PG&E DC Fast Charging Demonstration Project

IWC Meeting
Detroit, MI
September 2, 2010

Efrain Ornelas
Pacific Gas and Electric Co.
Clean Air Transportation Department

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PG&E DC Fast Charge Demonstration and Testing

Summary of Project

- **PG&E Fast Charger Demonstration Project Funded by $172,000 CARB grant under Assembly Bill 1811, Alternative Fuel Incentive Program (AFIP) Testing Program**
- **One key area of focus for PG&E is the grid impacts and power quality affects of operating DC fast charging stations that will serve the light-duty vehicle market.**
- **Two sites (San Francisco and Vacaville) will serve to demonstrate and evaluate EV fast charging technologies (DC Fast Charging) in conjunction with PG&E's testing of the Mitsubishi i-MiEV electric vehicle and Nissan's ongoing testing of their PEV.**
  - Vacaville site chosen due to ease of access, solar power option and site is approx. halfway between SF and SAC on Hwy 80.
- **In addition, PG&E and its partners will assist others with the "lessons learned" from constructing and operating these DC Fast Charging stations and looking at impacts and benefits of these systems**.

PG&E DC Fast Charge Demonstration and Testing

These DC Fast Chargers will be 50-60Kw stations that have maximum output of 125-150 amps at 500 volts DC (EV battery packs operate at between 300 - 350VDC).

These stations are designed to charge a vehicle from a 20% state-of-charge (SOC) to a 80% SOC in 30 minutes, depending on the maximum size of the battery pack.

The Vacaville station was provided by our testing partner, Tokyo Electric Power Company (TEPCO) and is the exact same stations installed in Japan.

The charge rate and charge duration is managed by the vehicle and the high rate of charge is limited to the 20-30 minute time frame due to the heat rise caused by the high current rates and internal resistance of the battery. Maintaining battery thermal limits are key to not effecting the life of the battery.

PG&E DC Fast Charge Demonstration and Testing

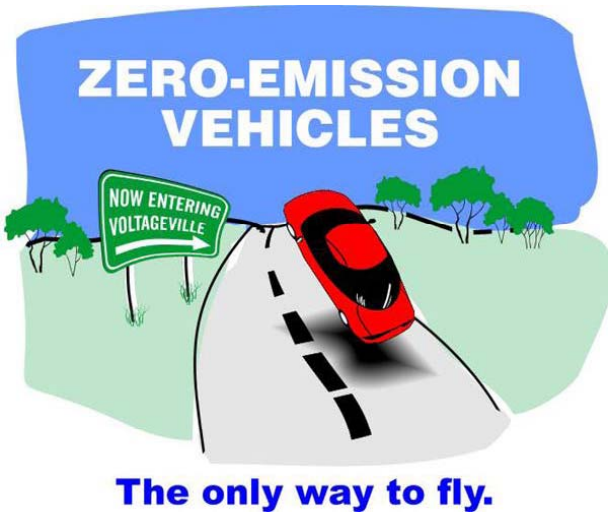
- **Goal: Access impacts and benefits of DC Charging systems**
  - Key focus for PG&E is the grid impacts
    - Voltage and current fluctuations
    - KW average and peak demand
    - Power quality (Harmonic distortion, voltage flicker etc)
    - Grid effects of DC fast charging stations under various vehicle charging scenarios i.e. time of day of re-charge, duration of charging, Vehicle State of Charge (SOC), drive profile prior to charge event and charge profile seasonal variability due to ambient temperature impacts
  - Secondary benefits - Technology assessment
    - Identify technical requirements to do future “Smart Fast Charging”
    - Partner with Mitsubishi and other OEMs to study viability and user acceptance of fast charging
    - Study DC Fast charging and renewable integration benefits and issues
      - DC Fast Charger tied to existing 45 Kw photovoltaic system

PG&E DC Fast Charge Demonstration and Testing

Status

- **Charger installation completed**
  - Initial commissioning halted due to charger malfunction
  - Identified faulty component and conferred with TEPCO on repairs
  - Received replacement PC Board from TEPCO and repairs completed on April 21st, 2010.
  - DC Fast Charger “power-up” and testing was successful
  - Operational as of May 1st, 2010
  - First Publicly accessible DC Fast Charger in the Nation
  - Charger has successfully completed 52 charge sessions
    - Completed stress testing: eight (8) consecutive charging sessions as part of Mitsubishi Media Drive

Vacaville EV Charging stations



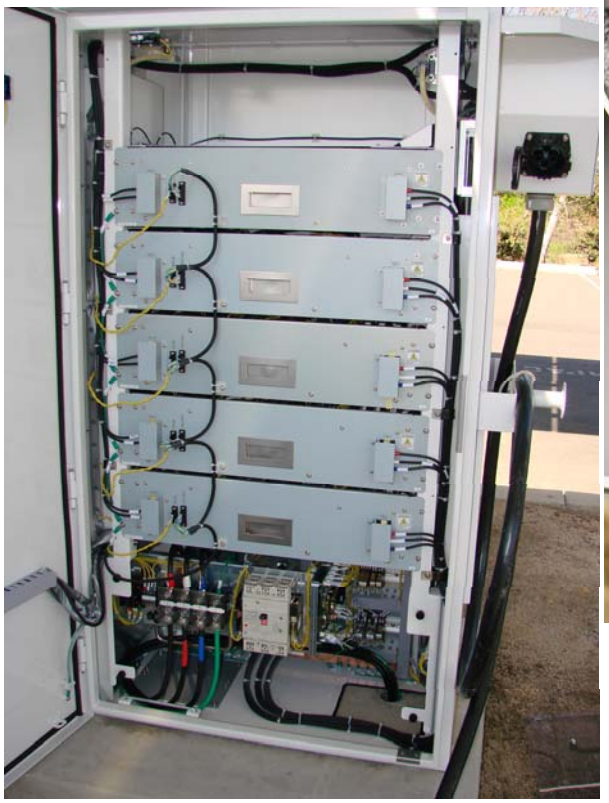
TEPCO DC Level 2 Charger

TEPCO Charger Specifications

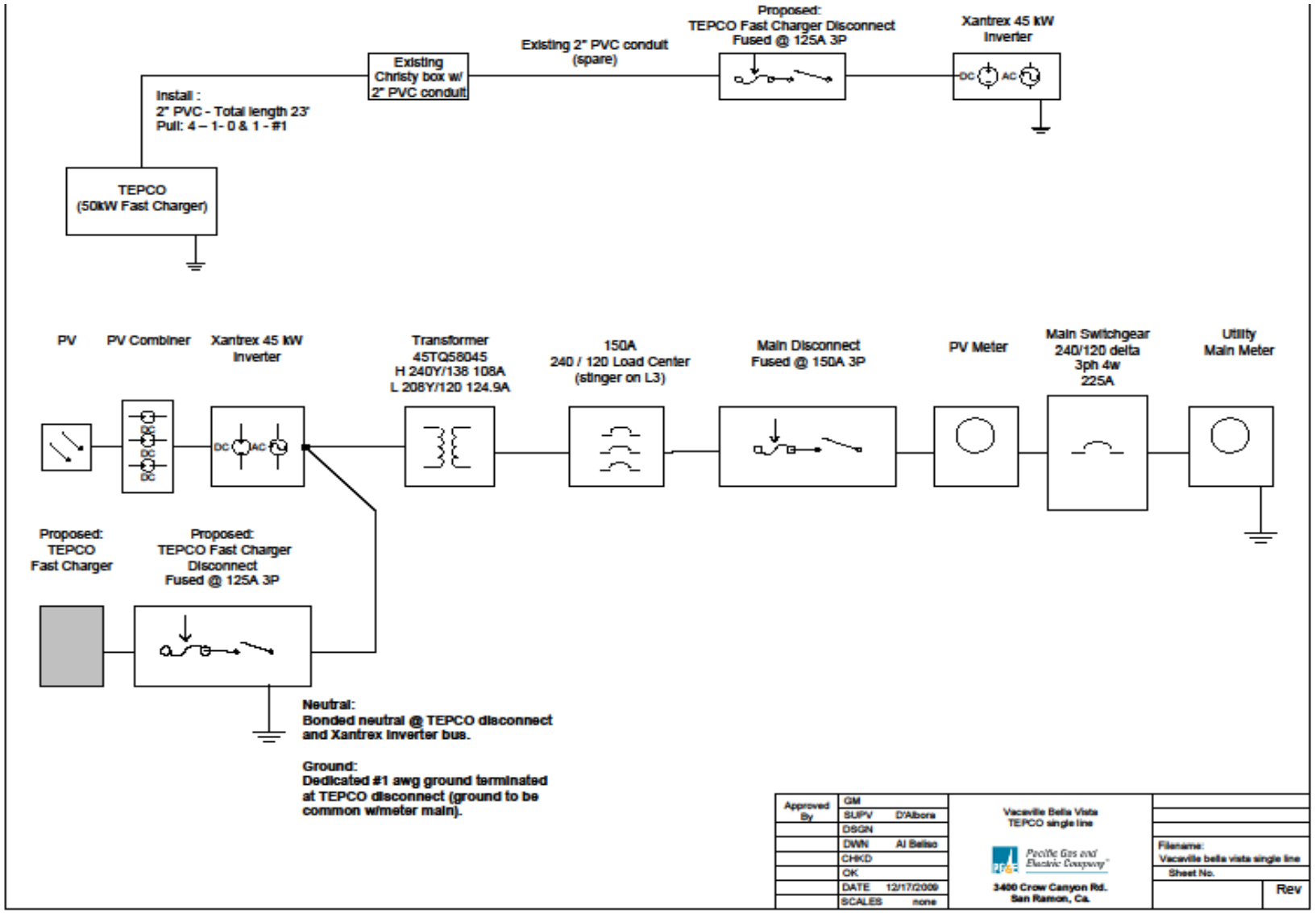
Maker: Takaoka Electric Manufacturing Co.
Type: Switching type, constant current
Power Supply-Input: 3-phase 200V
+/- 10% (208V installation)
DC output power: 50kW-Maximum
DC output Voltage: 500V-Maximum
DC output Current: 125A

大黒 PA に設置する急速充電器

TEPCO DC Level 2 Charger – Installed at Vacaville site



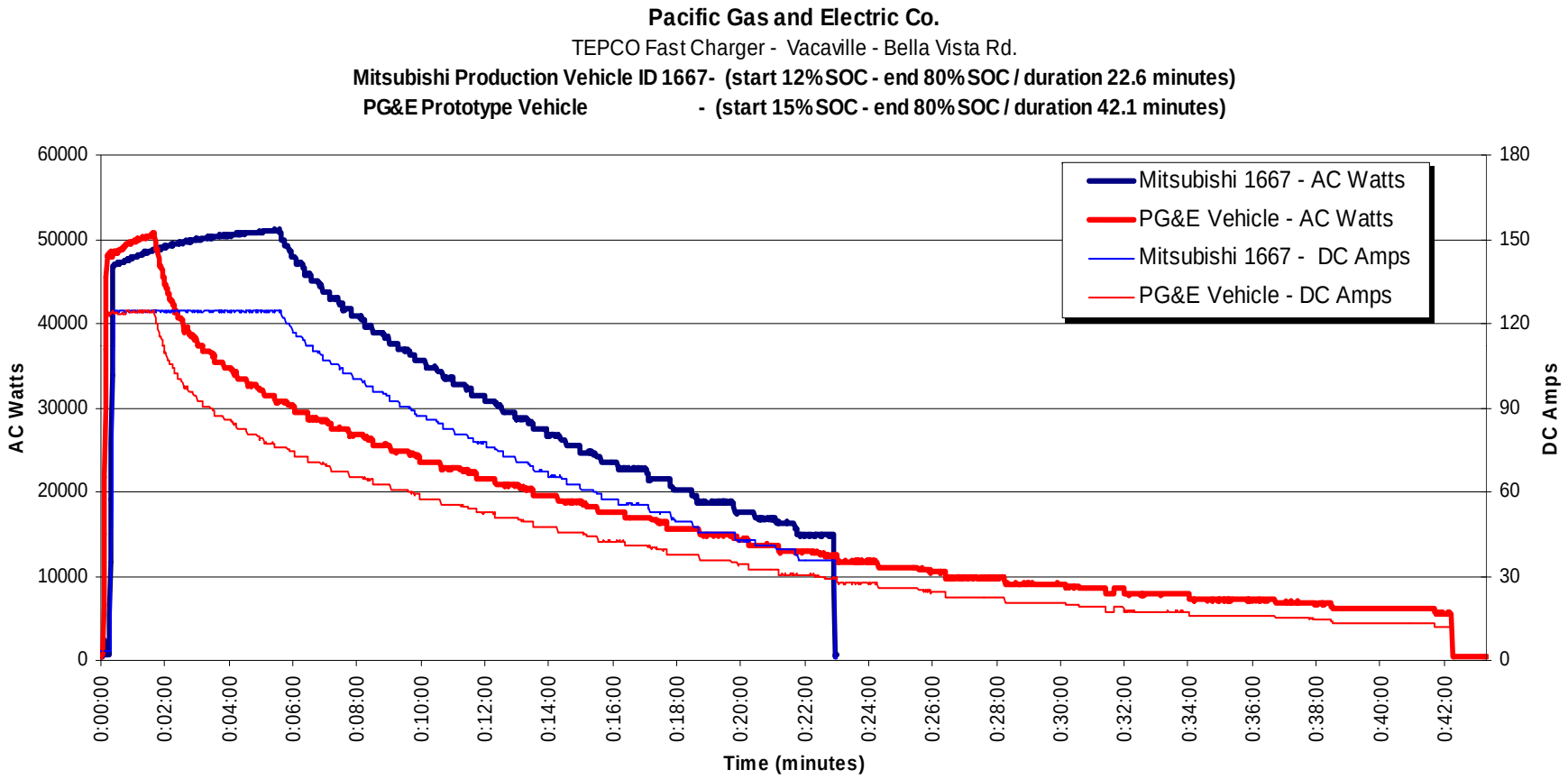
DC Fast Charger Interconnection Diagram



Test Vehicle: Mitsubishi iMiEV

Test Vehicle: Nissan Leaf

Test results from first Charging event: Mitsubishi



Charging With Solar

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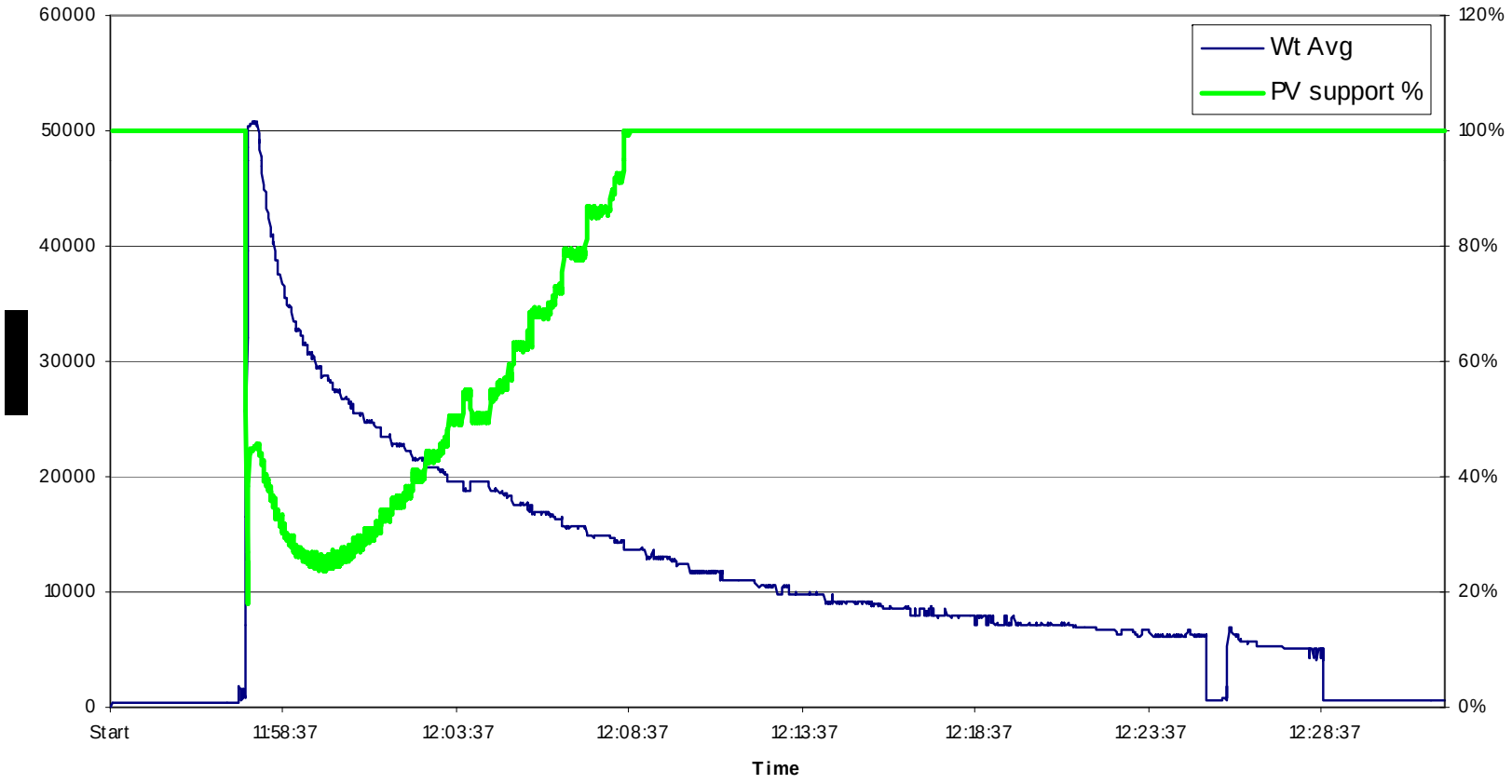
TEPCO Fast Charger - PG&E Vacaville
Vehicle: PG&E IMiEV
Test: PV output in reference to TEPCO demand



Test results from first Charging event: Nissan

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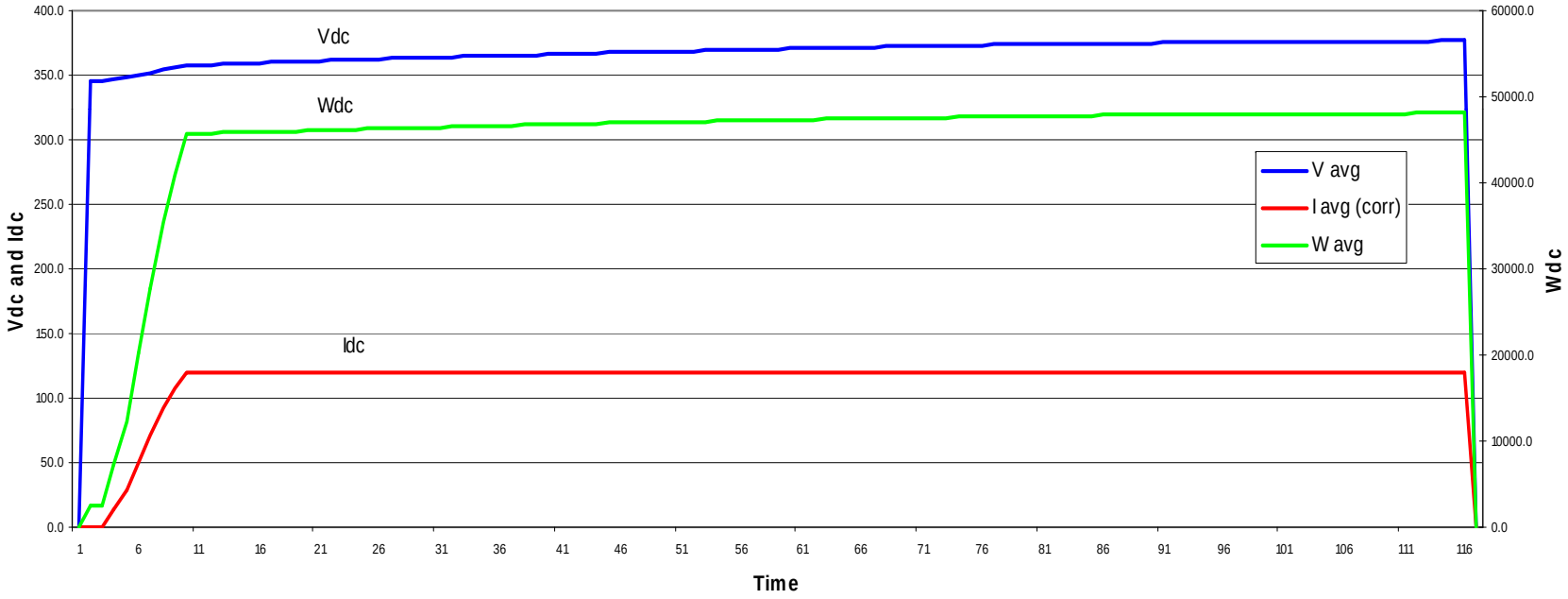
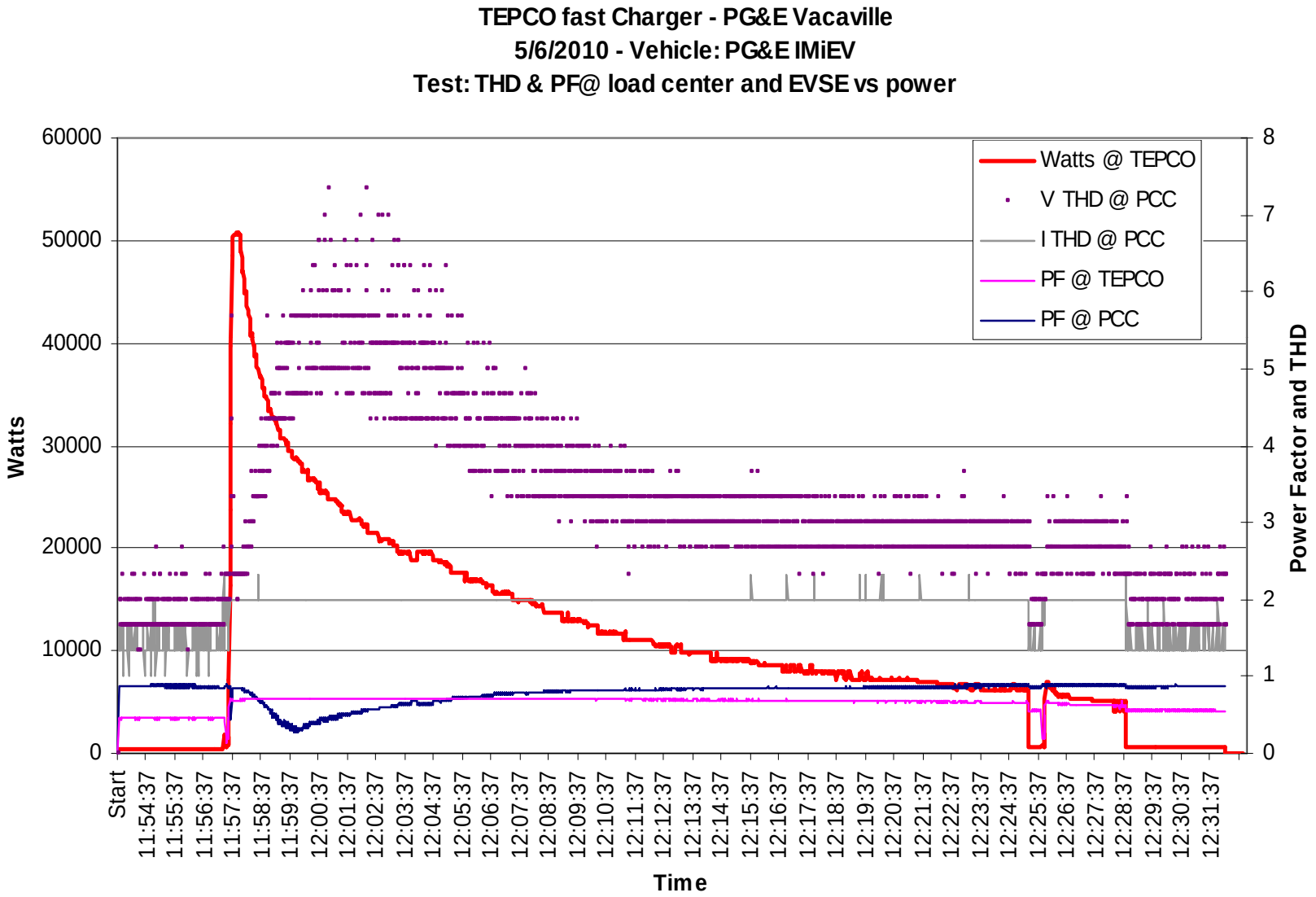
TEPCO Fast Charger - Vacaville - Bella Vista Rd.
Nissan Leaf Prototype **(30 minute cycle)**
July 8, 2010




TEPCO fast Charger - PG&E Vacaville
5/6/2010 - Vehicle: PG&E IMiEV
Test: THD & PF@ load center and EVSE vs power
Watts
Power Factor and THD
Time
Watts @ TEPCO
V THD @ PCC
I THD @ PCC
PF @ TEPCO
PF @ PCC
60000
50000
40000
30000
20000
10000
0
8
7
6
5
4
3
2
1
0
Start
11:54:37
11:55:37
11:56:37
11:57:37
11:58:37
11:59:37
12:00:37
12:01:37
12:02:37
12:03:37
12:04:37
12:05:37
12:06:37
12:07:37
12:08:37
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12:30:37
12:31:37

Power Quality View

Pacific Gas and Electric Co. - TEPCO 50 kW Fast Charger

Location: Davis St.& Bella Vista Dr. Vacaville, CA.

TEPCO 50kW Fast Charger
Serial # 09H00922
Model # HFR1-50B2
updated: 5/27/2010

Manufacturer information:	
Power level	50
Mfg recommended supply voltage	200
Frequency	50/60
Phase	3
kVA	60
kW	50
Vdc	50 - 500
Idc	10 -125
Weight	300 kg
Mfg date	Mar-09
Installed	Jan-09
Operational	Mar-10
Vacaville Permit #	1000202

Test information:	Date	Notes:	charge time	soc (start/end)	kWh	IV charts available	V THD avg @ 240V PCC	I THD avg @ 240V PCC	Voltage Flicker @ 240V PCC	PF @ 240V PCC	PF @ TEPCO
TEPCO serial # 09H00922											
PG&E vehicle prototype IMiEV	3/11/2010	service req'd				no					
Mitsubishi production IMiEV # 1667	3/11/2010	service req'd				no					
PG&E vehicle prototype IMiEV	3/19/2010	test - passed				no					
PG&E vehicle prototype IMiEV	4/16/2010	video shoot				no					
PG&E vehicle prototype IMiEV	4/27/2010	vehicle test	42 minutes	15 / 80	12	yes			na		
Mitsubishi production IMiEV # 1667	4/27/2010	vehicle test	21 minutes	12 / 80	13	yes			na		
PG&E vehicle prototype IMiEV	5/6/2010	vehicle test	28 minutes	xx / 80	15	yes	5%	2%	na	0.7	0.8

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Summary of Findings To-Date:

- Charger ramps to full power thus minimizing voltage flicker concerns
- Production vehicle charge profiles are more aggressive and representative of improved battery pack design
  - ➢ Some Vehicles by design will shuts down charger at 80% SOC in fast charge mode.
  - ➢ Some vehicles charge profiles are based on a set time to charge, generally set at 20-30 minutes depending on battery design.
  - ➢ Grid impacts will vary based on vehicles charging profile
- Initial Power Quality tests indicate that Voltage and Current Total Harmonic Distortion are well within SAE J2894 (Power Quality Requirements for Plug-in Vehicle Chargers) standard

Testing Continues

- Further analysis of various charging events will continue
  - Seasonal variations
  - TOU variations
  - Solar variation and charging impacts
- Upgrade to latest UL approved coupler
- Modeling of multiple chargers based on actual charging data
- User surveys on Fast Charger use and operation

Pacific Gas and Electric Company

Questions?

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