EIA’s Annual Energy Outlook 2021: Projections for Battery Storage in the United States

For
2021 EIA Energy Storage Workshop
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By
Vikram Linga, Renewable Energy Analyst
Overview

• Annual Energy Outlook (AEO) and NEMS Intro

• AEO2021 Battery Storage Costs and Assumptions

• AEO2021 Battery Storage Results

• Conclusions
Annual Energy Outlook (AEO) Overview

• Produces annual projections to 2050:
  – Energy consumption by sector, fuel type, region
  – Production by fuel
  – Energy imports/exports
  – Energy prices
  – Technology trends
  – Carbon dioxide emissions; environmental policy indicators
  – Macroeconomic measures and energy market drivers

• National Energy Modeling System (NEMS):
Regional energy-economy model of the United States
NEMS Modular Structure

- A key aspect of the NEMS is its coverage of all sectors of the energy economy.
- Where appropriate and significant information exists, each sector is represented by a detailed structural model of the market.
AEO 2021 Battery Storage Capacity by Case

9 standard annual cases:

- **Reference**
  - baseline w/ only current policy, not proposed

- **Low/High Renewables Cost**
  - low: 2050 renewables cost is 40% of Reference
  - high: no renewables cost decline in projection
  - battery storage included as “renewable”

- **Low/High Oil and Gas Supply**
  - Varying production costs and resource availability for oil and natural gas

- **Low/High Economic Growth**
  - GDP growth = 1.6 – 2.6%

- **Low/High Oil Price**
  - 2050 Oil price = $48/b – $173/b

Primary assumptions for Battery Storage in AEO2021

• Two technology options
  – Standalone battery energy storage system
    • 4 hours to charge and discharge
    • Round trip efficiency (discharge / charge) = 0.85
  – PV plus battery hybrid
    • 150 MW PV installed for every 50 MW of 4 hour battery
    • Inverter limited to PV capacity (150 MW inverter for 150 MW PV + 50 MW battery)
    • Hybrid battery only charges from hybrid PV, not from power grid

• Two applications
  – Arbitrage: shift energy from high supply/low demand hours to low supply/high demand hours
  – Reserve Margin: provide capacity to meet regional reserve requirements
### Primary assumptions for Battery Storage in AEO2021

<table>
<thead>
<tr>
<th></th>
<th>$/kW</th>
<th>$/kWh</th>
<th>Power Capacity (MW)</th>
<th>Duration (Hours)</th>
</tr>
</thead>
<tbody>
<tr>
<td>AEO 2021 (Sargent &amp; Lundy 2019)</td>
<td></td>
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</tr>
<tr>
<td>50 MW x 4 hour</td>
<td>1391</td>
<td>348</td>
<td>50</td>
<td>4</td>
</tr>
<tr>
<td>PV-Hybrid (PV 150 MW, Battery 50 MW)</td>
<td>1783</td>
<td>-</td>
<td>150*</td>
<td>4</td>
</tr>
<tr>
<td>2019 Form EIA-860</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>&gt;2 hour (n=45)</td>
<td>2575</td>
<td>575</td>
<td>4.7</td>
<td>4.6</td>
</tr>
</tbody>
</table>

* The inverter capacity for the PV plus Battery hybrid technology in NEMS is set to the PV capacity

Source: U.S. Energy Information Administration, [Annual Energy Outlook 2021](https://www.eia.gov/outlooks/aeo/

U.S. electricity generation and share from selected fuels and renewable sources

U.S. electricity generation from selected fuels
AEO2021 Reference case
billion kilowatthours

- Natural gas: 36%
- Renewables: 40%
- Nuclear: 21%
- Coal: 19%
- Other: 11%

U.S. renewable electricity generation, including end use
AEO2021 Reference case
billion kilowatthours

- Solar: 47%
- Wind: 16%
- Geothermal: 41%
- Hydroelectric: 2%
- Other: 34%

Source: U.S. Energy Information Administration, Annual Energy Outlook 2021
Battery storage deployment depends on regional characteristics

- Strong correlation with PV builds
- Outside of Texas and California, strong growth in Southeast MISO and SERC regions
- West region has strong wind and natural gas growth

Source: U.S. Energy Information Administration, Annual Energy Outlook 2021
Projected installation costs for solar PV and battery storage

Overnight installation cost, selected AEO2021 side cases

Reference case
2020 dollars per kilowatt

<table>
<thead>
<tr>
<th>Year</th>
<th>Solar Hybrid</th>
<th>Solar PV</th>
<th>Battery Storage (SA)</th>
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<tr>
<td>2020</td>
<td>$1,800</td>
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<td>$1,600</td>
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<td>$1,200</td>
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Low Renewables Cost case
2020 dollars per kilowatt

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Low Oil and Gas Supply case
2020 dollars per kilowatt

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Note: Series begin in 2021
Standalone vs. PV hybrid battery storage deployment

- **Reference case:** nearly all future builds from PV plus storage hybrid
  - Investment tax credit only applied to battery storage when paired with PV

- **Low Oil and Gas Supply Case:** standalone battery systems built to replace reserve gas units
  - More competitive in the capacity market

Standalone vs. PV hybrid battery storage deployment

- Low renewables costs drive hybrid builds, high gas prices drive standalone builds
- Strong growth for southeast region mostly standalone
- Strong growth in Texas mostly standalone

Source: U.S. Energy Information Administration, Annual Energy Outlook 2021
Use of batteries varies by season and region, but is generally shifting solar production to the evening hours

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Reference Case</th>
<th>2022 Hourly Generation by Month, California (GWh)</th>
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<tbody>
<tr>
<td>Jan</td>
<td>0.20</td>
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<tr>
<td>Feb</td>
<td>0.15</td>
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<tr>
<td>Mar</td>
<td>0.10</td>
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<tr>
<td>Apr</td>
<td>0.05</td>
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<tr>
<td>May</td>
<td>0.00</td>
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<td>Nov</td>
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- curtailment storage
- pumped storage solar
- solar hybrid wind
- oil and gas peakers gas combined-cycle
- hydroelectric nuclear coal
- coal
Use of batteries varies by season and region, but is generally shifting solar production to the evening hours.
Conclusions

• In all scenarios of EIA’s Annual Energy Outlook 2021, we project that utility scale battery storage capacity in the United States will grow dramatically from today’s levels over the next 30 years.

• California and Texas look to continue their ongoing investments into energy storage. In some scenarios, parts of the MISO & SERC regions could have relatively favorable environments for deployment of battery storage as well.

• Lowering technology costs results in increased deployment of battery storage across the USA, while increasing gas prices results in more focused deployment in certain regions via standalone systems.

• Opportunities to improve NEMS modeling.
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For more information

U.S. Battery Storage Market Trends | www.eia.gov/analysis/studies/electricity/batterystorage/

Electric Power Monthly | www.eia.gov/electricity/monthly/

Electric Monthly Update | www.eia.gov/electricity/monthly/update/

EIA-860 Data Files | www.eia.gov/electricity/data/eia860/

EIA-860M Data Files | www.eia.gov/electricity/data/eia860m/

Today in Energy | www.eia.gov/todayinenergy

Annual Energy Outlook | www.eia.gov/outlooks/aeo/
Questions?
Supplemental slides
Potential model development to improve AEO’s representation of energy storage

• What is worth modeling in detail, when are simplifications justified?
  – Adding some features to the model may have a negative impact on run time and EIA resources without having an impact on run results. Other features could improve the model
    • 9 vs 864 vs 8760 model time slices/year
    • Currently 25 regions, are more needed? (transmission constraints)
    • Hybrid battery storage
      – Dynamic dispatch
      – Should generators other than PV be able to pair with batteries? (wind, fossil, etc)
      – Should hybrid batteries be able to charge from the grid in the model?
      – Different options for how to size the inverter?
      – Capture value of ancillary services such as spinning reserves
      – Intraday or seasonal storage needed to model strict carbon scenarios
Crude oil price assumptions and natural gas price projections

North Sea Brent crude oil price
AEO2021 side cases
2020 dollars per barrel

2010 2020 2030 2040 2050
$0 $20 $40 $60 $80 $100 $120 $140 $160 $180 $200
2020 history | projections
High Oil Price
Low Oil and Gas Supply
Reference
High Oil and Gas Supply
Low Oil Price

Natural gas price at Henry Hub
AEO2021 side cases
2020 dollars per million British thermal units

2010 2020 2030 2040 2050
$0 $1 $2 $3 $4 $5 $6 $7
2020 history | projections
Low Oil and Gas Supply
High Oil Price
Reference
Low Oil Price
High Oil and Gas Supply
Gross domestic product and population growth assumptions

U.S. gross domestic product assumptions  
AEO2021 economic growth cases  
trillion 2012 dollars

U.S. population assumptions  
AEO2021 economic growth cases  
millions

2010 2020 2030 2040 2050

2020

history  projections

High Economic Growth
Reference

Low Economic Growth

2010 2020 2030 2040 2050

2020

history  projections

High Economic Growth
Reference

Low Economic Growth

$0 $5 $10 $15 $20 $25 $30 $35 $40 $45

$0 100 200 300 400 500

$0 $100 $200 $300

2021 EIA Energy Storage Workshop  
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Delivered energy across end-use sectors
AEO2021 economic growth cases
quadrillion British thermal units

Indexed delivered energy across end-use sectors
AEO2021 economic growth cases
2019 = 1.0