# Oregon Department of Energy Analysis of 13 Principles for Amending the Carbon Dioxide (CO2) Standards

## Overview

ORS 469.503(2)(a) and OAR 345-024-0570 give the Council the authority to reset the Council's carbon dioxide (CO2) emissions standard for base load gas plants. ORS 469.501(1)(o) and OAR 345-024-0610 give the Council the authority to reset the Council's CO2 emissions standards for non-base load power plants. ORS 469.503(2)(b) and OAR 345-024-0640 give the Council the authority to reset the Council's CO2 emissions standard for nongenerating energy facilities. OAR 345-024-0610 and -0640 require the CO2 standards for non-base load power plants and nongenerating energy facilities to be equivalent to the CO2 standard for base load gas plants.

**OAR 345-024-0570 Modification of the Standards for Base Load Gas Plants**

> *The Council may by rule modify the carbon dioxide emissions standard for base load gas plants in OAR 345-024-0550 if the Council finds that the most efficient stand-alone combined cycle, combustion turbine, natural gas fired energy facility that is commercially demonstrated and operating in the United States has a net heat rate of less than 6,955 Btu per kilowatt hour higher heating value adjusted to ISO conditions. In modifying the carbon dioxide emission standard, the Council shall determine the rate of carbon dioxide emissions per kilowatt hour of net electric output of such energy facility, adjusted to ISO conditions and reset the carbon dioxide emissions standard at 17 percent below this rate.*

Under the above authority and in compliance with the above statutes and rules, the Department has identified what could be the most efficient combined cycle, combustion turbine (CCCT) natural gas-fired energy facility operating in the U.S. The Grand River Energy Center in Chouteau, Oklahoma has a tested higher heating value (HHV) net heat rate adjusted to ISO conditions of 6,326 Btu per kilowatt hour (kWh). ***A summary of the test data is attached to this document.***

Since 6,326 Btu/kWh is less than the existing benchmark heat rate of 6,955 Btu/kWh (called out in OAR 345-024-0570, see above), the Department recommends the Council adopt 6,326 Btu/kWh as the new benchmark heat rate in OAR 345-024-0570 and use 6,326 Btu/kWh to reset the carbon dioxide (CO2) emissions standard for base load gas plants in OAR 345-025-0550. To reset the base load CO2 standard, 6,326 Btu/kWh must first be reduced by 17% to 5,251 Btu/kWh. Then 5,251 Btu/kWh must be multiplied by 0.000117 lbs. CO2/Btu to convert the heat rate into an emissions rate. This conversion yields an emissions rate of 0.614 lbs. CO2/kWh.

Therefore, in compliance with the above statutes and rules, the Department recommends the CO2 emissions standard for base load gas plants be reset to 0.614 lbs. CO2/kWh, and the standards for non-base load power plants and nongenerating energy facilities be reset to that equivalent. The standard for non-base load power plants would be reset to 0.614 lbs. CO2/kWh, and the standard for nongenerating energy facilities would be reset to 0.458 lbs. CO2/hp-hr [the horsepower hour (hp-hr) equivalent of 0.614 lbs. CO2/kWh]. The current rate for base load and non-base load pants is 0.675 lbs./kWh and the current rate for nongenerating facilities is 0.504 lbs. CO2/hp-hr.

## 13 Principles

OAR 345-024-0510 specifies 13 principles [also specified in ORS 469.503(2)(b)] that the Council must consider and balance in adopting or amending CO2 emissions standards for fossil-fueled power plants:

**OAR 345-024-0510 Principles for the Adoption of New Standards for Fossil-Fueled Power Plants**

> *The Council shall adopt carbon dioxide emissions standards for fossil-fueled power plants by rule. In adopting or amending such carbon dioxide emissions standards, the Council shall consider and balance at least the following principles. In the rule-making record, the Council shall include findings on these principles:*

**(1) Promote facility fuel efficiency;**

Pursuant to statute and rule, the proposed CO2 emissions standards are 17 percent lower than the emissions rate of the most efficient natural gas-fired CCCT operating in the U.S. Ensuring the standard is set modestly below the most efficient technology available and operating helps drive the development of more fuel efficient plants because the more efficient a plant is the less CO2 emissions that plant must offset to meet the standard. Fuel efficiency is the most direct and most certain way to reduce CO2 emissions.

**(2) Promote efficiency in the resource mix;**

Depending on load growth, fuel costs, and the retirement of aging power plants in Oregon, the proposed CO2 emissions standards may promote an increase in the percentage of high efficiency natural gas-fired power plants sited in Oregon relative to other conventional thermal power plants sited in Oregon. The proposed CO2 emissions standards are not predicted to promote an increase or decrease in the percentage of non-conventional energy facilities sited in Oregon. In 2000, natural gas was around 8 percent of the regional mix. As of January 2018, natural gas is around 14% of the regional mix.

**(3) Reduce net carbon dioxide emissions;**

Indirectly reducing the net CO2 emissions from fossil-fueled energy facilities sited in Oregon is the main function of the existing CO2 emissions standards. The proposed standards will continue to indirectly reduce the net CO2 emissions of future fossil-fueled energy facilities sited in Oregon by requiring those facilities to reduce their net greenhouse gas emissions to meet or beat the applicable CO2 standard. The proposed CO2 emissions standards may also directly reduce the gross CO2 emissions from future fossil-fueled energy facilities sited in Oregon by encouraging developers to build the most efficient energy facility possible. Facilities have three compliance pathways to reduce their net greenhouse gas emissions: 1) Monetary Pathway, where facilities pay The Climate Trust to procure greenhouse gas offset projects; 2) Self-Implementation Pathway, where facilities procure or implement their own greenhouse gas offset projects; and

3) Cogeneration Pathway, where new facilities are designed to displace greenhouse gas emissions that would have otherwise occurred but for the energy supplied by the new facility. To date, all site certificate holders have complied via the monetary pathway. Carbon dioxide is just one of many greenhouse gases that may be reduced through greenhouse gas offset projects.

**(4) Promote cogeneration that reduces net carbon dioxide emissions;**
The proposed CO2 emissions standards do not affect cogeneration as an option for an offset.

**(5) Promote innovative technologies and creative approaches to mitigating, reducing or avoiding carbon dioxide emissions;**
The proposed CO2 emissions standards do not affect the opportunity for a developer to comply via the Self-Implementation Pathway or the Cogeneration Pathway that already exist, where developers can propose to implement innovative technologies and creative approaches to mitigating, reducing or avoiding CO2 emissions, including offset projects that are more cost-effective than relying on the monetary path. Also, the Monetary Pathway does not limit the types of greenhouse gas offset projects a qualified organization (The Climate Trust) may procure.

**(6) Minimize transaction costs;**
The proposed CO2 emissions standards do not affect the Monetary Pathway that already exists, a pathway that presents an opportunity for a developer to minimize transaction costs by allowing compliance through a single transaction, i.e. providing the required offset funds to a qualified organization.

**(7) Include an alternative process that separates decisions on the form and implementation of offsets from the final decision on granting a site certificate;**
Continued use of the existing Monetary Pathway fulfills this principle.

**(8) Allow either the applicant or third parties to implement offsets;**
The proposed CO2 emissions standards do not affect the Self-Implementation Pathway that already exists.

**(9) Be attainable and economically achievable for various types of power plants;**

## Table 1

**Table 1** compares the excess emissions (in short tons) of the two most efficient facilities the existing and proposed standards are based upon if those facilities were built in Oregon with a nominal generating capacity of 370 MW. The left column shows the excess emissions of the River Road Generating Plant in Vancouver, WA (the facility upon which the existing standard is based), if that facility were constructed in Oregon under the existing standard. The right column shows the excess emissions of the Grand River Energy Center in Chouteau, OK (the facility upon which the proposed standard is based), if that facility were constructed in Oregon under the proposed standard.

By design, and contrary to intuition, resetting the CO2 standards to a lower net emissions rate based upon the most efficient technology currently in operation (effectively decreasing the threshold limit for a facility's net CO2 emissions) actually has the net effect of decreasing, not increasing, the excess quantity of CO2 emissions a highly efficient power plant would need to account for in order to comply with the CO2 standards. This decrease is shown in Table 1.

The decrease in the excess quantity of CO2 emissions that a highly efficient power plant must account for under a lower CO2 standard arises from the fact that as plants become more efficient, the 17 percent reduction of the emissions rate of the most efficient power plant operating in the U.S. (i.e., how the standard is reset) becomes a smaller and smaller absolute reduction.

Assumptions:
*The assumption of 370 MW is for illustrative purposes only. The assumption of annual operating hours of 8,760 (a 100% capacity factor) and 30 years of operation are specified in rule.*

| **Table 1**<br>**Under the Proposed Standard -**<br>**Excess Emissions Decrease for Plants Sited in Oregon With the Most Efficient Technology** | | **Then**<br>**(Yr. 2000)**<br>**River Road**<br>**Existing Standard** | **Now**<br>**(Yr. 2018)**<br>**Grand River**<br>**Proposed Standard** |
|---|---|---|---|
| **A** | Heat Rate - Most Efficient Technology (Btu/kWh) | 6,955 | 6,326 |
| **B** | CO2 Emissions Rate (lbs. CO2/Btu of Natural Gas) | 0.000117 | 0.000117 |
| **C** (=A*B) | Gross CO2 Emissions Rate (lbs. CO2/kWh) | 0.8137 | 0.7401 |
| **D** | **EFSC Standard - Net CO2 Emissions Rate** (lbs. CO2/kWh) | **0.675** | **0.614** |
| **E** (=C-D) | Excess CO2 Emissions Rate (lb. CO2/kWh ) | 0.1387 | 0.1261 |
| | | | |
| **F** | Lifetime Plant Output (million kWh) **370 MW Plant * 8,760 hours * 30 years** | 97,236 | 97,236 |
| **G** (=F*C) | Lifetime Gross CO2 Emissions (million lbs.) | 79,124 | 71,968 |
| **H** (=G/2000) | Lifetime Gross CO2 Emissions (million short tons) | 39.56 | 35.98 |
| | | | |
| **I** (=F*E) | Lifetime Excess CO2 Emissions (million lbs.) | 13,490 | 12,266 |
| **J** (=I/2000) | **Lifetime Excess CO2 Emissions** (million short tons) | **6.75** | **6.13** |
| **K** | **Net Decrease Between Standards** (million short tons) | | **(0.61)** |

## Table 2

**Table 2** shows the excess emissions (in short tons) of two facilities under the proposed standard. The left column shows the estimated excess emissions of a hypothetical, less efficient, natural gas-fired power plant sited in Oregon under the existing standard. The right column shows the estimated excess emissions of the same hypothetical, less efficient, plant if it were sited under the proposed standard rather than the existing standard.

Assumptions:
*The assumptions of a nominal capacity of 370 MW and a design heat rate of 6,688 Btu/kWh are for illustrative purposes only. The assumption of annual operating hours of 8,760 (a 100% capacity factor) and 30 years of operation are specified in rule.*

| **Table 2**<br>**Under the Proposed Standard -**<br>**Excess Emissions Increase for Plants Sited in Oregon With Less Efficient Technology** | | **Then**<br>**(Yr. 2013)**<br>**Less Efficient Plant Under Existing Standard** | **Now**<br>**(Yr. 2018)**<br>**Less Efficient Plant Under Proposed Standard** |
|---|---|---|---|
| **A** | Heat Rate<br>(Btu/kWh) | 6,688 | 6,688 |
| **B** | CO2 Emissions Rate<br>(lbs. CO2/Btu of Natural Gas) | 0.000117 | 0.000117 |
| **C**<br>(=A*B) | Gross CO2 Emissions Rate<br>(lbs. CO2/kWh) | 0.7825 | 0.7825 |
| **D** | **EFSC Standard - Net CO2 Emissions Rate**<br>(lbs. CO2/kWh) | **0.675** | **0.614** |
| **E**<br>(=C-D) | Excess CO2 Emissions Rate<br>(lbs. CO2/kWh ) | 0.1075 | 0.1685 |
| | | | |
| **F** | Lifetime Plant Output (million kWh)<br>**370 MW Plant @ 8,760 hours @ 30 years** | 97,236 | 97,236 |
| **G**<br>(=F*C) | Lifetime Gross CO2 Emissions<br>(million lbs.) | 76,087 | 76,087 |
| **H**<br>(=G/2000) | Lifetime Gross CO2 Emissions<br>(million short tons) | 38.04 | 38.04 |
| | | | |
| **I**<br>(=F*E) | Lifetime Excess CO2 Emissions<br>(million lbs.) | 10,452 | 16,384 |
| **J**<br>(=I/2000) | **Lifetime Excess CO2 Emissions**<br>(million short tons) | **5.23** | **8.19** |
| **K** | **Net Increase Between Standards**<br>(million short tons) | | **+ 2.97** |

## Table 3

**Table 3** shows an estimate of the cost of compliance for two facilities under the proposed standard. The column on the left shows the cost of compliance for the Grand River Energy Center (the highly efficient plant the proposed standards are based upon) if that plant were to be sited in Oregon with a nominal generating capacity of 370 MW under the proposed standard. The column on the right shows the cost of compliance for a hypothetical, less efficient, 370 MW natural gas-fired plant sited in Oregon under the proposed standard.

Assumptions:
*As in Tables 1 and 2, the assumption of a nominal capacity of 370 MW and a design heat rate of 6,688 Btu/kWh are for illustrative purposes only. The assumption of annual operating hours of 8,760 (a 100% capacity factor) and 30 years of operation are specified in rule.*

| **Table 3**<br>**EFSC Compliance Costs Under Proposed Standards** | | **Grand River Energy Center** | **Less Efficient Power Plant** |
|---|---|---|---|
| **A** | Excess Tons CO2<br>(million tons over 30 years) | 6.13<br>(see Table 1) | 8.19<br>(see Table 2) |
| **B** | Offset Fund Rate<br>($/ton CO2) | $ 1.90 | $ 1.90 |
| **C**<br>(=A*B) | Offset Funds Required<br>($ million) | $ 11.65 | $ 15.56 |
| **D** | Contracting and Selection Funds<br>(10% of first $500k, 4.286% of remainder)<br>($ million) | $ 0.53 | $ 0.70 |
| **E** | **Total Monetary Path Requirement**<br>**($ million)** | **$ 12.18** | **$ 16.26** |

## Table 4

**Table 4** shows an estimate of the siting, construction and operating costs of a representative 370 MW gas-fired CCCT power plant over 30 years. The left column shows the plant operating 7,884 hours per year (90% capacity factor). The right column shows the plant operating 5,256 hours per year (60% capacity factor). The cost data is from the 7th Power Plan from the Northwest Power and Conservation Council (NWPCC) and has been converted from $2012 to $2018 for illustrative purposes.

Assumptions:

*The assumption of a nominal capacity of 370 MW is for illustrative purposes only. The assumption of a 90% annual operating capacity factor for base load operation (EFSC rules classify plants operating more than 75% of total operating capacity as base load) is used to reflect a typical plant's availability inclusive of maintenance and unplanned outages. The assumption of a 60% annual operating capacity factor for the plant under non-base load operation (EFSC rules classify plants operating less than 75% of total operating capacity as non-base load) is for illustrative purposes only. The assumption of a 30 year operating life is specified in rule.*

| **Table 4**<br>**NWPCC Construction and Operating Costs** | | **Base Load Operation** | **Non-Base Load Operation** |
|---|---|---|---|
| **A** | Nominal Capacity (MW) | 370 | 370 |
| **B** | Life of Plant (Years) | 30 | 30 |
| **C** | Operating Capacity Factor | 90% | 60% |
| **D** | Annual Hours of Operation (Hours/Year) | 7,884 | 5,256 |
| **E** | Levelized Cost of Electricity (LCOE)*<br>in 2018 dollars ($/MWh)<br>*Includes capital, fixed and variable O&M, fixed and variable fuel using a median fuel price forecast, and BPA P2P Transmission. | $65.75 @ 90% | $78.43 @ 60% |
| **F**<br>(=A*D*E) | Annual Cost*<br>in 2018 dollars ($M/Year) | $191.8 | $152.5 |
| **G**<br>(=PV of F) | **Lifetime Present Value Costs**<br>in 2018 dollars ($B, Billions of Dollars)<br>PV @ 4% discount rate for 30 years | **$3.317** | **$2.637** |
| **H** | Cost of Construction (2018 $M/MW) | $1.262 | $1.262 |
| **I**<br>(=H*A) | **Construction Cost**<br>in 2018 dollars ($M, Millions of Dollars) | **$466.9** | **$466.9** |

## Table 5

**Table 5** shows the likely costs of compliance with the proposed CO2 standards via the Monetary Pathway for the facilities identified in Table 4.

NOTE: *Unlike the assumption of a 90% annual operating capacity factor for the base load operation used in Table 4 for estimating construction and operating costs, compliance costs are calculated using an annual operating capacity factor of 100% because EFSC statutes and rules specify a 100% capacity factor for base load operation.*

| **Table 5**<br>**EFSC Compliance Costs for Most Efficient Technology** | **Base Load Operation** | **Non-Base Load Operation** |
|---|---|---|
| Capacity Factor Used for Compliance | 100% | 60% |
| Lifetime Excess CO2 Emissions (million short tons) | 6.13<br>(See Table 1) | 3.68 |
| **Total Monetary Path Requirement ($M)** | **12.18**<br>**(See Table 3)** | **7.32** |

## Table 6

**Table 6** shows the likely compliance cost via the Monetary Pathway as a percentage of the present value of life-cycle plant costs and as a percentage of construction cost for the two power plant classifications in EFSC rules, base load and non-base load. The estimates of plant construction and operating costs are from Table 4 and the estimates of compliance costs are from Tables 3 and 5. The compliance cost for the less efficient non-base load plant is calculated for this table only, and is not present in any other tables in this document.

| **Table 6**<br>**Economic Feasibility of Proposed Standard in 2018 dollars** | **Base Load (370 @ 90%)**<br>Less Efficient Plant | **Base Load (370 @ 90%)**<br>Most Efficient Plant | **Non-Base Load (370 @ 60%)**<br>Less Efficient Plant | **Non-Base Load (370 @ 60%)**<br>Most Efficient Plant |
|---|---|---|---|---|
| Monetary Path as % of **Lifetime Present Value Costs** (including fuel) | 16.26M / 3.32B<br>**0.49%** | 12.18M / 3.32B<br>**0.37%** | 9.77M / 2.64B<br>**0.37%** | 7.32M / 2.64B<br>**0.28%** |
| Monetary Path as % of **Construction Cost** | 16.26M / 466.9M<br>**3.48%** | 12.18M / 466.9M<br>**2.61%** | 9.77M / 466.9M<br>**2.09%** | 7.32M / 466.9M<br>**1.57%** |

In the range of cases studied, the costs for a 370 MW CCCT power plant to comply with the proposed CO2 standards are: 1) less than 0.5 percent of the total lifetime present value costs to site, construct, and operate that plant for 30 years, and 2) less than 3.5% of the total costs to construct that plant. This analysis compares the cost of compliance with the EFSC CO2 standard to only a subset (construction and operation costs) of the full suite of costs that could inform a developer's decision regarding the most cost-effective location of where to site, construct, and operate a CCCT plant for 30 years. The full suite includes various economic and regulatory compliance costs that vary depending on the exact location of the plant and the regulatory policies of different states and local governments. For example:

- Variable economic costs include those associated with the transmission of electricity from the generating facility itself to the load that electricity is intended to serve. In particular, transmission costs to wheel electricity long distances and the costs of transmission line losses increase the further a generating plant is sited away from the load that plant is built to serve.
- Variable regulatory costs could include climate change policies that require generating facilities to internalize the costs associated with their greenhouse gas emissions. This could occur through application of the social cost of carbon (an estimate of the monetized damages caused by a one-ton increase in CO2 or its equivalent in a given year) in regulated utilities' Integrated Resource Planning processes, a carbon tax, a market-based cap-and-trade system, or any other rule or law regulating greenhouse gas emissions in any Oregon or non-Oregon jurisdiction.

Therefore, the Department estimates that the costs to comply with the newly proposed EFSC standard would not be the sole determining factor on where to site, construct, and operate a CCCT plant, nor be of such a magnitude to significantly influence the determination on where to site, construct, and operate a CCCT plant. Based on this analysis, the Department recommends that the Council conclude that the proposed standard is attainable and economically achievable.

**(10) Promote public participation in the selection and review of offsets;**

The proposed CO2 emissions standards do not affect public participation in the review of offset projects a developer proposes to the Council.

**(11) Promote prompt implementation of offset projects;**

The proposed CO2 emissions standards do not affect the certificate holder's responsibility to begin offset projects or to make offset funds available to the qualified organization prior to beginning construction; nor does it affect the requirements on the qualified organization to contract for projects within a specified time.

**(12) Provide for monitoring and evaluation of the performance of offsets;**

The proposed CO2 emissions standards do not affect monitoring and evaluation of the performance of offsets.

**(13) Promote reliability of the regional electric system.**

The proposed CO2 emissions standards are not likely to affect regional reliability of the electric system. The proposed standards are economically achievable, as discussed in principle (9) above. Therefore, if the reliability of the regional system required a plant to be developed in Oregon, the proposed standards would not prevent that. However, the Department knows of no electric reliability problem that can be resolved only by building a power plant in Oregon rather than another Northwest state.

**Recommendation**
The Department recommends that the Council find that most efficient CCCT natural gas-fired power plant operating in the U.S. is the Grand River Energy Center in Oklahoma. Based on this finding, and after the Council considers and balances the 13 principles under 345-024-0510 and makes findings on these 13 principles, the Department also recommends that the Council adopt the proposed changes to OAR 345-024-0550, 345-024-0570, 345-024-0590 and 345-024-0620 that modify and reset the CO2 standards. These proposed changes include:

345-024-0570 - Replacing 6,955 Btu/kWh with 6,326 Btu/kWh;

345-024-0550 - Replacing 0.675 lbs. CO2/kWh with 0.614 lbs. CO2/kWh

345-024-0590 - Replacing 0.675 lbs. CO2/kWh with 0.614 lbs. CO2/kWh

345-024-0620 - Replacing 0.504 lbs. CO2/hp-hr with 0.458 lbs. CO2/kWh.