



**Proposed Amended Rule 1111–
Reduction Of NOx Emissions From Natural-
Gas-Fired, Fan-Type Central Furnaces**

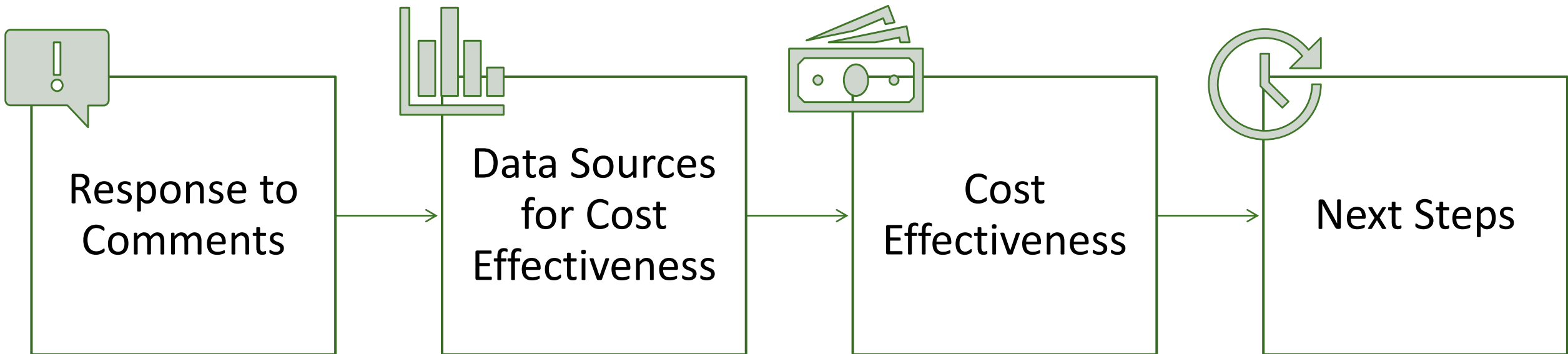
**Proposed Amended Rule 1121–
Control of Nitrogen Oxides From Residential
Type, Natural Gas-Fired Water Heaters**

Working Group Meeting #2
November 28, 2023, 9:00 AM (PST)

Join Zoom Meeting:
<https://scaqmd.zoom.us/j/97271436016>
Meeting ID: 972 7143 6016

Agenda

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Summary of Working Group Meeting #1

In the previous Working Group Meeting, Staff provided background on:

Rule Development Process

Control Measures for Residential Space and Water Heating

Best Available Retrofit Control Technology (BARCT) Assessment

Regulatory Requirements

Zero-Emission Technologies

Challenges

Manufacturer Survey

Incentives



Stakeholder Comments from Working Group Meeting #1

Response to Comments – Fuel Cells

Comment:

- Staff should consider fuel cells in analysis

Response:

- Fuel cells are a potential zero-NOx source for space and water heating
- Fuels cells that provide power and heat for homes (called micro-CHPs) are commercially available in Japan and Europe
- Little to no market penetration in U.S.
- Not enough cost information in U.S. for analysis
- Stakeholders are encouraged to provide cost information for staff analysis

Area	Cost of Micro-CHPs
Japan	\$13,300
Europe	\$20,500-\$26,600

Response to Comments – Dual Fuel

Comment:

- Staff should consider dual fuel heaters in analysis

Response:

- Dual fuel systems have a heat pump with a gas furnace for back-up
- Heat pumps are available for all residential ranges and cold-climate heat pumps work at low temperatures
- Cost is higher because both a heat pump and furnace need to be purchased
- Difficult to guarantee the gas unit is only operated as back-up
- Staff may consider dual fuel in areas where heat pump-only units are found to be impractical

Response to Comments – Panel Upgrades

Comment:

- Staff should consider panel upgrade costs

Response:

- Staff will consider costs for panel upgrades for some cases
 - 87% of homes in South Coast AQMD have central or room AC (would not require panel upgrade for HVAC heat pumps)
- TECH installs for single family homes:
 - Panel upgrades needed for 4% of Heating, Ventilation and Air Conditioning (HVAC) heat pump and 9% of heat pump water heaters
 - Average cost difference for installs with panel upgrades: \$2,600 for heat pump HVAC, \$1,800 for heat pump water heaters
- Internet search: Majority of results suggest panel upgrade cost of less than \$3,000

Data Sources for Cost Effectiveness



Data Sources for Cost Effectiveness - Overview

Capital Costs

- TECH Clean California database for actual installation costs for space and water heating heat pumps
- E3 Residential Building Study for conventional gas appliance costs

Operating Costs

- California Energy Commission's Residential Appliance Saturation Study for energy use for space heating
- Energy Star's estimated energy use for water heating

Capital Cost Data Sources – TECH Clean California

- ▶ Data gathered from thousands of heat pump installations in California as part of state incentive program
- ▶ Used August 2023 data
- ▶ Majority of installations in 2022
- ▶ Percentage of projects needing panel upgrades:
 - HVAC – **4%**
 - Water Heating – **9%**
- ▶ Average cost of installation in Los Angeles, Orange, San Bernardino and Riverside Counties
 - HVAC – **\$17,900**
 - Water Heating – **\$5,900**



techcleanca.com/public-data/

Capital Cost Data Sources – E3 2019 Residential Building Study

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- ▶ Collected capital cost information on conventional gas units, broken out by construction type and climate zone
- ▶ Averaged out climate zones 6, 9, and 10 (three most common climate zones in South Coast area) and weighted average of housing age, and applied Consumer Price Index (CPI) adjustment from 2018 to 2022 for comparison to TECH cost data
 - Gas Water Heater – **\$3,000**
 - Gas Furnace and AC – **\$18,800**
 - Gas Furnace Only – **\$10,000**



www.ethree.com/e3-quantifies-the-consumer-and-emissions-impacts-of-electrifying-california-homes/

Operating Cost Data Sources – 2019 Residential Appliance Saturation Study (RASS)

- ▶ The California Energy Commission conducted a study on actual annual energy use of home appliances in California
- ▶ Includes energy use broken out by climate zones, housing type, and utility provider
- ▶ Using So Cal Gas and So Cal Edison data as most broadly representative for South Coast AQMD region
- ▶ No information on heat pump water heaters



www.energy.ca.gov/publications/2021/2019-california-residential-appliance-saturation-study-rass

Zero-Emission Option	Conventional Option	
HVAC Heat Pump	Gas Furnace	Furnace Fan
565 kWh	127 therms	101 kWh

Operating Cost Data Sources – Energy Star

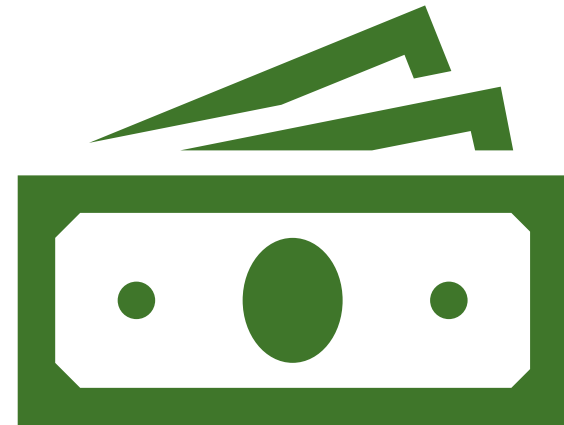
EnergyStar provides estimates of annual energy use for certified water heaters

- ▶ Not actual usage data, seeking out additional data sources
- ▶ Compared 45-55 gallon natural gas water heaters with 55-65 gallon heat pump water heaters (larger tank to account for lower recovery rate)
- ▶ Annual energy use:
 - Conventional Gas Water Heater – **188-192 therms**
 - Heat Pump Water Heater – **887-1184 kWh**



www.energystar.gov/productfinder/product/certified-water-heaters/

Cost Effectiveness



Assumptions

- ▶ Equipment Useful Life: 15 years for both space and water heaters
 - Furnaces can have longer lifetimes, but are often paired with air conditioners, which have a 15-20 year lifetime per U.S. Department of Energy*
- ▶ Capital costs drawn from TECH data and E3 study
 - Costs for heat pumps are expected to decrease as manufacturers increase production and installers become more familiar
- ▶ Operating fuel use drawn from RASS for space heating and EnergyStar for water heating

*<https://www.energy.gov/energysaver/central-air-conditioning>

Assumptions – Panel Upgrades

- ▶ Panel upgrade cost assumed to be **\$3,000** with lifetime of 30 years
 - Adjusted to \$1,500 to account for longer useful panel life versus equipment (15 years)
- ▶ The cost of panel will be shared by both space and water heaters
 - Adjusted the panel upgrade cost to \$750 for each
- ▶ Weighting panel upgrades according to TECH data on percent of homes where panel upgrades are needed (4% for HVAC, 9% for water heating)
 - Analysis by Redwood Energy* shows homes with 100-amp panels may not need upgrades for heat pump installations

*<https://www.redwoodenergy.net/research/a-pocket-guide-to-all-electric-retrofits-of-single-family-homes>

Baseline Emissions and Incremental Costs

- ▶ Lifetime Baseline NO_x Emissions: Annual Fuel Use × Emission Factor × Lifetime of Unit
 - Emission Factor: 10 ng/J for water heating, 14 ng/J for space heating
- ▶ Zero-emission options assumed to have no emissions
- ▶ Incremental cost difference between a combustion unit and a zero-emission unit is divided by emission reduction to get cost effectiveness per ton of NO_x

	Residential Furnaces	Residential Water Heaters
Annual Fuel Use (therms)	127	190
Emission Factor (lb/therm)	0.00325	0.00232
Lifetime Per Unit Baseline Emissions (ton of NO _x)	0.0031	0.0033

Assumptions

- ▶ Fuel switching cost referenced the residential utility rate forecast
 - Electricity prices are sourced from 2022 California Energy Commission (CEC) Energy Demand Update*
 - Gas prices sourced from CEC's 2021 Integrated Energy Policy Report Energy Forecast**
 - Los Angeles Department of Water and Power (LADWP) and Southern California Edison (SCE) electricity prices differ
 - Staff estimated the electricity price by weighing according to population
 - ▶ LADWP: $4 \text{ million residents} \div 17.2 \text{ million (region population in 2022 AQMP)} = 0.23$
 - ▶ SCE Weight: $13.2 \text{ million} \div 17.2 \text{ million} = 0.77$

* 2022 CEC Energy Demand Update: <https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2022-integrated-energy-policy-report-update>

** 2021 CEC IEPR: <https://www.energy.ca.gov/data-reports/reports/integrated-energy-policy-report/2021-integrated-energy-policy-report>

Discounted Cash Flow Method

- ▶ Discounted cash flow, or DCF, is a common valuation technique that uses expected future cash flows in conjunction with a discount rate to estimate the present fair value
- ▶ Discounted cash method (DCF) with Present Value Factor (PVF): $PVF = \frac{(1 + r)^N - 1}{r * (1 + r)^N}$
 - r = real interest rate (discount rate, 4%)
 - N = years of equipment life
- ▶ Multiplied by Present Value Factor (PVF) of 11.118 for space and water heaters

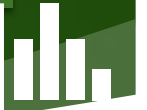
Initial Cost-Effectiveness Calculation

- ▶ Cost-effectiveness means the cost of the potential control option divided by emission reduction potential of the potential control option
 - Measured in cost per ton of pollutant reduced
 - **Cost-Effectiveness** = Total Capital Cost ÷ Emissions Reduced Over Equipment Life

$$CE \left(\$/\text{tons NO}_x \text{ reduced} \right) = \frac{\text{Incremental Difference in Initial Capital Investment Cost} + (\text{Fuel Switching Cost} \times PVF)}{\text{Lifetime Emission Reductions}}$$

- Assumptions:
 - Costs are the incremental costs for new installations and replacements of natural gas fueled units versus zero-emission units
 - Proposal considers replacement at the end of unit lifetime

Cost-Effectiveness Threshold



2022 Air Quality Management Plan (AQMP)

- Established cost-effectiveness screening threshold of \$325,000 per ton of NOx reduced based on 2021 dollars
- AQMP stated that the threshold will be adjusted based on annual California Consumer Price Index (CPI)
- PAR 1111 and 1121 currently considers a **\$349,000** cost-effectiveness screening threshold using 2022 dollars
- **Note: 2022 AQMP threshold is neither considered a starting point for control costs, nor an absolute cap**

Incentives

- ▶ Wide variety of government incentives available for heat pumps
- ▶ Incentives are subtracted from heat pump capital costs to find cost effectiveness when incentives are used
- ▶ Potential South Coast AQMD Clean Air Appliances Rebate Program (CAARP)

Incentive Type	HVAC	Water Heating
Inflation Reduction Act	30% or \$2,000	30% or \$2,000
TECH Incentive	\$1,000	\$3,100
CAARP Incentive	TBD	TBD
CAARP Low Income	TBD	TBD
Current Incentive Stacking	\$3,000	\$5,100

Cost Effectiveness – Space Heating

- ▶ Assuming heat pump is replacing both furnace and AC, or just furnace in homes with no AC
 - Weighted average 87% of homes with furnace and AC, 13% of homes with just furnace
- ▶ Costly to replace a furnace and no AC, but cost saving to replace both furnace and AC
- ▶ Initial costs have largest effect, fuel switching shows modest cost savings
- ▶ Incentives make heat pumps even more cost effective than base case

Category	Additional Cost (Replacing AC and furnace)	Additional Cost (Replacing furnace)	Cost Effectiveness (Weighted Average)	Cost Effectiveness - Panel Upgrade Shared with Water Heater (Weighted Average)
No Incentives	-\$1,700	\$7,100	(\$154,000)	\$(165,000)
With IRA Incentive	-\$3,700	\$5,100	(\$800,000)	(\$811,000)
With TECH Incentive	-\$2,700	\$6,100	(\$477,000)	(\$488,000)
Both Incentives	-\$4,700	\$4,100	(\$1,124,000)	(\$1,134,000)

Cost Effectiveness – Water Heating

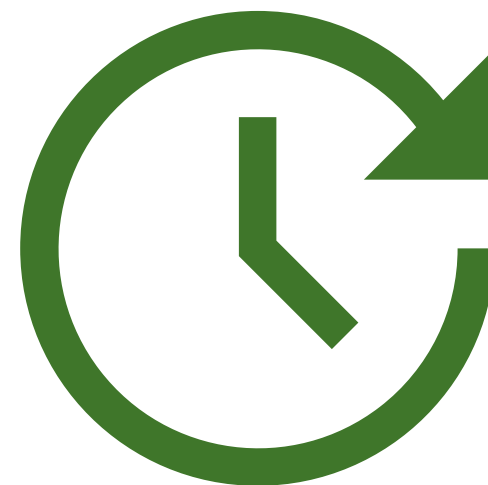
- ▶ Initial costs have largest effect, with modest fuel switching cost savings
- ▶ Incentives necessary to bring cost effectiveness under the screening threshold
- ▶ Additional cost of \$2,700 without incentives

Category	Additional Cost	Cost Effectiveness	Cost Effectiveness (Panel Upgrade Shared with HVAC)
No Incentives	\$2,700	\$854,000	\$833,000
With IRA Incentive	\$900	\$320,000	\$299,000
With TECH Incentive	-\$400	(\$84,000)	(\$105,000)
Both Incentives	-\$2,200	(\$618,000)	(\$639,000)

Summary


- ▶ Replacing both AC and furnace with a heat pump is under the screening threshold and can provide overall savings
 - Cases with just furnace replacement may exceed screening threshold
- ▶ Replacing a gas water heater with a heat pump water heater is costly
 - Requires incentives to be below screening threshold
 - Expect prices to drop as technology matures

Next Steps



Next Steps

Identify and evaluate special cases (e.g. apartments, manufactured homes) that may have significantly different cost effectiveness



Continue Working Group Meetings



Conduct site visits and hold stakeholder meetings



Anticipated Public Hearing: 4th Quarter 2024

Sign Up for Notifications

- To receive newsletter updates via email for notifications regarding the 1111 and 1121 rule development and other forthcoming building appliances rules, please subscribe by checking the **Rule 1111**, **Rule 1121** and **Building Appliances** check boxes located under Rule Updates:

<http://www.aqmd.gov/sign-up>

- To receive printed copies of South Coast AQMD publications via mail, please visit:

<http://www.aqmd.gov/nav/contact/subscription-services>

The screenshot shows the 'Sign Up' page for the South Coast AQMD. At the top, it says 'Sign Up' and provides a brief overview: 'The South Coast AQMD offers periodic newsletter updates via Email on a variety of topics. Click on the Manage Subscriptions link at the bottom of the form to update your subscriptions (unsubscribe from lists, subscribe to additional lists, or change your Email address).' Below this, there are instructions: 'If you wish to receive daily pollution forecasts or alerts for specific pollution levels in your area, sign up for Air Alerts.' and 'For printed copies of South Coast AQMD publications that mailed to you, please visit Subscription Services (charges may apply).' The main form section is titled 'Enter the following information:' and contains four input fields: 'Email Address', 'Re-Enter Email Address', 'First Name (optional)', and 'Last Name (optional)'. Below the form, there is a section for selecting subscription options under the heading 'Rule Updates:'. Three options are listed, each with a checkbox: 'Building Appliances' (circled in red), 'Rule 1111' (circled in red), and 'Rule 1121' (circled in red). The descriptions for these options are: 'Working Group for Residential and Commercial Building Appliances', 'Reduction of NOx Emissions from Natural-Gas-Fired, Fan-Type Central Furnaces', and 'Control of Nitrogen Oxides from Residential - Type, Natural-Gas-Fired Water Heaters'.

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