VOLUME 4

SUPPLY-SIDE RESOURCE ANALYSIS

KCP&L GREATER MISSOURI OPERATIONS COMPANY (GMO)

INTEGRATED RESOURCE PLAN

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HIGHLIGHTS

- Over twenty generating technologies in various stages of development maturity have been analyzed and screened as potential future supply-side resources

- Candidate generation resources that passed screening included combustion turbines (CT), combined-cycle (CC), wind, and solar options and were made available as new generation resources in Integrated Analyses

- Existing power plant efficiency improvements have been an ongoing initiative at GMO generating units

- Future power plant efficiency projects have been identified and expected to be completed in upcoming years

- Existing generation resources have been studied to determine future environmental retrofit requirements and expected maintenance needs

SECTION 1: SUPPLY-SIDE RESOURCE

(1) The utility shall evaluate all existing supply-side resources and identify a variety of potential supply-side resource options which the utility can reasonably expect to use, develop, implement, or acquire, and, for purposes of integrated resource planning, all such supply-side resources shall be considered as potential supply-side resource options. These potential supply-side resource options include full or partial ownership of new plants using existing generation technologies; full or partial ownership of new plants using new generation technologies, including technologies expected to become commercially available within the twenty (20)-year planning horizon; renewable energy resources on the utility-side of the meter, including a wide variety of renewable generation technologies; technologies for distributed generation; life extension and refurbishment at existing generating plants; enhancement of the emission controls at existing or new generating plants; purchased power from bi-lateral transactions and from organized capacity and energy markets; generating plant efficiency improvements which reduce the utility's own use of energy; and upgrading of the transmission and distribution systems to reduce power and energy losses. The utility shall collect generic cost and performance information sufficient to fairly analyze and compare each of these potential supply-side resource options, including at least those attributes needed to assess capital cost, fixed and variable operation and maintenance costs, probable environmental costs, and operating characteristics.

GMO issued a Request for Proposal (RFP) dated December 11, 2017 for capacity and related energy. The RFP is attached as Appendix 4A, "GMO Capacity RFP". In total, thirteen responses were received, one of which was from KCP&L.

1.1 NEW PLANT RESOURCE OPTIONS

1.1.1 TECHNOLOGY CATEGORIES

The evaluation of potential supply-side resource options began with the identification of twenty-three existing or new technology alternatives. The information for these potential supply-side technologies was gathered from multiple sources including the Electric Power Research Institute (EPRI), the Department of Energy (DOE), responses to recent Request for Proposals (RFP), and other internal resources. The supply-side technologies were broken down into the following categories:

- Base load technologies
- Intermediate load technologies
- Peaking load technologies
- Renewable technologies

1.1.2 TECHNOLOGY DEVELOPMENT STATUS

For each technology, the development status was also considered and identified as either mature, commercial, demonstration, pilot, or developmental. Following is a brief description of these different technology stages:

- Mature technologies are proven and well established in the electric power generation industry.
- Commercial technologies are in operation, but efforts to optimize the heat rate and reduce the O&M costs are still on-going.
- Demonstration technologies have designs that are quite advanced, but very few plants exist with actual operating experience.
- Developmental technologies are still emerging.

These technologies and their current development status are shown below in Table 1 and Table 2.

Table 1: Generating Technology Categories

BASE LOAD		
Pulverized Coal	**Integrated Gasification CC**	**Nuclear**
SCPC	IGCC	Large Scale - AP1000
SCPC w/CC	IGCC w/CC	Small Modular Reactors
INTERMEDIATE LOAD		
Combined Cycle	**Fuel Cell**	**Energy Storage**
CC: 2x1 7FA	Solid Oxide	Compressed Air Energy Storage
CC: 2x1 M501 GAC Turbines		Pumped Hydro
CC: Advanced w/CC		Lithium-ion Battery
PEAKING LOAD		
Combustion Turbines and Small Scale Alternatives		
CT: 7FA.05		
CT: LM6000 (2x)		
CT: LMS100		
Reciprocating Engines		
RENEWABLES		
Solar PV - Single Axis Tracking	Wind	Landfill Gas
Solar PV - Central Station	Biomass BFB Boiler	

Table 2: Technology Development Status

Generation Category	Technology	Maturity
Combined Cycle	CC: 2x1 7FA	Mature
Combustion Turbine	CT: 7FA.05	Mature
	CT: LM6000 (2x)	Mature
	CT: LMS100	Commercial
Energy Storage	Compressed Air Energy Storage	Commercial
	Pumped Hydro	Mature
	Lithium-ion Battery	Commercial
Fuel Cells	Solid Oxide	Developmental
Integrated Gasification Comb Cycle	IGCC	Demonstration
	IGCC w/CC	Demonstration
Nuclear	Large Scale (AP1000)	Mature
	Small Modular Reactors	Developmental
Pulverized Coal	SCPC	Mature
	SCPC w/CC	Demonstration
Small Scale Alternatives	Reciprocating Engines	Mature
Renewables	Solar PV - Central Station	Commercial
	Solar PV - Single Axis Tracking	Commercial
	Wind	Commercial
	Biomass BFB Boiler	Commercial
	Landfill Gas	Mature

1.2 LIFE EXTENSION & EMISSION CONTROL ENHANCEMENT OPTIONS

In addition to the potential new supply-side resource options identified above, GMO evaluated the life extension and refurbishment of existing generating plants, along with the enhancement of the existing emission controls. To evaluate the life extension, an internal review of the long-term plant equipment needs was developed by using the Life Assessment and Management Program (LAMP). Further discussion of the LAMP process and associated estimated costs over the 20-year planning period can be found in Section 4.1.2.

1.3 CAPACITY & ENERGY MARKET OPTIONS

In order to consider existing market alternatives, GMO evaluated the option to purchase an ownership interest in the Dogwood Energy Center. Capital cost and operating characteristics were provided by Dogwood Energy, LLC, and the facility was passed on as an alternative in the integrated resource analysis.

1.4 PLANT EFFICIENCY IMPROVEMENTS

GMO works proactively to improve plant efficiency on the entire generation fleet. In addition to reducing production costs, reducing fuel use for a given amount of electric energy produced also effectively improves air quality-related emissions. Large baseload coal units produce the largest share of MWhs, so they are the natural focus of plant efficiency improvements

Daily attention to operational issues that may be negatively impacting plant efficiency is the first step to improvement. To monitor degradation, GMO employs the following:

1.4.1 SOFTWARE

EtaPRO© - Performance monitoring software from GP Strategies that performs real-time and continuous performance calculations to monitor equipment degradation. Platform also employs Advanced Pattern Recognition (APR) models to monitor equipment health. Software is implemented on the following units:

- Iatan Units 1 & 2

1.4.2 MANPOWER

Engineering positions dedicated to Plant Efficiency are staffed as follows:

- Supervising Engineer - Fleet Performance
- Iatan Performance/Combustion Engineer

- Contracted Remote Monitoring - contract with GP Strategies. Monitors and recommends operational improvements monthly.

Monitoring allows prioritization of projects that remedy efficiency degradation and/or make improvement. GMO invests significant capital on improvement projects to maintain or improve plant efficiency. These projects are detailed in Table 3 below:

Table 3: Power Plant Efficiency Projects

Project Description	Unit	Year	Performance Impact
Iatan Station			
Replace Air Heater Cold End Baskets	Iatan 1	2015	Nominal
Traveling Screen Upgrade	Iatan 1	2015	Moderate
Online Air In-Leakage Monitor	Iatan 2	2017	Nominal
Water Lance Addition	Iatan 2	2017	Nominal
Replace LP Rotors (w/enhanced performance option)	Iatan 1	2017	Significant
Combustion Air Inlet Screens	Both	2017	Nominal
Mill Throat Upgrade	Iatan 1	2017	Nominal
Mill Overhauls	Iatan 2	2018	Nominal
Intelligent Sootblowing	Iatan 2	2018	Moderate
Replace Cold End APH Baskets	Iatan 2	2018	Nominal
Rotating Classifiers	Iatan 1	2019	Moderate
HP Heater Replacement	Iatan 1	2021	Nominal
Upgrade IP Rotor	Iatan 1	2022	Nominal

GMO's performance efforts have resulted in the following key accomplishments:

- GMO's Iatan 2 continues to be one the most efficient plants in the United States
  - Consistently the top plant burning sub-bituminous Powder River Basin (PRB) coal.

- Industry leader in Optimization
    - KCP&L has partnered with Siemens to Optimize Sootblowing and Combustion processes. These efforts were featured in recent POWER magazine articles.

1.5 EXCLUDED TECHNOLOGIES

During the process of identifying potential supply-side alternatives, certain resource alternatives were excluded from the pre-screening exercise based on not being viable candidate resource options. The reasons certain resource alternatives could not be developed or implemented include lack of technology maturity, lack of suitability for this geographic region, and environmental concerns. Resources excluded from the pre-screening exercise and the reason for exclusion are listed in Table 4 below:

Table 4: Technologies Excluded From Pre-Screening

Technology	Reason For Exclusion
Central-Station Geothermal	Central US lacks adequate geological resources
Municipal Solid Waste	Developmental phase, environmental concerns concerning delivery of waste
Hydrokinetic (Run-of-River)	Experimental/unproven technology and wildlife concerns
Animal Waste	Delivery issues and high moisture content is problematic

Hydrokinetic technology is designed to channel and convert current from the river into electricity by the rotation of a turbine from the river flow. Potential issues beyond the economic feasibility include rivers being full of debris and sediment, turbine depths of at least nine feet to avoid collisions with boats, and aquatic life disturbance.

Municipal Solid Waste (MSW) technologies were also excluded from the prescreening process for several reasons. Some of the MSW technologies, in particular gasification and plasma arc, are in the developmental stage with limited data to support the capital cost estimates. While MSW incineration is a proven commercially available option, there are significant environmental concerns including air pollution control. Given that, it is doubtful a new MSW incineration plant could be sited or permitted. The potential of limited regional supplies of MSW, along with potential issues on delivery of sufficient supplies to fuel the technologies, are also limiting factors for these technologies. Finally, much of the revenue stream for MSW technologies comes in the form of 'tipping fee' revenues, which is a payment made for diverting the waste from the landfills. This revenue stream is another large unknown that makes it difficult to project the total cost of MSW technologies.

Animal Waste technologies, including anaerobic digestion, direct combustion, co-firing, and gasification, were excluded from the prescreening process. These technologies are viewed as an alternative, renewable fuel for electricity generation, but they have several key barriers. Some of the primary problems inherent with using animal waste as fuel include limited regional availability, prohibitive transportation costs, high moisture content which requires pre-drying of animal waste, and unmanageable ash disposition and slagging that can cause frequent boiler shutdowns. Due to these issues, these technologies were not included in the prescreening process.

SECTION 2: SUPPLY-SIDE ANALYSIS

The utility shall describe and document its analysis of each potential supply-side resource option referred to in section (1). The utility may conduct a preliminary screening analysis to determine a short list of preliminary supply-side candidate resource options, or it may consider all of the potential supply-side resource options to be preliminary supply-side candidate resource options pursuant to subsection (2)(C). All costs shall be expressed in nominal dollars.

2.1 SUPPLY-SIDE RESOURCE COST RANKINGS

(A) Cost rankings of each potential supply-side resource option shall be based on estimates of the installed capital costs plus fixed and variable operation and maintenance costs levelized over the useful life of the potential supply-side resource option using the utility discount rate. The utility shall include the costs of ancillary and/or back-up sources of supply required to achieve necessary reliability levels in connection with intermittent and/or uncontrollable sources of generation (i.e., wind and solar).

Each of the technologies identified in Table 1 above were initially ranked based on their relative annualized utility cost, which was then broken down into an average cost per MWh. In calculating the average cost per MWh, the following characteristics were considered:

- The unit size and capacity factor, which varied depending on the technology's generating unit duty cycle (base load, intermediate, or peaking). Renewable technologies were considered as a separate group due to the requirement that some renewable alternatives would have to be passed on to the integrated resource analysis, irrespective of the cost ranking, in order to meet the MO Renewable Energy Standard (RES). The unit sizes and capacity factors varied widely across all technologies, and the net capacity and capacity factors for each alternative are shown below in Table 5 and Table 6.

- The total capital requirement for building the unit, including the plant capital costs, transmission capital costs, owner costs, and interest during construction. A levelized fixed charge rate (FCR) was applied to these capital requirements to arrive at an annual carrying cost for each technology. The levelized FCR calculation considers the book life, tax life, debt and equity rates to arrive at the annual rate, which is then applied to the total capital requirement. The technology capital costs, including interest during construction, are shown below for each alternative in Table 7.

- The fixed O&M and variable O&M costs. The fixed O&M costs include operating labor, total maintenance costs, and overhead charges. The variable O&M costs include any materials that are consumed in proportion to the energy output, and the calculation of annual variable O&M cost is dependent upon the capacity factor assumption mentioned above. The fixed O&M and variable O&M cost assumptions for each technology are shown below in Table 8 and Table 9.

- The fuel costs based on a projected long-term average cost per MWh, along with the technology heat rate (where applicable). Further discussion of fuel cost projections is provided below in Section 5.1. The primary fuel types for each technology are shown below in Table 10.

- The probable environmental costs, including forecasted allowance prices for SO_2, NO_x, and CO_2, applied using the appropriate emission rates for each technology. The projected emission rates for each technology are shown below in Table 11. Further discussion on the development of the probable environmental costs is provided below in Section 2.2.

Table 5: Technology Net Capacity

Generation Category	Technology	Capacity (MW)
Combined Cycle	CC: 2x1 7FA	620
Combustion Turbine	CT: 7FA.05	207
	CT: LM6000 (2x)	88
	CT: LMS100	92
Energy Storage	Compressed Air Energy Storage	441
	Pumped Hydro	280
	Lithium-Ion	100
Fuel Cells	Solid Oxide	1
Integrated Gasification Comb Cycle	IGCC	1200
	IGCC w/CC	520
Nuclear	Large Scale (AP1000)	2234
	Small Modular Reactors	1340
Pulverized Coal	SCPC	1300
	SCPC w/CC	650
Small Scale Alternatives	Reciprocating Engines	107
Renewables	Solar PV - Central Station	3
	Solar PV - Single Axis Tracking	5
	Wind	100
	Biomass BFB Boiler	50
	Landfill Gas	3

Table 6: Technology Capacity Factors

Generation Category	Technology	Capacity Factor
Combined Cycle	CC: 2x1 7FA	60%
Combustion Turbine	CT: 7FA.05	10%
	CT: LM6000 (2x)	10%
	CT: LMS100	10%
Energy Storage	Compressed Air Energy Storage	23%
	Pumped Hydro	27%
	Lithium-Ion	16%
Fuel Cells	Solid Oxide	0
Integrated Gasification Comb Cycle	IGCC	85%
	IGCC w/CC	85%
Nuclear	Large Scale (AP1000)	90%
	Small Modular Reactors	90%
Pulverized Coal	SCPC	85%
	SCPC w/CC	85%
Small Scale Alternatives	Reciprocating Engines	0
Renewables	Solar PV - Central Station	18%
	Solar PV - Single Axis Tracking	27%
	Wind	54%
	Biomass BFB Boiler	90%
	Landfill Gas	88%

Table 7: Technology Capital Costs **Confidential**

[redacted]

Table 8: Technology Fixed O&M Costs ** Confidential**

[redacted]

Table 9: Technology Variable O&M Costs ** Confidential**

[redacted]

Table 10: Technology Primary Fuels

Generation Category	Technology	Primary Fuels
Combined Cycle	CC: 2x1 7FA	Natural Gas
Combustion Turbine	CT: 7FA.05 CT: LM6000 (2x) CT: LMS100	Natural Gas Natural Gas Natural Gas
Energy Storage	Compressed Air Energy Storage Pumped Hydro Lithium-Ion	Natural Gas Hydro None
Fuel Cells	Solid Oxide	Natural Gas
Integrated Gasification Comb Cycle	IGCC IGCC w/CC	Coal Coal
Nuclear	Large Scale (AP1000) Small Modular Reactors	Uranium Uranium
Pulverized Coal	SCPC SCPC w/CC	Coal Coal
Small Scale Alternatives	Reciprocating Engines	Natural Gas
Renewables	Solar PV - Central Station Solar PV - Single Axis Tracking Wind Biomass BFB Boiler Landfill Gas	Solar Solar Wind Biomass - Wood Landfill Gas

Table 11: Technology Emission Rates

Technology	NO_x (lbs/mmBtu)	SO_2 (lbs/mmBtu)	Hg (lbs/TBtu)	CO_2 (lbs/mmBtu)	PM (lbs/mmBtu)
CC: 2x1 7FA	0.01	-	-	119	0.01
CT: 7FA.05	0.01	-	-	119	0.01
CT: LM6000 (2x)	0.03	0.01	-	114	0.01
CT: LMS100	0.10	0.01	-	113	0.01
Compressed Air Energy Storage	0.01	0.001	-	117	-
Pumped Hydro	-	-	-	-	-
Lithium-Ion	-	-	-	-	-
Fuel Cell - Solid Oxide	-	-	-	115	-
IGCC	0.01	0.03	1.20	206	0.02
IGCC w/CC	0.01	0.02	1.20	21	0.02
Large Scale - AP1000	-	-	-	-	-
Small Modular Reactors (SMR)	-	-	-	-	-
SCPC	0.06	0.10	1.20	206	0.02
SCPC w/CC	0.05	0.06	1.20	144	0.02
Reciprocating Engines	0.02	-	-	122	0.03
Solar PV - Central Station	-	-	-	-	-
Solar PV - Single Axis Tracking	-	-	-	-	-
Wind	-	-	-	-	-
Biomass BFB Boiler	0.10	0.01	-	-	0.02
Landfill Gas	0.20	0.10	-	-	-

2.2 SUPPLY-SIDE RESOURCE PROBABLE ENVIRONMENTAL COSTS

(B) The probable environmental costs of each potential supply-side resource option shall be quantified by estimating the cost to the utility to comply with additional environmental legal mandates that may be imposed at some point within the planning horizon. The utility shall identify a list of environmental pollutants for which, in the judgment of the utility decision-makers, legal mandates may be imposed during the planning horizon which would result in compliance costs that could significantly impact utility rates. The utility shall specify a subjective probability that represents utility decision-maker's judgment of the likelihood that legal mandates requiring additional levels of mitigation will be imposed at some point within the planning horizon. The utility, based on these probabilities, shall calculate an expected mitigation cost for each identified pollutant.

Environmental laws or regulations that may be imposed at some point within the planning horizon may impact air emissions, water discharges, or waste material disposal. Following is a brief discussion of each of these pollutants that could result in compliance costs that may have a significant impact on utility rates.

2.2.1 AIR EMISSION IMPACTS

2.2.1.1 National Ambient Air Quality Standards

The Clean Air Act (CAA) requires the Environmental Protection Agency (EPA) to set National Ambient Air Quality Standards (NAAQS) for four air pollutants associated with fossil-fuel generation, including particulate matter (PM), ground-level ozone, sulfur dioxides (SO_s), nitrogen dioxide (NO_2). These air pollutants are regulated by setting human health-based or environmentally-based criteria for permissible levels.

2.2.1.2 Particulate Matter

In 2013, the EPA strengthened the PM standard. The Kansas City area is currently in attainment of the 2013 PM NAAQS. No additional emission control equipment is currently needed to comply with this standard. It is not known whether the Kansas City area will remain in attainment of a future revision of the standard. Future non-attainment of revised standards could require additional reduction technologies, emission limits, or both on fossil-fueled units.

2.2.1.3 Ozone

In 2015, the EPA strengthened the NAAQS for ground-level ozone. The Kansas City area is currently in attainment of the 2015 Ozone NAAQS. No additional emission control equipment is currently needed to comply with this standard. Future non-attainment of revised standards could result in regulations requiring additional NO_x reduction technologies, emission limits or both on fossil-fueled units.

2.2.1.4 Sulfur Dioxide

In 2010, the EPA strengthened the NAAQS for SO_2. The Kansas City area is currently in attainment of the 2010 SO_2 NAAQS except for a small area of Jackson County, Missouri. No additional emission control equipment is currently needed to comply with this standard. Future non-attainment of revised standards could result in regulations requiring additional SO_2 reduction technologies, emission limits or both on fossil-fueled units.

2.2.1.5 Nitrogen Oxides

In 2010, the EPA strengthened the NAAQS for NO_2. The Kansas City area is currently in attainment of the 2010 NO_2 NAAQS. No additional emission control equipment is currently needed to comply with this standard. Future non-attainment of revised standards could result in regulations requiring additional NO_2 reduction technologies, emission limits or both on fossil-fueled units.

2.2.1.6 Cross-State Air Pollution Rule

In 2011, the EPA finalized the Cross-State Air Pollution Rule (CSAPR), requiring eastern and central states to significantly reduce power plant emissions that cross state lines and contribute to ground-level ozone and fine particle pollution in other states. The CSAPR Update Rule took effect in 2017 with more stringent ozone-season NO_x emission budgets for electric generating units (EGUs) in many states to address significant contribution and maintenance issues with respect to the ozone NAAQS established in 2008. No additional emission control equipment is currently needed to comply with this rule. The Company complies through a combination of trading allowances within or outside its system in addition to changes in operations as necessary. Future, strengthened ozone, NO_2, or SO_2 standards could result in additional cross-state rule updates requiring additional trading of allowances, emission reduction technologies or reduced generation on fossil-fueled units.

2.2.1.7 Regional Haze

In June 2005, the EPA finalized amendments to the July 1999 Regional Haze Rule. These amendments apply to the provisions of the Regional Haze Rule that require emission controls known as best available retrofit technology, or BART, for industrial facilities emitting air pollutants that reduce visibility by causing or contributing to regional haze.

The pollutants that reduce visibility include $PM_{2.5}$, and compounds which contribute to $PM_{2.5}$ formation, such as NO_x, SO_2, and under certain conditions volatile organic compounds, and ammonia.

Under the 1999 Regional Haze Rule, states are required to set periodic goals for improving visibility in natural areas. As states work to reach these goals, they must develop regional haze implementation plans that contain enforceable measures and strategies for reducing visibility-impairing pollution.

The Regional Haze Rule directs state air quality agencies to identify whether visibility-reducing emissions from sources subject to BART are below limits set by the state or whether retrofit measures are needed to reduce emissions. It also directs these agencies to file Regional Haze plans with the EPA for approval.

2.2.1.8 Carbon Dioxide

In August 2015, the EPA finalized the Clean Power Plan (CPP). The rule's compliance target is 2030. The rule contains three interim compliance periods: 2022-2024, 2025-2027, and 2028-2029. Beginning in 2030, states and generating units must maintain the 2030 goal, reporting compliance every two years thereafter. By 2030, the EPA projects the CPP would achieve CO_2 emission reductions from the power sector of approximately 32% from CO_2 emission levels in 2005.

The rule includes three different forms of state goals: a rate-based form, a mass-based form, and a mass-based form allowing for new sources to participate. The EPA based the state goals on the weighted average of EPA-established uniform CO_2 emission performance rates for both steam generating units (1,305 lb CO_2/MWh) and natural gas-fired stationary combustion turbines (771 lb CO_2/MWh).

In February 2016, the U.S. Supreme Court granted a stay request of the CPP. The Court's order indicate that the stay will remain in effect through a determination by the Court to deny any petitions from the court of appeals that are filed, or after a judgment is issued by the Court if the Court takes the case.

In October 2017, the EPA proposed to repeal the CPP. EPA proposes a change in the legal interpretation as applied to section 111(d) of the CAA, on which the CPP was based, to an interpretation that the Agency proposes is consistent with the CAA's text, context, structure, purpose, and legislative history, as well as with the Agency's historical understanding and exercise of its statutory authority. Under this interpretation, the CPP exceeds the EPA's statutory authority and would be repealed.

On December 2017, the EPA issued an advance notice of proposed rulemaking (ANPRM) in which the agency is considering proposing emission guidelines to limit greenhouse gas (GHG) emissions from existing EGUs and is soliciting information on the proper respective roles of the state and federal governments in that process, as well as information on systems of emission reduction that are applicable at or to an existing EGU, information on compliance measures, and information on state planning requirements under the CAA. This ANPRM does not propose any regulatory requirements.

An ANPRM is an action intended to solicit information from the public to inform the EPA as the Agency considers proposing a future rule. In light of the proposed repeal of the CPP in October 2017, this ANPRM focuses on considerations pertinent to a potential new rule establishing emission guidelines for GHG likely expressed as carbon dioxide emissions from existing EGUs. In this ANPRM, the EPA sets out and requests comment on the roles, responsibilities, and limitations of the federal government, state governments, and regulated entities in developing and implementing such a rule, and the EPA solicits information regarding the appropriate scope of such a rule and associated technologies and approaches.

Through this ANPRM, the EPA solicits information on multiple aspects of a potential rule that would establish emission guidelines for States to establish performance standards for GHG emissions from existing EGUs.

Until the litigation and rulemaking regarding the CPP is resolved, it is difficult to determine the impact but could the addition of emission reduction technologies, reduced generation, alternate generation or demand reduction technologies.

2.2.1.9 Mercury and Air Toxics Standards

In 2011, the EPA finalized a rule to reduce emissions of toxic air pollutants from power plants. These mercury and air toxics standards (MATS) for power plants reduced emissions from new and existing coal and oil-fired electric EGUs. Control equipment was installed to comply with this rule. No additional emission control equipment is currently needed to comply with this standard. It is not known whether the rule will be strengthened in the future. Future strengthening of the rule could require additional reduction technologies, emission limits, or both on coal and oil-fired units.

2.2.2 WATER EMISSION IMPACTS

2.2.2.1 Clean Water Act Section 316(A)

GMO's river plants comply with the calculated limits defined in the current permits. Future regulations could be issued that would restrict the thermal discharges and require alternative cooling technologies to be installed at coal-fired units using once through cooling.

2.2.2.2 Clean Water Act Section 316(B)

In May 2014, the EPA finalized standards to reduce the injury and death of fish and other aquatic life caused by cooling water intake structures at power plants and factories. The rule could severely restrict cooling water inlet structures and potentially require closed cycle cooling technologies instead.

2.2.2.3 Zebra Mussel Infestation

GMO monitors for zebra mussels at generation facilities, and a significant infestation could cause operational changes to the stations.

2.2.2.4 Total Maximum Daily Loads

A Total Maximum Daily Load (TMDL) is a calculation of the maximum amount of a given pollutant that a body of water can absorb before its quality is impacted. A stream is considered impaired if it fails to meet Water Quality Standards established by the Clean Water Commission. Future TMDL standards could restrict discharges and require equipment to be installed to minimize or control the discharge.

2.2.3 WASTE MATERIAL IMPACTS

2.2.3.1 Coal Combustion Residuals (CCR's)

In December 2014, the EPA finalized regulations to regulate CCRs under the RCRA subtitle D to address the risks from the disposal of CCRs generated from the combustion of coal at electric generating facilities. The rule requires periodic assessments; groundwater monitoring; location restrictions; design and operating requirements; recordkeeping and notifications; and closure, among other requirements, for CCR units. The regulations could require existing CCR surface impoundments to be closed and landfills designed and constructed to more stringent standards.

For the purposes of ranking the supply-side resource options, the subjective probabilities assigned to comply with future environmental laws or regulations are listed as follows:

- A cap and trade program requiring the use of CO_2 allowances for generation technologies that emit CO_2 = 100% probability
- Cooling towers required to comply with Clean Water Act (CWA) Sections 316(a) and (b) = 100% probability

- Closure of CCR surface impoundments and additional more stringent requirements on CCR landfills. = 100% probability

The probable environmental cost for each supply-side resource can be found below in Table 12.

2.3 PRELIMINARY SUPPLY-SIDE CANDIDATE RESOURCE OPTIONS

(C) The utility shall indicate which potential supply-side resource options it considers to be preliminary supply-side candidate resource options. Any utility using the preliminary screening analysis to identify preliminary supply-side candidate resource options shall rank all preliminary supply-side candidate resource options based on estimates of the utility costs and also on utility costs plus probable environmental costs. The utility shall—

Each of the supply-side resource options identified was ranked in terms of a ‘utility cost’ estimate and a ‘utility cost plus probable environmental cost’ estimate. The utility cost estimate is expressed in dollars per megawatt-hour, and it is comprised of fixed O&M, variable O&M, fuel cost, and a levelized carrying cost applied to the capital costs incurred for the technology installation and the transmission interconnection (if applicable). In developing the dollar per MWh cost, the technology heat rate and the projected capacity factor also play an important role. In particular, the capacity factor can have a large impact and the base load technologies have the highest capacity factors, followed by the intermediate load and peaking load technologies. The capacity factor of renewable technologies can vary significantly depending on the type of renewable resource. All of the capacity factor assumptions can be found in Table 6 above.

2.3.1 POTENTIAL SUPPLY-SIDE RESOURCE OPTION TABLE

1. Provide a summary table showing each potential supply-side resource option and the utility cost and the probable environmental cost for each potential supply-side resource option and an assessment of whether each potential supply-side resource option qualifies as a utility renewable energy resource; and

The development of the nominal utility costs for each of the twenty potential new supply-side resource options was calculated in an Excel workbook, which is attached as a worksheet. Rankings were developed for these technologies for both the ‘utility’ cost and the ‘utility plus probable environmental’ cost. The difference between the 2 rankings is driven primarily by the potential of environmental costs for CO_2 emissions in anticipation of legislation being passed to reduce U.S. emissions. The estimated probable environmental costs in nominal dollars for each of the twenty technologies are shown in Table 12 below.

The ‘utility cost’ rankings for all the supply-side resource options are shown below in Table 13. The ‘utility cost plus probable environmental’ rankings are show below in Table 14. Both the utility cost and probable environmental cost rankings show the lowest-cost alternatives to include wind, combined cycle and supercritical pulverized coal technologies. For these cost rankings, it is important to note that the energy storage/battery technologies only store energy and do not produce it, so a cost of energy was added into the dollar per MWh cost based upon projected market power prices.

Table 12: Probable Environmental Cost

Technology	Capacity Factor	Probable Environmental Cost ($/MWh)
CC: 2x1 7FA	60%	$4.70
CT: 7FA.05	10%	$7.03
CT: LM6000 (2x)	10%	$6.67
CT: LMS100	10%	$6.20
Compressed Air Energy Storage	23%	$2.69
Pumped Hydro	27%	$0.00
Lithium-Ion	16%	$0.00
Fuel Cell - Solid Oxide	30%	$4.27
IGCC	85%	$10.58
IGCC w/CC	85%	$1.30
Large Scale (AP1000)	90%	$0.00
Small Modular Reactors	90%	$0.00
SCPC	85%	$10.70
SCPC w/CC	85%	$8.30
Reciprocating Engines	10%	$6.08
Solar PV - Central Station	18%	$0.00
Solar PV - Single Axis Tracking	27%	$0.00
Wind	54%	$0.00
Biomass BFB Boiler	90%	$0.00
Landfill Gas	88%	$0.01

Table 13: Technology Ranking by Nominal Utility Cost

Rank	Technology	Capacity Factor (%)	Nominal Utility Cost ($/MWh)
1	Wind	54%	$ 48.15
2	CC: 2x1 7FA	60%	$ 51.85
3	SCPC	85%	$ 66.99
4	Landfill Gas	88%	$ 75.94
5	IGCC	85%	$ 85.19
6	Small Modular Reactors	90%	$ 92.14
7	SCPC w/CC	85%	$ 99.54
8	Large Scale Nuclear	90%	$ 101.75
9	Solar PV Single Axis Tracking	16%	$ 117.79
10	Compressed Air Energy Storage	23%	$ 124.04
11	IGCC w/CC	85%	$ 128.19
12	CT: 7FA.05	10%	$ 132.67
13	Biomass BFB Boiler	85%	$ 145.20
14	Reciprocating Engines	10%	$ 162.97
15	Solar PV Central Station	17%	$ 163.69
16	Pumped Hydro Energy Storage	27%	$ 166.81
17	Lithium-ion Battery	27%	$ 217.41
18	CT: LMS100 (1X)	10%	$ 222.37
19	CT: LM6000 (2X)	10%	$ 239.27
20	Fuel Cell - Solid Oxide	30%	$ 305.34

Table 14: Technology Ranking by Nominal Probable Environmental Cost

Rank	Technology	Capacity Factor (%)	Nominal Utility Cost ($/MWh)
1	Wind	54%	$ 48.15
2	CC: 2x1 7FA	60%	$ 58.80
3	Landfill Gas	88%	$ 75.94
4	SCPC	85%	$ 82.80
5	Small Modular Reactors	90%	$ 92.14
6	IGCC	85%	$ 100.82
7	Large Scale Nuclear	90%	$ 101.75
8	SCPC w/CC	85%	$ 111.80
9	Solar PV Single Axis Tracking	16%	$ 117.79
10	Compressed Air Energy Storage	23%	$ 128.03
11	IGCC w/CC	85%	$ 130.11
12	CT: 7FA.05	10%	$ 143.05
13	Biomass BFB Boiler	85%	$ 145.20
14	Solar PV Central Station	17%	$ 163.69
15	Pumped Hydro Energy Storage	27%	$ 166.81
16	Reciprocating Engines	10%	$ 171.93
17	Lithium-ion Battery	27%	$ 217.41
18	CT: LMS100 (1X)	10%	$ 231.54
19	CT: LM6000 (2X)	10%	$ 249.12
20	Fuel Cell - Solid Oxide	30%	$ 311.65

2.3.2 ELIMINATION OF POTENTIAL SUPPLY-SIDE RESOURCE OPTIONS

2. Explain which potential supply-side resource options are eliminated from further consideration and the reasons for their elimination. 22.040 (2) (C) 2.

2.3.2.1 Supply-Side Resource Options Eliminated

The technology options that were eliminated from further consideration based of the pre-screening analysis, along with the reason for their elimination, are addressed in the discussion below. It should be noted that some of the higher-cost options were passed on to integrated resource analysis because the technology was required to help meet the Missouri Renewable Energy Standard (RES) Requirements, regardless of its cost ranking. On the other hand, certain low-cost options were not passed on to the integrated resource analysis for a multitude of reasons. Following is a discussion of the supply-side candidate resource options that were not passed on to the integrated resource analysis.

2.3.2.1.1 Supercritical Pulverized Coal

Even though Supercritical Pulverized Coal (SCPC) technology is a mature technology and ranks as one of the low-cost options, due to current and potential future environmental regulations and future expected capacity needs are significantly lower than a typical coal unit size, SCPC was not passed on to the integrated resource analysis.

2.3.2.1.2 Nuclear

Even though large scale nuclear technology is a mature technology and ranks as one of the low-cost options, due to current and potential future permitting and environmental regulations as well as future expected capacity needs are significantly lower than a typical nuclear unit size, nuclear technology was not passed on to the integrated resource analysis.

2.3.2.1.3 Integrated Gasification Combined Cycle Technologies

The Integrated Gasification-Combined Cycle (IGCC) technologies were not passed on to the integrated resource analysis. These technologies are in the demonstration stage with very little operating experience, and they also have higher projected capital costs and operating expenses relative to the pulverized coal technologies.

2.3.2.1.4 Landfill Gas Technology

The landfill gas technology was not passed on to the integrated resource analysis, due to the limited regional availability of landfill gas opportunities. However, GMO will continue to pursue innovative renewable projects including landfill gas-to-energy projects, such as the existing 1.6 MW landfill power generation facility in partnership with the City of St. Joseph.

2.3.2.1.5 Combustion Turbine (CT) Technologies

Three combustion turbine technologies were identified for the prescreening process and one of those was chosen to move into integrated resource analysis. As shown in Table 14 above, their nominal cost rankings on a dollar per MWh basis were relatively similar. The CT technologies of the LM6000 and the LMS100 were not passed on to the integrated resource planning process. The GE 7FA.05 combustion turbine technology was passed on to the integrated resource planning process. For further discussion, refer to Section 4.1.1.1

2.3.2.1.6 Biomass Bubbling Fluidized Bed (BFB) Boiler Technology

This technology was not passed on to integrated resource analysis due to the high capital and fixed O&M costs, along with potential lack of fuel in this region and its inability to compete with cheaper renewable alternatives such as wind.

2.3.2.1.7 Energy Storage Technologies

The energy storage technologies included in the prescreening process were compressed air energy storage (CAES), pumped hydro, and lithium-ion batteries. Due to their relatively high cost, along with the early development stage and limited utility application, these energy storage technologies were not passed on to the integrated resource analysis. These technologies will continue to be monitored and will also be considered for their ability to accommodate the impact of hour-by-hour fluctuations from variable wind and solar resources.

2.3.2.1.8 Fuel Cell Technologies

The solid oxide fuel cell technology was not passed on to integrated resource analysis. Fuel cells are still in the technology development stage, and they are high-cost relative to the other technologies in the prescreening process that were passed on to the integrated resource analysis.

2.3.2.1.9 Solar Technologies

The solar thermal technologies in the prescreening process– parabolic trough and dish – were excluded from integrated resource analysis due to high cost and the geographic region requirements. High temperatures and solar concentration systems are required for the thermal technologies to operate with reasonable efficiencies, and the highest quality resources for solar thermal within the United States are located in the Southwest (Nevada, Arizona, California, New Mexico). No solar thermal facilities currently exist in the Midwest, due to these geographic requirements. However, to meet the solar requirements of the MO RES, solar photovoltaic (PV) fixed flat-plate technology was passed on to the integrated resource analysis.

2.3.2.1.10 Small Scale CT Technologies

The reciprocating engine small scale CT technology was not passed on to the integrated resource analysis process. The primary disadvantage is the higher cost relative to the larger scale GE 7FA.05 CT that was passed on to the integrated resource analysis.

SECTION 3: INTERCONNECTION AND TRANSMISSION REQUIREMENTS

(3) The utility shall describe and document its analysis of the interconnection and any other transmission requirements associated with the preliminary supply-side candidate resource options identified in subsection (2)(C).

3.1 <u>INTERCONNECTION AND TRANSMISSION CONSTRAINTS ANALYSIS</u>

(A) The analysis shall include the identification of transmission constraints, as estimated pursuant to 4 CSR 240-22.045(3), whether within the Regional Transmission Organization's (RTO's) footprint, on an interconnected RTO, or a transmission system that is not part of an RTO. The purpose of this analysis shall be to ensure that the transmission network is capable of reliably supporting the preliminary supply-side candidate resource options under consideration, that the costs of the transmission system investments associated with preliminary supply-side candidate resource options, as estimated pursuant to 4 CSR 240-22.045(3), are properly considered and to provide an adequate foundation of basic information for decisions to include, but not be limited to, the following:

1. Joint ownership or participation in generation construction projects;

2. Construction of wholly-owned generation facilities;

3. Participation in major refurbishment, life extension, upgrading, or retrofitting of existing generation facilities;

4. Improvements on its transmission and distribution system to increase efficiency and reduce power losses;

5. Acquisition of existing generating facilities; and

6. Opportunities for new long-term power purchases and sales, and short-term power purchases that may be required for bridging the gap between

other supply options, both firm and non-firm, that are likely to be available over all or part of the planning horizon.

In general, all major GMO transmission upgrade projects are currently made available as public information through either GMO's public OASIS site or as part of the Southwest Power Pool's (SPP) Transmission Expansion Plan (STEP). In addition, there are also smaller projects of minimal cost and construction time that are not available for public viewing, since they do not result in increases in transmission capacity or transfer capability. These would include projects for replacement of damaged, worn out, or obsolete equipment.

The major regional transmission constraints currently impacting the GMO transmission system are the Iatan-Stranger Creek 345kV line, the St. Joseph-Hawthorn 345kV line, and the Cooper South Flowgate. The first two constraints will be mitigated with the completion of the Iatan-Stranger Creek 161kV voltage conversion project in 2018, which creates a second Iatan-Stranger Creek 345kV line, while the Cooper South Flowgate constraint impact was reduced with the completion of the Nebraska City-Mullin Creek-Sibley project in late 2016.

As a member of SPP, GMO participates in the SPP open access transmission tariff (OATT). All transmission service requests, including generation interconnection requests, must be submitted to the SPP and studied in a non-discriminatory process. Due to the nature of this 'open access' transmission system process, it makes it difficult to predict future transmission constraints.

Due to the iterative nature of the Aggregate Facility Study process, it is not possible to identify specific transmission upgrades needed to delivery energy from a resource in the RTO footprint to GMO until the process for a specific transmission service request has been completed. Any new generation resource requesting interconnection to the transmission system will have to go through the SPP Generator Interconnection process and the Aggregate Study process. These processes are designed to provide adequate transmission capacity for resource interconnection and delivery to load.

3.2 NEW SUPPLY-SIDE RESOURCES OUTPUT LIMITATIONS

(B) This analysis shall include the identification of any output limitations imposed on existing or new supply-side resources due to transmission and/or distribution system capacity constraints, in order to ensure that supply-side candidate resource options are evaluated in accordance with any such constraints.

As discussed in Section 3.1, output limitations are difficult to predict without knowledge of the specific project site. In regards to renewable resources in the southwest Kansas region, it is known that the total current firm transmission service requests to SPP exceed the total transmission service availability which will be provided by transmission construction projects. Until large scale investments in transmission upgrades are made, the timing of future renewable resource additions in that region will be difficult to determine with certainty. This could lead to output and/or delivery limitations on future renewable resource additions in the southwest Kansas region.

SECTION 4: SUPPLY-SIDE CANDIDATE RESOURCE OPTIONS

(4) All preliminary supply-side candidate resource options which are not eliminated shall be identified as supply-side candidate resource options. The supply-side candidate resource options that the utility passes on for further evaluation in the integration process shall represent a wide variety of supply-side resource options with diverse fuel and generation technologies, including a wide range of renewable technologies and technologies suitable for distributed generation.

Based on the estimated capacity required over the 20-year planning period and anticipated solar additions needed to meet Missouri Renewable Portfolio Standards rules, the supply-side technologies passed on to the integrated resource analysis as candidate resource options are listed in Table 15 below. In addition to these new technology options, purchasing an ownership interest in the Dogwood Energy Center was also moved into the integrated resource analysis. Cost and operating data for the technologies that moved on to the integrated resource analysis came from multiple sources including the Electric Power Research Institute (EPRI), the Department of Energy (DOE), responses to recent Request for Proposals (RFP), and other internal resources.

Table 15: Candidate Resource Options

Technology	Description
Combined Cycle	2x1 7FA
Combustion Turbine	7FA.05
Renewables	Wind Solar PV Central Station
Existing Resource	Partial Ownership - Dogwood Energy Center

4.1 IDENTIFICATION PROCESS FOR POTENTIAL SUPPLY-SIDE RESOURCE OPTIONS

(A) The utility shall describe and document its process for identifying and analyzing potential supply-side resource options and preliminary supply-side candidate resource options and for choosing its supply-side candidate resource options to advance to the integration analysis.

4.1.1 NEW PLANT RESOURCE OPTIONS

Following is a discussion of the supply-side candidate resource options that were advanced to the integration analysis for new generation additions:

4.1.1.1 Combined Cycle Technology

The combined cycle (CC) technology of the 2x1 GE 7FA.05 was passed on to the integrated resource analysis process. The local engineering firm Power Engineers, Inc. assisted in providing CC technology characteristics that were used in the integrated resource analysis providing data appropriate for the GMO service territory.

4.1.1.2 Combustion Turbine Technology

The combustion turbine (CT) technology of the GE 7FA was passed on to the integrated resource analysis process as being representative of the larger group of CT technologies that were considered, which included the LMS100 and the LM6000.

4.1.1.3 Wind Technology

Wind generation was passed on to the integrated resource analysis, due to its ability to help meet the Missouri Renewable Energy Standard (RES) requirements and a low cost on a dollar per MWh basis when compared to other prescreened technologies.

4.1.1.4 Solar Technology

As an alternative for meeting the Missouri RES solar carve out requirements, the solar photovoltaic (PV) technology was passed on to the integrated resource analysis.

4.1.2 ENVIRONMENTAL RETROFIT & LIFE EXTENSION OPTIONS

For the 20-year planning period, GMO has evaluated potential environmental retrofits and future capital projects considered necessary to ensure continued reliability of the coal-generation units.

4.1.2.1 Environmental Retrofits

Future potential environmental retrofit equipment costs have been incorporated into Sibley Unit 3 and Iatan Unit 1 costs. Future potential environmental regulations are the drivers for the equipment assumed. Budgetary costs, fixed and variable O&M costs determined through the studies are provided in Figure 1 through Figure 3 below.

Figure 1: Environmental Retrofit Capital Costs **Confidential**

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Figure 2: Environmental Retrofit Fixed O&M Costs **Confidential**

[redacted]

Figure 3: Environmental Retrofit Variable O&M Costs ** Confidential **

[redacted]

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4.1.2.2 Life Assessment & Management Program

An internal review of long-term plant equipment needs was developed using the Life Assessment and Management Program (LAMP). The program was developed in the late 1980's for the purpose of identifying, evaluating, and recommending improvements and special maintenance requirements necessary for continued reliable operation of KCP&L coal-fired generating units. The program was expanded to now include the GMO coal-fired generating units. The primary objectives of the LAMP program include:

1. Identify and recommend unit requirements associated with future operating plans

2. Identify and recommend areas of improvement and special maintenance requirements necessary to extend the operating life of each unit

3. Identify and recommend areas of improvement to achieve any or all of the following goals:

    a. Capacity

    b. Performance

    c. Reliability/Availability

    d. Safety/ Environmental

    e. Operational Changes

4. Provide a basis for identification and prevention of major component failure, and costly interruptions associated with continued use of existing equipment

5. Provide the tools for managing and protecting remaining life of critical components/assets.

Current schedules of identified LAMP projects and costs for Sibley Units 2 and 3, and Lake Road 4/6 are provided in Appendix 4B, LAMP Data.

(B) The utility shall indicate which, if any, of the preliminary supply-side candidate resource options identified in subsection (2)(C) are eliminated from further consideration on the basis of the interconnection and other transmission analysis and shall explain the reasons for their elimination.

None of the preliminary supply-side candidate resource options were eliminated from consideration based on interconnection or other transmission analysis. For further discussion of the SPP open access transmission tariff (OATI) in which GMO participates, refer above to Section 3.1.

4.2 INTERCONNECTION COST FOR SUPPLY-SIDE RESOURCE OPTIONS

(C) The utility shall include the cost of interconnection and any other transmission requirements, in addition to the utility cost and probable environmental cost, in the cost of supply-side candidate resource options advanced for purposes of developing the alternative resource plans required by 4 CSR 240-22.060(3).

The cost of interconnection was added to the cost of supply-side candidate resource options using a weighted average of recent interconnection requests with the Southwest Power Pool (SPP). There was a separate analysis of the cost for interconnection requests related to wind projects versus other non-wind projects, with the results showing higher interconnection costs for wind projects. This cost adder on a dollar per kW basis is shown below in Table 16. The detailed analysis of the interconnection calculations has been provided in the Volume 4 workpapers.

Table 16: Transmission Interconnect Cost Projection ** Confidential **

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SECTION 5: SUPPLY-SIDE UNCERTAIN FACTORS

(5) The utility shall develop, and describe and document, ranges of values and probabilities for several important uncertain factors related to supply-side candidate resource options identified in section (4). These cost estimates shall include at least the following elements, as applicable to the supply-side candidate resource option:

5.1 FUEL FORECASTS

(A) Fuel price forecasts, including fuel delivery costs, over the planning horizon for the appropriate type and grade of primary fuel and for any alternative fuel that may be practical as a contingency option;

Fuel price forecasts were developed for coal, natural gas, fuel oil, and uranium. KCP&L performed an investigation to determine the best possible commodity forecasts for use in the supply-side resource analysis and modeling, and that investigation showed that using an average of forecasts proves to be most reliable. The result of the averaging process is that random errors cancel each other out, when forecasts from multiple sources are utilized. Several assumptions apply when averaging multiple forecasts, including the belief that all expert forecasts are interchangeable and the closer to the time period being forecast, the lower the expected error to actual. A detailed description of the fuel price forecasting methodology can be found in Appendix 4C, “Fuel Price Forecasting”. Following is an overview of the forecasting process applied for coal, natural gas, and fuel oil.

5.1.1 COAL FORECAST

A composite coal price forecast was created by combining the forecasts of the IHS Energy (IHS), Energy Information Administration (EIA), PIRA Energy Group (PIRA), Energy Ventures Analysis (EVA), JD Energy (JDE), and Hanou Energy Consulting (HEC). Each source provided their forecast in either nominal or real dollars. The forecasts that were provided in real dollars were converted to nominal dollars using Moody’s Analytics’ GDP implicit price deflator. The forecasts were then combined and weighted equally to create a composite price forecast that represents the base case consensus of the major forecast sources. The variation of individual forecasts within the composite was then used within a t-distribution to mathematically calculate high and low forecast price curves. The three resultant price curves with their probability of occurrence were base 50%, high 25%, and low 25%. To ensure the early part of the forecast reflects expected cost, to the extent contracts are in place, actual contract prices or projections of those contract prices are used for the duration of the contract, which is typically less than six years.

5.1.2 NATURAL GAS FORECAST

A composite Henry Hub natural gas price forecast was created by combining forecasts from the IHS, EIA, PIRA, and EVA. As with the coal forecast, each source provided their forecast in either nominal or real dollars. The forecasts that were provided in real dollars were converted to nominal dollars using Moody's Analytics' GDP implicit price deflator. The forecasts were then all combined in equal weight to create a composite price forecast representing the expected or base case consensus of the forecast sources. The variation of individual forecasts within the composite was then used within a t-distribution to mathematically calculate high and low forecast price curves. The three resultant price curves with their probability of occurrence were base 50%, high 25%, and low 25%. To better synchronize the early part of the forecast with current market data, the first few years of the forecast are overwritten by the NYMEX strip and a "bridge" is constructed from the NYMEX strip to the long-term forecast described above.

5.1.3 FUEL OIL FORECAST

A composite crude oil price forecast was created by combining forecasts from the IHS, EIA, PIRA, and EVA. As with the coal and natural gas forecasts, each source provided their forecast in either nominal or real dollars. The forecasts that were provided in real dollars were converted to nominal dollars using Moody's Analytics' GDP implicit price deflator. The forecasts were then all combined in equal weight to create a composite price forecast representing the expected or base case consensus of the major forecast sources. The variation of individual forecasts within the composite was then used within a t-distribution to mathematically calculate high and low forecast price curves. The three resultant price curves with their probability of occurrence were base 50%, high 25%, and low 25%.

The ‘Base’, ‘High’, and ‘Low’ fuel price forecasts are shown below in Table 17. The sources used in developing the forecasts are shown below in Table 18.

Table 17: Fuel Price Forecasts – Coal, Natural Gas, Fuel Oil
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Table 18: Source Forecasts for Coal, Natural Gas, and Fuel Oil

Forecast Source	Coal	Natural Gas	Fuel Oil
IHS Energy	x	x	x
Energy Information Administration	x	x	x
PIRA Energy Group	x	x	x
Energy Ventures Analysis	x	x	x
JD Energy	x		
Hanou Energy Consulting	x		

5.2 NEW FACILITY CAPITAL COSTS

(B) Estimated capital costs including engineering design, construction, testing, startup, and certification of new facilities or major upgrades, refurbishment, or rehabilitation of existing facilities;

Capital cost estimates for the technologies that moved on to integrated resource analysis were developed for both 'High' and 'Low' capital cost scenarios. As a starting point for all technologies, the 'High' capital cost estimate was set at 115% of the 'Mid' cost and the 'Low' capital cost estimate was set at 90% of the 'Mid' cost. The 'Mid', 'High', and 'Low' capital cost ranges and the resulting capital cost estimates on a $/kW basis are shown below in Table 19 and Table 20.

Table 19: Technology Capital Cost Ranges

Technology Description	Mid Range	High Range	Low Range
2x1 Combined Cycle: 2x1-7FA	100%	115%	90%
CT: 7FA.05	100%	115%	90%
Solar PV Central Station	100%	115%	60%
Wind	100%	115%	80%

Table 20: Capital Cost Estimates Utilized in Integrated Resource Analysis
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5.3 FIXED AND VARIABLE O&M

(C) Estimated annual fixed and variable operation and maintenance costs over the planning horizon for new facilities or for existing facilities that are being upgraded, refurbished, or rehabilitated;

The range of values for estimated annual fixed and variable operation and maintenance costs for new facilities considered in integrated analysis are shown below in Table 21 and Table 22. The 'High' O&M cost estimates were set at 110% of the 'Mid' cost estimate and the 'Low' O&M cost estimates were set at 90% of the 'Mid' cost.

Table 21: Fixed O&M Estimates Utilized In Integrated Resource Analysis
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[redacted]

Table 22: Variable O&M Estimates Utilized in Integrated Resource Analysis
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5.4 EMISSION ALLOWANCE FORECASTS

(D) Forecasts of the annual cost or value of emission allowances to be used or produced by each generating facility over the planning horizon;

The forecasted cost of emission allowances over the planning horizon are shown in Table 23 through Table 27 below:

Table 23: SO_2 Group 1 Price Forecast **Confidential**

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Table 24: SO_2 Group 2 Price Forecast **Confidential**

[redacted]

Table 25: NO_x Annual Price Forecast **Confidential**

[redacted]

Table 26: NO_x Seasonal Price Forecast **Confidential**

[redacted]

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Table 27: CO_2 Price Forecast **Confidential**

[redacted] shown in Table 28 below:

Table 28: Source Forecasts for Emission Allowances

Forecast Source	SO_2	NO_x	CO_2
IHS	x	x	x
PIRA	x	x	x
Energy Ventures Analysis	x	x	x
JD Energy	x	x	
Synapse			x

5.5 LEASED OR RENTED FACILITIES FIXED CHARGES

(E) Annual fixed charges for any facility to be included in the rate base, or annual payment schedule for leased or rented facilities; and

There are no leased or rented facilities included in any of the GMO alternative resource plans or in the rate base, so this rule does not apply to this IRP evaluations.

5.6 INTERCONNECTION OR TRANSMISSION COSTS FOR SUPPLY-SIDE CANDIDATES

(F) Estimated costs of interconnection or other transmission requirements associated with each supply-side candidate resource option.

The estimated cost of interconnection associated with the supply-side candidate resource options is shown above in Section 4.2.