Exploring the Implications of Electricity Storage on Natural Gas Consumption Using NEMS-REStorePlus

Prepared for the American Petroleum Institute

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Objective

Analyze The Impact Of Grid Storage On Natural Gas Markets

(Volumes And Prices)

- Alternative Resource Base**
  - Baseline
  - Low Resource
- Alternative Grid Storage Costs***
  - Baseline
  - Low Cost

Scenarios*

	Resource Levels	
Cost Levels	OnLocation Baseline (***Adjusted*** EIA High Resource Case)	Low Resource Levels (***Adjusted*** EIA 2018 Low Resource Case)
Baseline Costs (Reference Costs from Lazard 2017)	Base Cost	Low Resource - Base Cost LR - Base
Lower Costs (Interpolated from Lazard 2017)	Low Cost	Low Resource - Low Cost LR - Low Cost

** Base Cost, Low Cost, LR-Base and LR-Low Cost are used on the following figures to denote the scenarios.*

** *OnLocation adjusted the EIA High and Low Resource cases of 2018 to create the resource/gas price scenarios used in this study.*

**** see notes on slide 33 for additional information on sources used*

Approach

- Using NEMS-REStorePlus (modified version of EIA's 2018 NEMS model), analyze a set of scenarios targeting levels of costs for Grid Storage and levels of resource availability impacting natural gas production and prices
  - ReStorePlus model is a add-on to the NEMS model that allows a more detailed hourly dispatch to allow for the arbitrage loading and discharging of the Grid Storage

Highlights

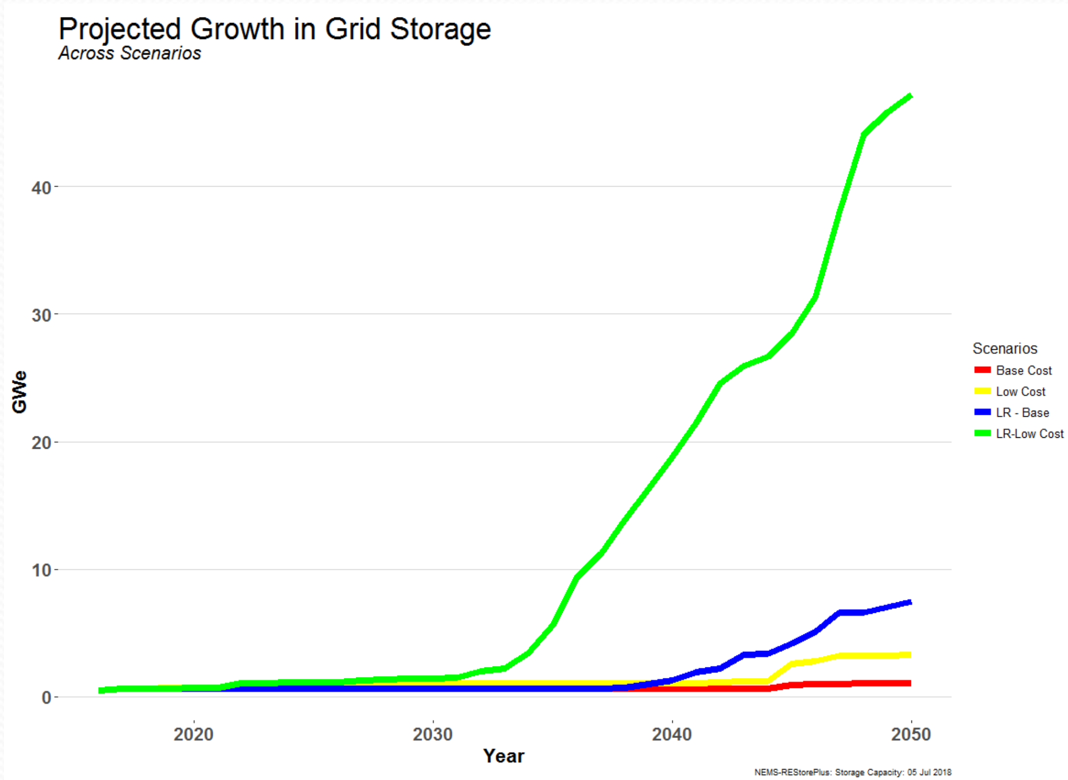
1. Both gas prices and battery costs drive the rate of adoption of storage with 47 gigawatts built by 2050 in the low resource-low cost scenario, 7, 3 and 1 gigawatts in the low resource-baseline cost, high resource-low cost and high resource-baseline costs scenarios respectively, arbitrage limit suggests 150-200 gigawatts potential maximum market
2. Most of the storage builds occur in 4 regions: Southeast, MidSouth, Central and Southwest regions
3. Electricity prices, residential electricity and total energy expenditures not measurably impacted by storage penetration
4. Electricity sales and natural gas volumes are not measurable impacted by storage penetration
5. In the face of high natural gas prices
   - Solar PV is the winner
   - CC is the loser
   - CTs are mixed due to their role with storage backing up renewables (e.g., solar PV)
6. Solar PV gives up the most capacity, albeit relatively small amounts, *when competing against storage* with some turbine builds being marginally impacted

Caveats

- Assumes no limitation in Grid Storage build out due to manufacturing constraints
- Grid Storage costs continue to decline materially over the next 5-10 years
- Grid Storage is assumed to not pay the standard regional transmission hookup charge
- There is no policy or regulatory impediment to storage adoption
- Grid Storage is assumed to be able to cycle virtually everyday without degradation of battery life, capacity or efficiency
- Storage owners are assumed to receive capacity value in markets when capacity reserves are needed
- Only arbitrage and capacity reserve values are considered for storage; does not include possible operating reserve, other ancillary values or transmission deferments
- Storage owners are assumed optimize and able to capture full arbitrage value
- After 20 year lifetime, storage capacity reinvestment is assumed implicitly
- Financing costs for storage assumed to be the same as for other generation assets
- Analysis does not consider behind-the-meter storage

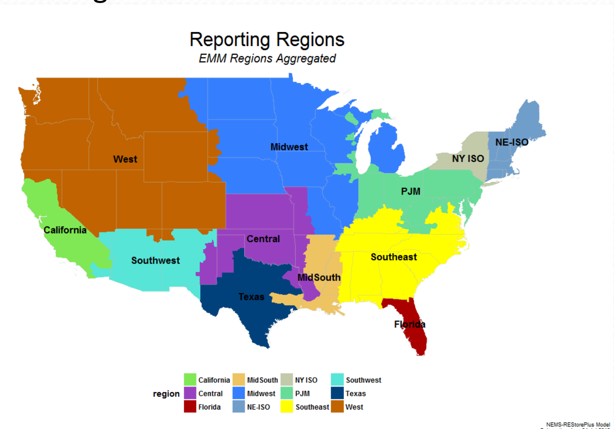
Highlight

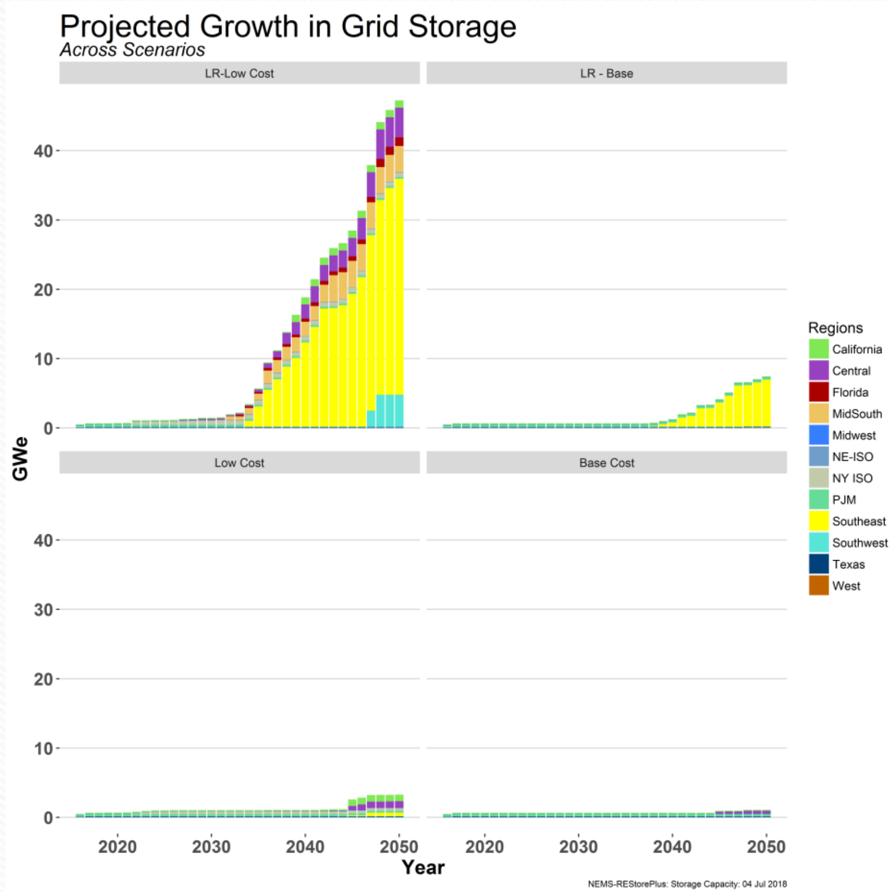
- Low Resource – High NG Prices
  - Model builds 47 gigawatts of storage by 2050 in the Low cost case (LR-Low Cost)
  - Model builds in 7.5 gigawatts by 2050 in the Base cost case (LR – Base)
- High Resource – Low NG Prices
  - Model builds 3.2 gigawatts of storage by 2050 in the Low cost case (Low Cost)
  - Model builds in 1.1 gigawatts by 2050 in the Base cost case (Base Cost)



Highlight

- Model builds 47 by 2050 in Low Resource - Low Costs Cases (LR-Low Cost)
  - Most of the builds are in the Southeast- 31 Gigawatts
  - The Central, MidSouth and Southwest regions build 4.2, 3.8, 4.6 gigawatts respectively
- Model builds in 7.5 gigawatts by 2050 in the Base cost case (LR – Base)
- The High Resource scenarios had little storage builds



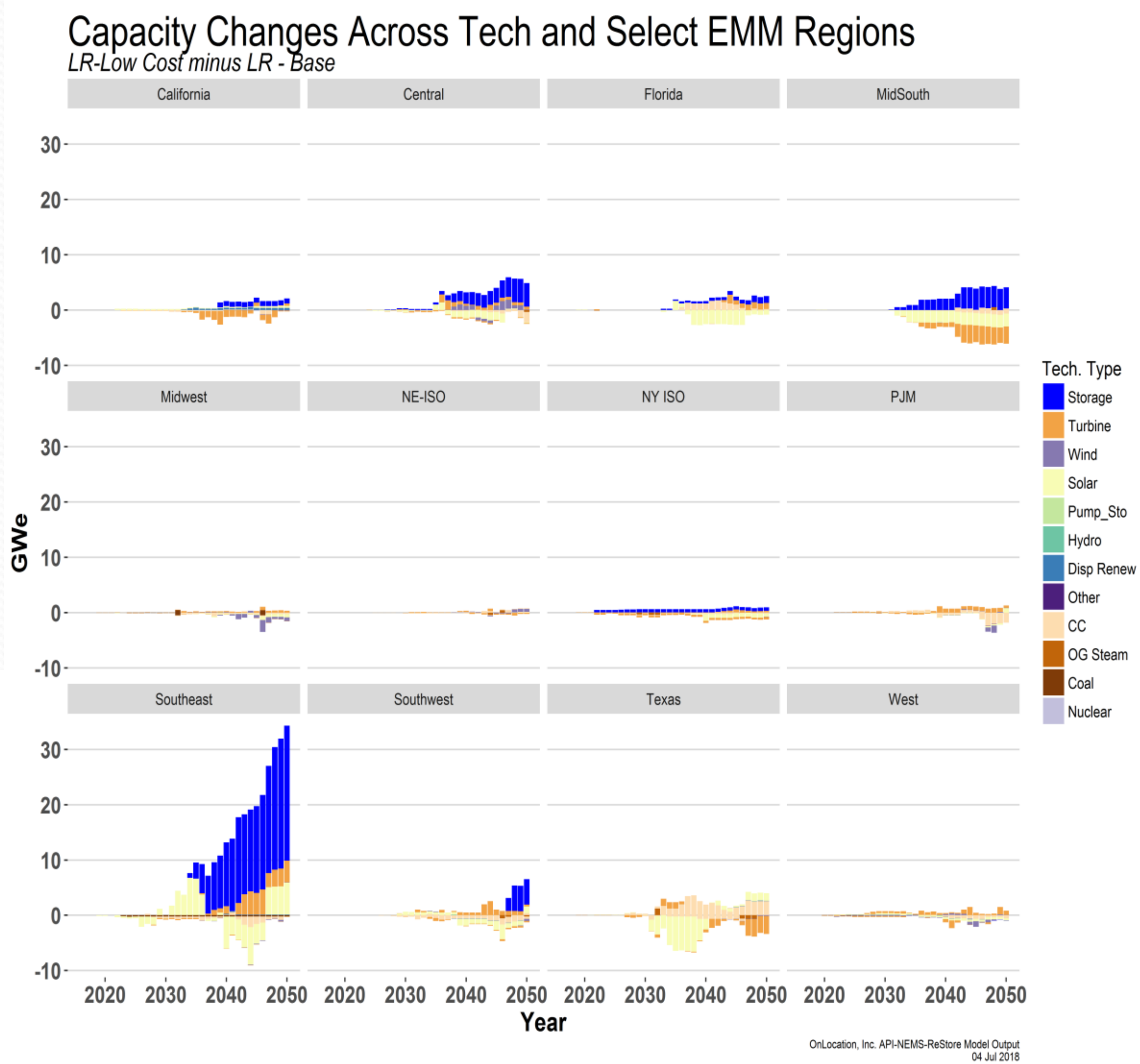


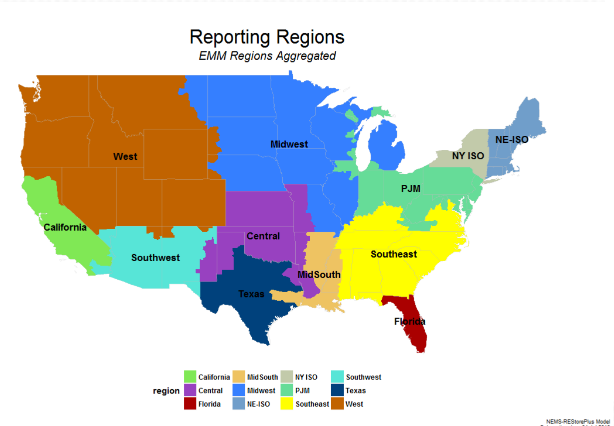
Highlight

Focusing on the Low Resource Scenario

The differences between the low cost and base cost scenarios are shown

- As pointed out on the previous slide, most of the action is in the Southeast, Central, MidSouth and Southwest regions
- Several regions experience some small movement but this is, in part, attributable to the model noise

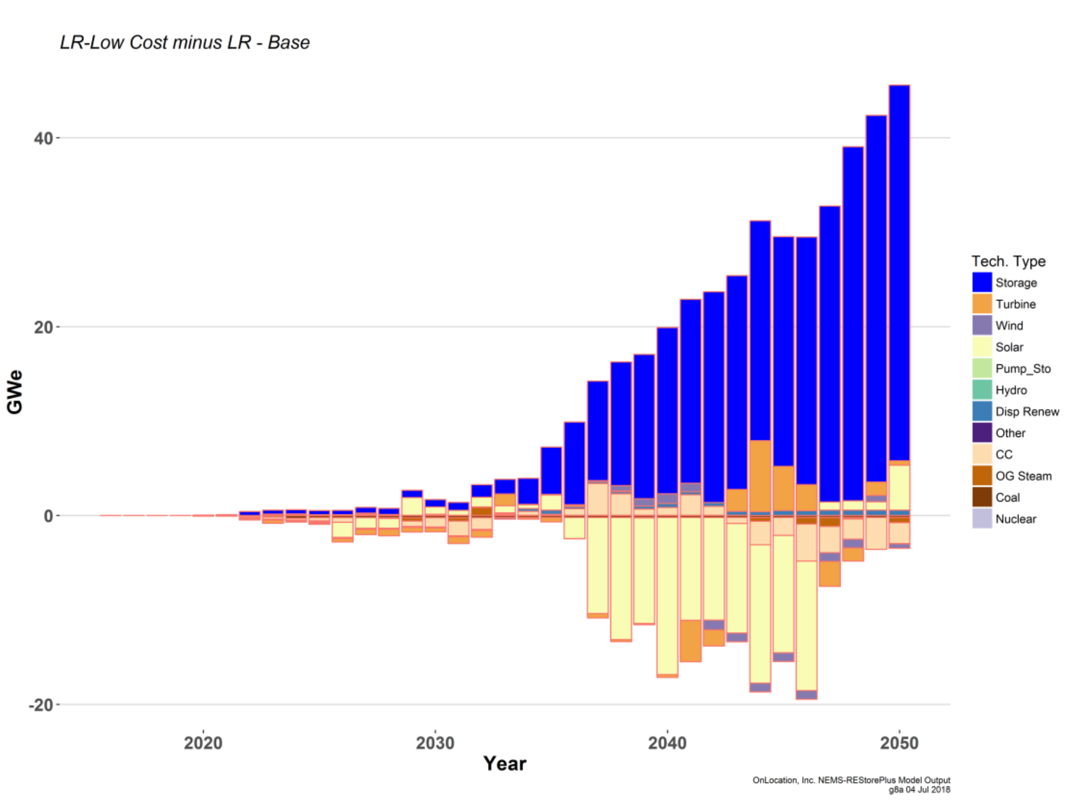




Highlight

Focusing on the Low Resource Scenario

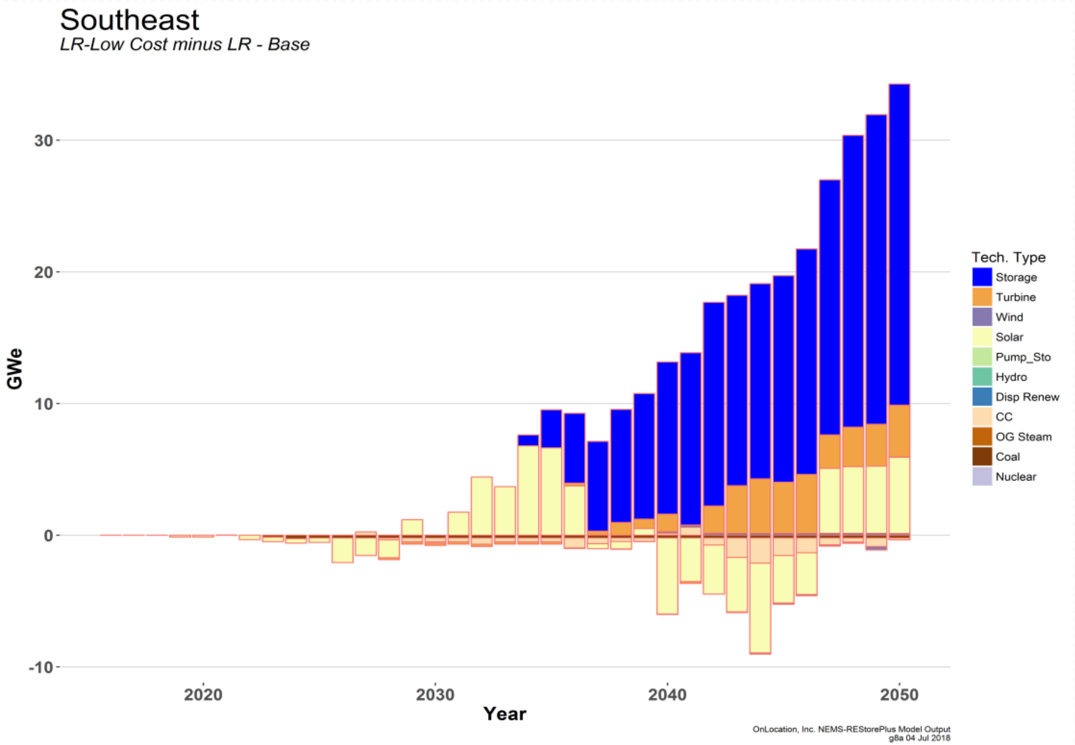
- When the cost of storage is reduced, the primary technology it displaces is solar PV, albeit by a small portion of the total solar PV penetration
- The next three slides provide a regional view of this displacement

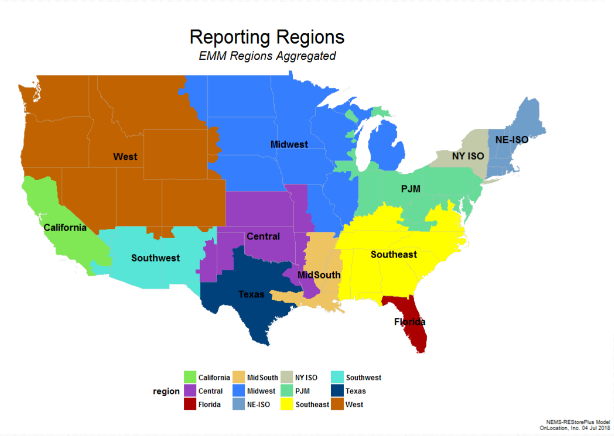


Highlight

Focusing on the Low Resource Scenario

- In the Southeast, the substitution of storage is a mixed bag switching back and forth across time.

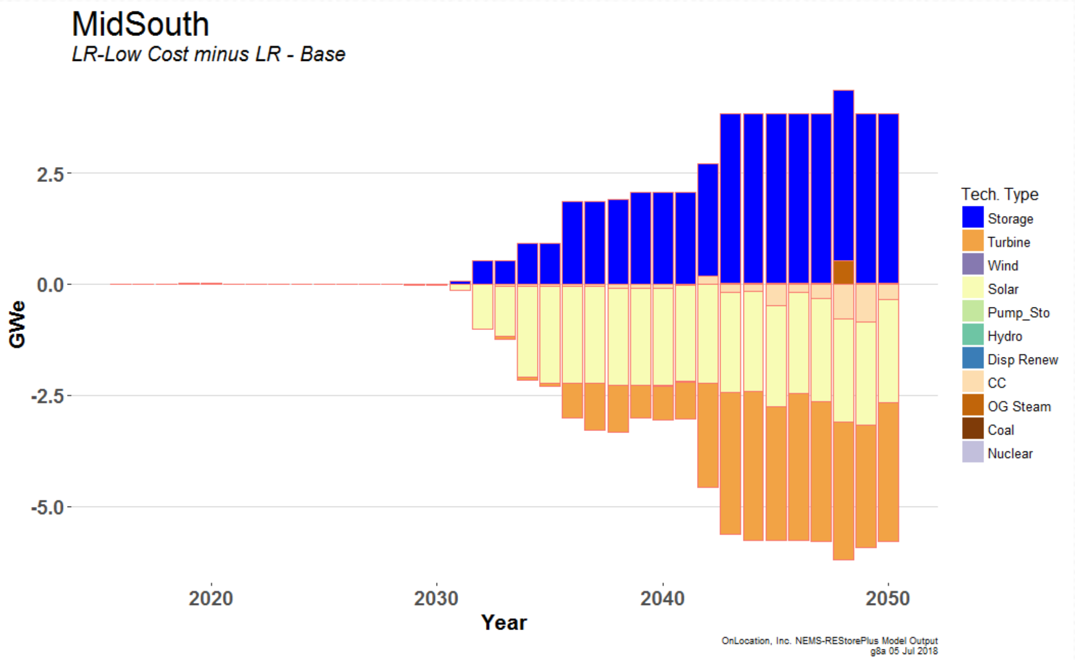


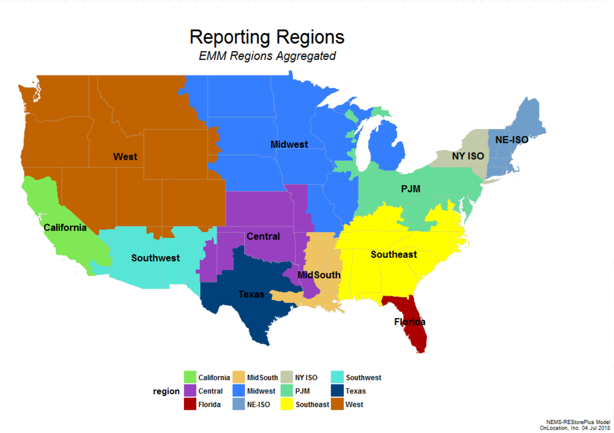


Highlight

Focusing on the Low Resource Scenario

- In the MidSouth, the picture is much more consistent across time with storage displacing both solar and Turbines.

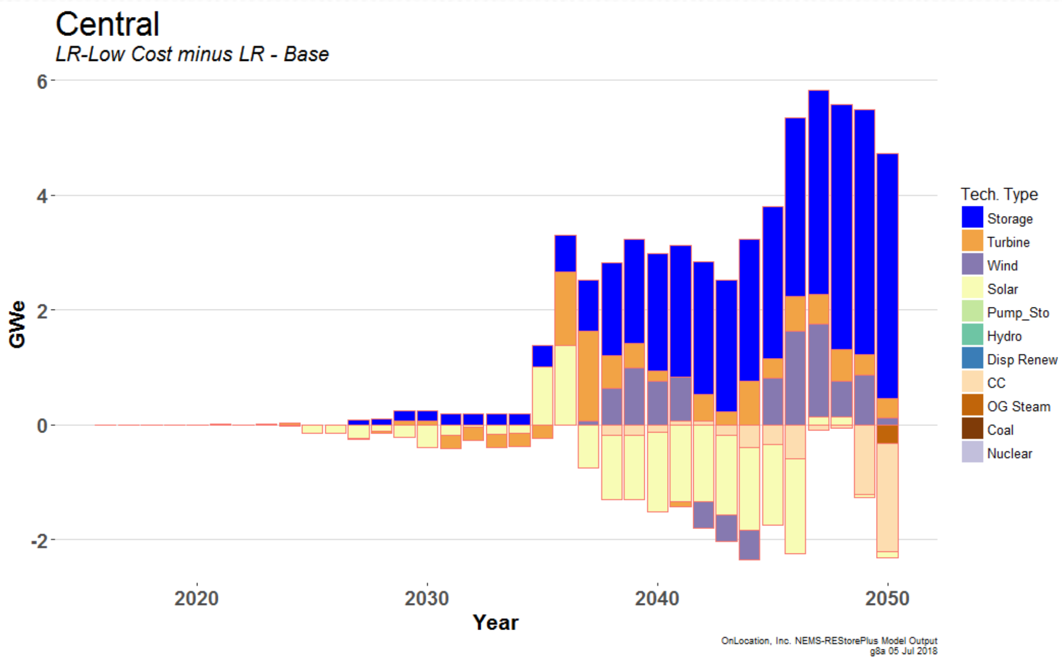


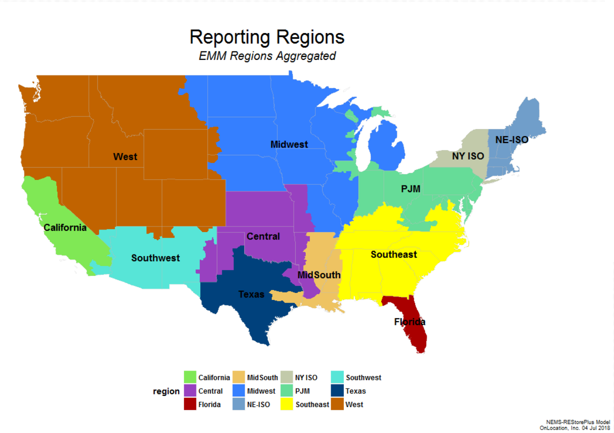


Highlight

Focusing on the Low Resource Scenario

- While solar is displaced by the penetration of storage technology, it appears that wind is given a small benefit
- Further, it appears that Turbines benefit a bit as well





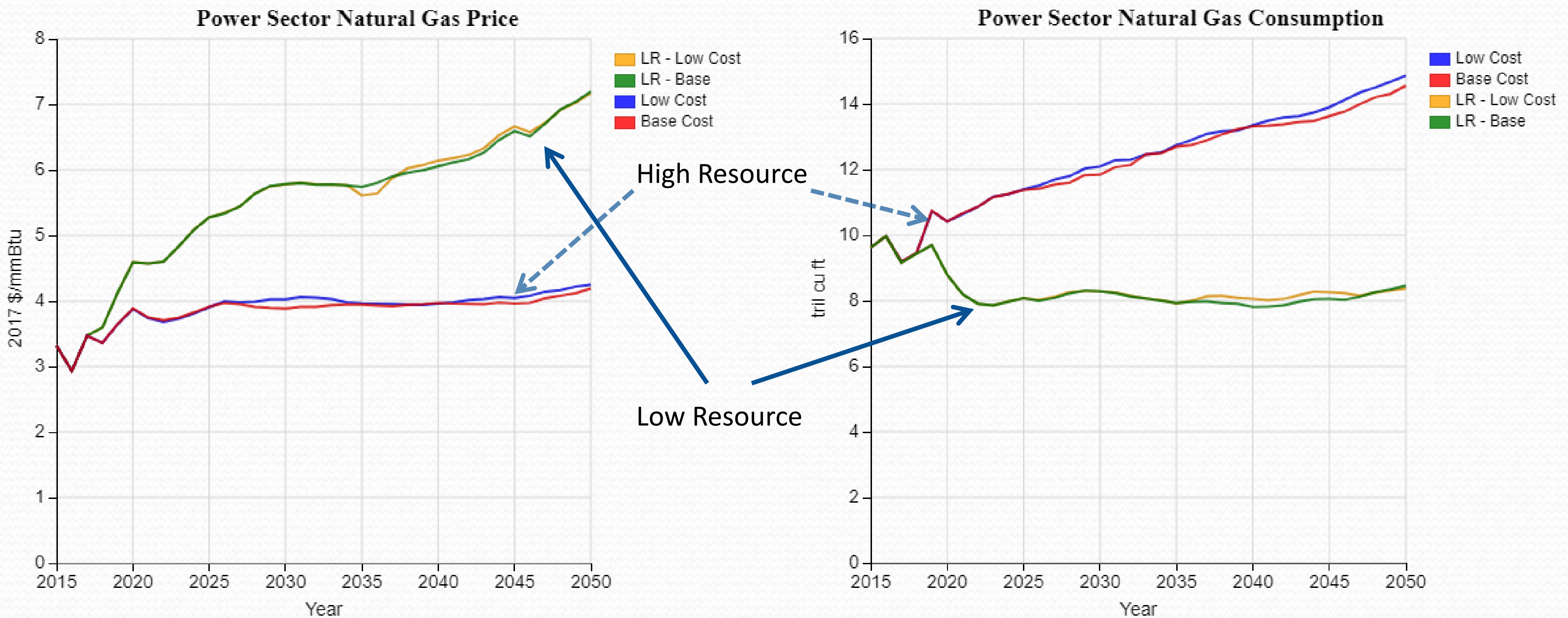
National Results

- Natural Gas Volumes and Prices
- Electricity Sales and Prices
- Electric Power Capacity Additions and Utilization
- Consumer Expenditures

Natural Gas Volumes and Prices

To Power Sector

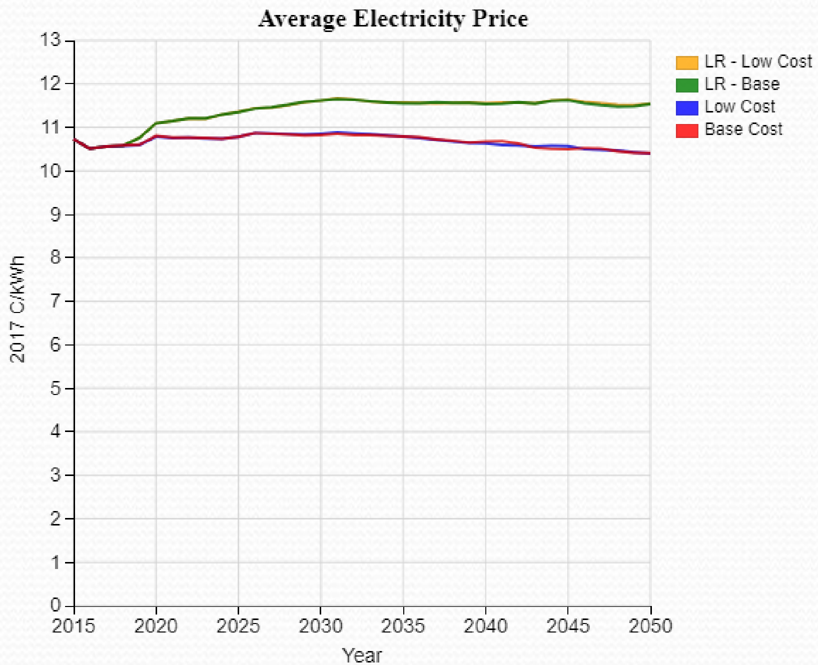
- **Natural gas prices are not materially impacted by storage penetration**
- **Low resource case drives up natural gas prices substantially**
- **Higher natural gas prices reduce materially gas consumption in the power sector**

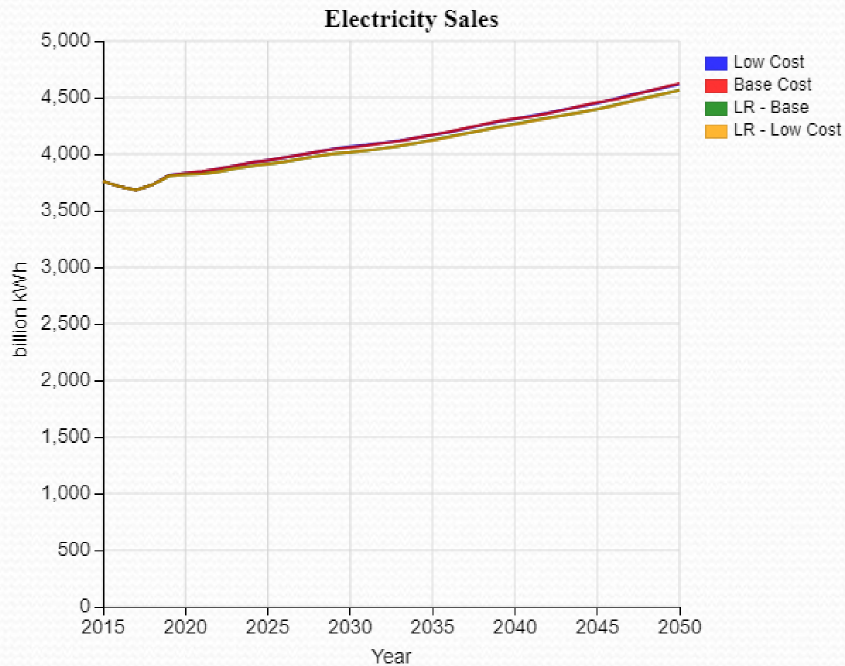


Electricity Sales and Prices

- **Electricity prices remain constant within Resource Scenarios**
- **Higher gas prices have a significant impact on electricity prices**

- **Electricity sales move only slightly in response to changing prices**

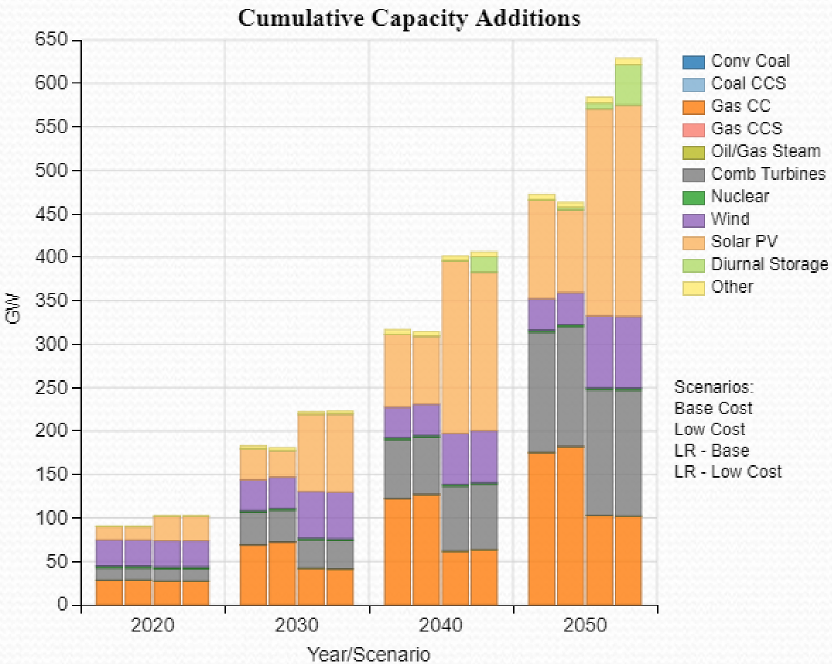




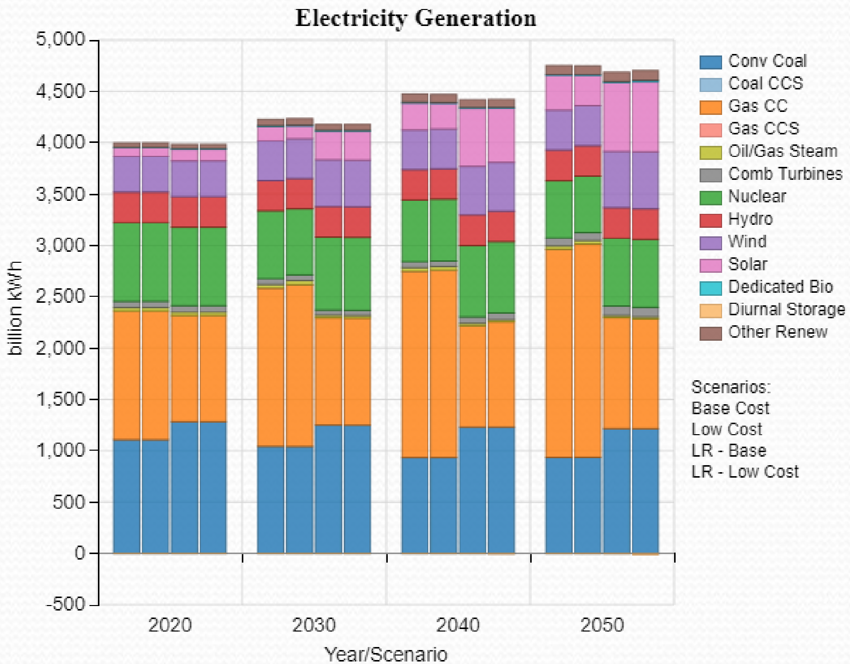
Electric Power

Additions and Utilization

Additions

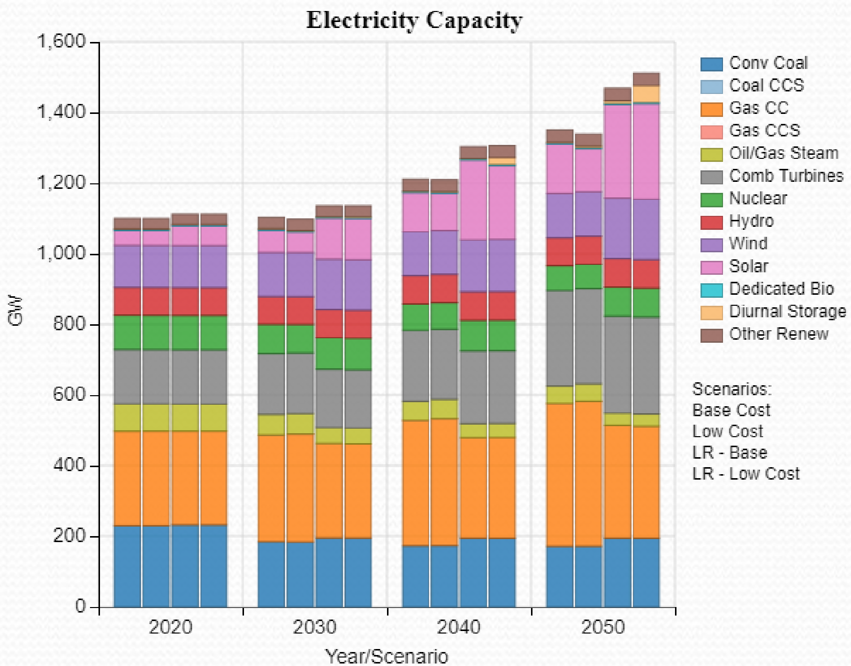


Generating Mix

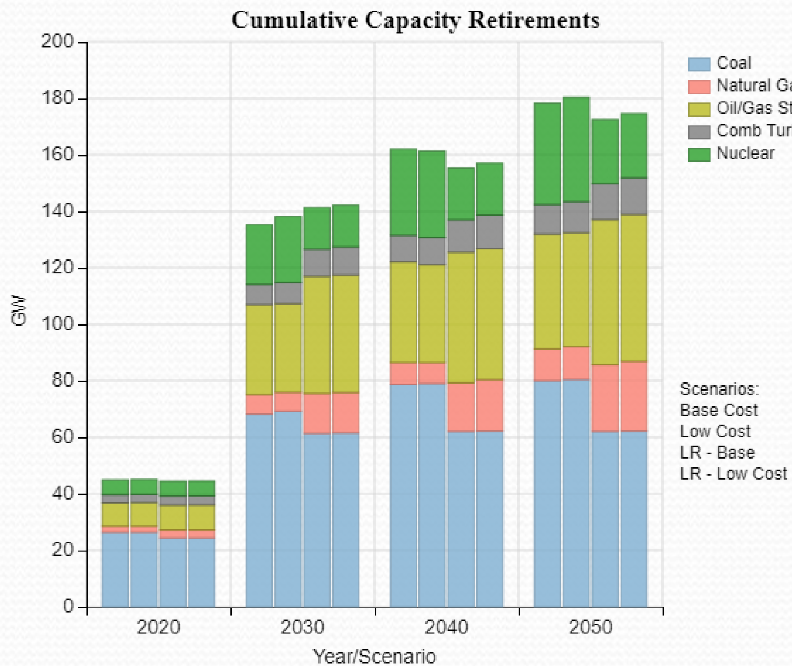


Capacity Total and Retirements

Capacity



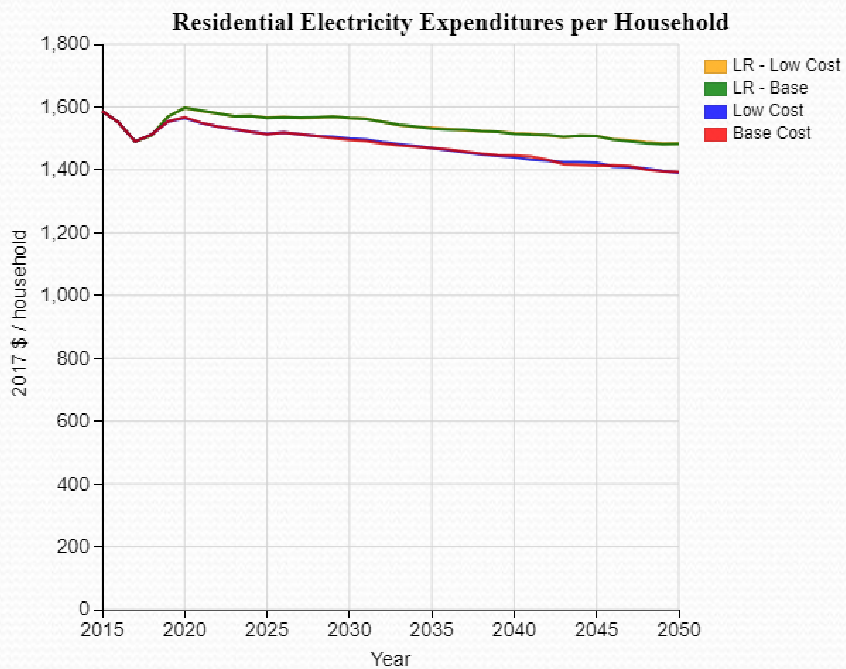
Retirements

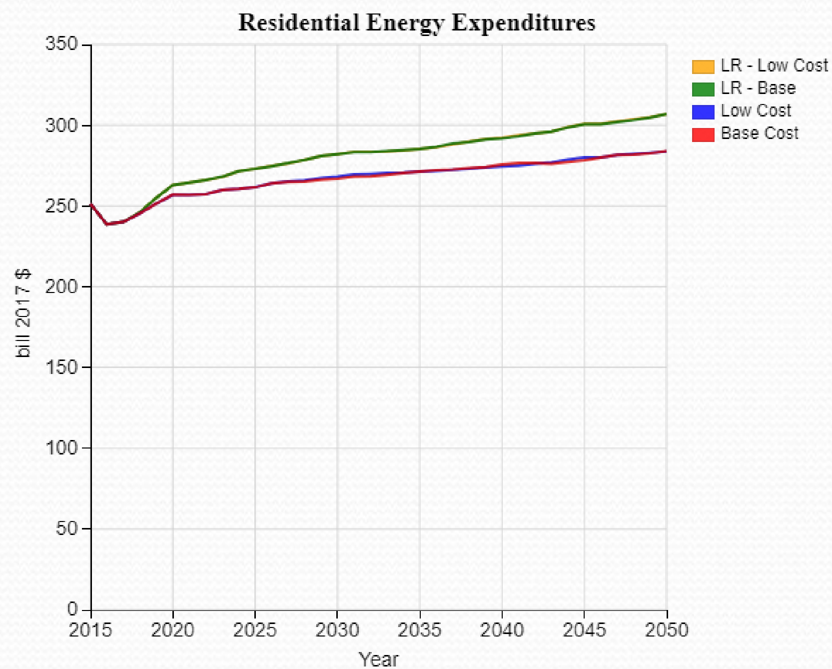


Consumer Prices

Electricity and Total Residential Use

Reductions in Energy Use Per Household Offset By Rising Household Formations





Select Regional Statistics

Power Technology Result

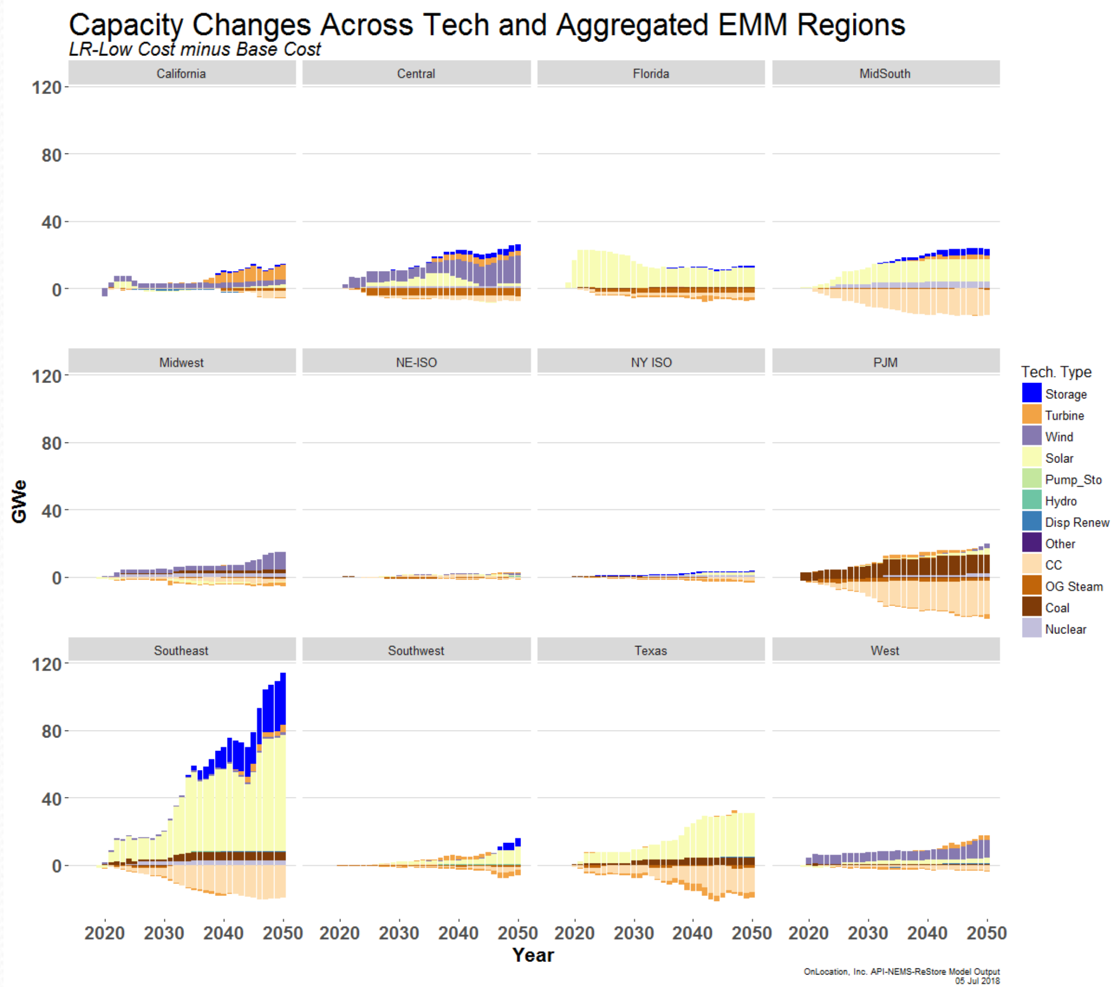
- Low Resource Cases Differences from Baseline

- Regional Capacity and Generation for 2035 and 2050

- Electric Power Capacity and Utilization
  - Storage and Gas Turbine
  - Renewable Solar PV and Wind
  - Combined Cycle Natural Gas and Coal

Impact of Higher Natural Gas Prices on Regional Builds

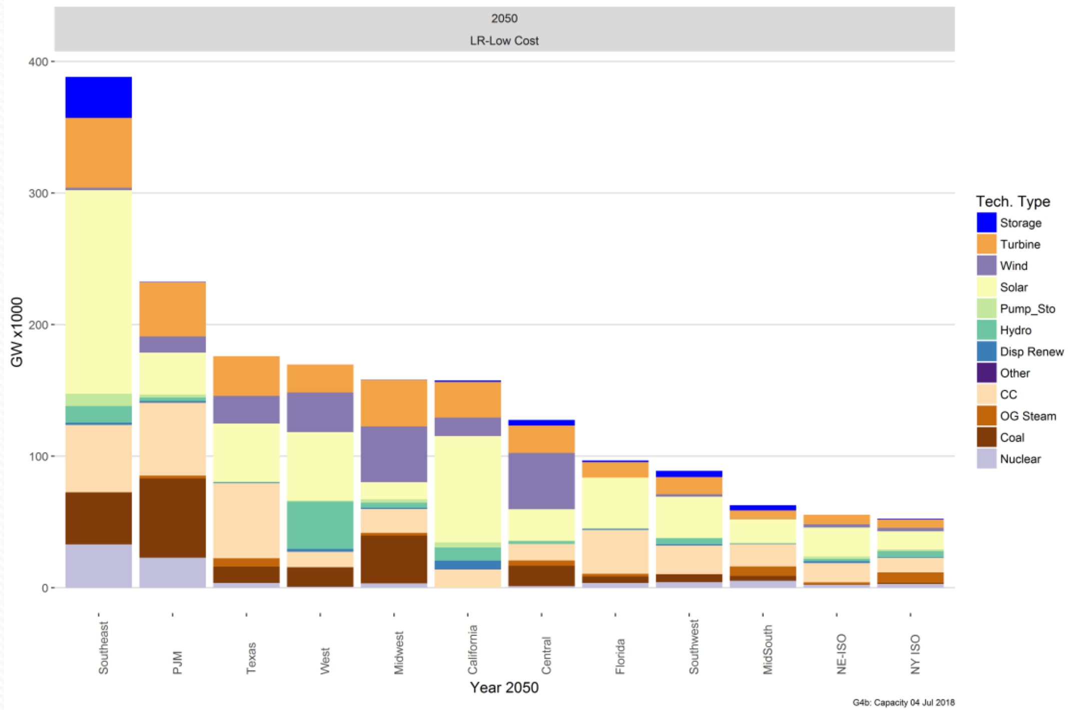
- Low Resource (High natural gas prices) have a significant impact on the regional builds
  - Solar PV is the winner
  - CC is the loser
  - CTs are mixed due to their role with storage backing up renewables (e.g., the solar)
- Also note that California is not impacted much due to their limited reliance on natural gas



Regional Capacity

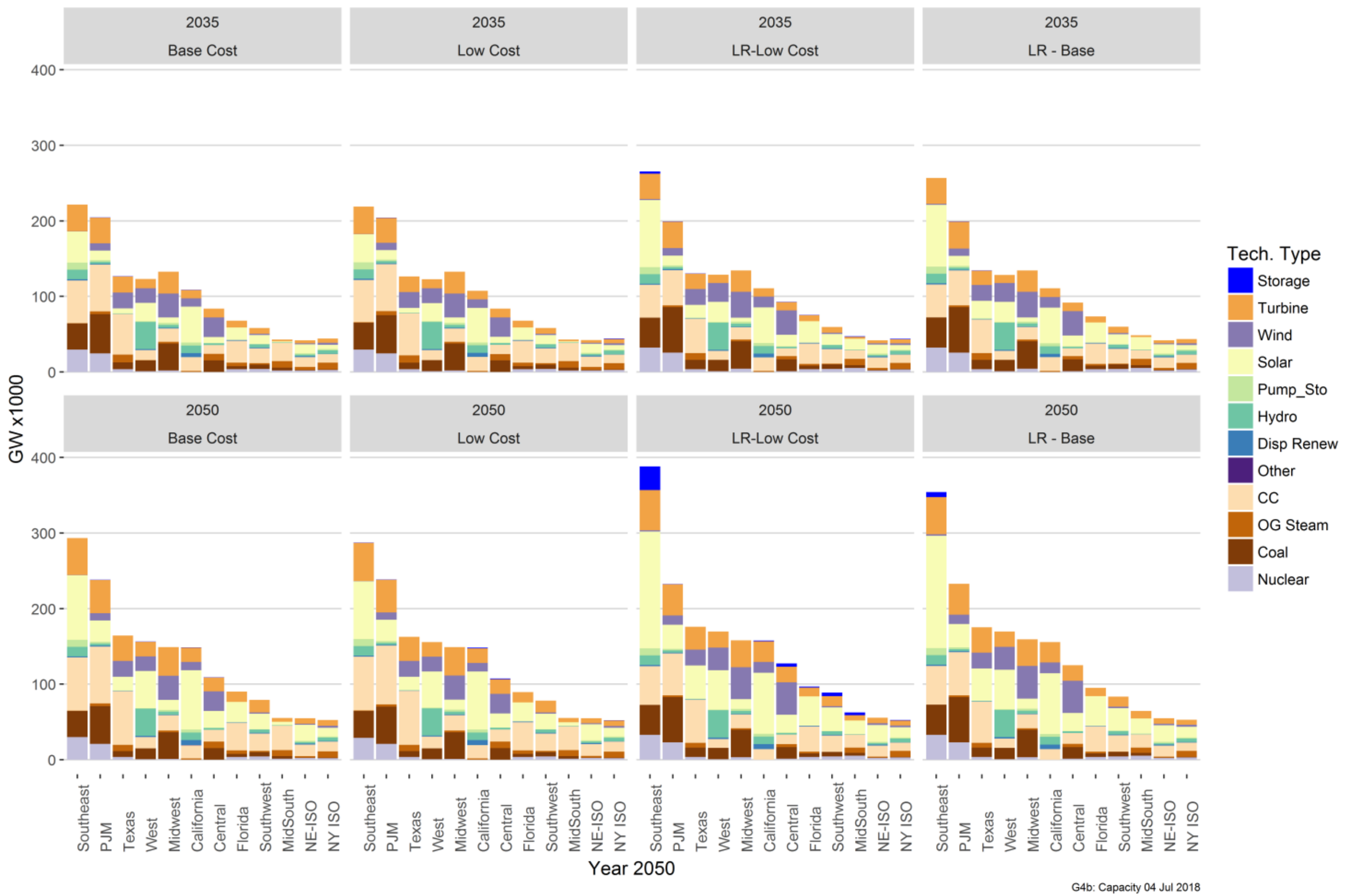
Low Resource – Low Cost

- Regions are sorted (roughly) by total capacity
- Figure highlights the market shares of the different generating technologies
- The variance in the role of storage on each systems capacity is worth noting



Regional Capacity

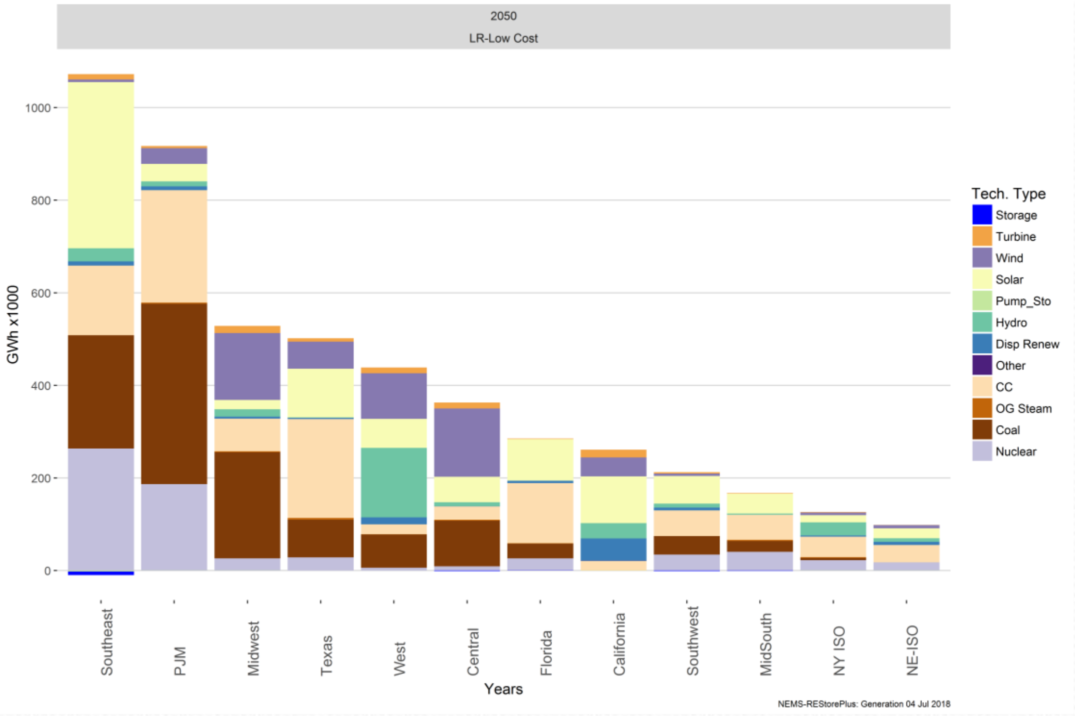
Across Scenarios in 2035 and 2050



Regional Generation

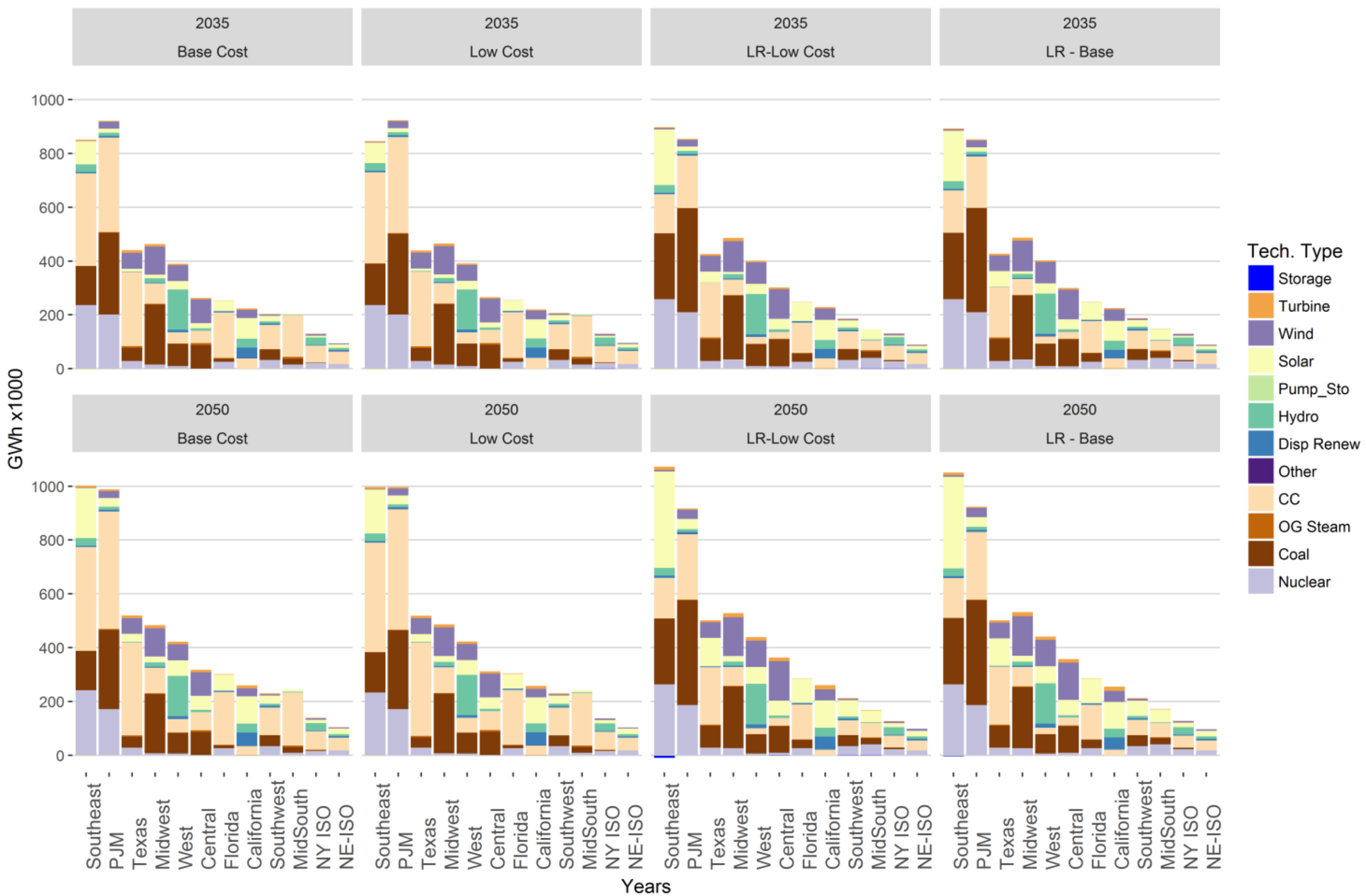
Low Resource – Low Cost

- In contrast to the generating capacity, the continued role of CC is very striking, particularly given the high natural gas prices
- Note that coal generation persists to the end of the forecast although it is shrinking throughout the forecast period
- Further, note the substantial penetration of solar and wind



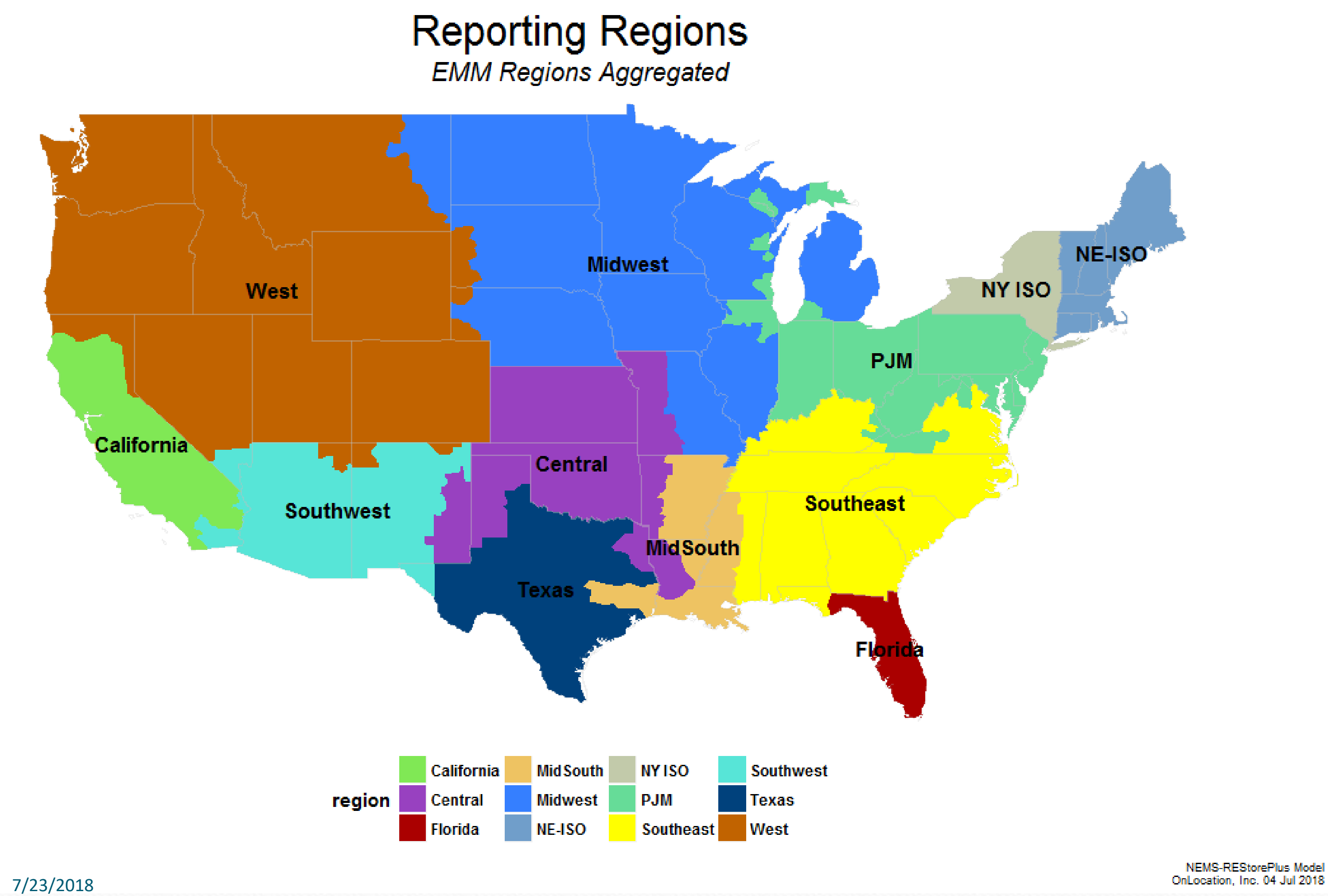
Regional Generation

Across Scenarios in 2035 and 2050



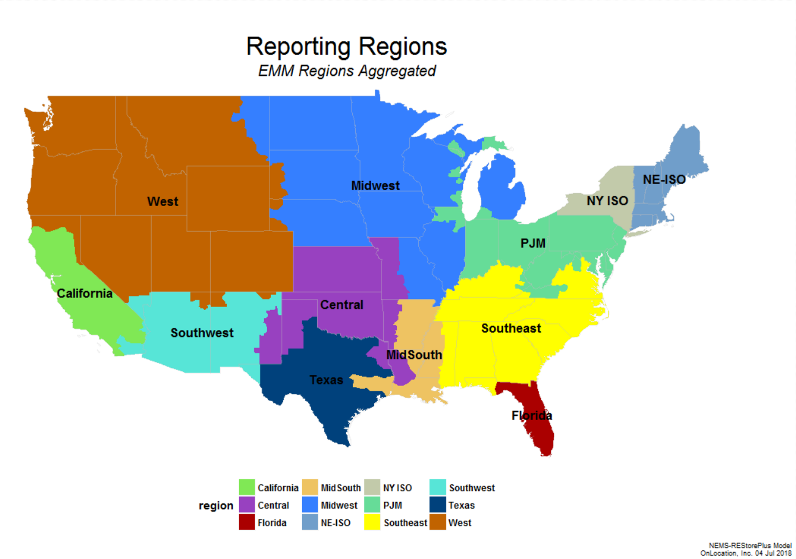
NEMS-REStorePlus: Generation 04 Jul 2018

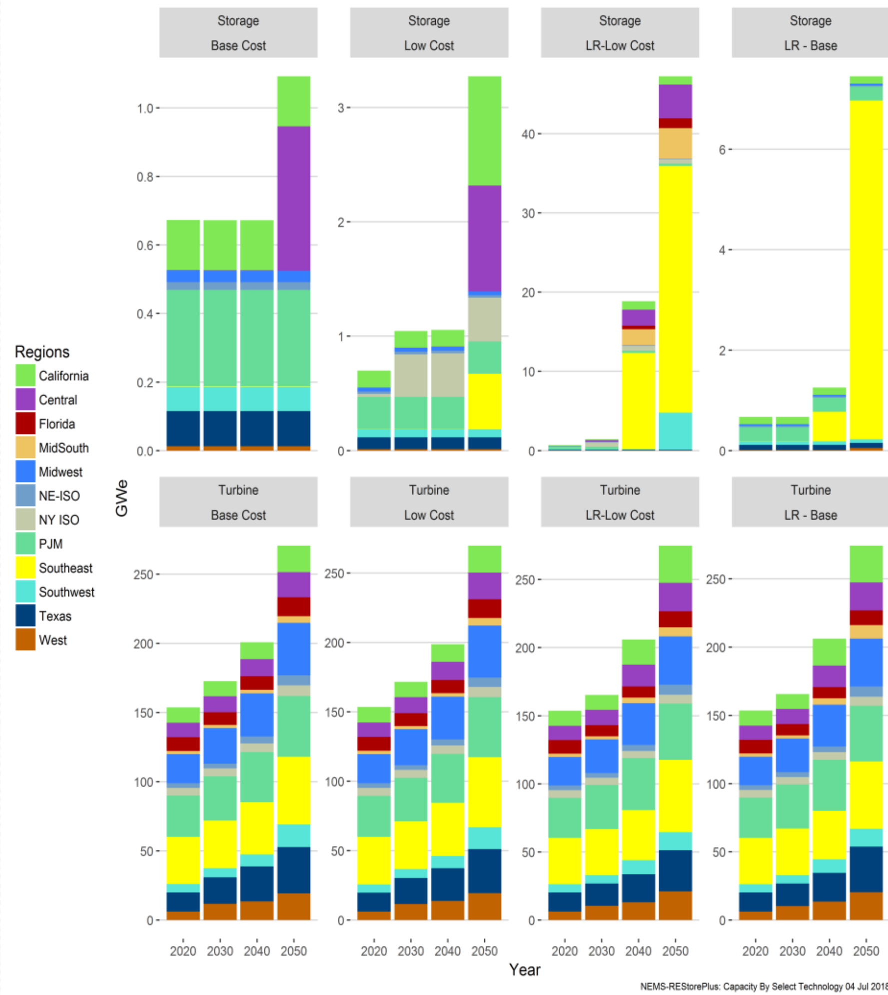
Aggregated Model Regions



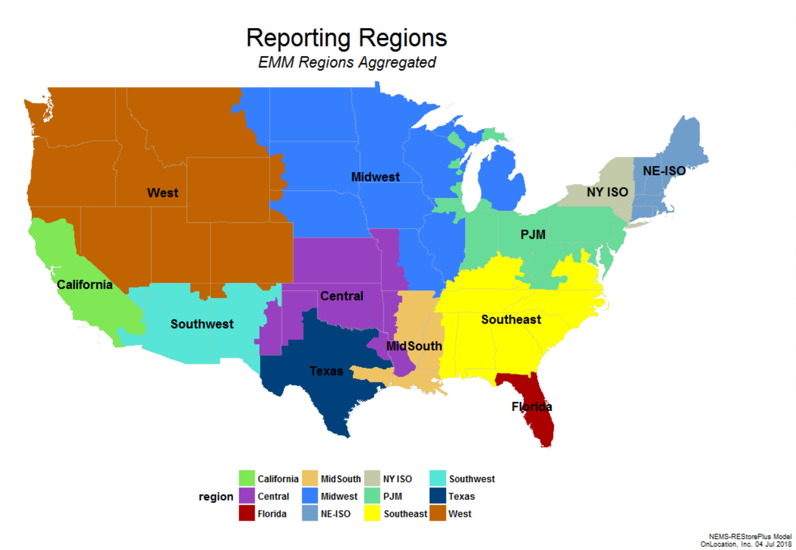
Storage and Turbine Capacity

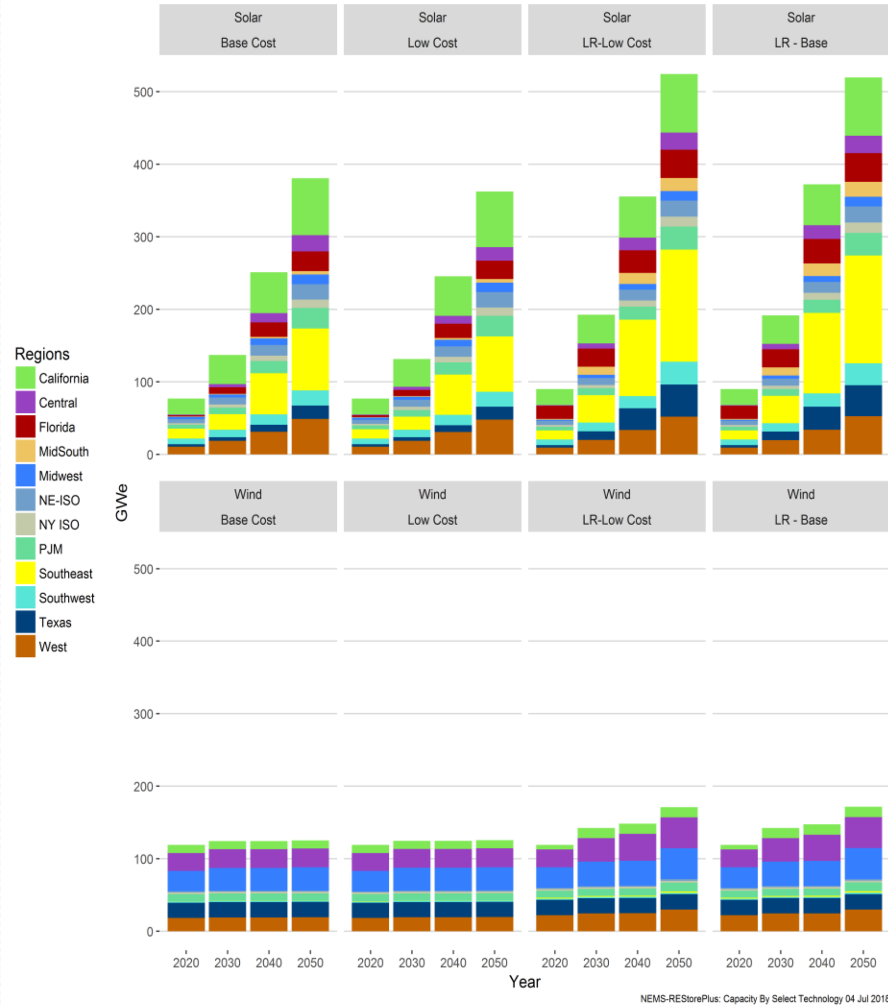
Take care to note the changes in scale across each of the facets!



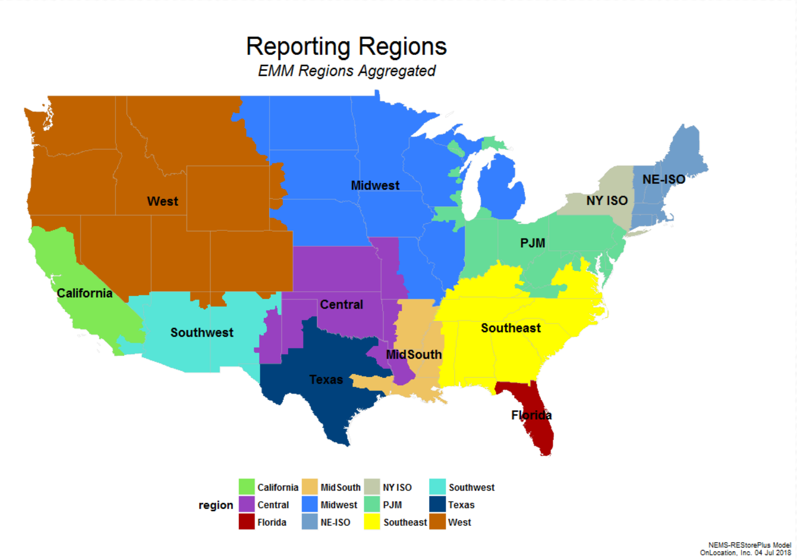


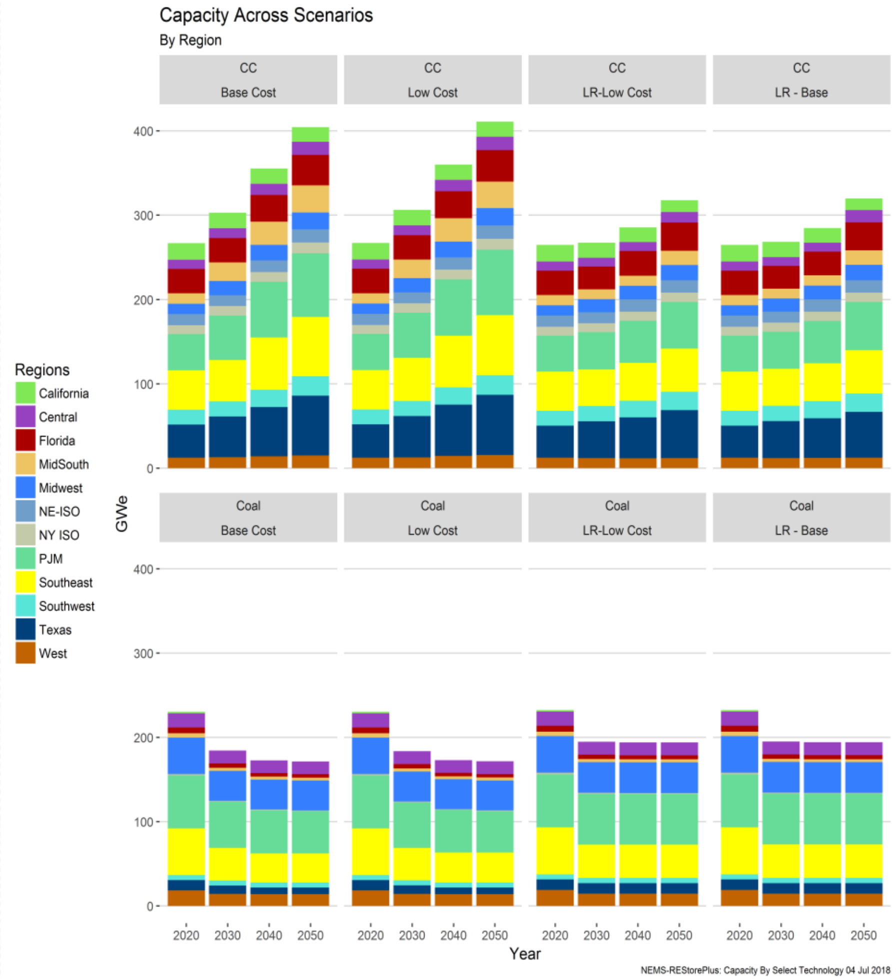
Solar PV and Wind Capacity



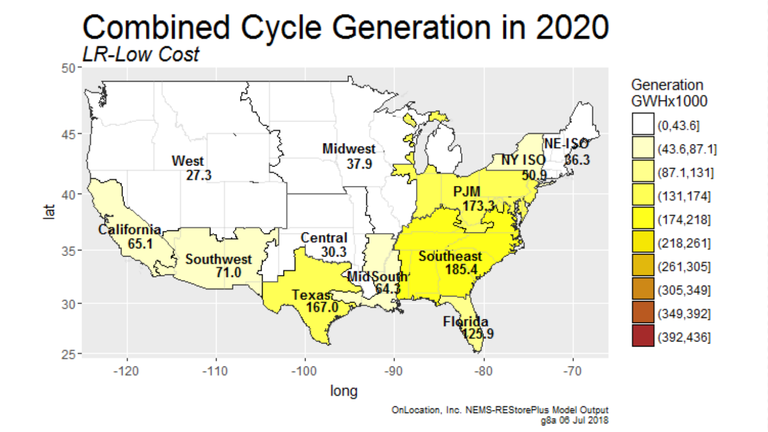


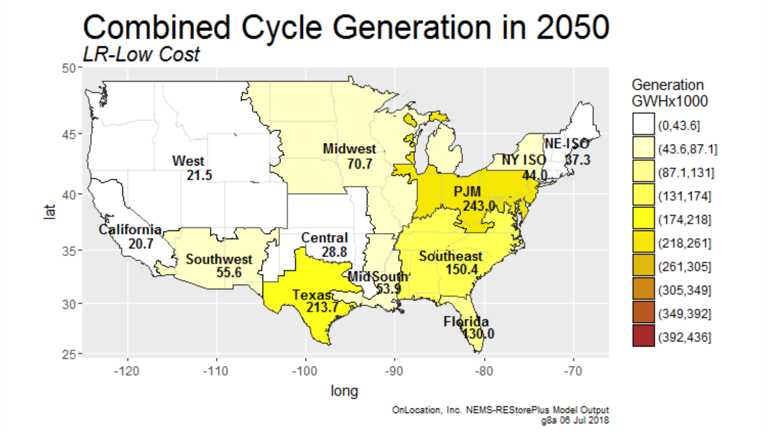
Combined Cycle (CC) and Coal

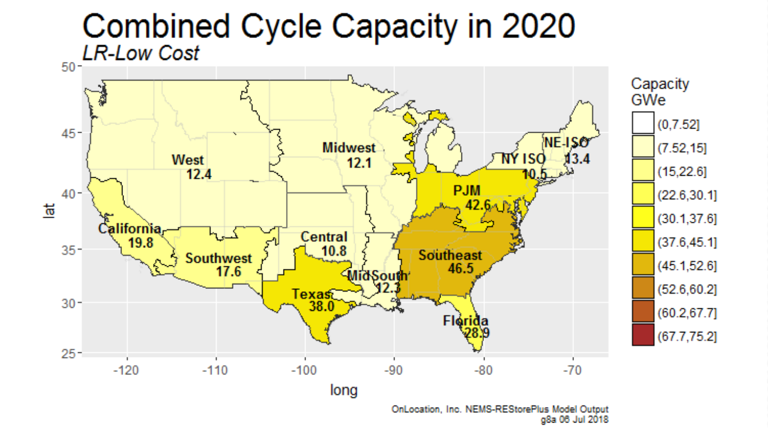


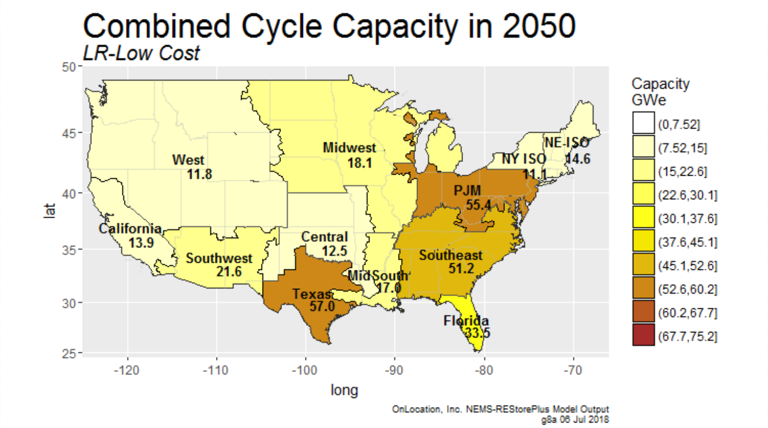


Combined Cycle Generation and Capacity in LR-Low Cost Scenario

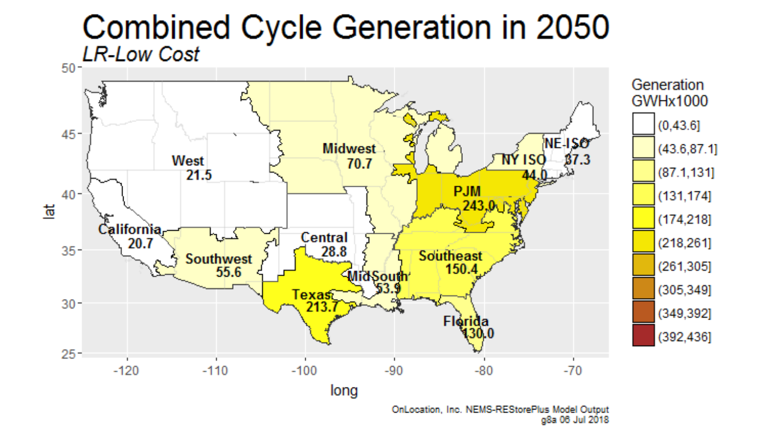


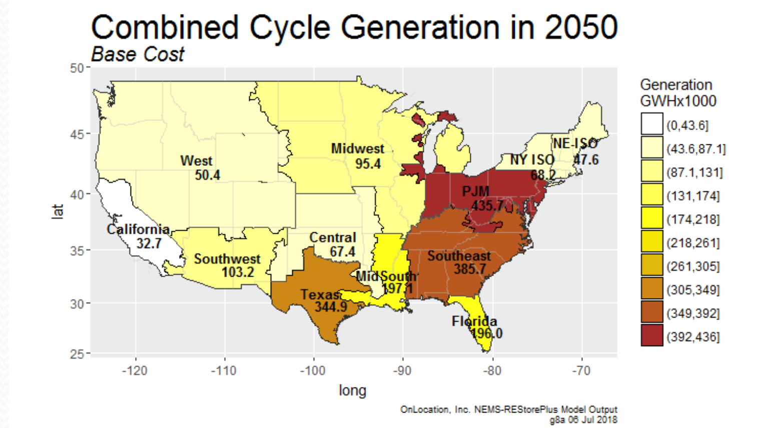


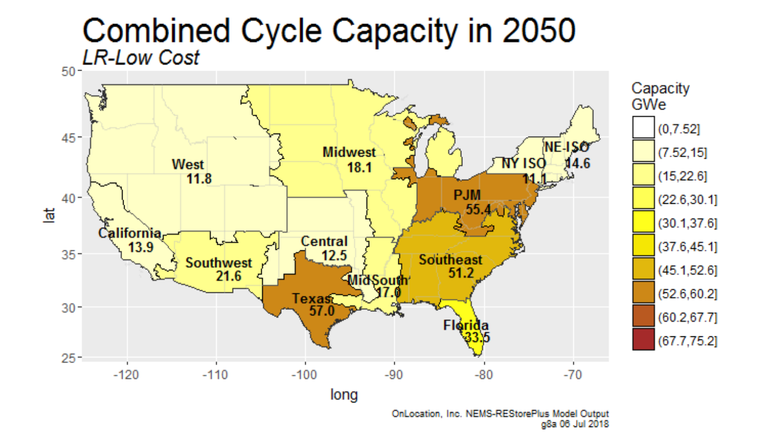


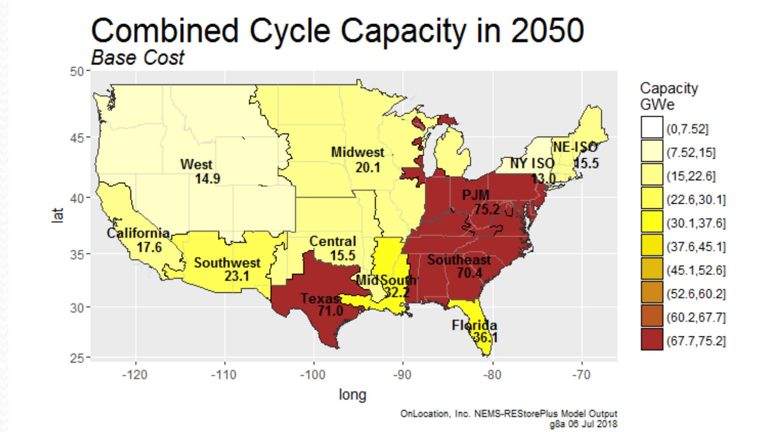


Combined Cycle Generation and Capacity Contrasted with Baseline NG Prices in 2050

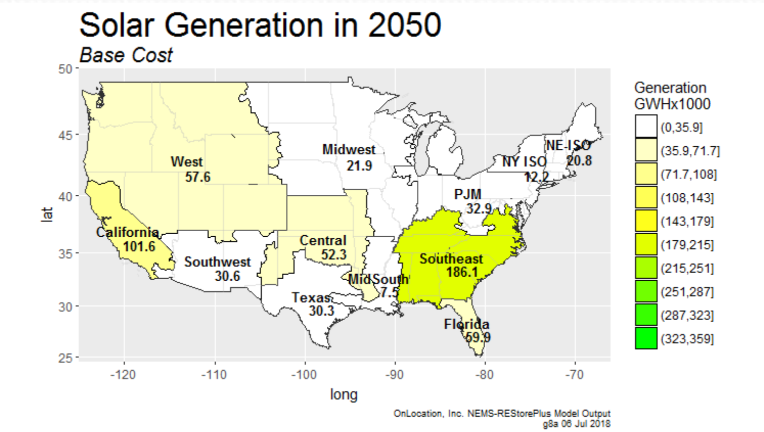


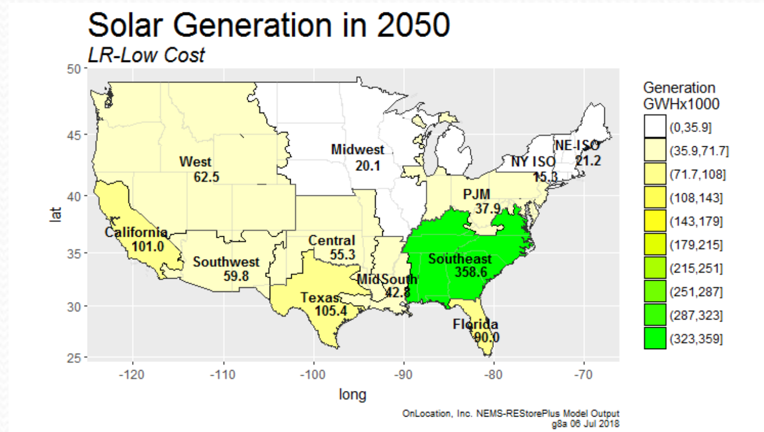


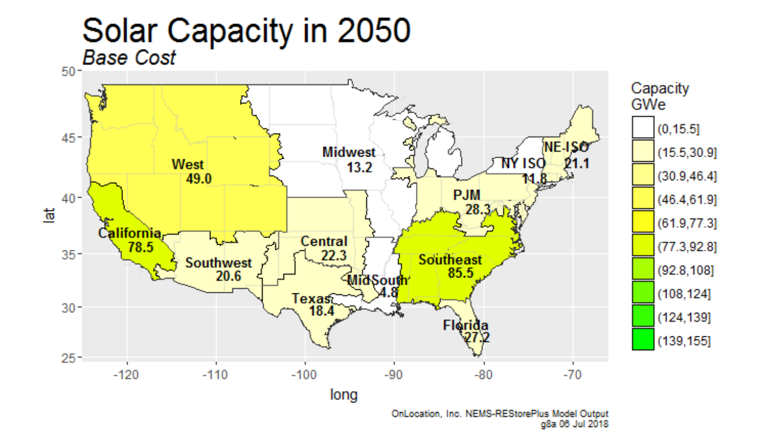


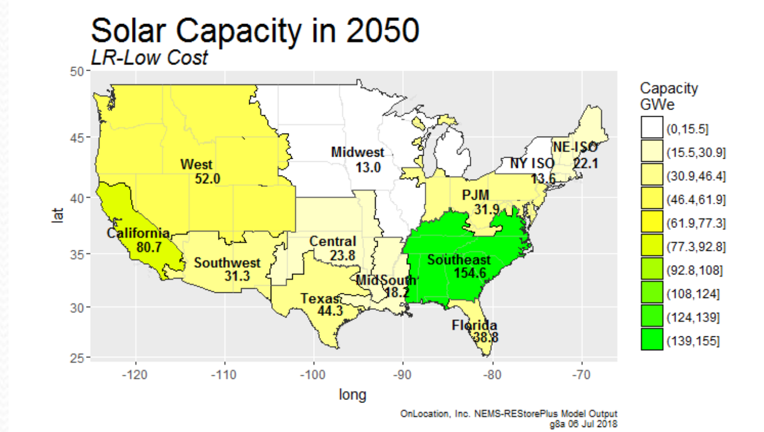


Solar Generation and Capacity: Baseline NG Prices Vs Low Resource High NG Prices in 2050







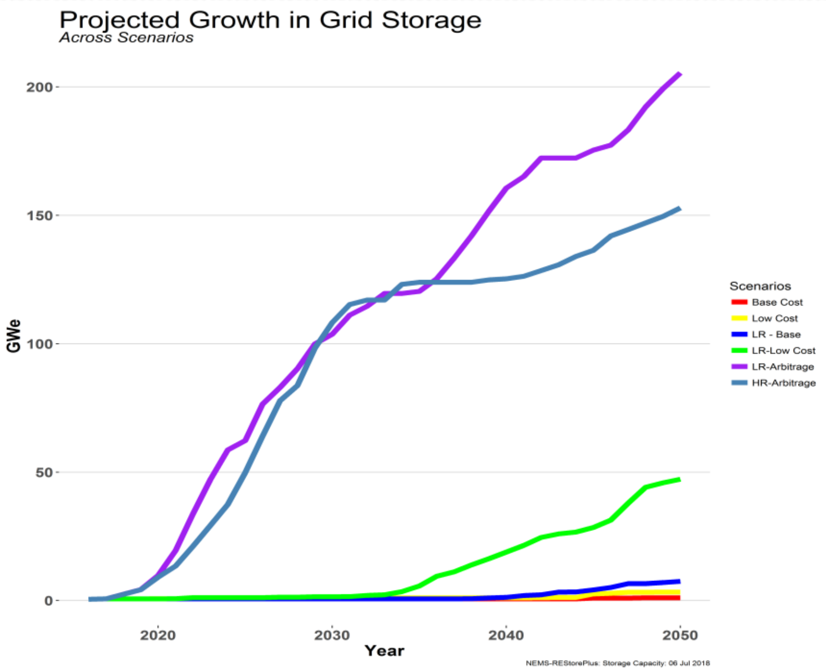


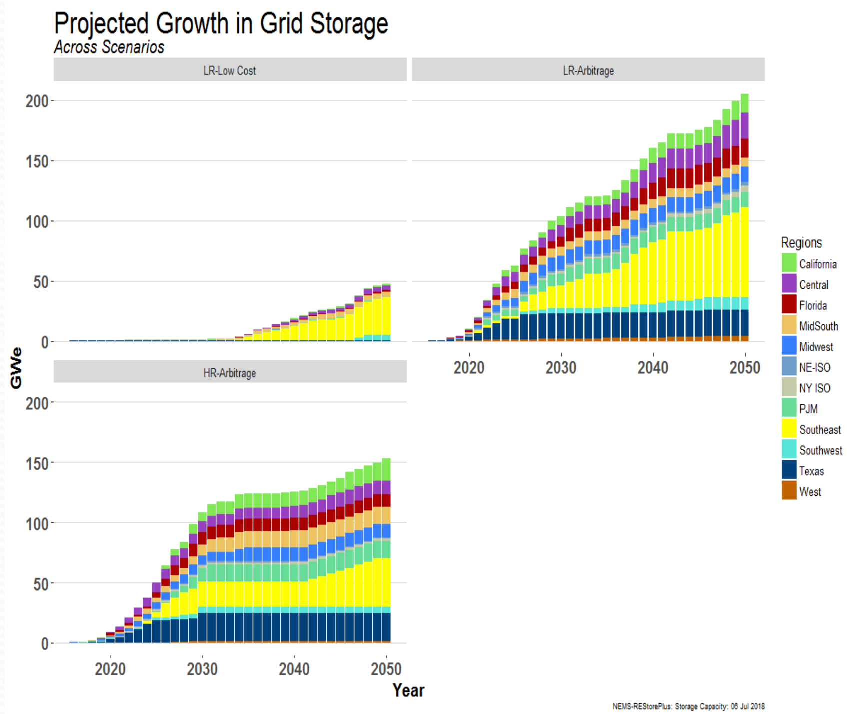
Maximum Potential With Arbitrage

As The Only Constraint

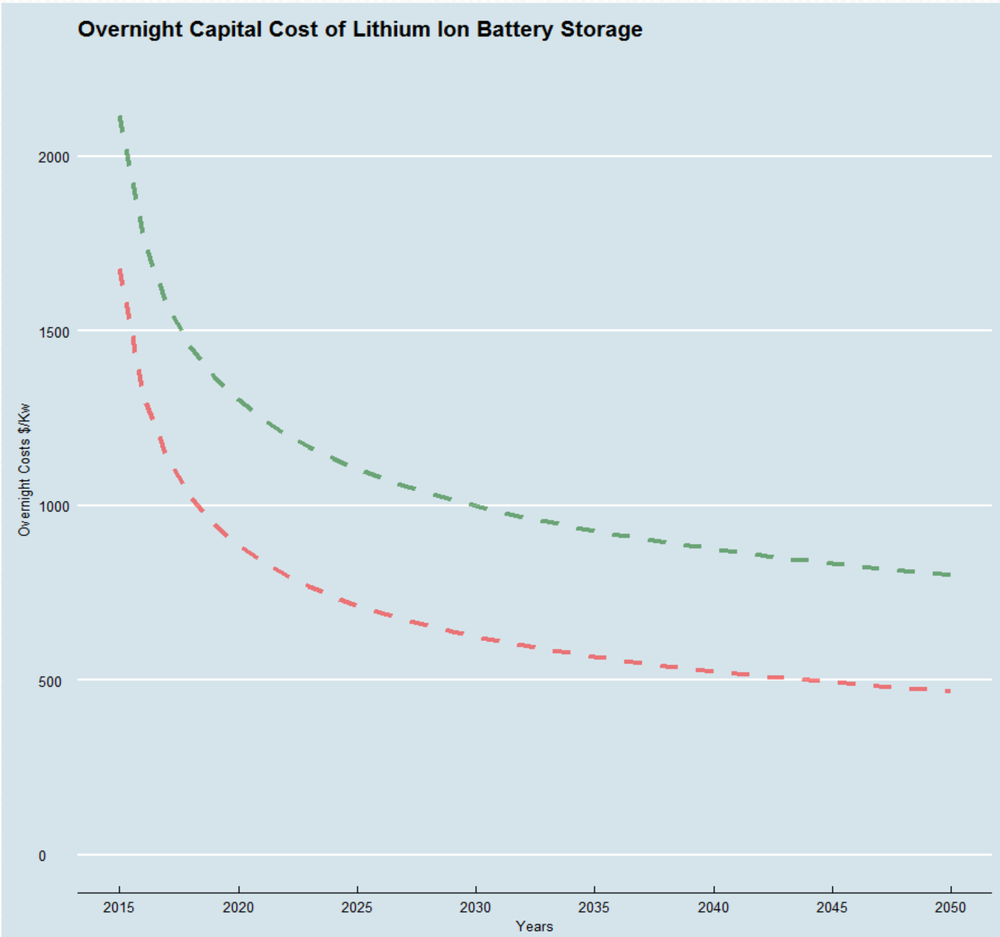
- **Maximum potential of storage given diurnal electricity price differences**
- **High NG Prices yields potential of 200+ Gigawatts**
- **Baseline NG Prices yields potential of 150+**

- **Arbitrage scenarios assume essentially free storage capital costs, only accounts for arbitrage**





Battery Storage Costs Used in the Analysis



$/KW

Year	High	Low
2015	2117.4	1677.3
2016	1754.4	1310.4
2017	1571.6	1134.3
2018	1453.6	1023.8
2019	1368.2	945.6
2020	1302.2	886.2
2021	1248.9	838.8
2022	1204.4	799.9
2023	1166.6	767.0
2024	1133.7	738.8
2025	1104.7	714.1
2026	1079.0	692.3
2027	1055.8	672.9
2028	1034.8	655.3
2029	1015.6	639.4
2030	998.0	624.9
2031	981.7	611.6
2032	966.6	599.2
2033	952.5	587.8
2034	939.3	577.2
2035	927.0	567.2
2036	915.4	557.9
2037	904.4	549.2
2038	894.0	540.9
2039	884.2	533.1
2040	874.8	525.7
2041	865.9	518.7
2042	857.4	512.0
2043	849.3	505.6
2044	841.5	499.6
2045	834.0	493.8
2046	826.9	488.2
2047	820.0	482.9
2048	813.4	477.8
2049	807.0	472.9
2050	800.9	468.2