RESOURCE ALTERNATIVES

This section of the IRP reviews the supply-side and demand-side resources reviewed in the resource plan. Black & Veatch developed a 2013 Power Station Characterization Study (B&V Study) for IPL, which is the main source of information for traditional supply-side resources, and covers a wide range of alternatives. Additionally, IPL relied on information from the 2016 National Renewable Energy Laboratory - Annual Technology Baseline ("NREL – ATB") to update solar and wind cost and performance data, as well as potential wind projects.[1] A copy of the Table of Contents from the 2013 Power Station Characterization Study is included in Appendix 3A.

3.0 Supply-Side Alternatives

Many technologies are applicable to supply-side resources. These technologies are separately discussed in subsequent sections. For purposes of this B&V Study, supply-side technologies are categorized as follows:

Category	Technology
Renewable	Wind
	Solar-Photovoltaic
	Solar-Thermal
	Biomass
	Geothermal
	Biogas-Anaerobic Digestion
	Biogas-Landfill Gas
	Hydro
Fossil Fuel	Pulverized Coal
	Combined Cycle
	Combustion Turbine
	Integrated Gasification Combined Cycle
Purchased Power	Cogeneration/Distributed Generation
	Independent Power Producer
	Another Utility
	MISO Market Energy
Nuclear	Nuclear

3.0.1 Renewable

The IRP discusses eight renewable technologies: wind, solar-photovoltaic, solar-thermal, biomass, geothermal, biogas-anaerobic digestion, biogas-landfill gas and hydro.

[1] Information about the NERL-ABT is available at: http://www.nrel.gov/analysis/data_tech_baseline.html.

3.0.1(a) Wind

IPL has significantly expanded the wind resources in its portfolio, and continues with further wind expansion:

- IPL has Power Purchase Agreements ("PPAs") for approximately 250 MW (nameplate) of wind energy, of which almost all is located in Iowa.
- In 2009, IPL installed 200 MW of owned-wind generation in Iowa (Whispering Willow Windfarm – East or "WWE").
- In 2016, the Iowa Utilities Board approved advance ratemaking principles for a wind addition up to 500 MW in Iowa (Docket No. RPU-2016-0005, "New Wind Project"). IPL expects this project to be in-service in the 2019-2020 timeframe.
- In 2017, IPL acquired the 99 MW Franklin County wind farm, placing it into its wind portfolio.
- IPL signed a 15 year PPA for the 200 MW Turtle Creek wind farm in Mitchel County, Iowa, to be developed in 2018.
- In 2017, IPL filed a request for advanced ratemaking principles with the Iowa Utilities Board for an additional 500 MW of wind generation (Docket No. RPU-2017-0002, "New Wind II Project").

Summary historical data for IPL's wind resources is included in Appendix 3B. For EGEAS modeling, IPL approximates representative capacity factors based on actual data from a historical year. Section 8 of the B&V Study focuses on renewable energy technology options.

For new wind cost and performance data, IPL approximated its New Wind II Project with capital cost trajectories scaled to the 2016 NREL-ATB information.

3.0.1(b) Solar-Photovoltaic (PV)

With declines in capital costs, PV has received increased consumer and utility recognition. Solar PV was modeled as a resource option in the EGEAS analysis for this IRP based on 2016 NREL-ATB information. In September 2017, IPL commissioned a 5 MW utility-owned solar installation in Dubuque, Iowa—the largest single operating solar generation system in Iowa. Experience gained building, operating, and maintaining this solar facility will be invaluable as we look to the future.

3.0.1(c) Solar-Thermal

A general feature of solar thermal systems (also known as "Concentrating Solar Power" or "CSP") and PV solar technologies is that peak output typically occurs on summer days when electrical demand, while not necessarily at its daily peak, is high. However, the costs of CSP technology are still greater than PV, and CSP appears better suited for the Southwestern United States. There is poor potential for utilization of solar thermal energy within IPL's service territory. Coupling the high technology costs with poor potential for utilization makes this technology an unattractive option for IPL at this time.

3.0.1(d) Biomass

There is reasonable potential for power production from biomass combustion in IPL's service territory. However, fuel stream limitations, higher biomass capital costs, and declining costs for wind and solar resources make biomass less attractive.

3.0.1(e) Geothermal

Geothermal power is limited to locations where geothermal pressure reserves are found. Well temperature profiles determine the potential for geothermal development and the type of geothermal power plant installed. Because there are no known significant geothermal sources in this region, the potential for electricity generation from geothermal energy is poor in IPL's service territory.

3.0.1(f) Biogas-Anaerobic Digestion

The most common applications of anaerobic digestion use industrial wastewater, animal manure or human sewage. In agriculture applications, anaerobic digesters can be installed where there is a clean, continuous source of manure. For on-farm manure digestion, the resource is readily accessible and only minor modifications are required to the existing manure management techniques. In some cases, economies of scale may be realized by transporting manure from multiple farms to a central digestion facility. IPL's service territory covers vast areas of farm land with large numbers of livestock; therefore, there is some potential for anaerobic digestion within IPL's service territory.

3.0.1(g) Biogas-Landfill Gas

From an energy generation perspective, landfill gas (LFG) is a valuable resource that can be burned as fuel by reciprocating engines, small combustion turbine generators or other devices. Gas production in a landfill is primarily dependent upon the depth of waste in place, age of waste in place and amount of precipitation received by the landfill. There is some potential for power generation from LFG in IPL's service territory.

3.0.1(h) Hydro

Hydroelectric generation is usually regarded as a mature technology that is unlikely to advance. The best sources of hydro generation in IPL's service territory have already been developed. Therefore, additional hydroelectric generation in IPL's service territory is most likely limited to upgrading of existing facilities. Currently, hydroelectric power is a very small percentage of IPL's resource mix.

3.0.2 Fossil Fuel

Much of the historical electrical energy generated by IPL's generating facilities has been from fossil fuels such as coal and natural gas. However, as discussed elsewhere in this resource plan, IPL's energy portfolio mix is evolving to include significantly more wind energy.

3.0.2(a) Pulverized Coal

Pulverized coal is a mature technology that historically provided a sizable portion of energy in the Midwest.

3.0.2(b) Combined Cycle

Combined cycle refers to the recovery of heat from one turbine, as an example from a combustion turbine, to generate steam to run another generator. Input fuels are oil, natural gas or coal gas. Such units are more efficient than pulverized coal units and can be constructed in stages.

3.0.2(c) Combustion Turbine

IPL has a number of combustion turbines on its system, but these units are peaking units and generate only a small amount of the total electrical energy produced by IPL. Combustion turbine units continue to be attractive options for meeting system requirements at peak times.

3.0.2(d) Integrated Gasification Combined Cycle

The integrated gasification combined cycle (IGCC) application for power generation uses the Shell Coal Gasification Process.

3.0.3 Purchased Power

IPL purchases electrical energy from the Midcontinent Independent System Operator ("MISO"), other utilities, independent developers and power marketers. The decisions regarding purchased power are primarily functions of need, availability, and cost. IPL will continue to purchase power when it makes sense to do so.

3.0.3(a) Cogeneration

Cogeneration refers to facilities that produce electricity, as well as other forms of energy, such as steam.

3.0.3(b) Independent Power Producer

An independent power producer ("IPP") is a non-utility that produces electrical energy for use by electric utilities. IPPs use the same technologies as electric utilities. Capacity and energy from IPPs will continue to be evaluated and used, if available and economical.

3.0.3(c) Another Utility

IPL may purchase power from other utilities on a short-term or seasonal basis, if available and economical.

3.0.3(d) MISO Market Energy

IPL purchases power many hours throughout the year from MISO. In IPL's IRP modeling, energy from the market can be purchased in every hour of every year of the study period when available and economic.

3.0.4 Nuclear

Typical nuclear units are rated at 600 MW or larger and have high capital requirements. Nuclear was modeled as a resource alternative in the EGEAS analysis for this resource plan.

3.1 Demand-Side Alternatives

DSM programs for this resource plan are categorized into two types of programs: conservation (non-dispatchable) and load management (dispatchable). IPL has achieved considerable demand and energy savings from DSM programs. DSM programs will continue to be a potential resource alternative, provided such programs are economical.

3.2 Future Resource Alternatives

Based on the screening of all resource alternatives and the conclusions given in Sections 3.0 and 3.1, purchased power, combustion turbines, combined cycles, pulverized coal, IGCC, wind, biomass, biogas, solar and nuclear were all evaluated in some form for this resource plan. IPL is committed to meeting the demands of its customers with economic, reliable, safe and environmentally sound resources. Furthermore, IPL's DSM programs and renewable resource portfolio demonstrate IPL's commitment to environmentally sound resources as part of its resource mix.

Information as to the types, sizes and costs for all future units modeled in EGEAS for this resource plan is given in Appendix 3C. With respect to resource costs changing over time, nominal change rates for O&M expenses and capital investment can be found in Appendix 3D.

FINAL

2013 POWER STATION CHARACTERIZATION STUDY

B&V PROJECT NO. 179934
B&V FILE NO. 40.1200

REVISION 2

PREPARED FOR

Alliant Energy

NOVEMBER 2013

BLACK & VEATCH
Building a world of difference.

Table of Contents

LIST OF TABLES

LIST OF FIGURES

IPL's Existing Purchased Wind Sources

GWH output:

EGEAS Name	MW	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2012-2016 average
WIND CERRO HWKEY	41.3	101	100	106	101	101	91	103	105	95	84	75	82	87	90	93	88	88	89
WIND FLYING	43.5					156	151	152	144	141	125	134	142	149	143	154	144	138	146
WIND BINGM WINDM	15								43	42	40	41	43	44	43	46	43	42	44
WIND ADAMS	6					14	13	15	15	14	13	13	13	13	7	11	13	12	11
WIND BEAVER MINW	3.9					11	10	11	11	10	9	9	10	10	10	11	8	8	9
WIND BUENA STORM	78.75	214	206	229	192	180	193	205	185	162	147	167	189	196	194	193	186	155	185
WIND HANCOCK	56.8					156	138	153	148	139	130	139	140	149	146	155	150	150	150
WIND HARDIN HILL	14.7									29	39	39	47	47	49	49	45	46	47
WIND JCT HILLTOP	8													23	31	31	28	25	27
WIND WHSP WLW	200											353	568	579	639	622	653	630	625

CF % output:

EGEAS Name	MW	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2012-2016 average
WIND CERRO HWKEY	41.3	28%	28%	29%	28%	28%	25%	28%	29%	26%	23%	21%	23%	24%	25%	26%	24%	24%	25%
WIND FLYING	43.5					41%	40%	40%	38%	37%	33%	35%	37%	39%	38%	40%	38%	36%	38%
WIND BINGM WINDM	15								33%	32%	30%	31%	33%	34%	33%	35%	33%	32%	33%
WIND ADAMS	6					26%	25%	28%	29%	27%	24%	25%	25%	26%	14%	22%	25%	24%	22%
WIND BEAVER MINW	3.9					32%	31%	31%	33%	30%	28%	27%	29%	29%	29%	32%	25%	22%	27%
WIND BUENA STORM	78.75	31%	30%	33%	28%	26%	28%	30%	27%	24%	21%	24%	27%	28%	28%	28%	27%	22%	27%
WIND HANCOCK	56.8					31%	28%	30%	30%	28%	26%	28%	28%	30%	29%	31%	30%	30%	30%
WIND HARDIN HILL	14.7			(new and trending up similar to WWE)						23%	30%	31%	37%	37%	38%	38%	35%	35%	37%
WIND JCT HILLTOP	8													33%	44%	44%	40%	36%	39%
WIND WHSP WLW	200											20%	32%	33%	36%	35%	37%	36%	36%

ADAMS = G McNeilus, NcNeilus Windfarm LLC, and GARMAR Wind
MinnWind I&II = Community Renewables

Generic Alternative Characteristics
IPL 2017 IRP

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EGEAS Unit	Rated Capacity (MW)	Operating Capacity (MW)	Reserve Capacity (MW)	Forced Outage Rate	Full Load Heat Rate (BTU/kWh)	Fuel Price ($/MMBTU)	Fixed O&M Cost ($/kW-Yr)	Technology Variable O&M ($/MWh)	Iowa Generation Tax ($/MWh)	EGEAS Variable O&M ($/MWh)	EPC Costs ($/kW)	Owner's & AFUDC Cost	Capital Cost ($/kW)	MACRS Deprec Sched (Years)	Operating Life, Book Life (Years)	ROE	Levelized Carrying Charge Rate
CT-38 (GE LM6000 PH)	37.9	37.9	32.617	13.94%	10,120		$ 30.45	$ 12.11	$ 0.61	$ 12.72	$ 1,579	30%	$ 2,053	15	35	10.300%	9.911%
CT-88 (GE LMS100PA)	87.8	87.8	82.585	5.94%	8,990		$ 13.72	$ 7.41	$ 0.61	$ 8.03	$ 1,211	30%	$ 1,574	15	35	10.300%	9.911%
CT-93 (Wartsila 6x18V50SG)	92.7	92.7	87.194	5.94%	10,040		$ 13.46	$ 13.54	$ 0.61	$ 14.16	$ 1,500	30%	$ 1,950	15	35	10.300%	9.911%
CT-192 (GE 7F 5-Series)	191.7	191.7	180.313	5.94%	10,210		$ 6.69	$ 18.23	$ 0.61	$ 18.84	$ 707	30%	$ 920	15	35	10.300%	9.911%
CC-300 (1x1 GE 7F 5-Series)	299.8	299.8	289.127	3.56%	6,700		$ 9.27	$ 3.16	$ 0.61	$ 3.77	$ 1,083	35%	$ 1,463	20	35	11.000%	10.739%
CC-605 (2x1 GE 7F 5-Series)	604.7	604.7	583.173	3.56%	6,640		$ 6.31	$ 3.10	$ 0.61	$ 3.71	$ 867	35%	$ 1,170	20	35	11.000%	10.739%
CC-300J	300	300	289.320	3.56%	6,640		$ 6.31	$ 3.10	$ 0.61	$ 3.71	$ 867	35%	$ 1,170	20	35	11.000%	10.739%
SOLAR50 (PV 25.6% CF)	50	50	25.000	0.00%	-		$ 16.48	$ -	$ 0.61	$ 0.61	-	-	$ 1,997	5	25	11.000%	10.117%
BIOMASS35 (Directed Fired)	35	35	32.127	8.21%	13,250		$ 153.31	$ 11.10	$ 0.61	$ 11.72	$ 5,498	25%	$ 6,873	5	35	11.000%	9.157%
BIOGAS10 (Landfill Gas)	10	10	8.832	11.68%	12,500		$ 74.01	$ 18.50	$ -	$ 18.50	$ 2,643	20%	$ 3,172	5	35	11.000%	9.157%
WIND 100 (44% CF)	100	100	15.5	0.00%	-		$ 35.81	$ -	$ -	$ -	-	-	$ 1,738	5	40	11.000%	8.908%
PC600 (USCPC)	600	600	550.740	8.21%	9,290		$ 25.20	$ 3.64	$ 0.61	$ 4.25	$ 2,687	45%	$ 3,897	20	35	11.000%	10.739%
PC420wCC (USCPC w/CC)	420	420	385.518	8.21%	13,453		$ 48.11	$ 6.96	$ 0.61	$ 7.57	$ 6,868	45%	$ 9,958	20	35	11.000%	10.739%
IGCC568	568	568	521.367	8.21%	8,800		$ 37.26	$ 6.79	$ 0.61	$ 7.40	$ 3,963	55%	$ 6,143	20	35	11.000%	10.739%
PPCT 1YR 50 (capacity only)	50	0	50	0.00%	-	-	$ 15.00	-	-	-	-	-	-		1	-	-
PPCT 10YR 150	150	150	141.090	5.94%	10,210	ref to CT-192	$ 106.95	$ 18.23	$ 0.61	$ 18.84	-	-	-		10	-	-
PPCC 10YR 150	150	150	144.660	3.56%	6,640	ref to CC-605	$ 144.51	$ 3.10	$ 0.61	$ 3.71	-	-	-		10	-	-
PPPC 10YR 150	150	150	137.685	8.21%	9,290	ref to PC600	$ 485.51	$ 3.64	$ 0.61	$ 4.25	-	-	-		10	-	-
NUCLEAR 300J	300	300	275.370	8.21%	10,400		$ 148.60	$ -	$ 0.61	$ 0.61	$ 4,407	45%	$ 6,390	15	35	11.000%	10.346%

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Costs are 2017$

In EGEAS, Solar ITC impact is modeled using Detailed Capital Costs:

30% of capital investment, 30% x $1,997/kW / (1 - 41.57% tax gross-up) = -1025 $/kW-yr over 1 year

Assumes ITC reduces to 26% for 2022 solar, 22% for 2023 solar, 10% for 2024 solar, and 0% for 2025+ solar

In EGEAS, Wind 10 year PTC impact is levelized and modeled with Detailed Capital Costs:

$23.89/MWh x 44% CF x 8760 h / 1000 kW per MWh / (1 - 41.57% tax gross-up) * 96% tax dampening impact * 1.0823 = -164 $/kW-yr over 10 year book life and 100% LFCR

where 1.0823 is an escalation adjustment because the EGEAS 10 year Detailed Costs are fixed at the start value, but PTCs escalate each year

Assuming a construction schedule such that PTC declines 20% for 2021 wind, 40% for 2022 wind, 60% for 2023 wind, and 100% for 2024 wind

IPL 2017 IRP
Nominal Escalation Rates, to next year (EGEAS EDIT file convention)

General Escalation Rate per Wood Mackenzie H2 2016 Long Term Outlook
General Escalation Rate applicable to capital and O&M, with the exception of Wind and Solar capital maturity curves and Solar Fixed O&M.
Wind and Solar nominal capital escalation rates, and Solar Fixed O&M, per 2016 NREL – ATB (National Renewable Energy Laboratory - Annual Technology Baseline),
http://www.nrel.gov/analysis/data_tech_baseline.html
inflated to nominal per the Wood Mackenzie escalation rate

Year	General Escalation Rate (incl Wind Fixed O&M)	Wind Capital Escalation Rate	Solar Capital Escalation Rate	Solar Fixed O&M Escalation Rate
	[TRADE SECRET DATA BEGINS			
2017				
2018				
2019				
2020				
2021				
2022				
2023				
2024				
2025				
2026				
2027				
2028				
2029				
2030				
2031				
2032				
2033				
2034				
2035				
2036				
2037				

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