CLIMATE ACTION RESERVE

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Mexico Boiler Efficiency

Project Protocol

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Abbreviations and Acronyms

BAU	Business as usual
Btu	British Thermal Unit
CDM	Clean Development Mechanism
CEL	Certificados de Energía Limpia (Clean Energy Certificates)
CER	Certified Emission Reductions
CFE	Comisión Federal de Electricidad
CH_4	Methane
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CONUEE	Comisión Nacional para el Uso Eficiente de la Energía
CRE	Comisión Reguladora de Energía
CRT	Climate Reserve Tonne
ENCC	National Strategies on Climate Change
EPA	U.S. Environmental Protection Agency
GHG	Greenhouse gas
HHV	Higher heating value
IMP	Instituto Mexicano del Petróleo
INDC	Intended Nationally Determined Contribution
INECC	Instituto Nacional de Ecología y Cambio Climático
ISO	International Organization for Standardization
J	Joule
kg	Kilogram
kWh	Kilowatt-hour
LHV	Lower heating value (“poder calorífico neto” (PCN), in Spanish)
LGCC	Ley General de Cambio Climático (General Law on Climate Change)
MMBtu	Million British Thermal Unit
MMCFD	Million cubic feet per day (or MMPCD, in Spanish)
MW	Megawatt
NAMAs	Nationally Appropriate Mitigation Actions
NOM	Norma Oficial Mexicana (Mexican Official Standard)
N_2O	Nitrous oxide
PCN	Poder calorífico neto (“lower heating value” (LHV), in English)
PECC	Special Program on Climate Change
PEMEX	Petróleos Mexicanos
PJ	Petajoule
PND	National Development Plan
QA/QC	Quality Assurance and Quality Control
RENE	National Emissions Registry

Reserve	Climate Action Reserve
SEMARNAT	Secretaría de Medio Ambiente y Recursos Naturales (Secretariat of Environment and Natural Resources)
SENER	Secretaría de Energía (Secretariat of Energy)
SSR	Source, sink, and reservoir
t	Metric ton or tonne (Mg or 1,000 kg)
TJ	Terajoule
UNFCCC	United Nations Framework Convention on Climate Change

1 Introduction

The Climate Action Reserve (Reserve) Mexico Boiler Efficiency Project Protocol provides guidance to account for, report, and verify greenhouse gas (GHG) emission reductions associated with boiler efficiency improvements in Mexico.

The Reserve is an offset registry serving the California cap-and-trade program and the North American voluntary carbon market. The Reserve encourages actions to reduce GHG emissions and works to ensure environmental benefit, integrity, and transparency in market-based solutions to address global climate change. It operates the largest accredited registry for the California compliance market and has played an integral role in the development and administration of the state's GHG offset program. For the voluntary market, the Reserve establishes high quality standards for carbon offset projects, oversees independent third-party verification bodies, and issues and tracks the transaction of carbon credits (Climate Reserve Tonnes or CRTs) generated from such projects in a transparent, publicly-accessible system. The Reserve is a private 501(c)(3) nonprofit organization based in Los Angeles, California.

Project developers that initiate Mexico Boiler Efficiency projects use this document to quantify and register GHG reductions with the Reserve. The protocol provides eligibility rules, methods to calculate reductions, performance-monitoring instructions, and procedures for reporting project information to the Reserve. Additionally, all project reports receive annual, independent verification by ISO-accredited and Reserve-approved verification bodies. Guidance for verification bodies to verify reductions is provided in the Reserve Verification Program Manual and Section 8 of this protocol.

This protocol is designed to ensure the complete, consistent, transparent, accurate, and conservative quantification and verification of GHG emission reductions associated with a Mexico Boiler Efficiency project.[1]

[1] See the WRI/WBCSD GHG Protocol for Project Accounting (Part I, Chapter 4) for a description of GHG reduction project accounting principles.

2 The GHG Reduction Project

2.1 Background

The government of Mexico acknowledges that climate change represents the primary global environmental challenge of this century and has been a leader amongst developing nations with its progressive goals, targets and regulatory action at both the national and international level.

Internationally, Mexico has been a member party to the United Nations Framework Convention on Climate Change (UNFCCC) since it was signed in 1992. As a member party, Mexico has submitted 5 national communications providing information on GHG inventories, with the most recent in 2012. Leading up to the 2015 UNFCCC Conference of the Parties in Paris (COP 21), Mexico[2] was the first developing country (and one of the first countries overall) to release its post-2020 climate action plan, or Intended Nationally Determined Contribution (INDC), and was a leader in expressing its willingness to achieve a legally binding agreement with the participation of all Parties to the UNFCCC.

Domestically, Mexico published two National Strategies on Climate Change (ENCC) in 2007 and 2013. The 2013 ENCC established 10, 20, and 40 year visionary goals for addressing climate change, focusing on adaptation and low emission development. In 2009 and 2014, Mexico adopted two Special Program on Climate Change (PECC), which outlined policy planning instruments, strategies, specific action items and an annex of the complementary activities; the last version of the PECC includes developing infrastructure for current and future carbon markets, an emphasis on the Nationally Appropriate Mitigation Actions (NAMAs), and prioritizes GHG mitigation actions.[3]

In 2012, the Mexican Congress unanimously passed a General Law on Climate Change (LGCC), making Mexico the first developing country to pass a comprehensive law on climate change.[4] The LGCC mandates a 30% reduction in emissions below Business as Usual (BAU) by 2020 and a 50% reduction below 2000 levels by 2050.[5] It also establishes a number of clean energy goals, such as the "promotion of energy efficiency practices, the development and use of renewable energy sources and the transfer and development of low carbon technologies"[6] and establishes a number of public policy instruments, such as the mandatory GHG reporting system, the National Emission Register (RENE).[7] RENE imposes a reporting obligation on companies or facilities emitting more than 25,000 tCO_2e/year, covering some 3,000 companies from a variety of sectors, with 2015 being the first year all of these companies were required to report on their emissions from 2014.[8] The RENE system is intended to be expanded in the future to include the voluntary registration of carbon offset projects based in Mexico, and later expanded further to the certification of such projects by SEMARNAT.[9]

The Mexican Congress passed a tax on fossil fuels as part of the 2013 fiscal reform package. The amount of tax to be paid varies by the emissions intensity of the fossil fuel in question,

[2] Fransen et al. (2015).
[3] PMR (2015). *Mexico: National Context*.
[4] Mexico (2015, March 30). *Intended Nationally Determined Contribution*.
[5] Cámara de Diputados del H. Congreso de la Unión (2016). *Ley General de Cambio Climático*.
[6] *Ibid*.
[7] *Ibid*.
[8] EDF, CDC Climat Research, Caisse des Dépôts Group, IETA (2015). *Mexico: An Emissions Trading Case Study*.
[9] SEMARNAT (2015, September). *National Emissions Register: Mitigation Component*.

relative to natural gas, with natural gas itself exempt from the tax. The tax on fossil fuels theoretically allows emitters to use carbon offset credits generated from Clean Development Mechanism (CDM) projects, or Certified Emissions Reductions (CER), to help meet the fossil fuel tax liabilities, though the rules for applying CER have not yet been developed.[10]

In addition to the LGCC and the tax on fossil fuels, in December 2013, Mexico's Congress voted to modify the Constitution to allow both domestic and foreign private investment in the energy sector.[11] This change effectively ended the monopolies held by state-owned PEMEX and CFE, in the oil and gas sector and electricity sector, respectively. All of these factors have combined to facilitate and provide incentives for comprehensive reform in the energy sector. Most recently, in December 2015, the Energy Transition Act was published, describing the new legal order related to renewable technologies for electricity generation.[12]

Appendix B contains further detailed information on this regulatory framework in Mexico.

2.1.1 Background on Industrial and Power Generation Sectors

Within this legal framework, Mexico's industrial and power generation sectors represent a significant opportunity to achieve emissions reductions through boiler efficiency improvements.

Fossil fuels used for power generation in Pemex, CFE and for power generation by independent producers for power sales or self-consumption amounted to 2,101 Petajoules (PJ) in 2014[13] and produced GHG emissions amounting to nearly 135 million tonnes of CO_2, or 32% of the country's total fossil combustion related CO_2 emissions.[14]

Meanwhile, Mexico's industrial sector used 1,568 PJ of energy total in 2014.[15] Excluding indirect emissions from electricity use and energy used for transformation (548.8 PJ), one can estimate that the industrial sector in Mexico produces approximately 67 million tonnes CO_2 per year, resulting from fossil fuel consumption of 982 PJ.[16] The table below indicates the consumption of secondary energy from fossil sources used in Mexico's industrial sector, excluding the power sector, for 2014.

[10] Cámara de Diputados del H. Congreso de la Unión (2015). *Ley del Impuesto Especial sobre Producción y Servicios*, Artículo 2: Tasas del Impuesto.
[11] Cámara de Diputados del H. Congreso de la Unión (2013). *Decreto por el que se reforman y adicionan diversas disposiciones de la Constitución Política de los Estados Unidos Mexicanos, en Materia de Energía.*
[12] Cámara de Diputados del H. Congreso de la Unión (2015). *Ley de Transición Energética.*
[13] SENER (2015). *Balance Nacional de Energía 2014*.
[14] Based on data in *Inventario Nacional de Gases y Compuestos de Efecto Invernadero – Sectores Interés Nacional (2014) Emisiones por Combustión por Quema de Combustibles Fósiles* (INECC, 2015 estimation).
[15] SENER (2015). *Balance Nacional de Energía 2014*.
[16] *Ibid.*

Table 2.1. Industrial Energy Use and Estimated Emissions from Fossil Fuel Consumption in the Industrial Sector in Mexico for 2014

	Petajoules[17]	EF ($kgCO_2/TJ$)[18]	tCO_2
TOTAL	**1,019.7**		**67,136,303**
Dry gas	603.3	56,100	33,844,008
Petroleum coke	113.5	97,500	11,067,225
Residual fuel oil	14.9	77,400	1,155,582
Coal	77.4	94,600	7,325,824
Coke of coal	68.9	94,600	6,516,994
Diesel	60.4	74,100	4,473,417
Liquefied petroleum gas	42.5	63,100	2,680,488
Gasoline and naphtha	1.1	69,300	72,765
Bagasse	37.7	0[19]	0

It is also worth noting the table above does not consider energy used for steam production in refineries, gas processing plants or thermal power plants. According to this same energy balance data, coal and heavy fuel oil use by CFE amount to some 612 PJ, with combined GHG emissions estimated at 53.5 $MtCO_2$. Given that these fuels cannot be used in gas turbines or combined cycle gas plants, and given heavy fuel oil internal combustion engine power plants represent a small fraction of the total, it is estimated that some 580 PJ and 51 $MtCO_2$ can be attributed to steam generation from those types of fuels alone.[20] These numbers are likely to be very conservative, given that 23 boilers utilized by CFE are fueled by natural gas (6), or a combination of heavy fuel oil and natural gas (17). This is not considered in the previous discussion as data in the 2014 National Energy Balance do not allow for a precise identification of the natural gas fraction consumed by those boilers. It must also be considered that that these figures do not include PEMEX boilers.

2.1.2 Background on Energy Efficiency and Boilers

According to the International Energy Agency (IEA), based on a study of industrial systems globally, steam systems account for approximately 38% of total energy usage of industrial systems, while motor systems account for approximately 15%.[21] Based on the figures in Table 2.1, therefore, just over a third of the 67 million tCO_2e may be attributable to generating steam in the industry, or roughly 22.3 million tCO_2e. IEA further estimates that globally the energy efficiency of steam production can be increased by at least 10%, estimating that in Mexico such an improvement could reduce energy use for industrial processes by approximately 31 PJ per year.[22] Based on the emissions estimates in Table 2.1, such a 10% improvement in efficiency could reduce industrial steam boiler emissions by as much as 2 million tCO_2 per year in Mexico.

The former figures are in addition to the effects of energy efficiency improvements in CFE and PEMEX boilers.

There is significant opportunity for emissions reductions due to improved energy efficiency and improved steam distribution efficiency at boilers used in the industrial and power generating sectors.

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[17] *Ibid.*
[18] *2006 IPCC Guidelines for National Greenhouse Gas Inventories*, Volume 2, Table 2.2.
[19] As bagasse is biomass, according to major GHG accountability and reporting standards it is considered CO_2 neutral.
[20] SENER (2015). *Balance Nacional de Energía 2014*.
[21] IEA (2007).
[22] *Ibid.*

Appendix B contains further information on laws relevant to the project activities and regulatory compliance requirements.

2.2 Project Definition

For the purpose of this protocol, the GHG reduction project is defined as the implementation of eligible project activities at an eligible boiler or group of eligible boilers, located at a single facility or project site. Eligible boiler equipment is defined in Section 2.2.1, and eligible project activities are defined in Section 2.2.2.

For projects comprised of more than one boiler, all boilers in the project must have an eligible start date, as defined in Section 3.2, independently pass the Performance Standard Test (as defined in Section 3.4.1), be quantified separately (according to Section 5), and meet all protocol monitoring and reporting requirements (Sections 6 and 7). More than one boiler project may be implemented at a single facility concurrently, so long as each individual project is clearly defined and has its own start date and crediting period, and meets protocol monitoring and reporting requirements. Joint verifications for facilities with multiple projects are also possible, as described in more detail in Section 8.

2.2.1 Eligible Boiler Types

For the purpose of this protocol, project activities shall be implemented at an eligible boiler or group of boilers. A boiler is defined as a closed vessel or arrangement of vessels and tubes and a heat source, in which water is heated to produce steam to drive turbines or engines, generate power, or drive other industrial process applications. This definition of “boiler” includes components of the boiler unit which are most relevant for determining its rated thermal efficiency, particularly the burner, flue stack, blowdown system, deaerator, feed water preheater, air preheater and economizer, in addition to the boiler unit itself. These subcomponents may not be common to all categories of boilers, but when present, either pre-existing in the baseline scenario or installed as part of the project activities, these components will be included within the project boundary (see Figure 2.1 in Section 2.2.2 below).

A boiler must have a rated capacity of 9.8 MW (33.5 MMBtu/h or 8.44 x 10^6 kcal/h) or greater to be eligible under this protocol. As discussed further in Section 3.4.1, eligible boilers must also meet or exceed the Performance Standard, which varies based on boiler capacities, as follows:

- Boilers 9.8 to 100 MW (33.5 – 341.4 MMBtu/h or 8.44 x 10^6 – 86.03 x 10^6 kcal/h)
- Boilers > 100 MW (> 341.4 MMBtu/h or 86.03 x 10^6 kcal/h)

Equipment ineligible under this protocol includes boilers with nominal heat transfer capacity below 9.8 MW (< 33.5 MMBtu/h or 8.44 x 10^6 kcal/h), hot water heaters,[23] furnaces, and process heaters.[24]

[23] Given their energy consumption levels, boilers smaller than 9.8 MW and hot water heaters would likely need additional incentives to make verification of emission reductions under this protocol cost-effective.
[24] For each of these equipment categories, there is no comprehensive data set or sources to allow for proper analysis of performance efficiencies needed to establish sound efficiency thresholds. This is necessary to make a protocol application practical. Nevertheless, a dedicated protocol or future inclusion of these additional devices in this protocol could be discussed at a future date.

2.2.2 Eligible Project Activities

For the purpose of this protocol, the GHG reduction project is defined as a project that implements one or more of the following technologies and practices ("project activities") at an eligible boiler (as defined in Section 2.2.1):

1. **Retrofitting existing boilers.** The project retrofits an existing boiler, installing one or more new efficiency improvement technologies to the existing boiler.

2. **Installing new high-efficiency boilers.** The project installs a new boiler that demonstrates greater efficiency than conventional alternatives. The existing boiler (that is replaced) may be retired or dismantled and sold for parts; however, the old boiler may not be repurposed and remain in use elsewhere at the same plant or facility, as a means of increasing steam generation capacity.[25] The intention of this restriction is to reduce "leakage."[26] De-commissioned boiler subcomponents that are installed to enhance efficiency, such as economizers, can be re-used without this risk of leakage. The project developer must demonstrate to the verifier that the old boiler is not still in use elsewhere at the same plant or facility and is not being used to expand capacity.[27] The project may increase nominal capacity at the facility with the installation of a higher capacity boiler, but no emission reductions will be credited for the capacity increase.

There is no definitive list of types of equipment that are eligible for inclusion in this protocol as the project activities noted above, and no equipment is specifically excluded from eligibility under these project activities. Whether a type of equipment is relevant or not for generating emission reductions will depend on whether it fits within the definitions of an "eligible boiler" and "eligible project activity" (defined in Section 2.2.1 and 2.2.2), whether it's effects can be seen, assessed, and measured within the project boundary (defined in Section 2.2.3), and whether it contributes to an improvement in boiler efficiency (as calculated in Section 5).

For all projects, this protocol allows for boilers (both new and retrofitted) to switch from a higher carbon-intensity fuel to a lower carbon-intensity fuel (e.g., from coal to natural gas) over the course of the project. However, while this protocol allows for and encourages such a fuel switch in projects, fuel switching itself is not an eligible project activity. This protocol is designed to encourage energy efficiency improvements. The nationwide trend in Mexico to switch to lower carbon intensity fuels, particularly natural gas, and the regulatory incentive provided by the tax on fossil fuels make this activity "business as usual."[28]

As such, emission reductions resulting from a fuel switch will not generate credits under this protocol; only emission reductions from the project activities listed above are creditable.

Section 5.1.1 provides guidance on quantification for projects that include a fuel switch, while Appendix A provides additional context on why fuel switching was generally deemed non-additional.

[25] The new high-efficiency project boiler may be a larger boiler, thereby increasing capacity at the facility, but the "retired" pre-existing boiler may not be used to facilitate a capacity expansion at the project site or facility, through the continued use of that retired boiler on-site.
[26] Leakage may occur where inefficient equipment is repurposed elsewhere, thus perpetuating the life of such inefficient equipment, where in the absence of such inefficient equipment, more efficient equipment may have been used.
[27] Please note, Section 3.4.1 includes additional eligibility criteria for this project type.
[28] See Appendix A and Appendix B for additional discussion on this national trend.

2.2.3 The Physical Project Boundary

The physical boundary of a project includes any components of one or more boilers and each boiler's associated steam generation system that will change between the baseline and project scenarios. The physical boundary will typically be limited to the components of the boiler unit which are most relevant for determining its rated thermal efficiency, namely the boiler, burner, flue stack, blowdown system, air preheater and economizer. The physical project boundary does not include steam distribution and condensate return systems, due to complexity involved in accounting for such improvements. See Figure 2.1 below.

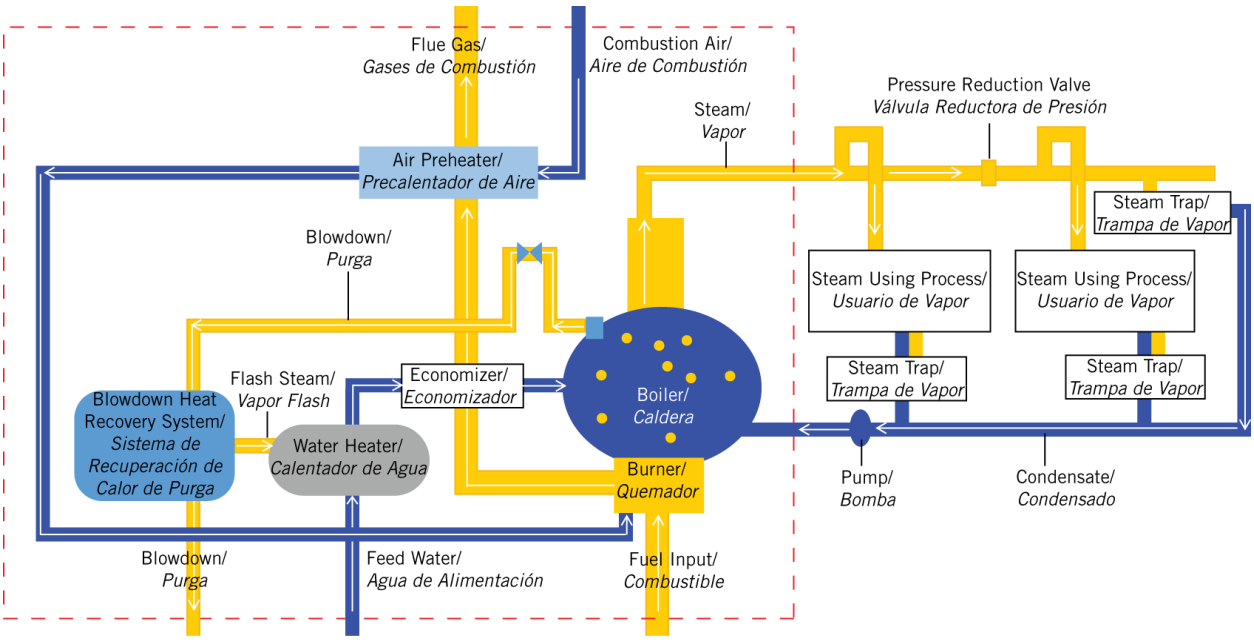

Figure 2.1. Physical Boundary for Industrial Boiler Projects[29]

2.3 The Project Developer

The "project developer" is an entity that has an active account with the Reserve, develops and submits a project for listing and registration with the Reserve, and is ultimately responsible for all project reporting and verification. Project developers may be energy service companies, facility owners, facility operators, or GHG project financiers, and may include entities wholly or partly controlled by government. In all cases, the project developer must attest to the Reserve that they have exclusive claim to the GHG reductions resulting from the project. Each time a project is verified, the project developer must attest that no other entities are reporting or claiming (e.g., for voluntary reporting or regulatory compliance purposes) the GHG reductions caused by the project.[30]

Under this protocol, the project developer is the only party required to hold an account with the Reserve and be involved with project implementation.

[29] Diagram adapted from the U.S. EPA (2008) Climate Leaders Program *Industrial Boiler Efficiency Methodology*.
[30] This is done by signing the Reserve's Attestation of Title form, available at http://www.climateactionreserve.org/how/program/documents/

3 Eligibility Rules

Projects must fully satisfy the following eligibility rules in order to register with the Reserve. The criteria only apply to projects that meet the definition of a GHG reduction project (Section 2).

Eligibility Rule I:	Location	→	*Mexico*
Eligibility Rule II:	Project Start Date	→	*The date the system resumes or enters regular operation, following an initial start-up period of up to 6 months after project activities are implemented.*
		→	*No more than six months prior to project submission*
Eligibility Rule III:	Additionality	→	*Meet performance standard*
		→	*Exceeds any legally mandated efficiency improvements*
Eligibility Rule IV:	Regulatory Compliance	→	*Meet regulatory requirements*

3.1 Location

Only projects located in Mexico are eligible to register reductions with the Reserve under this protocol. All components of the physical boundary of each project, as described in Section 2, must be located in Mexico for the project to be eligible. Under this protocol, reductions from projects located outside of Mexico are not eligible to register with the Reserve.

3.2 Project Start Date

The project start date is defined as the date, selected by the project developer, within an initial start-up period of up to 6 months following the date on which an improved-efficiency boiler and the associated steam generation system becomes operational. For the purposes of this protocol, a boiler and its steam generation system is considered operational on the date the system resumes or enters regular operation consuming energy inputs and generating relevant energy outputs (i.e., steam, heat, electricity, or a combination thereof), following the implementation of project activities, as defined in Section 2.2.2 (e.g., after a retrofit to install efficiency improving technologies or installation of a new boiler).[31] As noted above, the "start date" shall be selected by the project developer as a date no more than 6 months after the boiler and associated steam generation system becomes operational (i.e., the start date must be no later than the initial 6 month start-up period following resumed regular operation).[32]

Any project comprised of multiple boilers must select a single project start date, which shall be within the initial 6-month start-up period for the first boiler in the project to resume operation, upon completion of the project activities. Additional project activities may be implemented at

[31] If the contract for commissioning boiler efficiency improvements includes operational performance guarantees, then the date the owner takes over operations could be used as the start date, provided that date is within 6 months of the date on which the system first begins consuming energy inputs following the commissioning of efficiency improvements.

[32] The initial start-up period allows for monitoring systems to be installed, calibrated, and any other QA/QC requirements to be met prior to the start of the project.

additional boilers located at the same facility and to-be-included in the same project at any time; however, project developers must submit a revised listing form covering these additional boilers by the end of each additional boiler's respective 6-month initial start-up period, to indicate that the boiler will begin reporting with the project by the end of that start-up period. Notably, boilers that are added after the project's start date will be held to the crediting period associated with the project's original start date, regardless of when additional boilers were added. Alternatively, project activities may be implemented at additional boilers and included as a new separate project; joint verifications for facilities with multiple projects are described in more detail in Section 8.

To be eligible, the project must be submitted to the Reserve[33] no more than six months after the project start date, unless the project is submitted during the first 12 months following the date of adoption of this protocol by the Reserve board (the Effective Date, or November 1, 2016). For a period of 12 months from the Effective Date of this protocol (Version 1.0), projects with start dates no more than 24 months prior to the Effective Date of this protocol are eligible. Specifically, projects with start dates on or after November 1, 2014 are eligible to register with the Reserve if submitted by November 1, 2017. Projects with start dates prior to November 1, 2014 are not eligible under this protocol. Projects may always be submitted for listing by the Reserve prior to their start date.

3.3 Project Crediting Period

The crediting period for both retrofit and new boiler projects under this protocol is ten years. This is a one-time crediting period and cannot be renewed.

The Reserve will cease to issue CRTs for GHG reductions if at any point in the future, the efficiency levels and/or emission reductions achieved by the implementation of project activities become legally required. For further details on the effects of legal requirements, see the terms of the Legal Requirement Test (Section 3.4.2). Thus, the Reserve will issue CRTs for GHG reductions quantified and verified according to this protocol for a maximum of one ten-year crediting period after the project start date, or until the project activity is required by law.

At the end of the crediting period new projects may be initiated at the same boiler units at the same facility, through the implementation of new project activities.

3.4 Additionality

The Reserve registers only projects that yield surplus GHG reductions that are additional to what would have occurred in the absence of a carbon offset market.

Projects must satisfy the following tests to be considered additional:

1. The Performance Standard Test
2. The Legal Requirement Test

[33] Projects are considered submitted when the project developer has fully completed and filed the appropriate project Submittal Form, available at http://www.climateactionreserve.org/how/program/documents/.

3.4.1 The Performance Standard Test

Projects pass the Performance Standard Test by meeting a performance threshold, i.e., a standard of performance applicable to all boiler efficiency projects, established by this protocol. The performance threshold represents a level of energy efficiency that is beyond "business as usual" compared to existing boilers of the same fuel-type. A full discussion of the analysis on data from existing boilers in Mexico used to inform the performance standard can be found in Appendix A of this protocol.

To meet the performance standard, all project types are required to improve energy efficiency to meet or exceed energy efficiency performance threshold in Table 3.1. More specifically, once project activities have been implemented, project boiler fuel efficiency ($\eta_{P,y}$), as calculated according to guidance in Section 5, must meet or exceed the energy efficiency performance threshold in Table 3.1 that corresponds to the project boiler's size threshold. As long as the project boiler meets or exceeds this threshold, the efficiency of the existing baseline boiler does not impact eligibility. The same threshold applies to all fuel types and project types.

Table 3.1. Performance Standard Threshold

Boiler Capacity	Performance Threshold
Boilers 9.8 to 100 MW (33.5 –341.4 MMBtu/h)	80.5%
Boilers > 100 MW (>341.4 MMBtu/h)	82%

For new boiler projects, there is an additional component of the performance standard, during the first reporting period for each boiler in the project. For new boiler projects, at the time of the project start date, the old existing boiler (that is replaced as the project activity) may be no older than 35 years old (i.e., no more than 35 years may have passed since the time the boiler first began operation after its first commissioning until the project start date). Boilers older than 35 years are assumed to be old enough that it is "business as usual" to be replaced with newer, more efficient boilers in the near term, and as such, are not eligible for this "new boiler" project type. Boilers of any age (including older than 35 years), however, are eligible for the retrofit project type, as long as they exceed the performance threshold are eligible for the retrofit project type, as long as they exceed the performance threshold in Table 3.1.

The Performance Standard Test is applied at the time a project applies for registration with the Reserve.

3.4.2 The Legal Requirement Test

All projects are subject to a Legal Requirement Test to ensure that the GHG reductions achieved by a project would not otherwise have occurred due to federal, state, or local regulations, or other legally binding mandates. To satisfy the Legal Requirement Test, project developers must submit a signed Attestation of Voluntary Implementation form[34] prior to the commencement of verification activities each time the project is verified (see Section 8). In addition, the project's Monitoring Plan (Section 6) must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test.

[34] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

The Reserve did not identify any existing federal, state, or local regulations that obligate existing boilers to operate at a minimum level of efficiency. A summary of the Reserve's research on legal requirements is provided in Appendix B.

As noted in Section 2.1, Mexico has been mitigating carbon emissions at the national level with a tax on fossil fuels since 2013. While the tax on fossil fuels does provide incentive for regulated entities (namely fuel importers and processors) to improve energy efficiency, it does not require improved efficiency at boilers, and therefore does not impact additionality. Further, this protocol does not include "fuel switching" from a higher carbon-intensity fuel to a lower carbon-intensity fuel as a separate project activity. The protocol permits fuel switching but does not credit emission reductions from fuel switching. If Mexico develops and implements an Emission Trading System in the future, it is possible that facilities implementing projects under this protocol may be included under an emissions cap. In that case, emission reductions may be reported to the Reserve up until the date that the emissions cap takes effect, as it is standard international best practice for offset projects to not credit emission reductions that occur at facilities covered by an emissions trading system cap.

3.5 Regulatory Compliance

Projects must be in material compliance with all applicable laws (e.g., air, water quality, and safety), including environmental regulations, in order to be credited for GHG reductions. Project developers are required to disclose to the verifier all instances of non-compliance of the project with any law. Whether a violation has an impact on the issuance of CRTs to a project will depend upon whether 1) the violation is related to the project or project activities, and 2) whether the violation is material. The verifier will assess whether a violation is related to the project or project activities. There may be many activities occurring at a facility at which the boiler is located that are unrelated to the project. Once the verifier has determined that the violation is related to the project activities and the reporting period being verified, they shall then assess the materiality of the violation. Violations that are administrative (such as an expired permit without any other associated violations or tardiness in filing documentation) are not considered material and do not affect CRT crediting. Any other type of violation that is project-related is generally considered material.

If a material violation is found to have occurred at the project facility, then the project would not be issued CRTs from the point in time when the violation occurred, until the point at which the violation was remedied to the satisfaction of the relevant regulatory authority. The project developer must carefully document all instances of non-compliance and relevant communications with regulators and provide such information to their verifier.

Project developers must attest that project activities do not cause violations of applicable laws (e.g., air, water quality, safety, etc.). To satisfy this requirement, project developers must submit a signed Attestation of Regulatory Compliance form[35] prior to the commencement of verification activities each time the project is verified.

[35] Attestation forms are available at http://www.climateactionreserve.org/how/program/documents/.

4 The GHG Assessment Boundary

The GHG Assessment Boundary delineates the GHG sources, sinks, and reservoirs (SSRs) that must be assessed by project developers in order to determine the net change in emissions caused by a boiler efficiency project.[36]

Figure 4.1 illustrates all relevant GHG SSRs associated with project activities and delineates the GHG Assessment Boundary.

Table 4.1 provides greater detail on each SSR and justification for the inclusion or exclusion of certain SSRs from the GHG Assessment Boundary.

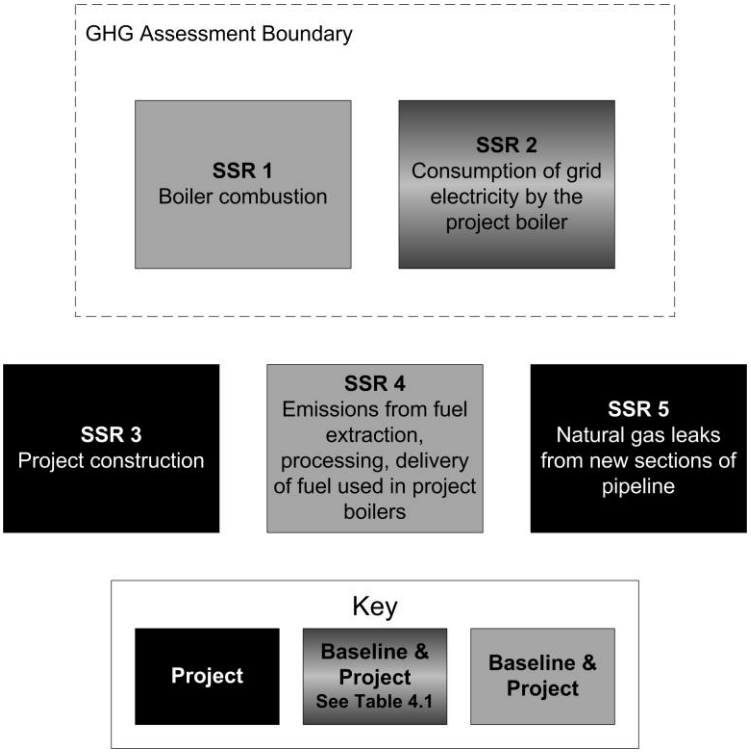

Figure 4.1. General Illustration of the GHG Assessment Boundary

[36] The definition and assessment of SSRs is consistent with ISO 14064-2 guidance.

Table 4.1. Description of all Sources, Sinks, and Reservoirs

SSR	Source Description	GHG	Included (I), Excluded (E), or Optional (O)	Baseline (B) or Project (P)	Justification/Explanation
1 Boiler combustion	Emissions from fuel combustion at boiler, including all eligible subcomponents in the boiler project boundary, including emissions from incomplete combustion of fuels	CO_2	I	**B, P**	CO_2 – Primary emission reductions opportunity for the project activities. CH_4/N_2O – Excluded for simplification and because emissions are expected to be very small. Conservative to exclude.
		CH_4	E		
		N_2O	E		
2 Consumption of grid electricity by the project boiler	Indirect emissions associated with changes in consumption of electricity from the grid by the project boiler, including all eligible subcomponents in the project boundary	CO_2	O (for reporting project benefits) I (for reporting project emission increases)	**B, P**	Electricity consumption is expected to make up a small portion of total emissions from a single boiler. Thus it will not be necessary to calculate grid electricity emissions, as long as projects can demonstrate to the verifier that emissions did not materially increase. Where project activities are expected to materially increase electricity consumption, that increase must be quantified. If emission reductions from reduced grid electricity consumption are significant for a given project, accounting for this SSR is optional, as long as additional monitoring and reporting requirements are met.[37]
3 Project construction	Project construction and emissions from decommissioning an old boiler, installation of a new boiler, or retrofitting an existing boiler	CO_2 CH_4 N_2O	E	**P**	Project emissions for such changes should be negligible and therefore are excluded.
4 Emissions from fuel extraction, processing, delivery of fuel used in project boilers	Facilities where fuel used undergoes extraction, processing and delivery	CO_2 CH_4 N_2O	E	**B, P**	The difference between baseline and project emissions for such changes should be negligible and therefore are excluded.

[37] Verifiers must use their professional judgment to assess the reasonableness of all claims related to the consumption of grid electricity, for each reporting period.

SSR	Source Description	GHG	Included (I), Excluded (E), or Optional (O)	Baseline (B) or Project (P)	Justification/Explanation
5 Natural gas leaks from new sections of pipeline	Natural gas leaks from new sections of natural gas distribution pipeline installed due to the project to service the project boiler	CH_4	E	**P**	This protocol does not credit emission reductions associated with the fuel switch to natural gas, as such this project will not directly lead to the construction of new sections of pipeline.

5 Quantifying GHG Emission Reductions

GHG emission reductions from a boiler efficiency project are quantified by subtracting actual project emissions from the calculated baseline emissions. Baseline emissions are an estimate of the GHG emissions from sources within the GHG Assessment Boundary (see Section 4) that would have occurred in the absence of the project. Project emissions are actual GHG emissions that occur at sources within the GHG Assessment Boundary. Project emissions must be subtracted from the baseline emissions to quantify the project boiler's total net GHG emission reductions (Equation 5.1).

If the project is comprised of more than one eligible boiler, the emissions and emission reductions of each boiler must be quantified separately, as described in Equation 5.1 and then emission reductions from all boilers must be summed. Similarly, the boiler fuel efficiency and all other parameters must be calculated separately for each individual boiler, for use in both the quantification of emission reductions for Equation 5.1, as well as for demonstrating that each project boiler has met the Performance Standard Threshold, as described in Section 3.4.1.

Quantification of both boiler retrofit projects and new boiler projects will follow the same quantification methodology, as discussed below.

GHG emission reductions must be quantified and verified on an annual basis, except within the first reporting period of the project, when a shorter or slightly longer timeframe may be included in reporting, and for any additional boiler's added to the project after it starts, in which the first reporting period for each respective project boiler may report less than a full year's emission reductions, so as to report along with the project's reporting cycle. The length of time over which GHG emission reductions are periodically quantified and verified is called the "reporting period."

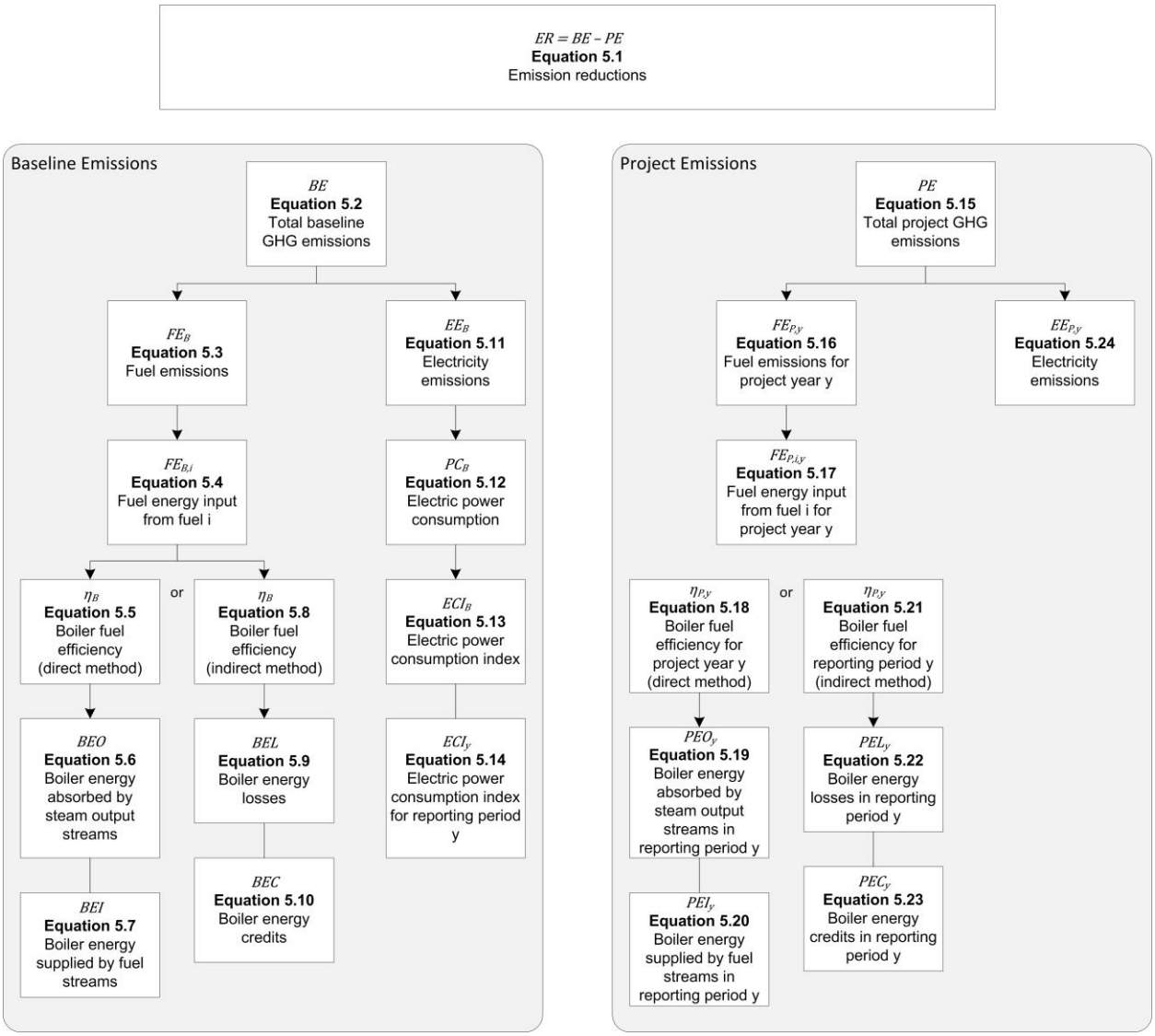

Figure 5.1. Equation Map for Mexico Boiler Efficiency Projects

Equation 5.1. Calculating GHG Emission Reductions

$$\boldsymbol{ER = BE - PE}$$

Where,			Units
ER	=	Total emission reductions for the reporting period	tCO_2e
BE	=	Total baseline emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.1)	tCO_2e
PE	=	Total project emissions for the reporting period, from all SSRs in the GHG Assessment Boundary (as calculated in Section 5.2)	tCO_2e

5.1 Quantifying Baseline Emissions

Total baseline emissions for the reporting period are estimated by calculating and summing the emissions from all relevant baseline SSRs that are included in the GHG Assessment Boundary (as indicated in Table 4.1).

In order to ensure that any changes in the operating regime of the boiler between the baseline and project scenarios do not affect the comparability of the emissions profiles of the baseline and project scenarios, data on the useful energy transferred from the project reporting period will be applied to the baseline period. The baseline and project boiler efficiencies should then be calculated and reported separately.

Calculate total baseline emissions using Equation 5.2.

Equation 5.2. Quantifying Total Baseline GHG Emissions

$$\boldsymbol{BE = FE_B + EE_B}$$

Where,			Units
BE	=	Total baseline emissions for the reporting period, from all SSRs in the GHG Assessment Boundary	tCO_2e
FE_B	=	Baseline fuel emissions (as calculated in Equation 5.3)	tCO_2e
EE_B	=	Baseline electricity emissions (as calculated in Equation 5.11)	tCO_2e

5.1.1 Quantifying Baseline Fuel Emissions

Baseline fuel emissions are estimated by using Equation 5.3. As the baseline is the continuation of “business as usual” (BAU) conditions if the project had not occurred, it is a counter-factual claim regarding what the baseline fuel emissions would have been; therefore, these emissions must be estimated.

For all projects that involve the switching of fuels from a higher to a lower carbon-intensive fuel, baseline emissions will be calculated using an emission factor for fuel consumed in the project scenario. This will ensure that no emission reductions are credited for the switching of fuels

itself, which is outside the scope of this protocol,[38] but will still allow for emission reductions to be credited for other efficiency gains associated with the new equipment.

In order to ensure that changes in the operating regime of the boiler between the baseline and project scenarios do not affect the comparability of the emissions profiles of the baseline and project scenarios, fuel emissions must be calculated using an estimate of fuel energy inputs, rather than simply the volume of fuel used in the baseline. If fuel emissions were calculated simply using the volume of fuel used in the baseline, then changes in operational regime could give rise to an overestimation or underestimation of emission reductions, without any change in efficiency, i.e., if the facility temporarily slowed down its demand for steam, it would be credited for associated emission reductions due to lower fuel consumption.

Equation 5.3. Quantifying Baseline Fuel Emissions

$$\boldsymbol{FE_B = \sum_i (FE_{B,i} \times EF_{Fuel_{CO_2,B,i}})}$$

Where,			Units
FE_B	=	Baseline fuel emissions	$kgCO_2$
$FE_{B,i}$	=	Baseline fuel energy input, from fuel i (as calculated in Equation 5.4)	TJ
$EF_{Fuel,CO2,B,i}$	=	Baseline CO_2 emission factor, from fuel i, on a higher heating value (HHV) basis, as described further below and in Box 5.1. (Projects that switch from a higher to lower carbon-intensive fuel over the course of the project must use the fuel emission factor for the fuel used in the project scenario here)	$kgCO_2/TJ$

If project developers have verifiable records on fuel i to calculate the emission factor for fuel i ($EF_{Fuel,CO2,B,i}$), they may use the calculated EF. Otherwise, project developers shall use the defaults published in the Instituto Mexicano del Petroleo (IMP) study commissioned by INECC.[39] The IMP emission factors are calculated on a lower heating value (LHV) basis and must be converted to the higher heating value (HHV) basis before being applied in Equation 5.3; this conversion is described in Box 5.1 below. Where multiple data points are available for the same fuel source throughout the reporting period, then the fuel EF should be an average of such values. Verifiers should be satisfied that methods, tools and equipment used to calculate any fuel EF are conservative and appropriate.

[38] See Appendix A for the Reserve's assessment of fuel switching.
[39] The relevant defaults can be found via the IMP (2014): http://www.inecc.gob.mx/descargas/cclimatico/2014_inf_fin_tipos_comb_fosiles.pdf.

Box 5.1. Converting Emission Factors from Lower Heating Value to Higher Heating Value

This protocol uses the default emission factors published in the Instituto Mexicano del Petroleo (IMP) study commissioned by INECC.[40] However, as is the case with IPCC and other emission factor sources, the IMP emission factors are calculated on a lower (or net) heating value basis (LHV or PCN, for "poder calorífico neto" in Spanish) and must be converted to a higher heating value (HHV) basis before being applied in the protocol equations, which all use HHV for consistency with ASME PTC 4-2013, BS 845, and the CONUEE *Boiler Efficiency Tool*.

Emission factors, such as $EF_{Fuel,CO2,B,i}$ and $EF_{Fuel,CO2,P,i}$ expressed on a LHV basis must be converted to a HHV by using the following procedure[41]:

For gaseous fuels: Multiply LHV basis emission factor by 0.9 to obtain a HHV basis emission factor.

For liquid or solid fuels: Multiply LHV basis emission factor by 0.95 to obtain a HHV basis emission factor.

The baseline fuel energy input from fuel i, $FE_{B,i}$, is calculated based on measured, estimated, or default higher heating value and measured project reporting period consumption for fuel i and an efficiency ratio of baseline fuel efficiency to project fuel efficiency as per Equation 5.4.

Calculating the fuel efficiency ratio allows us to represent a hypothetical fuel consumption in the baseline (higher) that would be needed to supply the same useful energy as required for operational demands in the project reporting period y, provided the baseline efficiency of the project boiler was lower.

Equation 5.4. Quantifying Baseline Fuel Energy Input from Fuel i

$$\boldsymbol{FE_{B,i} = HHV_{B,i} \times QF_{P,i,y} \times \frac{\eta_{P,y}}{\eta_B} \times \frac{NBRC_B}{NBRC_P}}$$

Where,			Units
$FE_{B,i}$	=	Baseline i fuel energy input, from fuel i	TJ
$HHV_{B,i}$	=	Baseline higher heating value, from fuel i, as described below.	TJ/kg or TJ/m^3
$QF_{P,i,y}$	=	Consumption of fuel i, from project reporting period y	kg or m^3
$\eta_{P,y}$	=	Project boiler fuel efficiency for project reporting period y (as calculated in Section 5.2.2)	%
η_B	=	Baseline boiler fuel efficiency (as calculated in Section 5.1.2)	%
$NBRC_B$	=	Nominal baseline boiler rated capacity (See note below)	MW
$NBRC_P$	=	Nominal project boiler rated capacity (See note below)	MW

Note: Nominal boiler rated capacity ratio must only be used in new boiler projects when project boiler capacity exceeds that of the baseline boiler. For all other instances, $\boldsymbol{\frac{NBRC_B}{NBRC_P} = 1}$

[40] *Ibid.*

[41] Preferred method to convert emission factors from a LHV basis to a HHV basis is described in the API *Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Natural Gas Industry*, Section 4.2, Equations 4-7 and 4-8.

The higher heating value (HHV) of fuels may be determined by a certified laboratory, or it may be determined by the project developer themselves using a standard method to determine HHV from composition (for gaseous fuels), or by calorimetric techniques.[42] The calculation of HHV should be sufficiently documented including keeping records on procedures and instrumentation used, as well as qualifications and/or training of relevant staff performing such procedures.

5.1.2 Calculating Baseline Boiler Efficiency

When one talks about boiler efficiency, boiler fuel efficiency is what is being evaluated: the efficiency with which the boiler converts the energy supplied by fuel to steam.

It is common practice internationally to calculate boiler fuel efficiency via one of two methods: the direct method (also known as the input-output method) and the indirect method (also known as the energy balance method). The direct method is described in Equation 5.5 for the baseline and Equation 5.18 for the project reporting period, while the indirect method is described in Equation 5.8 for the baseline and Equation 5.21 for the project reporting period.

These equations are consistent with two of the most widely recognized methodologies: the American Society of Mechanical Engineers *Fired Steam Generators Performance Test Code*, known as ASME PTC 4-2013,[43] and the British Standard 845[44] (BS 845). These underlying methodologies provide additional calculations for how the various input parameters used in Equation 5.5, Equation 5.8, Equation 5.18, and Equation 5.21 are calculated. For the implementation of this protocol, boiler fuel efficiency must be calculated by using one of these methodologies (ASME PTC 4-2013 or the BS 845) or the CONUEE *Boiler Efficiency Tool*,[45] which follows the ASME PTC 4-2013 method.

The Reserve strongly encourages project developers to use of the CONUEE *Boiler Efficiency Tool* to support project implementation and streamline boiler efficiency calculations. CONUEE worked closely with the Reserve during protocol development to re-design their *Boiler Efficiency Tool* to ensure it would best support both project developers and CONUEE's stakeholders in Mexico more generally.

The same method for calculating boiler fuel efficiency in the baseline (Section 5.1.2) must be applied for calculating boiler fuel efficiency for the project reporting period (Section 5.2.2). More specifically, if a project developer chooses to use the ASME energy balance method for the baseline, they must use the ASME energy balance method for the project reporting period; they cannot then apply the BS energy balance method or the ASME input-output method for the project reporting period.

Almost universally, the indirect method is preferable for calculating boiler fuel efficiency, due to lower uncertainty associated with the higher number of measured input parameters, and the difficulty associated with achieving accurate measurements for inputs in the direct method. However, when accurate measurements for the inputs necessary for the direct method are possible, the direct method is typically preferable.

[42] Preferred methods include: ASTM (2014b) ASTM D240-14, ASTM (2011b) ASTM D3588–98(2011), ISO 6976:2016, or other methods included in the IMP (2014) report, available on the INECC website: http://www.inecc.gob.mx/descargas/cclimatico/2014_inf_fin_tipos_comb_fosiles.pdf
[43] ASME (2014), PTC 4-2013.
[44] British Standards (BS) Institution (1987), BS 845-1:1987.
[45] Information on accessing the CONUEE *Boiler Efficiency Tool* is provided at http://www.climateactionreserve.org/how/protocols/mexico-boiler-efficiency/.

Baseline boiler fuel efficiency, η_B, shall be calculated using any of the methods above, so long as the project developer is able to demonstrate sufficient accuracy of measurements, which is often challenging when using the input-output (or direct) method.

5.1.2.1 Direct (Input-Output) Method for Calculating Baseline Boiler Fuel Efficiency

The ASME PTC 4-2013 describes the Input-Output method as a method of determining steam generator efficiency by direct measurement of output (all energy absorbed by the working fluid that is not recovered within the steam generator envelope) and input (the total chemical energy available from the fuel).[46] It is also called the "direct method."

Equation 5.5. Calculating Baseline Boiler Fuel Efficiency (Direct / Input-Output Method)

$$\boldsymbol{\eta_B = \frac{BEO}{BEI} \times 100}$$

Where,			Units
η_B	=	Baseline boiler fuel efficiency	%
BEO	=	Baseline boiler energy absorbed by steam output streams (as calculated in Equation 5.6)	TJ
BEI	=	Baseline boiler energy supplied by fuel streams (as calculated in Equation 5.7)	TJ

Baseline boiler energy absorbed by steam output streams, BEO, is calculated as per Equation 5.6.

Equation 5.6. Calculating Baseline Boiler Energy Absorbed by Steam Output Streams

$$\boldsymbol{BEO = \sum_j QS_{B,j} \times \frac{(h_{j,out} - h_{j,in})}{10^9}}$$

Where,			Units
BEO	=	Baseline boiler energy absorbed by steam output streams	TJ
$QS_{B,j}$	=	Total baseline flow of fluid stream j[47] leaving boiler boundary	kg
$h_{j,out}$	=	Enthalpy of fluid in stream j leaving boiler boundary	kJ/kg
$h_{j,in}$	=	Enthalpy of fluid entering boiler boundary, feeding stream j	kJ/kg
10^9	=	Unit conversion factor (kJ to TJ)	

Baseline boiler energy supplied by fuel streams, BEI, is calculated as per Equation 5.7.

[46] *Ibid*.
[47] Fluid stream j is comprised of blowdown and steam.

Equation 5.7. Calculating Baseline Boiler Energy Supplied by Fuel Streams

$$\boldsymbol{BEI = \sum_{i} (HHV_{B,i} \times QF_{B,i})}$$

Where,			Units
BEI	=	Baseline boiler energy supplied by fuel streams	TJ
$HHV_{B,i}$	=	Baseline higher heating value for fuel i	TJ/kg or TJ/m^3
$QF_{B,i}$	=	Baseline boiler fuel i consumption	kg or m^3

5.1.2.2 Indirect (Energy Balance) Method for Calculating Baseline Boiler Fuel Efficiency

The ASME PTC 4-2013 describes the energy balance method as a method of determining steam generator efficiency by a detailed accounting of all energy entering and leaving the steam generator envelope. It is also sometimes called the "heat balance method" or the "indirect method." The Reserve expects most project developers will prefer this energy balance method as it entails the lowest total uncertainty.

In the energy balance method, all energy is described in terms of net 'losses' and 'credits' to the overall energy balance. Energy losses are defined as the energy that exits the steam generator envelope other than the energy in the output stream(s).[48] Energy credits are defined as the energy entering the steam generator envelope other than the chemical energy in the as-fired fuel. These credits include sensible heat in the fuel, entering air, and atomizing steam; energy from power conversion in coal pulverizers, circulating pumps, primary air fans, and gas recirculation fans; and chemical reactions such as sulfation, amongst others. Credits can be negative, such as when the air temperature is below the reference temperature.[49]

Equation 5.8. Calculating Baseline Boiler Fuel Efficiency (Indirect / Energy Balance Method)

$$\boldsymbol{\eta_B = \frac{(BEI - BEL + BEC)}{BEI} \times 100}$$

Where,			Units
η_B	=	Baseline boiler fuel efficiency	%
BEI	=	Baseline boiler energy supplied by fuel streams (as calculated in Equation 5.7)	TJ
BEL	=	Baseline boiler energy losses (as calculated in Equation 5.9)	TJ
BEC	=	Baseline boiler energy credits (as calculated in Equation 5.10)	TJ

As noted above, energy losses are defined as the energy that exits the steam generator envelope other than the energy in the output stream(s). Baseline boiler energy losses are calculated as per Equation 5.9.

[48] ASME (2014), PTC 4-2013.
[49] *Ibid*.

Equation 5.9. Calculating Baseline Boiler Energy Losses

$$\boldsymbol{BEL} = \sum_{\boldsymbol{m}} \boldsymbol{BEL_m}$$

Where,			Units
BEL	=	Baseline boiler energy losses	TJ
BEL_m	=	Baseline boiler energy loss item m	TJ

Further guidance on boiler energy losses to be considered is presented in the CONUEE *Boiler Efficiency Tool User Manual*.

As noted above, energy credits are defined as the energy entering the steam generator envelope other than the chemical energy in the as-fired fuel. Baseline boiler energy credits are calculated as per Equation 5.10.

Equation 5.10. Calculating Baseline Boiler Energy Credits

$$\boldsymbol{BEC} = \sum_{\boldsymbol{n}} \boldsymbol{BEC_n}$$

Where,			Units
BEC	=	Baseline boiler energy credits	TJ
BEC_n	=	Baseline boiler energy credit item n	TJ

5.1.3 Quantifying Baseline Electricity Emissions

In the absence of specific project activities that are expected to significantly change the consumption of grid electricity by the project, it is assumed that in most cases, electricity consumption within the project boundary will not be materially affected by the project. Thus the calculation of emissions from grid electricity consumed will not be required, except in cases where project activities are expected to materially increase such electricity consumption. Project developers must demonstrate that electricity emissions are not reasonably expected to materially increase. Where material increases in electricity consumption are foreseeable such projects must calculate the increase in project emissions according to this section. Verifiers must exercise their professional judgment to determine whether this is the case, and may ask project developers for further information regarding their projects to assure themselves of this.

Project developers also have the option to include the quantification of grid electricity emissions, where there is the expectation that project activities will materially reduce grid electricity consumption and thus increase the emission reductions generated by the project. Project developers must be able to accurately measure changes in electricity consumption in both the baseline and project scenario, according to monitoring requirements in Section 6, in order to claim any associated emission reductions. In the absence of direct metering of the boiler in both the baseline and the project reporting periods, it is unlikely for a verifier to be assured of the accuracy of electricity related GHG accounting.

Equation 5.11. Quantifying Baseline Electricity Emissions

$$EE_B = PC_B \times EF_{Grid,y}$$

Where,			Units
EE_B	=	Baseline electricity emissions (reported in CO_2e emissions from consumed electricity)	$kgCO_2e$
PC_B	=	Baseline electric power consumption	MWh
$EF_{Grid,y}$	=	National electricity grid emission factor in Mexico[50] or emission factor calculated using the CDM *Tool to calculate the emission factor for an electricity system*,[51] for reporting period y	$kgCO_2e/MWh$

As previously noted, in order to ensure that changes in the operating time and regime of the boiler between the baseline and project scenarios do not affect the comparability of the two, emissions from the consumption of grid electricity must not be calculated simply using electricity consumed in each relevant baseline or project scenario. If electricity emissions were calculated simply using electricity consumed in each relevant period, then changes in operational time or regime could lead to an overestimation or underestimation of emission reductions without any change in efficiency, i.e., if the factory temporarily slowed down the demand for steam, they would be credited for associated emission reductions for the reduction in electricity consumed.

Instead, baseline electric power consumption must be based on the relationship between power consumption in the reporting period y, as well as to the relative power consumption to steam absorbed energy in both the baseline and project scenarios.

Equation 5.12. Quantifying Baseline Electric Power Consumption

$$PC_B = PC_{P,y} \times \frac{ECI_B}{ECI_{P,y}}$$

Where,			Units
PC_B	=	Baseline electric power consumption	MWh
$PC_{P,y}$	=	Project electric power consumption for reporting period y	MWh
ECI_B	=	Baseline electric power consumption index	MWh/TJ
$ECI_{P,y}$	=	Electric power consumption index for reporting period y	MWh/TJ

[50] Project developers should use the national electricity grid emission factor most closely corresponding to the time period during which the electricity was used, which can be sourced from SEMARNAT (2016), RENE: http://www.gob.mx/semarnat/acciones-y-programas/registro-nacional-de-emisiones-rene.

[51] If sufficient data is available, project developers may opt to calculate their own emission factor using the CDM TOOL07, available at https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v5.0.pdf.

Equation 5.13. Quantifying Baseline Electric Power Consumption Index

$$ECI_B = \frac{PC_H}{\sum_i (HHV_{B,i} \times QF_{H,i}) \times \eta_B}$$

Where,			Units
ECI_B	=	Baseline electric power consumption index	MWh/TJ
PC_H	=	Historical electric power consumption (use the average annual consumption for the past three years)	MWh
$HHV_{B,i}$	=	Baseline higher heating value for fuel i, as described in Section 5.1.1	TJ/kg or TJ/m^3
$QF_{H,i}$	=	Historical boiler fuel i consumption (use the average annual consumption for the past three years)	kg or m^3
η_B	=	Boiler fuel efficiency for baseline	%

Equation 5.14. Quantifying Electric Power Consumption Index for Reporting Period y

$$ECI_y = \frac{PC_{P,y}}{\sum_i (HHV_{i,y} \times QF_{P,i,y}) \times \eta_{P,y}}$$

Where,			Units
ECI_y	=	Electric power consumption index for reporting period y	MWh/TJ
$PC_{P,y}$	=	Project electric power consumption for reporting period y	MWh
$HHV_{i,y}$	=	Baseline higher heating value for fuel i as described in Section 5.1.1	TJ/kg or TJ/m^3
$QF_{P,i,y}$	=	Project boiler fuel i consumption for reporting period y	kg or m^3
$\eta_{P,y}$	=	Project boiler fuel efficiency for reporting period y	%

5.2 Quantifying Project Emissions

Project emissions are actual GHG emissions that occur within the GHG Assessment Boundary as a result of the project activity. Project emissions must be quantified every reporting period on an *ex post* basis.

Equation 5.15. Quantifying Total Project GHG Emissions

$$PE_y = FE_{P,y} + EE_y$$

Where,			Units
PE_y	=	Total project emissions, from reporting period y, from all SSRs in the GHG Assessment Boundary	tCO_2e
$FE_{P,y}$	=	Project Fuel Emissions (as calculated in Equation 5.16)	tCO_2e
EE_y	=	Project Electricity Emissions for reporting period y (as calculated in Equation 5.24)	tCO_2e

5.2.1 Quantifying Project Fuel Emissions

Project fuel emissions for project reporting period y are estimated by using Equation 5.16.

Equation 5.16. Quantifying Project Fuel Emissions for Project Year y

$$FE_{P,y} = \sum_{i} (FE_{P,i,y} \times EF_{Fuel_{CO_2},P,i,y})$$

Where,			Units
$FE_{P,y}$	=	Project fuel emissions in project year y	$kgCO_2$
$FE_{P,i,y}$	=	Project fuel energy input from fuel i in project year y	TJ
$EF_{Fuel,CO2,P,i,y}$	=	Project CO_2 emission factor for fuel i in project year y, on an HHV basis, as described further below	$kgCO_2/TJ$

If project developers have verifiable records on fuel i to calculate the emission factor for fuel i ($EF_{Fuel,CO2,B,i}$), they may use the calculated EF. Otherwise, project developers shall use the defaults published by the Instituto Mexicano del Petroleo (IMP).[52] As noted in Section 5.1.1, these IMP emission factors are calculated on a lower heating value (LHV) basis and must be converted to the higher heating value (HHV) basis before being applied in Equation 5.16, as described in Box 5.1. Where multiple data points are available for the same fuel source throughout the reporting period, then the fuel EF should be an average of such values. Verifiers should be satisfied that methods, tools and equipment used to calculate any fuel EF are conservative and appropriate.

The project fuel energy input from fuel i for project year y, $FE_{P,y}$, is calculated based on measured, estimated or default higher heating value and measured project year y consumption for fuel i.

Equation 5.17. Quantifying Project Fuel Energy Input from Fuel i for Project Year y

$$FE_{P,i,y} = HHV_{P,i,y} \times QF_{P,i,y} \times \frac{NBRC_B}{NBRC_P}$$

Where,			Units
$FE_{P,i,y}$	=	Project fuel energy input from fuel i in project year y	TJ
$HHV_{P,i,y}$	=	Project higher heating value for fuel i in project year y, as described further below	TJ/kg or TJ/m^3
$QF_{P,i,y}$	=	Project boiler consumption of fuel i for project year y	kg or m^3
$NBRC_B$	=	Nominal baseline boiler rated capacity (See note below)	MW
$NBRC_P$	=	Nominal project boiler rated capacity (See note below)	MW

Note: Nominal boiler rated capacity ratio must only be used in new boiler projects when project boiler capacity exceeds that of the baseline boiler. For all other instances, $\frac{NBRC_B}{NBRC_P} = 1$

The higher heating value (HHV) of fuels may be determined by a certified laboratory, or it may be determined by the project developer themselves using a standard method to determine HHV

[52] The relevant defaults can be found via the IMP (2014): http://www.inecc.gob.mx/descargas/cclimatico/2014_inf_fin_tipos_comb_fosiles.pdf.

from composition (for gaseous fuels), or by calorimetric techniques.[53] The calculation of HHV should be sufficiently documented including keeping records on procedures and instrumentation used, as well as qualifications and/or training of relevant staff performing such procedures.

5.2.2 Calculating Project Boiler Fuel Efficiency

As discussed in Section 5.1.2, boiler fuel efficiency for the project reporting period y, $\eta_{P,y}$, can be calculated by the direct method (input-output method) or by the indirect method (energy balance method), as per Equation 5.18 and Equation 5.21, which are consistent with ASME PTC 4-2013[54] and BS 845.[55] These underlying methodologies provide additional calculations for how the various input parameters used in Equation 5.18 and Equation 5.21 are calculated. For the implementation of this protocol, boiler fuel efficiency must be calculated by using either of these methodologies (ASME PTC 4-2013 or the BS 845) or the CONUEE *Boiler Efficiency Tool*.

As noted above, the Reserve strongly encourages use of the CONUEE *Boiler Efficiency Tool* to streamline these boiler efficiency calculations. The CONUEE *Boiler Efficiency Tool* follows the ASME PTC 4-2013 method and was re-designed in parallel with this protocol to support project developers. This CONUEE *Boiler Efficiency Tool* allows users to calculate efficiencies using either the energy balance method or the input-output method.

The same method for calculating boiler fuel efficiency in the baseline (per Section 5.1.2) must be applied for calculating boiler fuel efficiency for the project reporting period (in Section 5.2.2).

5.2.2.1 Direct (Input-Output) Method for Calculating Project Boiler Fuel Efficiency

Equation 5.18. Calculating Boiler Fuel Efficiency (Direct / Input-Output Method) for Project Reporting Period y

$$\boldsymbol{\eta_{P,y} = \frac{PEO_y}{PEI_y} \times 100}$$

Where,			Units
$\eta_{P,y}$	=	Project boiler fuel efficiency for project reporting period y	%
PEO_y	=	Project boiler energy absorbed by steam output streams in project reporting period y (as calculated in Equation 5.19)	TJ
PEI_y	=	Project boiler energy supplied by fuel streams in project reporting period y (as calculated in Equation 5.20)	TJ

Project boiler energy absorbed by steam output streams in project reporting period y, PEO_y, is calculated as per Equation 5.19.

[53] Preferred methods include: ASTM (2014b) ASTM D240-14, ASTM (2011b) ASTM D3588–98(2011), ISO 6976:2016, or other methods included in the IMP (2014) report, available on the INECC website: http://www.inecc.gob.mx/descargas/cclimatico/2014_inf_fin_tipos_comb_fosiles.pdf
[54] ASME (2014), PTC 4-2013.
[55] British Standards (BS) Institution (1987), BS 845-1:1987.

Equation 5.19. Calculating Project Boiler Energy Absorbed by Steam Output Streams in Project Reporting Period y

$$\boldsymbol{PEO_y = \sum_j \left[QS_{P,j,y} \times \frac{(h_{j,out} - h_{j,in})}{10^9} \right]}$$

Where,			Units
PEO_y	=	Project boiler energy absorbed by steam output streams in project reporting period y	TJ
$QS_{P,j,y}$	=	Total project flow of fluid stream j[56] leaving boiler boundary in project reporting period y	kg
$h_{j,out}$	=	Enthalpy of fluid in stream j leaving boiler boundary	kJ/kg
$h_{j,in}$	=	Enthalpy of fluid entering boiler boundary, feeding stream j	kJ/kg
10^9	=	Unit conversion factor (kJ to TJ)	

Project boiler energy supplied by fuel streams in project reporting period *y*, PEI_y, is calculated by using Equation 5.20.

Equation 5.20. Calculating Project Boiler Energy Supplied by Fuel Streams in Project Reporting Period y

$$\boldsymbol{PEI_y = \sum_i (HHV_{i,y} \times QF_{P,i,y})}$$

Where,			Units
PEI_y	=	Project boiler energy supplied by fuel streams in project reporting period y	TJ
$HHV_{i,y}$	=	Project higher heating value for fuel i for reporting period y, as described in Section 5.2.1	TJ/kg or TJ/m^3
$QF_{P,i,y}$	=	Project boiler fuel i consumption for reporting period y	kg or m^3

5.2.2.2 Indirect (Energy Balance) Method for Calculating Project Boiler Fuel Efficiency

In the energy balance method, all energy is described in terms of net ‘losses’ and ‘credits’ to the overall energy balance. Energy losses are defined (by the ASME PTC 4-2013) as the energy that exits the steam generator envelope other than the energy in the output stream(s). Energy credits are defined (by the ASME PTC 4-2013) as the energy entering the steam generator envelope other than the chemical energy in the as-fired fuel. These credits include sensible heat in the fuel, entering air, and atomizing steam; energy from power conversion in coal pulverizers, circulating pumps, primary air fans, and gas recirculation fans; and chemical reactions such as sulfation, amongst others. Credits can be negative, such as when the air temperature is below the reference temperature.

[56] Fluid stream j is comprised of blowdown and steam.

Equation 5.21. Calculating Project Boiler Fuel Efficiency (Indirect / Energy Balance Method) for Project Reporting Period y

$$\boldsymbol{\eta_{P,y} = \frac{(PEI_y - PEL_y + PEC_y)}{PEI_y} \times 100}$$

Where,			Units
$\eta_{P,y}$	=	Project boiler fuel efficiency for project reporting period y	%
PEI_y	=	Project boiler energy supplied by fuel streams in project reporting period y	TJ
PEL_y	=	Project boiler energy losses in project reporting period y	TJ
PEC_y	=	Project boiler energy credits in project reporting period y	TJ

Project boiler energy losses in project reporting period y are calculated as per Equation 5.22.

Equation 5.22. Calculating Project Boiler Energy Losses in Project Reporting Period y

$$\boldsymbol{PEL_y = \sum_m PEL_{m,y}}$$

Where,			Units
PEL_y	=	Project boiler energy losses in project reporting period y	TJ
$PEL_{m,y}$	=	Project boiler energy loss item m for the project boiler in reporting period y[57]	TJ

Further guidance on boiler energy losses to be considered is presented in CONUEE *Boiler Efficiency Tool User Manual*.

Project boiler energy credits in project reporting period y are calculated as per Equation 5.23.

Equation 5.23. Calculating Project Boiler Energy Credits in Project Reporting Period y

$$\boldsymbol{PEC_y = \sum_n PEC_{n,y}}$$

Where,			Units
PEC_y	=	Project boiler energy credits in project reporting period y	TJ
$PEC_{n,y}$	=	Project boiler energy credit item n in reporting period y[58]	TJ

[57] The energy loss parameter refers to each applicable energy loss category used to assess boiler efficiency. Categories should be included if there is expected to be a change in associated energy loss between the baseline and project.
[58] The energy credit parameter refers to each applicable energy credit category used to assess boiler efficiency. Categories should be included if there is expected to be a change in associated energy credit between the baseline and project.

5.2.3 Quantifying Project Electricity Emissions

As noted in Section 5.1.3, the calculation of emissions from grid electricity consumed will not be required, except in cases where project activities are expected materially to increase such electricity consumption. Project developers must demonstrate that electricity emissions are not reasonably expected to materially increase. However, project developers also have the option to include the quantification of grid electricity emissions, where there is the expectation that project activities will materially reduce grid electricity consumption and thus increase the emission reductions generated by the project.

Equation 5.24. Quantifying Project Electricity Emissions

$$EE_{P,y} = PC_{P,y} \times EF_{Grid,y}$$

Where,			Units
$EE_{P,y}$	=	Project Electricity Emissions (CO_2 emissions from consumed electricity)	$kgCO_2$
$PC_{P,y}$	=	Quantity of electricity consumed during the reporting period y	MWh
$EF_{Grid,y}$	=	National electricity grid emission factor in Mexico[59] or emission factor calculated using the CDM *Tool to calculate the emission factor for an electricity system*,[60] for reporting period y	$kgCO_2e/MWh$

[59] Project developers should use the national electricity grid emission factor most closely corresponding to the time period during which the electricity was used, which can be sourced from SEMARNAT (2016), RENE: http://www.gob.mx/semarnat/acciones-y-programas/registro-nacional-de-emisiones-rene.

[60] If sufficient data is available, project developers may opt to calculate their own emission factor, using the CDM TOOL07, available at https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v5.0.pdf.

6 Project Monitoring

The Reserve requires a Monitoring Plan to be established for all monitoring and reporting activities associated with the project. The Monitoring Plan will serve as the basis for verifiers to confirm that the monitoring and reporting requirements in this section and Section 7 have been and will continue to be met, and that consistent, rigorous monitoring and record keeping is ongoing at the project site. The Monitoring Plan must cover all aspects of monitoring and reporting contained in this protocol and must specify how data for all relevant parameters in Table 6.1 will be collected and recorded.

At a minimum, the Monitoring Plan shall include the frequency of data acquisition; a record keeping plan (see Section 7.2 for minimum record keeping requirements); the frequency of instrument cleaning, inspection, field check, and calibration activities; the role of individuals performing each specific monitoring activity; and a detailed project diagram. The Monitoring Plan should include QA/QC provisions to ensure that data acquisition and meter calibration are carried out consistently and with precision.

Finally, the Monitoring Plan must include procedures that the project developer will follow to ascertain and demonstrate that the project at all times passes the Legal Requirement Test and the Regulatory Compliance Test (Section 3.4.2 and 3.5, respectively).

Project developers are responsible for monitoring the performance of the project and ensuring that the operation of all project-related equipment is consistent with the manufacturer's recommendations.

6.1 Monitoring Requirements

6.1.1 Fuel Consumption

The consumption of fuel must be monitored and measured by the project developer. Methods of measuring solid, liquid, or gaseous fuels are discussed further below.

In the case of liquid or gaseous fuels, permissible measurement methods are as follows:

1. The consumption of liquid or gaseous fuel should be measured through the use of flow meters, installed before the fuel intake to each boiler for which credits are sought. This measurement equipment used to monitor fuel consumption must directly meter:
    - The total flow of fuel delivered to each boiler, measured continuously and recorded at least every 15 minutes or totalized and recorded at least daily; and
    - Where it is practical to do so, projects shall also measure the total aggregate flow of fuels used in all project boilers (for each fuel type), measured continuously and recorded at least every 15 minutes or totalized and recorded at least daily. The purpose of this measurement of total fuel flow is to provide redundancy in data which may prove useful where there is insufficient flow data for a particular meter/boiler. Where there is insufficient flow data for a particular meter/boiler, flow to that device might be deduced by subtracting flow to all other devices from the total flow data. Depending on site conditions it might not be practical/possible to arrange metering in this manner.

2. In the case of a facility where the relevant gaseous or liquid fuels are consumed solely in a single project boiler, and that this boiler is the only consumer of gas supplied by the

existing supply and storage system, the project may use a combination of secondary documented records such as fuel invoices and calculations of fuel inventories to demonstrate fuel consumption.

Flow data for gaseous fuels must be reported at standard conditions.[61]

In the case of solid fuels, permissible measurement methods are as follows:

1. The preferred method of measuring consumption is via the continuous measurement of such fuels immediately prior to combustion, such as via the use of conveyor belt scales or similar devices.
2. Where this is not possible, it may be possible to measure consumption via secondary means such as truck scales, stocks calculations, delivery receipts etc. For secondary measurements of fuels, stock calculations must be performed at least quarterly.

If none of these measurement methods were in place during the baseline, a series of combustion tests across the boiler's relevant[62] operational range must be performed by qualified staff of the project developer, a third party service technician, or manufacturer of the boiler and/or relevant subcomponents, according to the method in ASME PTC 4-2013 or another comparable method. Such a combustion test must be performed prior to the implementation of project activities at the boiler site (i.e., prior to the retrofit or installation of the new boiler), but not more than three years prior to the project's start date; the results of this combustion test may be applied to the boiler's baseline for the duration of the crediting period. A combustion test allows for the determination of capacity and performance at a specific operational point. At minimum, at least three operational points in the boiler's relevant load range must be tested, low, medium, and high, and averaged together. However, more test points are encouraged. The verifier must confirm that the given test points are sufficiently representative of the boiler's relevant load ranges and that such testing was carried out in an appropriate manner.

Additional quality assurance and quality control (QA/QC) requirements for meters are discussed in Section 6.2 below.

6.1.2 Electricity Consumption

If any emission reductions are claimed in relation to material changes in electricity consumption, measurement of electricity consumption must be done through the use of meters at each boiler. In all other instances the consumption of electricity can be demonstrated through the use of invoices and other evidence deemed acceptable to a verifier.

If none of these measurement methods were in place during the baseline, a series of demand load data tests across the operational range of the system using network power testers may be performed by the project developer, a third party service technician or manufacturer of the boiler and/or relevant subcomponents. A demand load data test allows for the determination of consumed power versus load at a specific operational point. At minimum, a load / power demand curve for the relevant operational range must be derived from such measurements. The project developer is expected to provide a load profile for the boiler over a typical operation

[61] Official Mexican Standard for gaseous fuels (NOM-001-SECRE-2010) requires all volumetric measurements of natural gas to be reported at standard pressure and temperature conditions of 101.325 kPa (1 atm, 1.03323 kg/cm^2 abs or 14.6959 psia) and 288.15 K (15°C or 59°F).

[62] The relevant operation range refers to the boiler load range where the boiler operates at least 95% of the total operation time. Start, shut down, or abnormal operation conditions due to extraordinary circumstances, are not considered as normal operation to establish this range.

period (at least one normal operation day), additional to calculations for historical power consumptions based on the data gathered or the developed demand load curve. The verifier must confirm that the given test points are sufficiently representative of the boiler's relevant electric load range and such testing was carried out in an appropriate manner.

6.1.3 Fluid Streams

When using the direct method and monitoring the fluid stream leaving the boiler ($QS_{B,j}$), which may be comprised of a combination of blowdown and output steam, a flow meter must be used to monitor the flow of steam continuously, recording it every 15 minutes. Flow data must be reported on a mass basis. Additional QA/QC requirements for meters are discussed in Section 6.2 below.

If flow meter data is not available in the baseline, the project developer must use the indirect method.

6.1.4 Other Parameters

Measurements of the following parameters are to be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845 or CONUEE tool) for baseline calculations:

- boiler fuel efficiency
- boiler energy losses / credits
- energy absorbed by steam output streams

6.2 Measurement Instrument QA/QC

This section contains mandatory requirements, as well as additional suggestions, which are designed specifically to provide cost-effective means to address common risks for projects and provide the most cost-effective means to maximize CRT issuance. In the Reserve's extensive experience, QA/QC of measurement instruments is one of the highest risk areas for projects to fail monitoring requirements and lose potential CRT issuance. Meeting the requirements of this section and implementing additional QA/QC recommendations, where feasible, will be a most critical means for project developers to reduce the risk of not achieving full potential CRT issuance.

Implementing the additional and/or more frequent QA/QC recommendations may be especially important if choosing the extended, optional verification periods discussed in Section 7.4, so that any potential errors may be discovered and corrected sooner, resulting in the loss of less CRTs (i.e., more frequent field checks may uncover a failure to meet meter QA/QC requirements in an interim period, which may have otherwise gone unnoticed until verification).

All flow meters and any other measurement instrumentation used for quantifying any relevant parameters or properties must be:

- In calibration (accurate to +/- 5% of the true value being measured or as per manufacturer's recommendations, whichever results in a lower uncertainty range) at time of installation. Calibration accuracy can be demonstrated through either a recent field check (as installed) or calibration by the manufacturer or a certified calibration service.

- Maintained per manufacturer's guidance, as well as cleaned and inspected on a quarterly basis, with the activities performed and as found/as left condition of the

equipment documented.

- Field checked for calibration accuracy by an appropriately trained individual or a third-party technician with the percent drift documented, using either a portable instrument (such as a gas analyzer)[63] or manufacturer specified guidance once annually, at the end of but no more than 60 days prior to or after the end date of the reporting period.

- Calibrated by the manufacturer or an independent certified calibration service per manufacturer's guidance or every 5 years, whichever is more frequent. Meters shall be calibrated to the range of conditions expected on site (e.g., flow rate, temperature, pressure, gas composition) and as found/as left condition of the equipment documented.

Project developer staff may perform QA/QC activities, except the minimum manufacturer or third-party factory calibration noted in the paragraph above, as long as proper training of such staff is demonstrated by appropriate documentary evidence including: the existence of written procedures, record keeping procedures, non-conformance follow-up procedures, training certifications or similar documentary evidence of this nature. The existence of valid certifications such as ISO 9001, ISO 14001 or similar certifications may also be taken as supporting evidence of a record keeping system of appropriate quality. Verifier professional judgment will determine whether additional assurance of staff competence is needed, such as interviews with relevant staff.

If a stationary meter that was in use for 60 days or more is removed and not reinstalled during a reporting period, that meter shall either be field-checked for calibration accuracy prior to removal or calibrated (with percent drift documented) by the manufacturer or a certified calibration service prior to quantification of emission reductions for that reporting period.

If the field check on a piece of equipment reveals accuracy outside of a +/- 5% threshold, calibration by the manufacturer or a certified service provider is required for that piece of equipment, with as found/as left condition of the equipment documented.

For the interval between the last successful field check and any calibration event confirming accuracy below the +/- 5% threshold, all data from that meter must be scaled according to the following procedure. These adjustments must be made for the entire period from the last successful field check until such time as the meter is properly calibrated and re-installed.

For calibrations that indicate the flow meter was outside the +/- 5% accuracy threshold, the project developer shall estimate total emission reductions using i) the metered values without correction, and ii) the metered values adjusted based on the greatest calibration drift recorded at the time of calibration. The lower of the two emission reduction estimates shall be reported as the scaled emission reduction estimate.

For example, if a project conducts field checks quarterly during a year-long verification period, then only three months of data will be subject at any one time to the repercussions noted above. However, if the project developer feels confident that the meter does not require field checks or calibration on a greater than annual basis, then failed events will accordingly require the penalty

[63] It is recommended that a professional third party calibration service be hired to perform flow meter field checks if using pitot tubes or other portable instruments, as these types of devices require professional training in order to achieve accurate readings.

to be applied to the entire year's data. Further, frequent calibration may minimize the total accrued drift (by zeroing out any error identified), and result in smaller overall deductions.

6.3 Missing Data

In situations where fuel flow measurements or other critical data necessary for emissions calculations are missing, the project developer shall apply the data substitution methodology provided below. This methodology may also be used for periods where the project developer can show that the data are available but known to be corrupted (and where this corruption can be verified with reasonable assurance). For periods when it is not possible to use data substitution to fill data gaps, no emission reductions may be claimed.

The Reserve expects that projects will have continuous, uninterrupted data for the entire verification period. However, the Reserve recognizes that unexpected events or occurrences may result in brief data gaps.

The following data substitution methodology may be used only for data gaps that are discrete, limited, non-chronic, and due to unforeseen circumstances. Substitution may only occur when flow rates during the data gap must be consistent with normal operation. If corroborating parameters fail to demonstrate this requirement, no substitution may be employed. If the requirement above can be met, the following substitution methodology maybe applied:

Duration of Missing Data	Substitution Methodology
Less than six hours	Use the average of the four hours immediately before and following the outage
Six to 24 hours	Use the 90% lower or upper confidence limit of the 24 hours prior to and after the outage, whichever results in greater conservativeness
One to seven days	Use the 95% lower or upper confidence limit of the 72 hours prior to and after the outage, whichever results in greater conservativeness
Greater than one week	No data may be substituted and no credits may be generated

For periods when it is not possible to use data substitution to fill data gaps, no emission reductions may be claimed.

6.4 Monitoring Parameters

Prescribed monitoring parameters necessary to calculate baseline and project emissions are provided in Table 6.1.

Table 6.1. Project Monitoring Parameters

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
General Project Parameters						
	Regulations	Project developer attestation of compliance with regulatory requirements relating to the project	Environmental regulations	n/a	Each verification cycle	Information used to: 1) To demonstrate ability to meet the Legal Requirement Test – where regulation would require boiler efficiencies commensurate with project boiler efficiencies. 2) To demonstrate compliance with associated environmental rules, e.g., criteria pollutant limits.
Equation 5.1	ER	Total emission reductions for the reporting period, for all boilers	tCO_2e	C	Each verification cycle	
Equation 5.1 Equation 5.2	BE	Total baseline emissions for the reporting period, from all SSRs in the GHG Assessment Boundary	tCO_2e	C	Each verification cycle	
Equation 5.1 Equation 5.15	PE	Total project emissions for the reporting period	tCO_2e	C	Each verification cycle	
Baseline Calculation Parameters						
Equation 5.2 Equation 5.3	FE_B	Baseline fuel emissions for project boiler	tCO_2e or $kgCO_2$	C	Each verification cycle	
Equation 5.2 Equation 5.11	EE_B	Baseline electricity emissions from boiler	tCO_2e	C	Each verification cycle	
Equation 5.3 Equation 5.4	$FE_{B,i}$	Baseline fuel energy input for boiler from fuel i	TJ	C	Each verification cycle	

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.3	$EF_{Fuel,CO2,B,i}$	Baseline CO_2 emission factor for fuel i for the boiler as provided in Appendix B	$kgCO_2/TJ$	C or R	Each verification cycle	If project developers have verifiable records on fuel i to calculate the emission factor for fuel i ($EF_{Fuel,CO2,B,i}$), they may use the calculated EF. Otherwise, project developers shall use the defaults published in the Instituto Mexicano del Petroleo (IMP) study commissioned by INECC.[64] Projects that switch from a higher to lower carbon-intensive fossil fuel over the course of the project must use the fuel emission factor for the fuel used in the project scenario.
Equation 5.4 Equation 5.7 Equation 5.13 Equation 5.14	$HHV_{B,i}$	Baseline higher heating value for boiler from fuel i	TJ/kg or TJ/m^3	C or R	Once	Supplier information, determined by a certified laboratory, or determined by composition by the project developer. [65] For fuel switch to a lower carbon intensity fuel in the project boiler during crediting period, this value must be used as project higher heating value.
Equation 5.4	$QF_{P,i,y}$	Consumption of fuel i from project reporting period y	kg or m^3	M or O	Continuous, or according to fuel invoicing frequency	Continuous measurement
Equation 5.4	$\eta_{P,y}$	Project boiler fuel efficiency for project reporting period y	%	C	Each verification cycle	To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.
Equation 5.4 Equation 5.5 Equation 5.8 Equation 5.13	η_B	Baseline boiler fuel efficiency	%	C or O	Once	To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.

[64] The relevant defaults can be found here: http://www.inecc.gob.mx/descargas/cclimatico/2014_inf_fin_tipos_comb_fosiles.pdf.

[65] The higher heating value (HHV) of fuels may be determined by a certified laboratory, or it may be determined by the project developer themselves using a standard method to determine HHV from composition (for gaseous fuels), or by calorimetric techniques. The calculation of HHV should be sufficiently documented including keeping records on procedures and instrumentation used, as well as qualifications and/or training of relevant staff performing such procedures. Preferred methods include: ASTM (2014b) ASTM D240-14, ASTM (2011b) ASTM D3588–98(2011), ISO 6976:2016, or other methods included in the IMP (2014) report, available on the INECC website: http://www.inecc.gob.mx/descargas/cclimatico/2014_inf_fin_tipos_comb_fosiles.pdf.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.4 Equation 5.17	$NBRC_B$	Nominal baseline boiler rated capacity	MW	O	Once	To be determined based on documentation from the boiler manufacturer. Must be reported on the same basis as $NBRC_P$.
Equation 5.4 Equation 5.17	$NBRC_P$	Nominal project boiler rated capacity	MW	O	Once	To be determined based on documentation from the boiler manufacturer. Must be reported on the same basis as $NBRC_B$.
Equation 5.5 Equation 5.6	BEO	Baseline boiler energy absorbed by steam output streams	TJ	C	Once	To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.
Equation 5.5 Equation 5.7 Equation 5.8	BEI	Baseline boiler energy supplied by fuel streams	TJ	C	Once	Use average fuel consumption for past 3 years for calculation. To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.
Equation 5.6	$QS_{B,j}$	Total baseline consumption of fluid stream j leaving boiler boundary	kg	M or O	Once	Continuous measurement. If flow meter data is not available in the Baseline, the project developer is encouraged to use the indirect method.
Equation 5.6	$h_{j,out}$	Enthalpy of fluid in stream j leaving boiler boundary	kJ/kg	R	Default	From steam tables or steam properties software.[66]
Equation 5.6	$h_{j,in}$	Enthalpy of fluid entering boiler boundary, feeding stream j	kJ/kg	R	Default	From steam tables or steam properties software.[66]
Equation 5.7	$QF_{B,i}$	Baseline boiler fuel i consumption	kg or m^3	M or O	Once	Continuous measurement, or according to fuel invoicing frequency.
Equation 5.8 Equation 5.9	BEL BEL_m	Baseline boiler energy losses Baseline boiler energy losses for item m	TJ	C	Once	To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.

[66] The project developer may choose any generally accepted steam tables or software. The Reserve encourages the use of NIST/ASME Steam Properties Database: Version 3.0, which can be found at http://www.nist.gov/srd/nist10.cfm.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.8 Equation 5.10	BEC BEC_n	Baseline boiler energy credits Baseline boiler energy credits for item n	TJ	C	Once	To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.
Equation 5.11 Equation 5.12	PC_B	Baseline electric power consumption for boiler	MWh	C	Once	Continuous measurement, or according to power supplier invoicing frequency.
Equation 5.11	$EF_{Grid,y}$	National electricity grid emission factor in Mexico for reporting period y or, a project-specific emission factor calculated for reporting period y	$kgCO_2e/MWh$	R		Project developers should use the national electricity grid emission factor most closely corresponding to the time period during which the electricity was used, which can be sourced from http://www.gob.mx/semarnat/acciones-y-programas/registro-nacional-de-emisiones-rene. Alternatively, if sufficient data is available, project developers may opt to calculate their own emission factor, using the CDM *Tool to Calculate the Emission Factor for an Electricity System*, which can be sourced from: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v5.0.pdf.
Equation 5.12 Equation 5.14 Equation 5.24	$PC_{P,y}$	Project electric power consumption for boiler for reporting period y	MWh	C	Monthly	Continuous measurement, or according to power supplier invoicing frequency.
Equation 5.12 Equation 5.13	ECI_B	Baseline electric power consumption index for boiler	MWh/TJ	C	Once	To be determined for baseline period.
Equation 5.12 Equation 5.14	$ECI_{P,y}$ ECI_y	Electric power consumption index for boiler for reporting period y	MWh/TJ	C	Each verification cycle	Continuous measurement
Equation 5.13	PC_H	Historical electric power consumption for boiler	MWh	C	Once	To be determined for baseline period from operation records.
Equation 5.13	$QF_{H,i}$	Historical boiler fuel i consumption at boiler	kg or m^3	M or O	Once	Continuous measurement

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.14	$HHV_{i,y}$	Project higher heating value for fuel i for boiler for reporting period y	TJ/kg or TJ/m^3	C or R	Each verification cycle	Supplier information, determined by a certified laboratory, or determined by composition by the project developer. [67] For fuel switch to a lower carbon intensity fuel in the project boiler during crediting period, the baseline HHV must be used as project higher heating value.
Equation 5.14	$QF_{P,i,y}$	Project boiler fuel i consumption for project year y	kg or m^3	M or O	Continuous, or according to fuel invoicing frequency	Continuous measurement
Equation 5.14	$\eta_{P,y}$	Project boiler fuel efficiency for project reporting period y	%	C	Each verification cycle	To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.
Project Calculation Parameters						
Equation 5.15 Equation 5.16	$FE_{P,y}$	Project fuel emissions from boiler	tCO_2e	C	Each verification cycle	
Equation 5.15 Equation 5.24	$EE_{P,y}$	Project electricity emissions from boiler for reporting period y	tCO_2e	C	Each verification cycle	
Equation 5.16 Equation 5.17	$FE_{P,i,y}$	Project fuel energy input for boiler from fuel i in project year y	TJ	c	Each verification cycle	

[67] The higher heating value (HHV) of fuels may be determined by a certified laboratory, or it may be determined by the project developer themselves using a standard method to determine HHV from composition (for gaseous fuels), or by calorimetric techniques. The calculation of HHV should be sufficiently documented including keeping records on procedures and instrumentation used, as well as qualifications and/or training of relevant staff performing such procedures. Preferred methods include: ASTM (2014b) ASTM D240-14, ASTM (2011b) ASTM D3588–98(2011), ISO 6976:2016, or other methods included in the IMP (2014) report, available on the INECC website: http://www.inecc.gob.mx/descargas/cclimatico/2014_inf_fin_tipos_comb_fosiles.pdf.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.16	$EF_{Fuel,CO2,P,i,y}$	Project CO_2 emission factor for fuel i for boiler in project year y	$kgCO_2/TJ$	C or R	N/A	If project developers have verifiable records on fuel i to calculate the emission factor for fuel i ($EF_{Fuel,CO2,B,i}$), they may use the calculated EF. Otherwise, project developers shall use the defaults published in the Instituto Mexicano del Petroleo (IMP) study commissioned by INECC.[68]
Equation 5.17 Equation 5.20	$HHV_{i,y}$	Project higher heating value for fuel i for boiler for reporting period y	TJ/kg or TJ/m^3	C or R	Each verification cycle	Supplier information, determined by a certified laboratory, or determined by composition by the project developer.[69] For fuel switch to a lower carbon intensity fuel in the project boiler during crediting period, this value must be used as project higher heating value.
Equation 5.17 Equation 5.20	$QF_{P,i,y}$	Project boiler fuel i consumption for project year y	kg or m^3	M or O	Continuous, or according to fuel invoicing frequency	Continuous measurement
Equation 5.18 Equation 5.21	$\eta_{P,y}$	Project boiler fuel efficiency for project reporting period y	%	C	Each verification cycle	To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.
Equation 5.18 Equation 5.19	PEO_y	Project boiler energy absorbed by steam output streams in project reporting period y	TJ	C	Each verification cycle	To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.
Equation 5.18 Equation 5.20 Equation 5.21	PEI_y	Project boiler energy supplied by fuel streams in project reporting period y	TJ	C	Each verification cycle	Calculated from project fuel consumption and HHV data.

[68] The relevant defaults can be found here: http://www.inecc.gob.mx/descargas/cclimatico/2014_inf_fin_tipos_comb_fosiles.pdf.

[69] The higher heating value (HHV) of fuels may be determined by a certified laboratory, or it may be determined by the project developer themselves using a standard method to determine HHV from composition (for gaseous fuels), or by calorimetric techniques. The calculation of HHV should be sufficiently documented including keeping records on procedures and instrumentation used, as well as qualifications and/or training of relevant staff performing such procedures. Preferred methods include: ASTM (2014b) ASTM D240-14, ASTM (2011b) ASTM D3588–98(2011), ISO 6976:2016, or other methods included in the IMP (2014) report, available on the INECC website: http://www.inecc.gob.mx/descargas/cclimatico/2014_inf_fin_tipos_comb_fosiles.pdf.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.19	$QS_{P,j,y}$	Total project consumption of fluid stream j leaving boiler boundary in project reporting period y	kg	M or O	Once	Continuous measurement. If flow meter data is not available in the Baseline, the project developer is encouraged to use the indirect method.
Equation 5.19	$h_{j,out}$	Enthalpy of fluid in stream j leaving boiler boundary	kJ/kg	R	Default	From steam tables or steam properties software.[70]
Equation 5.19	$h_{j,in}$	Enthalpy of fluid entering boiler boundary, feeding stream j	kJ/kg	R	Default	From steam tables or steam properties software.[70]
Equation 5.21 Equation 5.22	PEL_y $PEL_{m,y}$	Project boiler energy losses in project reporting period y Project boiler energy loss item m in reporting period y	TJ	C	Each verification cycle	To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.
Equation 5.21 Equation 5.23	PEC_y $PEC_{n,y}$	Project boiler energy credits in project reporting period y Project boiler energy credit item n in reporting period y	TJ	C	Each verification cycle	To be determined according to adequate methodology or tools (ASME PTC 4-2013, BS 845, or CONUEE tool) for baseline calculations.
Equation 5.24	$PC_{P,y}$	Project electric power consumption for boiler for reporting period y	MWh	C	Monthly	Continuous measurement, or according to power supplier invoicing frequency.

[70] The project developer may choose any generally accepted steam tables or software. The Reserve encourages the use of NIST/ASME Steam Properties Database: Version 3.0, which can be found at http://www.nist.gov/srd/nist10.cfm.

Eq. #	Parameter	Description	Data Unit	Calculated (C) Measured (M) Reference (R) Operating Records (O)	Measurement Frequency	Comment
Equation 5.24	$EF_{Grid,y}$	National electricity grid emission factor in Mexico for reporting period y or, a project-specific emission factor calculated for reporting period y	$kgCO_2e/MWh$	C or R	Each verification cycle	Project developers should use the national electricity grid emission factor most closely corresponding to the time period during which the electricity was used, which can be sourced from http://www.gob.mx/semarnat/acciones-y-programas/registro-nacional-de-emisiones-rene. Alternatively, if sufficient data is available, project developers may opt to calculate their own emission factor, using the CDM *Tool to Calculate the Emission Factor for an Electricity System*, which can be sourced from: https://cdm.unfccc.int/methodologies/PAmethodologies/tools/am-tool-07-v5.0.pdf.

7 Reporting Parameters

This section provides requirements and guidance on reporting rules and procedures. A priority of the Reserve is to facilitate consistent and transparent information disclosure among project developers. Project developers must submit verified emission reduction reports to the Reserve annually at a minimum.

7.1 Project Submittal Documentation

Project developers must provide the following documentation to the Reserve in order to register a boiler efficiency project:

- Project Submittal form
- Project diagram
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form
- Verification Report
- Verification Statement

Project developers must provide the following documentation each reporting period in order for the Reserve to issue CRTs for quantified GHG reductions:

- Verification Report
- Verification Statement
- Project diagram (if changed from previous reporting period)
- Signed Attestation of Title form
- Signed Attestation of Voluntary Implementation form
- Signed Attestation of Regulatory Compliance form

At a minimum, the above project documentation (except for the project diagram) will be available to the public via the Reserve's online registry. Further disclosure and other documentation may be made available on a voluntary basis through the Reserve. Project submittal forms can be found at http://www.climateactionreserve.org/how/program/documents/.

7.2 Joint Project Verification

Because the protocol allows for multiple projects at a single project site or facility, project developers have the option to hire a single verification body to verify multiple projects at a facility through a "joint project verification." This may provide economies of scale for the project verifications and improve the efficiency of the verification process.

Under joint project verification, each project, as defined by the protocol, is submitted for listing, listed, and registered separately in the Reserve system. Furthermore, each project requires its own separate verification process and Verification Statement (i.e., each project is assessed by the verification body separately as if it were the only project at the facility). However, all projects may be verified together by a single site visit to the facility. Furthermore, a single Verification Report may be filed with the Reserve that summarizes the findings from multiple project verifications.

7.3 Record Keeping

For purposes of independent verification and historical documentation, project developers are required to keep all information outlined in this protocol for a period of 10 years after the information is generated or 7 years after the last verification. This information will not be publicly available, but may be requested by the verifier or the Reserve.

System information the project developer should retain includes:

- All data inputs for the calculation of the project emission reductions, including all required sampled data
- Copies of all permits, Notices of Violations (NOVs), and any relevant administrative or legal consent orders dating back at least 3 years prior to the project start date
- Executed Attestation of Title, Attestation of Regulatory Compliance, and Attestation of Voluntary Implementation forms
- Onsite fuel use records
- Onsite grid electricity use records
- Results of CO_2e annual reduction calculations
- Initial and annual verification records and results
- All maintenance records relevant to the monitoring equipment

7.4 Reporting and Verification Cycle

To provide flexibility and help manage verification costs associated with boiler efficiency projects, there are three verification options to choose from after a project's initial verification and registration. Regardless of the option selected, project developers must report GHG reductions resulting from project activities during each reporting period. A "reporting period" is a period of time over which a project developer quantifies and reports GHG reductions to the Reserve. Under this protocol, the reporting period cannot exceed 12 months, except during a project's initial verification. A "verification period" is the period of time over which GHG reductions are verified. Under this protocol, a verification period may cover multiple reporting periods (see Section 7.4.4). The end date of any verification period must correspond to the end date of a reporting period.

A project developer may choose to utilize one option for the duration of a project's crediting period, or may choose different options at different points during a single crediting period. Regardless of the option selected, reporting periods must be contiguous; there may be no time gaps in reporting during the crediting period of a project once the initial reporting period has commenced.

7.4.1 Initial Reporting and Verification Period

The initial reporting and verification period must be no longer than 12 months after the project start date, except in the case of historic projects (those submitted in the first 12 months after protocol adoption with start dates as far back as November 1, 2014), which may register more than 12 months of data in the first reporting period. The project developer must have the required verification documentation (see Section 7.1) submitted within 12 months of the end of the initial reporting period. A project developer may also register a project's initial verification period as a zero-credit reporting period (see the Reserve Program Manual for more information on zero-credit reporting periods).

Once a project is registered and has had at least 3 months of emission reductions verified, the project developer may choose one of the verification options below.

7.4.2 Option 1: Twelve-Month Maximum Verification Period

Under this option, the verification period may not exceed 12 months. Verification with a site visit is required for CRT issuance. The project developer may choose to have a sub-annual verification period (e.g., monthly, quarterly, or semi-annually).

7.4.3 Option 2: Twelve-Month Verification Period with Desktop Verification

Under this option, the verification period cannot exceed 12 months. However, CRTs may be issued upon successful completion of a desktop verification as long as: (1) site-visit verifications occur at two-year intervals; and (2) the verifier has confirmed that there have been no significant changes in data management systems, equipment, or personnel since the previous site visit. Desktop verifications must cover all other required verification activities.

In order to utilize this option, there are two additional requirements that must be satisfied:

1. Prior to a desktop verification commencing, the project developer must attest to the verifier that there have been no significant changes to the project's data management systems, project set up/equipment, or site personnel involved with the project since the last site-visit verification. For each verification period, the project developer must provide the following documentation for review by the verifier prior to the desktop verification commencing:
    a. A schematic of system equipment and configuration, detailing any changes since the previous site visit, and any other supporting documentation for system or operation changes.
    b. A list of personnel performing key functions related to project activities (personnel who manage and perform monitoring, measurement, and instrument QA/QC activities for the project), and documentation of any personnel or roles or changes since the pervious site visit; this shall include documented handover of personnel changes, including personnel change dates.
    c. The sections from the Monitoring Plan that summarize the data management systems and processes in place and a summary of any changes to the systems or processes since the previous site visit.

2. Desktop verifications must be conducted by the same verification body that conducted the most recent site-visit verification.

For projects using this option, the initial verification in this cycle shall be a full verification, including a site visit, and shall cover a minimum of 3 months and maximum 12 months of project data. All subsequent verification periods under this option shall be 12-month verification periods.

Taking into consideration the Reserve's policy that a verification body may provide verification services to a project for a maximum of six consecutive years (see the Verification Program Manual, Section 2.6 for more information), Table 7.1 below details what the verification cycle might look under Option 2.

Table 7.1. Sample Verification Cycle under Option 2

Reporting Period	Verification Activity	Verification Body (VB)
Year 1 *(initial verification)*	Site-visit verification	VB A
Year 2	Desktop verification	VB A
Year 3	Site-visit verification	VB A
Year 4	Desktop verification	VB A
Year 5	Site-visit verification	VB A
Year 6	Desktop verification	VB A
Year 7	Site-visit verification	VB B *(new verification body)*
Year 8	Desktop verification	VB B
Year 9	Site-visit verification	VB B
Year 10	Desktop verification	VB B

7.4.4 Option 3: Twenty-Four Month Maximum Verification Period

Under this option, the verification period cannot exceed 24 months and the project's monitoring report must be submitted to the Reserve for the interim 12-month reporting period. The project monitoring report must be submitted for projects that choose Option 3 to meet the annual documentation requirement of the Reserve program. It is meant to provide the Reserve with information and documentation on a project's operations and performance, and adherence to the project's monitoring plan. It is submitted via the Reserve's online registry, but is not a publicly available document. A monitoring report template for Mexico Boiler Efficiency projects will be made available at http://www.climateactionreserve.org/how/program/documents/. The monitoring report shall be submitted within 30 days of the end of the interim reporting period.

All project developers utilizing the 24-month verification period must submit the monitoring report within 30 days of the end of the interim reporting period.

Under this option, CRTs may be issued upon successful completion of a site-visit verification for GHG reductions achieved over a maximum of 24 months. CRTs will not be issued based on the Reserve's review of project monitoring plans/reports. Project developers may choose to have a verification period shorter than 24 months.

Taking into consideration the Reserve's policy that a verification body may provide verification services to a project for a maximum of six consecutive years (see the Verification Program Manual, Section 2.6 for more information), Table 7.2 below details what the verification cycle might look under Option 3.

Table 7.2. Sample Verification Cycle under Option 3

Reporting Period	Verification Activity	Verification Body (VB)
Year 1 *(initial verification)*	Site-visit verification	VB A
Year 2	Project monitoring plan and report submitted to Reserve	n/a
Year 3	Site-visit verification for years 2 and 3	VB A
Year 4	Project monitoring plan and report submitted to Reserve	n/a
Year 5	Site-visit verification for years 4 and 5	VB A
Year 6	Project monitoring plan and report submitted to Reserve	n/a
Year 7	Site-visit verification for years 6 and 7	VB B *(new verification body)*
Year 8	Project monitoring plan and report submitted to Reserve	n/a
Year 9	Site-visit verification for years 8 and 9	VB B
Year 10	Site-visit verification for year 10	VB B

8 Verification Guidance

This section provides verification bodies with guidance on verifying GHG emission reductions associated with the project activity. This verification guidance supplements the Reserve's Verification Program Manual and describes verification activities specifically related to boiler efficiency projects.

Verification bodies trained to verify boiler efficiency projects must be familiar with the following documents:

- Climate Action Reserve Program Manual
- Climate Action Reserve Verification Program Manual
- Climate Action Reserve Mexico Boiler Efficiency Project Protocol

The Reserve's Program Manual, Verification Program Manual, and project protocols are designed to be compatible with each other and are available on the Reserve's website at http://www.climateactionreserve.org.

Only Reserve-approved verification bodies that have been accredited to ISO 14065 and 14064-3 and trained by the Reserve for this project type are eligible to verify boiler efficiency project reports. Please refer to the Verification Program Manual for more information on accreditation requirements.[71]

8.1 Verification of Multiple Projects at a Single Facility

Because the protocol allows for multiple projects at a single project site or facility, project developers have the option to hire a single verification body to verify multiple projects under a joint project verification. This may provide economies of scale for the project verifications and improve the efficiency of the verification process. Joint project verification is only available as an option for a single project developer; joint project verification cannot be applied to multiple projects registered by different project developers at the same facility.

Under joint project verification, each project, as defined by the protocol, must be registered separately in the Reserve system and requires its own verification process and Verification Statement (i.e., each project is assessed by the verification body separately as if it were the only project at the facility). However, all projects may be verified together by a single site visit to the facility. Furthermore, a single Verification Report may be filed with the Reserve that summarizes the findings from multiple project verifications.

Finally, the verification body may submit one Notification of Verification Activities/Conflict of Interest (NOVA/COI) Assessment form that details and applies to all of the projects at a single facility that it intends to verify.

If during joint project verification, the verification activities of one project are delaying the registration of another project, the project developer can choose to forego joint project verification. There are no additional administrative requirements of the project developer or the verification body if a joint project verification is terminated.

[71] The Reserve's Verification Program Manual can be found at http://www.climateactionreserve.org/how/verification/verification-program-manual/.

8.2 Standard of Verification

The Reserve's standard of verification for boiler efficiency projects is the Mexico Boiler Efficiency Project Protocol (this document), the Reserve Program Manual, and the Verification Program Manual. To verify a boiler efficiency project report, verification bodies apply the guidance in the Verification Program Manual and this section of the protocol to the standards described in Sections 2 through 7 of this protocol. Sections 2 through 7 provide eligibility rules, methods to calculate emission reductions, performance monitoring instructions and requirements, and procedures for reporting project information to the Reserve.

8.3 Monitoring Plan

The Monitoring Plan serves as the basis for verification bodies to confirm that the monitoring and reporting requirements in Section 6 and Section 7 have been met, and that consistent, rigorous monitoring and record keeping is ongoing at the project site. Verification bodies shall confirm that the Monitoring Plan covers all aspects of monitoring and reporting contained in this protocol and specifies how data for all relevant parameters in Table 6.1 are collected and recorded.

8.4 Verifying Project Eligibility

Verification bodies must affirm a boiler efficiency project's eligibility according to the rules described in this protocol. The table below outlines the eligibility criteria for boiler efficiency projects. This table does not present all criteria for determining eligibility comprehensively; verification bodies must also look to Section 3 and the verification items list in Table 8.2.

Table 8.1. Summary of Eligibility Criteria for a Mexico Boiler Efficiency Project

Eligibility Rule	Eligibility Criteria	Frequency of Rule Application
Start Date	For 12 months following the Effective Date of this protocol, a pre-existing project with a start date on or after November 1, 2014 may be submitted for listing; after this 12-month period, projects must be submitted for listing within 6 months of the project start date.	Once during first verification
Location	Mexico	Once during first verification
Performance Standard	For Boilers 9.8 to 100 MW (33.5 –341.4 MMBtu/h), Performance Threshold = 80.5% For Boilers > 100 MW (>341.4 MMBtu/h), Performance Threshold = 82% For new boiler projects only, existing (baseline) boiler must be no older than 35 years since commissioning to be eligible.	Once during first verification
Legal Requirement Test	Signed Attestation of Voluntary Implementation form and monitoring procedures for ascertaining and demonstrating that the project passes the Legal Requirement Test.	Every verification
Regulatory Compliance Test	Signed Attestation of Regulatory Compliance form and disclosure of all non-compliance events to verifier; project must be in material compliance with all applicable laws.	Every verification

8.5 Core Verification Activities

The Mexico Boiler Efficiency Project Protocol provides explicit requirements and guidance for quantifying the GHG reductions associated with the boiler efficiency improvements. The Verification Program Manual describes the core verification activities that shall be performed by verification bodies for all project verifications. They are summarized below in the context of a boiler efficiency project, but verification bodies must also follow the general guidance in the Verification Program Manual.

Verification is a risk assessment and data sampling effort designed to ensure that the risk of reporting error is assessed and addressed through appropriate sampling, testing, and review. The three core verification activities are:

1. Identifying emission sources, sinks, and reservoirs (SSRs)
2. Reviewing GHG management systems and estimation methodologies
3. Verifying emission reduction estimates

Identifying emission sources, sinks, and reservoirs
The verification body reviews for completeness the sources, sinks, and reservoirs identified for a project, such as, *inter alia*, fuel combustion, un-combusted fuel from the boiler, increased grid electricity consumption and new sections of natural gas pipeline.

Reviewing GHG management systems and estimation methodologies
The verification body reviews and assesses the appropriateness of the methodologies and management systems that the boiler efficiency project operator uses to gather data and calculate baseline and project emissions.

Verifying emission reduction estimates
The verification body further investigates areas that have the greatest potential for material misstatements and then confirms whether or not material misstatements have occurred. This involves site visits to the project facility (or facilities if the project includes multiple facilities) to ensure the systems on the ground correspond to and are consistent with data provided to the verification body. In addition, the verification body recalculates a representative sample of the performance or emissions data for comparison with data reported by the project developer in order to double-check the calculations of GHG emission reductions.

8.6 Verification Period

Per Section 7.4, this protocol provides project developers three verification options for a project after its initial verification and registration in order to provide flexibility and help manage verification costs associated with boiler efficiency projects. The different options require verification bodies to confirm additional requirements specific to this protocol, and in some instances, to utilize professional judgment on the appropriateness of the option selected.

8.6.1 Option 1: Twelve-Month Maximum Verification Period

Option 1 does not require verification bodies to confirm any additional requirements beyond what is specified in the protocol.

8.6.2 Option 2: Twelve-Month Verification Period with Desktop Verification

Option 2 requires verification bodies to review the documentation specified in Section 7.4.3 in order to determine if a desktop verification is appropriate. The verifier shall use his/her professional judgment to assess any changes that have occurred related to a project's data management systems, equipment, or personnel and determine whether a site visit should be required as part of verification activities in order to provide a reasonable level of assurance on the project's verification. The documentation shall be reviewed prior to the COI/NOVA renewal being submitted to the Reserve, and the verification body shall provide a summary of its assessment and decision on the appropriateness of a desktop verification when submitting the COI/NOVA renewal. The Reserve reserves the right to review the documentation provided by the project developer and the decision made by the verification body on whether a desktop verification is appropriate.

8.6.3 Option 3: Twenty-Four Month Maximum Verification Period

Under Option 3 (see Section 7.4.4), verification bodies shall look to the project monitoring report submitted by the project developer to the Reserve for the interim 12-month reporting period as a resource to inform its planned verification activities. While verification bodies are not expected to provide a reasonable level of assurance on the accuracy of the monitoring report as part of verification, the verification body shall list a summary of discrepancies between the monitoring report and what was ultimately verified in the List of Findings.

8.7 Mexico Boiler Efficiency Verification Items

The following tables provide lists of items that a verification body needs to address while verifying a boiler efficiency project. The tables include references to the section in the protocol where requirements are further specified. The table also identifies items for which a verification body is expected to apply professional judgment during the verification process. Verification bodies are expected to use their professional judgment to confirm that protocol requirements have been met in instances where the protocol does not provide (sufficiently) prescriptive guidance. For more information on the Reserve's verification process and professional judgment, please see the Verification Program Manual.

Note: These tables shall not be viewed as a comprehensive list or plan for verification activities, but rather guidance on areas specific to boiler efficiency projects that must be addressed during verification.

8.7.1 Project Eligibility and CRT Issuance

Table 8.2 lists the criteria for reasonable assurance with respect to eligibility and CRT issuance for boiler efficiency projects. These requirements determine if a project is eligible to register with the Reserve and/or have CRTs issued for the reporting period. If any requirement is not met, either the project may be determined ineligible or the GHG reductions from the reporting period (or subset of the reporting period) may be ineligible for issuance of CRTs, as specified in Sections 2, 3, and 6.

Table 8.2. Eligibility Verification Items

Protocol Section	Eligibility Qualification Item	Apply Professional Judgment?
2	Verify that the project meets the definition of a Mexico Boiler Efficiency project.	No
2.3	Verify ownership of the reductions by reviewing Attestation of Title.	No
3.2	Verify project start date.	No
3.2	Verify accuracy of project start date based on operational records.	Yes
3.2	Verify that the project has documented and implemented a Monitoring Plan.	No
3.3	Verify that project is within its 10-year crediting period.	No
3.4.1	Verify that the project meets the Performance Standard Test.	No
3.4.2	Confirm execution of the Attestation of Voluntary Implementation form to demonstrate eligibility under the Legal Requirement Test.	No
3.4.2	Verify that the project Monitoring Plan contains a mechanism for ascertaining and demonstrating that the project passes the Legal Requirement Test at all times.	No
3.5	Verify that the project activities comply with applicable laws by reviewing any instances of non-compliance provided by the project developer and performing a risk-based assessment to confirm the statements made by the project developer in the Attestation of Regulatory Compliance form.	Yes
6	Verify that monitoring meets the requirements of the protocol. If it does not, verify that a variance has been approved for monitoring variations.	No

8.7.2 Quantification

Table 8.3 lists the items that verification bodies shall include in their risk assessment and recalculation of the project's GHG emission reductions. These quantification items inform any determination as to whether there are material and/or immaterial misstatements in the project's GHG emission reduction calculations. If there are material misstatements, the calculations must be revised before CRTs are issued.

Table 8.3. Quantification Verification Items

Protocol Section	Quantification Item	Apply Professional Judgment?
2.2.1, 2.2.2, 2.2.3, 4	Verify that appropriate system boundaries in line with protocol guidance are chosen for the boiler.	Yes
4	Verify that all SSRs in the GHG Assessment Boundary are accounted for.	No
5.1	Verify that the baseline emissions are properly aggregated.	No
5.1.1, 5.1.2, 5.2.1, 5.2.3	Verify that the project developer applied the correct emission factors for fossil fuel combustion and grid-delivered electricity.	No
5.1.1, 5.1.2, 5.2.1, 5.2.3	If default emission factors are not used, verify that project-specific emission factors are have been calculated using an acceptable method and/or by an appropriately experienced testing facility.	Yes
5.1.1, 5.2.1	Verify that the project developer correctly monitored, quantified, and aggregated fossil fuel use.	Yes

Protocol Section	Quantification Item	Apply Professional Judgment?
5.1.1, 5.2.1	Verify that the project developer correctly applied the emission factors published in the Instituto Mexicano del Petroleo (IMP) study commissioned by INECC.[72]	No
5.1.2, 5.2.3	Verify that the project developer correctly monitored, quantified, and aggregated electricity use.	Yes
5.1.2, 5.2.3	Verify that no material increase in electricity consumption due to project is expected, or where such changes are expected, such increases have been accounted for in accordance with protocol requirements.	Yes
5.2	Verify that the project emissions were calculated according to the protocol with the appropriate data.	No

8.7.3 Risk Assessment

Verification bodies will review the following items in Table 8.4 to guide and prioritize their assessment of data used in determining eligibility and quantifying GHG emission reductions.

Table 8.4. Risk Assessment Verification Items

Protocol Section	Item that Informs Risk Assessment	Apply Professional Judgment?
6	Verify that the project Monitoring Plan is sufficiently rigorous to support the requirements of the protocol and proper operation of the project.	Yes
6	Verify that appropriate monitoring equipment is in place to meet the requirements of the protocol.	No
6	Verify that the individual or team responsible for managing and reporting project activities are qualified to perform this function.	Yes
6	Verify that appropriate training was provided to personnel assigned to greenhouse gas reporting duties.	Yes
6	Verify that all contractors are qualified for managing and reporting greenhouse gas emissions if relied upon by the project developer. Verify that there is internal oversight to assure the quality of the contractor's work.	Yes
7.2	Verify that all required records have been retained by the project developer.	No

8.7.4 Completing Verification

The Verification Program Manual provides detailed information and instructions for verification bodies to finalize the verification process. It describes completing a Verification Report, preparing a Verification Statement, submitting the necessary documents to the Reserve, and notifying the Reserve of the project's verified status.

[72] The relevant defaults can be found here: http://www.inecc.gob.mx/descargas/cclimatico/2014_inf_fin_tipos_comb_fosiles.pdf.

9 Glossary of Terms

Accredited verifier	A verification firm approved by the Climate Action Reserve to provide verification services for project developers.
Additionality	Project activities that are above and beyond "business as usual" operation, exceed the baseline characterization, and are not mandated by regulation.
Anthropogenic emissions	GHG emissions resultant from human activity that are considered to be an unnatural component of the Carbon Cycle (i.e., fossil fuel destruction, de-forestation, etc.).
Biogenic CO_2 emissions	CO_2 emissions resulting from the destruction and/or aerobic decomposition of organic matter. Biogenic emissions are considered to be a natural part of the Carbon Cycle, as opposed to anthropogenic emissions.
Carbon dioxide (CO_2)	The most common of the six primary greenhouse gases, consisting of a single carbon atom and two oxygen atoms.
CO_2 equivalent (CO_2e)	The quantity of a given GHG multiplied by its total global warming potential. This is the standard unit for comparing the degree of warming which can be caused by different GHGs.
Direct emissions	GHG emissions from sources that are owned or controlled by the reporting entity.
Effective Date	The date of adoption of this protocol by the Reserve board: November 1, 2016.
Energy credits	Defined by ASME PTC 4-2013 as the energy entering the steam generator envelope other than the chemical energy in the as-fired fuel. Credits can be negative, such as when the air temperature is below the reference temperature.
Energy losses	Defined by ASME PTC 4-2013 as the energy that exits the steam generator envelope other than the energy in the output stream(s).
Emission factor (EF)	A unique value for determining an amount of a GHG emitted for a given quantity of activity data (e.g., metric tons of carbon dioxide emitted per barrel of fossil fuel burned).
Fossil fuel	A fuel, such as coal, oil, and natural gas, produced by the decomposition of ancient (fossilized) plants and animals.
Greenhouse gas (GHG)	Carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), sulfur hexafluoride (SF_6), hydrofluorocarbons (HFCs), or perfluorocarbons (PFCs).
GHG reservoir	A physical unit or component of the biosphere, geosphere, or hydrosphere with the capability to store or accumulate a GHG that has been removed from the atmosphere by a GHG sink or a GHG captured from a GHG source.

GHG sink	A physical unit or process that removes GHG from the atmosphere.
GHG source	A physical unit or process that releases GHG into the atmosphere.
Global Warming Potential (GWP)	The ratio of radiative forcing (degree of warming to the atmosphere) that would result from the emission of one unit of a given GHG compared to one unit of CO_2.
Higher Heating Value	Defined by ASME PTC 4-2013 the total energy liberated per unit mass of fuel upon complete combustion as determined by appropriate ASTM Standards. The higher heating value includes the latent heat of the water vapor. When the heating value is measured at constant volume, it must be converted to a constant pressure value for use in this Code.
Indirect emissions	Emissions that occur at a location other than where the project is implemented, and/or at sources not owned or controlled by project participants.
MMBtu	One million British thermal units.
Mobile combustion	Emissions from the transportation of employees, materials, products, and waste resulting from the combustion of fuels in company owned or controlled mobile combustion sources (e.g., cars, trucks, tractors, dozers, etc.).
Project baseline	A “business as usual” GHG emission assessment against which GHG emission reductions from a specific GHG reduction activity are measured.
Project developer	An entity that undertakes a GHG project, as identified in Section 2.3 of this protocol.
Steam generator envelope	The steam generator envelope is the physical boiler enclosure.
Tonne (t, metric ton)	A common international measurement for the quantity of GHG emissions equal to 1 Mg or 1,000 kg and equivalent to about 2204.6 pounds or 1.1 short tons.
Verification	The process used to ensure that a given participant’s GHG emissions or emission reductions have met the minimum quality standard and complied with the Reserve’s procedures and protocols for calculating and reporting GHG emissions and emission reductions.
Verification body	A Reserve-approved firm that is able to render a verification opinion and provide verification services for operators subject to reporting under this protocol.

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Appendix A Development of the Performance Standard

A.1 Background Introduction to the Reserve's Standardized Approach to Additionality

The starting place for an assessment of additionality is often to ask the simple question, *Would this project have taken place, if not for the incentive provided by the carbon credit?* The Reserve assesses the additionality of projects through the application of a Performance Standard Test and a Legal Requirement Test. The Legal Requirement Test is an eligibility criterion, described in Section 3.4.2, and is based on research summarized in Appendix B, which addresses the question, *Are the proposed project activities mandated by any regulations in the jurisdiction in question*?" The Performance Standard Test is also an eligibility criterion, described in Section 3.4.1, and is developed based on the research summarized in this appendix. As discussed in more depth below, in developing the Performance Standard Test, the Reserve's research asks the questions, *What technologies, activities, and/or level of performance are beyond "business as usual"? What drivers or barriers to implementation are currently influencing that level of performance?*

A.2 Developing a Performance Standard Test

To inform the Performance Standard Test, the Reserve typically undertakes an assessment of prevailing practice in the specific industry and jurisdiction in question, which includes assessing drivers of adoption for a given practice or technology, as well as what the barriers to adoption might be. The Reserve seeks to develop a performance standard that represents a level of performance (applied to those particular project activities) that goes beyond what is common practice in the industry today. The purpose of the performance standard in this protocol, therefore, is to establish a performance threshold applicable to all boiler energy efficiency projects that is significantly better than average boiler efficiency in Mexico. Project boilers that meet or exceed this efficiency-based performance threshold are eligible under this protocol, having demonstrated that they go beyond common practice and are therefore "additional."

A.2.1 Preliminary Analysis to Inform Protocol Development

Much of the Reserve's early analysis of boiler energy efficiency opportunities began first with an assessment of boiler energy efficiency opportunities in the U.S. The Reserve commissioned an issue paper, undertaken by consulting firm SAIC, which was finalized in 2009.[73] This work then informed further unpublished background research undertaken by the Reserve and SAIC for the U.S. EPA's Climate Leaders Program, on the potential for boiler efficiency opportunities in Mexico in 2011. The Reserve continued to explore boiler energy efficiency opportunities in Mexico and in 2013 commissioned two issue papers to study boiler and furnace energy efficiency in Mexico. Results from this analysis were first presented to the Reserve in 2013, and updated papers presented in 2014. Highlights of this analysis are summarized below.

According to the International Energy Agency (IEA), Mexico annually uses approximately 460 PJ of energy to generate steam, and the energy consumed to produce steam can be decreased by at least 50 PJ, and emissions reduced by as much as 3 million tCO_2e per year in Mexico.[74] While the results of this preliminary analysis demonstrated significant technical potential for boiler energy efficiency improvements in Mexico, as highlighted above and further in Section 2.1

[73] A copy of the Boiler Efficiency Improvements issue paper can be downloaded from the Reserve website here: http://www.climateactionreserve.org/how/future-protocol-development/issue-papers/.
[74] IEA (2007).

of the protocol, it was clear that a lack of published data on boiler efficiency would make the development of an offsets protocol with a standardized performance threshold difficult. Notably, no official database exists in the country on the number, type, size, and efficiency of boilers currently installed and operating in Mexico. There is only one single reference on this subject, corresponding to a USAID-funded study titled *Estimate of Industrial Boiler Facilities in Mexico*, which was undertaken to determine the number of boilers by boiler type and design, developed for CONUEE (then CONAE) in 1999.[75] A discussion of some conclusions from this study is provided further below, since the conclusions drawn from this study are relevant, even though it is based on data which are no longer current.

A.2.1.1 Results from Analysis of the CONUEE Study and Underlying Data

The CONUEE study, *Energy Efficiency in Steam Generation and Distribution Systems Pilot Project*,[76] involved boiler audits at 37 companies across 12 states in Mexico, mostly in Estado de México, Veracruz and Jalisco. The study included the chemicals, food, paper, textiles and manufacturing industrial sectors, all of which use large quantities of steam in their operations. Overall, the 37 companies that participated in the program had a collective annual primary energy consumption of 25,522,655 GJ/year, or approximately 2% of the industrial sector's overall primary energy consumption.[77]

In unpublished work developed by SAIC and the Reserve for the U.S. EPA's Climate Leaders Program, SAIC used the CONUEE report and the Microsoft Access database containing the underlying data from the audits cited in the report, were used to develop some proposed performance threshold options. These performance thresholds were ultimately based on 83 boilers at 27 Mexican facilities in a series of audits in the late 1990s. The boilers were grouped by fuel-type burned (fuel oil, diesel, natural gas, etc.), and each boiler was ranked from most efficient to least efficient within its group. SAIC set the proposed performance threshold at the efficiency within each fuel group corresponding to the upper 25th percentile.[78] These proposed performance thresholds have been included below, for reference:

Fuel	Upper 25th Percentile (%)
Fuel Oil	82.4%
Diesel	82.0%
Natural Gas	81.0%
Gas Oil	81.2%
Liquefied Petroleum Gas	82.4%
Petroleum Coke	82.4%
Coke of Coal	82.4%

A.2.2 Methodology for Assessing Boiler Energy Efficiency in Mexico

Utilizing results from this early analysis, the Reserve put together a proposed scope for exploring carbon offset opportunities for industrial energy efficiency opportunities in Mexico, and secured funding to develop a Mexico energy efficiency protocol from the U.S. Agency for International Development (USAID), which provided funding through its Mexico Low Emission Development Program (MLED), as well as from Mexico's Secretariat of Energy (SENER)

[75] CONAE (1999).
[76] *Ibid.*
[77] CONAE (1999). Cited in unpublished research of the U.S. EPA Climate Leaders Program.
[78] Unpublished research of the U.S. EPA Climate Leaders Program. 25% was selected for illustration purposes only.

through its Fund for Energy Transition and Sustainable Use of Energy (Fondo para la Transición Energética y el Aprovechamiento Sustentable de la Energía (FOTEASE)).

Due to the numerous opportunities for energy efficiency improvements across Mexico's industrial and commercial sectors and priorities of USAID, SENER and other stakeholders to include as wide a range of these improvements as possible, the initial scope for this protocol development process sought to address energy efficiency at both industrial boilers and furnaces in Mexico. From the start, the Reserve focused on an evaluation process to determine which industrial and commercial energy consumption practices could best be incorporated into a Mexican energy efficiency protocol.

Due to the wide range of equipment included in those two subsets and the high level of variability between boiler and furnace efficiency, the Reserve first sought to limit the scope to include only process heaters, instead of all types of furnaces, and later, decided to exclude process heaters as well, due to several factors including the differences between steam boilers and process heaters, and the huge variety of process fluids for furnaces. There is also no international precedent for attempting to include such a wide range of energy efficiency measures across an entire sector(s) in a single carbon offset protocol, and the Reserve was concerned, from a policy perspective, that too broad of a definition would invite unnecessary scrutiny from the environmental community and other stakeholders. From a practical perspective, challenges with data acquisition, discussed further below, combined with the complexity and disparity among the many potential eligible equipment types considered in the initial scope, necessitated that the scope of the protocol be refined and narrowed from that initial starting position, to best ensure the protocol can be developed on time and within budget.

As such, the Reserve determined it best to focus on a strong protocol to incentivize improved boiler efficiency in a subset of large boilers that represent a major portion of industrial energy consumption and the majority of emission reduction opportunities. If additional funding is available in the future, the Reserve may consider developing a protocol to incentivize improved process heater efficiency as well, to address the unmet opportunity identified in the initial issue papers.

As part of the protocol development process, the Reserve convened a work group to whom it presented both our initial proposed scope, as well as subsequent scope refinements, which are discussed in depth in a report to the Mexico Boiler Efficiency workgroup.[79] Once the scope was limited to boilers only, the refined scope of protocol development included four main project activities, namely:

1. **Retrofitting existing boilers.** Installing new efficiency improvement technologies to existing boilers.
2. **Installing new high-efficiency boilers.** Installing a new boiler that demonstrates greater efficiency than conventional alternatives
3. **Early retirement of existing boilers.** Replacing an existing, inefficient boiler with a more efficient boiler prior to the end of its useful life and scheduled retirement.
4. **Fuel Switching.** Through retrofits, switching boiler fuel use from a high-carbon intensity fuel to low-carbon intensity fuel.

[79] Climate Action Reserve (2015). *Memo to the Mexico Boiler Efficiency Workgroup: Recommendations from the Climate Action Reserve for a Refined Protocol Scope*.

Drawing on the combined expertise of the protocol development team and the work group, the Reserve then undertook research to explore the feasibility of developing a range of performance standard options covering these activities.

The Reserve team determined early on that there was insufficient, recently published data available on boiler efficiencies in Mexico to facilitate the development of a standardized performance threshold necessary to include all boilers in Mexico. With limited resources, the Reserve and technical team further refined recommendations for equipment types to be included in the protocol. Due to various policy, data and technical rationale, it was determined that it would be most efficient for the protocol to focus exclusively on steam boilers greater than 9.8 MW. This size threshold generally excludes smaller water heaters and water tube boilers, Further, financial calculations by the Reserve estimated a minimum boiler size of at least 9.8 MW (or 33.5 MMBtu/h) for net positive cash flow as a carbon offset project; allowing for multi-boiler projects at a single facility might improve the positive cash flow further, and/or allow for smaller boilers to participate, which might be a possible protocol expansion in the future. From a policy perspective, the lack of available data on which to base a performance standard threshold, combined with the complexity and disparity among many potential eligible equipment types, necessitated additional refinements and narrowing of scope. In terms of data availability, international best practice in terms of standardized carbon offset additionality assessments (pioneered by the Reserve) requires that methodologies only include equipment and activities for which there is sufficient data to develop robust scope and additionality assumptions. Given a lack of available published data on even this smaller subset of boilers, the Reserve undertook primary research to obtain such necessary data.

A.3 Summary of Primary Data Collection and Analysis Performed by the Reserve

A.3.1 Collection of Primary Data on Boiler Energy Efficiency in Mexico

Following the initial analysis described above, the Reserve had a clear understanding of the type of data necessary for development of the desired performance standard options. The Reserve first attempted to engage directly with Original Equipment Manufacturers (OEM) to elicit information regarding the performance of equipment manufactured and/or serviced by those parties and data on their market estimations. This attempt was unsuccessful, as no OEM was willing to disclose any such information.

The Reserve also turned to work group members to further efforts for gathering data. SEMARNAT graciously offered to be the focal point for organizing a data request effort, directed to all users with boilers of approximately 9.8 MW or greater, registered in the federal database of air emissions stationary sources. The Reserve team provided SEMARNAT with a detailed excel-based data request form, which SEMARNAT in turn forwarded to stakeholders, together with a formal invitation to provide information in an anonymous fashion; together, MLED and the Reserve also engaged with some key stakeholders directly. Overall, the data request was sent to 107 companies with whom SEMARNAT, MLED and/or the Reserve were already engaged with on energy efficiency efforts. The Reserve also engaged directly with representatives and staff from a number of these stakeholder companies to encourage participation, answer clarifying questions, and ask our clarifying questions on the operations data itself, to ensure accurate interpretation of the data. As a part of this process, the Reserve team has kept all responses confidential and anonymous.

The data request forms called for submission to the Reserve of data on various key data points, including information on maintenance, whether key subcomponents were used, equipment age and expected lifetime, fuel types and volume of fuel consumed, steam output properties, and an internal assessment of boiler efficiency from the boiler owners themselves.

A.3.2 Summary of Primary Data Collection and Analysis Performed by the Reserve

As a response to these data requests the Reserve team received data from 37 companies or industrial units engaged in a wide range of businesses in the industrial, manufacturing, oil and gas, and petrochemical sectors. Unfortunately, we were unable to include the electricity sector due to a lack of data. In total, 125 boilers were analyzed, ranging from 1.4 to 229.4 MW in size. All data were analyzed, despite the fact that the lowest capacity included in the protocol now is 9.8 MW. However, in the analysis summarized here, boilers below a capacity of 9.8 MW are excluded. The total boiler data count for categories included in the protocol (i.e., 9.8 MW or above) was 115 boilers.

Only 112 out of the original 125 boilers included efficiency data, which was a primary driver for the survey. If we take into account only the boilers pertaining to the categories to be included in the protocol, efficiency data were provided for 107 of 115 boilers. Boilers burning biomass or biomass derived fuels were also excluded from further analysis. Though the number of boilers currently using biomass is small, including these boilers in the full population skewed the efficiency data, as the biomass boilers were either very old and inefficient or brand-new with particularly high efficiencies. As such, though boilers using biomass are eligible for this protocol, their efficiencies did not ultimately inform the analysis herein, bringing the population of boilers with efficiency data included in the analysis down to 96 eligible boilers.

Multiple different analyses were performed on these boilers, examining efficiencies according to fuel type, capacity, inclusion of specific energy efficiency technology, etc. The following results are specific to these 96 eligible boilers.

In particular, graphs plotting data dispersion are provided below for the eligible boilers. The red line in each graph represents the linear data trend for graphed data sets.

Figure A.1, below, shows all boilers 9.8 MW and greater, where the efficiency ranges from 69.2% to 87.2%. As anticipated, the trend line has an ascending slope, meaning that in general, the higher capacity boilers have better performance levels than the lower capacity ones. This was an expected behavior, as normally higher capacity boilers have better control systems and heat recovery equipment, whereas radiation and convection losses represent a smaller percentage of total heat input in larger boilers than in smaller ones, given ratios of exposed area to total volume decrease with increasing boiler size.

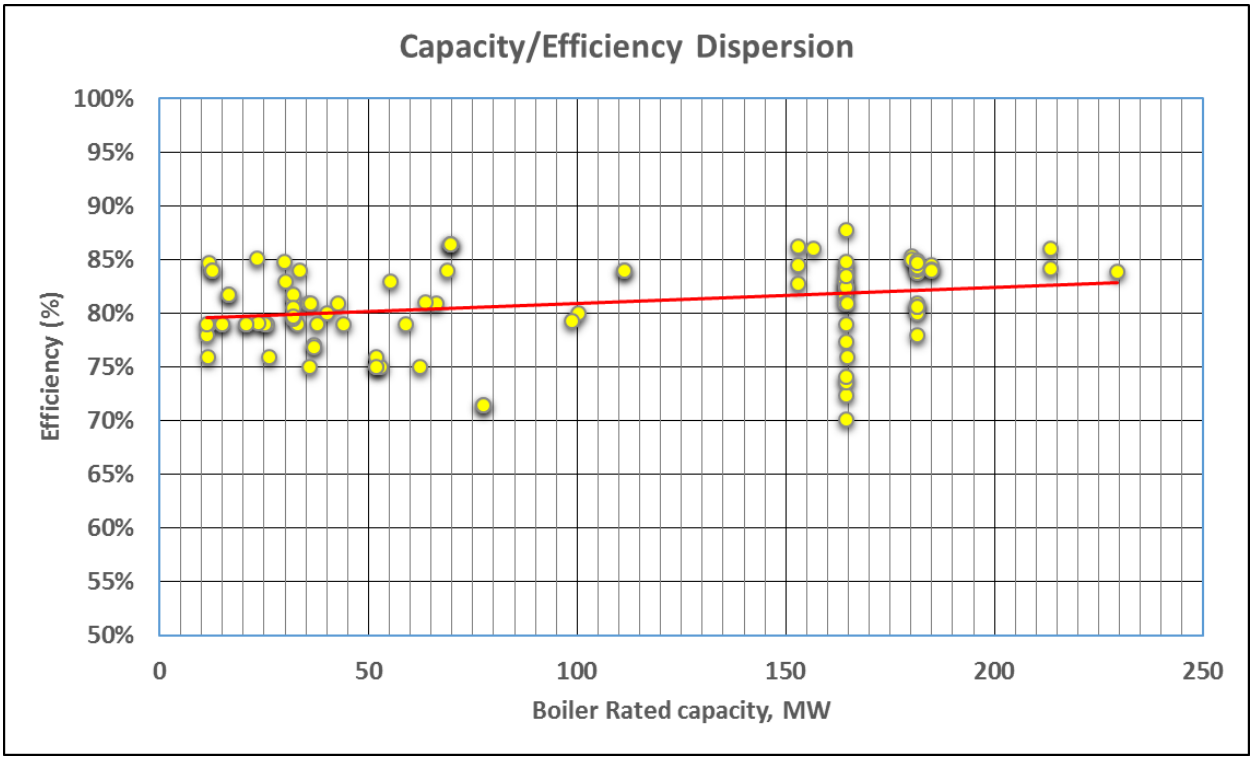

Figure A.1. Capacity/Efficiency Dispersion of All Boilers 9.8 MW and Greater

The boiler population in Mexico for this boiler capacity range (9.8 MW and greater) has been estimated at 2,900 boilers. The sample of 96 boilers was assessed to have a confidence interval of 9.84[80] with a 95% confidence level, and as such, the Reserve believes that the sample was statistically representative of a total population of 2,900 boilers.

A.4 Data Management and Important Considerations on Reported Efficiency Data

Upon receipt of the data from the various sources discussed above, the Reserve evaluated the way reported efficiency values were estimated, in order to assess whether some additional data management or correction of such values was needed or not; it was immediately clear that some additional level of data management would be necessary in order to ensure reported boiler efficiency results were calculated consistently across all reporting data sources and as close to the correct, on-the-ground values as possible. The main considerations to consider, in better understanding the need for and process of data management, as well as the implications and subsequent best approach for establishing the performance standard threshold based on that data is discussed in depth below.

Almost immediately, the Reserve identified the possibility that some reported efficiencies were taken directly from flue gas analyzer displays, a fact which was confirmed through direct communication with boiler operators Taking efficiency measurements from the flue gas analyzer results in higher reported efficiencies than actually occurs, as the flue gas analyzers' efficiency readings do not consider all of the potential energy losses other than waste heat in the flue gases. The main losses to be considered, beyond the aforementioned waste heat in flue gases,

[80] As found on the Creative Research Systems website (sample size calculator) at http://www.surveysystem.com/sscalc.htm.

are radiation and convection losses, which normally represent 0.5% to 1.5% of total heat input, and manufacturer's margin or undetermined losses,[81] which are generally estimated as 0.5% to 1% of total heat input to the boiler in the relevant capacity range.

The result of this reporting error is that reported efficiencies from direct flue gas analyzer readings are between 1% and 2.5% higher than actual performance efficiencies, which should include these additional energy losses, While the Reserve was able to confirm that this reporting error did not occur in a number of circumstances, it is possible that this reporting error may have been present in up to 50% of the data. As there was enough information to identify which data points had been over-reported, efficiency data were modified to correct for these unreported losses in a conservative way, recognizing that the result was a slightly higher than actual mean efficiency, making the performance threshold based on this mean slightly more rigorous. How the Reserve managed for these unreported losses is discussed further below.

Other reported efficiencies were estimated by using measured data intended for environmental compliance tests on criteria air pollutants. These incidences were readily identified by assessing the reported efficiency level, generally over 87% and as great as 96%. The main losses in a boiler are those related to waste heat in flue gases. The minimum level attainable for such losses is a function of the fuel type and quality, and of the boiler equipment. The main parameters used to assess the level of these losses are the excess oxygen level and the flue gas temperature and composition. Considering the minimum level of both radiation and convection losses and manufacturer's margin, these losses would represent 1% of total heat input. The above would mean that maximum attainable efficiency for well operated, well equipped modern boilers would be around 87%, so any efficiency higher than this could only be achieved by means of condensing economizers to eliminate the wet flue gas loss (not suitable except for small boilers), or by using very low excess air equipment, which is not the norm for Mexican industrial boilers. For all of these instances, boiler operators provided data on the fuel type, excess oxygen level and flue gas temperature, which made it easy to identify that in all but one case, stack measurements for environmental purposes were used and they were below water condensing temperature, which was not representative of actual operation.

In order to address these shortcomings, for each of the boilers described above the following three steps were taken with regards to data management:

1. Operators were asked to indicate if reported efficiencies were based on lower or higher heating value (LHV or HHV). When LHV was reported to have been used, conversion to HHV efficiency was made, and if the result fell below the 87% threshold, it was used for analysis.
2. Operators provided data on actual oxygen level and flue gas temperature, which allowed for a conservative boiler efficiency determination.
3. When recorded time series efficiency data existed for the same boiler, determined for optimization purposes, the average efficiency of the three more recent years was used instead.

[81] "It is difficult to predict all losses with exact precision, yet most boiler suppliers are required to provide the purchaser with a guarantee of minimum thermal efficiency from the boiler. To cover the uncertainty of performance, the manufacturer keeps a safety margin or allowance when giving a guarantee of the boiler's performance. This value may vary from manufacturer to manufacturer. A typical value for unaccounted loss or margin is 1.5%." (Basu, 2015)

Meanwhile, in some cases reported boiler efficiencies had a negative sign or were not correctly written; in each case, the Reserve checked with the boiler operators and corrected accordingly for analysis purposes.

On average, it is estimated that reported efficiencies described herein are 2 to 3 percentage points above the actual operating efficiency values, as estimated by using the ASME PTC 4-2013 method, as ASME PTC 4-2013 gives consideration to several other losses and credits that are not accounted for in simplified approaches.

The figures reported herein do not consider efficiency determination uncertainty, which is typically about ±1%, and are not included as they would not significantly affect results for the overall sample.

A.5 Setting the Performance Threshold

Better and more abundant information is always preferable. Nevertheless, as discussed in Section A.3, the sample of primary boiler operations data received is sufficient to furnish an assessment of "business as usual" boiler efficiencies in Mexico and to inform a performance standard threshold for this protocol.

Having analyzed all data, and based on feedback on potential performance thresholds from the workgroup, the Reserve ultimately decided to set two performance thresholds, one for boilers 9.8 MW to 100 MW and one for boilers larger than 100 MW, due to the fact that the larger capacity boilers clearly had higher efficiencies. The performance standard was set at the mean of the analyzed data for all boilers within the respective size ranges. Due to the fact that the reported efficiencies are likely to be 2 to 3 percentage points higher than actual operating conditions, as well as the fact that many of the companies who reported data are already engaged in energy efficiency activities with CONUEE, the Reserve believes this is conservative. A boiler that passes the performance threshold and is therefore eligible under this protocol needs to achieve a level of performance that is better than approximately 50% of existing boilers in Mexico. In other words, the Reserve determined that if boilers implementing the project activities discussed in this protocol are able to increase boiler efficiency and achieve an efficiency equal to or better than the efficiency in Table A.1 (see below), that boiler project is considered additional.

Table A.1. Performance Standard Threshold (reproduced from Table 3.1)

Boiler Capacity	Performance Threshold
Boilers 9.8 to 100 MW (33.5 –341.4 MMBtu/h)	80.5%
Boilers > 100 MW (>341.4 MMBtu/h)	82%

A.6 Excluding Fuel Switch Projects

Though the Reserve initially sought to include a wide range of potential project activities in the proposed scope, over the course of the protocol development process the Reserve decided to exclude fuel switching activities. That is, while a switch from a high carbon-intensity fuel to lower carbon-intensity fuel such as natural gas is certainly desirable from a greenhouse gas and general environmental perspective, this project activity could not be deemed "additional" under this protocol. In addition, this protocol is focused on energy efficiency activities, not fuel switching activities.

Such a fuel switch is not legally required, but there are numerous existing drivers which call into question whether such a fuel switch is occurring due to these other drivers, or due to a carbon offset incentive. In 2012, the Mexican Congress unanimously passed a General Law on Climate Change (LGCC), that mandates a 30% reduction in emissions below "business as usual" by 2020 and a 50% reduction below 2000 levels by 2050.[82] It also establishes a number of clean energy goals, such as the "promotion of energy efficiency practices, the development and use of renewable energy sources and the transfer and development of low carbon technologies."[83] Mexico has had a tax on fossil fuels since it was passed by Congress in 2013. The amount of tax to be paid varies by the emissions intensity of the fossil fuel in question, relative to natural gas, with natural gas itself exempt from the tax. In addition to the General Law on Climate Change and the tax on fossil fuels, on December 2013, Mexico's Congress voted to modify the Constitution to allow both domestic and foreign private investment in the energy sector.[84] This change effectively ended the monopolies held by state-owned PEMEX and CFE, in the oil and gas sector and electricity sector, respectively. All of these factors have combined to facilitate and provide incentives for comprehensive reform in the energy sector. Most recently, in December 2015, the Energy Transition Act was published, describing the new legal order related to renewable technologies for electric generation.[85]

As such, numerous existing drivers encouraging a fuel switch to natural gas include:

- The goals and objectives outlined in the Mexican General Law on Climate Change (LGCC) and supporting regulation
- Financial incentive provided by exempting natural gas from the tax on fossil fuels (i.e., lower taxes payable for lower carbon-intensive fuels)
- The general trend in Mexico and globally to switch to lower carbon-intensive fuels, and natural gas, in particular. In Mexico, this switch to natural gas has been driven by market forces for the past few years

Additional background on this fuel switch trend is provided in Section 2.1 of the protocol, while Section 2 and Appendix B contain further information on the regulatory background relevant to climate change policy in Mexico, as well as further information on industrial emissions and the emissions potential of this protocol.

A.7 Limitations on New Boiler Projects

The new boiler project type incentivizes the early retirement of an inefficient boiler, to be replaced with a new, high efficiency boiler sooner than the boiler would have been replaced under "business as usual." As such, it is important to evaluate the typical ages of boilers in operation in Mexico and the ages boilers are typically retired.

The average age of the eligible boiler sample is 30 years from date of commissioning. However, there were many boilers in the sample that were significantly older than that, with some boilers remaining in use for 40 or 50 years.

[82] Cámara de Diputados del H. Congreso de la Unión (2016). *Ley General de Cambio Climático.*
[83] *Ibid.*
[84] Cámara de Diputados del H. Congreso de la Unión (2013). *Decreto por el que se reforman y adicionan diversas disposiciones de la Constitución Política de los Estados Unidos Mexicanos, en Materia de Energía.*
[85] Cámara de Diputados del H. Congreso de la Unión (2015). *Ley de Transición Energética.*

A graph presenting the capacity/age dispersion for the boilers in the sample is presented in Figure A.2.

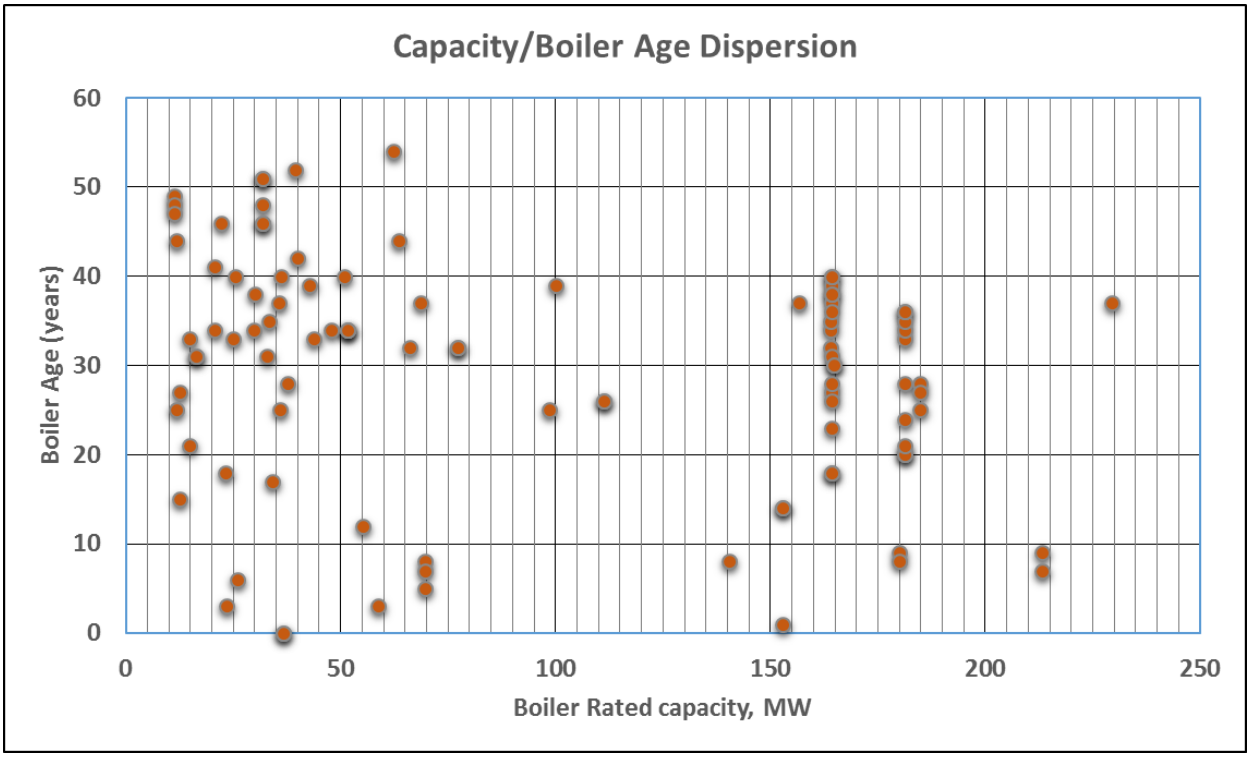

Figure A.2. Capacity/Boiler Age Dispersion of All Boilers 9.8 MW and Greater

Workgroup members also shared anecdotally that it is not uncommon for boilers in Mexico to be even older. No data directly reporting “age of retirement” was collected. Based on the boiler sample and anecdotal evidence from the workgroup, the Reserve decided to allow new boiler projects only when the existing baseline boiler is 35 years or less, as it is assumed that beyond 35 years old, the likelihood of a “business as usual” boiler replacement increases.

Appendix B Summary of Legal Requirements and Regulatory Framework Research

As noted in Appendix A, the starting place for an additionality assessment is often to ask the simple question, *Would this project have taken place, if not for the incentive provided by the carbon credit?* The Reserve assesses the additionality of projects through the application of a Performance Standard Test and a Legal Requirement Test. The Performance Standard Test and underlying research are discussed in Section 3.4.1 and Appendix A, respectively. The Legal Requirement Test is described in Section 3.4.2, while the underlying research informing this Legal Requirement Test is summarized here, addressing the question, *Are the proposed project activities mandated by any regulations in the jurisdiction in question?*

B.1 National Climate Policy in Mexico's Legal Framework

The following provides further details on some of the key developments in Mexican climate-related policy and law.

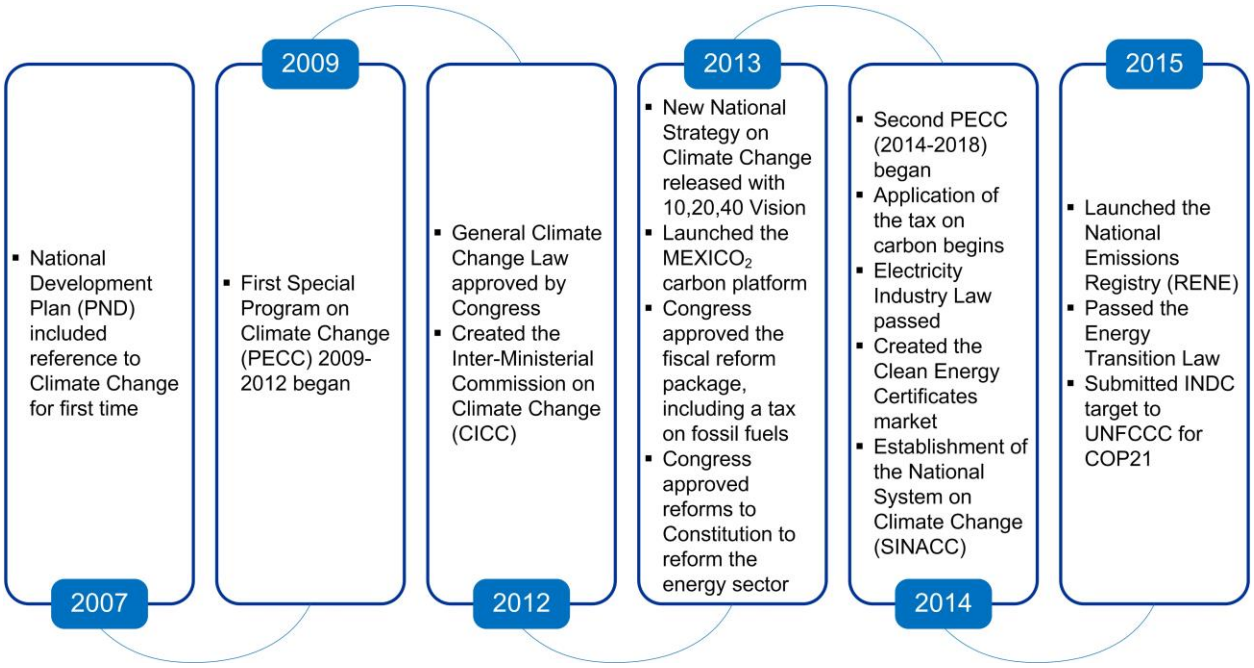

Figure B.1. Timeline of Mexican Climate Change Policy

B.1.1 International Commitments

Mexico has been a member party to the United Nations Framework Convention on Climate Change (UNFCCC) since it was signed in 1992. As a member party, Mexico has submitted five National Communications, with the most recent in 2012. National Communications to the UNFCC provide information on GHG inventories, plans to implement climate change adaptation and mitigation measures, and other information pertinent to achieving the objective of the Convention.[86]

[86] UNFCCC (2014). National Reports. Available at http://unfccc.int/national_reports/items/1408.php

Leading up to the 2015 UNFCCC Conference of the Parties in Paris, Mexico[87] was the first developing country (and one of the first countries overall) to release its post-2020 climate action plan, or Intended Nationally Determined Contribution (INDC), and was a leader in expressing its willingness to achieve a legally binding agreement with the participation of all Parties to the UNFCCC. Mexico's INDC included a GHG reduction target of 22% by 2030 relative to a BAU baseline scenario. Moreover, it was one of the only countries to distinctly state a target for reducing emissions of black carbon, for which it set a target of 51% by 2030 relative to BAU. Moreover, Mexico further reported it would be able to achieve greater reductions, up to 40% for GHG and 70% for black carbon, with additional international support, particularly through technology transfers and financial aid. Finally, Mexico's INDC uniquely stated that their emissions will need to peak by 2026 at the latest in order to achieve its GHG reductions goal.[88]

B.1.2 Domestic Policies and Policy Instruments

As required in the Mexican Constitution, the Federal Government, under the leadership of the president, publishes a National Development Plan (PND) to outline vision and objectives for national, state and municipal planning every five years. The 2007-2012 PND signified a milestone in the nation's strategic planning, referring specifically to climate change in a national planning tool for the first time.[89]

Also in 2007, Mexico published its first National Strategy on Climate Change (ENCC), recognizing climate change as one of the primary challenges at the global level. The 2007 ENCC included mitigation and adaption measures.[90] Mexico published its second ENCC in 2013 with 10, 20 and 40 year visions to address national priorities related to climate change, which focus on adaptation and low emission development.[91]

Mexico released its first Special Program on Climate Change (PECC) for 2009-2012 in order to provide specific targets and actions to operationalize the PND and ENCC. The PECC provided both short-term and long-term goals. The long-term vision included reductions in GHG emissions of 50% from 2000 or 70% from the BAU projected emissions for 2050. To achieve this long-term vision, the PECC outlined reductions for 2020 and 2030 as a 20.6% and 41.0% respectively as compared to the BAU projections, and set the short-term goal of 51 million tCO_2e in 2012 compared to BAU projects.[92] Mexico exceeded its 2012 goal by 4% by achieving reductions of 52.76 million tCO_2e.[93]

Mexico's General Law on Climate Change (LGCC), published on June 6, 2012 set three overarching goals: to create a pathway towards low-carbon development, to build resiliency of people, ecosystems and infrastructure, and to establish inclusive policies that coordinate amongst all levels of government and include all sectors of society. The LGCC further established an indicative aspirational goal of 30% reduction in emissions by 2020, below a projected BAU scenario for 2020; and a 50% reduction in emissions by 2050 below emissions from the year 2000. It also mandates the *"promotion of energy efficiency practices, the development and use of renewable energy sources and the transfer and development of low carbon technologies,"* as well as points out that "*the Ministry of Energy (SENER), in coordination*

[87] Fransen et al. (2015).
[88] Mexico (2015). *Intended Nationally Determined Contribution*.
[89] Mexico (2007). *Plan Nacional de Desarrollo 2007 – 2012.*
[90] CICC (2007). *Estrategia Nacional de Cambio Climático: 2007*.
[91] CICC (2013). *Estrategia Nacional de Cambio Climático: Visión 10-20-40.*
[92] CICC (2009). *Programa Especial de Cambio Climático: 2009-2012.*
[93] CICC (2012). *Quinta Comunicación Nacional ante la Convención Marco de las Naciones Unidas sobre el Cambio Climático.*

with the Federal Commission of Electricity (CFE) and Energy Regulatory Commission (CRE), will promote electricity generation from clean energy sources reach at least 35 percent by 2024."[94]

The LGCC further established several policy instruments and government bodies to oversee the implementation and evaluation of climate change regulations. The National Institute of Ecology and Climate Change, for example, was created as a decentralized entity to coordinate and evaluate the implementation of the LGCC. Additionally, the LGCC setup the Climate Change Fund to channel financial resources for climate change mitigation and adaptation measures, and established the Inter-Ministerial Commission on Climate Change (CICC). The CICC is compiled of 13 Secretariats and has the authority to propose alternatives regulatory instruments, under the law, related to emissions. Moreover, the LGCC states that an emissions trading scheme could link to other countries or international carbon markets. Finally, the LGCC mandated the integration of a National Emissions Registry, further discussed below.[95]

Following the LGCC, Mexico released its second Special Program on Climate Change (PECC) for 2014-2018. The second PECC included 5 objectives, 26 strategies, 99 actions and an annex of complementary actions to help Mexico reach the emissions reductions outlined in the LGCC. In addition, the second PECC contained 2 measureable indicators for each of the 5 over-arching objectives. The objectives included:

1. To increase resiliency by developing strategic infrastructure;
2. To conserve and manage ecosystems and develop mitigation and adaptation measures;
3. To transition into a competitive low-emissions economy;
4. To reduce emissions of short-lived climate pollutants, and;
5. To establish a consolidated national climate strategy with coordinated efforts across state, municipal, and federal agencies.[96]

The second PECC also contained several targets for emissions reductions. As an indicator for the third goal, the PECC set the 2018 target for tonnes of CO_2 equivalent emitted per megawatt-hour as 0.35 tCO_2e/MWh compared to the 2014 baseline of 0.456 tCO_2e/MWh. Additionally, targets for mitigating methane and black carbon were established for the fourth goal as 161,724 tonnes of CH_4 and 2,156 tonnes of black carbon mitigated per year by 2018, as compared to 0 tonnes mitigated in 2014.[97]

In November 2013, the launch of a voluntary carbon exchange platform, MexiCO_2, was carried out, which aims to support Mexico in reaching its emission reduction targets. The carbon exchange platform is also intended to serve as a registry for all carbon projects in Mexico and to play a role in validating Mexican projects already certified under voluntary standards, including the Climate Action Reserve, Gold Standard, the Verified Carbon Standard, and Plan Vivo.[98]

In 2015, the National Emission Registry (RENE)[99] required for the first time that emitters report GHG emissions from the previous year. RENE imposes a reporting obligation for all companies

[94] Cámara de Diputados del H. Congreso de la Unión (2016). *Ley General de Cambio Climático.*
[95] *Ibid.*
[96] SEMARNAT. *Programa Especial de Cambio Climático 2014 – 2018 (PECC)*. CICC.
[97] *Ibid.*
[98] Calderon, Ciro (2015). *Mexico Aims for Inclusivity with New Carbon Norm, But Does It Bring Rigor?*
[99] Cámara de Diputados del H. Congreso de la Unión (2016). *Ley General de Cambio Climático.*

emitting more than 25,000 tCO_2e/year, which amounted to some 3,000 companies for 2015.[100] Both RENE and MexiCO_2 could further serve to support the potential design of an anticipated national compliance market in Mexico.

In addition to these policy measures and instruments, Mexico has recently implemented a tax on fossil fuels and undergone an energy reform. Both of which are discussed further below.

B.1.2.1 The Tax on Fossil Fuels in Mexico

In 2013, Mexico's Congress passed a tax on the sale and import of all fossil fuels according to their carbon content, except natural gas produced in or imported to Mexico. The amount of tax to be paid varies based on the emissions intensity of the fuel in question, relative to natural gas. The implicit price per tonne of CO_2, for most covered fuels, ranges between MXN40-50 (US$2.50-3).[101] The point of obligation (the entities in the economy that must directly pay the tax) is set right at the top of the supply chain, i.e., on fuel importers and domestic processors. The application of an environmental tax at this level of the system can be an effective way to apply an environmental imposition on the whole economy, especially where there is a lack of robust GHG emissions data for downstream entities.

The tax on fossil fuels in Mexico is unique in that it allows the use of carbon offset credits generated from CDM projects, or Certified Emission Reduction (CERs), in Mexico to meet obligations from the tax on fossil fuels. Instead of allowing offsets to be used to cover a fixed volume of carbon emission obligations (as offsets are typically used in other emission trading systems), parties are allowed to use CER to reduce their overall tax bill by an amount equivalent to the market value of the CER at the time the tax is paid. However, the underlying regulatory mechanisms to allow the use of offsets are still under development, and regulated entities have not yet had the opportunity to use this mechanism in practice. Market participants anticipate further refinement of the law to clarify and operationalize existing rules, as well as to potentially expand the pool of offsets eligible for application against tax obligations, such as other certified offsets generated in Mexico (i.e., Climate Reserve Tonnes or CRTs).[102]

B.1.2.2 Mexico's Energy Reform

In the past several years, Mexico has been undergoing a significant and comprehensive reform in the energy sector. On December 2013, Mexico's Congress voted to modify the Constitution to allow both domestic and foreign private investment in the energy sector, effectively ending the monopolies held by state-owned PEMEX and CFE, in the oil and natural gas sector and electricity sector, respectively.[103]

The energy reform removed the historical vertical integration of electricity generation, transmission, distribution and commercialization of electricity, replacing it with the Wholesale Power Market overseen by the National Center for Energy Control (CENACE). The wholesale market consists of a spot market and futures market for energy as well as a market for associated services and products. The market sets prices based on energy supply, demand and losses, allowing the price to reflect the marginal cost of generation as well as the saturation of

[100] SEMARNAT. *Preguntas Frecuentes: Registro Nacional de Emisiones (RENE) para el reporte de emisiones de compuestos y gases de efecto invernadero*.
[101] Cámara de Diputados del H. Congreso de la Unión (2013). *Ley del Impuesto Especial sobre Producción y Servicios*, Artículo 2: Tasas del Impuesto.
[102] *Ibid*
[103] Cámara de Diputados del H. Congreso de la Unión (2013). *Reforma 212: Constitución Política de los Estados Unidos Mexicanos.*

the electrical grid and level of electricity loss due to transmission. Moreover, the reforms allowed private companies to compete with CFE for the first time to sell directly to medium and large sized consumers,[104] and for private companies to compete with PEMEX to place bids on oil and gas exploration and production contracts.

In 2014, the Mexican government followed-up with secondary reforms to help meet the nation's clean energy goals, including a new Electric Industry Law that established a market for Clean Energy Certificates (CEL). Obligated entities, including qualified users, suppliers, and holders of legacy contracts that produce fossil-fuel based electricity, are required to acquire a minimum quantity of CELs starting in 2018. SENER set the minimum quantity for 2018 at 5% of the entity's total energy consumption, with the percentage set to gradually increase.[105]

Each CEL is equivalent to 1 MWh of energy generated by clean energy sources, without the use of fossil fuels. There are no price preferences given to one source of clean energy over another. The Mexican Energy Regulatory Commission oversees the Clean Energy Market and issues certificates to entities that meet the requirements published in 2015 and provide sufficient evidence to demonstrate they generated a specified amount of energy from clean energy sources. Major power consumers may then purchase CEL to meet their compliance obligations starting in 2018.[106]

December 24, 2015, the Mexican government published The Energy Transition Law (LTE), which described the new legal order related to promoting increased use of renewable energy technologies for electric generation.

The law repealed previously enacted legislation[107] on energy transition and sustainable electricity production, while providing a new regulatory framework to facilitate coordination within the energy sector and established explicit clean energy goals for the long-term as well as the agencies and mechanisms to achieve these goals. Further, it encouraged internalizing externalities when evaluating the cost of electricity generation and reducing pollutants throughout the electricity supply chain.[108]

B.1.3 National Trend Towards Increased Use of Natural Gas

Mexico has steadily been increasing its consumption of natural gas over the last decade, with a large push since the energy reforms in 2013. In part due to volatile prices of petroleum and dropping prices of natural gas in the United States, Mexican energy consumers have largely been switching to natural gas over petroleum-derived fuels. Also, Mexico's energy reform and commitment to reduce GHG emissions further pushed energy consumers towards natural gas as policies and regulations nudged and incentivized the consumption of natural gas over more GHG intensive fuel oils.[109] In 2014, the Mexican government created an agency, the National Center of Natural Gas Control (CENAGAS), to advance the infrastructure and storage system for natural gas in the country. In 2015, the government then passed the Five Year Plan for Expansion of the National Transport and Integrated Storage System for National Gas 2015-

[104] CRE. *Preguntas frecuentes sobre la nueva regulación en temas eléctricos*.
[105] SENER (2014). *Lineamientos que establecen los criterios para el otorgamiento de Certificados de Energías Limpias*.
[106] *Ibid.*
[107] *Ley para el Aprovechamiento de Energías Renovables y Financiamiento de la Transición Energética* (LAERFTE); *Ley para el Aprovechamiento Sustentable de la Energía* (LASE).
[108] Cámara de Diputados del H. Congreso de la Unión (2015). *Ley de Transición Energética*.
[109] EIA (2016). Natural Gas Data: https://www.eia.gov/dnav/ng/hist/n9132mx2m.htm.

2019. The plan describes the country's strategy to meet increasing electricity demand by promoting greater storage and transportation capacity for natural gas.[110]

In part due to the energy reform, greater investment has already started to flow into the construction of infrastructure for natural gas. Currently, there are 15 pipeline projects under development or planned, amounting to over 3,750 km of pipeline in order to increase the import of natural gas, primarily from Texas. Since 2010, Mexican imports of natural gas from the United States have already tripled, and by 2019, they are expected to more than double current capacity.[111,112] Even with the increasing supply of imported natural gas in Mexico, however, demand for natural gas has increased faster nationwide, with problems due to natural gas shortages in some regions of Mexico.[113]

Since PEMEX first explored shale gas in 2011 in northern Mexico, it has continued to expand its exploration, production and consumption of natural gas domestically.[114] Through the creation of Subsidized Productive Businesses (EPS) for Exploration and Production (PEP), and for Industrial Transformation, PEMEX plans to increase production of natural gas by an average annual rate of 0.5%. The portfolio of projects for expanding natural gas supply starting in 2020, includes 29 exploitation projects, 17 exploration projects, 2 integrated exploration and exploitation projects and 30 infrastructure and support projects.[115]

According to SENER's *Prospectiva de Gas Natural y Gas L.P.,* the demand for natural gas is expected to increase over the next decade. More specifically, demand for natural gas and liquid petroleum gas will increase by 8% and 128.9% per year on average respectively from the 2013-2028 period, while demand for fuel oil, diesel and traditional gasoline is predicted to decrease over the same period, with fuel oil demand decreasing of 11.6% per year.[116]

The electricity sector has been the largest consumer of natural gas, with national production of electricity from natural gas increasing from 42.9% in 2004 to 57.0% in 2014.[117] By 2028, total demand for natural gas is expected to increase by 112.1%, in comparison to 2013 levels.[118]

CFE has been gradually switching the generation of electricity from fuel oil to natural gas over the past decade. Natural gas consumption is projected to increase over a period from 2013 to 2018, from 39% of CFE's total demand for energy sources to 67%.[119]

Further, due to requirements of the Energy Transition Law, the General Law for Climate Change, the Electric Industry Law, the National Program for Energy Sustainability, and the Program for Development of the National Electric System (PRODESEN), CFE Operation has established some specific and progressive goals for transition to cleaner fuels, as well as a substitution of installed capacity of certain technology types.

[110] SENER (2015). *Plan Quinquenal de Expansión del Sistema de Transporte y Almacenamiento Nacional Integrado de Gas Natural 2015-2019*.
[111] EIA (2016). Natural Gas Data: https://www.eia.gov/dnav/ng/hist/n9132mx2m.htm.
[112] Clemente (2016).
[113] Anecdotal information shared with Reserve by stakeholder workgroup.
[114] EIA (2015), Mexico country overview: http://www.eia.gov/beta/international/analysis.cfm?iso=MEX.
[115] SENER (2014). *Prospectiva de Gas Natural y Gas L.P. 2014-2028.*
[116] *Ibid.*
[117] SENER (2015). *Prospectiva del Sector Eléctrico 2015-2029*.
[118] SENER (2014). *Prospectiva de Gas Natural y Gas L.P. 2014-2028.*
[119] *Ibid.*

Table B.1. Evolution of Installed Capacity by Technology 2016 - 2030

Year	2016		2030	
Conventional Thermoelectric (Fuel Oil)	10,220 MW	14.52%	2,244 MW	2.05 %
Coal fired power plant	5,378 MW	7.64%	4,098 MW	3.75%
Subtotal	**15,598 MW**	**22.16%**	**6,342 MW**	**5.80%**
Combined cycle (Natural Gas)	26,587 MW	37.78%	42,643 MW	38.99%
Total	**70,376 MW**	**100%**	**109,367 MW**	**100%**

The total includes the addition and removal capacity. Source: PRODESEN 2016 - 2030, prepared by SENER sources.[120]

According to SENER, total national demand for natural gas will continue to rise at an average annual rate of 3.5% from 2013-2029, increasing from 6,852.4 million cubic feet per day (MMCFD) in 2013 to 11,595.2 MMCFD in 2028. Continued increase will primarily take place within the electricity sector as consumption will increase at a projected annual growth rate of 4.4%, rising from 3,3227 MMCFD in 2013 to 6,344 MMCFD in 2028. Within the public sector (including CFE), demand for fuel for electricity generation is expected to increase by 1.6% per year, with natural gas projected to represent 89.9% of the increased demand. The continued substitution of petroleum-based fuels with natural gas within the electricity sector is largely based on plans for further installation of combined-cycle gas turbines, as well as the projected lower price of natural gas, and the continued expansion of infrastructure for the transportation, storage and distribution of natural gas.

These trends in natural gas consumption are predicted to take place throughout the economy as a whole, with all sectors likewise increasing their demand. Within the industrial sector, SENER estimates the demand for natural gas will increase during the 2013-2018 period by 5.1% average annually, to a share of 76.1% of the sector's total energy demand by 2028.[121] SENER also estimates that the industrial sector will cease consuming fuel oil by 2020.[122]

B.2 Research Informing the Legal Requirement Test

In addition to the full review of the Mexican regulatory framework pertaining to climate change and greenhouse gas emissions, discussed above, the Reserve further informed protocol development through extensive research into legal requirements in Mexico that may relate to the project activity. To ensure regulatory additionality, no laws or regulation may exist that require the project activity of retrofitting existing boilers to improve energy efficiency or replacing older, inefficient boilers with new higher efficiency boilers. No current federal, state or local laws, regulations, or rules related to improving energy efficiency at existing boilers were identified.

As noted in Section 2.1 and above, Mexico has been mitigating carbon emissions at the national level with a tax on fossil fuels since 2013. While this does provide some incentive for those covered by the tax, notably fuel importers and processors, to improve energy efficiency on site, as a means to reduce emissions and their tax obligation, the Reserve's assessment of the impact on the project is that this tax on fossil fuels does not, itself, require improved efficiency at boilers and does not impact additionality here. Similarly, even though the tax on fossil fuels does exempt natural gas fuels, the tax does not directly require a full switch, instead providing a small incentive to implement this switch.

[120] SENER (2016). *Programa de Desarrollo del Sistema Eléctrico Nacional 2016 – 2030* (PRODESEN).
[121] SENER (2014). *Prospectiva de Gas Natural y Gas L.P. 2014-2028.*
[122] *Ibid*.

Table B.2. Mexican Regulations Related to the Efficiency of Boilers

Law	Title (original Spanish)	Title (translated)
NOM-020-STPS-2011	Recipientes sujetos a presión, recipientes criogénicos y generadores de vapor o calderas – Funcionamiento – Condiciones de Seguridad.	Pressure vessels, cryogenic containers and steam generators or boils – Operation – Safety Conditions.
NOM-085-SEMARNAT-2011	Contaminación atmosférica-Niveles máximos permisibles de emisión de los equipos de combustión de calentamiento indirecto y su medición.	Air-pollution- maximum permissible emission limits for indirect heating combustion equipment and its measurement.

Source: http://www.sener.gob.mx/webSener/portal/Mobil.aspx?id=982

Currently, there is no minimum efficiency requirement for new or existing boilers of any kind, and there are no Mexican regulations governing which type of fuel must be used in industrial boilers or when they must be retired. The only NOMs with similarly related requirements (NOM-002-ENER-1995 and NOM-012-ENER-1996) were repealed in 2003; these NOMs did, however, set minimum efficiencies for new boilers of 100kW to 8,000 kW and 7.5 kW to 100kW, respectively.[123,124]

Due to evaluation of this regulatory landscape, the Reserve believes that no legal requirement currently exists in Mexico currently that directly requires the implementation of any project activity incentivized by this protocol. Even so, as described in Section 3.4.2 of the protocol, the project developer must demonstrate to the verifier that at each reporting period there is no legal requirement in place requiring the implementation of those project activities, demonstrate the process by which the project developer ascertains this, and sign an Attestation of Voluntary Compliance each reporting period that the project activity continues to be voluntary.

B.2.1 Regulatory Compliance at the Boiler's Facility

As noted in Section 3.5 of the protocol, only emission reductions achieved while the project is in regulatory compliance may be credited. As such, any relevant state or local regulation must be identified and assessed for its effect on regulatory compliance at the project site.

No state or local regulations relating to requirements of certain levels of boiler efficiency or requirements for use of certain fuel type were identified at the time of developing the protocol.

NOM-085-SEMARNAT-2011 provides rules for maximum allowable air pollution emissions of combustion equipment, including carbon monoxide (CO).[125] Projects should be aware of and ensure they remain in compliance with NOM-085. However, while CO levels can increase up to 3-4 times due to project activities, namely efficiency improvements that change the amount of excess air for combustion, during protocol development process stakeholders stated that it seems unlikely that projects would cause such increases in CO emissions to rise beyond levels prescribed in NOM-085.

[123] Secretaria de Gobernación (SEGOB), SENER (2003). *Resolución por la que se cancela la Norma Oficial Mexicana NOM-002-ENER-1995*.
[124] *Ibid*.
[125] NORMA Oficial Mexicana. NOM-085-SEMARNAT-2011. Available at http://dof.gob.mx/nota_detalle.php?codigo=5232012&fecha=02/02/2012.