# Centralized or decentralized: what is the more sustainable choice? A case study on bread

## Perceived sustainability

One of the perceived sustainability improvements in food chains is to shift from centralized to decentralized. Thus, instead of processing on and distributing from one location, the raw or intermediate products are shipped and processed further on different locations, which also facilitates supply based on demand. This factsheet shows an environmental impact comparison of different scenarios; bread produced central, par-bake bread produced central followed by decentral final baking, bread produced at the decentral bakery and (decentral) home baked bread (Figure 1).

## The ACE calculator

*The ACE calculator provides **insights** in the effects of **interventions** on **sustainability** within **boundaries** of the food production and distribution chain.*

The calculator aids in quantification of the environmental sustainability impacts of food processing systems and is able to include a wide range of interventions. Possible interventions include alternative ingredient and sourcing, energy sources, packaging, processing and end-of-life options.

**Sustainability indicators**: $CO_2$-eq, energy, water

**Take home message**

The more sustainable choice can be made by quantifying sustainability indicators as water and energy consumption and greenhouse gas emissions. Here the Agro-Chain greenhouse gas Emissions (ACE) calculator was used to identify and prioritize these indicators. The central par-baked bread was slightly less sustainable than bread from the central or decentral bakery, due to the additional baking and freezing steps, which increased energy use. Home baked bread is more sustainable when baked in a bread baking machine than the three other routes or when an oven is used for baking.

**Main assumptions**

The functional unit is 1 kg of ready-to-eat bread, using the same recipe in all scenarios. Wheat flour is sourced from European-grown wheat and transported 100 km by truck from mill to bakery/retailer. The central scenarios require an extra 100 km for bread transport from bakery to retailer. The central and central par-bake scenarios differ in baking time and cooling process. Both chains have 2% factory loss. The decentral bakery has relatively higher energy use (smaller equipment) and no process losses. All three scenarios use natural gas for baking. Home baked bread is baked in an electric oven or bread baking machine. Plastic packaging is included except for decentral home. Bread losses in the factory and unsold bread go to animal feed. The assumptions are supported by scientific literature.

## Case study

Bread is the most important staple food in the Netherlands. Hence a sustainability improvement has a large effect.

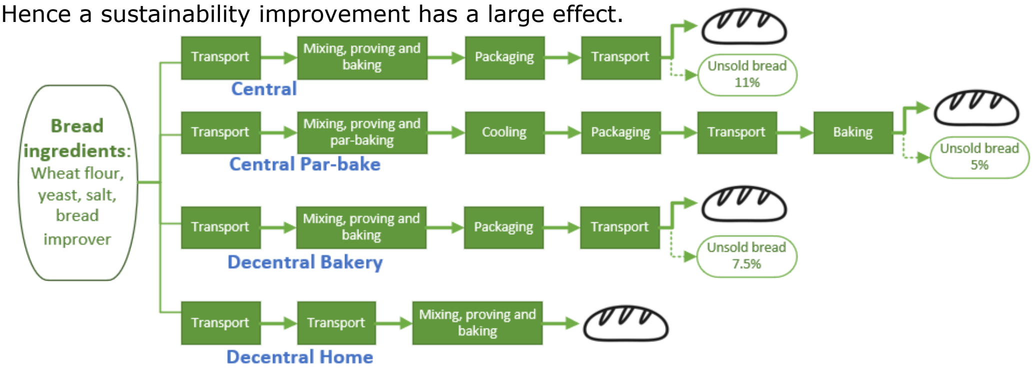


**Figure 1:** Processing steps in the different bread case scenarios.

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## Results

GHG emissions and energy use are shown in Figure 2 and 3. For the decentral home scenario, it is assumed that 50% of bread is baked in a bread baking machine and 50% in an electrical oven.

- Ingredients and processing have the largest contributions on GHG emissions and energy usage.
- Between scenarios, processing is mainly responsible for differences in GHG emissions and energy consumption. For example, central par-baking requires 18-34% more energy in processing than central and decentral bakeries.
- The GHG emissions of processing depend on the energy source used for baking. Decentral home uses electricity, while the other scenarios use natural gas. Natural gas has lower GHG emissions than (grey) electricity per MJ of energy.
- Higher unsold bread percentages lead to increased ingredient emissions due to more raw materials needed. In the central scenario (11% unsold bread), ingredient GHG emissions are 0.47 kg $CO_2$/kg bread, compared to 0.42 kg $CO_2$/kg in the decentral home scenario (no unsold bread). However, on the total emissions this difference is relatively small.
- Transport contributes less than 3.5% to GHG emissions and energy use, so it is not a key factor in choosing between centralized or decentralized systems in this case study.
- The central par-baked bread requires more energy due to the additional process steps (freezing and extra baking). On the overall picture, this has more impact than the energy saved by having less unsold bread (5% instead of 11%).
- The sustainability of home baking is largely determined by the equipment used: oven or bread baking machine (Figure 3B).

The water use of the bread cases is depicted in Figure 4.

- The ingredients are the main contributors to the water use. The differences observed between scenarios are related to the losses in the supply chain: processing losses and unsold bread.

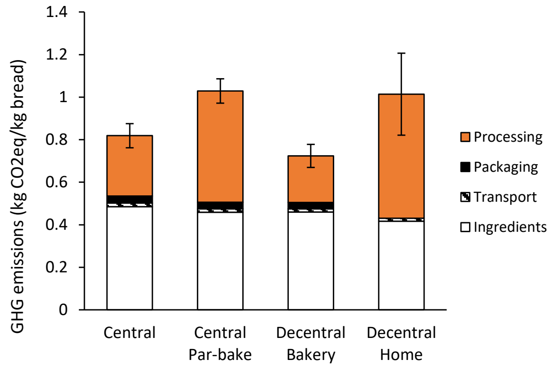


**Figure 2:** GHG emissions of ready-to-eat bread for different bread case scenarios.

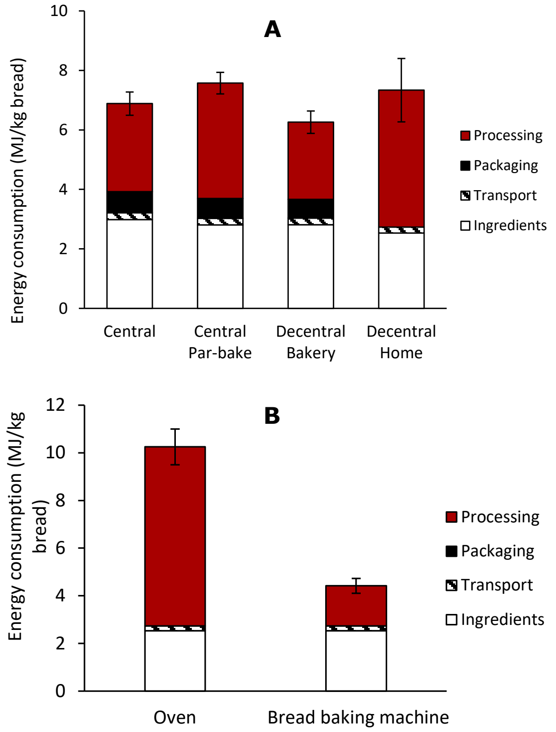


**Figure 3:** Energy consumption of ready-to-eat bread for different bread case scenarios (A) and different baking devices at home (B).

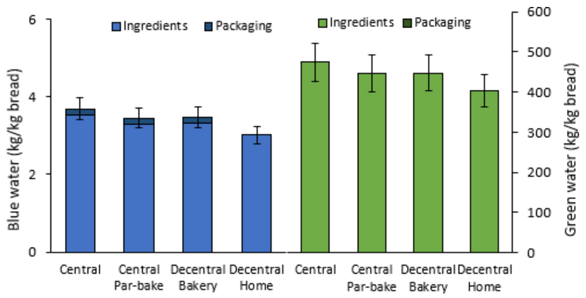


**Figure 4:** Blue and green water consumption for different bread case scenarios.

### Advise for 'the sustainable choice': centralized or decentralized bread?

Bread's sustainability is mainly driven by processing, not logistics. While central or decentralized bakeries appear more sustainable than central par-baked processing, par-baked bread is more sustainable in terms of food loss, as it's baked on demand and results in less unsold bread. Therefore, there is not one "sustainable choice." For home-baked bread, baking multiple loaves at once reduces energy demand per loaf. Consumer losses were not considered in this study, but they are significant as bread is the most wasted product at home with 6.24 kg per person/year (Voedingscentrum, 2022). Home baked breads usually have a shorter shelf-life and therefore consumer waste might be even larger than with the commercial breads.

Please keep in mind that the comparison of centralized to decentralized chain is case specific. In this case, the distances were small, and the effect was negligible. For longer transport distances, the outcome may be different.

Please find complete information in the report or contact us for more details. Learn more about our [sustainability assessment tools](sustainability assessment tools).


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