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MV Drives in Power Generation

MV Drives in Power Plants - Contents

Power Generation “Hot Topics”

- Global Warming and Choice of primary energy sources
  - Rising cost of fossil fuels
  - CO_2 emissions (trading, capturing, storage?)
  - Future of ‘alternative’ energy sources and the side Effects
- Market liberalization (increased competition)
  - Freedom to choose electricity supplier
  - Consolidation
- Profitability
  - Varying demand
  - Cost of production, Demand to raise Efficiency

ABB

What is / does a Drive ?

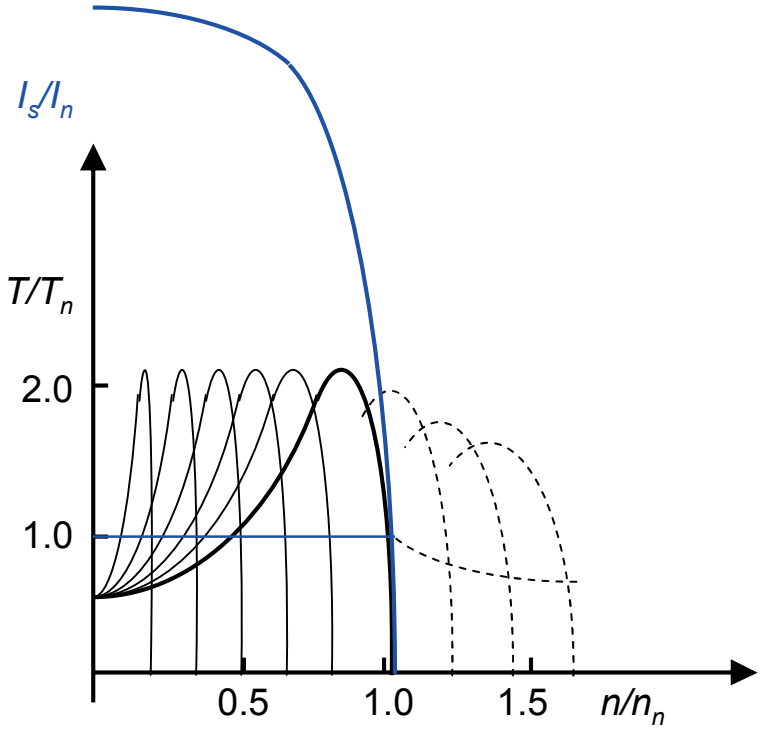

Fig. Starting currents and torque curves of an induction motor at fixed vs. variable frequency

Why Speed Control?

- Most processes require flow / pressure control according to the prevailing process conditions
- The most effective way to control process flow is to control the speed of the machine

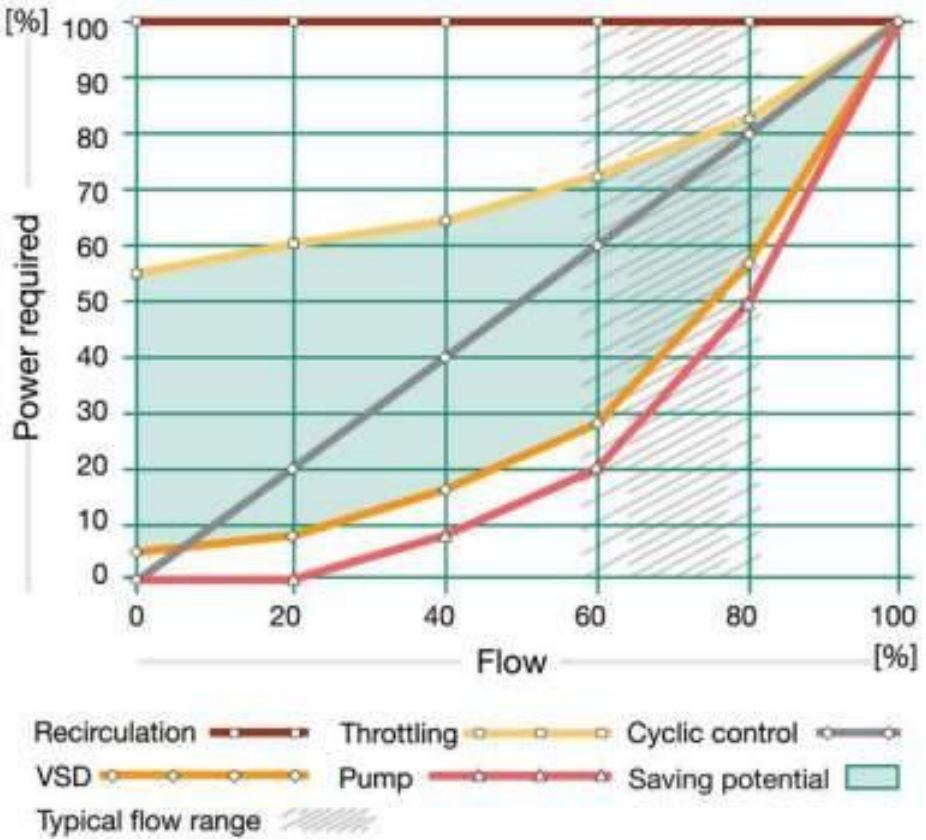

Fig: Typical power requirements for various pump control methods, including VFD system

Motivation

- Industry uses 50% of all electricity,
  65% of which is used in electric motors.
  - Conventional motors always run at their maximum capacity.

- Even up to 70% of that energy can be saved by varying the motor speed acc to the actual need for energy.

- Today only about 5% of the world's motors are fitted with energy-saving drives.

ABB

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- ✓ Facts
- → Fields of Activities
- Your Benefits
- Offerings
- Experience
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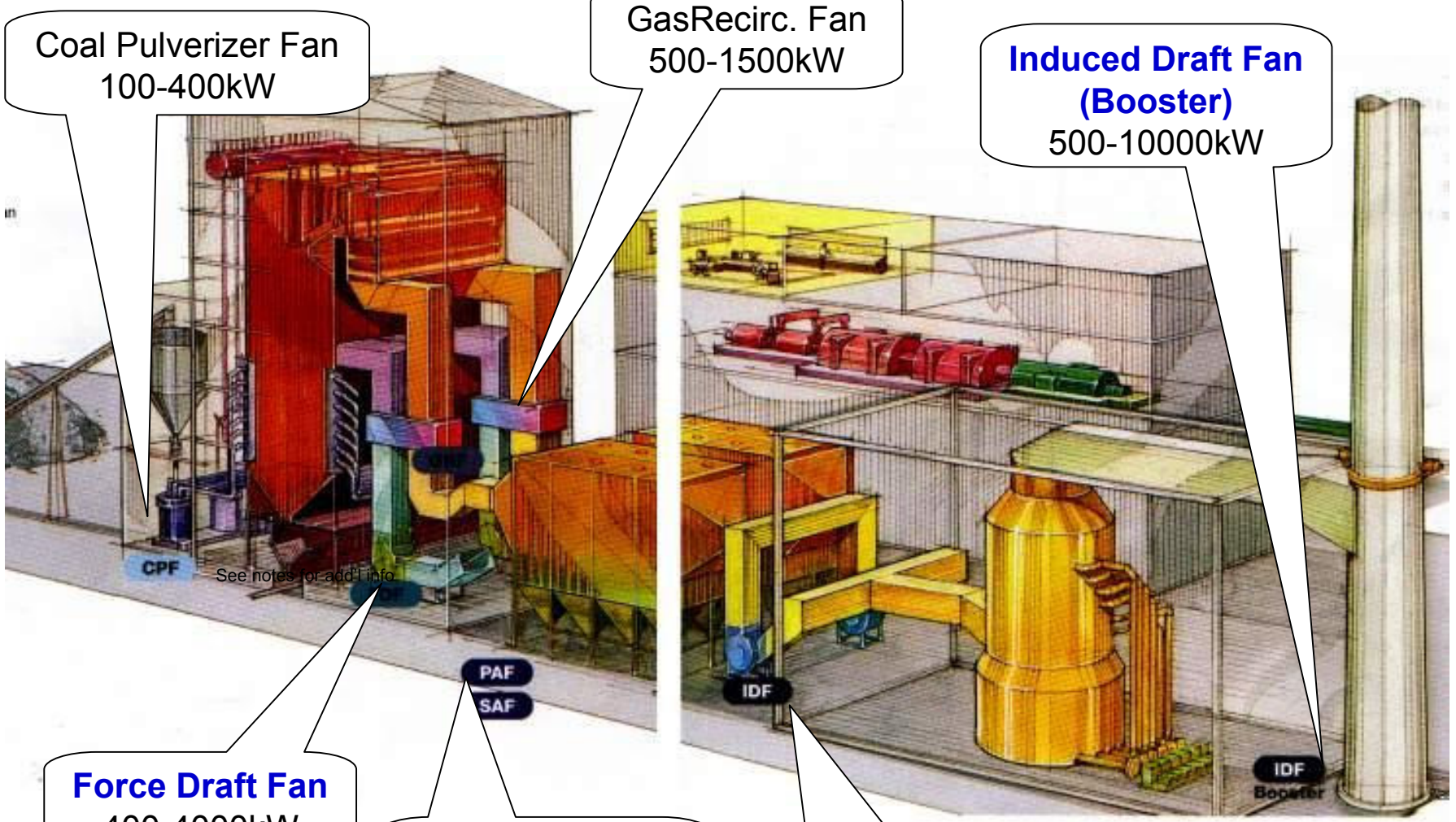
PG segments with main MVD applications

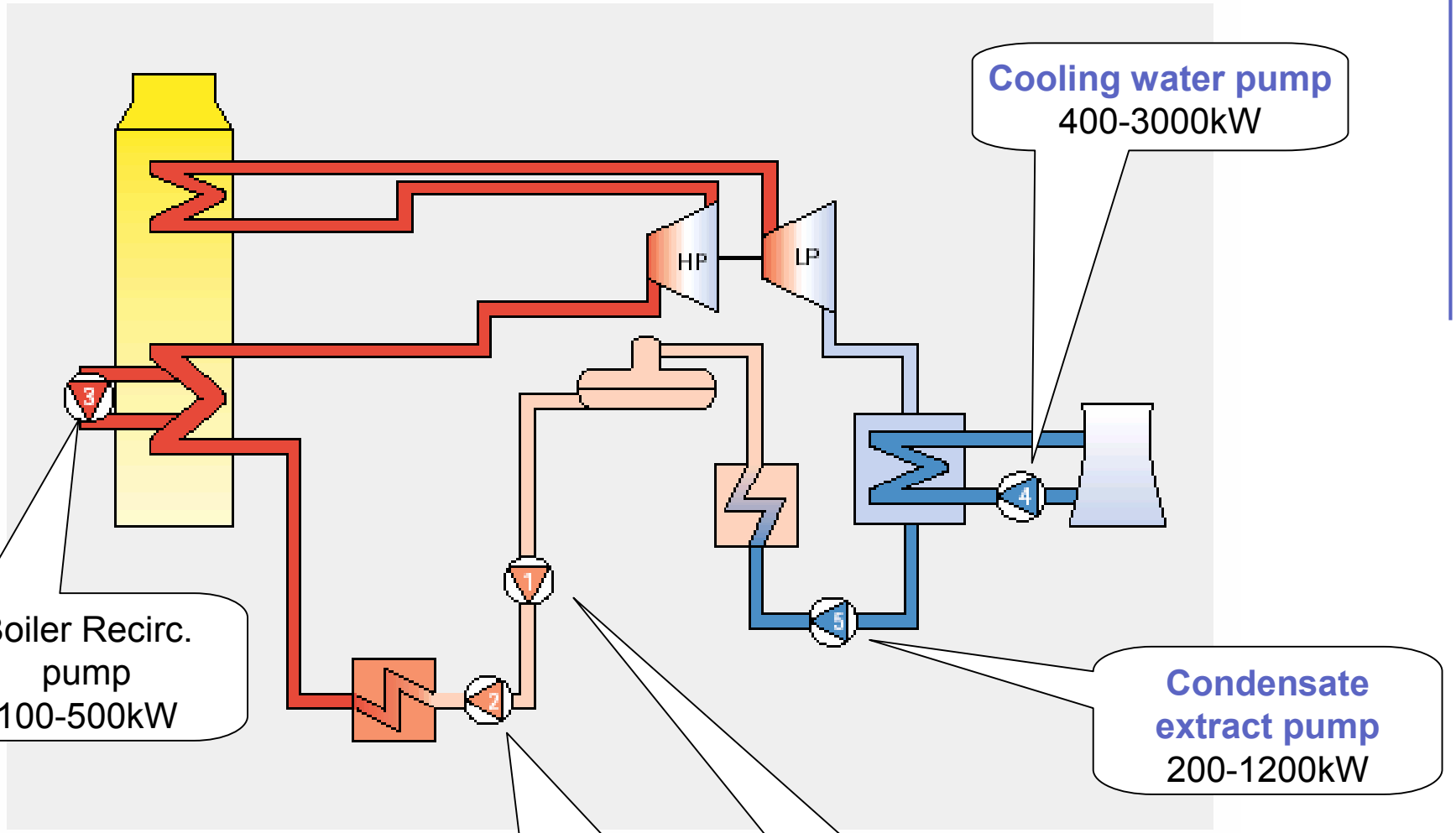
Segments \ Applications		Soft Starters for	Auxiliary Drives for
THERMAL (Solid-fuelled)		Coal mills (VSI)	Feed-water pump, FD-, ID fans, Coal conveyors Cooling water pump
THERMAL GAS Turbine		Gas Turbine (LCI.ST)	Feed-water pump of HRSG, Fuel Gas Compressor Cooling water pump
HYDRO, Pump-Storage		Hydro Turbines of Pumped Storage Power Plants (LCI.SO)	-

Aux. Fan Applications; “Coal-fired” power stn.



See speaker notes for add’l info

Aux. Pump Applications; “Coal-fired” power stn.



Cooling water pump
400-3000kW

Boiler Recirc.
pump
100-500kW

Condensate extract pump
200-1200kW

Boiler Feed Pump
2000-15000kW

Feed-water
Booster pump

See speaker notes for add’l info

Some Typical Auxiliary power demands (kW)

Reference Power Plant [MWe]	175 (HRSG)	300 sub	600 sup	600/700 sub
Boiler feed pump	2x2800	2x4200	1x1700*	2x10700
Boiler circulation pumps		3x175	2x1000	2x326
Main condensate pumps	2x250	2x400	2x750	2x950
Cooling water pumps	2x400	2x900	2x2028	2x2060
Closed cooling water pumps			2x250	2x315
Secondary cooling water pumps				2x200
Pulverizers	4x207	4x340	6x510	6x670
Forced draught fans	2x242	2x418	2x816	2x1017
Induced draught fans	2x1459	2x2515	2x2924	2x3645
Primary air fans	2x490	2x845	2x1322	2x1648
Electrostatic precipitators	1x230	2x200	4x200	4x200
Conveyors	1x275 1x230	2x275	1x275 1x250 1x230	1x275 1x250 1x230
Stacker	1x300	1x300	1x300	1x300
Reclaimer				1x250

Always controlled Process

Source: Variable Speed at Lower Cost – Final Report, DECRC 29.07.98

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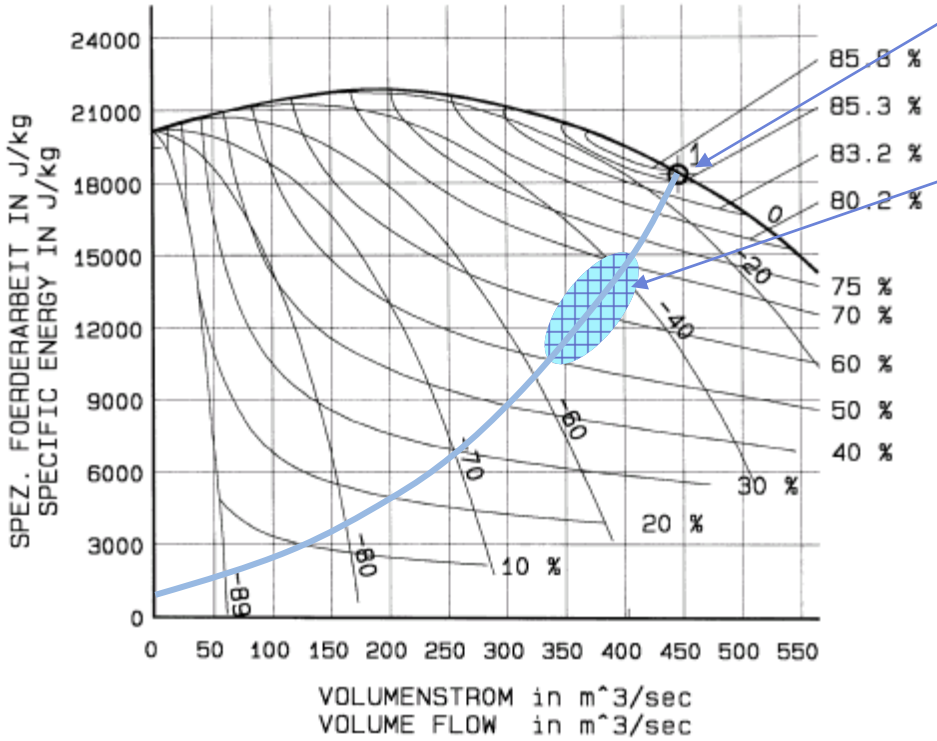
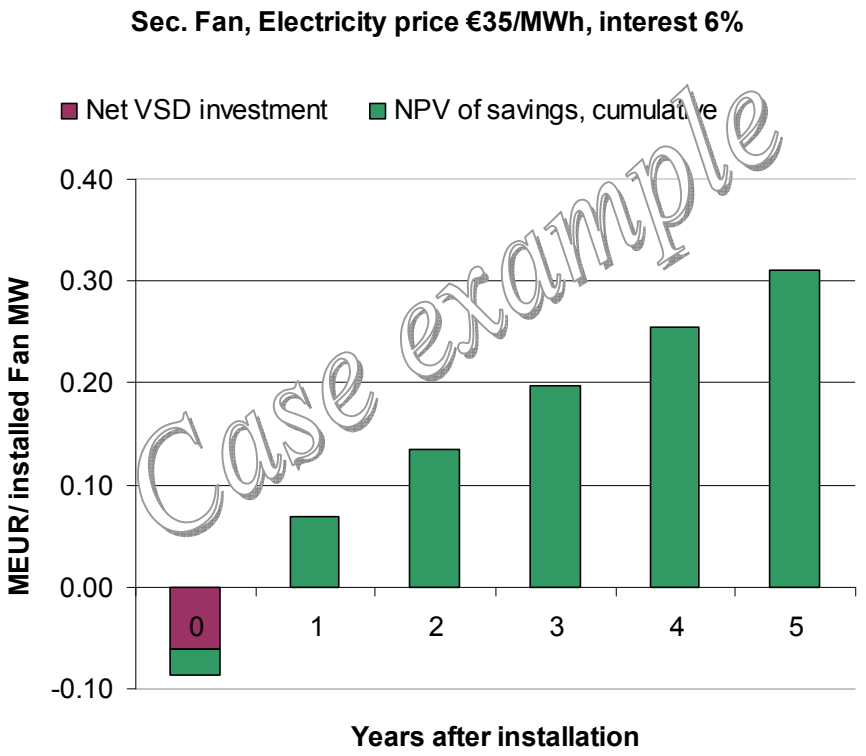
Terminology; Radial Fan TB & MCR



- TB (Test Block condition)
  - With contingency factors
- MCR
(Maximum Continuous Rating)
  - Normal full load (100%) operation of the Flue Gas system
- "*The power demand for the TB rating is significantly larger than for the MCR with the MCR rating being between 60 and 75 percent of the TB rating.*"
[IEEE Std 958-2003]

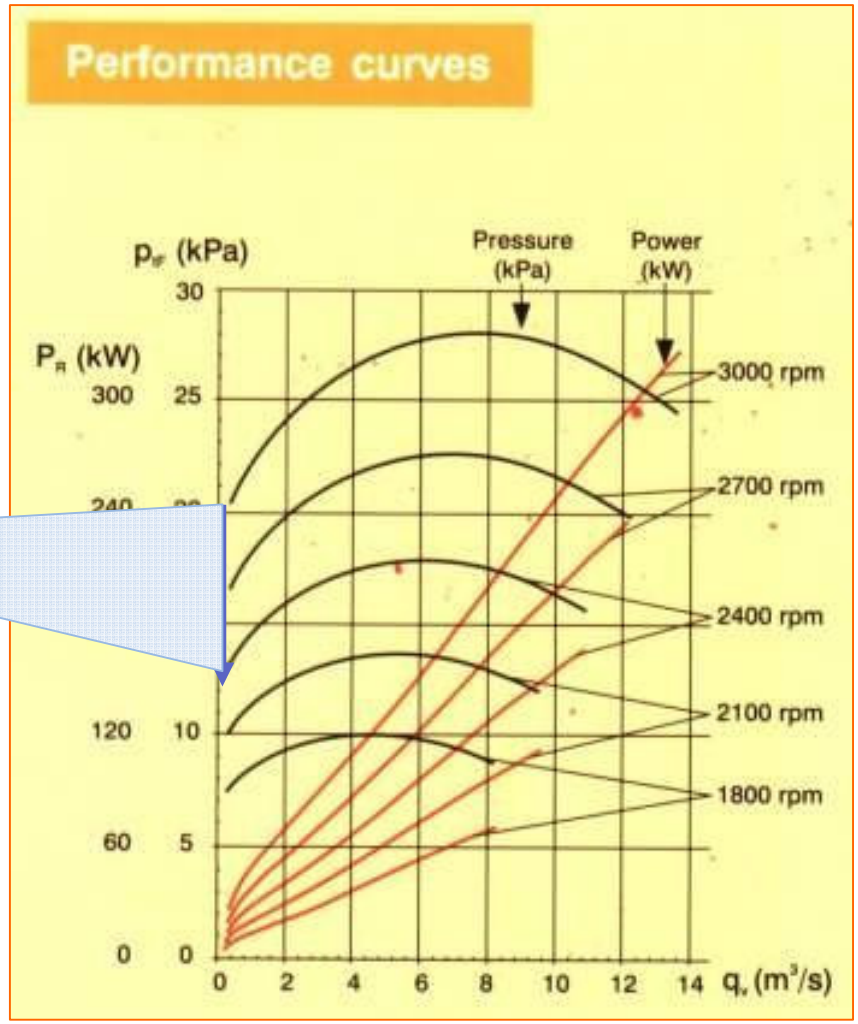
Specific VFD benefits for Boiler Fans

- Best efficiency with all flow situations at close to unity p.f.
  - ID fan load always varies – even at “Baseload” stations
    - Due to e.g. ambient temperature, fuel quality, dampness, etc.
  - Utilization of operation points and adaptation to design margins
    - TB vs. MCR
- Techno-Economically optimized dimensioning of components
  - Motor, Transformer and Drive acc to Temp Rise Time Coefficient (not necessarily acc to starting capability /SCC of supply net)
    - VSD inherently Soft-starts, i.e. reduces mechanical & electrical stress

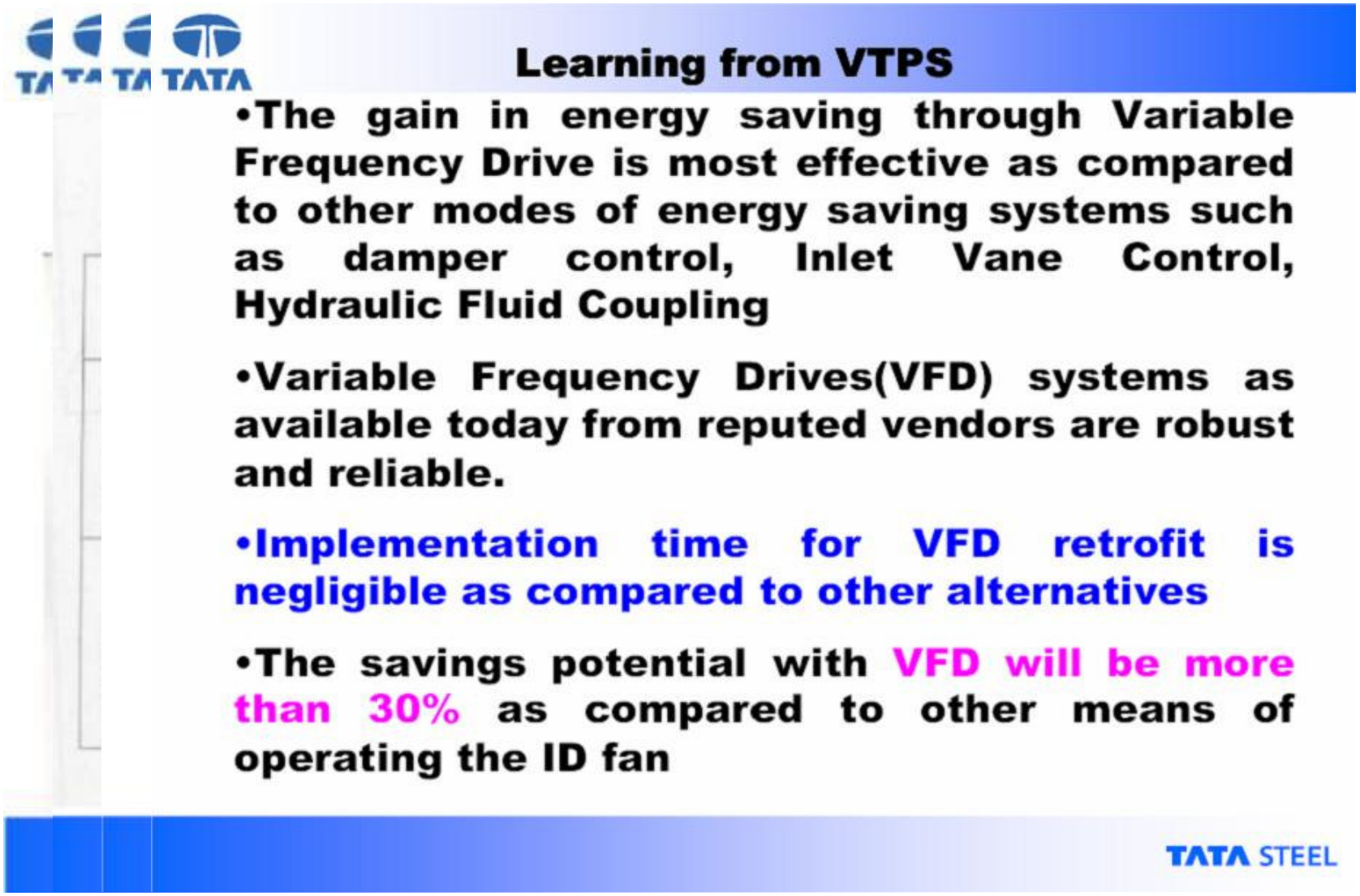


Specific VFD benefits for Boiler Fans II

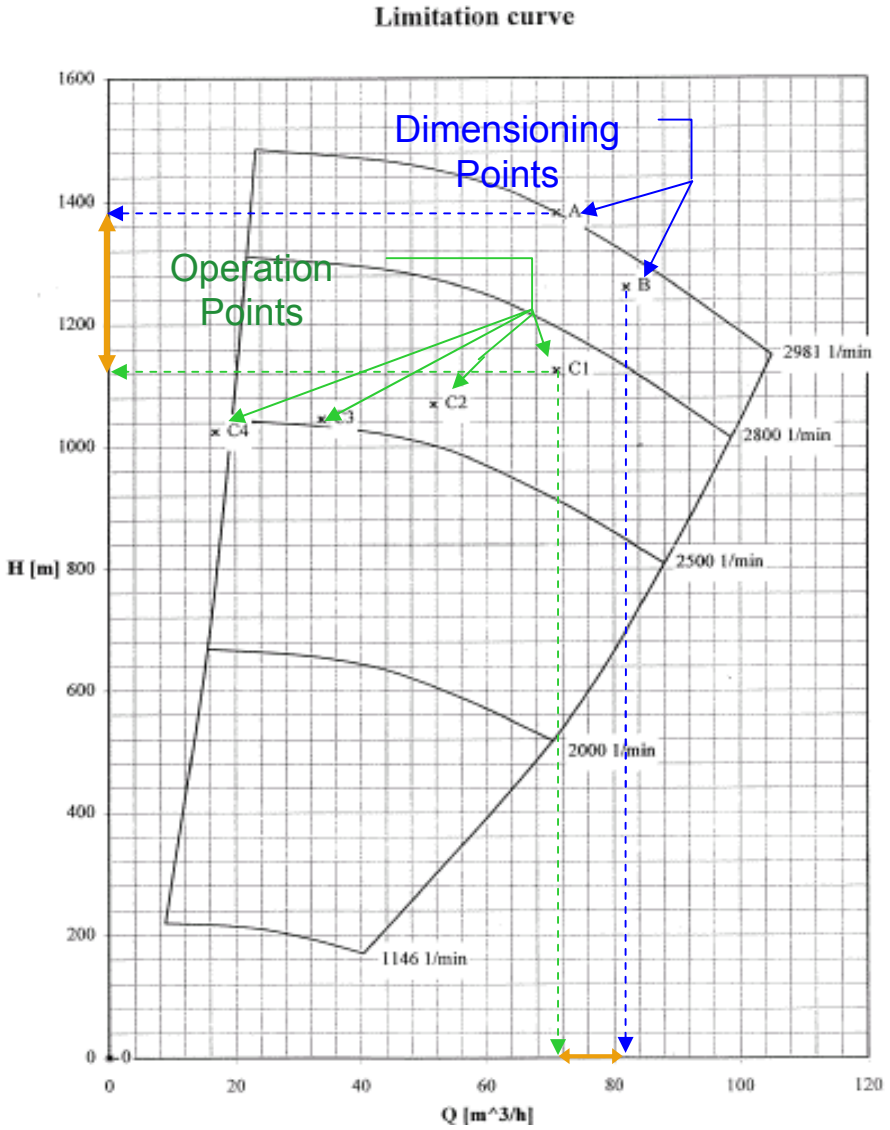
- Easy controllability and wide control range, even beyond 50 Hz
- Reduced Noise
- Reduced risk of boiler implosion due to controlled (lower) fan curve



Customer statement



Application : Boiler Feed Pump



- Pressures : 100-250 bar
- Flow : 20-400 m^3/h
- Mechanical speeds up to 3000 - 5000 rpm
- Normal speed controlling area 80-95%
- For a VFD package dimensioning the "Maximum", "Normal", and "Minimum" operation points need to be known (P, n)

Case: Boiler feed pump - Vaskiluoto

- Fluid coupling compared to ABB frequency converter drive
  - Measured losses in a Boiler Feed Pump application;

Boiler fuel power		100 %	75 %	50 %
dH	m	2506	1913	1252
Flow	kg/s	190	142	94
Power of pump	kW	5445	3096	1378
Efficiency of Pump	%	85,8	86,1	83,8
"Voith" losses	kW	442	953	1033
Motor losses	kW	?	?	?
TOTAL LOSSES	kW	442	953	1033

DH	m	2506	1913	1252
Flow	kg/s	190	142	94
Power of pump	kW	5445	3096	1378
Efficiency of Pump	%	85,8	86,1	83,3
Frequency converter loss	kW	58	50	48
Motor losses	kW	174	111	85
Transformer losses	kW	47	29	16
TOTAL LOSSES	kW	279	190	149

Case: Boiler feed pump - Vaskiluoto

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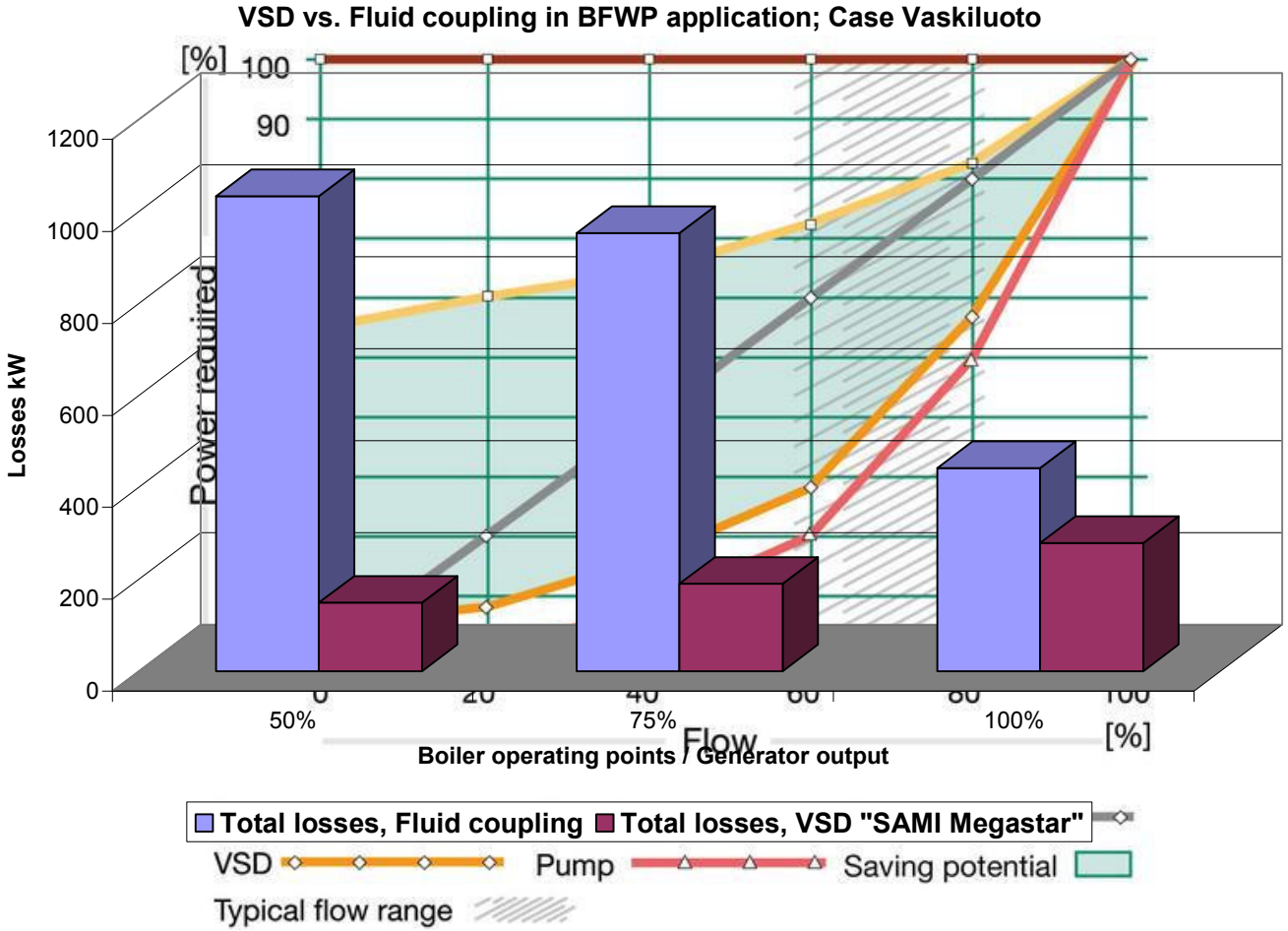

The Smartest Investment?

- ELECTRIC variable speed drives (EVSD) are more EFFICIENT than mechanical solutions
- Improved PROCESS CONTROL
- Reduced MAINTENANCE (e.g. throttle valve) and longer equipment lifetime
- Soft Start = reduced impact on supply net
- Noise reduction
- Energy Saving => More Production and Increased Revenue
- Electric Variable Speed Drive – the Smartest Investment

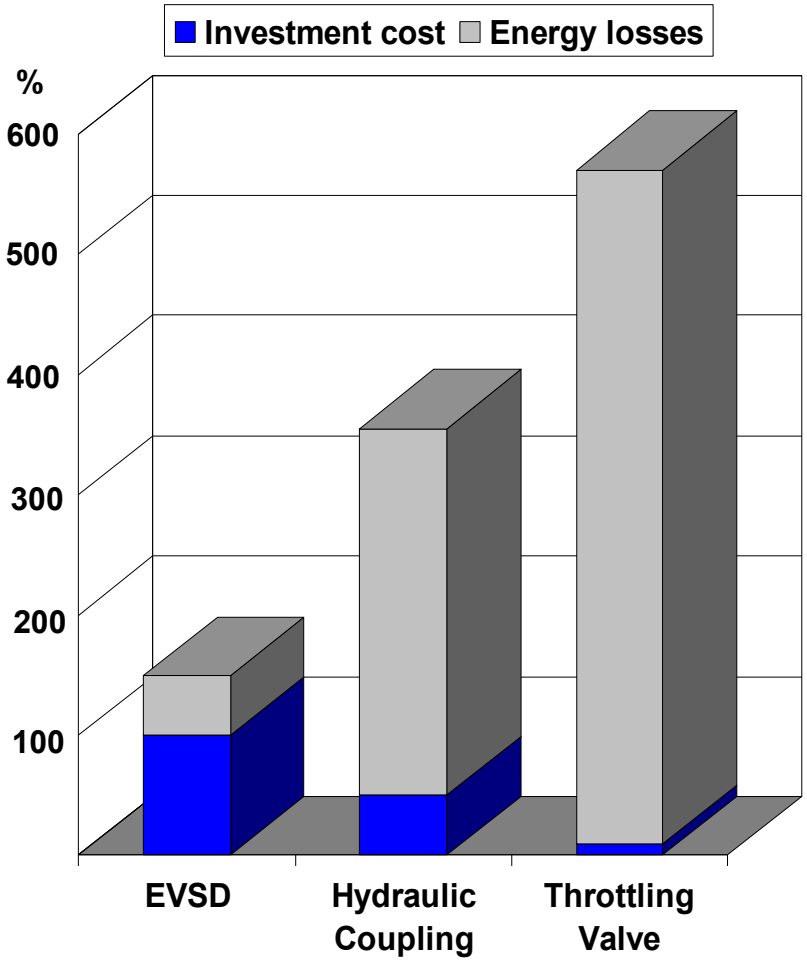

Diagram: Impact of investment costs and energy losses of different solutions for a 1300 kW pump application, calculated for three years operation

(Based on 8760 h/y operation, an average flow demand of 80%, 0.05 USD/kWh, 6% interest rate)

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Medium Voltage AC Drives

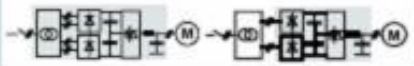
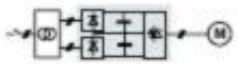
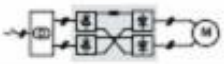
Product	ACS 1000	ACS 5000	ACS 6000	MEGADRIVE-LCI
Type of converter	VSI-NPC Voltage Source Inverter Neutral-Point Clamped	VSI-MF Voltage Source Inverter Multilevel-Fuseless	VSI-NPC Voltage Source Inverter Neutral-Point Clamped	LCI Load Commutated Inverter
Typical applications	Pumps, fans, conveyors, extruders, mixers, compressors, grinding mills, suitable for retrofit of existing motors	Compressors, extruders, pumps, fans, grinding mills, conveyors, marine propulsion, bar and rod mills, blast furnance blowers, gas turbine starters	Pumps, fans, conveyors, extruders, compressors, grinding mills, marine propulsion, rolling mills, mine hoists	Compressors, pumps, fans, blast furnace blowers, pump storage plants
Typical photo	 ACS 1000i ACS 1000	 ACS 5000	 ACS 6000	 MEGADRIVE-LCI
Typical system diagram				
Converter cooling	Air (A) / Water (W)	Air (A) / Water (W)	Water (W)	Air (A) / Water (W)
Power range	A: 315 kW – 2 MW W: 1.8 – 5 MW	A: 2 – 7 MW W: 5 – 24 MW	W: 3 – 27 MW	A: 2 – 31 MW W: 7 – 72 MW / higher on request
Input section	Diodes: 12/24-pulse rectifier	Diodes: 36-pulse rectifier	Diodes: 12/24-pulse rectifier (LSU) or IGCT: Active rectifier (ARU)	Thyristors: 6/12/24-pulse rectifier
Output section	IGCTs: 3-level VSI, sinusoidal output	IGCTs: 5-level VSI-MF, 9-level output waveform	IGCTs: 3-level VSI, 5-level output waveform	Thyristors: 6/12-pulse inverter
Output voltage	2.3/3.3/4.0/4.16 kV Optional: 6.0/6.6 kV with step-up transformer	6.0 – 6.9 kV Optional: 4.16 kV	3.0 – 3.3 kV Optional: 2.3 kV	2.1 – 10 kV
Maximum output frequency	66 Hz (optional 82.5 Hz)	75 Hz (higher optional)	75 Hz (Twin: 250 Hz)	60 Hz (optional 120 Hz)
Field weakening	> 45 Hz (max. 1:1.5)	> 30 Hz (lower optional)	> 6.25 Hz (max. 1:5)	Customized
Speed-torque quadrants			 LSU ARU	
Special features & benefits	* Sinusoidal output * Constant network power factor over whole speed range * DTC (Direct Torque Control) * Fuseless	* Constant network power factor over whole speed range * DTC (Direct Torque Control) * Fuseless	* Constant network power factor over whole speed range * Optimized pulse pattern to minimize network harmonics (with IGCT) * DTC (Direct Torque Control) * Multi-motor drives with common DC bus * Fuseless	* Soft start of large synchronous motors and generators * Fuseless
Examples of options	* Braking chopper * Synchronous bypass * Integrated input transformer	* Braking chopper * Application I/O supervision, interlockings * Integrated input transformer	* Reactive power compensation (ARU) * Braking chopper * Customized	Customized
Type of motor	Induction motor	Induction, synchronous or permanent magnet motor	Induction, synchronous and/or permanent magnet motor	Synchronous motor

ABB Switzerland Ltd, MV Drives
Email: mvdrives@ch.abb.com

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Case: Booster Fan - Abbott power plant, UIUC

Customer's need

- To reduce the operational costs and to improve the overall efficiency
- fixed speed scrubber booster fan, 1000 hp, regulated by inlet vanes

ABB's response

- Fast installation of MV AC drive, type ACS1000, meant minimal disruption and cost

Customer's benefits

- No more start-up problems
- Total process controllability
- Energy savings USD 63,000 p.a.
- Maintenance reduced by USD 10,000 p.a.
- Payback 24 months

Challenge: Old Fluid-coupling

- Feed-water pump in a power station – initial situation 2001:
  - 3 x 1,6 MW 10 kV pump motors
  - Control by Vorecon fluid-coupling
  - Poor pumping efficiency, specially at partial loads
  - Poor response time

KAINUUN VOIMA OY

Solution: Fluid-coupling Replaced with EVSD

- Investment in 2003
  - 1 new pump 2,6 MW
  - AMA 500L2L -motor
  - ACS1000 –MV Drive for speed control
- Results
  - Energy saving 1020 MWh
  - Remarkably reduced maintenance
  - Satisfactory fast response

KAINUUN VOIMA OY

Case: New Feed-water pump drives

Customer's need

- Completely new power plant producing electricity, process and district heat

ABB's response

- Complete plant electrification including MV Drives type ACS1000; 3.3 kV for Feed-Water Pumps (2x100%), with 2-pole motors;
  2271 kW, 3371 rpm
  2601 kW, 3422 rpm (20 min)

Customer's benefits

- About 150 kW less consumption, < 4 yr pay-back
- World class electrification solution on "single-source, one contract" - delivery, with "start-on-time" responsibility

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MV Drives – for more efficient Power Generation

- Conclusion
  - Specifying VFD Technology is an investment with short-pay-back
  - We can help you to find out how much
    YOU could generate more saleable energy ?

- ABB delivers MV Drives to Power generation
  - Feed-water -, Cooling water -, Circ water – etc. pumps
  - F.D & I.D (booster) fans, Fuel gas booster compressors
  - Coal mills & conveyors,…
  - Starters for Gas Turbine, Pump storage, Synchr. Condenser, …
  - Wind, Wave, Bio-Energy, Geothermal applications, …

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