9. Integrated Resource Plan and Risk Analysis

Highlights

- *Ameren Missouri has developed a robust range of alternative resource plans that reflect different combinations of energy efficiency, demand response, various types of new renewable and conventional generation, and retirement of each of its existing coal-fired generators.*
- *In addition to the scenario variables and modeling discussed in Chapter 2, two critical independent uncertain factors have been included in the final probability tree for risk analysis: coal prices and demand-side management (DSM) costs.*

Ameren Missouri's modeling and risk analysis consisted of a number of major steps:

1. Identification of **alternative resource plan attributes**. These attributes represent the various resource options used to construct and define alternative resource plans – demand side resources, new renewable and non-renewable supply side resources, and retirement of existing supply side resources.
2. Development of the **baseline capacity position**, which reflects forecasted peak demand, reserve requirements and existing resources.
3. Development of **planning objectives** to guide the development of alternative resource plans.
4. Development of the **alternative resource plans**. The alternative resource plans were developed using the plan attributes identified in step 1, the base capacity position developed in step 2, and the planning objectives identified in step 3.
5. Identification and screening of **candidate uncertain factors**, which are key variables that can influence the performance of alternative resource plans.
6. **Sensitivity analysis** and selection of critical uncertain factors, which are key variables that are determined to have a significant impact on the performance of alternative resource plans.
7. **Risk analysis** of alternative resource plans, which is used to evaluate the performance of alternative resource plans under combinations of the scenarios discussed in Chapter 2 and the critical uncertain factors identified in step 6.

This chapter describes these various steps and the results and conclusions of our integration and risk analysis.

9.1 Alternative Resource Plan Attributes[1]

Development of alternative resource plans includes considering various combinations of demand-side and supply-side resources to meet future capacity needs. However, alternative resource plans may also include elements or attributes that serve the other planning objectives described in Section 9.3. Including these elements can significantly affect the capacity position that needs to be considered when developing alternative resource plans. Figure 9.1 includes the attributes considered during the development of resource plans. As has been mentioned, a pre-analysis was used to determine which Meramec and Keokuk options would be included in all alternative resource plans.

Figure 9.1 Attributes of Alternative Resource Plans

Retirements (End of Year)
- Meramec Retired 2022/2020
- Sioux Retired 2033
- Labadie 2 Units Retired 2036/2024
- Labadie 2 Units Retired 2042/2024
- Rush Island Retired 2045/2024

New Supply-Side Types
- Combined Cycle (Nat. Gas)
- Simple Cycle (Nat. Gas)
- Nuclear
- Pumped Hydroelectric
- Solar
- Wind with Simple Cycle

Energy Efficiency
- Maximum Achievable Potential (MAP)
- Realistic Achievable Potential (RAP)
- Missouri Energy Efficiency Investment Act (MEEIA) Cycle 2 Only

Demand Response
- MAP
- RAP
- None

Renewable Portfolios
- Missouri Renewable Energy Standard (RES)
- RES Plus

9.2 Capacity Position

To determine the timing and need for resources Ameren Missouri first developed its baseline capacity position including:

- Existing plant capabilities based on Ameren Missouri's annual generating unit rating update (i.e., July 2017 planned ratings)
- Existing obligations for capacity purchases and sales
- Peak demand forecast, as described in Chapter 3

[1] 4 CSR 240-22.060(1); 4 CSR 240-22.060(3)

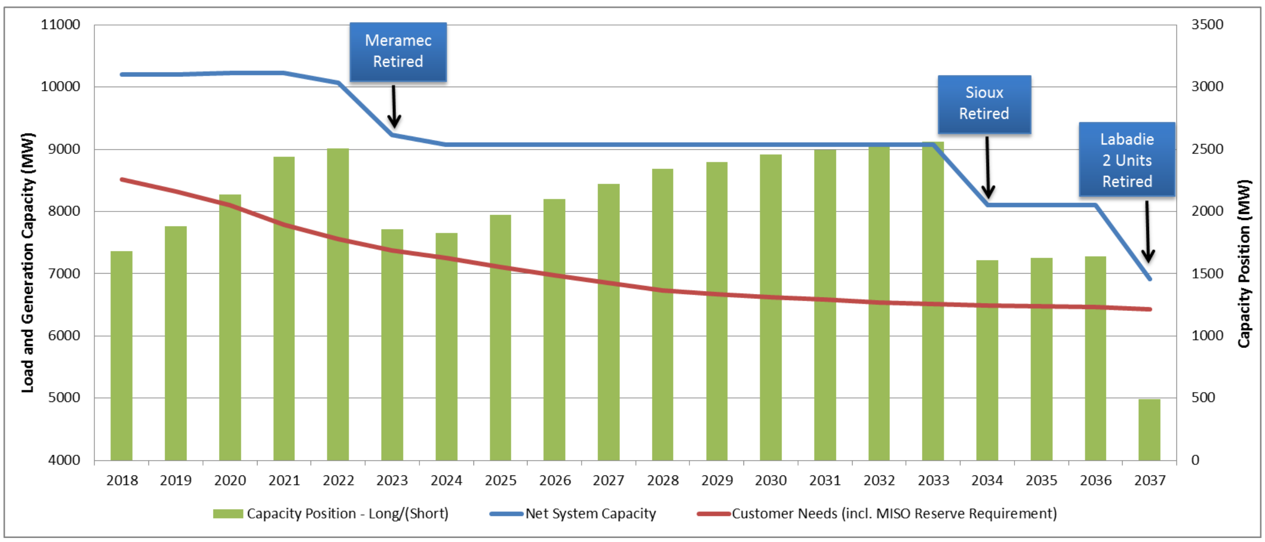
- Planning reserve margin (PRM) requirement, based on MISO's Planning Year 2017 Loss of Load Expectation (LOLE) Study Report (November 2016). Table 9.1 shows the MISO System PRM from 2018 through 2026. The long-range PRM was assumed to continue at 15.7% through the remainder of the planning horizon.

Table 9.1 MISO System Planning Reserve Margins 2015 through 2023

Year	2018	2019	2020	2021	2022	2023	2024	2025	2026
PRM Installed Capacity	15.6%	15.3%	15.4%	15.5%	15.5%	15.6%	15.6%	15.7%	15.7%

Figure 9.2 shows Ameren Missouri's net capacity position with no new major generating resources. The chart shows the system capacity, customer needs (including the MISO reserve requirement), and capacity above/below the MISO requirement (i.e., long/short position). The customer needs include peak load reductions due to RAP energy efficiency and demand response. The system capacity includes the capacity benefit of the RES Compliance portfolio.

Figure 9.2 Net Capacity Position – No New Resources (Baseline)



Retirements

Ameren Missouri is considering retirement of some or all of its six older gas- and oil-fired CTG units – Fairgrounds, Kirksville, Meramec CTG-1, Meramec CTG-2, Mexico, Moberly, and Moreau – with a total net capacity of 324 MW, over the next 20 years. Chapter 4 - Table 4.3 provides a summary of the planned CTG retirements. The CTG retirements were included in all alternative resource plans.

Coal energy center retirements were also included in the capacity planning process. Sioux retirement by December 31, 2033, was common in all resource plans, based on prior analysis of Ameren Missouri's coal power plant life expectancy by Black and Veatch. Two different Meramec retirement options were considered: 1) retirement by December 31, 2020, and 2) retirement by December 31, 2022. While the retirement dates for two units at Labadie and Rush Island, as determined by the Black and Veatch life expectancy study, are beyond the 20-year planning horizon, we have evaluated potential early retirements for both energy centers - by December 31, 2024. The alternative retirement dates for Labadie and Rush Island were based on the ability to avoid significant costs associated with environmental regulations; the potential for an explicit price on carbon starting in 2025, included in the scenarios described in Chapter 2, was the primary driver for the alternate retirement date. Labadie retirement by the end of 2024 coupled with Meramec retirement by the end of 2020 was also evaluated in an alternative resource plan.[2]

DSM Portfolios

DSM portfolios were included in capacity planning separately as energy efficiency and demand response. Energy efficiency (EE) and demand response (DR) programs not only reduce the peak demand but also reduce reserve requirements associated with those demand reductions. The following combinations of DSM portfolios were evaluated: 1) RAP EE and DR, 2) RAP EE Only, 3) RAP DR Only, 4) MAP EE and DR, 5) MAP EE Only, 6) MAP DR Only, and 7) No DSM after MEEIA Cycle 2. The No DSM portfolio reflects completion of Ameren Missouri's current three-year program cycle with no further energy efficiency or demand response during the planning horizon.

Renewable Portfolios[3]

Compliance with Missouri's Renewable Energy Standard (RES) was updated to reflect current assumptions, including baseline revenue requirements, and an updated 10 year forward looking model which calculates the impact of a 1% rate cap.

Ameren Missouri performed its RES compliance analysis with the *2017 IRP RES Compliance Filing Model* (model). The model is designed to calculate the retail rate impact, as required by the Commission's RES rules.[4] This model determines the quantity of renewable energy needed to meet both the overall RES portfolio standard and the solar portfolio standard "carve-out" absent any rate impact constraints. The model then determines the amount of renewable energy, both solar and non-solar that can be built without exceeding an average 1% revenue requirement increase over a ten-year period. Ameren Missouri's expected renewable energy credit (REC) position is presented in Figure 9.3.

[2] EO-2017-0073 1.E
[3] EO-2017-0073 1.N
[4] 4 CSR 240-20.100(5)

Figure 9.3 Ameren Missouri's RES REC Positions

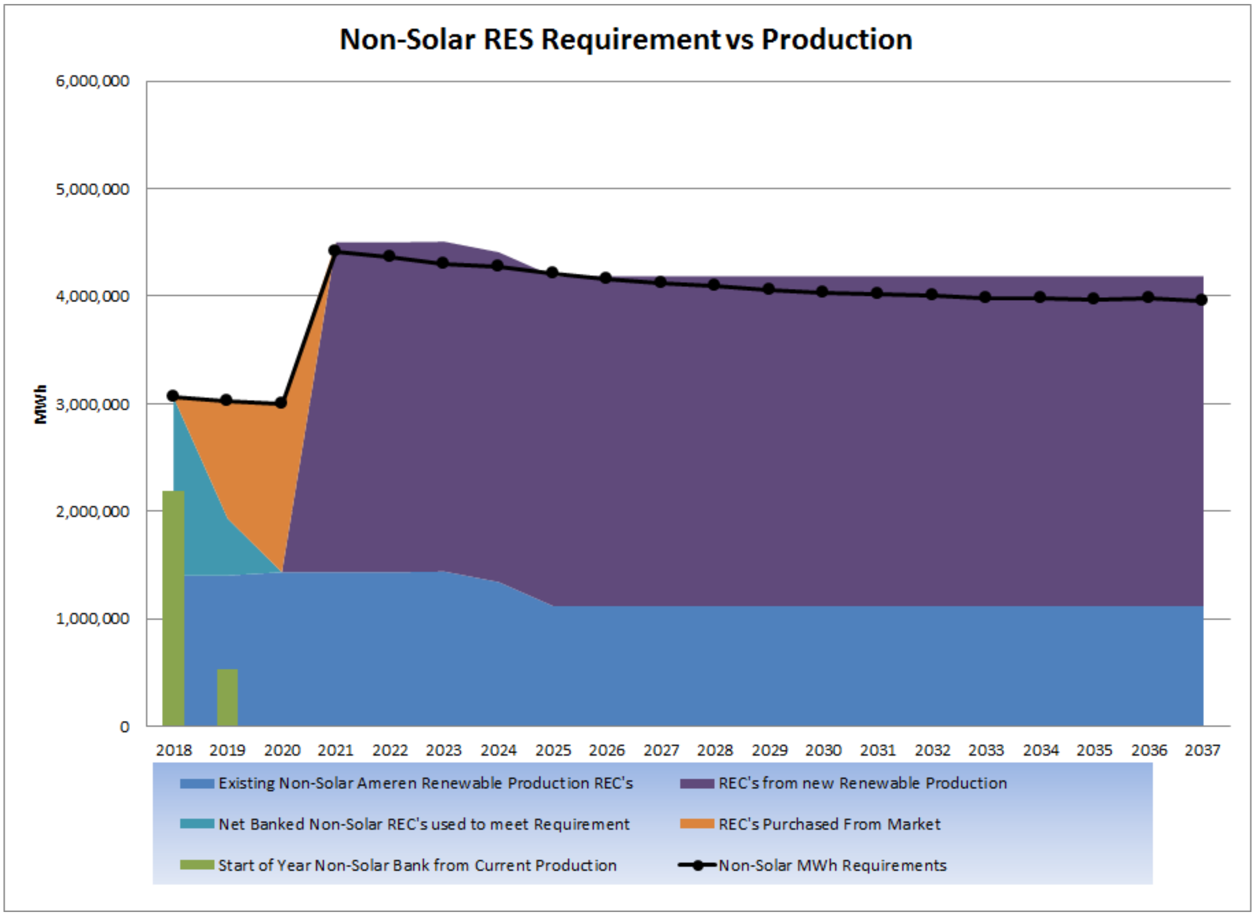


Figure 9.3 shows that Ameren Missouri expects to meet the overall REC requirement until 2021 with a combination of banked RECs, renewable generation and purchased RECs. Starting in 2021, Ameren Missouri will be able to fully meet the overall standard using RECs generated by its existing qualifying resources and additional wind resources.

Table 9.2 shows the amounts of wind and solar resources needed. The RES compliance portfolio established by the model is used for alternative resource plans and reflects wind resource additions that take advantage of Production Tax Credits, allowing full compliance with the Renewable Energy Standard while remaining under the one percent rate cap limitation. Appendix A shows the amounts of wind, and solar resources needed in Term 1 (2018-2027) and Term 2 (2028-2037).

When developing the RES compliance investment needs, consideration was given to the potential difference between RAP DSM investment vs MAP DSM investment. After modeling both, the difference in the level of renewable generation added was determined to be insignificant. Specifically, the difference was 3 MW of investment in solar and 28 MW's of wind investment for the entire 20 year term of the IRP. Therefore to provide a level comparison between plans with regard to RES compliance all portfolios are accompanied by the same level of renewable investment when evaluating alternative resource plans.

In addition to the RES Compliance portfolio, we also included a "RES Plus" portfolio to evaluate the cost of additional solar resources. The economics of solar resources may improve over time if trends toward lower cost continue while power market prices increase.

Table 9.2 shows the timing of new resources for renewables included in the alternative resource plans.

Table 9.2 Alternative Resource Plans - Renewable Portfolios

Renewable Additions		Nameplate Capacity (MW)																			
		2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033	2034	2035	2036	2037
RES Compliance	Wind	0	0	0	700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Solar	0	0	0	0	25	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0
RES Plus	Wind	0	0	0	700	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	Solar	0	0	0	0	25	0	0	25	0	50	0	0	0	0	0	0	0	0	0	0

Non-renewable Supply-side Resources

Non-renewable supply-side resource types were added last in the capacity planning process. If the capacity shortfall in a given year met or exceeded the build threshold, then supply side resources would be added to eliminate the shortfall. The build threshold was determined to be 300 MW (based on half the size of a combined cycle) regardless of the type of supply side resource under consideration. The full rated capacity and the build thresholds for each supply side type are shown in Table 9.3. Ameren Missouri has assumed reliance on short-term capacity purchases to cover shortfalls that are less than the build threshold and has assumed that any long capacity position would be sold into the market. The earliest in-service for each supply-side resource is also shown in Table 9.3. The in-service date constraints represent the expectations for construction lead time as well as the commercial availability of each technology.

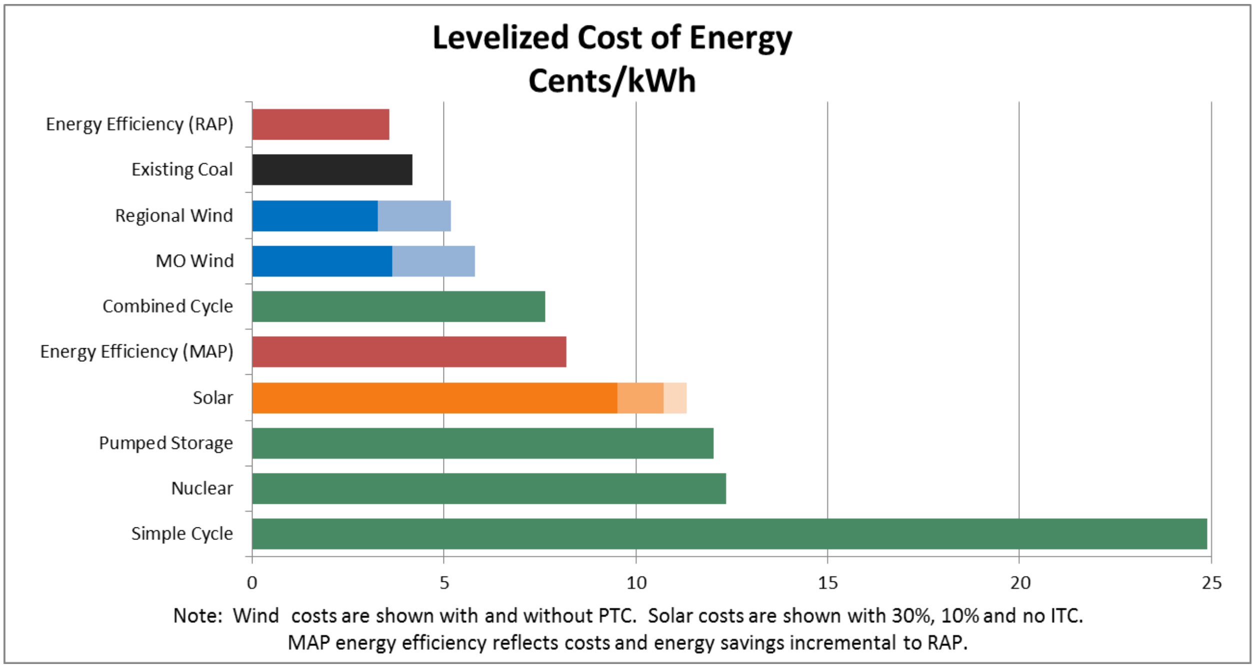
Table 9.3 Build Threshold for Supply Side Types

Supply Side Type	Capacity (MW)	Build Threshold (MW)	Earliest Year In-Service
CC-Natural Gas	600	300	2022
SC-Natural Gas	704	300	2022
Nuclear	1100	300	2027
Pumped Hydro	600	300	2024
Solar	1000	300	2019
Wind and Simple Cycle	664	300	2022

The remaining net capacity position was modeled in the financial model as capacity purchases and sales priced at the avoided capacity costs as discussed in Chapter 2. The capacity purchases and sales were also adjusted for the various peak demand forecasts associated with each of the 15 scenarios and DSM impacts.

Figure 9.4 below summarizes the LCOE for all resources evaluated in the alternative resource plans.

Figure 9.4 Levelized Cost of Energy – All Resources[5]



9.3 Planning Objectives

The fundamental objective of Missouri's electric resource planning process is to provide energy to its customers in a safe, reliable and efficient way, at just and reasonable rates while being in compliance with all legal mandates, and in a manner that serves the public interest and is consistent with state energy and environmental policies.[6] Ameren Missouri considers several factors, or planning objectives, that must be considered in meeting the fundamental objective. Planning objectives provide a guide to the decision making process while ensuring the resource planning process is consistent with business planning and strategic initiatives.

Five planning objectives were used in the development of alternative resource plans: Environmental/Renewable/Resource Diversity, Financial/Regulatory, Customer

[5] 4 CSR 240-22.010(2)(A)
[6] 4 CSR 240-22.010(2)

Satisfaction, Economic Development, and Cost. These planning objectives, which are the same as those discussed in Ameren Missouri's 2011 and 2014 IRPs, were selected by Ameren Missouri decision makers and are discussed below:[7]

Environmental/Renewable/Resource Diversity

Ameren Missouri has relied for many years on a portfolio that consists, in large part, of large, efficient coal-fired generators. Current and potential future environmental regulations may have a significant impact on Ameren Missouri's coal-fired fleet and its selection of future generation resources. Ameren Missouri seeks to transition its generation portfolio to one that is cleaner and more diverse in a responsible fashion. To test various options for advancing this transition, alternative resource plans were developed to include MAP or RAP energy efficiency, renewables in addition to those required for RES compliance, new gas-fired generation, new nuclear generation, storage resources, early coal retirements, and additional reductions in CO_2 emissions.

Financial/Regulatory

The continued financial health of Ameren Missouri is crucial as it will need access to large amounts of capital for complying with renewable energy standards and environmental regulations, investing in new supply side resources, and funding continued energy efficiency programs while maintaining or improving safety, reliability, and customers' ability to control their energy use and costs. While making its investment decisions, it is important for Ameren Missouri to consider factors that may influence its access to capital markets. This includes measures of cash flow, profitability, and creditworthiness as well as assessment of risks associated with investment management and recovery.[8]

Customer Satisfaction

While there are many factors that can influence customer satisfaction, there are several that can be significantly affected by resource decisions. Ameren Missouri has focused on levelized annual rates, inclusion of energy efficiency and demand response programs, inclusion of new clean energy resources, and significant reductions in CO_2 emissions to assess relative customer satisfaction expectations.[9]

Economic Development

Ameren Missouri assesses the relative economic development potential of alternative resource plans in terms of job growth opportunities associated with its resource investment decisions. Plans were rated on a relative scale based on direct jobs (FTE-

[7] 4 CSR 240-22.010(2)(C)
[8] 4 CSR 240-22.060(2)(A)6
[9] 4 CSR 240-22.060(2)(A)4

years) including both construction and operation.[10] We have assumed that second and third level economic impacts would not significantly affect the relative economic development potential of alternative resource plans, and therefore, have not included such impacts in our assessment.

Cost

Ameren Missouri is mindful of the impact that its future resource choices will have on its customers' rate and bills. Maintaining reasonable costs while meeting its other planning objectives is of utmost importance to Ameren Missouri. Cost alone does not and should not dictate resource choices, but it is a very important factor in making resource decisions. Therefore, minimization of present value of revenue requirements was used as the primary selection criterion.[11]

9.4 Determination of Alternative Resource Plans[12]

Eighteen alternative resource plans were developed to incorporate different combinations of demand-side and supply side resource options, seek to fulfill Ameren Missouri's planning objectives, and answer key questions, including the following:

- Does inclusion of Energy Efficiency/Demand Response reduce overall customer costs?
- What level of DSM, RAP or MAP, results in lower costs?
- Is early retirement of Rush Island Energy Center cost effective?
- Is early retirement of Labadie Energy Center cost effective?
- Is early retirement of Meramec Energy Center cost effective?
- Is it cost effective to advance retirement of Meramec Energy Center coupled with advancing another energy center retirement, if necessary, such that Ameren Missouri is not more than 10% long in net capacity?
- What are the benefits of including renewables beyond those needed for RES compliance?
- What is the impact of pursuing only new renewables?
- How would our plans and customer costs be affected if DSM cost recovery and incentive needs are not met?
- How do various supply side resource options compare?
- What is the impact of reducing CO_2 emissions further?

Table 9.4 provides a summary of the alternative resource plans.

[10] 4 CSR 240-22.060(2)(A)7
[11] 4 CSR 240-22.060(2)(A)1; 4 CSR 240-22.010(2)(B)
[12] 4 CSR 240-22.060(3)

Table 9.4 Alternative Resource Plans[13]

Plan Name	Energy Efficiency	Demand Response	Renewables	New Supply Side	Coal Retirements
A-RAP	RAP	RAP	RES Plus	-	Base
B-RAP EE only	RAP	-	RES Plus	-	Base
C-RAP DR only	-	RAP	RES Plus	2 CCs in 2037	Base
D-MAP	MAP	MAP	RES Plus	-	Base
E-MAP EE only	MAP	-	RES Plus	-	Base
F-MAP DR only	-	MAP	RES Plus	CC in 2037	Base
G-No DSM-CC	-	-	RES Plus	CC in 2034 2 CCs in 2037	Base
H-No DSM-SC	-	-	RES Plus	2 SCs in 2034 2 CCs in 2037	Base
I-No DSM-Pumped Storage	-	-	RES Plus	Pumped Hydro in 2034 2 CCs in 2037	Base
J-No DSM-Nuclear	-	-	RES Plus	Nuclear in 2034 CC in 2037	Base
K-No DSM-Wind&SC	-	-	RES Plus	Wind in 2031-2034 (2000 MW total) SC in 2034 2 CCs in 2037	Base
L-No DSM-Solar	-	-	RES Plus	Solar in 2031-2037 (4000 MW total)	Base
M-Rush Island Retired 2024	RAP	RAP	RES Plus	CC in 2037	Rush Island 12/31/2024
N-Labadie Retired 2024	RAP	RAP	RES Plus	CC in 2034	Labadie 12/31/2024
O-Meramec 2020-Labadie 2024	RAP	RAP	RES Plus	CC in 2034	Meramec 12/31/2020 Labadie 12/31/2024
P-Meramec Retired 2020	RAP	RAP	RES Plus	-	Meramec 12/31/2020
Q-RES Compliance only	RAP	RAP	RES	-	Base
R-RAP-35% CO2 Reduction	RAP	RAP	RES Plus	-	Base

Does inclusion of Energy Efficiency/Demand Response reduce overall customer costs?

Plans A and D include both EE and DR at RAP and MAP levels, respectively. Plans B and E differ from plans A and D, respectively, only in that they do not include DR, while plans C and F differ from plans A and D, respectively, only in that they do not include EE programs. Therefore, these plans can be compared to assess the impact on cost and other performance measures due to inclusion of EE or DR at either the RAP or MAP level.

What level of DSM, RAP or MAP, results in lower costs?[14]

Plans with the same attributes except for the level of energy efficiency and/or demand response resources have been evaluated and provide a comparison for the DSM portfolios as described above.

[13] 4 CSR 240-22.010(2)(A); 4 CSR 240-22.060(3); 4 CSR 240-22.060(3)(A)1 through 8; 4 CSR 240-22.060(3)(B); 4 CSR 240-22.060(3)(C)1; 4 CSR 240-22.060(3)(C)2; 4 CSR 240-22.060(3)(C)3

[14] Ameren Missouri added demand response programs to the alternative resource plans starting in 2019 and not only in years where there was a need to reduce peak demand due to shortfalls in Ameren Missouri's planning capacity reserve margins; 4 CSR 240-22.060(3)(A)7

Is early retirement of Rush Island Energy Center cost effective?

Plan M evaluates the cost effectiveness of early retirement of Rush Island Energy Center.[15]

Is early retirement of Labadie Energy Center cost effective?

Plan N evaluates the cost effectiveness of early retirement of Labadie Energy Center.[16]

Is early retirement of Meramec Energy Center cost effective?

Plan P evaluates the cost effectiveness of early retirement of Meramec Energy Center.[17]

Is it cost effective to advance retirement of Meramec Energy Center coupled with advancing another energy center retirement, if necessary, such that Ameren Missouri is not more than 10% long in net capacity??

Plan O evaluates the cost effectiveness of early retirements of Meramec and Labadie Energy Centers.[18]

What are the benefits of including renewables beyond those needed for RES compliance?

To assess the relative benefits of including additional renewable resources, several alternative resource plans were developed that exceed the level of renewable investment indicated by the RES compliance model (alternative resource plans except for plan Q). Plans A and Q can be compared to assess the costs/benefits of additional renewables. Also included are resource plans K and L that feature wind and solar, respectively, as a major supply side resource.

What is the impact of pursuing only new renewables?

Plan L is the all renewables alternative resource plan without DSM beyond MEEIA Cycle 2.[19]

How do various supply-side resource options compare?

The relative performance of the new supply-side resources can be determined by comparing Plans G through L.

[15] 4 CSR 240-22.060(3)(A)7
[16] 4 CSR 240-22.060(3)(A)7
[17] 4 CSR 240-22.060(3)(A)7
[18] 4 CSR 240-22.060(3)(A)7; EO-2017-0073 1.E
[19] 4 CSR 240-22.060(3)(A)2

How would our plans and customer costs be affected if DSM cost recovery and incentive needs are not met?

Plans G through L also evaluate the impact if DSM cost recovery and incentive requirements are not met.

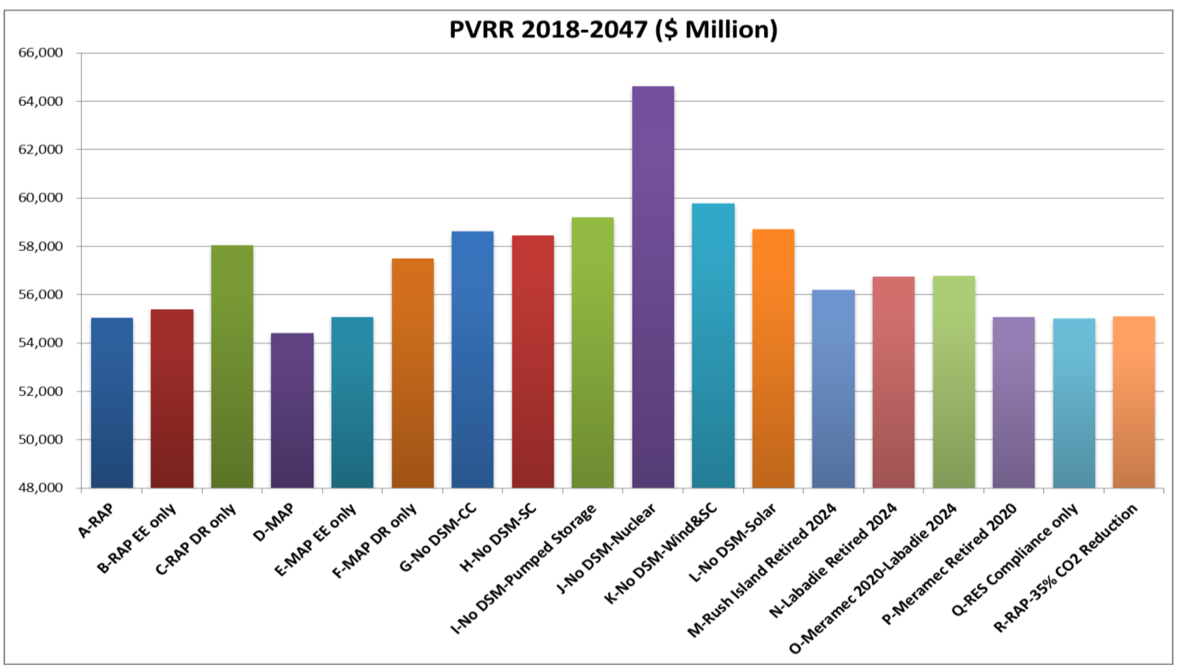
What is the impact of reducing CO_2 emissions further?

Plan R is constructed with the same plan attributes as plan A, but has reduced coal generation such that CO_2 emissions are at least 35% below 2005 emissions by 2030.

The type, size, and timing of resource additions/retirements for the alternative resource plans (i.e., Plans A-R) are provided in Appendix A and also in the electronic workpapers.[20]

Integration, sensitivity and risk analyses for the evaluation of alternative resource plans were done assuming that rates would be adjusted annually for the 20-year planning horizon and 10 additional years for end effects, and by treating both supply-side and demand-side resources on an equivalent basis. Integration analysis was performed on the most likely scenario of the probability tree (Scenario 13) as explained in Chapter 2. Integration analysis present value of revenue requirements (PVRR) results are shown below in Figure 9.5. Results for the remaining performance measures for integration analysis are provided in the workpapers.[21]

Figure 9.5 Integration PVRR Results



[20] None of the alternative resource plans analyzed include any load-building programs
4 CSR 240-22.060(3)(B); 4 CSR 240-22.080(2)(D); 4 CSR 240-22.060(3)(D)

[21] 4 CSR 240-22.060(4)

It should be noted that all costs and benefits in all analyses were expressed in nominal dollars, and Ameren Missouri's current discount rate of 5.95% was used for present worth and levelization calculations. Also, in all integration, sensitivity, and risk analyses, it was assumed that rates are adjusted annually (i.e., no regulatory lag).[22]

9.5 Sensitivity Analysis

Sensitivity analysis involves determining which of the candidate independent uncertain factors are critical independent uncertain factors. Once identified in this step, critical uncertain factors were added to the scenario probability tree discussed in Chapter 2.

9.5.1 Uncertain Factors[23]

Ameren Missouri developed a list of uncertain factors to determine which factors are critical to resource plan performance. Table 9.5 contains the list as well as information about the screening process.

Table 9.5 Uncertain Factor Screening

Uncertain Factor	Candidates?	Critical?	Included in Final Probability Tree?
Load Growth	✔ **	--	✔
Carbon Policy	✔ **	--	✔
Fuel Prices			
Coal	✔	✔	✔
Natural Gas	✔ **	--	✔
Nuclear	✘	✘	✘
Project Cost (includes transmission interconnection costs)	✔	✘	✘
Project Schedule	✔	✘	✘
Purchased Power	✘	✘	✘
Emissions Prices			
SO_2	✘	✘	✘
NO_x	✘	✘	✘
CO_2	✔ **	--	✔
Forced Outage Rate	✔	✘	✘
DSM Cost Only	✔	✔	✔

[22] 4 CSR 240-22.060(2)(B)
[23] 4 CSR 240-22.040(5); 4 CSR 240-22.040(5) (B) through (F); EO-2017-0073 1.A(1)-(3)
4 CSR 240-22.060(5); 4 CSR 240-22.060(5) (A) through (M)

Uncertain Factor	Candidates?	Critical?	Included in Final Probability Tree?
DSM Load Impacts&Costs	✓	✗ α	✗ α
Foreseeable Emerging EE Technologies	✓	✗ β	✗ β
Foreseeable Distributed Generation	✓	✗ β	✗ β ✓ γ
Foreseeable Energy Storage Technologies	✓	✗	✗
Fixed and Variable O&M	✓	✗	✗
Return on Equity	✓	✗ ε	✗ ε
Interest Rates	✓	✗ ε	✗ ε

** Included in the scenario probability tree
-- Not tested in sensitivity analysis
α DSM impacts and costs combined. Costs not the same costs as in “DSM Cost Only” sensitivity.
β Included as part of DSM load impacts and costs sensitivity
γ Included as part of load forecast sensitivity
ε Return on Equity and Long-term Interest rates were combined

Chapter 2 describes how three of the candidate uncertain factors were determined to be critical dependent uncertain factors, which defined the fifteen scenarios. The three critical dependent uncertain factors are: load growth, market effects of environmental policy, and natural gas prices. Energy and capacity prices are an output of the scenarios and reflect a range of uncertainty consistent with the scenario definitions.

A review of these candidates prior to the sensitivity analysis determined several could be eliminated without conducting quantitative analysis.

- Nuclear Fuel Prices – Our 2011 and 2014 IRP analyses concluded that nuclear fuel prices were not critical to the relative performance of the alternative resource plans; the same conclusion is expected to be obtained should high/low nuclear prices be included in the sensitivity analysis, particularly given the significant increase in our assumption for nuclear capital costs.
- Purchased Power – Purchased power is excluded since Ameren Missouri is a member of MISO and Ameren Missouri has employed planning criteria that minimize our dependence on the market.
- SO_2 and NOx Emissions Prices – SO_2 and NOx Emissions Prices were excluded as candidates because of the expectation for very low prices as a result of current and expected environmental regulations.

There are two pairs of candidate independent uncertain factors that are highly correlated:

- Interest Rates and Return on Equity
- DSM Load Impacts and Costs

Including all the possible permutations of high/base/low would geometrically increase the size of the analysis, with some combinations being much less meaningful and less probable. Since the expectation is that these factors are highly correlated, we have made the simplifying assumption that the individual probability nodes for each pair be combined into a single probability node reflecting the high value for both, base value for both, and low value for both without explicitly considering the less likely and less meaningful joint probabilities.

In addition to including DSM load impacts and costs, Ameren Missouri also analyzed only DSM costs changing in high and low scenarios while the load impacts remain the same. It is important to note that the high and low case costs in the "DSM Cost Only" candidate uncertain factor are different than the high and low case costs in the "DSM Load Impacts and Costs" candidate factor. More detail on the DSM sensitivities can be found in Chapter 8.

Uncertain Factor Ranges[24]

We use the sensitivity analysis to examine whether or not candidate independent uncertain factors have a significant impact on the performance of alternative resource plans, as measured by their impact on PVRR.

The candidate uncertain factors are characterized by a 3-level range of values for this analysis; those 3 levels being low, base, and high values.

Unless the meaning of low, base, and high are treated in a standardized manner, the probability of occurrence for the value used for "low" for one uncertain factor could be significantly different than the probability of occurrence for the value used for "low" for other uncertain factors. Thus, for all of the uncertain factors, Ameren Missouri standardized the meaning of low to be the value found at the 5th percentile of a probability distribution of values for an uncertain factor, the value at the 50th percentile to be the base value, and the value at the 95th percentile to be the high value. The probability distribution for each candidate uncertain factor was inferred from a series of estimated values produced by subject matter experts for each uncertain factor.

[24] 4 CSR 240-22.060(7)(C)1A; 4 CSR 240-22.060(7)(C)1B

For the majority of candidate uncertain factors, probability distributions were used to obtain the values for low, base, and high. This process began with subject matter experts providing/revising estimates of (A) an expected value, (B) estimates of deviations from that expected value, and (C) the probabilities of those deviations from the expected value. That information was used to create the probability distribution collectively implied by that data. Values at the 5th, 50th, and 95th percentiles of those implied probability distributions were then obtained for use as the values for low, base, and high for the various candidate independent uncertain factors. Appendix A contains the standard value, estimated deviation and probabilities for project costs, project schedule, fixed operations & maintenance (FOM), variable operations & maintenance (VOM), equivalent forced outage rate (EFOR), environmental capital expenditures, and transmission-retirement expenditures.

Example

The expected value for total project cost including transmission interconnection costs for the greenfield Combined Cycle option is $1,282/kW-year (2016$). Project cost and some other candidate uncertain factors are characterized by differing standard values among various supply-side types, while standard values for some other candidate uncertain factors are not uniquely correlated to each supply side type. For example the Long Term Interest Rates uncertain factor does not differ depending on the supply-side type; it is the same across all supply-side types.

The subject matter experts, in this example, members of Ameren Missouri's generation organization, provided estimates of deviations from the standard value as well as the probabilities of those deviations. An example of that initial uncertainty distribution is shown in Table 9. 9.6. In this example, the first of these estimates for project cost deviations was a -10% deviation from the expected value with a 20% probability of occurring. These deviation estimates provide sufficient information to derive continuous probability distributions from which the low/base/high values can be derived.

Table 9.6

CC Project Cost Uncertainty Distribution	
Deviation	**Probability**
-10%	20%
0%	50%
15%	20%
30%	10%

The process of developing the probability distributions involved using Crystal Ball software. This software, when provided with a series of observations like these deviation estimates, can determine the probability distribution implied by the set of estimates. An example of the result of analyzing deviation estimates using Crystal Ball is shown in Figure 9.6. From this distribution, the deviation values for the low, base, and high values (.84, 1.03, 1.25) are obtained at the respective percentiles in Figure 9.6. By multiplying these values by the expected value $1,282/kW-year, we estimate the costs at the 5th, 50th, and 95th percentiles; e.g., the low value at the 5th percentile would be:

.84 x 1,282 = $1,077

Figure 9.6 Example of Probability Distribution---CC Project Cost

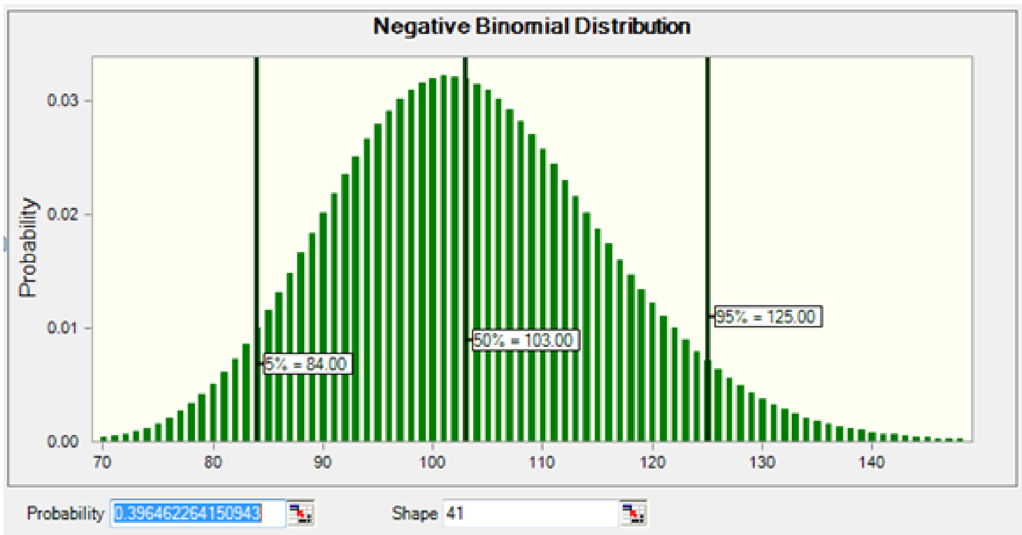


Figure 9.7 shows the resulting range of project costs, which also include interconnection costs estimates, for each new supply-side resource. For most of the technologies shown in Figure 9.7, base values found at 50th percentile were very close to their expected values. For the nuclear technology, however, the base value inferred from the probability distribution was 27% higher than the expected value- $7,545/kW vs $6,134/kW.

Figure 9.7 Resource-Specific Project Cost Ranges ($/kW)

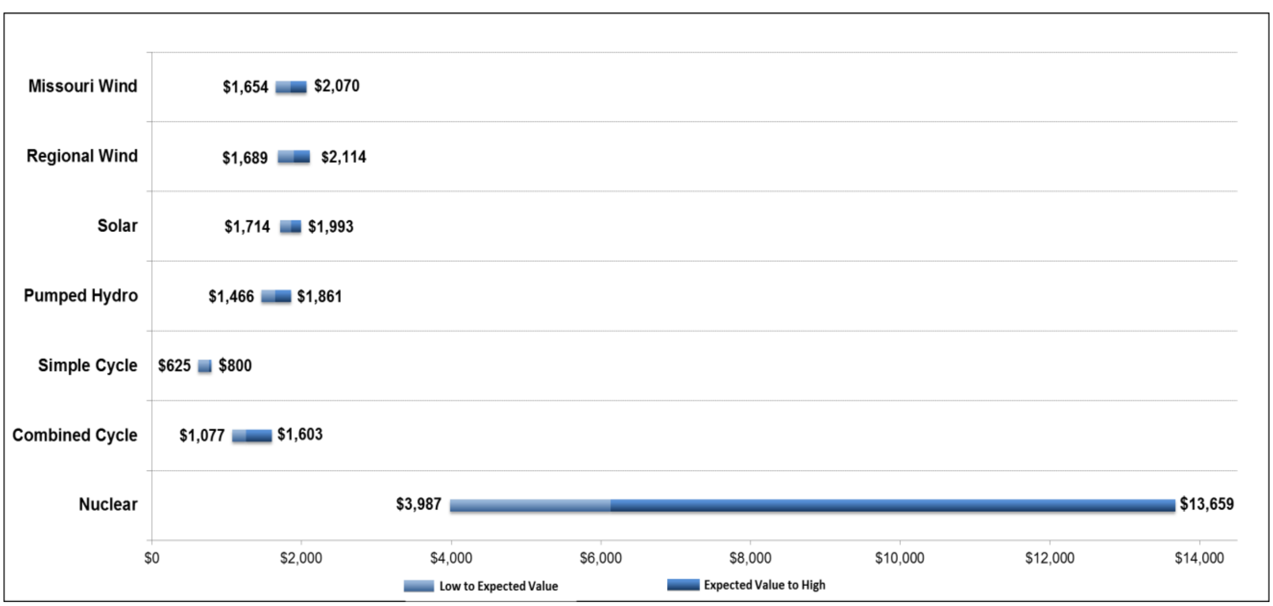


Table 9.7 shows the uncertain factor ranges for the various candidate uncertain factors. It should be noted that, for the project schedule uncertainty, as the number of years in a project schedule change, the distribution of the cash flows was also updated to be consistent with those changes.

Table 9.7 Resource-Specific Uncertain Factor Ranges

Uncertain Factor	Value	Probability	CC (Nat. Gas)	SC (Nat. Gas)	Pumped Hydro	Nuclear	Solar *	Regional Wind	Missouri Wind
Project Cost	Low	10%	$1,077	$625	$1,466	$3,987	$1,714	$1,689	$1,654
($/kW)	Base	80%	$1,320	$709	$1,663	$7,790	$1,863	$1,917	$1,877
2016 $	High	10%	$1,603	$800	$1,861	$13,679	$1,993	$2,114	$2,070
Project Schedule	Low	10%	27	27	55	68	9	36	36
(Months)	Base	80%	36	36	73	91	12	48	48
	High	10%	48	48	95	119	16	63	63
Fixed O&M	Low	10%	$6.71	$6.57	$2.98	$125.60	$13.29	$21.89	$21.89
($/kW-yr)	Base	80%	$8.11	$7.93	$3.60	$154.37	$16.04	$26.42	$26.42
2016 $	High	10%	$10.18	$9.92	$4.49	$190.41	$20.11	$33.12	$33.12
Variable O&M	Low	10%	$1.61	$6.64	$2.95	$1.86	$0.00	$0.00	$0.00
($/MWh)	Base	80%	$4.18	$7.91	$3.71	$2.31	$0.00	$0.00	$0.00
2016 $	High	10%	$6.75	$9.18	$4.66	$2.91	$0.00	$0.00	$0.00
EFOR	Low	10%	1%	0%	0%	1%	-	-	-
(%)	Base	80%	2%	5%	5%	2%	-	-	-
	High	10%	5%	10%	10%	3%	-	-	-

* Ameren Missouri used a declining cost curve for solar, but the same multipliers were applied to estimate low and high project costs.
- Assumed capacity factor for solar and wind resources include effects of FOR.

Table 9.8 contains the non-resource specific uncertain factor ranges analyzed.

As discussed in Chapter 2, long-range interest rate assumptions are based on the December 1, 2016, semi-annual Blue Chip Financial Forecast, a consensus survey of 49 economists. Ameren Missouri internal experts used this same set of data and process to develop a range of interest rate assumptions for use in the 2017 IRP. The high and low interest rate assumptions are based on the average of the 10 highest and 10 lowest forecasts from the survey. Additionally, the high and low forecasts for Treasury rates are used as inputs to the calculation of high and low ranges for allowed return on equity (ROE) using the same process as discussed in Chapter 2.

Table 9.8 Non-Resource Specific Uncertain Factor Ranges

Uncertain Factors	Low	Base	High
Probability -->>	10%	80%	10%
Coal Price		Varies By Year	
Long Term Interest Rates	5.3%	6.0%	6.7%
Return on Equity	10.3%	10.6%	10.9%
DSM Load Impact and Cost			
MAP - EE Load Impact	82%	100%	111%
MAP - EE Cost	84%	100%	117%
RAP - EE Load Impact	82%	100%	111%
RAP - EE Cost	84%	100%	118%
MAP - DR Load Impact	81%	100%	108%
MAP - DR Cost	119%	100%	111%
RAP - DR Load Impact	81%	100%	108%
RAP - DR Cost	119%	100%	111%
DSM Cost Only			
MAP - EE Cost	80%	100%	135%
RAP - EE Cost	80%	100%	135%
MAP - DR Cost	85%	100%	125%
RAP - DR Cost	85%	100%	125%

Note that the DSM Load Impact and Cost uncertain factor includes higher costs for the DR low load impacts, because when items such as avoided costs are varied, the program mix changes as the cost effectiveness changes, and more expensive programs fill the gap. Chapter 8 includes details on how low and high ranges were obtained for DSM portfolios.

9.5.2 Sensitivity Analysis Results[25]

To conduct the sensitivity analysis, each of the 18 candidate resource plans was analyzed using the varying value levels (low/base/high) for each of the candidate independent uncertain factors, for the most likely scenario in the probability tree (Scenario 13). An uncertainty-probability weighted result for PVRR was obtained for each plan for each relevant candidate uncertain factor. Finally, the results of using a "non-base" value were compared to the results of using an integration/base value for each plan for each candidate uncertain factor. The sensitivity analysis results for all of

[25] 4 CSR 240-22.060(5); 4 CSR 240-22.060(7)(A); 4 CSR 240-22.060(7)(C)1A

the candidate independent uncertain factors (resource-specific and non-resource specific) are presented in Appendix A.

The sensitivity analysis identified two critical independent uncertain factors: DSM Cost Only and Coal Prices. Table 9.9 shows the change in PVRR ranking (i.e., number of positions the plan moved in the ranking) for the two critical independent uncertain factors compared to the integration/base value.

Table 9.9 Critical Independent Uncertain Factors – Change in PVRR Ranking

	Integration	DSM Cost Only			Coal Price		
Plan	Ranking	PWA	Low	High	PWA	Low	High
A-RAP	3	0	1	0	0	0	0
B-RAP EE only	7	0	0	-1	0	0	0
C-RAP DR only	12	0	0	0	0	0	0
D-MAP	1	0	0	0	0	0	0
E-MAP EE only	5	0	-3	2	0	-1	1
F-MAP DR only	11	0	0	0	0	0	0
G-No DSM-CC	14	0	0	0	0	0	0
H-No DSM-SC	13	0	0	0	0	0	0
I-No DSM-Pumped Storage	16	0	0	0	0	0	0
J-No DSM-Nuclear	18	0	0	0	0	0	0
K-No DSM-Wind&SC	17	0	0	0	0	0	0
L-No DSM-Solar	15	0	0	0	0	0	0
M-Rush Island Retired 2024	8	0	0	0	0	0	0
N-Labadie Retired 2024	9	0	0	0	0	0	0
O-Meramec 2020-Labadie 2024	10	0	0	0	0	0	0
P-Meramec Retired 2020	4	0	1	0	0	1	1
Q-RES Compliance only	2	0	1	0	0	0	0
R-RAP-35% CO2 Reduction	6	0	0	-1	0	0	-2

Table 9.10 shows the change in PVRR ($) for the two critical independent uncertain factors compared to the integration/base values.

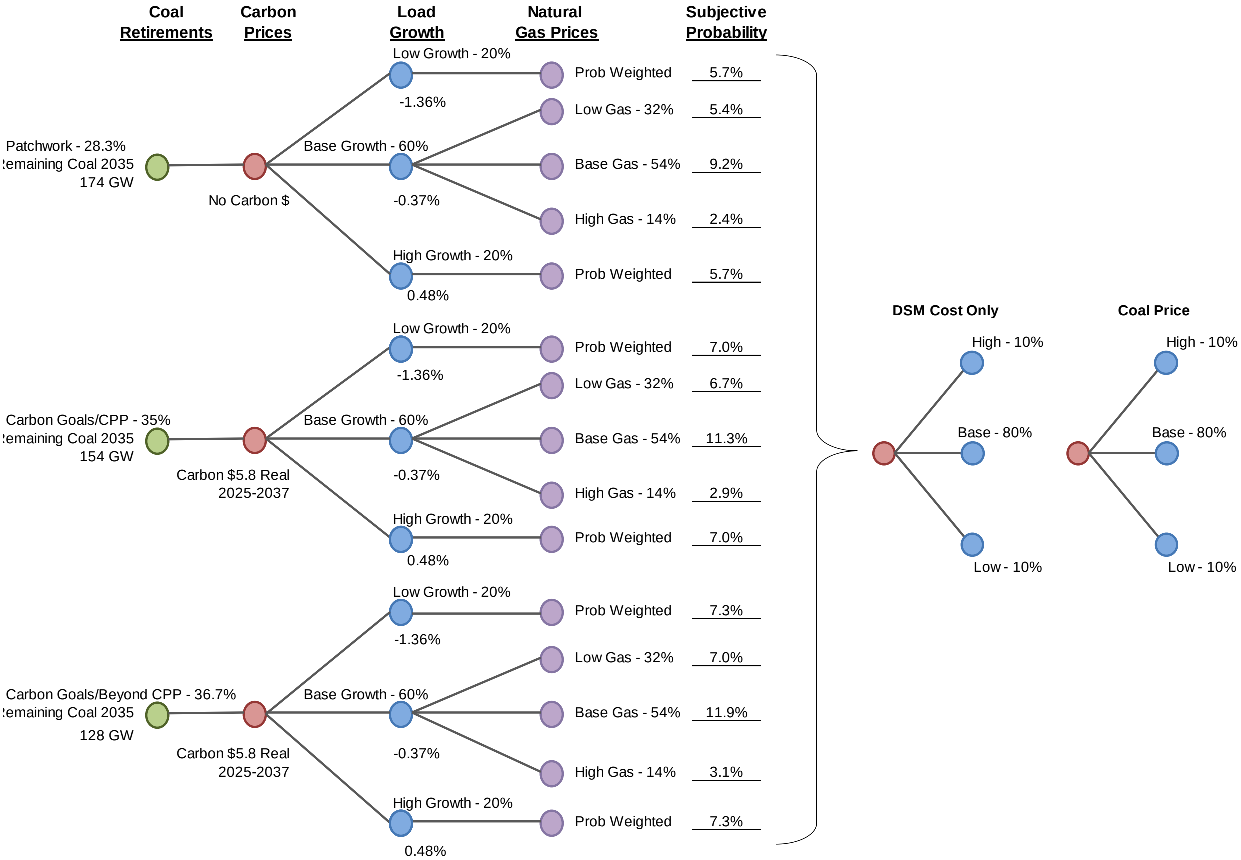
Table 9.10 Critical Independent Uncertain Factors – Change in PVRR (Million $)

Plan	Integration PVRR	DSM Cost Only			Coal Price		
		PWA	Low	High	PWA	Low	High
A-RAP	55,037	25	-336	589	-51	-1,878	1,364
B-RAP EE only	55,374	21	-281	493	-51	-1,878	1,364
C-RAP DR only	58,041	4	-55	96	-51	-1,878	1,364
D-MAP	54,398	46	-609	1,068	-51	-1,878	1,364
E-MAP EE only	55,083	39	-517	904	-51	-1,878	1,364
F-MAP DR only	57,485	7	-92	164	-51	-1,878	1,364
G-No DSM-CC	58,614	0	0	0	-51	-1,878	1,364
H-No DSM-SC	58,457	0	0	0	-51	-1,878	1,364
I-No DSM-Pumped Storage	59,182	0	0	0	-51	-1,878	1,364
J-No DSM-Nuclear	64,610	0	0	0	-51	-1,878	1,364
K-No DSM-Wind&SC	59,761	0	0	0	-51	-1,878	1,364
L-No DSM-Solar	58,695	0	0	0	-51	-1,878	1,364
M-Rush Island Retired 2024	56,202	25	-336	589	-45	-1,465	1,019
N-Labadie Retired 2024	56,736	25	-336	589	-40	-1,294	897
O-Meramec 2020-Labadie 2024	56,766	25	-336	589	-37	-1,252	884
P-Meramec Retired 2020	55,067	25	-336	589	-49	-1,836	1,351
Q-RES Compliance only	55,018	25	-336	589	-51	-1,878	1,364
R-RAP-35% CO2 Reduction	55,102	25	-336	589	-52	-1,828	1,311

The DSM Cost Only uncertain factor was selected as a critical independent uncertain factor because of the variety in the change in PVRR ranking. Coal price was selected as a critical independent uncertain factor because of the high impact potential on relative results of early retirement plans compared to other plans.

These two critical independent uncertain factors were added as nodes to the scenario probability tree that was developed in Chapter 2. The updated and expanded probability tree is shown in Figure 9.8, with the two critical independent uncertain factors shown on the right-hand side.

Figure 9.8 Final Probability Tree Including Sensitivity Analysis Results[26]



9.6 Risk Analysis[27]

The Risk Analysis consisted of running each of the candidate resource plans in Table 9.4 through each of the branches on the final probability tree shown in Figure 9.8. The probability tree consisted of 135 different branches. Each branch is the combination of different value levels among the fifteen scenarios, themselves defined by combinations of the three critical dependent uncertain factors (load growth, gas prices, and environmental regulations/carbon policy), and the two critical independent uncertain factors (DSM cost and coal price). Each branch therefore represents a unique combination of the critical uncertain factors. Once all the combinations are calculated, the sum of the individual branch probabilities equals 100%.

[26] 4 CSR 240-22.060(6)
[27] 4 CSR 240-22.060(6)

9.6.1 Risk Analysis Results

The PVRR results of the risk analysis of the 18 alternative resource plans are shown in Figure 9.9. The levelized rate results for the risk analysis are shown in Figure 9.10. The PVRR results are lower for plans with RAP or MAP DSM compared to plans without DSM. The advancement of Labadie and Rush Island Energy Centers exhibit much higher PVRR results and higher levelized rates compared to plans with similar attributes but without early retirement assumptions. Plan J (No DSM-Nuclear) exhibits the highest PVRR and the highest levelized rates followed by Plan K (No DSM-Wind&SC), which has the second highest PVRR, and by Plan E (MAP EE Only), which has the second highest levelized rates. Results for other performance measures can be found in Chapter 9 - Appendix A.

Figure 9.9 Probability-Weighted PVRR Results

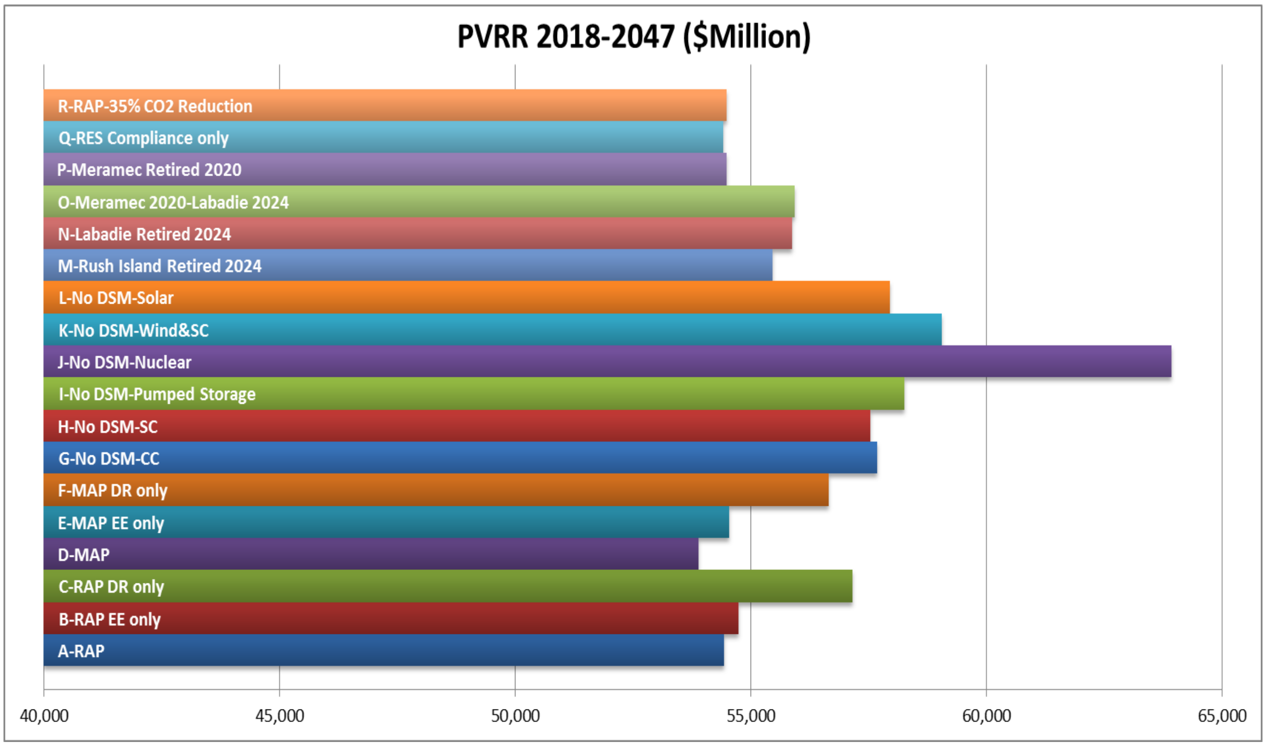
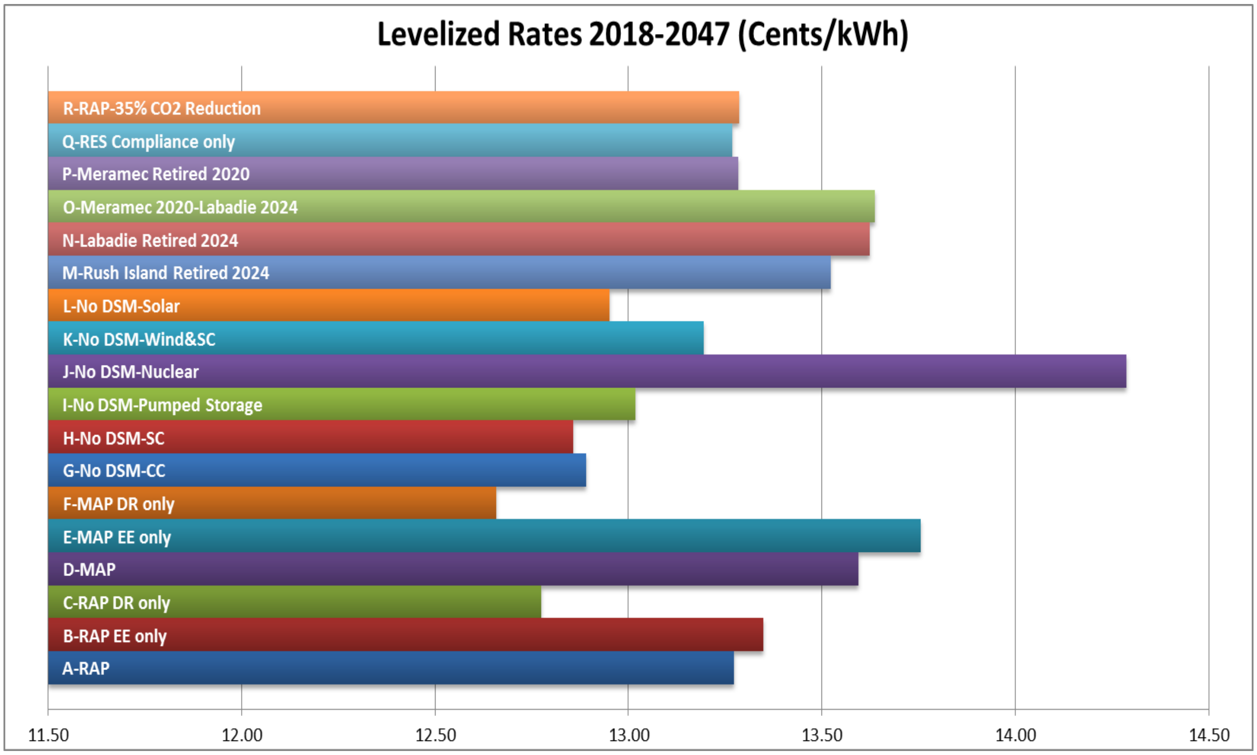


Figure 9.10 Probability-Weighted Levelized Rate Results



If decision making were solely based on PVRR and levelized rate impacts, then the analysis would be complete at this point. Since decision making is multi-dimensional, Ameren Missouri created a scorecard that embodies its planning objectives to evaluate the performance of alternative resource plans. With 18 alternative resource plans, Ameren Missouri can take a closer look at the performance of the plans by evaluating their relative strengths and weaknesses in meeting our planning objectives and whether other factors may be important in the selection of the preferred resource plan. Chapter 10 – Strategy Selection includes the additional analysis and decision-making considerations that lead to the selection of the Resource Acquisition Strategy.

9.7 Conclusions from Integration and Risk Analysis

Below are several conclusions from the integration and risk analysis.

- Inclusion of energy efficiency and demand response results in generally lower costs.
- Wind, solar and natural gas combined cycle resources are attractive options for development due to their competitive overall cost, relatively low capital cost and relatively short lead time.

- Early retirement of coal generation resources (plans M-O) results in significantly higher costs to customers and rates. Advancing retirement of Meramec Energy Center also increases costs to customers.
- Plans with additional renewable resources beyond those included for RES compliance are competitive from a cost standpoint.[28]
- Meeting all future resource needs with renewable resources (Plan L) results in the fourth highest PVRR among the eighteen plans. However, this plan is competitive with other supply side only plans, and greater reductions in the cost of solar resources could further improve their comparative economics.
- Meaningful reductions in CO_2 as analyzed in Plan R can be achieved at a modestly higher cost.

9.8 Resource Plan Model

Ameren Missouri has used a modular approach to modeling for this IRP as it did in the 2014 IRP. Instead of using MIDAS or other off-the-shelf alternatives for integration and risk analyses, Ameren Missouri continues to use a combination of stand-alone models for 1) production costing, 2) market settlements, 3) revenue requirements, and 4) financial statements. Items 2-4 on this list are collectively referred to as the "Financial Model." This approach permitted analysts maximum flexibility, customization and trouble-shooting capabilities. It also lends itself to greater transparency for stakeholders by limiting the use of proprietary third-party software.

Ameren Missouri used a generation simulation model from Simtec, Inc., typically referred to as RTSim (Real-Time Simulation) for production cost modeling.[29] RTSim provides a realistic simulation of an electric generating system for a period of a few days to multiple years. According to Simtec's marketing materials, RTSim finds higher profitability, lower risk, "free market" transactions, maintenance schedules, emission compliance strategies and fuel procurement schedules while maintaining reliable, reasonable cost service to the traditional regulated market sector.

RTSim simulates hourly chronological dispatch of all system generating units, including unit commitment logic that is consistent with the operational characteristics and constraints of system resources. The model plans are based on a capacity planning spreadsheet, which was used to determine the timing of new resources. The RTSim model contains all unit operating variables required to simulate the units. These variables include, but are not limited to, heat rates, fuel costs, variable operation and

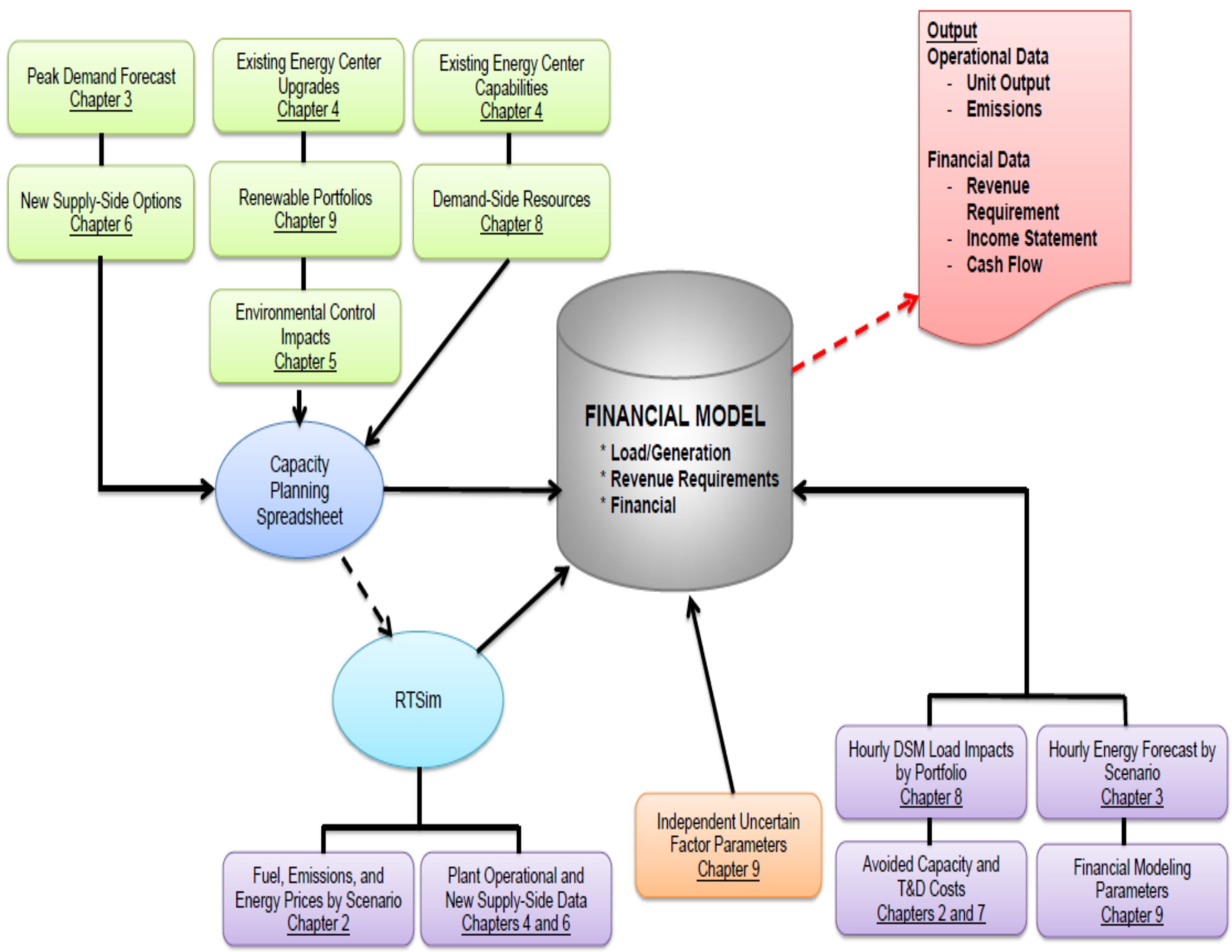
[28] 4 CSR 240-22.060(4)(E)
[29] 4 CSR 240-22.060(4)(H)

maintenance costs, emission rates, emission allowance costs, scheduled maintenance outages, and full and partial forced outage rates. The generation fleet is dispatched competitively against market prices. The multi-area mode of the Ventyx Midas® model was used for the creation of forward price curves as described in Chapter 2.

Ameren Missouri developed its own revenue requirements and financial model using Microsoft Excel. This model incorporates the capacity position and RTSim outputs, as well as other financial aspects regarding costs external to the direct operation of units and other valuable information that is necessary to properly evaluate the economics of a resource portfolio. The financial portion of the model produces bottom-line financial statements to evaluate profitability and earnings impacts along with revenue requirement and various financial and credit metrics.

Figure 9.11 shows how the various assumptions are integrated into the financial model.

Figure 9.11 Resource Plan Model Framework[30]



30 4 CSR 240-22.060(4)(H)

Future Plans for Modeling Tools

Ameren Missouri plans to continue to evaluate options for modeling tools for use in its resource planning process. Having developed a modular approach to our modeling, we have the flexibility to evaluate models with varying degrees of capabilities (production costing, market settlements, revenue requirements, and financial statements) that can be used in place of, and/or in combination with, the current modules. As a result, we expect that our modeling needs over time will be characterized more by evolution rather than the deployment of a single integrated solution. Our current modular approach was in large part an outcome of our evaluation of solutions that are currently commercially available. For example, we were unable to identify any available integrated solutions that produce full financial statements other than MIDAS, which is no longer being developed by Ventyx. Our current approach also allows us to expand our review of production costing solutions beyond those used primarily for long-term resource planning. We may be able to identify a production costing solution that can be applied to long-term resource planning, fuel budgeting, and possibly shorter-term trading support analysis.

We expect to continue our efforts to improve the efficiency, effectiveness and transparency of our modeling tools into 2018. The nature and timing of any changes we make will largely be a function of our assessment of the currently available options. As we consider these options, we plan to share thoughts with other Missouri utilities and with our stakeholder group. This may or may not provide opportunities to move to a common modeling platform. Ameren Missouri will remain open to such an outcome while ensuring that its own tools and processes are able to support our business needs and objectives.

9.9 Compliance References