The Calculation of Methane and CO2 Emissions from Flare Systems

MAWG September 23

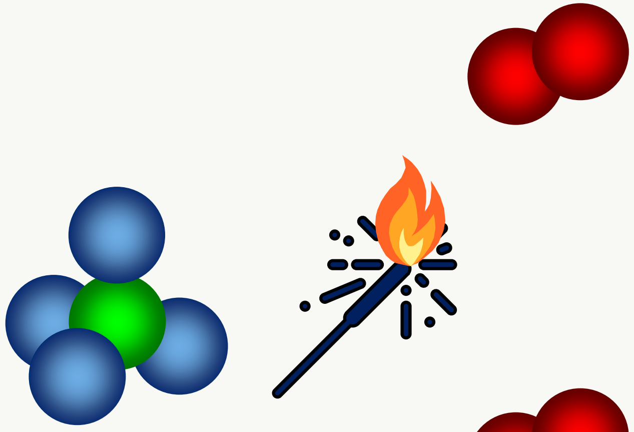
Amy Ross

A common misconception….

Flare combustion efficiency = 98%

Combustion

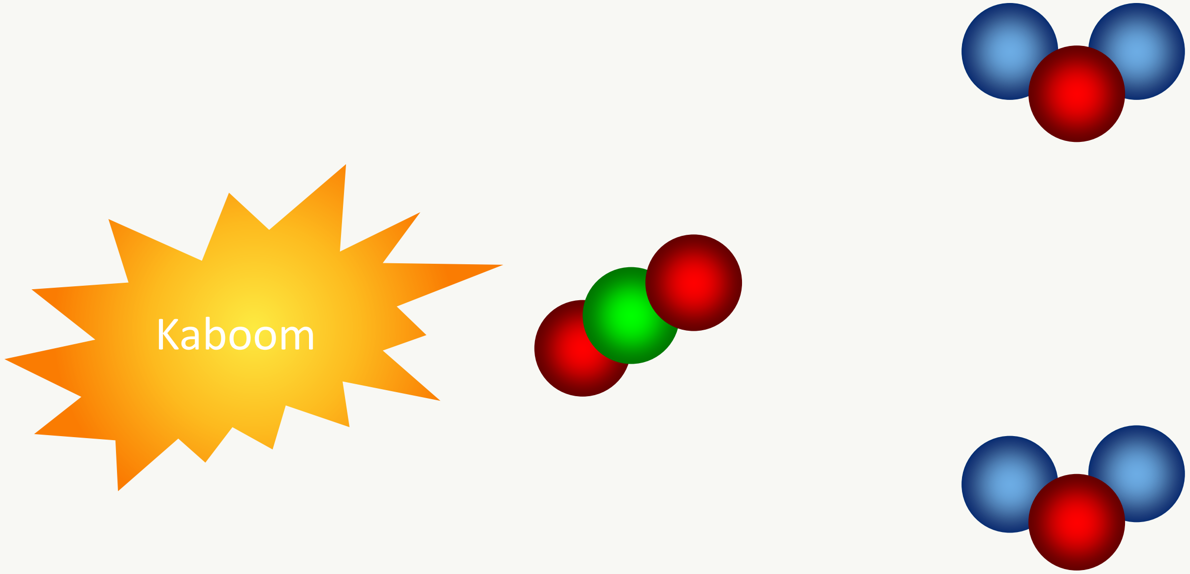
Back to school



Methane
CH_4

Oxygen
$2 \times O_2$

Combustion

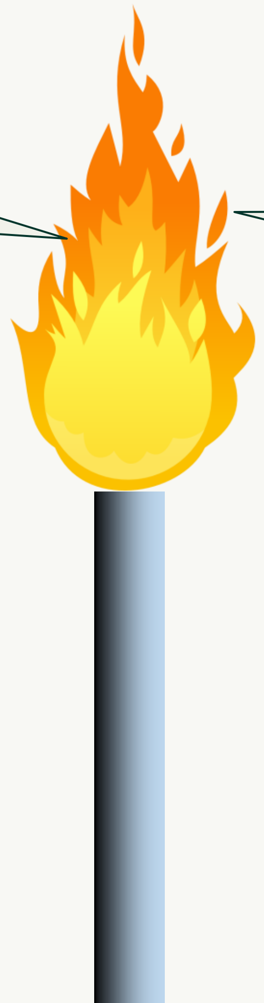


Carbon
Dioxide
CO_2

Water
2 x H_2O

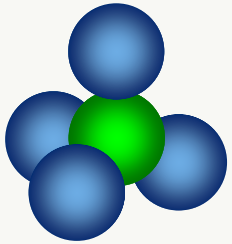
Assumed Flare Combustion Efficiency

Remaining 2% -unburnt hydrocarbons, principally methane



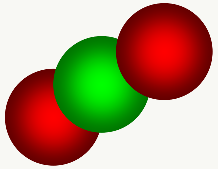
Combustion efficiency assumed to be 98% for current CO_2 emission calculations

Incomplete Combustion



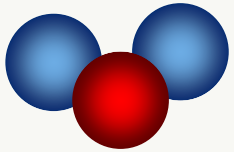
2

CH4



98

CO2



196

H2O

Methane

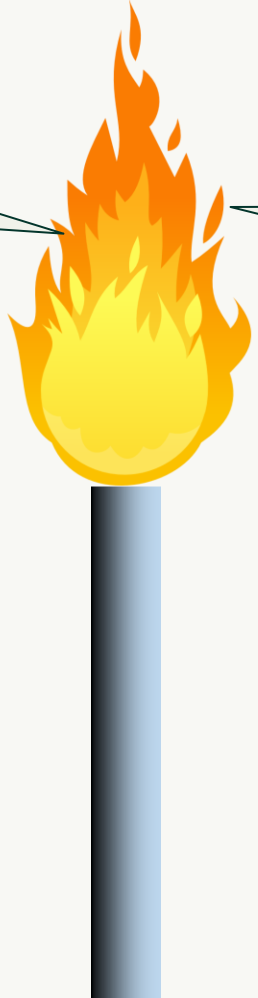
- Methane's Global Warming Potential is:
  - 84 times more potent than CO_2 per kg over a 20 year period
  - 28 times more potent than CO_2 per kg over a 100 year period

- The fossil fuel industry is responsible for one-third of anthropogenic methane emissions.

Assumed Flare Combustion Efficiency

Remaining 2% -unburnt hydrocarbons, principally methane

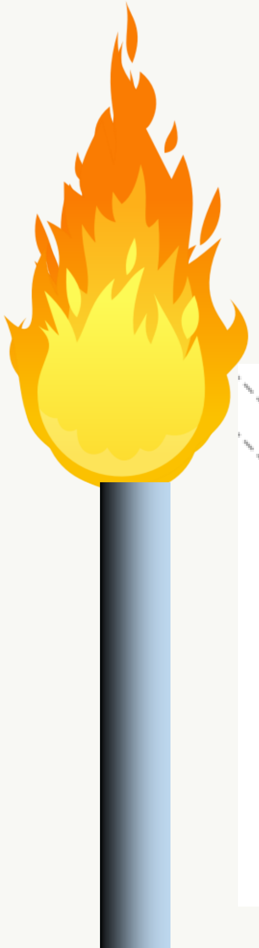
Combustion efficiency assumed to be 98% for current CO_2 emission calculations

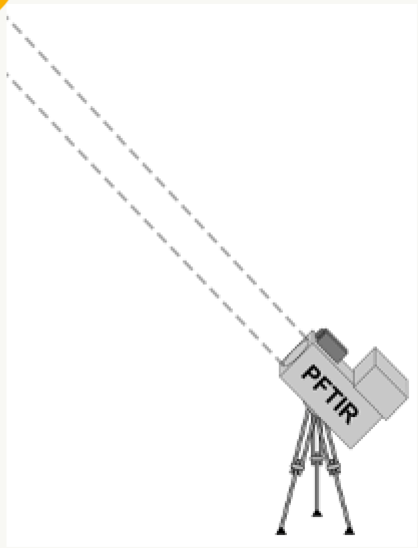


Drive to increase flare combustion efficiency
How is it measured?

Increasing focus on methane emissions
Tonnes CO_2e = 28 to 84

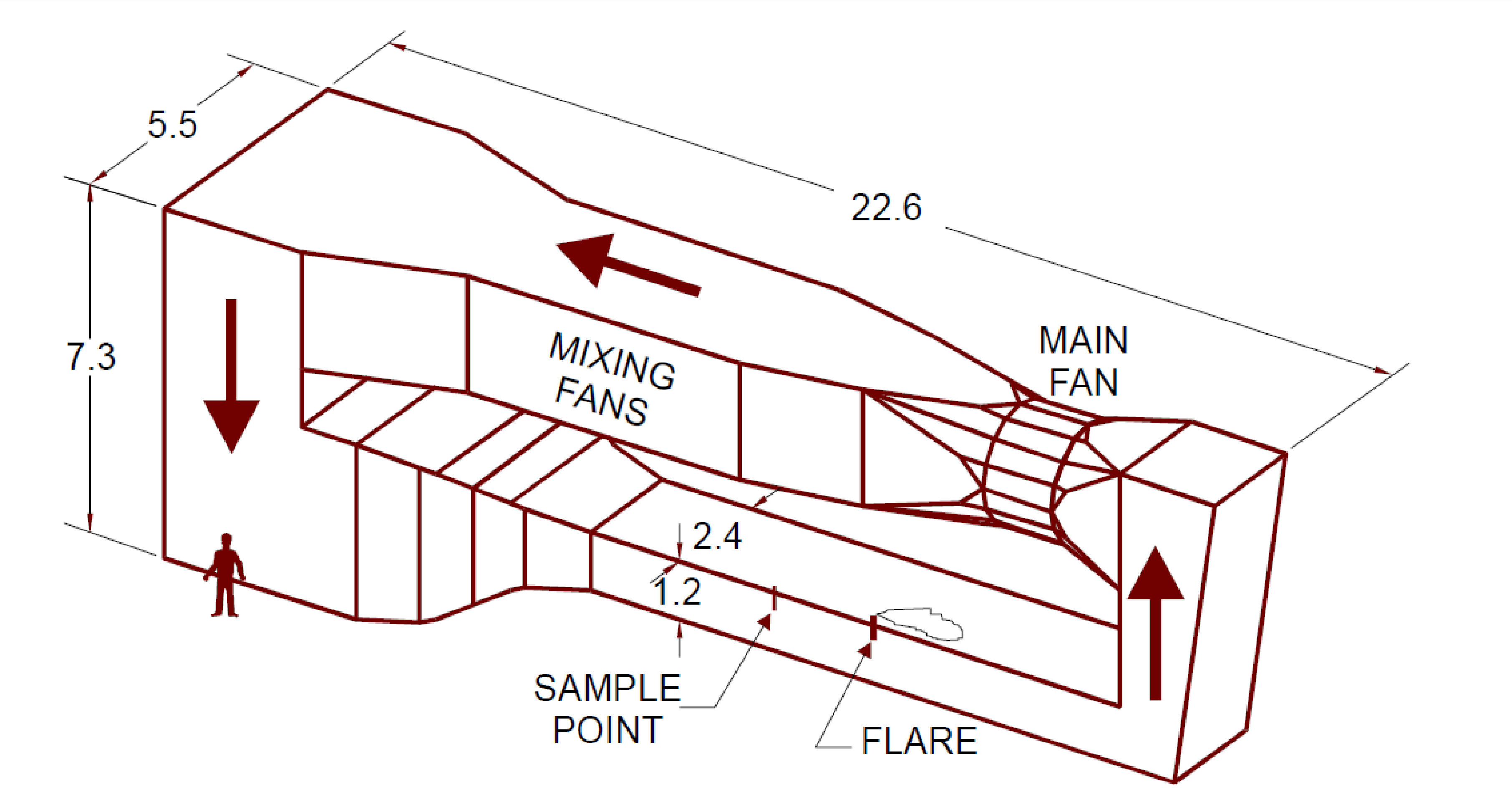
Measurement Options





Research

Research

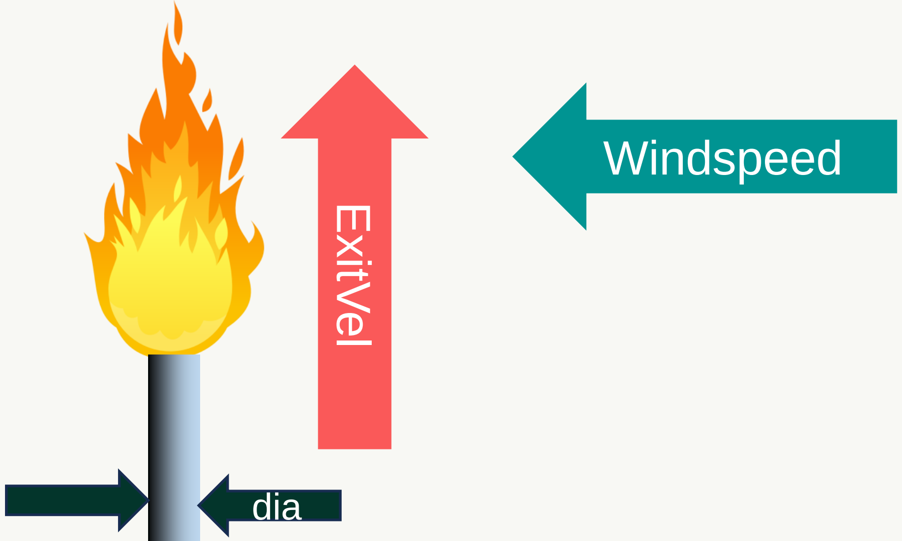


Research

Flare Combustion Efficiency Equation

Using semi-empirical algorithms obtained from the University of Alberta (studies over 20 years)

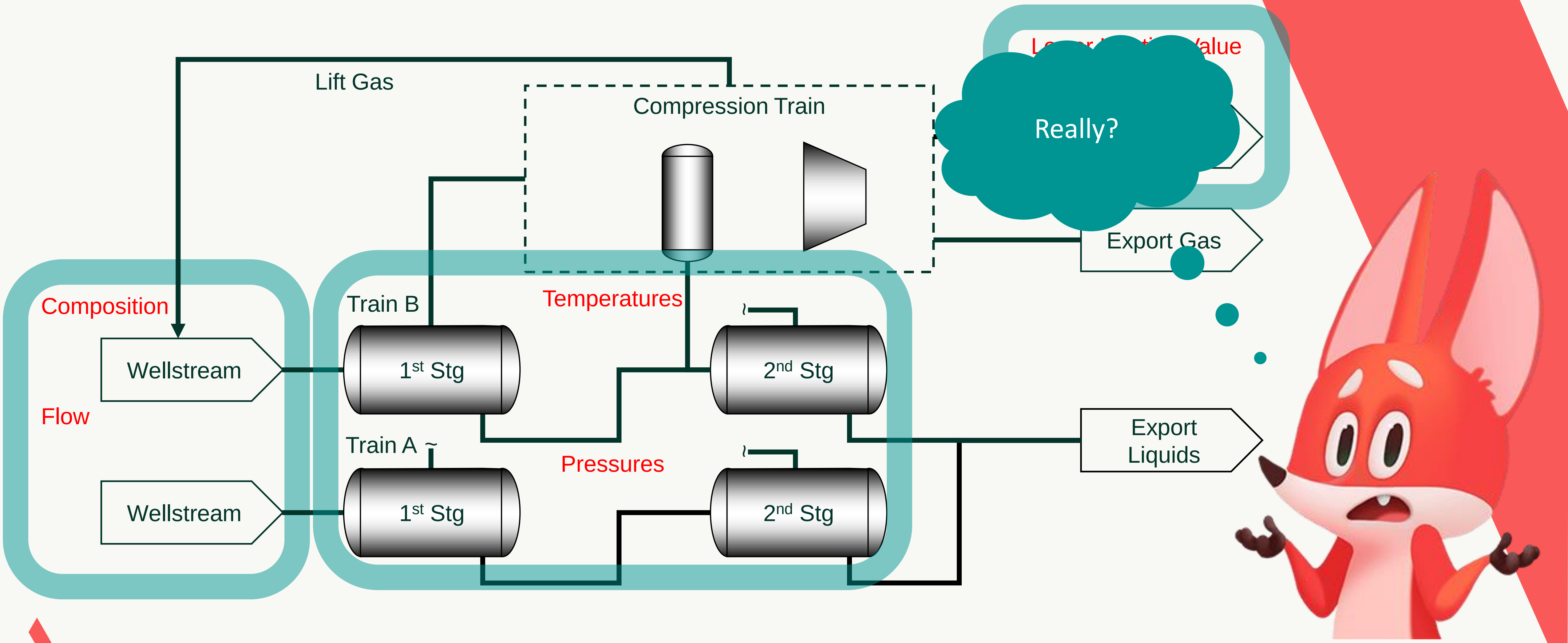
$$Eff = 1 - 0.001066\left(\frac{LHV_{CH4}}{LHV_f}\right)^3 e^{\left(\frac{0.317\,Windspeed}{(ExitVel\ g\ dia)^{1/3}}\right)}$$



Lower Heating Value

$$Eff = 1 - 0.001066\left(\frac{LHV_{CH4}}{LHV_f}\right)^3 e^{\left(\frac{0.317\,Windspeed}{(ExitVel\ g\ dia)^{1/3}}\right)}$$

Process Simulation Model



Process Simulation Model

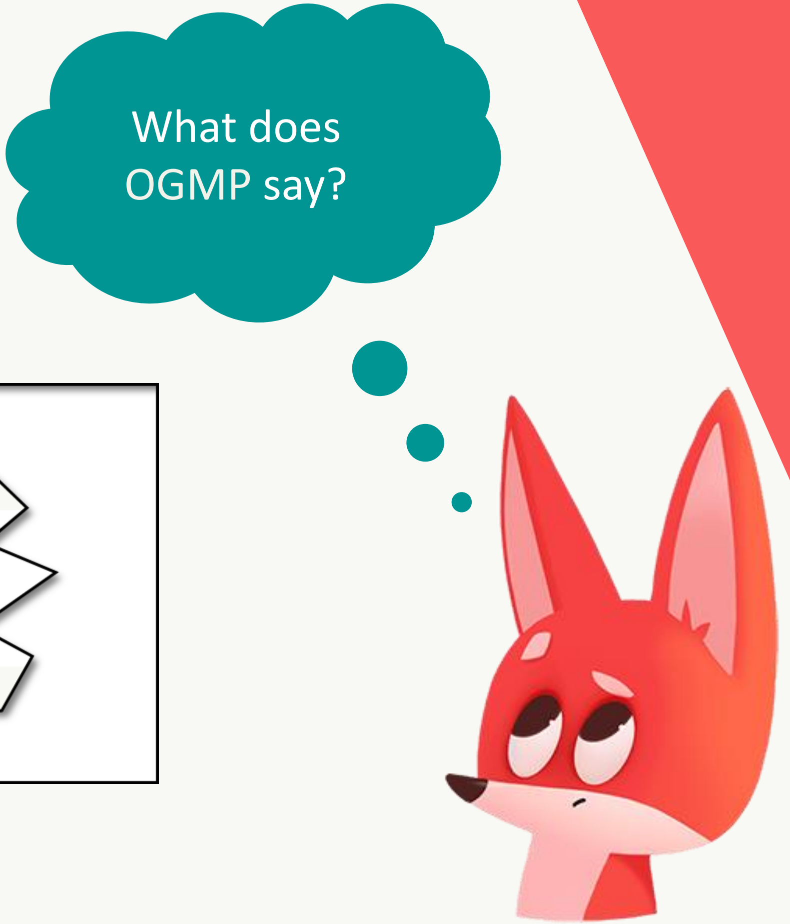
UN environment programme

TGD – Flare Efficiency

Approved by the Steering Group 24 June 2021

OGMP Technical Guidance Document - Flare Efficiency

Gas composition	Directly sampled or indirectly determined using a mass balance/ process simulation.



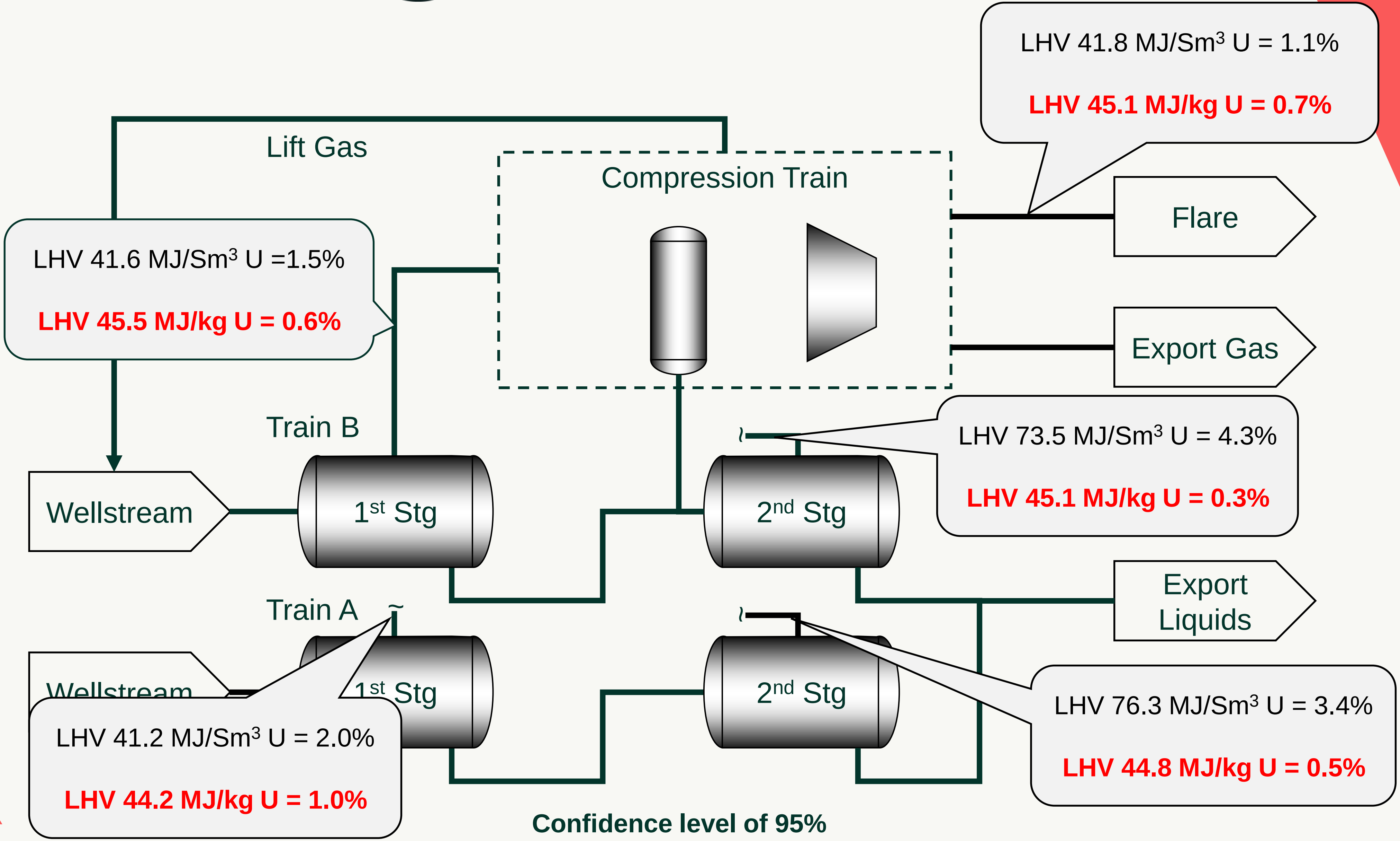
The Oil & Gas Methane Partnership 2.0

The oil & gas methane partnership 2.0 (OGMP 2.0) is the flagship oil & gas reporting and mitigation programme of the United Nations Environment Programme (UNEP).

OGMP 2.0 directly engages oil & gas companies that have the agency to act on the problem of methane emissions. It supports them to better understand their emission profiles and, most importantly, to use this knowledge to mitigate these emissions in a cost-effective way, focussing on the most material sources.

https://ogmpartnership.com

CHARM



Confidence level of 95%

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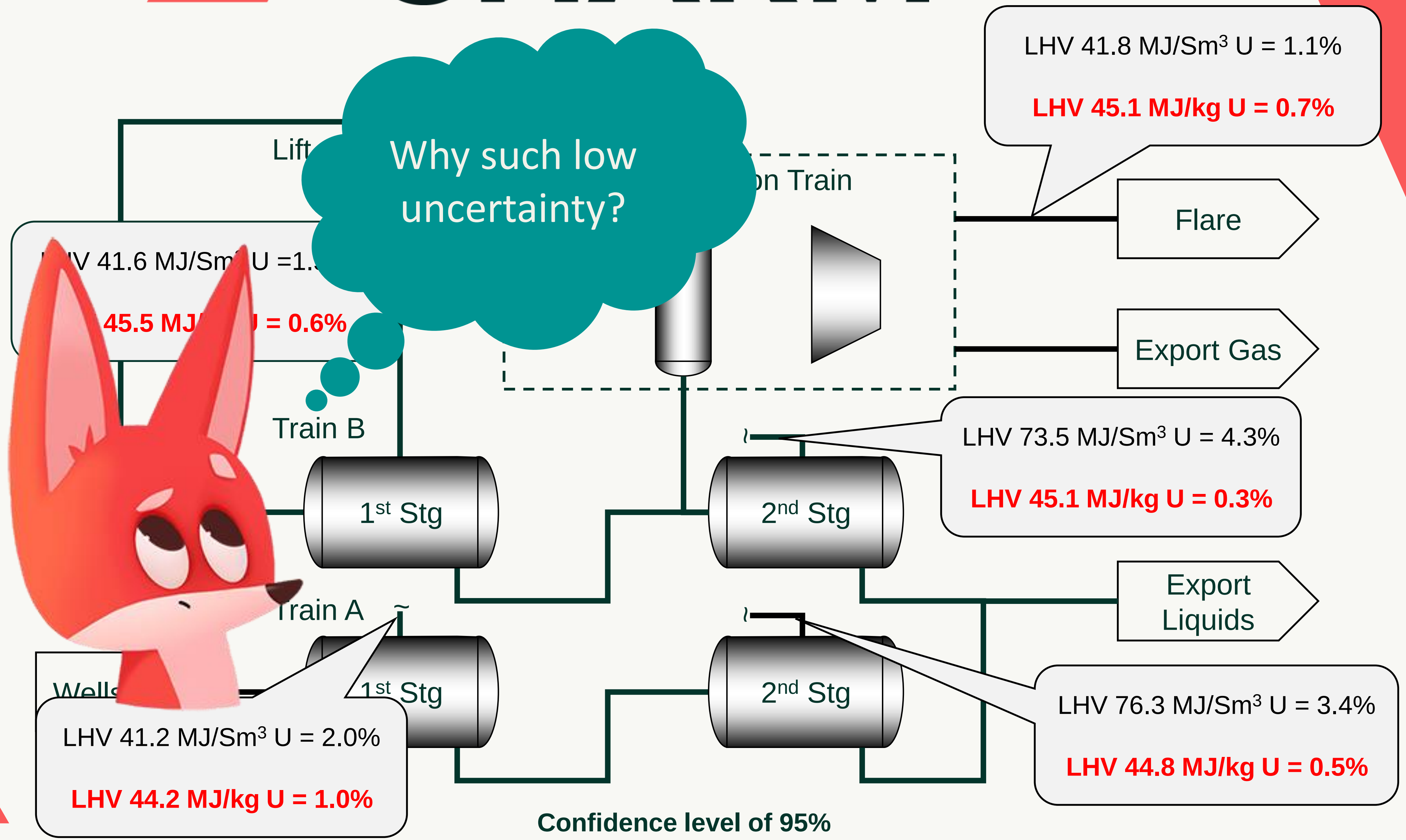
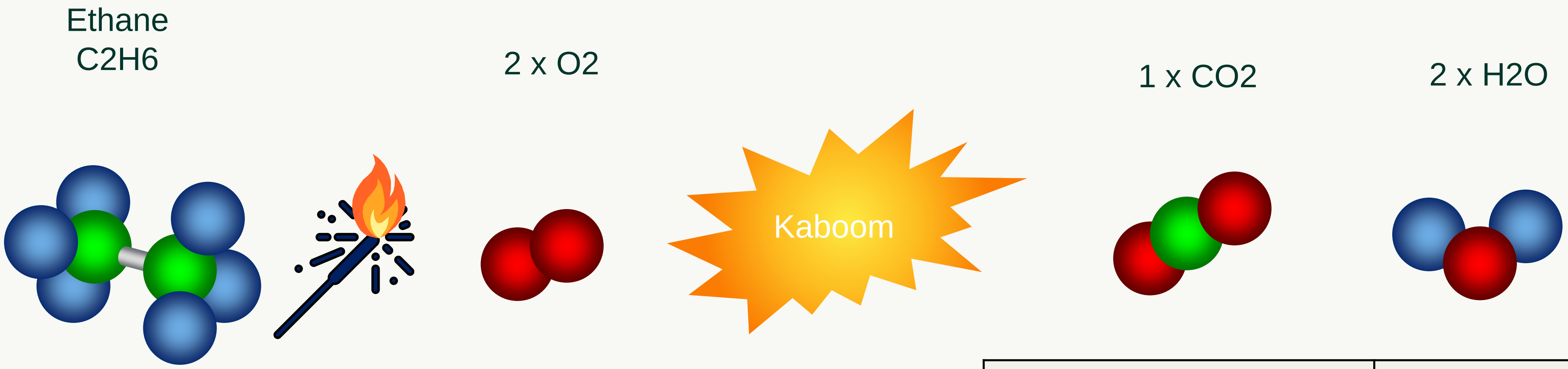


Confidence level of 95%

Lower Heating Value

Energy Released (MJ)	802.6
Moles (kmol)	1
Volume (Sm^3)	23.6
Mass (kg)	16.04
LHV (MJ/Sm^3)	34.0
LHV (MJ/kg)	50.0

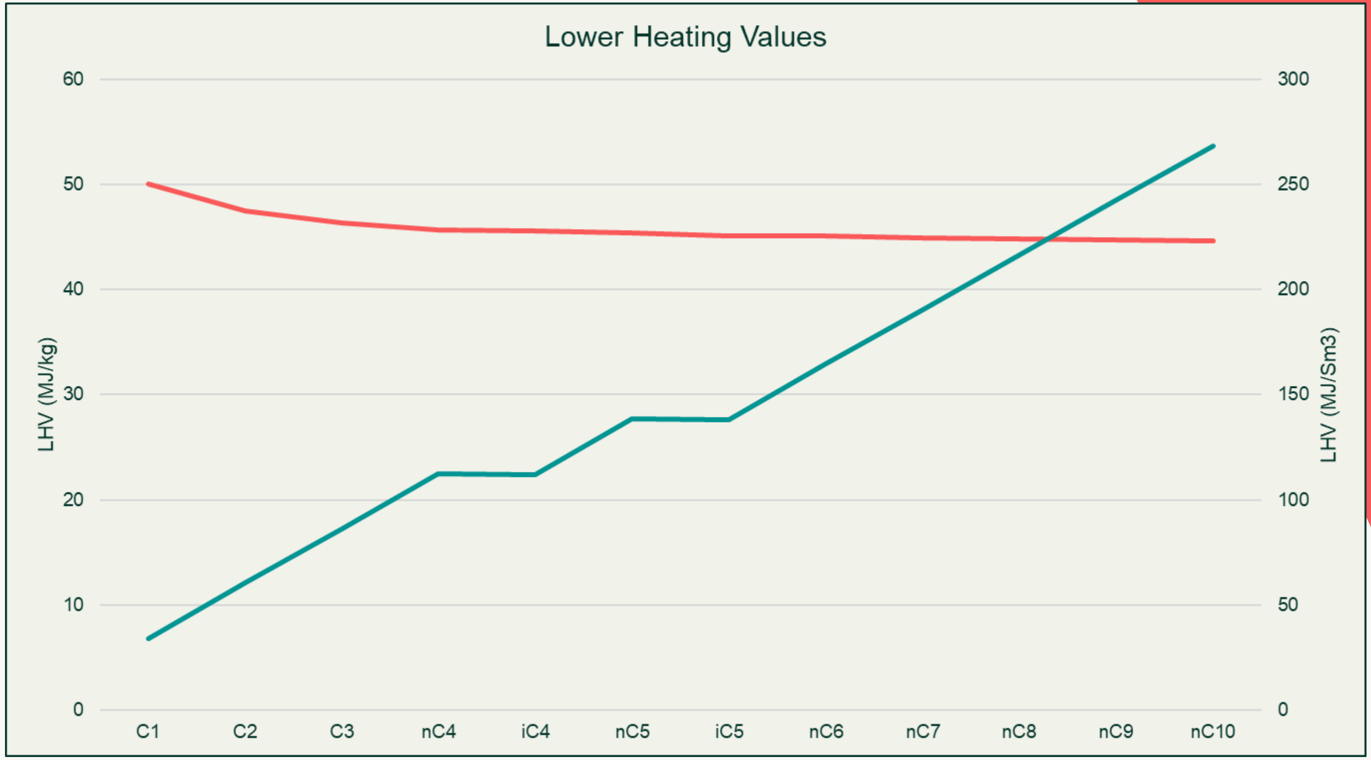
Lower Heating Value



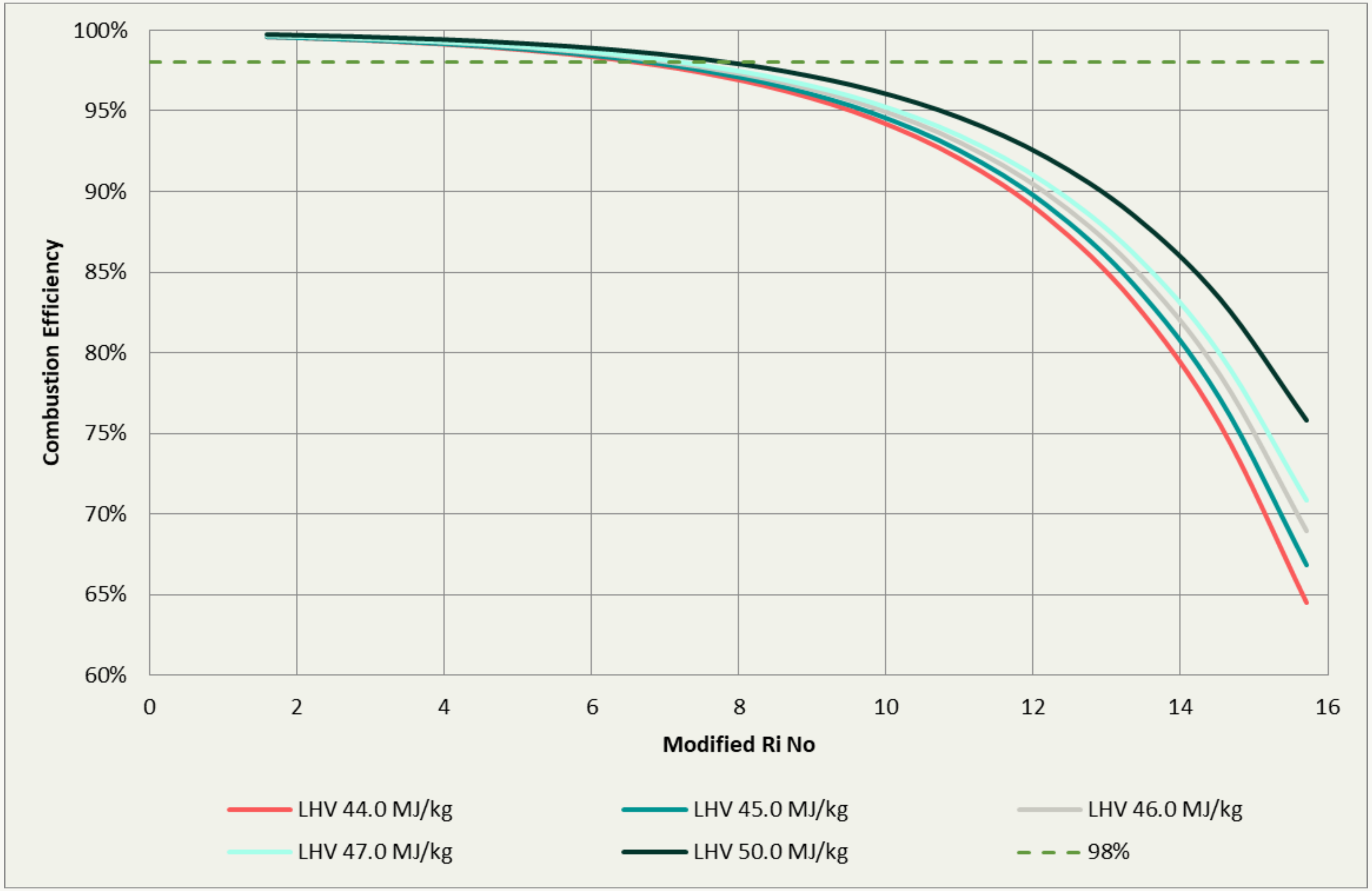
Energy Released (MJ)	**1428.8**
Moles (kmol)	**1**
Volume (Sm^3)	**23.4**
Mass (kg)	**30.07**
LHV (MJ/Sm^3)	**60.4**
LHV (MJ/kg)	**47.5**

Lower Heating Value

	LHV (MJ/Sm^3)	LHV (MJ/kg)
C1	33.9	50.0
C2	60.4	47.5
C3	86.4	46.3
nC4	112.4	45.7
iC4	112.0	45.6
nC5	138.4	45.4
iC5	138.1	45.1
nC6	164.4	45.1
nC7	190.4	44.9
nC8	216.4	44.8
nC9	242.4	44.7
nC10	268.4	44.6



Combustion Efficiency



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Now What?

Once you know how to calculate your combustion efficiency you can start to think about how to operate your facilities to minimise the tonnes of CO_2e.

Anything Else?

National Greenhouse and Energy Reporting Act 2007

GHG Accounting Method	Description
Method 1	Default methodologies utilising an average emissions factor, with an assumed fuel consumption and carbon content.
Method 2	Site specific emissions factor for gaseous fuels, developed by manual or online sampling and compositional analysis. Sampling and analysis is required to meet nominated requirements and standards.
Method 3	As above, solely utilising online analysers and prescribed standards for gas sampling.
Method 4	Continuous or periodic emissions monitoring at the stack/point of release to the atmosphere.

Method 1

3.86 Method 1—gas flared from natural gas production

(1) Method 1 is:

$$E_{ij} = Q_i \times EF_{ij}$$

where:

E_{ij} is the emissions of gas type (*j*) measured in CO_2-e tonnes that result from a fuel type (*i*) flared in the natural gas production during the year.

Q_i is the quantity of fuel type (*i*) measured in tonnes of gas flared during the year.

Note: This quantity includes all of the fuel type, not just hydrocarbons within the fuel type.

EF_{ij} is the emission factor for gas type (*j*) measured in CO_2-e tonnes of emissions per tonne of gas flared in the natural gas production during the year as determined under subsection (2).

(2) For ***EF_{ij}*** mentioned in subsection (1), columns 3, 4 and 5 of an item in the following table specify the emission factor for fuel type (*i*) specified in column 2 of that item.

Item	fuel type (i)	Emission factor of gas type (j) (tonnes CO_2-e/tonnes fuel flared)		
		CO_2	CH_4	N_2O
1	Gas	2.7	0.133	0.026
2	Crude oil and liquids	3.20	0.009	0.06

Method 2

3.87 Method 2—gas flared from natural gas production

Method 2 is:

$$E_{ico_2} = Q_h \times EF_{hi} \times OF_i + QCO_2$$

3.87A Method 2A—natural gas production (flared methane or nitrous oxide emissions)

Method 2A is:

$$E_{ij} = Q_h \times EF_{hij} \times OF_i$$

Summary

1
- University of Alberta equation provides a physical model

2
- Use process simulation model for LHV

3
- Reduce tonnes of CO2e

4
- Potential to improve NGER reporting….

5
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