Rethinking Subsea Boosting for Optimized Subsea Field Development

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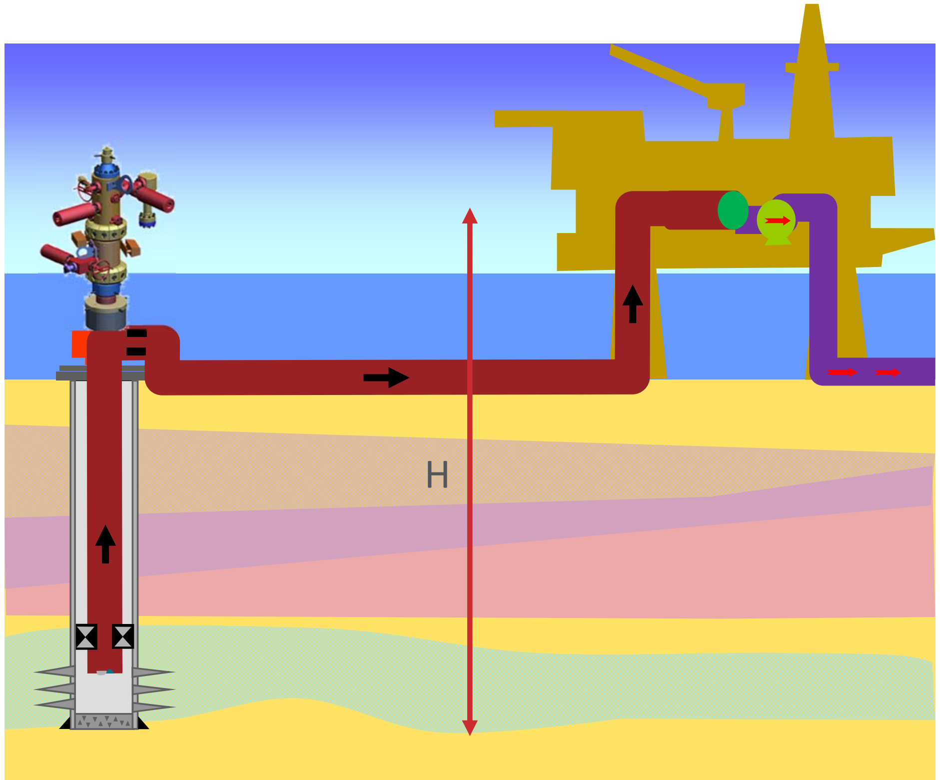
Outline

1. Introduction – Subsea Boosting
2. Boosting Technology - Pumps
3. Value Drivers
4. Re-thinking Subsea Boosting

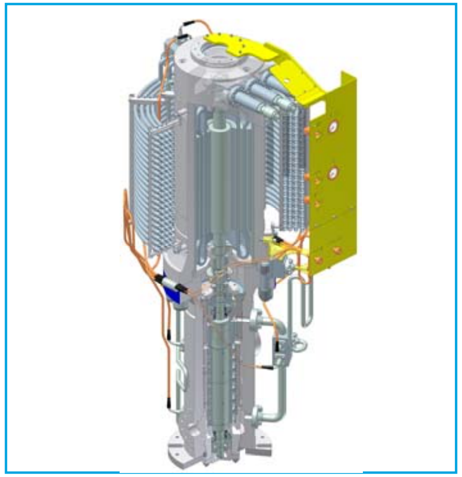
Introduction – What is Subsea Boosting and its applications

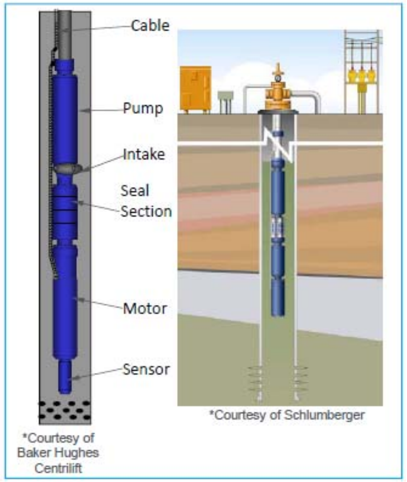
What is Subsea Boosting

To add energy to fluids to move them against gravity and friction



- The pumps will transfer fluids from low pressure areas
- Pumps transfer fluids from low elevations to higher elevations
- Pumps transfer fluids from local locations to distant locations





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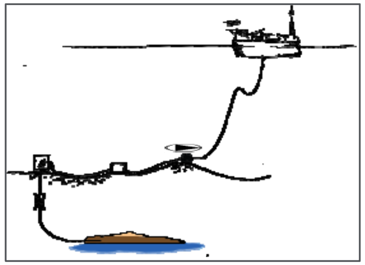
Application of Subsea Boosting

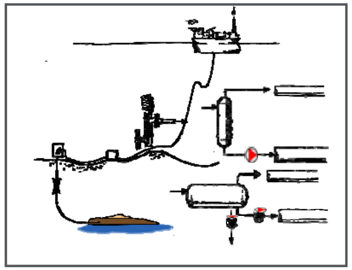
Subsea Boosting

Mudline Boosting Without Separation



- Single Phase Pump
- Multiphase Pump
- Wet Gas Compressor

Mudline Boosting with Separation



- Single Phase Pump
- Multiphase Pump
- Dry Gas Compressor

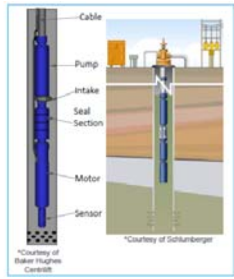
Produced Water Re-Injection

- Single Phase Pump

Raw Seawater Injection

- Single Phase Pump

Downhole Boosting (ESP)



- ESP Pump

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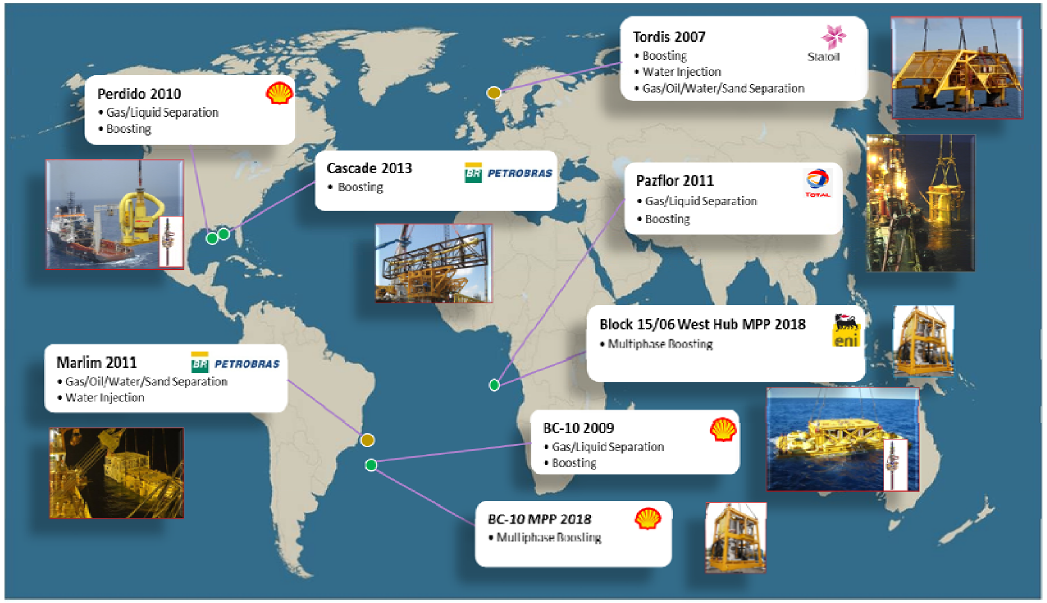
Why Re-thinking Subsea Boosting

To reduce subsea development cost

The opportunity for Subsea Boosting to become a standard in the industry is right now

- Subsea boosting have been in use for 20 years
- Played an important role in development of subsea processing projects
- Are playing an increasingly important role in the improvement of recovery rates and profitability.
- But in most cases the system is Big, Heavy and Costly



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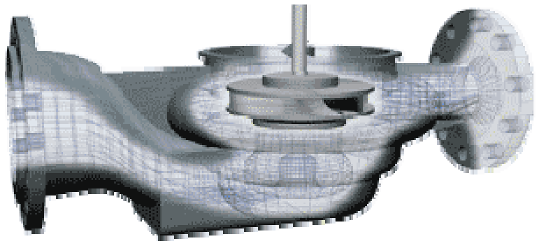
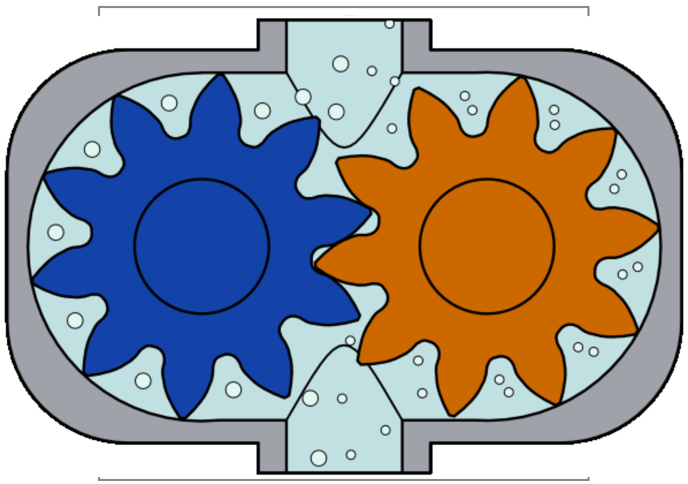
Boosting Technology - Pumps

Liquid and Multiphase Boosting

- **Increase well-stream and/or export line pressure**
  - Increase and accelerate production
  - Enable production from low pressure reservoirs

- **Pump types**
  - Single Phase
  - Multiphase





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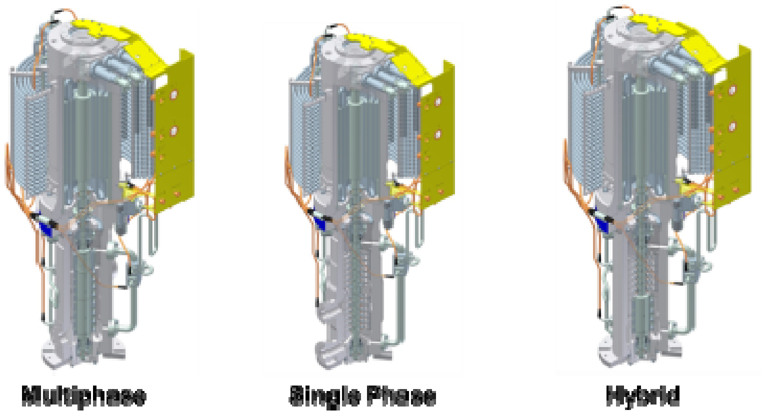
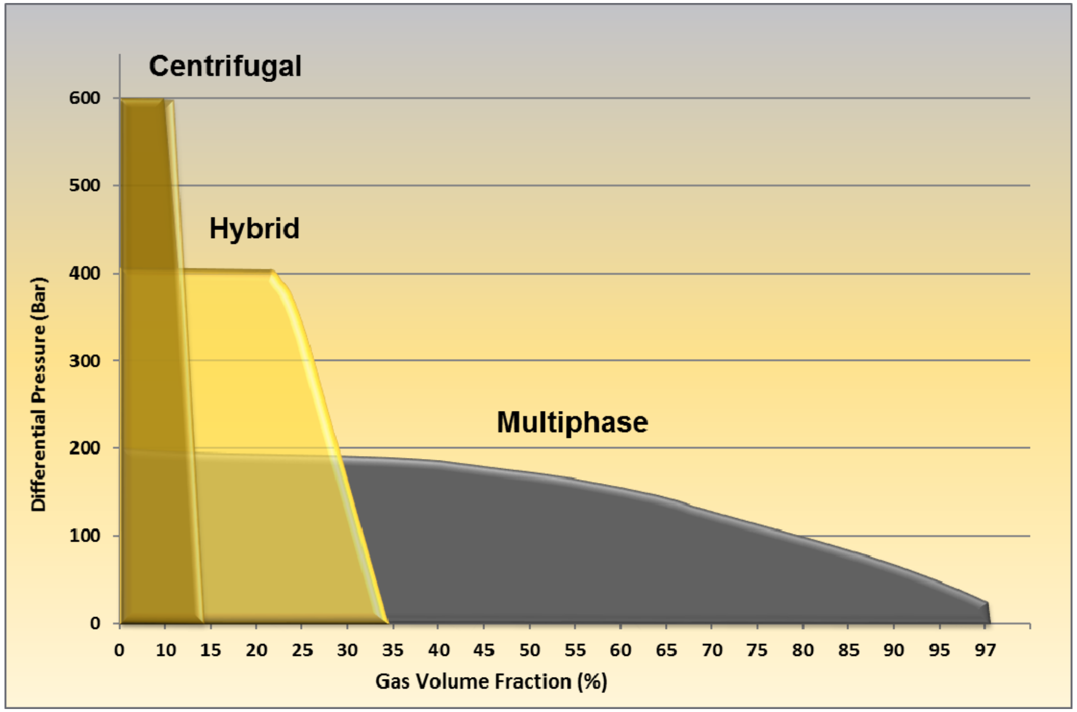
Pump Technologies

3 types of hydraulics available to select from:

- **Single phase:** Very high pressure boost for pure liquid phases
- **Hybrid:** Medium high pressure boost with relatively low GVF
- **Multiphase:** High pressure liquid and gas, relatively medium to high GVF





Achievable differential pressure is dependent on amount of gas in liquid

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High Speed Motor – High Speed Pump

- High efficiency Synchronous motor performance, up to 4x 'air gap' and small diameter Permanent Magnet (PM) rotor
- Cable wound stator allows the use of a water-glycol barrier fluid.
- Enables the pump to rotate at across a large range of operating speeds up to a maximum of 6,000 rpm.
- A large range of operating speeds increases adaptability to production uncertainty.

Delivery in 2018 for:
- BC 10
- Block 15/06 West Hub

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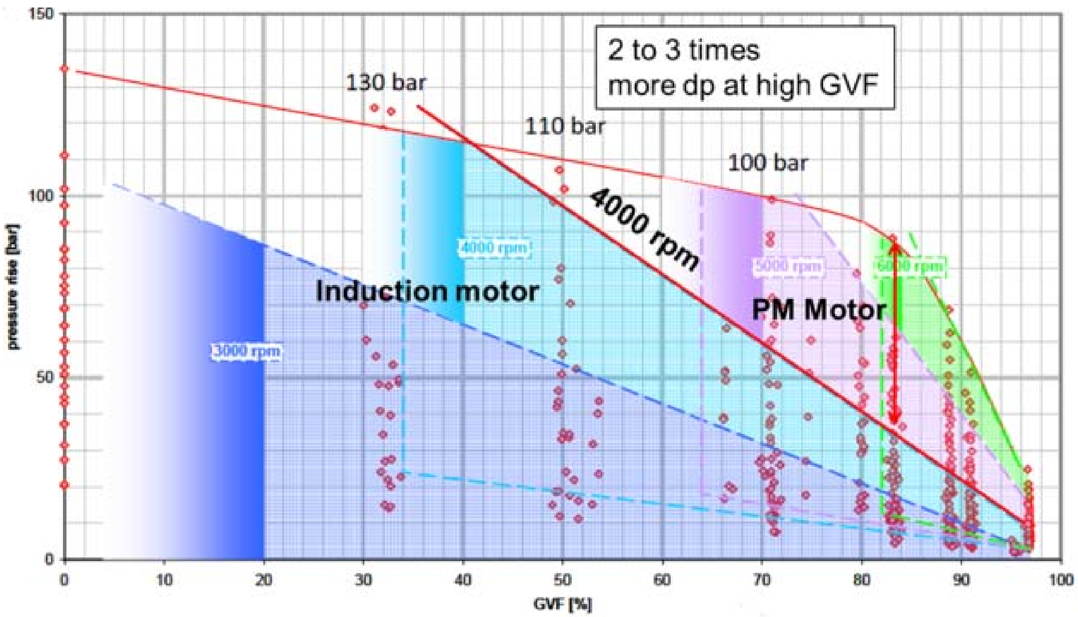


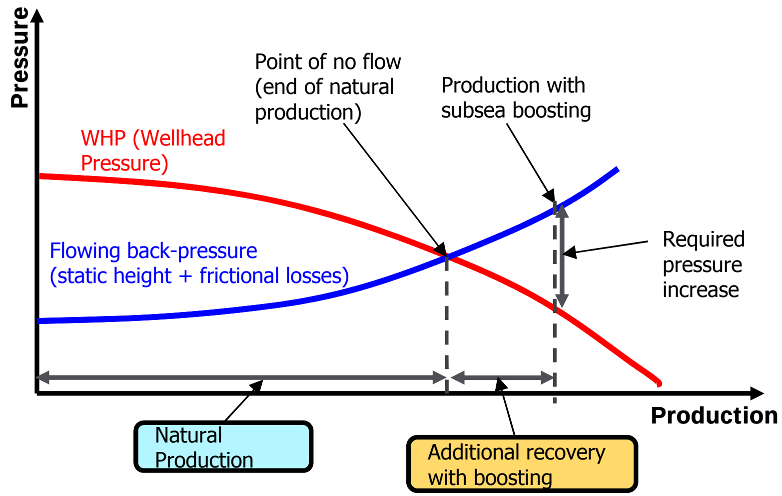
Allows for:

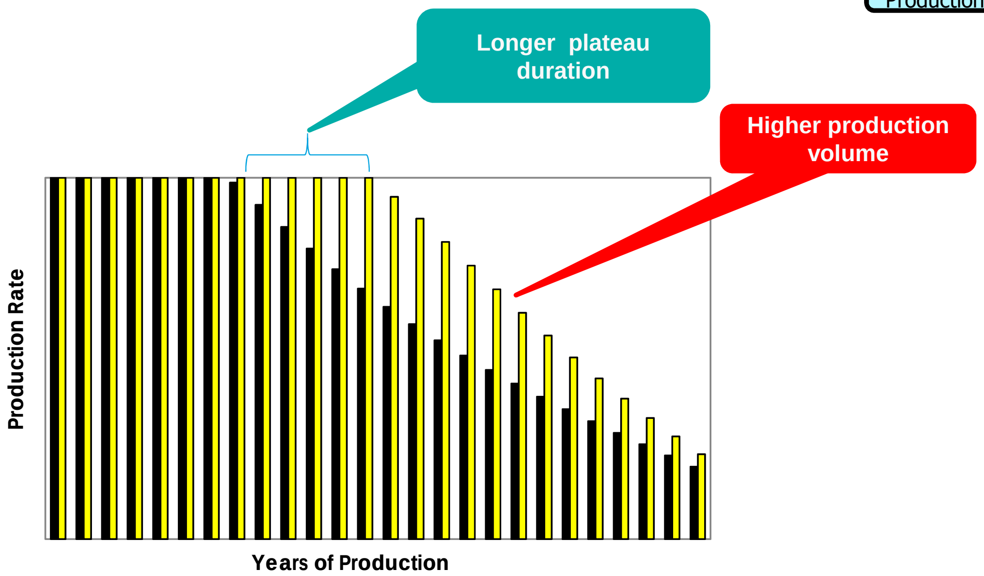
- High GVF
- High boost
- Deep water
- Long tie back

Subsea Boosting – Value Drivers

Economic Drivers – Maximize NPV

- Increase Oil Recovery





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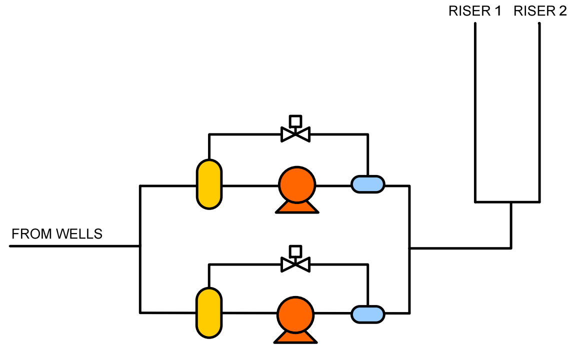
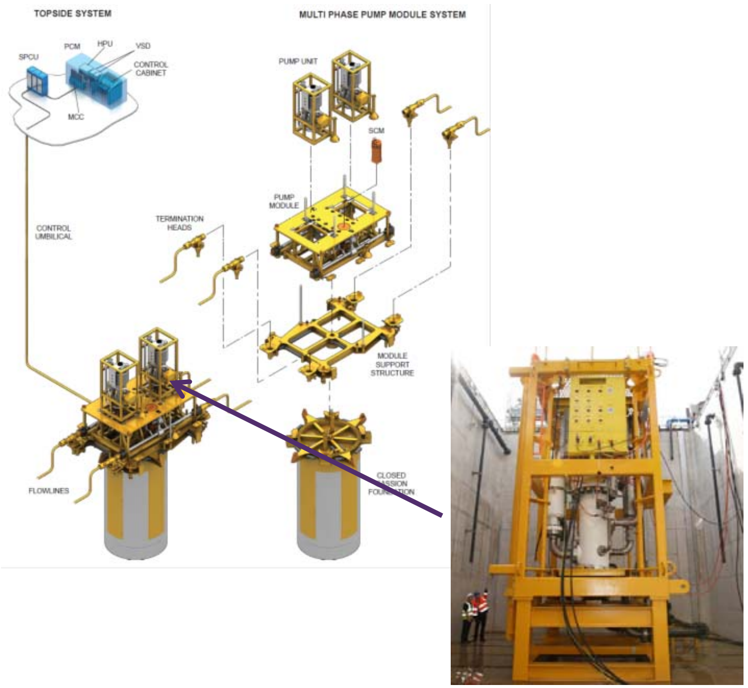
Main Drivers for Boosting

- Main drivers:
  - Low pressure reservoirs (Greenfield)
  - Declining reservoir pressure (Brownfield)
  - Increasing watercut (Brownfield)
  - Increase and accelerate production (Greenfield/Brownfield)

- System solution especially dependent of:
  - Power and differential pressure requirements (function of production rates)
  - Step-out; subsea/topside transformers and/or VSD’s, AC or DC transmission?
  - Injection reservoir characteristics (in case of injection pumps)





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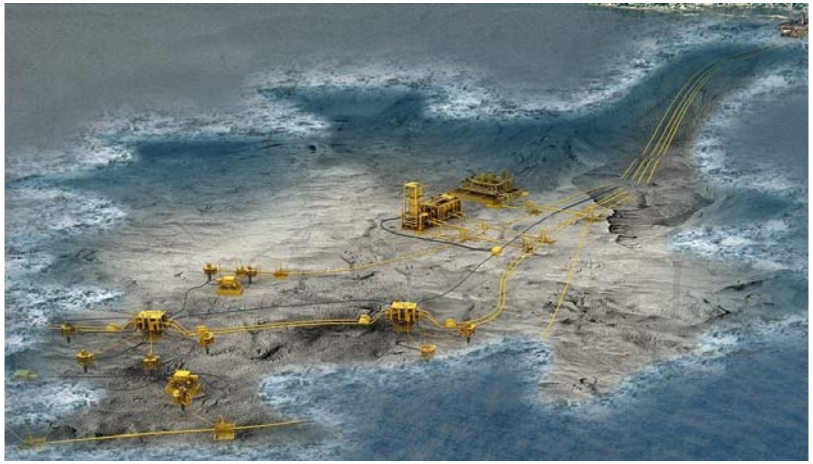
Rethinking Subsea Boosting System

Optimization by Integration of SPS and SSP equipment

The degree of integration depends on existing system or requirements for a new development.

- Greenfield – fully integrated
- Brownfield – partial integration



Case specific cost reduction (Brownfield)

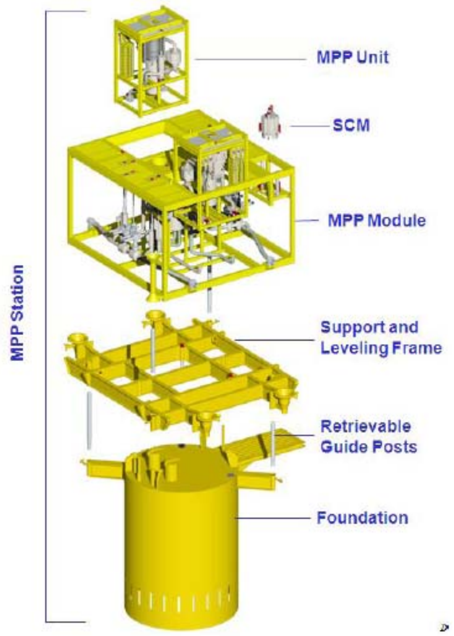
- Re-use existing SPS infrastructure
- Reduced SURF scope
- Optimize existing pipeline infrastructure

Optimization by Integration of SPS and SSP equipment

Green Field Case:

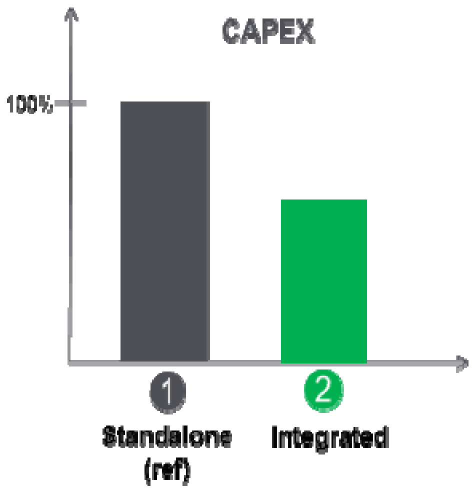
Incorporate the MPP into the SPS Structure. This represents the arrangement with the largest cost reduction potential:

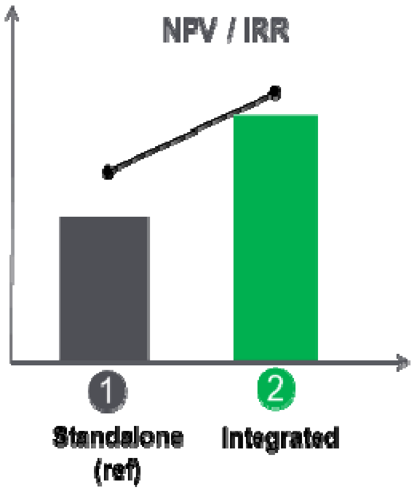
- Hardware cost reduction
- Reduced cost of gas lift gas due to boosting (where applicable)
- Reduced cost of SURF including power umbilical
- Combined control functions

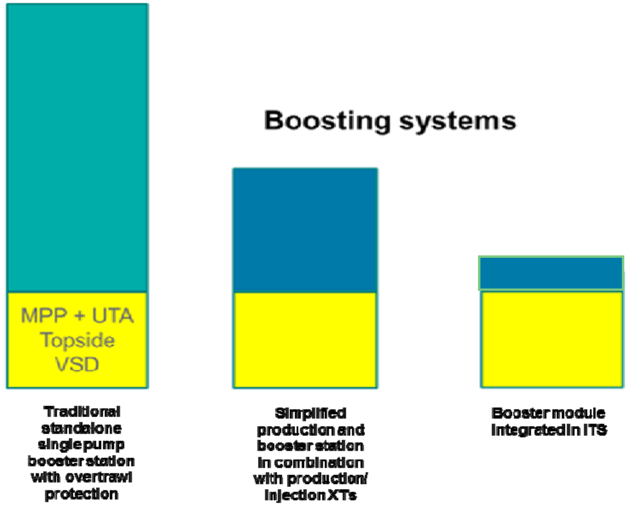


Good Business Case by Integration

- Integrated Subsea boosting will give a positive contribution to the NPV and IRR.







The alternative configuration with a central manifold system and two off booster pumps is estimated to provide:

- 20 – 25% cost reduction
- Up to 50% size and weight reduction

Cost Reduction by Topside Simplifications

Most of the installed subsea boosting systems are as a standalone installation hooked up to new or existing infrastructure. Placing processing equipment on the seabed would release space and weight on topside design.

Cost can be saved if part of this topside scope of work can be simplified, eliminated or avoided entirely. Less equipment on topside will contribute to optimize the design or even enable development of marginal fields.

Incentives and drivers:

Brownfield:

- Very limited topside space available
- Big topside modifications required

Greenfield:

- Reduce floater size, weight, deck space and loads
- Reduce topside hook up - less construction work
- Simpler umbilical – lower cost

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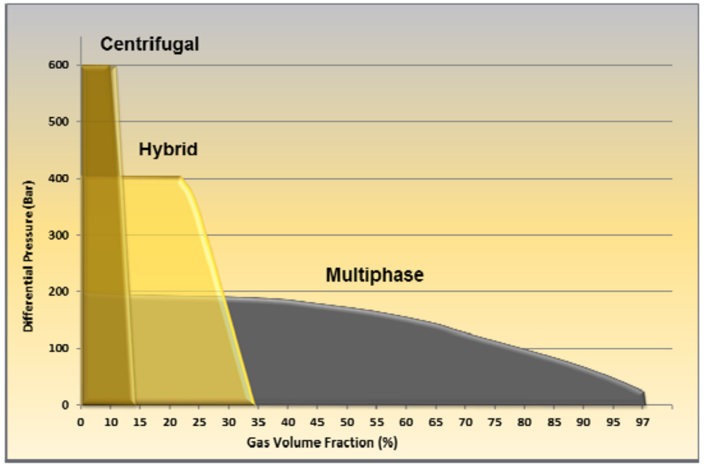
Increased Boosting after Separation

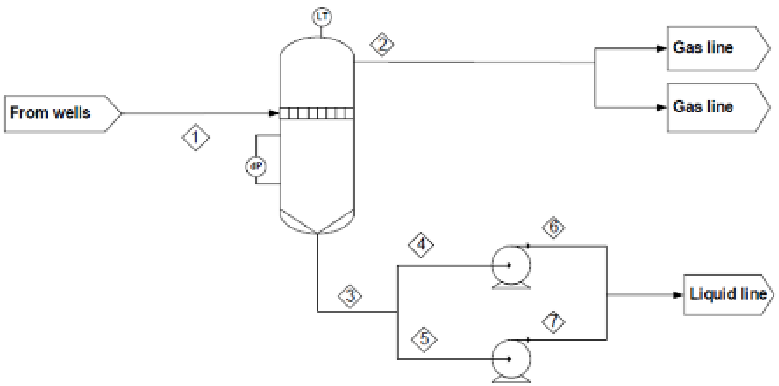
Maximize Recovery

- Gas/Liquid separation
- Liquid boosting at higher pressure

Enable long distance transport

- No local receiving facilities
  - opens for many new development options





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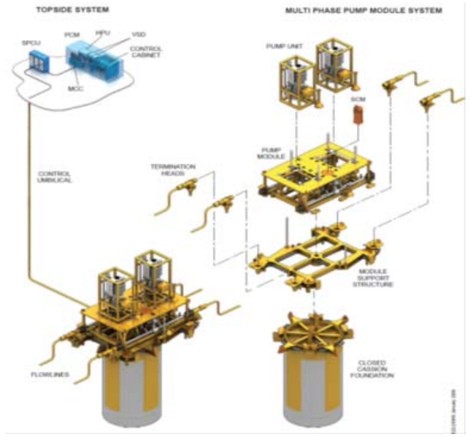
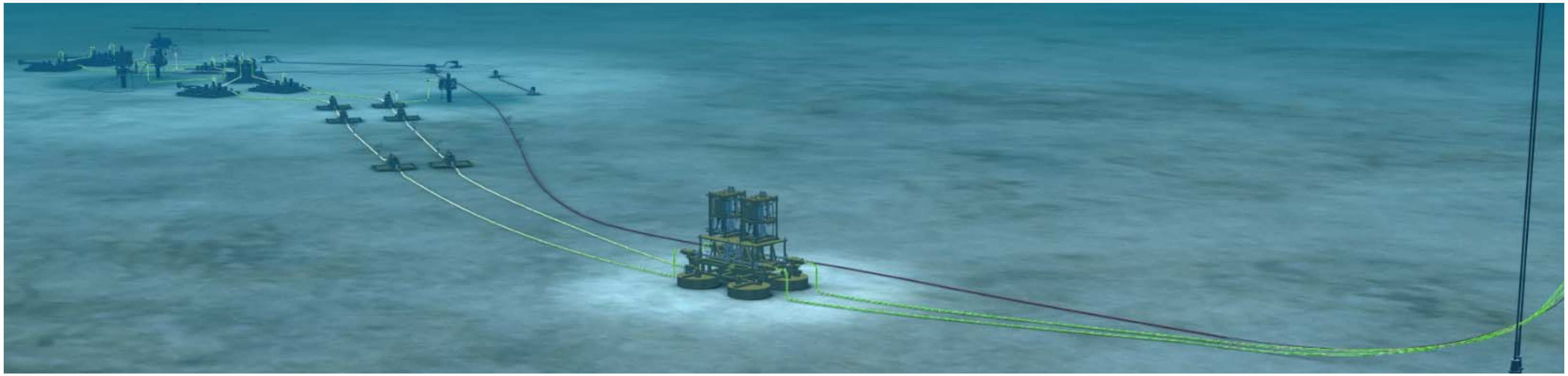
Subsea Boosting – Other Optimization

- Reduce, optimize and Integrate with SURF scope
- Re-use and leverage exiting infrastructure, i.e. SPS Control Umbilical
- Simplify installation smaller modules – simpler, lighter and configurable
- Low cost driven design of all units – applying vendor based material and welding specifications, standard products and configurable system solution





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Summary and Conclusions

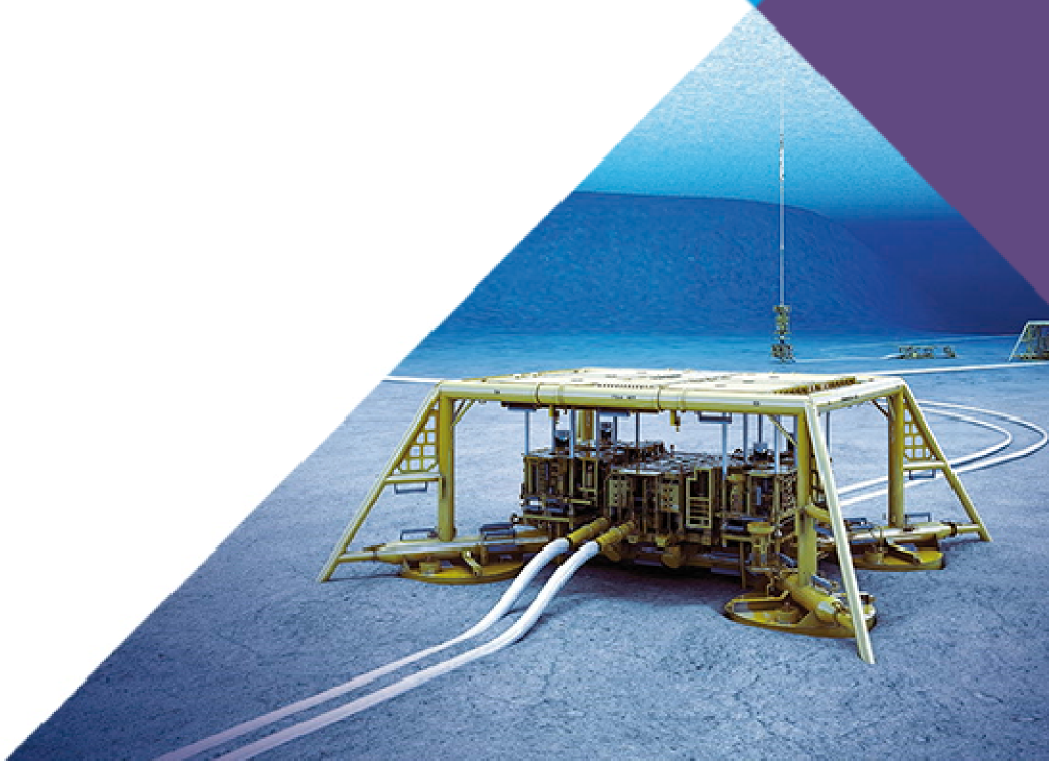
Summary Subsea Boosting

- Improves business cases and lowers break even cost
- Accelerates and/or increase production of existing fields
- Enables new field developments

Conclusions Subsea Boosting

- Re-thinking is necessary in the subsea industry as a response to new challenge of low oil prices
- Potential in exploiting existing or new subsea infrastructure to reuse or co-use functions, structural elements and topside installation

Thank You



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