

Metrology Saves Energy

- Case Studies in Korea

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KRISS
Better Standards, Better Life!

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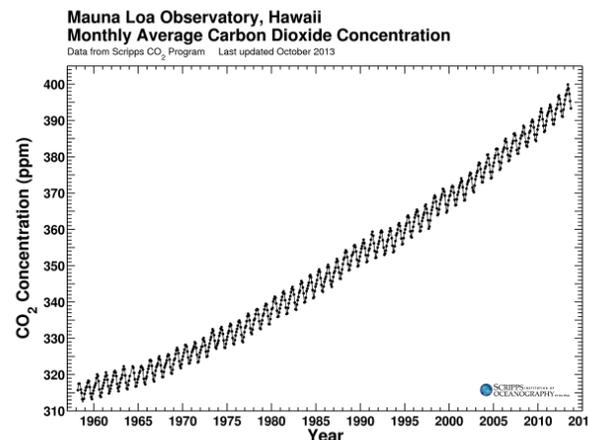
1. Background

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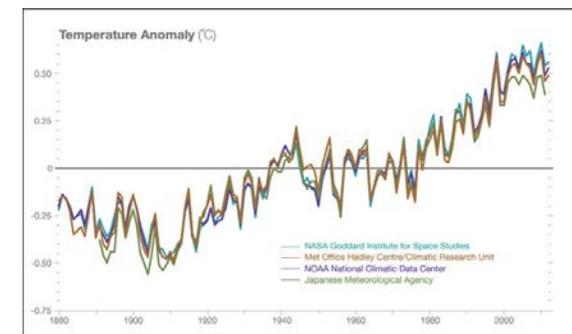
- The biggest challenge to the human race: **Climate change**
 - **Global warming** due to the greenhouse gases emitted by human activities
 - CO₂: an important heat-trapping gas, the highest concentration in 650,000 years (403.28 ppm)
 - Global temperature: increased by **0.8 °C** since 1880
 - Greenhouse gases are released when burning fuels to get useful forms of energy.
 - Climate change is real and humans are causing it.



Variation of the temperature anomaly



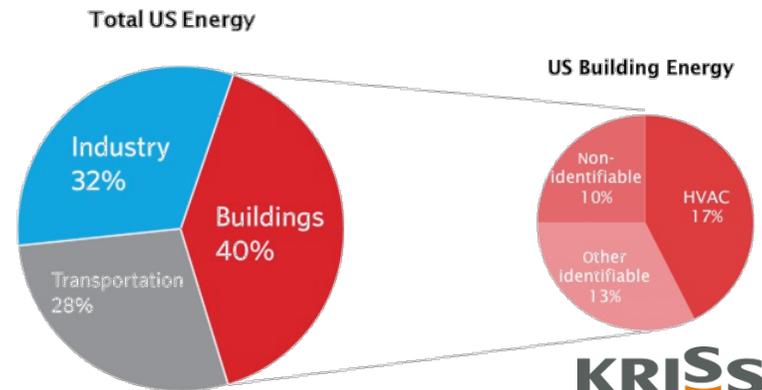
Keeling curve



1. Background

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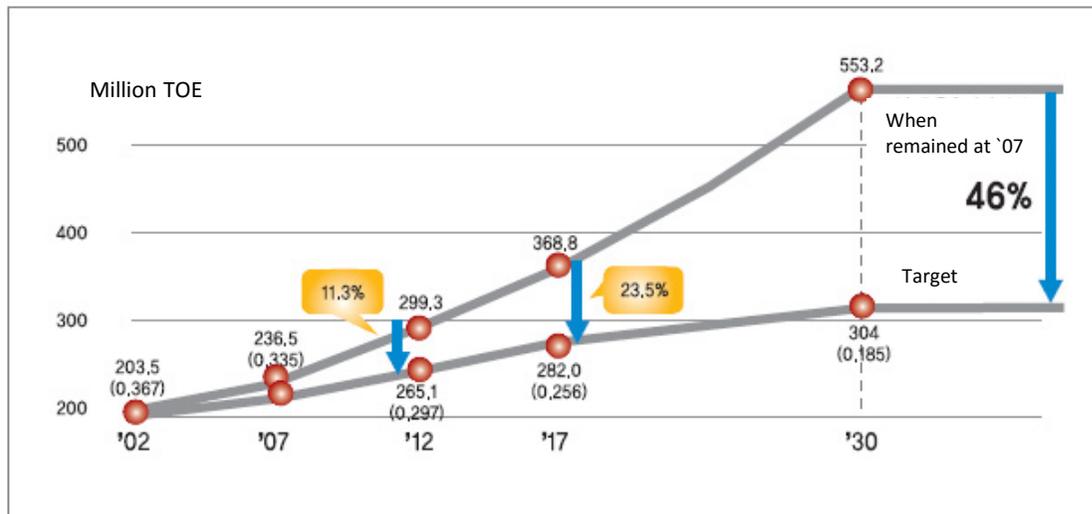
- Stopping the climate change is impossible, but we can slow down it.
 - Reducing the amount of the greenhouse gas emission
 - Need to **reduce the amount of energy** we consume
 - **Energy saving by efficient use**, replace with renewable energies, etc.
- Efficient use of energy can be applied to everywhere.
 - Energy consumed in industries and commercial buildings are the two largest portions.
 - Need to study how we can save energy there.
 - Need to study how **metrology can contribute to save energy** there.
 - Energy saving in buildings
 - Focused on an efficient HVAC operation
 - Energy saving in industries



2. Government policy in Korea

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- Low potential of energy saving in private sectors without government policy.
 - Due to energy-intensive industrial structure
 - Goal: to improve the national energy efficiency by 46 % until 2030.
 - Need a stronger policy to achieve low-energy and low-carbon economy
 - Target management for energy intensive companies and buildings
 - Introduction of green credit between companies (supplement to the above)



Prospect of Korea's
energy consumption and
target

2. Government policy in Korea

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- Target management for energy intensive companies and buildings
 - More than half of the GHG emission (58 %) is due to the energy-intensive companies and buildings
 - Force those sectors to reduce GHG emission by improving energy efficiency
 - When exceeding their allowed amount of GHG emission, they have to buy remaining Green credit from non energy-intensive companies, etc.
 - Directly related to the profits of companies and commercial buildings.
 - Good potential for improving energy efficiency.



3. Energy savings in buildings

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- Severance hospital (Yonsei university health system)

- One of the largest hospitals in Korea
 - More than 3000 beds
- One of the largest energy consuming buildings in Korea
 - Designated as a major greenhouse gas emission site (i.e., energy intensive building)
 - More than \$ 11,000,000 spent a year as an energy cost
- Due to the inherent characteristics as a hospital, **most of the energy is used in the air-conditioning** (i.e., heating, ventilating, cooling, etc.).



Source	2008	2009	2010	3-year average	Rate
Natural gas / toe	6,628	7,157	7,311	7,032	31.2 %
Electricity / toe	14,995	15,126	16,496	15,538	68.8 %
Sum / toe	21,622	22,283	23,804	22,570	100 %

3. Energy savings in buildings

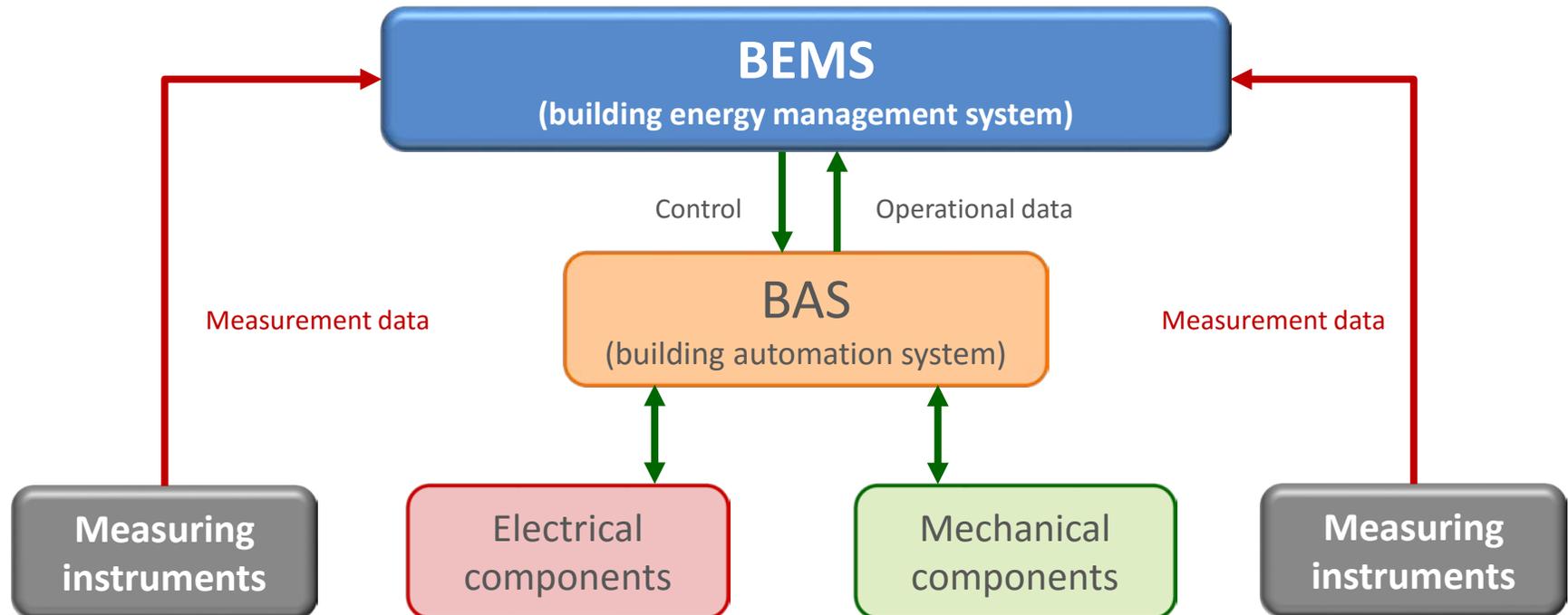
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- The way Severance hospital operated the HVAC system in the past.
 - Set-point (i.e., temperature) on-off control
 - No consideration on the outside air temperature
 - Inefficient use of electricity/gas
 - Time schedule-based start-up/stop
 - Turning on/off the system at a pre-scheduled times
 - Wasting energy during no air-conditioning demands
 - Always ventilating the building with the outside air
 - Unnecessarily large amount of heating/cooling load arose.
- Could they be smarter?
 - Introduced an intelligent energy management system based on measurements.

3. Energy savings in buildings

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- Building energy management system (BEMS)
 - Actively controls HVAC systems, lightings, (hot) water supply system based on **measurements of temperature, humidity, and air quality** (i.e., CO₂ concentration), etc.



3. Energy savings in buildings

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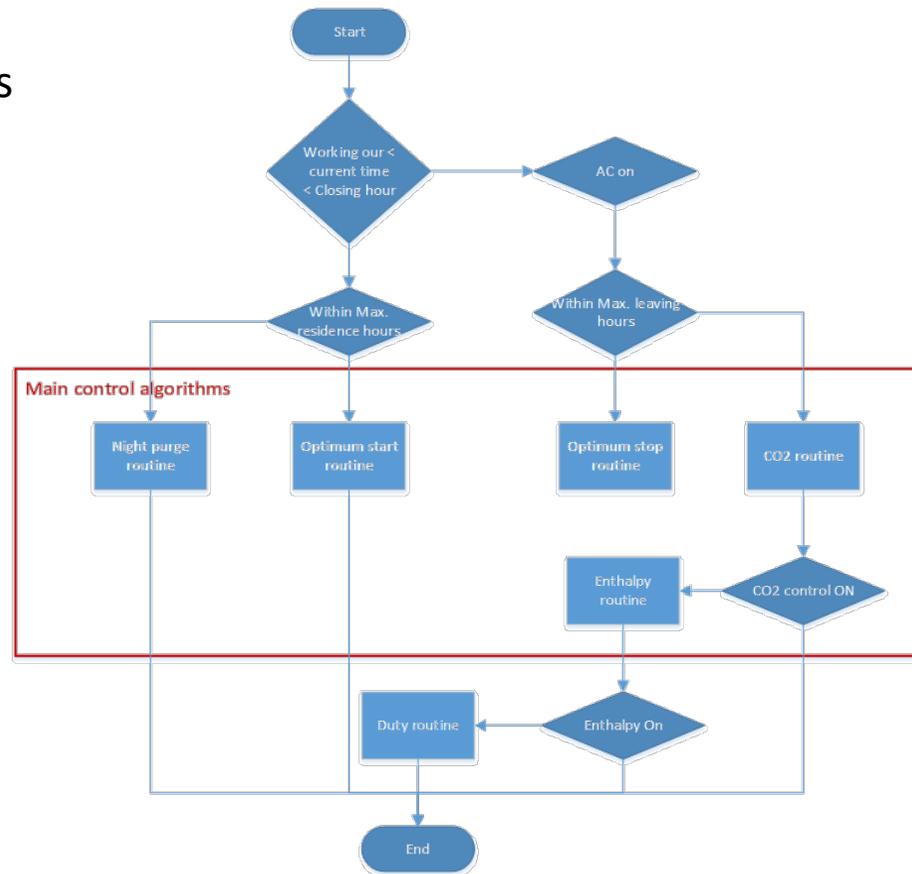
- Main algorithms of the BEMS
 - Optimum start/stop
 - Measured: Indoor air temperature, outside air temperature, working schedule
 - Controlled: Air-conditioning system start-up/switch-off schedule
 - Expected: Optimize energy consumption for air conditioning
 - CO₂ control
 - Measured: Indoor CO₂ concentration
 - Controlled: Ventilation (amount of the intake air from outside)
 - Expected: Reduce heating/cooling loads
 - Enthalpy control
 - Measured: Indoor/Outside air temperatures, indoor/outside air humidities
 - Controlled: Ventilation (intake amount of outside air)
 - Expected: Reduce cooling load

3. Energy savings in buildings

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Control algorithm

- Comprises 4 main algorithms
 - Optimum start
 - Optimum stop
 - CO₂
 - Enthalpy



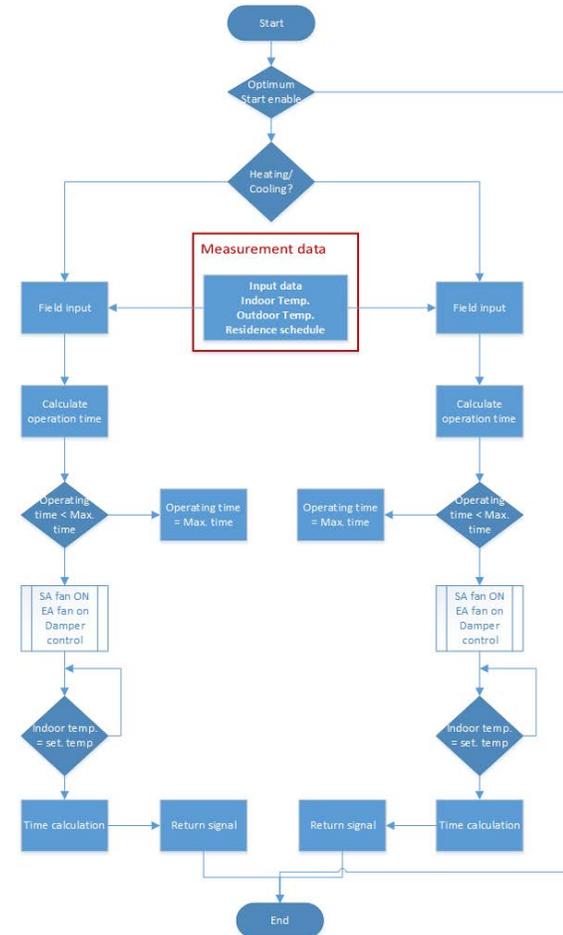
3. Energy savings in buildings

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Control algorithm

Optimum start

- Measured: Indoor air temperature, outside air temperature, working schedule
- Calculated: **Optimum operation schedule**
- Controlled: Air-conditioning system start-up/switch-off
- Expected: **Optimize energy consumption for air conditioning**



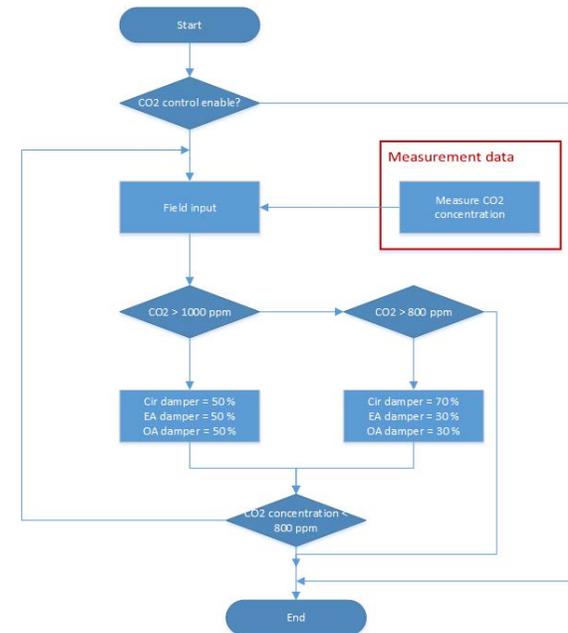
3. Energy savings in buildings

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Control algorithm

CO₂ control

- Measured: Indoor CO₂ concentration
- Set: Optimum indoor CO₂ concentration
- Controlled: Ventilation (intake amount of outside air)
- Expected: Reduce heating/cooling loads



3. Energy savings in buildings

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■ Result

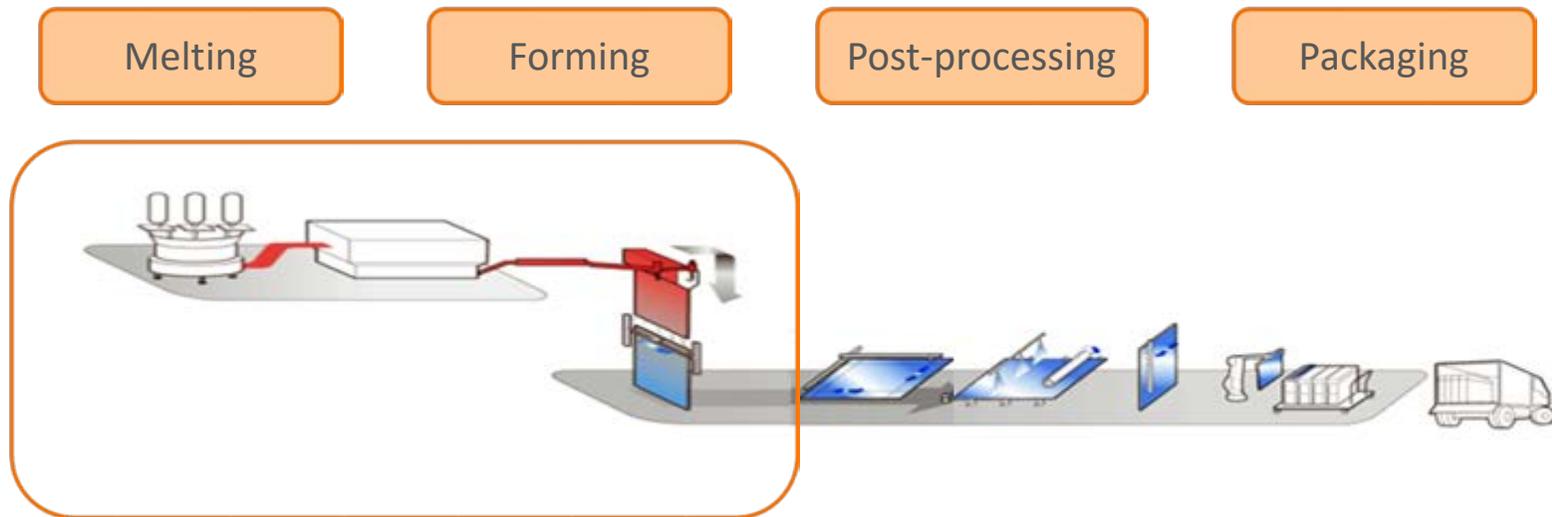
- Tentative operation at 3 buildings for a month
- Overall saving rate: **12.09 %**
- Total amount of energy saved : **230.92 toe** (\$104,000 (prediction for a year))
- By measuring temperature, humidity, CO₂ concentration, and adopting an intelligent control system, **more than 10 % of energy was saved.**

Building	Saved energy / toe	Saving rate / %	Saved energy /\$	ROI / year
Main Bd.	165.15	10.75	66,000	6.04
Dental clinic Bd.	63.88	20.23	37,000	2.05
Research Bd.	1.90	3.25	1,000	25.42
Sum	230.92	12.09	104,000	4.66

4. Energy savings in industries

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- Samsung Corning precision materials
 - Produces glasses for LCDs.
 - Annual sales: around 500 million USD.
 - Production process



**Melting and forming processes determine
the final quality of the products!**

4. Energy savings in industries

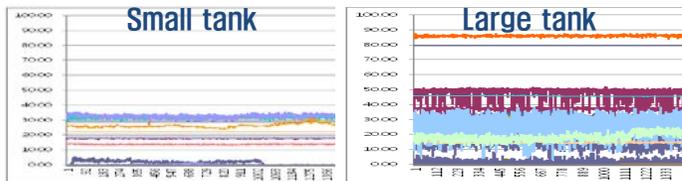
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- Important factors influencing the melting and forming processes
 - Flowrates of LNG, O₂, and N₂
 - Temperature of the crucible
 - Power to the furnace
- Small change in the control parameters could result in huge change in the final product quality.
 - Accurate measurement of the control parameters were essential.
 - Eliminating individual characteristics of sensors was important
 - To reduce dispersion of measured data
 - Calibration of the sensors should have been done.
- Accurate measurement of the control parameters leads to efficient process control.
 - Need to improve the measurement of the control parameters.

4. Energy savings in industries

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- The way Samsung Corning measured the control parameters in the past
 - Flowmeters were not calibrated.
 - Measured flowrates from difference flowmeters **differed by 30 %!**
 - Only differential pressure gauges were used to estimate flowrates
→ Unreliable estimation of the flowrate.
 - Thermometers (i.e., pyrometers) were not calibrated.
 - Thermocouples were used to correct dispersions.



Variation in the nitrogen flowrate

- Could they be more accurate?
 - Calibrated flowmeters and minimized the effect of multiple thermometers.

4. Energy savings in industries

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■ Accurate flowrate measurement

- Calibrated their flowmeters using a traceable sonic nozzle.
 - Measurement uncertainty was **decreased by 95 %**.
- Calibrated measurement instruments.
 - To be certain on the read data.
- Flow speed was periodically measured using pitot tubes.
 - To diagnose any problems in ducts in advance.



Sonic nozzle calibration system



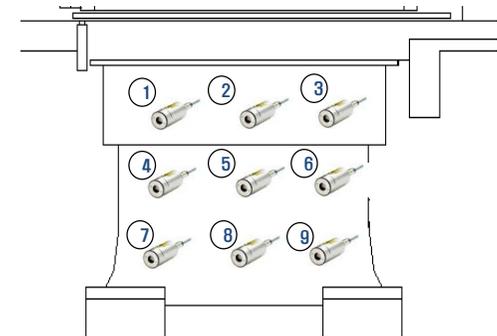
■ As a result,

- The measurement uncertainty of the flowrate was **decreased from 6.1 % to 0.3 %**.
- Due to the accurate measurement of the control parameters, energy cost was decreased by 150,000 USD a month.
- **Simple calibration of the sensors and instruments resulted in energy saving.**

4. Energy savings in industries

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- Reliable temperature measurement.
 - An accurate (i.e., calibrated) thermometer was **not** required in the process.
 - A reproducible thermometer was more important.
 - Temperatures measured by different pyrometers **at the same position dispersed a lot.**
 - Tried to find a golden pyrometer which showed the smallest difference from the original pyrometer at different positions.
 - Golden pyrometer: **the most robust one to the position change.**
 - Original pyrometer: correct?

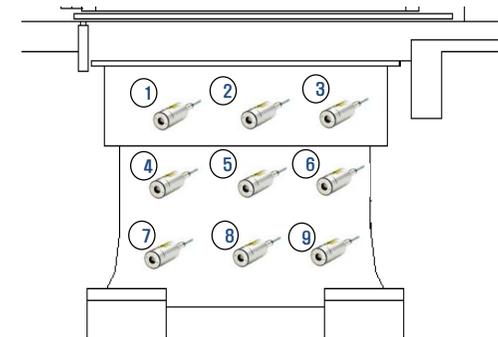


Pyrometer positions

4. Energy savings in industries

- Reliable temperature measurement.
 - Finding a golden pyrometer

Pyro Position	Pyro #1	Pyro #2	Pyro #3	Pyro #4	Pyro #5	Pyro #6	Pyro #7	Pyro #8	Pyro #9
#1	932	928 [-4]	930 [-2]	931 [-1]	935 [+3]	930 [-2]	927 [-5]	931 [-1]	933 [+1]
#2	930 [-1]	931	928 [-2]	931 [0]	930 [-1]	932 [+1]	927 [-4]	931 [0]	936 [+5]
#3	936 [-5]	944 [+3]	941	940 [-1]	945 [+4]	937 [-4]	938 [-3]	946 [+5]	944 [+3]
#4	768 [-3]	773 [-2]	775 [+4]	771	768 [-3]	764 [-7]	774 [+3]	773 [-2]	767 [-4]
#5	773 [-3]	781 [+5]	778 [-2]	777 [-1]	776	780 [+4]	781 [+5]	779 [+2]	772 [-4]
#6	772 [+6]	761 [-5]	767 [+1]	766 [0]	769 [+3]	766	771 [+5]	772 [+3]	764 [+2]
#7	706 [+1]	707 [+2]	701 [-4]	705 [0]	710 [+4]	706 [+1]	705	707 [+2]	709 [+3]
#8	719 [+2]	715 [-2]	710 [-7]	718 [+1]	714 [-3]	716 [-1]	719 [+2]	717	715 [-2]
#9	726 [+5]	722 [+1]	718 [-3]	721 [0]	723 [+2]	722 [+1]	717 [-4]	724 [+3]	721
+	4	3	1	0	5	0	4	5	4
-	3	4	6	0	3	3	4	1	3

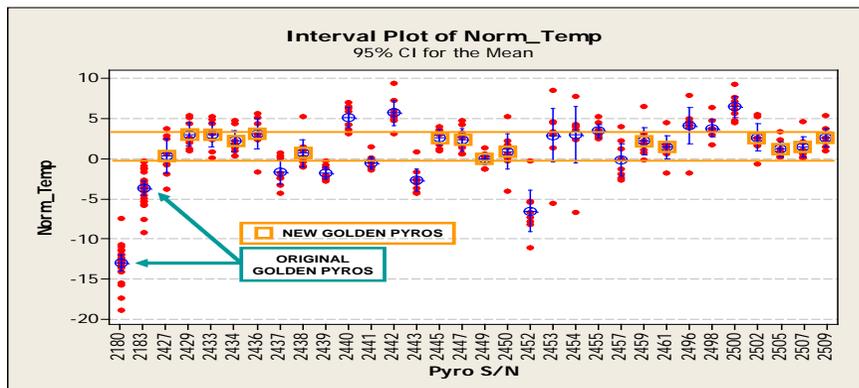


Pyrometer positions

4. Energy savings in industries

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- Reliable temperature measurement.
 - After finding the golden pyrometer,
 - Other pyrometers were corrected according to the readings from the golden pyrometer.
 - Eliminated individual characteristics of the different pyrometers (at least).
 - Similar to measuring temperature using one pyrometer.
 - As a result,
 - Temperature scattering was reduced from ± 16 °C to ± 1 °C.
 - Forming process was stabilized due to the reliable measurement of temperature.
 - Saved money spent for thermocouples.



5. Summary

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- The climate change is the biggest challenge to the human race.
 - To slow down the climate change, energy should be efficiently used.
- Around 40 % and 30 % of the total energy is consumed in buildings and industries.
 - In buildings, around 40 % of energy is used in HVAC (i.e., temperature control).
 - In industries, process parameters are determining factors for saving energy.
- Two examples showed that energy can be efficiently used based on measurements.
 - By measuring related quantities and being smart.
 - By measuring process parameters more accurately.
- Can metrology contribute to save energy and to slow down the climate change?
- Metrology can save energy and slow down the climate change.
 - Many sectors are awaiting metrology.



Thank you.