

Chapter 5 - Appendix B

Characterization Data – Renewable and Storage Resources¹

Resource Option	Renewable Resource	Operations Mode	Technology Description	Plant Output, MW	Heat Rate HHV, Btu/kWh	Assumed Fuel Type / Source	Fuel Flexibility	Technology Maturity	Permitting, months	NTP to COD, months	Assumed Annual Capacity Factor, percentage	Forced Outage Rate, percentage
Compressed Air Energy Storage	n/a	Peaking	CAES	600	4,400	Nat Gas/Electric	Limited	Developing	18 to 24	48	30%	5%
Pumped Hydro Storage	n/a	Peaking	Pumped Storage	600	n/a	Hydro	n/a	Mature	36 to 48	72	25%	n/a
Wind	Wind	Intermittent	Wind	100	n/a	Wind	n/a	Mature	18 to 36	12	36%	n/a
Solar	Solar	Intermittent	PV	1	n/a	Solar	n/a	Mature	9 to 15	12	21%	n/a
Co-firing (St. Louis Region) 0 Note 1	Biomass	Baseload	Existing Host	28.8	10,125	Wood	Yes	Mature	12 to 18	12	85%	9%
Wood-fired Standalone (Ellington Region)	Biomass	Baseload	Sub Critical	13.5	14,500	Wood	Yes	Mature	18 to 24	32	80%	9%
Poultry-litter Standalone (Monett Region)	Biomass	Baseload	Sub Critical	29.6	14,500	Wood/Litter	Yes	Mature	18 to 24	32	80%	9%
Ozark Beach	Hydro	Baseload	Hydro	5	n/a	n/a	n/a	Mature	21 to 27	24	40%	5%
Clearwater	Hydro	Baseload	Hydro	5.3	n/a	n/a	n/a	Mature	21 to 27	24	40%	5%
Pomme De Terre	Hydro	Baseload	Hydro	4.6	n/a	n/a	n/a	Mature	21 to 27	24	60%	5%
Mississippi L&D 21	Hydro	Baseload	Hydro	10	n/a	n/a	n/a	Mature	21 to 27	24	40%	5%
Bridgeton	LFG	Baseload	RICE	8	13,560	LFG	No	Mature	12 to 18	15	92%	5%
Fred Weber	LFG	Baseload	CT	13	12,250	LFG	No	Mature	12 to 18	15	90%	5%
Lemons East	LFG	Baseload	RICE	2	13,750	LFG	No	Mature	12 to 18	15	90%	5%
Missouri Pass	LFG	Baseload	RICE	2.5	12,500	LFG	No	Mature	12 to 18	15	90%	5%
Yeolia Maple Hill	LFG	Baseload	RICE	4	13,750	LFG	No	Mature	12 to 18	15	92%	5%
Mercer County 1	AD	Baseload	RICE	3.9	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Sullivan County 1	AD	Baseload	RICE	3.2	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Gentry County 1	AD	Baseload	RICE	2.1	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Putnam County 1	AD	Baseload	RICE	2.1	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Sullivan County 2	AD	Baseload	RICE	2.1	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Gentry County 2	AD	Baseload	RICE	1.9	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Sullivan County 3	AD	Baseload	RICE	1.8	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Mercer County 2	AD	Baseload	RICE	1.1	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Putnam County 2	AD	Baseload	RICE	3.2	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Sullivan County 4	AD	Baseload	RICE	3.1	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Vernon County	AD	Baseload	RICE	1.4	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Johnson County	AD	Baseload	RICE	2.5	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Lincoln County	AD	Baseload	RICE	1.4	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%
Lewis County	AD	Baseload	RICE	1.2	12,000	Digester Gas	No	Mature	12 to 18	12	90%	5%

¹ 4 CSR 240-22.040(1)(A); 4 CSR 240-22.040(1)(B); 4 CSR 240-22.040(1)(C); 4 CSR 240-22.040(1)(D); 4 CSR 240-22.040(1)(I); 4 CSR 240-22.040(1)(J)

Characterization Data – Renewable and Storage Resources²

Resource Option	Renewable Resource	Tax Life, years	Economic Life, years	Owner's Cost, percent	AFUDC Cost, percent	Total Owner's Cost, percent	EPC Capital Cost, \$1,000	EPC Capital Cost, \$/kW	Total Project Cost - Includes Owners Cost, \$1,000	Total Project Cost - Includes Owners Cost, \$/kW
Compressed Air Energy Storage	n/a	20	30	30%	16%	46%	\$690,000	\$1,150	\$1,006,800	\$1,680
Pumped Hydro Storage	n/a	20	40	43%	4%	47%	\$1,157,287	\$1,930	\$1,700,000	\$2,830
Wind	Wind	5	20	10%	9%	19%	\$181,800	\$1,818	\$200,000	\$2,000
Solar	Solar	5	20	1%	4%	5%	\$5,941	\$5,941	\$6,000	\$6,000
Co-firing (St. Louis Region) 0 Note 1	Biomass	7	20	26%	4%	30%	\$21,600	\$750	\$27,400	\$950
Wood-fired Standalone (Ellington Region)	Biomass	7	20	19%	11%	30%	\$96,500	\$7,150	\$114,900	\$8,510
Poultry-litter Standalone (Monett Region)	Biomass	7	20	19%	11%	30%	\$153,900	\$5,200	\$183,200	\$6,190
Ozark Beach	Hydro	20	30	22%	8%	30%	\$12,500	\$2,500	\$15,300	\$3,050
Clearwater	Hydro	20	30	22%	8%	30%	\$21,200	\$4,000	\$25,900	\$4,880
Pomme De Terre	Hydro	20	30	22%	8%	30%	\$16,100	\$3,500	\$19,600	\$4,270
Mississippi L&D 21	Hydro	20	30	22%	8%	30%	\$50,000	\$5,000	\$61,000	\$6,100
Bridgeton	LFG	7	15	25%	5%	30%	\$24,300	\$3,040	\$30,400	\$3,800
Fred Weber	LFG	7	15	25%	5%	30%	\$39,000	\$3,000	\$48,800	\$3,750
Lemons East	LFG	7	15	25%	5%	30%	\$6,500	\$3,240	\$8,100	\$4,050
Missouri Pass	LFG	7	15	25%	5%	30%	\$8,900	\$3,570	\$11,200	\$4,460
Veolia Maple Hill	LFG	7	15	25%	5%	30%	\$13,000	\$3,240	\$16,200	\$4,050
Mercer County 1	AD	7	15	26%	4%	30%	\$42,900	\$11,000	\$54,100	\$13,860
Sullivan County 1	AD	7	15	26%	4%	30%	\$36,000	\$11,250	\$45,400	\$14,180
Gentry County 1	AD	7	15	26%	4%	30%	\$25,000	\$11,900	\$31,500	\$14,990
Putnam County 1	AD	7	15	26%	4%	30%	\$25,100	\$11,950	\$31,600	\$15,060
Sullivan County 2	AD	7	15	26%	4%	30%	\$25,100	\$11,950	\$31,600	\$15,060
Gentry County 2	AD	7	15	26%	4%	30%	\$23,100	\$12,150	\$29,100	\$15,310
Sullivan County 3	AD	7	15	26%	4%	30%	\$22,000	\$12,200	\$27,700	\$15,370
Mercer County 2	AD	7	15	26%	4%	30%	\$14,900	\$13,500	\$18,700	\$17,010
Putnam County 2	AD	7	15	26%	4%	30%	\$36,000	\$11,250	\$45,400	\$14,180
Sullivan County 4	AD	7	15	26%	4%	30%	\$35,000	\$11,300	\$44,100	\$14,240
Vernon County	AD	7	15	26%	4%	30%	\$18,100	\$12,900	\$22,800	\$16,250
Johnson County	AD	7	15	26%	4%	30%	\$29,000	\$11,600	\$36,600	\$14,620
Lincoln County	AD	7	15	26%	4%	30%	\$17,900	\$12,800	\$22,600	\$16,130
Lewis County	AD	7	15	26%	4%	30%	\$16,000	\$13,350	\$20,200	\$16,820

² 4 CSR 240-22.040(1)(A); 4 CSR 240-22.040(1)(E); 4 CSR 240-22.040(8)(B)

Characterization Data – Renewable and Storage Resources³

Resource Option	Renewable Resource	First Year Fixed O&M Cost, \$1,000/yr	First Year Fixed O&M Cost, \$/kW-yr	First Year Variable O&M Cost, \$1,000/yr	First Year Variable O&M Cost, \$/MWh	First Year Total O&M Cost, \$/MWh	First Year Fuel Cost, \$/MBtu	NOx, lbm/MBtu	SO ₂ , lbm/MBtu	CO ₂ , lbm/MBtu
Compressed Air Energy Storage	n/a	2,820	4.7	5319	3.4	5.2	6.09	0.1	0.0006	117
Pumped Hydro Storage	n/a	1910	3.18	4244	3.23	6.41	n/a	0	0	0
Wind	Wind	5,000	50	0	0	50	n/a	0	0	0
Solar	Solar	10	10	0	0	10	n/a	0	0	0
Co-firing (St. Louis Region) 0 Note 1	Biomass	1,300	45	0	0	45	2.66	0	<0.1	carbon neutral
Wood-fired Standalone (Ellington Region)	Biomass	4000	295	1400	15	310	2.98	0	<0.1	carbon neutral
Poultry-litter Standalone (Monett Region)	Biomass	4400	150	2200	11	161	2.69	0	<0.1	carbon neutral
Ozark Beach	Hydro	0	0	90	5	5	n/a	0	0	0
Clearwater	Hydro	0	0	95	5	5	n/a	0	0	0
Pomme De Terre	Hydro	0	0	120	5	5	n/a	0	0	0
Mississippi L&D 21	Hydro	0	0	175	5	5	n/a	0	0	0
Bridgeton	LFG	300	40	700	10.9	50.9	2	0	Note 1	carbon neutral
Fred Weber	LFG	300	20	820	10.4	30.4	2	0	Note 1	carbon neutral
Lemons East	LFG	300	170	180	11.2	181.2	2	0	Note 1	carbon neutral
Missouri Pass	LFG	100	40	260	12.9	52.9	2	0	Note 1	carbon neutral
Veolia Maple Hill	LFG	700	170	360	11.2	181.2	2	0	Note 1	carbon neutral
Mercer County 1	AD	3,600	920	0	0	920	n/a	0	Note 1	carbon neutral
Sullivan County 1	AD	3000	930	0	0	930	n/a	0	Note 1	carbon neutral
Gentry County 1	AD	2000	975	0	0	975	n/a	0	Note 1	carbon neutral
Putnam County 1	AD	2100	980	0	0	980	n/a	0	Note 1	carbon neutral
Sullivan County 2	AD	2100	980	0	0	980	n/a	0	Note 1	carbon neutral
Gentry County 2	AD	1900	990	0	0	990	n/a	0	Note 1	carbon neutral
Sullivan County 3	AD	1800	992	0	0	992	n/a	0	Note 1	carbon neutral
Mercer County 2	AD	1200	1075	0	0	1075	n/a	0	Note 1	carbon neutral
Putnam County 2	AD	3000	930	0	0	930	n/a	0	Note 1	carbon neutral
Sullivan County 4	AD	2900	940	0	0	940	n/a	0	Note 1	carbon neutral
Vernon County	AD	1500	1040	0	0	1040	n/a	0	Note 1	carbon neutral
Johnson County	AD	2400	950	0	0	950	n/a	0	Note 1	carbon neutral
Lincoln County	AD	1400	1030	0	0	1030	n/a	0	Note 1	carbon neutral
Lewis County	AD	1300	1065	0	0	1065	n/a	0	Note 1	carbon neutral

Note 1 - SO₂ emissions are highly variable. Sulfur in bio-gas can range from 100 ppmvd to 12,000 ppmvd.

³ 4 CSR 240-22.040(1)(F); 4 CSR 240-22.040(1)(G); 4 CSR 240-22.040(1)(K)1.; 4 CSR 240-22.040(8)(C)

Characterization Data – Renewable and Storage Resources⁴

Resource Option	Renewable Resource	Plant Maintenance Pattern, week/year	Water Consumption, gal/min	VOM Escalation Rate, percent	Present Worth Discount Rate, percent	Fixed Charge Rate, percent	Candidate Option	Cost Rank	LCOE, ¢/kWh
Compressed Air Energy Storage	n/a	n/a	n/a	3.00%	7.67%	12.03%	No	10	18.30
Pumped Hydro Storage	n/a	n/a	n/a	3.00%	7.67%	11.83%	Yes	13	21.77
Wind	Wind	n/a	n/a	3.00%	7.70%	12.22%	Yes	2	10.81
Solar	Solar	n/a	n/a	3.00%	7.70%	12.22%	Yes	16	37.3
Co-firing (St. Louis Region) 0 Note 1	Biomass	3-3-3-3-3-8	0	3.00%	7.70%	12.49%	Yes	1	5.90
Wood-fired Standalone (Ellington Region)	Biomass	3-3-3-3-3-8	300 to 400	3.00%	7.70%	12.49%	No	15	29.02
Poultry-litter Standalone (Monett Region)	Biomass	3-3-3-3-3-8	300 to 400	3.00%	7.70%	12.49%	No	12	20.68
Ozark Beach	Hydro	1	0	3.00%	7.70%	12.42%	No	6	11.80
Clearwater	Hydro	1	0	3.00%	7.70%	12.42%	No	11	18.92
Pomme De Terre	Hydro	1	0	3.00%	7.70%	12.42%	No	4	11.01
Mississippi L&D 21	Hydro	1	0	3.00%	7.70%	12.42%	No	14	23.67
Bridgeton	LFG	1-1-3	0	3.00%	7.70%	14.18%	No	5	11.42
Fred Weber	LFG	1-1-3	0	3.00%	7.70%	14.18%	Yes	3	10.90
Lemons East	LFG	1-1-3	0	3.00%	7.70%	14.18%	No	9	14.17
Missouri Pass	LFG	1-1-3	0	3.00%	7.70%	14.18%	No	7	12.86
Veolia Maple Hill	LFG	1-1-3	0	3.00%	7.70%	14.18%	No	8	13.94
Mercer County 1	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	17	39.77
Sullivan County 1	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	18	40.53
Gentry County 1	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	22	42.79
Putnam County 1	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	23	42.99
Sullivan County 2	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	23	42.99
Gentry County 2	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	25	43.63
Sullivan County 3	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	26	43.77
Mercer County 2	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	30	48.18
Putnam County 2	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	18	40.53
Sullivan County 4	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	20	40.80
Vernon County	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	28	46.20
Johnson County	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	21	41.68
Lincoln County	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	27	45.80
Lewis County	AD	1-1-3	0 to 20	3.00%	7.70%	14.18%	No	29	47.68

CAES was excluded because Ameren Missouri decided to evaluate pumped storage as the mass energy storage technology. The anaerobic digestion (AD) and biomass stand-alone projects were excluded based on cost. The remaining landfill gas and hydro projects were excluded because they are relatively small and opportunistic in nature. Ameren Missouri will continue to consider these projects but they were not analyzed further in this IRP.⁵ Ozark Beach was disqualified since it is owned and operated by Empire District Electric.

⁴ 4 CSR 240-22.040(2); 4 CSR 240-22.040(9)(B); 4 CSR 240-22.040(1)(H); 4 CSR 240-22.040(1)(K)3.; 4 CSR 240-22.040(2)(C); 4 CSR 240-22.040(9)(A)2.; 4 CSR 240-22.040(9)(A); 4 CSR 240-22.040(9)(A)1.

⁵ 4 CSR 240-22.040(9)(A)3.

Characterization Data – Renewable and Storage Resources⁶

Capital Cost Uncertainty Distribution.					
Deviation	-30%	-15%	0%	15%	30%
Probability	5%	25%	40%	25%	5%

Fixed O&M Cost Uncertainty Distribution.					
Deviation	-30%	-15%	0%	15%	30%
Probability	5%	25%	40%	25%	5%

Variable O&M Cost Uncertainty Distribution.				
Biomass Combustion – Standalone				
Deviation	-50%	Base	50%	
Probability	25%	50%	25%	
Biomass Combustion – Co-firing				
Deviation	-60%	Base	40%	80%
Probability	15%	50%	25%	10%
LFG – Reciprocating Engine				
Deviation	-50%	Base	50%	
Probability	25%	50%	25%	
LFG – Combustion Turbine				
Deviation	-50%	Base	50%	
Probability	25%	50%	25%	
Hydroelectric				
Deviation	-50%	Base	50%	
Probability	25%	50%	25%	

Forced Outage Rate Uncertainty Distribution.			
Biomass Combustion – Standalone			
EFOR	7%	10%	13%
EFORd	7%	10%	12%
Probability	-25%	50%	25%
Biomass Combustion – Co-firing			
EFOR	4%	8%	12%
EFORd	4%	8%	12%
Probability	-25%	50%	25%
LFG – Reciprocating Engine			
EFOR	3%	8%	12%
EFORd	3%	7%	11%
Probability	-25%	50%	25%
LFG – Combustion Turbine			
EFOR	2%	7%	12%
EFORd	2%	6%	11%
Probability	-25%	50%	25%
Hydroelectric			
EFOR	1%	3%	8%
EFORd	1%	3%	7%
Probability	-25%	50%	25%

⁶ 4 CSR 240-22.040(9)(C); 4 CSR 240-22.040(8)(B)2.; 4 CSR 240-22.040(8)(C)2.

Table 5.B.1 Potential Items for Owner's Costs⁷

Potential Owner's Costs	
Project Development: Site selection study Land purchase/options/rezoning Transmission/gas pipeline rights of way Road modifications/upgrades Demolition (if applicable) Environmental permitting/offsets Public relations/community development Legal assistance Utility Interconnections: Natural gas service (if applicable) Gas system upgrades (if applicable) Electrical transmission Supply water Wastewater/sewer (if applicable) Spare Parts and Plant Equipment: Air quality control systems materials, supplies, and parts Acid gas treating materials, supplies and parts Combustion turbine and steam turbine materials, supplies, and parts HRSG materials, supplies, and parts Gasifier materials, supplies, and parts Balance-of-plant equipment materials, supplies and parts Rolling stock Plant furnishings and supplies Operating spares Owner's Project Management: Preparation of bid documents and selection of contractor(s) and suppliers Provision of project management Performance of engineering due diligence Provision of personnel for site construction Management	Plant Startup/Construction Support: Owner's site mobilization O&M staff training Supply of trained operators to support equipment testing and commissioning Initial test fluids and lubricants Initial inventory of chemicals/reagents Consumables Cost of fuel not recovered in power sales Auxiliary power purchase Construction all-risk insurance Acceptance testing Taxes/Advisory Fees/Legal: Taxes Market and environmental consultants Owner's legal expenses: • Power Purchase Agreement (PPA) • Interconnect agreements • Contracts--procurement & construction • Property transfer Owner's Contingency: Owner's uncertainty and costs pending final negotiation: • Unidentified project scope increases • Unidentified project requirements • Costs pending final agreement (e.g., interconnection contract costs) Financing: Development of financing sufficient to meet project obligations or obtaining alternate sources of funding Financial advisor, lender's legal, market analyst, and engineer Interest during construction Loan administration and commitment fees Debt service reserve fund Miscellaneous: All costs for above-mentioned Contractor-excluded items, if applicable

The technologies evaluated by Black and Veatch estimated generic transmission interconnection costs as a percentage of the EPC cost. Ameren Missouri included an estimate of 2.5 Million for the interconnection cost of pumped hydro at the Church Mountain site. The interconnection cost for solar was assumed to be located at an existing Ameren Missouri power plant site.

⁷ 4 CSR 240-22.040(3); 4 CSR 240-22.040(6)

Compliance References

4 CSR 240-22.040(1)(A)	1, 2
4 CSR 240-22.040(1)(B)	1
4 CSR 240-22.040(1)(C)	1
4 CSR 240-22.040(1)(D)	1
4 CSR 240-22.040(1)(E)	2
4 CSR 240-22.040(1)(F).....	3
4 CSR 240-22.040(1)(G)	3
4 CSR 240-22.040(1)(H)	4
4 CSR 240-22.040(1)(I).....	1
4 CSR 240-22.040(1)(K)1.	3
4 CSR 240-22.040(1)(K)3.	4
4 CSR 240-22.040(2)	4
4 CSR 240-22.040(2)(C)	4
4 CSR 240-22.040(3)	6
4 CSR 240-22.040(6)	6
4 CSR 240-22.040(8)(B)	2
4 CSR 240-22.040(8)(B)2.	5
4 CSR 240-22.040(8)(C)	3
4 CSR 240-22.040(8)(C)2.	5
4 CSR 240-22.040(9)(A)	4
4 CSR 240-22.040(9)(A)1.	4
4 CSR 240-22.040(9)(A)2.	4
4 CSR 240-22.040(9)(A)3.	4
4 CSR 240-22.040(9)(B)	4
4 CSR 240-22.040(9)(C)	5