AEO2019 Renewable Electricity Working Group Meeting

EIA Renewable Electricity Working Group

May 15, 2018

Washington, DC

Overview of Annual Energy Outlook 2019 (AEO2019)

- Unlike AEO2018, which was a full report, AEO2019 will be a limited release
  - Reference (existing law and policy)
  - High/low oil and gas resource and technology
  - High/low oil price
  - High/low economic growth

- This presentation will
  - Highlight some of the key findings from AEO2018
  - List the priorities for changes to the renewable electric power sector portion of the model

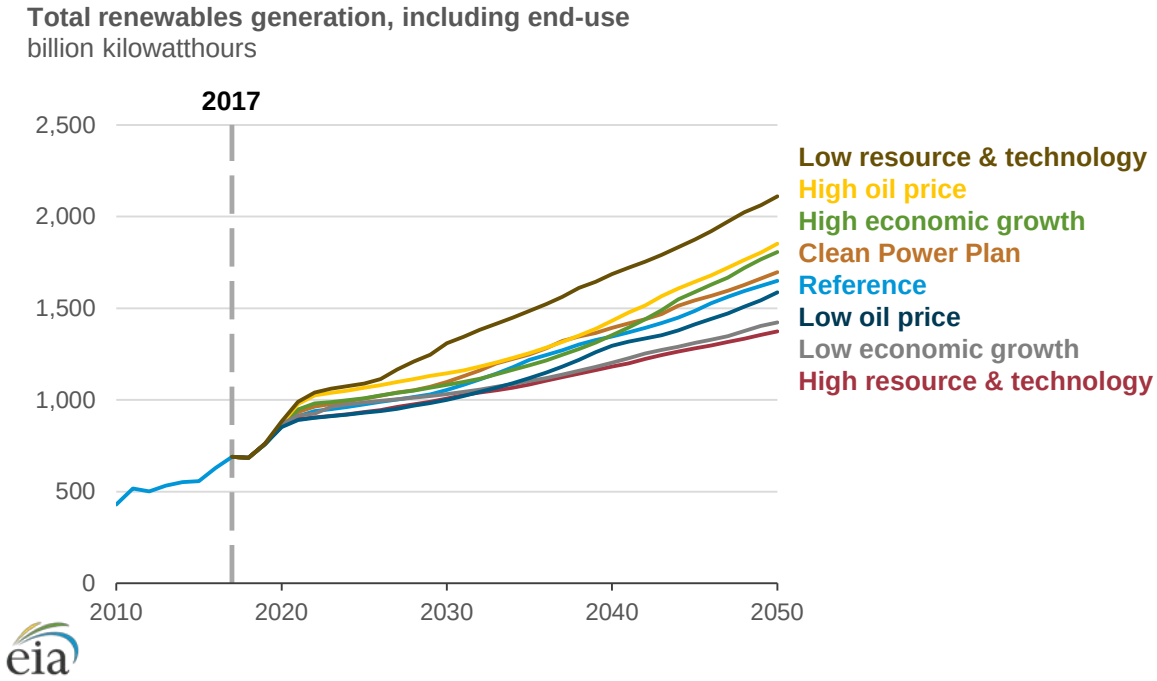
Other NEMS Working Groups

- For more information on the electric power sector updates, contact Kenneth Dubin (Kenneth.Dubin@eia.gov) to be added to the Electricity Working Group.
- Updates include:
  - Investigating the impact of 2017 tax reform legislation on electric sector
  - Updating methods for projected changes in generation costs (S&L study)
  - Evaluating the treatment of generation-at-risk
  - Representing impacts of generation diversity
  - Updating capital cost report
- For more information on end-use sector updates, contact Kevin Jarzomski (Kevin.Jarzomski@eia.gov) to be added to the Buildings Working Group.
  - Date: Thursday, May 31, 2018
  - Time: 1:30 p.m. to 2:30 p.m. (ET)
  - Location: Room 2E-069, DOE Forrestal Building or by WebEx

Renewable Electric Power Sector Updates from AEO2018

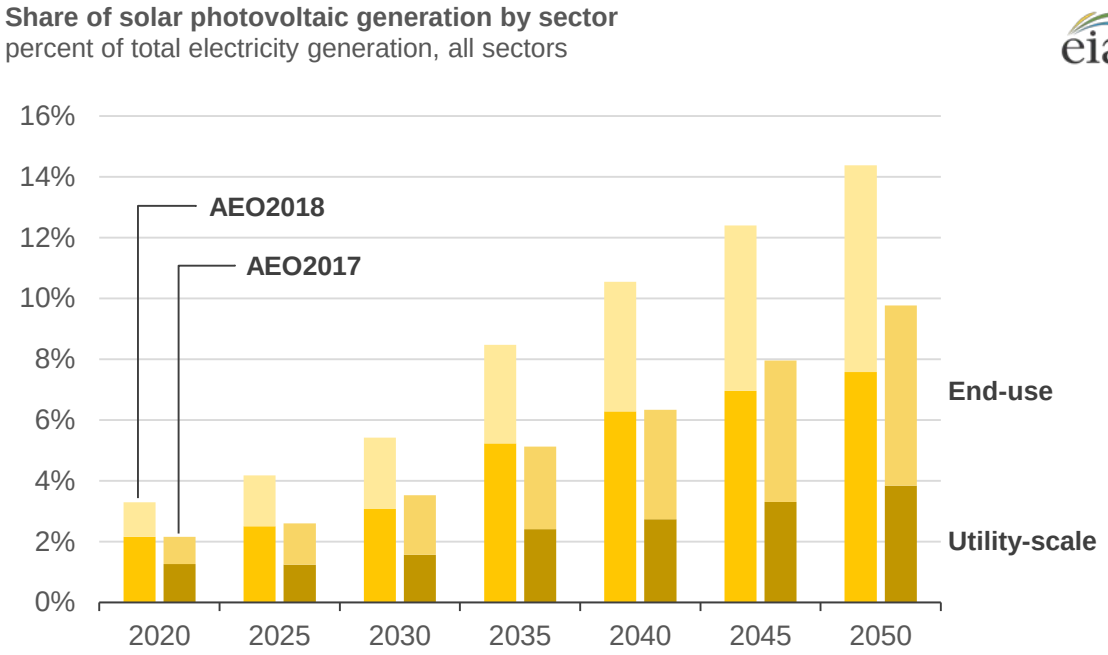
- **Renewable generation:** Improved representation of renewable generation resources.
- **Curtailment and energy storage:** Integrated energy storage as a capacity expansion option.
- **Potential hydro builds:** Reassessed data sources of potential hydro builds.
- **State-level renewable policy:** Defined technology-specific carve-outs in Renewable Portfolio Standard (RPS)
- **Project Financing:** Revised assumptions for cost of capital to finance new generating capacity.
- **Additional data updates:** Updated standard input assumptions as needed.

Increasing cost competitiveness of renewables leads to growth in generation even with projection for low electricity demand and low natural gas prices



Source: ref2018.1213a, highmacro.1213a, highrt.1213a, lowprice.1213a, ref_cpp.1213a, highprice.1220a, lowmacro.1213a, lowrt.1213a

Share of solar PV generation increases with better representation of solar resources and RPS carve-outs in each region



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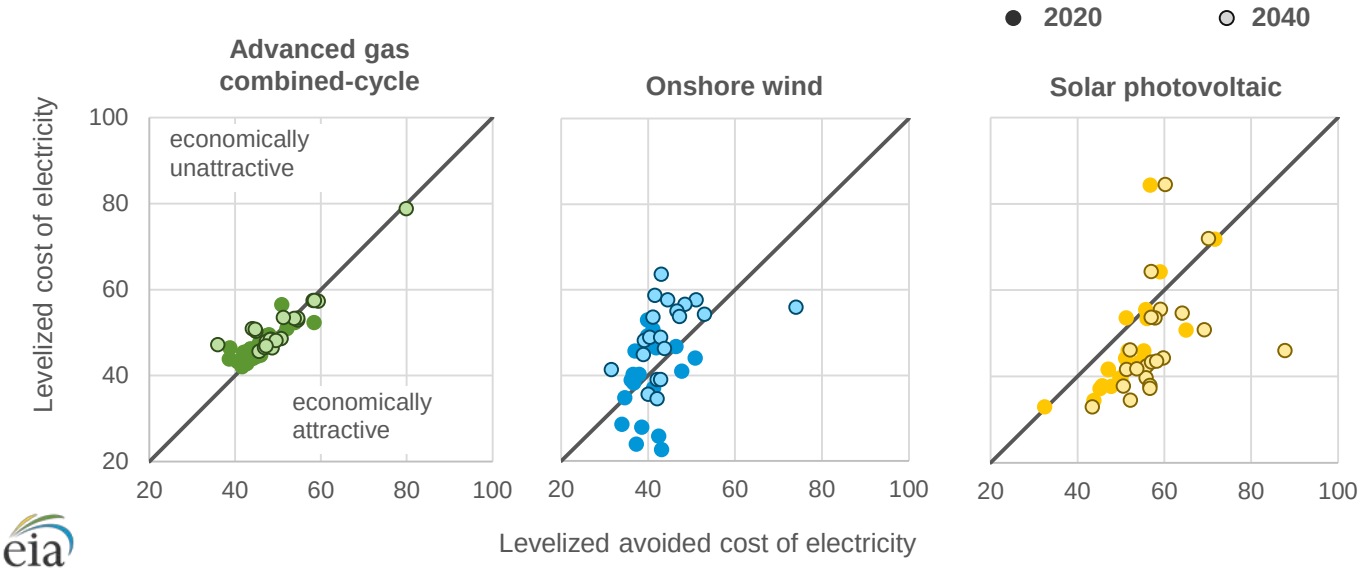
LCOE/LACE projects wind will become less competitive over time, while solar maintains its competitive position

Levelized cost of energy with tax credits and levelized avoided cost of energy by region and technology, 2020 and 2040
2017 dollars per megawatthour



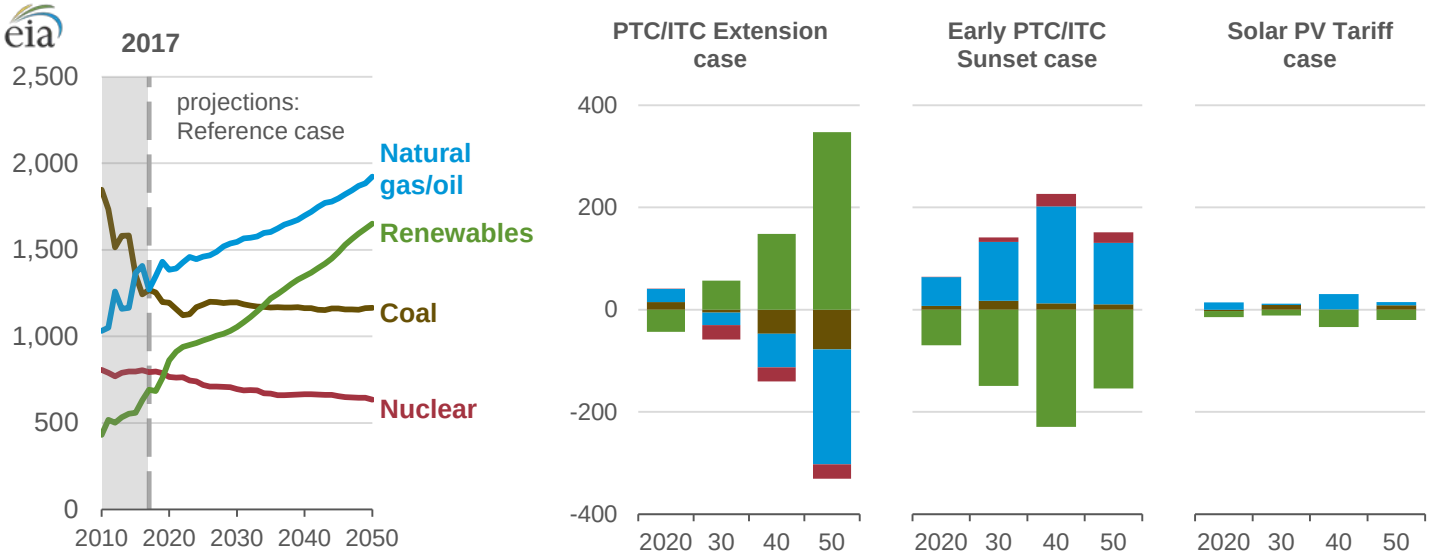
Source: ref2018.d121317a

Renewable and electricity policy cases build around three alternative scenarios

- Extension case: existing federal tax credits that have scheduled reductions and sunset dates to remain at their full credit value through 2050
  - Production Tax Credit (PTC) retains the full value
  - Investment Tax Credit (ITC) value of 30% remains in effect for the residential, commercial, and electric power sectors
- Early Sunset case: existing federal tax credits expire completely in 2019, prior to their currently scheduled phaseouts and expirations
- Solar PV Tariff case: increased capital cost of PV systems (both utility-scale and end-use solar) from the recently approved tariff of 30% on crystalline silicon (c-Si) solar PV cells and modules imported into the U.S., with effective period of four years and declining rate of 5% annually
  - 10% increase to utility-scale solar capital cost
  - 4% increase to residential sector and 6% increase to commercial sector solar capital costs

Similar total generation across cases as fuels replace one another in the mix; natural gas–renewables tradeoff most evident in PTC/ITC Extension case

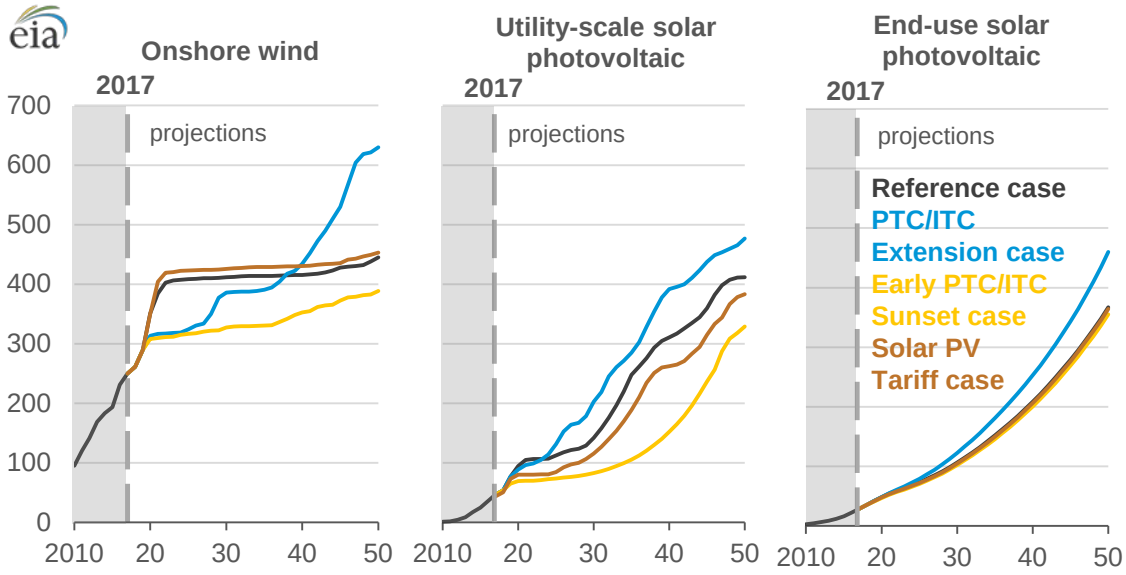
All sectors electricity generation by fuel type, 2010–50, and change in electricity generation from Reference case, 2020, 2030, 2040, and 2050
billion kilowatthours



ref2018.d121317a, extend50.d032118a, sunset.d022318a, tariff1.d030118a

Tax credits and solar tariffs affect timing of projected renewable power plant deployment

U.S. electricity generation by technology, 2010–2050
billion kilowatthours



Source: ref2018.d121317a, extend50.d032118a, sunset.d022318a, tariff1.d030118a

Renewable Electric Power Sector Updates for AEO2019

- **Completed or Likely Completed for AEO2019:**
  - Integrate a new renewables/energy storage mini-dispatch model (REStore)
  - Model weighted-average capacity value algorithm for solar/wind
  - Update renewable-related input assumptions for the spinning reserves requirement
  - Re-evaluate short-term elasticity bound algorithm approach
  - Update evaluation for renewable energy conversion from kWh to BTUs

- **Possible Model Updates for AEO2019:**
  - Include second solar/wind technology to capture performance/cost tradeoffs
  - Change the solar thermal technology profiles to one with storage
  - Assess retail price structure impacts of distributed PV
  - Replace LFG model with a simplified, trend approach
  - Update biomass resources

- **Long Term Development Projects:**
  - Re-evaluate solar/wind resources as a part of re-regionalization effort
  - Study retirement/repowering decisions for wind (and other renewables)
  - Re-evaluate capacity factor learning for wind technologies

Renewable Updates: Done(ish)

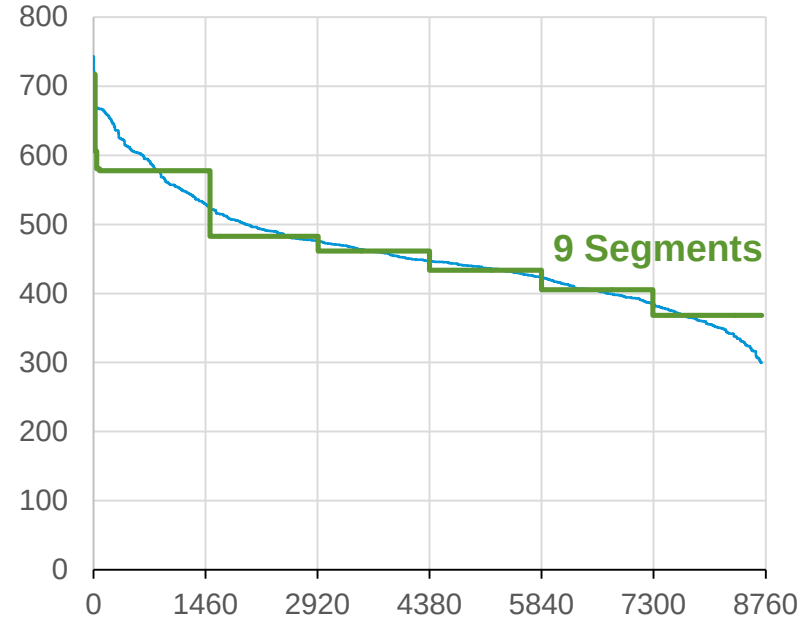
- **Integrate a new energy storage mini-dispatch model**
  - Last AEO, EIA included a first iteration of battery storage capacity expansion in NEMS
  - This AEO, EIA is updating the representation to more accurately capture the cost dynamics

- **Capacity value algorithm for solar/wind**
  - Previously, EIA used a single peak time slice to evaluate the availability of non-dispatchable renewables to contribute to capacity requirements
  - This AEO, EIA will evaluate the capacity credit at a more granular time interval

REStore uses 24-hour weekday and weekend day types for each month of the year to evaluate renewable and storage technologies

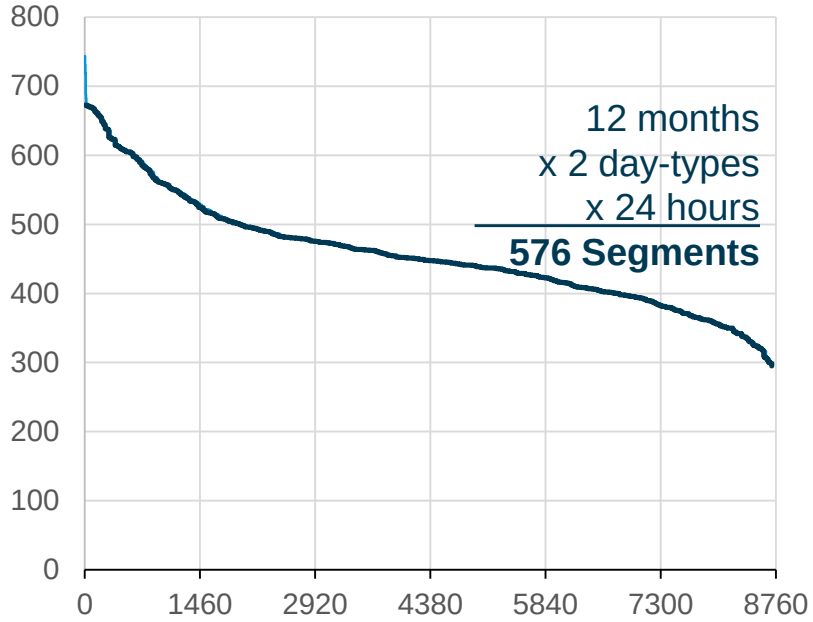
Example NEMS load duration curve

gigawatts



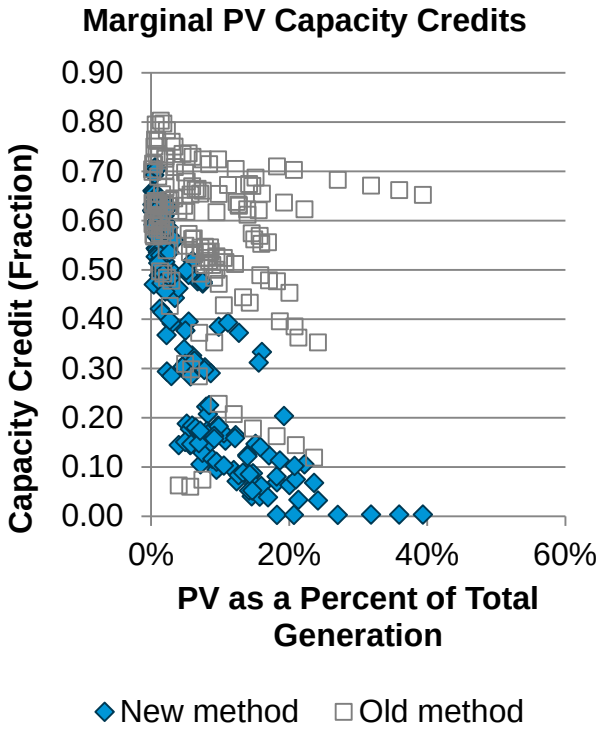
Example REStore load duration curve

gigawatts



New capacity credit approach prevents over attribution of capacity value for non-dispatchable technologies, like solar

	New Method		Old Method	
	2025	2035	2025	2035
peak load	40.2	43.5	40.2	43.5
Avg load at time of net peak	39.8	40.5		
margin target	0.15	0.15	0.15	0.15
target * peak	6.0	6.5	6.0	6.5
capacity constraint	45.8	47.0	46.3	50.0
PV capacity	0.35	9.88	0.35	9.88
PV cap credit fraction	0.62	0.09	0.70	0.62
Reliable PV capacity	0.22	0.93	0.25	6.09
Implied non-PV requirement	45.6	46.1	46.0	43.9



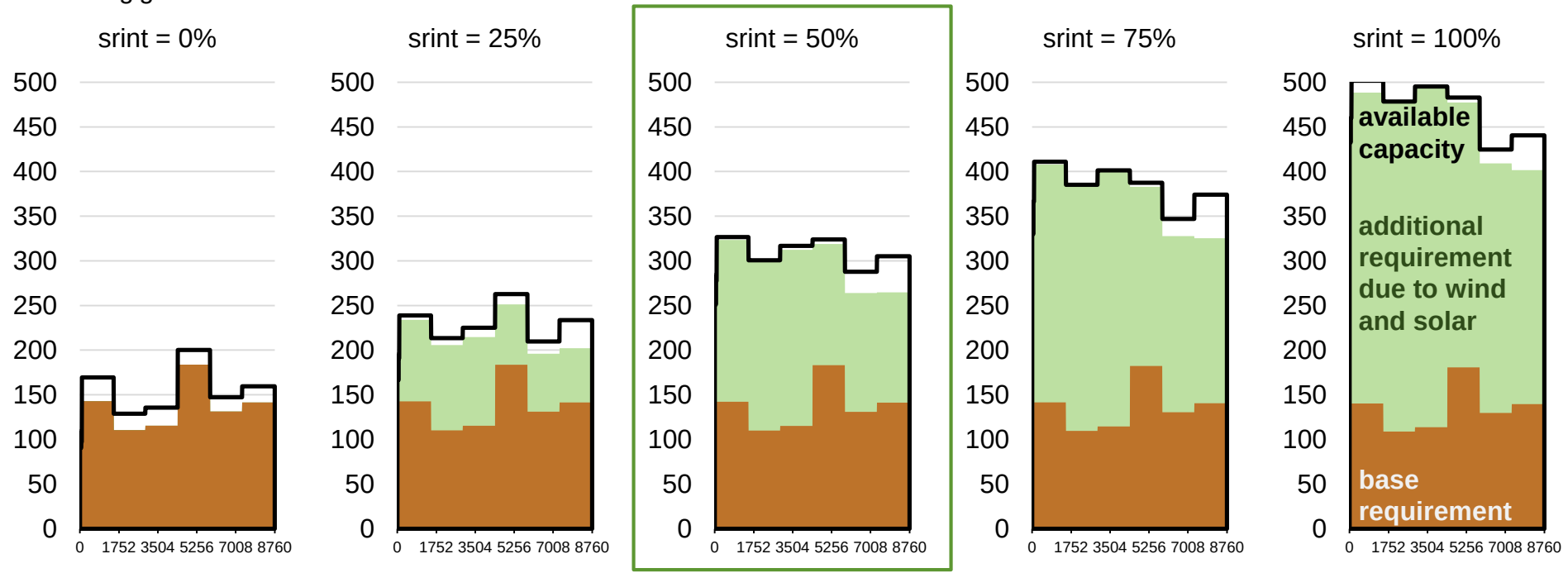
Renewable Updates: Likely to get Done

- **Spinning reserves requirement**
  - Spinning reserves are the available reserve capacity that is ready to meet load quickly in order to maintain grid stability during unforeseen load swings
  - A portion of non-dispatchable renewable generation (solar and wind) add to the amount of spinning reserves required, EIA is investigating what this value should be; it is currently set at 50%
- **Short-term elasticity bound**
  - NEMS places short-term capacity expansion limit when capacity increases too rapidly in a given year, to reflect supply shortages. The current limit is 10 years (moving). However, this may get revised to use heavier weighting for years immediately following the rapid capacity build year and tapers off toward 10th year.
- **Renewable energy conversion from KWh to BTUs**
  - In order to compare energy production across sectors, EIA converts kWh to BTUs; for conventional fuels this is done through the use of their heat rates, but noncombustible renewable technologies do not have heat rates
  - Currently, EIA just uses a single, static value to reflect the fossil-fuel equivalent heat rate for renewables; however as the fleet shifts to more natural gas CCs, the conversion value should change

In high renewable scenarios, the renewable fraction for the spinning reserves requirement becomes increasingly binding

Spinning reserve requirements by load slice, high renewable scenario (2050)

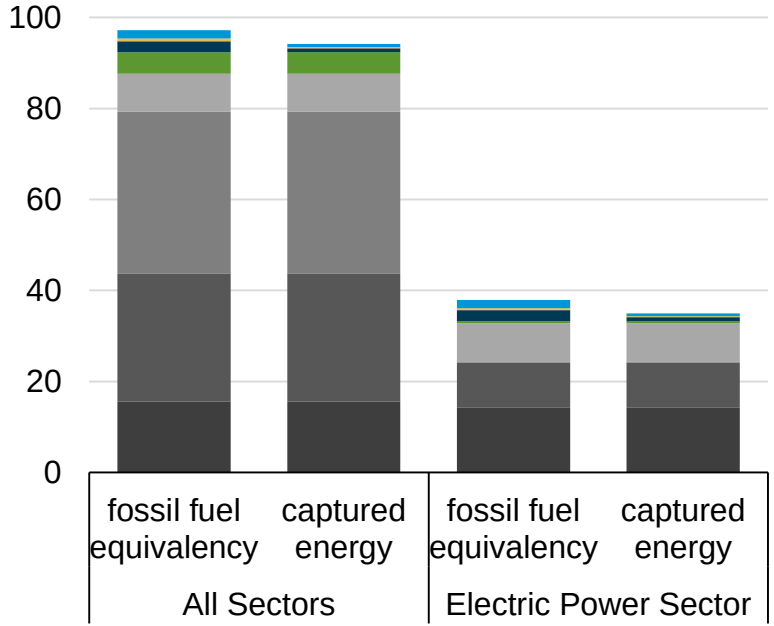
gigawatts



The captured energy approach reduces the apparent renewable consumption as compared to the fossil fuel equivalency approach

energy consumption by source, 2015

quadrillion British thermal units (Quads)



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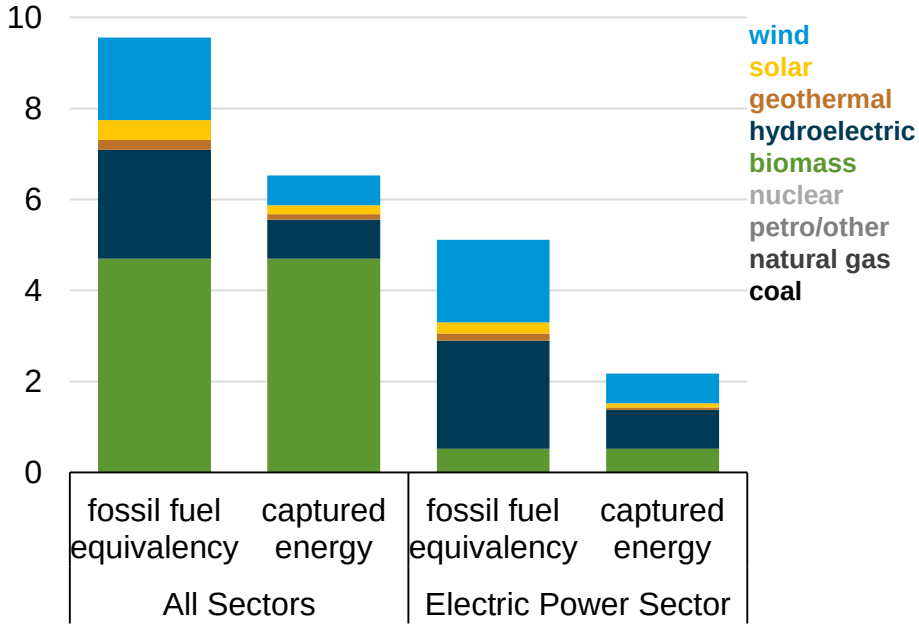
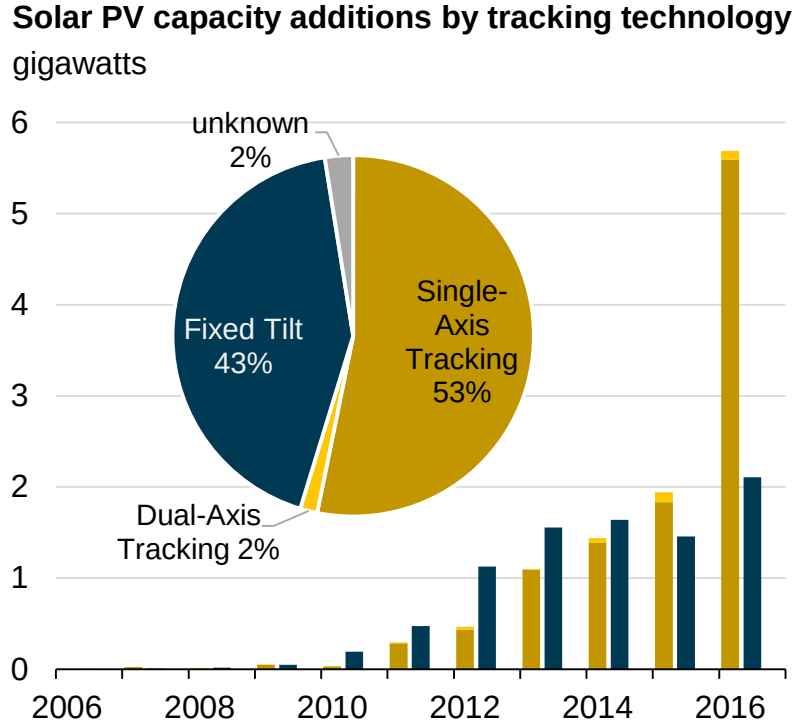


Renewable Updates: Possible Projects

- **Solar/Wind technology options**
  - EIA added fixed-tilt as a 2nd technology last year, however we saw limited deployment in the model; since then, we conducted an analysis that looked at different pricing/performance metrics for the fixed tilt; we're considering assumption updates
  - Option to also integrate a second technology for onshore wind; however research is limited
- **Solar thermal technology profiles**
  - EIA models a solar thermal power tower w/o storage, option to update to a power tower with molten salt energy storage
- **Retail price structure impacts of distributed PV**
  - Reconsider representation of electric power price with increasing deployment of distributed generation to adequately address the ability to recover system costs
- **LFG simplified, trend model**
  - Replace outdated LFG model with model that accounts for new capacity additions based primarily on factors exogenous to electricity markets
- **Biomass resources**
  - Update biomass feedstock data to reflect the most recent DOE's *Billion-Ton Report*

Tested the flexibility of NEMS to evaluated the economic tradeoffs between fixed-tilt and single axis tracking systems

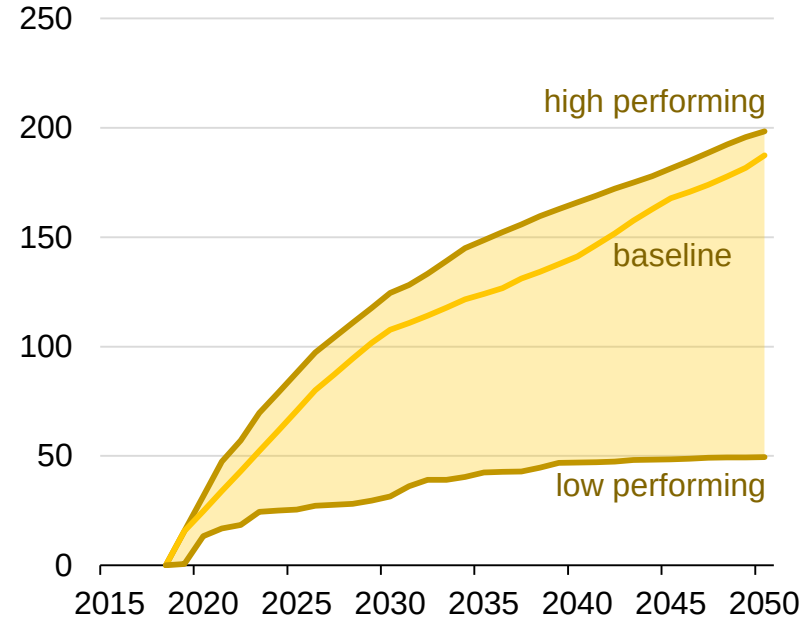
- Ran scenarios investigating fixed-tilt system deployment in NEMS, testing included:
  - Ranges in costs
    - Baseline
    - 10% reduction
    - 25% reduction
    - 50% reduction
  - Range in performance
    - +3% capacity factor
    - Baseline capacity factor
    - -3% capacity factor
  - Range in orientation
    - South-facing
    - West-facing



Fixed-tilt solar is primarily built out in the lowest cost scenarios; in these instances, west-facing projects were more competitive

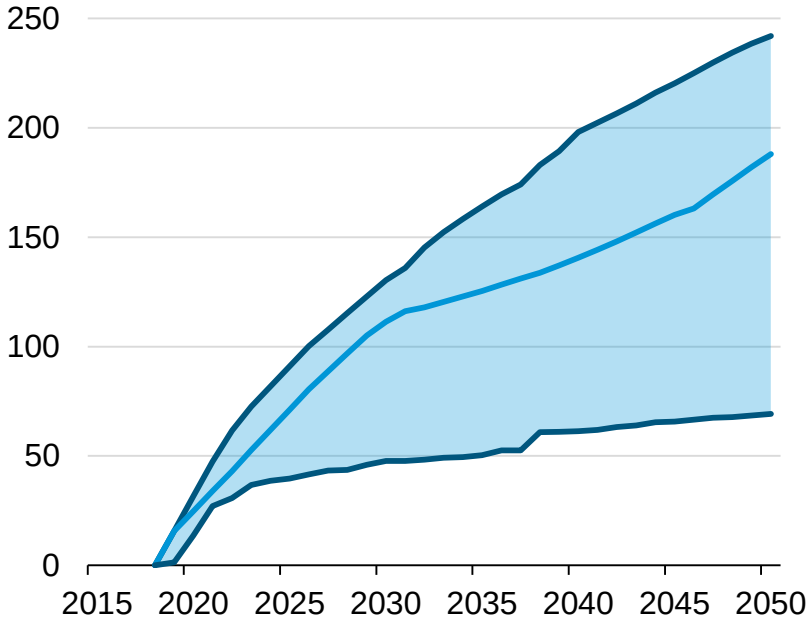
South-facing fixed-tilt cumulative unplanned additions

gigawatts



West-facing fixed-tilt cumulative unplanned additions

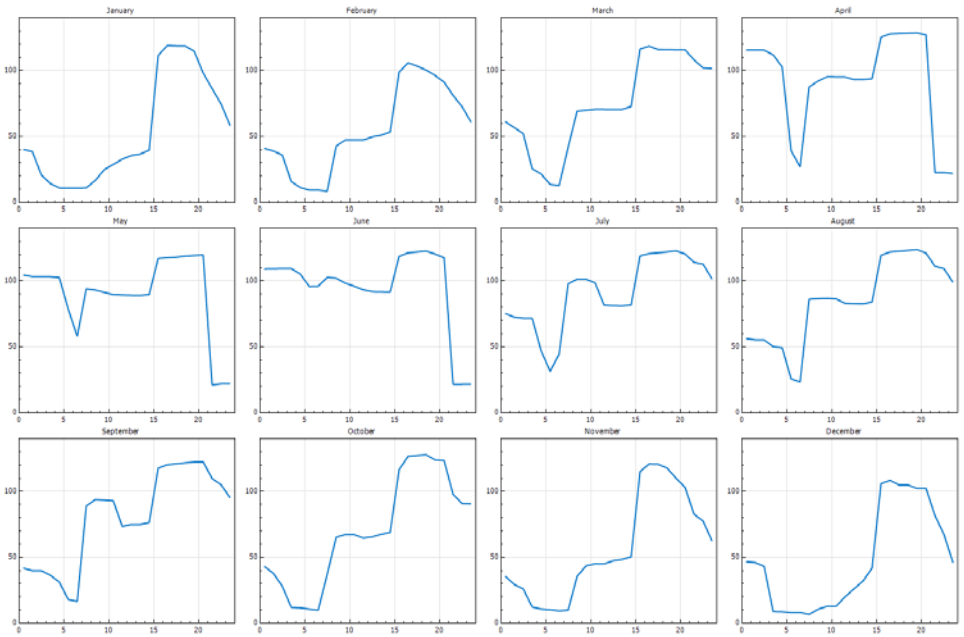
gigawatts



Solar thermal with energy storage updates were delayed from last year, this year we plan on using a new model to evaluate profiles

- Currently, EIA models solar thermal as a central-receiver tower without integrated energy storage.
- EIA is changing the existing technology to a power tower with molten salt energy storage.
  - We used System Advisory Model (SAM) dispatch optimization method to develop static, regional, hourly-generation profiles, but they look weird
  - Plan on using the new mini-dispatch model to update CSP profiles

Example CSP power tower with storage generation profiles



Renewable Updates: Long Term Projects

- **Solar/Wind resource supply curves**
  - EIA is moving towards a new regional structure; part of this effort includes enhancements to the renewable resources
- **Retirement/repowering decisions for wind (and other renewables)**
  - EIA is investigating decision process in retirement/repowering decisions for wind (and other renewables) to better model projections of new installed capacity
- **Capacity factor learning for wind technologies**
  - Capacity factors by vintage for wind technologies are being reinvestigated to attempt to derive a capacity factor learning curve

Electricity Updates: Capital Cost Assumptions

- **Updated for AEO2018:**
  - Battery storage, hydro (non-powered dams), fixed-tilt PV
- **Updated for AEO2017:**
  - Coal with 90% CCS
- **Updated for AEO2016:**
  - Coal with 30% CCS, Combined Cycle, Combustion Turbine, Nuclear, PV (tracking), Onshore Wind
- **Updated prior to AEO2016:**
  - Gas CC w/CCS, Fuel Cells, Hydro (other), Biomass, Geothermal, MSW, Offshore Wind, CSP
- *Note: costs not updated in a particular cycle are adjusted to reflect learning from year-to-year capacity additions*

Upcoming Publications and Events

- **AEO2018 Issues in Focus**
  - Alternative renewable and electricity policy cases that build around three alternative scenarios: PTC/ITC Extension case, Early PTC/ITC Sunset set, and Solar PV Tariff case.
- **EPRI: 21st Energy and Climate Research Seminar, Wednesday, May 17**
  - Washington Marriott Georgetown, 1221 22nd St NW, Washington, D.C.
  - Cara Marcy will be speaking about AEO2018 energy storage results in the afternoon session:
    Policy and Market Trends for Energy Storage and Renewables
- **DC Transmission Study to be released shortly**
  - *Assessment of the Potential for High-Voltage Direct Current Transmission to Mitigate Impacts of Non-Dispatchable Generation Technologies*
- **EIA Annual Conference 2018, June 4-5**
  - Washington Hilton, 1919 Connecticut Ave., NW, Washington, DC, 20009
  - The renewables team will be hosting a breakout session on June 5th:
    Current Market and Future Outlook for Energy Storage

Contact Information

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The REStore sub-model objective function dispatches generating capacity in order to meet hourly load while minimizing cost

minimize the total costs of the system = cost of operating energy storage + cost of operating generating technologies

$$Min\ TC = \sum_{h} \omega_h \left[\sum_{T_S} \frac{C_h^{T_S}}{2} \left(S_{T_S,h}^{in} + S_{T_S,h}^{out} \right) + \sum_{T} \left(C_h^{T} G_{T,h} + R_T^{+} G_{T,h}^{+} + R_T^{-} G_{T,h}^{-} \right) \right]$$

ω_h ≡ Day weight of day containing hour h

C_h^T ≡ Variable generation cost of tech T in hour h in $/MWh

$S_{T_S,h}^{in/out}$ ≡ Storage inflow/outflow in hour h in MW

$G_{T,h}$ ≡ Operated capacity use of technology group T in hour h

$R_T^{+/-}$ ≡ Load change cost for tech T in hour h in $/MW

Completed testing of different fixed-tilt panel configurations and included test cases for lower/higher capacity factors and costs