Energy Efficiency & Solar: The Leading Customer-Based Resources

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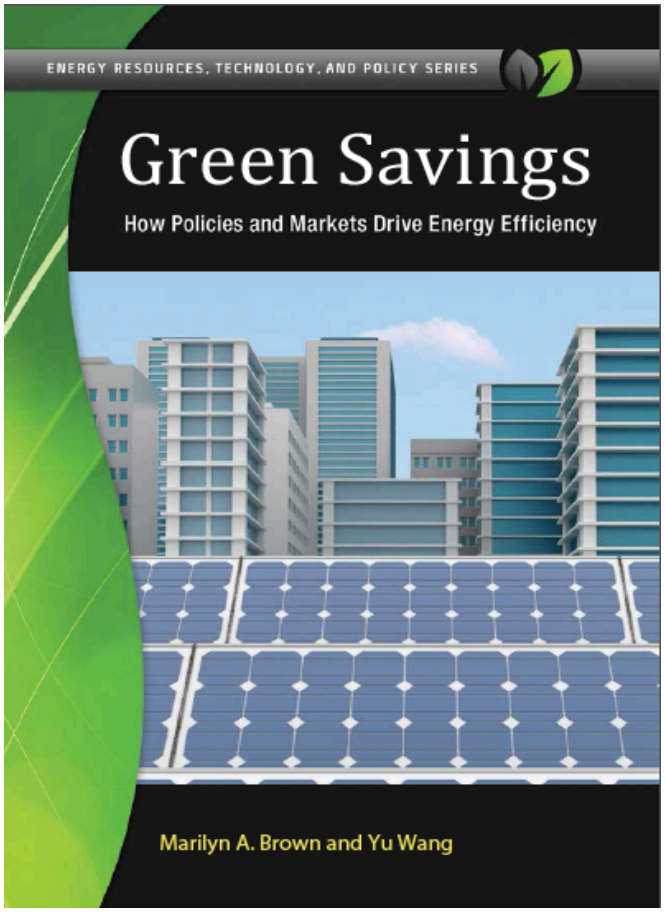
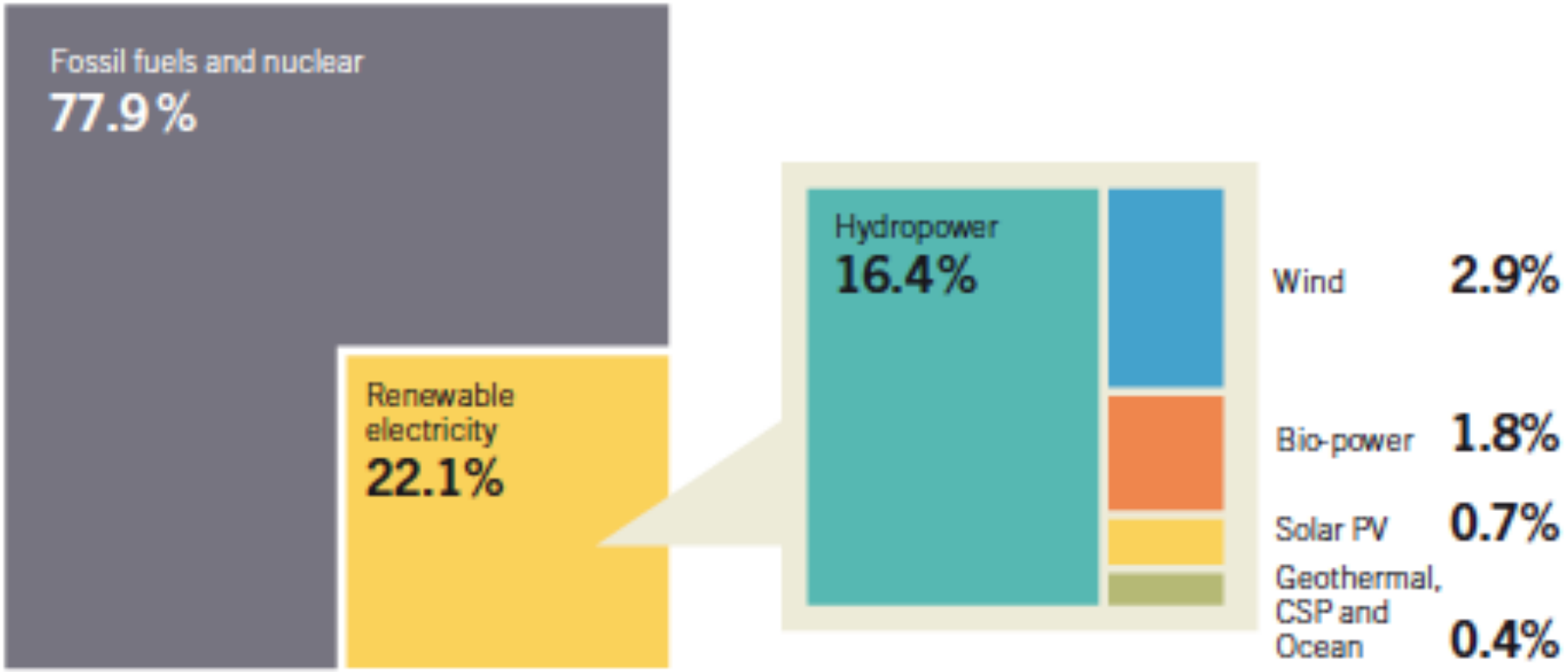


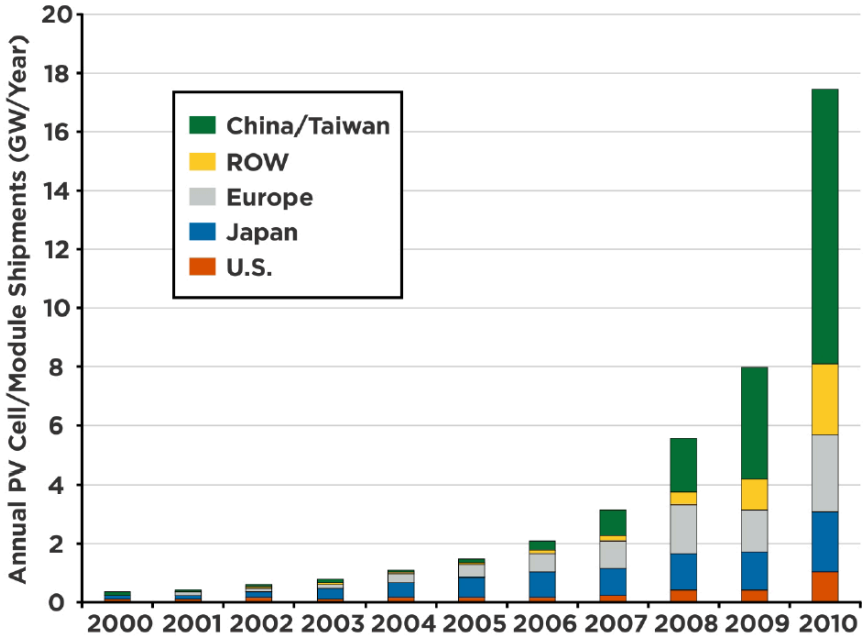
TenneSEIA Annual Meeting
November 9, 2015
Nashville

Estimated Renewable Energy Share of Global Electricity Production, 2013



Source: RENEWABLES 2014 GLOBAL STATUS REPORT
http://www.ren21.net/portals/0/documents/resources/gsr/2014/gsr2014_full%20report_low%20res.pdf

Rapid Rise of PV Cell and Module Shipments: 2000-2010

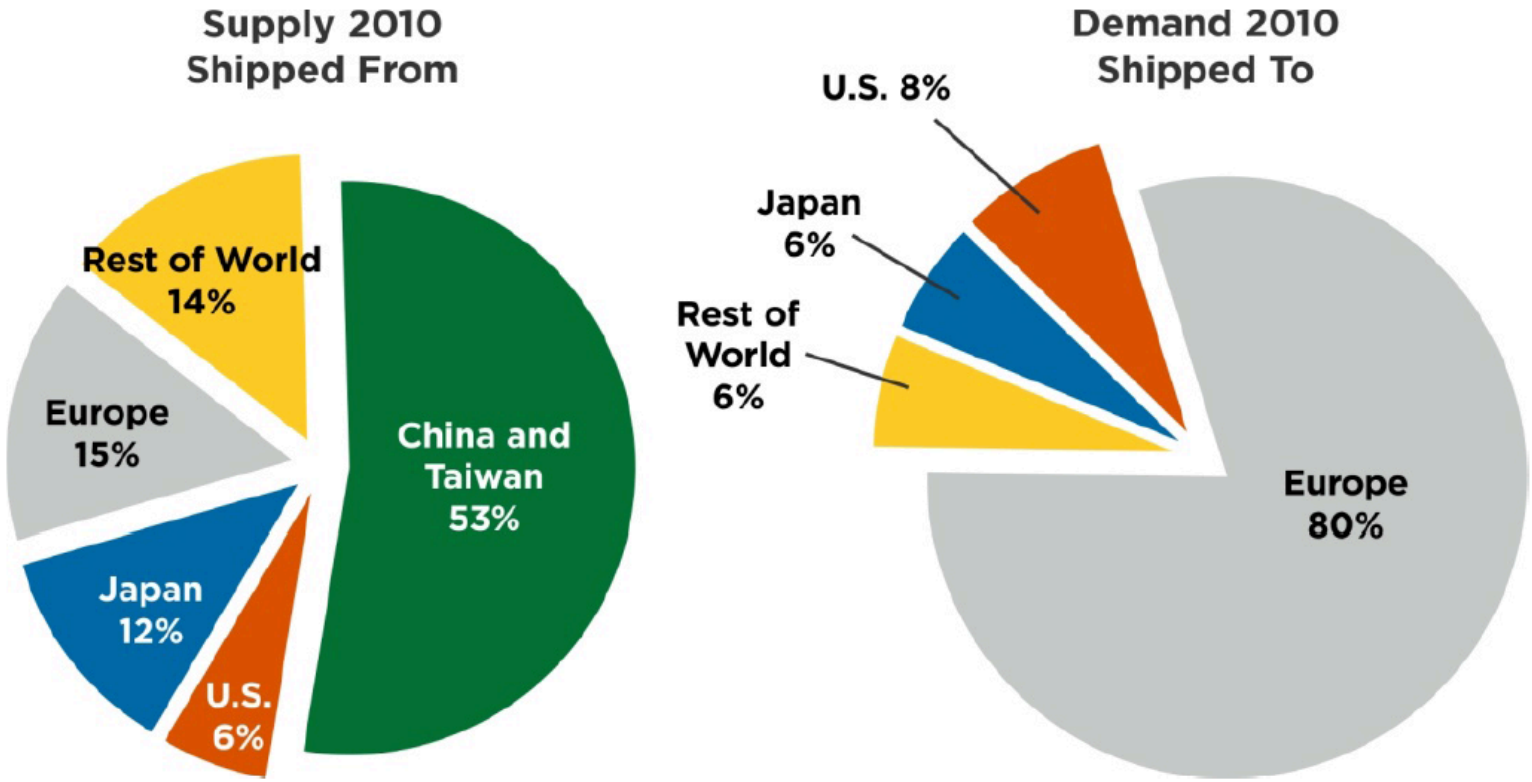


Source: National Renewable Energy Laboratory. 2012. *SunShot Vision Study*

	2011 Production a % of World Total	
Company Name	Chinese Company	U.S. Company
Sunpower	5.8%	
First Solar		5.7%
Trina Solar	4.9%	
Yingli Green Energy	4.6%	
Canadian Solar	3.8%	
Hanwha SolarOne	2.7%	
SunPower		2.7%
JinkoSolar	2.2%	
LDK Solar	1.6%	
JA Solar	1.2%	
ReneSola	0.8%	
Total = 27.6%		

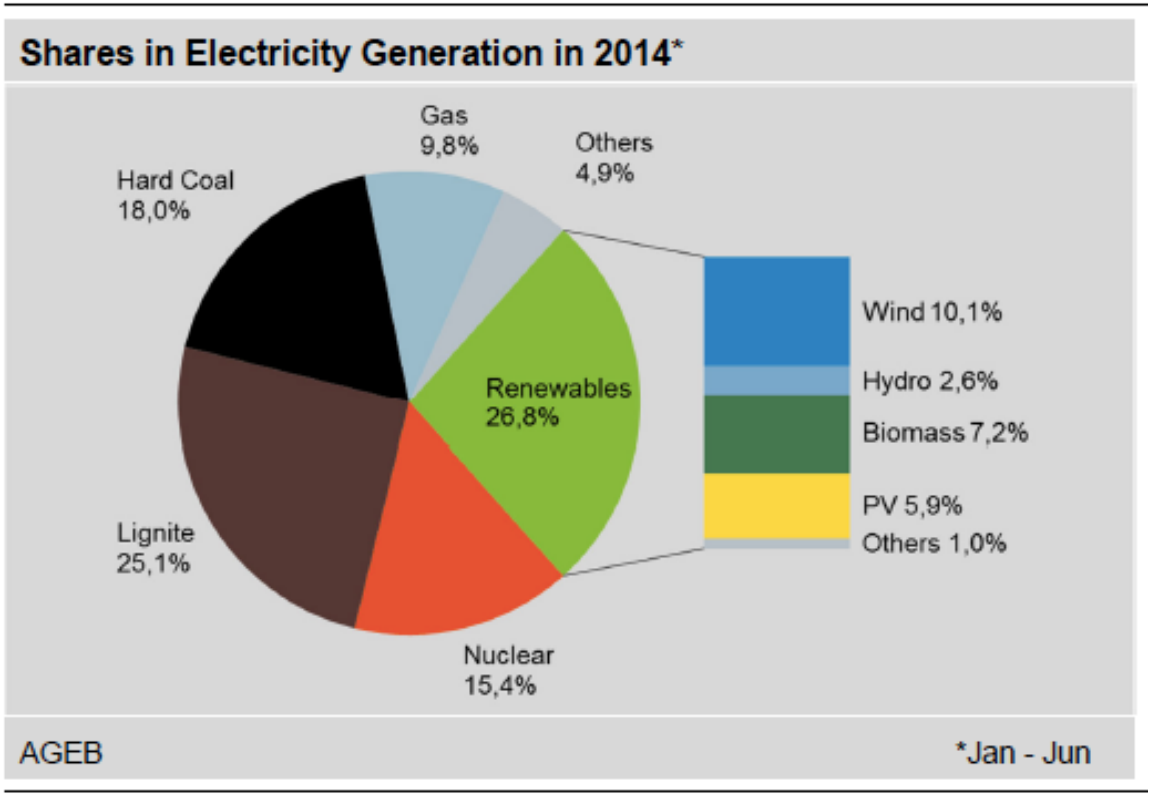
Source: Xiaojing Sun. 2014

China Dominates Solar Shipments; Europe Dominates Solar Demand



Source: National Renewable Energy Laboratory. 2012. *SunShot Vision Study*

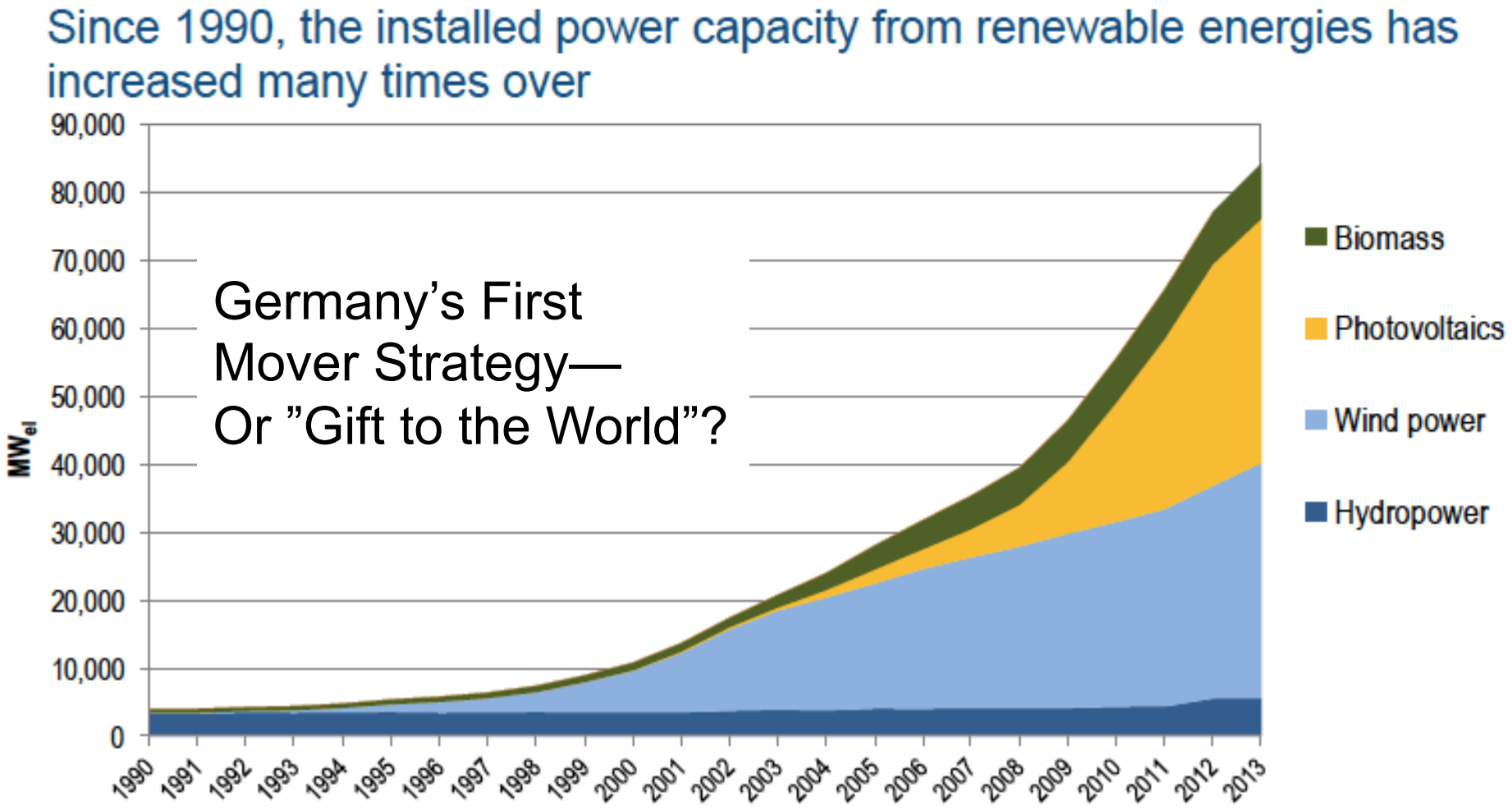
Germany's Electricity Fuel Mix was 27% Renewable in 2014 (U.S. = 13%)



Coal is pushing gas out of the German electricity market because of high gas prices. So CO_2 emissions are rising: the Energiewende "paradox."

Source: Markus Steigenberger, "Energiewende, Structural Change and Decarbonisation - The Macro Perspective of the Great Transition," Presentation to the Energy Study Tour, Berlin, December 9, 2014.

Historic Development of Renewable Energies in Germany



Source: Oliver Frank (German Energy Agency, DENA), "Renewable Energies in Germany," Presentation to the Energy Study Tour, Berlin, December 11, 2014.

Germany's Electricity Prices are High, But Electricity Bills are Not

Average Household Electricity Bills in EUR/Year

	Consumption (kWh)	Price (Ct/kWh)	Bill (EUR)
Denmark	4,000	30	1,200
U.S.	11,800	9	1,060
Germany	3,500	30	1,050
Japan	5,600	18	1,010
Spain	4,400	23	1,010
Canada	10,800	8	850
U.K.	4,200	19	800
France	5,000	16	800
Italy	2,700	25	680

Germany's high level of energy efficiency has made a difference.

Source: Markus Steigenberger, "Energiewende, Structural Change and Decarbonisation - The Macro Perspective of the Great Transition," Presentation to the Energy Study Tour, Berlin, December 9, 2014.

Co-Optimizing Sustainable Buildings

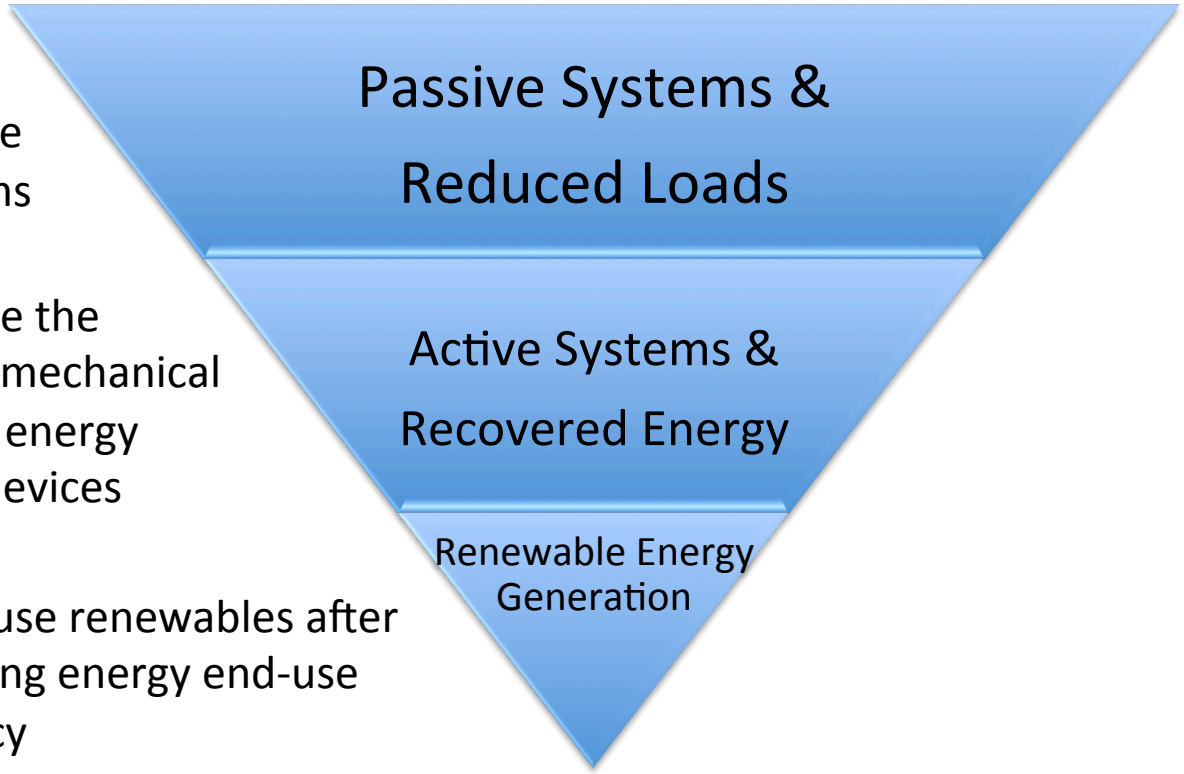
- Buildings are more efficient than ever
- At the same time, solar PV systems cost less than ever before
- This leads to the question of how these can be co-optimized?

Answer: Go on a diet first, then have a solar-system "dessert."

Focus first on climate-responsive design and systems

Then improve the efficiency of mechanical systems and energy conversion devices

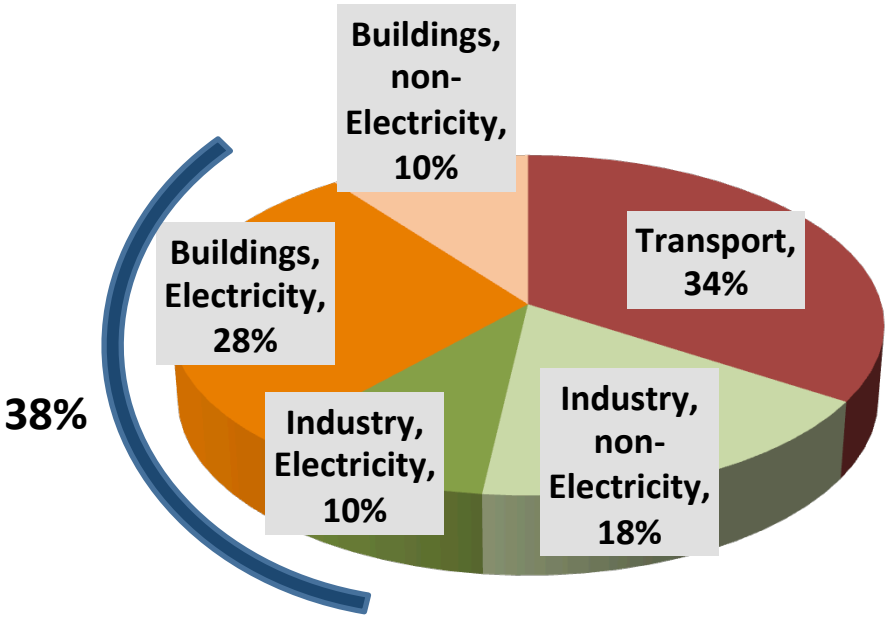
Finally, use renewables after optimizing energy end-use efficiency



The U.S. Goal: Affordable, Clean, and Reliable Electricity

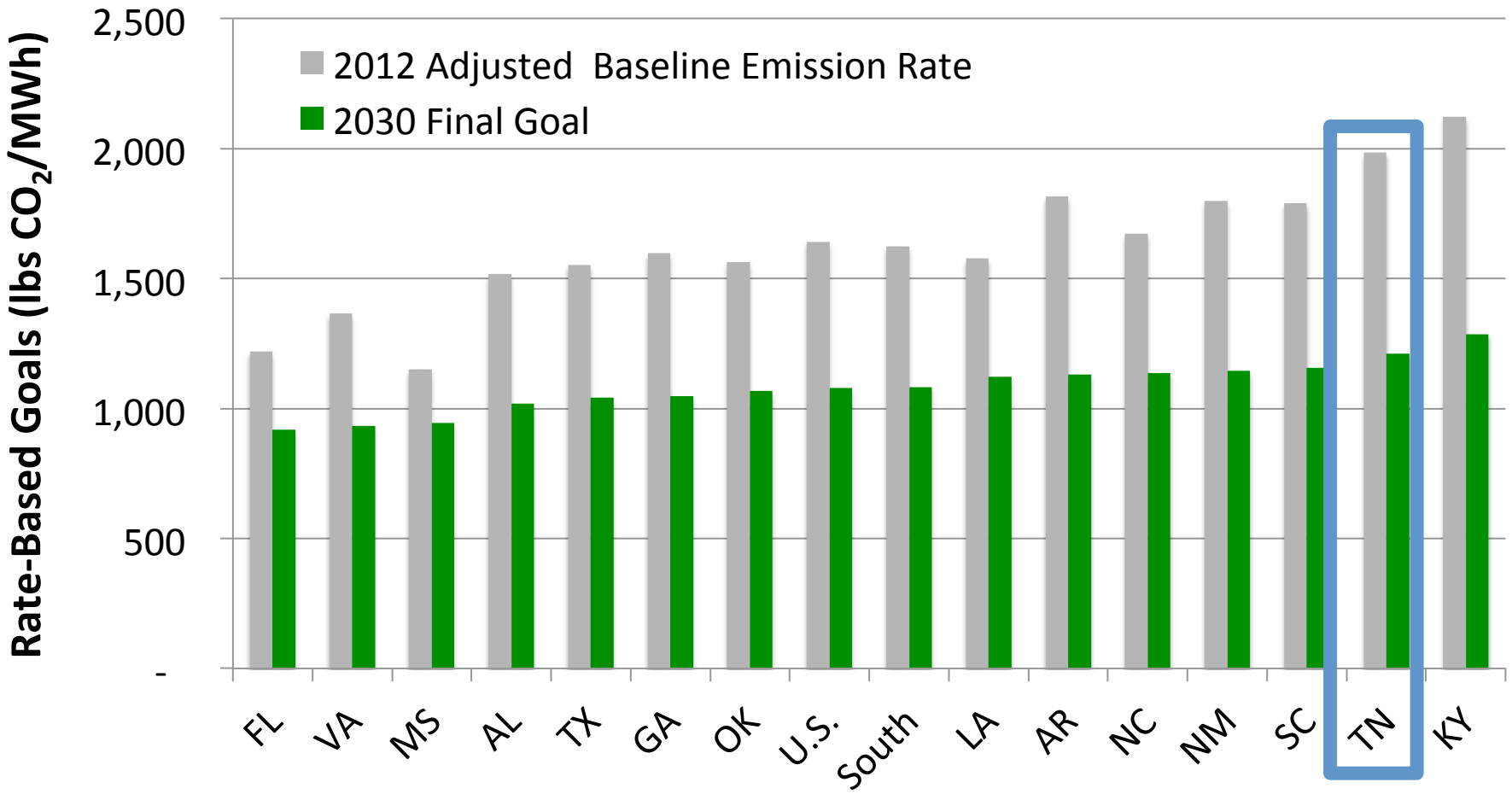
- Pope Francis reminded us that "Climate change is a problem that can no longer be left to future generations."
- Countries are gathering in Paris in December to participate in UN climate talks
- EPA's Clean Power Plan is the first ever U.S. regulation to limit carbon pollution from existing fossil power plants
- It shows U.S. commitment and will motivate both EE and solar

U.S. CO_2 Emissions from the Energy Sector (2013)



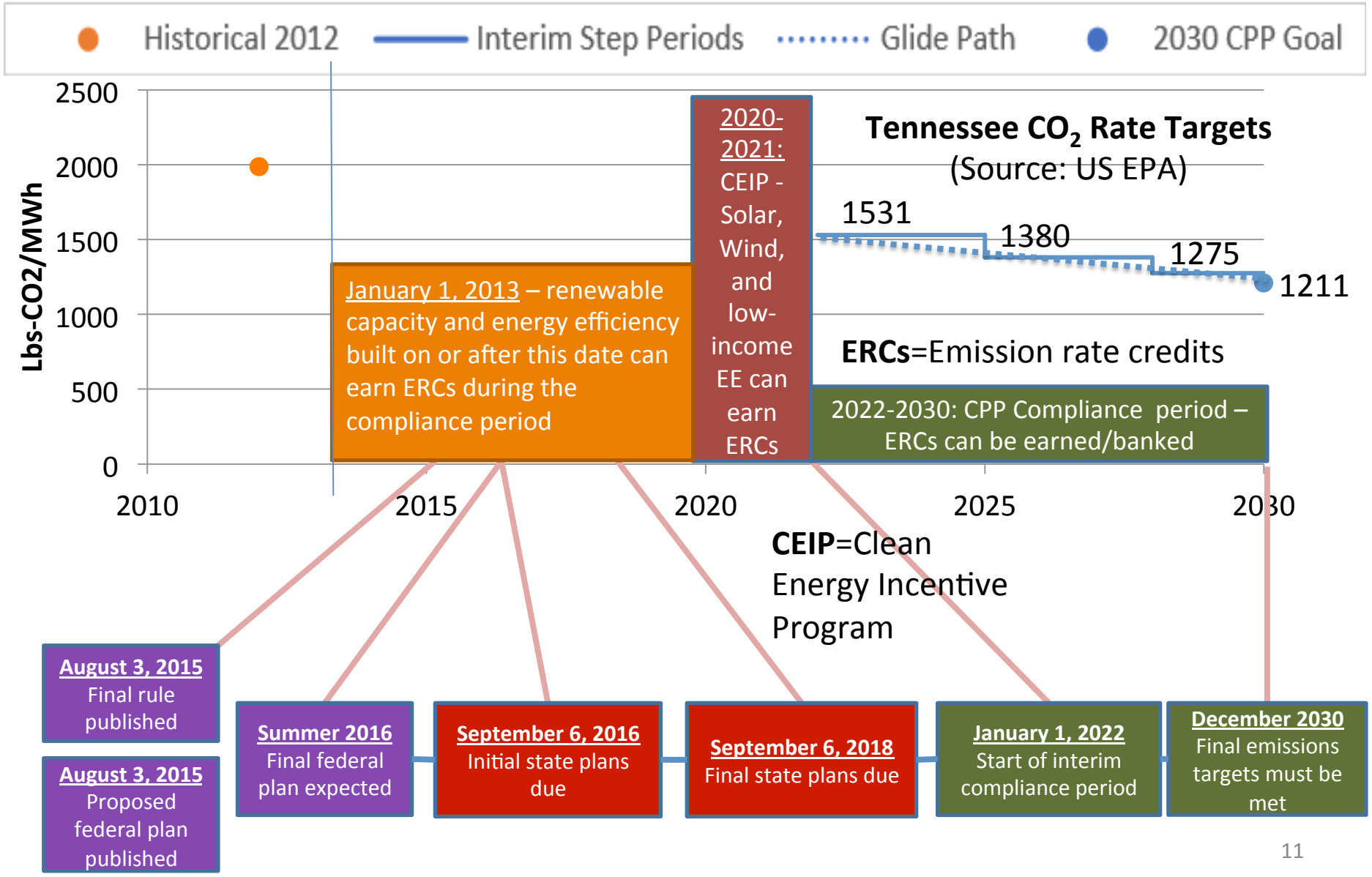
Source of Data: EIA. 2015. *Annual Energy Outlook 2015*, Table 18.

Tennessee's CPP Goals are Similar to Those of Other Southern States



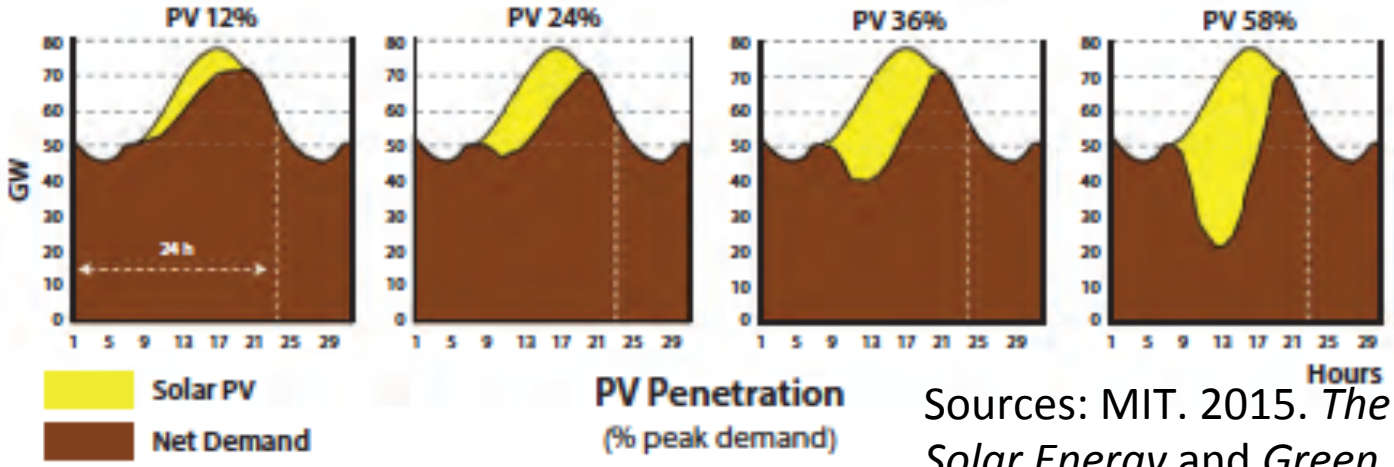
Source of 2012 Emission Rates:
https://blog.epa.gov/blog/wp-content/uploads/2015/08/State-tables-tab-1.pdf

The Clean Power Plan Timeline

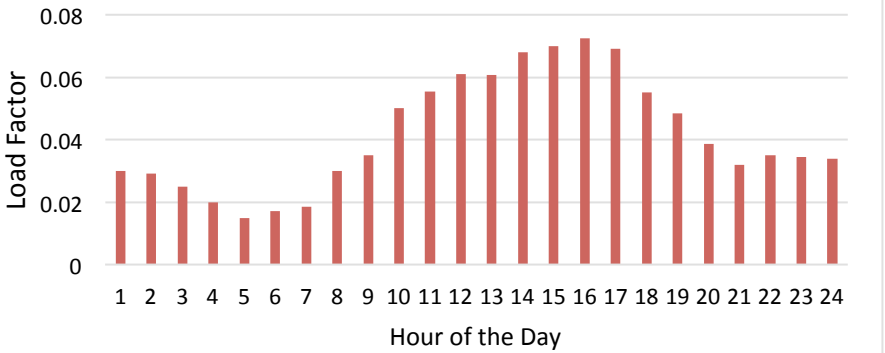


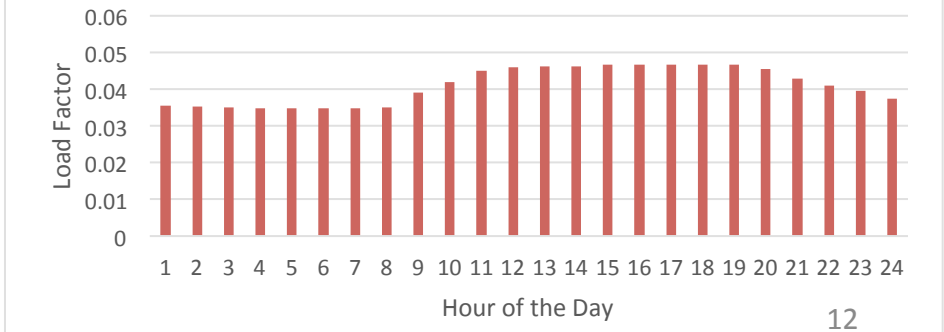
Matching Load to Generation: Increasingly Important

Figure 8.1 ERCOT Net Load for a Typical Summer Day at Different Levels of Solar PV Penetration

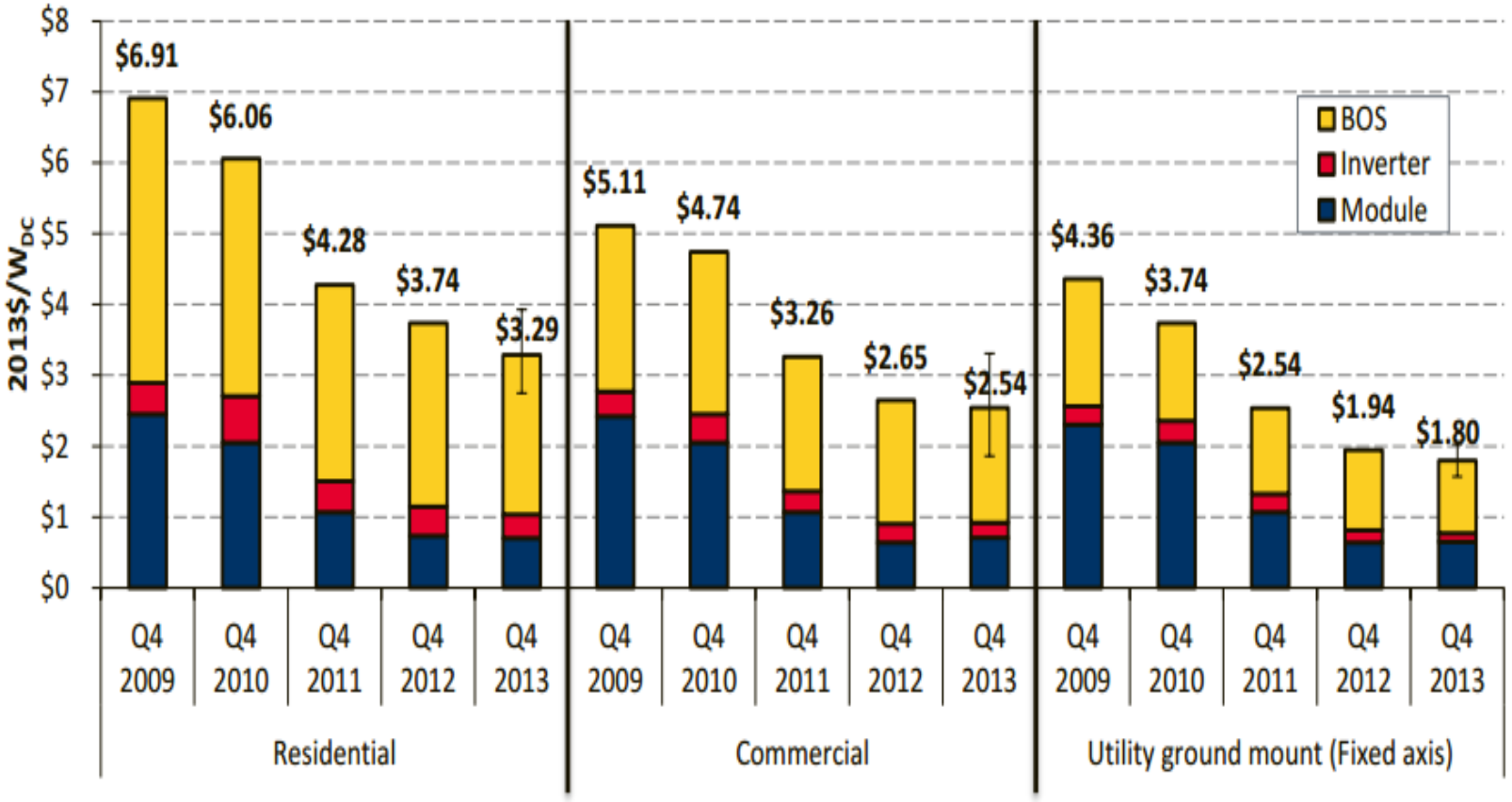


Sources: MIT. 2015. *The Future of Solar Energy* and *Green Savings*





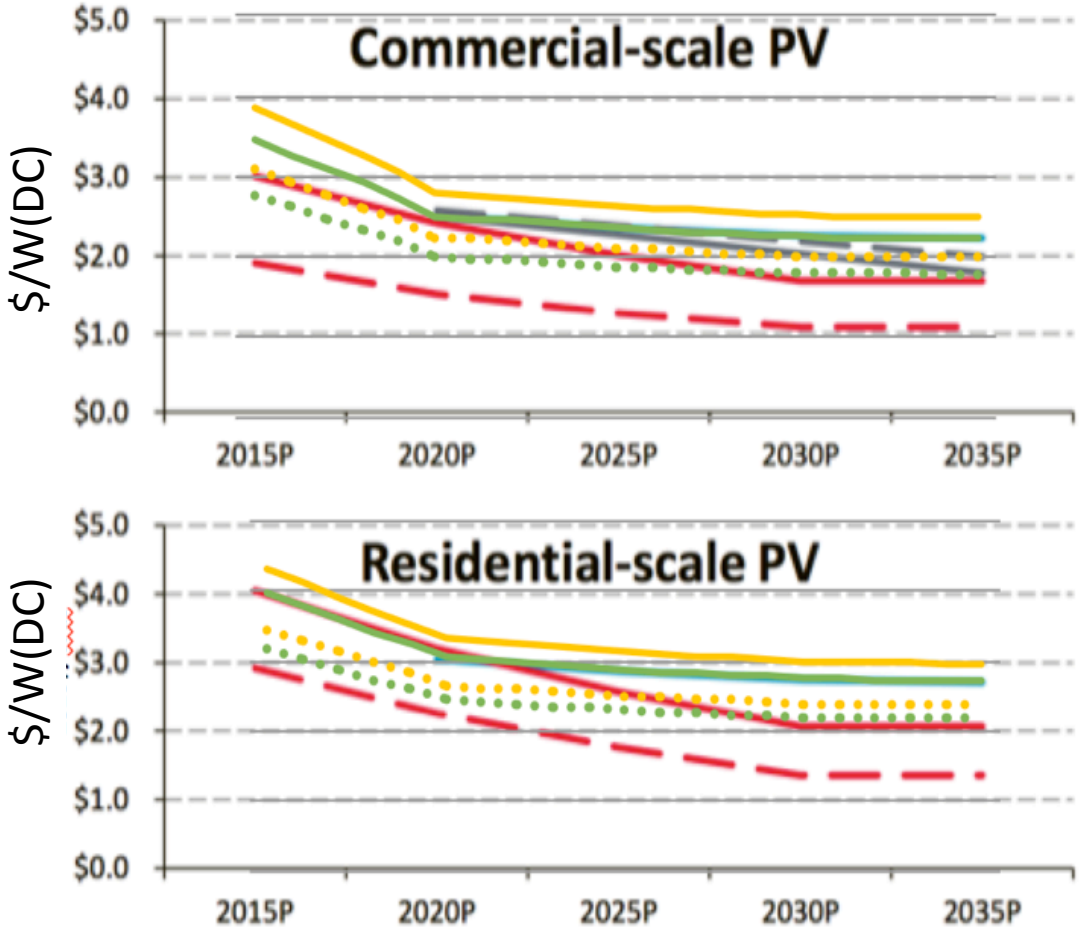
Declining Cost of Solar PV Modules: BOS "Soft Costs" are Lagging



- **Modules are 99% cheaper than 35 years ago.**
- **The best opportunities to bring down the price of solar energy are now reductions in "soft costs."**

Source: National Renewable Energy Laboratory, *Sunshot Vision Study,* Golden, CO, 2012.

Looking Ahead: Residential & Commercial Solar System Costs



Reported by Tracking the Sun VIII

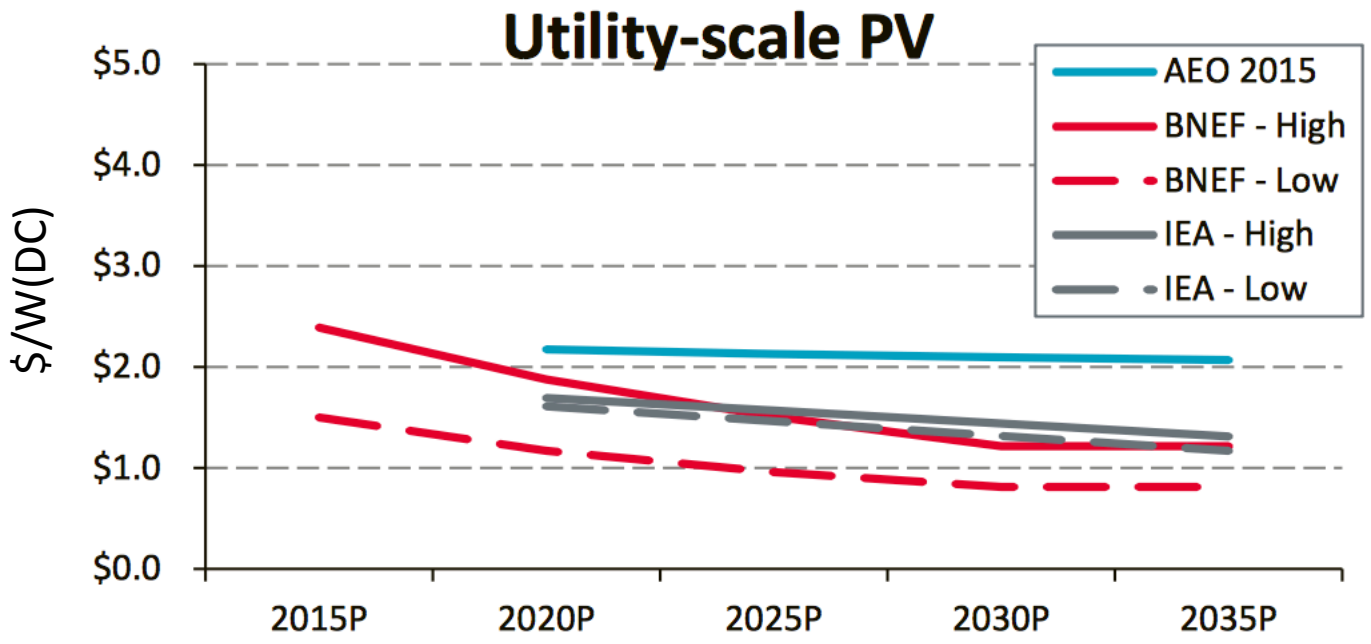
- BNEF - High
- BNEF - Low
- IEA - High
- IEA - Low

Reported by NEMS 2015 Commercial and Residential Module inputs

- 2014 Reference
- 2014 Low Cost RE
- 2015 Reference
- 2015 w. 20% Cost Reduction

Sources: Photovoltaic System Pricing Trends: Historical, Recent, and Near-Term Projections, 2015 Edition; NEMS 2015 Edition Kgentk and Rsgentk input file a

Looking Ahead: Utility-Scale Solar System Costs

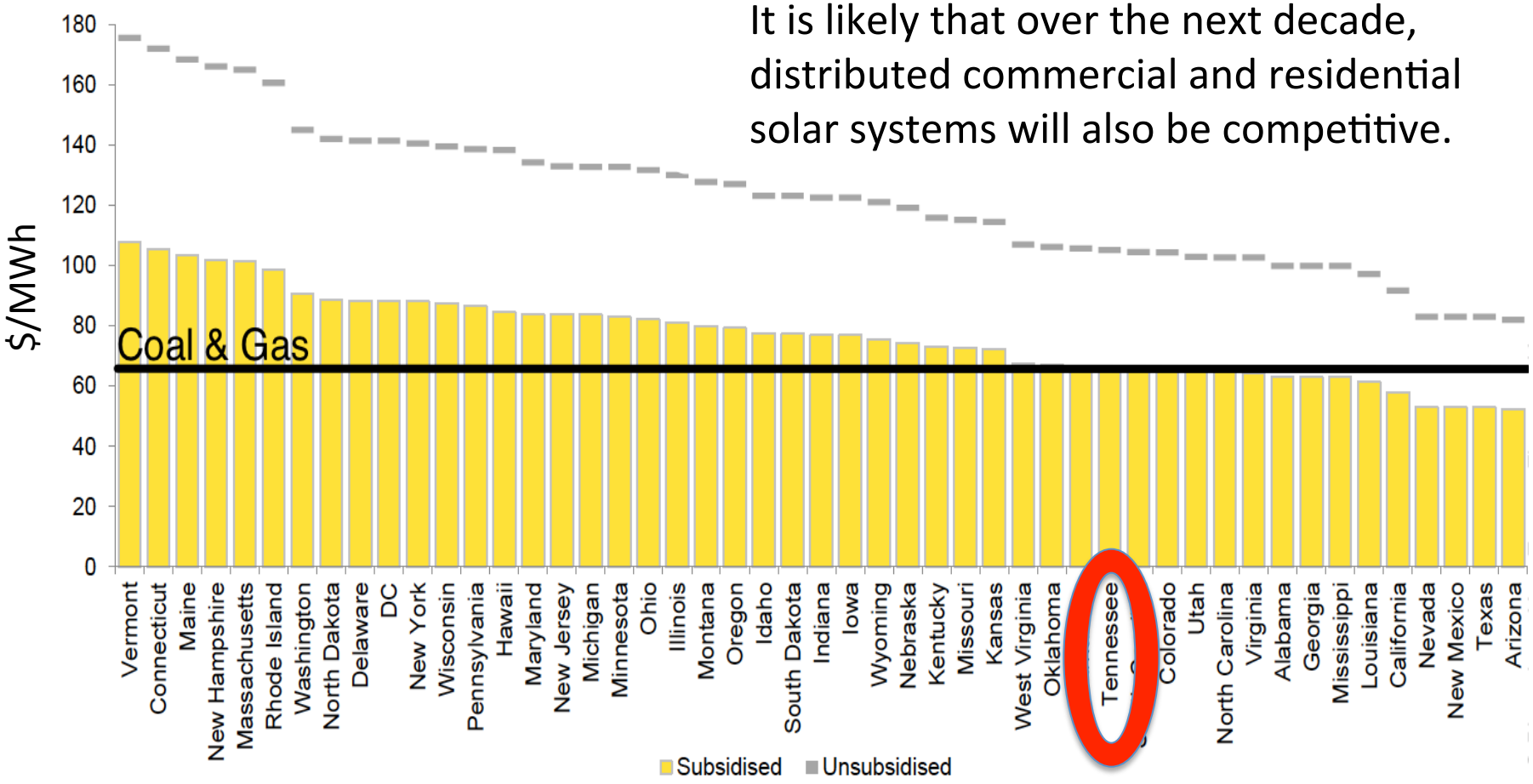


Sources: International Energy Agency, "World Energy Outlook 2014," November 2014 (New Policy & 450 Scenarios for utility-scale & commercial-scale); Bloomberg New Energy Finance, "H1 2015 North American PV Outlook" (01/16/15); U.S. Energy Information Administration, Annual Energy Outlook 2015 (June 2015). In years where projection was not made, most recent projection used.

Source: Feldman, et al., 2015.

Tennessee's Utility-Scale Solar System Costs (with Subsidies) are Competitive

It is likely that over the next decade, distributed commercial and residential solar systems will also be competitive.



Source: Bloomberg New Energy Finance (BNEF)

For More Information

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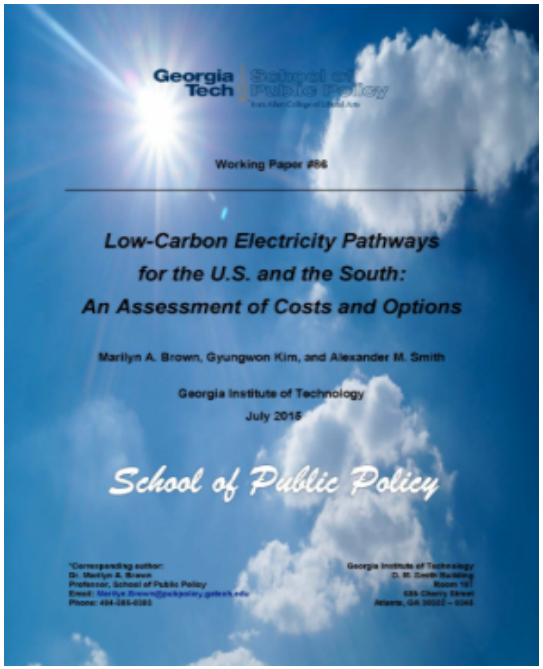
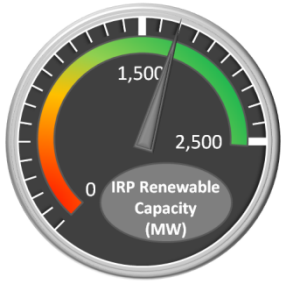


TVA's Renewable Energy Portfolio



Resource	Operating[1] Nameplate Capacity (MW)	In Process[2]* Nameplate Capacity (MW)
Hydroelectric[3]	4,207	0
Wind[4]	1,542	0
Solar	137	352*
Biomass	64	5
Totals	**5,950**	**357**
Grand Total [5]**	**6,307**	
IRP Renewable Operating Capacity [6]	**1,702**	

Updated 10-1-15

1. Also known as executed or installed projects.
2. Includes contracted and approved projects plus received applications in process except GPP CRRs that have not submitted a PA. Includes EPA Projects.
   *Includes Feb. 2015 Board Approval of 80 MW Solar. 3. Hydroelectric capacity based on conventional generator rating.
4. The owner of a 300 MW facility is retaining the renewable attributes, but TVA has the option to purchase those attributes in the future.
5. Includes operating and committed totals from capacity report, and applications in process (that may fluctuate)
6. All midwest wind projects and renewable projects that began operations in FY 11 and later which align with the 2011 IRP.

Total Renewable Energy Spend (20 Years)

TVA's anticipated spend through 2038, including all previous commitments and anticipated spending over next two years equates to over $1.6 B

Category	FY16	FY17	FY18-38	Total
Commitments & Future Spend ($Millions)	61	76	1,505	1,642

2015 TVA Renewable Energy Options

Renewable Generation Options

	Renewable Energy Programs			PURPA	
	Green Power Providers	Solar Solutions Initiative	Renewable Standard Offer	Dispersed Power Program	Negotiated Proposals
Project Size	Up to 50kW	>50kW - 1MW	>50kW - 20MW	Up to 80MW	> 20MW
Annual Capacity	11.3 MW	20 MW	100 MW	No Cap	N/A
Price	Above retail	Above Market	Market	Avoided cost (short-term)	Avoided Cost (long-term)
Qualifying Technology				All	All

Renewable Energy Credit (REC) Options

Green Power Switch

Products	Green Power Switch (Original)	Southeastern RECs (pilot)
Target Markets	Primarily Residential	Primarily Commercial

energyright® solutions TVA

2015 Renewable Energy Programs

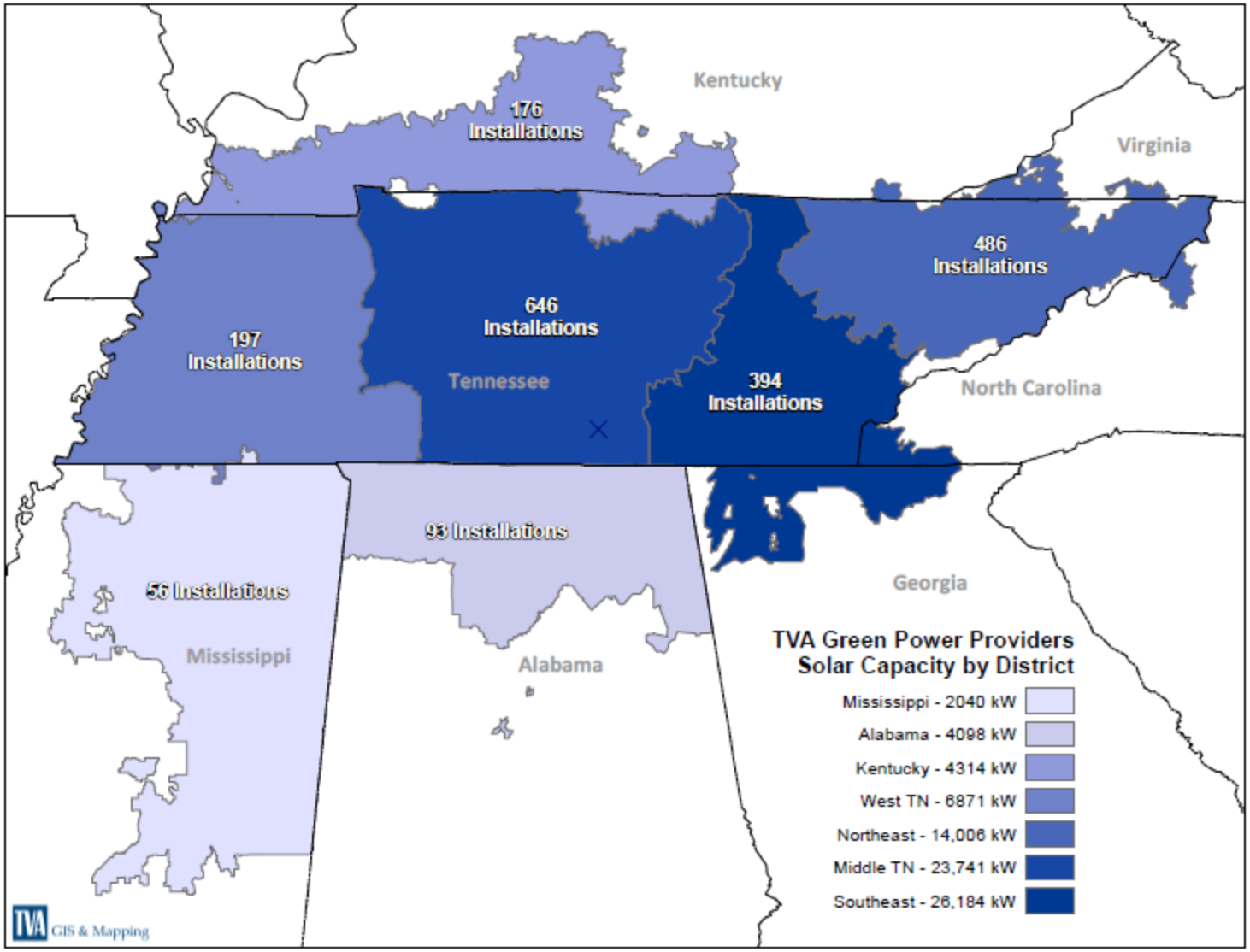
Green Power Switch (GPS) – Renewable Energy Credits
Enables residential, commercial, and direct-serve customers to purchase renewable energy credits (RECs) to help support renewables growth and meet individual or corporate objectives.

Green Power Providers (GPP) – Small-scale Generation
Encourages development of renewable projects of up to 50kW in size
Target Market – End-use customers (residential & small commercial)

Solar Solutions Initiative (SSI) – Midsize Generation
Encourages development of renewable projects of up to 1 MW in size
Target Market – Midsize Renewable Developers (local NABCEP certified)

Renewable Standard Offer (RSO) – Utility-scale Generation
Encourages development of renewable projects of up to 20 MW in size
Target Market – Large Renewable Developers

Distribution of GPP Installations



Future Directions

Small-scale

- Continue to provide consumers with a small-scale option

Midsize

- Transition to TVA customers - local power companies (LPCs) & Direct Serve Industrials
- Opportunity to explore new business models (e.g., community solar)
- TVA will provide tools and training for LPCs to take a more active role

Utility-scale

- Not limited by programmatic caps, competitively evaluated alongside other generation sources
- TVA's portfolio additions based on system need & least-cost planning