Proposed Amended Rule 1153.1

Emissions of Oxides of Nitrogen from Commercial Food Ovens

Working Group Meeting #4
August 31, 2022

Join Zoom Webinar Meeting

https://scaqmd.zoom.us/j/99936500985

Teleconference Dial-In: 1-669-900-6833

Webinar Meeting ID: 999 3650 0985

Agenda

- Summary of WGM #3
- Technology Manufacturer
- Equipment Categories and Initial BARCT Limit
- Cost-Effectiveness and Incremental Cost-Effectiveness Analysis
- Proposed BARCT Limit
- Next Steps

Summary of WGM #3

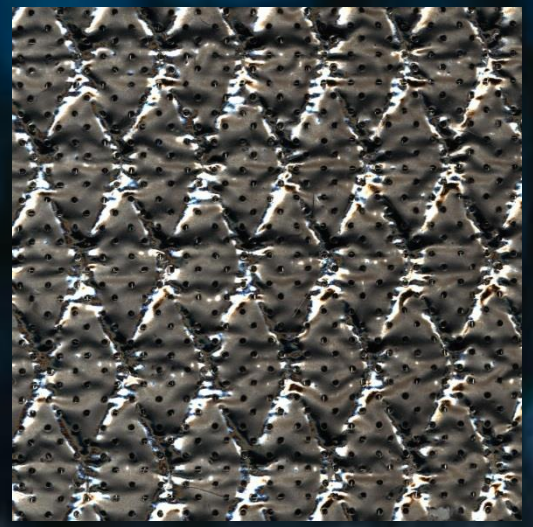
- Working Group Meeting #3 held on July 27, 2022
- Follow up on comments received from WGM #2
- Discussed baseline emissions
- Continued the BARCT assessment
  - Discussed various equipment types and burner types used
  - Concluded that burner technology is the most feasible NOx control option for food ovens
  - Proposed an initial BARCT limit of 30 ppm for all food ovens
- Discussed technology demonstration and emerging technology

Burner Manufacturer Presentation

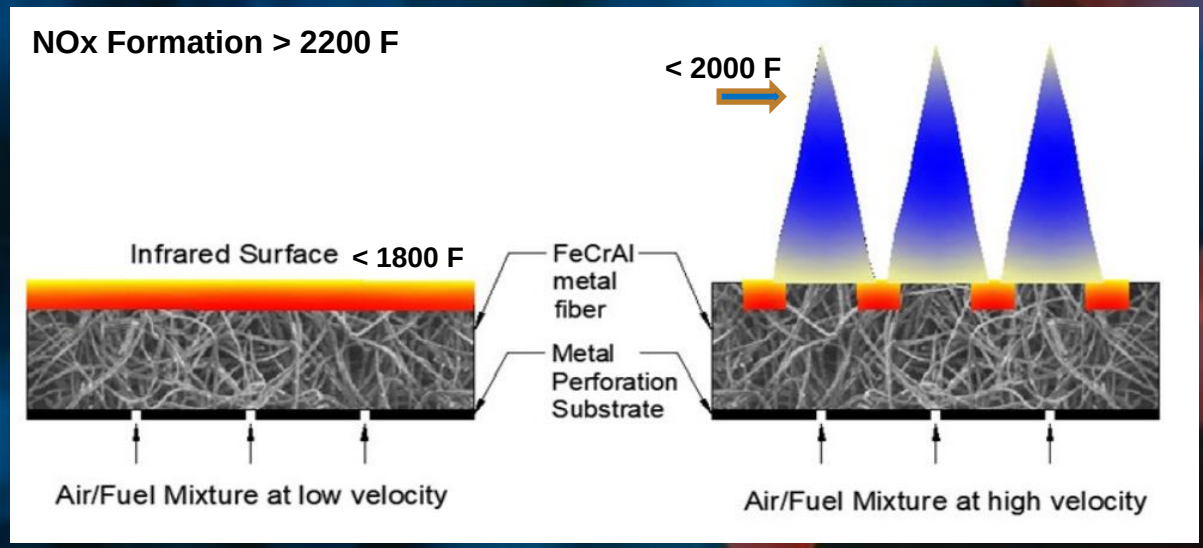
METAL FIBER GAS BURNERS and COMBUSTION SYSTEMS

Metal Fiber Technology

- Metal Fiber Alloy: FeCrAlM, 25-27%Cr, 5%Al, ~0.01%M
- Randomly distributed fiber web sheet
- Integrated with mesh, perforated foil, or expanded metal
- Sintered at elevated temperatures



Low NOx Technology



- Lean Pre-Mix Combustion
- Reduced peak flame temperature via:
  - High excess air
  - Heat absorption by metal fibers
  - Flame heat converted to IR energy
- Perfect mixing of fuel and air required

Benefits of Metal Fiber

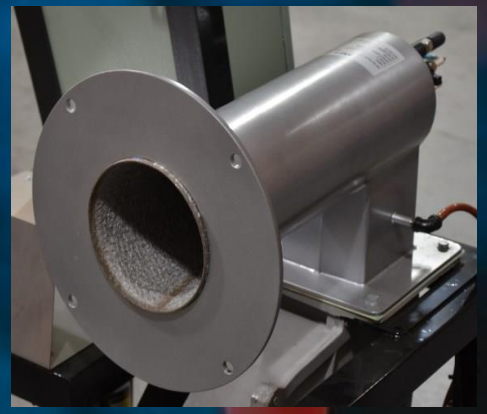
- Inherently Low NOx and CO
- NOx 9 ppm and CO near zero
- Turndown up to 5:1 w/20:1 in RTP Operation
- Does not require FGR or Staged-Combustion for Low Emissions
- Maintains High System Efficiencies
- Unlimited Burner Head Geometry
- Very High Firing Capacities over 2 MMBH/FT2
- Hi-Intensity IR and Blue-Flame Operating Modes
- Wide Range of Gaseous Fuels (Natural, Propane, Butane, Hydrogen)
- Excellent Resistance to Thermal Oxidation
- Highly Resistant to Flashback
- Instant Heat-up and Cool-down
- Mechanical Impact and Thermal Shock Resistant

MFT
Micron Fiber-Tech

PRODUCTS

CLAM SHELL BURNER

IWFC BURNER



LARGE TUBE BURNER

FLAT ROUND BURNER

RIBBON BURNER

IWFC BURNER

SMALL TUBE BURNER

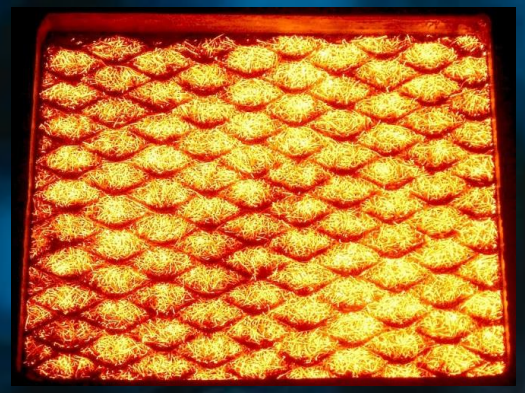
PRODUCTS
BLUE FLAME

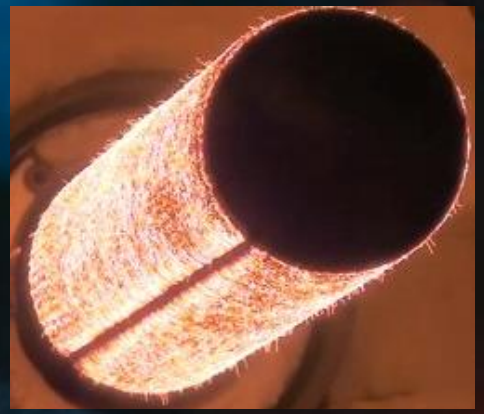
All MFT metal fiber burners are targeted to reach below 9 ppm NOx levels in blue flame mode, outperforming all NOx regulations worldwide. Blue flame burners require a premix blower to provide enough excess air to keep NOx emissions low.

PRODUCTS

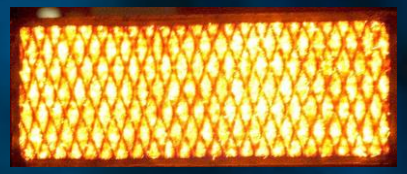
INFRA-RED FLAME

MFT offers an array of infrared burners suited for every type of application, ranging from food equipment to paper drying to process heating. IR burners can be atmospheric or powered-premix blower type.





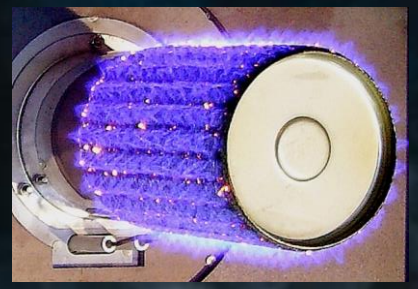
Metal Fiber Burner Durability



DF-mat, surface temp 1780F, 25,000 hours

DFS-mat, Surface temp 1735F, 40,000 hours

S-mat, Surface temp 1700 F, 60,000 hours



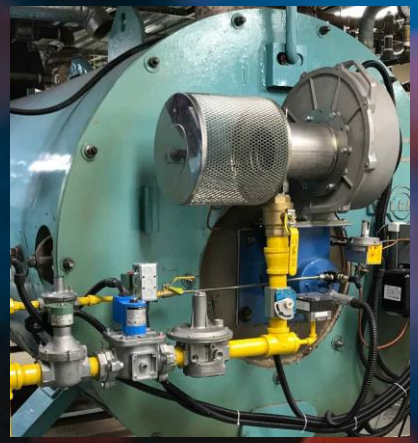
10+ years for <5ppm NOx,
7+ years for <9ppm NOx
5+ years for <30ppm NOx

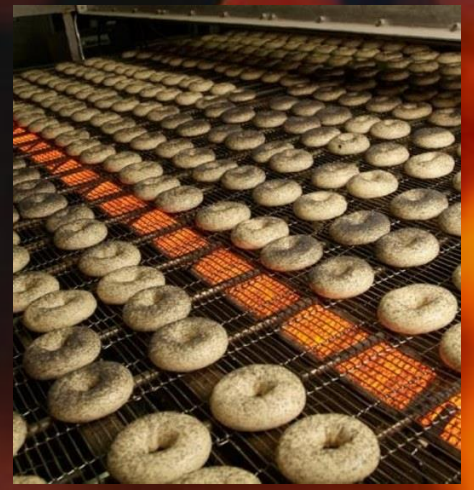
Industries Served

Alternative Fuels:	Bio-fuels, pyrolysis, waste gas
Automotive:	Ovens, washers, air heaters, oxidizers, and boilers
Building Materials:	Dryers, kilns, ovens, calciners, and boilers
Chemical:	Dryers, heaters, boilers, process
Container:	Ovens, furnaces, dryers, and air heaters
Food Processing:	Dryers, ovens, washers, fryers, and smokehouses
Paint Finishing:	Ovens, washers, air heaters, oxidizers
Petrochemical:	Heaters, reboilers
Plastics:	Thermoformers, flame laminators, and ovens
Printing:	Dryers, heaters, oxidizers
Pulp and Paper:	Yankees, Dryers, and oxidizers
Textiles:	Dryers, predryers, and oxidizers

APPLICATIONS

- Air Heaters
- Aluminum/Lead Melters
- Automotive Paint Lines
- Asphalt Heaters
- BBQ Grill
- Boilers
- Coffee Roasters
- Dairy Dryers
- Flare Burners
- Furnaces
- Fryers
- Incinerators
- Kilns
- Paper Dryers
- Paint/Powder Booth Dryers
- Print Dryers
- Smoke Houses
- Spray Dryers
- Thermal Fluid Heaters
- Tortilla Ovens
- Tunnel Ovens
- VOC Elimination/Oxidizers
- Water Heaters
- And more…





Food Industry Users of Metal Fiber Burners

TECHNOMAIZ	TYSON
GRUMA	SUNNY FRESH
MISSION	ACCUTEMP
RAVELO	INGENEUMATICA
MIDDLEBY	GOLD COAST BAKERY
CARGILL	QUALITY SAUSAGE COMPANY
WOOD STONE	LAWRENCE EQUIPMENT

Suppliers of Metal Fiber Burners

- MICRON FIBER-TECH
- MIDCO
- WEBSTER
- INDUSTRIAL COMBUSTION
- ST JOHNSON
- BURNERTECH
- METRO SERVICES
- SELAS
- BEKAERT
- ERATEC
- HONEYWELL
- MAXON
- VAPA
- POLIDORO
- RED-RAY
- RIELLO
- SOLARONICS
- WEISHAUPT
- POWER FLAME
- WORGAS
- FLYNN
- BECKETT
- INNOVATIVE
- ALZETA

Equipment Categories and Initial BARCT Limits

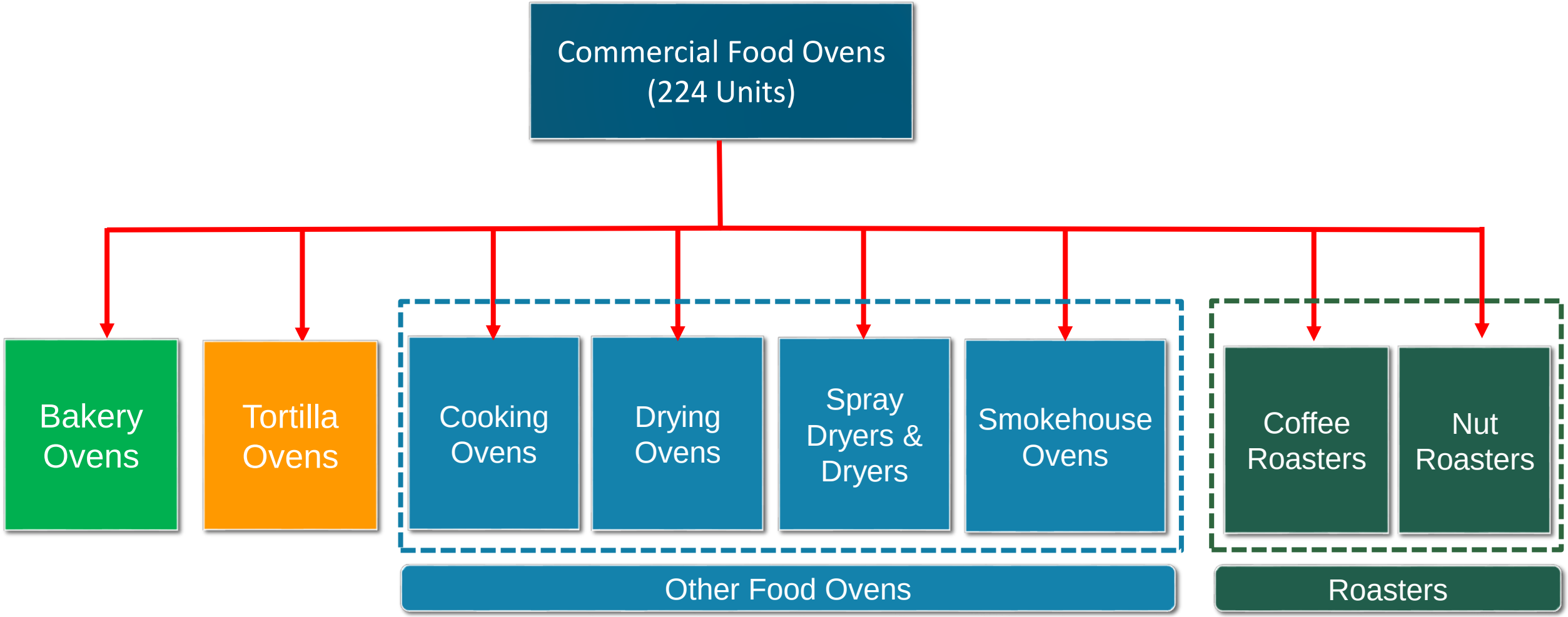
Considerations for Micron Fiber Burners

- Staff has been evaluating the technical feasibility of a 9 ppm limit
  - To date, staff is only aware of validated third-party source test data for infrared (IR) burners utilizing the metal fiber mesh in tortilla ovens
    - Source test results for other IR burners range from 9 ppm – 15 ppm
    - Units have a permit limit of 30 ppm
  - No test data for other burner types
- Staff will consider the cost effectiveness for tortilla ovens equipped with IR burners to retrofit to meet a 15 ppm NOx limit
- May consider other burners based on additional data, or during a future rule amendment or technology assessment

Burner Control Technology Summary

- Food ovens are designed for a specific type of burner
- Most bakery and tortilla ovens use ribbon burners
  - Modern ribbon burners along with control systems meet 30 ppm NOx limit
  - Some units replaced or upgraded to newer burner controls, such as combination ribbon/IR or IR burners only, that meet 30 ppm NOx limit
  - Cost for ribbon burners typically exceed cost for traditional low-NOx burners
- Other types of food ovens and dryers that use traditional low-NOx burners for air heating can achieve 30 ppm NOx
- Roasters are indirect-fired units that use traditional low-NOx burners achieving 30 ppm NOx

Commercial Food Oven Categories



Commercial Food Ovens

Burner Type by Category			
Category	**Description**	**Burner Type**	**Considerations**
Bakery and Tortilla Ovens	• 98 units in Category • Ovens are used to cook bakery or tortilla products • Conveyor type or tunnel type • Air heater • 2019 NOx Emissions: 0.11 tpd	• Ribbon Burners • Infrared (IR) Burners • Low NOx Burners (i.e., Maxon OvenPak type, Eclipse Winnox) • Mesh fiber burners	• Ribbon Burners, and LNB can achieve 30 ppm • IR Burners can achieve 15 ppm • Commercially available • AMF offers an electric tunnel oven but very few real-world installations
Other Food Ovens	• 72 Units in Category • Spray Dryers • Dryers • Cooking Ovens • Smokehouse Ovens • 2019 NOx Emissions: 0.07 tpd	• Low NOx Burners (i.e, Maxon OvenPak type, Eclipse Winnox) • Mesh fiber burners	• Traditional OvenPak style LNB options available • Two smokehouse ovens are electric, but also uses steam • Some units such as dryers use steam as a heat source
Roasters	• 54 Units in Category • Coffee Roasters • Nut Roasters • 2019 NOx Emissions: 0.02 tpd	• Low NOx Burners (i.e, Maxon OvenPak type, Eclipse Winnox) • Mesh fiber burners	• Indirect-fired units • Single burner • Most are small units exempted with permit conditions limiting operation

Initial BARCT Limit

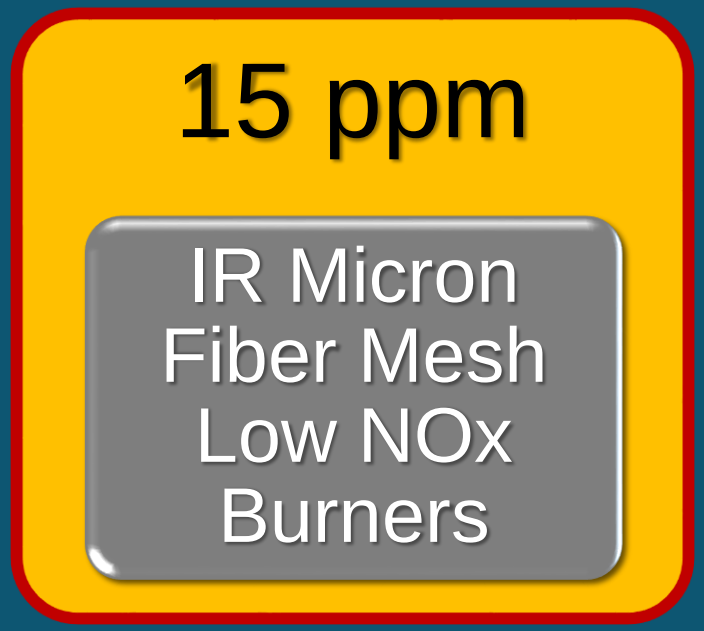
	Rule 1153.1	Existing Units	Other Regulatory Agencies	Technology Assessment	Initial BARCT NOx Limit	Proposed BARCT NOx Limit
Bakery Ovens	40 and 60 ppm	13 - 47 ppm	40 and 60 ppm	0* to 30 ppm	30 ppm	*Need to conduct cost-effectiveness and incremental cost-effectiveness*
Tortilla Ovens	40 and 60 ppm	8.4 – 52 ppm	40 and 60 ppm	5 to 30ppm	30 ppm and 15 ppm	*Need to conduct cost-effectiveness and incremental cost-effectiveness*
Other Food Ovens	40 and 60 ppm	16 - 67 ppm	40 and 60 ppm	0** to 30 ppm	30 ppm	*Need to conduct cost-effectiveness and incremental cost-effectiveness*
Roasters	40 and 60 ppm	25 – 66 ppm	40 and 60 ppm	9 to 30 ppm	30 ppm	*Need to conduct cost-effectiveness and incremental cost-effectiveness*

*One oven manufacturer offers an electric oven; limited real-world installation and operation
**Smokehouse ovens are electric; Three are electric and uses high pressure steam

Initial BARCT NOx Limit

Total NOx Emission: 0.2 tpd

- 30 ppm limit is currently achievable with commercially available burner technology
  - Ribbon burners
  - Infrared burners
  - Traditional low-NOx burners (LNB)
- Supplied by several manufacturers and various options available
- 30 ppm proven in commercial food oven applications
  - Many units are currently performing at or below 30 ppm
  - Confirmed by validated third-party source test data



- IR burners have been used in several other applications such as industrial ovens, boilers, etc. and have achieved 9 ppm NOx limit
  - Third party source test validates that 9 ppm can be achieved with IR burners
  - Similar ovens equipped with same burners source test results between 15 – 9 ppm
- IR burners can be supplied by several different manufacturers
- Potential for technology transfer in commercial food ovens assuming limited turndown (4 to 1) is acceptable
  - Equipment can be redesigned to use staged burner control to increase turndown (additional costs or potential equipment replacement)
  - Requires further evaluation and assessment
- 9 – 15 ppm NOx limit has not been proven in commercial food ovens, other than ovens equipped with IR burners, due to lack of third-party source test data

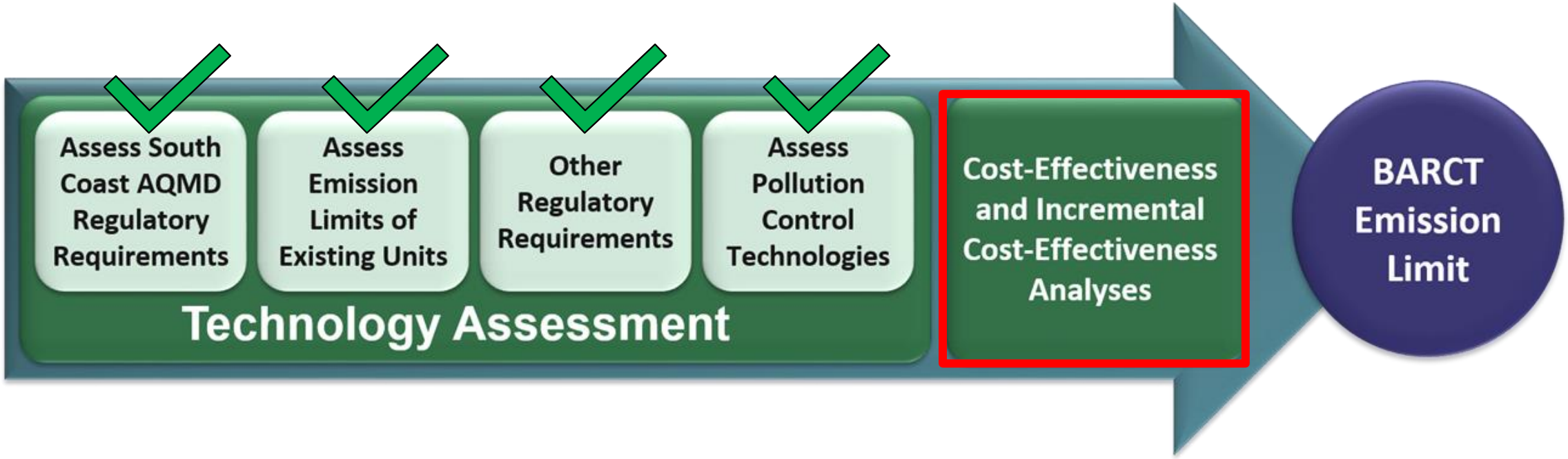
Zero Emission

Emerging and Currently in Development

- Staff evaluated two potential emerging options for zero emission technology
  - Rondo Energy heat battery system
  - AMF Electric bakery tunnel oven
- Rondo heat battery system has been used in other industrial applications but not in commercial food ovens
- AMF offers an electric bakery tunnel oven
  - Limited number of real-world installations
    - No cost information has been provided and cost assessment must include fuel switching costs
  - May not be suitable for all applications
  - Requires large electrical input (~714 kW)
- Large bakery company has explored electrical options to meet future sustainability goals
  - Increased electricity requirements is challenge
- Further evaluation of zero emission options is needed to assess long-term feasibility

Cost-Effectiveness and Incremental Cost-Effectiveness Analysis

Cost-Effectiveness and Incremental Cost-Effectiveness



Cost-Effectiveness

- Cost-effectiveness is a measure that compares the costs of pollution reduction to amount of pollutant reduced
  - Measured in cost per ton of pollutant reduced
- South Coast AQMD typically uses the *Discounted Cash Flow Method* to calculate cost-effectiveness
  - **Cost-Effectiveness** = Present Value/Emissions Reduced Over Equipment Life
  - **Present Worth Value** = Capital Cost + (Annual Operating Costs x *Present Worth Value Formula*)
  - **Present Worth Value Formula** = $(1-1/(1+r)^n)/r)$
    - r = (*i*-f)/(1+f)
    - *i* = nominal interest rate
    - f = inflation rate
    - n = number of cycles
- South Coast AQMD Governing Board established $50,000/tons of NOx removed with approval of 2016 Air Quality Management Plan

Incremental Cost-Effectiveness

- Once BARCT assessment is complete and NOx limits are established, staff considers incrementally more stringent options
- Incremental Cost-effectiveness (I-CE) is calculated as follows:

$$I\text{–}CE\left(\$/_{tons\ NOx\ reduced}\right) = \frac{Incremental\ Difference\ in\ Cost\ (Present\ Worth\ Value)}{Incremental\ Difference\ in\ Emission\ Reductions\ (Lifetime\ Reductions)}$$

Burner Total Installation Cost Estimates

- **Ribbon and Infrared (IR) burners**
  - Two facilities provided total installed cost for ribbon burner replacements
    - Total Installed Cost (TIC) ranged from $300,000 to $4.2 MM
      - $4.2 MM for oven replacement to meet 30 ppm (currently performing at 33 ppm)
  - Vendors also provided capital cost estimates
    - Includes additional equipment such as mounting plates, igniter, and flame sensors
    - Installation cost assumed to be 3 times the capital which includes support structure
    - TIC ranged from $30,000 to $226,000
- **Traditional LNB**
  - Cost for burners provided from vendors
  - Installed costs assumed to be 50% of burner cost
    - Total Installed Cost (TIC) ranged from $14,000 to $45,000
    - If unit required multiple burners, cost was multiplied by number of burners

Burner Cost Curve

- Staff developed cost curve based on provided cost data
  - Cost curve is used to estimate cost for the units where no cost information was available
- Cost curve will be used to obtain equation by using a power curve fit
- Equation will be used in Rule of Sixth-Tenths, a ratio and proportioning method used estimate costs for similar equipment

Rule of Six-Tenths

- Also known as 0.6 power factor rule
- Ratio and proportioning method used to approximate cost based on known cost for similar equipment
- Equation is derived from cost estimates:
  - Facilities and vendor quotes
  - Costs converted to a $ per MMBtu/hr and plotted to obtain cost-curve
  - Using a power curve-fit of the data will give equation
- New cost-curve generated provides equation
  - "N" the size exponent
  - "C_A" the known cost of equipment of corresponding size

$$C_B = C_A \left(\frac{S_B}{S_A} \right)^N$$

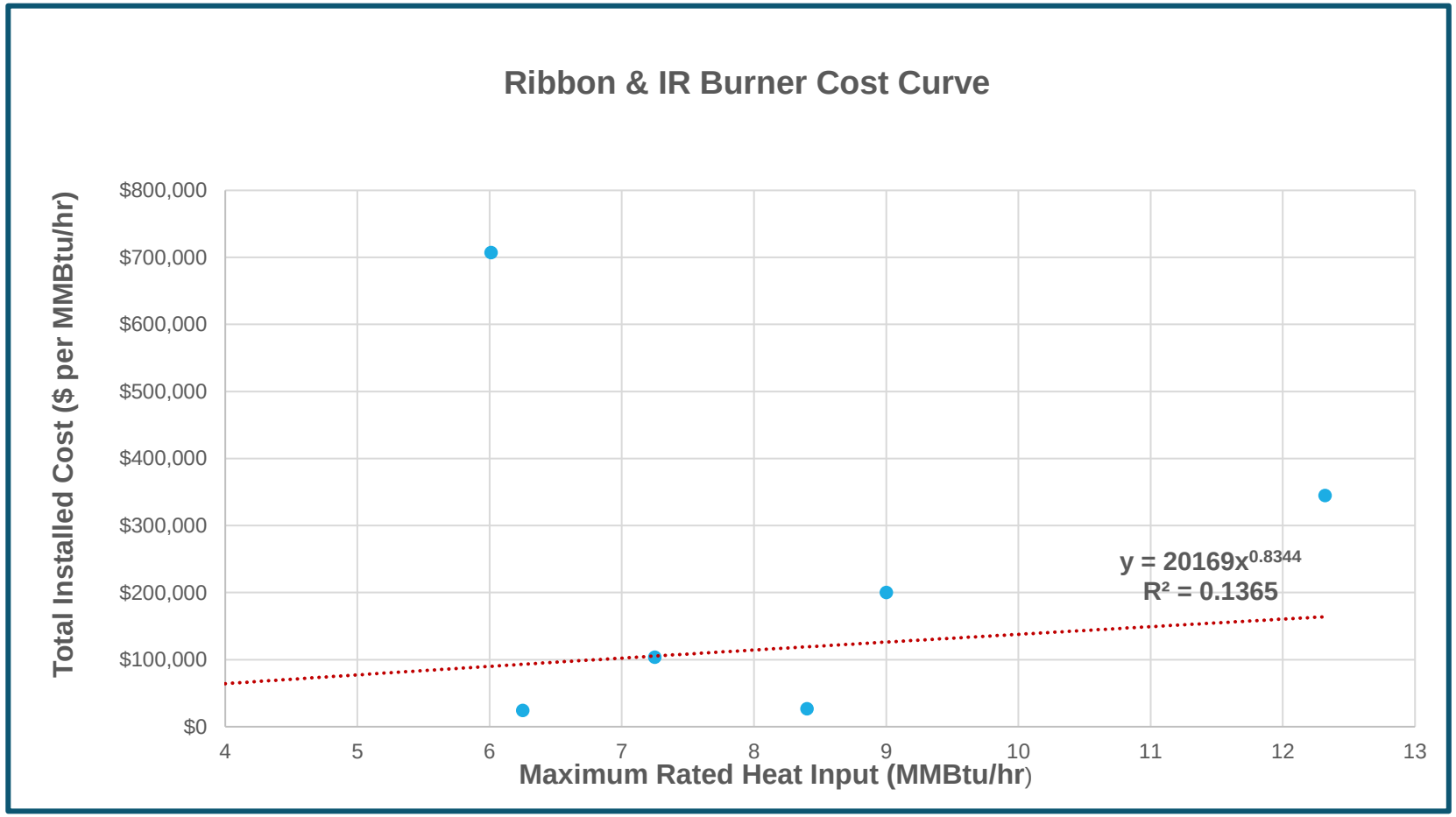
C_B = approximate cost of equipment having size S_B (MMBtu/hr, hp, scfm, etc.)

C_A = known cost($) of equipment having corresponding size S_A (same units as S_B)

(S_B/S_A) = ratio size factor

N = size exponent (varies 0.3 to >1.0, but average is 0.6)

Ribbon and IR Burner Cost Curve



Based on the power curve, burner cost is:

$$y = \$20{,}169\ (x)^{0.8344}$$

Where x, ratio size factor (S_B/S_A)

- Solving for y, will give a $/MMBtu/hr
- Multiplying by the burner size (MMBtu/hr) will give TIC of the burners

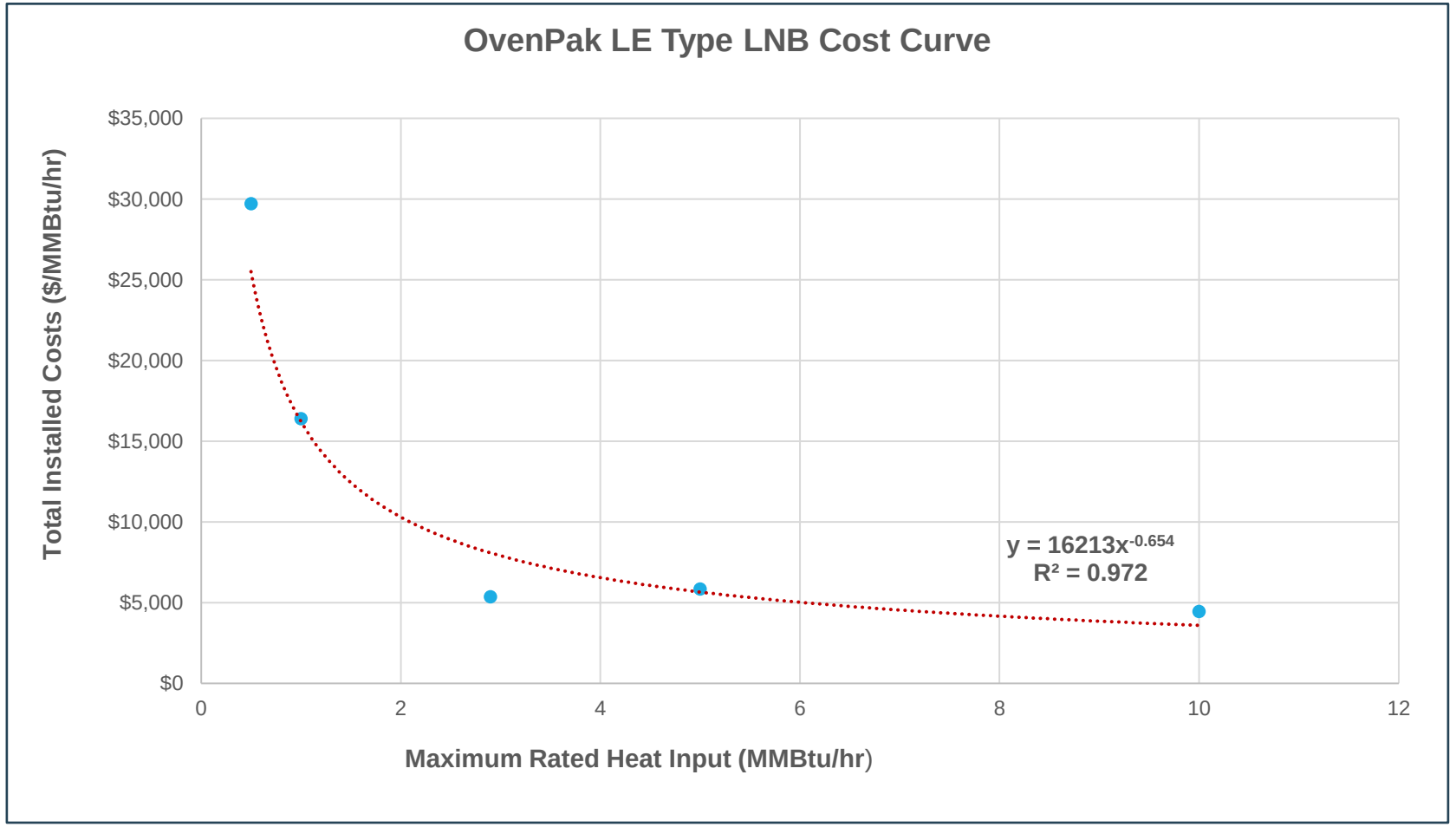
Example:

Heat Input: *4 MMBtu/hr*

$/MMBtu/hr: *$35,964*

TIC: *$143,855*

Low NOx Burners Cost Curve



Based on the power curve, burner cost is:

$$y = \$16{,}213\ (x)^{-0.654}$$

Where x, ratio size factor (S_B/S_A)

- Solving for y, will give a $/MMBtu/hr
- Multiplying by the burner size (MMBtu/hr) will give TIC of the burners

Example:

Heat Input: *4 MMBtu/hr*
$/MMBtu/hr: *$4,670*
TIC: *$18,681*

Cost-Effectiveness Assessment

Cost-Effectiveness of Initial BARCT Limit

- Cost-Effectiveness analysis did not include:
  - Units performing below initial proposed BARCT limit
  - Electric units or steam heated units
  - Units that were shutdown or removed
  - Units that are exempt from the Rule 1153.1 limits
    - Staff assumed units are exempt if they met the following:
      - No source test data or permit limit
      - Units with permit condition limiting operation (i.e., daily fuel usage limit or pounds of product processed per month)
      - No annual emissions reported (AER) data
  - Assumed 25-year equipment life and $1,000 per year for operation & maintenance (O&M) cost
    - O&M cost includes compliance test and source test costs which is assumed to be approximately $4,000
- Staff identified post combustion control as next stringent option, but technology was determined not feasible for food oven applications
  - Incremental cost-effectiveness was not conducted

Bakery Ovens

- NOx emissions for category is 0.11 tpd
- Total of 76 units
- Units not included in cost-effectiveness
  - 46 units currently have a permit limit, or are performing below 30 ppm
  - 8 units exempt
- Some individual units can have up to:
  - 181 ribbon burners (30 ppm limit)
  - 314 infrared burners (30 ppm limit)
- One unit performing at 33 ppm
  - Did not include in cost-effectiveness
  - High cost to achieve 30 ppm ($4.2 MM)
  - Proposing to include a near limit to address high cost-effectiveness for ovens performing near BARCT limit

Cost-Effectiveness		
Bakery Ovens	30 ppm	Emission Reductions
Cost-Effectiveness	$46,000	0.0076

Tortilla Ovens

- NOx emissions for category is 0.16 tpd
- 22 units and operate above 500 °F
- Units included in cost-effectiveness for 30 ppm:
  - 9 units use both ribbon and IR burners
    - Up to 82 ribbon burners
    - Up to 54 IR burners
    - 8 units operating from 41 to 43 ppm (54 and 60 ppm permit limit)
    - One unit did not have source test, so assumed performing at 40 ppm
- Units included in cost-effectiveness for 15 ppm:
  - 13 units use IR burners only
    - All currently performing below 15 ppm
    - Recently retrofitted with new IR burners (2019)
- Ribbon burners can achieve less than 30 ppm
- IR burners can achieve less than 15 ppm

Cost-Effectiveness		
Tortilla Ovens	30 ppm **(Ribbon and IR burners)**	15 ppm **(IR burners only)**
Cost-Effectiveness	$19,000	Currently Achieving
Emission Reductions (tpd)	0.0067	0

Other Food Ovens

- NOx emissions for category is 0.07 tpd
- Total of 72 Units
  - 20 units have permit limit or performing below 30 ppm
- Units excluded from cost-effectiveness:
  - 25 units that use steam as heat source (Rule 1146)
  - One smokehouse oven is electric
  - Three smokehouse ovens are steam heated
  - Three smokehouse ovens are electric and steam heated
  - 12 exempt units
- Units included in cost-effectiveness:
  - 6 units performing at 66.8 ppm
  - 2 with no source test data, so assumed 40 ppm
  - Units have a single burner
  - Cost ranged from $12,000 to $38,000

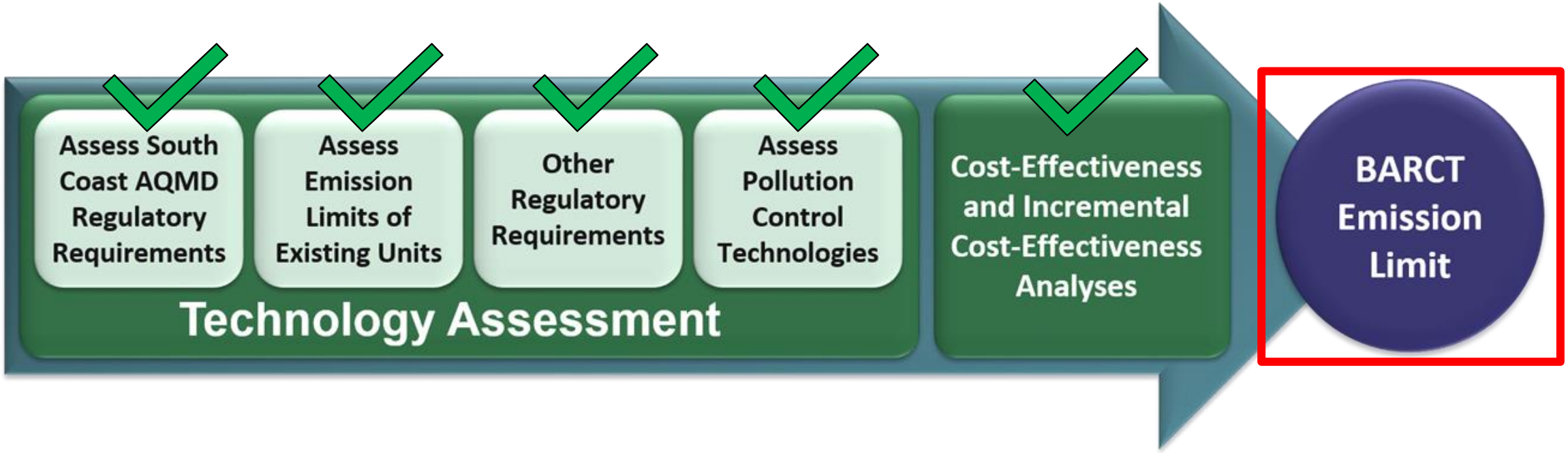
Cost-Effectiveness		
Other Food Ovens	30 ppm	Reductions (tpd)
Cost-Effectiveness	$16,000	0.0023

Roasters

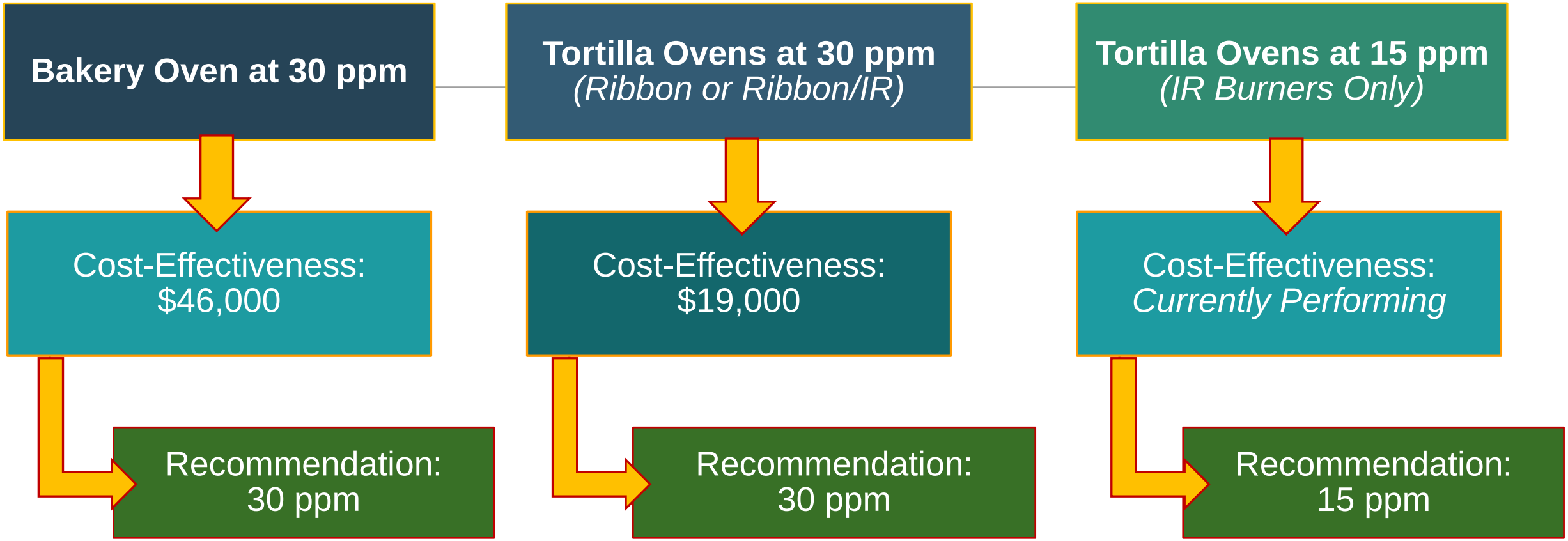
- NOx emissions for category is 0.02 tpd
- 53 roasters are located at non-RECLAIM facilities
- One located at RECLAIM facility
- Units not included in cost-effectiveness:
  - 10 units currently have a permit limit 30 ppm or performing below
  - 42 units are exempted
    - Units have rated heat input of less than 1 MMBtu/hr
    - Units have permit condition limiting pounds of product roasted per month
    - No source test information, permit limit, and AER available
- Units included in cost effectiveness:
  - Three units have a permit limit of 40 ppm
    - No source test data, so assumed performing at 40 ppm
    - Units have one burner
    - Cost ranged from $18,000 to $33,000

Cost-Effectiveness		
Roasters	30 ppm	Reductions (tpd)
Cost-Effectiveness	$41,000	0.00032

Proposed BARCT Emission Limit



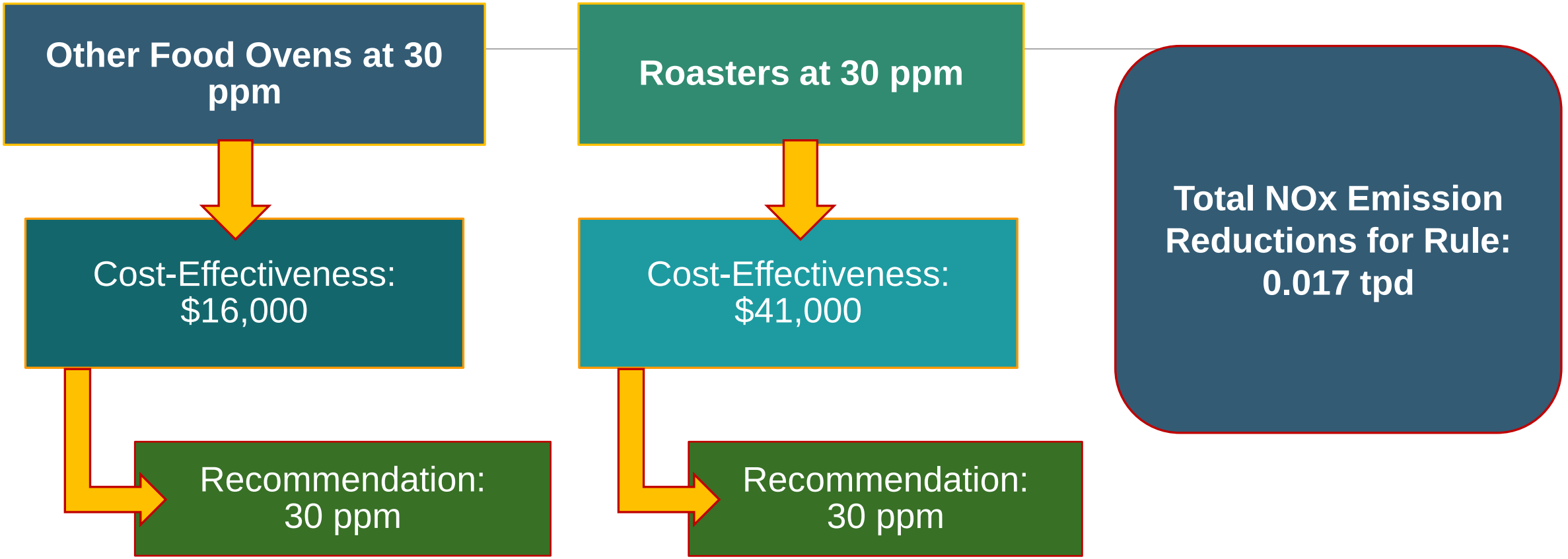
Staff Recommendation



Staff Recommendation for Bakery Ovens and Tortilla Ovens

- BARCT NOx limit at 30 ppm at 3% O_2 and maintain CO limit at 800 ppm at 3% O_2
- Near NOx Limit of 35 ppm for bakery oven category

Staff Recommendation



Staff Recommendation for Other Food Ovens and Roasters

- BARCT NOx limit at 30 ppm at 3% O_2 and maintain CO limit at 800 ppm at 3% O_2

Implementation Timeline

- AB 617 targets emission reductions for those sources that “have not modified emission related permit conditions for the greatest period of time”
- Stranded Assets are a consideration for PAR 1153.1 for facilities who recently retrofit to meet existing limits
- Staff considering requirement for facilities to retrofit burners at the time of replacement or no longer than 20 year burner life based on 50 percent or more burner replacement

Zero Emission Technology Assessment

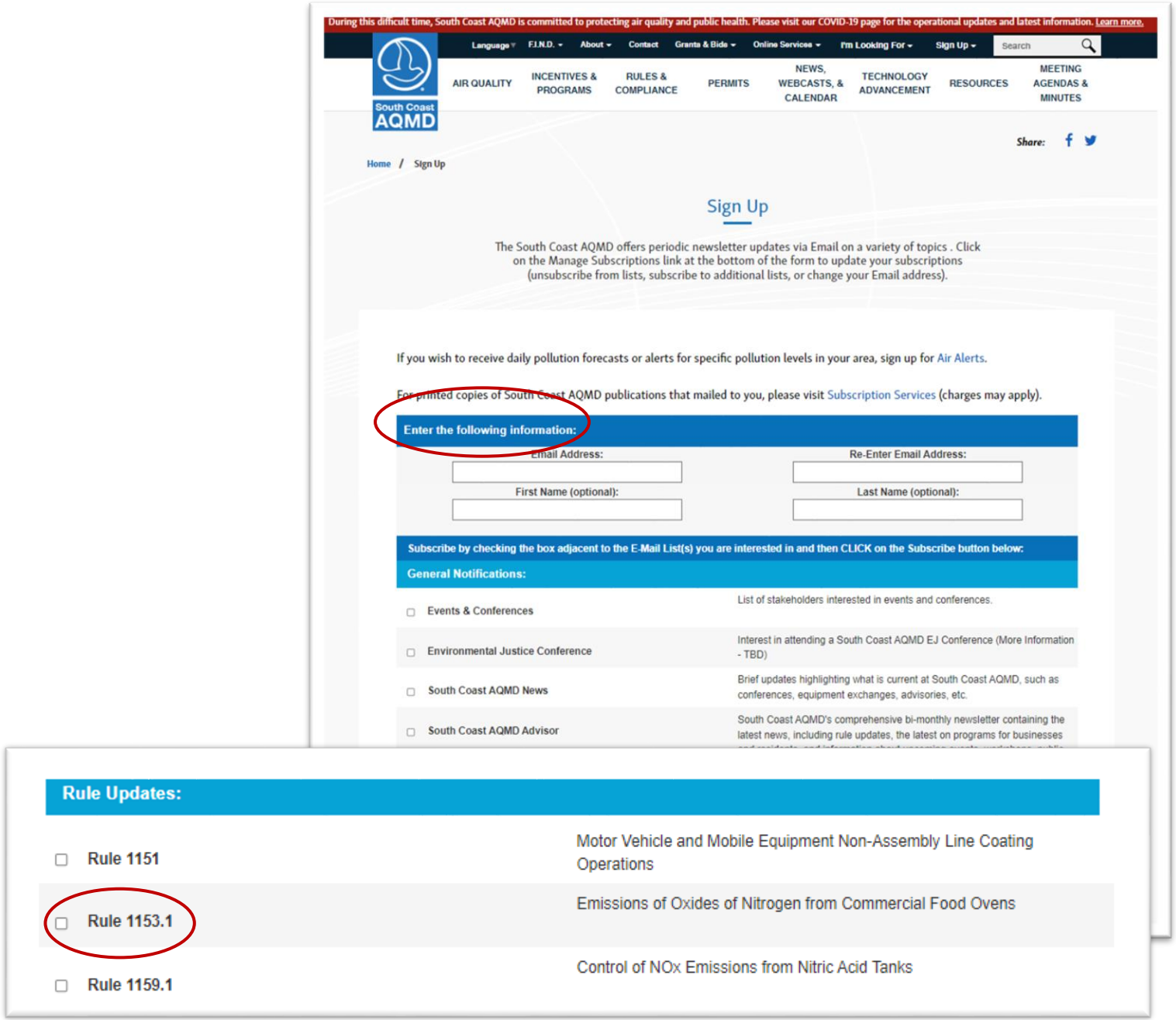
- Staff recommending technology evaluation to assess maturity and feasibility of zero emission technology for commercial food oven applications
  - Multiple large bakery ovens may consume approximately double the amount electricity of an entire facility
- Stakeholder raised technical feasibility and cost concerns regarding the energy demands
- Could consider a third-party assessment that aligns with the 2022 AQMP implementation

Next Steps

- Continue Site Visits and Stakeholder Meetings
- Continue meeting with Technology Vendors
- Release Draft Staff Report and Draft Rule Language
- Public Workshop
- Public Hearing December 2022

Receiving PAR 1153.1 Updates

- To receive email updates, sign up at South Coast AQMD sign up page *http://www.aqmd.gov/sign-up*
- Enter email address and name
- Subscribe by scrolling down to “Rule Updates” and check the box for Rule 1153.1 and click on the subscribe button at bottom of page
- Future meeting notices, links to documents, and any updates will be sent via email



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