Case studies of air cooled vacuum steam condensers performance improvements

2013 ACCUG Meeting

October 14-17, 2013

CASE 1 - ACC CLEANING SYSTEM & FAN OPTIMISATION

Situation ACC until 2010

- **Cleaning of ACC until 2010 was max. 2 times/year**
- **Simply cleaning in a fixed period without looking at loss of performance**

Reduction in production of steam due to poor condensation

Temperature up to 25°C	Percentage reduction in steam compared to maximum design temperature at 25°C	Reduction of steam compared to maximum steam flow at 25°C	Reduction in waste incinerated with steam flow at 25°C
25 to 28°C	Up to 6.23%	Up to 2.65 kg/s	Up to 3.24 t/h
29 to 32°C	Up to 14.54%	Up to 6.18 kg/s	Up to 7.67 t/h
33 to 36°C	Up to 22.86%	Up to 9.70 kg/s	Up to 12.02 t/h

Revenue losses through loss in electricity production

Example of calculations for loss of revenue (minimum case)

30 days temperatures over 25 °C approx. 10 h/day

300 h x ca. 5t/h loss of waste throughput

=

1500 Tons less throughput

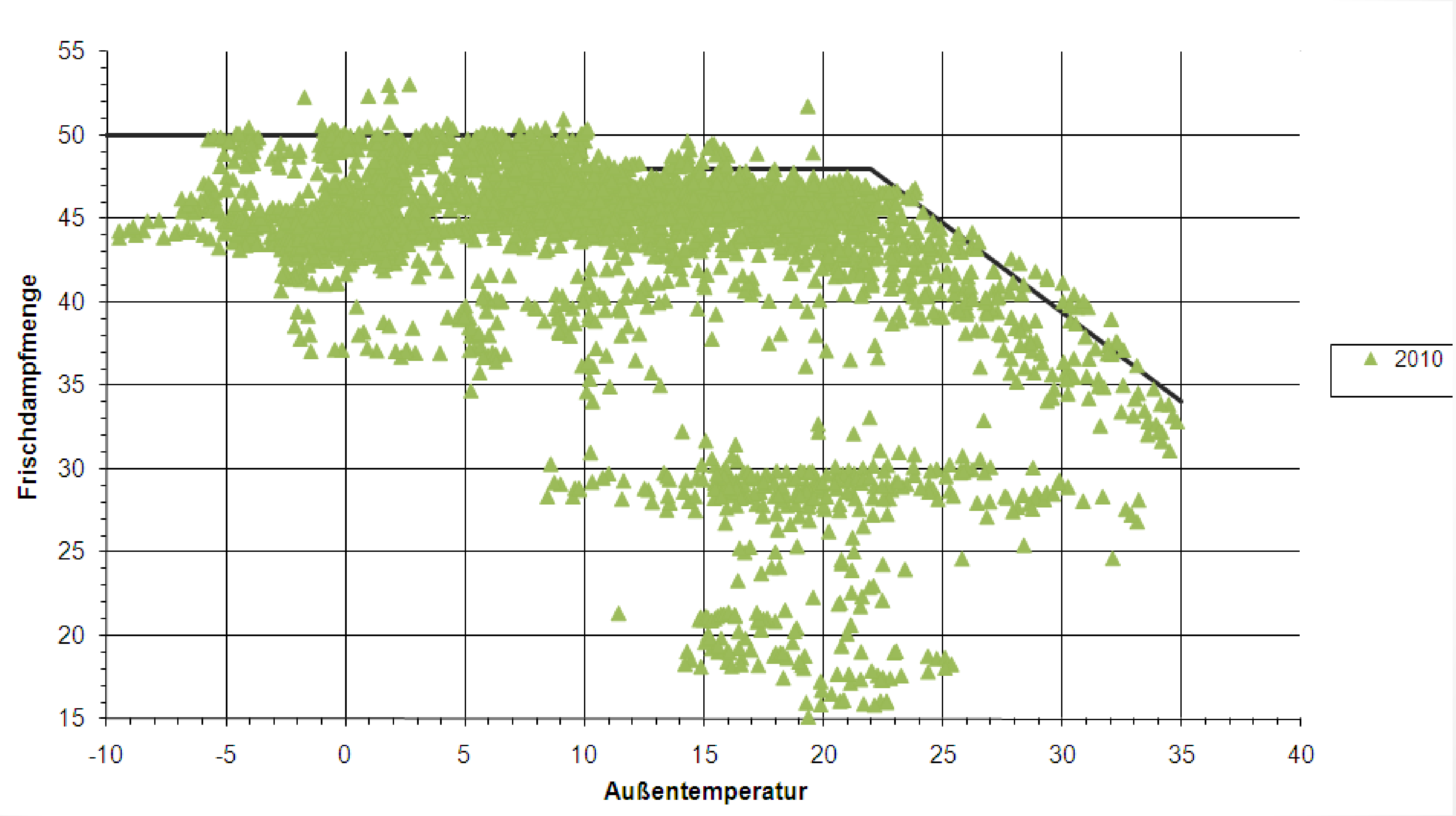
+

5kg/s steam = approx. 5MW * 300h

=

1500 MWh less electricity throughput per year

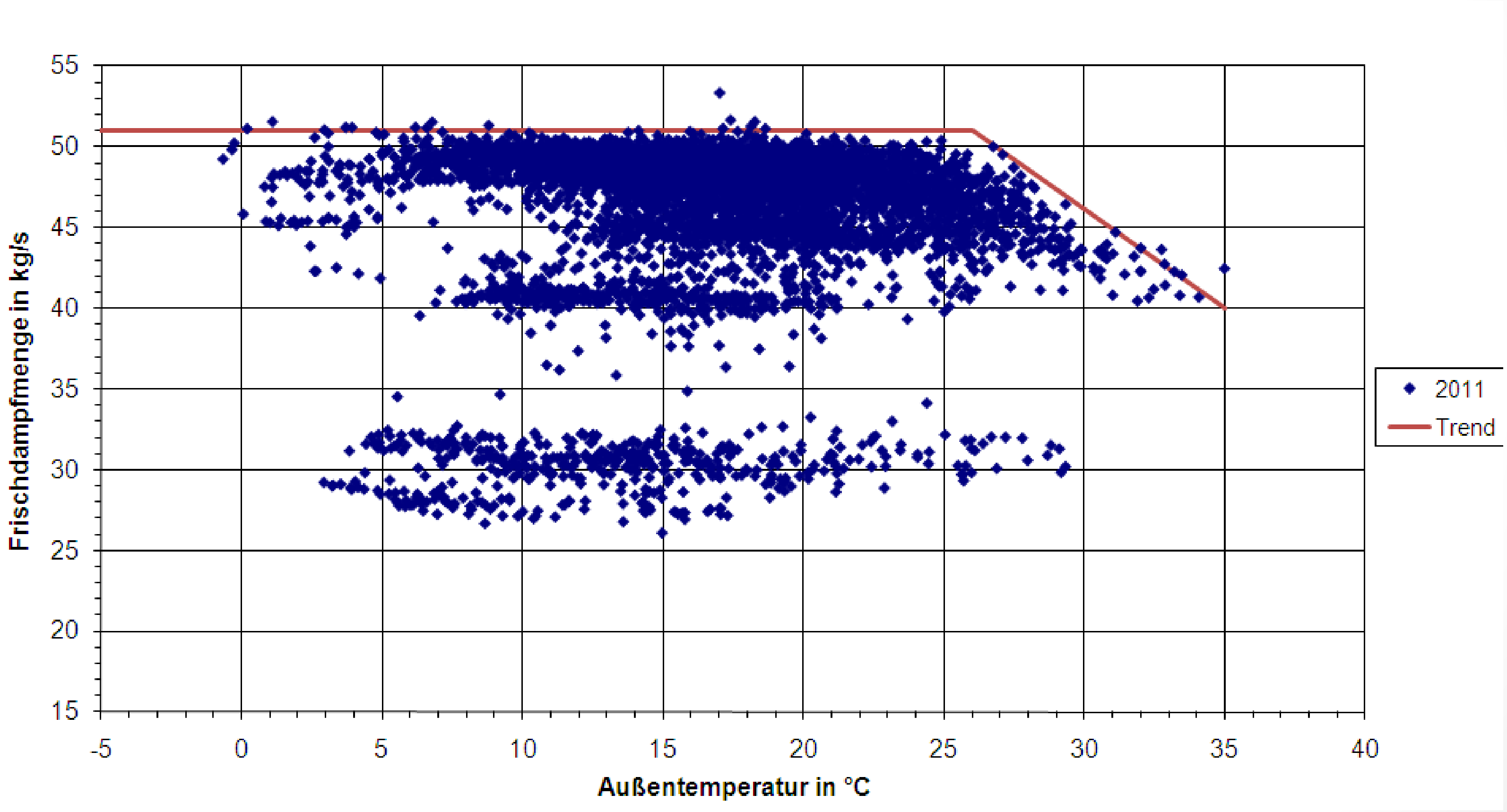
Evaluation 2010



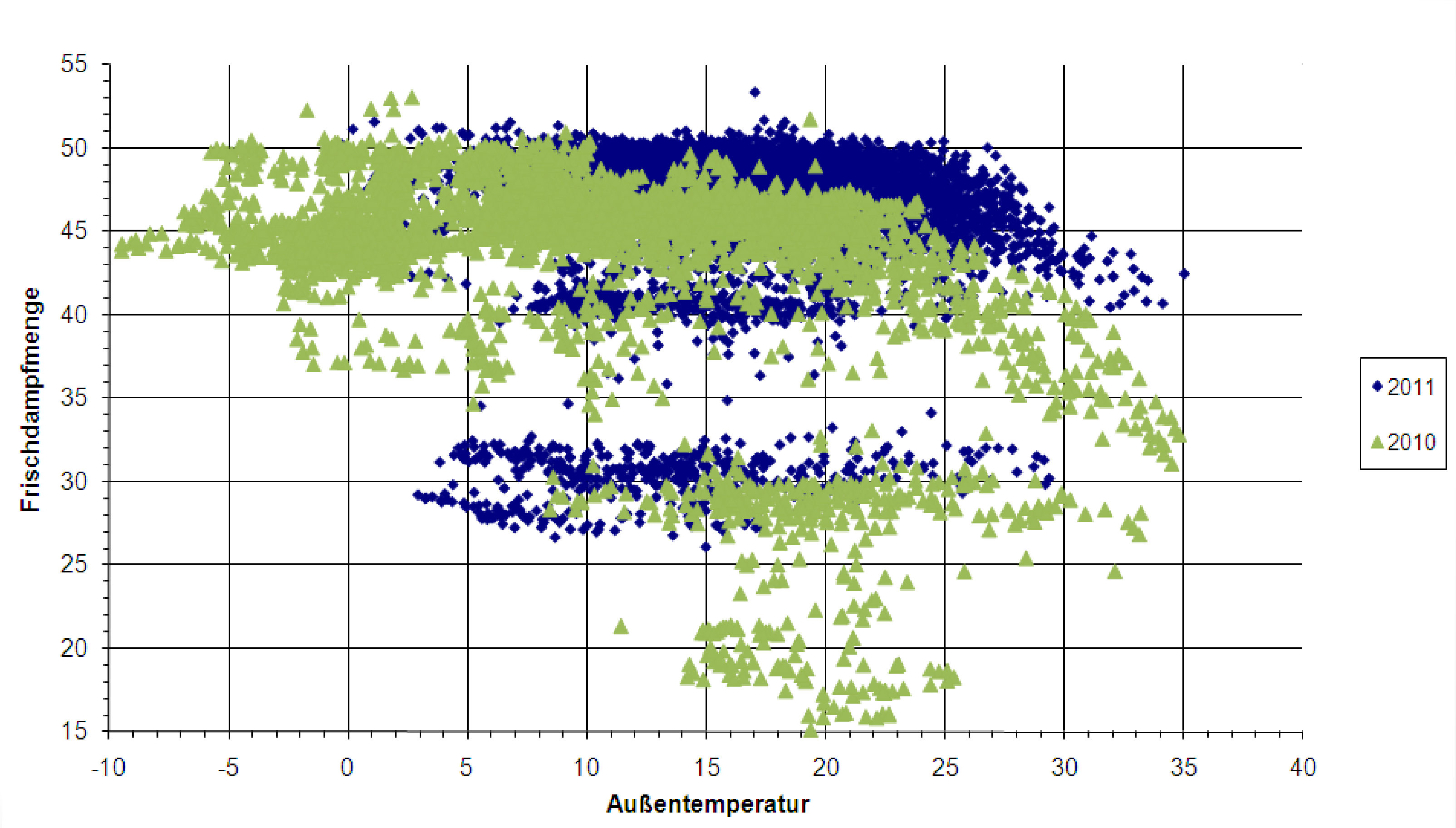
Situation in 2011

- **1. Cleaning after winter**
- **2. Cleaning after middle pollen phase**
- **3. Cleaning after end of pollen phase**
- **4. + 5. Cleaning in summer**
- **6. Cleaning in Automn**
- **7. Cleaning before winter**

Evaluation 2011



Comparison between 2010 & 2011



Challenges for 2012

Mission

- **Faster cleaning**
- **Improved efficiency of fan system → more condensation capacity**

Optimization Winter 2011-2012

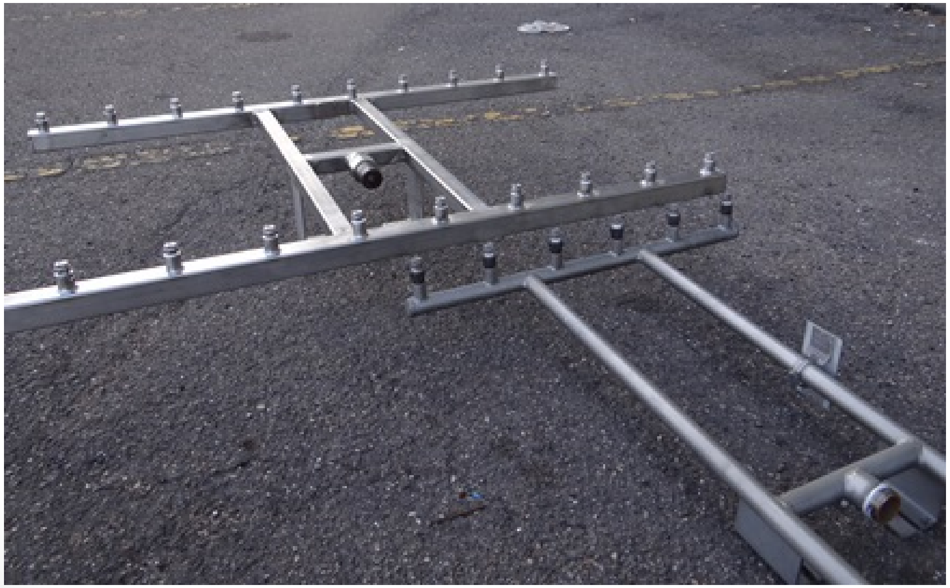
Original cleaning system

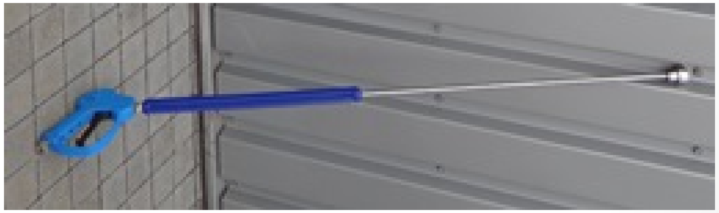
- **Flexible hoses with check valves**
- **HP unit working pressure = 110 bar**
- **Number of nozzles for cleaning head = 12**
- **Incorrect position of nozzles versus bundle and nozzle orientation**
- **No option to rinse plenum chamber (after cleaning) and bottom rows bundle**

Optimization Winter 2011-2012

Improved cleaning system

- **Removed check valves and installed ball valves**
- **New high capacity HP unit working pressure incl. Soft-start = 120 bar**
- **Number of nozzles for cleaning head = 24**
- **Correct position of nozzles versus bundle and nozzle orientation**
- **Tube union Tee for HP gun (rinsing off dirt inside plenum and lower rows of bundle)**





Optimization Winter 2011-2012

Optimization Winter 2011-2012

Improvement made by modification cleaning machine

- **Before it took 7 hours to clean 1 side (2 fans) and with new optimized system is took only 3 hours for 1 side**
  - **Only 1 passage for cleaning head now versus 2 passages before due to higher pressure and better positioning & orientation of the nozzles**
  - **Cleaning head approx. 2 times wider then original cleaning head**
- **Better cleaning result per cleaning**
- **4 cleaning sessions per year (versus 7 in 2011) due to improved cleaning results**

Optimization Winter 2011-2012

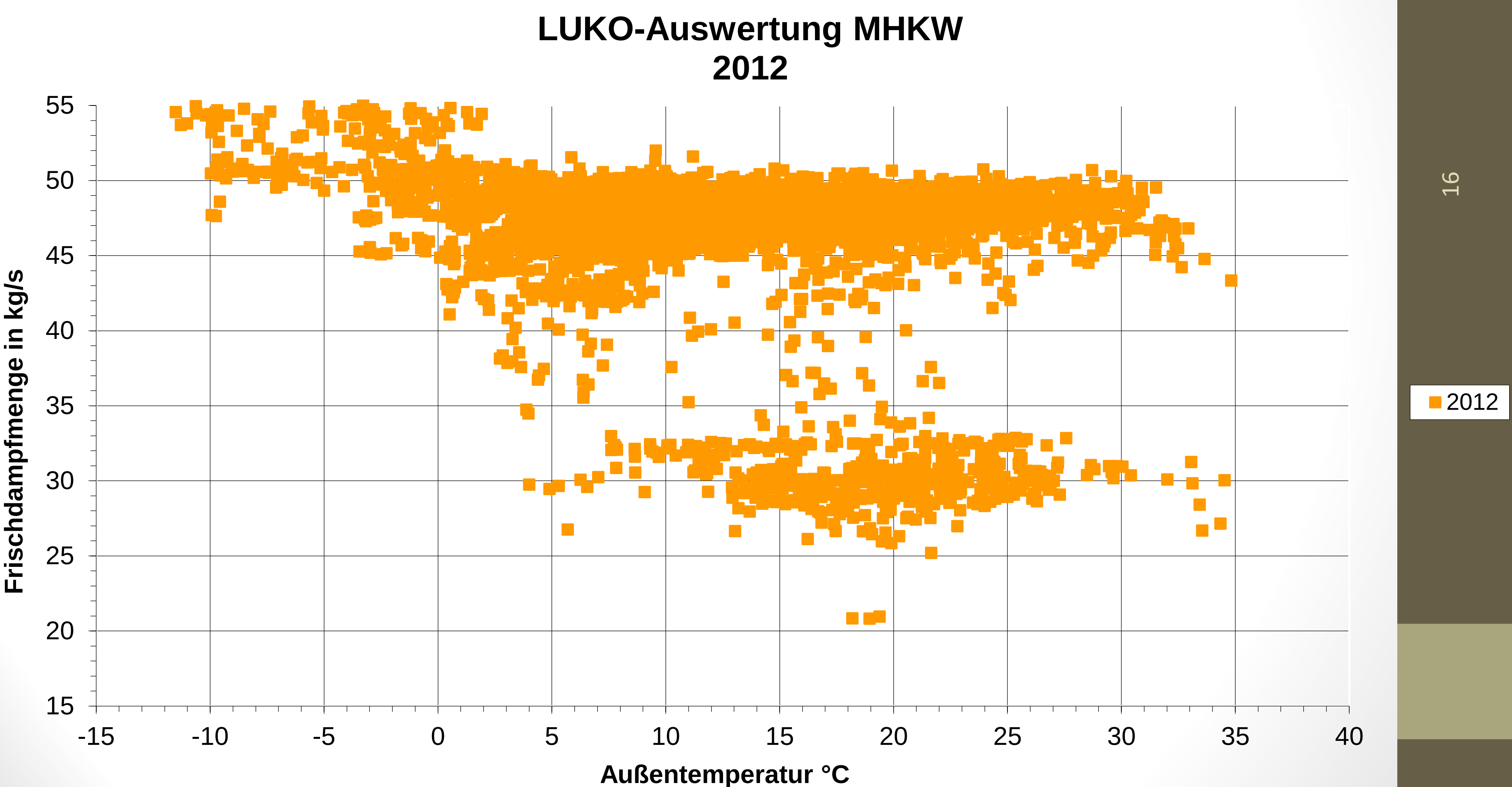
Original fan system

- **Margin over on motors**
- **Fairly low pressure capacity of existing fans → as soon as ΔP increases due to wind or external fouling, fans was starting to cavitate/stall**

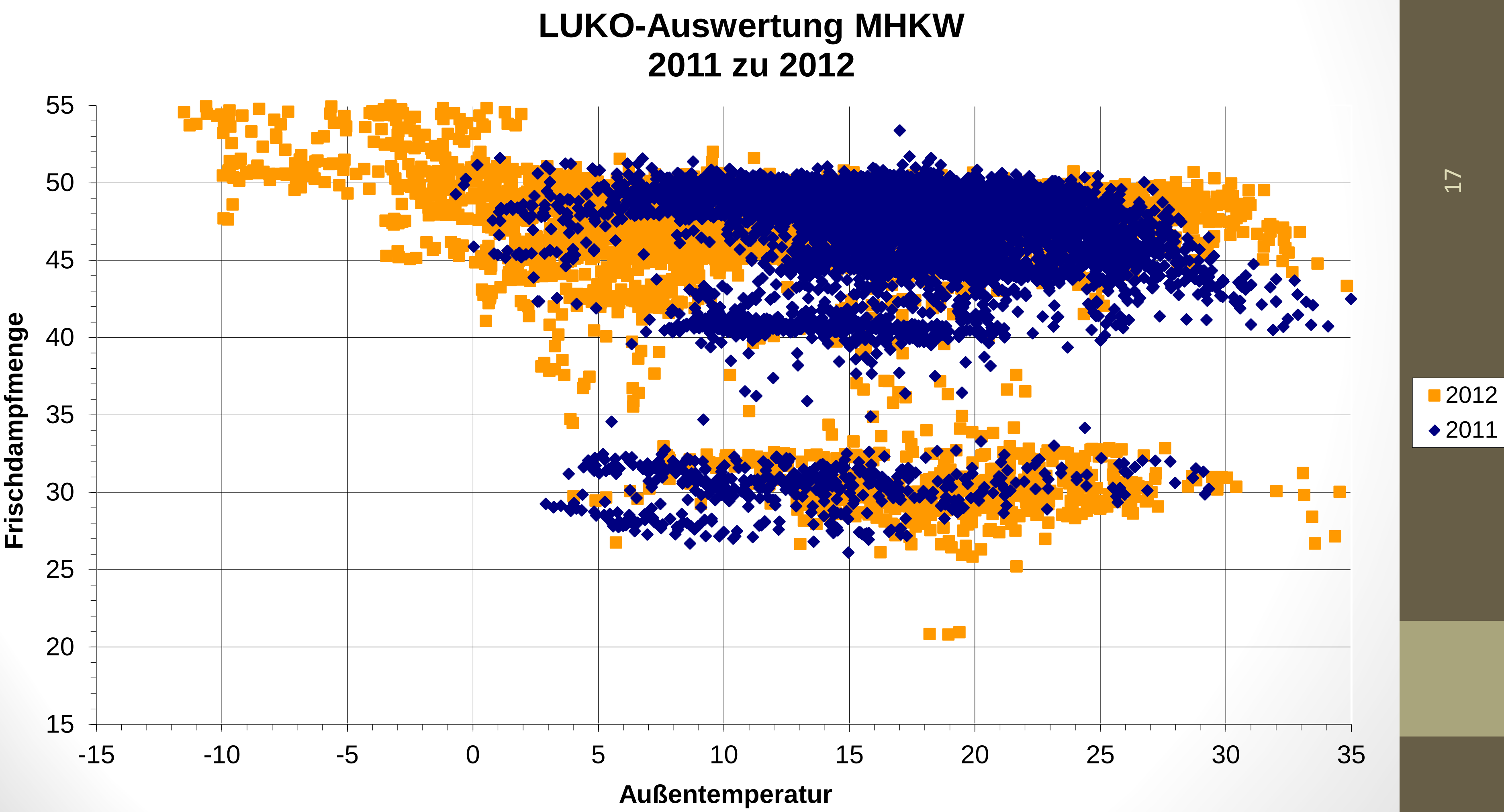
New Situation fan system

- **Increase by 15% in fan RPM by increasing frequency of VSD's from 50 Hz to 57.5 Hz.**
- **Decrease in pitch angle from 19.1^{o} to 14.0^{o}**
- **Improved airflow of minimum 8-10% versus original situation**
- **Improved pressure capacity of fan to cope with wind and especially external fouling**

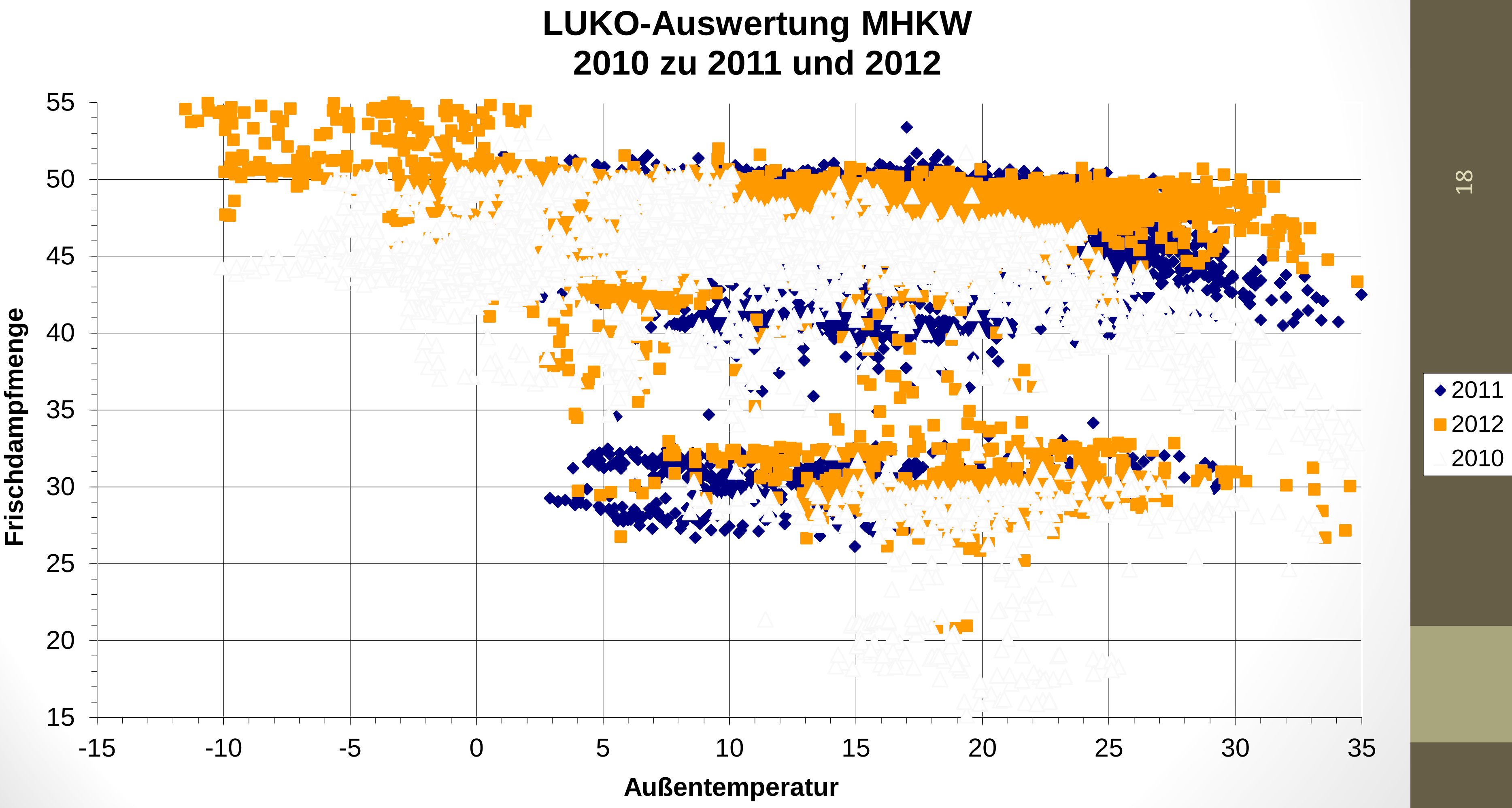
Evaluation 2012



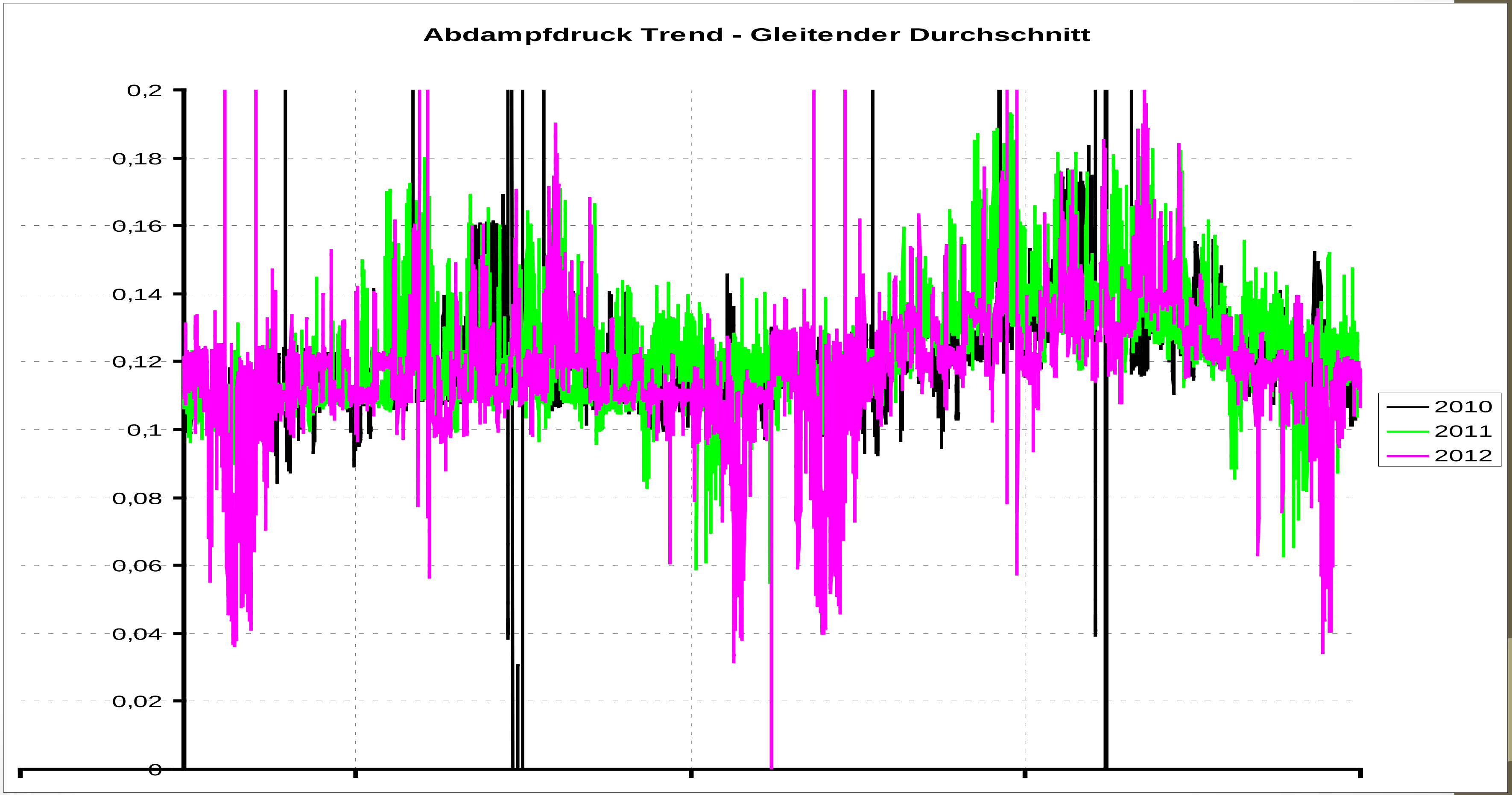
Comparison between 2011 & 2012



Evaluation 2010 / 2011 / 2012



Evaluation 2010 / 2011 / 2012 (Back pressure)



Consequence of improvement

CASE 2 – INSTALLATION OF VARIABLE SPEED DRIVES

Existing situation

- No variable speed drives
- No room for VSD in sub-station (MCC)
- Pitch angle : 19^o
- Fan tip speed : 30.9 m/s
- Motor power : 162 amps
- Temperature range : -20^oC $+ 30^oC$

Average measured data

Airflow: 534 m3/s Static pressure: 55 Pa Amperage : 136 Amps

Traditional Solutions

- New fan with more blades or wider blades AND / OR
- New higher rating motor AND / OR
- Increased heat transfer surface

ELFLOW BV solution

- Increased tip speed of fan by 20% (50 to 60 Hz)
- Decreased pitch angle from 19^{o} to 16^{o}
- Fully loaded motor to 158 Amps

ELFLOW BV SOLUTION ADVANTAGES

New IP20 VSD with IP66 casing inside each cell instead of in sub station

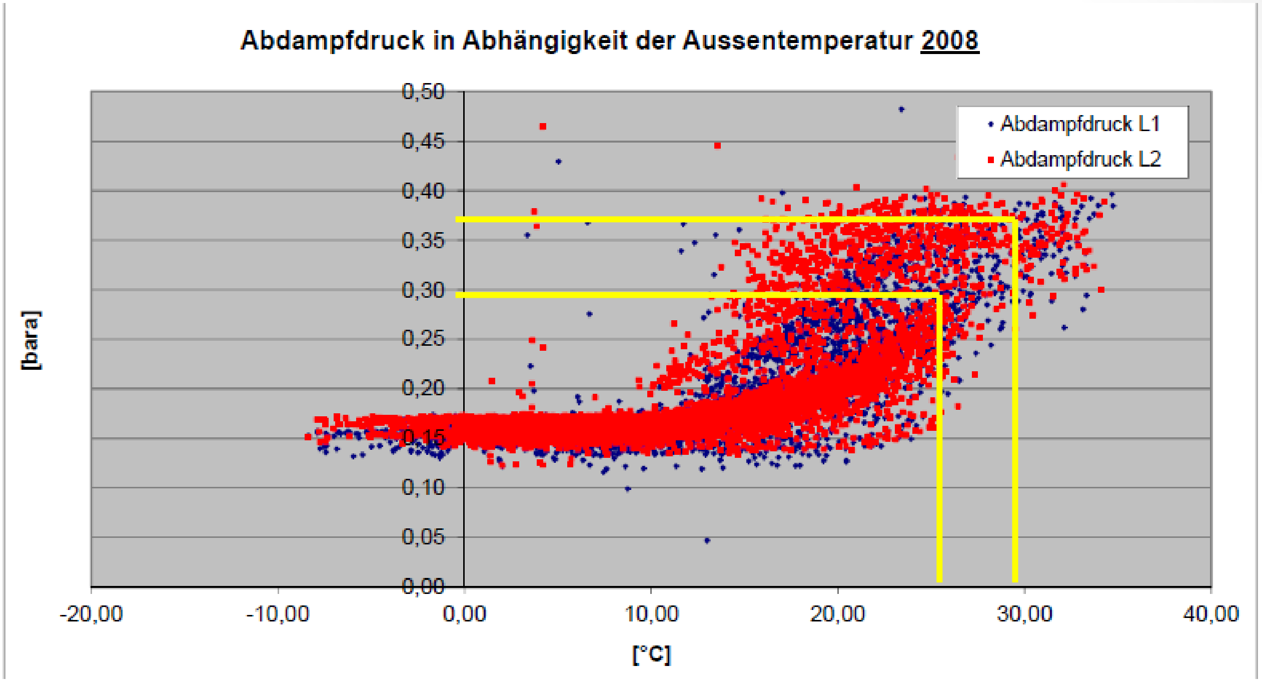
Savings

- No new sub-station
- No new fans, motors or bundles
- No costly DU/DT filter (close to motor)
- No costly Sinus filter (close to motor)
- No extra cooling as fan is cooling VSD
- No cabling from sub-station to motor (if VSD is installed in sub station)

ELFLOW BV SOLUTION ADVANTAGES

Advantages

- No need anymore for extra capacity on motor → Fans will turn slower in winter as cooling is not an issue at -20^{o}C!!!!!!! This power can be utilized to increase airflow during summer operation
- Lower noise level during night/cooler period (when it is cooler and when noise limitations are stricter)
- Decreased total power consumption required by ACC during a year as regulation is optimized by VSD
- Strongly reduced load on fan blades, gearboxes and motor when running at lower RPM
- No wind-milling (fans will only run slower)
- Reduced maintenance costs of gearbox and fans (no start-stop)
- Ability to increase fan RPM by approx. 20% (50 to 60 Hz or 60 to 70 Hz) and therefore efficiency and pressure capacity
- Increased pressure capacity of fan by approx. 40%
- Increased static efficiency of fans by 6%
- Increased airflow of fans by 14% versus original situation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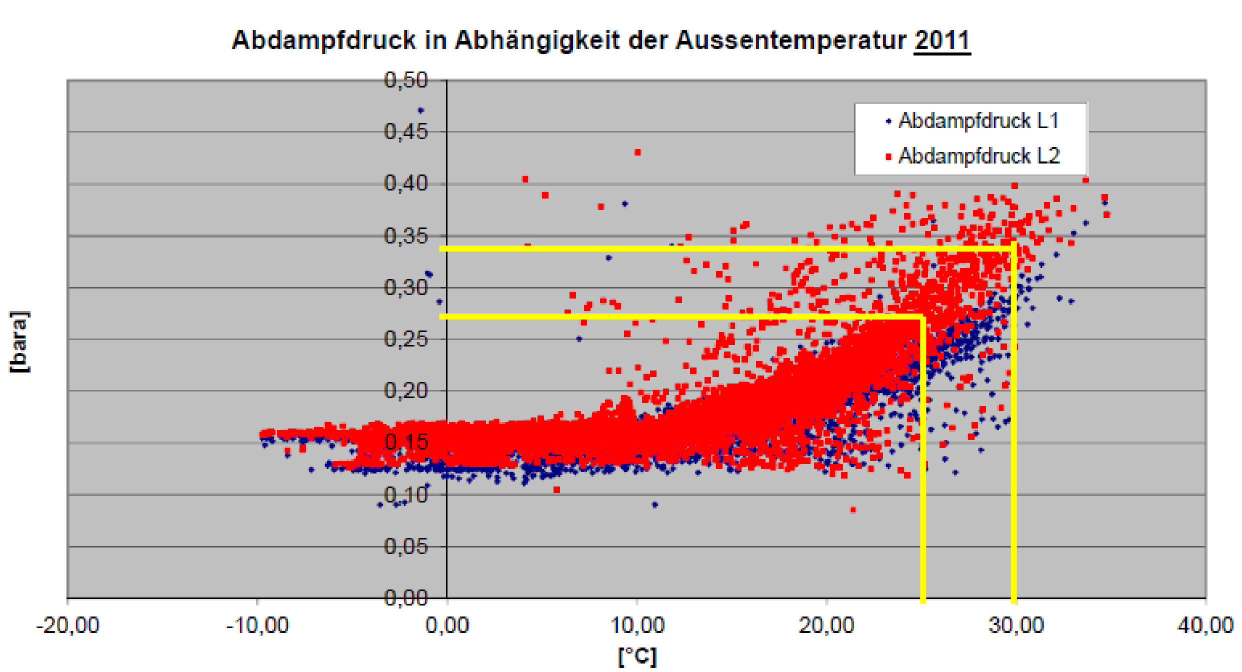
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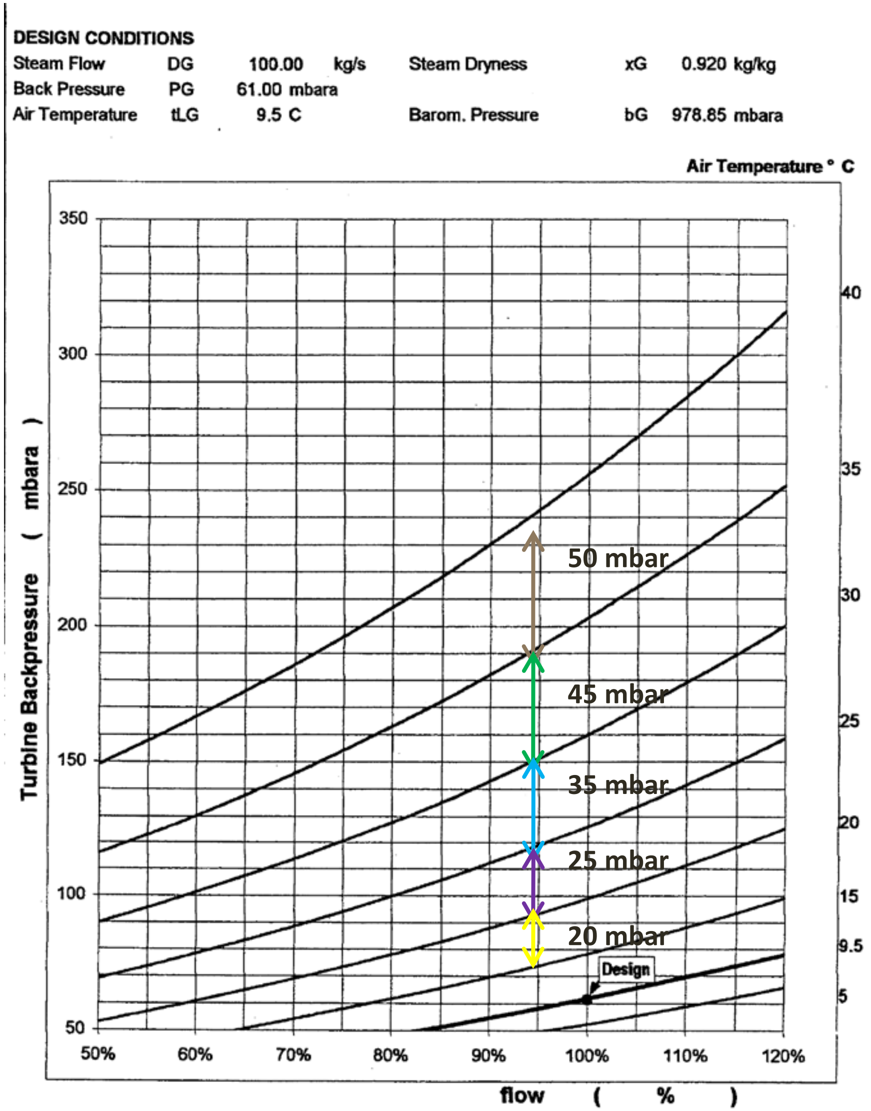
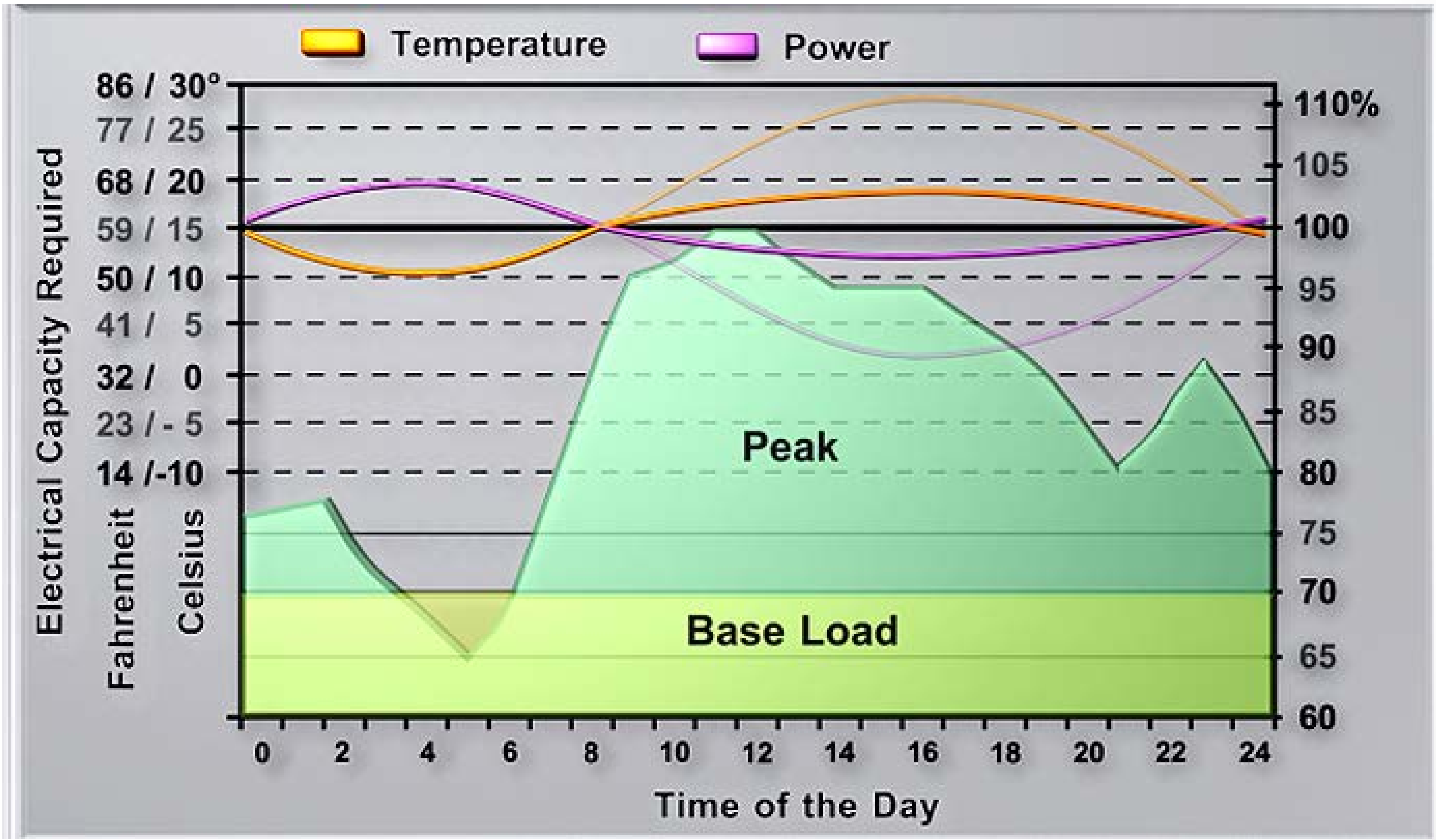
CASE 3 – ADIABATIC COOLING FOR ACC IMPROVEMENT

Adiabatic cooling



Typical ACC performance curve (Alstom turbine) illustrating improvement in vacuum with increments of 5*C in air temperature (at same steam flow rate)

Price of electricity varies with air temp.



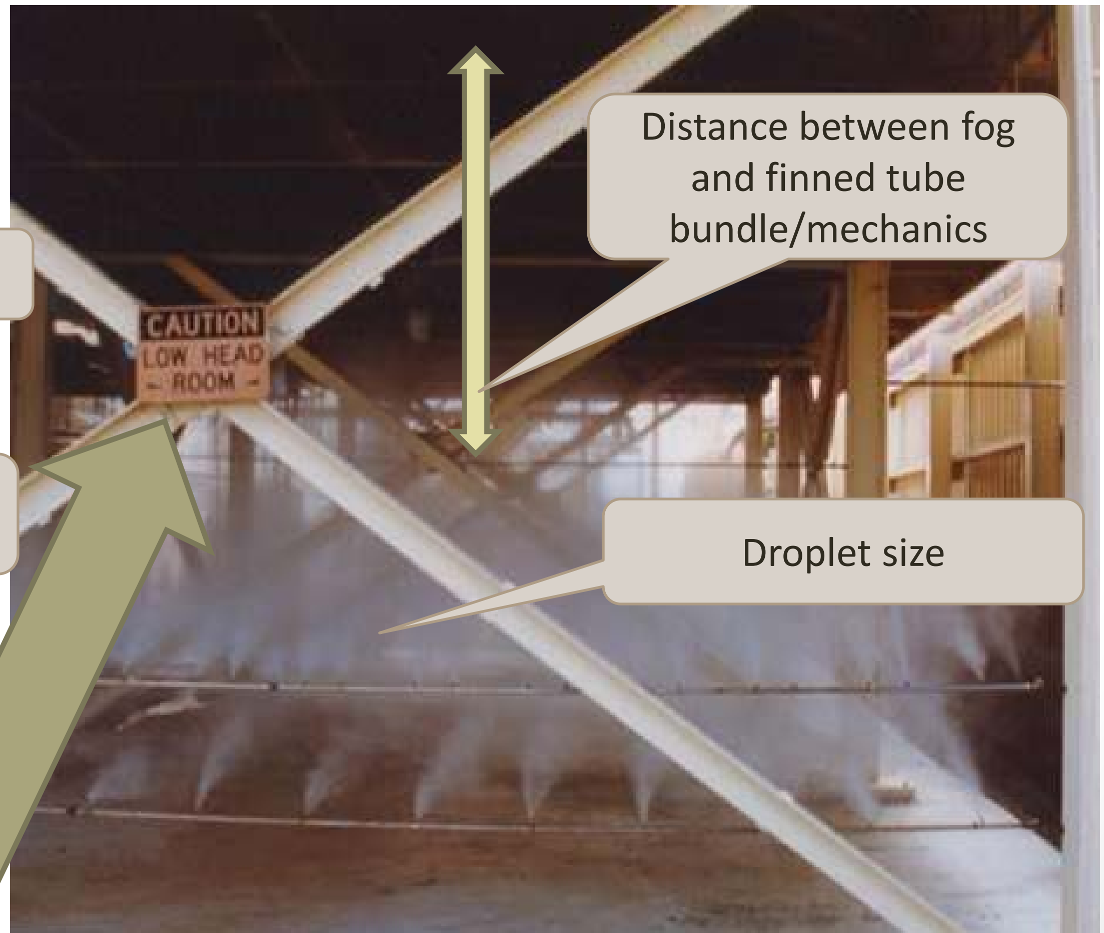
Reduce ambiant air temperature

Proper chilling system depends on …..

25 °C

Climate conditions

Face velocity



Possible Reduction in ambiant air temperatures using COOLINGMIST™ system