Faster Charging - Opportunities and Challenges at 350kW and Higher

June 13, 2023

IN PARTNERSHIP WITH

DEPOTS Electric Truck Bootcamp Series

1. **Best Practices for Utility-Fleet Relationships** (April 25th) ✓
2. **Grants and Incentives for the Trucks and Infrastructure** (May 16th) ✓
3. **Electric Truck Developments** (May 30th) ✓
4. **Faster Charging — Opportunities and Challenges at 350KW and higher** (June 13th)
5. **Opportunities to Extend BEV Range** (June 27th)
6. **Electricity Resiliency and Availability** (July 11th)
7. **Current and Future Regulations for Zero Emission Trucks** (July 25th)
8. **Managed Charging to Improve Availability, Cost and Range** (August 8th)
9. **Scaling Charging Infrastructure Equipment** (August 22nd)
10. **Electric Depot Site Planning and Construction** (September 5th)

2021 Bootcamp is still available at: https://runonless.com/electric/bootcamp-electric/

RUN ON LESS ELECTRIC DEPOT

DEPOTS Electric Truck Bootcamp Series

Up Next: Opportunities to Extend BEV Range

June 27, 2023 1:00p ET

Andreas Kammel
Vice President Alternative Drivetrains
TRATON

Andrew Kotz
Senior Research Engineer – Commercial Vehicle Technologies
National Renewable Energy Laboratory (NREL)

John Kresse
Director – Advanced Electrification Technologies
Cummins Inc.

Jason Schieck
Sr. Director of Product Marketing and Strategy
Hyliion

2023 DEPOT Fleets

Update from The Run Planning…

Follow the Fleets, Drivers, OEMs, EVSEs, Utilities and more:

RunOnLess.com and on Twitter @RunOnLess

RUN ON LESS ELECTRIC DEPOT

NACFE
NORTH AMERICAN COUNCIL FOR FREIGHT EFFICIENCY

Today's Bootcamp Sponsor

RUN ON LESS ELECTRIC DEPOT

ELECTRIC DEPOT BOOTCAMP

Quiz for Today's Session

Completing Today's Quiz:

- Go to runonless.com and click back into the session
- Click 'Take Quiz' button
- Create username and password to keep track of your progress
- Spend a few minutes answering the questions and receive your 2023 RoLE - DEPOT badges

RUN ON LESS ELECTRIC DEPOT

What You Should Know

Q&A

Submit your questions to the host using the Q&A box in the upper right-hand corner

Recording

A recording of today's webinar will be available on runonless.com

Technical Issues

Contact Stephane Babcock at

stephane.babcock@gladstein.org

RUN ON LESS ELECTRIC DEPOT

NACFE NORTH AMERICAN COUNCIL FOR FREIGHT EFFICIENCY

IN PARTNERSHIP WITH RMI ENERGY. TRANSFORMED.

ELECTRIC DEPOT BOOTCAMP

Today's Bootcamp Speakers

Faster Charging - Opportunities and Challenges at 350kW and Higher

Ted Bohn
Principal Electrical Engineer
Argonne National Laboratory (ANL)

Watson Collins
Senior Technical Executive
Electric Power Research Institute (EPRI)

Emil Youssefzadeh
Founder & Chairman of the Board
WattEV

Ryan Menze
Charger Hardware and Software Engineering Manager
Daimler Trucks North America

RUN ON LESS ELECTRIC DEPOT

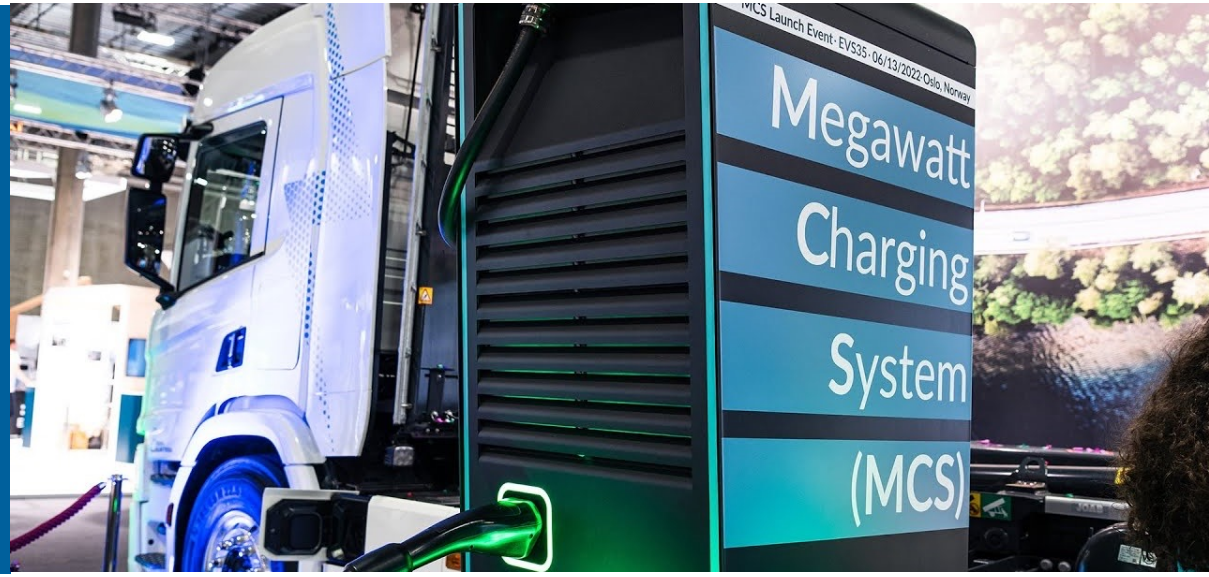
Hosted by:

Rob Graff

Senior Technical Advisor

ELECTRIC DEPOT BOOTCAMP

NACFE ROL-E DEPOT #4: FASTER CHARGING — OPPORTUNITIES AND CHALLENGES AT 350KW AND HIGHER



EVS 35 Launch of MCS (SAE J3271)

THEODORE BOHN
Principal Electrical Engineer
Argonne National Laboratory
tbohn@anl.gov, 630-816-7382

June 13th, 2023
12:00-1:00 CDT; Web Meeting

This work is supported by DOE-Vehicle Technology Office, Lee Slezak program manager

MW+ MULTI-PORT EV CHARGING SYSTEM LABELED SEGMENTS POWER DISTRIBUTION, DC AS A SERVICE; P2030.13, ETC

From Source to Load (grid-to-battery)

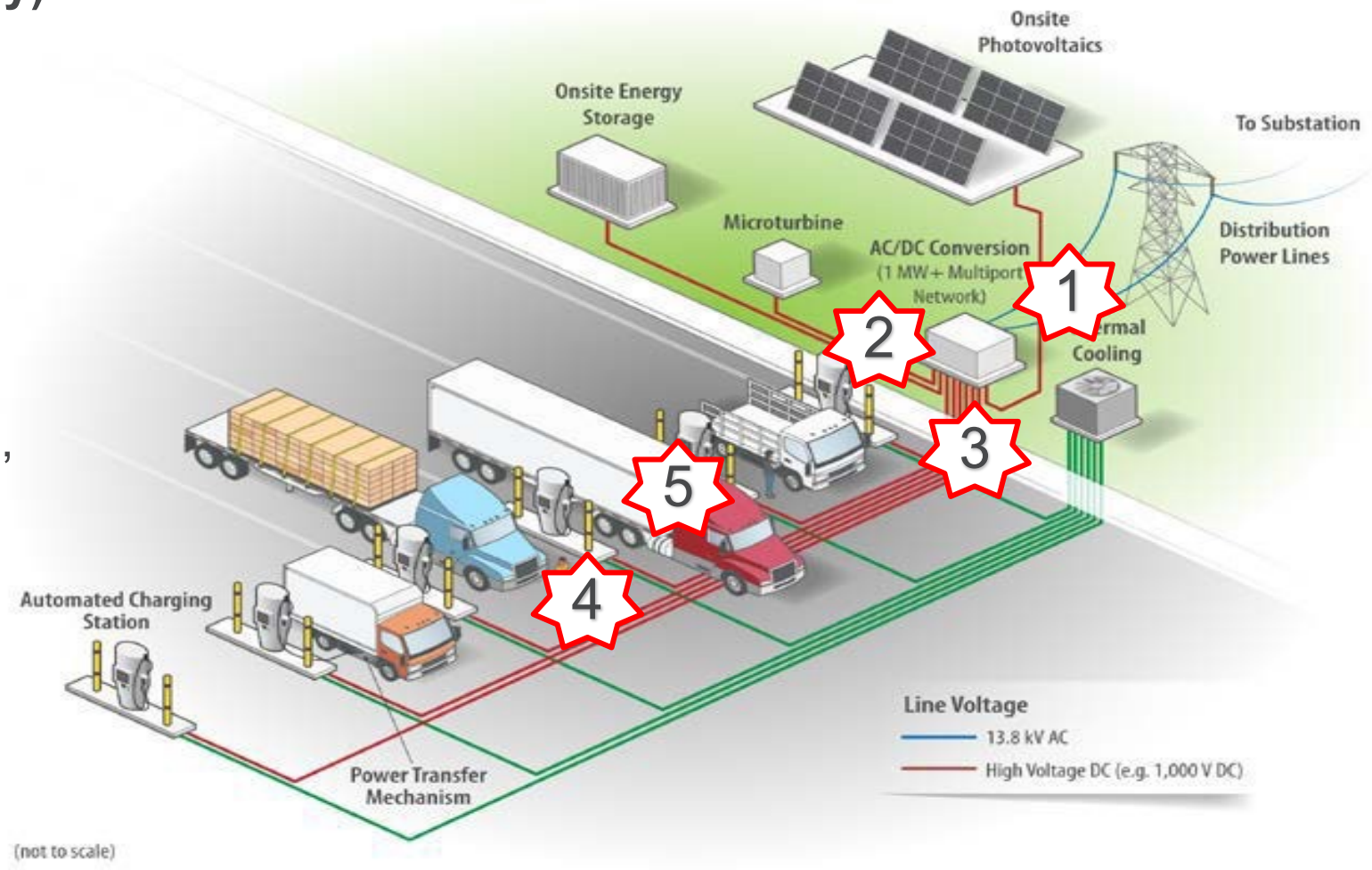
1) Utility Interconnection

2) AC/DC Power Conversion

3) DC Distribution, w/DER Elements

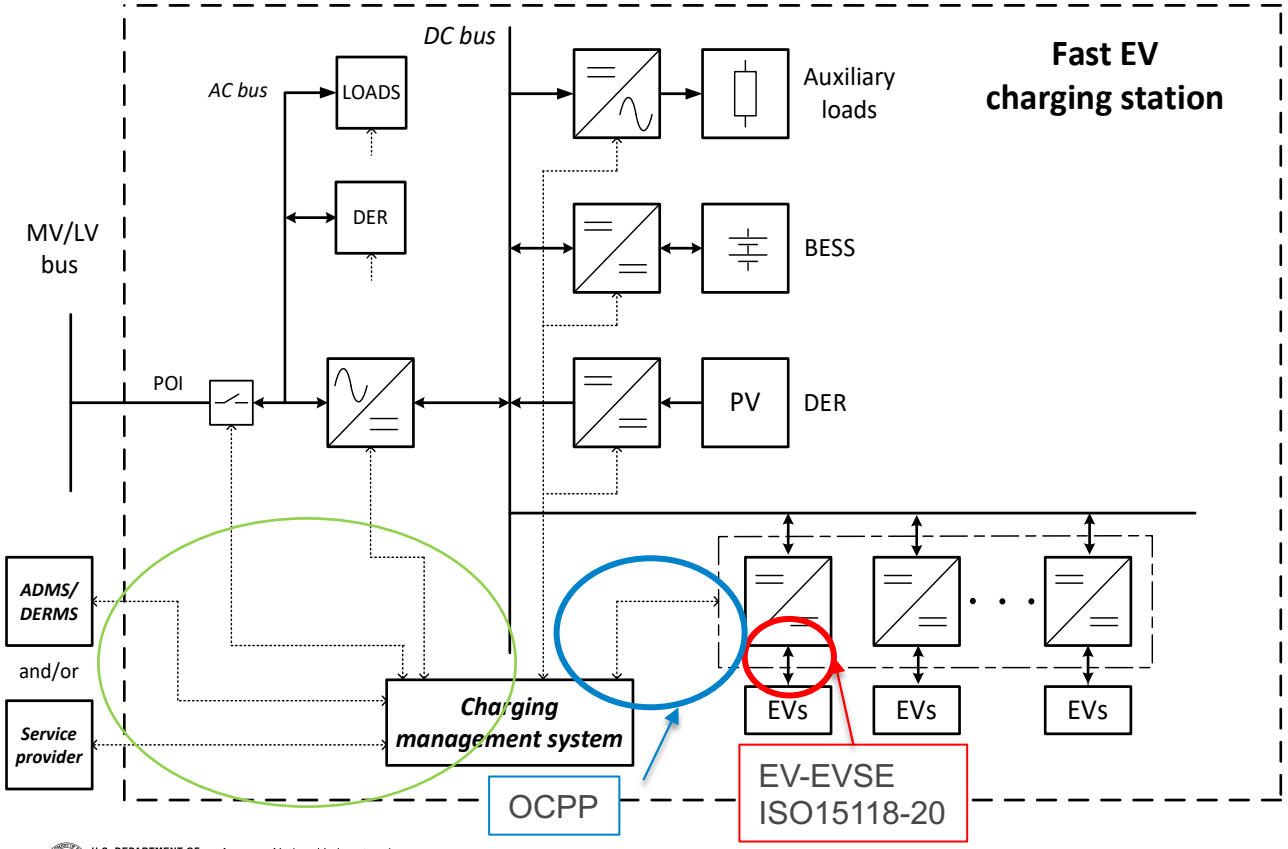
4) DC Dispenser Electronics, Cables, Couplers, Micro-siting

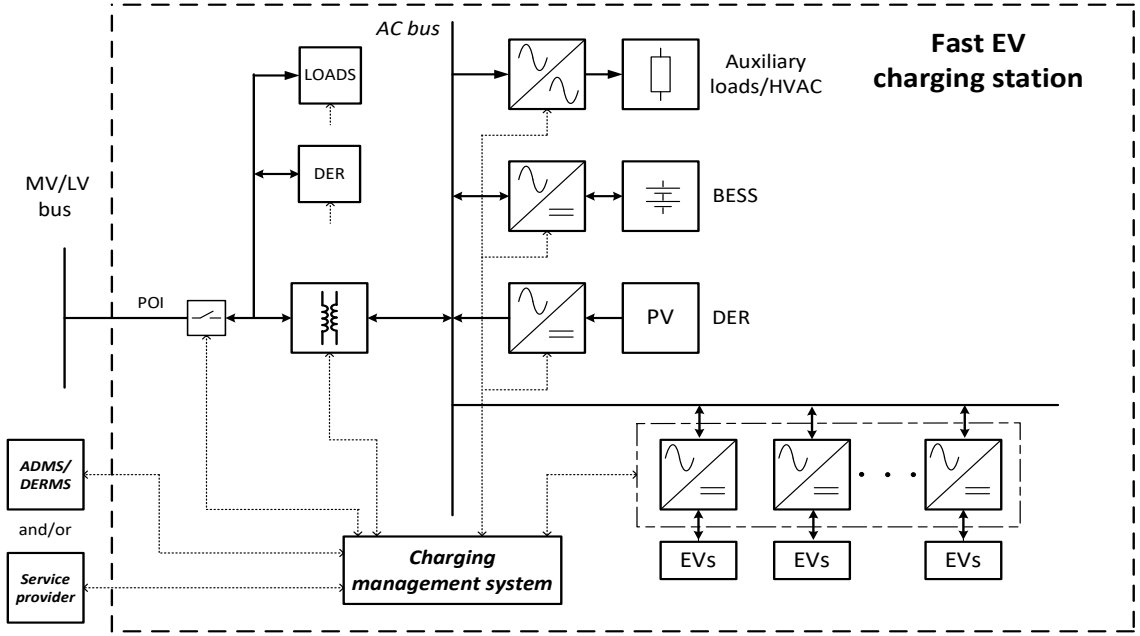
5) Vehicle Inlet, Battery-BMS, Safety



IEEE P2030.13- GUIDE FOR ELECTRIC TRANSPORTATION FAST CHARGING STATION MANAGEMENT SYSTEM FUNCTIONAL SPECIFICATION

- DC and AC bus system diagrams in P2030.13
- Dotted lines represent protocols between components/subsystems and for the most part, the charging management system 'block'. (lines all pass through this block.) Some dotted lines very clear; others are the opposite of clear (xx number of options), abstract functions.





Simplifying Grid Services

SERVICES

- Energy Market Price Response
- Peak Capacity Management
- Spinning Reserve/Ramping
- Meet Obligation to supply capacity in a wholesale Energy Market
- Frequency Regulation
- Fast Frequency Response / Artificial Inertia
- Distribution Voltage Management

SERVICE REQUEST

request

- ENERGY
- POWER
  - Active
  - Reactive

CONTRACT ELEMENTS

- Service Requester — who
- Service Provider — who
- Service Location — where
- Event Signal Type — how
- Requested Service Type — what
- Quantity — how much
- Cost — how much
- Response Time — when
- Recurring Type — when
- Start Time — when
- End Time — when

a common vocabulary
and
well-defined
information exchange messages
for energy services.

OASIS
WS-Calendar, EMIX
Energy Interoperation

MEGAWATT CHARGING SYSTEM-SUBSECTIONS

- SAE J3271 TIR covers the system level charging description/requirements. The subsystem requirement specifications will be referenced in the main document, pointing to subsections listed below.

- **Subtopic documents:** (base document TIR first, then subsections)
  - SAE J3271/1; Electromechanical coupler/inlet requirements (like J1772)
  - SAE J3271/2; Physical/software layer communication (~J2931, J2847, J1939)
  - SAE J3271/3; Charging cables (cooling, cord handling/automated connection)
  - SAE J3271/4; Use cases including DER/microgrid interconnections (V2G)
  - SAE J3271/5; Interoperability/testing requirements

State of MCS Component Development/Announcements

SAE J3271 Coupler manufacturers (8), some with UL2251 certification in 2023

(Amphenol, Cavotec, Evalucon, Huber+Suhner, Phoenix Contact, Rema, Staubli, T.E.)

~14 companies have shown prototypes, brochures, or press releases MW MCS EVSEs

(ABB, Alpitronic, Atlis, BTCP, Cavotec, (CAT), Charge America, DesignWerk, Heliox, Hitachi Energy, Imagen Energy, Power Electronics SA, Tritium)

CLOSER TO PRODUCTION 3000A MCS SYSTEMS

- Gen 4 BTCPower 350kW towers (2x500A output, 6x500=3000A for 3 towers)
- Dispensers with liquid cooled 1500A/3000A charging cables; 1000vdc today; 1500v soon
- Example here of full 3000A test on air cooled loads; compared w/500A CCS vehicle loads

Examples of J3271 MCS Couplers

Examples of J3271 MCS Couplers (Rema, Amphenol)

ACT Expo- SAE J3271 MCS EVSEs

Charge America- Amphenol

ABB (Rema coupler)

Power Electronics SA- Rema

TAKEAWAY TALKING POINTS

- CCS charging can deliver 1000v/500A=0.5MW and MCS can deliver 1500v/3000A=4.5MW
- Supplying power to the site of groups of these chargers can be challenging, specifically long lead times on interconnection agreements, transformers and permits as well as demand fees
- IEEE P2030.13 is a guide to charging system distribution management including DC as a Service and Energy Services Exchange to connect resources in a standardized format
- SAE J3271 Megawatt Charging System covers utility interconnection to battery terminals, separated in 5 volumes, harmonized with IEC/ISO related MW charging standards
- Five years in the making, there are 8 MCS coupler manufacturers, ~14 EVSE manufacturers and several vehicle manufacturers showing prototype implementations

DEPOT Bootcamp

Faster Charging – Opportunities and Challenges at 350 kW and Higher

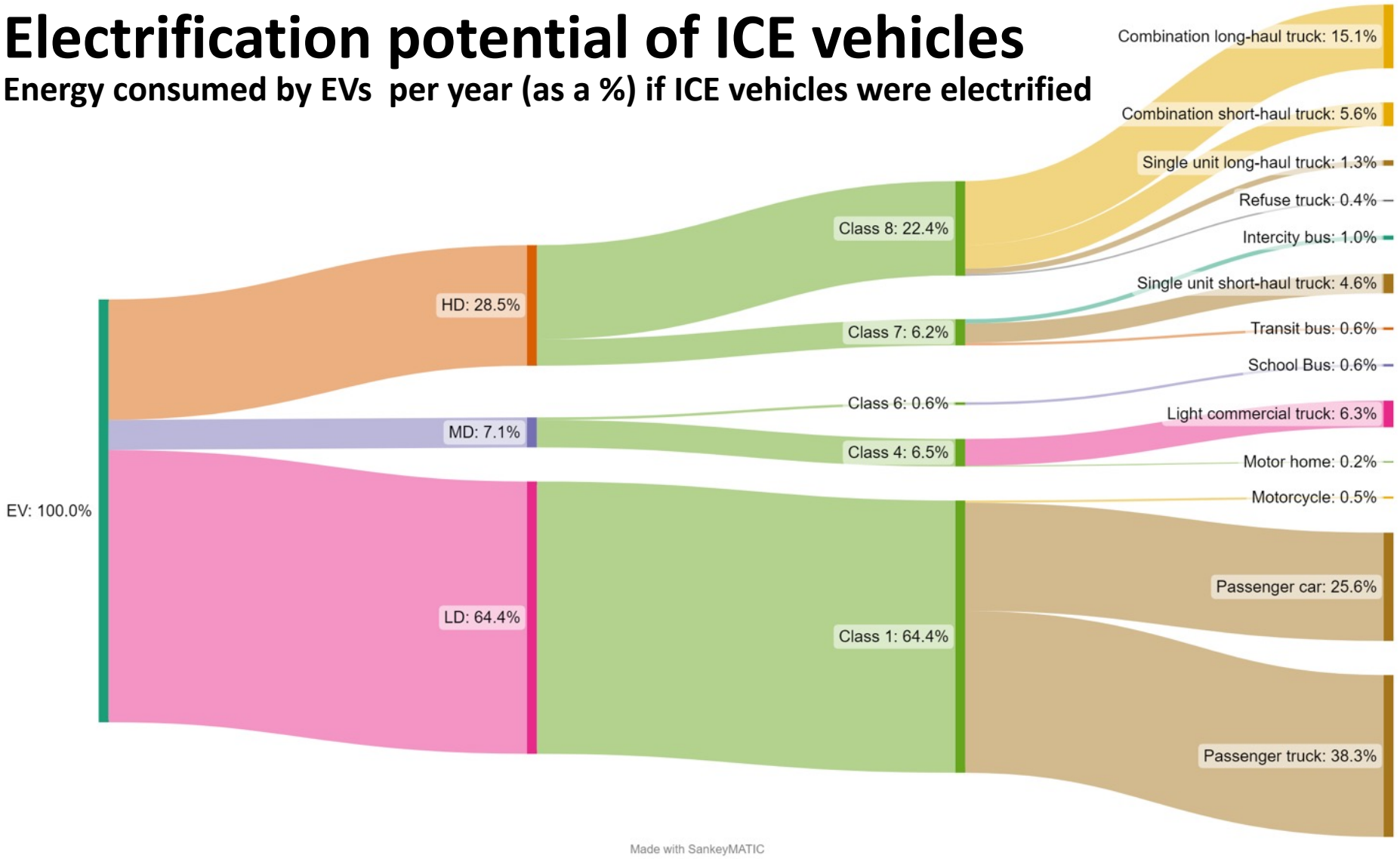
Watson Collins
Sr. Technical Executive

June 13, 2023

How much energy will it take to electrify transportation?

Electrification potential of ICE vehicles

Energy consumed by EVs per year (as a %) if ICE vehicles were electrified



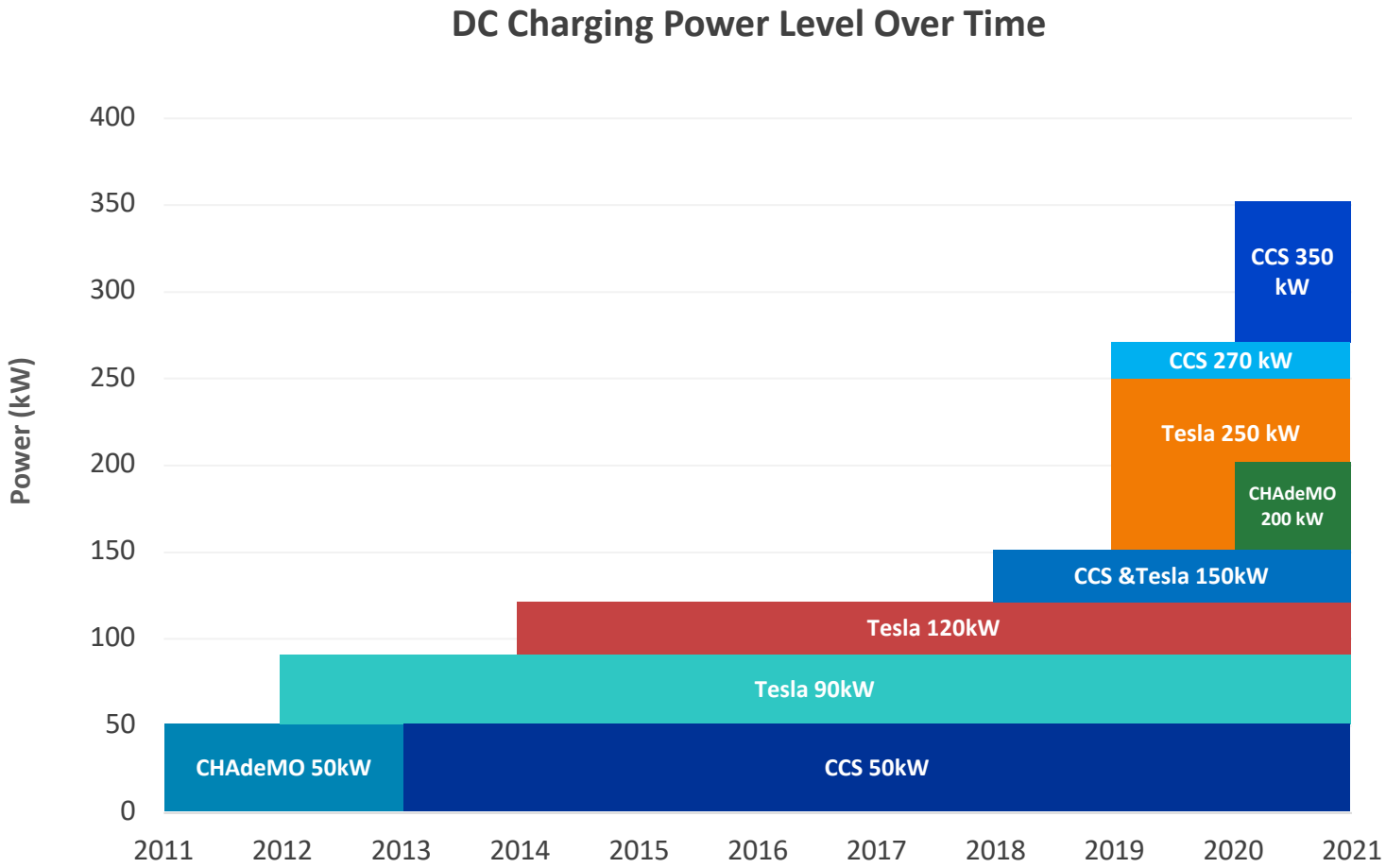
1880.4 TWh/year

- **63.9% Light Duty**
- **35.4% MDHD**
- **0.7% Motor Home and Motorcycle**

Trend:

DC charging power is increasing

Light-duty EVs

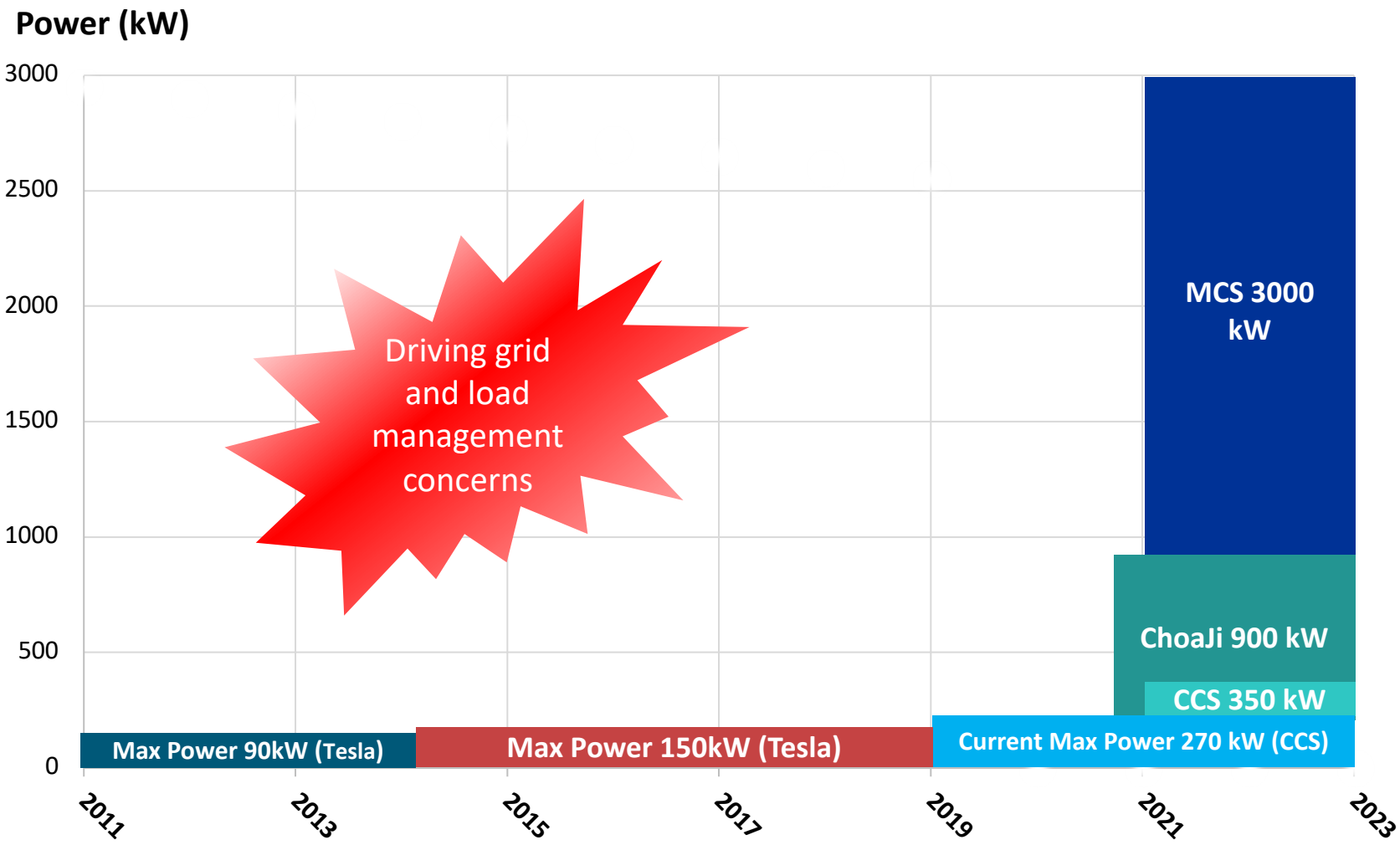


Trend:

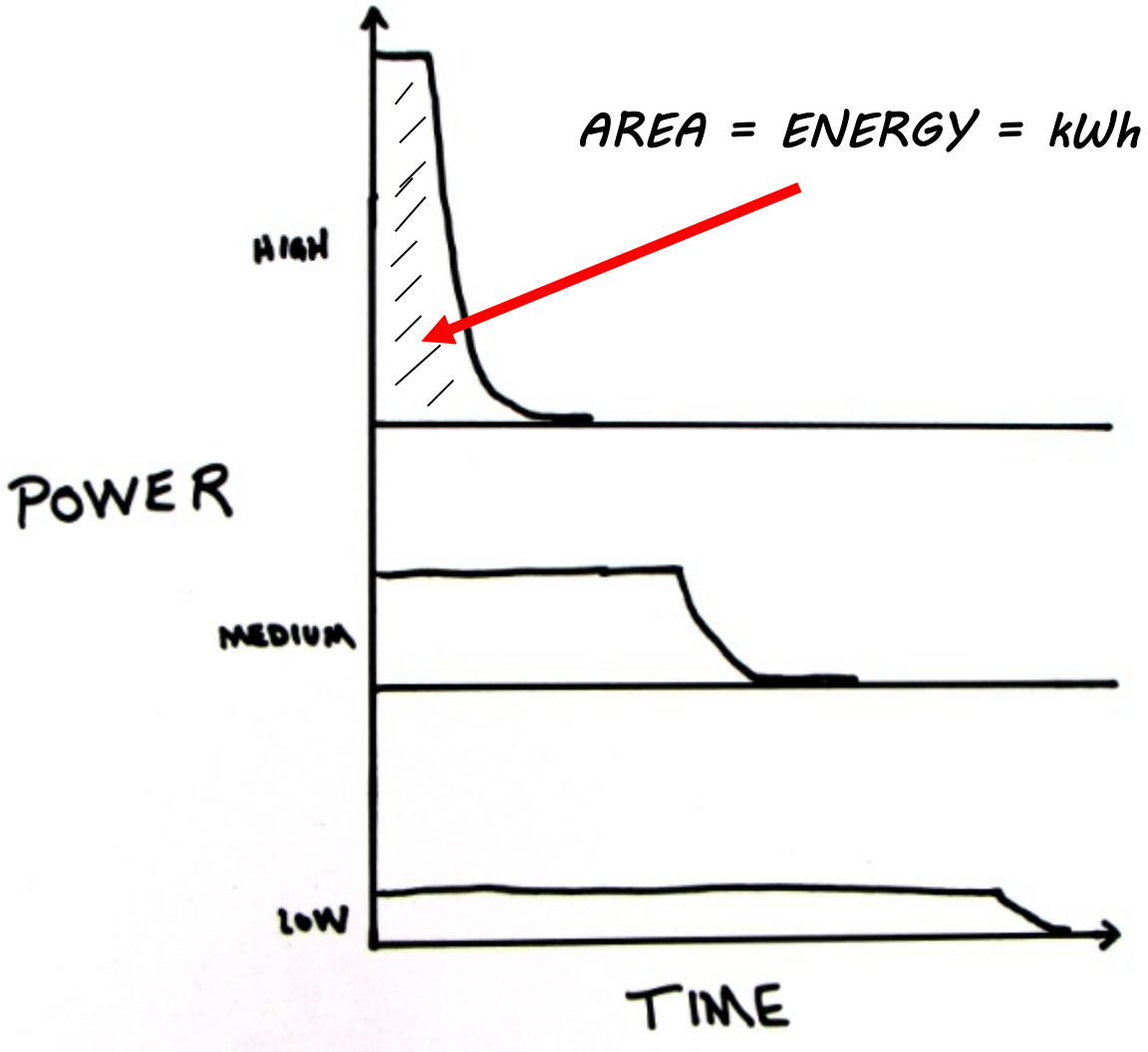
DC charging power is increasing

Medium and heavy-duty EVs

Future DC charging power level over time



What Are the Best Strategies to Charge an EVs?

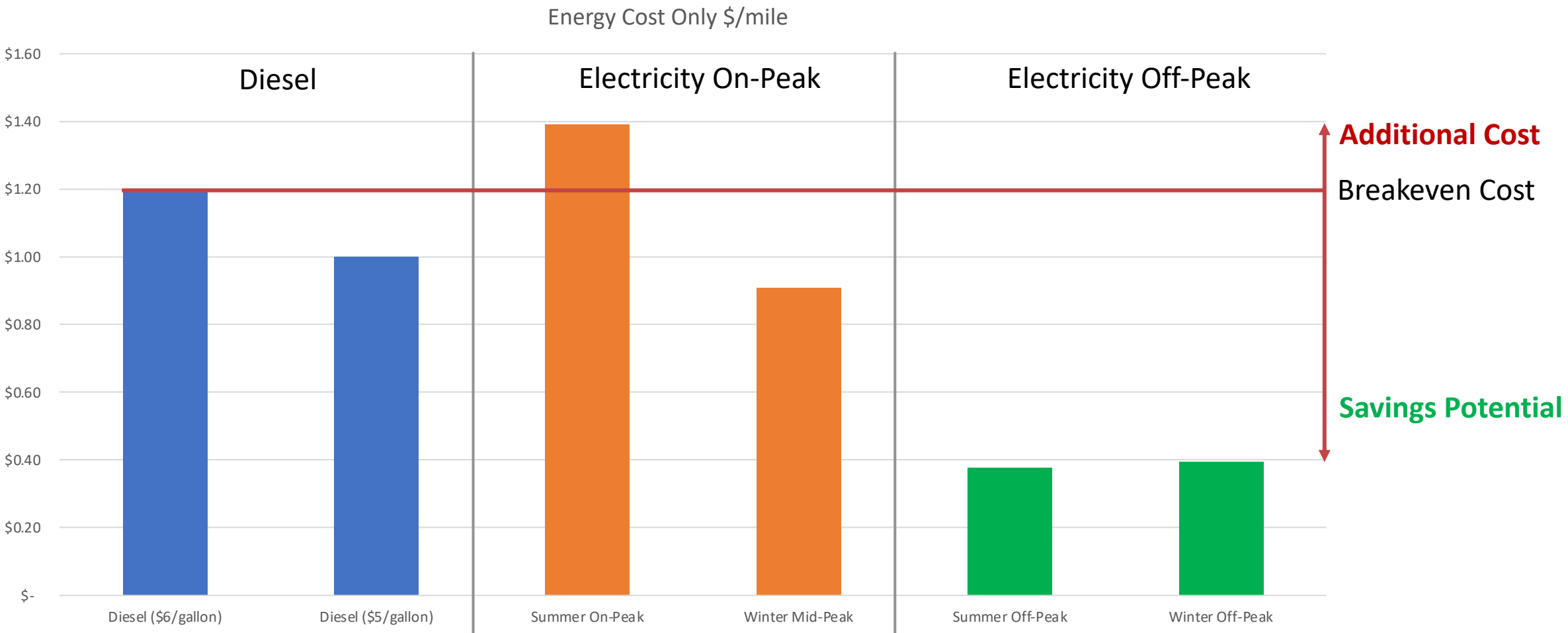


"The general rule for EVs: the slower you charge, the cheaper it is, the less expensive the infrastructure, and the better for the batteries."

… But the specific application determines the dwell time potential

For Fleets, 'When' Vehicles Charge Can Impact Costs

Fleets that can take advantage of Off-Peak charging will be at an advantage

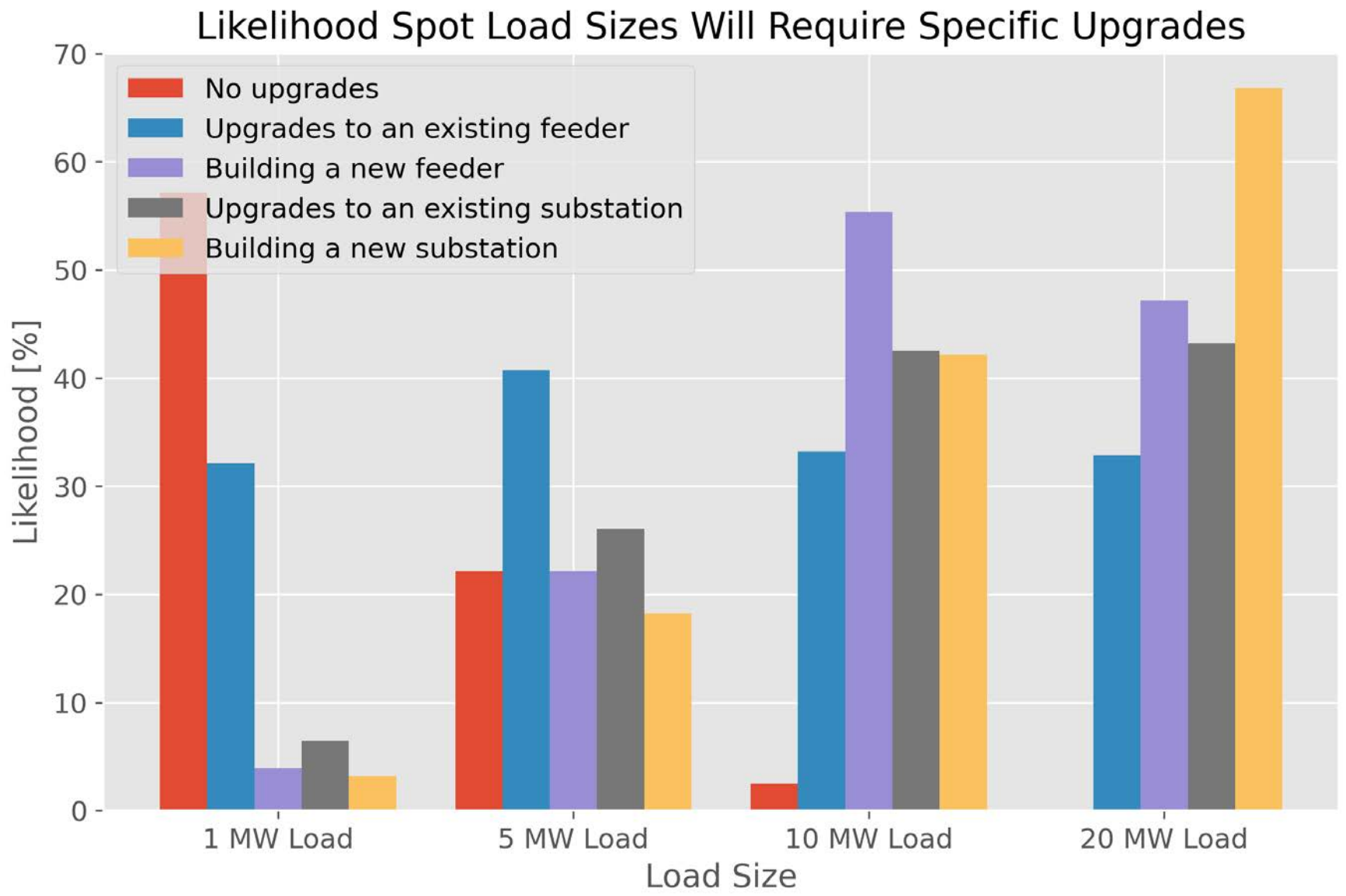


Assumptions: Prices per mile are <u>not</u> grossed up to cover other fixed charges, return of capital investment, LCFS credits, …, 2.5 kWh/mile consumption, 5 miles/gallon diesel consumption

Approximate vale of LCFS credit $0.32/mile, approximate amortized cost of infrastructure $0.25/mile ($0.5M investment, 7 year amortization, 8 charging sessions/day, 250kWh /session)

Reference: SCE TOU-EV-9, Average of 2022 rates, Cal. PUC Sheet No. 72718-E, Cal. PUC Sheet No. 73205-E, Cal. PUC Sheet No. 73614-E, Cal. PUC Sheet No. 74018-E, Cal. PUC Sheet No. 74566-E

Higher Power Impacts on Utility Grid Infrastructure



Identifying Future Fleets | Where, When, How Many?

Where?

- **Where** are the fleets dwelling?
- **Where** are likely warehouses that may have electric vehicles?
- **Where** would they charge en-route?

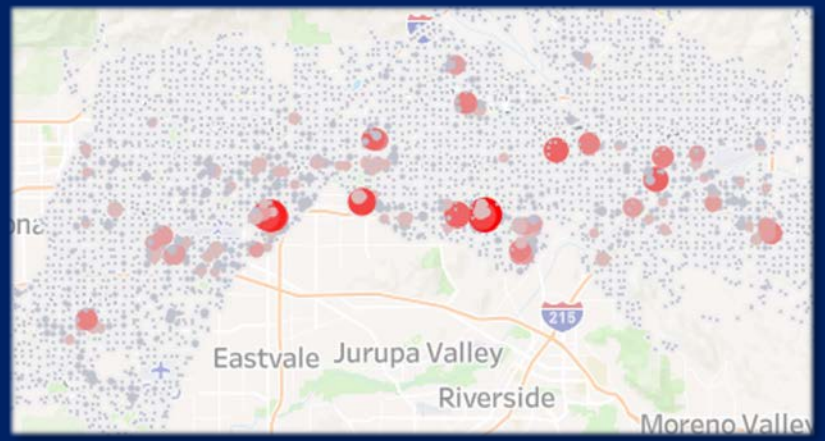


Figure: Vehicle activity maps

When?

- **When** would fleets most likely charge?
- **When** would we expect different vehicle fleets to electrify?
- **When** would it be best for vehicle to charge?

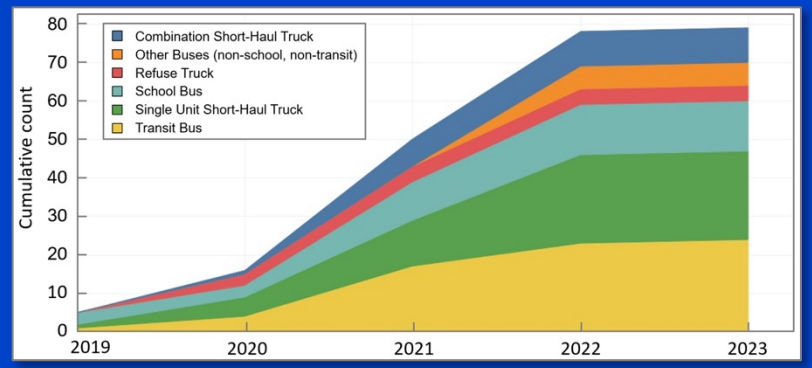


Figure: Technology Maturity

How Many?

- **How many** MDHD vehicles are there currently?
- **How many** vehicles would be located at one location?

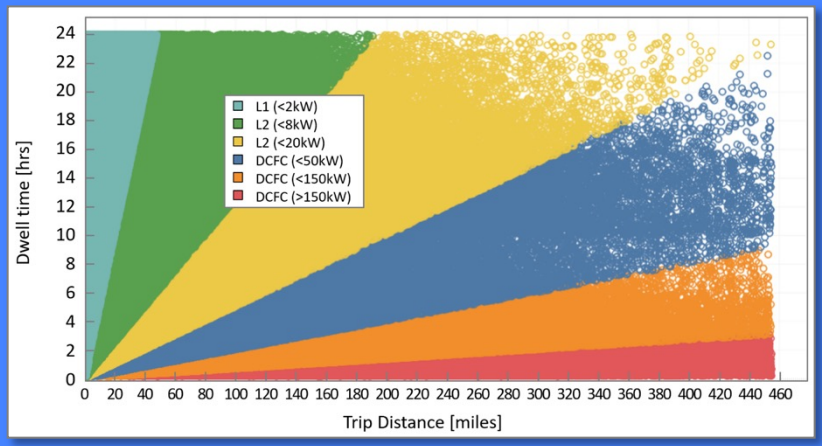


Figure: Charging Needs

All these questions vary by vehicle segment

Thank You!

Watson Collins,

wcollins@epri.com

Sr. Technical Executive

eTRUC

The Electric Truck Research and Utilization Center

EPRI

CALSTART

Project Overview

Project Purpose

- Create a California research hub to facilitate and accelerate the electrification of the medium and heavy-duty (MD/HD) vehicle market in key areas starting with drayage and expanding into .

Project Goals and Objectives

Stakeholder Engagement

- **Engage broad stakeholders with a 'Community-First' approach** and use input to **promote equity and workforce development** opportunities in priority communities (pollution burdened and impacted communities).

Technology Advancement

- **Advance Research, Development, and Demonstration (RD&D) activities that extend the delivery range** of large weight class battery electric trucks beginning with drayage operations.

Corridor Planning

- **Plan, design, and deploy innovative, scalable public corridor charging strategies** for MD/HD electric trucks, beginning with drayage trucks.

Project Team

SITE HOSTS
TravelCenters of America
MHX

KEY UTILITY PARTNER
Southern California Edison

PROJECT PARTNERS
Burns & McDonnell
Cambridge Systematics, Inc.
GRID Alternatives
Lawrence Berkeley National Laboratory
Momentum
National Renewable Energy Laboratory
Paul International
Southern California Association of Governments/GNA
UC Riverside

R&D for High Powered Charging

Targeted Level of Performance

- Capable of providing 100 miles of range for a HD BEV drayage truck in less than 10 minutes;
- Uses only open standards for connectors and communications to increase interoperability across different vehicles and control systems;
- Modular design that can be scaled up with future BEV truck deployment;
- Delivered at a total cost below 500 $/kW.

GridFAST

EVs2Scale 2030

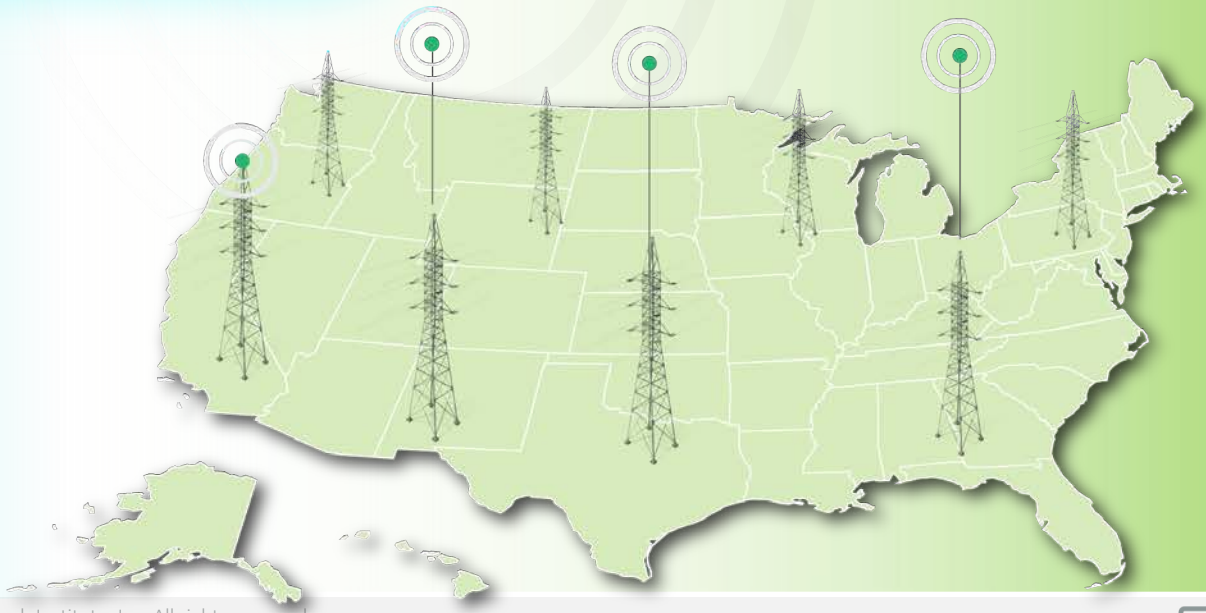
Improve Transparency in EV Charging Planning to Inform Grid Investments + Accelerate Grid Interconnects

Customers provide 2023-2035 plans defining loads, locations, timing

- TRUCKING FLEET OPERATORS
- FUELING RETAILERS
- CHARGING SITE DEVELOPERS
- FLEET OPERATORS

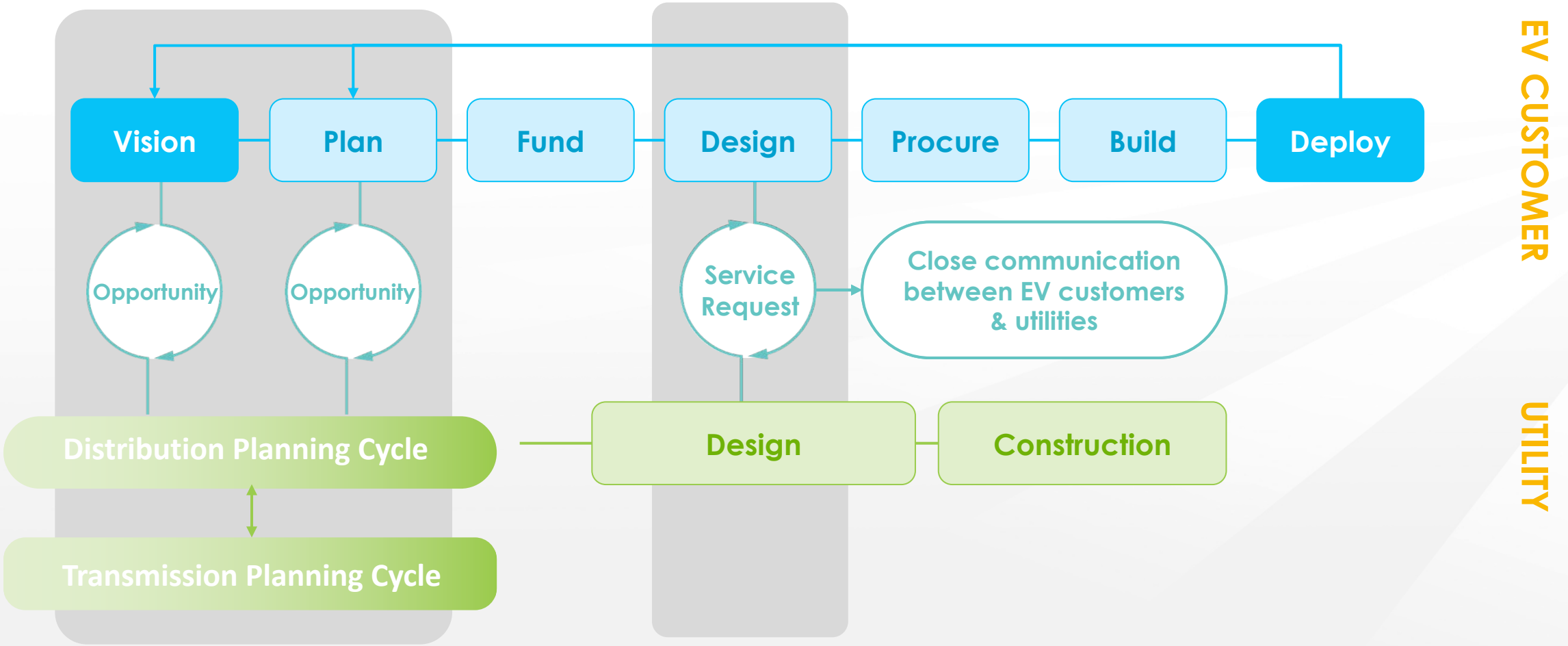
GridFAST
Secure Online Data Exchange Platform

Utilities provide information on grid readiness, timing to support EV charging loads



EPRI

How might we help EV customers and utilities get *actionable* information, *earlier* in this process?



Together...Shaping the Future of Energy®

WattEV

Faster Charging

Opportunities & Challenges at 350 kw and higher

NACFE Run on Less
Electric Depot Bootcamps Session #4

June 13 2023

Emil Youssefzadeh

www.wattev.com

Presentation Agenda

1. What does a truck charging depot look like?

2. How do we calculate average charge session?

3. Use Case Examples

4. Importance of Interoperability

5. Power Challenges

6. Migration to MCS

What does a truck charging depot look like?

Port of Long Beach
Charging Depot at Present

www.wattev.com

How do we calculate average charge session?

BATTERY CAPACITY

Class-8 Truck	Rated Battery Capacity (KWh)	80% Charge (KWh)	Range (mi)
Type-1	475 KWh	330	140
Type-2	565 KWh	452	205
Type-3	733 KWh	586	266

2.2 KWh/mi

How do we calculate average charge session?

CCS - 1
360 KW CHARGE

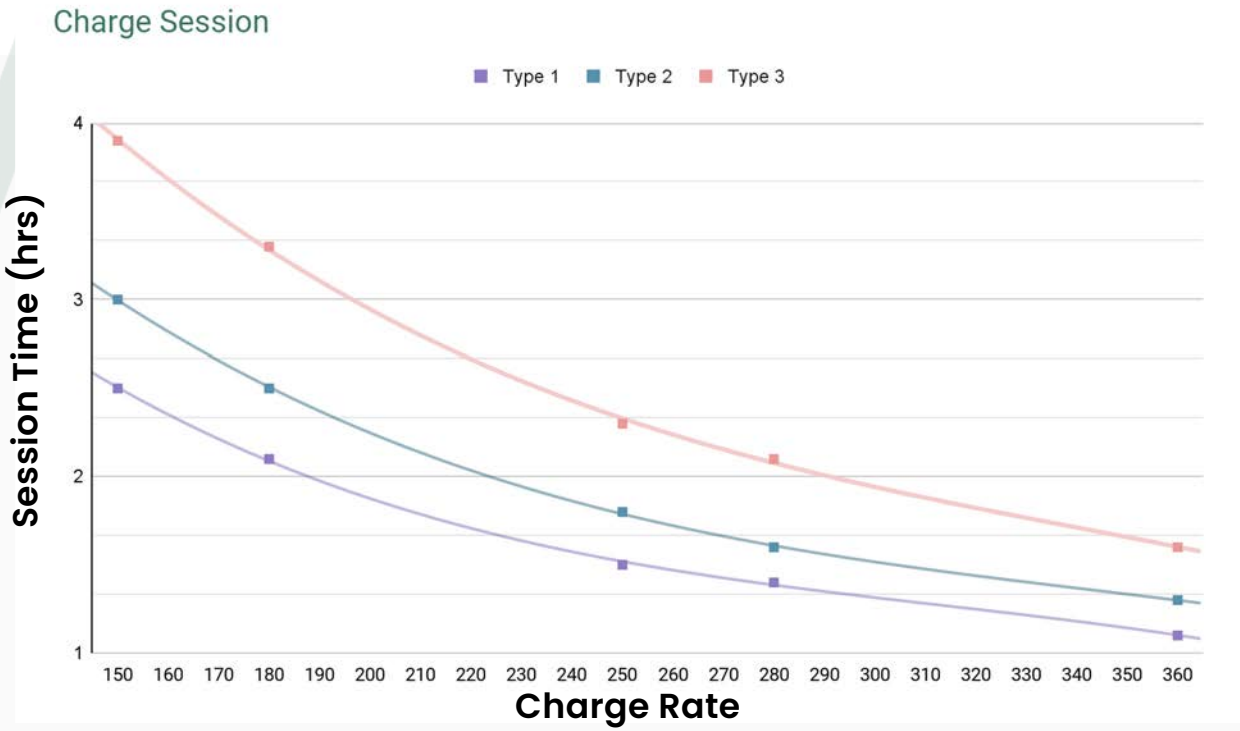
CHARGING SPEED

Truck Type	Charging Arrangement	KW
Type-1	ONE CHARGE PORT	150 KW
Type-2 & 3	DUAL CHORD 360 KW; BUT ONE CHORD USED	180 KW
Type-2 & 3	ONE CHARGE PORT	250 KW
Type-1	DUAL CHORD WITH DUAL INLETS	280 KW
Type-3	ONE CHORD - ONE INLET	300 KW
Future MCS Inlet	ONE CHORD - ONE INLET	1200 KW

MCS - 1
1200 KW CHARGE

MCS

Rated Battery Capacity (KWh)	Session (KWh)	Range (mi)	CCS - 1 (Hours)					MCS (Min)
			150 KW	180 KW	250 KW	280 KW	360 KW	
475	380	173	2.5	2.1	1.5	1.4	1.1	19
565	452	205	3.0	2.5	1.8	1.6	1.3	23
733	586	266	3.9	3.3	2.3	2.1	1.6	29

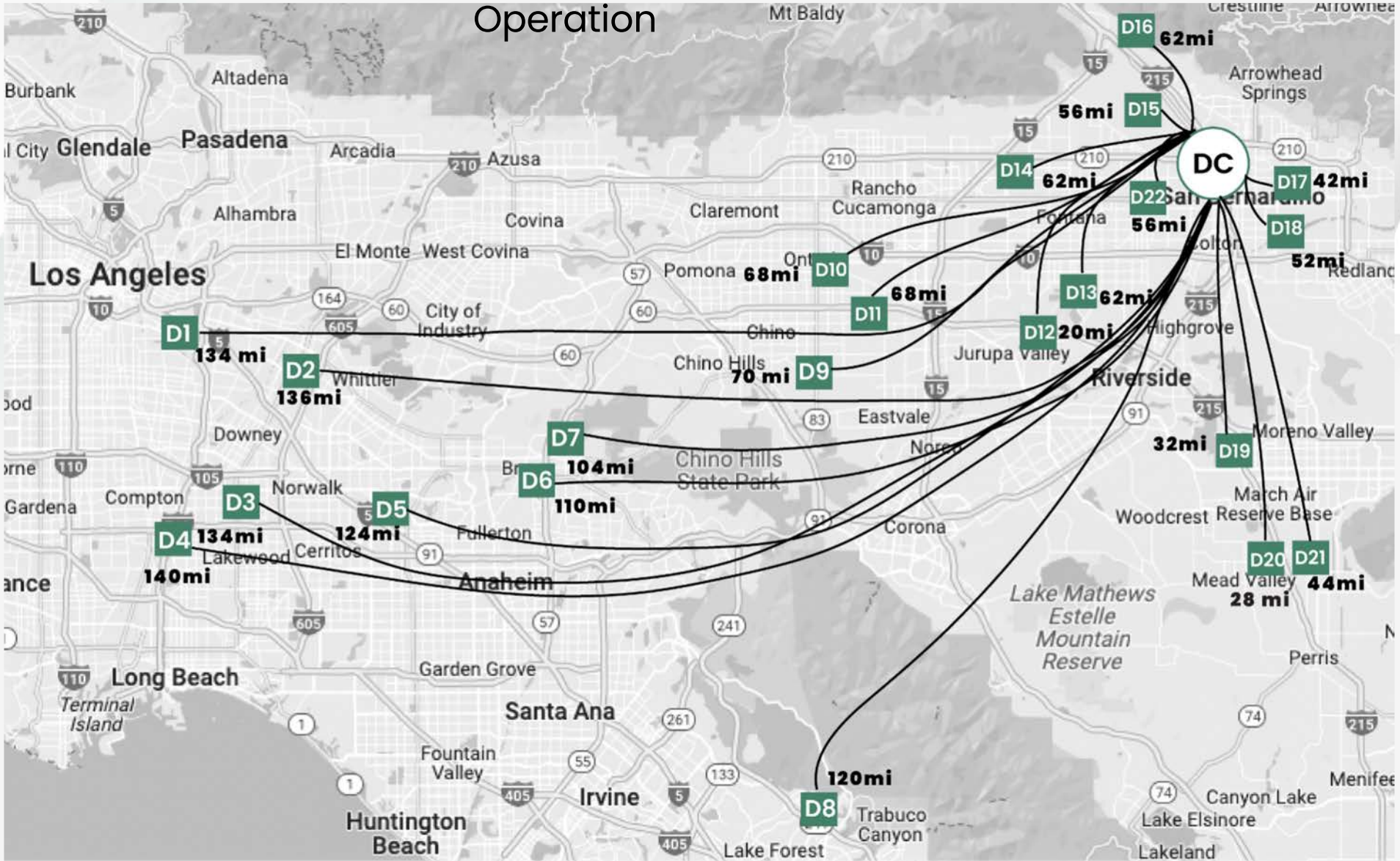


Case Studies

12
Trucks

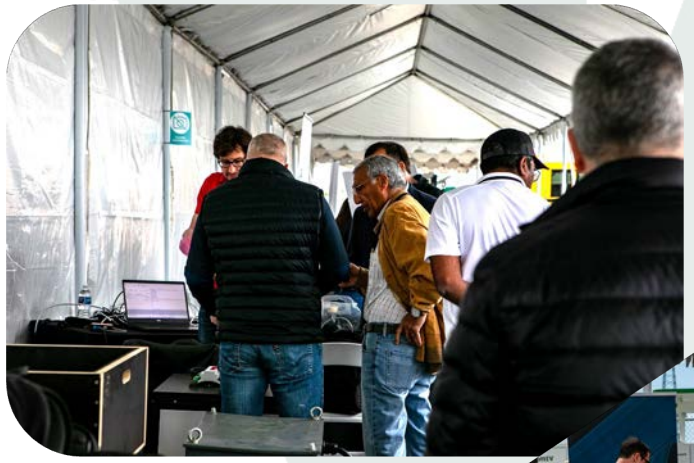
3
Staggered Shifts Operation

4
Trucks Charged per Shift



Importance of Interoperability

- ISO 15118 -2
- OCPP 1.6 Version Number



www.wattev.com

Power Challenges & Migration to MCS

The utilities will not be capable of meeting the power requirements

Depends

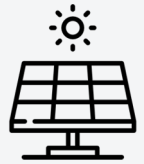
"What we're finding or, more importantly, what our customers can't find is the charging infrastructure to run these products. Infrastructure build outs are failing, and we're destined to fail to meet the ambitious goals of this state, of our country and the world until emphasis is put on meeting the charging needs of the electric fleet."

The utilities are too slow

True

There is no solution other than grid power

False



MYTH & REALITY

Port of Long Beach
Charging Depot with Addition of MCS Chargers

www.wattev.com

Thank you.

www.wattev.com

DAIMLER TRUCK

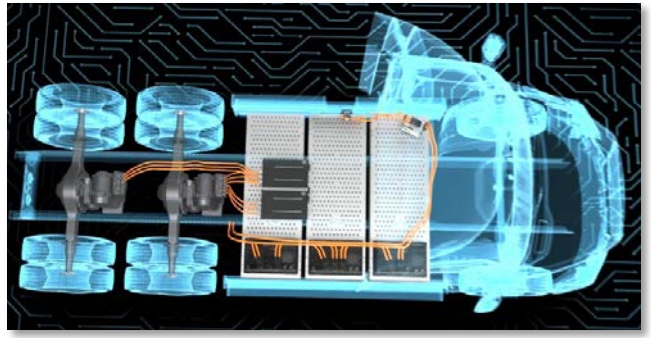
Commercial Vehicle Charging overview

Ryan Menze

Daimler Truck North America

Daimler Truck North America believes MCS will enable broader BEV commercial vehicle adoption

Technology



X

Cost Parity

X

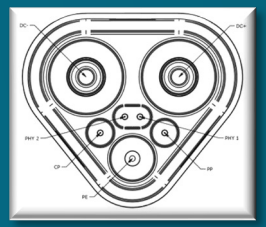
Infrastructure

DTNA supports CCS through the transition phase, but see a future where MCS is the charging port for commercial vehicles

Current Phase

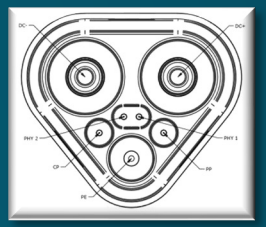
Utilize existing hardware

Transition Phase



Leverage faster charge rates and increased security for broader BEV adoption

Future Phase



MCS becomes exclusive charging connector for commercial vehicles

Q&A

Faster Charging - Opportunities and Challenges at 350kW and Higher

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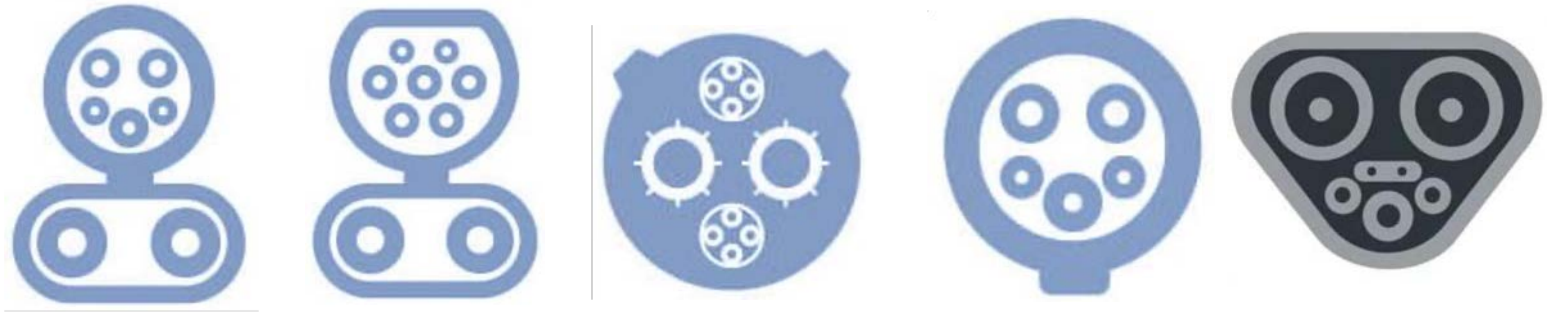
RUN ON LESS ELECTRIC DEPOT

Hosted by:

Rob Graff

Senior Technical Advisor

ELECTRIC DEPOT BOOTCAMP



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NORTH AMERICAN COUNCIL FOR FREIGHT EFFICIENCY

NACFE.org

Let's Stay Connected…
… And charged up!

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BY NACFE
NORTH AMERICAN COUNCIL FOR FREIGHT EFFICIENCY

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NACFE (& Spanish: NACFE LATAM)

NACFE

@NACFE_Freight & **@RunOnLess**

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