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E X A M P L E S

Compressor Station Efficiency Improvement GHG Project Using the Performance Standard Baseline Procedure

Following is a hypothetical project illustrating how to use the performance standard procedure to estimate baseline emissions. All names in the example are fictional. Also, the information here is quite general; project developers would normally be expected to provide more detailed information.

The numbering of the sections in this example corresponds to the numbering of the chapters in Part II of the Project Protocol.

Background and Overview of Natural Gas Compressor Station GHG Emissions

Natural gas compressor stations, which are typically found every 100 to 150 km along a gas pipeline, are instrumental in maintaining adequate pressure for the gas to travel through a pipeline system. Compressor stations usually contain more than one compressor. Although the compressor itself is not a source of GHG emissions, the compressor is powered by a driver, typically a gas or diesel engine or gas turbine that releases GHG emissions, specifically carbon dioxide (CO_2) and methane (CH_4). It is the complete unit encompassing the compressor and its associated driver that is hereafter referred to as the "compressor."

Significant reductions in CO_2 and CH_4 can be achieved by improving the compressor efficiency or the process efficiency (e.g., load optimization). This hypothetical case study illustrates a pipeline project in Indonesia that reduces CO_2 and CH_4 emissions at a new compressor station by installing higher-efficiency (lower-emitting) compressors. The case study is designed to illustrate the steps a project developer would take to develop a performance standard for compressor station GHG emissions. The efficiency values are illustrative and should not be used to develop an actual performance standard. Each compressor installed under this GHG project has a fuel efficiency of 10.6 megajoules of natural gas/kilowatt hour of compression (MJ/kWh).

GHG PROJECT DESCRIPTION

The information provided in this case study is intended to provide context for the GHG project. Some of this information is reported to meet the requirements in Chapter 11 of the Project Protocol. Additional information should also be reported when documenting and reporting an actual GHG project (see Chapter 11).

GHG project title: Jogja pipeline compressor station efficiency improvement project.

Description: The GHG project will install high-efficiency compressors used to maintain adequate pressure for gas to move along a pipeline. This involves installing compressors as part of an extension of a pipeline within an existing natural gas transmission system. Each compressor will be fuelled by natural gas. This pipeline extension will deliver gas to a natural gas power plant that is currently under construction.

Size: The GHG project installs 30 new state-of-the-art, high-efficiency compressors.

Geographical location: Yogyakarta region in Indonesia.

Names of project partners: Jogja Gas Pipelines, Inc. (a private natural gas transmissions company), and the Indonesian Energy Agency (the government agency that deals with gas pipelines). The pipeline is owned by Jogja Gas Pipelines, Inc., and the land and gas in the pipeline are owned by the Indonesian Energy Agency.

Project technology: High-efficiency pipeline compressors. (These compressors require 10.6 MJ/kWh of compression.)

Chapter 5: Defining the GHG Assessment Boundary

5.1 IDENTIFYING PROJECT ACTIVITIES

This GHG project involves just one project activity: installing higher-efficiency compressors as part of an extension of a pipeline within an existing natural gas transmission system.

5.2 & 5.3 IDENTIFYING PRIMARY EFFECTS AND CONSIDERING ALL SECONDARY EFFECTS

The primary and secondary effects associated with this project activity are identified in Table E2.1.

5.4 & 5.5 ESTIMATING THE RELATIVE MAGNITUDE AND ASSESSING THE SIGNIFICANCE OF SECONDARY EFFECTS

Since the power plant's demand for natural gas—and the associated pipeline and compressors required to deliver this gas—will be the same with or without the GHG project, there will be no net difference between baseline emissions and project activity emissions associated with one-time activities, and therefore no one-time effects. By reducing natural gas usage at the compressors, the GHG project will slightly reduce demand for natural gas. This in turn will slightly reduce GHG emissions from extracting and transporting natural gas. To be conservative, such GHG reductions will be ignored. Therefore, no significant secondary effects are identified. Therefore, the GHG assessment boundary includes only GHG sources associated with the primary effect.

Chapter 6: Selecting a Baseline Procedure

The performance standard procedure was chosen, since there is a relative degree of uniformity for compressor technology in the commercial market.

Chapter 7: Identifying the Baseline Candidates

To identify the list of baseline candidates, different alternatives are considered whose products or services are comparable to the project activity within a relevant geographic area and temporal range. Since the performance standard procedure is being used, baseline candidates include all the individual plants, technologies, or practices whose products or services are similar to those of the project activity.

Compressor Station GHG Project

TABLE E2.1 Primary and secondary effects

PRIMARY EFFECT	SECONDARY EFFECTS	
	ONE-TIME EFFECTS	UPSTREAM AND DOWNSTREAM EFFECTS
Reduction in combustion emissions from generating off-grid electricity from reduced fuel use by compressors (per unit of natural gas transported).	Considered: • GHG emissions associated with the manufacture, installation, and decommissioning of compressors. Magnitude/Significance: The project activity will cause GHG emissions associated with the manufacture, installation, and decommissioning of compressors. However, these same activities would have occurred in the baseline scenario, producing GHG emissions from the same GHG sources. The result is zero net change between project activity GHG emissions and baseline emissions, so there are no one-time GHG effects.	Considered: • Reduced GHG emissions associated with reduced mining/extraction of natural gas. • Reduced GHG emissions associated with reduced transportation of natural gas. Magnitude/Significance: The project will cause an absolute reduction in demand for natural gas, leading to reductions in GHG emissions associated with extracting and transporting natural gas. Such GHG reductions would constitute positive secondary effects; to be conservative, these GHG reductions are assumed to be zero. No other inputs or outputs are associated with the project that might cause secondary effects.

7.1 DEFINING THE PRODUCT OR SERVICE PROVIDED BY THE PROJECT ACTIVITY

The service provided by the project activity is the compression of a particular volume of natural gas so that the gas can be delivered to a power plant.

7.2 IDENTIFYING POSSIBLE TYPES OF BASELINE CANDIDATES

Since only compressor stations can provide this service, the identified baseline candidates include all compressor stations used for gas pipelines within the geographic area and temporal range described under section 7.3.

7.3 DEFINING THE GEOGRAPHIC AREA AND TEMPORAL RANGE

7.3.1 DEFINING THE GEOGRAPHIC AREA

As an initial default, the geographic area considered was the country of Indonesia. However, this default was rejected, despite a sufficient number of compressors found in Indonesia to develop a performance standard. Instead, the final geographic area selected was global, since the project involves implementing technologies that are commercially available globally.

7.3.2 DEFINING THE TEMPORAL RANGE

The initial temporal range considered was all compressors that went into operation during the last five years. However, compressor efficiency improves at a fairly rapid pace, so it was decided to use a temporal range of the previous three years. This takes a conservative approach by considering only the more recent and more efficient compressor technologies, and still provides a large enough data set to develop the performance standard.

7.4 DEFINING OTHER CRITERIA USED TO IDENTIFY BASELINE CANDIDATES

The following factors were considered in identifying baseline candidates:

- **General market conditions.** Due to the energy mix in Indonesia, the host country, natural gas is the only potential fuel source for the proposed power plant. Similarly, receipt of the gas via a pipeline is the only viable option for transporting the natural gas.
- **Relevant legal requirements.** There are no regulations or laws in Indonesia governing the use of compressor technology or installation for the purposes of transporting natural gas in pipelines. To check for legal

requirements, applicable national, regional, and local laws were researched. In addition, Jogja Gas Pipelines, Inc., checked with local lawyers and government officials for any additional information. No applicable laws were found.

7.5 IDENTIFYING THE FINAL LIST OF BASELINE CANDIDATES

The resulting list of baseline candidates and associated data are provided in Table E2.2. This list consists of all compressors that went on line between 2001 and 2003 globally. All selected candidates are capable of providing the same quality and quantity of service as the compressors employed by the GHG project.

Chapter 9: Estimating Baseline Emissions—Performance Standard Procedure

9.1 SPECIFYING THE APPROPRIATE PERFORMANCE METRICS

For this project activity, a production-based performance metric is appropriate, since it is possible to quantify performance in terms of units of input per unit of product or service. The service in this case is the compression of natural gas. The amount of compression provided by compressor station drivers can be reliably inferred from their kilowatt-hours of electrical output. Thus, the units of service for the performance metric are kilowatt-hours (kWh).

The compressor station input related to the project activity's primary effect is a fuel: natural gas. Quantities of natural gas can be measured in terms of energy content (e.g., megajoules (MJ)). Therefore, for this project activity, the units for the relevant input are megajoules.

TABLE E2.2 Identified baseline candidates and data set for developing the GHG performance standard

COMPRESSOR	YEAR OPERATION STARTED	# OF COMPRESSOR UNITS AT EACH STATION	CAPACITY (KW/UNIT)	DESIGN FUEL USAGE (MJ/KWH)
Station A (Russia)	2003	25	70	10.5
Station B (China)	2003	10	70	11.1
Station C (Germany)	2003	5	50	12.2
Station D (Norway)	2003	25	55	11.5
Station E (Chile)	2003	30	65	12.7
Station F (Russia)	2003	22	60	11.5
Station G (Algeria)	2003	21	50	12.5
Station H (U.S.)	2002	18	50	15.5
Station I (U.S.)	2002	6	60	14.8
Station J (Nigeria)	2002	12	50	14
Station K (Qatar)	2002	15	60	14
Station L (China)	2002	23	55	15
Station M (China)	2002	36	50	15.5
Station N (Indonesia)	2002	14	30	16
Station O (Russia)	2002	20	40	15.5
Station P (U.S.)	2002	25	60	15.5
Station Q (Russia)	2002	25	50	15.9
Station R (Norway)	2001	13	40	16
Station S (Bolivia)	2001	26	50	15.2
Station T (Russia)	2001	21	50	15.5
Total # of Compressors		392		

EXAMPLES

The performance metric used to determine GHG emissions from baseline candidates is MJ/kWh.

9.2 CALCULATING THE GHG EMISSION RATE FOR EACH BASELINE CANDIDATE

Data on the performance rates for each baseline candidate were obtained in the process of identifying the baseline candidates (Table E2.2). Performance rates for compressor stations are measured using the performance metric MJ/kWh, also called the "design fuel usage." Design fuel usage data were found from the manufacturers' specification sheets for the drivers used at the compressor stations. The design fuel usage for a particular technology depends on the load at which the technology is run. Where the load data proved difficult to find, 100 percent load was assumed in order to be conservative (see Box E2.1). (This would result in the lowest possible design fuel usage for a particular technology.)

GHG emission rates were calculated for each baseline candidate using the IPCC emission factor for natural gas: 15.3 tonnes of C/TJ = 0.056 kg CO_2eq/MJ. The results are shown in Table E2.3.

BOX E2.1 Sample calculation of design fuel usage where load data are unavailable

A compressor station has a maximum rated capacity of 70 kilowatts (kW). Fuel usage over one year was measured at 7.5 million MJ, but no data are available on load or output (in kWh). Design fuel usage would be calculated as follows:

$$\frac{(7.5 \text{ million MJ/year})}{(70 \text{ kW}) \cdot (8{,}760 \text{ hours/year}) \cdot (100\% \text{ load factor})} = 12.2 \text{ MJ/kWh}$$

This fuel usage calculation is conservative, because if the load were in fact less than 100 percent, actual design fuel usage (and resulting GHG emissions) would be higher.

9.3 CALCULATING THE GHG EMISSION RATE FOR DIFFERENT STRINGENCY LEVELS

Different stringency level GHG emission rates were calculated as follows:

Most stringent: The lowest-emitting baseline candidate is Station A (0.59 kg CO_2eq/kWh).

TABLE E2.3 Baseline candidate GHG emission rates

BASELINE CANDIDATE	GHG EMISSION RATE (KG CO_2/KWH)
Station A	0.59
Station B	0.62
Station C	0.69
Station D	0.65
Station E	0.71
Station F	0.65
Station G	0.70
Station H	0.87
Station I	0.83
Station J	0.79
Station K	0.83
Station L	0.84
Station M	0.87
Station N	0.90
Station O	0.87
Station P	0.87
Station Q	0.89
Station R	0.90
Station S	0.85
Station T	0.87

Mean: The output-weighted average emission rate is 0.78 kg CO_2eq/kWh.

Median: The median (50^{th} percentile) of this data set is equal to the GHG emission rate of the twelfth most efficient group of compressor units in the data set—i.e., Station S. This emission rate is 0.85 kg CO_2eq/kWh.

25^{th} percentile: The 25^{th} percentile of this data set is equal to the GHG emission rate of the sixth most efficient group of compressor units in the data set—i.e., Station G. This emission rate is 0.70 kg CO_2eq/kWh (see Box E2.2).

10^{th} percentile: The 10^{th} percentile of this data set is equal to the GHG emission rate of the third most efficient group of compressor units in the data set—i.e., Station D. This emission rate is 0.65 kg CO_2eq/kWh (see Box E2.2).

BOX E2.2 How to calculate the 10^{th} and 25^{th} percentiles

KG CO_2/KWH	COMPRESSOR RANKING
0.59	1–25
0.62	26–35
0.65	36–60
0.65	61–82
0.69	83–87
0.70	87–108
0.71	109–138
0.79	139–150
0.83	151–156
0.83	157–171
0.84	172–194
0.85	195–220
0.87	221–245
0.87	246–265
0.87	266–301
0.87	302–319
0.87	320–340
0.89	341–365
0.90	366–378
0.90	379–392

For the 25^{th} percentile:

$w = (392) \cdot (\frac{25}{100}) + 0.5 = 98.5 \quad g = 98, f = 0.5, \text{ and } a = 392$

$pe = (1 - 0.5) \cdot (0.70) + 0.5(0.70) = 0.70 \text{ kg } CO_2eq/kWh$

For the 10^{th} percentile:

$w = (392) \cdot (\frac{10}{100}) + 0.5 = 39.7 \quad g = 39, f = 0.7, \text{ and } a = 392$

$pe = (1 - 0.7) \cdot (0.65) + 0.7(0.65) = 0.65 \text{ kg } CO_2eq/kWh$

9.4 SELECTING AN APPROPRIATE STRINGENCY LEVEL FOR THE PERFORMANCE STANDARD

The 10^{th} percentile stringency level was chosen, corresponding to a performance standard of 0.65 kg CO_2eq/kWh. This stringency level is equivalent to the emission rates of Stations D and F, both recently constructed compressor stations. The data graphed in Figure E2.1 reveal that the compressor stations that started operation in 2003 (Stations A–G) have significantly lower emission rates on average than those that came on line in 2001 and 2002 (Stations H–T). Taking account of this trend, the 10^{th} percentile seems reasonable, given that it equates roughly to the average emission performance of the 2003 compressor stations. For this and other reasons (e.g., considerations about additionality, which are not discussed here), the 10^{th} percentile stringency level is determined to be a reasonable estimate for the baseline emission rates for future compressor stations.

9.5 ESTIMATING BASELINE EMISSIONS

Baseline emissions are calculated as the performance standard emissions rate multiplied by the project activity level of service (measured in kWh). It is assumed that the kilowatt-hours of output (and therefore the amount of gas compressed) remains the same in the baseline scenario and project, since the project activity itself will not significantly alter the supply of, or demand for, natural gas. Annual baseline emissions are calculated under section 10.2.2 as part of quantifying the GHG reductions.

Chapter 10: Monitoring and Quantifying the GHG Reductions

For this project example, monitoring and quantifying GHG reductions are relatively straightforward. This section presents a simple overview of how monitoring and quantification requirements can be met. Technical details related to monitoring conditions and equipment specifications are omitted.

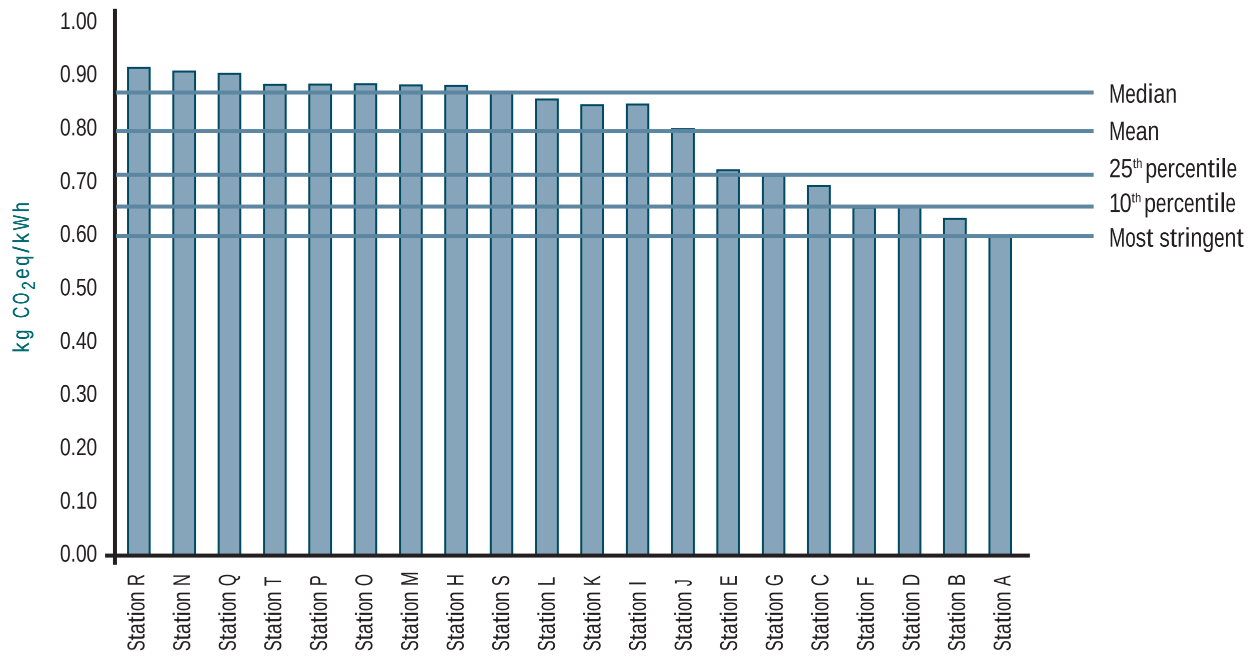
10.1 CREATING A MONITORING PLAN

Because there are no significant secondary effects, the monitoring plan is devoted to the Jogja project's single primary effect—i.e., reductions in combustion emissions from generating off-grid electricity resulting from reduced fuel use by compressors. Elements of the monitoring plan are described below.

10.1.1 MONITORING PROJECT ACTIVITY EMISSIONS

- For each of the 30 compressors installed under the GHG project, fuel usage data will be collected continuously using natural gas flow meters. The data will be converted to units of MJ, based on standard factors for the energy content of natural gas. Uncertainty associated with these measurements will be low.

FIGURE E2.1 Different stringency levels applied to the compressor data set



- CO_2 emissions will be calculated by multiplying fuel usage data (in MJ) for each compressor by the IPCC emission factor for natural gas (0.056 kg CO_2eq/MJ).

10.1.2 MONITORING BASELINE PARAMETERS

No baseline parameters are monitored. The performance standard is assumed to be a valid indicator of baseline emissions for a period of 3 years (see section 10.2.1).

10.1.3 DESCRIBING QA/QC MEASURES

- All data will be collected electronically and archived for 10 years.
- Equipment will be checked and calibrated bi-annually.

10.2 QUANTIFYING GHG REDUCTIONS

10.2.1 IDENTIFYING THE TIME PERIOD OVER WHICH GHG REDUCTIONS WILL BE QUANTIFIED

From the limited global data set on new compressor stations between 2001 and 2003, it appears that compressor station efficiency and GHG emissions performance have been improving and improved noticeably in 2003. The gains in efficiency seen in 2003, however, are not expected to proceed as rapidly in the near future. Given recent trends and future expectations, the performance standard is assumed to be valid for a period of 3 years.

10.2.2 CALCULATIONS FOR QUANTIFYING GHG REDUCTIONS

The GHG reductions are calculated as the difference between the baseline emissions and the project activity emissions:

GHG Reduction = Baseline emissions
– Project activity emissions

Because secondary effects were considered negligible (i.e., baseline and project activity emissions associated with one-time, upstream, and downstream GHG sources are equivalent), they were not included in the GHG reduction equation. Therefore, the total GHG reductions are equal to the change in GHG emissions associated with reducing fuel consumption by the compressors.

Table E2.4 illustrates the assumptions used for calculating baseline and project activity emissions. All compressors operate under the same conditions (i.e., load and hours of operation). The GHG project will install thirty compressors.

TABLE E2.4 Baseline and project activity emissions

	ASSUMPTION FACTORS	BASELINE VALUES	PROJECT ACTIVITY VALUES
1	Power/Max Load (kW)	70	70
2	Operating Hours (hrs/yr)	8,300	8,300
3	Load Factor (%)	80	80
4	No. of Compressors	30	30
5	GHG Emission Rate* (kg CO_2eq/kWh)	0.65	0.60

*These figures are rounded; results below were calculated with unrounded numbers.

Baseline emissions for a compressor are expressed by the performance standard emission rate (0.65 kg CO_2eq/kWh) multiplied by the total kWh of compression provided (13.9 million kWh, derived from rows 1–4 of Table E2.4). Project activity emissions are calculated using the high-efficiency compressor design fuel usage (10.6 MJ/kWh) multiplied by the IPCC emission factor for natural gas (0.056 kg CO_2eq/MJ) multiplied by the total kWh of compression provided (also 13.9 million kWh).

Compressor Station GHG Project

Baseline Emissions =

(Power load) · (Operating Hours) · (Load Factor) · (# of Compressors) · (Performance Standard Emission Rate) / 1,000

$$= \frac{(70) \cdot (8{,}300) \cdot (80\%) \cdot (30) \cdot (0.65)}{1{,}000}$$

= 9,004 t CO_2eq/year

Project Activity Emissions =

(Power load) · (Operating Hours) · (Load Factor) · (# of Compressors) · (Project Activity Emission Rate) / 1,000

$$= \frac{(70) \cdot (8{,}300) \cdot (80\%) \cdot (30) \cdot (0.60)}{1{,}000}$$

= 8,299 t CO_2eq/year

GHG Reductions =

Baseline Emissions – Project Activity Emissions

= 9,004 – 8,299

= 705 t CO_2eq/year

Actual GHG reductions will be quantified annually using monitored data, for a period of 3 years.