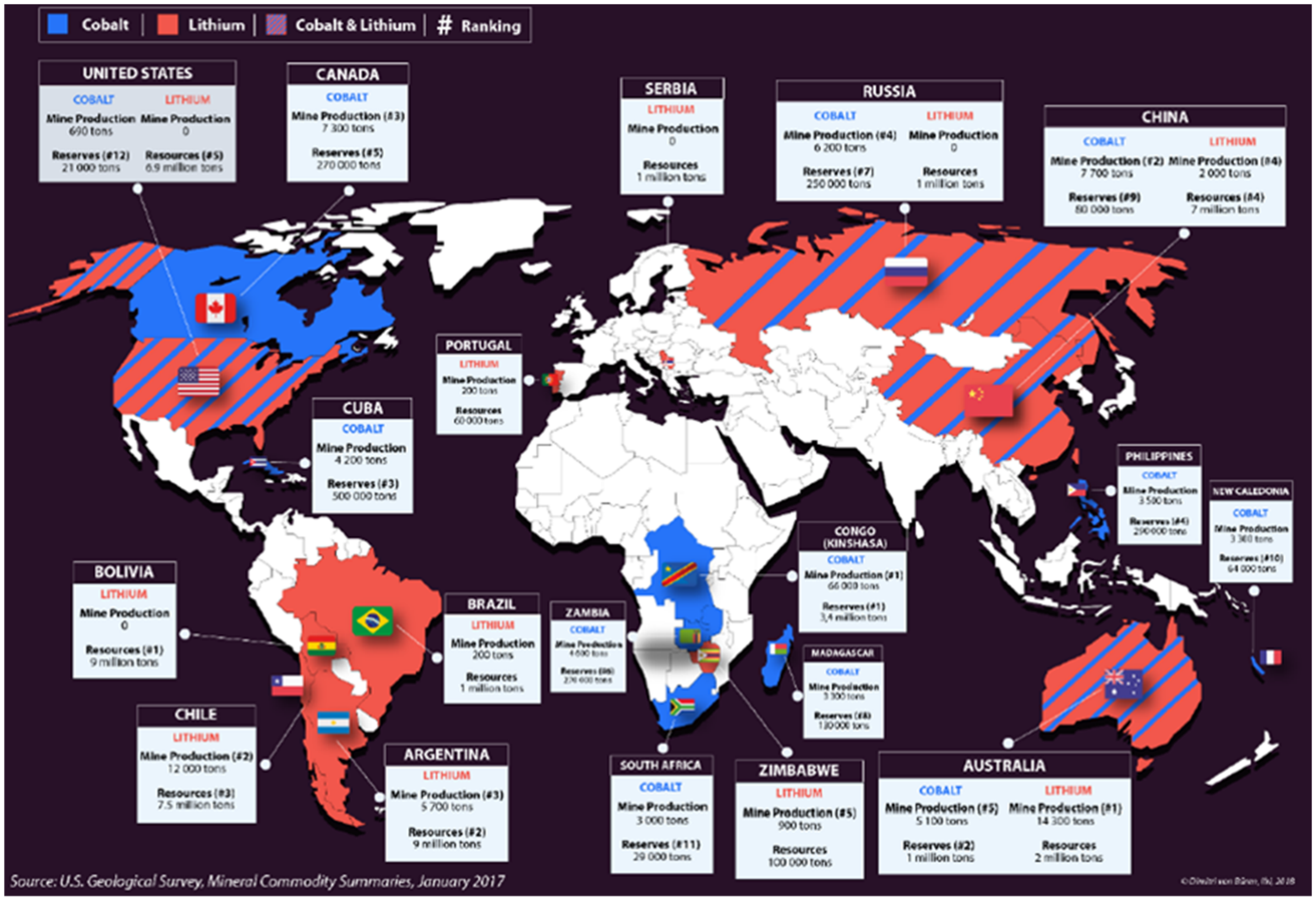
Aluminum Foil



Cell Materials

Anode	Cathode	Binders	Electrolyte	Foils	Separator
Carbon/graphite Carbon + silicon Titanate	Metal oxides • Cobalt • Nickel Manganese Cobalt (1:1:1; 6:2:2, 8:1:1) • Nickel Cobalt Aluminum • Manganese Iron phosphate	Organic Solvents 	LiPF6 Ethylene carbonate Dimethyl carbonate 	Copper Aluminum	Polyethylene Polypropylene

Cell Raw Materials

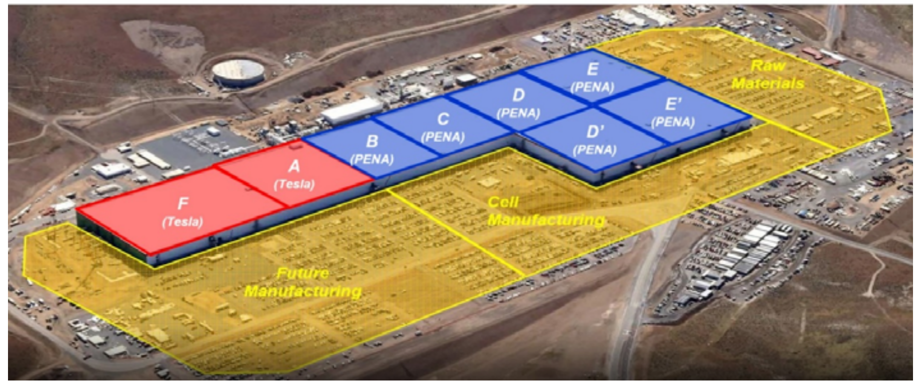


Source: The Energy Transition and the Challenge of Critical Raw Materials, January 2018, French institute for International Relations

Cell Manufacturing

- Clean room/very low humidity
- Electrode
  - Mixing
  - Coating
  - Drying
  - Calendaring/compressing
  - Slitting/cutting
- Cell assembly
  - Rolling/folding/stacking
  - Can insertion/pouch folding
  - Tab welding
  - Electrolyte filling
  - Can/pouch sealing
- Activation/aging
  - Two-to-three week process

Achieved target of 35GWh per year production

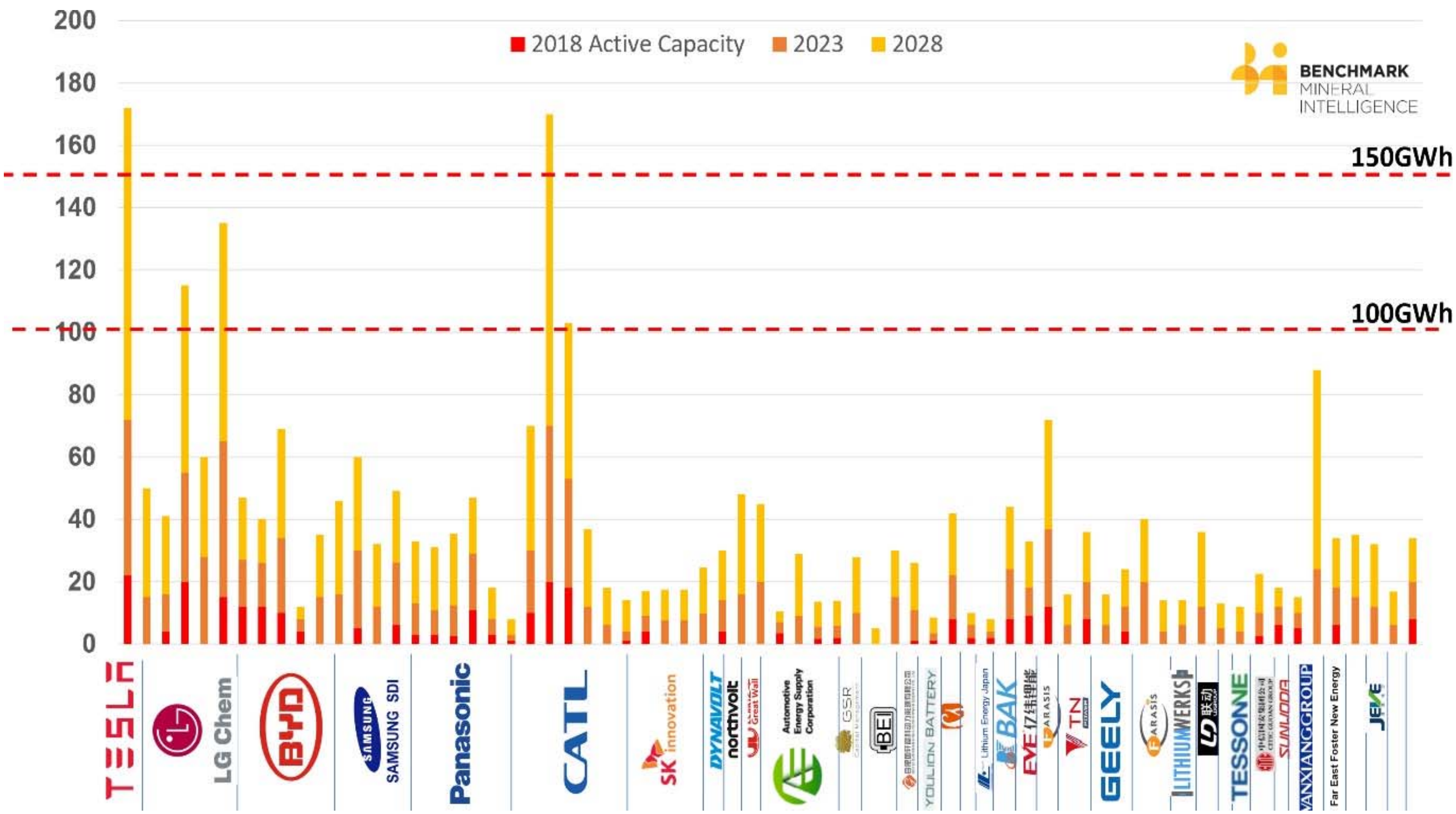


Panasonic Gigafactory

Source: Panasonic Energy of North America a Gigafactory Update, International Battery Seminar 2020

Suppliers

- Cells
  - LG Chem
  - Samsung SDI
  - Panasonic
  - CATL
  - BYD
- Materials
  - BASF
  - Umicore
  - Johnson Matthey
  - Mitsubishi Chemical



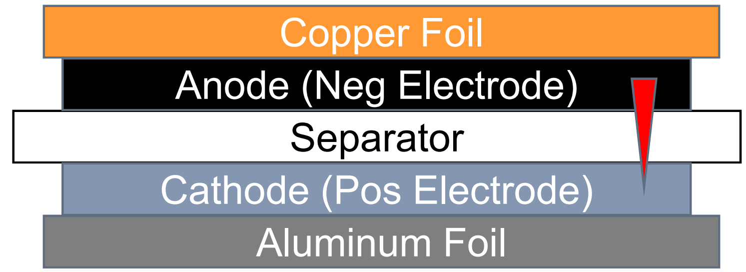
Source: U.S. Senate Committee on Energy and Natural Resources
Simon Moores, Managing Director, Benchmark Mineral Intelligence

Sales and Distribution

- Direct from cell suppliers
  - Limited to only the highest volume purchasers
- Distributors
- Li-Ion cells are generally not directly available to consumers
- Cell Suppliers exert a lot of control of how their cells are used and in what applications

Failure Mechanisms

- Internal short circuit
  - Thermal runaway
  - High self-discharge
- Wear out
  - Degradation of the active materials
    - Reduced ability to store energy
    - Reduces ability to transfer power
- Loss of can or pouch sealing
  - Electrolyte evaporation
    - Loss of ability to store energy or transfer power
- Battery controls failures
  - Over voltage
  - Over current
  - Over temperature



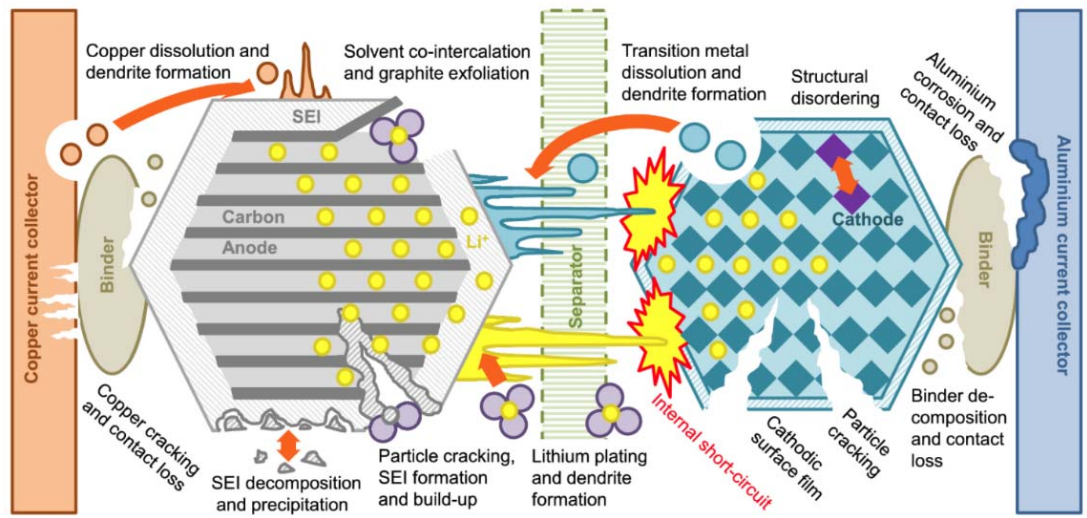


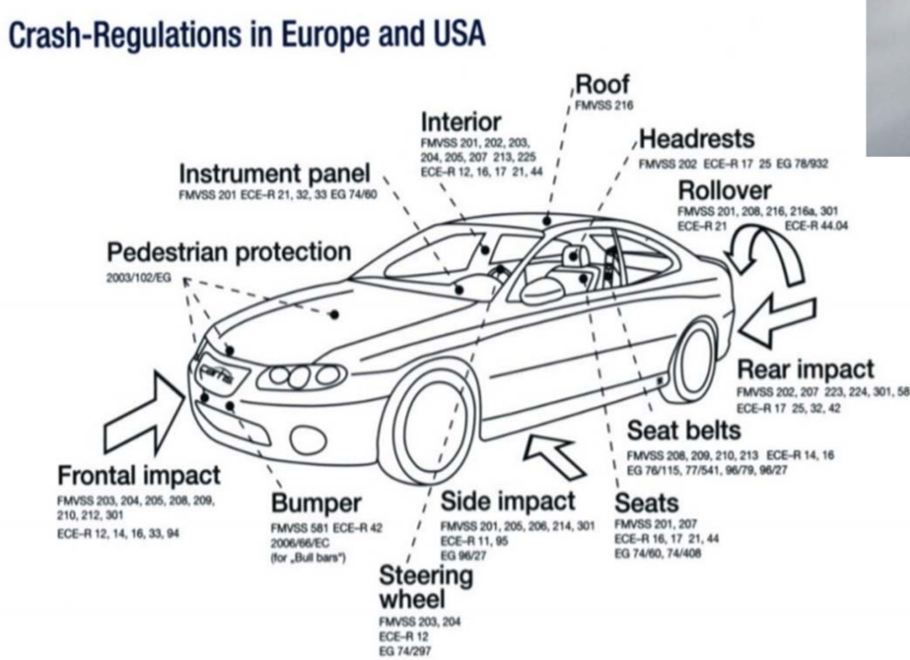
Fig. 1. Degradation mechanisms in Li-ion cells.

Source: Birkl. Degradation Diagnostics for lithium ion cells
Journal of Power Sources. Volume 341, 15 February 2017

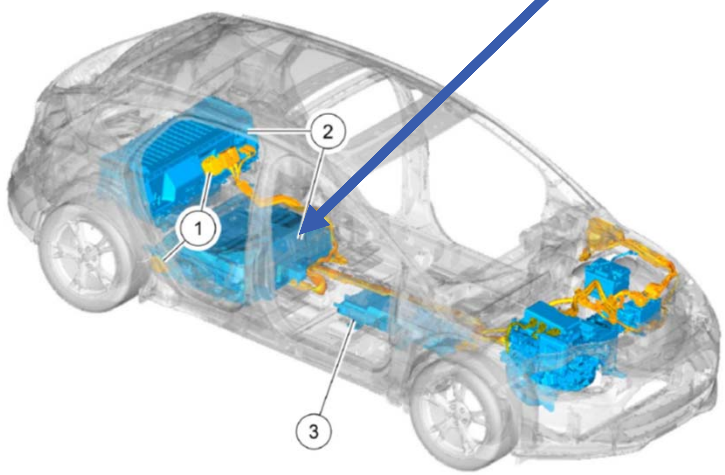
Vehicle Integration

Battery System Safety

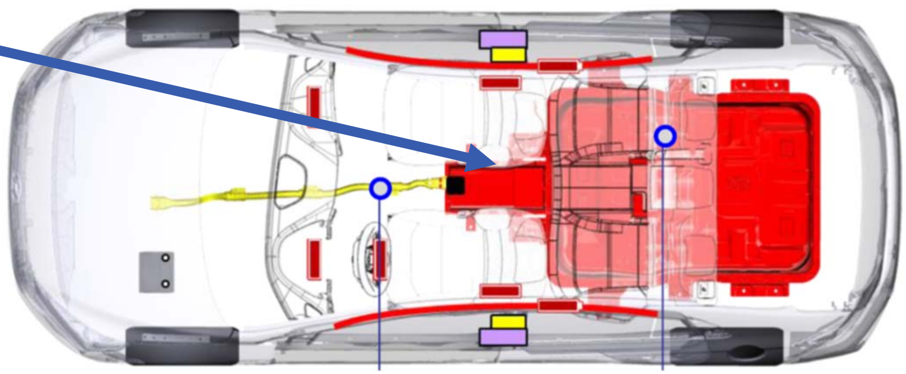
- Passive Safety
  - High voltage, shock hazards
  - Standards and regulations
    - FMVSS 305 — Electric Powered Vehicles: Electrolyte Spillage and Electrical Shock Protection
    - FMVSS 301 — Fuel System Integrity – Rear Impact
    - FMVSS 208 — Occupant Crash Protection



Battery Integration Into the Vehicle: Class 1



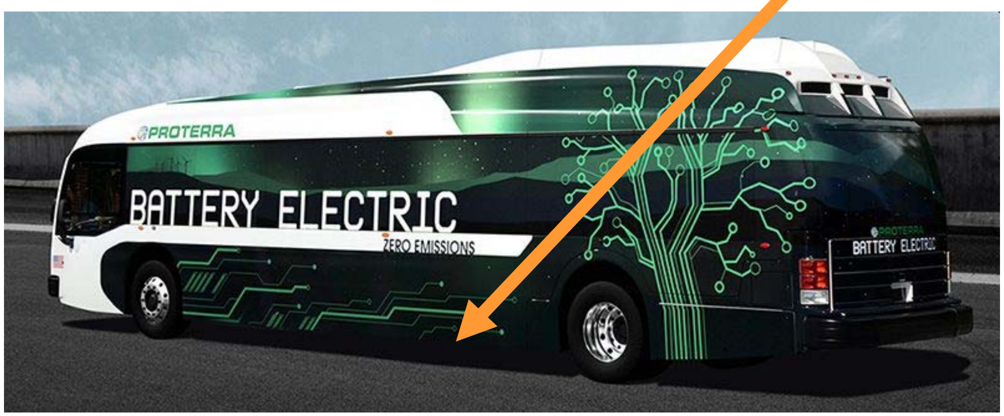
2017 Ford Focus Electric



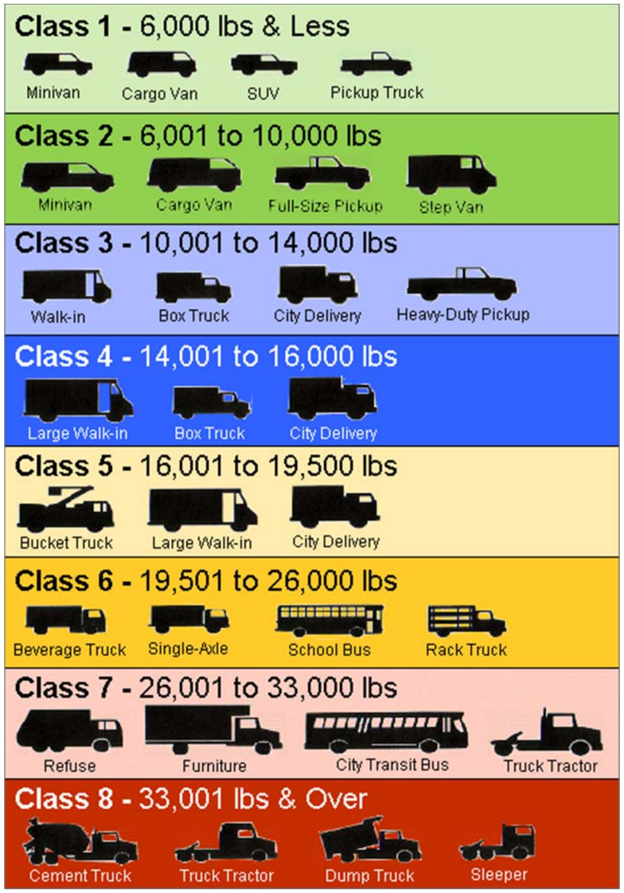
2018 Hyundai Ionic

Battery Integration Into the Vehicle: Classes 4, 6, and 8

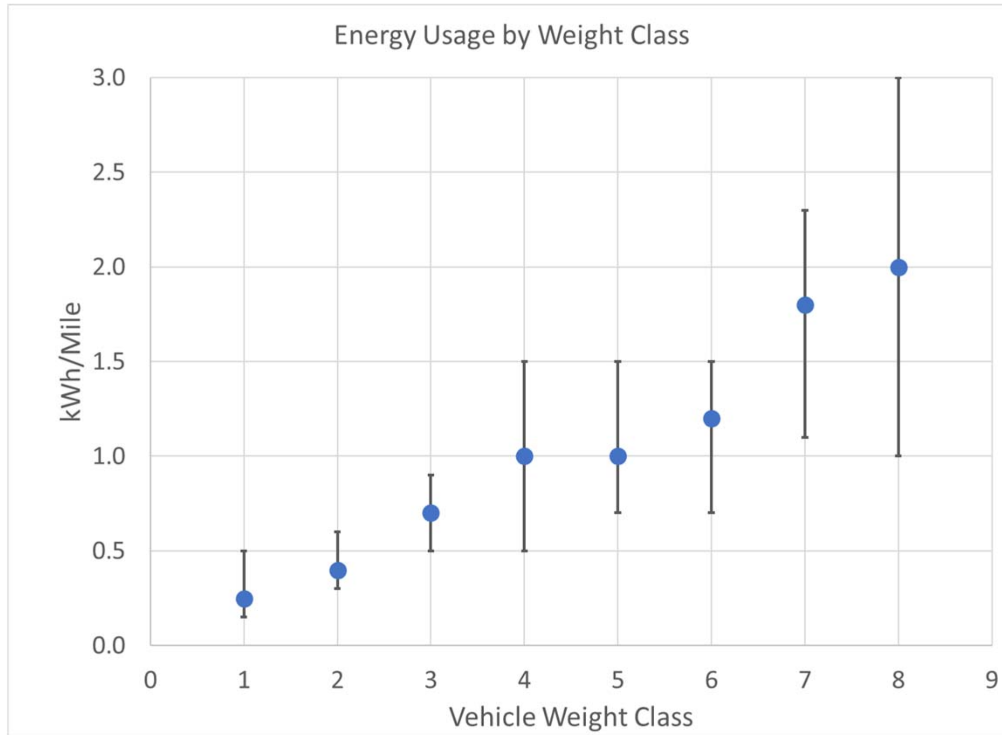
High Voltage Battery



Energy Consumption



Energy Consumption increases with mass
but is also a function of aerodynamics, tire type, and size



Source: *Medium- and Heavy-Duty Vehicle Electrification, The Assessment of Technology and Knowledge Gaps,* Oak Ridge National Laboratory

Battery Pack Metrics

	Energy Consumption (kWh/mile)	Battery Size (kWh)	Battery Cost ($)	Battery Volume (liters)	Battery Volume (gal)	Battery Mass (kg)	Battery Mass (lbs)
Class 1	0.3	75	5,625	136	36	273	601
Class 2	0.6	150	11,250	273	72	545	1203
Class 7	1.5	375	28,125	682	180	1364	3006
Class 8	2.0	500	37,500	909	240	1818	4008

Assumptions:

- 250-mile range
- USABC Goals for Low-Cost / Fast-Charge Advanced Batteries for EVs - CY 2023
  - $75/kWh, 550 Wh/liter, 275 Wh/kg

Charging Systems

Charging Systems

- Electric Vehicle Supply Equipment (EVSE)
- Onboard AC transfer-to-vehicle
  - Level 1: portable 1.5 kW
  - Level 2: hard-wired 3.6 kW to 20 kW
- Offboard, DC fast charging
  - Level 3: 40 kW to 200 kW
  - Charge networks
- Wireless
- Swapping

Charging Systems

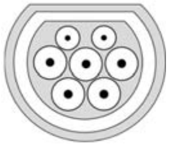
SAE J1772 L1-2

SAE J1772 CCS L1-3

CHAdeMO L3

Tesla L1-3

SAE J3068 CCS2
(three-phase power; charging of medium- and heavy-duty electric vehicles)



Charge Time

Battery energy / average charge power = charge time

kWh / kW = hours DG9

75 kWh / 7.2 kW = 10.4 hours

150 kWh / 7.2 kW = 20.8 hours

500 kWh / 7.2 kW = 69.4 hours

500 kWh / 200 kW = 2.5 hours

Slide 33

DG9 formatted list, using tabs to align at "="

Dave Garrett, 10/20/2020

Transportation and Safety Regulations

- USDOT/PHMSA
- UN 38.3 Model Regulation
  - 8 safety tests required to be passed
- Packaging
- Labeling
- International Air Transport Association (IATA)
  - Regulations on shipping by air

Battery End of Life

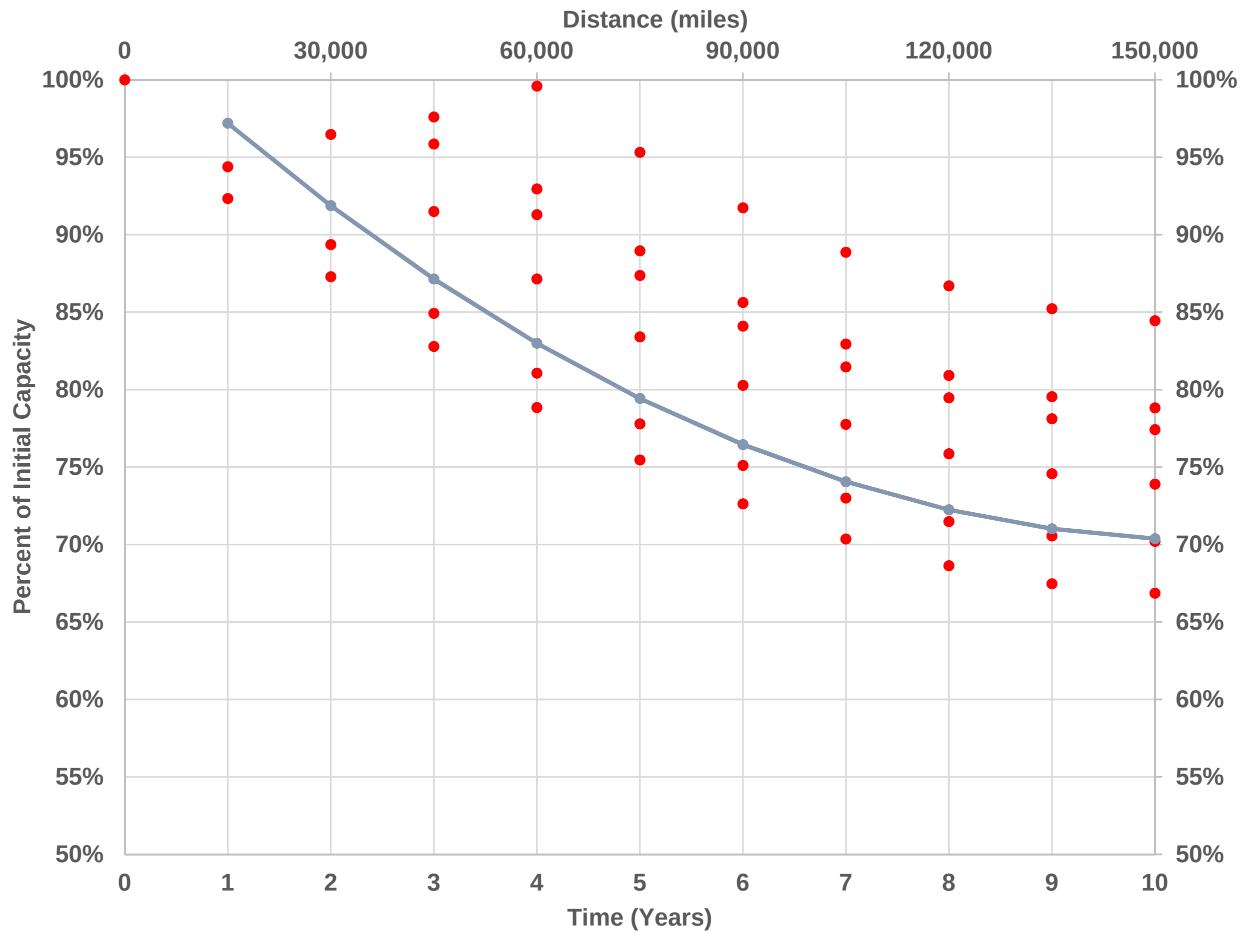
What Is “End of Life” for a Battery?

Wear out

- Degradation of the ability of the cell to store charge due to electrochemical stresses and side reactions
- Affected by temperature, charging behavior, driving behavior (discharge), and cell chemistry

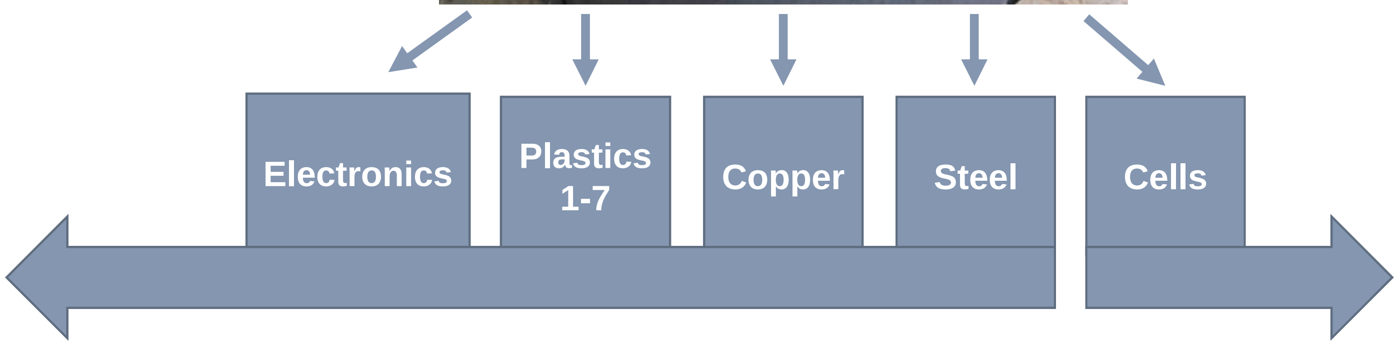
Warranty considerations

- What capacity or range is too low?
- Breakage
  - Road vibration and shock impact on the mechanical structure



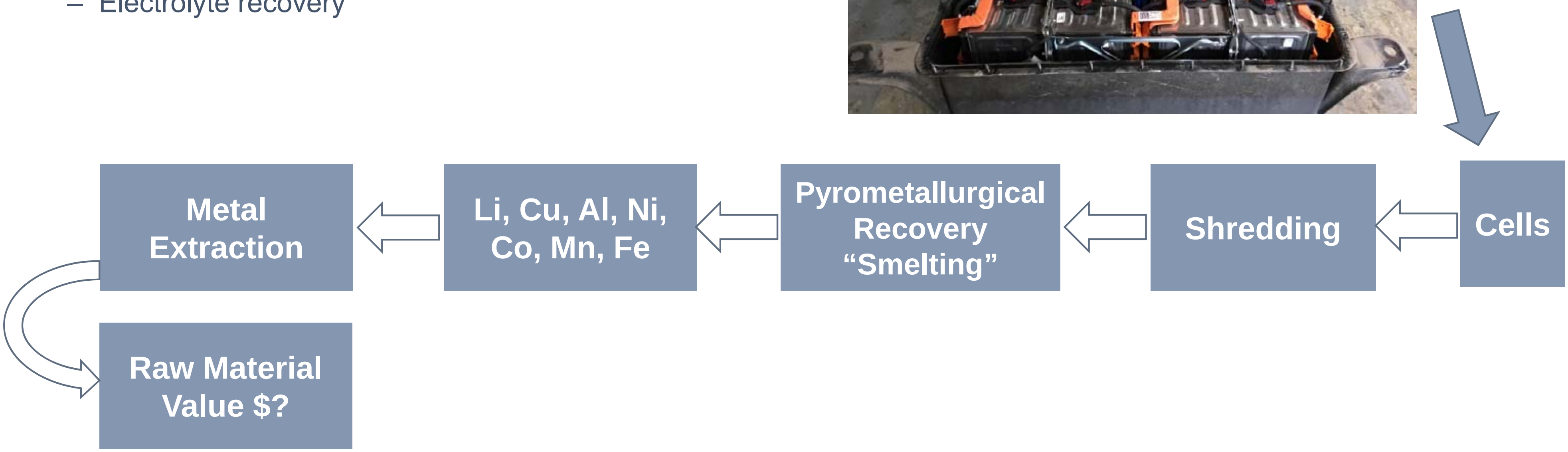
Disposal and Recycling

- Remanufacturing/service
- Disposal — recycling
  - Disassembly
  - Sorting



Disposal and Recycling

- Cell disposal/recycling
  - Smelting
- Emerging technologies
  - Argonne National Lab — ReCell Center
  - Cathode-to-cathode recycling
  - Electrolyte recovery



Grid Energy Storage

- Renewable shifting/smoothing
- Capacity/congestion relief
- Increased PV accommodation

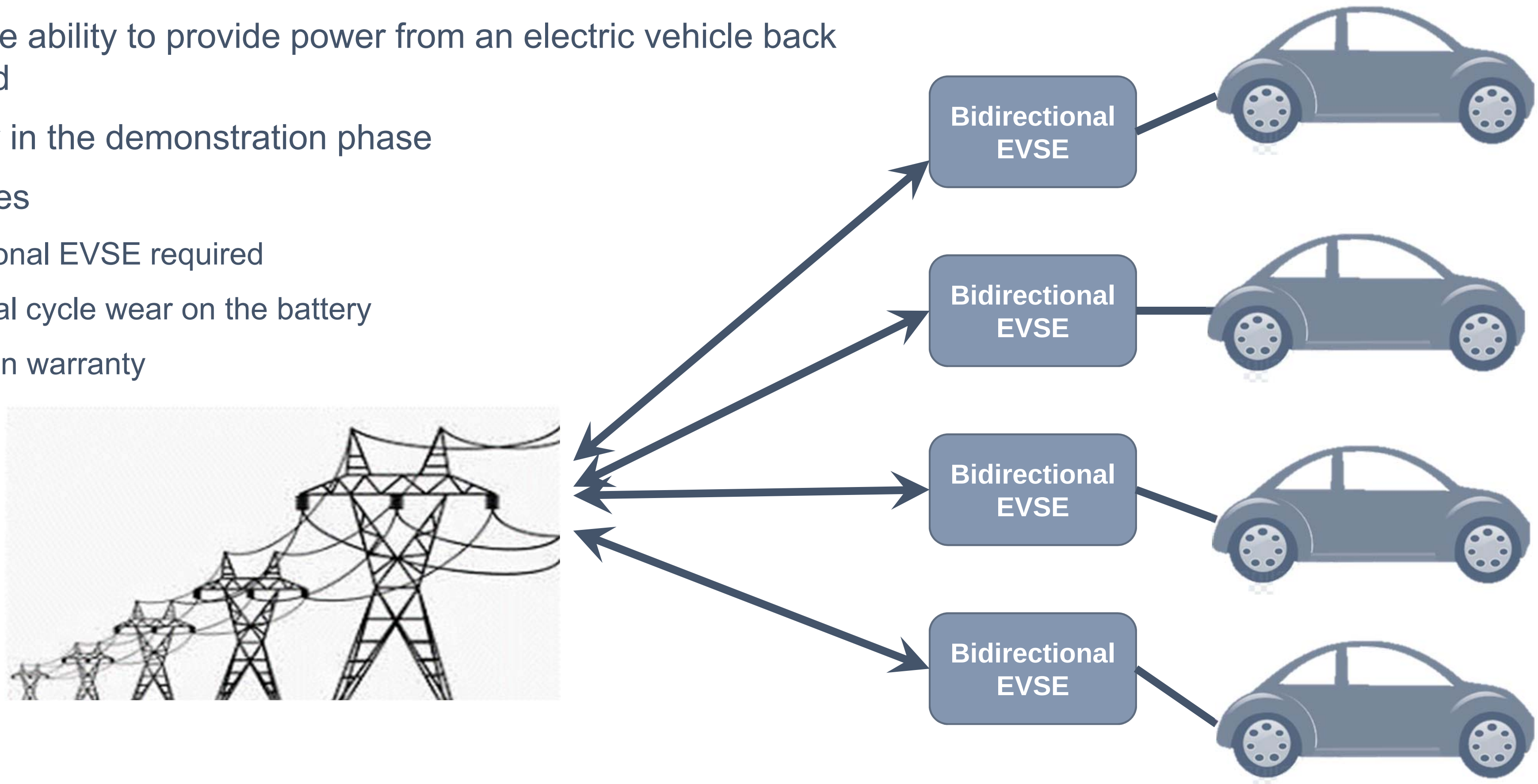
‘Largest Battery Storage Project In The World’ Unveiled In East Otay Mesa

An AES Corp. affiliate supplied this 30-MW battery storage project to San Diego Gas & Electric in 2017. In 2020, AES is adding 100 MW of batteries near a natural gas plant in Long Beach, Calif.
Source: San Diego Gas & Electric Co.

Source: “Batteries and Energy Storage: Looking Past the Hype,” Haresh Kamath, Senior Program Manager, Energy Storage and Distributed Generation, EPRI

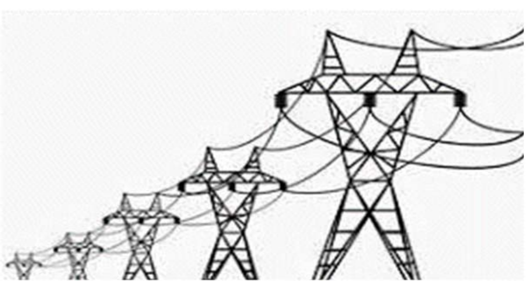
Vehicle to Grid (V2G)

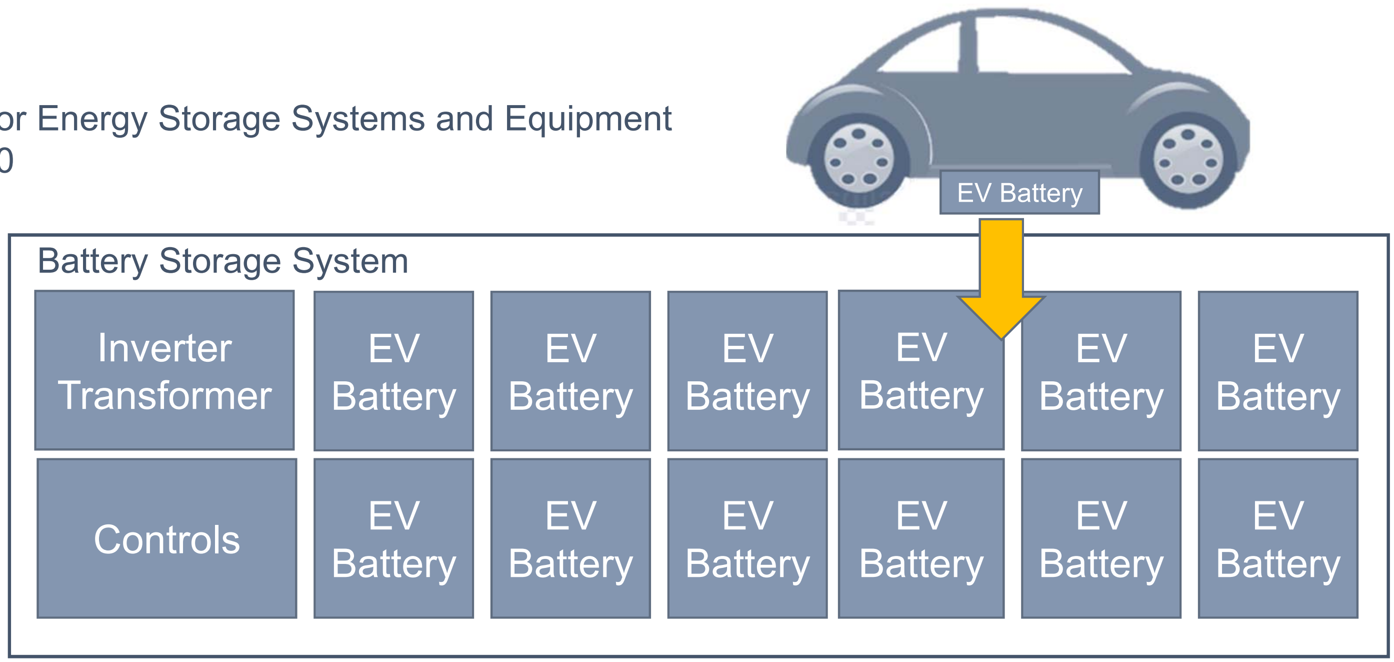
- V2G is the ability to provide power from an electric vehicle back to the grid
- Presently in the demonstration phase
- Challenges
  - Bidirectional EVSE required
  - Additional cycle wear on the battery
  - Impact on warranty



Grid Energy Storage

- Secondary use
- After its first life in the car, can the battery be used for other applications?
  - Challenges
    - Different form factor
    - Different suppliers (pack and cell)
    - Varying age/capacity
- Standards and Regulations
  - ANSI/CAN/UL 9540 Standard for Energy Storage Systems and Equipment Edition Date: February 27, 2020





Emerging Markets and Applications

Electric Aviation

Nonroad Vehicles

Electric Aviation

- Aerial ride sharing
- Short commute
- Autonomy



Nonroad Vehicles

- Conversion from lead acid to Li-Ion under way
- Applications that required internal combustion engines (ICE) can be serviced with electric drive + Li-Ion

JetBlue Introduces the Largest Electric Ground Service Equipment (eGSE) Fleet at New York's JFK International Airport, Cutting Four Million Pounds of Greenhouse Gas Emissions per Year

-- Committed to Long-Term Sustainable Energy Solutions and Operational Efficiency, Conversion will Save JetBlue More Than $500,000 in Ground Fuel Costs per Year --

Q & A

Wednesday, October 28, 2020

FIRST ANNUAL SIDLEY BATTERY SCHOOL

Electric Vehicles: Technology, Law, and Policy

Session 2: Legal Roundtable

SPEAKERS

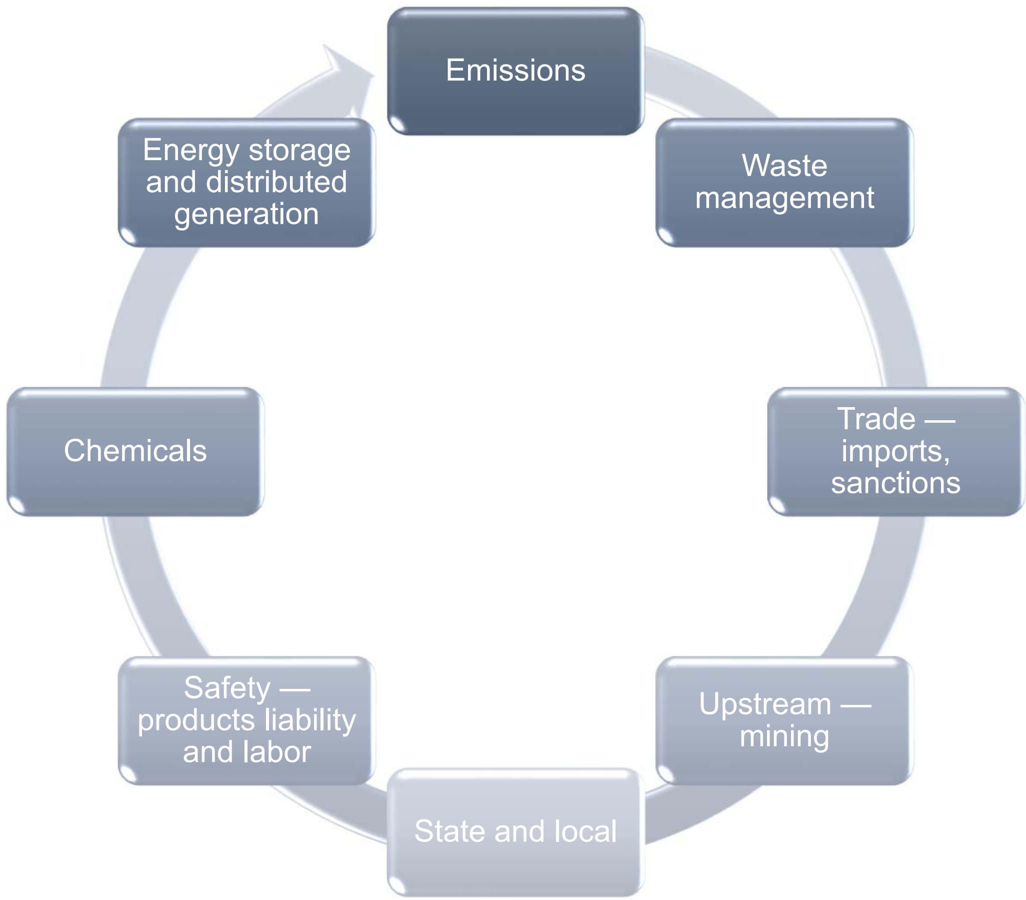
Kenneth W. Irvin • Justin A. Savage
Samina M. Bharmal • Joseph T. Zaleski

SIDLEY

Agenda

- Overview of Legal Issues
- Environmental, Social, and Governance
- Electrification
- Waste
- Electricity and the Grid
- Hypotheticals

Overview


Emissions
Waste management
Trade — imports, sanctions
Upstream — mining
State and local
Safety — products liability and labor
Chemicals
Energy storage and distributed generation

Emissions – Where Do They Occur?

Upstream

- Mining
- Supply chain
- Some manufacturing

Operational

- Manufacturing
- ***Tailpipe emissions***
- Electricity mix
- Credit generation
- Battery life

Downstream

- Recycling
- Disposal

Emissions – EVs and ESG Goals

- Environmental, Social, and Governance (ESG) focus on **E**: reducing emissions and environmental impacts
- Many companies and investors looking to electrification to reduce emissions impacts, but there are boundaries to consider
- Scopes
  - Scope 1: Direct emissions
    - Operational control
    - Equity control
    - Financial control
  - Scope 2: Energy consumption
    - Electricity mix
  - Scope 3: Value chain
    - Upstream, including supply chain
    - Downstream, including recycling and customer use

Emissions – EVs and ESG Goals

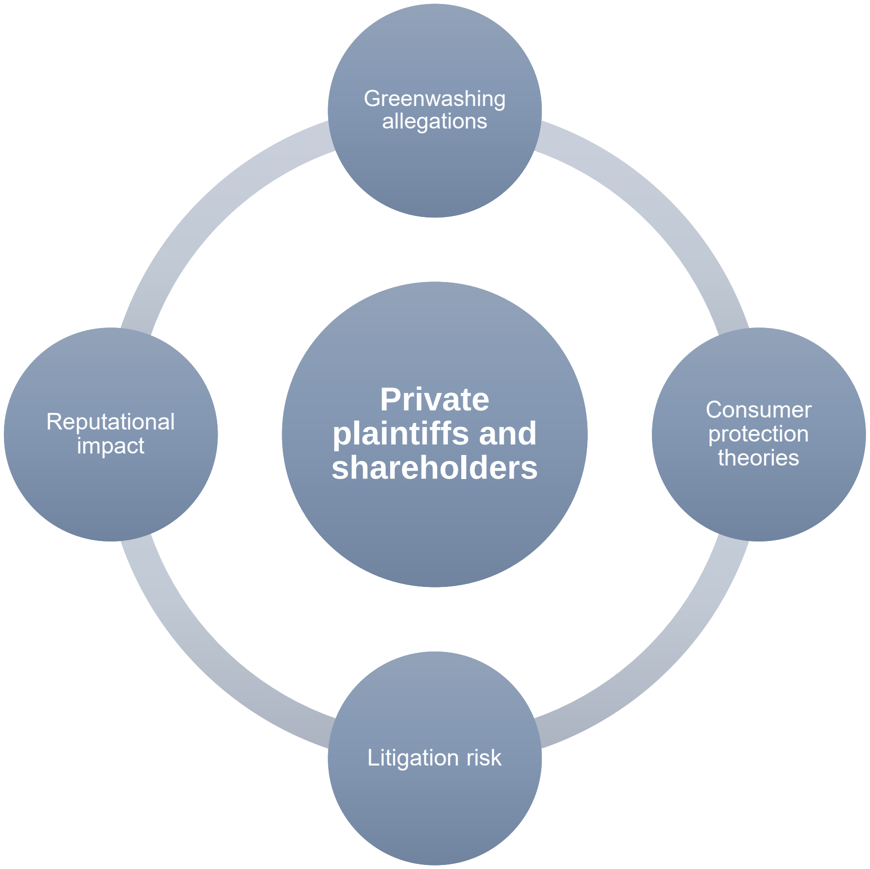
Scope 3
- Mining
- Supply chain
- Some manufacturing

Scope 1
- Manufacturing
- Tailpipe emissions for owned vehicles

Scope 2
- Electricity mix for manufacturing
- Electricity mix for charging

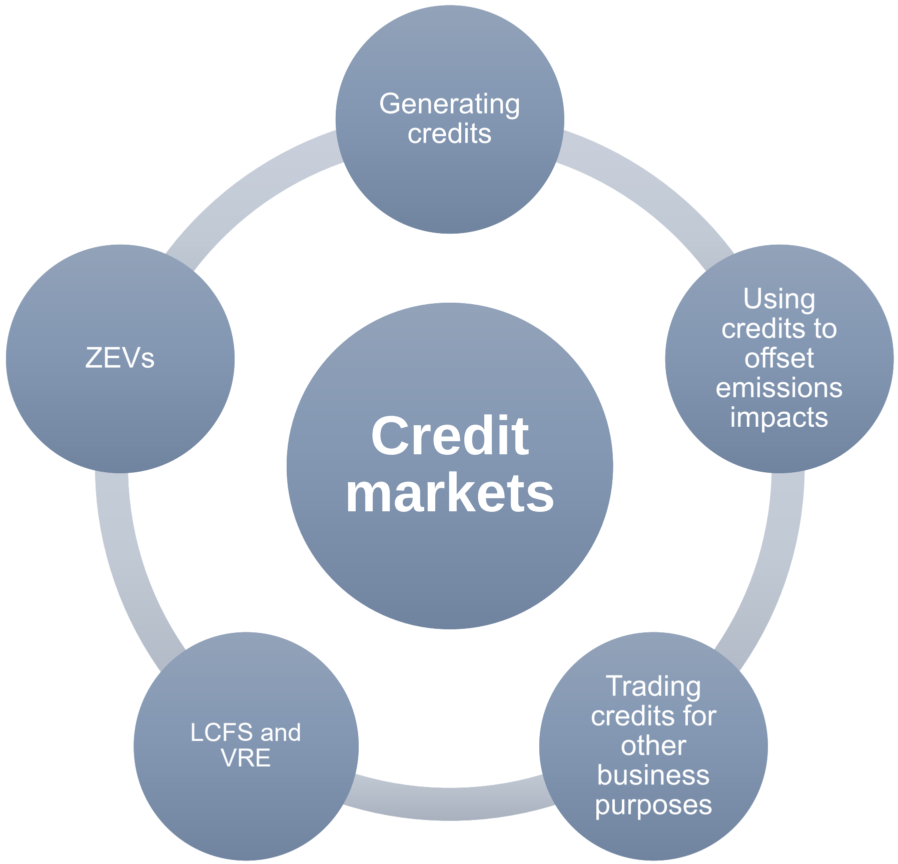
Scope 3
- Tailpipe emissions from customer vehicles
- Recycling
- Disposal

Emissions – EVs and ESG – Legal Considerations



Emissions – EVs and ESG – Legal Considerations

Emissions – EVs and ESG – Legal Considerations



Emissions – EVs and ESG – Legal Considerations

EV and GHG requirements

- California ZEV
- California Cap & Trade
- California LCFS
- California Executive Order on EVs
- Participating states

Voluntary emissions reductions

- Opt-in status
- Marketing statements

Emissions – EVs and ESG – Legal Considerations

What's next in legal developments?

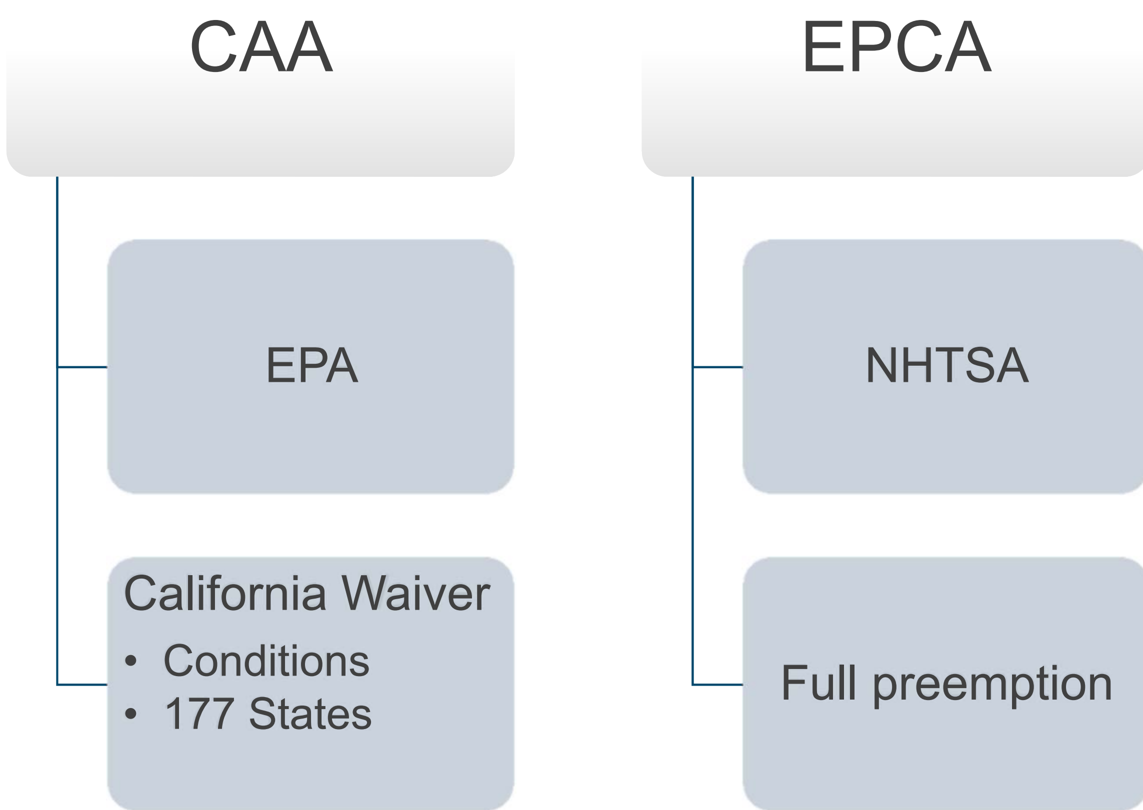
States

- ZEV mandate and CAA waiver
- Net-zero goals
- States as investors

Federal

- CFTC, GAO, SEC, FERC
- Carbon tax
- Cap & Trade
- Election

Emissions Regulations – Statutory Background



Emissions Regulations – Regulatory Background – Prior EPA/NHTSA Rulemakings

May 2009 — Obama Administration announces “One National Program”

- NHTSA/EPA jointly establish fuel economy and greenhouse gas standards

July 2009 — EPA granted California’s preemption waiver, allowing California to establish its own GHG standards

- Decision based, in part, on Supreme Court’s finding in *Massachusetts v. EPA,* that carbon dioxide is an “air pollutant” under the CAA

2012-2015 — California Advanced Clean Car Program, including GHG regulations and ZEV mandate

- Ten other States have elected to adopt California’s ZEV mandate

EPA/NHTSA issued standards for MY 2012-2016 and MY 2017-2025 vehicles

- Collective rulemakings allowed manufactures to meet all fuel economy and emissions standards with a single national fleet
- Average fleet-wide fuel economy increases up to 54.5 mpg by MY 2026

Emissions Regulations – California's Advanced Clean Cars Program

- California's Advanced Clean Cars Program includes the Zero Emission Vehicle (ZEV) mandate
  - Battery-electric, hydrogen fuel-cell, plug-in hybrids
  - Includes ZEV credit trading program

Model Year	Credit Percentage Requirement
2018	4.5%
2019	7.0%
2020	9.5%
2021	12.0%
2022	14.5%
2023	17.0%
2024	19.5%
2025 and Subsequent	22.0%

- **ZEV defined** – "a vehicle that produces zero exhaust emissions of any criteria pollutant (or precursor pollutant) or greenhouse gas under any possible operational modes or conditions"

Emissions Regulations – California's Advanced Clean Cars Program

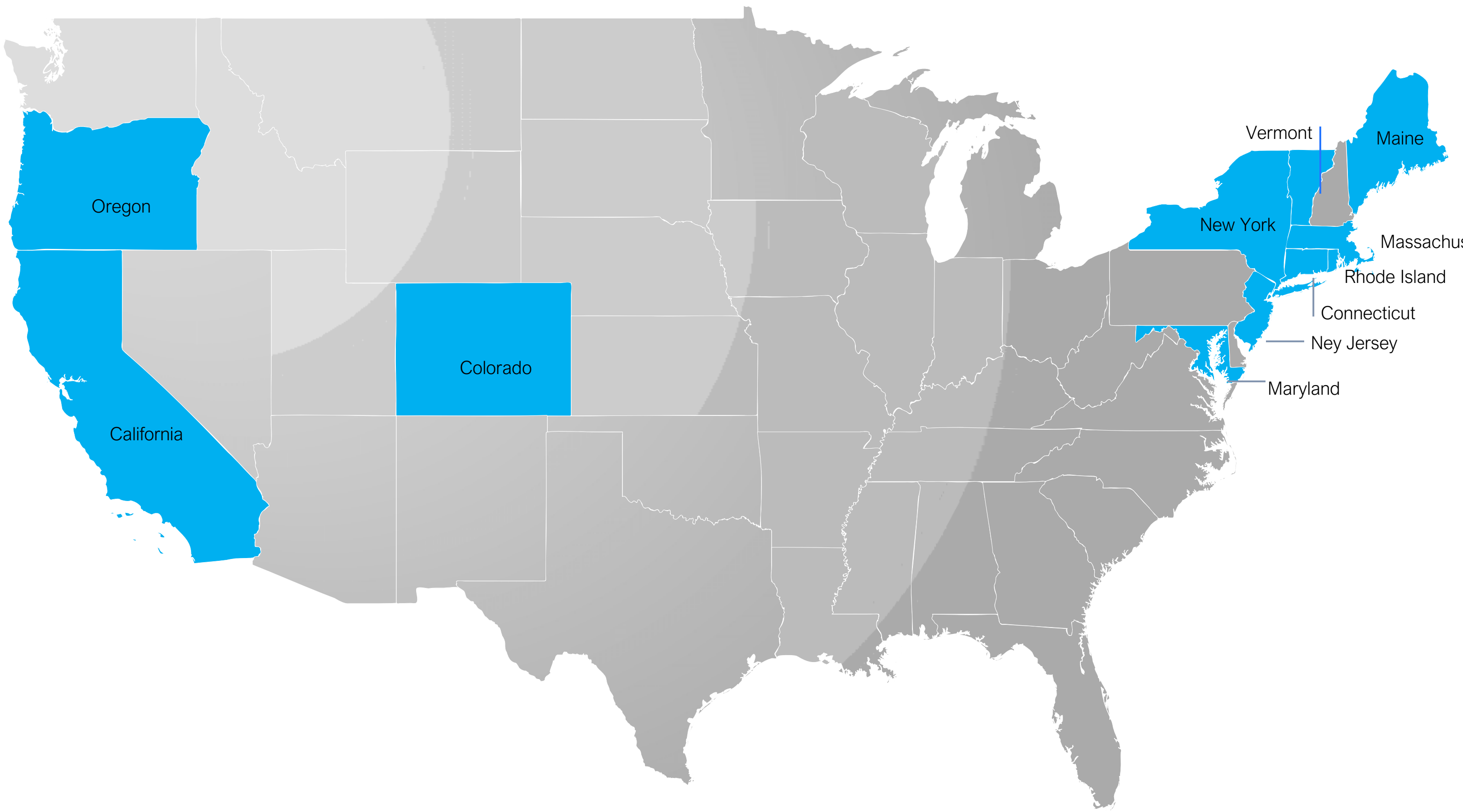
- States have adopted California's standards under CAA Section 177
  - Known as CAA 177 states
  - Minnesota and New Mexico intention to adopt

- Ten states have adopted ZEV
  - Colorado
  - Connecticut
  - Maine
  - Maryland
  - Massachusetts
  - New Jersey
  - New York
  - Oregon
  - Rhode Island
  - Vermont

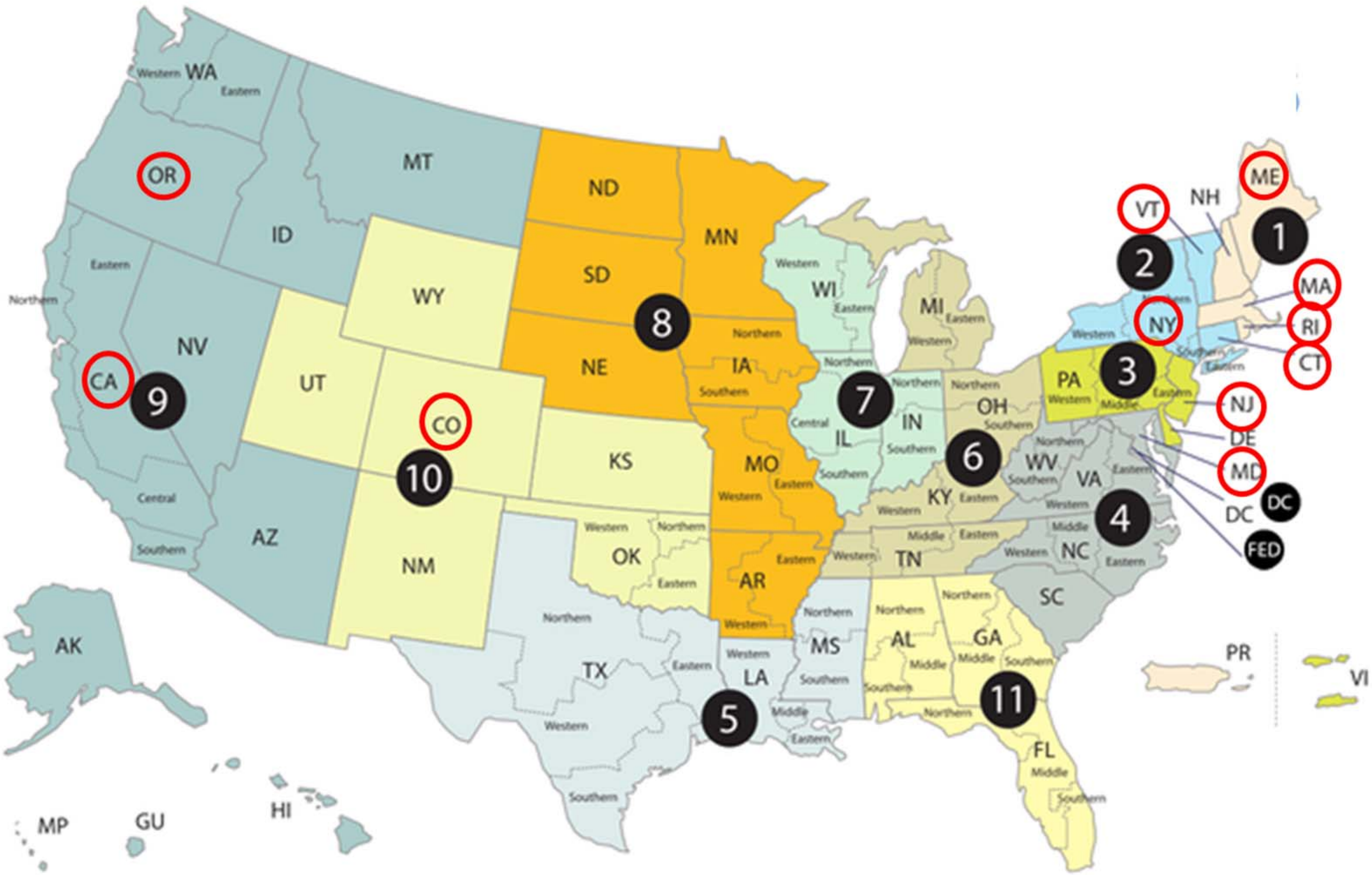
State	Legislation	Year Adopted	Model Year Effective
California	AB 1493	2002	2005
New Jersey	P.L. 2003, Chapter 266	2004	2009
Connecticut	Public Act 04-84	2004	2008
Washington	House Bill 1397	2005	2009
Vermont	Amendments to Subchapter XI	2005	2009
New York	Chapter III, Subpart 218-8	2005	2009
Maine	Amendments to Chapter 127	2005	2009
Rhode Island	Air Pollution Control Regulation No. 37	2005	2009
Massachusetts	Amendments to the state's LEV regulations	2005	2009
Oregon	Regulations (Division 257; OAR 340-256-0220)	2006	2009
Pennsylvania	Amendments to Title 25, Chapters 121 and 126	2006	2008
Maryland	Senate Bill 103	2007	2011
Washington D.C	Act 17-323	2008	2012
Delaware	Regulation 1140	2010	2014
Colorado	Colorado CAL LEV EO B2018-006 .pdf	2018	2022

Source: https://mde.maryland.gov/programs/Air/MobileSources/Pages/states.aspx

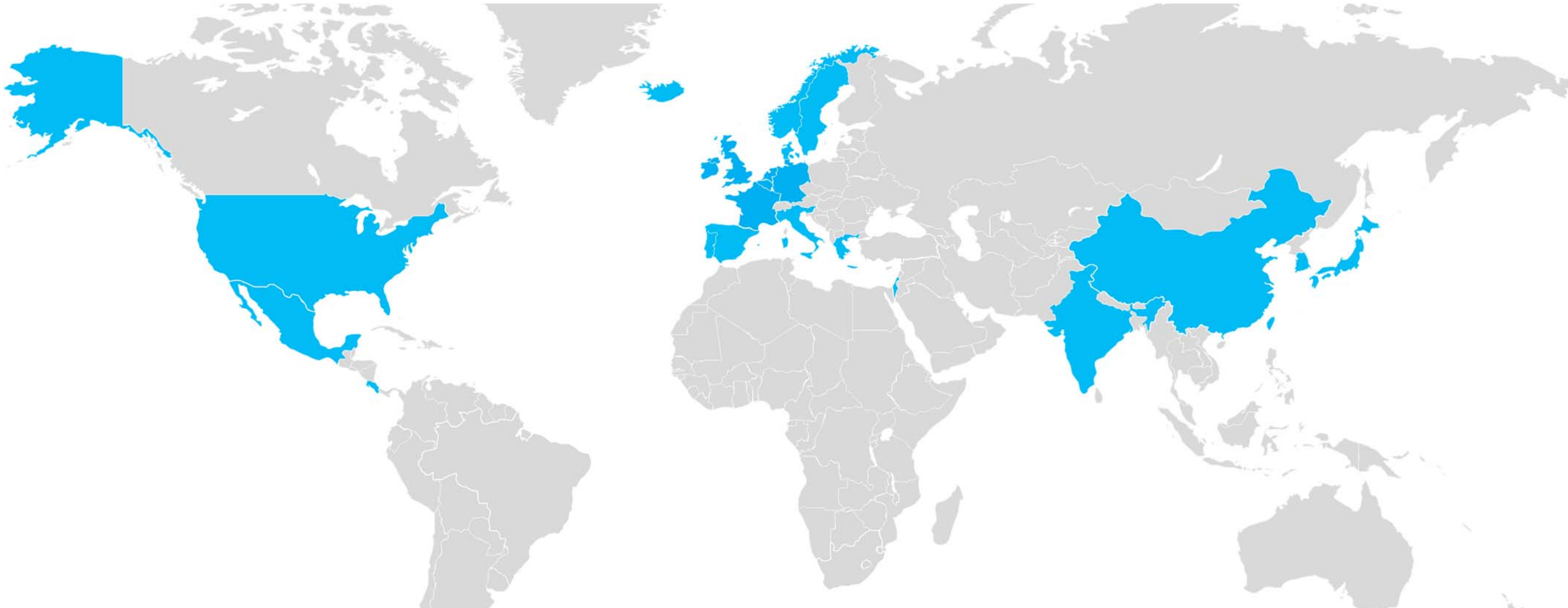
Emissions Regulations – States with ZEV Mandates



Emissions Regulations – States with ZEV Mandates – Circuit Overlay



Countries Considering Combustion Engine Bans



**Map includes countries with bans limited to individual cities only*

Emissions Regulations – Safer Affordable Fuel Efficient (SAFE) Vehicle Rule

SAFE Vehicles Rule (or SAFER):

- Most recent federal regulation affecting GHG emissions from light-duty vehicles
- Revokes California Advanced Clean Cars Program and ZEV mandate

The details:

- Less stringent federal fuel economy standards
  - Allows cheaper vehicles, encourages customers to purchase newer, safer vehicles sooner
- Revoked California waiver to avoid two separate GHG standards
- EPCA preempts California regulations because regulating tailpipe GHG is effectively regulating fuel economy, which EPCA prohibits for states
- Bifurcated rulemaking (SAFER Part I and Part II)

SAFER Part I (Sept. 2019) → SAFER Part II (Apr. 2020) → Litigation in progress

Emissions Regulations – SAFER Litigation – Legal Questions

Does EPCA preempt California regulations?

- Broad statutory language
- EPCA intends one fuel economy standard
- CAA preemption waiver does not “federalize” state standards otherwise preempted under EPCA
- *VERSUS*
- Precedent in California and Vermont district court that EPCA does not preempt state GHG standards

Can EPA withdraw a previously granted waiver?

- California GHG and ZEV standards don’t meet the CAA waiver standard
- California GHG and ZEV standards “technologically infeasible”
- *VERSUS*
- EPA lacks authority to withdraw waiver
- Reliance of interest of states and industry on prior standards

Union of Concerned Scientists, et al. v. NHTSA, et al. (D.C. Cir. No. 19-1230)

Petitioners

- States: CA; CO; CT; DE; D.C.; HI; IL; ME; MD; MA; MI; MN; NV; NJ; NM; NY; NC; OR; PA; RI; VT; VA; WA; WI
- Municipalities/Cities: Los Angeles; New York; Bay Area Air Quality Management District; Sacramento Metropolitan Air Quality Management District; South Coast Air Quality Management District; City and County of San Francisco
- NGOs: Union of Concerned Scientists; Center for Biological Diversity; Conservation Law Foundation; Environment America; Environmental Defense Fund; Environmental Law and Policy Center; Natural Resources Defense Council; Public Citizen; Sierra Club; Chesapeake Bay Foundation, Inc.; Communities for a Better Environment
- Industry: National Coalition for Advanced Transportation; Calpine Corporation; Consolidated Edison, Inc.; National Grid USA; New York Power Authority and Power Companies Climate Coalition; Advanced Energy Economy

Respondents – United States

Intervenors

- States: AL; AK; AR; GA; LA; MI; NE; OH; SC; TX; UT; WV; IN
- Industry: Automotive Regulatory Council; Coalition for Sustainable Automotive Regulation; American Fuel & Petrochemical Manufacturers

Emissions Regulations – Heavy-Duty GHG Phase 2 Rule

- Heavy-duty regulation is less contentious
- Federal Phase 2 GHG Rule issued October 25, 2016
  - Applies to medium-duty and heavy-duty engines and vehicles
  - Regulates engine and vehicle manufacturers
- Sets more stringent GHG emissions requirements
  - For model years 2021-27
  - Allows credit banking and trading to meet emissions standards
- Phase 2 multiplies credits for advanced technologies
  - 3.5x for plug-in hybrids
  - 4.5x for electric vehicles
  - 5.5x for fuel cell vehicles
  - 40 C.F.R. 1037.150(p)

Electric vehicle means a vehicle that does not include an engine, and is powered solely by an external source of electricity and/or solar power.

Emissions Regulations – What's Next?

1. It shall be a goal of the State that 100 percent of in-state sales of new passenger cars and trucks will be zero-emission by 2035. It shall be a further goal of the State that 100 percent of medium- and heavy-duty vehicles in the State be zero-emission by 2045 for all operations where feasible and by 2035 for drayage trucks. It shall be further a goal of the State to transition to 100 percent zero-emission off-road vehicles and equipment by 2035 where feasible.

2. The State Air Resources Board, to the extent consistent with State and federal law, shall develop and propose:

   a) Passenger vehicle and truck regulations requiring increasing volumes of new zero-emission vehicles sold in the State towards the target of 100 percent of in-state sales by 2035.

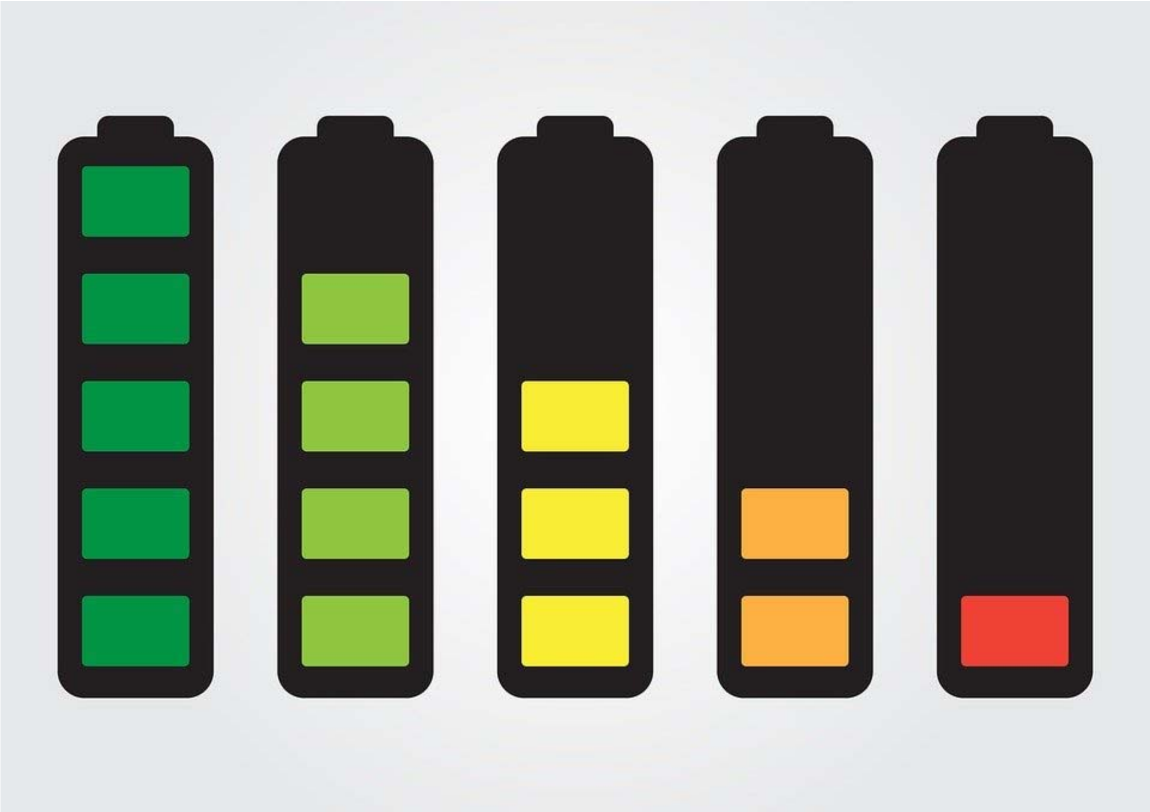
   b) Medium- and heavy-duty vehicle regulations requiring increasing volumes of new zero-emission trucks and buses sold and operated in the State towards the target of 100 percent of the fleet transitioning to zero-emission vehicles by 2045 everywhere feasible and for all drayage trucks to be zero-emission by 2035.

   c) Strategies, in coordination with other State agencies, U.S. Environmental Protection Agency and local air districts, to achieve 100 percent zero-emission from off-road vehicles and equipment operations in the State by 2035.

- California Executive Order (Sept. 23, 2020)
  - Applies to light-duty, medium-duty, heavy-duty, and off-road
  - New legal issues?
    - Preemption?
    - Commerce clause?
- Federal role
  - SAFER litigation outcome
  - Election
    - Administrative policy changes
    - New legislation?

End of the Road for a Li-Ion Battery

- Federal waste law
  - Solid waste/hazardous waste
  - Universal waste
  - Batteries as universal waste
- Handlers of universal waste
  - Small quantity handlers
  - Large quantity handlers
- Universal waste transporters
- Destination facilities
- RCRA enforcement
- State-level developments
- Lithium-Ion recycling and reuse



Key Takeaways

- "Batteries," including EV lithium-ion, managed under streamlined federal "universal waste" requirements
- Relate to handling, transporting, and managing batteries
  - Federal regulatory onus on those who accept discarded batteries, rather than individual drivers or fleet owners
  - No specific federal "stewardship" requirements (yet); e.g., no quotas/requirements to recycle or reuse EV Li-Ion batteries
- Some state-level action around more comprehensive recycling/reuse requirements
- Vehicle and battery pack manufacturers engaging in voluntary, in-house take-back/"closed-loop" battery recycling programs
- Private battery recycling sector still emerging as recycling economy continues to develop
- Regulatory framework will likely need to "catch up" in near to medium term

Waste Regulations Under Federal Law

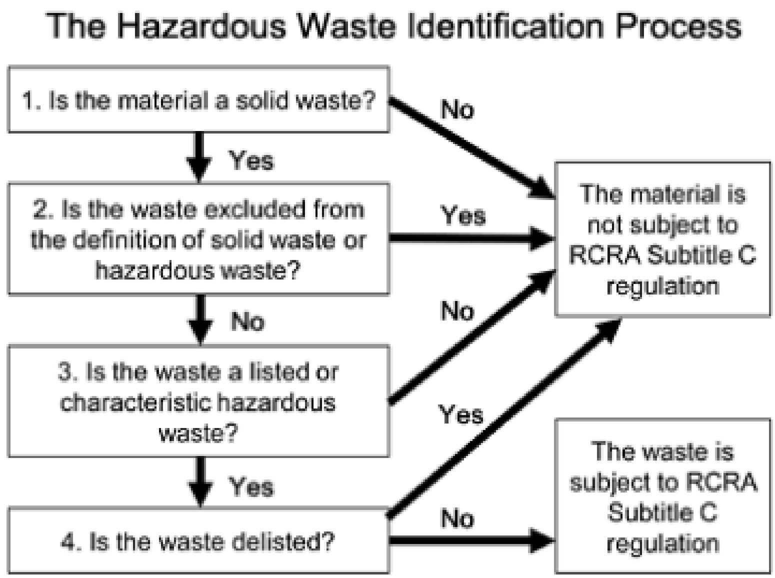
Primary federal law governing handling and disposal of solid and hazardous waste is the Resource Conservation and Recovery Act (RCRA) (42 U.S.C. § 6901 *et seq.*)

- Administered by U.S. EPA
- Grants EPA authority to control *hazardous waste* from "cradle to grave" — generation, transportation, treatment, storage, and disposal
- Governing regulations promulgated at 40 C.F.R. Pts. 239 through 282

Solid Waste and Hazardous Waste Under RCRA

RCRA Key Terms:

- “Solid Waste” — any discarded material not specifically excluded by EPA’s regulations (40 C.F.R. § 261.2)
  - In practice, means any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, resulting from industrial, commercial, mining, and agricultural operations, and from community activities
  - Need not be physically “solid” to qualify
- “Hazardous Waste” — a solid waste, not specifically excluded as a hazardous waste under EPA regulations, and exhibits characteristics of hazardous waste or is a specifically listed waste (40 C.F.R. § 261.3)
  - Characteristics of hazardous waste include ignitability, corrosivity, reactivity, or toxicity
  - Other hazardous wastes collected in four lists: F List (non-specific sources); K List (specific sources); P List and U List (pure and commercial grade formulations)



Universal Waste Under RCRA

- EPA's RCRA regulations also create category called "universal waste"
  - Products that otherwise qualify as "hazardous waste"
  - But "universal waste" designation by EPA streamlines otherwise applicable, onerous hazardous waste management standards for specifically created categories commonly generated by wide variety of establishments
  - Meant to: promote collection and recycling and reduce regulatory burden on generators/stores that wish to collect and transport these categories of waste
- Five types of universal waste:
  - Pesticides
  - Mercury-containing equipment
  - Lamps
  - Aerosol Cans
  - ***Batteries***

Batteries as Universal Waste, cont'd

Universal waste regulations define "battery" as:

> "…a device consisting of one or more electrically connected electrochemical cells which is designed to receive, store, and deliver electric energy. An electrochemical cell is a system consisting of an anode, cathode, and an electrolyte, plus such connections (electrical and mechanical) as may be needed to allow the cell to deliver or receive electrical energy. The term battery also includes an intact, unbroken battery from which the electrolyte has been removed."
> 40 C.F.R.§ 273.9.

Batteries as Universal Waste, cont'd

May a handler of universal waste manage broken or damaged batteries as universal wastes?

A handler of universal waste may only manage broken or damaged hazardous waste batteries as universal wastes if the breakage or damage does not constitute a breach in the cell casing. The definition of battery in Section 273.9 does not explicitly state that all batteries must be whole; however, the definition includes an intact, unbroken battery from which the electrolyte has been removed (60 FR 25492, 25504; May 11, 1995). Additionally, the requirements for handlers of universal waste allow certain management activities, such as sorting and mixing batteries, provided the batteries or cell casings are not breached and remain intact (Sections 273.13(a)(2) and 273.33(a)(2)). Therefore, universal waste batteries are intended to be intact (i.e., where the casing of each individual battery cell is not breached). EPA recognizes that batteries may become damaged or broken during handling. Therefore, the requirements for handlers of universal waste require that they contain any universal waste battery that shows evidence of leakage, spillage, or damage that could cause leakage under reasonably foreseeable conditions in a container (Sections 273.13(a)(1) and 273.33(a)(1)). The container must be closed, structurally sound, compatible with the battery's contents, and capable of enclosing potential releases. For example, the container should have no structural defects, severe rusting, or deterioration (60 FR 25492, 25522; May 11, 1995). Universal waste handlers should contact the appropriate implementing agency to inquire about any additional or more stringent requirements that may apply.

Source: EPA, *Frequent Questions About Universal Waste* ("May a handler of universal waste manage broken or damaged batteries as universal wastes?"), https://www.epa.gov/hw/frequent-questions-about-universal-waste#batteries3

Batteries as Universal Waste, cont'd

Specific exclusions:

- Lead-acid batteries managed under the specific provisions of 40 C.F.R. Part 266, Subpart G
  - Lead-acid batteries not managed under Part 266 are covered by universal waste rules
- Batteries that are not yet wastes under Part 261
- Batteries that are not hazardous waste
  - Must exhibit one hazardous waste criteria — ignitibility, corrosivity, reactivity, or toxicity

Batteries become waste when:

- Used battery is discarded (e.g., sent for reclamation)
- Unused battery when handler decides to discard it

Batteries as Universal Waste, cont'd

- Universal waste regulations do not spell out specific categories of batteries (other than lead-acid, with reference to specific handling requirements under Part 266)
  - E.g., no call-out for nickel-cadmium or lithium-ion
- But lithium-ion batteries meet general battery definition and very likely meet at least one of the RCRA hazardous waste characteristics (e.g., ignitability)

- EPA meant to cover emerging battery formulations (including those in development for EVs):

  "It was noted by one commenter that automotive batteries of various formulations are currently under development for use in electric vehicles, and thus, in the future, the chemistry of automotive batteries (e.g., lead-acid versus other formulations) may not be as easily identifiable as it is at this time**. The Agency would like to clarify that under the hazardous waste regulations as revised by today's addition of part 273, if the handler believes a battery is a hazardous waste but is not clear whether the battery is lead-acid or another chemical formulation, the battery should be managed under part 273 regulations.** The Agency believes, however, that the final part 273 requirements are simple and straightforward enough that management of any mixed battery types, **including electric vehicle batteries**, will not be overly burdensome."

  [60 Fed. Reg. 25492, 25505 (May 11, 1995) (emphasis added)]

Handlers of Universal Waste

- Universal waste handler (40 C.F.R. § 273.9):
  - Generator of universal waste, or
  - Owner/operator of a facility that receives universal waste from other universal waste handlers, accumulates it, and sends to another universal waste handler
  - Excludes: persons who treat, dispose of, or recycle universal waste, or off-site transportation of universal waste
- Two sub-categories of handlers: small quantity and large quantity
- Small Quantity Handler (40 C.F.R. § 273.9)
  - Universal waste handler that accumulates less than 5,000 kgs (~11,000 lbs) of universal waste at any time (counted collectively)
- Large Quantity Handler (40 C.F.R. § 273.9)
  - Universal waste handler that accumulates at least 5,000 kgs (~11,000 lbs) of universal waste at any time (counted collectively)
    - Retained through end of calendar year where the 5,000 kg threshold is reached or exceeded
- Household wastes and very small quantity generators (less than 100 kg per month) are technically outside these regs but may choose to manage as universal waste [40 C.F.R. § 273.8]

Small Quantity Handler Requirements

- Prohibited from disposing of universal waste/diluting or treating universal waste (except for responding to releases)
- Prohibited from sending/taking universal waste to somewhere other than another universal waste handler, "destination facility," or foreign destination
  - "Destination facility" is a facility that treats, disposes of, or recycles a particular category of universal waste
- No EPA notification requirement for universal waste handling activities
- No EPA identification number required
- No requirement to keep records of shipment of universal waste
- Can store universal waste for one year from time it is generated (exception if activity is solely for purpose of recovery, treatment, or disposal)
- Must inform all employees handling/managing universal waste; must describe proper handling and emergency procedures for the waste
- Must abide by labeling requirements (e.g., mark batteries with "Waste Battery" or other indication)

[40 C.F.R. Part 273, Subpart B]

Small Quantity Handler Requirements, cont'd

- Required to manage batteries in a way that prevents releases of any universal waste or component of universal waste to the environment
  - Required to contain universal waste battery that shows leakage, spillage, or damage that could cause leakage
  - Must immediately contain all releases/residues from universal waste
  - If there is a release, must determine if it is hazardous (and if so, manage in compliance with Parts 260–272); handler would be considered the generator
- May also sort batteries; mix battery types in one container; discharge batteries; regenerate used batteries; disassemble batteries or battery packs into individual batteries/cells; remove batteries from "consumer products"; or remove electrolyte from batteries
- But: small quantity generators that remove electrolyte or create solid waste from processes described above must independently determine if the resulting materials constitute hazardous waste
  - If yes, handler is also considered generator of hazardous waste and must manage in compliance with Parts 260-272
  - If no, handler can manage waste in compliance with applicable federal, state, and local solid waste laws

[40 C.F.R. Part 273, Subpart B]

Large Quantity Handler Requirements

Very similar to small quantity provisions, except:

- Required to send written notification to regional EPA before meeting or exceeding 5,000 kg limit (but renotification not required)
- EPA identification number is required
- Must keep record of shipment of each universal waste received at the facility; must keep record of each shipment sent off-site (three-year record retention obligation)
- Must ensure that all employees are thoroughly familiar with proper waste handling and emergency procedures

[40 C.F.R. Part 273, Subpart C]

Universal Waste Transporters

- Person engaged in the off-site transportation of universal waste by air, rail, highway, or water [40 C.F.R. § 273.9]
  - Must transport to universal waste handler, destination facility, or foreign destination
- Prohibited from disposing of universal waste or diluting/treating, except for responding to releases
- Required to comply with all Department of Transportation (DOT) requirements in 49 C.F.R. Parts 171-180
- May only store universal waste at facility for 10 days or less; otherwise, entity becomes a handler
- Required to immediately contain all releases of universal waste or other residues; must determine whether material resulting from spill is hazardous waste
- Small and large quantity handlers can self-transport universal waste off-site (consistent with Part 273), but they are considered universal waste transporters for that action and must abide by the relevant RCRA and DOT regulations

[40 C.F.R. Part 273, Subpart D]

Destination Facilities

- Treatment, disposal, and recycling facilities
- Subject to all applicable requirements under general RCRA hazardous waste treatment, storage, and disposal facilities
  - Must have a RCRA permit for such activities
- Must keep record of each shipment received
- Recyclers that do not store universal waste on-site prior to recycling must comply with RCRA notification requirements and other applicable recycling requirements in 40 C.F.R. § 261.6(c); but may be otherwise exempt from federal permitting requirements

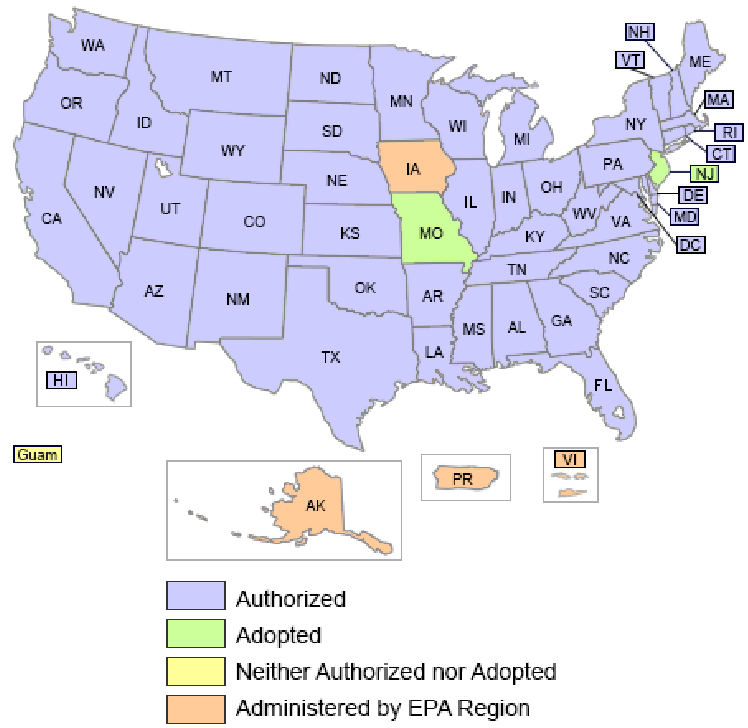
[40 C.F.R. Part 273, Subpart E]

Enforcement Risk

- EPA/state agencies have authority to pursue enforcement actions for alleged violations of universal waste handling, transportation, and disposal requirements [42 U.S.C. § 6928]
- EPA has entered into settlements with federal faculties (e.g., Department of Veterans Affairs) and private entities for alleged violations of universal waste requirements
  - Alleged waste battery violations typically relate to labeling/storage
  - Typically coupled with other non-universal waste RCRA provisions
- Not aware of enforcement against EV Li-Ion battery handlers or recyclers

State-Level Universal Waste Law

- U.S. EPA is the primary regulator of RCRA hazardous waste requirements
- State's full adoption of universal waste rule optional (less stringent than previous RCRA requirements)
  - Except for 1996 "Battery Act" requirements — phase out of use of mercury in batteries/nickel-cadmium and small sealed lead-acid battery disposal and recycling
- States can adopt different universal waste standards, but must provide at least equivalent protection to federal rule/cannot regulate fewer handlers
  - States may also adopt additional universal waste categories
- 44 states have included the federal battery universal waste provisions
  - Most of the other jurisdictions have some variation on federal battery universal waste rule



Source: https://www.epa.gov/hw/state-universal-waste-programs-united-states

State-Level Li-Ion Provisions

- California
  - Convened a Lithium-Ion Battery Recycling Advisory Group per AB 2832
    - Under existing state law (Rechargeable Battery Recycling Act of 2006), all retailers must have in place a system for accepting and collecting used rechargeable batteries for reuse, recycling, or proper disposal; includes take-back program of used rechargeable batteries at no cost to consumers
    - But law specifically excluded vehicular batteries, while covering other, smaller lithium-ion batteries
  - Mission is to advise CA legislature on policies related to recovery and recycling of lithium-ion batteries sold with motor vehicles in state
  - Working toward legislative policy recommendations
- New York
  - NY Rechargeable Battery Law (2010) — requires manufacturers of certain rechargeable batteries that sell in or into New York to collect and recycle them through manufacturer-funded program
  - Prohibits disposal of covered batteries
    - Covers lithium-ion batteries explicitly; **however, excludes battery packs weighing more than 25 lbs and batteries used as principal source of power for vehicles**

Current State of Play in Li-Ion Recycling and Reuse

- Federal action?
  - White House EO 13817 (“A Federal Strategy to Ensure Secure and Reliable Supplies of Critical Minerals”) (Dec. 20, 2017)
  - Department of Energy (DOE) Vehicle Technology Office, *Research Plan to Reduce, Recycle, and Recover Critical Materials in Lithium-Ion Batteries* (June 2019)
- Currently, appears that some EV manufacturers and battery pack manufacturers handle used battery take-back as part of vehicle maintenance and service
- Number of start-ups and some more established e-waste and battery recycling firms that are contracting with companies to handle Li-Ion end-of-life management
- Economics of recycling still developing
  - But see, e.g., New York state announcement of Li-Cycle Incorporated “Hub” expansion in Rochester
- Some promise in the reuse market, related to electric grid and generation space

New FERC Orders Usher in New Opportunity for Battery Storage

Two FERC orders (Order 841 and Order 2222) usher in new opportunity for battery storage, especially fleets of EVs.

- This also presents a complex set of challenges for grid operators, utilities, and state regulators to align the rules for operating behind-the-meter assets connected to low-voltage distribution grids to those governing bulk markets.
- The cross-jurisdictional complexities have already drawn the opposition of state regulator and utility groups.
- In June, a federal court denied efforts by state regulators to challenge Order 841 on the grounds that FERC can't impose rules on distributed energy resources (DERs) connected to distribution grids under state regulations.)
  - The court also denied a request for states to be able to "opt out" of participating in Order 841-created markets.
  - That court victory has given FERC confidence to assert broad authority over how DERs beyond energy storage assets can take part in wholesale markets under Order 2222, said Neil Chatterjee, the Republican chairman of FERC.
  - For example, the latest order (Order 2222) doesn't offer states the option of opting out of the market structures that ISOs and RTOs will create to comply with it.
- The order on "distributed energy resources" is the latest supported by Chatterjee, to reflect the changing patterns of generating, transmitting and distributing electricity.
- "DERs can hide in plain sight in our homes, businesses and communities across the nation. But their power is mighty," Mr. Chatterjee said.

V2G Storage Potential

New research from The Brattle Group suggests that 20 million EV batteries will contain up to 1,600 GWh of energy storage capacity, and can provide up to 300 GW of power output through Vehicle-to-Grid (V2G) technology.

- This V2G storage capability vastly exceeds the grid's current and projected storage capability.
- V2G can fit into the consumer lifestyle:
  - As average vehicle models have increasingly large batteries (upwards of 200-300 miles of range), the consumer could charge and discharge some portion of that battery if the consumer doesn't need the full range on a regular basis (the average U.S. driver goes less than 30 miles per day).
- V2G participants will need adequate compensation for these impacts.
  - Aggregators will need to develop plans to efficiently and cost-effectively swap out batteries at the end of their useful life, potentially recycling or using those discarded battery packs for other grid management purposes.

The total statewide benefit from a single use case ranged up to an estimated $200 million per year based on scoring of the use cases by Working Group participants (see Section A for scoring details).

While the Working Group recognized the challenge of simultaneously advancing 320 use cases, ***an important result is that there are many potential VGI use cases that can provide value, and that the potential market for VGI solutions is diverse and interwoven across a broad swath of the transportation and power sectors.*** Given the use case assessment work performed by the Working Group, it appears that the work of developing markets for VGI solutions will demand persistent action for the next several years. ***California should take an inclusive and collaborative approach to VGI opportunities given the evolving nature of the regulatory and market landscape.***

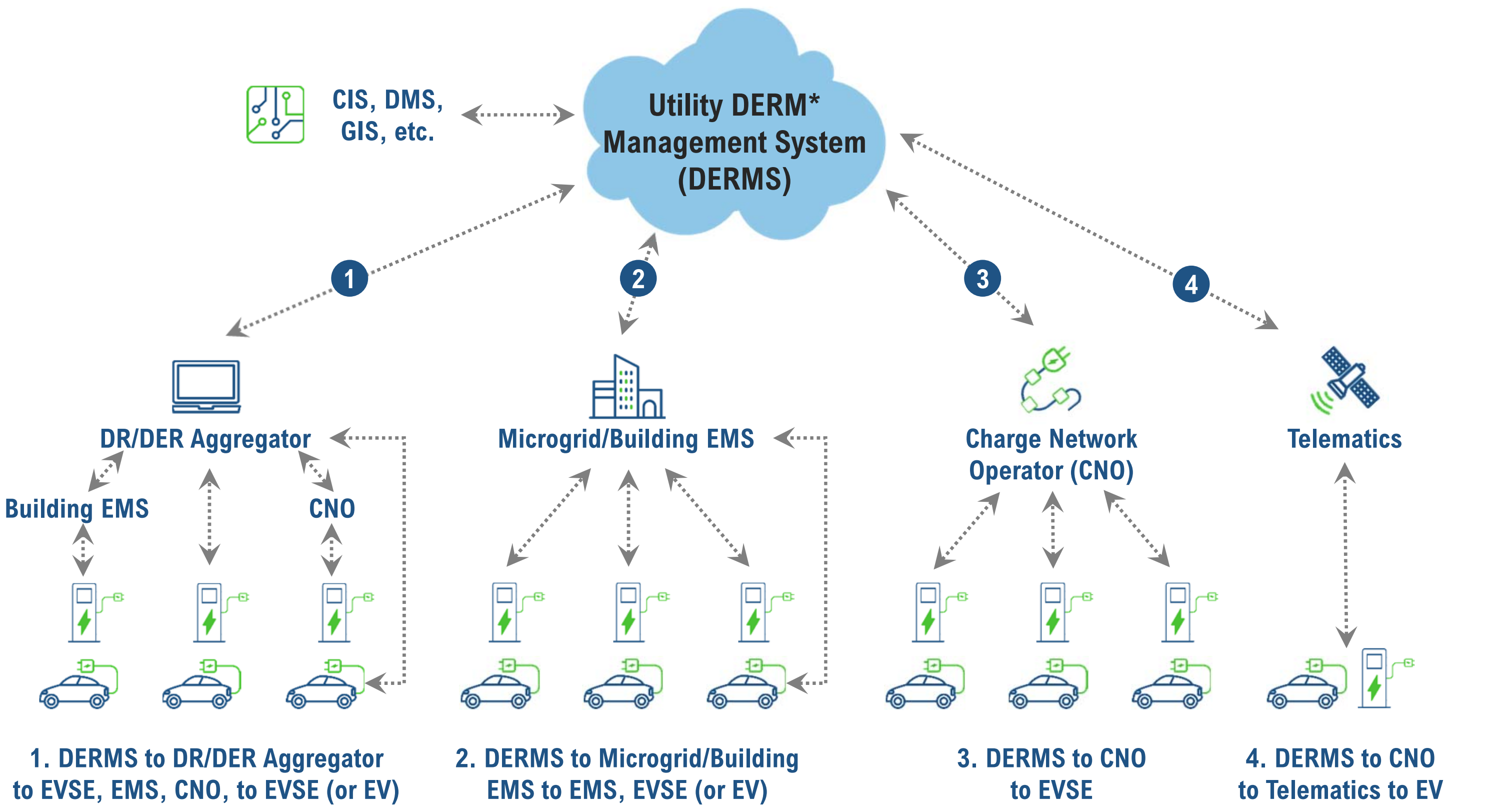
Source: FINAL REPORT OF THE CALIFORNIA JOINT AGENCIES VEHICLE-GRID NTEGRATION WORKING GROUP, June 30, 2020, California Public Utilites Commission DRIVE OIR Rulemaking (R. 18-12-006)

V2G Storage Potential, cont'd

V2G offers a tool to minimize grid impacts and prevent renewable energy curtailments.

- V2G value stacking has the potential to accelerate EV deployment:
  - Some proponents speculated that with potential V2G values, EVs could essentially become free for the consumer.
  - The vehicle Original Equipment Manufacturer (OEM), or other aggregator, could make money through V2G and VPP services for the utility.
- In markets that enable large-scale aggregation, the value stack could include:
  - Vehicle batteries integrated with PV to sell services via long-term PPAs
  - Non-wires alternative planning (depending on the regulatory and market rules)
  - Ancillary services
  - Short-term energy and capacity
  - Forward capacity
  - Peak/off-peak price arbitrage
  - Further, V2G could be used for demand charge management. For example, Peak Power Inc. is exploring how to deliver existing electricity market revenues directly to EV owners (individual and fleet) via V2G applications in Toronto.

Opportunities for the Electricity Industry in Preparing for an EV Future



*Distributed energy resource management

Source: Smart Electric Power Alliance, 2020.

- **Distribution Utility:** determines grid requirements; specific device or Group DER settings; communicates to DER
- **DR/DER Aggregator:** receives grid requirements; specific device or Group DER settings; communicates to DER; monitors and reports to DERMS
- **Building EMS:** receives grid requirements; determines how to implement; reports results to DERMS
- **Charge Network Operator:** receives grid requirements; determines how to implement; reports results to DERMS
- **EV:** with off-board, on-board or split inverter, uni- or bi-directions, AC or DC
- **EVSE:** with off-board, on-board or split inverter, uni- or bi-directional, AC or DC
- **Telematics:** Vehicle Telematics System — receives grid requirements; determines how to use EVs to meet grid needs

Federal Energy Regulatory Commission Sees the Path

- Order 841 and Order 2222 allow states and utilities "authority to oversee the interconnection of individual DERs."
- That's a key concern, given that DERs have significant impacts on distribution grid operations and reliability.
- Order 2222 requires RTOs and ISOs to establish a comprehensive process ensuring distribution utilities can review the individual DERs that are the constituent parts of an aggregation.
- Integrating aggregated DERs will lower consumer costs, increase electric reliability, and unlock the potential for new innovation.
- On the other hand, some observed that FERC's orders for PJM's and NYISO's capacity markets erect barriers to the entry of new technologies in those markets — a fact that could bear on how state-supported, carbon-free DERs are valued by them.

From Theory Into Practice

V2G-enabled EVs into commercial grid-services tenders — shifting the tech from theory to practice.

- Electric vehicles are beginning to help to solve Europe's grid flexibility problems.
- EVs are already playing a role in grid-balancing markets in Norway, Sweden, and the Netherlands.
- EVs have bid into the Dutch secondary reserve market, coordinated by German virtual power plant firm Next Kraftwerke.
- EVs have a 50 % market share among new vehicle sales in Norway.
- Tibber, the company behind the bids in Scandinavia, is now gearing up to do the same in Europe's largest economy, Germany.

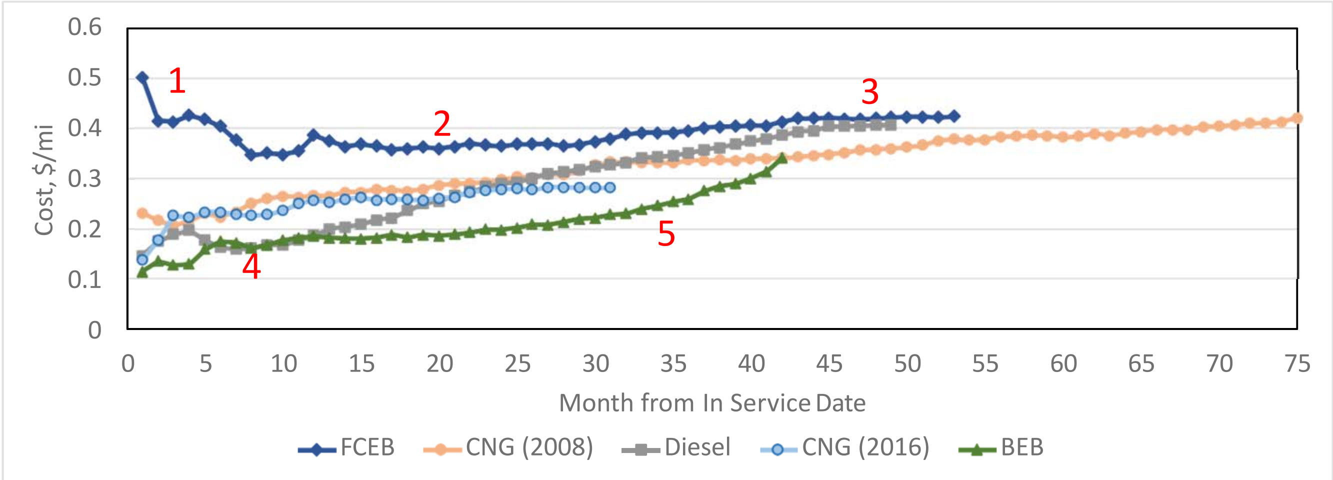
Growth Projections

- Tibber estimates that around 200 EVs are needed to provide 1 MW to the flexibility markets where the company is currently active.
- The reality is that some vehicles will be disconnected at any given time. In Sweden, Tibber has access to tens of thousands of EVs but typically bids thousands of vehicles at a time.
- Deloitte expects EVs to claim a 40 % market share of new car sales in Europe by 2030.
- That figure will surpass 20 % before the middle of the decade.
- With 15.3 million vehicles of all fuel types sold in 2019, Tibber's potential swarm has lots of scope for growth.

Challenges Ahead

The V2G opportunities look attractive, but there are myriad challenges.

- Getting the right EV charging standards in the market is key — failure to standardize offers a pitfall — like Beta versus VHS (if you're old enough to know about that).
- State and local utilities are charging full steam at EV charging infrastructure, but requirements to be V2G-ready are far from standardized.
- Purpose-built stationary EV and battery interchange will be key to allowing V2G to realize full competition gas peaker plants, other demand response sources, and utility-scale battery deployments.



Source: U.S. Department of Energy, Hydrogen & Fuel Cells Program. "2019 Annual Merit Review Proceedings." https://www.hydrogen.energy.gov/annual_review19_acceleration.html

California Sets Interconnection Rules to (Hopefully) Encourage V2G

California has (already) gigawatts' worth of EV chargers, with more gigawatts coming as part of its push to electrify transportation. Enabling them to export EV battery capacity, rather than simply stop charging, could make them an even more valuable grid resource.

- The new California Public Utilities Commission (CPUC) ruling (Rule 21) clarifies that V2G DC charging, or bidirectional EV chargers, can be interconnected with utility permission. That's a first for a state utility commission, according to the California Energy Storage Alliance.
- CPUC's Proposed Transportation Electrification Framework was developed to guide future EV investments. California utilities are concerned the time required to finalize the framework will delay near-term efforts to roll out EV infrastructure; expect CPUC decision in 2020.

Source: CPUC, Transportation Electrification Framework, Energy Division Staff Proposal, February 2020.

Key Elements of the Proposed Transportation Electrification Framework

FOCUS AREAS	FRAMEWORK GOAL	PROPOSED APPROACH
(1) Identify EV Infrastructure Needs and Define Utility's Role	Ensure utilities target high-value investments to increase EV adoption without limiting opportunities for non-regulated entities	•CPUC identifies key market barriers to widespread EV adoption •State agencies then identify the priority market segments and infrastructure needs to meet emission targets •CPUC assesses whether non-regulated entities can build necessary infrastructure or if utilities should do so
(2) Develop Utility Transportation Electrification Plans (TEP)	Establish a structured, repeatable process for identifying and approving future EV investments	•IOUs submit strategic 10-year TEPs every two years to CPUC •Propose investments based on CPUC-approved EV Scorecard that identifies needs to meet California policy goals •Identify role in transforming the transportation sector •Ensure load is optimally integrated into the T&D system
(3) Set Near-Term EV Infrastructure Priorities	Provide utilities guidance on near-term priorities to accelerate approval while framework is finalized	•Leverage EVs for grid resilience •Target residents without access to home EV charging •Target MDV/HDV fleet infrastructure •Add infrastructure during new building construction •Accelerate deployment in disadvantaged communities

Source: CPUC, Transportation Electrification Framework, Energy Division Staff Proposal, February 2020.

Hypotheticals

Hypothetical 1

You've got a handle on how to get the battery manufactured. How do you decide which products to electrify?

a) Emissions reductions goals

b) Vehicle type

c) Vehicle regulations

Hypothetical 2

How do you address business and customer concerns about performance?

a) Charging infrastructure

b) Credits

Hypothetical 3

It's time for a new battery. What do you do about the old one?

a) Recycling

b) Take-back

c) Disposal management

Q & A

Panelists

JUSTIN SAVAGE is global co-leader of the firm's Environmental practice and serves on the firmwide Marketing and Practice Development committee. He also serves on the firm's COVID-19 Task Force. Justin focuses on high-stakes environmental litigation and strategic counseling, including government enforcement actions, internal investigations, and rulemaking challenges.

Justin A. Savage

Partner

jsavage@sidley.com

Washington, D.C. +1 202 736 8853

KEN IRVIN, a co-leader of Sidley's global Energy practice area team, represents clients on a variety of regulatory, enforcement, compliance, and transactional matters involving the U.S. wholesale electricity and natural gas markets. Ken has extensive experience representing clients in regulatory and investigations proceedings before the Federal Energy Regulatory Commission (FERC) and multiple state energy regulatory agencies, which includes handling FERC enforcement matters and self-reports.

Kenneth W. Irvin

Partner

kirvin@sidley.com

Washington, D.C. +1 202 736 8256

SAMINA M. BHARMAL is the associate lead for the group's Environmental, Social, and Governance (ESG) matters. She advises clients on green marketing claims and the use of environmental attributes and credits for achieving net-zero or other greenhouse gas emission reduction goals. Samina has extensive experience in high-stakes federal litigation and enforcement defense, with a focus on emissions regulations and rulemakings. She has been recognized as a SuperLawyers Rising Star in Environmental Law and was selected for the Leadership Counsel on Legal Diversity.

Samina M. Bharmal

Associate

sbharmal@sidley.com

Washington, D.C. +1 202 736 8350

JOSEPH T. ZALESKI is an associate in the Environmental group focusing his practice on regulatory counseling, enforcement defense, and litigation. Joseph draws on past experience with energy and agriculture policy to advise clients on a variety of issues within the Clean Air Act, Resource Conservation and Recovery Act, Toxic Substances Control Act, and Federal Insecticide, Fungicide, and Rodenticide Act.

Joseph T. Zaleski

Associate

jzaleski@sidley.com

Washington, D.C. +1 202 736 8898

Mobile Source & Fuels Team

Samuel B. Boxerman

Partner

sboxerman@sidley.com
Washington, D.C. +1 202 736 8547

David T. Buente Jr.

Partner

dbuente@sidley.com
Washington, D.C. +1 202 736 8111

Justin A. Savage

Partner

jsavage@sidley.com
Washington, D.C. +1 202 736 8853

Peter Whitfield

Partner

pwhitfield@sidley.com
Washington, D.C. +1 202 736 8531

Susan V. Harris

Counsel

svharris@sidley.com
Chicago +1 312 853 4663

Samina M. Bharmal

Associate

sbharmal@sidley.com
Washington, D.C. +1 202 736 8350

Aaron L. Flyer

Associate

aflyer@sidley.com
Washington, D.C. +1 202 736 8127

Allison H. In

Associate

ain@sidley.com
Washington, D.C. +1 202 736 8184

Simone Jones

Associate

simone.jones@sidley.com
Washington, D.C. +1 202 736 8224

Nicole E. Noëlliste

Associate

nnoelliste@sidley.com
Washington, D.C. +1 202 736 8680

Hannah Posen

Associate

hposen@sidley.com
Chicago +1 312 853 0701

ESG Team

Holly J. Gregory

Partner

holly.gregory@sidley.com

New York +1 212 839 5853

Heather M. Palmer

Partner

hpalmer@sidley.com

Houston +1 713 495 4525

Rebecca Grapsas

Counsel

rebecca.grapsas@sidley.com

New York +212 839 8541

Sydney +61 2 8214 2235

Samina M. Bharmal

Associate

sbharmal@sidley.com

Washington, D.C. +1 202 736 8350

Leonard Wood

Associate

lwood@sidley.com

Houston +1 713 495 4679

Energy Team

Kenneth W. Irvin

Partner

kirvin@sidley.com

Washington, D.C. +1 202 736 8256

Averill H. Conn

Counsel

aconn@sidley.com

Houston +1 713 495 4678

Paul M. McBride

Counsel

pmcbride@sidley.com

New York +1 212 839 5346

Gina S. Khanna

Associate

gkhanna@sidley.com

Washington, D.C. +1 202 736 8829

RCRA/Waste Team

Samuel B. Boxerman

Partner

sboxerman@sidley.com

Washington, D.C. +1 202 736 8547

David T. Buente Jr.

Partner

dbuente@sidley.com

Washington, D.C. +1 202 736 8111

Laurence S. Kirsch

Partner

lkirsch@sidley.com

Washington, D.C. +1 202 736 8777

Heather M. Palmer

Partner

hpalmer@sidley.com

Houston +1 713 495 4525

Joseph T. Zaleski

Associate

jzaleski@sidley.com

Washington, D.C. +1 202 736 8898

TSCA Team

Samuel B. Boxerman

Partner

sboxerman@sidley.com

Washington, D.C. +1 202 736 8547

Timothy K. Webster

Partner

twebster@sidley.com

Washington, D.C. +1 202 736 8138

Andrew R. Stewart

Counsel

astewart@sidley.com

Washington, D.C. +1 202 736 8854

Samina M. Bharmal

Associate

sbharmal@sidley.com

Washington, D.C. +1 202 736 8350

Marshall R. Morales

Associate

mrmorales@sidley.com

Washington, D.C. +1 202 736 8920

Allison H. In

Associate

ain@sidley.com

Washington, D.C. +1 202 736 8184

Joseph T. Zaleski

Associate

jzaleski@sidley.com

Washington, D.C. +1 202 736 8898