


**MANUFACTURERS COUNCIL OF THE  
CENTRAL VALLEY:**  
April 15<sup>th</sup>, 2009


**Presentation:**  
**San Joaquin Valley Boiler NOx Regulations &  
Boiler Energy Efficiency Opportunities**

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(CIBEP)

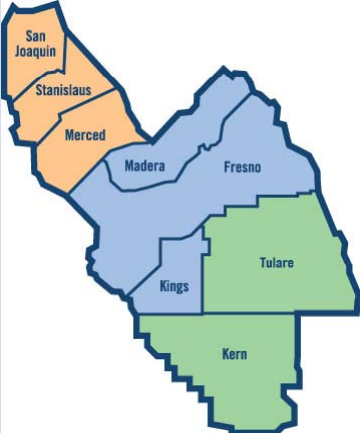
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**Presentation Agenda**

- New SJV Boiler NOx Regulations
- Boiler NOx Formation
- NOx Reduction/Compliance Strategies & Impacts on Efficiency
- Combining Energy Efficiency with Boiler NOx Upgrades:
  - Excellent Opportunity To Do Both
  - Benefits & Examples
- PG&E Rebate/Incentive Programs

2 

**San Joaquin Valley (SJV)  
Air Pollution Control District**





3 

**New Boiler NOx Regulations –  
San Joaquin Valley: Rule 4307 & 4320**

Rated Heat Input (million BTU/hr)	NOx Limit (ppmv @ 3% O2)	Compliance Option / Schedule	Compliance Deadline
≥ 2 to ≤ 5	30	Unless new units installed after January 1, 2010, which are required to meet 9 or 12 ppm NOx (see Rule 4307)	
> 5 to ≤ 20	9	Option A. Standard Schedule	July 1, 2012
	6	Option B. Enhanced Schedule	July 1, 2014
		Option C. Pay an Annual Emissions Fee for compliance	
> 20	7	Option A. Standard Schedule	July 1, 2010
	5	Option B. Enhanced Schedule	July 1, 2014
		Option C. Pay an Annual Emissions Fee for compliance	

Table does not include Oilfield/Refineries & Schools & low usage boilers  
Table only includes boilers using natural gas.  
See the actual regulations for further information and specific compliance requirements.

4 




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### New Boiler NOx Emissions Regulations – San Joaquin Valley

- San Joaquin Valley Air Pollution District
  - Rule 4320 & 4307 [www.valleyair.org](http://www.valleyair.org)
- Rule 4320 replaces 4306
  - Compliance dates: 2010 to 2014
  - Options: Comply or Pay Annual Fee
    - Fee starts in January 2010
    - Recognize compliance may not be cost effective for all facilities
  - New Regulations:
    - 5 to 20 MM Btu = 6 or 9 ppm NOx
    - > 20 MM Btu = 5 or 7 ppm NOx

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### New Boiler NOx Emissions Regulations – San Joaquin Valley

- Rule 4307 covers small boilers from 2 to 5 MM Btu & was amended:
  - Existing boilers: 30 ppm NOx
  - Amendments effect new or replacements boilers installed on or after 2010
    - Must meet lower NOx limits of 9 or 12 ppm

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### Overview of Boiler NOx Formation

- Boilers have burners which use combustion to produce heat to make hot water or steam
  - NOx is a by-product of combustion
- NOx is a pollutant contributing to:
  - Ozone, Particulate Matter, Acid Rain
- 3 Types of NOx Formation:
  - Thermal NOx
  - Prompt NOx
  - Fuel Bound NOx (not a concern if PUC gas)

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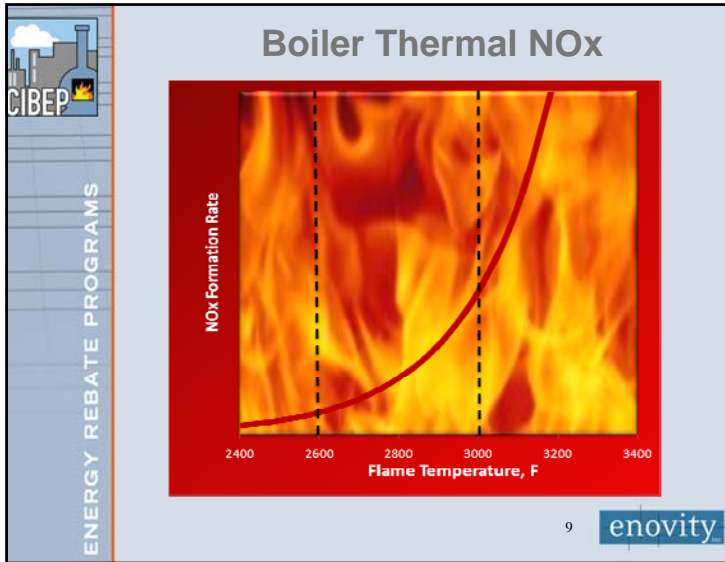
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### Overview of Boiler Thermal NOx

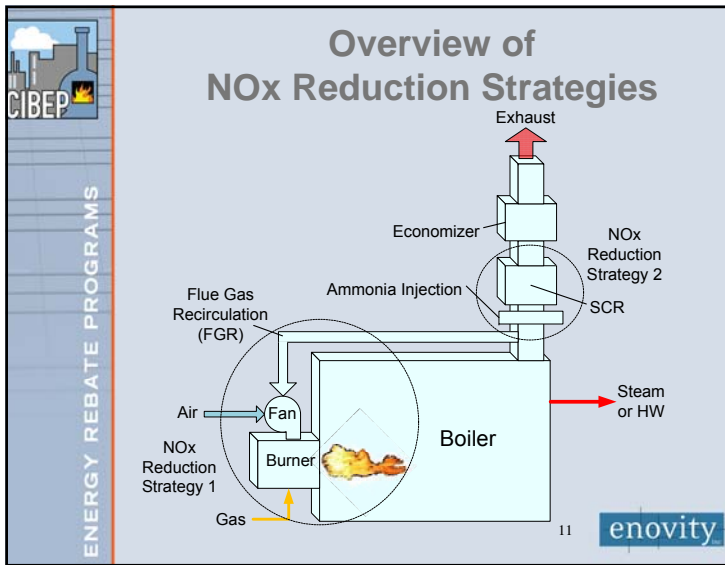
- Thermal NOx is the largest contributor to the overall total NOx
- Combustion: Fuel + Air(O<sub>2</sub>+N<sub>2</sub>) + Ignition
 

Ideal Combustion:  
 $CH_4 + O_2 + N_2 \Rightarrow CO_2 + H_2O + N_2 + O_2 + Heat$
- Under high temperatures of combustion (> 2600F), Thermal NOx is formed:
 
$$N_2 + O_2 + Heat \Rightarrow NOx$$
- Thermal NOx is an exponential function of flame temperature

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- Overview of NOx Reduction Strategies**
- 1) Burner Modifications or New Burner:**
    - Available down to 9 ppm NOx
    - Less than 7 ppm NOx burners being developed
    - Less expensive than exhaust treatment / SCR
    - Cost effective on boilers < 20 MM Btu
    - Can decrease efficiency depending on the NOx level & burner type, without additional upgrades
  - 2) Exhaust Treatment (SCR):**
    - Selective catalytic reduction (SCR): equipment added to treat the NOx after combustion
    - NOx reduction less than 5 ppm
    - To date, installed on water-tube boilers >50 MMBtu
    - More expensive than burner options
    - Less impact on efficiency
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**Combustion Efficiency is a Function Of 1) Excess O<sub>2</sub> & 2) Stack Temperature**

Excess Air / O <sub>2</sub> , %		DOE Combustion Efficiency:				
		Exhaust Stack Temperature Minus Combustion Air Temperature, °F				
Air	O <sub>2</sub>	200	300	400	500	600
9.5	2.0	85.4	83.1	80.8	78.4	76.0
15.0	3.0	85.2	82.8	80.4	77.9	75.4
28.1	5.0	84.7	82.1	79.5	76.7	74.0
44.9	7.0	84.1	81.2	78.2	75.2	72.1

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**Strategy 1: Reducing Burner Combustion NOx Formation**

- Burner NOx Reduction Methods:
  - Flue Gas Recirculation (FGR)
  - Altering the fuel / air ratio and excess O<sub>2</sub>
  - Using staged fuel or air
  - Improve the fuel / air distribution & mixing
  - Improve the flame distribution (reduce hot spots)
  - Using staged combustion (both fuel & air)
- Most are focused on lowering the flame temp.
- Challenge: lowering flame temp. w/o reducing efficiency & flame stability
  - Increased excess O<sub>2</sub> will decrease efficiency
  - FGR has less impact on efficiency but can increase fan HP

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**Strategy 1: Summary of Low & Ultra Low NOx Burners**

Low NOx Burners: 30 ppm NOx

- Uses FGR
- Can maintain 3 to 5% excess O<sub>2</sub> with good controls
- Good turndown > 8 to 1 and flame stability

Ultra Low NOx Burners: 9 to 15 ppm NOx

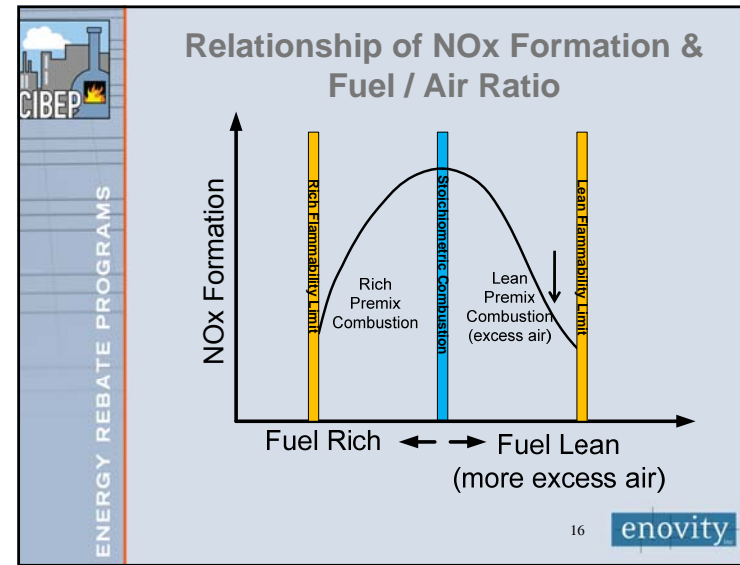
- Below 7 ppm in development
- Uses FGR and different fuel/air ratios & staging
- Some designs may have:
  - Higher excess O<sub>2</sub> (can range from 5 to 9%)
  - Larger fan HP (15% to 50% more)
  - Less turndown (3 or 4 to 1) & flame stability
- Improvements made & will continue
  - Many now at 5 to 7% excess O<sub>2</sub>


14 enovity

**Strategy 1: Ultra Low NOx Burners**

- Common Conventional Designs:
  - Utilize higher FGR & lean mixture designs:
    - Lean Premix – Gas Nozzles & Metal Fiber
    - Lean Rapid Mix – Gas Nozzles
    - With or without secondary fuel staging
- New Designs Aimed at Improving Efficiency:
  - Lower excess O<sub>2</sub> (3 to 5%), FGR & fan HP
  - One Example: Staged Combustion
    - Fuel/air combusted in multiple stages (rich & lean)
    - Low NOx in each stage of combustion
  - Availability & Actual Performance?

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## Strategy 2: NOx Reduction with SCR Exhaust Gas Treatment

- SCR – engineered, new equipment solution:
  - Requires sufficient space and proper design, install & controls
  - Uses ammonia injection & catalyst to reduce NOx
  - Requires min. exhaust temp. ~ 300 to 400F
  - Excessive boiler cycling can be an issue
  - Ammonia slip & leakage usually not an issue
- Large Water-tube Boilers: recommend SCR over ULN Burner for efficiency & lower NOx
  - Successful installations in Central Valley
- In development for Fire-tube Boilers:
  - To handle lower stack temperatures and reduce the cost


17 




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## Summary: NOx Compliance Options

1. Existing Burner Retrofit / Modification
  - May be applicable if going from 15 to 9 ppm or from 9 to 7 ppm (???)
2. Install New Burner (Replacement)
  - For 30, 15 or 9 ppm NOx
  - Availability for less 7 ppm NOx (???)
3. Install New Boiler
  - New boiler vs. new burner will depend on...
4. Install SCR System
  - Water-tube good option, Fire-tube?
5. De-rate a Boiler Below Size Range
6. Pay the SJVUAPCD Annual Emissions Fee Option

18 





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## Summary: NOx Compliance Options – Rule 4320 & 4307 by Boiler Size

Rated Heat Input (million BTU/hr)	NOx Limit (ppmv @ 3% O <sub>2</sub> )	Compliance Deadline	NOx Reduction Methods & Compliance Options
2 to 5	30 - Existing	Jul 1, 2009	1) Burner Retrofit 2) New Burner or Boiler 3) De-rate Boiler
	12 - New	Jan 1, 2010	1) New Atmospheric Boiler
	9 - New	Jan 1, 2010	1) New Non-Atmospheric Boiler
5 to 20	9	Jul 1, 2012	1) Burner Retrofit (15 to 9ppmv) 2) New Burner or Boiler 3) De-rate Boiler
	Or 6	Jul 1, 2014	New burner technology in development - availability ? (SCR likely not feasible)
	Or Annual Fee	NA	Pay annual fee
> 20	7	Jul 1, 2010	1) Possible Burner Retrofit 2) New Burner or Boiler (depending on availability ?) 3) SCR (>30 MMBtu/hr)
	Or 5	Jul 1, 2014	1) SCR (>30 MM Btu/hr)
	Or Annual Fee	NA	Pay annual fee

Table does not include Oilfield/Refineries & Schools in San Joaquin Valley and low usage boilers in both AQMDs.  
Table only includes boilers using natural gas.  
See the actual regulations for further specific compliance requirements.


19 




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## Recommendations for Evaluating Boiler NOx Upgrades

- Evaluate site specific options & proposals
  - Address any design or installation issues
  - Evaluate experience & expertise of contractors and manufacturers
  - Look at existing equipment condition
  - Obtain actual vs. design performance data for a site specific installation
  - Ask for performance guarantees
  - Potential future lower NOx regulations ?
  - Impact on efficiency & other opportunities
- Evaluate total operating cost: energy, operations, and fee compliance


20 




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## Why Combine Boiler Energy Efficiency w/ NOx Upgrades?

- Mitigate efficiency decrease & increased operating cost from NOx reduction
- Energy & utility cost savings
  - Increase efficiency beyond existing
  - 1 to 5% efficiency improvement possible
- As a single project:
  - Reduced downtime
  - More cost-effective for implementing energy efficiency upgrades than if done separately
  - Create a payback that otherwise might not exist


21 




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## Why Combine Boiler Energy Efficiency w/ NOx Upgrades?

- Reduced greenhouse gas emissions (AB-32, potential carbon emissions regulations)
- Rebates / incentives may be available for the energy efficiency upgrades
- May increase boiler capacity
- May improve operations & maintenance
- Replace aged, end of life equipment


22 




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## Example Energy Efficiency Measures – Directly Related to NOx Upgrades:

- Burner Controls Upgrade (*for 30 ppm NOx*):
  - Parallel Positioning or
  - Parallel Positioning with O<sub>2</sub> Trim Control
  - Upgrade from jack-shaft linkage control
- Burner Combustion Fan VFD (*all NOx*):
  - For larger fan HP & longer operating hours
- SCR Installation & ULN Burner Replacement:
  - Replace a High Excess Air, ULN Burner with a Low Excess Air 30 ppm NOx Burner with SCR
  - For Boilers >20 MMBtu/hr, existing ULN burner
  - Potential gas and electric savings


23 



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## Example Energy Efficiency Measures – Directly Related to NOx Upgrades:

- 5-20 MMBtu, 9ppm - Compare Efficiencies of New Ultra Low NOx Burners:
  - Likely comes standard w/ parallel positioning or both parallel positioning & O<sub>2</sub> trim control
    - To maintain NOx levels & stability
  - Compare & evaluate total efficiency of new burner options from different manufacturers
    - New burner efficiencies may vary & may be less than existing
  - Total Efficiency is a function of
    - Excess O<sub>2</sub>, Stack Temperature, FGR %
    - Fan HP

24 

**Example Energy Efficiency Measures – Directly Related to NOx Upgrades:**

- High-Efficiency Boilers (vs. Standard-Efficiency):
  - If replacing, evaluate the highest efficiency possible
  - Efficiencies >84%, depending on the application
- Condensing & Direct-Contact HW Boilers:
  - 87% to 95% efficiency depending on the inlet temp.
  - Excellent for loads with low inlet water <140F
- Steam to HW Conversions (if only HW)
- High-Pressure Steam Boilers:
  - Add Economizer: 2 to 5% efficiency improvement
- Steam Generators: for highly variable loads
  - Can reduce boiler system runtime

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**Example Energy Efficiency Measures – Indirect to NOx:**

**Heat Recovery & Preheating Opportunities:**

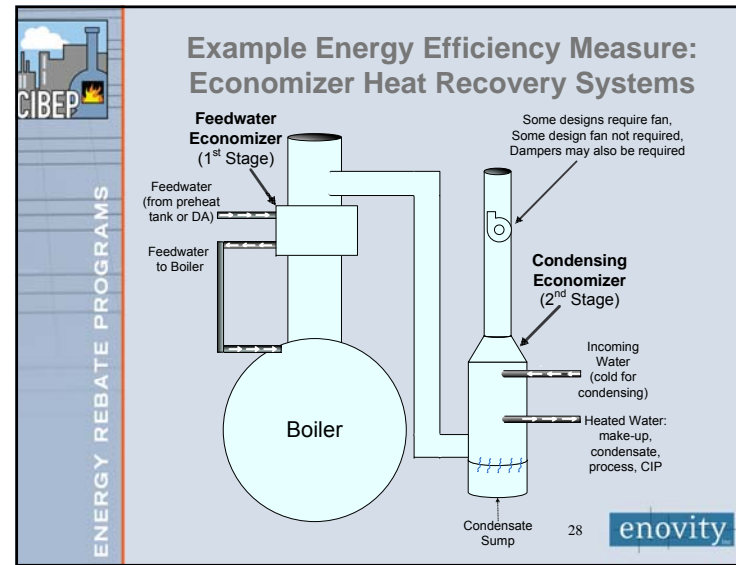
- Exhaust Feedwater Economizer
- Exhaust Condensing or 2<sup>nd</sup> Stage Economizer
- Blowdown Heat Recovery:
- Condensate Recovery:
  - 100 Btu per lb of condensate not returned (~ 0.1% savings per every 1% condensate lost)
- Combustion Air Preheaters: 30 ppm burners
- Process Heat Recovery
- **Solar Thermal Preheating:**
  - Just approved for PG&E incentives
  - New designs / technology

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**Example Energy Efficiency Measure – Feedwater Economizer Heat Recovery:**

- Uses exhaust waste heat from the boiler to pre-heat feed-water into the boiler
  - Means less energy needed to make steam
  - Results in lower stack temperature
- Applicable to high pressure steam boilers
  - Low pressure steam: less savings or look at preheating condensate return
- Typical 2% to 5% efficiency gain: (~1% for every 40F stack temperature reduction)
- Considerations for installing economizers:
  - Sufficient space, material selection, back pressure, feedwater flow controls & piping

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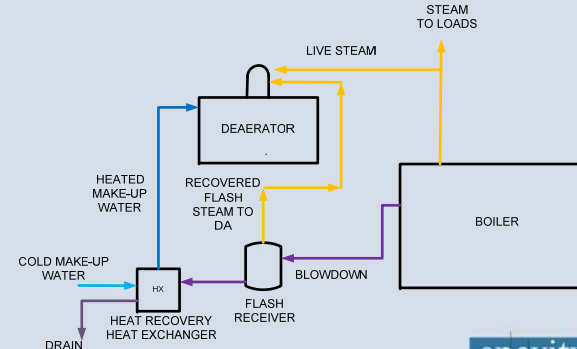
### Example Energy Efficiency Measure: Condensing Economizer Heat Recovery

- Application specific:
  - Larger boilers with nearby large low temperature heating load (process water, CIP, make-up, domestic HW, condensate, etc.)
- More savings than feed-water economizer due to latent heat transfer (5 to 10%)
- Designed to handle & remove condensation
- Different system designs & material selections
  - Closed heat exchanger, direct contact types
  - May require an auxiliary fan or pump
- Water-side & air-side controls are important !



### Example Energy Efficiency Measure – Blowdown Heat Recovery:

- Preheat make-up water, recover flash steam
- Savings of 1 to 2% depending on blow-down




### Example Energy Efficiency Measures – Indirect to NOx:

- Pump VFDs: Hot-Water, Feed-water (electric)
- **Pipe, Tank & HX Insulation:**
  - Insulate bare hot surfaces, reduce heat losses
- Replace Failed Steam Traps
- Fix Steam or HW Leaks
- Make-up Water Reverse Osmosis Treatment
  - For steam systems with high make-up water & high TDS levels. Reduces boiler blow-down
- Thermosober: Gas-Fired Heat Pump
  - Produces both cooling & hot water more efficiently



### Rebates & Incentives for PG&E Customers

- Encourage you to contact your PG&E Account Rep.
- PG&E Core Programs
  - Mass Market “Deemed” Rebate Programs
  - Calculated Programs
- PG&E Partnership/3rd Party Programs
  - Enovity’s 3rd Party CIBEP for Boilers
  - Other 3rd Party Programs for Other Market Segments & Systems/Technologies





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## PG&E Deemed Boiler Rebates

<http://www.pge.com/mybusiness/energysavingsrebates/rebatesincentives/ref/heating/>

- PG&E Rebates for:
  - New High-efficiency Boilers & Heaters
  - Replace Failed Steam Traps
  - Pipe & Tank Insulation (low-temp.)


33 




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## Enovity's Commercial Industrial Boiler Efficiency Program (CIBEP)

- Offers incentives & no cost professional services to large PG&E customers:
  - To help implement cost-effective boiler system energy efficiency projects
  - Available to agriculture, food, beverage, commercial & industrial facilities\*
  - Hot water or steam boilers > 3 MM Btu/hr
- One of PG&E's Partnership Programs
  - Funded by California utility ratepayers under the auspices of the CPU

\* Other eligibility requirements may apply 34 





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## CIBEP helps you improve your boiler system efficiency by:

Providing professional services to help implement energy efficiency projects from start to finish:

- Onsite audit/evaluation & measurements
- Detailed analysis & recommendations
- Report summarizing potential reductions in energy, cost, and greenhouse gas emissions
- Implementation assistance including:
  - Obtaining & reviewing contractor proposals
  - The CIBEP is contractor neutral & does not provide installation and contractor services
- Independent verification of installed savings


35 




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## CIBEP helps you improve your boiler system efficiency by:

- Providing Financial Incentives
  - Cash incentives provided to buy down the cost of energy efficiency upgrades
  - Incentives same as the PG&E NRR-DR
    - \$1.0/therm; \$0.09/kWh; \$100/ peak kW
  - Improves payback to meet hurdle rates
  - Typically covers 30-50% of incremental cost




36 

**CIBEP – How to participate?**

- Contact a Program Representative or Submit a Program Participation Agreement:
  - [www.enovity.com/programs/cibep.html](http://www.enovity.com/programs/cibep.html)
  - Phone: 415-974-0390 x 148
  - Email: [BoilerEfficiency@enovity.com](mailto:BoilerEfficiency@enovity.com)
- Enovity, Inc.  
100 Montgomery Street, Suite 600  
San Francisco, CA  
94104
- Program Manager: Rachel Christenson  
Technical Director: Eric Koepfel


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37 


**In Summary**

- New NOx Requirements In Place
- May Require Boiler Upgrades
- Evaluate Your Options for NOx Reduction & Compliance
- Combine Energy Efficiency with the NOx Upgrades
- PG&E has Energy Efficiency Programs & Incentive/Rebates

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38 

**Questions?**



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39 