

**QUANTIFICATION PROTOCOL FOR PUMP SYSTEM CONVERSION TO  
REDUCE GREENHOUSE GAS EMISSIONS**

Submitted to:

Alberta Environment

And

Climate Change Central

March, 2009

**~~Disclaimer:~~**

~~The information provided in this document is intended as guidance only and is subject to revisions as learnings and new information comes forward as part of a commitment to continuous improvements. This document is not a substitute for the law. Please consult the *Specified Gas Emitters Regulation* and the legislation for all purposes of interpreting and applying the law. In the event that there is a difference between this document and the *Specified Gas Emitters Regulation*, the *Specified Gas Emitters Regulation* or the legislation prevails.~~

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## 1.0. Project and Methodology Scope and Description

This quantification protocol is written for the gas and/or oil operator or any operator in the oil and gas industry where natural gas or electricity is used to power pumps for fluid displacement. Some familiarity with, or understanding of, the operation of gas and/or oil operations is assumed.

The opportunity for generating carbon offsets with this proposed protocol arises from the direct and indirect reduction of greenhouse gas emissions resulting from converting high GHG intensive pumps to low/no GHG intensive pumps. In this protocol, the project developer will install, update or retrofit pumps or the power source for these pumps at a facility to reduce GHG emissions.

It must be stated that this proposed protocol does not stipulate a process change but rather a change in the type of pumps used and consequently the elimination or reduction of greenhouse gases. It is assumed that the new pump configuration will eliminate or reduce these greenhouse gases.

### 1.1. Protocol Scope and Description

This proposed protocol serves as a generic ‘recipe’ for project proponents to follow in order to meet the measurement, monitoring, and greenhouse gas quantification requirements for reductions resulting from converting high GHG intensive pumps to low/no GHG intensive pumps. Once this conversion has occurred, greenhouse gas emission will have decreased considerably. Replacement of end-of-life pumps is also considered in the scope of this protocol. The intent of this inclusion is to stimulate project developers to convert to low/no GHG intensive pumps. AA process flow diagram for a typical project converting high GHG intensive pumps to low/no GHG intensive pumps is shown in **FIGURE 1.1**.

#### Protocol Approach:

The general protocol approach requires the calculation of greenhouse gas emissions from manufacture’s technical specifications for high GHG intensive pumps and low/no GHG intensive pumps and metered quantities in the project. The manufacturer’s technical specifications are used to determine a pump-specific Emission Factor (EF), which allows for a high degree of project accuracy.

The baseline condition has been identified as the use of high GHG intensive pump systems at a facility prior to conversion to low/no GHG intensive pump systems. A process flow diagram for the baseline condition prior to converting high GHG intensive pumps to low/no GHG intensive pumps is shown in **FIGURE 1.2**. Baseline emissions likely stem from one of more of the following: electricity generation used to power pumps, vented natural gas, and fuel extraction and processing of fossil fuels used in the baseline. The protocol approach includes determination of baseline greenhouse gas emissions by selecting emission factors from manufacture’s technical specifications for high GHG intensive pumps. As such, no metering is required to determine baseline

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~~emissions because these are established on a comparison basis. The baseline is determined using Emission Factors (EF)~~

~~Metered quantities of either electricity or fluid displaced in the project condition are applied to pump-specific EFs to estimate baseline emissions.~~—Examples of how to determine these EFs for gas powered pumps is shown in **APPENDIX A**. High GHG intensive pump systems are typically powered by natural gas, which is sourced from the fuel supply for the facility, or by on-grid or off-grid electricity. ~~As such, baseline emissions stem from:~~

- ~~□ electricity generation used to power pumps;~~
- ~~□ vented natural gas;~~
- ~~□ fuel extraction and processing.~~

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The project condition has been identified as the use of low/no GHG intensive pump systems at a facility ~~subsequent to conversion to low/no GHG intensive pump systems after the conversion.~~ Similarly to the methodology used to calculate baseline emissions, ~~project emissions are calculated using EF from manufactures' technical specifications.~~ This requires the project developer to meter either ~~The protocol approach includes determination of project greenhouse gas emissions by metering the electricity used consumed or to run this new pump system the fluid.~~ Flexibility is given to the project proponent to meter ~~displaced in the new pump system fluid as opposed to electricity if this facilitates determining emission for the project and baseline conditions.~~ ~~L~~

~~L~~ow/no GHG intensive pump systems ~~may are be~~ powered by natural gas, typically sourced from the fuel supply for the facility and recaptured downstream, or by on-grid or off-grid electricity. As such, project emission ~~likely stem from one of the following: om:~~

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- ~~□ electricity generation used to power pumps and fuel s;~~
- ~~□ fuel extraction and processing.~~

### Protocol Applicability:

To demonstrate that a project meets the requirements under this protocol, the project developer must supply sufficient evidence to demonstrate that:

- ~~1. The conversion to low/no GHG intensive pumps must provide the same level of services as the high GHG intensive pumps as demonstrated by unit operational performance data, and/or facility process flow diagrams and/or other equipment technical specifications. Functional equivalence may also be demonstrated through an affirmation by the project developer or a third party.~~
- ~~2. The project is a conversion from high GHG intensive pumps to low/no GHG intensive pumps systems, which includes end-of-life replacements, and not~~

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facilities originally constructed to use low/no GHG intensive pump systems. This may be demonstrated by facility process flow diagrams and/or accounting records, work orders, invoices or other vendor/third party documentation/evidence. Conversions may also be demonstrated through an affirmation by the project developer or a third party.

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~~1. Demonstrate functional equivalence between fluids pumped before and after the conversion does not affect facility operations.~~

~~2. The fluid displaced should be the same. It is understood that there is no change in fluid type or process, but rather a change in pump type or energy source to power the pump as affirmed by facility personnel.~~

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~~3. The project must meet the requirements for offset eligibility as specified in the applicable regulation and guidance documents for the Alberta Offset System. [Of particular note:~~

- a. [The date of equipment installation, operating parameter changes or process reconfiguration are initiated or have effect on the project on or after January 1, 2002 as indicated by facility records;]
- b. [The project may generate emission reduction offsets for a period of 8 years unless an extension is granted by Alberta Environment, as indicated by facility and offset records. Additional credit duration periods require a reassessment of the baseline condition; and,]
- c. [Ownership of the emission reduction offsets must be established as indicated by facility records.]

#### **Protocol Flexibility:**

The proposed protocol is applicable to any kind of pump conversion program intended to reduce/eliminate greenhouse gas emissions. Given the diversity of pumps operated in the oil and gas industry, the following flexibility mechanisms have been put in place:

1. Site specific emissions factors may be substituted for the generic emission factors indicated in this protocol document. The methodology for generation of these emission factors must be sufficiently robust to ensure accuracy. As an example, energy source to power the pumps may come from electricity. The most current electricity displacement factor for on-grid electricity in Alberta can be found in Environmental Canada references documents such as Canada's emissions inventory. This value will be reviewed and updated periodically and the most current value should be used by the proponent. ~~If the operator is a self-generator, the emissions factor can be calculated from the fuel source the project proponent is using.~~
2. This protocol establishes greenhouse gas emissions for the project conditions based on metered electricity. Flexibility is given to the project developer to measure

displaced fluids rather than electricity if this approach is easier to implement. The project developer should therefore be cautious when establishing the Emissions Factor (EF) for fluid-based metering. As such, the EF for the fluid-based metering has units of tCO<sub>2</sub>e/m<sup>3</sup> or tCO<sub>2</sub>e/kg of displaced fluid. Refer to **APPENDIX A** for details.

3. Retroactive credits are accepted under this protocol for projects that were implemented before the creation of this protocol. The claim is based on an adjusted baseline including:

- Annual electricity displacement factors;
- Volumes of fluids displaced; and
- Commissioning or decommissioning of devices.

Documentation must be provided in order to establish retroactive credits. These may include electricity bills, purchase orders or invoices for displaced fluids, purchase orders or invoices for high GHG and low/no GHG intensive pump systems installed at the facility. Emissions are quantified in the same manner as emissions in section 2.5. Commissioning or decommissioning of pumps systems within a facility.

4. Pump system conversion can take place at single or multiple sites. As such, the protocol allows for flexibility in aggregating offsets from multiple projects.

If applicable, the proponent must indicate and justify why flexibility provisions have been used.

### 1.2. Glossary of New Terms

Functional Equivalence	The project and the baseline should provide the same function and quality of products or services. This type of comparison requires a common metric or unit of measurement (such as flow rate) for comparison between the Project and Baseline activity (Refer to the Guidance Document for the Alberta Offset System) The functional equivalence in this protocol <del>is the pressure provide by the natural gas and air pneumatic system</del> <u>volume of fluid displaced, measured in terms of electricity displacement.</u>
High GHG Intensive Pump	Any pump that uses pressurized natural gas to power a pump to displace a fluid. <u>This natural gas is subsequently vented to the atmosphere. The pump may also run on electricity. This natural gas is subsequently vented to the atmosphere.</u>
Low/No GHG Intensive Pump	Any pump that uses electricity to power a pump to displace a fluid <u>or recaptures natural gas.</u> <del>This</del> electricity may come from renewable or non-renewable sources
Pump	A pump is an apparatus used to move or displace fluids, such as

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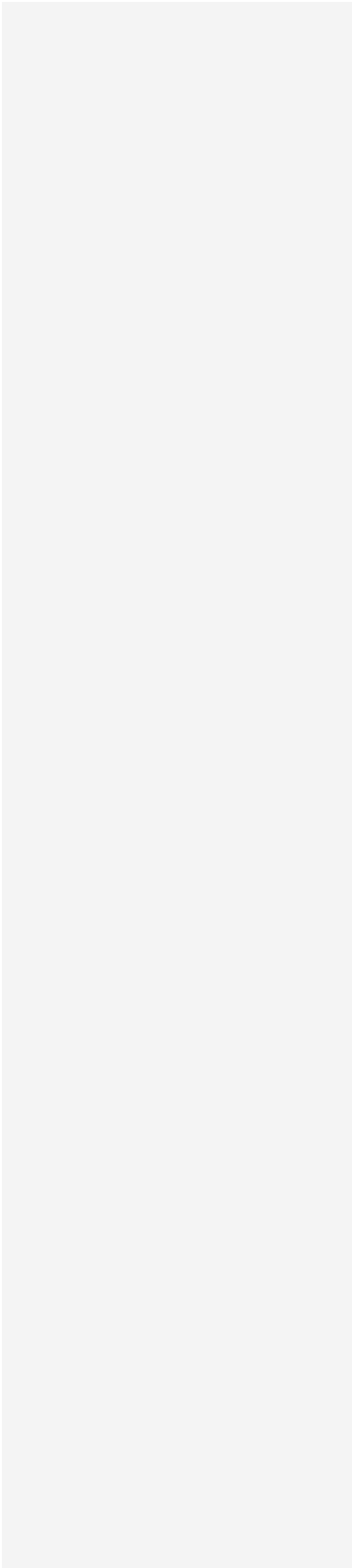
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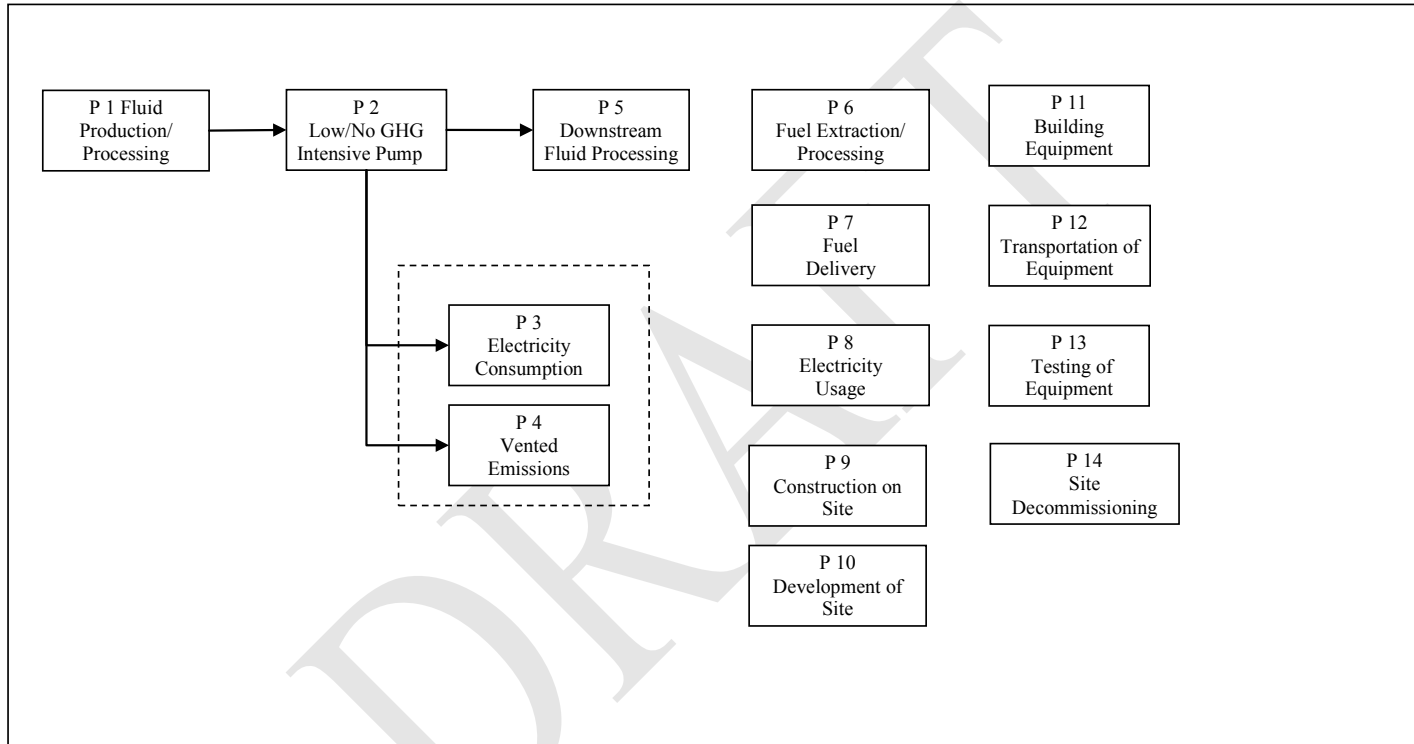
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gases, liquids or slurries.

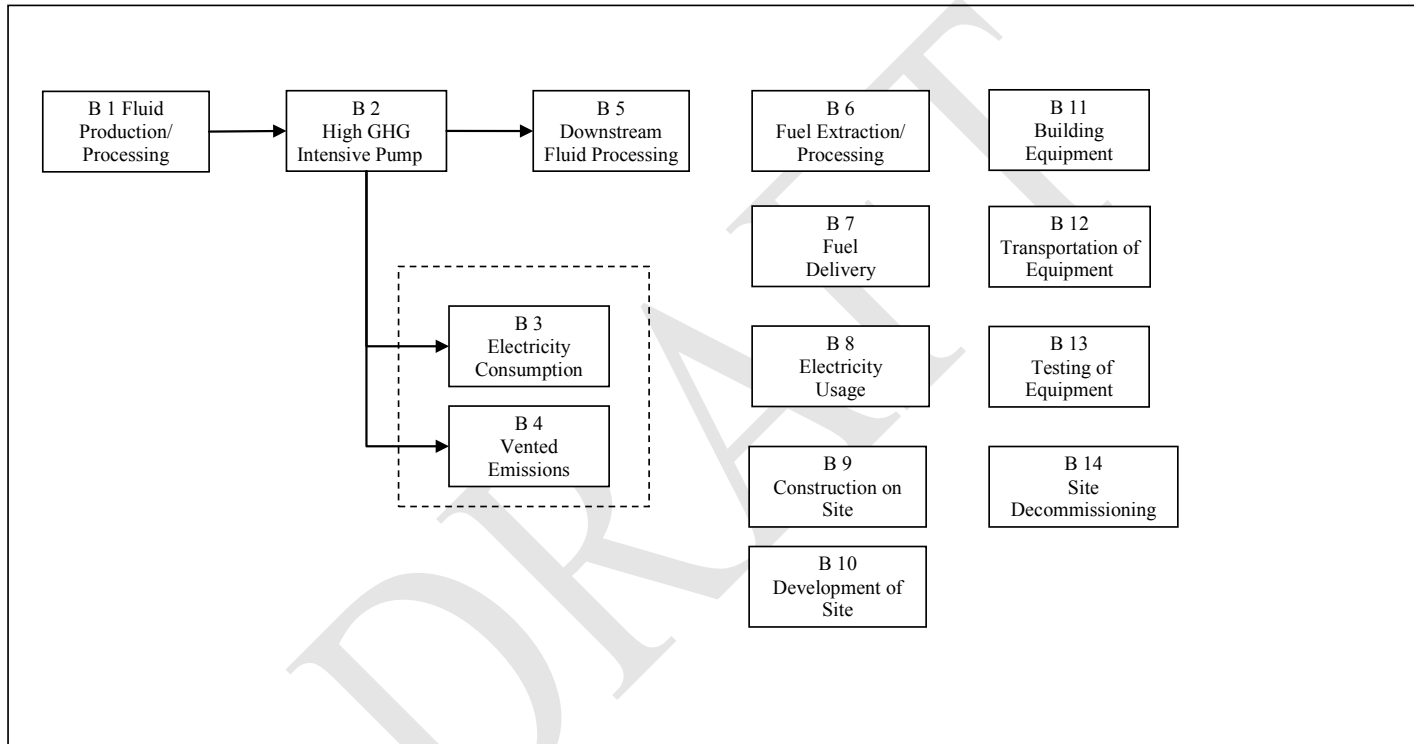
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**FIGURE 1.1: Process Flow Diagram for Project Condition**



**FIGURE 1.2: Process Flow Diagram for Baseline Condition**



## 2.0. Quantification Development and Justification

The following sections outline the quantification development and justifications.

### 2.1. Identification of Sources and Sinks (SS's) for the Project

SS's were identified for the project by reviewing the seed documents and relevant process flow diagrams pertaining to the operation of natural gas processing facilities. This process confirmed that the SS's in the process flow diagrams covered the full scope of eligible project activities under the protocol.

Based on the process diagrams provided in **FIGURE 1.1**, the project's SS's were organized into life cycle categories in **FIGURE 2.1**. Description of each of the SS's and their classification as controlled, related or affected are provided in **TABLE 2.1**.

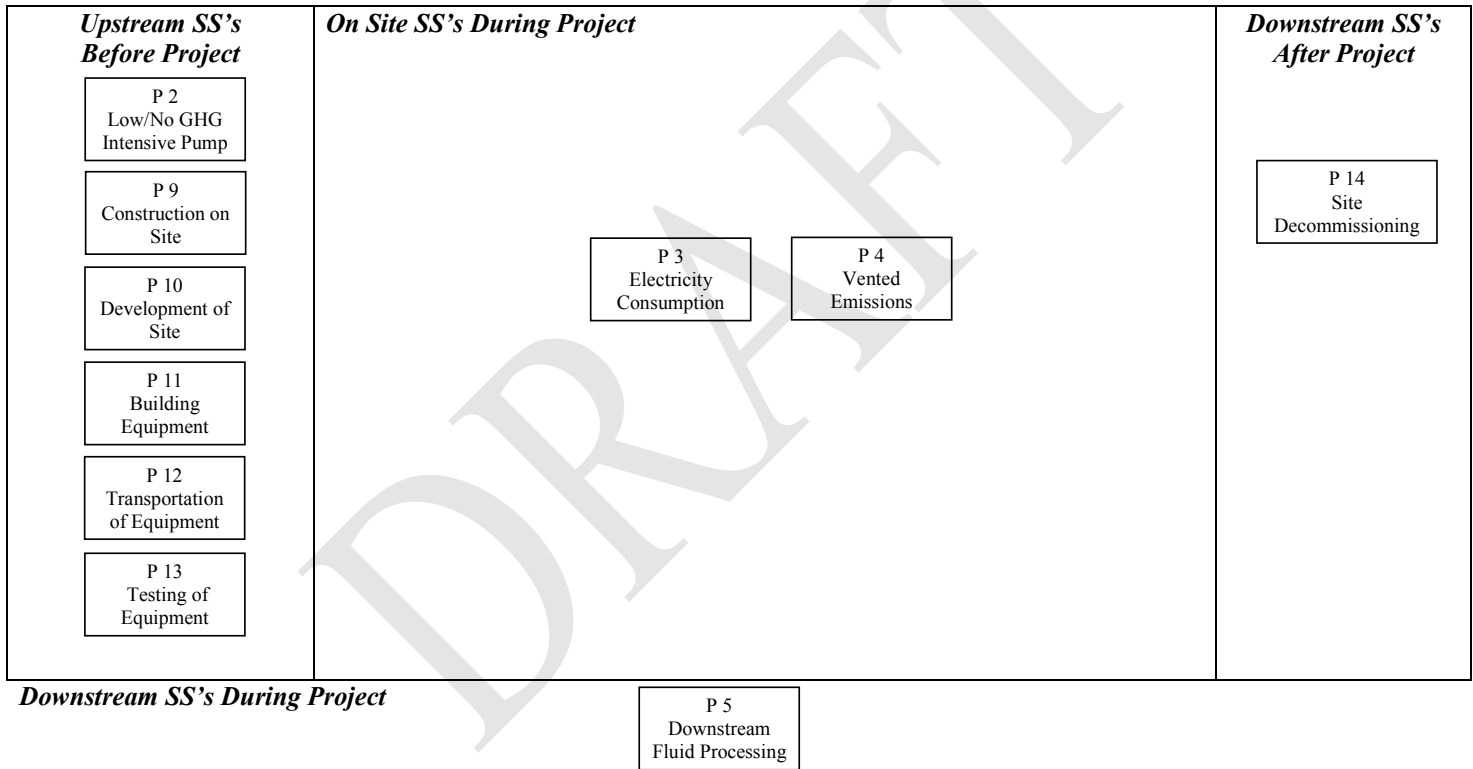
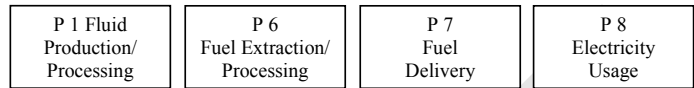
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**FIGURE 2.1: Project Element Life Cycle Chart**

*Upstream SS's During Project*



**TABLE 2.1: Project SS's**

1. SS	2. Description	3. Controlled, Related or Affected
<b>Upstream SS's during Project Operation</b>		
P 1 Fluid Production/Processing	Each of the fluids displaced throughout the project will need to be sourced and processed. Types and quantities of fluids used would need to be tracked. This will allow for the calculation of greenhouse gas emissions from the various processes involved in the production, refinement, and storage of the fluids.	Related
P 6 Fuel Extraction/Processing	Each of the fuels used throughout the project will need to be sourced and processed. This will allow for the calculation of greenhouse gas emissions from the various processes involved in the production, refinement, and storage of the fuels. The total volumes of fuel for each of the SS's in this project are considered in this SS. Types and quantities of fuels used would need to be tracked.	Related
P 7 Fuel Delivery	Each of the fuels used throughout the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gas. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's and there is no other delivery.	Related
P 8 Electricity Usage	Electricity may be required for operating the facility. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. Quantity and source of the power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions. Electricity for pump system is taken into account in activity P3.	Related
<b>Onsite SS's during Project Operation</b>		
P 3 Electricity Consumption	Electricity may be required for operating the pumps. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. Quantity and source of the power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Controlled
P 4 Vented Emissions	Some pump systems use natural gas from the facility's fuel supply. Once the natural gas has powered the pump, it is left to vent to the atmosphere. Vented emissions in the project can be captured and reintroduced to the pipe network. Quantity and gas composition of the natural gas are important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions avoided.	Controlled
<b>Downstream SS's during Project Operation</b>		
<b>Other</b>		

Pump Conversion

P 2 Low/No GHG Intensive Pump	The low/no GHG intensive pump system and accessories such as power supply and assembly need to be manufactured by a specialized company. Quantity and source of the power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Related
P 9 Construction on Site	The process of construction at the site may require a variety of heavy equipment, smaller power tools, cranes, and generators. The operation of this equipment will have associated greenhouse gas emissions from the use of fossil fuels and electricity.	Related
P 10 Development of Site	The site may need to be developed. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas, storm water drainage, offices, vent stacks, firefighting water storage lagoons, etc., as well as structures to enclose, support and house the equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
P 11 Building of Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, system control, and safety systems. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabrication and assembly.	Related
P 12 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site will all need to be delivered to the site. Transportation may be completed by train, truck, barge, or by some combination, or even by courier. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
P 13 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test anaerobic digestion fuels or fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity	Related
P 14 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related
P 5 Downstream Fluid Processing	Each of the displaced fluids throughout the project may need to be processed downstream. Types and quantities of fluids used would need to be tracked. This will allow for the calculation of greenhouse gas emissions from the various processes involved in the production, refinement, and storage of the fluids downstream.	Related

## 2.2. Identification of Baseline

The type and volume of fluid displaced in the baseline is assumed to be the same as in the project condition as required by design purposes or by facility operations. As such, the conversion is a change in the way the fluid is displaced and not the volume of fluid displaced. This allows a relationship to be established between the project condition and baseline condition based on type and volume of fluid displaced. EFs from the baseline and project are applied to measured quantities in the project to calculate emissions from the project itself and the baseline. As a result, this baseline methodology ensures functional equivalence because volumes of fluid displaced in baseline and project conditions are assumed to be equal.

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The use of EF and metered quantities is an accepted methodology to calculate emissions. As an example, industry uses CAPP EFs to report annual emissions from oil and gas facilities<sup>1</sup>. These are general EFs and are accepted by industry. Therefore, determining EFs from manufactures' technical specifications is highly accurate because these are determined from rigorous and scientific procedures for specific pumps as opposed to a general EF.

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The baseline condition is defined, including the relevant SS's and processes, as shown in **FIGURE 1.2**~~FIGURE 1.2~~. More detail on each of these SS's is provided in the following section, section 2.3.

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## 2.3. Identification of SS's for the Baseline

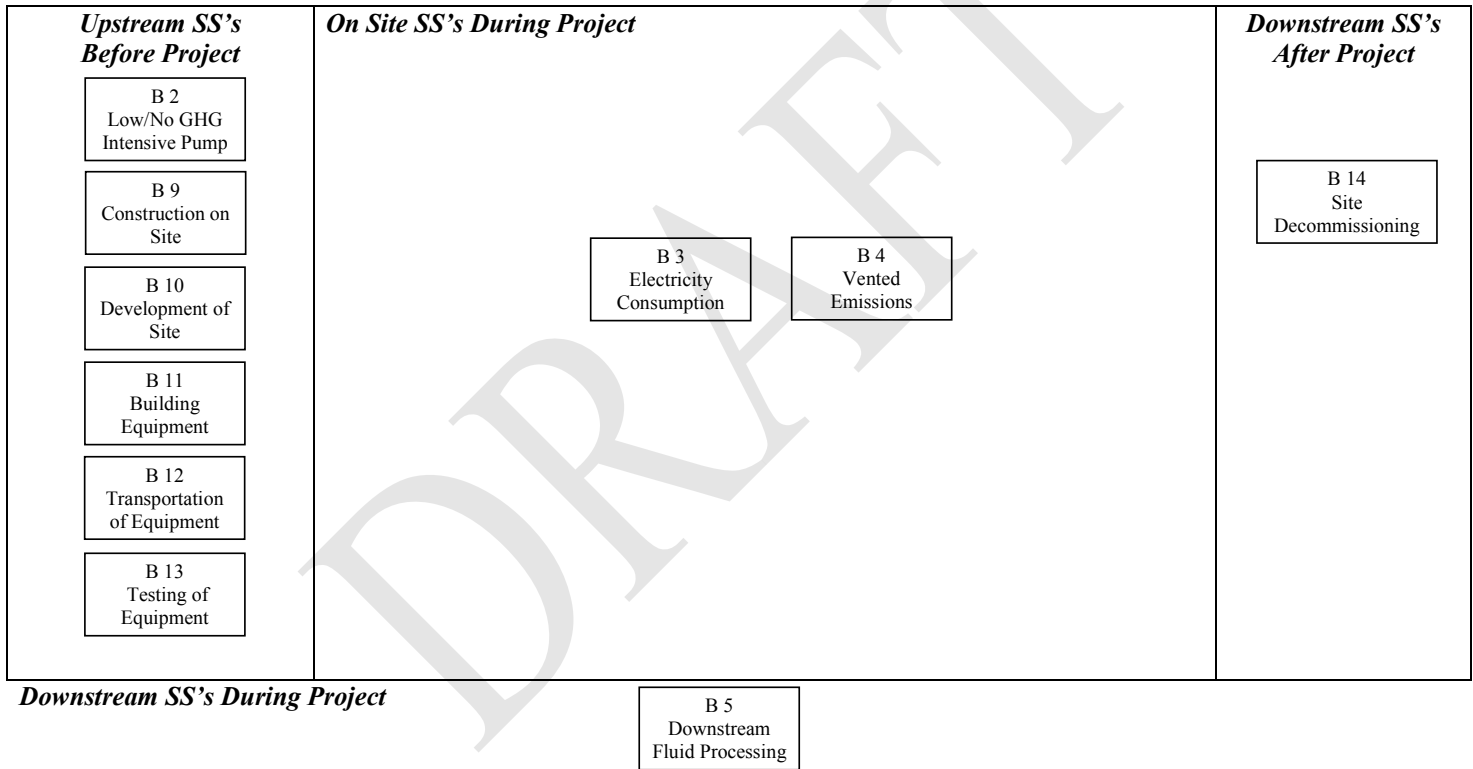
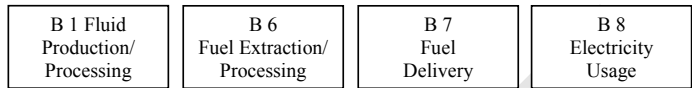
Based on the process diagrams provided in **FIGURE 1.2**~~FIGURE 1.2~~, the project's SS's were organized into life cycle categories in **FIGURE 2.2**~~FIGURE 2.2~~. Description of each of the SS's and their classification as 'controlled', 'related' or 'affected are provided in **TABLE 2.2**~~TABLE 2.2~~.

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<sup>1</sup> CAPP (April 2003). Guide-Calculating Greenhouse Gas Emissions; CAPP (May, 2002). Guide-Estimation of Flaring and Venting Volumes from Upstream Oil and Gas Facilities.

**FIGURE 2.2: Baseline Element Life Cycle Chart**

*Upstream SS's During Project*



**TABLE 2.2: Baseline SS's**

1. SS	2. Description	3. Controlled, Related or Affected
<b>Upstream SS's during Project Operation</b>		
B 1 Fluid Production/Processing	Each of the fluids displaced throughout the project will need to be sourced and processed. This will allow for the calculation of greenhouse gas emissions from the various processes involved in the production, refinement, and storage of the fluids. Types and quantities of fluids used would need to be tracked.	Related
B 6 Fuel Extraction/Processing	Each of the fuels used throughout the project will need to be sourced and processed. This will allow for the calculation of greenhouse gas emissions from the various processes involved in the production, refinement, and storage of the fuels. The total volumes of fuel for each of the SS's in this project are considered in this SS. Types and quantities of fuels used would need to be tracked.	Related
B 7 Fuel Delivery	Each of the fuels used throughout the project will need to be transported to the site. This may include shipments by tanker or by pipeline, resulting in the emissions of greenhouse gas. It is reasonable to exclude fuel sourced by taking equipment to an existing commercial fuelling station as the fuel used to take the equipment to the site is captured under other SS's and there is no other delivery.	Related
B 8 Electricity Usage	Electricity may be required for operating the facility. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. Quantity and source of the power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions. Electricity for pump system is taken into account in activity P3.	Related
<b>Onsite SS's during Project Operation</b>		
B 3 Electricity Consumption	Electricity may be required for operating the pumps. This power may be sourced either from internal generation, connected facilities or the local electricity grid. Metering of electricity may be netted in terms of the power going to and from the grid. Quantity and source of the power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	Controlled
B 4 Vented Emissions	Some pump systems use natural gas from the facility's fuel supply. Once the natural gas has powered the pump, it is left to vent to the atmosphere in the baseline condition. Quantity and gas composition of the natural gas are important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions vented to the atmosphere.	Controlled
<b>Downstream SS's during Project Operation</b>		
<b>Other</b>		
B 2 High GHG Intensive	The high GHG intensive pump system and accessories such as power supply and assembly need	Related

Pump Conversion

Pump	to be manufactured by a specialized company. Quantity and source of the power are the important characteristics to be tracked as they directly relate to the quantity of greenhouse gas emissions.	
B 9 Construction on Site	The process of construction at the site may require a variety of heavy equipment, smaller power tools, cranes, and generators. The operation of this equipment will have associated greenhouse gas emissions from the use of fossil fuels and electricity.	Related
B 10 Development of Site	The site may need to be developed. This could include civil infrastructure such as access to electricity, gas and water supply, as well as sewer. This may also include clearing, grading, building access roads, etc. There will also need to be some building of structures for the facility such as storage areas, storm water drainage, offices, vent stacks, firefighting water storage lagoons, etc., as well as structures to enclose, support and house the equipment. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to develop the site such as graders, backhoes, trenching machines, etc.	Related
B 11 Building of Equipment	Equipment may need to be built either on-site or off-site. This includes all of the components of the storage, handling, processing, combustion, air quality control, system control, and safety systems. These may be sourced as pre-made standard equipment or custom built to specification. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment for the extraction of the raw materials, processing, fabrication and assembly.	Related
B 12 Transportation of Equipment	Equipment built off-site and the materials to build equipment on-site will all need to be delivered to the site. Transportation may be completed by train, truck, barge, or by some combination, or even by courier. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels to power the equipment delivering the equipment to the site.	Related
B 13 Testing of Equipment	Equipment may need to be tested to ensure that it is operational. This may result in running the equipment using test anaerobic digestion fuels or fossil fuels in order to ensure that the equipment runs properly. These activities will result in greenhouse gas emissions associated with the combustion of fossil fuels and the use of electricity	Related
B 14 Site Decommissioning	Once the facility is no longer operational, the site may need to be decommissioned. This may involve the disassembly of the equipment, demolition of on-site structures, disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions would be primarily attributed to the use of fossil fuels and electricity used to power equipment required to decommission the site.	Related
B 5 Downstream Fluid Processing	Each of the displaced fluids throughout the project may need to be processed downstream. Types and quantities of fluids used would need to be tracked. This will allow for the calculation of greenhouse gas emissions from the various processes involved in the production, refinement, and storage of the fluids downstream.	Related

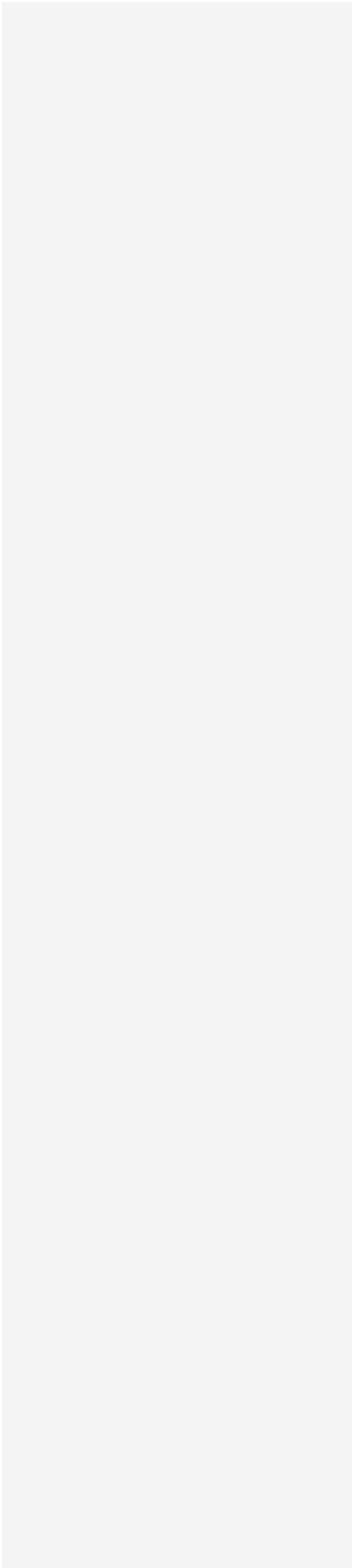
#### 2.4. Selection of Relevant Project and Baseline SS's

Each of the SS's from the project and baseline condition were compared and evaluated as to their relevancy using the guidance provided in Annex VI of the "Guide to Quantification Methodologies and Protocols: Draft", dated March 2006 (Environment Canada). The justification for the exclusion or conditions upon which SS's may be excluded is provided in ~~TABLE 2.3~~**TABLE 2.3**, below. All other SS's listed previously are included.

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**TABLE 2.3: Comparison of SS's**

1. Identified SS	2. Baseline (C, R, A)	3. Project (C, R, A)	4. Include or Exclude from Quantification	5. Justification for Exclusion
<b>Upstream SS's</b>				
P 1 Fluid Production/Processing	N/A	Related	Excluded	Excluded as fluid production/processing is not impacted by the implementation of the project and as such the baseline and the project conditions will be functionally equivalent.
B 1 Fluid Production/Processing	Related	N/A	Excluded	
P 6 Fuel Extraction/Processing	N/A	Related	Included	N/A
B 6 Fuel Extraction/Processing	Related	N/A	Included	N/A
P 7 Fuel Delivery	N/A	Related	Excluded	Excluded as the fuel delivery is not impacted by the implementation of the project and as such the baseline and the project conditions will be functionally equivalent.
B 7 Fuel Delivery	Related	N/A	Excluded	
P 8 Electricity Usage	N/A	Related	Excluded	Excluded as electricity usage is not impacted by the implementation of the project and as such the baseline and the project conditions will be functionally equivalent.
B 8 Electricity Usage	Related	N/A	Excluded	
<b>Onsite SS's</b>				
P 3 Electricity Consumption	N/A	Related	Included	N/A
P 4 Vented Emissions	N/A	Related	Included	N/A
B 3 Electricity Consumption	Related	N/A	Included	N/A
B 4 Vented Emissions	Related	N/A	Included	N/A
<b>Downstream SS's</b>				
P 5 Downstream Fluid Processing	N/A	Related	Excluded	Excluded as downstream fluid processing is not impacted by the implementation of the project and as such the baseline and the project conditions will be functionally equivalent.
P 5 Downstream Fluid Processing	Related	N/A	Excluded	
<b>Other</b>				
P 2 Low/No Intensive Pump	N/A	Related	Excluded	Emissions from low/no GHG intensive pump are not material given the long project life and the minimal time required for construction of pumps and accessories.

Pump Conversion

B 2 High GHG Intensive Pump	Related	N/A	Excluded	Emissions from high GHG intensive pump are not material given the long project life and the minimal time required for construction of pumps and accessories.
P 9 Construction on Site	N/A	Related	Excluded	Emissions from construction on site are not material given the long project life and the minimal construction on site typically required.
B 9 Construction on Site	Related	N/A	Excluded	Emissions from construction on site are not material for the baseline condition given the minimal construction on site typically required.
P 10 Development of Site	N/A	Related	Excluded	Emissions from development of site are not material given the long project life and the minimal development of site typically required.
B 10 Development of Site	Related	N/A	Excluded	Emissions from development of site are not material for the baseline condition given the minimal development of site typically required.
P 11 Building of Equipment	N/A	Related	Excluded	Emissions from building of equipment are not material given the long project life and the minimal building equipment typically required.
B 11 Building of Equipment	Related	N/A	Excluded	Emissions from building of equipment are not material for the baseline given the minimal building equipment typically required.
P 12 Transportation of Equipment	N/A	Related	Excluded	Emissions from transportation of equipment are not material given the long project life and the minimal transportation of equipment typically required.
B 12 Transportation of Equipment	Related	N/A	Excluded	Emissions from transportation of equipment are not material for the baseline given the minimal transportation of equipment typically required.
P 13 Testing of Equipment	N/A	Related	Excluded	Emissions from testing of equipment are not material given the long project life and the minimal testing of equipment typically required.
B 13 Testing of Equipment	Related	N/A	Excluded	Emissions from testing of equipment are not material for the baseline given the minimal testing of equipment typically required.
P 14 Site Decommissioning	N/A	Related	Excluded	Emissions from decommissioning of site are not material given the long project life and the minimal decommissioning typically required.
B 14 Site Decommissioning	Related	N/A	Excluded	Emissions from decommissioning of site are not material for the baseline given the minimal decommissioning typically required.

## 2.5. Quantification of Reduction, Removals, and Reversals of Relevant SS's

### 2.5.1. Quantification Approach

Quantification of the reductions, removals and reversals of relevant SS's for each of the greenhouse gases will be completed using the methodologies outlined in **TABLE 2.4**, below. These calculation methodologies serve to complete the following three equations for calculating the emission reductions from the comparison of the baseline and project conditions.

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The general approach is to calculate the offsets as follows:

$$\text{Emission Reduction} = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}}$$

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Electricity Consumption}} + \text{Emissions}_{\text{Vented Emissions}}$$

$$\text{Emissions}_{\text{Project}} = \text{Emissions}_{\text{Fuel Extraction / Processing}} + \text{Emissions}_{\text{Electricity Consumption}} + \text{Emissions}_{\text{Vented Emissions}}$$

where

$\text{Emissions}_{\text{Baseline}}$  = sum of the emissions under the baseline condition.

$\text{Emissions}_{\text{Fuel Extraction/Processing}}$  = emissions under SS B 6 from fuel extraction and processing of fuels used in the baseline

$\text{Emissions}_{\text{Electricity Consumption}}$  = emissions under SS B 3 from electricity used to operate pumping system

$\text{Emissions}_{\text{Vented Emissions}}$  = emissions under SS B 4 from vented gas to operate pumping systems

$\text{Emissions}_{\text{Project}}$  = sum of the emissions under the project condition.

$\text{Emissions}_{\text{Fuel Extraction/Processing}}$  = emissions under SS P 6 emissions from fuel extraction and processing used in the project

$\text{Emissions}_{\text{Electricity Consumption}}$  = emissions under SS P 3 from electricity used to operate pumping system

$\text{Emissions}_{\text{Vented Emissions}}$  = emissions under SS P 4 from capture of vented gas to operate pumping systems

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**TABLE 2.4: Quantification Procedures**

1. Project / Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
<b>Project SS's</b>						
P 6 Fuel Extraction/ Processing	$Emissions_{Fuel\ Extraction / Processing} = \sum (Vol. Fuel_i * EF_{Fuel_i CO_2}); \sum (Vol. Fuel_i * EF_{Fuel_i CH_4}); \sum (Vol. Fuel_i * EF_{Fuel_i N_2O})$					
	Emissions <sub>Fuel</sub> Extraction / Processing	kg of CO <sub>2</sub> e	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregate for each of these SS's.
	Volume of Each Type of Fuel/ Vol. Fuel <sub>i</sub>	m <sup>3</sup>	Measured	Direct metering or reconciliation of volumes based on P3 and P4	Continuous metering or monthly reconciliation	Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	CO <sub>2</sub> Emissions Factor for Fuel Including Production and Processing / EF <sub>Fuel CO<sub>2</sub></sub>	kg CO <sub>2</sub> per m <sup>3</sup>	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH <sub>4</sub> Emissions Factor for Fuel Including Production and	kg CH <sub>4</sub> per m <sup>3</sup>	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on

	Processing / EF Fuel <sub>CH4</sub>					Canada's emissions inventory.
	N <sub>2</sub> O Emissions Factor for Fuel Including Production and Processing / EF Fuel <sub>N2O</sub>	kg N <sub>2</sub> O per m <sup>3</sup>	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P 3 Electricity Consumption	<p><i>The following equation (1) should be used to calculate emissions from Electricity Consumption for projects that use electricity from the grid. Note that this emission factor can be based on electricity displacement factor for Alberta. Equation (2) is used if the metered quantity is the volume of fluid displaced.</i></p> <p>1. Emissions<sub>Electricity Consumption</sub> = Σ (EF<sub>Electricity</sub> * Electricity Use<sub>i</sub>)</p> <p><i>2. Emissions<sub>Electricity Consumption</sub> = Σ ((EF<sub>Electricity</sub> / EF<sub>New Pump i</sub>) * Vol.<sub>Fluid i</sub>)</i></p> <p><i>The following equation (23) should be used to calculate emissions from Electricity Consumption for projects that use on-site electricity generated from fossil fuels. Note that this emission factor can be based on electricity displacement factor in Alberta or from an approved displacement factor for self generators.</i></p> <p><i>2.3</i> Emissions<sub>Electricity Consumption</sub> = Σ (Vol. Fuel<sub>i</sub> * EF<sub>Fuel i CO2</sub>);                  Σ (Vol. Fuel<sub>i</sub> * EF<sub>Fuel i CH4</sub>);                  Σ (Vol. Fuel<sub>i</sub> * EF<sub>Fuel i N2O</sub>).</p> <p><i>Note that pumps running on renewable energy sources such as solar or power have a default EF of 0 kg of CO<sub>2</sub>e /kWh.</i></p>					
	Emissions <sub>Electricity Consumption</sub>	kg of CO <sub>2</sub> e	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregate for each of these SS's.

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	Emission Factor for Grid-Generated <del>or Self-Generated</del> Electricity / EF	kg of CO <sub>2</sub> e/kWh	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	Electricity Used by Pump <sub>i</sub> / Electricity Use <sub>i</sub>	kWh	Measured	Direct metering or reconciliation of volumes	Continuous metering or monthly reconciliation	Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.
	<u>Emissions Factor for Low/No GHG Intensive Pump/</u> <u>EF<sub>New Pump i</sub></u>	<u>m<sup>3</sup>/kWh</u>	<u>Estimated</u>	<u>Estimated based on manufacture's technical specifications for project pump</u>	<u>N/A</u>	<u>Available from the manufacturer and should be an average under steady state operations.</u>
	<u>Volume of Fluid Displaced <sub>i</sub> /</u> <u>Vol. <sub>Fluid i</sub></u>	<u>m<sup>3</sup></u>	<u>Measured</u>	<u>Direct metering or reconciliation of volumes</u>	<u>Continuous metering or monthly reconciliation</u>	<u>Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.</u>
	Volume of Fossil Fuel <sub>i</sub> / Vol. Fuel <sub>i</sub>	m <sup>3</sup>	Measured	Direct metering or reconciliation of volumes	Continuous metering or monthly reconciliation	Both methods are standard practice. Frequency of metering is highest

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						level possible. Frequency of reconciliation provides for reasonable diligence.
	CO <sub>2</sub> Emissions Factor Each Type of Fuel <sub>i</sub> / EF Fuel CO <sub>2</sub>	kg CO <sub>2</sub> per m <sup>3</sup>	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH <sub>4</sub> Emissions Factor for Each Type of Fuel <sub>i</sub> / EF Fuel CH <sub>4</sub>	kg CH <sub>4</sub> per m <sup>3</sup>	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N <sub>2</sub> O Emissions Factor for Each Type of Fuel <sub>i</sub> / EF Fuel N <sub>2</sub> O	kg N <sub>2</sub> O per m <sup>3</sup>	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
P 4 Vented Emissions	Captured under B4					
<b>Baseline SS's</b>						
	Emissions <sub>Fuel Extraction / Processing</sub> = $\Sigma (\text{Vol. Fuel}_i * \text{EF Fuel}_i \text{CO}_2)$ ; $\Sigma (\text{Vol. Fuel}_i * \text{EF Fuel}_i \text{CH}_4)$ ; $\Sigma (\text{Vol. Fuel}_i * \text{EF Fuel}_i \text{N}_2\text{O})$					
B 10 Fuel Extraction/ Processing	Emissions <sub>Fuel Extraction / Processing</sub>	kg of CO <sub>2</sub> e	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely

						aggregate for each of these SS's.
	<p><del>Volume of Fossil Fuel i / Emissions</del></p> <p><del>Fuel Gas</del></p> <p><del>Volume of Fossil Fuel i / Emissions</del></p> <p><del>Fuel Gas</del></p>	<p><del>m<sup>3</sup></del></p> <p><del>m<sup>3</sup></del></p>	<p><del>Estimated</del></p> <p><del>Estimated</del></p>	<p><del>Estimated based on volumes of fuel type for B3 and B4</del></p> <p><del>Estimated based on volumes of fuel type for B3 and B4</del></p>	<p><del>-</del></p> <p><del>=</del></p>	<p><del>Estimated using technical specifications for equipment used in baseline condition</del></p> <p><del>Estimated using technical specifications for equipment used in baseline condition</del></p>
	CO <sub>2</sub> Emissions Factor for Fuel Including Production and Processing / EF Fuel <sub>CO2</sub>	kg CO <sub>2</sub> per m <sup>3</sup>	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	CH <sub>4</sub> Emissions Factor for Fuel Including Production and Processing / EF Fuel <sub>CH4</sub>	kg CH <sub>4</sub> per m <sup>3</sup>	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
	N <sub>2</sub> O Emissions Factor for Fuel Including Production and Processing / EF Fuel <sub>N2O</sub>	kg N <sub>2</sub> O per m <sup>3</sup>	Estimated	From Environment Canada reference documents	Annual	Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.
B 3 Electricity Consumption	<p><i>The following equation (1) should be used to calculate emissions from Electricity Consumption for projects that used electricity from the grid. Note that this emission factor can be based on electricity displacement factor for Alberta. Equation (2) is used if the metered quantity is the volume of fluid displaced.</i></p>					

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<p>1. <math>Emissions_{Electricity\ Consumption} = \sum (Electricity\ Use_i * (EF_{New\ Pump_i} / EF_{Old\ Pump_i}) * EF_{Electricity})</math></p> <p>2. <math>Emissions_{Electricity\ Consumption} = \sum ((EF_{Electricity} / EF_{New\ Pump_i}) * Vol_{Fluid_i})</math></p> <p><i>The following equation (3) should be used to calculate emissions from Electricity Consumption for projects that used on-site electricity generated from fossil fuels.</i></p> <p><del>The following equation is used to calculate emissions from pump systems that operate on electricity prior to the project being implemented.</del></p> <p>3. <math>Emissions_{Vented} = \sum (PC_{Electric\ Pump_i} * Electricity\ Use_i / EF_{Old\ Pump_i})</math>  <math>Emissions_{Electricity\ Consumption} = \sum (Vol_{Fuel_i} * EF_{Fuel_i\ CO2} * (EF_{New\ Pump_i} / EF_{Old\ Pump_i}))</math>  <math>\sum (Vol_{Fuel_i} * EF_{Fuel_i\ CH4} * (EF_{New\ Pump_i} / EF_{Old\ Pump_i}))</math>  <math>\sum (Vol_{Fuel_i} * EF_{Fuel_i\ N2O} * (EF_{New\ Pump_i} / EF_{Old\ Pump_i}))</math></p> <p><i>Note that some pumps do not operate annually but rather part of the year.</i></p>					
<p><u>Emissions<sub>Electricity Consumption</sub></u>  <del>Vented-Emissions</del></p>	kg of CO <sub>2</sub> e	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregate for each of these SS's.
<p><u>Electricity Used by Pump i / Electricity Use i</u>  <u>Pump Capacity for Electric Pump / PC<sub>Electric Pump i</sub></u></p>	kWhm <sup>3</sup> -fluid per kWh	Measured	Estimated	<p>Continuous metering or monthly reconciliation N/A</p>	<p>Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence. Pump Capacity is usually available</p>

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Pump Conversion

						from the manufacturer and should be an average under steady state operations
<u>Emissions Factor for Low/No GHG Intensive Pump/</u> <u>EF<sub>New Pump i</sub></u>	<u>m<sup>3</sup>/kWh</u>	<u>Estimated</u>	<u>Estimated based on manufacture's technical specifications for project pump</u>	<u>N/A</u>	<u>Available from the manufacturer and should be an average under steady state operations.</u>	
<u>Emissions Factor for High GHG Intensive Pump/</u> <u>EF<sub>Old Pump</sub></u> <u>Electricity Used by Pump i</u> <u>/Electricity Use<sub>i</sub></u> <u>Emissions Factor for Pump Prior to Conversion i /EF<sub>Old Pump i</sub></u>	<u>m<sup>3</sup>/kWh</u> <u>kWh</u> <u>m<sup>3</sup> fluid per kWh</u>	<u>Estimated</u> <u>Measured</u> <u>Estimated</u>	<u>Estimated based on manufacture's technical specifications for project pump</u> <u>Direct metering or reconciliation of electricity consumption from P3</u> <u>Estimated based on manufacture's technical specifications for project pump</u>	<u>N/A</u> <u>Continuous metering or monthly reconciliation</u> <u>N/A</u>	<u>Available from the manufacturer and should be an average under steady state operations. Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence. Pump Capacity is usually available from the manufacturer and should be an average under steady state operations</u>	
<u>Emission Factor for Grid-Generated Electricity / EF</u>	<u>kg of CO<sub>2</sub>e/kWh</u>	<u>Estimated</u>	<u>From Environment Canada reference documents</u>	<u>Annual</u>	<u>Reference values adjusted annually as part of Environment</u>	

Pump Conversion

	<u>Electricity</u>					<u>Canada reporting on Canada's emissions inventory.</u>
	<u>Volume of Fluid Displaced i / Vol. Fluid<sub>i</sub></u>	<u>m<sup>3</sup></u>	<u>Measured</u>	<u>Direct metering or reconciliation of volumes</u>	<u>Continuous metering or monthly reconciliation</u>	<u>Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.</u>
	<u>Volume of Fossil Fuel i / Vol. Fuel<sub>i</sub></u>	<u>m<sup>3</sup></u>	<u>Measured</u>	<u>Direct metering or reconciliation of electricity consumption from P3</u>	<u>Continuous metering or monthly reconciliation</u>	<u>Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.</u>
	<u>CO<sub>2</sub> Emissions Factor Each Type of Fuel i / EF Fuel<sub>CO2</sub></u>	<u>kg CO<sub>2</sub> per m<sup>3</sup></u>	<u>Estimated</u>	<u>From Environment Canada reference documents</u>	<u>Annual</u>	<u>Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.</u>
	<u>CH<sub>4</sub> Emissions Factor for Each Type of Fuel i / EF Fuel<sub>CH4</sub></u>	<u>kg CH<sub>4</sub> per m<sup>3</sup></u>	<u>Estimated</u>	<u>From Environment Canada reference documents</u>	<u>Annual</u>	<u>Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.</u>

	<u>N<sub>2</sub>O Emissions Factor for Each Type of Fuel i / EF<sub>Fuel_N2O</sub></u>	<u>kg N<sub>2</sub>O per m<sup>3</sup></u>	<u>Estimated</u>	<u>From Environment Canada reference documents</u>	<u>Annual</u>	<u>Reference values adjusted annually as part of Environment Canada reporting on Canada's emissions inventory.</u>
B 4 Vented Emissions	<p>The fuel gas supply is methane-rich gas used at the facility. As such, the calculation of emission from the baseline will only use the methane component; the carbon dioxide component is not included as emissions are negligible.</p> <p><u>The following equation (1) is used to calculate emissions from pump systems that operate on natural gas supplied from the facility's fuel gas supply during the baseline condition using metered quantities of electricity.</u></p> $1. \text{Emissions}_{\text{Vented Emissions}} = \sum (\text{PC}_{\text{Electric Pump } i} * \text{Electricity Use } i * \text{EF}_{\text{New Pump } i} * \text{EF}_{\text{Gas Pump } i} * \rho_{\text{CH}_4} * \%_{\text{CH}_4 \text{ Fuel}} / \%_{\text{CH}_4 \text{ Reference}} * \text{GWP}_{\text{CH}_4})$ <p><u>Equation (2) is used to calculate emissions from pump systems that operate on natural gas supplied from the facility's fuel gas supply during the baseline condition using metered quantities of fluid displaced.</u></p> $2. \text{Emissions}_{\text{Vented Emissions}} = \sum (\text{Vol}_{\text{Fluid } i} * \text{EF}_{\text{Gas Pump } i} * \rho_{\text{CH}_4} * \%_{\text{CH}_4 \text{ Fuel}} / \%_{\text{CH}_4 \text{ Reference}} * \text{GWP}_{\text{CH}_4})$ <p><u>Note that some pumps do not operate annually but rather part of the year.</u></p>					
	Emissions <sub>Vented Emissions</sub>	kg of CO <sub>2</sub> e	N/A	N/A	N/A	Quantity being calculated in aggregate form as fuel and electricity use on site is likely aggregate for each of these SS's.
	<u>Electricity Used by Pump i / Electricity Use<sub>i</sub></u> <u>Pump Capacity for Electric Pump / PC</u>	<u>kWh</u> <u>m<sup>3</sup> fluid per kWh</u>	<u>Measured</u> <u>Estimated</u>	<u>Direct metering or reconciliation of electricity consumption from P3</u> <u>Estimated based on manufacture's</u>	<u>Continuous metering or monthly reconciliation</u> <u>N/A</u>	<u>Both methods are standard practice.</u> <u>Frequency of metering is highest level possible.</u> <u>Frequency of</u>

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Pump Conversion

	<u>Electric Pump</u>			<u>technical specifications for project pump</u>		<u>reconciliation provides for reasonable diligence.</u> Pump Capacity is usually available from the manufacturer and should be an average under steady state operations
	<u>Emissions Factor for Low/No GHG Intensive Pump/</u> <u>EF<sub>New Pump</sub></u> <u>Electricity Used by Pump i</u> <u>/Electricity Use<sub>i</sub></u>	<u>m<sup>3</sup>/kWh</u>	<u>Estimated</u> <u>Measured</u>	<u>Estimated based on manufacture's technical specifications for project pump.</u> <u>Direct metering or reconciliation of electricity consumption from p3</u>	<u>N/A</u> <u>Continuous metering or monthly reconciliation</u>	<u>Available from the manufacturer and should be an average under steady state operations.</u> <u>Both methods are standard practice.</u> <u>Frequency of metering is highest level possible.</u> <u>Frequency of reconciliation provides for reasonable diligence.</u>
	<u>Emissions Factor for Fuel Gas Vented by Gas-Powered Pump/EF<sub>Gas Pump</sub></u>	<u>m<sup>3</sup> gas per m<sup>3</sup> fluid</u>	<u>Estimated</u>	<u>Estimated based on manufacture's technical specifications for baseline pumps.</u> <u>Refer to APPENDIX A for details.</u>	<u>N/A</u>	<u>Volumes of gas used to power gas-powered pumps can be estimated using information from facility operations.</u>
	<u>Density of Methane / ρ<sub>CH4</sub></u>	<u>Kg / m<sup>3</sup></u>		<u>0.717kg/m<sup>3</sup> at STP</u>	<u>N/A</u>	<u>If this value is used all values must be</u>

Pump Conversion

			Estimated			adjusted for standard temperature and pressure.
Reference Percent Methane in Fuel Gas /%CH <sub>4</sub> Reference	%		Estimated	From manufacture's assumptions in determining technical specifications for given pump	N/A	Reference values from manufacture's assumptions when calculating vented rates provides for reasonable diligence and accuracy.
Percent Methane in Fuel Gas /%CH <sub>4</sub> Fuel	%		Measured	Direct Measurement	Annual	Fuel gas volumes should remain relatively stable during steady-state operation.
Global Warming Potential of Methane/ GWP <sub>CH<sub>4</sub></sub>	Kg CO <sub>2</sub> e/Kg CH <sub>4</sub>		Estimated	From Environment Canada; IPCC	Annual	The applicable global warming potential of CH <sub>4</sub> is 21 as per the IPCC, ISO, Environment Canada and other internationally accepted best practice guidance.
<u>Volume of Fluid Displaced i / Vol.<sub>Fluid-i</sub></u>	<u>m<sup>3</sup></u>		<u>Measured</u>	<u>Direct metering or reconciliation of volumes</u>	<u>Continuous metering or monthly reconciliation</u>	<u>Both methods are standard practice. Frequency of metering is highest level possible. Frequency of reconciliation provides for reasonable diligence.</u>

### 2.5.2. Contingent Data Approach

Contingent means for calculating or estimating the required data for the equations outlined in section 2.5.1 are summarized in **TABLE 2.5**, below.

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## 2.6. Management of Data Quality

In general, data quality management must include sufficient data capture such that the mass and energy balances may be easily performed with the need for minimal assumptions and use of contingency procedures. The data should be of sufficient quality to fulfill the quantification requirements and be substantiated by company records for the purpose of verification.

The project proponent shall establish and apply quality management procedures to manage data and information. Written procedures should be established for each measurement task outlining responsibility, timing and record location requirements. The greater the rigor of the management system data, the more easily an audit will be to conduct for the project.

### 2.6.1. Record Keeping

Record keeping practices should include:

- a. Electronic recording of values of logged primary parameters for each measurement interval;
- b. Printing of monthly back-up hard copies of all logged data;
- c. Written logs of operations and maintenance of the project system including notation of all shut-downs, start-ups and process adjustments;
- d. Retention of copies of logs and all logged data for a period of 7 years; and
- e. Keeping all records available for review by a verification body.

### 2.6.2. Quality Assurance/Quality control (QA/QC)

QA/QC can also be applied to add confidence that all measurements and calculations have been made correctly. These include, but are not limited to:

- a. Protecting monitoring equipment (sealed meters and data loggers);
- b. Protecting records of monitored data (hard copy and electronic storage);
- c. Checking data integrity on a regular and periodic basis (manual assessment, comparing redundant metered data, and detection of outstanding data/records);
- d. Comparing current estimates with previous estimates as a 'reality check';
- e. Provide sufficient training to operators to perform maintenance and calibration of monitoring devices;
- f. Establish minimum experience and requirements for operators in charge of project and monitoring; and
- g. Perform recalculations to make sure no mathematical errors have been made.

**TABLE 2.5: Contingent Data Collection Procedures**

1. Project / Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justify measurement or estimation and frequency
<b>Project SS's</b>						
P 6 Fuel Extraction/Processing	Volume of Each Type of Fuel/ Vol. Fuel <sub>i</sub>	L/m <sup>3</sup> /other	Estimated	Reconciliation of volume of fuel used within given time period	Monthly	Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.
P3 Electricity Consumption	Electricity Used by Pump i /Electricity Use <sub>i</sub>	kWh	Estimated	Reconciliation of electricity used within given time period	Monthly	Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.
	<u>Emissions Factor for Low/No GHG Intensive Pump/ EF<sub>New Pump,i</sub></u>	<u>m<sup>3</sup>/kWh</u>	<u>Estimated</u>	<u>Estimated based on technical specifications for project pump of similar type</u>	<u>N/A</u>	<u>Available from any manufacturer when the more accurate and precise method cannot be used.</u>
	<u>Volume of Fluid Displaced i / Vol. Fluid<sub>i</sub></u>	<u>m<sup>3</sup></u>	<u>Estimated</u>	<u>Reconciliation of volume of fluid displaced within given time period</u>	<u>Monthly</u>	<u>Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.</u>
	Volume of Fossil Fuel i / Vol. Fuel <sub>i</sub>	m <sup>3</sup>	Estimated	Reconciliation of volume of fuel used within given time	Monthly	Provides reasonable estimate of the parameter when the

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Pump Conversion

				period		more accurate and precise method cannot be used.
Baseline SS's						
PB 6 Fuel Extraction/Processing	Volume of Each Type of Fuel/ Vol. Fuel <sub>i</sub>	L/m <sup>3</sup> /other	Estimated	Reconciliation of volume of fuel used within given time period	Monthly	Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.
PB 3 Electricity Consumption	Electricity Used by Pump <sub>i</sub> /Electricity Use <sub>i</sub>	kWh	Estimated	Reconciliation of electricity used within given time period	Monthly	Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.
	<u>Emissions Factor for Low/No GHG Intensive Pump<sub>i</sub></u> <u>/EF<sub>New Pump i</sub></u> <u>Volume of Fossil Fuel<sub>i</sub> / Vol. Fuel<sub>i</sub></u>	<u>m<sup>3</sup> fluid per kWh</u>	<u>Estimated</u> <u>Estimated</u>	<u>Estimated based on technical specifications for project pump of similar type</u> <u>Reconciliation of volume of fuel used within given time period</u>	<u>N/A</u> <u>Monthly</u>	<u>Available from any manufacturer when the more accurate and precise method cannot be used.</u> <u>Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.</u>
	<u>Emissions Factor for High GHG Intensive Pump<sub>i</sub></u> <u>/EF<sub>New Pump i</sub></u>	<u>m<sup>3</sup> fluid per kWh</u>	<u>Estimated</u>	<u>Estimated based on technical specifications for project pump of similar type</u>	<u>N/A</u>	<u>Available from any manufacturer when the more accurate and precise method cannot be used.</u>

Pump Conversion

	<u>Volume of Fluid Displaced i / Vol. Fluid<sub>i</sub></u>	<u>m<sup>3</sup></u>	<u>Estimated</u>	<u>Reconciliation of volume of fluid displaced within given time period</u>	<u>Monthly</u>	<u>Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.</u>
	<u>Volume of Fossil Fuel i / Vol. Fuel<sub>i</sub></u>	<u>m<sup>3</sup></u>	<u>Estimated</u>	<u>Reconciliation of volume of fuel used within given time period</u>	<u>Monthly</u>	<u>Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.</u>
B 4 Vented Emissions Fuel Gas	<u>Electricity Used by Pump i / Electricity Use<sub>i</sub></u>  <u>Pump Capacity for Electric Pump / PC<sub>Electric Pump i</sub></u>	<u>kWh</u>  <u>m<sup>3</sup> per kWh</u>	<u>Estimated</u> <u>Estimated</u>	<u>Reconciliation of volume of fuel used within given time period from P3. Estimated based on manufacturer's technical specifications for project pump of similar make or determined by the project proponent using field data. Refer to APPENDIX A.</u>	<u>Continuous metering or monthly reconciliation</u> <u>N/A</u>	<u>Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used. Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.</u>
	<u>Emissions Factor for Low/No GHG Intensive Pump i / EF<sub>New Pump i</sub></u> <u>Electricity Used by Pump i / Electricity</u>	<u>m<sup>3</sup> fluid per kWh</u> <u>kWh</u>	<u>Estimated</u> <u>Estimated</u>	<u>Estimated based on technical specifications for project pump of similar type. Reconciliation of</u>	<u>N/A</u> <u>Continuous metering or monthly reconciliation</u>	<u>Available from any manufacturer when the more accurate and precise method cannot be used. Provides</u>

	<u>Use<sub>i</sub></u>			<u>volume of fuel used within given time period from P3</u>		<u>reasonable estimate of the parameter when the more accurate and precise method cannot be used.</u>
	Emissions Factor for Fuel Gas Vented by Gas-Powered Pump/EF <small>Gas Pump</small>	m <sup>3</sup> gas per m <sup>3</sup> fluid	Estimated	Estimated based on manufacture's technical specifications for baseline pumps of similar make	N/A	Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.
	Percent Methane in Fuel Gas Used by Manufacturer/% <sub>CH4</sub> <small>Reference</small>	%	Estimated	From accredited sources or industry standards for similar types of equipment	-	Provides reasonable and conservative estimate of the parameter when the more accurate and precise method cannot be used.
	Percent Methane in Fuel Gas/% <sub>CH4</sub> <small>Fuel</small>	%	Estimated	From accredited sources or industry standards	-	Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.
	<u>Volume of Fluid Displaced i / Vol<sub>Fluid-i</sub></u>	<u>m<sup>3</sup></u>	<u>Estimated</u>	<u>Reconciliation of volume of fluid displaced within given time period</u>	<u>Monthly</u>	<u>Provides reasonable estimate of the parameter when the more accurate and precise method cannot be used.</u>

**APPENDIX A -- Examples of how to determine Emissions Factors**

This section serves as a guide to establish Emissions Factors (EF) for gas-powered pumps which can include chemical pumps, glycol dehydrators among others. The project proponent should justify the selection of the EF based on sound engineering principles, knowledge of the pump operating characteristics, and reasonable assumptions. Two examples are provided in the following pages. These are used for illustrative purposes. The assumptions made here are general. If the project proponent has access to more detailed assumptions or characteristics of the pumps, these should take precedence over the general approach presented here.

The final section of this appendix details the steps necessary to determine the EF in terms of units of metered fluids.

**EF for Gas Powered Chemical Injection Pumps**

Determining the EF for a gas powered pump is made using the manufacture’s technical specifications for a given pump. The determination is also based on the facility operator’s working knowledge of the pumps. As an example, a gas powered chemical injection pump is used to pump methanol into a pipeline. The manufacture’s technical specifications for gas consumption are given in **FIGURE A.1**.

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**FIGURE A. 1 Gas consumption for a given gas powered pump**

**GAS CONSUMPTION CHART**  
Standard Cubic Feet of Gas Required to Pump One Gallon

Piston Size		1/2"		3/8"		1/4"		3/16"	
Stroke		Full	1/3	Full	1/3	Full	1/3	Full	1/3
Injection Pressure In PSI	6000			374	1122	497	1491	589	1776
	5000			355	1065	405	1215	575	1725
	4000			314	942	369	1107	560	1680
	3500	95	285	278	834	355	1065	555	1665
	3000	84	252	243	729	340	1020	545	1635
	2000	76	228	185	555	308	924	530	1590
	1500	71	213	177	531	288	864	476	1428
	1000	62	186	164	492	270	810	469	1407
	500	57	171	148	444	248	744	462	1386
	200	54	162	126	378	245	735	458	1374
	100	53	159	120	360	244	732	457	1371

Source: [http://www.arrowengine.com/media/chempump\\_overview.pdf](http://www.arrowengine.com/media/chempump_overview.pdf), p.9

The facility operator assumes that the pump operated with the following characteristics:

- Pistons Size-3/8”;
- Injection Pressure- 3000 PSI; and
- Stroke- Full

Based on these characteristics, the EF is **243** ft<sup>3</sup> of gas/ gallon of chemical. In SI units the EF is 1834.66 m<sup>3</sup> gas/ m<sup>3</sup> chemical. The mass EF is **1315.45** kg of gas / m<sup>3</sup> chemical assuming a density of .717 kg/m<sup>3</sup> for methane and 100% methane composition in fuel gas.

### **EF for Gas Powered Glycol Dehydrators**

The determination of the EF for glycol dehydrators follows the EPA's methodology presented in *Lessons Learned-Replacing Gas-Assisted Glycol Pumps with Electric Pumps*. The EF is defined as

$$EF = PGU * G * WR * OC$$

where

EF = Emissions Factor (scf natural gas /MMcf gas processed);

PGU = Pump Gas Usage (scf natural gas emitted/gallon TEG);

G = Glycol-to-Water Ratio (gallons of TEG/lb water removed);

WR = Water Removed Rate (lb water removed/MMcf gas processed); and

OC = Over circulation ratio.

The following industry accepted Rules-of-Thumb apply:

- PGU → 3 cubic-ft/gal for gas-assisted pumps, 1 cubic-ft/gal for electric pump; the difference being 2 cubic-ft/gal.
- G = 3 gal TEG/ lb water.

Numerical Example:

Given

- PGU = 2 scf natural gas emitted/gallon TEG;
- G = 3 gallons of TEG/lb water removed;
- OC = 1:1 to 2.1:1;
- Inlet pressure 800 psig; and
- Inlet temperature 94°F.
  
- WR = 53 lb water removed/MMcf gas processed:

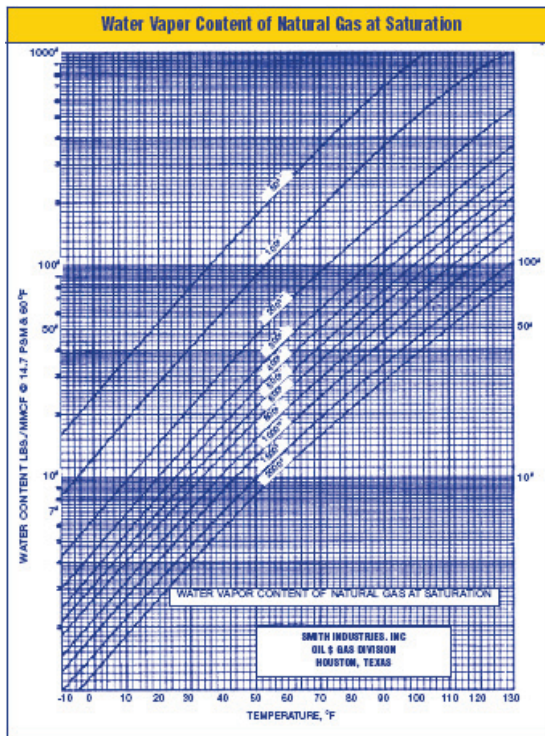
Using the table provided in [FIGURE A. 2](#), the point of intersection of the x axis (temperature) with the 800 psig curve is read with the corresponding value on the y axis. A value of 60 lb water removed/MMcf gas processed is used as a base for WR. 7 lb water removed/MMcf gas processed is the standard water content for pipeline gas and is

subtracted from 60 lb water removed/MMcf gas processed. The amount of water that must be removed is therefore 53 lb water removed/MMcf gas processed.

$$EF = PGU * G * WR * OC = 2 * 3 * 53 * (\text{Range } 1.1 \text{ to } 2.1)$$

Based on these characteristics, the EF will range from **318** to **668** scf of natural gas emitted/MMcf gas processed. In SI units the EF is **318** to **668** m<sup>3</sup> gas/ MMm<sup>3</sup> gas processed. The mass EF is **228** to **478.95** kg of gas / MMm<sup>3</sup> gas processed assuming a density of .717 kg/m<sup>3</sup> for methane and 100% methane composition in fuel gas.

**FIGURE A. 2 Water vapor content of natural gas at saturation**



Source: [http://www.epa.gov/gasstar/documents/ll\\_glycol\\_pumps3.pdf](http://www.epa.gov/gasstar/documents/ll_glycol_pumps3.pdf), p16

### Flexibility Mechanism

The EF for fluid based metering is calculated using the methodology outlined in the **EF for Gas Powered Chemical Injection Pumps** section. The project proponent must be careful in choosing and justifying the emissions using the characteristics of the pumps based on manufacturer’s technical specifications. By multiplying the EF with the measured of estimated volume of fluid pumped, the total emissions are established.

**Pump Capacity for Electric Pump for electrical pumps using field data**

Pump Capacity for Electric Pump /  $PC_{\text{Electric Pump } i}$  is a data parameter that is usually available from the manufacturer's technical specifications for electric pumps. This protocol uses that information, or information from similar pump types. In cases where this parameter cannot be established from either the manufacturer's technical specifications or pumps of similar characteristics, the parameter is estimate using field data.

Essentially, the estimation of this parameter requires two data sources collected from field measurements:

- Metering of volume of fluid displaced by type i pump; and
- Metering of electricity consumption by type i pump.

Data streams for the two metered quantities are synchronous. A deviation from this is permissible as on as the data quantities are taken over the same period and reflect a steady state. Dividing the metered volume of fluid by the metered electricity consumption will establish the pump capacity. Units should be express as:

$m^3$  fluid per kWh

**APPENDIX B - Emissions Factor for Selected Fuels<sup>2</sup>**

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<sup>2</sup> Source: Environment Canada (2006). NATIONAL INVENTORY REPORT, 1990-2005: GREENHOUSE GAS SOURCES AND SINKS IN CANADA. (Subject to Updates-Project developers should contact Environment Canada for the latest factors).

**Relevant Emission Factors**

**TABLE B.1: Emission Intensity of Fuel Extraction and Production (Diesel, Natural Gas and Gasoline)**

<b>Diesel</b>		
<b>Production</b>		
Emissions Factor (CO <sub>2</sub> )	0.138	kg CO <sub>2</sub> per Litre
Emissions Factor (CH <sub>4</sub> )	0.0109	kg CH <sub>4</sub> per Litre
Emissions Factor (N <sub>2</sub> O)	0.000004	kg N <sub>2</sub> O per Litre
<b>Natural Gas</b>		
<b>Extraction</b>		
Emissions Factor (CO <sub>2</sub> )	0.043	kg CO <sub>2</sub> per m <sup>3</sup>
Emissions Factor (CH <sub>4</sub> )	0.0023	kg CH <sub>4</sub> per m <sup>3</sup>
Emissions Factor (N <sub>2</sub> O)	0.000004	kg N <sub>2</sub> O per m <sup>3</sup>
<b>Processing</b>		
Emissions Factor (CO <sub>2</sub> )	0.090	kg CO <sub>2</sub> per m <sup>3</sup>
Emissions Factor (CH <sub>4</sub> )	0.0003	kg CH <sub>4</sub> per m <sup>3</sup>
Emissions Factor (N <sub>2</sub> O)	0.000003	kg N <sub>2</sub> O per m <sup>3</sup>
<b>Gasoline</b>		
<b>Production</b>		
Emissions Factor (CO <sub>2</sub> )	0.138	kg CO <sub>2</sub> per Litre
Emissions Factor (CH <sub>4</sub> )	0.0109	kg CH <sub>4</sub> per Litre
Emissions Factor (N <sub>2</sub> O)	0.000004	kg N <sub>2</sub> O per Litre

**TABLE B.2: Emissions Factors for Natural Gas and NGL's**

<b>Source</b>	<b>Emissions Factor</b>		
	<b>CO<sub>2</sub> g/m<sup>3</sup></b>	<b>CH<sub>4</sub> g/m<sup>3</sup></b>	<b>N<sub>2</sub>O g/m<sup>3</sup></b>
<b>Natural Gas</b>			
Electric Utilities	1891	0.49	0.049
Industrial	1891	0.037	0.033
Producer Consumption	2389	6.5	0.06
Pipelines	1891	1.9	0.05
Cement	1891	0.037	0.034
Manufacturing Industries	1891	0.037	0.033
Residential, Construction, Commercial/Institutional, Agricultural	1891	0.037	0.035
	<b>g/L</b>	<b>g/L</b>	<b>g/L</b>
<b>Propane</b>			
Residential	1510	0.027	0.108
All Other Uses	1510	0.024	0.108
<b>Ethane</b>	976	N/A	N/A
<b>Butane</b>	1730	0.024	0.108

**TABLE B.3: Emissions Factors for Refined Petroleum Products**

Source	Emissions Factor (g/L)		
	CO <sub>2</sub>	CH <sub>4</sub>	N <sub>2</sub> O
<b>Light Fuel</b>			
Electric Utilities	2830	0.18	0.031
Industrial	2830	0.006	0.031
Producer Consumption	2830	0.006	0.031
Residential	2830	0.026	0.006
Forestry, Construction, Public Administration, and Commercial/Institutional	2830	0.026	0.031
<b>Heavy Fuel Oil</b>			
Electric Utilities	3080	0.034	0.064
Industrial	3080	0.12	0.064
Producer Consumption	3080	0.12	0.064
Residential	3080	0.057	0.064
Forestry, Construction, Public Administration, and Commercial/Institutional	3080	0.057	0.064
<b>Kerosene</b>			
Electric Utilities	2550	0.006	0.031
Industrial	2550	0.006	0.031
Producer Consumption	2550	0.006	0.031
Residential	2550	0.006	0.031
Forestry, Construction, Public Administration, and Commercial/Institutional	2550	0.006	0.031
<b>Diesel</b>	2730	0.133	0.4