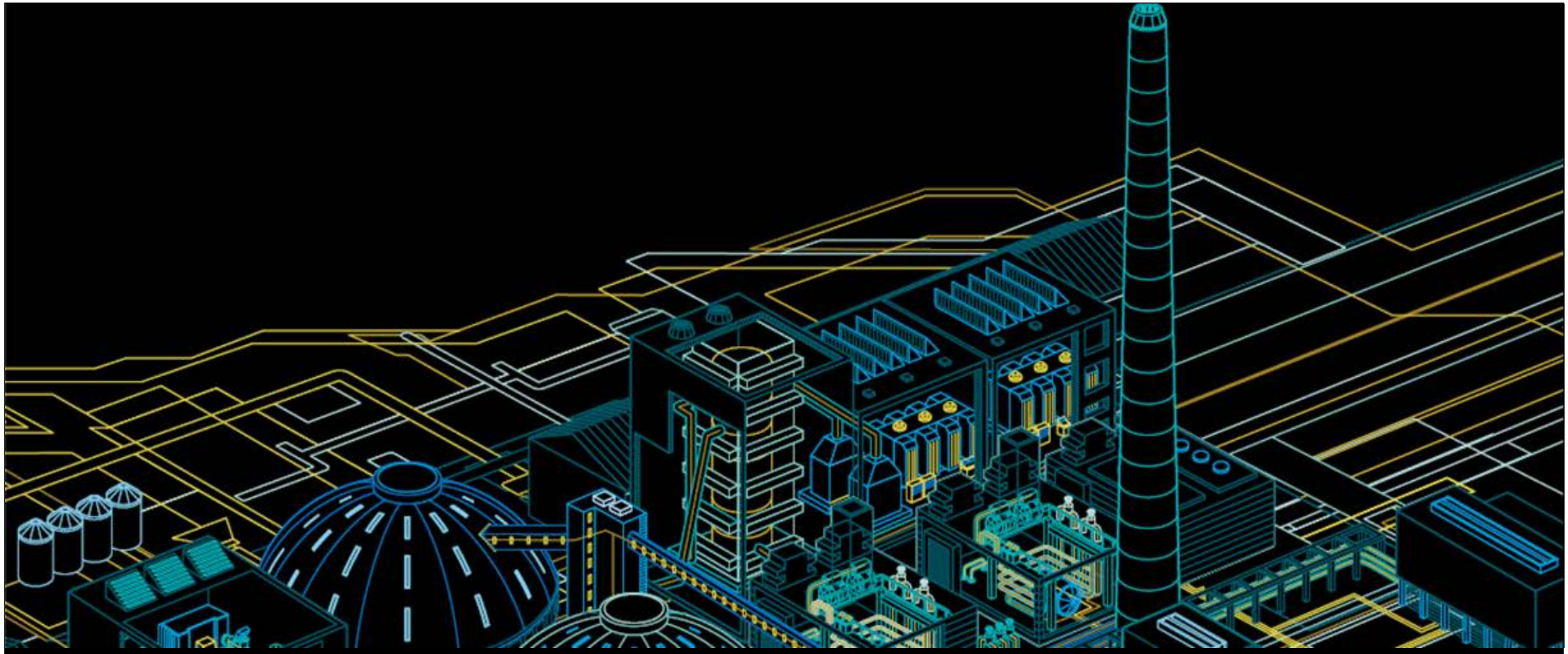


MV Drives, March 2011

ABB drives in power generation
Medium voltage drives for more efficient and reliable plant operation

Power and productivity for a better world™

Variable speed drives in power generation

- A thermal power plant usually consumes 5 – 8% of the electricity it produces
- Processes driven by electric motors typically consume 80% of this electricity
- Variable speed drives (VSDs) improve the heat rate by increasing the efficiency of these processes
- An improved heat rate and power output results in higher profitability and faster return on investment

VSDs increase plant availability and flexibility through improved process control and reduce emissions and maintenance costs.

Fields of application

Gas turbine power plants	GT starters, drives for fuel gas booster compressors, boiler (HRSG) feed-water pumps and cooling water pumps
Steam generating boilers, waste incinerators	Drives for boiler feed-water, cooling water and circulation water pumps, FD and ID fans
District heating, Combined Heat and Power	Drives for water circulation pumps in industrial and municipal Combined Heat and Power (CHP) plants
Fuel handling	Drives for conveyors and coal mills
Selective Catalytic Reduction, Flue Gas Desulphurization	Drives for ID booster fans, limestone slurry feed and absorbent circulation pumps and oxidation air compressors
Clean coal and CO_2 capture	Drives and soft starters for syngas, air and CO_2 compressors
Pumped storage hydro power plants	Soft starters for hydro turbines
Renewable energy	Drives for geothermal power plants and soft starters for synchronous condensers
Nuclear power plants	Drives for feed-water, condensate recirculation and cooling-water pumps

Benefits of variable speed drives

- High availability
- Fast and precise process control under all conditions
- Minimized energy consumption
- Reduced CO_2 emissions
- Minimized actuator equipment
- Soft starting features for a longer lifetime of electrical and mechanical equipment
- Reduced maintenance costs

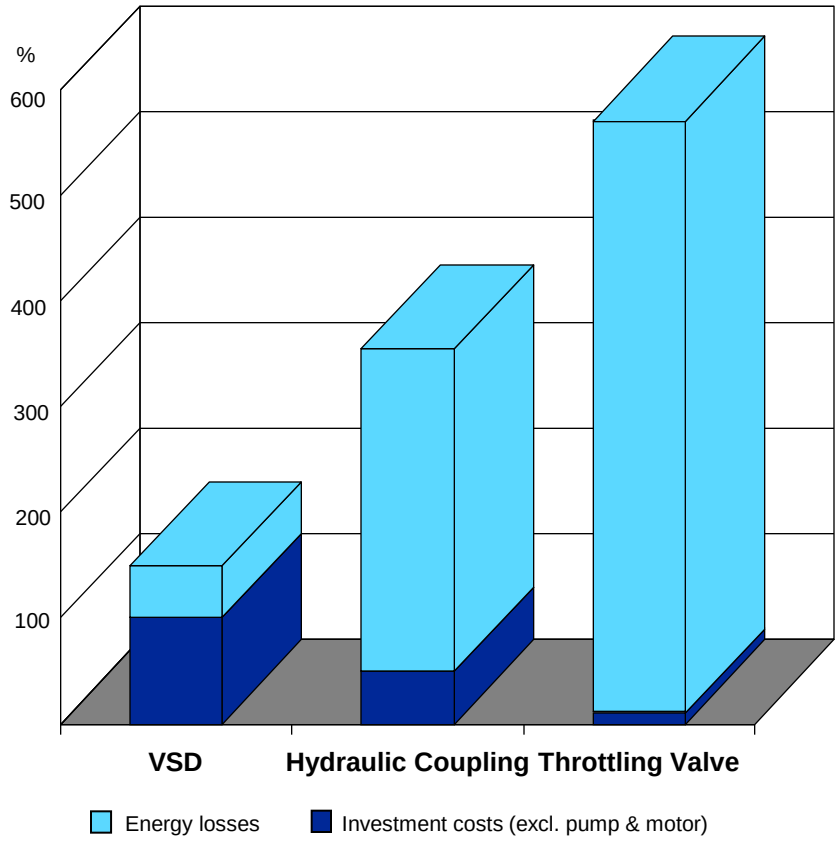
Mechanical vs. electrical control

Control methods of processes driven by pumps or fans:

- Electrically with variable speed drives
- Mechanically with inlet guide vanes, throttling valves or hydraulic couplings

	Electrical	**Mechanical**
Variable speed	Variable speed drive	Hydraulic coupling
Fixed speed	On-off	Throttling valve or inlet guide vane

Mechanical vs. electrical control

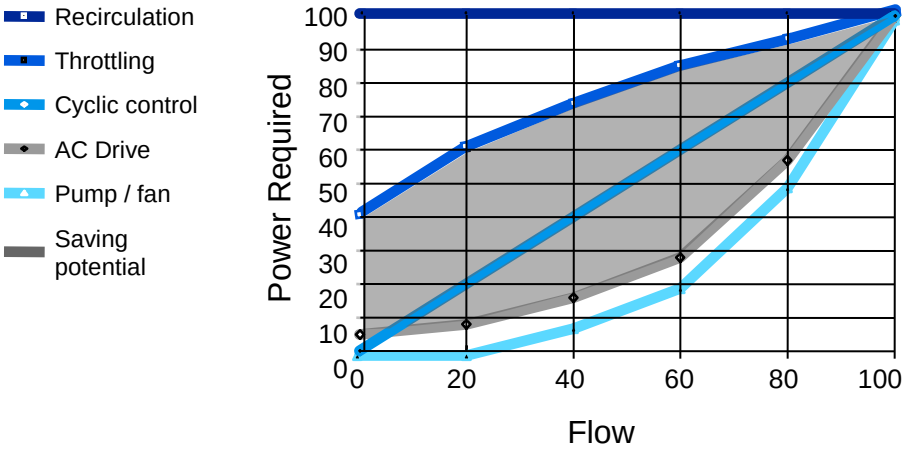


Comparison of investment costs and energy losses of different control methods.
*calculated for a 1300 kW (1740 hp) pump application, for three years operation

- Mechanical fixed-speed solutions
  - Practically impossible to achieve the optimal process efficiency over whole speed range
- Mechanical variable-speed solutions
  - Losses in hydraulic coupling reduce overall system efficiency
  - An increase in production capacity usually requires a costly reconstruction of the whole process
- Electric variable speed drives
  - Change in production volume achieved by changing the motor speed
  - Fans and pumps will be operated at Best Efficiency Point (BEP), resulting in:
    - Energy savings
    - Decrease of CO_2 emissions
    - Minimized operating costs

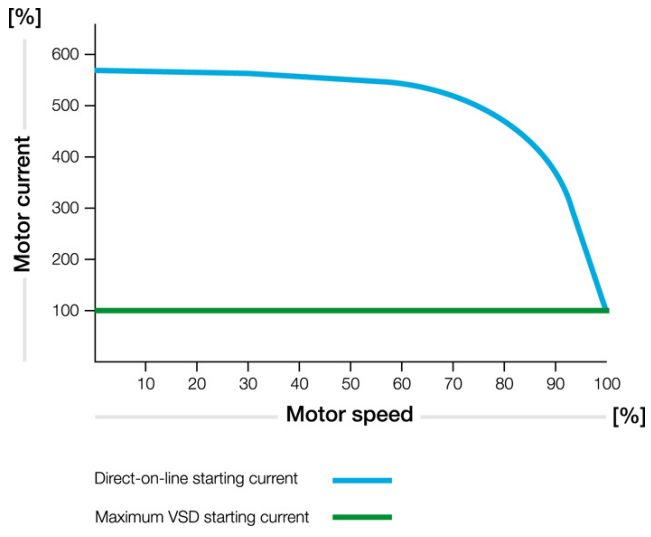
Energy savings and reduced emissions

Power consumption for various control methods



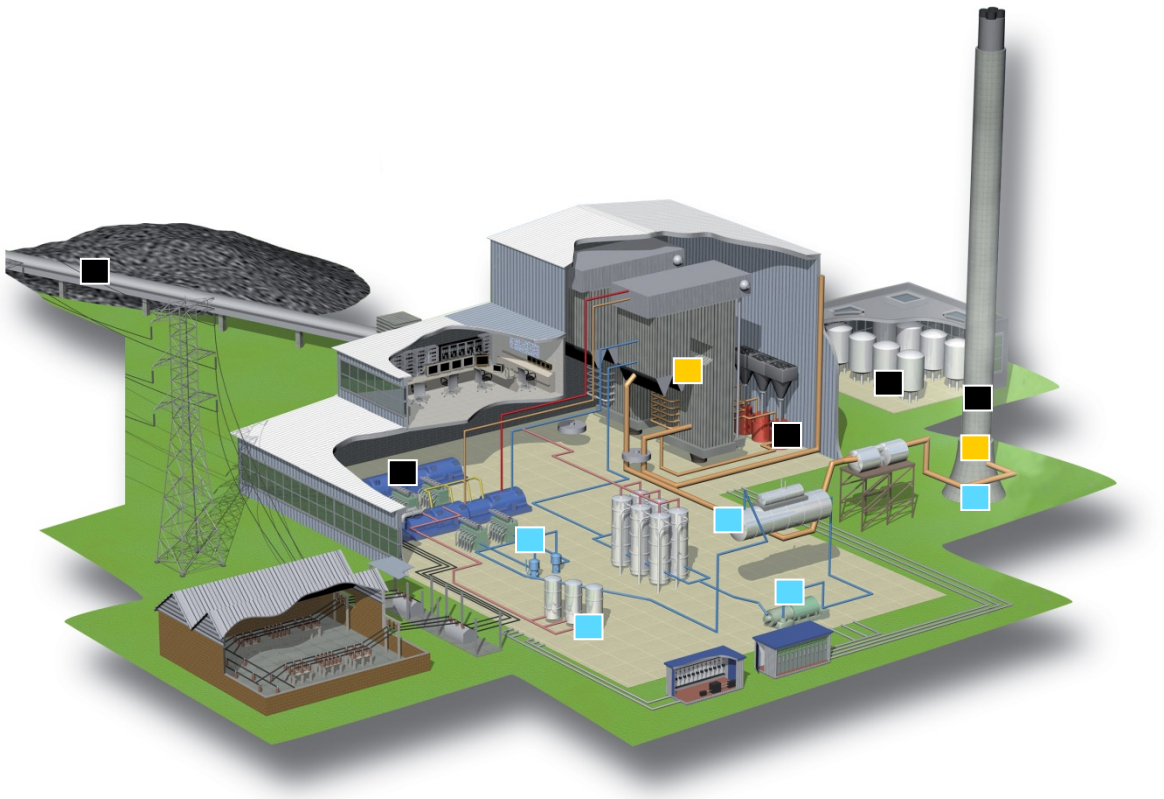
- Pumps and fans typically run at partial loads
- Huge energy savings can be achieved by controlling their speed with variable speed drives
- A pump or fan running at half speed consumes as little as one eighth of the energy compared to one running at full speed
- Energy consumption can be reduced by as much as 60% with variable speed drives
- Variable speed drives help to reduce CO_2 and NO_x emissions

Soft starting



- A direct-on-line started electric motor can cause starting currents of up to six times the nominal current
  - Voltage drops can disturb processes, especially in weak networks
- Benefits of soft-starting electric motors with variable speed drives:
  - No process disturbance due to voltage drops; no trips of other electrical devices connected to same bus
  - No excessive thermal or mechanical stress on the motor; longer lifetime of the motor
  - Immediate start-up without warming-up delay (e.g. steam turbines)
  - Controlled and smooth start-up

Variable speed drives for power generation applications



Pumps

- Boiler feed-water pump
- Condensate extraction pump
- Cooling water pump
- District heating circulation pump
- Limestone slurry feed and absorbent circulation pump

Fans

- Primary air fan
- Secondary air fan
- ID fan
- ID booster fan

Other

- Conveyor
- Coal mill
- Oxidation air compressor
- Gas turbine starter
- Fuel gas booster compressor

Components of variable speed drives

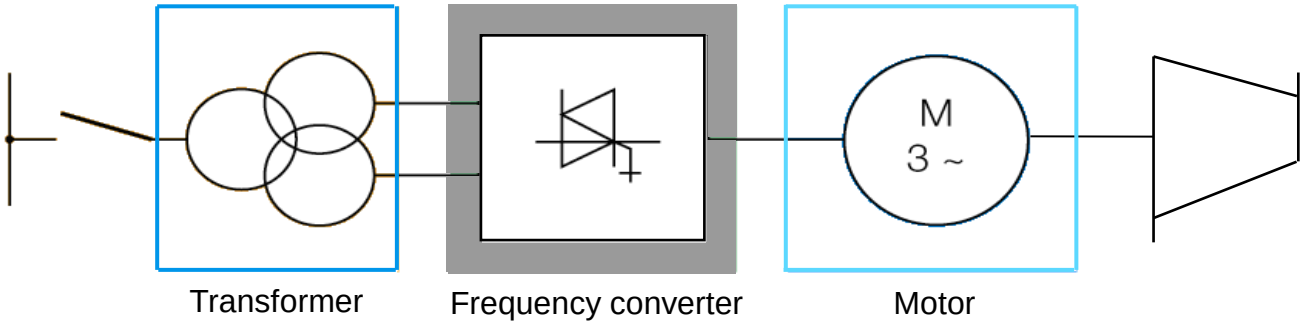


ABB can offer the complete variable speed drive system or assist in selecting components that match the process requirements.

A variable speed drive system consists of:

- Input transformer
- Frequency converter
- Electric motor

Medium voltage variable speed drives

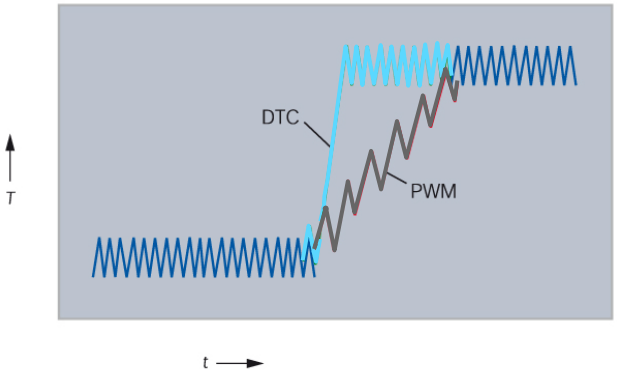
- Power range: 250 kW – more than 100 MW
- Voltage range: 2.1 kV – 10 kV
- Products available for operation with external transformer, integrated transformer or for direct-to-line connection (transformerless)

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, configuration 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)



Direct Torque Control

- 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?

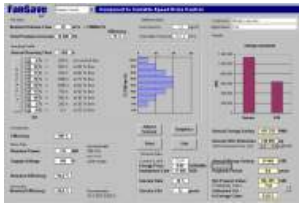
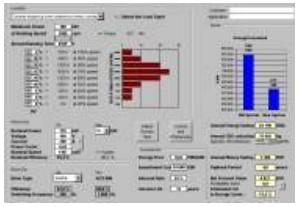
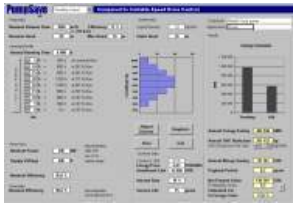
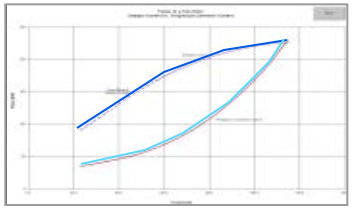





ABB has developed the following tools to assist in the calculation of energy savings:

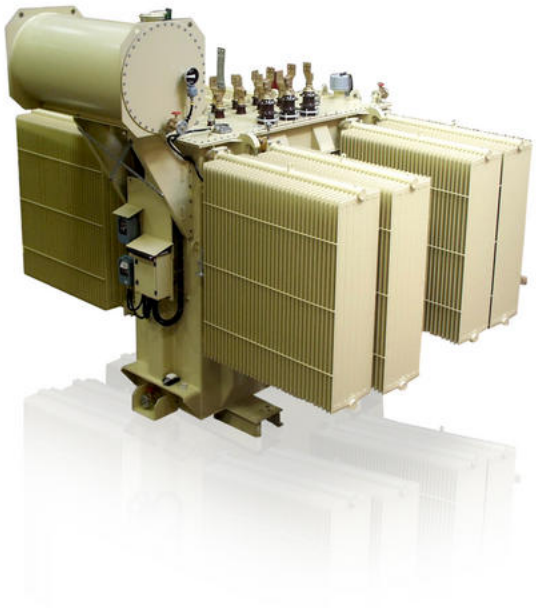
- FanSave – for comparison of energy consumption between different fan control methods
- PumpSave – for comparison of energy consumption between different pump control methods

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 isolation 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

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

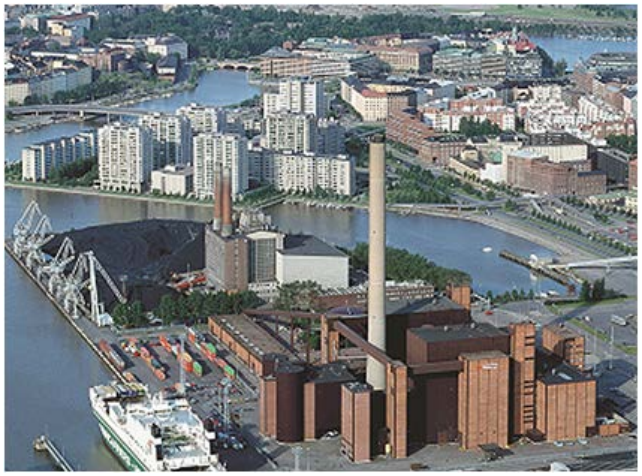
Worldwide service and support

- Worldwide service network
- 24 x 365 support line
- Local support
- Supervision of installation and commissioning
- System upgrades for optimized operation & migration
- Life cycle management
- Remote diagnostics
- Customized maintenance contracts
- Spare parts and logistics network
- Training

Case example
University of Illinois power plant, USA

- An US university power plant installed a 1,000 hp AC drive from ABB for its scrubber booster fan.
- Energy efficiency improved by 25% against that of inlet vanes.
- **Energy saving: about 1,460,000 kWh/year**
- **Reduction of CO_2 emissions: 730,000 kg/year**
- **Other benefits:**
  - Better process controllability
  - Less maintenance by soft starting
  - No more start-up problems

Case example
Helsinki Energy, Finland



- Helsinki Energy replaced fixed-speed motors, which were driving four boiler feed-water pumps of each 4,500 kW, with ACS 1000 variable speed drive systems.
- As boiler feed-water pumps are one of the biggest energy consumers in power plants, energy efficiency improved considerably.

Benefits:

- **Improved power plant efficiency**
- **Reduced maintenance costs**

Case example
Mälarenergi, Sweden

- A Swedish electric power and district heating provider replaced the resistors and slip-ring motors, which controlled the district heating pumps, with four ABB variable speed drive systems, each rated at 1,765 kW.
- By reducing the losses caused by the flow control method, saleable electricity was increased by approximately 35 GWh/year.

Benefits:

- **Increased electricity production by more than 5%**
- **Better stability in the district heating network**
- **Reduced maintenance costs**

Case example
GKM, Germany

- A German coal-fired power plant replaced the hydraulic couplings, which were regulating two boiler feed-water pumps of 5.8 MW each with ABB AC drives

Benefits:

- **Estimated energy saving: about 12,000 MWh/year**
- **Reduction of CO_2 emissions: about 10,000 tons/year**
- **Improved efficiency of pump drive system**

Case example
Valorsul, Portugal

Three ACS 2000 direct-to-line variable speed drives, rated at 700 kW, control the ID fans at Valorsul's WtE plant.

- Six ABB variable speed drives replaced damper control on induced draft fans and secondary air fans at Valorsul's waste-to-energy plant in Portugal.
- Benefits
  - Annual energy savings of about € 240,000
  - Reduction of CO_2 emissions by about 4.5 tons per day
- The ID fans are controlled by ACS 2000 direct-to-line drives
- The three ACS 2000 drives are connected to one transformer via a common AC bus

Case example
A2A, Italy

Canavese district heating plant, Italy

- Two ACS 5000 variable speed drives, rated at 3 MW, soft start two 6 MW heat pump motors at two district heating plants in Milan
- Benefits
  - Simplified plant start-up
  - Negligible impact on the network
  - Longer lifetime of equipment

Case example
TORRESOL Energy, Spain

Valle 1 and Valle 2 solar thermal power plants in San José, Cadiz, Spain

(© SENER / TORRESOL ENERGY)

Four, 1520 kW ACS 1000i medium voltage variable speed drives are being used to control the speed of feed water pumps which is helping to improve energy efficiency at two concentrated solar power (CSP) plants in Spain.

Benefits

- Better plant efficiency
- Easy installation
- Saving valuable space
- Longer lifetime of equipment
- Increased network stability

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