2019 IRP Electric Supply-Side Resources - Thermal

Draft as of 1/24/19

2018 $	Units	Frame Peaker		CCCT	Recip Peaker		
		1x0 F-Class Dual Fuel CT (NG)	1x0 F-Class Dual Fuel CT (FO)	1x1 F-Class CC (NG Only)	12x0 18 MW Class RICE (NG Only)	12x0 18 MW Dual Fuel RICE (NG)	12x0 18 MW Dual Fuel RICE (FO)
ISO Capacity Primary	MW	225	217	336	219	201	173
Winter Capacity Primary (23° F)	MW	237	229	348	219	201	173
Incremental Capacity DF (23 degrees F)	MW			19			
Capital Cost + Duct Fire*	$/KW	$825		$1,167	$1,192	$1,357	
O&M Fixed (b)	$/KW-yr	$11.40		$13.44	$3.74	$11.59	
Flexibility	$/KW-yr						
O&M Variable	$/MWh	$0.69		$2.45	$5.30	$5.80	
Start Up Costs	$/Start	$6,502					
Capacity Credit	%						
Operating Reserves	%	3%	3%	3%	3%	3%	3%
Forced Outage Rate	%	2.38%	2.38%	3.88%	3.30%	3.30%	3.30%
Heat Rate – Baseload (HHV)	Btu/KWh	9,904	10,056	6,624	8,445	8,582	8,780
Heat Rate – Turndown (HHV)	Btu/KWh	15,794	12,856	7,988	11,288	11,471	11,736
Heat Rate – DF	Btu/KWh			8,867			
Min Capacity	%	30%	50%	38%	30%	30%	30%
Start Time (hot)	minutes	21	21	45	5	5	5
Start Time (warm)	minutes	21	21	60	5	5	5
Start Time (cold)	minutes	21	21	150	5	5	5
Start up fuel (hot)	mmBtu	366	338	839	69	69	57
Start up fuel (warm)	mmBtu	366	338	1,119	69	69	57
Start up fuel (cold)	mmBtu	366	338	2,797	69	69	57
Ramp Rate (a)	MW/min	40	40	40	16	16	16
Location		PSE	PSE	PSE	PSE	PSE	PSE
Fixed Gas Transport	$/Dth/Day	$0.00		$0.77	$0.77	$0.00	
Fixed Gas Transport	$/KW-yr	$0.00		$44.70	$56.98	$0.00	
Variable Gas Transport	$/MMBtu	$0.04		$0.06	$0.06	$0.04	
Fixed Transmission	$/KW-yr	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Variable Transmission	$/MWh	$0.00	$0.00	$0.00	$0.00	$0.00	$0.00
Emissions:							
CO_2 - Natural Gas	lbs/MMBtu	118		118	118	122	
CO_2 - Distillate Fuel Oil	lbs/MMBtu		160				160
NOx - Natural Gas	lbs/MMBtu	0.004		0.008	0.029	0.037	
NOx - Distillate Fuel Oil	lbs/MMBtu		0.014				0.130
First Year Available		2022	2022	2022	2022	2022	2022
Economic Life	Years	30	30	30	30	30	30
Greenfield Dev. & Const. Lead-time	years	1.8	1.8	2.7	2.3	2.3	2.3

2019 IRP Electric Supply-Side Resources - Renewables

Draft as of 1/24/19

2018 $	Units	On-Shore Wind - MT (Site #3)	On-Shore Wind - MT (Site #3)	On-Shore Wind - SE Wash.	Offshore Wind - WA Coast	Solar PV - WA	Biomass
ISO Capacity Primary	MW	100	300	300	300	100	15
Winter Capacity Primary	MW						
Capacity Credit	%						
Operating Reserves	%	3%	3%	3%	3%	3%	3%
Capacity Factor	%	45.8%	45.8%	31.9%	35.3%	24.2%	85%
Capital Cost (a)	$/KW	$1,722	$1,617	$1,633	$6,547	$1,614	$9,695
O&M Fixed	$/KW-yr	$37.00	$37.00	$37.00	$120.00	$21.90	$345.20
O&M Variable	$/MWh	$0.00	$0.00	$0.00	$0.00	$0.00	$6.60
Land Area	acres/MW	48.2	48.2	48.2		5 - 7	6 - 8
Degradation	%/year	0	0	0	0	0.50%	N/A
Location	-	Eastern MT	Eastern MT	Eastern WA	Coast of WA	Eastern WA	Western WA
Fixed Transmission	$/KW-yr	$53.38	$53.38	$33.64	$33.64	$24.04	$21.52
Variable Transmission	$/MWh	$0.00	$0.00	$2.19	$2.19	$2.19	$0.00
Loss Factor to PSE	%	4.6%	4.6%	1.9%	1.9%	1.9%	1.9%
Heat Rate – Baseload (HHV)	Btu/KWh						14,599
Emissions:							
NO_x	lbs/MMBtu						0.03
SO_2	lbs/MMBtu						0.03
CO_2	lbs/MMBtu						213
First Year Available		2022	2022	2022	2022	2022	2022
Economic Life	Years	25	25	25	25	20	30
Greenfield Dev. & Const. Leadtime	years	2.0	2.0	2.0	3.2	1.0	3.3

2018 $	Solar + Battery	Solar PV - WA	Li-Ion 2-hr (2 Cycles Daily)
ISO Capacity Primary	125	100	25
Winter Capacity Primary			
Capacity Credit			
Operating Reserves	3%	3%	3%
Capacity Factor	24.2%	24.2%	
Capital Cost (f)	$3,164	$1,614	$1,550
O&M Fixed	$42.44	$21.90	$20.54
O&M Variable			
Land Area	5 - 7	5 - 7	
Degradation	0.50%	0.50%	(d)
Location	Eastern WA	Eastern WA	PSE
Fixed Transmission	$24.06	$24.04	0
Variable Transmission	$2.19	$2.19	0
Loss Factor to PSE	1.9%	1.9%	
Heat Rate – Baseload (HHV)			
Emissions:			
NO_x			
SO_2			
CO_2			
First Year Available	2022	2022	2022
Economic Life	20	20	20
Greenfield Dev. & Const. Leadtime	1	1	1
Forced Outage Rate	2%		2%
Operating Range (e)	2%		2%
R/T Efficiency	82%		82%
Discharge at Nominal Power	2		2

Notes

a - Capital cost does not include ITC

Li-ion BESS: Additional capacity prepurchased included in capital to ensure 20 yr operating life

d - Fixed O&M costs costs include augmentation by OEM ensuring MW and MWh rating for project life.

e - Battery can discharge upto the indicated percent of nameplate

f - Capital costs for Battery does not include interconnection costs. The interconnection cost is included on the solar capital cost.

2019 IRP Electric Supply-Side Resources - Energy Storage

Draft as of 1/24/19

2018 $	Units	Pumped Hydro Energy Storage		Battery Energy Storage System (BESS)			
		Closed Loop (8 Hour)	Closed Loop (8 Hour)	Li-Ion 2-hr (2 Cycles Daily)	Li-Ion 4-hr (2 Cycles Daily)	Flow 4-hr (2 Cycles Daily)	Flow 6-hr (2 Cycles Daily)
Nameplate Capacity	MW	500	300	25	25	25	25
Winter Capacity	MW						
Capacity Credit	%						
Operating Reserves	%	3%	3%	3%	3%	3%	3%
Capital Cost	$/KW	$2,661	$2,679	$1,930	$3,059	$2,111	$2,758
O&M Fixed	$/KW-yr	$14.55	$17.40	$20.54	$32.16	$30.80	$40.27
O&M Variable	$/MWh	$0.90	$1.50	$0.00	$0.00	$0.00	$0.00
Forced Outage Rate	%	1%	1%	2.0%	2.0%	5.0%	5.0%
Degredation	%/year	(a)	(a)	(d)	(d)	(d)	(d)
Operating Range (e)	%	147-500 MW (b)	112.5-300 MW (c)	2.0%	2.0%	2.0%	2.0%
R/T Efficiency	%	80%	80%	82%	87%	73%	73%
Discharge at Nominal Power	Hours	8	8	2	4	4	6
Loss Factor to PSE	%	1.9%	1.9%				
Location		PNW	PNW	PSE	PSE	PSE	PSE
Fixed Transmission	$/KW-yr	$21.52	$21.52				
Variable Transmission	$/MWh						
Flexbility Benefit	$/KW-yr						
First Year Available		2025	2025	2021	2021	2021	2021
Economic Life	Years	30+	30+	20	20	20	20
Greenfield Dev. & Const. Leadtime	years	5 - 8	5 - 8	1	1	1	1

Notes

PHES (assumed to represent a slice of a larger project).

a - PHES degradation close to zero

b - The operating range minimum is the average of the minimum at max (111 MW) and min head (183 MW).

c - The operating range minimum is the average of the minimum at max (86 MW) and min head (139 MW).

Li-ion BESS: Additional capacity prepurchased included in capital to ensure 20 yr operating life

d - Fixed O&M costs costs include augmentation by OEM ensuring MW and MWh rating for project life.

e - Battery can discharge upto the indicated percent of nameplate