Department of Commerce
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Survey of Combined Cycle Combustion Turbine Greenhouse Gas Emission Rates

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Report to the Legislature
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Acknowledgements

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Executive Summary

In 2007, Washington State established a greenhouse gas (GHG) emission performance standard (EPS) for baseload electricity generation. The authorizing legislation requires the Department of Commerce (Commerce) Energy Office to survey and determine the average emissions of GHGs for new and commercially available natural gas-fired combined cycle combustion turbines (CCCT), and report this value to the Legislature by June 30, 2013. Commerce is to adopt by rule the average available GHG emission value, and if it is lower than the current standard of 1100 lb/MWh, it becomes the updated EPS for the state.

Commerce surveyed 19 CCCT models and determined an average GHG emission rate of 980 lb/MWh, which is the proposed updated EPSvalue.

As a test, Commerce evaluated existing CCCT power plants using the methodology described on page three to determine if the methodology produced values consistent with actual emissions. Commerce found that the average calculated emission rate[1] was significantly higher than the average reported emission rate: 939 lb/MWh versus 866 lb/MWh.

This suggests that the Commerce methodology and the proposed EPS update value of 980 lb/MWh are sufficiently generous to allow high-efficiency installations to comply under all reasonable operating conditions.

Impacts of the proposed EPS update

There are two CCCTs in Washington whose GHG emission rates exceed the current EPS of 1,100 lb/MWh. The status of these two CCCTs will not change with this proposed updated EPS.

Two older CCCTs will have difficulty complying with the EPS update – this is the marginal impact of the change.

One of these CCCTs is owned by a utility and serves customers of that utility, so it is unaffected by updated EPS. The other CCCT is an independent power provider and will not be able to renew long-term contracts with Washington utilities since it will likely not be able to meet the updated EPS. The power sold by this CCCT represents less than one percent of electricity sales in Washington State.

[1] Excluding two outlier CCCTs for reasons described in Appendix B.

Background

In 2007, Washington established a greenhouse gas (GHG) emission performance standard (EPS) for baseload electricity generation.[2] The initial EPS was set at a GHG emission rate of 1,100 pounds per megawatt-hour (lb/MWh), which is the same rate specified by law in Oregon and California. Utilities may not enter into long-term contracts (five or more years in length) with a baseload generating facility,[3] nor may utilities invest in a facility, when the GHG emissions of the facility exceed the standard.

Utilities may enter into short-term contracts with a non-compliant facility, and utilities that own a non-compliant facility may continue to do so if the output services that utility's own load. The law also provides that investor-owned utilities may apply to the Utilities and Transportation Commission for exemptions to the law based on certain reliability and cost criteria. The governing boards of consumer-owned utilities are also authorized to make exemption determinations on similar criteria.

The 2012 EPS Update

RCW 80.80.050 specifies that the Energy Office of the Department of Commerce (Commerce) "shall provide interested parties the opportunity to comment on the development of a survey of new combined cycle natural gas thermal electric generation turbines commercially available and offered for sale by manufacturers and purchased in the United States to determine the average emissions of greenhouse gas for these turbines." The turbines referred to in this language are called combined cycle combustion turbines (CCCTs) in the industry, a term used in this document as well.

The law also requires Commerce to report the results of its survey to the Legislature every five years beginning June 30, 2013, and adopt by rule the average available greenhouse gas emissions output every five years beginning five years after July 22, 2007. If the average greenhouse gas emissions output determined in the survey is lower than the current standard, it becomes the new greenhouse gas emission performance standard for the state.

In consultation with stakeholders, Commerce interpreted the language of RCW 80.80.050 as follows:

- "Survey" means a collection of data describing new, commercially available, and purchased CCCT models,[4] and adjustments allowing estimates of their operational emission rates.
- "Average emission rate" means the operational emission rate[5] as defined later in this document.

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[2] The law is codified in Revised Code of Washington (RCW) chapter 80.80: http://apps.leg.wa.gov/rcw/default.aspx?cite=80.80

[3] A baseload electric generation is defined as "electric generation from a power plant that is designed and intended to provide electricity at an annualized plant capacity factor of at least 60 percent." Electric generating plants that are licensed to operate as peaking units for less than 60 percent of the hours in a year are not subject to the provisions of the EPS.

[4] The data was gathered from a literature review of CCCT performance and is based on values reported by Gas Turbine World in its 2011 GTW Handbook.

- "New" means offered for manufacture during calendar year 2011.
- "Commercially available" CCCTs are available in the U.S. and designed to generate alternating current at 60 hertz, but do not include CCCTs made under license from GE and Siemens, as these copies of existing GE and Siemens products have essentially identical heat rates and are rarely installed in the U.S.
- "Purchased" CCCTs are CCCTs purchased by utilities or independent power producers in the U.S. during 2005-2010, and currently installed or in the process of being installed. These constraints limited the number of CCCTs that could be included in the survey, as several new machines were not commercially available or had not been purchased. The same applies for a large number of older and very small CCCTs that were not historically purchased by utilities.

During the development of the EPS survey, Commerce held two stakeholder meetings and received comments on the draft EPS survey. Commerce has responded to the comments and incorporated changes into the rulemaking process based on those comments. A technical subgroup of stakeholders participated in three conference calls to refine the EPS survey methodology.

Survey Methodology

Commerce determined that the individual CCCT GHG emission rates from which the average is calculated should be "real world" operational emission rates, because in order to show compliance in the future, the operators of new CCCTs will be required to submit actual emissions data. The operational emission rates calculated in the survey are significantly higher than the reference rates[6] provided by CCCT manufacturers.

For each CCCT model, the survey estimates an operational emission rate from the manufacturer's reference rate by applying adjustment factors for partial load operation, frequent stops and starts, and several other operational or design factors that have an impact on CCCT GHG emission rates. The survey methodology outlined in this report is a highly modified version of the step-wise approach used by the Northwest Power and Conservation Council for calculating operational GHG emissions from the reference CCCT performance values published by manufacturers. Stakeholders were encouraged to comment on Commerce's survey methodology, including the adjustment factors, at two public meetings and the three technical subgroup conference calls. The survey methodology and definitions for a number of key inputs and adjustment factors are presented in Appendix A.

The CCCT design and adjustment factors described in Appendix A were used to develop a spreadsheet that calculated the average operational emission rate for the CCCT models considered in the survey. This is the proposed EPS value. The spreadsheet is shown in Table 1.

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[5] Reference emission rates or efficiencies are commonly given for CCCTs. Operational emission rates or efficiencies take into account multiple real world factors that increase the emission rate.

[6] In actuality, manufacturers rarely supply a reference GHG emission rate, but rather a reference heat rate. Heat rate is the quantity of fuel energy consumed per unit of electricity generated. The GHG emission rate can be unambiguously calculated from the heat rate, so to simplify discussion, the body of this report treats emission rates only. See Appendix A for a full description of the conversion from heat rate to emission rate.

Manufacturer and model	Design year	Nominal class	Format	Net rated output	Gross clean and new heat rate				Adjusted heat rate - net & ageing	Duct firing heat rate	Adjusted heat rate w/ duct firing	Heat rate adj. for stop/start/ partial load	Heat rate adj. for Climate and Inlet Cooling	Theoretical efficiency	Emission rate
				MW	Btu_{LHV}/kWh	Btu_{HHV}/kWh	Emission rate	Efficiency	Btu_{HHV}/kWh	Btu_{HHV}/kWh	Btu_{HHV}/kWh	Btu_{HHV}/kWh	Btu_{HHV}/kWh	percent	lb. GHG/MWh
Alstom															
KA24-2	1996	F	2 X 1	660	5,853	6,484	763	53%	6,857	9,400	7,302	7,740	7,896	44%	929
General Electric															
106FA	1991	F	1 X 1	119	6,199	6,868	808	50%	7,262	9,750	7,724	8,188	8,352	42%	982
206FA	1991	F	2 X 1	239	6,132	6,794	799	50%	7,184	9,750	7,646	8,104	8,267	42%	972
S107FA	2008	F	1 X 1	277	5,948	6,590	775	52%	6,968	9,400	7,414	7,858	8,016	43%	**943**
S207FA	2008	F	2 X 1	542	5,889	6,524	767	52%	6,899	9,400	7,344	7,785	7,942	44%	**934**
S107EA	1977	E	1 X 1	135	6,680	7,401	870	46%	7,826	9,750	8,288	8,785	8,962	39%	1054
S207EA	1979	E	2 X 1	270	6,695	7,417	872	46%	7,843	9,400	8,289	8,786	8,963	39%	1054
LM2500+G4 RC	2005	Aero	1 X 1	48.9	6,819	7,555	888	45%	7,988	9,750	8,451	8,958	9,138	38%	1075
LM6000PF Sprint	2006	Aero	2 X 1	123	6,365	7,052	829	48%	7,457	9,750	7,919	8,394	8,563	41%	1007
Mitsubishi															
MPCP1(M501G)	1995	G	1 X 1	399	5,843	6,473	761	53%	6,845	9,400	7,291	7,728	7,883	44%	**927**
MPCP2(M501G)	1995	G	2 X 1	800	5,823	6,451	759	53%	6,822	9,400	7,267	7,703	7,858	44%	**924**
MPCP1(M501F)	1994	F	1 X 1	285	5,976	6,621	779	52%	7,001	9,400	7,446	7,893	8,052	43%	947
MPCP2(M501F)	1994	F	2 X 1	572	5,955	6,597	776	52%	6,976	9,400	7,422	7,867	8,025	43%	944
Siemens															
SGT6-8000H 2S	2010	H	2 X 1	820	5,687	6,301	741	54%	6,662	9,400	7,108	7,534	7,686	45%	**904**
SCC6-5000F	1989	F	1 X 1	307	5,990	6,636	780	51%	7,017	9,400	7,463	7,911	8,070	43%	**949**
SCC6-5000F	1989	F	2 X 1	620	5,960	6,603	777	52%	6,982	9,400	7,428	7,873	8,032	43%	**945**
SCC6-2000E/F	1989	E	1 X 1	171	6,626	7,341	863	46%	7,762	9,750	8,224	8,718	8,893	39%	1046
SCC6-2000E/F	1989	E	2 X 1	342	6,560	7,268	855	47%	7,685	9,400	8,131	8,618	8,792	40%	1034
SCC-700	1998	Aero?	1 X 1	44	6,672	7,392	869	46%	7,816	9,750	8,278	8,775	8,951	39%	1053
Averages and totals															
Averages (Heat Rate or Efficiency)					**6,193**	**6,861**	**807**	**50%**	**7,255**		**7,707**	**8,169**	**8,334**	**41.9%**	**980**

Table 1: Washington State survey of new, commercially available, and purchased CCCTs. The emission rates averaged to produce the proposed EPS of 980 lb/MWh appear in the rightmost column. (Source: Washington State Energy Office workbook no. W0024)

Nineteen CCCT models were evaluated in the EPS survey. The majority (82 percent) of utility and independent power producer orders for CCCTs in the U.S. over the last six years included just five CCCT models.[7] Because of the market's reliance on a limited number of CCCTs, the survey of 19 CCCTs is sufficient to establish an average emission value for new, commercially available, and purchased CCCTs.[8]

The average reference emission rate of the surveyed turbines was 807 lb GHG/MWh (range 740 to 890 lb/MWh). After all design and operational adjustments were made by Commerce, the average survey GHG emission rate decreased to **980 lb/MWh** – the proposed EPS update value. The adjusted emission rates of the individual turbine models ranged from a low of 904 lb/MWh to a high of 1,075 lb/MWh.

How the EPS Update Impacts the Existing CCCT Fleet

There are two CCCTs in Washington whose GHG emission rates exceed the current EPS of 1,100 lb/MWh. The status of these two CCCTs will not change with this required update of the EPS.

Commerce collected CCCT GHG emissions data to determine how the EPS update will impact the rest of the existing fleet in Washington. Commerce found that two older CCCTs will have difficulty complying with the EPS update – this is the marginal impact of the change. One of these CCCTs is owned by a utility and serves customers of that utility, so it is unaffected by the EPS update.[9] The other CCCT is an independent power provider and will not be able to renew long-term contracts with Washington utilities since it will likely not be able to meet the EPS update.[10] The power sold by this CCCT represents less than one percent of electricity sales in Washington State.

To check whether the survey calculates operational GHG emission values consistent with actual emissions, Commerce compared the reported, actual emissions from existing CCCTs to the calculated, operational emissions using the EPS survey methodology (Appendix B). Figure 1 shows that most CCCTs operate well below the proposed EPS update value. The most important conclusion that can be drawn from the comparison in Figure 1 is that CCCT reported emission rates are below the corresponding EPS survey calculated emission rates. This implies that the survey methodology is generous to existing CCCTs.

Commerce found that the average calculated emission rate[11] was significantly higher than the average reported emission rate: 939 lb/MWh versus 866 lb/MWh. This suggests that the Commerce EPS survey methodology and the proposed EPS update value of 980 lb/MWh are

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7 Gas Turbine World Handbooks: 2007-2008 Handbook, Vol. 26 p.156; 2009 Handbook, Vol. 27, p.160; 2010 Handbook, Vol.28, p. 159; 2012 Handbook, Vol. 29, p. 145.

8 When a customer orders a CCCT, they can select numerous optional and semi-unique features, but the unit ordered will at its core have a specific models of gas and steam turbines. Commerce focused on the core parts of the CCCT, but also took into account optional features like duct firing and inlet air cooling.

9 Existing, non-complaint CCCTs are allowed to serve a utility's own customers with no restrictions.

10 This facility is currently in negotiations for purchase by a Washington utility.

11 Excluding two outlier CCCTs for reasons described in Appendix B.

relatively generous. Utilities will be able to use the calculator methodology to comfortably and confidently determine the impact of the EPS on real operating and purchasing decisions.

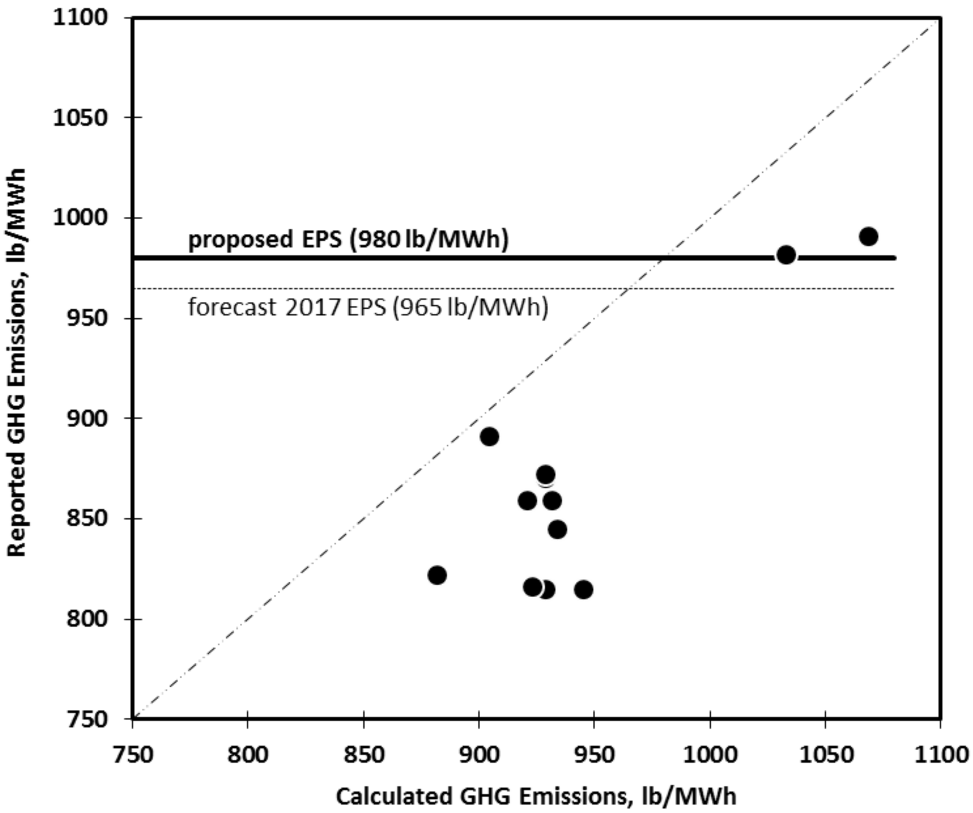

Figure 1: Emission rates reported by 12 CCCTs located in or near Washington. The CCCTs are ordered on the horizontal axis by the calculated emission rate for that make and model according to Commerce's survey methodology. If a CCCT falls below the dashed, diagonal line then its actual emissions rate is less than its calculated emission rate. The thick, horizontal line is the proposed EPS of 980 lb/MWh, and the light, horizontal line is a forecast value for the survey result in 2017 – 965 lb/MWh. Ten of the 12 turbines fall below both the proposed EPS and the forecast survey result in 2017. (Source: Washington State Energy Office workbook no. W0025)

Future EPS Updates

As previously noted, Washington statute requires Commerce to update the EPS value every five years. The two primary drivers of future EPS values are the rate of improvement in CCCT efficiency and changes in CCCT adjustment factors.

Combined-cycle natural gas turbine technology has reached a level of technological maturity such that future efficiency gains, and corresponding GHG emissions reductions, will be quite small.[12] Commerce estimates that new CCCT GHG emissions will improve at 0.3 percent per year in the near-term, and that the rate of improvement will likely slow over time as CCCTs

[12] The large jump between the current EPS and the proposed new value of 980 lb/MWh is due to the high value of the current EPS. The value of 1,100 lb/MWh was originally adopted in a 2006 California law and does not appear to have a basis in any documented, analytical process.

approach their theoretical limits of development. At this rate of change, all other factors held constant, the 2017[13] update of the EPS will be 965 lb/MWh. This hypothetical future EPS value is shown in Figure 1 and indicates that the existing fleet of CCCTS are below this hypothetical value.

Several of the CCCT adjustment factors could change over the next five years as well. Most likely to change is the stop/start and partial load factor if CCCTs are used more frequently to offset increasing, variable renewable resource generation. If this were to occur and the adjustment factor increased from the current value, the forecast CCCT efficiency improvement would be partially offset and the resulting 2017 update would be above 965 lb/MWh.

[13] The 2017 EPS update will be the standard in place from 2017 through 2022.

Appendix A: EPS Survey Methodology, Definitions, and Adjustment Factors

Definitions

Heat rate: A key performance metric for CCCTs, or any thermal power plant, is its heat rate. Heat rate is the amount of chemical energy input, expressed in British thermal units (Btu) needed to produce a kilowatt-hour (kWh) of electricity. GHG emission rates are calculated from heat rates, so this is the first piece of information needed for updating the state's EPS. Typical heat rates for new CCCTs range from 6,300 to 7,300 Btu/kWh. A lower number represents a more efficient power plant.

Power plant efficiency: Another common performance metric is CCCT efficiency, and can be calculated from the heat rate. This is a measure of the percentage of the chemical energy in the fuel that is converted to electricity. It is calculated as 3,413 Btu, the amount of energy in one kWh, divided by the CCCT heat rate. Typical optimal efficiencies for new CCCTs range from 45 to 54 percent. A higher number represents a more efficient power plant.

New and clean performance: New and clean performance represents the performance (heat rate or efficiency) of a power plant when it is new and generally running at optimal conditions (unless otherwise specified). New and clean performance values may be expressed on a net basis, where onsite power losses are taken into account.

Operational performance: Operational performance (heat rate or efficiency) is what Commerce is focusing on for the EPS survey and EPS update. It represents real world CCCT performance and takes into account many factors that essentially increase the average heat rate (decrease the efficiency) and GHG emission rate of a given CCCT. These adjusting factors are referred to in this Appendix as adjustment factors, and adjustment factors in the main body of the text. Three key adjustment factors that deserve special mention are plant degradation or ageing, stop/start cycling, and partial load operation.

- Plant degradation or ageing captures the loss of efficiency that occurs as a plant is used and operational hours build up. In this analysis the ageing adjustment factor attempts to represent a middle-aged plant that is at the end of a maintenance cycle (maintenance partially restores CCCT performance).
- Cycling a CCCT by stopping and starting it frequently reduces average efficiency and this is taken into account in the EPS survey.
- Operating a CCCT at partial load for extended periods, say at 50 percent of its rated output, also increases the average annual heat rate and decreases efficiency.

These adjustment factors and others are accounted for in the EPS survey. All told, the adjustment factors in the survey increase the new and clean heat rate by nearly 22 percent and decrease efficiency by a similar amount. Commerce used the EPS survey to calculate GHG emissions for existing regional CCCTs and compared these values to the reported emission values. This comparison suggests that the EPS survey is conservative[14] (see Appendix B).

[14] Conservative means that the assumptions increased the EPS value so a higher level of GHG emissions is permitted under the law.

The final operational heat rate approach used in the EPS survey (and associated operational emission rate) is very generous and should enable new CCCTs to remain in compliance with the EPS for decades. Note that Commerce did not focus on the most extreme possible combination of adjustment factors when determining CCCT operational performance measures, as this combination of factors is a low-probability event.

Average GHG emission rate: The quantity of greenhouse gases emitted (overwhelmingly CO2), expressed in pounds per megawatt-hour of electricity production calculated on an annual basis. This value can be calculated using the new and clean or the adjusted operational heat rate for a CCCT. The final EPS survey value that is presented in Figure 1 on page 4 is calculated from the average annual operational heat rates determined in the survey for 19 new, commercially available, and purchased CCCTs. Commerce used a simple average, although a weighted average[15] could have been used as an alternative.

Key Design Criteria and Operational Adjustment Factors Used in the EPS Survey

1. **Turbine manufacturers**: Commerce reviewed the CCCTs from the four largest CCCT manufacturers: General Electric, Siemens, Mitsubishi, and Alstom.

2. **Plant architecture**: Commerce evaluated two system architectures: “1x1” (one combustion turbine followed by one steam turbine) and “2 x 1” (two combustion turbines followed by one steam turbine). These are the most common architectures for CCCTs.

3. **Class of combustion turbine**: For each manufacturer and system architecture, Commerce surveyed one to four classes (design vintages) of combustion turbines. Two aero-derivative CCCTs, a less common and less efficient design, were also included in the survey.[16]

4. **Purchased and available**: Commerce excluded CCCTs that, while listed as available, have not been purchased in sufficient numbers by utilities or independent power producers over the past five years to be considered “new, commercially available, and purchased.”[17]

5. **CCCT heat rates**: Commerce obtained reference heat rates for the CCCT configurations from the 2011 and 2012 Gas Turbine World Handbooks (converting to higher heating value heat rates using the conversion factor 1.108).

6. **System loss adjustment**: A uniform adjustment (percentage increase) of 2 percent was applied to the CCCT heat rates noted above to account for typical system losses: inlet and exhaust pressure drops, transformer loss, emission control system loss, etc.

[15] The CCCTs in the survey could have been weighted by size (megawatts capacity) and/or the anticipated frequency of the purchase of specific models. Weighting would have resulted in a lower average GHG emission rate.

[16] New models of CCCTs that are listed by manufacturers, but haven’t been ordered or built are not included in the survey.

[17] The survey includes the new and clean heat rate for 19 representative new CCCTs. Heat rate values are adjusted to take into account a number of design and operational factors that influence CCCT heat rate and GHG emissions. The survey does not include CCCTs that are commercially available, but were not sold/purchased by utilities or independent power producers in the U.S. from 2005-2010.

7. **Ageing adjustment**: A uniform adjustment factor of 3.5 percent was applied to the CCCT heat rates to account for performance degradation due to use of the CCCT. Performance degradation is comprised of reversible and non-reversible elements. Periodic maintenance can partially restore CCCT performance.

8. **Duct firing adjustment**: CCCTs often have supplemental and lower efficiency duct firing that can boost facility output for a short period. Commerce further adjusted the heat rate of each configuration to reflect 15 percent of additional capacity from full duct firing at 37.5 percent of operational hours, or 2,464 annual hours.[18] Duct firing heat rate was assumed to be 9,400 and 9,750 Btu/kWh for large and small CCCTs respectively.

9. **Start/stop/low output adjustment**: Commerce worked with stakeholders and others to establish an adjustment factor of 6 percent to CCCT heat rates for typical start/stop cycling and low-output operation.

10. **Cooling technology adjustment**: Commerce worked with stakeholders to develop an adjustment factor of 1 percent for CCCTs that use air-cooling technology and inlet cooling.

11. **Conversion to emission factors**: Determine final adjusted heat rate for all CCCT configurations and multiply by the appropriate natural gas emission factor to arrive at an emission rate of pounds CO_2 per MWh for all configurations. The emission factor used in the survey is the value specified by the Washington Department of Ecology: 117.6 lb/million Btu.

12. **Include other GHG gases**: Add standard values (lb/MWh) for methane and nitrogen oxides emissions based on Department of Ecology reports.

13. **Average emission factor**: Average across all CCCT in the survey to arrive at the average GHG emission factor (this will be the state's updated emission performance standard). This is a simple average and not weighted for anticipated frequency of purchase of the new CCCTs.

[18] A survey of regional CCCTs with duct firing indicated the average duct firing capacity value to be 14.3 percent. Another smaller survey revealed that CCCTs used their duct firing about 33 percent of the time.

Appendix B: Reported versus Calculated GHG Emissions for Existing CCCTs

Existing CCCTs were evaluated using the EPS survey methodology to determine if the methodology produced emission rate values consistent with actual turbine operations. Commerce identified the type and vintage for existing CCCTs in Washington and Oregon and "ran" the EPS survey on these CCCTs to estimate their emission rates. Reported[19] GHG emission rate values (2010) for the existing CCCTs were paired with the EPS survey values and are presented in Table 2 below and Figure 1 on page four. The two CCCTs that exceed the current EPS are shown in italics, while the two CCCTs likely to exceed the proposed EPS are shown in bold. These four CCCTs share some characteristics: they are earlier vintages, smaller, and two are cogeneration units.

Considering the entire group of existing CCCTs, the calculated and reported emission rates are fairly close: 957 lb/MWh versus 945 lb/MWh. However, it is actually more reasonable to exclude the two highest emitting existing CCCTs from the average.

- The Centralia Big Hanaford facility is primarily being run for short periods as a peaking plant (the steam turbine is rarely used) and consequently has much higher than expected emissions.
- The Bellingham facility was designed as a co-generation plant, but the paper mill that was its thermal host was closed about eight years ago, which explains the high emission rate for this plant.[20]

If the Bellingham and Big Hanaford facilities are excluded, the average calculated emission rate for the remaining CCCTs is much higher than the reported emission rate: 939 lb/MWh versus 866 lb/MWh. This suggests that the performance adjustment factors in the EPS survey methodology are generous and that the proposed EPS update value of 980 lb /MWh is conservative,[21] and will accommodate power plant ageing and a wide range of sub-optimal operation.

[19] Emission rates reported to the Washington Department of Ecology, EFSEC, or the U.S. EPA.

[20] The Washington EPS gives credit for cogeneration thermal energy. The Bellingham facility no longer supplies the paper mill with thermal energy and cannot take this emission credit.

[21] Conservative means the assumptions increased the EPS value so a higher level of GHG emissions is permitted under the law.

Facility	Ownership	CCCT model	Nominal class	Start year	Capacity (MW)	Est. heat rate (new & clean)	Adjusted heat rate	Calculated emission rate	Reported emission rate 2010
						BtuHHV/kWh	BtuHHV/kWh	lb GHG/MWh	lb GHG/MWh
Chehalis	utility	207FA	F	2003	520	6,725	7,689	904	891
Mint Farm	utility	107FA	F	2008	319	6,747	7,941	934	845
Frederickson	utility/independent	107FA	F	2002	270	6,747	7,923	932	859
Grays Harbor	independent	207FA	F	2008	620	6,692	7,899	929	870
Goldendale	utility	S107FA	F	2004	250	6,747	7,899	929	815
Hermiston	utility/independent	S107FA	F	1996	475	6,869	8,038	945	815
River Road	utility	S107FA	F	1997	250	6,848	7,830	921	859
Coyote Springs 1	utility	S107FA	F	1995	266	6,882	7,898	929	872
Coyote Springs 2	utility	S107FA	F	2003	287	6,747	7,850	923	816
Port Westward	utility	M501G	G	2007	500	6,473	7,497	882	822
Ferndale	**independent**	**S107EA**	**E**	**1994**	**245**	**7,684**	**9,087**	***1,069***	***991***
Sumas	***utility***	**S107EA**	**E**	**1993**	**125**	**7,684**	**8,786**	***1,033***	***982***
Bellingham	*utility*	*106C*	*Frame 6*	*1993*	*160*	*7,865*	*8,993*	*1,058*	*1,407*
Big Hanaford	*independent*	*LM6000PC*	*Aero*	*2002*	*248*	*7,279*	*8,577*	*1,009*	*1,389*
							Averages	Calculated	Reported
							All CCCTs	957	945
							Excludes 2 highest	939	866
							Newest CCCTs	919	845

Table 2: Calculated and Reported GHG Emissions for the Current Washington/Oregon Fleet of CCCTs. (Source: Washington State Energy Office workbook no. W0025)