SMAQMD BACT CLEARINGHOUSE

EXPIRED

CATEGORY Type: **IC ENGINE SPARK - PRIME**

BACT Category: Non-Agricultural Fossil Fueled Engines >

BACT Determination Number:	143	**BACT Determination Date:**	**5/14/2018**

Equipment Information

Permit Number: 24929
Equipment Description: IC ENGINE PRIME POWER
Unit Size/Rating/Capacity: Minor Source BACT
Equipment Location: KAISER FOUN HOSP SOUTH
6880 POWER INN RD SACRAMENTO, CA

BACT Determination Information

District Contact: Joe Carle Phone No.: (916) 874-4863 email: jquok@airquality.org

ROCs	**Standard:**	25 ppmvd @ 15% O2
	Technology Description:	
	Basis:	Achieved in Practice
NOx	**Standard:**	5 ppmvd @ 15% O2
	Technology Description:	
	Basis:	Achieved in Practice
SOx	**Standard:**	Comply with listed fuel options (see comments)
	Technology Description:	Operate exclusively on PUC-quality natural gas, commercial propane, butane, or liquefied petroleum gas, or a combination of such gases (see comments for alternative compliance)
	Basis:	Achieved in Practice
PM10	**Standard:**	Emissions ≤ uncontrolled natural gas combustion
	Technology Description:	
	Basis:	Achieved in Practice
PM2.5	**Standard:**	Emissions ≤ uncontrolled natural gas combustion
	Technology Description:	
	Basis:	Achieved in Practice
CO	**Standard:**	56 ppmvd @ 15% O2 for < 2,064 bhp
	Technology Description:	For four stroke lean burn engines >500 bhp, 47 ppmvd @ 15% O2; For ≥ 2,064 bhp, 33 ppmvd @ 15% O2
	Basis:	Achieved in Practice
LEAD	**Standard:**	
	Technology Description:	
	Basis:	

Comments: This determination excludes biogas fueled engines and electrical generating engines.
Alternative compliance for SOx can be one of the following:
a) Limit gaseous fuel sulfur content to no more than five (5) grains of total sulfur per one hundred (100) standard cubic feet; or
b) Install and properly operate an Emission Control system that reduces SO2 emissions by at least 95% by weight.

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777 12th Street, Third Floor

SACRAMENTO METROPOLITAN AIR QUALITY MANAGEMENT DISTRICT

Sacramento, CA 95814

BEST AVAILABLE CONTROL TECHNOLOGY DETERMINATION

DETERMINATION NOS.: 143

DATE: May 14, 2018

ENGINEER: J. Carle

Category/General Equip Description: Internal Combustion (I.C.) Engine

Equipment Specific Description: I.C. Engine – Prime, Non-Agricultural, Fossil-Fueled, Non-Electrical Generating

Equipment Size/Rating: Engines ≥ 50 BHP

Previous BACT Det. No.: None

This Best Available Control Technology (BACT) determination category was determined under the project for A/C 24929 (City of Sacramento). The engine being used is a direct-drive prime power water pump at a water lift station.

This determination will focus on prime powered gaseous-fueled spark ignited engines greater than or equal to 50 bhp, because spark ignited engines have the ability to achieve the lowest emission standards for NOx. A case-by-case, site-specific BACT determination may be required for proposed engines that must be installed in areas where gaseous fuels are not feasible. Additionally, this determination will not consider standards and technologies that apply to engines used for electrical generation (i.e. distributed generation). BACT standards for engines used only for generating electricity will also be reviewed on a case-by-case basis.

This determination will also include Best Available Control Technology for Toxics (T-BACT) for the hazardous air pollutants (HAP) associated with gaseous fuel combustion.

BACT/T-BACT ANALYSIS

A. ACHIEVED IN PRACTICE (Rule 202, §205.1a):

The following control technologies are currently employed as BACT/T-BACT for gaseous-fueled prime engines by the following agencies and air pollution control districts:

Note: Tables 3.2-1, 3.2-2, and 3.2-3 of AP-42 list benzene, formaldehyde, PAHs, naphthalene, acetaldehyde, acrolein, propylene, toluene, xylenes, ethyl benzene, and hexane as the primary drivers for health risks associated with natural gas combustion. These HAPs/organic compounds are emitted as VOC and the same control technologies that control VOCs also control the listed HAPs.

US EPA

BACT

Source: EPA RACT/BACT/LAER Clearinghouse (See Attachment A)

No determinations were found for prime power spark ignited units (excluding biogas and electrical generation) ≤ 500 BHP

Prime Power, Natural Gas-Fired, > 500 BHP IC Engines (excluding engines used to generate electricity)				
Pollutant	Rich Burn		Lean Burn	
	Standard	RBLC ID	Standard	RBLC ID
VOC	0.12 g/bhp-hr	PA-0287	0.091 g/bhp-hr	TX-0755
NOx	0.2 g/bhp-hr	PA-0287	0.45 g/bhp-hr	LA-0292
SOx	No standard	N/A	No standard	N/A
PM10	No standard	N/A	No standard	N/A
PM2.5	No standard	N/A	0.003 lb/hr	LA-0292
CO	0.26 g/bhp-hr	PA-0287	0.083 g/bhp-hr	TX-0755

T-BACT

Source: EPA RACT/BACT/LAER Clearinghouse (See Attachment A)

No determinations were found for prime power spark ignited units (excluding biogas and electrical generation) ≤ 500 BHP

Prime Power, Natural Gas-Fired, > 500 BHP IC Engines				
Pollutant	Rich Burn		Lean Burn	
	Standard	RBLC ID	Standard	RBLC ID
Formaldehyde	0.014 g/bhp-hr	PA-0287	0.05 g/bhp-hr	PA-0301

RULE REQUIREMENTS:

40 CFR Part 60 Subpart JJJJ – Standards of Performance for Stationary Spark Ignition Internal Combustion Engines: This regulation applies to owners/operators of new stationary spark ignition engines (SI ICE) that commenced construction after June 12, 2006. [40 CFR §60.4230(a)(4)]

40 CFR §60.4233(d)

Owners and operators of stationary SI ICE with a maximum engine power greater than 25 BHP and less than 100 BHP must comply with the emission standards for field testing in 40 CFR 1048.101(c) for their non-emergency stationary SI ICE. For engines greater than or equal to 100 BHP see table below for emission standards.

40 CFR Subpart JJJJ Table 1: Emission Standards					
Engine Type and Fuel	Maximum Engine Power	Manufacture Date	Emission Standards (A) g/bhp-hr (ppmvd at 15% O_2)		
			NOx	CO	VOC (C)
Non-Emergency SI Natural Gas and Non-Emergency SI Lean Burn LPG (B)	100≤HP<500	7/1/2008	2.0 (160)	4.0 (540)	1.0 (86)
		1/1/2011	1.0 (82)	2.0 (270)	0.7 (60)
Non-Emergency SI Lean Burn Natural Gas and LPG	500≤HP<1,350	1/1/2008	2.0 (160)	4.0 (540)	1.0 (86)
		7/1/2010	1.0 (82)	2.0 (270)	0.7 (60)
Non-Emergency SI Natural Gas and Non-Emergency SI Lean Burn LPG (except lean burn 500≤HP<1,350)	HP≥500	7/1/2007	2.0 (160)	4.0 (540)	1.0 (86)
		7/1/2010	1.0 (82)	2.0 (270)	0.7 (60)

(A) Owners and operators of stationary non-certified SI engines may choose to comply with the emission standards in units of either g/bhp-hr or ppmvd at 15% O2
(B) The emission standards applicable to emergency engines between 25 BHP and 130 BHP are in terms of NOx + HC.
(C) For purposes of this subpart, when calculating emissions of VOC compounds, emissions of formaldehyde should not be included.

40 CFR Part 63 Subpart ZZZZ – National Emissions Standards for Hazardous Air Pollutants for Stationary Reciprocating Internal Combustion Engines: This regulation applies to owners/operators of stationary reciprocating internal combustion engines (RICE) located at both major and area sources of Hazardous Air Pollutant (HAP) emissions. [40 CFR §63.6585]

40 CFR §63.6590(c)
An affected source that meets any of the criteria in paragraphs (1) through (7) of this section must meet the requirements of this part by meeting the requirements of 40 CFR part 60 subpart IIII, for compression ignition engines or 40 CFR part 60 subpart JJJJ, for spark ignition engines. No further requirements apply for such engines under this part.

California Air Resource Board (CARB)

BACT
Source: CARB BACT Clearinghouse (See Attachment B)

Prime Power, Natural Gas-Fired IC Engines (excluding engines used to generate electricity)				
Pollutant	Rich Burn		Lean Burn	
	Standard	Source	Standard	Source
VOC	0.15 g/bhp-hr	SCAQMD 12/14/1999	No standard	N/A
NOx	0.15 g/bhp-hr	SCAQMD 12/14/1999	No standard	N/A
SOx	No standard	N/A	No standard	N/A
PM10	No standard	N/A	No standard	N/A
PM2.5	No standard	N/A	No standard	N/A

Prime Power, Natural Gas-Fired IC Engines (excluding engines used to generate electricity)				
Pollutant	Rich Burn		Lean Burn	
	Standard	Source	Standard	Source
CO	0.6 g/bhp-hr	SCAQMD 12/14/1999	No standard	N/A

T-BACT

There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:

CARB does not have a statewide rule for control of stationary spark-ignited IC engines. However, the state develops, when necessary, guidelines that set Reasonable Available Control Technology (RACT) and Best Available Retrofit Technology (BARCT). These guidelines establish the minimum requirements for RACT and BARCT that Districts must consider when developing all feasible measures for attainment of the California Ambient Air Quality Standards.

CARB RACT/BARCT Guidelines for Stationary Spark-Ignited Internal Combustion Engines (11/2001)

This document presents the determination of reasonably available control technology (RACT) and best available retrofit control technology (BARCT) for controlling NOx, VOC, and CO from stationary, spark-ignited reciprocating internal combustion engines. The following are recommendations CARB has made to assist in rulemaking.

Summary of BARCT Standards for Stationary Spark-Ignited Internal Combustion Engines.				
Spark-Ignited Type	% Control of NOx	ppmv @ 15% O_2		
		NOx	VOC	CO
Rich Burn				
Waste Gas	90	50	250	4,500
Cyclically-loaded Field Gas Fueled	--	300	250	4,500
All Other	96	25	250	4,500
Lean Burn				
Two Stroke, Gaseous Fueled, < 100 HP	--	200	750	4,500
All Other	90	65	750	4,500

Sacramento Metropolitan AQMD

BACT
Source: SMAQMD BACT Clearinghouse
No BACT Determination.

T-BACT
No T-BACT Determination.

RULE REQUIREMENTS:
Rule 412 – Stationary Internal Combustion Engines Located at Major Stationary Sources of NOx (Adopted 6/1/1995)
This rule applies to any non-agricultural prime power stationary internal combustion engine rated at more than 50 BHP located at a major stationary source of NOx.

Spark Ignited Rich Burn Engines are Exempt from Emission Limits		
If the engine rating is greater than…	…but less than or equal to…	And the actual annual hours of operation are less than or equal to…
50 bhp	75 bhp	200 hours
75 bhp	125 bhp	120 hours
125 bhp	155 bhp	100 hours
155 bhp	200 bhp	80 hours
200 bhp	300 bhp	60 hours
300 bhp	400 bhp	45 hours
400 bhp	525 bhp	40 hours

Spark Ignited Rich Burn Emission Limits ppmv @ 15% O2 (g/bhp-hr)		
NOx	**CO**	**NMHC**
25	4,000	250

Spark Ignited Lean Burn Emission Limits ppmv @ 15% O2 (g/bhp-hr)		
NOx	**CO**	**NMHC**
65	4,000	750

Alternative Control requirement: As an alternative to the NOx emission limits specified above a stationary internal combustion engine shall achieve and maintain a percent NOx reduction by volume limit specified below as measured concurrently across an emission control device. If internal modifications are made to an engine the percent reduction shall be calculated from source test data before and after internal modification.

Engine Type	NOx Reduction
Spark Ignited Rich Burn	90%
Spark Ignited Lean Burn	90%

Rule 420 – Sulfur Content of Fuels (8/13/81)
No person shall burn any gaseous fuels containing sulfur compounds in excess of 50 grains per 100 cubic feet, calculated as hydrogen sulfide at standard conditions, or any liquid fuel or solid fuel having a sulfur content in excess of 0.5% by weight.

South Coast AQMD

BACT

Source: SCAQMD BACT Guidelines for Non-Major Polluting Facilities, page 76 (2/2/18)

I.C. Engine, Stationary, Non-Emergency						
Maximum engine power	VOC	NOx	SOx	CO	PM	Inorganic
> 50 bhp	Compliance with Rule 1110.2	Compliance with Rule 1110.2	See Clean Fuels Policy (A)	Compliance with Rule 1110.2	See Clean Fuels Policy (A) and Compliance with Rule 1470 (B)	N/A

(A) SCAQMD's Clean Fuels Policy defines a Clean Fuel as one that produces air emissions equivalent to or lower than natural gas. The requirement of a clean fuel is based on engineering feasibility. Engineering feasibility considers the availability of a clean fuel and safety concerns associated with that fuel. SCAQMD's Clean Fuel Policy lists natural gas, methanol, liquid petroleum gas (LPG), and hydrogen as clean fuels.

(B) Rule 1470 - Requirements for Stationary Diesel-Fueled Internal Combustion and Other Compression Ignition Engines applies to diesel compression ignition engines and does not apply to this BACT Determination

T-BACT

There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:

Reg XI, Rule 1110.2 – Emissions From Gaseous- and Liquid-Fueled Engines (6/3/16)
This rule is applicable to all stationary and portable engines over 50 rated brake horsepower (bhp).

Requirements:

SCAQMD Rule 1110.2 Emissions Limits (excluding new electrical generation devices)	
Pollutant	Published Value (ppmvd @ 15% O2)
VOC	30 ppmvd
NOx	11 ppmvd
CO	250 ppmvd

San Joaquin Valley Unified APCD

BACT

Source: SJVUAPCD BACT Guideline 3.3.12 (3/09/15)

Non-Agricultural Fossil Fuel-Fired IC Engines > 50 bhp (A)		
Pollutant	Achieved In Practice	Technologically Feasible
VOC	25 ppmvd @ 15% O_2 or 0.15 g/bhp-hr	For rich burn engines only: 12 ppmvd @ 15% O_2 or 0.069 g/bhp-hr
NOx	0.07 g/bhp-hr or 5 ppmvd @ 15% O_2	N/A
SOx	Compliance with SJVUAPCD Rule 4702 SOx emission control requirements	N/A
PM10 (B)	0.06 g/bhp-hr (Total PM)	N/A
PM2.5	N/A	N/A
CO	For four stroke lean burn engines >500 bhp: 47 ppmvd @ 15% O_2 For all engines ≥ 2,064 bhp: 33 ppmvd @ 15% O_2 For all other engines: 56 ppmvd @ 15% O_2 or 0.6 g/bhp-hr	N/A

(A) For the purposes of this determination, fossil fuels includes diesel, gasoline, natural gas, propane, kerosene, and similar hydrocarbon compounds derived from petroleum oil or natural gas. Fossil fuels also include similar synthetic fuels such as biodiesel and/or any fuel containing one or more fossil fuels.

(B) This total PM10 emission limit is based on EPA Method 5 (front half and back half) testing, which typically yields results as much as four times higher than when using the ISO 8178 Test Method which only reports filterable (i.e. front half) emissions.

T-BACT

There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:

Rule 4702 – INTERNAL COMBUSTION ENGINES (Amended 11/14/13)

This rule applies to any internal combustion engine rated at 25 brake horsepower or greater. See table below for emission limits.

Emission Limits for a Spark Ignited Internal Combustion Engine Rated at > 50 bhp Used Exclusively in Non-Agricultural Operations ppmv @ 15% O2 (g/bhp-hr)			
Engine Type	NOx Limit ppmv @ 15% O_2	CO Limit ppmv @ 15% O_2	VOC Limit ppmv @ 15% O_2
Rich Burn			
Cyclic Loaded, Field Gas Fueled	50	2000	250
Limited Use (A)	25	2000	250
Rich Burn Engines (excluding waste gas fueled & cyclic loaded, field gas fueled)	11	2000	250

Lean Burn			
Two-Stroke, gaseous fueled, > 50 bhp and < 100 bhp	75	2000	750
Limited Use (A)	65	2000	750
Lean-Burn Engine used for gas compression	65 or 93% reduction	2000	750
Lean-Burn Engine, not listed above	11	2000	750

(A) Limited Use Engine is defined as an engine that is limited by a permit condition to be operated no more than 4,000 hours per calendar year.

SOx Emission Control Requirements

Non-agricultural operation spark-ignited engines shall comply with one of the following requirements:

1. Operate engine exclusively on PUC-quality natural gas, commercial propane, butane, or liquefied petroleum gas, or a combination of such gases; or
2. Limit gaseous fuel sulfur content to no more than five (5) grains of total sulfur per one hundred (100) standard cubic feet; or
3. Install and properly Operate an Emission Control system that reduces SO_2 emissions by at least 95% by weight

San Diego County APCD

BACT

Source: NSR Requirements for BACT (June 2011), (pg 3-15 & 3-16)

Internal Combustion Engine, Piston Type, Non-Emergency & Non-cogeneration – Natural Gas Fuel, Lean Burn, ≥2000 bhp (A)		
Pollutant	Achieved in Practice	Technologically Feasible
VOC	1.0 g/bhp-hr	0.6 g/bhp-hr
NOx	0.15 g/bhp-hr, SCR	0.07 g/bhp-hr, SCR
SOx	Low sulfur fuel 10 grains/100 cf natural gas	N/A
PM10	0.1 g/bhp-hr, PCV filter	N/A
PM2.5	0.1 g/bhp-hr, PCV filter	N/A
CO	N/A	N/A

(A) Applicant may choose to limit Potential to Emit (PTE) from the equipment to less than 10 pounds per day for each pollutant in lieu of meeting the stated BACT requirement.

Internal Combustion Engine, Piston Type, Non-Emergency & Non-cogeneration – Natural Gas Fuel, Rich Burn, ≥200 bhp (A)		
Pollutant	Achieved in Practice	Technologically Feasible
VOC	0.15 g/bhp-hr	0.15 g/bhp-hr, NSCR
NOx	0.15 g/bhp-hr, NSCR	0.07 g/bhp-hr, NSCR
SOx	Low sulfur fuel 10 grains/100 cf natural gas	N/A
PM10	0.1 g/bhp-hr, PCV filter	N/A
PM2.5	0.1 g/bhp-hr, PCV filter	N/A

Internal Combustion Engine, Piston Type, Non-Emergency & Non-cogeneration – Natural Gas Fuel, Rich Burn, ≥200 bhp (A)		
Pollutant	Achieved in Practice	Technologically Feasible
CO	N/A	N/A

(A) Applicant may choose to limit Potential to Emit (PTE) from the equipment to less than 10 pounds per day for each pollutant in lieu of meeting the stated BACT requirement.

T-BACT

There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:

Regulation 4, Rule 69.4 – Stationary Reciprocating Internal Combustion Engines – Reasonably Available Control Technology (7/30/03)

This rule applies to stationary I.C. Engines ≥ 50 BHP located at a stationary source which emits or has a potential to emit 50 tons per year or more of NOx.

A person shall not operate a stationary internal combustion engine subject to this rule unless:

1. The emission concentration of NOx, in parts per million by volume (ppmv), calculated as nitrogen dioxide at 15% oxygen on a dry basis, or in grams of NOx per brake horsepower-hour, are not greater than the following:

Engine Category	Concentration of NOx g/bhp-hr (ppmv)
Rich burn engines using fossil derived gaseous fuel or gasoline	0.9 (50)
Lean burn engines using gaseous fuel	2.3 (125)

OR

Uncontrolled NOx emissions are reduced with add-on control equipment by not less than the following:

Engine Category	Weight Percent Reduction
Rich burn engines using fossil derived gaseous fuel or gasoline	90%
Lean burn engines using gaseous fuel	80%

2. The emission concentration of carbon monoxide (CO), calculated at 15% oxygen on a dry basis, shall not exceed 4,500 ppmv

Regulation 4, Rule 69.4.1 – Stationary Reciprocating Internal Combustion Engines – Best Available Retrofit Control Technology (11/15/00)

This rule applies to stationary I.C. Engines ≥ 50 BHP.

A person shall not operate a stationary internal combustion engine subject to this rule unless:

1. The emission concentration of NOx, in parts per million by volume (ppmv), calculated as nitrogen dioxide at 15% oxygen on a dry basis, or in grams of NOx per brake horsepower-hour, are not greater than the following:

Engine Category	Concentration of NOx ppmv
Rich burn engines using fossil derived gaseous fuel or gasoline	25
Lean burn engines using gaseous fuel	65

OR

Uncontrolled NOx emissions are reduced with add-on control equipment by not less than the following:

Engine Category	Weight Percent Reduction
Rich burn engines using fossil derived gaseous fuel or gasoline	96%
Lean burn engines using gaseous fuel	90%

2. The emission concentration of carbon monoxide (CO), calculated at 15% oxygen on a dry basis, shall not exceed 4,500 ppmv; and

3. For all rich-burn engines, emissions of VOC, calculated as methane at 15% oxygen on a dry basis, shall not exceed 250 ppmv.

Bay Area AQMD

BACT

Source: BAAQMD BACT Guideline 96.3.2 (5/7/03)

IC Engine – Spark Ignition, Natural Gas Fired Rich Burn Engine ≥ 50 bhp		
Pollutant	Achieved in Practice (A)	Technologically Feasible (B)
VOC	0.15 g/bhp-hr (25 ppmvd @ 15% O_2) using NSCR, 3-way catalyst	0.069 g/bhp-hr (12 ppmvd @ 15% O_2) using a 3-way catalyst + air/fuel ratio controller
NOx	0.15 g/bhp-hr (9 ppmvd @ 15% O_2) using NSCR, 3-way catalyst	0.071 g/bhp-hr (4 ppmvd @ 15% O_2) using a 3-way catalyst + air/fuel ratio controller
SOx	Use natural gas	N/A
PM10	Use natural gas	N/A
PM2.5	N/A	N/A
CO	0.60 g/bhp-hr (56 ppmvd @ 15% O_2) using a 3-way catalyst	N/A

(A) Reference: CARB "Guidance for the Permitting of Electrical Generation Technologies," September 2001
(B) Reference: SJVUAPCD: Aera Energy Oilfield

Source: BAAQMD BACT Guideline 96.3.3 (5/7/03)

IC Engine – Spark Ignition, Natural Gas Fired Lean Burn Engine ≥ 50 bhp		
Pollutant	Achieved in Practice (A)	Technologically Feasible (B)
VOC	0.15 g/bhp-hr (32 ppmvd @ 15% O_2) using an oxidation catalyst	N/A

IC Engine – Spark Ignition, Natural Gas Fired Lean Burn Engine ≥ 50 bhp		
Pollutant	Achieved in Practice (A)	Technologically Feasible (B)
NOx	0.15 g/bhp-hr (12 ppmvd @ 15% O_2) using SCR	0.07 g/bhp-hr (6 ppmvd @ 15% O_2) using SCR
SOx	Use natural gas	N/A
PM10	Use natural gas	N/A
PM2.5	N/A	N/A
CO	0.60 g/bhp-hr (74 ppmvd @ 15% O_2) using an oxidation catalyst	0.10 g/bhp-hr (12 ppmvd @ 15% O_2) using an oxidation catalyst

(A) Reference: CARB "Guidance for the Permitting of Electrical Generation Technologies," September 2001
(B) Reference: Tehama County APCD: NEO California Power, LLC – Red Bluff, California (ammonia slip limited to 10 ppmvd @ 15% O_2)

T-BACT

There are no T-BACT standards published in the clearinghouse for this category.

RULE REQUIREMENTS:

Reg 9, Rule 8 – Nitrogen Oxides and Carbon Monoxide from Stationary Internal Combustion Engines (7/25/07)

This rule applies to stationary internal combustion engines with an output rated by the manufacturer at more than 50 brake horsepower.

Emission Limits – Spark Ignited Engines Powered by Fossil Derived Fuels		
Engine Type	NOx Limit ppmvd @ 15% O2	CO Limit ppmvd @ 15% O2
Rich Burn	25	2000
Lean Burn	65	2000

Summary of Achieved in Practice Control Technologies

The following control technologies have been identified and are ranked based on stringency:

UNIT CONVERSION FOR NOx, VOC & CO

Depending on the agency, VOC, NOx, and CO emission standards were listed in either ppmvd @ 15% O_2 or in g/bhp-hr. For purposes of comparison all g/bhp-hr standards have been converted to ppmvd @ 15% O_2. The equations used for this conversion are based on Santa Barbara County APCD's Piston IC Engine Technical Reference Document. If the type of engine was not specified, the conversion factor for naturally aspirated natural gas engines was used and the results were rounded up to the nearest whole number.

$EF_{ppmvd} = (g/bhp\text{-}hr)_P * CF_P$

Where:

$(g/bhp\text{-}hr)_P$ = emission rate of pollutant in exhaust

CF_P = conversion factor of pollutant

For Naturally Aspirated natural gas engines:

CF_{VOC} = 163

CF_{NOx} = 57

CF_{CO} = 93

For Turbocharged natural gas engines:

CF_{VOC} = 170

CF_{NOx} = 59

CF_{CO} = 97

RICH BURN ENGINES – NOx, VOC & CO

The control method for all rich burn engine BACT determinations achieved in practice was through non-selective catalytic reduction (NSCR) or also commonly called a 3-way catalyst. NSCR reduces the emissions for NOx, VOC, and CO using one control device. The level of reduction for each pollutant depends on the air to fuel ratio that is driving the engine. As the air to fuel ratio gets more lean NOx reduction goes down but VOC and CO reduction goes up. Due to each individual pollutant reduction being interdependent, determinations as a whole will be ranked for these three pollutants, with an emphasis on NOx reduction, rather than emission levels for individual pollutants.

Achieved in Practice Standards for NOx, VOC & CO for Rich Burn Engines					
Rank	Standard (ppmvd @ 15% O_2)	Technology Description	Source	Year	Comments
1	NOx: 5 VOC: 25 CO: < 2,064 BHP: 56 ≥ 2,064 BHP: 33	None Listed	SJVUAPCD BACT	2015	SJVUAPCD has applied this standard to several rich-burn engines of various horsepower ratings.
2	NOx: 9 VOC: 25 CO: 56	NSCR	CARB BACT Clearinghouse	1999	SCAQMD BACT Determination
2	NOx: 9 VOC: 25 CO: 56	NSCR	BAAQMD BACT	2003	For natural gas-fired only
3	NOx: 9 VOC: 25 CO: No Limit	NSCR	SDCAPCD BACT	2011	For natural gas-fired and ≥200 BHP only
4	NOx: 11 VOC: 30 CO: 250	None Listed	SCAQMD Rule 1110.2	2016	SCAQMD BACT standards require compliance with Rule 1110.2
5	NOx: 12 VOC: 20 CO: 25	NSCR	EPA BACT Clearinghouse	2011	Determination from Pennsylvania Dept. of Environmental Protection
6	NOx: 25 or 90% reduction VOC: 250 CO: 4,000	None Listed	SMAQMD Rule 412	1995	Only applies to engines at major sources of NOx

LEAN BURN ENGINES – NOx, VOC & CO

High NOx reductions are, typically, achieved through Selective Catalytic Reduction (SCR) for lean burn engines. VOC and CO reductions are achieved through an oxidation catalyst in line with the SCR in the exhaust stream. The effectiveness of a catalyst is dependent on properties of the exhaust stream such as temperature and composition. Because both catalysts are in line in the exhaust stream emission reductions can be interdependent and therefore determinations as a whole will be ranked for these three pollutants, with an emphasis on NOx reduction, rather than emission levels for individual pollutants.

Achieved in Practice Standards for NOx for Lean Burn Engines					
Rank	Standard (ppmvd @ 15% O_2)	Technology Description	Source	Year	Comments
1	NOx: 5 VOC: 25 CO: 4 stroke > 500 BHP: 47 ≥ 2,064 BHP: 33 All other: 56	None listed	SJVUAPCD BACT	2015	
2	NOx: 9 VOC: 163 CO: None	SCR	SDCAPCD BACT	2011	Only applies to natural gas fueled engines ≥ 2,000 BHP
3	NOx: 11 VOC: 30 CO: 250	None listed	SCAQMD Rule 1110.2	2016	SCAQMD BACT refers to Rule 1110.2
4	NOx: 12 VOC: 32 CO: 74	SCR & oxidation catalyst	BAAQMD BACT	2003	Only applies to natural gas fueled engines
5	NOx: 26 VOC: 19 CO: None	Lean burn using natural gas and good combustion techniques	EPA BACT Clearinghouse	2016	From Louisiana Department of Environmental Quality for a 5,000 BHP natural gas fueled engine driving a compressor
6	NOx: 65 or 90% reduction VOC: 750 CO: 4,000	None listed	SMAQMD Rule 412	1995	Only applies to major sources of NOx
7	NOx: 65 or 90% reduction VOC: 750 CO: 4,500	None listed	CARB RACT/BARCT Guidelines	2001	

PM10 & PM2.5

SJVUAPCD lists 0.06 g/bhp-hr standard for PM10 in their non-agricultural fossil fueled IC engine BACT determination. This standard is achieved through PM10 reductions by use of a diesel particulate filter (DPF). The use of a DPF is technologically infeasible for a spark ignited engine and therefore will not be considered.

The uncontrolled emission factors for PM10 and PM2.5 from AP-42 Table 3.2-3 (7/00), filterable and condensable PM, is 0.0194 lb/MMBtu. Due to the units used in AP-42 the emission factor can only be converted to g/bhp-hr by using an individual engine's brake-specific fuel consumption. Various new natural gas-fired engines that are on the market for commercial and industrial applications, at various horsepower ratings, were examined and when using the uncontrolled AP-42 emission factor emission rates on average fell below 0.1 g/bhp-hr.

The SCAQMD standard was ranked higher than the BAAQMD standard because it allows the use of various fuels as long as emission rates are lower than that of uncontrolled natural gas-fired spark ignited engine.

Achieved in Practice Standards for PM					
Rank	Standard	Technology Description	Source	Year	Comments
1	Emissions ≤ to those of uncontrolled natural gas combustion	N/A	SCAQMD	2016	SCAQMD Clean Fuels Policy requires use of fuel with emissions ≤ natural gas
2	Use natural gas	N/A	BAAQMD	2003	
3	0.1 g/bhp-hr	PCV Filter	SDCAPCD	2003	For natural gas-fired only
4	No standard	N/A	EPA, CARB, SMAQMD	N/A	

SOx

Engines used for the compression of natural gas are commonly fueled on the unprocessed natural gas from the field well. The sulfur content of the fuel can vary greatly depending on the well that is being extracted. Because both the SCAQMD and BAAQMD BACT determinations do not specify a sulfur content of natural gas, standards that do specify sulfur content were ranked higher.

The SCAQMD standard was ranked higher than the BAAQMD standard because it allows the use of various fuels as long as emission rates are lower than that of uncontrolled natural gas-fired spark ignited engine.

Achieved in Practice Standards for SOx				
Rank	Standard	Source	Year	Comments
1	1. Use PUC-quality natural gas, commercial propane, butane, LPG, or a combination these gasses; or 2. Limit gaseous sulfur content to no more than 5 grains total sulfur per 100 scf, or 3. Use an emission control system that reduces SO_2 by 95% weight.	SJVUAPCD Rule 4702	2015	SJVUAPCD BACT refers to Rule 4702 for SOx
2	Low sulfur fuel 10 gr per 100 scf of natural gas	SDCAPCD BACT	2003	
3	Emissions ≤ to those of natural gas combustion	SCAQMD BACT	2016	SCAQMD Clean Fuels Policy requires use of fuel with emissions ≤ natural gas

Achieved in Practice Standards for SOx				
Rank	Standard	Source	Year	Comments
4	Use natural gas	BAAQMD BACT	2003	
5	Fuel not in excess of 50 gr per 100 scf of gaseous fuel	SMAQMD Rule 420	1981	
6	No standard	CARB, EPA	N/A	

Toxics

HAPs are emitted as VOC and the same control technologies that control VOCs also control the HAPs and, therefore, the achieved in practice standards for HAPs are the same as for VOC.

Summary Table

The following control technologies have been identified as the most stringent, achieved in practice control technologies:

Best Control Technologies Achieved in Practice			
Pollutant	Equipment/Operation Sub Category	Standard	Source
VOC	All Engines	25 ppmvd @ 15% O_2	SJVUAPCD BACT
NOx	All Engines	5 ppmvd @ 15% O_2	SJVUAPCD BACT
SOx	All Engines	1. Use PUC-quality natural gas, commercial propane, butane, LPG, or a combination of these gasses; or 2. Limit gaseous sulfur content to no more than 5 grains total sulfur per 100 scf; or 3. Use an emission control system that reduces SO2 by 95% weight.	SJVUAPCD BACT & Rule 4702
PM10	All Engines	Emissions ≤ to those of uncontrolled natural gas combustion	SCAQMD BACT
PM2.5	All Engines	Emissions ≤ to those of uncontrolled natural gas combustion	SCAQMD BACT

Best Control Technologies Achieved in Practice				
Pollutant	Equipment/Operation Sub Category		Standard	Source
CO	4 Stroke Lean Burn Engines > 500 BHP		47 ppmvd @ 15% O_2	SJVUAPCD BACT
	All Other Engines	< 2,064 BHP	56 ppmvd @ 15% O_2	
		≥ 2,064 BHP	33 ppmvd @ 15% O_2	
HAPs	All Engines		25 ppmvd @ 15% O_2	SJVUAPCD BACT

B. TECHNOLOGICALLY FEASIBLE AND COST EFFECTIVE (Rule 202, §205.1.b.):

Technologically Feasible Alternatives:
Any alternative basic equipment, fuel, process, emission control device or technique, singly or in combination, determined to be technologically feasible by the Air Pollution Control Officer.

The table below shows the technologically feasible alternatives identified as capable of reducing emissions beyond the levels determined to be "Achieved in Practice" as per Rule 202, §205.1.a.

Technologically Feasible Alternatives			
Pollutant	Emission Source Category	Standard	Source of Standard
VOC	Rich Burn Engines	0.069 g/bhp-hr (12 ppmvd @ 15% O_2) using a 3-way catalyst and air/fuel ratio controller	BAAQMD BACT (A)
		12 ppmvd @ 15% O_2 or 0.069 g/bhp-hr	SJVUAPCD BACT (B)
	Lean Burn Engines	No other technologically feasible option identified	N/A
NOx	Rich Burn Engines	0.071 g/bhp-hr or 4 ppmvd @ 15% O2 using a 3-way catalyst and air/fuel ratio controller	BAAQMD BACT (A)
		0.07 g/bhp-hr using NSCR	SDAPCD BACT
	Lean Burn Engines	0.07 g/bhp-hr or 6 ppmvd @ 15% O2 using SCR	BAAQMD BACT (C)
		0.07 g/bhp-hr using SCR	SDAPCD BACT
SOx	All Engines	No other technologically feasible option identified	N/A
PM10	All Engines	No other technologically feasible option identified	N/A
PM2.5	All Engines	No other technologically feasible option identified	N/A
CO	All Engines	No other technologically feasible option identified	N/A

(A) Emission limit based on a rich burn spark ignited engine permitted by SJVUAPCD for Aera Energy Oilfield.
(B) Emission limit based on technologically feasible limit in the BAAQMD BACT Guideline 96.3.2 (5/7/03)
(C) Emission limit based on a lean burn spark ignited engine permitted by TCAPCD for NEO California Power, LLC.

For VOC both SJVUAPCD and BAAQMD list that rich burn spark ignited engines have a technologically feasible emission limit of 12 ppmvd @ 15% O2 or 0.069 g/bhp-hr. The only non-electric generating engines found to be subject to this emission standard are three identical natural gas compressor engines permitted by the SJVUAPCD (with an accompanying NOx standard of 5 ppmvd @ 15% O_2 for NOx). Through conversations with the SJVUAPCD it was found that these engines were permitted around 2002 and the last known source test was performed in 2013. Despite SJVUAPCD updating their BACT determination for non-agricultural fossil fueled IC engines in 2015, this standard was not listed as achieved in practice. Because there is no long-term compliance verification and that the fact that this standard was only found achieved on a single type of engine for a single application, staff is unable to conclude that this standard is achieved in practice or technologically feasible for this general source category.

For NOx BAAQMD lists 0.071 g/bhp-hr for rich burn spark ignited engines and 0.07 g/bhp-hr for lean burn spark ignited engines as technologically feasible emissions limits. SDAPCD lists 0.07 g/bhp-hr for both rich burn and lean burn engines as technologically feasible. However SJVUAPCD lists 0.07 g/bhp-hr or 5 ppmvd @ 15% O_2 as achieved in practice for all non-agricultural fossil fuel-fired IC engines greater than 50 bhp. Therefore a 0.07 g/bhp-hr NOx limit can be considered achieved in practice for both lean and rich burn engines.

Cost Effectiveness Determination:
Since the identified technologically feasible controls (3-way catalysts, air/fuel ratio controllers, SCR, NSCR, and oxidation catalysts) and emission limits by BAAQMD, and SDAPCD have been found to be achieved in practice by other districts, a cost analysis is not required.

C. SELECTION OF BACT:

Based on the above analysis, BACT for VOC, NOx, SOx, PM10, and CO will remain at what is currently achieved in practice and BACT for PM2.5 will be set to be the same as for PM10.

Volatile hazardous air pollutants (VHAP) are the primary driver for health risks associated with gaseous fueled engines. VHAPs are emitted as VOC, and the same control technologies that control VOC also control VHAPs. Therefore, the BACT for VOC and T-BACT for HAPs are the same. See the tables below for a summary of the BACT Determinations.:

Table 1: BACT FOR I.C. ENGINES, PRIME, NON-AGRICULTURAL FOSSIL-FUELED, NON-ELECTRICAL GENERATING, ≥ 50 BHP

Pollutant	Standard	Source
VOC	25 ppmvd @ 15% O_2	SJVUAPCD
NOx	5 ppmvd @ 15% O_2	SJVUAPCD
SOx	1. Use PUC-quality natural gas, commercial propane, butane, LPG, or a combination of these gasses; or 2. Limit gaseous sulfur content to no more than 5 grains total sulfur per 100 scf; or 3. Use an emission control system that reduces SO2 by 95% weight.	SJVUAPCD
PM10	Emissions ≤ to those of uncontrolled natural gas combustion	SCAQMD

Table 1: BACT FOR I.C. ENGINES, PRIME, NON-AGRICULTURAL FOSSIL-FUELED, NON-ELECTRICAL GENERATING, ≥ 50 BHP		
PM2.5	Emissions ≤ to those of uncontrolled natural gas combustion	SCAQMD
CO	4-stroke, lean burn engines > 500 bhp: 47 ppmvd @ 15% O_2 All other engines ≥ 2,064 bhp: 33 ppmvd @ 15% O_2 All other engines < 2,064 bhp: 56 ppmvd @ 15% O_2	SJVUAPCD

Table 2: T-BACT FOR SPARK IGNITED I.C. ENGINES, PRIME, GASEOUS-FUELED (EXCLUDING BIOGAS), NON-ELECTRICAL GENERATING, ≥ 50 BHP		
Pollutant	**Standard**	**Source**
HAP(A)	25 ppmvd @ 15% O_2	SJVUAPCD

(A) A full list of the hazardous air pollutants (HAP) from natural gas combustion can be found in AP-42, Section 3.2 Natural Gas-fired Reciprocating Engines, Tables 3.2-1, 3.2-2, and 3.2-3.

REVIEWED BY: _____ **DATE:** _____

APPROVED BY: _____ **DATE:** 5/14/18

Attachment A

Review of BACT Determinations published by EPA

List of BACT determinations published in EPA's RACT/BACT/LAER Clearinghouse (RBLC) for Natural Gas (includes propane & liquefied petroleum gas) I.C. Engines:

Rich Burn Spark-Ignited IC Engines > 500 BHP (Process Code: 17.130)							
RBLC#	**Permit Date(A)**	**Rating**	**Fuel**	**Pollutant**	**Standard**	**Control Technology**	**Case-By-Case Basis**
PA-0302	4/16/2014	Not Listed	Natural gas	NOx	0.2 g/bhp-hr	NSCR	N/A
PA-0302	4/16/2014	Not Listed	Natural gas	VOC	0.2 g/bhp-hr	NSCR	N/A
PA-0302	4/16/2014	Not Listed	Natural gas	CO	0.3 g/bhp-hr	NSCR	N/A
PA-0302	4/16/2014	Not Listed	Natural gas	Formaldehyde	2.7 ppmvd @ 15% O_2	NSCR	N/A
PA-0287	9/27/2011	1,980 BHP	Natural gas	NOx	0.2 g/bhp-hr	NSCR	Other Case-By-Case
PA-0287	9/27/2011	1,980 BHP	Natural gas	CO	0.26 g/bhp-hr	NSCR	Other Case-By-Case
PA-0287	9/27/2011	1,980 BHP	Natural gas	VOC	0.12 g/bhp-hr	NSCR	Other Case-By-Case
PA-0287	9/27/2011	1,980 BHP	Natural gas	Formaldehyde	0.014 g/bhp-hr	NSCR	Other Case-By-Case

(A) Due to the large number of entries only determinations made (based on Permit Date) entered since 01/01/2007 are included in the above table.

Lean Burn Spark-Ignited IC Engines > 500 BHP (Process Code: 17.130)							
RBLC#	**Permit Date(A)**	**Rating**	**Fuel**	**Pollutant**	**Standard**	**Control Technology**	**Case-By-Case Basis**
LA-0292	1/22/2016	5,000 BHP	Natural gas	PM2.5	0.003 lb/hr	Use natural gas and good combustion techniques	BACT-PSD
LA-0292	1/22/2016	5,000 BHP	Natural gas	NOx	0.45 g/bhp-hr	Lean burn combustion using natural gas & good combustion techniques	BACT-PSD

Lean Burn Spark-Ignited IC Engines > 500 BHP (Process Code: 17.130)							
RBLC#	**Permit Date[(A)]**	**Rating**	**Fuel**	**Pollutant**	**Standard**	**Control Technology**	**Case-By-Case Basis**
LA-0292	1/22/2016	5,000 BHP	Natural gas	VOC	0.113 g/bhp-hr	Oxidation catalyst using natural gas & good combustion techniques	BACT-PSD
TX-0755	5/21/2015	3,785 BHP	Residue gas equivalent to natural gas	NOx	0.5 g/bhp-hr	Ultra lean burn technology	BACT-PSD
TX-0755	5/21/2015	3,785 BHP	Residue gas equivalent to natural gas	CO	0.083 g/bhp-hr Note: The emission standard for this permit has been changed to **0.50 g/bhp-hr**	Ultra lean burn technology with an oxidation catalyst	BACT-PSD
TX-0755	5/21/2015	3,785 BHP	Residue gas equivalent to natural gas	VOC	0.091 g/bhp-hr Note: The emission standard for this permit has been changed to **0.40 g/bhp-hr**	Ultra lean burn technology with an oxidation catalyst	BACT-PSD
PA-0301	3/31/2014	2,370 BHP	Natural gas	NOx	0.5 g/bhp-hr	Air/fuel ratio controller	Other Case-By-Case
PA-0301	3/31/2014	2,370 BHP	Natural gas	CO	47 ppmvd @ 15% O_2 or 93% reduction	Oxidation catalyst with an air/fuel ratio controller	Other Case-By-Case
PA-0301	3/31/2014	2,370 BHP	Natural gas	VOC	0.25 g/bhp-hr	Oxidation catalyst with an air/fuel ratio controller	Other Case-By-Case
PA-0301	3/31/2014	2,370 BHP	Natural gas	Formaldehyde	0.05 g/bhp-hr	Oxidation catalyst with an air/fuel ratio controller	Other Case-By-Case
PA-0301	3/31/2014	3,550 BHP	Natural gas	NOx	0.5 g/bhp-hr	Air/fuel ratio controller	Other Case-By-Case
PA-0301	3/31/2014	3,550 BHP	Natural gas	CO	47 ppmvd @ 15% O_2 or 93% reduction	Oxidation catalyst with an air/fuel ratio controller	Other Case-By-Case

Lean Burn Spark-Ignited IC Engines > 500 BHP (Process Code: 17.130)							
RBLC#	**Permit Date[(A)]**	**Rating**	**Fuel**	**Pollutant**	**Standard**	**Control Technology**	**Case-By-Case Basis**
PA-0301	3/31/2014	3,550 BHP	Natural gas	VOC	0.25 g/bhp-hr	Oxidation catalyst with an air/fuel ratio controller	Other Case-By-Case
PA-0301	3/31/2014	3,550 BHP	Natural gas	Formaldehyde	0.05 g/bhp-hr	Oxidation catalyst with an air/fuel ratio controller	Other Case-By-Case
TX-0680	6/14/2013	1,183 BHP	Natural gas	NOx	0.5 g/bhp-hr	Ultra-lean burn technology	BACT-PSD
TX-0680	6/14/2013	1,183 BHP	Natural gas	CO	0.252 g/bhp-hr	Oxidation catalyst	BACT-PSD
TX-0680	6/14/2013	1,183 BHP	Natural gas	VOC	0.245 g/bhp-hr	Oxidation catalyst	BACT-PSD
TX-0680	6/14/2013	1,380 BHP	Natural gas	NOx	0.5 g/bhp-hr	Ultra-lean burn technology	BACT-PSD
TX-0680	6/14/2013	1,380 BHP	Natural gas	CO	0.252 g/bhp-hr	Oxidation catalyst	BACT-PSD
TX-0680	6/14/2013	1,380 BHP	Natural gas	VOC	0.245 g/bhp-hr	Oxidation catalyst	BACT-PSD
OK-0153	3/1/2013	1,775 BHP	Natural gas	NOx	0.5 g/bhp-hr	N/A	BACT-PSD
OK-0153	3/1/2013	1,775 BHP	Natural gas	CO	0.36 g/bhp-hr	Oxidation catalyst	BACT-PSD
OK-0153	3/1/2013	1,775 BHP	Natural gas	VOC	0.13 g/bhp-hr	Oxidation catalyst	BACT-PSD
PA-0287	9/27/2011	1,380 BHP	Natural gas	NOx	0.5 g/bhp-hr	N/A	Other Case-By-Case
PA-0287	9/27/2011	1,380 BHP	Natural gas	CO	0.12 g/bhp-hr	Oxidation catalyst	Other Case-By-Case
PA-0287	9/27/2011	1,380 BHP	Natural gas	VOC	0.12 g/bhp-hr	Oxidation catalyst	Other Case-By-Case
PA-0287	9/27/2011	1,380 BHP	Natural gas	Formaldehyde	0.04 g/bhp-hr	Oxidation catalyst	Other Case-By-Case

Lean Burn Spark-Ignited IC Engines > 500 BHP (Process Code: 17.130)							
RBLC#	**Permit Date[(A)]**	**Rating**	**Fuel**	**Pollutant**	**Standard**	**Control Technology**	**Case-By-Case Basis**
MI-0393	10/14/2010	4,735 BHP	Natural gas	NOx	0.5 g/bhp-hr	Low emission design and good combustion practices	BACT-PSD
MI-0393	10/14/2010	4,735 BHP	Natural gas	VOC	0.19 g/bhp-hr	Oxidation catalyst	BACT-PSD
MI-0390	11/24/2008	4,735 BHP	Natural gas	NOx	0.5 g/bhp-hr	N/A	BACT-PSD
LA-0232	06/24/2008	4,735 BHP	Natural gas	NOx	7.31 lb/hr	Good combustion practices	BACT-PSD
LA-0232	06/24/2008	4,735 BHP	Natural gas	VOC	1.84 lb/hr	Oxidation catalyst	BACT-PSD

(A) Due to the large number of entries only determinations made (based on Permit Date) entered since 01/01/2007 are included in the above table.

= Selected as the most stringent BACT determination achieved in practice.

Attachment B

Review of BACT Determinations published by ARB

List of BACT determinations published in ARB's BACT Clearinghouse for ICE: Spark Ignition, Natural Gas:

Rich Burn Spark-Ignited IC Engines						
Source	**A/C Date**	**Rating**	**Function**	**Pollutant**	**Standard**	**Control Technology**
SCAQMD	12/14/1999	171 BHP	Drive compressors/chillers	NOx	0.15 g/bhp-hr	Catalyst Converter and Air/Fuel Ratio Controller
				CO	0.6 g/bhp-hr	Catalyst Converter and Air/Fuel Ratio Controller
				VOC	0.15 g/bhp-hr	Catalyst Converter and Air/Fuel Ratio Controller
SCAQMD	8/21/2003	2,000 BHP	Drives a Water Pump	NOx	9 ppmvd @ 15% O_2	NSCR with Air/Fuel Ratio Controller
				CO	60 ppmvd @ 15% O_2	NSCR with Air/Fuel Ratio Controller
				VOC	26 ppmvd @ 15% O_2	NSCR with Air/Fuel Ratio Controller

= Selected as the most stringent (or most recent if standards are equivalent) BACT determination achieved in practice.