MARGINAL CONVENTIONAL WELL PRIORTIZATION PLAN

Methane Emissions Reduction Program for Marginal Conventional Wells

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WORK PERFORMED UNDER AGREEMENT

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SUBMITTED BY

Illinois Department of Natural Resources
One Natural Resources Way
Springfield, IL 62702

PRINCIPAL INVESTIGATOR

Daniel Brennan
(217) 782-0179
Dan.Brennan@illinois.gov

SUBMITTED TO

U.S. Department of Energy
National Energy Technology Laboratory

Chris Cadez
Christopher.Cadez@netl.doe.gov

A Methodology for Prioritizing Marginal Conventional Wells for Plugging in Illinois

Developed for "Mitigating Emissions from Marginal Conventional Wells in Illinois" by the Illinois State Geological Survey

Version 1 – October 2024

Contact: methane@isgs.illinois.edu

Introduction

Purpose

The US EPA and DOE awarded Illinois with $17,367,009 in formula funding to assist oil and gas well owners and/or operators as they reduce methane emissions from low-producing marginal conventional wells (MCWs) on nonfederal lands through voluntary, permanent well plugging.

Based on recent well plugging activities that the Illinois Department of Natural Resources (IDNR) has performed as part of the US Department of Interior's Orphaned Well Site Plugging, Remediation, and Restoration Program, the average cost to plug a well in Illinois is approximately $40,000. This cost includes employing Illinois oilfield service companies under master contracts that comply with prevailing wage requirements under the Davis-Bacon Act. Hence, it is expected that approximately 350 wells could be plugged with available funding minus administrative costs and the costs associated with emissions measurements and project prioritization.

The purpose of this paper is to describe the methodology that will be used to prioritize wells that are volunteered for plugging in Illinois.

Problem Statement

The challenge addressed by the prioritization is twofold and, in both cases, relates to resource scarcity:

1. There are more than 26,000 MCWs in Illinois, with more than 3,000 MCWs currently in Temporary Abandonment (TA) status (Figure 1). Wells are placed into TA status when an operator is holding a wellbore in anticipation of future utilization, such as in an enhanced oil recovery project. However, many of these wells are likely placed into TA status for economic reasons, such that a combination of low oil prices and low production rates make the wells subeconomic to operate continuously. Given uncertainty about the interest well owners/operators will have in this program, the large population of TA status wells suggests that the number of wells volunteered could significantly exceed the available funding for plugging.
2. Service companies and P&A expertise and resources are scarce. Plugging project selection based on emissions alone would be extremely inefficient. Highest priority wells may be geographically distant from one another. Selections should be high-priority, high efficiency, and our choices should be transparent and defensible. This includes current assessments

of the likelihood that the wells currently in TA status (Figure 1) could transition into orphan status.

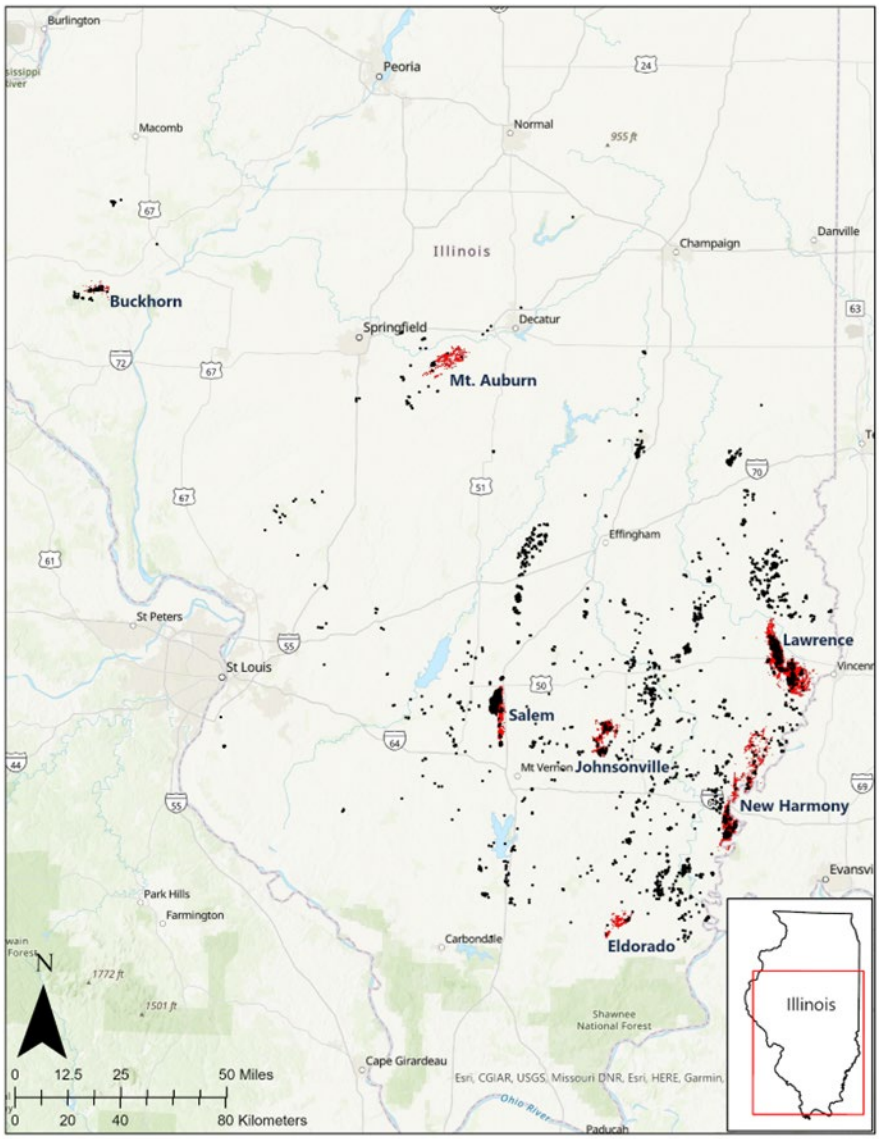

Figure 1. Map of wells in temporarily abandoned (TA) status (black circles) associated with major oils fields (shaded in red). The concentration of TA wells is in central and southern Illinois.

Scope

The scope of the prioritization methodology developed herein is limited to the State of Illinois. All data will be specific to Illinois MCWs. However, given that there are an estimated 770,000 MCWs in the United States, the prioritization methodology developed for Illinois may have broader applications in other states that contain low-volume emitters from MCWs and span an expansive range of thermal maturation of formations within the basin.

The initial proposed methodology will be updated iteratively during the period of performance as marginal conventional wells are volunteered and added to the plugging list as new methane

measurement data will result in revised interpretations of the drivers of methane emissions. These inputs will result in a rebalancing of the resultant prioritization criteria.

Research Design

Approach

The prioritization will use a variety of quantitative and qualitative data that will be generated as part of field inspections of well sites, review of regulatory documents that contain well construction information, and through geospatial analysis of well locations. The design of the database will capture both quantitative and qualitative inputs, including photos, audio, visual, and olfactory (AVO) inspection, and site assessment. Only wells that are volunteered by well owners/operators to be permanently plugged will be analyzed.

The prioritization approach will consider 27 different factors divided into eight different categories (Table 1). Each category and the types of data to be collected and used are described below.

Table 1. Prioritization categories and factors being considered for selecting volunteered MCWs for plugging in Illinois.

Category	**Factor**
Methane Emissions	Methane leak detected
	Methane leak > MDL 100 g/hr (~1 metric ton / yr)
	Methane leak > 2.3 kg/hr (20 metric ton / yr)
	Methane concentration in bulk gas composition
Construction	Well age
	Surface equipment on site
Economic	Operator total well inventory
	Operator TA wells vs total well inventory
	Well productivity
Geologic Setting	Thermal/Burial History
	Proximity to faults
	Other methane sources (drift, CBM)
Reservoir Geology	Completion interval
	Years since discovery of reservoir/field
Operational	Surface pressure
	Gas head volume
	Gas rate
	Oil rate
	Current well status
	TA status duration (if applicable)
Maintenance	Liquid leaks at fittings and joints
	Visible holes in the casing or flowlines
	Vegetation around well / in contact with metal
	Oil stained ground around the wellhead
Proximity to Life	Human receptors
	Building setbacks
	Ecological receptors

Methane Emissions – Empirical measurements from MCWs including whether methane emissions were detected, quantification of the leakage rate, and compositional data including Methane concentration of the bulk natural gas in the wellbore. Isotopic methane measurements will also assist in determining the source of emissions.

Construction – Regulatory documents provide useful information about how age of the well, which can be correlated with potential casing and cement bond issues. The quality of well construction materials and practice may also be correlated with the market price of oil at the time the well was constructed. Visual inspection of the well site provides information about the plumbing and quantity of surface equipment and potential sources of leaks. A greater quantity of surface equipment and plumbing on site has been correlated to a greater number of potential leaks (Omara et al., 2022).

Economic – Factors that indicate the likelihood of an MCW becoming an orphaned well. These factors include the total number of wells in an operator's inventory and the proportion of those wells that are currently in TA status. Less capitalized operators may resort to abandonment/non-renewal of annual well license fee that results in orphan well status. In addition, inherited legacy wells may fall to family-relation owners who have no interest in maintenance, operation, or plugging.

Geologic Setting and Reservoir Geology - With the understanding the MCWs may become orphaned wells under a different economic/regulatory environment, emissions predictions become important in the prioritization assessment. We hypothesize that methane emissions are governed, in part, by geologic setting (e.g., oil producing formation, thermal/burial history, infiltration of drift gas, proximity to basement faults). Formations intersected by wells located near or in hydrocarbon generation sources or along migration pathways may provide conduits for both oil and gas infiltration. As noted in Figure 2, there is a correspondence between well clustering and structural features, including basement faults.

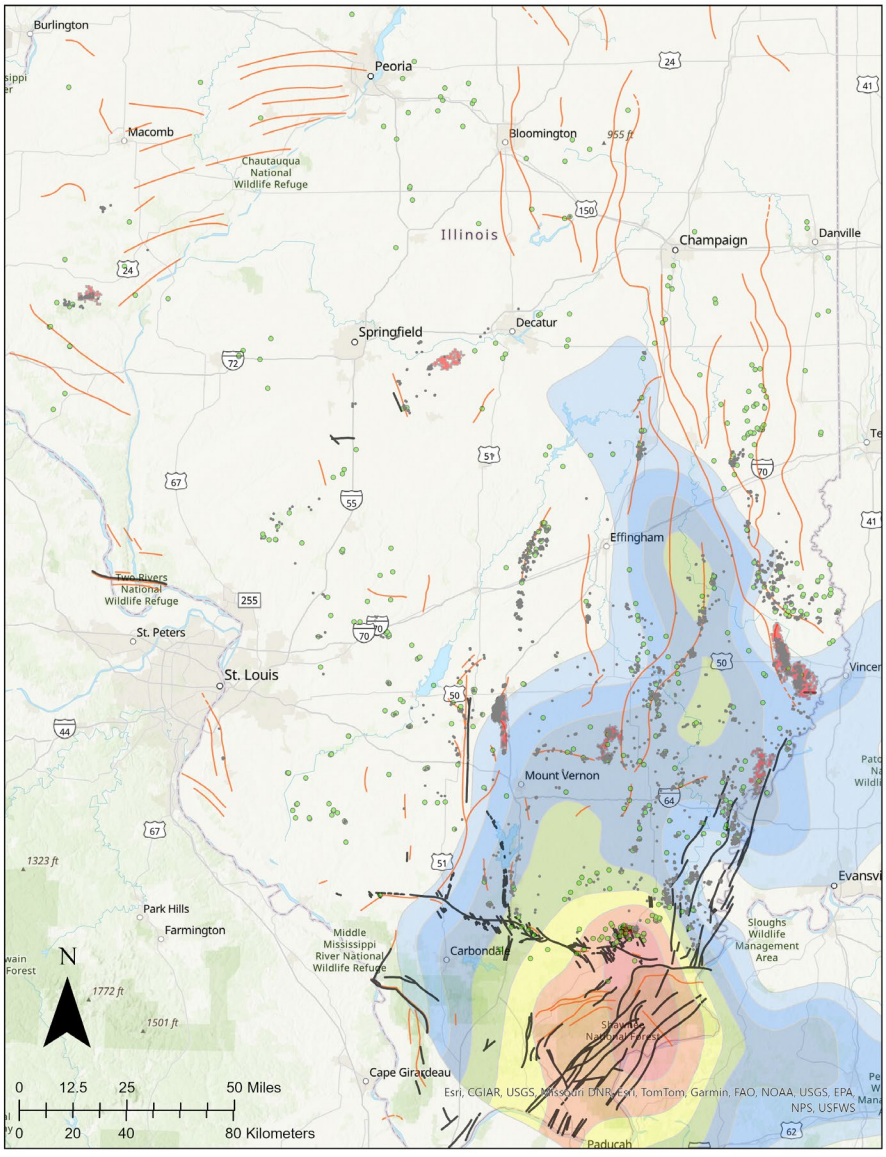

Figure 2. Map depicting the southcentral portion of the Illinois Basin with structural features (red), basement faults (black), and well locations (green). Map depicts well clustering around structural features and major fault zones.

Operational – Current operational data from MCWs can indicate the likelihood of a well to become a methane emitter if other factors (such as well construction or maintenance) are ignored. Surface pressure, the duration of TA status (if applicable), production data (BO/day or mcf/day), and general operational indicators can help in the predictive assessment of current/future methane emissions.

Maintenance - Recent studies have shown that wells that are poorly maintained or the operator cannot produce maintenance documents or inspection reports (service companies or developed by Illinois Department of Natural Resources) may be evaluated at higher risk for fugitive emissions. Spatial clustering of integrity issues that cause emissions may be grouped or expected, in part, by operator owning those leases.

Proximity – Proximity is the physical separation between MCWs and humans that may be directly impacted by the permanent plugging and abandonment of the wellbore. GIS overlays of buildings, roads, and environmentally sensitive areas will highlight areas of increased risk due to human and ecological factors. Knowledge of modern setback regulations and types of structures (i.e. schools, commercial buildings), may indicate wells that should be prioritized for plugging.

Implementation

For each well that is volunteered to participate in the program, desk and field-based data collection will be performed to populate data for each of the factors listed in Table 1. Desk-based methods include database queries and geospatial analysis. Field-based data collection includes wellsite visits to make direct observations. These methods are described in the next section.

Each factor will be translated into a normalized score. Scores for all factors will be summed to determine an overall well score. If a well measurement/rate indicates an extremely high level of emissions, that factor will be weighted higher than other prioritization factors. Otherwise, the scores for all factors will be weighted the same, but as more wells are volunteered, certain factors scores may be weighted more heavily. This weighting will be adjusted based on feedback from IDNR and operators.

Data Collection Methods

During the first year of MERP program implementation, the ISGS will be focused on developing the prioritization methodology utilizing actual methane compositional and isotopic data from a minimum of 25 wells across the Illinois basin. This will allow assessment of the geologic factors that impact gas generation/production and establish a predictive capability to evaluate wells in potentially high-risk regions that are or may become, higher-volume methane emitters, Table 2 lists the general field areas where gas sampling will be concentrated. These areas provide wells which represent a range of well ages, perforated formations, hydrocarbon trap type, reservoir fluid drives, and proximity to areas that are (or were) zones of hydrocarbon generation from source rocks. Results from this sampling will be incorporated as a factor in the prioritization.

Table 2. Screening criteria for gas compositional and isotopic sampling. Oilfield names are in reference to those highlighted in Figure 1.

Oilfield Name	**Screening criteria**					
	Operational factors		Geological factors			
	Well Depth (ft)	Well Age (yr)	Geologic formation	Trap type	Reservoir Drive	Proximity to HC kitchen
Buckhorn	600	40	Silurian-Ordovician	Stratigraphic	Solution gas, Bottom water	Not
Eldorado	2500	70	Mississippian	Structural	Solution gas	High
Johnsonville	3000, 4000	75, 50	Mississippian	Structural	Solution gas, Bottom water	Medium

Lawrence	1000-2000	75-40	Pennsylvanian-Mississippian	Structural	Solution gas, Bottom water	Low
Mt. Auburn	1900	40	Silurian	Stratigraphic	Solution gas	Not
New Harmony	2800-3900	80-40	Mississippian-Devonian	Fault	Solution gas, Bottom water	Medium
Salem	1900, 3500	85	Mississippian-Devonian	Structural	Solution gas	Low

Only wells volunteered for plugging by the well owner/operator will be analyzed for prioritization. Wells that are volunteered will first be subjected to a screening protocol for detecting and classifying methane emissions using a high sensitivity solid state methane leak detector. The methane detector will be used to classify methane emissions from a well into one of three categories:

1. Not detected. Emissions are not higher than background levels.
2. Detected. Emissions are higher than background levels.
3. Detected and may be high. Emissions are higher than background levels and any one of five qualifying criteria are present that indicate emissions rates may be high (i.e., there is a noticeable gas odor [VOCs, H2S], there is the sound of gas leaving the well, venting of gas is causing movement of the air, stressed nearby vegetation, or bubbling in nearby surface waters, methane concentrations are above 1000 ppm anywhere in the well vicinity).

Wells that fall into the “detected” or “detected and may be high” categories will then be subjected to a protocol designed to provide quantitative estimates of methane emissions rates that meet program data quality objectives and can be aggregated to meet reporting requirements. For these wells, a high-flow sensor will be employed to determine the rate of methane emissions (recorded in units of mass per hour) from the well which will be one of the key criteria for plugging prioritization.

All wells, regardless of whether methane leaks were detected, will be subjected to a third measurement wherein a valve on the wellhead will be opened and a second measurement will be made with the high-flow sampler to determine the potential methane emissions if the well were to remain in TA status and deterioration of wellhead equipment resulted in a future leak. Coincident with this measurement, gas samples will be collected from each well for compositional and isotopic analysis in the lab to 1) provide an independent check on the concentration of methane in the bulk gas emanating from the wellbore, and 2) provide data for analyzing the source of the methane (e.g., the expected gas composition and isotopic signature for a given reservoir).

Data Analysis Techniques

NETL’s PRIMO (P & A Project Optimizer) is an open-source decision support tool that will be used to assist in the selection of impactful and efficient plugging projects. It has been designed (development is still ongoing) to support the states who are engaged in MERP to help organizations determine which marginal conventional wells (MCWs) or other low-producing wells are the best

candidates for plugging. It operates by receiving input data regarding the volunteered MCWs, along with well assessment metrics, and user-defined project preferences. After successful running of the tool, users obtain outputs that consist of MCW rankings and recommendations for P&A projects. It is fully customizable and provides three main capabilities:

1. Ranking candidate wells (based on user preferences)
2. Identifying high-impact, high-efficiency P&A project candidates (with transparently computed scores for relevant metrics)
3. Comparing competing P&A projects quantitatively (through transparently computed project impact and efficiency scores)

In summary, PRIMO provides users the flexibility to create their own prioritization metrics for multiple factors. The total priority score is the sum of its scores for all the factors for any given well. A clustering step is involved where wells are clustered based on their characteristics such as location, age, and depth. From these clusters, one or more wells can be chosen to form a P & A project. Finally, an optimization criterion is developed based on the priority scores and user-provided state-wide program constraints to identify the optimal P&A projects. Thus, PRIMO helps users to take decisions in their prioritization. More details regarding the tool can be found in documentation provided by NETL via a link appended to this document. Utilization of this tool will help manage efficient use of award funds and effective scheduling/mobilization and planning of service companies involved in well plugging.

Ethical Considerations

The ISGS is hosting a public facing website where well owners/operators can volunteer wells to be plugged. Wells volunteered for plugging and all associated data will be kept confidential through the prioritization process. This confidentiality is meant to protect those well owners/operators whose wells are assigned a low prioritization score and ultimately are not selected to be plugged. Given feedback from well owners/operators as part of the community outreach effort over the last year, providing this confidentiality is an important part of building trust and ensuring engagement in the MERP program. The ISGS will also post or link to information supplied by DOE/NETL on the technical program, methane measurement guidelines, and any updates that require public outreach. In addition, the type of measurement instrumentation used, the technical specifications of those instruments, and a general overview of how the measurements are taken, specific to the instrument, will be made available on the website. It is our intention to be as transparent as possible to our industry stakeholders and provide an un-biased prioritized list of plugging project selections to IDNR for execution.

IDNR's data sharing website will include the following for each well location: operator/well owner, well type (e.g., oil, gas), production rate prior to plugging, methane emissions prior to plugging, documentation of zero emissions post-plugging, total cost of well plugging, and whether the plugged well is in a disadvantaged community as identified using the CEJST. In addition, data on the website will be aggregated to include the total number of wells plugged, the total number of plugged wells of each type, the total production rate of plugged wells prior to plugging, total volume of mitigated methane emissions, total costs of well plugging, and number of wells plugged in disadvantaged communities as identified by the CEJST tool.

Conclusion

The ISGS approach to the prioritization methodology incorporates numerous (including geologic) factors which will enhance the predictive capability of assessing and sampling/measuring wells in geographic areas considered higher risk. With thousands of potential MCWs to consider, and hundreds that may be volunteered, the ability to pre-screen before in-field visits are planned is critical. Integration and utilization of the PRIMO tool for data analysis will accelerate the prioritization process and provide an avenue for efficient utilization of award funds, that by costing necessity, only covers approximately 350 MCWs in a basin which contains over 26,000 MCWs. Application of the factors described herein and incorporated in the PRIMO tool allows a transparent and defensible plugging list to be developed and transferred to IDNR and the State of Illinois for execution. As additional geochemical data and methane measurements are collected through the project period of performance, certain factors and approaches may be modified to increase specificity of critical factors and improve prioritization assessment. Therefore, the ISGS prioritization methodology will be considered an evolving process moving forward and will be continuously evaluated.

References

Omara, M., Zavala-Araiza, D., Lyon, D.R. et al. Methane emissions from US low production oil and natural gas well sites. Nat Comm. 13, 2085 (2022). https://doi.org/10.1038/s41467-022-29709-3

PRIMO - The P&A Project Optimizer — PRIMO 0.1.dev0 documentation