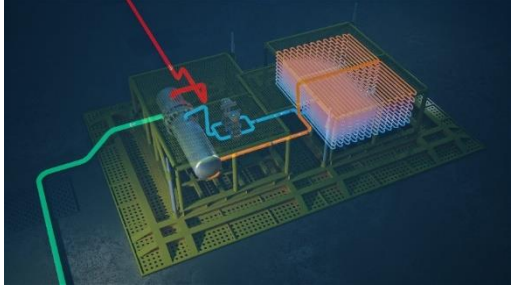
SubCool™



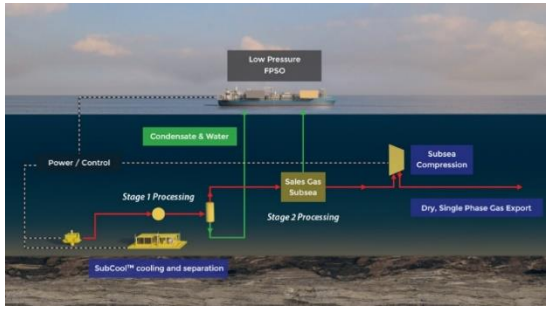
How the SubCool Hybrid Concept can Revolutionise Subsea Processing

AOG

Perth, 23rd February 2017

SubCool

A Revolution is Subsea Processing
The SubCool Hybrid Concept



Background

- Why ? What are the business drivers ?
- Subsea, Surface or FLNG ?

Subsea Dehydration &

The SubCool Hybrid Concept

The Market :- Focus on ‘ Platform or Gas-to-Surface’ Replacement

Summary

Background – The Problem

Many global deepwater gas fields are uncommercial and remain stranded

Many of these fields are typically:-

beyond fixed platform depth (175m)
more than 100km from their export destination
larger than 0.5 TCF

Current solutions are challenged, even before recent energy price falls

New lower cost solutions are required

We need a winning business case !

Background – The Problem

We need to ask WHY ?

(Toyota – ‘5 Why’s analysis’)

What is cost effective and what is not ?

Propositions

- We need good technology, however we don’t need technology for technology's sake
- We need to avoid costly complexity – where possible ‘Keep It Super Simple’ KISS

Solve the basic challenge :-

How to get remote hydrocarbons to market ?

The Problem – Current solutions

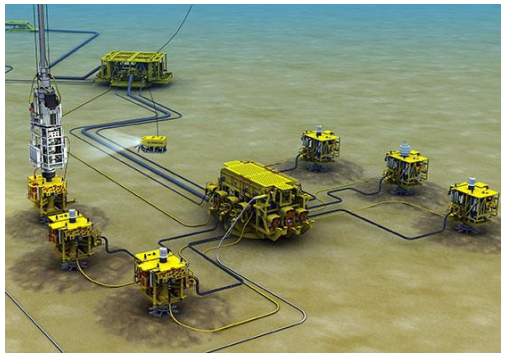
1. Deepwater surface gas processing solutions result in 'mega-facilities'

Surface processing of high pressure gas results in facilities that are large, heavy and costly

Large risers plus flow assurance costs are higher in deep water

2. FLNG was labelled as an alternative

- *Many have not proceeded*
- *CAPEX costs, and especially OPEX costs are very high*
- *Complexity and Safety are also key challenges*



3. Subsea processing is a great success over short distances

- *Complexity plus shear 'Physics Limits' mean subsea processing struggles over longer distances*

What generates high cost facilities ?

Key distinction between processing gas and processing liquids

- **HIGH** Pressure Gas Systems have a disproportionate impact on size, weight and cost of deepwater surface facilities
  - Including High Pressure Risers, ESD Valving, Flare and Utility Systems

- Liquids can be processed on the surface relatively efficiently, at **LOW** pressure
  - E.g. Brazil and West Africa, using an FPSO to produce liquids is not questioned
  - An FPSO is a very efficient, proven unit
  - Even on oil developments, it is the **HIGH** pressure gas system on an FPSO that takes up a substantial area, size, weight and cost

Surface or Subsea for Processing Oil & Gas ?

Process engineering fundamentals are important

- Key distinction between processing gas and processing liquids

Cold is required for gas processing

- **Cold is available on the seabed**

Heat is required for liquid separation and stabilisation

- **Heat lowers viscosities which are a key enabler of droplet coalescence**

Conclusion

- **Liquid processing is most efficiently undertaken on the surface**

  (in the context of gas-condensate subsea processing & field development)

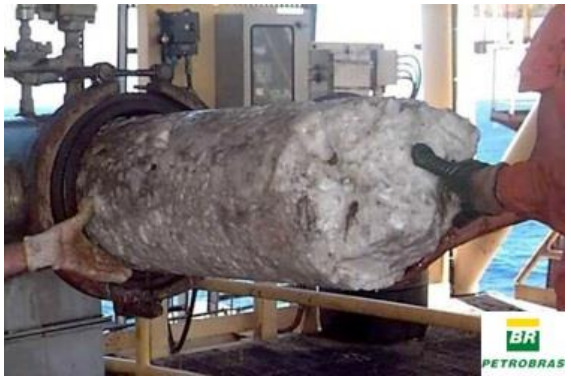
Water is well known as a key problem in gas processing

Water causes corrosion and hydrate plugs

Subsea production systems typically inject chemicals (Glycol or MEG), and install insulation or trace heating/DEH to prevent hydrates

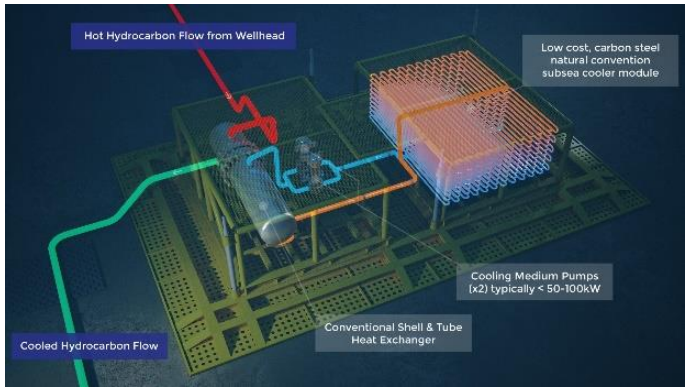
- solutions work well over short distances
- however they are high cost over long distances

These are 'end of pipe' solutions



'Gas Dehydration' is a fundamentally standard unit operation on gas platforms & onshore

Dehydration is the ultimate solution to allow low cost, long distance transport in 'water dry' pipelines



The SubCool™ Sales Gas Subsea' process allows for simple and robust 'subsea dehydration'

A Revolutionary 'Hybrid Concept'

SubCool™ has an innovative development solution by processing gas and liquids at the fundamentally most efficient location

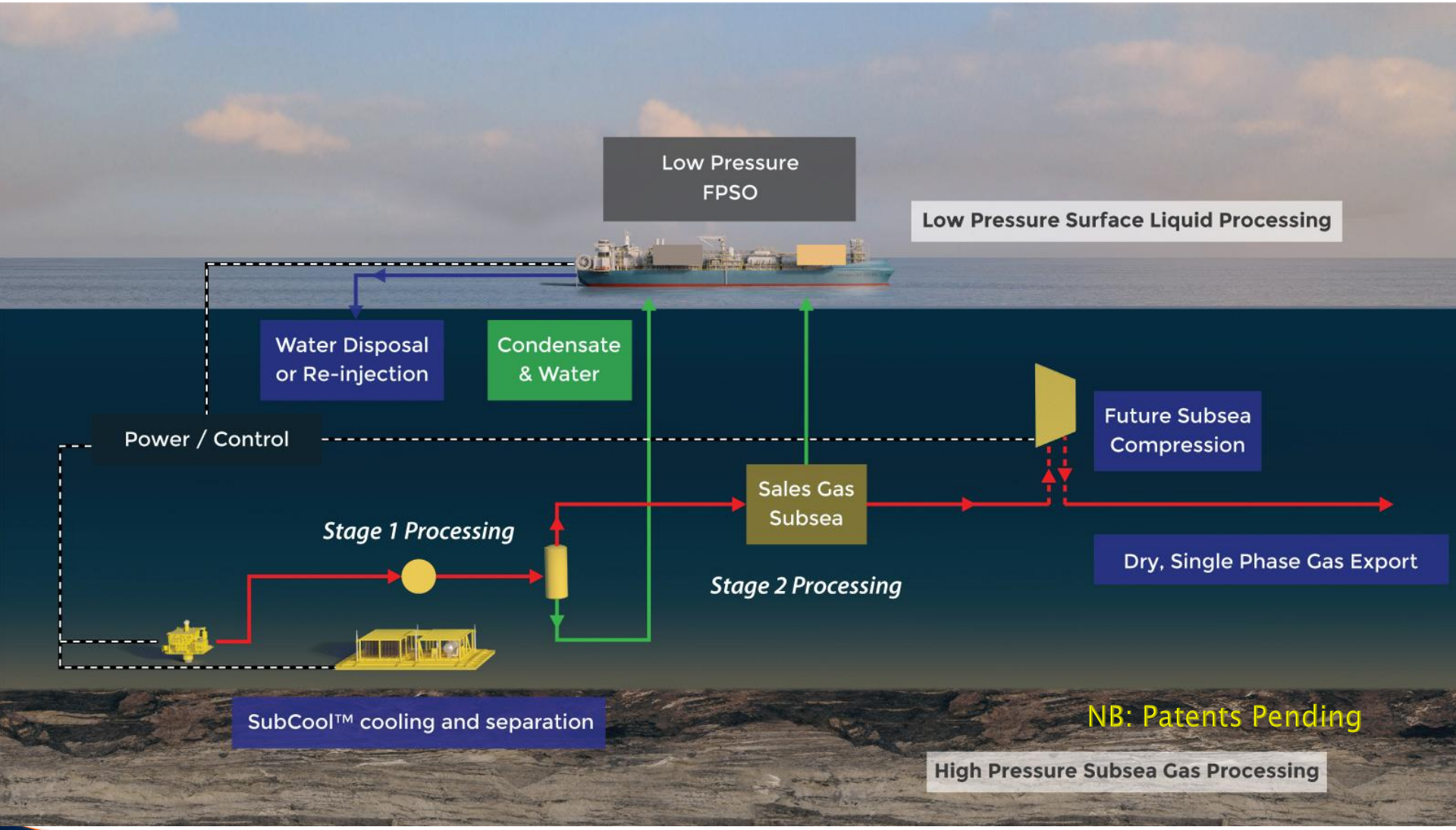
- Not Surface, Not Subsea, but the ultimate 'Hybrid'

Three key components

1. Subsea - 1st Stage - Robust Active Subsea Cooling and Separation
2. Subsea - 2nd Stage - 'Sales Gas Subsea' process. Subsea dehydration for dry, single phase (or dense phase) gas export
   - The high pressure gas remains subsea
3. Surface : A compact, low pressure surface unit for liquids processing and surface support
   - E.g. 4000 tonnes instead of 24,000 tonnes, 20 bar instead of 200 bar
   - Provides virtually 'unlimited' distance capability
   - Enables simpler, lower cost, 'local' subsea compression - when and if required

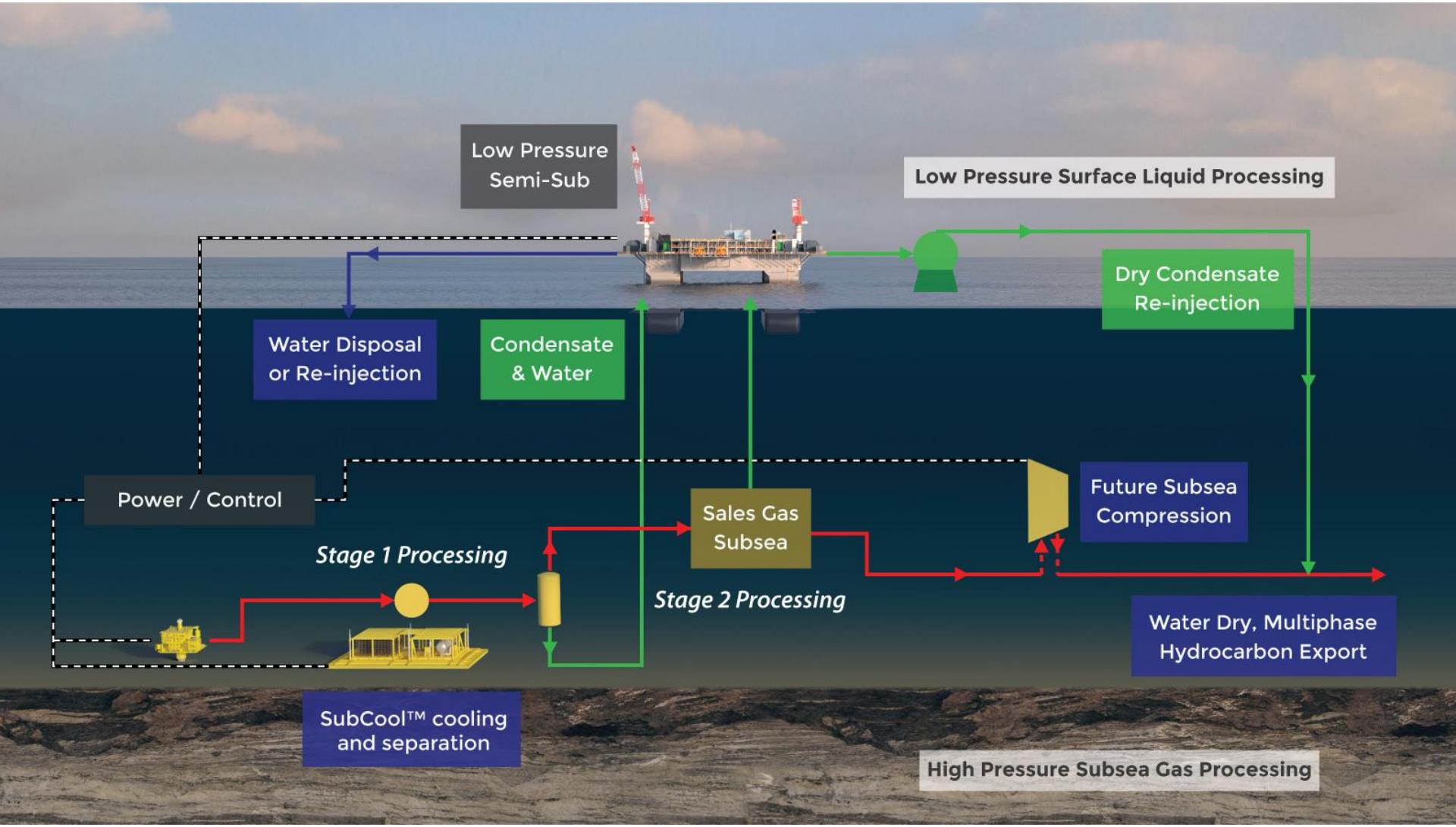
‘Sales Gas Subsea’ Hybrid Concept

Scheme 1 - Local Condensate Storage & Export – Dry, Single Phase Gas Subsea Export



‘Sales Gas Subsea’ Hybrid Concept

Scheme 2 – Minimally Manned Semi-Sub, with Dry, Multiphase Subsea Export



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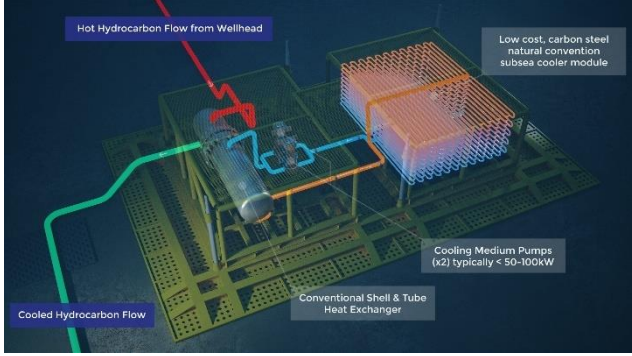
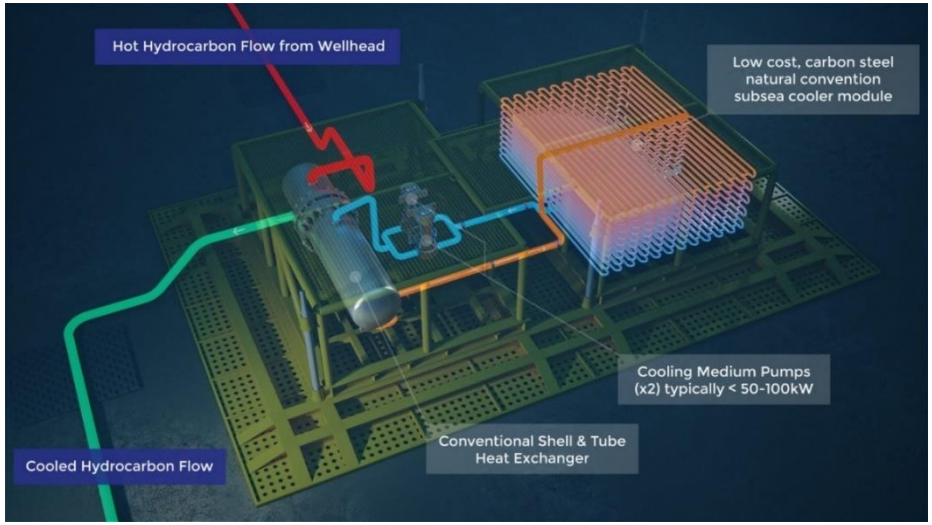
Key Processing Features



- Design can be naturally robust, tolerant
  - We can design for a level of separator carry-over
  - Pressure and temperature profile along the pipeline results in drier gas conditions
- Cooling is the basis for subsea dehydration
  - Active cooling under development
  - Heat exchangers and cooling components are relatively simple
- Subsea Separation Systems are the key
  - Quality testing is available
  - Gas-liquid separation is the simplest
  - ‘In-line’ separators offer great upside potential

The SubCool™ Robust Active Subsea Cooler

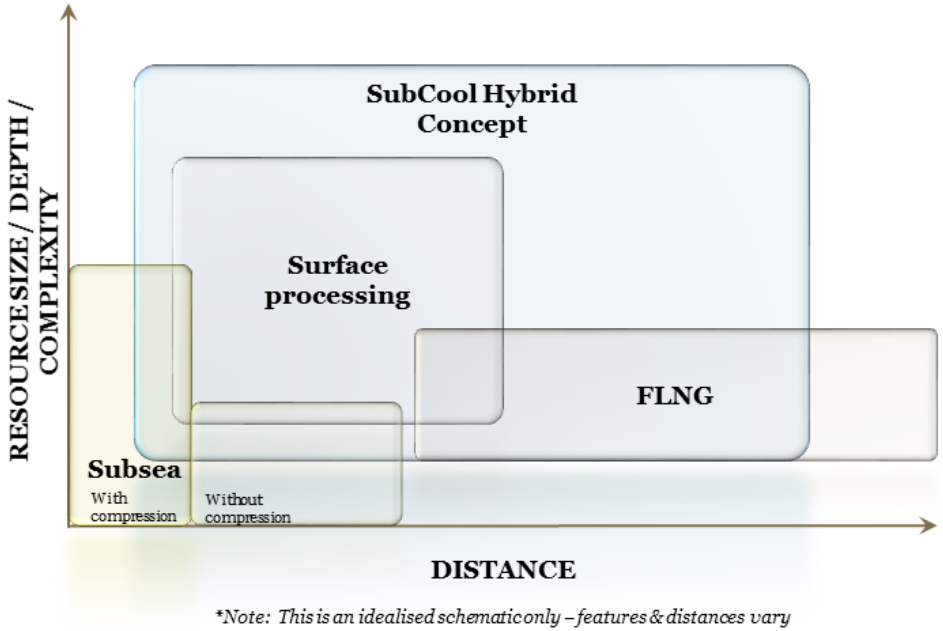
- Proven components – Standard Heat Exchanger – no 'bespoke design'
- Safety – Full pressure containment on tube failure
- Low power – kW not MW
- Temperature Control Robustness
  - low sensitivity to coating/marine growth
- Maintainability – change out of cooling medium modules



Technology Status

- SubCool™ Sales Gas Subsea process is innovatively applied onshore gas processing technology
  - No new ‘magic widgets’
  - Technology is known, easy to understand, design and verify
- Technical qualification of remaining components for subsea operation should be straight forward
- The industry is now ready for subsea processing
  - The great success of subsea boosting, compression and separation projects over the last decades
  - Multiple subsea systems providers
  - Subsea construction vessels are more readily available

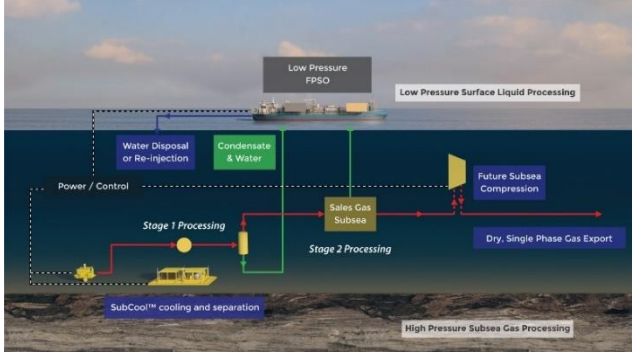
SubCool™ Idealised Envelope of Application



Note: This is an idealised schematic only – features & distances vary

- The key is replacing 'Surface Processing – Gas-to-Surface' solutions
- Costs to fall further with 'standardisation'
- Application Envelope will grow

SubCool™ Summary Points 1



The SubCool Hybrid Concept is a revolutionary solution enabling development of stranded gas fields

It is not subsea, not surface, but a truly unique and optimal combination

High pressure gas is fully processed subsea, including subsea dehydration

Liquids are processed on a radically smaller, low pressure, surface facility

The surface facility provides virtually unlimited distance capability.

Power and control is simplified for lower cost subsea compression

All components are proven and require a minimum of technical development

Hybrid Concept – Summary Points 2

Safety is unquestionably improved over conventional surface solutions

The SubCool Hybrid Concept has fundamental processing advantages.

These result in lower CAPEX and OPEX costs than other solutions

- Costs should fall further with continued standardisation in subsea processing

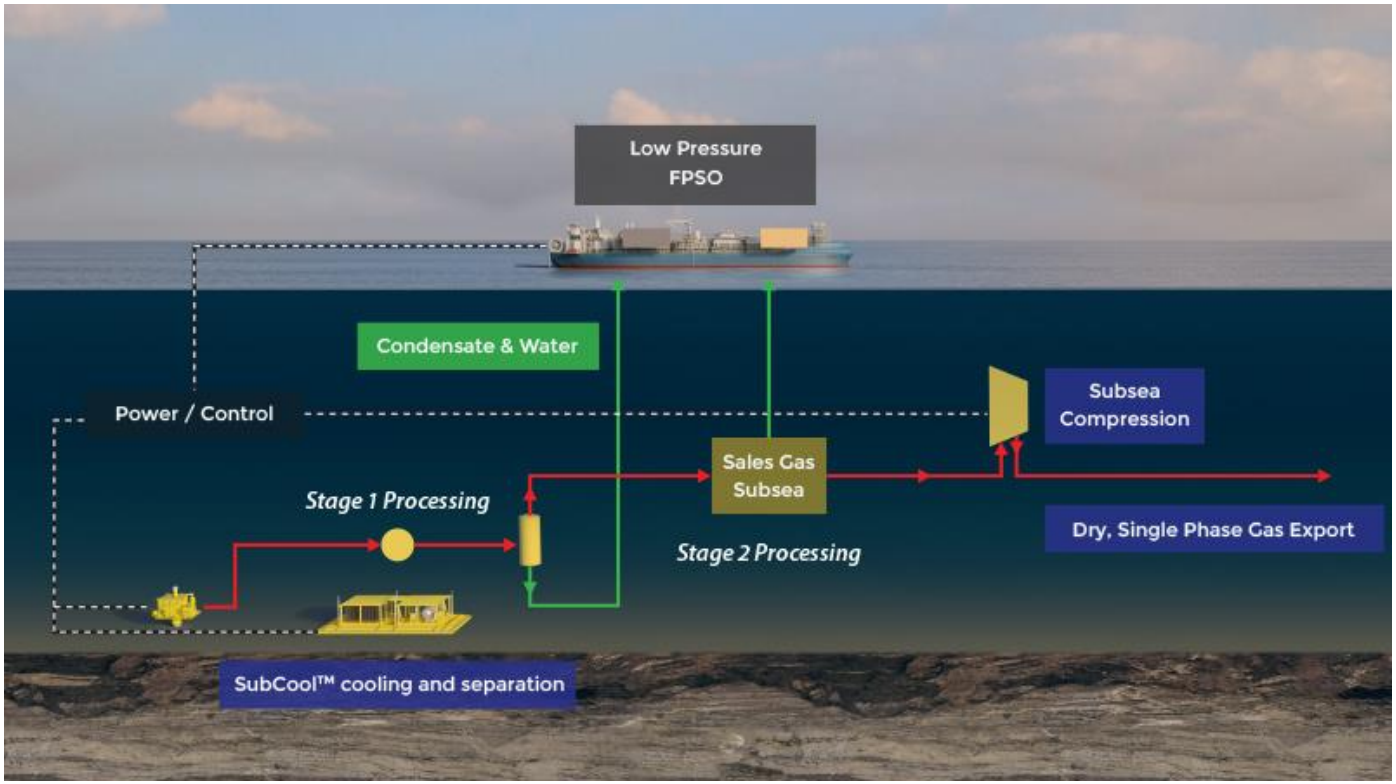
With a winning business case, the SubCool Hybrid Concept can create a step change increase in subsea processing installations :- a ‘revolution’

Further study and investment in the SubCool™ Hybrid Concept to undeveloped gas resources is justified

A Revolution in Subsea Processing

The SubCool Hybrid Concept for Developing Stranded Gas

Q&A



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