Developing a Business Model for Commercial Electric Vehicle Charging Infrastructure

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Motivation for Research

- Major vehicle OEMs are looking to develop and offer commercial electric trucks
- Charging infrastructure is a necessary and pivotal complementary component for offering commercial EVs to the market
- Many factors around charging infrastructure that affect CEVs that must be better understood
- Charging has an influence on fleet operations, mitigating negative impacts and minimizing costs will improve CEV attractiveness

Environmental Motivation

- Freight industry produces approximately 10% of global GHG emissions
- Emissions from freight is expected to increase fourfold by 2050
- Commercial vehicles comprise 4% of vehicles on the road, but 20% of transportation fuel consumed
- Diesel trucks are responsible for 47% of NOx emitted, a leading cause of upper respiratory health

Research Questions

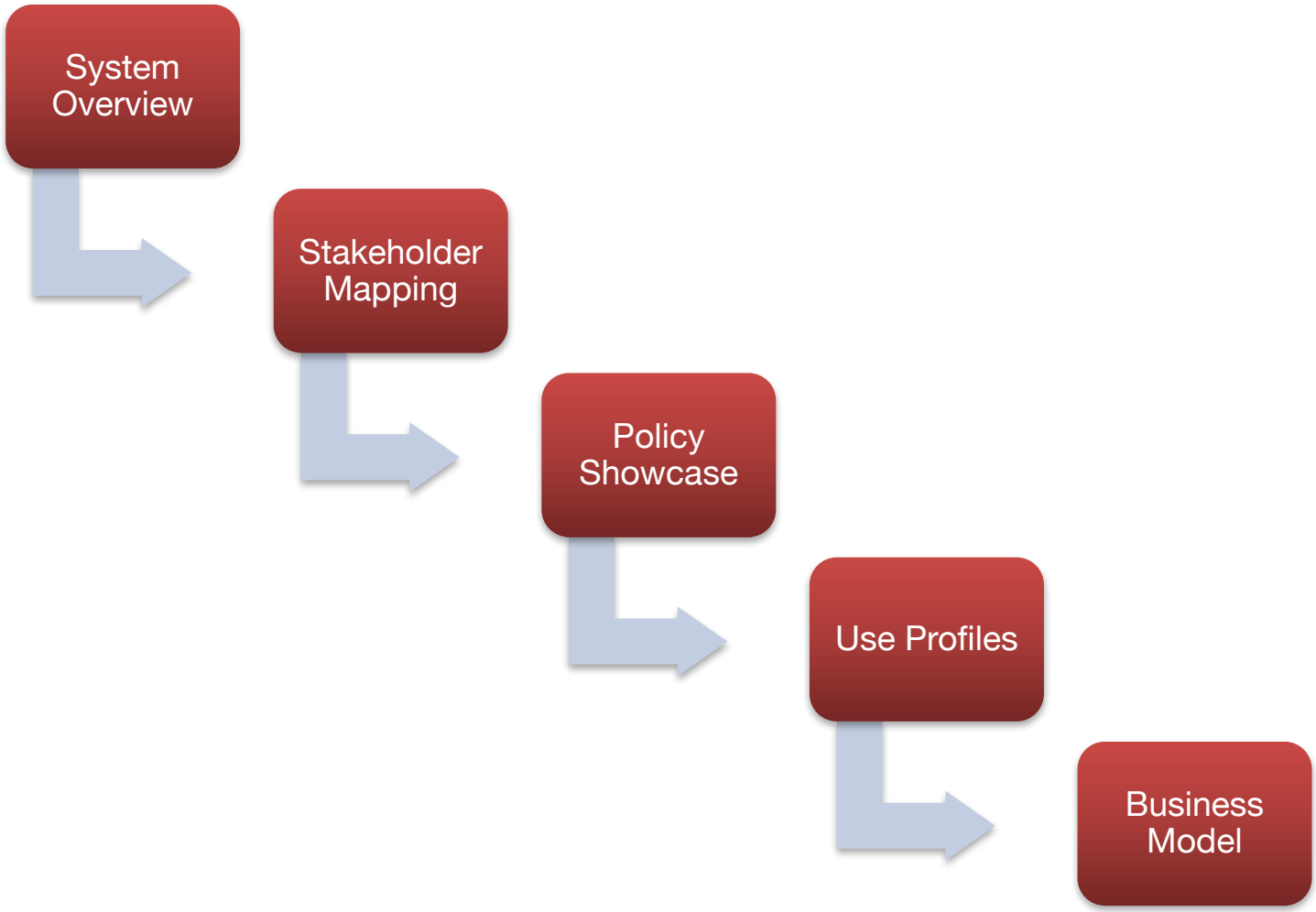
Research Question 1: What criteria must be considered when designing charging infrastructure strategies and solutions in order to support a commercial electric truck fleet?

Research Question 2: How might a business model be designed when offering charging infrastructure to fleet operators?

Who are the major partners and stakeholders involved, and who maintains ownership of the infrastructure?

How might a business model be adapted or changed for different vehicle applications and users?

Methodology



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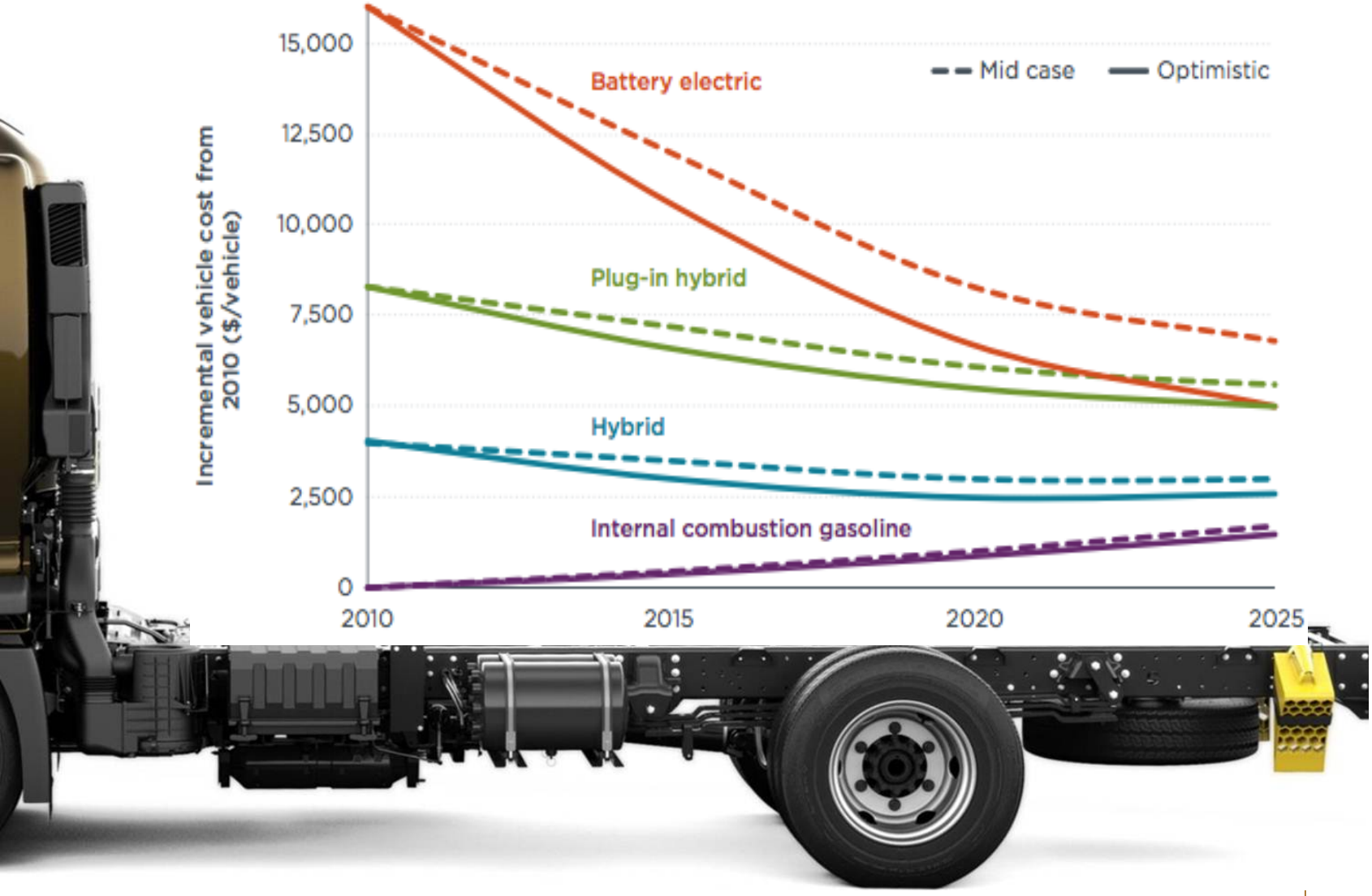
Scope

- Battery electric vehicles
- Best-available technology: focus on charging stations
- Examined from a systems perspective with a business lens
- Use profiles: Urban goods distribution and Refuse trucks

Incremental Technology Cost



Source: International Council on Clean Transportation

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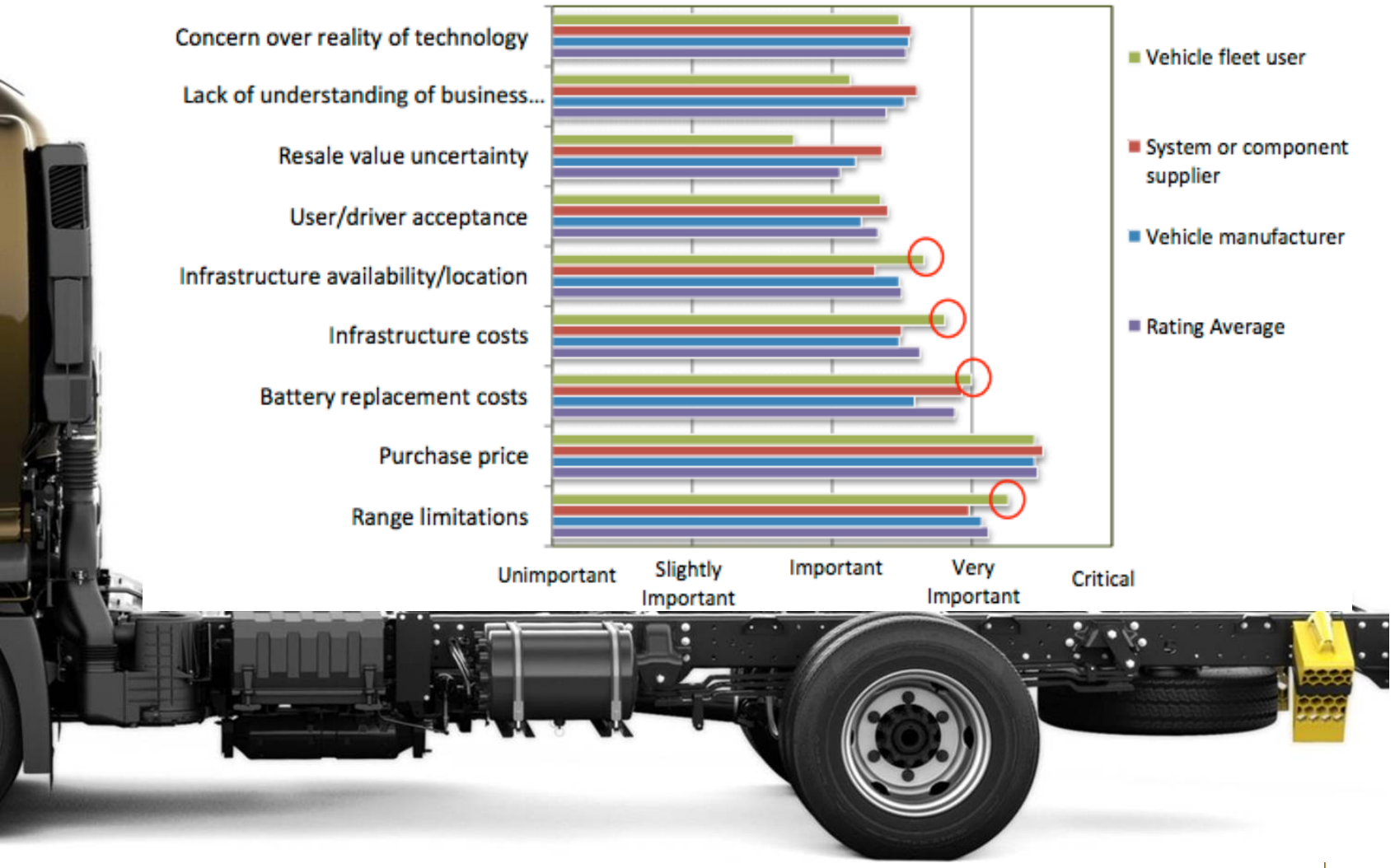
Please rate the importance of each of the following barriers to wider deployment and use of E-Trucks.



Source: CALSTART E-Truck Task Force - PDF link

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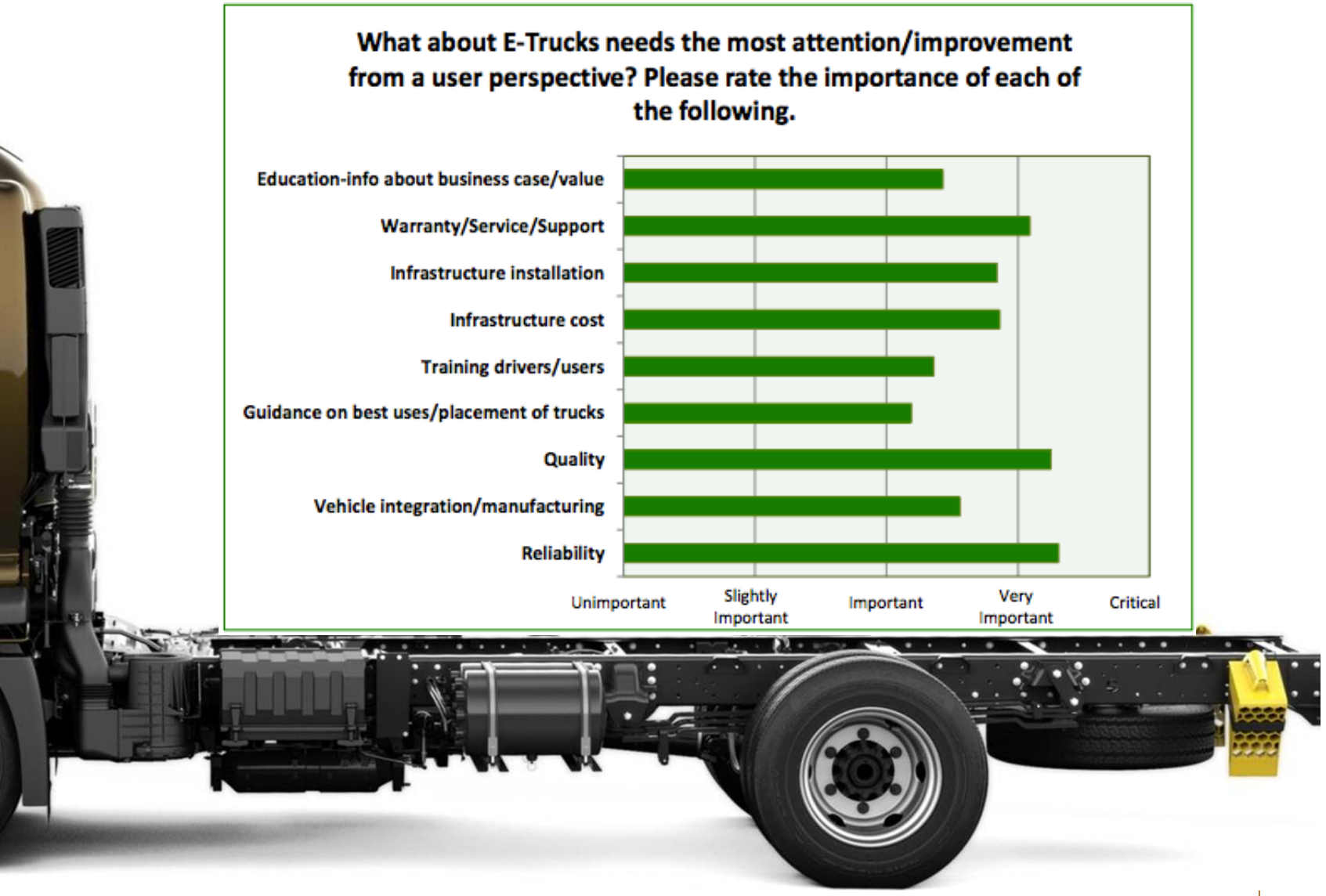

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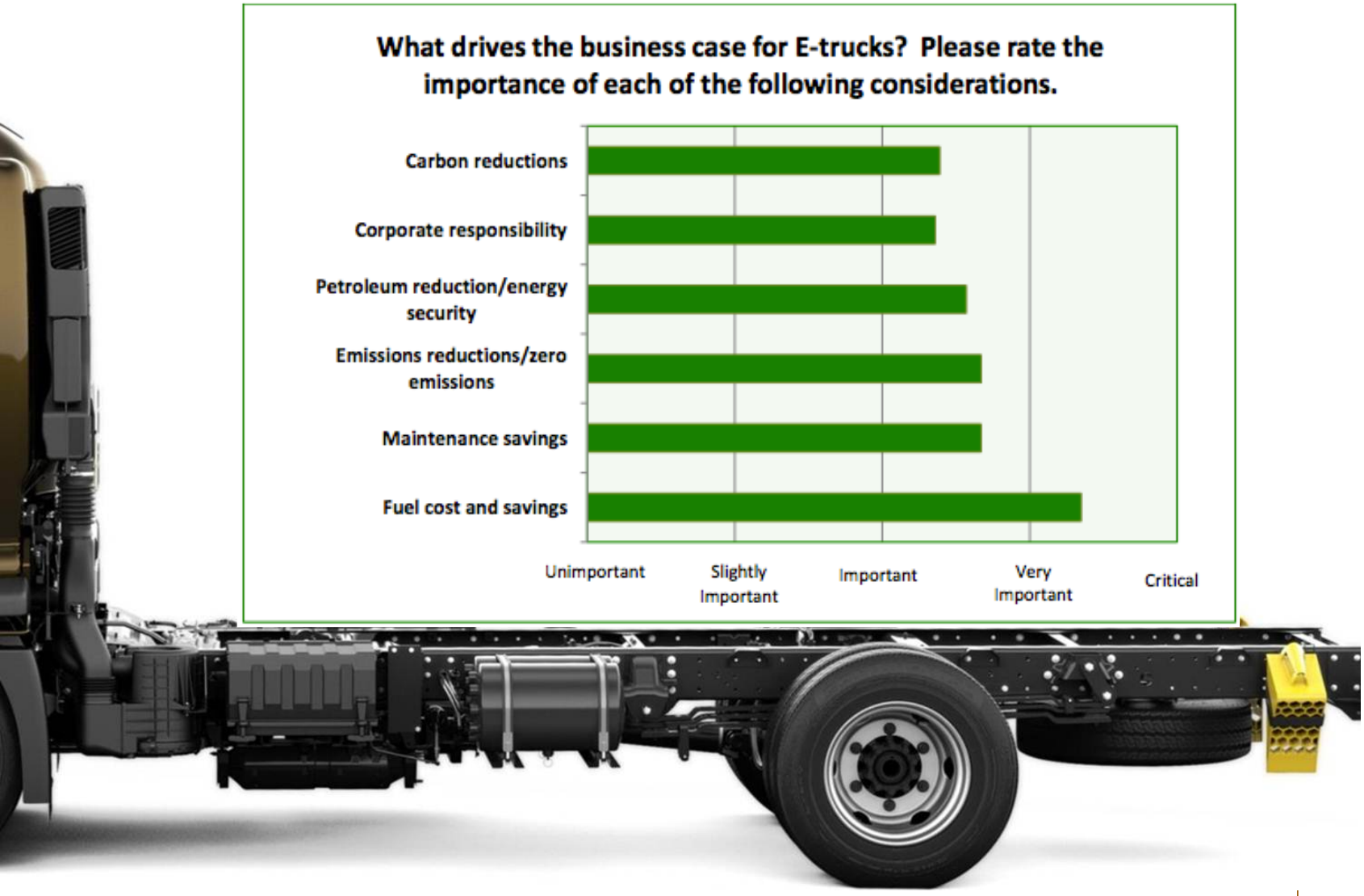

Source: CALSTART E-Truck Task Force - [PDF link]

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Charging Infrastructure

- State of Technology
- Installation
- Management Platforms
- Fleet Integration
- Standardisation
- Grid Integration
- Battery Health
- Route Planning
- Plug Types
- Smart Charging
- Charging Methods
- Alternative Methods

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Comparison of Level 1, 2, 3 EVSE*

	Level 1	Level 2	Level 3
Phase	Single Phase AC	Single Phase AC Three Phase AC	DC
Amperage	10 to 16 A	16, 32 or 63 A	63 to 125 A (typical) Up to 400 A
Voltage	120 V (N. America) 240 V (Europe)	230 to 400 V	400 V and higher
Power Output	1.4 to 1.9 kW	3.7 to 22 kW	44 kW and higher
Plug Types	Household Plug SAE J1772	SAE J1772 IEC 62196	CCS Combo 1 & 2 CHAdeMO Tesla
Typical Application	Home charging	Home charging Public charging station	Fast charging

*Electric Vehicle Supply Equipment

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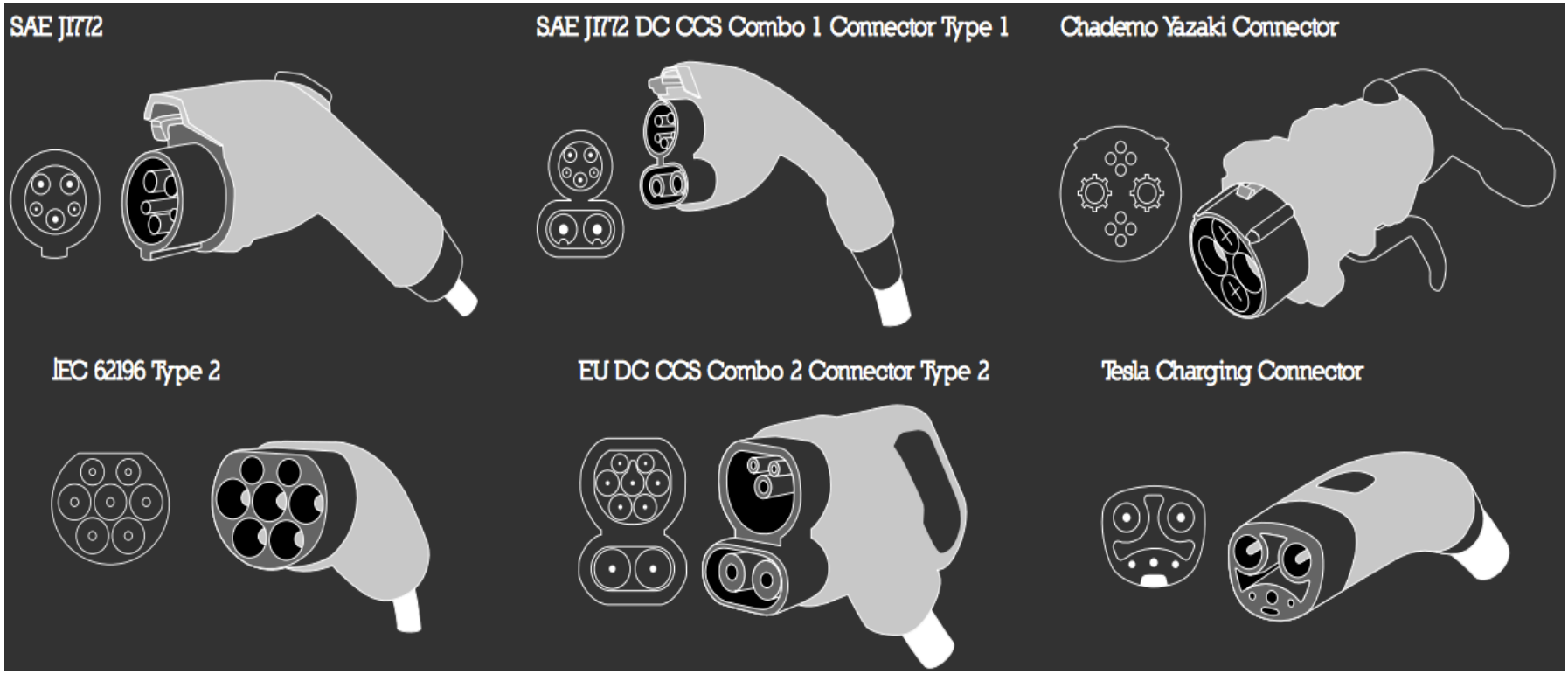
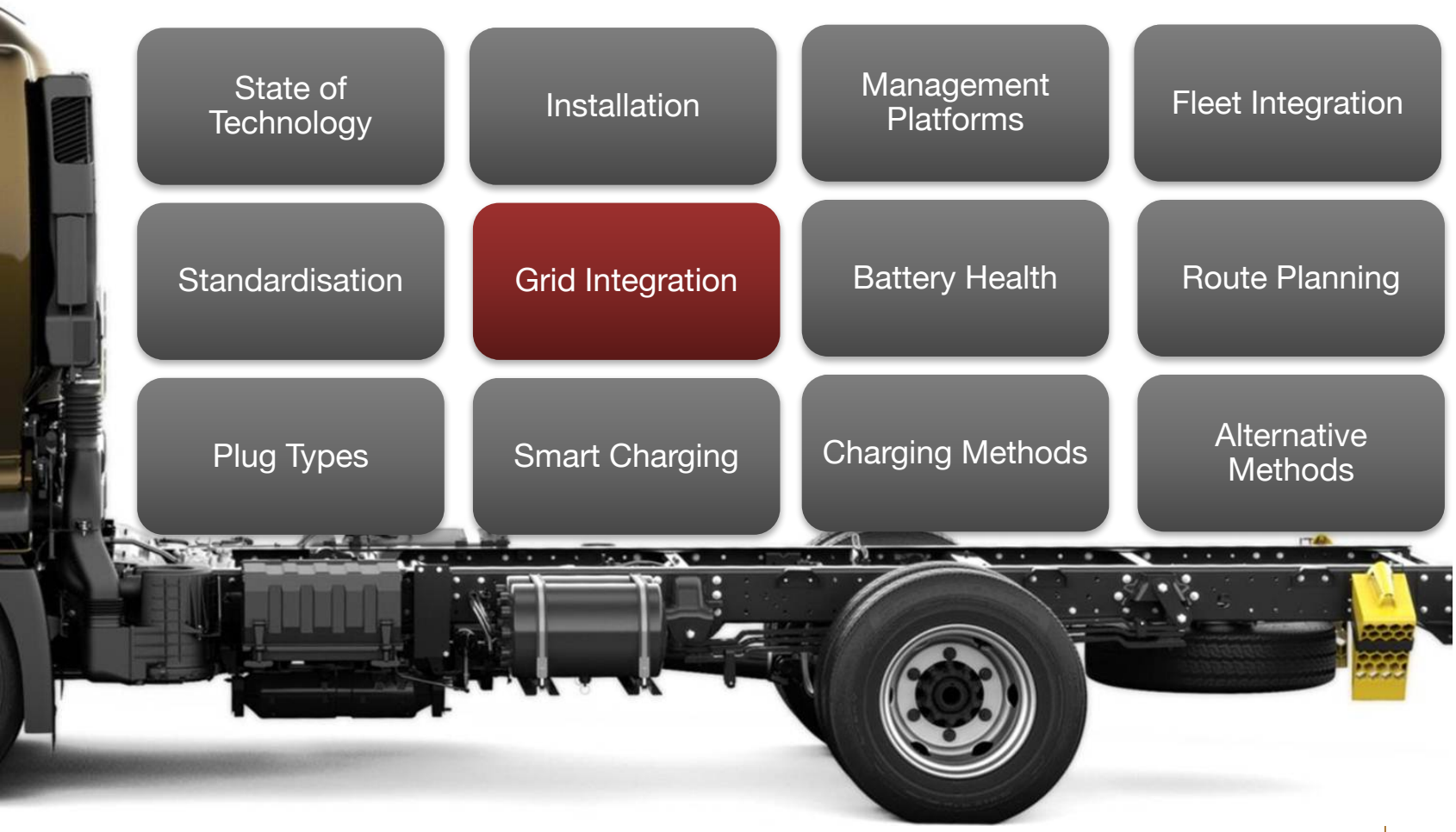
Plug Type Standards

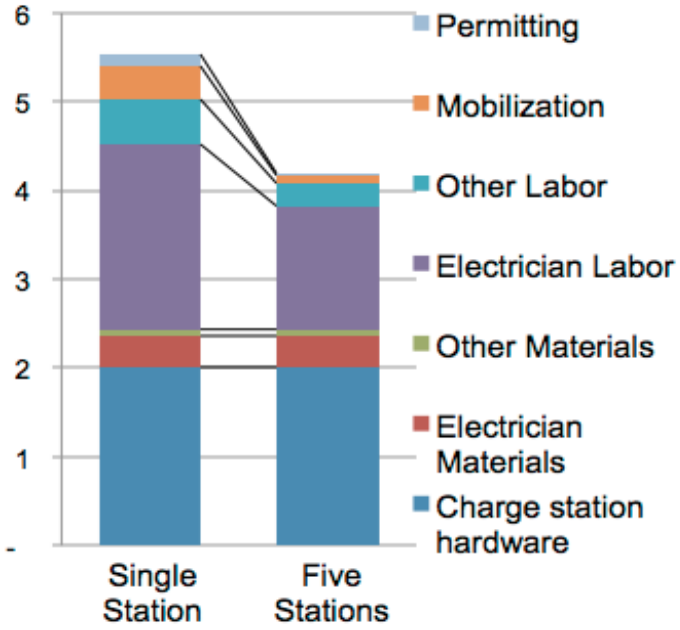


- High likelihood that CCS Combo 2 will become CEV plug standard in EU - flexibility for AC and DC charging – also driven by EU consumer EV market

- Ownership of grid infrastructure upgrades is a central hurdle
- Opportunity for vehicle-to-grid regulation services

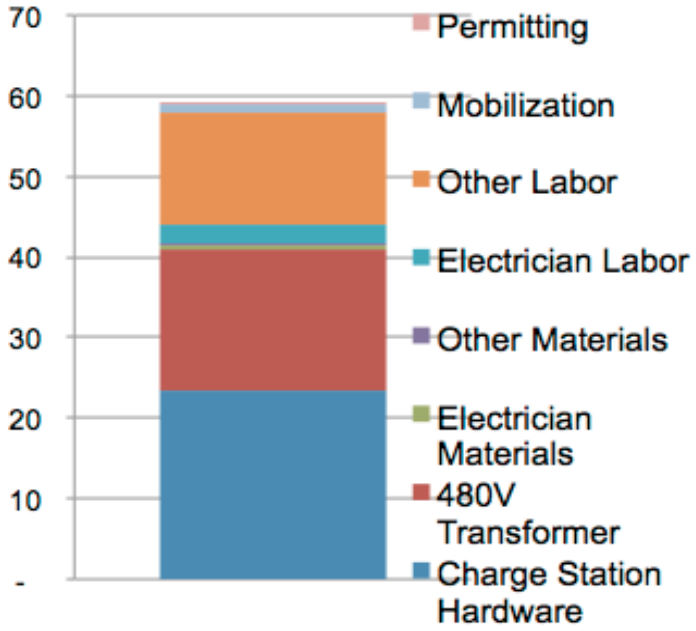


EVSE Cost Breakdown



Parking Garage Installation –

Cost per charger, thousands USD



Curbside DC Fast Charger Installation –

Cost per charger, thousands USD

Source: Agenbroad, J., & Holland, B. (2014, April 29). Pulling Back the Veil on EV Charging Station Costs. http://blog.rmi.org/blog_2014_04_29_pulling_back_the_veil_on_ev_charging_station_costs

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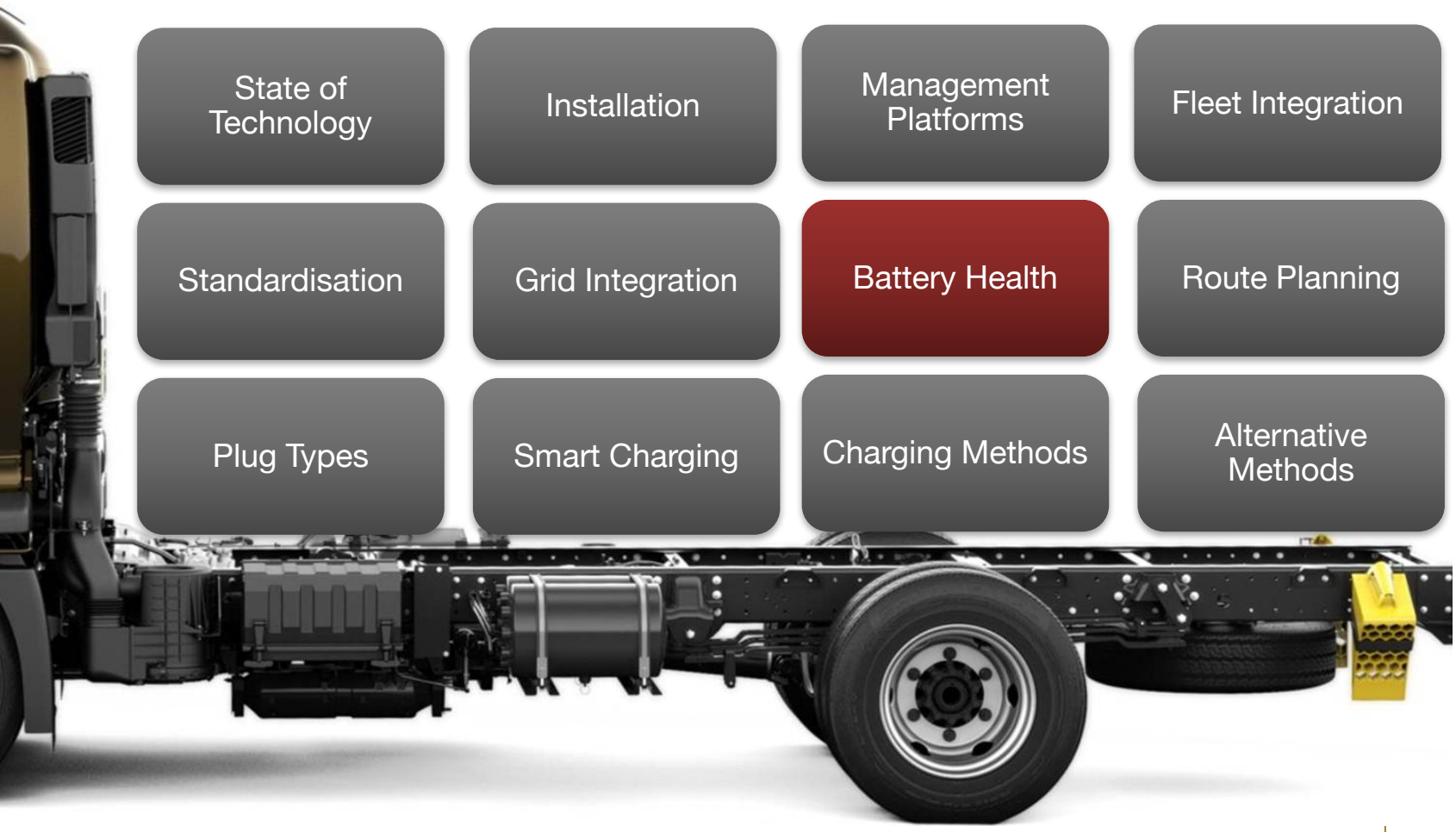
- Potential for battery cells to have different chemistries in order to optimize battery for both fast & slow charging



Application in Practice: Frito Lay

- One of the world's largest CEV fleets – over 200 delivery trucks (Smith Newton)
- Interviewed Steve Hanson – Frito Lay's EV Fleet Manager

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Application in Practice: Frito Lay

Practical Issues

- Siting charge points at depot (distance between grid interconnection and chargers)
- Driver training for proper handling electric plug and charging (cable replacement costs)
- Placement of charging cable on the vehicle (usage profile of vehicle – e.g. may be backed-in to stall or headfirst)
- Cost of transformer upgrades

Application in Practice: Frito Lay

Systematic Challenges

- Utility attitude towards CEVs and charging infrastructure
- Lack of smart charging software platforms for commercial applications
- Lack of template for permitting EVSE
- Accountability on design and interface between EVSE and vehicle
- Poor component standardisation

Smith Newton v. Renault Midlum

- Payload: 5.5-7.5 tonnes
- Gross vehicle weight: 7.5, 10 or 12 tonnes
- Average operating range: 65-190 km
- Recharging time: 8 hour average
- Electric motor power: 134 kW (peak)
- Total battery capacity: modular, 40-120 kWh

- Payload: 5.5 tonnes
- Gross vehicle weight: 16 tonnes
- Average operating range: 100km
- Recharging time: standard 8 hours
- Electric motor power: 103 kW
- Total battery capacity: 150 kWh

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Smith Newton Charging Averages

Average Vehicle Charging Frequency	1.8 per day
Average Vehicle Charge Energy per Day	41.8 kWh/day
Average Energy Delivered per Charge	22.9 kWh
Average Duration of Charge Event	6.8 hours
Average Distance between Charges	22.7 km

*Note: Averages are drawn for Smith Newton in North America

Source: Prohaska, R., Ragatz, A., Simpson, M., Kelly, K., (2016). Medium-Duty Plug-in Electric Delivery Truck Fleet Evaluation. NREL. 2016 IEEE Transportation Electrification Conference and Expo. Dearborn, Michigan. http://www.nrel.gov/docs/fy16osti/66755.pdf

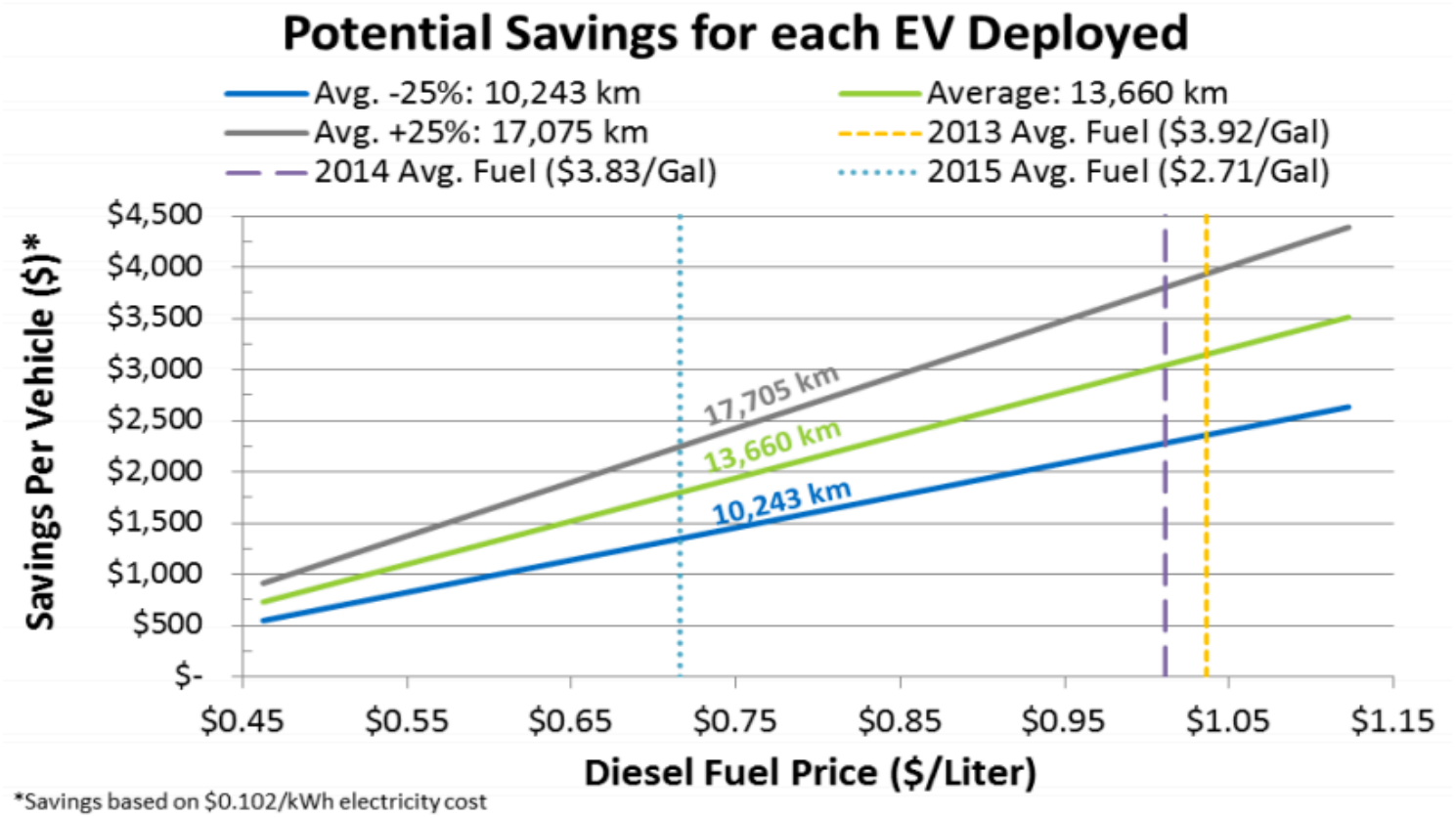
Smith Newton Route Averages

Average Distance Travelled per Day	41.4 km
Average Number of Stops per Day | per Kilometre	50.4 | 1.9
Average Regenerative Braking Events	5.5 per km
Average Daily Driving Speed	35.1 kph

*Note: Averages are drawn for Smith Newton in North America

Source: Prohaska, R., Ragatz, A., Simpson, M., Kelly, K., (2016). Medium-Duty Plug-in Electric Delivery Truck Fleet Evaluation. NREL. 2016 IEEE Transportation Electrification Conference and Expo. Dearborn, Michigan. http://www.nrel.gov/docs/fy16osti/66755.pdf

Fuel cost saving projections per CEV deployed



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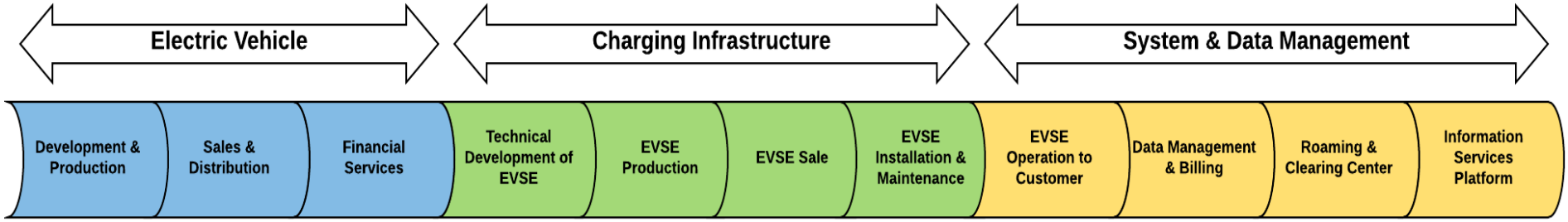
Extending the Value Chain



Morphological box for decision making for offering electro-mobility services

1	Type of power supply	Conductive (wired)	Inductive (wireless)	Battery swapping	
2	Technology	1-phase Mode 1	1-/3-phase Mode 2	EV dedicated equipment Mode 3	DC charging Mode 4
3	Power	Low power < 3.7 kW	Medium power 3.7 - 22 kW	High power 22 - 50 kW	Very high power > 50 kW
4	Accessibility	Private in private domain	Semi-public in private domain	Public in private domain	Public in public domain
5	Payment (billing)	No payment (free)	Fixed rate (e.g. monthly)	Pay per charge	Pay per used resources
6	Information flow	None	Unidirectional	Bidirectional	
7	Identification	No identification, free access	Private location, no specific identification	Single user identification	
8	Roaming from EMSP to CSO	No roaming	Bilateral	Central clearing agent	
9	Contents of charging service	Charging + electricity	Only charging		

Source: Madina, C., Zamora, I., & Zabala, E. (2016). Methodology for Assessing Electric Vehicle Charging Infrastructure Business Models. Energy Policy, 89284-293. doi:http://dx.doi.org/10.1016/j.enpol.2015.12.007

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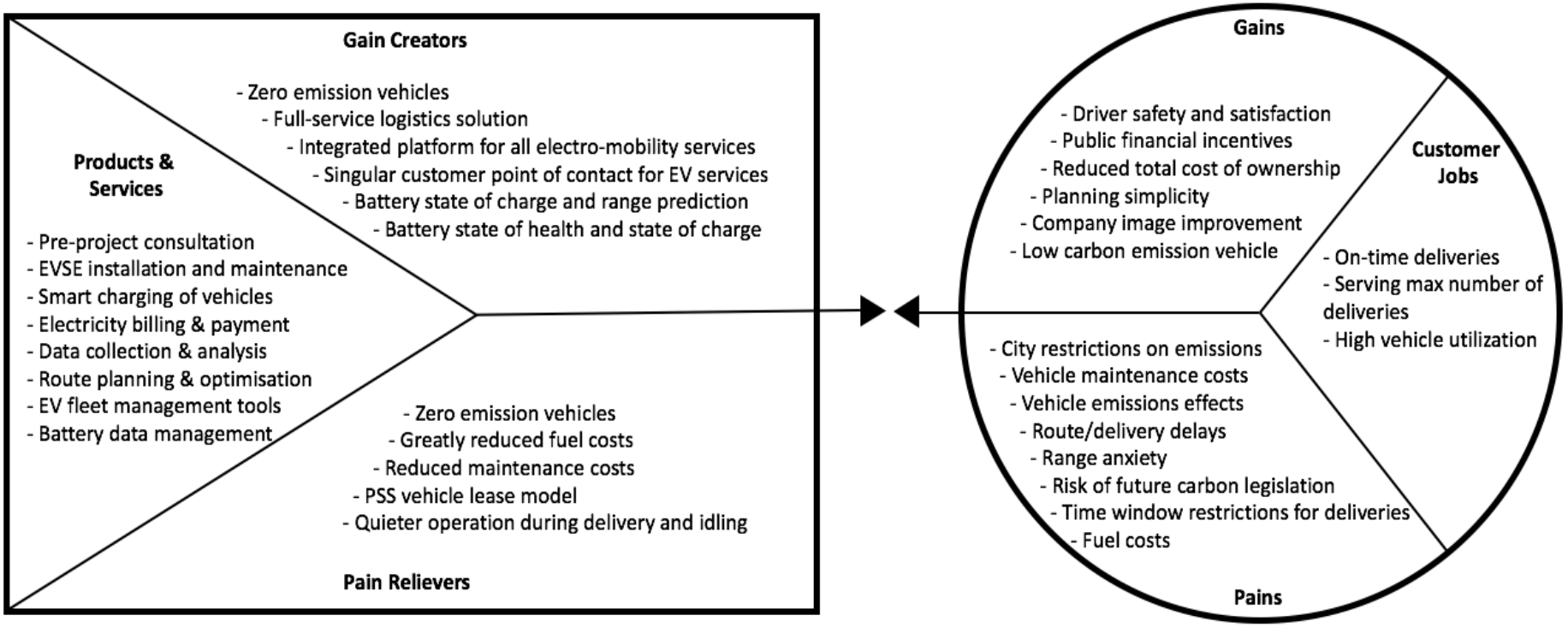
Product Service System

- Integration of Products and Services
- Improve efficiency for positive economic and environmental effects
- Use-oriented model: Vehicle lease
- Vehicle OEM can act as an “Electro-mobility Service Provider” (EMSP) in order to *Extend the Value Chain*

Value Proposition

- Offering a centralized and robust platform for all related electro-mobility services for zero-emission truck is a big draw for fleets looking to adopt low-carbon solutions
- Contract simplicity encourages adoption
- Automated or semi-automated logistics management platform
- Displaying how CEVs can lower total cost of ownership through fuel cost savings is pivotal

Value Proposition Canvas



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Business Model Canvas

- Customer Segment: Urban goods distribution
- Best available technology: Charging stations
- To be used as a decision-making tool by vehicle OEM or EMSP for determining charging services
- Centered around vehicle lease model

Key Partners

- EVSE Supplier
- EVSE Installer (preferably Supplier)
- Utility and/or Distribution Operator
- Regulator (Municipality)

Key Activities

- EV fleet optimization
- EVSE Installation & grid integration
- Data collection & analysis
- Platform management & Back office support
- CEV expert consultation

Key Resources

- EVSE Technology
- ICT Platform
- Evaluation tools & algorithms
- Back-office services and IT infrastructure
- Software development and automation experts

Value Proposition

- Zero-emission trucks
- Full-service solution trucks, EVSE and services
- Singular platform for all related electro-mobility services
- Simplicity of single point-of-contact for customer
- Automated or semi-automated smart charging management

Customer Relationships

- Expert planning during consultation phase
- High level of individual attention in service provision
- Sophisticated and robust interaction through online platform

Channels

- Primary channel: online management platform
- Pre-project consultation
- Client relationship management (1 to 1 support)

Customer Segments

- Small to medium distribution companies
- Large urban logistics firms
- Small businesses with delivery needs
- Secondary customer: utility company (vehicle-to-grid services)

Cost Structure

- EVSE hardware, installation and maintenance
- Grid integration and service fees
- Platform development and maintenance
- Employee wages for expert consultation
- Depreciation of EVSE assets
- Replacement cost of EVSE hardware
- Risk of early-commitment to a developing technology
- Look to leverage shared ownership opportunities

Revenue Streams

- Vehicle lease (with EV 'price premium')
- EVSE joint-sale with partner
- Consultation, platform access and services
- Revenue becomes extended over period of service rather than one-time product sale

Business Model Canvas

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Key Activities

- Fleet optimization – consultation for vehicle type and chargers
- Charging station installation, grid integration and maintenance
- Data collection and analysis – smart charging and route optimization
- Platform management & customer support
- Smart charging, fleet integration, route optimisation, automated data collection and analysis are big value-adds for electric fleets.

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Key Resources

Physical	Intellectual
• EVSE hardware • Servers for data collection and analysis • Office space	• Systems understanding of CEV, charging infrastructure, grid and fleet integration • Algorithms and software platform creation for: Smart charging Route optimization Battery management
Human	**Financial**
• EVSE installation and maintenance • Software programmers • Software platform managers • Consultation experts (pre- and post-sales)	• R&D for software platform and future technologies • Capital for upfront infrastructure investments • Wages for installers, programmers, managers and consultants

EVSE Ownership Scenarios

- **Fleet operator/owner**: high upfront capital – may deter potential customers
- **Utility**: ownership of associated grid upgrades – financial costs could be mitigated by partnership
- **EVSE supplier**: reduces risk for vehicle OEM
- **Vehicle OEM**: retain more control over system, requires capital, encourages adoption

EVSE Ownership

- Finding opportunities for shared ownership between involved stakeholders can help to assist the deployment of charging infrastructure and lower overall system costs

- Involving the utility or distribution system operator is a pivotal partner for EVSE ownership

- A PSS approach with a vehicle lease model can help to alleviate customer purchase price concerns while extending the length of revenue accumulation (over the life of contract)

Risk

- Technology Change – risk of becoming obsolete
- Urban goods distribution – strong initial segment to focus on
  - Depot charging – best for EVSE stations
  - Prepared for electric trucking solutions *today*
- Customer segment helps vehicle OEM gain market share & institutional learning
  - As vehicle OEM develops a given urban market, opportunity charging will become an opportunity

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Complementary Future Solutions

- Battery – Modular design and/or Mixed Chemistry
- Spent batteries can receive 2nd life with charging stations – big potential to be paired with fast chargers
- Solar PV panels – vehicle OEM as energy provider, which can own solar assets and sell the electricity to fleet operators

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