Considerations for Corridor and Community DC Fast Charging Complex System Design

PI: James Francfort
Presenter: John Smart
Idaho National Laboratory

June 8, 2017

U.S. Department of Energy
Vehicle Technologies Office 2017 Annual Merit Review
And Peer Evaluation Meeting

Project ID: VAN024
INL/MIS-17-41871

Overview

Timeline

- Start: August 2016
- End: April 2017
- 100% complete

Barriers

- Infrastructure availability has long been a major barrier to plug-in electric vehicle (PEV) adoption
- Charging time is a barrier to consumer acceptance of PEVs

Budget

- Total: $150,000
  - INL: $120,000
  - EAI: $20,000
  - Atlas: $10,000

Partners

- Electric Applications Incorporated (EAI)
- Atlas Public Policy

Relevance

Example: 2017 Chevrolet Bolt, currently on sale, has an EPA-estimated range of 238 miles (www.chevrolet.com)

- Battery electric vehicles (BEVs) with larger battery packs, longer ranges are being introduced at mass-market prices

Source: media.chevrolet.com

- Larger batteries, longer range mean BEVs need faster charging infrastructure
  - Consumers are accustomed to the gasoline refueling experience (<10 minutes)
  - To fully charge long-range BEV in 10 – 20 min, it may require charge rates up to 350 kW

- This project studied the design and costs of high-power, multi-port DC fast charging complexes that provide a gas station-like experience

Objectives

Determine necessary considerations for deployment of high-power DC fast chargers (DCFCs) to provide convenient fast charging for BEV drivers

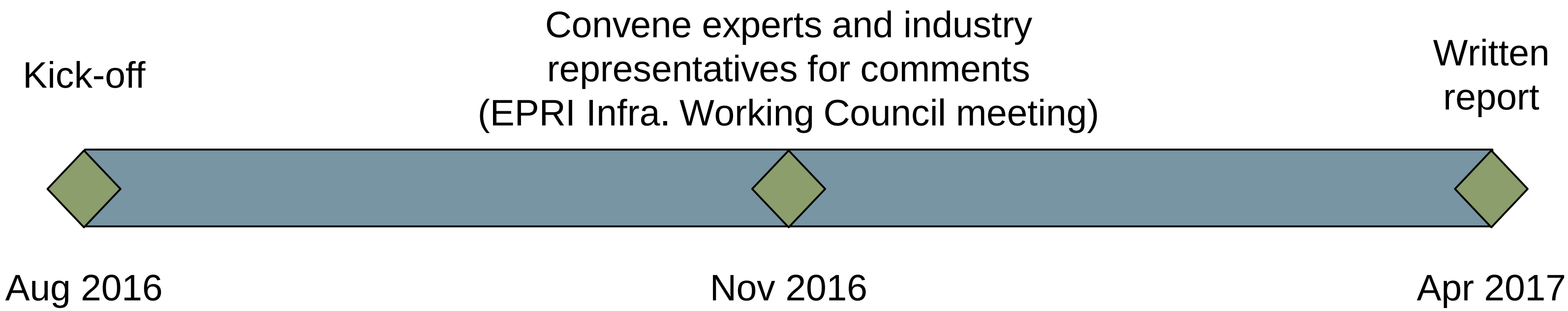
- Summarize lessons learned from previous projects
- Present general design considerations for multi-port DCFC complexes

Estimate the costs associated with deploying and operating DCFC complexes

- Perform DCFC complex design case study
- Estimate rough order of magnitude (ROM) cost
- Analyze business case

Approach

- Review previous DC fast charging projects to understand how DCFCs have been used and any issues that arose
- Identify DCFC complex system design parameters with respect to:
  - Customer usage
  - Grid impact
  - Location (rural vs. urban)
  - Strategy for system upgrades as technology evolves
- Perform DCFC complex design case study
- Use literature, prior work, personal expertise, and industry input to develop cost estimates for installing and operating hypothetical rural and urban fast charging complexes



Accomplishments

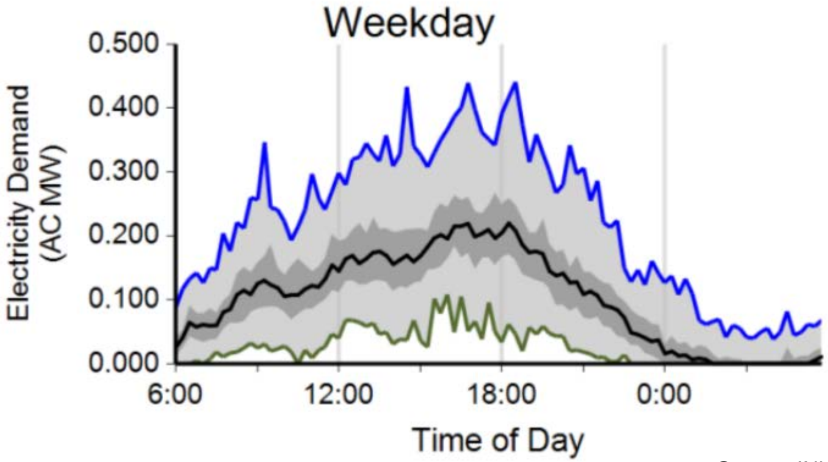
- The project was completed and a final report was published to provide a guide post for industry
- Based on simplified assumptions, overall costs can be reduced by:
  - Incorporating energy storage and onsite solar generation
  - Employing a phased upgrade strategy
- However, costs may still be too high to make a reasonable business case, based on revenue from charging alone
- High-power DCFC charging complexes may need additional revenue sources to be financially viable
- The following slides detail findings and recommendations for future work

Lessons Learned from Previous DCFC Projects

Fast charger usage:

- The most highly utilized DCFCs tended to be located close to major transportation corridors
- Most drivers used DCFC in cities on short outings, but DCFC on travel corridors proved able to extend driving range
- DCFCs were used most often between 4 pm and 7 pm, and most charges last between 5 and 25 minutes

Aggregate DCFC Charging Demand



Source: INL

Lessons Learned from Previous DCFC Projects

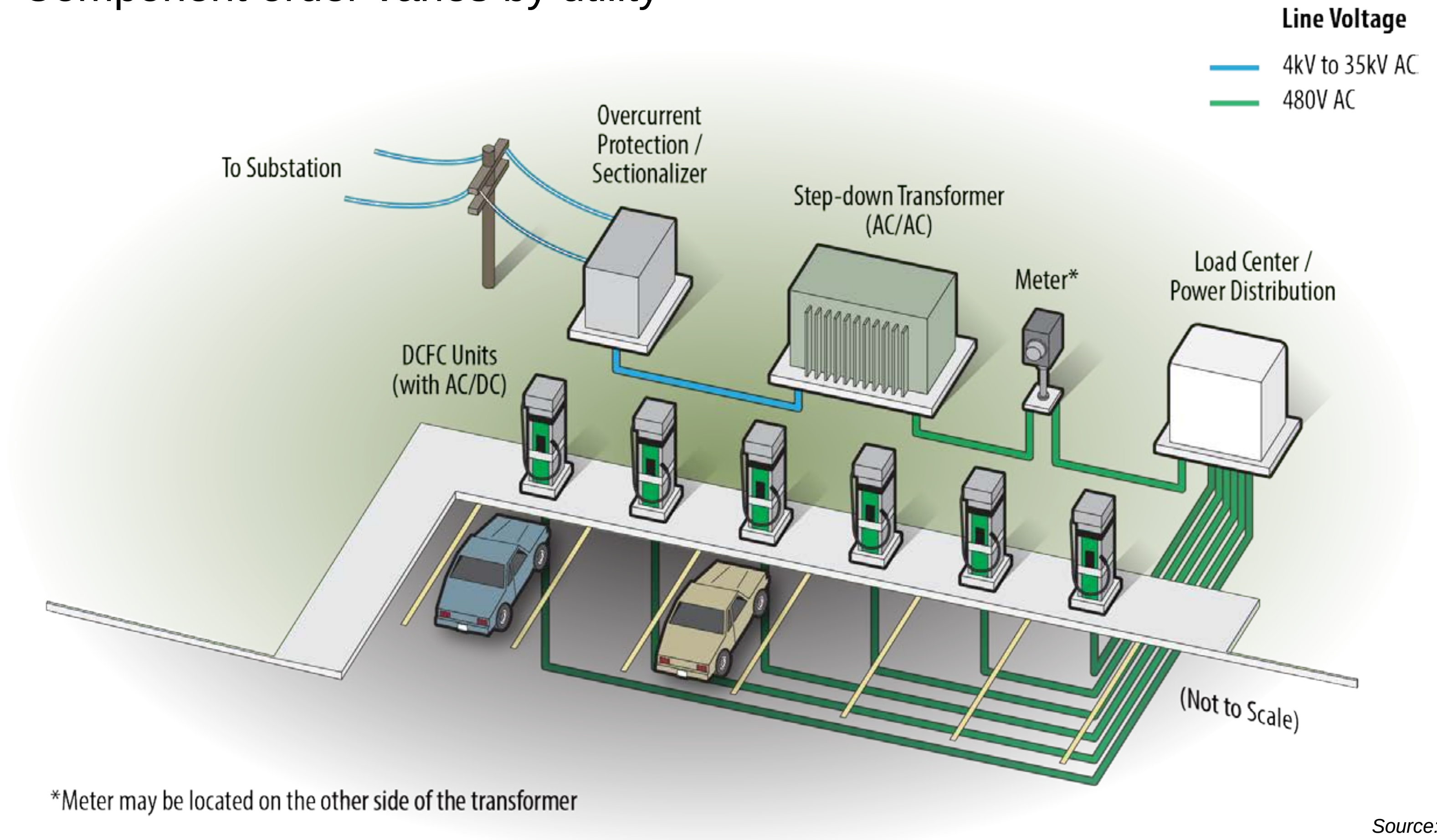
Challenges:

- Private investment in public charging is often not profitable under current market conditions
- Operating costs can be significant barrier
- Monthly electricity costs can be extremely high depending upon utility rate structures
- Capital costs are also significant
- New electrical service is often required for installation, significantly increasing site costs
- Surface and underground work (trenching, paving, etc) is one of the major cost drivers of DCFC installation

Source: INL

DCFC Complex Design Considerations

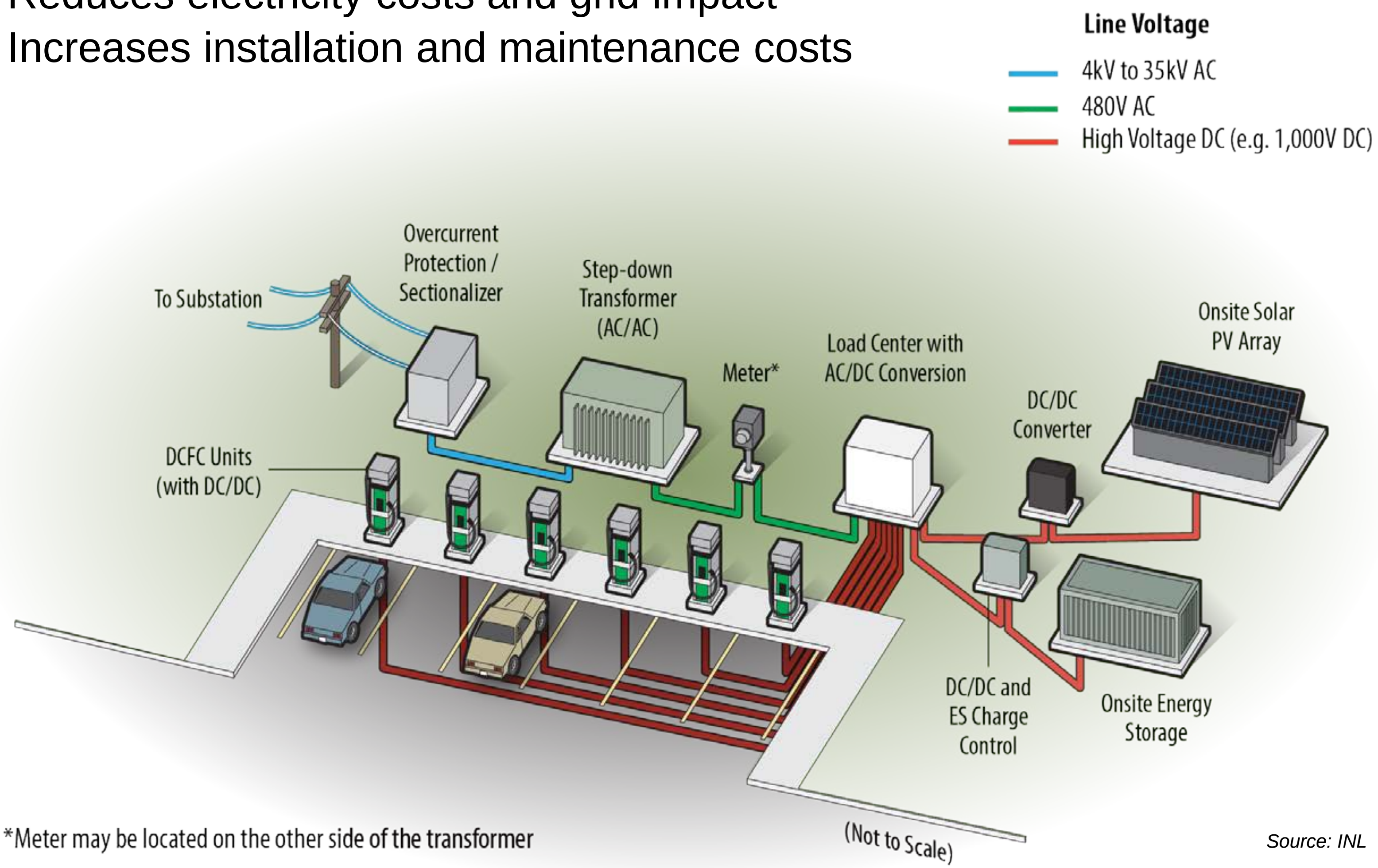
- DCFC complex design expected to include components as shown
- Component size may vary for urban vs. rural complexes
- Component order varies by utility



Source: INL

DCFC Complex Design Considerations

- On-site energy storage (ES) and photovoltaic (PV) solar generation decouples power/energy provided to vehicles from power/energy drawn from the grid
  - Reduces electricity costs and grid impact
  - Increases installation and maintenance costs



*Meter may be located on the other side of the transformer

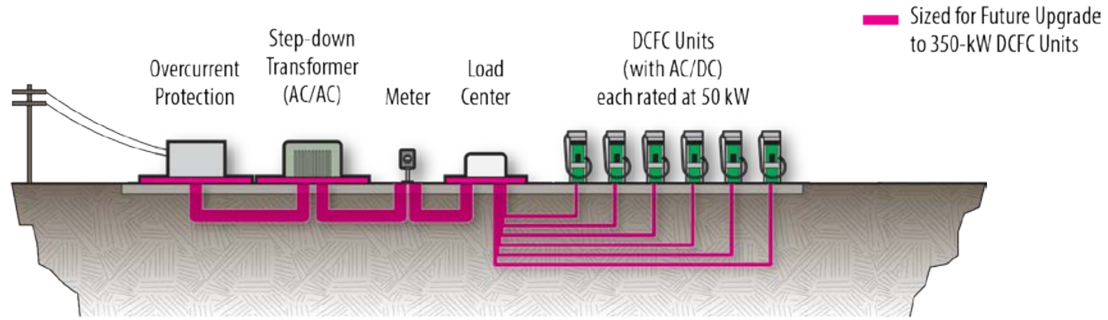
Source: INL

Upgradability

- Complex should be designed to accommodate upgrades to higher capacity
- Portions of site can be sized for future power expansion on initial install
  - Choose component size so surface/underground work (trenching, conduit, paving) only needs to be done once
  - Concrete pads, transformer vault sized for higher power to reduce cost, ensure adequate expansion space

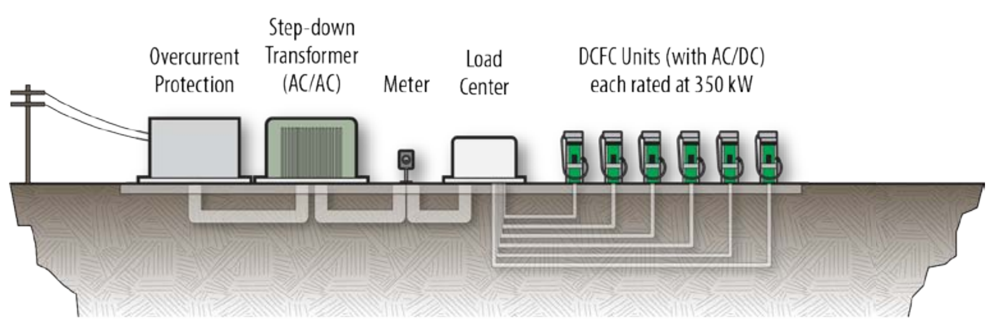
Strategy to upgrade to higher power without ES and PV

6 x 50 kW DCFC units installed but site constructed to support 6 x 350 kW units



A) DCFC complex with 50-kW chargers and no ES and PV systems

Components upgraded for 6 x 350 kW DCFC units

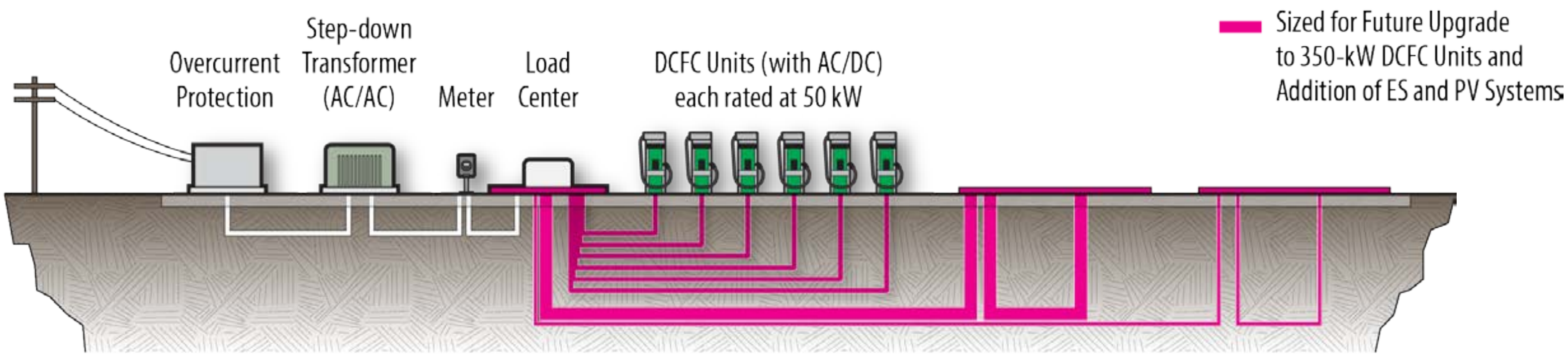


B) DCFC complex with 350-kW chargers and no ES and PV systems

Upgradability

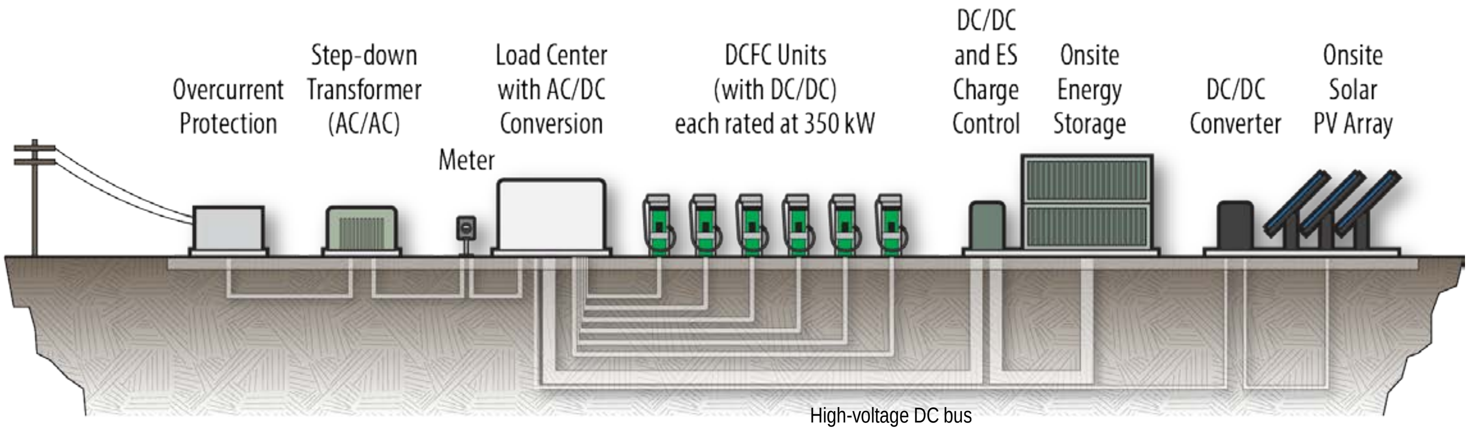
Strategy to upgrade to higher power with ES and PV

6 x 50 kW DCFC units installed but site constructed to support 6 x 350 kW units



A) DCFC complex with 50-kW chargers and no ES and PV systems at initial installation

Components upgraded for 6 x 350 kW DCFC units



B) DCFC complex with 350-kW chargers and ES and PV systems

Design Case Studies for Cost Estimation

- Designs were chosen for hypothetical DCFC complexes in order to estimate capital and operating costs
- “Minimum” and “Ultimate” capability requirements were specified to approximate short-term and future scenarios
- Customer demand was based on load factor (i.e. energy/demand) of 30%, an ideal case for minimal grid impact

	Minimum Capability	Ultimate Capability
# of Charge Units	6 charge units	6 charge units
Charge Power	50 kW	350 kW
Grid Power Supply w/o Energy Storage	160 kW	1,060 kW
Grid Power Supply w/ Energy Storage	110 kW	210 kW

Cost Comparison

- Developed ROM cost estimates for station capital cost and operating cost
- Given the assumptions used,
  - For minimum capability, it is more cost-effective without ES and PV
  - For ultimate capability, it is cheaper to use ES and PV and keep grid power low

Minimum Capability – Six 50 kW					
		Rural Corridor		Urban Community	
Design Configuration	Maximum Grid Power (kW)	Capital Cost	Annual Operating Cost	Capital Cost	Annual Operating Cost
With ES and PV	110	$574,500	$170,600	$502,000	$163,000
Without ES and PV	160	$392,000	$170,700	$385,500	$165,500
Difference		-$182,500	$100	-$116,500	$2,500

Does not pay back

Does not pay back

Ultimate Capability – Six 350 kW					
		Rural Corridor		Urban Community	
Design Configuration	Maximum Grid Power (kW)	Capital Cost	Annual Operating Cost	Capital Cost	Annual Operating Cost
With ES and PV	210	$2,030,500	$389,000	$1,636,500	$343,000
Without ES and PV	1,060	$1,728,000	$514,500	$1,721,500	$500,500
Difference		-$302,500	$125,500	$85,000	$157,500

~3 year pay-back period

Favorable costs

Business Case Analysis

- Cases for urban and rural complexes using 50 kW and 350 kW chargers were analyzed using tool developed by Atlas Public Policy
- In the cases studied, break-even cost per kWh was calculated:

Financing Period	Customer Cost metric	Minimum Rural Six 50-kW	Minimum Urban Six 50-kW	Ultimate Rural Six 350-kW	Ultimate Urban Six 350-kW
5 Years	Electricity Cost ($/kWh)	$0.88	$0.93	$1.04	$1.01
	Equivalent Gasoline Cost ($/gal)*	$7.54	$7.91	$8.91	$8.65
10 Years	Electricity Cost ($/kWh)	$0.69	$0.73	$0.77	$0.76
	Equivalent Gasoline Cost ($/gal)*	$5.91	$6.25	$6.60	$6.51

* Based on 30 mpg vehicle

- Other revenue streams may be necessary
  - On-site sales (e.g. gas station model)
  - Investment through public and/or private partnership

***** CAUTION *****

Refinement of assumptions and design optimization strongly recommended

Response to Previous Reviewers' Comments

- This project was not reviewed in previous years

Collaboration and Coordination

- INL is the lead on this project
- Electric Applications Incorporated
  - Developed ROM cost estimation tool
- Atlas Public Policy
  - Performed business case analysis

Remaining Challenges and Barriers

- Low-cost design of fast charging complexes requires understanding consumer charging demand, which is dependent upon many factors and requires more research
- DCFC complex design is location-specific and requires site-by-site optimization and coordination with the utility
- Impact of charging demand on the electric grid could be significant and should also be studied
- Electric utility engagement is required to determine whether rate structure can be or should be modified

Proposed Future Research

- This project is complete
- A follow-on study has been launched to:
  - Improve assumptions for customer usage
  - Perform DCFC complex design optimization using sophisticated tools to minimize cost
  - Repeat business case analysis based on lowest-cost designs and considering a network of complexes
  - Engage electric utilities about demand charges (major component of operating cost)

Summary

- As BEV battery capacity and driving range increase, the importance of fast charging infrastructure also increases
- Design considerations were determined for high-power, multi-port DCFC complexes that could meet this need
- A case study based on current assumptions was developed for urban and rural DCFC complexes
  - Hypothetical charging complexes designed
  - Rough-order-of-magnitude cost estimates performed
  - Business case analyzed for 50 kW and 350 kW complexes
- Profitability of DCFC complexes is difficult given the assumptions from this case study
  - Further research is necessary

Technical Back-Up Slides

Complex Design Parameters (w/ ES and PV)

Demand Metric	Minimum		Ultimate	
	Corridor	Community	Corridor	Community
Average vehicle charge energy per session (kWh)	80	20	80	20
Average daily number of charge sessions per port	2.0	6.9	4.8	16.5
Average daily number of charge sessions per complex	11.8	41.2	28.8	99.2
Minimum load factor	30%	30%	30%	30%

Performance Criteria	Minimum		Ultimate	
	Corridor	Community	Corridor	Community
Level of Service Requirements				
Maximum number of vehicles charging simultaneously	3	3	3	3
Maximum number of consecutive sets of vehicles	2	2	2	2
Power Requirements				
Peak DCFC unit power output to PEV (kW/port)	50	50	350	350
Peak coincident DCFC unit power to PEVs (kW/complex)	150	150	1,050	1,050
Complex “house” load demand from grid (kW)(1)	10	10	10	10
Peak ES system power output (kW)	50	50	850	850
Peak power drawn from the grid (kW)	110	110	210	210
Energy Consumption Based On Monthly Consumer Demand				
Energy consumed by PEVs (kWh/mo)	28,713	25,063	70,080	60,347
Complex “house” load factor	70%	70%	70%	70%
Energy consumed by “house” load (kWh/mo)	5,110	5,110	5,110	5,110
Total energy consumed by complex (kWh/mo)	33,823	30,173	75,190	65,457
Grid energy consumed (kWh/mo)	24,090	24,090	45,990	45,990
PV energy generated (kWh/mo)	9,733(2)	6,083(3)	29,200(4)	19,467(5)
Percent of energy generated by PV	29%	20%	39%	30%
Energy Storage Requirements				
ES capacity (kWh)(6)	208	52	505	126

1 Complex “house” loads are the electrical loads required to operate the DCFC complex. These loads represent power/energy demand from the grid in addition to power/energy transferred to vehicles during charging.

2 40 kW of solar providing 8 equivalent hours of energy at full power per day

3 25 kW of solar providing 8 equivalent hours of energy at full power per day

4 120 kW of solar providing 8 equivalent hours of energy at full power per day

5 80 kW of solar providing 8 equivalent hours of energy at full power per day

6 ES capacity required to meet level of service requirements plus 30% additional capacity

Capital and Operating Costs (w/ ES and PV)

Capital costs

Cost Components With ES and PV	Minimum Corridor Six 50-kW	Minimum Community Six 50-kW	Ultimate Corridor Six 350-kW	Ultimate Community Six 350-kW
Engineering[1]	$3,000	$5,000	$4,000	$6,000
Permit[2]	$1,000	$3,000	$1,500	$4,500
Utility interconnection cost[3]	$20,000	$20,000	$20,000	$20,000
Load center and meter section[4]	$5,500	$5,500	$5,500	$5,500
AC/DC conversion[5]	$100,000	$100,000	$200,000	$200,000
ES system	$83,000[6]	$21,000[7]	$505,000[8]	$126,000[9]
PV system	$8,000[10]	$5,000[11]	$24,000[12]	$16,000[13]
DCFC unit hardware[14]	$150,000	$150,000	$1,050,000	$1,050,000
Conduit and cables[15]	$12,000	$12,000	$15,000	$15,000
Concrete pads material and labor[16]	$19,000	$14,000	$20,000	$15,000
Accessory materials[17]	$12,500	$12,500	$12,500	$12,500
Site surface and underground work[18]	$50,000	$50,000	$50,000	$50,000
Fixed site improvements[19]	$40,000	$40,000	$40,000	$40,000
Equipment installation costs[20]	$40,000	$40,000	$50,000	$50,000
Project management	$30,500[21]	$24,000[22]	$33,500[21]	$26,000[22]
Total	**$574,500**	**$502,000**	**$2,030,500**	**$1,636,500**

Operational costs

Cost Components With ES and PV	Rate	Minimum Capability		Ultimate Capability	
		Corridor	Community	Corridor	Community
Grid demand	$12/kW	$1,320[1]	$1,320[1]	$2,520[2]	$2,520[2]
Grid energy[3]	$0.12/kWh	$2,891[4]	$2,891[5]	$5,519[6]	$5,519[7]
Site lease	$1/sq-ft	$6,000	$6,000	$6,000	$6,000
Equipment warranty[8]	1%/mo	$3,410	$2,760	$17,790	$13,920
Site maintenance[9]	$50/unit	$450	$450	$450	$450
Communications	$150	$150	$150	$150	$150
TOTAL MONTHLY COST	- -	**$14,221**	**$13,571**	**$32,428**	**$28,558**

See next slide for notes

Capital and Operating Costs (w/ ES and PV)

1 Costs include civil, structural and electrical engineering and assume significant reuse of non-site specific work from others
2 Local permit and inspection fees
3 Utility interconnection costs include overhead line extension (2 poles) at distribution voltage and 300kVA distribution transformer
4 600A load center with six fused disconnects and separate meter section with current transformers
5 AC/DC converter hardware at $1.00/W
6 208 kWh at 50 kW supplied by ES; ES cost of $400/kWh, ES sized 30% over required energy
7 52 kWh at 50 kW supplied by ES; ES cost of $400/kWh, ES sized 30% over required energy
8 505 kWh at 850 kW supplied by ES; ES cost of $1,000/kWh as a result of high power requirement, ES sized 30% over required
9 126 kWh at 850 kW supplied by ES; ES cost of $1,000/kWh as a result of very high power requirement, ES sized 30% over required
10 40 kW of solar providing 8 equivalent hours of energy at full power, costing $200/kW
11 25 kW of solar providing 8 equivalent hours of energy at full power, costing $200/kW
12 120 kW of solar providing 8 equivalent hours of energy at full power, costing $200/kW
13 80 kW of solar providing 8 equivalent hours of energy at full power, costing $200/kW
14 DCFC unit hardware only at $0.50/W (DC/DC system)
15 Material only for underground and exposed conduit and all power and control cabling based on DCFC complex configuration shown in Figure 10
16 Pads and curbs based on DCFC complex configuration shown in Figure 10 (corridor includes travel costs)
17 Materials include lighting (per Figure 10), landscape plants and irrigation materials, signage and bollards
18 Costs include grading, trenching/boring, pavement cutting, backfill and surface patching
19 Costs include lighting and signage installation, pavement striping, bollard and irrigation system installation, and landscaping planting
20 Cost include DCFC and ancillary electrical equipment installation
21 15% of material, labor and subcontract costs (no ES, PV or DCFC equipment cost included)
22 12% of material, labor and subcontract costs (no ES, PV or DCFC equipment cost included)

1 Peak monthly demand = 100 kW from DCFC plus 10 kW complex “house” loads. Higher power required to meet service level requirements provided by ES
2 Peak monthly demand = 200 kW from DCFC plus 10 kW complex “house” loads. Higher power required to meet service level requirements provided by ES
3 Includes energy from complex “house” loads
4 Load factor of 30% requires 2.0 charges of 80 kWh per port per day, including use of 40% of energy supplied by PV
5 Load factor of 30% requires 6.9 charges of 20 kWh per port per day, including use of 40% of energy supplied by PV
6 Load factor of 30% requires 4.8 charges of 80 kWh per port per day, including use of 25% of energy supplied by PV
7 Load Factor of 30% requires 16.5 charges of 20 kWh per port per day, including use of 25% of energy supplied by PV
8 1% of major equipment cost (ES, PV, DCFC, and AC/DC)
9 Total of nine units (six DCFC and one each of ES, PV, and AC/DC)

Complex Design Parameters (w/out ES and PV)

Demand Metric	Minimum		Ultimate	
	Corridor	Community	Corridor	Community
Average vehicle charge energy per session (kWh)	80	20	80	20
Average daily number of charge sessions per port	2.0	6.9	4.8	16.5
Average daily number of charge sessions per complex	11.8	41.2	28.8	99.2
Resulting load factor	27%	24%	9%	8%

Performance Criteria	Minimum		Ultimate	
	Corridor	Community	Corridor	Community
Level of Service Requirements				
Maximum number of vehicles charging simultaneously	3	3	3	3
Maximum number of consecutive sets of vehicles	None	None	None	None
Power Requirements				
Peak DCFC unit power output to PEV (kW/port)	50	50	350	350
Peak coincident DCFC unit power to PEVs (kW/complex)	150	150	1,050	1,050
Complex “house” load demand from grid (kW)	10	10	10	10
Peak ES system power output (kW)	0	0	0	0
Peak power drawn from the grid (kW)	160	160	1,060	1,060
Energy Consumption Based On Monthly Consumer Demand				
Energy consumed by PEVs (kWh/mo)	28,713	25,063	70,080	60,347
Complex “house” load factor	70%	70%	70%	70%
Energy consumed by “house” load (kWh/mo)	5,100	5,100	5,100	5,100
Total energy consumed by complex (kWh/mo)	33,823	30,173	75,190	65,457
Grid energy consumed (kWh/mo)	33,823	30,173	75,190	65,457
PV energy generated (kWh/mo)	0	0	0	0
Percent of energy generated by PV	0%	0%	0%	0%
Energy Storage Requirements				
ES capacity (kWh)	0	0	0	0

Capital and Operating Costs (w/out ES and PV)

Capital costs

Cost Components With Energy Storage	Minimum Corridor Six 50-kW	Minimum Community Six 50-kW	Ultimate Corridor Six 350-kW	Ultimate Community Six 350-kW
Engineering[1]	$3,000	$5,000	$4,000	$6,000
Permit[2]	$1,000	$3,000	$1,500	$4,500
Utility interconnection cost	$20,000[3]	$20,000[3]	$41,500[4]	$41,500[4]
Load center and meter section	$5,500[5]	$5,500[5]	$15,000[6]	$15,000[6]
AC/DC conversion[7]	$0	$0	$0	$0
ES system[8]	$0	$0	$0	$0
PV system[9]	$0	$0	$0	$0
DCFC unit hardware	$180,000[10]	$180,000[10]	$1,470,000[11]	$1,470,000[11]
Conduit and cables[12]	$10,000	$10,000	$14,000	$14,000
Concrete pads material and labor[13]	$15,000	$10,000	$16,000	$11,000
Accessory materials[14]	$12,500	$12,500	$12,500	$12,500
Site surface and underground work[15]	$40,000	$40,000	$40,000	$40,000
Fixed site improvements[16]	$40,000	$40,000	$40,000	$40,000
Equipment installation costs[17]	$35,000	$35,000	$40,000	$40,000
Project management	$27,500[18]	$21,500[19]	$33,500 [18]	$27,000[19]
Total	**$389,500**	**$382,500**	**$1,728,000**	**$1,721,500**

Operational costs

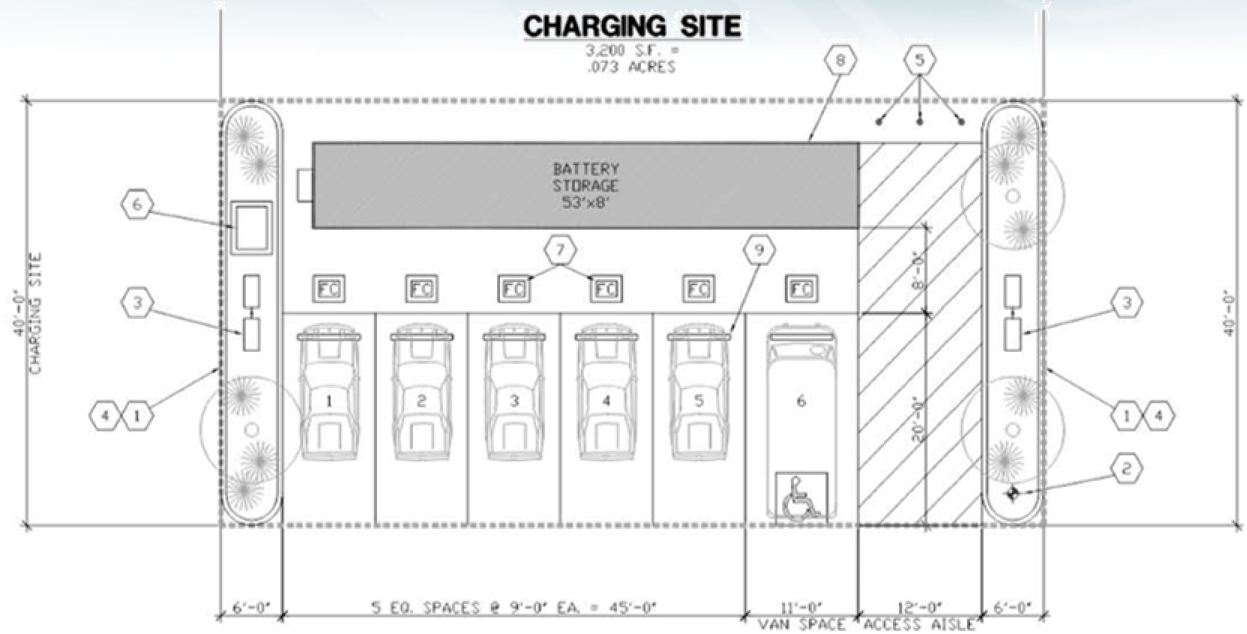
Cost Components Without Energy Storage	Rate	Minimum Capability		Ultimate Capability	
		Corridor	Community	Corridor	Community
Grid demand	$12/Kw	$1,920[1]	$1,920[1]	$12,720[2]	$12,720[2]
Grid energy[3]	$0.12/kWh	$4,059[4]	$3,621[5]	$9,023[6]	$7,855[7]
Site lease	$1/sq-ft	$6,000	$6,000	$6,000	$6,000
Equipment warranty[8]	1%	$1,800	$1,800	$14,700	$14,700
Site maintenance	$50/unit	$300	$300	$300	$300
Communications	$150	$150	$150	$150	$150
TOTAL MONTHLY COST	- -	**$14,229**	**$13,791**	**$42,893**	**$41,725**

See next slide for notes

Capital and Operating Costs (w/out ES and PV)

1 Costs include civil, structural and electrical engineering and assume significant reuse of non-site specific work from other sites
2 Local permit and inspection fees
3 Utility interconnection costs include overhead line extension (2 poles) at distribution voltage and 300 kVA distribution transformer
4 Utility interconnection costs include overhead line extension (2 poles) at distribution voltage and 1,500 kVA distribution transformer
5 600A load center with six fused disconnects and separate meter section with current transformers
6 2,000A load center with six fused disconnects and separate meter section with current transformers
7 No AC/DC converter installed
8 No ES installed
9 No PV installed
10 DCFC unit hardware only at $0.60/W (AC/DC system)
11 DCFC unit hardware only at $0.70/W (AC/DC system)
12 Material only for underground and exposed conduit and all power and control cabling based on DCFC complex configuration shown in Figure 10
13 Pads and curbs based on DCFC complex configuration shown in Figure 10 (corridor includes travel costs)
14 Materials include lighting (per Figure 10), landscape plants and irrigation materials, signage and bollards
15 Costs include grading, trenching/boring, pavement cutting, backfill and surface patching
16 Costs include lighting and signage installation, pavement striping, bollard and irrigation system installation, and landscaping planting
17 Cost include DCFC and ancillary electrical equipment installation
18 15% of material, labor and subcontract costs (no DCFC equipment cost included)
19 12% of material, labor and subcontract costs (no DCFC equipment cost included)

1 Peak monthly demand = 150 kW from DCFC plus 10 kW complex “house” loads. Higher power required to meet service level requirements provided by ES
2 Peak monthly demand = 1,050 kW from DCFC plus 10 kW complex “house” loads. Higher power required to meet service level requirements provided by ES
3 Includes energy from complex “house” loads
4 Customer demand assumed at 2.0 charges of 80 kWh per port per day
5 Customer demand assumed at 6.9 charges of 20 kWh per port per day
6 Customer demand assumed at 14.8 charges of 80 kWh per port per day
7 Customer demand assumed at 16.5 charges of 20 kWh per port per day
8 1% of DCFC equipment cost



ISLAND EXHIBIT

SCALE: 1"=10.00'

** ISLAND SCHEME ASSUMES FLUSH CONDITION AT PAVING WITH NO SIDEWALK RAMPING

KEY NOTES

1. NEW LANDSCAPED PLANTER AREA
2. NEW FIRE HYDRANT
3. NEW PARKING LOT SITE LIGHTING
4. NEW 6" HIGH CONCRETE CURB
5. 8" DIAMETER CONCRETE FILLED PIPE BOLLARD – TYPICAL
6. NEW PAD MOUNTED ELECTRICAL TRANSFORMER
7. NEW FAST CHARGER DISPENSER FOR ELECTRIC VEHICLES – TYPICAL OF 6 LOCATIONS
8. NEW BATTERY STORAGE CONTAINER
9. NEW CONCRETE WHEEL STOP – TYPICAL OF 6 LOCATIONS

SITE DESIGN CRITERIA

CHARGING SITE AREA:	3,200 S.F. (.073 ACRES)
CHARGER DISPENSER PARKING PROVIDED:	6 SPACES INCLUDING 1 VAN ACCESSIBLE SPACE
TYPICAL PARKING SPACE SIZE:	9'-0" WIDE X 20'-0" LONG
ACCESSIBLE VAN SPACE SIZE:	11'-0" WIDE X 20'-0" LONG
ACCESSIBLE VAN AISLE WIDTH:	9'-0" MINIMUM WIDTH
DRIVE AISLE – FOR TWO WAY TRAFIC ON-SITE:	24'-0" MINIMUM WIDTH

Idaho National Laboratory

Reviewer-Only Slides

Publications and Presentations

- Graham, R., Francfort, J., Garetson, T. “US DOE – US DOT Corridor and Community DC Fast Charging Complex,” Presentation to EPRI Infrastructure Working Council, November 2016.
- Francfort, J., Salisbury, S., Smart, J., Karner, D., Garetson, T., “Considerations for Corridor and Community DC Fast Charging Complex System Design,” INL Technical Report INL/EXT-17-40829, April 2017.

Critical Assumptions and Issues

- Numerous design assumptions were made:
  - Charge power levels that vehicles will draw in the future
  - Capital/installation and maintenance costs of DCFC units and energy storage systems
  - Level of customer demand for charging
- It is assumed that vehicles in the future will be able to charge at up to 350 kW

Questions?

Contact us by email:

John.Smart@inl.gov

Or contact us by phone:

John Smart – (208) 526-5922