NC STATE UNIVERSITY

SUSTAINABLE FLEET TECHNOLOGY

CONFERENCE & EXPO 2023

Track C Session 2: Managing Electric Demand Charges

August 15, 2023

NC CLEAN ENERGY TECHNOLOGY CENTER

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION

Sustainable Fleet Conference – Raleigh 2023

Tom DelViscio – Sr. Manager - Customer Fleet Electrification

DUKE ENERGY®

Electric Vehicles (EVs) Market Penetration, Improvements, and Expansion

Ultra Low Emissions Vehicles

BEV - Battery Electric Vehicles :

- An electric vehicle that uses batteries to store and deploy power which powers electric motors to drive the wheels.
- Nissan Leaf, the whole range of Teslas, the Polestar 2, the BMW i3, Hyundai Kona Electric, Kia Soul EV, VW's ID.3 and e-Golf…

PHEV - Plug in Hybrid Electric Vehicles :

- Partially electric vehicle. Key difference is PHEVs and HEVs can be charged up like a battery electric vehicle by plugging in to an EV charge point. Regular Hybrid Vehicles cannot.
- Provides flexibility to use it like a BEV reducing the need for carbon production for very short durations. Typically have small batteries and are only capable of driving between 30 and 50 miles on all-electric mode.
- Popular PHEVs include the Mitsubishi Outlander, Hyundai Ioniq, MINI Countryman PHEV, and the Volvo XC60 T8

HEV - Hybrid Electric Vehicle :

- Regular hybrid vehicles (HEVs), think Toyota Prius, can't be plugged in. They charge via regenerative braking or by using the engine like a generator.
- In essence then, to charge them, you need to fuel them with gasoline.

FCEV - Fuel Cell Electric Vehicles :

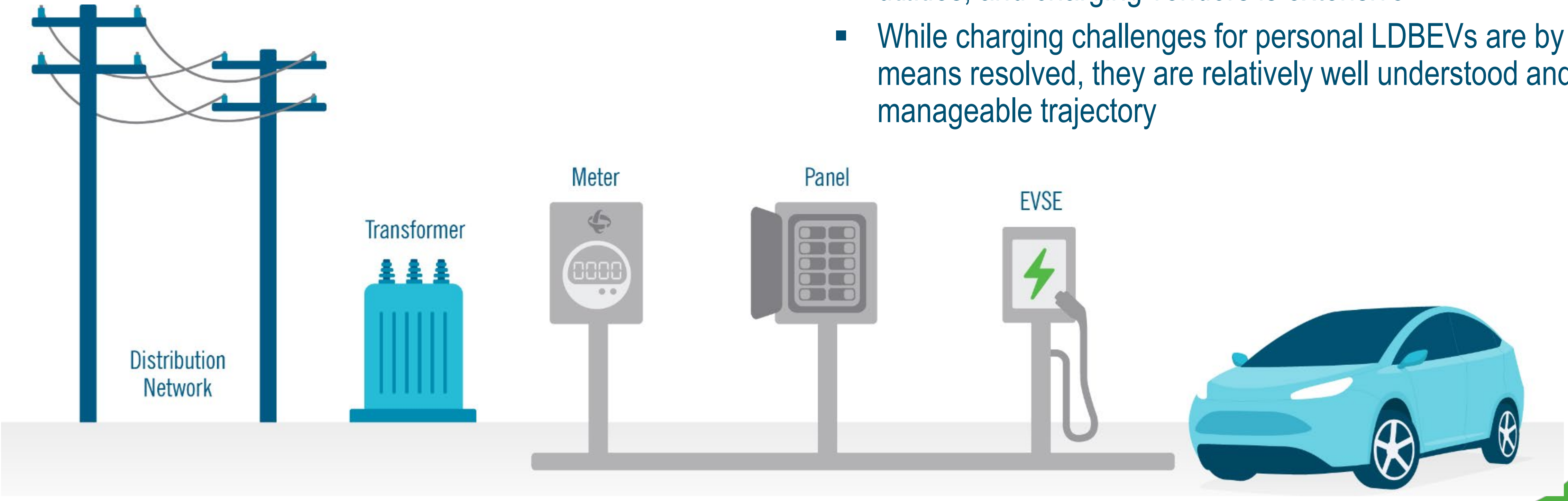
- A small offshoot of EVs that use hydrogen fuel cells to create an electrical charge that's used to power motors that drive the wheels. Fueled same way as a combustion engine vehicle, hydrogen is the most abundant element in the world, and their only waste product is water vapor.
- The main issues lack of hydrogen infrastructure, high cost of fueling, and very little choice of hydrogen vehicles.
  The Toyota Mirai is one of the few.

ULEV - Ultra Low Emissions Vehicle :

- Acronym used to describe the whole collection of vehicles that produce very low amounts of CO_2, in the UK it's a class of vehicle that produces less than 75 grams of CO_2 per kilometer. In the US, it's vehicles that produce less than half the CO_2 per km of the current year's average models.

Understanding the Average EV

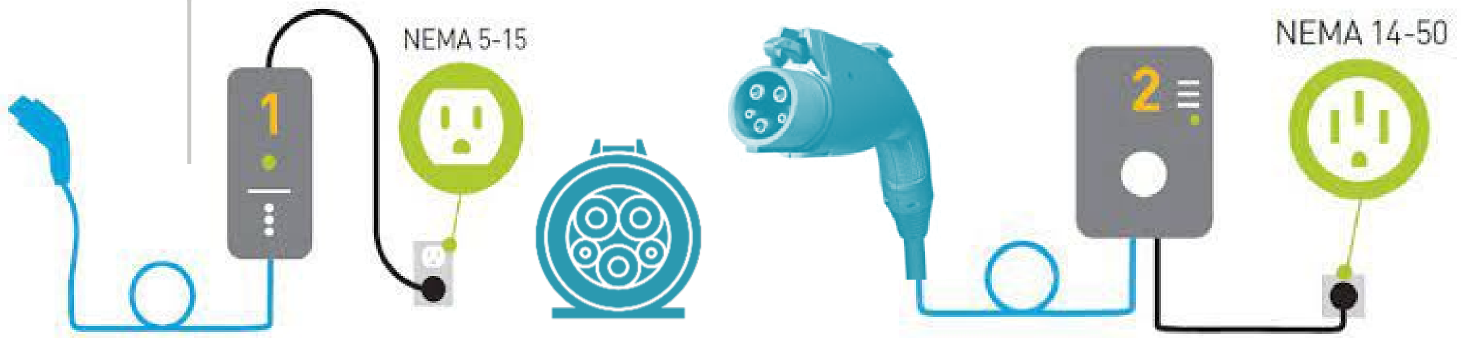
- Sales of light-duty battery-electric vehicles (LDBEVs) have steadily risen since 2010
- LDBEV sales in the US nearly doubled in 2021, (85%)*
- Sales of plug-in hybrid vehicles grew 138%*
- Daily energy requirements per vehicle is relatively low and typically have a minimum impact to electric grids
- Charging opportunities are high, as they are of idle use for 95% of their life
- Generally parked either at home or workplace
- Road trips or long commutes are the rare exception
- EVs are a newer technology – as such documentation of deployment obstacles among manufacturers, consumers, utilities, and charging vendors is extensive
- While charging challenges for personal LDBEVs are by no means resolved, they are relatively well understood and a manageable trajectory

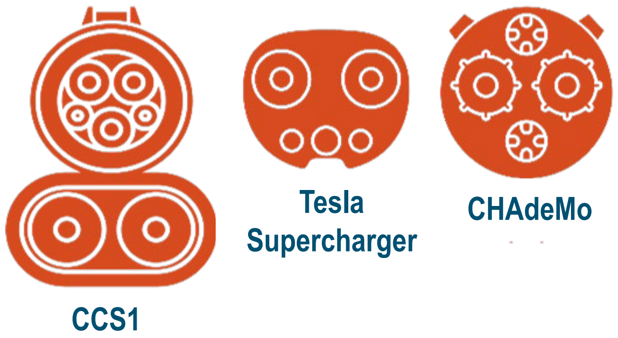


*U.S. Department of Energy's (DOE) Vehicle Technologies Office

EVSE Characteristics

Level 2: SAE J1772 connector rated from 1.4 kW to 19.2 kW





	LOW POWER AC LEVEL TWO (L2)	HIGH POWER AC LEVEL TWO (L2)	DC LEVEL THREE (DCFC or L3)
Use Case:	Similar to an electric range Sedans and small SUVs (Tesla Model 3 50-82kWh battery, Chevy Bolt EUV 65kWh) Standard NEMA 14-50 outlet	MUD, Public, Workplace LD and MD Trucks (Ford Lightning 98-131kWh battery, E-Transit van 68-120kWh) Has to be hard wired for the heavier loads	Similar to a large home improvement or small fast-food restaurant. MD and HD trucks, transit busses, and long-distance travel (HD battery packs <400kWh)
Charge Time:	For a **75kW** battery pack, **20** miles vehicle range per hour of charge and **7** hours to charge battery from **20%-80%**	For a typical **120kW** battery pack, **20** miles vehicle range per hour of charge and **7** hours to charge battery from **20%-80%**	Sedans and LD can achieve **80%** charge in **<1HR**, MD & HD trucks may take up to **8** hrs to fully charge at **50kW** charge rate

Typical Input Power Needs

Low Power AC Level Two (L2):

Voltage	208/240V AC	
kW level	7.2	3.6
Amperage	40	15

High Power AC Level Two (L2):

Voltage	208/240V AC	
kW	19.2	11.5
Amperage	80	60

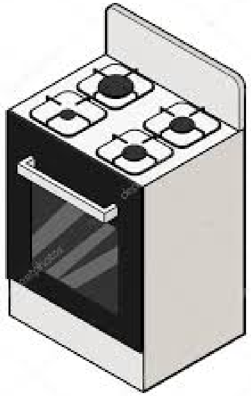
DC Level Three (DCFC or L3):

Voltage	480V AC 3 phase			
kW	350	175	120	50
Amperage	450	300	200	80

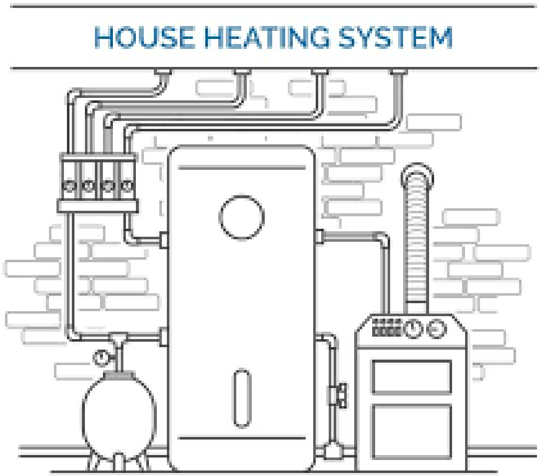
*Charging speeds are limited based on vehicle on-board charging characteristics and real time conditions

Scale of Vehicle Charging

7.2kW Charger is comparable to an Oven or a Dryer

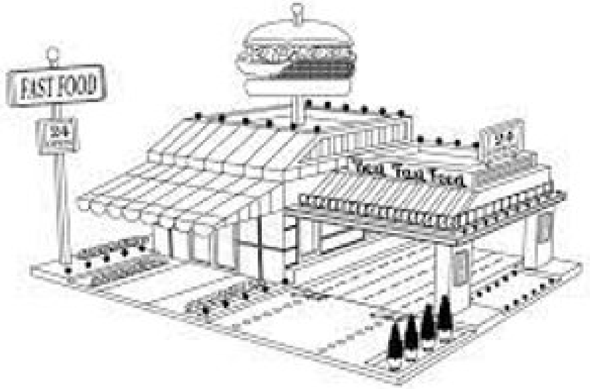


19.2kW Charger is comparable to a 5-ton HVAC system for 2,500sqft house



50kW Charger is comparable to a 12-unit apartment complex

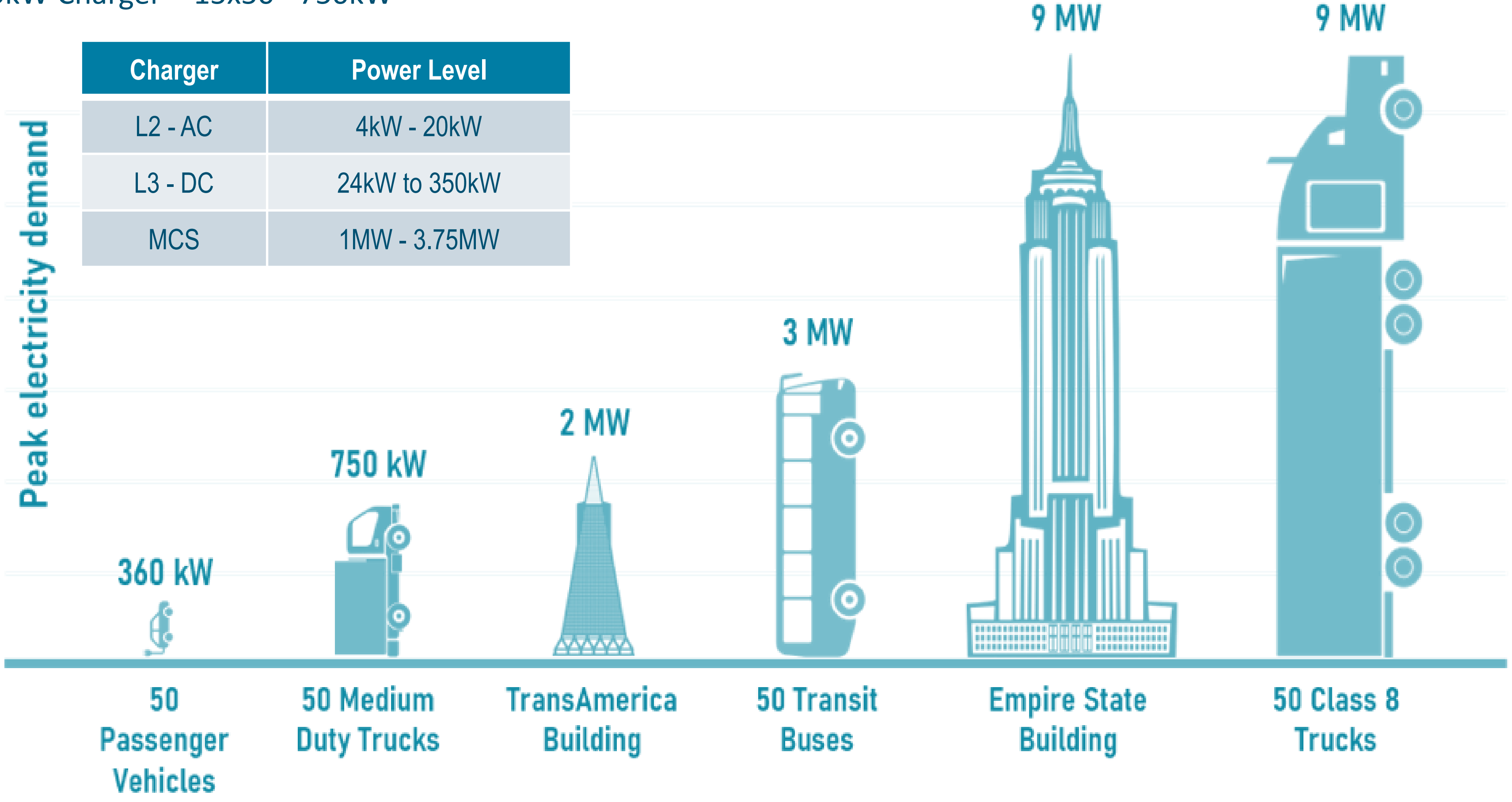
150kW Charger is comparable to a small fast-food restaurant



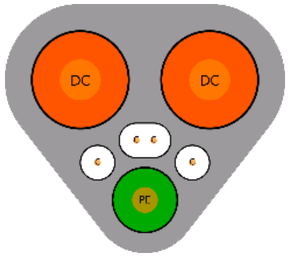
Load Comparison

[*] Assumptions: Passenger car charging rate 3.6 kW, the MD EV truck charging rate is 7.4 kW, and the transit bus charging rate is 60kW.
L2 Charging Max is 7.2 kW so 7.2x50= 360
MD L2 15kW Charger = 15x50= 750kW

Charger	Power Level
L2 - AC	4kW - 20kW
L3 - DC	24kW to 350kW
MCS	1MW - 3.75MW



Potential Scale of Future Charging



Megawatt Charging System (MCS) can deliver up to 3.75MW of power per charger

The first MCS charging stations, will be backward compatible with current standards and will be 1MW

Real time maximum demand at any point in time

800
Average US homes (@ 1.25 kW)

20
DC Fast Chargers (@ 50 kW)

150
Level 2 Chargers (@ 6.6 kW)

25
Overnight Depot Chargers (@ 60 kW)

Fleet Electrification Trends & Concerns

- Trends:
  - Large fleet customers making electrification adoption announcements
  - Companies creating organizations to facilitate their fleet transitions
  - Multiple small conversions/pilots
  - More resourceful companies taking advantage of available capacity
  - Regulators inquiring and/or opening dockets on Grid Readiness
- Concerns:
  - Aggressive timelines
  - Lack of data for modeling and forecasting
  - Early adopters consume available capacity
  - Capacity planning lacks customer commitment
  - Commercial/Industrial site clustering
  - Obligation to serve
  - “Used & Useful”

Understanding the Fleet Dilemma

- Companies today, especially fleet operators are experiencing political and customer pressure to decarbonize their footprint
- For medium- and heavy-duty (MD, HD) fleets the scale of obstacles is more complex
- Consider vehicle choices and routes variability
- Development of charging solutions that fit their needs today and scale with EV technology of the future
- MD and HD vehicles are purchased and operated by companies using business and sometimes tax-payer dollars with a responsibility to remain competitive
- For the business and its customers there is little to no room for EV failure where profit margins are tight and down time equals lost profits
- MD/HD fleets have limited charging windows, and how they are used is a function of tradeoffs of space and cost.

Today

- 100 Class 6 trucks (School bus, beverage, rack truck)
- 30 Class 8 trucks (Fire truck, semi, dump truck)
- Site load today ~ 500 kW

Electrified

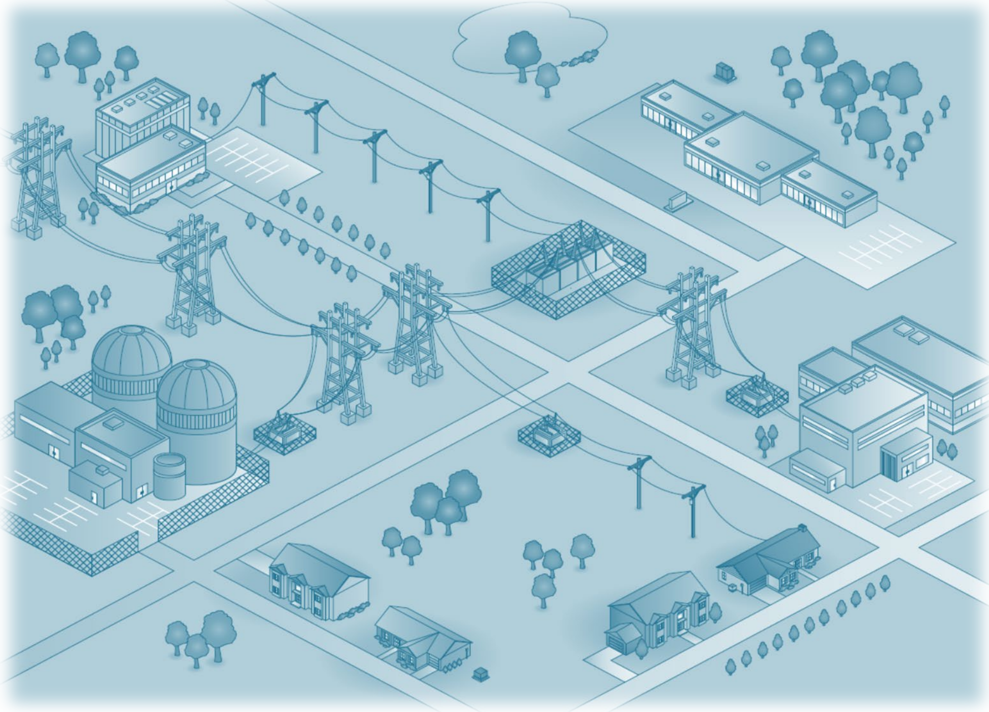
- Class 6 trucks: ~ 100 kWh each per day
  - 10,000 kWhs in 8 hours = 1250 kW
- Class 8 trucks: ~ 400 kWh each per day
  - Assume 4-6 vehicles charging = 2 – 3 MW

Grid Readiness – Broken Down

Is the grid ready for growth from transportation electrification?

The answer is not simple and must be broken down into multiple parts:

1. Bulk Electric System
2. The Distribution Grid
3. Hyperlocal Load Growth
    a. Residential Transformers
    b. Fleet Electrification
    c. DCFC Load
4. Load Management



Residential Transportation Electrification Solutions

Typical suburban neighborhood transformer serving 8 houses

4AM Saturday

2pm Today

10PM Friday

Opt Out

9PM Tonight

12pm Today

No EV

8PM Thursday

1AM Tomorrow

Consider likely charging times and EV owner battery health management

Case for Managed Charging

Transformer Balancing Strategy

- Charging windows
- Special rates / response to pricing signals
- Override / Opt Out request (OR)
- Afternoon Peak Event Load Reduction
- Demand Response Events
    - Reduced L2 to L1 for period

Mobile Communication and Notification Protocol

- Smart charger
    - Two-way communication with utility management software
- Dumb charger
    - Manual communication with App
- Pricing signals
- Event notification

Impacts of Electrification and Fleet Clustering

Analysis of feeders for long-term fleet electrification impacts to the electric distribution system have a variety of challenges for today's utility grid.

Typical Scenarios

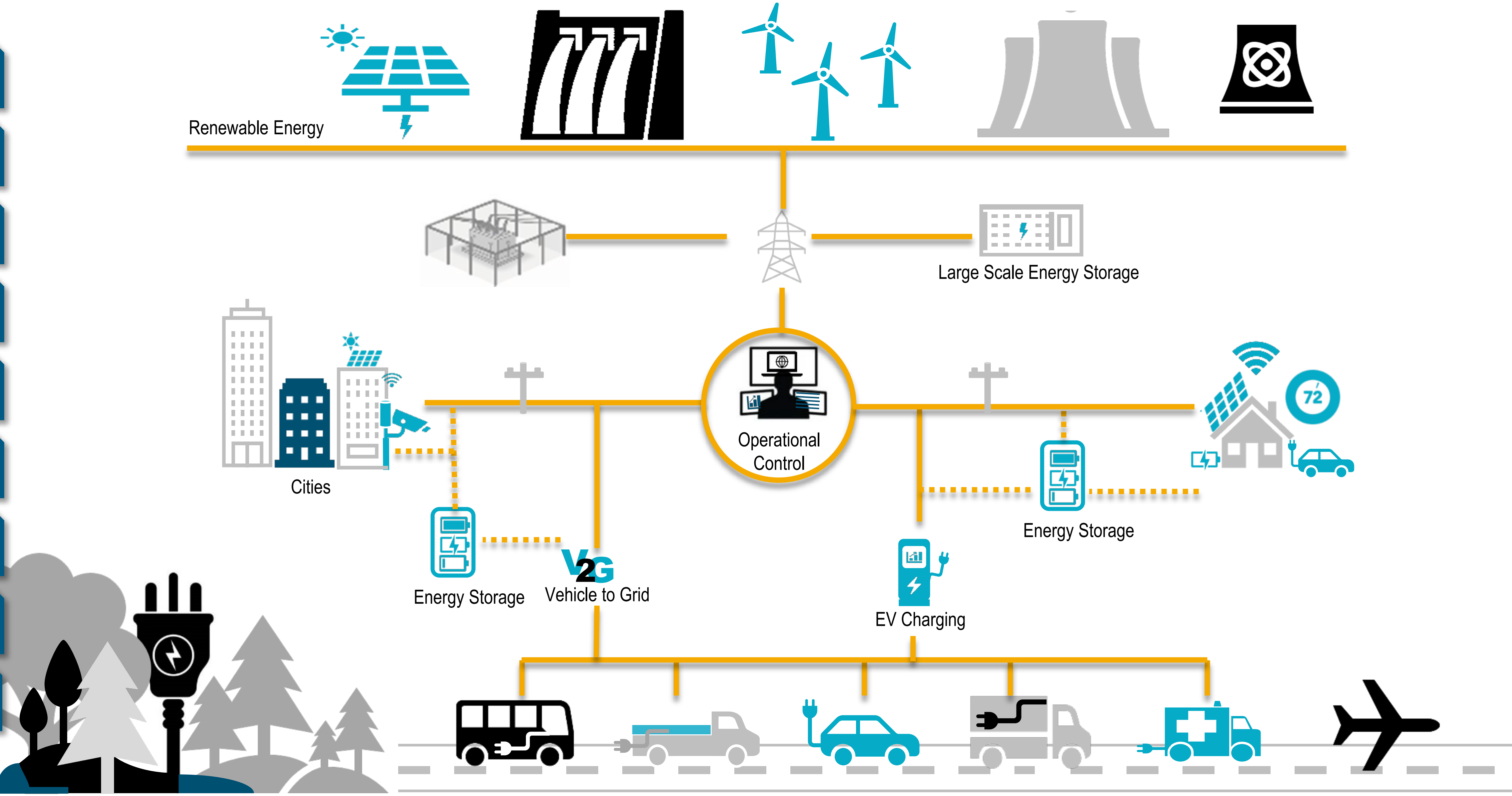
- Fleets on circuits vary. Hitachi and ABB found that of 19 circuits studied over **68% of them needed upgrades** when nearby fleets fully electrify.
- In some clustering cases circuits showing 5MW or more of spare capacity today, can become **200% overloaded** following fleet electrification.
- Substation can see greater than **50% increase in peak load** due to fleet electrification and an **additional 20% increase** from home and public charging.
- As all fleets on a circuit electrify, utilities can see upwards of 300 to 500 fleet vehicles in an area leading to **excess of 25MW or greater** at times.

Conclusion

Utilities, system operators, and policymakers should **act now and begin forecasting and planning** for the medium- and long-term impacts of fleet electrification.

Integration of Electric Vehicles to Modern Utility Grid

- Clean Energy Production
- Accurate Load Forecasting
- Grid Modularity and Adaptability
- National Account Partnerships
- Right Size Grid Improvement Plans
- Proactive Grid Upgrades
- Customer Offerings
- Rate Design & Infrastructure Tariffs
- Storage Capacity Bridges and Buffers



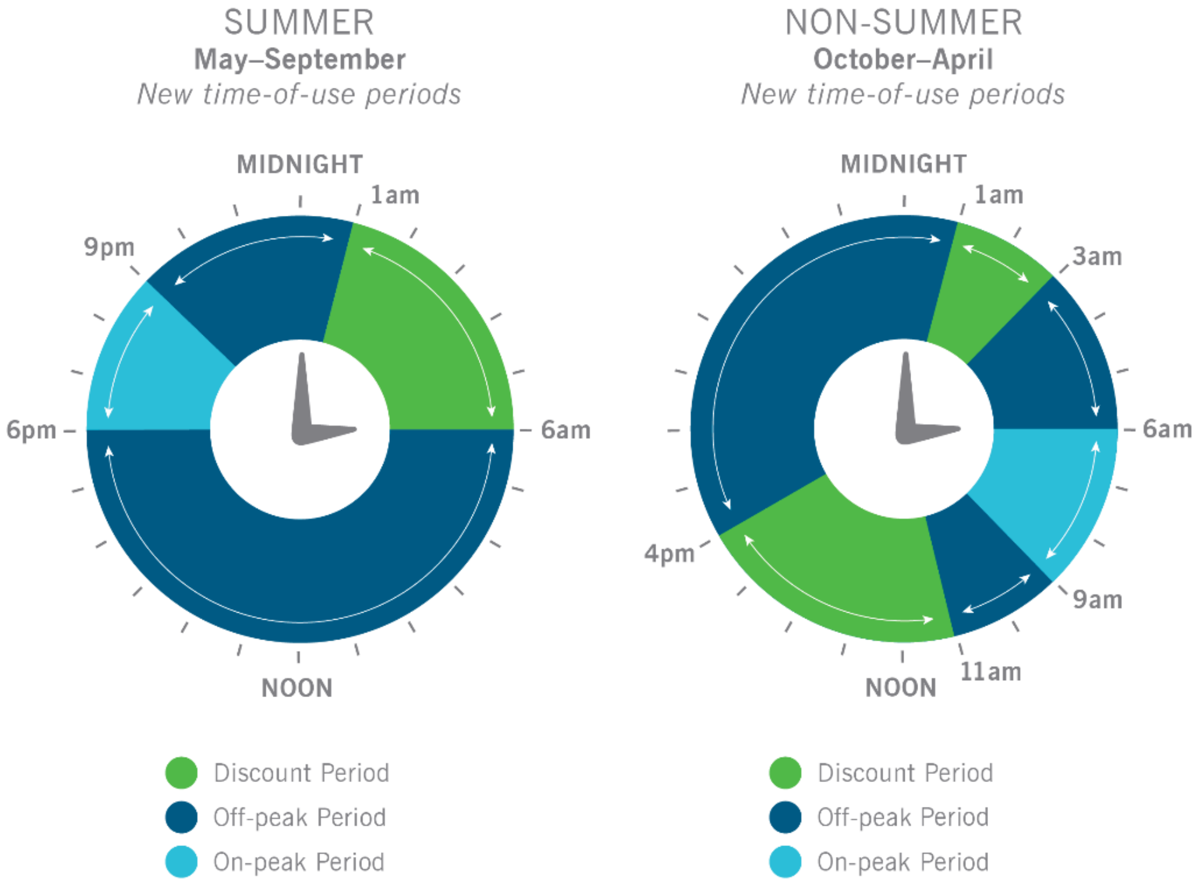
Major Cities | Municipalities | Neighborhoods | Airports | Trucking Fleets | Rental Fleets | Shipping Fleets | Vehicle Dealership

Potential EVSE Effects on Electrical Grid

	LOW POWER AC LEVEL TWO (L2)	HIGH POWER AC LEVEL TWO (L2)	DC LEVEL THREE (L3/DCFC)
Typical locations and charging profile:	Residential charging typically is evening and overnight. Workplace charging occurs during normal business hours for employee vehicles and overnight for workplace vehicles.	Residential charging typically is evening and overnight. Workplace charging occurs during normal business hours for employee vehicles and overnight for workplace vehicles.	Located at fleet depots and in high traffic areas. Depot charging occurs when vehicles have downtime which is mostly late evening and overnight. High traffic charging occurs sporadically and cannot be controlled.
Grid effect:	Residents charging vehicles when they get home from work could be loading system during peak time, potential to push use to off-peak with credits or education	Workplaces charging vehicles in a depot setting after business hours could be loading system during peak, potential for rate structures enhancements and education to push use to off-peak times	Getting companies to charge during non-peak times will aide in system reliability, will need rate structures and education to get depot charging to a favorable time.
Infrastructure effect:	Homeowners typically do not communicate EV additions. If 10 homes on a transformer all electrify, could see 72 kW additional load unexpectedly.	Depots could be looking to install multiple 19.2kW chargers to charge fleets overnight. 10-19.2kW chargers represent 192kW. Multiple fleets on the same feeder circuit adding multiple chargers represent large growth, 100-19.2kW chargers on a feeder would add 1920kW.	HD and fleet users looking to depot charge vehicles during 8hr downtimes will need 50kW chargers. A fleet may need 10-50kW chargers representing 500 kW. Fleets clustered on the same feeder circuit would be even larger, 100-50kW chargers on a feeder would add 5MW of load.

Rate Design Modernization and New TOU Periods

- Stakeholder collaborative yielded Rate Design Roadmap in March 2022.
- Designs supported by AMI data and population level analyses.
- Modernization includes:
  - System-aligned TOU Periods
  - Cost-based demand charge restructuring
  - 3-hour on-peak period vs. historic 8-12 hours
  - New rate options that better support distributed energy tech, including EVs
  - Alignment across Carolinas



Duke Energy Rate Options for Electric Vehicles in NC & SC

		NC		SC	
		DEC	**DEP**	**DEC**	**DEP**
Residential	TOU TOU-D TOU-CPP	RT* RSTC, RETC	R-TOU R-TOUD R-TOU-CPP	RT* RSTC*, RETC*	R-TOUD R-TOU-CPP
Small & Medium Business	TOU TOU-D TOU-CPP	OPT-V SGSTC	SGS-TOUE MGS-TOU SGS-TOU-CPP	OPT	MGS-TOU
Large Business	TOU-D Hourly Pricing	OPT-V HP	LGS-TOU HP*	OPT HP	LGS-TOU HP
		*Available Jan-24 pending approval	*Available Oct-23 pending approval	*In Development	

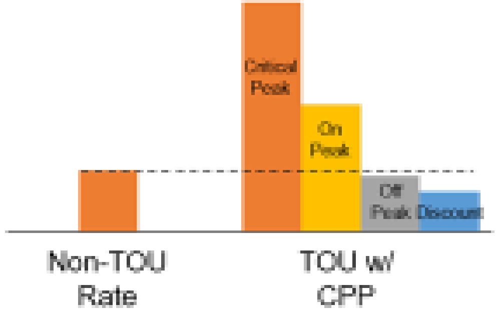
Note – TOU rates are not required for EV customers but may present material savings based on charging behaviors.

Rate Strategies for EV Customers

Residential

Critical Peak Pricing Tariffs

RSTC, RETC, R-TOU-CPP



Discount charging saves $10+ /mo.

ICE	BEV Non-TOU	BEV Discount
14k mi/yr.	14k mi/yr.	14k mi/yr.
25 mpg	3.5m/kWh	3.5m/kWh
$3.25/gal.	$0.13/kWh	$0.08/kWh
$1,820/yr.	$520/yr.	$320/yr.
Savings →	**70%**	**80%**

Non-Residential w/ Integrated Fleet

TOU Rate Options

Ex. = SGSTC, OPTV, MGS-TOU

Strategy for Lowest Cost:

1. Charge in discount window to minimize overall costs
2. Avoid EV charging when non-EV operations are highest
3. Avoid charging during narrow 3-hour on-peak window

Non-Residential w/ Dedicated Fleet or HLF

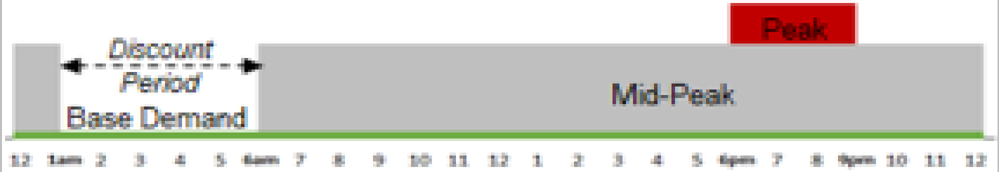
TOU or Hourly Pricing

Ex. = LGS-TOU, Hourly Pricing

Strategy for Lowest Cost:

1. Concentrate in Discount Periods
2. Slow charging speeds during non-discount periods
3. For Hourly Pricing, limit charging during grid constraints *(1% of hours)*

Demand Periods for May–Sept.



- Demand charges allow for lower $/kWh energy charges.

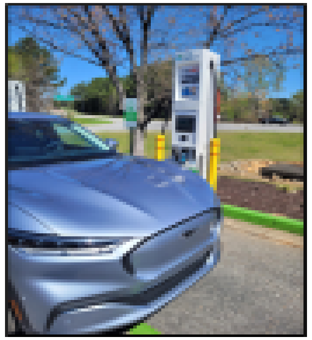
DC Fast Charge

TOU or Hourly Pricing

Ex. = LGS-TOU, Hourly Pricing

Strategy for Lowest Cost:

1. Pricing strategy to discourage on-peak consumption
2. For Hourly Pricing, limit charging during grid constraints *(1% of hours)*



Questions???

Thank you!

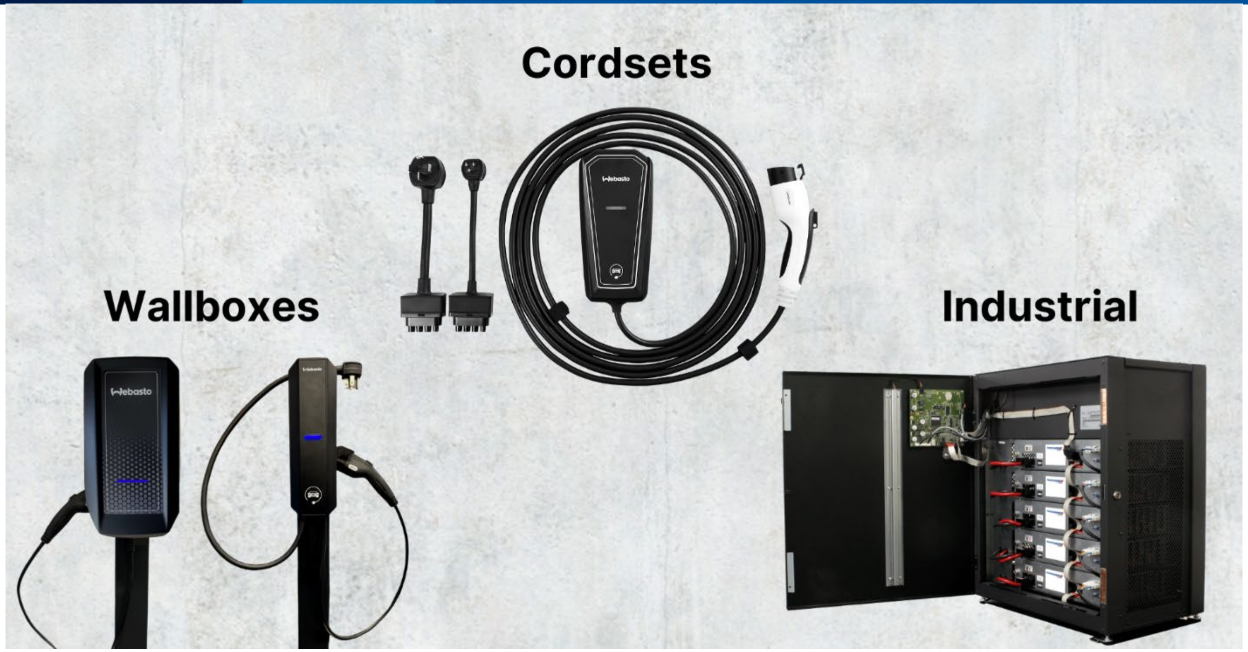
DUKE ENERGY®

OCPP Interoperability: Sustainable Future of Charging

Silke Kirchner, Ph.D., Webasto Charging Systems Inc., Monrovia CA

Sustainable Fleet Technology Conference, August 15-16th 2023, Raleigh NC

Webasto



Cutting-Edge Products and Solutions for over 120 Years

- Sunroofs, Panorama Roofs, Convertible Roofs
- Fuel and Electric Operated Heaters
- Cooling Systems

E-Mobility Offerings for Today - and Next Generations

- Battery Systems
- Charging Solutions
- Applications and Services

Our Solution tailored to Your Use Case

Agenda

1. EV Systems Interoperability to Accelerate EV Fleet Adoption

2. Current Challenge: Backend Systems Interoperability

3. Solution: Open and Standardized Communication Protocols

- OCPP
- Protocols for E-Ecosystems
- ISO 15118
- Protocols for eRoaming

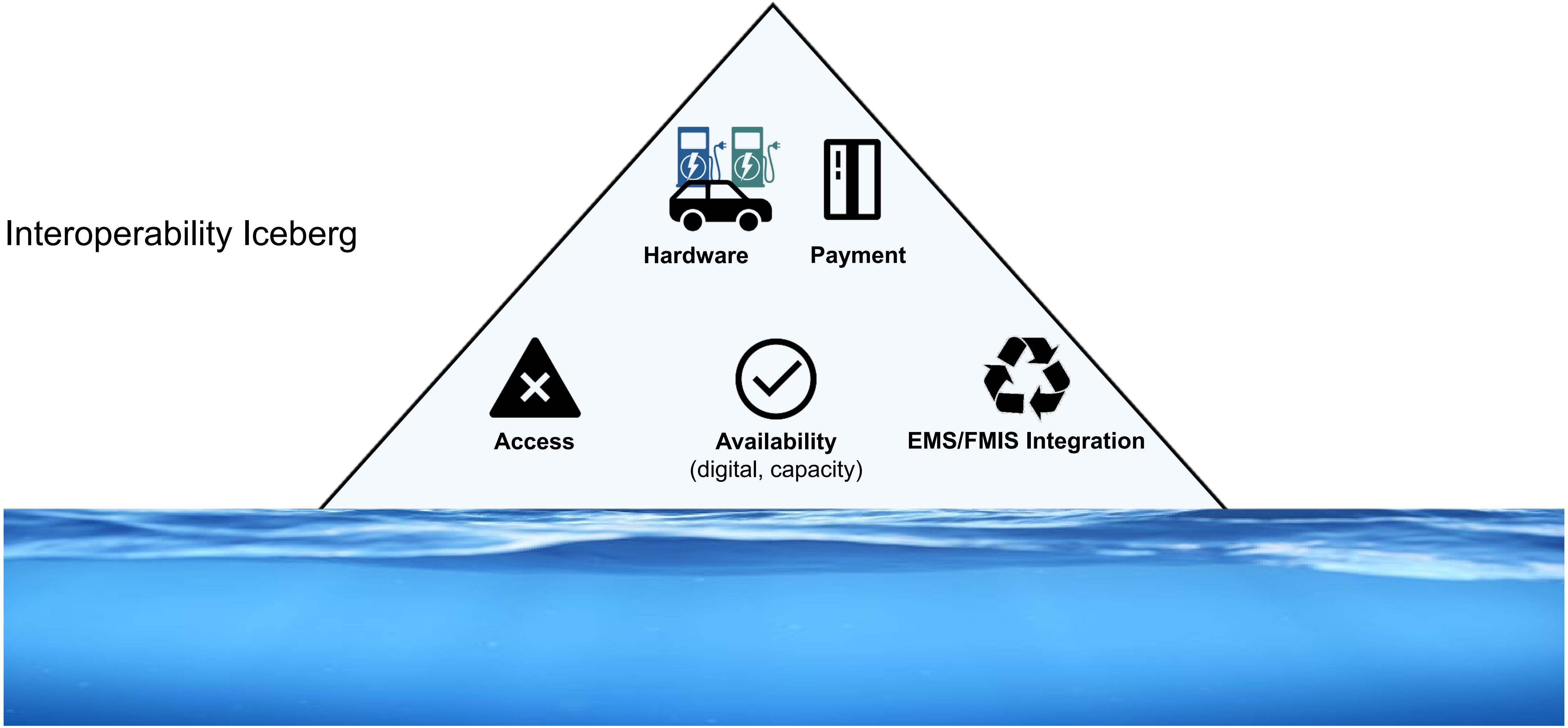
4. Conclusion and Outlook

1. EV Systems Interoperability to Accelerate EV Fleet Adoption

- **Improve** user experience
- **Optimize** fleet performance based on energy prices and available capacity
- **Reduce** cost of owner ship / total operating costs
- **Improve** charger uptime
- **Ensure** energy resilience of modern DER grid
- **Enable** financial incentives and meet Federal / State Mandates (e.g., ACF by CARB)

2. Current Challenge: Backend Systems Interoperability

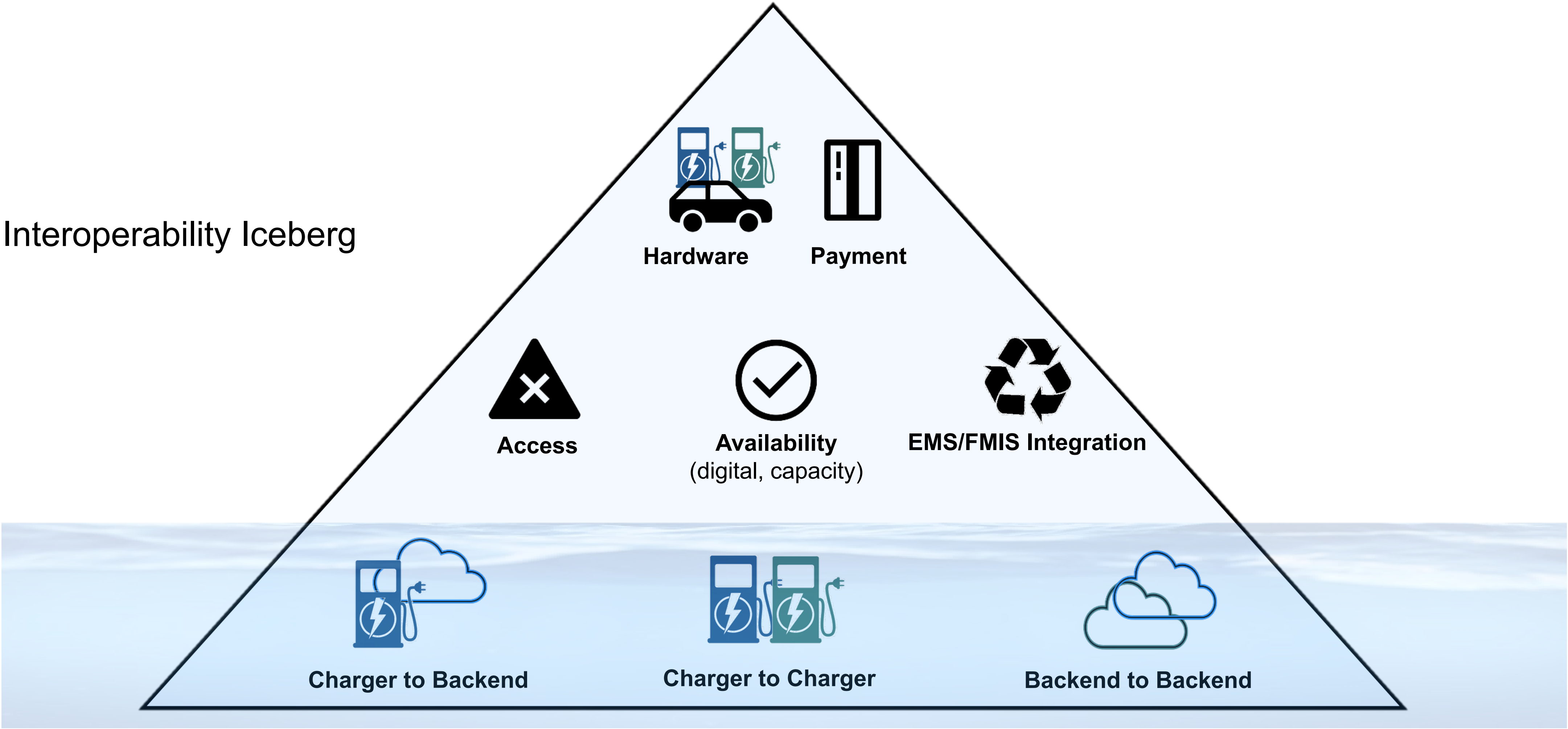
Interoperability Iceberg



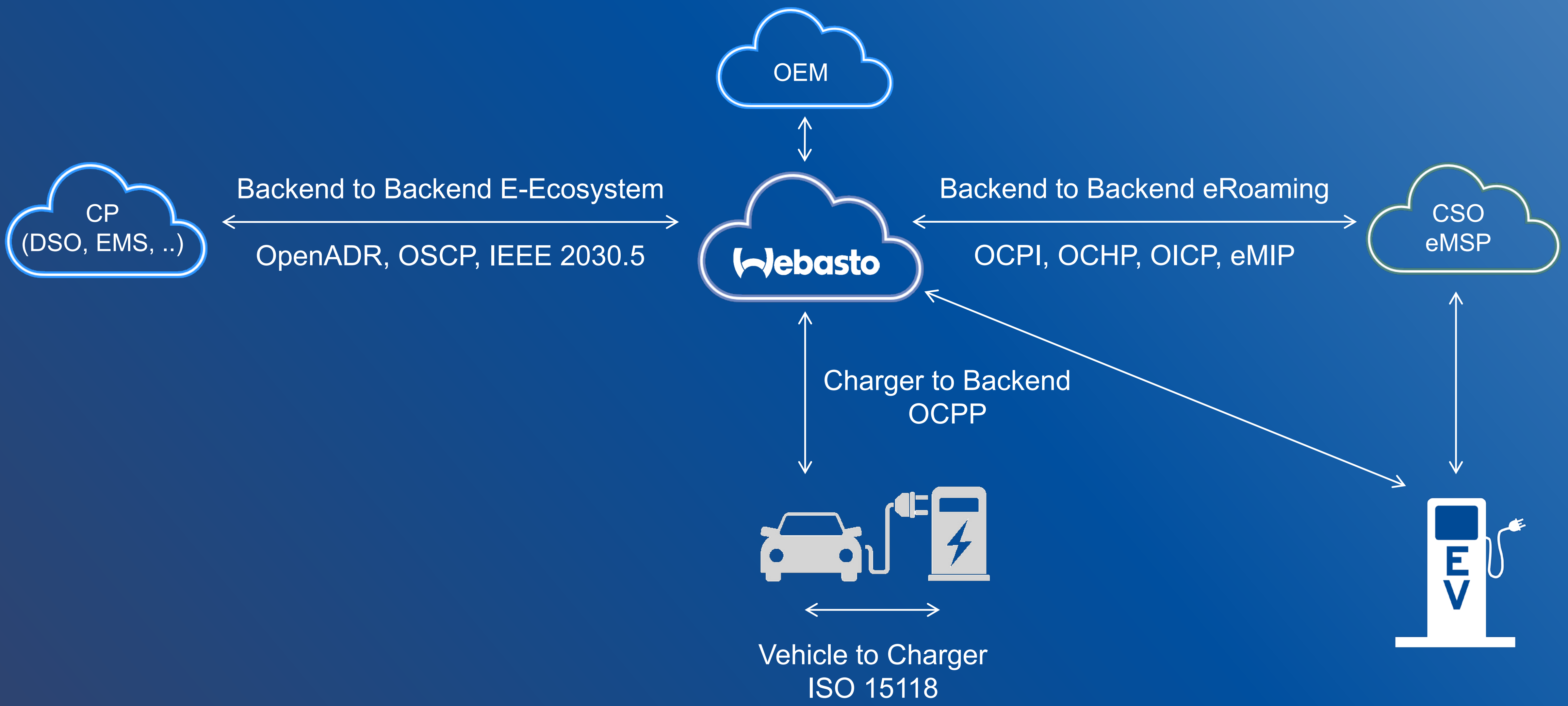
Webasto

2. Current Challenge: Backend Systems Interoperability

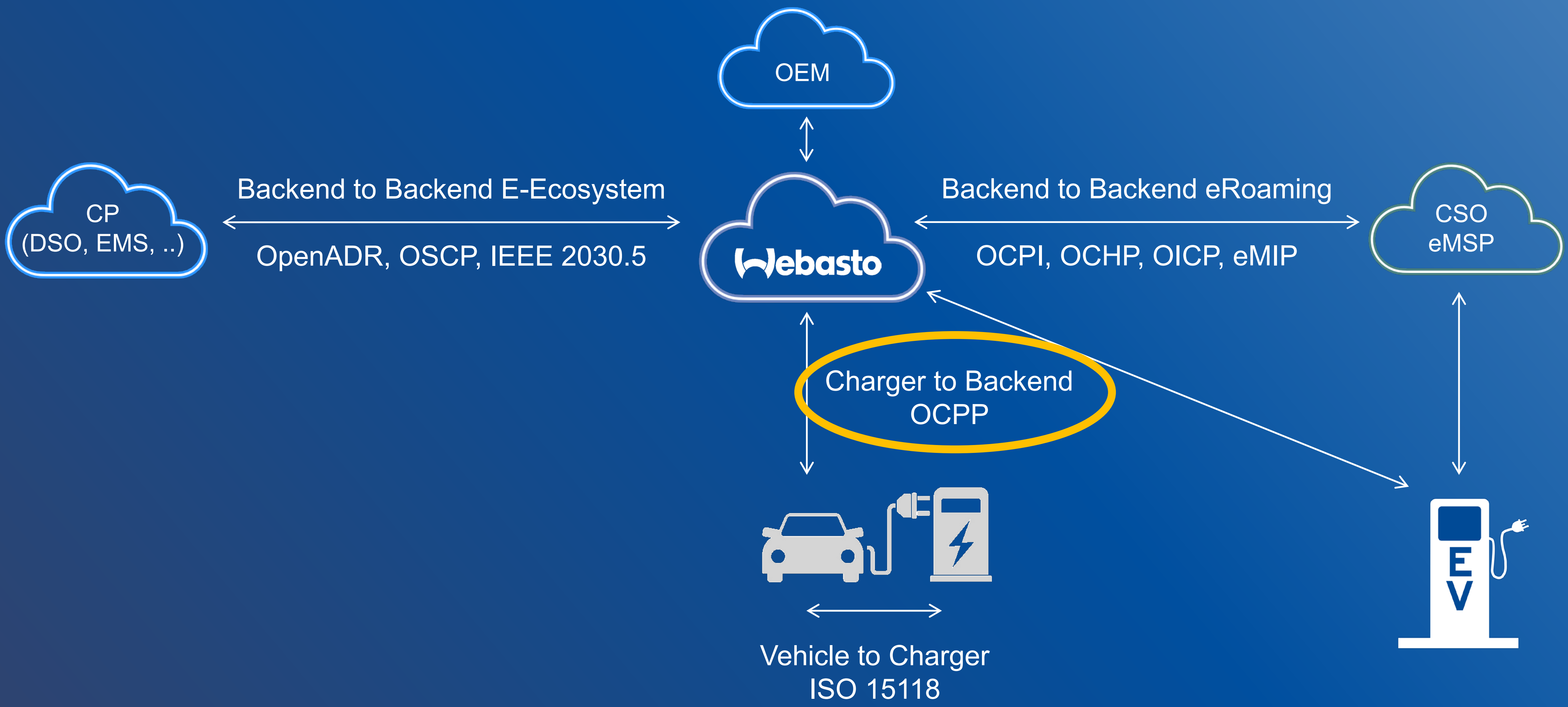
Interoperability Iceberg



3. Solution: Open and Standardized Communication Protocols

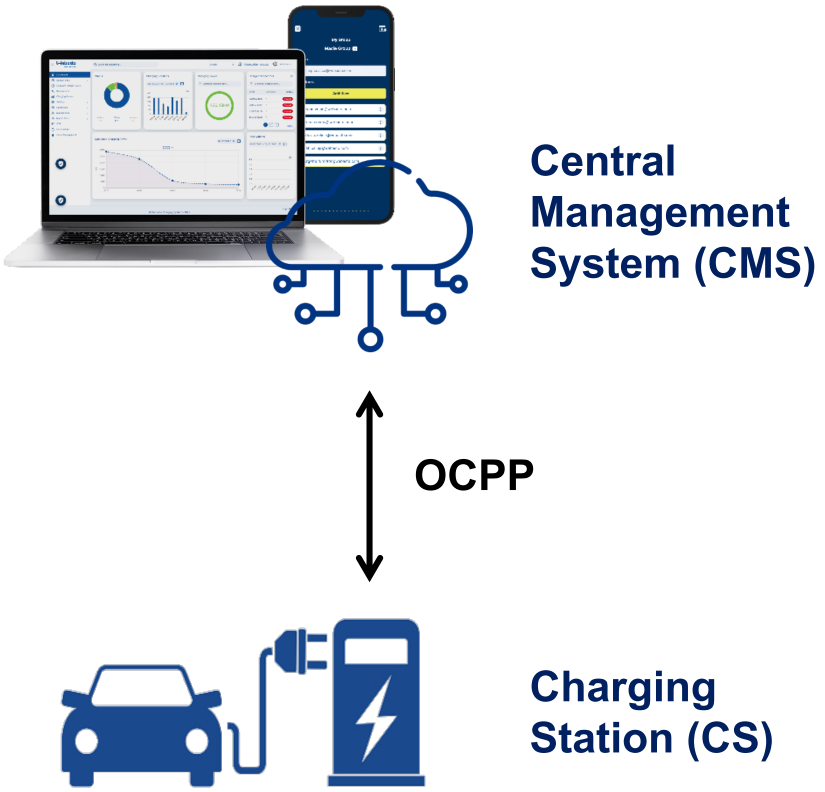


3. Solution: Open and Standardized Communication Protocols



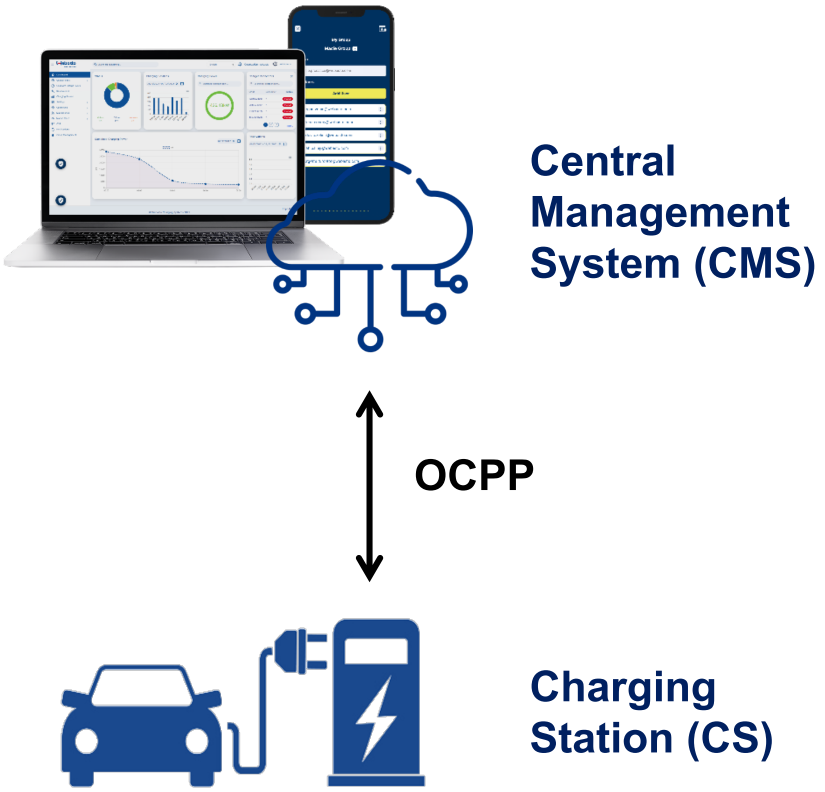
Open Charge Point Protocol (OCPP)

- Main de facto open communication protocol between charging station (CS) and central management system (CMS) in the US
- Enables any CMS to connect with any version compatible CS
- Data source for a fleet management information system (FMIS) for informed decisions and optimize fleet performance
- Services include payments, set tariff, certificate management, smart charging, reservation, etc.
- Continuous updates and improvements

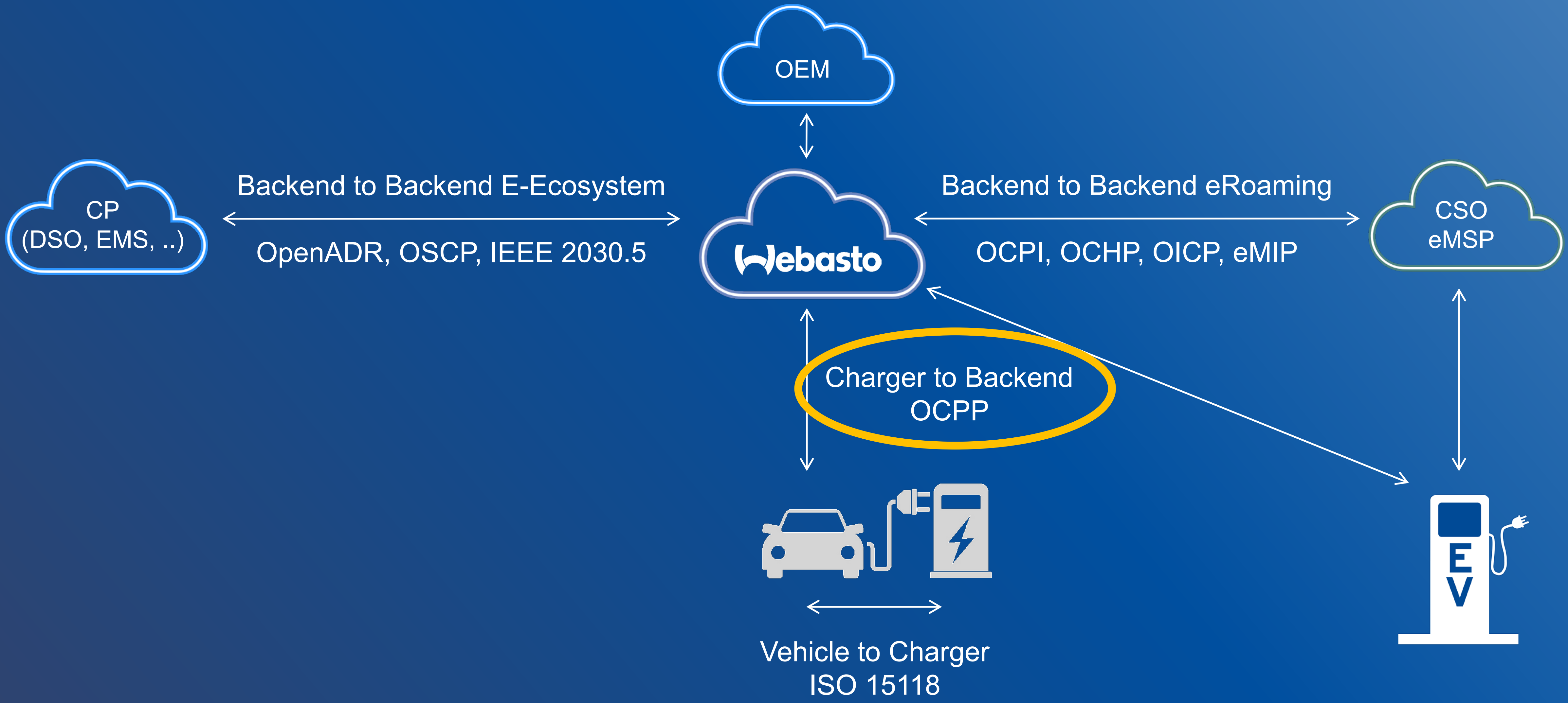


OCPP to Improve Charger Uptime

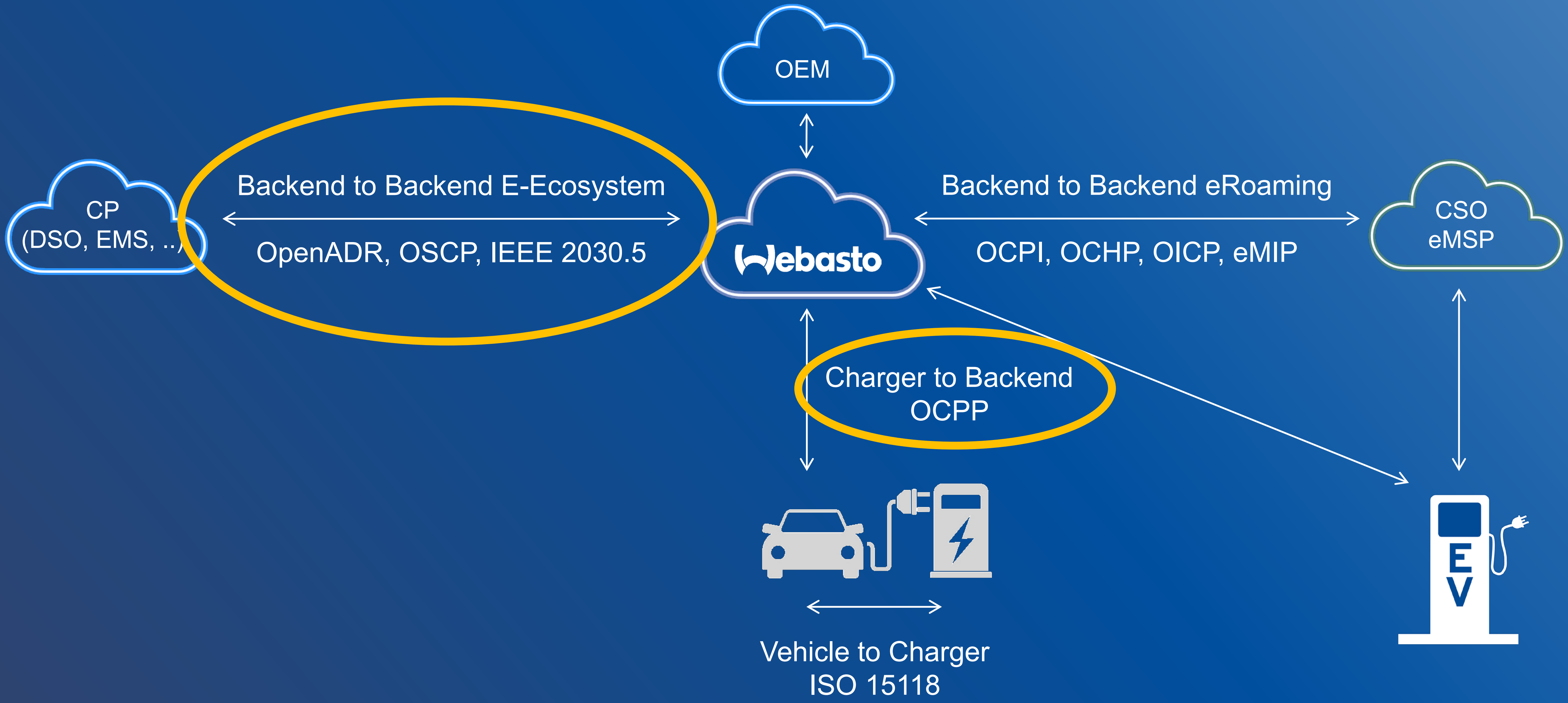
- Fast Detection of charger downtime and causes
- Ensure connection through Websocket ping
  OCPPCommCtrl.WebSocketPingInterval
- Ensure firmware functionality through Heartbeat interval messaging
- EVSE sends StatusNotification (*status* and *errorCode*)
- CMS can send a *TriggerMessage.req(requestedMessage = "StatusNotification", connectorId = 0)*
- Security Event notification



3. Solution: Open and Standardized Communication Protocols



3. Solution: Open and Standardized Communication Protocols



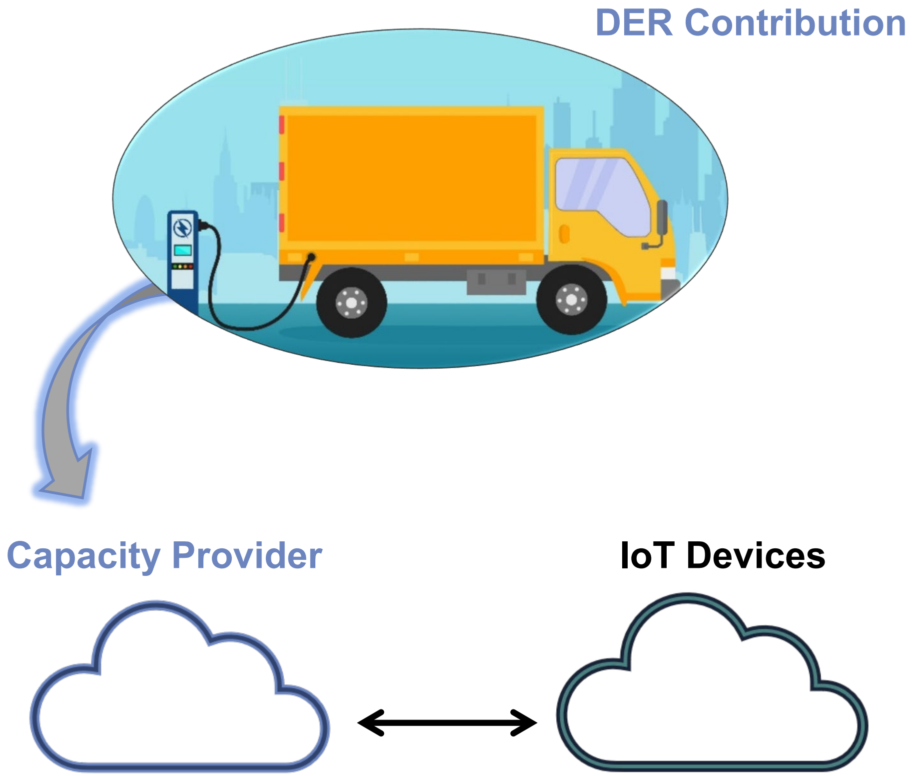
Decentralized Renewable Energy Production

- Decentralized production of renewable energy for net-zero emissions transition by 2050

- Distributed Energy Resources (DERs):

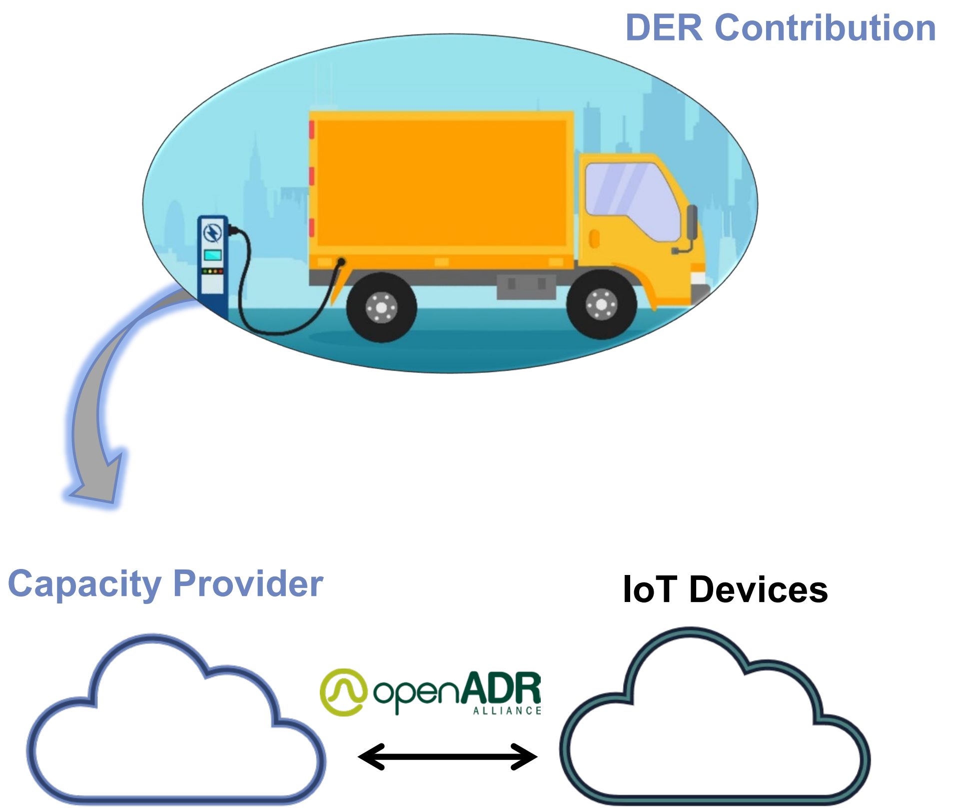
  Photovoltaics, wind turbines, heat pumps, electric energy storage (EES), etc.

- Standardized DER systems communication for grid reliability and stability



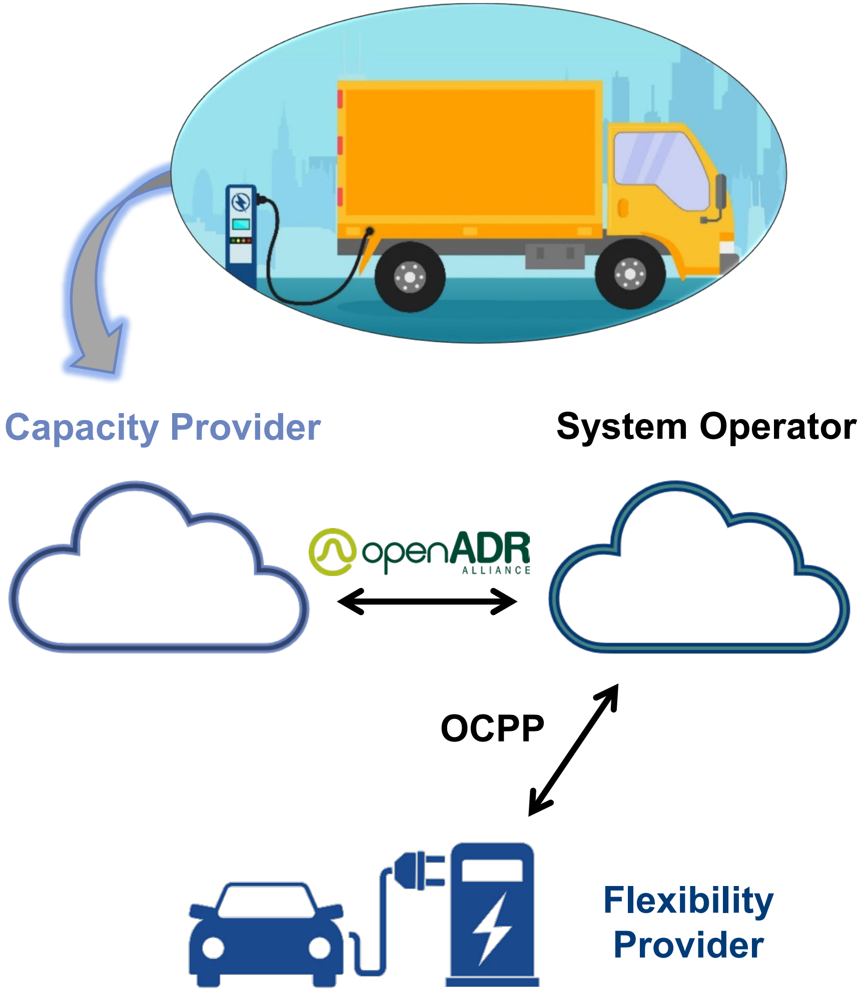
OpenADR protocol

- Standardizes the two-way demand-response (DR) communication between an CPs, aggregators, and end devices
- Includes information related to changes in DR/DER electric energy availability
- Motivation based: shifting demand through increasing/lowering prices, rewards, etc.

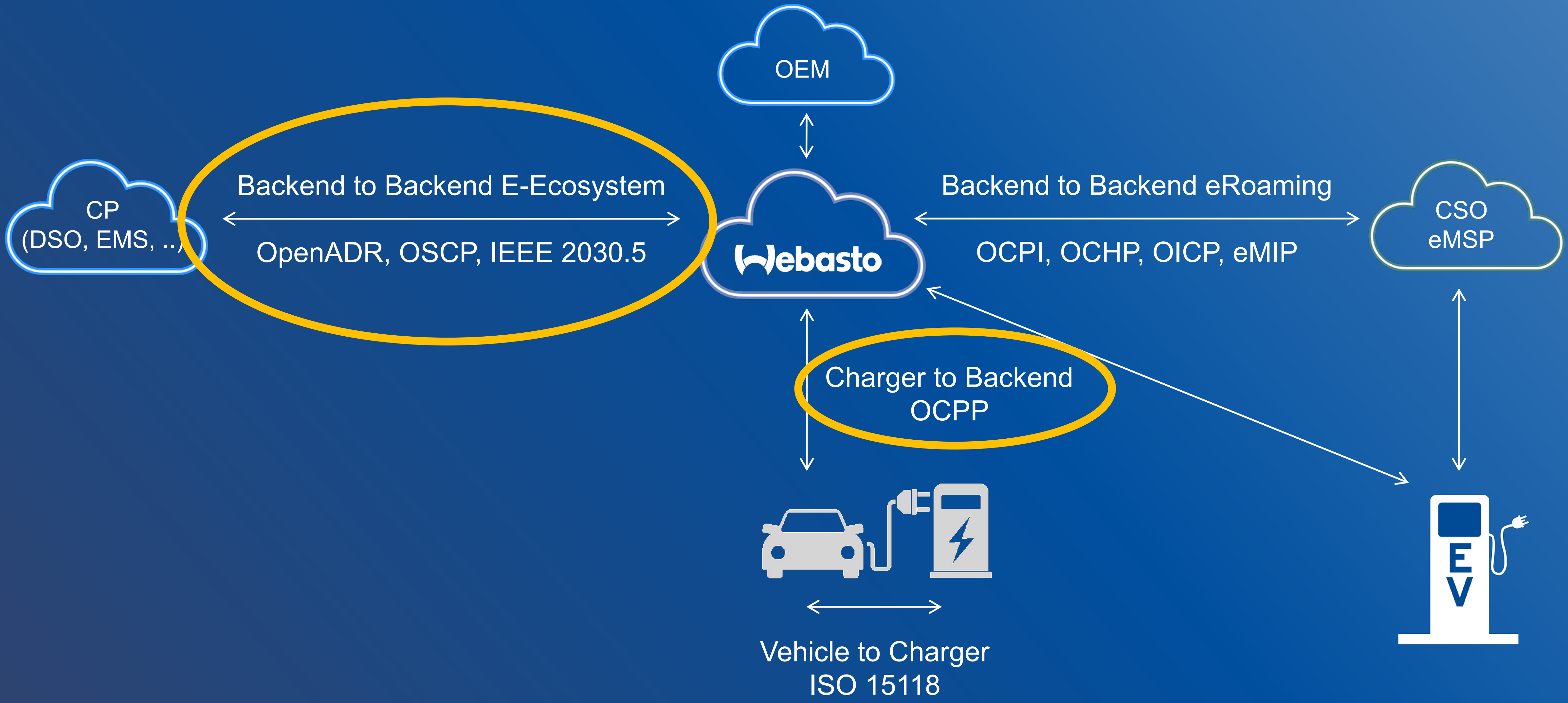


Combining OCPP with OpenADR

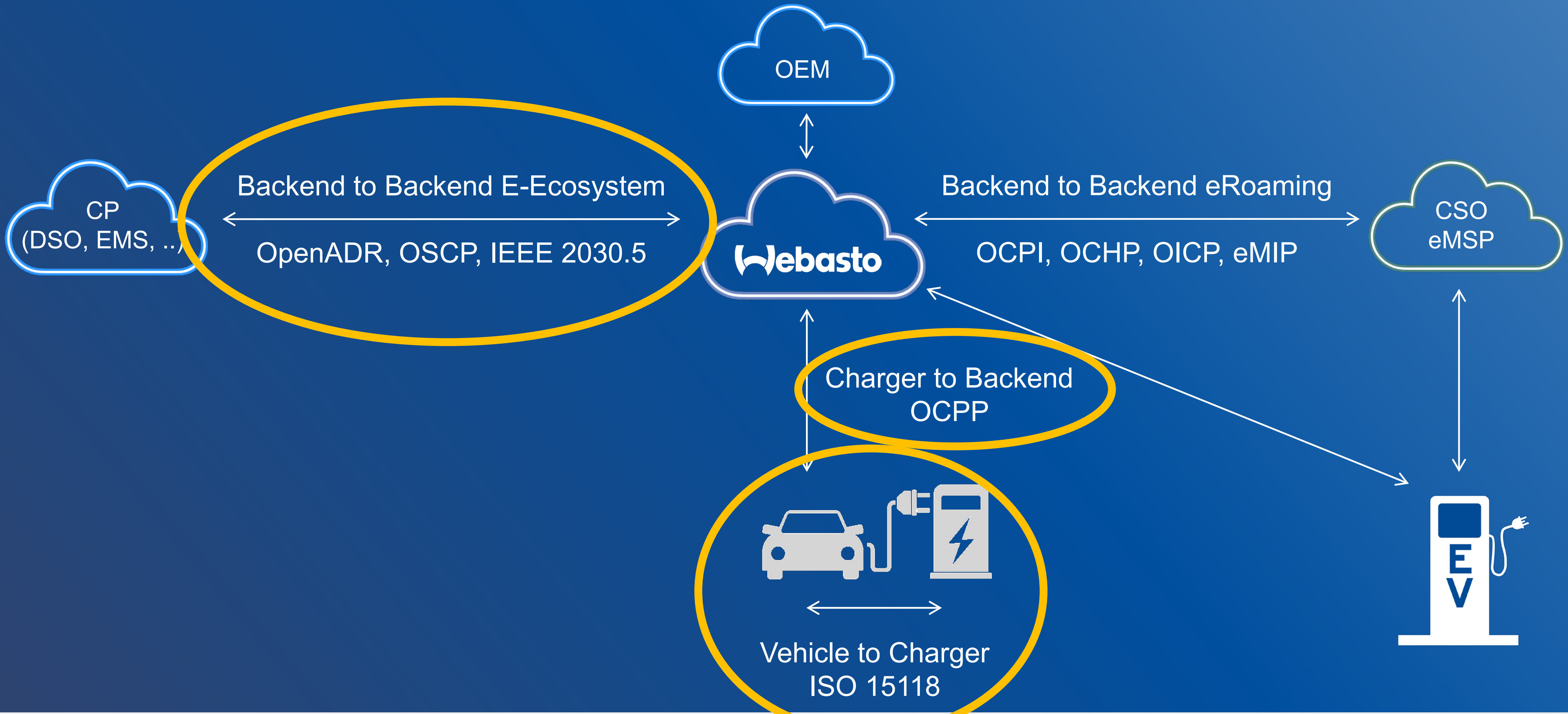
- CS as Flexibility Provider, able react (=smart) to changes in currently and locally available grid capacity
- Optimizing charging schedules based on energy prices, available capacity, and vehicle dispatch priority
- Provide grid overload protection, throttling or postponing a charging process



3. Solution: Open and Standardized Communication Protocols

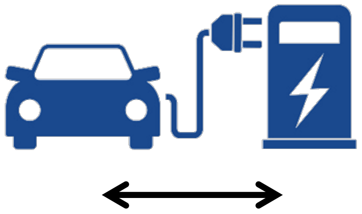


3. Solution: Open and Standardized Communication Protocols



ISO 15118 Road vehicles - Vehicle to Grid Communication Interface

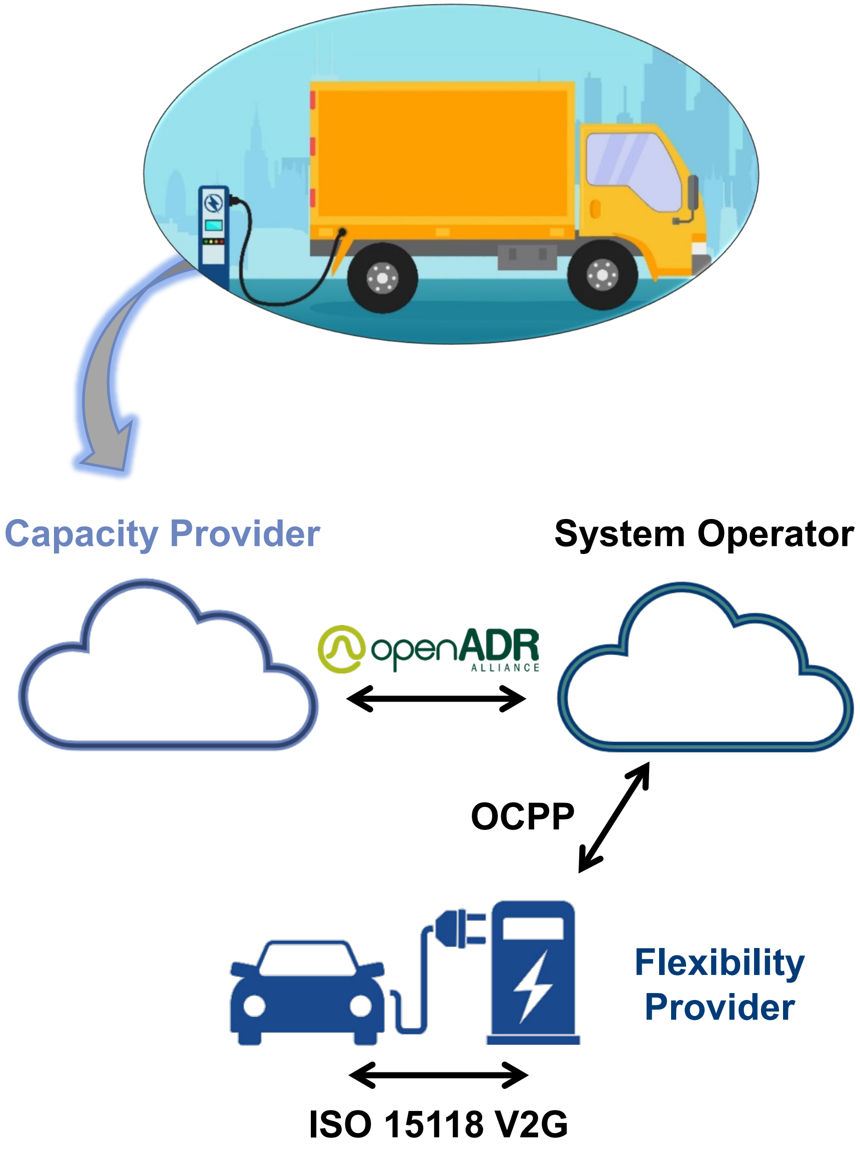
- International standard series contains specifications for secure, local, and bidirectional communication between EV and CSs
- Plug and Charge (PnC) i.e., automatic authorization and payment upon connecting the CS with the EV
- Vehicle to Grid (V2G) i.e., EV can supply energy back to the grid
- Dis-/charging authentication and authorization through digital certificates that are exchanged locally between the EV and the CS



Vehicle to Charger
ISO 15118

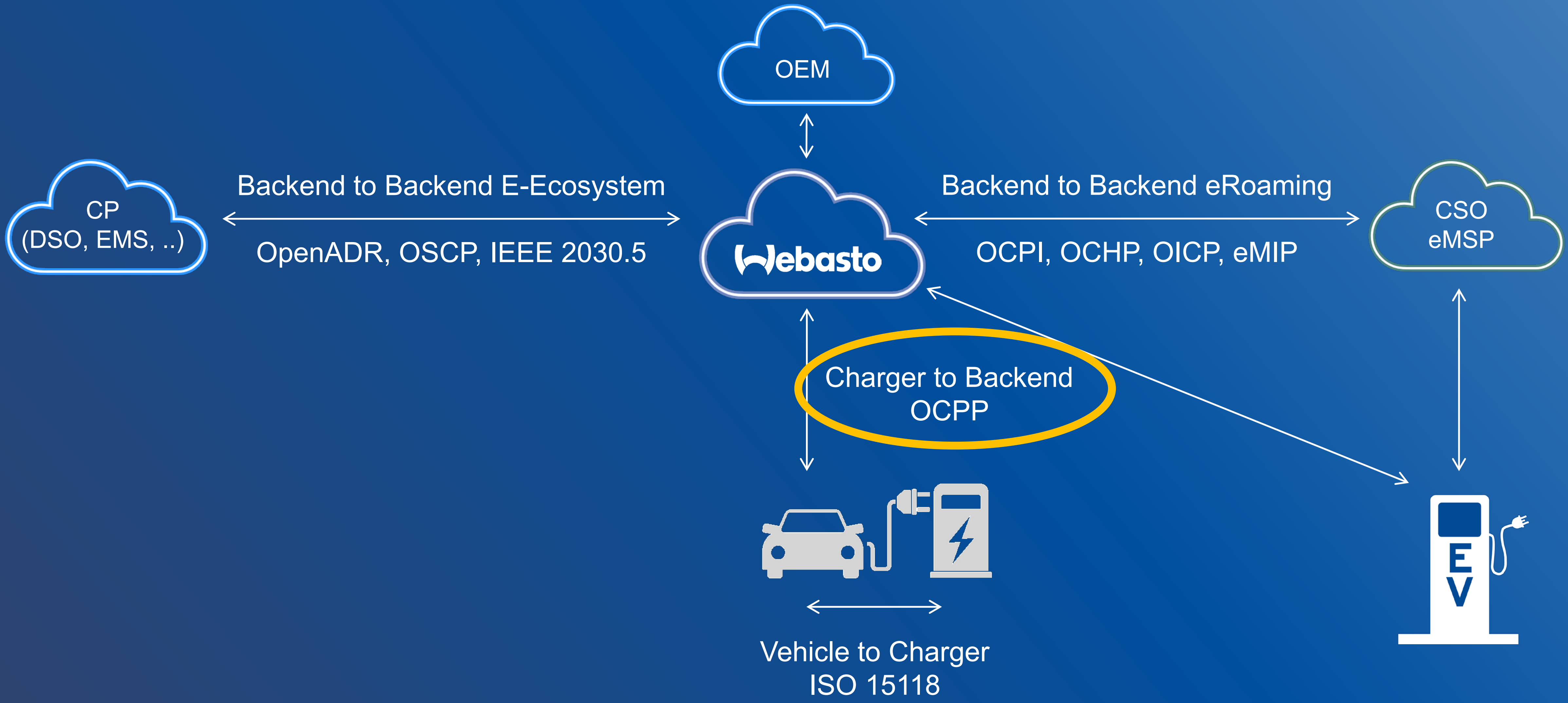
Combining OCPP and ISO 15118 V2G

- EV as mobile EES unit feeding green energy back to the grid, reduce cost of ownership
- Enhance modern DER grid stability
- EV communicates with the grid to determine the best discharging schedule based on:
  - Driver relevant information, e.g., schedule for departure to ensure reliable and safe transport,
  - CS response, and Grid feedback
- Example: School buses largest batteries on wheels, available during peak grid hours

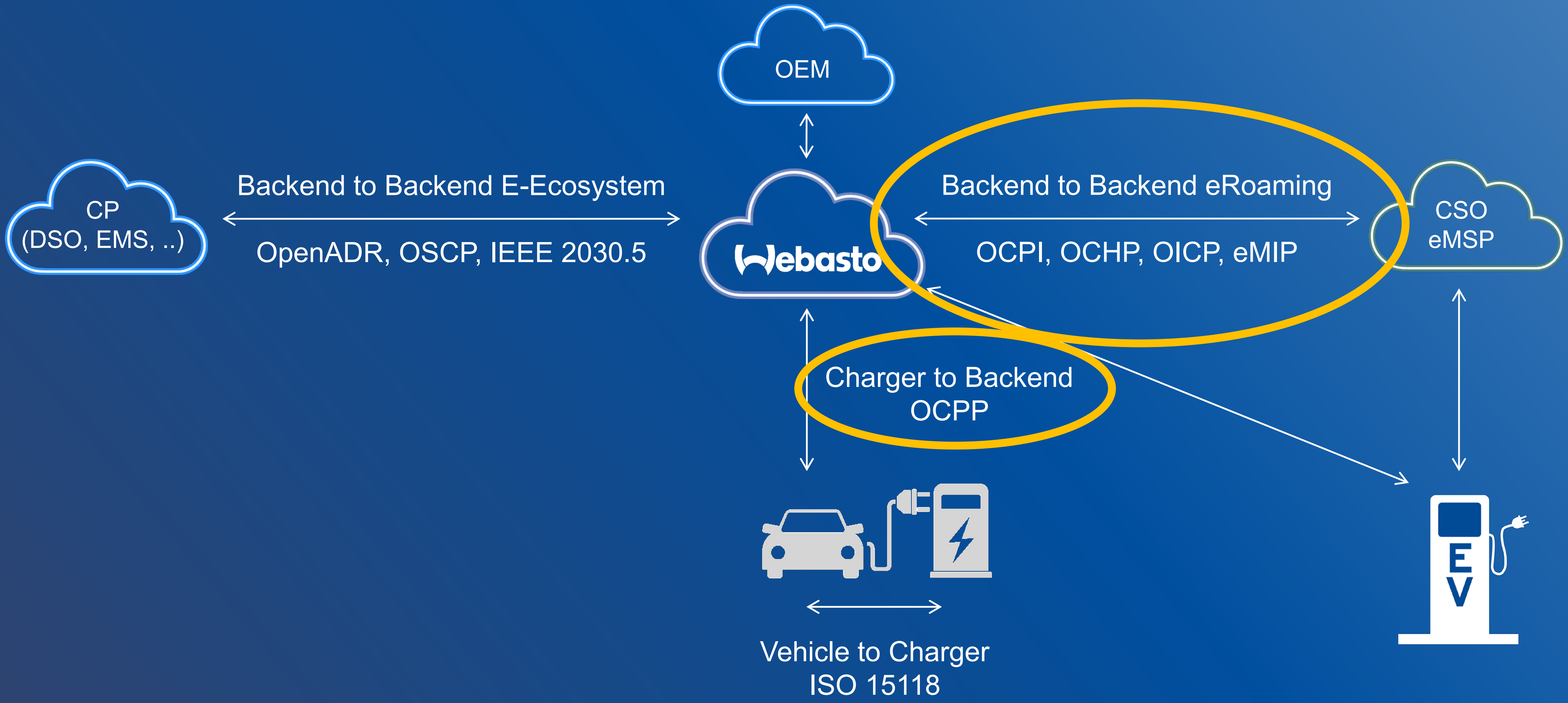


Webasto

3. Solution: Open and Standardized Communication Protocols

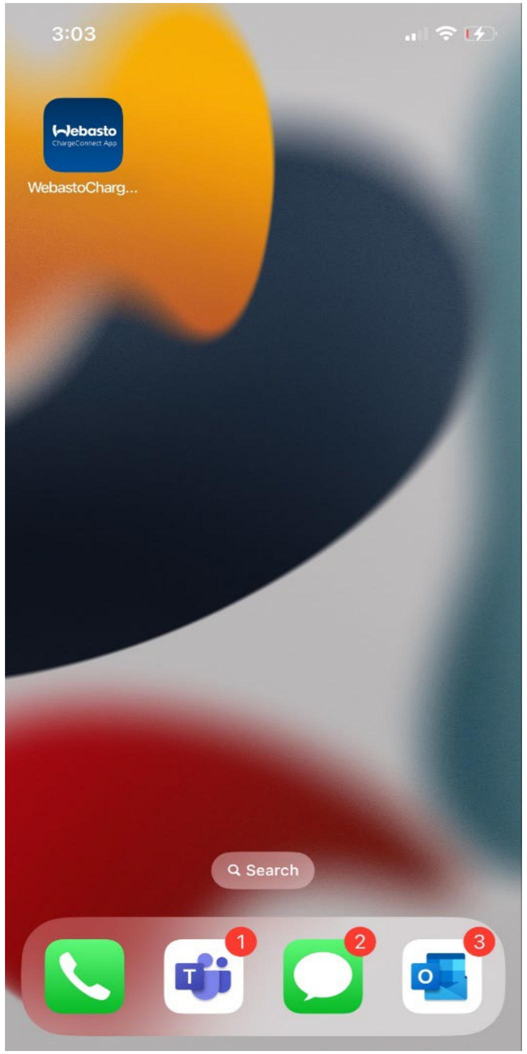


3. Solution: Open and Standardized Communication Protocols



eRoaming

- “Charge anywhere”
- One mobile app supports charging authentication, payments, and reservations across multiple CS networks
- CMS needs to integrate through defined communication protocols with eRoaming platforms

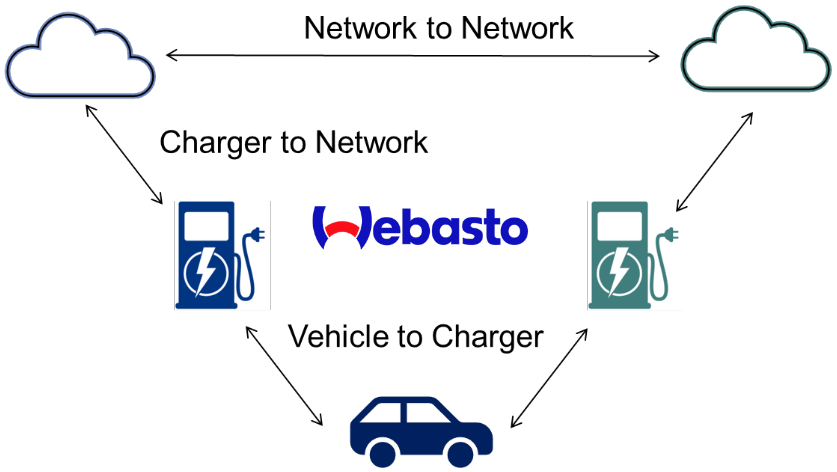


eRoaming Platform Examples

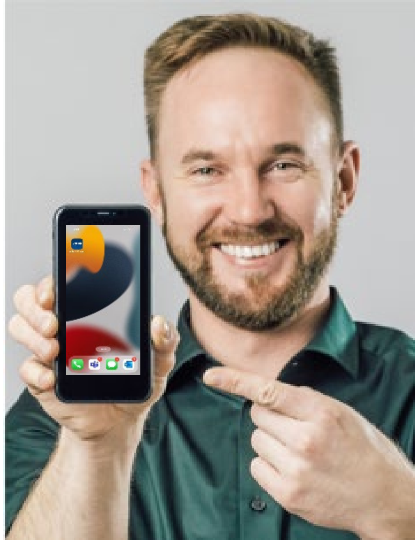
Name	EVRoaming Foundation – Realising cross-border charging
Type	Peer to Peer Networking / Hybrid with Hubs
Players	Freshmile, Chargepoint, Google Maps, Last Mile Solutions, NKL (global)
Comm. Protocol	Open Charge Point Interface (OCPI) (NEVI requirement)

Name	Gireve	e-clearing.net	HUBJECT	ChargeHub
Type	Hub	Hub	Hub	Hub
Comm. Protocol	eMobility Interoperation Protocol (eMIP 1.0.14), Open Charge Point Interface Protocol (OCPI)	Open Clearing House Protocol (OCHP 1.4), Open Charge Point Interface Protocol (OCPI)	Open InterCharge Protocol (OICP), Open Plug&Charge Protocol (OPCP 1.0.0)	Open Charge Point Interface Protocol (OCPI)

4. Conclusion and Outlook



- At Webasto our mission is to unify the EV landscape and support open communication protocols to drive a user-friendly and green future
- Key players, such as eMSPs, CSOs, OEMs, DSOs, and utilities maintain efforts to update open communication protocols
- Success is driven by market dynamics/stakeholder acceptance as well as and State/Federal incentives, such as NEVI



Thank you for your attention.

Meet us at booth #213!

Your contact person:

Silke Kirchner, Ph.D.

Digital Platform Manager, OCA Rep.
Webasto Charging Systems Inc.
Webasto Group

Mobile: +1 (626) 862-9524
E-Mail: Silke.Kirchner@webasto.com

DAIMLER TRUCK

SUSTAINABLE FLEET TECHNOLOGY CONFERENCE & EXPO 2023

J. Mark Childers
Manager Powertrain & Technology Sales
Mark.childers@daimlertruck.com

FREIGHTLINER FUSO WESTERN STAR Thomas BUILT BUSES BHARATBENZ SETRA

ELECTRIFICATION FOR ALL