

the Grid-Integrated Vehicle with Vehicle to Grid Power

Technical Panel
PJM/EPRI Energy Storage Summit

by

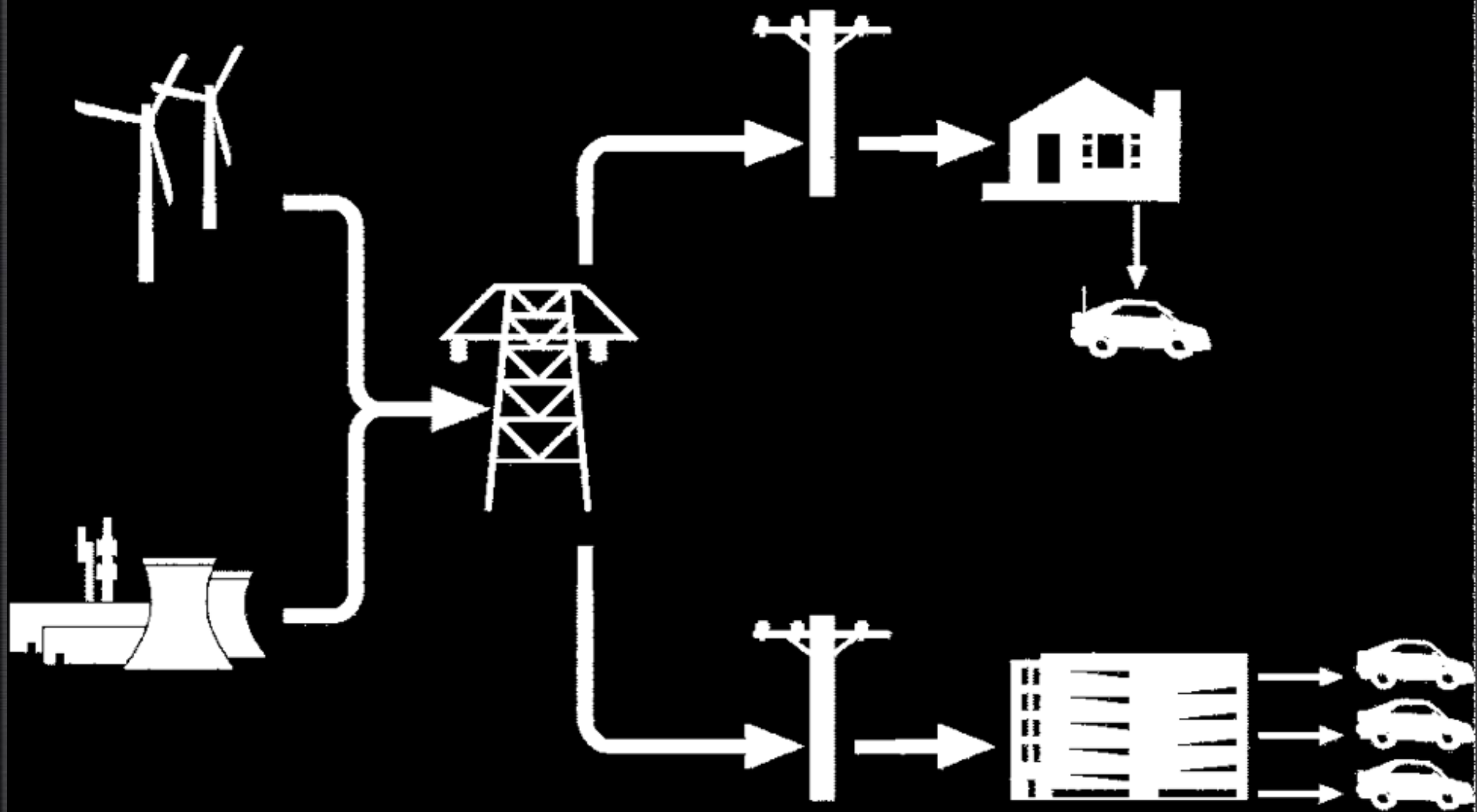
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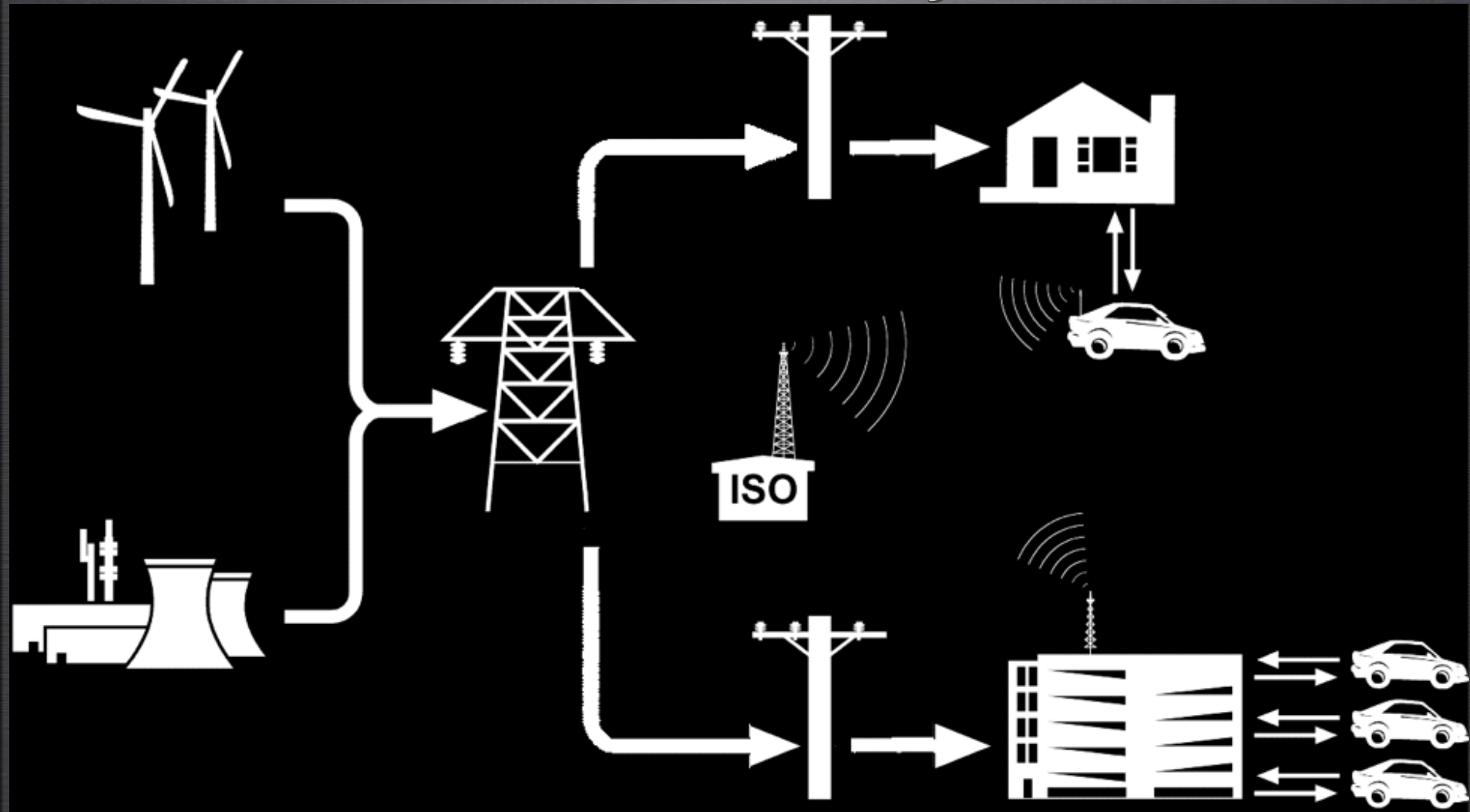
19 April 2010

The Grid-Integrated Vehicle,
with
Vehicle-to-Grid power

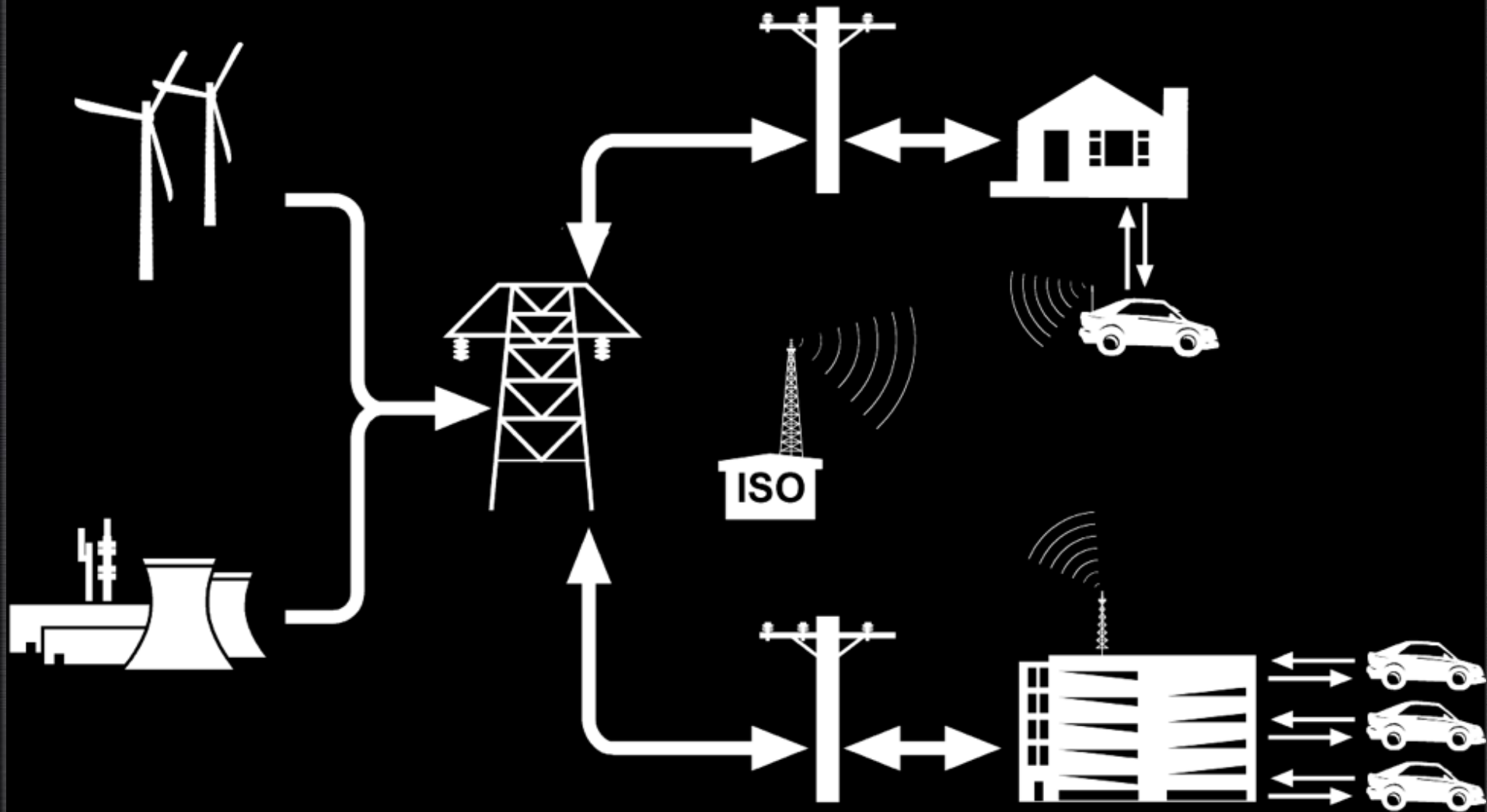
Plug-in for charging



GIV: Control by Grid

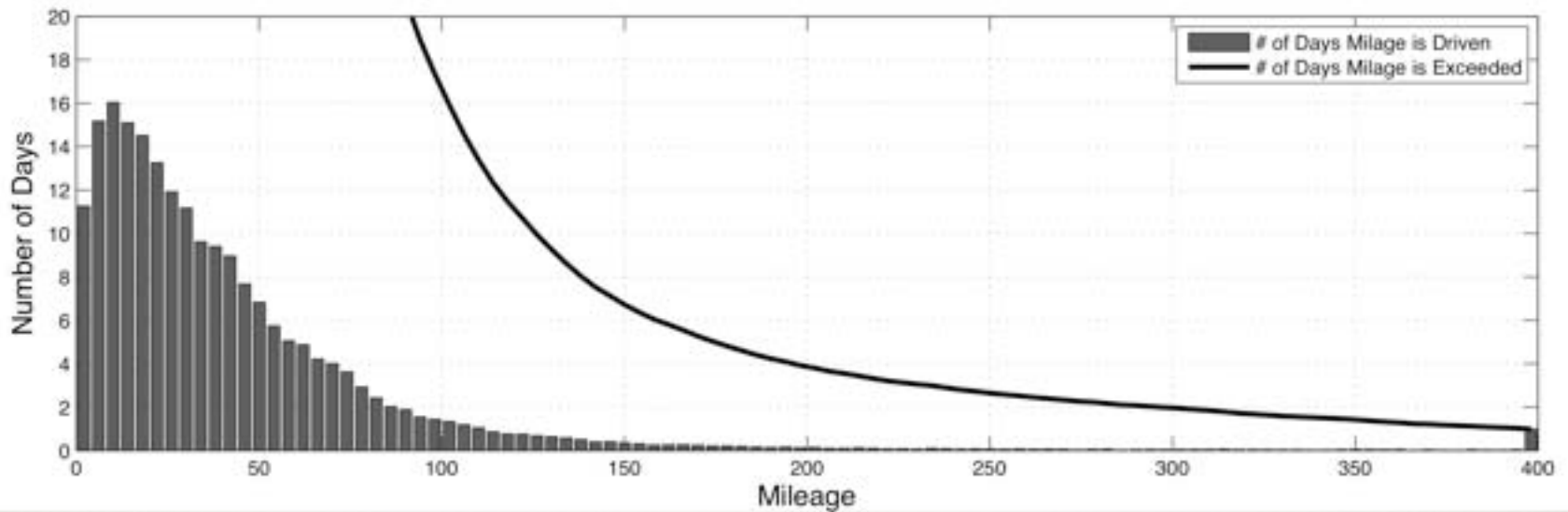


GIV+V2G: 2-Way Power Flow



Plug-in cars as an underutilized resource

- US car used 1 hour/day, parked 23 h/d
- Average daily travel = 30 mi, thus
 - **Most storage unused most days**
- Drive train output = 100 kW
- Practical power through grid = 10 - 20 kW
- Cars as significant power? Compare:
 - Vehicle fleet at 15 kW each car, with
 - Total load for country (GW)



Miles/day Distribution

Based on ~400 (gasoline) cars for one year (from Nat Pearre et al analysis)

- Distribution of miles/day has long tail on high side -- vacations, trips
- Most days, most of battery is unused
- Are vacations and other long trips predictable?
- If so, then the battery need not be filled each morning
- Battery as resource, available most of the time.

Applications Niche

- Storage at the ends of the distribution system
- Second use of customer equipment, thus capital costs are just controls
- Total resource is very large

Assumptions for Adoption rate Calculations

- Light vehicle purchase rate (non-recession) ~15 million/year
- Assume 2 models of GIV vehicle initially, each 150,000 per year
 - PHEV model: assume 3 kW, 8 kWh
 - EV model: assume 15 kW, 30 kWh
- Starting in year 10, 1/2 of fleet is plug-in
- Assume 2/3 buyers participate as GIV

Adoption rate

	Year 1 150,000/year	Years 1-10 150,000/year	Years 11-20 7.5m/year
PHEV 3 kW; 8 kWh	300 MW	3 GW	150 GW
	800 MWh	8 GWh	400 GWh
EV 15 kW; 30 kWh	1.5 GW	15 GW	750 GW
	3 GWh	30 GWh	1.5 TWh

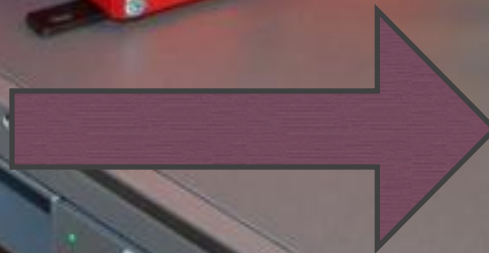
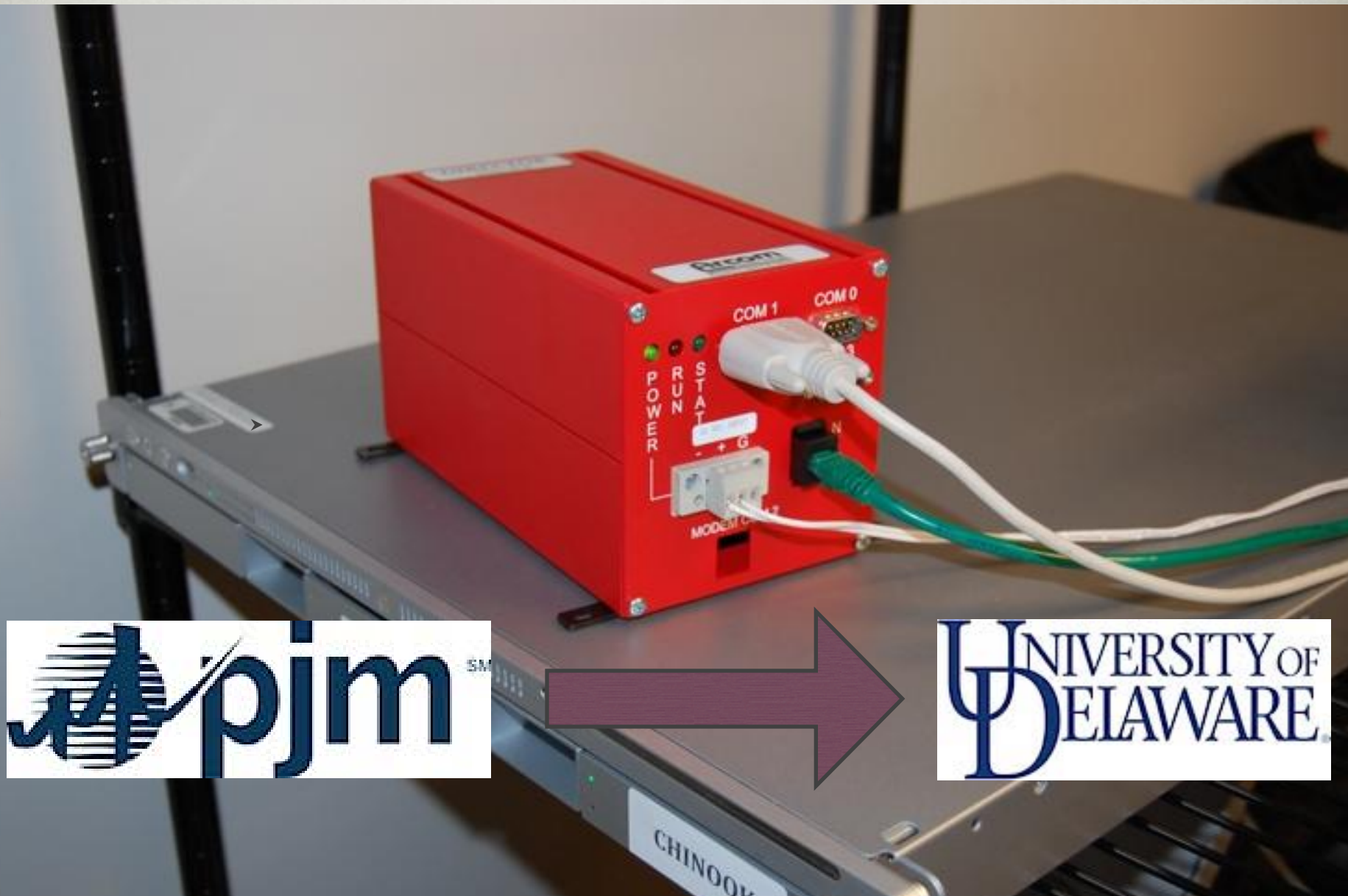
Cost

- On-board intelligence, ~\$400
- Communications, ~\$200
- EV: \$40/kW; \$20/kWh
- PHEV: \$200/kW; \$75/kWh

IMPLEMENTATION

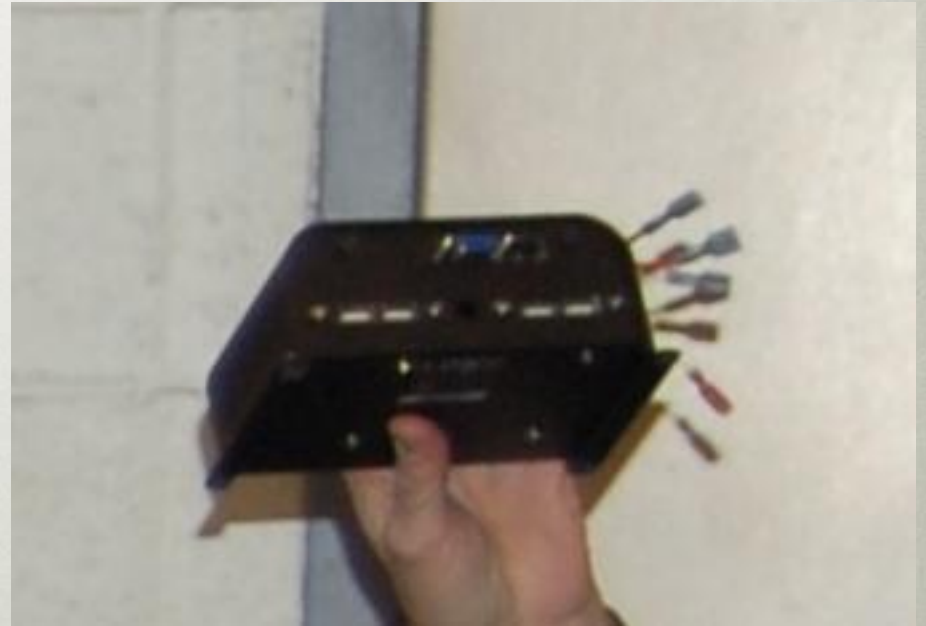
technology running,
laws passed, in daily use

Link from ISO to UD server

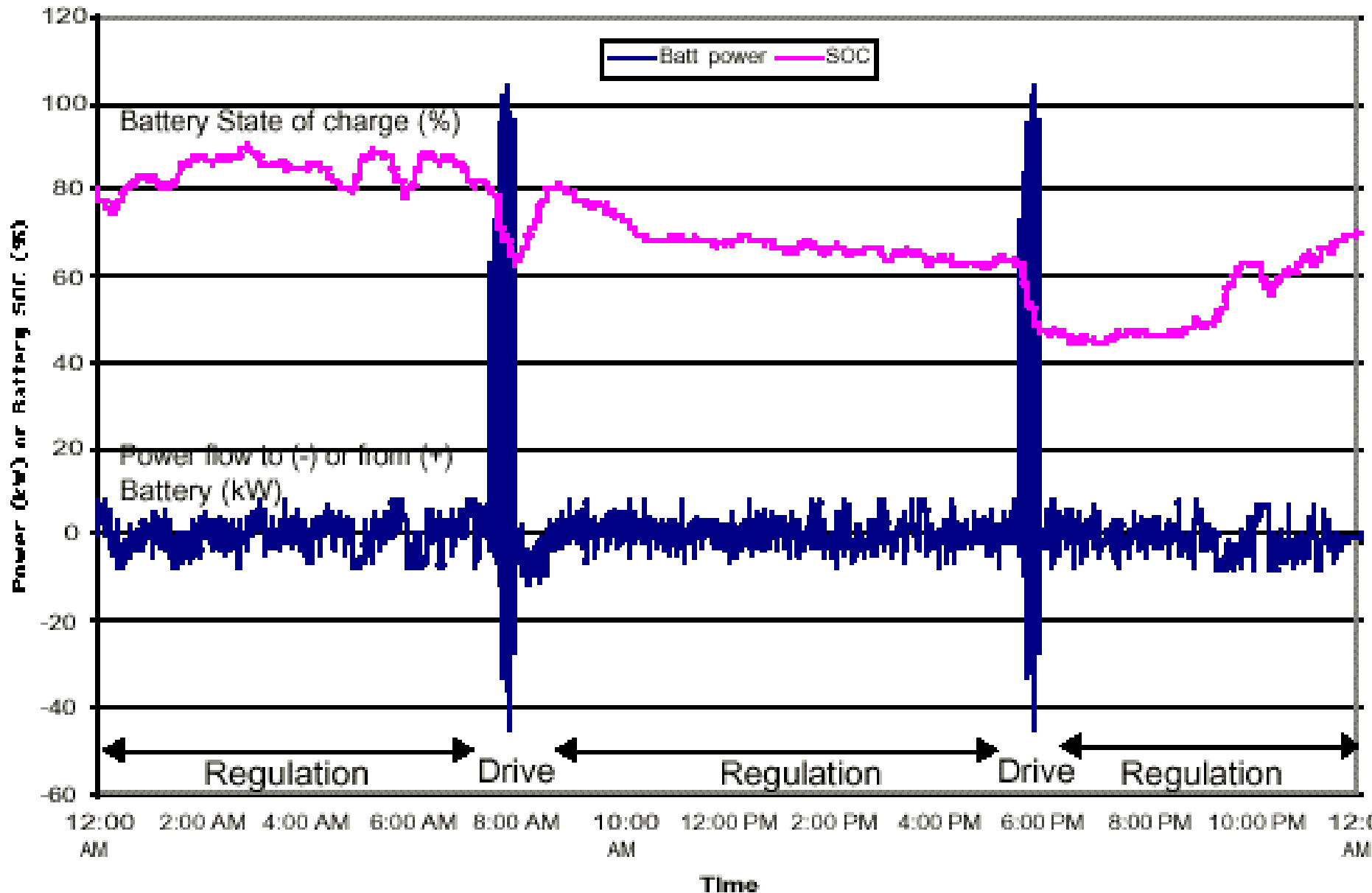


Vehicle Smart link (VSL) in Car

- No moving parts, fits under dash
- Receives signal from coalition server
- Reports capacity and current state back to coalition server
- Try to predict next use of car (time, distance)
- Automotive-grade Linux computer



Regulation, drive, regulation, drive



Dispatch and scheduling

Vehicle to Grid -- Coalition Server

University of Delaware

Coalition Status

ISO	Power Capacity Up (kW)	Power Capacity Down (kW)	Power Requested (kW)	Power Provided (kW)	Energy Charge (kWh)	Energy Empty (kWh)	Number of Cars
PJM	49.37	49.37	-14.80	-15.81	104.30	35.70	4
CAL-ISO	0.00	0.00	0.00	0.00	0.00	0.00	0
Simulated-ISO	0.00	0.00	0.00	0.00	0.00	0.00	0

Hide Charts

CAL-ISO

Simulated-ISO

PJM

Individual Vehicle Status

Car Name	Power Capacity Up (kW)	Power Capacity Down (kW)	Power Requested (kW)	Power Provided (kW)	Energy Charge (kWh)	Energy Empty (kWh)	Miles	Volts (V)	Amps (A)	Monthly Credit (\$)
UD-296	0.00	0.00	0.00	0.00	29.05	5.95	91.30	211	22.5	33.17
UD-170	11.23	11.23	-3.36	-3.95	12.60	22.40	39.60	234	16.9	76.31
DEState5205	10.70	10.70	-3.21	-2.05	33.25	1.75	104.50	214	9.6	21.73
DEState0000	17.36	17.36	-5.21	-5.70	31.50	3.50	99.00	248	23	24.59
UD-210	10.08	10.08	-3.02	-4.09	26.95	8.05	84.70	210	19.5	23.38

Permitted by Load-Serving Entity (local utility)

City of Newark Generator Interconnection Application - Short Form (For Use with Generators 25 kW or Less)

An applicant (Generator Owner) makes application to the City of Newark to install and operate a generating facility of 25kW or less interconnected with the City of Newark utility system.

Section 1. Applicant Information

Name: UNIV OF DELAWARE
Mailing Address: 222 S. CHAPEL
City: NEWARK State: DE Zip Code: 19716
Facility Location (if different from above): 401 Wyoming Rd
Telephone (Daytime): Area Code 302 Number 831-4407 (Evening) Area Code 302 Number 893-2148
City of Newark Electric Account No. : 08000002497-00 Pole Number: _____



Section 2. Generator Technical Information

NEM - Net Energy Metering

Is Generator powered from a Renewable NEM Qualifying Energy Source: Yes No
Type NEM Qualifying Energy Source (if applicable): Solar Wind Hydro Electric Vehicle
Generator (or solar collector) Manufacturer, Model Name & Number: AC Propulsion eBox
(Battery System) Output Power Rating in kW: 120 kW
Inverter Manufacturer, Model Name & Number (if used): AC Propulsion AC-150
Rating in kW: 19.2 kW



Permitted by Load-Serving Entity (local utility)

Will a generator disconnect device, accessible to the City of Newark, be installed? Yes No

If the Generator Owner elects not to install a manual disconnect device accessible to the City of Newark, the Generator Owner assumes all risks and consequences when a service meter must be "pulled" to disconnect the generator thereby also interrupting all utility electric service to the Customer site.

Will an automatic transfer switch be used? Yes No

Supply specifications for the transfer switch showing UL listing and "Break before Make" contacts.

Section 3. Generator/Equipment Certification

~~Generating systems that use utilize inverter technology must be compliant with IEEE 420 and Underwriters Lab. UL 1741.~~ By signing below, the Applicant certifies that the installed generating equipment meets the appropriate preceding requirement(s) and can supply documentation that confirms compliance. *

Signed (Applicant): *Amir M. Johnson* Date: *1/8/09*

* Documentation has been provided to the City certifying that the AL-150 inverter meets IEEE 1547 standards.

"meets IEEE 1547 standards"



Law to codify interconnects, net metering for V2G



SPONSOR: Sen. Simpson & Rep. Kowalko
Sen. McDowell; Rep. Hocker

DELAWARE STATE SENATE
145th GENERAL ASSEMBLY

SENATE BILL NO. 153

AN ACT TO AMEND TITLE 26 OF THE DELAWARE CODE RELATING TO CUSTOMER SITED ENERGY RESOURCES.

BE IT ENACTED BY THE GENERAL ASSEMBLY OF THE STATE OF DELAWARE (Two-thirds of all members elected to each house thereof concurring therein):

Section 1. Amend §1001, Title 26 of the Delaware Code by adding two new definitions reading as follows, and renumbering existing definitions alphabetically.

“(1) ‘Aggregator’ means any person or entity who contracts with an electric distribution company, electric supplier or PJM Interconnection (or its successor) to provide energy services, which facilitate battery storage systems for grid-integrated electric vehicles and related technologies.

(14) ‘Grid-Integrated Electric Vehicle’ means a battery-run motor vehicle that has the ability for two-way power flow between the vehicle and the electric grid and the communications hardware and software that allow for the external control of battery charging and discharging by an electric distribution company, electric supplier, PJM Interconnection, or an aggregator.”



Define:

Aggregator

Grid-integrated electric vehicle

Law to codify interconnects

Section 2. Amend §1014, Title 26 of the Delaware Code by adding a new subsection to read as follows:

(g) A retail electric customer having on its premises one or more grid-integrated electric vehicles shall be credited in kilowatt-hours (kWh) for energy discharged to the grid from the vehicle's battery at the same kWh rate that customer pays to charge the battery from the grid, as defined in (e)(1) of this section. For electric customers with time of use rates, the kWh rate for charging and discharging shall be the rate in effect when charging or discharging occurs. Excess kWh credits shall be handled in the same manner as net metering as described in (e)(1) of this section. To qualify under this subsection, the grid-integrated electric vehicle must meet the requirements in (d)(1)a., (d)(1)b. and (d)(4) of this section. Connection and metering of grid integrated vehicles shall be subject to the rules and regulations found in (e)(2), (e)(3), and (e)(4) of this section.

Net metering for V2G

Net is at rate at time of use

Interconnection requirements, etc
same as distributed renewables



Manufacturing



GIV with controls and V2G,
licensed from UD -- Built in
from factory



Documentation for partners

TSO/ISO/Wind operator

↕ ①

Aggregation server

↕ ②

Driver ↔ ④ VSL ↔ ⑤ VMS (OEM) ↔ ⑥ drive system & battery (OEM)

↕ ③

EVSE

Modularized interfaces

Next Steps

- Demonstrate at 1 MW level (~100 cars)
- Work with OEMs now ready to add GIV capabilities
- Establish permitting for V2G in more utilities and more states
- Design EVSE (charge spots) for GIV
- Serve on standards committees

Thanks to our sponsors



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AIR RESOURCES BOARD

END

More information:

www.udel.edu/V2G

www.magicconsortium.org