FLORIDA SOLAR ENERGY CENTER®

Creating Energy Independence

Driven by the Sun – PV is (way)Cheaper than Gasoline

Brief Information and Opinions

Florida PSC Workshop on Electric Vehicle Charging Stations – 6 Sep 2012

Robert M. Reedy, PE
Director, Solar Systems Research Division
Florida Solar Energy Center
+1.321.638.1470
reedy@fsec.ucf.edu

"Game Changers" The New Electric Cars

- 80% of VMT is less than 40 miles per day
- 26% of Florida vehicles are small cars
- 4,000 kWh/yr for 12,000 miles
- **If all small cars electric**
  - 1.4 billion gallons of gasoline saved per year
  - $2.6 billion net cost savings per year if PV electric
  - 15 TWh (billion kWh) additional energy needs per year (4 MORE LARGE POWER PLANTS)!

Nissan Leaf (all electric)

Chevy Volt (plug-in hybrids)

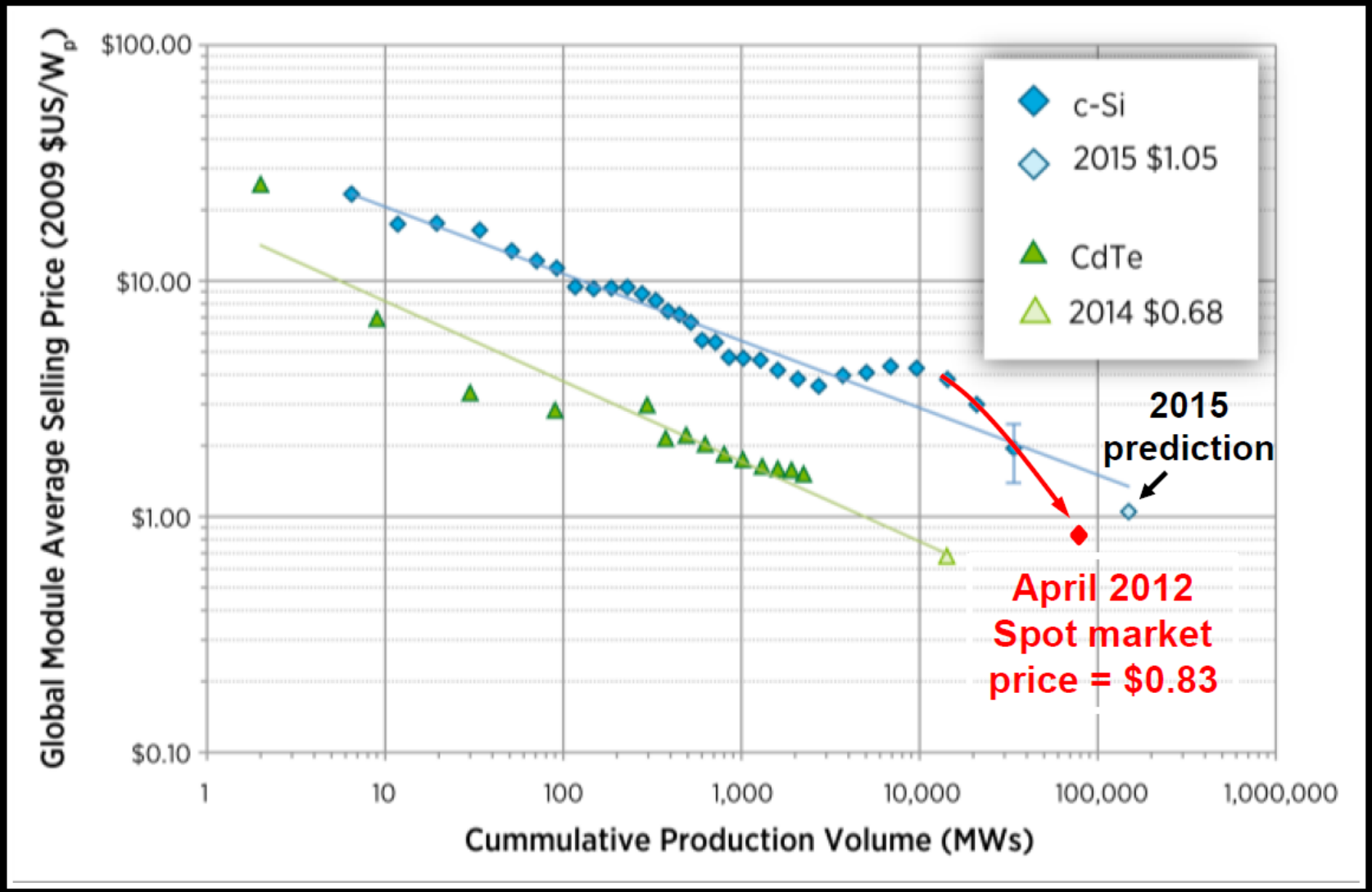
Total Cost of Electric Car ≈ Cost of Gasoline Car at the end of 5 years

Residential Electricity is Equivalent to $0.97 Per Gallon Gasoline

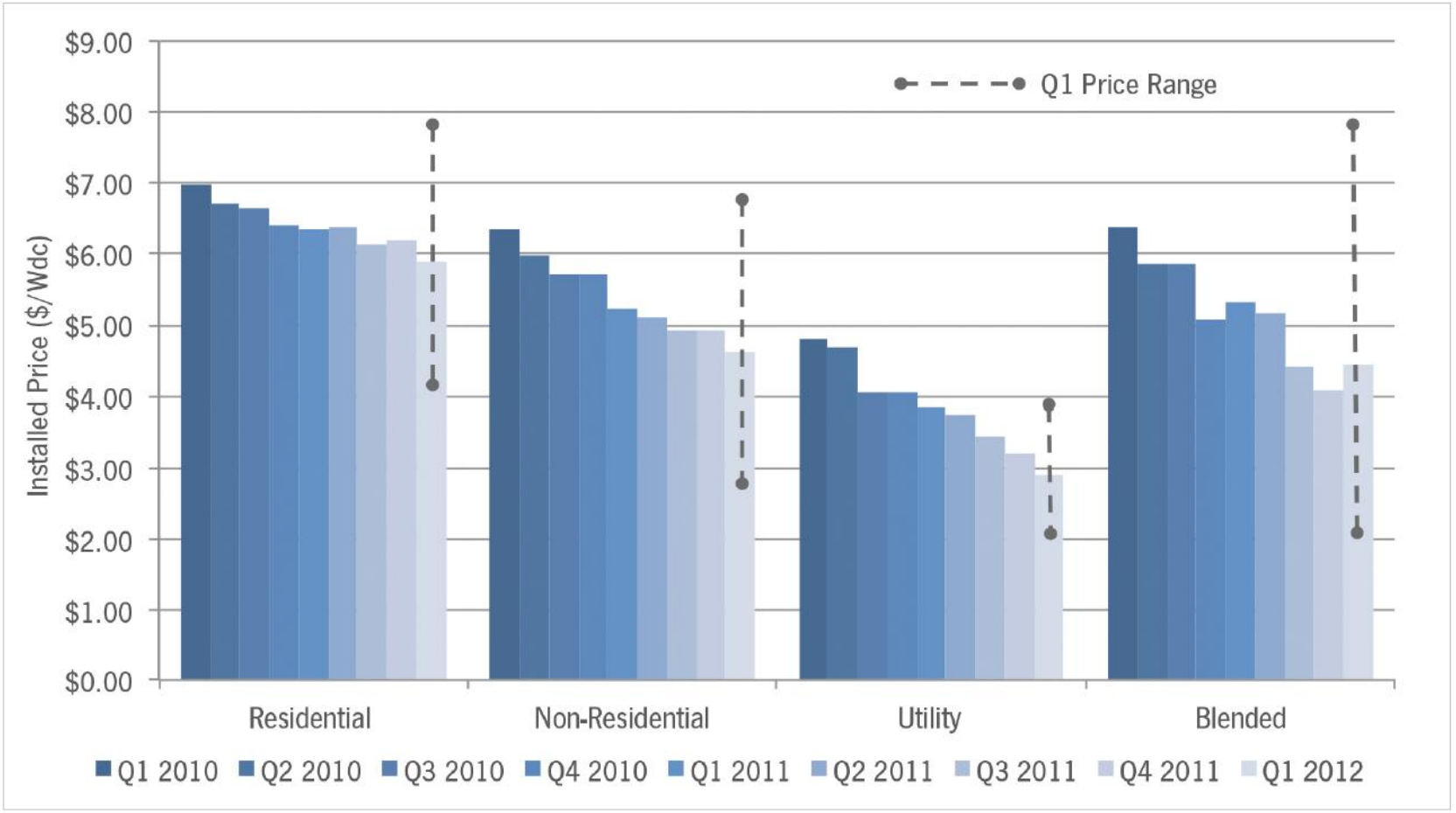
	Fuel Efficiency	Fuel Price	Cost per Mile	Cost per 12,000 Miles
Gasoline Car 	25 mpg	$3.25 per gal	13¢ per mile	$1,560
Electric Car 	3 miles per kWh	11.6 ¢/kWh ($0.97 per gal equiv.)	3.9¢ per mile	$464

Costs of PV modules are dropping below the power law experience curves

Sources: (CdTe) First Solar Earnings Presentation, SEC Filings;
(c-Si) Navigant, Bloomberg NEF, NREL internal cost models



Installed Price of PV

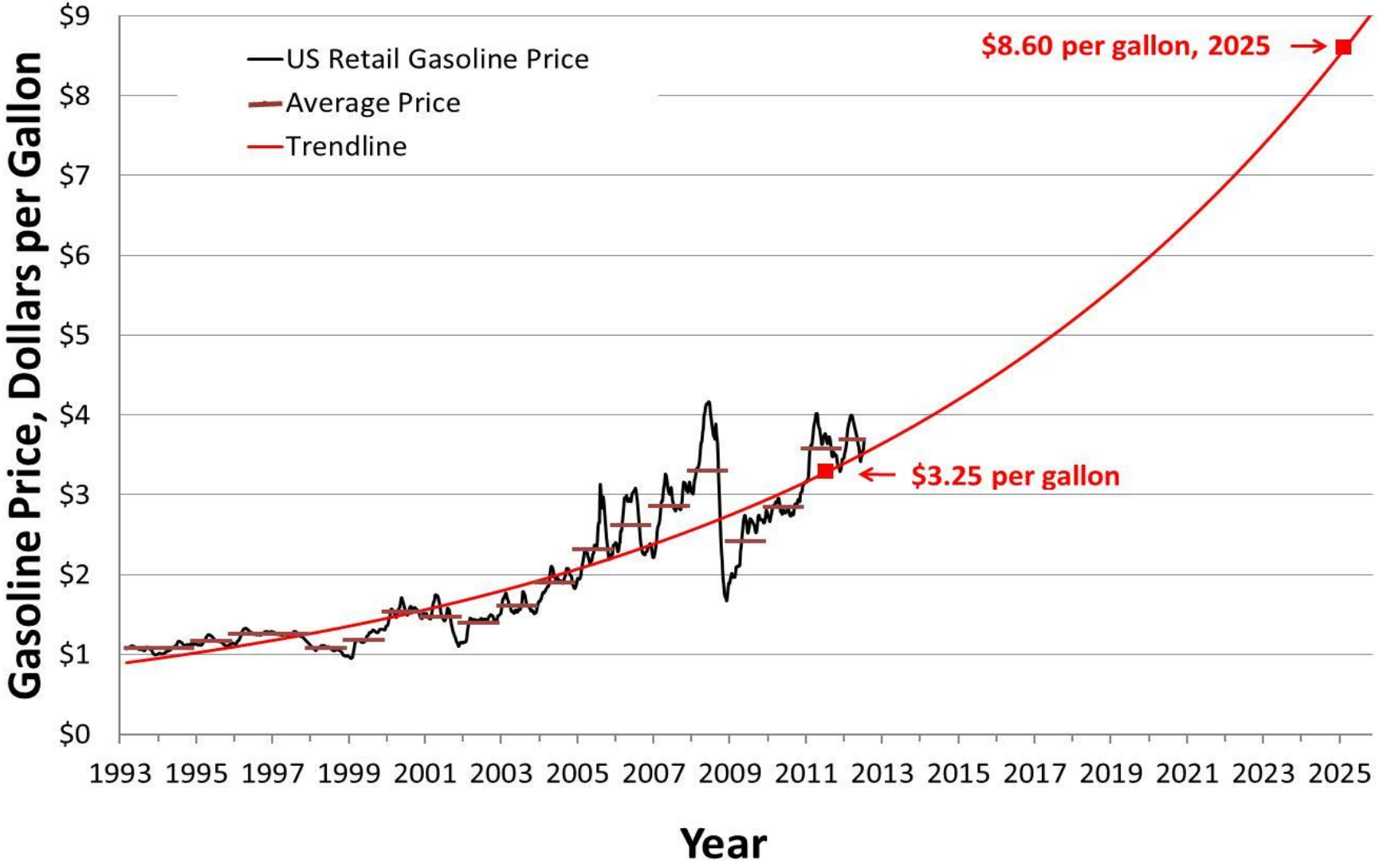


National Weighted Average System Prices, 2010 –Q1 2012

Residential Photovoltaic Power is Equivalent to $1.08 Per Gallon Gasoline

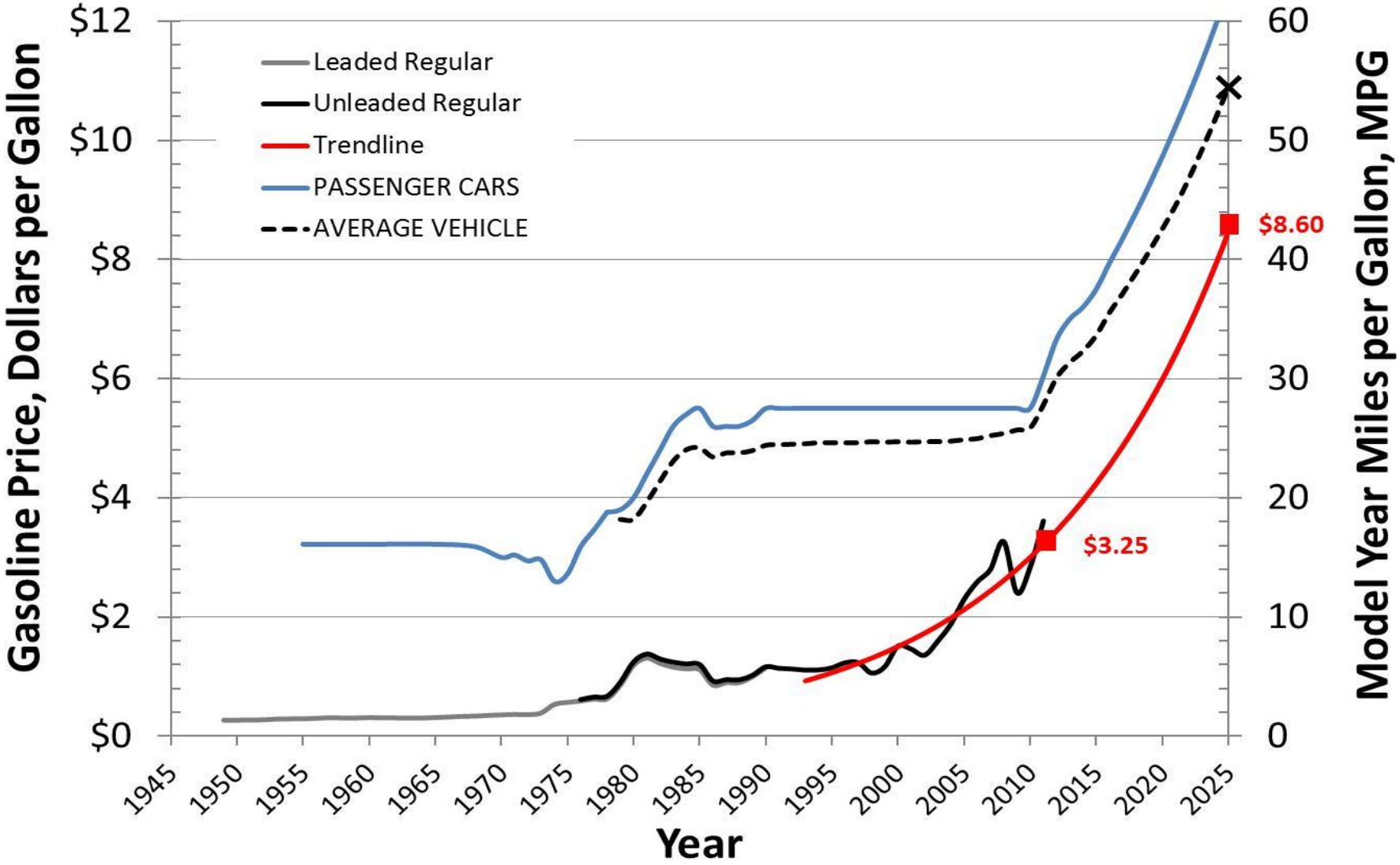
	Fuel Efficiency	Fuel Price	Cost per Mile	Cost per 12,000 Miles
	25 mpg	$3.25 per gal	13¢ per mile	$1,560
	3 miles per kWh	13 ¢/kWh ($1.08 per gal equiv.)	4.3¢ per mile	$520

Future Price of Gasoline?

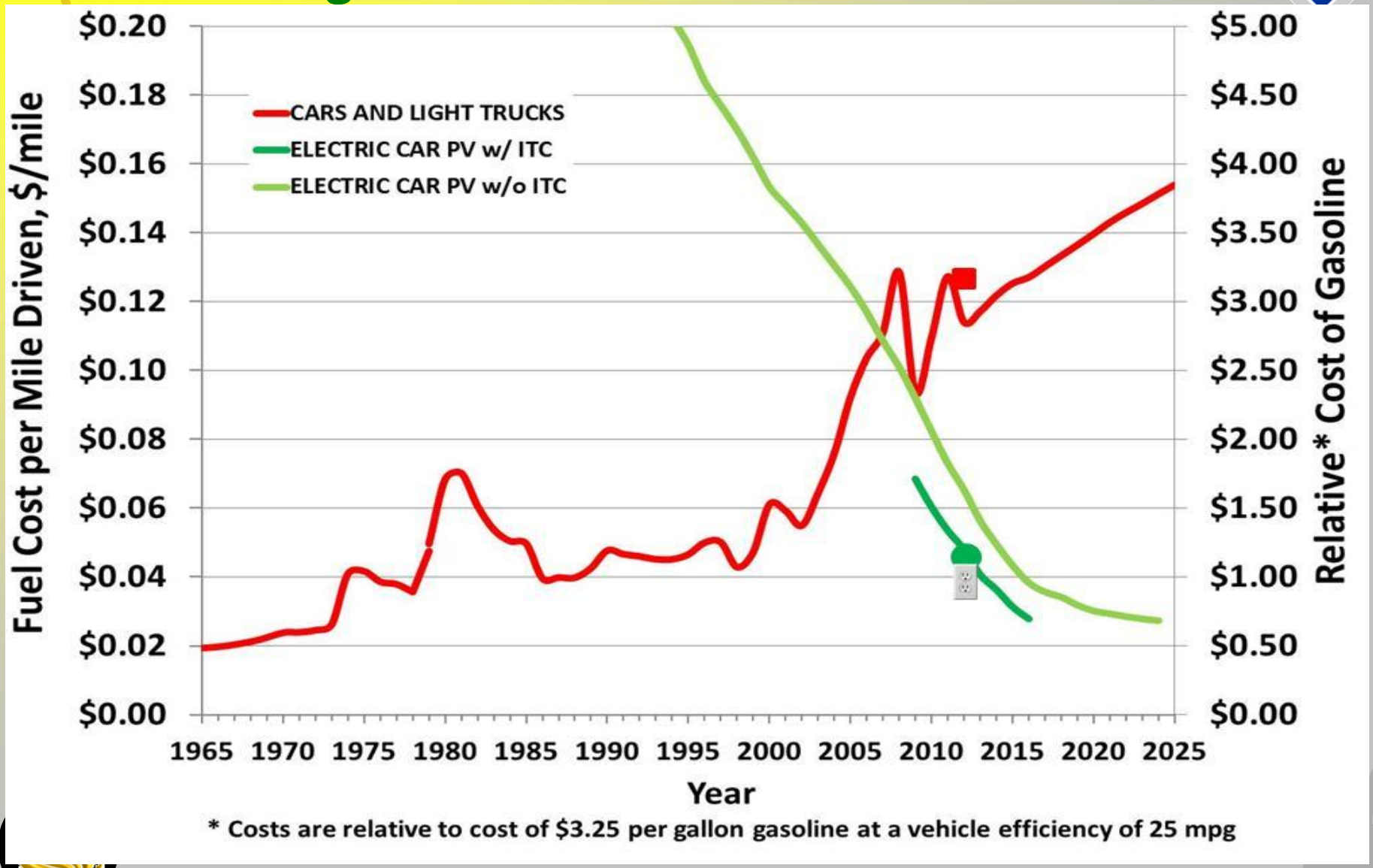


Price of Gasoline?

LIGHT-DUTY VEHICLE FUEL ECONOMY STANDARDS, 1955-2025



PV: $1.08 a gallon today, & less than a $1 a gallon tomorrow --



"Back of the Envelope" Numbers
All Small Cars PV Electric by 2030:

Annual Florida Gasoline use	8.4 billion gal/y
Florida on-road vehicles	14.3 million
Florida Small Cars (26.3%)	3.76 million
Displaced Gasoline (16.7%)	1.4 billion gal/y
Displaced Gasoline Cost ($3.25 /gal)	$4.6 billion/y
PV Electricity (4 Power Plants)	15.0 TWh/y
PV Capital Cost ($2.9 Wp-dc installed)	$20.4 billion
PV Job-Years (manuf. & install.)	238,000
PV Electricity Cost ($0.13 /kWh)	$1.96 billion/y
Cost Savings	$2.63 billion/y
Displaced OPEC oil imports	67 %

Submitted for your consideration:

Florida will drive PV powered electric cars!

Given More EVs, How Do We Charge Them?

- Many Factors point to growing demand for EVs
- Previous speakers confirmed trend
- Florida's electric grid will be impacted
- Residential PV equates to **$1.08**/eq gal

Both EV & PV is Gotta Happen; Gonna Happen…

So where does the PV go?

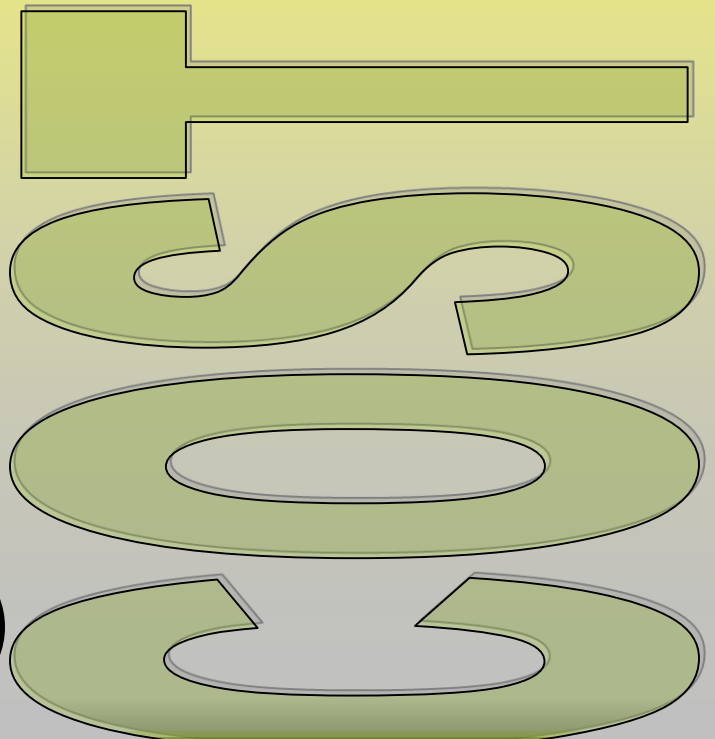
Sidebar re: Future Grid– Also on The Way

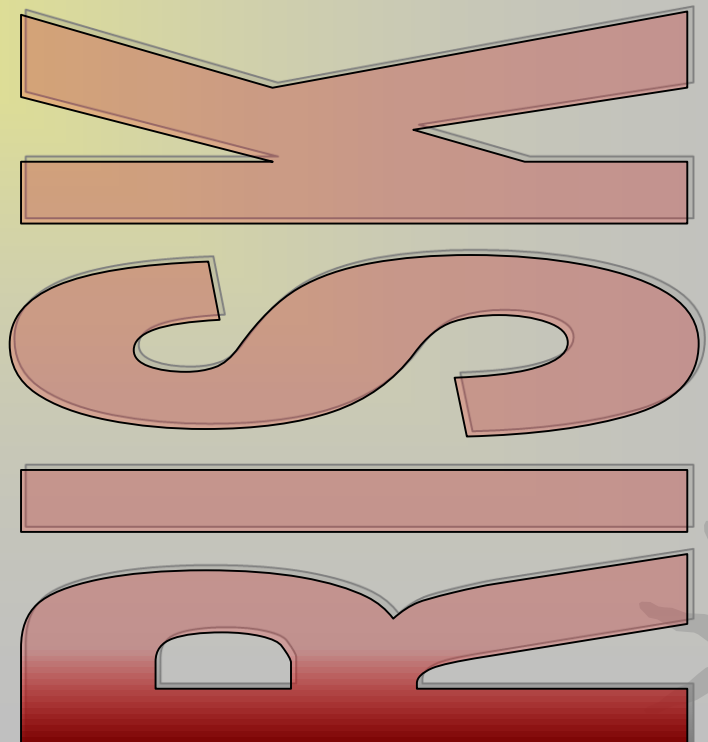
- Back-to-Back DC links inserted in major AC ties
- New major Transmission is DC
- Widely dispersed DG (primarily solar)
- Reactive power control via Inverters
- Ancillary services via Inverters
- Improved System Stability
- Resistance to Fault Induced Delayed Voltage Recovery (FIDVR)

Behold: The "asynchronization" of the Grid…

Where?

- **Physical**
  - Parking Canopies
  - Residential Roof
  - Commercial Roof
  - Institutional Roof
- **Electrical**
  - Grid Tie – Distributed
  - Grid Tie – Central Station
  - Off Grid (Stand-alone)





Electrical – Grid-Tied Central Station (Large Ground Mount)

- Advantages include:
  - Can be Lowest *Generated* Energy Cost
  - Monitoring & Control simplified
  - Ownership/Finance simplified
  - Clarity of Rate Base issues
  - 88-92% Energy Benefit (regardless of EV use)
- Disadvantages include:
  - 8-12% EV charging energy lost in T&D
  - No mitigation of EV impacts on feeder
  - Significant complications and cost to wire the charging stations (particularly parking lots)

Electrical – Grid-Tied Distributed Gen (Roof/Canopy Mount)

- Advantages include:
  - Can be Lowest *Delivered* Energy Cost
  - Highest Energy Yield
  - Mitigation of Feeder Impacts
  - Benefit to entire system on peak (except “needle” morning peak)
  - PV energy used 100%
- Disadvantages include:
  - Capital Cost highest
  - Control/Monitoring more complex
  - Significant complications and cost to wire the charging stations (particularly parking lots)

Electrical – Off Grid Stand-Alone (Roof/Canopy Mount)

- Advantages include:
  - Can be Lowest *Delivered* Energy Cost (to vehicle only)
  - DC-DC Converters can be 98-99% efficient
  - EV has no impact on feeder during day
  - Benefit to entire system on peak (except “needle” morning peak)
  - PV Parking canopy needs no external wiring

- Disadvantages include:
  - Charging rates are variable, very low in bad weather, no nighttime capability
  - PV energy utilization dependent on demand
  - No grid inverters, therefore no ancillary services (VAR, voltage support, etc) available to utility
  - Maximum roof/canopy area per vehicle likely limiting
  - More suited for “boost” or “opportunity” charging
  - DC charging standard needed in vehicles to realize full benefits

"The EV Effect"

- Better EVs & Lower EV costs drive:
- Better Baseload generation utilization and Lower Baseload costs, driving:
- Lower* Overall rates, driving:
- Higher EV utilization….

* or mitigating increases

"The PV Effect"

- Lower PV costs drive:
- Lower Peak/Super-Peak generation costs, driving:
- Lower* Overall rates, driving:
- Higher EV utilization….

* or mitigating increases

"The PV-EV Effect"

- Lower* Overall rates, drive:
- Lower PV costs; driving:
- Utility investment in PV peaking generation (both DG and Central Station), driving:
- Lower PV costs!

- **Repeat.**

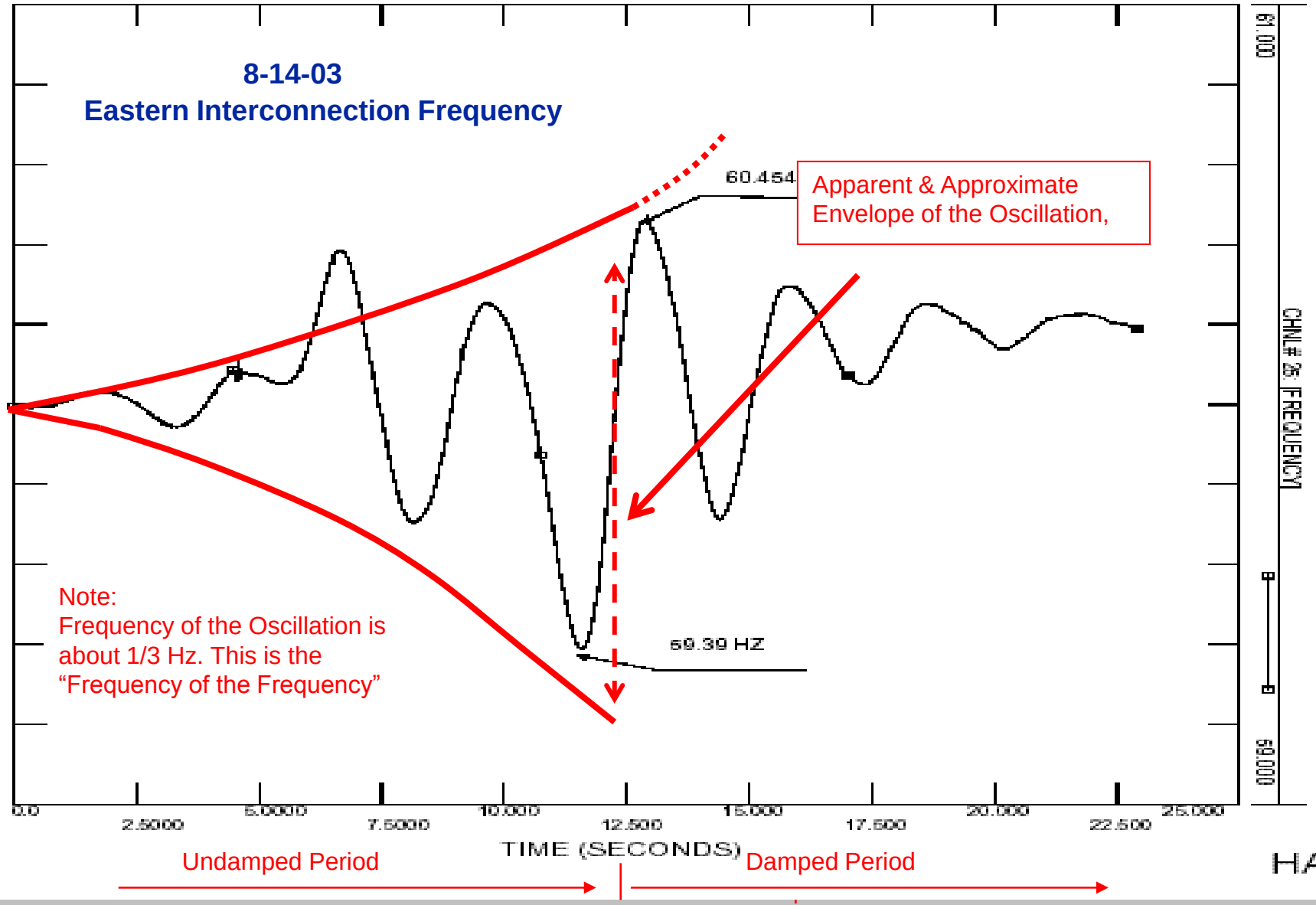
* or mitigated

Florida Solar Energy Center

Creating Energy Independence Since 1975

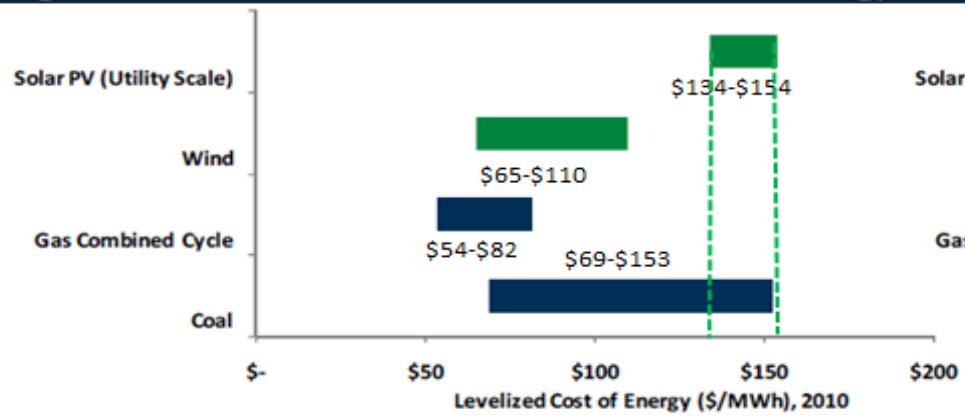
A Research Institute of the University of Central Florida

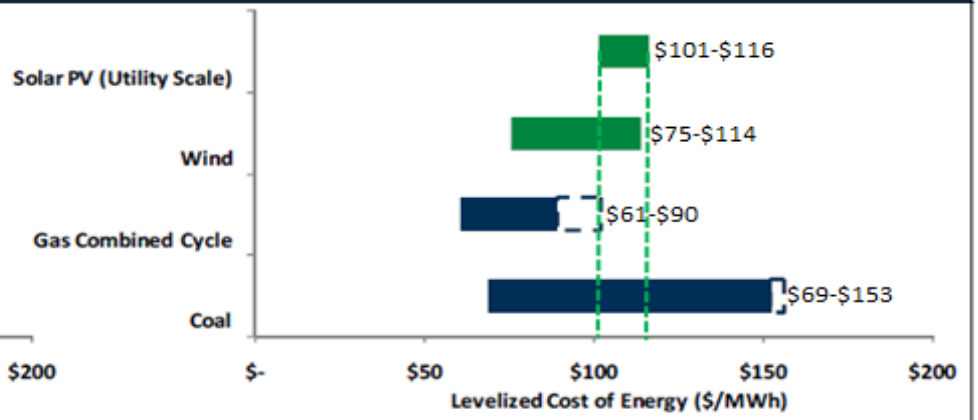
A HUGE Argument for Doing It!



Extra Slides

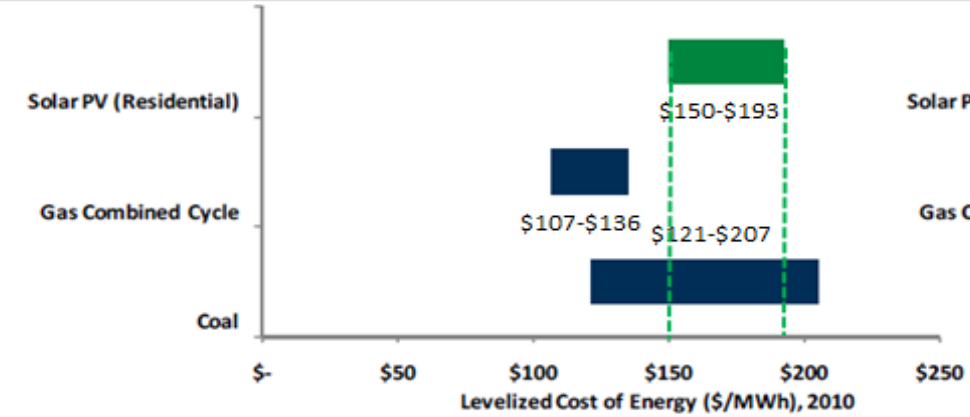
Figure 2: U.S. Levelized Cost of Wholesale Energy in 2010 and 2015

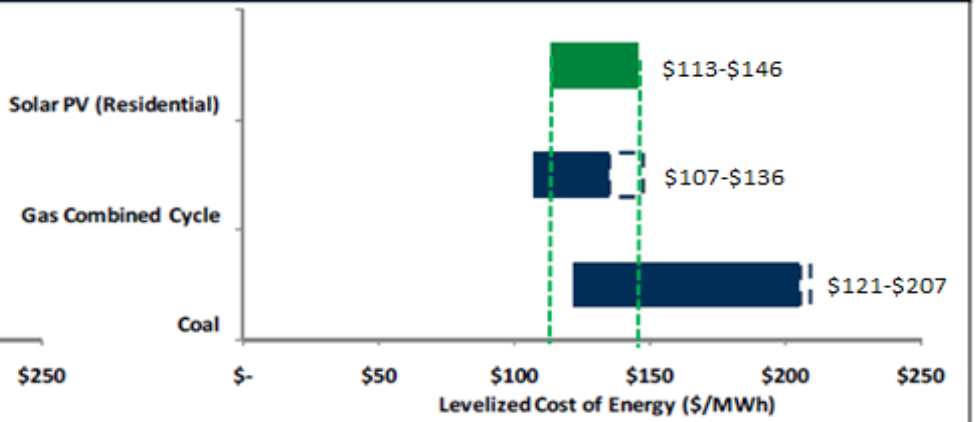




Sources: "Levelized Cost of Energy Analysis – Version 4.0", Lazard, June 2010; Hudson estimates
Notes: Solar PV assumes conventional silicon modules; gas assumes $4/MMBtu in 2010 and $5/MMBtu in 2015. Dotted lines include carbon tax of $30/ton.

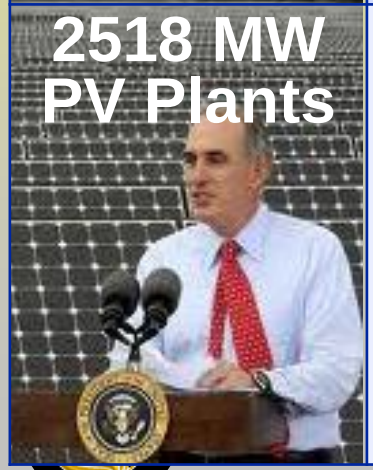
Figure 3: U.S. Levelized Cost of Retail Energy in 2010 and 2015





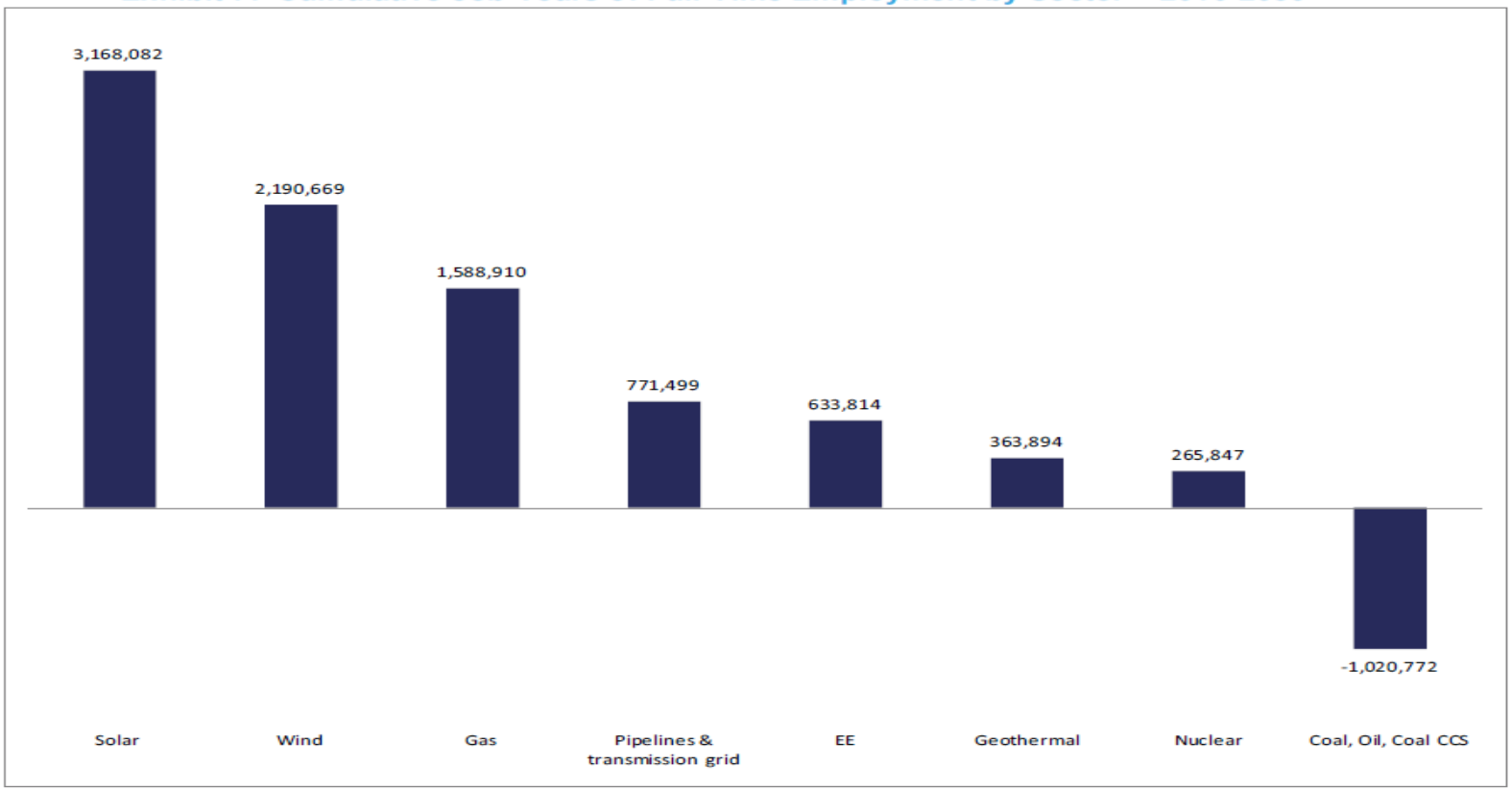
Sources: "Levelized Cost of Energy Analysis – Version 4.0", Lazard, June 2010; Hudson estimates
Notes: Solar PV assumes conventional silicon modules; gas assumes $4/MMBtu in 2010 and $5/MMBtu in 2015; retail energy for gas and coal incorporate a $53/MWh cost of transmission and distribution. Dotted lines include carbon tax of $30/ton.

PV Electrons $1.08 per Gallon and Cheaper than Coal

	Installed date	Capacity Factor	Electricity Production	**Cost** per MWh (2015)	**Job-Years**
	**~2018**	**0.80**	**3.5 TWh**	**$65-$150**	**250**
	**~2015**	**0.17**	**3.5 TWh**	**$105 - $115**	**57,900** ½ manufacturing; ½ installation

Repowering America: Creating Jobs

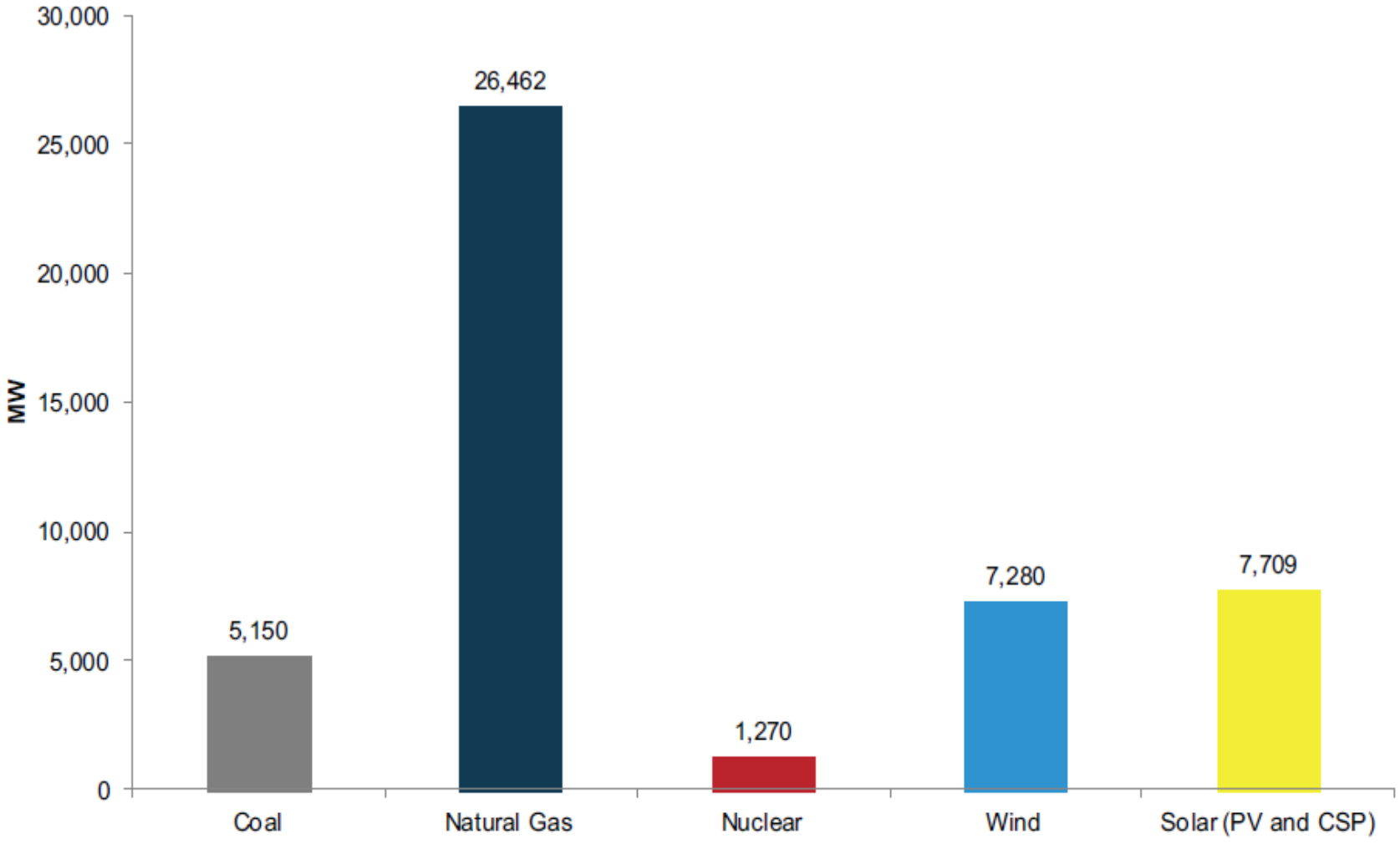
Exhibit 7: Cumulative Job-Years of Full-Time Employment by Sector – 2010-2030



Source: WPK Model, DBCCA Analysis.

The cumulative 7.9 million increase in net job-years is an impressive outcome and is largely driven by CIM jobs required in the plant building phase. Almost 64% (5.1 million) of the job-years created are a result of the CIM that results from the new RE investments, the change from coal to gas fired power plants, and associated infrastructure pipeline and transmission line investments.

Figure 2 Planned Generating Capacity Additions from New Generators by Energy Source, 2012-2015



Sources: EIA, DBCCA analysis, 2012

PV Grid Parity?