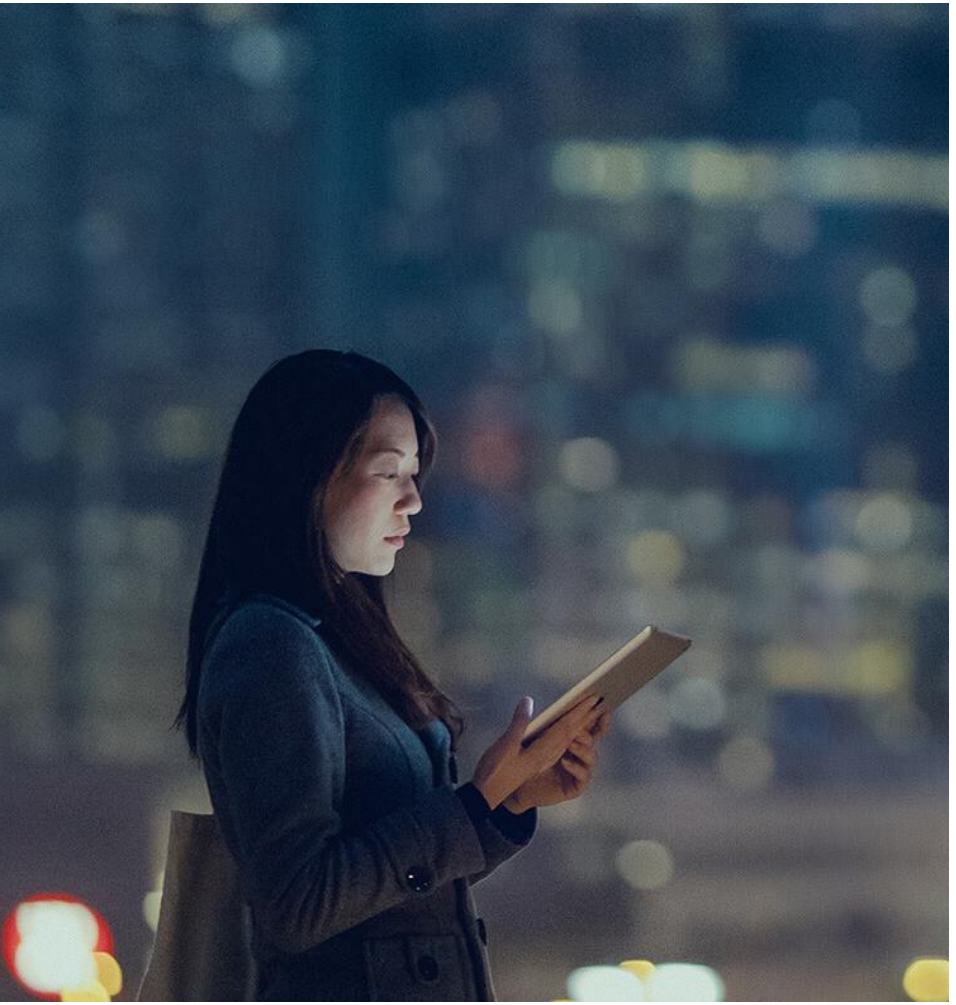
IRP Project Update

PSAT Meeting

November 7, 2019

Agenda



MLGW Opening Remarks / Safety brief	10:00 am
Schedule and Recap on last PSAT Meeting	10:10 am
Transmission and LTCE Update	10:25 am
ICF Study Review	10:45 am
Working Lunch	11:30 am
Brattle Study Review	11:45 am
Breakout Session	12:30 pm
Summary of Breakout & Next steps	1:30 pm
Meeting adjourn	2:00 pm

Schedule

Where we are

- Finalizing all input assumptions
- Finalized all Strategies and Scenarios
- LTCE on Strategy 3: MISO + Self Supply underway
- Modeling Strategy 1: All TVA (still gathering TVA data) & Strategy 2: Full MISO underway
- Transmission analyses underway

What we plan to present in the next 3 PSAT meetings

January 23 2020

- Results on Strategy 2 & 3 on all Scenarios
- Assumptions on Strategy 1

February 27 2020

- Complete Strategy 1 on all Scenarios
- Risk Analysis & Transmission Analysis results

March 26 2020

- Recommendations, select best portfolio, Gap Analysis

Recap on 9/16 PSAT Meeting

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- PSAT members provided comments/suggestions on mainly two questions:
  1. List of generation options:
     - Group 1: research Nuclear (modular), and Hydroelectric w/ Mississippi River
     - Group 2: research Hydro, Residential / Commercial, Geothermal, Microgrids
  2. Prioritize the recommended scenarios:

	Reference Scenario	High Tech	High Reg.	No Inflation	Worst Historical	Best Historical	Climate Crisis	MISO Operational Change
Group 1	5	4-5	5	1	3	1	4-5	1
Group 2	4	4	4	5	2	2	4	

  3. PSAT members generally concurred the comprehensiveness of other options presented:
     - Sensitivity, Stochastics, Transmission approaches
  4. The highlighted scenarios are given priority in our LTCE runs.

Final Strategies and Scenarios

*Strategy**

- Strategy 1 : TVA (Full requirement contract)
- Strategy 2 : Full MISO (Full market purchase from MISO)
- Strategy 3 : MISO + Self Supply

*Self Supply dropped

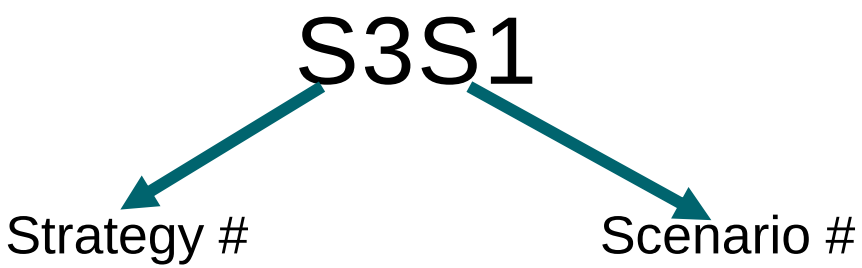
*Scenario***

- Scenario 1 : Reference Scenario
- Scenario 2 : High Regulation
- Scenario 3 : High Technology
- Scenario 4 : Climate Crisis
- Scenario 5 : No Inflation

**Future state of the world

**Details on Scenario assumptions included in Appendix

LTCE Case Nomenclature



Total Planned LTCE Cases

	Strategy 1*	Strategy 2*	Strategy 3
Scenario 1	S1S1	S2S1	S3S1
Scenario 2	S1S2	S2S2	S3S2
Scenario 3	S1S3	S2S3	S3S3
Scenario 4	S1S4	S2S4	S3S4
Scenario 5	S1S5	S2S5	S3S5

*Only one resource portfolio under full MISO or TVA Strategy, costs will vary among scenarios; Five resource portfolios under Strategy 3 due to variations from self-build

Transmission Update (work is ongoing)

- **Strategy 1 :** TVA, BAU for transmission
- **Strategy 2 :** Full MISO: 2 options: Deal or Middle-Ground
- **Strategy 3 :** MISO+Self Supply: 3 options: Deal, Middle-Ground, and No-Deal

	Wheeling Fee	Exit Fee	New Transmission	Reliability	Self-Supply	Total Transmission Cost*
Deal	Full, high fee $30~50/kw-year	High, one-time	Minimal connection required to join MISO, some new facilities required for interconnection of new resources	As is	Flexible, moderate	Depending on exit and wheeling fee, subject to negotiation.
Middle-Ground	Partial, low fee	Medium one-time	Strong connection, capacity to cover peak load less self supply. Duplicated facilities. Some interconnection.	Stronger, for both	Flexible, moderate	Above, plus $100~$150 M
No-Deal	No fee	No	Strong connection, Strategy 2 likely infeasible, Strategy 3 likely feasible (need analysis to confirm). Duplicate facilities raise costs. Some interconnection.	Minimum, reduced for both	Strong self-supply required	$150~$300 M

*Transmission costs are preliminary and subject to refinement

Recap on last PSAT Meeting

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PSAT members responded to questions on Demand Forecast, Gas / Supply, and LTCE Topics

1. Demand Forecast feedback (*Siemens updated its load forecast with latest 2019 data*):
   - Load growth is expected to be generally flat, EE and small DG will offset population or EV growth.
   - Rooftop PV or EV adoption should be considered without incentives (adoption should be based on economics)
2. Gas and Supply Options feedback:
   - Combine Cycle plants should be considered as a viable option.
   - Small Modular Nuclear does not appear to be viable today due to the cost, but could become more attractive in the future if technology advanced significantly.
   - Bellefonte Nuclear should not be considered as a viable option in this study.
3. LTCE feedback
   - The RPS goal for Strategy 3 should be relatively low in the Reference Scenario (note: 5%-15% considered).
   - An annual capital expenditure limit should be considered (i.e. 3 times annual payment to TVA,~$3B).
   - Net market exports should be limited to minimize excess generation.

Proposed Changes

1. RPS Goals for Strategy 3: MISO + Self Supply

Scenario	Ref. Scenario S1	High Regulation S2	High Tech. S3	Climate Crisis S4	No Inflation S5
Year	2025-2039	2025-2029 and 2030-2039	2025-2039	Climate Action Plan, 60% by 2020	All years flat
RPS %	5% to 15%	15% to 20%, 20% to 40%	15% to 30%	65% by 2025, 75% by 2035 and 100% by 2050	0%

2. Capital Limit
   - Will use 3rd party capital cost for generation development
   - Limits will be based on how much can be interconnected in a given year
3. Market Trade
   - Limit net export – goal is to meet but not exceed requirement
4. Emission Limit
   - No limit for Scenario S1 & S5, limit for Scenario 2 and 4.
5. Solar Cost and Capacity Factor updated

LTCE Constraints for Strategy 3

- **RPS** (see previous slide)
- **Reserve Margin Target**
  - Target reserve margin of 16.8%, same as MISO. Purchase from MISO capacity market is an option to meet reserve margin, but is limited to 600 MW to minimize market risk. (MISO: $10,000~60,000/MW-year)
- **Net Import**
  - On an annual energy basis, ensure MLGW to be a net importer
- **Import and Export Constraints used in LTCE**

	Summer (MW)	Winter (MW)
MLGW – MISO	2500	2500
MISO – MLGW	3500	3500

*based on strong transmission buildout, subject to refinement from transmission analysis

- **Technology Limits**
  - At least one CCGT 950 MW is required for reactive power support

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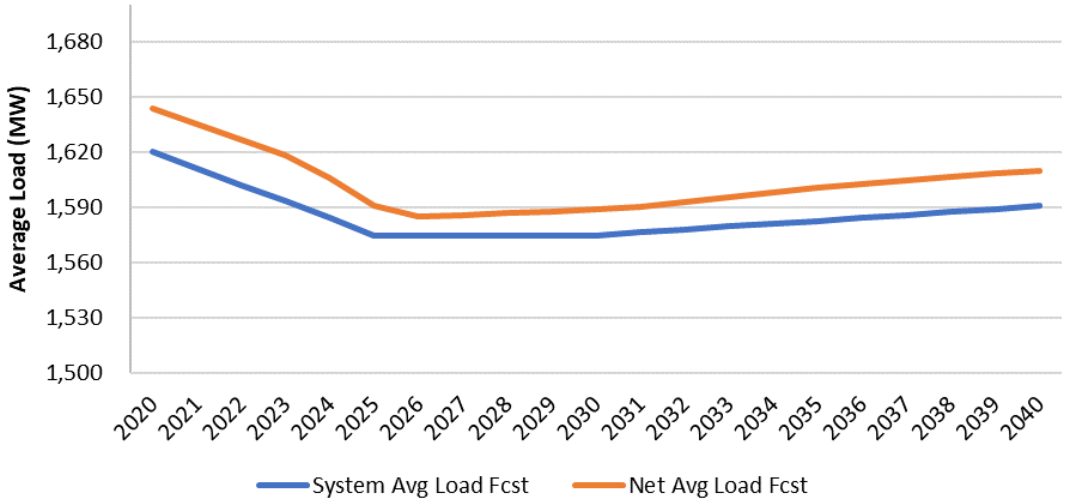
LTCE Assumptions Update S3S1

Load Forecast Updates Since Last Meeting

- Updated forecast based on new data through Sept. 2019 and limited to five years (2014-19) instead of ten (2008-2018).
  - Better reflects recent trends without weight of recessionary impacts from early data (2008-2013).
  - Average load forecast still decreasing, but at a reduced rate when compared to 10 year regression analysis.
  - Peak load forecast is now increasing slightly compared to 10 year regression analysis that was decreasing over time.
- Included known development loads in downtown Memphis, new Amazon facility, and new FedEx facility, increasing average load by approximately 24MW and peak load by approximately 34MW.
- EV peak forecast was revised based on updated peak profile.
- EE average and peak forecasts updated from 0.3% of sales to 0.5% of sales based on a review of EIA Form 861 data of EE portfolios from comparable regional electric utilities.
- DS penetration projections are based on NREL's DG model for a comparable midwestern municipal utility with updates for Memphis and did not change.

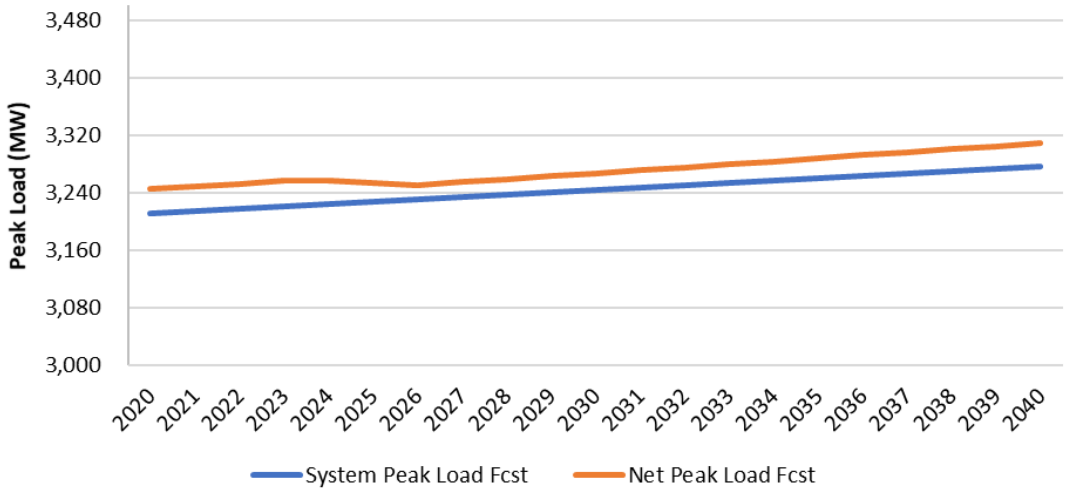
Net Average Load Forecast



- Regression modeling suggests a reduction in average load in the near term (5 years).
- Net adjustments from EE and Distributed solar offset the EV growth.
- We updated the load forecast to reflect known development loads in downtown.

	2020	2025	2030	2035	2040
System Average-MW	1,620.00	1,574.84	1,574.84	1582.73	1590.66
EV-MW	0.70	2.72	7.07	13.46	20.07
EE-MW	-0.00	-9.68	-16.22	-16.30	-16.39
DS-MW	-0.00	-0.01	-0.02	-2.47	-7.84
Development Loads-MW	23.05	23.05	23.05	23.05	23.05
Net System Average-MW	1,643.75	1,590.92	1,588.72	1,600.47	1,609.55
EV+EE+DS+Dev. Loads as %	1.5%	1.0%	0.9%	1.1%	1.2%

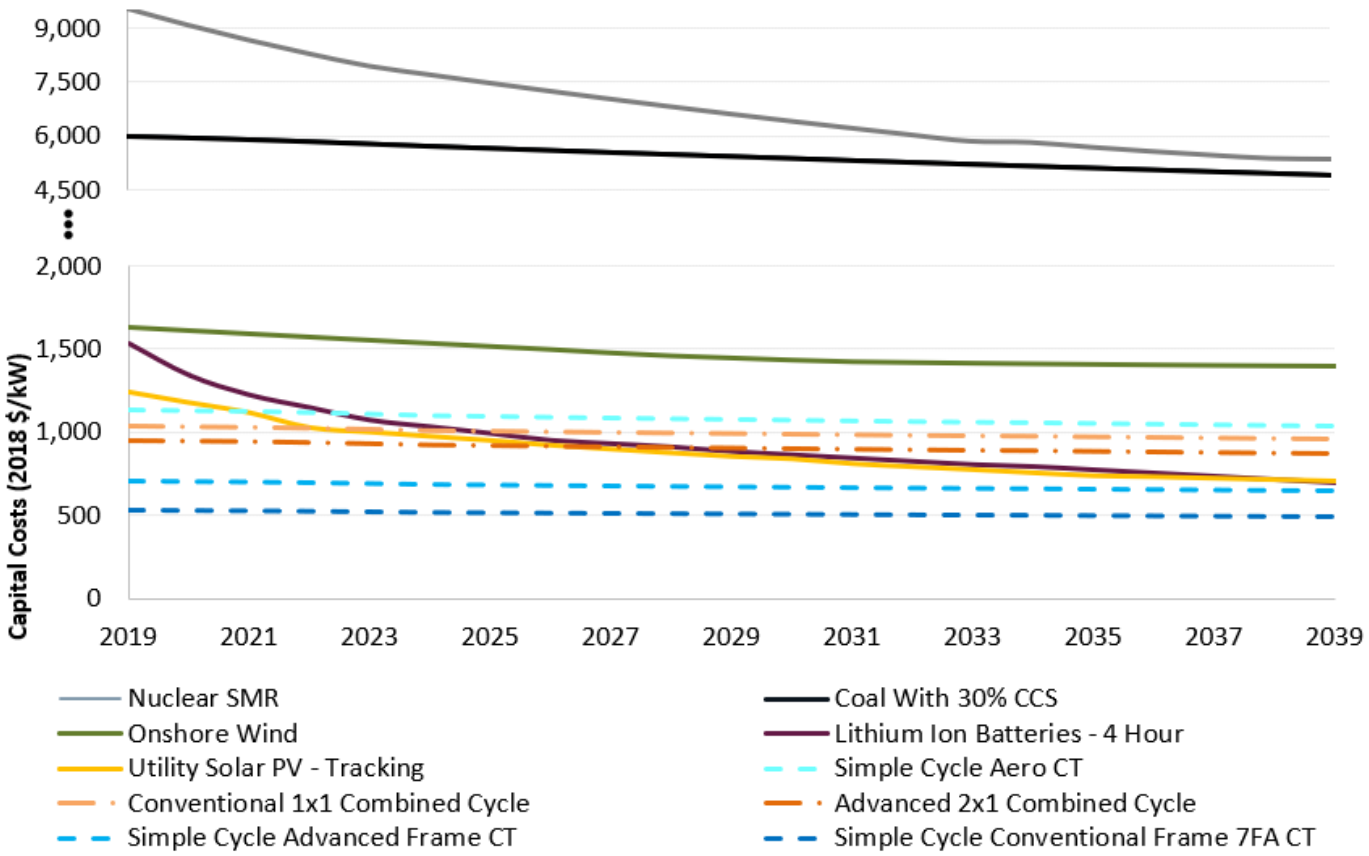
Net Peak Load Forecast



- Peak forecast reflects new development in downtown Memphis. Amazon and FedEx add significantly to the peak.
- New development and EV growth more than offset DS and EE reductions.

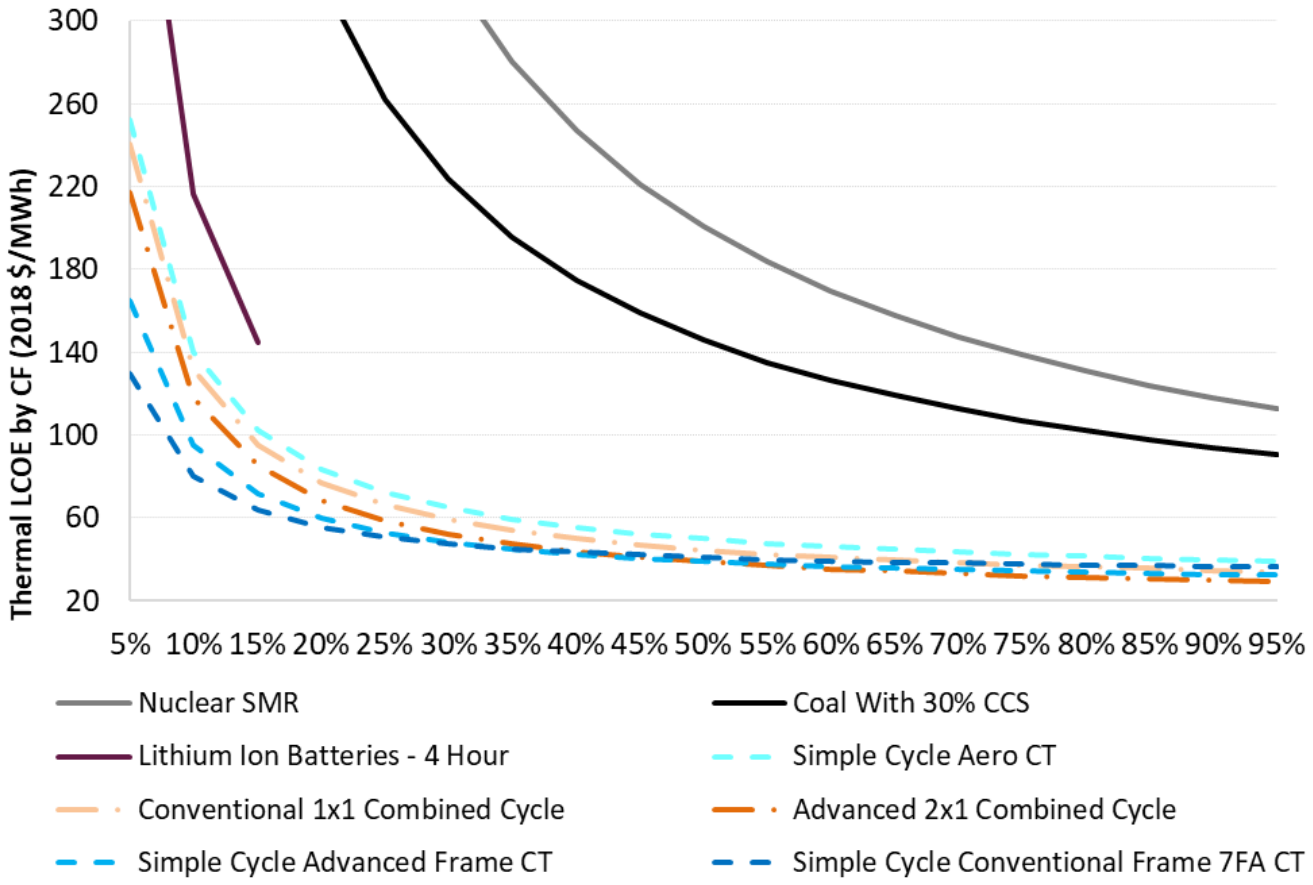
	2020	2025	2030	2035	2040
System Peak-MW	3,211.38	3,227.72	3,244.15	3,260.66	3,277.25
EV-MW	0.50	1.97	5.12	9.75	14.53
EE-MW	-0.00	-9.38	-16.22	-16.30	-16.39
DS-MW	-0.00	-0.00	-0.00	-0.08	-0.26
Development Loads-MW	34.10	34.10	34.10	34.10	34.10
Net System Peak-MW	3,245.99	3,254.11	3,267.15	3,288.12	3,309.24
EV+EE+DS+Dev. Loads as %	1.1%	0.8%	0.7%	0.8%	1.0%

Technology Options – Capital Costs



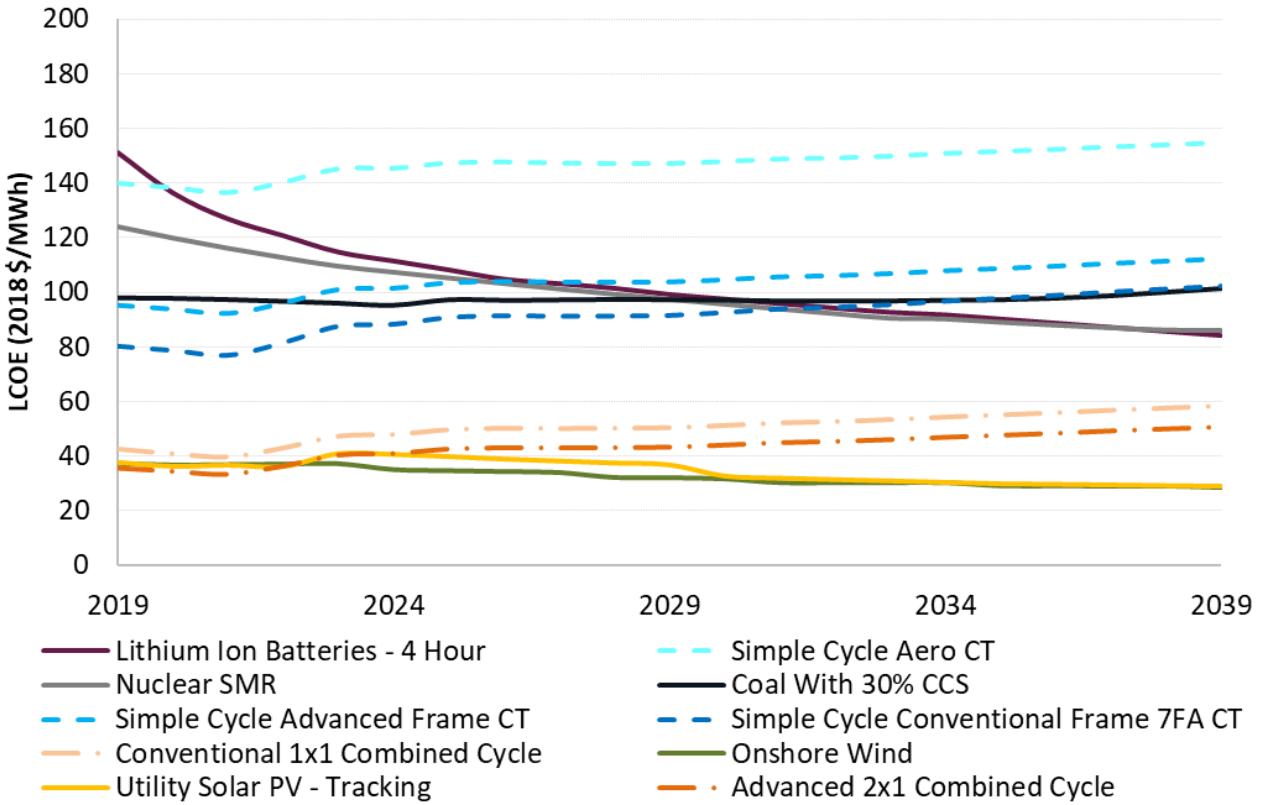
- From capital cost standpoint, nuclear and coal are the highest cost. Both options unlikely to be competitive as others.
- All of our capital cost assumptions are considered to be “All-In” capital costs which include EPC costs (engineering, procurement, construction), developer costs (land, permitting, employees, etc.), and financing interest during construction.
- However, these capital costs only include onsite costs up to the point of interconnection. Separate transmission interconnection cost applies.

Thermal Technology Options – LCOE at Various Capacity Factors



- For low capacity factors which are expected for peaking services, the Simple Cycle Conventional and Advanced Frame CT have the lowest cost, followed by the Simple Cycle Aero CT. Therefore, we would expect frame CT to be selected first, unless size requirements favor the smaller Aero CT.
- For base load services (higher capacity factors), the lowest cost is observed for the Advanced 2x1 CCGT, followed closely by the Conventional 1x1 CCGT. Hence, the LTCE decision is likely to be made largely on size requirements.
- Again SMR and coal are showing relatively higher costs for the same Capacity Factor.
- For storage the capacity factor is determined by the number of cycles expected over the year.

Technology Options – LCOE



Technology	Advanced 2x1 Combined Cycle	Conventional 1x1 Combined Cycle	Simple Cycle Advanced Frame CT	Simple Cycle Conventional Frame 7FA CT	Simple Cycle Aero CT	Coal With 30% CCS	Utility Solar PV - Tracking	Onshore Wind	Lithium Ion Batteries - 4 Hour	Nuclear SMR
Expected Capacity Factor (%)	60%	55%	10%	10%	10%	85%	22%	40%	15%	85%

- LCOE provides guidance on similar groupings of technologies but does not account for daily or hourly factors that impact modeling results.
- Based on this chart, the renewables and CCGT are more favorable than nuclear or clean coal plants.
- LCOE is highly dependent on capacity factor assumptions, where typical capacity factors for each technology are shown below the graph.
- Siemens' forecasts account for a phasing-in of bifacial solar technology and a capacity factor increase of 2.4% starting from 2030.

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Breakout Session

Breakout Session

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RPS, CO_2, Transmission, and Reserve Margin Topics

1. Do you agree with the various RPS goals as proposed for Strategy 3? (page 6)
2. Should there be CO_2 limits on Reference Scenario?
3. Should we consider all of the transmission options for Strategy 2 & 3?
4. Preference on MISO capacity purchase or self build to meet reserve margin requirement?

ICF

1. Are there issues raised by ICF that need to be considered in the MLGW analyses?

Brattle

1. Are there issues raised by Brattle that need to be considered in the MLGW analyses?

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Appendix: Scenarios

Scenarios

Siemens will utilize scenario based modeling to evaluate various regulatory constructs. The Reference Scenario 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 Reference Scenario.

	CO_2	Gas Reg.	Economy	Load	Gas Price	Coal Price	Renewables and Storage Cost	EE Cost
Reference Scenario (S1)	Base	None	Base	Base	Base	Base	Base	Base
High Technology (S2)	None	None	Higher	Higher	Lower	Lower	Lower	Lower
High Regulation (S3)	High CO_2 Price	Fracking Ban	Lower	Lower	Higher	Lower	Higher	Higher
Climate Crisis (S4)	High CO_2 Price	Fracking Ban	Lower	Lower	Higher	Higher	Much Lower	Lower
No Inflation (S5)	None	None	Flat	Flat	Flat	Flat	Flat	Flat

Scenario Narratives

Reference Scenario (refers to the broader market)

- The Reference Scenario is the “most likely” case, built with commodity forecasts based on Siemens base line forecasts
- All other scenarios reference this Scenario (individual uncertainties are at the same levels or are higher or lower)
- In the Reference Scenario:
  - 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 Reference Scenario, 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 advancements in key technologies that unlock more shale gas, increasing supply at lower gas prices relative to the Reference Scenario.
- Less demand for coal results in lower coal prices relative to the Reference Scenario.
- Utility-sponsored EE costs rise early in the forecast but ultimately fall back to below base levels due to technology advancements, 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 EVs, 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 Reference Scenario 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 Reference Scenario.
- Renewables and battery storage are widely implemented to avoid paying high CO_2 prices which drive 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 fossil generation toward renewable energy.
- Utility-sponsored EE costs are higher as more codes and standards are implemented, leaving less low hanging fruit.

Scenario Narratives

No Inflation or “Today” Scenario

- This Scenario tests the dependence of the portfolios to future outcomes; it tests the decisions considering today’s conditions.
- Everything are assumed to stay flat throughout the study years

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 costs.

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Glossary

Glossary

- All-in Capital Cost = The capital costs for building a facility within the plant boundary, which includes equipment, installation labor, owners costs, allowance for funds used during construction, and interest during construction.
- Appalachia Basin = Marcellus Shale Play and Utica Shale Play.
- Average Demand = Average of the monthly demand in megawatts.
- Average Heat Rate = The amount of energy used by an electrical generator to generate one kilowatt hour (kWh) of electricity.
- Baseload Heat Rate = The amount of energy used by an electrical generator to generate one kilowatt hour (kWh) of electricity at baseload production. Baseload production is the production of a plant at an agreed level of standard environmental conditions.
- Breakeven Cost = Average price of gas required to cover capital spending (ideally adjusted to regional prices).
- BAU = Business As Usual
- BTU = British Thermal Unit = unit of energy used typically for fuels.
- CF = Capacity Factor. The output of a power generating asset divided by the maximum capacity of that asset over a period of time.
- CC = Combined Cycle
- EE = Energy Efficiency
- CCS = Carbon Capture and Sequestration
- CT = Combustion Turbine
- DER = Distributed Energy Resources, distributed generation, small scale decentralized power generation or storage technologies
- DS = Distributed Solar
- Dth = Dekatherm (equal to one million British Thermal Units or 1 MMBtu)
- EFT = Enhanced Firm Transportation (varies by pipeline but can include short- or no-notice changes to day-ahead nominations of fuel delivery
- FID = Final Investment Decision
- FOM = Fixed operations and maintenance costs
- FT = Firm Transportation. FT capacity on a natural gas pipeline is available 24/7 and is more expensive than interruptible transportation (IT) capacity but unused FT capacity can be sold on secondary market.
- Futures = Highly standardized contract. Natural gas futures here are traded on the New York Mercantile Exchange (NYMEX) or Chicago Mercantile Exchange (CME).
- GT = Gas Turbine

Glossary

- PPA = Power Purchase Agreement; contract to purchase the power from a generating asset
- IPP = Independent Power Producer
- IRP = Integrated Resource Plan
- LNG = Liquified natural gas
- LCOE = Levelized cost of energy
- LOLE = Loss of load expectation
- LOLH = Loss of load hours
- LTCE = Long Term Capacity Expansion Plan; optimization process to select generation
- MMBTu = million British Thermal Units, unit of energy usually used for fuels
- MWh = unit of energy usually electric power = 1 million watts x hour
- MW = unit of power = 1 million watts
- Peak Demand = The maximum demand in megawatts (MW) in a year.
- PV = Photovoltaic
- Reserve Margin = The amount of electric generating capacity divided by the peak demand.
- RPS = Renewable Portfolio Standard: a regulation that requires the increased production of energy from renewable energy sources
- SMR = Small Modular Reactor
- “Sweet Spot” Core Acreage = Areas within a natural gas play that offer the highest production at least cost.
- Utility Scale = large grid-connected power generation, could be solar, gas, diesel, etc.
- VOM = Variable operations and maintenance costs
- Wheeling = a transaction by which a generator injects power onto a third party transmission system for delivery to a client (load).