Reducing Economic Uncertainty in CO_2 Separation Through Advanced Simulation

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PRESENTATION OUTLINE

- Modelling Techniques – Legacy vs Mass Transfer Rate
- Rate-Based Model **-ProTreat®**
- Case Study: LNG CO_2 Absorption Operation Model
- Simulation Model
- Case Study: Results
- Propagation of Uncertainty
- Conclusion

AS WE BEGIN

- C.A.R. Hoare famously said – *there are two ways to construct a software – making it so simple there are <u>obviously no deficiencies</u>, or so complicated that there are <u>no obvious deficiencies</u>*

MODELLING TECHNIQUES FOR LNG ABSORBER-STRIPPERS

- Ideal stage-based models – Legacy technology – treats each LNG absorber tray as an ideal stage – when it really is not – and makes superficial adjustments
  - Extensive adoption persists, despite its obsolescence and structural deficiencies, there are challenges in changing deeply entrenched industry practices
- Mass transfer rate based models – available commercially over 30 years now – better represent gas absorption type systems and rigorously handle tray-by-tray calculations
  - Diffusion across bulk gas to interface » physical solubility (interface) » diffusion of gas from interface to bulk liquid » chemical reaction » diffusion of reaction products and heat to bulk liquid » » model structurally closer to physical phenomenon

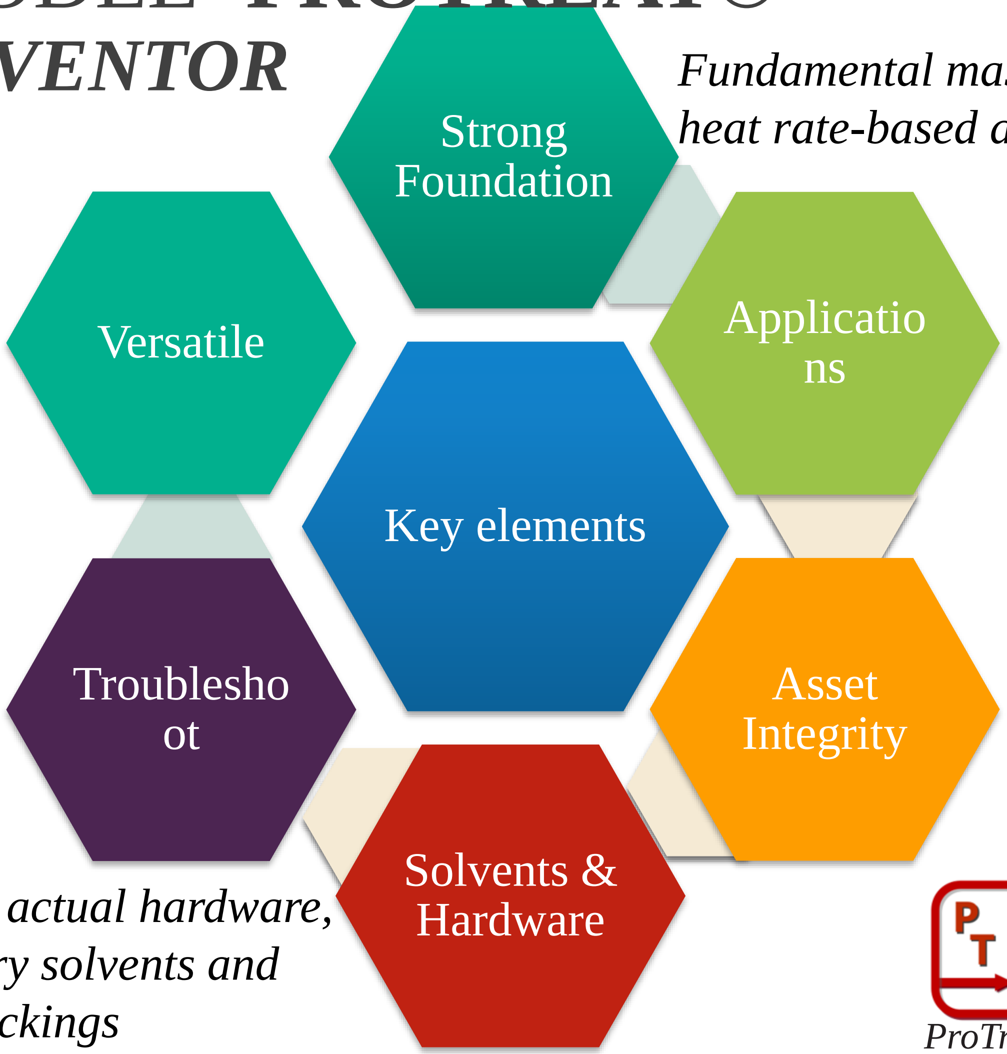
RATE-BASED MODEL -**PROTREAT®**

THE ORIGINAL INVENTOR

Fundamental mass and heat rate-based approach

CAPE-OPEN, flexible and integrable with downstream SRU (SulphurPro®)

AGR, AGE, TGT, SWS, LNG, Caustic, CO_2 Capture



Sensitivity studies and gauge plant performance

Corrosion prediction

Relates to actual hardware, Proprietary solvents and vendor packings

OGT | ProTreat®

ProTreat 9.0 is out now, Released on November 2025

CASE STUDY: LNG CO_2 ABSORPTION OPERATION MODEL

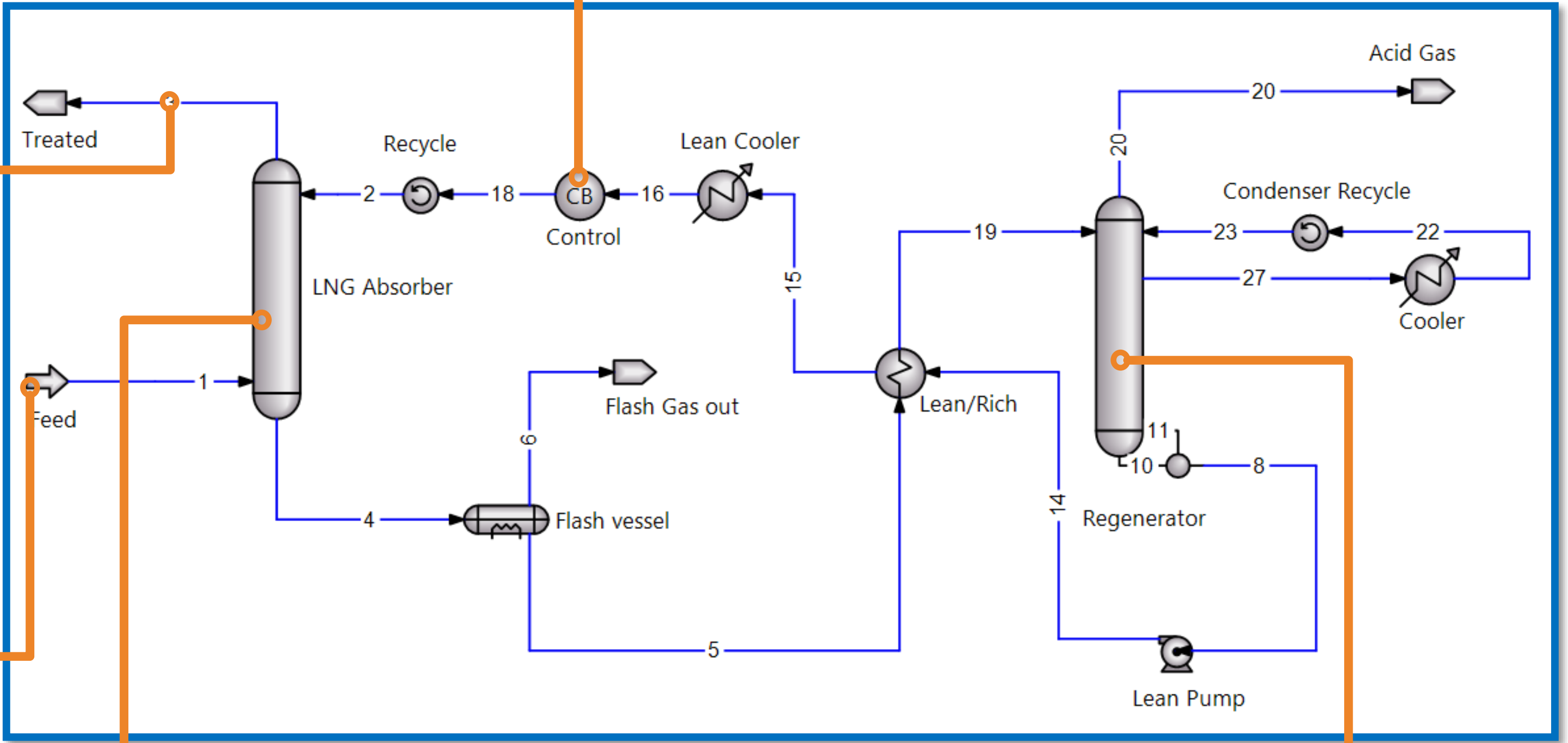
- LNG absorption-regeneration unit with a target CO2 below 50 ppmv in the treated gas
- Currently, unit meeting spec @ feed gas flow rate of **113 MMSCFD (1,04,400 kg/h)**
- **Unit was overtreating –** identify opportunities for operational optimization within the existing system
- The MTR-based model provided flexibility to optimize amine circulation while still meeting the required specifications
- In contrast, the legacy ideal model was found to be misleading for optimization purposes, as it underpredicts the amine circulation rate.

SIMULATION MODEL

3:Treated [Material Stream]		
H2S	0.085	ppmv
CO2	0.033	ppmv

1:Feed [Material Stream]		
Total Flow	113.76	MMSCFD
T	39.00	C
P	55.00	barg
Water	0.16	mol %
CO2	3.00	mol %
H2S	0.20	mol %
CH4	87.86	mol %
C2H6	6.49	mol %
C3H8	2.00	mol %
N2	0.30	mol %

LNG Absorber [Column]		
Packing Material	Metal	
Packed Depth	18.000	meters
Packing Size	40	
Diameter	3.500	meters



Control [Control]		
Total Flow	175.001	m^3/hr
MDEA	39.999	wt %
Pip	1.000	wt %

Regenerator [Column]		
Number of Trays	22	
Number of Passes	2	
Diameter	2.268	meters
Heat Duty	12.266	MW

Spec – CO_2 less than 50 ppmv in treated gas

CASE STUDY: RESULTS

- Ideal model underpredicts circulation as 112 m3/h
- MTR model says existing tower with current circulation will allow to meet spec
  - But MTR model allows circulation optimization and analyse the effects on hydraulics, treated gas
  - Circulation rate optimized to 131 m3/h
  - (175-131) = 44 m3/h **X** 120 kg steam /m3 of solvent
  - Steam saved = 5,280 Kg of steam/h
  - i.e., **USD 1,900.8 savings per day** *@Steam price of USD 0.015 per Kg*
- Reliable models decrease the uncertainty unlike ideal models which underpredicted circulation rate by 14.5% relative to optimized circulation conditions

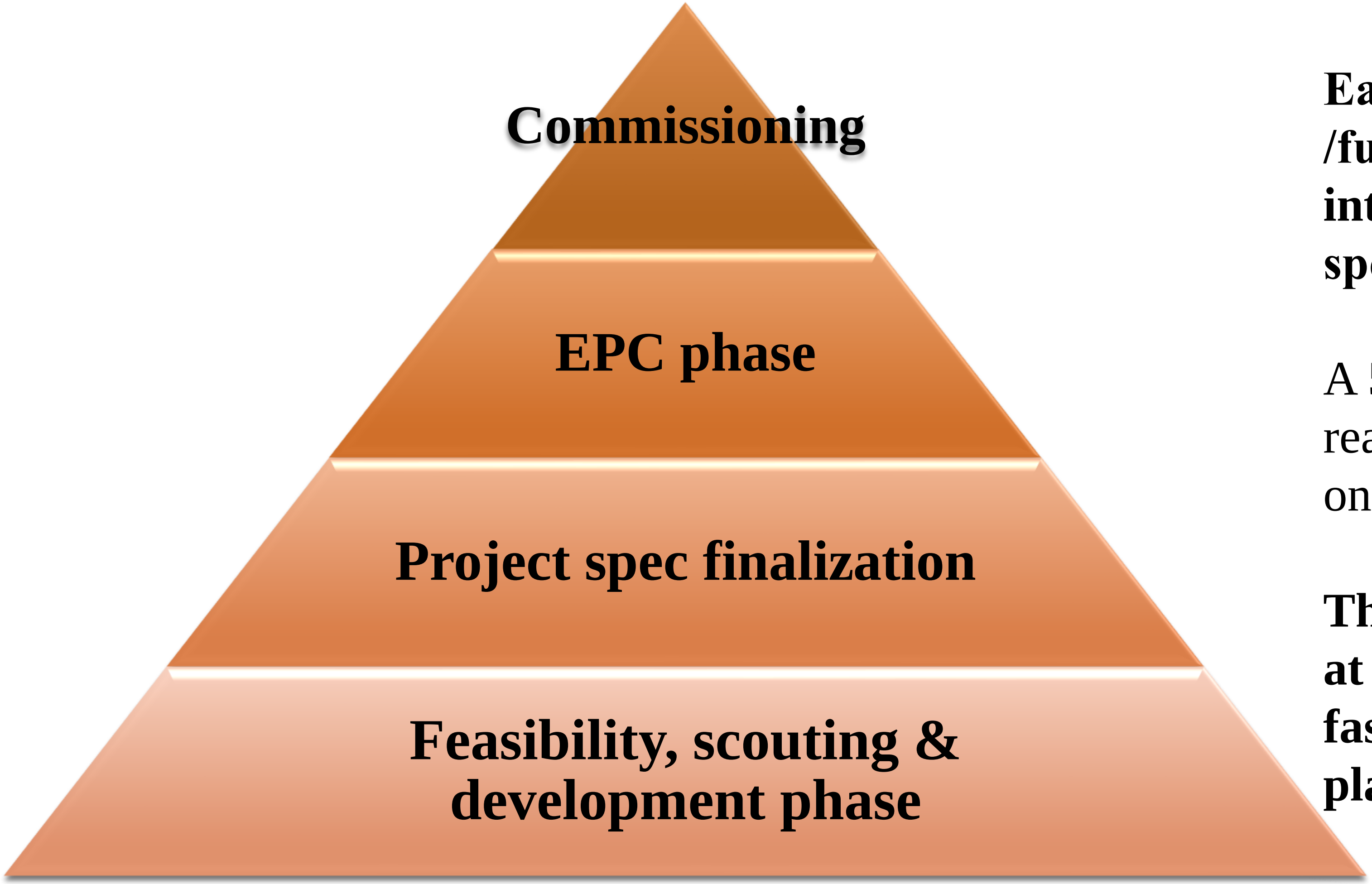
WHY MTR-BASED MODELING MAKES ECONOMIC SENSE

- Operational optimization converts variability into sustained savings
- Software investment recovers cost within early projects – investment is self-justifying
  - One tower savings often offsets annual software cost
  - Few weeks of operational savings recover annual license
- Design accuracy reduces overdesign and provides capital savings
- Right-sized designs avoid hidden lifetime costs

APPLICATION AREAS OF MTR MODELLING

- Gas & LPG Treating, Sour Water Stripping, and Caustic Treating
- Deep CO_2 removal with formulated MDEA, DGA, and proprietary solvents
- H_2S, CO_2, and trace sulfur species removal
- With ionic and physical bifunctionality, model sulfolane and amine blends including amine contamination with glycols
- NH_3 and H_2 production, CO_2 removal with activated MDEA, and Hot-Pot (K_2CO_3) with promoters
- Models the whole sulfur train, including Tail Gas and Incineration units
- Generic and proprietary amines for sweetening, water removal with glycols, and methanol holdup

PROPAGATION OF UNCERTAINTY



Early uncertainty (at the "simulation /fundamentals" layer) propagates upward into bigger cost/risk consequences during spec finalization → EPC → commissioning.

A 5% uncertainty in an early assumption can reappear as 15–20% spread in final outcomes once multiple decisions build on it.

The cheapest time to reduce uncertainty is at the base and this is where rigorous and fast MTR based simulation has a role to play.

CONCLUSION

- A model can be a true-mass transfer rate-based model only if it accounts all fundamental science behind each and every step of the process - **ProTreat®**
- The value of economic sound models is not only limited to design but also operations
  - Operations enjoy the benefit of profile monitoring in true MTR models – gives you operational edge for variable feeds
- Software License Pay Back Period – few trays or few weeks of steam savings

ABOUT OGT – WHO WE WORK WITH (OPERATORS/SUPPLIERS)

ExxonMobil
Badak LNG
IndianOil
Williams
aramco
CF
SULZER
EASTMAN
bp
HARVEST MIDSTREAM
Anadarko Petroleum Corporation
angola LNG
OCI
BRUNEI FERTILIZER INDUSTRIES
Atlantic
Moving a generation ahead
OXY
Chevron
PHILLIPS 66
INEOS
bangchak
lyondellbasell
SUNCOR ENERGY
Nutrien
AMINES PLASTICIZERS
RASCHIG
DOW
KINDER MORGAN
ConocoPhillips
KOCH-GLITSCH
中国石油工程建设有限公司
CHINA PETROLEUM ENGINEERING & CONSTRUCTION CORP

ABOUT OGT – WHO WE WORK WITH (ENG./CONSULTING)

AS WE END…

- Which simulation model would you prefer: the one that has *obviously no deficiencies*, or the one that has *no obvious deficiencies*?

Thank You!

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