ENOUGH

EUROPEAN FOOD CHAIN SUPPLY TO REDUCE GHG EMISSIONS BY 2050

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Modelling approaches to identify decarbonisation opportunities

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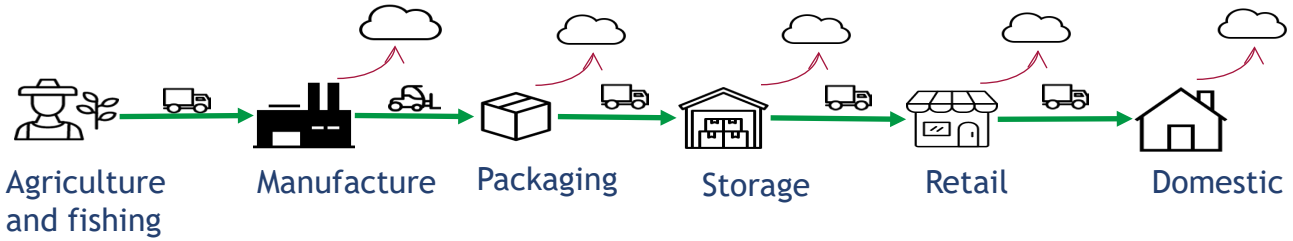
INRAE

ENOUGH Workshop
13/08/2025
Manchester

A tool to evaluate and optimize GHG emissions of food supply chains



To simulate and analyze GHG emissions

To identify the contribution of every step

To evaluate the impact of logistics (ex: local / long distance), technologies...

To provide insight but also turn it into action by suggesting ways to improve

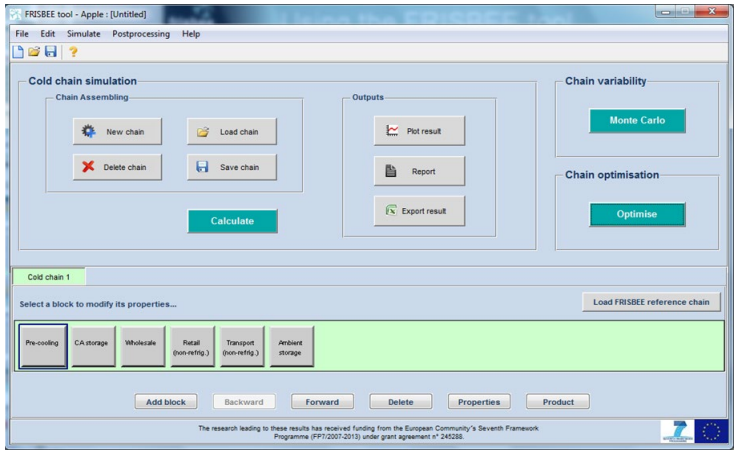
Public target:

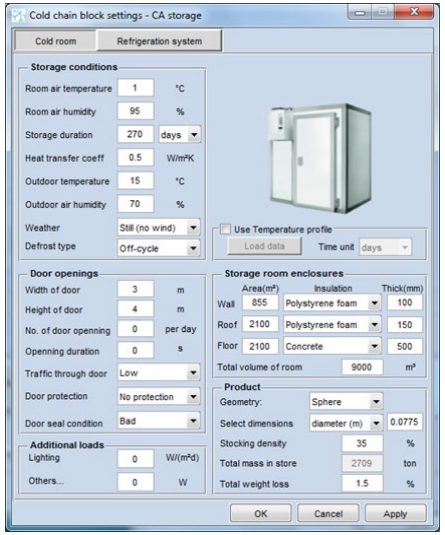
- Stakeholders involved in supply chains
- Researchers, students looking for a simulation tool
- Policy makers
- And more generally everyone interested in

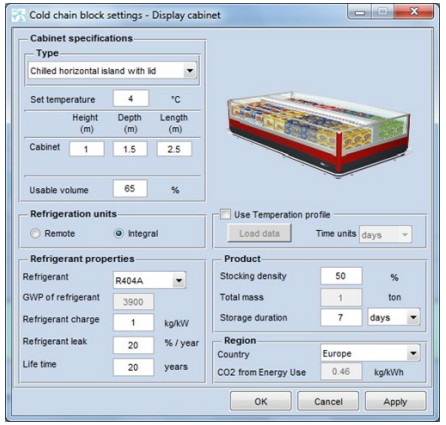
Background
FRISBEE TOOL

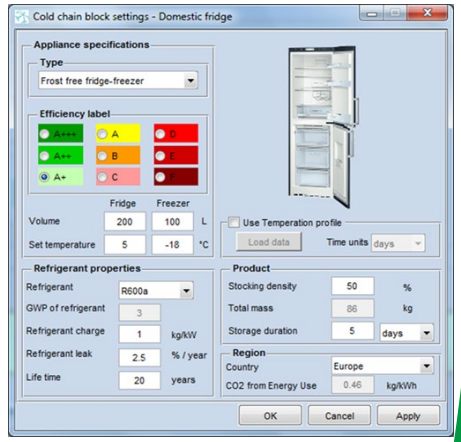
A Matlab application for Microsoft Windows

Allows the user to assess food cold chains with 3 criteria: food quality evolution, energy use and environmental impact (CO_2 emission)





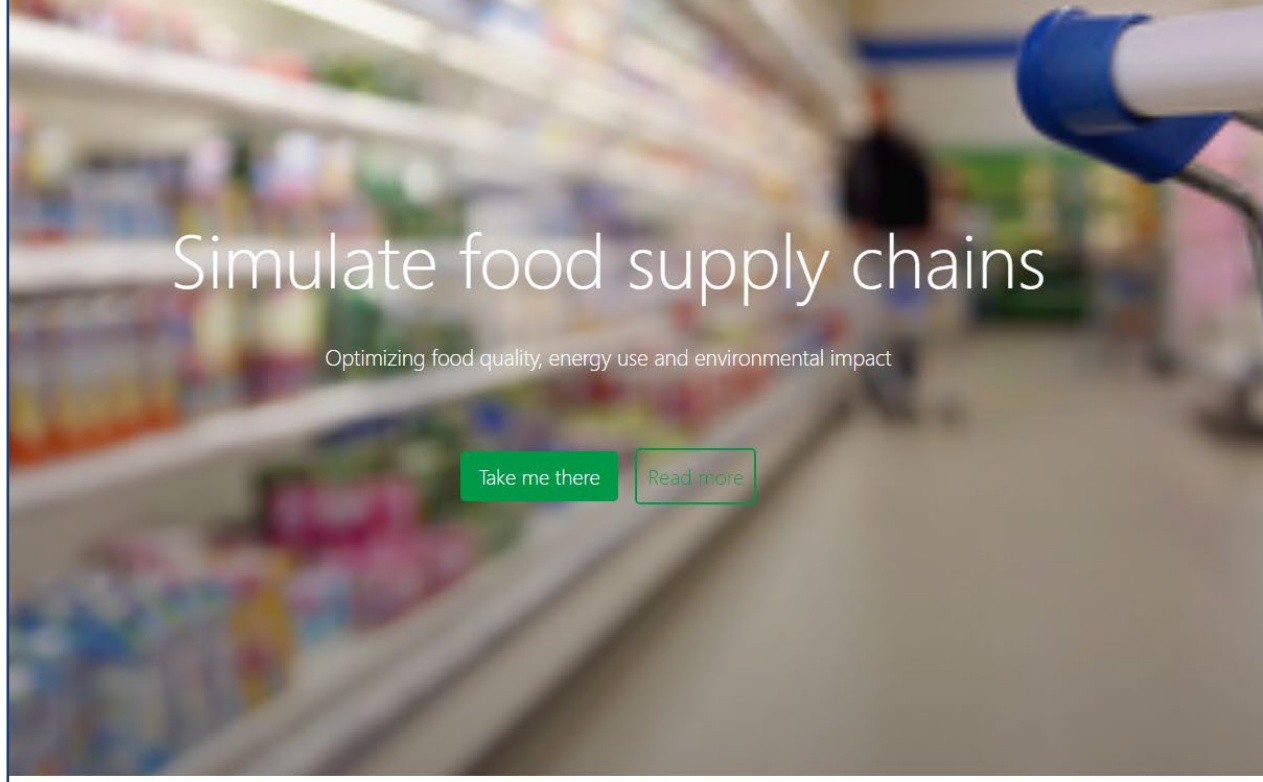




ENOUGH tool

- A web application to simulate food supply chains and assess greenhouse gas emissions has been developed and is freely available.

- Extending the scope to every food supply chain
  - Food processes (heating...)
  - Transport
  - Packaging
  - Renewable energy sources
  - Enlarged database of products

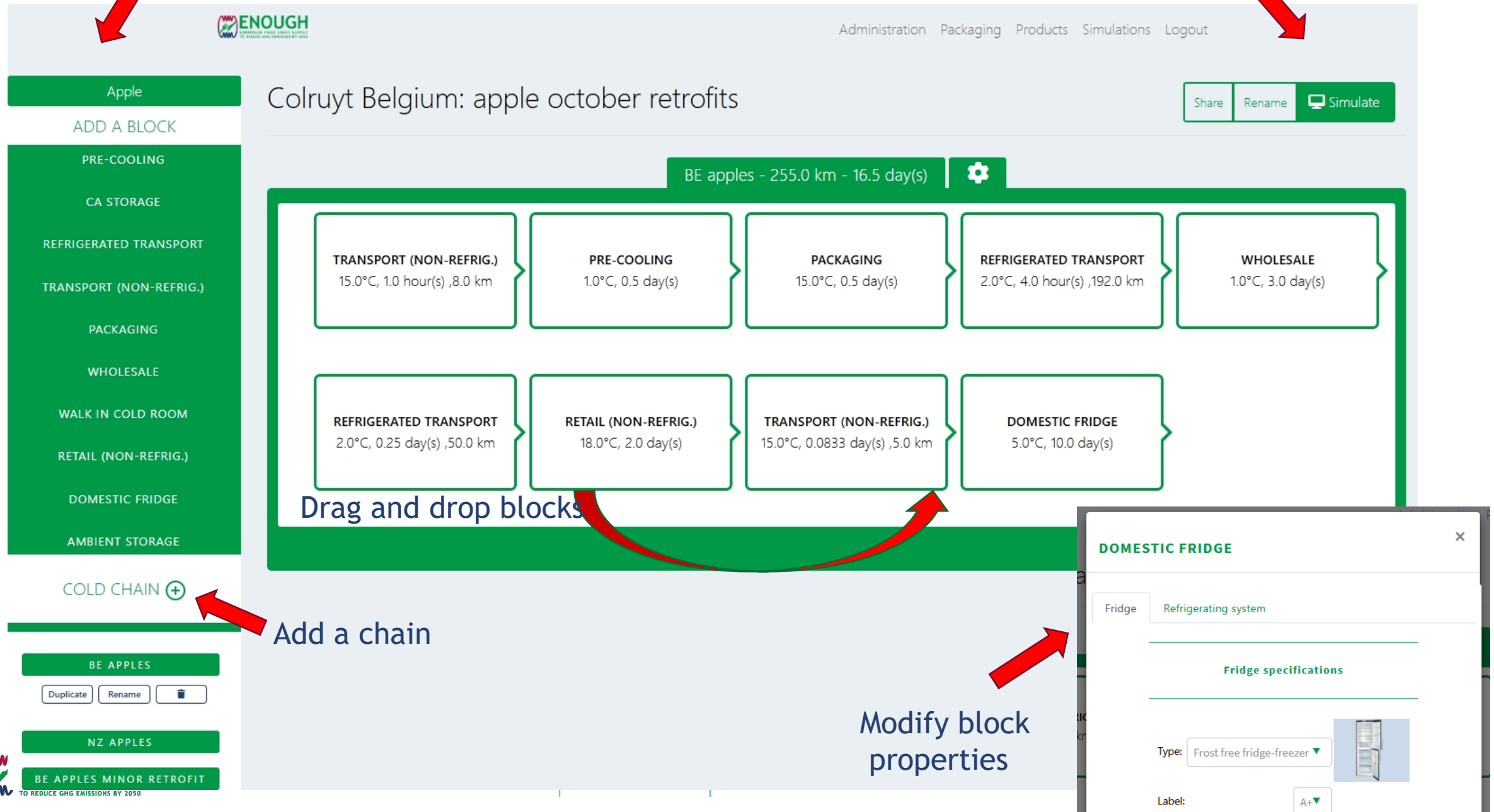


To develop a web tool to simulate and analyze GHG emissions at the scale of a food supply chain

User interface

Add blocks

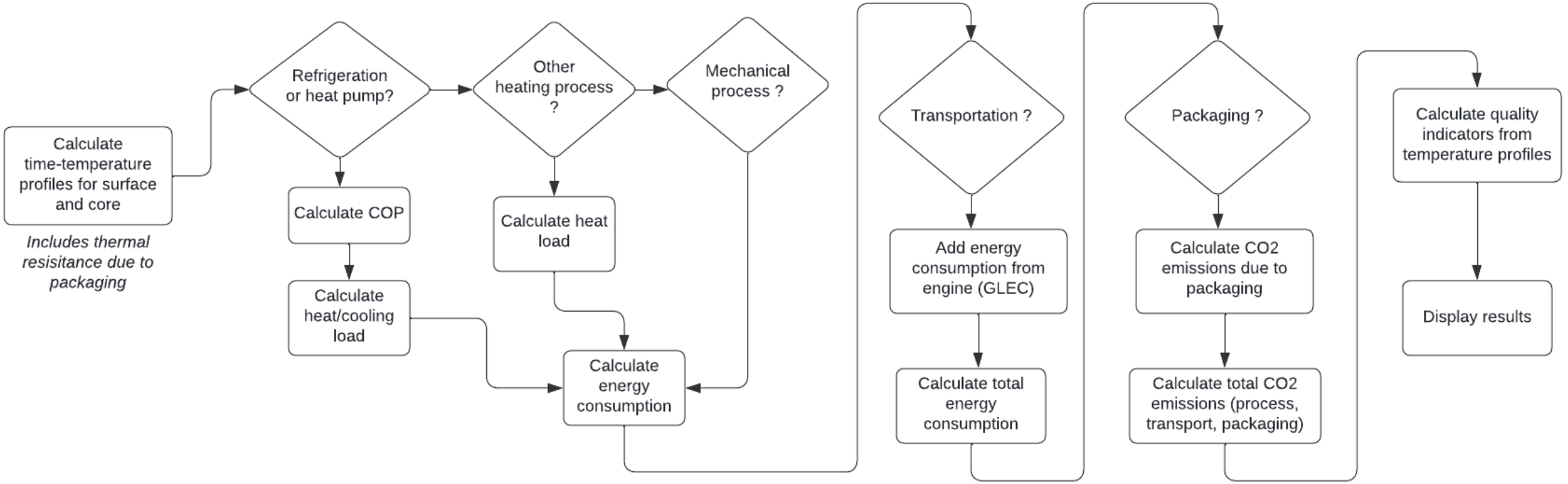
Run simulation



Add a chain

Modify block properties

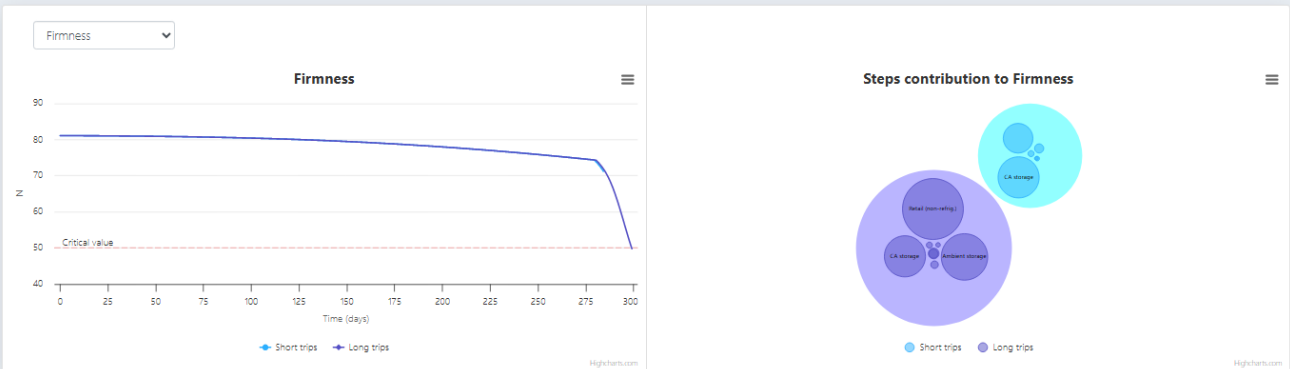
Simulation

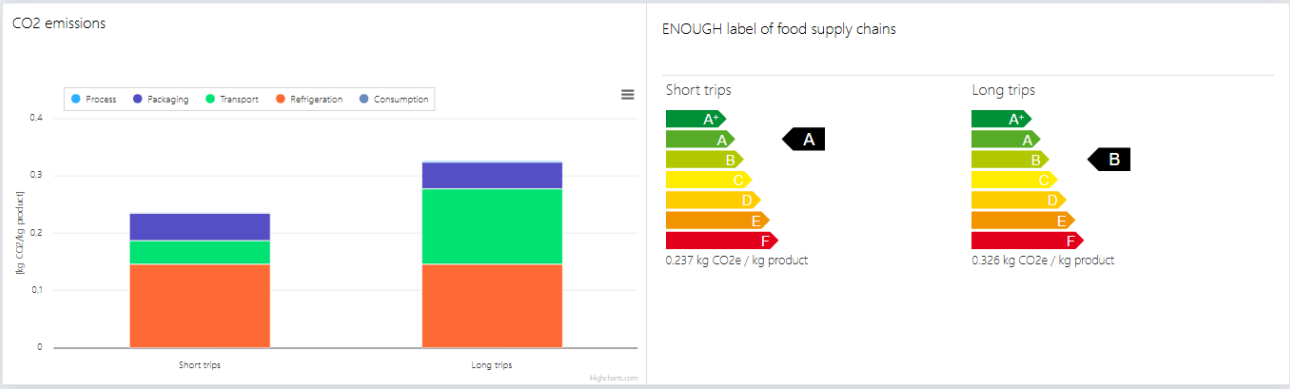


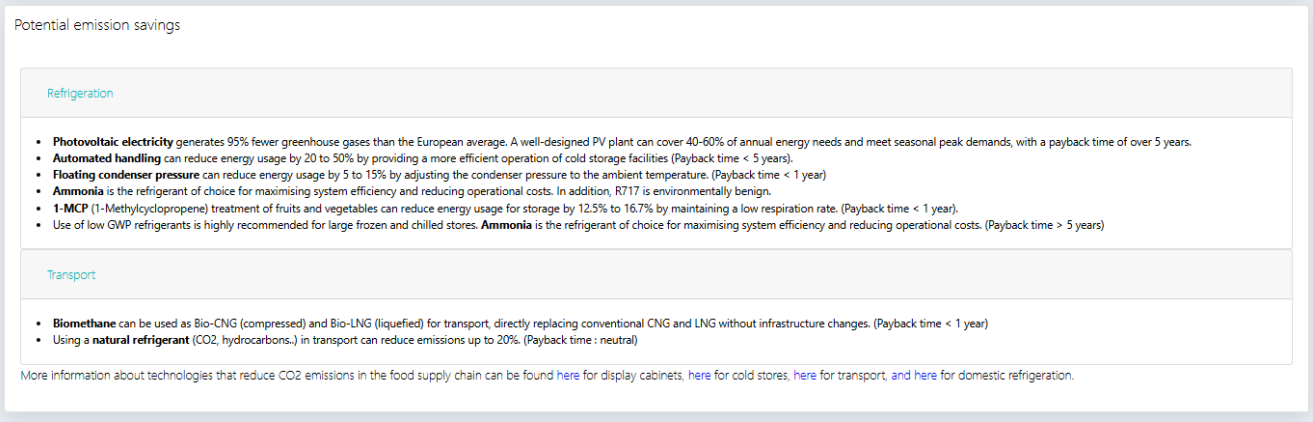
Primary data source: Ademe, Agribalyse, GLEC, IPCCC, STEP (Inrae), CoolProp

Results

- Energy / kg product
- CO2 eq emissions / kg product
- Product quality
- Exergy efficiency
  - Potential for energy recovery
- Suggestions of decarbonation opportunities
  - Based on WP2 roadmaps

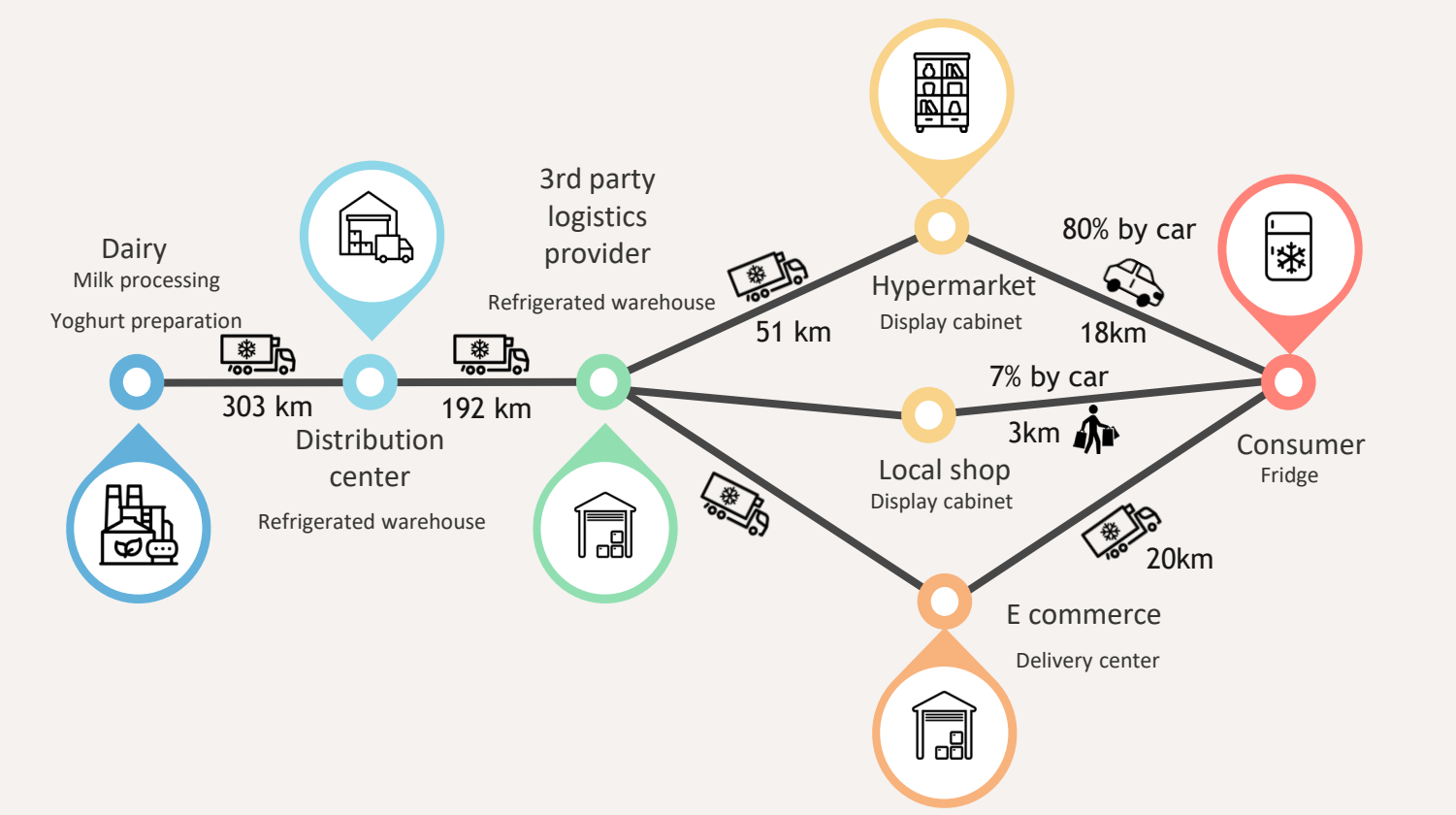






YOGHURT CHAIN

Case study from Radford, Alan, et Techset Comp Ltd. « Assessing Transport Energy Consumption in Two Product Supply Chains ». *International Journal of Logistics* 9, nº 3 (22 février 2011): 237-52. https://doi.org/10.1080/13675560600859243.



- Primary data obtained through surveys (type of vehicle, mass transported, distance…)
- Detailed input data in the report :

  Rizet, C, et Basile Keita. « Chaînes logistiques et consommation d'énergie: cas du yaourt et du jean », 2005, 92.
- National distribution case study, not very long distances
- Focus on the last delivery: comparison between shops and e-commerce

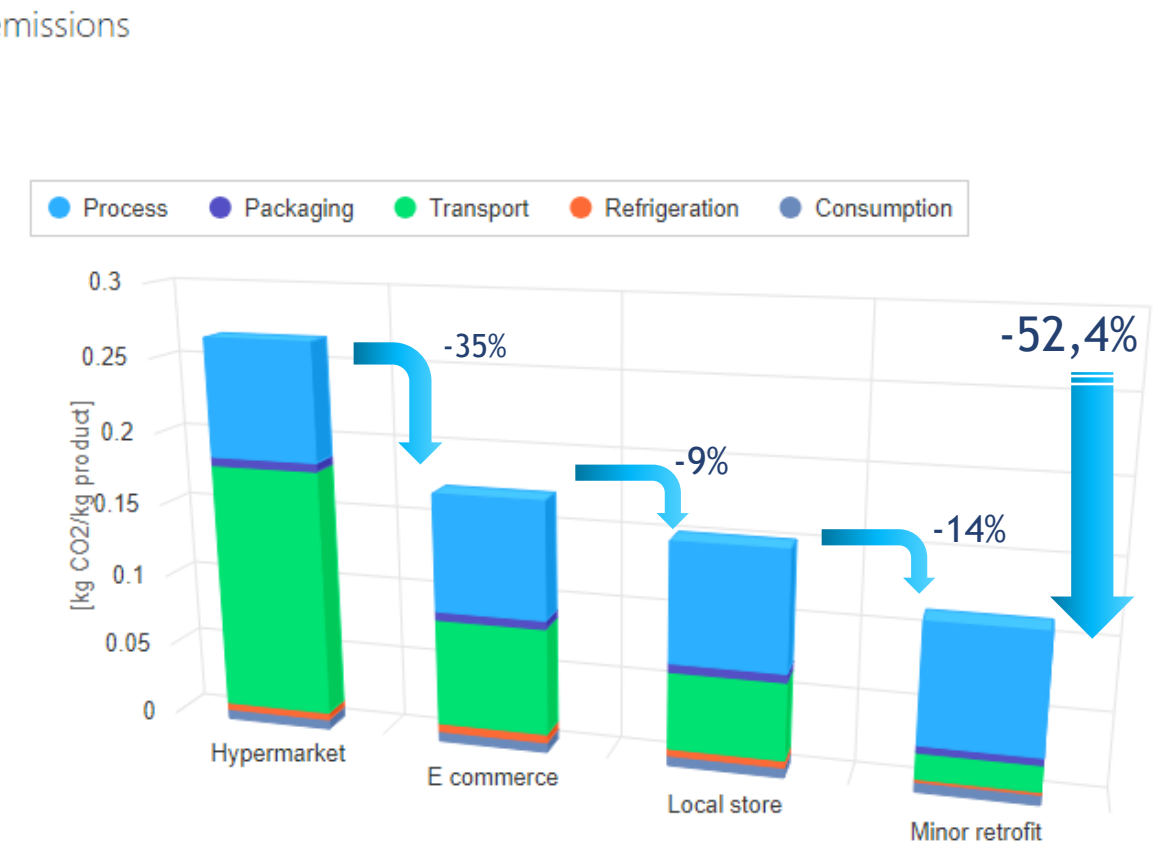
Yoghurt chain

Stages in the logistic chain

RESULTS
Potential emissions savings

- Comparison hypermarket and e-commerce
  - E-commerce
    - No emissions for retail
    - Mass transported higher (emission intensity)
  - Local store: only 7% by car

- Minor retrofits
  - For cold storage blocks
    - Renewable energy (50% autosufficiency)
    - Floating condenser pressure



Importance of mass transported: emission intensity

Examples for road transport

Articulated truck up to 34 t GvW

Payload : 19-22t

Emission intensity (diesel): 95 gC02/t.km

Rigid truck 7,5-12 t GvW

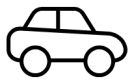
Payload : 2,5-9t

Emission intensity (diesel): 210 gC02/t.km

Van < 3,5 t

Payload 1-2 t

Emission intensity (diesel): 793 gC02/t.km



Consumer car

Mass transported (survey): 30 kg hypermarket, 15 kg supermarket, 5 kg local shop

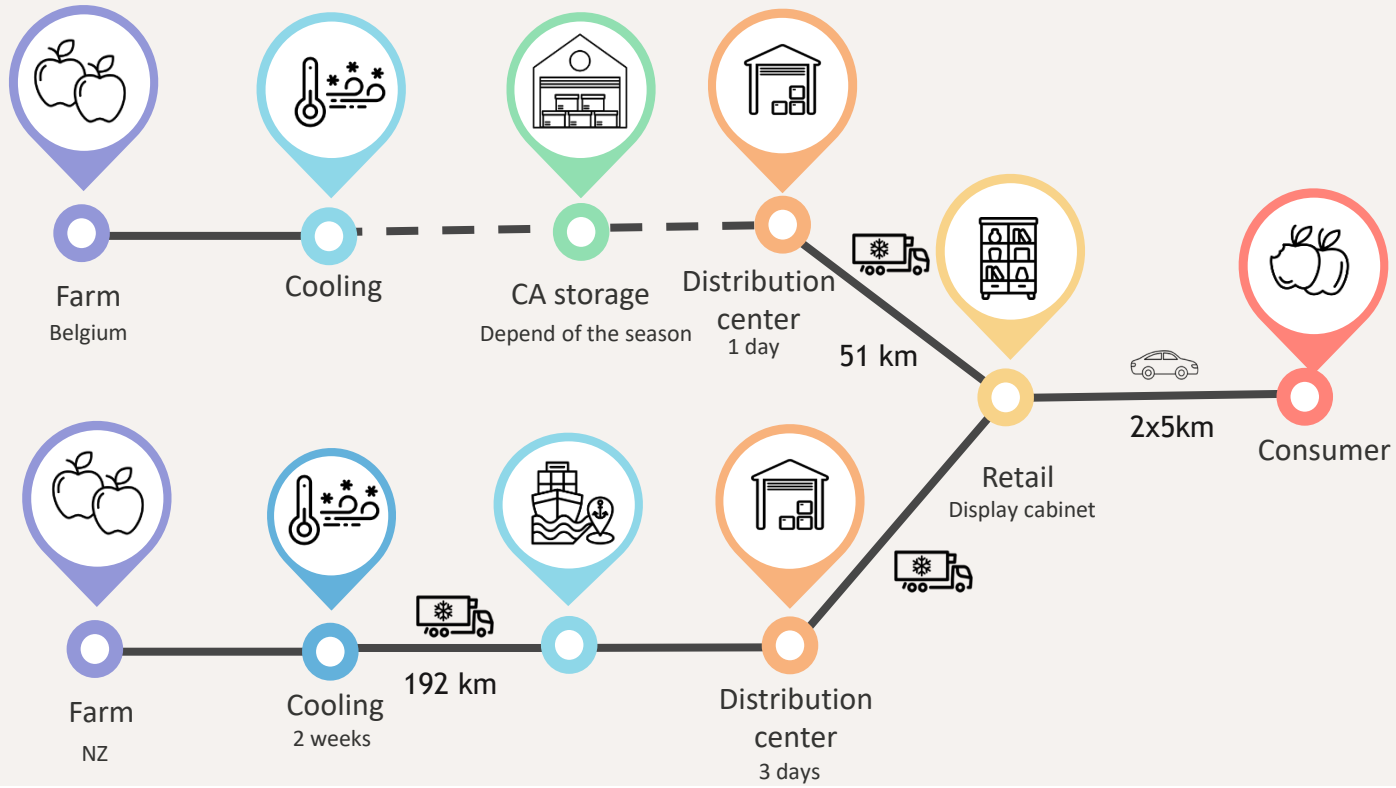
Emission intensity (diesel): from 3000 to 8000 gC02/t.km

Emission intensity

Emissions to transport 1 ton of goods over 1 km

APPLE CHAIN IN BELGIUM

Case study from Goossens, Y. et al. « How Origin, Packaging and Seasonality Determine the Environmental Impact of Apples, Magnified by Food Waste and Losses ». *The International Journal of Life Cycle Assessment* 24, nº 4 (1 avril 2019): 667-87. https://doi.org/10.1007/s11367-018-1522-0.



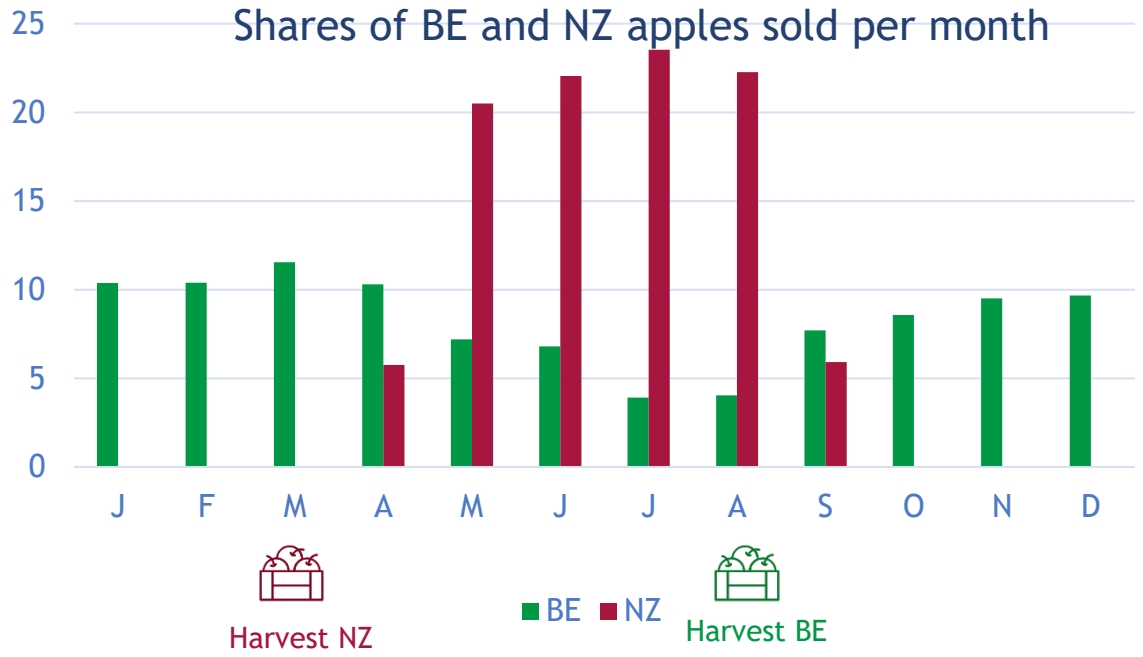
- Primary data obtained from Colruyt group (type of vehicle, mass transported, distance…)
- CA storage only for December and later

Apple chain

Stages in the logistic chain

Case study description

Share of apple sales



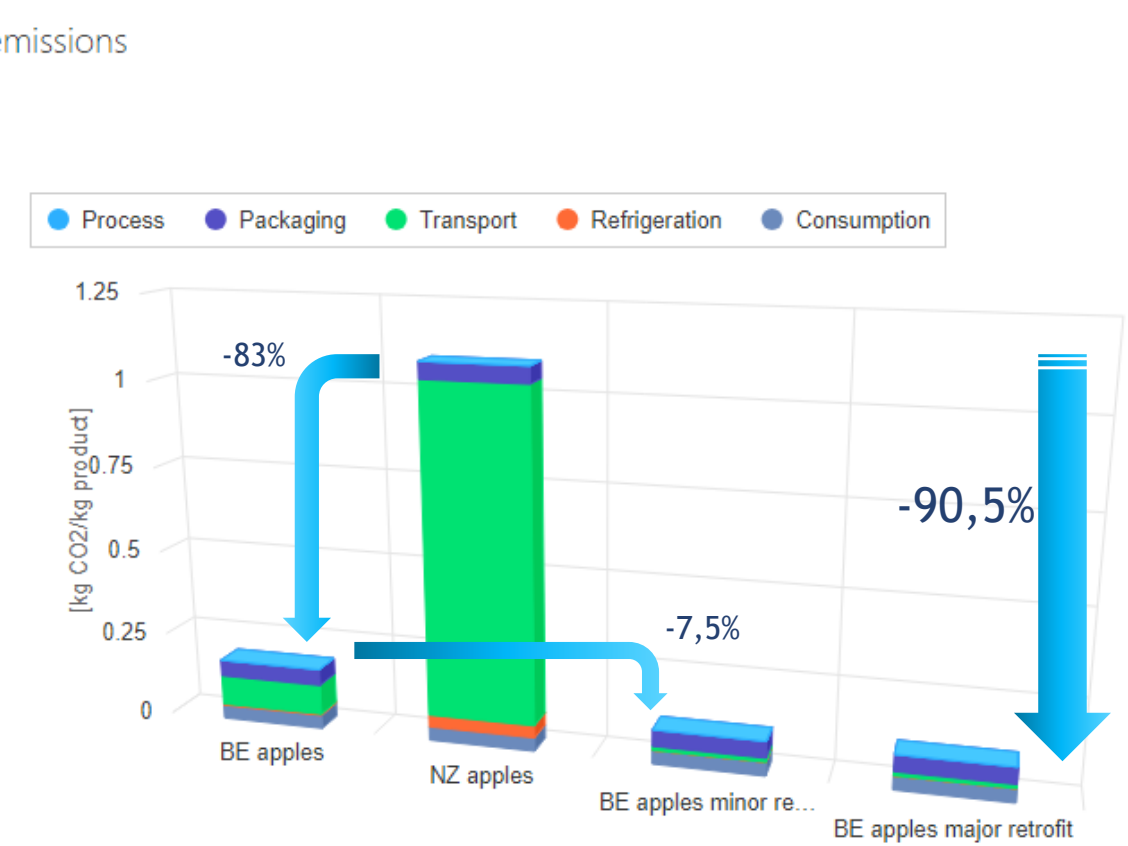
Source: Colruyt group

Imported apples: 40% of apples being sold

NZ apple: 27554km from Wellington to Antwerp

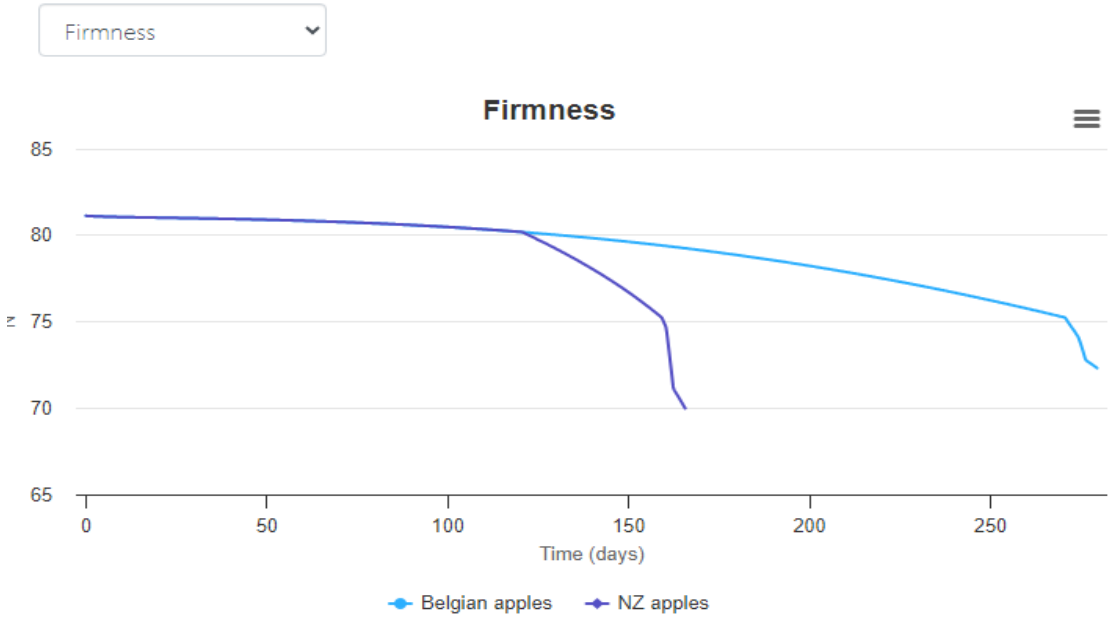
RESULTS
Potential emission savings

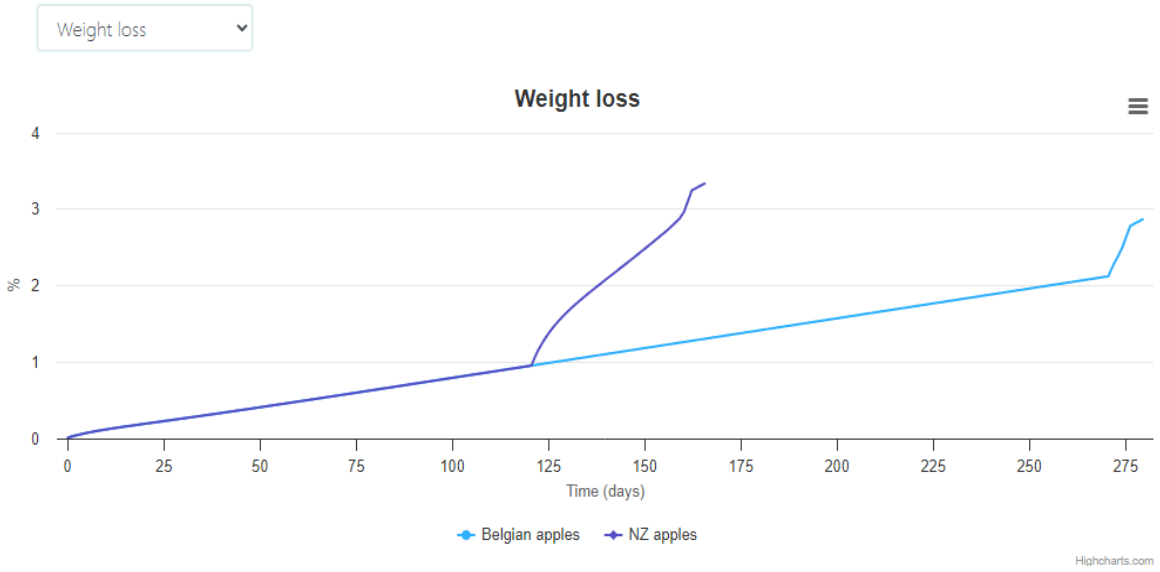
- If minor retrofits
  - For cold storage blocks
    - Renewable energy (50% autosufficiency)
    - Floating condenser pressure
  - For transport
    - Biomethane (large vehicles)
- If major retrofits (or new devices)
  - R744 refrigeration unit
  - Automation handling in warehouse

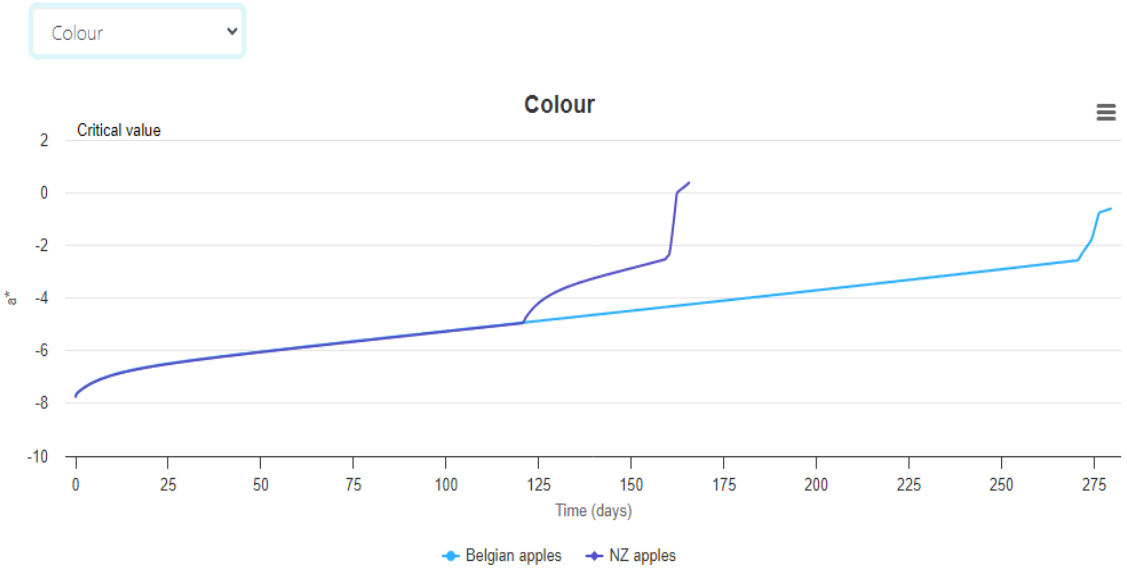


What about quality ?

- Even in the worst case : 9 months of controlled atmosphere storage for local apple (in August)
  - Firmness, colour and weight loss have been found relatively similar







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THANK YOU !

enough-emissions.eu