Catalytic Heaters as an Alternative to Methane Venting in CHOPS

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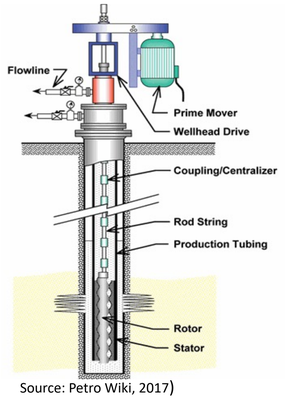
What is CHOPS?

- Cold Heavy Oil Production with Sand (CHOPS) is a means of extracting heavy oil
- No steam or polymers are used
- Oil is produced under a solution gas drive using a progressive cavity pump
- Sand is produced with the oil to improve inflow performance
- Gas (predominantly methane) is produced up the annulus



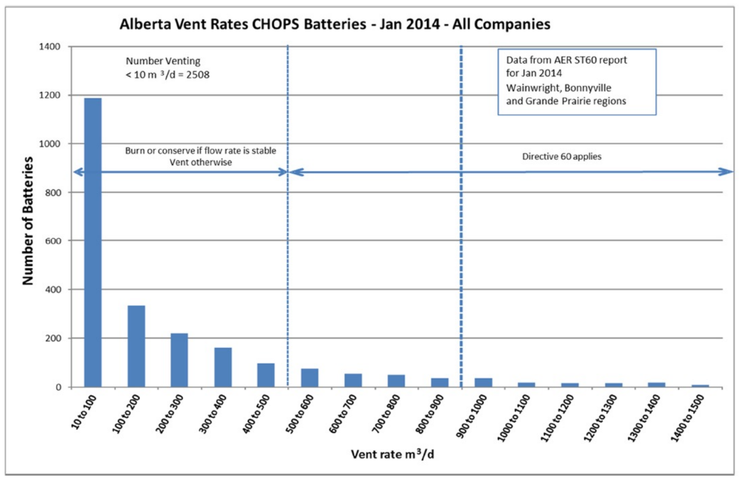
Source: Petro Wiki, 2017)

CHOPS' Contribution to Canada's Energy Sector

- CHOPS accounted for ~40,000 bbl/d of Husky's Production in 2018
- Accounts for ~40% of Saskatchewan's heavy oil production in Lloydminster Region
- Contribution to Alberta's production is lower but substantial in Wainwright and Bonnyville regions

Methane Emissions a Serious Issue

- Majority of CHOPS wells produce from 10-300 m^3/d (0.35- 10.6 mscf/d)
- Small volumes per well but the cumulative volume is significant
- Targeting methane emissions is viewed as a highly effective means of reducing the climate impact of the energy sector



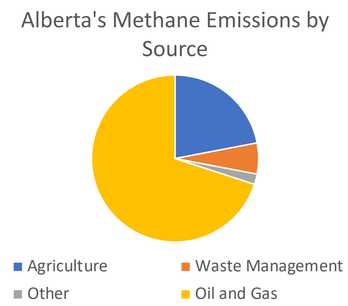
Source: Bruce Peachey, U of A, (2014)

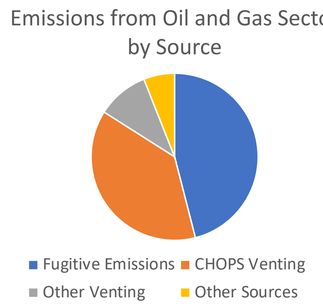
Challenges in Reducing Methane Venting

- Gas gathering and transportation to market is uneconomic in todays environment (500 m^3/d (17.6 mscf/d) of gas is worth only ~$45/d)
- Operation of flares/incinerators is challenging due to intermittent flow of produced gas (typically <300m^3/d (10.6 mscf/d))

CHOPS Contribution to GHG Emissions

- Methane has ~25x the warming potential of CO_2 over a 100 year time span
- Accounts for ~80% of vented volumes in Alberta (Data unavailable for SK)
- Venting from CHOPS accounts for ~27% of Alberta's Methane Emissions





Source: Emissions Reduction Alberta, 2020

Reducing Methane Emissions Critical to Energy Sector

- Methane emissions from upstream oil and gas is increasingly being targeted by governments, investors and the public
- Federal and Provincial governments targeting 40-45% reduction below 2012 levels by 2025 (Source: CERI, 2019)
- Technical solutions must be brought forward if CHOPS is to remain a viable method of heavy oil production

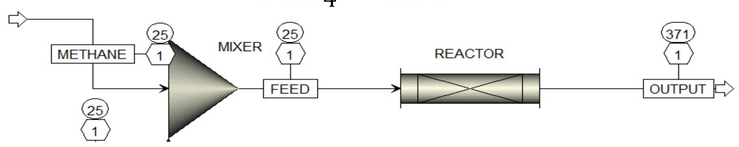
Our Solution – Catalytic Heaters

- Catalytic heaters essentially act as a flameless flare
- Methane is oxidized to less harmful CO_2 in the presence of atmospheric oxygen and a platinum catalyst
- Conversion of ~86% was achieved for ideal flow-rates
- Catalytic heaters can better handle low and variable gas flows compared to flares
- Platinum group catalyst selected due to improved resistance to degradation by contaminants such as excess water and sulphur
- Design can be applied to new and existing wells

Developed Model

- ASPEN Plus used to model conversion of methane and to size units
- Power-law kinetics used to model first order reaction
- Three cases conducted at 100, 200 and 300 m^3/d of methane with increasing catalyst pad thickness for higher gas rates resulting in 86% conversion

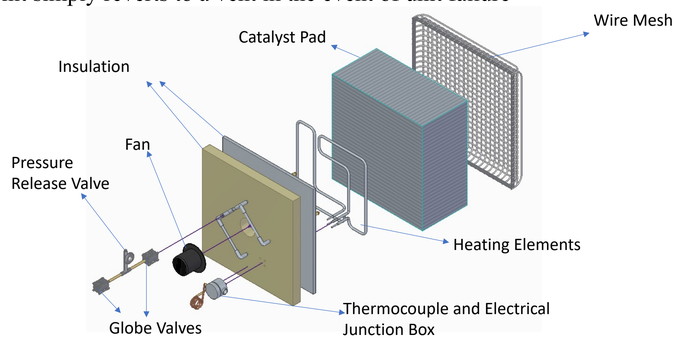
$$-RCH_4 = KTe^{\frac{Ea}{RT}}$$



Aspen Plus Model

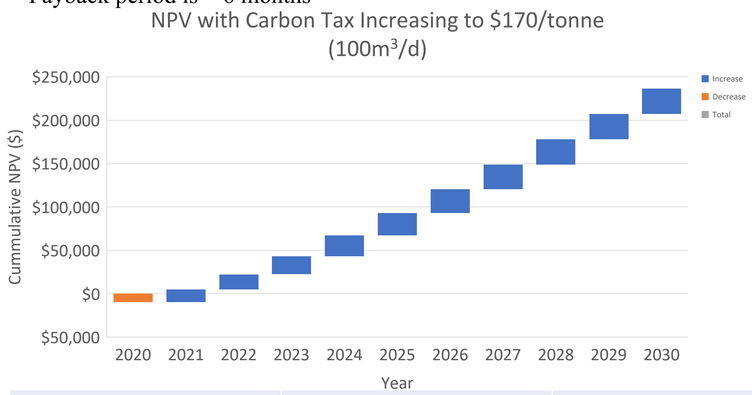
Safety is Inherent to the Design

- Safety is built into the design as the unit is chemically limited as to how much heat can be generated due to limited surface contact with catalyst
- Class 1, Div. 1 rated for use in explosive environments
- Unit simply reverts to a vent in the event of unit failure



Economic and Environment Analysis

- Capital cost of a unit fit to handle 100m^3/d is estimated at $10000
- NPV analysis assumes pad replacement every three years and a 10% rate of return
- Payback period is ~ 6 months



Vented Volume (m^3/d)	Vented Volume (scf/d)	GHG Reduction (t-CO2eq/year)
50	1765.5	229.1
100	3531	458.2
150	5296.5	687.2
200	7062	916.3
250	8827.5	1145.4
300	10593	1374.5

Conclusions

- At present, the majority of CHOPS production is not compatible with methane reduction targets
- Technical solutions are essential to ensure CHOPS remains viable
- Catalytic heaters could reduce the amount of CO_2eq by 75% for CHOPS assets
- Payback period for a single unit is ~ 6 months with a return on future tax savings of over 2500% over a 10 year period.