

# PEER REVIEW

METHODOLOGY FOR THE QUANTIFICATION,  
MONITORING, REPORTING AND VERIFICATION  
OF GREENHOUSE GAS EMISSIONS  
REDUCTIONS FROM

PLUGGING ABANDONED AND  
ORPHANED OIL AND GAS WELLS

VERSION 1.0

April 2022

# METHODOLOGY FOR THE QUANTIFICATION, MONITORING, REPORTING AND VERIFICATION OF GREENHOUSE GAS EMISSIONS REDUCTIONS FROM PLUGGING ABANDONED AND ORPHANED OIL AND GAS WELLS

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A leading carbon offset program founded in 1996 as the first private voluntary GHG registry in the world, ACR operates in the voluntary and regulated carbon markets. ACR has unparalleled experience in the development of environmentally rigorous, science-based offset methodologies as well as operational experience in the oversight of offset project verification, registration, offset issuance and retirement reporting through its online registry system.

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# ACKNOWLEDGEMENTS

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**In collaboration with:**

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Fellow Environmental Partners  
Oklahoma



Well Done Foundation  
Montana



Native State Environmental  
Texas

# ACRONYMS

ACR	American Carbon Registry
API	American Petroleum Institute
AOOG	Abandoned and Orphan Oil or Gas Well
BLM	Bureau of Land Management
BOEPD	Barrels of Oil Equivalent Per Day
CH <sub>4</sub>	Methane
CO <sub>2</sub>	Carbon Dioxide
CO <sub>2</sub> e	Carbon Dioxide Equivalent
EIA	Energy Information Agency
EOR	Enhanced Oil Recovery (Tertiary Recovery)
GHG	Greenhouse Gas
GM	Gas Migration
IOGCC	Interstate Oil and Gas Compact Commission
IPCC	Intergovernmental Panel on Climate Change
M	One Thousand
MM	One Million
Mcf	Volume of 1,000 cubic feet
MMT	Million Metric Tons
MCFD	One Thousand Cubic Feet Per Day
MIT	Mechanical Integrity Test

Mtoe	Million tons of oil equivalent
N <sub>2</sub> O	Nitrous Oxide
O&G	Oil and Gas
OPA	Oil Pollution Act of 1990
ppm	Parts per million
ppmv	Parts per million by volume
P&A	Plug and Abandon
SSR	Sources, Sinks, and Reservoirs
TA	Temporary Abandonment
t	Metric ton

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# 1 BACKGROUND AND APPLICABILITY

## 1.1 SUMMARY DESCRIPTION OF THE METHODOLOGY

This methodology provides the quantification and accounting frameworks, including eligibility and monitoring requirements, for the creation of carbon offset credits from the reduction in methane emissions by plugging abandoned and orphaned oil and gas (AOOG) wells. The study of AOOG wells is an active area of research, and this document will be updated accordingly. This methodology is intended to be used to incentivize the closure—plugging and reclamation—of leaking oil and gas wells that are not in use, sometimes for decades, that would otherwise continue to emit methane to the atmosphere. Methane is a potent greenhouse gas that is already responsible for significant warming. This methodology is intended to help operators and jurisdictions prioritize leaking methane as an environmental risk.

For this methodology, ACR will use the term **abandoned wells** to refer to unplugged wells with no recent production (last six consecutive months), which have a known, solvent operator. There are numerous terms that refer to non-producing<sup>1</sup> wells and because the regulation of O&G wells is done predominately on a state or provincial level, and many of those regulations rely upon well status, it is important to identify and consolidate classifications across regulatory boundaries. In this methodology, the term “abandoned” will include wells classified in the different states and provinces as dormant, deserted, inactive, junked, suspended, neglected, shut-in, idle, waiting on completion, and temporary abandoned. After six months without activity, most wells are never returned to production.

The term **orphaned wells** in this methodology will refer to wells without a solvent operator, and that are not plugged or have been poorly plugged and require additional plugging measures to prevent emissions. Many of the same terms under “abandoned” can also apply to “orphaned” wells. The distinction ACR is making is between these two terms is whether the well is associated with an active or solvent operator or has become the responsibility of the state or province. Different regulatory requirements and responsibilities may apply depending on whether the well is associated with an operator. For example, plugging liabilities can shift to the state or province when a well is orphaned, and the timing requirements of its plugging responsibility may no longer be present.

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<sup>1</sup> [Appendix B](#) shows the amount of non-producing—“abandoned” and “orphan”—wells by state according to Enverus database for non-producing wells, and state orphan wells lists.

The U.S. Environmental Protection Agency (EPA), in its latest National GHG Inventory,<sup>2</sup> reports 6.6 million metric tons of carbon dioxide equivalent (MMT CO<sub>2</sub>e) emissions from abandoned and orphaned oil and gas (AOOG) wells in the United States on an annual basis. However, several studies report that methane emissions from these wells are likely underestimated.<sup>3</sup> The factors contributing to this potential underestimation include the uncertainties associated with the total number of AOOG wells and their emission rates, as well as the limited population of wells studied. Estimates of the onshore AOOG well population in the US vary from approximately 2.3 million to 3.2 million according to recent studies.<sup>4</sup> Publicly available databases, such as the National Oil and Gas Gateway, or the Bureau of Land Management (BLM) Oil and Gas Statistics, do not provide a complete picture of the AOOG well population and, according to the EPA,<sup>5</sup> private resources (such as Enverus or HSI databases) may underreport the population by over one million wells. One recent study analyzed historical and new field datasets to quantify the number of AOOG wells in Pennsylvania,<sup>6</sup> individual and cumulative methane emissions, and the well attributes that characterize this problem. The study shows that methane emissions from AOOG wells persist over multiple years and likely decades, high emitters appear to be unplugged gas wells, and the number of AOOG wells may be as high as 750,000 in Pennsylvania alone.<sup>6</sup>

Numerous studies show that methane is being emitted from AOOG wells, but the well population and emission rates need to be better characterized to estimate total emissions and identify high emitters. Currently, less than 1% of AOOG wells in Canada and the U.S. have been measured and documented.<sup>7</sup> Despite questions as to the representativeness of these measurements from this limited number of wells, they are being used to estimate national scale methane emissions. Inaccurate reporting of AOOG well count and emission volumes are a problem that persists in every major oil and gas producing country. Hence, there is a need to design practical solutions and incentives to solve these complex challenges. The use of this methodology will support the improvement of AOOG well inventories, as well as the development of more accurate and representative emission factors for CH<sub>4</sub> emissions in the US and Canada as data from participating projects become available.

Stringent regulatory requirements to properly plug and remediate wells were not in place nationwide until the 1950s; thus, wells plugged before that time are likely to have been improperly plugged, if at all. Although state and provincial regulatory requirements mandate that operators

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<sup>2</sup> (US EPA, 2019)

<sup>3</sup> (Williams et al., 2021) (Townsend-Small et al., 2016)

<sup>4</sup> (Saint-Vincent et al., 2020)(Kang et al., 2021)

<sup>5</sup> (U.S. EPA, 2018)

<sup>6</sup> (Kang et al., 2016)

<sup>7</sup> (Williams et al., 2021)

plug wells at the end of their productive lives,<sup>8</sup> plugging criteria vary in quality and comprehensiveness, and wells are often left without plugging<sup>9</sup> or surface remediation.<sup>10</sup> Even when there is a solvent operator associated with a well, many states and provinces allow operators to categorize wells as “idle”<sup>11</sup> for a certain amount of time or, in some cases, indefinitely.<sup>8</sup> Many wells remain classified as active or producing beyond their economic life to avoid plugging costs and/or maintain producing privileges or mineral leases. These wells have a higher likelihood of becoming orphaned, therefore transferring liability to the state or province and its taxpayers.

In almost all jurisdictions, bonding requirements—a financial commitment operators make to cover the eventual cost of plugging and remediation<sup>12</sup>—are insufficient to cover the actual costs of proper well plugging and site remediation at the end of a well’s productive life. Available bonding data suggest that states on average have secured less than one percent (1%) of the amount needed to plug orphan wells (estimated at \$280 billion in the US).<sup>13</sup> Exacerbating the funding deficit for plugging orphan wells, new studies suggest that after the 2020 economic downturn, at least 30 oil and gas exploration and production companies, which operate 116,245 wells in 32 states and four Canadian provinces/territories, have filed for bankruptcy.<sup>14</sup> Canadian observations show that a drop in oil prices leads to an increase in the number of orphaned wells in the subsequent three years.<sup>14</sup> Shortfalls in state and provincial plugging funds, and the latent growth of AOOG wells population due to economic downturn and world-wide carbon-neutral transitions, demonstrate that tools such as this methodology can provide a solution to the AOOG well plugging crisis.

As the world transitions to a carbon-neutral economy, the number of wells that need to be plugged will likely increase.<sup>14</sup> This methodology provides the science-based mitigation strategies necessary to drastically cut emissions from AOOG wells using carbon credits as one source of funding. However, the positive impacts extend far beyond reducing CH<sub>4</sub> emissions to the atmosphere by addressing the cost to society (taxpayers) of these wells remaining unplugged. Remediation of AOOG wells in the near term could result in immediate positive environmental impacts on the quality of water, air, climate, and human ecosystem health with the added to societal benefits such as the wellbeing of nearby communities, jobs creation and economic stimulation. Additionally, other gases besides methane are often emitted from AOOGs. While these gases may not contribute to GHG emissions, the plugging and abandoning of these AOOGs will provide quantifiable, local air quality benefits. Finally, data acquisition will lead to an

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<sup>8</sup> (IOGCC, 2020)

<sup>9</sup> (Kang et al., 2021)

<sup>10</sup> Remediation typically refers to surface restoration and clean up (See [Definitions](#))

<sup>11</sup> We use the term “idle” in this methodology for a non-producing well; note that this term could also be referred to as, for instance, “inactive”, “suspended” or “temporarily abandoned”, by various states, provinces, or federal governments.

<sup>12</sup> (Lyon & Peltz, 2016)

<sup>13</sup> (“Billion Dollar Orphans,” 2020)

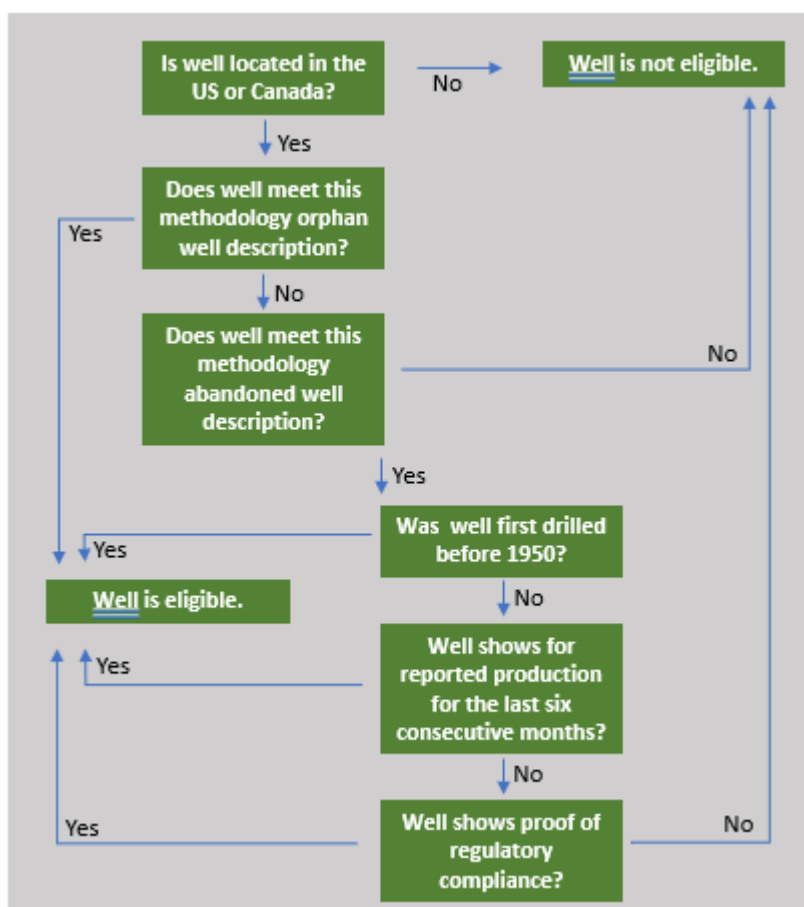
<sup>14</sup> (Kang et al., 2021)

increased understanding of the scope of the orphan wells problem, including well emissions and plugging costs, for industry, regulators, and the general population.

## 1.2 APPLICABILITY CONDITIONS

In addition to a project meeting the latest ACR program eligibility requirements as found in the ACR Standard, individual wells must satisfy the eligibility requirements detailed in Figure 1 to be eligible.

**Figure 1: Eligibility Decision Tree**



1. The project is located in the United States or Canada.
2. For operated wells, Project Proponent must provide documentation that the wells in the project are in regulatory compliance.
3. The well is emitting CH<sub>4</sub> with no regulatory requirement to prevent the release.
4. The well must meet the definition of “orphaned” per [Appendix A](#).

Because these wells do not have a solvent operator and are therefore managed by the state or province in which they reside, no regulations are in place to require P&A operations within a mandated timeframe. Under these circumstances, any plugging that occurs is additional to that which is required by law. Therefore, all orphaned O&G wells are eligible to participate in this methodology.

If an operator takes title of an orphaned well with the intent of performing plugging operations, that well is still considered orphaned under this methodology. Within 12 months of taking title the operator must demonstrate intent to abandon the well by registering project with ACR.

If well does not meet the definition for “orphaned”, to be considered “abandoned”, wells must fall within one or more of the following timeframe categories:

#### **ELIGIBILITY CATEGORY #1: Wells Drilled Before 1950**

Although there were different requirements at the state, province, and federal level to ensure that natural resources were protected, it was not until the 1950s when modern regulatory standards in all US jurisdictions required specific provisions for plugging and documenting oil and natural gas wells before they are abandoned. Plugging techniques have since improved and jurisdictions have requirements to ensure environmental protection. Previous, unregulated, abandonment methods included materials such as wood, rocks, and linen absorbers being used as plugs instead of cement. Currently, regulations prescribe the depth intervals which must be sealed with cement as well as the materials that are allowed in plugging practices. Since many wells were drilled prior to modern P&A regulations came into effect, operators may not have been required to plug or reclaim them. If the proposed project passes the [Regulatory Surplus Test](#), plugging that occurs on these wells is considered additional to that which is commonly required by law. Therefore, all O&G wells with a spud date prior to December 31st, 1949 are eligible to participate in this methodology.

#### **ELIGIBILITY CATEGORY # 2: Oil & Gas Wells with a Designated Operator Drilled in 1950 or Later**

Wells that were first drilled January 1st, 1950 or later, which have a designated operator, which meet the description of this methodology for “abandoned” to be part of offset project only if project proponents:

1. Show proof of state/provincial level well status change to non-productive status, OR
2. Show no reported production for the last consecutive six months under a corresponding American Petroleum Institute (API) number, UWI, or CWIS.

## 1.3 CREDITING PERIOD

Per the ACR Standard, the project crediting period is the length of time for which a GHG Project Plan is valid, and during which a project can generate credits against its baseline scenario. Orphan well plugging projects under this methodology will have a crediting period of twenty years. Credits will be issued for twenty years of emissions the year that the well is plugged. Projects involving abandoned wells with operators will be credited for five years and eligible for a single renewable for an overall possible project life of 10 years. Project proponent must demonstrate that the wells would remain in compliance in their current condition for the full five-year crediting period. At the end of the first crediting period, a review of any regulatory updates that require plugging of wells will need to be completed to assure that the project is still additional. It must be demonstrated by the project proponent that their well would still be in regulatory compliance if the methane leak continued. A 5% leakage deduction will be applied to all projects.

## 1.4 REPORTING PERIOD

The reporting period begins with the measurement of methane emissions and ends when project proponents confirm that there are no post-plugging emissions. Each well within a project will have its own reporting period. For aggregated wells in a single project, the reporting period starts with the first methane measurements and ends with the confirmation sampling on the last well that is plugged. Validation must be completed within 12 months of the plugging of the last well in the project.

For wells with an operator, there is a second reporting period when Project Proponents must demonstrate that the well would still be in compliance past the initial five-year crediting period.

The project term for an AOOG well plugging project includes the post-plugging monitoring period, as specified in Chapter Six of this methodology.

## 1.5 PROJECT START DATE

For this methodology, the start date corresponds to the completion of plugging activities of the first plugged well included in a project. This date will be confirmed by the jurisdiction when the well is reclassified as plugged or decommissioned. All wells in a project must be plugged within 24 months of the start date.

## 1.6 PERIODIC REVIEWS AND REVISIONS

ACR might require revisions to this methodology to ensure that monitoring, reporting, and verification systems adequately reflect changes in the project activities. This methodology may also

be periodically updated to reflect regulatory changes, measurement protocol revisions, or expanded applicability criteria. Before beginning a project, the Project proponent shall ensure that they are using the latest version of the methodology and any relevant Errata and Clarifications.

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## 2 PROJECT BOUNDARIES

### 2.1 GEOGRAPHIC BOUNDARIES

The physical project boundary demarcates the GHG emission sources included in the project and baseline emissions calculations. An abandoned and orphan well plugging project may include multiple wells. For this methodology, the boundary will be confined to all wells aggregated and to be plugged by a single Project Proponent.<sup>15</sup> Wells in a project must follow the latest ACR Standard requirements for aggregation. Tracking and record keeping for wells varies by jurisdiction and the project proponent must check with the applicable authorities.

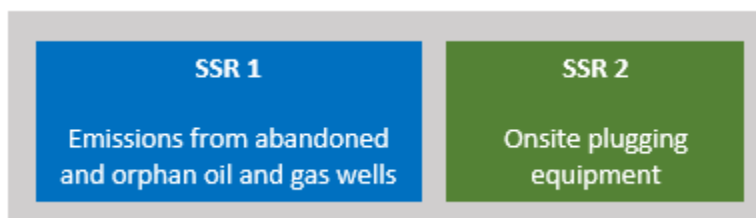
### 2.2 GHG ASSESSMENT BOUNDARY

Eligible offsets consist of methane that would otherwise be emitted into the atmosphere by AOOG wells within the project.

Physical boundaries are orphan and abandoned wells identified as emitters. Methane that is emitting from surface equipment that is directly connected to leaking wells may also be considered under this methodology. This does not include residual hydrocarbons in onsite storage tanks, only active emissions directly connected to the well that are confirmed to cease upon plugging. These wells are not productive and will not result in leakage- no wells will be drilled to replace orphan wells or abandoned wells which are in compliance but not producing.

#### **Figure 2: Plugging AOOG Wells Project Assessment Boundary Diagram**

The project assessment boundary, depicted by the light grey box in Figure 3, is where the plugging of AOOG wells activities happen in the project.



All SSRs inside Table 1 are included and must be accounted for under this methodology.

<sup>15</sup> According to [The ACR Standard](#), Project proponents wishing to develop a project for registration on ACR shall follow the Standard and must apply an ACR-approved methodology.



**Table 1: Sources, Sinks and Reservoirs**

SSR		DESCRIPTION	GHG	BASELINE (B) PROJECT (P)	INCLUDED OR EXCLUDED
1	Abandoned and orphan oil and gas wells that emit methane	Emissions from orphan and abandoned oil and gas wells	CH <sub>4</sub>	B	Included
2	Plugging Operations (Equipment)	Emissions from mobile mechanical equipment for plugging	CO <sub>2</sub>	P	Included
			CH <sub>4</sub>		
			N <sub>2</sub> O		

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## 3 BASELINE DETERMINATION AND ADDITIONALITY

### 3.1 BASELINE DETERMINATION

Per the ACR Standard, the GHG project baseline is a counterfactual scenario that forecasts the likely stream of emissions or removals to occur if the Project Proponent does not implement the project, i.e., the "business as usual" case.

In this methodology, the baseline is defined by the AOOG well emissions without the project and, therefore, the continual unmitigated release of methane to the atmosphere.

### 3.2 ADDITIONALITY ASSESSMENT

Emission reductions from AOOG well plugging projects must be additional or deemed not to occur in the business-as-usual scenario. Assessment of the additionality of a project shall be made based on passing the Regulatory Surplus Test and the Practice-Based Performance Standard.

The Regulatory Surplus test requires that AOOG well plugging projects are surplus to regulations, i.e., the emission reductions achieved by plugging these wells are not required by applicable regulation. The Practice-Based Performance Standard ensures that the plugging of these wells reduces the current emissions—considered business as usual—generated by not only high-emitting wells, but all unplugged abandoned and orphan wells within a project.

#### 3.2.1 Regulatory Surplus Test

To pass the regulatory surplus test, the project proponent must demonstrate that there is no existing law, regulation, statute, legal ruling, or other regulatory framework that mandates the project or effectively requires the GHG emission reductions associated with the project activity. In this case, as explained in [Appendix A](#), since regulations are not uniformly enforced in the different states and provinces, wells that fit within the **abandoned** and **orphaned** well categories, as described by this methodology, and comply with all eligibility requirements, are considered additional.

### 3.2.2 Performance Standard

As noted in the analysis presented in [Appendix A: Development of Performance Standard](#), the additionality requirement is met due to inadequate regulation and enforcement at state and provincial levels. For orphaned wells that lack a solvent operator, there is the added challenge of not having a responsible party that regulators can hold accountable. Although state and provincial government agencies intend to ensure suitable and timely well plugging for abandoned and orphan wells, resources for achieving this, including enforcement and bonding, are largely inadequate. All wells that meet this methodology's orphan and abandoned well description and eligibility section, are considered to pass the performance standard.

Please see [Appendix A](#) for a complete discussion on the development of the performance standard.

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## 4 QUANTIFICATION OF GHG EMISSION REDUCTIONS

Quantification of project emission reductions requires calculation of baseline emissions and project emissions.

### 4.1 BASELINE EMISSIONS

Baseline verification is required to quantify methane emissions from AOOG wells in the business-as-usual scenario, where the well is unplugged, and no mitigation activities have been conducted. Prior to sampling, background levels of methane must be recorded upwind of the well to be plugged. This measurement must be taken with the same sampling device as the well measurements and should be collected prior to each sampling event. Baseline emissions are determined by direct measurement of emissions rates from AOOG wells. Measuring these emissions may be done using a calibrated methane-specific gas detector and a tested enclosure-based (also referred to as chamber-based or static chamber) method.<sup>16</sup> Chamber design shall be approved by ACR, or other experts, during project review—project proponents who wish to consult with experts prior to sampling may contact ACR. The enclosed chamber shall encompass the emitting well and at least 10 cm of immediately adjacent soils to also capture any methane emissions that may be migrating up the well annulus. The enclosure-based methods require the measurement of well-mixed gas concentrations inside the chamber using a methane analyzer. Other methane quantification measurement technologies exist and are continuously being developed. Project proponents may utilize other technologies but shall consult with ACR prior to measurement collection to confirm that their equipment and sampling protocols meets ACR requirements. Other methods must be able to demonstrate that all emissions are being captured and measured by their equipment. The chamber method is used in this methodology to illustrate measurement and calculation requirements. Other quantification methods may be used provided that they can demonstrate detection limits at or below 1.0 g/hour of methane.

#### 4.1.1 Temporal Variation

Emissions measurements, taken over a minimum 30-day period, are required to determine pre-plugging conditions for every well in the project boundary. The following measurements are needed (see [Appendix D](#) for timeline):

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<sup>16</sup> (Livingston & Hutchinson, 1995)

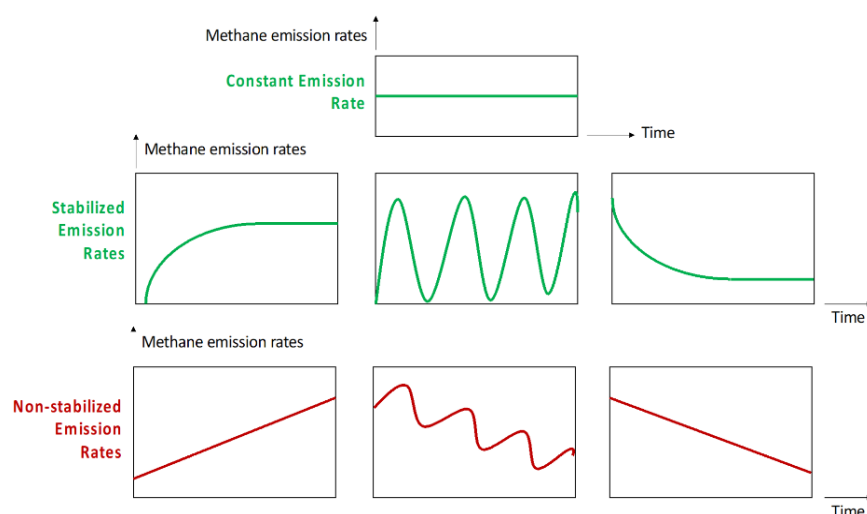
- Two 2-hour continuous-in-time measurement series for pre-plugging monitoring. Sampling begins with the first continuous-in-time measurement. The second continuous-in-time measurement will be conducted at least 30 days after the first.
- For post-plugging verification, it is considered sufficient to verify that there are no emissions above background. If emissions are detected, the well must be remediated until there are no emissions or emissions must be quantified to be subtracted from the total credits to be generated.

Sampling can be conducted for longer than 2-hour minimum to reach stable emission rates (Figure 4). All results collected as part of the project sampling must be submitted in sampling report, including all methane emission measurements and calculations.

Emission rates can be considered stabilized if emission rates over a 2-hour period vary by a factor of 10 or less—meaning that the ratio of measurement  $n$  to measurement  $n+1$  is less than 10 or larger than 0.1. For continuous-in-time measurements using the chamber method, the chamber must remain on top of the wellhead for a minimum duration of two hours. For ACR approved, non-chamber-based sampling, a 2-hour stabilized emission rate is required. This can be done by collecting flow rates at a maximum of 10-minute intervals over a 2-hour period.

### Figure 3: Constant, Stabilized, and Non-Stabilized Emission Rates Example

Example methane emission rates over time considered to be stabilized and not stabilized.



## 4.1.2 Steady-State and Non-Steady-State Chambers

For non-steady-state chambers, the methane emission rate  $Q_s \left[ \frac{\text{MASS}}{\text{TIME}} \right]$  is calculated using:

## Equation 1: Methane Emission Rate - Non-Steady-State Chambers

$$Q_s = V_{\text{eff}} \frac{dC}{dt}$$

### WHERE

$Q_s$	Methane flow rate from the well determined using non-equilibrium-based chamber $\left[ \frac{\text{MASS}}{\text{TIME}} \right]$
$V_{\text{eff}}$	Effective chamber volume $[\text{Volume}]$
$\frac{dC}{dt}$	Time rate of change in methane concentrations inside the chamber $\left[ \frac{\text{MASS}}{\text{VOLUME} \times \text{TIME}} \right]$

The effective chamber volume ( $V_{\text{eff}}$ ) represents the volume that is sampled for methane concentration accumulations in the chamber.

### 4.1.3 Steady-State Chambers

The methane emission rate,  $Q_d \left[ \frac{\text{MASS}}{\text{TIME}} \right]$  is calculated using:

## Equation 2: Methane Emission Rate - Steady-State Chambers

$$Q_d = q (C_{\text{eq}} - C_b)$$

### WHERE

$Q_d$	The methane emission rate from the well determined using equilibrium-based chamber $\left[ \frac{\text{MASS}}{\text{TIME}} \right]$
$q$	Flow of air flushed through the chamber $\left[ \frac{\text{VOLUME}}{\text{TIME}} \right]$
$C_{\text{eq}}$	Methane concentration in the chamber at equilibrium $\left[ \frac{\text{MASS}}{\text{VOLUME}} \right]$
$C_b$	Methane concentration of the air flushed through the chamber $\left[ \frac{\text{MASS}}{\text{VOLUME}} \right]$

## 4.1.4 Pre-Plugging and Post-Plugging Emission Calculation

To determine the net GHG reductions for wells, monitoring of methane emissions before and after plugging the well is required. The 100-year global warming potential value used in this calculation is specified in the most recent ACR Standard.

The baseline (pre-plugging) emissions, BE (t CO<sub>2</sub>e/year), and post-plugging emissions, PPE (t CO<sub>2</sub>e/year) are computed using:

### Equation 3: Pre-Plugging and Post-Plugging Emission Calculation

$$BE = \left( \sum_1^w Q_{\text{pre-plugging}} \right) \times GWP_{100}(\text{CH}_4)$$

$$PPE = \left( \sum_1^w Q_{\text{post-plugging}} \right) \times GWP_{100}(\text{CH}_4)$$

#### WHERE

$Q_{\text{pre-plugging}}$	Total pre-plugging annual emission rate of all wells to be plugged in the project boundary $\left[ \frac{\text{Kg CH}_4}{\text{Year}} \right]$
$Q_{\text{post-plugging}}$	Total post-plugging annual emission rate of all plugged wells in the project boundary $\left[ \frac{\text{Kg CH}_4}{\text{Year}} \right]$ . This measurement is only required to be collected if there are emissions above background after plugging.
$w$	Total number of wells to be plugged in a project
$GWP_{100}(\text{CH}_4)$	100-year global warming potential for methane (CH <sub>4</sub> )

If the observed change in emission rates during initial testing exceeds a factor of 10, meaning that the ratio of measurement  $n$  to measurement  $n+1$  is less than 10 or larger than 0.1, additional measurements can be collected. If the variation in the measured methane emission rates does not exceed a factor of 10, the  $Q_{\text{pre-plugging}}$  (t CH<sub>4</sub>/year) rate is considered stable.

If emission rates do not stabilize, this methodology cannot be applied.

## 4.2 PROJECT EMISSIONS

Depending on project-specific circumstances, certain emissions sources shall be subtracted from total project emission reductions using the equations below, this includes emissions from plugging activities at the well site. Project proponents are responsible for reporting any non-standard emissions or reductions for ACR's consideration.

### Equation 4: CO<sub>2</sub> Emissions from Fossil Fuel Combustion for Equipment Used at Plugging Project

$$EQ_{CO_2} = FF_y \times FF_{ef}$$

#### WHERE

$EQ_{CO_2e}$	CO <sub>2</sub> e emissions from fossil fuel used in equipment at plugging project (t CO <sub>2</sub> e)
$FF_y$	Total quantity of fossil fuel consumed (gallons)
$EF_{ef}$	Fuel specific emission factor for fuel (t CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O/gallon)— See <a href="#">Appendix F</a>

### Equation 5: Total Project Emissions

$$PROJECT_{total} = EQ_{CO_2}$$

#### WHERE

$PROJECT_{total}$	Project emissions (t CO <sub>2</sub> e)
$EQ_{CO_2}$	Plugging Specific Operations Emissions (t CO <sub>2</sub> , CH <sub>4</sub> , and N <sub>2</sub> O)

## 4.3 EMISSIONS REDUCTIONS

Post-plugging emissions only need to be quantified if methane is detected above background after well is plugged. If methane is detected after well is plugged, proponent must remediate well until there are no emissions or quantify emissions rates.



## Equation 6: Emission Reductions

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$$ER = BE - PPR - PROJECT_{total}$$

### WHERE

<b>ER</b>	Emissions Reductions ( $t_{CO_2e}$ )
<b>BE</b>	Baseline Emissions ( $t_{CO_2e}$ )
<b>PPR</b>	Post-Plugging Emissions ( $t_{CO_2e}$ )
<b>PROJECT<sub>total</sub></b>	Project Emissions ( $t_{CO_2e}$ )

Calculated emissions reductions are multiplied by the number of years in the crediting period (20 for orphan wells, 5 for operated wells) to determine credit generated.

PEER REVIEW

## 5 PERMANENCE

### 5.1 PERMANENCE & REVERSAL RISK

Since project proponents must demonstrate that plugging AOOG results in reduced methane emissions, post-plugging monitoring must be conducted. Permanence in this methodology requires demonstration of well and plug integrity and prevention of emission pathways from the reservoir.

Plugged wells are required to be tested for atmospheric leakage to determine if the well is properly plugged. The test shall involve a methane detector screening the area within 5 cm of the ground surface for at least 5 minutes. The detector can be a handheld sensor and can be a multi-gas sensor but shall have a lower detection limit of 1 ppmv methane. If methane concentrations exceeding 1 ppmv above background are detected, methane flow rate using a chamber-based method shall be measured as detailed in the above sampling section. For buried wells, an area of at least 1 m<sup>2</sup> shall be measured. If the measured methane flow rate exceeds 1.0 g/hour, then the plugged well is considered a poorly plugged well and shall be re-plugged prior to credits associated with that well are grants. Prior to credits being issued, Project Proponents must demonstrate that the well has been designated as “plugged”, or equivalent, by the appropriate jurisdiction.

## 6 MONITORING AND DATA COLLECTION

Each project shall include a GHG monitoring plan sufficient to meet the requirements of the [ACR Standard](#). The plan shall collect all data required to be monitored and in a manner that meets the requirements for accuracy and precision of this Methodology. Project proponents shall use the template for GHG project plans available at [www.americancarbonregistry.org](http://www.americancarbonregistry.org). Additionally, projects are required to submit a GHG monitoring report for each reporting period. Project Proponents shall use the template for GHG monitoring reports available at [americancarbon-registry.org/carbon-accounting/tools-templates](http://americancarbon-registry.org/carbon-accounting/tools-templates). Project proponents should coordinate with ACR and verification body to determine if equipment and documentation, in conjunction with appropriate communication, can substitute for field visits during project activities.

### 6.1 DESCRIPTION OF THE GHG PLAN

The monitoring project implementation is required to document all project activities that could cause an increase in GHG emissions compared to the baseline scenario.

The project proponent must prepare a GHG monitoring plan describing (for each separately) the following: a) project implementation; b) technical description of the monitoring task; c) data to be monitored and collected; d) overview of data collection procedures; e) frequency of the monitoring; f) quality control and quality assurance procedures; g) data archiving; and h) organization and responsibilities of the parties involved in all the above. These are expanded upon in the sections below.

### 6.2 DATA COLLECTION AND PARAMETERS TO BE MONITORED

The project proponent is responsible for monitoring the performance of the offset project and conducting each component of the plugging process in a manner consistent with the methodology. The following data must be collected and reported to ACR:

- Design, specification, and approval of the chamber and chamber methodology or other approved measurement equipment
- Photographs of the deployed measurement system
- Measurements of methane concentrations over time observed in the chamber
- Environmental conditions: precipitation, temperature, humidity

In addition, the following information about the well shall be provided:

- Well identifier: API, UWI, or CWIS
- Surface location of the well
- Photo(s) of the well at ground surface
- Documentation that the well is in regulatory compliance (owned wells only) from appropriate jurisdiction
- Documentation that the sampler and plugger have rights to access and plug well

## 6.2.1 Methane Analyzer Specifications

The methane analyzer must be able to analyze methane-specific concentrations. Combustible gas or multi-gas species analyzers that measure a range of gases including methane shall not be used, unless it also provides methane-specific concentrations. Moreover, the analyzer shall have or exceed the following specifications:

- Working range of environmental conditions (e.g., temperature, humidity)
- Methane-specific detection from 1 ppmv to 100% methane
- Manufacturer's specifications for calibration and and calibration logs.

## 6.2.2 Chamber Specifications

There are two main enclosure-based methods: non-steady-state and steady-state. The steady-state chamber involves continuous flow of a known gas (e.g., air) at a fixed rate using a pump. Non-steady-state chambers do not require a pump. Data collected from non-steady-state chamber measurements include a time series of methane concentrations in the chamber and the chamber volume. Data collected from steady-state chamber measurements includes equilibrium methane concentrations, air flow through the chamber, methane concentrations in the gas pumped through the chamber, and chamber volume. [Appendix D](#) contains resources for chambers.

For inclusion in the project plan, a chamber design includes:

- Materials used to build the chamber, including name and manufacturer
- Fans: the type, number, orientation and location within the chamber
- Vent tube material, diameter, and length
- Gas analyzer: flow rate, sampling frequency, precision, upper and lower detection limits, schedule for calibration, calibration method
- Dimensions (height, diameter or widths) and corresponding volume

- Shape: cylinder, rectangular prism, or other

The footprint of the enclosure should be sufficiently large to cover the full footprint of the well and a minimum 10 cm buffer around the well. The materials used to build the chambers shall be tested to ensure that it does not affect methane concentrations in the chamber (e.g., via degassing or sorption).

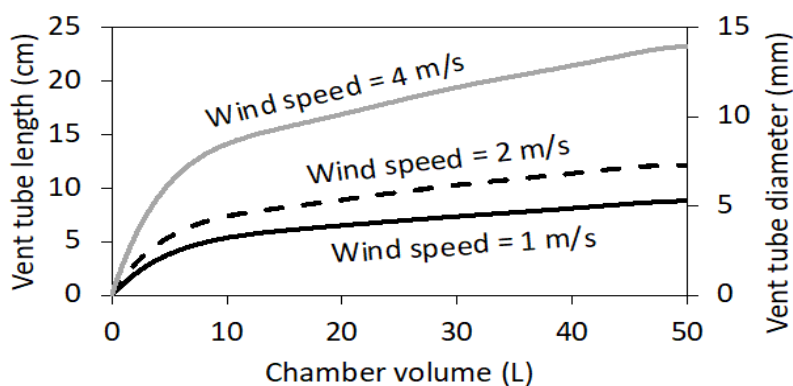
The enclosure shall have a separate detachable base that is inserted 2-6 cm below ground surface and that is open to the atmosphere. This base shall be installed before the rest of the chamber.

The upper portion of the enclosure shall have a vent tube with a diameter and length based on wind speeds and the chamber volume (Figure 6).<sup>17</sup>

Prior to each sampling event, the chamber must be tested to ensure that it is airtight and functioning properly. The project proponent shall monitor and record this testing and include with their baseline sampling submission. This is separate from the calibration of the methane meter, which should be done per manufacturer's specifications. Calibration logs must be included in the baseline sampling submission.

**Figure 4: Vent Tube Length and Diameter for Selected Wind Speeds and Chamber Volumes**

Vent tube length and diameter for selected wind speeds and chamber volumes.



**SOURCE:** Livingston and Hutchinson (1995)

To ensure that the gases inside the chamber are well-mixed and that the chamber is sealed appropriately, fans or other devices that provide sufficient circulation without affecting pressures inside the chamber shall be installed. The location and orientation of the fans shall be used to ensure that the effective well-mixed volume in the chamber is equivalent to the volume inside the chamber. The location, number, and types of fans are considered a part of the chamber design.

## 6.3 PARAMETERS

UNIT	PARAMETER	POTENTIAL EVIDENCE	SOURCE	BASELINE OR PROJECT	FREQUENCY OF MONITORING
(t CO <sub>2</sub> e/year)	BE	Enclosure-based measurements	Enclosure-based measurements	B	1/crediting period
(t CO <sub>2</sub> e/year)	PPE	Quantification measurements	Quantification measurements	P	1/crediting period
$\left[\frac{\text{MASS}}{\text{TIME}}\right]$	Q <sub>s</sub>	Non-steady-state enclosure-based measurements	Non-equilibrium-based chamber measurement	B and P	1/non-equilibrium-based chamber measurement
[VOLUME]	V <sub>eff</sub>	Non-steady-state enclosure-based measurements	Non-equilibrium-based chamber measurement	B and P	1/non-equilibrium-based chamber measurement
$\left[\frac{\text{MASS}}{\text{VOLUME} \times \text{TIME}}\right]$	$\frac{dC}{dt}$	Non-steady-state enclosure-based measurements	Non-equilibrium-based chamber measurement	B and P	1/non-equilibrium-based chamber measurement
$\left[\frac{\text{MASS}}{\text{TIME}}\right]$	Q <sub>d</sub>	Steady-state enclosure-based measurements	Equilibrium-based chamber measurement	B and P	1/equilibrium-based chamber measurement
$\left[\frac{\text{VOLUME}}{\text{TIME}}\right]$	q	Steady-state enclosure-based measurements	Equilibrium-based chamber measurement	B and P	1/equilibrium-based chamber measurement
$\left[\frac{\text{MASS}}{\text{VOLUME}}\right]$	C <sub>eq</sub>	Steady-state enclosure-based measurements	Equilibrium-based chamber measurement	B and P	1/equilibrium-based chamber measurement

METHODOLOGY FOR THE QUANTIFICATION, MONITORING, REPORTING AND VERIFICATION OF GREENHOUSE GAS EMISSIONS REDUCTIONS FROM  
**PLUGGING ABANDONED AND ORPHANED OIL AND GAS WELLS**

Version 1.0



$\left[ \frac{\text{MASS}}{\text{VOLUME}} \right]$	$C_b$	Steady-state enclosure-based measurements	Equilibrium-based chamber measurement	B and P	1/equilibrium-based chamber measurement
(t CH <sub>4</sub> /year)	$Q_{\text{pre-plugging}}$	Enclosure-based measurements	Enclosure-based measurements	B	1/well
(t CH <sub>4</sub> /year)	$Q_{\text{post-plugging}}$	Enclosure-based measurements	Enclosure-based measurements	B	1/well
Kg CO <sub>2</sub> /Kg CH <sub>4</sub>	$\text{GWP}_{100}(\text{C H}_4)$		Greenhouse gas inventory reports	B and P	1/project
	w			B and P	1/project
(t CH <sub>4</sub> /year)	$\overline{Q}_1$	Continuous-in-time measurements	Continuous-in-time-measurements	B and P	1/well
(t CH <sub>4</sub> /year)	$\overline{Q}_{1,j}$	Continuous-in-time measurements	Continuous-in-time-measurements	B and P	1/well
	N	Continuous-in-time measurements	Continuous-in-time-measurements	B and P	1/well
	$Q_k$	Point-in-time measurements	Point-in-time measurements	B and P	Minimum 6/well
	P	Point-in-time measurements	Point-in-time measurements	B and P	Minimum 6/well
°C	Temperature			B and P	
t CO <sub>2e</sub>	$\text{EQ}_{\text{CO}_2e}$	Fuel consumed	Fuel measurements	P	1/project

Vol	FFy	Fuel consumed	Fuel measurements	P	1/project
t CO <sub>2</sub> e/vol	EFef	Emissions Factor	EPA Emission Factor Hub	P	1/project
t CO <sub>2</sub> e/vol	EFef	Emissions Factor	EPA Emission Factor Hub	P	1/project

PEER REVIEW



## 7 QUALITY ASSURANCE AND CONTROL

QA/QC procedures shall be implemented during all phases of the project to assure data quality and completeness. This methodology incorporates the calibration requirements contained in the EPA Mandatory Greenhouse Gas Reporting requirements for facilities that emit GHG. Calibration procedures specified by the equipment (gas analyzers) manufacturers must be used, and calibration records for all monitoring equipment should be kept for verification, including the method or manufacturer's specification used for calibration.

### 7.1 OFFSET OWNERSHIP

Since oil and gas well plugging projects involve complex interest management frameworks, the ownership to the title of CO<sub>2</sub>-equivalent credits associated with the project's emission reductions must be clearly defined. This can be done through contracts amongst the parties in which one of the companies has clear ownership of the credits. Alternatively, through contract, title to the credits can be transferred to an outside third party, who will be the responsible party to ACR.

Owners of CO<sub>2</sub> credits shall provide assurances that they have the legal right to fulfill project commitments. The documentation associated with ownership and legal rights shall be maintained by the Project Proponent and provided during verification. The documents shall be retained for a minimum period of three years following the end of the crediting period.

### 7.2 CONSERVATIVE APPROACH AND UNCERTAINTY

The emission reduction calculations in this methodology are designed to minimize the possibility of overestimation and over-crediting of GHG emission reductions due to uncertainties. This methodology follows the approach designed for direct measurements of methane emissions from AOOG wells in Pennsylvania,<sup>17</sup> one of the states with the greatest number of abandoned and orphan wells in the US. Estimates for errors assumed are +/- 20%, which is the generally accepted random error for static chambers.

A potential source of uncertainty that has been discussed through the course of the development of this methodology is that plugging of a single well within an interconnected pool may not,

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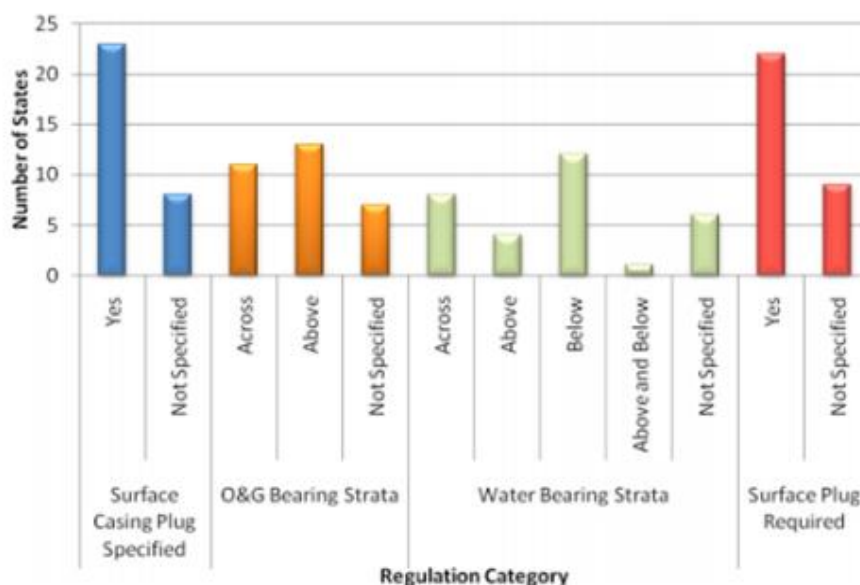
<sup>17</sup> (Kang et al., 2014)

over time, result in reduced methane emissions. To mitigate this unlikely uncertainty, this methodology will apply a 5% leakage deduction to all projects.

## 7.3 PLUGGING STANDARDS

As detailed in [Appendix A](#), regulation for Plugging and Abandoning oil and gas wells differ in timelines, requirements, and requisites. Figure 5 provides a comparison of the plugging requirements in different states with focus on key elements of plugging perforations in the oil and gas strata, cementing across the freshwater zone, and surface casing plugging. To assure plugging integrity, this methodology will incorporate the [American Petroleum Institute \(API\) Recommended Practice \(RP\) 65-3 – Wellbore Plugging and Abandonment Standard](#), as well as local, state, and provincial responsible agency's plugging requirements that go beyond the API standard. If there is conflict between different jurisdictional requirements- ACR will review and approve plugging methods.

**Figure 5: Elements of State Well-Plugging Regulations**



**SOURCE:** State Oil and Gas Regulatory Exchange, and Groundwater Protection Council, 2009

# DEFINITIONS

If not otherwise defined here, the current definitions in the latest version of the American Carbon Registry Standard apply.

Cement	Any material or combination of materials fluidized and pumped into the well to provide a seal
Field	Group of pools, which can be vertically stacked and are within a horizontal areal boundary
Inactive well	This definition can vary definition by jurisdiction. For this methodology, an oil or gas well that is no longer producing but has not yet been permanently sealed
Oil and Gas Commission/Regulator	Every state and province have a division, board, or commission responsible for overseeing the oil and gas industry. These entities issue permits, collect information used to assess fees and taxes, and hire inspectors to ensure compliance with environmental and safety regulations.
Orphan well	A well without a solvent operator and for which no records exist concerning drilling, plugging, or abandonment.
Parts per million	A unit of concentration frequently abbreviated to <b>ppm</b> . For gases, ppm refers to volume (or mole) units.
Plug	A verifiable barrier located within the wellbore that may be mechanical or cement.
Plug and Abandon (P&A)	To permanently seal and retire a wellbore, usually after either it is determined there is insufficient hydrocarbon potential to complete the well, or the well has reached its economic limit. Different regulatory bodies have their own requirements for plugging operations. Most require that cement plugs be placed and tested across any open hydrocarbon-bearing formations, across all casing shoes, across freshwater aquifers, and perhaps several other areas near the surface, including the top 20 to 50 ft (6 to 15 m) of the wellbore.
Plugging	A well is plugged by setting mechanical or cement plugs in the wellbore at specific intervals to prevent fluid flow. The plugging process usually requires a workover rig and cement pumped into the wellbore. This methodology

follows the American Petroleum Institute Wellbore Plugging and Abandonment Recommended Practice 65-3 of June 2021.

Pool	A subsurface hydrocarbon (natural gas and/or oil) accumulation.
Poorly plugged	A plugged well in which the flow rate exceeds 1.0 g/hour
Project Proponent	An individual or entity that undertakes, develops, and/or owns a project. This may include the project investor, designer, and/or owner of the lands/facilities on which project activities are conducted. The Project Proponent and landowner/facility owner may be different entities. The Project Proponent is the ACR account holder.
Severance tax	Severance tax is a state tax imposed on the extraction of non-renewable natural resources that are intended for consumption in other states
Site remediation	Remediation of a well site, including clean-up of spills and remediation of conditions endangering public health or safety, causing contamination of water or the surface, or creating a fire hazard
Spud	To commence drilling operations.
Surety Bond	In most states and provinces, oil, and gas well operators that are involved in exploring, drilling, and plugging of wells are required to secure a surety bond to guarantee the compliance of statutes and regulations set forth by each state for the issuance of a license or permit
Temporary Abandonment status	State of a well currently not producing oil and/or gas but that may return to production. Can also be a specific regulatory term in certain states or provinces.

# APPENDIX A: DEVELOPMENT OF PERFORMANCE STANDARD

During the spring of 2020, amid the COVID-19 pandemic and worldwide economic slowdown, global oil markets were subject to arguably the greatest volatility seen in the last 30 years (for example, in April 2020, U.S. benchmark oil prices dropped below zero for the first time in history). As oil and gas price volatility is likely to continue, oil and gas wells are at a greater risk to move from producing to abandoned to orphaned statuses without adequate bonding and without addressing currently orphaned wells.

According to the Director of North Dakota's Department of Mineral Resources, from March to April of 2020, North Dakota added 360 new orphaned wells. Indeed, the United States Environmental Protection Agency (EPA) states that since 1990, the reported population of abandoned wells has increased by 27%, and that in the US there are approximately 3.2 million abandoned wells. The Government of Alberta has estimated that there are currently 97,000 inactive wells in Alberta that have not been decommissioned and the British Columbia Oil and Gas Commission reports 8,500 dormant wells, or wells that have been largely inactive for 5 years, from which more than a quarter are leaking. Still, many AOOG wells are unaccounted for, and every year more orphaned and abandoned wells are discovered and reported. In Pennsylvania alone, there are between 470,000 and 750,000 such wells, with estimated state-wide emissions of 0.04–0.07 Mt methane (CH<sub>4</sub>) per year.

Unfortunately, the lexicon regarding AOOG wells is not uniform across all states and the federal government. For instance, the EPA refers to the term abandoned wells as follows:

- Wells with no recent production and that are not plugged. Common terms (such as those used in state databases) might include inactive, temporarily abandoned, shut-in, dormant, and idle.
- Wells with no recent production and no responsible operator. Common terms might include orphaned, deserted, long-term idle, and abandoned.
- Wells that have been plugged to prevent migration of gas or fluids.

In Canada, the same problem of regionally specific terminology persists. For example, the Alberta and Saskatchewan regulators deem the type of well described above as orphaned, where in British Columbia, these wells fall under the dormant site category. The major oil and gas producing provinces—Alberta, British Columbia, Northwest Territories, Ontario, Saskatchewan, and Yukon—have varying systems for managing wells for which no producer accepts the environmental liability. Provincial rules around “abandoned” wells include:

In contrast with some terminology used in the US, wells are considered “abandoned” in Alberta if they have been properly decommissioned according to the requirements of the Alberta Energy Regulator (AER). An “abandoned” well in Alberta is the equivalent of a “plugged” well in the US.

In Alberta, wells, facilities, or pipelines are considered orphaned when the licensee has become insolvent, and the Orphan Well Association (OWA) has undertaken the responsibility of abandonment and reclamation of wells for which the licensee is insolvent.

In British Columbia, orphan wells are those where the producer has declared bankruptcy or cannot be located and designated as such by the BC Oil and Gas Commission.

In Saskatchewan, orphaned sites can mean a well, facility or associated flowline, or their respective sites, if the entity responsible for the site does not exist, cannot be located, or does not have the financial means to contribute to the costs of remediation.

For this methodology, ACR will refer to the term “abandoned wells” as those wells with no recent production (i.e., within the preceding consecutive six months), a known, solvent operator, and that are not plugged or properly plugged. We refer to the term “orphaned wells” as those wells with no responsible operator and that are not plugged or properly plugged. For orphaned wells, the distinction ACR is making is whether the well is associated with insolvent operator or not. This distinction is important in that different regulatory requirements may apply depending on whether the well is associated with an operator. As [Appendix C](#) shows in detail, the IOGCC reports 56,000 documented orphaned wells in the US, highlighting that this amount is underestimated.

## A.1 FINANCIAL ASSURANCE FOR OIL AND GAS WELLS

At the time a well is drilled, an operator is often required to post a bond (for an individual well), or a blanket bond (for multiple wells located within a state or a province) that may be returned to the operator only after the well is plugged. Bonds are designed to help prevent or reduce taxpayer losses in every state because the bond money may be used to reclaim wells when operators or other liable parties do not reclaim the wells due to insolvency or cessation of business activities. In these situations, the wells are considered to be orphaned and become a state liability for remediation as there is no other responsible party. Ideally, these bonds would be high enough and would require oil and gas producers to account for the potential external environmental costs of their operations. However, in practice, bond funds are very often insufficient to cover proper plugging and reclamation expenses.

Proper remediation of all the U.S. and Canada’s AOOG wells would be an extremely large financial burden. A report from the Interstate Oil & Gas Compact Commission (IOGCC, a multi-state government entity that collects data on abandoned and orphaned oil and gas wells across



the U.S. and Canada) analyzed the ratio between the minimum bond requirement for an individual well based on state requirements and the actual average plugging cost per well. Per ACR analysis of the IOGCC data, bonds were insufficient to cover remediation costs in the United States and Canada. Further, this analysis found that in states such as Utah, Pennsylvania, Illinois, and Montana, bond requirements were sufficient to cover less than 5% of the average cost of plugging a well. In South Dakota, one operator orphaned numerous natural gas wells that will cost almost \$1 million to plug while the state only required \$10,000 in bond money from the operator. These analyses and examples demonstrate that the financial assurance mechanisms designed to ensure proper well remediation are woefully inadequate.

## A.2 REGULATORY CONSIDERATIONS FOR OIL AND GAS WELL REMEDIATION

State and provincial regulations to require financial assurance, through bonding, for plugging wells were first introduced in 1941 in North Dakota (however, in the case of Mississippi, financial assurance through bonding requirements was not introduced until 1992). Before a well is plugged and abandoned, wells are often idled for a certain amount of time, the maximum length of time that a well can be idled varies from state to state as shown in [Appendix B](#)). There are different regulatory paths a well can take in different jurisdictions including temporarily abandoned (TA) and long-term idle prior to being permanently plugged.<sup>18, 19</sup> In many jurisdictions it is possible to file for extension or temporarily return the well to production to restart the process. The initial term of the TA stage varies from as little as 12 months in certain states to up to 60 months.<sup>20</sup> To avoid abuse of the TA.<sup>21</sup> Ultimately, the TA extension process allows wells that, in many cases, will never be produced to remain inactive and for the operators of these wells to avoid proper remediation. This allows methane to continue to emit and the risk of groundwater contamination to persist long past the point that these wells should have been plugged/remediated.

Oil and gas industry has not been held accountable by regulators for the proper remediation of orphaned and abandoned oil and gas wells and this is demonstrated by many studies<sup>22, 23</sup> and

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<sup>18</sup> Meaning that operator has fulfilled all requirements for Temporarily Abandonment status

<sup>19</sup> Note that ACR refers to this stage as “temporarily abandoned” but, depending on state regulations this stage could be referred to, inter alia, as “idle”, “long term idle”, “inactive”, or “dormant”. Regardless of the specific term or status used to define these wells, the important factor is the length of time elapsed since the well was producing oil or gas. For purposes of this methodology, a well categorized as “temporarily abandoned” is considered to be “abandoned” to determine whether it is eligible under the performance standard.

<sup>20</sup> (Muehlenbachs, 2015)

<sup>21</sup> (IOGCC, 2019)

<sup>22</sup> (Ho et al., 2018a)

<sup>23</sup> (J. Ho et al., 2016)

different organizations.<sup>24</sup> The overall weakness in the regulatory environment to properly govern oil and gas well remediation has been studied extensively.<sup>25, 26</sup> These studies typically conclude that bonding reform is needed to increase funding to guarantee proper remediation, and that sectoral regulatory reform is necessary to ensure that proper remediation and abandonment procedures are in place to limit potential negative environmental and public health impacts associated with orphaned and abandoned oil and gas wells. According to IOGCC<sup>8</sup>, the State Oil and Gas Regulatory Exchange and the Groundwater Protection Council<sup>27</sup> regulatory provisions exist to provide exemptions and/or permit renewals at the state/provincial commission level that allow well operators to extend the time for temporary abandonment and even perpetuate it. TA status extensions leave a growing number of wells unplugged every year. According to the Natural Resources Defense Council and FracTracker Alliance,<sup>19</sup> regulations are not enforced by state and provincial oil and gas commissions, and other enforcement organizations (i.e. BLM), due to several factors including under staffing, lack of transparency, inconsistent data recording by different organizations with different objectives within states, lack of allowable enforcement infrastructure, and a lack of clarity around violations (for instance, in Colorado, even though some inspections are “unsatisfactory,” violations may not be recorded, in Wyoming, the Oil and Gas Conservation Commission has not tracked inspections or noncompliance issues for years, and, in the State of Utah, no fines have been levied for lack of appropriate remediation in two decades at least<sup>23</sup>). Therefore, it can be concluded that plugging wells at the end of their productive life, although required by law, is not uniformly enforced, and is not the observed trend.

Projects that meet a practice-based performance standard can be considered additional. Those wells that fall within eligibility categories identified in chapter two are considered to meet performance standards.

## A.3 U.S. STATE WELL PLUGGING FUNDS

All available analyses on state/provincial wells plugging funds have concluded that increased amounts of money are needed to remediate AOOG wells. Accordingly, the U.S. Government Accountability Office estimates that remediating an orphaned or abandoned well runs from \$20,000 to \$145,000 or more, putting the price tag for remediating America’s orphaned and abandoned wells somewhere between \$60 billion to \$435 billion.

Some states have established plugging, emergency remediation, and site restoration funds to ensure that wells for which no or insufficient financial assurance is available are properly plugged and abandoned. These plugging funds are financed differently by state but are typically

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<sup>24</sup> (Bloom, n.d.)

<sup>25</sup> (U. S. Government Accountability, 2019)

<sup>26</sup> (J. Ho et al., 2016)

<sup>27</sup> (State Oil and Gas Regulatory Exchange & Groundwater Protection Council, 2009)



funded via fees, fines, public revenue, and taxes.<sup>28</sup> Nevertheless, although these funds exist in some states, the conditions under which the funds can be used often make the goal of plugging wells difficult to achieve. For example, the state of Virginia has a fund to reclaim abandoned wells, but The Virginia Gas and Oil Act defines "Orphaned Well" as "...any well abandoned prior to July 1, 1950, or for which no records exist concerning its drilling, plugging or abandonment".<sup>29</sup> Therefore, any well **abandoned after July 1, 1950** or for which records do not exist is not a candidate for reclamation using state reclamation funds. Another case is Texas, where there were 440,000 producing oil and gas wells and 130,000 wells that were not producing.<sup>30</sup> Although the State has given funds to the Texas Railroad Commission (organization which regulates the industry in Texas) to plug wells, in a two-year period, the State only plugged an equal number of wells as the number of wells that were abandoned during that two-year period.<sup>29</sup> The available funding to remediate wells is simply insufficient to address the issue.

## A.4 CANADIAN WELL DECOMMISSIONING FUNDING

In April 2020, Canada announced a \$1.7B CAD fund to clean up orphaned and inactive wells. The \$1.7B CAD is structured as a jobs program, helping energy sector workers keep their jobs and fails to meet the magnitude of funds needed to remediate orphaned wells across Alberta alone, which has been estimated to cost \$100B CAD.<sup>31</sup> Finance Canada reports approximately 5,560 orphaned wells, with an additional 139,000 inactive wells across Alberta, BC, and Saskatchewan.<sup>32</sup> The average cost to plug a well in the Canadian provinces has been calculated at \$61,477 (CAD).<sup>33</sup>

## A.5 TIMING REQUIREMENTS FOR ABANDONED WELLS

Efforts have been made to normalize state and provincial regulations, specifically regarding timing requirements to plug a well. As explained in depth in this Practice-Based Performance Standard and shown in the graphic in [Appendix C](#) in the average well case, an operator has ap-

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<sup>28</sup> These include fees: annual, idle well, permits, civil penalties and settlements, fines: appropriations, and State Oil and Gas Agency operating budgets, forfeited bonds, and salvage

<sup>29</sup> (Buchele, 2019)

<sup>30</sup> (Texas Senate, 2019)

<sup>31</sup> (De Souza et al., 2018)

<sup>32</sup> (Harris, 2020)

<sup>33</sup> (IOGCC, 2019)

proximately five years of inactivity before the average regulatory body begins to require P&A operations or other preventative measures (i.e., Mechanical Integrity Test). Loopholes to this requirement have emerged over time which has contributed to an increase in the abandoned well population as described in this methodology. Per ACR observations on *Enverus Drilling Info* database searches, as well as in IOGCC reports, historically abandoned non-productive time before plugging averages between 5 and 10 years, therefore requiring P&A operations before that timeframe would not be considered common practice, which creates additionality within projects.

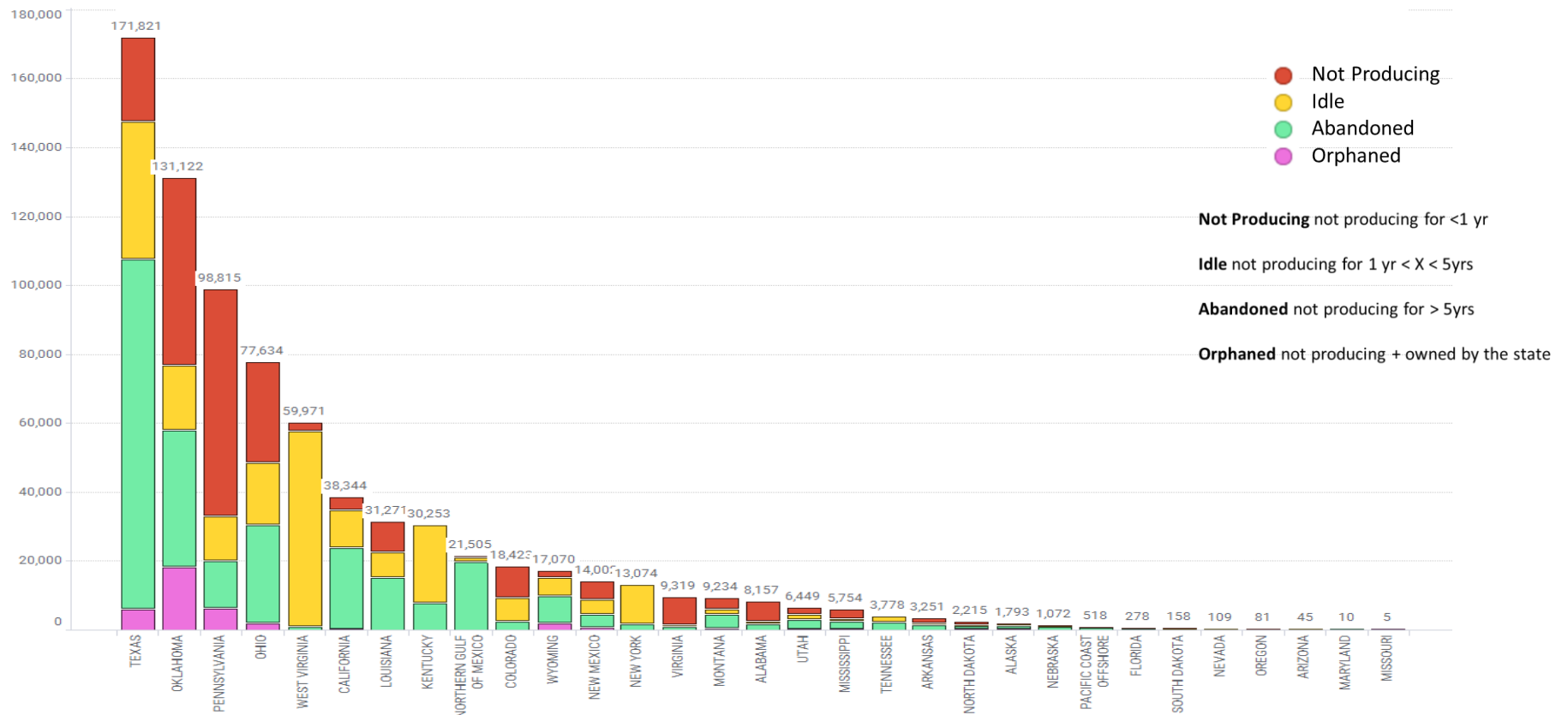
To comply with this methodology 10-year CH<sub>4</sub> emissions reduction credit, wells would need to be plugged approximately that much sooner than they would if this methodology were not in place—approximately 1-5 years after becoming idle. For orphaned wells, most jurisdictions lack the means to address the backlog of wells and it is possible that these wells would remain unplugged indefinitely or for long time periods, potentially allowing decades of emissions. It is also true that given the volume of AOOG in existence today, and those same historical plugging trends, it is not likely that the P&A service providers within the Oil Field Service Sector could keep up with the demand for plugging services this methodology may generate, therefore ACR has erred on the side of increased timeframe to allow the market to catch-up (hopefully creating jobs along the way). Generally, oil wells<sup>34</sup> to have less GHG emissions also allows for the increased timeframe whereas gas wells should be considered priority when plugging.

Based on the above discussion, at this time, certain AOOG wells detailed in Chapter 1 are considered to pass the performance standard test for additionality. Orphaned wells are a state liability, while many abandoned wells are at risk of becoming orphaned and, as discussed above, are highly unlikely to be remediated in the near term. To qualify for eligibility in this methodology, the title/ownership of an AOOG well must be transferred to an entity that will plug and monitor the well or the project proponent must demonstrate to ACR's satisfaction that they are eligible to plug a well, monitor for emissions, and receive credits.

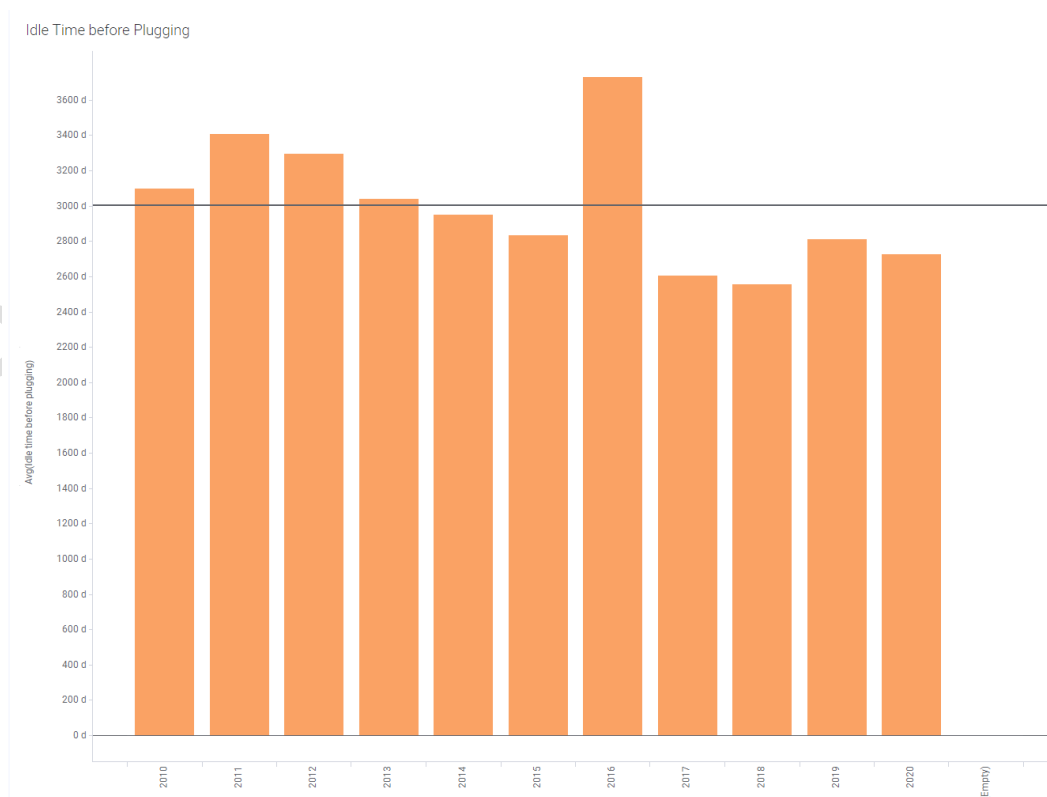
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<sup>34</sup> (Kang et al., 2019)

# APPENDIX B: NON-PRODUCING WELLS BY STATE



## APPENDIX C: AVERAGE TIME BETWEEN LAST PRODUCTION AND PLUGGING OF A WELL IN THE LAST DECADE



# APPENDIX D: TEMPORAL VARIATION & CHAMBER METHOD REFERENCES

## D.1 REFERENCES FOR CHAMBER METHOD GUIDANCE

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## APPENDIX E: TIME ALLOWED FOR WELLS TO BE NON-PRODUCING BEFORE P&A

AMOUNT OF TIME ALLOWED FOR EACH STEP IN THE P&A PROCESS				
US STATES/ CA PROVINCE	MAX WELL IDLE TIME (MONTHS)	EXTRA MONTHS ALLOWED	TEMPORARY ABANDONMENT ALLOWED	POSSIBILITY OF RENEWAL
UNITED STATES				
AL	6	1	12	
AK			60	yes
AZ	1		60	
AR	24	12	36	
CA	24	36		
CO			36	
ID	24		36	yes
IL	24	60	24	
IN	2		60	yes
KS	3	12	12	yes
KY	0		24	yes
LA	6		60	
MI	12		60	
MS	12	12	Indefinite	
MT	12		Not specified	

AMOUNT OF TIME ALLOWED FOR EACH STEP IN THE P&A PROCESS				
NE	12		12	
NV	12		12	
NM	15	12	60	
NY	12	3	15	
ND	12		12	yes
OH	24		12	
OK	12		Indefinite	
PA	12		60	yes
SD	12		60	yes
TX	12		Indefinite	yes
UT	12		60	yes
VA	36		Indefinite	yes
WV	12		60	yes
WY	24		Indefinite	yes
CANADA				
Alberta	18/24		Perpetuity	

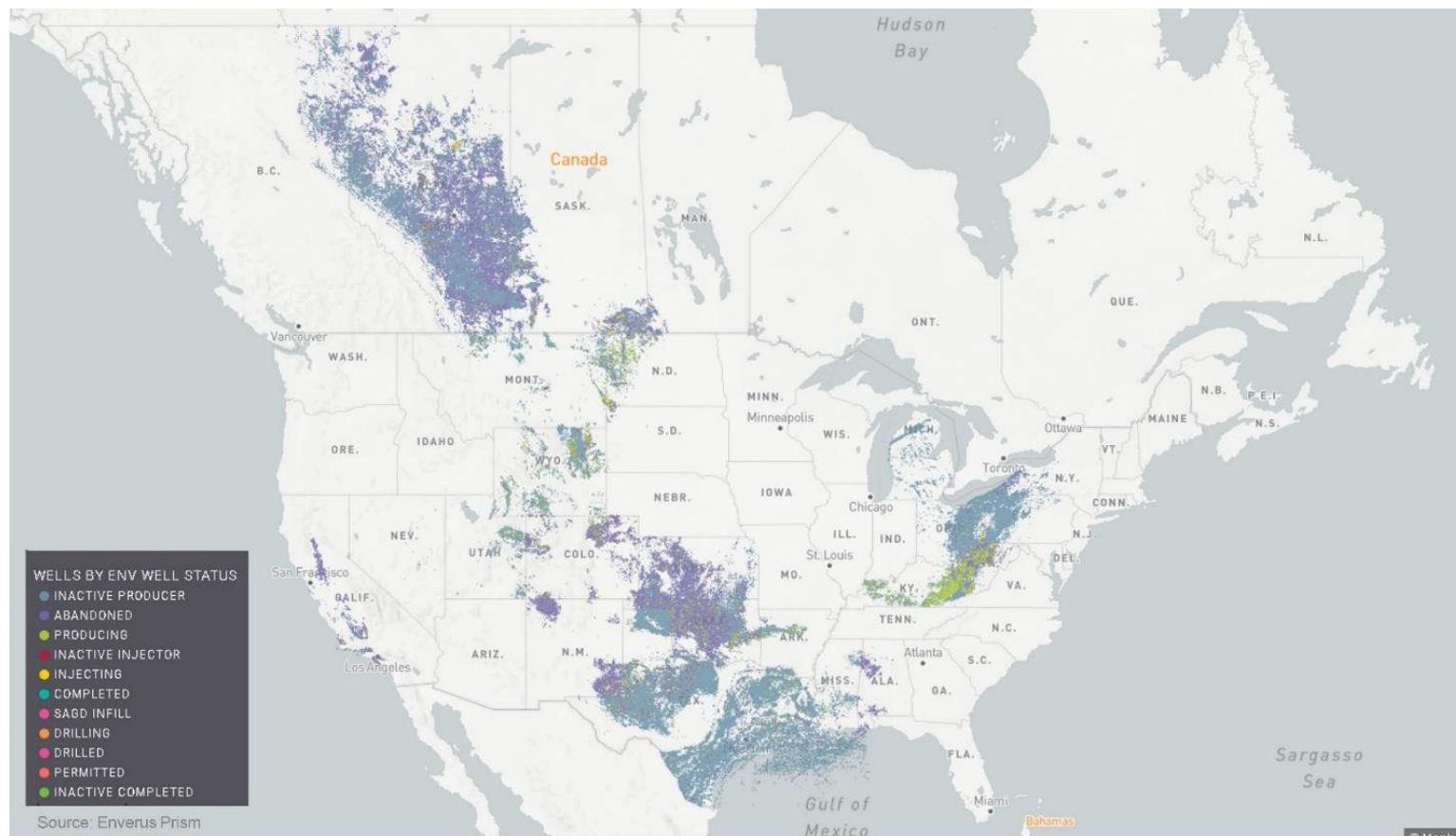
## APPENDIX F: EMISSION FACTORS

Project proponents shall use the current version of the U.S. Environmental Protection Agency's Emission Factors Hub ([GHG Emission Factors Hub | US EPA](#)) to determine the correct factors to use for their equipment. For diesel fuel, use No. 2 Fuel Oil.

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## APPENDIX G: O&G WELLS IN THE USA AND CANADA



## APPENDIX H: REFERENCES

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