

TECHNICAL POTENTIAL ASSESSMENT OF PLUG-IN HYBRID VEHICLES ON REGIONAL U.S. POWER GRIDS

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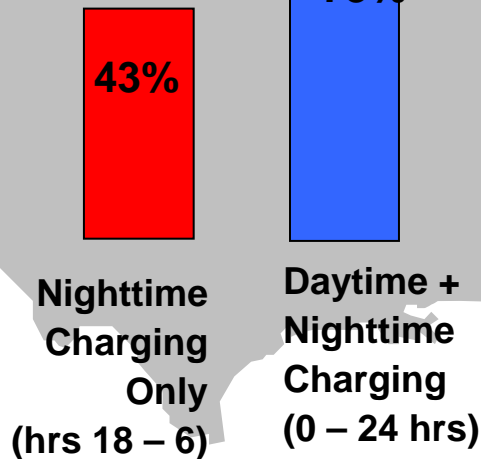
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Motivation and Objectives

- ▶ Can the power grid play a significant role in addressing U.S. dependence of oil?
 - What is the maximum throughput potential of the electric grid to deliver the energy needs of U.S. light duty vehicle fleet (cars, pickups, SUVs, vans)?
 - Assume future grid looks much like today's*
 - Assume vehicle mix is unchanged*
 - * rather have outcome driven by the assumptions
- ▶ What would be some of the impacts be on:
 - Gasoline/crude oil displacement
 - Emissions
 - Utility revenue requirements

Over 70% of the existing U.S. light-duty vehicle fleet (if PHEVs) could be fueled with available electric capacity

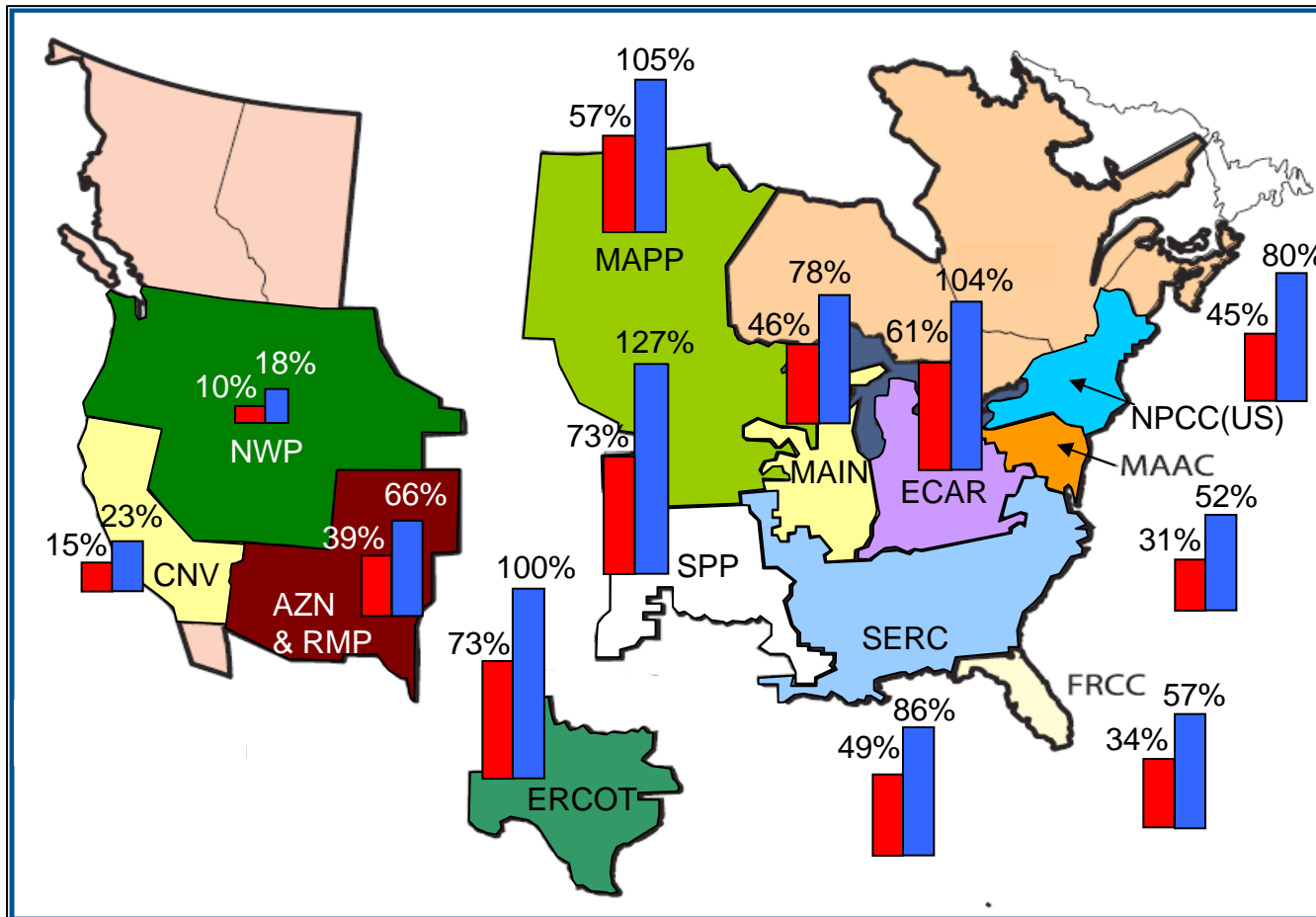
U.S. Overall





Assumptions

- ▶ PHEV specific energy requirements (EPRI 2004):
 - Compact 0.26 kWh/mi
 - Mid-size 0.30 kWh/mi
 - Mid-size SUV/Vans 0.38 kWh/mi
 - Full-size SUV 0.46 kWh/mi
- ▶ 87% charger efficiency
- ▶ 85% battery efficiency
- ▶ 8% T&D loss

Analysis by NERC Region*





 Nighttime Charging Only (hrs 18 – 6) Daytime + Nighttime Charging (0 – 24 hrs)

Summary

- ◆ Midwest: support almost the entire LDV fleet
- ◆ East: somewhat smaller potential
- ◆ West: supports fewer vehicles

% figures denote the percentage of LDV fleet supported by idle electric capacity

Regional Emissions Impacts (Well-to-Wheel*) with Today's Generation Mix

* Argonne National Laboratory's
GREET well-to-wheel model

Existing coal plants
break even on
greenhouse gases

Nationally, greenhouse
gases reduced 27% despite
increased reliance on coal

Plant mix for valley fill	ECAR	ERCOT	MACC	MAIN	MAPP	NPCC	FRCC	SERC	SPP	PNW	ARIZONA	CA	US total
	Power Generation Composition												
Natural Gas	32%	94%	74%	42%	1%	91%	69%	57%	78%	43%	63%	93%	
Coal	68%	6%	26%	58%	99%	9%	31%	43%	22%	57%	37%	7%	
Emissions	Emissions Ratio (Electric Vehicle/Gasoline Vehicle)												
Greenhouse gases	0.87	0.60	0.69	0.83	1.01	0.61	0.71	0.76	0.66	0.84	0.73	0.61	0.73
VOC: Total	0.11	0.04	0.06	0.10	0.14	0.04	0.07	0.08	0.06	0.10	0.07	0.04	0.07
CO: Total	0.01	0.02	0.02	0.02	0.01	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02
NOx: Total	1.02	0.38	0.59	0.93	1.35	0.41	0.64	0.76	0.54	0.93	0.71	0.39	0.69
Particulates	1.55	0.81	1.06	1.45	1.94	0.86	1.13	1.26	0.99	1.46	1.19	0.84	1.18
SOx	3.94	0.42	1.68	3.59	5.96	0.64	2.05	2.67	1.34	3.77	2.35	0.53	2.25
Urban: VOCs	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
CO	0.00	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
NOx	0.10	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.11	0.10
Particulates	0.60	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.61
SOx	0.35	0.04	0.14	0.30	0.51	0.05	0.17	0.23	0.12	0.37	0.24	0.08	0.19

SOx from vehicles doubles:
cap-and-trade will require
investment in cleaner plants

Urban air quality emissions
greatly reduced:
VOCs/CO/NOx > 90%
SOx = 80%
Particulates = 40%

- ▶ Moving emissions from tailpipes to smokestacks:
 - solves an intractable problem for CO₂ capture
 - improves cost effectiveness for other emissions

Increased Sales of Electricity from PHEVs Produce Lower Average Cost of Electricity

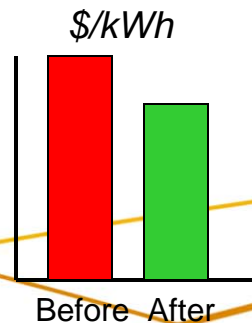
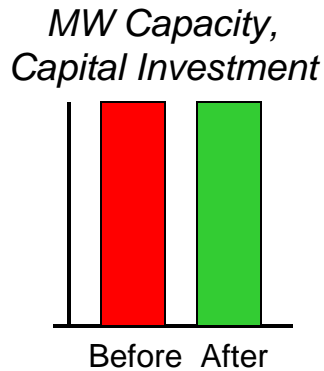
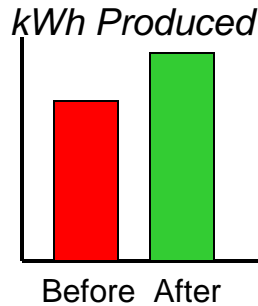
Increased sales

+

Same infrastructure, same capital investment

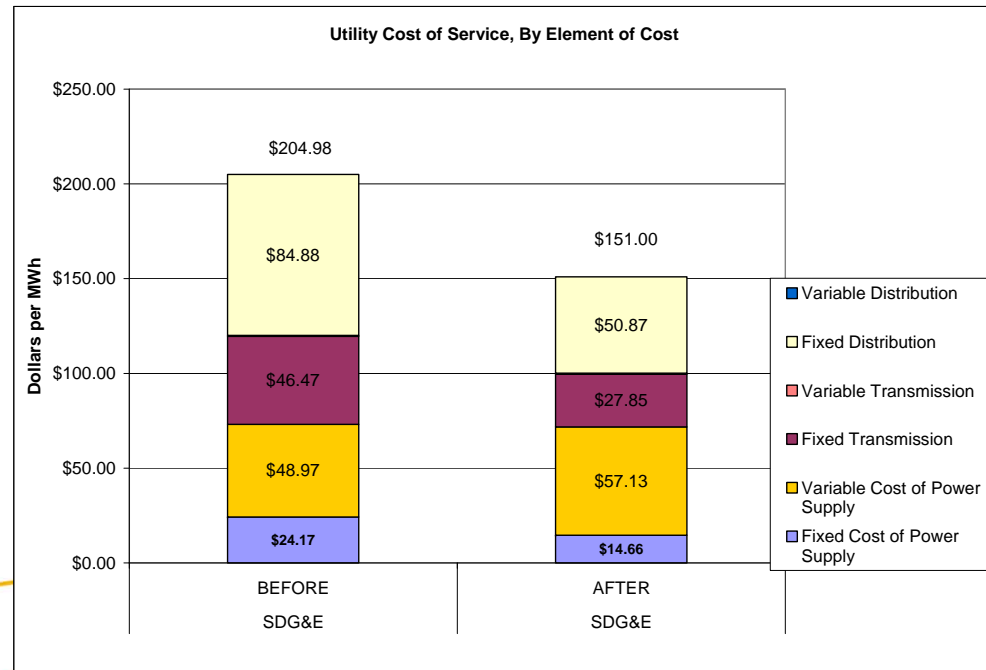
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Lower Average Cost



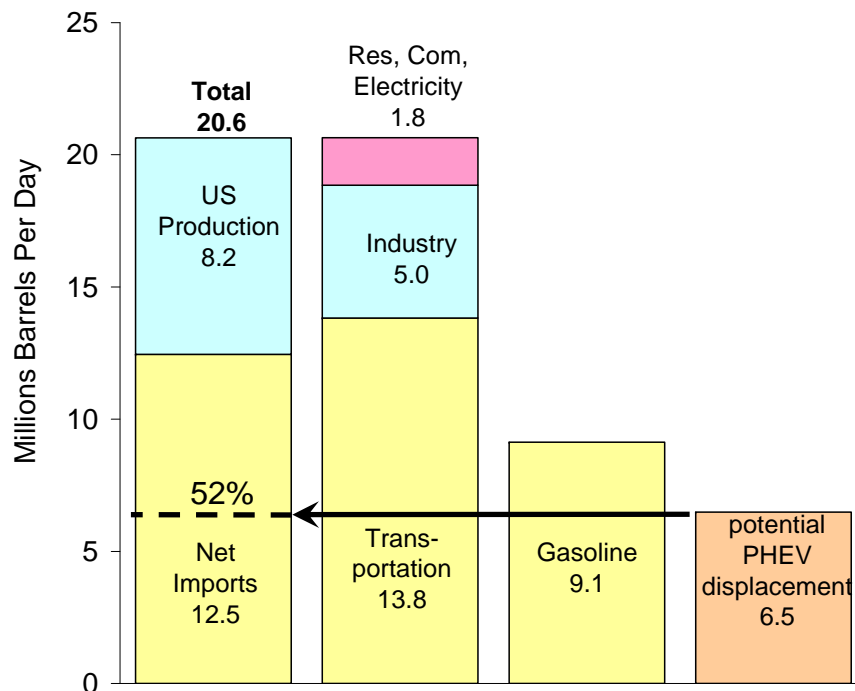
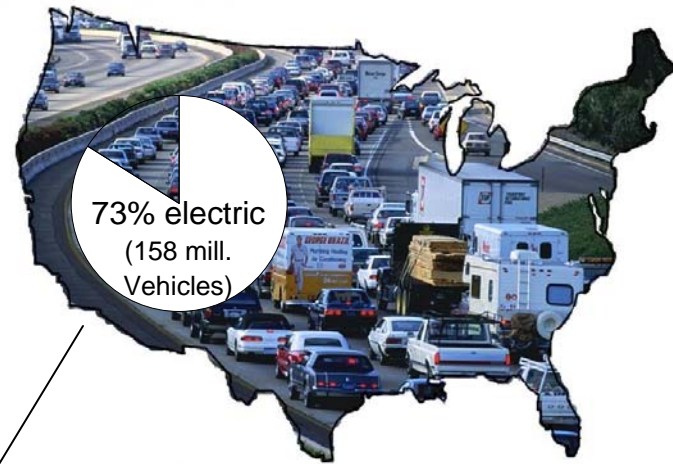
* analyzes of Cincinnati Gas & Electric and San Diego Gas & Electric

San Diego Gas & Electric Costs/MWh with PHEV Valley Filling



Results

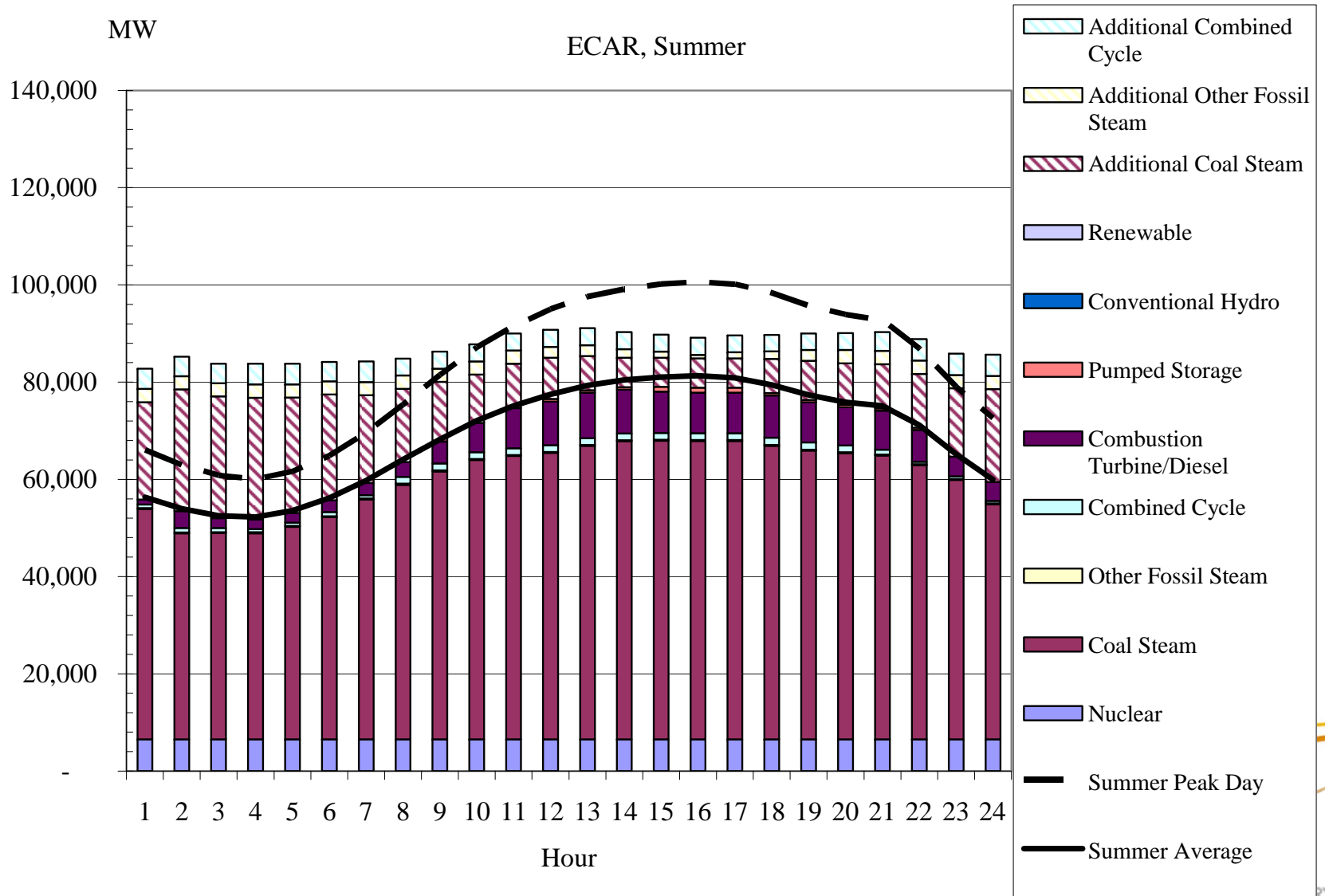
The idle capacity of the U.S. grid could supply **73%** of the energy needs of today's cars, SUVs, pickup trucks, and vans...
without adding generation or T&D capacity



- ▶ Potential to displace 6.7 MMbpd (equiv. to 52% of net imports)
- ▶ More sales + same infrastructure = downward pressure on rates
- ▶ Reduces CO₂ emissions by 27%
- ▶ Emissions move from tailpipes to smokestacks (and base load plants) ... cheaper to clean up
- ▶ Introduces vast electricity storage potential for the grid

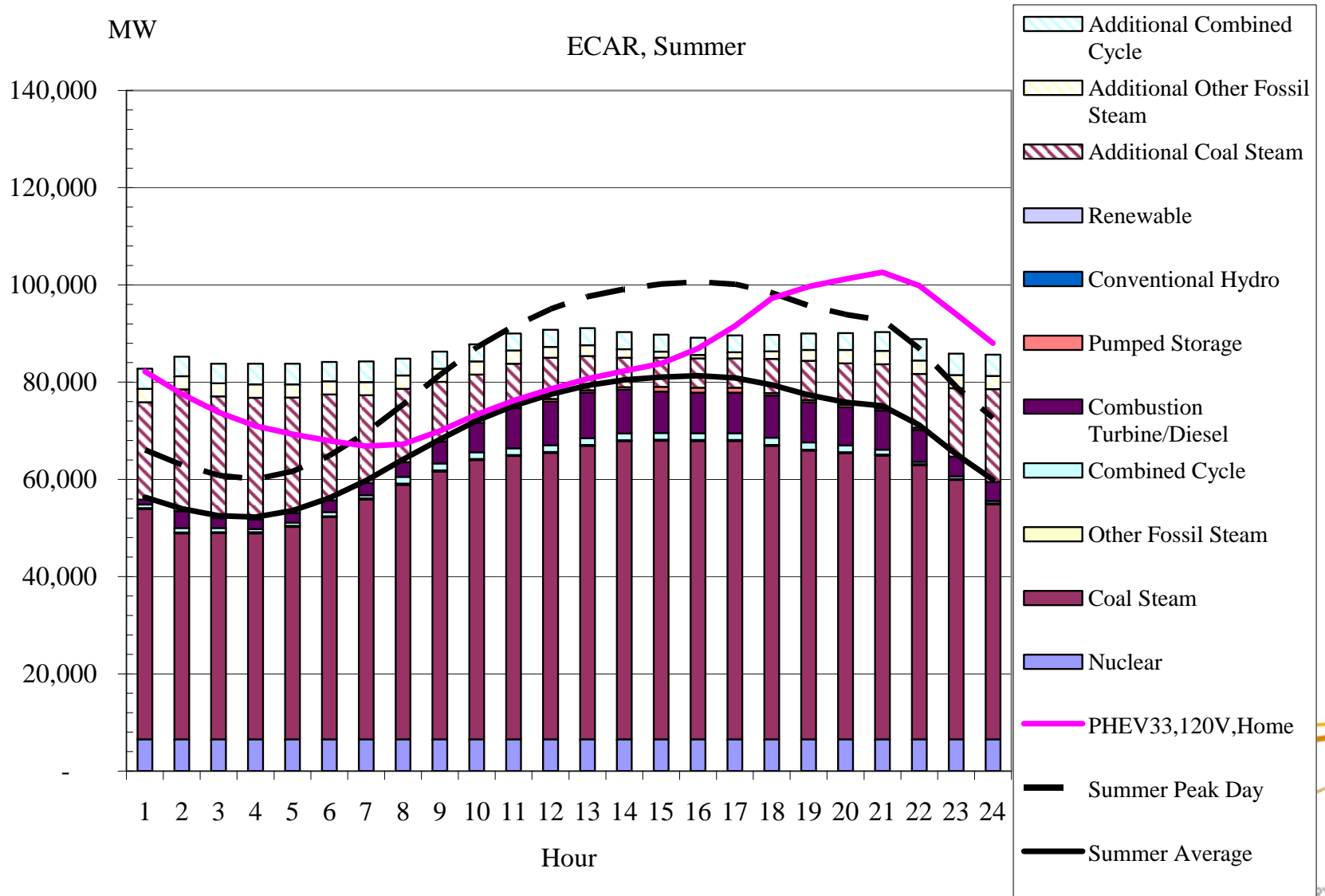
Source: EIA, Annual Energy Review 2005

Current Generation and "Valley-Filling" ECAR, Summer



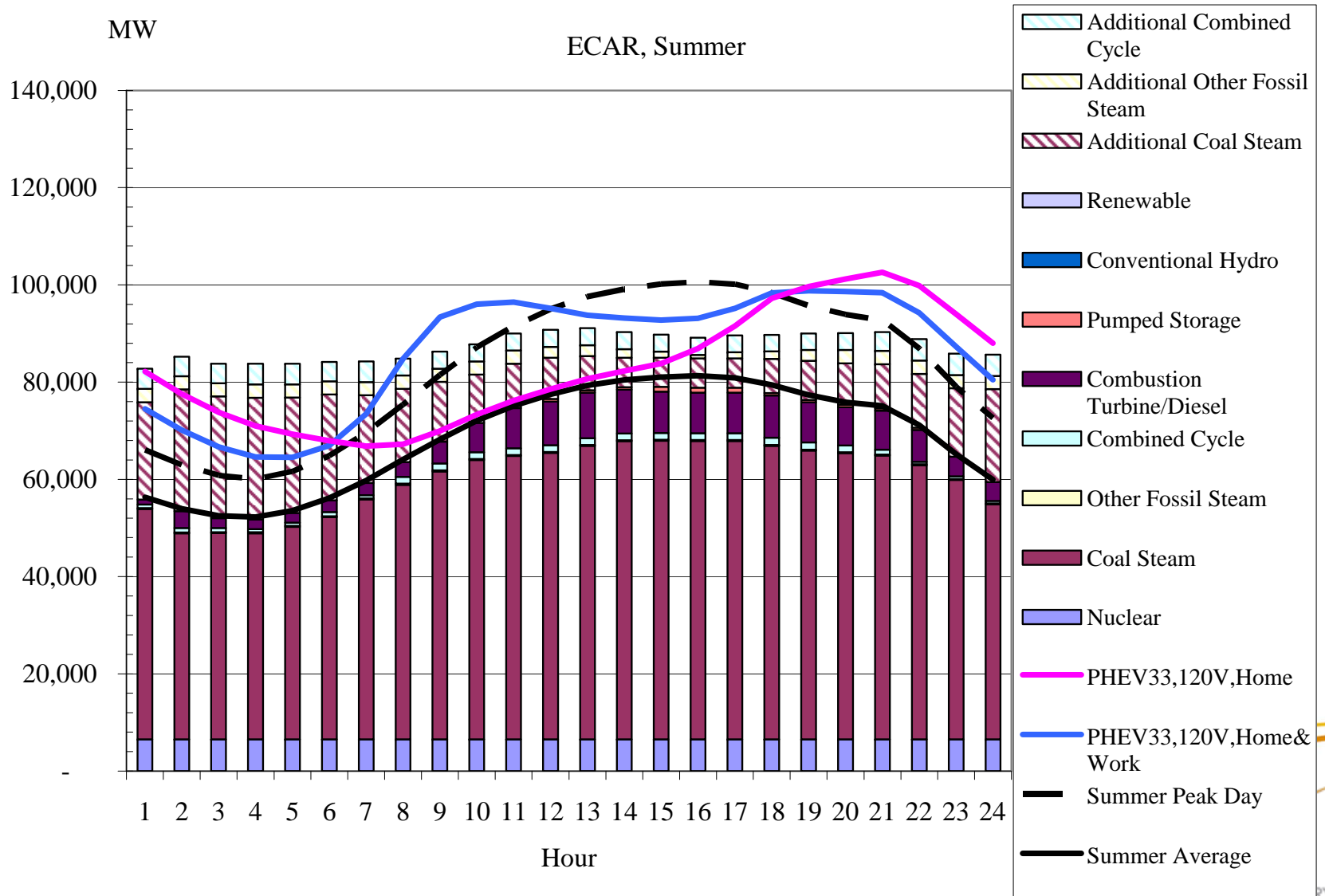
Assuming Charging When Vehicle Arrives at Charging Location

ECAR Summer



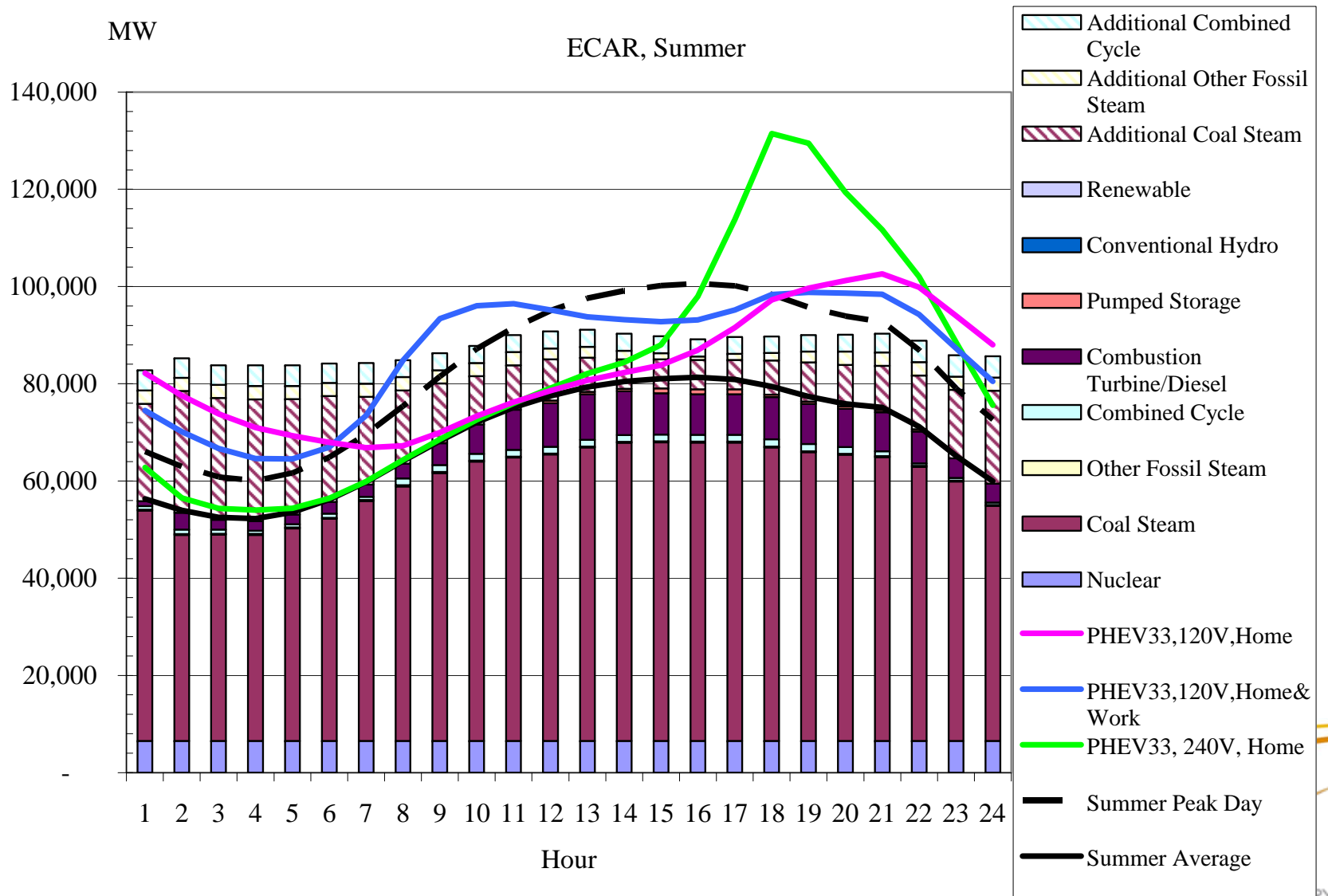
Assuming Charging When Vehicle Arrives at Charging Location

ECAR Summer



Assuming Charging When Vehicle Arrives at Charging Location

ECAR Summer



Summary

- ▶ Significant idle generation capabilities in the U.S. grid. Potential to support
 - Nationally, 73% of light duty vehicles (LDV) stock (2002), with 2002 grid with managed charging (optimal valley filling)
 - Nationally, 64% of light duty vehicles (LDV) stock (2002), with 2002 grid with unmanaged charging
- ▶ Reduction potential of gasoline equivalent to 52% of imported petroleum
- ▶ Emissions
 - Nationally, 27% reduction potential of GHG
 - Urban emissions ALL improved. Shifting emissions from tailpipes to power plant stacks
 - SOx, Particulates require scrubbers
- ▶ “Smart” charger will are likely to emerge.
 - “charge everywhere – bill at home”
 - Load management
 - Price-based: critical peak/time-of-use pricing/real-time pricing
 - Direct load control
 - Autonomous control to reduce stress during emergency condition
 - V2Home, V2Grid