2017 Sustainable Energy in America Factbook Congressional Briefing

February 10, 2017

Hosted in coordination with the
House and Senate Renewable Energy and Energy Efficiency Caucus

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Environmental and Energy Study Institute

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About the Factbook (1 of 4):
What is it and what's new

What is it?

- Aims to augment existing, reputable sources of information on US energy
- Focuses on **renewables, efficiency, natural gas**
- **Fills important data gaps** in certain areas (eg, investment flows by sector, contribution of distributed energy)
- Contains data through the end of 2016 wherever possible
- Employs **Bloomberg New Energy Finance data** in most cases, augmented by EIA, FERC, ACEEE, LBNL, and other sources where necessary
- Contains the very **latest information on new energy technology costs**
- Has been graciously underwritten by the **Business Council for Sustainable Energy**
- Is in its **fifth edition** (first published in January 2013)

What's new?

- **Format**: This year's edition of the Factbook (this document) consists of Powerpoint slides showing updated charts. For those looking for more context on any sector, the 2014 edition(1) can continue to serve as a reference. The emphasis of this 2017 edition is to *capture new developments that occurred in the past year*.
- **Updated analysis**: Most charts have been extended by one year to capture the latest data.
- **2016 developments**: The text in the slides highlights major changes that occurred over the past year.
- **New coverage**: This report contains data shown for the first time in the Factbook, including transmission investment, PURPA-driven solar build, battery pricing, natural gas exports, energy spending, biofuel blending and electric vehicle model availability.

(1) The 2014 Factbook can be found here: http://www.bcse.org/factbook/pdfs/2014%20Sustainable%20Energy%20in%20America%20Factbook.pdf

About the Factbook (2 of 4):
Understanding terminology for this report

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	FOSSIL-FIRED / NUCLEAR POWER	RENEWABLE ENERGY	DISTRIBUTED POWER, STORAGE, EFFICIENCY	TRANSPORT
SUSTAINABLE ENERGY (as defined in this report)	• Natural gas • CCS	• Solar • Wind • Geothermal • Hydro • Biomass • Biogas • Waste-to-energy	• Small-scale renewables • CHP and WHP • Fuel cells • Storage • Smart grid / demand response • Building efficiency • Industrial efficiency (aluminum) • Direct use applications for natural gas	• Electric vehicles (including hybrids) • Natural gas vehicles
OTHER CLEAN ENERGY (not covered in this report)	• Nuclear	• Wave / tidal	• Lighting • Industrial efficiency (other industries)	• Biofuels

2017 FACTBOOK HIGHLIGHTS

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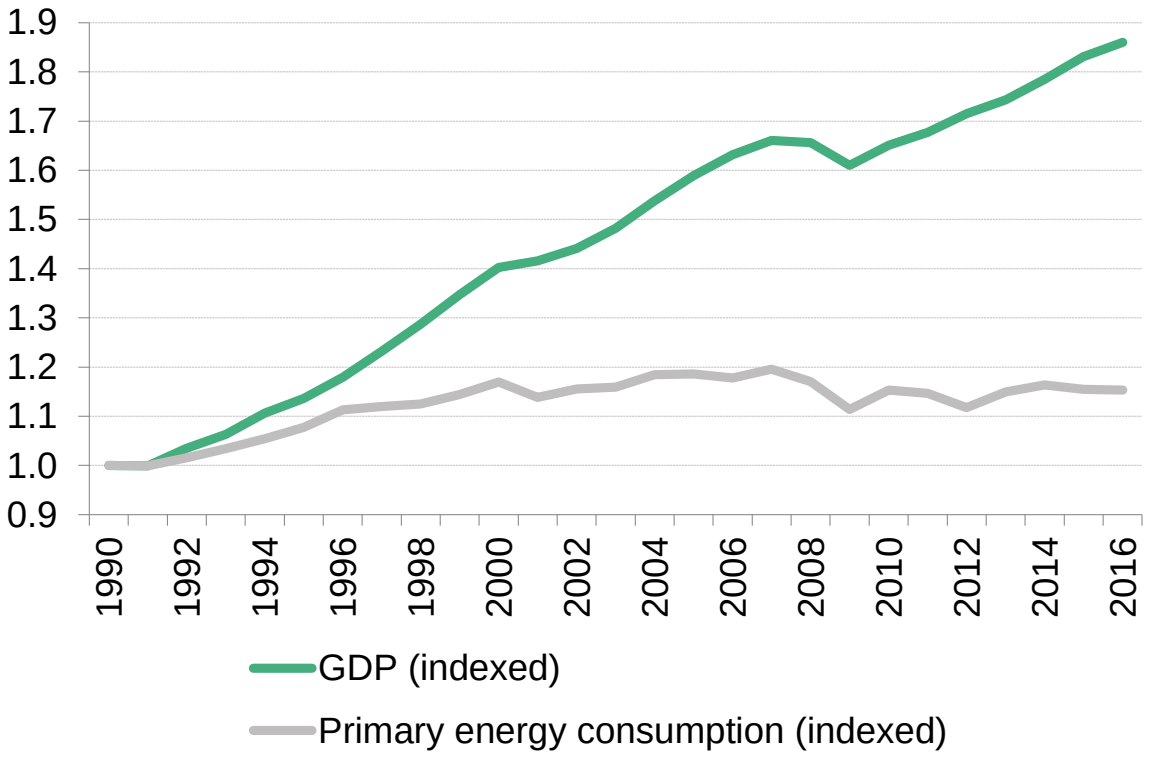
- **2016 saw a number of new landmarks in US energy:**
  - GDP grew 1.6%, while energy consumption fell 0.2%
  - Record solar PV build (12.5GW)
  - The US became a natural gas net exporter
- **Sustainable energy is the new normal:**
  - 92% of power generating capacity built in the past 25 years is renewable or natural gas
  - Natural gas has displaced coal as the largest source of power
  - Renewables provided 15% of power, up from 8% in 2007
  - Power-sector emissions 24% below 2005 levels, economy-wide down 12%
- **Meanwhile, energy prices are low and falling:**
  - Wind and solar costs have fallen dramatically and are competitive with gas and coal in many regions of the country
  - Consumers are dedicating less of household spending to electricity, natural gas, and overall energy than any other time on record

US energy overview:
The economy is more energy productive than ever

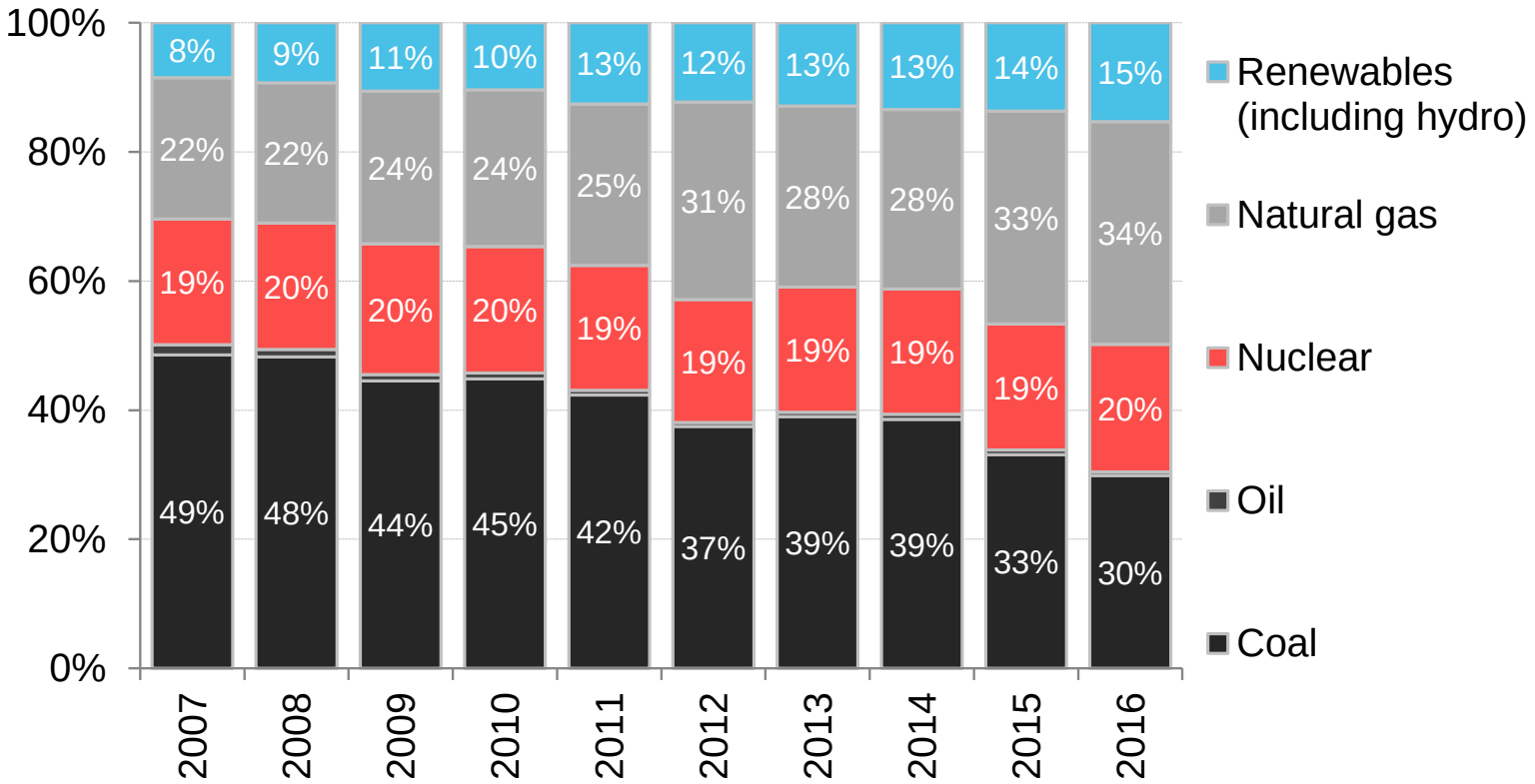


- Energy productivity continues to rise: in 2016, GDP rose 1.6% while total primary energy consumption fell by 0.2%.

Source: US Energy Information Administration (EIA), Bureau of Economic Analysis, Bloomberg Terminal

Notes: Values for 2016 energy consumption are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2016). GDP is real and chained (2009 dollars); annual growth rate for GDP for 2016 is based on consensus of economic forecasts gathered on the Bloomberg Terminal as of January 2017.

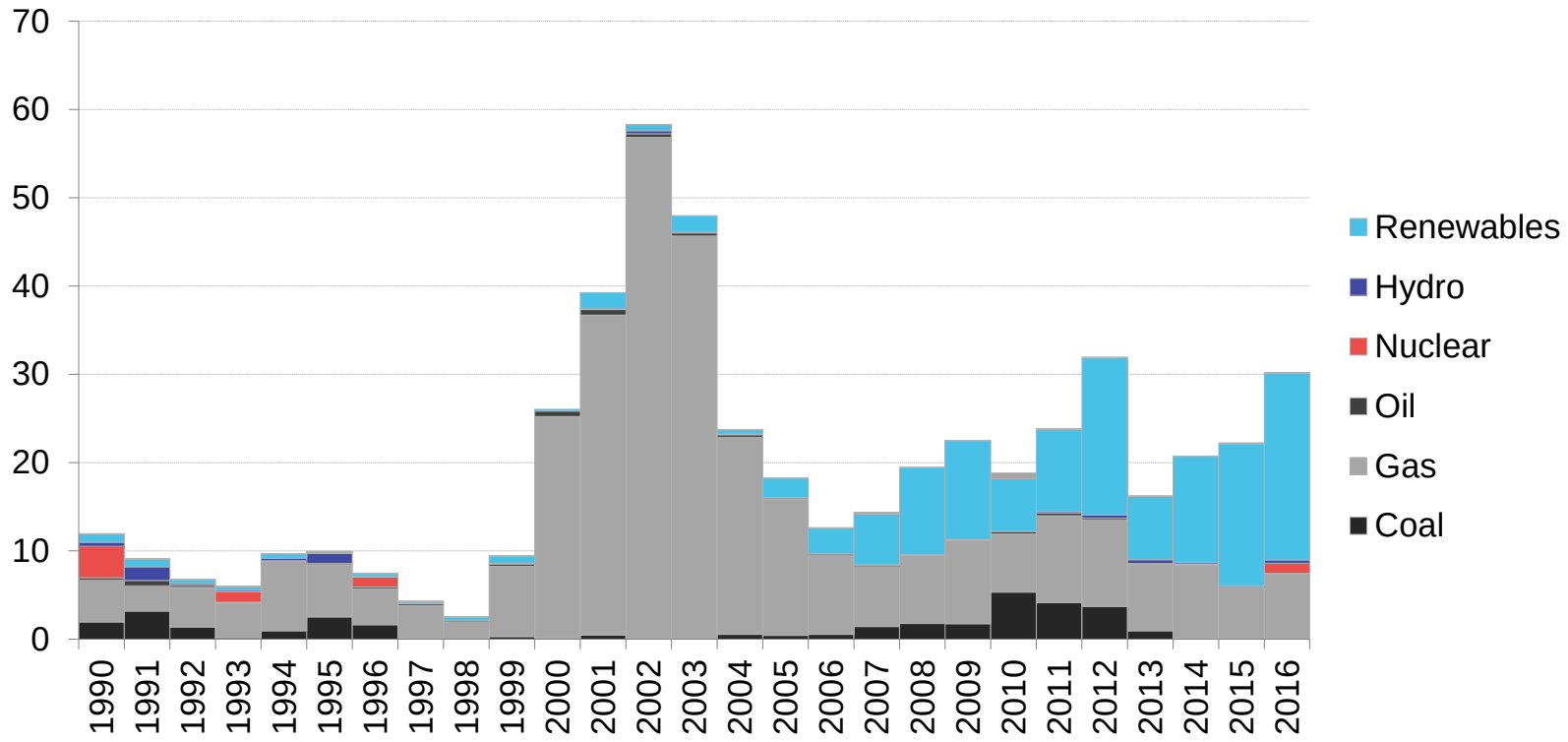
US energy overview:
Electricity generation mix



- Natural gas has eclipsed coal as the largest contributor to the US electricity mix, hitting 34% in 2016. Coal sank to second place, providing 30% of the mix – its lowest share on record.
- Since 2007: coal's share plummeted from 49% to 30%, while natural gas's grew from 22% to 34% and renewables from 8% to 15%.

Source: EIA Notes: Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through November 2016). In chart at left, contribution from 'Other' is not shown; the amount is minimal and consists of miscellaneous technologies including hydrogen and non-renewable waste. The hydropower portion of 'Renewables' includes negative generation from pumped storage.

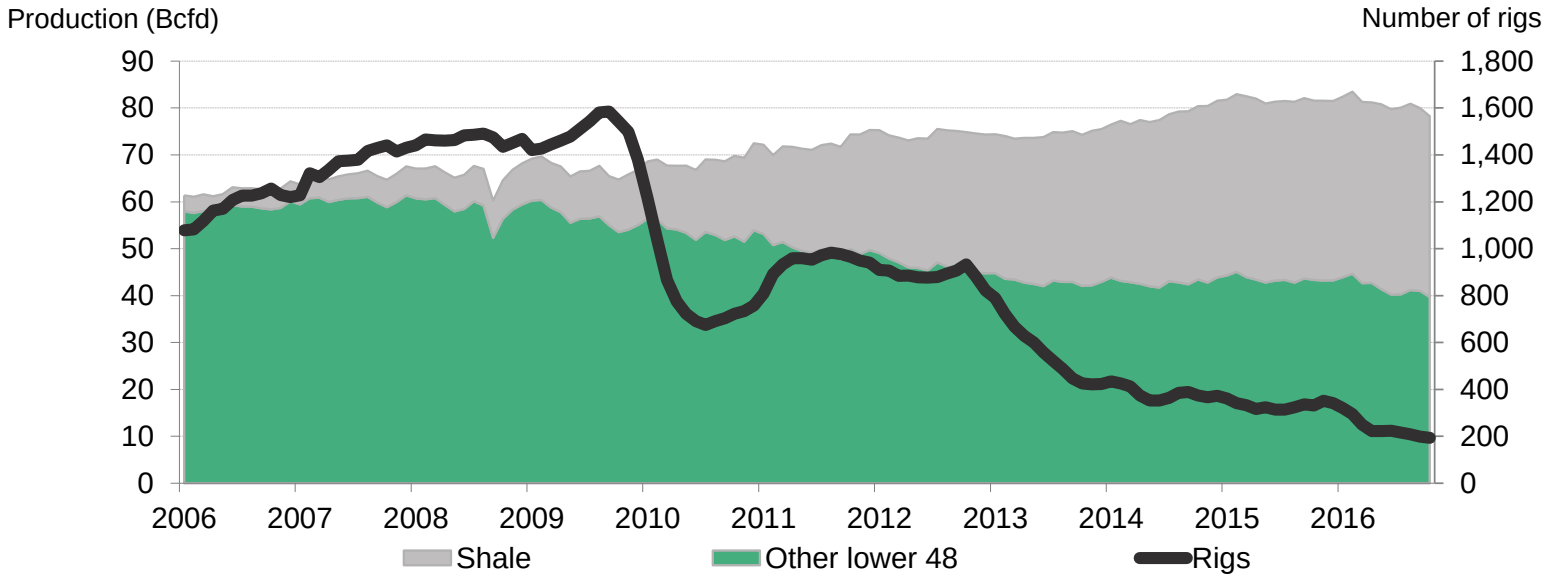
Electric generating capacity build by fuel type (GW)



- Last five years: 62% of new capacity additions have been renewable energy projects.
- Last 25 years: 92% has been natural gas plants or renewable energy projects.
- In 2016, renewables added 22GW of capacity, or roughly 70% of total build for the second straight year. Gas build totaled 7.4GW, and for the first time since the 1990s, there was also nuclear build of 1.1GW.

Source: EIA, Bloomberg New Energy Finance Note: All values are shown in AC except solar, which is included as DC capacity. "Renewables" here does not include hydro, which is shown separately. Last year's Factbook included anticipated nuclear build; however, the Watts Bar reactor was in fact turned on in 2016; accordingly, the nuclear build is shown here in 2016.

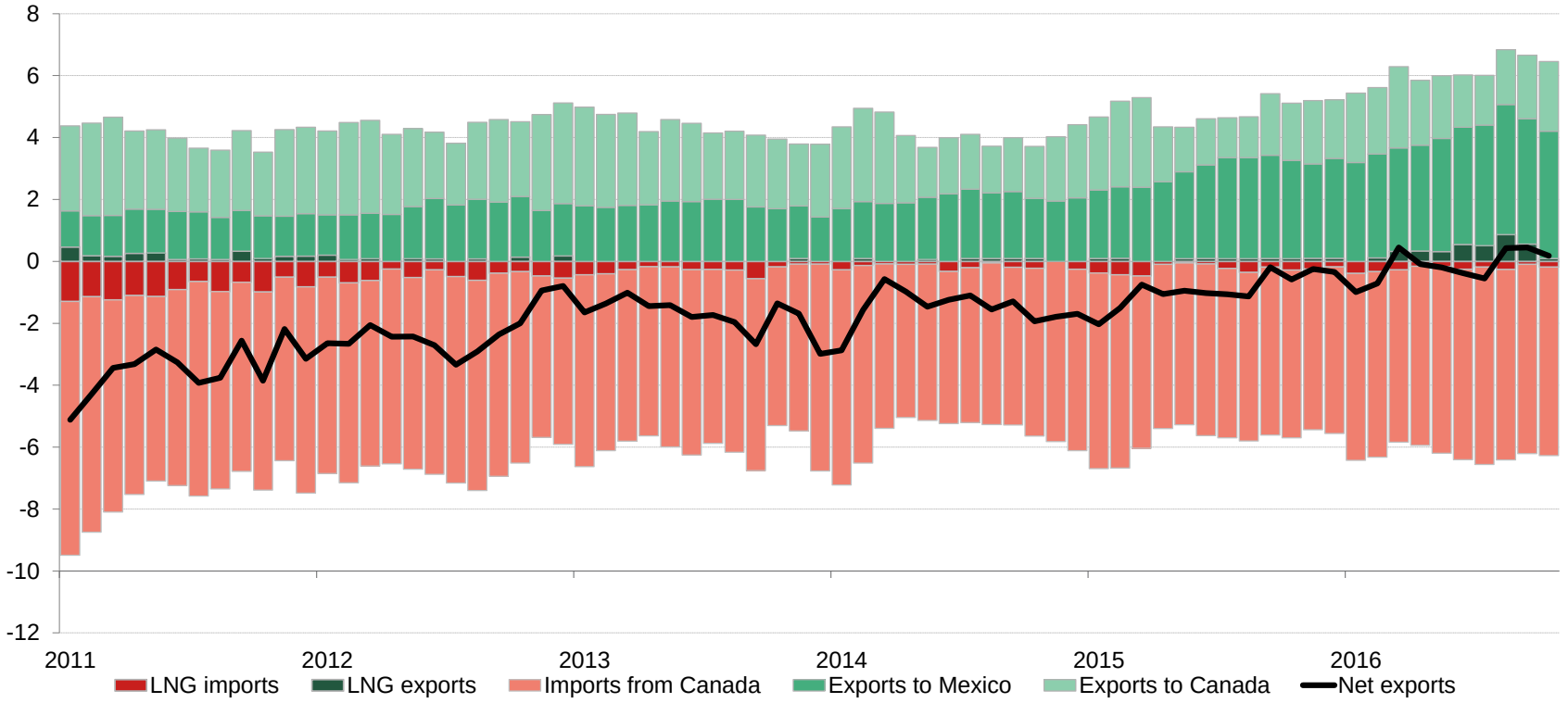
Deployment: US natural gas production and gas-directed rig count



- Rig count continued to shrink in 2016, falling 48% between December 2015 and the end of the following year as producers struggled to cope with the low-price environment.
- However, total US natural gas production held steady. This is due to a few reasons:
  - Producers are selectively drilling in productive 'sweet spots' and turning to an inventory of drilled but uncompleted wells (DUCs) to cost-effectively extract gas.
  - Technological improvements in efficiencies (like pad drilling and longer laterals) are shrinking well completion time, making it easier to speed up production and expand capacity for each well.

Source: Bloomberg New Energy Finance, EIA, Baker Hughes. Data up through the latest comprehensive numbers available (October 2016).

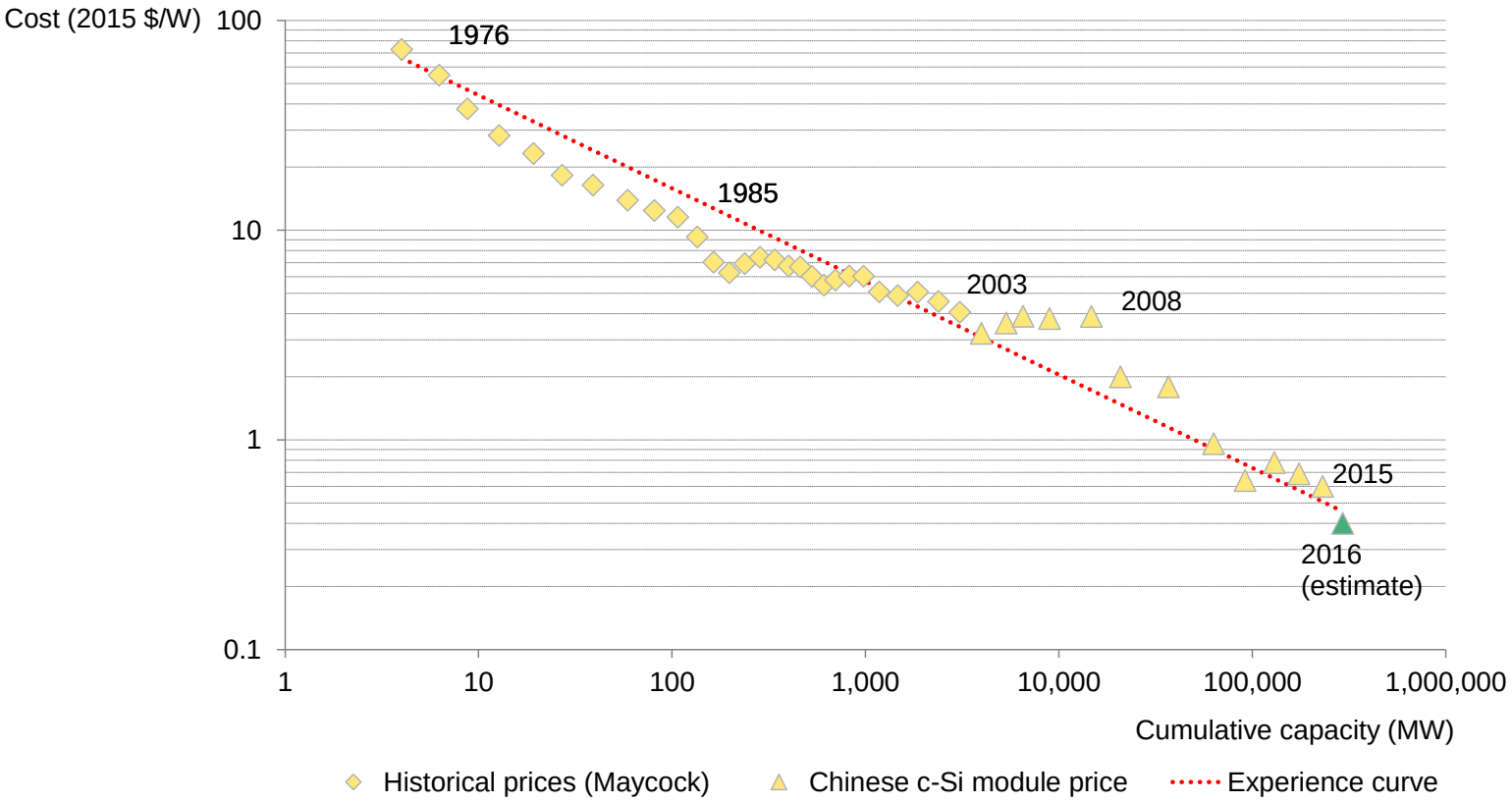
Deployment: US natural gas net exports (Bcfd)



- US natural gas net exports have been trending up since 2011, due in part to growing exports to Mexico as the deregulation of the energy market there continues to drive demand for US gas.
- In addition, 2016 marked the opening of two trains at the Sabine Pass LNG export terminal, which, combined with a decrease in imports, made the US a net LNG exporter.
- New, planned pipelines and LNG terminals will look to increase the US' role as an exporter going forward.

Source: Bloomberg New Energy Finance, EIA

Economics: Price of solar modules and experience curve (2015$/W as function of global cumulative capacity)

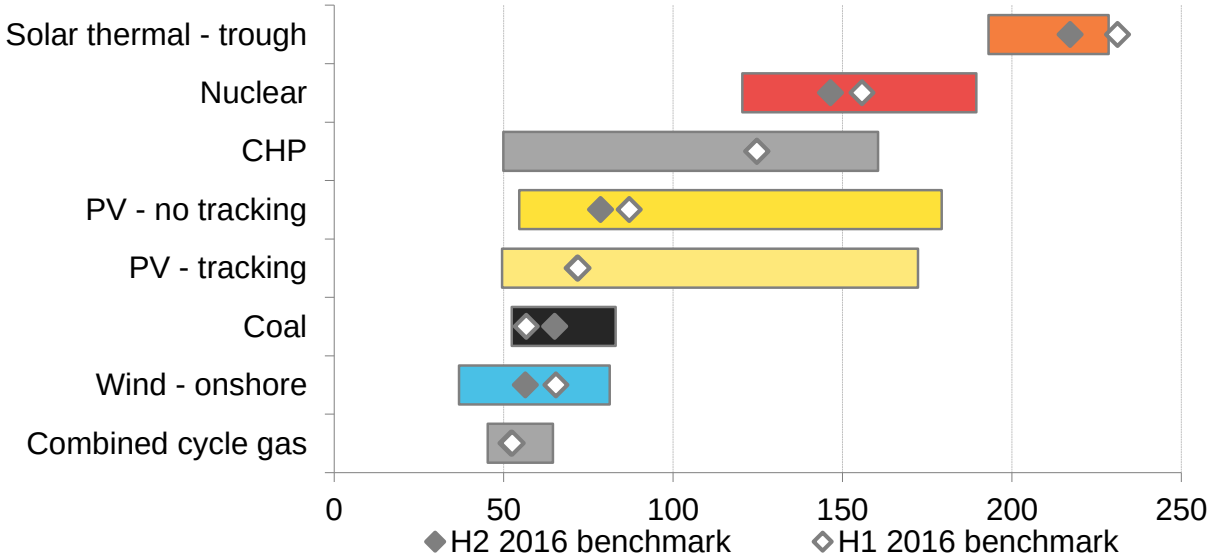


- The price of PV modules has roughly followed an experience curve with a learning rate of 26.5% - in other words, prices have fallen 26.5% for every doubling of cumulative installed capacity.
- From 2008 to 2009, module prices tumbled dramatically due to global oversupply, a dynamic that re-emerged in 2016. We estimate a global average module price of around $0.41/W in Q4 2016 and Q1 2017.

Source: Bloomberg New Energy Finance, Paul Maycock

Notes: The precise learning rate depends on the end-point chosen, but we believe $0.41/W to be slightly below the experience curve at the end of 2016. Figures in real 2015 dollars.

Economics: US levelized cost of electricity (*unsubsidized* across power generation technologies, H2 2016 ($/MWh)



- Since H1 2016, our US benchmark LCOE estimates have come down for renewable energy technologies, but increased for coal by $8/MWh. Competition from natural gas-fired generators and renewable energy have displaced coal generation, pushing down coal's average capacity factor and raising its LCOE.
- The US wind LCOE fell by $9/MWh from H1 2016 to reach $56/MWh in the second half of the year. In some US markets, average capacity factors for pipeline wind projects improved 3 percentage points. The *unsubsidized* LCOE for wind came in as low as $37/MWh in Texas, beating that of combined-cycle natural gas. The Production Tax Credit (PTC) and accelerated depreciation (MACRS), which are not factored into the analysis shown above, can make wind even more competitive on a $/MWh basis, with a 'subsidized' wind LCOE as low as $22/MWh.
- US solar PV (no tracking) saw its benchmark LCOE drop to $79/MWh. PV with tracking technology faces slightly higher capex costs, but its ability to capture more sunlight throughout the day raises its capacity factor, making it slightly cheaper than a similar array without tracking technology. In some regions of the country (the Southwest, Texas), solar PV can be built for $50/MWh – even without accounting for the value of the Investment Tax Credit (ITC) and MACRS.
- The LCOE for combined-cycle natural gas came in at $52/MWh, roughly unchanged from the first half of the year. The US has one of the lowest natural gas LCOEs in the Americas, due to its access to low-cost gas.

Source: Bloomberg New Energy Finance, EIA

Economics: Average 2015-H1 2016 offtake prices for wind and solar PPAs by signing date ($/MWh)

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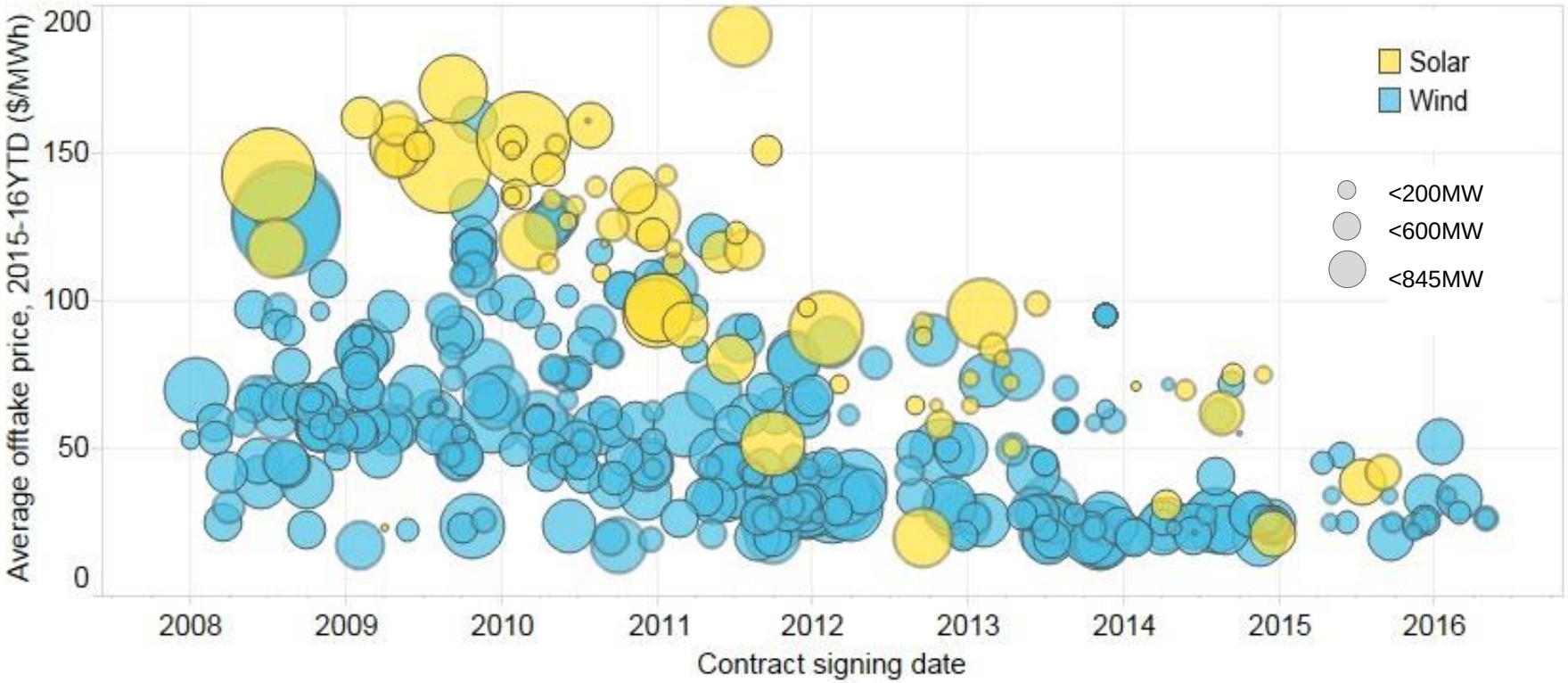
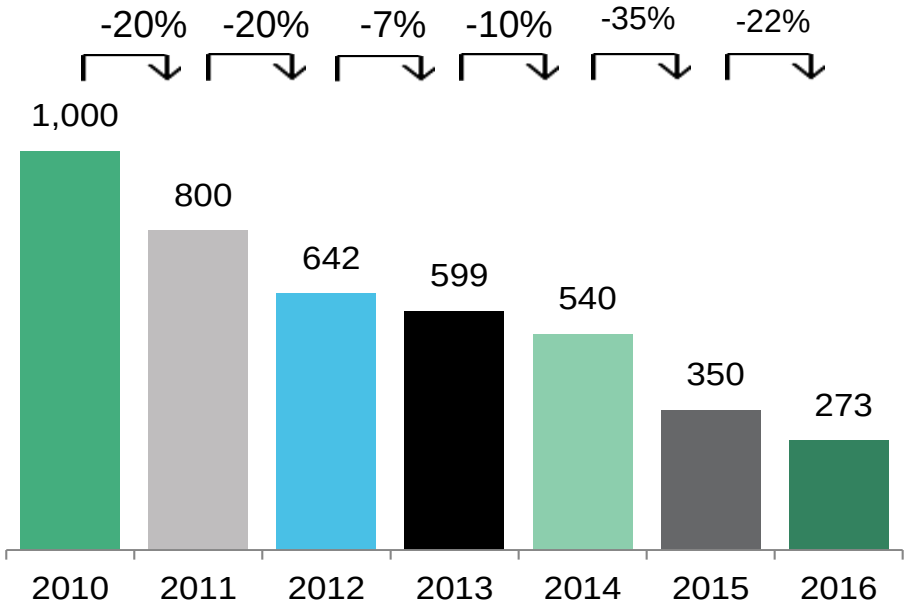


- Lower levelized costs translate into lower offtake prices: prices paid for solar and wind have fallen dramatically since 2008-2010.

Source: Bloomberg New Energy Finance, FERC EQR

Economics: Lithium-ion battery pack prices, 2010-2016 ($/kWh)



- Lithium-ion battery prices have fallen 73% since 2010. For the last two years, the change was propelled mostly by technology improvements (largely in energy density) and factory overcapacity, which resulted in growing competition between major battery manufacturers.
- The diminishing cost of lithium-ion battery packs is the driving factor behind the falling cost of BEVs.
- Stationary storage systems use similar cells, but the price of a fully installed stationary system can be twice the price illustrated here due to the cost of inverters, engineering and installation.
- BNEF has tracked lithium-ion battery prices since 2010 through an annual market survey process. It collects, anonymizes and aggregates price data for battery cells and packs. The numbers presented in the chart above include cell and pack prices for electric vehicles.

Source: Bloomberg New Energy Finance

Energy as share of total US personal consumption expenditure

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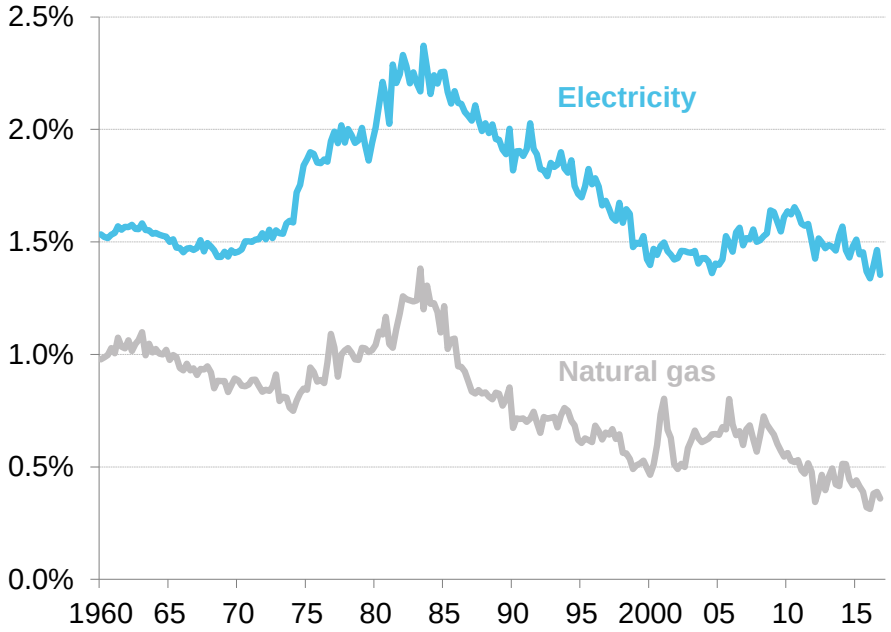
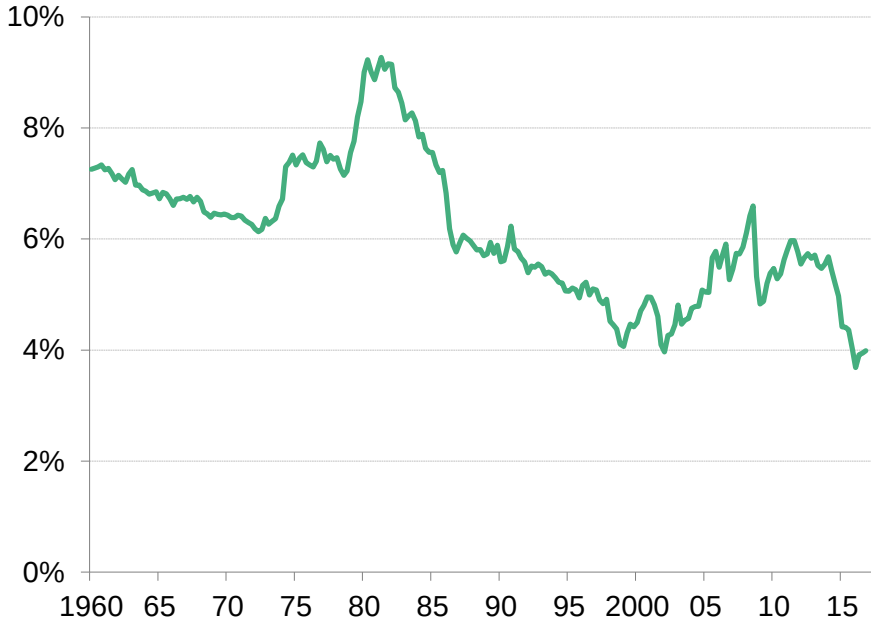
Electricity and natural gas as a share of total consumption expenditure



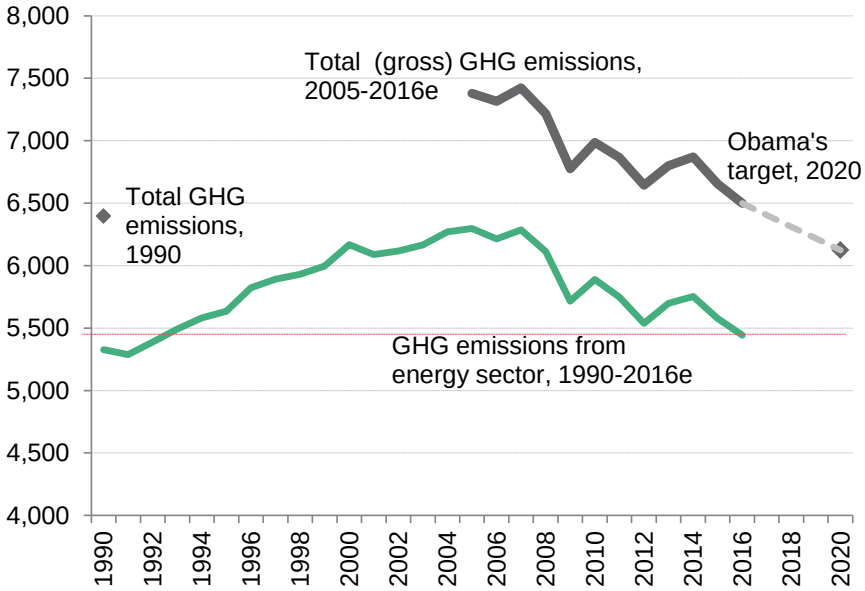
Total energy goods and services as a share of total consumption expenditure

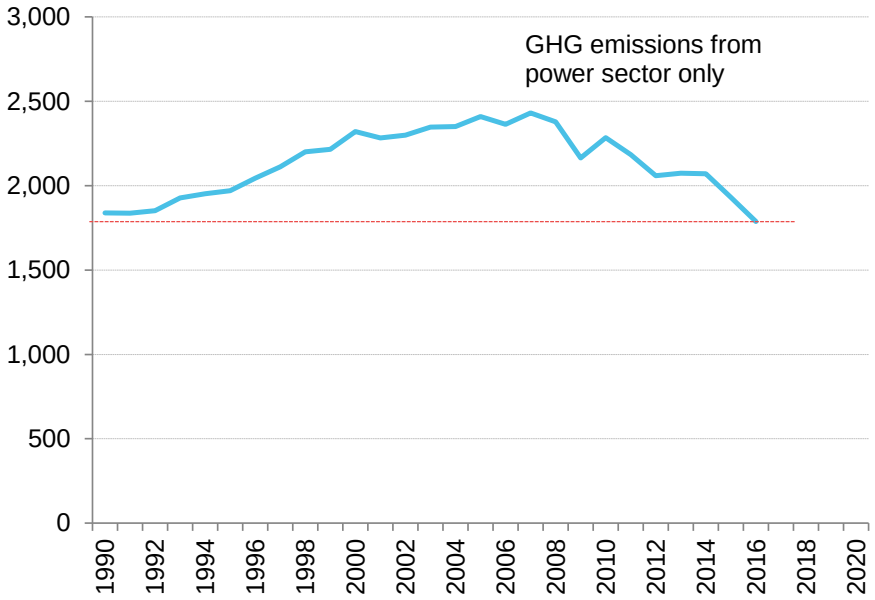


- Americans are dedicating less of their household spending to energy than at any other time on record: energy consumption as a share of total consumption expenditures averaged 3.9% in 2016, the first year in which this measure came in below 4% since at least 1959.
- Consumption costs for natural gas and electricity reflect a similar trend: natural gas represented under 0.4% of total spending, and electricity came in at 1.4%, both the lowest totals on record.

Source: Bureau of Economic Analysis, Bloomberg New Energy Finance Notes: Values for the fourth quarter of 2016 are preliminary.

US energy overview:
Greenhouse gas emissions, power sector, energy sector and economy-wide (MtCO2e)





- US GHG emissions are at their lowest levels in 25 years, falling to an estimated 6.5GtCO2e in 2016, 12% below 2005 levels.
- In 2016, power-sector emissions shrank 5.3% year on year, bringing them to 24.1% below 2005 levels.

Source: Bloomberg New Energy Finance, EIA, EPA

Notes: 'Sinks' refer to forests and green areas which absorb carbon dioxide. Values may differ from last year's, due to recalculations and revisions published by the EPA, primarily to methane emissions. Values for 2016 are projected, accounting for seasonality, based on latest monthly values from EIA (data available through October 2016). 'Obama's target' refers to a pledge made in Copenhagen climate talks in 2009. The target shown here assumes 17% reduction by 2020 on 2005 levels of total GHG emissions, but the actual language of the announcement left vague whether the reductions applied to economy-wide emissions or just emissions of certain sectors. Data for total GHG emissions comes from EPA's Inventory of US Greenhouse Gas Emissions and Sinks (1990-2014), published April 2016. Data for CO2 emissions from the energy sector comes from the EIA's Monthly Energy Review.

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About the BCSE

- The Business Council for Sustainable Energy (BCSE) is a coalition of companies and trade associations from the energy efficiency, natural gas and renewable energy sectors.

- The Council advocates for policies at state, national and international levels that:
  - increase the use of commercially-available clean energy technologies, products and services
  - support an affordable, reliable power system
  - reduce air pollution & greenhouse gas emissions

2017 BCSE Members

Financing: US *estimated* investment in energy efficiency through formal frameworks ($bn nominal)

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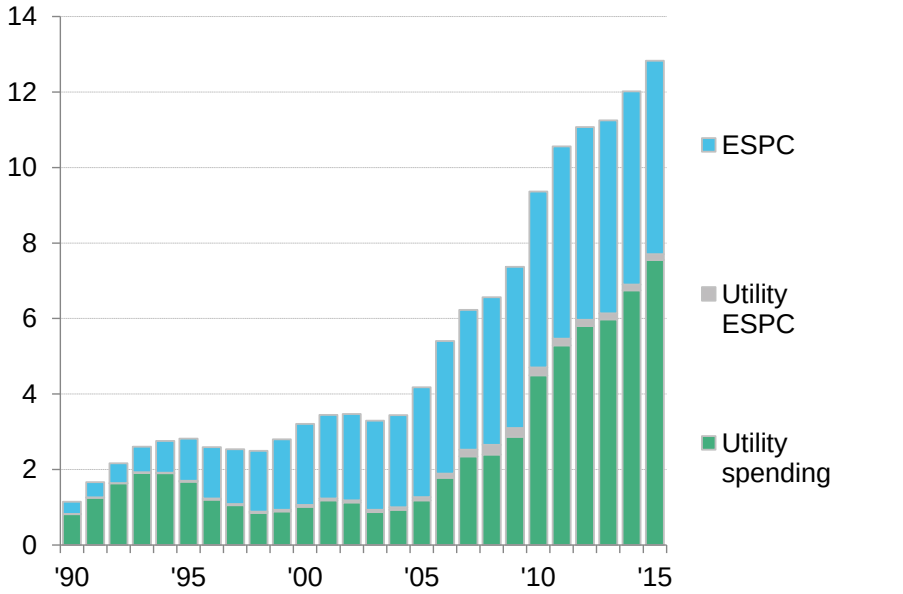
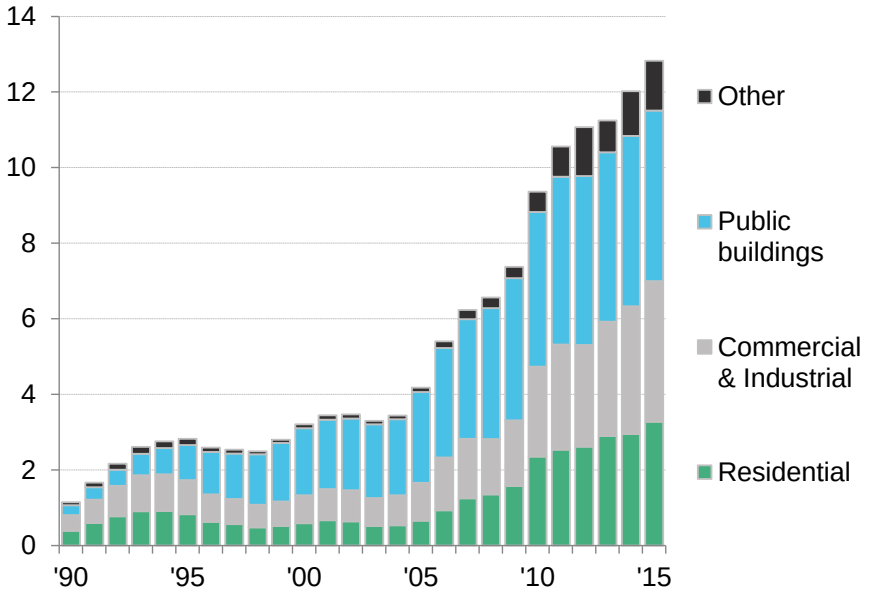
By framework



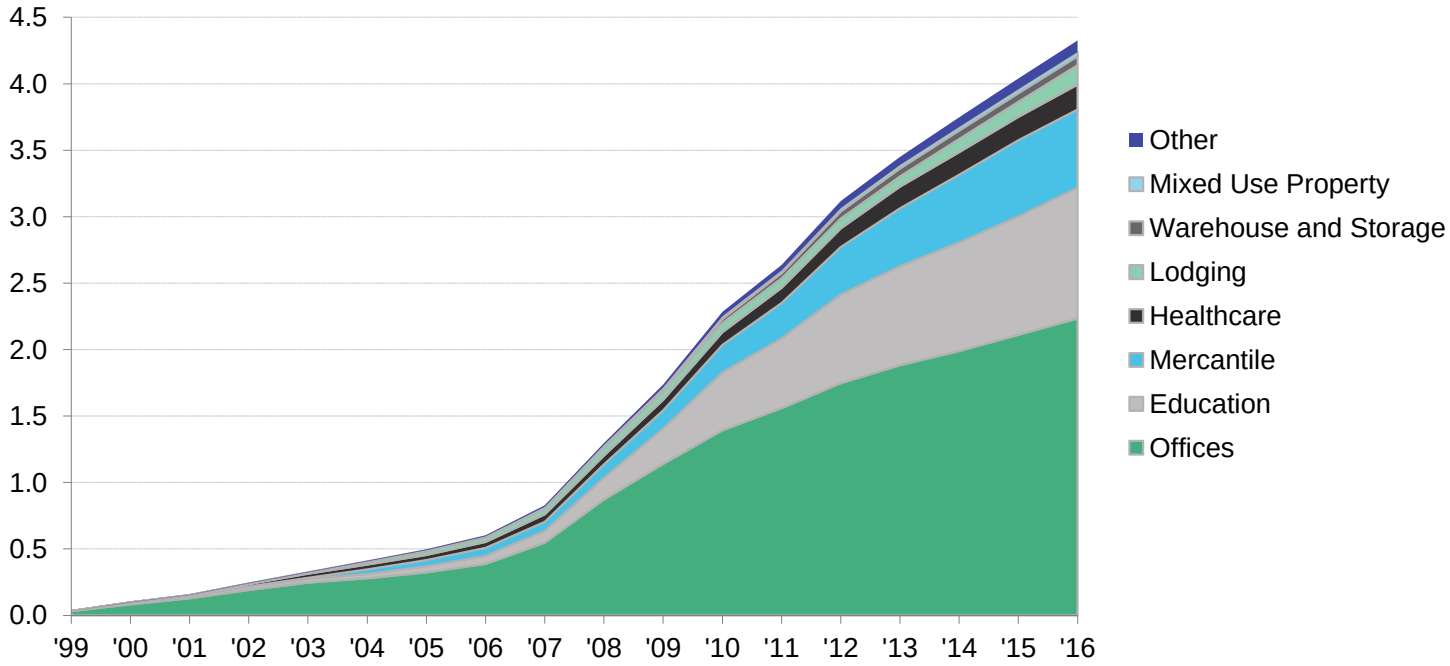
By sector



- Utility spending on energy efficiency remains the largest and fastest growing source of spending in this segment, accounting for 59% of investment in energy efficiency through formal frameworks.
- Energy-savings performance contracts (ESPC) are predominantly focused on public buildings. In 2015, ESPC spending for all measured sectors hit $5.3bn, bringing the five-year total to $26bn. Data from the Lawrence-Berkeley National Laboratory (LBNL) suggest that the ESPC market also averaged an estimated $5.3bn per year from 2011 to 2015. Anecdotal evidence collected by LBNL reveals that this figure may be incomplete, in part due to increased competition from smaller, non-traditional energy service companies (ESCOs), which do not meet LBNL's criteria for inclusion in the dataset graphed above.

Source: ACEEE, NAESCO, LBNL, CEE, IAEE, Bloomberg New Energy Finance Notes: The values for the 2015 ESPC market size shown here are estimates. The most recent published data from LBNL puts reported revenues at $5.3bn in 2014. The $5.3bn estimate for 2015 is based on a continuation of 2011-14 growth rates.

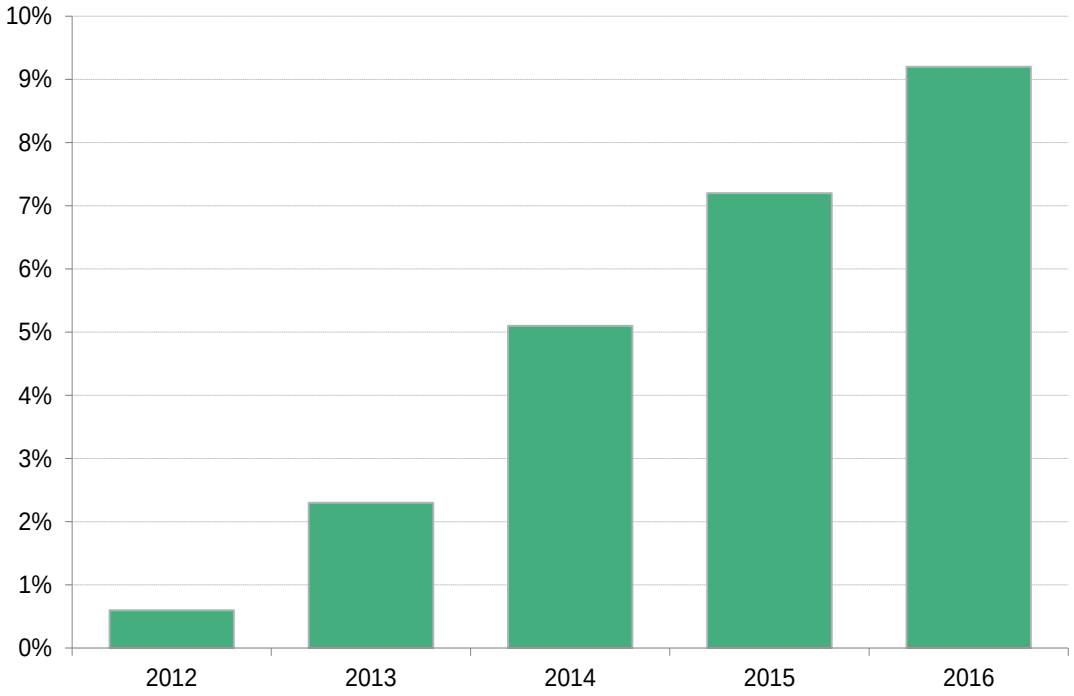
Deployment: Energy Star-certified floor space in US non-residential buildings by building type (bn sq-ft of floor space)



- As of 2016, 4.3bn sq-ft of US commercial building floor space was Energy Star-certified. This represents approximately 5% of total floorspace in US commercial buildings.
- Although adoption of Energy Star certification has increased rapidly, year-on-year additions peaked in 2012 and have been decreasing gradually since then. Likely reasons for this include the fact that some certified building are being re-certified, and that there are fewer 'easy wins' in the form of uncertified large office buildings.
- Offices and educational buildings account for 74% of certified buildings. They are also the segments where certification is growing most quickly, both in absolute terms (122 and 94 million sq-ft newly certified in 2016, respectively) and as a proportion of their addressable market (new 2016 certifications accounted for 0.8% of total floorspace for those segments). Certification in lodging is also picking up momentum, with 0.6% of the addressable market newly certified in 2016.

Source: EPA, Bloomberg New Energy Finance

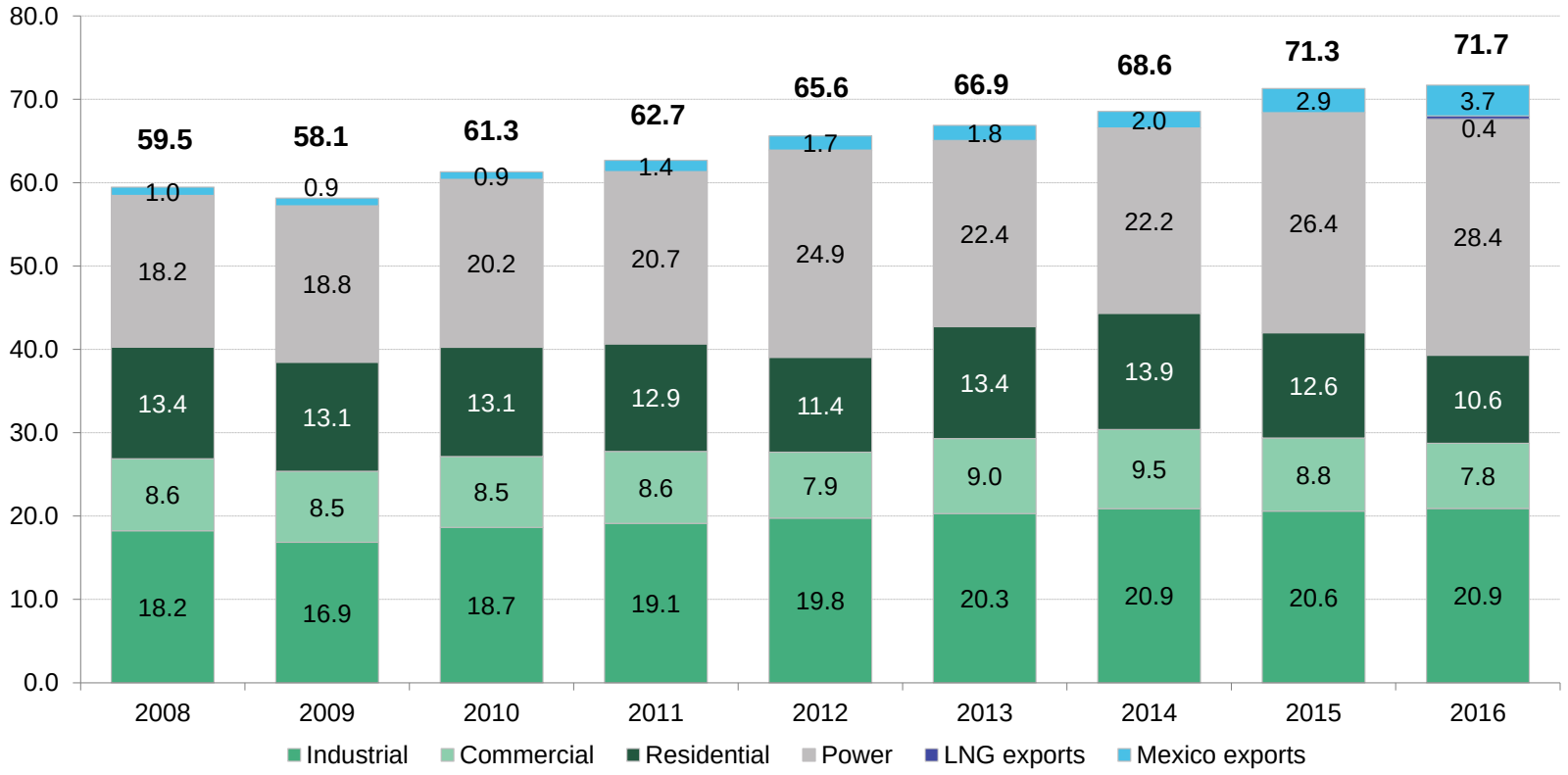
Deployment: Share of US vehicles sold with start-stop technologies, 2012-2016



- Start-stop systems automatically shut off the engine when the vehicle is stopped, thereby cutting fuel use and reducing idle emissions. A battery continues to power lights and accessories while the engine is off. The engine automatically restarts when the driver releases the brake pedal.
- Start-stop systems deliver up to 5% fuel savings for conventional internal combustion engine vehicles, depending on driving conditions.
- In Europe, vehicles with start-stop systems made up 80% of new vehicles sales in 2016. Europe got a head start on adopting start-stop technology a decade ago, in response to carbon reduction regulations.
- In the US there were at least 90 vehicle models with start-stop available in 2016, including the Ford Fusion and F-150, Chevy Malibu and Impala, Jeep Cherokee, Chrysler 200, Kia Sol and Rio, Dodge Ram and others.

Source: EPA, Bloomberg New Energy Finance, IHS

Deployment: US natural gas demand by end use (Bcfd)

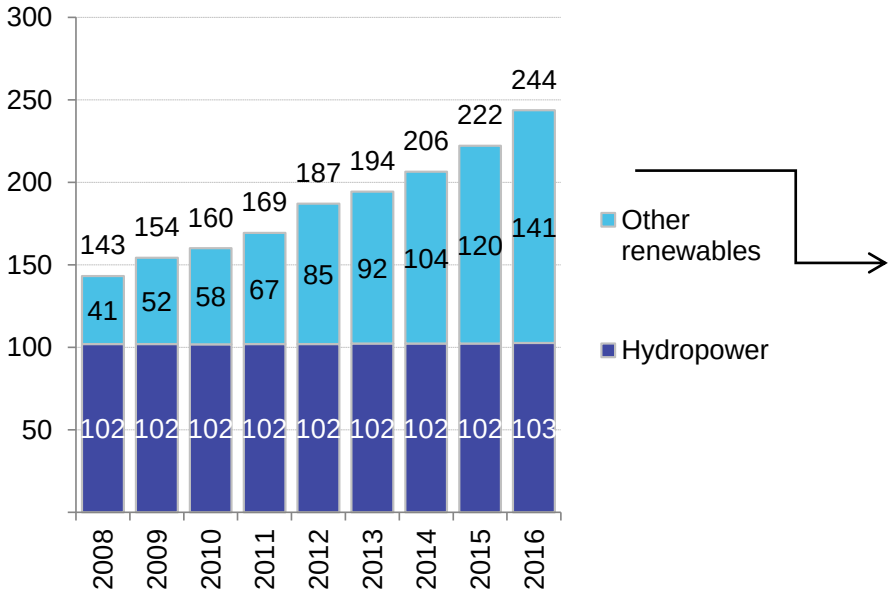


- Total US annual gas demand continues to grow slowly: 2016 demand represented a 21% increase from 2008 levels, and a slight year-on-year rise from 2015.
- The power sector drove domestic demand growth, offsetting declines in residential and commercial demand. Power sector gas consumption jumped 7% compared to 2015.
- Foreign demand also helped to buoy US gas demand. Pipeline exports to Mexico have nearly quadrupled since 2008, and the US started exporting liquefied natural gas (LNG) this past year.

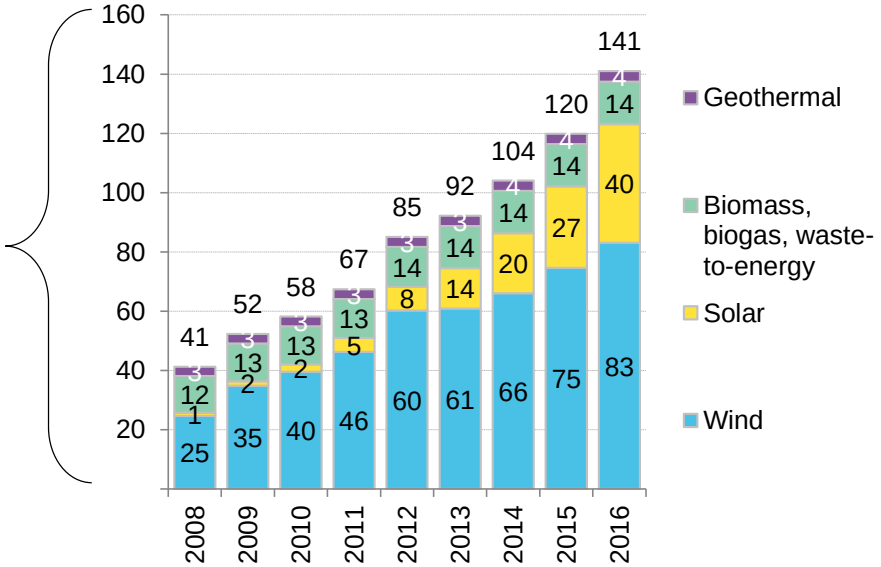
Source: Bloomberg New Energy Finance, EIA Note: Values for 2016 are projected based upon the latest available data (October 2016).

Cumulative renewable energy capacity by technology

US cumulative renewable capacity by technology (including hydropower) (GW)



US cumulative non-hydropower renewable capacity by technology (GW)



- Total renewable capacity has increased 70% since 2008, reaching 244GW in 2016. Year-on-year, hydropower capacity ticked up slightly to 103GW and other renewables grew by 21.1GW, or 18%. Wind and solar build in particular continues to climb due to supportive tax policies, state-level renewable portfolio standards (RPS) and falling system costs.
- Since 2008, new wind and solar build have almost quintupled their total installed capacity, expanding from only 26GW to 123GW at the end of 2016. The bulk of solar's additions have come within the past five years (35GW from 2012-16), as costs fell precipitously.

Source: Bloomberg New Energy Finance, EIA

Notes: All values are shown in AC except solar, which is included as DC capacity. Hydropower capacity includes pumped hydropower storage facilities. Totals may not sum due to rounding.

Deployment: US non-hydropower announced energy storage capacity (MW)

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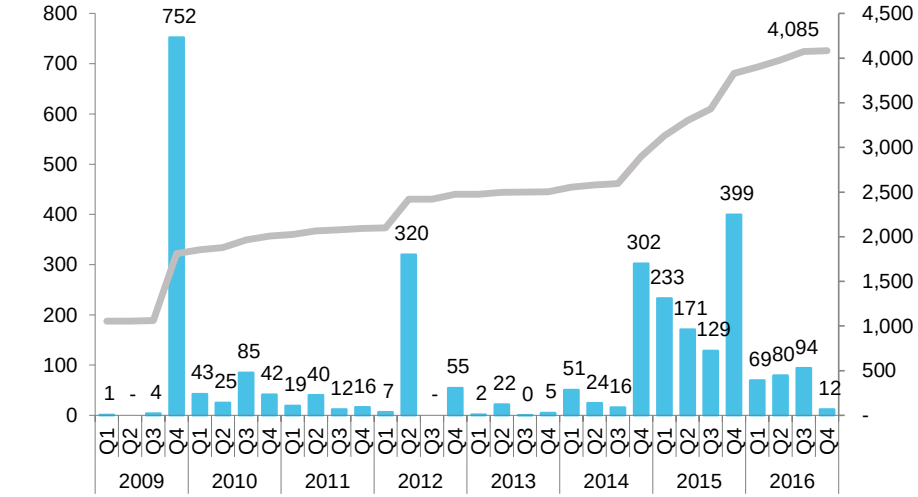
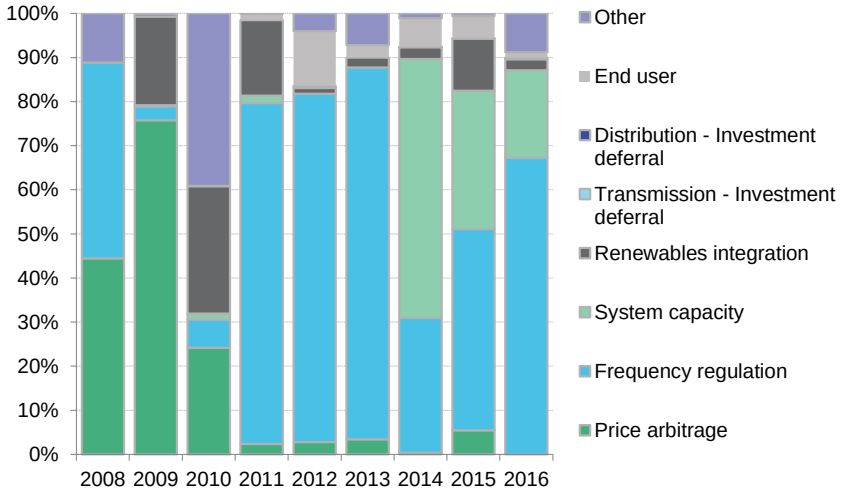
Announced



Mix of *applications* for announced projects (% by MW)



- The US remains the most dynamic energy storage market globally, with a variety of new business and financing models being deployed across the sector. Project activity has tended to be erratic, but new announced projects grew markedly in 2014-16.
- Most activity between 2009-2014 was policy-driven. The 2009 American Recovery and Reinvestment Act (ARRA) funded the majority of projects commissioned between 2011 and 2014.
- Since 2014, however, energy storage procurements in California have focused on contracting projects to supply Resource Adequacy (for system capacity) for the Californian grid, many of which will be delivered after 2019. In 2016, California additionally contracted 67MW-196.6MWh of energy storage projects to mitigate expected gas shortages due to the earlier leaks from the Aliso Canyon gas storage facility. These were delivered in four months, a record time from contracting to delivery. Most were expected to be commissioned by December 31.

Source: Bloomberg New Energy Finance Notes: Does not include pumped hydropower, underground compressed air energy storage, or flooded lead-acid batteries. Minimum project size for inclusion in this analysis is 100kW or 100kWh.

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Contributors:

Ethan Zindler

Colleen Regan

Rachel Jiang

Economics and Policy: Richard Chatterton, Abraham Louw, Stephen Munro, Dan Shurey

Natural Gas: Anastacia Dialynas, Jacob Fericy

Renewable Energy: Meredith Annex, Hugh Bromley, Amy Grace, Kyle Harrison, Lela Jgerenaia, Vertis McMillan, Alex Morgan, Dean Robertson, Nathan Serota, Ben Vickers

Energy Smart Technologies and Transportation: Claire Curry, Logan Goldie-Scot, Colin McKerracher, Thomas Rowlands-Rees, Aleksandra Rybczynska, Yayoi Sekine, Nikolas Soulopoulos, James Sprinz, Alejandro Zamorano-Cadavid