



Demonstrating ENOUGH calculation tool

WP4

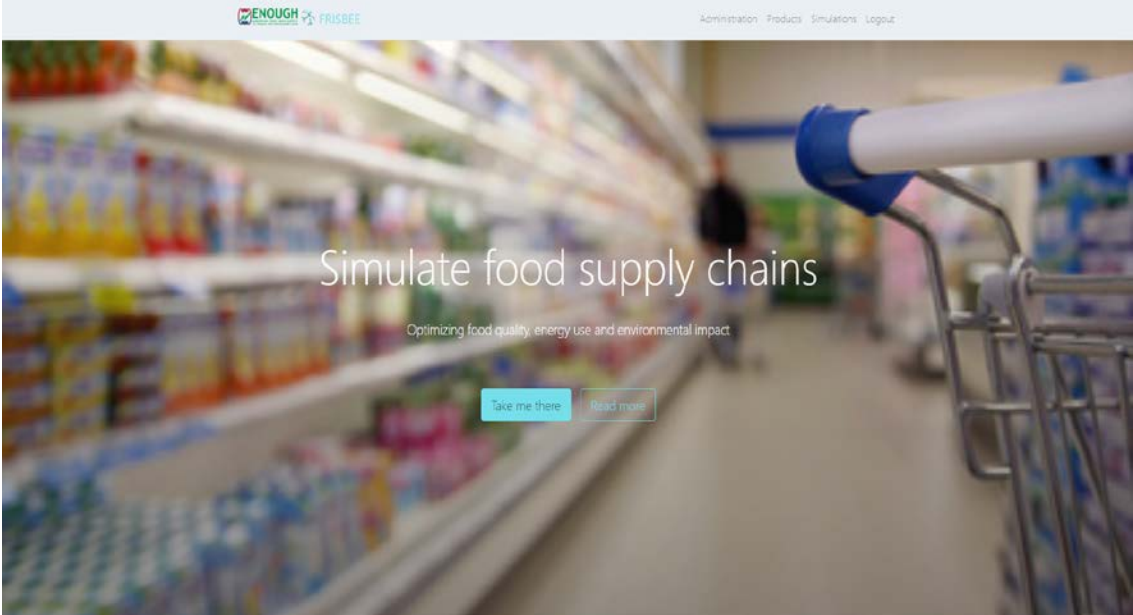
Denis Leducq, Graciela Alvarez (INRAE)

Enough decision support tool

Purpose of this tool:

To simulate and assess food supply chains on multiple criteria

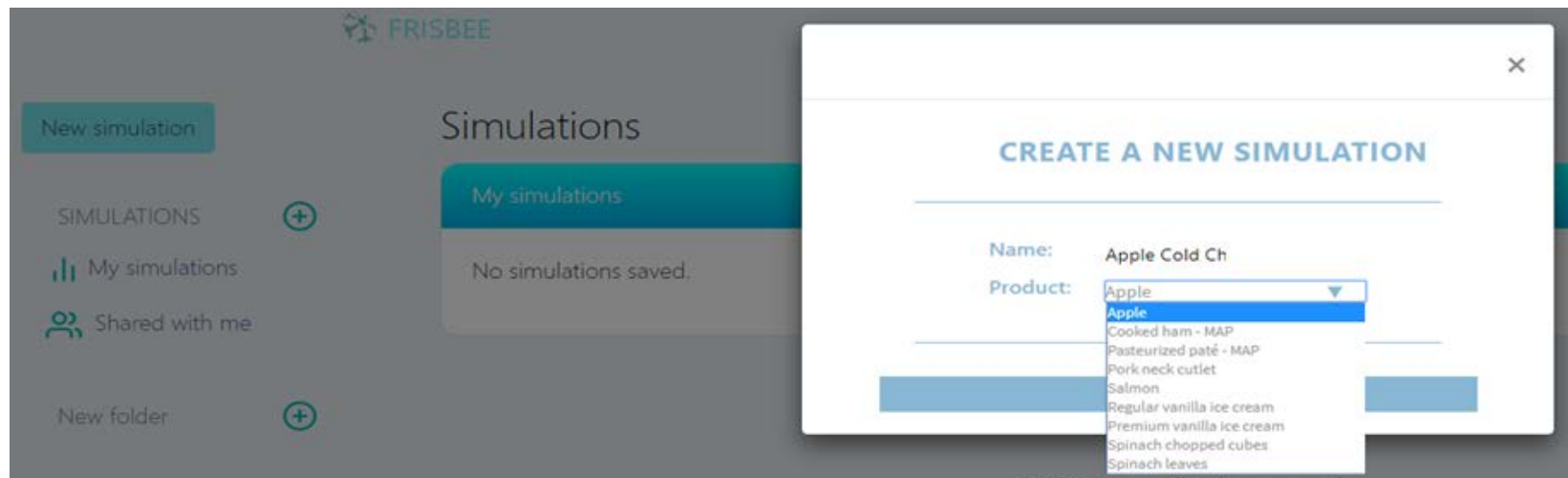
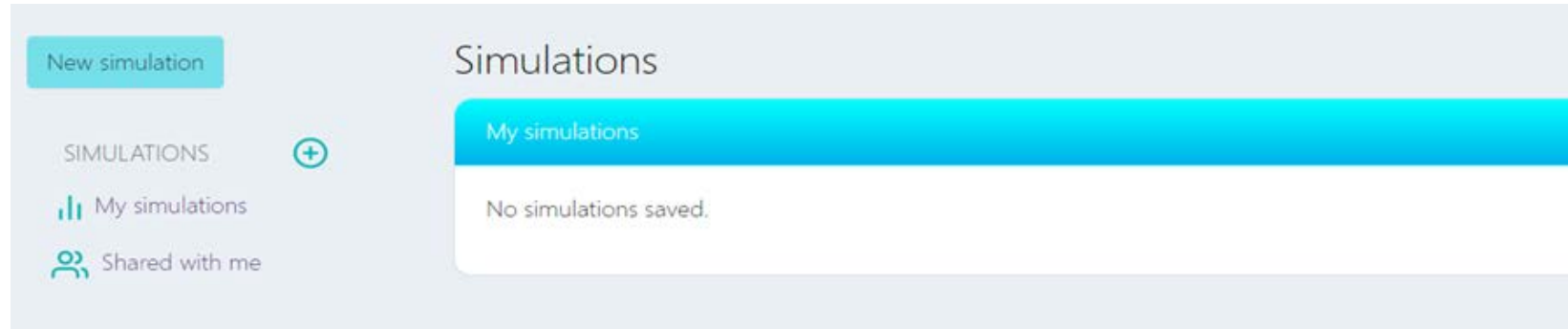
- Product quality and safety
- Energy consumption
- CO2 emission



Only 3 steps

- Select a product**
Six main product categories have been considered: fruits, ready to eat meal, meat, fish, vegetable and milk products
- Build the cold chain**
Select every step, personalize them or just start with the reference chain for a first simulation
- Simulate**
Evaluate the evolution of quality, the energy consumption, compare your custom chain with the reference chain

Create a simulation



Building the chain

Add blocks

Run simulation

Drag and drop blocks

Add a chain

Modify block properties

Ham Cold Chain

Share Rename Simulate

Ham Chain – 10 day(s)

Cutting and slicing 4°C, 1 day(s)

Refrigerated Transport 4°C, 1 day(s)

Display cabinet 4°C, 5 day(s)

Transport (Consumer) 20°C, 0.1 day(s)

Domestic Fridge 6°C, 2 day(s)

STORAGE CONDITIONS

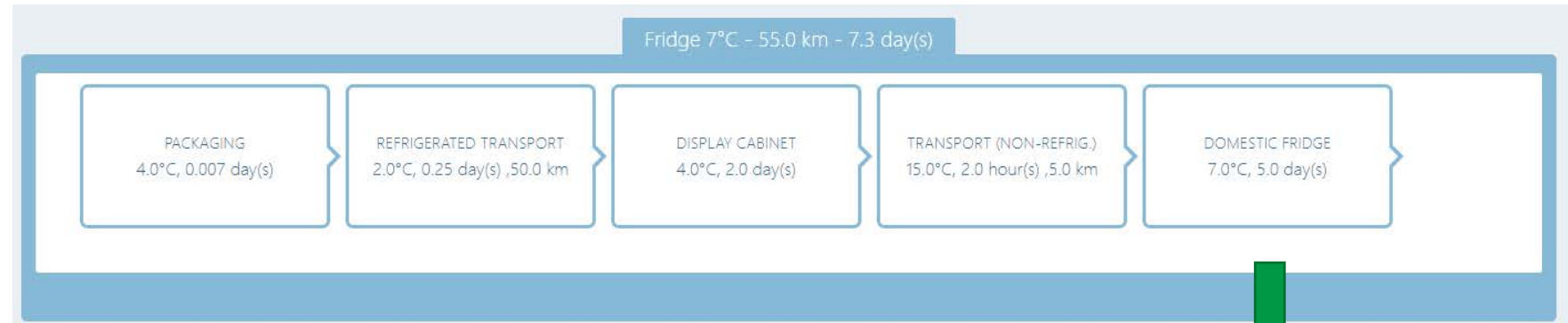
Storage duration:	120	days
Room air temperature:	1	°C
Room air humidity:	95	%
Heat transfer coeff:	0.5	W/m²K
Outdoor temperature:	15	°C

DOOR OPENINGS

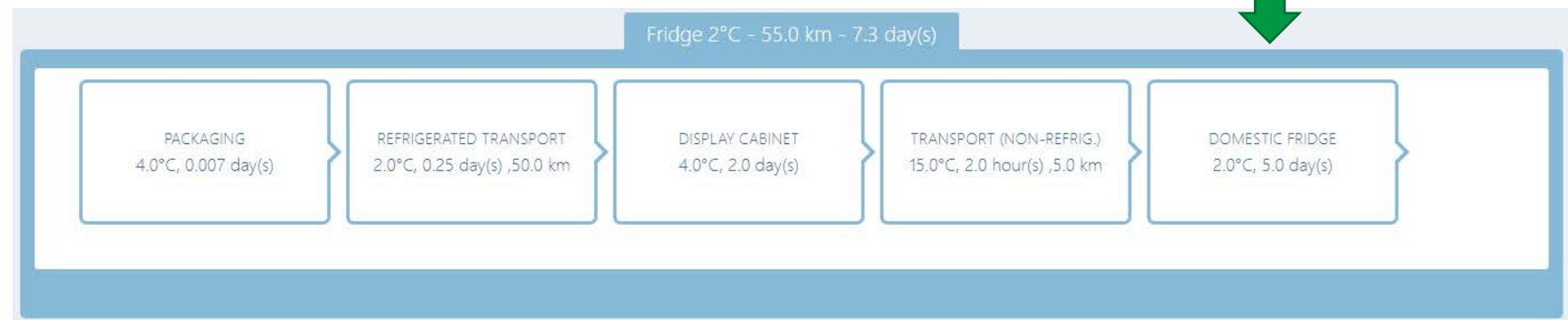
Width of door:	3	m
Height of door:	4	m
Ns. door opening:	0	per day
Opening duration:	0	s

Simulation example: cooked ham

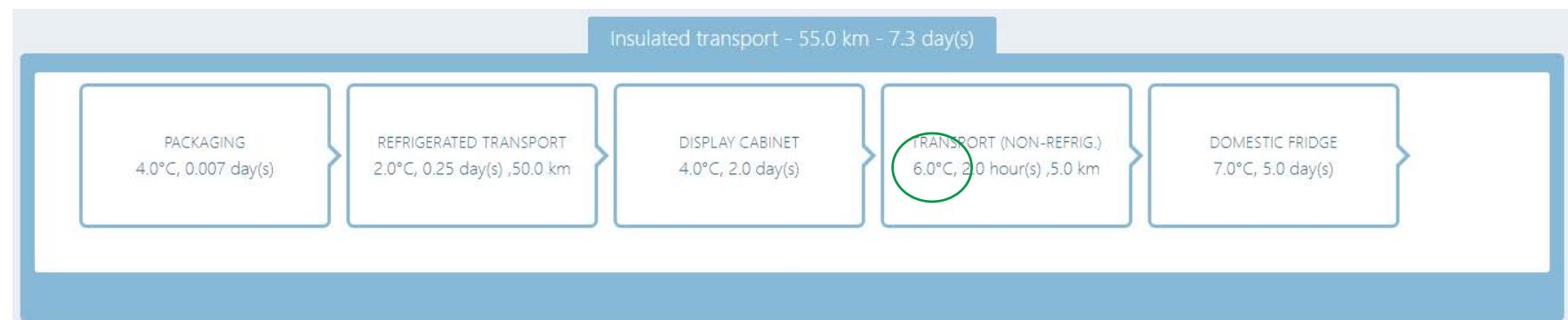
Fridge 7°C



Fridge 2°C



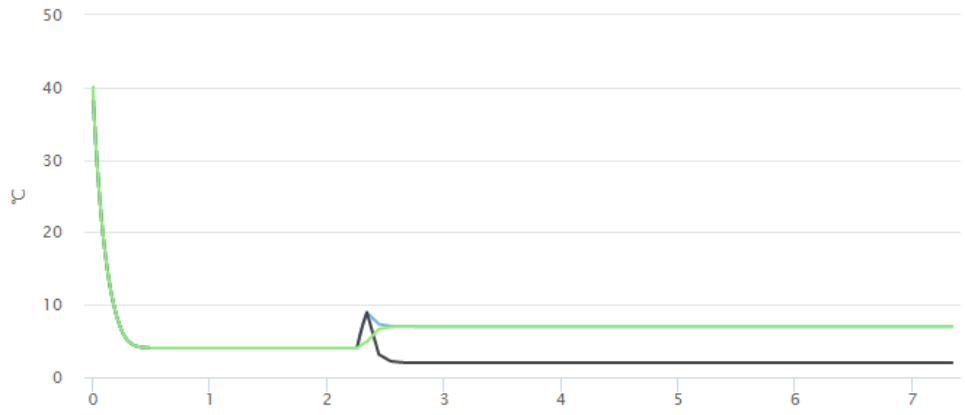
Insulated consumer transport



Results

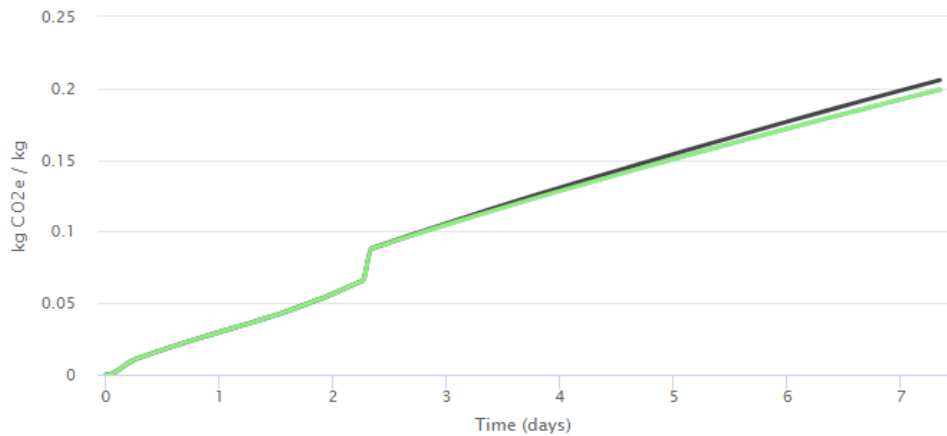
Surface temperature

Surface temperature evolution along cold chains



CO2 emission

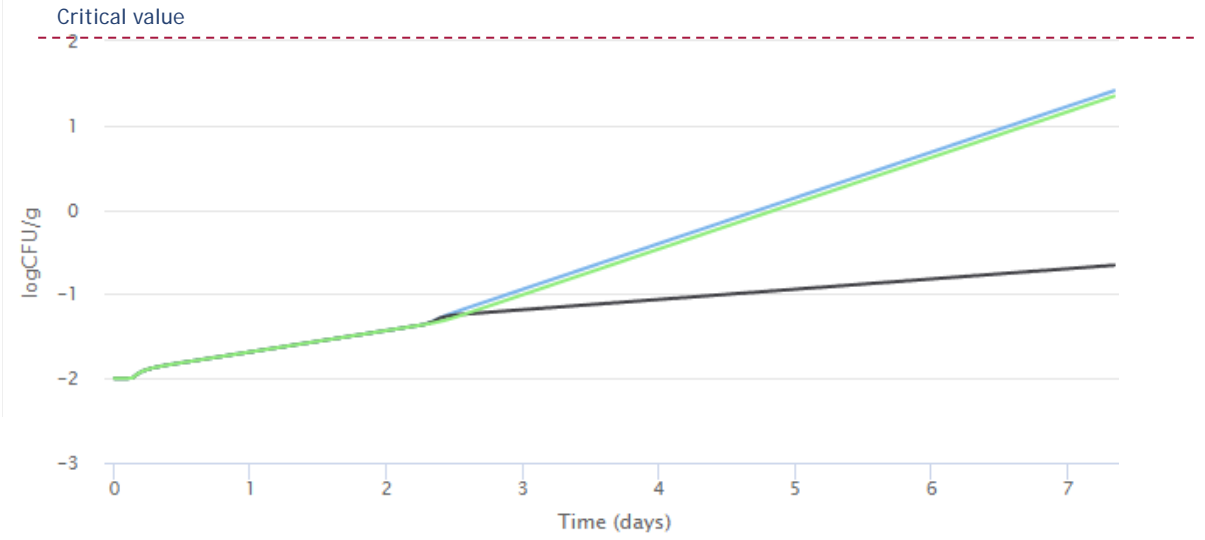
Total equivalent warming impact (CO2 equivalent)



— Fridge 7°C — Fridge 2°C — Insulated transport

Listeria monocytogenes

Listeria monocytogenes



● Fridge 7°C ● Fridge 2°C ■ Insulated transport

Chains ranking

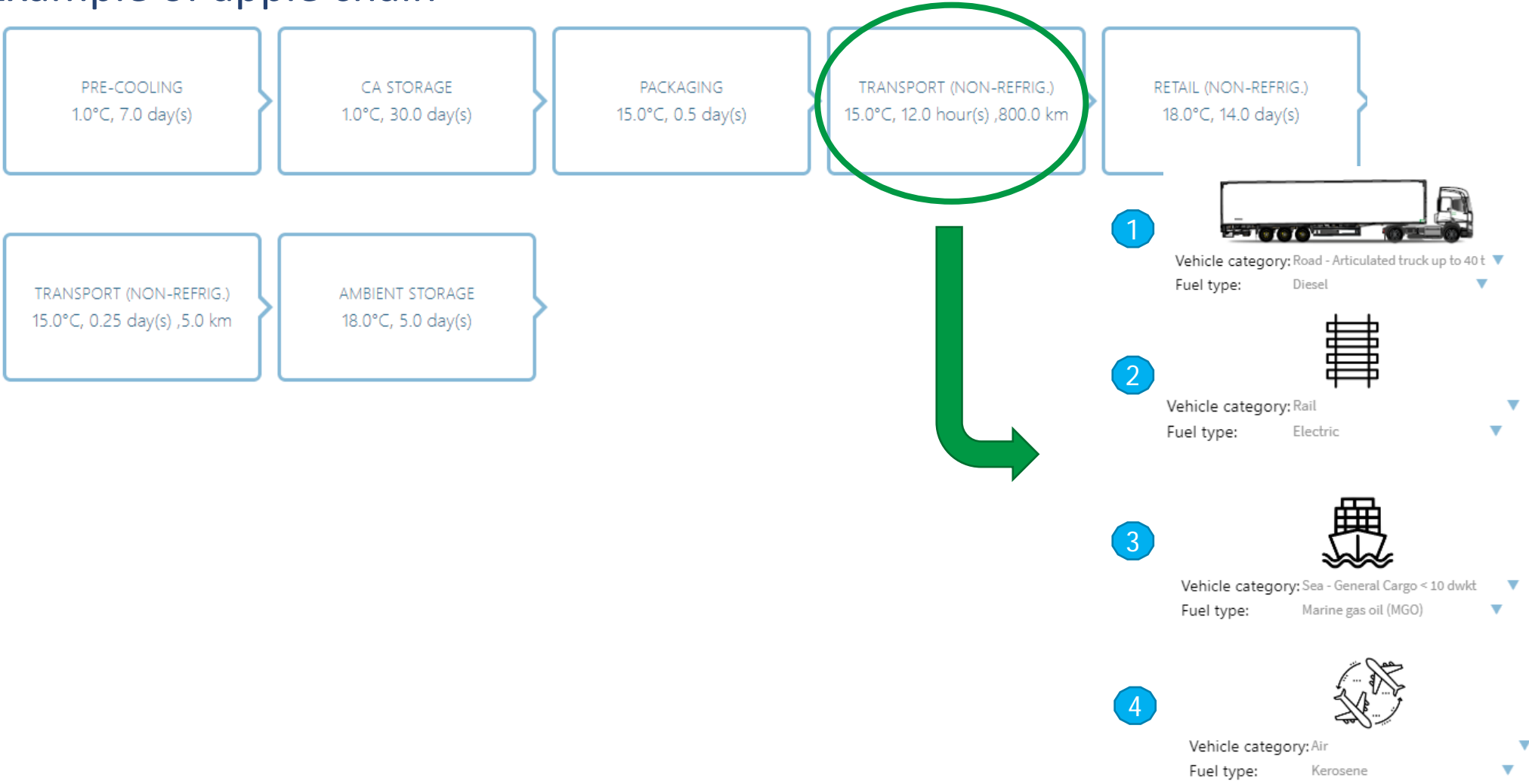
Multiple Criteria Decision Analysis (MCDA)

Rank	Chain name	Score	Distance	Listeria monocytogenes	Lactic acid bacteria	lactic acid bacteria	Water activity	Energy consumption	CO2 emission
			km	logCFU/g	logCFU/g	logCFU/g	-	kWh/kg	kg CO2/kg
1	Fridge 2°C	2.0	55.0	-0.66	3.20	4.38	-0.66	0.533	0.206
2	Insulated transport	-0.76	55.0	1.35	6.29	8.08	1.35	0.516	0.199
3	Fridge 7°C	-1.24	55.0	1.41	6.39	8.19	1.41	0.516	0.199

High impact of fridge temperature on product quality

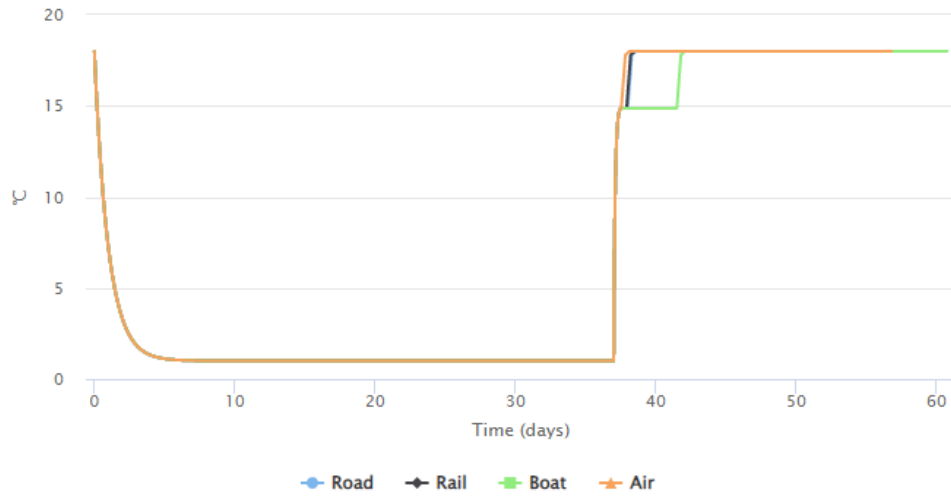
Other example: impact of transportation mode on GHG emissions

Example of apple chain

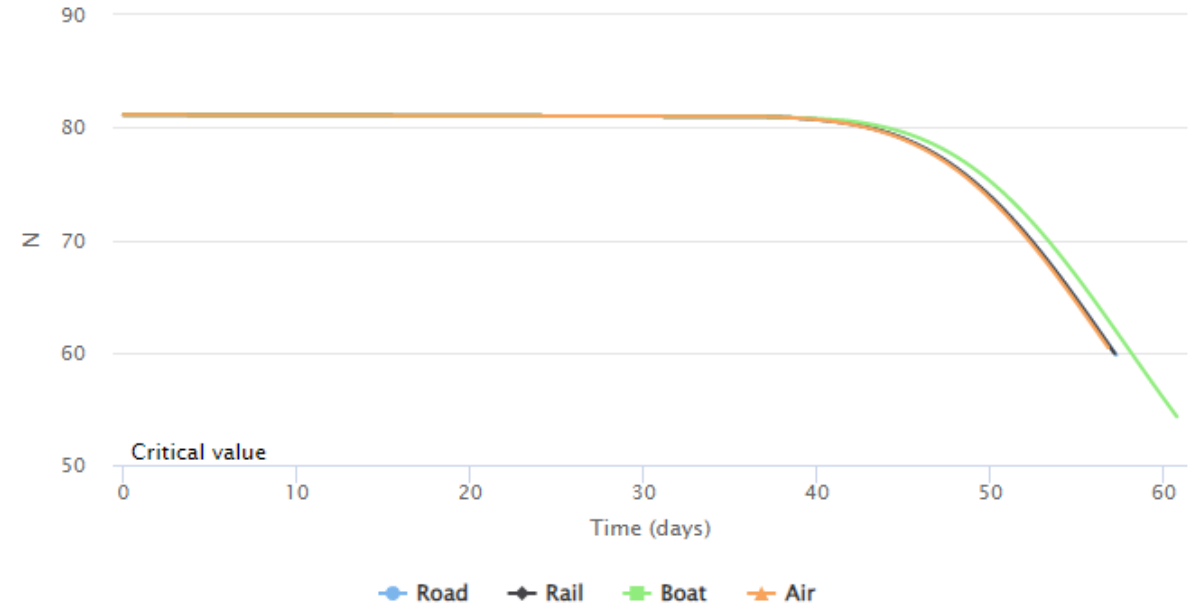


Results

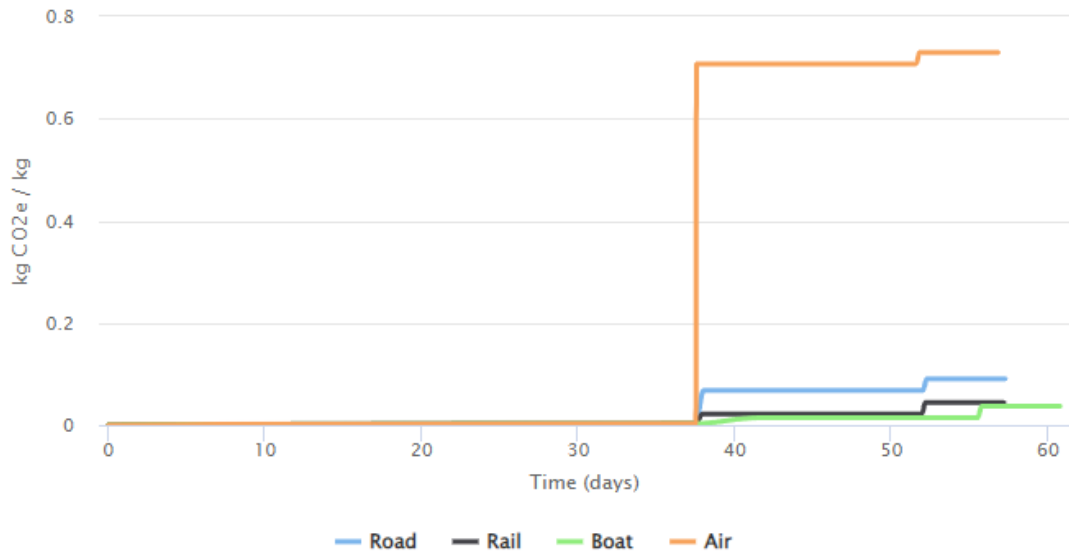
Surface temperature evolution along cold chains



Firmness



Total equivalent warming impact (CO2 equivalent)



Rank	Chain name	Score	Distance <i>km</i>	Firmness <i>N</i>	Colour <i>a*</i>	Relative volatile <i>None</i>	Weight loss <i>%</i>	Energy consumption <i>kWh/kg</i>	CO2 emission <i>kg CO2/kg</i>
1	Rail	1.49	805.0	59.91	9.19	561.36	3.05	0.159	0.044
2	Boat	1.1	805.0	54.30	9.81	550.30	3.46	0.133	0.037
3	Road	0.19	805.0	59.77	9.22	561.22	3.06	0.328	0.09
4	Air	-2.78	805.0	60.44	9.10	561.85	3.01	2.737	0.729

Much higher GHG emissions for air transport

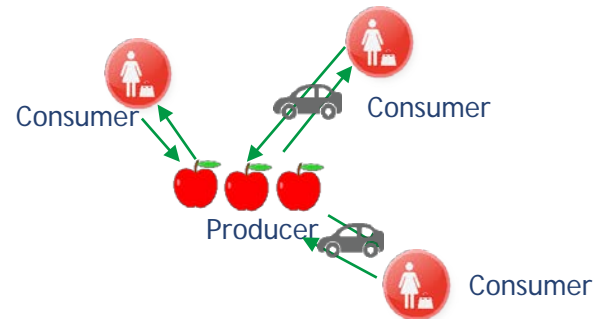
Other example: local or long distance

- Long distance chain



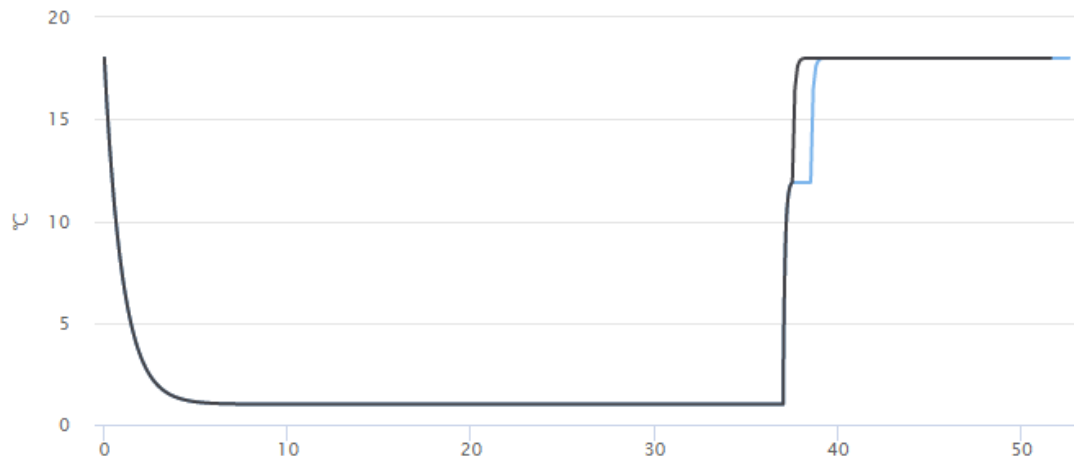
- Local chain

0 to 1 intermediary between producers and consumers

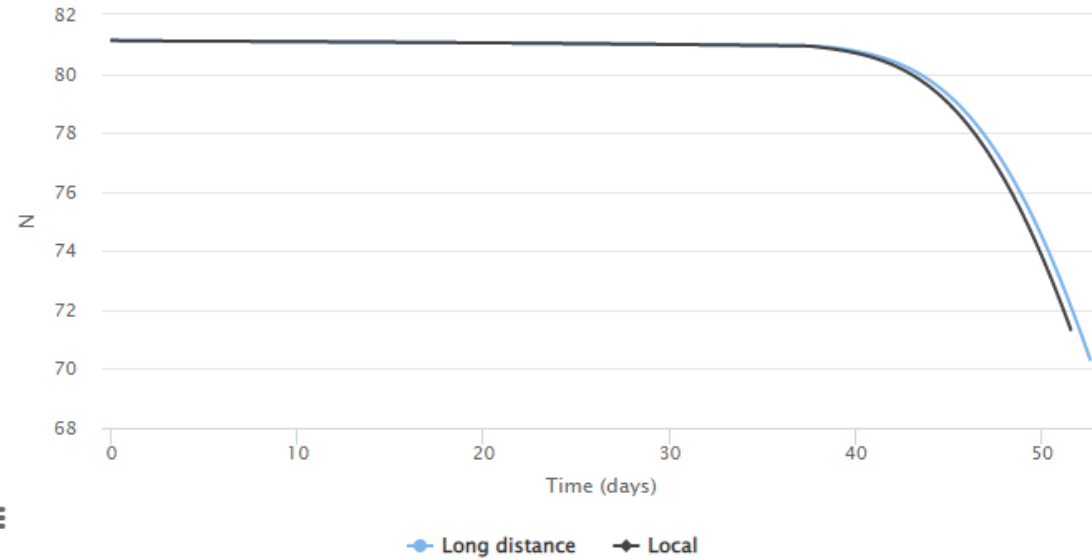


Results

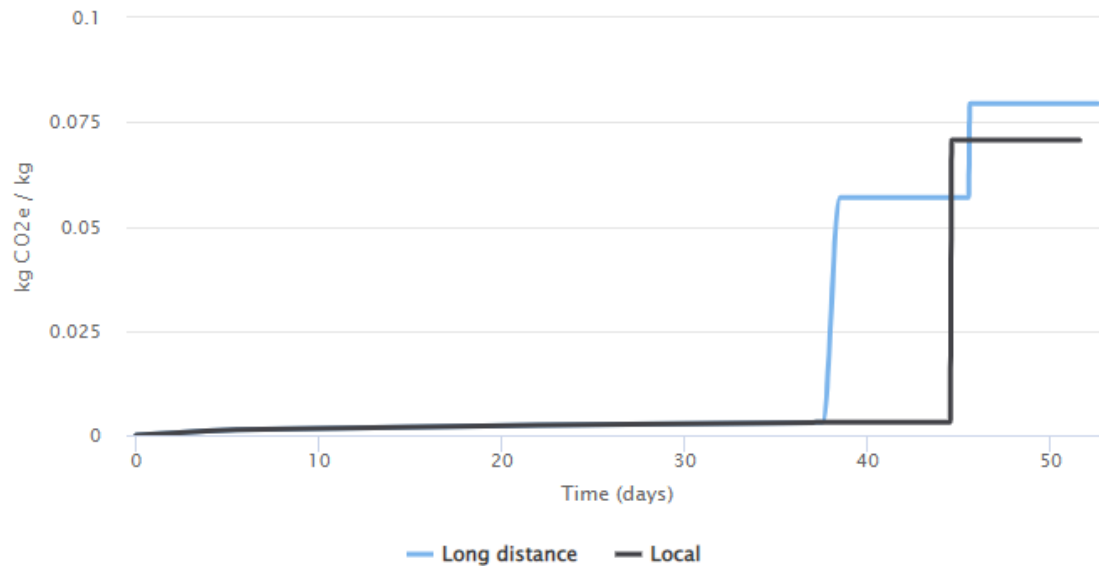
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1	Local	0.57	15.0	71.26	4.74	532.26	2.28	0.255	0.071
2	Long distance	-0.57	705.0	70.32	5.30	535.75	2.38	0.287	0.079

Shorter duration for local chain
Not much difference in terms of CO2 emissions due to small quantities transported by consumers

Other examples of simulations / assessments

Impact of refrigeration

Example: Pasteurised milk / UHT milk

Pasteurized milk requires **refrigeration** all along the food supply chain

Sterilization requires more energy consumption, but **no refrigeration** after

Impact of temperature for frozen products

Example: **-18°C to -12°C**, what would be the difference, especially on GHG emissions?

New technologies to reduce emissions

Renewable energy sources, heating recovery for food processes, energy storage, active packaging, « green » delivery, next generation refrigerator ...



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ENOUGH

EUROPEAN FOOD CHAIN SUPPLY
TO REDUCE GHG EMISSIONS BY 2050

Thank you for your attention

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