Integrated Resource Plan and Transmission Analysis

PSAT Meeting | February 27, 2020

Integrated Resource Planning (IRP)… a Recap

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Why do an IRP?

An Integrated Resource Plan will be:

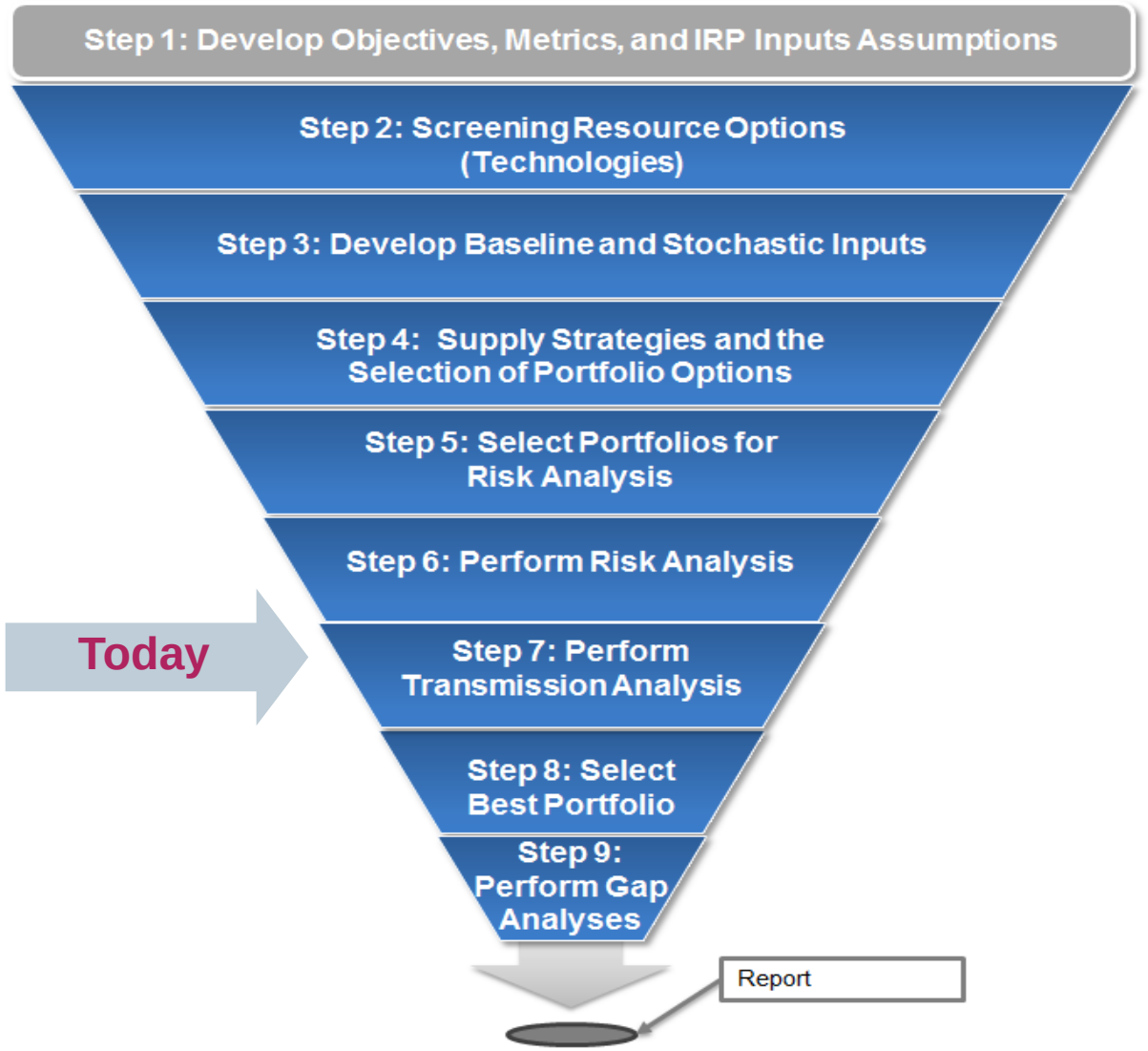
- Independent and unbiased
- Comprehensive regarding strategies and options
- Address the risk associated with market, regulatory and technology uncertainty
- Compare the TVA Full Requirements Contract to alternatives on an equivalent basis (generation, plus transmission, plus balancing, plus services)
- Reflect the opinions and views of PSAT and Stakeholders
- Reflect the objectives of MLGW, PSAT and Stakeholders

What is an IRP?

The purpose of an IRP is to provide a plan for energy resource (primarily generation and demand side programs) development to meet future load and compare the status quo (TVA FRC to market and self generation options):

- The plan must be forward looking and reflect views of future regulations, market conditions and expectations of technology changes
- The plan will suggest what portfolio of generating assets (power plants), energy efficiency programs and transmission adjustments best meet its future needs
- The plan must meet future regulatory requirements, and provide for a reliable supply of power to customers at lowest reasonable cost
- The IRP is quickly evolving into something more complex. In this case, TVA may be in a position to restrict MLGW's access to its transmission infrastructure. Hence, we must carefully consider options to interconnect with MISO under constrained conditions.

Where we are: Completing Steps 5-7 and will have a Recommendation to MLGW in March



PSAT Engagement Plan

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Start of IRP August 14, 2019	Monthly Meetings through February 2020	Objectives and Expectations
Describe the purpose of the IRP Describe the methodology that will be followed Gather PSAT insights into some key IRP issues	Provide guidance to: • Scenarios • Input assumptions • Options to be considered • Alternative Strategies • Preliminary results	• Get commitments to participate • Support the stakeholder process • Guidance and perspective

Stakeholder Engagement Plan

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Start of IRP August 14, 2019	Midpoint of IRP (November, 2019)	Conclusion of IRP (to be determined)
Engage wide range of stakeholders from the beginning of the process: • Inform, educate and listen • Provide high level overview of what to expect • Allow for comments and clarifications	Share: • Strategies to be considered • Options • Input Assumptions • Alternative Scenarios • Screening Analysis Give an opportunity to comment and recommend	• Present findings of the study and the recommended strategy and portfolio of assets • Provide an opportunity for comment and recommendations

What was Accomplished

The PSAT Guided the Process with Its Input

Guidance on the overall project needs to be:

- Comprehensive
- Transparent – don't hide calculations and assumptions
- Reflective of all of the City of Memphis's customers
- Community focused (many of the proposals received were self serving)

Guidance on the initial presentation:

- Requested additional sensitivities on extreme climate change, load and gas prices
- Agree with objectives and metrics, though resilience was not as critical for Memphis as for coastal regions
- Required input to reflect the most recent studies on renewable costs (declines) and importance of climate issues

Guidance on the consultant presentations:

- Bellefonte is too risky to consider given it was incomplete and the history of bringing projects online
- TVA had its chance to present as well

Guidance on recent presentations:

- Agrees that we should be conservative on transmission options (No Deal) but know impact of constraints
- Wants to move forward with MISO and bids when appropriate

The PSAT Guided the Process with Its Input

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Guidance on the overall project needs to be:

- Comprehensive – Thorough evaluation of generation and transmission options
- Transparent – don't hide calculations and assumptions – Report will provide details
- Reflective of all of the City of Memphis's customers – Objectives were agreed to by PSAT
- Community focused (many of the proposals received were self serving) - Covering weaknesses of studies

Guidance on the initial presentation:

- Requested additional sensitivities on extreme climate change, load and gas prices – Captured in Risk Analysis
- Agree with objectives and metrics, though resilience related to intermittency of renewables – is accounted for
- Required input to reflect the most recent studies on renewable costs (declines) and importance of climate issues – Study inputs were updated to reflect latest available data plus risk analysis

Guidance on the consultant presentations:

- Bellefonte is too risky to consider given it was incomplete and the history of bringing projects online
- TVA had its chance to present as well

Guidance on recent presentations:

- Agrees that we should be conservative on transmission options (No Deal) but know impact of constraints – Siemens is running No Deal transmission options to be conservative but also will run unconstrained case
- Wants to move forward with MISO and bids when appropriate – MISO is conducting study

The PSAT has Reviewed and Commented on the Following

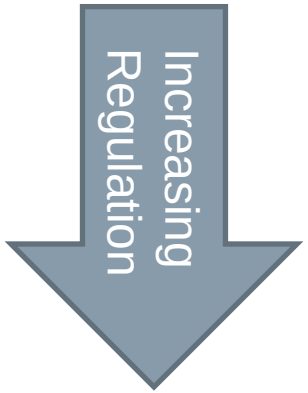
- PSAT reviewed and signed off on the objectives and metrics being used in the study to select the best alternative
- PSAT reviewed all the Strategies and Scenarios Selected for Study
- PSAT reviewed all the input assumptions for the reference case, the alternative scenarios and the stochastics
- PSAT listened to the representatives from TVA, Friends of the Earth and ICF concerning their views
- PSAT decided not to consider the Bellefonte Option
- PSAT had input into the local and transmission analyses performed (agreed with conservative view on transmission access to MISO)

The PSAT Concluded that this List was Appropriate for Evaluating Alternative Portfolios

OBJECTIVES (illustrative)	METRICS (illustrative)
Reliable	Meets or exceeds FERC/NERC/MISO reliability requirements
Least Cost (financial viability)	NPV of revenue requirements
Rate (price) Stability	95% confidence interval (worst outcome)
Sustainable	Carbon (proxy for total emissions)
Economic Growth	Qualitative (job creation)

Scenarios – Discuss and Comment

- The PSAT eliminated the Water Regs as inputs to the scenarios.
- The high-tech, high reg and the most extreme climate change scenarios were eliminated because renewables were already economic and reducing price would not change the portfolio (the cost will be captured in the stochastics).
- Additional scenarios were added; Low Load, High Load and High Load - Low Gas.
- Scenarios assessed under No Deal, but the Base Case or Reference will be studies without transmission limits.



	CO2	Gas Reg.		Economy	Load	Gas Price	Coal Price	Renewables and Storage Cost	EE Cost
Base Case	Moderate CO2			Base	Base	Base	Base	Base	Base
High Tech/Extreme Climate	Low CO2 Tax			Higher	Higher	Lower	Lower	Lower	Lower
High Reg.	High CO2 Price	Fracking Ban		Lower	Lower	Higher	Lower	Higher	Higher

**No bottom ash conversion required based on size of the unit and delay requirement for 2 years*
***ACE Delayed for 3 years*

Key Issue: Portfolio Expansion Strategies

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Supply Side Plan Technologies

- Generation Options: Solar PV, wind, biomass, utility-scale storage, combined cycles, flexible peakers (frame type or aeros), reciprocating engines, nuclear (generic)
- Demand Side Options: Energy efficiency, demand response
- Scenarios include Reference, low load, high load, high load/low gas
- Multiple strategies will be assessed as following:
  - Strategy 1: Full Requirements Contract with TVA
  - Strategy 2: Self Supply (found to be impractical) Strategy 2A: MISO (found to be impractical)
  - Strategy 3: MLGW-MISO combination with restricted transmission access (No Deal Case)
  - Strategy 4: MLGW-MISO combination with no restrictions on transmission access (Deal Case)
- Combination of scenarios and strategies can define portfolios and address a wide range of issues:

Scenarios / Portfolios		Portfolios			
		BAU/TVA		Combination (Deal – Unconstrained)	Combination (No Deal – Constrained)
State of the World	Reference	P1		P2	P3
	Scenario 2 (low load)				P4
	Scenario 3 (high load)				P5
	Scenario 4 (high load low gas)				P6

LTCE Buildout Comparison
Reference Proposed vs. Low Load

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- In the reference case there is one CT and 3 1x1 CC. About 2.55 GW of renewables selected.
- Low load results in a portfolio with less thermal (no CT) and similar renewables.

Reference

Ref Case Proposed	Advanced Frame CT	Convl. Frame 7FA CT	1x1 Combined Cycle	Utility Solar	Battery	Miss Solar	Arkansas Solar	Arkansas Wind	MISO_Cap
2025	0	237	1350	600	0	0	700	200	1639
2026	0	0	0	0	0	0	0	0	1632
2027	0	0	0	0	0	0	0	0	1626
2028	0	0	0	0	0	0	0	50	1611
2029	0	0	0	0	0	0	0	50	1597
2030	0	0	0	0	0	0	150	0	1550
2031	0	0	0	50	0	0	50	0	1523
2032	0	0	0	0	0	0	0	50	1521
2033	0	0	0	0	0	0	50	0	1522
2034	0	0	0	100	0	0	300	0	1441
2035	0	0	0	0	0	0	0	0	1458
2036	0	0	0	0	0	0	100	0	1452
2037	0	0	0	0	0	0	0	0	1469
2038	0	0	0	0	0	0	0	50	1480
2039	0	0	0	0	0	0	50	0	1487
Final:	**0**	**237**	**1350**	**750**	**0**	**0**	**1400**	**400**	**1487**

Base Load Base Gas	Thermal	Renew Local	Battery	Total Local	Renew MISO	MISO Cap	Total	2039 Demand	% reserve
End Total	1,587	750	0	2,337	1800	1,487	5,624	3,123	8.9%

Low Load

Low load Base Gas	Advanced Frame CT	Convl. Frame 7FA CT	1x1 Combined Cycle	Utility Solar	Battery	Miss Solar	Arkansas Solar	Arkansas Wind	MISO_Cap
2025	0	0	1350	600	0	0	0	50	1908
2026	0	0	0	0	0	0	0	50	1865
2027	0	0	0	0	0	0	50	50	1837
2028	0	0	0	0	0	0	0	50	1829
2029	0	0	0	0	0	0	0	50	1819
2030	0	0	0	50	0	0	800	50	1608
2031	0	0	0	50	0	0	150	0	1549
2032	0	0	0	50	0	0	50	0	1551
2033	0	0	0	50	0	0	0	0	1548
2034	0	0	0	200	0	0	0	50	1523
2035	0	0	0	0	0	0	0	50	1541
2036	0	0	0	0	0	0	50	0	1572
2037	0	0	0	0	0	0	0	0	1590
2038	0	0	0	0	0	0	0	0	1633
2039	0	0	0	0	0	0	50	0	1655
Final:	**0**	**0**	**1350**	**1000**	**0**	**0**	**1150**	**400**	**1655**

Low load Base Gas	Thermal	Renew Local	Battery	Total Local	Renew MISO	MISO Cap	Total	2039 Demand	% reserve
End Total	1,350	1,000	0	2,350	1550	1,655	5,555	3,084	8.9%

LTCE Buildout Comparison
Reference Proposed vs. High Load

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- In the High Load Case, two CTs are built and there is slightly less renewable capacity (2,350 MW vs 2,550 MW) than in the reference case.
- The cost of local renewable is close to the costs of MISO renewables.

Reference

Ref Case Proposed	Advanced Frame CT	Convl. Frame 7FA CT	1x1 Combined Cycle	Utility Solar	Battery	Miss Solar	Arkansas Solar	Arkansas Wind	MISO_Cap
2025	0	237	1350	600	0	0	700	200	1639
2026	0	0	0	0	0	0	0	0	1632
2027	0	0	0	0	0	0	0	0	1626
2028	0	0	0	0	0	0	0	50	1611
2029	0	0	0	0	0	0	0	50	1597
2030	0	0	0	0	0	0	150	0	1550
2031	0	0	0	50	0	0	50	0	1523
2032	0	0	0	0	0	0	0	50	1521
2033	0	0	0	0	0	0	50	0	1522
2034	0	0	0	100	0	0	300	0	1441
2035	0	0	0	0	0	0	0	0	1458
2036	0	0	0	0	0	0	100	0	1452
2037	0	0	0	0	0	0	0	0	1469
2038	0	0	0	0	0	0	0	50	1480
2039	0	0	0	0	0	0	50	0	1487
Final:	**0**	**237**	**1350**	**750**	**0**	**0**	**1400**	**400**	**1487**

Base Load Base Gas	Thermal	Renew Local	Battery	Total Local	Renew MISO	MISO Cap	Total	2039 Demand	% reserve
End Total	**1,587**	**750**	**0**	**2,337**	**1800**	**1,487**	**5,624**	**3,123**	**8.9%**

High Load

High Load Base Gas	Advanced Frame CT	Convl. Frame 7FA CT	1x1 Combined Cycle	Utility Solar	Battery	Miss Solar	Arkansas Solar	Arkansas Wind	MISO_Cap
2025	0	474	1350	600	0	0	600	0	1898
2026	0	0	0	0	0	0	0	0	1930
2027	0	0	0	0	0	0	0	0	1978
2028	0	0	0	0	0	0	0	100	2010
2029	0	0	0	50	0	0	0	0	2008
2030	0	0	0	150	0	0	50	0	1977
2031	0	0	0	50	0	0	50	0	1941
2032	0	0	0	0	0	0	0	50	1961
2033	0	0	0	0	0	0	50	0	1933
2034	0	0	0	0	0	0	300	50	1890
2035	0		0	0	0	0	0	0	1836
2036	0	0	0	0	0	0	150	0	1818
2037	0	0	0	0	0	0	0	0	1809
2038	0	0	0	50	0	0	50	0	1754
2039	0	0	0	0	0	0	0	0	1746
Final:	**0**	**474**	**1350**	**900**	**0**	**0**	**1250**	**200**	**1746**

High Load Base Gas	Thermal	Renew Local	Battery	Total Local	Renew MISO	MISO Cap	Total	2039 Demand	% reserve
End Total	**1,824**	**900**	**0**	**2,724**	**1450**	**1,746**	**5,920**	**3,525**	**8.9%**

LTCE Buildout Comparison
High Load Base Gas vs. High Load Low Gas

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- With low gas prices, the thermal fleet stays the same as the high load (3 CCs plus 2 CTs) but there is less renewable built: (1,700 MW vs 2,350 MW)
- The is greater utilization of the thermal fleet.

High Load

High Load Base Gas	Advanced Frame CT	Convl. Frame 7FA CT	1x1 Combined Cycle	Utility Solar	Battery	Miss Solar	Arkansas Solar	Arkansas Wind	MISO_Cap
2025	0	474	1350	600	0	0	600	0	1898
2026	0	0	0	0	0	0	0	0	1930
2027	0	0	0	0	0	0	0	0	1978
2028	0	0	0	0	0	0	0	100	2010
2029	0	0	0	50	0	0	0	0	2008
2030	0	0	0	150	0	0	50	0	1977
2031	0	0	0	50	0	0	50	0	1941
2032	0	0	0	0	0	0	0	50	1961
2033	0	0	0	0	0	0	50	0	1933
2034	0	0	0	0	0	0	300	50	1890
2035	0		0	0	0	0	0	0	1836
2036	0	0	0	0	0	0	150	0	1818
2037	0	0	0	0	0	0	0	0	1809
2038	0	0	0	50	0	0	50	0	1754
2039	0	0	0	0	0	0	0	0	1746
Final:	**0**	**474**	**1350**	**900**	**0**	**0**	**1250**	**200**	**1746**

High Load Base Gas	Thermal	Renew Local	Battery	Total Local	Renew MISO	MISO Cap	Total	2039 Demand	% reserve
End Total	**1,824**	**900**	**0**	**2,724**	**1450**	**1,746**	**5,920**	**3,525**	**8.9%**

High Load Low Gas

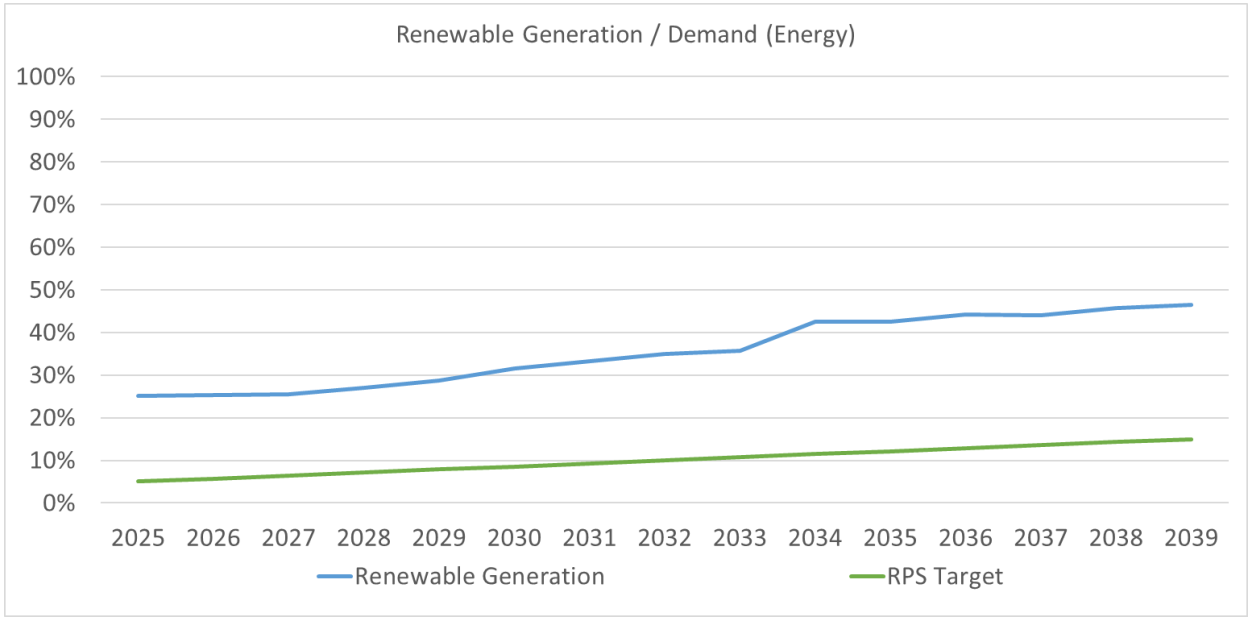
High Load Low Gas	Advanced Frame CT	Convl. Frame 7FA CT	1x1 Combined Cycle	Utility Solar	Battery	Miss Solar	Arkansas Solar	Arkansas Wind	MISO_Cap
2025	0	474	1350	600	0	0	0	0	2078
2026	0	0	0	0	0	0	0	0	2106
2027	0	0	0	0	0	0	0	0	2149
2028	0	0	0	0	0	0	0	0	2193
2029	0	0	0	0	25	0	0	0	2175
2030	0	0	0	100	0	0	100	0	2140
2031	0	0	0	0	0	0	150	0	2086
2032	0	0	0	0	0	0	0	0	2109
2033	0	0	0	0	0	0	50	0	2078
2034	0	0	0	50	0	0	400	0	2003
2035	0	0	0	0	0	0	0	0	1946
2036	0	0	0	0	0	0	100	0	1935
2037	0	0	0	0	0	0	0	0	1923
2038	0	0	0	0	0	0	0	100	1869
2039	0	0	0	0	0	0	0	50	1849
Final:	**0**	**474**	**1350**	**750**	**25**	**0**	**800**	**150**	**1849**

High Load Low Gas	Thermal	Renew Local	Battery	Total Local	Renew MISO	MISO Cap	Total	2039 Demand	% reserve
End Total	**1,824**	**750**	**25**	**2,599**	**950**	**1,849**	**5,398**	**3,525**	**8.9%**

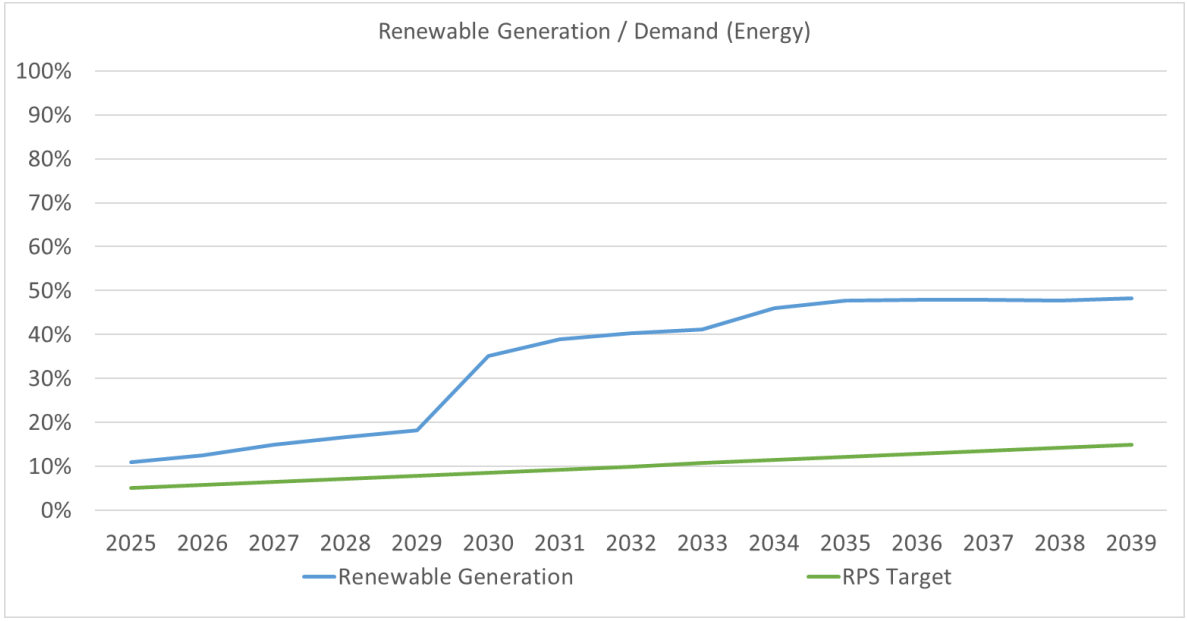
LTCE Results – Renewable Target (Reference and Low Load)

- The renewable capacity is the most economic option and both portfolios exceed the RPS targets.
- The model would select even more renewable capacity but for meeting reliability constraints

Reference



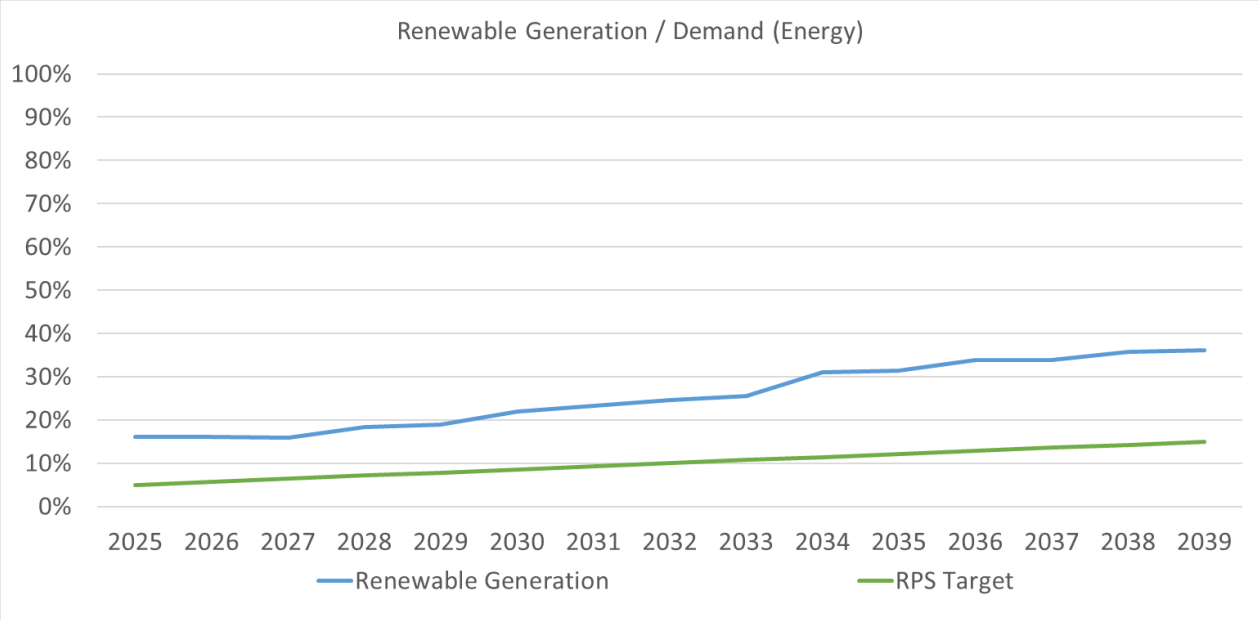
Low Load



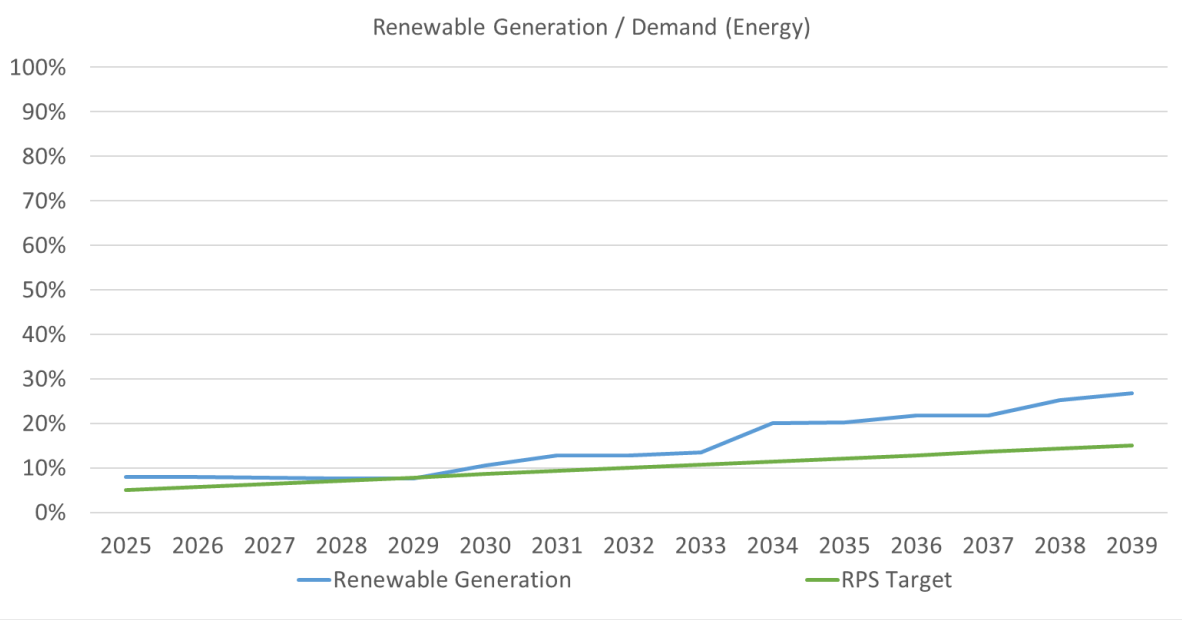
LTCE Results – Renewable Target (High Load Cases)

- The RPS target is binding in the high load and low gas scenario before 2033
- Low gas would drive higher thermal dispatch levels

High Load Base Gas



High Load Low Gas



Transmission Analysis Methodology

Siemens develop intermediate power flow cases from the LTCE results

- TVA has indicated that it is under no obligation to provide MLGW transmission access to MISO, hence Siemens has taken a conservative approach to assessing MLGW's transmission options (No Deal Case).
- Through power flow analyses, Siemens has determined an efficient transmission investment plan to achieve reliability requirements.
- Siemens has determined the mix of local and MISO resources and identified transmission upgrades needed to ensure a reliable source of supply.
- MISO is in the process of evaluating the impact of these investments on MISO's system.
- Siemens has estimated the investment in new transmission lines and the incremental interconnection costs required to achieve an economic solution. These costs will be added to the optimal generation costs to ensure an appropriate comparison to the TVA option.
- Siemens also ran an unconstrained case to determine the impact of restricted transmission access on MLGW's cost. This case could be a result of a Deal with TVA or by additional transmission investments which are being evaluated.

Preliminary Capital Costs and Interconnection Costs to Support the Reference LTCE (2200 MW Import Limit)

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- Studies to date have identified capital costs on Transmission and Interconnection totaling $560 M
  - Cost of transmission expansions: $318 M, including $23 M to TVA
  - Cost of MISO upgrade: $12 M (Freeport to Twinkletown)
  - Cost of internal reliability upgrades: $140 M
  - Cost of generator interconnections: $90 M
- Transmission O&M to be determined.
- Distribution costs not within the scope and not likely to be affected.
- All in 2019 $

To be Completed: Siemens has taken TVA's IRP Plan and developed forecasts for each component – We are Nearing Completion of This Analysis

TVA full requirements contract assessed (with TVA's support)

- Generation costs
  - Fuel costs
  - O&M
  - Capital cost
    - Interest /depreciation
- Transmission costs
  - O&M, Capital Cost
- Premiums/Overhead
  - e.g. bond retirement
  - Taxes they pay
- Other costs or benefits provided to the City (don't double count)

Type	Cost* $/MWh
Fuel Cost	
O&M	
Emission Cost	
Purchased Power	
Interest Expenses	
Depreciation	
Tax Equivalent	
Regulatory/transmission costs	
Total Cost of Power	
Selling Price to LPC	

To Be Completed: Siemens is Performing a Comparable Analysis for the MISO/Local Option

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- Generation costs
  - Fuel costs
  - O&M
  - Capital cost
    - Interest /depreciation
- Transmission costs
  - Investment, Interconnection, MISO
- Taxes (PILOT)
- Energy Efficiency Costs
- Economic Development Services.
- Overhead

Other costs (such as balancing authority, revenue grade meters on all tie lines with communications to control center, ability to pulse generators under MLGW control, SCADA up to performance standards, dispatch/generation desk in control room with staffing, planning staff and CIP compliance standards met.)

Type	Cost* $/MWh
Fuel Cost	
O&M	
Emission Cost	
Purchased Power	
Interest Expenses	
Depreciation	
Tax Equivalent	
Regulatory/transmission costs	
Total Cost of Power	
Selling Price to LPC	

Balancing Area Gap Analysis

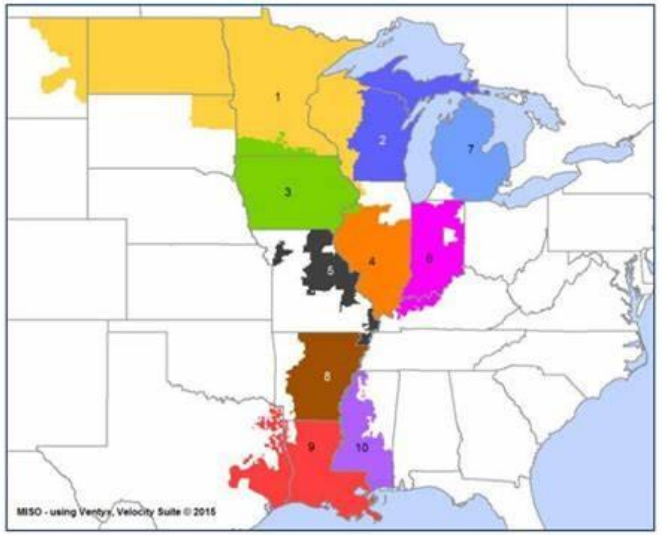
Prepare requirements document:

- NERC Balancing Authority (BA)
- MISO Local Balancing Authority (LBA)
- Industry best practices

Review MLGW existing capabilities through interviews and procedure/document:

- Control center: UPS/backup power, security access, and backup of essential functions
- SCADA and control systems capabilities
- Balancing area boundary metering
- Voice and data communications; ability to meet data exchange requirements
- Ability to perform operational and outage planning, real-time control, situational awareness
- Ability to plan and provide operating reserves
- Contingency and emergency response capabilities
- Energy accounting and transaction management capabilities
- Personnel staffing and training
- Cyber security measures

Prepare report and recommendations, including high level costs estimates for planning purposes



Source: MISO

Step 8: Select Best Portfolio and Document

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Portfolio /Criteria	Cost	Risk	Environmental	Reliability	Economic Dev.
Portfolio 1					
Portfolio 2					
Portfolio 3					
Portfolio 4					
Portfolio 5					
Portfolio 6					
Portfolio 7					

Index Ranking (0-10 Scale)	0.00	3.00	1.48	2.04	0.66	1.22	4.10	3.84	10.00	9.18	2.07
Assessment (Green < 3.33; Yellow 3.34-6.67; Red > 6.67)											

Index < 3.33 Index 3.34 – 6.67 Index > 6.67

Next steps to completion

- Complete the MISO transmission and Resource Adequacy study and adjust generation plan if necessary
- Risk Analysis on the MISO+Self Supply strategy portfolios using stochastics
- Complete TVA financial model
- Complete balancing authority/gap analysis
- Estimate transmission O&M cost on new facilities only
- Transmission PROMOD runs and stability analysis
- Draft IRP report
- Presentation for community meeting
- Final report

Questions

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