EVERGY METRO

SUPPLY-SIDE RESOURCE ANALYSIS

INTEGRATED RESOURCE PLAN

4 CSR 240-22.040

APRIL 2021

TABLE OF CONTENTS

TABLE OF TABLES

TABLE OF APPENDICES

INDEX OF RULES COMPLIANCE

VOLUME 4: SUPPLY-SIDE RESOURCE ANALYSIS

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, battery storage, 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 Evergy Metro 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.

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 existing or new technology alternatives. The information for these potential supply-side technologies was gathered from multiple sources including 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 characteristics are 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		
Ultra Supercritical Coal, 90% CCS	Advanced Nuclear	Small Modular Reactor
Intermediate Load		
Combined-Cycle, Single Shaft	Combined-Cycle, Multiple Shaft	Combined-Cycle, Single Shaft, 90% Carbon Capture
Peaking Load		
Combustion Turbine, Aeroderivative	Combustion Turbine, Industrial Frame	Internal Combustion Engine
Renewables/Other		
Solar PV	Solar Thermal	Solar PV w/Battery Storage
Wind	Battery Storage	Fuel Cells
Landfill Gas	Biomass	

Table 2: Technology Development Status

Generation Category	Technology	Maturity
Combined Cycle	Combined-Cycle, Single Shaft	Mature
	Combined-Cycle, Multiple Shaft	Mature
	Combined-Cycle, Single Shaft, 90% Carbon Capture	Demonstration
Combustion Turbine	Combustion Turbine, Industrial Frame	Mature
	Combustion Turbine, Aeroderivative	Mature
Pulverized Coal	Ultra Supercritical Coal, 90% CCS	Demonstration
Nuclear	Advanced Nuclear	Mature
	Small Modular Reactor	Developmental
Small Scale Alternatives	Internal Combustion Engine	Mature
Renewables	Solar PV	Mature
	Solar PV w/Battery Storage	Commercial
	Solar Thermal	Commercial
	Wind	Mature
	Landfill Gas	Mature
	Biomass	Commercial
Other	Battery Storage	Commercial
	Fuel Cells	Commercial

1.2 PLANT EFFICIENCY IMPROVEMENTS

Evergy works to proactively improve plant efficiency across the entire generation fleet. In addition to reducing production costs, improved plant efficiency also effectively improves air quality-related emissions. Large baseload coal units produce the largest share of MWhs, so they are the natural priority of plant efficiency improvements and the focus of this section.

Plant efficiency is influenced by many different factors including operational issues, maintenance, and equipment degradation. Evergy employs a variety of resources to proactively improve plant efficiency:

1.2.1 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:
    - Hawthorn Unit 5, 6&9
    - Iatan Units 1 & 2
    - LaCygne Units 1 & 2
- Power BI – Plant Efficiency data is visualized using software from Microsoft, increasing real-time, awareness of plant performance issues on a mobile platform.
- P3000 – Closed Loop Optimization software from Siemens monitors unit processes and makes real-time changes to operating parameters based on expert rules and advanced algorithms. Evergy has (or is in progress) implemented optimization on the following units:
    - Hawthorn Unit 5
    - LaCygne Units 1 & 2
    - Iatan Units 1 & 2

1.2.2 PERSONNEL

- Engineering – positions dedicated to Plant Efficiency are staffed as follows:
  - Performance Engineer Manager - Fleet Performance
  - Central Performance Engineer - Fleet
  - Hawthorn Performance/Combustion Engineer
  - Iatan Performance/Combustion Engineer
  - LaCygne Performance/Combustion Engineer

- Remote Monitoring & Diagnostics (M&D Center) – the M&D Center supports continuous online monitoring (a service formerly contracted through GP Strategies), including plant efficiency and equipment performance/reliability issues.
  - Generation M&D Center is staffed with a Manager, Engineer, and 2 Analysts

1.2.3 O&M PRACTICES

- Top tier plant efficiency requires conscientious Operations and Maintenance strategies. Plant efficiency is always a key consideration of regular operator rounds and preventative maintenance. In addition, cleaning/maintenance of certain equipment is critical – and this often requires special equipment and/or vendors. This maintenance is typically performed on an 'as needed' basis and is typically guided by equipment performance monitoring. The following are examples of recent 'major' O&M-related efforts performed by specialty contractors that have direct plant efficiency benefits:
  - Condenser & Heat Exchanger Tube Cleaning (darting)
  - Condenser Air In-leakage testing (online helium or offline flood test)
  - Steam Turbine Open/Inspect/Clean (media blasting)
  - Air Heater Element Cleaning (wash, vacuum, or media/chem clean)
  - Boiler Chemical Clean (to remove internal scale/deposits)

    - Boiler & Flue Cleaning (vacuum, explosive cleaning, or media blasting)
    - Feedwater Heater Tube Leak Repair (explosive plugs)

1.2.4 CAPITAL

Evergy invests significant capital on projects to maintain or improve plant efficiency. Examples of these projects are listed in Table 3 below.

In addition to the resources listed in Table 3, Evergy is planning to invest in additional wireless sensors for Continuous On-line Monitoring (COLM). This equipment will allow more robust identification of equipment degradation, including performance issues – especially on medium-to-high value assets. Several trial/demonstration projects are in progress.

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

- Evergy Coal Fleet benchmarks top quartile (tier 1) on efficiency
- Iatan Unit 2 continues to be one the most efficient plants in the U.S.
    - Consistently the top plant burning sub-bituminous Powder River Basin (PRB) coal.
- Industry leader in Optimization
    - Evergy has optimized Sootblowing and Combustion processes on several units. These efforts were featured in POWER magazine articles.

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
Burner Replacement	Iatan 2	2016	Nominal
Online Air In-Leakage Monitor	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
Turbine Overhaul	Iatan 2	2018	Nominal
Replace Cold End APH Baskets	Iatan 2	2018	Nominal
Mill Overhauls	Iatan 2	2018	Nominal
Mill Outlet Diffuser Upgrade	Iatan 1	2019	Nominal
Replace Air Heater Cold End Seals	Iatan 2	2020	Nominal
Intelligent Sootblowing	Iatan 1	2021	Nominal
Combustion Optimizer	Iatan 2	2021	Nominal
Replace Condenser Exhausters	Iatan 1	2021	Nominal
Water Lance Addition	Iatan 2	2021	Nominal
Intelligent Sootblowing	Iatan 2	2022	Moderate
HP Heater Replacement	Iatan 1	2026	Nominal
Upgrade IP Rotor	Iatan 1	2026	Nominal
Hawthorn Station			
ZoloBOSS Installation	Hawthorn 5	2013	Nominal
Closed Loop Sootblowing Optimization	Hawthorn 5	2013	Nominal
Closed Loop Combustion Optimization Software	Hawthorn 5	2014	Nominal
Automated Overfire Air Dampers	Hawthorn 5	2015	Nominal
Combustion Air Inlet Screens	Hawthorn 5	2015	Nominal
Air Heater Basket/Seal Replacement	Hawthorn 5	2016	Nominal
Condenser Rebundle	Hawthorn 5	2016	Nominal
HP #1 FWH Replacement	Hawthorn 5	2016	Nominal
HP/IP and LP Turbine Overhaul	Hawthorn 9	2017	Nominal
Gas Turbine Blade and Vane Replacement	Hawthorn 6	2018	Nominal
Automate Burner Total Air Registers	Hawthorn 5	2018	Nominal
Boiler Blowdown Recovery Flash Tank	Hawthorn 5	2019	Moderate
Classifier Replacement	Hawthorn 5	2020	Moderate
LP Turbine Overhaul	Hawthorn 5	2020	Nominal
HP/IP Turbine Overhaul	Hawthorn 5	2023	Moderate
BFP Runner Repl	Hawthorn 5	2023	Nominal
LP Turbine Overhaul	Hawthorn 5	2026	Nominal
LP Turbine Overhaul	Hawthorn 9	2027	Nominal
LaCygne Station			
Startup System Valve Replacement	LaCygne 1	2017	Moderate
Pulverizer Classifiers	LaCygne 2	2017	Nominal
Boiler Blowdown Recovery Flash Tank	LaCygne 2	2018	Moderate
BFP Runner Replacement	LaCygne 1	2018	Nominal
BFP Runner Replacement	LaCygne 2	2018	Nominal
Startup Boiler Feed Pump	LaCygne 1	2019	Nominal
Vacuum Priming System Replacement	LaCygne 1	2019	Nominal
Air Heater Baskets Repl	LaCygne 1	2020	Nominal
BFP Recirc Valves Replacement	LaCygne 1	2020	Nominal
BFP Runner Replacement	LaCygne 1	2020	Nominal
Sec Air Flow Controls Replacement	LaCygne 1	2021	Nominal
LP Turbine Buckets	LaCygne 2	2024	Moderate
Replace #4 feedwater heater	LaCygne 1	2024	Moderate
Replace 22 Heater	LaCygne 2	2025	Moderate
IP Turbine Upgrade	LaCygne 1	2025	Significant
Sec AH Hot End Basket Replacement	LaCygne 2	2025	Nominal
Primary AH Baskets Repl	LaCygne 2	2025	Nominal
Estimated Performance Impact: Nominal - Less than 0.1% efficiency improvement; Moderate - 0.1 - 0.5% improvement; Significant - Greater than 0.5% improvement			

1.3 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

Central Station (large scale) geothermal energy systems require heat reservoirs deep below the earth's surface. In the U.S. these reservoirs are located in western portions of the country but not in the midwest.

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 quantities 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:

- Net capacity for each potential supply-side resource option vary widely across the technologies reviewed. The net capacity for each alternative supply-side resource are shown in Table 5 below.

- Total capital requirement for building each supply-side resource option, 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. Capital costs, including interest during construction, are shown below for each alternative in Table 6.

- Fixed O&M costs for each potential supply-side resource option 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 7 and Table 8.

- Probable environmental costs for each potential supply-side resource option include forecasted allowance prices for SO_2, NO_x, and CO_2 are applied using the appropriate emission rates for each technology. The projected emission rates for each technology are shown below in Table 9. Further discussion on the development of the probable environmental costs is provided below in Section 2.2.

Table 5: Technology Net Capacities

Generation Category	Technology	Capacity (MW)
Combined Cycle	Combined-Cycle, Single Shaft	409
	Combined-Cycle, Multiple Shaft	1060
	Combined-Cycle, Single Shaft, 90% Carbon Capture	650
Combustion Turbine	Combustion Turbine, Industrial Frame	233
	Combustion Turbine, Aeroderivative	103
Pulverized Coal	Ultra Supercritical Coal, 90% CCS	650
Nuclear	Advanced Nuclear	2156
	Small Modular Reactor	600
Small Scale Alternatives	Internal Combustion Engine	21
Renewables	Solar PV	150
	Solar PV w/Battery Storage	150 + 50 MW/200 MWh
	Solar Thermal	115
	Wind	200
	Landfill Gas	36
	Biomass	50
Other	Battery Storage	50 MW/200 MWh
	Fuel Cells	10

Table 6: Technology Capital Costs

Generation Category	Technology	Capital Cost (2019 $/kW)
Combined Cycle	Combined-Cycle, Single Shaft	$1,156
	Combined-Cycle, Multiple Shaft	$1,036
	Combined-Cycle, Single Shaft, 90% Carbon Capture	$2,561
Combustion Turbine	Combustion Turbine, Industrial Frame	$702
	Combustion Turbine, Aeroderivative	$1,175
Pulverized Coal	Ultra Supercritical Coal, 90% CCS	$6,259
Nuclear	Advanced Nuclear	$6,459
	Small Modular Reactor	$6,681
Small Scale Alternatives	Internal Combustion Engine	$1,928
Renewables	Solar PV	$1,351
	Solar PV w/Battery Storage	$1,808
	Solar Thermal	$7,535
	Wind	$1,100
	Landfill Gas	$1,663
	Biomass	$4,388
Other	Battery Storage	$1,394
	Fuel Cells	$7,038

Table 7: Technology Fixed O&M Costs

Generation Category	Technology	Fixed O&M (2019 $/kW-year)
Combined Cycle	Combined-Cycle, Single Shaft	$14.10
	Combined-Cycle, Multiple Shaft	$12.20
	Combined-Cycle, Single Shaft, 90% Carbon Capture	$27.60
Combustion Turbine	Combustion Turbine, Industrial Frame	$7.00
	Combustion Turbine, Aeroderivative	$16.30
Pulverized Coal	Ultra Supercritical Coal, 90% CCS	$59.54
Nuclear	Advanced Nuclear	$121.64
	Small Modular Reactor	$95.00
Small Scale Alternatives	Internal Combustion Engine	$35.16
Renewables	Solar PV	$15.25
	Solar PV w/Battery Storage	$32.17
	Solar Thermal	$85.40
	Wind	$26.34
	Landfill Gas	$20.10
	Biomass	$125.72
Other	Battery Storage	$24.80
	Fuel Cells	$30.78

Table 8: Technology Variable O&M Costs

Generation Category	Technology	Variable O&M (2019 $/MWh)
Combined Cycle	Combined-Cycle, Single Shaft	$2.55
	Combined-Cycle, Multiple Shaft	$1.87
	Combined-Cycle, Single Shaft, 90% Carbon Capture	$5.84
Combustion Turbine	Combustion Turbine, Industrial Frame	$4.50
	Combustion Turbine, Aeroderivative	$4.50
Pulverized Coal	Ultra Supercritical Coal, 90% CCS	$10.98
Nuclear	Advanced Nuclear	$2.37
	Small Modular Reactor	$3.00
Small Scale Alternatives	Internal Combustion Engine	$5.69
Renewables	Solar PV	$0.00
	Solar PV w/Battery Storage	$0.00
	Solar Thermal	$0.00
	Wind	$0.00
	Landfill Gas	$6.20
	Biomass	$4.83
Other	Battery Storage	$0.00
	Fuel Cells	$0.59

Table 9: Technology Emission Rates

Generation Category	Technology	NO_x (lbs/mmBtu)	SO_2 (lbs/mmBtu)	CO_2 (lbs/mmBtu)
Combined Cycle	Combined-Cycle, Single Shaft	0.008	0.000	117.00
	Combined-Cycle, Multiple Shaft	0.008	0.000	117.00
	Combined-Cycle, Single Shaft, 90% Carbon Capture	0.008	0.000	11.70
Combustion Turbine	Combustion Turbine, Industrial Frame	0.030	0.000	117.00
	Combustion Turbine, Aeroderivative	0.090	0.000	117.00
Pulverized Coal	Ultra Supercritical Coal, 90% CCS	0.060	0.090	20.6
Nuclear	Advanced Nuclear	0.000	0.000	0.00
	Small Modular Reactor	0.000	0.000	0.00
Small Scale Alternatives	Internal Combustion Engine	0.020	0.000	117.00
Renewables	Solar PV	0.000	0.000	0.00
	Solar PV w/Battery Storage	0.000	0.000	0.00
	Solar Thermal	0.000	0.000	0.00
	Wind	0.000	0.000	0.00
	Landfill Gas	0.020	0.000	117.00
	Biomass	0.080	0.030	206.00
Other	Battery Storage	0.000	0.000	0.00
	Fuel Cells	0.000	0.000	117.00

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 six air pollutants which are considered harmful to public health and the environment. These pollutants include particulate matter (PM), ozone, sulfur dioxides (SO_2), nitrogen dioxide (NO_x), carbon monoxide (CO) and Lead (Pb). Following is a brief description and current state of each NAAQS.

2.2.1.1.1 Particulate Matter

In 2013, the EPA strengthened the PM standard and maintained the same requirements in a 2020 final rule. The Kansas City area is currently in attainment of the 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.

2.2.1.1.2 Ozone

In 2015, the EPA strengthened the NAAQS for ozone and maintained the same requirement in a 2020 final rule. The Kansas City area is currently in attainment of the 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 nitrogen oxides (NOx) reduction technologies, emission limits or both on fossil-fueled units. NOx is considered a precursor pollutant for ozone formation.

2.2.1.1.3 Sulfur Dioxide

In 2010, the EPA strengthened the NAAQS for SO_2 and maintained the same requirement in a 2019 final rule. The Kansas City area is currently in attainment of the 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.

2.2.1.1.4 Nitrogen Dioxide

In 2010, the EPA strengthened the NAAQS for NO_2. The Kansas City area is currently in attainment of the 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.

2.2.1.1.5 Carbon Monoxide

In 2011, the EPA maintained the existing NAAQS for CO. The Kansas City area is currently in attainment of the CO 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 CO reduction technologies, emission limits or both on fossil-fueled units.

2.2.1.1.6 Lead

In 2016, the EPA strengthened the NAAQS for lead. The Kansas City area is currently in attainment of the lead 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 lead reduction technologies, emission limits or both on fossil-fueled units.

2.2.1.2 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 ozone and fine particle pollution in downwind 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 to modeling nonattainment and maintenance areas in downwind states with respect to the 2008 ozone NAAQS. In 2020 EPA proposed the Revised CSAPR Update Rule and found that nine states including Kansas, Missouri, and Oklahoma have insignificant impact on downwind states' nonattainment and/or maintenance areas. As a result, they proposed no additional reductions in these states' allowances. The final Revised CSAPR Update Rule is expected in 2021 and could potentially include changes from the proposed rule which could result in lower allowances for the states in question. 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, PM, 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.

2.2.1.3 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 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, and SO_2.

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 periodically 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 affected sources are below limits set by the state or whether retrofit measures are needed to reduce emissions.

Evergy Metro's existing emission controls at its La Cygne, Iatan and Hawthorn Generating Station maintain compliance with these requirements. Future visibility progress goals could result in additional SO_2, NO_x and PM controls or reduction technologies on fossil-fired units.

2.2.1.4 Carbon Dioxide

In January 2021, a three-judge panel in the D.C. Circuit issued a mandate vacating and remanding the ACE rule back to EPA. Absent an approved request for rehearing the mandate becomes effective on March 12, 2021. At that time the CPP will be reinstated which will require EPA to modify compliance timelines many of which have already passed. At this point it is not known if EPA will leave the CPP in place or replace it with a different rule that regulates GHG emissions.

Until the litigation and rulemakings related to greenhouse gas emissions are resolved, it is difficult to determine the impact but could require the addition of emission reduction technologies, reduced generation, alternate generation or demand reduction technologies.

2.2.1.5 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 generating units (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 Effluent Limitation Guidelines (ELG)

In 2015, EPA established the effluent limitations guidelines (ELG) and standards for wastewater discharges, including limits on the amount of toxic metals and other pollutants that can be discharged. Implementation timelines for this 2015 rule varied from 2018 to 2023. In April 2019, the U.S. Court of Appeals for the 5th Circuit (5th Circuit) issued a ruling that vacated and remanded portions of the original ELG rule.

In October 2020, the EPA published the final ELG Reconsideration Rule. This rule adjusts numeric limits for flue gas desulfurization (FGD) wastewater and adds a 10% volumetric purge limit for bottom ash transport water. The timeline for final FGD wastewater compliance is now as soon as possible on or after one year following publication of the final rule in the federal register but no later than December 31, 2025. Evergy Metro is currently in compliance with this regulation, but future strengthening of the rule could require additional reduction technologies, on coal and oil-fired units.

2.2.2.2 <u>Clean Water Act Section 316(A)</u>

Evergy'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, a reduction or shutdown of certain plants during periods of high river water temperature, or application of a thermal variance process.

2.2.2.3 <u>Clean Water Act Section 316(B)</u>

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 require modifications to cooling water inlet screens and fish return systems.

2.2.2.4 <u>Zebra Mussel Infestation</u>

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

2.2.2.5 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)

April 2015, 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.

In March 2019, the D.C. Circuit issued a ruling to grant the EPA's request to remand the Phase I, Part I CCR rule in response to a prior court ruling requiring the EPA to address un-lined surface impoundment closure requirements. In August 2020, the EPA published the Part A CCR Rule. This rule reclassified clay-lined surface impoundments from "lined" to "un-lined" and established a deadline of April 11, 2021 to initiate closure. In November 2020, the EPA published the final Part B CCR Rule. This rule includes a process to allow unlined impoundments to continue to operate if a demonstration is made to prove that the unlined impoundments are not adversely impacting groundwater, human health or the environment. Evergy Metro has plans in place to comply with the Part A CCR rule which includes initiating closure of all unlined impoundments by the deadline of April 11, 2021.

Future rule modification could require additional monitoring or remediation of current or closed impoundments and landfills along with additional requirements related to design and construction of future units 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 = 60% mid case and 20% high case
- Closure of CCR surface impoundments on CCR landfills. = 100% probability

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. Cost estimates are expressed in dollars per megawatt-hour, and 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.

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 costs for each of the potential new supply-side resource options were calculated utilizing 2020 EIA AEO data as well as assumptions and financials developed by Evergy. Rankings were developed for these technologies for both the 'utility' cost and the 'utility plus probable environmental' cost. The difference between the two rankings is driven primarily by the potential of CO_2 emissions cost anticipated to commence in 2026. The LCOE rankings of the supply-side resource options are shown below in Table 10. LCOE rankings including probable environmental costs are shown in Table 11 below. Additionally, Table 12, Table 13 and Table 14 provide cost of electricity based upon capacity factor. See Appendix A for the workbook utilized to develop these data.

Table 10: Supply Side Candidates Ranking by Levelized Cost of Electricity

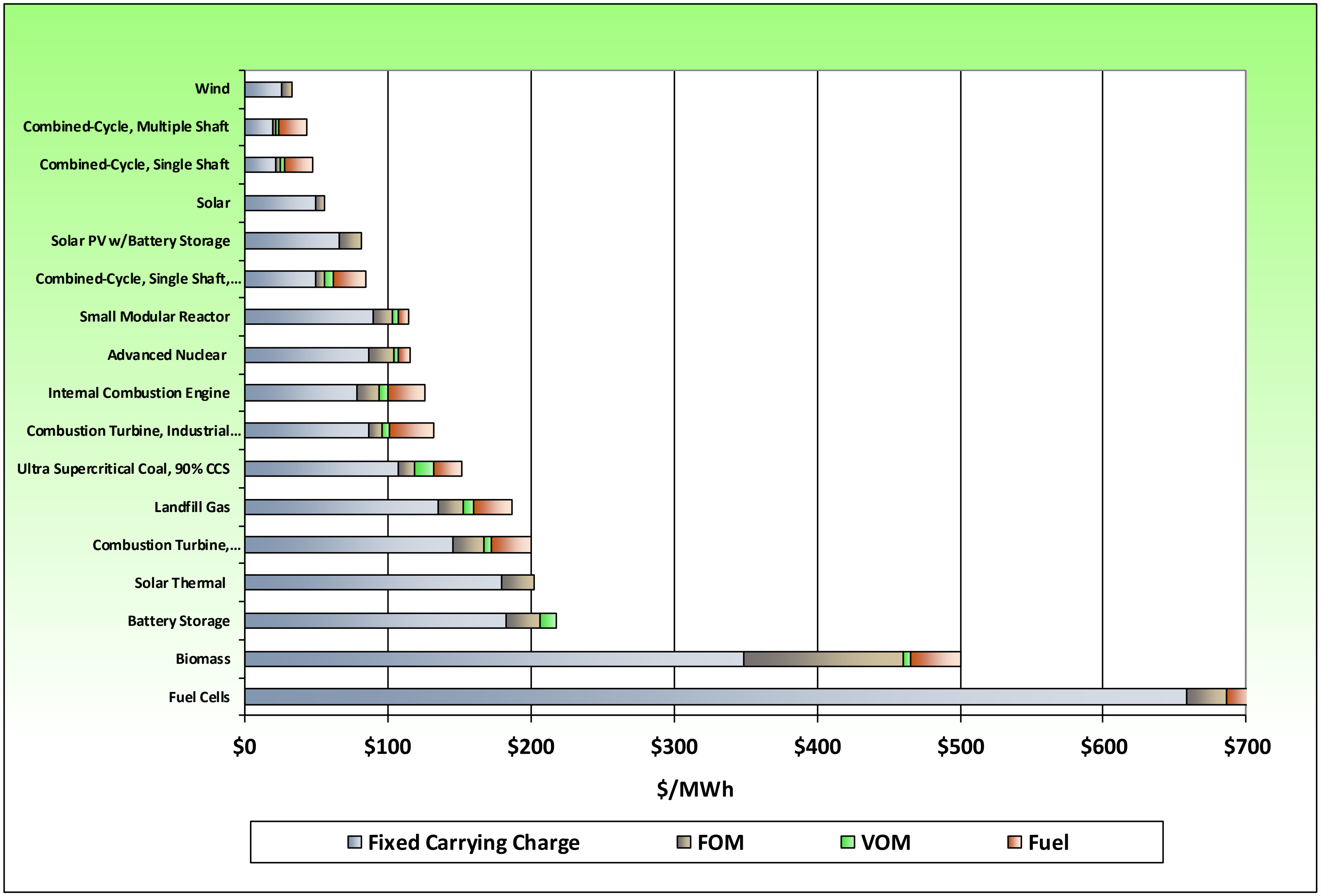


Table 11: Supply Side Candidates Ranking by Levelized Cost of Electricity including Environmental Cost

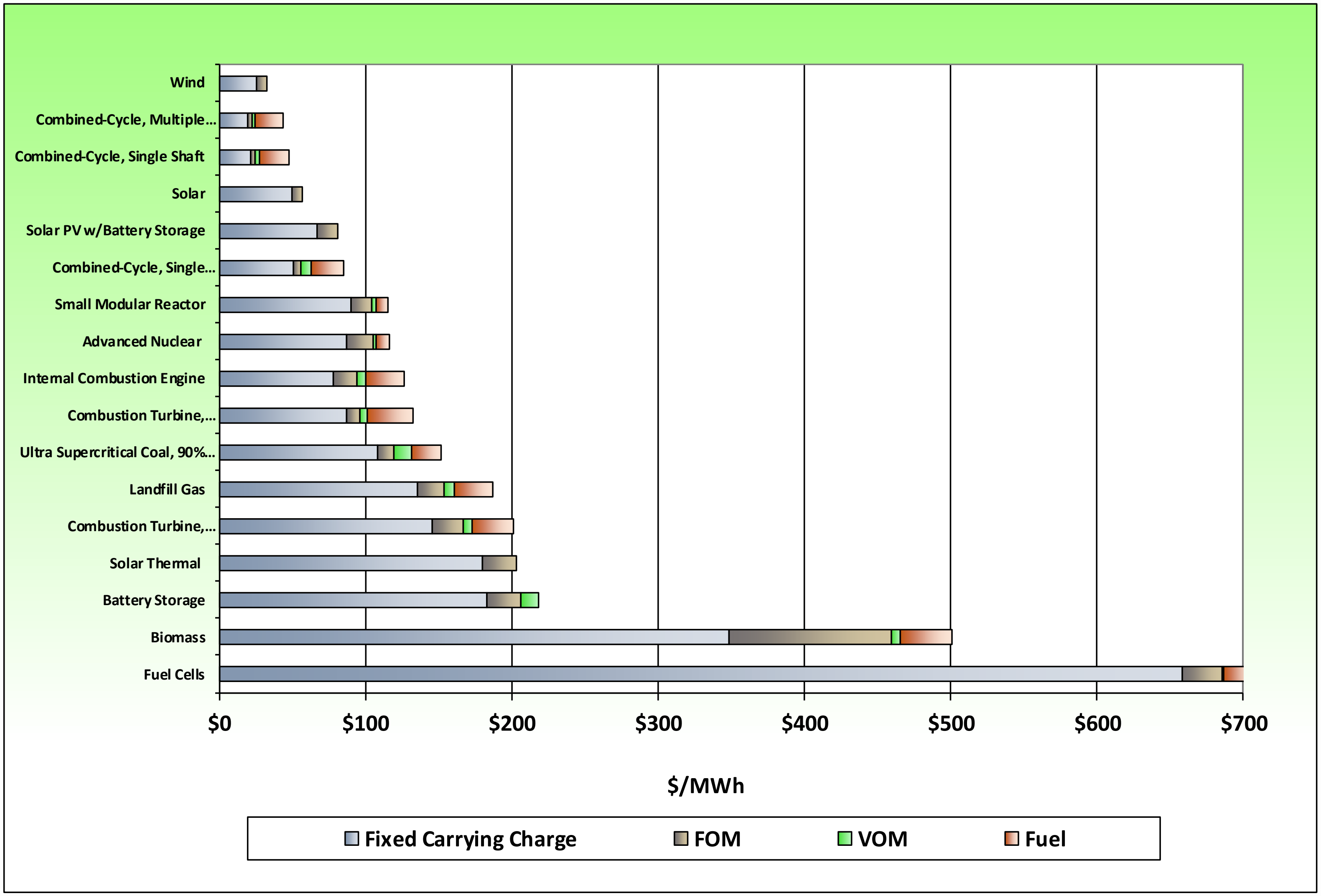


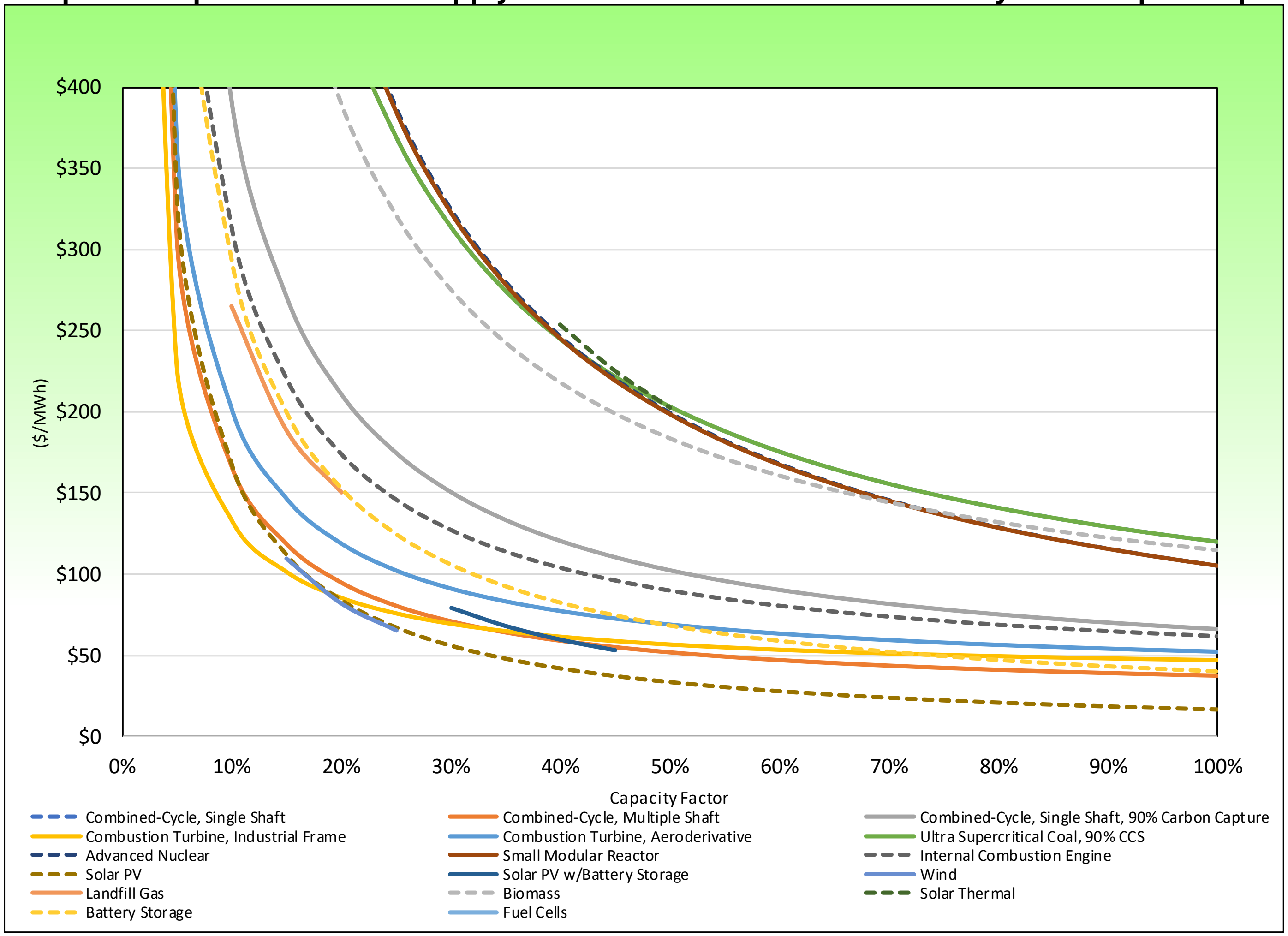
Table 12: Supply-Side Candidates Cost of Electricity Based Upon Capacity Factor - $/MWh

Technology	1%	5%	10%	15%	20%	25%	30%	35%	40%	45%
Combined-Cycle, Single Shaft	$ 1,629	$ 345	$ 185	$ 131	$ 104	$ 88	$ 78	$ 70	$ 64	$ 60
Combined-Cycle, Multiple Shaft	$ 1,460	$ 310	$ 167	$ 119	$ 95	$ 81	$ 71	$ 64	$ 59	$ 55
Combined-Cycle, Single Shaft, 90% Carbon Capture	$ 3,658	$ 756	$ 393	$ 272	$ 212	$ 175	$ 151	$ 134	$ 121	$ 111
Combustion Turbine, Industrial Frame	$ 1,000	$ 230	$ 134	$ 102	$ 86	$ 76	$ 70	$ 65	$ 62	$ 59
Combustion Turbine, Aeroderivative	$ 1,706	$ 370	$ 203	$ 147	$ 119	$ 102	$ 91	$ 83	$ 77	$ 73
Ultra Supercritical Coal, 90% CCS	$ 8,370	$ 1,704	$ 870	$ 593	$ 454	$ 370	$ 315	$ 275	$ 245	$ 222
Advanced Nuclear	$ 9,441	$ 1,897	$ 954	$ 640	$ 483	$ 388	$ 325	$ 281	$ 247	$ 221
Small Modular Reactor	$ 9,356	$ 1,880	$ 946	$ 634	$ 479	$ 385	$ 323	$ 278	$ 245	$ 219
Internal Combustion Engine	$ 2,845	$ 596	$ 315	$ 221	$ 175	$ 146	$ 128	$ 114	$ 104	$ 96
Solar PV	$ 1,688	$ 338	$ 169	$ 113	$ 84	$ 68	$ 56	$ 48	$ 42	$ 38
Solar PV w/Battery Storage	$ 2,375	$ 475	$ 237	$ 158	$ 119	$ 95	$ 79	$ 68	$ 59	$ 53
Solar Thermal	$ 10,135	$ 2,027	$ 1,013	$ 676	$ 507	$ 405	$ 338	$ 290	$ 253	$ 225
Wind	$ 1,641	$ 328	$ 164	$ 109	$ 82	$ 66	$ 55	$ 47	$ 41	$ 36
Landfill Gas	$ 2,334	$ 495	$ 265	$ 188	$ 150	$ 127	$ 112	$ 101	$ 93	$ 86
Biomass	$ 6,943	$ 1,425	$ 735	$ 505	$ 390	$ 321	$ 275	$ 243	$ 218	$ 199
Battery Storage	$ 2,840	$ 577	$ 294	$ 200	$ 153	$ 125	$ 106	$ 92	$ 82	$ 74
Fuel Cells	$ 10,309	$ 2,079	$ 1,050	$ 708	$ 536	$ 433	$ 365	$ 316	$ 279	$ 251

Table 13: Supply-Side Candidates Cost of Electricity Based Upon Capacity Factor - $/MWh (continued)

Technology	50%	55%	60%	65%	70%	75%	80%	85%	90%	95%	100%
Combined-Cycle, Single Shaft	$ 56	$ 53	$ 51	$ 49	$ 47	$ 46	$ 44	$ 43	$ 42	$ 41	$ 40
Combined-Cycle, Multiple Shaft	$ 52	$ 49	$ 47	$ 45	$ 44	$ 42	$ 41	$ 40	$ 39	$ 38	$ 37
Combined-Cycle, Single Shaft, 90% Carbon Capture	$ 103	$ 96	$ 91	$ 86	$ 82	$ 79	$ 76	$ 73	$ 71	$ 68	$ 67
Combustion Turbine, Industrial Frame	$ 57	$ 55	$ 54	$ 53	$ 52	$ 51	$ 50	$ 49	$ 48	$ 48	$ 47
Combustion Turbine, Aeroderivative	$ 69	$ 66	$ 63	$ 61	$ 59	$ 58	$ 56	$ 55	$ 54	$ 53	$ 52
Ultra Supercritical Coal, 90% CCS	$ 204	$ 189	$ 176	$ 165	$ 156	$ 148	$ 141	$ 135	$ 130	$ 125	$ 120
Advanced Nuclear	$ 200	$ 183	$ 168	$ 156	$ 146	$ 137	$ 129	$ 122	$ 116	$ 110	$ 105
Small Modular Reactor	$ 198	$ 181	$ 167	$ 155	$ 145	$ 136	$ 128	$ 121	$ 115	$ 110	$ 105
Internal Combustion Engine	$ 90	$ 85	$ 81	$ 77	$ 74	$ 71	$ 69	$ 67	$ 65	$ 64	$ 62
Solar PV	$ 34	$ 31	$ 28	$ 26	$ 24	$ 23	$ 21	$ 20	$ 19	$ 18	$ 17
Solar PV w/Battery Storage	$ 47	$ 43	$ 40	$ 37	$ 34	$ 32	$ 30	$ 28	$ 26	$ 25	$ 24
Solar Thermal	$ 203	$ 184	$ 169	$ 156	$ 145	$ 135	$ 127	$ 119	$ 113	$ 107	$ 101
Wind	$ 33	$ 30	$ 27	$ 25	$ 23	$ 22	$ 21	$ 19	$ 18	$ 17	$ 16
Landfill Gas	$ 81	$ 77	$ 74	$ 71	$ 68	$ 66	$ 64	$ 62	$ 61	$ 59	$ 58
Biomass	$ 183	$ 171	$ 161	$ 152	$ 144	$ 138	$ 132	$ 127	$ 122	$ 118	$ 115
Battery Storage	$ 68	$ 63	$ 59	$ 55	$ 52	$ 49	$ 47	$ 45	$ 43	$ 41	$ 40
Fuel Cells	$ 228	$ 209	$ 193	$ 180	$ 169	$ 159	$ 151	$ 143	$ 136	$ 130	$ 125

Table 14: Graphical Representation of Supply-Side Candidates Cost of Electricity Based Upon Capacity Factor



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.

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 below.

2.3.2.1.1 Ultra-Supercritical Pulverized Coal with 90% Carbon Capture and Storage (CCS)

Due to the current cost estimate and lack of technology maturity, this resource option was not passed on to the integrated resource analysis.

2.3.2.1.2 Nuclear and Small Modular Reactor

Due to current and potential future permitting, cost estimates and environmental regulations, large scaled nuclear technologies were not passed on to the integrated resource analysis.

2.3.2.1.3 Combustion Turbine (CT) Technologies

Two combustion turbine technologies were identified for the prescreening process and one of those was chosen to move into integrated resource analysis. An industrial frame combustion turbine technology was passed on to the integrated resource planning process.

2.3.2.1.4 Biomass 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 lower cost renewable alternatives such as wind.

2.3.2.1.5 Fuel Cell Technologies

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

2.3.2.1.6 Solar Technologies

Solar thermal technology in the prescreening process was 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.

2.3.2.1.7 Internal Combustion Engines

Internal combustion engine technology was not passed on to integrated resource analysis. The primary disadvantage is the higher cost relative to the larger scale combustion turbine 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 INTERCONNECTION AND TRANSMISSION CONSTRAINTS ANALYSIS

(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.

As a member of SPP, Evergy 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 deliver energy from a resource in the RTO footprint to Evergy Metro 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. With 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 the supply-side technologies passed on to the integrated resource analysis as candidate resource options are listed in Table 15 below. Cost and operating data for the technologies that moved on to the integrated resource analysis came from the 2020 U.S. Energy Information Administration Annual Energy Outlook and responses from the April 2020 Request for Proposals (RFP).

Table 15: Candidate Resource Options

Generation Category	Technology
Combined Cycle	Combined-Cycle, Single Shaft
Combustion Turbine	Combustion Turbine, Industrial Frame
Renewables	Solar PV Wind
Other	Battery Storage

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 Combustion Turbine Technology

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

4.1.1.2 Combined Cycle Technology

The single shaft combined cycle (CC) technology of the 1x1x1 H Class was passed on to the integrated resource analysis process.

4.1.1.3 Wind and Solar Technology

Wind and solar technology were passed on to the integrated resource analysis as low-cost representatives of renewable generation.

4.1.1.4 Battery Storage

Stand-alone battery storage was passed on the integrated resource analysis process.

4.1.2 ELIMINATION OF PRELIMINARY SUPPLY-SIDE RESOURCES DUE TO INTERCONNECTION OR TRANSMISSION

(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 Evergy Metro 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.

Table 16: Transmission Interconnect Cost Projection

Transmission Cost Estimates	CT	CC	Wind	Solar	Battery Storage
$/kW	$36	$62	$63	$0	$0

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, and fuel oil. Evergy Metro 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. Following is an overview of the forecasting process applied for natural gas, coal, and fuel oil.

5.1.1 NATURAL GAS FORECAST

A composite Henry Hub natural gas price forecast was created by combining forecasts from IHS Markit, Energy Information Administration, S&P Global Platts, Energy Ventures Analysis, and CME Futures. 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 low forecast was capped at the historical recent 5-year average to widen the band around the composite forecast. The three resultant price curves with their probability of occurrence were base 50%, high 15%, and low 35%. 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. Additionally, it was decided to cap the first five years of the low forecast at the 5-year historical average.

5.1.2 COAL FORECAST

To ensure the early part of the forecast reflects expected cost, actual contract prices are utilized to the extent contracts are in place. Prices for contracted coal volumes are supplemented with prices from Coaldesk’s latest available forward market valuation, which currently extends through 2024, for all uncontracted coal volumes in that timeframe. For forecasted prices beyond 2024, a composite coal price forecast was created by combining the forecasts from IHS Markit, S&P Global Platts, Energy Ventures Analysis, and JD Energy. The forecasts are combined and weighted equally to create a composite price forecast that represents the base case consensus of the major forecast sources.

5.1.3 FUEL OIL FORECAST

A composite crude oil price forecast was created by combining forecasts from IHS Markit, Energy Information Administration, S&P Global Platts, and Energy Ventures Analysis. 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 fuel price forecasts are shown in the tables below. The sources used in developing the forecasts are shown below in Table 20.

Table 17: Natural Gas Price Forecast

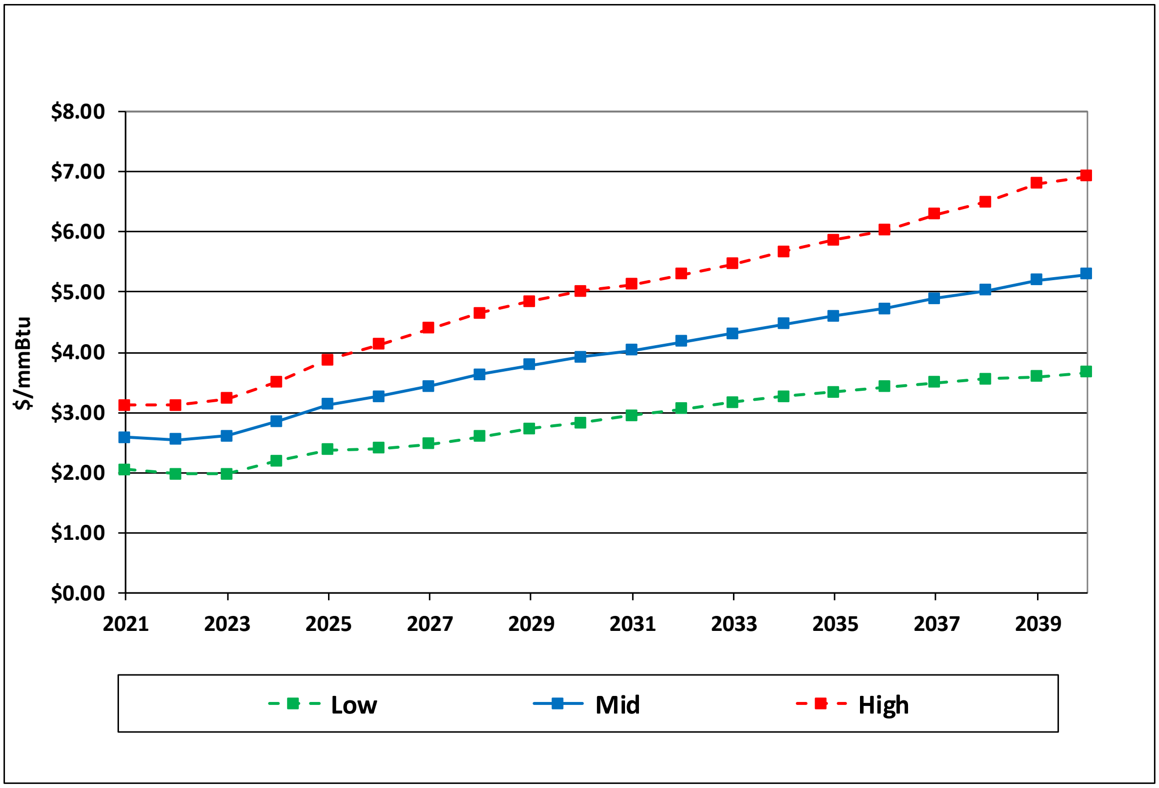


Table 18: Coal Price Forecast

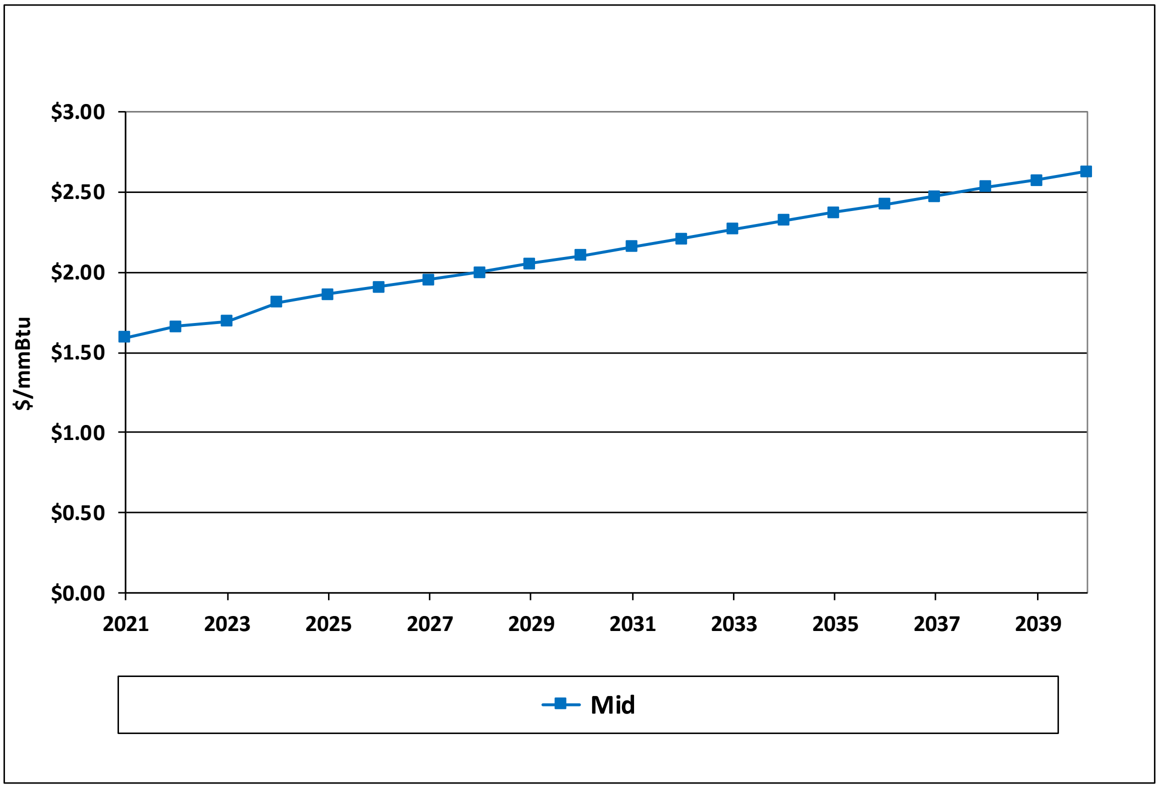


Table 19: Fuel Oil Forecast

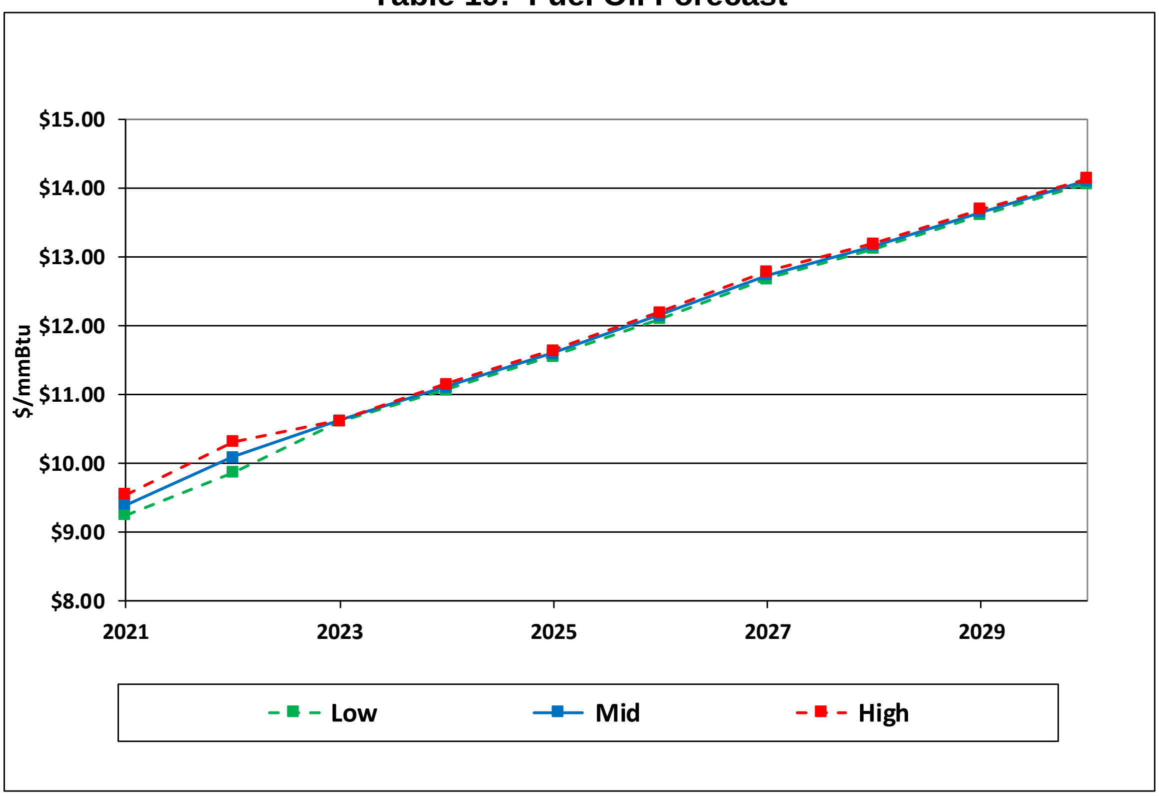


Table 20: Source Forecasts for Fuel

Forecast Source	Natural Gas	Coal	Fuel Oil
IHS Markit	x	x	x
Energy Information Administration	x		x
S&P Global Platts	x	x	x
Energy Ventures Analysis	x	x	x
JD Energy		x	
CME Futures	x		
Coaldesk, LLC		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. For combustion turbine and combined cycle 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. For wind and solar technologies, the 'High' capital cost estimate was set at 110% 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 21 and Table 22.

Table 21: Technology Capital Cost Ranges

Technology Description	Mid Range	High Range	Low Range
Combustion Turbine	100%	115%	90%
Combined Cycle	100%	115%	90%
Wind	100%	110%	90%
Solar	100%	110%	90%
Battery Storage	100%	110%	90%

Table 22: Technology Capital Cost Ranges

Technology Description	Mid Range ($/kW)	High Range ($/kW)	Low Range ($/kW)
Combustion Turbine - 2020 $	764	878	687
Combined Cycle - 2020 $	1175	1351	1057
Wind - 2020 $	1290	1420	1161
Solar - 2023 $	1100	1210	990
Battery Storage - 2020 $	1389	1528	1250

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;

Estimated annual fixed and variable operation and maintenance costs for new facilities considered in integrated analysis are shown below in Table 23 and Table 24 below.

Table 23: Fixed O&M Estimates Utilized in Integrated Resource Analysis

Technology Description	Fixed O&M (2020 $/kW-yr)
Combustion Turbine	7.14
Combined Cycle	14.45
Wind	26.88
Solar	15.57
Battery Storage	25.42

Table 24: Variable O&M Estimates Utilized in Integrated Resource Analysis

Technology Description	Variable O&M (2020 $/MWh)
Combustion Turbine	4.59
Combined Cycle	2.61
Wind	0
Solar	0
Battery Storage	0

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 is shown in Table 25 through Table 29 below:

Table 25: SO_2 Group 1 Price Forecast

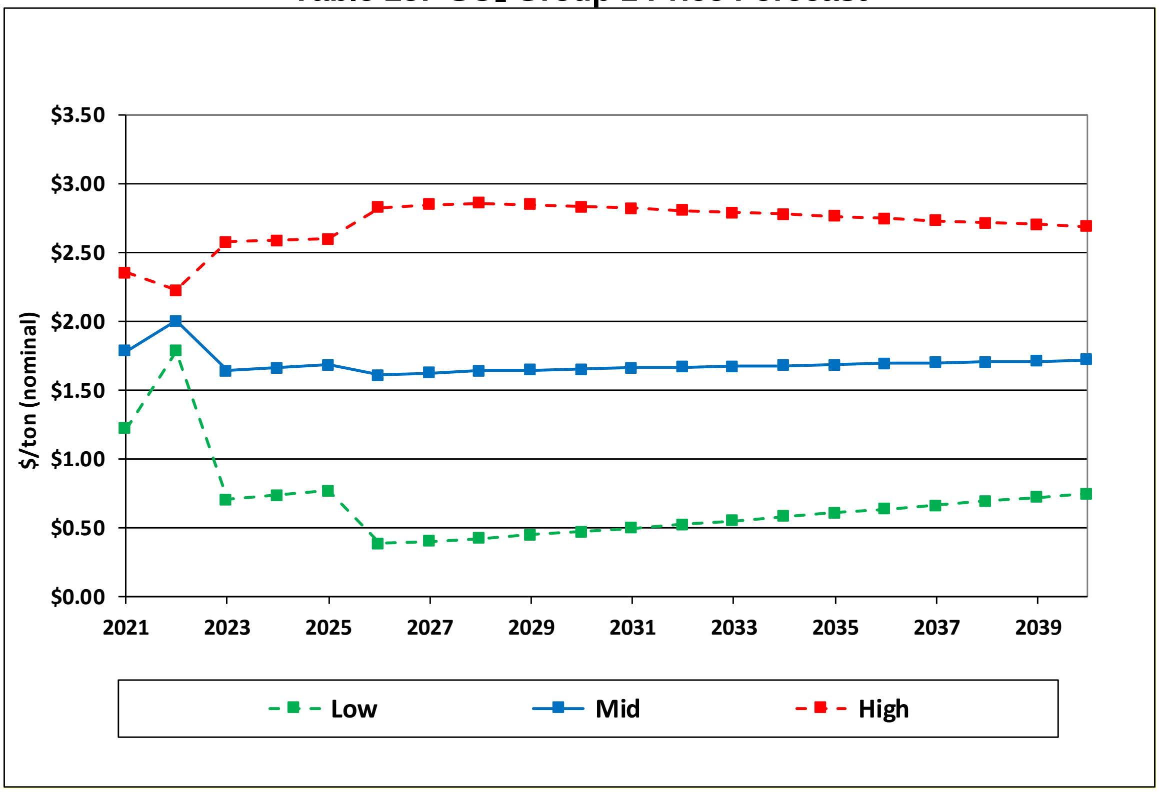


Table 26: SO_2 Group 2 Price Forecast

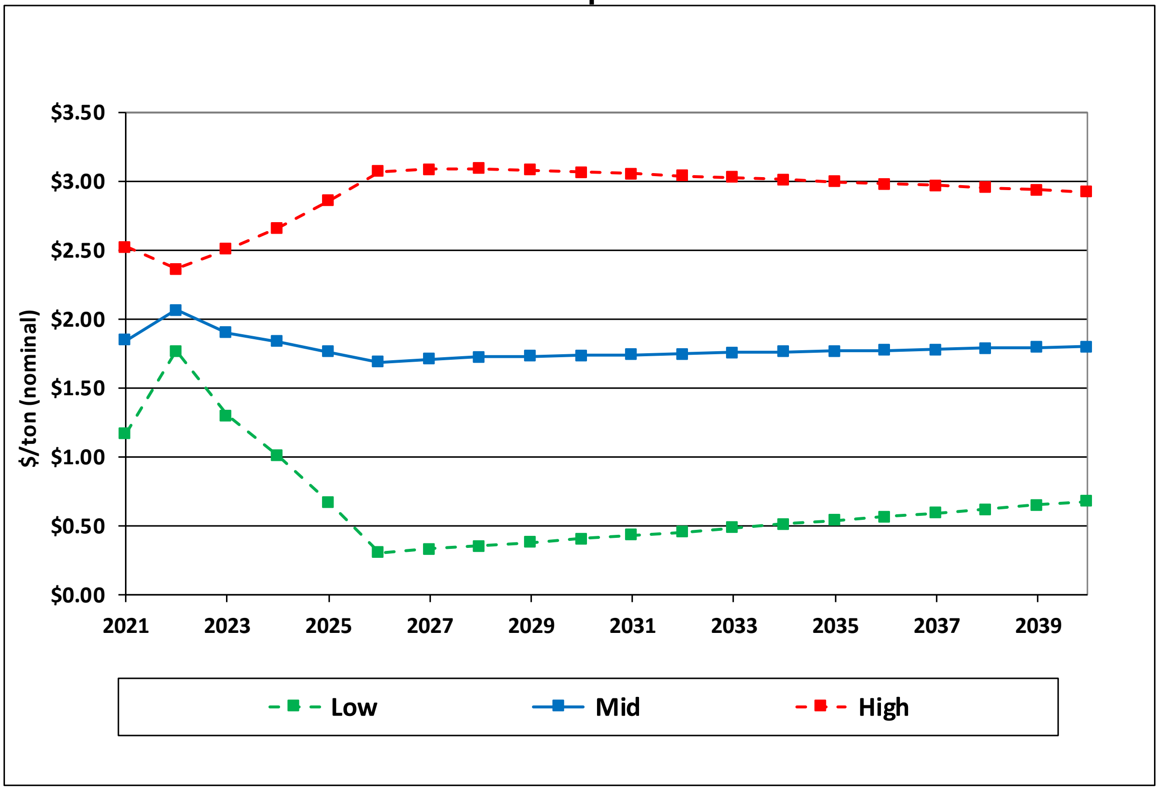


Table 27: NO_x Annual Price Forecast

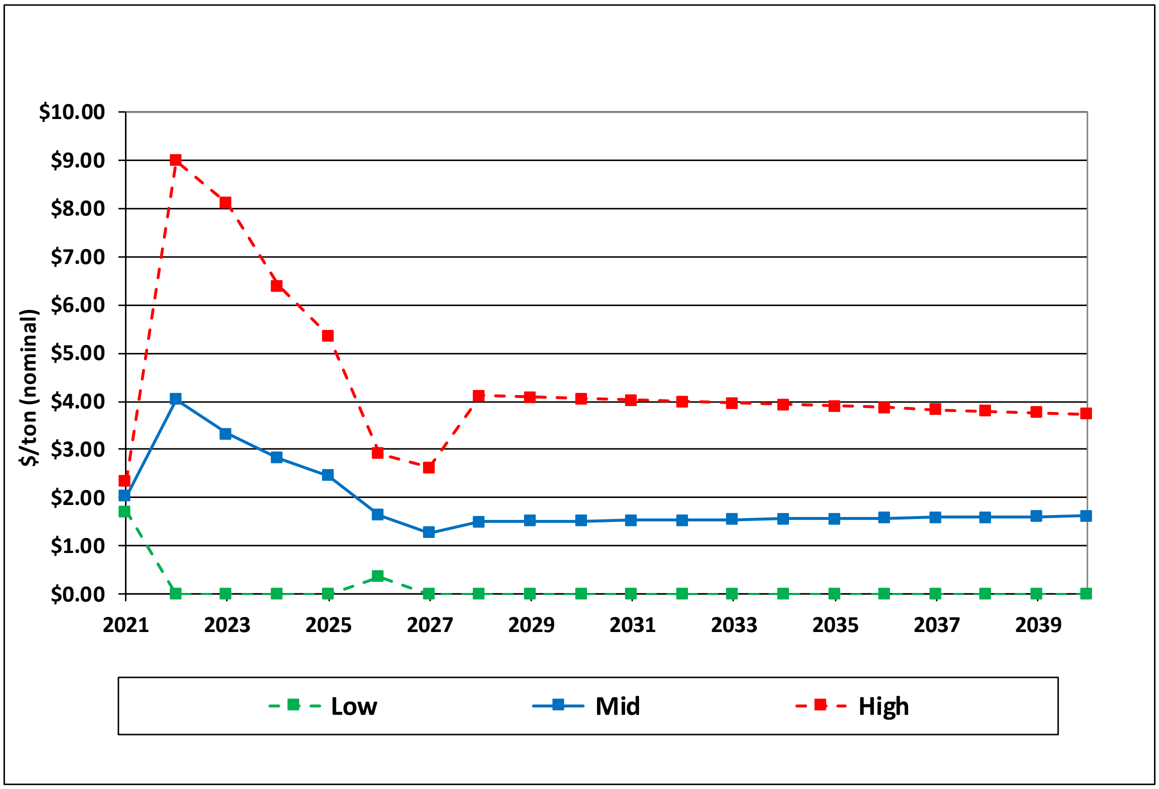


Table 28: NO_x Seasonal Price Forecast

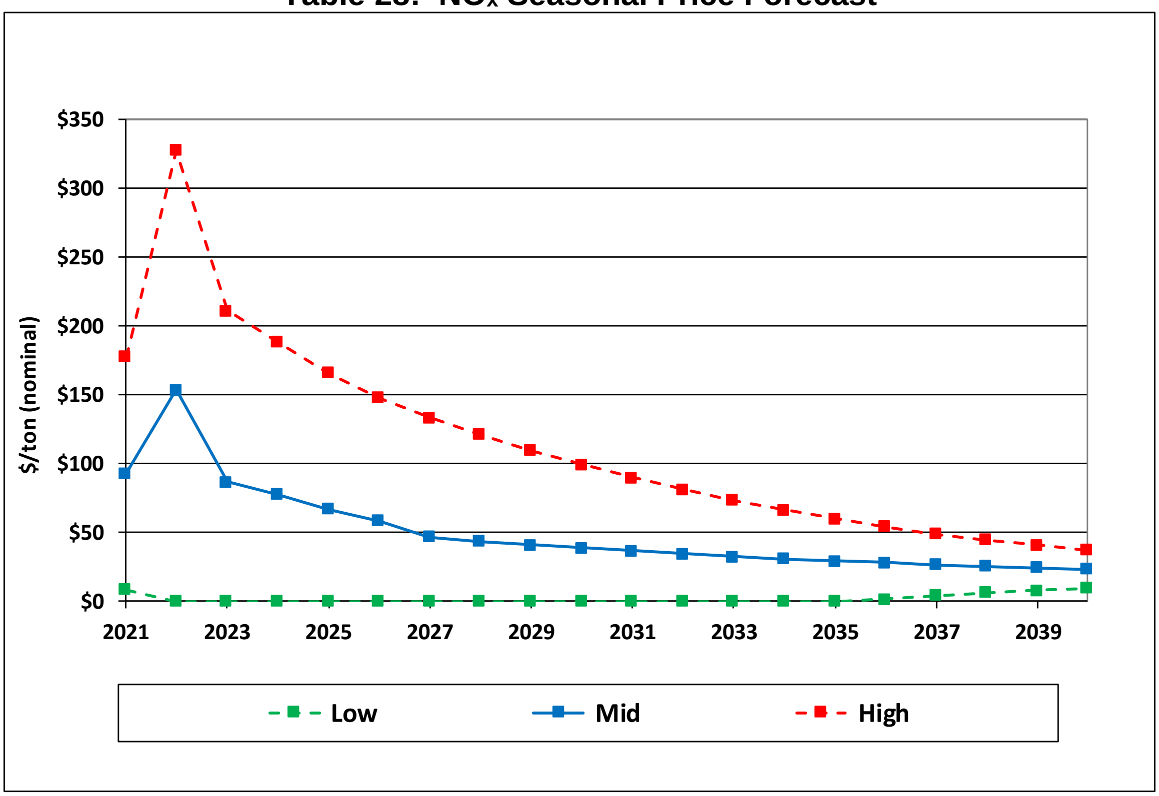


Table 29: CO_2 Price Forecast **Confidential**

[redacted]

The source forecasts utilized to develop the emission allowance forecasts are shown in Table 30 below:

Table 30: 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	
JD Energy	x	x	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 Evergy Metro alternative resource plans or in the rate base, so this rule does not apply to this IRP evaluation.

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.