



SAFE OPERATION OF TUBULAR REFORMER

Over Fire Protection and Topsoe Furnace
Manger

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Debojyoti Mandal

17th Dec 2022

TOPSOE

PRESENTATION AGENDA

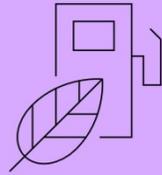
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|----------|---|
| 1 | TOPSOE AT A GLANCE |
| 2 | OUR VISION : LET'S DECARBONIZE THE WORLD |
| 3 | OVERFIRING PROTECTION & TFM |
| 4 | TOPSOE DIGITALIZATION OFFERINGS |
| 5 | TAKEAWAYS |

TOPSOE AT A GLANCE

Topsoe is a leading developer and provider of solutions and technologies to produce fuels and chemicals essential to the energy transition. For more than 80 years, we have been perfecting chemistry to help industries produce more efficiently. Today, it is our ambition to lead the global transition of heavy industry and transport to a zero-carbon future.

#1

In renewable diesel



#1

In ammonia

9%

Of revenue invested in R&D



6,225

In revenue
(DKK million)

903

EBIT before special items
(DKK million)

2,133

employees

An aerial photograph of a river delta, showing intricate patterns of water and land. The water is a mix of dark blue and green, while the land is a mix of brown and tan. The text is overlaid on the image in a clean, white, sans-serif font.

OUR VISION

**TO BE RECOGNIZED
AS THE GLOBAL LEADER
IN CARBON EMISSION REDUCTION
TECHNOLOGIES BY 2024**

TOPSOE

TOPSOE SOLUTIONS ACCELERATE THE ENERGY TRANSITION

ENABLING THROUGH SMART DIGITAL OFFERINGS

ENERGY SOURCES

Fuels and chemicals can be produced from various ways of both renewable and fossil feedstocks.



Renewable Electricity



Biomass, waste & carbon



Fossil energy

SOLUTIONS

Topsoe helps customers on their decarbonization journey through advanced energy solutions, such as Power-to-X, renewable fuels and blue solutions for the chemicals



Topsoe electrolysis solutions



Topsoe chemical solutions



Topsoe fuel solutions

CHEMICALS AND FUELS

For our customers, the output is more efficient processes or renewable feedstocks, that significantly can lower the carbon footprint, and thereby supporting them in their energy transition.



Hydrogen



Ammonia



Methanol



Fuels



Sulfur removal

UTILIZATION

The societal benefits of these end-products come, among other things, in the shape of a cleaner transportation sector and hard-to abate sectors such as steel, cement, and mining, who can reduce their carbon footprint



Transportation



Chemical & fertilizers



Heavy industry



*The **steam reformer** is the **beating heart** of the plant*

Reformer optimization

Large potential for optimization

Reformer optimization

- Potential often not realized
- High complexity

REFORMER CONDITIONS

OPERATING UNDER HARSH CONDITIONS



Refractory failure

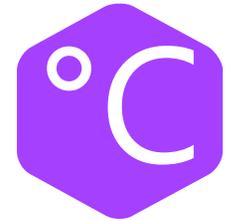


Tube rupture



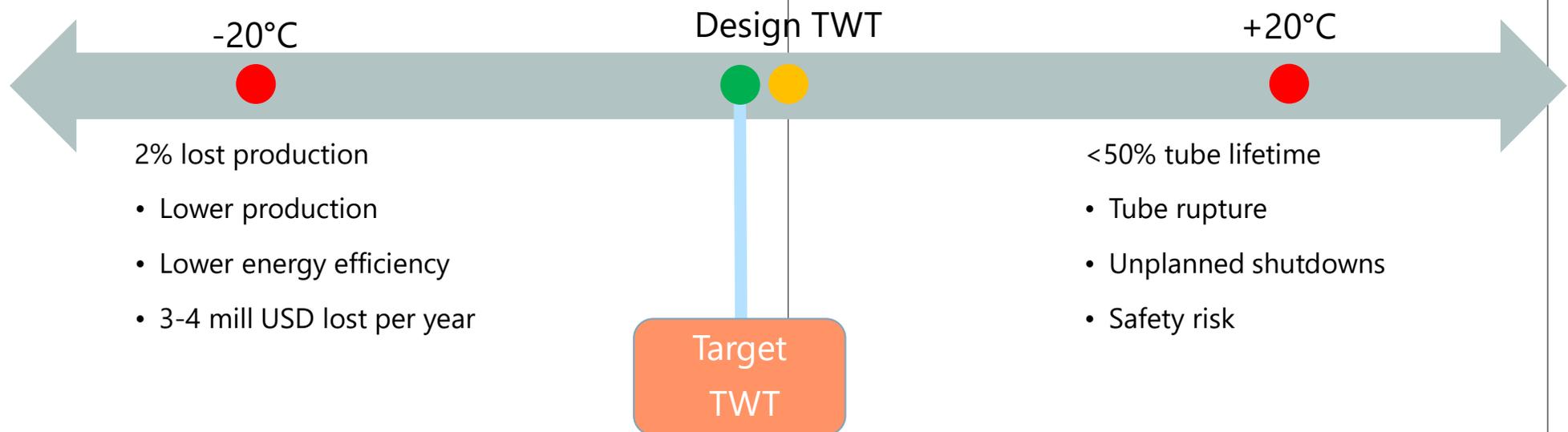
~20,000 \$/tube
Unplanned shutdown:
~1,000,000 \$/day

Safety and cost

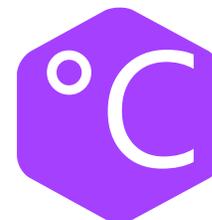


TUBE WALL TEMPERATURE MEASUREMENTS

WHY ACCURACY IS IMPORTANT?



Is your reformer operating at the target temperature?



CASE STORY: 10% HIGHER CAPACITY

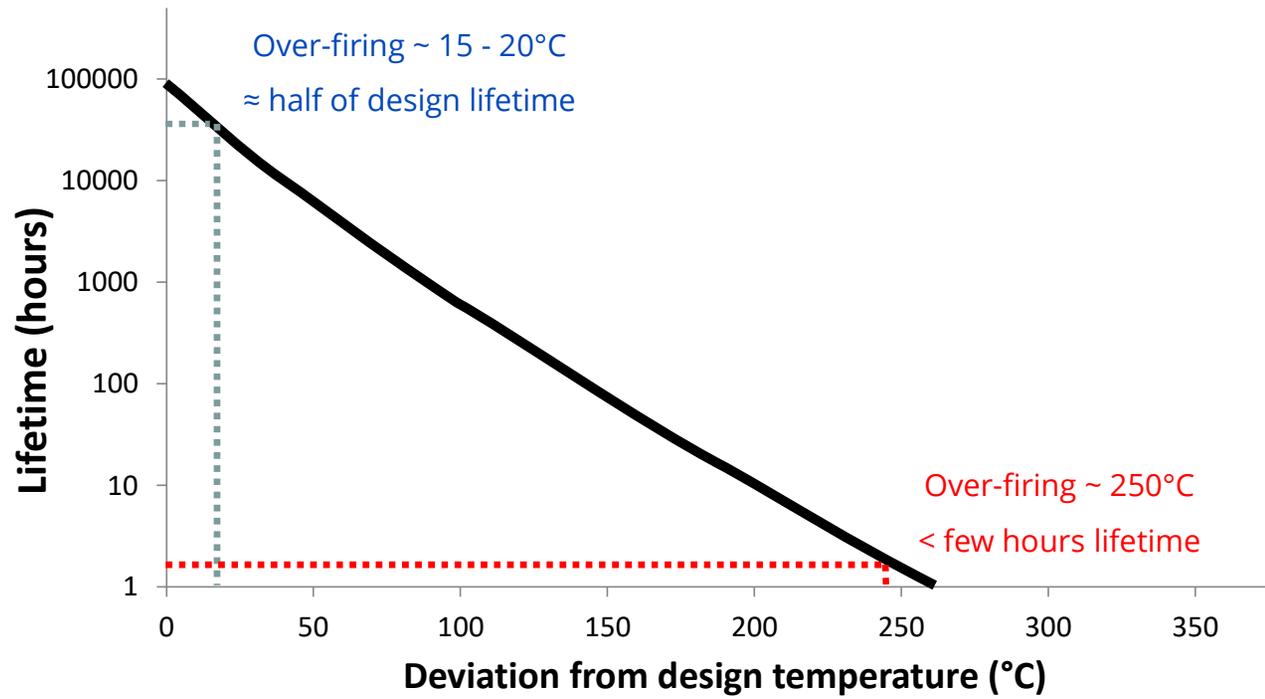
BURNER TRIMMING AT ASIAN HYDROGEN PLANT

	Min TWT	Max TWT	Avg. TWT	Deviation	Capacity
Before	922°C	986°C	955°C	-33°C / +31°C	90%
After	945°C	978°C	962°C	-17°C / +16°C	>105%

- Tube lifetime extended
- Optimizing from 50% to 105% equals 50 million USD pr. year

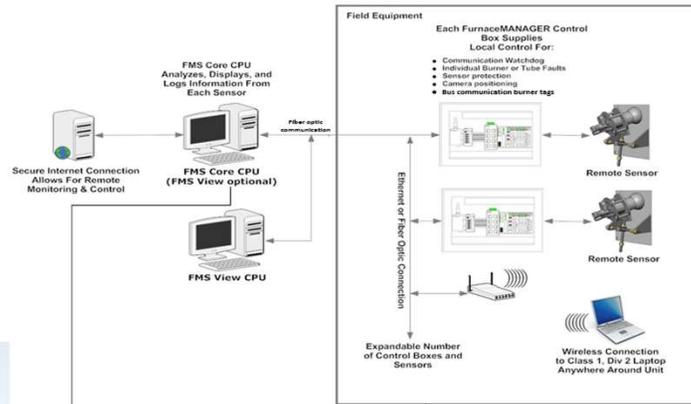


WHAT IS OVER-FIRING?



TOPSOE FURNACE MANAGER ARCHITECTURE

TOPOSE FURNACE MANAGER CONVERTS FIELD DATA TO KNOWLEDGE



*Topsoe Furnace Manager Also abbreviated as FMS: furnace manager system

Over firing protection calculations
+
Asymmetric burner logic
In DCS controller

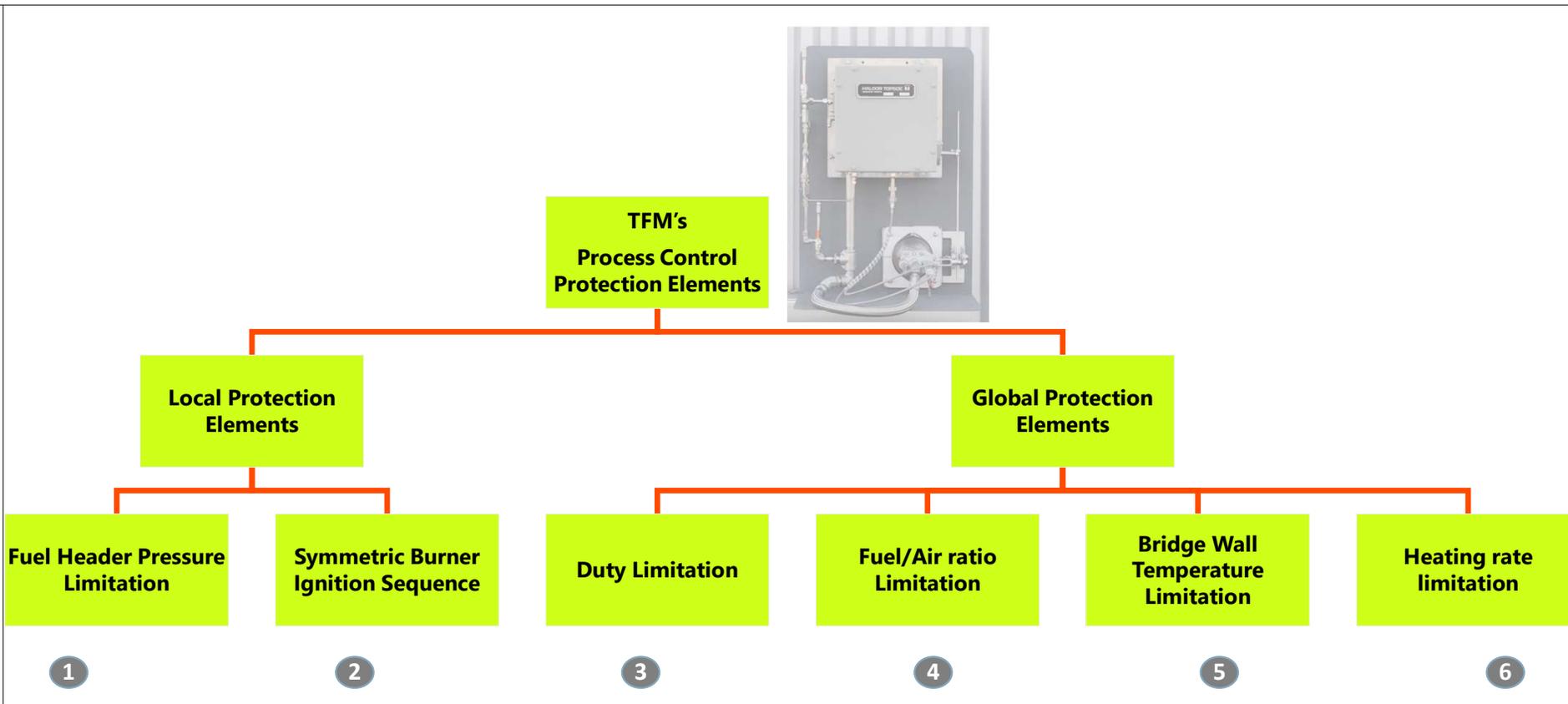
General instruments (like Pressure transmitter, analyzers, etc) required for Over firing protection to be connected to control system

Over firing protection + Topsoe Furnace manager communication architecture



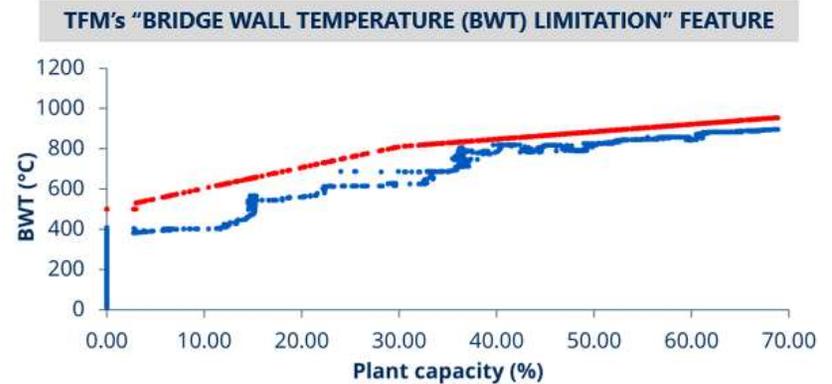
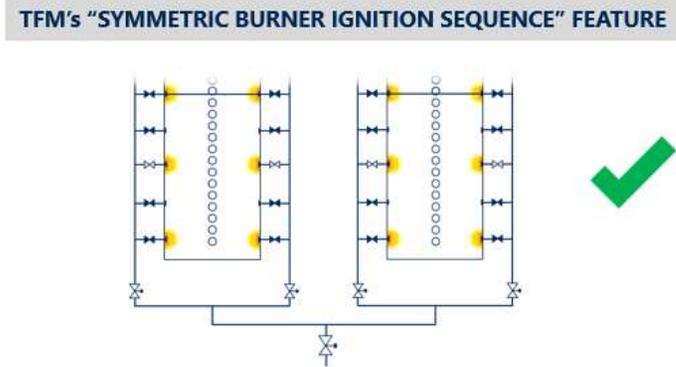
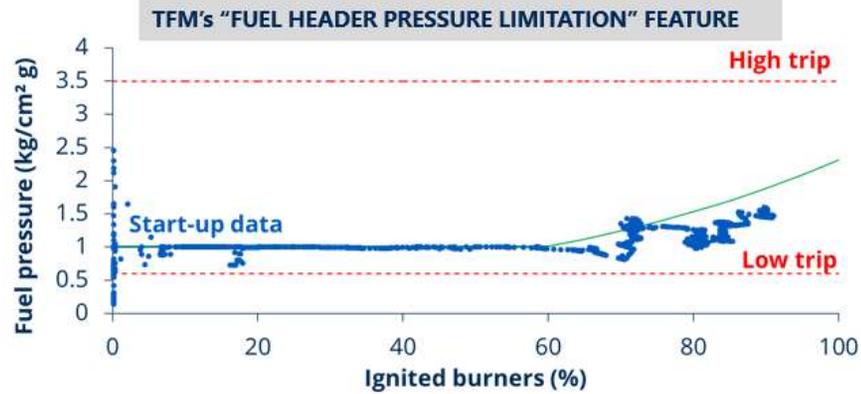
TFM'S OVERFIRING PROTECTION CONTROL SYSTEM

AVOIDS ANY OVERFIRING OF FURNACE DURING START UP & SHUT DOWN



TFM'S OVERFIRING PROTECTION CONTROL SYSTEM

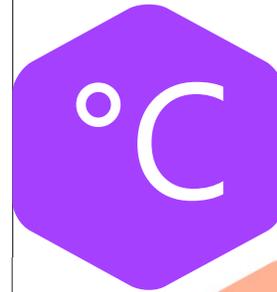
EXAMPLE OF CONTROL ELEMENTS



CONVENTIONAL METHODS

Unplanned shutdowns are a serious threat to plant economy

If shutdowns are caused by tube rupture, there will be significant costs due to both tube replacement and down time



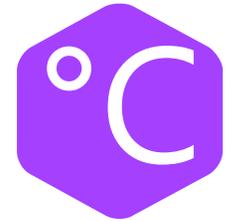
Minimize Risk



Manual inspection



Planned replacement



CASE STUDY OF AN UNSAFE INCIDENT IN AN HGU UNIT AND DAMAGES INCURRED

- A mishap in HGU resulted in replacement of 54 out of 224 tubes – Total repair cost: **~1.3Mn USD**
- 10 days Lost production time associated with removal of these 56 tubes and catalyst **~ 9.2 Mn USD**
- 30 days shutdown in future to install these 56 tubes – Lost production time; Downstream Units may operate at 20% reduced capacity – **~8.0 Mn USD**
- Unsafe operation of HGU leads to:
 - Dangerous exposure to plant personal
 - **Total cost of 18.5 M USD**



IR PYROMETRY VS TOPSOE FURNACE MANAGER (TFM)

AUTOMATE SAFE MONITORING OF FURNACE



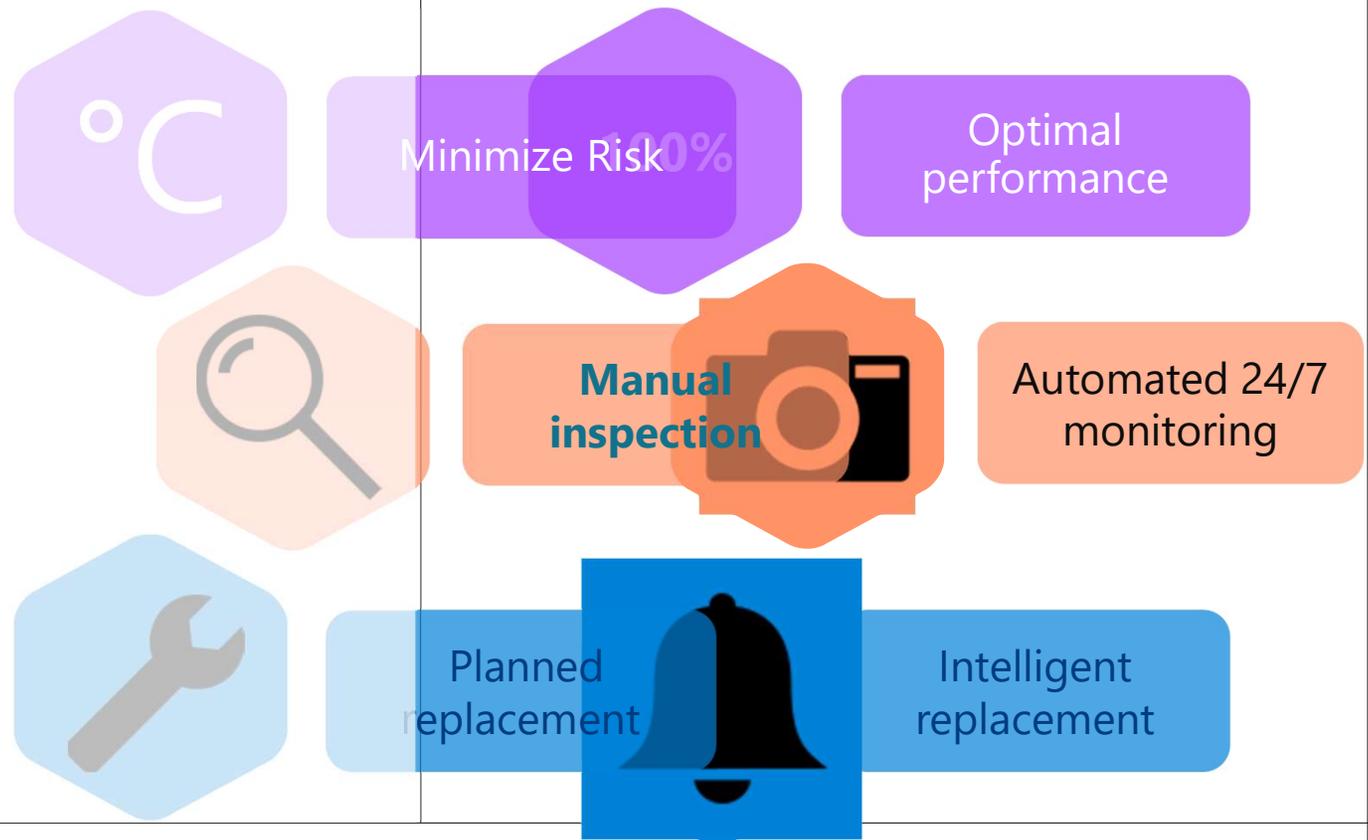
- Infrequent
- Inaccurate
 - Radiation effects
 - Peephole opening distortion
 - Manual errors
- Unsafe



- Real-time 24 x 7
- Accurate
 - Radiation effects avoided
 - No peephole opening
 - No manual measurement
- Safe – Includes Process Control IP for diminishing overheating incidents

TOPSOE FURNACE MANAGER

A NEW WAY FORWARD...



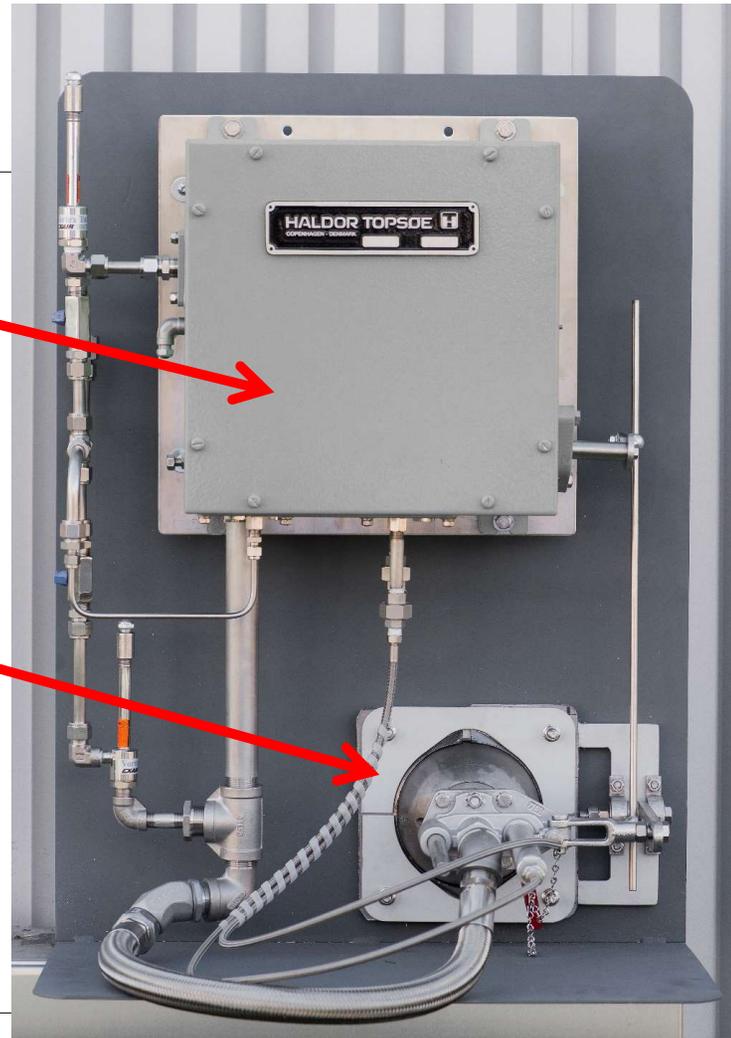
TOPSOE FURNACE MANAGER (TFM)

Data Acquisition unit

- Controller
- Switches
- Data transfer
- Actuation assembly

Image Acquisition unit

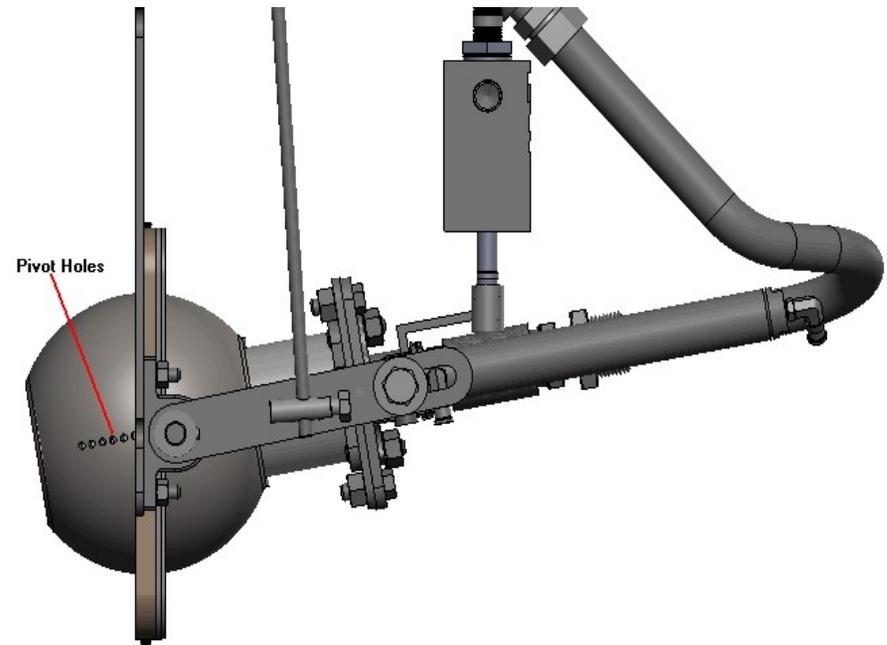
- Optics
- Sensor
- Communications cabling
- Pivoting mount assembly



TOPSOE FURNACE MANAGER (TFM)

TFM information is available 24/7 providing:

- **Asset protection**
 - Early detection of malfunction
- **Safe Operation**
 - Protect site personnel
- **Plant Optimization**
 - Enabling optimal performance



TOPSOE FURNACE MANAGER

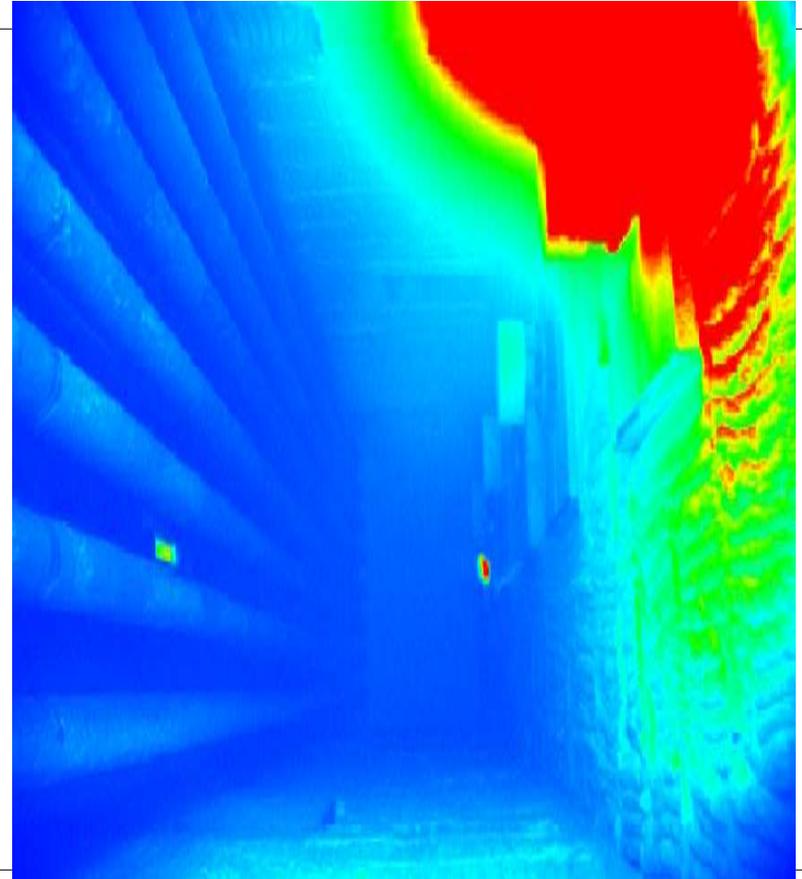
ENABLES OPERATIONAL EXCELLENCE

Enabling **online** reformer monitoring and automatically record data on:

Tube wall temperatures

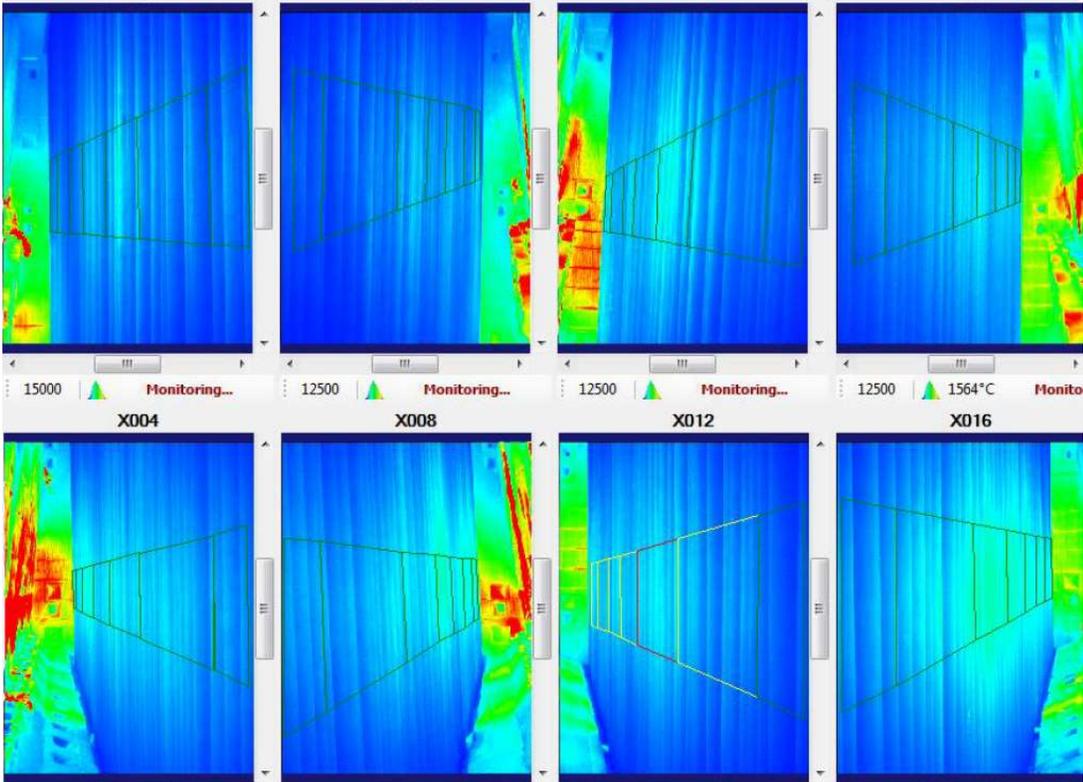
Burner status and performance

Reformer conditions

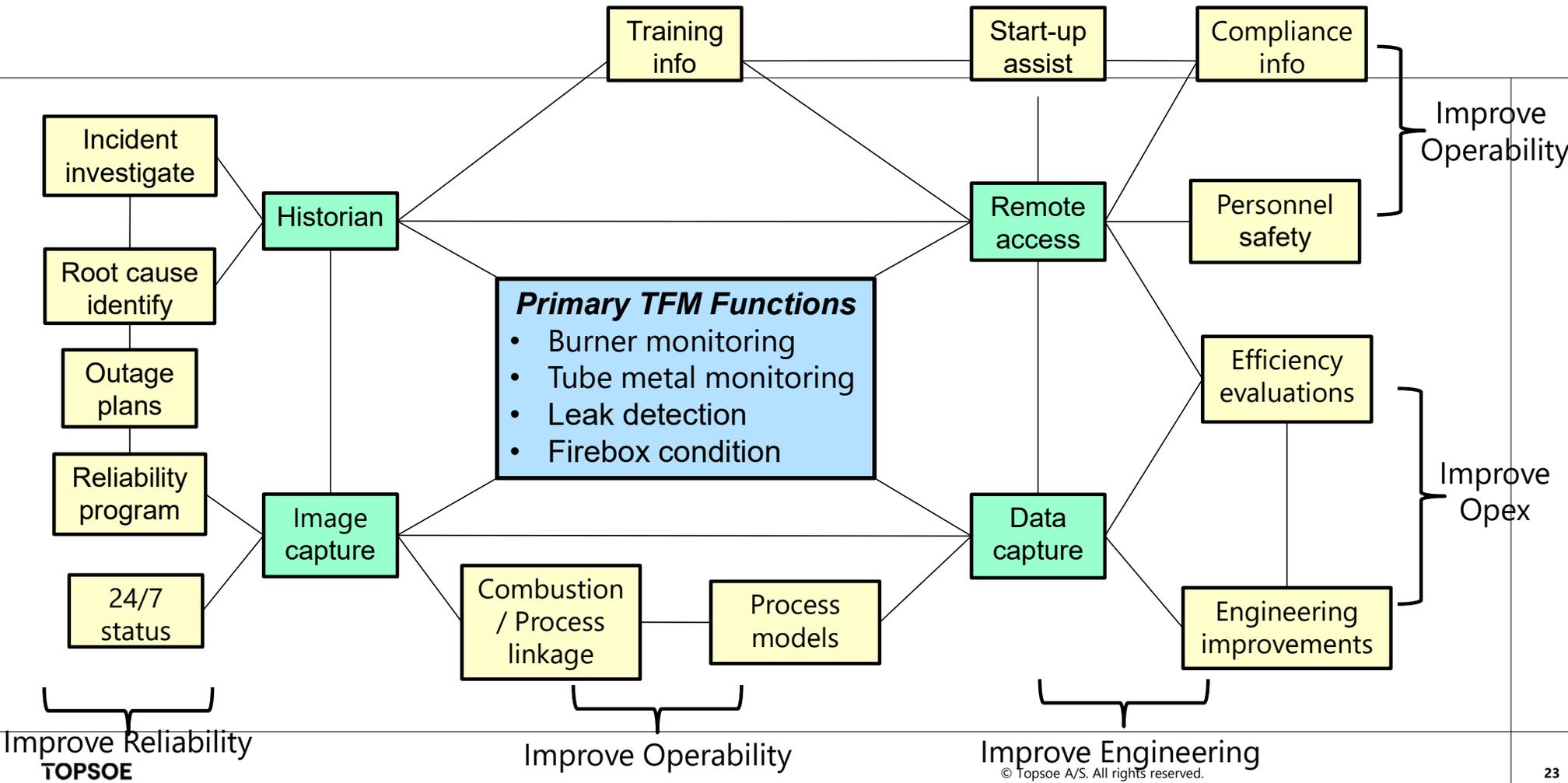


TFM CAMERA VIEW

SIDE FIRED FURNACE



TFM VALUE RIPPLE EFFECTS



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CUSTOMER VOICE AND COMMERCIAL REFERENCE

FROM TOPFIRED REFORMER

Safe Startup for World Scale H2 Plants with Topsoe Furnace Manager

Large, world-scale H2 plant steam methane reformer (SMR) fireboxes represent safety challenges due to size and complexity, such as personnel safety issues while interfacing with the firebox during the startup and light off of hundreds of burners

Ken Wohlgeschaffen
Chevron

layer of protection, during the critical first burner lighting phase. (Figure 3).



Figure 3. First SMR burner light off

Burner Lighting and Heat Up

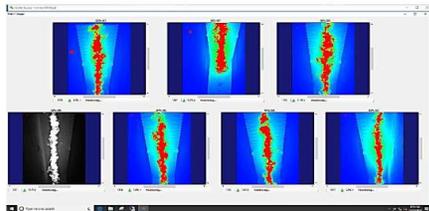


Figure 4. Burner Rows during Heat Up

Firebox Radiation After Plant Trip outs

It is normal, and to be expected, that during the very first startups of complex process equipment plant tryouts will occur.

For an SMR, it is critical to safety to understand the condition of the firebox during a plant tryout. With TFM, the firebox can still be "seen" with images even when burners have tripped offline. The radiation signature from the firebox contin-

From: "Wohlgeschaffen, Ken (KWohlgeschaffen)" <KWohlgeschaffen@chevron.com>
Date: June 18, 2019 at 4:03:38 PM CDT
To: "Scott W. Sexton [SCS]" <SCS@topsoe.com>, "Henrik Rasmussen [HWR]" <HWR@topsoe.com>
Subject: TFM Experience at Chevron, Richmond

Henrik & Scott:

Chevron is using your company's TFM technology at our Richmond, CA refinery. We are happy with the functionality and performance of the system.

Best Regards,

Ken Wohlgeschaffen
Hydrogen Network Team Leader
Chevron Richmond Refinery
(510) 242-4268 Office
(510) 685-3817 Cell



Total number of references worldwide=15

OPTIMISATION

DELIVERING VALUES TO CUSTOMER EXPECTATION

- Safer and Optimized operation = Peace of Mind.
- Expected increase in the average TWT by 10°C (or more).
 - Better reformer conversion= Lesser Feed Consumption = Lesser Specific Net Energy Consumption = Direct Saving in revenue.
- Result in reduction of a plant's green house gas emissions, as any improvement in the energy consumption will have a positive impact on (especially) CO₂ emissions.
- ZERO Downtime due to Reformer failure "Penny saved is penny earned"
- Increase in Reformer Safety = Decrease in Annual Insurance Premium

TOPSOE DIGITALIZATION OFFERINGS

CLEARVIEW

Enabling you meeting your targets every day...



OPERATOR SIMULATOR TRAINING & REMOTE ASSISTANCE

Maximize profitability, improve workforce safety and increase reliability.

Assisting the customers 24x7 remotely through advanced certified devices



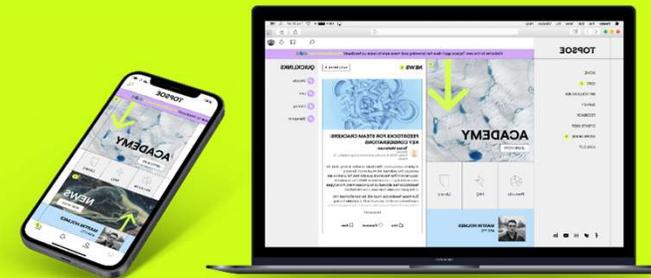
TOPSOE FURNACE MANAGER

Asset protection and optimal performance



TOPSOE ACADEMY

learning on the Go, whenever and wherever – via desktop, tablet and mobile



KEY TAKEAWAYS



DIGITALIZATION

Smart way to improve the bottom line & enabling sustainable energy transition



TOPSOE FURNACE MANAGER, OTS, 24X7 REMOTE SERVICES

- Enhance safety, protect your asset, enhance reliability, optimize the operation through continuous monitoring, Enhance operators skills
- Topsoe helps customers by providing through remote services



ENERGY TRANSITION

Topsoe is a leading developer and provider of solutions and technologies to produce fuels and chemicals essential to the energy transition



CLEARVIEW

Enabling to achieve optimal performance & meeting your target everyday and achieving operational excellence



DECARBONIZATION

Topsoe helps customers on their decarbonization journey through advanced energy solutions, such as Power-to-X, renewable fuels and blue solutions for the chemicals

DM[1

QUESTIONS?

TOPSOE

