AkerSolutions

part of Aker

‘Zero Emission Power Production for LNG Regasification’

‘’A concept for new environmental friendly regasication technology’’

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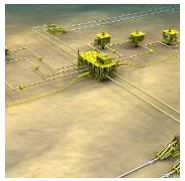
Aker Solutions
Operating businesses

Engineering solutions

Engineering

Product solutions



Subsea

Drilling Technologies

Mooring & Loading Systems

Process Systems

Field life solutions

Well Intervention Services

Oilfield Services & Marine Assets

Maintenance, Modifications & Operations

Business Management
Corporate structure

Executive Chairman
Øyvind **Eriksen**

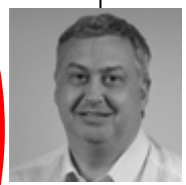
President [1] and
Chief Financial Officer
Leif **Borge**

Corporate Centre

- Chief Operating Officer
- Chief of Staff
- Chief Strategic Marketing
- Chief Technology Officer
- Chief HR Officer

Engineering (ENG)

Valborg Lundegaard



Subsea (SUB)

Alan Brunnen

Umbilicals (UMB)

Tove Røskaft

Drilling Technologies (DRT)

Thor Arne Håverstad

Mooring & Loading Systems (MLS)

Leif Haukom

Process Systems (PRS)

Michael Hambly

Well Intervention Services (WIS)

Wolfgang Puennel

Oilfield Services & Marine Assets (OMA)

Karl Erik Kjelstad

Maintenance, Modifications & Operations (MMO)

Tore Sjursen

[1] President of Aker Solutions ASA

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Engineering BA Management

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Study Background: Introduction

- LNG Regasification Process turns the cold LNG into Natural Gas so that it can be given to the End User.

- Traditionally 2 different methods are used for LNG Regasification:
  - Submerged Combustion Vaporisers (SCVs) using a burner as the heat source
  - Open Rack Vaporisers (ORVs) using sea water as the heat source

- But both methods have a negative impact on the environment:
  - SCVs: Emission of flue gases containing NO_x , CO, CO_2
  - ORVs: Discharge of large volumes of seawater containing hypo-chlorite and at up to 10°C colder than the seawater intake temperature

Study Motivation (External)

- Global warming due to increase in human emissions of CO_2 require new environmentally friendly products
- Kyoto agreement
- EU 2020 Goal
- There is an existing and growing market on offshore and onshore LNG Regas terminals
- There are restrictions on planning and building of LNG Regas terminals due to environmental regulations
- Upcoming new technology for environmentally friendly large scale energy production:
  - Post-combustion (*ACC*) – Available technology
  - Pre-combustion – Future Technology
  - **Oxyfuel – Emerging Technology**

Study Motivation (Internal)

- Aker Solutions controls the entire CO_2 value chain
  - *Aker Clean Carbon (ACC) owns technology on CO_2 capture*
  - *CO_2 from NG*
  - *CO_2 injection (Subsea/platform)*

- Aker Solutions has built two-third of world's offshore GBS structures
  - This Regas terminal is assumed to be built on GBS

- Experience on major onshore LNG regasification terminals

Study Aims

- Design a NEW environmental friendly LNG Regas terminal that does not produce any emission or effluents
  - Power generation with CO2 separation (minimal harmful emissions)
  - No discharges to sea

- This new technology will be a real competitor to the traditional LNG Regas market, in the areas where stricter environmental restrictions are enforced.

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Adriatic LNG Terminal Overview

Design

- Gravity-base structure (GBS) designed by Aker Solutions

Technical Features

- The structure is 180 m x 88 m
- LNG Regas process using four ORVs (seawater) + one SCV (waste heater boiler)
- Located 15 km off the east coast of Italy.
- Placed on the seabed in a water depth of approximately 30 metres.
- Pipes which transport gas to land

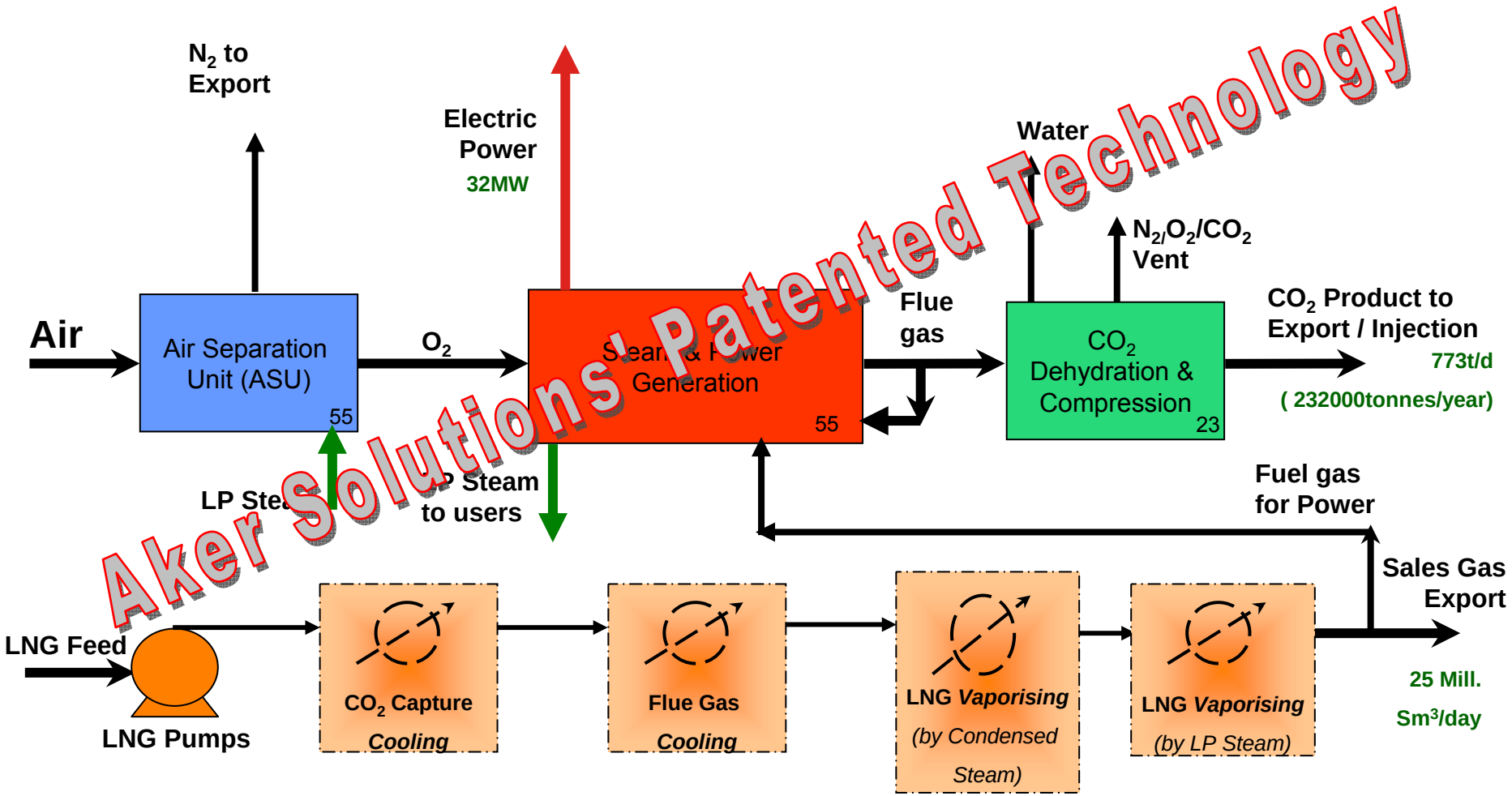
Adriatic LNG Regas Process

- 25 million Sm^3/day of sales gas
  - Equals 8 billion Sm^3/year – 5.9 MTPY

- Other existing Regas terminals are:
  - 0 – 5 MTPY

**MTPY = Million Tonnes Per Year*

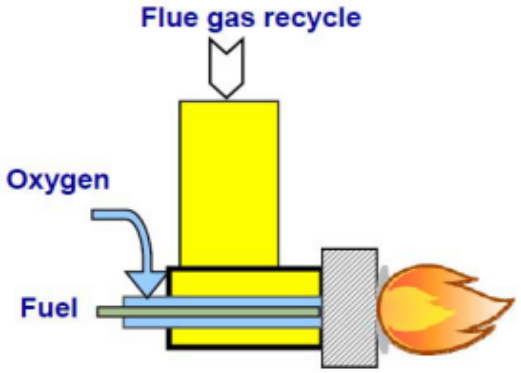
Overall Block Flow Diagram - Base Case



Design Features

- **New LNG Regas Process Systems:**
  - Air Separation Unit — ***Produce Oxygen***
  - Oxygen Fired Burner (Oxyfuel) — ***Clean combustion***
  - Onboard Steam & Power System — ***Power plant***
  - CO_2 Removal System — ***Flue gas (CO_2 / Water)***
  - CO_2 Compression / Export — ***CO_2 for EOR/Injection***

- **Regas Facility Features:**
  - Utilises the heat integration between the LNG gasification process and the power generation and CO_2 separation process



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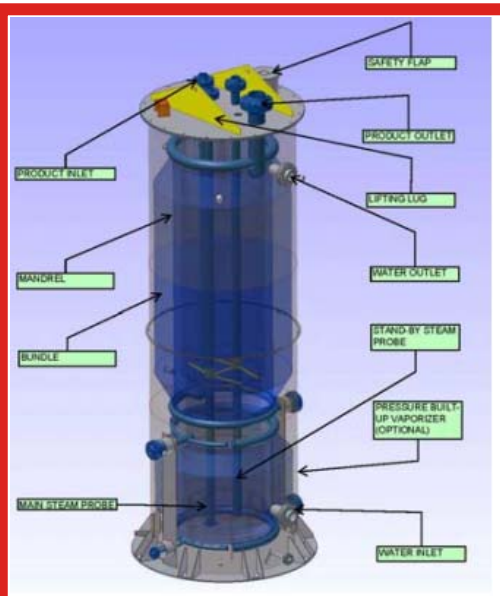
Equipment Design: LNG Regas Process

- Vertical pump
- *5 operating + 1 spare*



LNG Vaporisers

Designed & Supplied by Cryostar / Linde

- Spiral wounded tubes passing through a water bath
- Heating medium: Steam/ Condensate
- 4 exchangers in parallel

BFW

Fuel gas

Nat. Gas Export

168 m^3/h *(Actual flow)*

LNG Feed

LNG Pumps

CO_2 Dehydration & compression *Cooling*

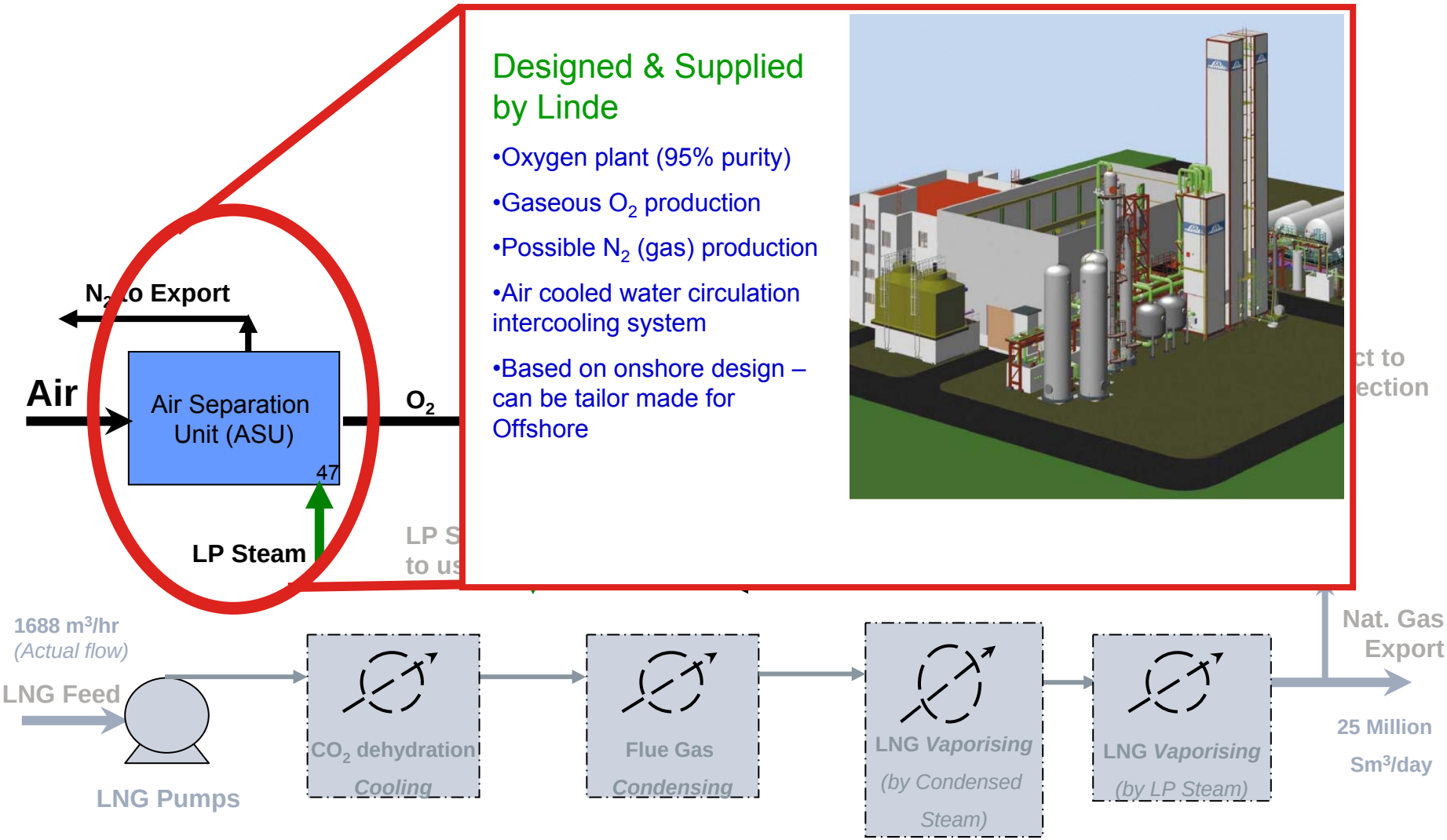
Flue Gas *Condensing*

LNG *Vaporising* *(by Condensed Steam)*

LNG *Vaporising* *(by LP Steam)*

25 Million Sm^3/day

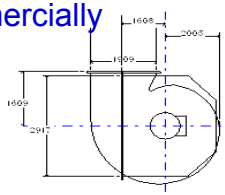
Equipment Design: Air Separation Unit



Equipment Design: Steam & Power System

Flue gas Fans: Howden

- Both fans (FG Fan and FG Recycle Fan) commercially available



Electric Power

BFW

Steam Condensate

Steam & Power Generation

55

Flue gas

Produced Water

$N_2/O_2/CO_2$ Vent

CO_2 dehydration & Compression

23

CO_2 Product to Export / Injection

LP Steam

LP Steam to users

Fuel gas for Power

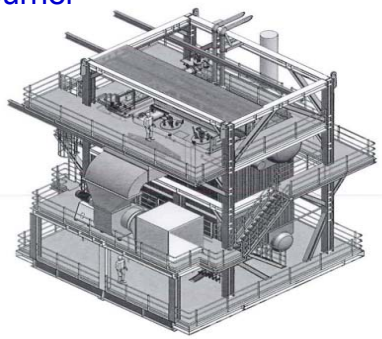
1688 m³

(Actual f

LNG Fe

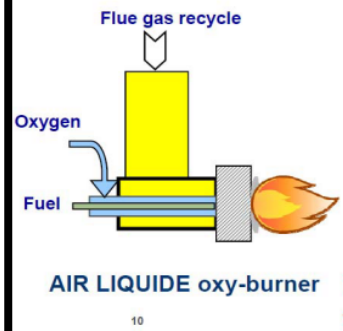
Boiler design: Ålborg boilers

- Offshore boiler design w/ econ
- Economizers reduce fuel cons. by 10%
- 40 bara & 400ºC MP steam
- Can be modified to fit Oxyfuel burner



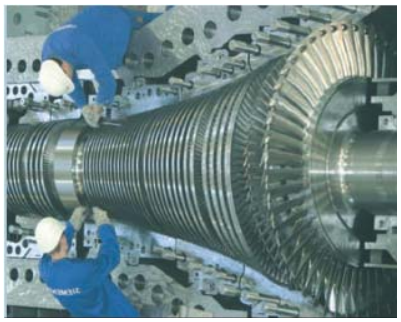
Oxyfuel burner: Vendor TBC

- Separate study by SINTEF
- Burners not commercially available
- Major developments ongoing
- 3 suppliers tested natural gas fired oxyfuel burners: Air Liquide, Jupieter Oxygen Corp & Clean Energy Systems



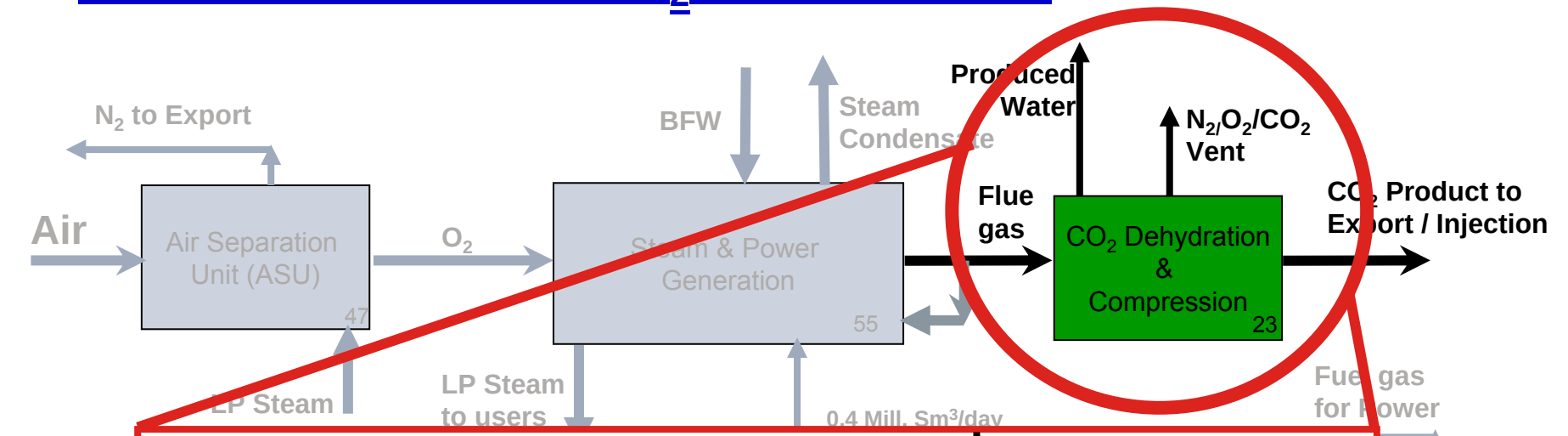
ST design : Alstom Power

- Condensing Steam Turbine
- Commercially available
- Condensate cooled by LNG cold (Cryostar/Linde's Water-bath technology)



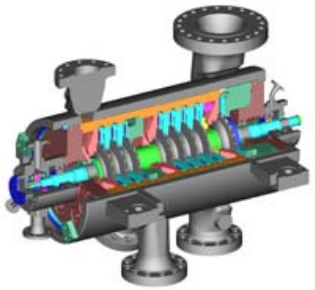
Zero

Equipment Design: CO_2 Removal Unit



Compressor design: Man Turbo / Dresser Rand

- Centrifugal 3-stage compressor
- Commercially available
- Vendor can also supply CO_2 pump

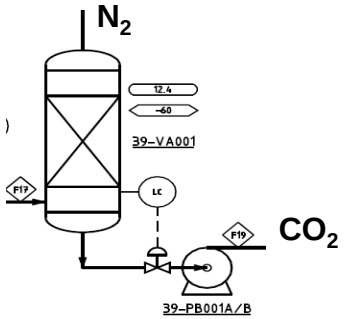


Intercoolers design: in-house

- *As described before*
- ST type –Using LNG cold
- MEG/Water as heat transfer medium for cooling to +5°C for compressor intercooling
- Methanol as heat transfer medium for cooling CO_2 to -40°C for cryogenic separation

Cold separator design: in-house

- Separates condensed CO_2 from nitrogen / oxygen at -40°C.
- Commercially available separation technology



Process Technology Status

Process System	Status	Required work
Air Separation Unit	Existing Technology for onshore plats	Qualification for offshore use
Oxygen Fired Burner (Oxyfuel)	Semi commercial. Small scale pilot plants NG 30MW exists. Ref. to Statoil Kårstø, BIGCCS	Technology development for larger scale. Technology Qualification required.
Steam Generation System	Existing Technology	Boiler vendor and Oxyfuel Burner vendor liaising with each other to develop the steam generation technology
Power Generation system	Steam Generator Technology Exists	None
Cryogenic CO_2 Liquefaction System	Known Technology Elements New Application Ref. to Statoil Kårstø, BIGCCS	Application and System Integration needs to be Qualified
Heat Integration System	Some heat exchanger equipment NOT off the shelf available	Equipment and System Integration needs to be Qualified
Utilities and off sites	Existing Technology	None

Overall system need: Identification and verification of the plant operation and flexibility.

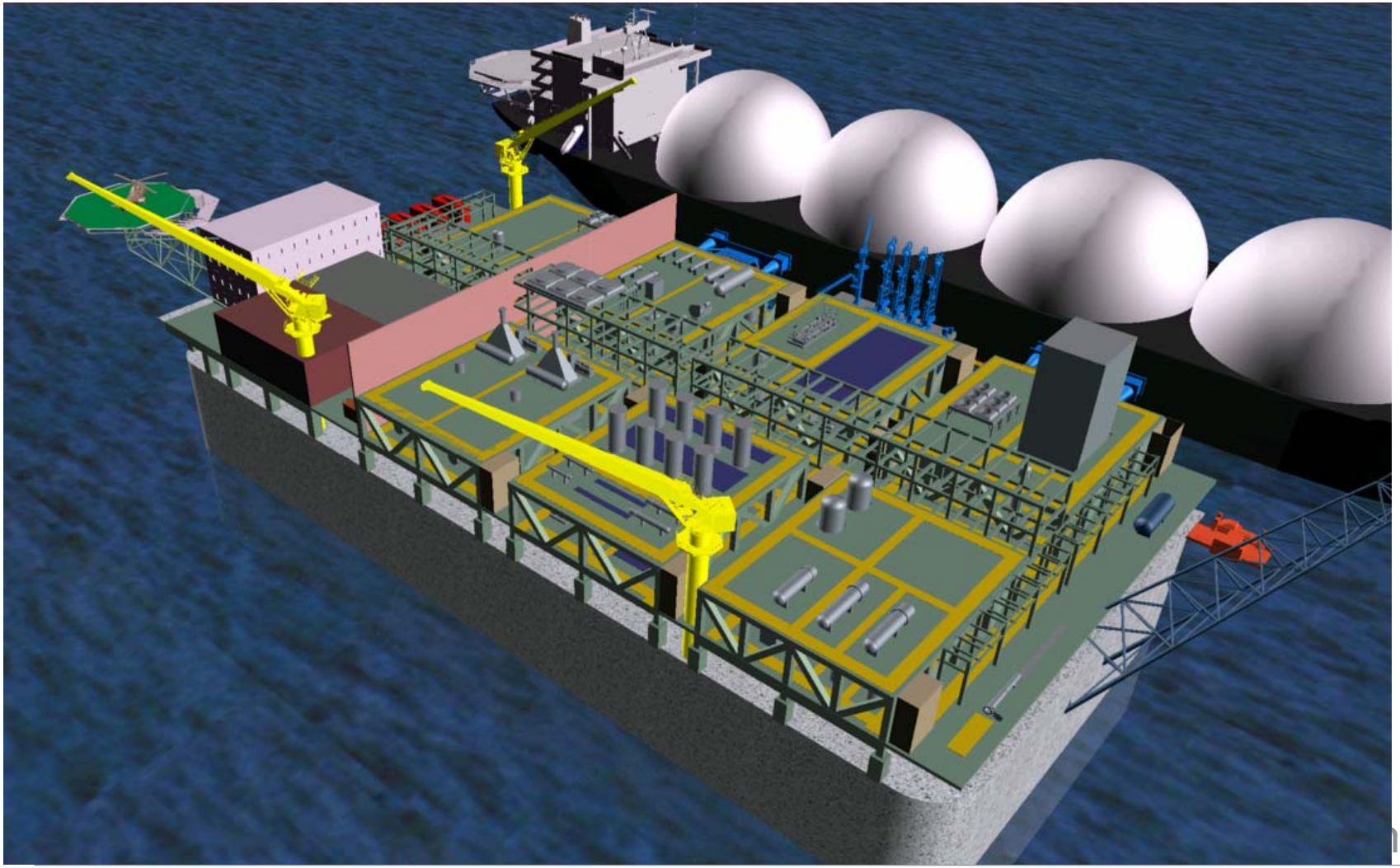
Layout Design

- **Basis for layout:**
  - GBS dimensions based on Adriatic (180m long x 88m wide)
  - 2 x LNG storage tanks of 125,000m^3 / tank
  - Equipment list developed by process

- **Layout philosophy:**
  - Topsides design to be inherently safe with segregation of hazardous and non hazardous system
  - LQ and utility areas located upwind of process facilities
  - Fire / blast wall provided between process and utility areas
  - Topsides modules split into system packages to reduce interface and hook-up and allow parallel fabrication activities

Layout Design

Iso view of Regas Topsides



Weight/Cost Estimate:

Cases	Weight Tonnes	Cost 2010 NOK	Cost NOK/kg
Base Case	26 607	15 000	564
Reference Case	19 000	11 000	580

- *Reference Case is As-Built figures for a comparable Regasification facility, scaled to 2010 price-level figures.*

- *The above figures exclude the cost of GBS:*
  - *The GBS size for the Base Case is same as for Reference case – hence GBS costs are excluded for comparision*

Evaluation Summary :

- The cost of new Regasification terminal (with CO_2 separation) is comparable with the existing Regas terminals without CO_2 capture.

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Future Work

- **Further development of the Patented Regas Technology**
  - **Assistance with technology maturity**
    - To feasibility stage with operational, functional description and safety
  - **Detailed benchmarking against Adriatic**

- **Identify marketing challenges for the New Regas Technology**
  - ***Identify potential partners for joint-development / Govt. bodies for funding the following tasks:***
    - Technology Verification
    - Pilot Test Programs
    - FEED
  - ***Develop Technology Qualification Plan with partners***
    - Involve potential test sites in further planning

- **Identify relevant proposed projects for the New Regas Terminal**
  - ***Possible Locations / prospects***

THANK YOU !

ANY QUESTIONS?

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