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4.1.3 Existing Nuclear Resource

Callaway Energy Center is located about 100 miles west of St. Louis, Missouri, in Callaway County. The plant started operations in December 1984 and is the only power plant that uses nuclear fuel in Ameren Missouri's generation fleet. Ameren Missouri has continued to make cost-effective investments in Callaway to replace equipment that is at the end of its service life, including components such as turbine rotors, steam generators and main transformers.

Callaway Energy Center is the second largest power generation facility on the Ameren Missouri system with a net capability of 1,194 MW.

4.1.4 Existing Renewable and Storage Resources

Currently, Ameren Missouri owns 379 MW of hydroelectric resources, 440 MW of pumped storage, a purchase power agreement for 102 MW of wind generation, and 6.6 MW (AC) of solar generation. By the first quarter of 2021, approximately 700 MW of additional wind generation is scheduled to be in-service, with most of that in service by the end of 2020.[2]

Existing Hydroelectric Resources

Keokuk

Ameren Missouri's Keokuk hydroelectric plant is located on the Mississippi River at Keokuk, Iowa, 180 miles north of St. Louis. The Keokuk Energy Center has a total net summer capability of 144 MW.

More than a million cubic yards of earth and rock were excavated to build the Keokuk dam and plant, which began operation in 1913. An engineering

[2] Ameren indicated in its May 12, 2020, quarterly earnings conference call that a portion of one wind project may be completed in early 2021 and noted contract provisions to offset the financial impacts of a change in eligibility for production tax credits resulting from such a delay.

marvel of its time, Keokuk is the largest privately owned and operated dam and hydroelectric generating plant on the Mississippi River. Over the years, Ameren Missouri has continued to invest in the modernization and repair of the plant and dam.

As it passes through the power plant, falling water spins turbines, or water wheels, which drive generators that produce electricity. Keokuk Plant is a "run-of-river plant," meaning that all water flowing downstream passes the plant on a daily basis. An average day of operation at Keokuk Plant saves the equivalent of nearly 1,000 tons of coal. The individual units at the Keokuk Energy Center, each having a nameplate rating of less than 10 MW, were certified as qualified renewable energy resources by the Missouri Department of Natural Resources ("MoDNR") in September 2011.

Osage

Ameren Missouri's Osage hydroelectric plant is located in Lakeside Missouri on the Osage River at the Lake of the Ozarks. The Osage Energy Center has a total net summer capability of 235 MW.

Osage began operation in 1931. For early settlers, the rolling Osage River in the heart of Missouri's Ozark wilderness provided a way of life and a source of livelihood, whether that was fishing, farming, logging or other pursuits. Then in the 1930s, the river was harnessed when Union Electric Company (now known as Ameren Missouri) built Bagnell Dam to provide power for a growing state and a budding economy. The 1930s-era building of Bagnell Dam and Ameren Missouri's Osage hydroelectric plant created a range of recreational opportunities in the now-popular Lake of the Ozarks.

Every hour the Osage Plant operates, other energy resources are preserved. As water passes through the dam, the pressure of the falling water spins water wheels, which drive generators that produce electricity. In a typical year, Osage Plant uses the clean energy of falling water to produce as much power as 225,000 tons of coal or one million barrels of oil.

In 2018, Ameren Missouri completed stability upgrades at Bagnell Dam to provide additional stabilization of the dam to conform to FERC guidelines. To stabilize the dam, 68 plastic encapsulated post-tensioned anchors were installed in the west retaining section, east retaining section, and spillway section. Additionally, mass concrete was installed across the downstream side of the west and east retaining sections.

Existing Pumped Storage

Taum Sauk

The Taum Sauk pumped storage plant is located approximately 120 miles southwest of St. Louis in the scenic Ozark highlands. The Taum Sauk Energy Center has a total net summer capability of 440 MW.

Taum Sauk Plant began operation in 1963, the turbines were completely rebuilt in 1999, and the upper reservoir rebuild project was completed in 2010. Taum Sauk is used primarily on a peaking basis and is put into operation when the demand for electricity is greatest. The pump storage system works much like a conventional hydroelectric plant, but is usually used only to meet daily peak power demands. Water stored in an upper reservoir is released to flow through turbines and into a lower reservoir during periods of high energy demand. Then, overnight, when the demand for electricity is low, the water is pumped back into the upper reservoir, where it is stored until needed.

In 2019, Ameren Missouri completed major upgrades on the Unit 1 and Unit 2 turbines at Taum Sauk to increase unit reliability and availability. The upgrades included rebuilding the wicket gates and upgrading seals, and will allow for improved unit startups, increased efficiency, and reduction in future maintenance costs. These enhancements will allow both units of Taum Sauk to qualify as supplemental and spinning reserve resources in MISO and to be available more often to support grid operations, which will be increasingly important as more intermittent generation resources penetrate the market.

Existing Renewables

Pioneer Prairie Wind Farm

In June 2009, Ameren Missouri executed an agreement to purchase 102 MW of wind power from Phase II of Horizon Wind Energy's Pioneer Prairie Wind Farm in northeastern Iowa in Mitchell County. The wind farm is fully operational with both phases having a total capacity of more than 300 MW. This Purchase Power Agreement runs from September 2009 through August 2024. The Pioneer Prairie Wind Farm was certified as a qualified renewable energy resource by the MoDNR in September 2011. The power Ameren Missouri is purchasing ties into the MISO transmission grid, of which the company is a member.

High Prairie Wind Farm

In May 2018, Ameren Missouri entered into an agreement to acquire, after construction, a 400 MW wind farm in Adair and Schuyler counties in northeast Missouri. The wind farm consists of 175 wind turbines that stand nearly 500 feet above the ground. Energy produced by the wind farm will power an estimated 120,000 homes. Ameren Missouri is scheduled to begin operating the High Prairie Wind Farm in October 2020.

Outlaw Wind Farm

In May 2019, Ameren Missouri entered into an agreement to acquire, after construction, a 299 MW wind farm in Atchison County in northwest Missouri. The wind farm consists of 91 wind turbines that range in total height from 442 to 590 feet above ground. Ameren Missouri is scheduled to take ownership and begin operation of the Outlaw Wind Farm in November 2020.

Ameren Headquarters Rooftop Solar

Ameren Missouri owns approximately 62 kW of various PV solar technologies at its headquarters office building in St. Louis. The solar generation was certified as a qualified renewable generation facility by the MoDNR on September 28, 2011.

O'Fallon Renewable Energy Center

In December 2014 Ameren Missouri began operation of 4.8 MW (AC) of solar generation at the O'Fallon Renewable Energy Center. The O'Fallon facility includes more than 19,000 polysilicon solar panels and is located on 25 acres of land owned by Ameren Missouri.

Lambert Community Solar

In August 2019, the Ameren Missouri Lambert Community Solar Energy Center began operation of 942 kW (AC) of solar generation. This facility supports the Community Solar Pilot Program, which provides customers with an opportunity to sponsor additional solar development. Qualifying customers may voluntarily subscribe to receive up to fifty percent of their average annual energy usage from the facility in blocks of 100 kWh. Participants commit to a minimum participation term of 24 months but may remain on the program for up to 25 years. The Lambert Community

Solar Energy Center was fully subscribed within fifty-five days and a subscriber waitlist continues to grow.

Ameren Missouri BJC Solar Partnership

In October 2019, the Ameren Missouri BJC Solar Partnership project was completed. This facility generates 1.57 MW (AC) of solar power directly onto the 12.47-kV grid while being hosted by the BJC Parking Garage. This project was completed through the Solar Partnership Pilot Program.

Maryland Heights Renewable Energy Center

The Maryland Heights Renewable Energy Center ("MHREC") is located in St. Louis County approximately 18 miles northwest of St. Louis. The MHREC is the largest landfill-gas-to-electric facility in Missouri and one of the largest in the country.

The MHREC began operation in June 2012. It has a total net summer capacity of 8 MW. This facility burns methane gas produced by the IESI Landfill in Maryland Heights, Missouri, in three Solar Mercury 50 gas turbines to produce electricity. The current contract with the landfill guarantees enough gas supply for three generators until 2032. In August 2012, the MHREC was certified as a qualified renewable energy resource by the MoDNR.

4.1.5 Levelized Cost of Energy Evaluation for Existing Resources[3]

The levelized cost of energy ("LCOE") was calculated for Ameren Missouri's existing resources. LCOE represents going-forward costs of ownership and operation and provides a basis for comparison to new resource alternatives. It is important to note that the LCOE figures do not fully capture all of the relative strengths of each resource type. Table 4.2 shows the component analysis for the LCOE for each energy center. The average LCOE for Ameren Missouri's coal energy centers is approximately $37/MWh including Meramec and $34/MWh excluding Meramec. The average LCOE for Ameren Missouri's entire generating fleet is approximately $39/MWh.

[3] 20 CSR 4240-22.040(2)(A); 20 CSR 4240-22.040(2)(B); 20 CSR 4240-22.040(2)(C)1

Table 4.2 Levelized Cost of Energy Component Analysis for Existing Resources

Existing Resources	Levelized Cost of Energy (¢/kWh)									
	Non-Environmental Costs					Probable Environmental Costs				Total Cost
	Non-Env Capital	Fixed and Variable O&M	Fuel	Decommission	Pump MWh	Env Capital	CO2	SO2	NOx	
Labadie	0.32	0.36	1.79	--	--	0.06	0.61	0.00	0.00	**3.16**
Rush Island	0.33	0.42	1.85	--	--	0.03	0.77	0.00	0.00	**3.41**
Meramec	0.75	4.97	15.48	--	--	4.38	0.00	0.00	0.00	**25.58**
Sioux	0.48	0.79	1.81	--	--	0.30	0.42	0.01	0.00	**3.81**
Audrain	1.56	0.38	3.51	--	--	--	0.37	0.00	0.00	**5.82**
Goose Creek	1.28	0.32	3.93	--	--	--	0.41	0.00	0.00	**5.94**
Pinckneyville	2.28	2.00	2.96	--	--	--	0.31	0.00	0.00	**7.55**
Raccoon Creek	1.24	0.50	4.08	--	--	--	0.43	0.00	0.00	**6.25**
Kinmundy	0.70	0.70	3.26	--	--	--	0.34	0.00	0.00	**5.00**
Meramec CTG	29.14	0.39	3.82	--	--	--	0.00	0.00	0.00	**33.36**
Peno Creek	4.82	2.92	3.28	--	--	--	0.34	0.00	0.00	**11.36**
Venice	0.50	0.77	3.38	--	--	--	0.36	0.00	0.00	**5.01**
Fairgrounds	0.01	0.14	7.95	--	--	--	0.18	0.00	0.00	**8.29**
Mexico	0.22	0.22	7.70	--	--	--	0.17	0.00	0.00	**8.31**
Moberly	0.20	0.34	5.11	--	--	--	0.12	0.00	0.00	**5.77**
Moreau	0.05	0.22	8.43	--	--	--	0.19	0.00	0.00	**8.90**
Callaway	1.30	1.67	0.63	0.08	--	--	0.00	0.00	0.00	**3.68**
Keokuk	2.55	0.70	0.00	--	--	--	0.00	0.00	0.00	**3.25**
Osage	2.50	0.89	0.00	--	--	--	0.00	0.00	0.00	**3.39**
Taum Sauk	4.13	2.59	0.00	--	4.63	--	0.00	0.00	0.00	**11.35**
Maryland Heights CTG	3.88	5.87	4.28	--	--	--	0.00	0.00	0.00	**14.03**
O'Fallon (Solar)	0.00	2.02	0.00	--	--	--	0.00	0.00	0.00	**2.02**
Lambert (Solar)	0.00	2.99	0.00	--	--	--	0.00	0.00	0.00	**2.99**
BJC (Solar)	0.00	0.70	0.00	--	--	--	0.00	0.00	0.00	**0.70**

4.1.6 Planned Changes to Existing Non-Coal Resources

During the 20-year planning horizon, Ameren Missouri is considering two Keokuk Energy Center Units for upgrades, two Osage Energy Center Units for upgrades, and the potential retirement of six CTG units.

Ameren Missouri is in the process of upgrading Keokuk Unit 5 & Unit 15 with this work starting in the fall of 2020 and being completed in the summer of 2021. The upgrades would increase each unit's capability by 2 MW at a cost of about $16 million per unit.

The original 89-year-old turbines at Osage units 2 and 4 are scheduled to be replaced by 2023 at a cost of about $35M. These upgrades are expected to result in 2% efficiency improvement, however Ameren Missouri is currently conducting an ongoing engineering study to better estimate the benefits.

CTG Retirements

Ameren Missouri previously conducted a high-level retirement evaluation of the existing CTG fleet. The potential retirement recommendation is based on operating experience, condition of the assets, and qualitative analysis. The qualitative analysis considered

factors such as condition of subsystems, obsolesce of control systems, availability of spare parts, and building condition. Based on the evaluation and in light of current market assumptions, Ameren Missouri plans to retire six of its older gas- and oil-fired CTG units (i.e., Fairgrounds, Meramec CTG-1, Meramec CTG-2, Mexico, Moberly, and Moreau), with a total net capacity of 262 MW, over the next 20 years. A combination of factors led to the potential CTG retirement recommendations, including the fact that the average age of those units is 43 years; and for some of the units, the long-term availability of spare parts is questionable. The lead time for obtaining spare parts is unknown. Table 4.3 provides a summary of the planned CTG retirements. The planned CTG retirements are included in the base capacity position (see Appendix B).

Table 4.3 Ameren Missouri Potential CTG Retirements during the Planning Period

Unit	Capacity (MW)	Fuel Type	Commerical Operation Date	Age as of 12/31/2019	Retirement Time Frame
Fairgrounds	55	Oil	1974	45	12/31/2026
Meramec CTG-1	0	Oil	1974	45	12/31/2021
Meramec CTG-2	45	Natural Gas/Oil	1999 *	43	12/31/2021
Mexico	54	Oil	1978	41	12/31/2026
Moberly	54	Oil	1978	41	12/31/2026
Moreau	54	Oil	1978	41	12/31/2026

* Meramec CTG 2 was acquired by Ameren Missouri in 1999 and is 1976 vintage

The results of a detailed condition assessment for each unit will be used as the basis for economic analysis to be considered along with other factors such as overall age, condition, reliability, safety and cost, significant capital needs, near-term capacity value, and availability of spare parts. Such economic analyses are generally initiated when a need for significant capital investment is identified and/or when expected market conditions change substantially.

4.2 Existing Steam Generation Evaluation

Ameren Missouri has evaluated its coal energy centers in terms of condition, base retirement assumptions, reliability trends, operation and maintenance costs, and capital expenditures. Table 4.4 lists the commercial operation date for each generating unit, the average age at each energy center as of 12/31/2019, and the base retirement assumptions consistent with our 2017 IRP. Additional retirement dates are analyzed and reported in Chapter 9.

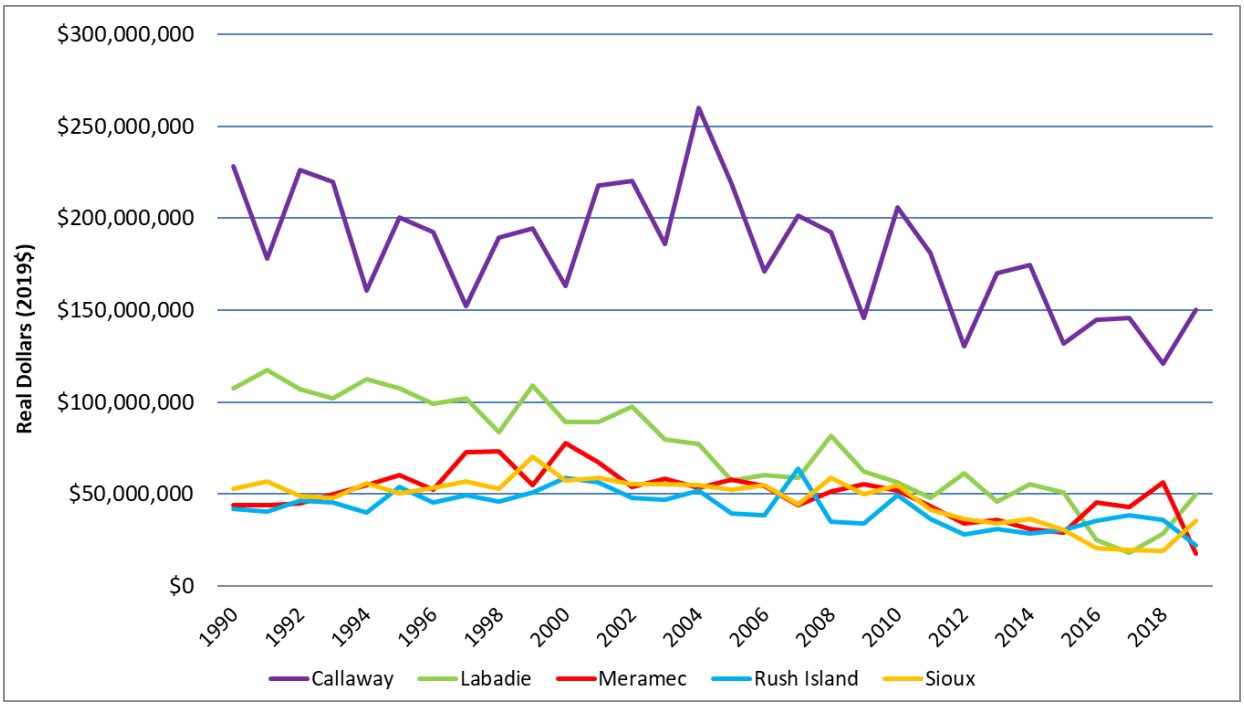
Table 4.4 Ameren Missouri Coal Energy Center Commercial Operation Dates, Average Age, and Base Retirement Assumptions[4]

Energy Center	Commercial Operation Date				Average Age as of 12/31/2019	Base Retirement Assumptions (Retirement Date)
	Unit 1	Unit 2	Unit 3	Unit 4		
Labadie	1970	1971	1972	1973	48	2042
Meramec	1953	1954	1959	1961	63	2022
Rush Island	1976	1977			43	2045
Sioux	1967	1968			52	2033

4.2.1 Operations and Maintenance Costs

Figure 4.3 shows the historical operations and maintenance ("O&M") costs for Ameren Missouri's four coal-fired energy centers from 1990 to 2019. The plant O&M costs were taken from the annual plant operating reports and then normalized to 2019 dollars using the Handy Whitman Index for Total Steam Production Plant. The average annual escalation for the period 1990 to 2018 was 3.1%. These costs are non-fuel O&M expenses. O&M expenses exhibit a moderate downward trend in the last 10-15 years.

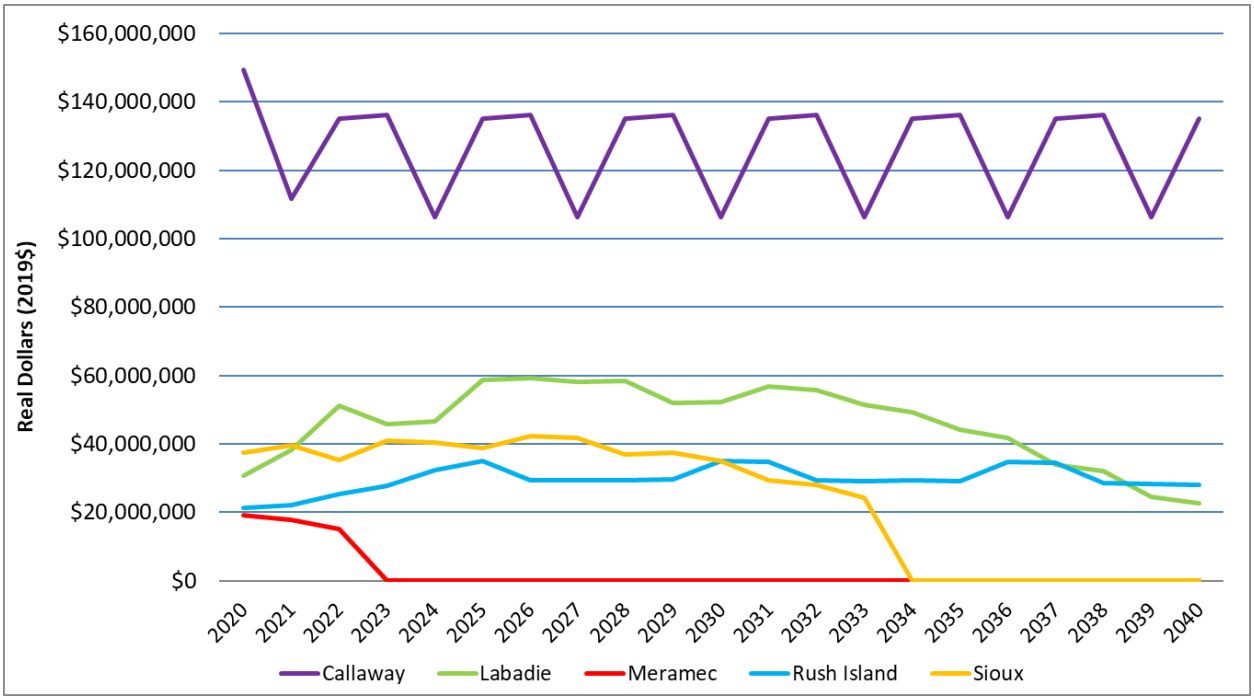
Figure 4.3 Historical Annual O&M for Ameren Missouri Energy Centers (2019$)



[4] The Labadie generating units are currently assumed to be retired in 2036 (two unites) and 2042 (two units).

The plant O&M costs are anticipated to remain relatively flat in real terms in the future. Figure 4.4 shows the future O&M costs from 2020 to 2040 in 2019 dollars using the base retirement date for each energy center. The labor portion of the O&M assumes a 50% pension and benefit loading factor. In addition, the O&M forecasts assume annual revenues from refined coal operations at Labadie, Rush Island, and Sioux through 2021. A six-year outage cycle for Labadie and Rush Island and a 3-year outage cycle for Sioux are assumed in the O&M forecast.

Figure 4.4 Future Annual O&M for Ameren Missouri Coal Energy Centers (2019$)



4.2.2 Capital Expenditures

Figure 4.5 shows the historical non- environmental capital expenditures from 2001 to 2019. The plant capital expenditures were taken from the Ameren Missouri accounting system and normalized to 2019 dollars using a 2% escalation rate.

Figure 4.5 Historical Non-Environmental Capital Expenditures for Ameren Missouri Coal Energy Centers (2019$)

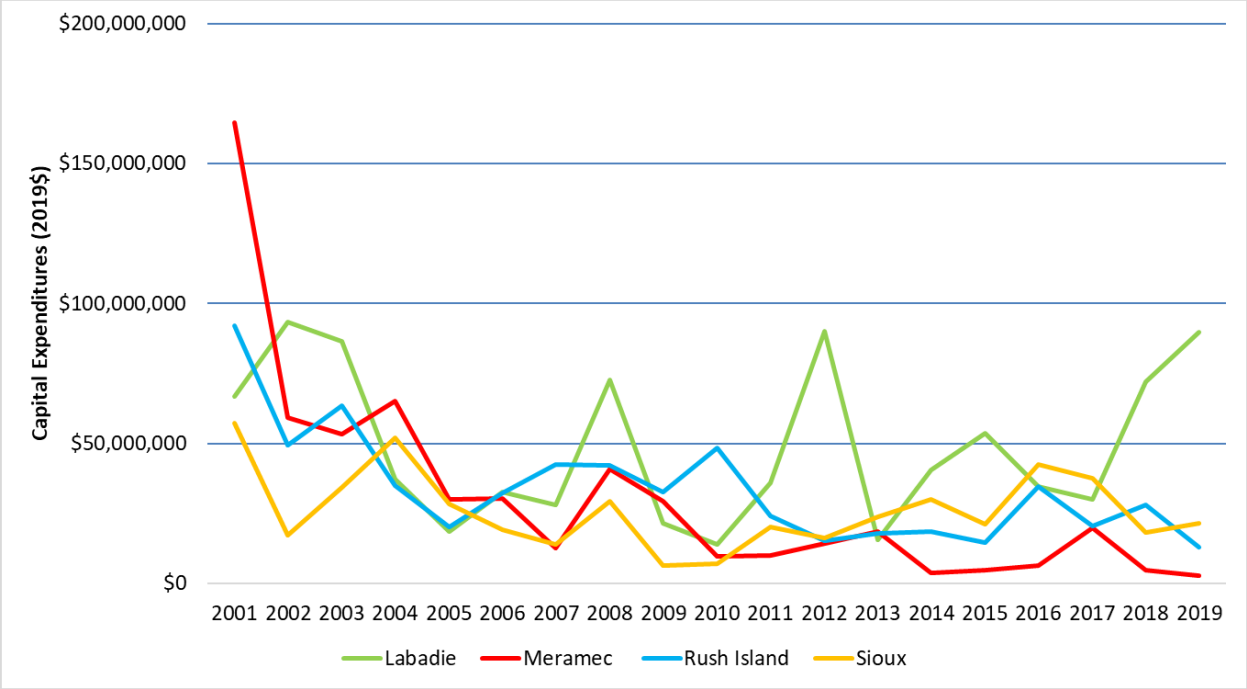
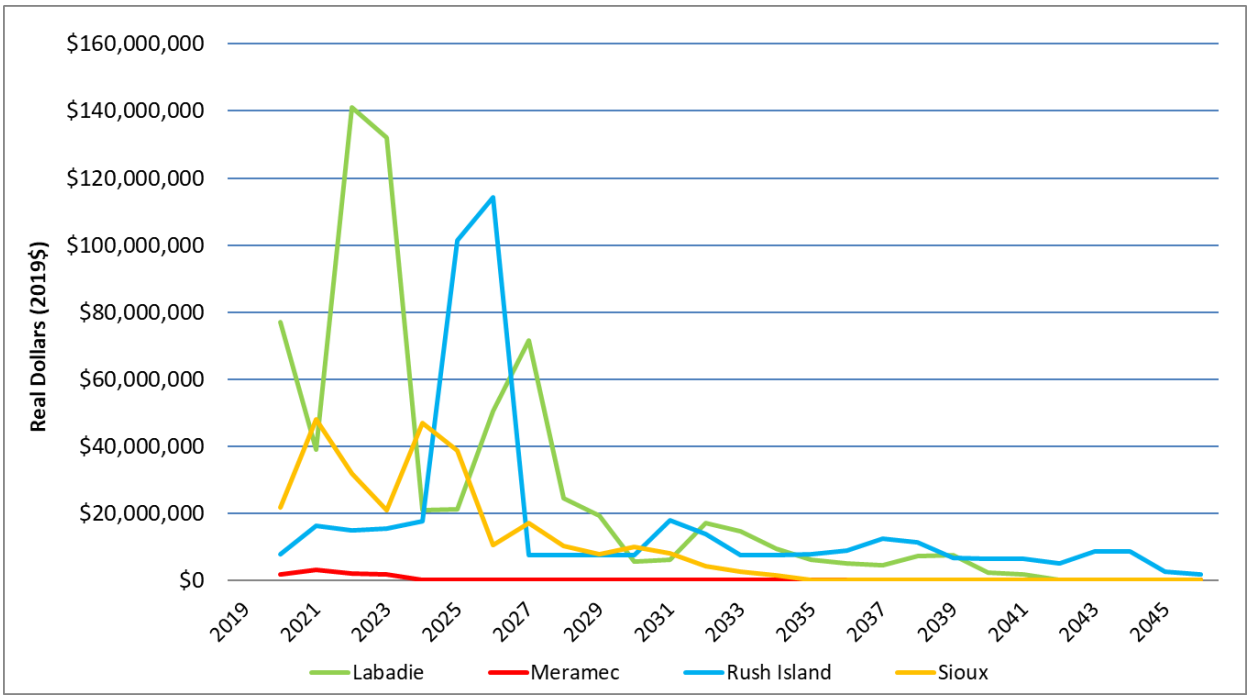


Figure 4.6 shows the future non-environmental capital expenditures for 2020 to 2045 using the base retirement date for each energy center. Future environmental capital expenditures are discussed in Chapter 5. The future non-environmental plant capital expenditures were provided by Ameren Missouri Power Operations Services and normalized to 2019 dollars using a 2% escalation rate. Labadie's capital expenditures show a slight increasing trend over time due to boiler and landfill projects. Meramec and Sioux energy centers show a decreasing trend in non-environmental capital expenditures over the time period. Rush Island capital expenditures are expected to remain relatively flat over the time period. Note that assumptions for capital expenditures may vary significantly for alternate retirement dates and that such differences are included in the assumptions used for the analysis of alternative resource plans described in Chapter 9.

Figure 4.6 Future Non-Environmental Capital Expenditures Ameren Missouri Coal Energy Centers (2019$)



4.3 Efficiency Improvement[5]

4.3.1 Existing Facility Efficiency Options

Ameren Missouri has implemented various initiatives to improve efficiency and reduce GHG emissions at its existing facilities. These initiatives include replacement of incandescent light bulbs with compact fluorescent light bulbs and LEDs, and standardization of low-energy usage light fixtures during system replacements. Another initiative to improve efficiency and reduce GHG emissions in the operation of heating, ventilation, and air conditioning (HVAC) equipment through the installation of programmable thermostats for control of HVAC systems is expected to reduce energy consumption during off-hours. The projects completed in 2011 through 2018 have reduced energy consumption by more than 3,600 MWh annually and reduced CO_2 emissions by more than 3,400 metric tons annually (assuming 0.94 metric tons of CO_2 per MWh). Ameren Missouri will continue assessing and implementing the projects that prove to be feasible on an ongoing basis.

[5] 20 CSR 4240-22.040(1)

4.3.2 Existing Energy Center Efficiency Options[6]

Ameren Missouri continues to be focused on maintaining the efficiency of its coal-fired generating units. Projects that improve efficiency that are a benefit to the company and to customers continue to be evaluated and executed when appropriate. Projects and work activities that restore efficiency lost due to equipment degradation or operating issues continue to be evaluated and executed on a regular basis.

Ameren Missouri performs long-term scheduled major maintenance outages. Much of the work performed during these major outages (such as replacement or repair of leaking valves, restoration of duct work, insulation of equipment, and cleaning of equipment) typically results in improved efficiency when the unit returns to service.

Ameren Missouri's generating resources utilize the Plant Reliability Optimization ("PRO") process to maintain assets in a cost efficient and effective manner to support conservative operations. The PRO process integrates personnel from all levels of the organization, and uses data to assess equipment condition to prioritize and plan resources and work. The process develops, implements, and standardizes best practices system-wide to reduce failure rates on critical equipment, balancing additional maintenance costs against potential production losses to optimize investments, while ensuring equipment performance and condition support of safe and reliable asset operation.

Ameren Missouri continues to utilize performance monitoring on its major Energy Centers, and has recently expanded focus to incorporate monitoring of wind and solar assets. Performance monitoring includes analysis of rotating equipment, vibration monitoring, Real Time Alarm Monitoring and expansion of monitoring services to the CTG fleet, along with exploring additional technologies and software to accomplish these goals. The Performance Monitoring function works closely with the Real Time Operations group, and complements Ameren Missouri's existing generation operations and dispatch functions.

Operational monitoring at Ameren Missouri’s coal plants is also an important tool in maintaining the heat rate (efficiency) at the coal plants. EtaPRO is a continuous monitoring software tool used at all the plants to monitor thermal performance of critical equipment. The EtaPRO system is maintained by Performance Engineering and is also used by performance engineers to generate plant heat rate (efficiency) reports. Operations personnel routinely check system components during operation and start-up modes to ensure that valve line-ups are correct and equipment performance is maintained.

[6] 20 CSR 4240-22.040(1)

4.4 Compliance References

20 CSR 4240-22.040(1) 2, 16, 17
20 CSR 4240-22.040(2) 2
20 CSR 4240-22.040(2)(A) 10
20 CSR 4240-22.040(2)(B) 10
20 CSR 4240-22.040(2)(C)1 10
20 CSR 4240-22.040(3)(B) 5