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VOLUME 4

SUPPLY-SIDE RESOURCE ANALYSIS

THE EMPIRE DISTRICT
ELECTRIC COMPANY – A LIBERTY UTILITIES COMPANY
(LIBERTY-EMPIRE)

4 CSR 240-22.040

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TABLE OF CONTENTS

NP

TABLE OF FIGURES

TABLE OF TABLES

TABLE OF RULE REQUIREMENTS

4 CSR 240-22.040 SUPPLY-SIDE RESOURCE ANALYSIS

SUPPLY-SIDE RESOURCE ANALYSIS

4 CSR 240-22.040 Supply-Side Resource Analysis

PURPOSE: This rule establishes minimum standards for the scope and level of detail required in supply-side resource analysis.

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.

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1.1 Overview of Existing and Committed Supply-Side Resources

The existing supply-side resources described in this section include those conventional and renewable resources that are in operation on the Empire District Electric Company, a Liberty Utilities Company ("Liberty-Utility") system or for which Liberty-Empire has power purchase agreements ("PPA"). Committed resources include those conventional and renewable resources for which commitments have already been made. Existing and committed resources as well as future resources were examined in the modeling process for this IRP.

Liberty-Empire's existing resources that are used to meet customer obligations include a coal-fired unit, natural gas-fired combustion turbines ("CT"), a hydroelectric facility, a combined cycle ("CC") unit, ownership shares in coal-fired units, an ownership share in a combined cycle unit, and long-term PPAs for coal and wind units. These resources are summarized in Table 4-1. The unit ratings represent Liberty-Empire's share for jointly owned units. All unit ratings described in this IRP report represent summer ratings (unless otherwise specified). Units are rerated from time to time and all assumptions are subject to change.

Table 4-1 – Liberty-Empire Supply-Side Resources – Existing and Committed

Power Plant Resource	Fuel Type	State	Interest (%)	Liberty-Empire Capacity (MW)	Start Date	Facility Resource Age (Years)
Asbury 1	Coal	MO	100	200	1970	49
Iatan 1	Coal	MO	12	84	1980	39
Iatan 2	Coal	MO	12	106	2010	9
Plum Point	Coal	AR	7.52	51	2010	9
Riverton 10 CT	Natural Gas	KS	100	13	1988	31
Riverton 11 CT[1]	Natural Gas	KS	100	15	1988	31
Riverton 12 CC	Natural Gas	KS	100	247	2016	12
Liberty-Empire Energy Center 1 CT	Natural Gas/ Oil	MO	100	82	1978	41
Liberty-Empire Energy Center 2 CT	Natural Gas/ Oil	MO	100	80	1981	38
Liberty-Empire Energy Center 3 CT	Natural Gas/ Oil	MO	100	40	2003	16

Liberty-Empire Energy Center 4 CT	Natural Gas/ Oil	MO	100	40	2003	16
State Line CT	Natural Gas/ Oil	MO	100	95	1995	24
State Line CC	Natural Gas	MO	60	292[2]	1997 & 2001[3]	22 & 18
Ozark Beach	Hydro	MO	100	16	1913	106
Total Liberty-Empire Installed Capacity				1,361		
Long Term Power Purchases	**Type**			**Liberty-Empire Capacity (MW)**	**End Date**	**Term (Years)**
Plum Point	Coal			50	2040	
Elk River Wind Farm[4] (150 MW PPA)	Wind			22	2025	20
Meridian Way Wind Farm[5] (105 MW PPA)	Wind			9	2028	20
Capacity Summary						
Total Coal				441		
Total Gas Turbine				365		
Total Combined Cycle				539		
Total Hydro				16		
Total Purchase including Wind				81		
TOTAL[6]				**1,442**		

1. Riverton 10 and 11 were manufactured in 1967 but were installed at Liberty-Empire in 1988; they are 51 years old.

2. Represents Liberty-Empire’s 60 percent share of a 495 MW State Line Combined Cycle unit.

3. One of the gas turbines at State Line CC was installed in 1997 and hence is 21 years old. The other gas turbine and the steam turbine were installed in 2001.

4. The Elk River Wind Farm consists of 100 1.5 MW turbines for a total of 150 MW. For purposes of the IRP, 15 MW of its installed capacity is counted toward Liberty-Empire’s reserve margin. This firm capacity is subject to rerating in the future. Although the term of the PPA is 20 years, the term can be extended once for a period of 5 years at Liberty-Empire’s option.

5. The Meridian Way Wind Farm began commercial operation on December 15, 2008. The facility is rated at 105 MW and approximately 10 MW is counted toward Liberty-Empire’s reserve margin. This firm capacity is subject to rerating in the future.

6. Liberty-Empire is currently proposing the addition of 600 MW of nameplate capacity through three new wind farms. This would represent 90 MW of capacity credit.

Liberty-Empire's generation by fuel type for 2018 is shown in Figure 4-1 and listed in Table 4-2. In 2018, 40 percent of Liberty-Empire's generation was supplied by coal, 47 percent from natural gas, and 14 percent was provided by renewable sources. The remaining generation was provided by non-contract purchases. As of March 1, 2014, the Southwest Power Pool ("SPP") Integrated Marketplace allows Liberty-Empire to buy generation from and sell generation to participants throughout the SPP region.

Figure 4-1 - Liberty-Empire Generation by Fuel Type for 2018

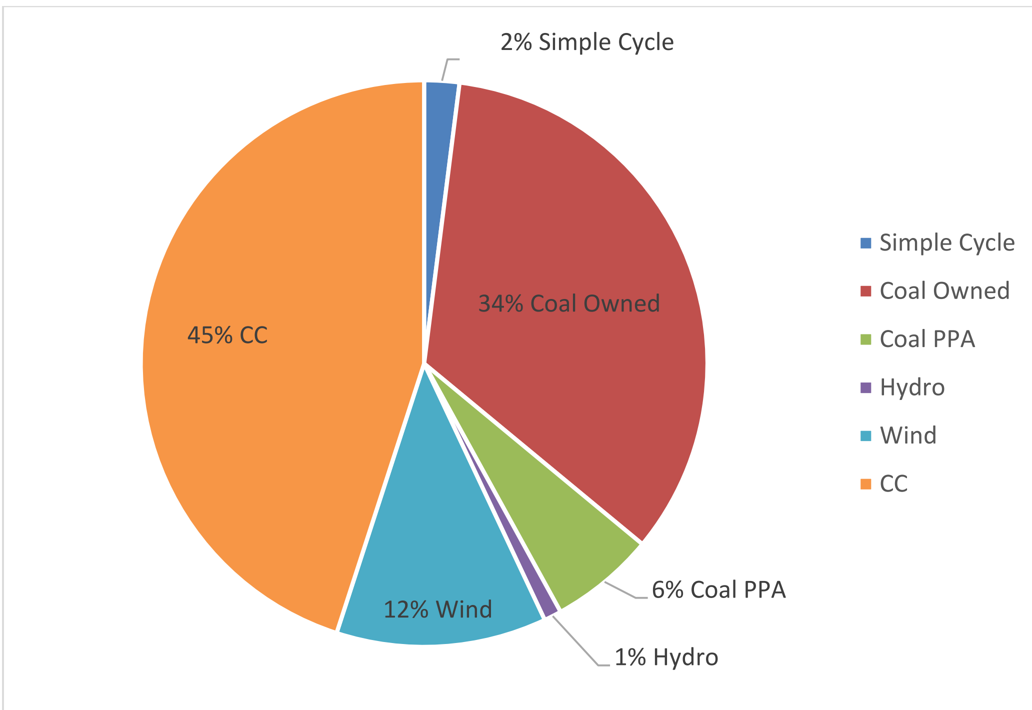


Table 4-2 – Liberty-Empire Generation by Fuel Type for 2018

Type	Generation in 2018 (MWh)	Percent of Liberty-Empire's total generation 2018
Coal Owned	2,247,846	34%
Coal PPA	399,579	6%
Total Coal	2,647,425	40%
Hydro	49,345	1%
Wind PPA	763,633	12%
Total Renewable	812,978	12%
Combined Cycle (NG)	2,978,863	45%
Simple Cycle (NG)	141,106	2%
Total Natural Gas	3,119,969	47%
Total System MWh (Net System Output)	**6,580,371**	**100%**

1.2 Description of Power Plants Owned by Liberty-Empire

1.2.1 Asbury

The Asbury plant, located near Asbury, Missouri, consists of one coal-fired unit totaling 200 MW. Unit 1 was installed in 1970. Many modifications have been made to the Asbury plant since Unit 1 achieved commercial operation in 1970. Selective Catalytic Reduction ("SCR") for nitrous oxides ("NO_X") control was added in 2008. The most recent upgrades were added during the Asbury Air Quality Control System ("AQCS") project. This project included the addition of a Dry Circulating Fluidized Bed Scrubber for sulfur dioxide removal, a Powder Activated Carbon Injection system for mercury removal, and a pulse jet fabric filter baghouse for removal of particulate matter ("PM") from the flue gas. The AQCS project also included a conversion from a forced draft boiler to a balanced draft, a turbine upgrade, and retirement of Unit 2. The upgrades to the Unit 1 turbine included a new rotor and inner cylinders for efficiency gains. The AQCS project brought Asbury from 189 MW to 200 MW (net generation) and brought it into compliance with the Mercury and Air Toxics Standards ("MATS") regulations.

Associated with the Asbury AQCS project, new regulations and other pending environmental regulations would require the construction of a coal combustion residual landfill and a modification to the bottom ash conveyance equipment at the Asbury plant if the plant remains operational. These requirements are a result of the Federal Resource Conservation and Recovery Act ("RCRA") discussed in Section 2.5.3 and the recent Effluent Limit Guidelines discussed in section 2.5.2.2.

1.2.2 Riverton

Liberty-Empire's Riverton Generating Plant is located at Riverton, Kansas, and has three natural gas-fired CT units (10, 11, and 12) with an aggregate generating capacity of 275 MW. Riverton Unit 12 CC is a natural gas-fired Siemens steam turbine/generator and a Siemens V84.3A2 CT with a total rating of 247 MW that was installed at the Riverton power plant in 2007. The steam turbine/generator, heat recovery steam generator ("HRSG"), cooling tower, and balance of plant equipment were completed and put into service in early 2016.

1.2.3 Iatan

Liberty-Empire owns a 12 percent undivided interest in the nominal 670 MW, coal-fired Iatan 1 located near Weston, Missouri as well as a 3 percent interest in the site and a 12 percent interest in certain common facilities. Liberty-Empire is entitled to 12 percent of the unit's available capacity and is obligated to pay for that percentage of the operating costs of the unit. For the purposes of this IRP, it is assumed that Liberty-Empire's share of the Iatan 1 capacity is 84 MW.

Iatan 1 is equipped with an SCR for the removal of NO_X, a wet scrubber for the removal of SO_2, a fabric filter baghouse for the removal of PM, and a powder activated carbon system for the removal of mercury. These additions, undertaken to comply with the Environmental Protection Agency's ("EPA") regulations and to meet the requirements for an air permit for Iatan 1, were completed in 2009.

Liberty-Empire also owns a 12 percent undivided interest in the Iatan 2 unit, which for the purposes of this IRP is assumed to be 106 MW. The AQCS (SCR, scrubber, fabric filter), constructed with the relatively new Iatan 2 unit, complies with the recent and anticipated air quality regulations.

1.2.4 State Line

Liberty-Empire's State Line Power Plant, located west of Joplin, Missouri, presently consists of State Line Unit 1, a CT with generating capacity of 95 MW ("State Line CT"), and a CC unit with generating capacity of 495 MW, of which Liberty-Empire is entitled to 60 percent, or 292 MW ("State Line CC"). All of the units at the State Line Power Plant burn natural gas as a primary fuel, with State Line Unit 1 having the ability to also burn fuel oil as a backup fuel. Burning fuel oil requires water injection for emissions control. The CC consists of two CTs with a HRSG on the back of each CT. Steam from the HRSGs is fed to the steam turbine. The CC can operate in two modes:

1. 1 x 1 mode (one CT and the steam turbine) with capacity of 150 MW
2. 2 x 1 mode (two CTs and the steam turbine) with total capacity of 292 MW (Liberty-Empire's share)

Studies are currently underway to evaluate possible efficiency and capacity upgrades for these units in conjunction with major inspections scheduled for 2020 and 2021 for Units 2-1 and 2-2. Other than the possible upgrades, routine maintenance will be conducted. The State Line CC and CTs have dry low NO_X burners, and there is an SCR on each HRSG.

1.2.5 Liberty-Empire Energy Center

Liberty-Empire has four CT peaking units at the Liberty-Empire Energy Center in Jasper County, Missouri (near the town of Sarcoxie), with an aggregate generating capacity of 242 MW. Energy

Center Units 1 and 2 are simple cycle frame CTs and were installed in 1978 and 1981. Energy Center Units 3 and 4 are aeroderivative CTs installed in 2003.

These peaking units operate on natural gas as well as fuel oil. All units undergo routine maintenance with inspections on a regular cycle and equipment is refurbished as needed. All of the CTs use water injection to control NO_X.

1.2.6 Ozark Beach

Liberty-Empire's hydroelectric generating plant, located on the White River at Forsyth, Missouri, has a generating capacity of 16 MW (four 4-MW units). In 2013, Liberty-Empire celebrated this facility's 100-year anniversary. These units have been updated periodically so that they can continue contributing to Liberty-Empire's renewable portfolio. Liberty-Empire began the renewal process for the FERC license in 2016. The relicensing process takes approximately five years to complete and does not expire for 30 years. The hydroelectric plant backs up the White River and created Lake Taneycomo, located in southwestern Missouri.

As part of the Energy and Water Development Appropriations Act of 2006 ("Appropriations Act"), a new minimum flow pattern was established to increase minimum flows on recreational streams in Arkansas. To accomplish this, the level of Bull Shoals Lake was increased an average of 5 feet. The increase at Bull Shoals decreased the net head waters available for generation at Ozark Beach by 5 feet and, thus, reduced Liberty-Empire's electrical output. The lost production represented about 16 percent of the average annual energy production for the unit.

The Appropriations Act required Southwest Power Administration ("SWPA"), in coordination with Liberty-Empire and Liberty-Empire's relevant public service commissions, to determine Liberty-Empire's economic detriment from the lost production. On June 17, 2010, SWPA posted a revised Final Determination that Liberty-Empire's customers' damages were $26.6 million. On September 16, 2010, Liberty-Empire received a $26.6 million payment from the SWPA, which was deferred and recorded as a non-current liability. Liberty-Empire originally increased Liberty-Empire's current tax liability by approximately $10.0 million, recognizing that the $26.6 million payment might have been considered taxable income in 2010. During the first quarter of 2011, Liberty-Empire submitted a pre-filing agreement with the Internal Revenue Service ("IRS") requesting that a determination be made regarding whether or not the payment could be deferred under certain sections of the Internal Revenue code. The IRS accepted Liberty-Empire's position that the payment be deferred for tax purposes and recognized over the next 20 years. As such, Liberty-Empire reduced the current tax liability in accordance with this deferral. The SWPA payment, net of taxes, is being used to reduce fuel expense for Liberty-Empire's customers in all of Liberty-Empire's jurisdictions.

1.2.7 Plum Point

The Plum Point Energy Station is a nominal 670 MW, sub-critical, coal-fired generating facility built near Osceola, Arkansas. Liberty-Empire owns 7.52 percent (approximately 50 MW) of the project. In addition, Liberty-Empire has a 30-year PPA for an additional 50 MW of capacity that began on September 1, 2010.

Plum Point is equipped with an SCR for NO_X removal, a dry scrubber for SO_2 control, combustion controls for volatile organic compounds ("VOC") mitigation, and a fabric filter baghouse for the removal of PM.

1.3 Generating Plant Efficiency Improvements to Reduce Energy Use

Liberty-Empire is continually evaluating generating resource efficiency improvement opportunities in which it can reduce its overall auxiliary load at existing power plants to reduce its own use of energy. As described above, Liberty-Empire's power supply portfolio is diverse in the type of power plants (such as coal, gas, and renewables). Potential improvement projects for reducing auxiliary loads are dependent on the type of power plant. Provided below are a few examples of projects that provide opportunities for reducing the utility's own use of energy at existing power plants:

- On-line condenser cleaning system
- Duct leakage reduction
- Insulation improvements

Several of the coal-fired power plants within Liberty-Empire's power supply portfolio just underwent plant upgrades (such as Iatan 1 and Asbury) or are relatively newer constructions (such as Iatan 2 and Plum Point). Newer coal plants are typically designed to reduce auxiliary load consumption in order to make the unit significantly more efficient. During upgrade projects (such as Iatan 1 and Asbury), utilities typically take the opportunity to implement additional efficiency projects. Due to the age of the newly constructed units and the recent upgrades at Iatan 1 and Asbury, it is anticipated that few plant efficiency projects remain that have not already been implemented.

Liberty-Empire does not specifically operate all of the units within its power supply portfolio and does not control the improvements implemented at those plants. For the plants that Liberty-Empire does operate, Liberty-Empire evaluates potential improvement projects as part of its regular operations and maintenance program for the plants. A list of the plant improvement projects that Liberty-Empire has implemented over the years has been regularly provided to the Commission as part of the FAC filings.

Liberty-Empire will continue to explore cost-effective generating plant efficiency improvements which reduce the utility's own use of energy.

1.4 Purchased Power

Liberty-Empire has existing PPAs for both conventional and renewable resources during the planning period. Liberty-Empire is the off-taker in a long-term PPA with Plum Point Energy Station that is in addition to its undivided ownership share of 7.52 percent (approximately 50 MW). The contract is for 50 MW of capacity and was entered on September 1, 2010.

Liberty-Empire is also an off-taker to two wind PPAs. On December 10, 2004, Liberty-Empire entered into a 20-year contract with PPM Energy to purchase all of the energy generated at the Elk River Wind Farm located in Butler County, Kansas. This wind farm began commercial operation on December 15, 2005. The facility consists of 100 1.5-MW turbines. Liberty-Empire also has the ability to extend the contract term for five years after the end of the 20-year contract period. Liberty-Empire has contracted to purchase all of the output of the project, which is estimated to be approximately 530,000 MWh of energy per year. 22 MW of the 150 MW of installed capacity is counted towards the Company's reserve margin. This is the actual current rating of the facility calculated per SPP criteria, but is subject to rerating in the future.

In June 2007, Liberty-Empire signed a contract with Horizon Wind Energy to buy wind energy from the Cloud County Wind Farm, LLC, which receives energy from the 105-MW Meridian Way Wind Farm located in Cloud County, Kansas, near Concordia. The contract expires in December of 2028. The facility is expected to generate approximately 330,000 MWh per year. The facility began commercial operation on December 23, 2008. 9 MW of the 105 MW of installed capacity is counted toward the Company's reserve margin. This is the actual current rating of the facility calculated per SPP criteria, but is subject to rerating in the future.

1.5 Emission Controls on Existing Units

Emission controls on existing units are described above for each plant in Section 1.2.

1.6 Existing Plant Upgrades

An examination of recent and possible upgrades to existing plants was conducted by Liberty-Empire during the development of this IRP. These include:

1. New pollution control systems were installed at the Iatan 1 unit. A scrubber, SCR, fabric filter, and powder activated carbon system were installed at Unit 1 in 2009.
2. New pollution control systems were installed at the Asbury 1 unit. Unit 1 is retrofitted with an SCR, scrubber, fabric filter, and a powder-activated carbon injection system. This AQCS project and steam turbine project was completed in 2015. Unit 2 was retired in 2013.
3. The conversion of Riverton 12 (a CT) to a CC unit was completed in 2016.
4. Liberty-Empire's normal, ongoing maintenance program at each of its plants addresses critical operational and mechanical issues to ensure the longevity of the units.

1.7 New Technology Options

1.7.1 All Supply-Side Resource Considerations

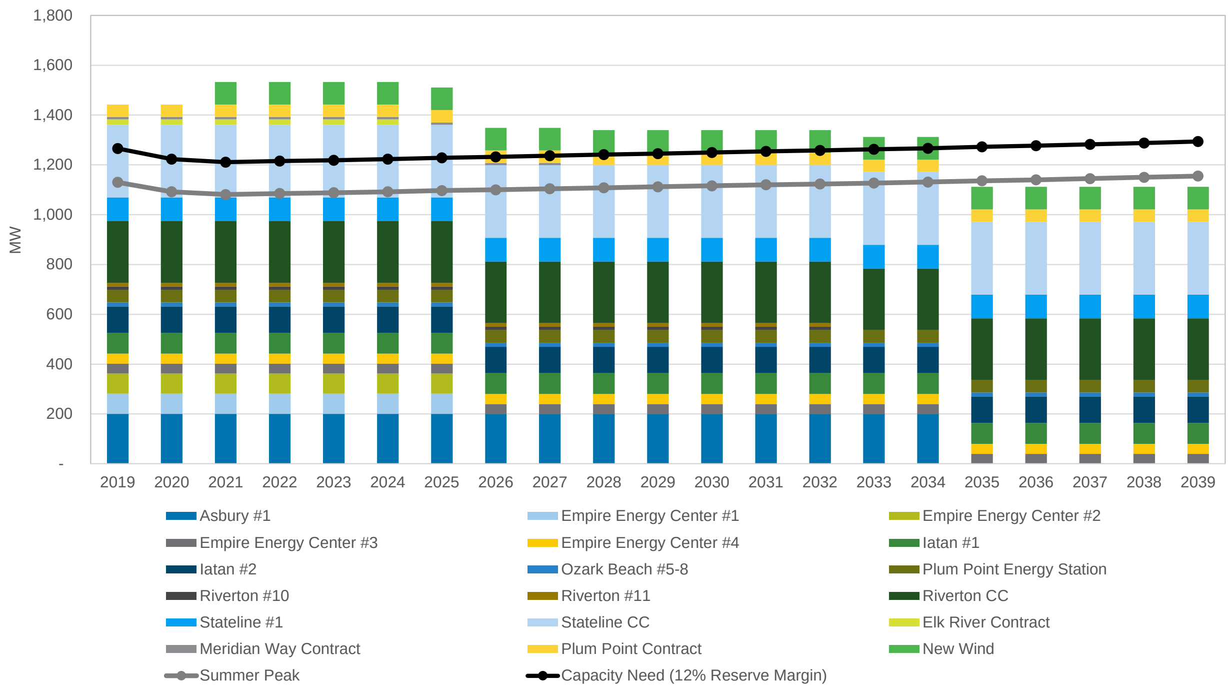
Liberty-Empire initially considered a wide range of supply-side resource technologies with varying levels of technology development, feasibility, and size. After considering Liberty-Empire's size, location, and interconnections, the potential supply-side resource options selected for further investigation are shown below:

1. Coal – supercritical coal with and without CCS or integrated gasification combined cycle with CCS
2. Natural gas-fired simple cycle – Aeroderivative CT, E-class frame CT, F-class frame CT
3. Natural gas-fired combined cycle – 2 x 1 F Class and 2 x 1 Advanced Class
4. Natural gas-fired reciprocating engines*
5. Traditional nuclear and small modular nuclear reactor
6. Wind – on-shore and off-shore, including re-powering of existing assets
7. Biomass – wood waste and poultry waste
8. Landfill gas
9. Solar photovoltaic ("PV")* – fixed tilt and single axis tracking, with and without storage
10. Energy storage* – lithium ion battery, lead acid battery, molten salt, Energy Vault concrete blocks
11. Combined heat and power ("CHP")*
12. Electric vehicle charging infrastructure

*Denotes a resource option evaluated as both a distributed and utility scale energy resource.

Given Liberty-Empire's size, current supply-demand balance (see Figure 4-2), and the expectation that new capacity needs associated with potential plant retirements in the future will be below 300 MW at any given point in time, it was assumed that partial ownership opportunities could exist for the various options, with a maximum block size of 200 MW. Therefore, each of the above options could be screened under their most ideal configurations to allow for a direct comparison of the different technologies.

Figure 4-2 – Existing Liberty-Empire Supply-Demand Balance



1.8 Excluded Technologies

The initial feasibility screen eliminated the following candidates from consideration:

- Off-shore wind, given the lack of the resource in Liberty-Empire's region;
- Re-powering of existing wind assets, given feedback from owners of the projects currently under contract with Liberty-Empire that they are not exploring re-powering opportunities at this time;
- CHP options, given uncertainty regarding feasible sites within Liberty-Empire's service territory and the lack of potential partners that have shown interest in pursuing CHP relationships with Liberty-Empire;

- Coal without CCS, given the difficulty permitting new coal plants and the current federal requirement (and the expectation for continued long-term federal restrictions on coal development over a long-term planning period) that new coal-fired electric generating units meet a CO_2 emission limit that would require some level of CCS;[1]
- Concrete block storage, given a lack of scalable technology and commercial applications that can meet the capacity requirements of energy storage. Liberty-Empire reviewed the Energy Vault storage system, which uses electric motors to lift 35-ton concrete blocks and stack them to form a tall tower. The stored passive energy is converted to electricity by dropping the stacked blocks one by one by a tether. Given the lack of commercial applications and the presence of significant technical and operational risks, Liberty-Empire does not believe that this technology is a viable option for the 2019 IRP. It should be noted that the performance of a single 35 MW demonstration tower in India should be available later in 2019. Once this demonstration installation is completed and has produced additional operating data, Liberty-Empire may be able to evaluate the feasibility of future applications.
- Lead acid batteries, given their shorter lifespans under high cycling conditions and higher maintenance costs compared with those of lithium-ion batteries. However, given the presence of local manufacturers for lead acid batteries in Missouri, Liberty-Empire will consider potential future applications if cost and operational parameters can be demonstrated to be comparable to the lithium-ion battery option that has mature technology and more transparent cost and operational data parameters available to use as assumptions.

[1] In December 2018, the EPA proposed a new rule for new source performance standards for coal-fired units that would raise the emission limit from 1,400 lb CO2/MWh to 1,900 lb CO2/MWh for large plants and 2,000 lb CO2/MWh for small plants. Given the uncertainty regarding this rule and the potential for additional revision under future administrations, Liberty-Empire's 2019 IRP does not assume that the proposed revisions will be maintained throughout the full planning period.

- Electric vehicle ("EV") charging infrastructure,[2] given lack of commercial applicability as a supply-side resource option and inability to consider this option as a firm, controllable capacity resource;
- 2 x 1 advanced class CC, given the large size of the option (~1,000 MW) and the inability to assume with confidence that Liberty-Empire would have access to a partial ownership interest in a new development in any proximity to its service territory.

[2] Liberty-Empire will continue to explore vehicle fleet electrification, which could provide substantial battery energy storage resources to the grid. However, given that such electricity is likely to be available only during the night and parts of the day, this type of effort would not develop a reliable capacity resource.

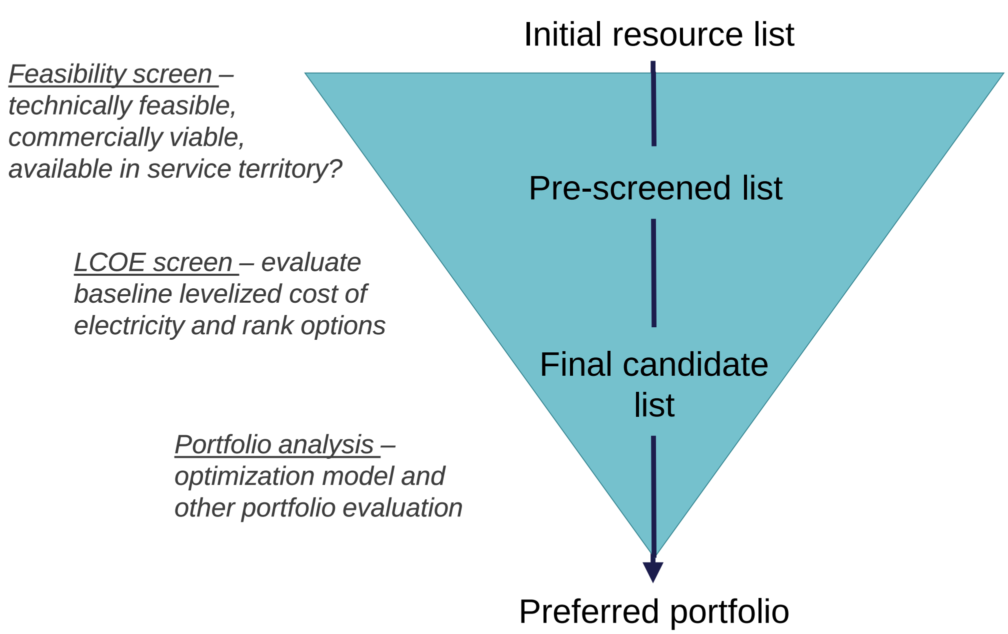
SECTION 2 ANALYSIS OF POTENTIAL SUPPLY-SIDE RESOURCE OPTIONS

(2) 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 Screening of Potential Options

Liberty-Empire performed two rounds of preliminary screening to determine a shortlist of supply-side candidate resource options prior to the full portfolio analysis. The first screening evaluated feasibility of the resource option within Liberty-Empire's service territory or surrounding SPP region (described in Section 1.8), and the second screening compared the levelized cost of electricity ("LCOE") associated with installed capital costs plus fixed and variable operation and maintenance costs for the potential resource options using the utility's discount rate. The screening process is illustrated in Figure 4-3.

Figure 4-3 – Supply-Side Resource Screening Approach



2.2 Cost Ranking Screening – LCOE Analysis for Utility Scale Resources

(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.

After the identification of potential supply-side resource options, Liberty-Empire developed planning-level cost estimates for the remaining technology options for the levelized cost screen. These estimates were developed using a market scan approach for cost and operational parameters, with review and input by Black and Veatch professionals. The market scan approach involved research into available and up-to-date market data points from public sources, other utility IRP filings and Requests for Proposals, proprietary subscription data sources, and Liberty-Empire's internal view based on recent project experience within Liberty-Empire and within Liberty Utilities. The scan developed current cost estimates for the technologies as well as projections for cost changes over time. Costs and analysis descriptors of the potential supply-side resource options are presented in Table 4-3.

The cost estimates presented in the table reflect all-in costs for the relevant resource option, including costs of engineering, procurement, and construction ("EPC"); land; base interconnects; owner's costs; and contingency costs. The average expected capacity factors for non-dispatchable renewable resources are based on expectations for renewable availability in the region, while the capacity factors for other resources are based on initial screening-level dispatch analysis in the SPP market. The fuller portfolio analysis includes hourly dispatch of all options.

Table 4-3 - Costs and Analysis Descriptors of Potential Supply-Side Resource Options

	Super-critical Coal	Coal IGCC	Combustion Turbine		Combined Cycle	Nuclear	
	With CCS	With CCS	Aero-derivative	F-Class Frame-Type CT	Conven-tional	Traditional	Small Modular
Size (MW)	650	650	50	250	650	1,100	160
Full Load Net Heat Rate, Btu/kWh	10,208	11,677	9,200	9,888	6,637	10,455	10,130
2019 Capital Cost, $/kW (2018 $)	5,670	7,962	1,229	803	1,086	7,773	N/A
2024 Capital Cost, $/kW (2018 $)	5,670	7,962	1,213	792	1,067	7,773	5,125
2029 Capital Cost, $/kW (2018 $)	5,670	7,962	1,178	769	1,040	7,773	5,125
Fixed O&M, $/kW-year (2018 $)	56.12	79.49	20.50	10.29	10.54	114.90	114.90
Ongoing Capex, $/kW-year (2018 $)	21.53	21.53	3.08	3.08	3.08	49.20	49.20
Variable O&M, $/MWh (2018 $)	8.07	9.33	9.62	9.62	1.74	1.57	1.57
Avg. Expected Capacity Factor (%)*	70%	70%	7.4%	4.8%	43%	90%	85%

	Reciprocating Engines			Landfill Gas	Biomass	Wind	Molten Salt Storage
	Large Size (Gas-fired)	Mid-Size (Gas-fired)	Distributed (Gas-fired)				
Size (MW)	216	108	2	5	50	100	50-140
Full Load Net Heat Rate, Btu/kWh	8,381	8,381	9,700	10,130	13,250	N/A	35% Efficiency
2019 Capital Cost, $/kW (2018 $)	1,170	1,322	1,021	3,218	5,070	1,662	947
2024 Capital Cost, $/kW (2018 $)	1,155	1,304	1,008	3,218	5,070	1,582	947
2029 Capital Cost, $/kW (2018 $)	1,122	1,267	979	3,218	5,070	1,515	947
Fixed O&M, $/kW-year (2018 $)	13.07	17.20	7.18	87.13	83.10	38.34	61.50
Ongoing Capex, $/kW-year (2018 $)	3.08	3.08	In FOM	In FOM	In FOM	11.35	In FOM
Variable O&M, $/MWh (2018 $)	7.12	7.12	30.75	24.60	7.98	0.0	0.0
Avg. Expected Capacity Factor (%)*	12.4%	12.4%	12.4%	85%	80%	47.4%	N/A

	Solar PV			Lithium Ion Storage (4-hour duration)		Solar PV + Storage (4:1 solar to storage ratio)	
	Fixed Tilt	Single Axis Tracking	Single Axis Tracking Distributed	Utility-Scale	Distributed	Utility Scale	Distributed
Size (MW)	50	50	5	25	5	50	5
Full Load Net Heat Rate, Btu/kWh	N/A	N/A	N/A	87.5% Efficiency	87.5% Efficiency	N/A	N/A
2019 Capital Cost, $/kW (2018 $)	1,189	1,324	1,426	1,847	1,945	1,431	1,603
2024 Capital Cost, $/kW (2018 $)	947	1,055	1,156	1,436	1,513	1,133	1,279
2029 Capital Cost, $/kW (2018 $)	830	925	1,027	1,185	1,249	979	1,105
Fixed O&M, $/kW-year (2018 $)	10.25	10.25	10.25	34.42	34.42	15.08	18.31
Ongoing Capex, $/kW-year (2018 $)	0.0	0.0	0.0	25.35	25.35	5.07	8.45
Variable O&M, $/MWh (2018 $)	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Avg. Expected Capacity Factor (%)*	20.2%	23.1%	23.1%	N/A	N/A	22.3%	22.3%

*Note that expected capacity factors for non-dispatchable resources are based on Liberty-Empire's assessment of expected capacity factors in its service territory, while capacity factors for dispatchable resources are based on a preliminary dispatch analysis conducted using base case market price inputs. These capacity factors are expectations for *energy* production and are not the same as credit for *capacity*.

When evaluating the LCOE, which is the net present value of the unit-cost of electricity over the lifetime of the generating resource, Liberty-Empire accounted for all capital costs, FOM, ongoing capex, VOM, fuel, and emission costs for all resource options. Capacity factor estimates were developed through screening-level dispatch analysis for each option. Liberty-Empire accounted for potential tax benefits for renewable and storage resources associated with the federal production tax credit ("PTC"), the federal investment tax credit ("ITC"), and accelerated depreciation rules. The PTC provides a credit of $24/MWh (in 2018$, which is indexed to inflation), while the ITC provides a credit as a fraction of the total cost of construction for the resource. Generally, wind resources are expected to take advantage of the PTC due to their high capacity factors, while solar resources take the ITC. Tax incentives are currently being phased out. Equipment must be safe-harbored by a certain date and the project must enter into service by a later date to qualify for the credits. The safe-harbor entails investment of at least 5 percent of the total project cost. Table 4-4 summarizes the phase-out schedule for the PTC and ITC.

Table 4-4 – PTC and ITC Phase-out Schedule

Year for Safe Harbored Equipment	Last Year to be Placed in Service for PTC	Wind PTC (%)	Last Year to be Placed in Service for ITC	ITC Rate (%)
2016	2020	100%	2020	30%
2017	2021	80%	2021	30%
2018	2022	60%	2022	30%
2019	2023	40%	2023	30%
2020	N/A	0%	2023	26%
2021	N/A	0%	2023	22%
2022	N/A	0%	2024	10%

Note: Wind resources can qualify for the 10% ITC after PTC expiry.

Renewable resources are also able to take advantage of accelerated depreciation for tax purposes. Nuclear and fossil-fired resources can generally be depreciated for tax purposes on 20- or 15-year schedules, while renewables and storage resources can take advantage of 7- or 5-

year schedules. These are summarized in Table 4-5, along with the book life depreciation schedules for all resource options.

Table 4-5 – Depreciation and Tax Life Assumptions

Technology	Tax Life	Book Life
Gas CC	20	30
Gas CT	15	30
Solar PV	5	30
Onshore Wind	5	30
Battery*	7	30
Coal (including IGCC)	20	40
Nuclear	15	40
Biomass	7	30
Wartsila/Reciprocating Engine	15	30
Landfill Gas	5	30

*Battery paired with solar is eligible for 5-year MACRs.

Note: Battery life assumed to be extended by one complete refurbishment/replacement of cells. These costs are included in ongoing capex assumptions.

The LCOE analysis incorporates the value of tax credits for renewable/storage technologies through the modeling of a hypothetical tax equity partnership between Liberty-Empire and a tax equity partner. Liberty-Empire has modeled the contribution that a tax equity partner would make to the total cost of a renewable project given the value of the tax credits (PTC for wind, ITC for solar/storage), accelerated MACRS tax depreciation, and an internal rate of return ("IRR") of 7 percent for the tax equity partner. Liberty-Empire has modeled the effects of a tax equity partnership for each generic technology as applicable (wind, solar, solar/storage) and for each year with different tax credit values, given the current phase-out schedule. The tax equity modeling results in a percentage reduction in capital cost for Liberty-Empire and an "adder" to fixed O&M costs for each resource, representing the additional cash payments Liberty-Empire must make to the tax equity partner over the life of the partnership.

In addition to the capital costs (adjusted for potential tax equity contributions), FOM costs, and VOM costs outlined above, the LCOE is significantly influenced by expectations for the price of fuel and emissions over time. The base LCOE analysis does not include a CO2 price, although Liberty-Empire has summarized expected environmental costs in the event that one is introduced over the planning period in Section 2.5.4. The projected fuel costs over time are summarized in Table 4-6.

Table 4-6 – Fuel Projections used in LCOE Analysis ($/MMbtu Nominal)

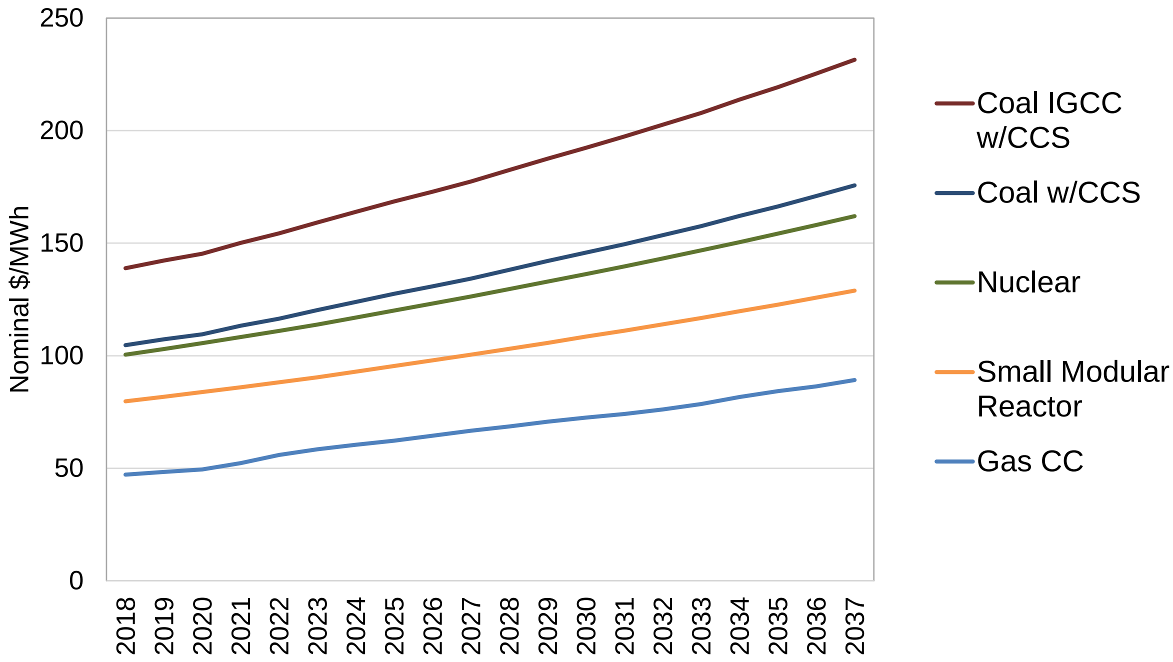
****Confidential in its Entirety****[3]

[redacted]

The outputs from the LCOE analysis over time have been summarized according to four major groupings for screening: non-renewable baseload/intermediate resource options, non-renewable peaking options, renewable resource options, and storage resources. Figure 4-4 summarizes the screening results for the non-renewable baseload/intermediate options in nominal dollars per MWh. This category includes conventional coal with CCS, coal IGCC with CCS, conventional nuclear, small modular reactor nuclear, and natural gas combined cycle. Each year represents the projected LCOE for a resource that would enter into service in that year. The natural gas combined cycle was the only option selected as a final candidate in the portfolio analysis.

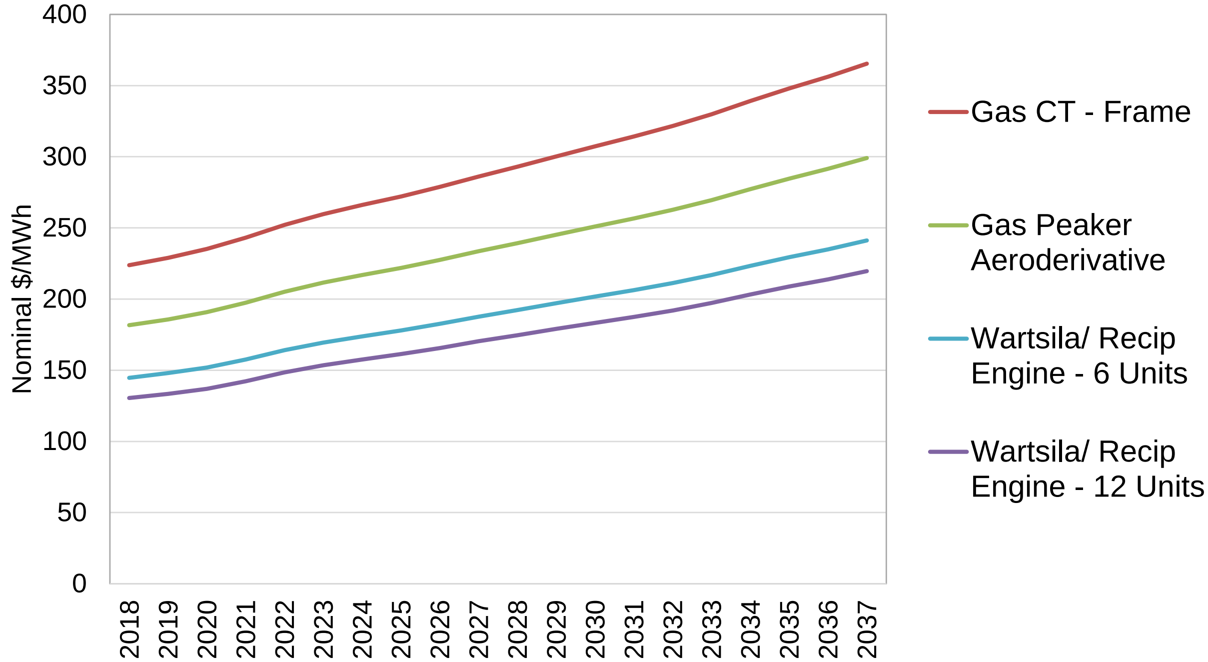
[3] 4 CSR 240-2.135(2)(A)1 allows information to be marked as confidential when it is reports, work papers, or other documentation related to work produced by internal or external auditors or consultants.

Figure 4-4 – LCOE Projections – Non-Renewable Baseload/Intermediate Resource Options



Non-renewable peaking resource options were evaluated separately from baseload and intermediate options since they can provide capacity with low upfront costs, even as their energy value is limited. Due to their low expected capacity factors (below 15%), the LCOE values of the peaking options tend to be higher than the baseload options, since fixed costs are spread across a lower number of megawatt hours. Figure 4-5 summarizes the screening results for the non-renewable peaking options in nominal dollars per MWh. Each year represents the projected LCOE for the resource that would enter into service in that year. Although the Wartsila reciprocating engine options have higher capital costs than the other peaker resources, their lower heat rates and higher capacity factors result in a lower LCOE. The aeroderivative resource option is also lower cost than the CT frame even though it has higher capital costs. Given lower LCOEs and the additional flexibility of aeroderivatives and reciprocating engines vs. frame machines (smaller and more modular sizes to fit with Liberty-Empire's load requirements and faster ramp rates that can take advantage of the growing intermittency in the SPP energy market), Liberty-Empire determined that the aeroderivatives and reciprocating engines are likely to provide higher value than frame machines. Therefore, the gas frame machines were not included as final candidates in the portfolio analysis.

Figure 4-5 – LCOE Projections – Non-Renewable Peaking Resource Options

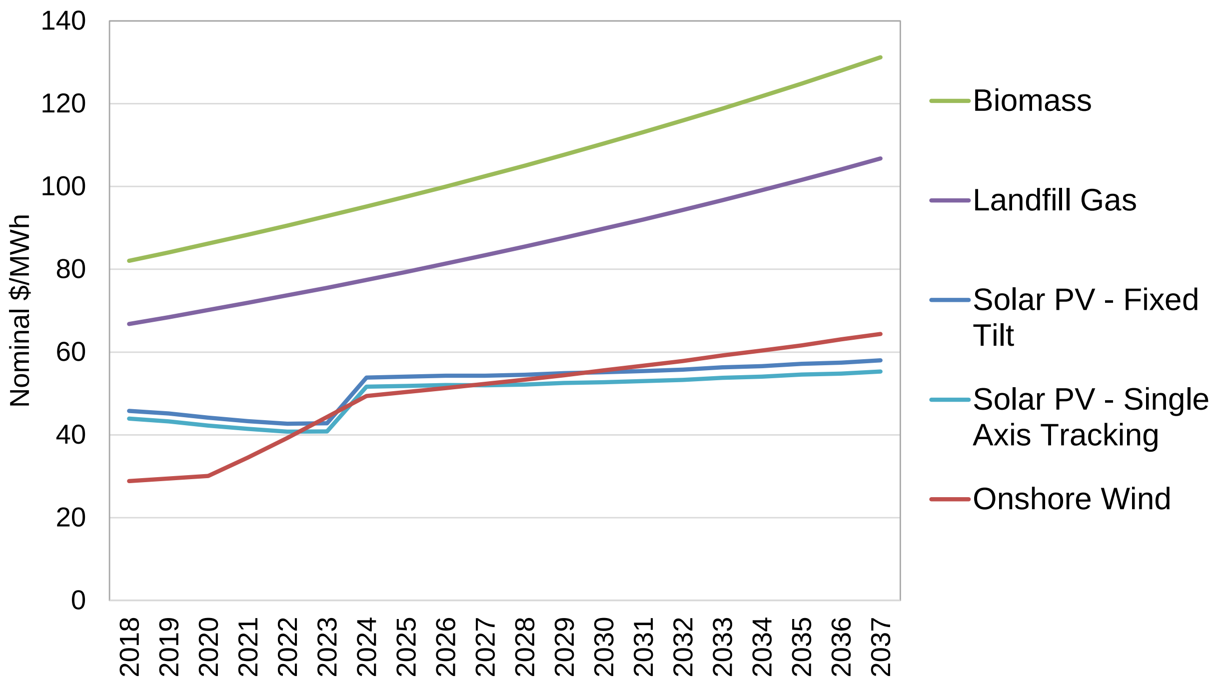


Renewable options were evaluated separately from the non-renewable resources. Figure 4-6 summarizes the screening results for the renewable options in nominal dollars per MWh. Each year represents the projected LCOE for the resource that would enter into service in that year. When tax incentives are incorporated for wind and solar resource options, these resources are the lowest cost options in the initial years of the planning period, with wind at a substantial cost advantage until the full expiration of the PTC in 2024. Over time, the expected costs of wind and solar increase in nominal terms due to the tax credit phase-outs, but wind and solar remain substantially lower cost than the other renewable options since their capital costs are expected to decline in real dollar terms, while the capital costs of other technologies are not.

The solar cost projections are close to wind costs over time and have more potential to decline in real dollar terms in future years based on the analysis of likely cost ranges over time (see discussion on Critical Uncertain Factors in Volume 6 and 7 for additional information). Furthermore, solar resources may offer more capacity value to Liberty-Empire than wind resources in the summer months, given their higher availability during summer days when the

SPP system realizes its system peak. Within the solar resource category, the small capital cost premium associated with single axis tracking is more than offset by the increase in expected capacity factor, which lowers its cost on an LCOE basis.

Figure 4-6 – LCOE Projections – Renewable Resource Options



2.3 Storage Resource Screening

Liberty-Empire believes that with observed rapid cost reductions and a growing availability of commercially viable options, storage is an important asset class to be considered as part of the 2019 IRP. Unlike conventional generation resources, however, storage resources do not provide net energy to the grid, but instead shift energy during a day or across a week. Hence, they cannot be appropriately evaluated in the traditional LCOE framework. In addition to energy shifting value, they also have the potential to provide capacity value and offer a host of ancillary services like frequency regulation and spinning reserves. As a result, Liberty-Empire has performed a "value stacking" exercise to evaluate the costs and comparative value of different storage options in providing benefits associated with capacity, day-ahead market energy arbitrage, real-time volatility value, and ancillary services value.

At this point in time, Liberty-Empire has not definitively eliminated any storage technologies from future consideration, since technologies are rapidly evolving and use cases are developing. However, for planning purposes in the 2019 IRP, Liberty-Empire has reviewed four distinct storage technologies (mechanical concrete block, lead acid battery, lithium ion battery, and molten salt) and identified two particular storage options with sufficient data to perform analysis, as discussed below.

Lithium-Ion Batteries

Lithium-ion batteries currently represent the industry standard option for utility scale storage technology, and they involve the transfer of lithium ions between electrodes during charging and discharging. There are variations in the exact chemistry of a lithium-ion battery. Generally, the cathode is made of lithiated metal oxides or phosphates and the anode is made of carbon or lithium titanate. The resulting electrodes are lightweight. Lithium is a highly reactive element, which means it can store a lot of energy in its atomic bonds and has high energy efficiency.

In the past few years, there has been a rapid build-out of lithium-ion manufacturing factories, including Tesla's Gigafactories, to meet the demand for batteries in EV applications, which are typically lithium-ion due to their light weight and high energy efficiency. Production costs have fallen significantly as a result of this increase in scale. Although lithium-ion batteries have a higher up-front cost than other alternatives like lead-acid batteries, they generally have important advantages over lead-acid batteries, primarily due to their superior volumetric energy density and gravimetric energy density, meaning that they are smaller and lighter. Lithium-ion batteries are also more resilient, and thus have longer life cycles and are less likely to be harmed if discharged too quickly or if extreme weather occurs.

Molten Salt Storage

Thermal energy storage with molten salt uses electrical energy collected from a renewable resource or from the grid, and stores the heat energy in a molten salt tank. It discharges electricity by converting the heat energy back into electrical energy through a steam generation system. Charging and discharging are carried out by separate systems which allow each to be independently sized to optimally meet their respective needs. For example, a large Rankine cycle and relatively small electric heaters allow the operator to charge over long-time periods and discharge over a shorter time window. The system uses cheap, readily available materials, such as salt, steel, and air.

Liberty-Empire has evaluated the feasibility of molten salt as the storage medium. It found that a thermal energy storage electric generation system could ramp from 15 MW to 140 MW in 12 minutes, providing a resource for load following and reserves. The cost of the thermal storage system itself is relatively inexpensive depending on the existing infrastructure that could be leveraged. However, preliminary feasibility testing found that molten salt storage combined with steam turbine technology would have a 35 percent round trip efficiency (based on steam turbine Rankine cycle efficiency), which is significantly lower than the typical 85 to 90 percent efficiency value of a lithium-ion battery.

In order to quantitatively assess the comparative costs and benefits of these two options, Liberty-Empire defined a charge duration parameter and a round trip efficiency parameter for each viable storage resource, along with additional parameters associated with charging and discharging time and the depth of discharge that is feasible. These preliminary planning-level estimates, which are subject to change upon further technical analysis and potential refinement during a project-specific assessment, are summarized in Table 4-7.

Table 4-7 – Preliminary Storage Parameter Details

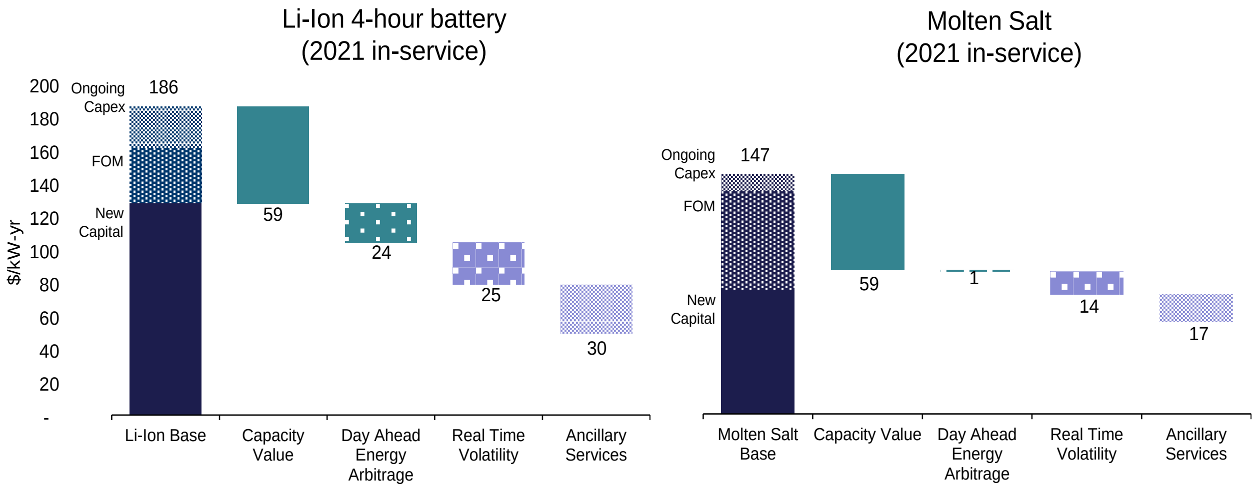
Parameter	Lithium Ion	Molten Salt
FOM ($/kW-yr)	33.6	60
Ongoing capex ($/kW-yr)	24.7	10.5
Round trip efficiency (%)	87.5%	35%
Storage duration (Hours)	4	5
Charge time (Hours)	4	15
Discharge time (Hours)	4	5
Depth of discharge (%)	85%	100%

Based on these operating parameters, Liberty-Empire performed an analysis of the levelized costs of the two potential storage resources and the levelized potential value that the resource could offer over a long-term planning period in the following categories:

- Capacity value, based on the avoided cost of capacity over time calculated by Liberty-Empire;
- A day-ahead energy arbitrage value, based on the expected hourly energy arbitrage value that the storage resource could realize in the SPP market in Liberty-Empire's base case power price forecast;
- The real-time volatility value that could be realized by the storage resources, based on a historical analysis of 5-minute interval data;
- Ancillary services value, based on potential SPP market revenues in the spinning reserve, regulation up, and regulation down markets.

The various cost and value components of each technology is summarized in Figure 4-7.

Figure 4-7 – Storage Screening Results for Li-Ion and Molten Salt



Overall, based on this screening analysis, Liberty-Empire found that the higher levels of flexibility and efficiency associated with lithium ion batteries offer significant value opportunities across multiple SPP markets, with additional long-term value potential associated with expected capital cost declines and expected growth of intermittent resource capacity in the market. While the screening analysis does indicate that other technologies may also be competitive depending on specific cost assumptions and operational parameters, Liberty-Empire has determined that lithium ion battery technology is the appropriate benchmark for all storage options in the IRP. As noted above, this conclusion will not preclude Liberty-Empire from further evaluation of emerging storage technologies as markets evolve and as potential use cases are further identified.

2.4 Screening – Distributed Resource Value

Distributed resource options for solar and battery storage have generally been found to be at a cost premium of about 12 to 14 percent to their utility scale counterparts, with a distributed reciprocating engine option being comparable or even lower cost than the utility scale alternative, albeit with a more expensive fuel source. Given the relatively similar fixed cost structure, Liberty-Empire has determined that it is not appropriate to eliminate the feasible distributed resource options through an LCOE approach, since they can also provide benefits to the system associated with avoided distribution-level expenditures. Therefore, the distributed resource options for solar, battery storage, and reciprocating engines have been preserved as candidate resource options.

2.5 Probable Environmental Costs of Potential Supply-Side Resource Options

(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.

Liberty-Empire is subject to various federal, state, and local laws and regulations with respect to air and water quality and with respect to hazardous and toxic materials and hazardous and other wastes including their identification, transportation, disposal, record-keeping, and reporting as well as remediation of contaminated sites and other environmental matters. Liberty-Empire operates its generating facilities in compliance with environmental laws and regulations.

Environmental laws or regulations that may be imposed at some point within the planning period 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. While Liberty-Empire is not in a position to accurately estimate compliance costs for any new requirements, it expects any such costs to be material, although recoverable in rates.

2.5.1 Air Emission Impacts

2.5.1.1 National Ambient Air Quality Standards

The Clean Air Act ("CAA") requires the EPA to set National Ambient Air Quality Standards ("NAAQS") for four air pollutants associated with fossil-fuel generation, including particulate matter, ground-level ozone, sulfur dioxide (SO_2), and nitrogen dioxides (NO_X). These air pollutants are regulated by setting human health-based or environmentally-based criteria for permissible levels. The EPA is reviewing the current 2015 ozone NAAQS to evaluate whether to reconsider, modify or maintain the standards by the required five-year deadline (October 2020).

2.5.1.2 Particulate Matter

In 2013, the EPA strengthened the PM standard. The Jasper County 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 Jasper County 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.

2.5.1.3 Ozone

In 2015, the EPA strengthened the NAAQS for ground-level ozone. The Jasper County 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.

2.5.1.4 Sulfur Dioxide

In 2010, the EPA strengthened the NAAQS for SO_2. The Jasper County area is currently in attainment of the 2010 SO_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 SO_2 reduction technologies, emission limits or both on fossil-fueled units.

2.5.1.5 Nitrogen Dioxides

In 2010, the EPA strengthened the NAAQS for NO_X. The Jasper County area is currently in attainment of the 2010 NO_X 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.

2.5.1.6 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_X, 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.

2.5.1.7 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 ("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.

Future visibility progress goals could result in additional SO_2, NO_X, and PM controls or reduction technologies on fossil-fired units.

2.5.1.8 Affordable Clean Energy Rule

In December 2017, the EPA issued an advance notice of proposed rulemaking ("ANPRM") in which the agency proposed emission guidelines to limit greenhouse gas ("GHG") emissions from existing EGUs and solicited 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 did not propose any regulatory requirements.

As a result of this ANPRM, on August 21, 2018, the EPA proposed the Affordable Clean Energy ("ACE") rule which would establish emission guidelines for states to develop plans to address GHG emissions from existing coal-fired power plants. The ACE rule replaces the 2015 Clean Power Plan, which the EPA has proposed to repeal because it exceeded EPA's authority. The Clean Power Plan was stayed by the U.S. Supreme Court and has never gone into effect.

The ACE rule has several components: a determination of the best system of emission reduction for greenhouse gas emissions from coal-fired power plants, a list of "candidate technologies" states can use when developing their plans, a new preliminary applicability test for determining whether a physical or operational change made to a power plant may be a "major modification" triggering New Source Review, and new implementing regulations for emission guidelines under Clean Air Act section 111(d). Until the litigation and rulemaking regarding the CPP and ACE is resolved, it is difficult to determine the impact but could mean the addition of emission reduction technologies, reduced generation, alternate generation, or demand reduction technologies.

2.5.1.9 Mercury and Air Toxics Standards

In 2011, the EPA finalized a rule to reduce emissions of toxic air pollutants from power plants. These MATS for power plants reduced emissions from new and existing coal and oil-fired electric EGUs. Control equipment was installed at Liberty-Empire facilities 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.

2.5.2 Water Related Impacts

Liberty-Empire operates under the Kansas and Missouri Water Pollution Plans that were implemented in response to the Federal Clean Water Act ("CWA"). Liberty-Empire operates its generation facilities in compliance with applicable regulations, and all facilities have received necessary discharge permits.

2.5.2.1 Clean Water Act Section 316(b)

On September 17, 2018, the Kansas Department of Health and Environment ("KDHE") issued a Certificate of Determination stating that the Riverton Generating Station cooling water intake structure ("CWIS") is in compliance with Section 316(b) of the CWA. The location, design, construction and capacity of the CWIS reflects the best technology available ("BTA") for minimizing adverse environmental impacts. Additionally, Iatan 2 and Plum Point Unit 1 also meet the BTA standard. Future modifications at the Iatan 1 facility could range from flow velocity reductions, traveling screen modifications, or the installation of a closed cycle cooling tower retrofit.

2.5.2.2 Surface Impoundments

Liberty-Empire owns and maintains a coal ash impoundment at the Asbury Power Plant. Additionally, Liberty-Empire owns a 12 percent interest in a coal ash impoundment at the Iatan Generating Station and a 7.52 percent interest in a coal ash impoundment at Plum Point. Future closure of all surface impoundments is anticipated.

Effluent Limitation Guidelines ("ELGs") for Steam Electrical Power Generating Point Sources are currently incorporated into all facilities' wastewater discharge permits. The EPA rule defines bottom ash transport water, fly ash transport water, and scrubber wastes as wastewaters which cannot be discharged after December 21, 2023.

2.5.3 Coal Combustion Residuals

In compliance with the EPA published final rule to regulate the disposal of coal combustion residuals ("CCRs") as a non-hazardous solid waste under subtitle D of the Resource Conservation and Recovery Act, Liberty-Empire has published a Closure Plan for the Asbury Plant CCR Impoundment. The plan schedule assumes Closure Initiation in November 2020 with completion of closure by October 2025. Liberty-Empire will need to construct at least one cell of a new landfill and complete the conversion of the existing bottom ash handling from a wet to a dry system at a potential cost of up to $3 million and $17 million, respectively, if Asbury continues to operate. The closure cost of the existing impoundment is estimated at $15 million.

Liberty-Empire has posted a $5.5 million asset retirement obligation ("ARO") for the Asbury pond closure costs. Liberty-Empire expects resulting costs to be recoverable in rates. Final closure of the other existing ash impoundment, for which an asset retirement obligation of $4.4 million has been recorded for Liberty-Empire's interest in the coal ash impoundment at the Iatan Generating Station, has been accounted for in Liberty-Empire's ARO. In December 2016, The Missouri Department of Natural Resources ("MDNR") granted Liberty-Empire a Utility Waste Disposal Area Construction Permit that can be used for CCR waste disposal. Construction of the landfill is not expected in the immediate future, as Liberty-Empire anticipates that the existing Asbury impoundment will be closed by leaving all accumulated CCR in place.

In 2014, the former Riverton Plant impoundment was closed as a CCR landfill in accordance with Kansas Department of Health and Environment regulations.

2.5.4 Assigning Environmental Probabilities

Liberty-Empire has evaluated the probable environmental costs of new supply side resource options associated with potential carbon prices and other emission costs associated with NO_X and SO_2. Based on Liberty-Empire's critical uncertain factor probability weighting, the base carbon price of $0/ton is given a 50 percent probability, with the high price (shown in Figure 4-17) also given a 50 percent probability. Future NO_X and SO_2 costs are assumed across all scenarios. Table 4-8 presents the levelized environmental cost expectations over the full twenty-year planning period.

Table 4-8 – Probable Environmental Costs

Technology	Levelized Probable Environmental Costs – Emissions-based ($/MWh)
Super-critical Coal w/ CCS	0.86
Coal IGCC w/ CCS	0.98
Conventional Coal	8.57
CT - Aero	4.49
CT - Frame	4.82
Combined Cycle	3.24
Nuclear	0.00
Small Modular Nuclear	0.00
Reciprocating Engine - Large	4.09
Reciprocating Engine - Medium	4.09
Reciprocating Engine - Distributed	4.73
Landfill Gas	0.00
Biomass	0.00
Wind	0.00
Molten Salt Storage	0.00
Solar PV - Fixed Tilt	0.00
Solar PV - Single Axis Tracking	0.00
Single Axis Tracking - Distributed	0.00
Lithium Ion Storage - Utility	0.00
Lithium Ion Storage - Distributed	0.00
Solar PV + Storage - Utility	0.00
Solar PV + Storage - Distributed	0.00

2.6 Selection of 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.

Based on the LCOE and storage screening analyses described above, Liberty-Empire identified the list of technologies presented below as preliminary supply-side candidate resource options. A description of the rationale for elimination of other potential technology options is provided in Section 2.6.3.

- Natural gas-fired simple cycle Aeroderivative CT
- Natural gas-fired CC – 2 x 1 F Class
- Natural gas-fired reciprocating engines*
- New on-shore wind
- Solar photovoltaic (PV)* – single axis tracking, with and without storage
- Energy storage – lithium ion battery*

*Denotes a resource option evaluated as both a distributed and utility scale energy resource.

2.6.1 Preliminary Supply-Side Candidate Options

2.6.1.1 Simple Cycle Technologies

A simple cycle gas turbine ("SCGT") plant utilizes natural gas to produce power in a gas turbine generator. Gas turbine manufacturers continue to develop high temperature materials and cooling techniques to allow higher firing temperatures of the turbines, resulting in increased efficiency. Typically, SCGTs are used for peaking power due to their fast load ramp rates and relatively low capital costs. Typical simple cycle plants operate with natural gas as the operating fuel. Often, the ability to operate on fuel oil is also required in case the demand for power exists when the natural gas supply does not.

Frame turbines are industrial turbines designed specifically for land-based power generation or mechanical drive applications that are typically used in intermediate to baseload applications. In simple cycle configurations, these engines typically have higher heat rates when compared to aeroderivative engines. As a result, frame turbines have been screened out of the integration phase due to a higher LCOE and less flexibility to offer Liberty-Empire in terms of modular sizing and fast ramping capabilities.

Aeroderivative turbines are considered mature technology and have been used in power generation applications for decades. These machines are commercially available from several vendors, including General Electric ("GE"), Siemens, and Mitsubishi-owned PW Power Systems. The aeroderivative combustion turbines assumptions are summarized in Table 4-9.

Table 4-9 – Combustion Turbine Aeroderivative Performance Parameters

Parameter	Aeroderivative CT
Earliest Feasible Year of Installation	2022
Lead Time in Years (includes development and construction)	2.0
Equivalent Forced Outage Rate	2.5%
Scheduled Outage Days per Year	9
ISO Net Output, Full Load MW	50
Full Load Net Heat Rate, Btu/kWh	9,200
Minimum Load Net Heat Rate, Btu/kWh	12,100
Capital cost, 2019 $/kW (2018 $)	1,229
Capital cost, 2024 $/kW (2018 $)	1,213
Capital cost, 2029 $/kW (2018 $)	1,178
Capital cost, 2034 $/kW (2018 $)	1,155
Fixed O&M, $/kW-year (2018 $)	20.50
Variable O&M, $/MWh (2018 $)	9.62
Ongoing capex, $/kW-year (2018 $)	3.08
CO_2 Emissions, lbs./MMBtu (HHV)	119

2.6.1.2 Combined Cycle Technologies

The basic principle of the Combined Cycle Gas Turbine ("CCGT") plant is to utilize natural gas to produce power in a gas turbine which can be converted to electric power by a coupled generator, and to also use the hot exhaust gases from the gas turbine to produce steam in a HRSG. This steam is then used to drive a steam turbine and generator to produce electric power. Additionally, natural gas can be fired in the HRSG to produce additional steam and associated output for peaking load, a process commonly referred to as duct firing.

The use of both gas and steam turbine cycles (Brayton and Rankine) in a single plant to produce electricity results in high conversion efficiencies. Combined cycle facilities have heat rates that have in recent history been in the 7,000 Btu/kWh range, with newer technologies achieving heat rates closer to 6,500 Btu/kWh. In this IRP, a greenfield 2 x 1 F-class CC option has made the candidate resource option list. Its parameters are summarized in Table 4-10.

Table 4-10 – Combined Cycle Performance Parameters

Parameter	Combined Cycle Gas Turbine
Earliest Feasible Year of Installation	2023
Lead Time in Years (includes development and construction)	3.0
Equivalent Forced Outage Rate	2.5%
Scheduled Outage Days per Year	9
ISO Net Output, Full Load MW	650*
Full Load Net Heat Rate, Btu/kWh	6,637
Minimum Load Net Heat Rate, Btu/kWh	7,300
Capital cost, 2019 $/kW (2018 $)	1,086
Capital cost, 2024 $/kW (2018 $)	1,067
Capital cost, 2029 $/kW (2018 $)	1,040
Capital cost, 2034 $/kW (2018 $)	1,021
Fixed O&M, $/kW-year (2018 $)	10.54
Variable O&M, $/MWh (2018 $)	1.74
Ongoing capex, $/kW-year (2018 $)	3.08
CO_2 Emissions, lbs./MMBtu (HHV)	119

*Note that the IRP analysis assumes that Liberty-Empire will have access to 200 MW block sizes.

2.6.1.3 Reciprocating Engine Technologies

The reciprocating, or piston, engine operates on the four-stroke Otto cycle for the conversion of pressure into rotational energy. Many different vendors offer reciprocating engines, and they are becoming more popular with their quick start times and operational flexibility. There are slight differences between manufacturers in engine sizes and other characteristics, but all largely share the common characteristics of quick ramp rates and quick start up.

The Wartsila 18V50SG (natural gas-fired) reciprocating engine was evaluated in this assessment as a potential candidate in blocks of twelve, six, or three engines. In addition to these utility scale estimates, a distributed resource option as a single 2 MW engine is also included. The parameters of all reciprocating engine options on the candidate resource option list are summarized in Table 4-11.

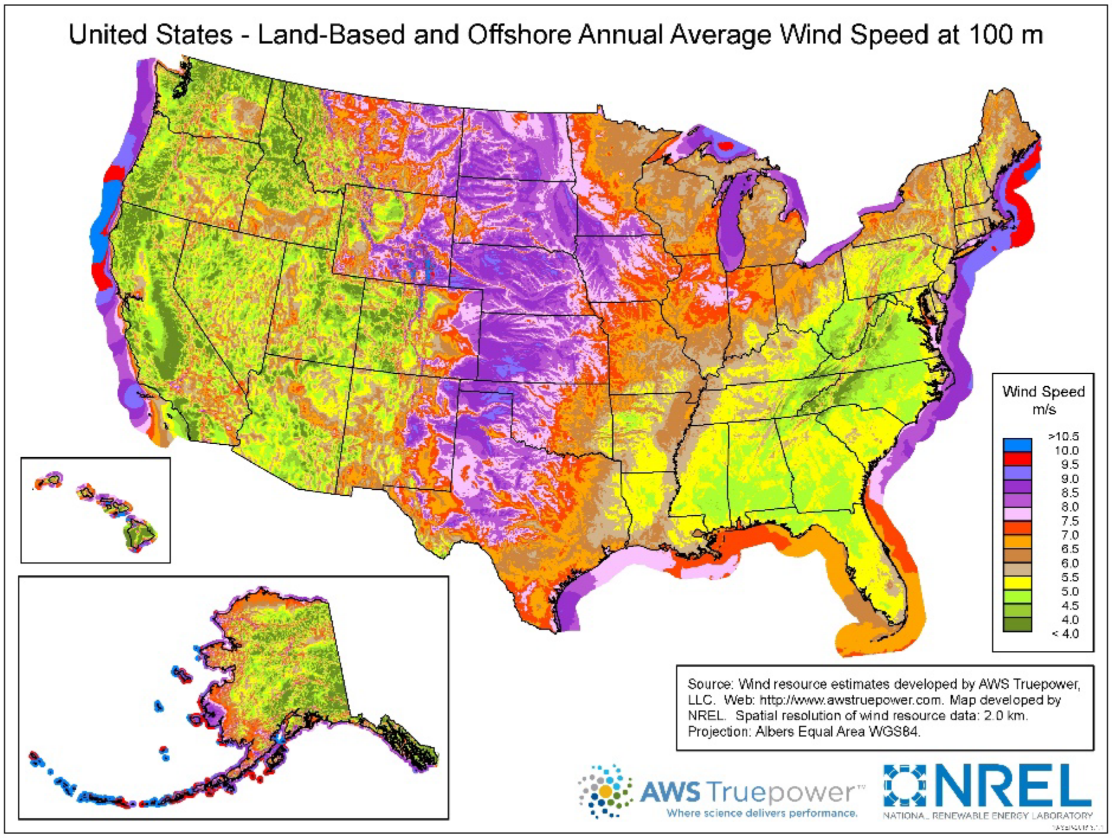
Table 4-11 – Reciprocating Engine Performance Parameters

Parameter	Reciprocating Engines – Large Size (12 Engines)	Reciprocating Engines – Mid Size (6 Engines)	Reciprocating Engines – Distributed Size
Earliest Feasible Year of Installation	2022	2022	2022
Lead Time in Years (includes development and construction)	3.0	3.0	3.0
Equivalent Forced Outage Rate	2.5%	2.5%	2.5%
Scheduled Outage Days per Year	9	9	9
ISO Net Output, Full Load MW	216	108	2
Full Load Net Heat Rate, Btu/kWh	8,381	8,381	9,700
Minimum Load Net Heat Rate, Btu/kWh	11,462	11,462	12,400
Capital cost, 2019 $/kW (2018 $)	1,170	1,322	1,021
Capital cost, 2024 $/kW (2018 $)	1,155	1,304	1,008
Capital cost, 2029 $/kW (2018 $)	1,122	1,267	979
Capital cost, 2034 $/kW (2018 $)	1,100	1,243	960
Fixed O&M, $/kW-year (2018 $)	13.07	17.20	7.18
Variable O&M, $/MWh (2018 $)	7.12	7.12	30.75
Ongoing capex, $/kW-year (2018 $)	3.08	3.08	In FOM
CO_2 Emissions, lbs./MMBtu (HHV)	119	119	119

2.6.1.4 Wind

Wind energy systems use the kinetic energy from wind to spin a large turbine blade, which spins an electromagnetic generator shaft to produce electricity. The power output from a wind turbine depends largely on the speed of the wind and how often it blows. The SPP region has some of the strongest winds in the U.S., as shown in Figure 4-8, making it an optimal region to deploy wind energy systems.

Figure 4-8 – Wind Speeds across the U.S. (Source: NREL)



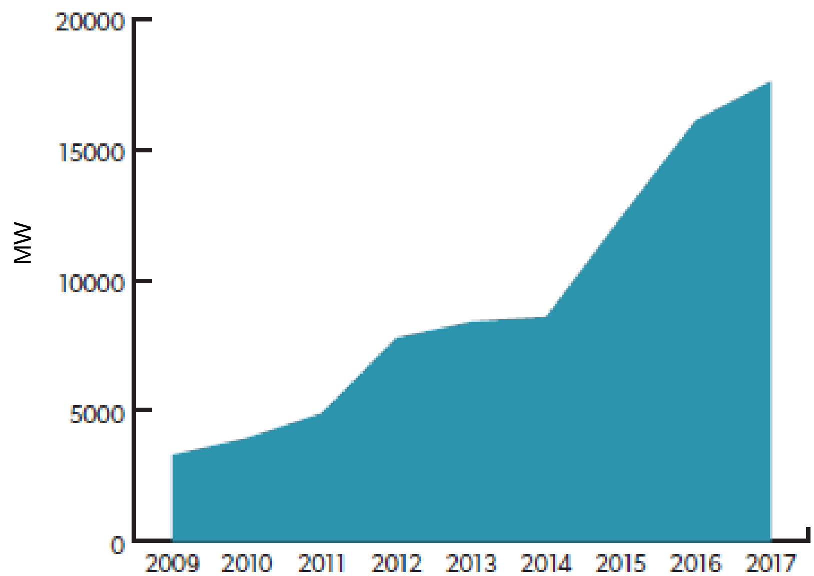
SPP has a relatively large number of wind energy systems. Between January 7, 2018 and January 7, 2019, wind generation accounted for 23.63% of total generation throughout the year in SPP. In February 2017, SPP became the first RTO in the U.S. to serve more than 50% of its load at a given time with wind energy. At 13:40 GMT on December 20, 2018, SPP surpassed another record with wind cresting at 16,382 MW.

The past decade has seen a rapid deployment of wind systems in the region. In 2009, wind energy systems had a combined total capacity of 3,400 MW, which had more than quadrupled to 17,596 MW by the end of 2017, as displayed in Figure 4-9.[4] In 2017, wind rose to second only to coal in terms of energy production and third in terms of generating capacity, behind coal and gas. SPP

[4] Southwest Power Pool (SPP). SPP Annual Report 2017. 2018. https://spp.org/documents/56849/2017%20annual%20report%20-%20printv3.pdf.

credits its successful and rapid deployment of wind to the region's high wind speeds, consolidated balancing authority responsibilities, and a robust transmission system. Generally, wind energy systems have become a more competitive resource nation-wide due to improvements in system designs such as larger rotor diameters, higher turbine heights, more aerodynamic designs, permanent-magnet direct-drive drivetrains, and stronger lighter-weight materials, as well as decreases in system component costs.

Figure 4-9 – SPP Installed Wind Capacity 2009-2017 (Source: SPP)



In 2017 and 2018, Liberty-Empire's Generation Fleet Savings Analysis and Customer Savings Plan demonstrated that wind resources offer a low-cost energy resource, especially when incorporating the benefits of federal tax credits, which are being phased out in the near-term. Cost and performance estimates for the wind option in the 2019 IRP are shown in Table 4-12. Note that all cost estimates are provided prior to consideration of federal tax credits and their potential impact on Liberty-Empire's capital cost contribution if a tax equity partner is utilized. The details of federal tax incentives and the tax equity partner modeling assumptions included in the 2019 IRP analysis are summarized in Section 2.

Table 4-12 – Wind Performance Parameters

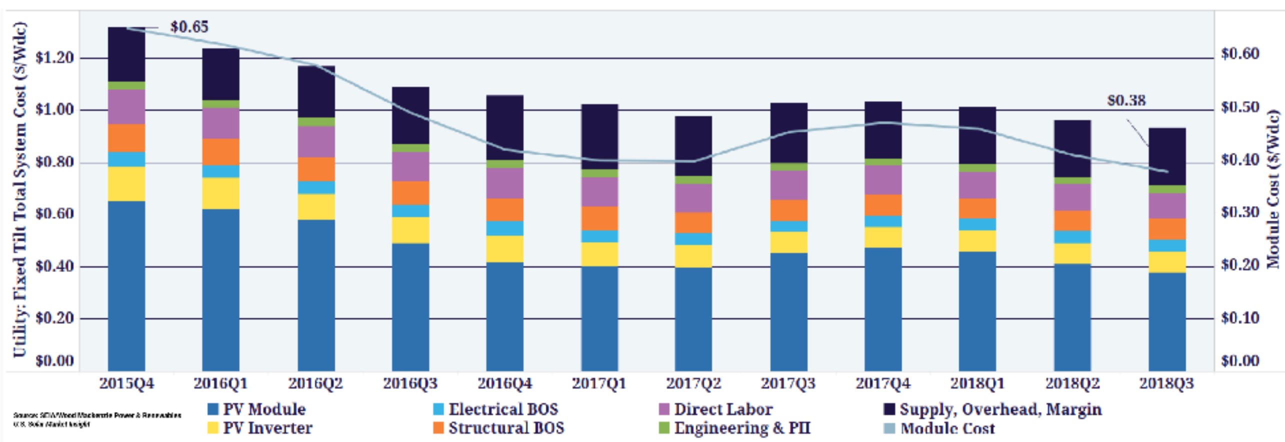
Parameter	Wind
Earliest Feasible Year of Installation	2021
Lead Time in Years (includes development and construction)	2.5
ISO Net Output, Full Load MW	100
Typical Capacity Factor	47.4%
Capacity Credit towards Peak	15% summer, 30% winter
Capital cost, 2019 $/kW (2018 $)	1,662
Capital cost, 2024 $/kW (2018 $)	1,582
Capital cost, 2029 $/kW (2018 $)	1,515
Capital cost, 2034 $/kW (2018 $)	1,470
Fixed O&M, $/kW-year (2018 $)	38.34
Ongoing capex, $/kW-year (2018 $)	11.35

2.6.1.5 Solar

Solar energy is converted into electricity through the use of solar panels, which are made up of PV cells. Today, the majority of PV cells are made from either crystalline silicon or thin-film semiconductor material. Silicon cells tend to convert sunlight to electricity more efficiently but are more costly to manufacture. Thin-film materials are less costly to manufacture, but also less efficient. Some PV systems use a tracking system that orients the panels towards the sun to capture more solar radiation throughout the day. The downside of trackers is that they require systems to have less-dense configurations and cost more to install and maintain over their lifetime. Thus, for a tracker to make economic sense, the net gains from increased electricity production must exceed the added installation and maintenance cost net of tax credits. Liberty-Empire has also found this to be the case in its screening analysis. PV systems are also increasingly including battery storage to compensate for the intermittent nature of solar energy, taking advantage of declining prices for storage technologies, the ITC benefit, existing interconnection, and to store direct current electricity not from the grid.

Over the past decade the cost of developing PV systems has dropped substantially with the improvement of technology, new materials, and lower installation costs. That being said, uncertainty surrounding the Section 210 solar tariff caused a brief spike in prices starting in the third quarter of 2017. Since the imposition of the 30% tariff in February of 2018, module prices have begun to fall again due to renewed market certainty following the lower-than-expected tariff imposition and a surplus in global module production caused by reductions in Chinese demand. The changes in prices impact utility scale systems the most, as modules typically constitute 40 to 50% of their total system costs. Historical PV module cost (line and right hand-side axis) and total fixed tilt system cost in dollars per Watt-DC (stacked bars and left hand-side axis) are shown in Figure 4-10. Liberty-Empire expects costs to continue to decline, as presented in the capital cost tables earlier in this section.

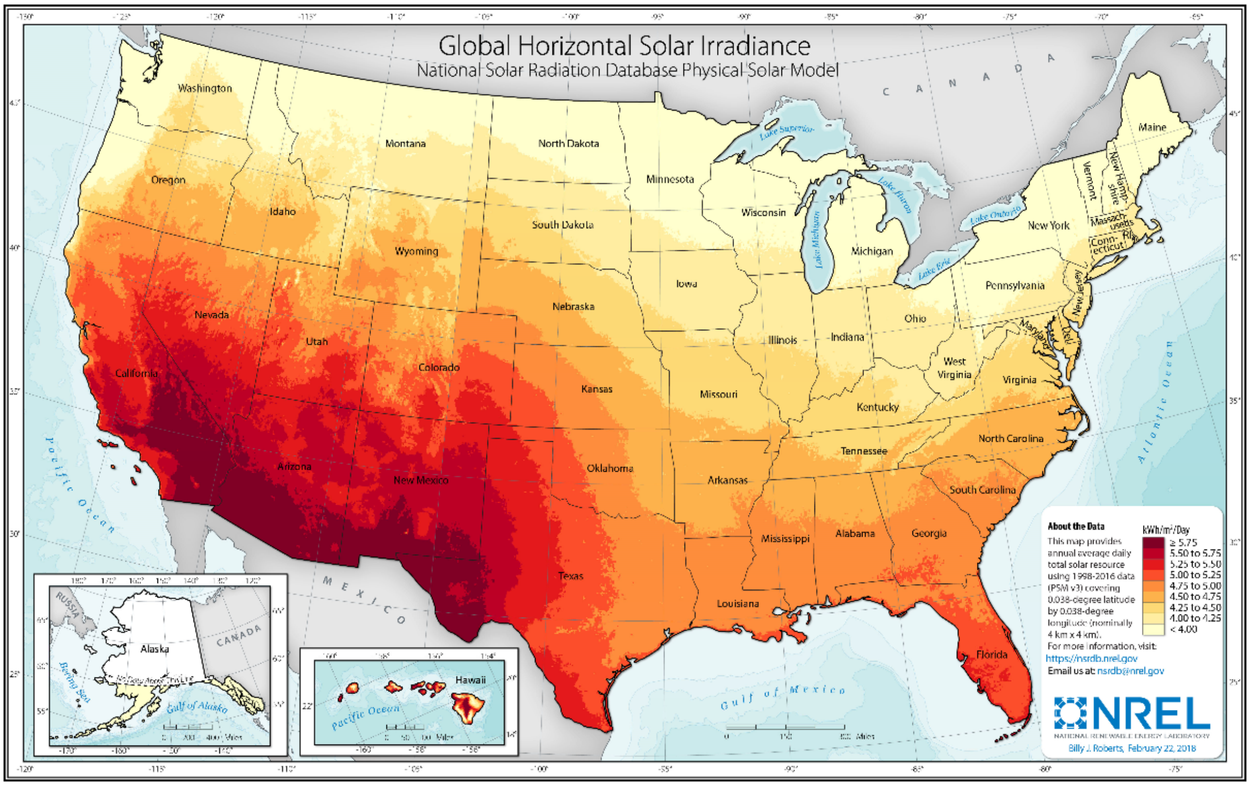
Figure 4-10 – Fixed-Tilt Utility Scale Solar PV System Pricing (Source: SEEIA)[3]



Solar irradiation is generally the strongest in the Southwest and weakest in the Northeast. The irradiation levels in the SPP region fall roughly in the middle of these two extremes, leaving it with a roughly average level of solar irradiation relative to the rest of the nation. Figure 4-11 presents nation-wide solar irradiation levels.

[3] Solar Energy Industries Association (SEIA). Solar Industry Research Data. 2018. https://www.seia.org/solar-industry-research-data

Figure 4-11 – Global Horizontal Solar Irradiance in the U.S. (Source: NREL)



Cost and performance estimates for the solar PV options (single axis tracking at both utility and community scale) are shown in Table 4-13. As with the wind estimates, all cost estimates are provided prior to consideration of federal tax credits and their potential impact on Liberty-Empire's capital cost contribution if a tax equity partner is utilized. The details of federal tax incentives and the tax equity partner modeling assumptions included in the 2019 IRP analysis are summarized in Section 2.

Table 4-13 – Solar PV Single Axis Tracking Performance Parameters

Parameter	Solar PV – Single Axis Tracking Utility Scale	Solar PV – Single Axis Tracking Community Scale
Earliest Feasible Year of Installation	2021	2021
Lead Time in Years (includes development and construction)	1.5	1.5
ISO Net Output, Full Load MW	50	5
Typical Capacity Factor	23.1%	23.1%
Capacity Credit towards Peak	50% summer, 5% winter	50% summer, 5% winter
Capital cost, 2019 $/kW (2018 $)	1,324	1,426
Capital cost, 2024 $/kW (2018 $)	1,055	1,156
Capital cost, 2029 $/kW (2018 $)	925	1,027
Capital cost, 2034 $/kW (2018 $)	819	920
Fixed O&M, $/kW-year (2018 $)	10.25	10.25
Ongoing capex, $/kW-year (2018 $)	0	0

Although the modeling assumes 1.5 year lead time for development, the GIA process at SPP has recently taken longer.

2.6.1.6 Storage Resources

Decreases in prices and improvements in manufacturing capacity have played important roles in the expansion of battery storage in recent years. Simultaneously, ongoing changes to industry regulation that allow or will allow stored energy resources to participate in wholesale electricity markets like SPP's Integrated Marketplace are likely to increase their value. The U.S. energy storage market hit a milestone with 100 MWh of grid-connected energy storage deployments in the fourth quarter of 2017. Lithium-ion had 98.8% market share in that quarter, leading the market for the 13th consecutive quarter.[5]

[5] Munsell, Mike. "US Energy Storage Market Tops the 1 GWh Milestone in 2017." Greentech Media, March 6, 2018. www.greentechmedia.com/articles/read/us-energy-storage-market-tops-the-gwh-milestone-in-2017.

As discussed in Section 2.3, Liberty-Empire has identified a lithium-ion battery option as the best benchmark for potential storage resource additions. Cost and performance estimates for the lithium-ion battery options are shown in Table 4-14, with additional commentary on the technology provided in Section 2.3. Assumptions for paired solar and battery storage systems were also developed for the candidate list. These paired systems use the costs and parameters associated with the single axis solar PV options in Table 4-13 and the costs and parameters associated with the lithium ion battery options in Table 4-14. For solar + storage resources, Liberty-Empire has assumed fixed-tilt solar and lithium-ion batteries with a combined capital cost based on a 4:1 ratio of solar to storage at the utility scale and a 2:1 ratio of solar to storage at the distributed scale, due to the need to manage Liberty-Empire's winter peak. As with the standalone wind and storage estimates, all cost estimates are provided prior to consideration of federal tax credits and their potential impact on Liberty-Empire's capital cost contribution if a tax equity partner is utilized. The details of federal tax incentives and the tax equity partner modeling assumptions included in the 2019 IRP analysis are summarized in Section 2.

Table 4-14 – Lithium Ion Battery Performance Parameters

Parameter	**Lithium Ion Battery – Utility Scale**	**Lithium Ion Battery – Distributed Scale**
Earliest Feasible Year of Installation	2021	2021
Lead Time in Years (includes development and construction)	1.5	1.5
ISO Net Output, Full Load MW	25	5
Storage duration (hours)	4	4
Round-trip efficiency (%)	87.5%	87.5%
Capital cost, 2019 $/kW (2018 $)	1,847	1,945
Capital cost, 2024 $/kW (2018 $)	1,436	1,513
Capital cost, 2029 $/kW (2018 $)	1,185	1,249
Capital cost, 2034 $/kW (2018 $)	1,035	1,090
Fixed O&M, $/kW-year (2018 $)	34.42	34.42
Ongoing capex, $/kW-year (2018 $)*	25.35	25.35

*Note that the ongoing capex assumes full replacement of cells after 15 years.

2.6.2 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.

Table 4-15 summarizes the expected utility levelized cost for each potential supply side resource option at select periods in time, and Table 4-8 presents the levelized environmental cost expectations.

Table 4-15 – Utility Cost by Supply Side Resource at Select Periods in Time

	Technology	Levelized Cost of Electricity (Nominal $/MWh)		
	Year	2019	2024	2029
Baseload	Combined Cycle	48	60	71
Baseload	Small Modular Nuclear	82	93	106
Baseload	Nuclear	103	117	133
Baseload	Super-critical Coal w/ CCS	107	124	142
Baseload	Coal IGCC w/ CCS	142	164	188
Peaking	Reciprocating Engine - Large	133	158	179
Peaking	Reciprocating Engine - Distributed	137	163	186
Peaking	Reciprocating Engine - Medium	148	174	197
Peaking	CT - Aero	186	217	245
Peaking	CT - Frame	229	266	300
Renewable	Wind	29	49	54
Renewable	Solar PV - Single Axis Tracking	43	51	52
Renewable	Single Axis Tracking - Distributed	43	52	53
Renewable	Solar PV - Fixed Tilt	45	54	55
Renewable	Landfill Gas	68	77	88
Renewable	Biomass	84	95	108

As discussed in Section 2, storage resources offer more value to the grid beyond energy shifting and capacity value, and thus it is not appropriate to value their costs in the traditional LCOE framework. As such, they have not been included in the table above.

2.6.3 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.

Liberty-Empire eliminated potential supply-side resource options within each of the LCOE categories outlined above: non-renewable baseload/intermediate resources, non-renewable peaking resources, and renewable resources.

In the non-renewable baseload/intermediate resource category, the screening analysis indicated that the natural gas combined cycle option is persistently lower cost over time than all other options, and 30 to 40% lower cost than the next best alternative. IGCC with CCS, coal with CCS, and traditional nuclear technology were all eliminated based on their significantly higher costs than the alternatives. In addition, CCS technology has not been technically or commercially demonstrated at a large scale and over the long-term planning period. Small modular nuclear was also considerably higher cost than the natural gas combined cycle option, but the LCOE was closer under conditions with high gas prices, high carbon prices, and low capacity factors for the natural gas combined cycle. However, given the significant discount for the natural gas combined cycle across nearly all scenarios, and the fact that small modular nuclear is an unproven technology on a commercial basis, Liberty-Empire determined that the small modular reactor option would not be viable. There were also no additional non-cost factors compelling Liberty-Empire to keep the small modular reactor as a candidate option.

In the non-renewable peaking resource category, the screening analysis indicated that the reciprocating engine and aeroderivative technology options were lower cost than the simple cycle frame option. It was also determined that the reciprocating engine and aeroderivative options could also provide additional value in the market to be monetized in the sub-hourly energy and ancillary services markets, given their fast start times and high levels of flexibility. Therefore, the simple cycle frame option was eliminated from further consideration.

In the renewable resource category, the screening analysis indicated that the biomass and landfill gas options were both significantly higher cost than the wind and solar options. Therefore, biomass and landfill gas were both eliminated from further consideration. Within the solar resource category, as discussed earlier, the small capital cost premium associated with single axis tracking was more than offset by the increase in expected capacity factor, resulting in Liberty-Empire determining that fixed tilt solar PV should be eliminated from further consideration.

SECTION 3 INTERCONNECTION AND TRANSMISSION REQUIREMENTS OF PRELIMINARY CANDIDATE OPTIONS

(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 nonfirm, that are likely to be available over all or part of the planning horizon.

3.1.1 Background

(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.

Liberty-Empire is a member of SPP and, as such, is now reliant on SPP's determination of which transmission lines will be built and on what schedule. As a member of SPP, Liberty-Empire is assigned a cost-sharing allocation of all lines that are built in the SPP footprint. That cost allocation varies per line.

SPP conducts three studies directly associated with transmission planning: large generation interconnect studies, aggregate transmission service studies, and the SPP integrated transmission plan ("ITP"). The large generation interconnect study determines all of the modifications needed to connect a new generator into the transmission system. The aggregate transmission service studies determine system upgrades required to grant transmission service from a generation source to a load. The ITP is a three-year study process which assesses SPP's regional transmission needs in the long- and near-term with the intention of creating a cost-effective, flexible, and robust transmission network that will improve access to the region's diverse generating resources. Therefore, Liberty-Empire modeled a generic transmission cost adder for each alternative resource examined in this IRP.

Currently, SPP uses a FERC-approved process called an aggregate transmission service study. In this process, SPP combines all long-term point-to-point and all long-term network resource transmission service requests received during a sequential six-month open season into a single aggregate transmission service study. Such an aggregated analysis should result in a more optimal expansion of the SPP transmission system than occurred previously with less aggregated analyses.

Liberty-Empire actively participates in transmission planning in the SPP footprint through committee membership, meeting attendance, participation as a customer and a transmission owner in the development and implementation of all of SPP's transmission studies, and other methods. In two recent cases involving the Open Access Transmission Tariff ("OATT") in the SPP, Liberty-Empire filed protests with the FERC. These cases involved the OATT "Highway/Byway" cost allocation methodology and the modified transmission planning process referred to as the ITP.

For the purposes of Liberty-Empire's 2019 IRP, Liberty-Empire assigned transmission costs on a dollar per kilowatt basis for each candidate resource examined in this IRP. This cost was $69.90/kW in 2018 dollars, escalating at 2.5 percent per year.

Liberty-Empire is providing information in this IRP on future transmission projects within Liberty-Empire's control areas that are planned by SPP in the SPP Transmission Expansion Plan ("STEP") (see Appendix D to Volume 4.5 of this IRP). This information has been approved by SPP's Board of Directors.

Since not all of Liberty-Empire's planned construction projects are accounted for in the ITP, details from Liberty-Empire's 2019 to 2024 Construction Budget for planned transmission and distribution projects are presented in Appendix H to Volume 4.5 of this IRP. Liberty-Empire's 2019 to 2024 Transmission and Construction Budget includes transmission system additions, transmission system rebuilds, distribution system additions, distribution system rebuilds, and distribution system extensions and service.

Plans for transmission projects within the SPP change frequently as conditions change on utility systems, including on Liberty-Empire's.

3.1.2 Losses

Liberty-Empire works to reduce system losses in a variety of ways. One is by evaluating losses of power transformers at the time of purchase. As old transformers are replaced, newer transformers have lower levels of losses. Another is by strategically installing capacitor banks on the distribution system. In the late 1990s, Liberty-Empire undertook a power factor campaign targeting installation of capacitor banks around the system. As can be seen in Table 4-16, Liberty-Empire's total system losses have generally decreased over time.

Table 4-16 – Historical System MWh Losses

Year	Firm Sales	Total Losses	Annual Losses	5-Year Rolling Average Losses
	(MWh)	(MWh)	%	%
1998	4,162,607	303,175	7.28	
1999	4,163,824	304,747	7.32	
2000	4,424,768	366,028	8.27	
2001	4,494,199	304,067	6.77	
2002	4,566,262	334,287	7.32	7.39
2003	4,594,856	347,676	7.57	7.45
2004	4,628,759	338,035	7.3	7.45
2005	4,923,486	361,858	7.35	7.26
2006	5,049,599	273,483	5.42	6.99
2007	5,118,460	356,396	6.96	6.92
2008	5,124,277	353,204	6.89	6.78
2009	4,901,435	349,647	7.13	6.75
2010	5,202,277	363,250	6.98	6.68
2011	5,082,772	351,949	6.92	6.98
2012	4,914,783	318,528	6.48	6.88
2013	4,966,280	348,358	7.01	6.90
2014	5,030,148	340,802	6.78	6.83
2015	4,940,028	341,154	6.91	6.82
2016	4,950,708	339,565	6.86	6.81
2017	4,841,356	315,230	6.51	6.81
2018	5,236,677	339,591	6.48	6.71

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.

Liberty-Empire cannot provide a generic list of the transmission upgrades needed to physically interconnect any given generation source within the SPP footprint. Each Generation Interconnection ("GI") request is required to submit to the SPP Generation Interconnection process as defined in the SPP transmission tariff. This process examines the specific location proposed for generator interconnection, its unique technical characteristics, and determines the necessary transmission upgrades necessary for that unique interconnection, as required by SPP. Presently, Liberty-Empire has applied to connect 500 MWs of wind generation at two native locations (Asbury and LaRussel, Missouri, i.e. GEN-2017-060 and GEN-2017-082, respectively; DISIS-2017-001). No results are available as to the cost of these associated interconnection costs due to delay in higher-queued studies (e.g. DISIS-2016-002).

SECTION 4 SUPPLY-SIDE CANDIDATE RESOURCE OPTIONS

4.1 Supply-Side Candidate Resource Options for Integration

(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.

As discussed in Section 2.6, the following supply-side candidate options were identified for including in the integration process:

- Natural gas-fired simple cycle aeroderivative CT
- Natural gas-fired combined cycle – 2 x 1 F Class
- Natural gas-fired reciprocating engines*
- New on-shore wind
- Solar PV – single axis tracking with and without lithium ion battery storage
- Energy storage* – lithium ion battery

*Denotes a resource option evaluated as both a distributed and utility scale energy resource.

4.2 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 transmission analysis.

4.3 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 interconnection cost for all supply-side candidate resource options was $69.90/kW (2018 $).

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;

Table 4-17 shows a comparison of historical fuel costs, including transportation and other fuel-related costs, for Liberty-Empire's facilities.

Table 4-17 – Liberty-Empire's Historical Delivered Fuel Costs ($/MMBtu)

****Confidential in its Entirety**[6]**

[redacted]

*Natural gas includes commodity, commodity charges, and derivative gain/loss, and excludes firm transportation

**Natural gas includes commodity, commodity charges, derivative gain/loss, and firm transportation

[6] 4 CSR 240-2.135(2)(A)1 allows information to be marked as confidential when it is marketing analysis or other market-specific information relating to services offered in competition with others.

The Asbury plant is fueled primarily by coal, with oil used as the start-up fuel. In 2018, Asbury burned a coal blend consisting predominantly of Western coal (also referred to as Powder River Basin ("PRB") coal) and small amounts of local coal (so-called blend coal). All of the Western coal for Asbury is shipped by rail, a distance of approximately 800 miles.

The Riverton Plant fuel requirements are now met by natural gas (Units 7, 8, and 9 are all retired as of June 2015). A Siemens V84.3 A2 CT (Unit 12) was installed at the Riverton plant in 2007 and has been converted to a one-on-one CC unit. Riverton 12 and two other smaller units are fueled by natural gas.

Units 1 and 2 at the Iatan plant are jointly-owned coal-fired generating units. Liberty-Empire's ownership share is 12 percent (approximately 84 MW of Unit 1 and 106 MW of Unit 2). Kansas City Power & Light ("KCP&L") is the operator of this plant and is responsible for arranging its fuel supply. The PRB coal burned at Iatan is transported by rail by the Burlington Northern and Santa Fe ("BNSF") Railway Company.

The coal-fired Plum Point Energy Station met the in-service criteria on August 12, 2010. Liberty-Empire owns, through an undivided interest, 7.52 percent (approximately 50 MW) of the project's capacity. Plum Point Services Company, LLC ("PPSC"), the project management company acting on behalf of the joint owners, is responsible for arranging its fuel supply. Liberty-Empire has a 15-year lease agreement, expiring in 2024, for 54 railcars for Liberty-Empire's ownership share of Plum Point. In December 2010, Liberty-Empire entered into another 15-year lease agreement for an additional 54 railcars associated with the Plum Point PPA.

The Energy Center and State Line simple cycle CT facilities are fueled primarily by natural gas with fuel oil available for use as backup. During 2018, fuel consumption at the Energy Center was 99.1-percent natural gas on a kWh-generated basis and 100-percent of the State Line Unit 1 generation came from natural gas in 2018. The State Line CC unit is fueled 100 percent by natural gas.

Liberty-Empire has firm transportation agreements with Southern Star Central Pipeline, Inc. with current expiration dates of December 1, 2025, for the transportation of natural gas to the SLCC. Liberty-Empire has additional firm transportation agreements to supply Riverton Unit 12 through September 1, 2025. These transportation agreements can also supply a portion of the natural gas required to State Line Unit No.1, the Liberty-Empire Energy Center or the Riverton Plant, as elected by Liberty-Empire on a secondary basis. Any remaining gas transportation requirements, although small, will be met by utilizing capacity release on other holder contracts, interruptible transport, or delivered to the plants by others.

The majority of Liberty-Empire's physical natural gas supply requirements will be met by short-term forward contracts and spot market purchases. Forward natural gas commodity prices and volumes are hedged several years into the future in accordance with Liberty-Empire's Risk Management Policy in an attempt to lessen the volatility in Liberty-Empire's fuel expenditures and gain predictability.

5.1.1 Coal Forecast

Figure 4-12 provides the forecasted price for Southern PRB coal.

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Figure 4-12 - Coal Price Forecast for Southern PRB Coal
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[redacted]

[7] 4 CSR 240-2.135(2)(A)1 allows information to be marked as confidential when using reports, work papers, or other documentation related to work produced by internal or external auditors or consultants.

The first four to five years of the coal price forecasts used for the Asbury, Iatan, and Plum Point facilities were derived by Liberty-Empire's fuels personnel and reflect contract knowledge over those years. The values for subsequent years use the fundamental ABB coal price forecast, combined with transportation adders for Liberty-Empire's coal units. ABB produces coal price forecasts using its coal sub-module. The coal sub-module utilizes a network LP that satisfies, at least possible cost, the demand for coal at individual power plants with supply from existing mines using the available modes of transportation. For each year and iteration, the sub-module executes in the following manner:

1. For each iteration, demand by each power generating plant is taken from the prior iteration of the power module. The sub-module takes into account the potential to switch or blend coals at each plant, where and to the extent that such potential exists.
2. Supply is represented by mine-level short- and long-run marginal cost curves, maximum output, and developable reserves.
3. Transportation is represented as the minimum cost rate for each mine-plant pairing, taking into account the modes of transportation that are possible, e.g. rail, truck, barge.
4. The network LP generates forecasts of annual FOB prices by mine, delivered prices by plant, and the characteristics of the coal delivered to each plant, e.g. sulfur and heat content.
5. Known contracts between specific mines and power plants are represented. These contracts influence the forecast of spot coal produced at each mine.

5.1.2 Natural Gas Forecast

Figure 4-13 depicts and Table 4-18 lists the forecasted natural gas prices (Henry Hub) for the base, high, and low scenario gas price scenarios. Figure 4-14 depicts and Table 4-18 lists the forecasted natural gas prices (Southern Star Delivered) for the base, high, and low gas price scenarios. The natural gas price forecast used for this IRP is based on the ABB Power Market Advisory database modified by ABB. Natural gas prices were developed for three possible gas price scenarios: high gas, low gas, and base gas.

Figure 4-13 - Forecasted Base, High, and Low Natural Gas Prices (Henry Hub)
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[redacted]

[8] 4 CSR 240-2.135(2)(A)1 allows information to be marked as confidential when using reports, work papers, or other documentation related to work produced by internal or external auditors or consultants.

Figure 4-14 - Forecasted Base, High, and Low Natural Gas Prices (Southern Star Delivered)
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[redacted]

[9] 4 CSR 240-2.135(2)(A)1 allows information to be marked as confidential when using reports, work papers, or other documentation related to work produced by internal or external auditors or consultants.

Table 4-18 - Forecasted Base, High, and Low Natural Gas Prices (Henry Hub and Southern Star)

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[redacted]

5.1.2.1 Natural Gas Price Forecasting Methodology

ABB produces natural gas price forecasts for each month at individual pricing hubs using its natural gas sub-module. The natural gas sub-module produces forecasts of monthly natural gas prices at individual pricing hubs. The Operations Component consists of a model of the aggregate U.S. and Canadian natural gas sector. For each month and iteration, it executes in the following manner:

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1. For each iteration of the Operations Component, natural gas demand by the power sector is taken from the prior iteration of the Power Module. The Power Module is a zonal model of the North American interconnected power system spanning 73 zones. The Module simulates separate hourly energy and annual capacity markets in all zones. The Module simulates the operations of individual generating units, i.e. not aggregations of units. The Power Module comprises two components, which simulate 1) operations and 2) conventional power plant capacity additions.
2. Canadian and L48 U.S. residential, commercial, and industrial ("RCI") demand forecasts are treated as exogenous inputs to the natural-gas sub module. RCI demand is forecast based on an analysis of RCI demand in the EIA Annual Energy Outlook ("AEO") and the National Energy Board of Canada ("NEBC") 25 year outlook. ABB also conducts its own research and analysis of industrial demand based on publically available analysis of forecast industrial demand. Historical data from the ABB Velocity Suite product are used as a starting point for demand growth applied based on growth rates taken from EIA and NEBC forecast and to add monthly seasonal shape to annual forecasts.
3. Imports and exports of LNG as well as pipeline exports to Mexico (outside CA connected Baja California) are also treated as exogenous demand sources drawing on the combined Canadian and L48 gas system. These forecasts are created based on analyses of: historical data for individual pipelines and import terminals, individual pipeline and LNG export projects, projected supply and demand for global LNG, and projected demand for natural gas in Mexico. North American production is represented in the Operations Component by a series of Lower 48 and Canadian supply curves. These relate production at a wellhead to the wellhead price of natural gas for each basin and geology in each year. Then, an annual production algorithm identifies the relative prices at each of the supply basins to the basin production necessary to meet annual gas demand. Regional storage is based upon a schedule of injections and withdrawals required to balance monthly demand and production. Then, monthly gas production, transportation and demand after storage are simulated within a gas network optimization model to provide both gas flows and prices at each point within the gas

network. Prices at each point in the topology are determined based upon wellhead prices plus transportation costs.

4. From this solution, the monthly Henry Hub price is identified directly from its geographic point within the gas network.

Table 4-19 delineates the three phases of the Reference Case long term natural gas price forecast.

Table 4-19 - ABB Reference Case Gas Price Forecasting Phases

Forecast Phase	Period Length	Data Source	Forecast Technique
Futures Driven	First 24 Months	NYMEX Henry Hub futures and market differentials	Calculated Henry Hub and liquid market center differentials
Blend	Months 25-48	ABB Advisors and NYMEX/Velocity Suite	Linear process to gradually equate near-term to long-term fundamentals
Long-term Fundamentals	Remaining planning period (to 2043)	ABB Advisors	Fundamental supply and demand analysis modeling

To derive the burner tip forecasts used, ABB first aggregates regional prices and basis swaps at major trading hubs. Using this historical data for the first 24 months of the forecast, ABB developed a differential price between the appropriate market center nearest to the power plant and the Henry Hub. Natural gas prices for the first 24 months of the forecast were driven by Henry Hub futures market prices plus a basis differential. For the following 24 months of the planning period (months 25-48), ABB blends the futures market price expectations with Liberty-Empire's long-term fundamental forecast so that by the end of this period, the gas price forecasts are consistent with Liberty-Empire's fundamental view. To forecast future burner tip gas prices beyond the initial 48-month period, ABB utilized a cost-minimization linear program model of gas supply and demand.

5.1.2.2 Natural Gas Risk Management Policy

Liberty-Empire works diligently to mitigate the price volatility associated with changes in natural gas pricing. In 2001, Liberty-Empire developed and implemented a Risk Management Policy ("RMP") to manage this volatility. The RMP serves to minimize Liberty-Empire's exposure to the impacts of fluctuating natural gas prices. In general terms, Liberty-Empire's RMP allows the use of various instruments to help manage price volatility, including (but not limited to) NYMEX Futures, Swaps, and Physical Purchases. The RMP includes a minimum annual quantity of natural gas whose price must be established in advance through either a financial instrument and/or physical gas contract. For example, Liberty-Empire has currently established the price on the following quantities of natural gas for the upcoming calendar years in Table 4-20.

Table 4-20 – Liberty-Empire Natural Gas Hedges

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5.2 Capital Costs of Supply-Side Candidate Options

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

The capital costs modeled for each resource option assumes an EPC contracting strategy. Each

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option includes an allowance for typical owner's costs, an on-site switchyard, transmission interconnect, natural gas interconnect, and water interconnect, as applicable. Ranges for high and low capital costs were developed for candidate supply-side resources as part of the larger process of developing cost and operational parameters. These ranges are shown in Table 4-21.

Table 4-21 – Capital Cost Ranges over Time for Candidate Supply Side Options

Capital Cost ($2018/kW)							
Case	**Year**	**Combined Cycle**	**Wind**	**Li-Ion Storage - Utility Scale**	**Reciprocating Engine - Large Size**	**Solar PV - Single Axis Tracking**	**Solar PV - Distributed**
Base	2019	1,086	1,662	1,847	1,170	1,324	1,426
Base	2024	1,067	1,582	1,436	1,155	1,055	1,156
Base	2029	1,040	1,515	1,185	1,122	925	1,027
Low	2019	873	1,428	1,271	1,001	1,119	1,200
Low	2024	858	1,122	882	987	755	809
Low	2029	836	1,067	662	959	509	546
High	2019	1,312	2,164	2,100	1,366	1,497	1,614
High	2024	1,289	2,117	1,848	1,348	1,367	1,497
High	2029	1,256	2,089	1,726	1,310	1,324	1,468

Capital Cost ($2018/kW)							
Case	**Year**	**Li-Ion Storage - Distributed**	**Solar PV + Storage - Utility Scale**	**Solar PV + Storage - Distributed**	**Reciprocating Engine - Medium Size**	**Reciprocating Engine - Distributed**	**Combustion Turbine-Aeroderivative**
Base	2019	1,945	1,431	1,603	1,322	1,021	1,229
Base	2024	1,513	1,133	1,279	1,304	1,008	1,213
Base	2029	1,249	979	1,105	1,267	979	1,178
Low	2019	1,339	1,166	1,284	1,130	874	1,051
Low	2024	929	792	871	1,116	862	1,037
Low	2029	698	546	601	1,084	838	1,008
High	2019	2,212	1,621	1,819	1,543	1,193	1,435
High	2024	1,947	1,467	1,654	1,523	1,177	1,416
High	2029	1,819	1,409	1,592	1,480	1,144	1,376

5.3 Fixed and Variable Costs of Supply-Side Candidate Options

(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;

O&M costs for the candidate options are included in the tables in the previous sections. Costs are broken out by fixed costs, variable costs, and major maintenance costs depending on the type of technology being evaluated.

Liberty-Empire believes the uncertainty that surrounds the O&M costs for any future power plant is significantly overshadowed by the uncertainty related to any of natural gas prices, market prices, and level of carbon taxes. Thus, the uncertainty associated with O&M costs is not considered further in this IRP.

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;

NO_x and SO_2, along with many other pollutants, are regulated by a number of State and Federal statutes that complicates price projections for the costs of emissions, the limits on the emissions themselves, and the projected future levels of emissions. The emissions costs assumed in the analysis, reflecting a combination of State and Federal requirements, are shown in the following figures. Figure 4-15 presents SO_2 price forecasts for the states of Missouri and Kansas, respectively. Figure 4-16 displays an annual price forecast for NO_x.

Figure 4-15 - SO_2 Group 1 (MO) Price Forecast

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[redacted]

Figure 4-16 - NO_X Annual Price Forecast

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[redacted]

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Liberty-Empire's base carbon scenario assumes no carbon price. Liberty-Empire is also evaluating a case where a CO_2 price is enacted in 2026. This CO_2 price is based Synapse Energy Economics' $60/ton by 2050 case, beginning in 2026. This case represents an 80% reduction in CO_2 emissions by 2050, consistent with the 2015 Paris Accord global target. Figure 4-17 shows the projected CO_2 costs ($/ton) assumed to be applicable no earlier than 2026.

Figure 4-17 – CO_2 Price Forecast

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[redacted]

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

Liberty-Empire has no leased or rental facilities.

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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.

Interconnection costs for all supply-side candidate resource options is assumed to be $69.90/kW ($2018). Interconnection costs are assumed to apply for all utility scale supply-side resources, but not distributed resources (solar, storage).

5.7 Market Price Forecast

Another uncertain factor to consider when modeling supply-side candidate resources is power market price. Market prices for market area SPP-KSMO were projected by ABB for use in the modeling. These prices reflect conditions in the market expected to be experienced by Liberty-Empire and use the most recent market information available. The projected average market prices for the three gas scenarios and the carbon price scenario (under the base case natural gas outlook) used for the modeling in this IRP are shown in Figure 4-18. Market prices were also developed for both the carbon tax/high gas and carbon tax/low gas scenarios.

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Figure 4-18 - Forecasted Average Market Price for SPP-KSMO

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[redacted]

[14] 4 CSR 240-2.135(2)(A)1 allows information to be marked as confidential when using reports, work papers, or other documentation related to work produced by internal or external auditors or consultants.