Corridor and Community DC Fast Charging Complex Blueprint

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January 2017
Transportation Research Board
Washington D.C., January 2017

www.inl.gov

Idaho National Laboratory

INL/CON-17-40802

Idaho National Laboratory

BACKGROUND

- The Department of Energy (DOE) identified vehicle technologies needed by the average American driver:
  - Affordable PEVs with increased all-electric range that meets all of their transportation needs
- One of the key roles of charging infrastructure is to support these extended range EVs with convenient charging that enables more electric miles driven, and promotes EV adoption
  - DOE also emphasizes that this must be done without negatively impacting the electric grid
- The most likely solution are well-placed Community and Corridor Charging Infrastructure Complexes equipped with DC Fast Chargers

METHOD

- **Experts from plug-in electric vehicle (PEV) manufacturers, and charging infrastructure and electric utility industries were used to supplement the lessons the INL team has learned from vehicle and charging infrastructure studies**
  - **EPRI Infrastructure Working Council meeting input**
  - **Private conversations with industry members**
- **This input helped refine the concept criteria and rough order of magnitude (ROM) costs of a Community and Corridor DC Fast Charging Complex Blueprint**
- **The Charging Complex Blueprint must support today's and tomorrow's EVs and their much larger traction battery packs**

CONCEPT DEFINITION

- **The DC Fast Charging Blueprint is a conspicuous multi-station fast charging complex that provides fast and convenient away-from-home charging, and promotes further adoption and use of the longer range EVs**

- **These complexes are intended to provide a connected network of the most convenient charging stations available to facilitate all-electric miles between and within metropolitan areas of the USA**

DCFC LESSONS LEARNED

- **Most of the existing population of 50 kW DC fast chargers (DCFCs) are used to extend travel for current EV models that operate primarily within urban areas. This can be seen by:**
  - **70% of all DCFC events occur within 20 miles of home[1]**
  - **Average SOC at start of fast charge is 35%[1]**
  - **In the EV Project, 61% of all DCFCs were less than 10 kWh[2]**
  - **The most highly utilized DCFCs tended to be located close to interstate highway exits[2]**

REF: Lessons Learned publications: 1) What Were the Use Patterns Observed at the Highly Utilized Direct Current Fast Charge Sites? June 2015 2) Plugged In: How Americans Charge Their Electric Vehicles Findings from the largest plug-in electric vehicle infrastructure demonstration in the world, Idaho National Laboratory, Sept 2015

DCFC LESSONS LEARNED, cont'd

- **DCFCs are used most often between 4 pm and 6 pm, and the second most frequent time period is between 11 am and 2 pm[1]**
- **Except Tesla Supercharging stations, nearly all existing DCFC stations have a single charger**
- **When comparing publicly accessible charging, DCFC is used five times more often than Level 2 EVSE convenience charging[2]**

REF: Lessons Learned publications: 1) What Were the Use Patterns Observed at the Highly Utilized Direct Current Fast Charge Sites? June 2015. 2) Plugged In: How Americans Charge Their Electric Vehicles Findings from the largest plug-in electric vehicle infrastructure demonstration in the world, Idaho National Laboratory, Sept 2015

CHARGING COMPLEXS IN RURAL LOCATIONS

- **Charging complexes are defined as either Rural or Urban locations**
- **Rural: fast charging complexes that are intended to support inter-urban travel**
  - **Located between urban centers and typically associated with other inter-urban facilities e.g. small towns, truck stops, fast food, convenience stores, tourist information centers**
  - **Charging at Rural Locations is expected to transfer more energy per charge event than at Urban Locations**

CHARGING COMPLEXS IN : URBAN LOCATIONS

- **Urban: fast charging complex that is expected to support intra-urban travel and EV owners who do not have regular overnight charging opportunities (multi dwelling units). May also support inter-urban travel**
  - **Not necessarily co-located with other activities, but are convenient to commuting travel corridors within a metropolitan area**
  - **Urban complexes are also used to connect to other urban areas, so energy transfer will vary from top offs to full charges**

DESIGN CRITERIA

- **Assumptions drives ROM costs**
  - **Siting**
  - **Expandability**
  - **Dispensers**
  - **Power/Energy**
  - **Grid Impact**
  - **Renewables**
  - **Compliance**
  - **Cost Factors**
  - **Power and Energy Factors**

SITING

- Rural
  - Direct access from State or Federal highway (<1,000 ft.)
  - Nearby access to grid power
  - Associated with other entities such as convenience stores, truck stops, restaurants, points of interest, etc.
  - Grid asset
    - Grid services provided from distributed energy storage or renewable energy generation
- Urban
  - Adjacent to high traffic streets and commuter routes
  - Nearby access to grid power
  - Direct access for site ingress and egress to street from both directions

EXPANDABILITY

- Charging complex designed to allow expansion from minimum capability required to full (Ultimate) capability
  - Site power supply
  - Dispenser power capability
- Minimum capability required
  - Six charge dispensers with a minimum of 50 kW capability
  - 100 kW grid power supply
  - Onsite energy storage
- Ultimate capability required
  - Six charge dispensers with ~350 kW capability
  - 200 kW grid power supply
  - Onsite energy storage

DISPENSERS

- Must be capable of meeting present and future energy throughput requirements
- Urban locations are more likely to provide a “top up” charge, while Rural locations are assumed to provide a near full charge
  - Minimum capability
    - Urban, 6 units at 50 kW
    - Rural, 6 units with a mixture of 50 kW and 150 kW
  - Ultimate capability
    - Urban, 6 units with a mixture of 50 kW and ~350 kW
    - Rural, 6 units with a mixture of 150 kW and ~350 kW

DISPENSERS, cont'd

- **Dispensers to be either or both CHAdeMO and CCS, and the future standard established for ultimate capability fast chargers**
- **Upgrade to ~350 kW as vehicles become available**
- **Allocate power when demand exceeds capacity. This can be done using various priority algorithms (e.g. FIFO, lowest SOC gets most power)**

POWER/ENERGY

- Modular design enables incremental growth from minimum to full capability without power system equipment replacement
- Capability to meet a defined Level of Service
  - Urban locations
    - Simultaneous full power delivery of 20 kWh from three dispensers
    - Immediately followed by full power delivery of 20 kWh from another three dispensers
      - (Assumes a fair amount of opportunity charges)

POWER/ENERGY, cont'd

- Rural locations
  - Simultaneous full power delivery of 80 kWh from three dispensers
  - Immediately followed by full power delivery of 80 kWh from another three dispensers
    - (Assumes full, not opportunity charges)

GRID IMPACT

- Charging facility grid Load Factor[1]
  - Minimum ≥ 30%
  - Ultimate ≥ 50%
- Energy storage preferred
  - Enables demand reduction
  - Supports Load Factor compliance
  - Recycle plan must be included
    - End-of-life recycle
    - End-of-life responsibility defined
- Charge power limitation may be employed for demand reduction after minimum service level is achieved

(1) Load Factor = Monthly Peak Demand / Monthly Energy Consumed X 730

RENEWABLES

- Rural
  - 40% of actual charge energy supplied shall be renewable
  - Renewable source need NOT be co-located, but more likely to be in rural settings than urban
  - This does NOT include energy supplied to grid services or local facilities
- Urban
  - 25% of actual charge energy supplied shall be renewable
  - Renewable source need NOT be co-located

COMPLIANCE

- **Fully permitted by local authorities meeting National Electric Code standards**
- **Addresses Americans with Disabilities Act accessibility**
  - **Vehicle Parking**
  - **Dispenser Access**
  - **Access to any other Facilities**
- **Point-Of-Sale security**
  - **Payment Card Industry (PCI) Data Security Standard (DSS)**

COST FACTORS

- Costs need to account for both minimum or initial costs as well as updating to meet ultimate fast charging capability
  - Capital costs
    - For equipment, land improvements, engineering
  - Operations costs
    - Electricity (energy, access and demand)
    - Facility running costs (property lease, insurance, communications, staffing, etc.)
    - Maintenance & repairs
    - Warranty

ROUGH ORDER OF MAGNITUDE (ROM) CHARGING FACILITY CAPITAL COST

	Minimum Rural Six 50-kW	Minimum Urban Six 50-kW	Ultimate Rural Six 350-kW	Ultimate Urban Six 350-kW
Engineering	$2,000	$3,000	$2,500	$3,500
Permit	$500	$2,500	$600	$3,000
Utility interconnection cost (1)	$5,000	$10,000	$10,000	$20,000
Transformer hardware (2)	$2,500	$2,500	$6,000	$6,000
Load center and meter section (3)	$3,500	$3,500	$6,000	$6,000
Energy storage system (ESS)	$83,200(4)	$20,800(5)	$353,600(6)	$126,286(7)
Photovoltaic Energy System (40% rural & 25% urban)	$8,000(8)	$5,000(9)	$24,000(10)	$16,000(11)
DCFC unit hardware	$150,000	$150,000	$360,000	$360,000
Conduit and cables	$15,000	$15,000	$19,000	$19,000
Concrete pads materials and labor (12)	$15,000	$10,000	$15,000	$10,000
Fixed site improvements (13)	$40,000	$40,000	$40,000	$40,000
Installation costs (14)	$30,000	$30,000	$40,000	$40,000
Total	$354,700	$292,300	$876,700	$649,786

ROM CHARGING FACILITY COST (notes)

(1) Utility interconnection costs include line extension at distribution voltage

(2) Transformers are utility property, so are priced separately

(3) Separate meter section with CTs

(4) 160 kWh at 50 kW supplied by ESS. ESS cost of $400/kWh. ESS sized 30% over required energy

(5) 40 kWh at 50 kW supplied by ESS. ESS cost of $400/kWh. ESS sized 30% over required energy

(6) 389 kWh at 850 kW supplied by ESS. ESS cost of $700/kWh kWh as a result of high power requirement. ESS sized 30% over required

(7) 97 kWh at 850 kW supplied by ESS. ESS cost of $1,000/kWh kWh as a result of very high power requirement. ESS sized 30% over required

(8) 40 kW of solar providing 8 equivalent hours of energy at full power, costing $200/kW

ROM CHARGING FACILITY COST (notes), cont'd

(9) 25 kW of solar providing 8 equivalent hours of energy at full power, costing $200/kW

(10) 120 kW of solar providing 8 equivalent hours of energy at full power, costing $200/kW

(11) 80 kW of solar providing 8 equivalent hours of energy at full power, costing $200/kW

(12) Rural labor includes travel costs

(13) Costs include site preparation (excavation, boring, concrete cutting), lighting, shelter, and signage equipment and installation, curbing, asphalt paving and striping, and landscaping

(14) Costs include conduit and cabling installation, electrical equipment installation, grid connection hardware and labor

ROM MONTHLY & ANNUAL OPERATING COSTS

Cost	Rate	Minimum Capability		Ultimate Capability	
		Rural	Urban	Rural	Urban
Demand	$12/kW	$1,200[1]	$1,200[1]	$2,400[2]	$2,400[2]
Energy	12¢/kWh	$1,577[3]	$1,971[4]	$5,256[5]	$6,570[6]
Site lease	$1/sq-ft	$6,000	$6,000	$6,000	$6,000
Warranty	1%	$2,500	$1,700	$7,140	$4,860
Maintenance	$50/unit	$300	$300	$300	$300
Communications	$150	$150	$150	$150	$150
TOTAL MONTHLY	- -	$11,727	$11,321	$21,246	$20,280
TOTAL ANNUALLY		$140,724	$135,852	$254,952	$243,360

ROM OPERATING COST (notes)

(1) **Peak monthly demand = 100 kW. Higher power required to meet Service Level requirements provided by ESS.**

(2) **Peak monthly demand = 200 kW. Higher power required to meet Service Level requirements provided by ESS.**

(3) **Load Factor of 30% requires 2 charges of 80 kWh per dispenser per day. 40% of energy supplied by photovoltaic.**

(4) **Load Factor of 30% requires 6 charges of 20 kWh per dispenser per day. 25% of energy supplied by photovoltaic.**

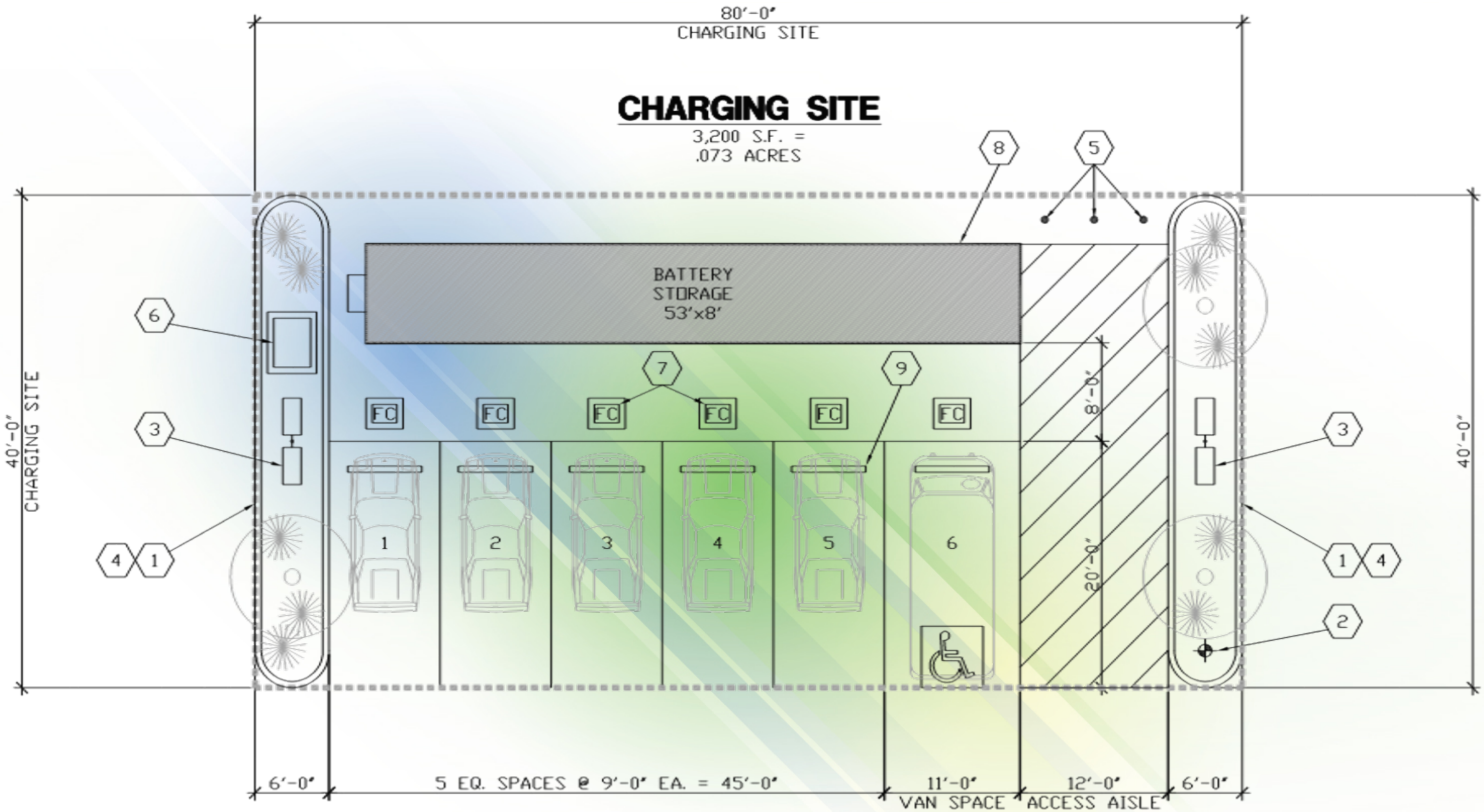
(5) **Load Factor of 50% requires 5 charges of 80 kWh per dispenser per day. 40% of energy supplied by photovoltaic.**

(6) **Load Factor of 50% requires 20 charges of 20 kWh per dispenser per day. 25% of energy supplied by photovoltaic.**

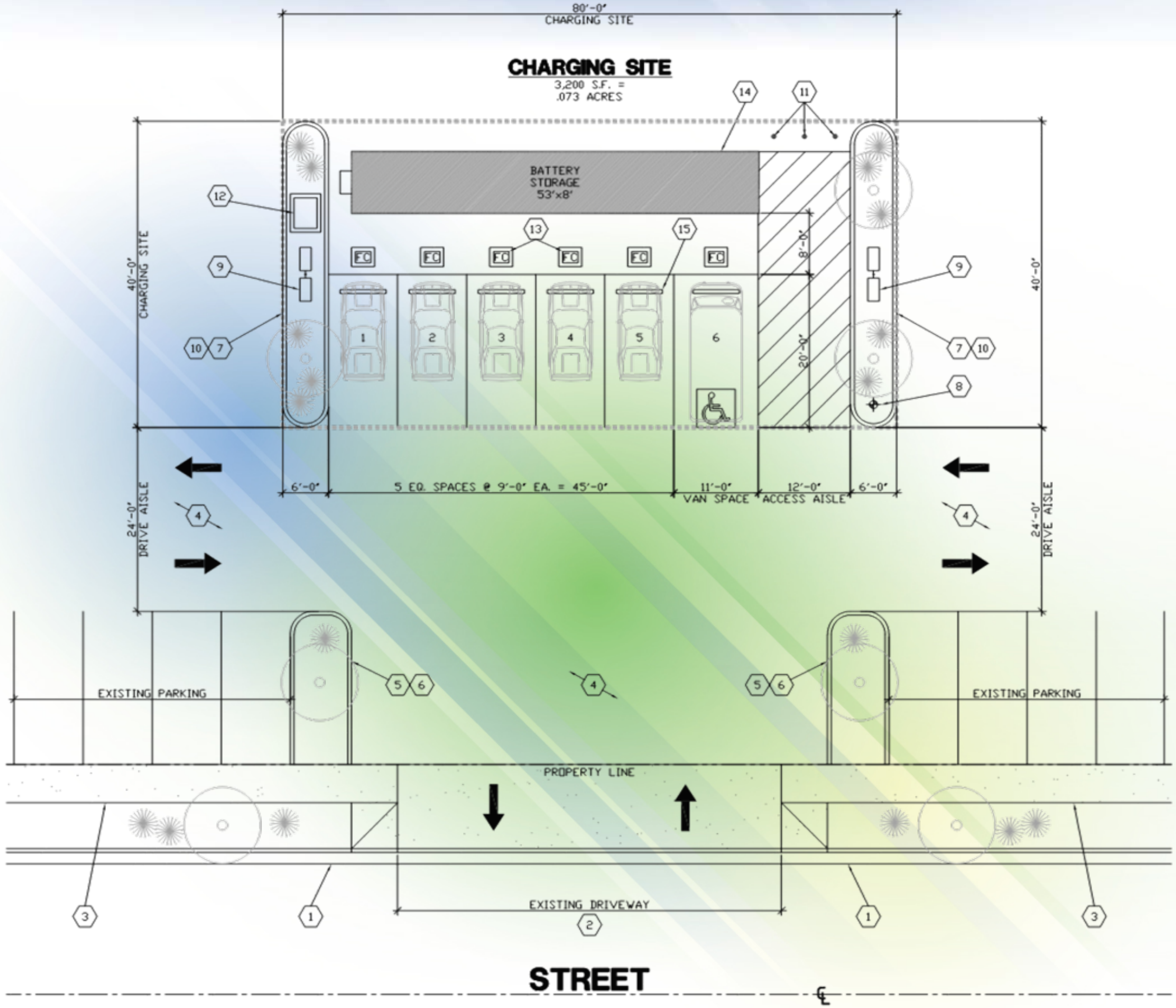
ROM POWER AND ENERGY ASSUMPTIONS FOR SIZING ENERGY STORAGE SYSTEM (ESS)

	Rural	Urban	Rural	Urban	
Dispenser Power (kW)	50	50	350	350	
Vehicle Charge Energy (kWh)	80	20	80	20	
Service Level (simultaneous vehicles)	3	3	3	3	Set the number of vehicles you want to charge simultaneously at FULL dispenser power (with maximum grid power, sizes the ESS power)
Service Level (repeats)	2	2	2	2	Set the number of times you want to repeat the Full power charges back-to-back (sizes ESS energy)
Grid Power (kW)	100	100	200	200	Set the Maximum Grid Power (limits demand charges and sizes the ESS power)
Load Factor	30%	30%	50%	50%	Set the Load Factor to something reasonable to protect the grid (with Maximum grid Power, determines how many vehicles need to be charged during the month)
Charge Demand (kW)	150	150	1,050	1,050	
ESS Power (kW)	50	50	850	850	
Minimum Grid Energy (kWh)	21,900	21,900	73,000	73,000	
Minimum Service (charges/dispenser/day)	2	6	5	20	Then the number of charges/dispenser/month reacts to Grid Power and Load Factor
Grid Energy Cost @ 12¢/kWh	$2,628	$2,628	$8,760	$8,760	
Grid Power Cost @ $12/kW/month	$1,200	$1,200	$2,400	$2,400	
ESS Capacity (kWh)	160	40	389	97.14	
ESS Cost ($/kWh)	$400	$400	$700	$1,000	
ESS System Costs ($)	$83,200	$20,800	$353,600	$126,286	

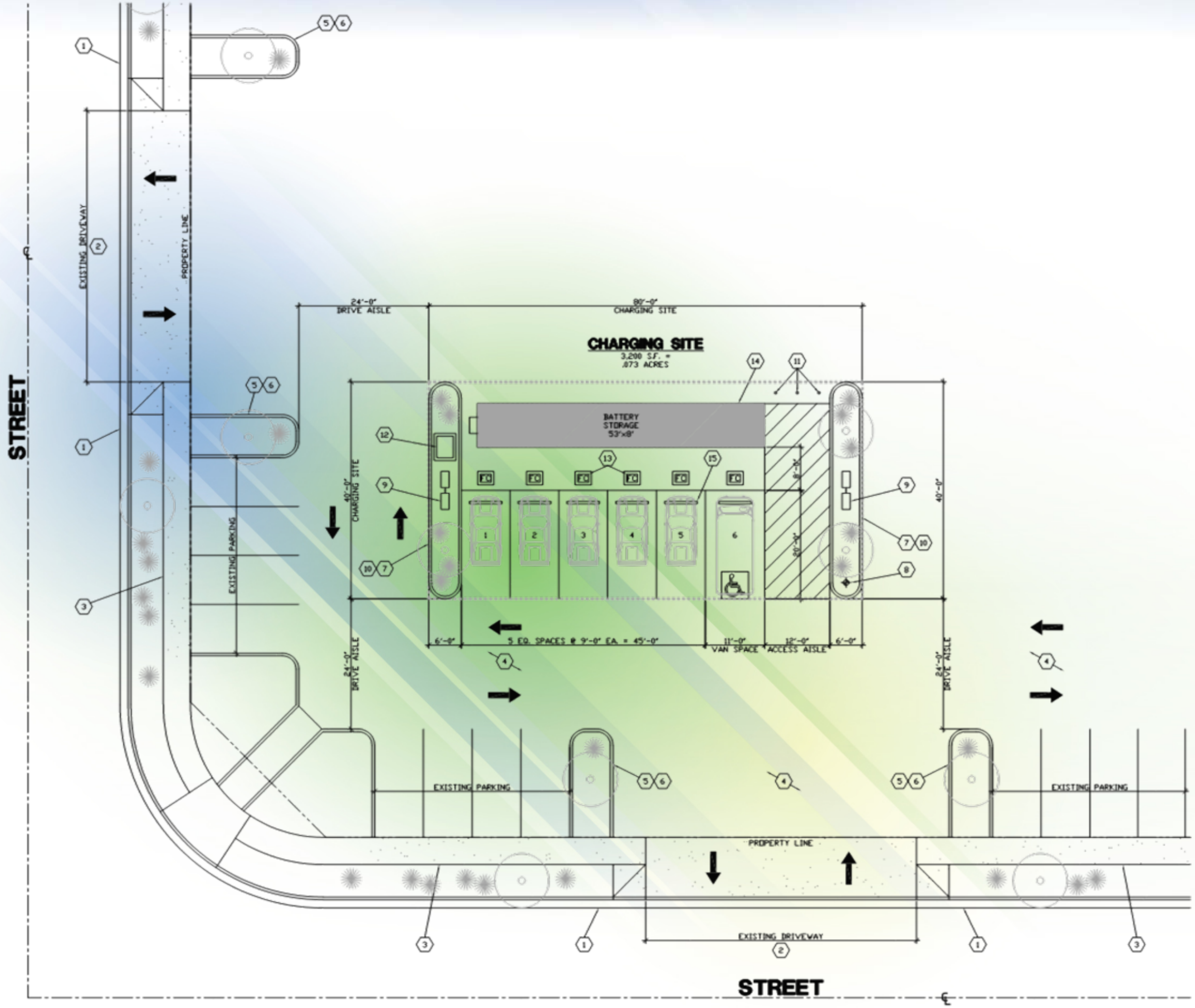
SAMPLE LAYOUTS – CHARGE ISLAND



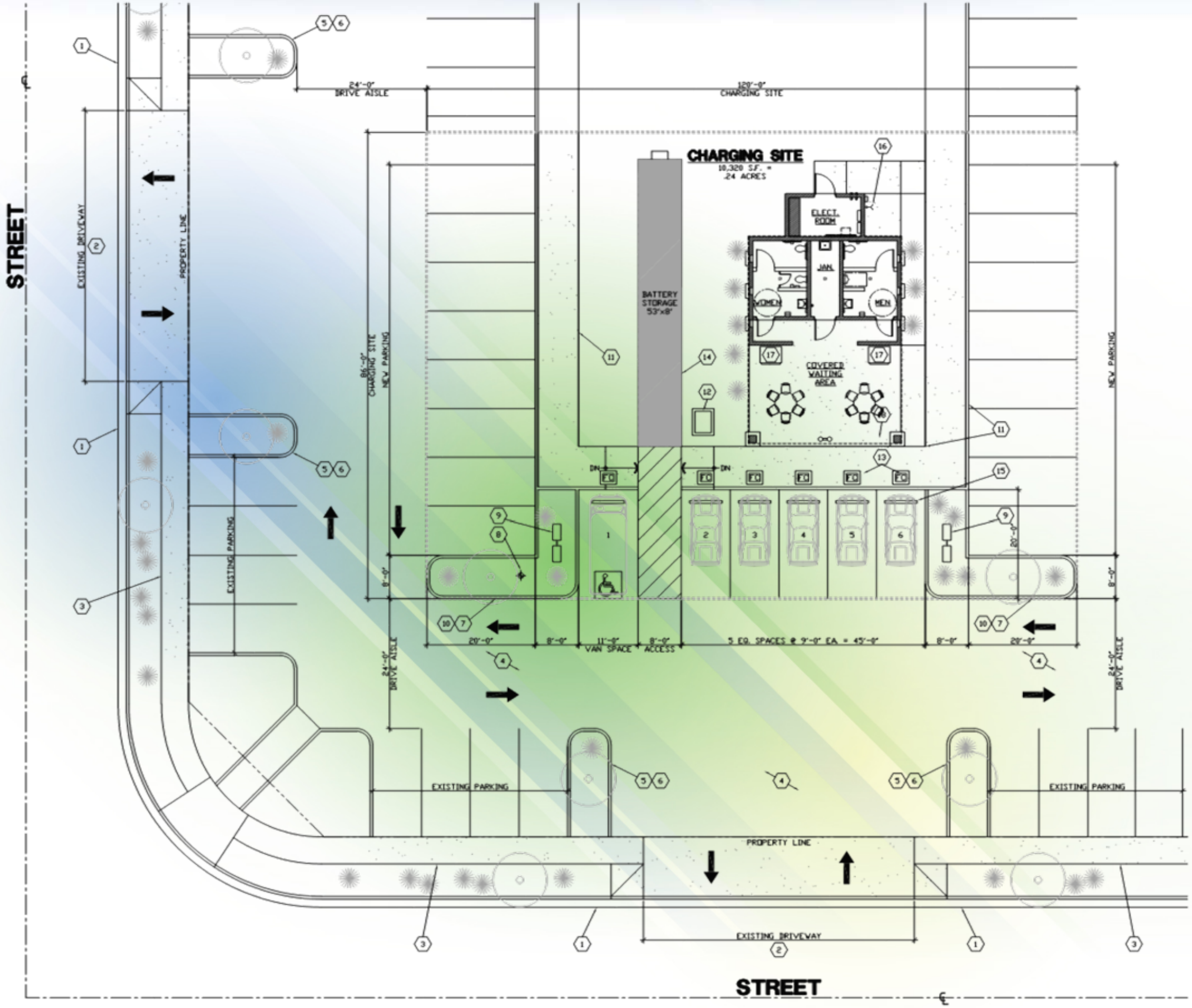
SAMPLE LAYOUTS – FRONTAGE SITE



SAMPLE LAYOUTS – CORNER SITE



SAMPLE LAYOUTS – REST AREA SITE



SUMMARY

- Comments from EPRI meeting considered
- Obtained additional input from DCFC providers in the U.S. and Europe, U.S. electric utilities, and PEV OEMs
- All hardware and subsystems are identified and costs estimated
- The most likely use cases are identified
- We defined as narrowly as possible, the ROM for costs
- The business case analysis is being performed by Atlas Public Policy

- Thank you for your attention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