ABB drives for chemical, oil and gas
Medium voltage drives for greater profitability and performance
# Variable speed drives for COG

## Upstream
- Oil & gas production and gathering
- Gas treatment
- Gas export
- Subsea

## Midstream
- Oil & gas transportation and distribution
- Oil & gas storage
- Gas liquefaction (LNG/CNG)
- Gas to liquid (GTL)
- Liquefied petroleum gas (LPG)

## Downstream
- Petroleum refining
- Petrochemical plants
- Air separation plants
- Chemical industry

<table>
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<th>Applications</th>
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<tr>
<td>Pumps</td>
</tr>
<tr>
<td>Compressors</td>
</tr>
<tr>
<td>Extruders</td>
</tr>
<tr>
<td>Mixers</td>
</tr>
<tr>
<td>Blowers</td>
</tr>
</tbody>
</table>
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
The investment in high efficiency, largely maintenance-free, variable speed drives helps to keep costs under control.

- Purchase cost 6%
- Energy cost 90%
- Maintenance cost 4%

Energy saving potential with variable speed drives
Higher efficiency and less emissions

- 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 CO₂ and NOₓ 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)

- 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 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

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

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

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

<table>
<thead>
<tr>
<th>Break-even point</th>
<th>1.5 years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net return on investment</td>
<td>900%</td>
</tr>
<tr>
<td>Net present value of savings</td>
<td>7 MUSD</td>
</tr>
<tr>
<td>Life-cycle cost savings</td>
<td>20%</td>
</tr>
</tbody>
</table>

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

- 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.

<table>
<thead>
<tr>
<th>Zone 0</th>
<th>Zone 1</th>
<th>Zone 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>… is expected to exist continuously or for very long periods of time.</td>
<td>… 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.</td>
<td>… 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.</td>
</tr>
</tbody>
</table>

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.
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

- 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 CO₂ and NOₓ 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 NOx 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 starting 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™