Trend Setting:
Visualizing U.S. Electric Sector data

March 16, 2018

Panelists

Pat Knight

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Moderator: Bruce Biewald, Founder and CEO

@SynapseEnergy

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Who we are

Synapse Energy Economics

- Founded in 1996 by CEO Bruce Biewald
- Research and consulting firm specializing in energy, economic, and environmental topics
- Services include economic and technical analyses, regulatory support, research and report writing, policy analysis and development, representation in stakeholder committees, facilitation, trainings, and expert witness services for public interest and government clients
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Agenda

1. A snapshot of the past and present
2. Where might we be going?

Note: Detailed notes and sources are available at the end of the slide deck.

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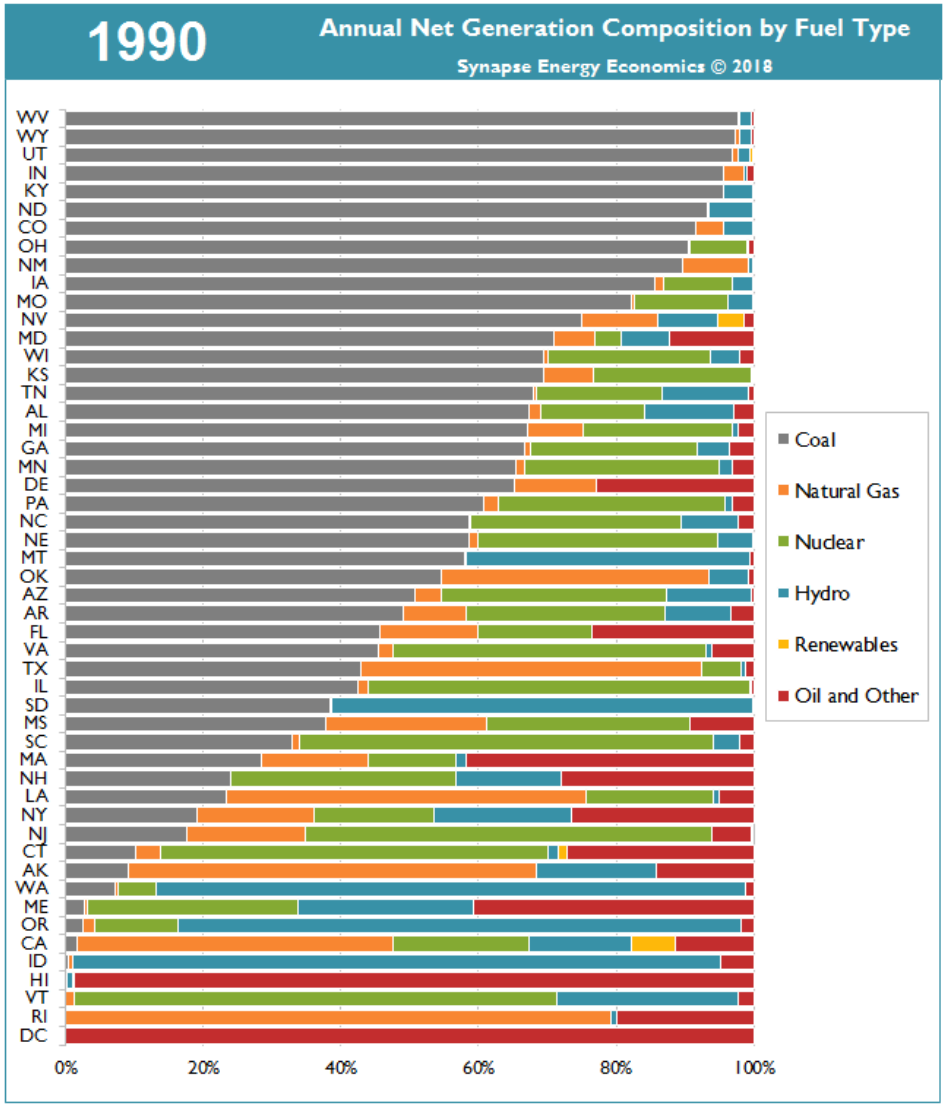
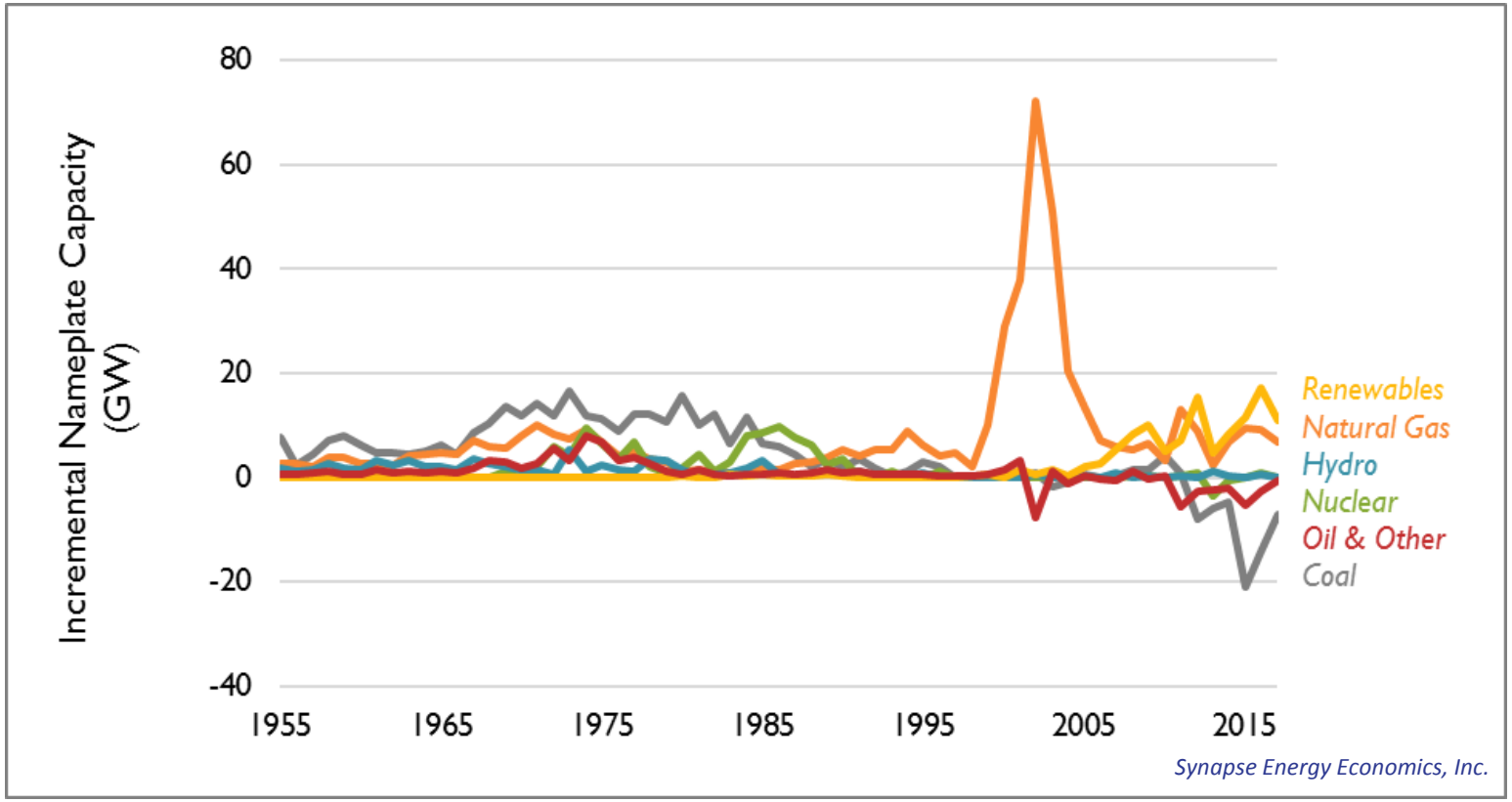
A snapshot of the past and present

Caveats!



- All values in this document are based on preliminary 2017 data and are subject to updates.
- Values are for utility-scale resources only; do not include capacity or generation numbers for distributed resources (like rooftop solar)
  - This information is not generally available at the same level of resolution, timing, and data quality as utility-scale capacity and generation data
- "Renewables" includes wind, solar, geothermal, and storage
- "Oil and Other" includes oil, biomass, solid waste, landfill gas, and other miscellaneous fuel types

Coal capacity continues to plummet below 1980s levels

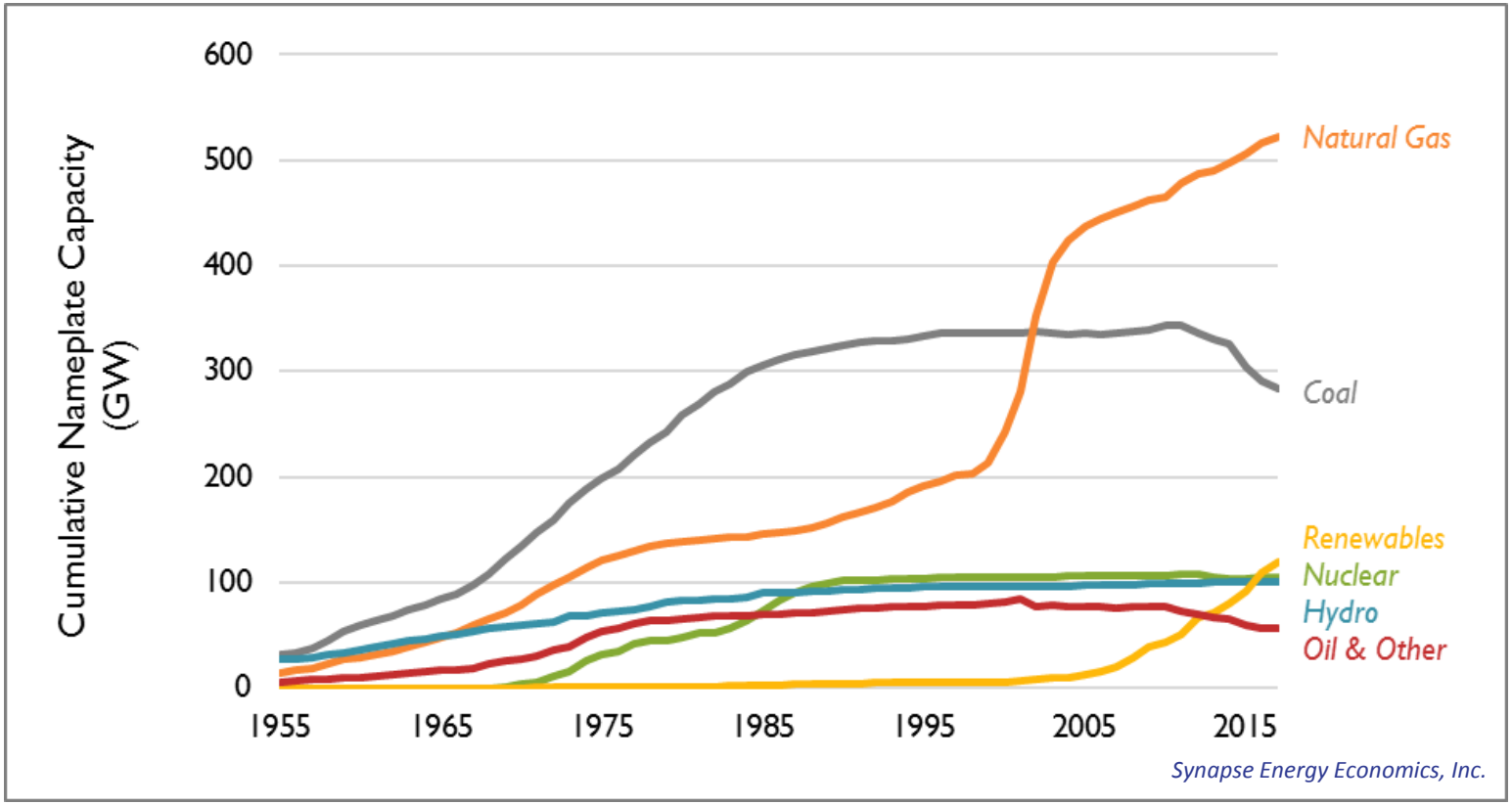


Note: This figure displays net nameplate values for utility-scale generators; annual capacity retirements are subtracted from annual capacity additions.

In this and all other figures, "Renewables" contains wind, solar, geothermal, and storage. "Oil and Other" contains oil, biomass, and other misc. fuel types.

While coal capacity and oil capacity are in decline, renewable and natural gas capacity grow every year. Renewable capacity additions were lower in 2016 than in 2017, but were still higher than any other resource type.

Renewable energy capacity now surpasses both hydroelectric and nuclear capacity



Note: This figure displays net nameplate values for utility-scale generators; annual capacity retirements are subtracted from annual capacity additions.

In 2016, renewable resources reached 10 percent of total U.S. generating capacity. In the 10 years since 2008, renewables have increased by 91 GW, compared to a 67 GW increase in natural gas over the same period. 54 GW of coal retired over these 10 years.

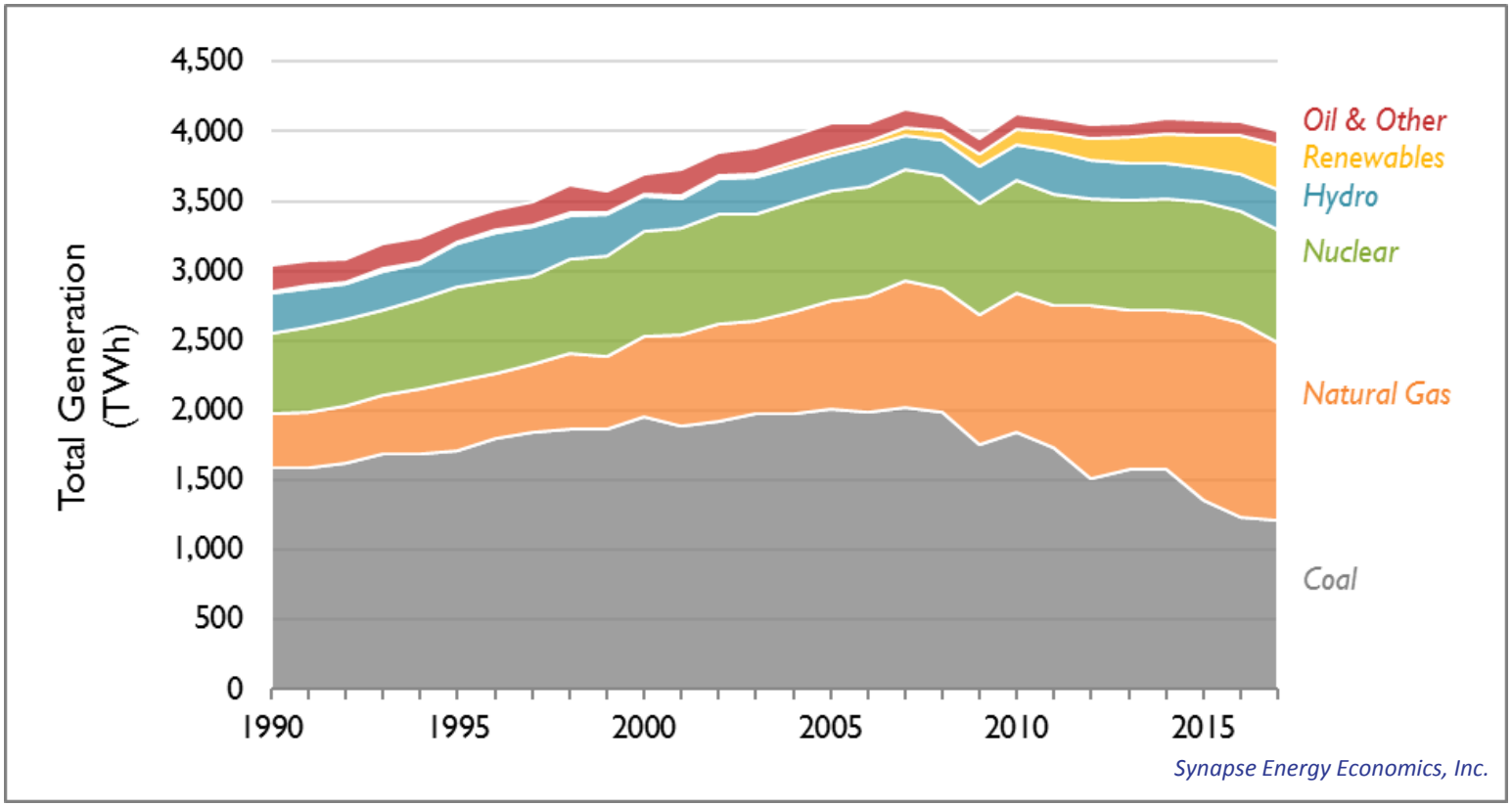
More new net capacity came from renewables than from any other resource—including natural gas

	Installed		Retired		Net (installed less retired)	
	2016	2017	2016	2017	2016	2017
Coal	0.1	-	8.7	6.9	-8.6	-6.9
Natural Gas	9.9	10.5	8.5	4.4	1.4	6.1
Nuclear	1.3	-	0.5	-	0.8	0.0
Hydro	0.4	0.2	0.1	0.1	0.3	0.1
Renewables	17.0	11.2	0.1	0.2	16.9	11.0
Geothermal	-	0.0	0.0	0.1	0.0	-0.1
Storage	0.2	0.1	0.0	-	0.2	0.1
Solar	8.0	4.7	0.0	-	8.0	4.7
Wind	8.8	6.3	0.1	0.0	8.7	6.3
Oil and Other	0.2	0.2	1.5	0.9	-1.3	-0.7
Biomass	0.0	0.1	0.2	0.1	-0.2	0.1
Oil	0.1	0.0	1.2	0.8	-1.1	-0.8
MSW	0.1	0.1	0.0	0.0	0.1	0.1
Other	0.0	-	0.0	-	0.0	0.0
Total	**28.8**	**22.1**	**19.3**	**12.5**	**9.4**	**9.7**

In 2017, the majority of renewable net capacity additions came from wind at 6.3 GW. Solar was close behind at 4.7 GW. Note that this does not include distributed renewable capacity additions.

Coal capacity is at its lowest point since 1982, with about 7 GW retiring in 2017.

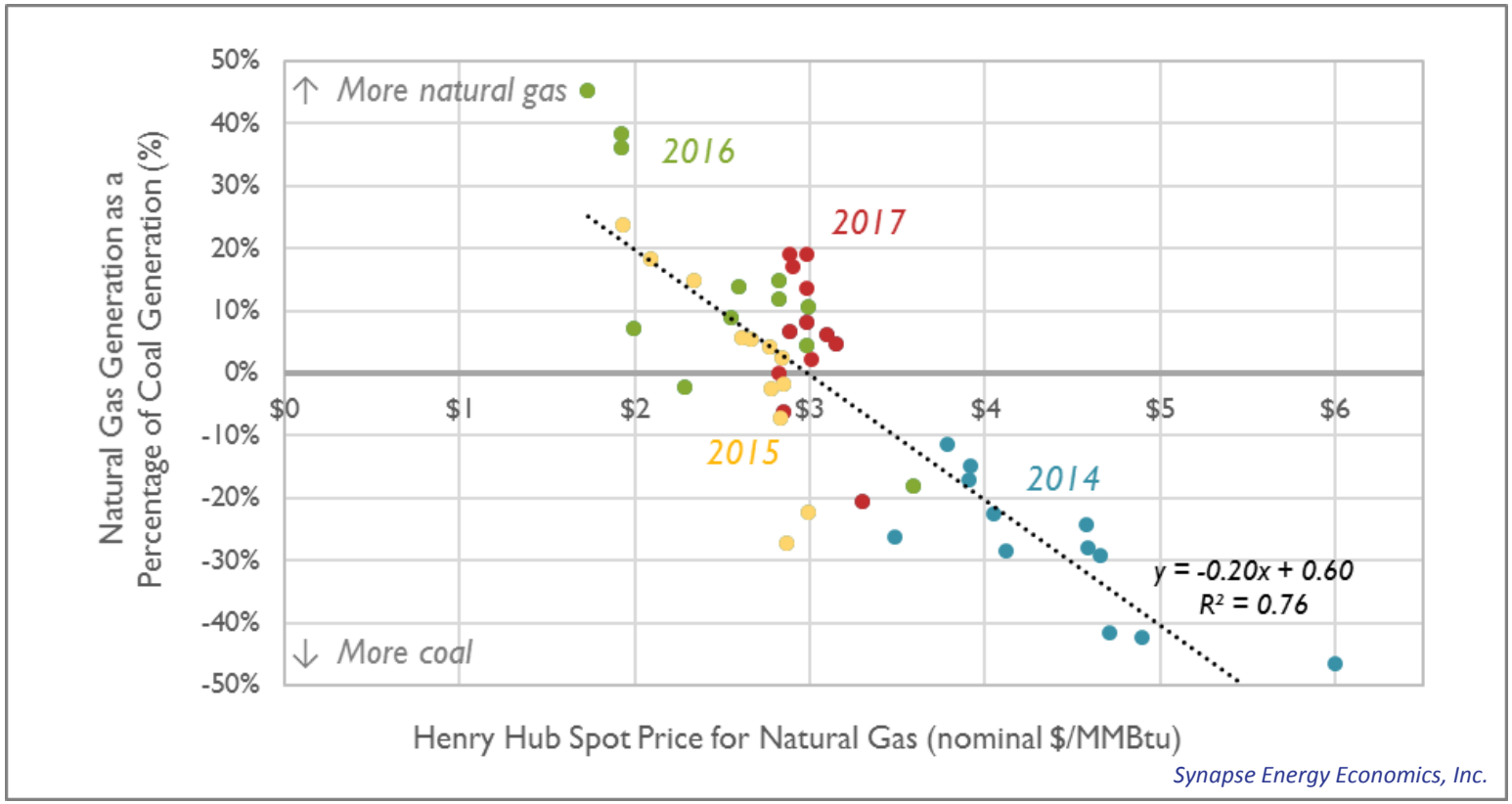
Coal generation is at its lowest level since 1982



In 2017, the amount of electricity generated from natural gas exceeded that from coal by 6 percent, down from 12 percent in 2016.

Since 2007, total annual U.S. generation has actually been negative, with an average annual growth rate of -0.35 percent per year.

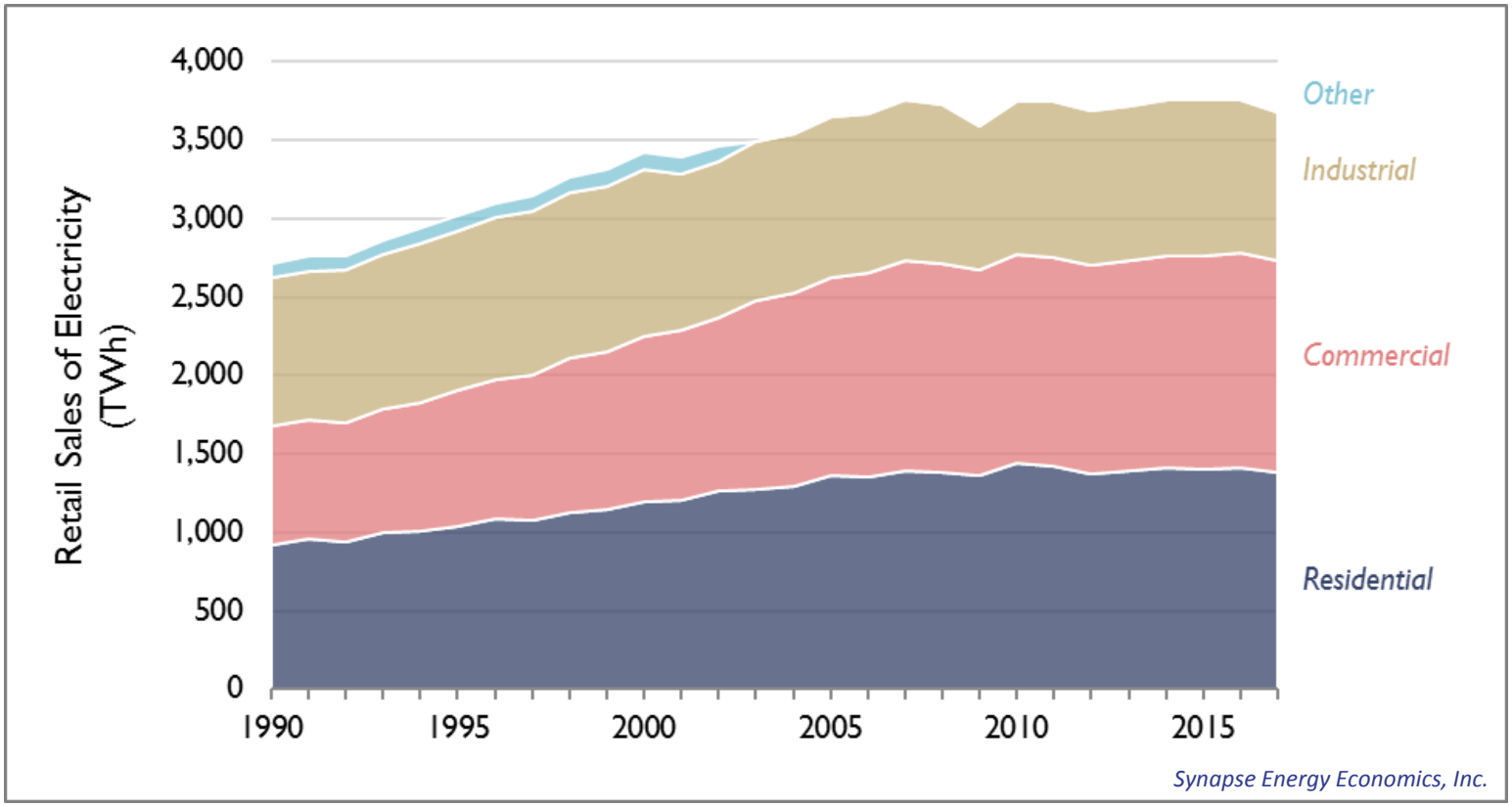
The ratio of natural gas generation to coal generation strongly depends on the price of natural gas



Note: Each circle represents a data point for a single month within the demarcated year.

On a national basis, when the price of natural gas is below $3 per MMBtu, natural gas generation has historically exceeded coal generation.

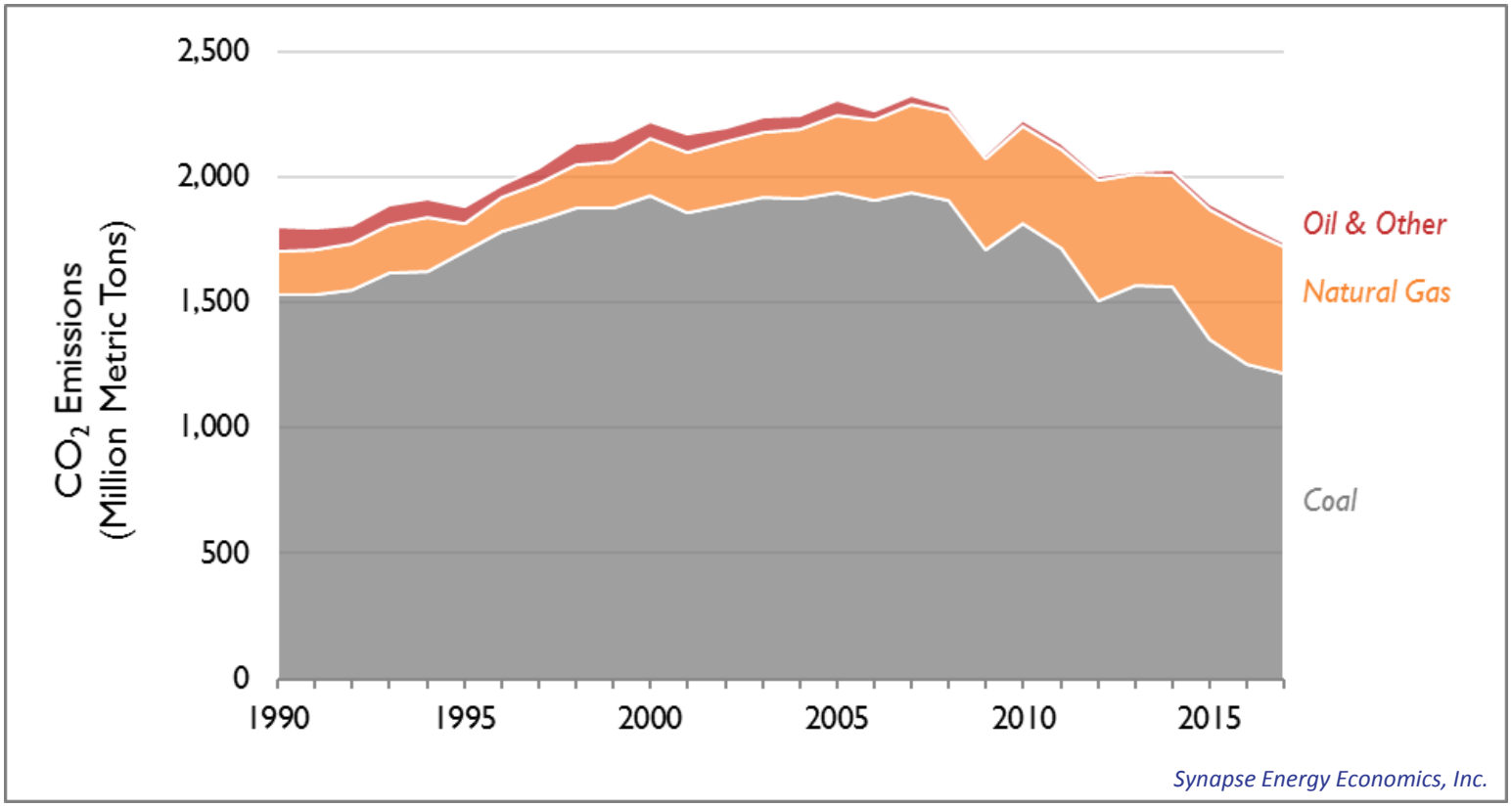
Retail sales have been flat since 2008, with an average annual growth rate of -0.2 percent



In many states, sustained lower sales are linked to increases in energy efficiency measures and behind-the-meter solar.

From 2016 to 2017, annual sales decreased by 2 percent, in part due to a warmer-than-typical winter and a cooler-than-typical summer.

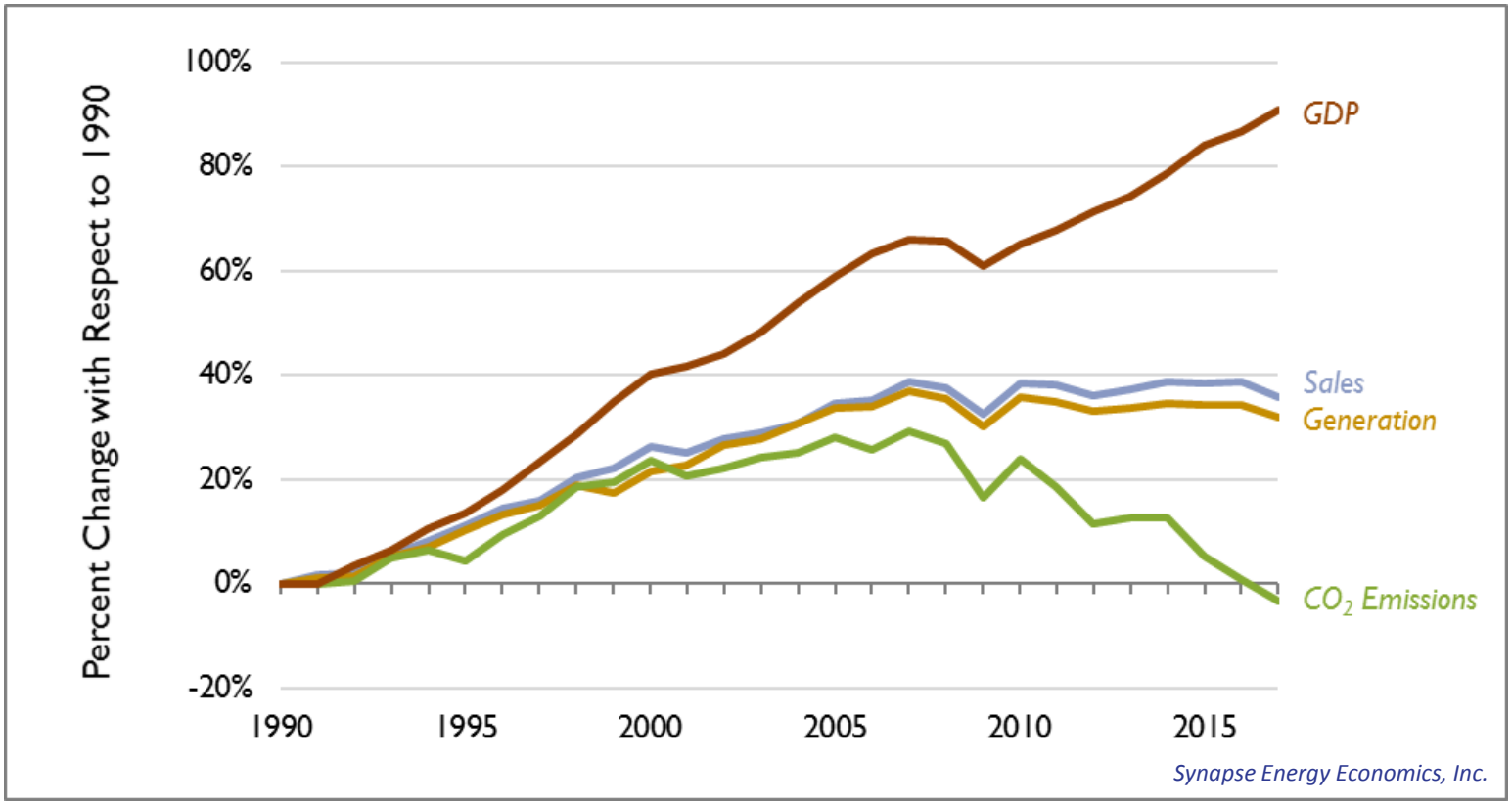
U.S. electric-sector CO_2 emissions are at their lowest levels since 1987



Since hitting an all-time peak in 2007, CO_2 emissions have dropped by 25 percent.

In 2017, coal represented 30 percent of generation, but 70 percent of CO_2 emissions.

Electric sales and CO_2 emissions are increasingly unrelated to GDP growth



Note: Values for GDP have been adjusted for inflation and are in constant –year dollars.

GDP has increased by 91 percent compared to 1990, while CO_2 emissions have fallen below 1990 levels. Retail sales and generation have grown by 36 percent and 32 percent, respectively.

Where might we be going?

Annual Energy Outlook (AEO) 2018

- Released on February 6, 2018 by the U.S. Energy Information Administration (EIA)
- Contains projections of energy use from the electric power, residential, commercial, industrial, and transportation sectors through 2050
- The AEO Reference case is not a forecast, but is instead a projection based on estimates of fuel availability, changes in technology costs, and currently enacted legislation
- In AEO 2018, EIA has removed the Clean Power Plan from its Reference case, putting it in a side case "with the Clean Power Plan"

Note: AEO 2018 is not necessarily representative of Synapse's thinking on these topics.

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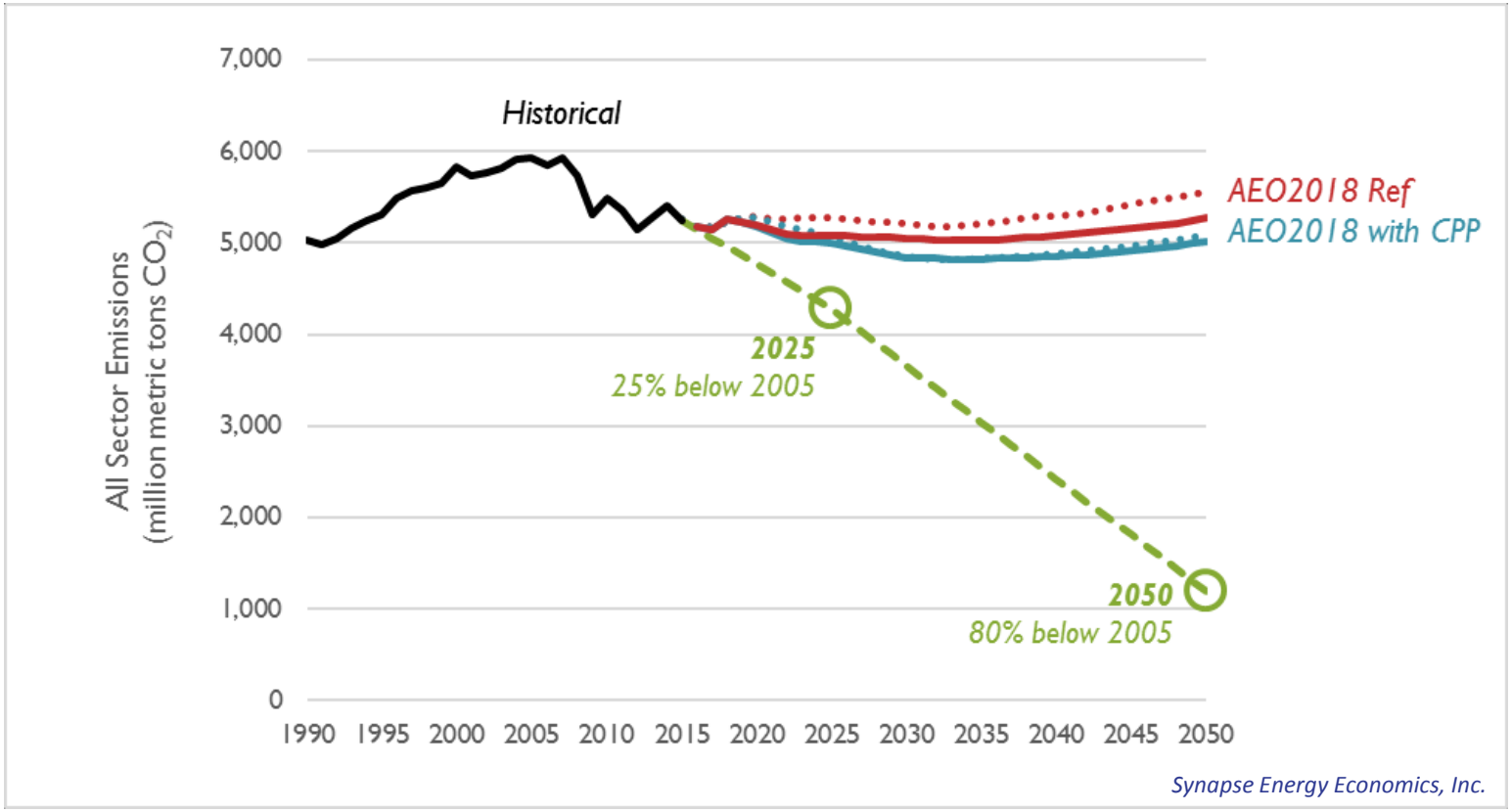
AEO 2018 projects a 4 percent reduction in CO_2 emissions by 2030, relative to AEO 2017

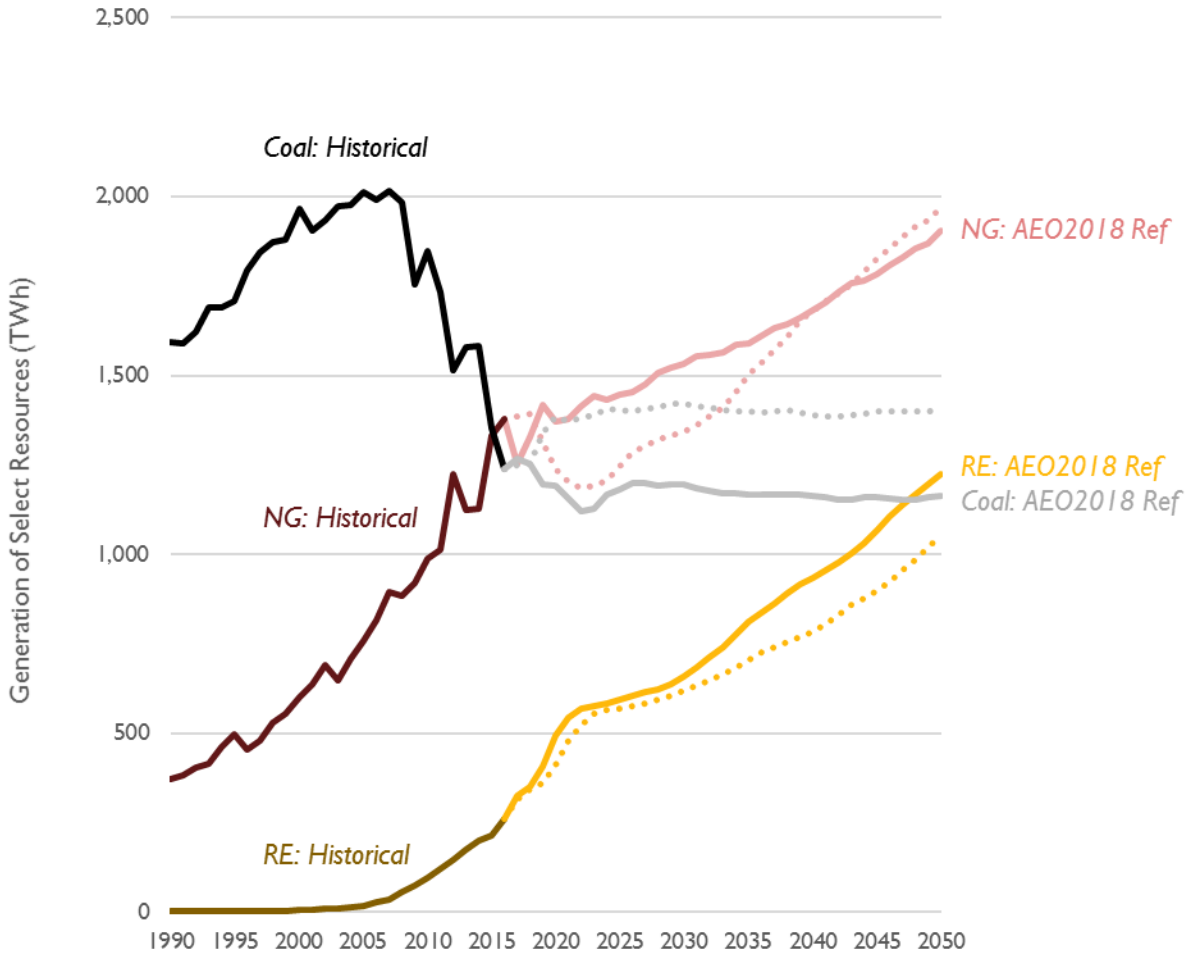


Note: Solid lines represent AEO2018 cases while dotted lines are the comparable cases from AEO2017.

Most of this emission reduction comes from the electric sector (which are 7 percent lower by 2030, relative to AEO 2017).

All-sector emissions are four-and-a-half times higher than is recommended by climate scientists to avoid a 2-degree heating scenario.

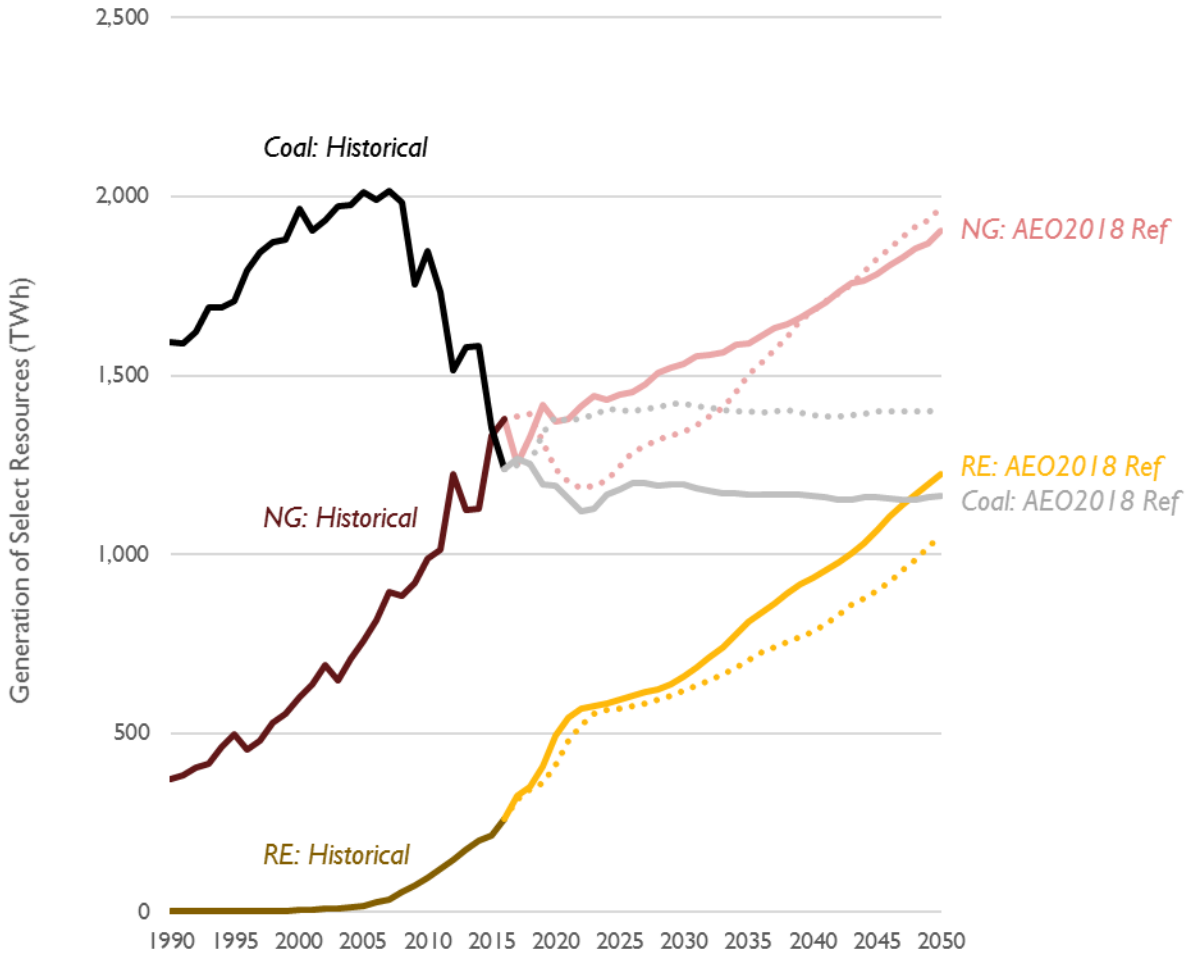
Shifts in electric generation are main drivers of changes in CO_2 emissions



- By 2030, EIA projects natural gas generation to increase by 14 percent, relative to AEO 2017
- By 2030, coal generation is 16 percent lower than projected last year

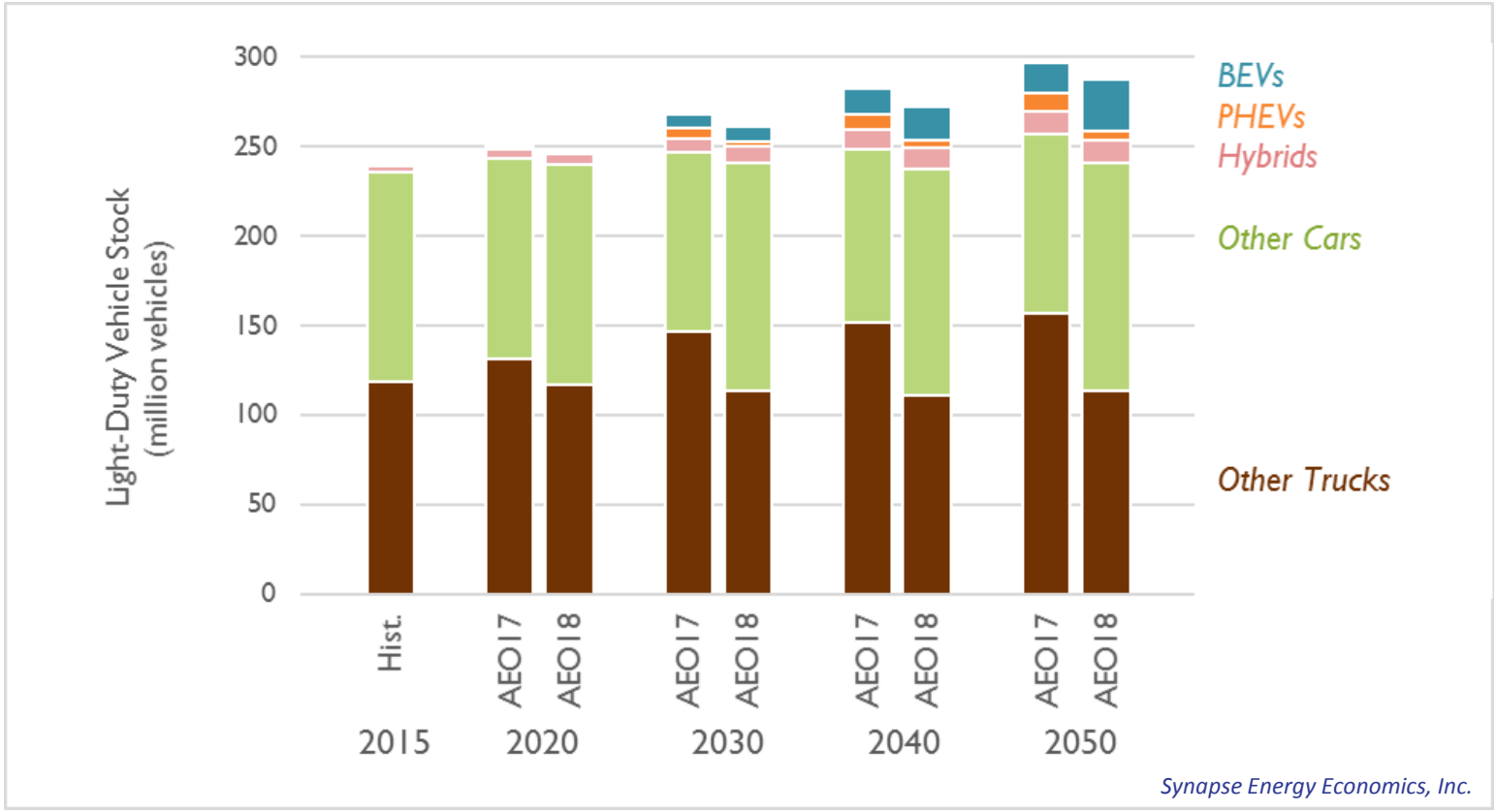
Note: Solid lines represent AEO2018 cases while dotted lines are the comparable cases from AEO2017. "NG" is natural gas, while "RE" includes wind and solar.

Shifts in electric generation are main drivers of changes in CO_2 emissions



- By 2030, wind and solar generation increases by 8 percent, relative to AEO 2017
- Solar increases by a factor of 2.8, with a relatively consistent forward-going growth
- But, new wind capacity (and generation, by association) additions cease in 2022
- AEO does not seem to account for state-specific requirements or targets to procure off-shore wind energy

AEO 2018 projects an increasing, but still limited number of electric vehicles (EVs)



Note: "BEVs" includes all-electric vehicles. "PHEVs" includes plug-in hybrids, while "Hybrids" constitutes non-plug-in hybrids. All other alternative light-duty vehicles are included in "Other Cars" and "Other Trucks."

AEO 2018 projects that by 2050, 10 percent of vehicles will be BEVs. LDV outputs from AEO's model (NEMS) are sensitive to assumptions on gasoline prices and fuel economy.

Questions?

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Link to Interactive Map: http://www.synapse-energy.com/tools/interactive-map-us-power-plants
or search "synapse map power plant"

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Notes and Sources

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"Oil and Other" contains oil, biomass, petcoke, solid waste, landfill gas, tires, purchases, and other miscellaneous fuel types.

Generation: All generation values are utility-scale and do not include distributed generation (e.g., rooftop PV) or energy efficiency. Generation values are from the U.S. Energy Information Agency (EIA), form EIA 923, 1990-2017.

Capacity: All capacity values are utility-scale nameplate capacity. These values do not include distributed generation (e.g., rooftop PV) or energy efficiency. Capacity values are from EIA 860 and EIA Electric Power Monthly, 2001-2017.

Sales: Prior to 2003, "other" sales included sales to transportation, public street and highway lighting, sales to public authorities, agricultural irrigations, and other miscellaneous sales. After 2003, this category only includes sales to transportation—all other miscellaneous sales types were re-distributed to either the industrial, commercial, or residential sectors. Sales values are from EIA 826, 1990-2017.

Emissions: CO_2 emission values for 1995-2017 are from U.S. Environmental Protection Agency Air Markets Program Data. CO_2 emission values prior to 1995 are electric sector emissions from EIA's State Carbon Dioxide Emissions database.

Gross Domestic Product: GDP values are from the Bureau of Economic Analysis, National Economic Accounts, accessed February 2018.

Natural gas prices: Monthly natural gas prices are from EIA's Henry Hub Natural Gas Spot Price dataset.