



Output-Based Regulation: Best Practices for Regulators

National CHP Turbine Technology and Regulatory Forum

March 6, 2003

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Prepared under contract for EPA

Overview

- Project scope and purpose
- What is output-based regulation?
- Why apply output-based regulation?
- How to implement output-based regulation?
- Case studies
- Who has implemented output-based regulation?
- Next steps

Output-Based Regulation: Best Practices for Regulators

- Project of EPA's CHP Partnership
- Purpose: Support air regulators seeking to encourage energy efficiency as a control strategy.
- Products:
 - White paper: Nuts and bolts -- What, why and how
 - Outreach and support to air regulators

What is Output-Based Regulation?

- Regulation that relates emissions to the productive output of a device or process.
 - Unit of emissions/unit of output
 - lb emission/MWh
- Can be applied for any process
 - Our focus is the power/large boiler sector

Measurement in Air Regulations

- Historically based on industry practice.
- Some regulations have always been output-based:
 - Engines - g/bhp-hr
 - Industrial processes - lb emission/ton of product
 - Cars - g/mi

Power Generation and Boiler Regulation Have Not Been Output-Based

- Boilers - $\text{lb/MMBtu}_{\text{in}}$
- Turbines - ppm
- Eliminate energy efficiency as a control option.

Output-based version is:

$\text{lb/MWh}_{\text{out}}$

$\text{lb/MMBtu}_{\text{out}}$

Why Output-Based Regulation?

- Recognizes and rewards efficiency which translates to:
 - Reduced fuel consumption (multimedia and energy security impacts)
 - Multi-emission reductions
- Provides a common basis for comparison - apples to apples.
- Relates cost (pollution) to benefit (productive output).

Evolution of Air Quality Regulation

- Initial focus was add-on/end of pipe controls to reduce existing pollution.
 - Great progress has been made on air quality.
- Pollution prevention (P2) is an additional tool to enable further, cost-effective progress.
 - Improving efficiency in any process is P2 at its best.
- Output-based regulations promote efficiency.

Efficiency as a Pollution Control Measure

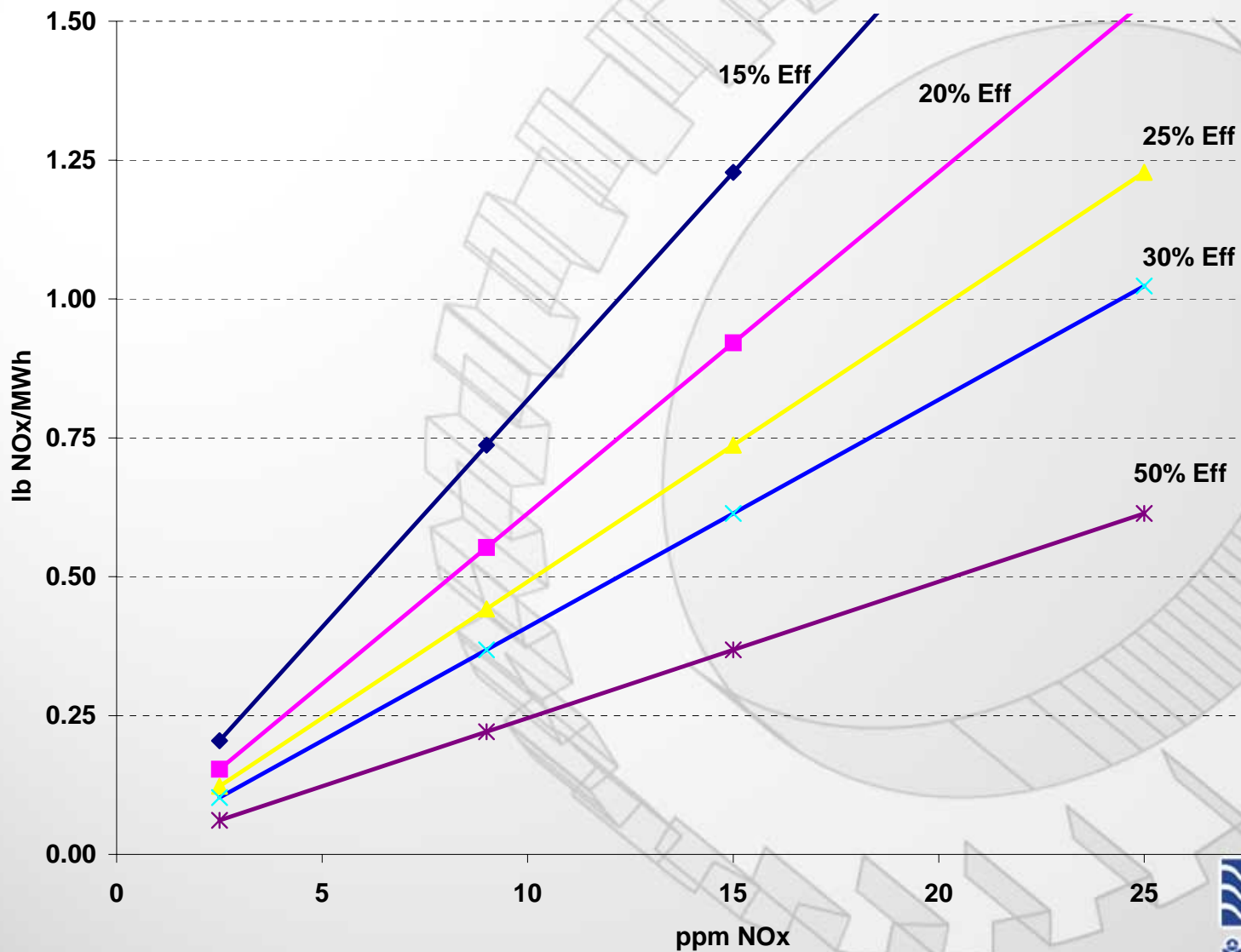
- Reduces all emissions, including non-regulated and greenhouse gases.
- It's always "on". No start-up, shut-down or malfunction interruptions.
- Provides additional options for emission reduction.
- Makes emission reduction more cost-effective.

Design Flexibility Benefits

- Incorporating efficiency allows alternatives to add-on pollution control.

Plant efficiency (percent)	Control device efficiency (percent)	Emission limit lb/MWh
34	60	1.3
40	50	1.3

Efficiency Effect on ppm Emissions



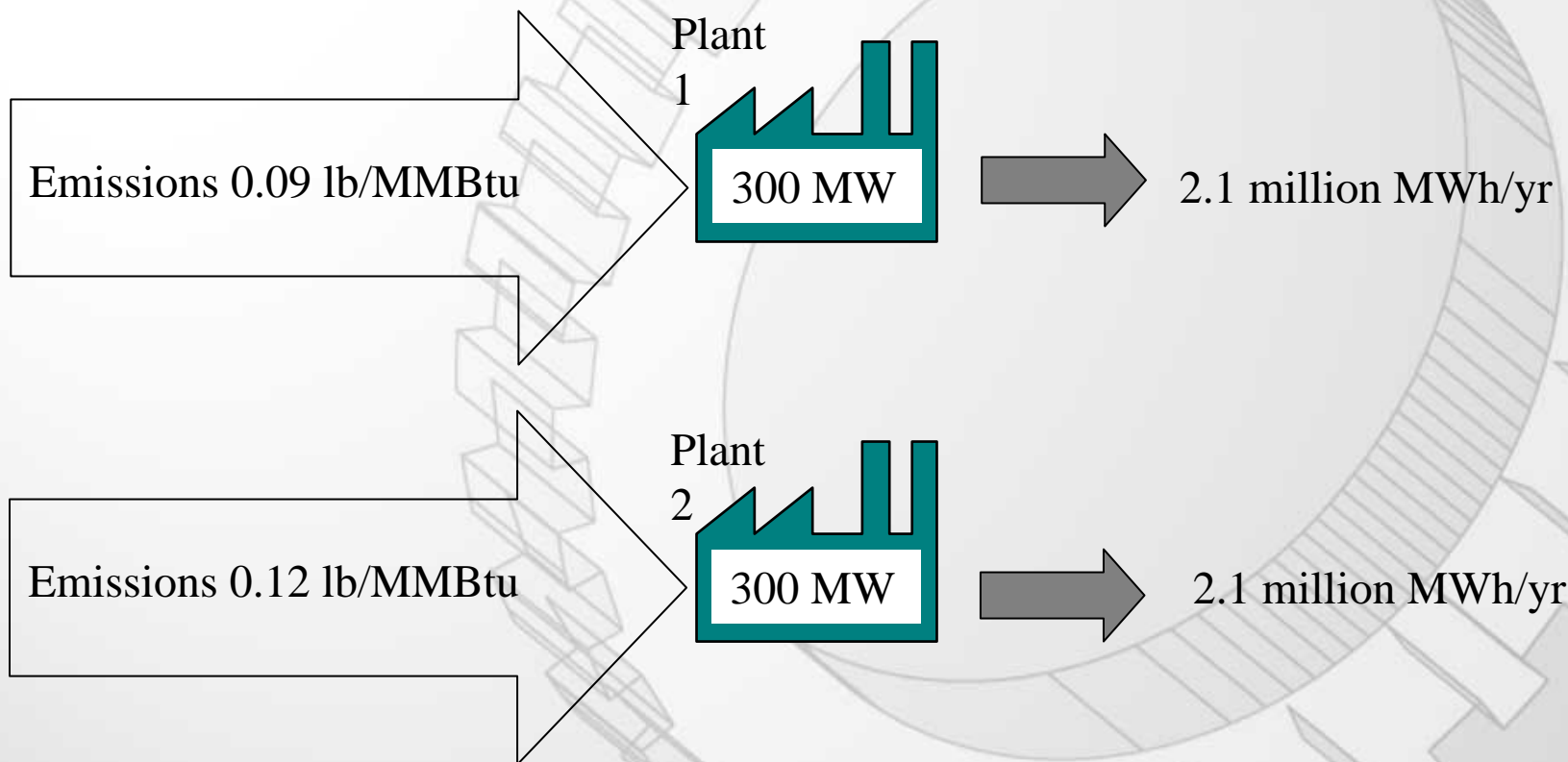
Applications of Output-Based Regulation

- Conventional emission rate regulations
- New rules for smaller generators
- State and Federal multipollutant programs
- Generation performance standards
- Allowance allocation in trading programs

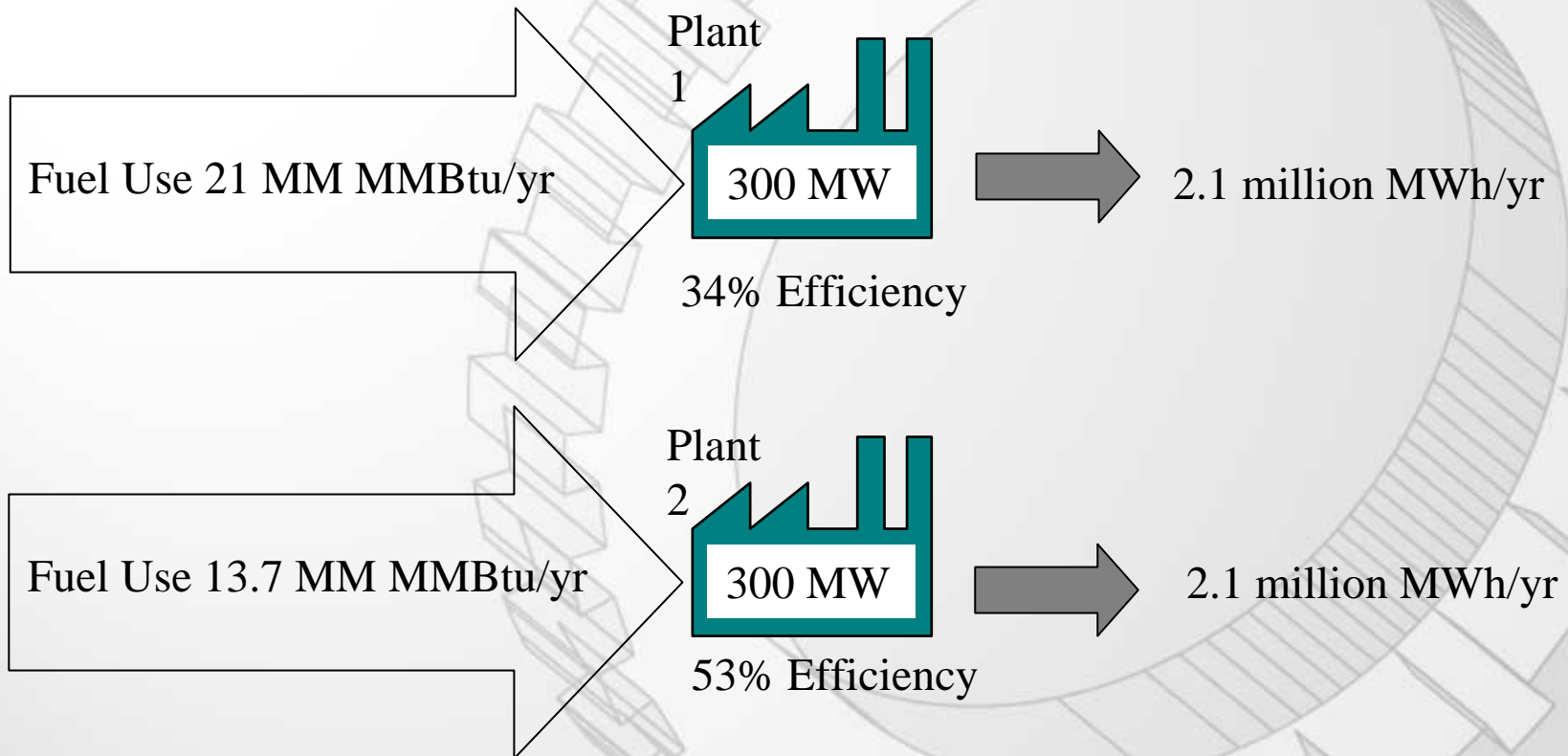
Conventional Rate Limits

- Output-based regulation allows and encourages efficiency to be used as a control option.
 - Combustion efficiency
 - Reduced parasitic loads
 - Generator efficiency
- Links emissions to productive output.

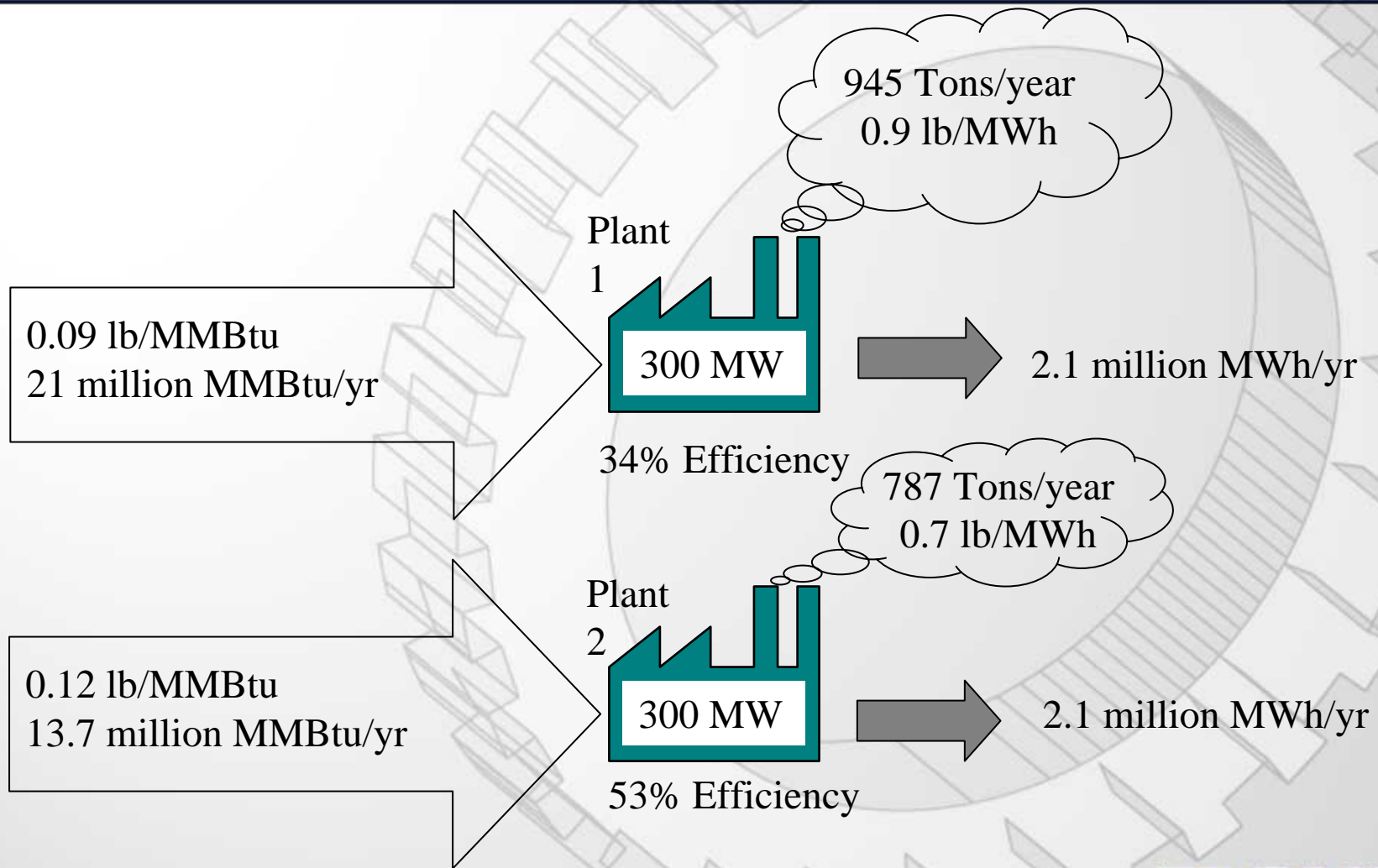
Benefits of Output-Based Regulation



Benefits of Output-Based Regulation



Benefits of Output-Based Regulation



Allowance Allocation

- Allowance allocation is a critical component of cap and trade programs.
- Input-based allocation rewards inefficiency.
- Output-based allocation rewards efficiency and encourages clean technology.

Input vs Output-Based Allocation

Basis of Allocation	Plant 1	Plant 2
<u>Heat Input</u>		
Heat Input (MMMMBtu/yr)	21.0	13.7
Percent of Total Heat Input	61%	39%
Allowances Allocated	909	591
Implied Emission Reduction	4%	25%
<u>Energy Output</u>		
Output (MMMMWh/yr)	2.10	2.10
Percent of Total Generation	50%	50%
Allowances Allocated	750	750
Implied Emission Reduction	21%	5%

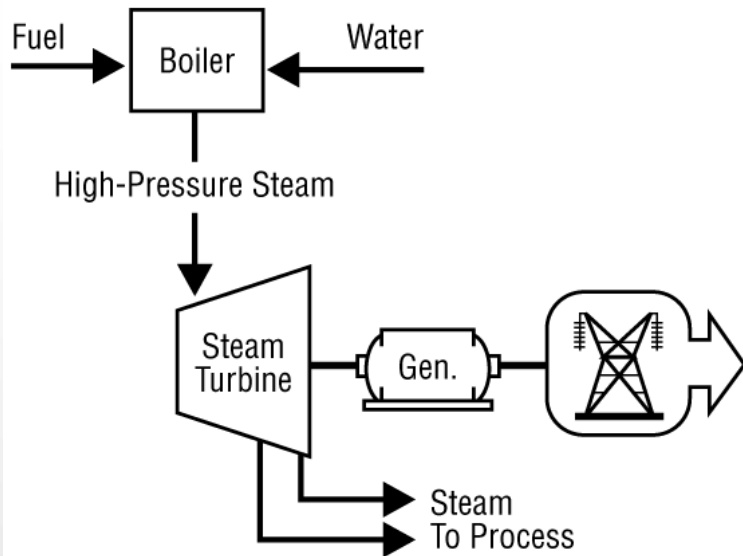
Example: CHP

Combined Heat and Power is the generation of electricity and heat sequentially from the same heat input.

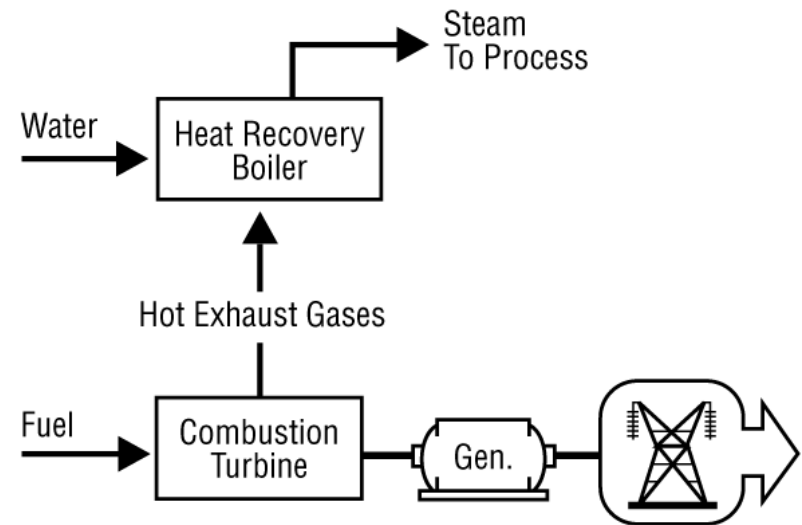
- Electricity primarily used on-site, but some can be sold back to grid. Grid can serve as back-up or swing provider.
- Thermal energy used for heating/cooling or process applications.

Typical CHP Systems

Steam Boiler/Steam Turbine:



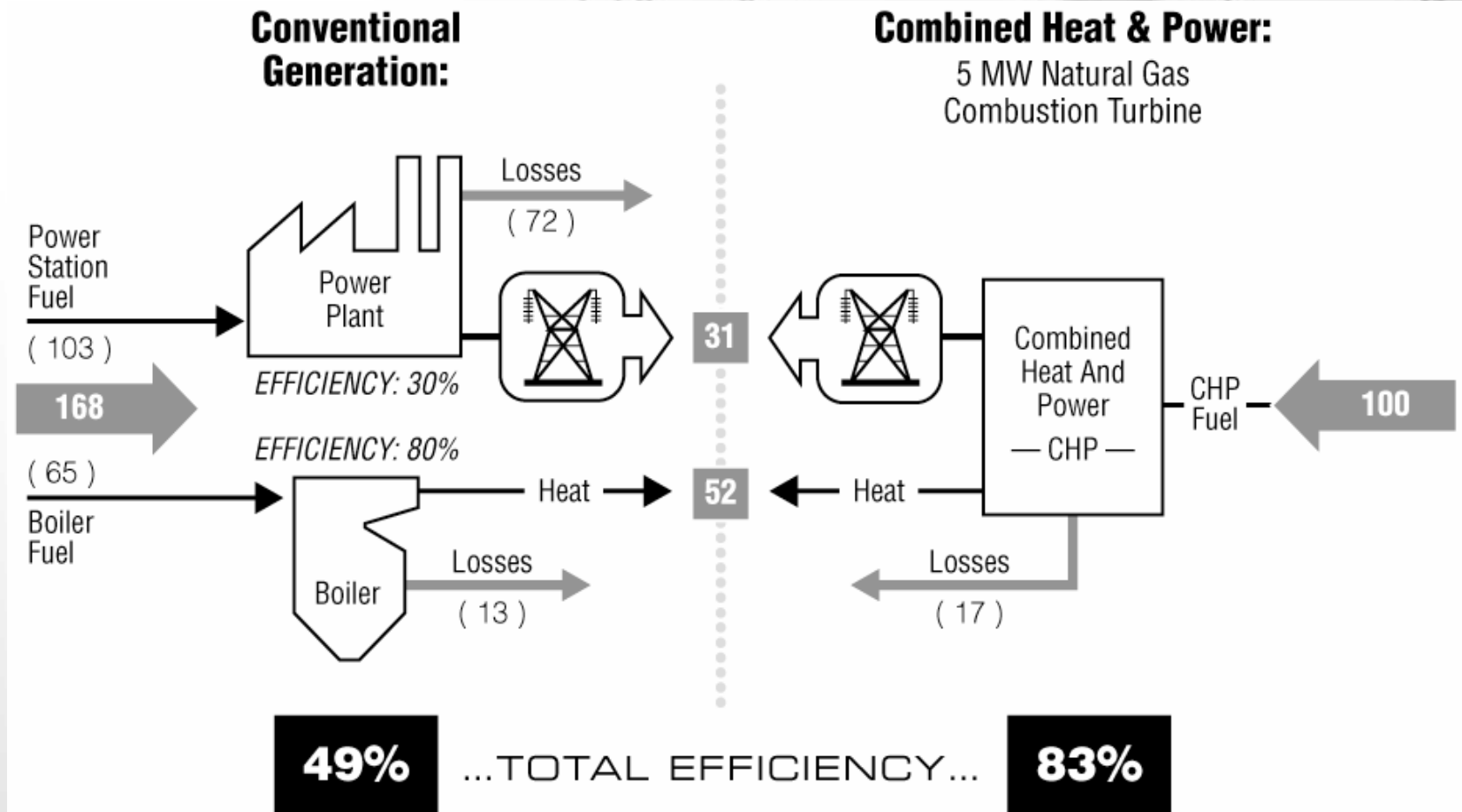
Gas Turbine or Engine/Heat Recovery Unit:



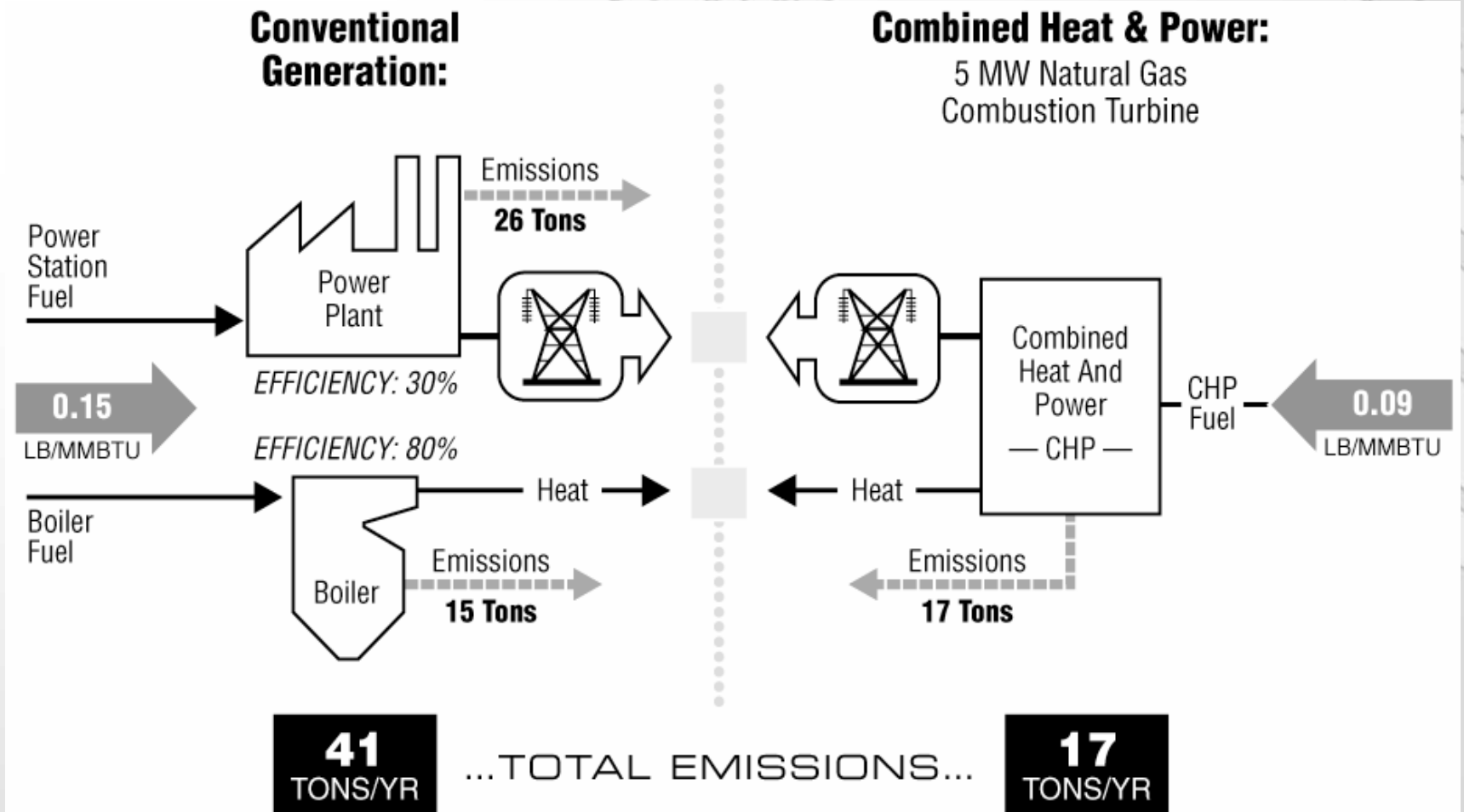
Advantages of CHP

- CHP is more efficient than separate generation of electricity and heat.
- Higher efficiency translates to lower cost.
- Use of waste or byproduct fuel, where available, further reduces cost.
- On-site electric generation avoids distribution costs, a significant component of grid electricity price.
- Increased reliability and power quality can also add significant value.

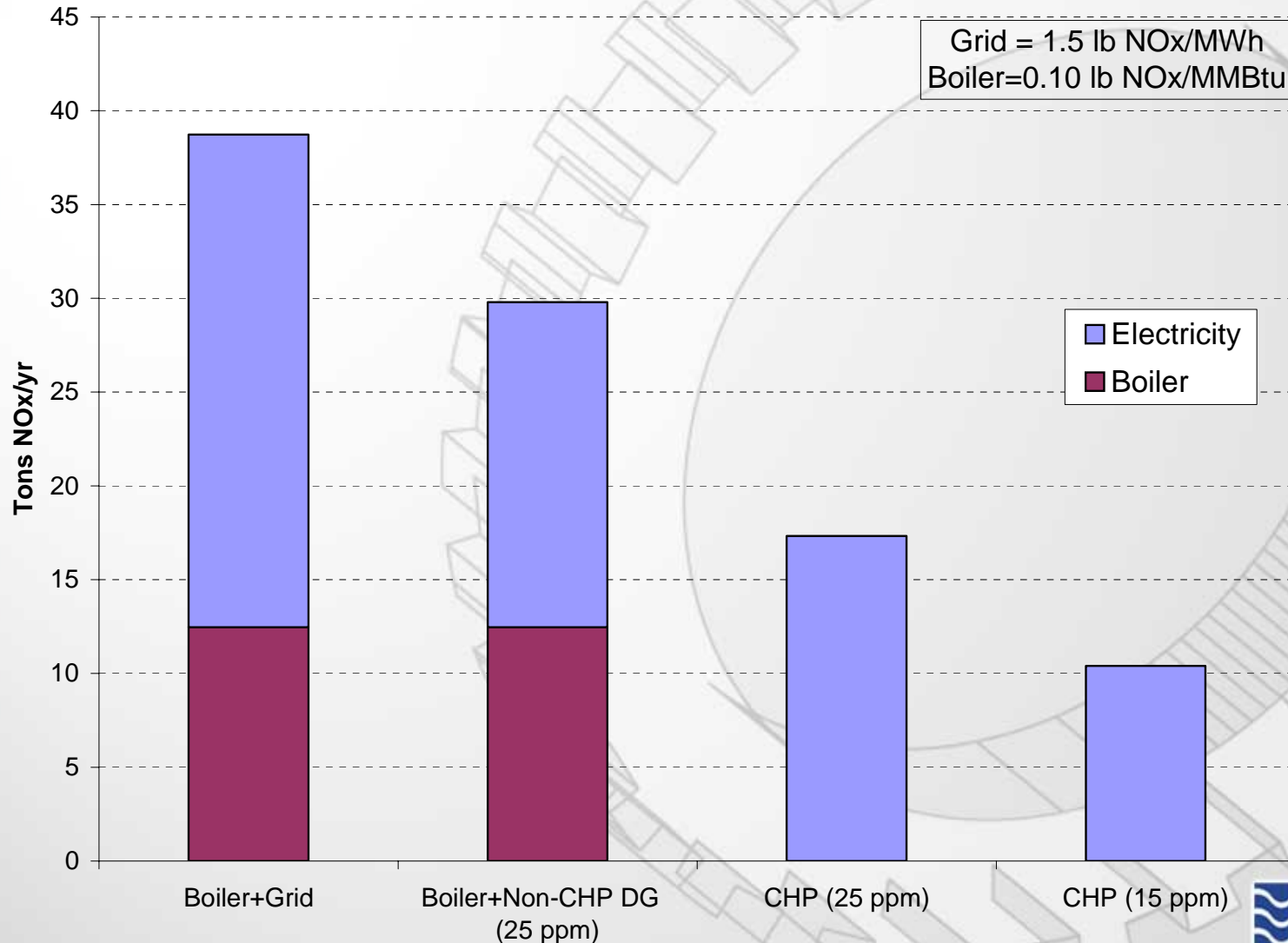
Efficiency Benefits of CHP



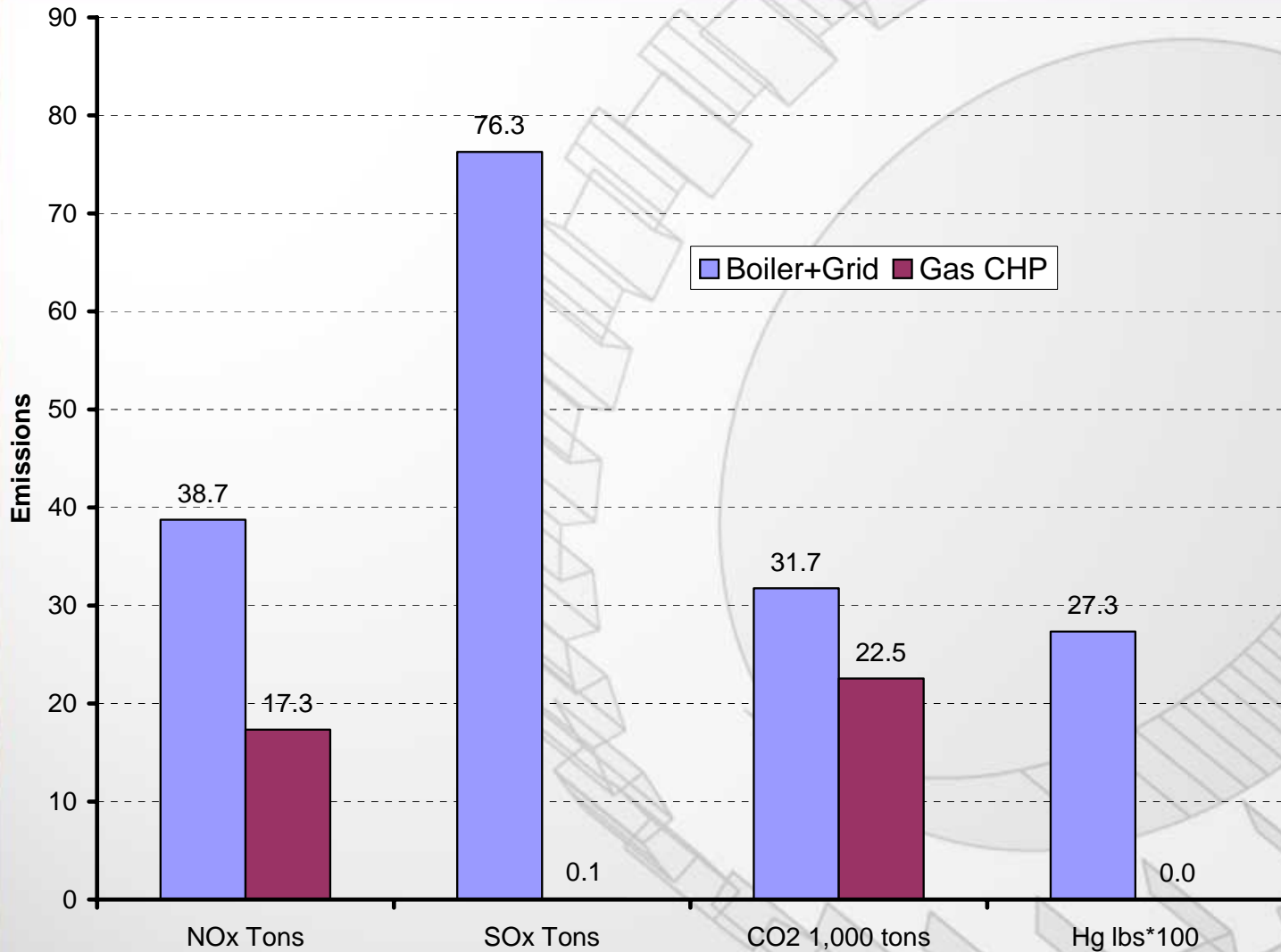
Environmental Benefits of CHP (NO_x)



Central Power vs On-Site CHP Emissions



Multipollutant CHP Benefits



Valuing CHP

- Conventional air regulation does not encourage CHP and can discourage it.
 - Promotes capital investment in tailpipe controls over new process technology.
- Output-based regulation is a key tool in recognizing and rewarding CHP.

How to Implement Output-Based Regulation

- Development of output-based emission limits
- Use of gross vs net energy output
- Compliance measurement
- Treatment of CHP

Development of Limits

- In the near term, we start with input-based limits and convert units to output format.
- Ideally, limits will be based on output-based measurements.
 - Output-based limits allow for uniform and direct comparisons.

Input to Output Conversion

- Power generation - lb/MMBtu, ppm or g/bhp-hr to lb/MWh.
- Industrial boilers - lb/MMBtu_{input} to lb/MMBtu_{output}.
- Requires unit conversions and efficiency factor.

Net vs Gross Output

- Net output deducts internal loads and losses.
- Use of net is closer to policy goal of recognizing overall efficiency.
- Calculation of net can be complicated for large power plants.
- Tradeoff must be made between policy goal and complexity.

Compliance Measurement

- Emission measurement is the same regardless of rule format.
- Output measurement may require new procedures but there are no fundamental barriers.
- Output is often measured as part of plant business (selling the product).

Output Measurement

- Electricity output is easily measured and often measured for commercial purposes.
- Thermal output of large boilers is often measured for plant operation purposes.
- CHP facilities often measure thermal output for sales purposes.
- *The technology is available.*

Accounting for Multiple Outputs

- CHP provides electric and thermal service with higher efficiency and lower emissions than conventional separate systems.
- Output-based regulation is key to recognizing efficiency benefits of CHP.
- Multiple outputs (heat and power) must be addressed.

Two Approaches for Calculation

- Add thermal output to electric output to reduce effective emission rate. (NSPS, CA, TX)
- Calculate credit for avoided thermal generator (boiler). (RAP Model Rule)
- First option is simpler. Second option more directly reflects actual emission benefits.

Thermal Output Approach

- Set basic standard in lb/MWh.
- For CHP system, compliance is calculated as:
emissions/(MWh_e + MWh_{th})
- Some regulations allow only partial thermal credit.
- Impact is primarily a function of system design (P/H).

Displaced Emission Approach

- Set basic standard in lb/MWh.
- For CHP system, compliance is calculated as:
 $(\text{emissions} - \text{avoided emissions})/\text{MWh}_e$
- Avoided emissions are the emissions that would have been created by a boiler providing the same thermal output.
- Reflects actual environmental benefits.

Case Study - NSPS

- In 1998 EPA promulgated revised NSPS for electric utility boilers.
- Changed from input-based, fuel-specific standard to a uniform output-based limit in order to encourage efficiency/consistency.
- Addressed issues of rule development, measurement and implementation

NSPS Implementation

- lb/MWh measure to encompass total plant efficiency.
- Gross output to simplify measurement.
- Limit initially based on conversion of input-based data. Final value based on measured output-based data.
- CHP credit based on 50 percent thermal credit.

Impacts of Output-Based NSPS

- Important indicator of EPA support for output-based regulation.
- Addressed many basic questions regarding output-based regulation, compliance measurement, treatment of CHP.
- Few if any new affected boilers built yet but the value for supporting other regulations has been great.

Case Study - National Model Emissions Rule for DG

- An output-based national model rule has been developed under DOE funding through a stakeholder process facilitated by the Regulatory Assistance Project.
- Draft rule available at: <http://www.raonline.org>

Model Rule

- Sets uniform output-based standards.
- Accounts for CHP output via displaced emissions.
- Encourages precertification.
- Three phases of progressively more stringent limits.

Who Has Done Output-Based Regulation?

- Conventional rate limits
- Distributed generation
- Allowance allocation
- Multipollutant programs
- Generation performance standards

Conventional Rate Limits

- EPA NSPS for utility boilers - uniform output-based limit with credit for CHP
- Ozone Transport Commission Model NO_x Rule - sets NO_x limits for combustion turbines in lb/MWh

Distributed Generation

- California SB 1298 certification program and BACT guidance - output-based limits for NO_x, VOC, CO and PM with some credit for CHP.
- Texas general permit for DG - output-based NO_x limits and full thermal credit for CHP.
- RAP Model Rule - Output-based limits for NO_x, CO, PM with emission credit for CHP.

Allowance Allocation

- Primarily for OTC and SIP call NO_x trading programs.
- Output-based systems in:
 - Connecticut
 - Massachusetts
 - New Hampshire
 - New Jersey

State Multipollutant Programs

- Output-based limits set for four pollutants in:
 - Massachusetts
 - New Hampshire

Federal Multipollutant Programs

- Clear Skies Initiative - Output-based emission performance standard replacement for NSR.
- Carper bill - output-based allocation
- Jeffords bill - output-based set asides for renewables, CHP, efficiency

Generation Performance Standard

- Derives from Massachusetts restructuring language.
- Requires retail sellers to meet output-based portfolio emission standards including out of state generation.
- Connecticut and New Jersey have considered similar requirements.

Next Steps

- Output-based regulation is the mechanism to encourage further efficiency improvements.
- We will do additional work to complete and distribute a draft report.
- Follow up with outreach and coordination to determine a Phase 2.