9. Modeling and Risk Analysis

Highlights

- *Alternative resource plans were developed by considering 5 attributes: supply-side resource type, Meramec status, DSM portfolio, RES requirements, and Noranda status.*
- *Among 216 alternative resource plans, 16 preliminary candidate resource plans were selected for further analysis.*
- *The sensitivity analysis identified 3 critical independent uncertain factors: Interest Rates, DSM Impacts and Cost, and Project Cost*
- *Incorporating the Meramec retirement analysis with the initial risk analysis results ultimately led to the selection of 14 candidate resource plans to be evaluated in the Strategy Selection.*

The modeling and risk analysis consisted of several major activities. First was the development of alternative resource plans. Using 5 plan attributes to develop alternative resource plans, Ameren Missouri analyzed 216 alternative resource plans. Next was a screening process based on a scorecard approach that embodied several measures linked to Ameren Missouri policy objectives. With the 16 plans that passed the initial screening process, a sensitivity analysis was performed to determine which independent uncertain factors are critical to resource plan selection. Those critical factors were then incorporated into the scenario probability tree to produce the final probability tree. The initial risk analysis, which incorporated all the critical uncertain factors, helped to further reduce the number of options to be included in candidate resource plans and supported the incorporation of the Meramec retirement analysis. Another round of risk analysis provided risk adjusted PVRRs for the 14 candidate resource plans.

In Chapter 10 – Strategy Selection, Ameren Missouri takes an even closer look at the performance of the plans by introducing real-world ratemaking and financial constraints. These constraints help us to better understand the implications of adopting capital intensive plans or an aggressive energy efficiency plan. Ameren Missouri is then able to expand the scorecard to include additional measures based on its policy objectives and ultimately select an appropriate strategy that accounts for trade-offs across multiple planning objectives.

9.1 Alternative Resource Plans[1]

Developing alternative resource plans includes the combination of various demand-side and supply-side resources to meet future capacity needs. However, there are other factors that could cause dramatic changes in the capacity position that need to be considered when developing plans. Figure 9.1 includes the five dimensions considered during the development of resource plans. The permutations of these five dimensions would create 432 plans. However, in practice, some combinations may create duplicate resource plans or plans that do not make sense.

Figure 9.1 Five Attributes of Alternative Resource Plans

Supply-Side Types
- Coal with Carbon Capture
- Combined Cycle (Greenfield)
- Combined Cycle (Meramec)
- Combined Cycle (Venice)
- Simple Cycle (Greenfield)
- Pumped Storage
- Nuke 30% (Partial Ownership)
- Nuke 50% (Partial Ownership)
- Wind with Simple Cycle

Renewable Portfolios
- Federal
- Missouri

Demand-Side Portfolios
- Maximum Achievable Potential
- Realistic Achievable Potential
- Low Risk
- None

Meramec Status
- Meramec Retired 2015
- Meramec Retired 2022
- Meramec Continues As-Is

Noranda Status
-Noranda Continues
-Noranda Contract Expires 2020

There are three circumstances that produce duplicate or unusable plans. First is the fact that either Maximum or Realistic Achievable Potential (MAP and RAP) DSM portfolios would meet future resource needs without additional supply-side resources. Second, the Meramec combined cycle retrofit option is not applicable if Meramec is not retired. Lastly, there are a few instances when Meramec continues and Noranda's contract expires in which there is no need for new supply-side resources.

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

- Existing plant capabilities based on the annual generating unit rating update
- Existing obligations for capacity purchases and sales
- Peak demand forecast
- 100 MW peak demand voltage reduction

[1] 4 CSR 240-22.060(1); 4 CSR 240-22.060(3); 4 CSR 240-22.010(2)(A)

- Reserve margin requirement, based on MISO's 2010 LOLE study, that starts at 15.4% in 2010, ramps up to 17% in 2015, and then continues at 17% through the remainder of the planning horizon. MISO completed its 2011 LOLE study in December, 2010, after Ameren Missouri had completed the bulk of its IRP analysis. The results of the 2011 study indicate a Planning Reserve Margin (PRM) requirement of 17.2% by 2015 growing to 18.2% in 2020. The increase from 2015 to 2020 is driven by assumptions regarding future congestion, which may be addressed through future transmission expansion plans. Without the congestion component, the long-range PRM is consistently near 17%.

Figure 9.2 is a net capacity position chart with no new resources that illustrates the effects of Meramec's status and Noranda's status on capacity needs.

Figure 9.2 Capacity Position – No New Resources

As described in Chapter 5, since renewable requirements are based on retail sales there is direct relationship between the amount of renewables needed, DSM impacts, and the status of Noranda. Therefore, there are 16 unique renewables portfolios which are combinations of renewables requirements (2, federal or state), DSM portfolios (4; None, Low Risk, RAP, or MAP), and Noranda's status (2, expires or continues).

As part of the capacity position build-up there are also various upgrade projects for Ameren Missouri's existing generating units. Ameren Missouri's 2008 IRP demonstrated that cost-effective upgrades will invariably result in lower PVRRs. Below is a list of the plant upgrade projects that were included in all resource plans.

- Rush Island Unit 1 – 13 MW in 2013
- Labadie Unit 2 – 11 MW in 2013
- Meramec Units 3 & 4 – 15 MW in 2011
- Callaway Unit 1 – 70 MW in 2017
- Audrain – 30 MW in 2020

Demand-side portfolios were included in capacity planning separately as energy efficiency and demand response. Energy efficiency portfolios were used as developed in Chapter 7, meaning the timing and amounts of energy efficiency were pre-determined for capacity planning purposes. However, demand response was included in alternative resource plans on an as-needed basis to meet capacity needs by shifting the timing only. Energy efficiency and demand response programs not only reduced the peak demand but also reduce reserve requirements associated with those demand reductions.

Major supply-side resource types were added last in the capacity planning process. While new generation might be required, two more considerations were made before concluding that a supply-side type would be built to be in-service for the year having the capacity shortfall.

First, it was determined if the capacity shortfall met or exceeded the build threshold for the supply side type under consideration.

Table 0.1 Build Threshold for Supply Side Types

Supply side type	Capacity, MWs	Build Threshold, MWs	Earliest Year In-Service
Coal w/CCS	679	340	2025
CC-Greenfield	600	300	2015
CC-Meramec	834	417	2015
CC-Venice	600	300	2015
SC-Greenfield	692	346	2014
Pumped Storage	600	300	2017
Nuclear 30%	480	240	2019
Nuclear 50%	800	400	2019
Wind w/Simple Cycle	410	205	2015

The build threshold decision for any particular year was dependent on the capacity of each supply side type compared to the capacity shortfall in any particular year. The build threshold was determined to be half of the full capacity for whatever supply-side type was under consideration. The full capacity and the build thresholds for each supply side type are shown in Table 0.1. Ameren Missouri would rely on short-term capacity purchases to meet its remaining needs.

Secondly, if a build threshold had been met, it was determined if a sufficient number of years remained between 2011 and the year of that capacity shortfall in order to build that supply-side type for the year in which the build threshold was met. If not, the in-service date was delayed the appropriate number of years to reflect the years required to build each supply side type. Coal with carbon capture is an exception to this rule. Based on Ameren's research full-scale carbon capture is not expected to be available before 2025; therefore, the coal resource option was constrained further. The earliest in-service date for each supply side resource is also shown in Table 0.1.

The remaining net capacity position was modeled in MIDAS as capacity purchases and sales priced at the avoided capacity costs discussed in Chapter 7. The capacity purchases and sales were also adjusted for the different peak demand forecasts associated with each of the 10 scenarios.

A list of the 216 alternative resource plans is shown in the electronic workpapers.[2] In those workpapers, the names consist of the Supply-Side resource type, Renewables requirements, DSM portfolio, Meramec status, and Noranda status. A 5-digit code is also provided as a plan identifier, which provided a simple short-hand way of referring to a particular plan during the analysis. The electronic workpapers also provide data for these alternative resource plans,[3] including: PVRR, PV (Present Value) of probable environmental costs, PV of out-of-pocket costs to participants in demand-side programs, levelized annual average rates, maximum single-year increase in annual average, pre-tax interest coverage, debt ratio, and ratio of net cash flow to capital expenditures.

The spreadsheet that was used to develop the alternative resource plans also includes all the relevant information to populate MIDAS.[4] Therefore, this spreadsheet was also used to generate all the MIDAS data overlays, translating the resource needs from the capacity position into usable modeling information. This connection dramatically streamlines the modeling process, provides an internal audit trail, and eliminates the potential for manual entry errors.

9.1.1 Resource Plan Model[5]

Ameren Missouri uses the Strategic Planning model from Ventyx, typically referred to as MIDAS. It is the same software that was used in the development of Ameren Missouri's 2008 IRP, and is used for ongoing analysis within Ameren Missouri.

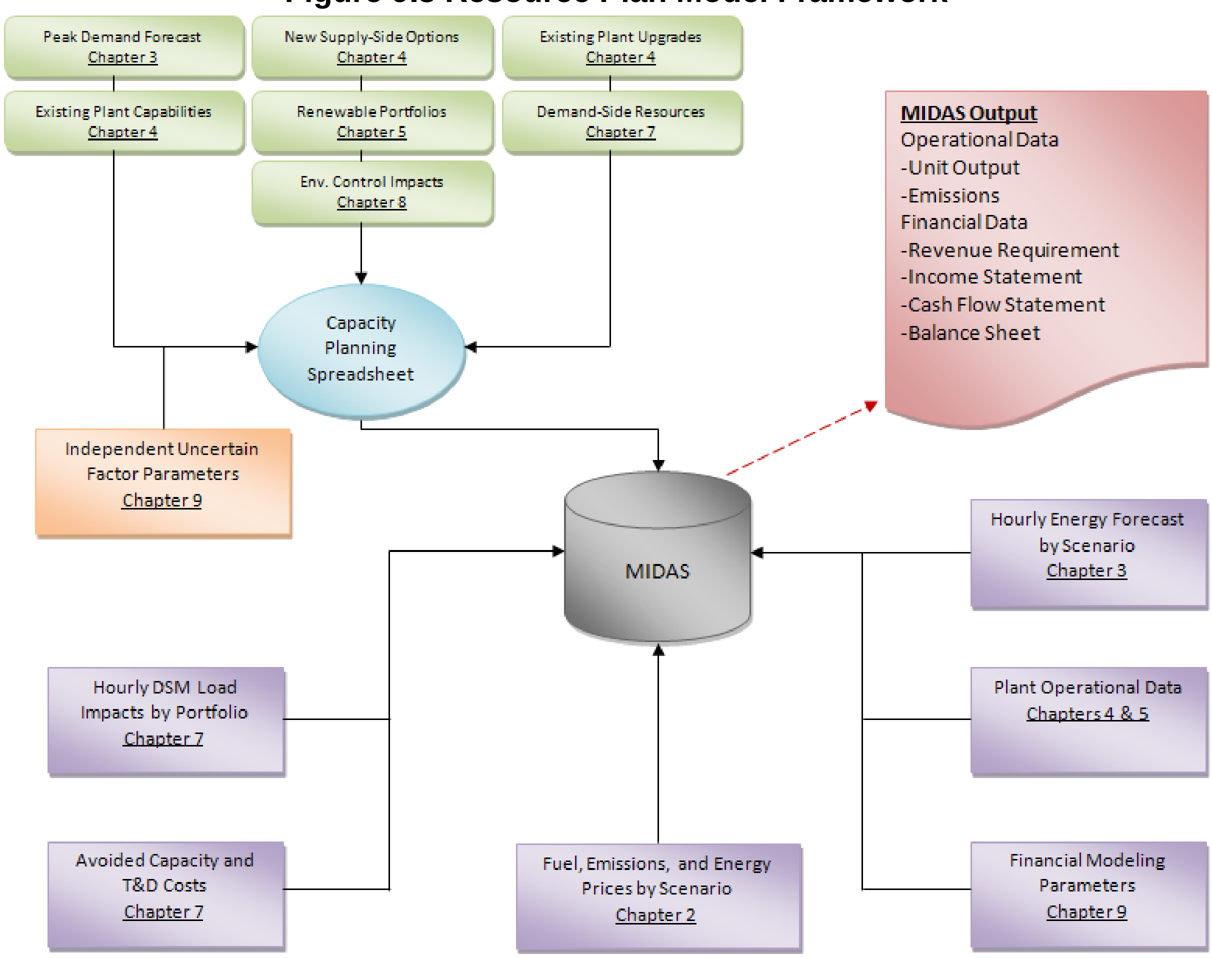
[2] "216 alternative resource plans - 060(2), 060(4), 060(4)(A).xls" on worksheet "Report"; 4 CSR 240-22.060(6)(A)
[3] 4 CSR 240-22.060(2); 4 CSR 240-22.060(4)
[4] "Cap Sheet_Risk_100510_GenerallyApplicable.xlsm" on worksheet "Calculations"
[5] 4 CSR 240-22.060(6)(E)

MIDAS 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 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 maintenance costs, emission allowance costs, scheduled maintenance outages, forced and partial outage rates. The generation fleet is dispatched competitively against market prices.

The financial module allows the ability to model other financial aspects regarding costs exterior to the direct operation of units and other valuable information that is necessary to properly evaluate the economics of a generation fleet. The financial module produces bottom-line financial statements to evaluate profitability and earnings impacts.[6]

Figure 9.3 provides an illustration of how the various outputs from other chapters come together as inputs into MIDAS.

Figure 9.3 Resource Plan Model Framework[7]



[6] 4 CSR 240-22.060(4)(A)
[7] 4 CSR 240-22.060(4)(D)

9.1.2 Preliminary Candidate Resource Plans

Selection of candidate resource plans from the 216 alternative resource plans began by developing and applying a preliminary scorecard.[8] This preliminary scorecard is distinguished from a more comprehensive version of the scorecard used for strategy selection. This scorecard used performance measures consistent with general resource planning and Ameren Missouri policy objectives. The results for each measure on the scorecard, as well as others, are provided in the electronic workpapers.[9]

The scorecard itself includes 6 diverse performance measures with varying weights to produce a single overall composite score for each alternative resource plan. Table 9.2 shows the policy objective categories, the measure used for each category, and the weight subjectively assigned to each category.[10]

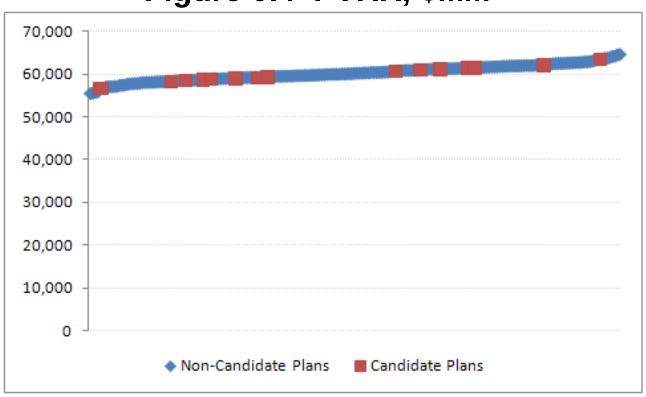
Table 9.2 Preliminary Scorecard

Policy Objective Category(ies)	Measure	Weighting
Environmental/Renewable/ Resource Diversity	Total plan carbon emissions	20%
Energy Efficiency	EE Portfolio	10%
Financial/Regulatory	PV Free Cash Flow	20%
Customer Satisfaction	Rate Increases	15%
Economic Development	Primary Job Growth (FTE-years)	10%
Cost	PVRR	25%
TOTAL		100%

Cost (25% Weighting)

Cost was represented by PVRR (Present Value of Revenue Requirements) and was calculated as a simple average of the 10 scenarios' results through 2039. The results for PVRR, the primary measure in IRP analysis, are shown for each of the 216 alternative resource plans in Figure 9.4. Of the candidate plans in the chart, the lowest cost plans are the DSM-only plans, while the baseload plans are the highest cost.

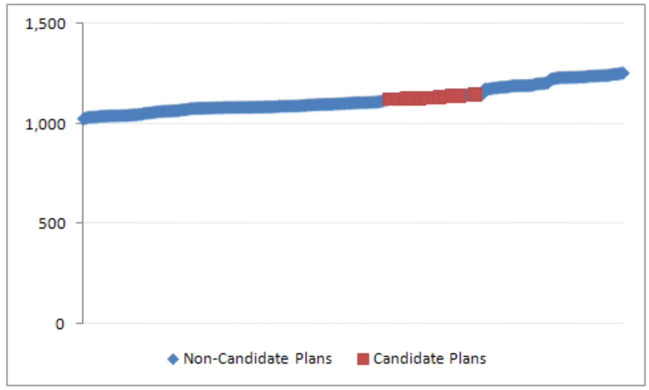
Figure 0.4 PVRR, $MM



[8] 4 CSR 240-22.060(4)
[9] 4 CSR 240-22.060(4); 4 CSR 240-22.060(4)(A); 4 CSR 240-22.060(6)(B)
"216 alternative resource plans - 060(2), 060(4), 060(4)(A).xls" on worksheet "Report"
"Scoring matrix with 12-29 data.xls" on worksheet "Scorecard-Report"
[10] 4 CSR 240-22.060(2); 4 CSR 240-22.010(2)(B)

Environmental (20% Weighting)

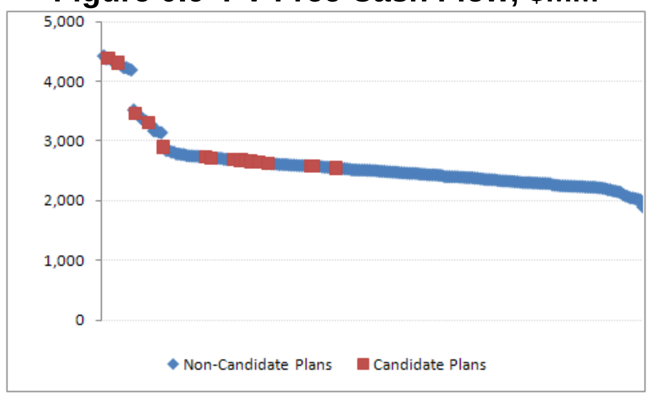
Figure 0.5 Carbon Emissions, MM Tons



Environmental / renewable resource diversity was represented by total carbon emissions during the 2011-2030 IRP timeframe, and is shown for each of the 216 alternative resource plans in Figure 9.5. The DSM only and nuclear plans produced the lowest carbon emissions. Controlling for Meramec retirement, the natural gas plans have higher carbon emissions. It is noteworthy that the coal resource option included 90% carbon capture; however, coal had higher levels of other emissions, such as SO_2 and mercury, than the gas resources.

Financial/Regulatory (20% Weighting)

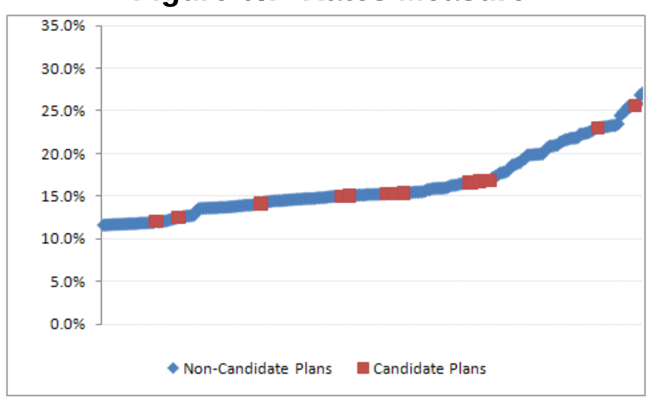
Figure 0.6 PV Free Cash Flow, $MM



Financial/regulatory was represented by PVFCF (Present Value of Free Cash Flow) through 2039, and is shown for each of the 216 alternative resource plans in Figure 9.6. With a shorter amortization period than that used to depreciate supply side resources, the DSM-only plans performed better on PVFCF than other plans.

Customer Satisfaction (15% Weighting)

Figure 0.7 Rates Measure

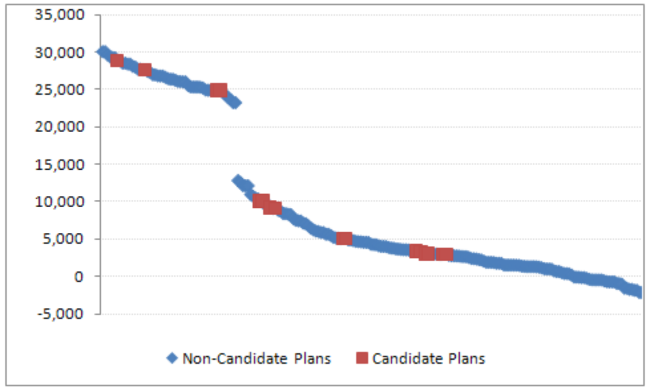


Customer satisfaction was represented by a composite of two rates measures, and is shown for each of the 216 alternative resource plans in Figure 9.7. That composite was the sum of the maximum single year percentage increase in rates and the average percentage increase in rates across the entire IRP timeframe. The natural gas plans performed best (lowest) on this measure with DSM-only plans in the middle and the baseload plans performing worst (highest).

Economic Development (10% Weighting)

Economic development was represented by each plan's full-time-equivalent job impact, and is shown for each of the 216 alternative resource plans in Figure 9.8. When the value of the Meramec attribute was "Retire", the total overall jobs were relatively low or negative since there were in some cases not enough jobs created by the implementation of other resources to offset those lost jobs at Meramec. On the high end of this measure, both the 30% ownership nuclear and the 50% ownership nuclear supply side types and some of the DSM-only supply side types had relatively high numbers of jobs compared to other plans.

Figure 0.8 Jobs (FTE-Years)



The FTE-year estimates for each major resource option are shown in Table 9.3 and are intended to be comparable and indicative of the different resource types. The estimates are also limited to the direct economic impact; that is, only those jobs that are directly connected to delivery of the resource. The FTE-years estimates for coal, natural gas, and wind were derived from the National Renewable Energy Laboratory's (NREL) Jobs and Economic Development Impacts (JEDI) models, which are publicly available. The Nuclear estimates were from a 2008 Development Strategies study assessing the economic impact of a new 1600 MW unit added at the Callaway site. For purposes of our analysis and screening, the entire total of jobs for nuclear were used regardless of the amount assumed to be owned by Ameren Missouri since the entire plant would have to be built to be a viable resource. The jobs for pumped storage were based on Ameren Missouri's recent experience with rebuilding its Taum Sauk facility. In estimating the economic impacts of the energy efficiency portfolios, Ameren Missouri assigned each program to an appropriate economic activity group that

Table 0.3 FTE-Year Estimates

Supply-Side Type	Construction FTE-Years	Ongoing FTE-Years
Coal w/CCS	7,182	68
CC-Greenfield	1,512	30
CC-Meramec	1,950	42
CC-Venice	937	30
SC-Greenfield	1,156	35
Pumped Storage	3,400	6
Nuke 30%	23,680	400
Nuke 50%	23,680	400
Wind/SC	977	54
EE Portfolio	**Total FTE-Years**	
MAP	26,790	
RAP	11,960	
Low Risk	3,490	

could be modeled using IMPLAN multipliers. This approach is consistent with how such economic impacts are typically modeled.

Energy Efficiency (10% Weighting)

Energy efficiency spending, 10% weight, was represented by spending on energy efficiency for the value levels of this sub-attribute of DSM. In rating the energy efficiency portfolios MAP was given the highest score of 1 with RAP plans receiving 0.9. The relatively low trade-off in the scoring is consistent with the definitions of the portfolios and RAP being an aggressive portfolio with the most realistic representation of achievable savings. The Low Risk portfolio was given a score of 0.1 while the plans without DSM received a score of 0.

Table 9.4 shows scoring results for a selection of the 216 alternative resource plans. The selection includes plans with only the Proposition C renewable portfolio and Meramec retirement in 2022 and excludes plans with no DSM. This scoring summary provides representative relative performance between the major resource options considered and provides a quantitative basis for the conclusions drawn from this phase of the analysis.

Table 0.4 Scorecard for Selected Alternative Resource Plans

		Category->	Environmental/ Renewable/ Resource Diversity	Energy Efficiency	Financial / Regulatory	Customer Satisfaction	Economic Development	Cost
		Weight->	20%	10%	20%	15%	10%	25%
Noranda Status	Plan Type	Unitized Score	Unitized Total plan carbon emissions	Unitized Energy Efficiency parameter	Unitized Free Cash Flow	Unitized blend: single yr max & 29yr avg % chg	Unitized Primary Job Growth (FTE-years)	Unitized PVRR
Noranda continues	DSM only-MAP case	0.932	0.922	1.000	0.987	0.873	0.839	0.941
	DSM only-RAP case	0.836	0.921	0.900	0.782	0.878	0.378	0.944
	Nuke 30%-Low Risk case	0.739	0.921	0.100	0.590	0.694	0.962	0.905
	Nuke 50%-Low Risk case	0.719	0.922	0.100	0.585	0.576	0.962	0.899
	SC greenfield-Low Risk case	0.685	0.910	0.100	0.604	0.847	0.161	0.914
	CC Meramec-Low Risk case	0.681	0.903	0.100	0.607	0.822	0.187	0.910
	CC greenfield-Low Risk case	0.678	0.905	0.100	0.599	0.815	0.170	0.911
	CC Venice-Low Risk case	0.677	0.902	0.100	0.603	0.817	0.153	0.912
	Wind with SC-Low Risk case	0.665	0.916	0.100	0.653	0.657	0.160	0.906
	Pumped Storage-Low Risk case	0.659	0.920	0.100	0.612	0.639	0.222	0.896
	Coal with CCS-Low Risk case	0.636	0.916	0.100	0.582	0.484	0.351	0.875
Noranda expires 2020	DSM only-MAP case	0.938	0.925	1.000	0.971	0.862	0.839	0.981
	DSM only-RAP case	0.836	0.923	0.900	0.746	0.863	0.378	0.980
	Nuke 30%-Low Risk case	0.765	0.924	0.100	0.583	0.832	0.925	0.947
	Nuke 50%-Low Risk case	0.753	0.926	0.100	0.531	0.841	0.900	0.943
	CC Meramec-Low Risk case	0.702	0.910	0.100	0.596	0.898	0.181	0.952
	Wind with SC-Low Risk case	0.699	0.918	0.100	0.617	0.863	0.157	0.949
	SC greenfield-Low Risk case	0.698	0.914	0.100	0.603	0.871	0.156	0.955
	CC greenfield-Low Risk case	0.696	0.909	0.100	0.597	0.865	0.168	0.952
	CC Venice-Low Risk case	0.694	0.907	0.100	0.600	0.865	0.150	0.953
	Pumped Storage-Low Risk case	0.690	0.921	0.100	0.606	0.785	0.222	0.940
	Coal with CCS-Low Risk case	0.660	0.919	0.100	0.574	0.582	0.349	0.919

Conclusions[11]

The observations from the analysis results led to the following conclusions:

- From an overall composite perspective, using the total weighted scores based on the Preliminary Scorecard in Table 9.2, the top plans were the DSM-only plans and nuclear plans.
- Plans with Federal RES requirements are more expensive. This is not surprising considering the Missouri RES rate cap limited the amount of renewable resources added. Only the Missouri RES portfolios were analyzed further.
- The three combined cycle options are nearly indistinguishable on the various performance measures. Since all three options perform so similarly and carry similar risks there is no need to continue to analyze all three options. The Greenfield combined cycle option was analyzed further as a representative of the combined cycle resource type. Further analysis outside this IRP will be needed to determine which site is more appropriate should construction of a combined cycle plant become more certain.
- The 50% nuclear resource option can be eliminated from further analysis considering its relative performance. The 30% ownership option adequately represents the nuclear supply-side type for the remaining analysis.
- Ameren Missouri developed the Low Risk DSM portfolio based on the continuation of the current regulatory framework. The analysis also shows the no-DSM option is more costly than the Low Risk portfolio. Therefore, there is no need to continue to analyze the alternative resource plans without DSM.
- The analysis indicates the cost of a plan increases as the time remaining before retirement of Meramec is shorter. Also, if Meramec continues there is less resource plan diversity since there are fewer resource needs. At this juncture in the analysis it is useful to reduce the number of plans but keep plan diversity. Since further analysis of Meramec retirement was yet to be conducted, only the plans with a 2022 retirement date were used for the sensitivity analysis.

Only 16 alternative resource plans were used for the sensitivity analysis after eliminating plans based on the screening analysis conclusions. Table 9.5 lists the 16 preliminary candidate resource plans[12].

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[11] 4 CSR 240-22.060(4)

[12] EO-2007-0409 – Stipulation and Agreement #35

Table 0.5 16 Preliminary Candidate Resource Plans

Supply-Side	Meramec Status	Renewable Portfolio	DSM Portfolio	Noranda Status
--	Retired 2022	Missouri RES	MAP	Continues
				Expires
--	Retired 2022	Missouri RES	RAP	Continues
				Expires
Coal w/CCS	Retired 2022	Missouri RES	Low Risk	Continues
				Expires
CC-Greenfield	Retired 2022	Missouri RES	Low Risk	Continues
				Expires
Simple Cycle	Retired 2022	Missouri RES	Low Risk	Continues
				Expires
Pumped Storage	Retired 2022	Missouri RES	Low Risk	Continues
				Expires
Nuke 30%	Retired 2022	Missouri RES	Low Risk	Continues
				Expires
Wind/SC	Retired 2022	Missouri RES	Low Risk	Continues
				Expires

9.2 Sensitivity Analysis[13]

Sensitivity analysis involves determining which of the candidate independent uncertain factors are critical independent uncertain factors.[14] Once identified in this step, critical uncertain factors were added to the scenario probability tree discussed in Chapter 2.

9.2.1 Uncertain Factors[15]

Ameren Missouri developed a list of 22 uncertain factors to determine which factors are critical to resource plan performance. Table 9.6 contains the list as well as information about the screening process.

Table 0.6 Uncertain Factor Screening

Uncertain Factor	Candidates?	Critical?	Included in Final Probability Tree?
Load Growth	✗**	--	✓
Interest Rates	✓	✓‡	✓‡
Carbon Policy	✗**	--	✓
Fuel Prices	✓*^	✗	✓††
Project Cost	✓	✓	✓
Project Schedule	✓	✗	✗
Purchased Power	✗	✗	✗
Emissions Prices	✗^	--	✗^
Fixed O&M	✓	✗	✗
Forced Outage Rate	✓	✗	✗
DSM Load Impacts	✓	✓†	✓†
DSM Cost	✓	✓†	✓†
Off-System Sales	✓	✗	✗
Investment Tax Credit	✗	✗	✗
Variable O&M	✓	✗	✗
Return on Equity	✓	✓‡	✓‡
Hourly Price Shapes	✗	✗	✗
Power Price Volatility	✗	✗	✗
Transmission Interconnection Costs	✗	✗	✗
Nuclear Incentives	✓	✗	✗
Wind Capacity Factor	✓	✗	✗
Solar Capacity Factor	✗	✗	✗

[13] 4 CSR 240-22.070(2)
[14] 4 CSR 240-22.070(1)
[15] 4 CSR 240-22.070(2)(A through L); 4 CSR 240-22.070(11)(A)2.

* Nuclear fuel prices only
** Included in the scenario probability tree
-- Not tested in sensitivity analysis
† DSM impacts and costs were combined
‡ Return on Equity and Long-term Interest rates were combined
†† Natural Gas Prices
^ SO_2, NO_x, coal prices, and energy prices were outputs of the scenarios

Chapter 2 described how 3 of these 22 candidate uncertain factors were determined to be critical dependent uncertain factors, which defined the scenarios. Those 3 factors were load growth, carbon policy, and natural gas prices.[16] It is also noteworthy that emissions prices, coal prices, and energy prices were outputs of the scenarios and thus 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.

- Purchased Power – As discussed in Chapter 4, Ameren Missouri did not include any Purchase Power Agreements as supply-side options so there is no application for the uncertain factor.
- Investment Tax Credit (ITC) – The ITC is limited to renewables and the earliest in-service dates of qualifying renewables in the candidate resource plans are at least 5 years beyond the date of reasonable extension of the investment tax credit.
- Hourly Price Shapes and Power Price Volatility - The price shaping methodology discussed in Chapter 2 already differentiated price shapes by altering on-peak/off-peak ratios of scenarios with and without carbon prices.
- Transmission Interconnection Costs – As discussed in Chapter 4, these costs are embedded in the project cost uncertain factor as a subcomponent of project cost.
- Solar Capacity Factor - Solar resources were included to meet renewable requirements and thus are consistent across plans. All plans would experience the same risk so varying solar capacity factor would not add any differentiation between plans.

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

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

Including the possible interactions of high/base/low would geometrically increase the analysis while some combinations would be less meaningful and less probable. Since the expectation is that these factors are highly correlated, the simplifying assumption is to combine the individual probably nodes into a combined probability node containing

[16] 4 CSR 240-22.070(4)

the high value for both, base value for both, and low value for both without explicitly considering the joint probabilities.

Uncertain Factor Ranges[17]

The sensitivity analysis examines whether or not candidate independent uncertain factors have a significant impact on the performance of candidate resource plans, as measured by their PVRR (present value of revenue requirements).

Most of the 13 candidates had a 3-level range of values for this analysis, those 3 levels being low, base, and high values. Two of the candidates, off-system sales and nuclear tax incentive, had a 2-level range of values, which were a default value and an alternative value.

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 this analysis, Ameren Missouri standardized the meaning of low to be the value found at the 10th percentile of a probability distribution of values for an uncertain factor, the value at the 50th percentile for the base value, and the value at the 90th percentile for the high value. The probability distribution used for each candidate uncertain factor was the one implied by a series of estimated values produced by a subject matter expert for that uncertain factor.

The selection of these particular percentiles (10 and 90) to represent low and high also reflected Ameren Missouri's incorporation of more extreme outcomes in this IRP than in its 2008 IRP[18]. In the 2008 IRP, "low" meant a value found at the 25th percentile, and "high" meant a value found at the 75th percentile. In addition, the amount of probability assigned to low and to high values in this IRP, compared to the amount of probability assigned to the base value, reflected consideration of more extreme outcomes. In this IRP, a 20% probability was used for the low value and for the high value, which is less than the 25% probability used for low and for high in the prior IRP. A lower probability is associated with a more extreme outcome, and a higher probability is associated with a less extreme outcome.

Ameren Missouri reviewed and considered use of available measurement techniques such as Value at Risk for appropriate uncertain factors when addressing risk associated with extreme outcomes[19]. Ameren Missouri reviewed, among others, the document suggested by Missouri Department of Natural Resources consultant Synapse on application of Value at Risk (VaR) in utility resource planning: "Energy Portfolio

[17] EO-2007-0409 – Stipulation and Agreement #34
[18] EO-2007-0409 – Stipulation and Agreement #33
[19] EO-2007-0409 – Stipulation and Agreement #33

Management: Tools and Practices for Regulators," Synapse Energy Economics, October 2006. This document suggests focusing on a particular region of a probability distribution, selecting a representative value in that region and an associated probability. That approach is similar to Ameren Missouri's approach for dealing with low, base, high values of uncertain factors.

For the majority of cases probability distributions were used to obtain the values for low, base, and high. This process began with subject matter experts providing estimates of (A) a standard value, (B) estimates of deviations from that standard value, and (C) the probabilities of those deviations from the standard value. That information was used to create the probability distribution collectively implied by that data. Values at the 10^{th}, 50^{th}, and 90^{th} 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.

Example

The standard value for Fixed Operations & Maintenance (FOM), for the greenfield Combined Cycle is $7.04/kW-year. FOM and some other candidate uncertain factors have differing standard values among various supply-side types, while some other candidate uncertain factors do not have different standard values among supply types. 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.

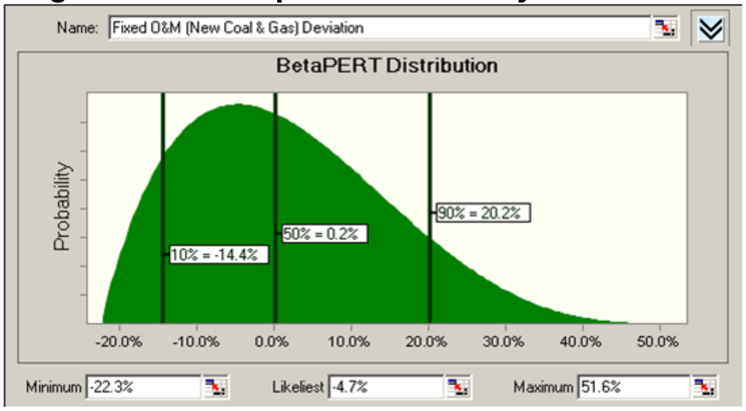
The subject matter expert, in this case Black and Veatch, provides estimates of deviations from the standard value as well as the probabilities of those deviations. An example of that initial uncertainty distribution is shown in Table 9.7. In this example, the first of these estimates for FOM deviations was a -20% deviation from the FOM standard value with a 5% probability of occurring. These deviation estimates provide sufficient information to derive continuous probability distributions from which the low/base/high values can be selected.

Table 0.7

Fixed O&M Uncertainty Distribution	
Deviation	**Probability**
-20%	5%
-10%	25%
0%	40%
15%	25%
30%	5%

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 0.. From this distribution the values for the low, base, and high deviations from the standard value (-14.4%, 0.2%, 20.2%) are shown at the respective percentile markers in the Figure and represent the 10^{th}, 50^{th}, and 90^{th} percentiles.

Figure 0.9 Example of Probability Distribution



The final step in the process of developing for low, base, and high values for uncertain factors involved multiplying the standard value for an uncertain factor times its low, base, and high deviation factors. Continuing with the FOM example, this step is shown in Table 9.8. The standard value of $7.04/kW-Year was multiplied by the quantity 1 plus the low, base, and high deviation factors (-14.4%, 0.2%, 20.2%) to create the low, base, and high values for FOM for the greenfield Combined Cycle.

Table 0.8

Standard value	$7.04
Deviation Low	-14.4%
Deviation Base	0.2%
Deviation High	20.2%
Value Low	$6.03
Value Base	$7.05
Value High	$8.46

Table 9.9 contains the uncertain factor ranges for the factors that are resource-specific while Table and 9.10 contains the uncertain factor ranges for factors that are common across supply-side options.

Table 0.9 Resource-Specific Uncertain Factor Ranges

Uncertain Factor	Value	Probability	Coal w/CC	CC Greenfield	SC Greenfield	Pumped Storage	Nuclear (100%)	Wind (100 MW)
Project Cost ($MM)	Low	20%	3,018	591	226	1,421	5,701	171
	Base	60%	3,533	692	264	1,663	6,755	200
	High	20%	4,238	830	317	1,995	8,001	240
Project Schedule (yrs*)	Low	20%	6	3	2	5	7	3
	Base	60%	7	4	3	6	8	4
	High	20%	9	5	4	8	9	5
Fixed O&M ($/kW-yr)	Low	20%	$31.93	$6.03	$5.90	$2.72	$37.88	$42.80
	Base	60%	$37.37	$7.05	$6.90	$3.19	$45.17	$50.10
	High	20%	$44.83	$8.46	$8.28	$3.82	$54.85	$60.10
Variable O&M ($/MWh)	Low	20%	$5.58	$1.97	$6.85	$1.74	$1.72	$3.14
	Base	60%	$10.90	$3.64	$12.80	$3.22	$2.05	$6.00
	High	20%	$15.81	$5.31	$18.75	$4.69	$2.49	$8.86
EFOR (%)	Low	20%	4.1%	1.1%	1.1%	0.7%	2.1%	2.7%
	Base	60%	8.0%	2.1%	5.0%	4.7%	2.4%	5.0%
	High	20%	11.9%	3.6%	8.9%	15.5%	2.7%	7.3%

Table 9.9 includes the uncertain factor for project schedule. It is noteworthy that 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 0.10 Uncertain Factor Ranges

Uncertain Factor	Low	Base	High
Probability->>	20%	60%	20%
Wind Capacity Factor	31.4%	37.6%	43.5%
Nuclear Fuel Price	varies by year		
Long Term Int. Rates	5.7%	7.2%	8.4%
Return on Equity	10.16%	11.35%	13.27%
Energy Efficiency Load Impact			
MAP	69%	96%	113%
RAP	74%	99%	115%
Low Risk	73%	100%	112%
Demand Response Load Impact			
MAP	72%	100%	118%
RAP	75%	100%	116%
Low Risk	73%	100%	112%
DSM Cost			
MAP	90%	100%	110%
RAP	90%	100%	110%
Low Risk	90%	100%	110%

The two candidate independent uncertain factors that had 2 value levels instead of the typical low/base/high structure were off-system sales and nuclear tax incentives.

As a default, with a 50% probability, off-system sales included no premium to achieve market sales or purchases. As an alternative, with a 50% probability, off-system sales were limited to those after a $10 premium was required to achieve market sales or purchases.

As a default, with a 75% probability, no nuclear tax incentives were included. As an alternative, with a 25% probability, a 10% tax credit plus the reduction of tax depreciation life from 15 to 5 years were included for nuclear plants.

9.2.2 Sensitivity Analysis Results

To conduct sensitivity analysis, each of the 16 preliminary candidate resource plans was analyzed using the varying value levels (low/base/high or default/alternative) for each of the 13 candidate independent uncertain factors, for each of the scenarios in the probability tree. A scenario-probability-weighted result (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 a base value for each plan for each candidate factor. The sensitivity analysis results are included in the electronic workpapers.[20]

The results of this process produced 210 comparisons that were plotted to determine what significant differences had occurred and for which candidate uncertain factors. The comparisons were made using 2 metrics: absolute value of the percent difference in PVRR, and absolute value of the difference in rank.

Figure 0.10 PVRR Impacts

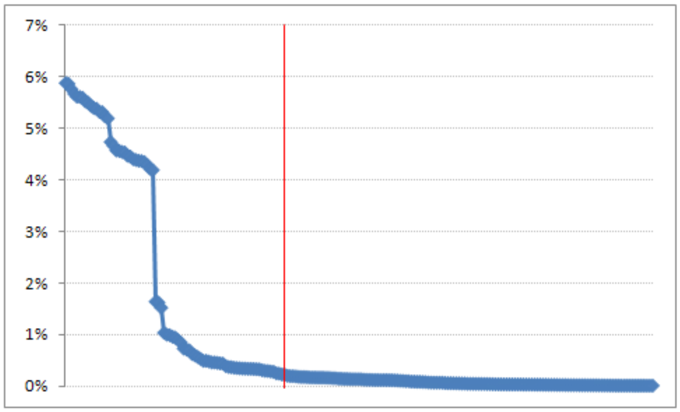


Figure 9.10 shows the sensitivity results for the absolute value difference in PVRR and shows that 95% of the differences are to the left of a red vertical line. Nearly half of those observations were for the long term interest rate and return on equity pair of uncertain factors. In fact, all of the impacts greater than 4% were from that pair. The DSM cost and load impact pair of uncertain factors and the project cost uncertain factor were the next largest contributors to changes in PVRR.

Figure 0.11 Rank Impacts

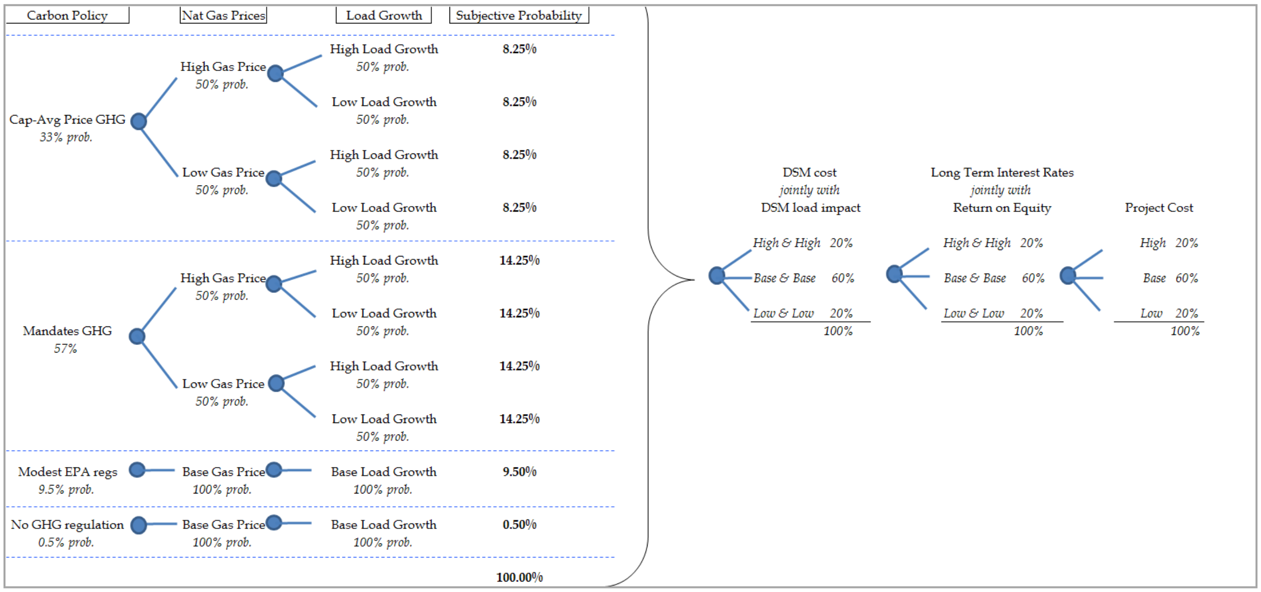
The second view of sensitivity analysis focused on the change in plan rank based on PVRR. In Figure 9.11 shows the results of this view and shows a red vertical line that separates non-zero rank changes on the left from zero rank changes on the right on this metric. A majority of the rank changes were attributed to the long term interest rate & return on equity pair of uncertain factors and the DSM cost and load impact pair of uncertain factors

The conclusion from the sensitivity analysis results on these two metrics was that three critical independent uncertain factors needed to be considered in the risk analysis: the long term interest rate & return on equity pair of uncertain factors, the DSM cost and load impact pair of uncertain factors, and the project cost uncertain factor.

[20] "Sensitivity analysis_111710.xls"

These 3 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 0.12, with these 3 critical independent uncertain factors shown on the right hand side.[21]

Figure 0.12 Final Probability Tree Including Sensitivity Analysis Results



9.3 Risk Analysis

The Risk Analysis consisted of running each of the 16 preliminary candidate resource plans in Table 9.5 through each of the branches on the final probability tree.[22] The probability tree consisted of 270 different branches. Each branch is the combination of different value levels among the 3 critical dependent uncertain factors (load growth, gas prices, and carbon policy) and the 3 critical independent uncertain factors (DSM cost together with DSM load impacts, project cost, and interest rates together with return on equity). 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%.

9.3.1 Risk Analysis Results

Figures 9.13 and 9.14 show the PVRR results of the risk analysis for the 16 preliminary candidate resource plans. The Figures are separated to show results with and without Noranda to facilitate comparisons of resource types. Both Figures show, with the additional uncertain factors incorporated, RAP is now the lowest cost plan. It is also noteworthy that Simple Cycle, Combined Cycle, Wind/Simple Cycle, and Nuclear plans

[21] 4 CSR 240-22.070(1); 4 CSR 240-22.070(3); 4 CSR 240-22.070(11)(A)
[22] 4 CSR 240-22.070(1)

are in a relatively tight range. Furthermore, the figures indicate the status of Noranda does not affect the relative performance of resource types.

Figure 0.13 Probability Weighted PVRR Noranda Continues

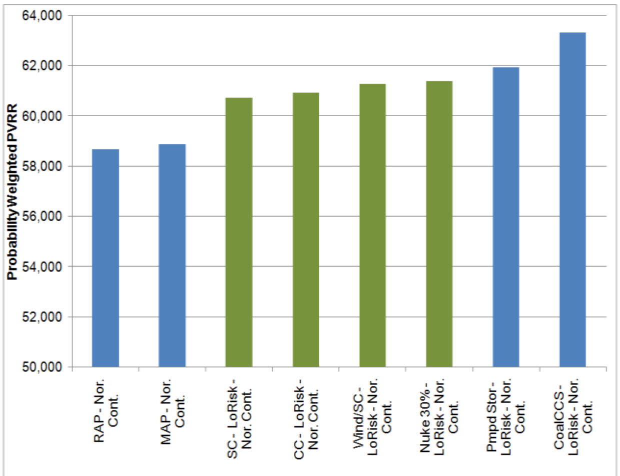
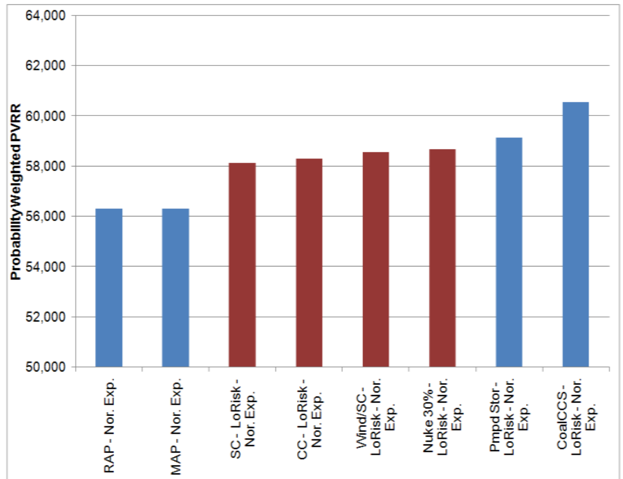


Figure 0.14 Probability Weighted PVRR Noranda Expires



Conclusions[23]

- Pumped storage and coal with carbon capture significantly underperform; therefore, there is no need to continue to analyze these resource options.

- RAP's risk adjusted PVRR is lower than MAP's risk adjusted PVRR. In addition, given the maturity of Ameren Missouri DSM programs, the challenging regulatory environment, and expected customer acceptance, MAP is not a resource that can be realistically implemented at this time.

- The status of Noranda has little impact on relative resource performance. All further analysis in this IRP was based on Noranda continuing as an Ameren Missouri customer throughout the planning horizon.

- The combined cycle option is an attractive option for near-term development due to its competitive overall cost, relatively low capital cost and relatively short lead time. It also adds intermediate gas to Ameren Missouri's portfolio.

- While the simple cycle resource option performs well on total cost, Ameren Missouri's existing resource portfolio includes a robust fleet of peaking resources already. For that reason, additional gas-fired peaking generation is considered a contingency resource option that may be pursued under circumstances when rapid resource deployment may be needed.

[23] 4 CSR 240-22.060(4)

9.3.2 Incorporating the Meramec Retirement Analysis

Initial analysis design called for a separate analysis of Meramec retirement possibilities through consideration of various values for the Meramec retirement attribute of resource plans. The relevant results from that step would be brought back into Risk Analysis.

Limiting the number of possibilities for the Meramec retirement analysis and reducing the number of resource plans allows the incorporation of the retirement analysis into the Risk Analysis. This also allowed for and enriched risk analysis with a more comprehensive consideration of environmental controls; and by having a variety of environmental controls possibilities, we introduced consideration of uncertainty for environmental control capital costs as part of the project cost uncertain factor.

The Meramec retirement analysis included the following options: continue as-is, retire and replace with new resources, continue with addition of environmental controls, and conversion to natural gas boiler operation. Environmental controls were either Moderate or Aggressive, as discussed in Chapter 8. A retirement date of 2016 was analyzed to match the avoidance of major environmental controls in the Aggressive scenario.

As a reminder, the alternative resource plans were originally developed by incorporating one major supply-side resource, if necessary, and then using market capacity purchases to meet the remaining capacity needs. By developing alternative resource plans in this manner the analysis provides a direct comparison of resource types. That direct comparison was analyzed in the initial risk analysis and this stage of the IRP analysis allows for the development of plans with multiple supply-side resource types ("multi-resource" plans). Multi-resource plans are only necessary in the case of Meramec retirement where resource needs are coincident with the 2016 Meramec retirement. As discussed in section 9.3.1, the combined cycle resource option is an attractive option to be developed in the near-term so it was used as the first major supply-side resource followed by one of the top four supply-side options: combined cycle, simple cycle, simple cycle/wind, and nuclear. Even with Meramec retirement in 2016, no supply-side resources are needed with RAP DSM. In the cases in which Meramec is not retired, only one major supply-side resource is needed late in the planning horizon. Table 9.11 shows the 14 final candidate resource plans that are created by incorporating the Meramec retirement analysis into the risk analysis.[24]

[24] EO-2007-0409 – Stipulation and Agreement #35; 4 CSR 240-22.060(4); 4 CSR 240-22.070(11)(A)1.

Table 9.11 14 Candidate Resource Plans

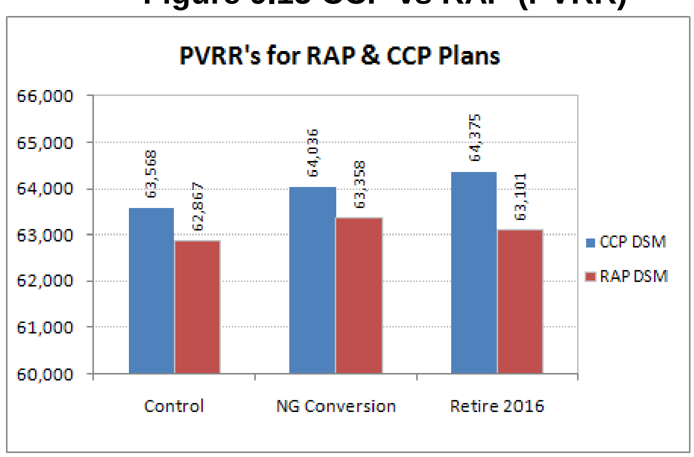
Envir. Scenario	Meramec Status	First Supply-Side	Second Supply-Side	Renewable Portfolio	DSM Portfolio	Noranda Status
Moderate	Continues As-Is	--	--	Missouri RES	RAP	Continues
Moderate	Continues As-Is	Combined Cycle	--	Missouri RES	Low Risk	Continues
Moderate	Continues As-Is	Simple Cycle	--	Missouri RES	Low Risk	Continues
Moderate	Continues As-Is	Nuclear 30%	--	Missouri RES	Low Risk	Continues
Moderate	Continues As-Is	Wind/SC	--	Missouri RES	Low Risk	Continues
Aggressive	Retired 2016	--	--	Missouri RES	RAP	Continues
Aggressive	Retired 2016	Combined Cycle	Combined Cycle	Missouri RES	Low Risk	Continues
Aggressive	Retired 2016	Combined Cycle	Simple Cycle	Missouri RES	Low Risk	Continues
Aggressive	Retired 2016	Combined Cycle	Nuclear 30%	Missouri RES	Low Risk	Continues
Aggressive	Retired 2016	Combined Cycle	Wind/SC	Missouri RES	Low Risk	Continues
Aggressive	Controlled	--	--	Missouri RES	RAP	Continues
Aggressive	Controlled	Combined Cycle	--	Missouri RES	Low Risk	Continues
Aggressive	Gas Conversion	--	--	Missouri RES	RAP	Continues
Aggressive	Gas Conversion	Combined Cycle	--	Missouri RES	Low Risk	Continues

9.3.3 DSM Portfolio Comparison[25]

Ameren Missouri tested an alternative combination of DSM resources by assuming implementation of all available demand response resources first, then incorporating energy efficiency as needed to just meet capacity needs. This allowed us to test, in a fully integrated fashion, whether the additional load reduction provided by the RAP portfolio was cost effective. As a reminder, the plans were originally created in an opposite fashion by using all available energy efficiency resources then using demand response to meet any remaining capacity needs. The new portfolio, the Capacity Calibrated Portfolio (CCP), produced energy savings between the RAP and Low Risk DSM Portfolios. For comparison, we considered plans for each of three Meramec paths -- control, retire, or natural gas conversion -- with both CCP and with RAP.

Results of this analysis showed that comparable RAP plans provided consistently better (lower) PVRRs than CCP plans, as shown in Figure 9.15, thus indicating that further analysis of the CCP portfolio is unnecessary.

Figure 9.15 CCP vs RAP (PVRR)



[25] 4 CSR 240-22.010(2)(A)

9.3.4 Risk Analysis 2.0 Results

Figures 9.16, 9.17 and 9.18 show the PVRR results of the risk analysis for the 14 candidate resource plans. The comparisons are grouped by resource type to facilitate the comparisons of different Meramec outcomes. Figure 9.16 shows the results under the Energy Bill Mandates scenarios while figure 9.17 shows the results under the Cap and Trade scenarios, and Figure 9.18 shows the results across all of the planning scenarios. It is evident from these results that continuing to operate Meramec without significant additional environmental controls will yield the lowest PVRRs. It is also evident that the supply-side resource options are performing very similarly while the DSM-only plans yield the lowest PVRRs. Other performance measures can be found in Chapter 9 – Appendix A.[26]

Figure 0.16

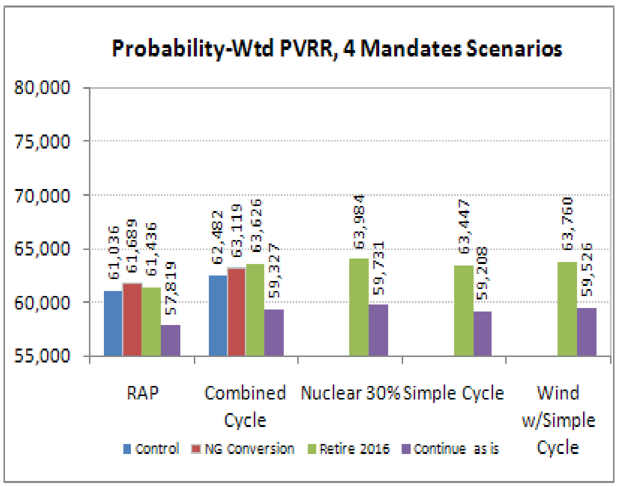


Figure 0.17

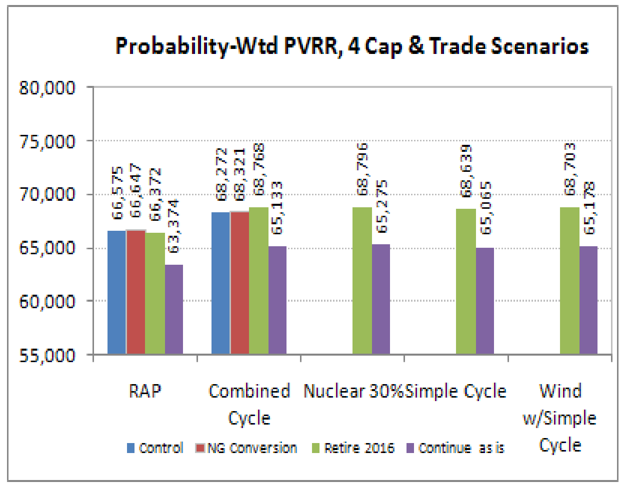
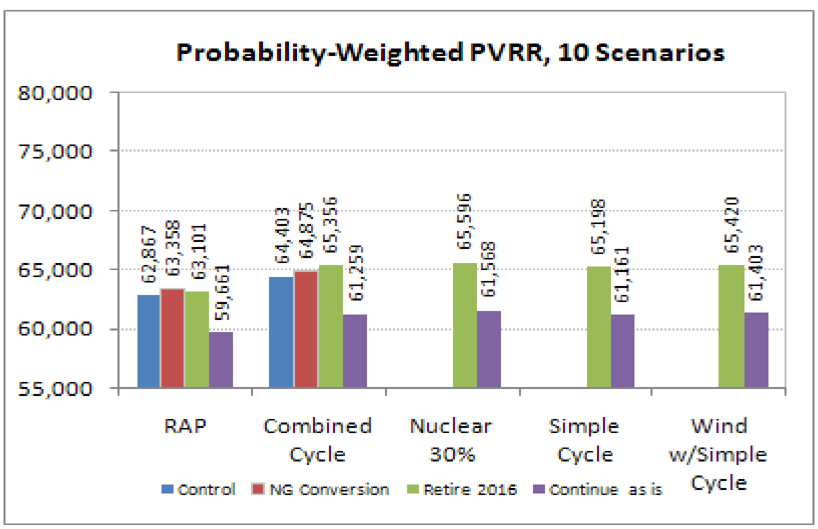


Figure 0.18



[26] 4 CSR 240-22.060(A); 4 CSR 240-22.060(6)(B); 4 CSR 240-22.060(6)(C)(1 through 10); 4 CSR 240-22.070(5); 4 CSR 240-22.070(5)(A); 4 CSR 240-22.070(5)(B)

If decision making were solely based on PVRR then the analysis would be complete at this point. Since decision making is multi-dimensional, Ameren Missouri created a scorecard that embodied its policy objectives. That scorecard was used throughout the analysis as a means to winnow a large number of resource plans down to a short list of the most promising plans. The analysis to this point has also been based solely on perfect ratemaking as modeled in MIDAS[27]. With only 14 plans remaining, Ameren Missouri can take an even closer look at the performance of the plans by introducing realistic ratemaking and financial constraints. Ameren Missouri is then able to expand the scorecard to include additional measures based on the policy objectives and ultimately select an appropriate strategy based on understanding the trade-offs across multiple planning objectives. Chapter 10 – Strategy Selection includes the additional analysis and decision-making considerations that lead to the selection of the Resource Acquisition Strategy.

[27] 4 CSR 240-22.060(4)(B)

9.4 Compliance References