EVS 27

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Barcelona, Spain
17th-20th November 2013

DC Fast Charging - Where do we Stand?

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EVS 27, Barcelona, Spain

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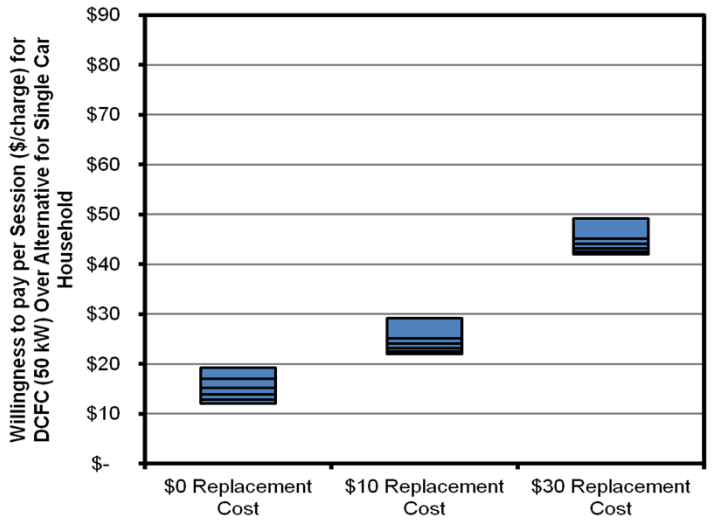
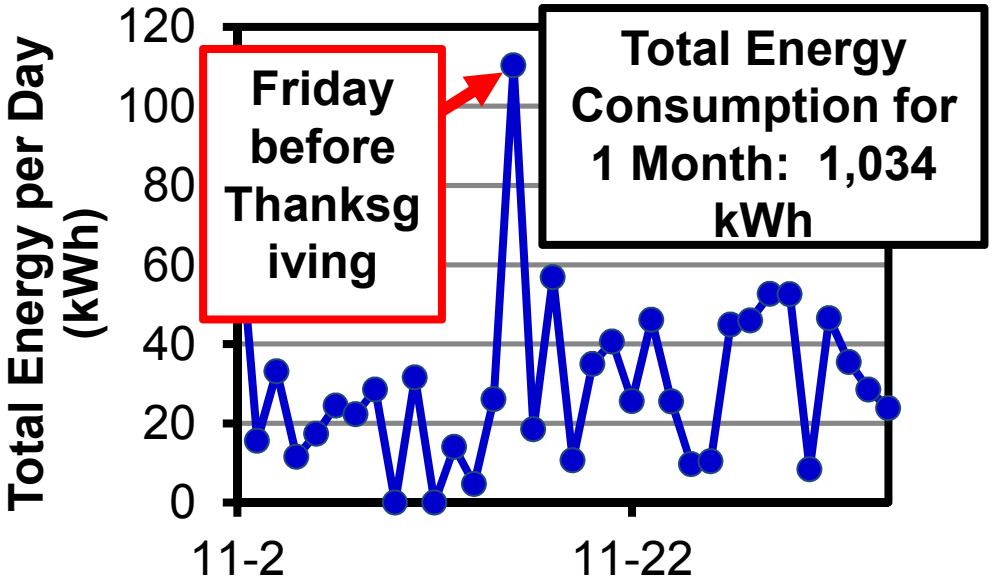
Fira Barcelona avele AVERE mea Ajuntament de Barcelona EVAAP EDTA European Commission

Public Charging May Address “Range Anxiety”

- Fast charging requires high power
- Unique challenges in terms of infrastructure, operational cost due to demand charges
- Creating a sustainable business case will require economics that match utilization.
- Simple and convenient solution has potential to strengthen range confidence; address psychological “barrier”
- Planned in coordination with home and work place charging solutions in region
- Potential to increase traffic for some retail locations

Market for DCFC is Small & Location Dependent





- Most energy is still likely to be transferred at home
- Location is everything – I-5 San Diego/LA corridor DCFC sees heavy traffic
- Consumers are willing to pay (on average) between $10-20/charge

DC Fast Charge Connectors in US

SAE Combo

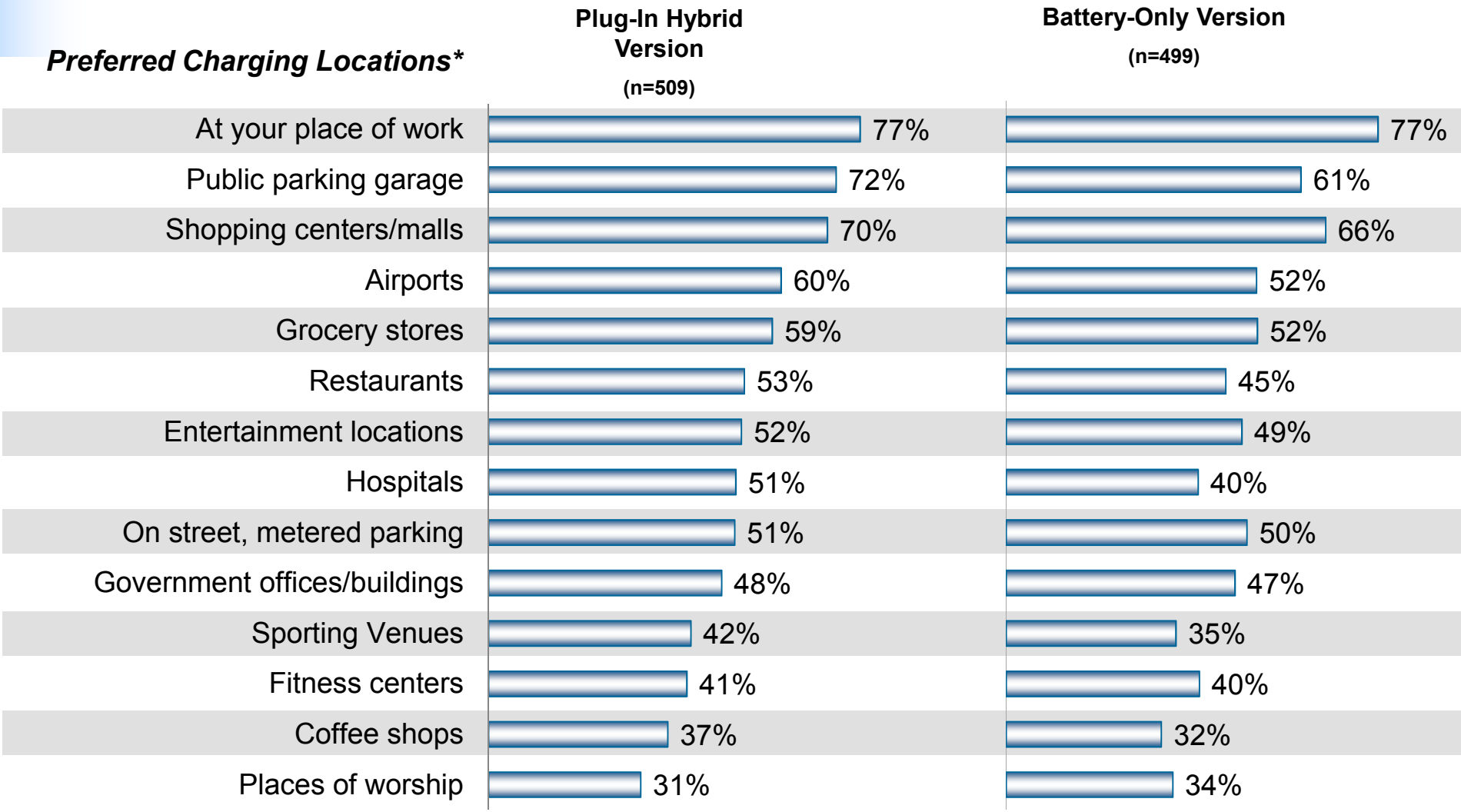
CHAdeMO

Tesla

Current Status of DC Fast Charging in US

- Public DC fast charger deployments in the North America:
  - ***CHAdeMO***: A DC charging protocol developed and adopted as a standard in Japan; limited to approximately 50kW
  - ***Tesla Supercharger***: a proprietary protocol developed by Tesla Motors; 120kW
- Approximately 200 CHAdeMO chargers deployed in the US
- Tesla has deployed eight Supercharger stations in the US, some with multiple fast chargers, with plans to deploy more than two dozen additional stations by late 2013
- Products that include the US Standard SAE Combo connector are expected by the end of 2013
  - Chevy Spark and BMW i3 are first vehicles expected to use Combo

Charging Preferences



** Preferred charging locations are based on 3-hour charging for the Plug-In Hybrid Version and 8-hour charging for the Battery-Only Version.*

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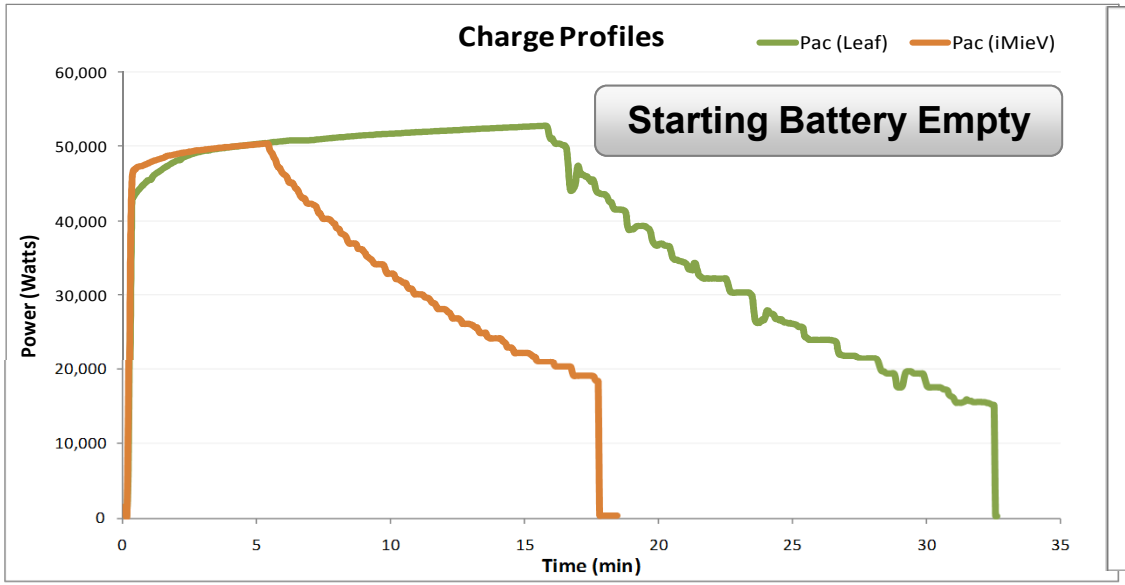
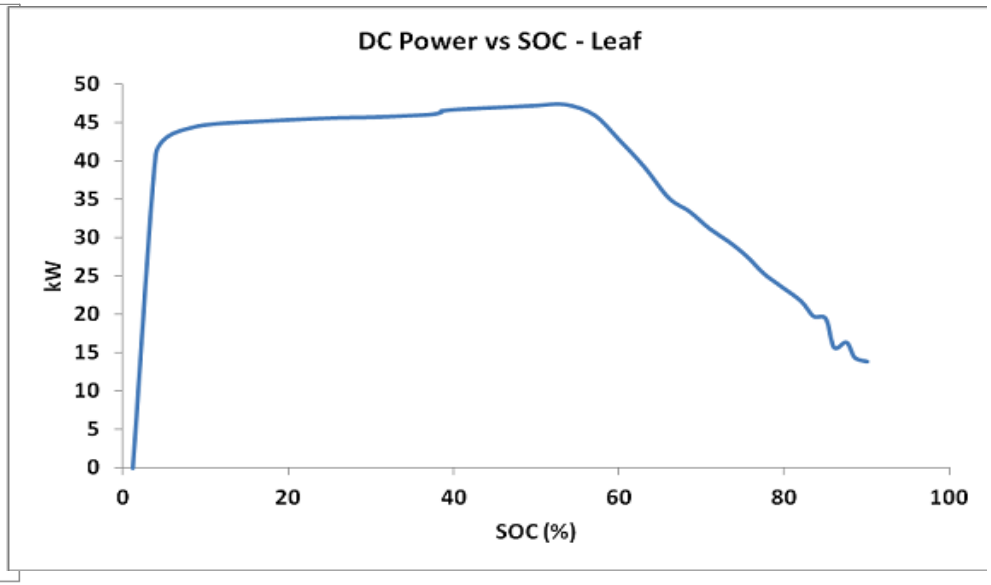
Charge Profiles using Eaton 50KW Charger





Eac(Leaf) = 21.28KWh

Eac(iMieV) = 10.47KWh

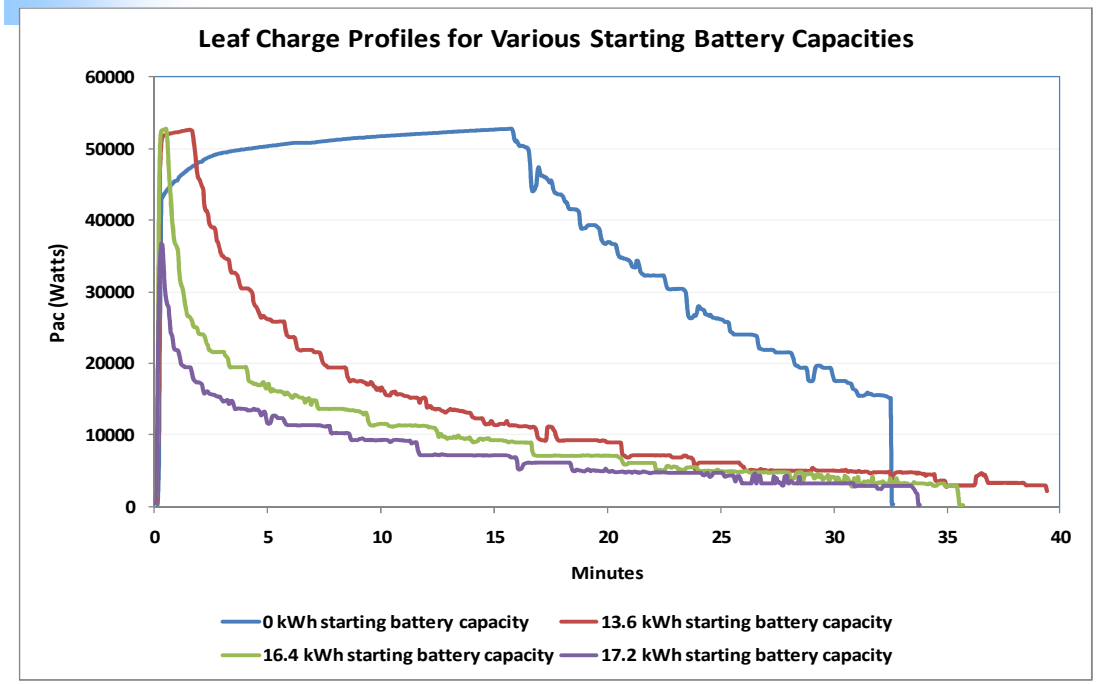
Eac(Leaf) = 13.15KWh

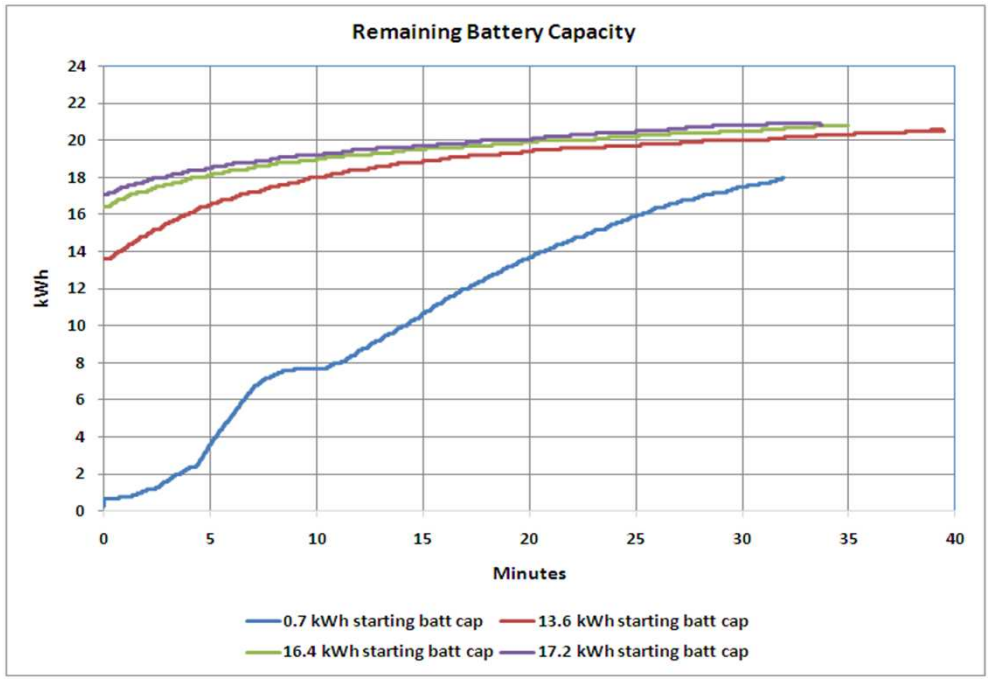
Eac(iMieV) = 4.16KWh

Eac(Leaf) = 8.14KWh

Eac(iMieV) = 6.30KWh

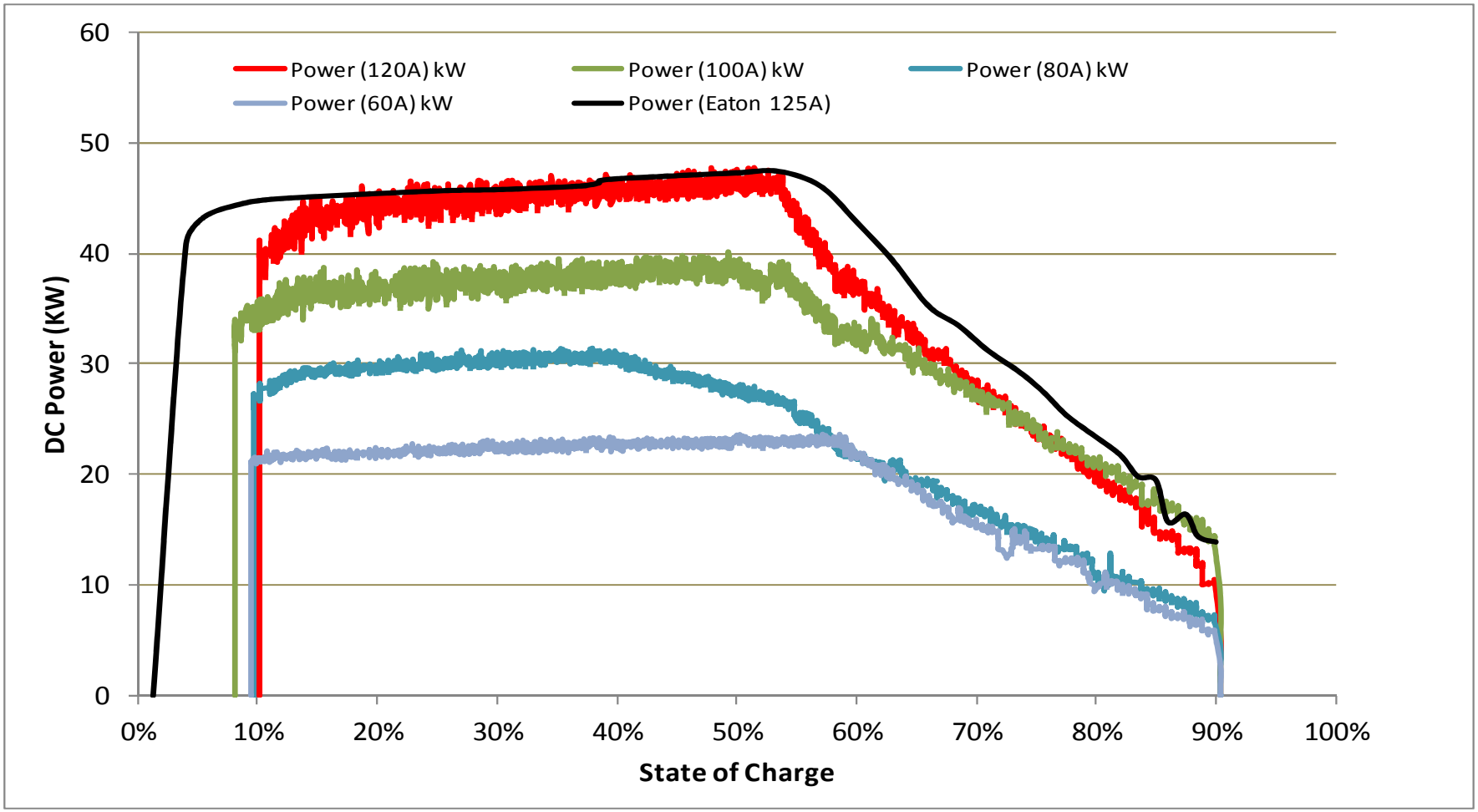
Effect of Starting Battery Capacities on Charge Profile





	TOTAL Pac (Pdc)	CC MODE Pac	CV MODE Pac
0khwr	21.28 (19.18)	13.15	8.14
13.6kwhr	8.62 (7.52)	1.30	7.32
16.4kwhr	5.98 (5.13)	0.33	5.65
17.2kwhr	4.38 (3.67)		4.38

SOC Profiles under Different Command Currents



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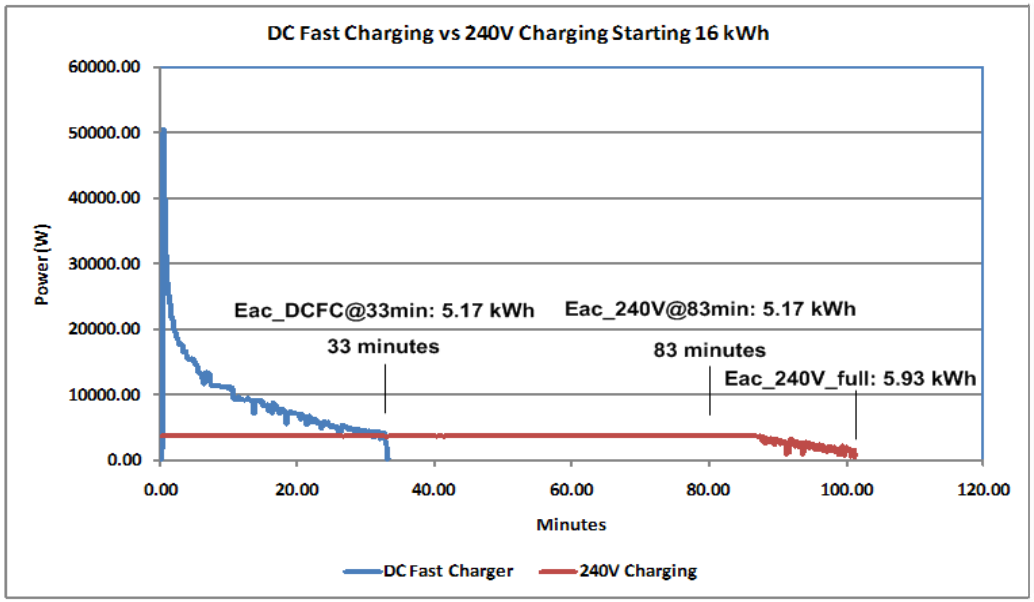
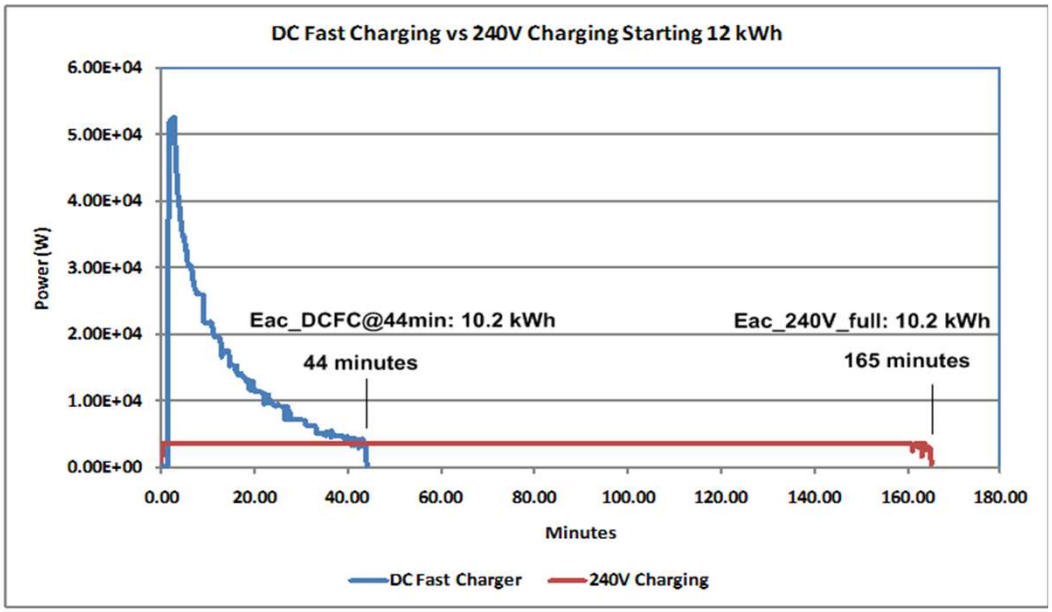
Starting Battery Capacity – DC Fast Charging versus 240V Charging





- 240V charging ends at 101 min
- Energy charged using 240V is more than DCFC charging (~ 5.93 kWh)

- 240V charging ends at 165 min
- Total energy charged is same for both DCFC and 240V

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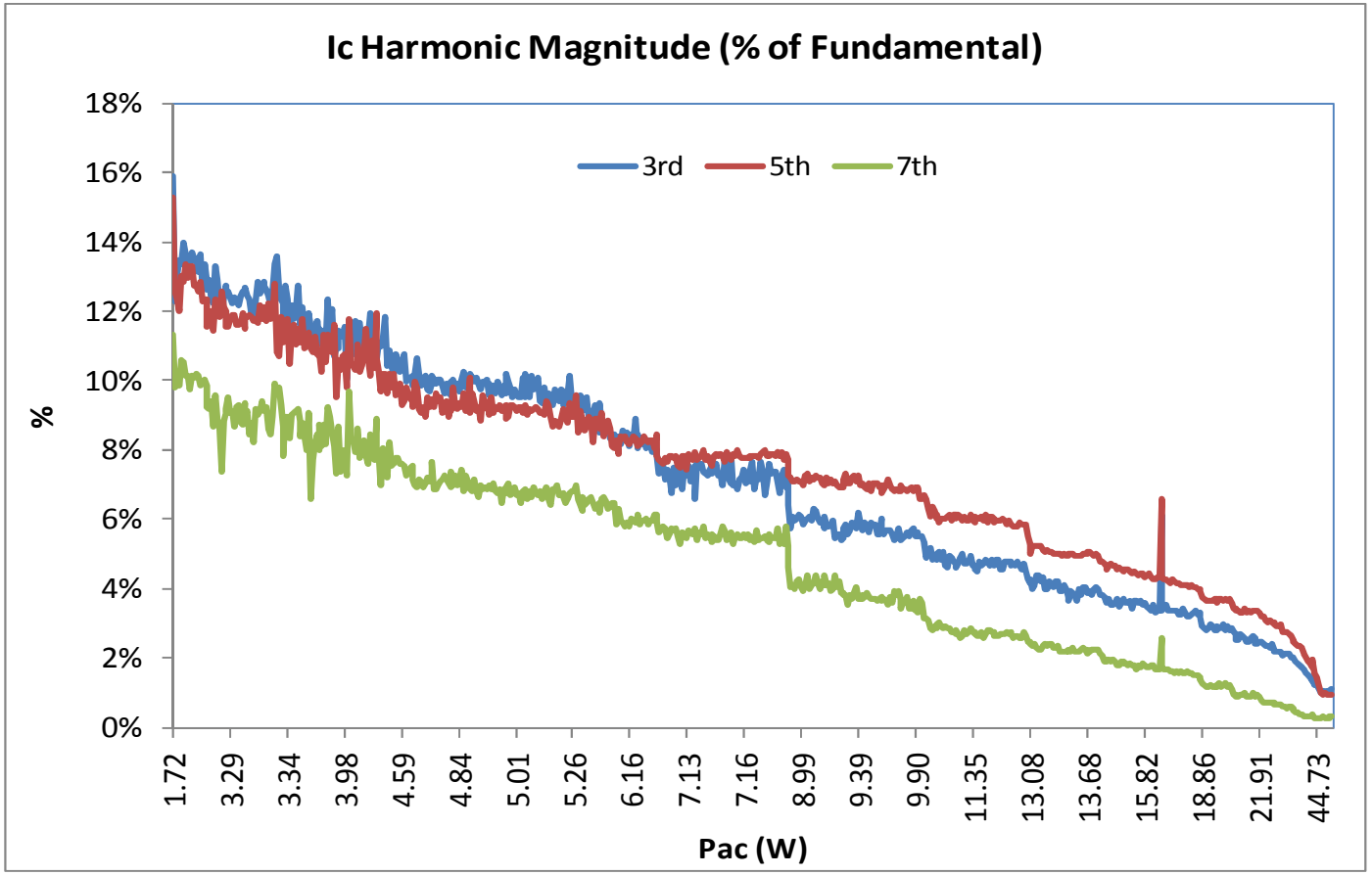
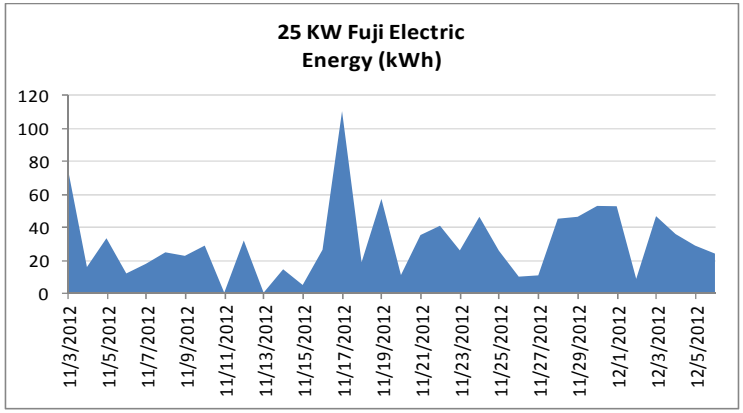
Harmonics vs Power



Harmonic spectrum indicates 3rd harmonic – possibly a single phase ancillary load

What Applications Make Sense?

- Business Models, customer needs, and utilization
- Low utilization Level – Economics of low-utilization sites will be dominated by capital costs for equipment installation and demand charges
- ***Intermediate utilization Level*** – Intermediate-utilization charging happens once fast charging demand at one location is high enough that *multiple ports* can be profitably installed and total charging capacity can be shared between number of vehicles at once
- ***High utilization Level*** – High-utilization charging occurs once charging is common enough that fast charging is a *customer expectation*. This level will also support multi ports and controlled charging of number of vehicles at once



Intelligent Universal Transformer (IUT) – a Paradigm Shift

Distribution Transformer

Intelligent Universal Transformer (IUT™)

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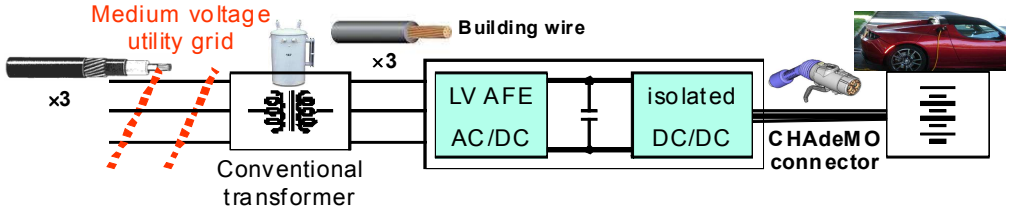
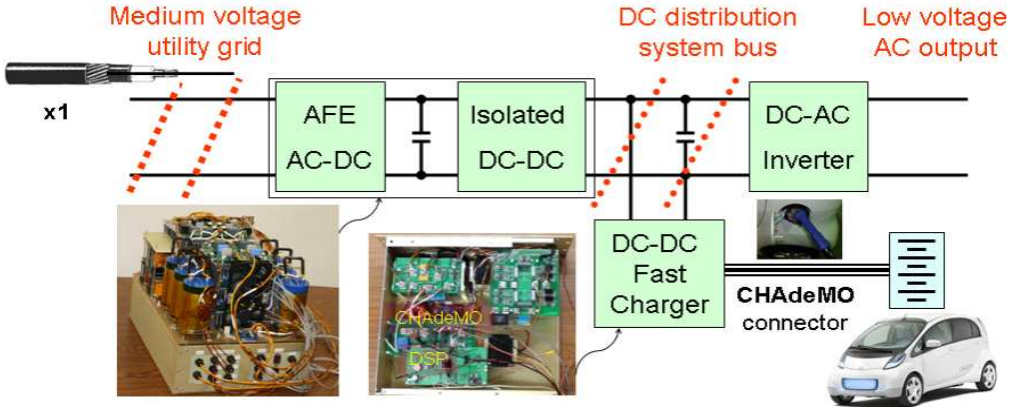
Medium-Voltage IUT Based DC Fast Charger

- **Conventional DC Fast Charger needs a new three-phase service**
  - Three-phase transformer
  - Three primary conductors and associated medium voltage fuses
  - Three high-current service conductors
  - 208/480 Vac DC fast charger
  - Overall efficiency (w xfmr) ~88-91%
  - Installation costs
- **IUT Direct DC Fast Charger**
  - Combines service transformer and DC fast charger into one unit
  - Needs only one primary conductor, no isolation transformer and no secondary conductors
  - Overall efficiency >95%
  - Installation costs

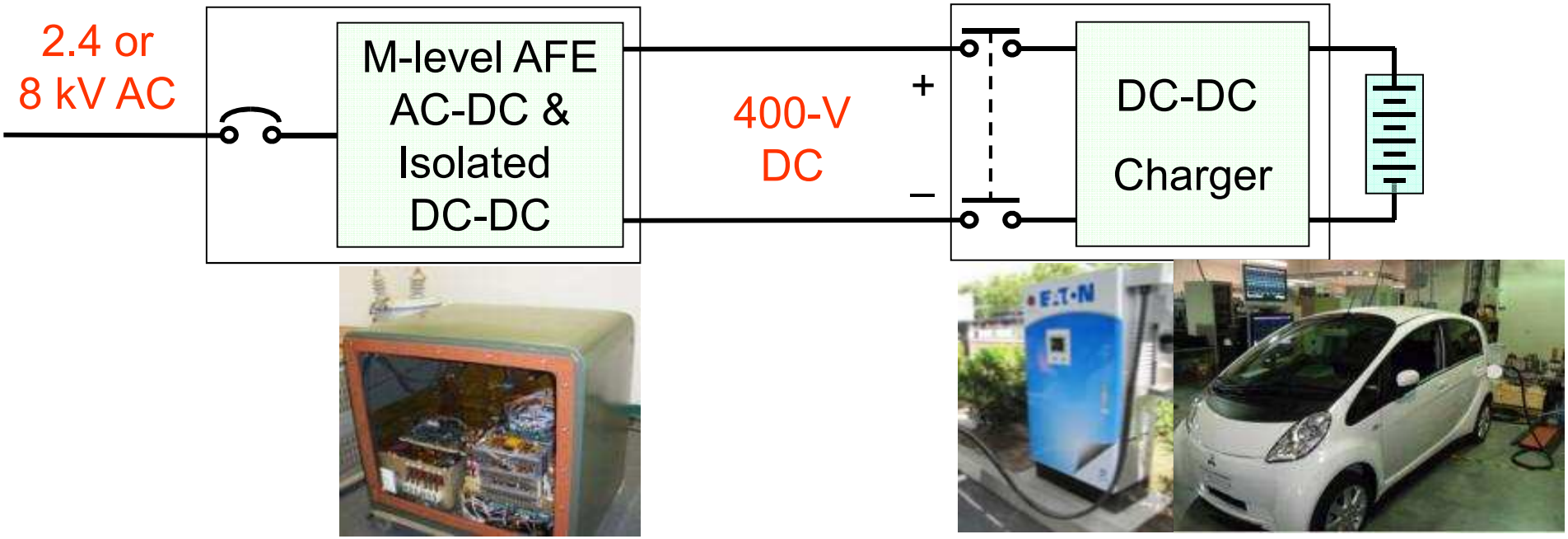


(a) Conventional DC fast charger with low-voltage power electronics



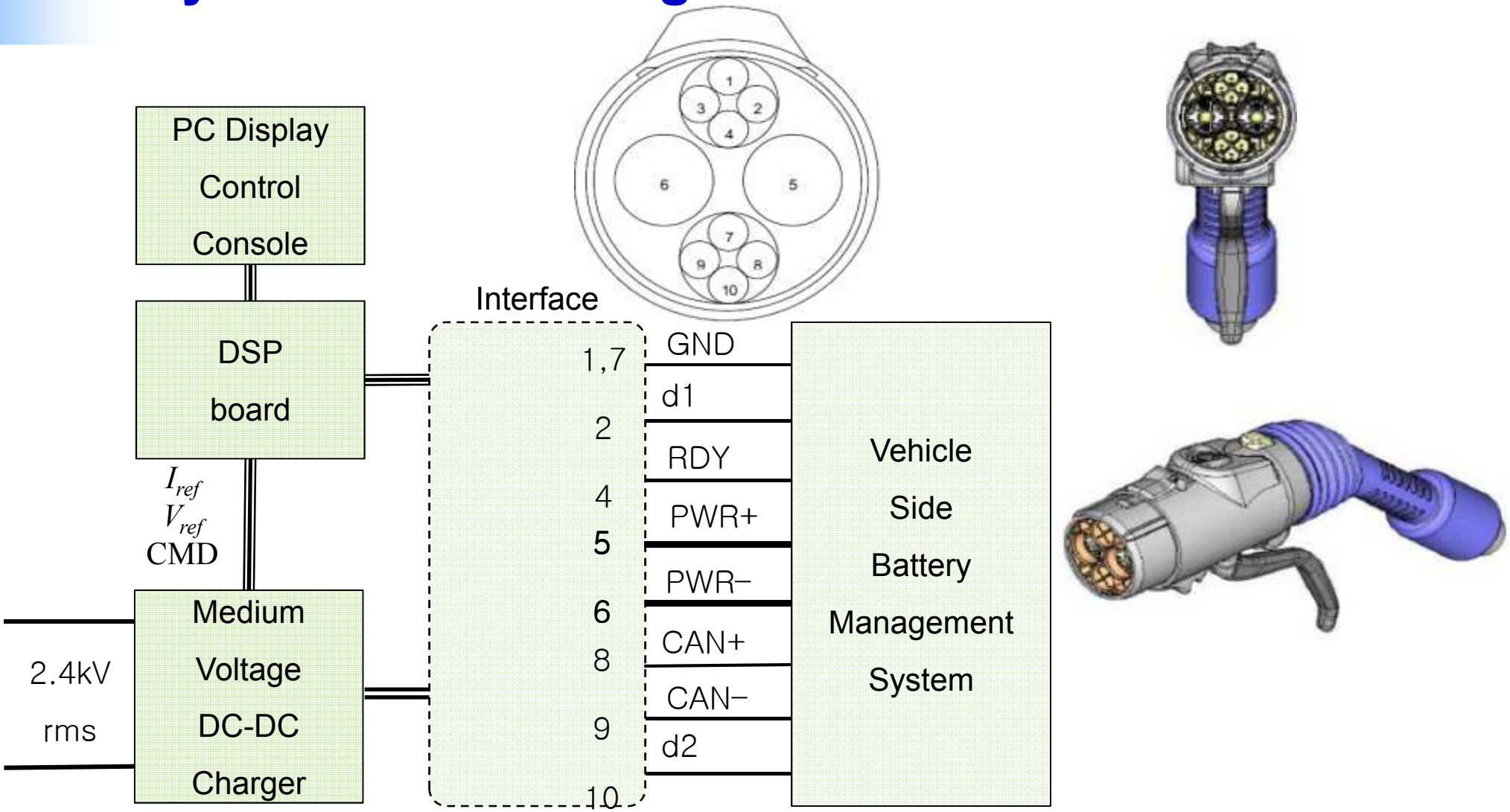
(b) EPRI DC fast charger with medium-voltage IUT

Configuration of Medium Voltage Fast Charger

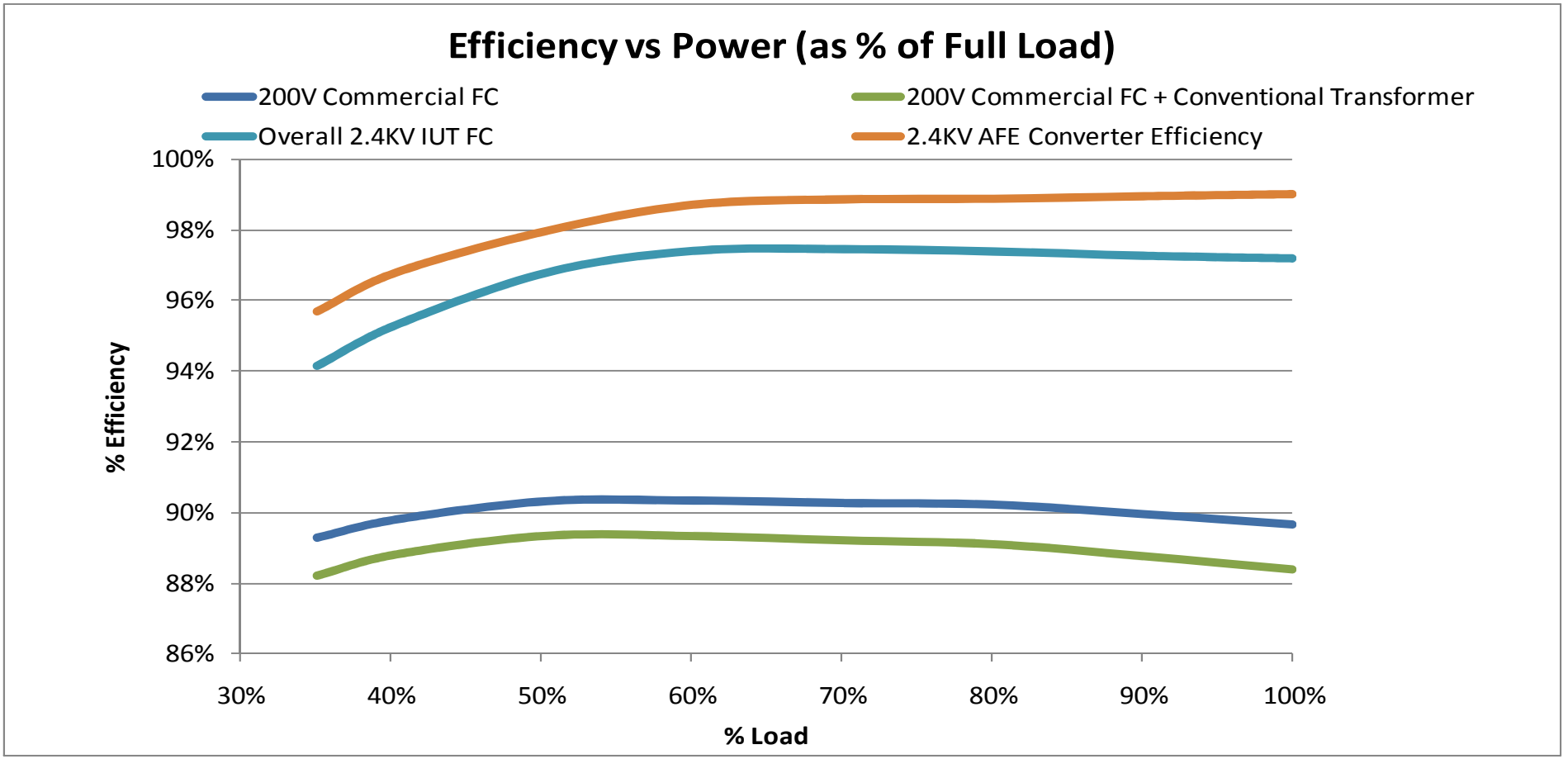


1. Multilevel active-front-end (AFE) converter is located at service entrance
2. AC input can be interrupted with high-voltage 12-kV vacuum switch
3. Low-voltage DC distribution system serves the charging station
4. DC voltage can be interrupted with a DC circuit breaker
5. Charger output is Chademo compatible

Utility Direct Fast Charger with CHAdeMO Interface



2.4KV 50kW Medium Voltage IUT Based DC Charger – Efficiency Comparisons



Summary of IUT – DC Fast Charging Application

- Can be less expensive than current 208/480 VAC DC fast chargers
- Significantly lower installation costs
- More flexible operation—integrate on-site renewables and storage
- **Can manage multiple charging connectors and standards seamlessly**
- The IUT can be a utility-owned asset and a third party can manage the ‘service station’ portion
- Next steps
  - Public demonstration of field-ready, certified unit (hopefully in 2014)