

ABB
Oil & Gas

Electrification for the Oil & Gas Industry



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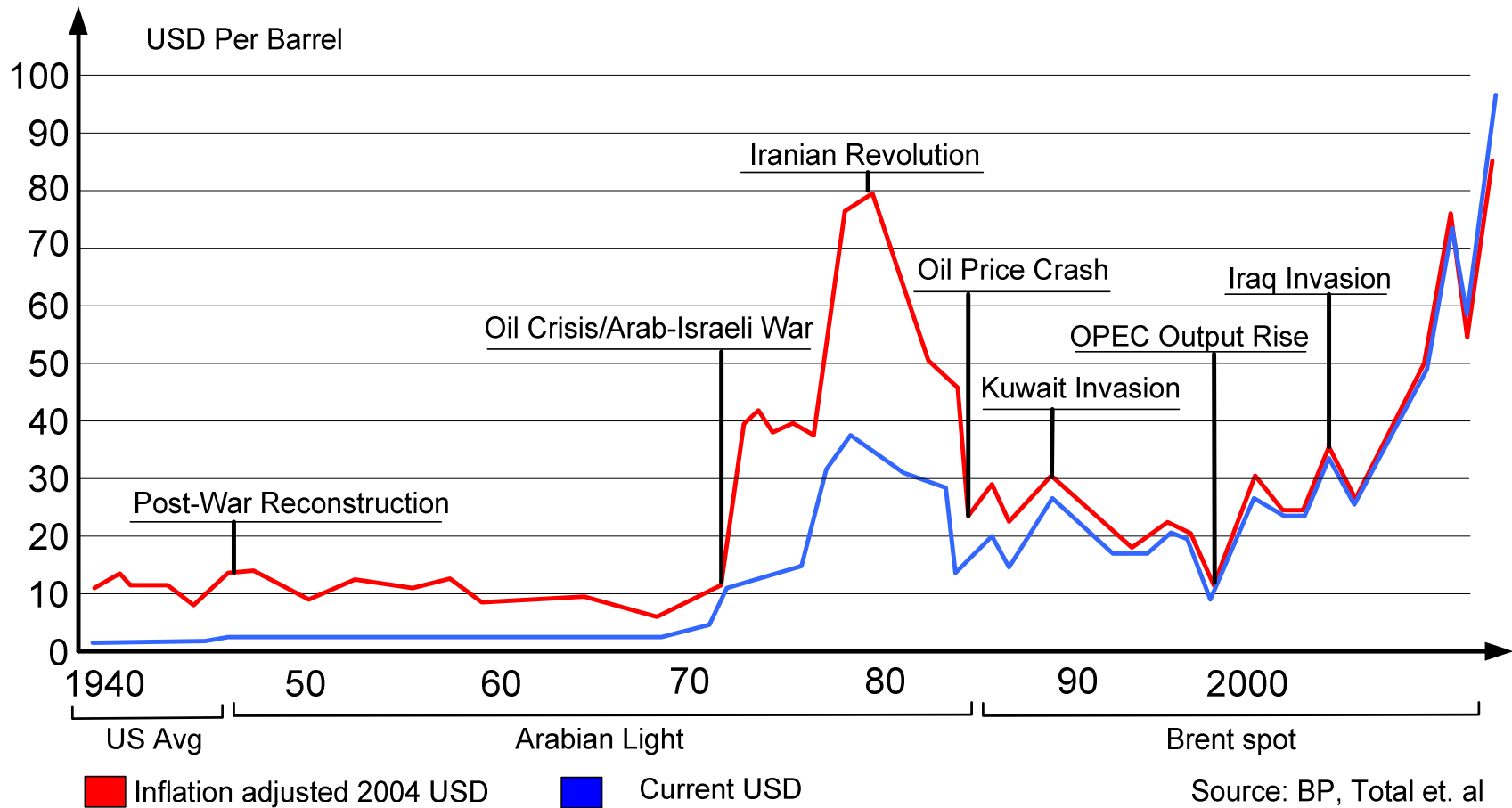
- Energy Efficiency and world energy demand
- Cost scenarios
- Example Cases

OIL AND GAS MARKET IS VERY ROBUST...

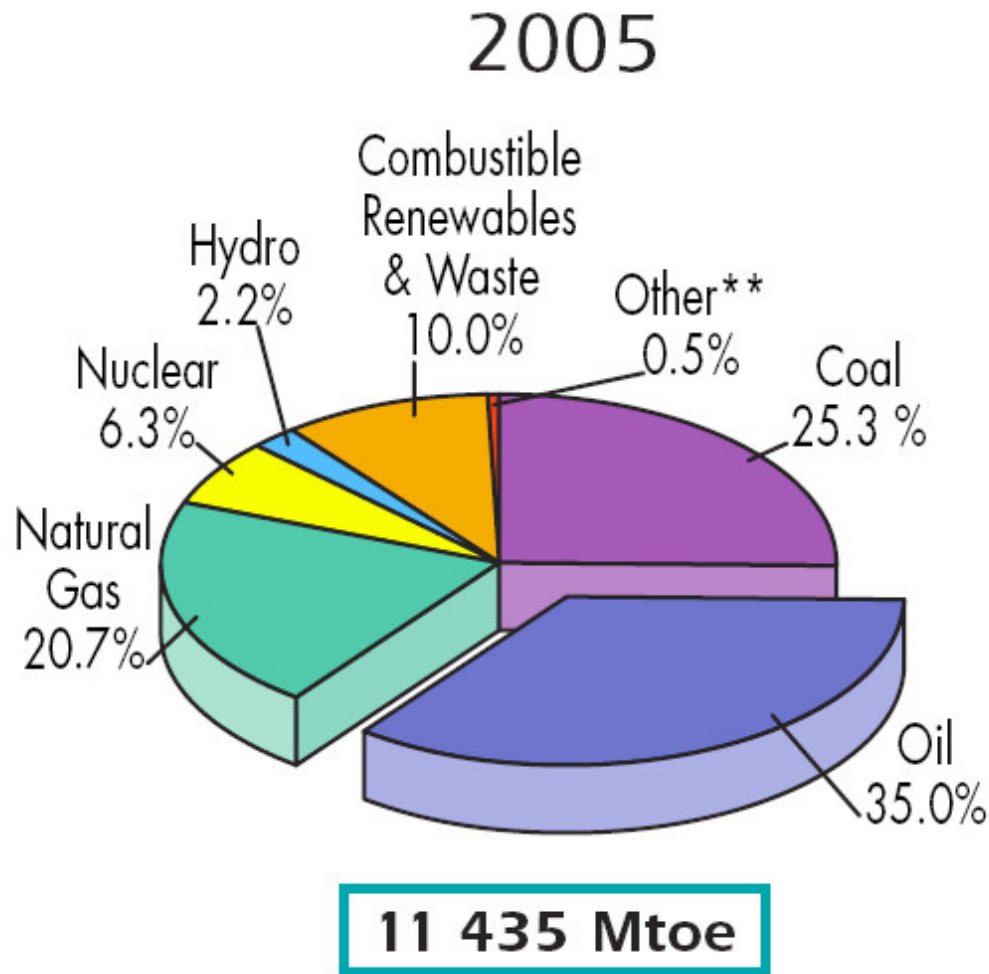


- Because of strong energy demand rise in new economies.

Crude oil prices since WW II



Energy sources (fossil = 81-86%)



- Equiv 136.000 TWh
- ~ 1000 times Norwegian electricity production
- ~ 6000 nuclear power plant blocks
- Largest windfarm unit is 200 mills at 2 MW with annual production 1,2 TWh
- To replace oil and gas consumption, 113.000 such farms, with a total of 23 million mills is needed
- at 100 meters distance, this will go 60 times around equator

But - The Efficiency Problem:

- Out of 11000 Mtoe only 68 % is actually available to the end user. The rest is lost in production, transportation, treatment, refining and generation. Of this 9100 Mtoe is fossil. (83%)
- The remaining energy, 7600 Mtoe is used for
 - 2000 Mtoe (26%) to industrial energy needs
 - 2000 Mtoe (26%) to transportation (at 30% efficiency)
 - 2900 Mtoe (38%) to Private, Public, Agriculture
 - 700 Mtoe (9%) to Other e.g. Petrochemical feedstock.
- CH₄ and C₈H_x gives an average CO₂ emission that is 1.8 times the weight of what is burned. C gives about 3,7 times as much
- CO₂ emitted is
 - Coal 2800 * 3,7 = 10400 Mill Ton
 - Hydrocarbon 6300 * 1,8 = 11300 Mill Ton
 - Sum 21700 Mill ton (= 1,5 · 10¹³ kg)
- The rest of CO₂ emissions from 1200 Mtoe of biofuels (wood, waste etc.) emits the balance of about 2300 Mill ton for a 2004 total of 24.000 Mill ton.

Why energy saving is not happening!

- Available energy is almost proportional to a society's wealth (per capita and with respect to GDP)

	T/pop *)	T/GDP**)
■ US, Canada, Kuwait :	7-10	0.20-0,5
■ UK, Germany, Norway:	4-6	0.15
■ China, Iran, Malaysia Brazil	1-2	0,3-0,8
■ Bangladesh, Eritrea, Haiti :	0,2-0,3	0,5-1

- Where energy is relatively cheaper efficiency decreases.
- You need MORE energy per GDP \$ for small economies.
=> Price increases will hit hardest where the potential is lowest.
- A car in West Europe costs about as much as the cost of the fuel it consumes in its lifetime => Transportation is seen as essential, and price elasticity is very high.

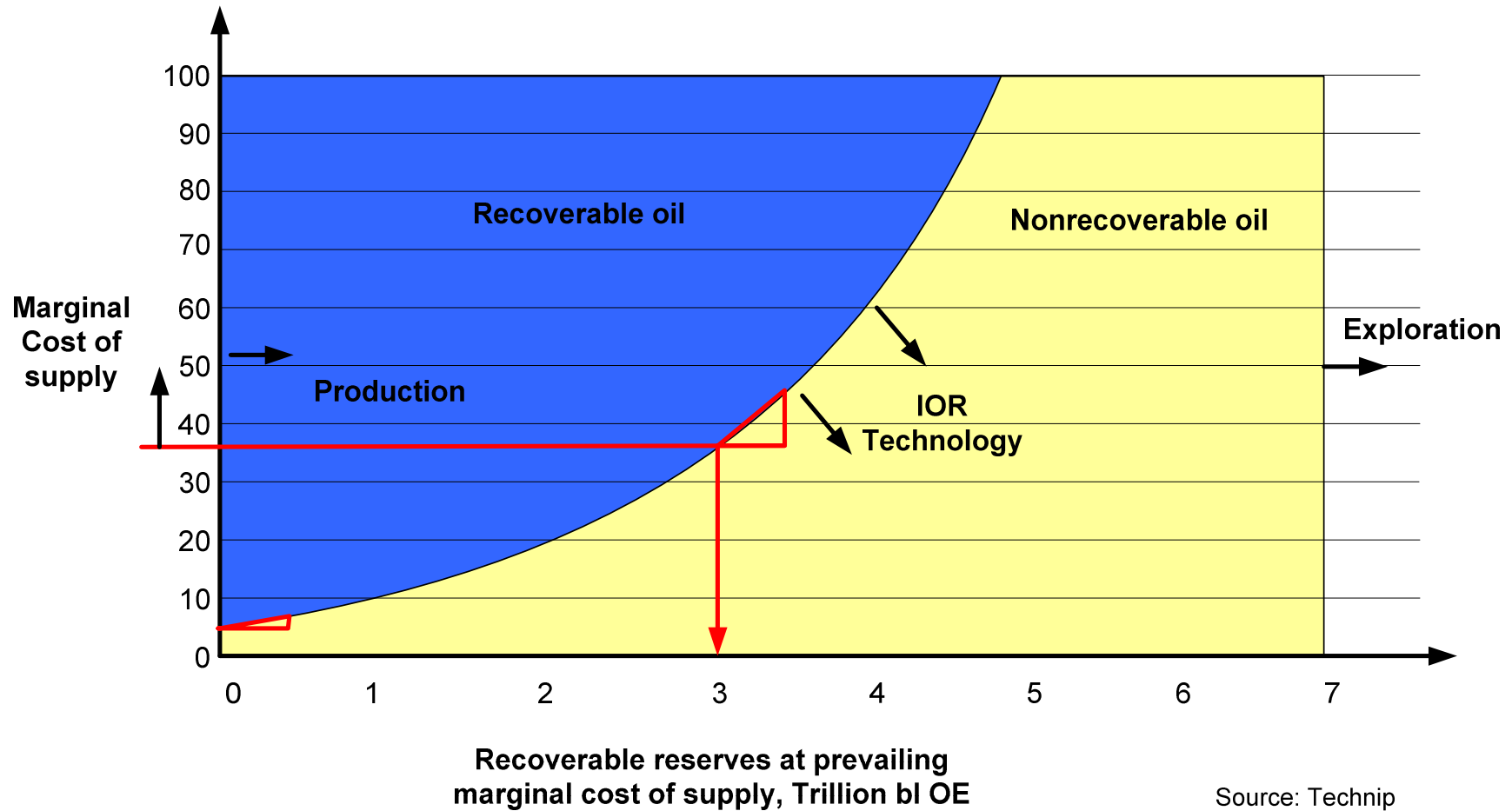
Source IEA

*) toe per capita and year

***) toe per 1000 USD GDP (year 2000 \$)



Recoverable reserves, price and technology

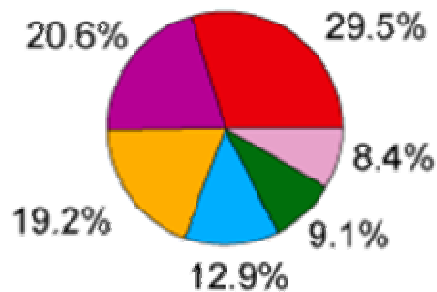
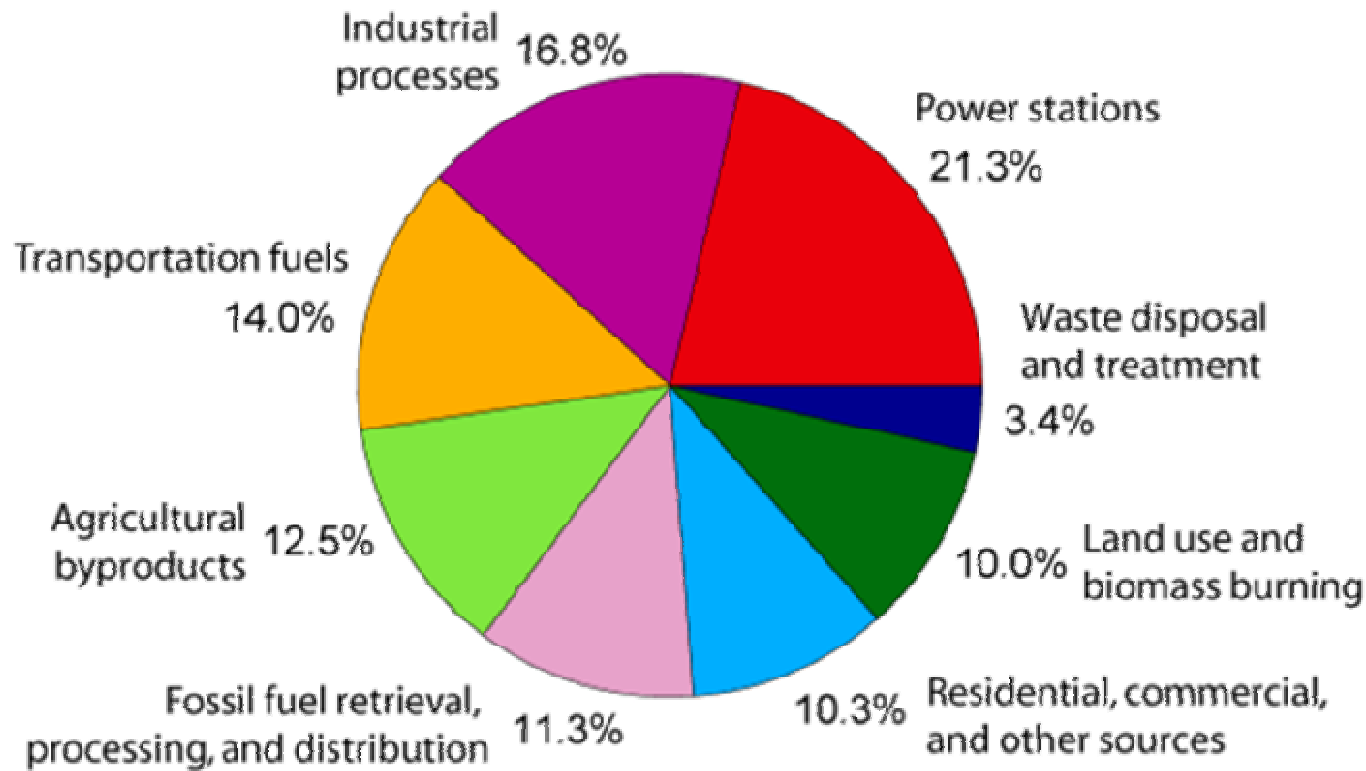


Source: Technip

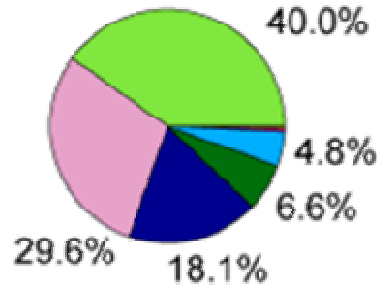
Initial conclusion

- Energy overuse is expensive
- Even if own hydrocarbon is used “for free”, margin erosion results.
- Excessive emissions in the hydrocarbon value chain, about 11% losses in the production and transportation of Oil and Gas (Piped, LNG) could be more than halved.

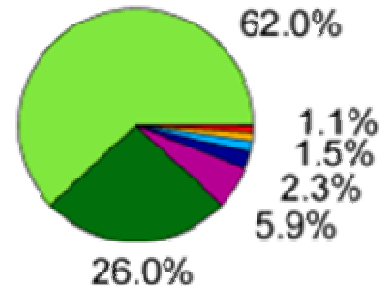
Annual Greenhouse Gas Emissions by Sector



Carbon Dioxide
(72% of total)



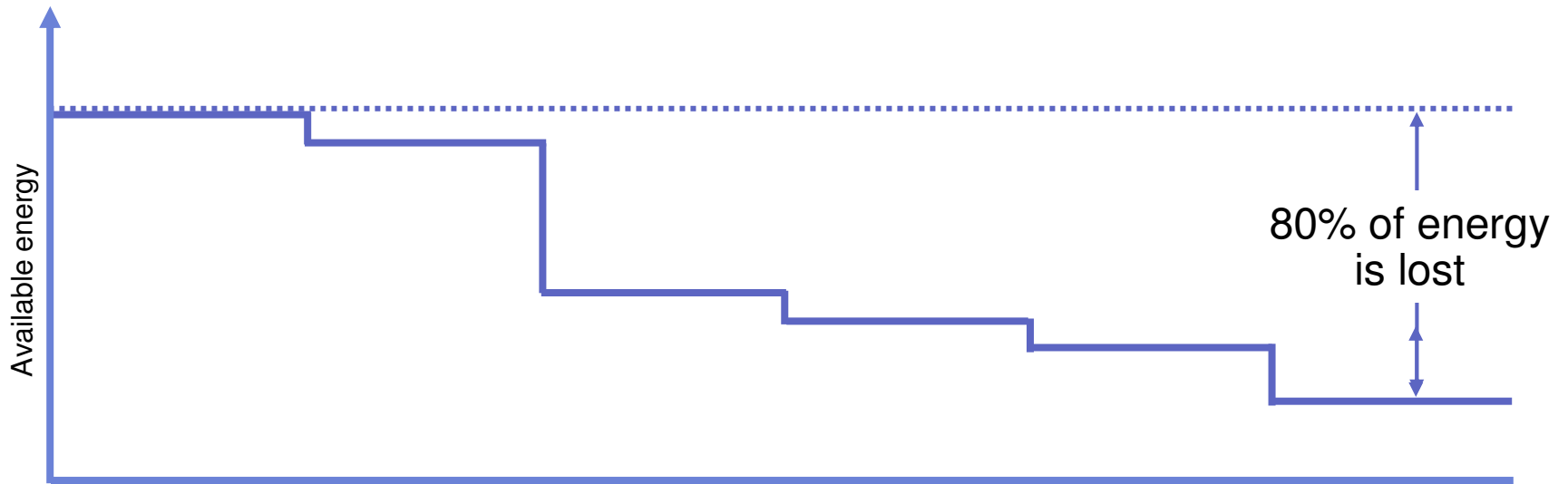
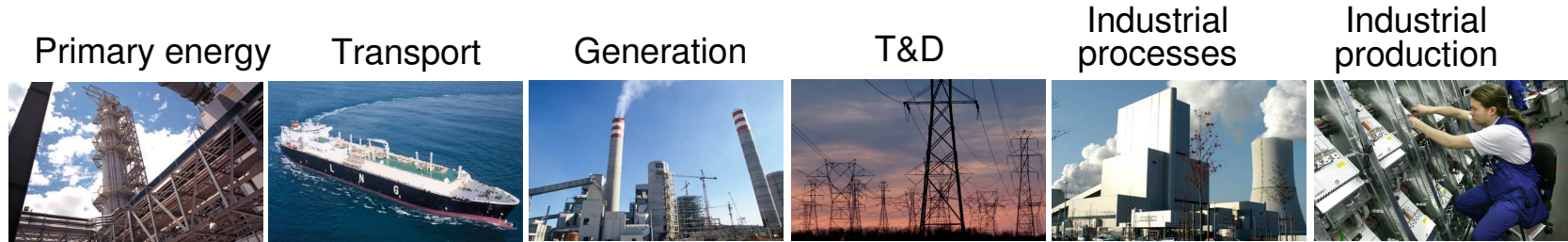
Methane
(18% of total)



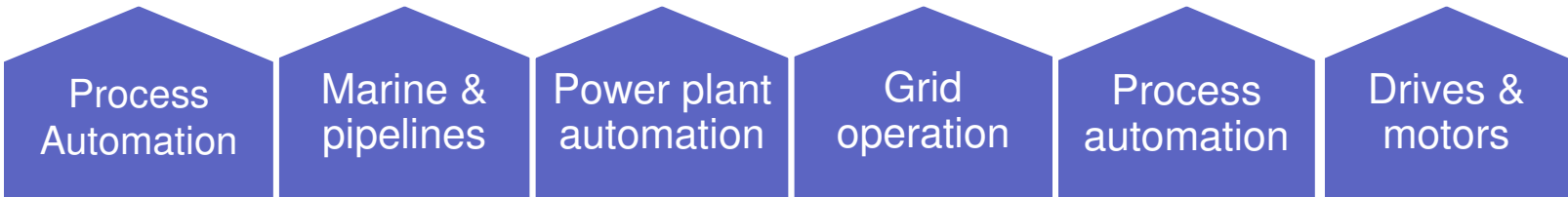
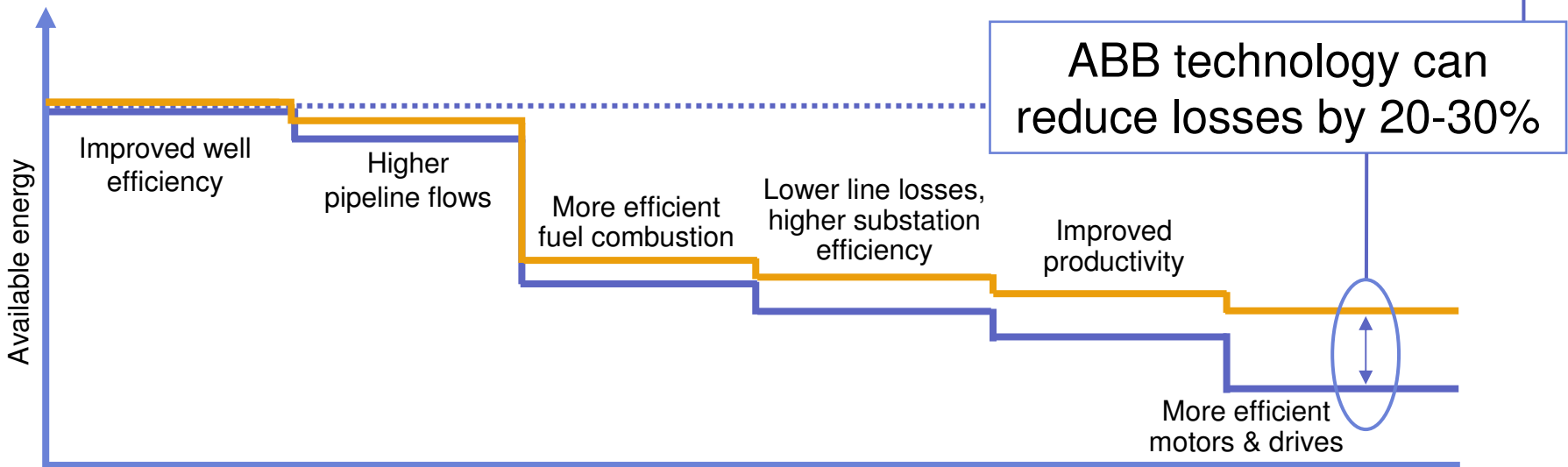
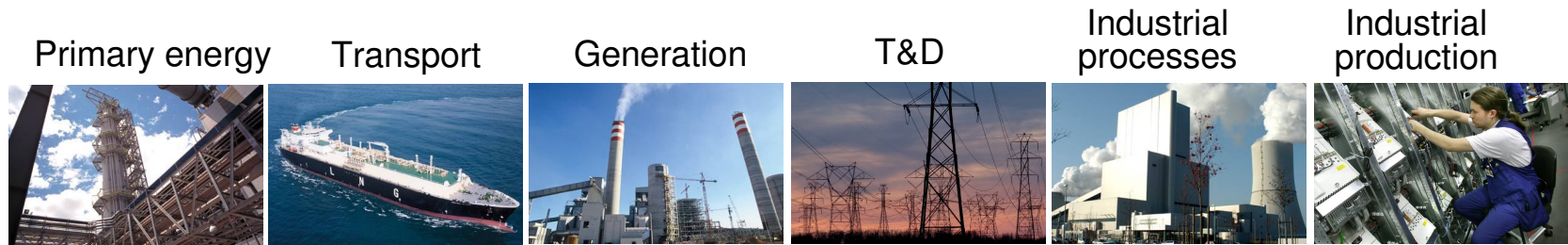
Nitrous Oxide
(9% of total)



Reducing losses along the energy chain



Reducing losses along the energy chain



Classical Powering Challenges



- Typical power consumption
 - 10-100 MW for new production field
 - >100 MW for oil sand/shales
 - 250 MW new 7.5 MTPA LNG Plant
 - 300 MW for large compressor stations (6->25 MPa, 150 Mscm/d)
- Typical power source
 - Local generation – diesel or gas
 - Power from grid – long distance
- Typical drawbacks –direct GT drive
 - Operating Efficiency 25-38 %
 - Typical availability <98 %
 - Maintenance and fuel costs
 - Emissions of CO₂ and NO_x

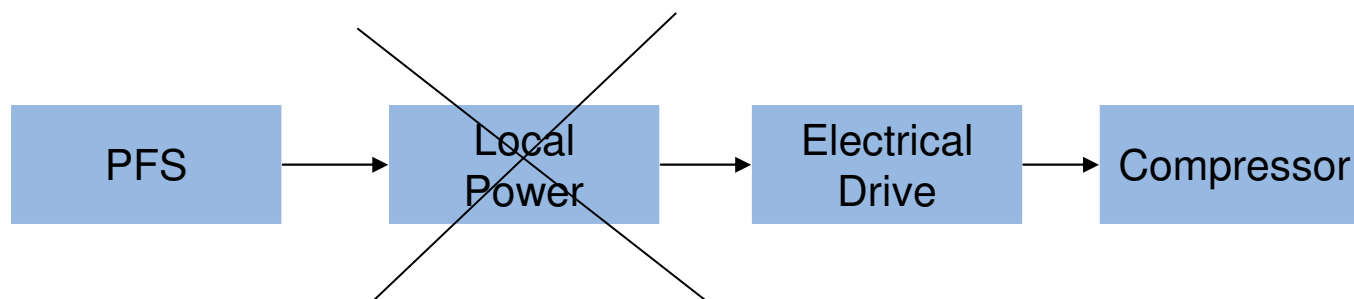


All Electric Characteristics and Benefits



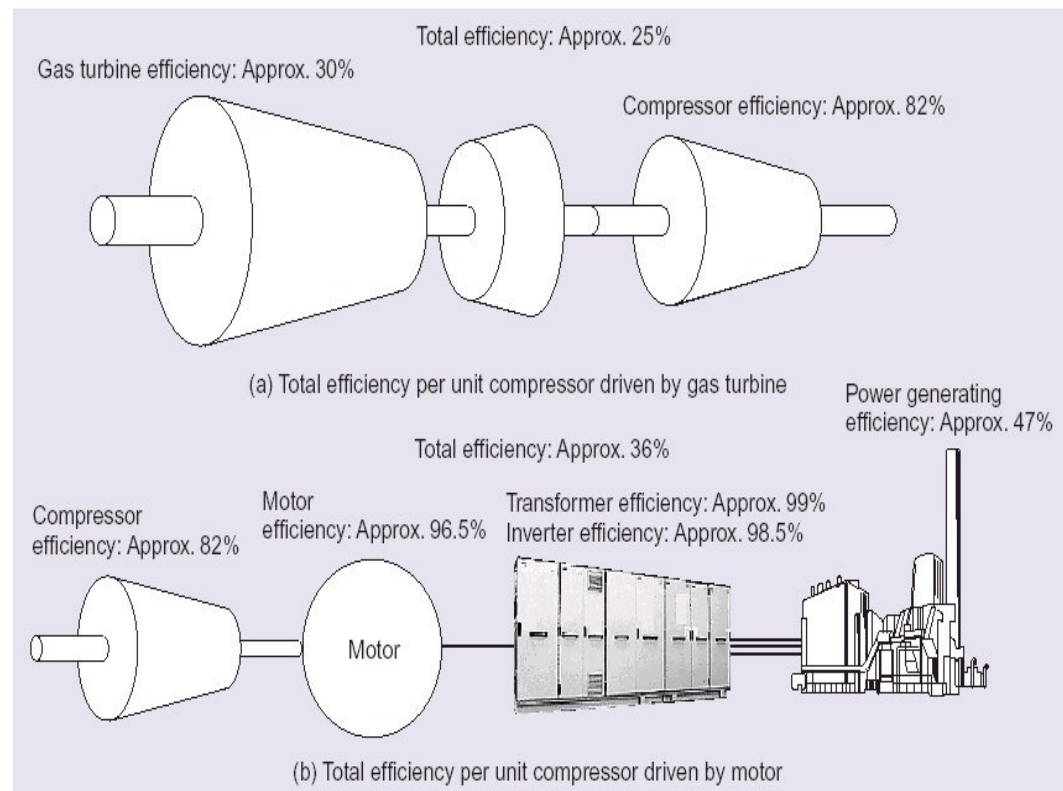
All electric definitions

- All electric refers to use electrical motors and drives for driving compressors i.e. replacing direct driven compressors
 - On LNG plants / Gas Treatment plants
 - On offshore rigs
- The concept can be extended on offshore platforms to take Power From Shore – PFS



Lower consumption = More product, Less emissions

- Variable speed industrial GT efficiency is 25-38%, off peak efficiency is <25%.
- Electrical system efficiency is > 95%
- Combined cycle or triple cycle generation (if low level heat required) = 58–>80%
- Gives:
 - > 30% less fuel gas consumption, potential for 60%.
 - > 30% lower emission, Lower tax/Quota
 - More gas to sell



System Base Parameters

Characteristic	Gas Turbines	Electric Drive
Weight and space	Light unit but space and weight consuming auxiliaries	Similar to that for gas turbines
Minor maintenance cycle	2,500 - 4,000 hours	25,000 hours
Major maintenance cycle	20,000 hrs	100,000 hrs
Minor maintenance duration [^])	6-10 days	1-2 days
In operation system MTBF	≈ 4,000 hours	> 25,000 hours
Control Response	Slow	Medium to quick
Efficiency	Narrow peak range	High over wide range
Logistics	Delivery time 3-4 years	Delivery 1-2 years
Average operational efficiency of system	25-38%	97% Drive + + 95% HVDC Transmission typ + 60-80% generation



Lower maintenance, More On-Stream time

- Variable or Fixed Speed Gas Turbine
 - Maintenance schedule
 - Flashing: 2000 h (4x 1 day/year)
 - Inspection 8000 h (1-2 days/ year)
 - Year 3, 9, 15,... Reblading & Repair at Mfg, 6-8 weeks each 50000 hr
 - Year 6, 12, 18,... Unit rebuild at mfg, 8-10 weeks each 50000 hr
 - Costs (in % of unit costs)
 - Annual flashing & Inspection 1%
 - Reblading and repair 20%
 - Unit rebuild: 35%
 - Typical availability 94-96%
- Electrical drive and HVDC systems
 - Maintenance schedule
 - Inspection and cleaning: 25.000 hour
 - Updates major maintenance: 40.000 - 100.000 hour
 - Costs (in % of unit costs)
 - VSDS 0,2%
 - HVDC 0,5-0,8%
 - Motor 0,15%
 - Typical availability 99,7%
 - Actual plants claim 10 normalized on stream days additional per year for plants in continuous operation (Statoil: Snøhvit LNG)

Controllability, Stability

- Electrical drives have more than 10 times faster response, excellent dynamic performance.
- Gives:
 - Better ballance between stages = Less recirculation
 - Lower surge margin = Improved thermodynamic performance range.
 - Larger trains = Higher efficiency
- Benefits:
 - Expected > 3.5% efficiency improvement

Benefits of Electrification

- Reduced Consumption of fuel gas: 30-70%
- Directly translates to reduced Emissions (CO₂, NO_x,S)
- Reduced Maintenance, 50% on drive system
- Increased plant stream time 5-10 days per year.
- Process efficiency improvement: 3.5%-5%
- Payback compare to conventional GT system: < ½ year

Example of All Electric 6.25 mtpa LNG

Conventional 6x 30 MW GT
+ EI 2 x 30 MW GT

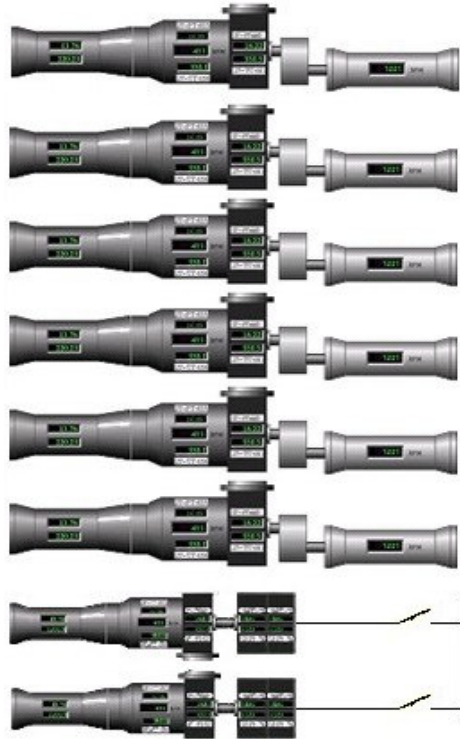
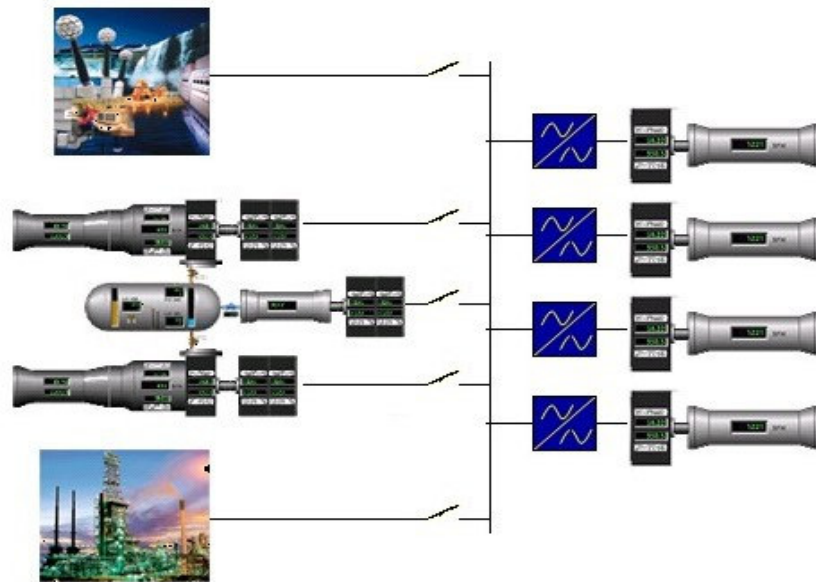


ABB Dual Cycle + 4 x 40 MW Drive



- 1 unit in maintenance > 50% of time
- Unplanned shutdown ~ 6% of time
- Loss of capacity of 20%
- 12 stream days lost

- Higher availability 10 stream days – 36 mUSD
- Tighter control - Lower recirculation – 5 mUSD
 - Maintenance cost 50%
 - Higher efficiency 36%



Reference Case – Analysis LNG Plant 6 MTPA

Characteristic	A. Electric Drive	B. Gas Turbines	Difference (Column B – Column A)
CAPEX system cost (main drives, auxiliary drives and power generation)	30 MUSD main drives 35 MUSD power plant 7 MUSD auxiliary drive	25 MUSD main GT 14 MUSD power plant 7 MUSD auxiliary drive	(26 MUSD)
LNG production	6,250,000 tons/year	6,250,000 tons/year	
Maintenance costs	5 MUSD/year	10 MUSD/year	5 MUSD
Shaft power efficiency	36%	25%	
Fuel gas consumption	450 mmSCM	648 mmSCM	200 mmSCM
Fuel gas use to LNG production	8%	10.4%	
CO2 emissions	800,000 tons	1,160,000 tons	360,000 tons
CO2 tax (EU where applicable)	13 MUSD	19 MUSD	6 MUSD
LNG value of fuel gas	100 MUSD	145 MUSD	45 MUSD
10 additional production days	36 MUSD	0	36 MUSD
Reduced Recirculation losses	0	5 MUSD	5 MUSD
Annual savings			≈ 71 MUSD

Reference Case – Gas compression, grid power

Characteristic Drive and compressor	A. Electric Drive (actual)	B. Gas Turbines (theoretical)	Difference (Column B – Column A)
Dimensioning capacity	Inlet 75 bar, out 220 bar	Inlet 75 bar, out 220 bar	
Daily full capacity volume	142 Mscm/day	142 Mscm/day	
Normalized full capacity days/year	250 days	250 days	
Required compression power	209 000 MW	209 000 MW	
Installed capacity	5 x 43 MW	6 x 43 MW	
Energy cost energy	70 €/MWh	0,1852 €/scm	
Cost of emissions	42,2 €/Ton	42,2 €/Ton	
Capex costs	65 000 000 €	96.000.000 €	25.000.000 €
Interest rate calculatonic	7%	7%	
Annual interest and write down	40 years 6.175.000 €	20 years 11.520.000 €	5.345.000 €
Average annual OPEX costs:			
Cost of energy/fuel gas	90.260.000 €	56.600.000 €	
Emissions related costs	0 €	19.400.000 €	
Lost capacity value	21 000 €	21.000.000 €	
Maintancance costs	711 000 €	6.200.000 €	
	SUM: 90 990 000 €	SUM: 103.300.000 €	12 310 000 €
Total cost of ownership/year	97.200.000 €	114.800.000 €	17 600 000 €
Additional export gas (if available)	-56 600 000 €		
Fuel gas consumption	-	305 mmSCM	305 mmSCM
CO2 emissions	-	458 800 tons	458 800 tons
Total Savings			60.255.000.000

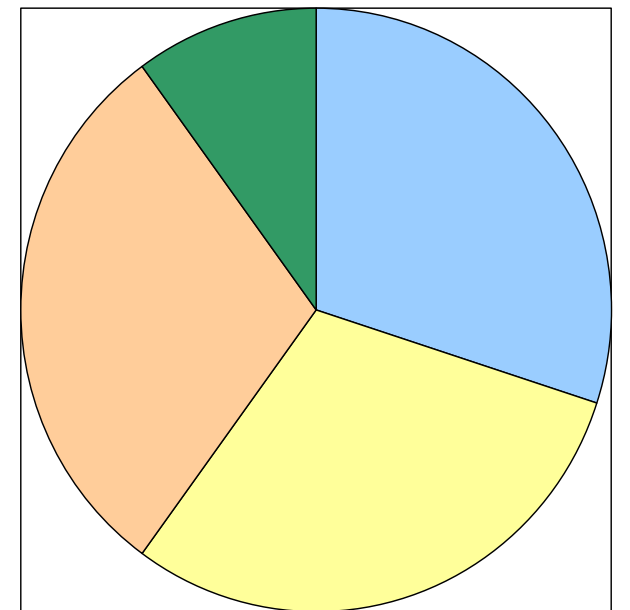
Reference Case – Gas compression, HVDC

Characteristic Drive and compressor	A. Electric Drive (actual)	B. Gas Turbines (theoretical)	Difference (Column B – Column A)
Dimensioning capacity Daily full capacity volume Normalized full capacity days/year Required compression power Installed capacity	Inlet 65 bar, out 250 bar 150 Mscm/day 250 days 287 000 MW 6 x 50 MW	Inlet 65 bar, out 250 bar 150 Mscm/day 250 days 287 000 MW 7 x 50 MW	
Energy cost energy CO2 quota credit (Emerging Economy)	18.6 €/MWh 24.0 €/Ton	0,0667 €/scm 24,0 €/Ton	
Capex costs Interest rate calculatoric Annual interest and write down	260 700 000 € 11% 40 years 35.200.000 €	122.500.000 € 11% 20 years 19.600.000 €	- 138.200.000 € -15.600.000 €
Average annual OPEX costs: Cost of energy/fuel gas Lost capacity value Maintancance costs	34.951.000 € 15 000 € 1.066 000 € SUM: 36 033 000 €	27.232.000 € 19.159.000 € 8.155.000 € SUM: 54.546.000 €	 18 513 000 €
Total cost of ownership/year Additional export gas (if available) Income from CO2 quota sales	71.200.000 € -75 606 000 € 14 700 000 €	74.146.000 € 	2 946 000 €
Balanced cost	-19.080 000 €	74.146.000 €	93 226 000 €
Fuel gas consumption	-	408 mmSCM	408 mmSCM
CO2 emissions	-	612 000 tons	612 000 tons

Electrification - The Value of Energy Efficiency

Typical 100 MW Facility:

- **Fuel** is saved cost of consumed energy (HC) (~30%)
- **Stability** is deferred production and on-stream time gained due to reduction in trips and scheduled shutdowns and improved stability (~30%)
- **Maintenance** is savings in turbomachinery maintenance costs. (~30%)
- **Emissions** is savings in emissions quota costs. (~10%)



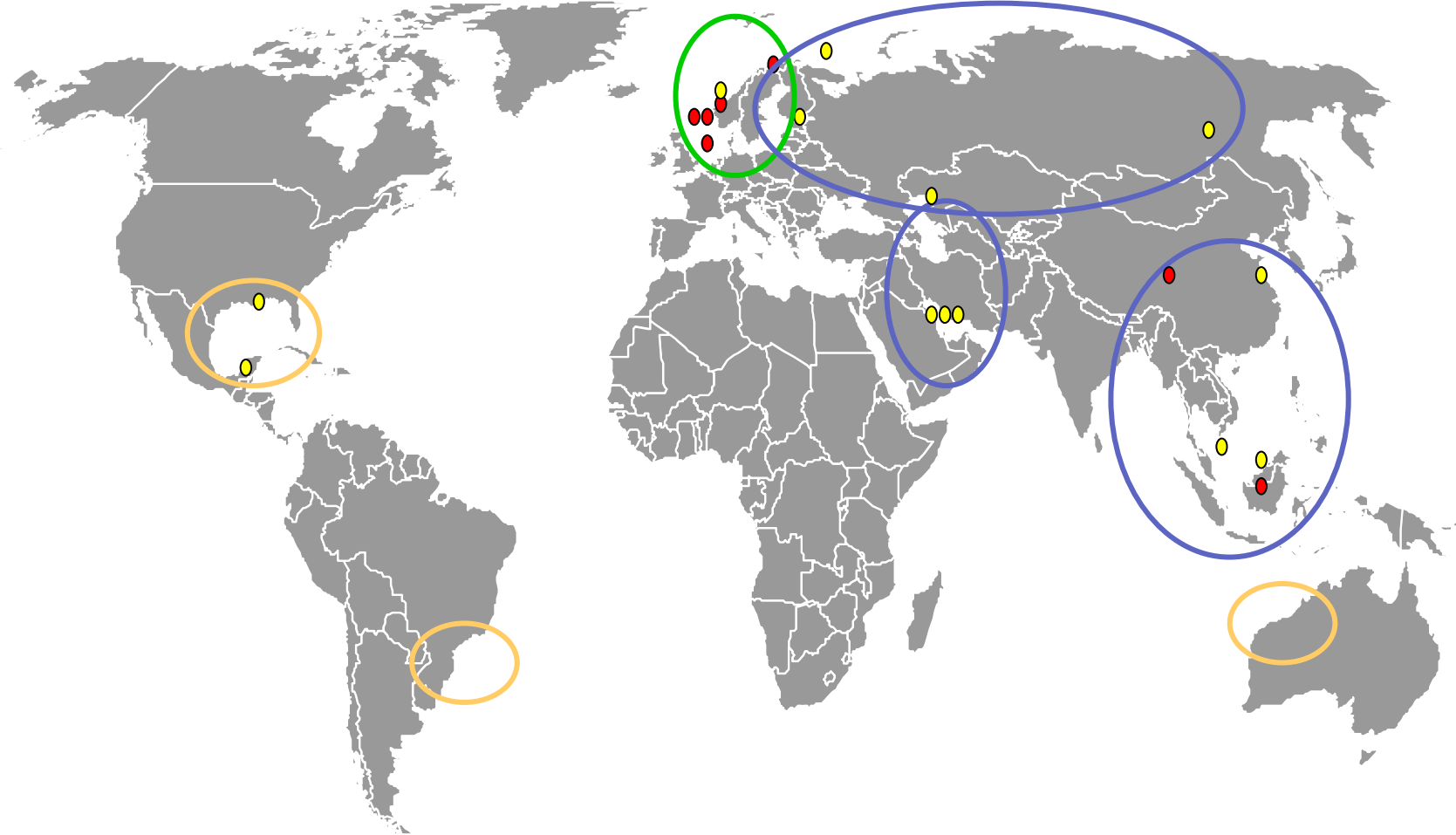
■ Fuel ■ Stability ■ Maintenance ■ Emissions






Reference Cases



Reference areas - Electrification

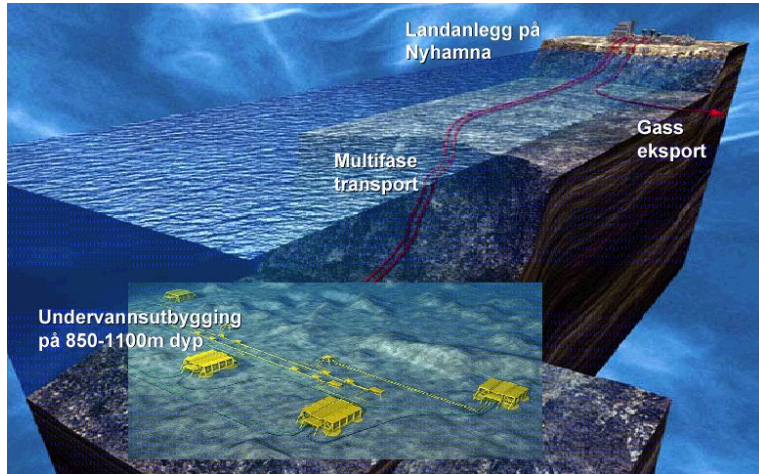


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-  Mature market
-  Developing Markets
-  Emerging regions



Electrification Reference – Ormen Lange

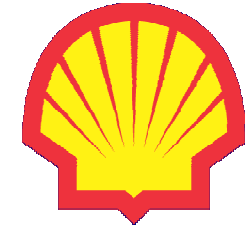


ExxonMobil



bp

StatoilHydro



Ormen Lange, ABB Scope of Supply

- Safety and Automation System (SAS)
- Process Information Management System (PIMS)
- SAS Emulator and Simulator Consoles
- Analyser Equipment

- Large Drives (3 x 48 MW + 2 x 7,5 MW)
- Electrical Control and Supervision System (ECSS)
- Electrical Equipment
 - High Voltage Switch Gear (32kV)
 - Transformers
 - Medium Voltage Switch Gear (11kV/6kV)
 - Low Voltage Switch Gear (MCC)
- Telecom

Total value US \$ 117 Million.



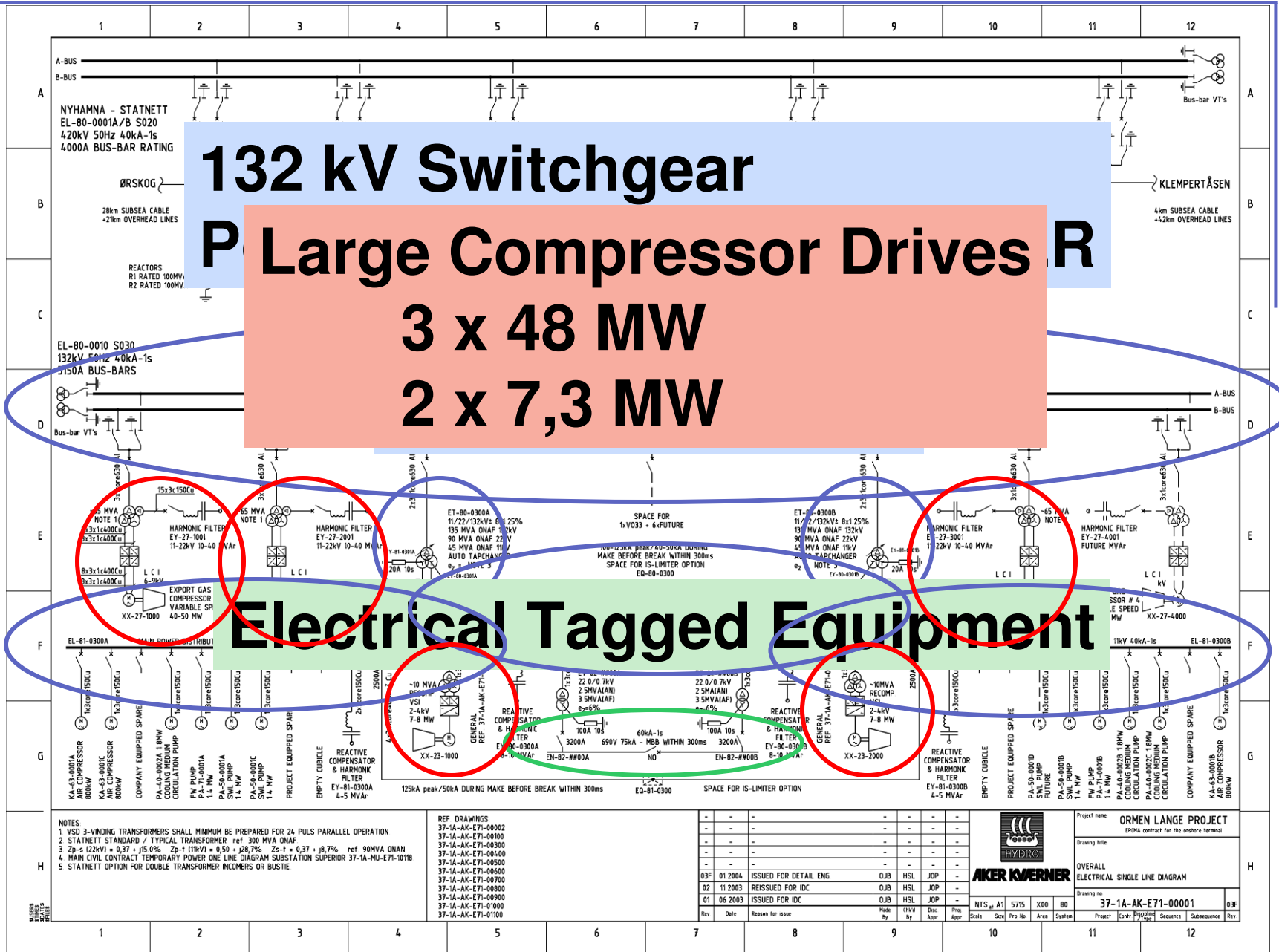
Ormen Lange SAS & PIMS - Sub sea, Nyhama and Export

- 1 Roads & Site Prep
- 2 Caverns
- 3 Cooling water tunnels
- 4 Pipeline landfalls
- 5 Construction jetty
- 6 Product jetty
- 7 Admin complex
- 8 Camp & offices

Gas Export: 72 Mill Sm³ /day



Ormen Lange – Overall Single Line Diagram

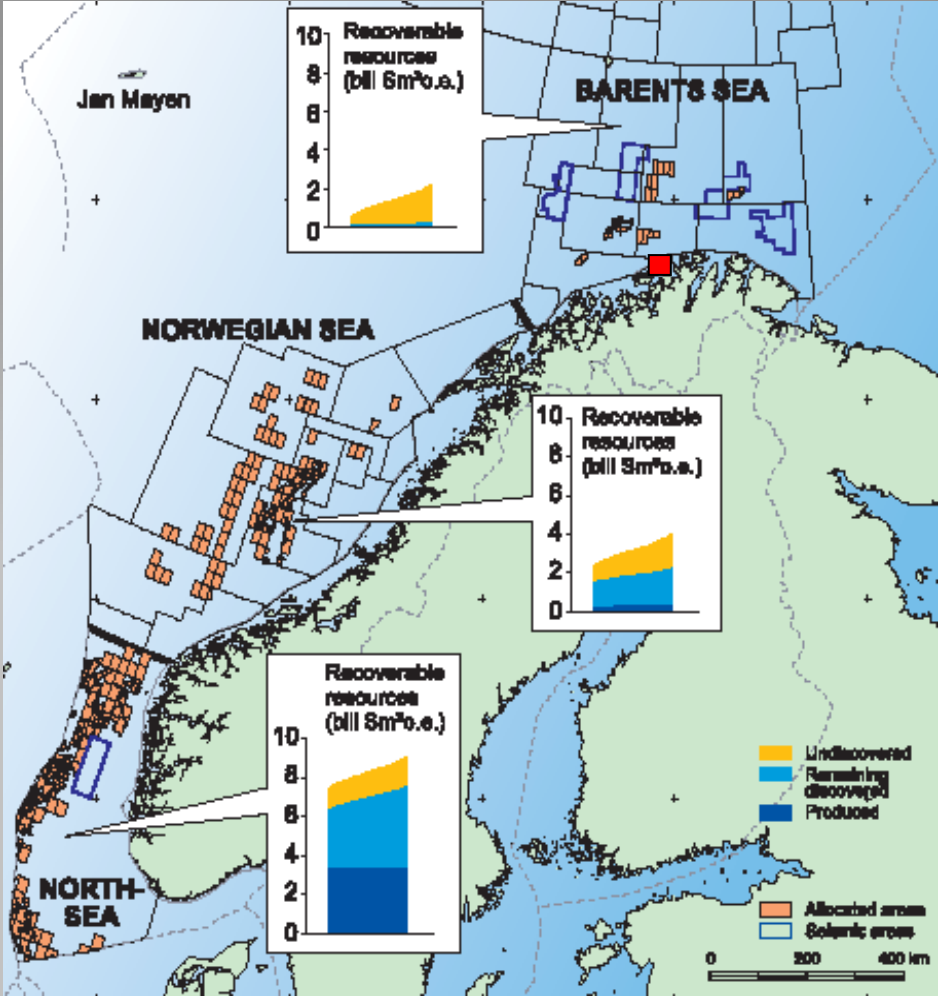


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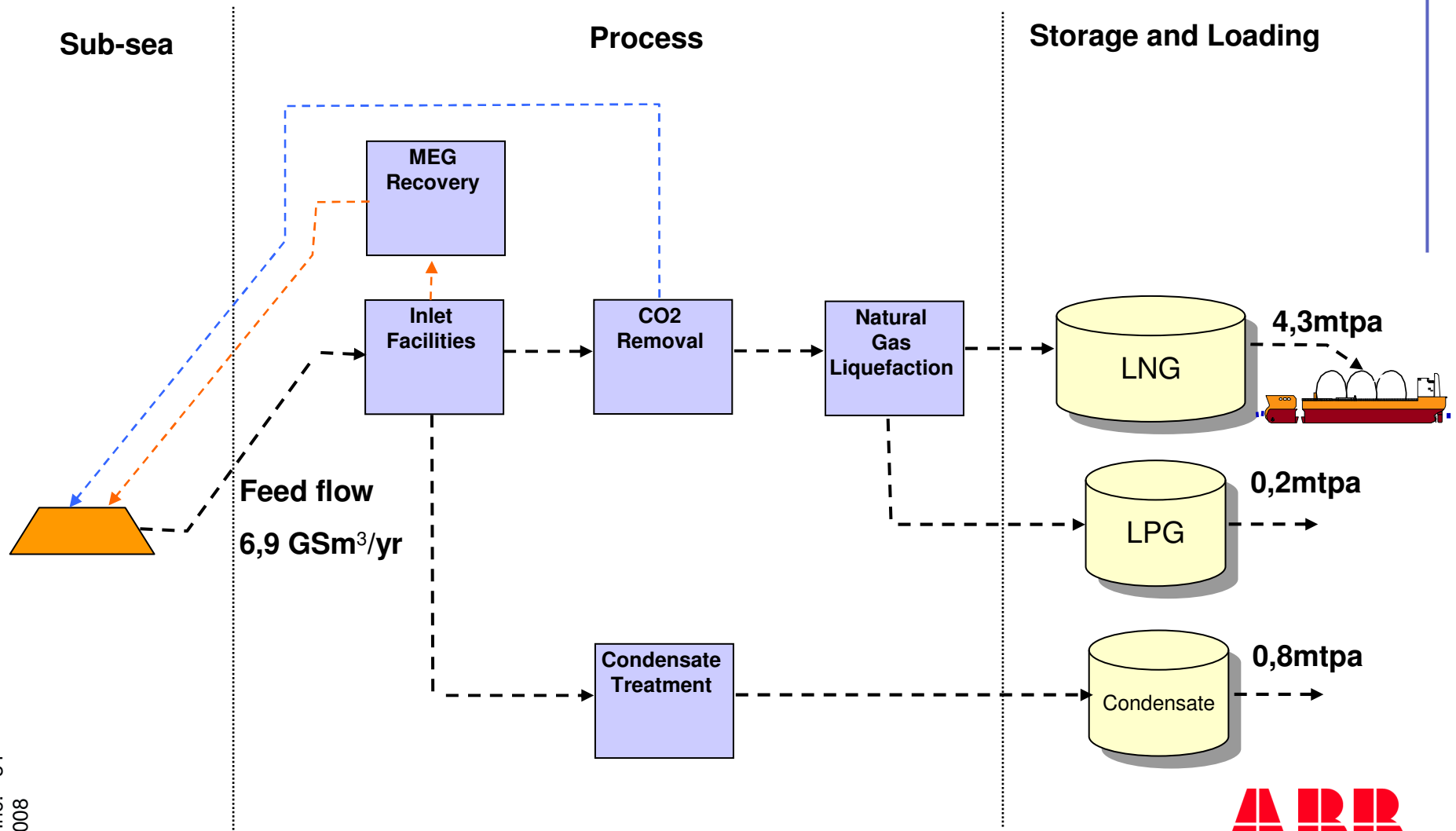
Benefits – Ormen Lange

- Based on Hydroelectric power
- Fuel Gas value: 150 mill scm/year (40 mill USD)
- Stability improvement: 1-2 full production days
- Maintenance: 4 Mill EUR
- Emissions 210.000 Tons CO₂

Snøhvit - Location

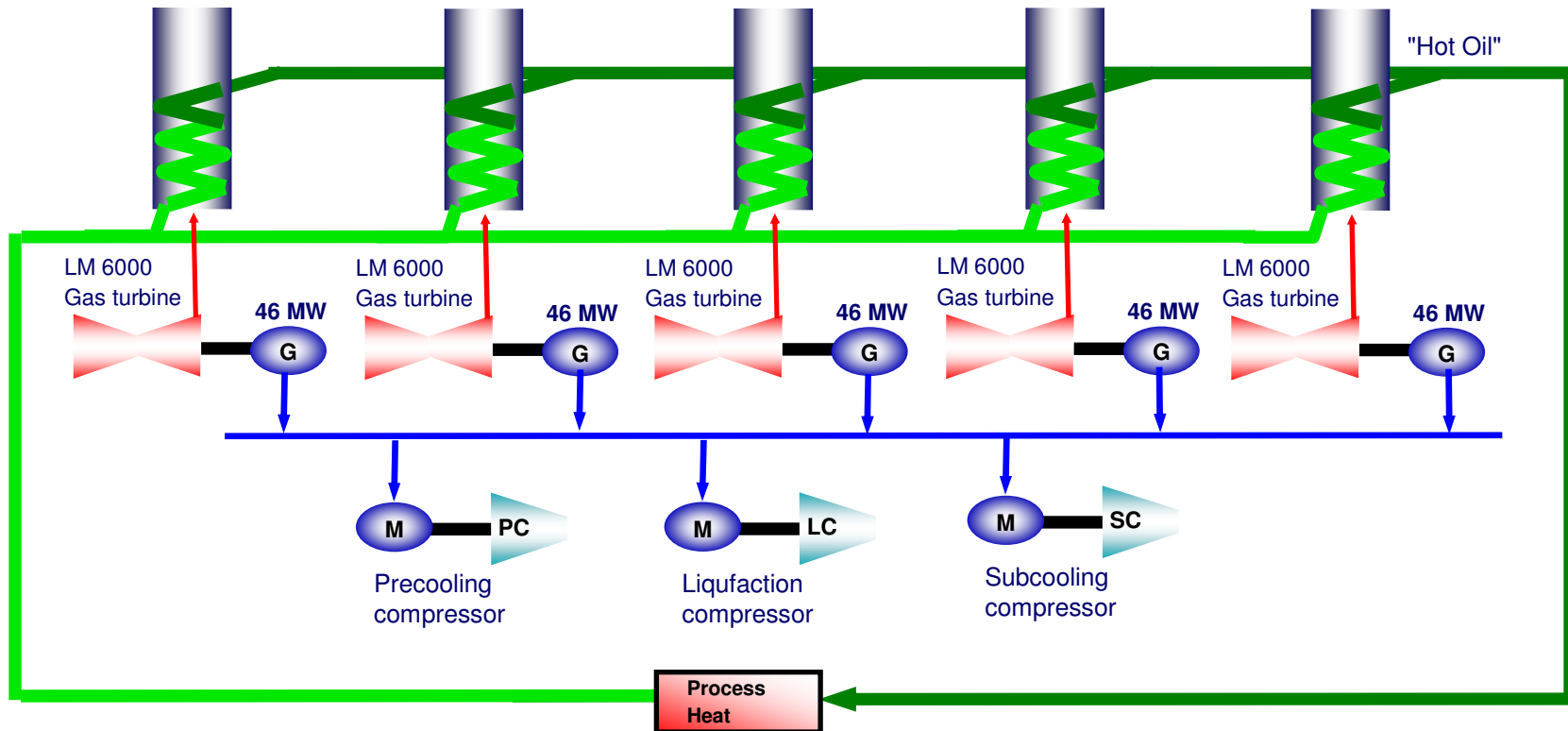


Snøhvit, Process Overview



Snøhvit, Energy System Configuration

5 x Gas turbines with electric generation, driving 3 x Liquefaction compressors and utilising exhaust temperatures for process heat demands



- 1,45 TWh electric energy, increasing to 1,64 TWh after 5-7 years
- 1,25 TWh Heat
- LNG Export 70 TWh

Snøhvit, ABB Scope of Supply

- Safety and Automation System (SAS)
- SAS Emulator and Simulator Consoles
- Instrumentation (pressure & temperature)
- Analyser Equipment

- Electrical Control and Supervision System (ECSS)
- Electrical Equipment
 - High Voltage Switch Gear (32kV)
 - Medium Voltage Switch Gear (11kV/6kV)
 - Low Voltage Switch Gear (MCC)

TOTAL VALUE approx US \$ 80 Million

Customer Argument on Electrification

- Fuel savings 25%
- Stability: 10 more on stream days / year
- Maintenance: Pending
- Emissions: 300.000 tons CO₂ Reduction

BP – Valhall Redevelopment

Remove Process and Living quarter, install new Platform, operational 2009

ABB Contracts (budget)

Automation scope	20 Mill US\$
HVDC Light	55 Mill US\$
Telecom	8 Mill US\$
Services	10 Mill US\$
Total	> 95 Mill US\$

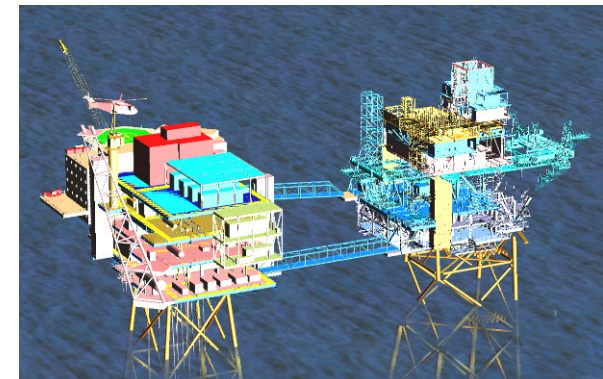
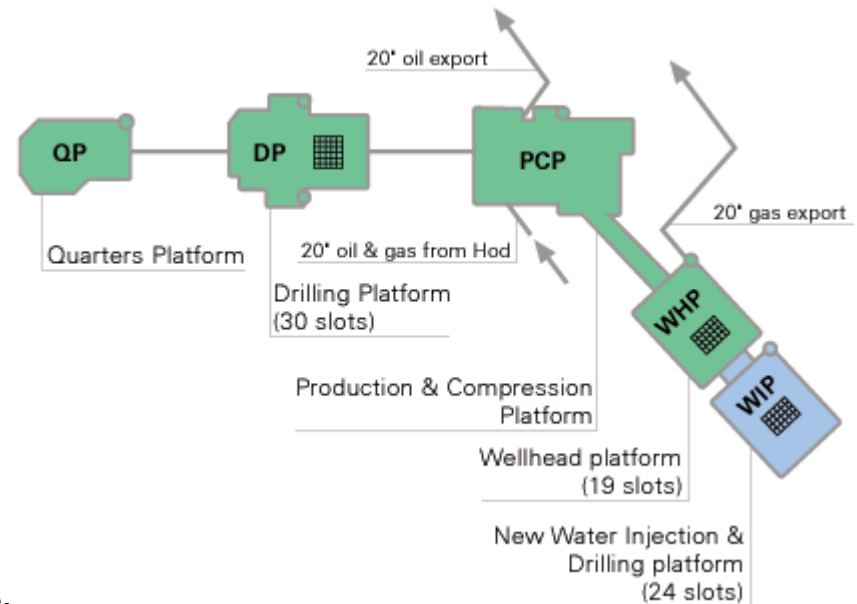
ABB Scope

Controllers, 20.000 Field I/O, Fieldbus, Workstations, Power Management, HVDC Light Power from shore, Telecom (tbd, Fibre optical comm to shore, wireless). Loop Design, Configuration, Installation, Commissioning, Compressor Control & Performance.

ABB Highlights

BP Field of the future concept: Onshore Control Room (No CCR offshore)

HVDC Light 290 km 78 MW, Fieldbus Foundation Based, Remote Asset Management



BP Operations – ABB supplied systems

Valhall North Flank



Valhall WIP



Valhall South Flank

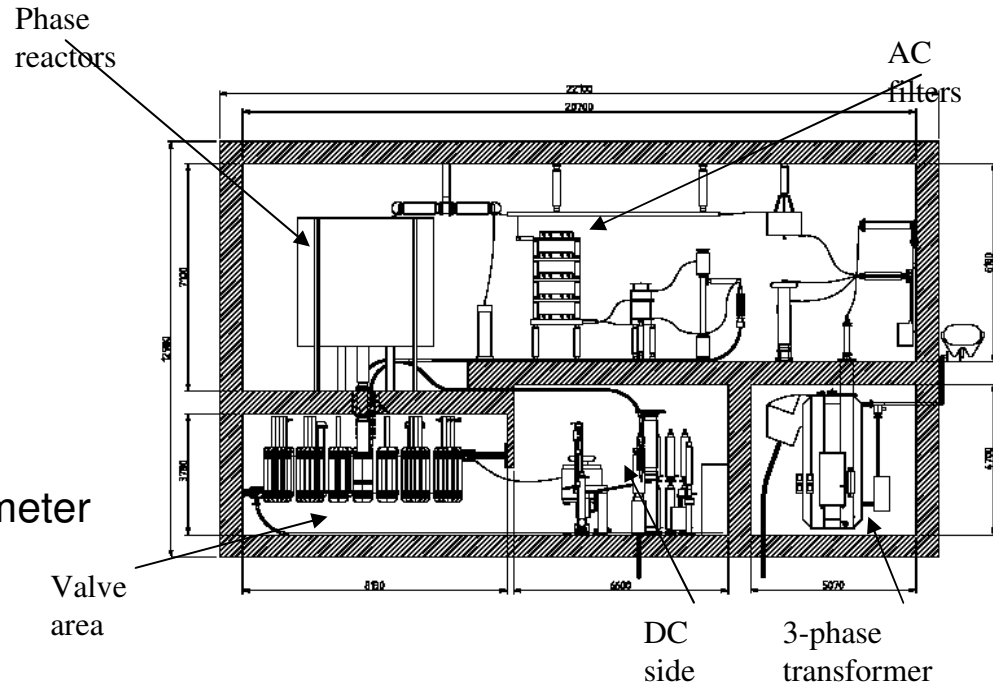


- Fire & Gas
- Emergency Shutdown
- Process Shutdown
- Process Control System

Valhall - HVDC

Technical Data

Commissioning year:	2009
Power rating:	78 MW
AC Voltage:	300 kV / 11 kV
DC Voltage:	150 kV
Length of DC cable:	292 km
Fibre optical communication in cable	



LxWxH = 22x15x13 meter



Troll A

FIELD

100 km northwest of Bergen, Norway and onshore gas plant
 Water depth 400 meters, power and pipeline to shore
 One Gravity base plus subsea tie ins
 75 mill scm Natural gas per day
 10.000 bpd NGL condensates. First installation 1996 and series of upgrades and extension with supply from ABB



ABB Contracts (1985-2005)

Automation scope	60 Mill US\$
Electrical scope	50 Mill US\$
HVDC and Motorformer (2005)	140 Mill US\$
Telecom	15 Mill US\$
Services	30 Mill US\$
Total	295 Mill US\$

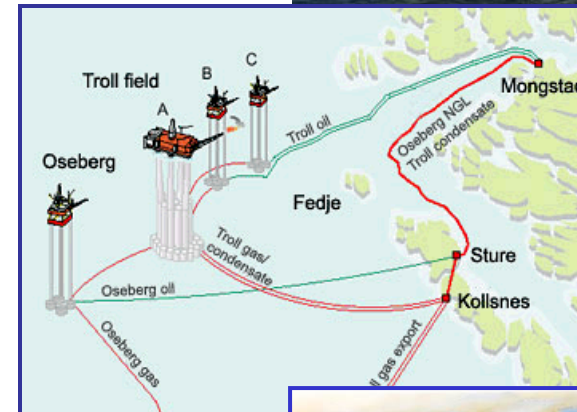


ABB Scope

Controllers, 25.000 Field I/O, Workstations, Supervisory system, Training Simulator, Generators, Large Drives Onshore (4x30 MVA), Recompression & HVDC Light offshore (40 MW), Transformers, MV & LV Switchboards, Power Management, Telecom, Loop Design, Configuration, Installation, Commissioning, Compressor Control & Performance.

Upgraded to 146,5 mill Sm³/Day 2006



Total ConocoPhillips



7. Troll-A HVDC Light commissioned in Feb. 2005

HVDC Light Transmission & Electric Drive System

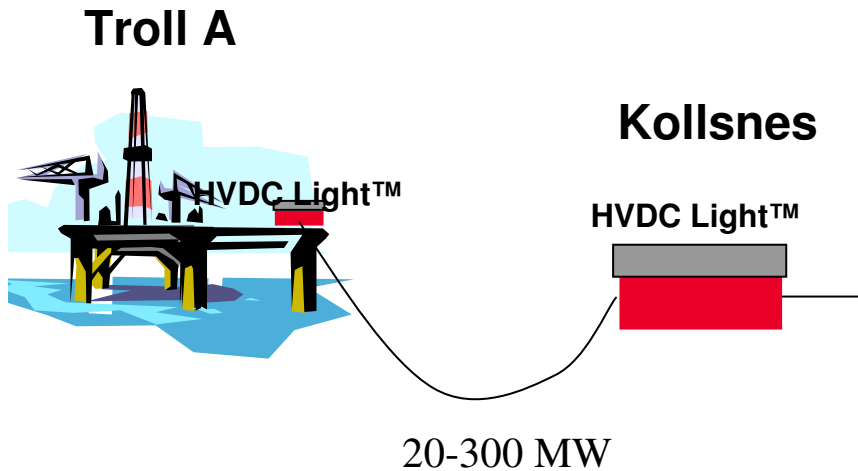


Key system data:

- Two HVDC Light[®] transmission systems
- Two 56-kV, 40-MW, 1800-rpm VHV Motors
- ± 60 kV DC
- 4x70 km sea cable
- **Avoided emission of 230,000 tones CO₂ annually**
- **Significantly reduced OPEX**
- **Significantly reduced risks associated with offshore gas turbines**
- **Reduced manning offshore due to the system's remote controllability and low maintenance**

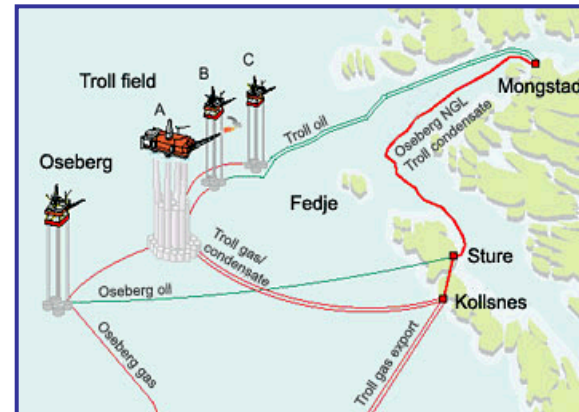
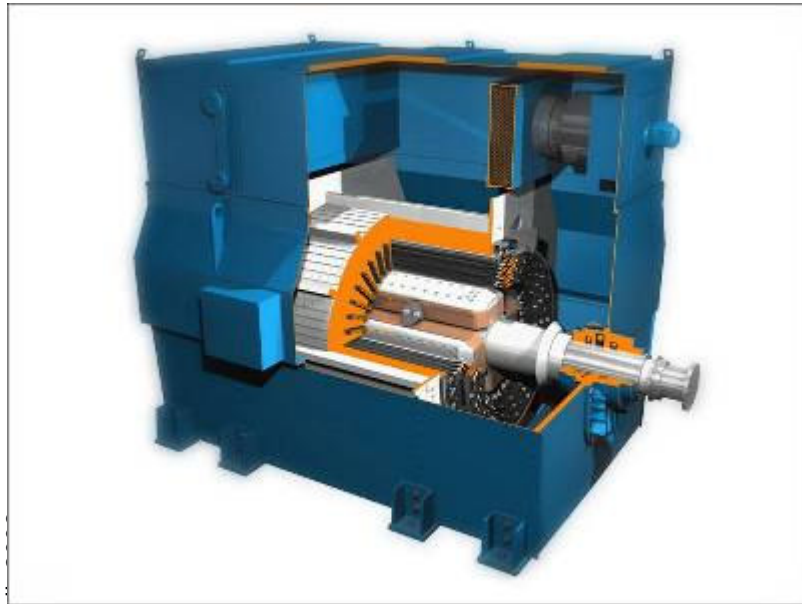


HVDC Light and VHV Motor



- Electrical power from shore to Troll A for pre-compression
- Converters located at Kollsnes and Troll A
- +/- 60 KV DC transmission
- 2x40 MW VHV Motor

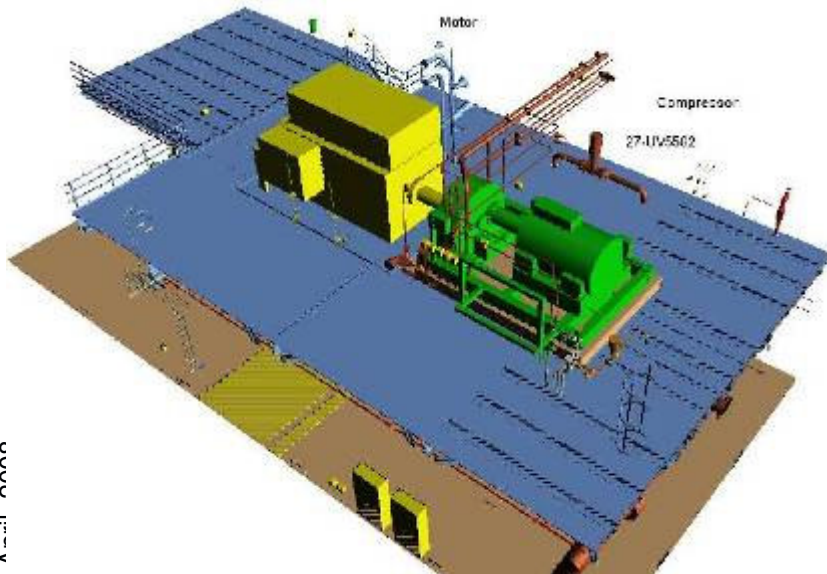
- Increased efficiency
- Reduced life cycle cost
- Reduction of gas emission



VSD system for export Gas Compressors



- 6 x Megadrive LCI system
- 6 x 41MW /48MW motors (EExp)
- 132 kV Transformers
- Filters units and reactors
- 12 pulse circuit system
- Synchronous machine with brushless excitation
- Water cooled
- Export Gas capacity upgraded to 146,5 mill Sm³/Day 2006



Troll A Electrification

- HVDC (precompression)
 - 200.000 Tons CO₂ (assuming dual cycle thermal)
 - Offshore Weight and size
 - 1627 > 550 tons over conventional LCI drive
 - Volume 10000 > 4480 m³
 - Higher CAPEX offset by lower OPEX
- Compression
 - Reduction of 458.000 Tons CO₂ (with Hydropower)
 - OPEX reduced by 19 mill USD
 - Cost of ownership reduced by 27 mill USD (incl saved fuel gas)



Power and productivity
for a better world™