



## Innovation in the LNG Industry: Shell's Approach

Adam Bradley, Honey Duan, Wiveka Elion  
Esther van Soest-Vercammen, Rob Klein Nagelvoort

Shell Global Solutions International B.V.

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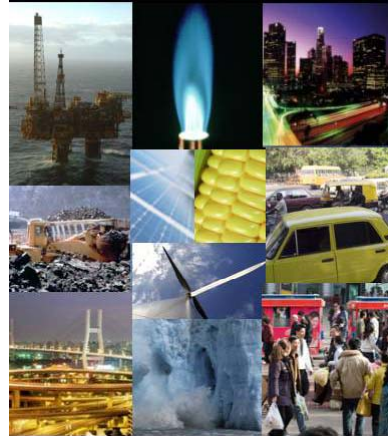
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## Three Hard Truths.

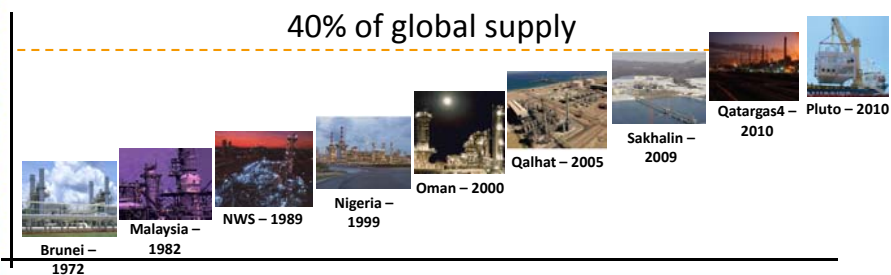
- World energy demand is accelerating
- Supply of “easy” oil and gas will struggle to keep pace
- Environmental pressures are increasing



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## History of Shell's Involvement

- Technical Advisor to nearly 40% of world LNG capacity
- Innovations focusing on
  - Reduced Capex, minimising technical risk, EE and GHG, Project delivery, fast starts and robust operation.



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## No More “Easy” Oil & Gas

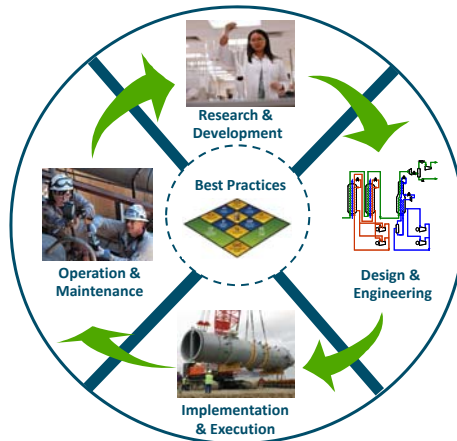
- Remote location, harsh climate
- Deep Water
- “Tight Gas”
- Depleted fields
- High N<sub>2</sub>, CO<sub>2</sub> content
- Sour gas



Photography courtesy of SEIC, Orman Lange 5

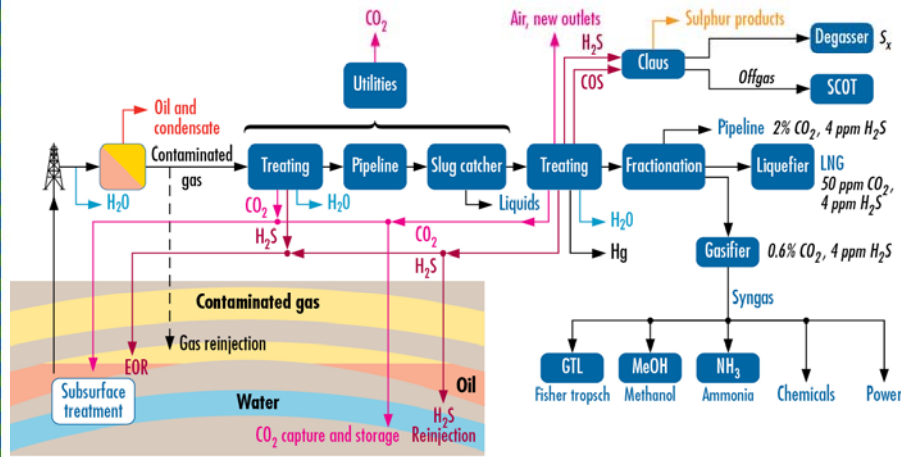
## Continuous Cycle of Improvement

- Over 45 years through:
- Research & Development
- Design & Engineering
- Implementation & Execution
- Operation & Maintenance



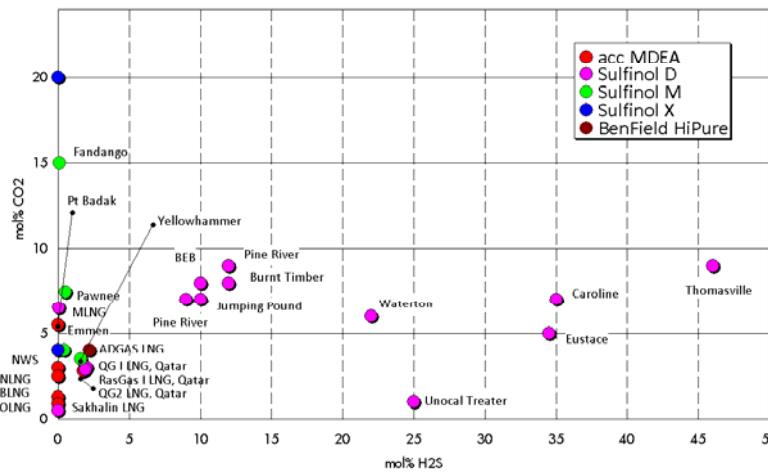
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# Technical Challenges



\*SCOT is a Shell trademark

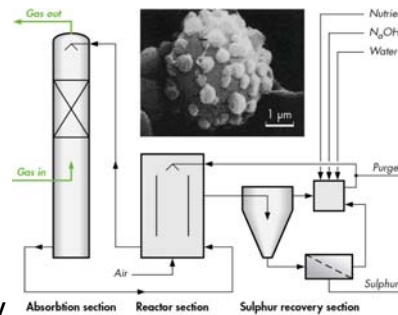
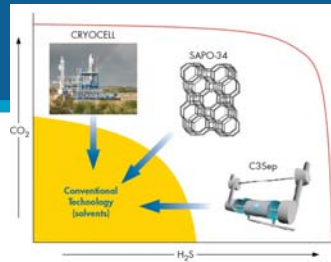
# Gas Treating Technology Application



\*Sulfinol is a Shell trademark

# Gas Treating Developments

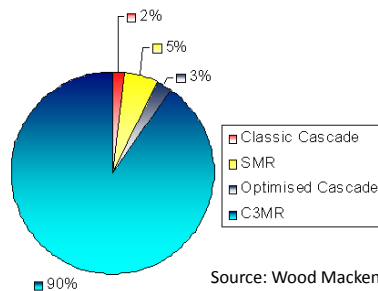
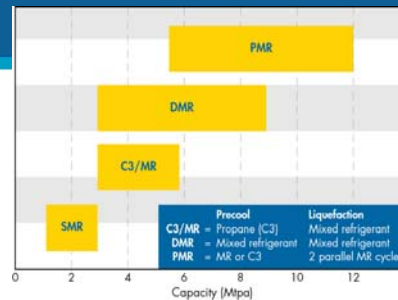
- ADIP™ & SULFINOL™ innovations
- Post combustion applications: CANSOLV™
- Column Internals – Shell HIFI & CONSEP™-X tray design
- CRYOCELL™, C3-Sep, membrane separation
- Sulphur recovery, including development with Paques B.V.



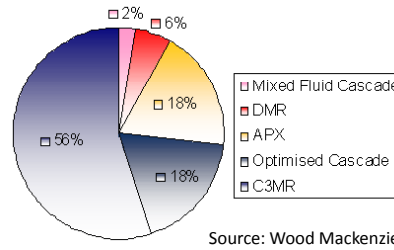
Biological desulphurisation process, developed with Paques B.V.

# Liquefaction Technology Development

- Shell has liquefaction capability across large capacity range
- Exploring alternatives to C3-MR technology



Source: Wood Mackenzie  
World Liquefaction capacity 1964 - 2000



Source: Wood Mackenzie  
New liquefaction technologies added between 2001 - 2012

## Sakhalin II – Project of “Firsts”

- First Russian LNG production plant
- First offshore oil platform, Molikpaq, installed on Russian shelf
- First of their type, PA-B platforms installed anywhere
- First access to Russian gas by Asia-pacific market



Photos courtesy of SEIC<sup>11</sup>

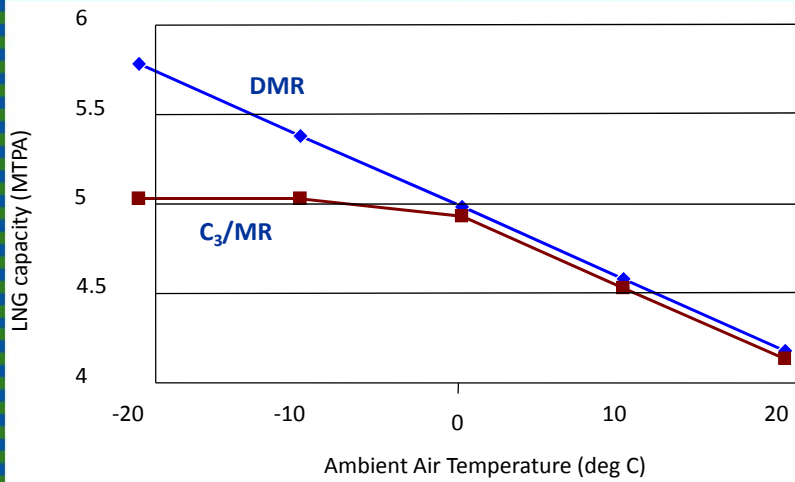
## DMR – Dual Mixed Refrigerant Technology

- Both refrigerant cycles use Mixed Refrigerants, which can be optimised for a wide range of Ambient T.
- DMR offers **higher** capacity for same driver set than C3/MR would
- Due to **better balance** between pre-cool and main cooling cycles in colder climates



Photos courtesy of SEIC<sup>12</sup>

## DMR – Balancing Power



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## Offshore LNG Production

- Floating LNG solutions
- When on-shore facilities are unfavourable
- 3.5 – 5 Mtpa gFLNG



### Facility Dimensions

Length between perpendiculars	468m
Width	74m
Circumference	1 km
Design Draught	17.4m
Displacement weight (fully loaded)	600,000 metric tonnes
Lightship weight (empty hull & topsides etc.)	205,000 metric tonnes

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## Innovation in Existing LNG Plants



### North West Shelf

- Creating vendor competition for cryogenic exchangers
- Introduction of air cooling



### Oman

- Low cost
- Production optimisation



### Brunei

- Extended lifetime beyond 60 years due to second rejuvenation project
- Integration with power station
- Over the years, producing 140% of its original design



### Malaysia

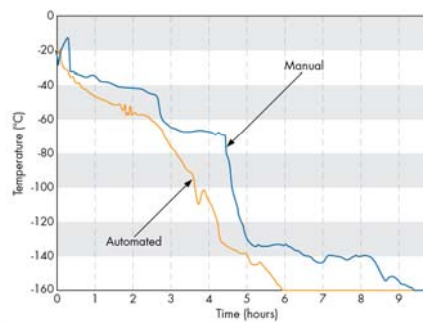
- Debottlenecking
- First axial compressor (increasing efficiency)

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## Operational Excellence

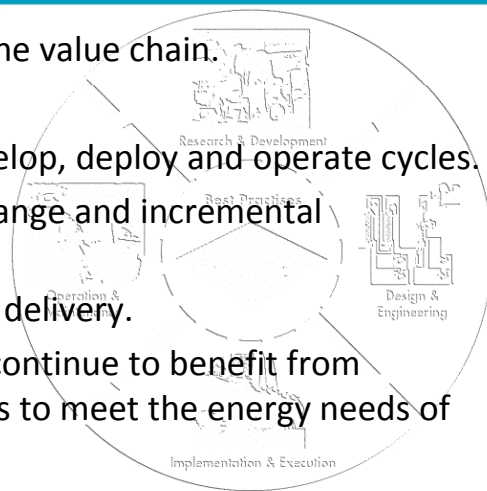
- Gas-GAME
- Advanced Process Control
- Automated MCHE cool-down
- Remote monitoring



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## Concluding Remarks

- Innovate throughout the value chain.
- Structured approach
- Based on identify, develop, deploy and operate cycles.
- Contributes to step change and incremental innovations.
- And successful project delivery.
- The LNG industry will continue to benefit from innovation as it evolves to meet the energy needs of the future.



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