Reducing brewing water usage

Untapped potential for brewing process water savings – from brewhouse to packaging

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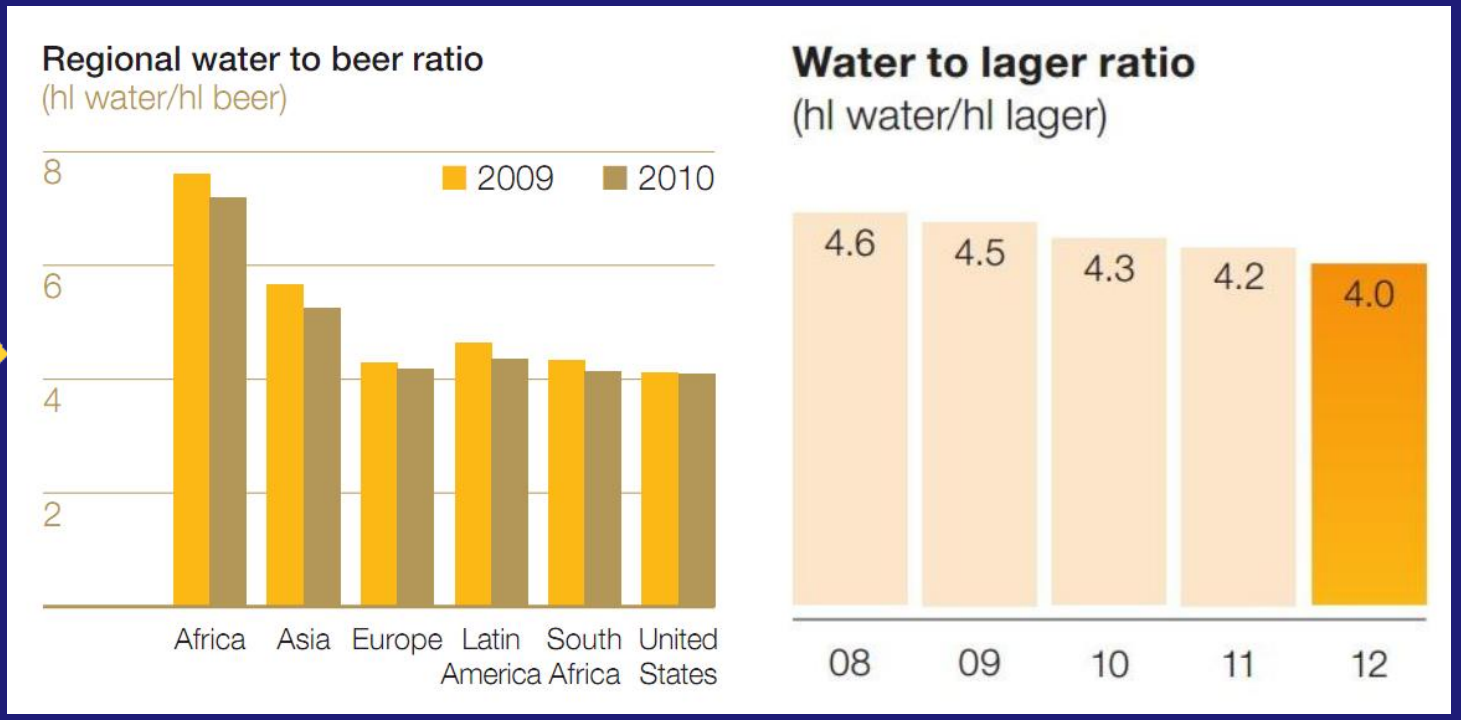
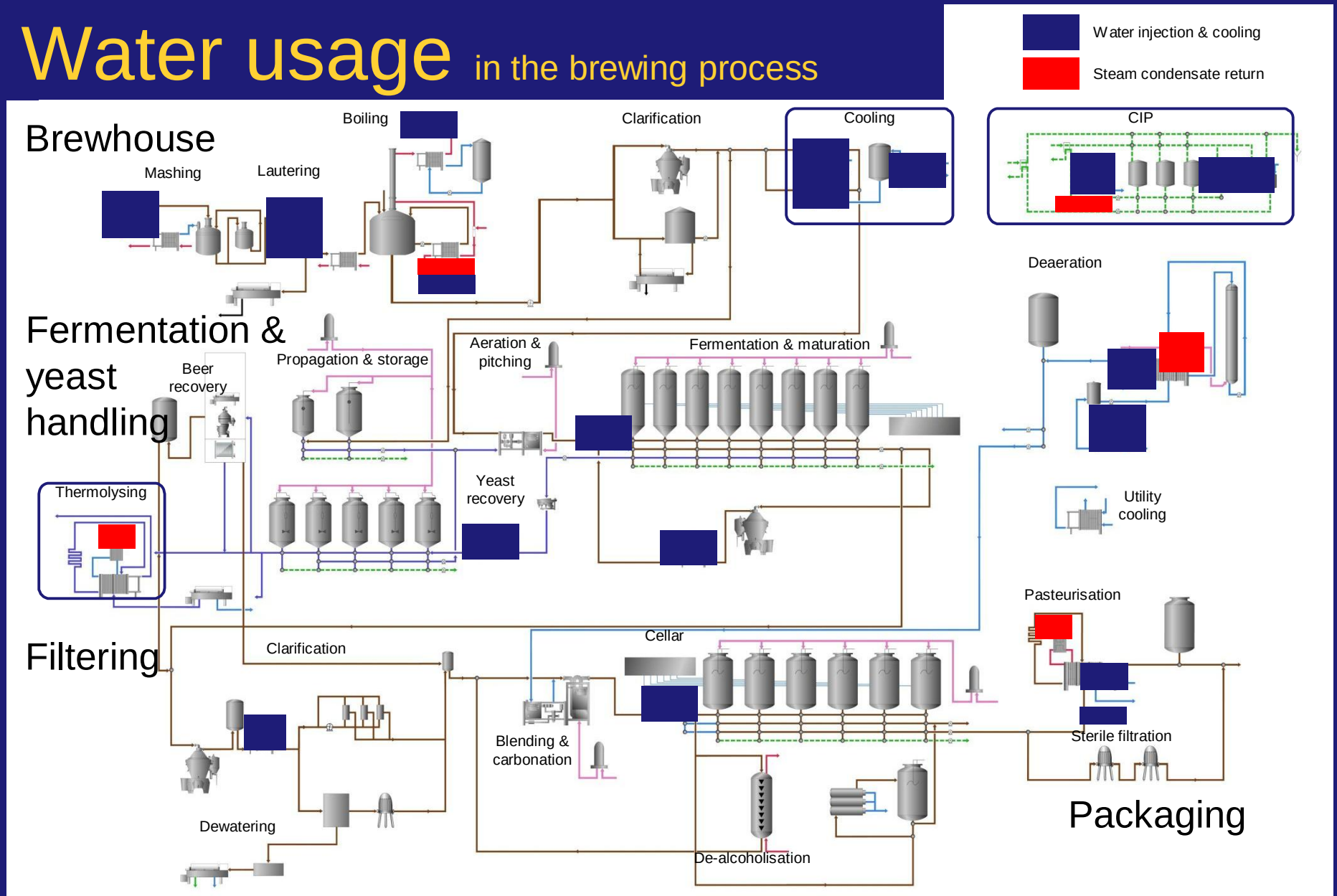
Brewing performance metric

hl water
per hl beer

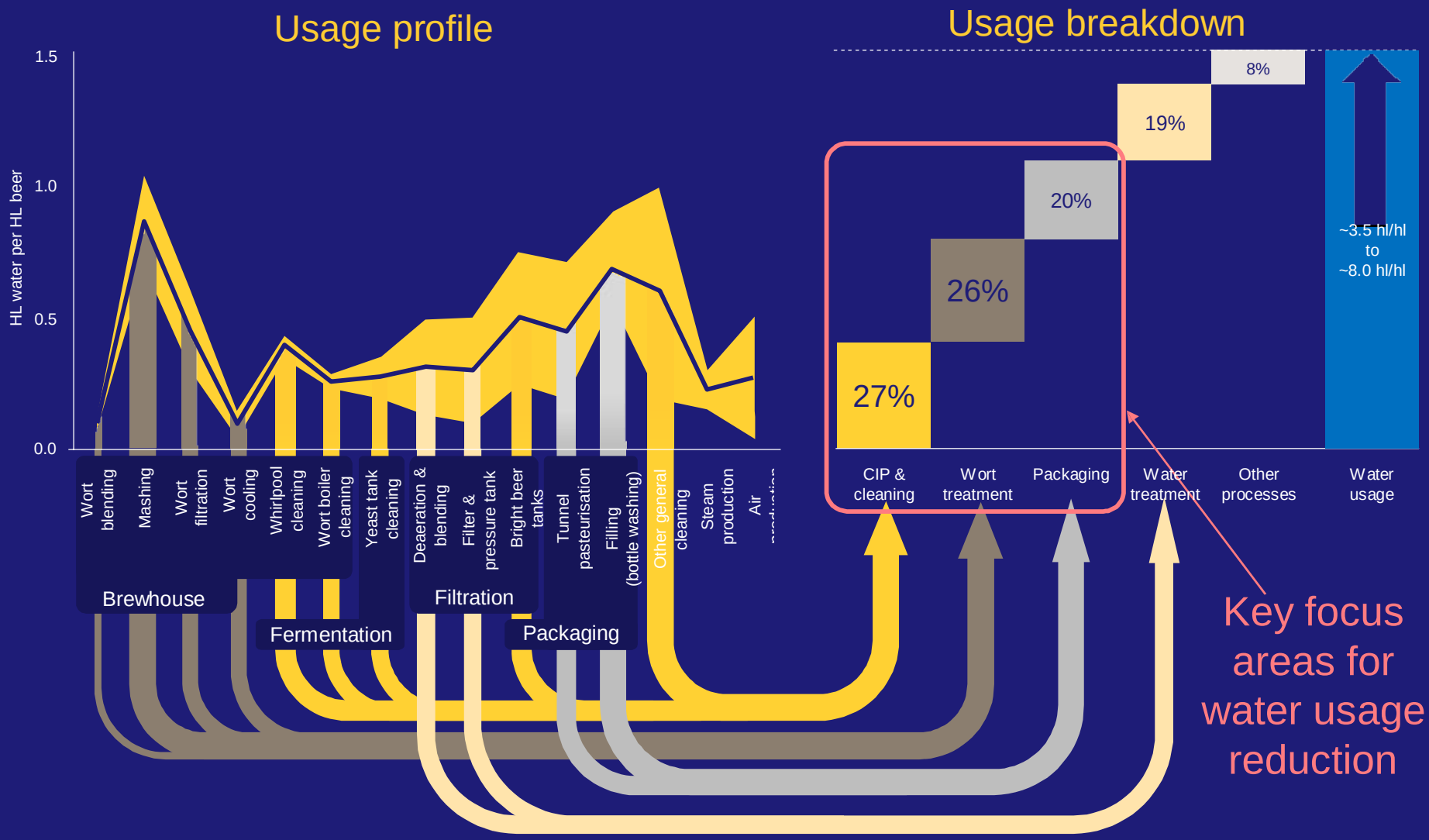


Cost per m^3 (including disposal)	2004	2012
Denmark	3.0 EUR	~7.0 EUR
Ghana	0.5 USD	1.0 USD

Water usage in the brewing process



Water usage in the brewing process



Three types of water reduction

Equipment

Large batches

- Fewer tanks
- Less chase pre-run water

  But …
  small batches?
  Filling times?

Process

Wort recovery

- Increased yield
- Minimise trub loss

Behaviour

Cleaning

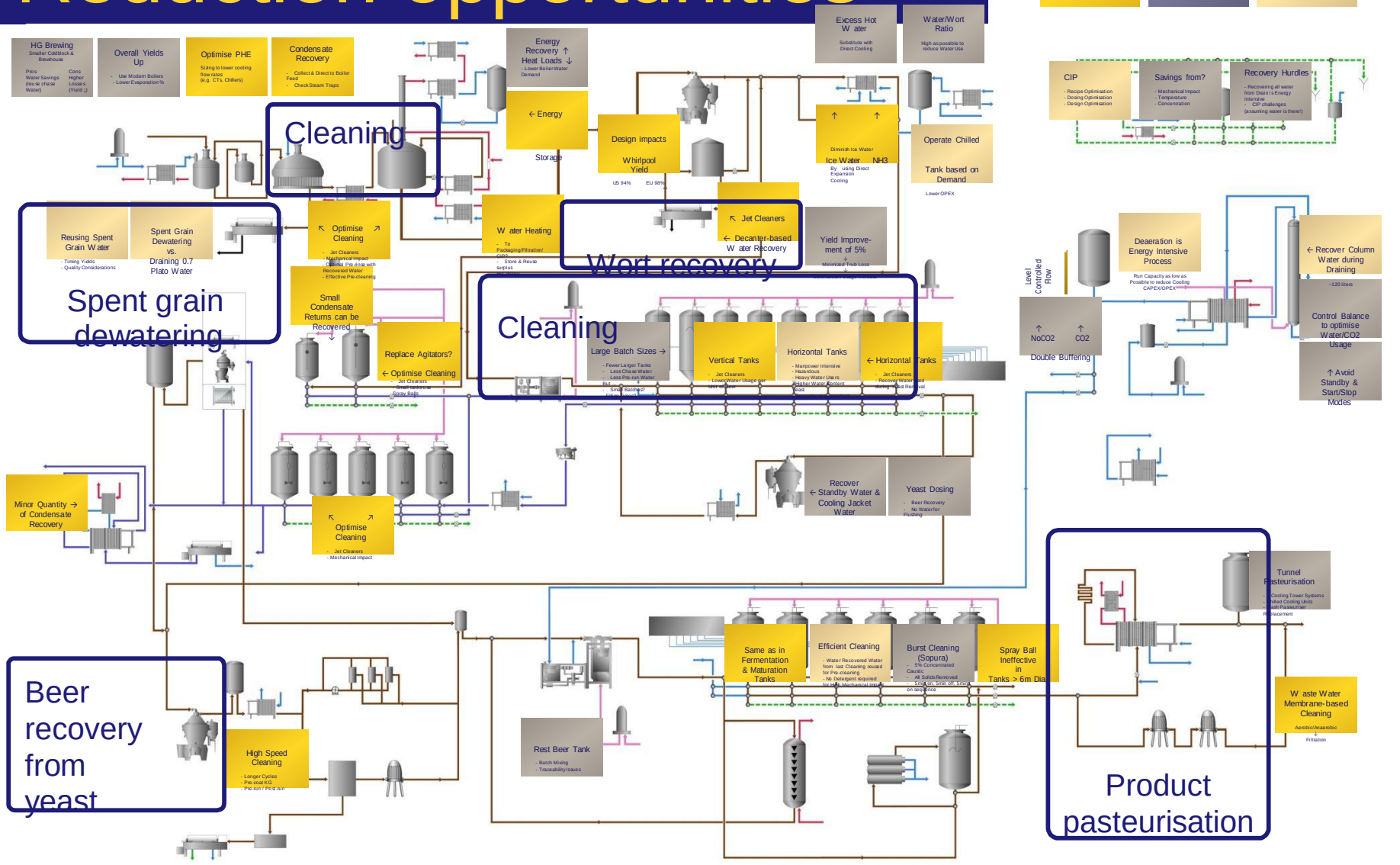
- CIP recipes

  Knowledge of recipes

- Manpower intensive

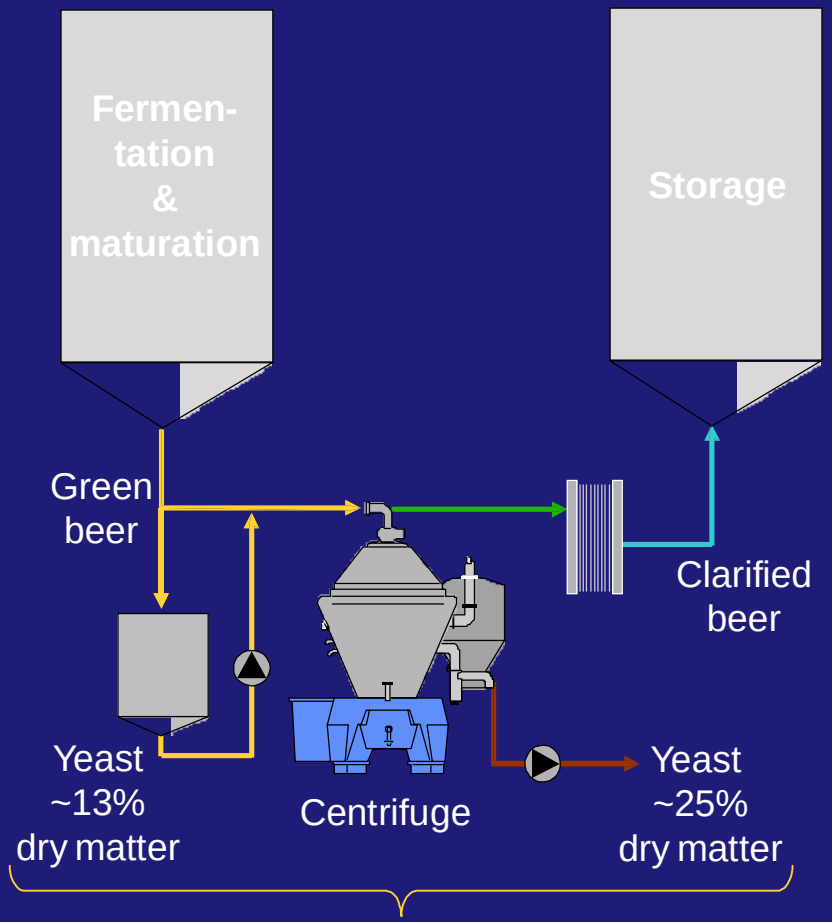
  General washdowns

Reduction opportunities



Beer recovery from yeast

Beer recovery from yeast



Efficient high-speed separation

- Single-pass dewatering
  From 13% up to 25% yeast dry matter
- Beer traceability maintained
  No mixing between brews
- Hygienic design
  Low DO pick-up

Benefits

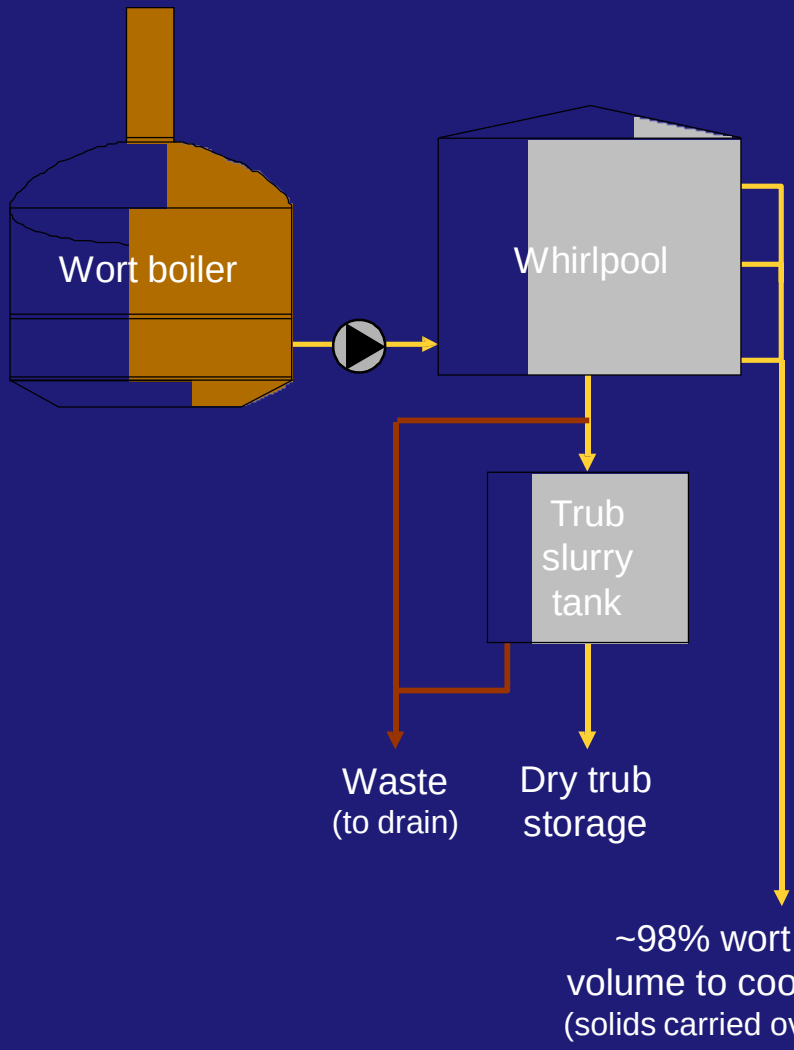
- Increased beer yield
  Up to 2% higher yield from same yeast and water input
- Decreased thermal loads
  Minimised yeast thermolysation requirement

KPI improvement

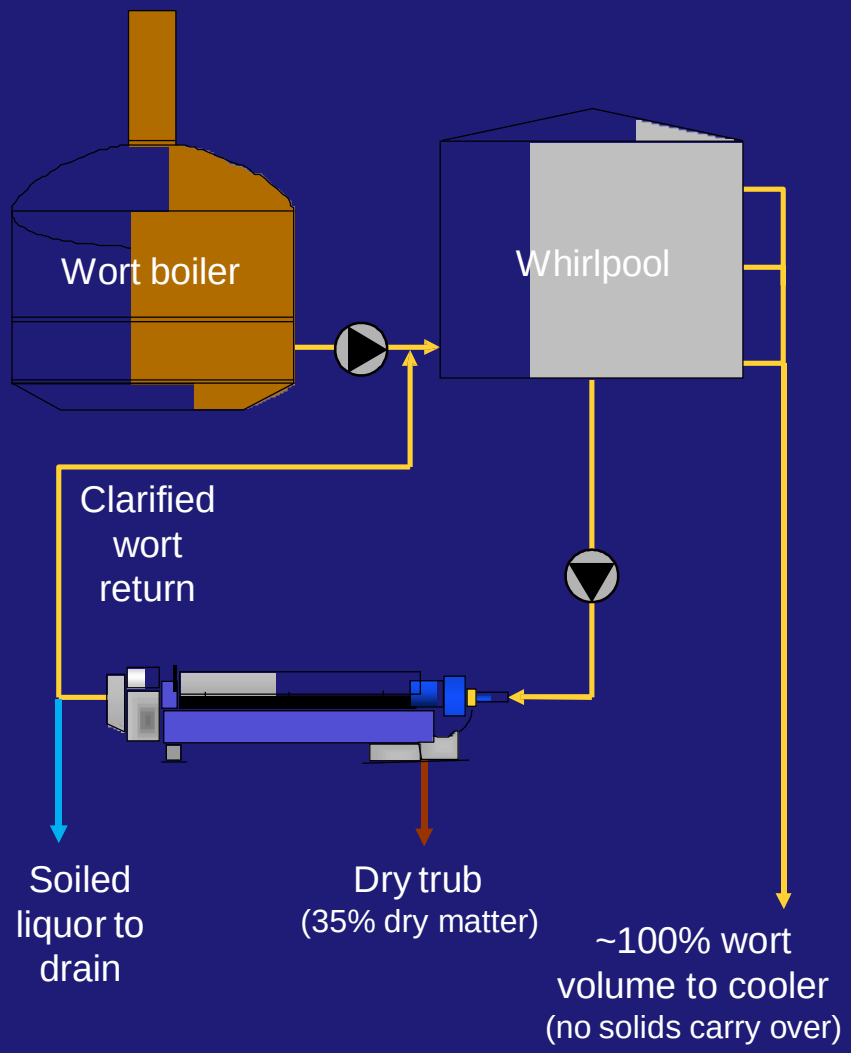
- 0.06 hl/hl (water/beer) reduction
- < 1 year payback period
  Including impact of recovered beer from 2.5 M hl HGB production, € 100 k investment

Wort recovery

Wort recovery from whirlpool bottom



Wort recovery from whirlpool bottom



Effective wort clarification

- ~100% wort to cooling phase
  No solids carry over

Benefits

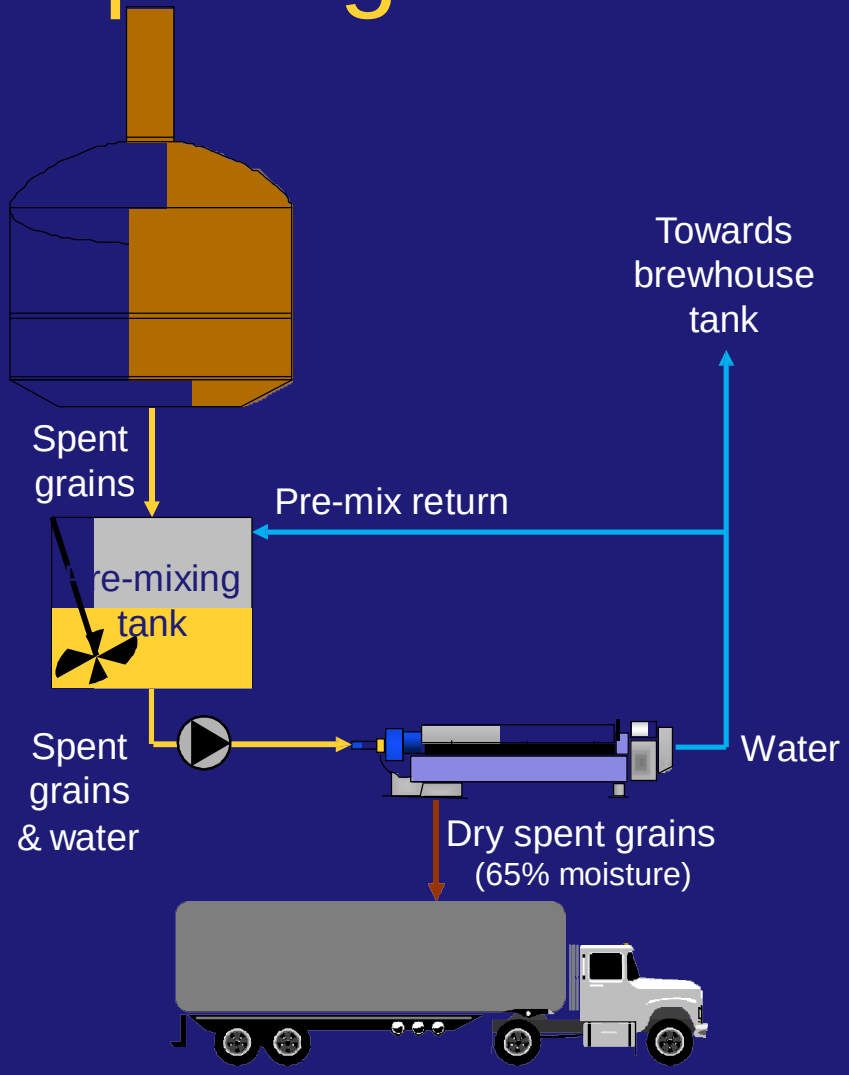
- Negligible wort loss (less than 0.1%)
  Lower brew costs (on the order of € 80/brew)
- Water-in-wort retention
  Decreased water demand (~14 hl/brew)
- No trub rinsing or flushing
  Reduced water for cleaning (~2,000 hl/week)
- Low moisture content trub
  35% dry matter → Higher value (added to spent grain)
  Added to grain → No disposal cost (~200 loads/year)

KPI improvement

- 0.06 hl/hl (water/beer) reduction
- < 1 year payback period
  Including impact of wort retention from 2,800 brews/year, € 250 k investment

Spent grain dewatering

Spent grain dewatering



Efficient high-speed grain drying

- Moisture content down from 85% to 65%

Benefits

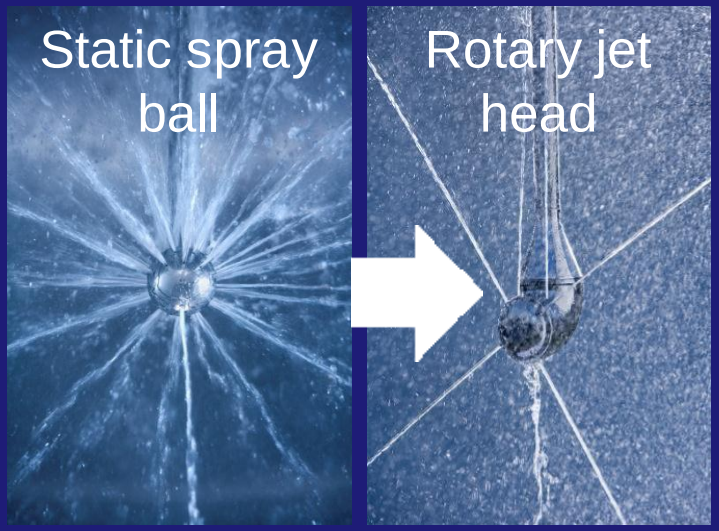
- Recovered water for pre-mix flushing
  Less water demand (on the order of 30 hl/hr)
- Low moisture content spent grains
  Compacted volume → Fewer transport loads
  65% dry matter → Higher value (as animal feed)

KPI improvement

- 0.05 hl/hl (water/beer) reduction
- < 3 year payback period
  Based on 6,750 hours/year, €180k investment

Improved tank cleaning

Improved tank cleaning Fermentation Tank



High-impact cleaning (rotary jet head)

- Use pre-rinse for residue removal
- Direct strikes fill/yeast band level

Benefits

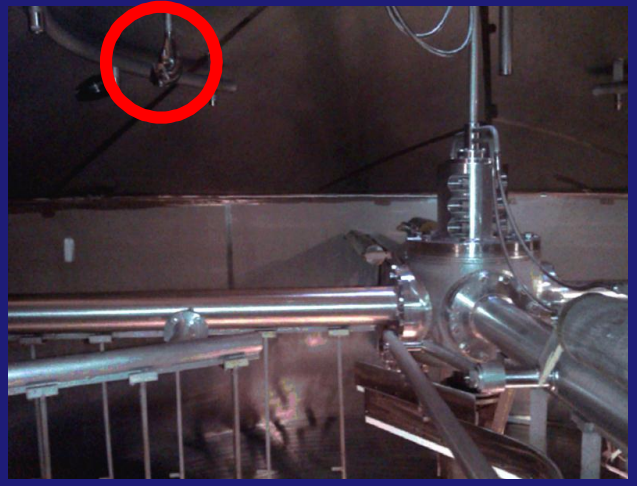
- Lower flow, same cleaning effect
  Vis-à-vis spray ball (~16 m^3/hr vs. ~60 m^3/hr)
- Shorter CIP cycles
  Vis-à-vis spray ball (~60 min vs. ~100 min)
- 360º coverage
  No areas left untreated
- Direct impact to vessel cone surface
  Effective residue removal

KPI improvement

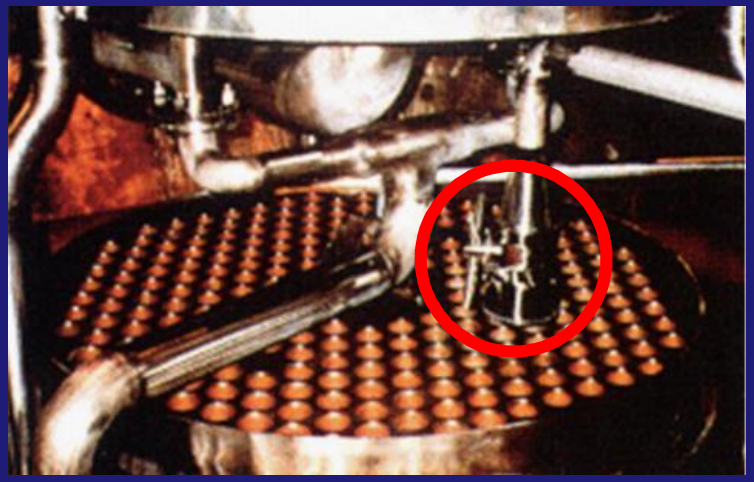
- 0.014 hl/hl (water/beer) reduction
- < 2 year payback period
  Based on 3 CIPs/month, € 5 k investment

Improved tank cleaning Brewhouse

Lauter tun



Wort kettle



Benefits
(vs. spray ball)

Excellent cleaning
- At raking arms
- Under false bottom
- Rules out manual cleaning

Effective cleaning
- “Hard-to-reach” internals
- Prevalence of spray balls (large flows, strong CIP)

KPI improvement
(vs. spray ball)

0.002 hl/hl
< 1.5 year payback period
(€ 11 k investment)

0.0005 hl/hl
< 1 year payback period
(€ 17 k investment)

Optimised product pasteurisation

Optimised product pasteurisation Conversion

Tunnel pasteuriser

Flash pasteuriser

From post-fill to pre-fill pasteurisation

- Post-fill warmer required

Benefits (vs. tunnel)

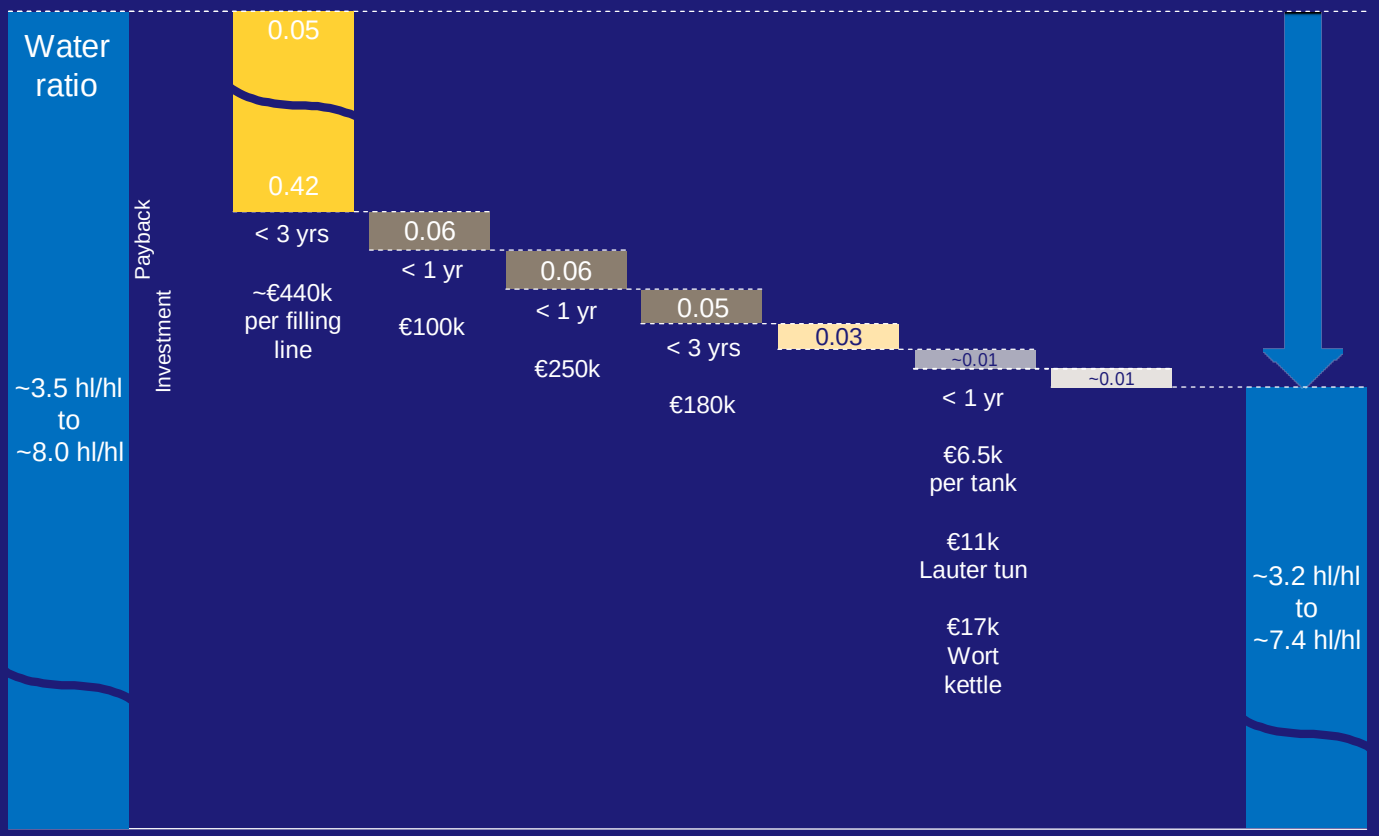
- Upgradeable
- Compact-footprint unit
  Flash ~50 m^2 (110 m^2 with warmer) vs. tunnel ~170 m^2
- Reduced steam requirement
  >110 kg steam/hr less per filling line (rated at 187 hl/hr)
- Minimised water usage
  From ~60 hl/hr down to ~3 hl/hr per filling line
- Lower overall operating costs
  Δ 155.3 k€

KPI improvement (vs. tunnel)

- 0.42 hl/hl (water/beer) reduction
- < 3 year payback period
  Based on € 434 k investment, incl. warmer
  (€ 50 k tunnel resale value)

Summary

Aggregate water reduction



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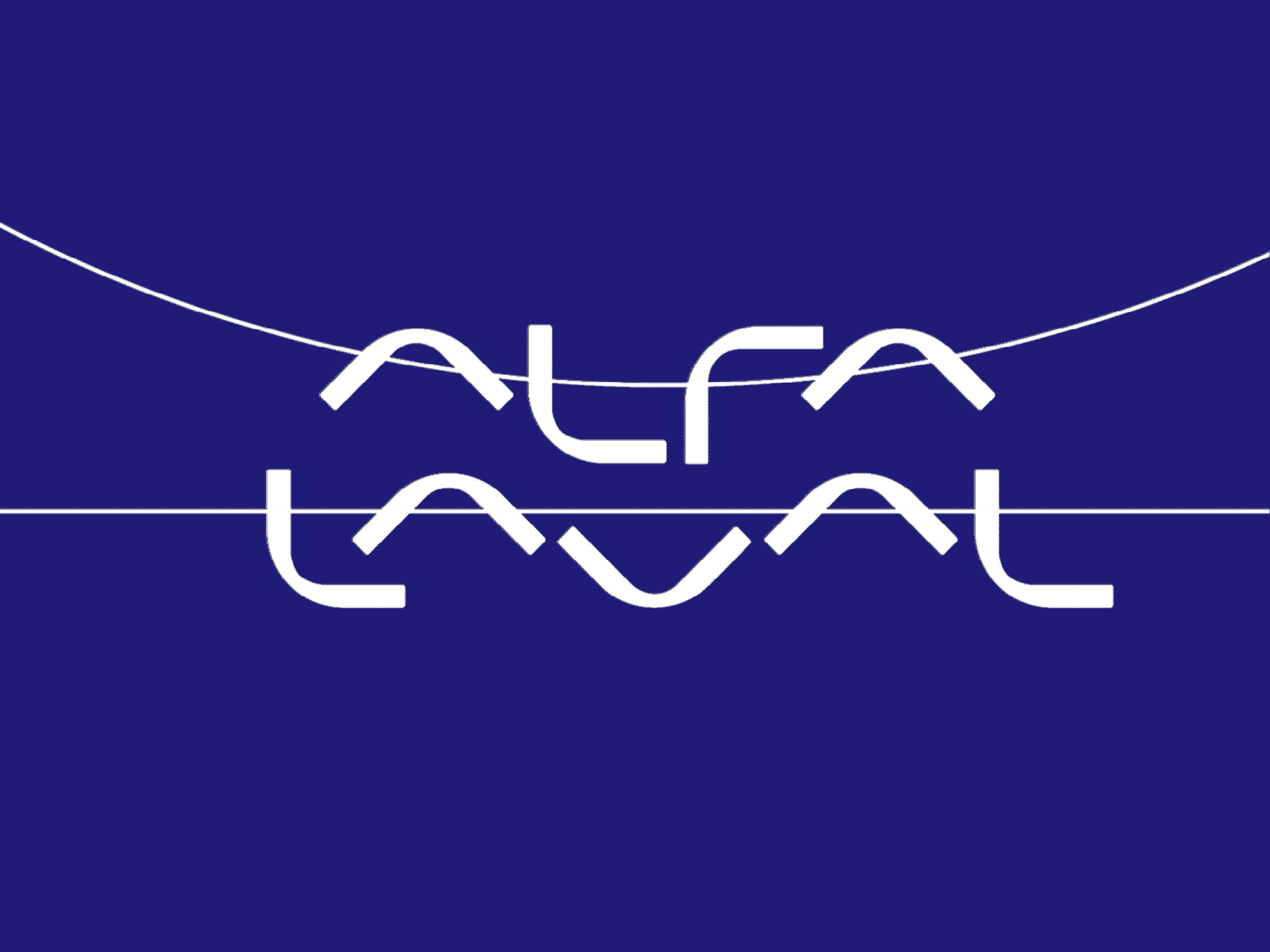
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Appendix A Brewery size assumptions and utilities costs

Parameter	Value	Unit	Notes:
Brewing Capacity	2.5	mill. hl/year	
Brew Size	600	hl	
Brews per Day	10		Brews done 280 days/year
High Gravity Target	15^{o}	Plato	
Sales Gravity Target	10^{o}	Plato	Approximate for 5% beer, dilution ratio of 1:2 (beer:water)
No. of Lines	1		
No. of Fermenters	24		3000 hl net per fermentation
Fermentation Time	10 to 12	days	
No. of Maturation Vessels	20		
Storage Time	9	days	
No. of Filtration Lines	1		
Filtration Frequency	2	batches/day	
Filtration Capacity	4000	hl	
Pre- Post-ramp Tanks	Yes		
No. of Bright Beer Tanks	10		1500 hl tanks
Storage Time	10	hours	
No. of Filling Lines	3		Rated at 187 hl/h per line
Tunnel/Flash Capacity	45000	BPH	Tunnel pasteurisers with water buffer systems
Container Type	Bottle		
Container Volume	355	ml	
Packaging Efficiency	77.3%		Based on 7.5 hours/8-hour shift, 3 shifts/day, 6 days/week, 50 weeks/year

Utilities Costs

Steam	0.08 €/kg
Water	3.0 €/m3
Electricity	0.1 €/kWh
Cooling	0.1 €/kWh
CO2	0.1 €/kg

Appendix B Water usage estimates

Sector	Usage	Process	Usage	Low	Medium	High	Low %	High %	Notes
Brewhouse	Wort Treatment	Wort Conditioning	0.10	0.08	0.10	0.12	2.2%	1.5%	Kunze, Wolfgang (2010), *Technology Brewing & Malting* (VLB, Berlin), p. 81: Wort treatment accounts for 27% of Kunze, p. 20: 100-130kg spent grains with 70-80% water content per HL beer
Brewhouse	Wort Treatment	Mashing	0.87	0.70	0.87	1.04	19.6%	12.8%	
Brewhouse	Wort Treatment	Wort Filtration	0.45	0.30	0.45	0.60	8.4%	7.4%	
Brewhouse	Wort Treatment	Wort Cooling	0.10	0.05	0.10	0.15	1.4%	1.8%	
Brewhouse	CIP & Cleaning	Whirlpool Cleaning	0.40	0.36	0.40	0.44	10.0%	5.4%	Kunze, p. 80: Brewhouse to fermentation cellar water use ranges from 1.8 to 2.2, with 30% for cleaning
Brewhouse	CIP & Cleaning	Wort Boiler Cleaning	0.26	0.24	0.26	0.29	6.6%	3.6%	Assuming the wort boiler needs 33% less water than the whirlpool
Fermentation & Yeast Handling	CIP & Cleaning	Yeast Tank Cleaning	0.28	0.20	0.28	0.35	5.6%	4.3%	
Filtering	Water Treament	Deareation & Blending	0.31	0.13	0.31	0.49	3.6%	6.0%	Based on remainder of bottle filling figures from Kunze (p. 80) minus simulation values for packaging
Filtering	Water Treament	Filter & Pressure Tank	0.30	0.10	0.30	0.50	2.8%	6.1%	Kunze, p. 80.
Filtering	Water Treament	Bright Beer Tanks	0.50	0.25	0.50	0.75	7.0%	9.2%	Kunze, p. 80: Overall range based on 47% of total for the storage cellar and filter & pressure tank room
Packaging	Packaging	Tunnel Pasteurisation	0.45	0.20	0.44	0.71	5.6%	8.7%	Based on 3x45,000 BPH (355ml) filling lines with varying prodution efficiencies; 20C cooling water
Packaging	Packaging	Filling (Bottle Washing)	0.69	0.57	0.59	0.90	16.0%	11.1%	Estimated using Kunze, p. 634, based on 3 filling lines
Other Processes	CIP & Cleaning	Other General Cleaning	0.60	0.20	0.60	1.00	5.6%	12.3%	Kunze, p. 80.
Other Processes	Other Processes	Steam Production	0.23	0.16	0.23	0.30	4.5%	3.7%	Kunze, p. 80.
Other Processes	Other Processes	Air Production	0.27	0.04	0.27	0.50	1.1%	6.1%	Kunze, p. 80.
		Total Consumption	5.80	3.57	5.69	8.13			
		Reference Point	5.10	Medium Sized Brewery (0.5 to 5 million hl/year)					