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Clean Fuel Regulations:

Quantification Method for Enhanced Oil Recovery with CO_2 Capture and Permanent Storage

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Foreword

The *Clean Fuel Regulations* require primary suppliers (i.e., producers and importers of gasoline and diesel) to reduce the carbon intensity of the gasoline and diesel they produce in and import into Canada for use in Canada. These Regulations also establish a credit market whereby the annual CI reduction requirement could be met via three main categories of credit-creating actions, including carrying out a Carbon Dioxide Equivalent (CO_2e) emission-reduction project in respect of liquid fossil fuels. Environment and Climate Change Canada (ECCC) provides the Quantification Method for Enhanced Oil Recovery with CO_2 Capture and Permanent Storage to determine the reductions from eligible projects of this type.

The full text of the Regulations and associated documents are available on ECCC's website: https://www.canada.ca/clean-fuel-standard.

If you have questions about the *Clean Fuel Regulations*, please contact the following email address: cfsncp@ec.gc.ca.

Disclaimer

This document does not in any way supersede or modify the *Canadian Environmental Protection Act*, 1999 or *Clean Fuel Regulations*, or offer any legal interpretation of those Regulations. Where there are any inconsistencies between this document and the Act or the Regulations, the Act and the Regulations take precedence.

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1.0 Introduction

This quantification method (QM) is intended for use by registered creators applying to have a CO_2e-Emission-Reduction Project recognized to create credits under the *Clean Fuel Regulations* (the Regulations).

Carbon dioxide (CO_2) is emitted in many industrial production processes. It can be produced as a result of fuel combustion or as an inherent part of the industrial process. This CO_2 may be captured for other uses, or vented directly to the atmosphere. Capturing CO_2 emissions and transferring them to permanent storage results in a reduction of anthropogenic CO_2 emissions to the atmosphere.

Carbon capture and storage projects eligible under this QM typically consist of four main components:

- Industrial processes or fuel combustion activities that generate CO_2;
- CO_2 capture and purification infrastructure, which can be included in a new-built facility or retrofitted to an existing facility;
- A CO_2 pipeline to transport CO_2 from the capture facility to the injection site(s); and
- Net geological sequestration of CO_2 through CO_2 injection into an oil reservoir. Produced CO_2, emerging from the subsurface due to oil production is typically processed and reinjected (i.e. recycled) into the oil-producing geological formation at CO_2 injection wells. Reinjected CO_2 quantities are not eligible for credit creation in this QM to ensure no double counting of volumes.

As per paragraph 32(2)(f) in the Regulations, this QM is applicable to projects carried out in Canada.

2.0 Terms and Definitions

The definitions in the Regulations apply. Refer to subsection 1(1) of the Regulations for other definitions not included in this document. This section includes only those additional definitions not found in the Regulations.

CO_2 Capture: the capture, purification and compression of CO_2 at a facility where it would otherwise be directly released to the atmosphere.

CO_2 Injection: an activity that places captured CO_2 into a long-term geological storage site.

CO_2 Storage: the long-term isolation of carbon dioxide in subsurface geological formations (synonymous with permanent storage).

CO_2 Transport System: any mode of transport used to move captured CO_2 to the CO_2 injection site.

Drilling Blowout: an unintended flow of wellbore fluids (oil, gas, water or other substance) at surface that cannot be controlled by existing wellhead or blowout prevention equipment or a flow from one pool to another pool(s) (underground blowout) that cannot be controlled by increasing the fluid density.

Drilling Kick: any unexpected entry of water, gas, oil or other formation fluid into a wellbore that is under control and can be circulated out.

Electrical Network: a network for the distribution of electricity that is subject to the standards of the North American Electric Reliability Corporation.

Enhanced Oil Recovery (EOR) Project: all CO_2 Capture, CO_2 Transport Systems, CO_2 Storage, CO_2 Injection, and related equipment.

Fossil Fuel Facility: a facility that produces, processes, stores, transports or distributes fossil fuels that are in the liquid state at standard conditions or petroleum feedstocks upstream of refining. It does not include a facility that primarily engages in the production, process, storage, transport or distribution of fossil fuels or petroleum feedstocks in the gaseous state at standard conditions.

Global Warming Potential (GWP): an index, based on radiative properties of greenhouse gases, measuring the radiative forcing following a pulse emission of a unit mass of a given greenhouse gas in the present-day atmosphere integrated over a chosen time horizon, relative to that of carbon dioxide. The GWP represents the combined effect of the differing times these gases remain in the atmosphere and their relative effectiveness in causing radiative forcing. The GWP characterization factors to use are provided in Appendix A of the *Fuel LCA Model Methodology*.

Injected Gas: the total quantity of CO_2 that is measured directly upstream of the injection wellhead. This quantity is from the project and used to determine the baseline activity level.

On-Site: the buildings, other structures and stationary equipment at a project location associated with the Enhanced Oil Recovery Project.

3.0 Eligibility

To demonstrate that a CO_2e-emission-reduction project meets the requirements under this QM, the registered creator must supply sufficient evidence that:

1. The project captures CO_2 directly from an emitting facility in Canada;
2. The project is injecting into an oil-producing geological formation capable of permanently storing CO_2 gases in Canada as defined by the relevant regulations in the province(s) or territory(ies) where it is located;
3. The captured and injected CO_2 is from one or more of the following eligible sources:
    a. CO_2 captured at a Fossil Fuel Facility not associated with production of low-CI fuels;
    b. CO_2 captured at a facility that supplies hydrogen, electricity or heat to a Fossil Fuel Facility, prorated based on the proportion of produced hydrogen, electricity or heat supplied to the Fossil Fuel Facility as described in Appendix A;
        i. Electricity must be supplied directly to the Fossil Fuel Facility, and not supplied through an electrical network;

        ii. Electricity must not be produced by a facility that combusts coal, petcoke or synthetic gas that is derived from coal or petroleum coke;
    c. CO_2 captured at a facility that supplies hydrogen to a facility that supplies electricity or heat to a Fossil Fuel Facility, prorated based on the proportion of produced hydrogen used to produce electricity or heat and the proportion of produced electricity or heat supplied to the Fossil Fuel Facility as described in Appendix A;
        i. Electricity must be supplied directly to the Fossil Fuel Facility, and not supplied through an electrical network;
4. The capture of CO_2 started on or after July 1, 2017;
5. The project must be in good standing with all operating permits and relevant regulations in the province(s) or territory(ies) where it is located;
6. The project must not be required to lower the reservoir pressure at abandonment below the pressure at the end of production operations as a condition of its permits and/or regulatory requirements.

The Minister may decline projects in province(s) or territory(ies) if it can not be demonstrated that they have relevant regulations to ensure permanent storage. This includes, but is not limited to, requirements for site characterization, well construction and operation, injection monitoring and well abandonment.

4.0 Crediting

4.1 Crediting Period

CO_2e-emission-reduction projects using this QM are eligible to create credits under the Regulations for a period of 20 years, beginning on the later of the day on which the project is recognized by the Minister or, any preferred day referred to in paragraph 34(2)(b) of the Regulations indicated in the application. A single five year extension of the crediting period may be permitted in accordance with subsections 42(1) and (2) of the Regulations.

4.2 Credit Creation

The owner or operator of a facility that injects the CO_2 into the oil-producing geological formation is the registered creator by default. The registered creator may differ from the default, if the owner or operator of the facility that injects the CO_2 into the oil-producing geological formation enters into an agreement with another party to create credits for the CO_2-emission-reduction project in accordance with section 21 of the Regulations.

The owner or operator of this facility that injects the CO_2 into the oil-producing geological formation or this party with whom they have entered into an agreement with in accordance with section 21 of the Regulations must register as a credit creator in accordance with section 25 of the Regulations and have the project recognized after submitting an Application for Recognition of CO_2e-Emission-Reduction Project prior to creating credits under the Regulations.

If more than one person applies for recognition for the same project, no credits will be granted for that project until an agreement is reached by the parties to designate the registered creator.

4.3 Class of Credits Created

Credits are created in the liquid class.

5.0 Project

5.1 Project Locations

A project consists of multiple interconnected locations. These may include:

- A facility where the generation of CO_2 that is captured by the project occurs;
- A facility where the CO_2 capture infrastructure, including compression/dehydration, is located (which may be at the same site as the CO_2 generation);
- A means of transporting CO_2 from the capture facility to the injection site(s);
- Compressor stations located along the CO_2 pipeline (where additional compression beyond what is provided at the capture facility is needed);
- The site(s) where CO_2 is injected into the oil-producing geological formation;
- The site(s) where CO_2 is produced and processed for re-injection into the geological formation.

Multiple CO_2 generation facilities, capture facilities, pipelines, injection sites and/or re-injection sites may be aggregated into a single project. See Appendix B for further details and example scenarios.

Each project location must be uniquely identified using global positioning system (GPS) coordinates (5 decimals), or in the case of a pipeline, using a map that allows for the determination of the GPS coordinates to 5 decimal places for any location along the pipeline. Supporting documentation demonstrating the project location(s) must also be provided that includes aerial photographs, maps or satellite imagery. The boundary used to determine on-site versus off-site sources and sinks at each project location should be indicated.

5.2 Sources and Sinks Relevant to the Project

The project is the capture, compression, transport, injection and re-injection of the CO_2 into an oil-producing geological formation for permanent storage. Project emissions associated with capture, compression, transport, injection, re-injection, and leakage from the subsurface to the atmosphere are subtracted from the baseline emissions to determine the net greenhouse gas reduction achieved by the project. The full list of sources is included in Figure 1 with further descriptions in Table 1.

Enhanced Oil Recovery with Carbon capture and storage projects primarily reduce carbon dioxide emissions, but small amounts of methane and nitrous oxide emissions may also be emitted because of combustion and upstream production emissions. The project must quantify the percent concentration of three species of greenhouse gas emissions - carbon dioxide, methane and nitrous oxide.

Figure 1: Sources and Sinks Relevant to the Project

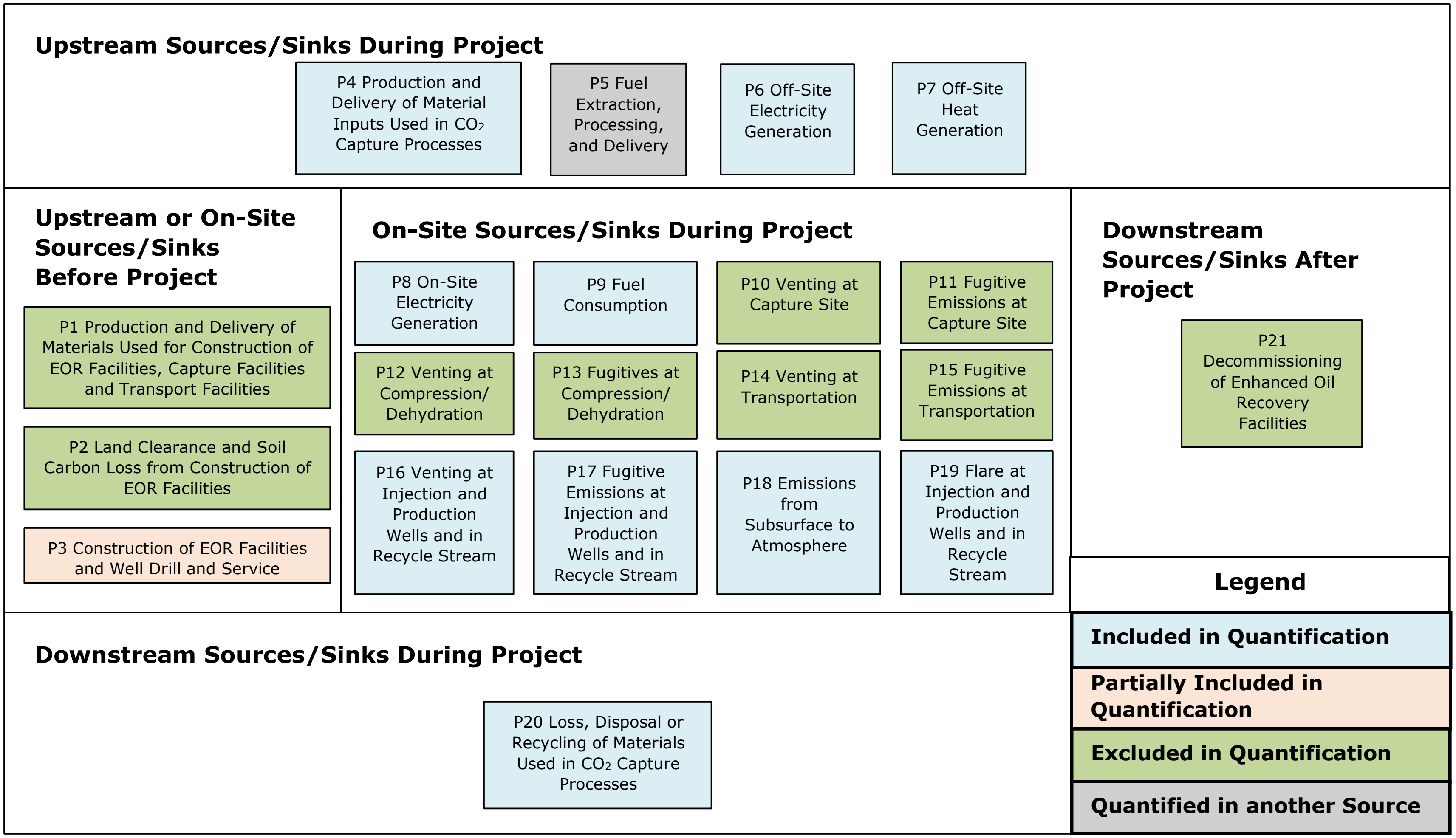


Table 1: Descriptions of Sources and Sinks

1. SS	2. Description	3. Included or Excluded from Quantification
Upstream Sources and Sinks before Project		
P1 - Production and Delivery of Materials Used for Construction of EOR Facilities, Capture Facilities and Transport Facilities	Materials used in the construction of carbon capture and storage facilities such as steel and concrete will need to be manufactured and delivered to the site. Emissions are attributed to fossil fuel and electricity consumption for material manufacture and fossil fuel consumption for material delivery.	Excluded
On-site Sources and Sinks Before Project		
P2 - Land Clearing and Soil Carbon Loss from Construction of EOR Facilities	The clearing of vegetative or forest land for site preparation may cause soil to release carbon dioxide into the atmosphere that was previously stored in soil.	Excluded
P3 - Construction of EOR Facilities and Well Drill and Service	Site construction will require a variety of heavy equipment, smaller power tools, cranes, generators and well drilling operations. The operation of this equipment will have associated greenhouse gas emissions from the use of fossil fuels and electricity and from the potential kick or blowout event that could release hydrocarbons during the drilling of injection and monitoring wells.	Partially included
Upstream Sources and Sinks During Project		
P4 - Production and Delivery of Material Inputs used in CO_2 Capture Processes	Material inputs, including specialized chemicals or additives such as amine sorbents, are required for CO_2 capture and processing. Greenhouse gas emissions are attributed to the fossil fuel consumption for transport of these materials, and the electricity and fossil fuel inputs for their production.	Included
P5 - Fuel Extraction, Processing, and Delivery	Each of the fuels used throughout the project will need to be extracted, processed and transported to the site. Delivery may include shipments by truck, rail or pipeline. CO_2, CH_4 and N_2O emissions are associated with these activities.	Excluded
P6 - Off-Site Electricity Generation	Emissions associated with the off-site generation of electricity that is consumed at project facilities.	Included
P7 - Off-Site Heat Generation	Emissions associated with the off-site generation of heat that is consumed at project facilities.	Included
On-Site Sources and Sinks During Project		
P8– On-Site Electricity Generation	Electricity inputs may be required for CO_2 capture, compression, transportation, injection and re-injection. Electricity may be generated independently or from cogeneration within the project boundary. The quantity and type of fuels consumed to generate electricity, and the quantity of electricity consumed by the project from each generating source would be tracked.	Included
P9 Fuel Consumption	Fuel use may be required for CO_2 capture, processing, compression, dehydration, transportation, injection and re-	Included

	injection or for heat or electricity generation. The quantity and type of fuels consumed from each source would be tracked.	
P10 - Venting at Capture Site	Some CO_2 is vented during the project. CO_2 venting may also be necessary for equipment maintenance or emergency shutdowns. These gases will be composed primarily of CO_2 with trace amounts of other gases.	Excluded
P11 - Fugitive Emissions at Capture Site	Unintended leaks of gas from the CO_2 capture and processing unit may occur through faulty seals, loose fittings, or equipment.	Excluded
P12 - Venting at Compression/ Dehydration	Planned and emergency venting may be necessary for compressor and dehydrator maintenance and/or emergency shutdowns.	Excluded
P13 – Fugitive Emissions at Compression/ Dehydration	Unintended leaks of gas from the compressor and/or dehydrator may occur through seals, loose fittings, equipment, or compressor packing.	Excluded
P14 - Venting at Transportation	Planned and emergency venting may be necessary for pipeline maintenance and/or shutdowns.	Excluded
P15 - Fugitive Emissions at Transportation	Unintended leaks of gas from the CO_2 pipeline, transportation equipment, and additional compressors may occur through seals, loose fittings, equipment, or compressor packing.	Excluded
P16 - Venting at Injection and Production Wells and in Recycle Stream	Planned and emergency venting may be necessary for injection or production well work overs, for mechanical integrity checks, and maintenance. Instances of venting must be logged, including the duration of the venting event and the estimated quantities and makeup of gasses vented.	Included
P17 - Fugitive Emissions at Injection and Production Wells and in Recycle Stream	Unintended or unplanned leaks of gas at the CO_2 injection wells or production wells may occur through valves, flanges, pipe connections, mechanical seals, or related equipment.	Included
P18 - Emissions from Subsurface to Atmosphere	Accidental emissions to the atmosphere may occur from gas migration through undetected faults, fractures and/or subsurface equipment resulting from compromised casing, cement, wellhead, packer or tubing. CO_2 that migrates from the intended storage complex but remain subsurface are considered the same as if they had leaked to the atmosphere and must be quantified accordingly. Intentional releases or removals/transfers of CO_2 or net reversals are included here also.	Included
P19 - Flare at Injection and Production Wells and in Recycle Stream	Planned and emergency flaring may be necessary for injection or production well sites or during work overs, mechanical integrity checks, re-injection stream flaring, These flare volumes and subsequent emissions are additional to baseline scenario flaring due to EOR scheme oil production. Instances of project flaring is logged,	Included

	including the duration of the flaring event, and sources of gases flared include any additional natural gas and the estimated quantities flared.	
Downstream Sources and Sinks During Project		
P20 - Loss, Disposal, or Recycling of Materials Used in CO_2 Capture Processes	Material inputs are either disposed or recycled at the end of their useful life. Greenhouse gas emissions result from the transportation of materials to industrial landfill and/or material recycling processes. Emissions are also associated with the loss of material during project operation.	Included
Downstream Sources and Sinks After Project		
P21 - Decommissioning of Enhanced Oil Recovery Facilities	Infrastructure is decommissioned at the end of project operations. This involves the disassembly of the equipment, demolition of on-site structures, landfill disposal of some materials, environmental restoration, re-grading, planting or seeding, and transportation of materials off-site. Greenhouse gas emissions result from fossil fuels combustion and electricity use.	Excluded

6.0 Baseline Scenario

6.1 Baseline Identification and Selection

The baseline scenario for projects using this QM is defined as the continued emission of CO_2 to the atmosphere that is captured and injected in the project. The CO_2 emissions from the baseline scenario are dynamic and will be quantified annually. The CO_2 emissions in the baseline scenario are based on data from the project and are measured directly upstream of the injection wellheads. These emissions do not include the quantity of any reinjected CO_2 (i.e. recycled CO_2) or previously credited CO_2.

The operation during the baseline is assumed to be enhanced oil recovery, without the use of CO_2. Thus, the oil produced from an EOR project can be assumed to be unchanged. The oil production is not an additional activity and does not factor into the calculation of sequestered CO_2.The emissions associated with oil production are considered equivalent in the baseline scenario and during the project so are excluded from the quantification.

Figure 2: Sources and Sinks Relevant to the Baseline Scenario

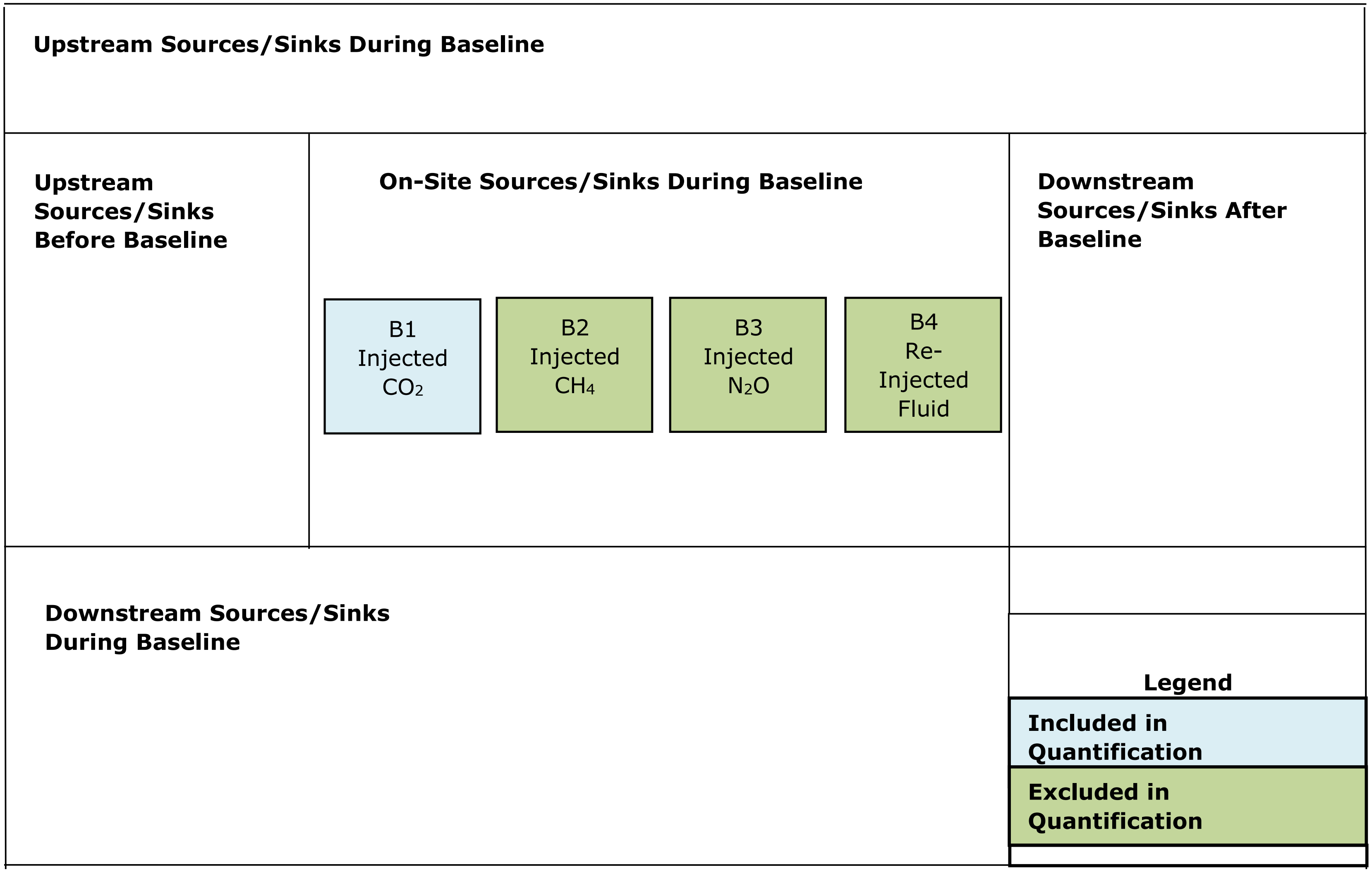


Table 2: Baseline SS

1. SS	2. Description	3. Included or Excluded from Quantification
Upstream Sources and Sinks During Baseline Operation – Not Applicable		
On-Site Sources and Sinks During Baseline		
B1 Injected CO_2	All CO_2 emissions released to the atmosphere in baseline as waste CO_2. Baseline emissions are based on data from the project, using the direct measurement of the quantity of fluid that is measured upstream of the injection wellheads in the project. Excludes reinjected fluid.	Included
B2 Injected CH_4	All CH_4 emissions released to the atmosphere in baseline. Baseline emissions are based on data from the project, using direct measurement of the quantity of fluid that has been measured upstream of the injection wellheads in the project.	Excluded
B3 Injected N_2O	All N_2O emissions released to the atmosphere in baseline. Baseline emissions are based on data from the project, using direct measurement of the quantity of fluid that has been measured upstream of the injection wellheads in the project.	Excluded
B4 Re-Injected Fluid	All CO_2 that is produced and re-injected at the EOR project must be accounted for and these quantities must be differentiated from B1 Injected CO_2. In some cases, this reinjected fluid is CO_2 that had been previously injected, but in other cases, the re-injected CO_2 was derived from carbonate materials in the project reservoir (i.e., formation CO_2).	Excluded
Downstream Sources and Sinks During Baseline – Not Applicable		
Downstream Sources and Sinks After Baseline – Not Applicable		

7.0 Quantification Methods

The quantification for each of the greenhouse gases uses the methodologies outlined below. These calculation methodologies use the following equations to calculate the emission reductions based on a comparison of the baseline scenario and the project. The calculations should only consider the emissions related to the capture, transportation and storage of the eligible portion of CO_2. For the purpose of subsection 36(3) of the Regulations, CO_2 captured from eligible sources (see section 3 of this QM) will be prorated based on the proportion of the quantity of crude oil or liquid fossil fuels that is not exported from Canada as described in Appendix A.

7.1 Emission Reduction Quantification

To determine the total emission reductions for the compliance period, the following equation must be used:

$$\text{Emission Reduction } (tCO_2e) = \text{Emissions}_{\text{Baseline}} - \text{Emissions}_{\text{Project}} - \text{Discounted Emission Reductions}$$

$$\text{Discounted Emission Reductions} = \text{Emissions}_{\text{Baseline}} * D$$

Where:

D = Discount applied to injected CO_2 and set equal to 0.005

7.2 Quantification of the Project Emissions

To determine the total emissions from the project for the compliance period, the following equation must be used:

$$\begin{aligned}
\text{Emissions}_{\text{Project}} = {} & \text{Emissions}_{\text{Construction of EOR Facilities and Well Drill and Service}} + \\
& \text{Emissions}_{\text{Production and Delivery of Material Inputs used in CO2 Capture Processes}} + \\
& \text{Emissions}_{\text{Off-Site Electricity Generation}} + \\
& \text{Emissions}_{\text{Off-Site Heat Generation}} + \\
& \text{Emissions}_{\text{On-Site Electricity Generation}} + \\
& \text{Emissions}_{\text{Fuel Consumption}} + \\
& \text{Emissions}_{\text{Venting at Injection and Production Wells and in Recycle Stream}} + \\
& \text{Emissions}_{\text{Fugitive Emissions at Injection and Production Wells and in Recycle Stream}} + \\
& \text{Emissions}_{\text{Subsurface to Atmosphere}} + \\
& \text{Emissions}_{\text{Flare at Injection and Production Wells and in Recycle Stream}} + \\
& \text{Emissions}_{\text{Loss, Disposal or Recycling of Materials Used in CO2 Capture Processes}}
\end{aligned}$$

$$\text{Total } CO_2 \text{ Equivalent Emissions} = \sum (CO_2 \text{ emissions}) * GWP_{CO2} + \sum (CH_4 \text{ emissions}) * GWP_{CH4} + \sum (N_2O \text{ emissions}) * GWP_{N2O}$$

Where:

$\text{Emissions}_{\text{Project}}$ = sum of the emissions from the project

$\text{Emissions}_{\text{Construction of EOR Facilities and Well Drilling and Service}}$ = emissions under P3 Construction of EOR Facilities and Well Drill and Service

$\text{Emissions}_{\text{Production and Delivery of Material Inputs used in CO2 Capture Processes}}$ = emissions under P4 Production and Delivery of Material Inputs Used in the CO_2 Capture Processes

$\text{Emissions}_{\text{Off-Site Electricity Generation}}$ = emissions under P6 Off-Site Electricity Generation

Emissions $_{\text{Off-Site Heat Generation}}$ = emissions under P7 Off-Site Heat Generation

Emissions $_{\text{On-Site Electricity Generation}}$ = emissions under P8 On-Site Electricity Generation

Emissions $_{\text{Fuel Consumption}}$ = emissions under P9 Fuel Consumption

Emissions $_{\text{Venting at Injection and Production Wells and in Recycle Stream}}$ = emissions under P16 Venting at Injection and Production Wells and in Recycle Stream

Emissions $_{\text{Fugitive Emissions at Injection and Production Wells and in Recycle Stream}}$ = emissions under P17 Fugitives at Injection and Production Wells and in Recycle Stream

Emissions $_{\text{Subsurface to Atmosphere}}$ = emissions under P18 Emissions from Subsurface to Atmosphere

Emissions $_{\text{Flare at Injection and Production Wells and in Recycle Stream}}$ = emissions under P19 Flare at Injection and Production Wells and in Recycle Stream

Emissions $_{\text{Loss, Disposal or Recycling of Material Used in CO2 Capture Processes}}$ = emissions under P20 Emissions from Loss, Disposal or Recycling of Materials Used in CO_2 Capture Processes

CO_2 Equivalent Emissions = sum of all greenhouse gas emissions converted to CO_2 equivalent terms, and does not apply to injected volumes of CH_4 or N_2O

7.3 Quantification of the Baseline Emissions

To determine the total emissions from the baseline for the compliance period, the following equation must be used:

$$\text{Emissions}_{\text{Baseline}} = \text{Emissions}_{\text{Injected CO2}}$$

Where:

Emissions $_{\text{Baseline}}$ = emissions based on data from the project, using the measured quantity of CO_2 injected in the project, but does not include CH_4, N_2O or re-injected (recycled or transferred) CO_2

Emissions $_{\text{Injected CO2}}$ = emissions under B1 Injected CO_2

8.0 Monitoring Requirements

8.1 Data Requirements

The following Table 3 provides monitoring, measurement, and quantification information that must be used to quantify the baseline and project emissions. Table 4 provides guidance on the measurement and monitoring requirements for injected gas. Table 5 lists the general monitoring requirements for fossil fuel and electricity inputs. All requirements of the Regulations apply.

A CI for off-site electricity generation (P6), that has been determined under section 79 and approved under section 85 of the Regulations, must adhere to all requirements, or the CI will cease to be valid, referred to in section 86 of the Regulations. A CI for a low-CI fuel used on-site (P8 and P9) that is gaseous at standard conditions that has been determined under section 76 and approved under section 85 of the Regulations, must adhere to all requirements, or the CI will cease to be valid, referred to in section 86 of the Regulations.

The registered creator or CI contributor will also be required to submit a CI Pathway Report annually on April 30 following the compliance period, in order to use the CI to create credits, or it will become invalid under section 86(2) of the Regulations.

Table 3: Sources and Sinks

All gas volumes must be at standard temperature and pressure conditions.

1.0 Project/ Baseline SS	**2. Parameter / Variable**	**3. Unit**	**4. Measured / Estimated**	**5. Method**	**6. Frequency**	**7. Justification for measurement or estimation and frequency**
Sources and Sinks Relevant to the Baseline Scenario						
B1 - Injected CO_2	$Emissions_{Injected\ CO2} = \sum (Vol._{Injected\ Gas} * \%_{CO2} * \rho_{CO2})/1000$					
	Emissions $_{Injected\ CO2}$	tonnes of CO_2e	N/A	N/A	N/A	Quantity being calculated.
	Volume of injected gas / Vol. $_{Injected\ Gas}$	m^3	Measured	Direct metering of volume of gas using a meter located as close as possible to each injection wellhead but prior to re-injected fluid injection point.	Continuous metering	Direct metering is standard practice. Frequency of metering is highest level possible.
	Concentration of injected CO_2 / % $_{Injected\ CO2}$	%Volume	Measured	Directly measured downstream of the capture and processing equipment or upstream of the injection field at a custody transfer point. When additional CO_2 streams comingle with a capture stream of known concentration, the concentration of comingled stream must be confirmed either by direct measurement of the comingled stream or by mass balance and a measurement of the additional capture stream. The	Daily	A minimum of daily samples averaged monthly on volumetric basis.

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
				measurement sample point may occur downstream of the tie in such that the concentration of the comingled stream is taken. Alternatively, the measurement can be taken downstream of the additional capture stream but upstream of comingling. In this case, the concentration of the comingled stream can be calculated by solving a single variable mass balance equation.		
	Density of injected CO_2 / $\rho_{\text{Injected CO2}}$	kg/m^3	Estimated	Must use a reference density, corrected to the conditions at which the volumes of gas are reported. Data conversions from all pressure and temperature compensated instruments must use the same pressure or temperature used for the specific meter calibration.	N/A	Densities must be used consistently throughout project.
Sources and Sinks Relevant to the Project						
P3 - Construction of EOR Facilities and	$Emissions_{\text{Well Drilling Activity}} = \sum (Vol._{\text{Gas Kick}} * \%_{CO2, CH4} * \rho_{CO2, CH4})/1000 * GWP_{CH4, N2O}$					
	$Emissions_{\text{Well Drilling Activity}}$	tonnes of CO_2e	N/A	N/A	N/A	Quantity being calculated.

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
Well Drill and Service	Volume of Vent Gas / Vol. $_{Gas\ Kick}$	m^3	Estimated	If the drilling activity resulted in a kick or a blowout, the volume of gas released must be estimated according to the relevant rules in the injection site jurisdiction.	Engineering estimate per event, as they occur before the project.	The measurement approach should be as frequent as the event.
	Concentration of CO_2, CH_4 in Vent Gas % $_{CO2,\ CH4}$	%Volume	Measured	A measured gas analysis should be obtained	Per event	The measurement approach should be as frequent as the event.
			Estimated	Must be determined based on process knowledge and/or engineering estimates.	Per event	
	Density of vented gas / $\rho_{CO2,\ CH4}$	kg/m^3	Estimated	Must use a reference density, corrected to the conditions at which the volumes of gas are reported. Data conversions from all pressure and temperature compensated instruments must use the same pressure or temperature used for the specific meter calibration.	N/A	Densities must be used consistently throughout project.
	$GWP_{CH4,\ N2O}$ Global Warming Potential	Unitless	Estimated	Values from *Fuel LCA Model Methodology* (Appendix A)	N/A	Must use values published in the most recent version for the compliance period in which credits are created.

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
P4 - Production and Delivery of Material Inputs used in CO_2 Capture Process	$Emissions_{\text{Production \& Delivery of Material Inputs used in CO2 Capture Process}} = \sum (Input_i * EF\ Input_{i\ CO2,\ CH4,\ N2O})$					
	$Emissions_{\text{Production \& Delivery of Material Inputs}}$	tonnes of CO_2e	N/A	N/A	N/A	Quantity being calculated.
	Quantity of material inputs consumed for carbon capture facility operation / $Input_i$	tonnes/L/ m^3/ Other	Estimated	Estimation of the quantity of material inputs consumed for the EOR project based on engineering design documents.	Annual	Procurement records or an engineering report will specify the quantity of material input required for an appropriately sized carbon capture facility. Represents most reasonable means of estimation.
	Emission factors for each type of material input / $EF\ Input_{i\ CO2,\ CH4,\ N2O}$	tonnes CO_2e per t/L/ m^3/other	Estimated	Project specific design	Annual	Production and delivery estimates for the emission factors for the material inputs.
P6 - Off-Site Electricity Generation	$Emissions_{\text{Off-Site Electricity Generation}} = \sum (Electricity_{Delivered} * 0.0036 * EF_{Electricity})/1000000$					
	Emissions Off-Site Electricity Generation	tonnes CO_2e	N/A	N/A	N/A	Quantity being calculated.
	Total quantity of delivered electricity from the electrical network or a directly connected source	MWh	Measured	Direct measurement of delivered electricity consumed at each facility involved in the capture, compression, transport, injection, storage, and re-injection of CO_2.	Continuous metering	Continuous direct metering represents the industry practice and the highest level of detail.

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
	consumed for the EOR project / Electricity $_{Delivered}$			The total electricity consumption is the sum of electricity consumption across individual components of the EOR project. Projects require an individual meter for delivered electricity.		
	Emission intensity factor for electricity generation / EF $_{Electricity}$	g CO_2e/MJ	Estimated	Emission intensity factors for each compliance period from the *Specifications for Fuel LCA Model CI Calculations* (Tables 12 or 13). Alternatively, if the source of low-CI electricity is not included in Table 13 of the *Specifications for Fuel LCA Model CI Calculations*, a registered creator or carbon-intensity contributor may determine a CI of electricity under section 79 of the Regulations and apply for approval under subsection 80(1). The CI of electricity must be approved by the Minister under section 85(1) of the Regulations in order to be used to create credits.	Annual	Reference value adjusted periodically. Must use the emission intensity factor published in the most recent version of the *Specifications for Fuel LCA Model CI Calculations* for the compliance period in which credits are created. The approved CI or the actual CI specified in the carbon-intensity-pathway report referred to in subsection 123(1) of the Regulations may be used.

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
P7 - Off-Site Heat Generation	$Emissions_{\text{Off-Site Heat Generation}} = \sum (Heat_i * EF)/1000$					
	$Emissions_{\text{Off-Site Heat Generation}}$	tonnes CO_2e	N/A	N/A	N/A	Quantity being calculated.
	Quantity of off-site heat consumed by the project / $Heat_i$	GJ	Measured	Direct measurement of the quantity of heat used by the carbon capture and storage project.	Continuous metering	Continuous metering is standard for boundary transfer.
	Emission intensity factor associated with heat / EF	g CO_2e/MJ	Estimated	A benchmark emission intensity factor may be used. Refer to the CI for Purchased or transferred Steam/Heat in Table 15 of the *Specifications for Fuel LCA Model CI Calculations* Or May be calculated. The allocation method Fuel Chargeable to Power (FCP), explained in Annex 4 of the *Specifications for Fuel LCA Model CI Calculations*, must be used to determine the CI of heat produced from a combined heat and power system. However, if the registered creator finds that this allocation method is not suitable for the quantification, for reasons such as the integration of	Annual	Reference value Must use the CI published in the most recent version of the *Specifications for Fuel LCA Model CI Calculations* for the compliance period in which credits are created.

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
				innovative technologies or fuels, they may request the use of an alternate allocation method as part of their project application with a justification.		
P8 On-Site Electricity Generation	*Emissions $_{On\text{-}Site\ Electricity\ Generation}$ = ∑ (Fuel $_{EOR}$ * HHV Fuel $_i$ * EF Fuel $_{i,}$)/1,000,000* *Where:* *Fuel $_{EOR}$ = (Elec $_{EOR}$ / Elec $_T$)* Fuel $_E$* If the project is not exporting electricity or is using electricity for oil handling, water treatment or for non-project purposes and there is no other reason to separately report P8 On-site electricity generation, the fuel can be accounted for in P9 Fuel Consumption. Low-CI fuel used on-site that is gaseous at standard conditions may be quantified using a CI that was determined using the Fuel LCA Model. The low-CI fuel must be produced on-site or at an adjacent site. Emission-reductions for the low-CI fuel must not be accounted for in credit creation under another compliance category or QM, and demonstrated by an attestation from the low-CI fuel production facility. Non-fossil fuel used on-site that is gaseous at standard conditions may be quantified using a CI that was determined using the Fuel LCA Model. The non-fossil fuel must be produced on-site or at an adjacent site. In all other cases, any non-fossil fuel or hydrogen used in the project must be quantified as if it were the fossil fuel it is displacing. For example, if a quantity of renewable natural gas or hydrogen is used in the project, it is considered to be an equivalent quantity of fossil natural gas for the purpose of calculating emissions from fuel consumption.					
	Emissions On-Site Electricity Generation	t of CO_2e	N/A	N/A	N/A	Quantity being calculated based on quantity of power sourced from on-site electricity generation facilities

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
	Proportionate quantity of Fossil Fuels Consumed to Generate Power at On-Site Generation Facilities for Use by the EOR project / $Fuel_{EOR}$	L	Calculated	Calculated relative to the metered quantities of electricity delivered to the project	Monthly	Allocation of Project Emissions based on proportion of total energy output from the electricity generation unit that is supplied to the EOR project is appropriate given that multiple energy users may source electricity from a power plant. Direct metering of electricity is appropriate
	Quantity of Fossil Fuels Consumed to Generate Electricity at On-Site Generation Facilities for Use by the EOR project / $Fuel_{E}$	L	Measured	Direct measurement of the volume of fossil fuels consumed at power generation facility and/or other direct connected facilities that provide power to the project	Continuous metering	Continuous direct metering represents the industry practice and the highest level of detail
	Energy Density of Each Type of Fuel / $HHV\ Fuel_{i}$	MJ/L	Estimated	HHV values from the *Specifications for Fuel LCA Model CI Calculations* (Table 8)	N/A	Must use the values published in the most recent version of the *Specifications for Fuel LCA Model CI Calculations* for the compliance period in which credits are created.

1.0 Project/ Baseline SS	**2. Parameter / Variable**	**3. Unit**	**4. Measured / Estimated**	**5. Method**	**6. Frequency**	**7. Justification for measurement or estimation and frequency**
	Emissions Factor for Combustion of Each Type of Fuel / EF Fuel $_i$	g CO_2e per MJ	Estimated	Factors from the *Specifications for Fuel LCA Model CI Calculations* (Table 15) Or A registered creator or carbon-intensity contributor may determine the CI of a low-CI fuel used on site that is gaseous at standard conditions under section 76 of the Regulations and apply for approval under subsection 80(1). The CI of the low-CI fuel must be approved by the Minister under section 85(1) of the Regulations in order to be used to create credits. The low-CI fuel must be produced on-site or at an adjacent site. As part of the project application, a registered creator may request approval of a CI of a non-fossil fuel used on site that is gaseous at standard conditions that was determined using the Fuel LCA Model. The non-fossil fuel must be produced on-site or at an adjacent site.	N/A	Must use the values published in the most recent version of the *Specifications for Fuel LCA Model CI Calculations* for the compliance period in which credits are created. The approved CI, the actual CI specified in the carbon-intensity-pathway report referred to in subsection 123(1) of the Regulations (low-CI fuel) or the actual CI specified in the annual credit-creation report (non-fossil fuel) may be used.
	Total Quantity of Electricity Supplied to End Users by the	GJ	Measured	Direct metering of quantity of electricity delivered to all direct connected facilities from the	Continuous Metering	Continuous direct metering represents the industry practice

<table>
<tr><th>1.0 Project/ Baseline SS</th><th>2. Parameter / Variable</th><th>3. Unit</th><th>4. Measured / Estimated</th><th>5. Method</th><th>6. Frequency</th><th>7. Justification for measurement or estimation and frequency</th></tr>
<tr><td></td><td>Generation Facility in the Project Scenario / $Elec_T$</td><td></td><td></td><td>generation plant; including the direct metering of the total electricity distributed to project, the regional electricity grid and an industrial system designation</td><td></td><td>and the highest level of detail</td></tr>
<tr><td rowspan="3">P9 Fuel Consumption</td><td colspan="6">$Emissions_{Fuel\ Consumption} = \sum (Vol.\ Fuel_i * HHV\ Fuel_i * EF\ Used_i)/1,000,000$

Low-CI fuel used on-site that is gaseous at standard conditions may be quantified using a CI that was determined using the Fuel LCA Model. The low-CI fuel must be produced on-site or at an adjacent site. Emission-reductions for the low-CI fuel must not be accounted for in credit creation under another compliance category or QM, and demonstrated by an attestation from the low-CI fuel production facility.

Non-fossil fuel used on-site that is gaseous at standard conditions may be quantified using a CI that was determined using the Fuel LCA Model. The non-fossil fuel must be produced on-site or at an adjacent site.

In all other cases, any non-fossil fuel or hydrogen used in the project must be quantified as if it were the fossil fuel it is displacing. For example, if a quantity of renewable natural gas or hydrogen is used in the project, it is considered to be an equivalent quantity of fossil natural gas for the purpose of calculating emissions from fuel consumption.</td></tr>
<tr><td>$Emissions_{Fuel\ Consumption}$</td><td>t of CO_2e</td><td>N/A</td><td>N/A</td><td>N/A</td><td>Quantity being calculated in aggregate based on quantity and type of fuel used</td></tr>
<tr><td>Quantity Fuel Used for On-Site Fuel Consumption / Vol. $Fuel_i$</td><td>L</td><td>Measured</td><td>Calculated based on measurement of the quantity of each of the fuels used on-site</td><td>Continuous metering or monthly reconciliation or allocation</td><td>Both methods are standard practice. Allocation of metered quantities is permitted (i.e., to separate out emissions for oil handling, etc.) Frequency of metering</td></tr>
</table>

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
						is highest level possible. Frequency of reconciliation provides for reasonable diligence
	Energy Density of Each Type of Fuel / HHV Fuel $_i$	MJ/L	Estimated	HHV values from the *Specifications for Fuel LCA Model CI Calculations* (Table 8)	N/A	Must use the values published in the most recent version of the *Specifications for Fuel LCA Model CI Calculations* for the compliance period in which credits are created.
	Emissions Factor for Combustion of Each Type of Fuel / EF Used $_i$	g CO_2e per MJ	Estimated	Factors from the *Specifications for Fuel LCA Model CI Calculations* (Table 15) Or A registered creator or carbon-intensity contributor may determine the CI of a low-CI fuel used on site that is gaseous at standard conditions under section 76 of the Regulations and apply for approval under subsection 80(1). The CI of the low-CI fuel must be approved by the Minister under section 85(1) of the	N/A	Must use the values published in the most recent version of the *Specifications for Fuel LCA Model CI Calculations* for the compliance period in which credits are created. The approved CI, the actual CI specified in the carbon-intensity-pathway report referred to in subsection 123(1) of

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
				Regulations in order to be used to create credits. The low-CI fuel must be produced on-site or at an adjacent site. As part of the project application, a registered creator may request approval of a CI of a non-fossil fuel used on site that is gaseous at standard conditions that was determined using the Fuel LCA Model. The non-fossil fuel must be produced on-site or at an adjacent site.		the Regulations (low-CI fuel) or the actual CI specified in the annual credit-creation report (non-fossil fuel) may be used.
P16 - Venting at Injection and Production Wells and in Recycle Stream	$Emissions_{\text{Venting at Injection and Production Wells and in Recycle Stream}} = \sum (Vol._{\text{Gas Vented}} * \%_{CO2,\ CH4,\ N2O} * \rho_{CO2,\ CH4,\ N2O})$					
	Emissions $_{\text{Venting at Injection and Production Wells and in Recycle Stream}}$	tonnes of CO_2e	N/A	N/A	N/A	Quantity being calculated.
	Volume of Vent Gas / Vol. $_{\text{Gas Vented}}$	m^3	Estimated	Estimate volume based on the pressure, length and diameter of the pipe being serviced.	Per event	This vented gas is downstream of the injection meter during maintenance blowdowns and should be as frequent as the maintenance event.

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
	Composition in Vent Gas / $\%_{CO2, CH4, N2O}$	%	Measured	The gas composition shall be directly measured during the event. Otherwise, operations data will be needed for an engineering estimate.	A minimum of daily samples per event, when possible. Otherwise, estimated composition of the vented gas based on its source.	CO_2 concentration may vary throughout the injection or re-cycle stream.
	Density of Vent Gas / ρ_{CO2}	tonnes/m^3	Estimated	Must use a reference density, corrected to the conditions at which the volumes of gas are reported. Data conversions from all pressure and temperature compensated instruments must be sure to use the same pressure or temperature used for the specific meter calibration.	N/A	Densities must be used consistently throughout project.
P17 – Fugitive Emissions at Injection and Production Wells and in Recycle Stream	$Emissions_{\text{Fugitive Emissions at Injection and Production Wells and in Recycle Stream}} = \sum (Source_i * ER_{Source\ i} * \%_{CO2, CH4, N2O}) + \text{Other Fugitive Releases}$					
	$Emissions_{\text{Fugitive Emissions at Injection and Production Well Sites and in Recycle Stream}}$	tonnes of CO_2e	N/A	N/A	N/A	Quantity being calculated.

1.0 Project/ Baseline SS	**2. Parameter / Variable**	**3. Unit**	**4. Measured / Estimated**	**5. Method**	**6. Frequency**	**7. Justification for measurement or estimation and frequency**
	Other Fugitive Releases	tonnes of CO_2	Estimated	Engineering estimate.	Per occurrence	This is from unintended/unplanned events, and accounts for CO_2 released after the meter and wellbore but not from the geological formation. Estimated based on the most detailed information available.
	Number of Sources after Injection Meter / Source $_i$	N/A	Estimated	Project-specific design.	Once	Estimated based on the number of sources after the injection meter, piping and re-injection equipment above the subsurface
	Emission Rate for Source / ER $_{Source\ i}$	tonne gas /source/year	Estimated	Emission rate in Appendix C	Annual	Estimates made for project specifics represent the most accurate means.
	Composition in Fugitive Gas / % $_{CO2,CH4,N2O}$	%	Measured or estimated	Measured preferred method. Engineering estimates of gas composition are acceptable in the absence of measured gas analysis	A minimum of daily samples, when possible. Otherwise, estimated composition of the vented	CO_2 concentration may vary throughout the injection or re-cycle stream.

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
					gas based on its source.	
P18 Emissions from Subsurface to Atmosphere	*$Emissions_{Subsurface\ to\ Atmosphere} = Mass\ CO_{2\ leaked}$*					
	Emissions $_{Subsurface\ to\ Atmosphere}$	tonnes of CO_2	N/A	N/A	N/A	Quantity being calculated.
	Mass of CO_2 leaked from the Subsurface to Atmosphere/ Mass $CO_{2\ leaked}$	tonnes of CO_2	Estimated	If a leak event occurs, the mass of CO_2 leaked from the subsurface to the atmosphere shall be estimated with a maximum overall uncertainty over the reporting period of ±7.5%. In case overall uncertainty of the applied quantification approach exceeds ±7.5%, an adjustment shall be applied. Refer to Appendix D for further guidance	N/A	Direct measurement is likely not possible, but the use of engineering estimates and accounting for the uncertainty would be a reasonable approach in the event leakage occurs. To be conservative calculations may use the detection threshold
P19 Flare at Injection and Production Wells and in Recycle Stream	*$Emissions_{Flare\ at\ Injection\ and\ Production\ Wells\ and\ in\ Recycle\ Stream} =$* $\sum ((Q_{Gas\ Flaring} \times 1000) \times EF_{i\ CO2,\ CH4,\ N2O} \times GWP)/1000000 + \sum ((Q_{Supplemental\ Gas} \times 1000) \times EF_{i\ CO2,\ CH4,\ N2O} \times GWP)/1000000$ Emission factors for flaring are default values. If a facility specific emission factor would like to be used, the procedure outlined in the Flaring Chapter of the Alberta Greenhouse Gas Quantification Methodology may be used.					
	Emissions $_{Flare\ at\ Injection\ and\ Production\ Wells\ and\ in\ Recycle\ Stream}$	tonnes of CO2e	N/A	N/A	N/A	Quantity being calculated

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
	Chemical compound released to the atmosphere, CO_2, N_2O, CH_4/ i	CO_2, N_2O, CH_4	N/A	N/A	N/A	Relevant greenhouse gases species released
	Volume of Gas sent to Flare or Incinerator / $Q_{Gas\ Flaring}$	e^3m^3	Measured	Online metering of volume of gas that is sent to flare or incinerator. Correlate to operational hours of flare or incinerator	Continuous metering	Online metering is standard practice
	Volume of Supplemental Gas to operate flare or incineration equipment at standard temperature and pressure. Pilot purge and/or supplemental fuel / $Q_{Supplemental\ Gas}$	e^3m^3	Measured or Estimated	Online metering of volume of gas used to operate the flare or incinerator (pilot/purge/supplemental fuel). If offline metering of volume of gas used to operate the flare or incinerator use method in Alberta's Greenhouse Gas Quantification Methodology		
	Flare emission factor for compound i/ EF_i	g/m^3	Estimated	Use default values for the appropriate device type (unassisted flare, assisted flare or incinerator) from the Flaring Chapter of the Alberta Greenhouse Gas Quantification Methodology. For flare gas, use default values for "Rich gas" for CO_2 and CH_4 and use default values for	N/A	Must use most current values published

1.0 Project/ Baseline SS	2. Parameter / Variable	3. Unit	4. Measured / Estimated	5. Method	6. Frequency	7. Justification for measurement or estimation and frequency
				“Hydrocarbon gas” for N_2O. For supplemental gas, use default values corresponding to the supplemental gas used.		
P20 - Loss, Disposal or Recycling of Material Used in CO_2 Capture Processes	$Emissions_{\text{Loss, Disposal or Recycling of Material Used in CO2 Capture Processes}} = \sum (Vol.\ Used_i * EF\ Used_{i\ CO2,\ CH4,\ N2O})$					
	Emissions $_{\text{Loss, Disposal or Recycling of Material Used}}$	tonnes of CO_2e	N/A	N/A	N/A	Quantity being calculated.
	Total Volume of Material Lost, Disposed or Recycled from the CO_2 Capture Process/Vol. Used $_i$	L/ m^3/ Other	Estimated	Estimation of the volume of material inputs lost, disposed or recycled for the CO_2 capture processes.	N/A	Engineering report will specify the volume of material input lost, disposed or recycled for an appropriately sized carbon capture facility. Represents most reasonable means of estimation. Loss, disposal or recycling estimates for the emission factors for the materials used.
	Emissions factor for each type of material input / EF Used $_{i\ CO2,\ CH4,\ N2O}$	tonnes CO_2e per L / m^3 / other	Estimated	Project-specific design.	Annual	Production and delivery estimates for the emission factors for the material inputs.

Table 4: Measurement and Monitoring Guidance for Injected Gas

Variable	Units of Measurement	Measurement Frequency	Additional Guidance
Flow rate of gas stream	L / m^3 / other	Continuous measurement of the gas flow rate, gas composition, and gas density where continuous measurement is defined as a minimum of one measurement every 15 minutes.	• Meter readings may need to be temperature and pressure compensated such that the meter output is set to standard reference temperatures and pressures. Estimates of composition and density are not permissible; • Flow meters must be placed based on manufacturer recommendations: o Flow meters should be located at the input to the gas transport equipment such that they are downstream of all capture and compression equipment to account for any fugitive losses or venting; and o Flow meters should be as close as possible to the injection wellheads to ensure accurate measurement of the injected volumes; • Flow meters must be calibrated according to manufacturer specifications. Meters must be checked/calibrated at regular intervals according to these specifications and industry standards; and • Ownership transfer must be clearly documented for CO_2 transferred (third party injection activity).
Concentration of gas stream	%	Continuous measurement of the gas composition and density where continuous measurement is defined as a minimum of one measurement every 15 minutes.	The gas composition shall be metered downstream of the capture and processing equipment while the volume is measured as close as possible to the point where CO_2 is injected into the geological formation.

Table 5: Measurement and Monitoring Guidance for Energy Inputs

Variable	Units of Measure	Measurement Frequency	Additional Guidance
Volume of fossil fuels combusted (gaseous)	ft^3 or m^3 or other	Continuous measurement of the gas flow rate where continuous measurement is defined as one measurement every 15 minutes.	• The flow meter readings must be corrected for temperature and pressure; • Flow meters shall be placed based on manufacturer recommendations and shall operate within manufacturers specified operating conditions at all times; and • Flow meters must be calibrated according to manufacturer specifications and shall be checked and calibrated at regular intervals according to these specifications.
Volume of fossil fuels combusted (liquid or solid)	L, m^3 or other	Reconciliation of purchasing records on a quarterly basis and inventory adjustments as needed.	Volume or mass measurements are made at purchase or delivery of the fuel. Reconciliation of purchase receipts or weigh scale tickets is an acceptable means to determine the volumes of fossil fuels consumed to operate the carbon capture and storage project.
Electricity Consumption	MWh	Continuous measurement of electricity consumption or reconciliation of maximum power rating for each type of equipment and operating hours.	• Electricity consumption must be from continuously metered data wherever possible; however, in certain cases other loads may be tied into the same electricity meter. Where this occurs, estimates with justification are required. In these cases, the maximum power rating of each piece of equipment is used in conjunction with a conservative estimate of operating hours to estimate the electricity consumption; and • Electricity meters must be calibrated by an accredited third party in accordance with manufacturer specifications.

9.0 Reporting Requirements

9.1 Application for Recognition of CO_2e-Emission-Reduction Project (section 34 and Schedule 4)

1. Items 1, and 2(g) of Schedule 4 of the Regulations.
2. Name of project.
3. An explanation of how the project is anticipated to lower the CI of a fuel in the liquid class.
4. If the registered creator is different from the owner or operator of the facility that injects the CO_2 into the oil-producing geological formation, the following information:
    a. The name, civic address, postal address, telephone number and, if any, email address of the owner or operator of the facility that injects the CO_2 into the oil-producing geological formation;
    b. The name, title, civic address, postal address, telephone number and, if any, email address of a contact person of the owner or operator of the facility that injects the CO_2 into the oil-producing geological formation.
5. For the purpose of items 2(a) and (b) of Schedule 4 of the Regulations, Project Location of the CO_2 generation facilities, capture facilities, pipelines, injection sites, and/or re-injection sites including GPS coordinates (5 decimals), civic addresses if any, and supporting documentation that includes aerial photographs, maps, or satellite imagery demonstrating the project locations. The boundary used to determine on-site versus off-site sources and sinks at each project location should be indicated.
6. For the purpose of item 2(c) of Schedule 4 of the Regulations, evidence that the capture of CO_2 started on or after July 1, 2017 as well as the duration of the project and the anticipated start and end dates of the project including capture at the capture facilities and injection at the injection sites.
7. Evidence that the project must not be required to lower the reservoir pressure at abandonment below the pressure at the end of production operations as a condition of its permits and/or regulatory requirements.
8. Whether the project is stand-alone or aggregated.
9. Project Description:
    a. Project components (e.g., equipment, systems, processes, technologies);
    b. Material and energy inputs, outputs, and flows within the project boundary.
10. For the purpose of item 2(f) of Schedule 4 of the Regulations, the annual reduction in the quantity of CO_2e that is anticipated to result from the project, expressed in tonnes of CO_2e, including:
    a. The quantity of CO_2 anticipated to be emitted from the capture site;
    b. The quantity of CO_2 anticipated to be injected into the CO_2 transport pipeline;
    c. The quantity of CO_2 anticipated to be sold to third parties (e.g., for enhanced oil recovery); and
    d. The quantity of CO_2 anticipated to be injected into each well in the project, that is or will be metered at the wellhead.
    e. Any relevant data and calculations and any technical documents that are used in support of those calculations.

11. Information pertaining to off-site heat (P7):
    a. An indication of whether off-site heat will be included in the quantification or will not be included in the quantification;
    b. If off-site heat will be included in the quantification, an indication of whether the emission factor associated with off-site heat will be the benchmark emission intensity factor or will be calculated;
    c. If the emission factor associated with off-site heat will be calculated and the heat is not produced from a combined heat and power system, the description of the method and the detailed equation and methodology used to calculate the emission factor.
12. If the registered creator requests the use of an alternate allocation method for a combined heat and power system to determine the CI of off-site heat (P7), the following information must be provided:
    a. The rational and justification for requesting an alternate method;
    b. The description of the alternate method;
    c. The detailed equation and calculation methodology.
13. If the registered creator requests the approval of a CI for a non-fossil fuel used on-site that is gaseous at standard conditions (P8 and P9) as part of the project application, the following information must be provided:
    a. Items 1 to 15 of Schedule 7, if the register creator applies for approval of a new pathway;
    b. Items 1, 3 and 6 of Schedule 8 in respect of the non-fossil fuel.

9.2 Annual Credit Creation Report

1. Report required as per section 120 of the Regulations with the requirements in Schedule 11.
2. All inputs into project and baseline scenario listed in Table 3 for each of the following segments: CO_2 capture, the CO_2 transportation system and CO_2 injection.
3. The values of *Eligibility Factor*, $Eligibility_{Hydrogen,Electricty,Heat}$, $Eligibility_{Canada}$ referred to in Appendix A as well as the calculation of these values including:
    a. The inputs and the calculation of each element of the formulas used to determine these values;
    b. The total volume V_{Canada} as well as the volume of the gasoline, diesel, crude oil or bitumen, as the case may be, included in V_{Canada};
    c. The total volume V_{Total} as well as the volume of the gasoline, diesel, crude oil or bitumen, as the case may be, included in V_{Total}.
4. The registered creator who obtains approval of the carbon intensity of a non-fossil fuel used on-site that is gaseous at standard conditions (P8 and P9) must provide the following information for the compliance period:
    d. Items 1, 2(a), (b) and (d) and 5 of Schedule 14 in respect to the non-fossil fuel.

10.0 Record Keeping Requirements

Refer to sections 165 to 168 of the Regulations and the Monitoring Plan referred to in section 136 and Schedule 21.

11.0 Permanence

A discount factor of 0.005 will be applied to the emissions in the baseline scenario in accordance with this QM. These credits are never returned to the registered creator.

The risk for unintentional release of carbon dioxide is estimated to be low. Many risks are mitigated by the regulatory process in provinces or territories. The registered creator will have to demonstrate that:

- The project is in good standing with all operating permits and relevant regulations in the province(s) or territory(ies) where it is located;
- The project must not be required to lower the reservoir pressure at abandonment below the pressure at the end of production operations as a condition of its permits and/or regulatory requirements.

The Minister may decline projects in province(s) or territory(ies) if it can not be demonstrated that they have relevant regulations to ensure permanent storage. This includes, but is not limited to, requirements for site characterization, well construction and operation, injection monitoring and, well abandonment.

However, some risk remains which may result in the unintentional release of sequestered CO_2 either during the project or in the future.

A discount factor of 0.005 is therefore applied as a conservative approach to manage uncertainty associated with unintentional releases of carbon dioxide or reversal after the crediting period.

11.1 Transfers of CO_2 from an EOR project

The permanence of the geologically sequestered CO_2 requires that it stay in the geologic formation in which it was injected. Transfers of CO_2 from projects must be treated as a project emission or reversal.

11.2 Reversals

A reversal is an accidental or intentional release or removal of previously injected and reported CO_2 from the EOR project (storage complex) during the post crediting period. However, a release or removal of CO_2 during a crediting period becomes a reversal if there is an insufficient amount of injected CO_2 in the reporting period to cover the released or removed amount of CO_2 (a net reversal).

This quantification method provides mechanisms to quantify releases and reversals (see Table 3). Appendix D provides a method for accounting for uncertainty: Estimating Emissions from Subsurface Equipment and EOR Subsurface Operations

Specific events that might result in a reversal include:

- Blowout or well kick;
- Mechanical integrity/ well failure/ integrity of existing wells in the field;
- Migration of CO_2 beyond the perimeter of the injection and recovery project site;
- Drilling through CO_2 plume to a lower formation;
- Seismic event;
- Subsequent withdrawal of injected CO_2 for deployment in other fields/into pipeline;
- Blowdown of injection wells;

- Unplanned/emergency flaring of formation gas; and
- Other acute (non-steady state) venting events.

12.0 Verification

For the verification of a report referring to a CO_2e-emission-reduction project, the relevant requirements set out in sections 129 to 154 of the Regulations and the relevant specifications set out in the *Method for Verification and Certification − Clean Fuel Regulations* apply, including the following requirements.

12.1 Materiality Thresholds

12.1.1 Quantitative Materiality Thresholds

The quantitative materiality thresholds to be applied while verifying the Annual Credit Creation Report for a CO_2e-emission-reduction project, are the quantitative materiality thresholds described in sections 150 and 151 of the Regulations and in the *Method for Verification and Certification − Clean Fuel Regulations.*

12.1.2 Qualitative Materiality Thresholds

The qualitative materiality thresholds to be applied while verifying the Annual Credit Creation Report for a CO_2e-emission-reduction project are described in the *Method for Verification and Certification − Clean Fuel Regulations.*

APPENDIX A: Proration of Eligible CO_2 and Emissions

Prorating Eligible CO_2 - Eligibility Factor

This Eligibility Factor describes what portion of the injected CO_2 can create credits as well as what portion of emissions related to this CO_2 is to be included in the project. There are two pieces that feed into the calculation of the Eligibility Factor that are each described in more detail below.

$$Eligibility\ Factor\ (\%) = Eligibilty_{Hydrogen,Electiricity,Heat} * Eligibilty_{Canada}$$

As an illustrative example, if a project captured CO_2 at a hydrogen production facility that supplied 90% of its produced hydrogen to a refinery and that refinery used in Canada or sold for use as a fuel in Canada 50% of the volume of its produced gasoline and diesel, the Eligibility Factor for this project would be 45%.

Prorating Eligible CO_2 – Hydrogen, Electricity or Heat

The equation below shows the procedure for prorating using hydrogen as a basis.

Where CO_2 is captured at a hydrogen production facility, a portion of that CO_2 is eligible for credit creation using this QM. When CO_2 is captured at a hydrogen production facility that supplies hydrogen to a facility that produces electricity or heat that is supplied to a Fossil Fuel Facility (FFF), a portion of that CO_2 is eligible for credit creation using this QM. These portions are related to the amount of produced hydrogen used for these purposes relative to the total hydrogen production and is described by the following equation.

$$Eligibilty_{Hydrogen}\ (\%) = \frac{Produced\ H2\ supplied\ to\ a\ FFF\ \left(\frac{kg\ H2}{year}\right) + Produced\ H2\ used\ to\ produce\ electricity/heat\ that\ is\ supplied\ to\ a\ FFF\ \left(\frac{kg\ H2}{year}\right)}{Total\ H2\ production\ \left(\frac{kg\ H2}{year}\right)} * 100$$

When CO_2 is captured at a facility that supplies heat or electricity to a FFF, the equation below shows the procedure for prorating using heat and electricity as a basis

$$Eligibilty_{Heat,Electricity}\ (\%) = \frac{Produced\ heat/electricity\ supplied\ to\ a\ FFF\ (MJ)}{Total\ heat/electricity\ production\ (MJ)} * 100$$

Prorating Eligible CO_2 – Not Exported from Canada

The project must reduce the carbon intensity of liquid fossil fuels or crude oil that are not exported from Canada.

$$\boldsymbol{Eligibility_{Canada}}\,(\%) = \frac{\boldsymbol{V_{Canada}}}{\boldsymbol{V_{Total}}}$$

Where:

V_{Canada} is one of the following, depending on the type of projects:

1. In the case of a CO_2e-emission-reduction project that reduces the CI of fossil fuels at a refinery in Canada, the volume of gasoline and diesel, expressed in m^3, produced at that refinery and that is used as a fuel in Canada or sold for use as a fuel in Canada during the compliance year.
2. In the case of a CO_2e-emission-reduction project that reduces the CI of fossil fuels, crude oil or bitumen processed or produced at an upgrader in Canada, the volume, expressed in m^3, of:
    a. diesel produced at that upgrader that has a reduced carbon intensity as a result of the activities carried out for the project and that is used as a fuel in Canada or sold for use as a fuel in Canada during the compliance year; and
    b. crude oil produced at that upgrader that has a reduced carbon intensity as a result of the activities carried out for the project and that is delivered to refineries in Canada for processing during the compliance year.
        i. If the crude oil, produced at the upgrader that has a reduced carbon intensity as a result of the activities carried out for the project and delivered to refineries in Canada, is part of a blend, then V_{Canada} is the volume of the blend, expressed in m^3, delivered to refineries in Canada for processing multiplied by the volume fraction of the crude oil within the blend that was produced at the upgrader and that has a reduced carbon intensity as a result of the activities carried out for the project.
3. In all other cases of a CO_2e-emission-reduction project that reduces the CI of fossil fuels at a facility in Canada, the volume of gasoline and diesel, expressed in m^3, that has a reduced carbon intensity as a result of the activities carried out for the project and that is produced, processed, transported, stored or distributed for use in Canada during the compliance year.
4. In all other cases of a CO_2e-emission-reduction project that reduces the CI of crude oil or bitumen at a facility in Canada, the volume of crude oil or bitumen, expressed in m^3, that has a reduced carbon intensity as a result of the activities carried out for the project and that is delivered to refineries in Canada for processing during the compliance year.
    a. If the crude oil, that has a reduced carbon intensity as a result of the activities carried out for the project and that is delivered to refineries in Canada, is part of a blend, then V_{Canada} is the volume of the blend, expressed in m^3, delivered to refineries in Canada for processing multiplied by the volume fraction of the crude oil within the blend that has a reduced carbon intensity as a result of the activities carried out for the project.

V_{Total} is

1. In the case of a CO_2e-emission-reduction project that reduces the CI of fossil fuels at a refinery in Canada, the total volume of gasoline and diesel, expressed in m^3, produced by that refinery during the compliance year.
2. In the case of a CO_2e-emission-reduction project that reduces the CI of fossil fuels, crude oil or bitumen processed or produced at an upgrader in Canada, the total volume, expressed in m^3, of:
    a. diesel produced at that upgrader that has a reduced carbon intensity as a result of the activities carried out for the project during the compliance year;

    b. crude oil produced at that upgrader that has a reduced carbon intensity as a result of the activities carried out for the project during the compliance year.

3. In all other cases of a CO_2e-emission-reduction project that reduces the CI of fossil fuels at a facility in Canada, the total volume of gasoline and diesel, expressed in m^3, that has a reduced carbon intensity as a result of the activities carried out for the project and that is produced, processed, transported, stored or distributed during the compliance year.
4. In all other cases of a CO_2e-emission-reduction project that reduces the CI of crude oil or bitumen at a facility in Canada, the total volume of crude oil or bitumen, expressed in m^3, produced, stored or transported during the compliance year that has a reduced carbon intensity as a result of the activities carried out for the project.

Additional requirements about supporting documentation:

Description	Unit	Measured /Calculated	Method	Frequency	Additional Details	Application / Annual Credit Creation Report
V_{Canada}	m^3	Calculated	Based on records and/or measurements, as the case may be. Crude oil may be measured in different units and converted into m^3 at standard conditions.	Annual	A volume of gasoline, diesel, crude oil or bitumen, as the case may be, may be included in V_{Canada} only if records are retained that establish that this volume of gasoline, diesel, crude oil or bitumen met the conditions mentioned in the description of V_{Canada}, for that type of project. The total volume V_{Canada} as well as the volume of the gasoline, diesel, crude oil or bitumen, as the case may be, included in V_{Canada} must be included in the report.	Annual Report
V_{Total}	m^3	Calculated	Based on records and/or measurements, as the case may be. Crude oil may be measured in different units and converted into m^3 at standard conditions.	Annual	The total volume V_{Total} as well as the volume of the gasoline, diesel, crude oil or bitumen, as the case may be, included in V_{Total} must be included in the report.	Annual Report

Prorating Eligible CO_2 and Emissions – Aggregation of Multiple Projects

Where multiple projects overlap in their project boundary, registered creators must demonstrate that all sources and sinks are properly accounted for and must ensure all emissions have been included and have not been double counted. For a complex CO_2 system or network, the emissions from that network must be included in the project using a proration of emissions across the network. Proration must occur on the basis of the mass of CO_2. The registered creators must provide verifiable justification for the method and values used to determine the system emission factor used.

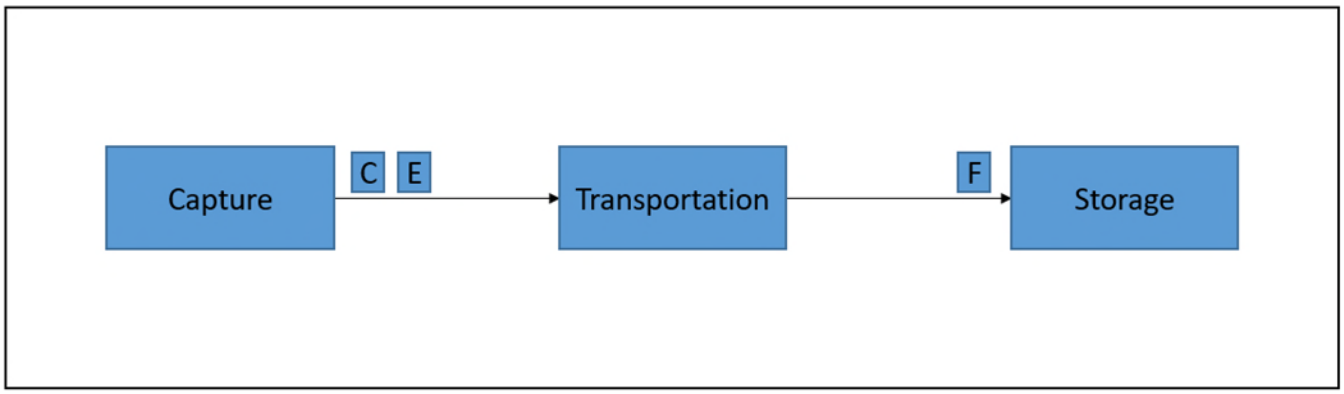
For example, if 50% of the CO_2 in a pipeline is associated with Project A, 40% with Project B and 10% is CO_2 ineligible to create credits, the emissions associated with transporting that CO_2 should reflect those proportions in the project account of each project.

APPENDIX B: Aggregation of Multiple Projects

The following provides guidance for projects in which CO_2 is being transported for use in EOR projects.

Gas flow/quantity measurement, CO_2 concentration measurement/sample points, and tracking of eligible CO_2 quantities must be carefully considered in complex networks. Scenarios 1 through 4 depict the gas flow measurement, CO_2 concentration measurement/sample points and tracking of eligible CO_2 quantities in a variety of project configurations from simple to more complex.

Scenario 1: Single Capture Single Storage

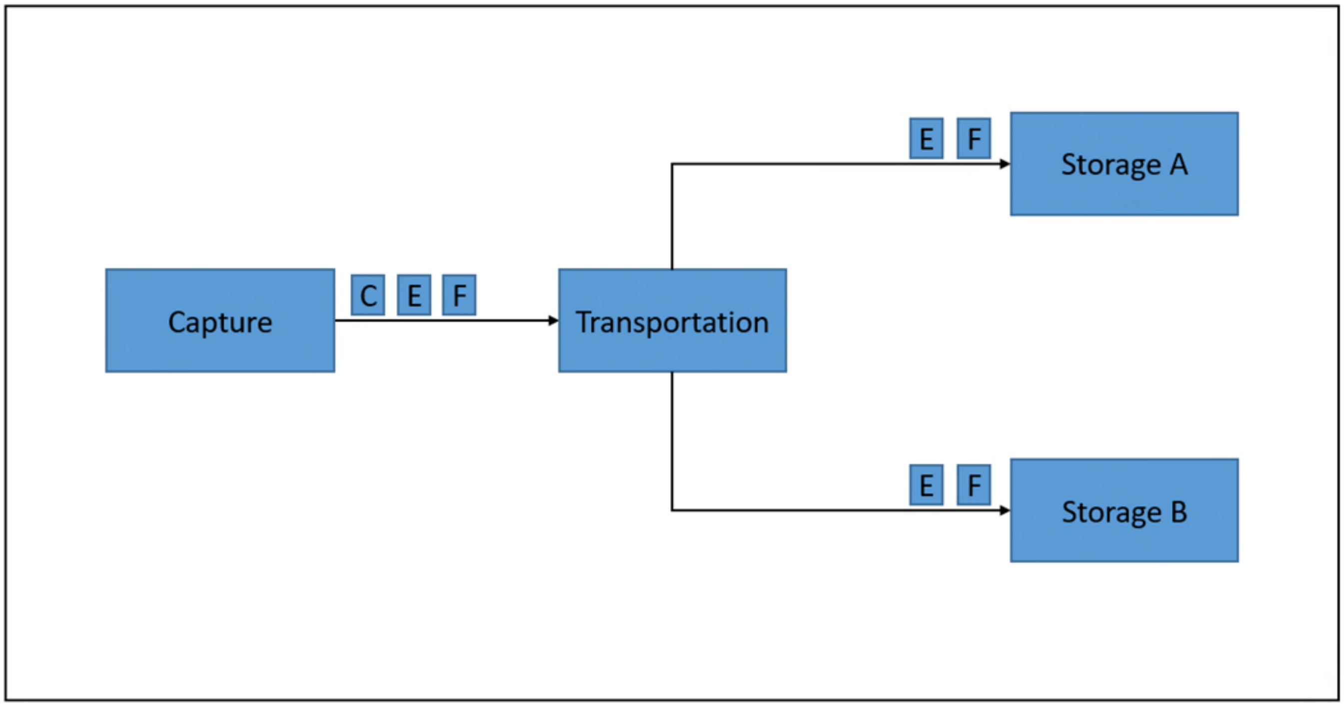


Must measure CO_2 concentration or gas composition (C). The sample point may be downstream of capture or at the storage location (injection well).

Must record the proportion of eligible CO_2 (E) at the capture site.

Must measure gas quantity (F) at storage location (injection well).

Scenario 2: Single Capture Multiple Storage

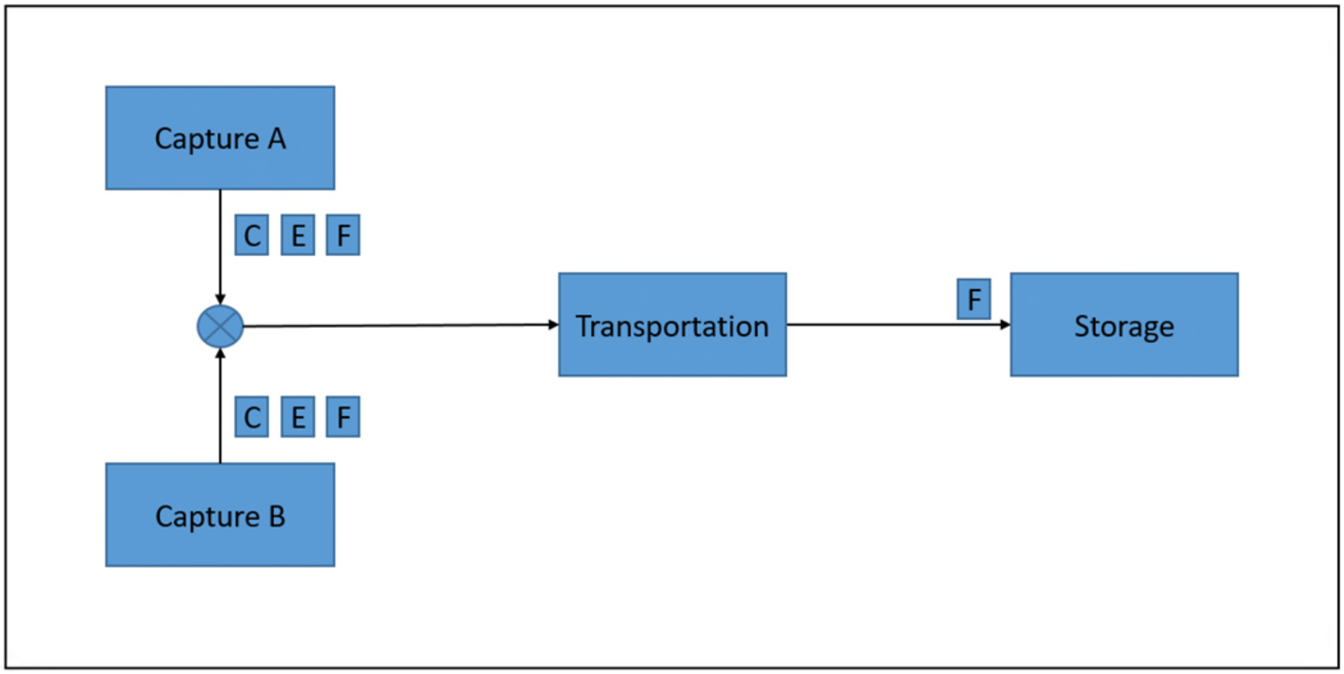


Must measure CO_2 concentration or gas composition (C) at either the capture site or points of storage. It is not required to measure both locations as the CO_2 concentration does not change.

Must record the proportion of eligible CO_2 (E) at the capture site and at each storage location (injection well).

Must measure gas quantity (F) at the capture site and at each storage location (injection well).

Scenario 3: Multiple Capture Single Storage



Must measure CO_2 concentration or gas composition (C) at each capture site upstream of the point of aggregation.

Must record the proportion of eligible CO_2 (E) at each capture site upstream of the point of aggregation and at the storage location (injection well).

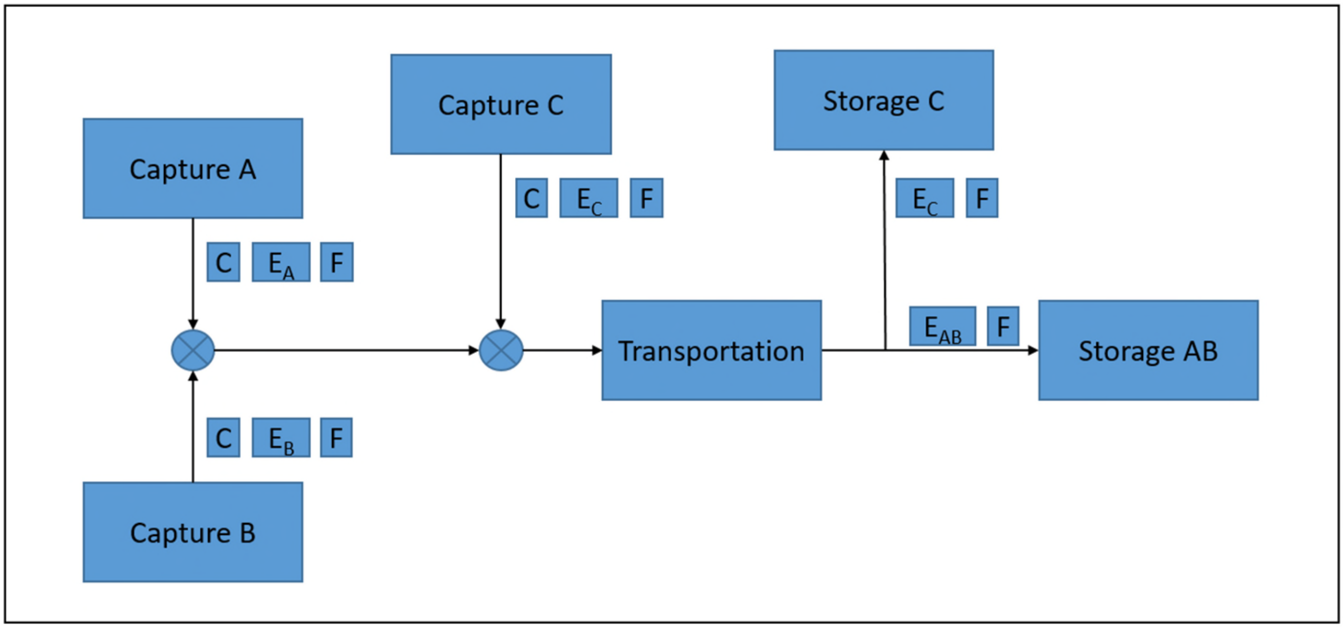
Must measure gas quantity (F) at each capture site upstream of the point of aggregation.

Allowable to calculate the CO_2 concentration and the proportion of eligible CO_2 (E) of the aggregated stream based on the weighted average of the incoming streams to be aggregated in a single variable, mass balance equation.

Must measure gas quantity (F) at storage location (injection well). CO_2 concentration at storage is the calculated concentration of the aggregated stream. The proportion of eligible CO_2 (E) at storage is the calculated proportion of eligible CO_2 of the aggregated stream.

If using weighted average, must be completed downstream of each new capture site that is added to the network.

Scenario 4: Multiple Capture Multiple Storage



Must measure CO_2 concentration or gas composition (C) at each capture sites upstream of the point of aggregation.

Must record the proportion of eligible CO_2 (E) at each capture site upstream of the point of aggregation and at the storage location (injection well).

Must measure gas quantity (F) at each capture site upstream of the point of aggregation.

Allowable to calculate the CO_2 concentration of the aggregated stream based on the weighted average of the incoming streams to be aggregated in a single variable, mass balance equation.
Weighted average calculation must be completed downstream each new capture site is added.

Must measure gas quantity at storage location (injection well). CO_2 concentration at storage is the calculated concentration of the aggregated stream. Must measure gas quantity at each capture site upstream of the point of aggregation

APPENDIX C: Reference Tables

Fugitive Emission Factors

Emission factors for fugitive emissions from a variety of component types can be found in the Compendium of Greenhouse Gas Emissions Estimation Methodologies for the Oil and Natural Gas Industry published by the American Petroleum Institute in 2009. Of particular note is Table 6-12: EPA Average Oil and Natural Gas Production Emission Factors which provides emission factors of tonnes of gas emitted. Other tables found in this section are often on the basis of the hydrocarbon portion of the gas and may require adjustments before they're applicable for reflecting emissions from CO_2 systems. Section 6.1.4 describes how to convert methane emission factors on a mass basis to CO_2 emission factors for CO_2 pipelines.

APPENDIX D: Guidance for Estimating Emissions from Subsurface Equipment and EOR Subsurface Operations

For the quantification of P18 Emission from Subsurface to Atmosphere, the quantity of emissions leaked from the subsurface equipment or EOR Subsurface operations to atmosphere for each of the leakage events must be estimated with a maximum overall uncertainty of ±7.5% over the reporting period. If the amount of emissions leaked can be estimated within an uncertainty range of ±7.5%, the estimated figure is reported and used. If the overall uncertainty exceeds ±7.5%, the following adjustment must be used:

$$CO_2\text{, Reported [t } CO_2\text{]} = CO_2\text{, Quantified [t } CO_2\text{]} * (1 + (\text{Uncertainty System [\%]}/100))$$

Where:

CO_2, Reported: Amount of CO_2 to be included into the annual credit creation report with regards to the leakage event in question;

CO_2, Quantified: Amount of CO_2 determined through the used quantification approach for the leakage event in question; and

Uncertainty System: The level of uncertainty which is associated to the quantification approach used for the leakage event in question.

Adapted from two sources:

1) IEA presentation, on ‘Monitoring and Reporting Guidelines for Injection and Storage’, Implications of the Inclusion of Geological Carbon Dioxide Capture and Storage as CDM Project Activities, https://cdm.unfccc.int/EB/050/eb50annagan1.pdf

which says:

“Maximum +/-7.5% uncertainty, if exceeded then add ‘uncertainty Adjustment’”

2) CDM UNFCC: It is important to be conservative and so err on the side of overestimation rather than underestimation. An example of how to apply this conservative principle is provided by the EU ETS Monitoring and Reporting Guidelines for CCS63. In these, if the uncertainty is above a specified level for the measured emissions of seepage, these measured emissions will be multiplied by an “uncertainty supplement”. In the EU case this is set for a maximum uncertainty of 7.5%, and if this cannot be achieved then measured emissions are multiplied by an uncertainty supplement (which is added to the measured emissions).