Plug-in Vehicles and the Smart Grid

David Kaplan
V2Green

Beyond Oil: Transforming Transportation
September 4-5, 2008

v2green

Outline

- Economics
- Scenarios
- Technology
- Market
- Conclusion

Groundwork

Plug-in Vehicles and the Grid

- Distribution impact
- Neighborhood problem

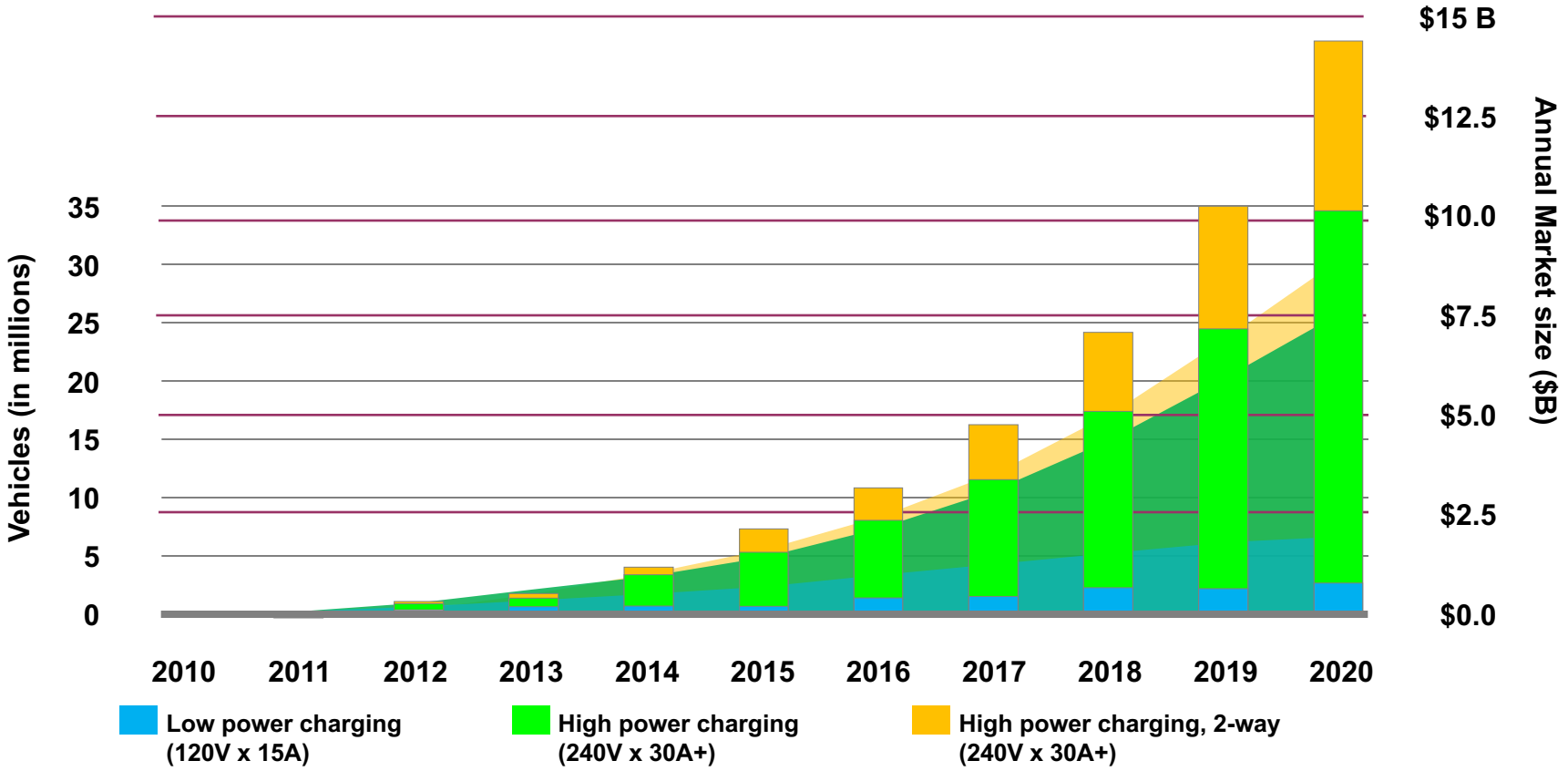
Smart Charging

- Control timing, pace, extent of vehicle **charging**
- Intelligently-managed **1-way** power flow
- **Immediately applicable**

V2G

- Control timing, pace, extent of **charging** and/or **discharging**
- Intelligently-managed **2-way** power flow
- Promising future, when enabled by battery cycle life or new ownership models

Economic Value of Smart Charging



Sources: EPRI / NRDC, V2Green

v2green

Smart Charging Scenarios

- Grid-Optimized charging
- Green-Power charging
- More Scenarios

Grid-Optimized Charging

Scenario:

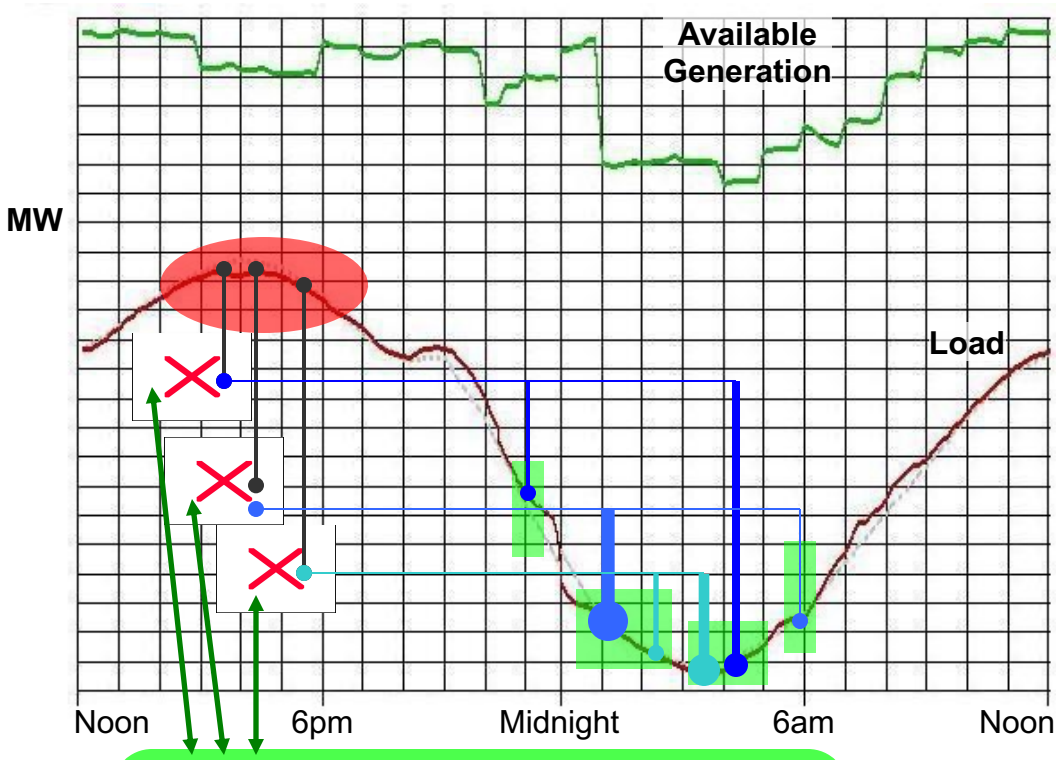
- Hot afternoon: A/C loading, etc.
- Drivers return home, plug in

Problem: Grid Rush Hour

- Grid stress
- Feeder over-loading
- Potential brown-outs

Solution: Smart Charging

- ***Grid-aware*** vehicles
  - Communicate driver requirements, battery requirements, SOC, etc.
- Grid and external inputs
- Schedule charging per driver, grid needs



Smart Charging System

- Vehicle Availability
- Load and Generation forecasts (DA, HA, RT, etc.)
- Pricing (DA, HA, RT, etc.)
- Grid control signals (AGC, etc.)
- External inputs - weather forecast, etc.

v2green

Green-Power Charging

Scenario:

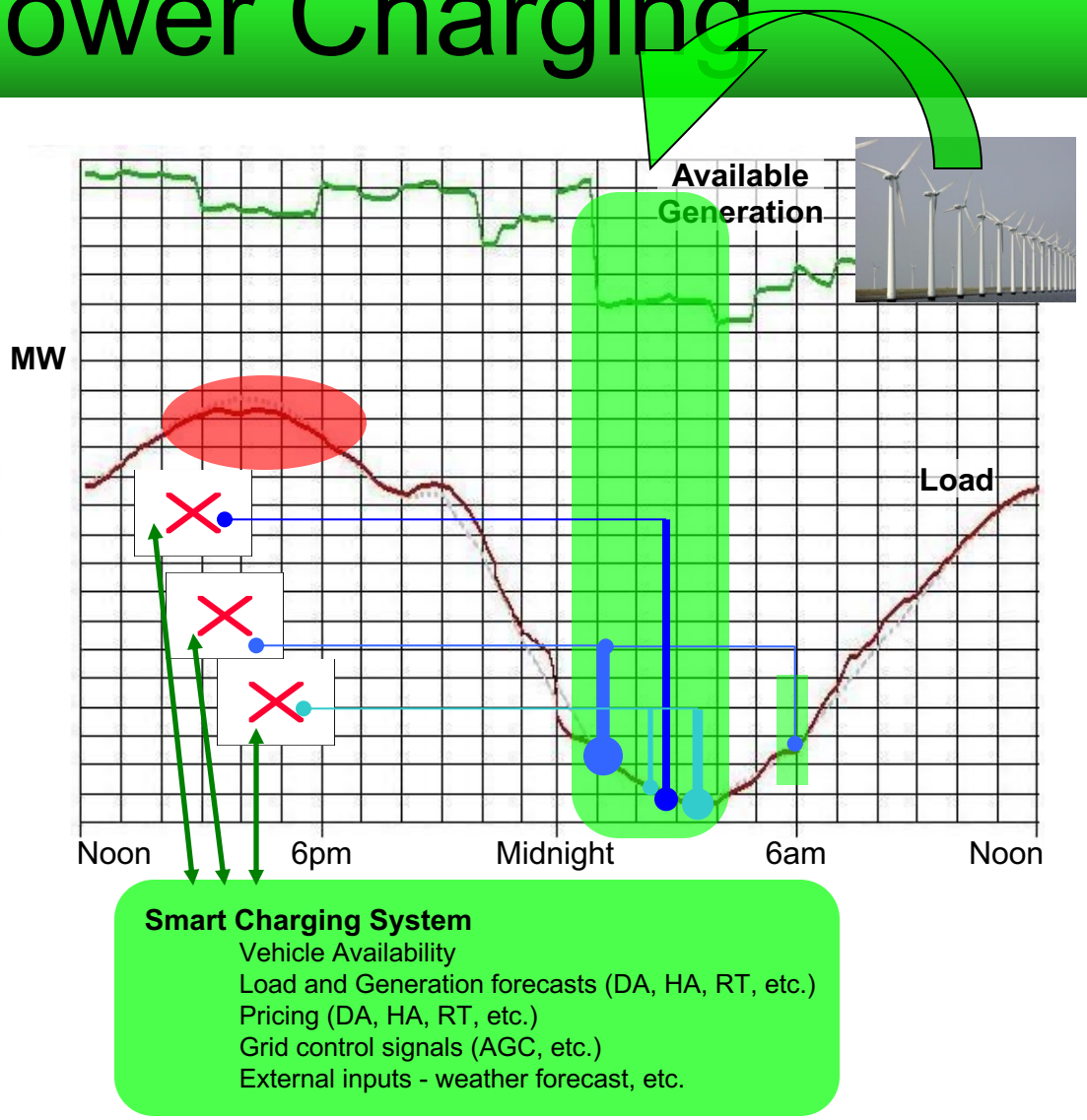
- Hot afternoon: A/C loading, etc.
- Drivers return home, plug in

Problem: Grid Rush Hour

- Grid stress
- Feeder over-loading
- Potential brown-outs

Solution: Smart Charging

- ***Grid-aware*** vehicles
  - Communicate driver requirements, battery requirements, SOC, etc.
- Grid and external inputs
- Schedule per driver needs
- Maximize green power charging
- Use ordinary power if needed



v2green

More Smart Charging Scenarios

- Ancillary Services
  - Regulation Down
  - Regulation Up (via load setpoint)
  - Spinning Reserves

- Demand Response

(Grid Signal) ←→ { Aggregated Load + Storage }

Technology

Smart Charging server

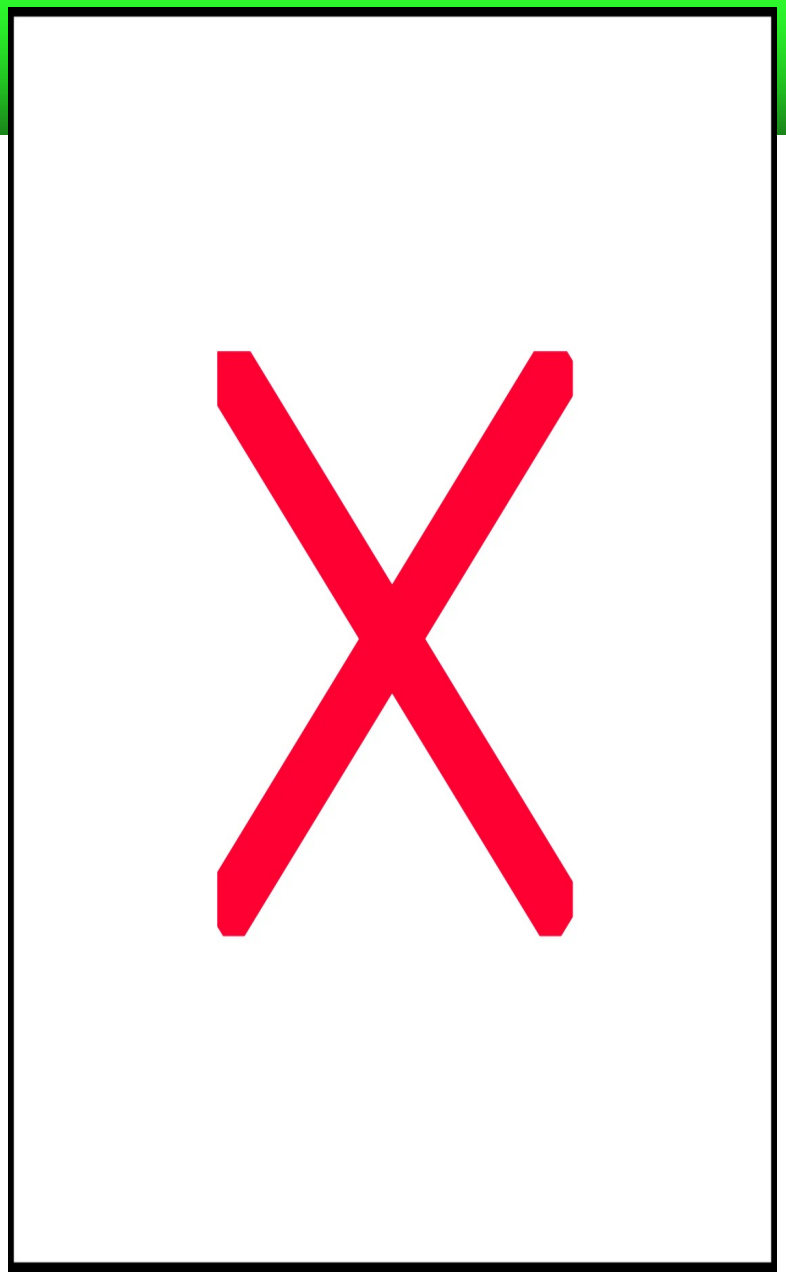
- Prediction, Optimization, Dispatch
- Grid location (substation, feeder)
- Vehicle resource management
- External interfaces
- Data Management

Transport-independent Communications

- Utility AMI
- Vehicle telematics
- Broadband
- Local wireless / PLC

Smart Charging client

- Communications
- Charging control
- Location-awareness
- Power metering



Vehicle-side Charging Control

3rd Party solutions

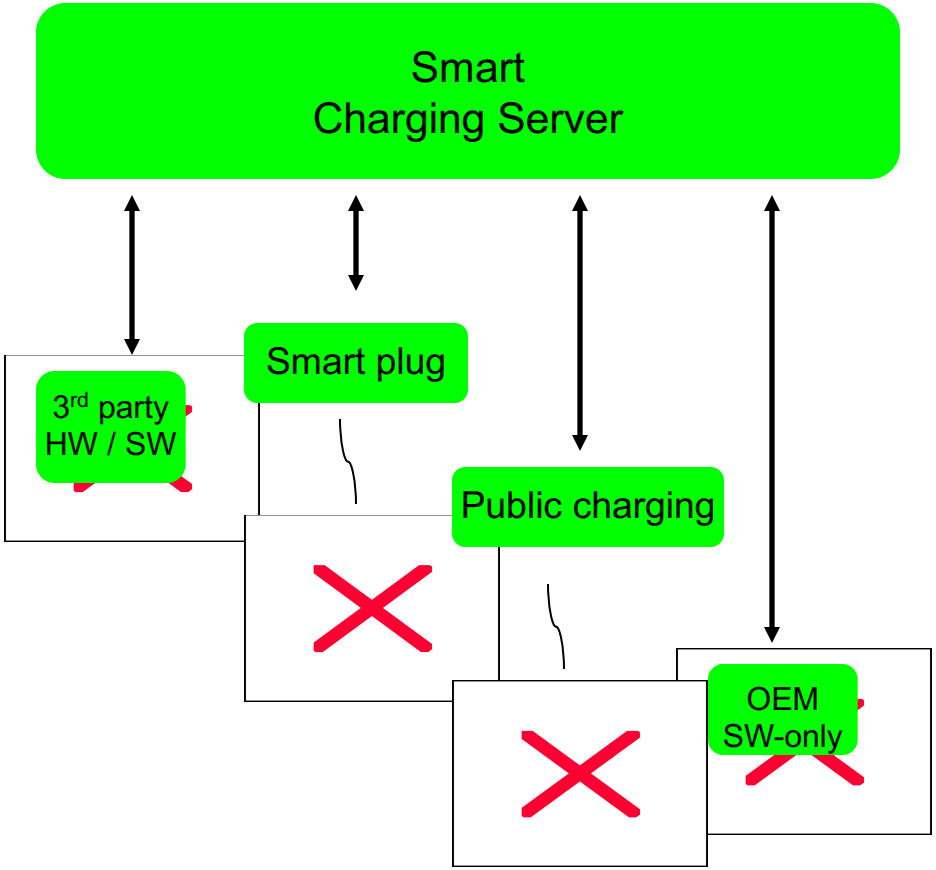
- On-board Hardware / Software available today
- Off-board: Smart Plug, Public Charging Infrastructure coming soon

OEM platforms enable on-board **Software-Only** charging control

- Leverage telematics, GPS, etc.

Standards will drive evolution

- Joint OEM-Utility working groups
- Connector – SAE J1772
- Communications – SAE J2836
- Use cases – EPRI IWC, SAE J2847



v2green

Market Evolution

2008-09

- Utility led field trials, 10s-100s of vehicles, converted PHEVs
- Research to identify charging behavior, vehicle performance, emissions impact

2009-10

- Expanded trials, 100s-1000s of vehicles, EVs and converted PHEVs, fleet-focused
- Refine charging model, establish value / incentives to utility and customer

2010 and beyond

- Commercial availability of major OEM PHEVs

  10,000s → 100,000s → 1,000,000s of vehicles
- Commercial Smart Charging deployments deliver power services revenue and cost savings: demand response, ancillary services, new tailored mechanisms

Smart Charging Benefits

Utility gains

- Reduced grid stress, increased renewables penetration
- Shared benefits with vehicle owner and manufacturer (like HVAC incentive programs)

Vehicle owner gains

- Lower-cost ‘electric fuel’
- Greener vehicle

Vehicle manufacturer gains

- Reduced-cost charging for vehicle customer
- Green product-line enhancements

Smart Charging maximizes the **economic** and **environmental** value of plug-in vehicles