Accord Combustor

NSTA Emissions Reduction Technology Showcase

18th February 2025

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Content

What is Combustor:

Combustor is based upon a publicly available, peer-reviewed study published by the University of Alberta (UoA) in 2004.

The UoA study provides a robust and repeatable methodology which has passed through rigorous academic scrutiny and is further supported by additional materials published in 2022.

The UoA study was conducted within a closed-loop wind tunnel; a fully controlled and enclosed test environment which allowed the capturing of all combustion products for analysis.

The UoA methodology is referenced within the Oil and Gas Methane Partnership (OGMP) 2.0 documentation and within the Offshore Energies UK Methane Action Plan (OEUK MAP).

Combustor has been developed to calculate Combustion Efficiency, Carbon Dioxide (CO2), Methane and Carbon Dioxide equivalent (CO2e) emission rates and cumulative totals. Functionality to support the optimisation of emission rates and uncertainty estimates for CE have also been developed.

- https://web.archive.org/web/20221222034340id
- https://www.sciencedirect.com/science/article/pii/S1743967122001210
- https://auprf.ptac.org/wp-content/uploads/2015/11/Final-Report-040826.pdf

Project Overview

The Combustor development was undertaken as a ‘Spark’ project approved and managed by the Net Zero Technology Centre (NZTC) in Aberdeen and ran for a fixed 12-month period.

The goals of the project were to complete a series of Combustion Efficiency (CE) desktop modelling exercises and conduct a live field trial of the application – applying lessons learned, adding functionality and reporting capabilities along the way.

The project was supported by bp, Harbour Energy, Serica, Ithaca and TotalEnergies who all played a very large part in the successful completion of the project.

Desktop models of CE were completed for the bp Glen Lyon, Harbour Energy Britannia, Serica Bruce and Ithaca Captain operating facilities.

A live version of Combustor has been running on the TotalEnergies Culzean asset since mid-October.

The UoA Algorithm

Literature value for Lower Heating Value (LHV) of Methane in Mass terms

Windspeed at the flare tip

$$\textbf{Combustion } \boldsymbol{Efficiency} = \mathbf{1 - 0.001066}\boldsymbol{e}^{\left(\frac{0.317*Windspeed}{(ExitVel*g*Dia)^{0.33}}\right)\left(\frac{LHV_{CH4}}{LHV_{Flare}}\right)^{3}}$$

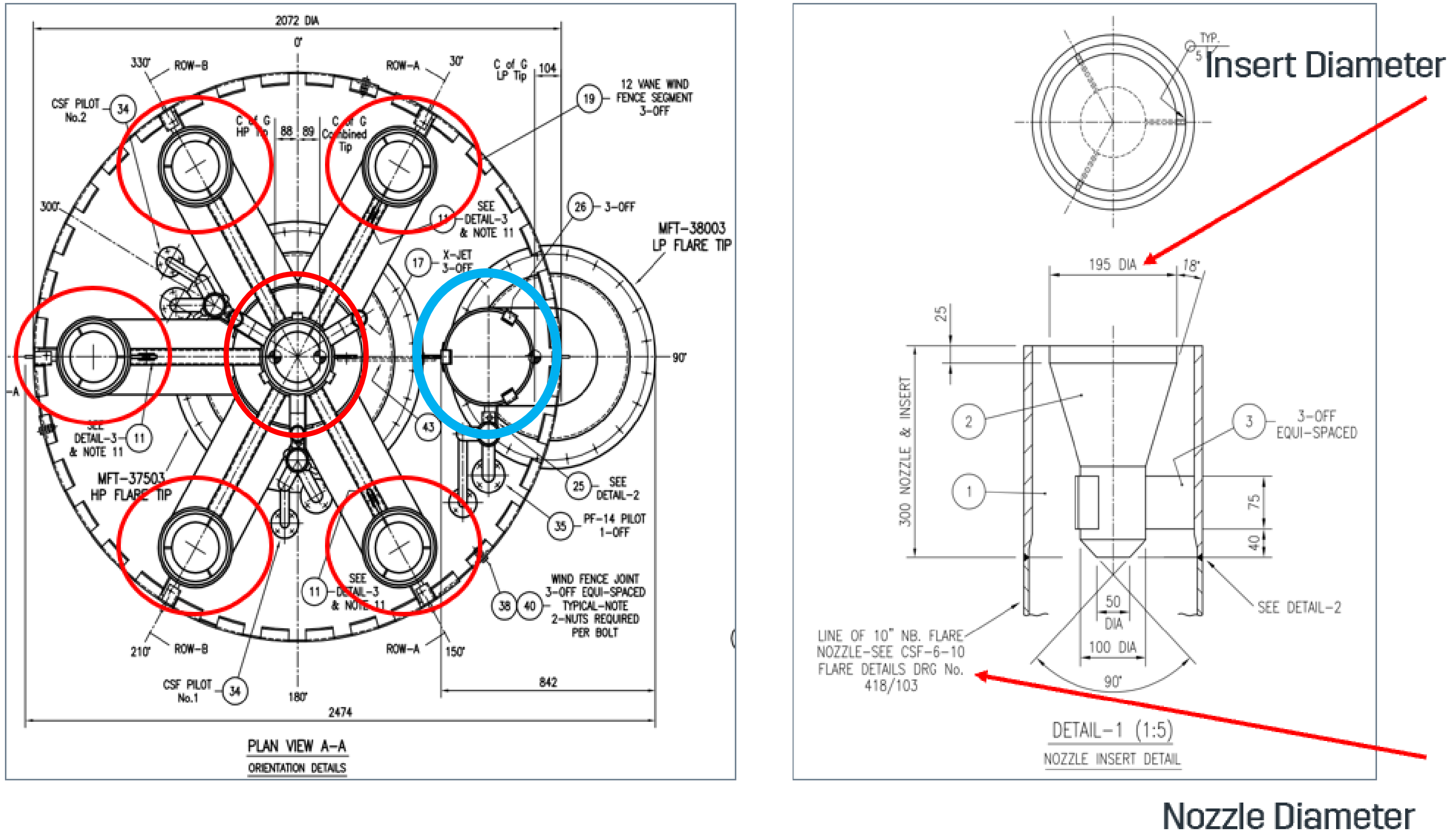
Exit velocity of flare gas *<u>at the flare tip</u>*

Characteristic diameter of the flare

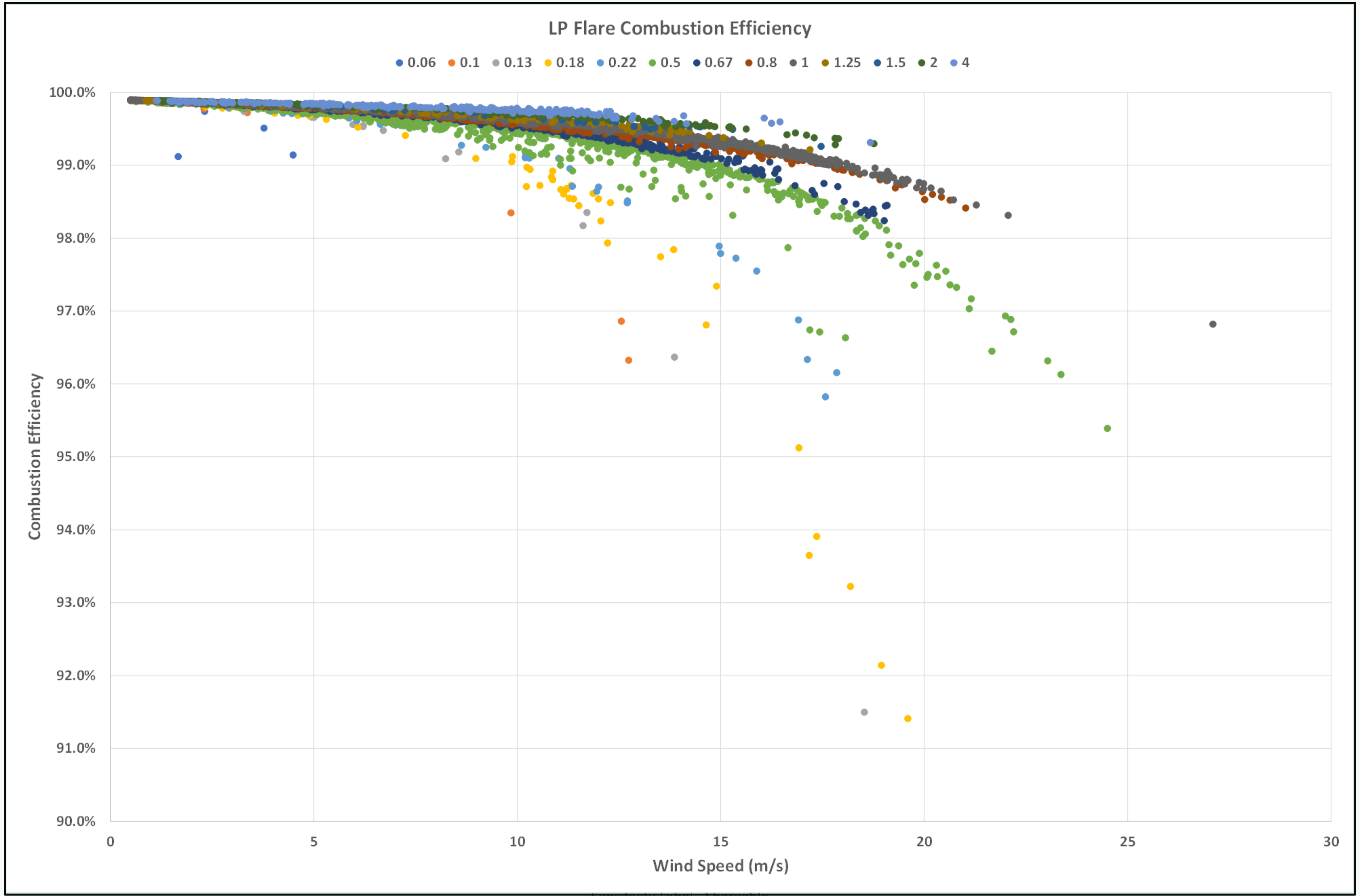
Lower Heating Value (LHV) of the flare gas *<u>immediately prior to combustion</u>* in Mass terms

bp Glen Lyon

HP and LP Flare GA

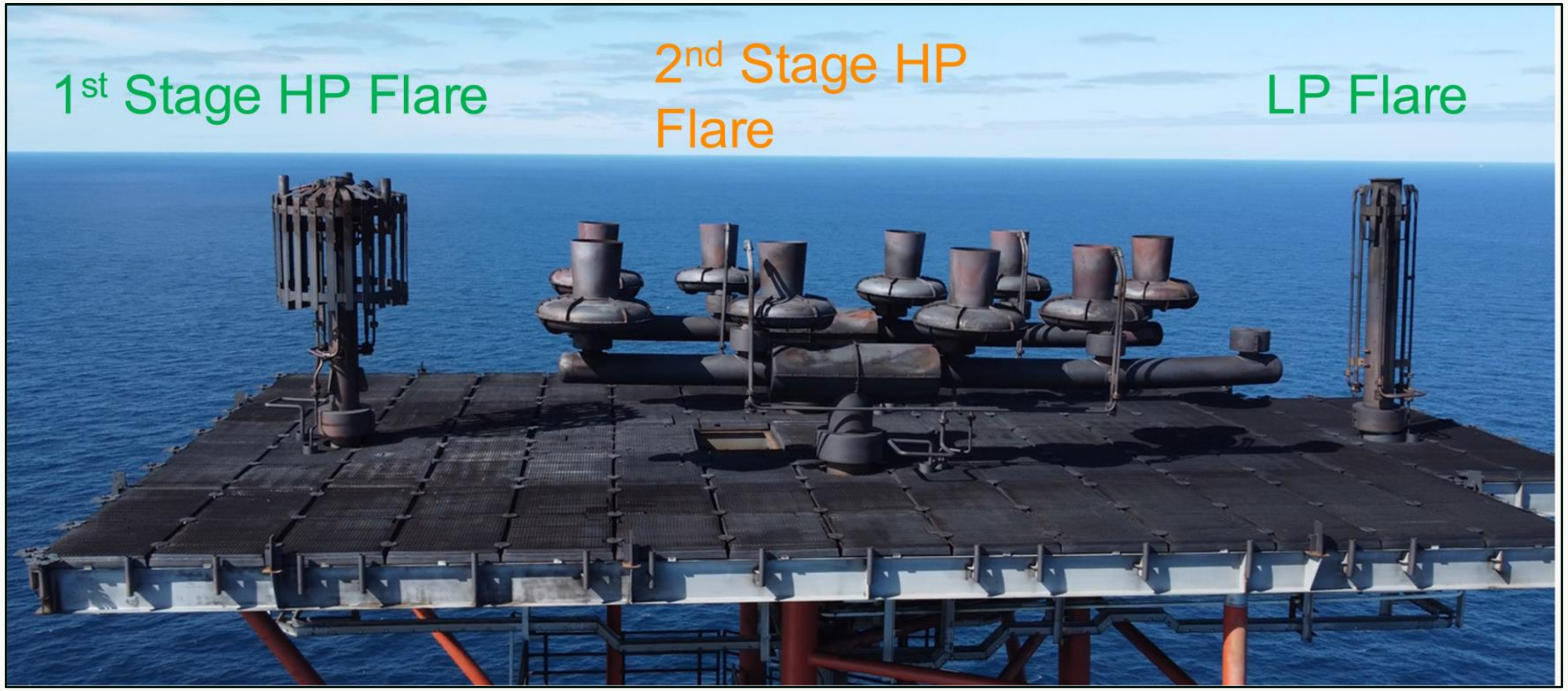


bp Glen Lyon



LP Flare Combustion Efficiency
0.06
0.1
0.13
0.18
0.22
0.5
0.67
0.8
1
1.25
1.5
2
4
Combustion Efficiency
100.0%
99.0%
98.0%
97.0%
96.0%
95.0%
94.0%
93.0%
92.0%
91.0%
90.0%
0
5
10
15
20
25
30
Wind Speed (m/s)

Serica Bruce



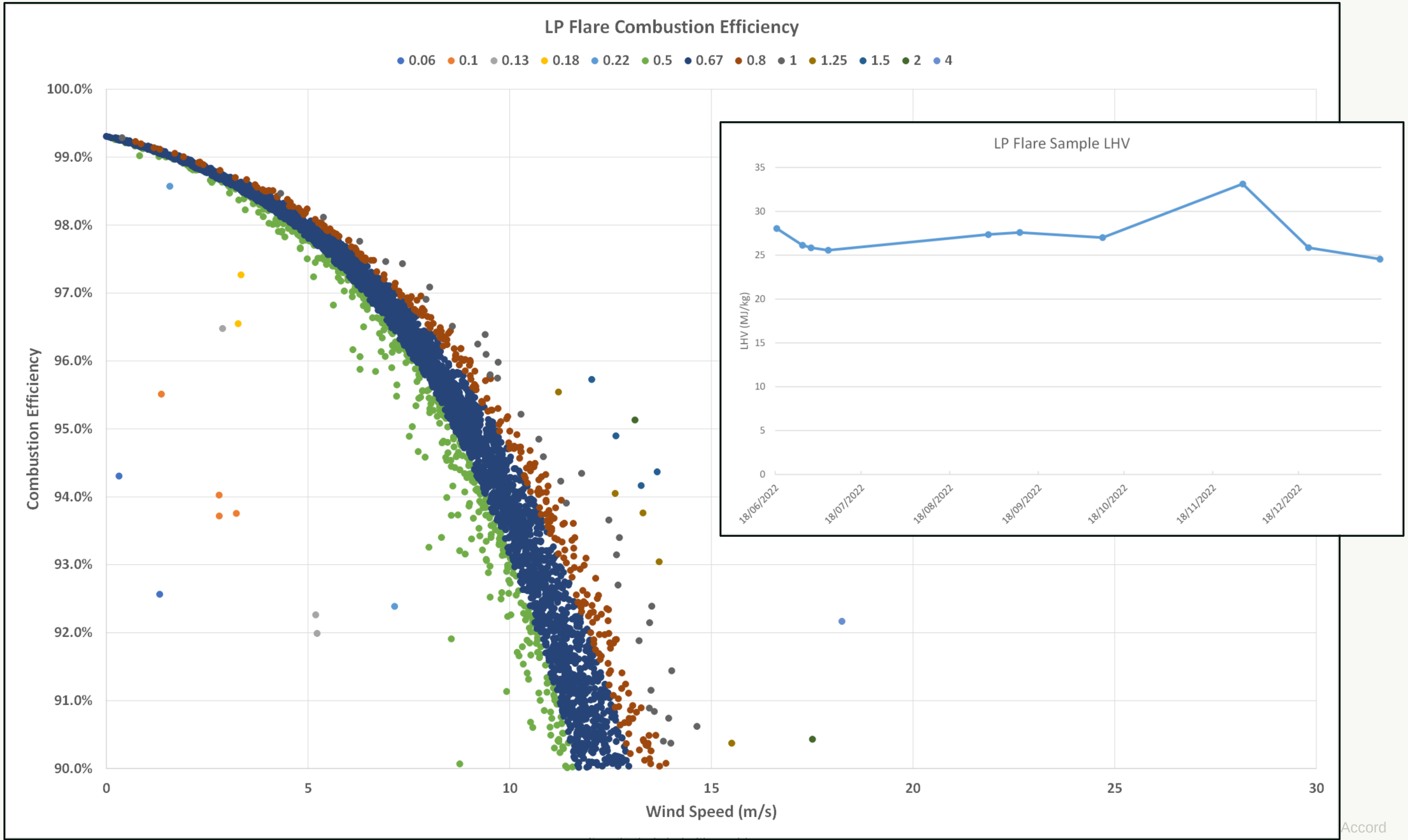
HP Flare
- Single meter measuring total stream to 1st & 2nd stage flare

1st Stage HP Flare
- Routine operations

2nd Stage HP Flare
- Start-up / Shutdown / Safety usage
- Coanda array 9 x 'Tulip' Flare tips
- HP Flare > 1000 m^3/h excluded from analysis

LP flare
- Routine operations

Serica Bruce LP Flare



Optimisation

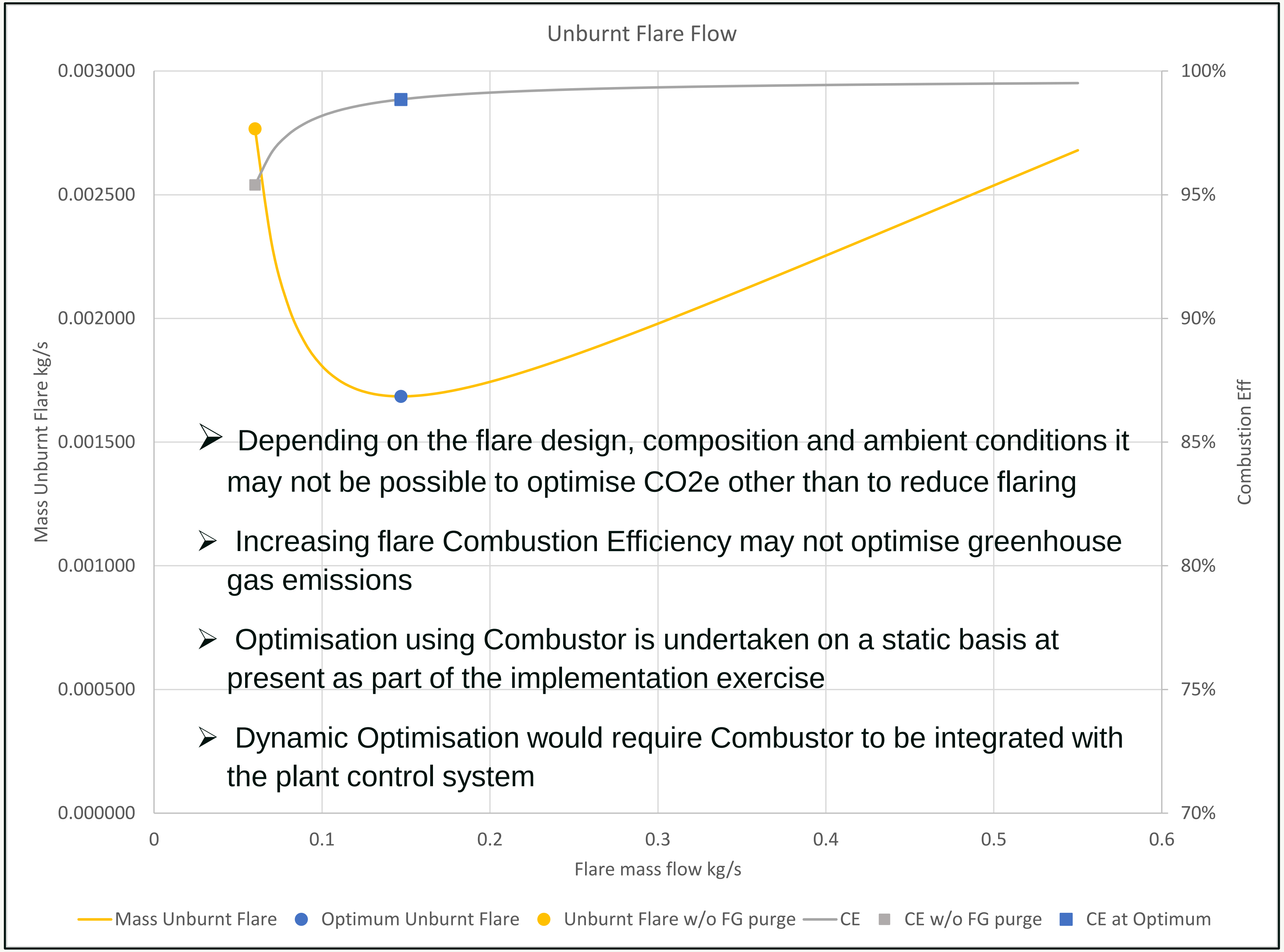
What should be optimised?

- Combustion Efficiency?
- Unburned Hydrocarbons?
- CO2e mass?
- CO2e $?

Some examples of Serica Bruce LP Flare optimisation

Example conditions	
Flare rate	170 Sm3/h (190 kg/h)
N2 purge	No
Fuel Gas LHV	42 MJ/kg
Wind Speed	10 m/s (22.4 mph)
CE	95.4%
Unburnt flare rate	10.0 kg/h (0.24 tonne/day)

Optimum unburnt flare conditions	
Fuel gas purge	385 Sm3/h (313 kg/h)
CE	98.8%
Unburnt flare rate	6.1 kg/h (0.15 tonne/day)
Absolute reduction	3.9 kg/h (0.09 tonne/day)
% reduction	39 %



- ➢ Depending on the flare design, composition and ambient conditions it may not be possible to optimise CO2e other than to reduce flaring
- ➢ Increasing flare Combustion Efficiency may not optimise greenhouse gas emissions
- ➢ Optimisation using Combustor is undertaken on a static basis at present as part of the implementation exercise
- ➢ Dynamic Optimisation would require Combustor to be integrated with the plant control system

Uncertainty

Calculated in two recognised ways:

- Analytically using the GUM, propagation of uncertainties using Taylor Series Method
- Monte Carlo, cross check

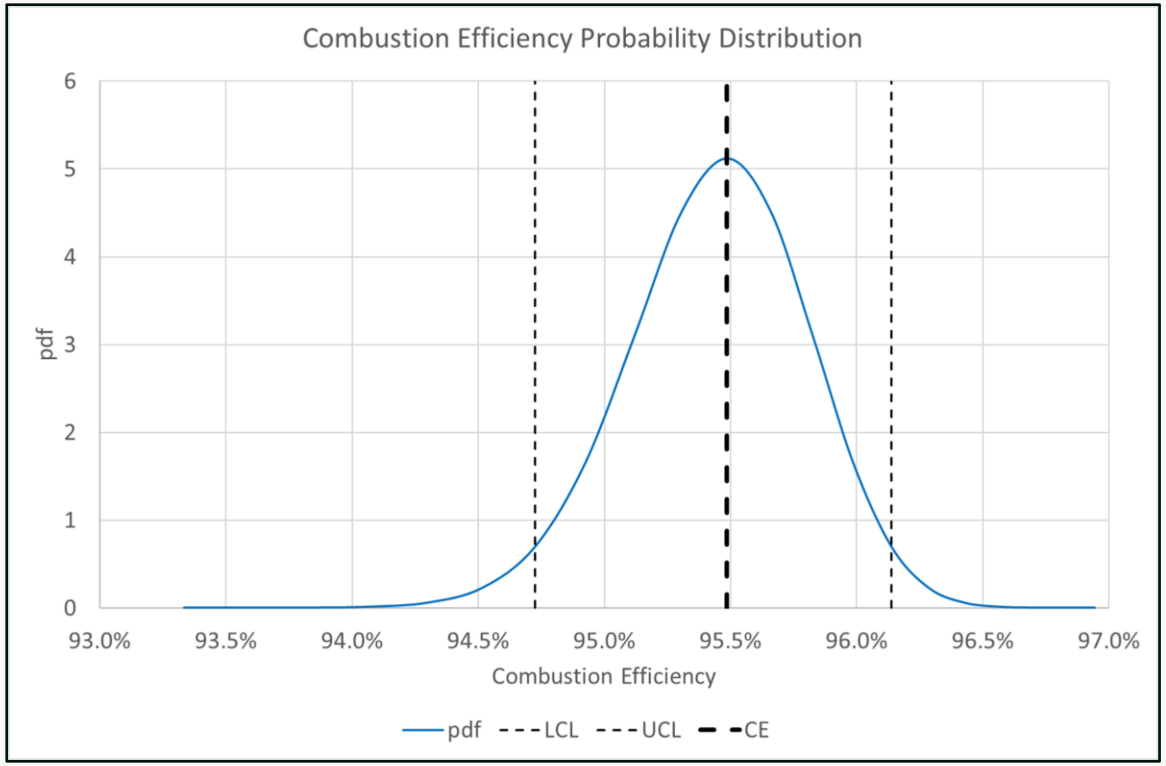
LHV_f	±0.6% Flare gas LHV from CHARM (MJ/kg)
U_w	±1% Wind speed (m/s)
U_f	±7.5% Flare exit velocity (m/s)
d	±1% Flare outer diameter (m)
A	UoA equation constant
B	UoA equation constant
AB	Covariance term

$$CE = 1 - A\left(\frac{LHV_{CH4}}{LHV_f}\right)^3 e^{\left(\frac{B\,U_w}{(U_f g d)^{1/3}}\right)}$$

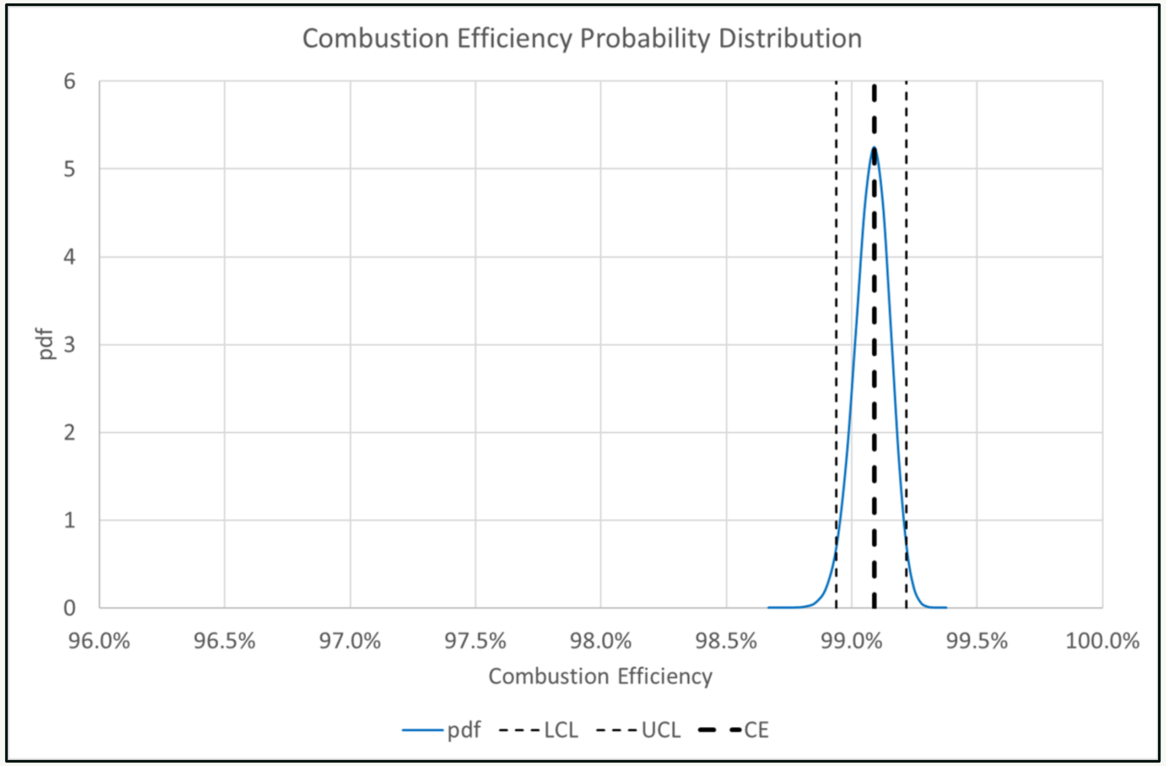
$$C_i = \frac{\partial CE}{\partial X_i}$$

$$Unc_{CE} = \sqrt{\sum_i (C_i * Unc_{Xi})^2}$$

Uncertainty



High Wind Speed 19 m/s



Average Wind Speed 10 m/s

Learnings and Developments

Not all asset process models (HYSYS) are up to date and we have found instances where plant modifications have not yet been incorporated. These instances can add some time to develop the CHARM process simulation model and require some additional support from asset process engineers.

We have developed an Asset Configuration Document (ACD) which details the build of CHARM/Combustor which provides a tool and record for Accord and client process engineers to approve the final build.

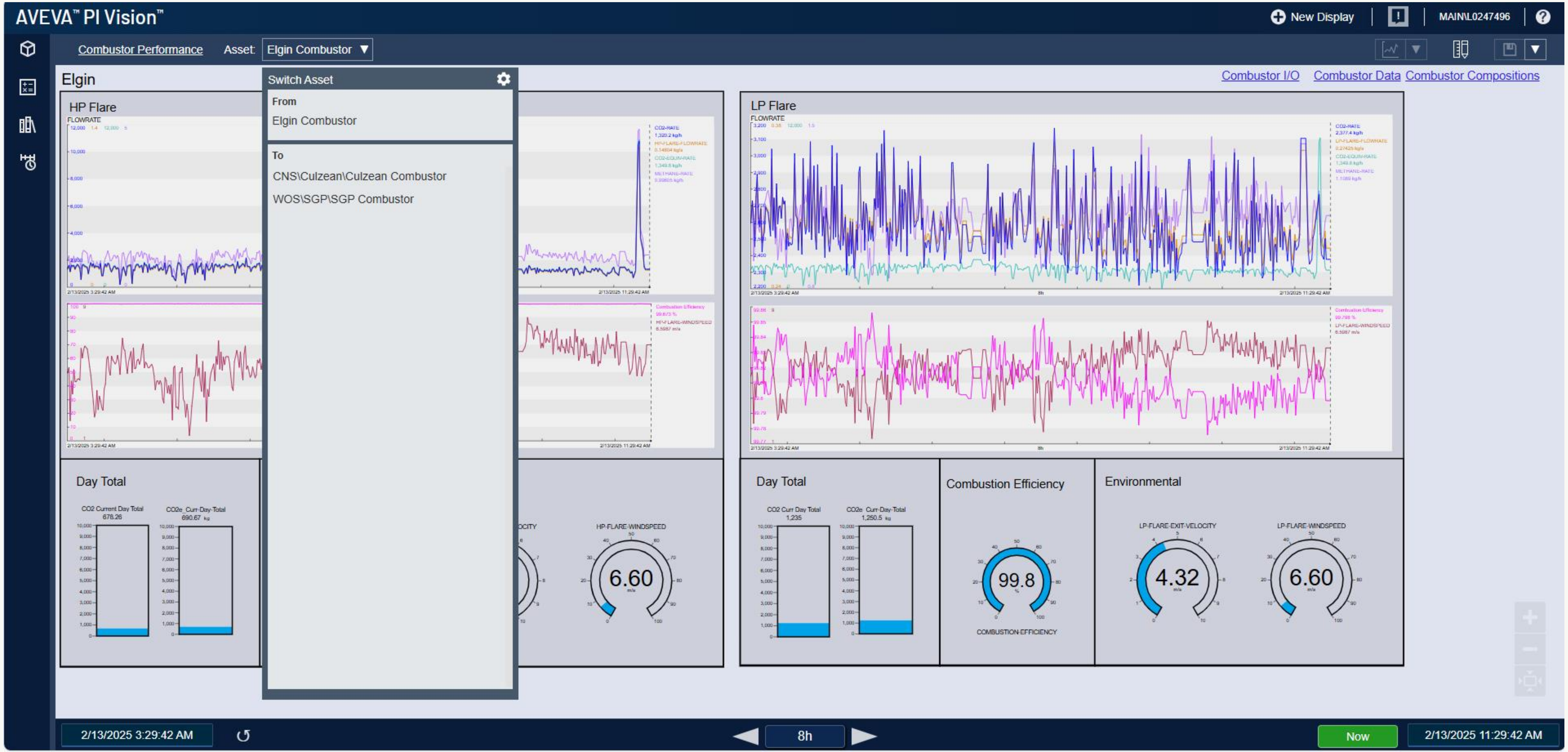
We have developed our own software connector tool which allows seamless integration between Combustor (operating in the cloud) and client data acquisition systems (PI) and means that deployment can be performed in hours with client IT support.

We are developing a method of validating Combustor compositions at the flare meter location using the measured speed of sound from installed ultrasonic flow meters. This functionality will be incorporated within Combustor within the next few months.

Given that the goal of Combustor is to help in measuring and reporting emitted quantities rather than just report on Combustion Efficiency, we have developed uncertainty calculations for CO_2e, CH_4 and CO_2 in order to qualify the reported emission quantities.

TotalEnergies Deployments

TotalEnergies UK have deployed Combustor on their Culzean, SGP, Elgin Franklin, Dunbar and North Alwyn assets.

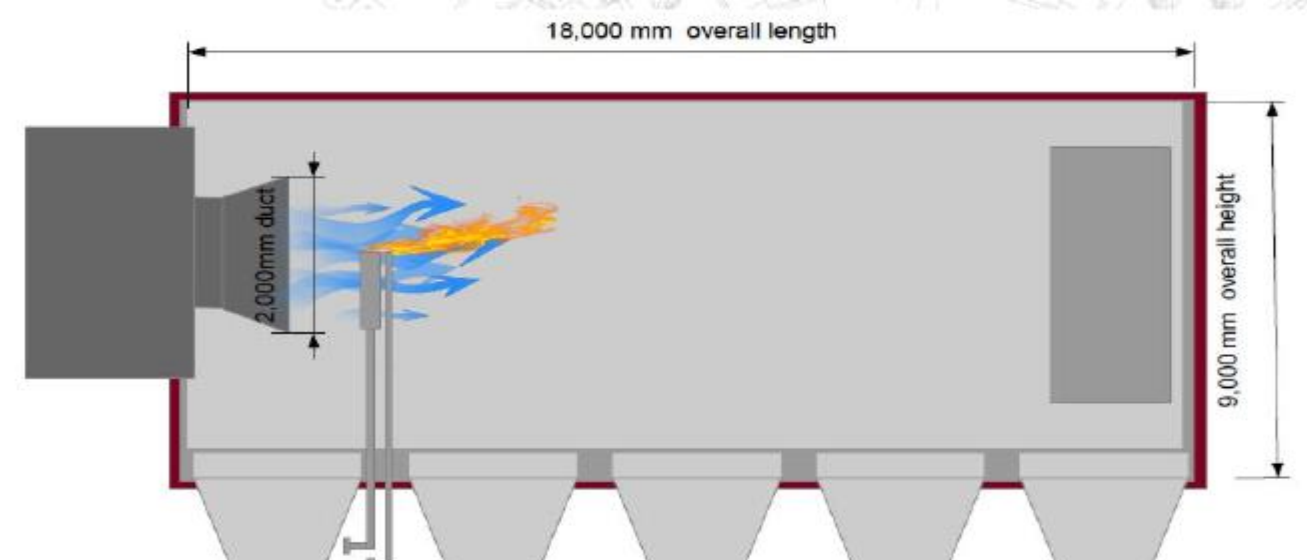


UoA Equation Verification: Wind Tunnel Testing

TotalEnergies UK together with Green Combustion, supported by Accord ESL, are conducting a series of controlled wind tunnel tests to examine how the Combustion Efficiency of a fourteen-inch (14”) diameter flare responds to changes in wind speed, exit velocity and lower heating value.

TotalEnergies central engineering group are in addition conducting tests on smaller diameter low pressure (LP) pipe flares and varying designs of high-pressure (HP) flare tips. The results from this testing, we hope to see published in the public domain in the near future.

It is anticipated that the results of these tests will provide additional information about the combustion performance of other flares sizes, and we hope to enhance the existing University of Alberta combustion efficiency algorithm to develop reliable algorithm(s) which may be used across industry.

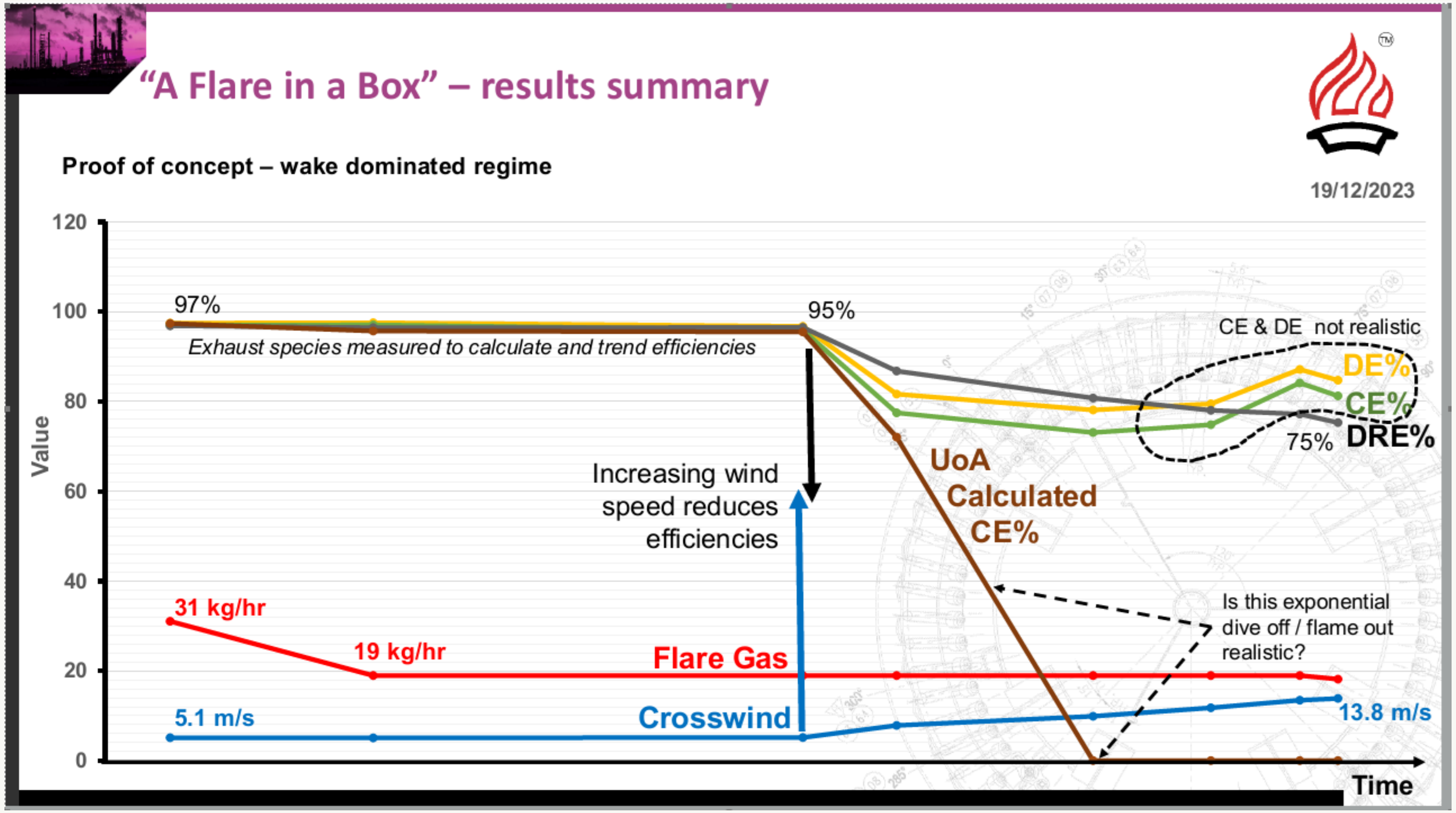


TotalEnergies

Wind Tunnel Testing

Photo’s from the wind tunnel test facility, operated by Centro Combustione Ambiente (CCA) in Bari, Italy are shown below.

Preliminary results



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