



SCALING ON-ROUTE & DEPOT TRANSIT INFRASTRUCTURE

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EPRI Infrastructure Working Council
Bus and Truck Charging Interface Group

BUILDING A WORLD OF DIFFERENCE®



SCALING ON-ROUTE & DEPOT TRANSIT INFRASTRUCTURE

- Black & Veatch - Transformative Technologies
- Electrification of Transit
- Solving the Charging Puzzle
- Systems & Program Approach
- Batteries & Energy Storage – Energy Networks
- Q & A



BLACK & VEATCH

Global Engineering, Consulting & Construction Firm

- Founded in 1915
- 10,000+ Professionals
- Employee-owned corporation
- \$3 billion in annual revenues in 2015
- More than 110 offices on 6 continents
- Completed projects in more than 100 countries
- Typically 7,000 concurrent projects



POWER



WATER



TELECOM

TRANSFORMATIVE TECHNOLOGIES

Electric Vehicle Infrastructure
Hydrogen Infrastructure
Energy Storage
Emerging Distributed Technology
Autonomous, Connected Vehicle Infrastructure



Over 700 Distributed Infrastructure Sites

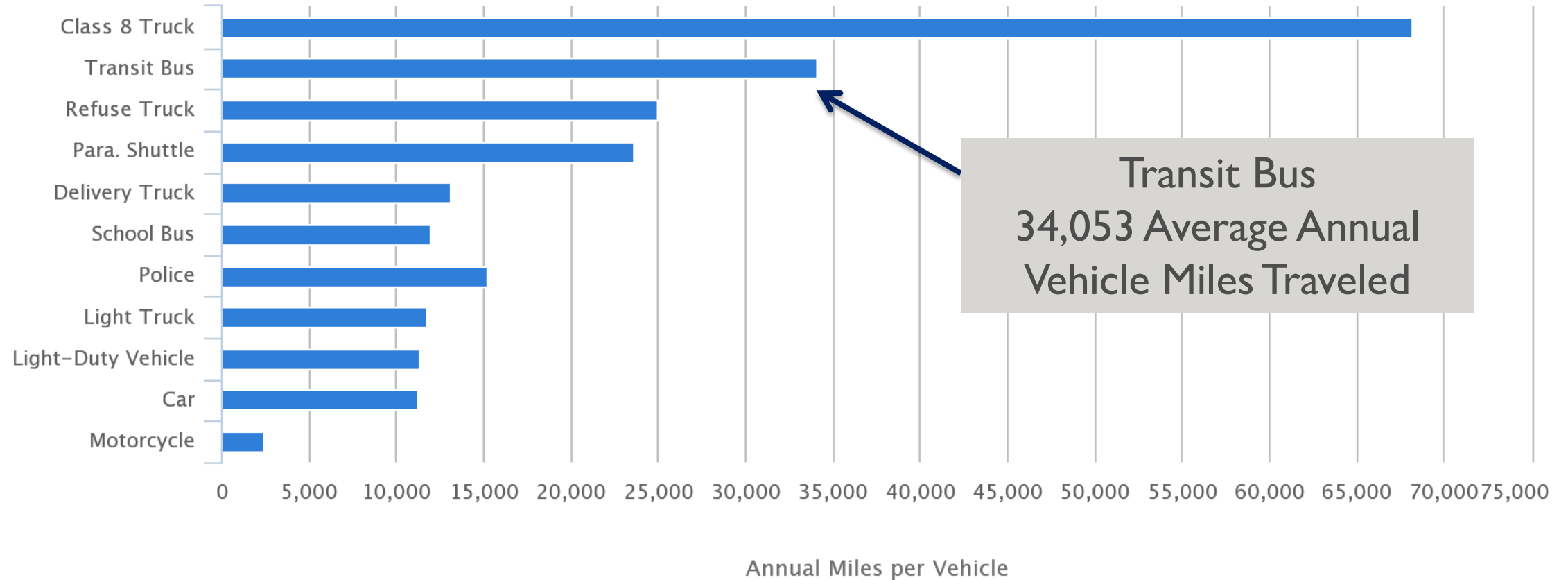


ELECTRIFICATION OF TRANSIT (EOT)

Sizing up the Infrastructure Challenge

ELECTRIFICATION CANDIDATES

Average Annual Vehicle Miles Traveled of Major Vehicle Categories



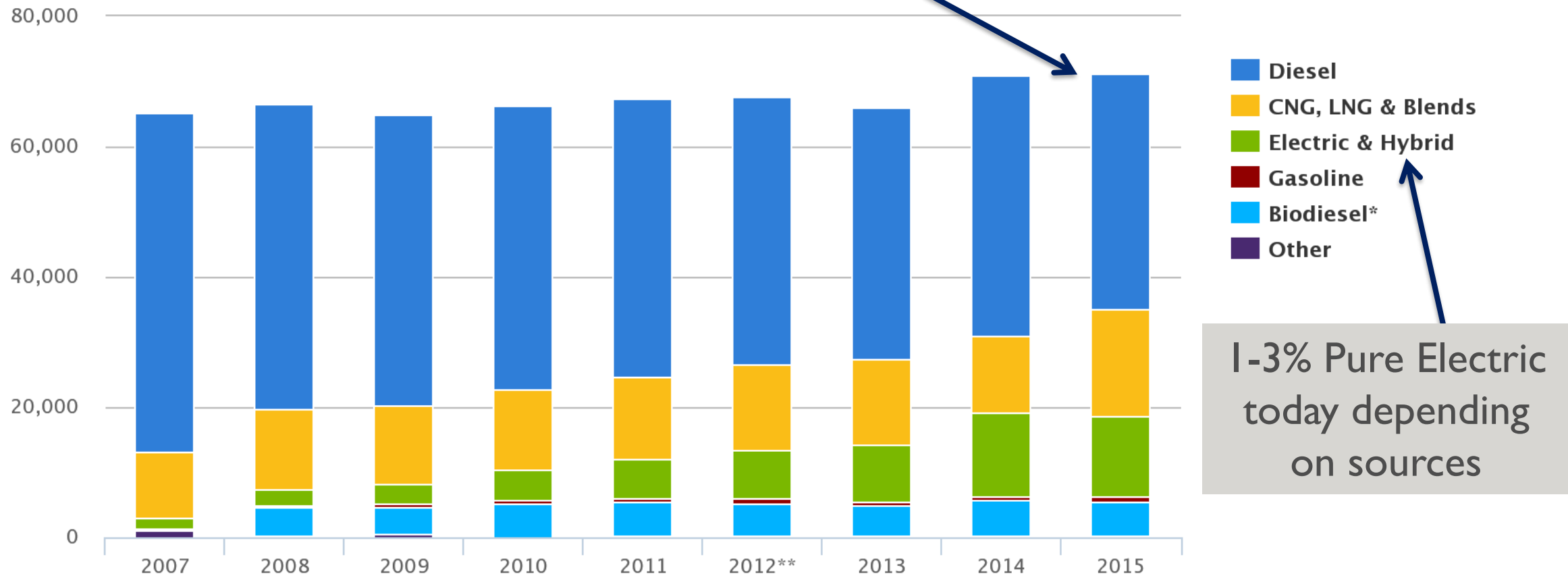
Transit Bus
34,053 Average Annual
Vehicle Miles Traveled

Last updated: June 2015
Printed on: March 25

Data Source: Federal Highway Administration Table VM-1 and American Public Transit Association's Public Transportation Fact Book Tables 6, 7, and 20. Retrieved from <http://www.afdc.energy.gov/data/>

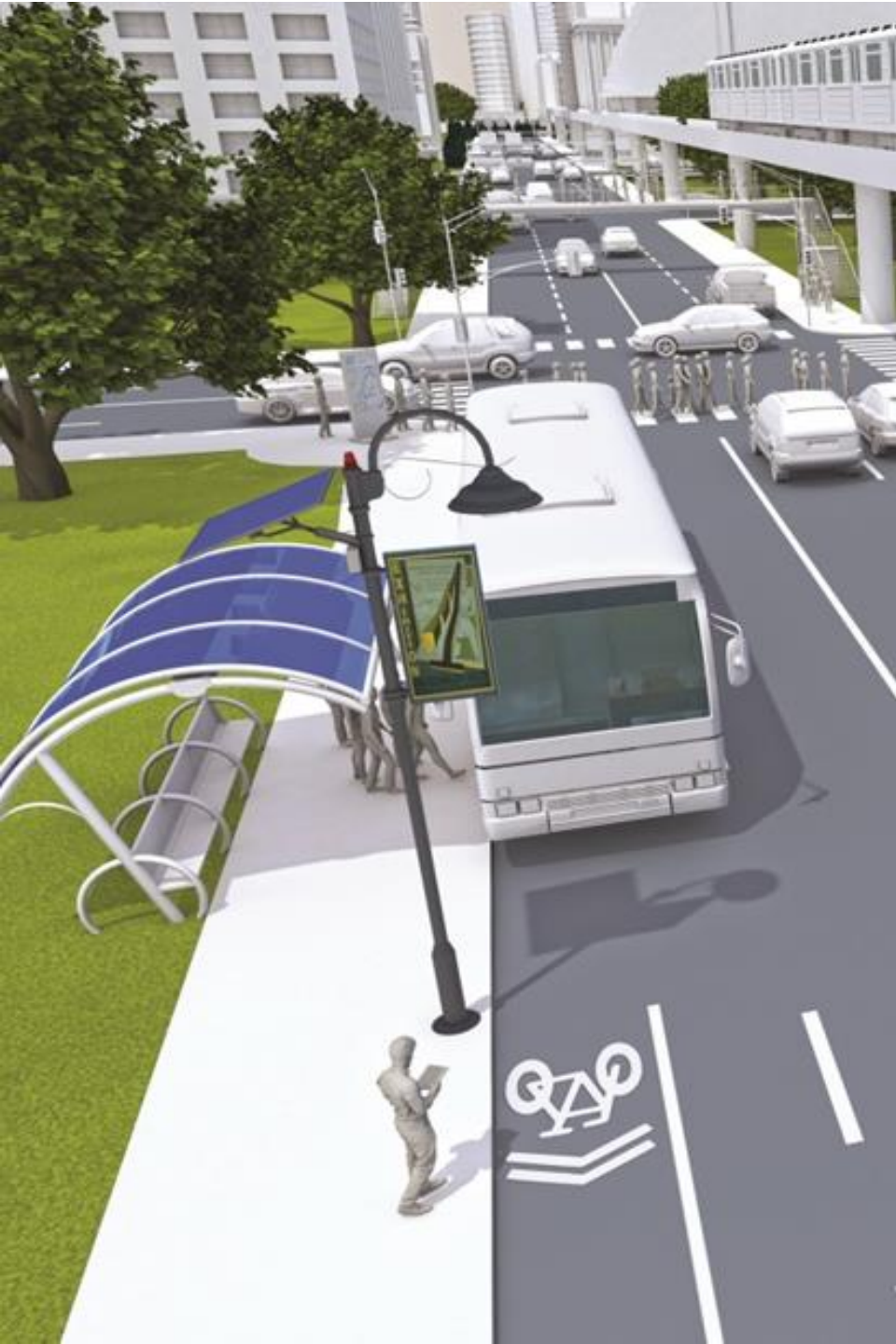
2015 US TRANSIT BUS FLEET COMPOSITION

71,136 Transit Buses



Last updated: August 2016
 Printed on: March 25

Data Source: American Public Transportation Association Fact Book Derived from Table 21 and 34 in Appendix A of Edition 2016. Retrieved from <http://www.afdc.energy.gov/data/>



US ELECTRIFICATION POTENTIAL

- 71,136 Transit Vehicles (2015)
- 34,053 Average Annual Vehicle Miles Traveled
- 93 Average Miles Per Day / 201 KWh*

14.3 Giga Watt Hours Per Day
5,208 Giga Watt Hours Per Year

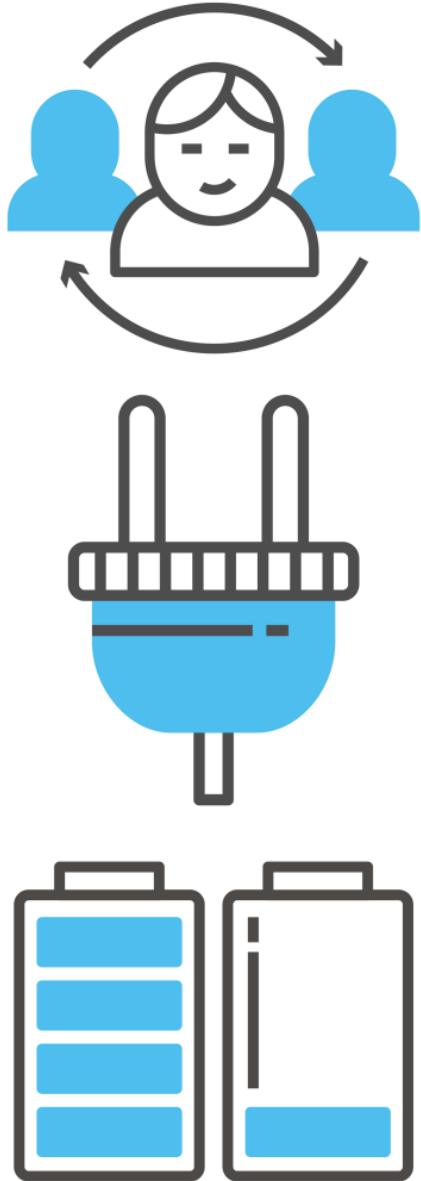
*Rough estimates using 201KWh per day. Does not include additional energy for articulated buses, weather, terrain, etc.



FLEET REQUIREMENTS @ 100% ELECTRIC*

- Birmingham, Alabama MAX - 56 Buses
11 Mega Watt Hours Per Day
- Santa Cruz Metro, California - 110 Buses
22 Mega Watt Hours Per Day
- The Bus - Honolulu, Hawaii 542 Buses, 21% Artic.
109 Mega Watt Hours Per Day
- New York MTA – 5,852 Buses
1.174 Giga Watt Hours Per Day

* Rough estimates using 201KWh per day. Does not include additional energy for articulated buses, weather, terrain, etc.



EoT: NEW RELATIONSHIPS & COLLABORATION

- Utility / Public / Partnerships / Inter-Agency
 - Deep Connections to Smart Cities
 - Resilience Requirements
 - Maximizing Grid Value of Energy Networks (*with and without wheels*)
 - Multi-Modal Transportation Systems
- >> Potential for Collaboration: Light Rail, Subways, Car Pool, Car Sharing, Taxi, Other Fleets
- >> Energy Storage can play a large role in unlocking opportunities.



EoT RAMP RATE FACTORS

- >> Technology Advances
- >> Total Cost of Ownership
- >> Early Use Cases, More Electrified Miles, Faster ROI
- >> ZEV Policy Support
- >> Leveraging Early Funding Opportunities
- >> Clean Energy Policy & Integration
- >> Financing Innovation, Green Banks
- >> Utility Investment

TRANSIT – LEADING THE WAY

Medium & Heavy duty applications poised to follow Transit:

- Over Road Coach
- School Bus
- Garbage Trucks
- Goods Movement
- ...
- ...



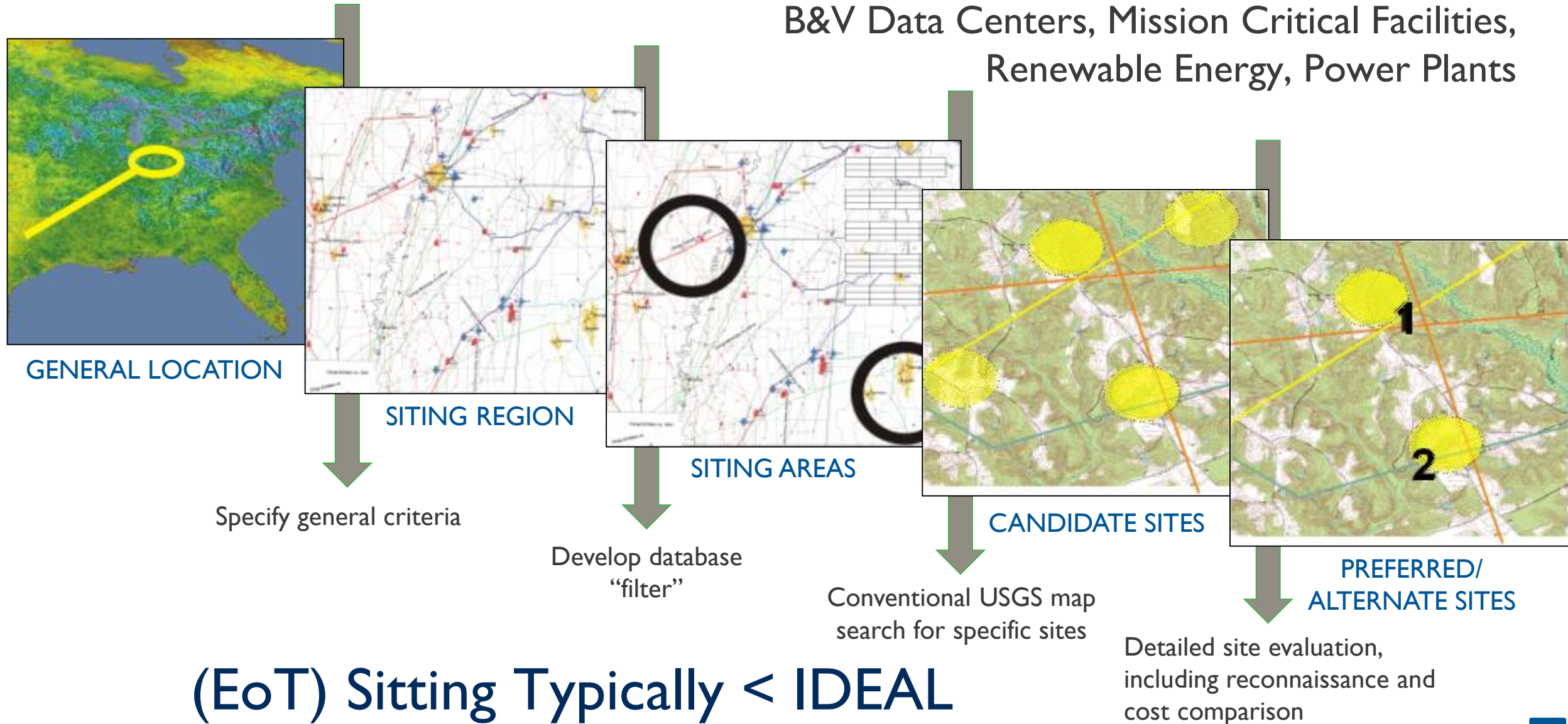


SOLVING THE CHARGING PUZZLE

On-Route, Depot or Hybrid Approach?

IDEAL WORLD SITE SELECTION PROCESS

B&V Data Centers, Mission Critical Facilities,
Renewable Energy, Power Plants





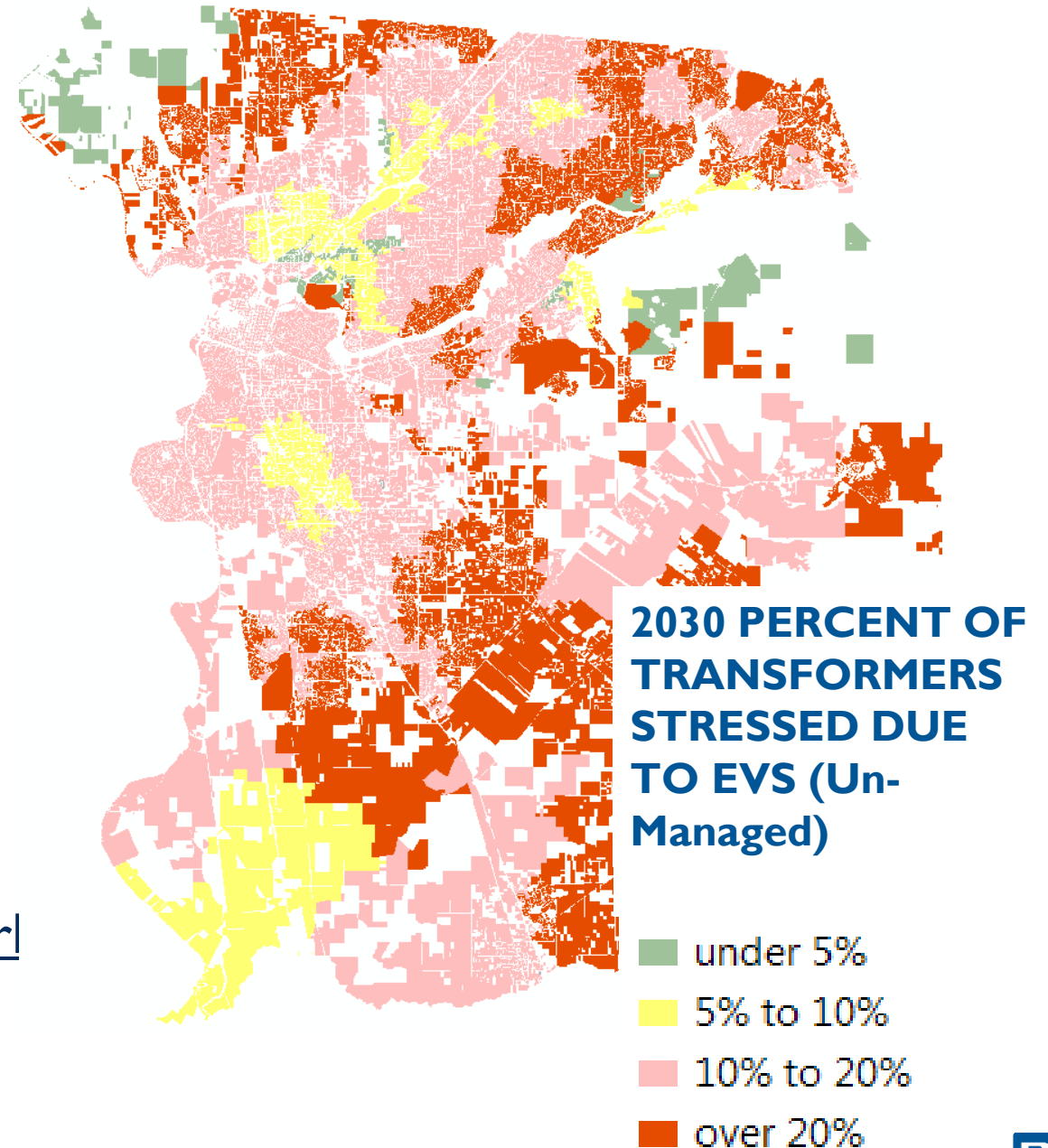
ON-ROUTE & DEPOT (COMMON ISSUES & OPPORTUNITIES)

- Pilot -> Full Electrification Support (Pilots are Easy)
 - Power Delivery & Energy Delivery
 - Up Front Capital Infrastructure Expenditures

 - Rapid Technology Advances
 - Standards, Communications
 - Distribution Grid Integration
 - Achieving Clean Energy Goals
 - Energy Storage & Management / Peak Shaving / Shifting
- >> Needs to be view as a System

ON-ROUTE TRANSIT INFRASTRUCTURE

- Distribution Grid / Utility Focus
 - Site / Land Use / Permitting
 - Time of Consumption vs. Grid Conditions
 - Demand Charges with Low Utilization
 - Traffic Controls & Non-Bus Hazards
 - Opportunities for Energy Storage
 - Co-located Facilities / Buildings with Load
 - Site Grid Integration / Feeder Support
- >> Roadmap needs to be developed for Network





DEPOT ISSUES & OPPORTUNITIES

- What does Depot Charging Look Like?
In Door, Out Door, Site Conditions, Existing Loads
 - Scalability factors are compounded
 - Space Utilization, Cord Lengths, Equipment Layouts
 - Utility Service Entrances
 - “Re-Powering” the Building / NEC Code
 - Rapid Technology Adoption
- >> Roadmap require per Facility

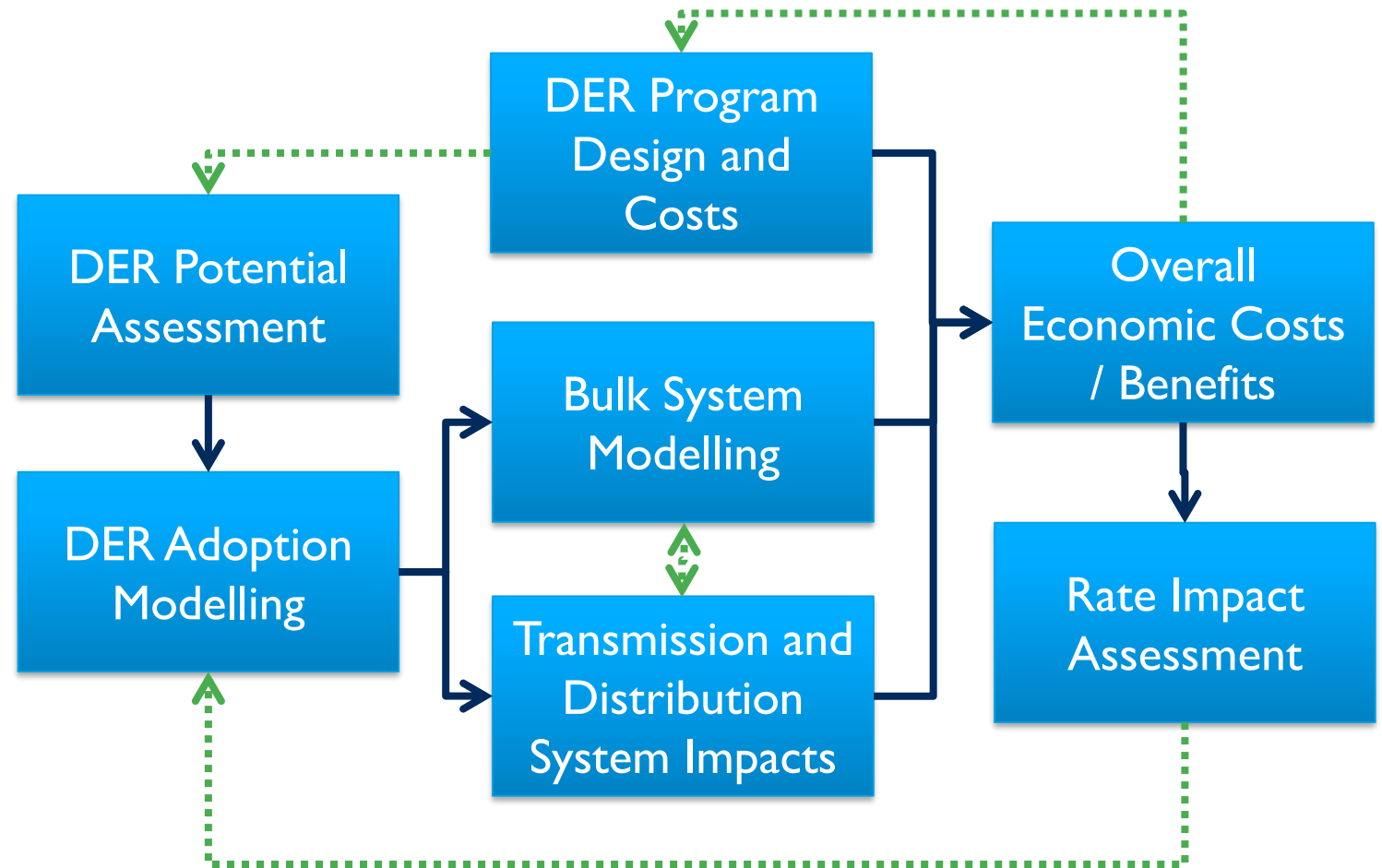


Systems & Program Approach

Utility Planning, Utility Coordination,
Program Execution



UTILITY- INTEGRATED DER ASSESSMENT & PLANNING



UTILITY COORDINATION

- Trusted Utility Relationships
 - Rate Option Analysis, Schedule & Cost Certainty
 - Utility Grade Engineering
 - Equipment Sizing and Demarcation Coordination
 - Engineering for Scalability & Utility Upgrades
 - Energy Management/ Grid Integration Planning & Innovation
 - Experience with Investor Owned, Municipal and Coops
- >> Faster interconnection, upgrades and establishment of new services.





PROGRAM APPROACH INFRASTRUCTURE DEPLOYMENT

- Process developed over 20 years
- Applied to Tens of Thousands of Sites

PROGRAM MANAGEMENT

- Regulatory support & compliance
- Subcontractor identification & management
- Asset management
- Budget & schedule control
- Reporting
- Delivery assurance



Project Execution Plan
Contracting approach
Schedule analysis and control
Feasibility studies
Financial planning and budget

Predictive Analysis of Demand
Site Assessment
Leasing
Construct- ability
Utility Coordination

Infrastructure systems design
BIM+
Preliminary design
Design development
Construction administration

Zoning and permitting research
Zoning submittal and approval
Permit expediting

Procurement
Purchasing
Inventory control
Fabricator expediting
Subcontractor qualification / management

Mobilization
Site kick-off
Site preparation/civil works
Skid installation
Electrical
Mechanical
Communications
Site Punch

Site Turn-over
Testing and Training
Startup and Commissioning
Project Closeout
Alarms and monitoring
Infrastructure management

HOW CAN ENERGY STORAGE HELP?

Advanced Microgrid Solutions

Hybrid Electric Building Stationary Storage Installation

Tesla Stationary Storage Installation for Escondido School District





BLACK & VEATCH

Thank you!

Learn more at bv.com.

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