

PG&E's view: PHEVs, V2G and the Progress so far

Efrain Ornelas
Sr. Program Manager
Electro Drive R&D
Clean Air Transportation
Department

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***Pacific Gas and
Electric Company***[®]

About PG&E



*Pacific Gas and
Electric Company*[®]

Pacific Gas and Electric Company, incorporated in California in 1905, is one of the largest combination natural gas and electric utilities in the United States.

There are approximately 20,000 employees who carry out Pacific Gas and Electric Company's primary business—the transmission and delivery of energy. The company provides natural gas and electric service to approximately 15 million people throughout a 70,000-square-mile service area in northern and central California.

Fast Facts:

- 123,054 circuit miles of electric distribution and 18,610 circuit miles of interconnected transmission lines.
- 40,123 miles of natural gas distribution pipelines and 6,136 miles of transportation pipelines.
- 5.0 million electric customer accounts and 4.1 million natural gas customer accounts.

Committed to Clean Air

PG&E operates the largest alternative fueled utility fleet in the nation, with more than 1,425 alternative fuel vehicles, of which more than 40 are heavy duty vehicles. The majority of these vehicles run on cleaner burning LNG and compressed natural gas. This year more than 200 more clean vehicles will be added to the total fleet of over 12,000 vehicles. Vehicles to be added include four Class 8 Kenworth HPDI LNG trucks, two Peterbuilt hybrid bucket trucks and a number of CNG Freightliner M2 trucks.

PG&E has always been actively involved in the development, demonstration and application of natural gas and electro-drive technologies, and in the last 2-3 years specifically in medium and heavy-duty Natural gas vehicles and PHEVs.

New Vehicle Technologies

Our goal in assessing and applying new drive technologies is to demonstrate the practical application in our fleet, and gain experience with these technologies to provide our fleet management options to conventionally fueled vehicles. *As part of our education program we gladly share our knowledge and expertise with all our customers.*

Key areas we consider and address:

- ◆ Capital, operating and long term fuel costs
- ◆ PG&E's GHG reduction goals
- ◆ Reliability and serviceability
- ◆ Operational flexibility
- ◆ Address idle reduction regulations
- ◆ Petroleum reduction and energy security issues
- ◆ Tail pipe emission reduction and regulations mandated by AQMDs, CARB, and EPA
- ◆ Noise pollution
- ◆ Worker Safety

Current Demonstration Projects

Mercedes Fuel Cell vehicle

Utility fleet demonstration: Three F-Cell vehicles in daily pool vehicle service in San Francisco headquarters with hydrogen fueling on-site



Current Demonstration Projects

International/EATON 4300 Hybrid Bucket Truck

- HTUF Utility WG RFP
- Diesel-Electric Hybrid
- 1 of 24 pre-production
- 26,000 GVW
- E-PTO w/ 45" Aerial
- 44 Kw Electric Motor
- Li-Ion Battery system
- 25 Kw APG
- Field trial underway in San Francisco



Current Demonstration Projects

Energy CS - Toyota Prius PHEV Conversion

- Based on existing Prius software
- One of 25 worldwide
- 1.3 kWh NiMH Toyota battery replaced with 9 kWh Li-ion battery
- 30 mile all electric range
- 6-8 hr charge on 120v
- 100+ mpg for 50 miles
- Net 180 lb additional



Current Demonstration Projects

Hymotion - Ford Escape PHEV Conversion

- 60+ MPG
- 12 Kwh Li-Ion battery
- Maintains OEM NiMh
- 40 miles EV range
- 120V Charging
- V2G and V2H capable
- 1.2 Kw exportable



"Plug-in" Ford Escape

Current Demonstration Projects

PHEV DaimlerChrysler-Dodge Sprinter

PG&E will demonstrate two PHEV Dodge Sprinter vans in utility fleet application. Delivery early 2008

- 20-mile electric range
- Up to 40% reduction in fuel consumption
- Better acceleration than stock Sprinter
- 15 kWh Lithium Ion advanced battery
- 120 hp electric motor (up to 280 hp peak)



2004 MODEL SHOWN

Current Demonstration Projects

PHEV Ford F550 SuperDuty Trouble truck

*Founding Member of the
EPRI PHEV Ford F550
Alliance:*

- Eaton Hybrid System
- E-PTO
- EV mode capable
- 15 Kwh Li-Ion Battery
- 10Kw APG
- Engine off on-station operation
- Prototype being built by Roush Performance



Current Demonstration Projects

Phoenix Motors EV SUT Demonstration

Dedicated EV

- 52 Kwh Li-Ion Battery
- 130 Mile real world range
- 1000# payload capacity
- 95 mph top speed
- Four ordered for early 2008 delivery
- Part of Fast Charge demo - Grant from CARB to test 10 minute recharge system



Why Plug-in Hybrid Vehicles?

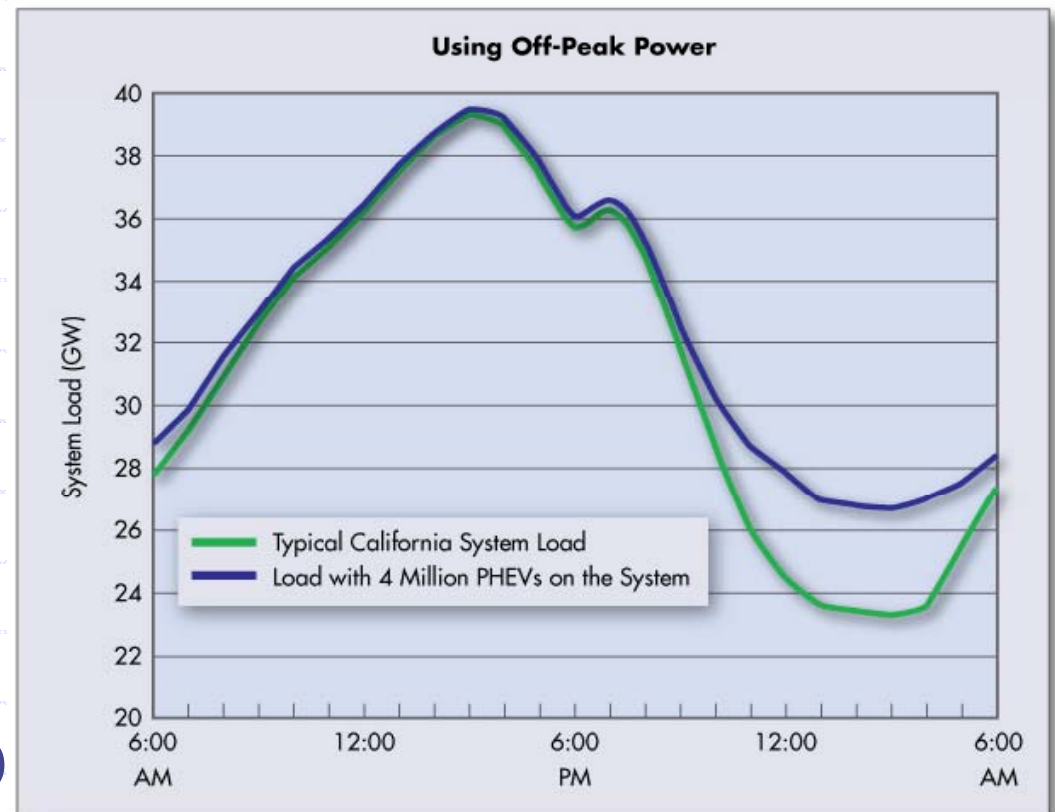
In general PHEVs provide attributes and options that are very attractive to utility fleets:

- **Approx. 50-90% reduced emissions**
- **Approx. 30-70% Improved Fuel economy**
- **EV “stealth” mode capable/lower noise levels in operation**
- **Reduced maintenance costs**
- **Improved low end performance**
- **Standby power and V2G/V2H capability**
- **No idle/engine off “on-station/E-PTO” operation**
- **Lower ave. fuel costs based on grid recharging for PHEV**
- **High impact technology, especially in the medium and heavy duty class vehicles, i.e. higher duty cycles, high idle times, high PTO operations etc.**

Why Plug-in Hybrid Vehicles?

Benefits From The Electric Grid

- ◆ Domestic, petroleum free, multiple feed stocks
- ◆ Excess off-peak capacity (Improved System load factor)
- ◆ Approx 30 % cost of petroleum (\$.60 gge)
- ◆ Reduces urban air pollution (ZEV miles)
- ◆ Generation only getting cleaner over time (regulations, technology)
- ◆ Reduced GHG emissions



Source EPRI

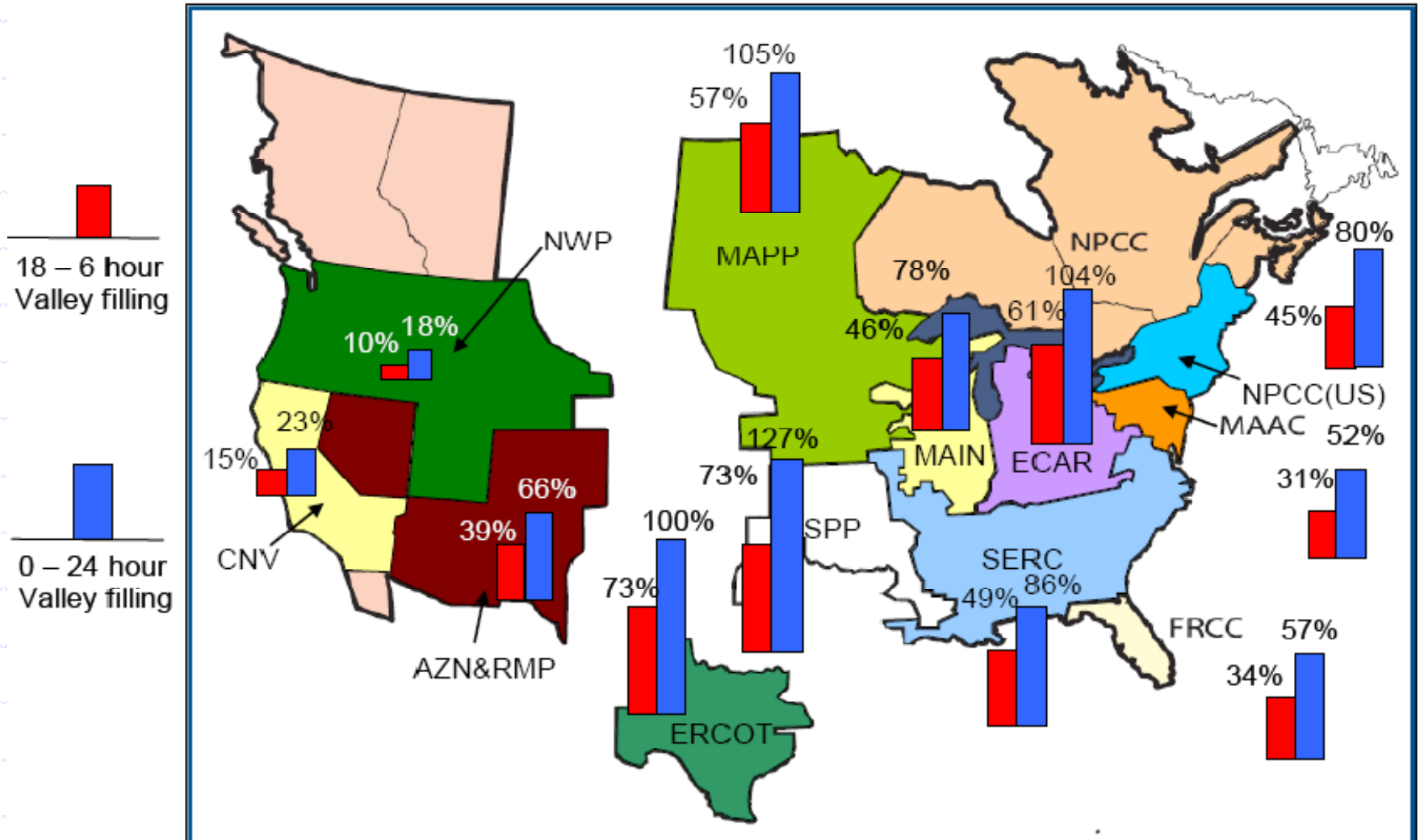
Why Plug-in Hybrid Vehicles?

Electricity as a Fuel

- ◆ Fuel diversity reduces impact from volatility and promotes stability
- ◆ Significant portion of existing generation fuel mix is currently CO₂ free
 - Approximately 56% of PG&E's energy portfolio is CO₂ free
- ◆ Recent and ongoing legislation promotes cleaner generation mix over time
 - RPS legislation enacted in 21 states
- ◆ Low fuel cost and minimal additional infrastructure required
- ◆ Time of Use rates for EV/PHEV charging can create economic incentives
 - Preferential rates for off-peak consumption
- ◆ Large night-time "off peak" usage can reduce overall system average rates
 - Improves utilization rates for existing generation portfolio
- ◆ Projected future renewables tend to be an off-peak energy resource

Why Plug-in Hybrid Vehicles?

Percentage of Light Duty Fleet That Can be Served From the Existing Grid

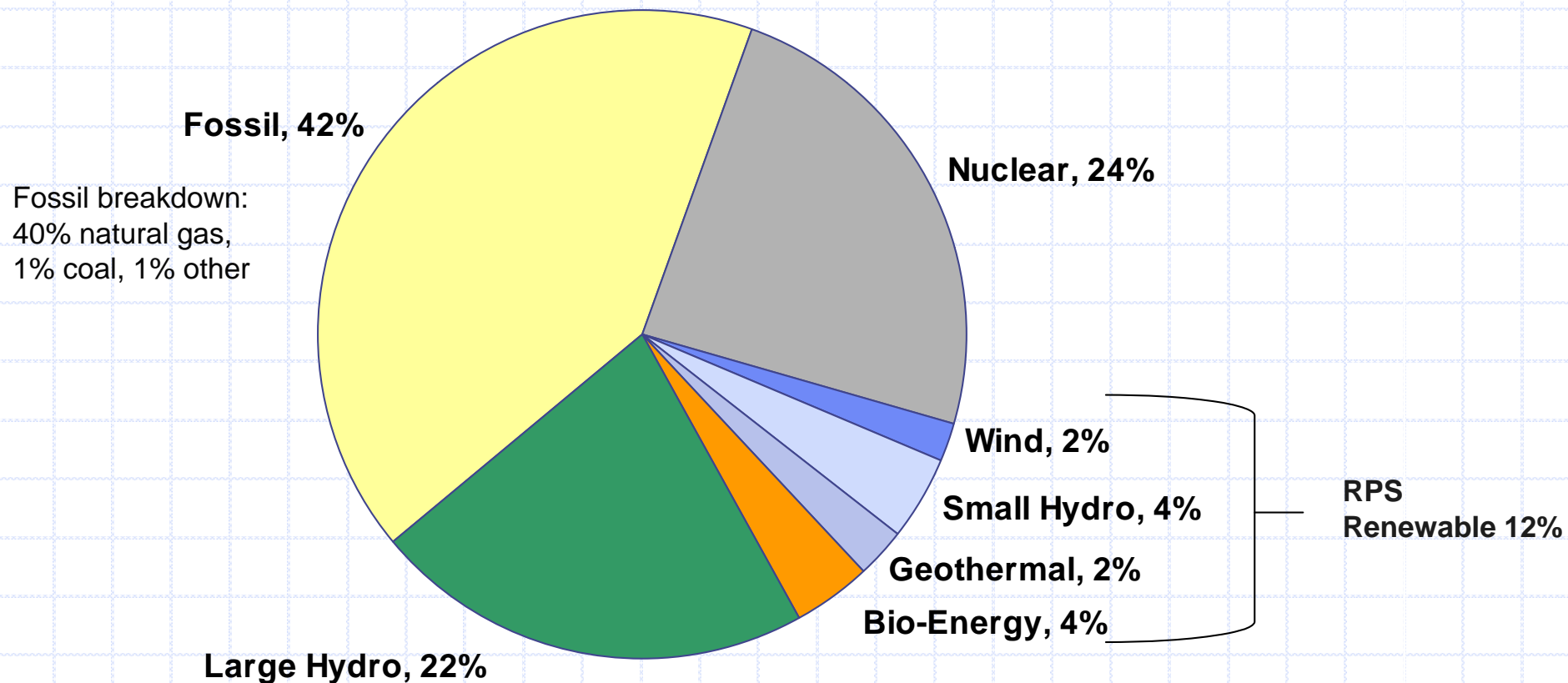


Why Plug-in Hybrid Vehicles?

Electricity as a Fuel

2006 Electric Energy Deliveries by Technology

PG&E's Energy Portfolio¹ is among the "cleanest" in the Industry



Why Plug-in Hybrid Vehicles?

GHG Reductions from Alternative Fuels & Hybrids

<u>Total CO2 Equivalent</u> <u>Vehicle Type</u>	<u>Emissions (g/mi)</u>	<u>Percent Reduction from</u> <u>Conventional Gasoline</u>
Conventional Vehicles	449	0%
Hydrogen ICE (NG-SR)	380	15%
Compressed Natural Gas	378	16%
Liquid Petroleum Gas	364	19%
Ethanol (E85)	344	23%
Moderate Hybrid-Electric	319	29%
Hydrogen FCV (NG-SR)	210	54%
Advanced Hybrid-Electric	210	54%
Plug-In Hybrid 20 (NG-gen)	171	62%
Electric Vehicle (NG-gen)	50	67%

Why Plug-in Hybrid Vehicles?

“Achievable” Benefits for California from Plug-In Hybrids

	2010	2015	2020
NOx + ROG Avoided (tpd)	0.86	4.75	7.11
PM Avoided (tpd)	0.11	0.55	0.84
GHG Displaced (mtpy)	1.39	7.56	11.50
Petroleum Displaced (mgpy)	137.50	753.75	1,145.00
Achievable Population	300,000	1,625,000	2,500,000

If half of all light-duty vehicles in CA were PHEVs, reduction of in GHG emissions would be 60 million tons per year. With cellulosic ethanol in a PHEV the reductions are more

Why V2G/V2H?

Potential Benefits

- PHEVs and EVs have huge benefits to customers, utilities, and society
- Demand Response – Shedding load at peak
- V2H – Backup power, hedging against peak prices
- V2G, Peak Shaving – Displace expensive peaker power with cheaper renewable power
- V2G, Ancillary Services – Potential for significant customer profit providing voltage regulation to grid

Why V2G/V2H?

Electric Grid Integration

- Costs and benefits to the utility system
 - Valley Filling and Peak Power
 - Ultimately allows high penetration of intermittent renewable energy
 - Distributed Storage for grid stability
 - Fast response, short duration ancillary services - \$10B/yr US (5%-10% gen costs)
 - Spinning Reserve
 - Regulation
 - Reactive Power
- Communication & control issues
 - Utility or Aggregator?

Current Demonstration Projects

Toyota Prius PHEV-V2G/V2H upgrade

- Modified by PG&E for V2G/V2H



- 1.2 Kw output @120V



Current Demonstration Projects

PG&E/EPRI/AC Propulsion E-BOX, V2G Demo

- Range 120 – 150 miles
- Acceleration 0 to 60 in 7.0 secs
- Top Speed 95 mph
- Drive system 120 kW
- Regenerative braking
- Battery Li Ion, 35 kWh
- Charger Onboard, plug in anywhere,
- Up to 20 kW Vehicle to grid (V2G) capable
- Phase I - V2G Smart meter integration and communications project
- Phase II – Smart Garage Link



Current Demonstration Projects

Intelligent Charging Demonstration Project

Demonstrate Next Generation Vehicle-to-Grid (V2G) from a Tesla Roadster and PG&E's electrical distribution system

- Demonstrate ability to remotely control Tesla Roadster's battery power system through SmartMeter
- Manage Battery system for grid support while keeping car available for use with minimum SOC settings
- Focus is on Regulation Down scenario and ISO command and control



TESLA MOTORS

V2G/V2H

Issues

- Customer acceptance – Value proposition
- Value of ancillary services – Business case
- OEM coordination: on-vehicle systems
- Battery cycling and reliability
- Charging/Connection standards and protocols
- Customer mobility among service territories
- Vehicle interaction with SmartMeter and Home Area Networks (HAN)
 - Communication standards and protocols for vehicle to HAN and Utility

In Closing

- ◆ PHEVs can have a significant near term benefit in reducing emissions and GHGs
- ◆ Proper application of technology can significantly reduce petroleum usage and lower operating costs
- ◆ Advanced Li-Ion battery are ready to play a major role today
- ◆ Utilities moving forward with AMI today. Integration of V2G/V2H concepts must be considered
- ◆ V2G is great concept, key to success is development of vehicle communication standards
- ◆ Business case for V2g is utility specific and detailed studies must be completed

Questions?

Efrain Ornelas

Pacific Gas and Electric
Clean Air Transportation Department

exo1@pge.com

415.972.5617



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