Energy Facility Siting Council

Rulemaking:
Phase 2 – Updates to Carbon Dioxide (CO_2) Standards

Rulemaking Advisory Committee (RAC)
Meeting #2

March 21, 2018
1-3pm

Jason Sierman, Energy Policy Analyst
Blake Shelide, Facilities Engineer
Lesley Jantarasami, Climate Policy Analyst

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Today's Presentation

- Review of how EFSC CO_2 standards function
- Review preliminary findings of ODOE's search for most efficient CCCT power plant operating in U.S.
- Group discussion regarding the preliminary findings
- Next steps, including opportunity for RAC to conduct its own research

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Review of EFSC CO_2 Standards

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Part 1: The Standards Themselves

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EFSC CO_2 Emission Standards

- Threshold standards applicable to large-scale fossil-fueled energy facilities proposed in Oregon.
- Threshold standards written in terms of pounds of CO_2 / kWh for generating facilities and pounds of CO_2 / hp-hr for nongenerating facilities.
- CO_2 emissions in excess of threshold standards must be offset.

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Applicability of New Standards

New standards would be applicable to:

- Unbuilt fossil-fueled energy facilities receiving a site certificate after the effective date of the rulemaking.
- Unbuilt fossil-fueled energy facilities receiving an amendment to a site certificate to extend its construction deadlines after the effective date of the rulemaking.
- Built or unbuilt fossil-fueled energy facilities receiving an amendment to a site certificate after the effective date of the rulemaking that adds new CO_2 emitting equipment or alters the operation of existing CO_2 emitting equipment included in the original site certificate.
- Facilities with express terms and conditions in its site certificate that require the application of new CO_2 standards under certain scenarios.

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3 Categories of CO_2 Standards

Standards regulate CO_2 emissions from 3 types of energy facilities:

1) **Base Load Gas Plants Standard**
   - Base Load w/ Power Augmentation (i.e. Duct Firing)

2) **Non-Base Load Power Plants Standard**
   - Regulates Power Augmentation Component

3) **Nongenerating Energy Facilities Standard**

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Base Load Gas Plants

- CO_2 standard = **0.675 lbs. CO_2 / kWh** of net power output
- CO_2 standard equates to a "threshold CO_2 emissions rate"
- CO_2 emissions in excess of standard must be offset
- Excess CO_2 rate = Gross CO_2 rate – Threshold CO_2 rate

Gross CO_2 Emissions Rate
− Threshold CO_2 Emissions Rate
Excess CO_2 Emissions Rate

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Base Load Gas Plants

- Annual operating hours (assumed constant, set in statute)
  - 8,760 hours/year (24 x 365)
- 30-year facility life (set in statute)
- Offsets account for statutory maximum of excess emissions
- Year 1 heat rate "true up," additional offsets? (see slide 19)
- No "true ups" based on actual operating hours b/c already paid statutory maximum

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Non-Base Load Power Plants

- CO_2 standard = **0.675 lbs. CO_2 / kWh** of net power output
- CO_2 standard equates to a "threshold CO_2 emissions rate"
- CO_2 emissions in excess of standard must be offset
- Excess CO_2 rate = Gross CO_2 rate – Threshold CO_2 rate

Gross CO_2 Emissions Rate
− Threshold CO_2 Emissions Rate
Excess CO_2 Emissions Rate

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Non-Base Load Power Plants & Power Augmentation

- Annual operating hours (variable, max. 6,600 hours set in rule)
  - Certificate holder proposes estimate of hours of operation
- 30-year facility life, unless approved for shorter period
- Offsets only account for estimated hours of operation
- Year 1 heat rate "true up," additional offsets? (see slide 19)
- 5-year reporting & "true up" if actual operating hrs > est. hrs

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Nongenerating Energy Facilities

- CO_2 standard = **0.504 lbs. CO_2 / hp-hr** of net power output
- CO_2 standard equates to a "threshold CO_2 emissions rate"
- CO_2 emissions in excess of standard must be offset
- Excess CO_2 rate = Gross CO_2 rate – Threshold CO_2 rate

Gross CO_2 Emissions Rate
− Threshold CO_2 Emissions Rate
Excess CO_2 Emissions Rate

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Nongenerating Energy Facilities

- Annual operating hours (variable)
  - Certificate holder proposes estimate of lifetime fuel usage
- 30-year facility life, unless approved for shorter period
- Offsets only account for estimated lifetime fuel usage
- No Year 1 heat rate “true up”
- Annual reporting & “true up” if cumulative actual fuel usage ever rises above estimated lifetime fuel usage

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Questions

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Part 2: Compliance w/ the Standards

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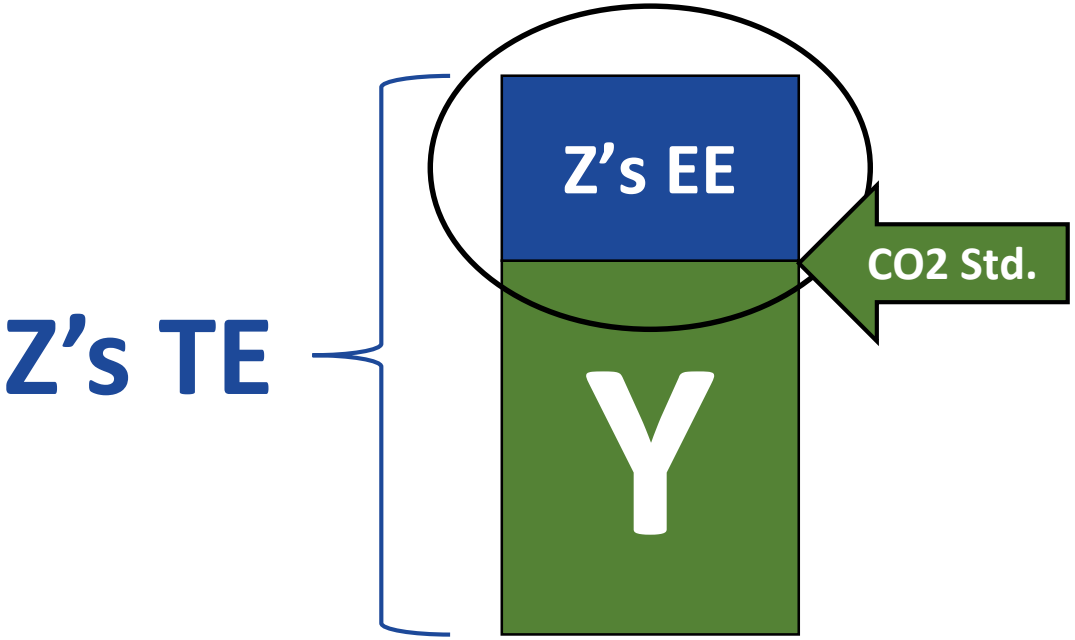
3 Pathways to Compliance

Excess emissions (not total emissions) must be offset using any of the following pathways:

1) **Monetary Payment**

2) Self-Implementation

3) Designed Displacement



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Monetary Payment Pathway

Total Required Funds are composed of two components:

1) Offset Funds

2) Selection and Contracting Funds

Required Funds are analyzed, assessed,approved and verified through a 4-step process

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What's a Heat Rate?

- A "Heat Rate" measures how efficiently a thermal power plant converts heat energy to electric energy.
- Heat energy is measured in BTUs (British Thermal Units).
- A heat rate measures the amount of heat energy (BTUs) required to generate 1 kWh of electricity.
- In a perfect world, a power plant burning 3,412 BTUs of natural gas would generate 1 kWh of electricity.
  - However, lots of heat energy is lost in the process and not all of it converts to electricity.

$$\text{Heat Rate (BTU/kWh)} = \frac{\text{Input Energy (BTU/hr)}}{\text{Output Power (kW)}}$$

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4-Step EFSC Process

1
Approval Phase

Proposed Heat Rate

Funds Estimated

2 
Construction Phase

Contracted Heat Rate

Funds Recalculated and Disbursed

3
Operating Phase

Tested Heat Rate

"true up"

Add'l Funds if Tested HR > Contracted HR

(*No refunds if THR < CHR*)

4
Operating Phase

Operating Hours

"true up"

Add'l Funds if Actual hrs > Estimated hrs

(*No refunds if actual < est.*)

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Calculating Offset Funds

Helpful to think of terms as such:

Equipment Heat Rate
- Turbines
- Engines
- Compressors

7,000 → **Total Emissions Rate** **0.819**

Ex. (7,000 Btu/kWh) x (0.000117 lb./Btu) = 0.819 lb./kWh

CO2 Standard **0.675** → **Allowable Emissions Rate** **0.675**

Offset funds are calculated based on:

- excess emissions rate,
- capacity, and
- operating hours

Total Emissions Rate **0.819** − **Allowable Emissions Rate** **0.675** = **Excess Emissions Rate** **0.144**

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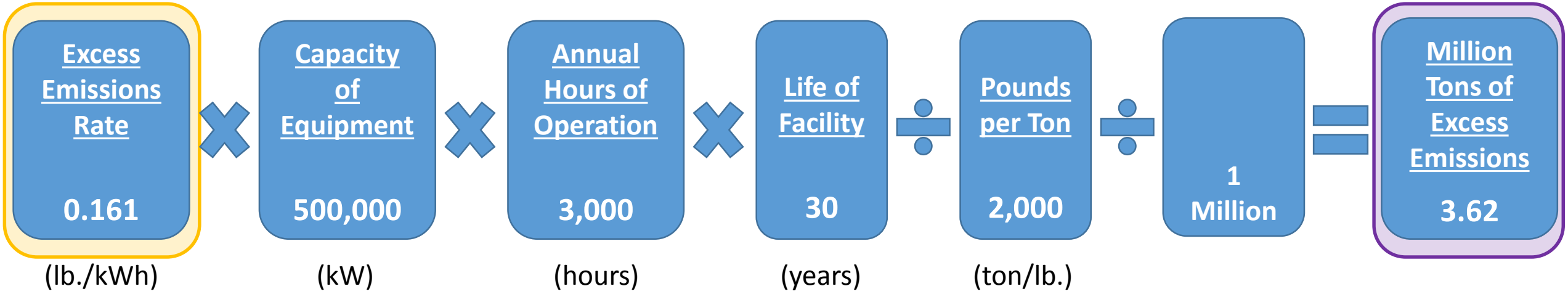
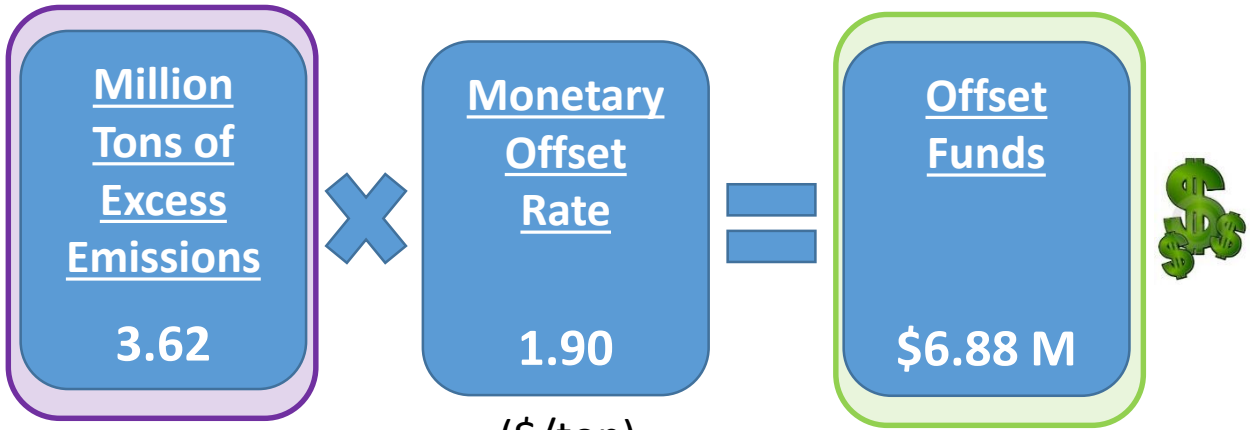
Calculating Offset Funds

Example: 500 MW CCCT operating 3,000 hours per year (non-base load)





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Calculating Selection & Contracting Funds

Example: 500 MW CCCT operating 3,000 hours per year (non-base load)

Selection & Contracting Funds =

10% of first $500,000 of offset funds + 4.286% of offset funds above $500,000

Offset Funds

$6.88 M

Selection & Contracting Funds =

10% x $500,000 = $50,000

4.286% x ($6.88 – $0.05) = $292,734

Selection & Contracting Funds

$0.29 M

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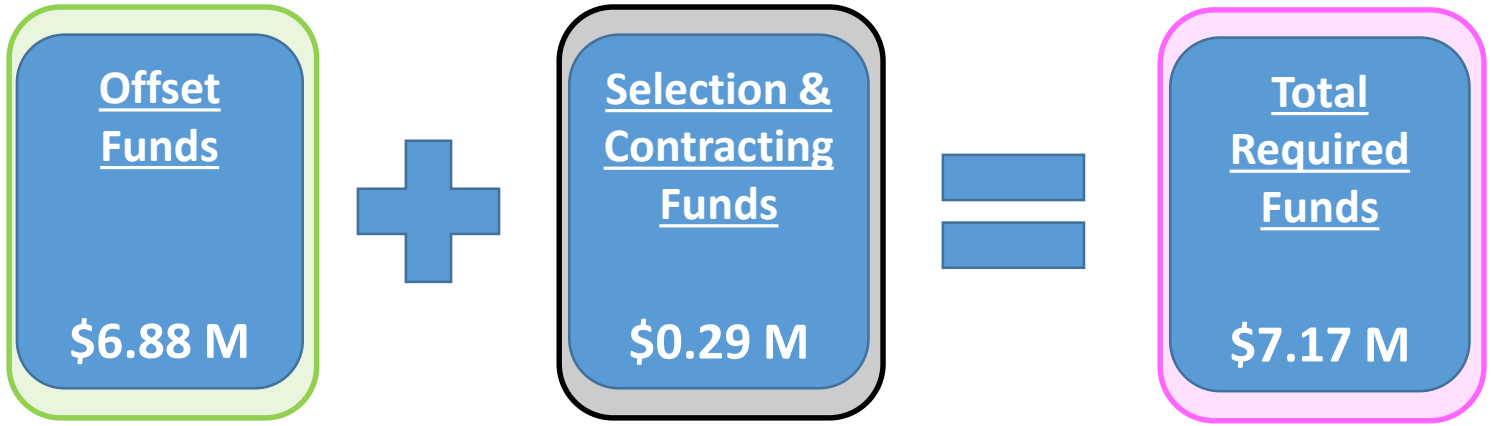
Total Required Funds

Example: 500 MW CCCT operating 3,000 hours per year (non-base load)



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Emission Performance Standard (EPS)

ORS 757.522 to 757.536

- A generating facility-based emissions standard requiring that all new long-term financial commitments for base load generation to serve Oregon consumers must be from power plants that have GHG emissions no greater than the typical (in 2009) combined cycle gas turbine plant.
  - “Long-term financial commitment" means an investment in or upgrade (with a number of exemptions) of a generating facility that produces baseload electricity or a baseload electricity contract (including renewals) with a term of more than five years.

- That level is established at 1,100 pounds of CO_2 per megawatt-hour for IOUs, COUs, and electricity service suppliers (ESSs).

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Review of Preliminary Findings

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Evaluation Process

Status

1) **Staff shares preliminary findings of search for most efficient natural gas-fired power plant operating in U.S.** — ***Complete***
    - **Statutory authority to modify CO2 standards, *see ORS 469.503(2)(a)***

2) Staff conducts preliminary analysis of 13 principles listed under ORS 469.503(2)(b) and OAR 345-024-0510. — ***In Process***

3) Staff asks RAC to vet preliminary findings, analysis of 13 principles and fiscal impact statement. — ***Next Steps***
    - After receiving RAC input, staff may identify new or different heat rate than what staff initially identified.

4) Staff presents Council with a summary of staff's evaluation and a summary of the input received from the RAC. — ***TBD***
    - Staff's presentation may include a recommendation that the existing CO_2 standards be modified, and recommendations as to what they should be modified to.

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Efficiency, Heat Rate, and the Standards

	A = 3,412 / B	**B**	**C**	**D** = B x C	**E** = D x 0.83
	Efficiency (energy out / energy in)	**Heat Rate** (BTU/kWh)	**Conversion Factor*** (lbs. CO_2/BTU)	**Emissions Rate** (lbs. CO_2/kWh)	**-17% Reduction Emissions Std.** (lbs. CO_2/kWh)
Perfect World	100%	3,412	0.000117	0.3992	0.331
1997 Statute	47%	7,200	0.000117	0.8424	0.70
2000 Rulemaking	49%	6,955	0.000117	0.8137	0.675
2018 Rulemaking	**??**	**????**	**0.000117**	**????**	**????**

*Conversion factor of 117 lbs. CO_2 per MMBtu set in rule and statute. ORS 469.503(2)(e)(J) and OAR 345-001-0010(38)(c), 345-021-0010(1)(y)(N)(vii), and 345-024-0620(1).

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What's a Heat Rate?

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- Heat energy is measured in BTUs (British Thermal Units).
- A heat rate measures the amount of heat energy (BTUs) required to generate 1 kWh of electricity.
- In a perfect world, a power plant burning 3,412 BTUs of natural gas would generate 1 kWh of electricity.
  - However, lots of heat energy is lost in the process and not all of it converts to electricity.

$$\text{Heat Rate (BTU/kWh)} = \frac{\text{Input Energy (BTU/hr)}}{\text{Output Power (kW)}}$$

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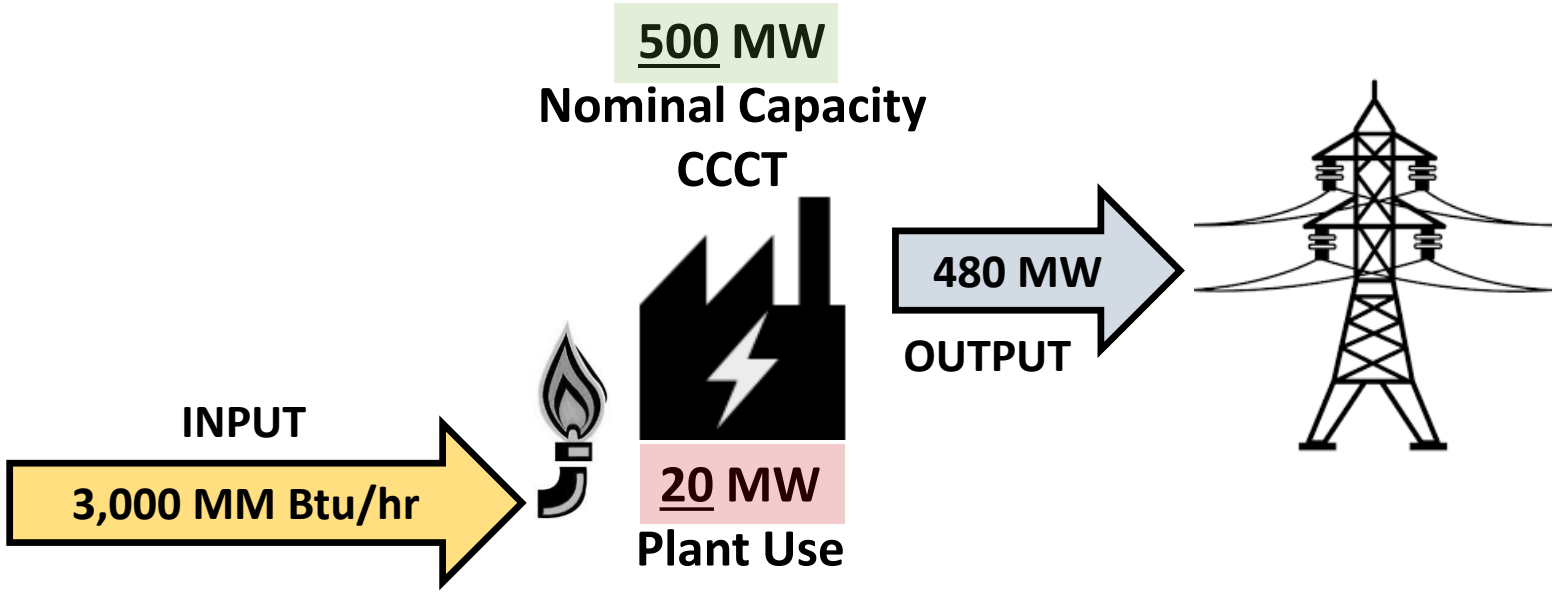
Heat Rate Research

- Staff recognized the difference between various measurements and statements of “heat rate”
- Variables include:
  1) Net vs. gross heat rate
  2) LHV (Lower Heating Value) vs. HHV (Higher Heating Value)
  3) Conditions (temperature, pressure, humidity)
  4) Capacity factor
  5) Manufacturer’s specified heat rate
  6) Field tested heat rate (commissioning, performance guarantee)
  7) Annual operating heat rate

Net Heat Rate > Gross Heat Rate



Type of Heat Rate	INPUT (Btu/hr)	OUTPUT (kW)	Heat Rate (Btu/kWh)
Gross	3,000,000,000	500,000	6,000
Net	3,000,000,000	480,000	6,250

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Higher Heating Value (HHV) > Lower Heating Value (LHV)

- Main priority is knowing which heating value is used for published ratings
  (for today's purposes it is less critical to fully understand difference between the two)
- Related to the latent heat of vaporization of water as a product of combustion
- LHV assumes that this heat *is not* recovered during the combustion process
  (temperature of combustion products is not returned to initial temperature)
- HHV assumes that this heat *is* recovered during the combustion process
  (temperature of the combustion products is returned to initial temperature)
- As expected, HHV > LHV
- HHV ≈ LHV x 1.11

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ISO Conditions

- Efficiency of a turbine is dependent on operating conditions.
- For like-to-like comparisons, it is necessary to specify standard conditions to which tested heat rates can be corrected.
- ISO conditions are specified in ISO-Standard 3977, and are generally:
  1) Temperature = 59°F (15°C)
  2) Pressure = 1 atm/14.7 psia
  3) Humidity = 60% RH
  4) Inlet/outlet pressure conditions
  5) 100% rated load
- Manufacturers provide correction factors for heat rates tested at non-ISO conditions.

Heat Rate Research

- Many variables of the heat rate the Council must find are set in statute:
  1) Gross heat rate vs. **Net heat rate**
  2) LLV vs. **HHV**
  3) Conditions: **ISO: Temp = 59°F, Press. = 1 atm/14.7 psia, Humidity = 60% RH**
  4) Capacity factor: **Base load (100% full power)**

- Ambiguity about what type of heat rate the Council must find:
  1) Manufacturer's spec heat rate,
  2) Field tested heat rate, or
  3) Annual operating heat rate

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Same CCCT, Different Heat Rates

Heat rates from the same CCCT can be measured in different ways

Type of Heat Rate	Hypothetical Example	Efficiency	EFSC Phase
Manufacturer's Spec (Generic gas turbine/steam turbine configurations)	5800	Highest	Application (Est. of funds for EFSC approval)
Designed (Project specific configuration)	5900		Construction (Funds paid to TCT)
Field Tested (Upon plant commissioning, part of performance guarantee, or similar. Follows test procedure and adjusted to ISO)	6100		Operating (Year 1 Heat Rate True Up)
Operating ("Real" annual fuel consumption and net generation)	6400	Lowest	n/a (No Heat Rate True Up after Year 1)

Heat Rate Research

- Statute specifies:
  - "Most efficient" CCCT plant that is "commercially demonstrated and operating in the United States"
  - Newly constructed plants are measured on a "new and clean basis"
  - Adjustment to ISO conditions

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Heat Rate Research

So when we look at the 3 main type of heat rate:

Type of Heat Rate	Determination	Rationale
Manufacturer's Spec Heat Rate		• Not "commercially demonstrated and operating" • Does not match type of heat rate used to determine a newly sited facility's required offsets for compliance
Field Tested Heat Rate		• Matches with category of field tested heat rate used to determine a newly sited facility's required offsets for compliance • Also reasonable since it serves as a midpoint between other heat rates
Annual Operating Heat Rate		• Not adjusted to ISO conditions, this number simply represents average annual "real" conditions • Does not match type of heat rate used to determine a newly sited facility's required offsets for compliance

Heat Rate Research Overview

- Most readily available data pertains to manufacturer's spec heat rate and annual operational heat rate, ***not tested heat rate***.

- Staff methodology for identifying the most efficient CCCT plant included review of the following datasets:

1) EIA (form EIA-923, EIA-860): Used to identify built CCCT plants with the most efficient annual operating heat rates, as well as planned CCCT plants. Used to prioritize and refine the list of plants to contact for tested heat rate data.

2) Trade Publications (Power Engineering): Used annual performance rankings to verify/confirm top operating heat rate facilities identified in EIA data. This was also used to refine the list of facilities to contact.

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Heat Rate Research Overview

3) Trade Publications (Gas Turbine World 2017 CCCT Ratings): Used to determine manuf. design specs for various generic turbine configurations. Used in combo w/ list of known plants. Configuration (1x1, 2x1, etc.) and turbine model were used to identify theoretical design heat rates and prioritize plants to contact.

4) Manufacturer Data: Websites, published materials, discussions w/ manufacturers (thx to PGE for help w/ MHPS). Used to confirm theoretical design performance.

5) States w/ Emissions Performance Standards: Discussions w/ regional states who shared data. Used to confirm methodologies.

6) Individual Power Plants/Generators: Direct contact with plant mgmt. and engineering staff to obtain tested heat rate data and documentation.

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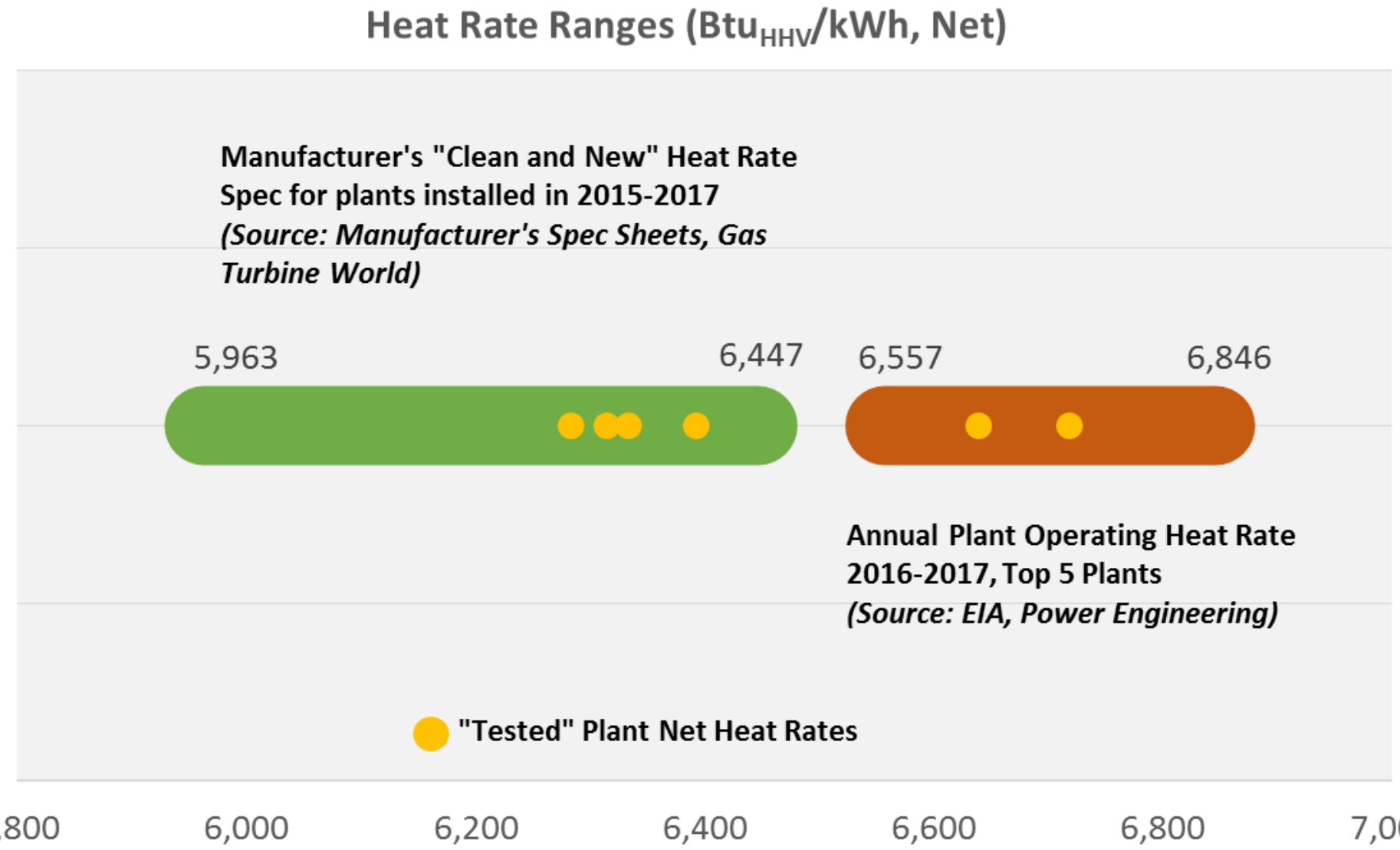
Heat Rate Range Summary To-Date



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Findings

Plant	Owner	State	Nominal Capacity (MW)	Tested Heat Rate (Btu/kWh)	Date of Test
Port Everglades	Florida Power Light	FL	1,237	6,238	n/a
Cape Canaveral	Florida Power Light	FL	1,210	6,314	n/a
Grand River Energy Center	**Grand River Dam Authority**	**OK**	**505**	**6,333**	**1/3/2018**
Riviera Beach	Florida Power Light	FL	1,212	6,393	n/a
Carty – Unit 1	Portland General Electric	OR	397	6,639	11/11/16
Cosumnes	Sacramento Municipal Utility District	CA	519	6,718	11/18/16

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Findings

Grand River Energy Center	
Owner	Grand River Dam Authority
Location	Chouteau, OK
First Year of Commercial Operation	2017
Approx. Cost	$ 296 MM
Turbine Make & Model	Mitsubishi Hitachi 501J
Nominal Capacity	505 MW
Tested HHV Net Heat Rate (adjusted to ISO conditions)	**6,333 Btu/kWh**
http://www.grda.com/electric/facilities/grand-river-energy-center/	

Photo courtesy of GRDA webpage (link in table).

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Group Discussion of Preliminary Findings

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Next Steps

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13 Principles Under 345-024-0510

In amending CO2 emissions standards, the Council shall consider and balance at least the following principles. In the rulemaking record, the Council shall include findings on these principles:

1) Promote fuel efficiency;
2) Promote efficiency in the resource mix;
3) Reduce net carbon dioxide emissions;
4) Promote cogeneration that reduces net carbon dioxide emissions;
5) Promote innovative technologies and creative approaches to mitigating reducing or avoiding carbon dioxide emissions;
6) Minimize transaction costs;

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13 Principles Under 345-024-0510

7) Include an alternative process that separates decisions on the form and implementation of offsets from the final decision on granting a site certificate;
8) Allow either the applicant or third parties to implement offsets;
9) Be attainable and economically achievable for various types of power plants;
10) Promote public participation in the selection and review of offsets;
11) Promote prompt implementation of offset projects;
12) Provide for monitoring and evaluation of the performance of offsets;
13) Promote reliability of the regional electric system.

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Fiscal Impact Statement

ORS 183.333 - (paraphrased summary)

(3) The agency shall seek the RAC's recommendations on whether the rule will have a fiscal impact, what the extent of that impact will be and whether the rule will have a significant adverse impact on small businesses.

(4) An agency shall consider an advisory committee's recommendations provided under subsection (3) in preparing the statement of fiscal impact required by ORS 183.335(2)(b)(E).

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Fiscal Impact Statement

ORS 183.335(2)(b)(E) - (paraphrased summary)

- A statement of fiscal impact identifying state agencies, units of local government and the public that may be economically affected by the adoption, amendment or repeal of the rule.
- An estimate of the economic impact on those identified as affected.
- In considering the economic effect of the proposed action on the public, the agency shall utilize available information to project any significant economic effect of that action on businesses which shall include a cost of compliance effect on small businesses affected.
- A housing cost impact statement.

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Questions

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Scope and Purpose of RAC

- Provide input on staff's preliminary findings:
  - Preliminary new most efficient heat rate = 6,333 Btu/kWh
  - Preliminary new CO_2 Standards = 0.615 lb. CO_2 / kWh and 0.459 lb. CO_2 / hp-hr
- Provide input on staff's evaluation of the 13 principles under ORS 469.503(b) and OAR 345-024-0510
  - *ODOE will email out after RAC Meeting #2*
- Provide input to staff on the fiscal impacts of this rulemaking
  - *ODOE will email out after RAC Meeting #2*
- Please provide input to staff by April 25, 2018

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Rulemaking Milestones

Milestone	Date
EFSC Approval and Appointment of a Rulemaking Advisory Committee (RAC)	December 15, 2017
RAC Meeting #1 - Teleconference w/ RAC	January 24, 2018
RAC Meeting #2 - ODOE office in Salem, OR	**March 21, 2018**
RAC Research Period – Add'l Input Deadline	April 25, 2018
EFSC Authorization to Issue Official Public Notice	April 26/27 (maybe no May EFSC mtg.)
RAC Meeting #3 - ODOE office in Salem, OR • Discuss Add'l Input (Heat Rate, 13 Principles, Fiscal)	Reschedule - TBD (was May 17, 2018)
Public Notice Issued	June 1
EFSC Rulemaking Hearing	June 28/29

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Questions

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