MV Drives, July 2012

ABB drives for chemical, oil and gas
Medium voltage drives for greater profitability and performance

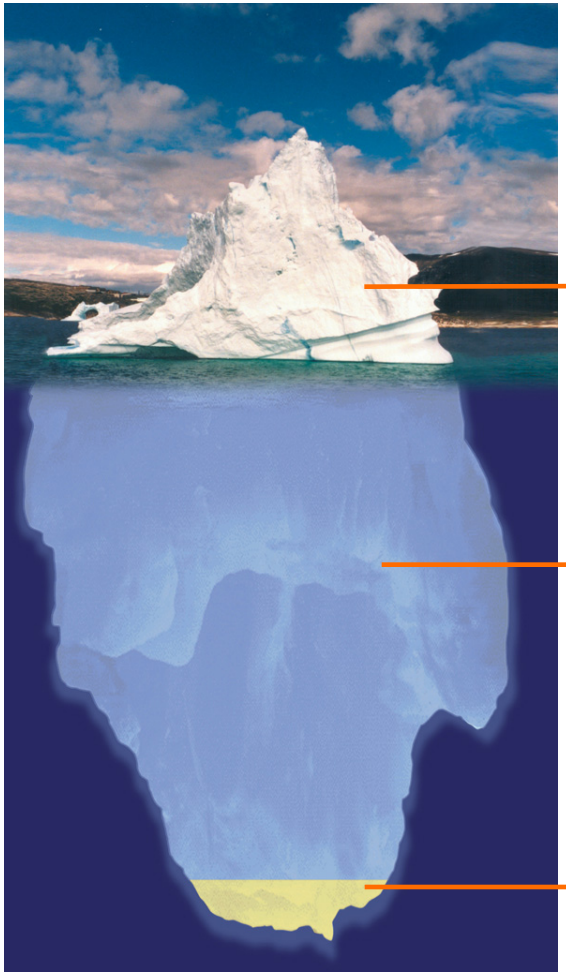
Variable speed drives for COG

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

Benefits of variable speed drives

- Higher efficiency and less emissions
- Improved control and flexibility of processes
- Improved product quality
- Power conversion
- Reduced starting impact on network and machinery
- High reliability and maximum availability of process equipment
- Minimized environmental impact

Investment in variable speed drives



- The investment in high efficiency, largely maintenance-free, variable speed drives helps to keep costs under control

Purchase cost 6%

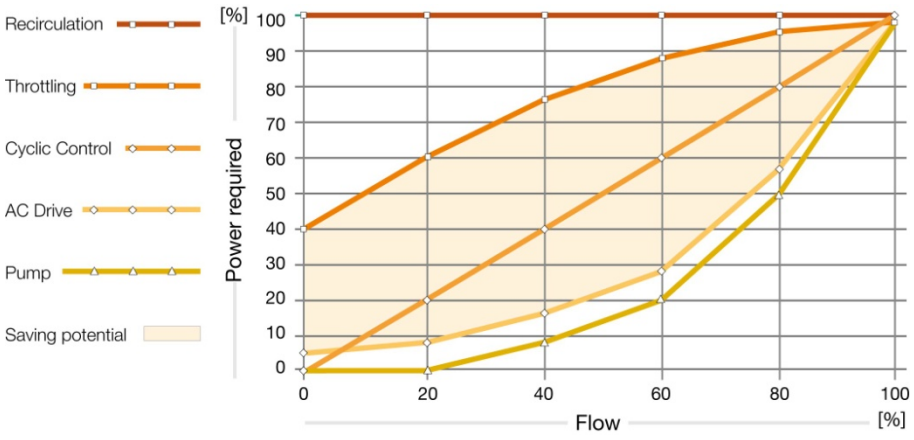
Energy cost 90%

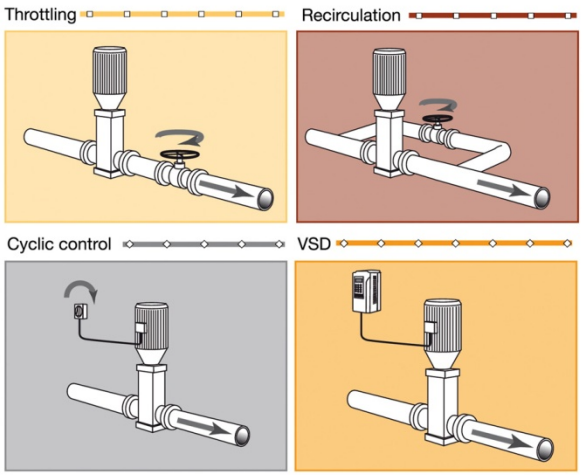
Energy saving potential with variable speed drives

Maintenance cost 4%

Higher efficiency and less emissions

Power consumption for various control methods





- The power to run a pump or compressor is roughly proportional to the cube of the speed
- A pump or compressor running at half speed consumes as little as one eighth of the energy compared to one running at full speed
- A small reduction in speed can make a big difference in energy consumption
- Many pump or compressor systems often run at partial load -> huge energy savings can be achieved by controlling their speed with variable speed drives
- Variable speed drives help to reduce CO_2 and NO_x emissions

Improved control and flexibility of processes

- Outputs of oil and gas fields can vary in their compounds, density, volume flow rates and pressure levels
- Due to the varying operating conditions, pumps and compressors cannot always be operated at their optimum design point
- With variable speed drives, processes are controlled by speed control → the equipment will run at its optimum operating point

Improved product quality

- The optimal product quality of some plastic materials requires operating flexibility over a distinct speed range
- Variable speed drives adjust the speed precisely to optimize the operation of process machinery

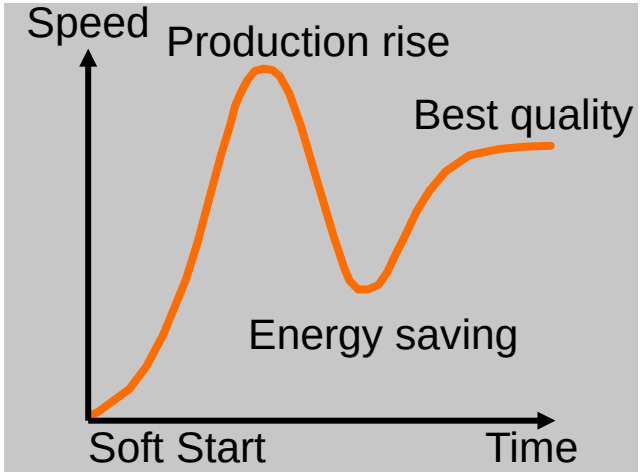
Power conversion

- Some processes have an energy excess, which can be converted into rotating power
- With variable speed drives, this rotating power can be converted into electrical energy, synchronized to grid frequency and fed back into the supply network

Impact on network and machinery

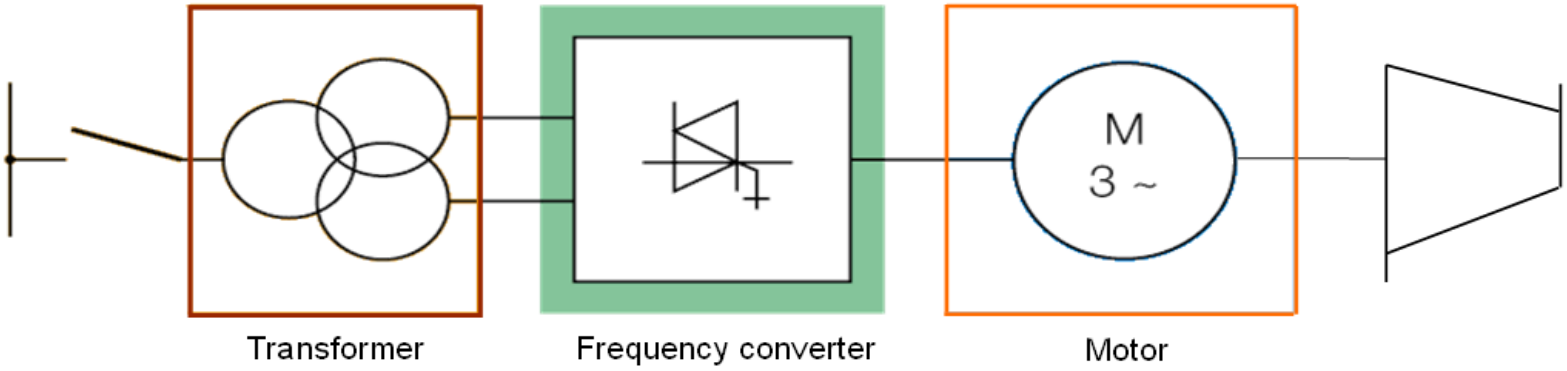
- Starting machinery with heavy load torque and/or high mass moment of inertia impose large stresses on supply network and mechanical equipment
- A direct-on-line started electric motor can cause starting currents of up to five or six times the nominal current
- In weak supply networks this will cause massive voltage drops on the supply bus

Soft starting – benefits



- Variable speed drives act as soft starters, reducing stress on network and equipment
  - During the starting process, variable speed drives progressively increase the motor speed and smoothly accelerate the load to its rated speed
- Soft starting eliminates high starting currents and voltage dips which can cause process trips
- No excessive thermal and mechanical stress on motor and no mechanical stress on the shaft system
  - Longer lifetime of equipment
- Immediate start-up without warming up (e.g. turbines)
- Gentle process start-up from zero speed

Components of variable speed drives



A variable speed drive system consists of:

- Input transformer
- Frequency converter
- Electric motor

Full drive package responsibility

ABB can offer the complete variable speed drive system – a single source offering coordinated work from design to production, testing, delivery and commissioning

- Advantages:
  - Minimized risk and reduced commissioning time
  - Optimized system with all associated auxiliaries
  - System design supported by a professional engineering team
  - Integrated manufacturing and delivery schedules for the complete drive system
  - Verification of the functionality, as well as the load performance of the drive system

MV drives
General Purpose Drives

ACS 1000, ACS 1000i

- Cooling: air / water
- Power range: 315 kW – 5 MW
- Output voltage: 2.3 – 4.16 kV
- Air-cooled ACS 1000 available with integrated input transformer and input contactor (ACS 1000i)

ACS 2000

- Cooling: air
- Power range: 250 – 2,600 kW
- Output voltage: 4.0 – 6.9 kV
- Available for direct-to-line connection, for connection to a separate two-winding transformer or with an integrated transformer

MV drives
General Purpose Drives

ACS 5000 air cooled

- Cooling: air
- Power range: 2 – 7 MW
- Output voltage: 6.0 – 6.9 kV

  (optional 4.16 kV)
- Available with integrated input transformer

MV drives
Special Purpose Drives

ACS 5000 water cooled

- Cooling: water
- Power range: 5 – 32 MW
- Output voltage: 6.0 – 6.9 kV (optional 4.16 kV)

ACS 6000

- Cooling: water
- Power range: 3 – 27 MW
- Output voltage: 3.0 – 3.3 kV
- Available as single or multidrives

MV drives
Special Purpose Drives

MEGADRIVE-LCI

- Cooling: air / water
- Power range: 2 – 72 MW (higher on request)
- Output voltage: 2.1 – 10 kV

High speed direct drive for gas compressors

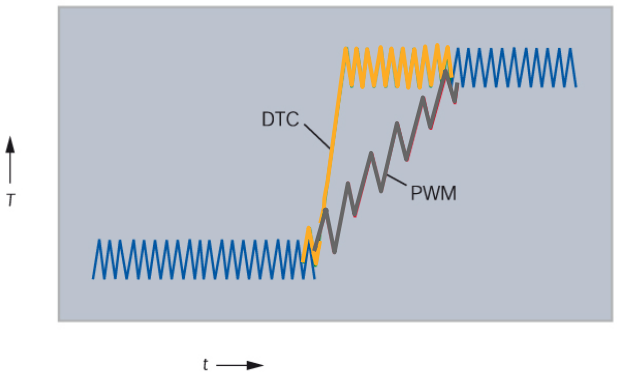
- ABB supplies high-speed variable speed drives for compressor applications
- Combined with a high-speed motor (above 200 Hz), the motor can be coupled to the compressor without using a gearbox
- Advantages:
  - Compact solution requiring less space
  - Higher availability
  - Reduced maintenance
  - Lower noise level

Technology highlights

- Direct Torque Control (DTC)
  - For highest torque and speed performance
- Power loss ride through
  - The drive system is able to withstand power supply disturbances
- Fuseless design
  - ABB medium voltage drives operate without fuses, resulting in less spare parts and fast re-starts
- Encoderless
  - ABB medium voltage drives can operate without encoders which are known to cause failures
- DriveMonitor™ (option)
  - Remote and real-time monitoring and diagnostics of ABB drives from any location in the world

Direct Torque Control (DTC)

Typical torque response (t) of a DTC drive, compared with flux vector control and open loop pulse width modulation (PWM)



- Provides fast, accurate and stepless control from zero to full speed
- Full torque with optimal speed accuracy over the whole speed range
- Negligibly low torque ripple
- Minimal inverter switching losses at maximal control performance
- No speed encoders needed

DriveMonitor™
Intelligent monitoring and control

DriveMonitor™ is an intelligent diagnostic system consisting of

- Hardware module (installed in- or outside of drive)
- Software layer (collecting and analyzing selected drive signals and parameters)

Functions

- Monitoring of drive's performance, and, if required, other shaft line components (main circuit breaker, transformer, motor)
- Fast fault finding process

How much energy do you save?

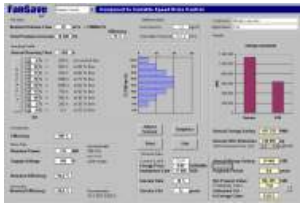
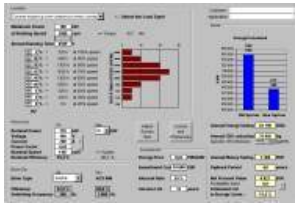
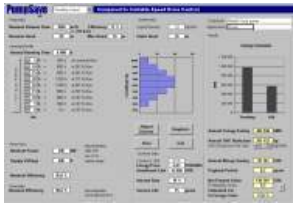
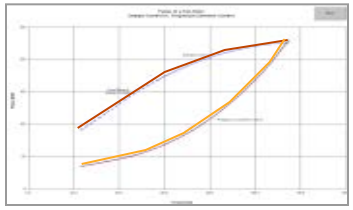





ABB has developed the following tools to assist in the calculation of energy savings:

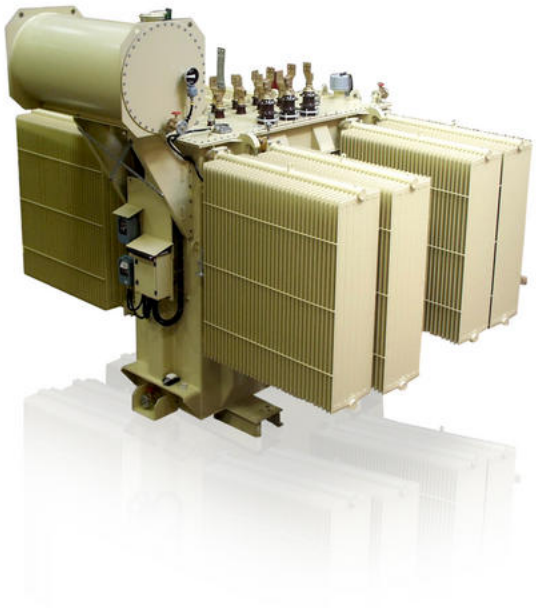
- FanSave – for comparison of energy consumption between different fan control methods
- PumpSave – for comparison of energy consumption between different pump control methods

High voltage motors

- Induction motors
  - Available up to 22 MW
  - Induction motors are usually the first choice for applications up to 12 MW

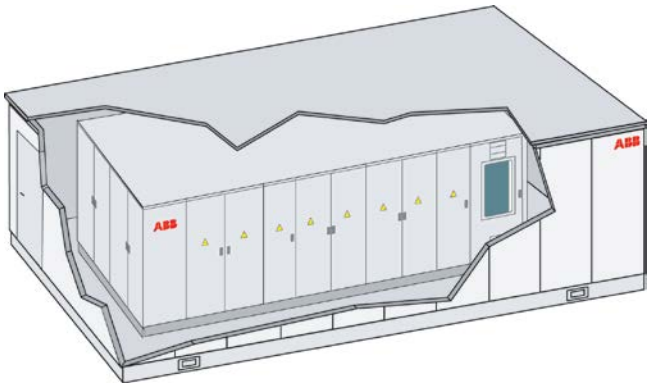
- Synchronous motors
  - Typically considered for higher power ratings (e.g. above 8 MW to more than 100 MW)

Input transformers



- Input transformers have two functions:
  - To adjust the network supply voltage to match the converter
  - To protect the motor from common-mode voltages
- ABB transformers are available for all ratings and primary voltages, oil or dry type

Other components



- Filters
  - For special customer needs and high power ratings in weak networks, filters and power factor correction equipment can be provided
- Recooling equipment
  - Fin-fan coolers or chillers for the cooling circuit of water-cooled frequency converters can be provided if cooling water is not available on site
- Switchgear
  - ABB offers medium voltage distribution switchgear for all drive sizes and other distribution tasks in the plant
- Outdoor control houses
  - Tailored to specific needs and site conditions
  - Mezzanine floor for cabling and piping, air conditioning and fire detection are standard options

Electric versus gas turbine drives

Comparison of…	Gas turbine	Variable speed drive
Efficiency	low	very high
Investment cost	high	medium
Operating cost	to be evaluated	to be evaluated
Maintenance	high (important)	very low
Reliability	medium	high
Availability	medium	high
Mean time to repair	a factor to be considered	very low
Pollution, emissions	high	none
Speed control range	limited	wide
Speed control accuracy	medium	high
Design flexibility	low	high
Starting time	medium to high	short
Noise level	very high	medium
Influence on power supply	none	investigation required
Environmental permit	required	not required

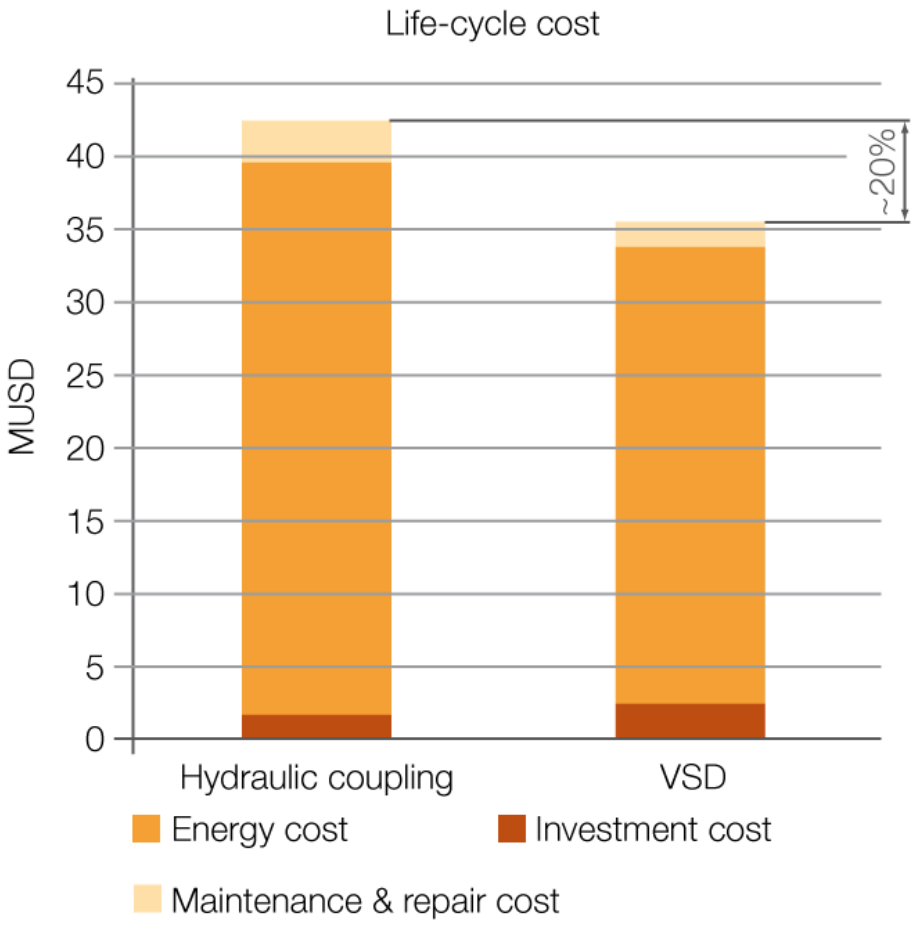
Optimizing cost and processes in LNG plants

- **Refrigeration processes traditionally driven by gas turbines**
  - Disadvantage:
    - Gas turbines must have starting aid, require constant maintenance and their efficiency deteriorates during their lifetime
- **Variable speed drives can act as starter / helper drives to start gas turbines**
  - Advantages:
    - Compensation of declining driving power of the gas turbine at high ambient temperatures
    - Operation as power generators if one of the gas turbines is running on excess power to balance power consumption between two refrigeration trains
- **Starter / helper drives can be upgraded to fully rated variable speed drive systems -> gas turbines can be substituted**
  - Advantages:
    - Lower investment cost
    - Higher uptime
    - Less maintenance
    - Reduced operation / production cost

Variable speed versus fixed speed motor with hydraulic coupling

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	very 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 MUSD**
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 USD
Operating time per year: 8000 hours

Hazardous environments

Potentially explosive zones in which explosive atmosphere containing gas or combustible dust			Explosive mixtures in temperature classes defining the maximum permissible temperatures of surfaces in electrical equipment, which do not exceed the ignition temperatures of the gas mixture.
… is expected to exist continuously or for very long periods of time.	… is expected to exist for short periods of time but during a year the accumulation of such events is not in excess of 1000 hours.	… is not expected and should it occur it will only exist for a very short period of time and where the accumulation of such events over a year does not exceed much in excess of 10 hours.	
Zone 0	**Zone 1**	**Zone 2**	

- Electrical and non-electrical equipment installed in potentially explosive atmospheres containing gas or combustible dust have to comply with the directive ATEX94/9/EC
- ABB was the first manufacturer to have its motors ATEX certified

Compliance with ATEX directive

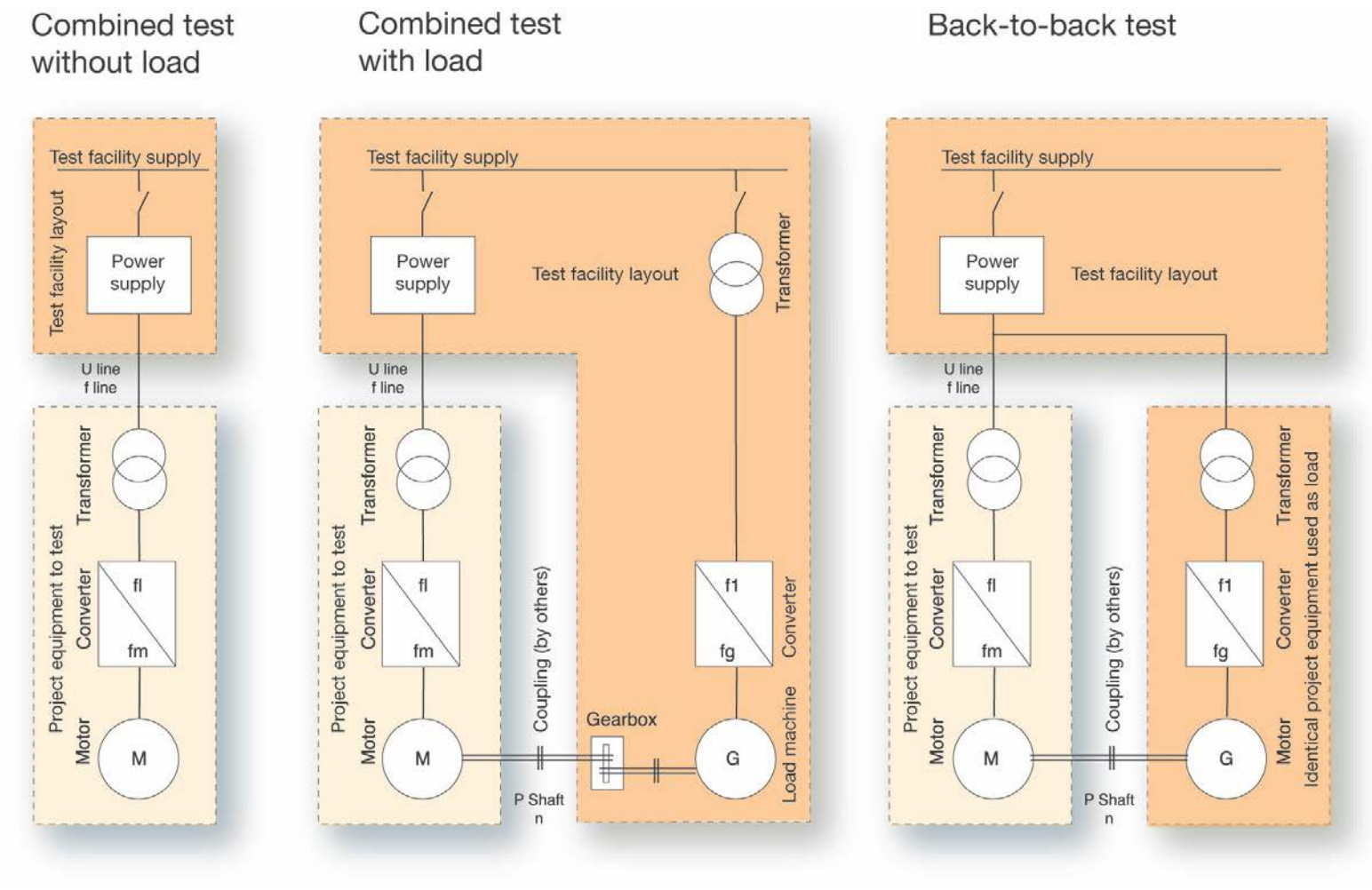
- Reinforced safety aspects
- Safer design, not only for normal operations, but also for starting conditions
- More demanding testing procedures
- Quality assurance for the design and manufacturing process
- Use of variable speed drive applications based on clear rules
  - Second rating plate
  - Certified loadability curves
  - Bearing currents controlled against external sparking

Testing

ABB is committed to ensuring the reliability of every drive we deliver.

- Every component of a drive is subjected to thorough testing in ABB's modern test facilities
- Routine tests, functional tests
  - Integral part of the scope of supply
  - Performed in accordance with international standards and ABB quality assurance procedures
- Combined tests
  - Tests with the complete drive system including transformer, converter and motor – can be performed

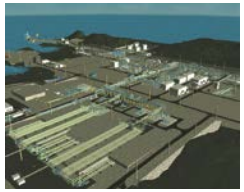
Test layouts



Worldwide service and support

- Supervision of installation and commissioning
- Training
- Remote diagnostics
- Customized maintenance contracts
- Local support
- 24 x 365 support line
- Spare parts and logistics network
- Worldwide service network

Case example
Ormen Lange, Norway


© Norsk Hydro

- Untreated wellstream gas from the Ormen Lange gas field is processed at the Nyhamna gas processing plant.
- From the plant it is exported to the UK – through the world's longest subsea pipeline.
- ABB supplied three 48 MW MEGADRIVE-LCI drive systems for the gas export compressors and two ACS 6000 for the gas processing plant.
- Benefits:
  - High reliability and availability
  - Low maintenance cost
  - High uptime and increased production hours
  - Operation of compressors at optimal speed / power range
  - High efficiency
  - No CO_2 and NO_x emissions

Case example
Daqing, China

- The mixer at the Daqing Petrochemical Plastic Factory was powered by a 20 year old motor which was limited to two speeds.
- This resulted in poor product quality which reduced the amount of plastics being produced.
- Daqing retrofitted its existing mixer motor with ABB‘s ACS 1000 variable speed drive.
- Benefits:
  - Energy savings of 30%
  - Increased production efficiency
  - Improved product quality
  - Reduced noise

Case example
Preem Petroleum, Sweden

- Preem Petroleum used to control the exhaust fan with a damper. However, this method was insufficiently accurate, leading to unacceptable levels of NOx emissions.
- The damper was replaced with ABB‘s ACS 1000 variable speed drive.
- Benefits:
  - Reduced NO_x emissions
  - Improved production stability
  - Increased process efficiency
  - Improved productivity

Case example
Repsol YPF, Argentina

- Repsol YPF replaced a steam turbine which was driving a blower motor with ABB‘s ACS 1000 variable speed drive.
- Benefits:
  - Full operation even during power supply disturbances
  - Full redundant operation since the unit operates with both steam and electric energy supplies
  - Reduced maintenance
  - Improved process control
  - Lower impact on electrical network
  - User-friendly operation
  - Savings projected for the first year, covered 33% of project cost

Case example
PEMEX, Mexico

- ABB supplied a MEGADRIVE-LCI soft starter to PEMEX to start up two compressor motors in sequence.
- The system is designed to allow a direct-on-line start of the motors if necessary.
- Benefits:
  - Increased profitability
  - Reduced operating cost
  - Higher availability of the plant's power grid
  - Minimized production loss
  - Longer lifetime of equipment
  - Reduced maintenance cost

Case example
Baker Hughes Centrilift, USA

- ABB supplied ACS 1000 variable speed drives to Baker Hughes Centrilift to control Electrical Submersible Pumps (ESP).
- Benefits:
  - Optimized ESP operation
  - Reduced operating cost
  - Maximized production and revenues
  - Seamless integration with motor/pump information system

Case example
Gas Services International, Singapore

- ABB‘s ACS 1000 variable speed drives control reciprocating compressors at the DEZGAS gas gathering complex.
- Benefits:
  - Compressor operation adjustable to actual demand
  - Low harmonics
  - No staring inrush currents
  - Reduced vibrations
  - Increased lifetime of equipment
  - Equipment designed for 52°C ambient temperature

Case example
RAG Haidach underground gas storage facility, Austria

Four MEGADRIVE-LCI variable speed drive systems, each rated at 15.5 MW, control the gas compressors at RAG's Haidach underground gas storage facility.

Benefits:

- Efficient operation across a range of head and flow conditions
- Reduced maintenance costs and longer lifetime of equipment
- Remote monitoring

Power and productivity
for a better world™