27th WORLD GAS CONFERENCE | JUNE 25-29 | WASHINGTON DC | 2018

IGU

Novel Conversion Approaches using Natural Gas

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Natural Gas Upgrading Processes and Drivers

- Dry Reforming to make syn-gas (H_2, CO)
  - Replace steam with CO_2
  - Reduce carbon footprint
  - Eliminates need for water
- Cool Reforming and Cool GTL (Gas to Liquids)
  - Uses both steam and CO_2 to make syn-gas
  - Reduce cost and simplifies gas-to-liquids process
  - Reduce carbon footprint
- Soft Oxidation
  - Eliminates flaring of sour gas wells
  - Increases product yield at well head

Dry Reforming of Methane (DRM)

Problem:

- Expensive: Uses precious metal catalysts
- Cokes: Catalysts deactivate due to carbon build up

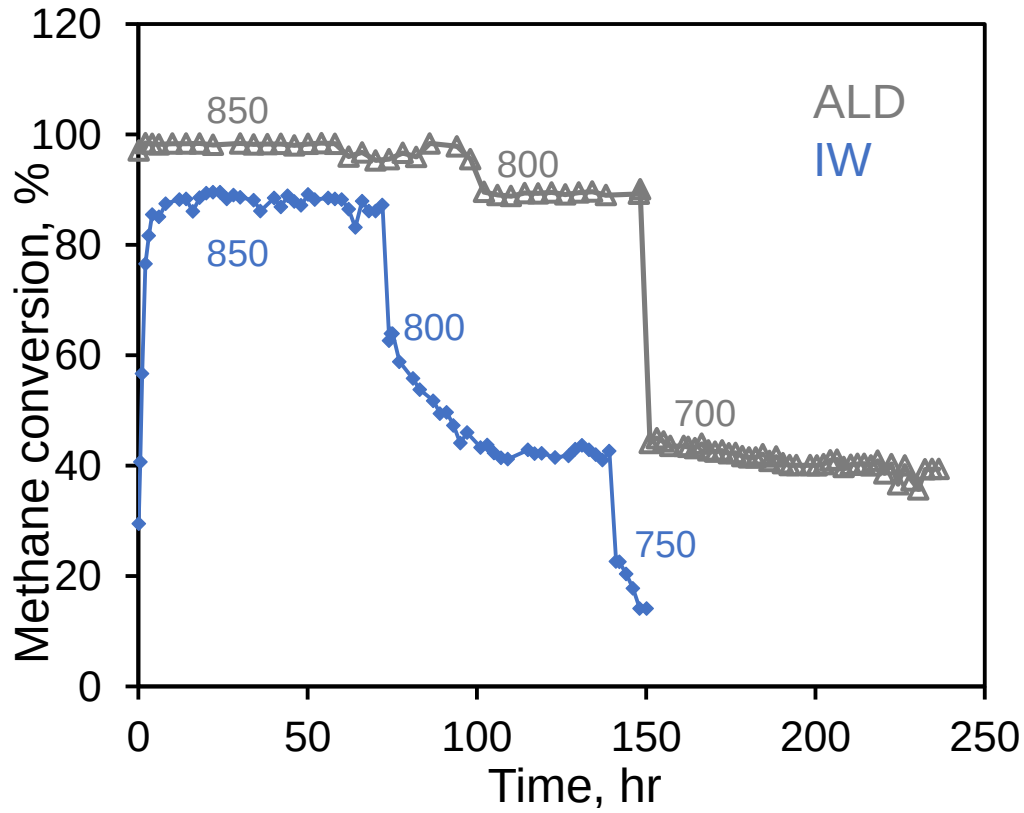
Approach:

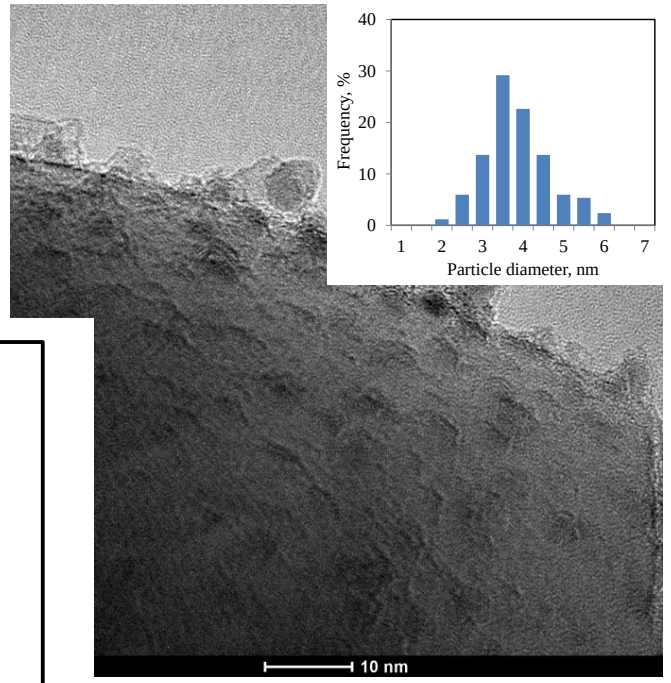
- Apply nano-catalysts using Atomic Layer Deposition (ALD)
- Use inexpensive catalysts, ex. Nickel

Encouraging Results for DRM using ALD

- Porous Alumina substrate best
- Better performance
- Better stability
- Little coking
- TRL = 2

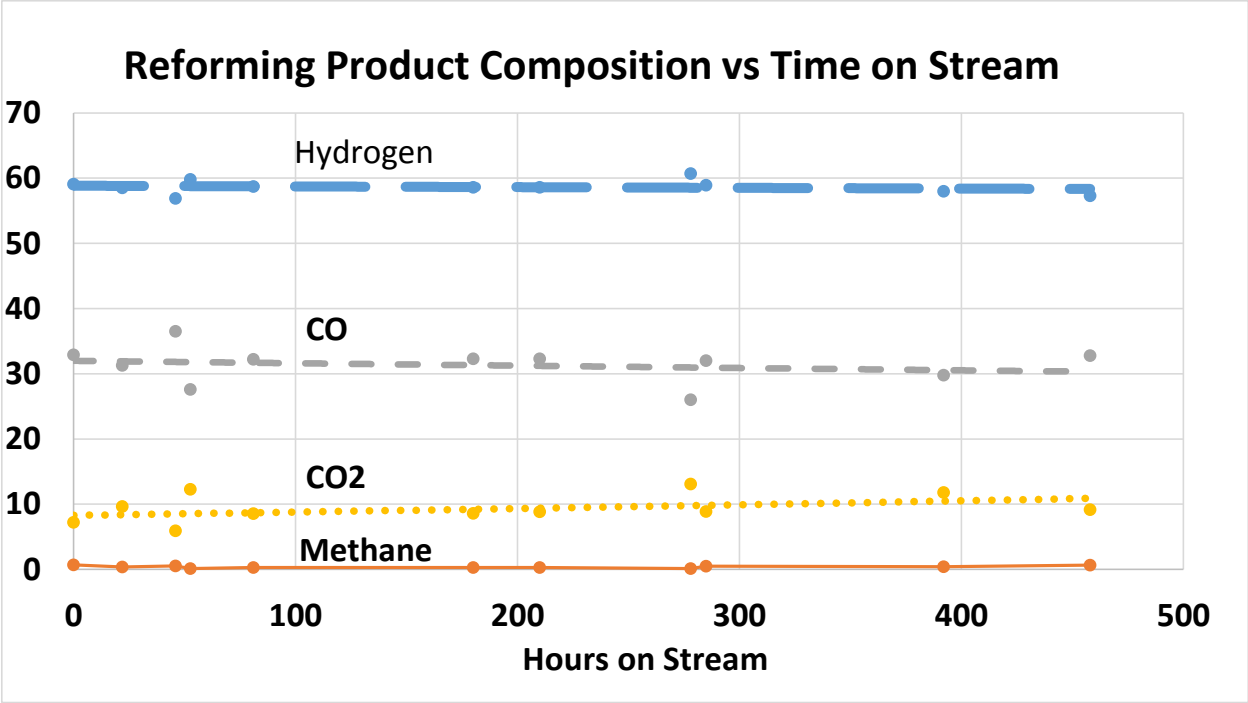
Nanoparticles used in ALD and Incipient Wetness (IW)





Cool Reforming to make “perfect” syn-gas

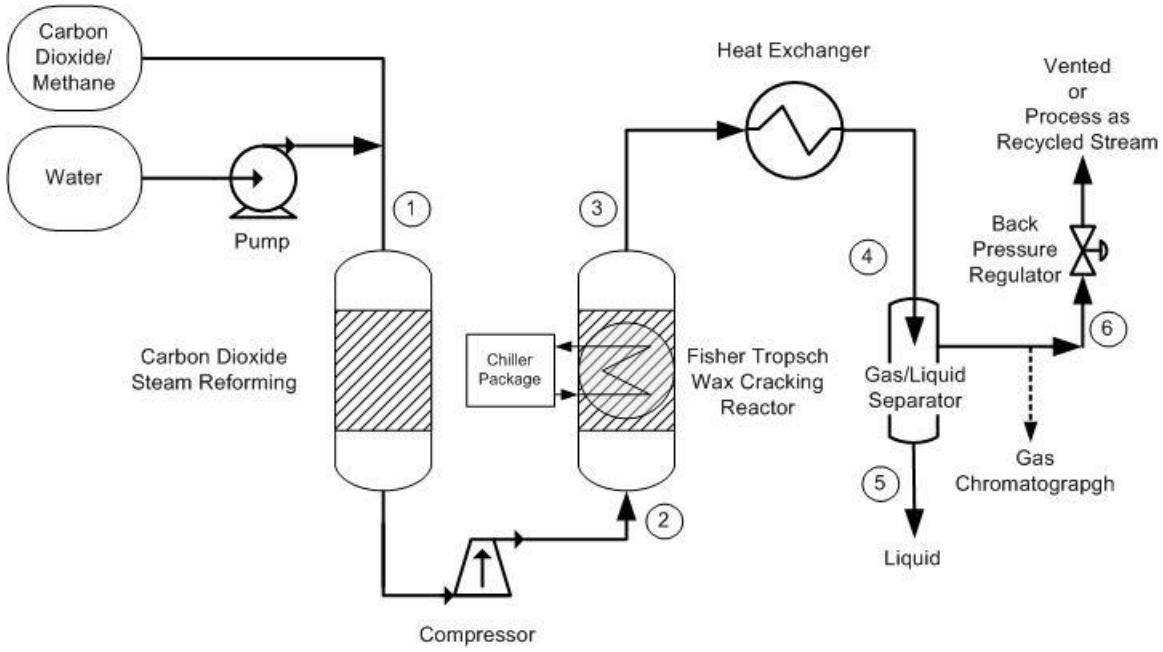
- Process: natural gas + steam + CO_2 to syn-gas (H_2, CO)
- Water and CO_2 ratio adjustable with fuel, for stable syn-gas output
- High conversion
- High yield
- Lower temperature
- Good stability



Cool Gas To Liquids (GTL)

- Simple GTL system
- Fischer Tropsch reactor at Cool Reformer pressure:
  - Commercial catalyst
  - No waxes
  - Lower temperature
  - Low/No recycle
- TRL = 3

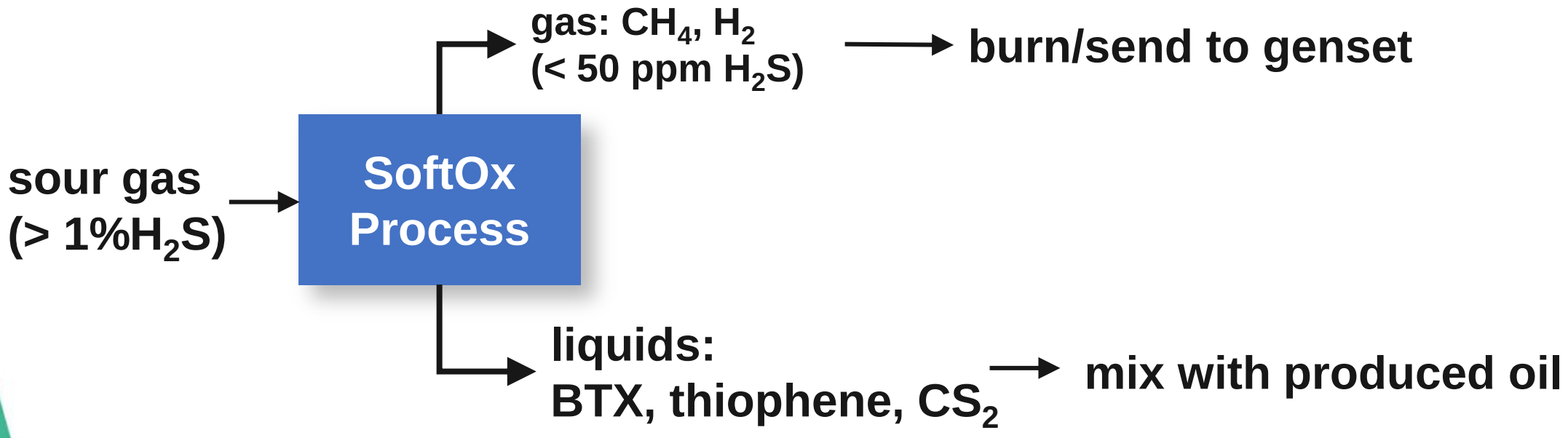
Cool GTL



Cool Reforming and GTL Applications

- Landfill gas sites
- Gas plants
- Reservoirs with high CO_2 and natural gas
- High CO_2 in flare gas

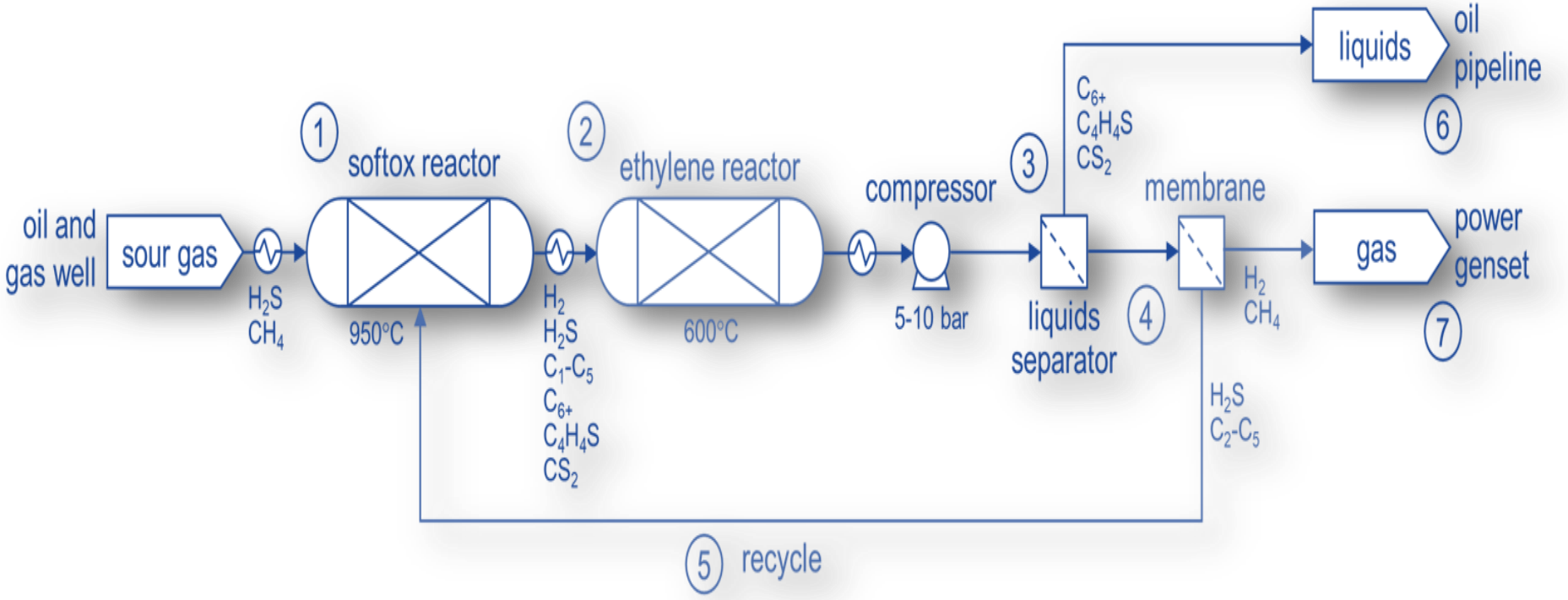
SoftOx (Soft Oxidation)



Convert wellhead sour gas into liquids that can be mixed with crude oil and a low-sulfur, H_2-rich gas for generating electrical power

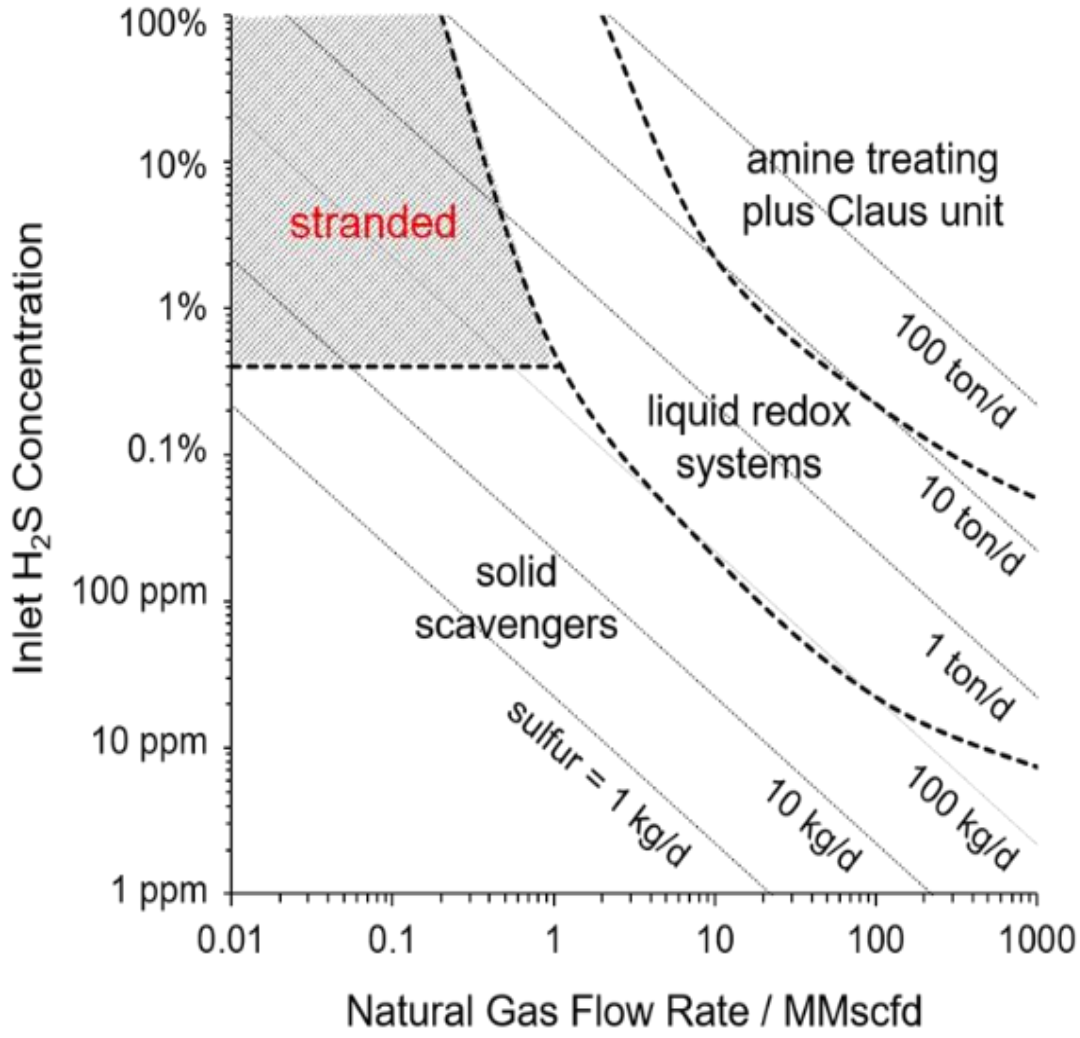
SoftOx solving the sour gas issue

- Reducing H_2S to allow power generation
- Added liquids to production
- Modular design
- Remote well head applications



SoftOx Application Space

- Low flow, high H2S
- Remote/stranded
- Little infrastructure
- Focused on flaring
- TRL = 4



Conclusions

- Atomic Layer Deposition (ALD) holds promise for Dry Methane Reforming (DMR)
- Cool reforming and Cool GTL has significant cost reductions that may enable GTL at smaller scales and reduce its carbon footprint
- Elimination of flaring using Soft Oxidation (SoftOx) can play a major role in the GHG reduction of remote gas fields
- All of these technologies address environmental issues for oil and gas production in a cost effective manner

Acknowledgements

- Co-authors: Terry Marker, Senior Institute Engineer,
  and Dr. Shiguang Li, R&D Manager
- Gas Technology Institute, Internal R&D funds
- Dane Boysen, Modular Chemical, valuable insights on SoftOx Process
- US Department of Energy (Contract No. DE-FE0029760) for the dry reforming work. We thank DOE/NETL Project Manager, Bruce Lani, for his assistance and many valuable discussions.
- We are grateful to Professor Liang's Research Group at the Missouri University of Science and Technology for their experimental work on dry reforming.