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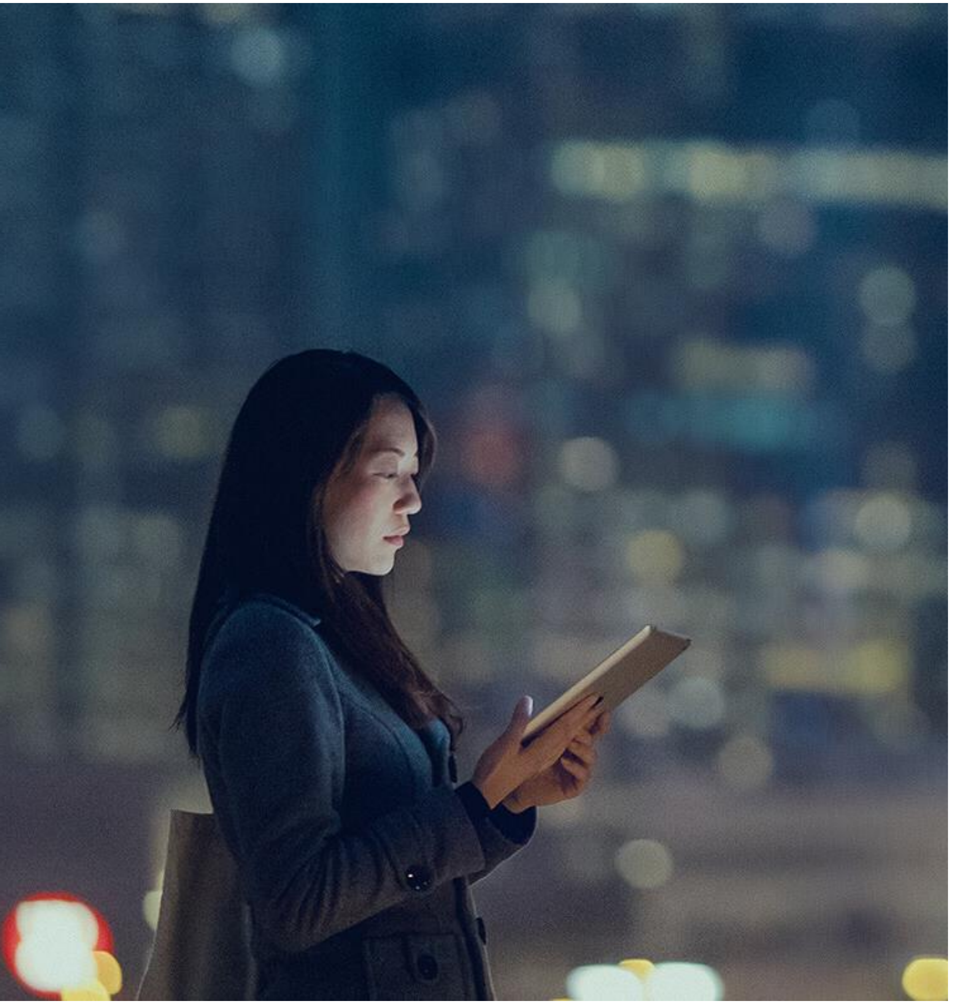
Integrated Resource Plan and Transmission Analysis PSAT Meeting

September 16, 2019

Agenda

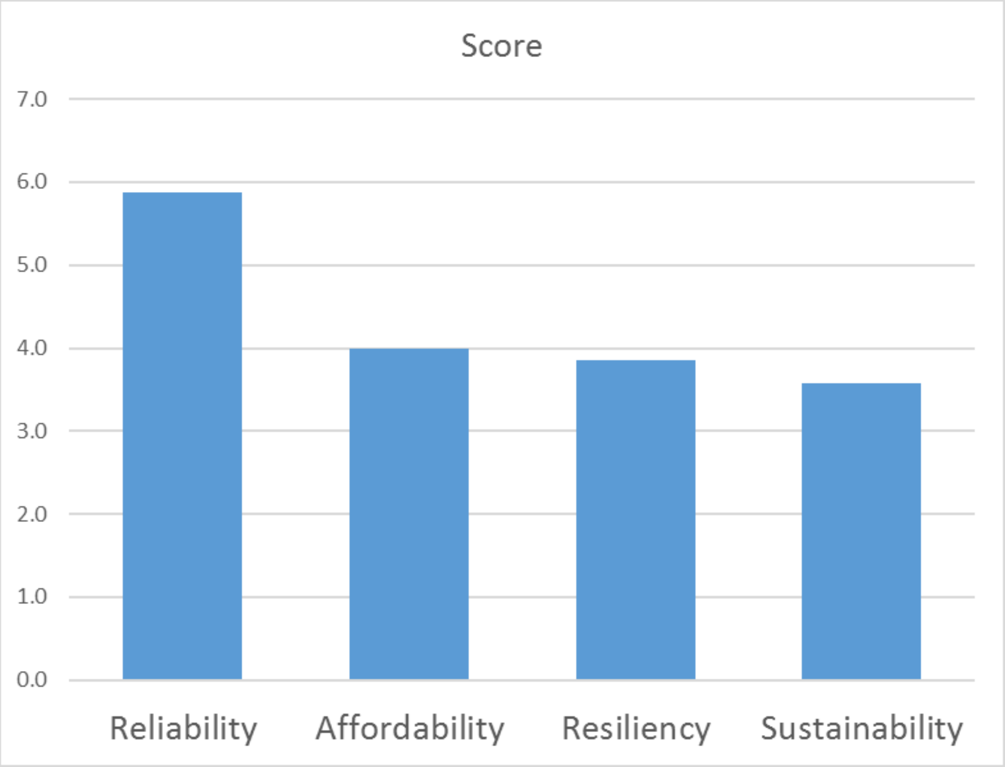


Welcome / Safety brief	10:00 am
Community Engagement Summary	10:10 am
Objective and Metrics	10:30 am
Scenario Discussion	11:00 am
Base Case, Scenario & Stochastic Inputs	11:30 am
Supply Options and WACC (working lunch)	12:00 pm
Transmission Options Discussion	12:30 pm
Breakout Sessions	1:00 pm
Summary of Breakout & next steps	1:45 pm

Recap of the Community Meeting

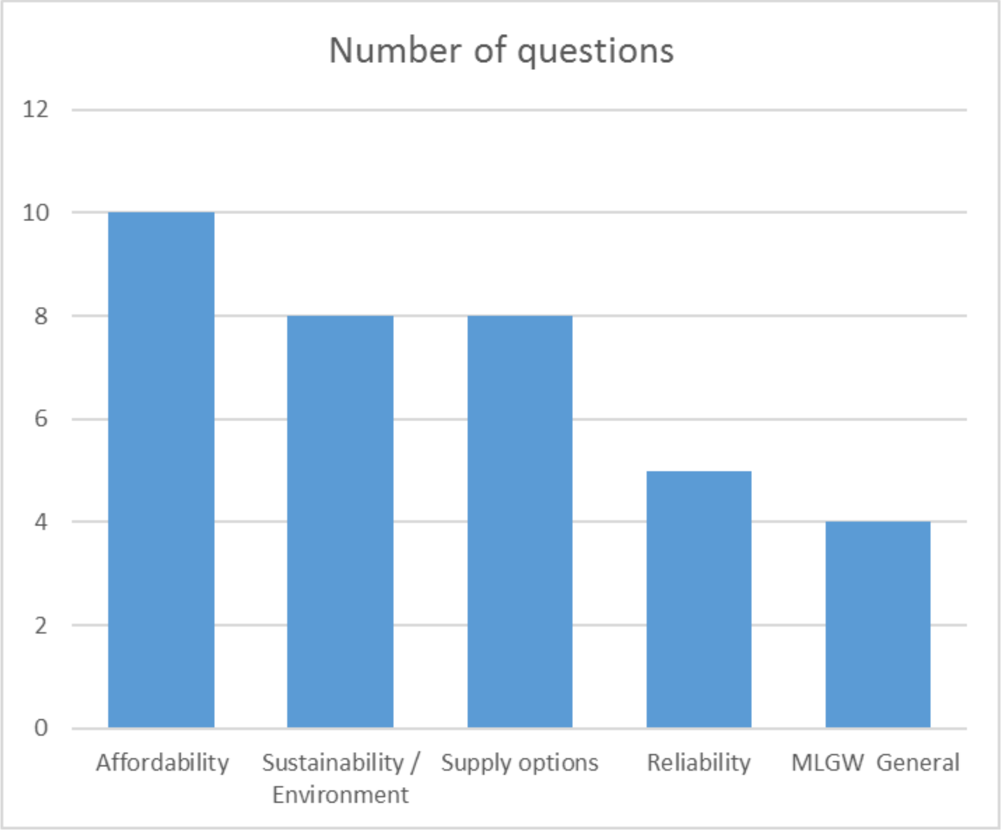
Community Engagement Meeting Summary

- The community engagement meeting was held on August 20, 2019, with over 40 registered participants
- Siemens presented the IRP process, covering:
  - *What recommendations/answers it will provide,*
  - *Objectives to be considered in the development of the answers, and*
  - *Overall process for community engagement.*
- The customers were asked to answers a series of questions and rank the importance of affordability, reliability, resiliency, and sustainability.
- The graph shows a summary of the answers and reliability was ranked first with an score of 5.9/10, followed by affordability, resiliency, and sustainability.



Community Engagement Meeting Summary

- Another way to understand what is important to the community or what they care about, is to see the nature of the questions.
- We catalogued them in:
  - **Affordability**: topics on cost to the customer and billing.
  - **Sustainability/environment:** includes EE, storage and solar.
  - **Supply Options:** TVA, new generation, interconnections with TVA and MISO, etc.
  - **Reliability:** status of the current system, will the lights stay on?
  - **MLGW General:** question on how the IRP awarded, who is the PSAT, labor bargaining.
- Affordability was the main concern, followed by sustainability and questions related to the IRP (supply options)



Objectives and Metrics

IRP Objectives & Metrics

For each resource portfolio, the objectives are tracked and measured to evaluate portfolio performance in the base case, in alternative scenarios, and across a wide range of possible future market conditions.

Objective	Measure	Unit
Affordability	20-Year NPVRR Average Rate	$ $/MWh
Reliability / Resource adequacy	Meets or exceeds LOLE requirements, and minimizes energy not served & load shed	LOLE days / year; 0.1 target MWh not served MW shed under contingency.
Price Risk (Minimization / Stability)	95% percentile value of NPVRR	$ changes
Environmental Risk Minimization	CO_2 , SO2 and NOx Emissions	Metric tons Metric tons /MWh
Market Risk	Energy Market Purchases or Sales outside of a +/- TBD% Band	%, MWh
Local Impact	Jobs Created	# of Jobs
Resiliency	Energy not served during extreme events (multiple lines out)	MWh not served.

Scenarios

Scenarios

Siemens will utilize scenario based modeling to evaluate various regulatory constructs. The base case is considered the most likely future and reflects all effective policies. The alternative scenarios are shown as higher than, lower than, or the same as the base case.

	CO_2	Gas Reg.	Economy	Load	Gas Price	Coal Price	Renewables and Storage Cost	EE Cost
Base Case	Base	none	Base	Base	Base	Base	Base	Base
High Tech	none	none	Higher	Higher	Lower	Lower	Lower	Lower
High Reg.	High CO_2 Price	Fracking Ban	Lower	Lower	Higher	Lower	Higher	Higher
No Inflation	None	none	Flat	Flat	Flat	Flat	Flat	Flat
Worst Historical Case	None	Highest	Highest	Highest	Highest	Highest	Base	Base
Best Historical Case	none	Lowest	Lowest	Lowest	Lowest	Lowest	Base	Base
Climate Crisis	High CO_2 Price	Fracking Ban	Lower	Lower	Higher	Higher	Much Higher then Lower	Lower
MISO Operational Changes	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD

Scenario Narratives

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Base Case (refers to the broader market)

- The base case is the "most likely" case, built with commodity forecasts based on Siemens base line forecasts
- All other scenarios reference the base case (individual uncertainties are at the same levels or are higher or lower than the base case)
- In the base case:
  - Illinois Basin Coal prices trend slightly downward due to declining demand, PRB basin prices increasing modestly over the 20-year forecast horizon due to real mining productivity declines.
  - Henry Hub gas prices move upward 48% in real dollars from 2019 to 2039.
  - Net and peak load forecasts increase at a moderate rate – (0.5-1%/year).
  - Capital costs generally decline slightly for fossil resources, more for wind and approximately 45% or more for solar and storage resources.

Scenario Narratives

High Technology

- This scenario assumes that technology costs decline faster than in the base case, allowing renewables and battery storage to be more competitive.
- Given the abundance of low to no carbon generating technologies, CO_2 is no longer an issue.
- Increased demand for natural gas is more than met with advances in key technologies that unlock more shale gas, increasing supply at lower gas prices relative to the base case.
- Less demand for coal results in lower coal prices relative to the base case.
- Utility-sponsored energy efficiency costs rise early in the forecast but ultimately fall back to below base levels due to technology advances, allowing for new and innovative ways to partner with customers to save energy.
- As technology costs fall, customers begin to move towards electrification. This results in more electric vehicles, higher adoption of rooftop solar/energy storage, and trend towards highly efficient electric heat pumps in new homes as the winters become more mild and summers become warmer.

Scenario Narratives

High Regulatory

- Carbon is priced higher than the base case due to more aggressive national regulation of carbon emissions.
- A fracking ban is imposed, driving up the cost of natural gas as the economic supply dramatically shrinks.
- Tighter regulations are implemented on burning coal. As these regulations are imposed, prices for coal decrease due to declining demand.
- High regulation costs are a drag on the economy and load decreases relative to the base case.
- Renewables and battery storage are widely implemented to avoid paying high CO2 prices which drives higher energy prices. Capital costs for renewables would face a certain amount of upward price pressure that comes from higher demand as utilities and developers shift away from new fossil generation toward renewable energy.
- Utility-sponsored energy efficiency costs are higher as more codes and standards are implemented, leaving less low hanging fruit.

Potential Additional Scenarios or Sensitivities

Scenarios are run to find a Least Cost Portfolio
Sensitivities are run to see how a Selected Portfolio performs

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No Inflation Case or “Today” Scenario

This scenario tests the dependence of the portfolios to future outcomes; it tests the decisions considering today’s conditions

Worse Snapshot

This assessment picks the worst/best past situation (~10-11 years back) on key variables. The technology cost is not going back to historical level and gas prices assume that prices could return to volatility seen prior to shale gas bloom.

MISO Operational Changes

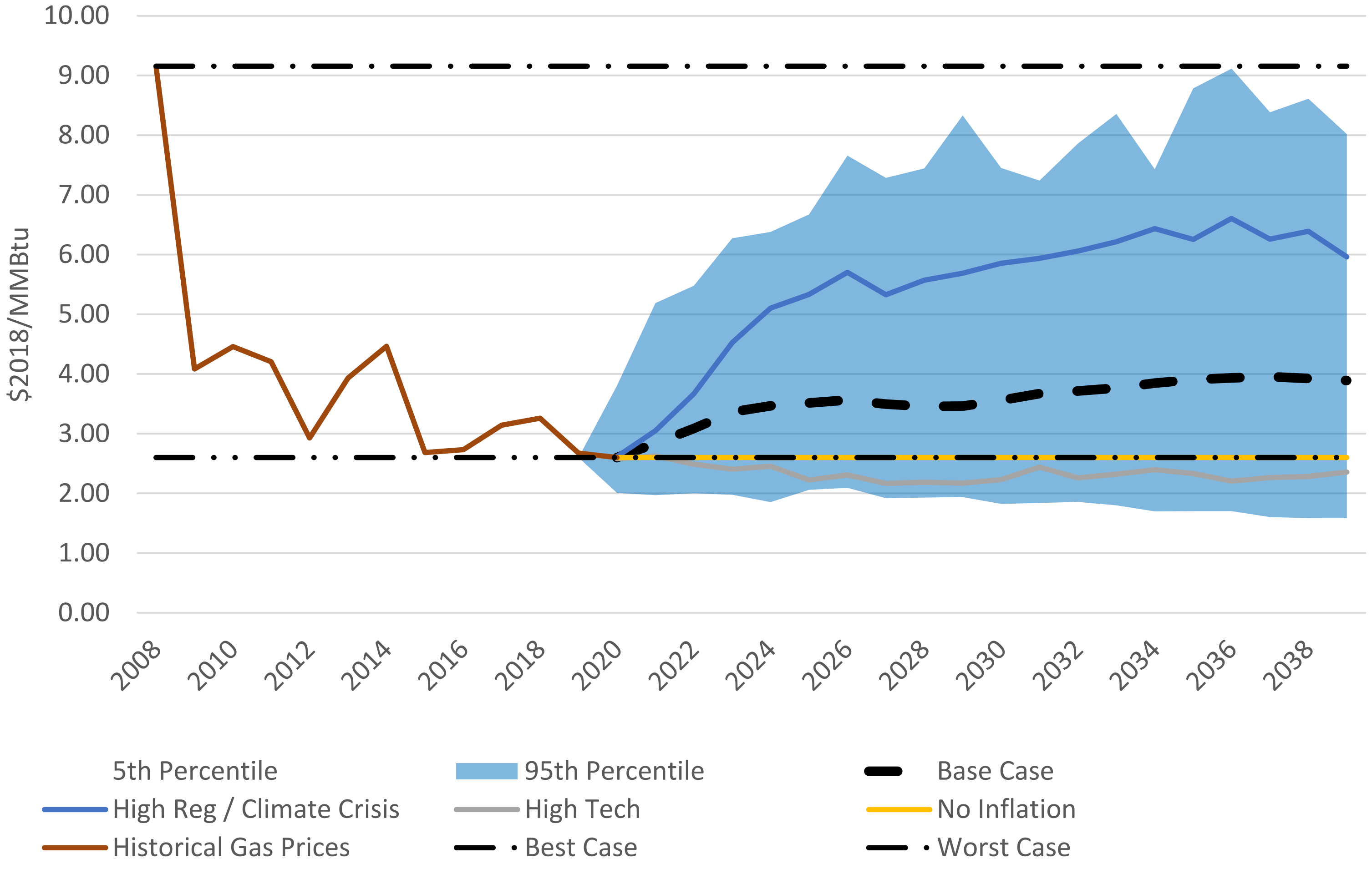
Considers the potential for MISO changing policies (ideas?)

Climate Crisis

Strong call to action; high CO_2 costs, extreme weather patterns, premium on resiliency, strong government incentives for EE, higher coal / gas prices (due to taxation). Technology costs of renewable and storage rise significantly in the mid-term due to increasing demand and declines rapidly in the long term thanks to more research and investment which brings down the cost.

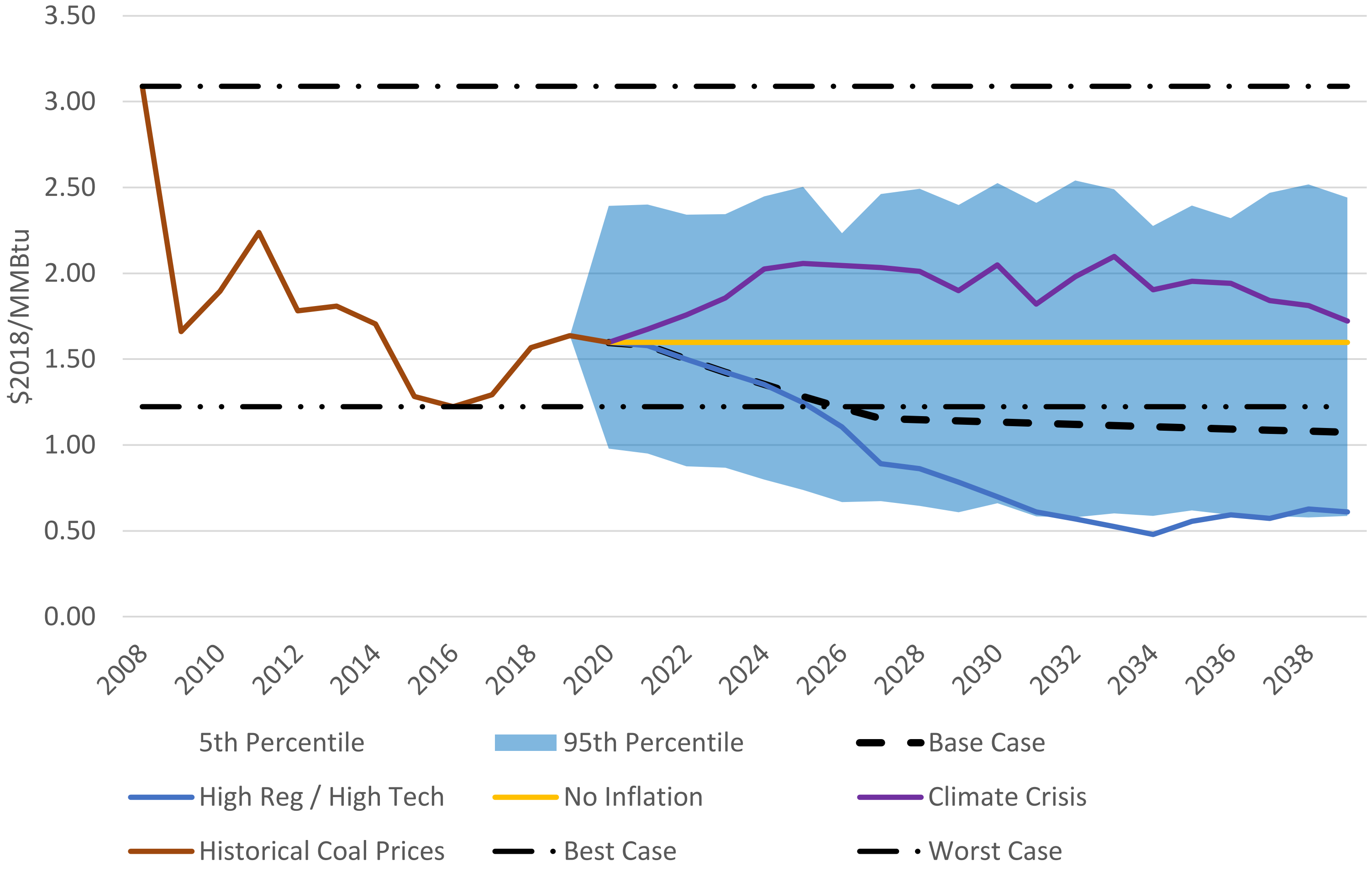
Base, Scenario and Stochastic Inputs

Henry Hub Prices



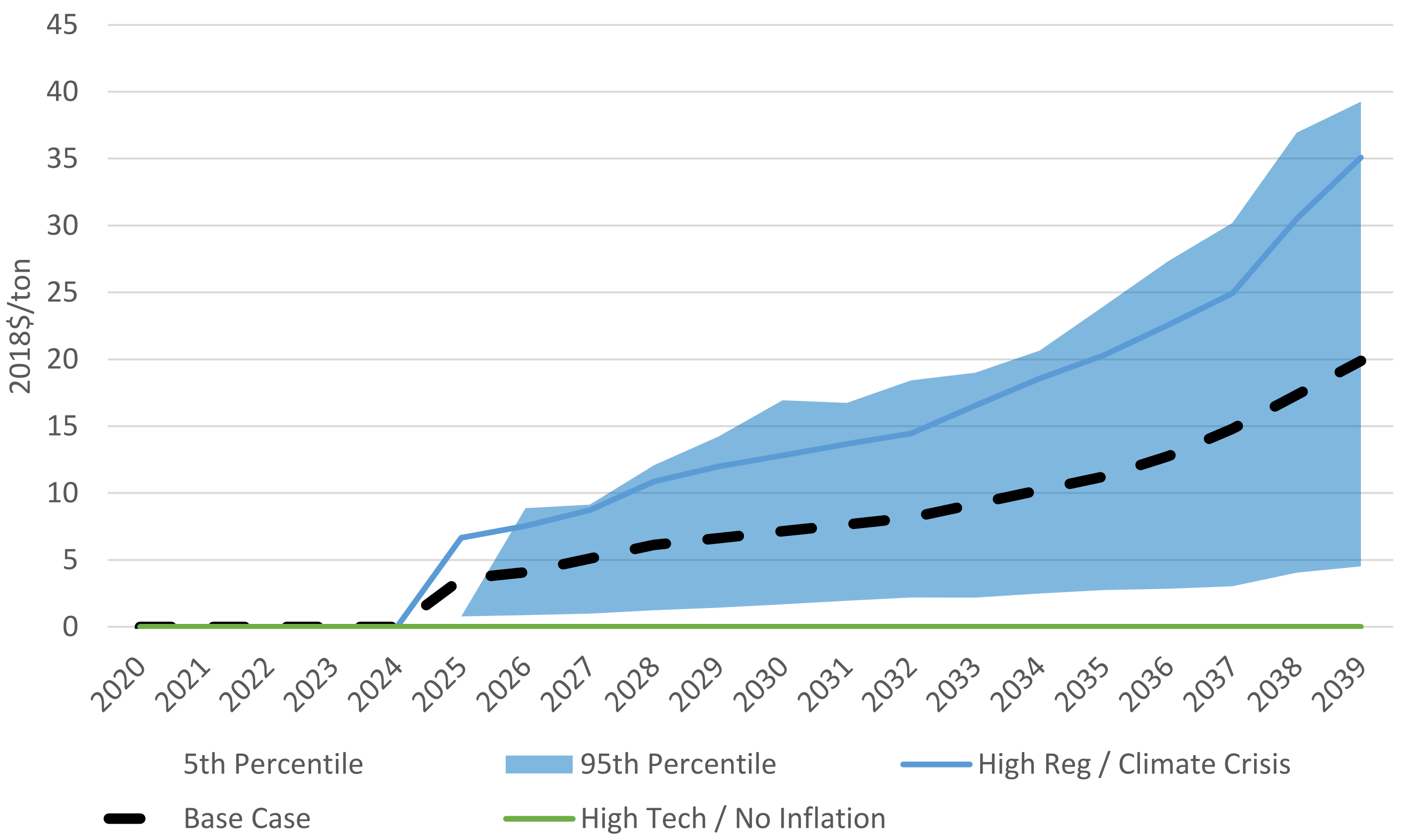
- Base Case gas prices are widely projected to increase slightly in real terms over time.
- In the High Regulation and Climate Crisis scenarios, prices for natural gas are expected to rise as the costs of production (and regulation) increase.
- In the High Technology scenario, continuous technology improvements in drilling and hydraulic fracturing persist over time and help to keep gas prices at relatively low levels, even with an increase in demand from low prices.

ILB Coal Price



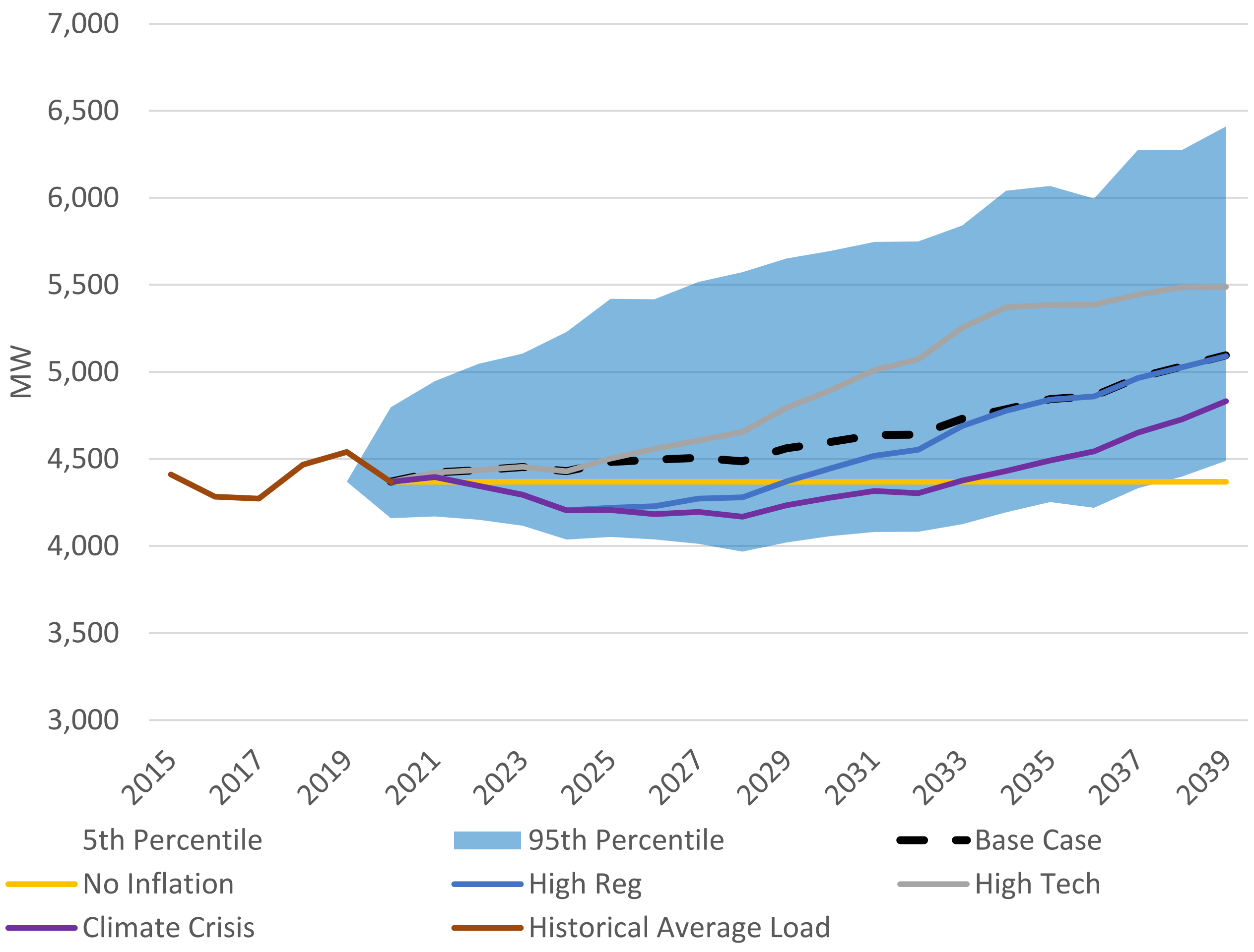
- The Base Case represents a reference outlook for ILB coal prices. Prices decline over the forecast period due to lower demand and additional consolidation in the mining industry.
- In the High Regulatory and High Technology scenarios, declining demand results in lower coal prices relative to the Base Case.
- In the Climate Crisis scenario, high mining extraction taxation drives up the coal prices to incent less coal consumption.

National CO_2 Prices



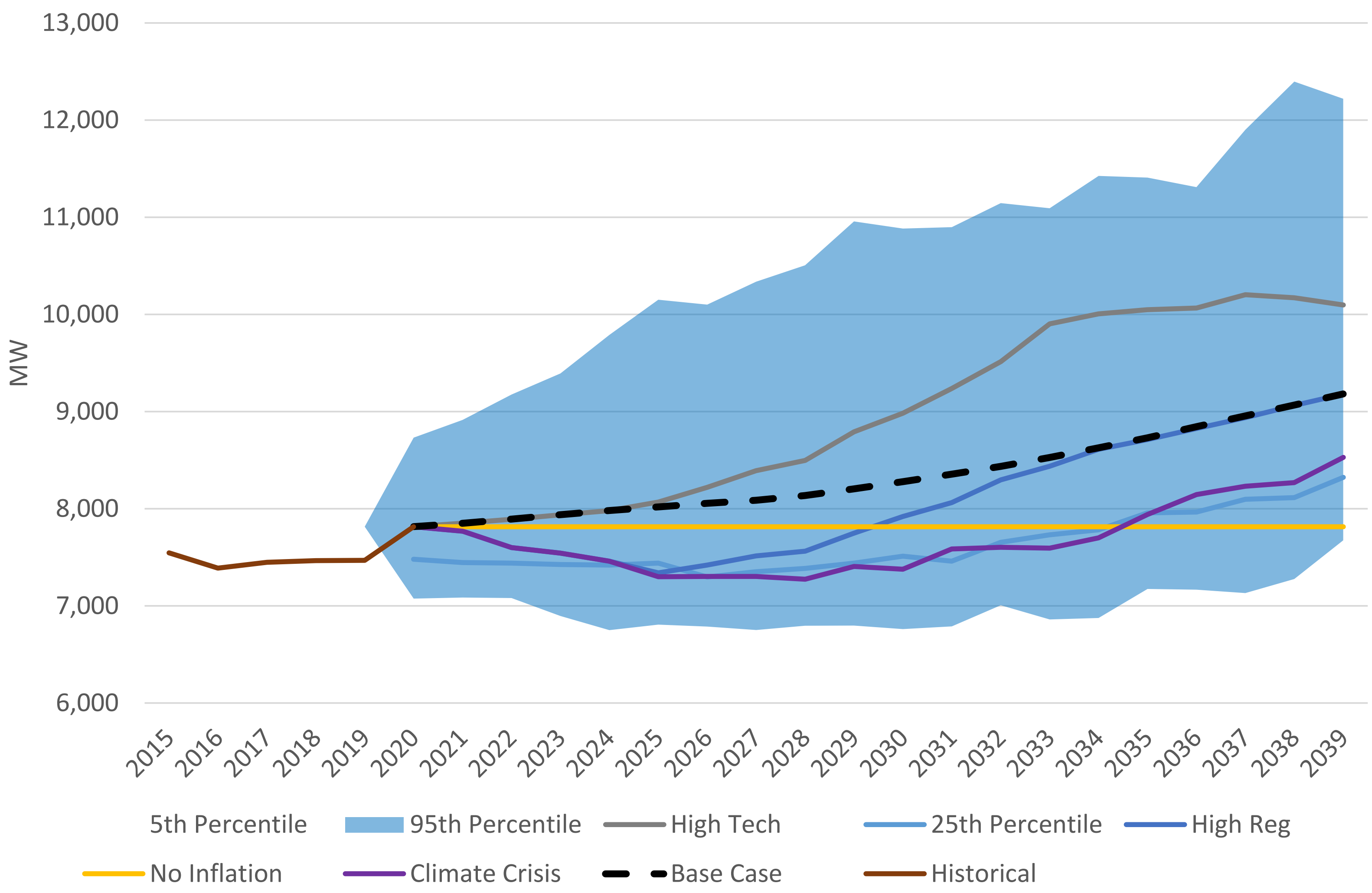
- The Base Case represents Siemens' reference outlook for a national price on carbon reflecting a moderate price on carbon beginning in the mid 2020s.
- In the High Regulatory and Climate Crisis Scenarios, carbon prices increase faster relative to the base case due to more aggressive national regulation of carbon emissions.
- The High Technology and No Inflation Scenarios represent a future with a negligible carbon price driven by either no significant regulation and/or favorable economics of non-emitting generation technologies.

MISO Arkansas Average Load Forecast



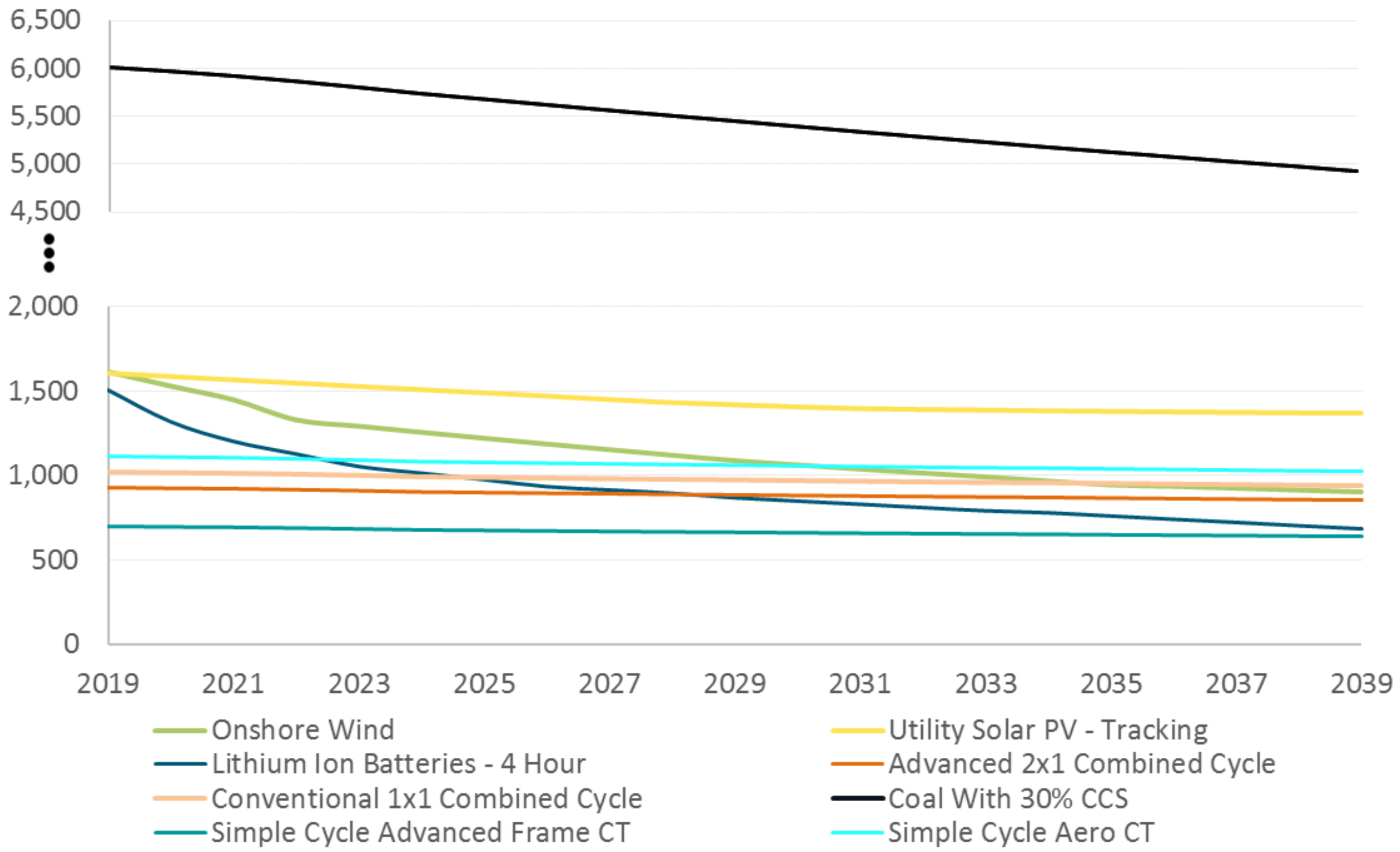
- The base case load forecast indicates slightly increasing load over time
- In High Tech scenario, increasingly healthy U.S. economy drives moderate energy sales in the near term and high energy sales in the long term.
- In High Reg scenario, tighter regulation is a drag for the economy leading to lower load growth in the mid-term, and moderate load growth in the long term.
- In Climate Crisis scenario, load growth is lower throughout the study horizon

MISO Arkansas Peak Load Forecast



- Base case peak load grows slightly over time.
- In High Tech scenario, increasingly healthy U.S. economy drives moderate energy sales in the near term and high energy sales in the long term.
- In High Reg scenario, tighter regulation is a drag for the economy leading to lower load growth in the mid-term, and moderate load growth in the long term.
- In Climate Crisis scenario, load growth is lower throughout the study horizon.

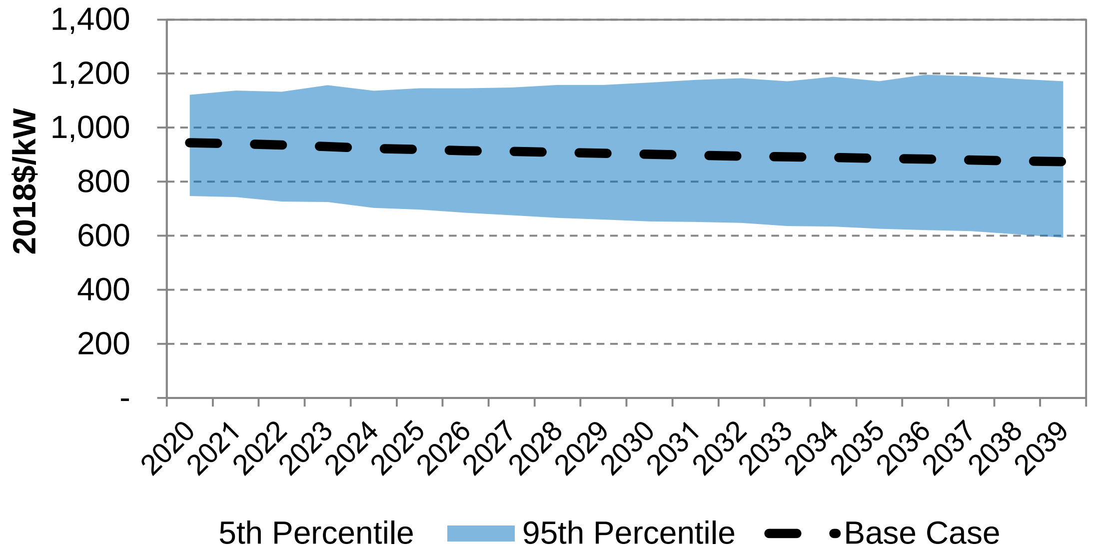
Base Case Capital Costs



- All-In Capital Costs ($/KW) include EPC, developers, and interest during construction
- Capital Cost estimates classified by AACE as a Class 4 study
  - True costs of development can vary by over 30% due to site specific requirements
- Renewable, storage, and CCS technologies decline while thermal technologies remain flat

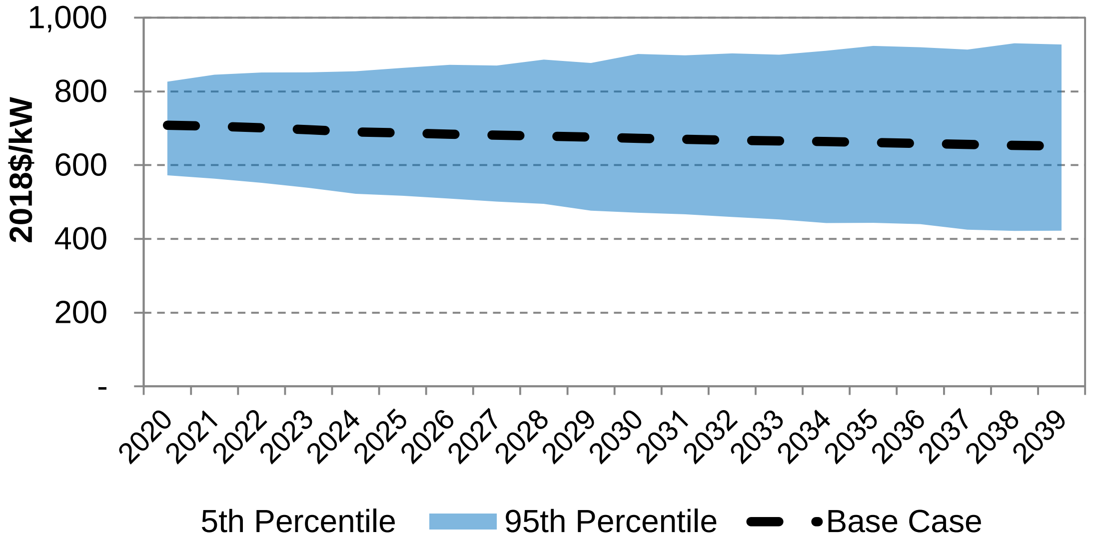
Capital Costs Distribution for CC and CT

Capital Costs for Advanced CCGT



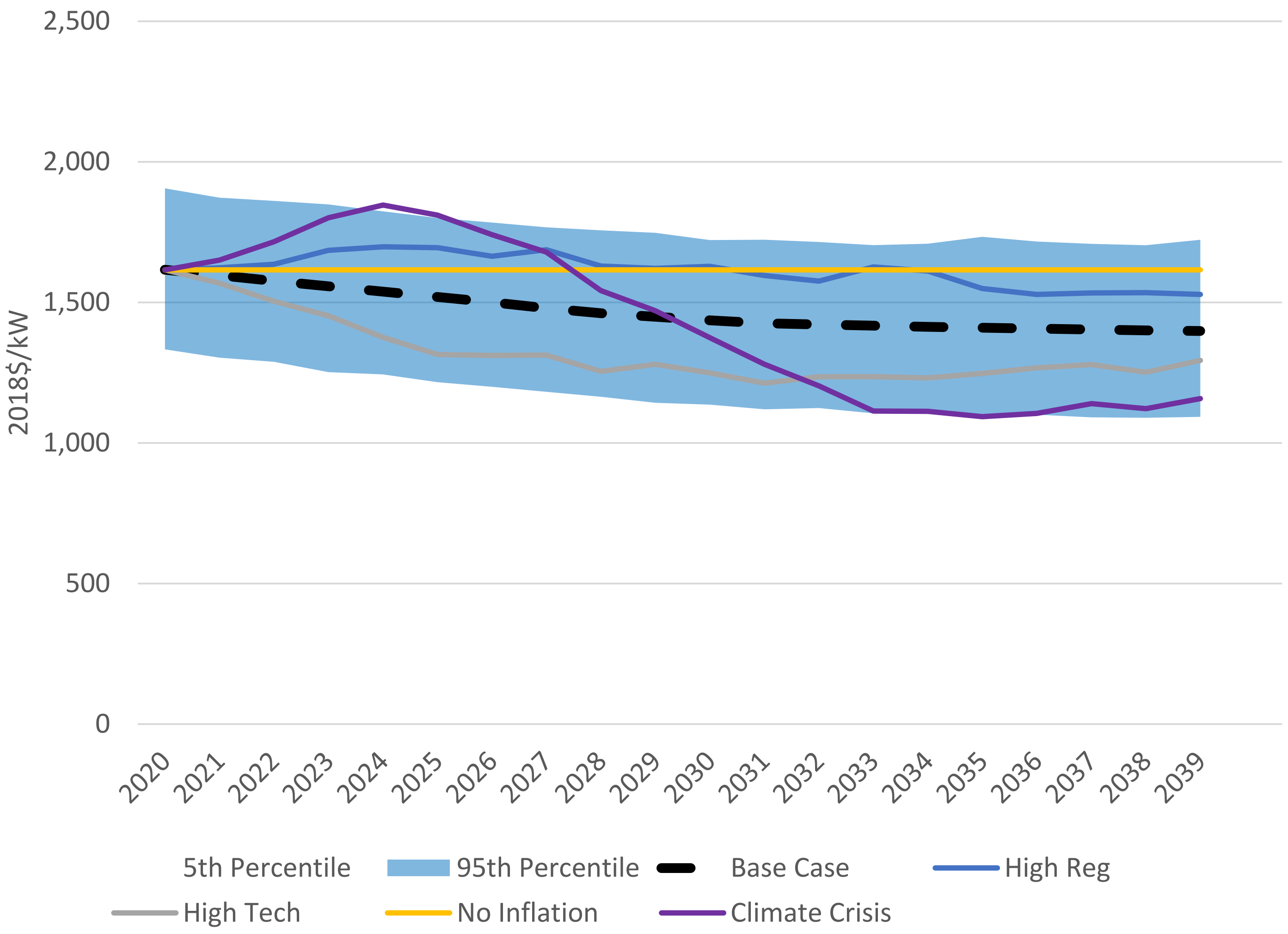
- Uses Advanced Frame GTs such as GE 7HA, Siemens 9000HL, or MIH 5000J
- Designed for increased capacity, reduced heat rates, and faster ramping

Capital Costs for Conventional CT - Aero



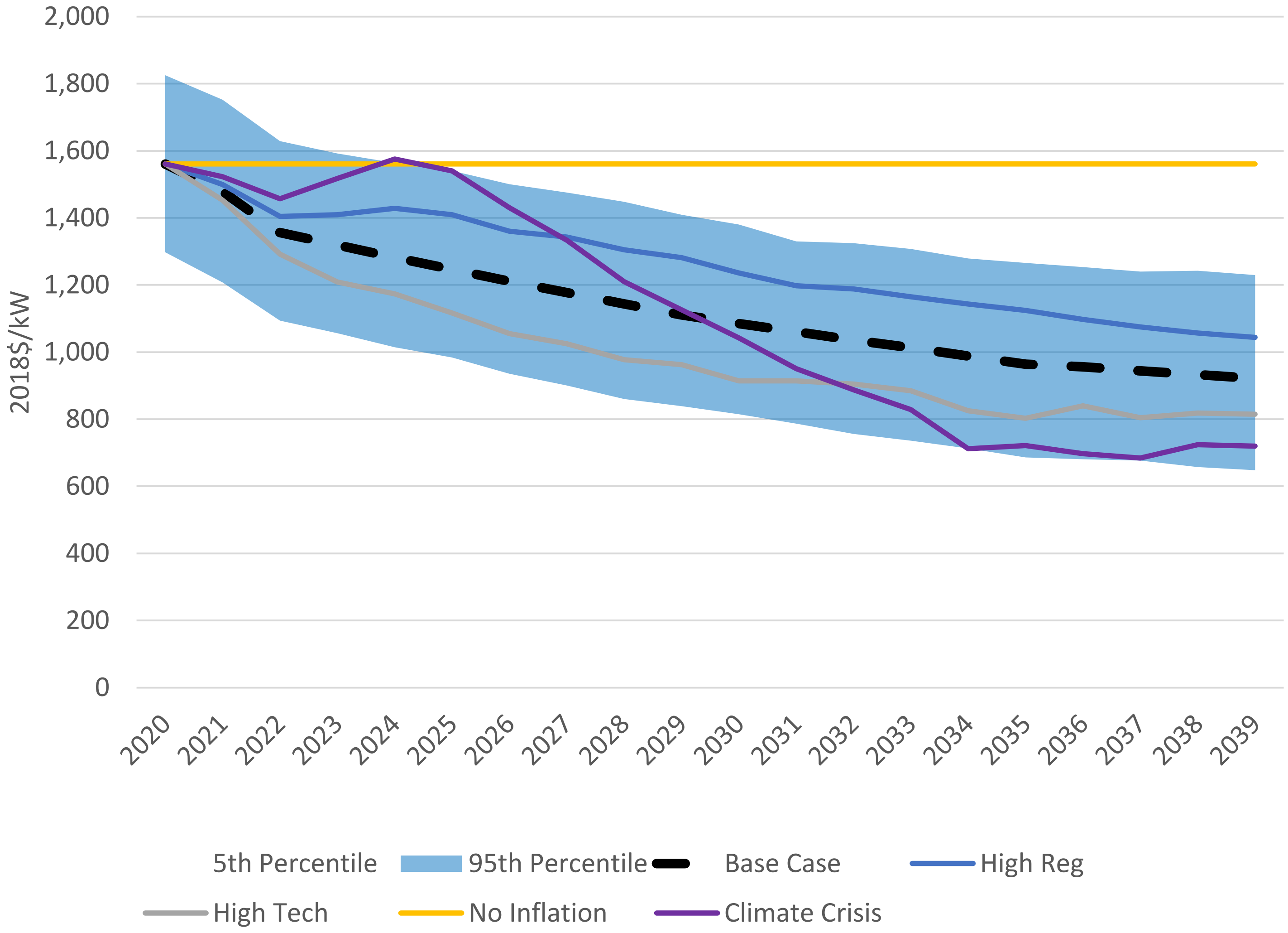
- Uses conventional aeroderivative CTs such as GE LM6000 or Siemens SGT-A65
- Designed for reliable cycling and fast ramping which can support incremental renewable generation

Capital Costs for Wind in Scenarios



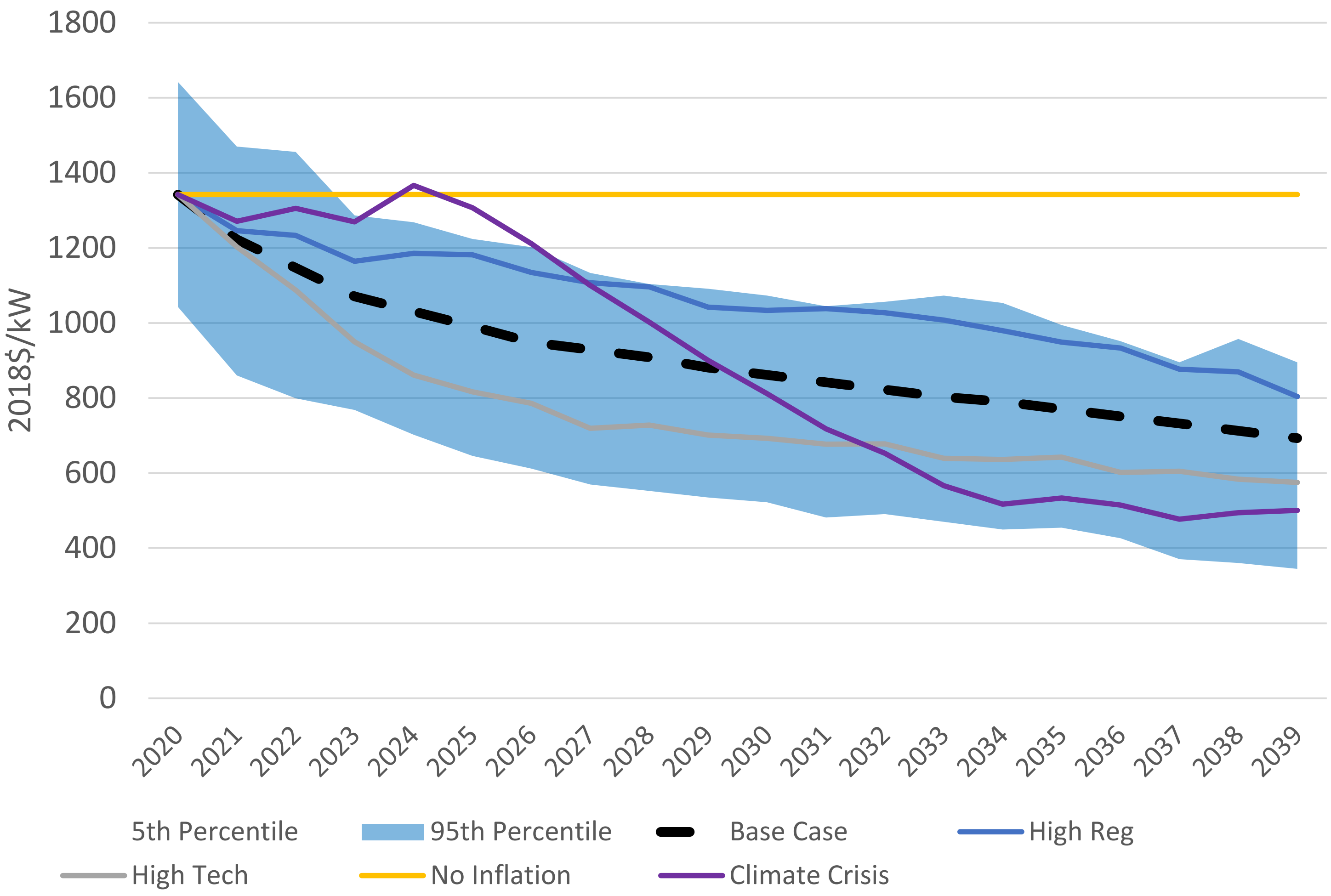
- More mature renewable technology than solar experiencing slight capital cost improvements.
- Manufacturers focused on improving capacity factors and operation at lower wind speed to reduce LCOE.
- High Technology scenario forecasts capital cost improvements from the base case.
- High Regulatory scenario sees upward price pressure that comes from higher demand.
- Climate Crisis scenario sees a cost increase in the mid-term due to increasing demand and rapid decline in the long term thanks to more research and investment which brings down the cost.

Capital Costs for Solar in Scenarios



- Due to technology improvements, growing economies of scale, and technology maturation, costs for solar have declined rapidly in recent years.
- High Tech case forecasts capital cost improvements from the base case.
- High Regulatory scenario sees upward price pressure that comes from higher demand.
- Climate Crisis scenario sees a cost increase in the mid-term due to increasing demand and rapid decline in the long term thanks to more research and investment which brings down the cost.

Capital Costs for Storage in Scenarios



- New manufacturing capacity and advancement of new LiB chemistries with cheaper materials such as aluminum, manganese, and phosphate lead to continued long term cost declines.
- High Tech case forecasts capital cost improvements from the base case
- High Regulatory scenario sees upward price pressure that comes from higher demand.
- Climate Crisis scenario sees a cost increase in the mid-term due to increasing demand and rapid decline in the long term thanks to more research and investment which brings down the cost.

Resource Options and WACC

Siemens maintains a database of technology research and analysis to estimate cost and performance assumptions

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Technology Database

- Database of all applicable studies, projects, and announcements as a basis for cost and performance assumptions
- All sources are within three years
- Key public sources include the NREL ATB, EIA AEO, Lazard LCOE, and Lazard LCOS annual reports.
- Key subscription based sources such as ThermoFlow, S&P Global, Energy Velocity, and Greentech Media are also included.
- Key sources may also include client confidential data

Screening Process

- Screens each source for equipment type, model, project scope, and location to develop qualified samples.
- Qualified samples are modified using variables including locational adjustments, inflation adjustments, and owner's interest rates to develop comparable national samples.

Technology Assumptions

- Use statistical analysis from the comparable national samples and expert opinion to determine likely cost ranges for each technology.
- For forecasting, consider several factors, such as the recent and expected rates of technological improvements for existing technologies and new technologies that are under development.
- In addition, both public and private sources are used as a comparison as guidance for forecasted projections.

Eight resources with diverse cost and performance metrics are proposed for the production cost model long term capacity expansion

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Technology	Advanced 2x1 Combined Cycle	Conventional 1x1 Combined Cycle	Simple Cycle Advanced Frame CT	Simple Cycle Aero CT	Coal With 30% CCS	Utility Solar PV - Tracking	Onshore Wind	Lithium Ion Batteries - 4 Hour
Fuel	Nat. Gas.	Nat. Gas.	Nat. Gas.	Nat. Gas.	Coal	Sun	Wind	Elec. Grid
Construction Time, Yrs	3	3	2	2	5	1	2	<1
Size (MW)	950	350	343	50	600	50	100	20 MWh
Baseload Heat Rate (Btu/kWh), HHV	6,164	6,560	8,704	9,013	9,750	N/A	N/A	N/A
Average Heat Rate (Btu/kWh), HHV	6,536	7,011	8,704	9,013	9,750	N/A	N/A	N/A
VOM (2018$/MWh)	1.81	5.01	3.87	5.45	7.14	0.00	0.92	1.39
FOM (2018$/kW-yr)	15.90	17.41	9.53	15.70	73.45	20.70	36.56	9.18
CO2 Emissions Rate (Lb/MMBtu)	119	119	119	119	144	0.00	0.00	0.00
2019 Capacity Factor (%)	60%	55%	10%	10%	85%	22%	40%	15%

Financial Assumptions for Market Economic Capacity Additions

Technology	Advanced 2x1 CCGT	Conventional 1x1 CCGT	Simple Cycle Advanced Frame CT	Simple Cycle Aero CT	Coal With 30% CCS	Utility Solar PV - Tracking	Onshore Wind	Lithium Ion Batteries (4 hrs.)
Fuel	Nat. Gas.	Nat. Gas.	Nat. Gas.	Nat. Gas.	Coal	Sun	Wind	Elec. Grid
Book Life	30	30	30	30	40	30	30	15
Debt Life	20	20	20	20	20	20	20	10
MACRS Depreciation Schedule	20	20	15	15	20	5	5	7
Cost of Equity (Utility / Merchant)	9.7% / 13.46%	9.7% / 13.46%	9.7% / 13.46%	9.7% / 13.46%	9.7% / 13.46%	9.7% / 13.46%	9.7% / 13.46%	9.7% / 13.46%
Cost of Debt (Utility / Merchant)	4.37% / 6.46%	4.37% / 6.46%	4.37% / 6.46%	4.37% / 6.46%	4.37% / 6.46%	4.37% / 6.46%	4.37% / 6.46%	4.37% / 6.46%
Equity Ratio (Utility / Merchant)	45% / 45%	45% / 45%	45% / 45%	45% / 45%	45% / 45%	45% / 45%	45% / 45%	45% / 45%
Debt Ratio (Utility / Merchant)	55% / 55%	55% / 55%	55% / 55%	55% / 55%	55% / 55%	55% / 55%	55% / 55%	55% / 55%
After Tax WACC (Utility / Merchant)	6.16% / 8.71%	6.16% / 8.71%	6.16% / 8.71%	6.16% / 8.71%	6.16% / 8.71%	6.16% / 8.71%	6.16% / 8.71%	6.16% / 8.71%

Technology assumptions are used to estimate the Levelized Cost of Energy for new resource options

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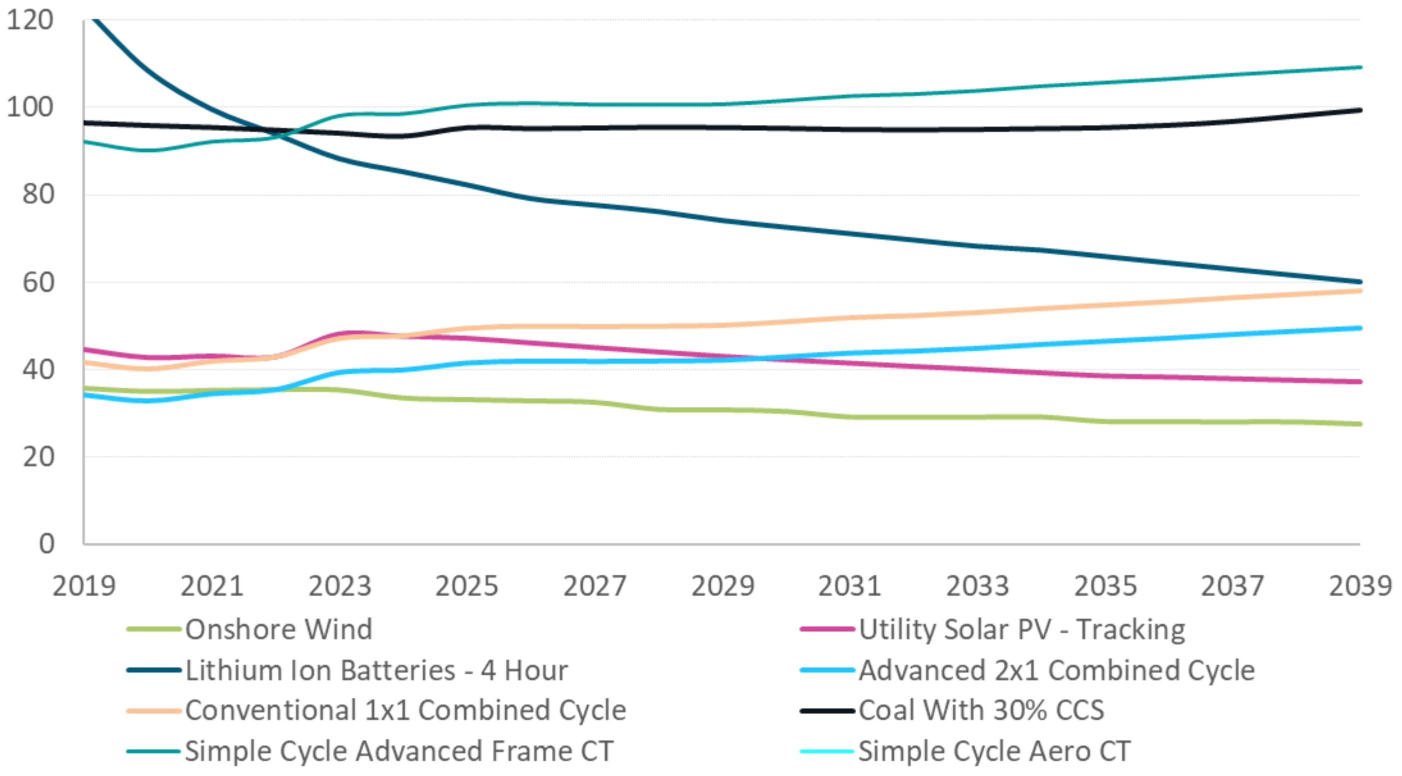
Levelized Cost of Energy by Technology, $/MWh



- Thermal technologies slightly increase over time due to US cost of carbon assumptions beginning in 2024
- Storage LCOE becomes cost competitive with thermal peakers by 2023
- Solar rises in the near term as the ITC declines
- Wind improvements in annual energy production drive costs down

These Levelized Cost of Energy estimates are dependent on output parameters from the production cost model and are subject to change

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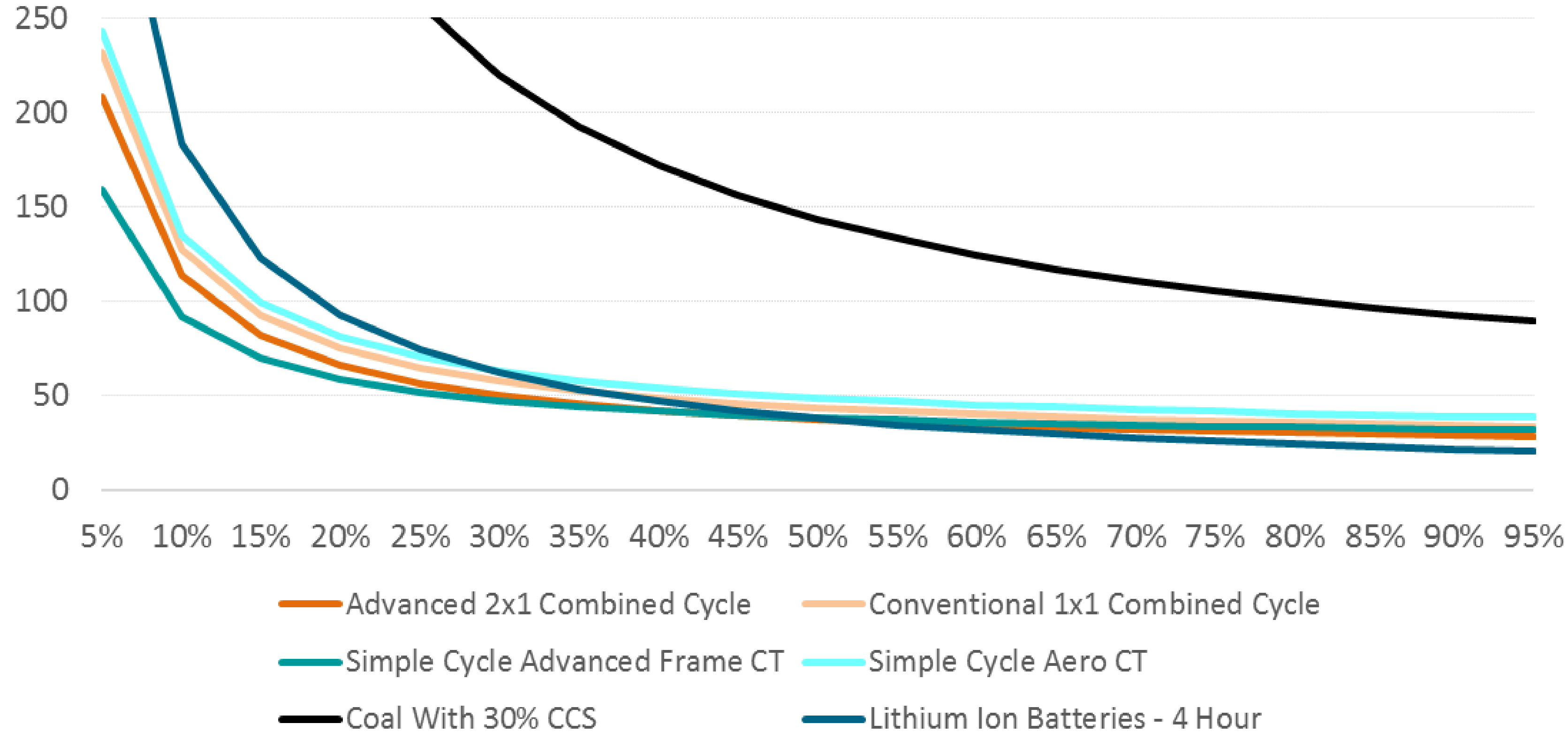
Levelized Cost of Energy by Capacity Factor, $/MWh



- The LCOE for these technologies at 5% capacity factor are 5-17x the LCOE at 95% capacity factor
- Unlike fuel costs which are an input to the model, storage charging costs are an output to the model
- LCOE does not capture parameters that should also be considered in resource development such as:
  - Development Time
  - Internal Rate of Return
  - Environmental policy and targets

Transmission

Transfer Limit Assessment

- Transmission analysis is required to assess power transfer limits and network performance under different strategies:
  - BAU (status quo with TVA)
  - MISO strategy (purchase from MISO)
  - Self supply option
  - Combined (self supply and MISO)
  - Possibly combination of all of the above.
- Commenced analysis to evaluate MISO and TVA transmission deliverability
- Identified transmission bottleneck and initial view on upgrade options
- Feed into LTCE and Nodal runs as interface limit

Transfer Limit Assessment

- Source and sink definition:
  - BAU (Source: TVA generators, Sink: MLGW)
  - MISO Strategy (Source: MISO South generators, Sink: TVA generators with high impact on MLGW)
  - Combined Strategy (same as above)
- High impact TVA generators:
  - Near MLGW, likely to ramp down if receiving power from MISO
- MISO South generators will ramp up and flows increase on MISO—TVA interface under MISO or Market Strategy
- Assess transfer limit under N-1 contingency conditions
- Identify needs for reinforcements

Name	MW
Allen CC	1070
Lagoon Creek CC	296
Southaven CC	720
Gleason CT	514
Magnolia CC	984
Shawnee Fossil	1197
Brownsville CT	450
Total	**5231**

Transfer Limit Assessment
Key Transmission Lines and Generators

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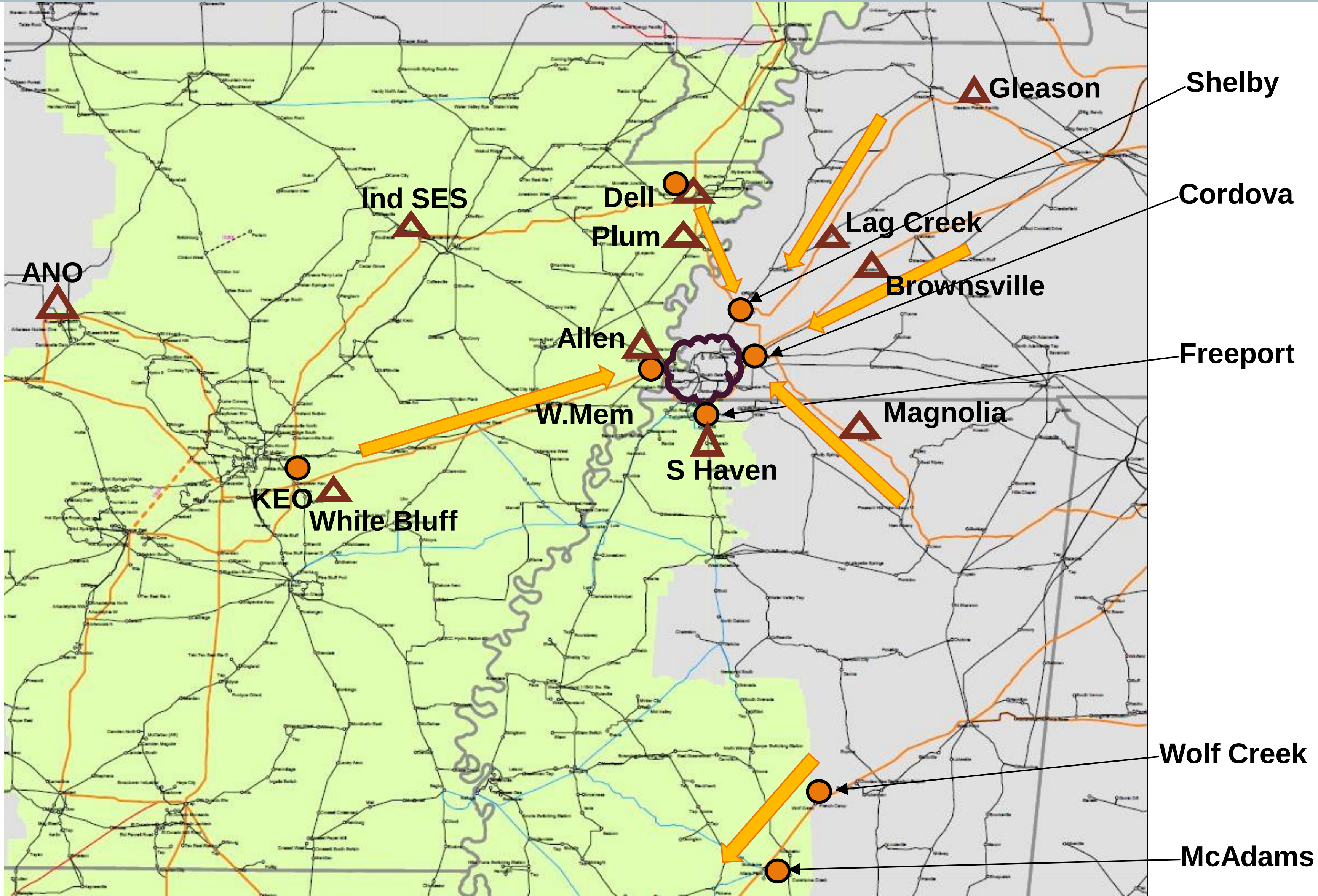
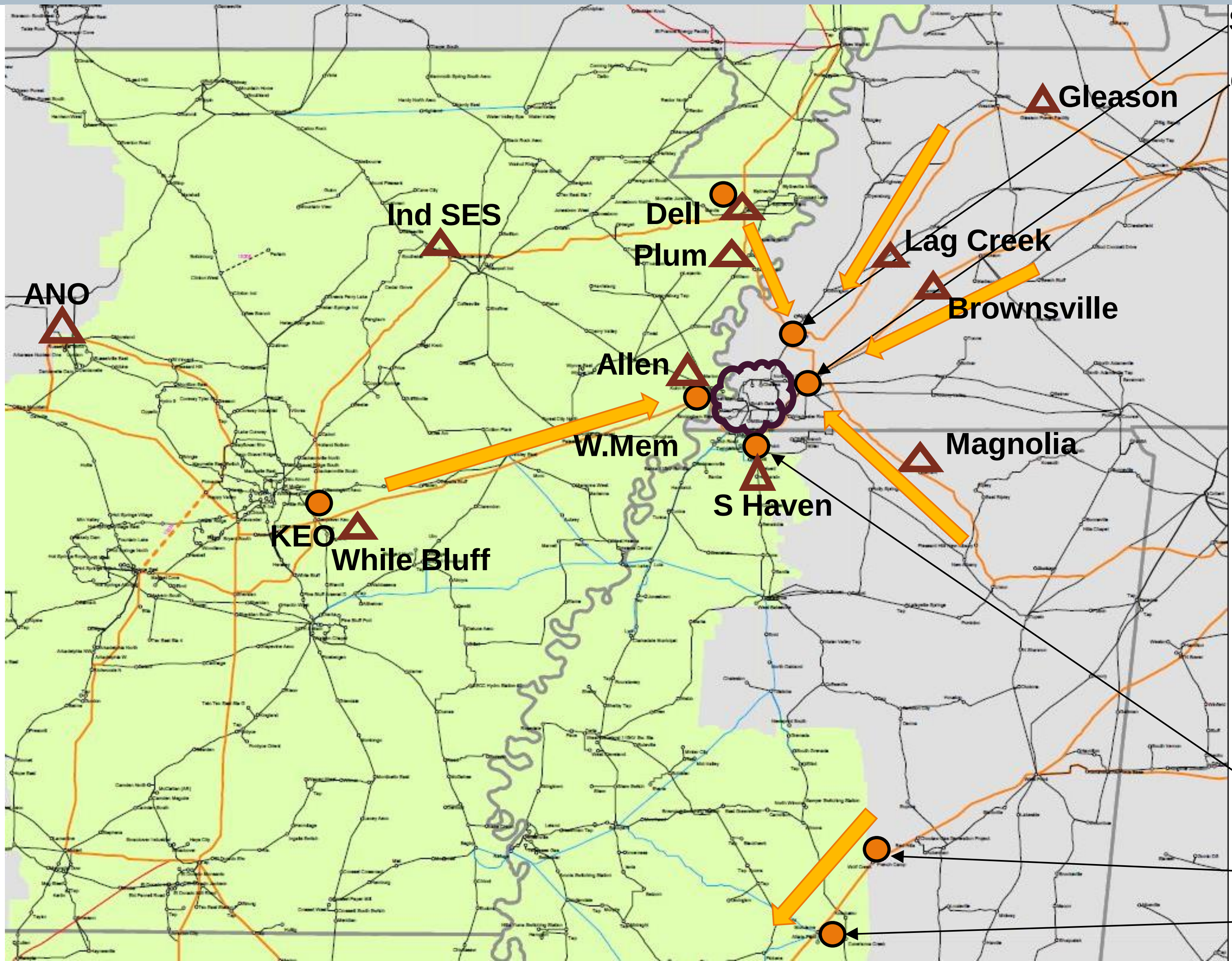


MISO to TVA 500 kV	Line Capacity MVA
Dell to Shelby	2575
KEO to W. Memphis	1732
McAdam to Wolf Creek to Choctaw	1949

- Under normal condition, more than 4300 MVA line capacity
- Under N-1 condition, KEO to West Memphis becomes bottleneck
- MLGW well interconnected with TVA under any conditions

△ Generator ● Substation

Transfer Limit Assessment
Line Flow Changes under Transfer



500 kV Line Flows	Before Transfer (MW)	After Transfer (MW)
Dell to Shelby	932	1492
KEO to W. Memphis	739	1365
McAdam to Wolf Creek	-710	116
Brownsville to Cordova	30	-50
Lag Creek to Shelby	250	83
Magnolia to Cordova	896	730

- Based on MMWG 2019 Summer base case
- Transfer 3450 MW from MISO S to TVA local generators

Transfer Limit Assessment

- Preliminary Results / Subject to refinement (2019)

	Incremental Transfer Capability (FCITC)			Comment
Strategy	Source to Sink	Summer (MW)	Winter (MW)	FCITC are additional flows before reaching limit, on top of existing flows.
MISO or Combined	MISO South to TVA local MLGW generators	3450	4500	More than MLGW summer peak load ~3270 MW (2019) could be served from MISO. (1830 MW Winter peak)
BAU TVA	TVA to MLGW	4,050	3,330	The load at MLGW could increase by 780 MW in summer or 1,500 in winter before limited under N-1 contingency.

- No transmission additions appear to be necessary. MLGW would have to have a physical connection to MISO; opportunities at Allen and/or Freeport.
- Most of the flow is over TVA lines in this case.

Breakout section

Breakout Section

The breakout objective is to give the PSAT option think about our presentation and provide feedback, in particular:

a. Please prioritize the recommended scenarios (5 is most important, 4 next, 3 moderate, 2 questionable validity, 1 not needed.)
b. Please prioritize the optional sensitivity/scenarios studies (5 is very important, etc.)
c. Are you comfortable with the direction of the key variables relative to the base case? (for each case – 5 very comfortable, etc.)
d. Are you comfortable with the ranges of the stochastic bands (for each variable 5 is very comfortable.)
e. the list of generation options comprehensive? (Yes or no, and if no, what would you add.)
f. Is transmission approach comprehensive? (Yes or no and if no, what would you add.)