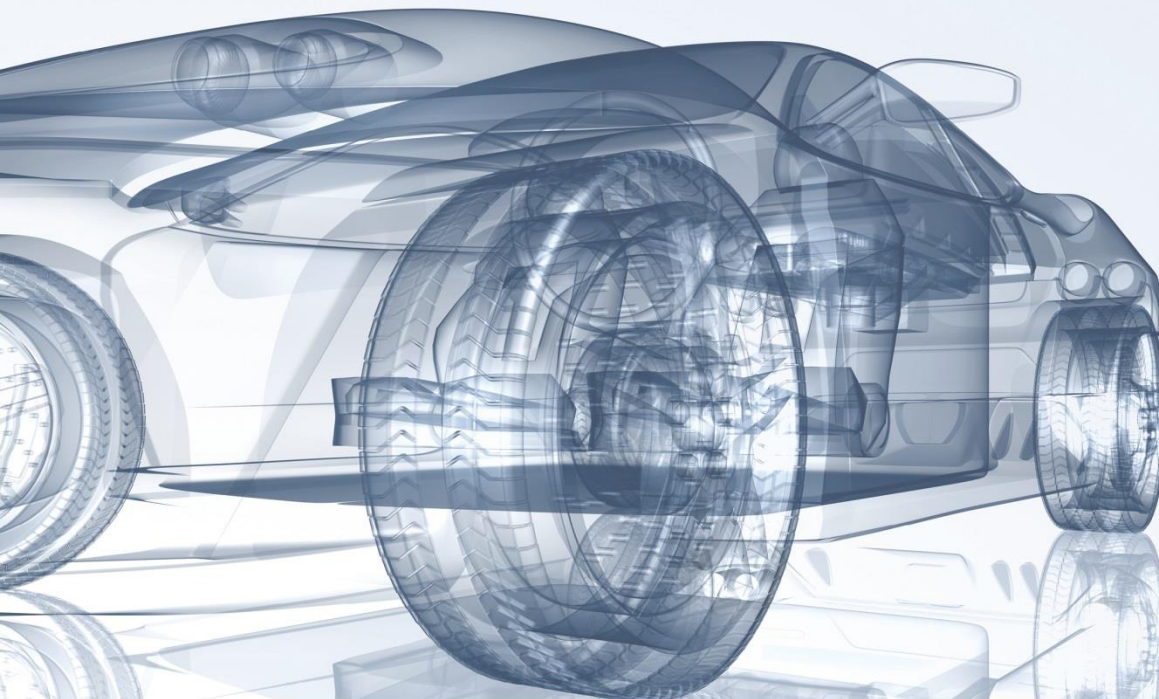


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Priming the United States Grid for High-Powered Electric Vehicle Charging

Paul Stith

Director, Strategy & Innovation
Transformative Technologies

Stuttgart, Germany - October 9, 2017



Priming the US Grid for High-Powered EV Charging

Agenda

- About Black & Veatch
- Vehicles, duty cycle and battery sizes
- Growing infrastructure requirements
- Getting energy where it's needed
- Collaboration & Recommendations

- Questions & Answers



About Black & Veatch



Power Infrastructure,
Renewables & Sustainability



Distributed
Infrastructure &
Mission Critical
Facilities



Transportation &
Transformative
Technologies



\$3.2B
Revenue



10,000+
Professionals



Scaling Distributed Clean Energy Infrastructure

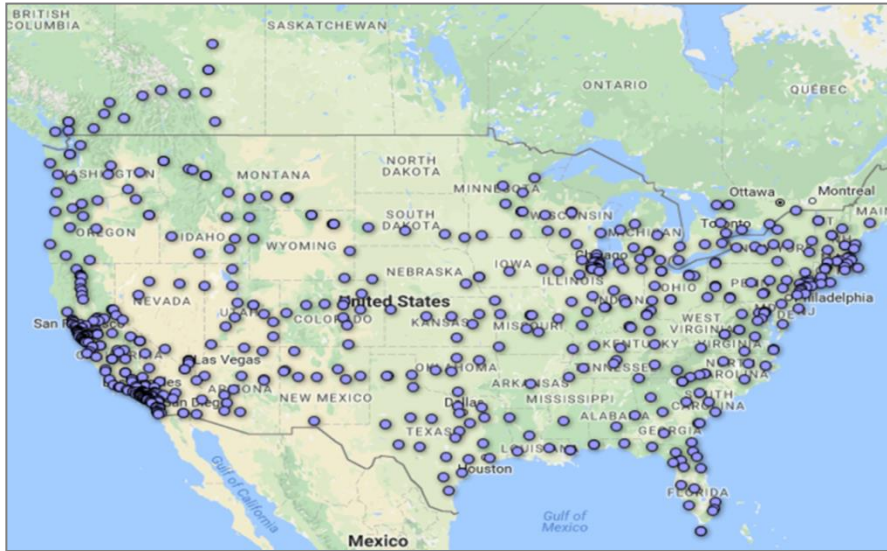
Electric Vehicle Infrastructure

Hydrogen Infrastructure

Energy Storage Networks

Emerging Distributed
Technology

Autonomous, Connected Vehicle
Infrastructure



We build complex networks faster



US Fleet Energy Consumption

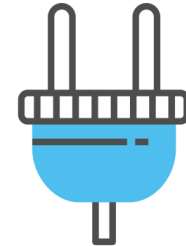
Vehicle Class	Vehicles (Millions)	Energy Used (Tbtu)	Electricity (TWh)	Energy Used (TWh) (% of Fleet)		
				10%	50%	100%
Light Duty Vehicles	240.2	14,630	4,300.0	92.7	463.3	926.6
Sedans	187.6	10,300	3,030.0	72.4	361.8	723.7
Pickups	52.6	4,330	1,270.0	20.3	101.5	202.9
Medium & Heavy Duty	10.9	5,460	1,600.0	45.0	225.0	450.0
Total Vehicles	251.1	20,090	5,900.0	137.7	688.3	1,376.6

Based on 2014 U.S. Department of Transportation, Bureau of Transportation Statistics



Vehicles, Duty Cycle and Battery Size

- As battery technologies progress it becomes more economical to use larger batteries
- More applications and duty cycles can be electrified
- Requires more infrastructure and power to deliver the energy



“Businesses that do not electrify will be at a competitive disadvantage...”



Step Change in Infrastructure Requirements

- High Power Corridor Charging
- High Utilization Vehicles
- Urban Charging Hubs & Depots
- High power On-route
- Capital Requirements

- Facility and Network Roadmaps

*Optimize for least regret investments
while scaling to meet requirements*



Transit: 250KWh Per Day Per Bus



Implications for Site Design, Power Delivery

- Cooling, Cables & Compounds
- Multiple Low Voltage Transformers
- Medium Voltage Utility Service
- Switch Gear Capacity
- Centralized Power Conversion
- DC Power Utility Delivery
- Inductive Charging

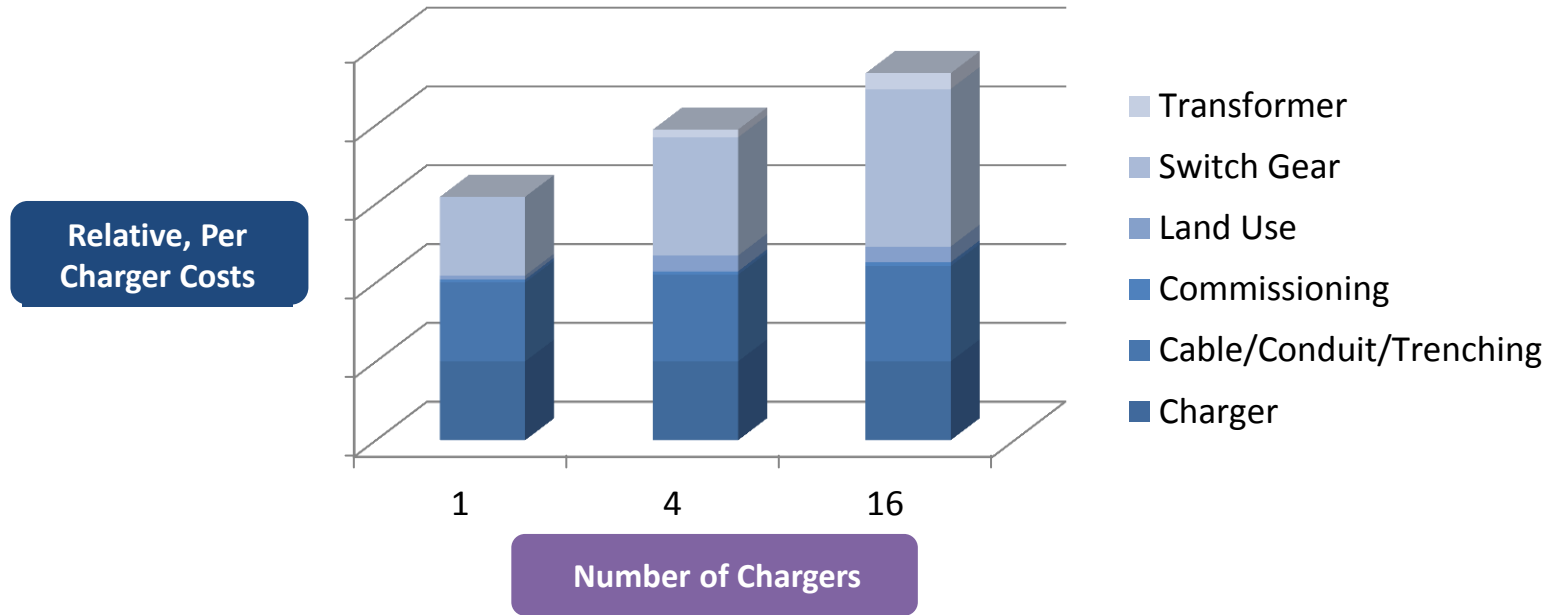
*Designs shaped by new technologies
and utility service provisioning*



Enabling Corridor Travel

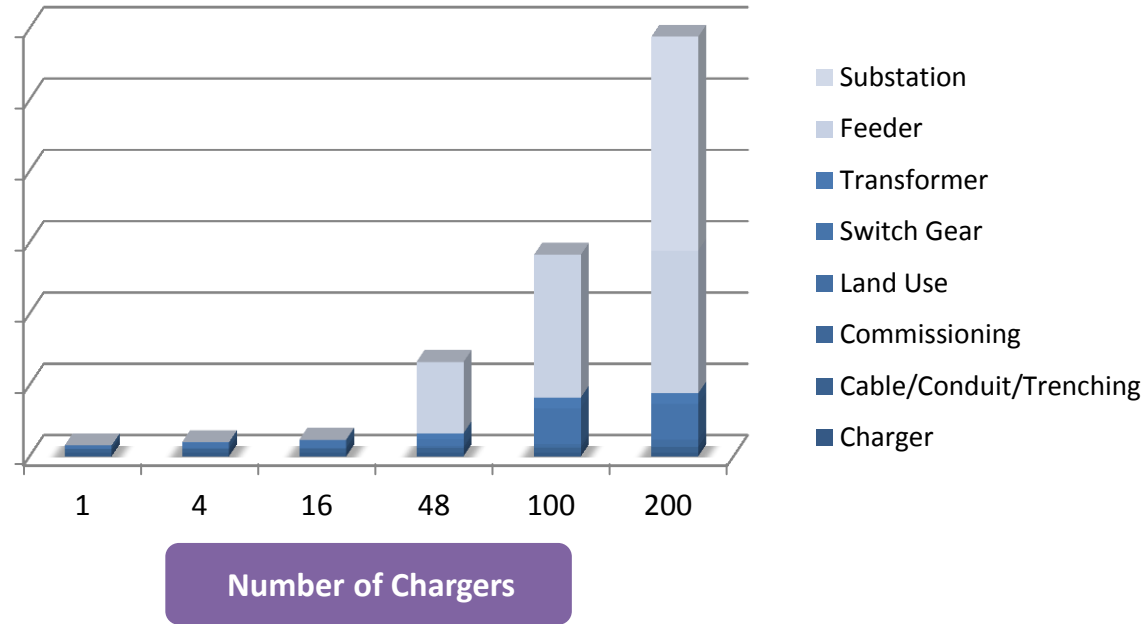


High Power Charging Deployments Scenarios



Scaling Up Requires Significant Capital

Relative, Per
Charger Costs



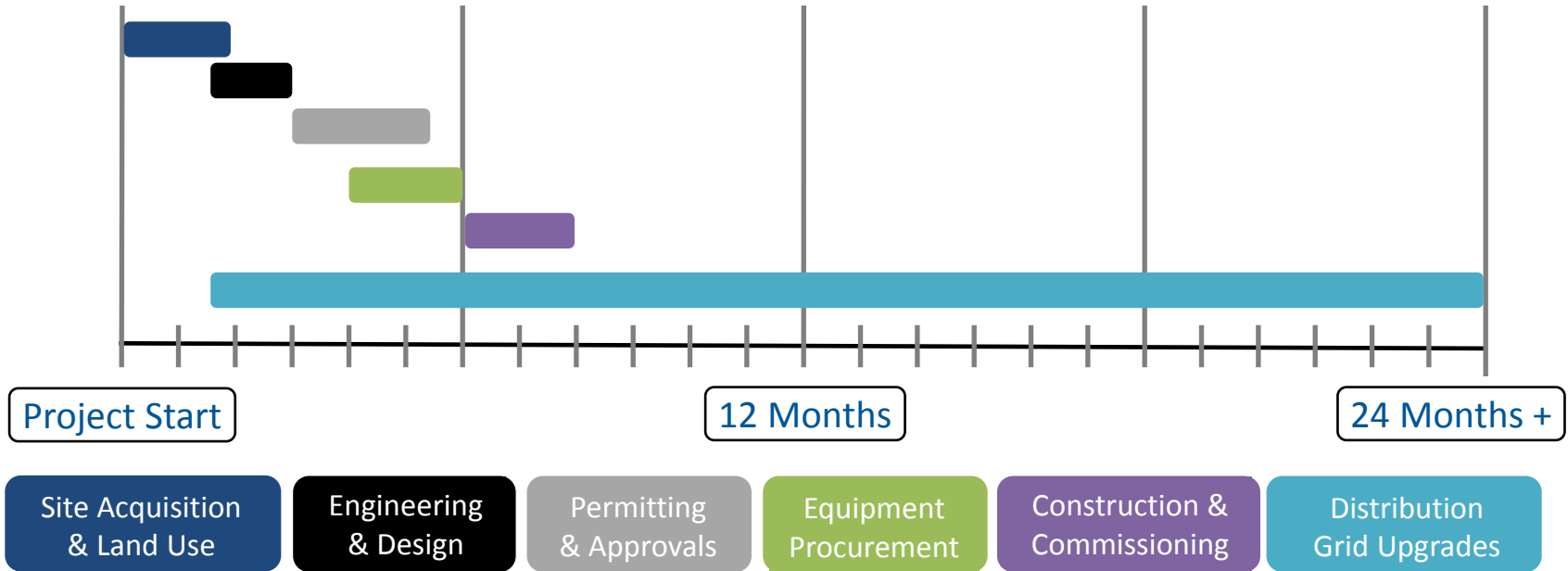
Scenario Assumptions

Ports	Power (MW)	Medium Voltage	Feeder Upgrade	New Feeder	Substation
1	0.125				
4	0.50				
16	2.00				
48	6.00	■			
100	12.50	■	■		
200	25.00	■		■	■

125KW Per Charger, Medium voltage grid supply for 4MW and larger configurations, 1 Mile of Feeder, New Substation



Grid Upgrades Can Require Significant Time



Power Availability, Energy Delivery, Resilience

- Siting decision factors:
 - Can you locate near power?
 - Cost to bring power?
- Energy Management Tools:
 - Distributed Generation
 - Energy Storage
 - Smart Charging
- Microgrids



The Grid has enough energy but not always in the right places.



Energy Storage, DER & Value Streams

- Storage with & without wheels
- Access to more value streams the closer to the grid edge
- Multiple roles & Network Effect
- Variable Renewables Energy Integration
- Geographic, Locational Value
- Autonomous Vehicles, Car Share



Behind the Meter Energy Storage



Stakeholders - Collaboration, Recommendations

Policymakers & Regulators

Policymakers & Regulators - Develop win-win strategies to:

- Leverage Public/Private investment
- Drive behaviors and adoption
- Create effective rate structures
- Educate and inform government, commercial and consumers



Stakeholders - Collaboration, Recommendations

**Policymakers &
Regulators**

Vehicle OEMs

Vehicle OEMs - Continue developing compelling vehicles and:

- Communicate infrastructure requirements
- Build awareness and drive new applications
- Exchange information with all stakeholders
- Educate and inform consumers & fleets



Stakeholders - Collaboration, Recommendations

Policymakers &
Regulators

Vehicle OEMs

Utilities

Utilities evolve and integrate EVs through:

- Engaging with customers
- Incorporating EVs into every aspect of business processes
- Providing rates and incentives that drive behaviors and adoption
- Invest in distribution grid modernization to integrate EVs and unlock value
- Creative infrastructure financing programs



Stakeholders - Collaboration, Recommendations

Policymakers &
Regulators

Vehicle OEMs

Utilities

Technology
Integrators

Technology Integrators – Advancing EV adoption through:

- Business innovation, organization and program development
- Modeling to support complex grid planning
- Coordinate between utility, vehicle OEMs, and charging providers
- Scalable engineering, land use and construction solutions to build complex networks faster



Questions?

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Thank you! Learn more at [bv.com](https://www.bv.com).

 [@Black_Veatch](https://twitter.com/Black_Veatch) & [@BVSII](https://twitter.com/BVSII)

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