Water and energy to whisky: What is the eco-efficiency of heat recovery in distilleries?

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Introduction: whisky, water, energy

- Over 400 distilleries in the United Kingdom (UK), 134 Scotch whisky distilleries
- 90% micro-distilleries
- Scotch whisky: Energy requirements met predominantly through fossil fuels (80% in 2016); goal: net zero by 2045
- Scotland: 70% of all licensed water abstractions in industry and commerce for distilleries, of which 80% for cooling water (in 2017)
- **But: Heat recovery potential in distilleries largely untapped**

What are pros and cons for heat recovery, environmentally and financially?

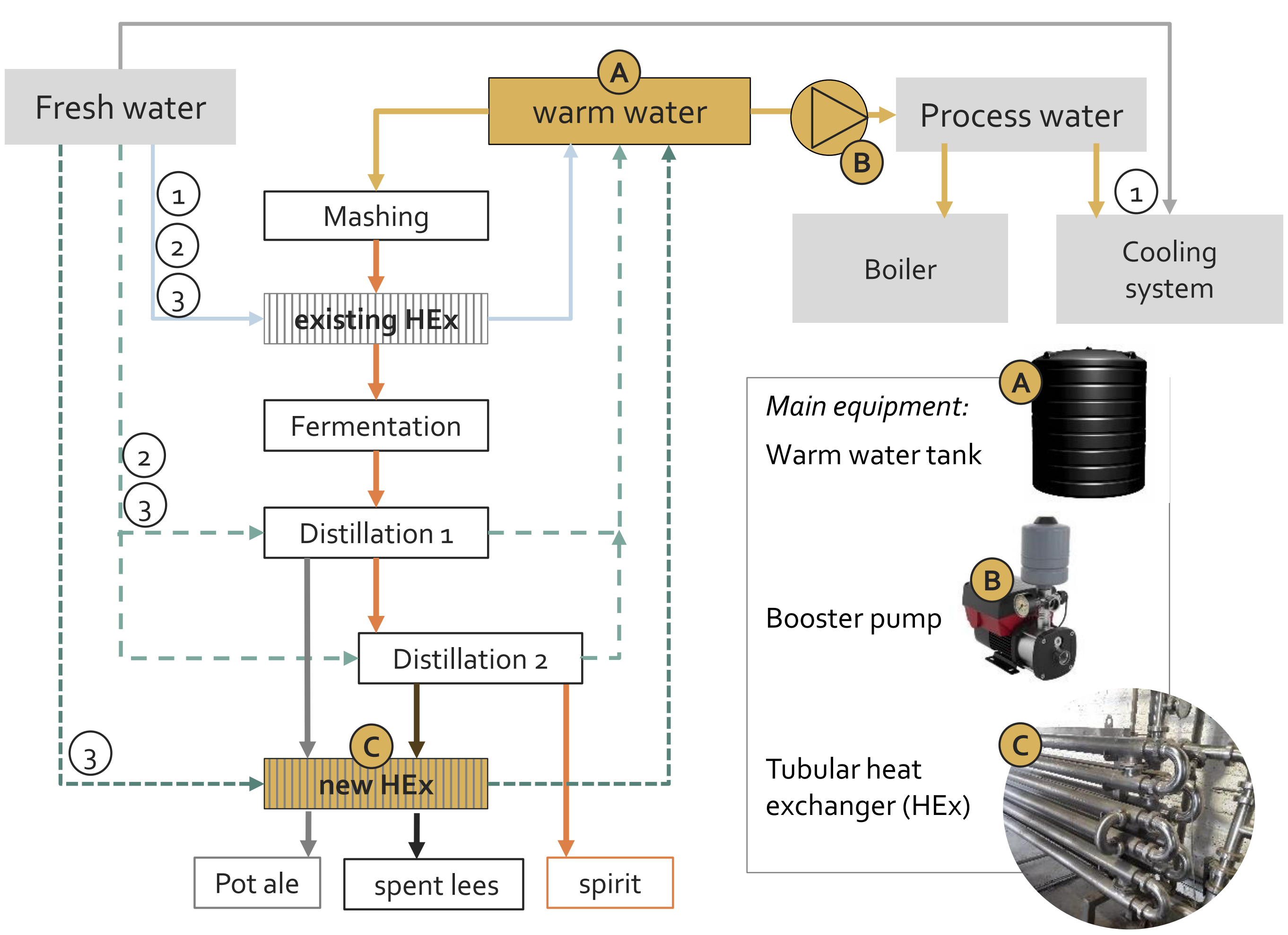
The case study: Arbikie, micro-distillery, Scotch whisky

https://www.arbikie.com/field-to-bottle

The case study: Arbikie, micro-distillery, Scotch whisky

3 heat recovery configurations:

1. From mashing
2. From mashing + distillations
3. From mashing + distillations + by-products



The case study: Arbikie, micro-distillery, Scotch whisky

2 production schedules:

A

2 mashes/day

B

3 mashes/day

> More efficient water and energy use

Methodology

Water and energy consumption for production of 1 litre pure alcohol (LPA) (FU):

Water

Fuel (diesel)

Electricity (grid)

Heat recovery equipment:

Tank (MDPE)

Pipework

Pump

Heat exchanger (stainless steel)

LCA

Climate Change (CC)
Water Scarcity Footprint (WSF)

Financial assessment

- Operational costs: water + energy
- Investment costs: equipment

Methodology

Water and energy consumption for production of 1 litre pure alcohol (LPA) (FU):

- Water
- Fuel (diesel)
- Electricity (grid)

Heat recovery equipment:

- Tank (MDPE)
- Pipework
- Pump
- Heat exchanger (stainless steel)

20 year lifetime

Base case:
Current costs

Heat recovery cases:
Current costs – $PV_{savings}$ + investment

Financial assessment

- Operational costs: water + energy
- Investment costs: equipment

Results 1: inventory

Water scarcity: overflow returns to same water shed > does not affect scarcity

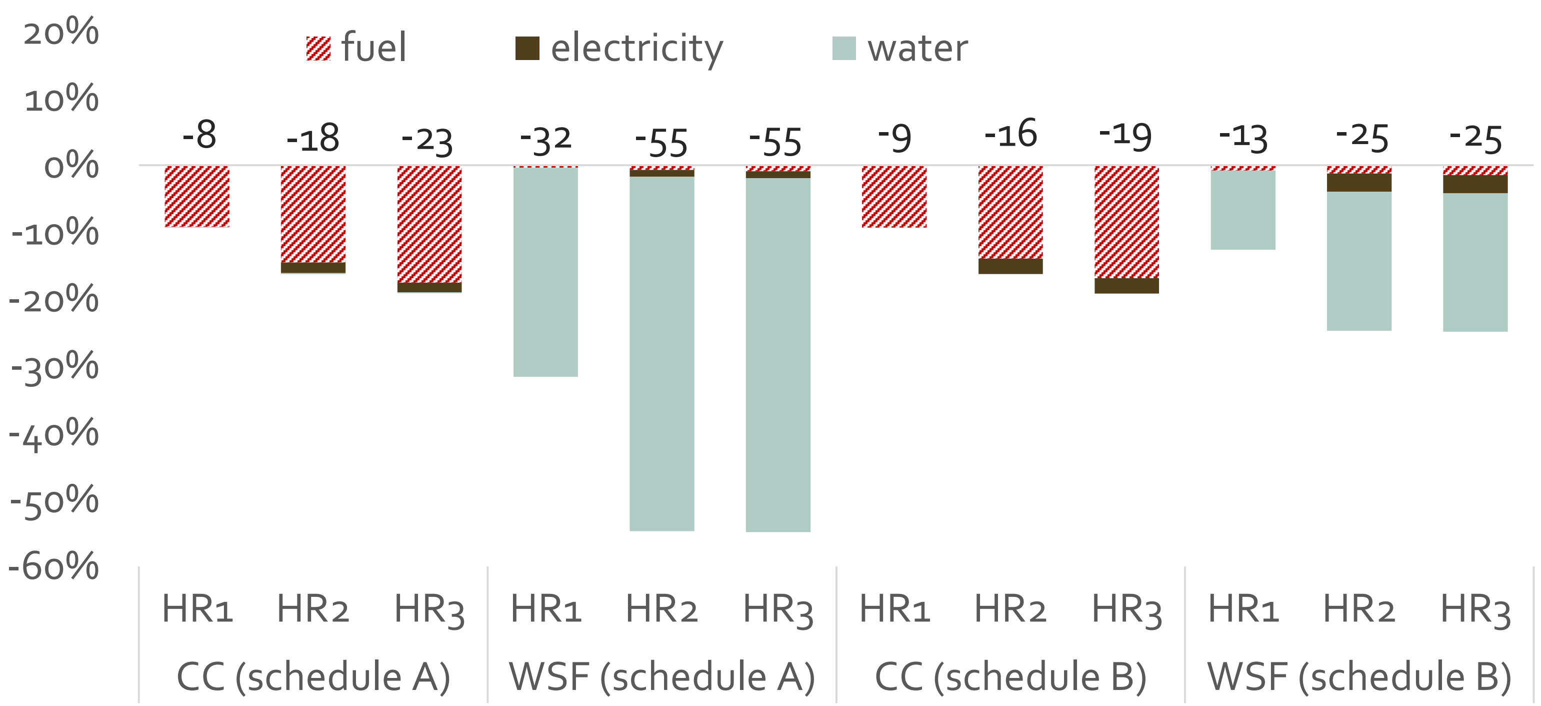
1. Inventory: Changes through heat recovery, compared to base case

	A1	A2	A3	B1	B2	B3
Fuel [%]	-10	-19	-25	-11	-17	-21
Electricity [%]	0	-11	-11	0	-13	-13
Water input [%]	-33	-57	-45	-12	+24	+70
Overflow [m3/year]	0	0	1406	226	2863	5484
Water scarcity [%]	-36	-61	-61	-18	-31	-31

- Energy savings throughout ☺
- But: higher water input required for heat recovery and/or overflow of pre-warmed water ☹
- necessity of water/heat sinks outside distillery!

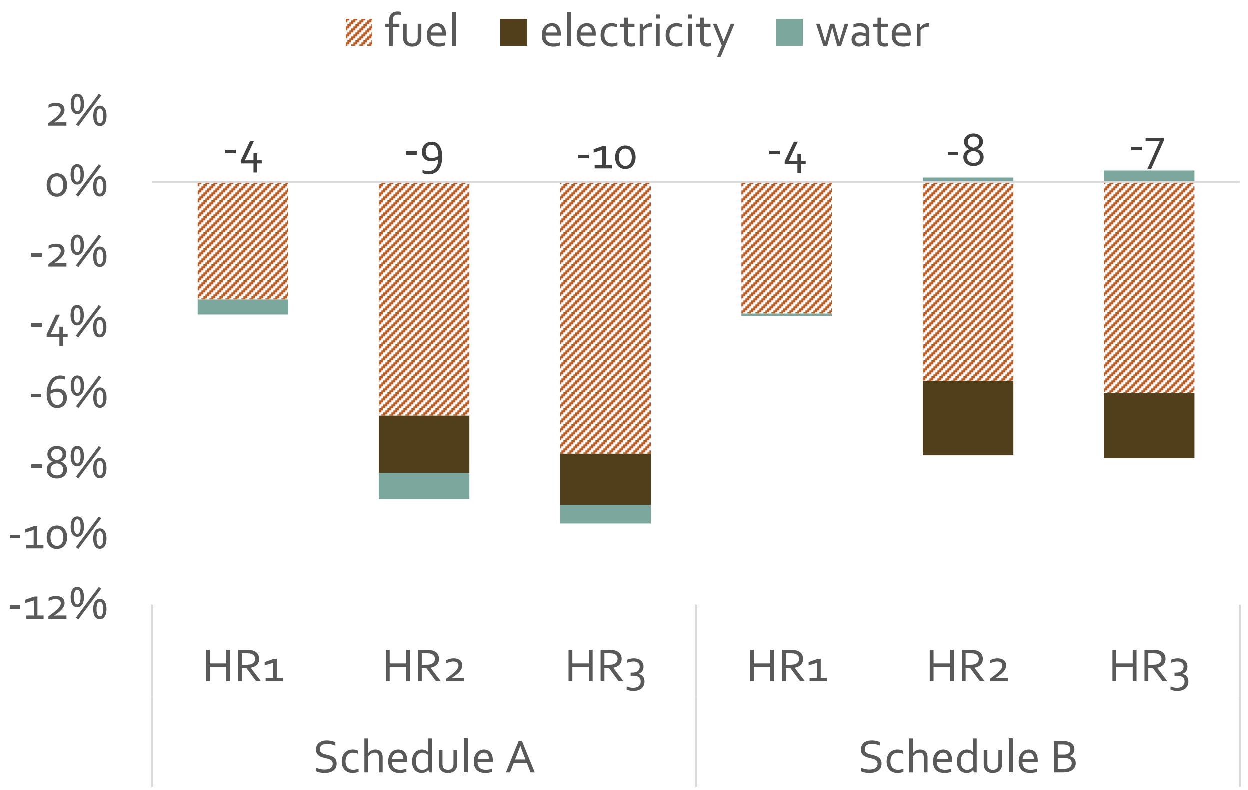
Results 2: LCA

2. LCA: Changes through heat recovery, compared to base case:



Results 3: Financial assessment

3. Costs: Changes through heat recovery, compared to base case:



Simple payback time: 0.5 to 1.8 years!

Results 4: Eco-efficiency

Eco-efficiency indicator:

$$EEI_{i,a} = \frac{impact_{i,a}}{\frac{1}{costs_a}}$$

Per impact category (CC, WSF), Per alternative

→ Relative scaling + averaging →

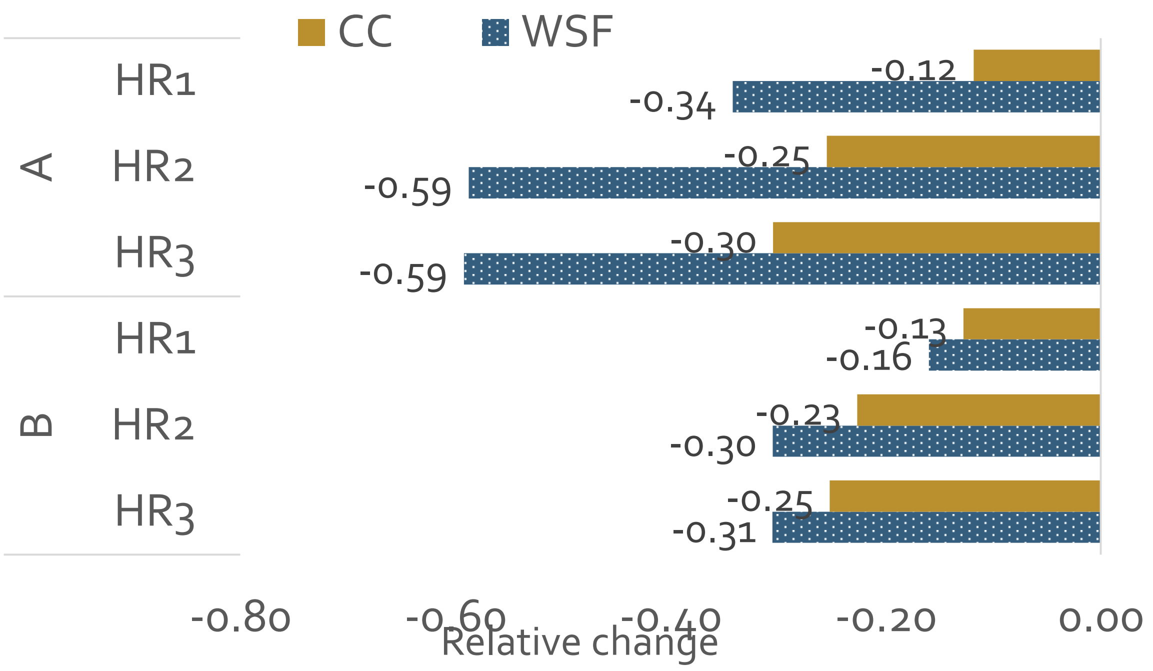
$$EE_a = \frac{\sum_i^I EEI_{i,a,norm}}{I}$$

Eco-efficiency score: Per alternative

a = alternative (base case or heat recovery configuration)
i = impact category

Results 4: Eco-efficiency

4. Eco-efficiency indicators: Changes through heat recovery, compared to base case:



Eco-efficiency scores:

	Base case	HR1	HR2	HR3
Schedule A	1.00	0.77	0.58	0.55
Schedule B	1.00	0.86	0.73	0.72

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Conclusion

- Heat recovery delivers benefits for climate change and water scarcity in all scenarios
- Heat recovery installations pay back quickly (max. 2 years)
- Issue: practicality of managing overflow
- Heat/water sinks outside distillery required
- Eco-efficiency shows: heat recovery from mashing, distillations and by-products desirable environmentally and financially

Thanks for your attention!

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