Multiscale Methane Measurements of a Contiguous onshore Natural Gas Production Region
Wyoming, USA

ECOS – Fall Meeting

Park City, UT

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Jonah Energy Overview

Jonah Energy LLC

- First US-based company to sign on to OGMP 2.0;
- Independent natural gas producer with concentrated asset base of 152,000 net acres in the Jonah Field, Sublette County, Wyoming
- Member of ONE Future, leading U.S. industry group advocating for quantification of methane emissions and alignment with OGMP 2.0

Key Statistics - 2021:

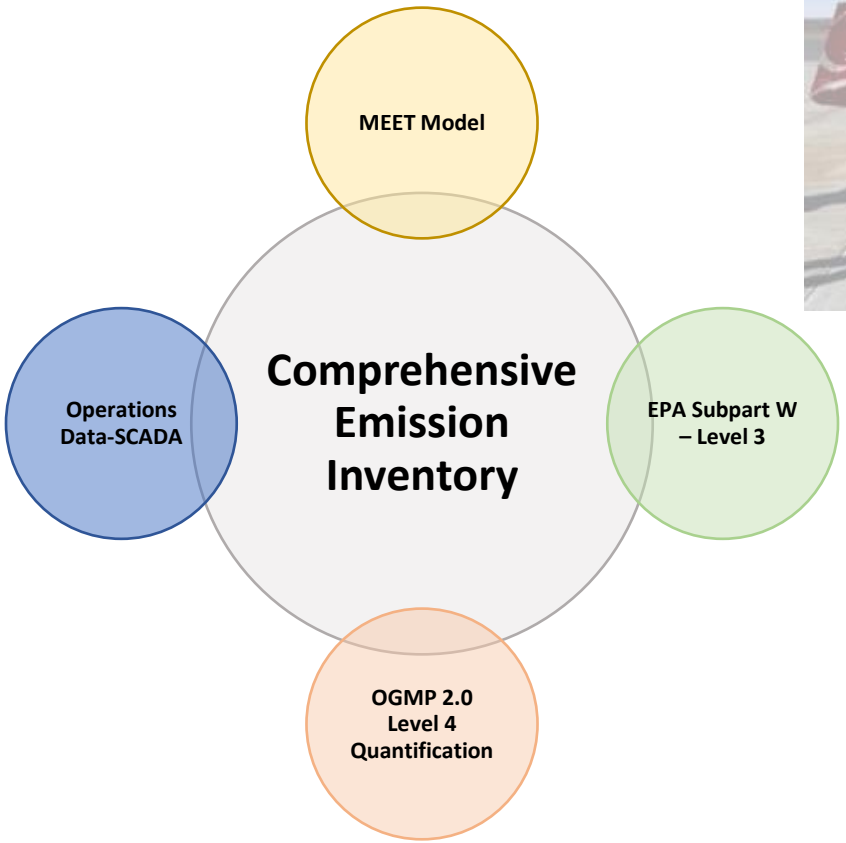
Average production: 447 MMcfe/d | Liquids contribution: 15% (vol), 26% (rev)

Multiscale Measurement Process

Layers to L4

Sub sampling

- Drone/methane sensor
- Build accurate distribution of site-level facility measurements



Basin-wide summary

- Mass flux
- Quantification of non-operated assets in mass flux
- Quantification of variable, non-production sources such as well workovers

Multiscale Measurement Process
Characterization of Facilities

Consistent, permitted Production Sources - *Sources consistently in basin mass flux; based on OGMP 2.0 U&R protocol:*

- **Wellheads**
- **Simple production facilities** – *2 or fewer tanks – implies lower production values*
- **Complex facilities** – *more than 2 tanks implies higher production values*
- **Complex facilities with wellsite compression**
- **Water management facilities**
- **Water and Oil hauling**
- **Manual liquid unloading events**

Variable, Intermittent Non-production Sources – *potentially not consistently in basin mass flux:*

- **Workovers**
- **Completions/Flowback**
- **Compressor blowdowns for maintenance**

Case Study – OGMP Levels 3, 4 and 5 Progression – Liquids Unloading

Level 3 Emission Estimate – Liquids Unloading

Option 1 - Count of wells with unloadings that vent, multiplied by an average emission factor per well, or
Option 2 - Count the number of unloading events (multiple events per well per year) multiplied by an average emission factor per event. (OGMP recommends using emission factors from a national study of liquid unloadings in the United States (Allen, et al., 2015))

Option 1

Average emissions per year for plunger lift/manual liquid unloadings at one well is 117,000 scf/well/year [1]

Jonah total - 3,315 m^3 per well per year

Option 2

Jonah average 4.3 events per well per year; the average emissions per event is 9,800 scf/event [1]

Jonah total – 1,194 m^3 per well per year

Unloading measurement system being installed by Allen, et al. team

[1] Allen, et al. Methane Emissions from Process Equipment at Natural Gas Production Sites in the United States: Liquid Unloadings, *Environmental Science & Technology*, 49 (1), 641–648, 2015.

Level 4 Estimate – Liquids Unloading

Count the number of unloading events at each site multiplied by a site-specific emission factor based on the following inputs:

- unloading event duration
- well tubing volume
- well depth
- well pressures and temperatures, and
- other site-specific parameters

Average Jonah well - 4.3 events per well per year

Average emission per event based on site specific inputs is 2,300 scf per event, or 9,890 scf/well/year

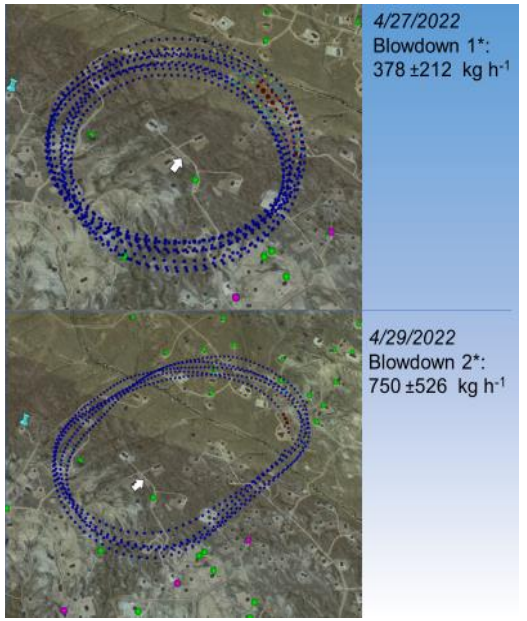
Average emissions per well per year are 4.3 events per well per year * 2,300 scf/event or 9,890 scf/well/year equal to

Jonah total – 280 m^3 per well per year
a factor of 4 lower than the estimate based on the Level 3 national emission factor

It is anticipated that the emission factor based on local data is more accurate, but this can be assessed with site level measurements (Level 5)

Level 5 Estimate – Liquids Unloading

When liquid unloadings occur, they dominate total emissions from the site; make site level measurements while unloading events are occurring

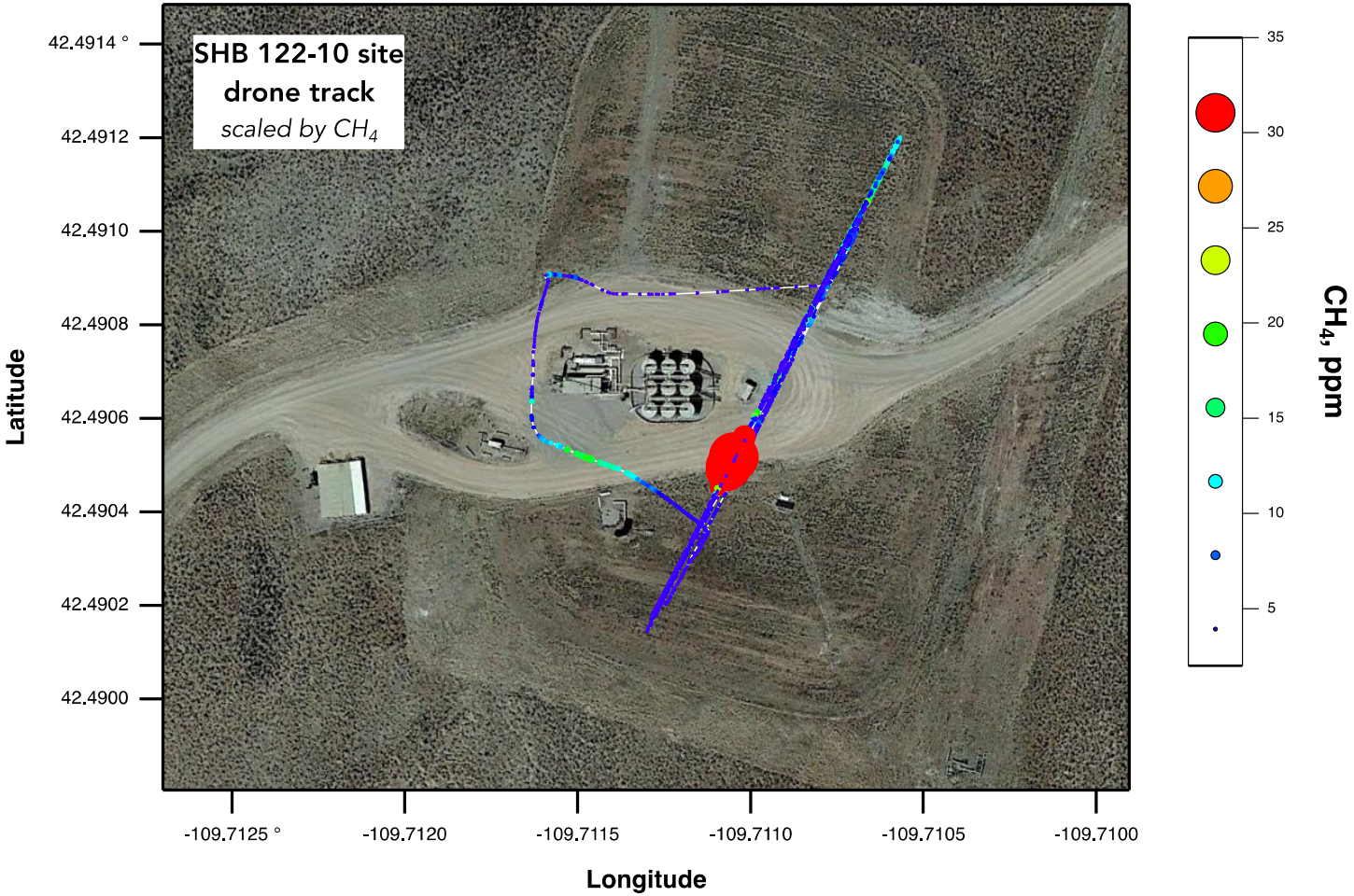


Airborne measurements (4/27/2022) *emission rate of 1,990±1,100 scf/event/well, or* **Jonah total – 242 m^3 per well per year, lower than Level 4 Jonah average**

Airborne measurements (4/29/2022) *emission rate of 3,940±2,770 scf/event/well, or* **Jonah total – 480 m^3 per well per year, higher than Level 4 Jonah average**

High uncertainty ranges in measured emission rates for events are likely due to variations in emission rates during the events

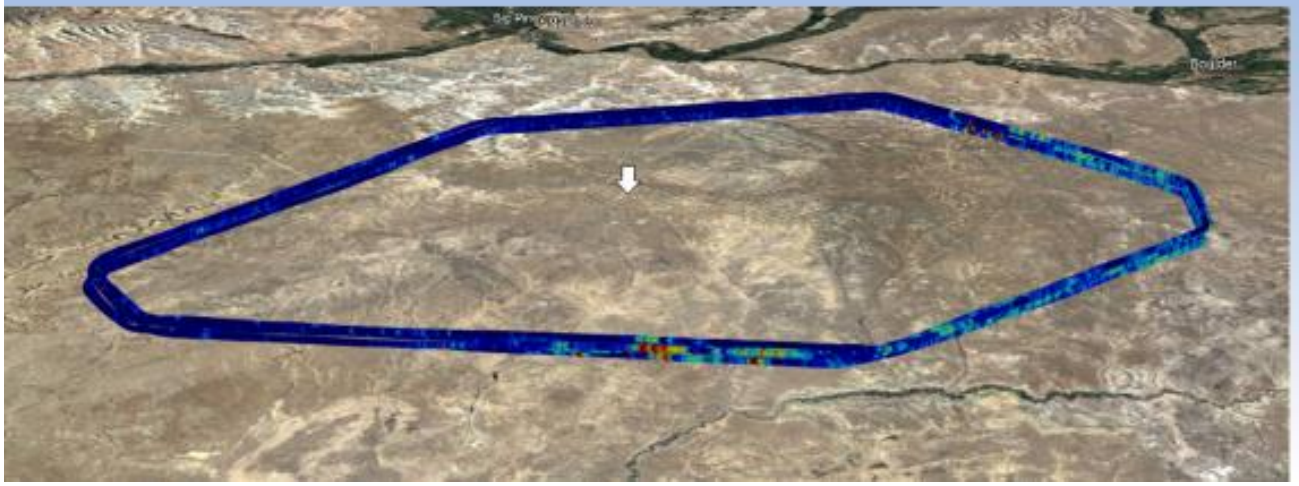
Site-level Reconciliation



Calculated CH_4 site emission rate: 2.8 ± 1.1 kg/hr

Basin-wide mass balance

4/26/2022
Total methane emissions:
1097 ±790 kg h^{-1}



4/29/2022
Total methane emissions:
833 ±137 kg h^{-1}

Thank You!

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