Welcome!

The program will begin soon.

You will not hear audio until we begin.

 

Preparing for H_2's Impact on Gas Infrastructure

Challenges with Operations and Engineering

Dr. James Holbeach - Global Director – Energy and Flow Assurance - Wood
Dr. Dale Erickson - Technical Authority - Real Time Operations – Wood
Mangala Ngala – Engineering Manager – Applied Intelligence, Intelligent Operations – Wood

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Contents

- Safety Moment
- Introduction to Wood
- History of gas blending and Virtuoso®
- Impact of H_2 in blended gas
- Case study (ops): Real time BMS
- Case study (design): H_2 blending into gas network
- Summary
- Q&A

Safety Moment: H_2 Flashback

What Happened?

- Explosion in a H_2 flare stack at the NASA Test Facility during Stage 2 development of the Saturn V Rocket

Key Events

- HP relief operation resulted in H_2 being directed to flare
- Flashback from the flare tip into the flare stack led to an explosion in the flare stack
- Destroyed 150 m of the flare system

Why Did it Happen?

- H_2-air mixtures have wide flammability range and high flame velocity
- Air migrated into the flare stack during maintenance works, making a combustible H_2-air mixture in flare stack that ignited when there was flashback from the flare tip

Lessons

- Conventional equipment may not be appropriate for H_2
- NASA favours burn ponds over flare stacks for H_2

Future Ready Now

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160+
year history

45,000
people

60+
countries

~$10bn
2019 revenue

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One of the world's leading consulting and engineering companies operating across Energy and the Built Environment.

Consulting

Projects

Operations

SPE International

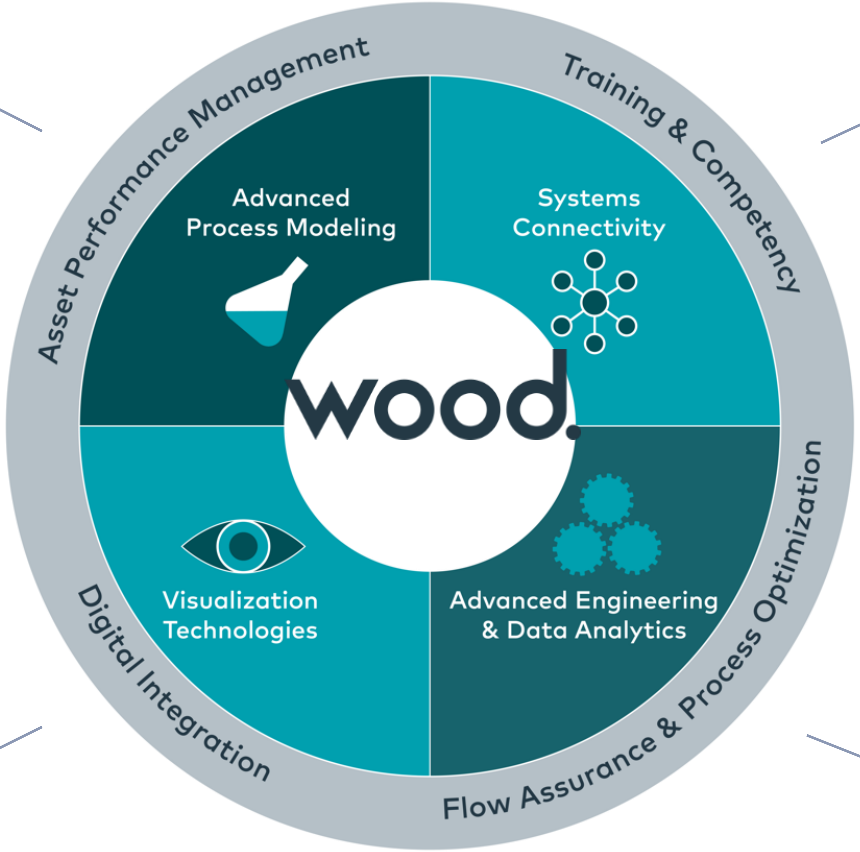
Intelligent Operations – our focus

APM (Asset Performance)

Upstream/Midstream/Downstream APMs
Operations Integrity & Optimization
Online Performance Monitoring
Emissions (Flares & GHG) Monitoring)
Process Digital Twins

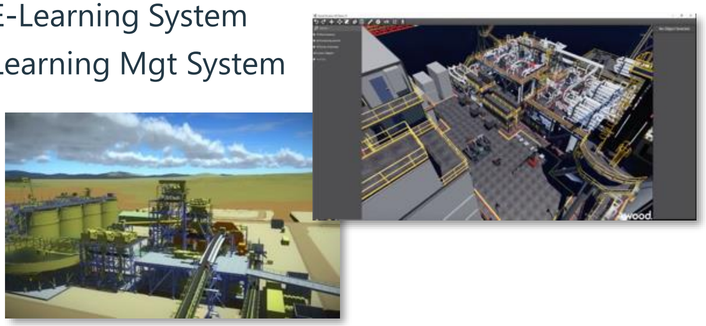
Digital Integration

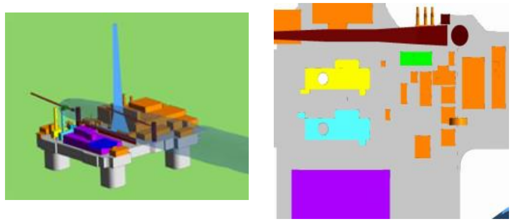
Data Ops
MES / Cloud Integration
Robotic Process Automation



Training & Competency

Operator Training System
E-Learning System
Learning Mgt System

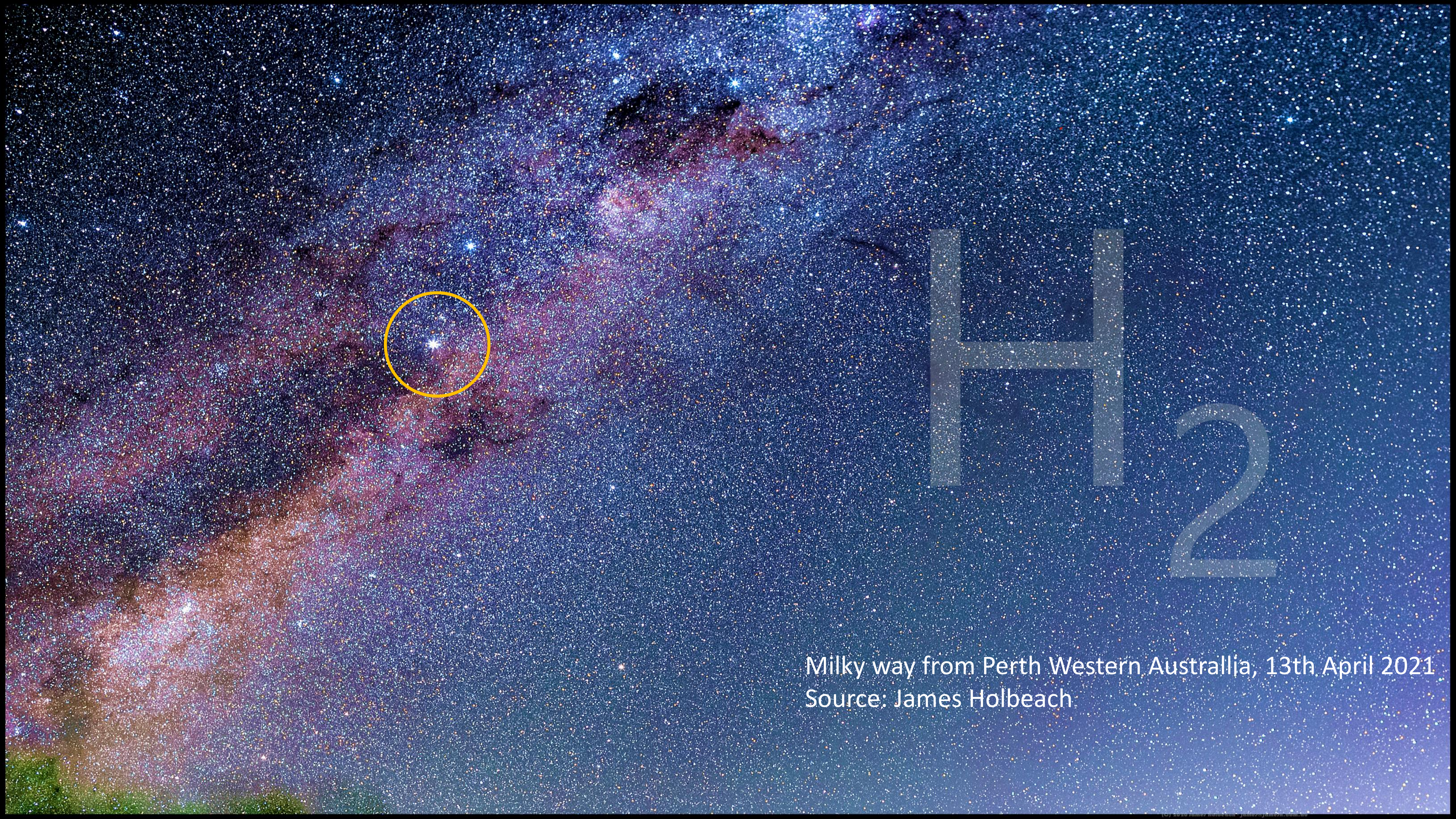




Flow Assurance & Process Optimization

Flow Assurance & Process Analytics
Production Chemistry
CFD (Computational Fluid Dynamics)
Dynamic Process Simulations
Metering & Allocation

IntelligentOps@woodplc.com


H_2
Milky way from Perth Western Australlia, 13th April 2021
Source: James Holbeach

Opportunities across the hydrogen value chain

We see significant challenges and **opportunities** across hydrogen value chain:

Making it.

Moving it.

Using it.

Dr. Dale Erickson

H_2 IN NATURAL GAS – IT’S A FLUID

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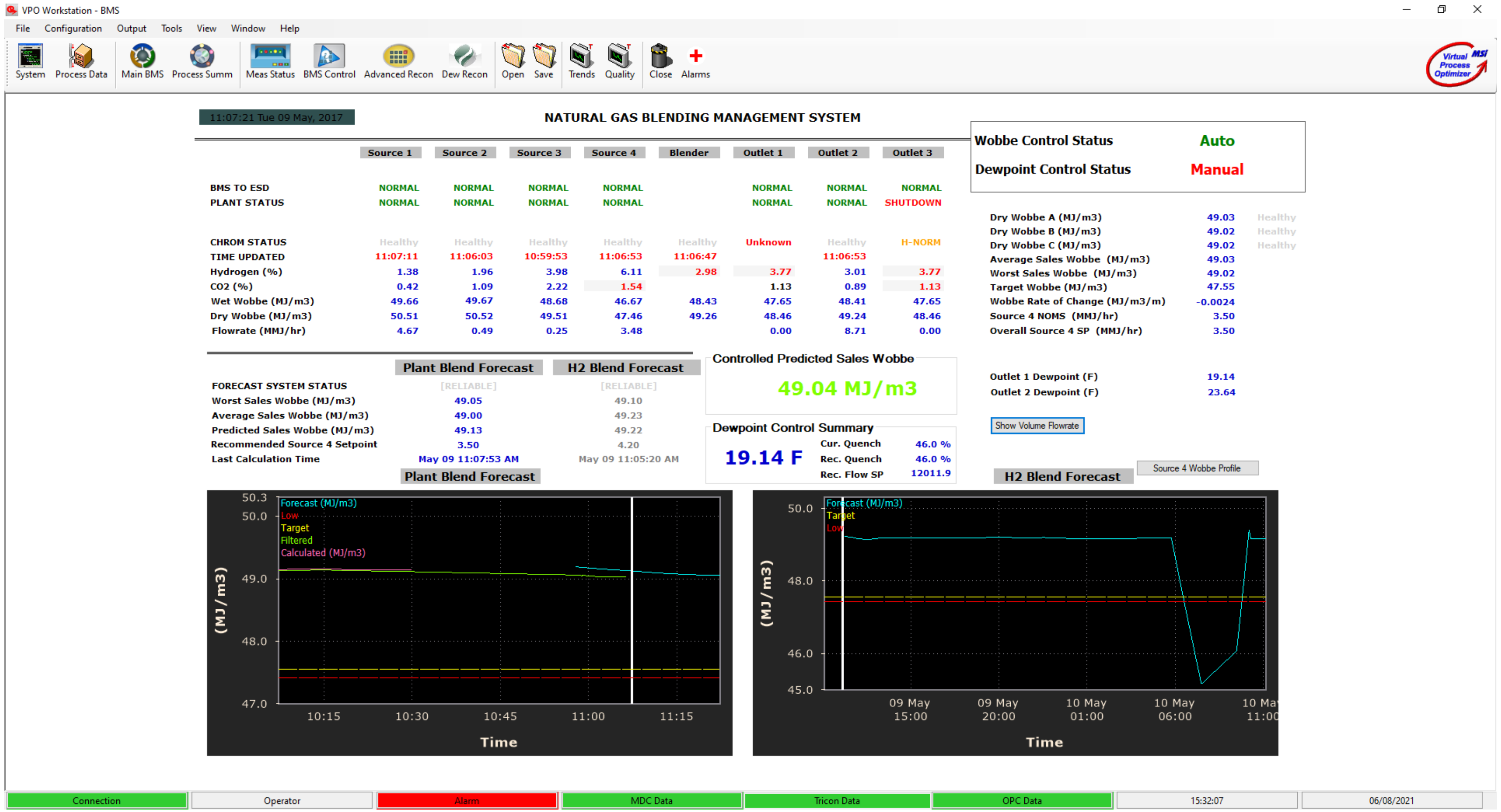
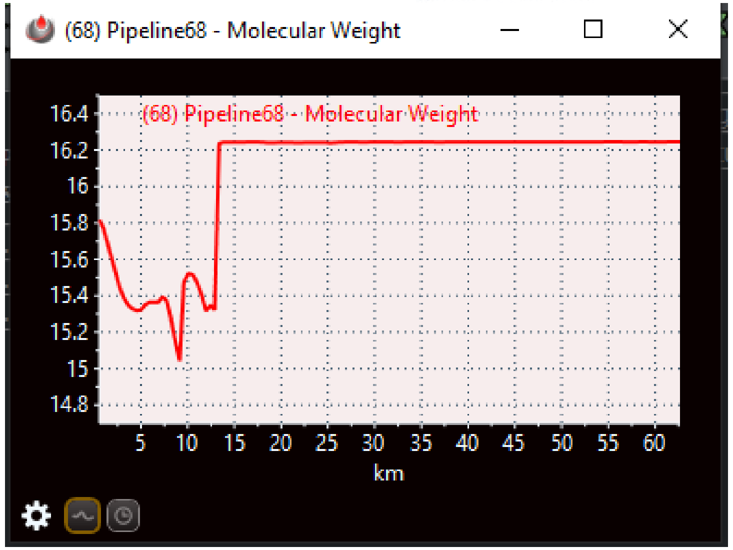
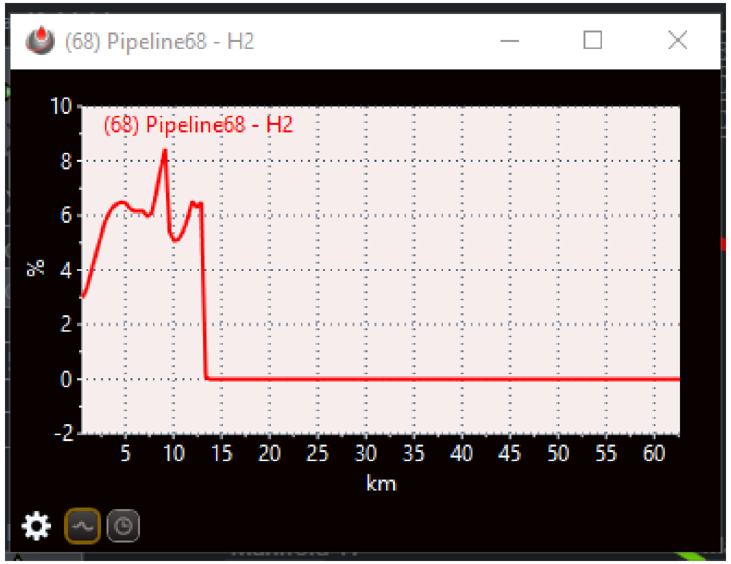
Gas Blending – Keep Gas in Specification



Virtuoso Tracking

- **Gas density** (ρ) is important for predicting pressure drop in pipeline networks
- Virtuoso tracks component composition and Molecular Weight (MW) in packets which match dispersion length
- The MW and H_2 concentration directly affect the density as next slides will explain





Gas Law

$$P \bullet \boldsymbol{MW} = \rho \bullet \boldsymbol{Z} \bullet R \bullet T$$

$$\rho = \frac{P \cdot \boldsymbol{MW}}{\boldsymbol{Z} \cdot R \cdot T}$$

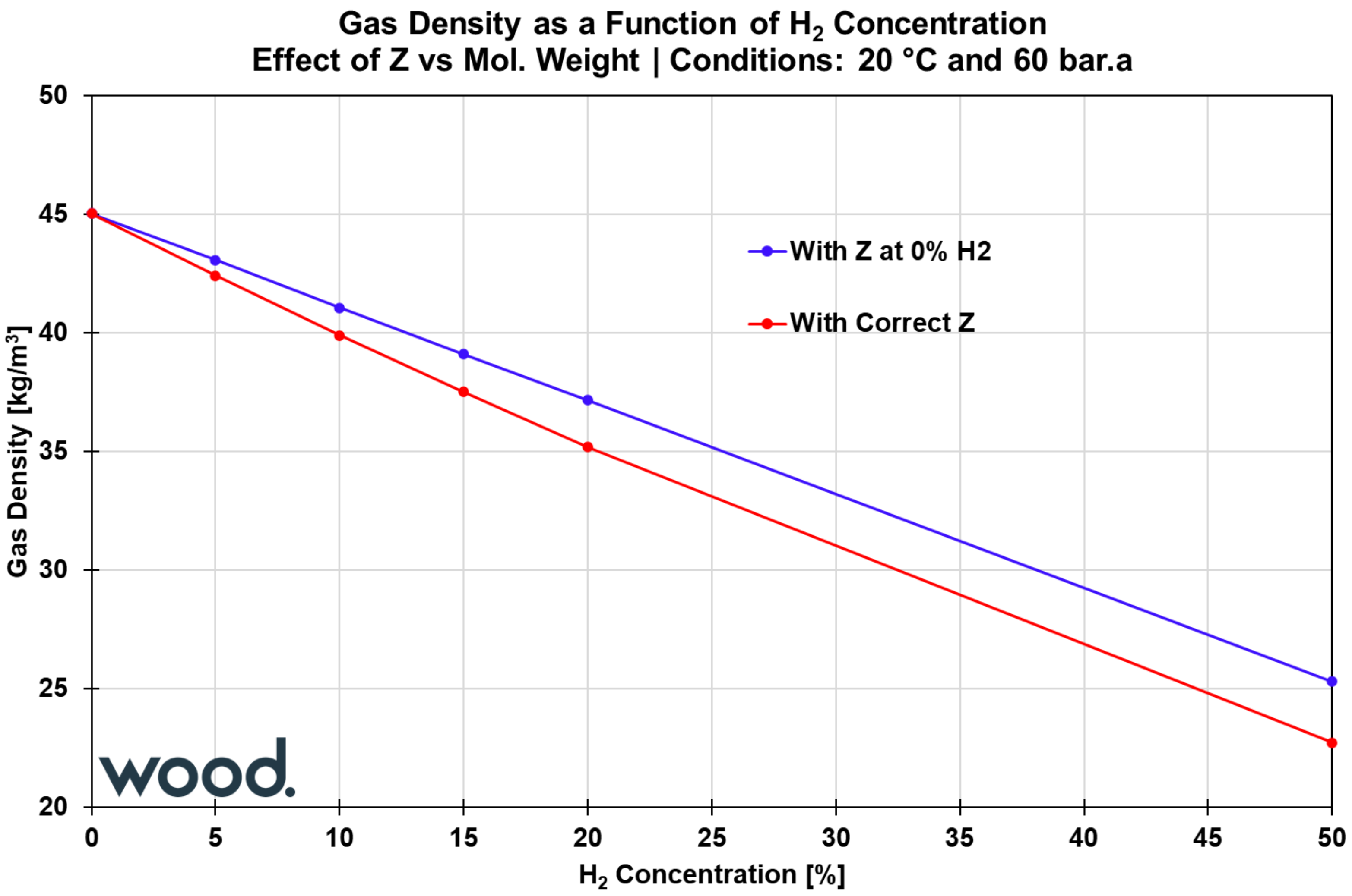
Variable	Description	Typical Values	Units
P	Pressure	10-60 (145-870)	barg (psig)
ρ	Density	20-100	kg/m^3
R	Ideal gas constant	8.314	$j.(mol.K)^{-1}$
T	Temperature	270-320	K
MW	Molecular Weight	Natural Gas = **16-21**	g/mol
Z	Compressibility	0.8-1	[-]

Component	MW
CH_4	**16.0**
C_2H_6	30.1
N_2	28.0
H_2O	18.0
CO_2	44.0
H_2	**2.0**

Thermo-Physical Properties

Molecular Weight

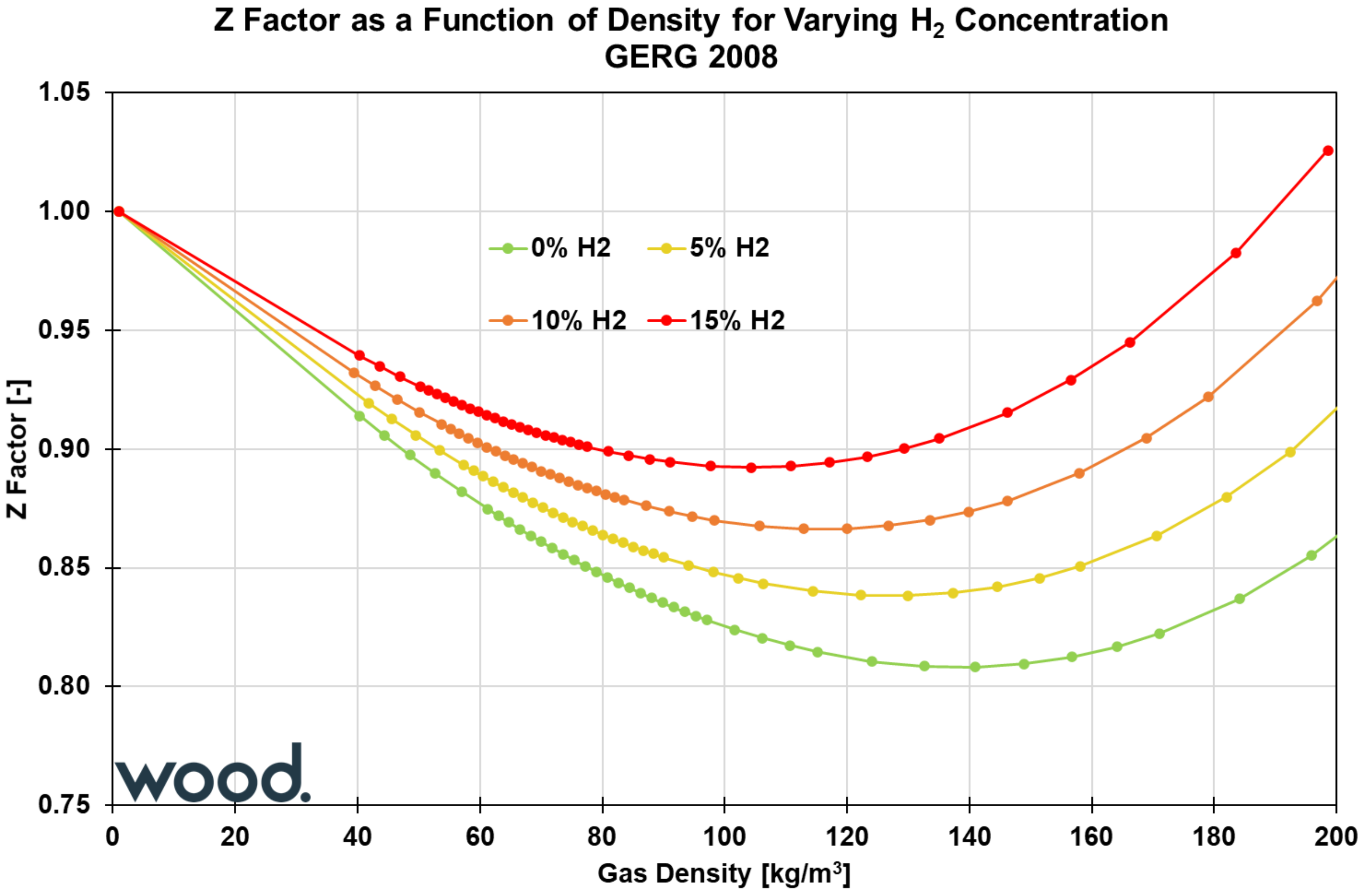
Density of H_2 mixture is 3-4 times as sensitive to the MW than the Z factor



Thermo-Physical Properties

Compressibility

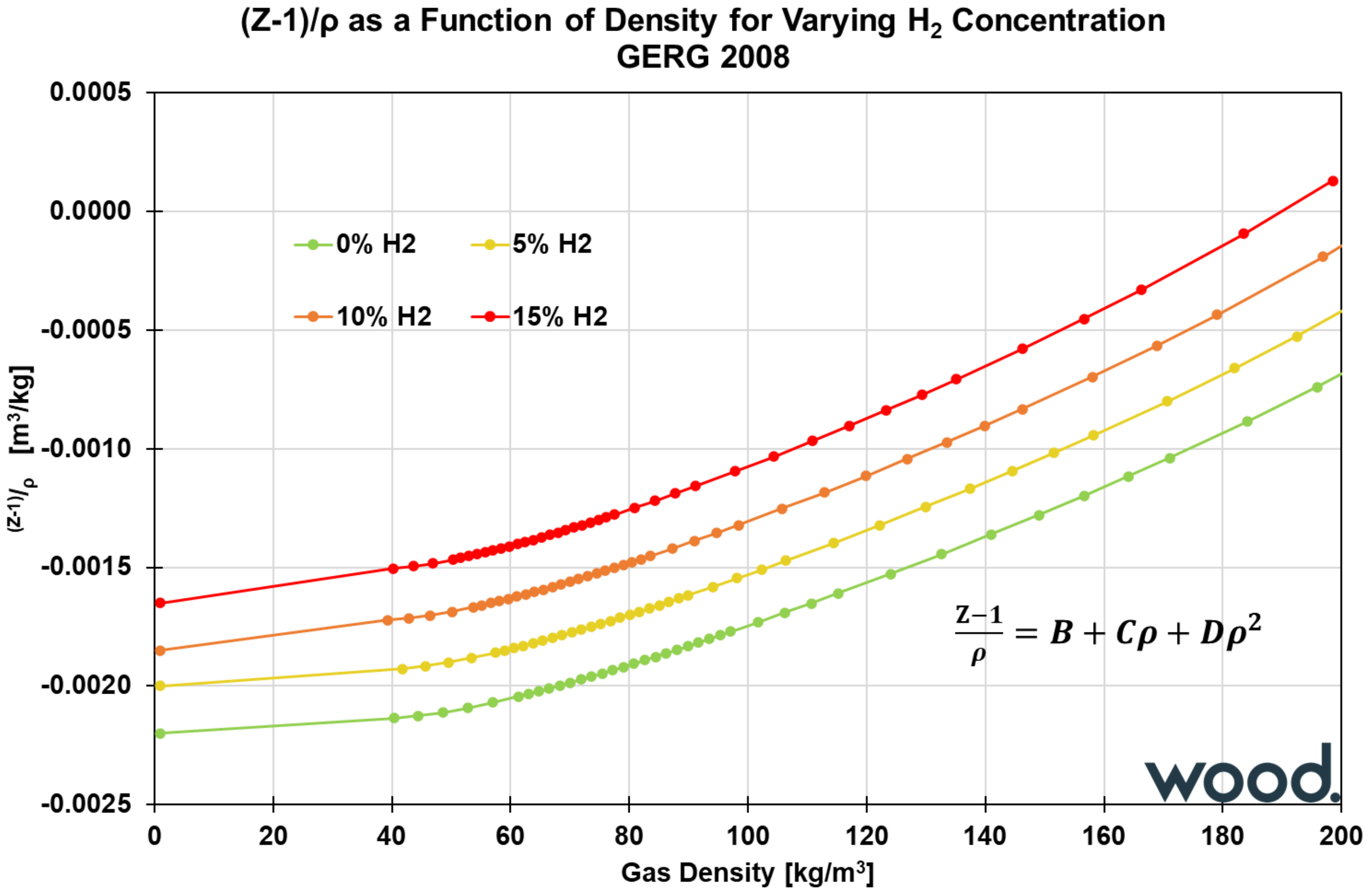
Compressibility is a function of the H_2 concentration



Thermo-Physical Properties

Impact of H_2

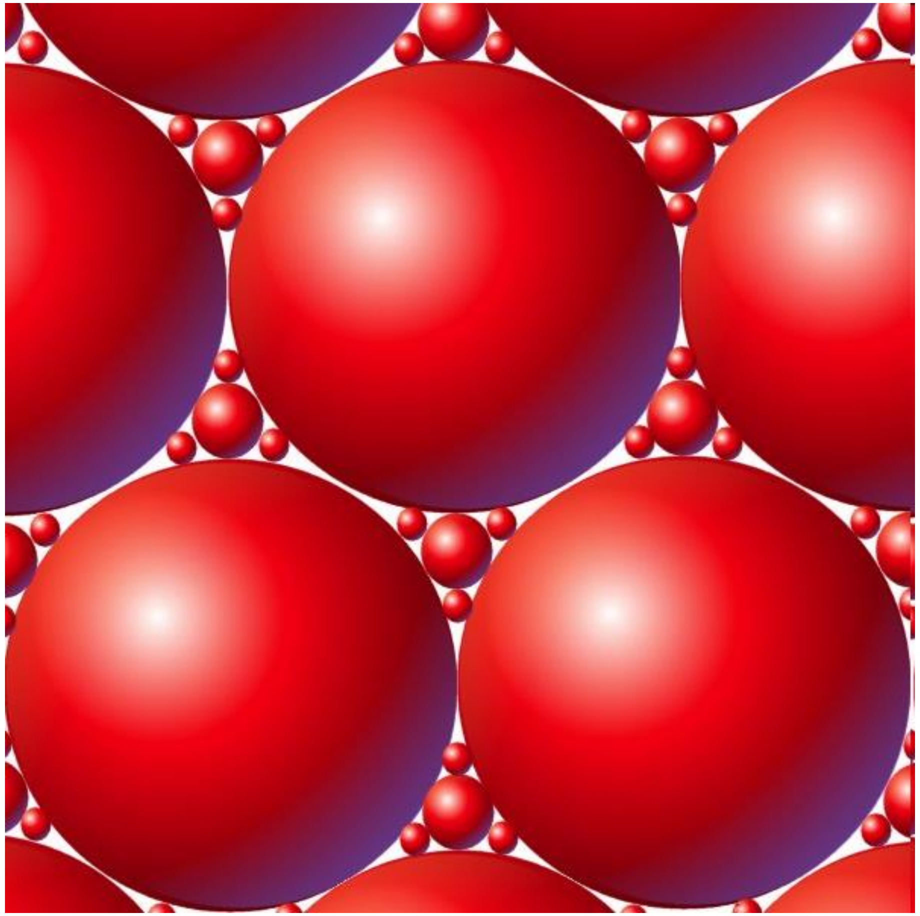
2nd Virial Coefficient is most effected by H_2



Key is the Mixing Rules

- Different molecules have different atomic diameters, energy levels, and kinetic diameters

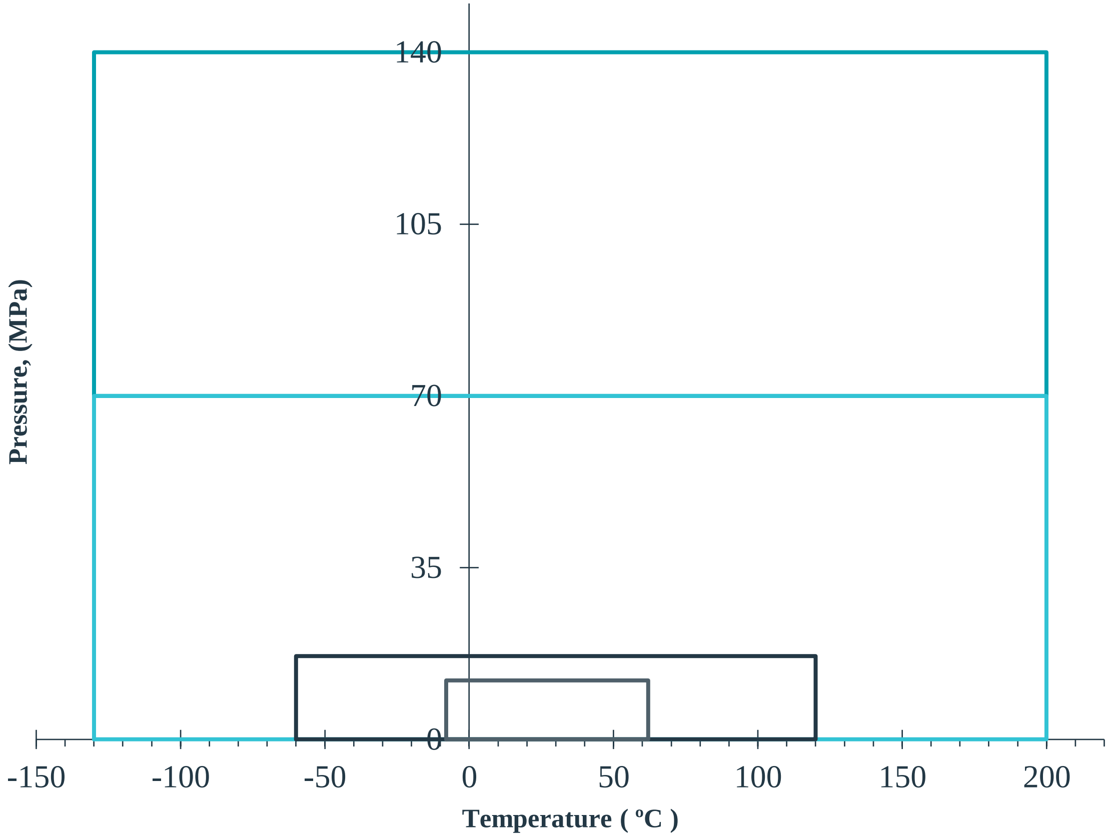
- Mixing rules dictate how molecules interact with each other



Thermodynamic Modelling

AGA-8 Model

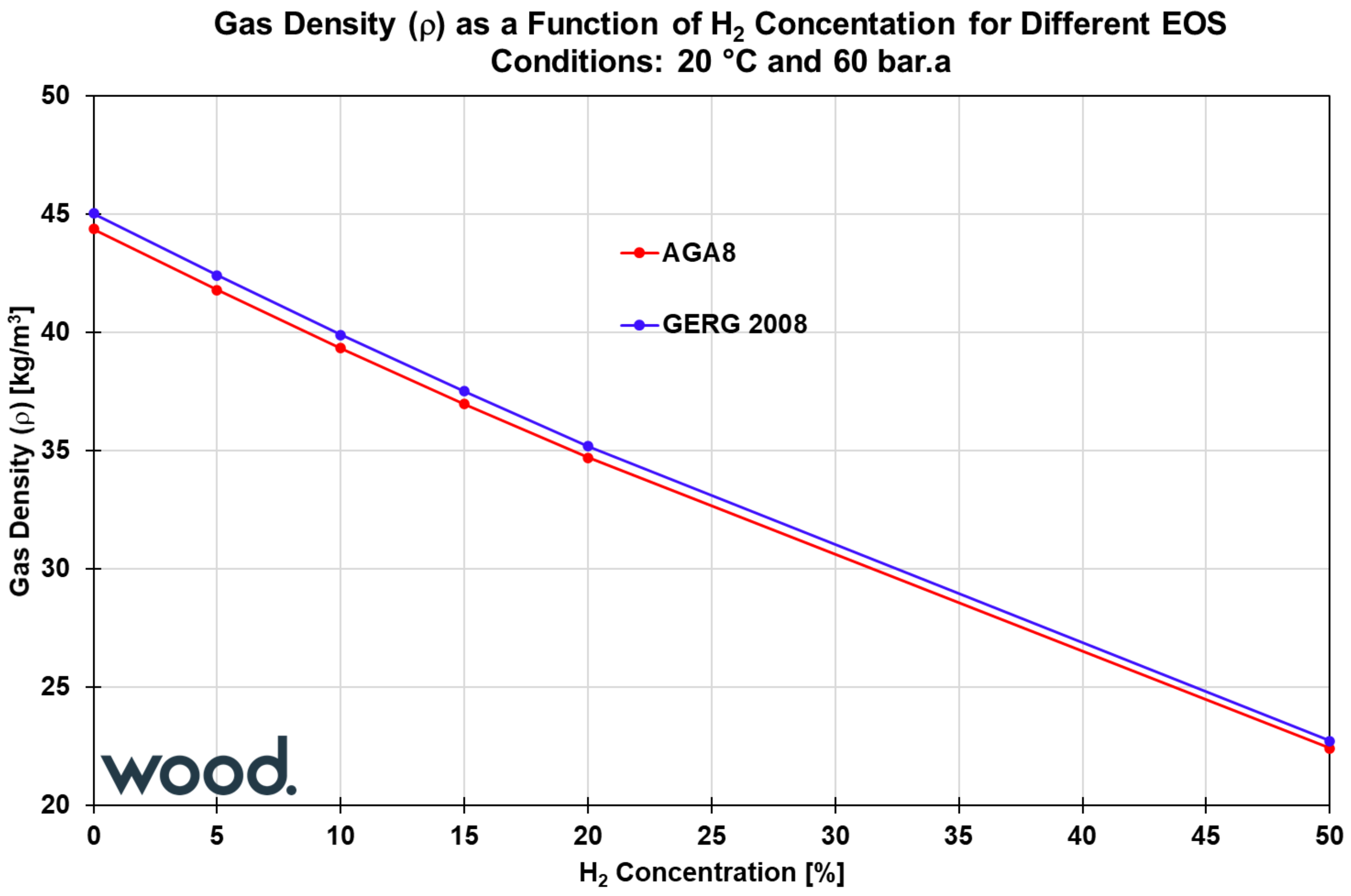
- This model can be applied for temperatures from -130°C to 400°C at pressures up to 280 MPa.



Thermophysical Properties

EoS

GERG 2008 Differs from AGA-8 By 1.5% for this Mixture

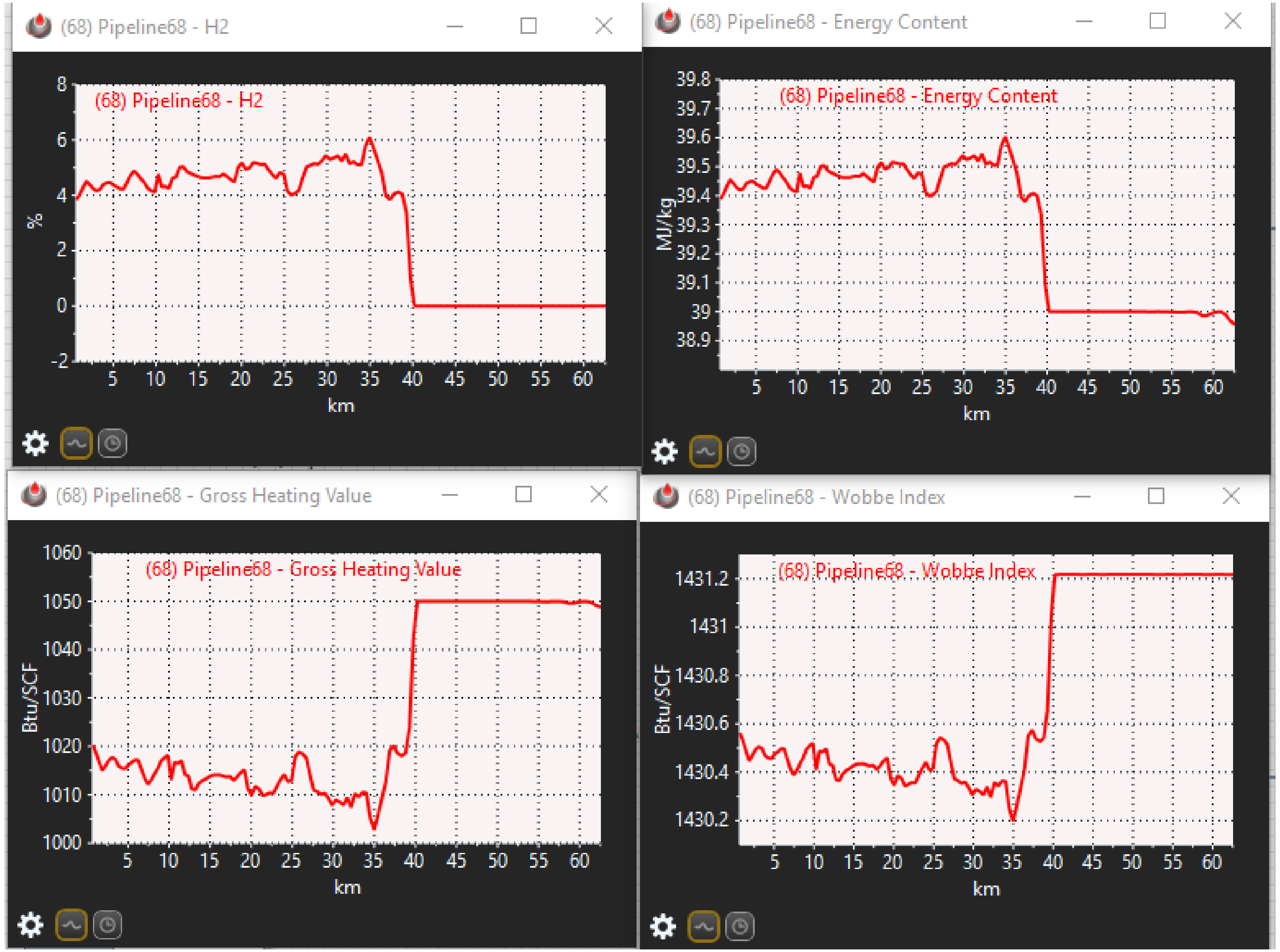


Key Points on H_2 Effect on Density

- Our work and literature show **error in density** predictions with H_2 mixtures can be around 2% higher than acceptable for custody transfer;
  - Significant issues for metering if not carefully considered
- **Lack of data** for wide range of multi-component mixtures which include H_2
  - Need more research
- Need to **know the H_2 concentration** accurately in a pipeline network because the effect of the MW is 4x that of the Z factor.
- Understand concentration distributions through tuned models
- A 1% increase in the H_2 concentration will approximately increase the Z factor by 1%

Energy Content is Tracked Like MW

On a volume basis, H_2 has a lower energy content than natural gas



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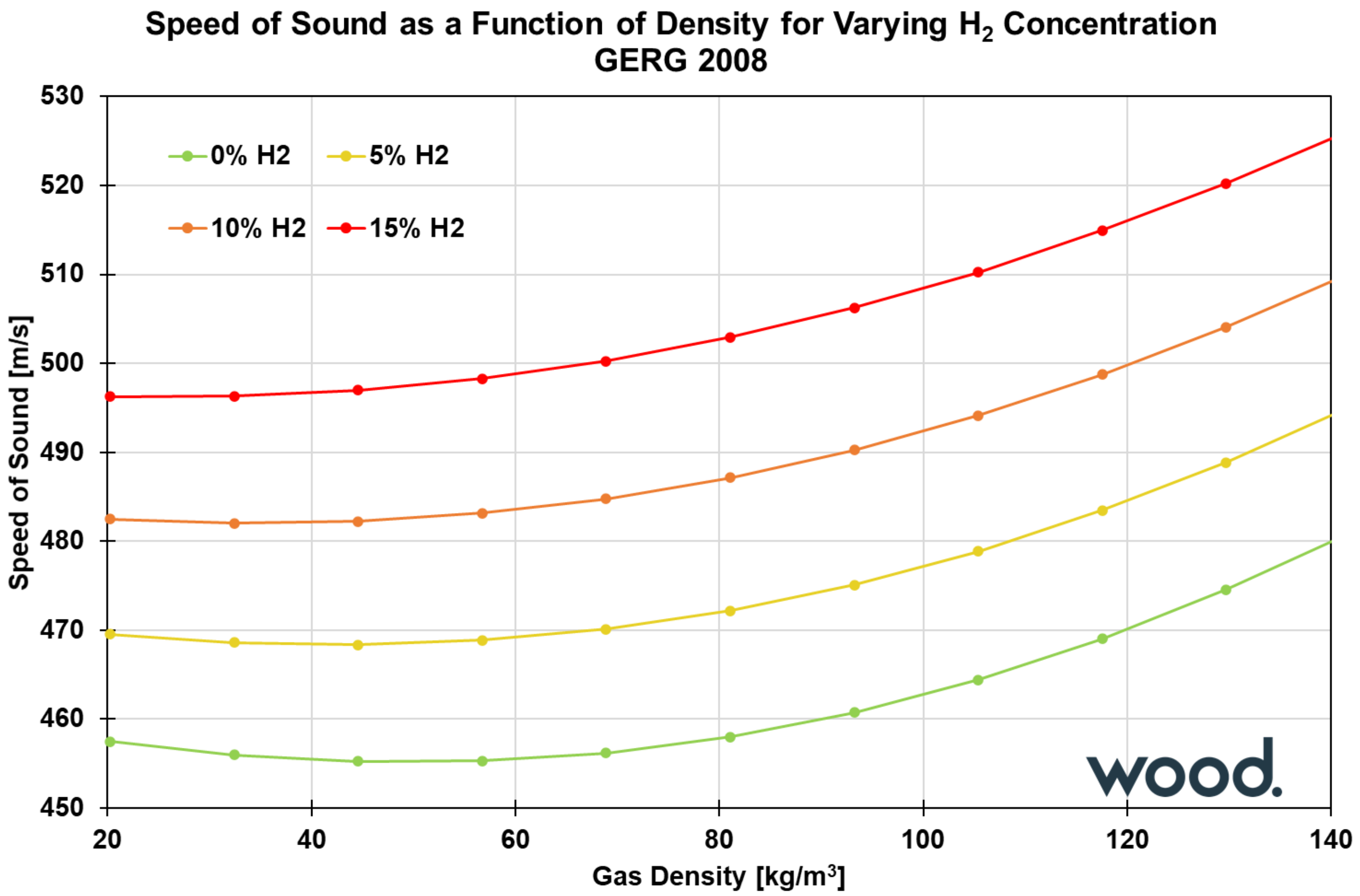
Thermo-Physical Properties

Speed of Sound

H_2 concentration has a large effect on the speed of sound within a normal pressure operating range

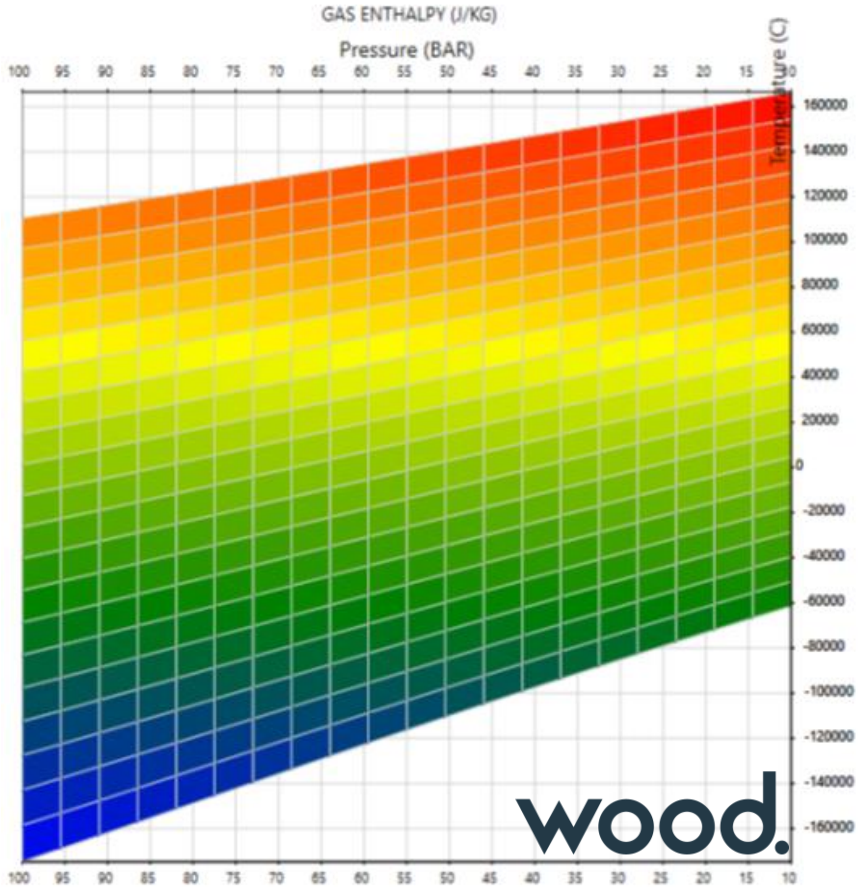


Thermo-Physical Properties

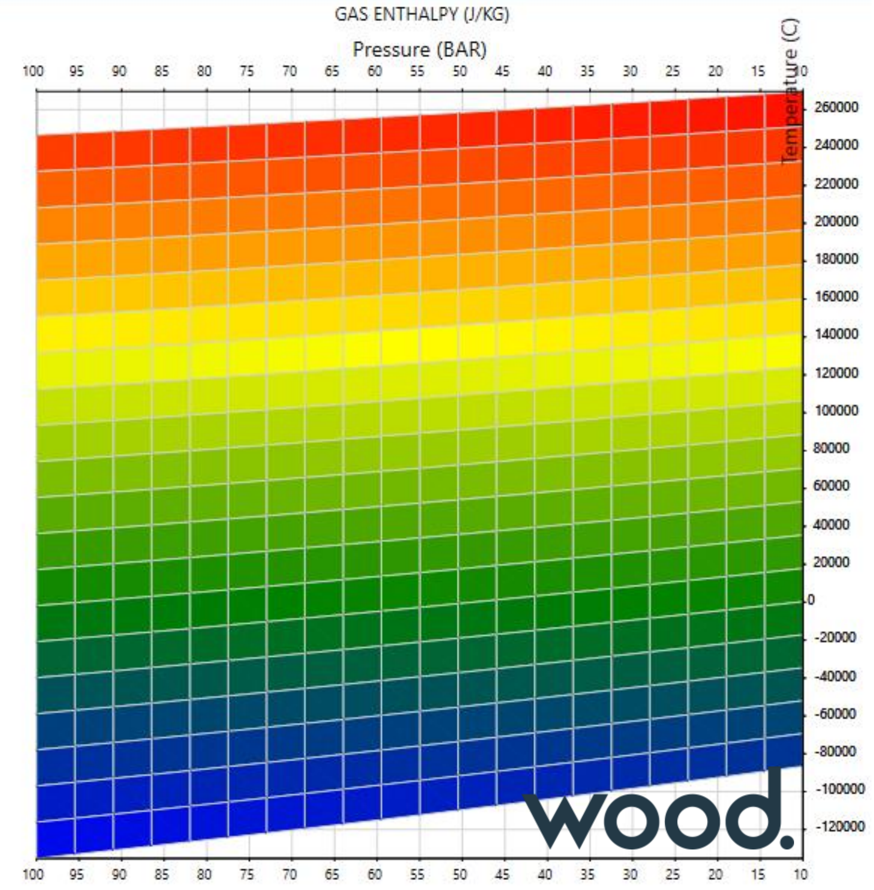
JT Co-efficients

More H_2 leads to less JT

0% H_2



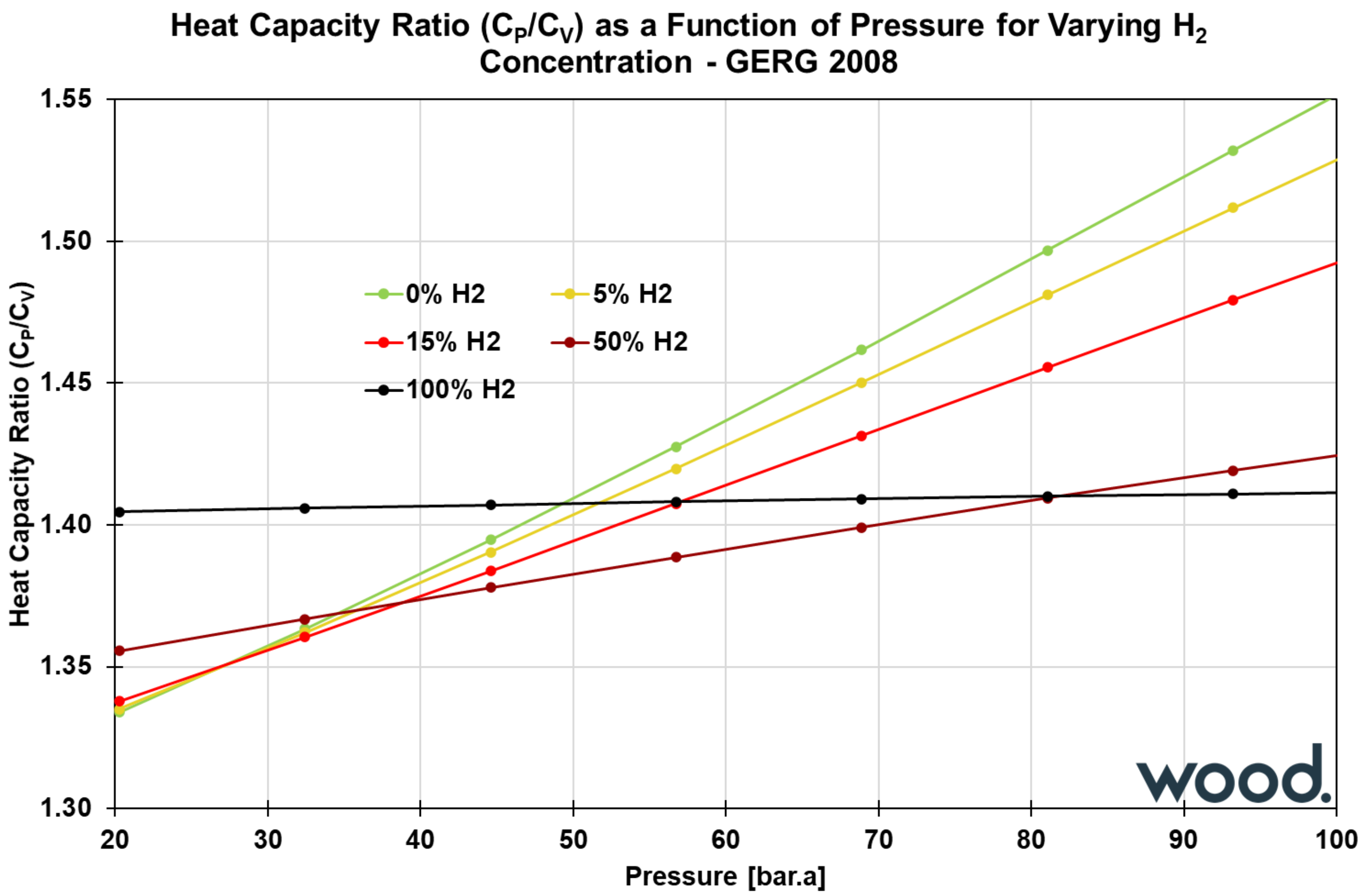
50% H_2



Thermo-Physical Properties

Heat Capacity Ratio

Compressor temperature calculations will be complex and uncertain



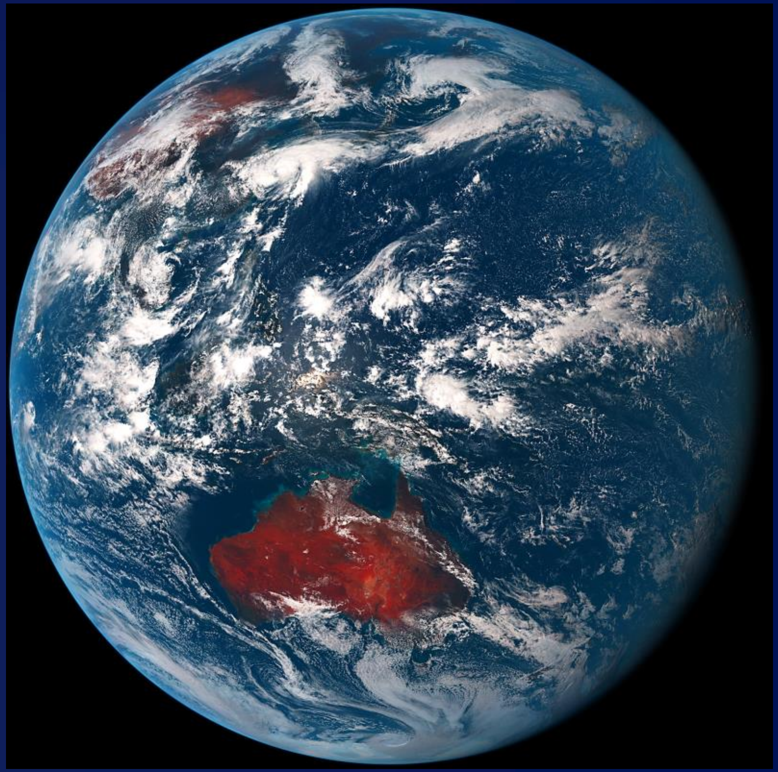
Dr. James Holbeach

H_2 CASE STUDIES

Virtuoso

10% of the world’s gas supply

Nothing new



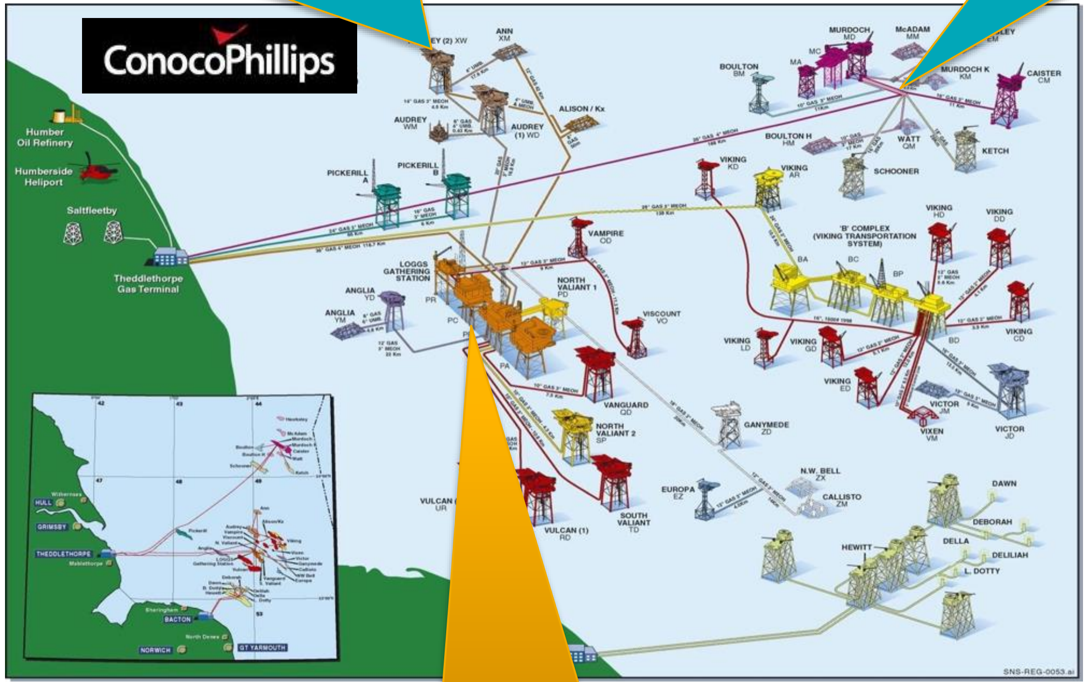
Earth from 35,800 km: 13th September 2021
Source: JAXA / JMA- Himawari 8

Closed loop control of Gas Blending – Southern North Sea

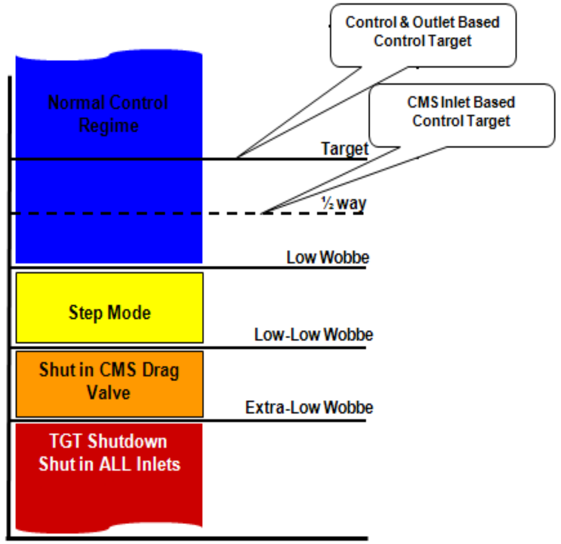
Production Optimization and Gas Blending Management

Virtuoso/Control controls gas blend in process facility to ensure low GCV gas is not exported to grid. Reaction time is < 2 mins.

Virtuoso/Control application controls 120 wells and over 10 infield flowlines



Virtuoso/Control application controls 140 wells and over 10 infield flowlines



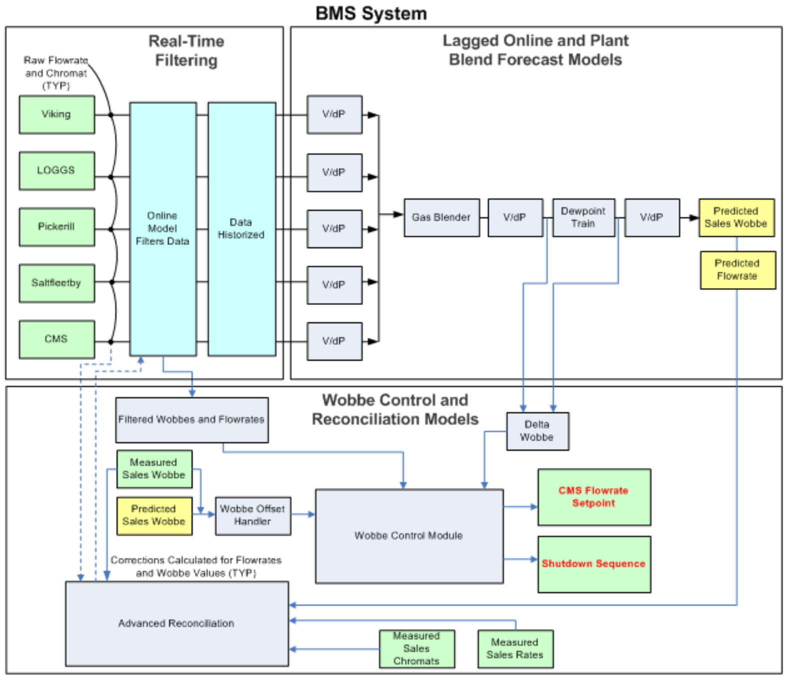
£5 Million penalty for delivering bad gas to the British Gas Grid

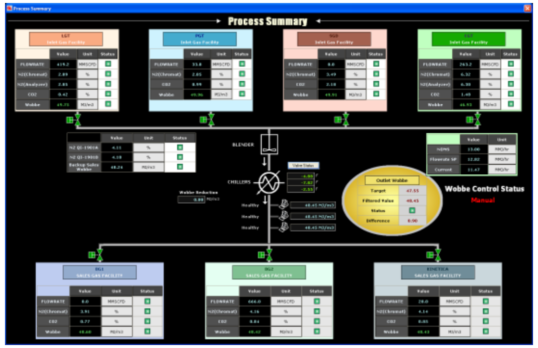
< Low Limit	Reduce Drag Valve to a Predefined Output Position
< Low-Low Limit	Close Drag Valve
< Extra-Low Limit	Close ALL gas inlets

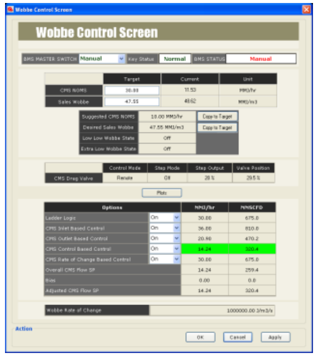
Virtuoso

Blending Management System (BMS)

- Wood provided a BMS system for ConocoPhillips:
  - Tracks the blend of CO_2/N_2 and the resulting Wobbe.
- Significant penalties, if deliver off spec gas.
- Some of the fields had gas which contained 18% N2
  - The fields could not be developed by themselves.
  - Mixing with good gas, client produced an extra $6 billion of revenue.
  - System tracked and blended gas from 5 different fields.
  - With very little modification, this system will work for H2.
- There has never been a case of getting bad gas into the network



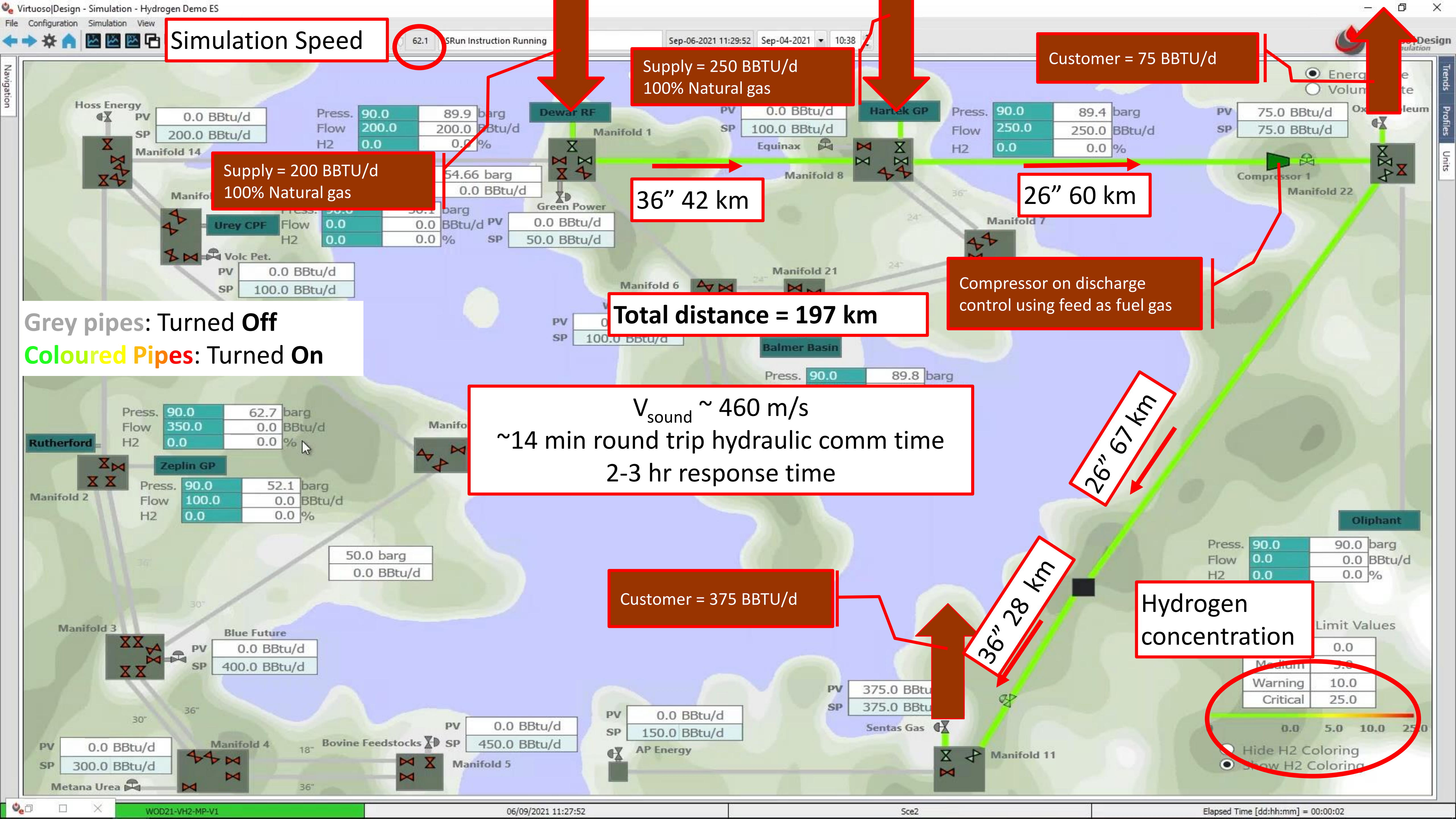


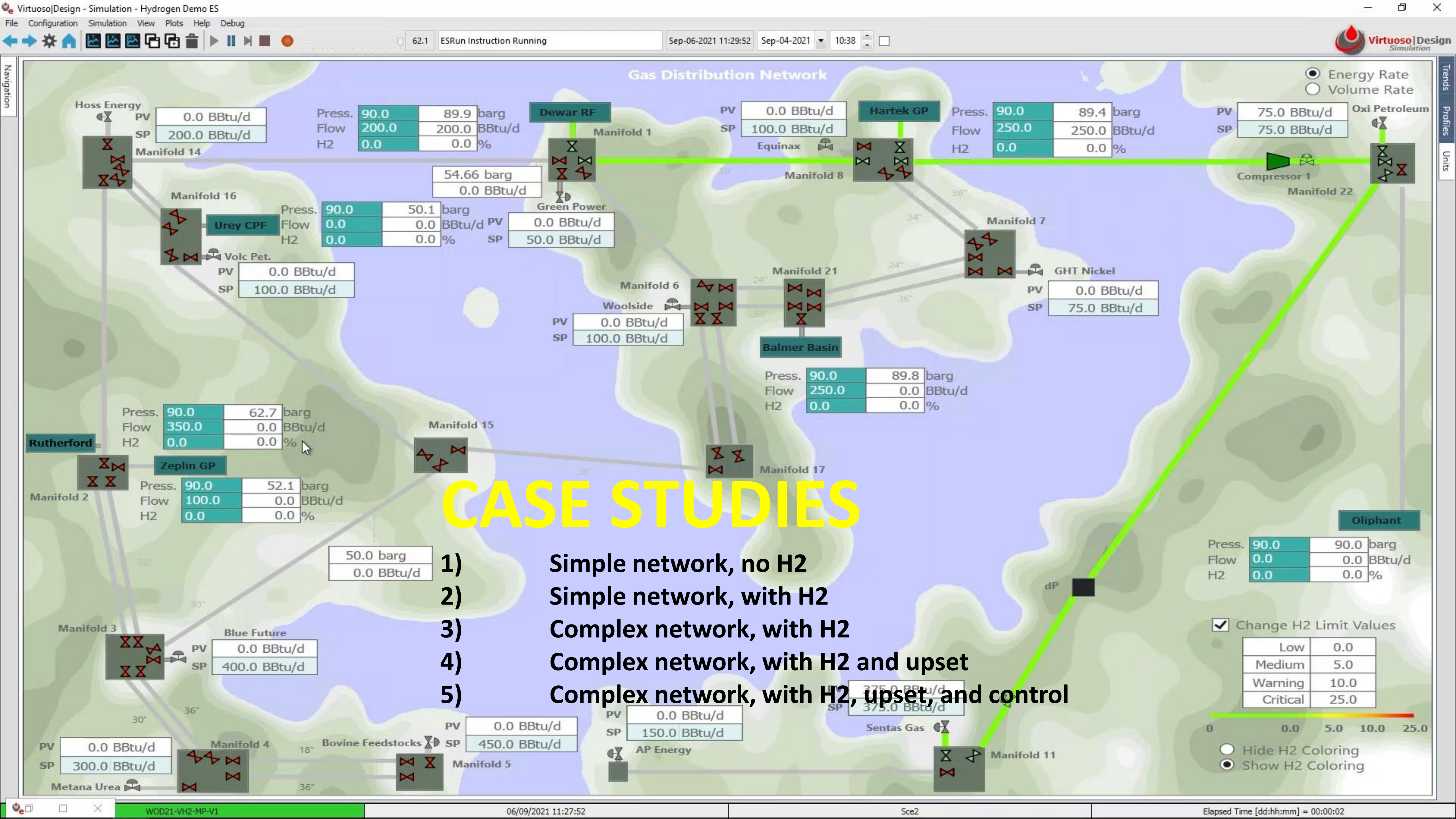


Kingoonya South Australia: 26th September 2019
Source: J. Holbeach

Cavendish

Hoss
Urey
Dewar
Tritania Island
Hartek
Oxalana
Mt Greyson
Grethon
Perta
Deut Plains
Rutherford
Aquagreen
Zeplin
Trit Downs
Oliphant
Protonia
Electrona
Warnable
Janr Lmao
Lavoisier
Metanal


Simulation Speed
Supply = 250 BBTU/d
100% Natural gas
Customer = 75 BBTU/d
Supply = 200 BBTU/d
100% Natural gas
36" 42 km
26" 60 km
Compressor on discharge
control using feed as fuel gas
Total distance = 197 km
Grey pipes: Turned Off
Coloured Pipes: Turned On
V_sound ~ 460 m/s
~14 min round trip hydraulic comm time
2-3 hr response time
26" 67 km
36" 28 km
Customer = 375 BBTU/d
Hydrogen concentration



CASE STUDIES

1) Simple network, no H2
2) Simple network, with H2
3) Complex network, with H2
4) Complex network, with H2 and upset
5) Complex network, with H2, upset, and control

Summary

Different:	• H_2 is not like natural gas nor other inerts (N_2/CO/CO_2/H_2O)
Tools:	• Standard natural gas models wont work. Use the right tool. MPEOS required- we recommend GERG 2008. Compositional transient modelling required
Operations:	• Transient operations will likely need to be considered vs. typical pseudo steady state ops
Reinvent the wheel:	• We are not: This has been done before but issues consider early, as H_2 is different
Metering:	• Will need to be updated. Need to correctly account for composition, use different models and factor in GC capabilities
Accuracy:	• There are currently significant gaps in the data; understand what are the uncertainties and how will they impact, ops and commercials

Moderated Q&A

Contact Card

Email us

Crux: "Southern Cross" 18th April 2021
Source: J. Holbeach

Further information:

woodplc.com/intelligentops
IntelligentOps@woodplc.com