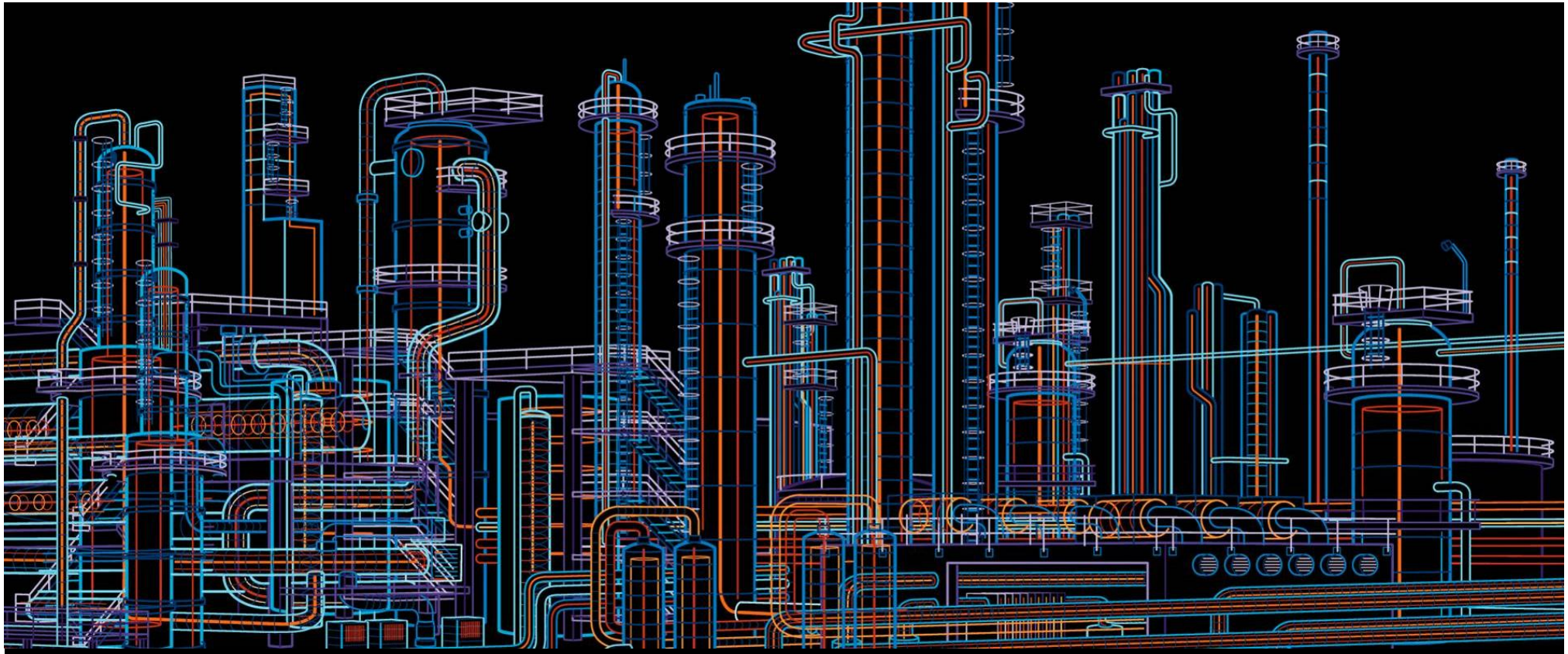
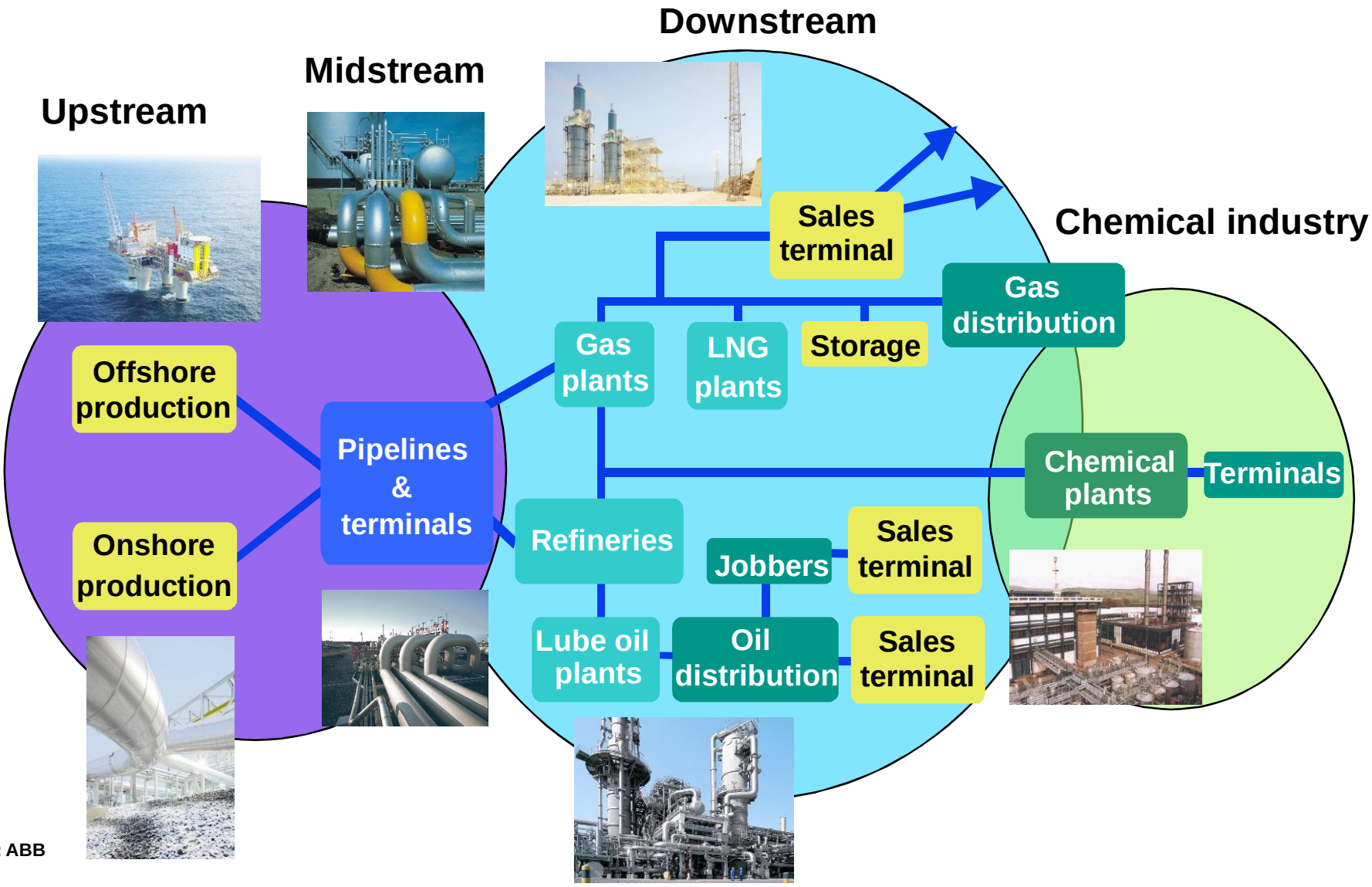


(Compiled by) Waqas Arshad, ABB, September 2014

Medium Voltage Drives, High MW Motors Chemical Oil & Gas (COG) industry Applications

Extracts from presentations by Adrian Guggisberg, Thomas Schmager, Heinz Lendenmann, John Petrolove

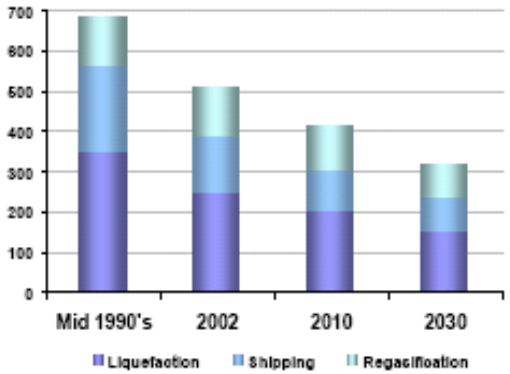
Chemical, oil & gas industry

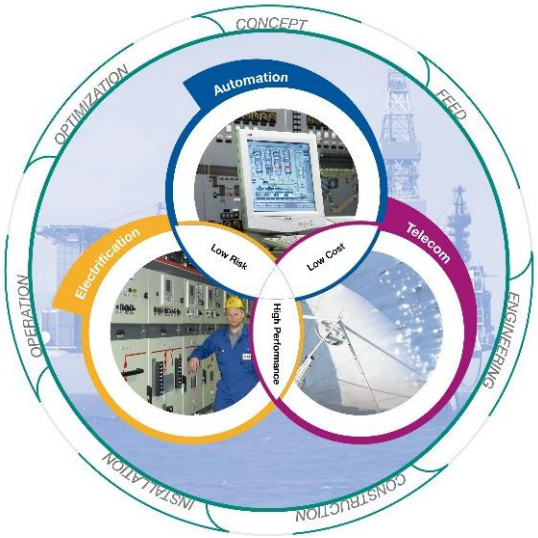


Source: ABB

LNG

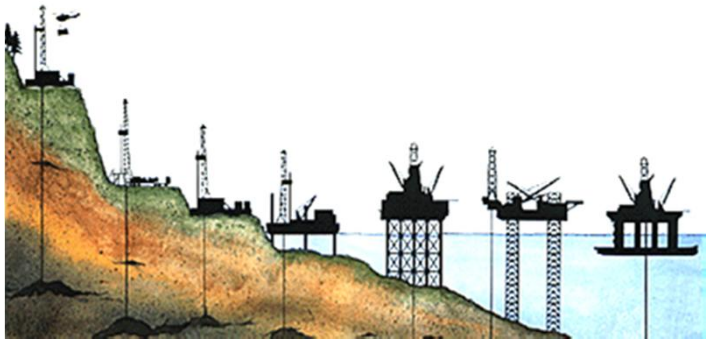
- Drivers
  - Gas price
  - Cost of Liquefaction
  - Global gas demand



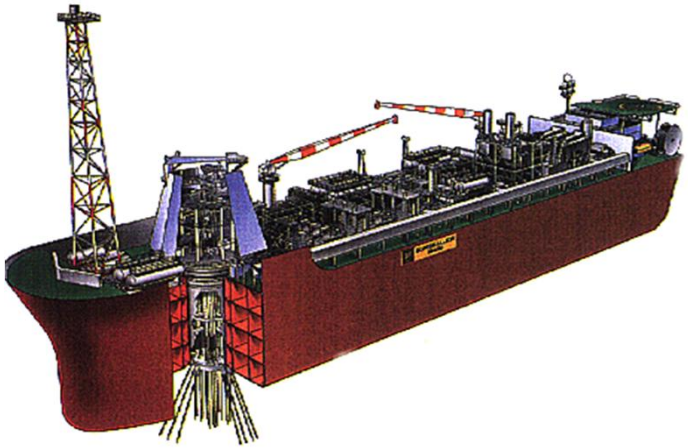


Gas Field	Liquefaction	Transportation	Regasification	Distribution
-Gas production	-Onshore	-Sea	-Onshore	-Pipelines
-Gas processing	-Offshore	-Land	-Offshore	-Power plants
-Gas gathering				-Industrial plants

MV AC drives in upstream oil and gas



- FPSO (Floating Production Storage and Offloading)
- Re-built tankers with drilling equipment, pumping, compression and generating units on deck. Compact process modules due to limited space on deck required
- For marginal field development or deep-water production
- Marine certified equipment (ABS, DnV, BV, Lloyds etc.)



- Pumps and compressors
- Onshore plant installations
- Offshore platforms
- Reliable operation in harshest industrial environments (Ex)
- Redundancy requirements (usually 3 x 50% or 2 x 100% installed capacity)

Gas liquefaction

LNG (Liquefied Natural Gas)

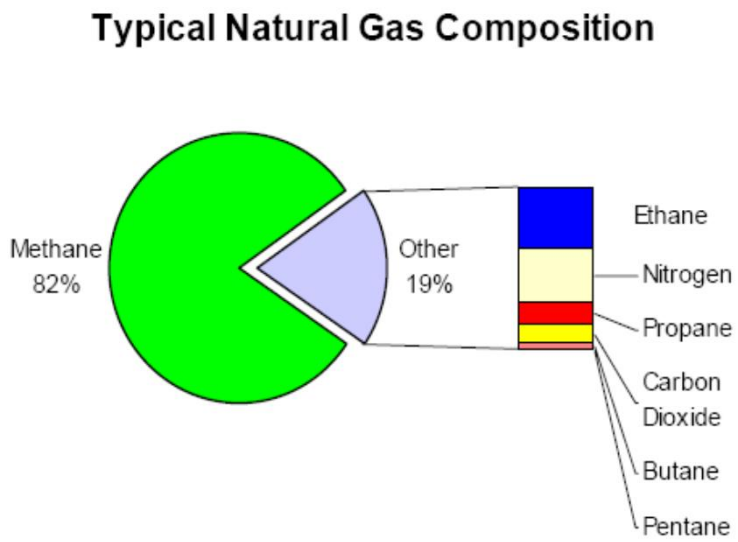
About five per cent of gas is shipped as LNG.

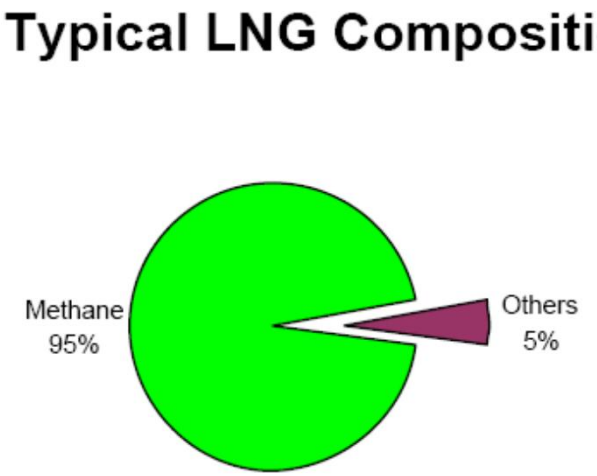
Liquefaction of methane by cooling it down to minus 162°C makes it occupying about 1/600 of the original volume.

One LNG train consists of

- two main compressor strings for the MR mixed refrigerant
- one PR propane refrigerant, as pre-cooling cycle
- one feed-gas compressor (FG)
- one end-flash-gas compressor (EFG) for enhanced utilization by recovery.

Gas Liquefaction



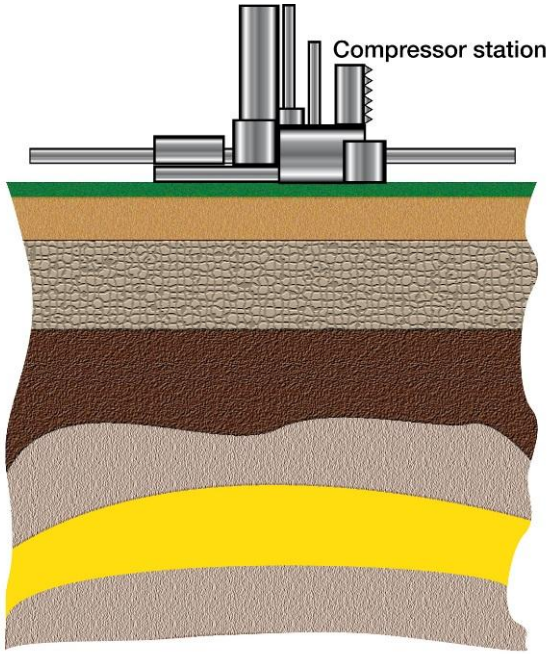


Composition of Natural Gas and LNG

Natural gas is composed primarily of methane, but may also contain ethane, propane and heavier hydrocarbons. Small quantities of nitrogen, oxygen, carbon dioxide, sulfur compounds, and water may also be found in natural gas.

The liquefaction process requires the removal of some of the non-methane components such as water and carbon dioxide from the produced natural gas to prevent them from forming solids when the gas is cooled to about LNG temperature (-165°C). At this temperature it occupies about 1/600 of the original volume of gas.

Gas transmission



Natural gas, mostly Methane is being transported as gas. Natural gas liquids (NGL's i.e. Propane, Butane, Ethane) are gradually removed from natural gas during production and processing are mostly transported in liquid form under pressure.

With each successive step in the chain of production, processing and gathering, natural gas is incrementally increased in pressure and cumulatively in volume. By the time that it is ready for transmission to the consumer market, its pressure and flow rates are optimized for the most economical levels for long distance transmission.

Gas is transported through pipeline networks

Booster stations are arranged at intervals to compensate for friction loss

Refinery Applications

- **Fluidized catalytic cracking (FCC)**
- **Wetgas (WGC)**
- **Hydrodesulfurisation (HDS)**
- **Hydocracking (HDC)**
- **Hydrotreating (HDT)**
- **Reforming**
- **Platforming (PLAT)**
- **Isomerisation (ISO)**
- **Visbreaking (VB)**
- **Delayed Coking (DC)**
- **Alkylation (ALK)**
- **others**

Application know-how in COG industry

	Applications
Upstream	Pumps Compressors
Oil & gas production and gathering	
Oil & gas separation	
Gas treatment	
Gas liquefaction (LNG/CNG)	
Midstream	
Oil & gas transportation and distribution	Pumps Compressors
Oil & gas storage	
Downstream	
Petroleum refining	Pumps Compressors Extruders Mixers Blowers Pumps
Petrochemical plants	
Air separation plants	
Chemical industry	

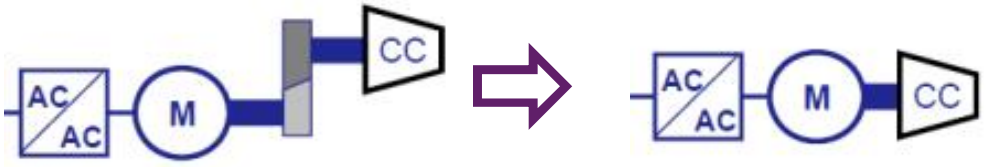
Why High Speed Motors

Market Drivers

- High Speed Motors + Drives have a much higher power density → smaller motors
- Eliminate gear boxes, smaller space requirements
- Reduce emissions & maintenance
- Increase efficiency & reliability, process availability
- New applications (e.g. subsea and inline compressors)
- Package solutions => better optimization

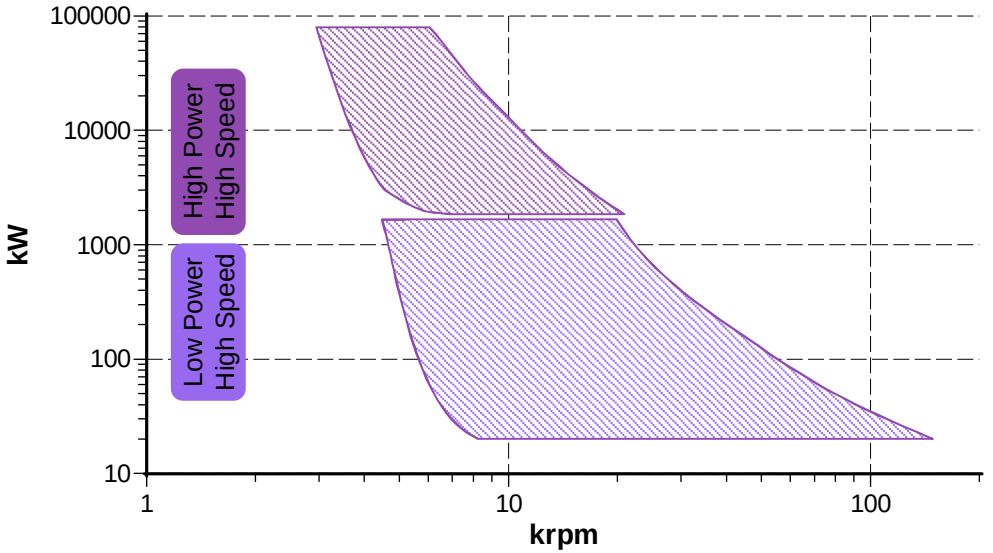
for variable speed direct drive of centrifugal gas compressors & injection pumps in COG, CCS, Power, and for turbo-machinery

High Power Motor + Drive

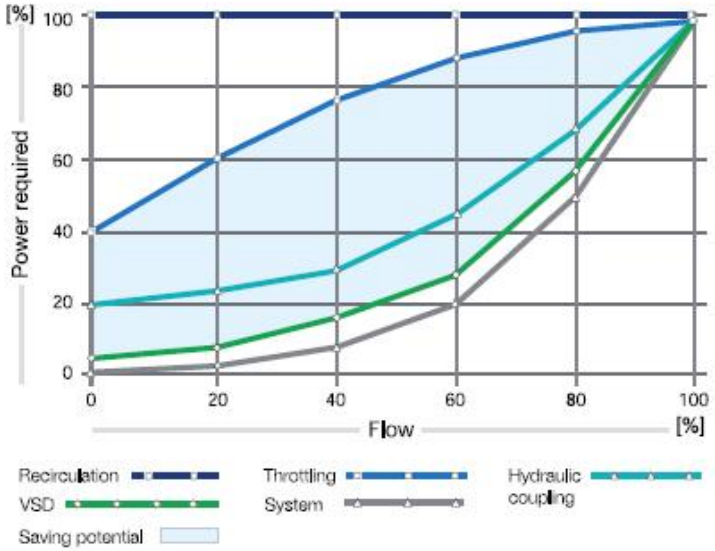


Market Threats

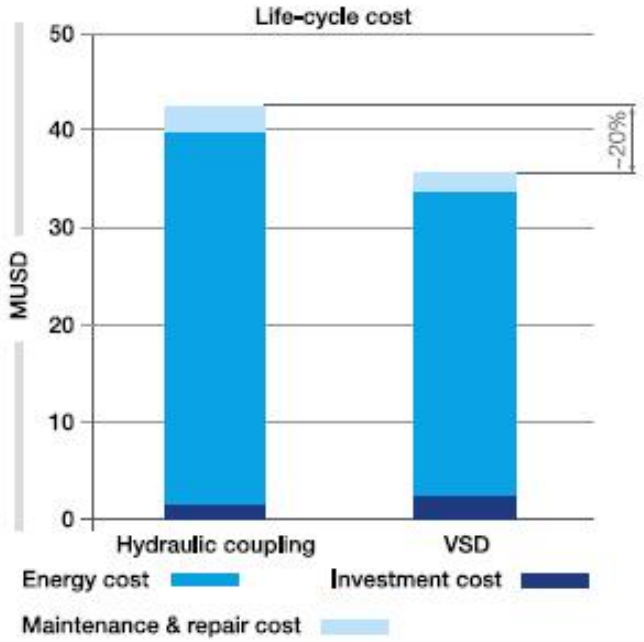
- Electric power availability in gas pipeline applications
- Motors are not yet available for all power and speeds e.g. LNG compressor drivers are far larger. However, the most compressor population is below 40MW
- Market acceptance of Variable Speed Drives
- Reliability of high-speed motors in general
- Capital cost of high-speed motor and magnetic bearings



Variable speed drives in chemical, oil and gas



Power consumption for various pump control methods



Comparison of ...	Hydraulic coupling	Variable speed drive
Efficiency	low (varies with load)	high (over entire load range)
Cooling requirements	high	low
Initial investment cost	low	medium
Maintenance	high	low
Availability	medium to high	high
Total life-cycle cost	high	very low
Influence on power supply	none	minimal with suitable topology
Inrush current from supply	up to 600% of rated current	less than rated current
Dynamic response	low	high
Environmental influence	high oil volume hazard	none
Space requirement at motor	extended shaft length	none
Weight	very high	medium
Speed control range	limited	wide and easy to adjust
Mean time to repair	several days	few hours

VSD vs. hydraulic coupling	
Break-even point	1.5 years
Net return on investment	900%
Net present value of savings	$7,000,000
Life-cycle cost savings	20%

The calculation is based on the following data:
Power: 9 MW; service life: 15 years; cost per kWh: $0.07; operating time per year: 8,000 hours

Benefits of variable speed drives
High performance and reliability increases plant availability and decreases maintenance costs
Smooth torque over the entire speed range reduces noise and vibration levels, which minimizes mechanical stress
Better efficiency, particularly at partial load results in lower energy costs
No inrush currents and voltage drops during starting
Regeneration of rotating power and braking capability
Improved speed control and process optimization
Enhanced operating flexibility to suit the process needs
Lower impact on piping/valve system results in longer equipment life and less maintenance
Better dynamic performance during starting and during supply grid turbulences
No on-site emissions

All electric LNG plants
Better, safer, more reliable - and profitable

Comparison of gas turbine and electric drive characteristics

Characteristics	Gas turbines	Electric drives
Weight and space	Light unit but space and weight consuming auxiliaries	Similar to that for gas turbines
Minor maintenance cycle	4,000 hours	25,000 hours
Major maintenance cycle	20,000 hours	100,000 hours
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	1 – 2 years
Average operational efficiency	25%	40%

Table 1 Comparison of gas turbine and electric drive characteristics

- Breakeven Point : 4/5 months

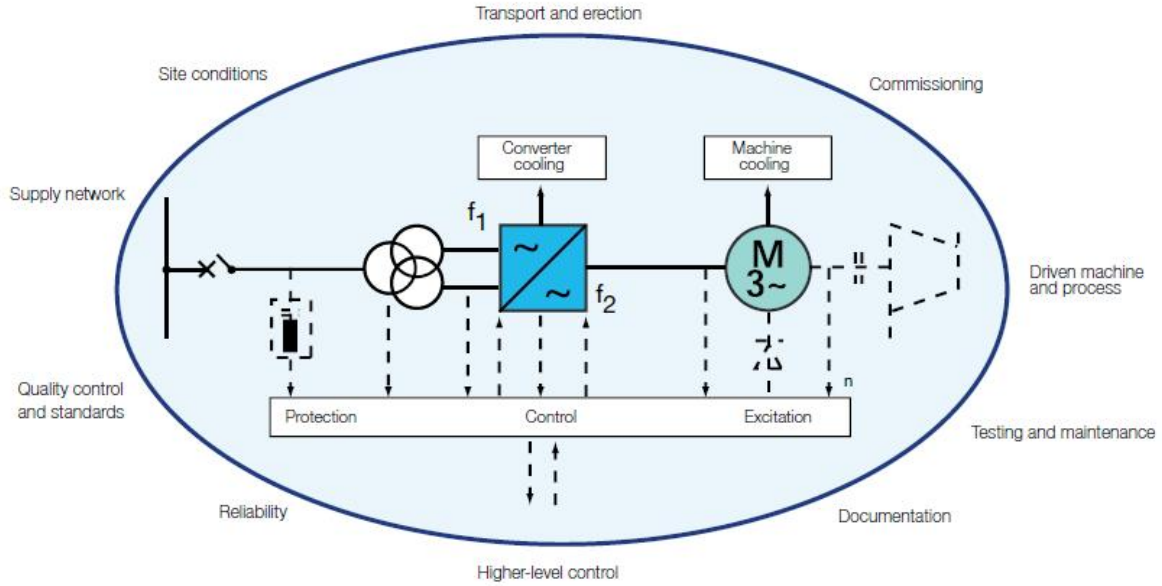
Annual savings using an All Electric Drive system

Characteristics	A. Electric Drives	B. Gas Turbines	Difference
CAPEX system cost[1]	Main drives $30 million Power plant $35 million Aux. drives $7 million	Main GT $25 million Power plant $14 million Aux. drives $7 million	$26 million
LNG production	6,250,000 tons/year	6,250,000 tons/year	
Maintenance costs	$5 million/year	$10 million/year	$5 million
Shaft power efficiency	36%	25%	
Fuel gas consumption	450 mmSCM	648 mmSCM	200 mmSCM
CO_2 emissions	800,000 tons	1,160,000 tons	360,000 tons
CO_2 quota cost where applicable (EU)	$13 million	$19 million	$6 million
Value of fuel gas	$100 million	$145 million	$45 million
Ten additional production days	$36 million	0	$36 million
Recirculation losses	0	$5 million	$5 million
Annual savings			**$91 – 97 million**

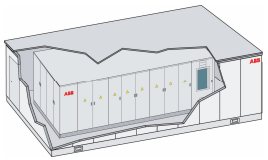
Table 2 Annual savings using an All Electric Drive system

[1] main drives, auxiliary drives and power generation

The Complete Picture



Higher system complexity



- Hazardous environments
- Filters
- Simulations and mechanical calculations
- Recooling equipment
- Switchgear
- Outdoor control houses
- Testing

Reliability and availability is a must
Full drive package responsibility

High speed direct drive for gas compressors
ABB supplies high-speed variable speed drives for compressor applications. Combined with a high-speed motor (above 200 Hz), the motor can be coupled to the compressor without using a gearbox. This compact solution requires less space and maintenance, has a lower noise level and a considerably higher availability compared to a solution utilizing a step-up gearbox.

Back-to-back test 48 MW / 3,500 rpm

Power and productivity
for a better world™