

COLUMBIA GENERATING STATION MARKET TEST

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SUMMARY

Billions of dollars in economic gains or losses are at stake from running the Columbia Generating Station, a nuclear energy facility owned and operated by Energy Northwest. A first-order market test suggests Pacific Northwest electricity customers could pay about \$1.64 billion more for Columbia's power than purchasing it from the wholesale power market through 2028. Energy efficiency measures, such as substituting LEDs for inefficient lighting, can more than offset Columbia's lost capacity. The Bonneville Power Administration (BPA), the sole purchaser of Columbia's output, should conduct its own market test to assess Columbia's economic competitiveness, as it originally pledged doing in 1998.

INTRODUCTION

A recent Bloomberg news service articleⁱⁱ reported that nuclear power reactors' profits have been squeezed by cheap natural gas and renewables. The revelation came with a better understanding of the economic magnitude. More than half of U.S. nuclear reactors are bleeding cash, racking up losses totaling about \$2.9 billion a year.

Nationally, nuclear power plants are getting paid \$20 to \$30 a megawatt-hour for their electricity. Meanwhile, it costs them an average of \$35 a megawatt-hour to run. That puts 34 of the nation's nuclear power plants out of the money, appearing to operate below their economic break-even point.

Unless subsidized, any facility running below its economic break-even point will eventually have to shut down. The economic shutdown rule states that "to produce in the short run, a firm must earn sufficient revenue to cover its variable costs."

MARKET TEST

Could it be true that Columbia's variable running costs are higher than other available options? Because the Columbia constitutes about 3.5 percent of the regional power capabilityⁱⁱⁱ, annual monetary gains or losses from its operation are a multibillion-dollar proposition.

What's a market test? We market-test every day when comparing the value of the goods and services we purchase. Consider this market test example. All other things being held equal, which service station would you buy gasoline from? Would it be the service station selling fuel for \$5 per gallon, or would you purchase from the one selling exactly the same product for \$2.50 per gallon? My bet is that you'll be pulling into the less costly service station along with me.

In 1998, BPA stated it would conduct a market test of Columbia to assess its economic competitiveness. This resulted from customer complaints that it would never be cost-effective.^{iv}

BPA's market test commitment stated: "This biennial test will determine whether the market value of the WNP-2 (now Columbia) output recovers annual operating costs of the plant. As recommended in the Cost Review, BPA will evaluate plant termination if operating costs are projected to exceed revenues achievable at market prices." BPA also stated its intention to solicit input, in a public process, on the precise nature of this market test.

The market test might have happened, but the exigencies of the 2000-2001 energy crisis took over. Many factors, including drought in the Pacific Northwest and fraudulent market manipulation, created a "perfect storm" for capacity shortfalls and volatile power prices.^v

BPA suddenly had to acquire 3,300 megawatts during a period of extremely high prices. Columbia reportedly saved the region \$1.4 billion dollars^{vi} compared to buying wholesale power from the Mid-Columbia (Mid-C) trading hub.

Years passed, and the market test issue was raised in 2013 in a battle between two consultants.

One concluded that Columbia's power was significantly more expensive than wholesale power purchased from the Mid-C hub. The report found if BPA could substitute Mid-C hub electricity for Columbia's through 2043, the region would save at least \$1.7 billion. The other report concluded that continuing to operate Columbia could save consumers \$1.6 billion through 2043, compared to constructing a new natural gas generation system.

Certainly, both are correct. However, they addressed two entirely different questions. Even its supporters admit Columbia's current running costs exceed Mid-C hub prices. However, permanently closing Columbia, and losing its capacity, deserves serious consideration.

"Clearly, the two studies were prepared by experts and assess an important resource in the Northwest power supply. The fact that they arrive at polar opposite conclusions is a puzzle, but also is an important issue for the region. Independent analysis of future resource costs is critical to making the best decisions about future sources of electricity. There are uncertainties on both sides of the issue, such as the future cost and performance of CGS, safety considerations of nuclear power, and costs of alternative power supplies."^{vii}

This multibillion-dollar puzzle certainly warrants a transparent evaluation on a regular basis.

COLUMBIA MARKET TEST

Are there potentially billions of dollars in gains or losses from running Columbia compared to purchasing electricity from the Mid-C hub?

As an economist, the challenge was to develop a transparent first-order model to evaluate the market test hypothesis. The math is pretty simple: mainly subtraction and multiplication.

The transparent data used to populate the model came from two sources. The Mid-C hub alternate came from the Northwest Power and Conservation Council.^{viii} It included the Mid-C's historic and forecast annual wholesale electricity price data. Columbia's historic and forecast variable running cost data was obtained from Energy Northwest.^{ix}

For example, in 2015 the Mid-C hub price was \$21.70 per megawatt-hour. Energy Northwest reported Columbia's variable running cost was \$50.50 per megawatt-hour that year. This means Columbia cost \$28.80 more per megawatt-hour of electricity than the Mid-C hub.

Columbia's energy production was also obtained from Energy Northwest^x, and the plant produced 8,142,000 megawatt-hours of electricity in 2015. By multiplication, Columbia's cost about \$234 million more than the equivalent Mid-C hub electricity.

Columbia became the higher cost resource beginning in 2009, and projections of its costs versus the wholesale market indicate that it will remain the higher cost resource through 2028. Regional ratepayers could cumulatively pay about \$1.64 billion more for Columbia's power than from using Mid-C hub electricity as a result.

The Council provided two sensitivity studies to bracket its Mid-C hub price forecast. Using the high Mid-C forecast, Columbia's losses were lower, but ratepayers could still pay a cumulative \$550 million more for Columbia's power than for the Mid-C hub. However, using the Council's low Mid-C forecast, Columbia's potential losses are staggering. Ratepayers could pay a cumulative \$3.1 billion more for Columbia's power than for using the Mid-C hub by 2028.

Economic impacts for individual BPA customers can be approximated by using their Tier One Cost Allocator (TOCA), one of BPA's customer charge billing determinants. For example, a hypothetical customer with a 1 percent TOCA could cumulatively pay about \$16.4 million more for Columbia's power than for the Mid-C hub.^{xi}

BPA's largest customer is Snohomish County PUD #1, which could pay a cumulative \$172 million more for Columbia's power than for the Mid-C hub power under the medium-price forecast. The bracket for the two sensitivity studies ranged between a loss of between \$60 million and \$340 million.

What alternatives to Columbia might provide better economic choices for our future?

ENERGY EFFICIENCY REMAINS TOP PRIORITY

It's well-proven and reliable: Energy efficiency is the lowest-cost and the highest-priority resource to meet new demand. Regionally, by saving more than 6,000 average MW since 1978, energy efficiency has proven an effective alternative to constructing new thermal power plants -

- at about 20 percent of their cost. Because energy efficiency costs about two-thirds of BPA's basic power rate, it also helps mitigate Columbia's negative economic impacts, which contributed to BPA's increased power costs since 2009.

Three years ago, the Swedish Academy of Sciences awarded the Nobel Prize to the inventors of the blue LED bulb. In industrial economies, replacing wasteful inefficient lighting with LEDs would reduce electricity consumption by about 15 to 25 percent, the Academy said.

Regionally, 15 percent waste is roughly equal to the electrical energy now consumed in Idaho and Montana. That's right: In theory, both Idaho and Montana could be powered with the energy now wasted by using inefficient lighting. Wasted electrical energy from inefficient lighting is the third-largest "state" in the Pacific Northwest. Put another way, wasted electrical energy from inefficient lighting represents a potential resource equal to more than 2.5 Columbia power plants.^{xii}

Perhaps you're thinking that while LED lighting may be a significant opportunity, how long will it take for it to reach a dominant market penetration? LEDs are projected to have an 84 percent market share of lumen-hour sales in the general lighting market by 2030. Nationally, LEDs will save consumers around \$26 billion at today's energy prices, and will reduce energy consumption equal to the use of about 24 million U.S. homes.^{xiii}

CONCLUSIONS

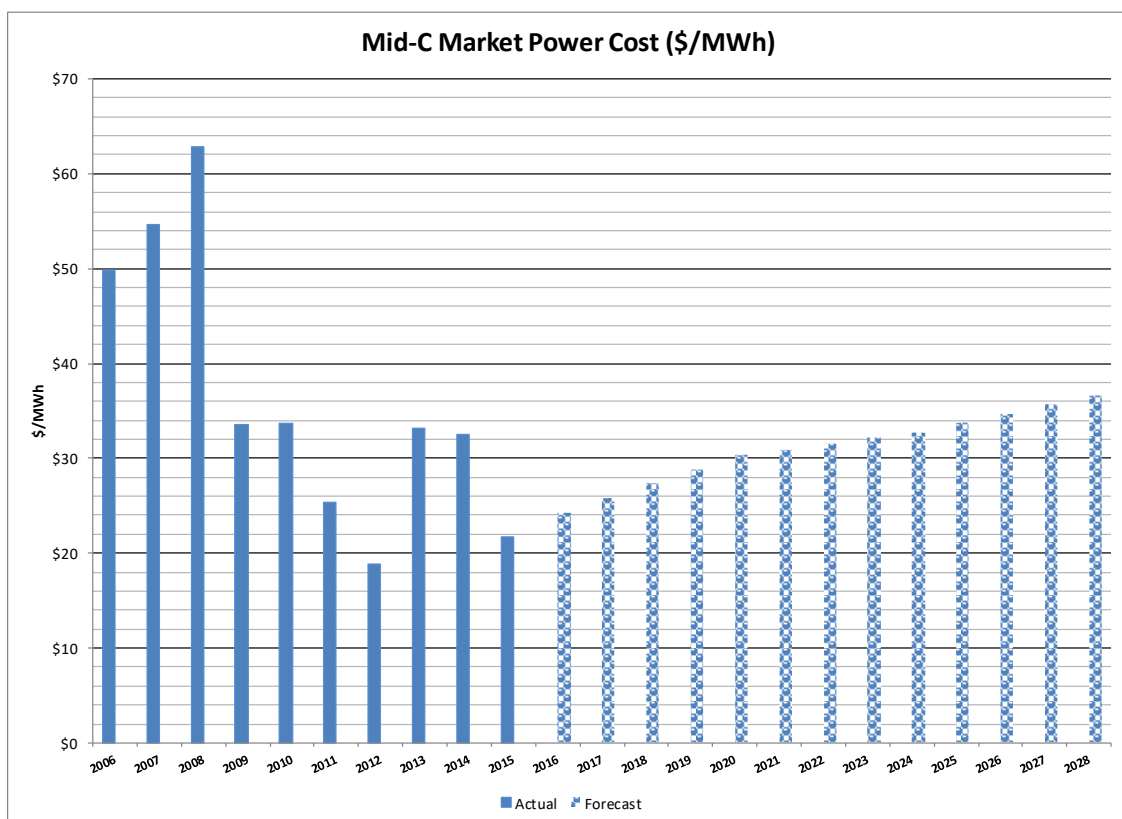
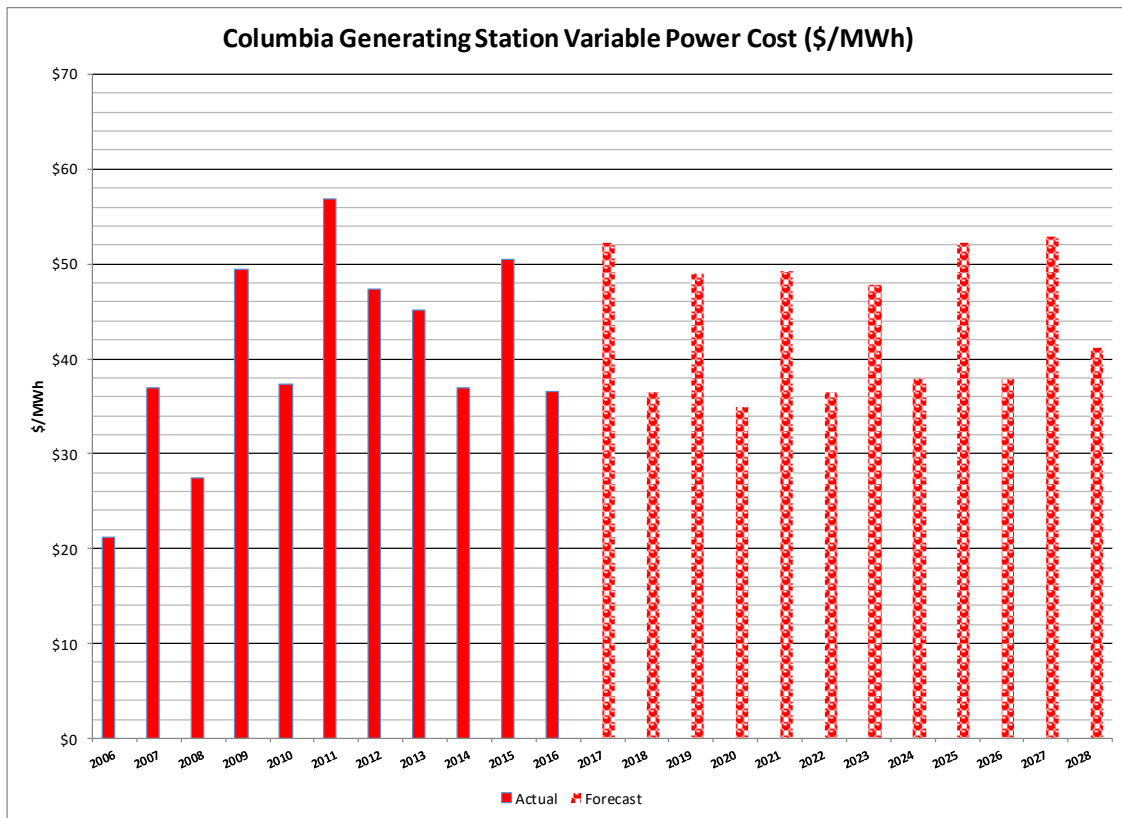
A first-order market test suggests Pacific Northwest electric customers could pay about \$1.64 billion more for Columbia's power than for the equivalent amount from the Mid-C hub through 2028.

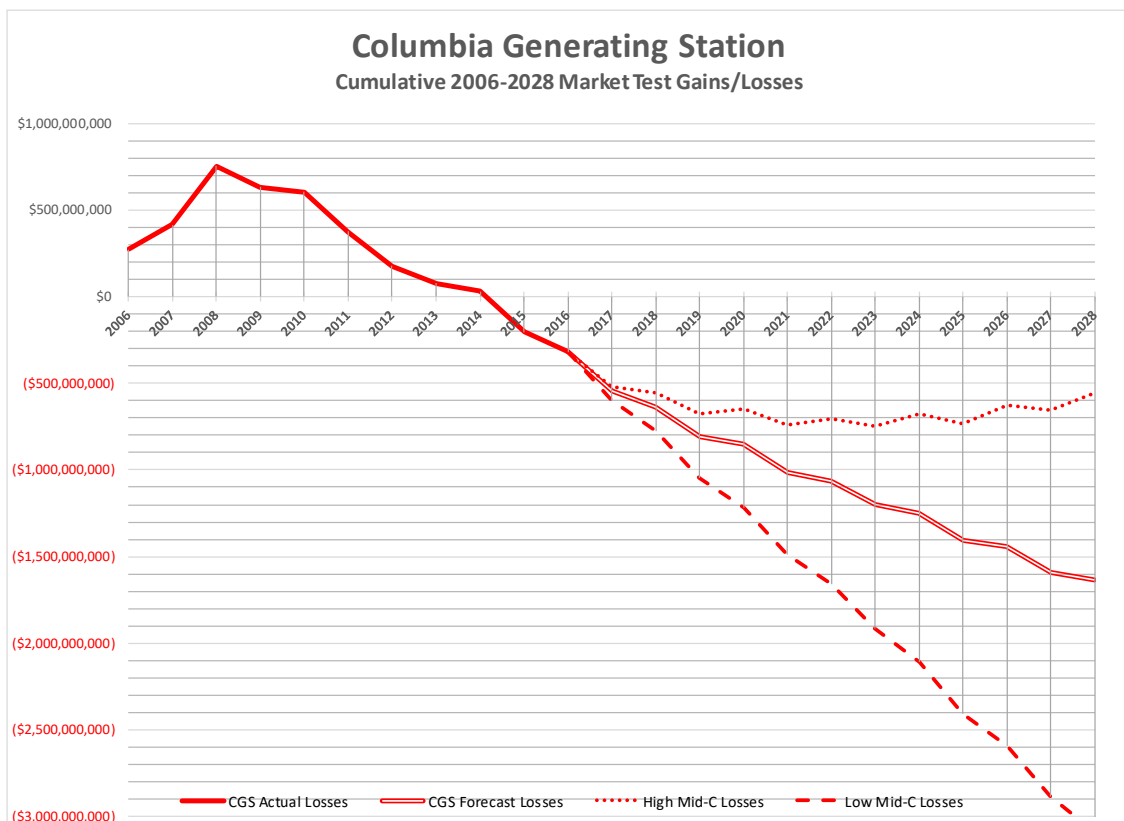
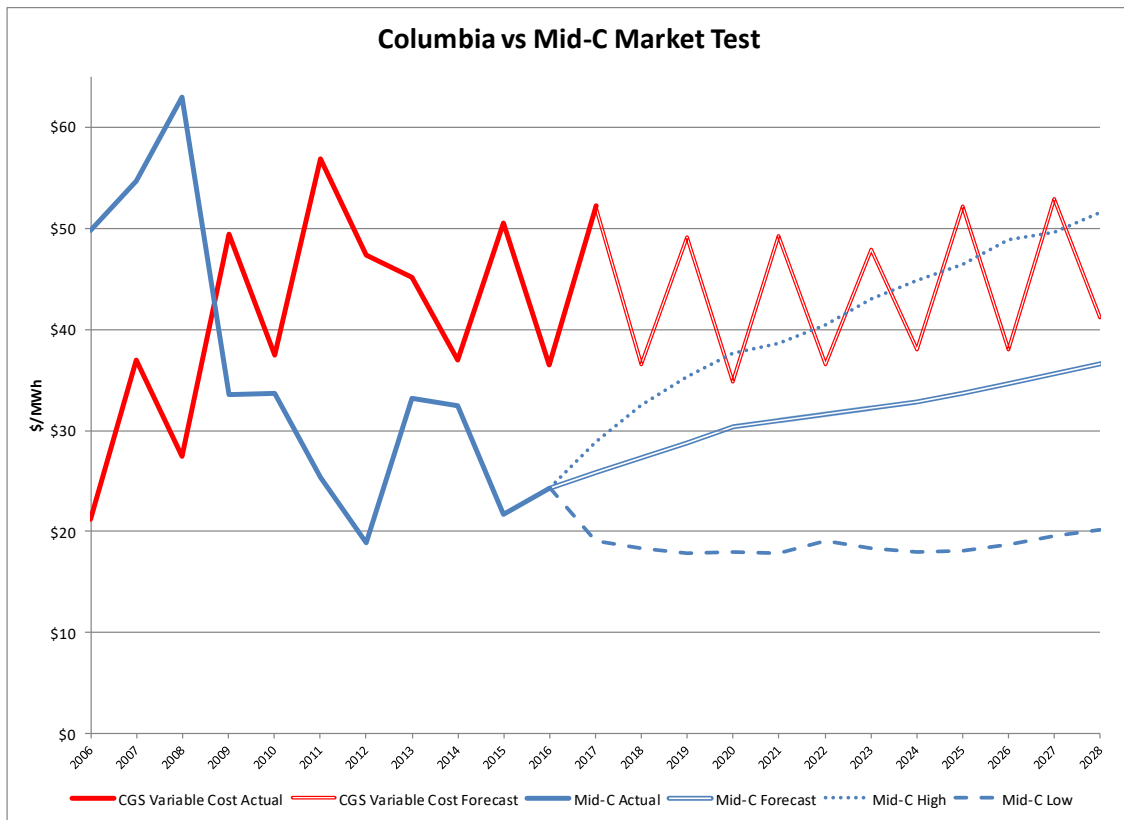
While unlikely, another "perfect storm" could wipe out the anticipated benefits gained from Mid-C hub replacement power. However, long-range national forecasts indicate power costs will continue to be stable through 2050.^{xiv}

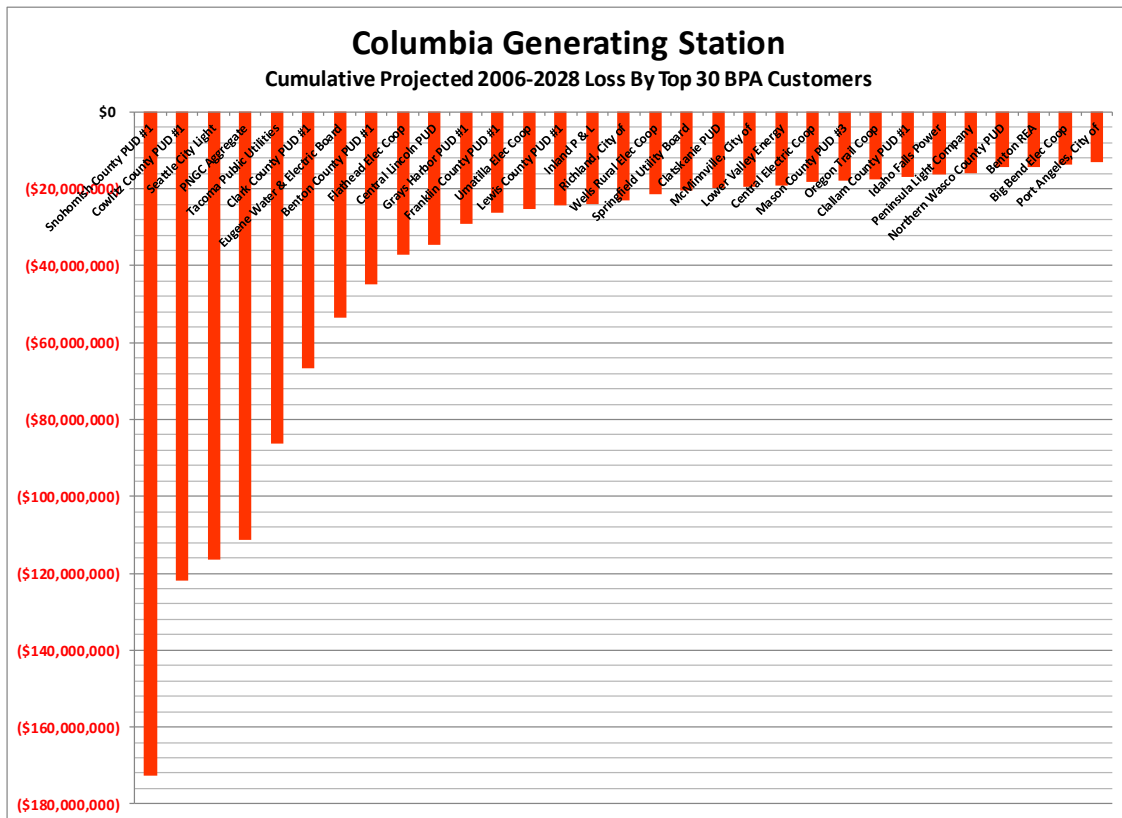
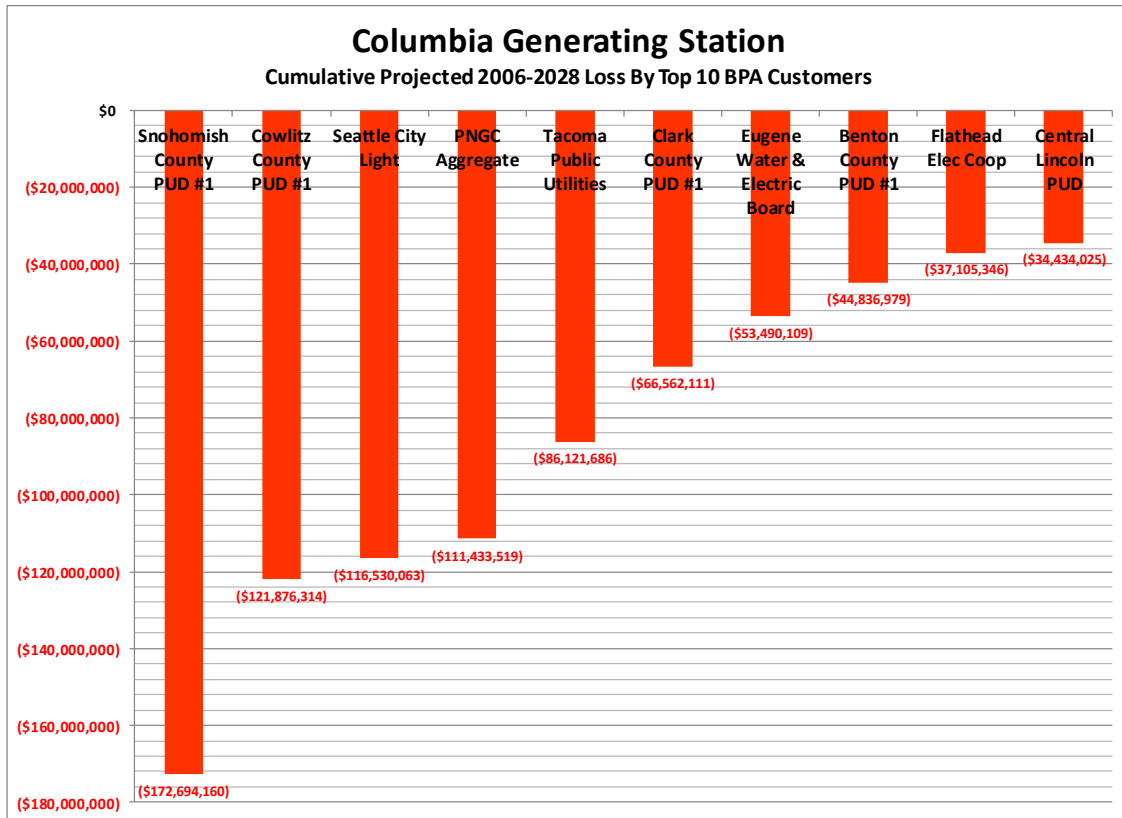
To best ensure its ratepayers are provided reliable power at the least cost, BPA should conduct its own market test to assess Columbia's economic competitiveness, as it originally pledged doing in 1998.

BPA also stated its intention to solicit input, in a public process, on the precise nature of this market test. This market test should evaluate Columbia's termination if its running costs are projected to exceed market prices.

Energy efficiency measures, such as substituting LEDs for inefficient lighting, can more than offset Columbia's lost capacity in the regional power market. We can avert these potentially massive economic losses. Why pay more when you can use less and get the same result for less money?







BPA FY16-FY17 Tier One Cost Allocator (TOCA)					CGS Market Test
BESID	Preference Customer	FY16 TOCA	FY17 TOCA	TOCA Mean	Cumu Loss/Gain Current Value
10354	Snohomish County PUD #1	10.8807%	11.1396%	11.0101%	(\$172,694,160)
10123	Cowlitz County PUD #1	7.7702%	7.7702%	7.7702%	(\$121,876,314)
10349	Seattle City Light	7.4294%	7.4294%	7.4294%	(\$116,530,063)
10298	PNGC Aggregate	7.1007%	7.1082%	7.1044%	(\$111,433,519)
10370	Tacoma Public Utilities	5.4902%	5.4912%	5.4907%	(\$86,121,686)
10103	Clark County PUD #1	4.2437%	4.2437%	4.2437%	(\$66,562,111)
10170	Eugene Water & Electric Board	3.4103%	3.4103%	3.4103%	(\$53,490,109)
10024	Benton County PUD #1	2.8586%	2.8586%	2.8586%	(\$44,836,979)
10179	Flathead Elec Coop	2.3657%	2.3657%	2.3657%	(\$37,105,346)
10047	Central Lincoln PUD	2.1925%	2.1982%	2.1953%	(\$34,434,025)
10191	Grays Harbor PUD #1	1.8607%	1.8406%	1.8507%	(\$29,027,936)
10183	Franklin County PUD #1	1.6641%	1.6641%	1.6641%	(\$26,101,654)
10388	Umatilla Elec Coop	1.6056%	1.6056%	1.6056%	(\$25,183,451)
10237	Lewis County PUD #1	1.5414%	1.5643%	1.5528%	(\$24,356,143)
10209	Inland P & L	1.5278%	1.5278%	1.5278%	(\$23,964,095)
10089	Richland, City of	1.4684%	1.4684%	1.4684%	(\$23,032,403)
10446	Wells Rural Elec Coop	1.3581%	1.3581%	1.3581%	(\$21,301,871)
10363	Springfield Utility Board	1.3067%	1.3094%	1.3080%	(\$20,516,598)
10105	Clatskanie PUD	1.3165%	1.2176%	1.2671%	(\$19,874,060)
10079	McMinnville, City of	1.2504%	1.2504%	1.2504%	(\$19,612,904)
10244	Lower Valley Energy	1.2201%	1.2201%	1.2201%	(\$19,136,706)
10046	Central Electric Coop	1.1607%	1.1607%	1.1607%	(\$18,205,484)
10247	Mason County PUD #3	1.1334%	1.1334%	1.1334%	(\$17,778,067)
10291	Oregon Trail Coop	1.1136%	1.1228%	1.1182%	(\$17,539,575)
10101	Clallam County PUD #1	1.0781%	1.0781%	1.0781%	(\$16,910,369)
10204	Idaho Falls Power	1.1212%	0.9561%	1.0386%	(\$16,290,888)
10307	Peninsula Light Company	1.0208%	1.0208%	1.0208%	(\$16,011,302)
10279	Northern Wasco County PUD	0.9184%	0.9184%	0.9184%	(\$14,405,310)
10025	Benton REA	0.9463%	0.8628%	0.9045%	(\$14,187,680)
10027	Big Bend Elec Coop	0.8678%	0.8678%	0.8678%	(\$13,611,019)
10087	Port Angeles, City of	0.8711%	0.8020%	0.8365%	(\$13,121,174)
10112	Columbia River PUD	0.8013%	0.8071%	0.8042%	(\$12,613,920)
10376	Tillamook PUD #1	0.7852%	0.7875%	0.7863%	(\$12,333,706)
10234	Kootenai Electric Coop	0.7232%	0.7232%	0.7232%	(\$11,343,430)
10157	Emerald PUD	0.7084%	0.7084%	0.7084%	(\$11,111,762)
10256	Midstate Elec Coop	0.6506%	0.6535%	0.6521%	(\$10,227,753)
10286	Okanogan County PUD #1	0.6510%	0.6510%	0.6510%	(\$10,211,597)
10118	Consumers Power	0.6477%	0.6477%	0.6477%	(\$10,158,895)
12026	Jefferson County PUD #1	0.6044%	0.6101%	0.6072%	(\$9,524,670)
10121	Coos Curry Elec Coop	0.5692%	0.5707%	0.5700%	(\$8,939,696)
10342	Salem Elec Coop	0.5341%	0.5356%	0.5348%	(\$8,388,915)
10113	Columbia REA	0.5345%	0.5345%	0.5345%	(\$8,383,818)
10258	Mission Valley	0.5289%	0.5363%	0.5326%	(\$8,354,487)
10231	Klickitat County PUD #1	0.5198%	0.5198%	0.5198%	(\$8,153,718)
10278	Northern Lights	0.5095%	0.5095%	0.5095%	(\$7,991,064)
10294	Pacific County PUD #2	0.5151%	0.4897%	0.5024%	(\$7,880,092)
10331	Raft River Elec Coop	0.4990%	0.5029%	0.5010%	(\$7,857,819)
10173	Fall River Elec Coop	0.4698%	0.4698%	0.4698%	(\$7,368,995)
10156	Elmhurst Mutual P & L	0.4556%	0.4572%	0.4564%	(\$7,158,658)
10235	Lakeview L & P (WA)	0.4546%	0.4569%	0.4557%	(\$7,147,836)
10391	United Electric Coop	0.4251%	0.4251%	0.4251%	(\$6,667,402)
10326	U.S. Naval Base, Bremerton	0.4104%	0.4104%	0.4104%	(\$6,436,440)
10236	Lane County Elec Coop	0.3923%	0.3925%	0.3924%	(\$6,154,344)
10434	Vera Irrigation District	0.3851%	0.3851%	0.3851%	(\$6,040,314)
10259	Missoula Elec Coop	0.3809%	0.3827%	0.3818%	(\$5,988,004)
10074	Forest Grove, City of	0.3784%	0.3784%	0.3784%	(\$5,934,754)
10451	Whatcom County PUD #1	0.3722%	0.3733%	0.3728%	(\$5,846,604)
10260	Modern Elec Coop	0.3674%	0.3706%	0.3690%	(\$5,788,177)
10288	Orcas P & L	0.3508%	0.3508%	0.3508%	(\$5,501,532)
10066	Centralia, City of	0.3456%	0.3456%	0.3456%	(\$5,420,911)
10072	Ellensburg, City of	0.3401%	0.3401%	0.3401%	(\$5,334,173)

BPA FY16-FY17 Tier One Cost Allocator (TOCA)					CGS Market Test
BESID	Preference Customer	FY16 TOCA	FY17 TOCA	TOCA Mean	Cumu Loss/Gain Current Value
10106	Clearwater Power	0.3314%	0.3327%	0.3321%	(\$5,208,379)
10197	Harney Elec Coop	0.3227%	0.3227%	0.3227%	(\$5,060,782)
10426	U.S. DOE Richland Operations Office	0.3696%	0.2455%	0.3076%	(\$4,824,017)
10186	Glacier Elec Coop	0.3023%	0.3023%	0.3023%	(\$4,741,435)
10057	Ashland, City of	0.2988%	0.2988%	0.2988%	(\$4,686,066)
10409	U.S. Naval Submarine Base, Bangor	0.2896%	0.2896%	0.2896%	(\$4,542,235)
10044	Canby, City of	0.2880%	0.2880%	0.2880%	(\$4,517,295)
10436	Vigilante Elec Coop	0.2716%	0.2716%	0.2716%	(\$4,259,747)
10333	Ravalli County Elec Coop	0.2626%	0.2626%	0.2626%	(\$4,118,111)
10136	Douglas Electric Cooperative	0.2581%	0.2588%	0.2585%	(\$4,054,116)
10029	Blachly Lane Elec Coop	0.2498%	0.2498%	0.2498%	(\$3,918,126)
10706	Port of Seattle - SETAC In'tl. Airport	0.2365%	0.2450%	0.2407%	(\$3,776,098)
10369	Surprise Valley Elec Coop	0.2316%	0.2330%	0.2323%	(\$3,643,795)
10067	Cheney, City of	0.2243%	0.2243%	0.2243%	(\$3,518,157)
10352	Skamania County PUD #1	0.2202%	0.2214%	0.2208%	(\$3,463,417)
10304	Parkland L & W	0.1986%	0.1995%	0.1991%	(\$3,122,424)
10064	Burley, City of	0.1969%	0.1975%	0.1972%	(\$3,093,406)
10239	Lincoln Elec Coop (MT)	0.1966%	0.1964%	0.1965%	(\$3,082,348)
10202	Hood River Elec Coop	0.1858%	0.1858%	0.1858%	(\$2,913,499)
10442	Wasco Elec Coop	0.1810%	0.1830%	0.1820%	(\$2,855,072)
10597	Hermiston, City of	0.1790%	0.1790%	0.1790%	(\$2,807,076)
10502	Yakama Power	0.1470%	0.2093%	0.1782%	(\$2,794,371)
10343	Salmon River Elec Coop	0.1752%	0.1751%	0.1751%	(\$2,746,845)
10109	Columbia Basin Elec Coop	0.1718%	0.1718%	0.1718%	(\$2,695,320)
10177	Ferry County PUD #1	0.1654%	0.1654%	0.1654%	(\$2,594,465)
10371	Tanner Elec Coop	0.1565%	0.1565%	0.1565%	(\$2,453,927)
10081	Milton-Freewater, City of	0.1423%	0.1430%	0.1427%	(\$2,237,551)
10284	Ohop Mutual Light Company	0.1399%	0.1407%	0.1403%	(\$2,200,691)
10230	Kittitas County PUD #1	0.1376%	0.1376%	0.1376%	(\$2,158,106)
10242	Lost River Elec Coop	0.1351%	0.1351%	0.1351%	(\$2,118,737)
10091	Rupert, City of	0.1336%	0.1336%	0.1336%	(\$2,095,680)
10061	Blaine, City of	0.1240%	0.1240%	0.1240%	(\$1,945,417)
10246	Mason County PUD #1	0.1200%	0.1266%	0.1233%	(\$1,934,202)
10083	Monmouth, City of	0.1186%	0.1186%	0.1186%	(\$1,860,247)
10448	West Oregon Elec Coop	0.1186%	0.1186%	0.1186%	(\$1,859,698)
10059	Bandon, City of	0.1082%	0.1083%	0.1083%	(\$1,698,064)
10080	Milton, Town of	0.1055%	0.1055%	0.1055%	(\$1,653,989)
10360	Southside Elec Lines	0.0959%	0.0959%	0.0959%	(\$1,504,667)
10285	Okanogan County Elec Coop	0.0925%	0.0926%	0.0925%	(\$1,451,103)
11680	Weiser, City of	0.0898%	0.0898%	0.0898%	(\$1,407,734)
10203	Idaho County L & P	0.0881%	0.0881%	0.0881%	(\$1,382,010)
10273	Nespelem Valley Elec Coop	0.0834%	0.0834%	0.0834%	(\$1,308,133)
10172	U.S. Airforce Base, Fairchild	0.0812%	0.0820%	0.0816%	(\$1,280,292)
10062	Bonnors Ferry, City of	0.0754%	0.0754%	0.0754%	(\$1,183,280)
10190	Grant County PUD #2	0.0736%	0.0736%	0.0736%	(\$1,154,734)
10440	Wahkiakum County PUD #1	0.0710%	0.0710%	0.0710%	(\$1,113,168)
10076	Heyburn, City of	0.0683%	0.0683%	0.0683%	(\$1,071,446)
10379	Steilacoom, Town of	0.0682%	0.0682%	0.0682%	(\$1,069,407)
10306	Pend Oreille County PUD #1	0.0706%	0.0497%	0.0602%	(\$943,770)
10086	Plummer, City of	0.0560%	0.0560%	0.0560%	(\$877,579)
10095	Sumas, Town of	0.0517%	0.0517%	0.0517%	(\$810,133)
10078	McCleary, City of	0.0505%	0.0506%	0.0505%	(\$792,801)
10144	Eatonville, City of	0.0475%	0.0478%	0.0476%	(\$747,079)
10094	Soda Springs, City of	0.0421%	0.0419%	0.0420%	(\$658,929)
10111	Columbia Power Coop	0.0416%	0.0419%	0.0417%	(\$654,616)
10482	Umpqua Indian Utility Cooperative	0.0407%	0.0409%	0.0408%	(\$639,636)
10158	Energy Northwest	0.0392%	0.0392%	0.0392%	(\$615,246)
10142	East End Mutual Electric	0.0381%	0.0381%	0.0381%	(\$597,757)
10068	Chewelah, City of	0.0373%	0.0373%	0.0373%	(\$585,366)
10338	Riverside Elec Coop	0.0336%	0.0336%	0.0336%	(\$527,645)
10065	Cascade Locks, City of	0.0313%	0.0314%	0.0313%	(\$491,570)
10097	Troy, City of	0.0289%	0.0289%	0.0289%	(\$453,298)
10378	Coulee Dam, City of	0.0287%	0.0287%	0.0287%	(\$449,377)
10071	Drain, City of	0.0272%	0.0272%	0.0272%	(\$425,849)
10408	U.S. Naval Station, Everett (Jim Creek)	0.0212%	0.0212%	0.0212%	(\$332,523)
10015	Asotin County PUD #1	0.0081%	0.0081%	0.0081%	(\$127,519)
10005	Alder Mutual	0.0077%	0.0078%	0.0077%	(\$121,245)
10174	Farmers Elec Coop	0.0072%	0.0072%	0.0072%	(\$112,776)
10406	U.S. DOE Albany Research Center	0.0065%	0.0065%	0.0065%	(\$101,953)
10055	Albion, City of	0.0056%	0.0056%	0.0056%	(\$88,464)
10070	Declo, City of	0.0051%	0.0051%	0.0051%	(\$79,680)
10116	Consolidated Irrigation District #19	0.0028%	0.0028%	0.0028%	(\$44,546)
10082	Minidoka, City of	0.0016%	0.0017%	0.0016%	(\$25,802)
	TOTALS	104.5156%	104.3457%	104.4307%	(\$1,638,000,529)

Market Test CGS vs. Mid-C	Mid-C Medium*	CGS Variable Cost**	Difference	CGS Production**	CGS Loss/Gain	CGS Loss/Gain
FY	\$/MWh	\$/MWh	\$/MWh	GWh/Year	\$/Year	\$ Cumulative
2006	\$49.82	\$21.20	\$28.62	9,636	\$275,750,386	\$275,750,386
2007	\$54.65	\$36.90	\$17.75	8,016	\$142,304,277	\$418,054,663
2008	\$62.90	\$27.50	\$35.40	9,594	\$339,645,635	\$757,700,298
2009	\$33.54	\$49.40	(\$15.86)	7,725	(\$122,541,615)	\$635,158,683
2010	\$33.66	\$37.40	(\$3.74)	8,124	(\$30,420,016)	\$604,738,667
2011	\$25.43	\$56.90	(\$31.47)	7,247	(\$228,085,797)	\$376,652,870
2012	\$18.90	\$47.30	(\$28.40)	6,984	(\$198,318,284)	\$178,334,587
2013	\$33.15	\$45.10	(\$11.95)	8,479	(\$101,309,161)	\$77,025,425
2014	\$32.50	\$37.00	(\$4.50)	9,781	(\$44,025,754)	\$32,999,672
2015	\$21.70	\$50.50	(\$28.80)	8,142	(\$234,470,059)	(\$201,470,388)
2016	\$24.29	\$36.50	(\$12.21)	9,617	(\$117,390,955)	(\$318,861,343)
2017	\$25.81	\$52.18	(\$26.37)	8,511	(\$224,471,544)	(\$543,332,888)
2018	\$27.32	\$36.54	(\$9.22)	9,769	(\$90,074,837)	(\$633,407,725)
2019	\$28.84	\$49.04	(\$20.20)	8,716	(\$176,091,998)	(\$809,499,723)
2020	\$30.35	\$34.88	(\$4.52)	9,816	(\$44,410,244)	(\$853,909,967)
2021	\$30.95	\$49.21	(\$18.26)	8,716	(\$159,134,259)	(\$1,013,044,226)
2022	\$31.55	\$36.47	(\$4.92)	9,789	(\$48,152,273)	(\$1,061,196,499)
2023	\$32.15	\$47.85	(\$15.69)	8,716	(\$136,778,650)	(\$1,197,975,148)
2024	\$32.75	\$37.98	(\$5.23)	9,816	(\$51,296,398)	(\$1,249,271,547)
2025	\$33.70	\$52.18	(\$18.48)	8,716	(\$161,035,672)	(\$1,410,307,219)
2026	\$34.67	\$37.97	(\$3.29)	9,789	(\$32,242,647)	(\$1,442,549,866)
2027	\$35.65	\$52.91	(\$17.27)	8,716	(\$150,505,055)	(\$1,593,054,921)
2028	\$36.62	\$41.20	(\$4.58)	9,816	(\$44,945,607)	(\$1,638,000,529)

*SOURCE: The Northwest Power and Conservation Council Wholesale Electricity Price Medium Forecast
<https://www.nwcouncil.org/energy/powerplan/7/technical>

** SOURCE: Energy Northwest Finance & Long-Range Planning
<https://www.energy-northwest.com/whoware/finance/Pages/default.aspx>

ENDNOTES

ⁱ Retired, former Deputy Director of Power & Telecommunications Systems, Department of Public Works & Utilities, City of Port Angeles and Energy Northwest Board of Directors member from 2013-2015.

ⁱⁱ *More Than Half of America's Nuclear Reactors Are Losing Money.* June 14, 2017. <https://www.bloomberg.com/news/articles/2017-06-14/half-of-america-s-nuclear-power-plants-seen-as-money-losers>

ⁱⁱⁱ Capability is the maximum amount of energy the plants are capable of producing over the course of an average year.

^{iv} BPA Cost Review Implementation Plan Fact Sheet #8, November 1998.

^v Energy Crisis of 2000/2001. SEE: <https://www.nwcouncil.org/history/EnergyCrisis>

^{vi} Columbia Generating Station Regional Value. SEE: <https://www.energy-northwest.com/ourenergyprojects/Columbia/Pages/Regional-Value.aspx>

^{vii} Hydrothermal Power Program. SEE: <https://www.nwcouncil.org/history/HydroThermal>

^{viii} Northwest Power and Conservation Council 2016 Wholesale Electricity Price Forecast.

SEE: <https://www.nwcouncil.org/energy/powerplan/7/technical>

^{ix} Energy Northwest Annual Reports 2006-2016. SEE: <https://www.energy-northwest.com/whoware/finance/Documents/2016%20Energy%20Northwest%20Annual%20Report.pdf>

^x Fiscal Year 2018 Columbia Generating Station Long Range Plan (2017-2028). SEE: <https://www.energy-northwest.com/whoware/finance/Documents/2018%20Budget%20Documents/Draft%202018%20CGS%20Long%20Range%20Plan.pdf>

^{xi} The remaining "Top 10" BPA customers are: Cowlitz County PUD #1, Seattle City Light, PNGC Power, Tacoma Public Utilities, Clark County PUD #1, Eugene Water & Electric Board, Benton County PUD #1, Flathead Elec Cooperative, and Central Lincoln PUD. Combined, they represent about 52% of BPA's total power sales with a cumulative equivalent estimated loss of \$845 million.

^{xii} LED technology uses semiconductors, and will respond to a variant of Moore's Law; future products will be better and cheaper than today's. Several manufacturers have ENERGY STAR®-qualified bulbs surpassing 100 lumens per watt. Comparatively, the typical efficiency of CFL bulbs is 55 to 70 lumens per watt. Traditional incandescent bulbs, which do not meet current efficiency standards, provide 13 to 18 lumens per watt.

^{xiii} LED Lighting Forecast. SEE: <https://www.energy.gov/eere/ssl/led-lighting-forecast>

^{xiv} Annual Energy Outlook 2017: Total Energy Supply, Disposition, and Price Summary Table.

SEE: https://www.eia.gov/outlooks/aeo/data/browser/#/?id=1-AEO2017®ion=0-0&cases=ref2017~ref_no_cpp&start=2015&end=2050&f=A&linechart=~::~~ref_no_cpp-d120816a.58-1-AEO2017~ref_no_cpp-d120816a.48-1-AEO2017&ctype=linechart&sourcekey=0