Webinars

wood.

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Introduction

Context – evolution of operational (digital) simulators

Getting ready for energy transition for H2 and CO2 capture

Leveraging of data for smoother operation of assets

Production monitoring and surveillance

Meters factor & errors in production allocation

Summary and Q&A

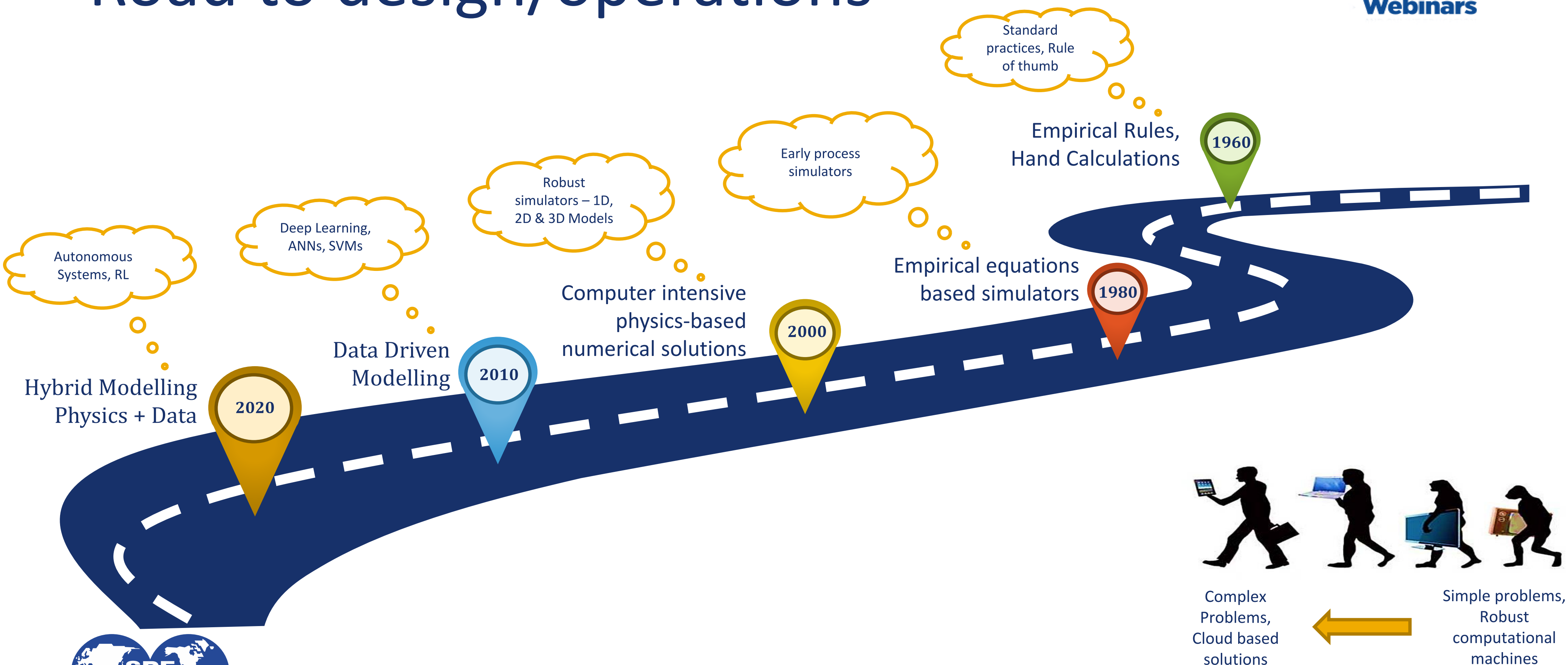
Presenters:
Temitope Solanke (Wood)
Dr Dale Erikson (Wood)

Special Thanks to:
Dr Hooman Haghighi (Wood)
Dr James Holbeach (Wood)
Abhinav Priyadarshi (Wood)

Milky Way, from Perth, Western Australia: 13th April 2021
Source: J. Holbeach

Evolution of operational (digital) simulators

Road to design/operations



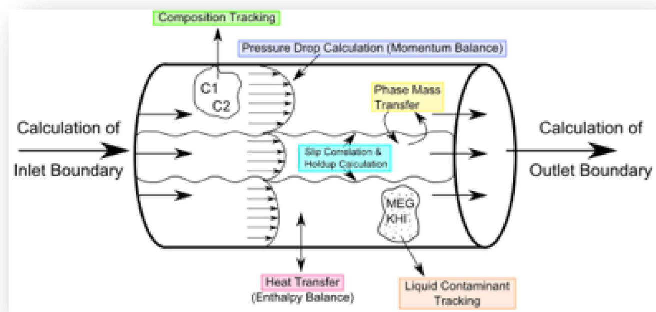
Physics based modelling

Degree of Complexity

Lumped Models

1D Models

3D Models

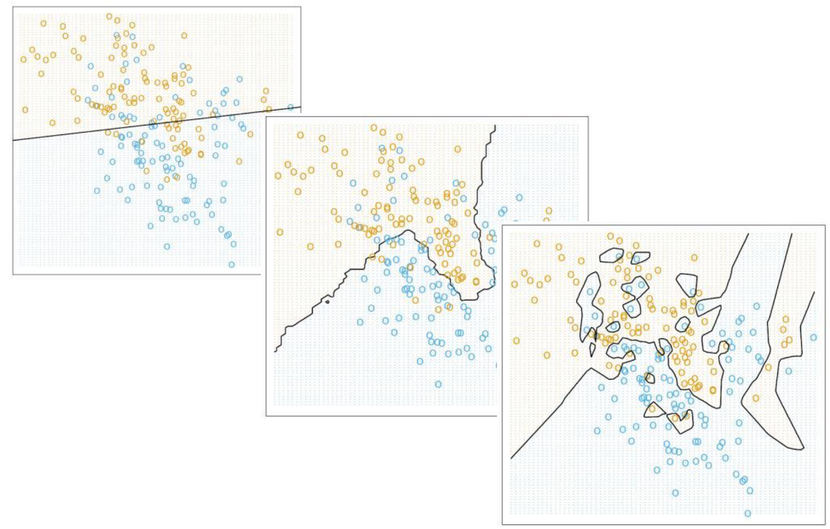


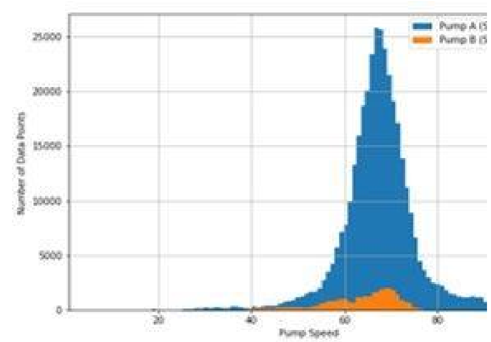
$$\frac{\partial \rho_i A_i v_i}{\partial t} + \frac{\partial \rho_i A_i v_i^2}{\partial x} = -A_i \frac{\partial p}{\partial x} - \rho_i g \cos\alpha A_i \frac{\partial h}{\partial x} - \rho_i g \sin\alpha A_i + \tau_j s_j - \tau_i s_i + \psi_i v_i$$

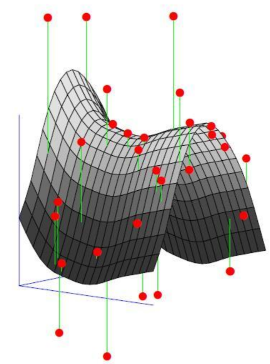
Data driven modelling

Data Driven models with different degrees of freedom

- **High Bias Model**
  - Linear or Logistic Classification and Regression Models (requires sparse data)
  - Quick to train, interpretability is high with low variance
  - Struggles to capture the behaviour of non-linear physical phenomena
- **Moderate Bias Models**
  - Support Vector Machines or shallow neural networks (requires limited data)
  - Training time is limited, less interpretability & higher variance compared to high bias model
  - Can capture many non-linear behaviour
- **Low Bias Models**
  - Deep Neural Networks (ANN, RNN requires large amount of data)
  - High training time, requires parallelisation, very limited interpretability
  - Extremely flexible models to capture complex behaviour of systems





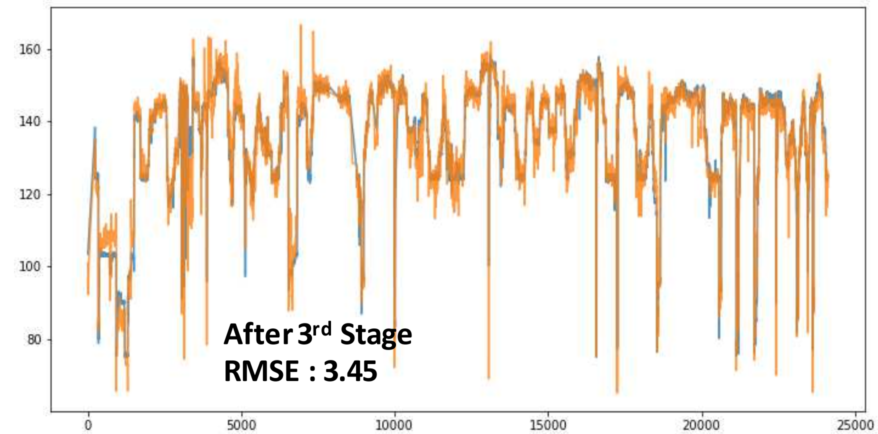


Ref: Friedman J., Hastie T.,Robert T. The Element of Statistical Learning, 2nd Edition, 2008

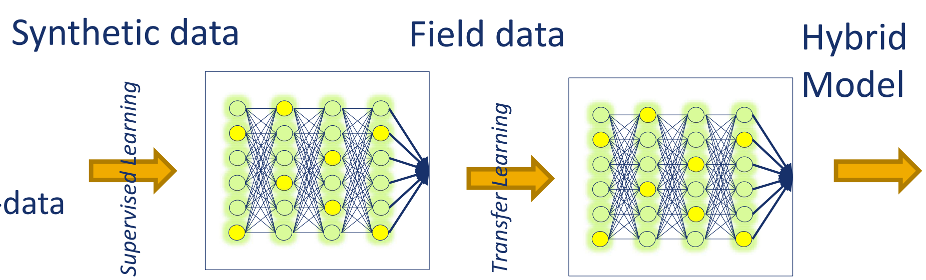
Hybrid modelling

- **Combination of Data Driven and Physics Based Models**

- **Tuning Parameters in Physics Based Models**
  - Requires domain knowledge to identify parameters
  - Automated optimisation solution to obtain the tuned parameters
  - Degree of flexibility dependent on SME defined models



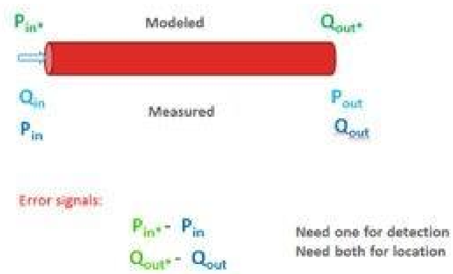
- **Combination of Simulated and Real field data for AI models**
  - High complexity models (typically ANN) trained on synthetic data generated using simulations
  - Trained model captures the physical behaviour of the system
  - Transfer learning techniques to further tune the AI models using real-data

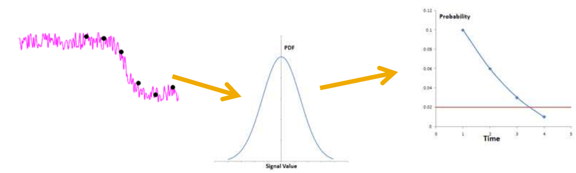


Anomaly detection

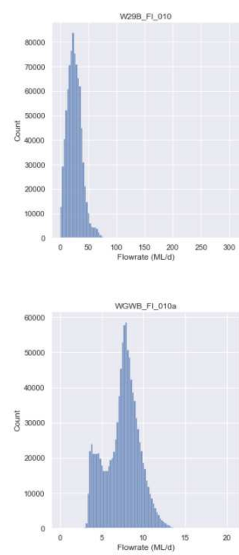
- **Model Based Anomaly Detection**
  - Benchmark physics based model
  - Comparison of model prediction vs real-field data
  - Typical used in Leak Detection, predictive maintenance

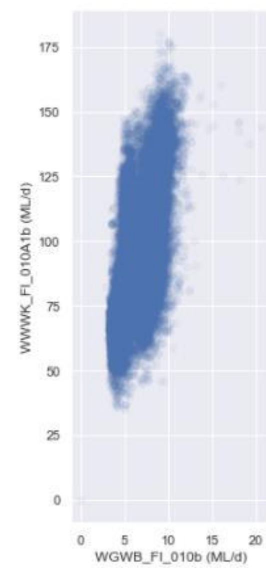
- **Stochastic Process Anomaly Detection**
  - Multivariate distribution
  - Using stochastic PDE fit probability distribution of output variable
  - Use Monte Carlo simulation for anomaly detection

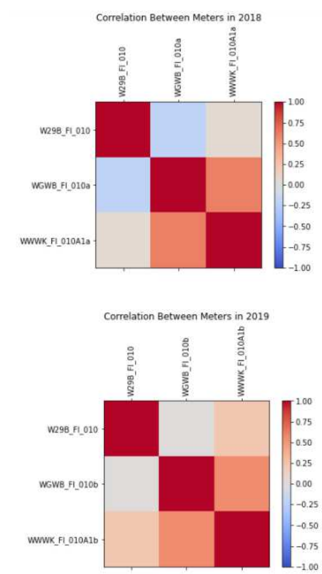




Field-specific statistical model to assess whether observed events are unlikely to represent normal pipeline behavior.







Operational digital transformation

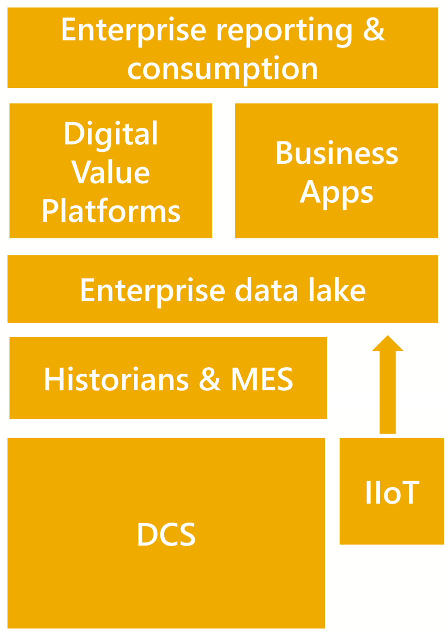
Webinars

Current

Cloud

Traditional engineering applications
Cloud platforms becoming normal
Dependence on Historians to channel traditional data

Edge
Large DCS
Hardware dominated
CAPEX heavy
OEM dependant

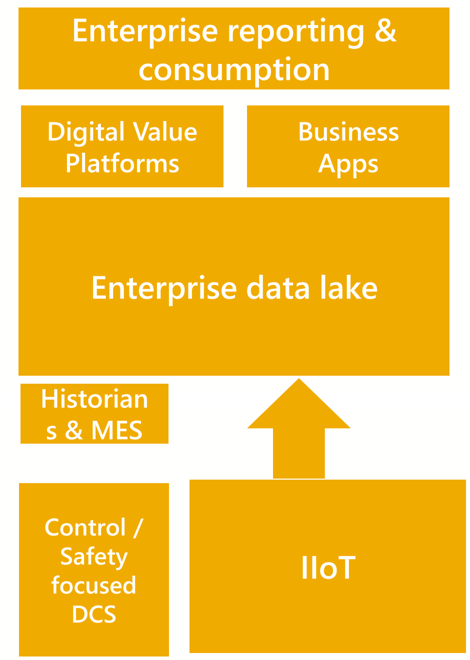


Future

Cloud

Open platforms – AI, stochastic solutions
Increase in available applications
More data, and data types, direct to Cloud via IIoT

Edge
Smaller DCS
Growth in IOT
Growth in Edge solutions



SPE International

Getting ready for energy transition for H2 and CO2 capture

1. Digital Twin Technology for H2 Transport
2. Digital Twin Technology for CCS and Transport

Digital twin technology for H2 transport

Opportunities across the hydrogen value chain

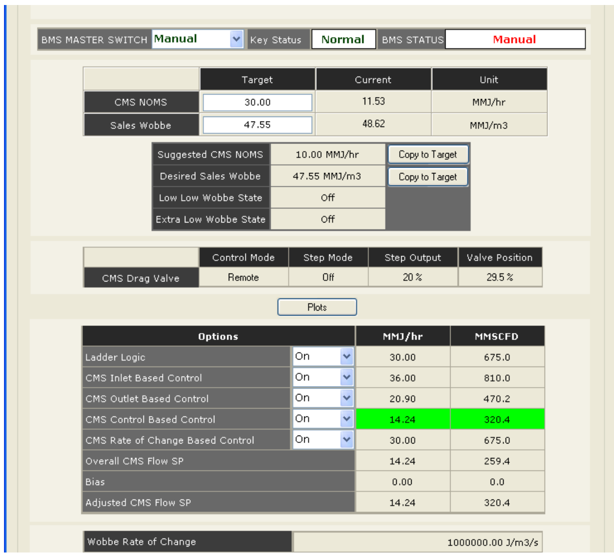
Webinars

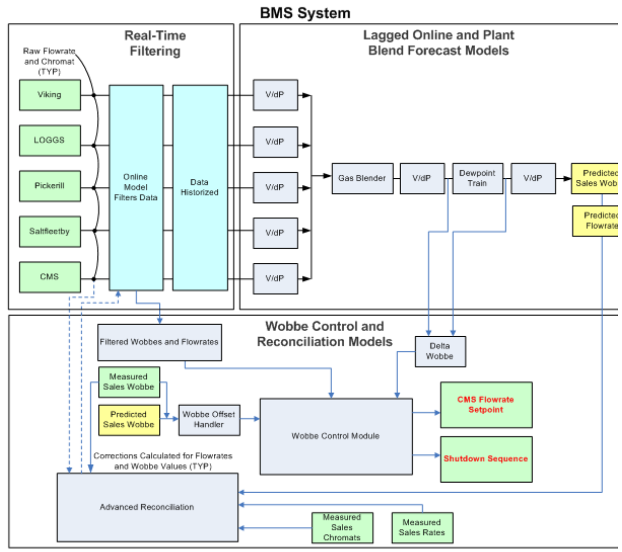
We see significant challenges and **opportunities** across hydrogen value chain:

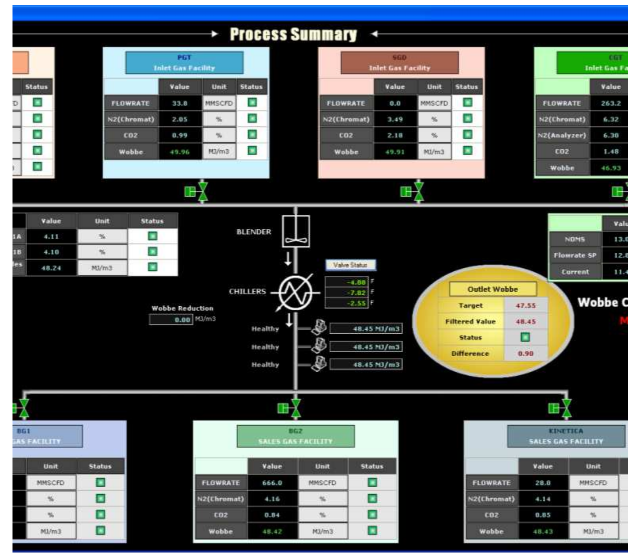
Making it.

Moving it.

Using it.







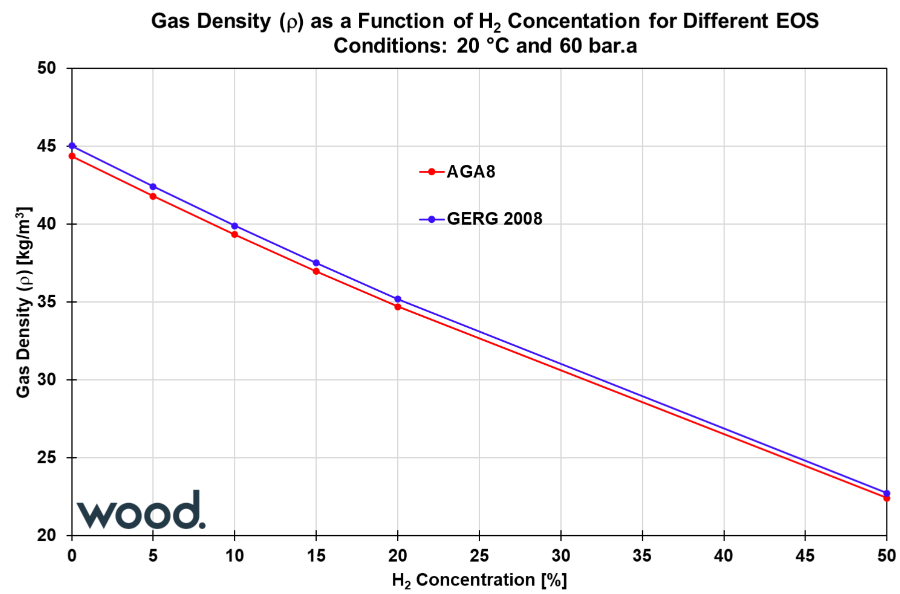
Blending Management System (BMS)

- Wood provided a BMS system for the client in the North Sea Region:
  - 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% N_2
  - the fields by themselves could not be developed.
  - 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 H_2.
- There has never been a case of getting bad gas into the network

Themo-physical properties - H2 vs NG

Density

- Gas density is important for predicting pressure drop in pipeline networks –
- Our work and literature show **error in density** predictions with H_2 mixtures can be around 2% higher than acceptable for custody transfer;
- **Lack of data** for wide range of multi-component mixtures which include H_2

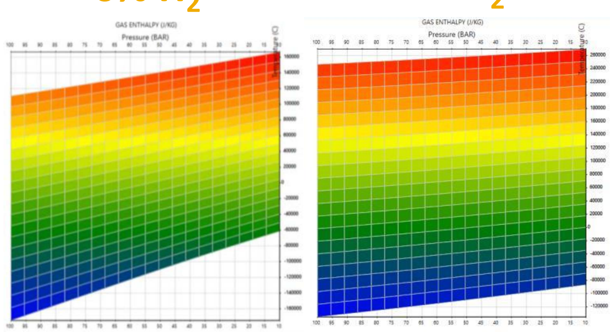


Significant issues for metering if not carefully considered

Themo-physical properties - H2 vs NG

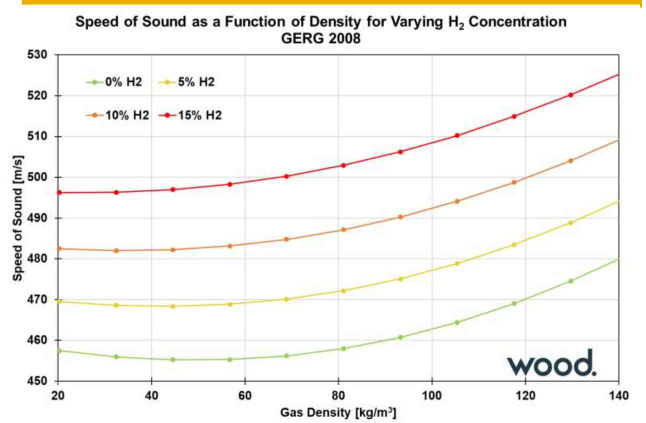
J-T Effect

0% H_2 50% H_2



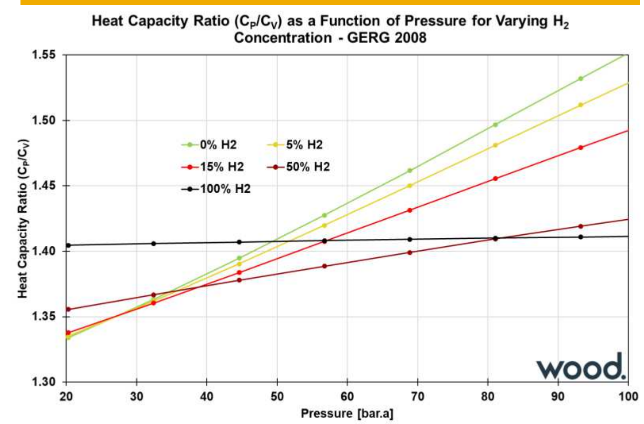
- More H_2 leads to less JT

Speed of Sound



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

Thermal Properties



- Compressor temperature calculations will be complex and uncertain

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

Virtuoso® - Industry Accomplishments

Delivered field-proven solutions for design, asset operations management & optimisation

Ensured delivery of **over 200 BCM of natural gas to Europe** since 2012.

Monitors and assures **10% of the world's gas supply and 30% world's LNG and the largest CO_2 injection system in the world and has been further advanced for H_2 tracking.**

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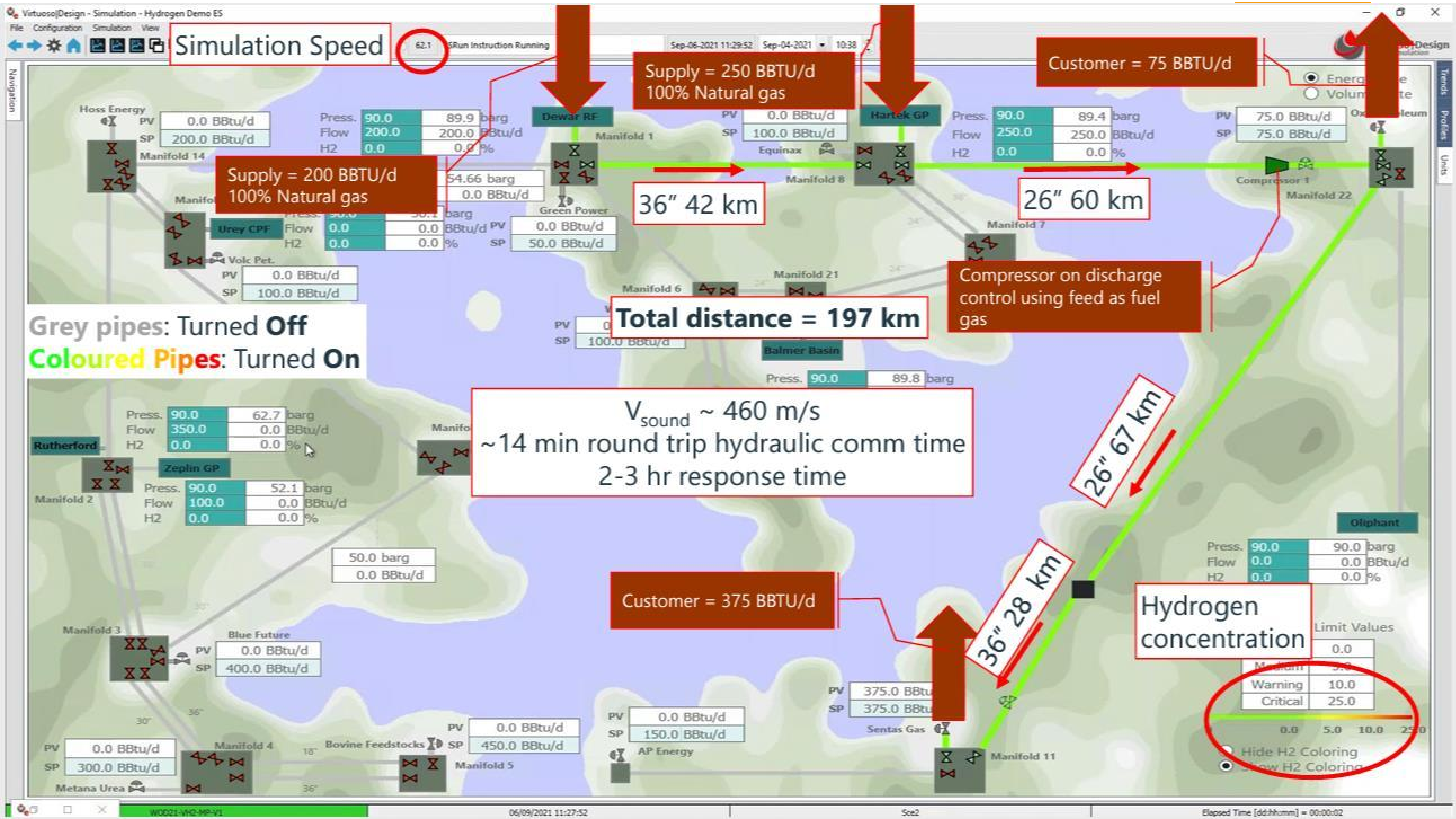
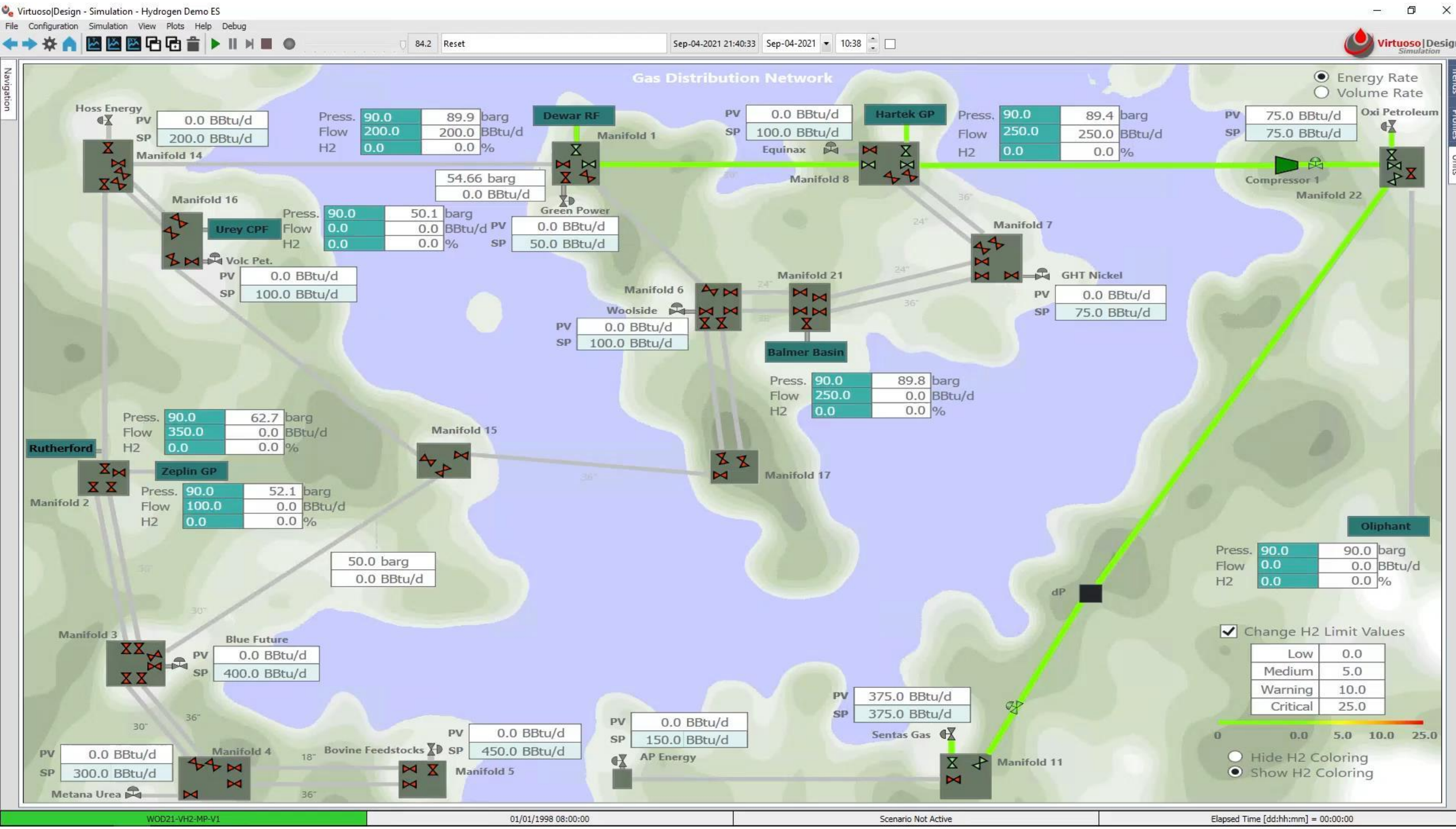
Repurposing and Operation

- **Integrity/safety aspects:**
  - Impact of hydrogen blending ratio and pressure on embrittlement, crack growth acceleration, burst/fatigue resistance of defects located in welds and growth acceleration, increased leakage;
  - Pipeline monitoring and maintenance practices and establishing a methodology (based on steel strength, chemical composition, years of exploitation, etc);
  - Establish a diagnostic on the Pipeline Management System (e.g. if the inspection approach is sufficient for operation and integrity management).
- **Operation Monitoring Aspects:**
  - Online & Offline Monitoring and Hydrogen Tracking and Distribution, e.g. for integrity reasons and also ensuring the Wobbe index is consistent and meets contractual obligations for all customers;
  - Impact of hydrogen blends on the accuracy of existing gas meters.

Cavendish


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


Simulation Speed
Supply = 200 BBTU/d
100% Natural gas
Supply = 250 BBTU/d
100% Natural gas
Customer = 75 BBTU/d
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
Dewar RF
Manifold 1
Hartek GP
Manifold 8
Manifold 7
Manifold 6
Manifold 21
Manifold 22
Compressor 1
Manifold 11
Manifold 14
Manifold 2
Manifold 3
Manifold 4
Manifold 5
Hoss Energy
Urey CPF
Volc Pet.
Green Power
Equinax
Balmer Basin
Rutherford
Zeplin GP
Blue Future
Bovine Feedstocks
Metana Urea
AP Energy
Sentas Gas
Oliphant
Limit Values
Warning
Critical
Hide H2 Coloring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View
Plots
Help
Debug
84.2
Reset
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Sep-04-2021
10:38
Virtuoso|Design
Simulation
Navigation
Trends
Profiles
Units
Gas Distribution Network
Energy Rate
Volume Rate
Hoss Energy
PV 0.0 BBtu/d
SP 200.0 BBtu/d
Manifold 14
Press. 90.0 89.9 barg
Flow 200.0 200.0 BBtu/d
H2 0.0 0.0 %
Dewar RF
Manifold 1
54.66 barg
0.0 BBtu/d
Green Power
PV 0.0 BBtu/d
SP 50.0 BBtu/d
PV 0.0 BBtu/d
SP 100.0 BBtu/d
Equinax
Hartek GP
Manifold 8
Press. 90.0 89.4 barg
Flow 250.0 250.0 BBtu/d
H2 0.0 0.0 %
PV 75.0 BBtu/d
SP 75.0 BBtu/d
Oxi Petroleum
Compressor 1
Manifold 22
Manifold 16
Urey CPF
Press. 90.0 50.1 barg
Flow 0.0 0.0 BBtu/d
H2 0.0 0.0 %
Volc Pet.
PV 0.0 BBtu/d
SP 100.0 BBtu/d
Manifold 7
GHT Nickel
PV 0.0 BBtu/d
SP 75.0 BBtu/d
Manifold 6
Woolside
PV 0.0 BBtu/d
SP 100.0 BBtu/d
Manifold 21
Balmer Basin
Press. 90.0 89.8 barg
Flow 250.0 0.0 BBtu/d
H2 0.0 0.0 %
Press. 90.0 62.7 barg
Flow 350.0 0.0 BBtu/d
H2 0.0 0.0 %
Rutherford
Zeplin GP
Manifold 2
Press. 90.0 52.1 barg
Flow 100.0 0.0 BBtu/d
H2 0.0 0.0 %
Manifold 15
Manifold 17
Oliphant
Press. 90.0 90.0 barg
Flow 0.0 0.0 BBtu/d
H2 0.0 0.0 %
50.0 barg
0.0 BBtu/d
dP
Change H2 Limit Values
Low 0.0
Medium 5.0
Warning 10.0
Critical 25.0
0 0.0 5.0 10.0 25.0
Hide H2 Coloring
Show H2 Coloring
Manifold 3
Blue Future
PV 0.0 BBtu/d
SP 400.0 BBtu/d
PV 375.0 BBtu/d
SP 375.0 BBtu/d
Sentas Gas
Manifold 11
PV 0.0 BBtu/d
SP 150.0 BBtu/d
AP Energy
PV 0.0 BBtu/d
SP 450.0 BBtu/d
Bovine Feedstocks
Manifold 5
Manifold 4
PV 0.0 BBtu/d
SP 300.0 BBtu/d
Metana Urea
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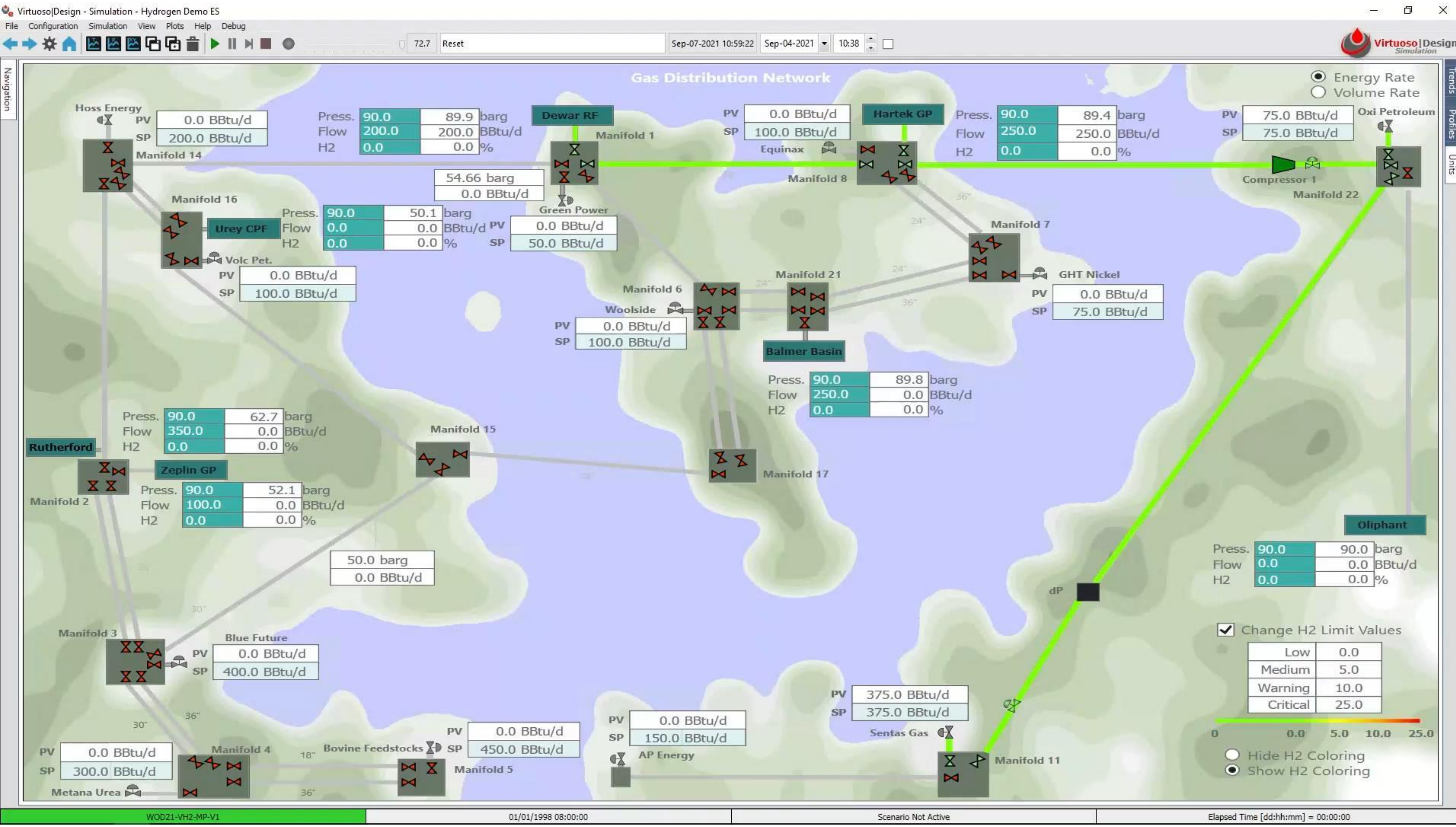

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Virtuoso|Design Simulation
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PV 375.0 BBtu/d
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Manifold 5
Manifold 4
PV 0.0 BBtu/d
SP 300.0 BBtu/d
Metana Urea
36"
24"
30"
18"
WOD21-VH2-MP-V1
01/01/1998 08:00:00
Scenario Not Active
Elapsed Time [dd:hh:mm] = 00:00:00

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

Karroun Hill NR: 31st August 2019
Source: J. Holbeach

Digital Twin Technology for CCS

The status of CCS (2020)

- Today, there are 65 commercial CCS facilities:
  - 26 are operating;
  - Two have suspended operations – one due to the economic downturn, the other due to fire;
  - Three are under construction;
  - 13 are in advanced development reaching front end engineering design (FEED);
  - 21 are in early development.

Ref: Global CCS Institute

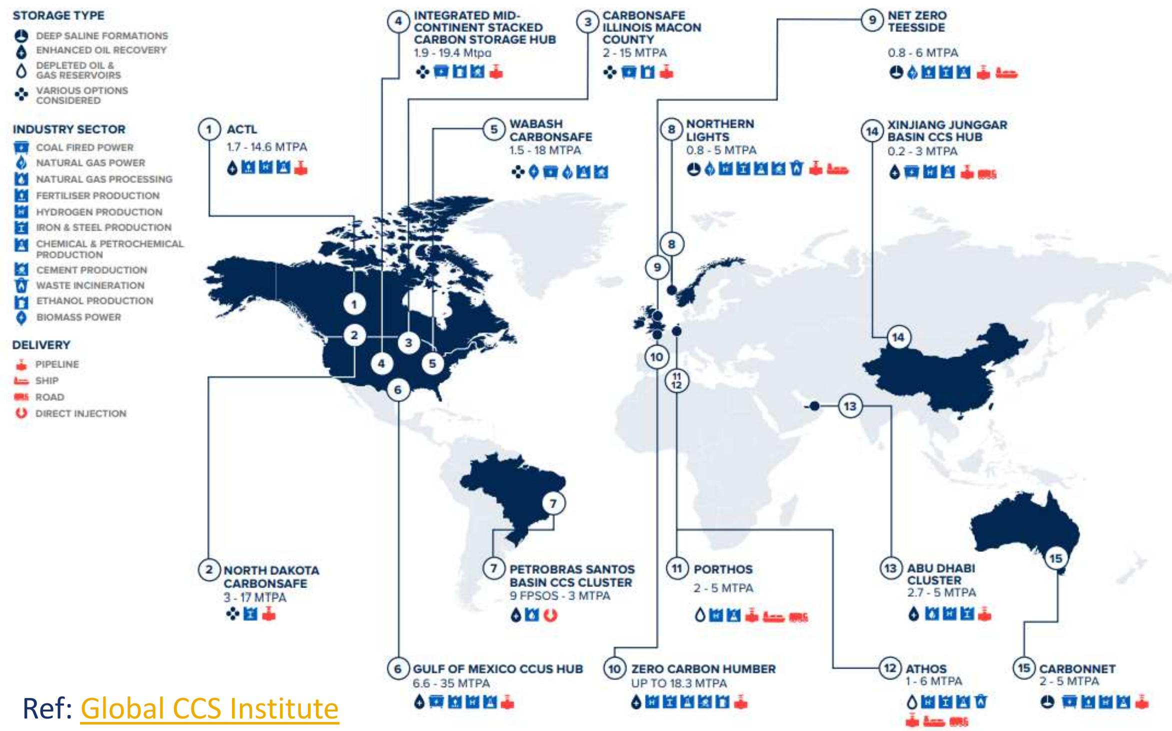
Meeting the goals of the Paris Agreement require:

- Capture facilities to increase x 100 to > 2,000 by 2050 (70-100 built each year)
- 200,000 km of pipeline by 2050, with an average pipeline build rate of 5,200-7,200 km per year
- 400 storage sites would be needed with 10-30 being established each year (capacity of 1 BCF of CO_2)

Hubs and clusters (2020)

- In 2040: 35E12 kg/year = 1.1 Million Kg/Sec

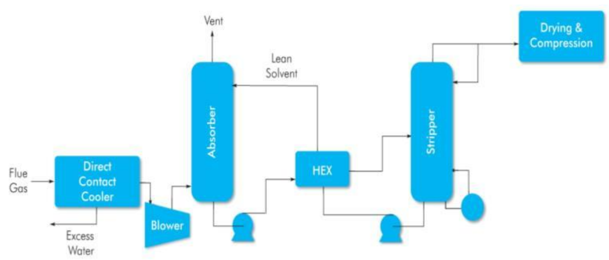
- This means world will need 10,000 storage facilities with capacity over 100 kg/Sec (200 MMSCFD) or 100-300 CCS units per year.

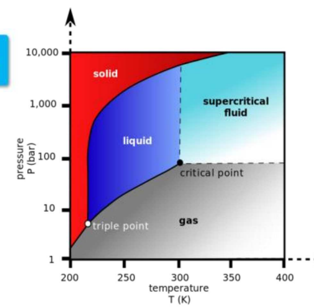


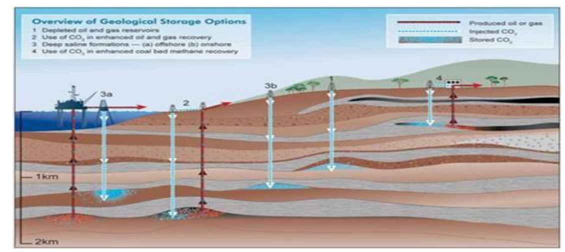
Ref: [Global CCS Institute]()

What Wood does

Full-chain experience, from Carbon Capture to Transportation and Storage







Carbon Capture

- Pre/Post/Oxy Combustion
- Physical, Chemical and Hybrid solvents
- Novel technologies including membranes, adsorbents, physical separation, fuel cells
- Licensed technologies evaluation
- Novel technology assessment
- Direct Air Capture & Bioenergy CCS

Transportation

- Transmission pipelines & gathering networks (onshore, offshore, liquid/gas/dense phase),
- Ship transport (CO_2 liquefaction, jetties, storage)
- Materials and corrosion
- Dynamic behaviour
- Flow assurance, CFD modelling,

Storage

- Well integrity modelling and assessment
- Specialised flow modelling, CFD
- Transient operations modelling
- Design & Modelling of CO_2 injection operations (online & offline)
- CO_2 injection into aquifers, water chemistry/ salinity considerations

from development to decommissioning

CO_2 injection monitoring

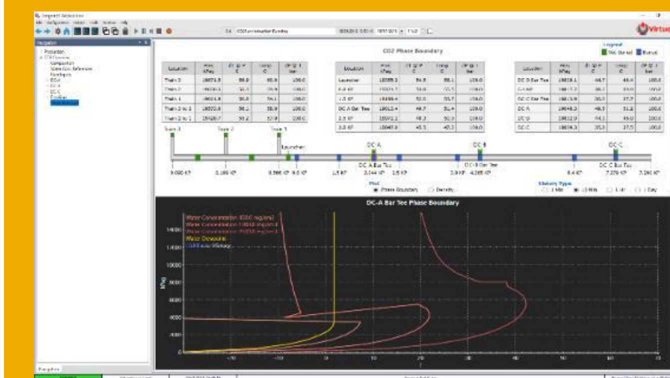
- Wood's Virtuoso:
- Manages CO_2 injection process and monitors operational integrity
- Virtual Flow Metering
- Models flow from the outlet of the compressors to the bottom of the injection well
- Handles steady-state and transient operations
- Online Monitoring and Forecast/Advisor
  - Operating Envelope Advisor
  - Captures system behaviour during steady state and transient operations.
  - Monitors and tracks water content, pressure and temperature, BTEX, and corrosion rates along the flowline and provides well integrity status.
  - Incorporates Wood's specialised CO_2 / water thermodynamic model for improved thermo-physical property predictions at various conditions, including impact of impurities and contaminants.
- Planning Engineering Simulator / Tool

Industry accomplishments

Delivered field-proven solutions for design, asset operations management & optimisation

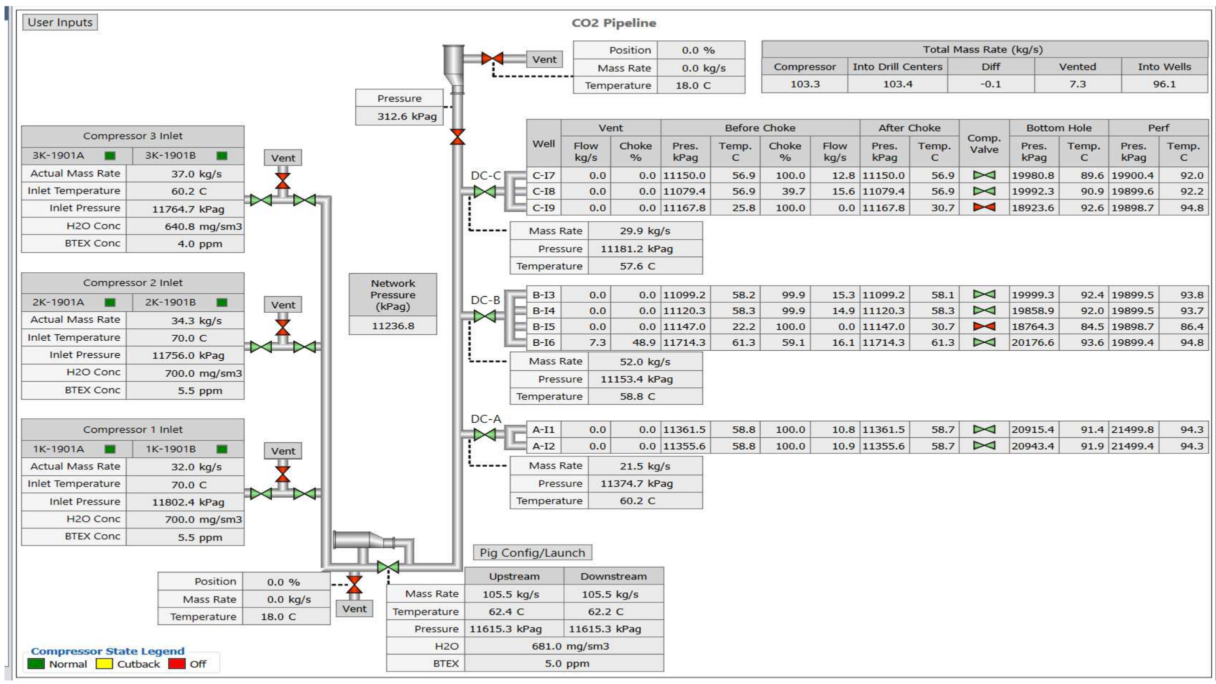
Ensured delivery of **over 200 BCM of natural gas to Europe** since 2012

Monitors and assures **10% of the world's gas supply and 30% world's LNG and the largest CO_2 injection system in the world**

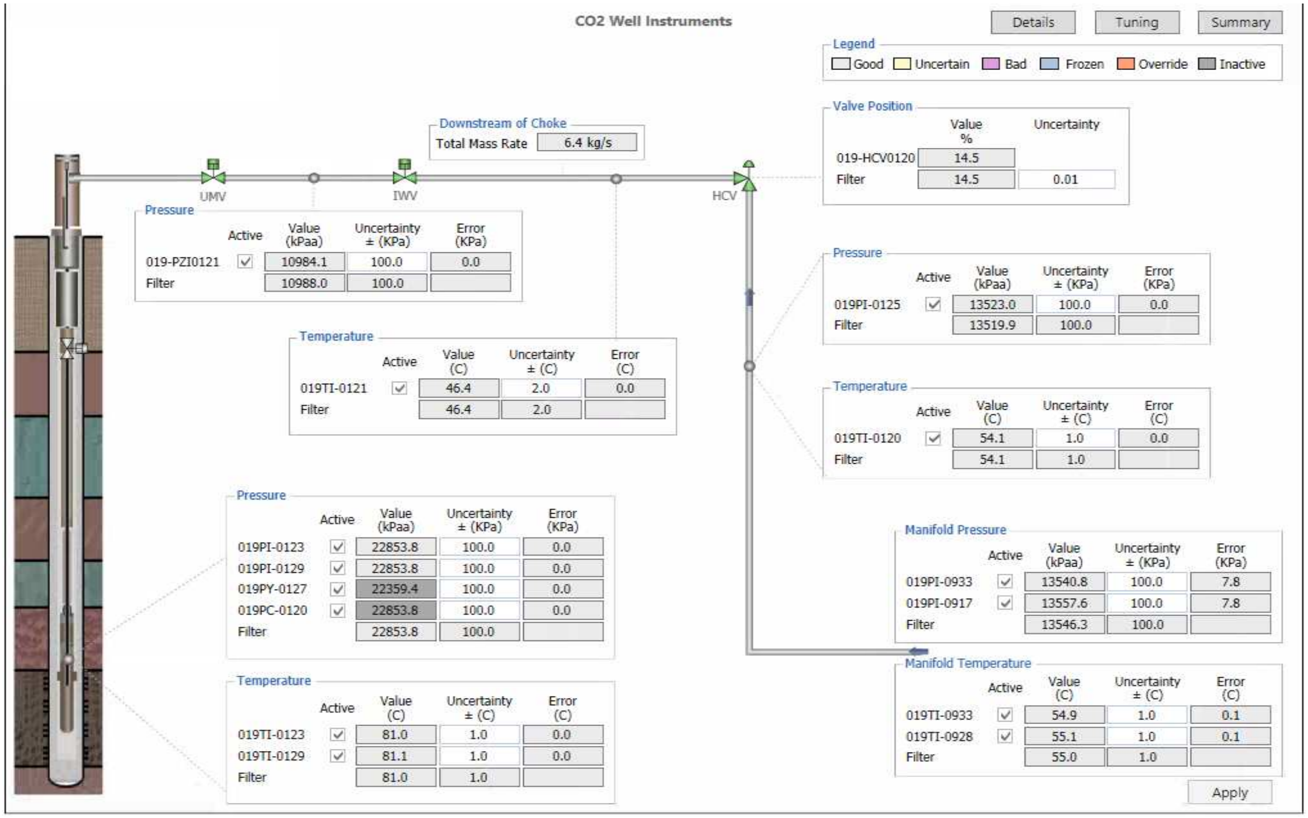


Virtuoso

Typical CO2 storage plant

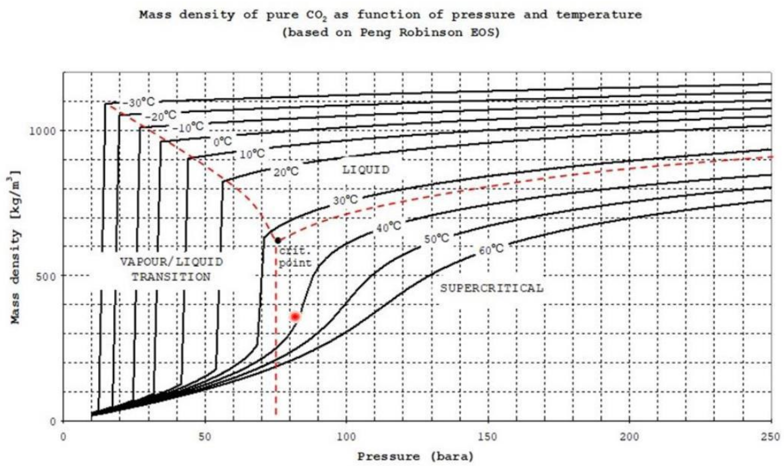


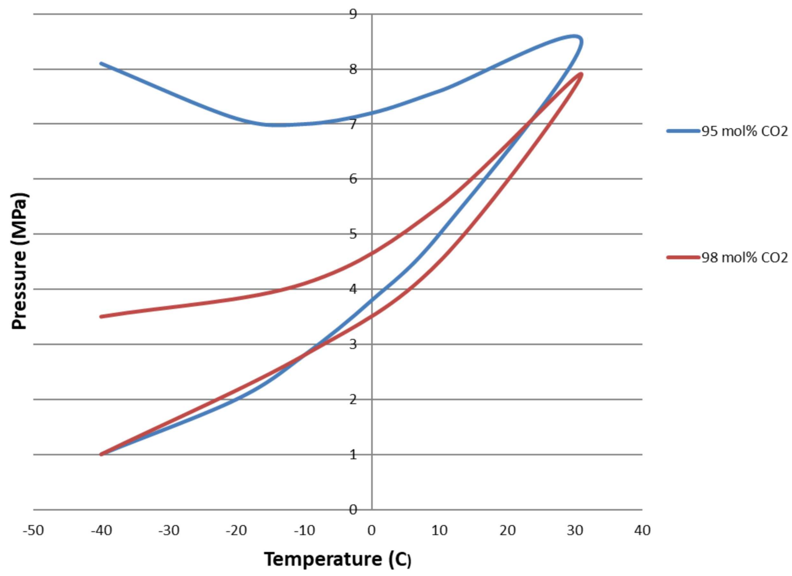
Well modeling and monitoring

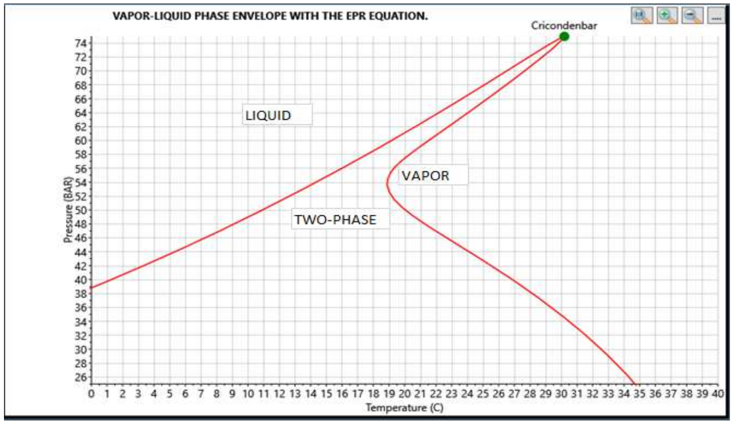


Modelling tools / limitations

- Success of operation relies significantly on accurate understanding of fluid composition, flow behaviour.
- Most thermo-hydraulic modelling tools are limited and not tested for transient operations of CO_2 rich fluid.
- Online Monitoring Tools could support the operation significantly and reduce some level of conservatism.







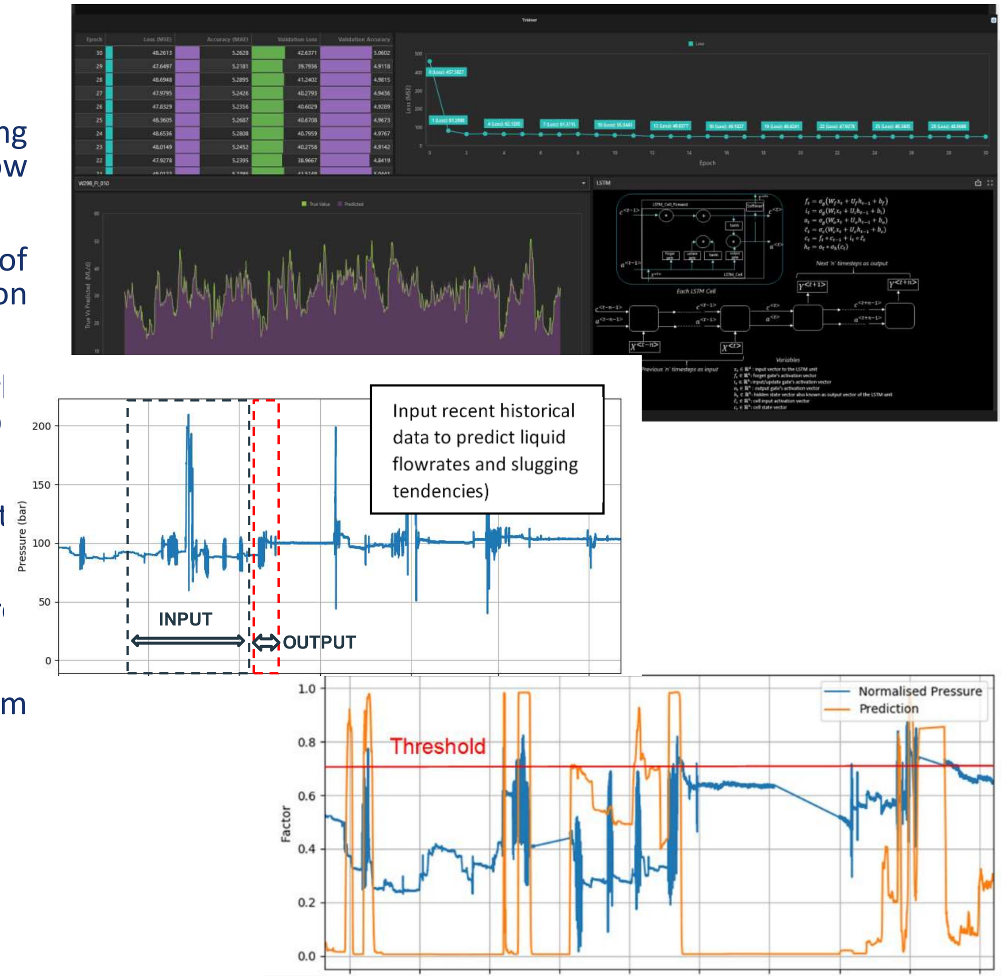
Leveraging of data for smoother operation of assets

1. Various use cases
2. Deep Reinforcement Learning (Bonsai Technology)
3. VMS Lite

Slugging prediction

“ANN Based Slugging Modelling”

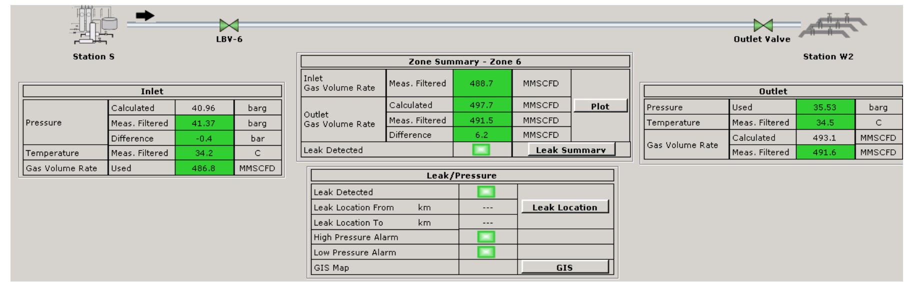
- The system consisted of multiple wells and manifolds; slugging (large pressure swings) occurred from time to time due to flow changes.
- The model development included rule-based identification of specific transient events and mapping those with classification metrics.
- A LSTM (Long Short-Term Memory) RNN (recurrent neural networ model was trained based on training set using multip hyperparameters
- Used all available instrumentation (P,T,Z,OP) from perforations t manifolds to topsides
- Trained the model with ~40 variables such as pressur temperature, valve positions etc.
- The model relied on real time data using parameters extracted from the PI historian to predict the results in future.



Leak detection

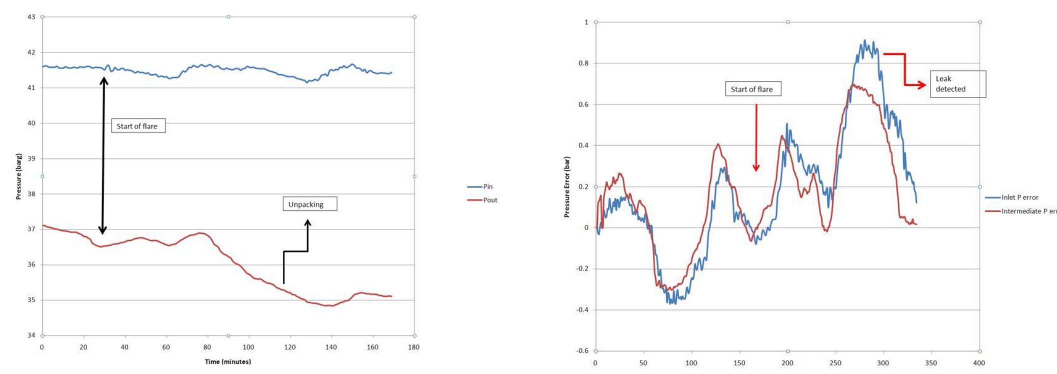
Large (40”) line supplying has to power plant; flared at 2-3% of flowrate

- Exploits available instruments: flow, pressure & temp.
- Designed for steady-state and transient flow conditions
- **Field-proven for multiphase operations, as well as single-phase (gas or liquids) pipelines**
- Embedded or standalone Statistical Leak Detection Technology. RTTM model enhanced with statistical analyses to maximize responsiveness and minimize false alarms.
- Test conditions
  - Line operated on pressure control
  - Plant free to consume gas at will
  - Plant increased consumption during test
  - Flare rate varied during test
  - Visually observable signals due to unpacking.
  - Leak detected first on pressure mismatch
  - Leak located accurately, near line inlet
  - No false alarms before or after test



small leak (<15 mmscfd) flare initiated near inlet of a 60 km pipeline flowing ~ 450 mmscfd

Stochastic field data handled by time-domain matrix of ‘error signals’ subjected to field-specific statistical analyses

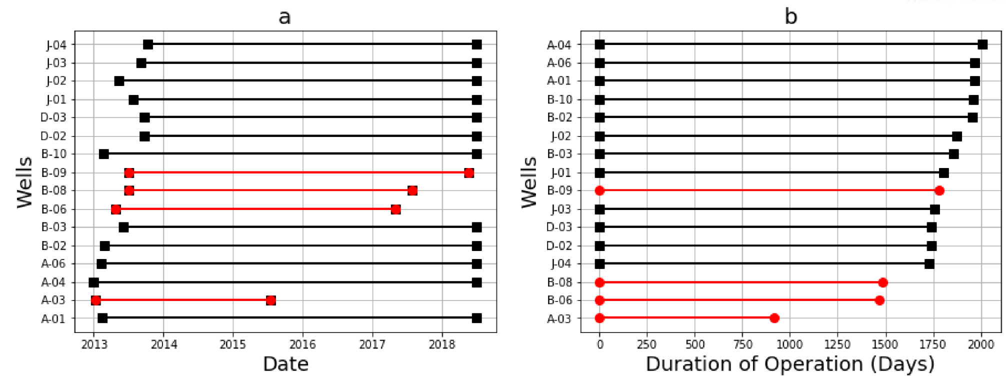


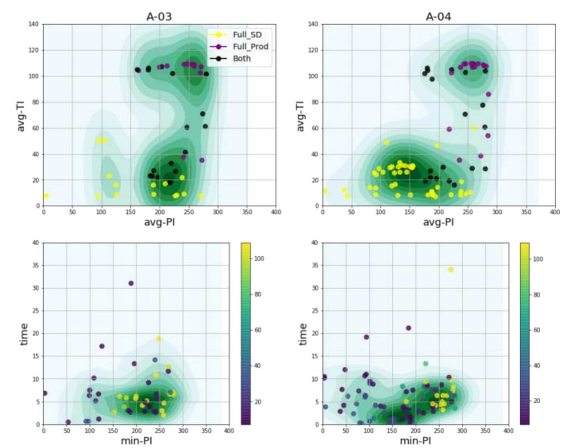
Field data and model predictions during 2% blind flare test in a large gas pipeline network, successfully completed by an existing Virtuoso installation in the Middle East.

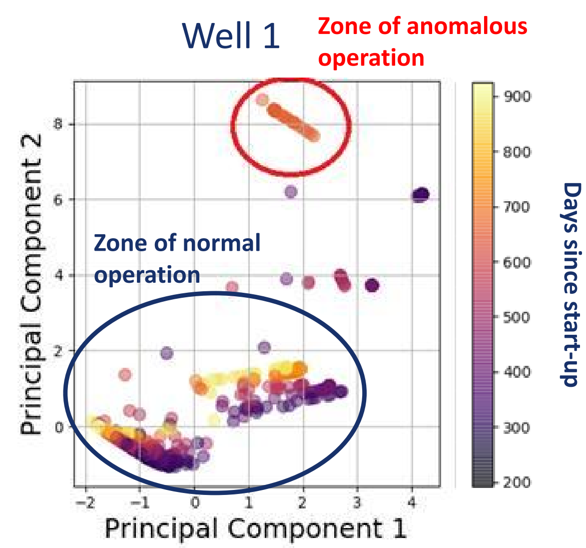
Choke valve failure

XT Failure Detection

- Used operational data on Cloud using Cognite Data Fusion to derive insights about XT performance.
- Identify key discrepancies between failing and operational wells.
- Monitoring and alerting for anomalous events
- Enhanced visualisation and analytics useful for rigorous monitoring.
  - Aggregating data and presenting more detail
  - Determining anomalous XT operation
  - Count of valve actuations
  - Monitoring cool down curves
  - Riser depressurization
  - And anomaly detection tool to identify outliers





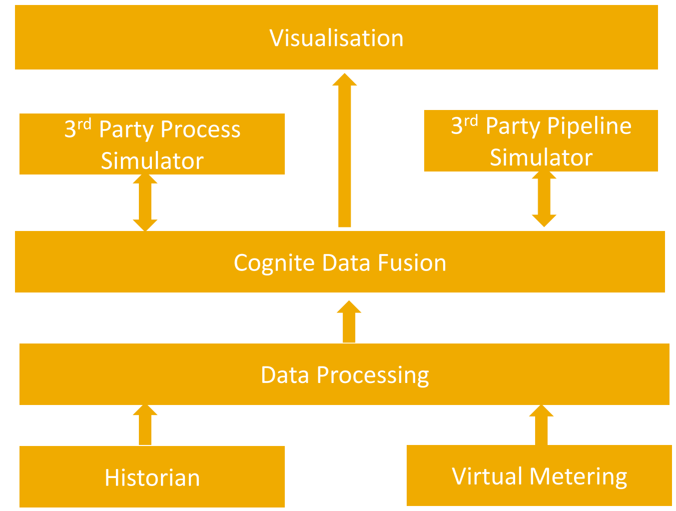


Process monitoring

Leveraging CDF Data Lake to process and monitor plant performance

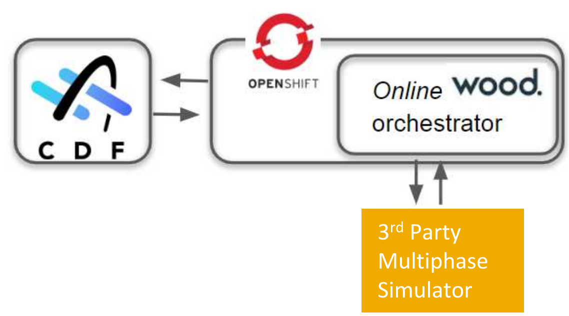
Integrated Production Monitoring

- Integrated Production solution covering both optimum use and distribution of Gas Lift and dynamic modelling of the liquid handling capacity of an entire oil field.
- This required the use of industry standard process simulation software and production network model
- Fully automated workflow coupling process simulator and data driven solutions with network model for full field optimisation runs. This integration was done through Cognite Data Fusion.



Online System Integration with Process Twin

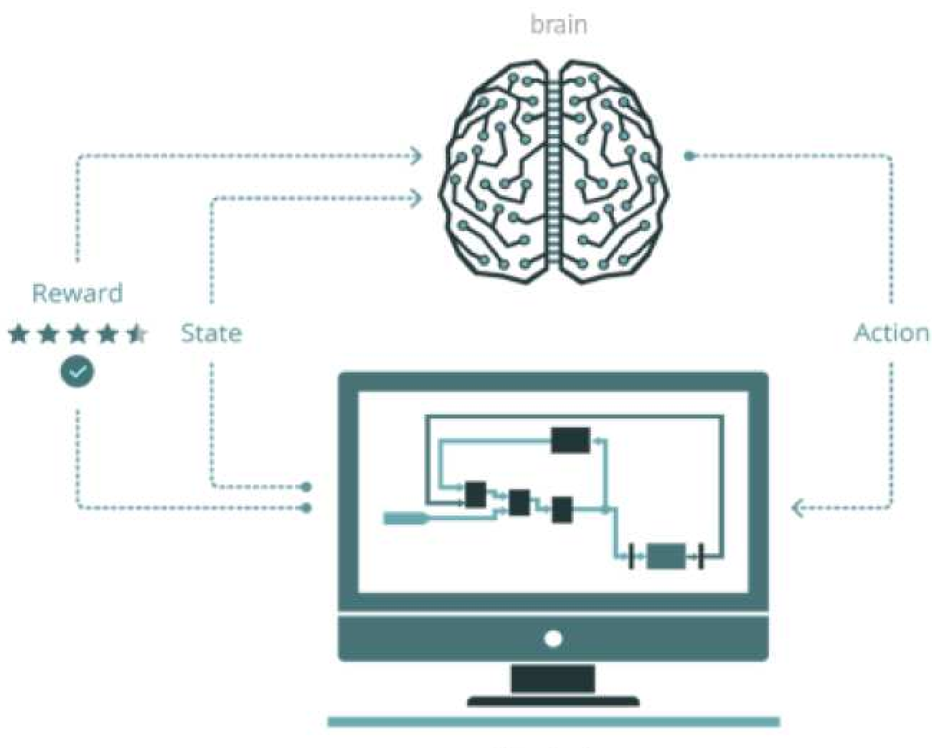
- Workflow solution using CDF to extract historian data
- The orchestrator allows industry standard multiphase simulator to receive scheduled live data from CDF for monitoring
- The simulations results allow close monitoring of process changes and increased foresight into operations.



Deep reinforcement learning (Bonsai technology)

Bonsai - Building brains for Industrial Control Systems

Combining state-of-the-art techniques in DRL, simulations, and machine teaching



How does it work?

DRL trains a brain through practice

Training a setup in simulation

A brain explores different configurations ('actions') to achieve an object ('state')

A brain in rewarded for achieving the desired state, penalized when it doesn't

Machine Teaching injects useful subject matter expertise into the training process to accelerate the learning

How is it deployed?

Train the brain by connecting to simulation models and running simulations

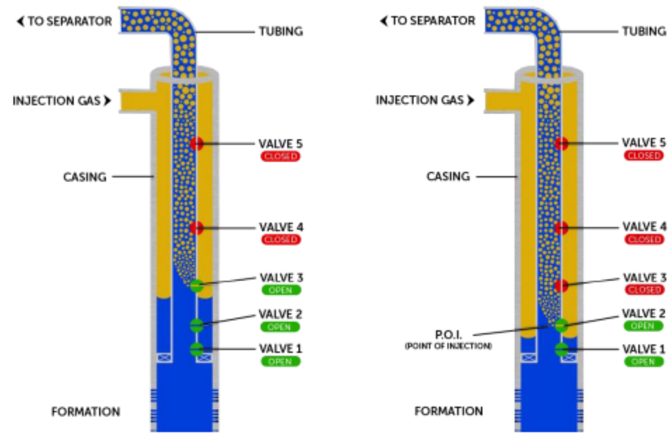
Deploy brain in the field and connect to control systems

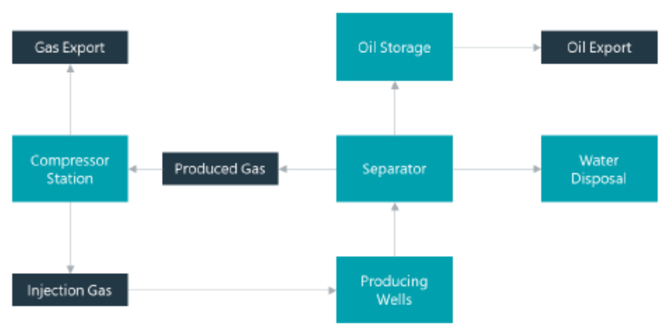
Deploy decision support system to allow system to run autonomous mode or to provide inputs to operations

Complex Gas Lift Optimisation

Business Problem

- Complex production system utilizing gas lift has many competing operational targets, such as oil production and gas nominations.
- Gas lift rates are used by operators to meet these targets but also have an effect on operating costs, such as fuel gas and compressor running costs.
- It is a complex challenge for operators to run the system in an optimal fashion while not violating any operating constraints





"50 Wells, 4 Well Pads, 30km gathering lines. Optimum Gas Lift rates for each well a challenging optimisation problem"

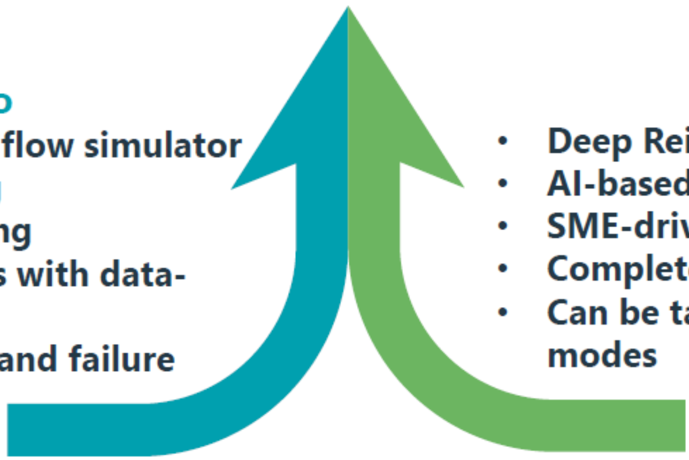
Virtuoso

bonsai

wood.

The Solution

Gas Lift Optimization



Virtuoso

- Transient multiphase flow simulator
- Virtual flow metering
- Heat transfer modeling
- Physics-based models with data-driven tuning
- Can simulate normal and failure modes

Bonsai

- Deep Reinforcement Learning
- AI-based industrial control
- SME-driven & Simulation-driven
- Complete toolkit
- Can be taught to handle failure modes

Solution

- Train a Bonsai brain that is able to balance the Optimization objectives:
- Gas Export Sales
- Oil Export Sales
- Penalty for Missing Gas Nominations
- Fuel Gas Costs
- Running Cost of Compressor
- Water Disposal Cost

Benefits & Considerations

Typical Project Benefits

- Increase oil recovery by 2 – 10 %
- Reduce gas lift by 10 – 30 %
- Increase sales gas and lift capacity
- Reduce compressor wear and tear
- Utility cost reduction

- Greenhouse gas reduction
- **> 1100 Tons of CO_2 equivalent per day**
- **~100,000 cars)**

Increase in margin of US$100M to $1B over 10 yrs

CUSTOMER INFORMATION

Input	Units	Input Item
1,000		No. of Wells
300	Days	Average Operating Days
50	BPD	Oil Produced per Well Average
100	MMSCFD	Gas Produced
10	%	Gas Usage in Lift
$ 40.00	USD	Sell Price per Barrel
$ 20.00	USD	Operating Cost per Barrel
$ 3.00	USD	Gas Sell Price

Calculated	Units	Calculated Item
50,000	BPD	Oil Volume Produced per Day
10	MMSCFD	Gas Consumed
0.01	MMSCFD	Gas Lift per Barrel
$ 2,000,000	USD	Daily Oil Revenue
$ 600,000,000	USD	Annual Oil Revenue
$ 1,000,000	USD	Daily Operating Cost
$ 300,000,000	USD	Annual Operating Cost

SOLUTION BENEFITS

Input	Units	Input Item
2	%	Expected Oil Volume Improvement 2-10%
20	%	Expected Gas Lift Usage Improvement Annual

Calculated	Units	Calculated Item
1,000	BPD	Oil Recovery Volume Increase per Day
$ 12,000,000	USD	Oil Revenue Improvement Annual
2	MMSCFD	Gas Usage Improvement
$ 1,800,000	USD	Operating Cost Improvement Annual
$ 0.51	USD	Operating Cost Improvement per Barrel
$ 0.02	USD	Solution Cost per Barrel

Input	Units	Other Item
		Reduced Capital for Demand Reduction
		Compressor Wear and Tear
		Fuel / Electricity Reduction
		Reduced Compressor Rental
	CO2e Tonnes	GHG Reduction

$ 13,800,000	USD	Revenue and Operating Cost Improvement Annual
$ 2,040,000	USD	New Daily Oil Revenue
$ 612,000,000	USD	New Annual Oil Revenue
$ 298,200,000	USD	New Annual Operating Cost
$ 19.49	USD	New Operating Cost per Barrel

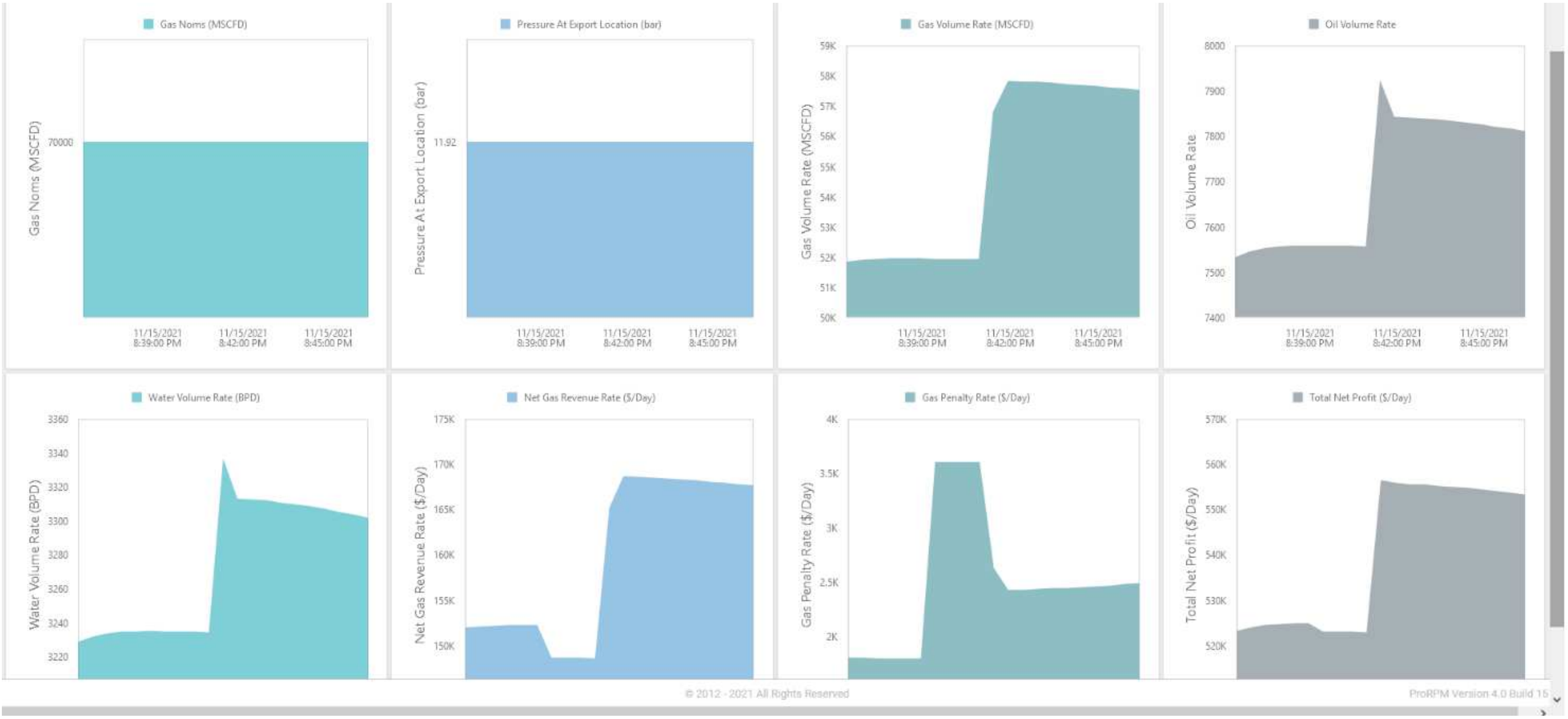
Significant value to operations with reduced manning operating 100s – 1000s of wells.

wood.

Training program

- Most Important Part
- Give “The Brain” Lesson based on Typical Behavior in the Plant
- For This System we had 18 Lessons where the following items are varied on a hourly cycle and simulated 35 days of field behavior
    - ➢ Which Wells are Online
    - ➢ Gas Nomination
    - ➢ Network Pressure
- Each Lesson had 1600 points and in the End Bonsai required 75 million iteration to train.
- Model must be fast and modular to Run on 25 separate Instantous at One Time

Demonstration of improvement when brain is turned on



VMS Lite

What is Vms Lite ?

DESCRIPTION

(VMS) is a model-based inferential multiphase metering package that continuously calculates the gas or oil flow rate from wells.

RATIONALE

Knowing the flow rate is critical to determining how a well is producing, the value of a day's production, and how much oil or gas remains in the ground.

PROCESS

By collecting data from the sensors in and around the wells. Using Empirical Equations & Machine Learning Methods

OUTSIDE PARTNERS

Company: Neal Analytics (A Microsoft Partner)

BENEFITS

With the use of Machine Learning to automate the process of VMS Lite tuning, reduces time by 80% & also increases the accuracy in determining the well flowrates.

POTENTIAL

Can be scaled to multiple fields with reduced manual intervention. Can be made into a product with scope for user customizations.

Empirical relationships for each well & tuning parameters

Tuning Parameters
1) Reservoir PI Term, 2) Tank PI Term, 3) Reservoir decay rate, 4) Tank decay rate, 5) Reservoir Pressure @ t=0, 6) Tank Pressure @ t=0, 7) Reservoir Pressure Head Term

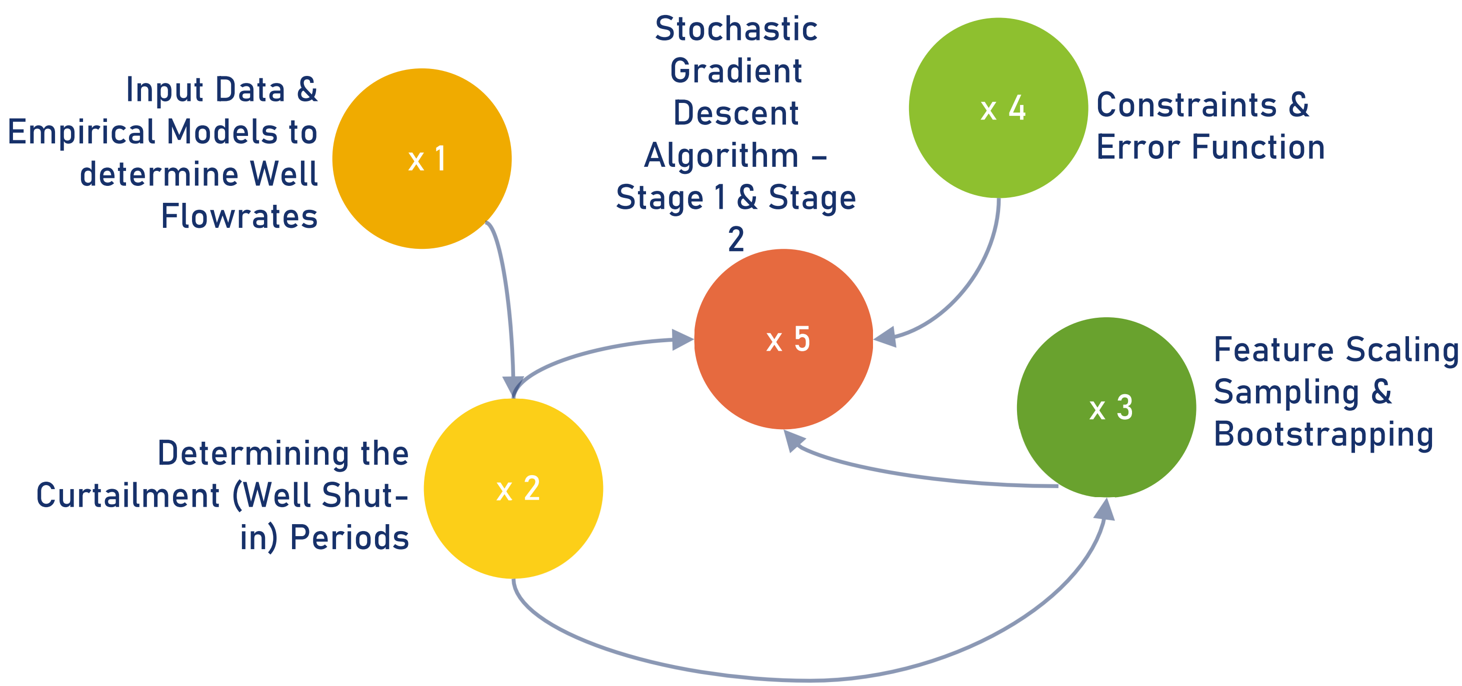
VMS Lite Model Inputs & Well Empirical Equations

- Pressures
- Temperatures
- Choke Positions
- Commingled overall flowrate

Outputs:

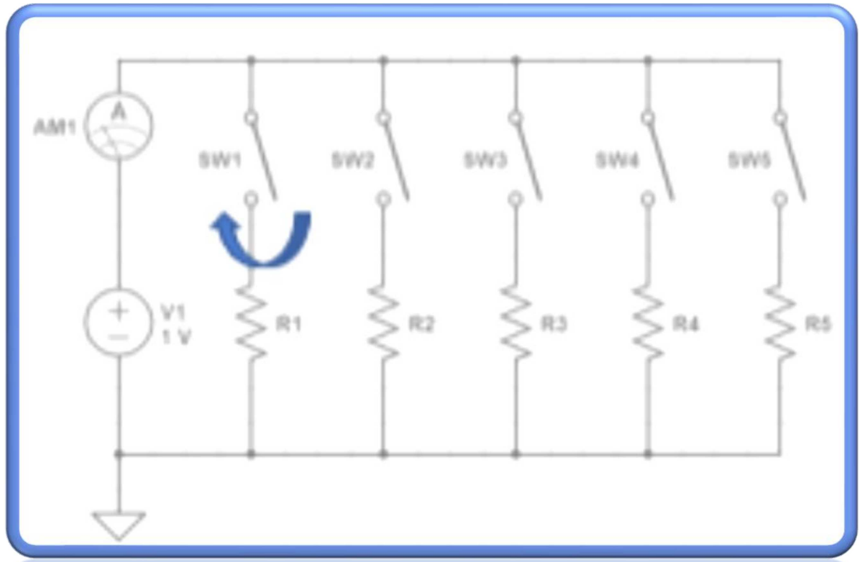
- Reservoir Model
- Choke Model
- Combined Gas Mass Flowrates from reservoir & choke models
- Temperature Correlation as a function of Gas flow rate
- Final Well flowrate at a time (t)
- Flowrate Error (Error 1)
- Temperature Error (Error 2)
- Objective Function- Minimize RMSE

VMS Lite Python model in a nutshell



Importance of curtailment period determination

VMS Lite is analogous to the problem of trying to determine the resistance of each resistor in the parallel circuit below given the voltage across all resistors and the sum of all currents.



Current across each resistor => Flow across each well
Resistance => Pressures/Temperatures & other parameters that define a well
Voltage => Function that maps the above parameters

Constraints

Webinars

In addition to minimizing the cost function, other conditions must also be satisfied by the parameters not described in the governing equations. These constraints are:

- PRES >= PSKIN >= PRES-20E5
- Pskin - Pres + 20e5 >= 0
- PBC + 35E5 >= PRES >= PBC
- 90E5 >= H >= 70E5

Where,
PRES -> Reservoir Pressure
PSKIN -> Bottomhole Pressure
PBC -> Pressure before choke
H -> Reservoir Pressure Head

To both minimize our cost function and satisfy these constraints a sequential-least-squares-quadratic-programming (SLSQP) algorithm was employed allowing constraint functions to be passed as arguments to the optimizer. (scipy library in python)

SPE International

Tuning & modifications

Addition of Temperature Error

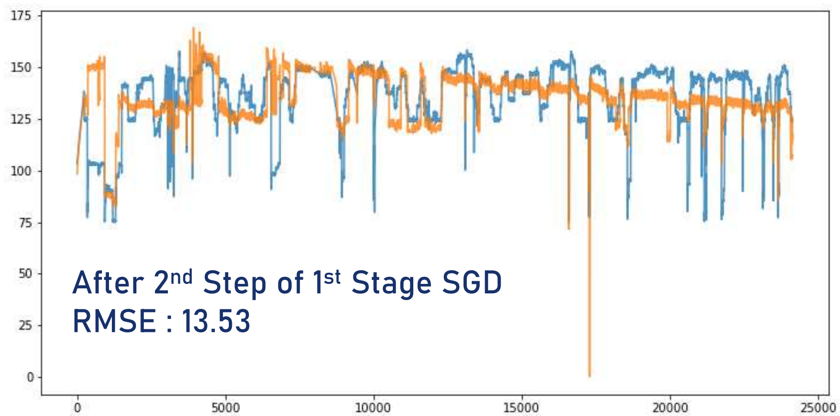
Changing Constraints

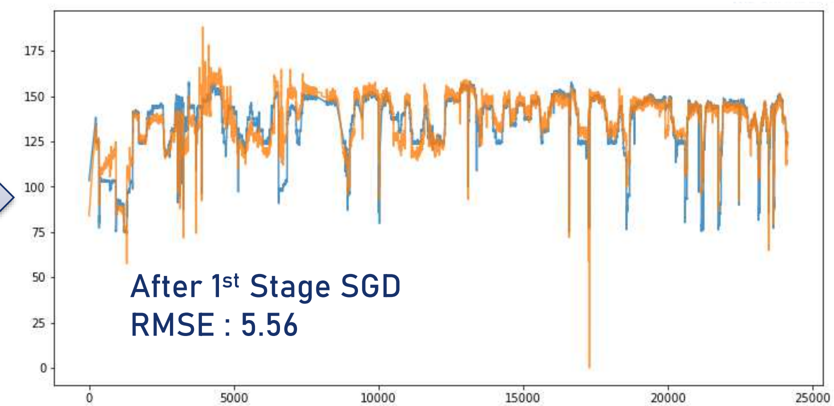
Analyzing Well Mixes

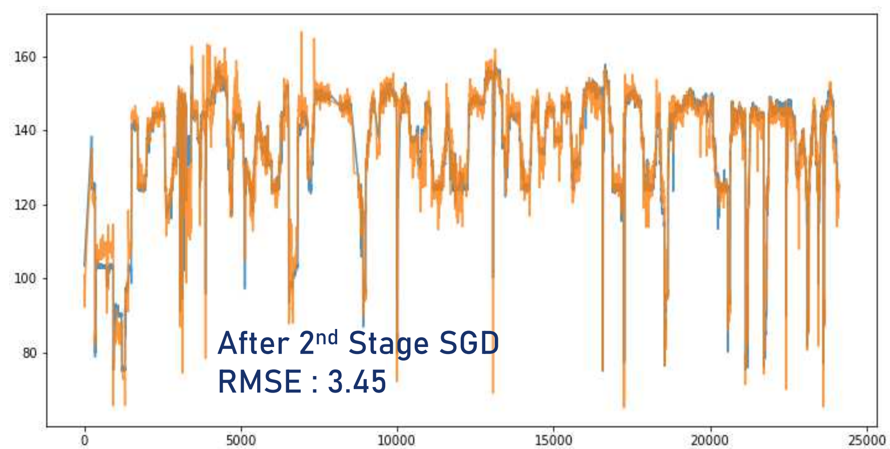
Excluding tuning Parameters from the Algorithm & calculating it as a part of the empirical equations

Changing functions to fit for a new field

Results – stochastic gradient descent







Increase in accuracy

- 01 — 90-94% — VMS Lite Excel Based Model.
- 02 — 94-95% — Excel Tuning Method by Products team to find Tuning parameters to obtain a global minima.
- 03 — 93-95% — Python SGD Stage 1 Algorithm from Neal Analytics
- 04 — 95-96% — Python SGD Stage 2 Algorithm from Neal Analytics
- 05 — 96-97% — After Tuning Modification & Improvements

Production monitoring

1. Production monitoring and surveillance
2. Meters factor / errors in production allocation

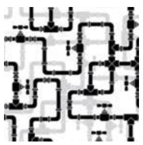
Production monitoring and surveillance

Asset Performance Management (APM)

Webinars

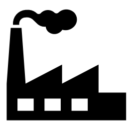
FEED → Project Delivery → Pre-Com / Commissioning → Start Up → Operations, Maintenance, Modifications → Decom

Oil & Gas Wells



Flowlines & Pipelines

Processing Facilities

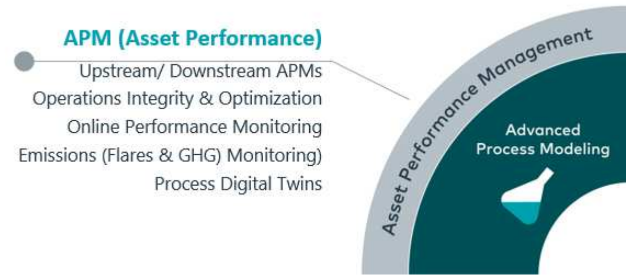


Manufacturing Facilities

Data/Process Analytics

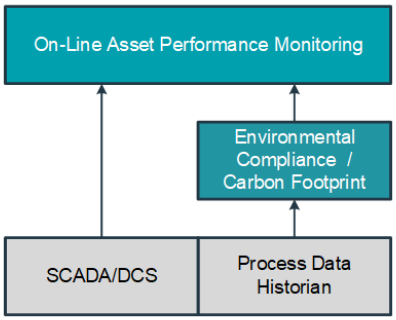
Virtuoso

ENV. Wood ENVision

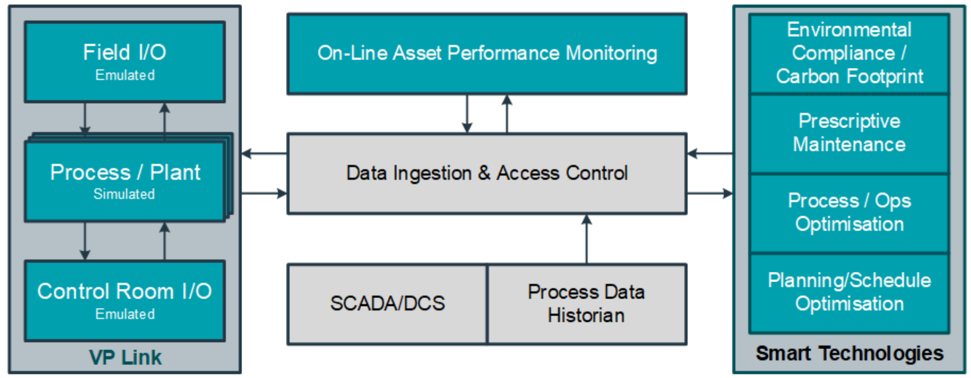


SPE International

APM - process twins during operations



On-Line Operations Monitoring



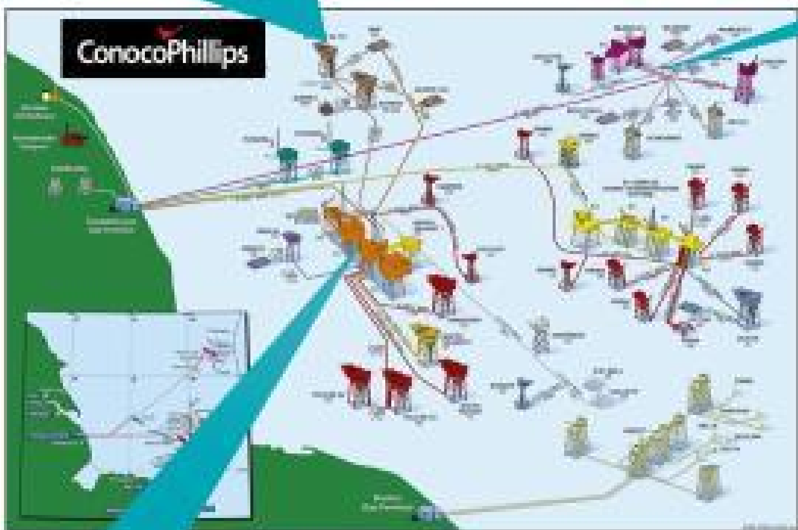
Process & Planning/Scheduling Optimization

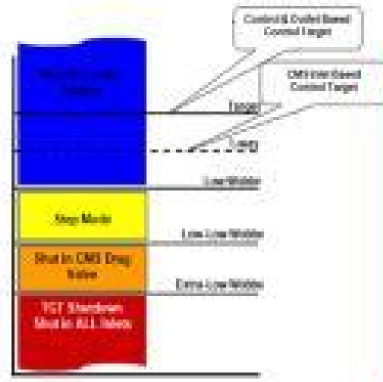
Southern North Sea

Production Optimization and Gas Blending Management

...controls gas blend in process facility
...ensure low GCV gas is not exported to grid.
...ction time is < 2 mins.

... application controls
120 wells and over 10 infield flowlines





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

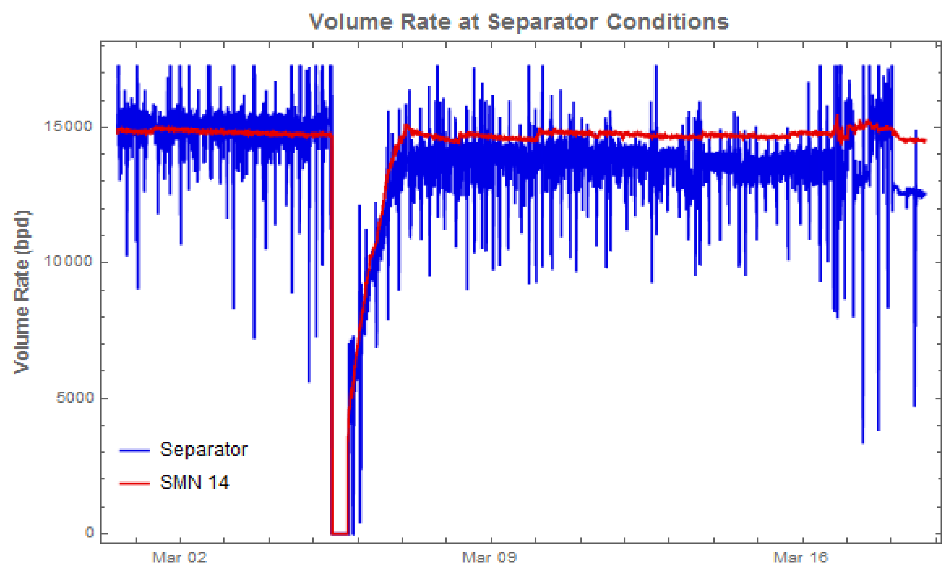
Low limit	Reduce Drag Valve to predefined output ...
Low-Low limit	Close Drag Valve
Extra-Low limit	Close ALL gas inlets

... application
...ontrols 140 wells and over 10
...nfield flowlines

Meters factor / errors in production allocation

Oilfield MPFM

- VMS tuning reveled discrepancies between subsea MPFM and Topside MPFM.
- Verified composition and tab files
  - Found some discrepancies with tab files being used and latest provided by client
  - Did not resolve volume rate discrepancies.
- Discussion with client revealed some concerns with accuracy of the meters and recommended using separator meter flow rates as reference.



Oilfield meter factor process

- Split measured volume rate in time based on routing
  - Determine when each well and flowline is aligned to a given specific separator
- Calculate a flash factor to get topside on the same basis as separator condition
  - Subsea volume rate at separator conditions already provided by VMS

$$Flash\ Factor = \frac{Q_{Separator,VMS}}{Q_{Topside,VMS}}$$

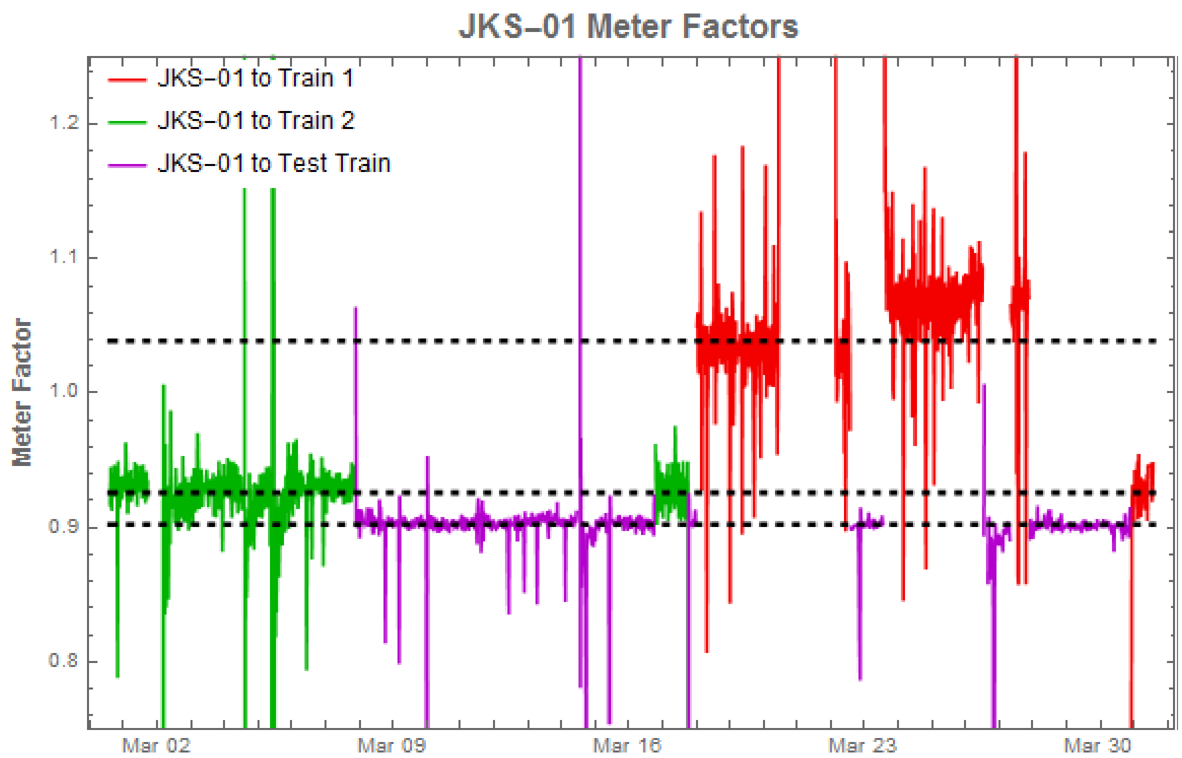
$$Q_{Flashed} = Flash\ Factor\ * \ Q_{Topside,Measured}$$

- Meter factor is the ratio of separator volume rate to flashed volume rate (topside or well meter)
  - Average of ratio to eliminate noise

$$MF = \frac{Q_{Separator,Measured}}{Q_{Flashed}}$$

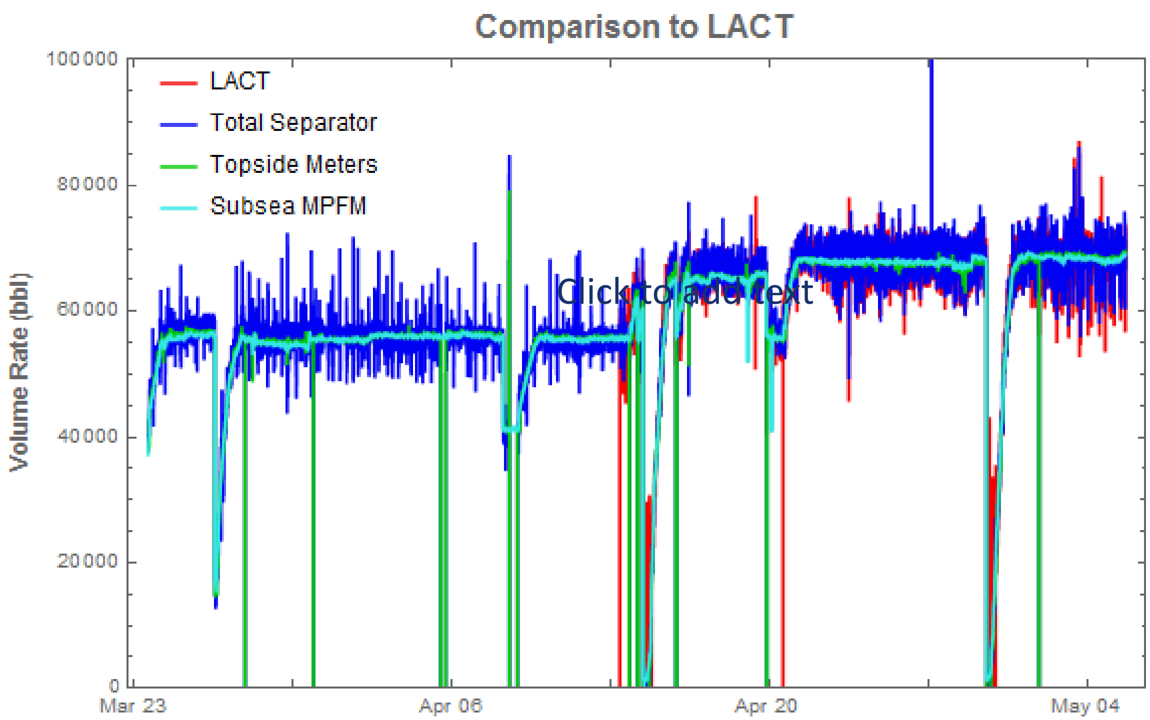
Oilfield MPFM round 2

- Topside Meter Factor
  - Calculate Meter Factor



Oilfield final results

- Volume rates for all meters at stock tank conditions



Summary and Q&A

Further information:

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IntelligentOps@woodplc.com

Contact Card

Email us

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