Master Brewers Association of the Americas
Dedicated to the technology of brewing.
MBAA Annual Conference

Sustainability from an Equipment Manufacturer's Standpoint

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KRONES

How should we define Sustainability in the brewery process…?

- Achieving a brewing process which is neutral in energy terms as much as possible.

- Optimizing your resources
  - Materials
  - Electrical
  - Steam
  - Water

- …while still maintaining a high level of quality in production

- Quality with Sustainability

THE RESOURCE OPTIMIZED BREWERY

How do you attain a “Resource Optimized” brewing process ?

Can it be attained by…

•How you operate your brewhouse and equipment?

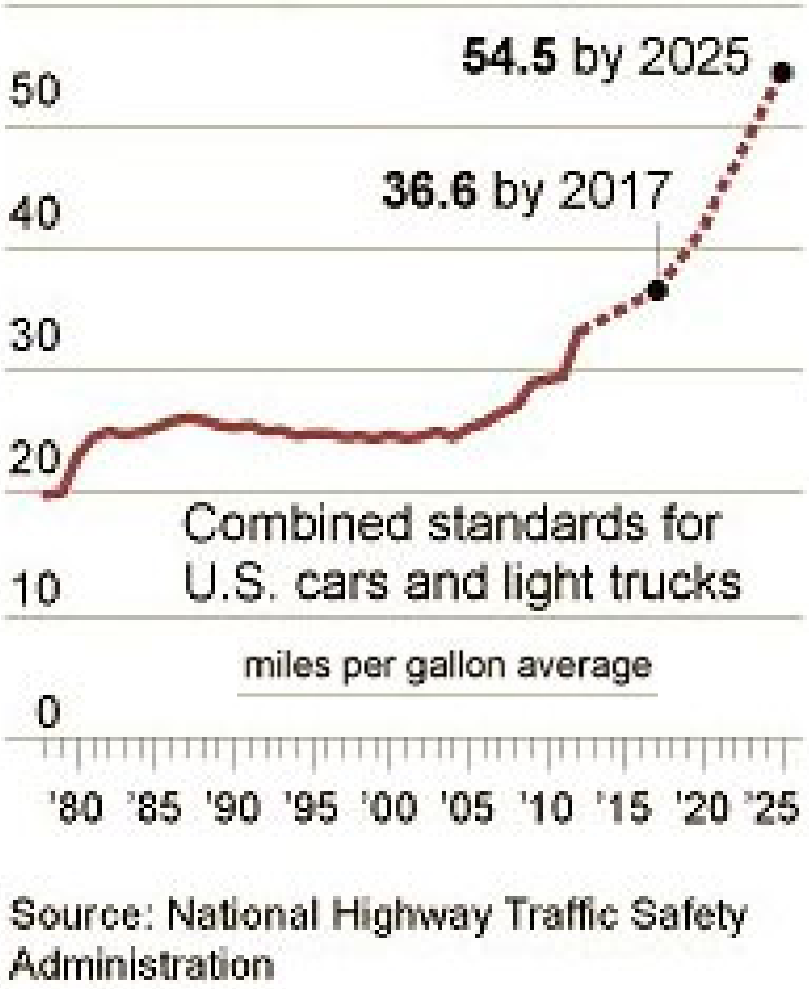
BUT.....

•How far can you actually go without having to rely upon more efficient equipment to achieve your goals?

•The research and development contribution of equipment manufacturers is key to helping achieve Sustainability Goals.

Contribution to Sustainability by Equipment Manufacturers?

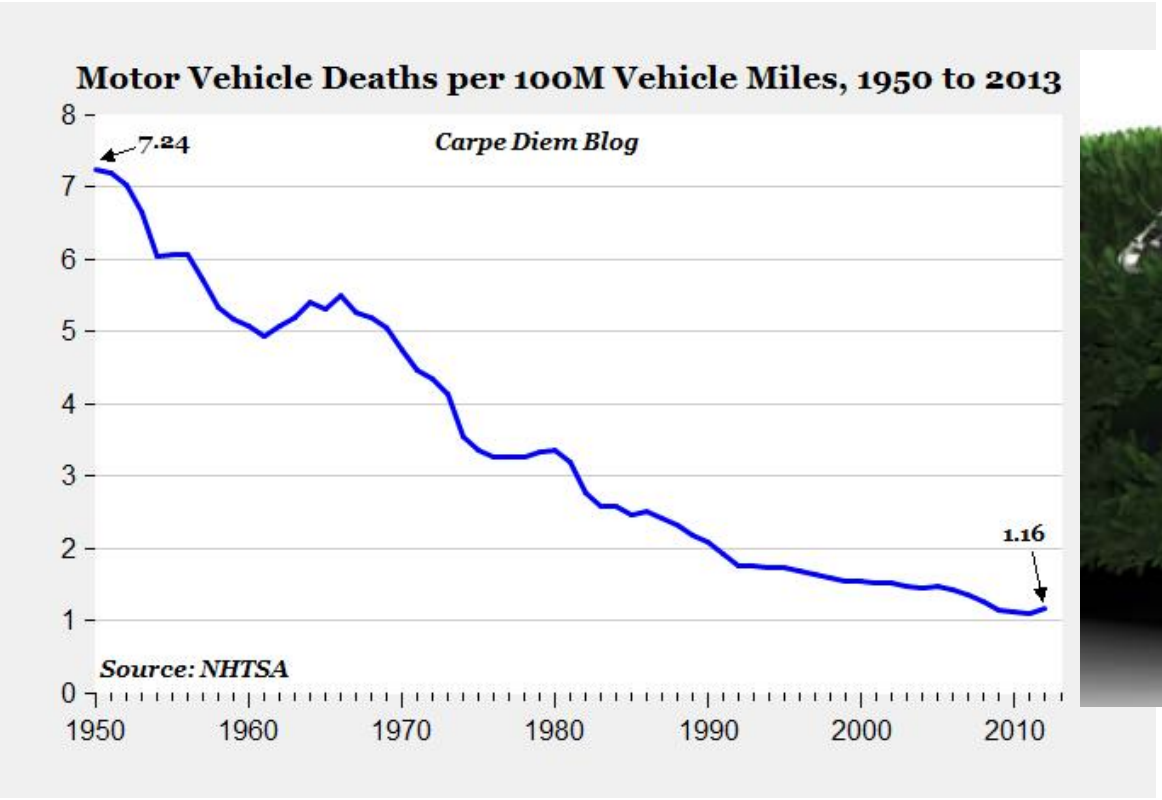
Lets draw an analogy with the Automotive Industry and recent advances in **Energy efficiency**…



Are these results Influenced more by how you operate a vehicle or by the equipment design itself?

Contribution to Sustainability by Equipment Manufacturers?

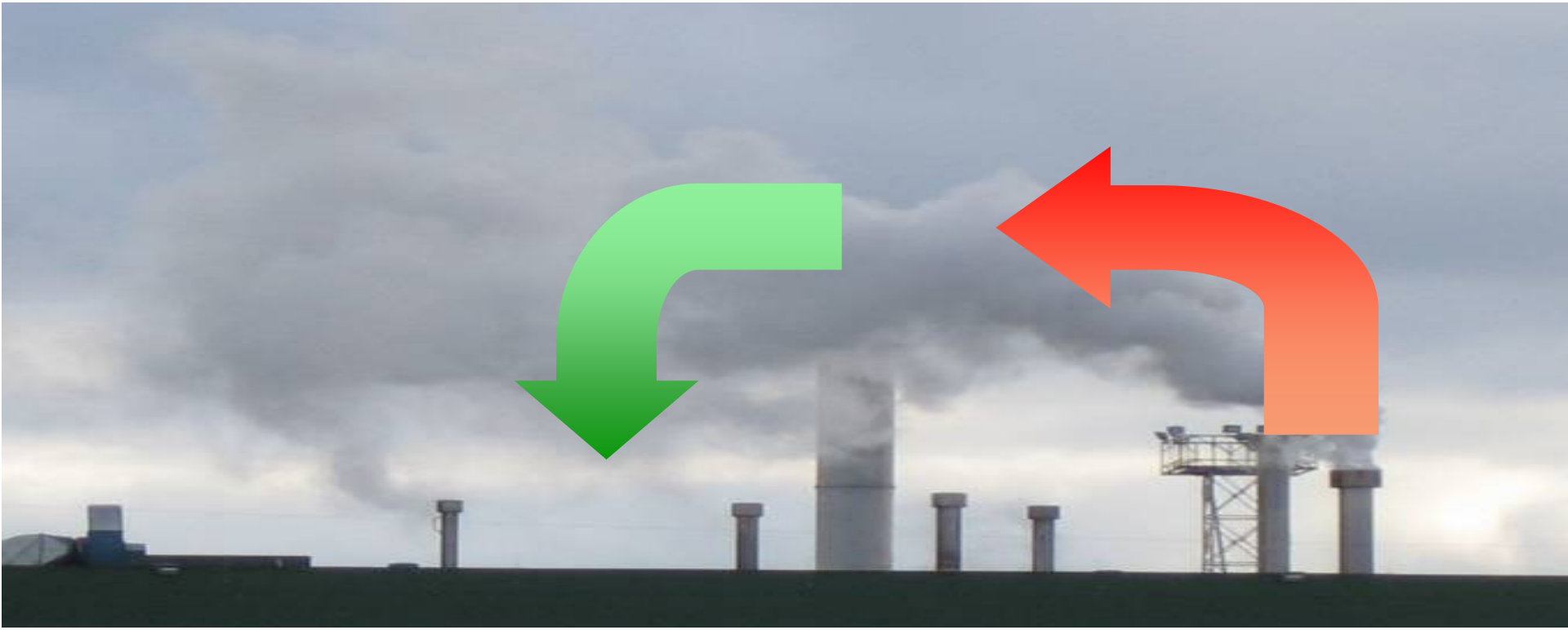
Lets draw an analogy with the Automotive Industry and recent advances in **Safety Standards**…



Are these results Influenced more by how you operate a vehicle or by the equipment design itself?

The Role of Brewery Process Equipment Manufacturers…

Developing & Implementing Equipment Solutions for **RESOURCE OPTIMIZED BREWERIES** facilitating efficient Production Quality in an **Affordable and Sustainable** way



Has been this Role for a long time..

Energy Recovery in the Brewhouse

- Kettle vapor condenser
- Condensate cooler
- Wort cooler

Application

- Lauter-wort heating
- Heat for mashing water
- Heat for sparging water
- Heat for cleaning

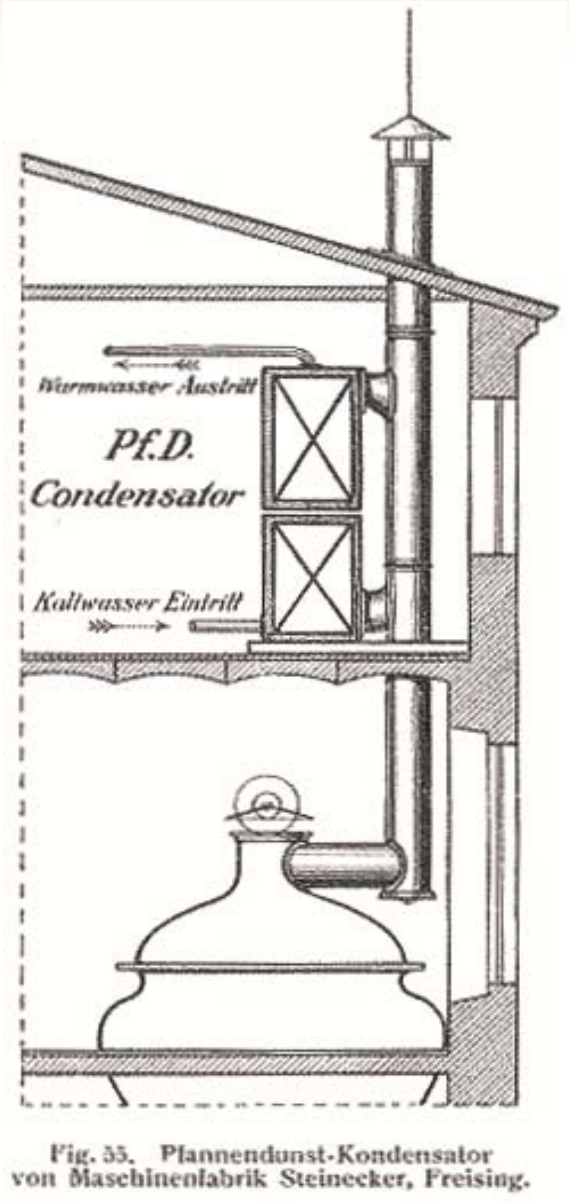


Fig. 55. Plannendunst-Kondensator von Maschinenfabrik Steinecker, Freising.

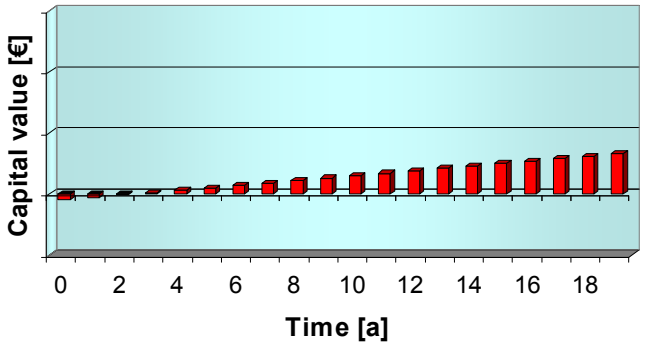
1926

Source: Katechismus der Brauereipraxis; J. Dworsky, K. Lense; (1926)

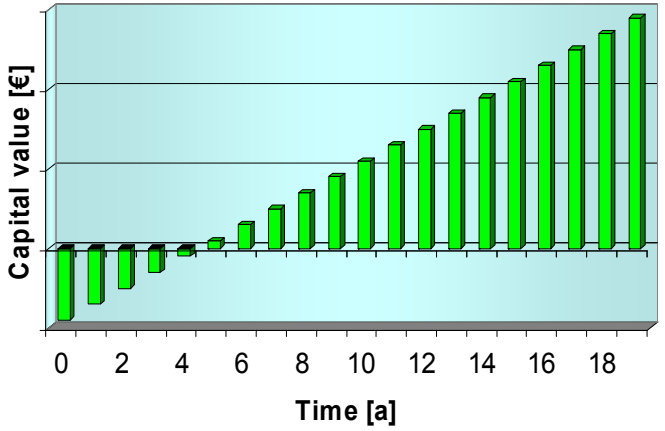
What's the Current Trend?
…Improving Brewhouse Yield or Energy Consumption?

- Overall brewhouse yield (OBY) of modern brew house lines is at 98 - 99%. It has practically reached the limit of what is technically possible.
- On that basis any capital investment aimed at increasing the yield can only achieve a low ROI.
- **Extract yield** was the critical cost factor for a brewery in the past, in future it will be the **price & consumption of oil and gas**

Investment increasing yield

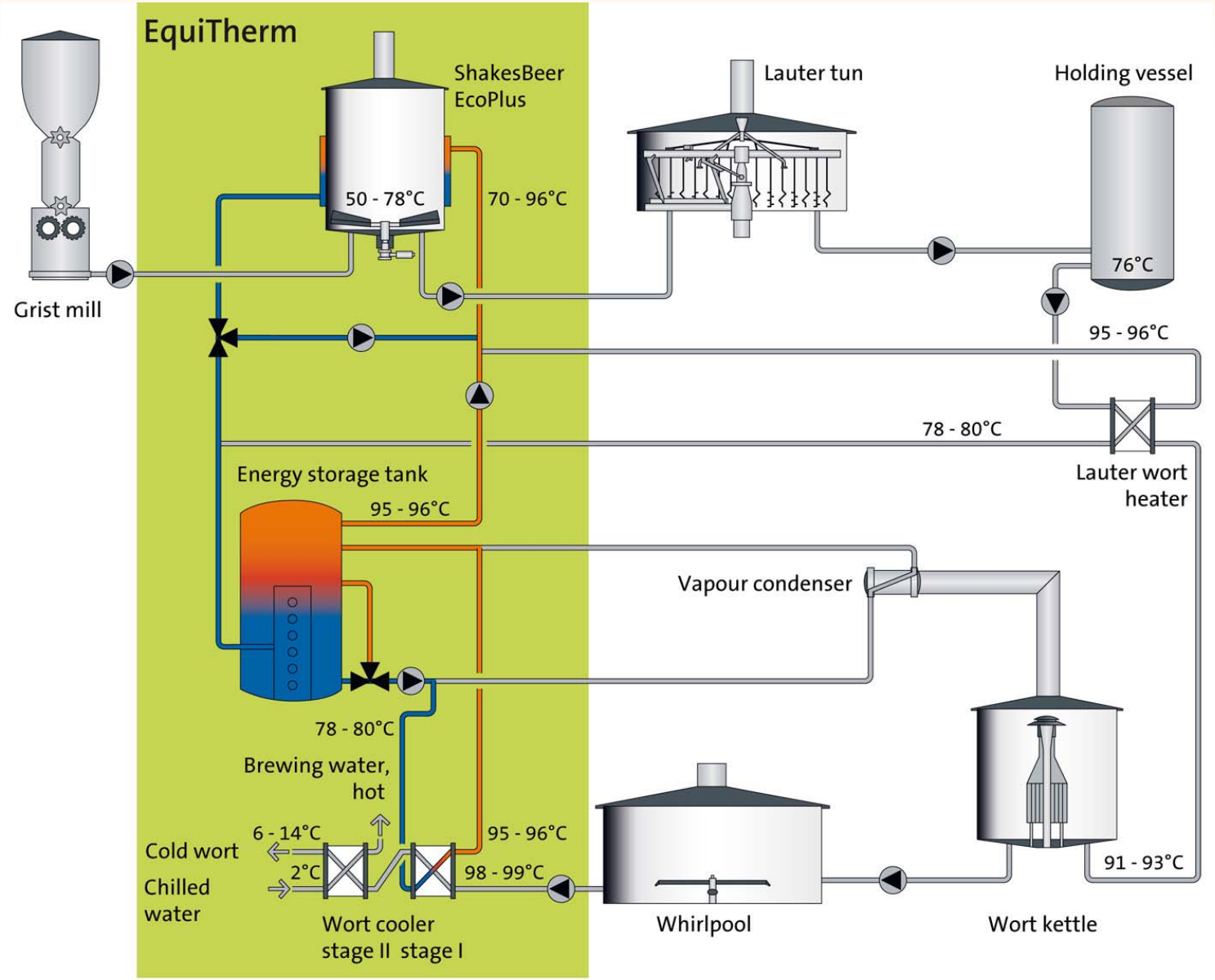


Investment reducing consumption



Energy & Material savings in the Brewhouse Area

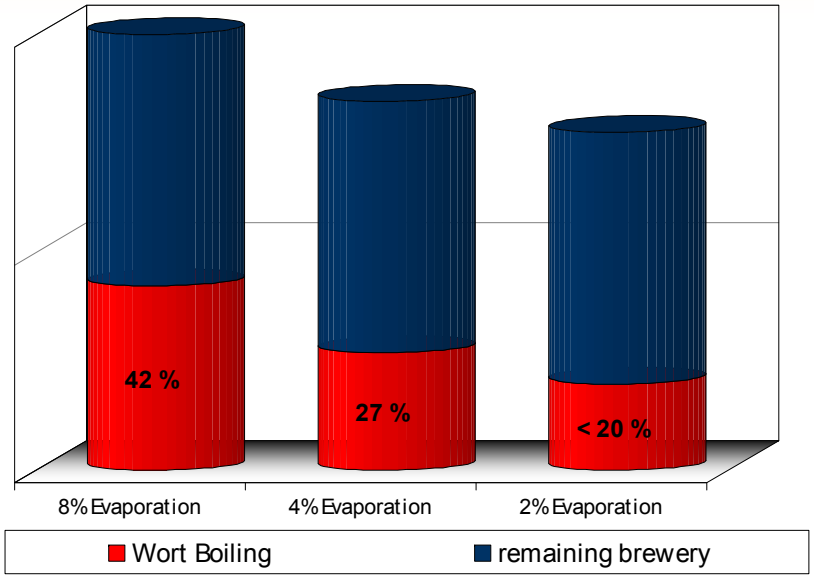
EquiTherm - Equipment & Technology

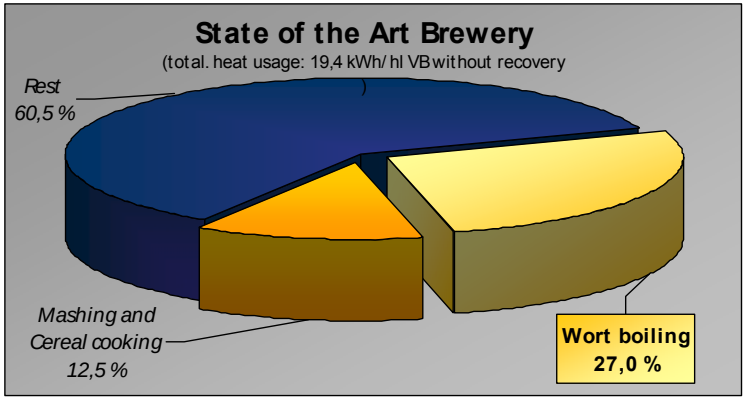


Percentage of wort heating and boiling of the total heat demand

- Wort boiling represents one of the greatest individual consumers in a brewery.
- For a state of the art brewery wort boiling can represent up to 30% of the total heat demand.
- Costs for primary energy sources continue to rise.

→ Large savings potential available

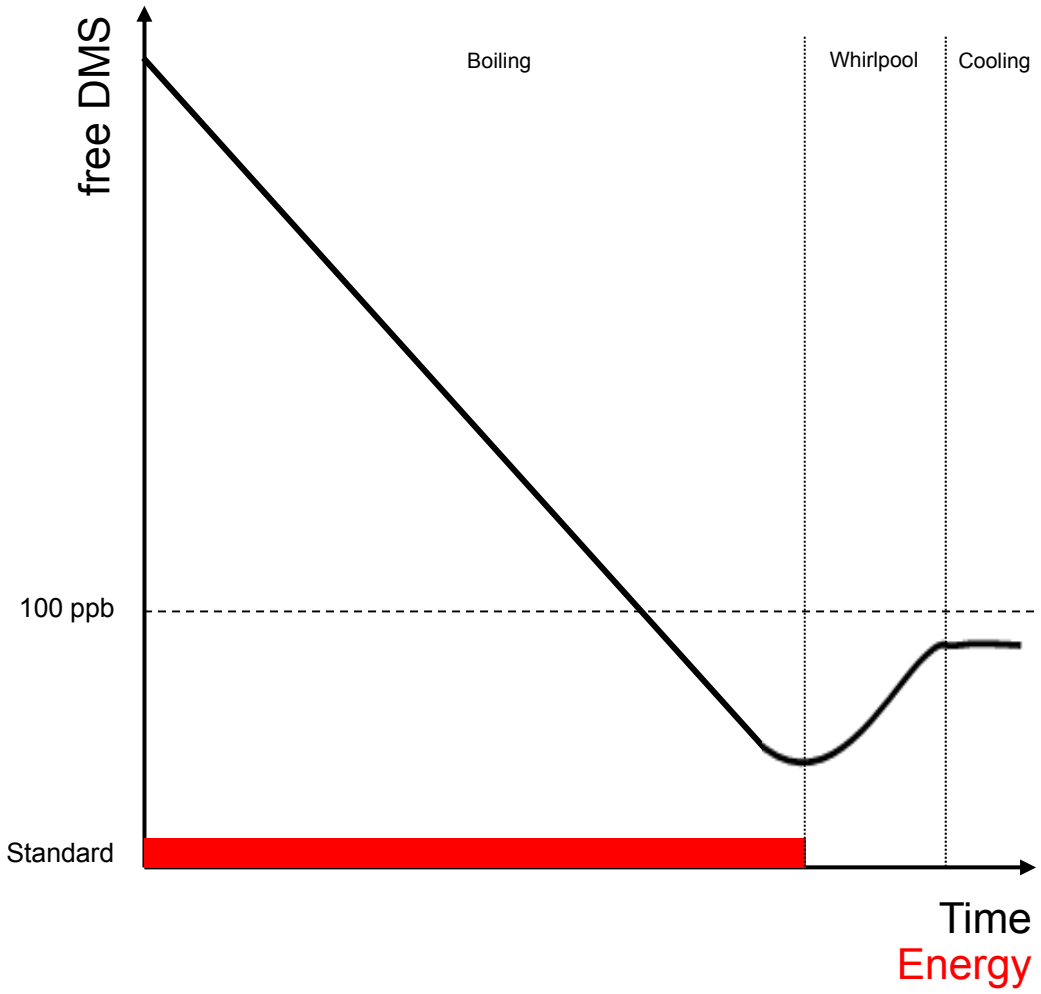




Wort Boiling Technology

- In conventional boiling systems the circulation of wort & reduction in the free DMS content, is coupled to evaporation

- During boiling DMS must be expelled so taste threshold value of 100 ppb is not exceeded considering also the re-increase in the whirlpool
  (high temperature separates more DMSp, but free DMS is no longer reduced because there is no circulation).



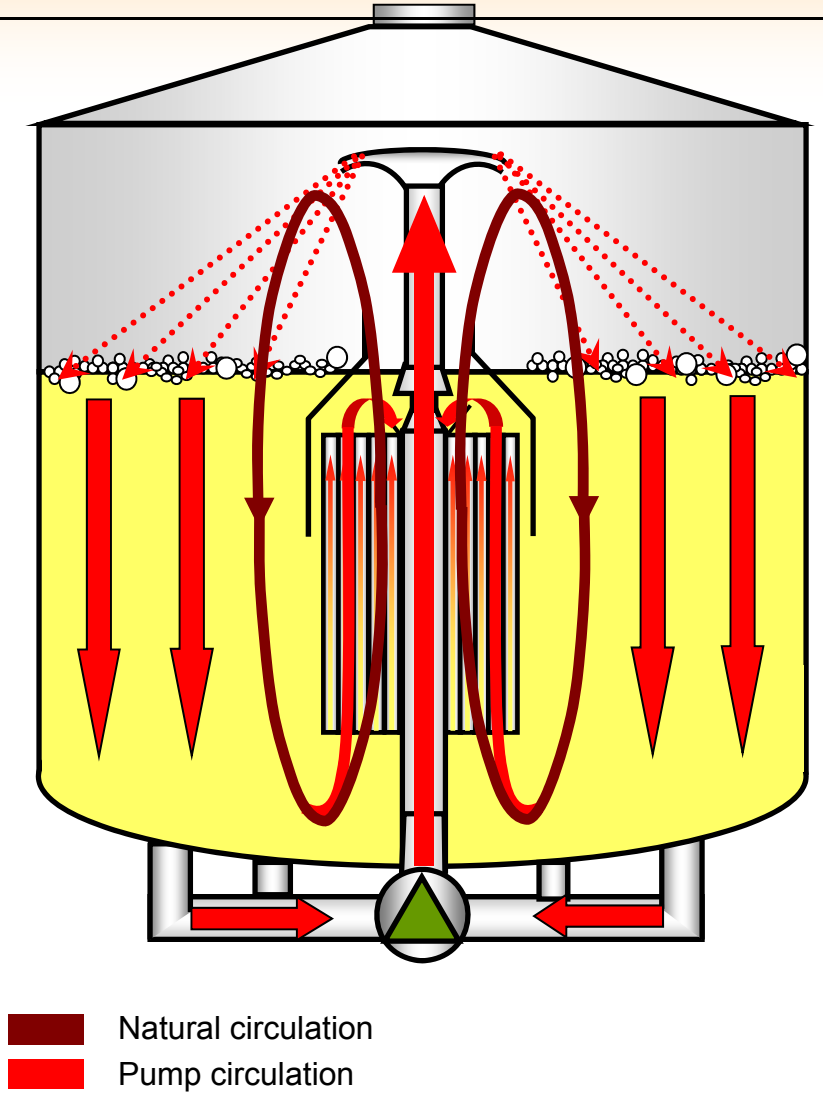
Wort Boiling Technology (Stromboli)

The Stromboli boil system has two circulation circuits: the natural circulation of the boiler and the pump circulation.

The boiling process is divided into three phases:

- Phase 1: Natural circulation by energy supply and pump circulation
- Phase 2: Pump circulation with reduced energy supply
- Phase 3: Natural circulation by energy supply and pump circulation

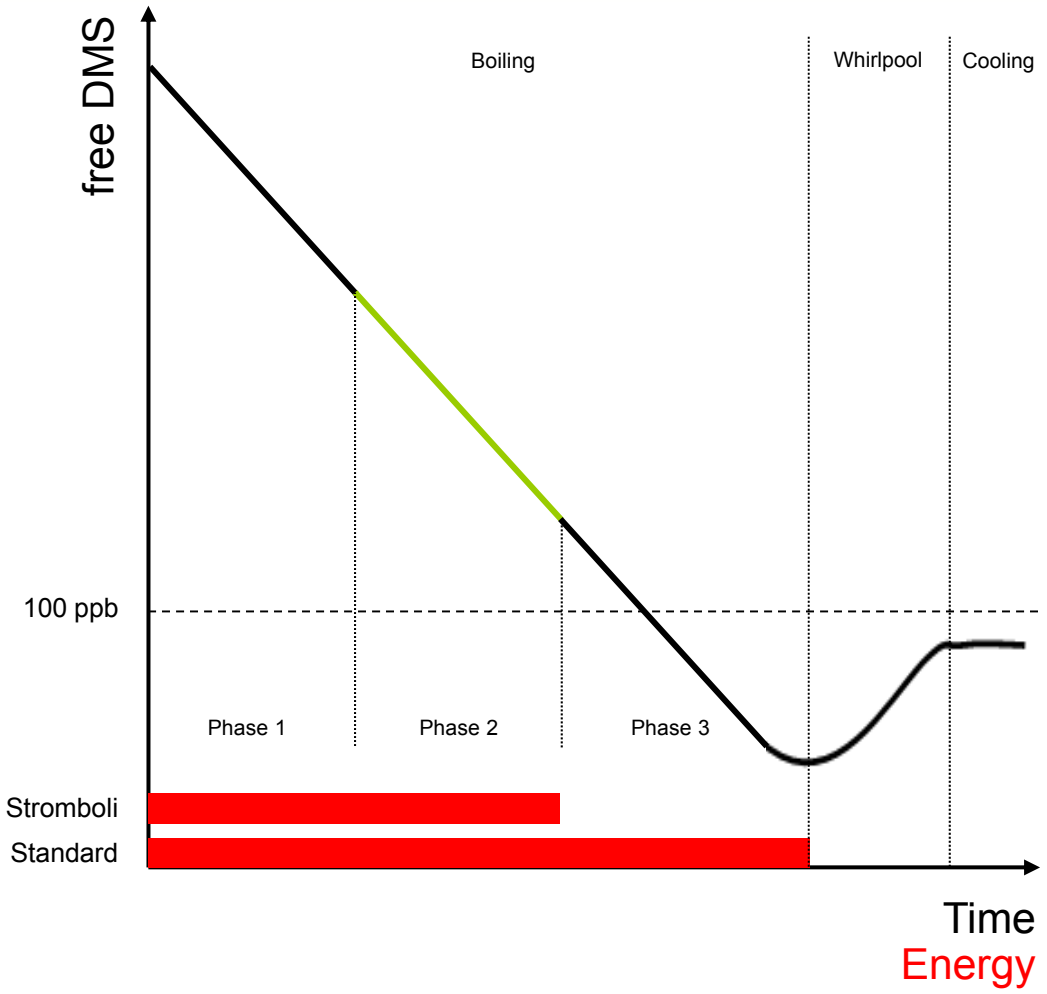
The circulation of wort can be separated from the total evaporation. By controlling the pump speed and phase duration new parameters are possible to customize and control the boiling process.



Wort Boiling Technology (Stromboli)

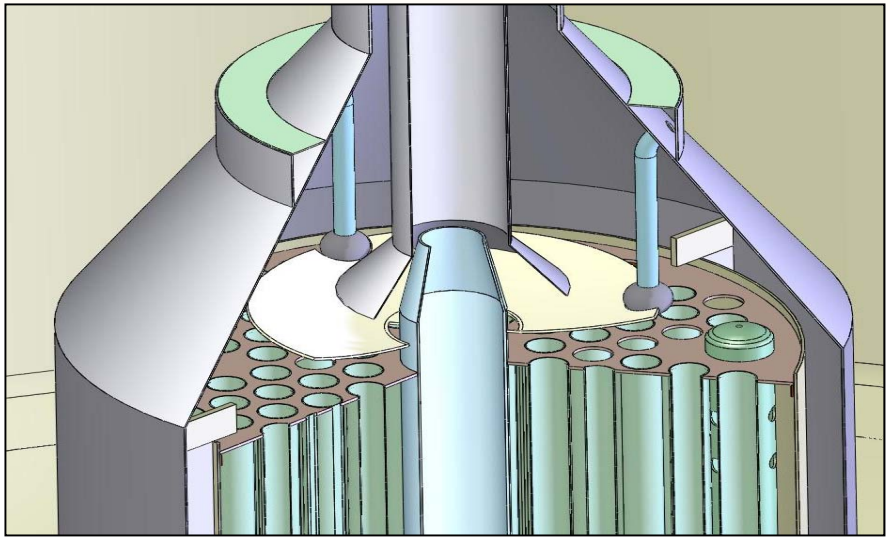
Stromboli wort boiling process

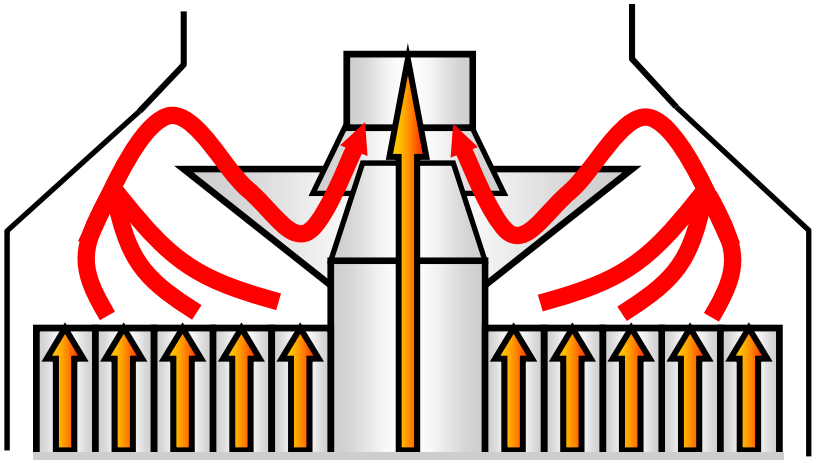
- Stromboli allows the circulation of the wort to be separated from the evaporation
- In phase 2 of the boiling process the wort is circulated with an external pump and the Venturi nozzle only
- The Stromboli wort boiling process therefore allows a reduction in the free DMS content with reduced energy input



Wort Boiling Technology (Stromboli)

- The core of the Stromboli internal boiler is a Venturi nozzle installed above the pipe bundle.
- Driven by an external pump, the wort is conveyed via the central ascending pipe. This creates a vacuum on the outside of the nozzle which supports the flow of wort in the pipe bundle.
- At a circulation rate with the 8-fold amount of wort to be boiled per hour, almost the same circulation rate is also generated by the Venturi nozzle. During dimensioning 4 m/s were selected as the maximum speed for the wort flow.





Wort Stripping Technology (Boreas)

- **Wort quality**
  - Wort has valuable substances but also some undesired components
  - If certain levels of these components are exceeded then a loss in quality will result
  - Wort stripping offers the abilty to remove undesired flavors from wort in a controlled way

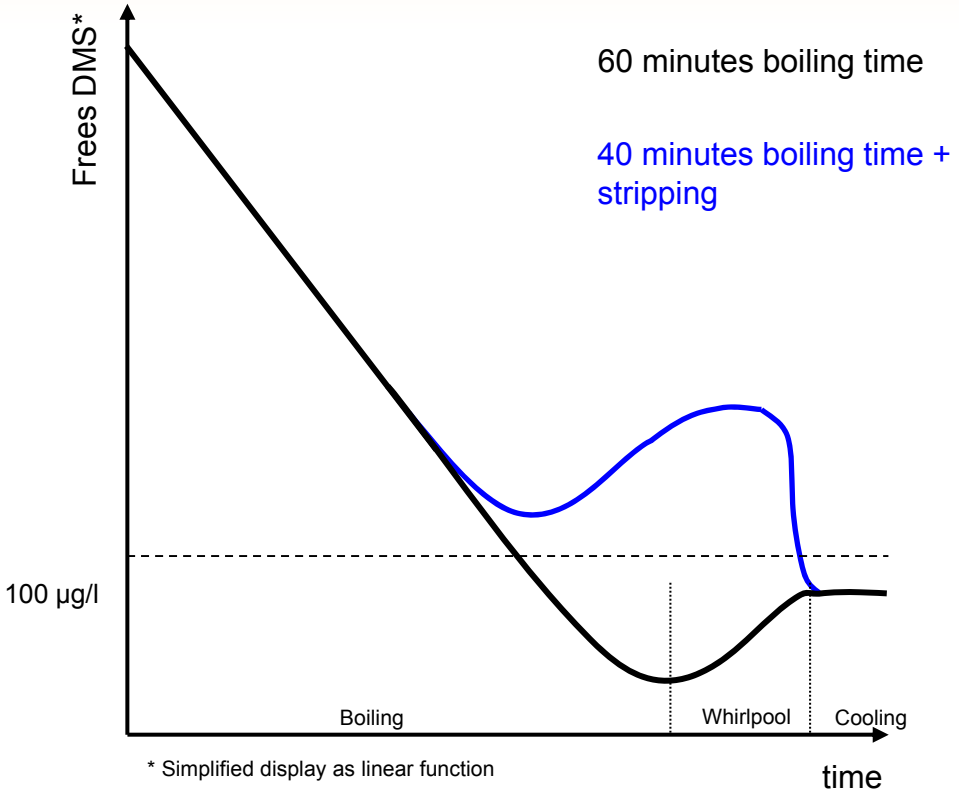
- **Energy savings**
  - Not only will quality improve, wort stripping also provides the possibility to reduce total evaporation and energy consumption during wort boiling step

➔ Stripping is a technology combining classical quality with modern brewing processes

Wort Stripping Technology (Boreas)

- Stripping enables a reduction of free DMS content below threshold even if boiling time is reduced from 60 to 40 minutes
- Wort stripping can be used for:
  - reducing the boiling time, i.e. saving energy, with constant wort quality

    or
  - reducing the percentage of free DMS with constant boiling time
- With this, wort stripping allows constant boiling processes with different raw material qualities

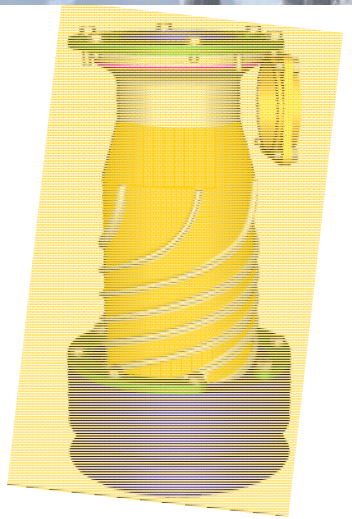


➔ Wort stripping allows the reduction of free DMS straight before wort cooling

Wort Stripping Technology (Boreas)

- Spin injector
  - Wort is set into rotation via the spin injector. Using the appropriate speed and angle, the wort is applied continuously already in the cover and a turbulent falling film runs down on the container wall.
  - The change of velocity at the outlet of the spin injector leads to a pressure drop in the wort layer, which supports the stripping effect.
  - The expelled free DMS is led to atmosphere through the inner space of the spin injector.

➔ The product path can be used for cleaning agents, no further installations are required.



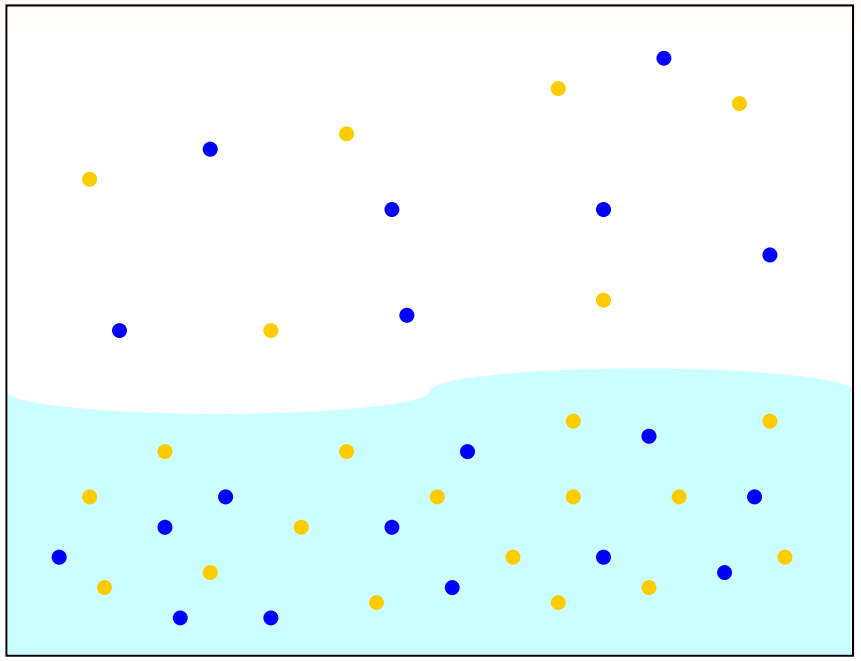
Wort Stripping Technology (Boreas)

- Evaporation of DMS is proportional to the creation of steam during the turbulent wort flow inside the stripping vessel
- Due to evaporation enthalpy, the intensity of the generation of water vapor occurs proportionally to the temperature difference between wort inlet and outlet
- In the gas “zone” of the stripping vessel a balance point between steam and free DMS is created. By the injection of strip gas the saturated gas will be displaced continuously
- Strip gas keeps the driving concentration gradient between wort film and gas zone at a constant level, so that the reproduction of water vapor and with this, the reduction of free DMS can be controlled

Wort Stripping Technology (Boreas)

- Use of Partial Pressure

- The total pressure in the stripping vessel is based on the partial pressures of the individual phases (shown here in a simplified way as H_2O and free DMS)
- Depending on the temperature there will be a balance between steam and free DMS in the gas phase. This will be proportional to the percentage of distribution between the individual partial pressures.
- Until the point of saturation there will be a constant evaporation of water and free DMS



1000 vessel pressure $_{95^\circ}$ = 150 mbar $_{DMS}$ + 850 mbar $_{H2O}$

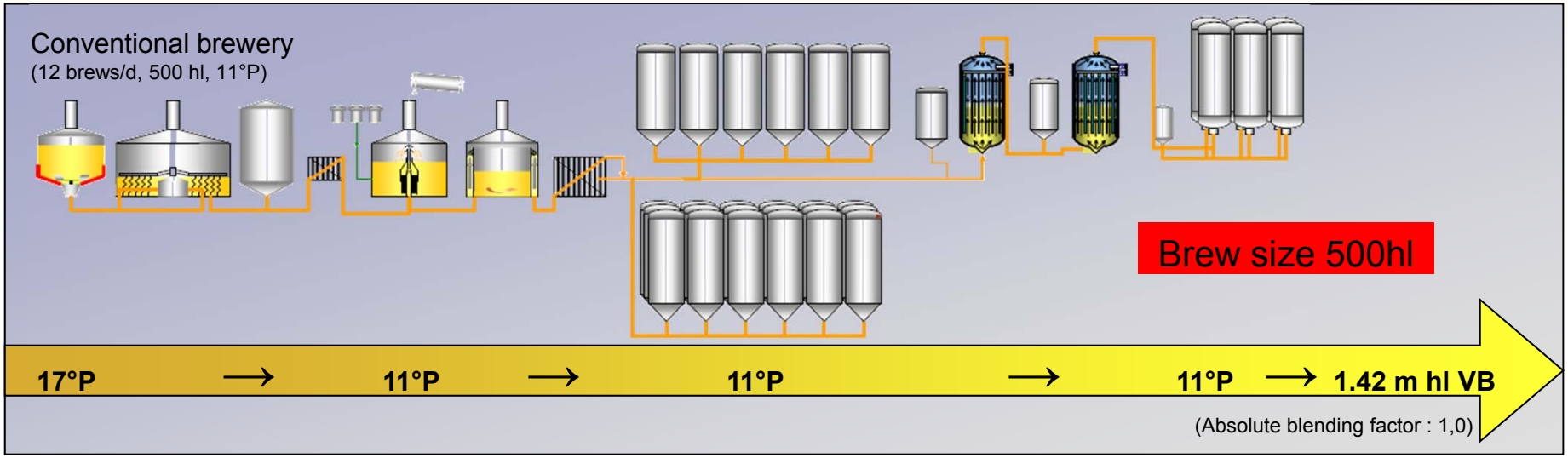
Wort

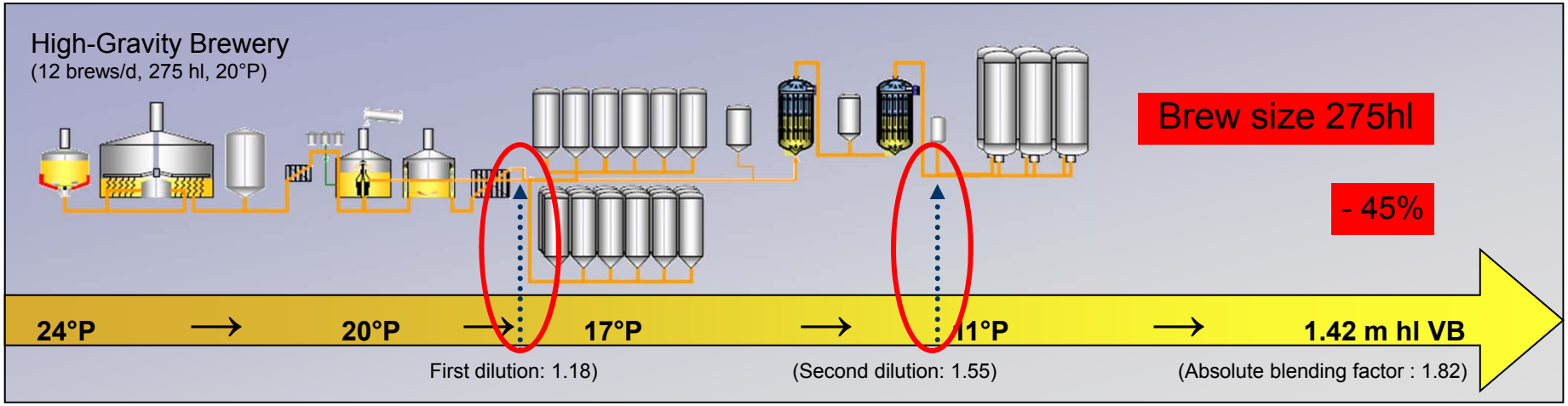
H_2O

Free DMS

Energy & Material savings in the Cold Block Area

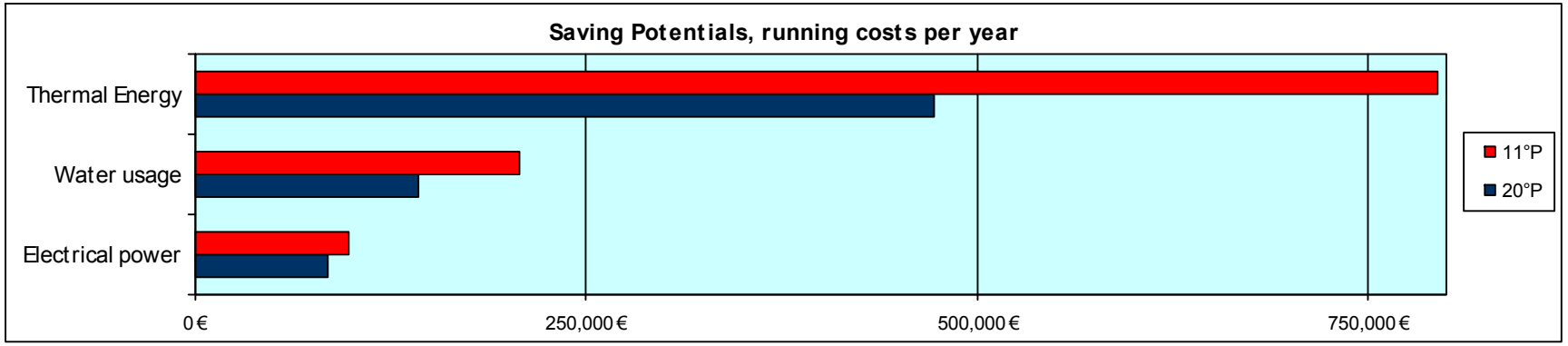
High Gravity Brewing





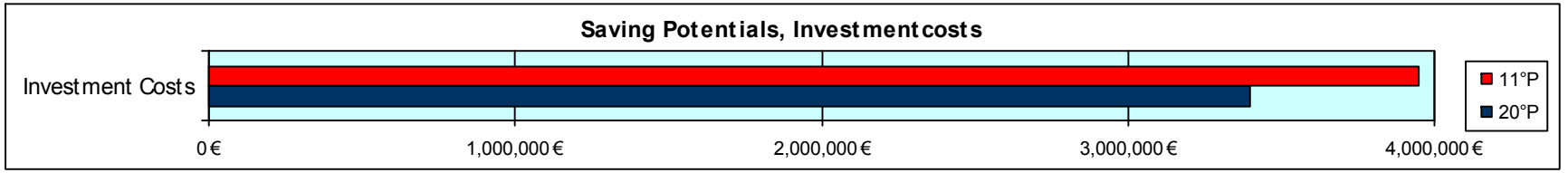
High Gravity Brewing

500 hl AW with 11°P -> 275 hl AW with 20°P



Calculation basis: Krones standard brewhouse; 8°C cold water temperature; 80° hot water temperature; 0.09 €/kWh (thermal); 0.12 €/kWh (electric); 0.10 €/hl fresh water

→ Total savings potential: up to € 400,000 per year

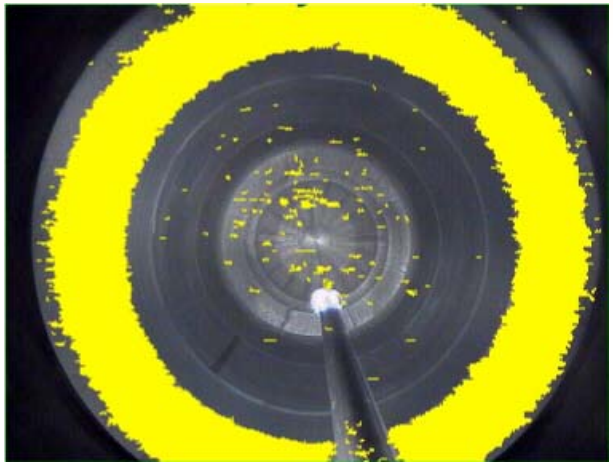


→ Total savings potential in investment costs: up to € 450,000

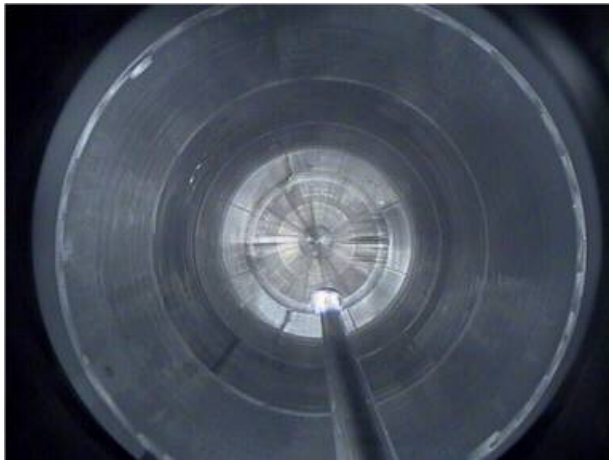
Additionally large potential in the cold area (tank, line and filter size; cooling energy, compressed air, …)

Reduction in CIP expenditure based on Visual Scanning Technology

- Integration of the TopScan in the CIP process
  - Dynamic cleaning process depending on the degree of dirt contamination
- "As little as possible but as much as necessary"
  - Reduction in the rinsing water consumption
  - Reduction in the cleaning agents
  - Time savings
  - Increased plant efficiency



before the CIP (contamination marked)



After a CIP time of 10 min.

Intelligient Pipe Fence Design in the Cellar

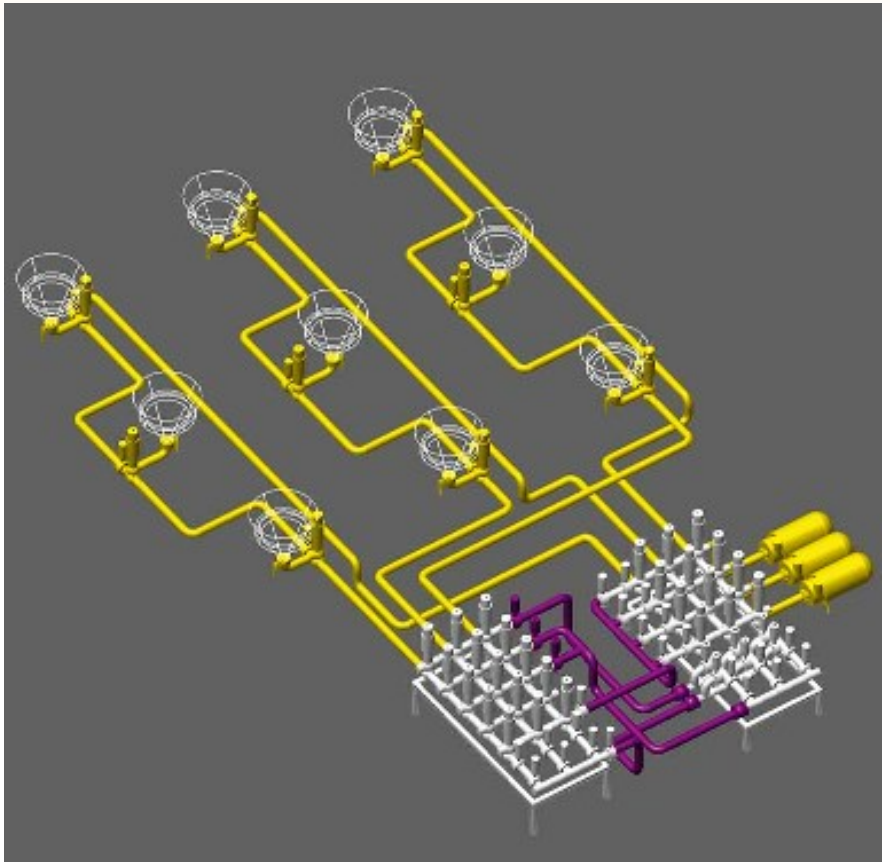
Pipe system concept

One valve block each for the filling and draining processes in the tank loop

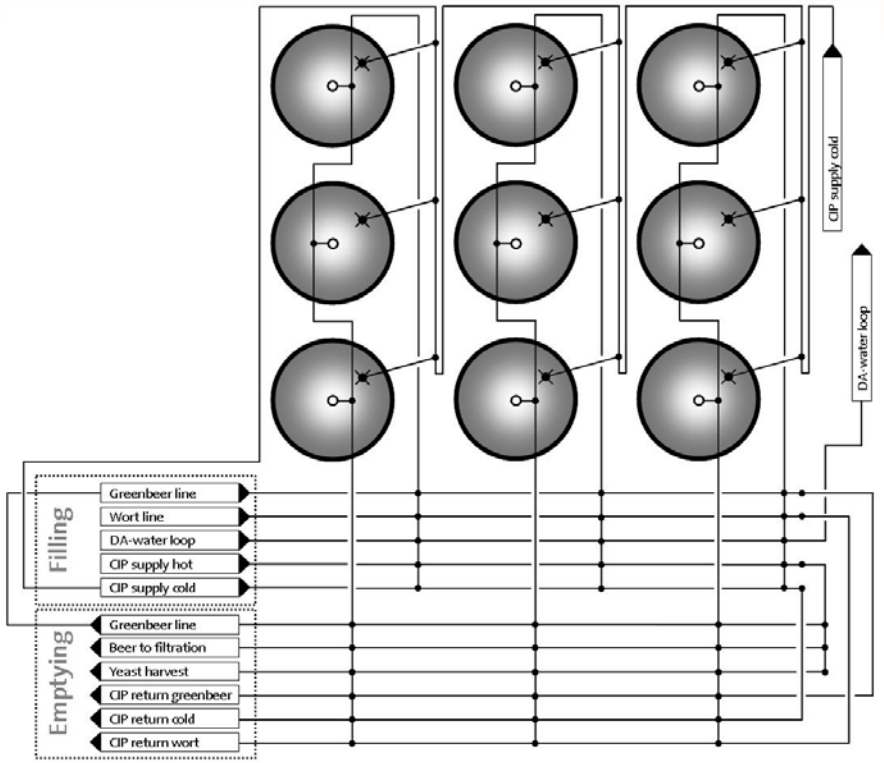
Connection of up to four tanks to one ring channel which in turn is connected to the main lines via double seat valves

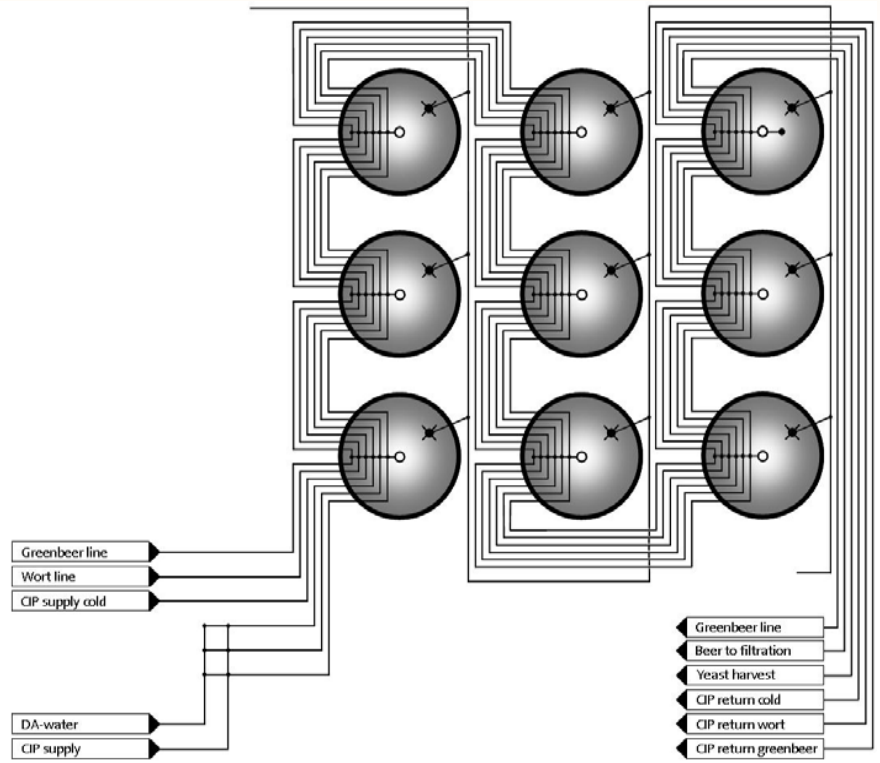
Required number of pipes and valves reduced by up to 30%

Required volume of water for displacement and cleaning agents reduced by up to 35% due to minimized pipe lengths



Intelligient Pipe Fence Design in the Cellar





Decentralised piping design

The short connection between the two valve blocks allows for savings to pipes, valves, cleaning media and displacement water

Linear piping design

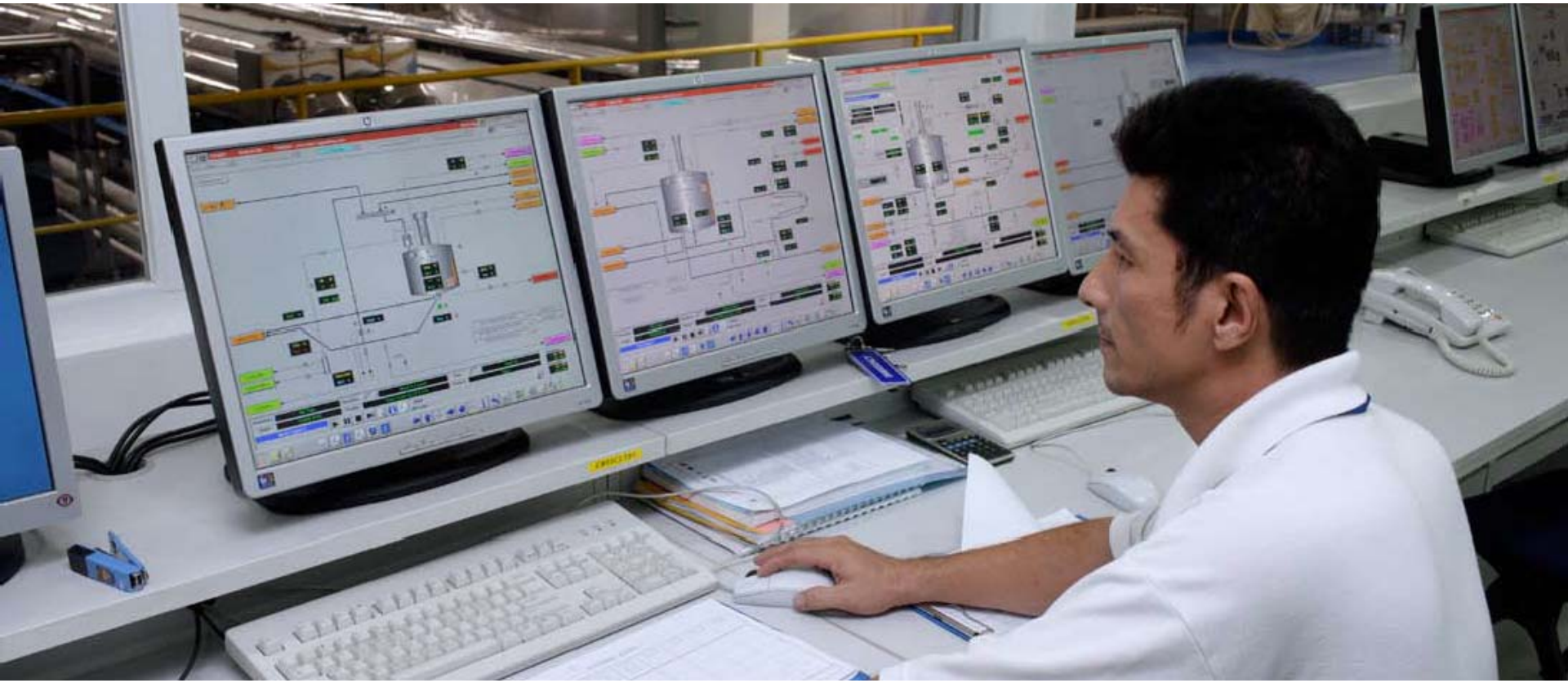
All pipes must be guided past all tanks. The amount of extra cost and work exponentially increases with each additional tank

Intelligient Pipe Fence Design in the Cellar

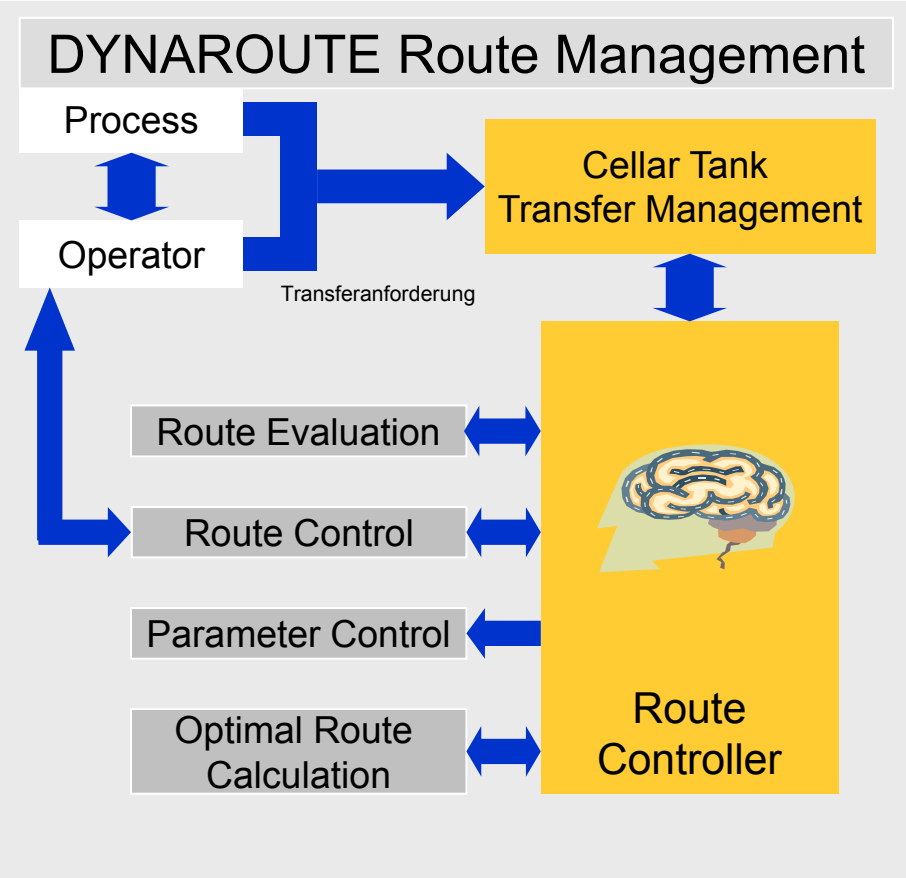
Material	Linear system	TwinPro	Saving %
Pipe system [m]	1404	1054	**25**
Bends	540	352	**35**
Double seat valves	132	89	**32**

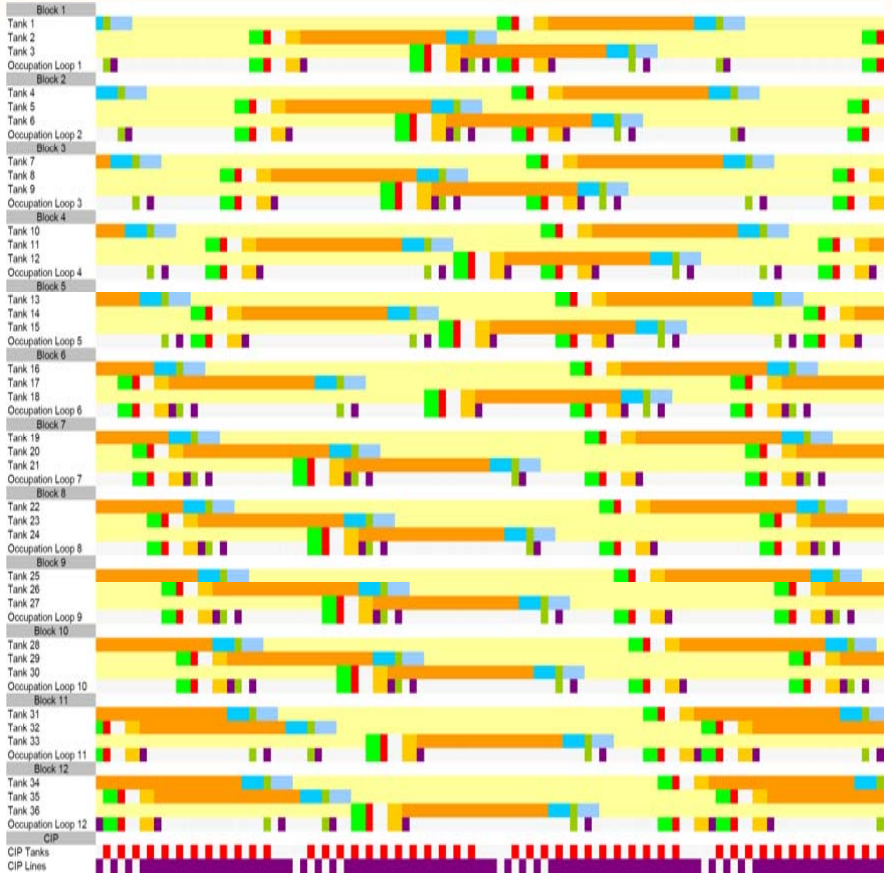
Push-out amounts	Linear system	TwinPro	Saving %
Wort line	9.2 hl	6.8 hl	
Beer feed pipe	9.2 hl	6.8 hl	
Yeast line	3.9 hl	5.4 hl	
CIP, product	18.4 hl	9.1 hl	
CIP yeast	7.8 hl	5.4 hl	
Total	48.5 hl	33.5 hl	**31**

Automation & Process Control



Process Control Automation in the Cellar



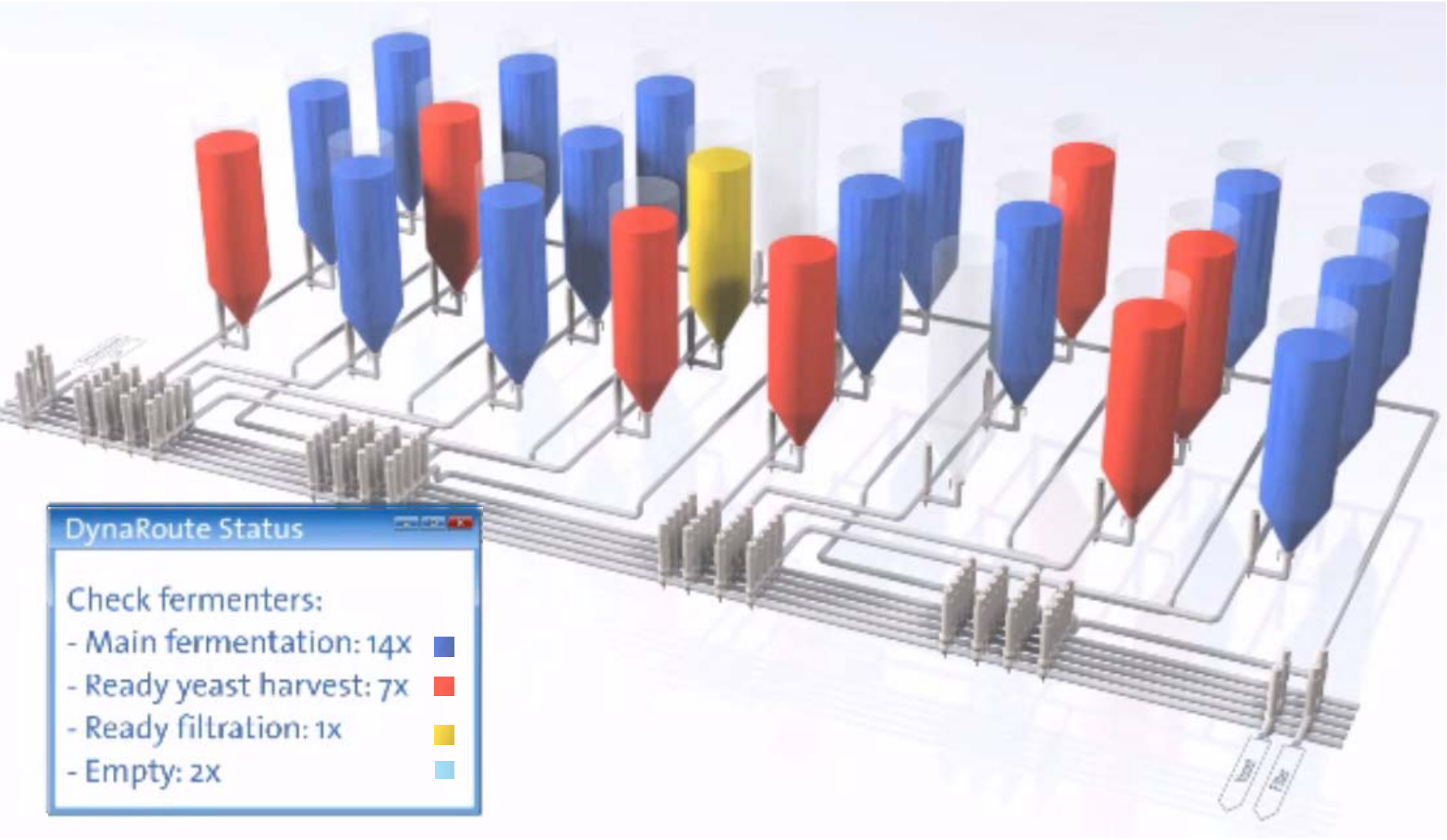


Filling
Main fermentation
Cooling 1
Yeast crop
Pipe cleaning
Cooling 2
Storage
Discharge
Tank cleaning
Waiting

PROCESS CONTROL AUTOMATION

Process Control Automation in the Cellar

GPS System for Cellar Operations



Process Control Automation in the Cellar

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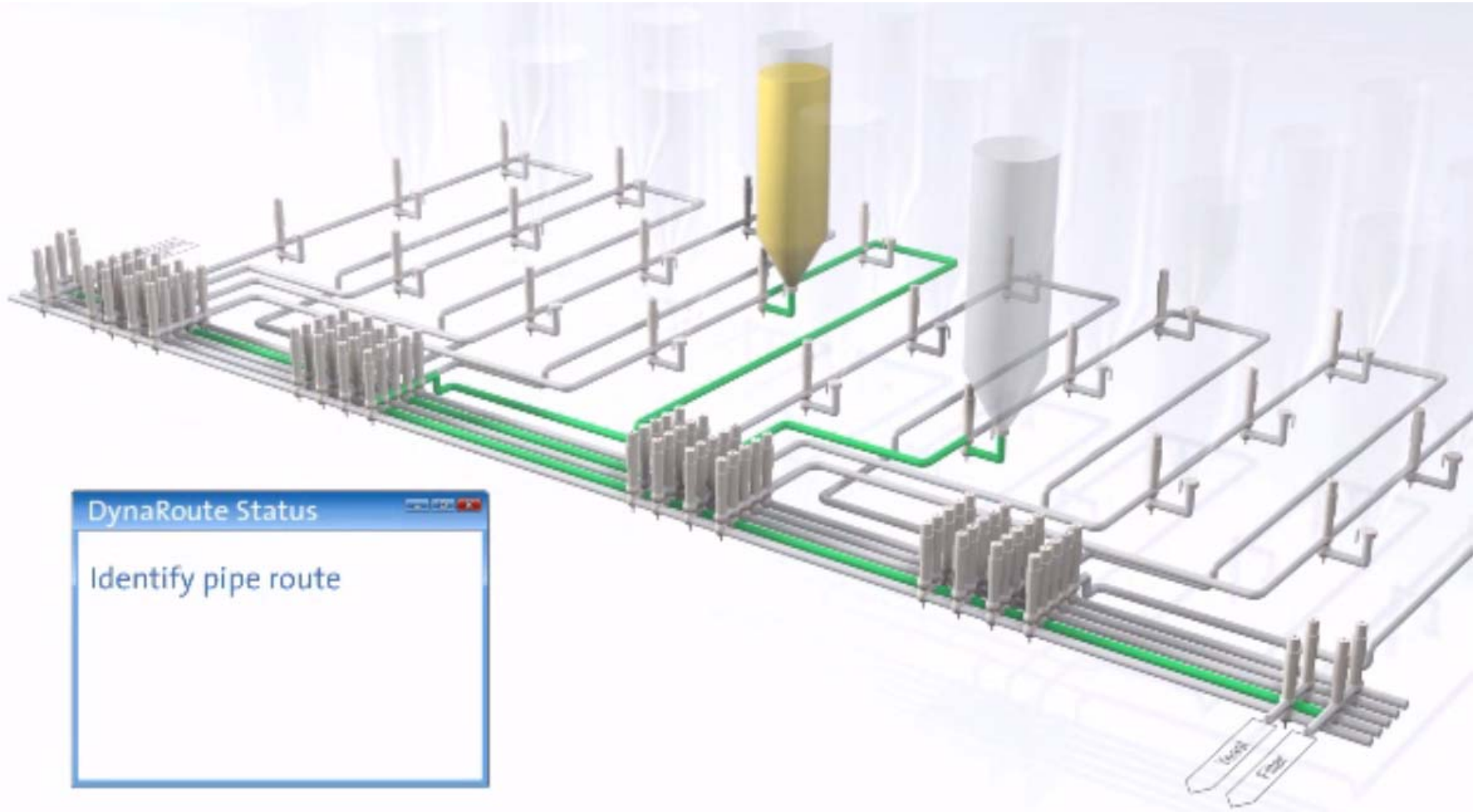
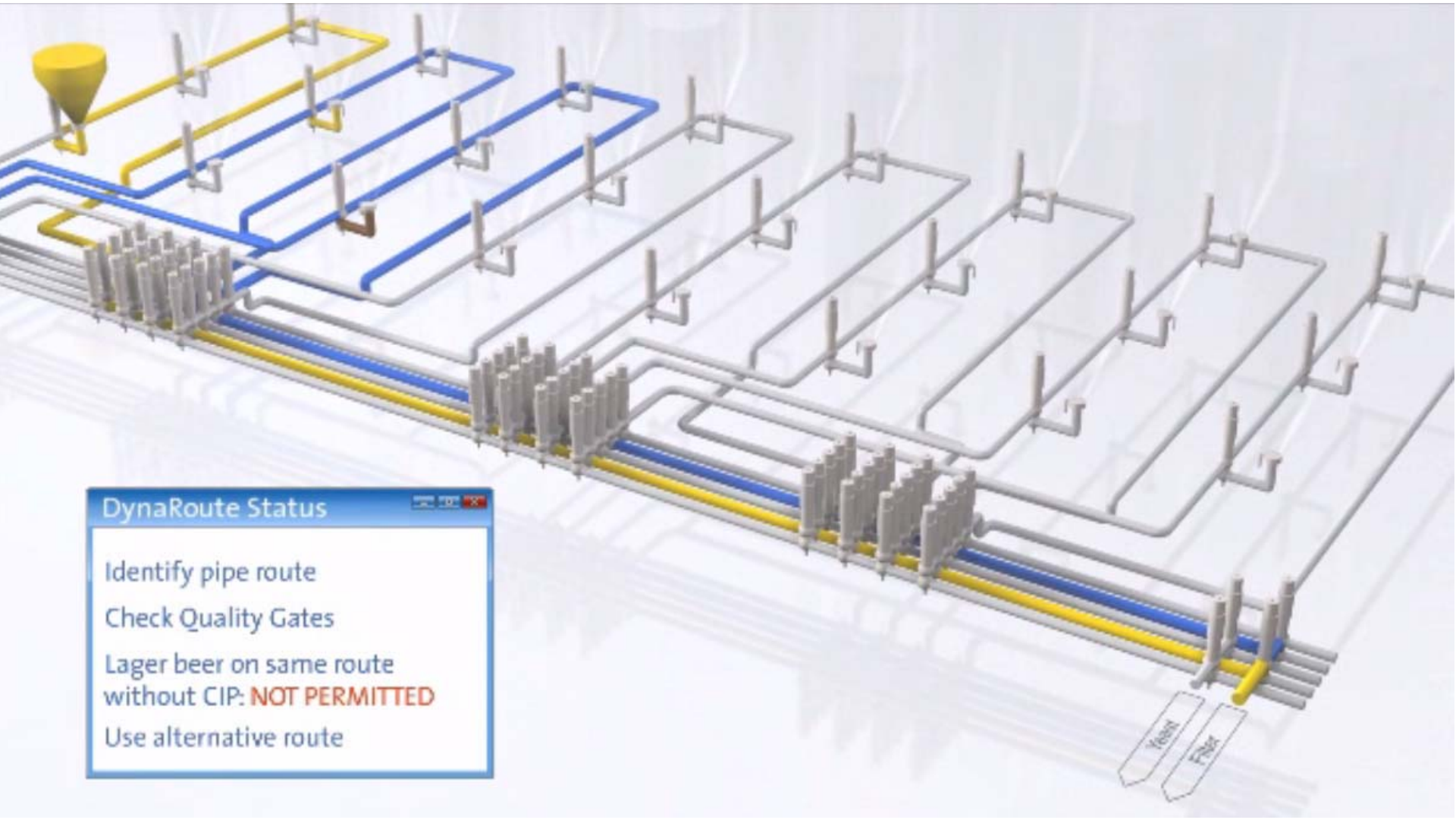


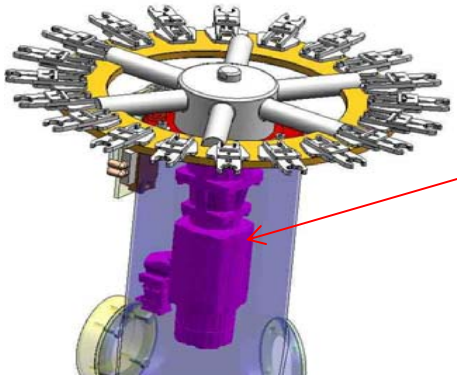
Process Control Automation in the Cellar

GPS System for Cellar Operations

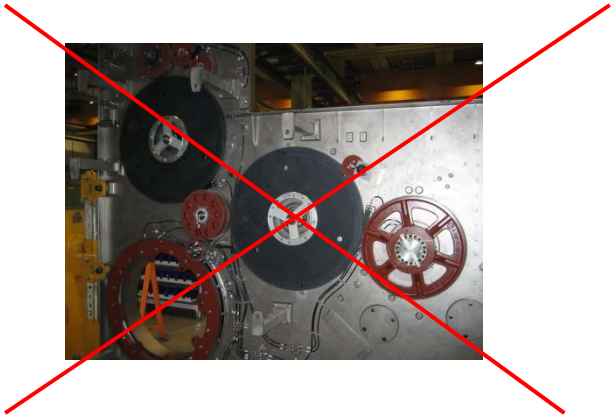


Filling & Packaging Technology

Filling & Packaging Technology

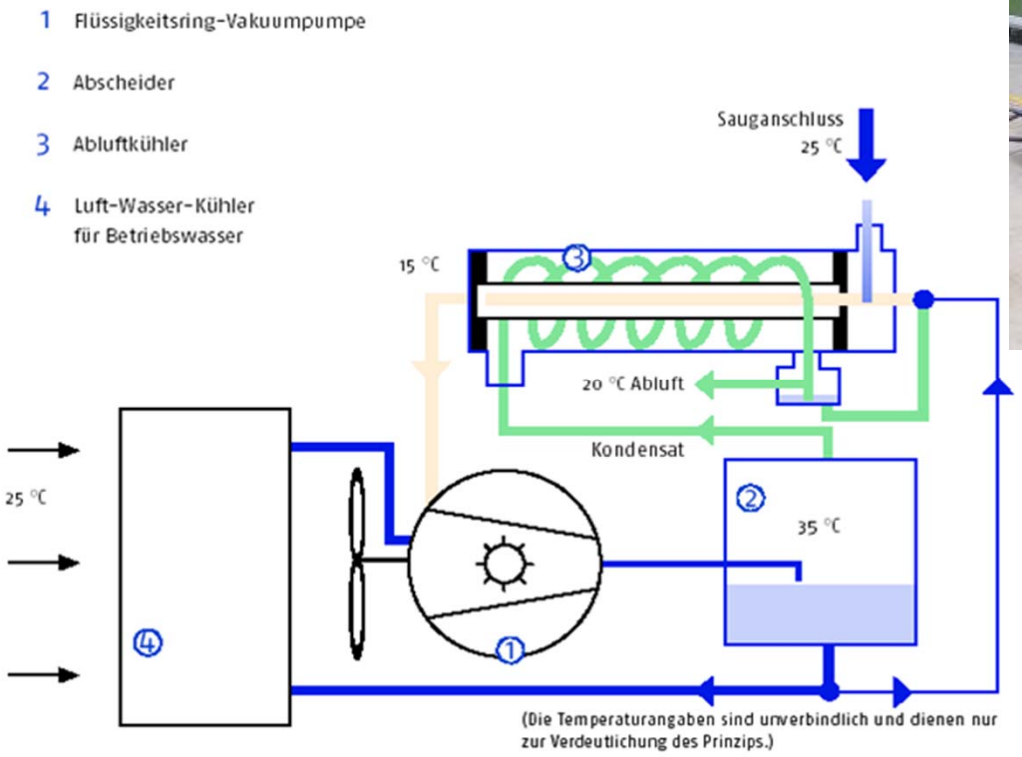


✓ Reduction of electrical consumption
- Use of servo technology
- No mechanical drive units
- Optimized motor sizes



Filling & Packaging Technology

- Operation with nearly no water
- Sealing water recirculation with cooling system



Filling & Packaging Technology

RINSER WATER RECLAIMED

Reclaimed water is filtered to 20 micron

Reuse it for bottle wash-off after the filler

Sustainable thinking

Zugspitze, Bavaria 2,962 m

Value
create value
together

Thanks for your attention!

KRONES