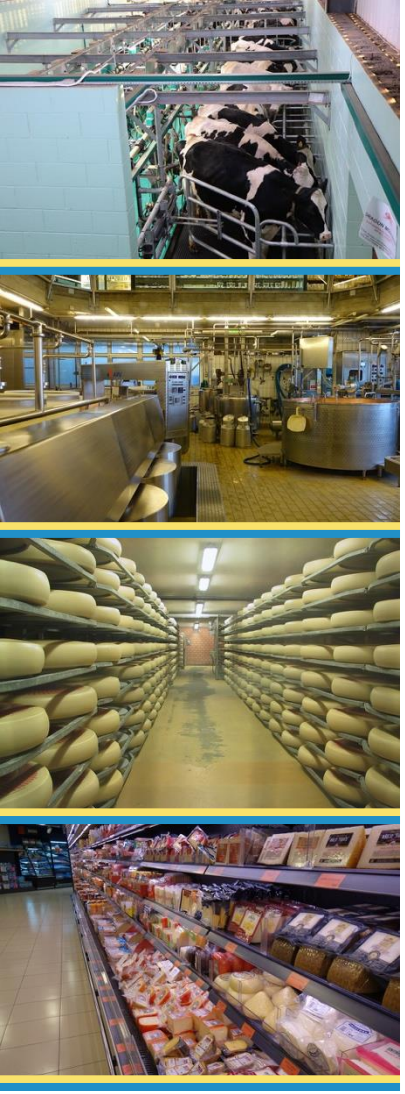

The BETTED Framework: A Systemic Approach to Energy Transition and Circularity in the Dairy Industry

Università di Brescia

Simone Zanoni
Università degli Studi di Brescia (Italy)

ZERO CARBON INDUSTRY 2026

4th February 2026

Co-funded by the European Union

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Executive Summary: The Synergistic Transformation

The Challenge

The EU dairy sector (12% of agricultural output) is squeezed by volatile milk prices (€0.25-€0.40/L) and strictly enforced Green Deal mandates.

Current processing relies heavily on fossil fuels (60-80% thermal energy) while simultaneously wasting massive amounts of heat through refrigeration venting.

The Solution

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- **Holistic Approach:** Shifting from isolated process optimization to supply chain-wide coordination.
- **The Toolbox:** A suite of 7 specialized tools to assess impact, cost (LCC), and supplier sustainability (DVS).

The Impact

- Simultaneous Heating & Cooling (SHC): Heat Pumps recover waste heat, offering up to 75% potential energy savings.
- **Renewables:** Integrating biogas and solar to close the <20% renewable energy gap in the current mix.

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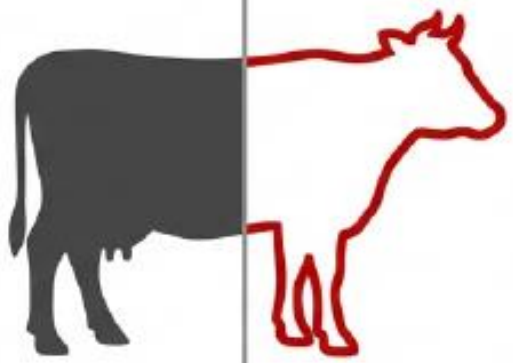
The Environmental Ledger: Culprit and Victim

Impact OF Dairy (The Liability)

Greenhouse Gases: Farming causes >10% of economy-wide GHG emissions.

Methane: Ruminants account for ~3% of global methane (25x potency of CO2).

Water Pollution: Eutrophication from nitrate runoff.



Impact ON Dairy (The Vulnerability)

Heat Stress: Climate change worsens animal reproductive performance.

Resource Scarcity: Water availability and soil fertility decline.

Disease: Outbreaks linked to changing weather patterns.

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Project summary

- BETTED (Boosting Energy Transition of ThE Dairy value chain) project aims to **facilitate companies** belonging to supply chains in the dairy sector to foster the **market uptake of energy efficiency measures** including the **use of renewables** and the deployment of **heat pumps** at the **value chain level**, moreover, the project will also significantly contribute to the **reduction of fossil fuels dependency** fast forwarding energy transition.

Immage source: Pixabay

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Energy efficiency issues in the dairy value chain

- Overall, dairy processing plants and farms can **identify numerous energy efficiency measures** and **renewable energy solutions** that enhance competitiveness, reduce production costs, decrease CO_2 emissions, and improve resilience against energy price fluctuations.
- A **systematic approach** allows these opportunities to be addressed step-by-step, integrating them into the broader framework of equipment maintenance and company development, rather than treating them as isolated initiatives.
- The **holistic perspective** supports long-term sustainability and operational efficiency, aligning energy management efforts with the company's growth and strategic objectives.

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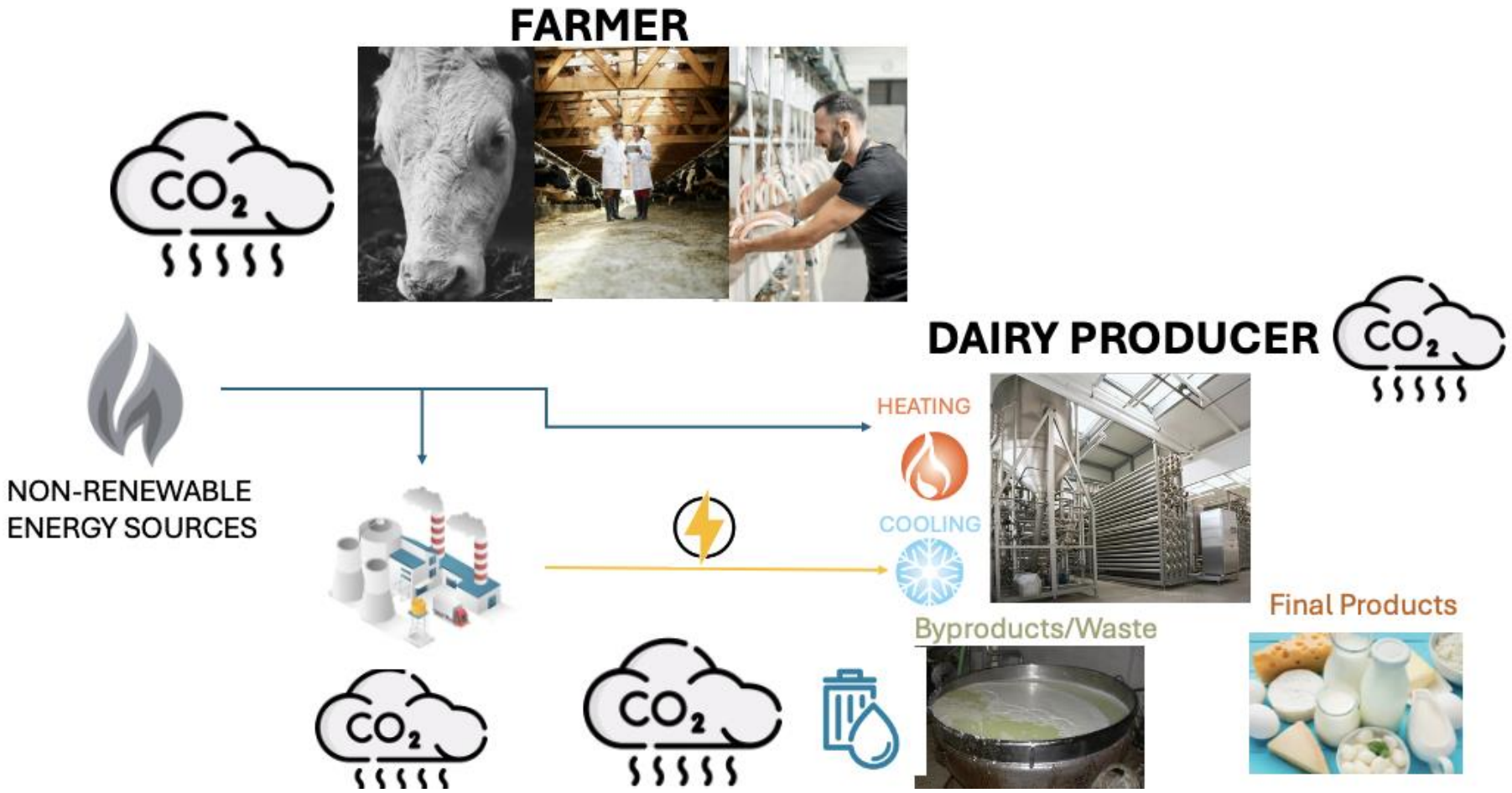
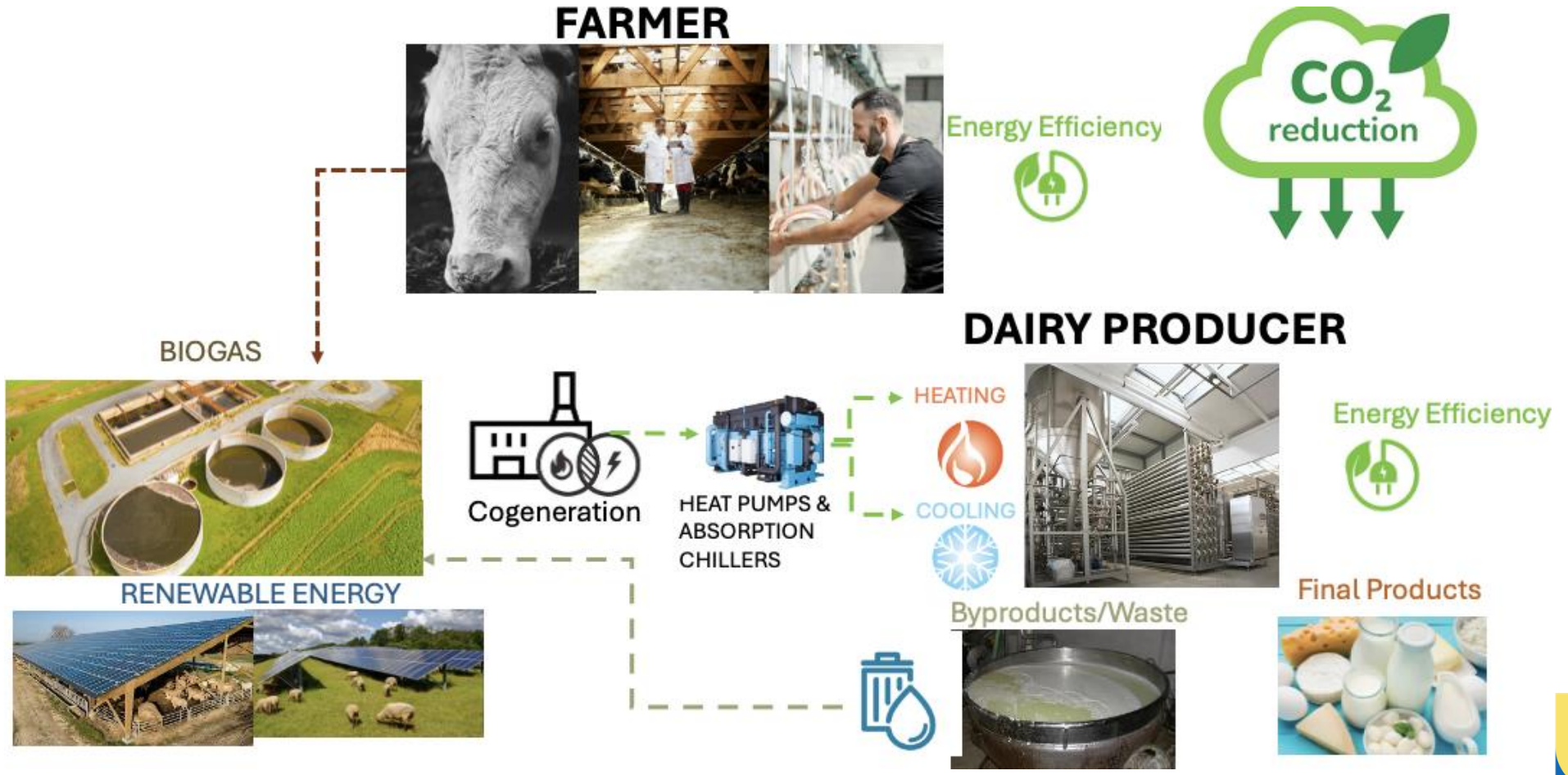
Traditional dairy value chain



BETTED dairy value chain



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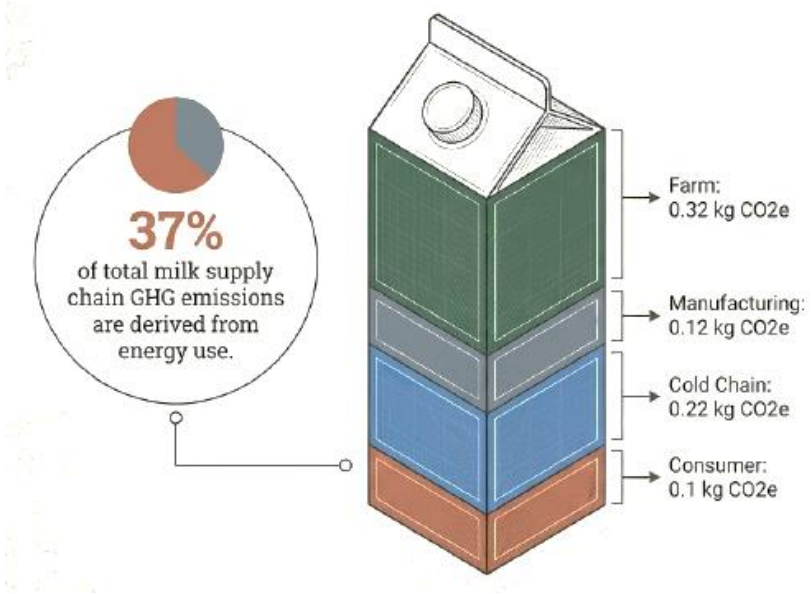
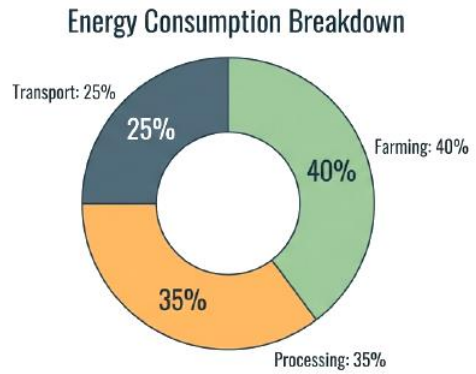
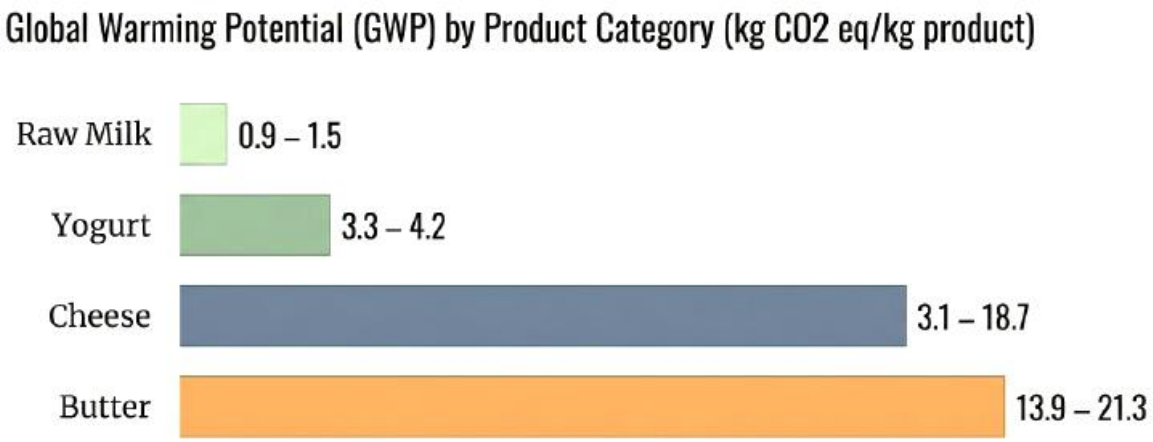
Environmental and Energy across the Value Chain





Thermal Demand (60-80%): Fossil fuels for steam boilers (pasteurization/drying).

Electric Demand (20-40%): Refrigeration and machinery (storage/cooling).



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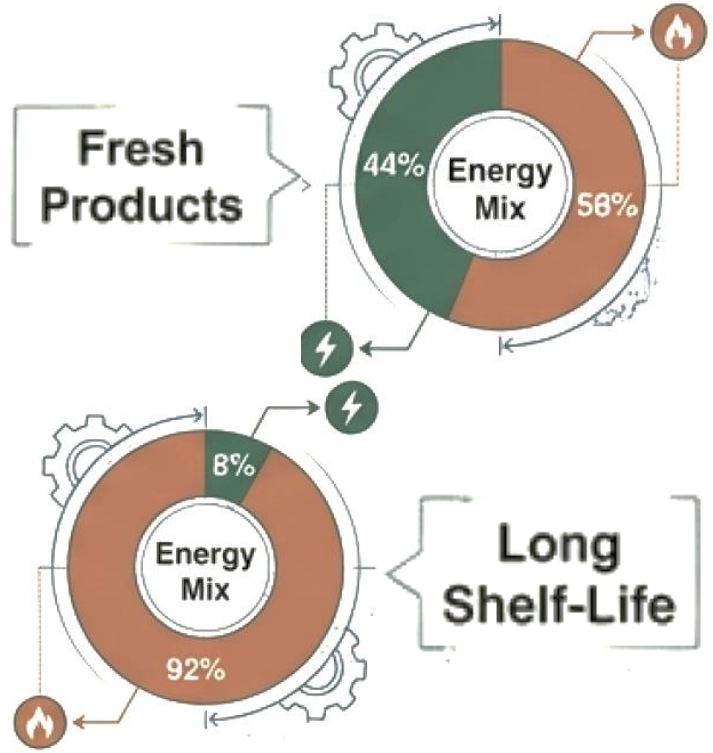
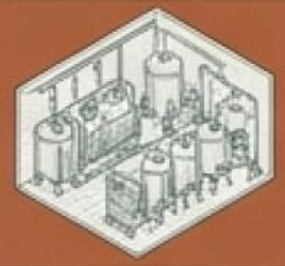
Processing: The Energy Cost of Hygiene and Preservation

Processing energy use per product	
Product Group	**Energy [MJ/kg]**
FDP (Fresh Dairy Products)	0.79
Cheese	3.3
BSM (Butter & Butter Blends)	4.0
Milk & Whey Powders	6.5



Hotspot Alert

The Clean-In-Place (CIP) Burden:
Cleaning accounts for 26% of energy in butter production and 19% in cheese.



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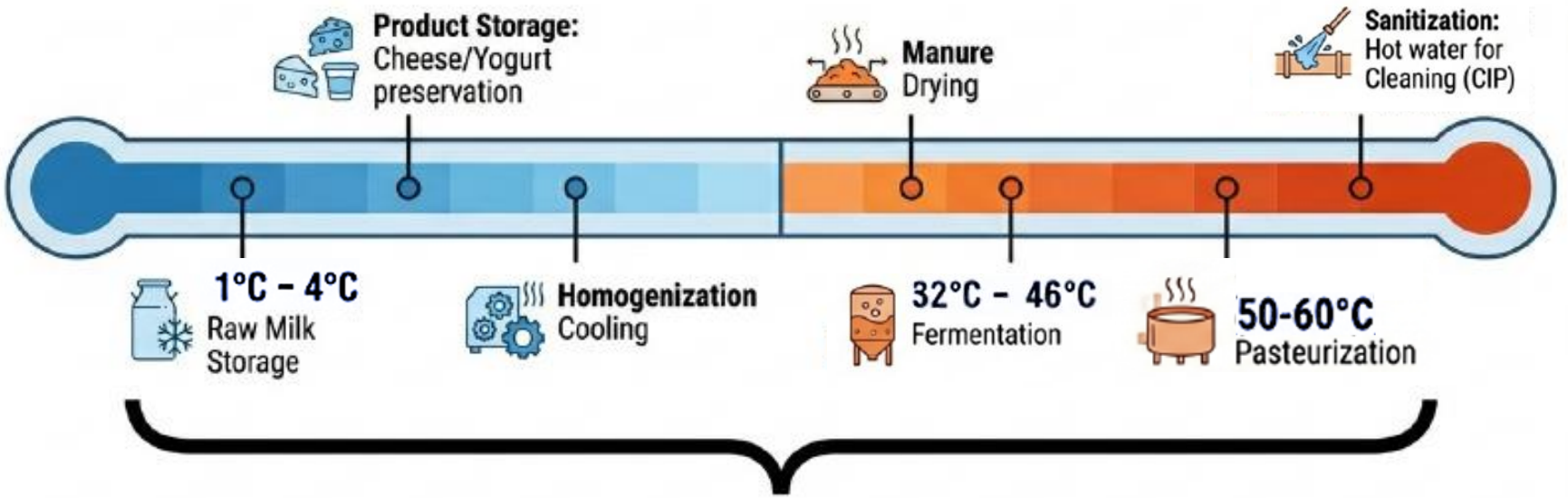
The Energy Paradox: A Battle of Extremes

- Dairy processing requires massive energy because heating and cooling demand occur simultaneously



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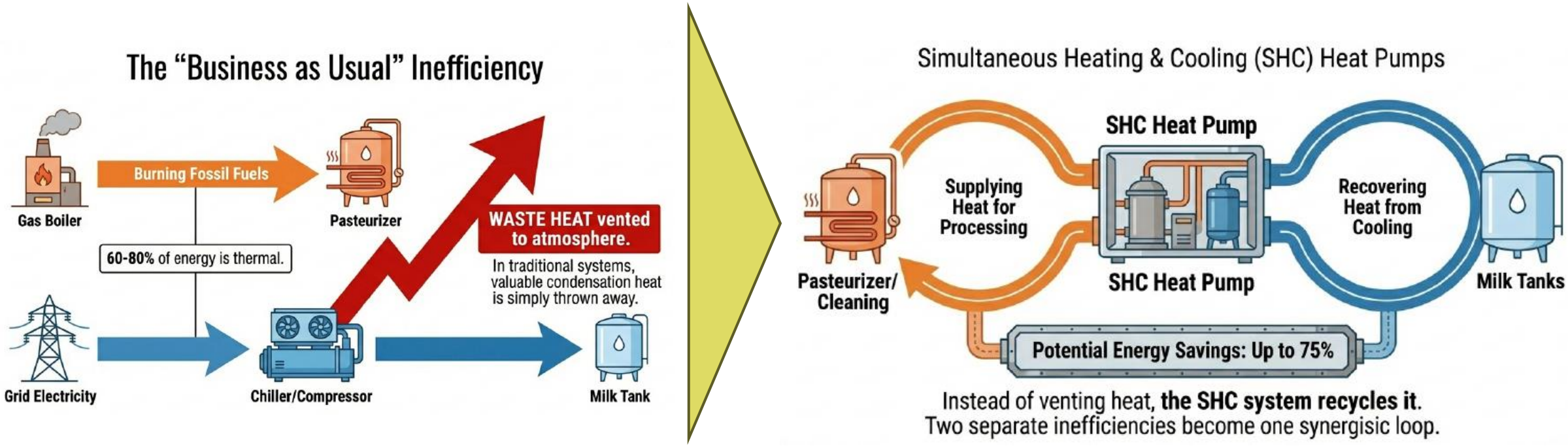
The Solution: Closing the Loop



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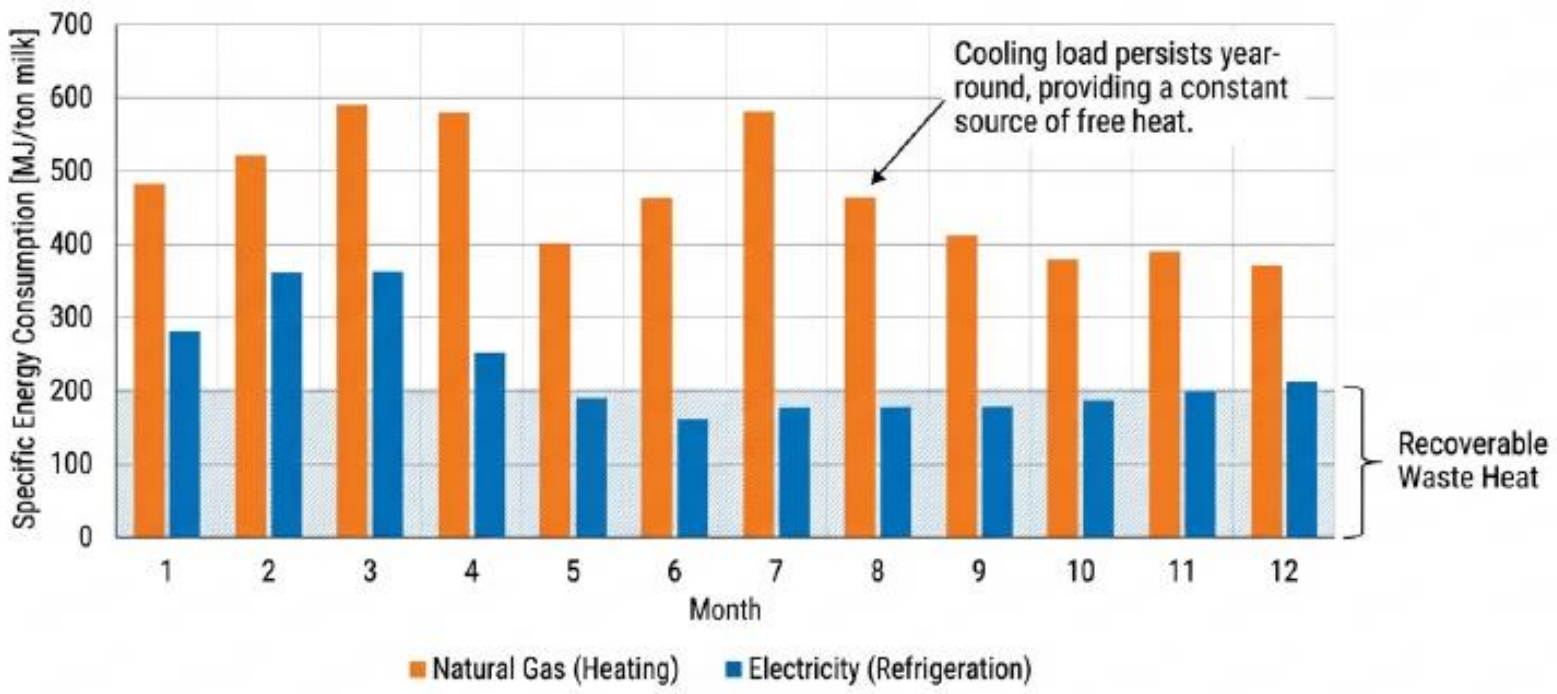
The Data: Untapped Potential Year-Round

Current Status:
Renewables represent <20% of total energy mix in dairy supply chains.

Opportunity: Consistent thermal and electric demand year-round makes dairy ideal for on-site renewables (Solar, Biogas).



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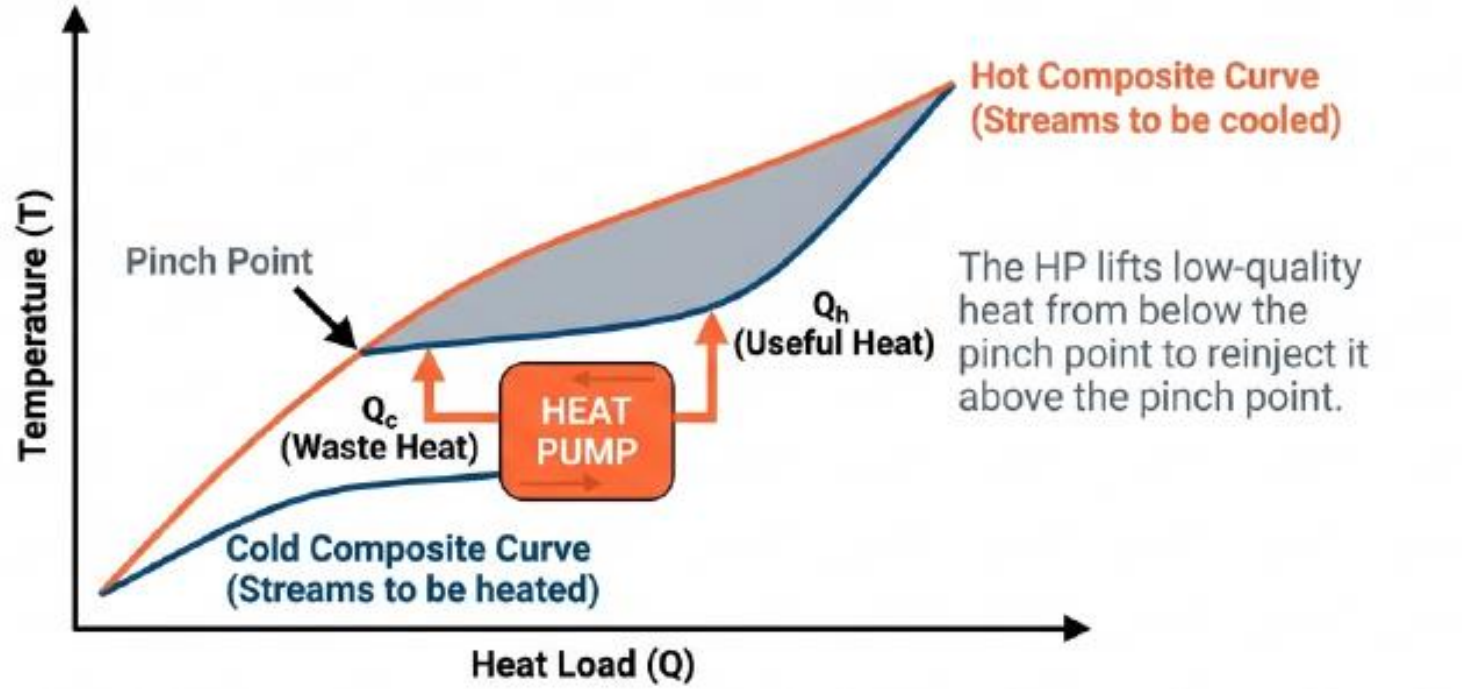
Bridging the Gap: Integrating the Heat Pump



Result: Drastic reduction in external boiler fuel (Q_h) and cooling water (Q_c).

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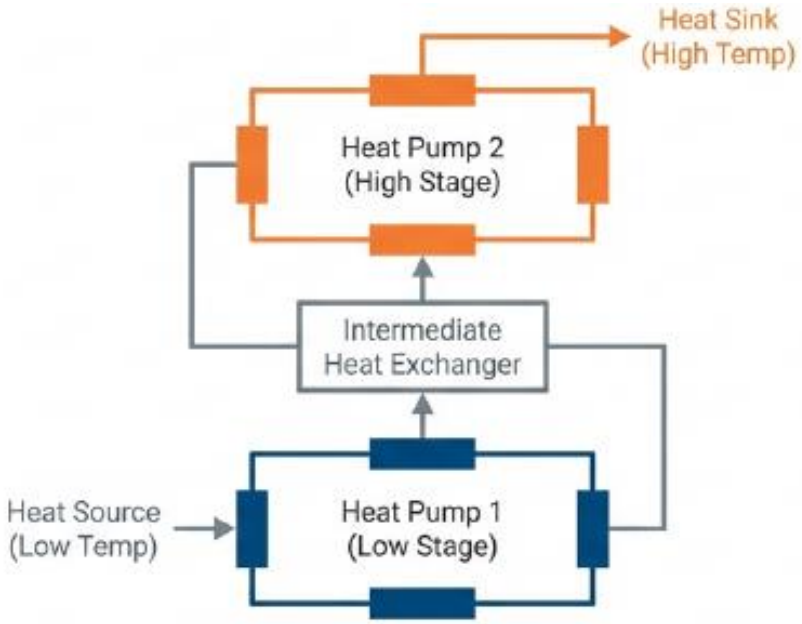
System Architecture: The Cascade Solution

- Handling large temperature lifts with stacked cycles



- Scenario: Large gap between Source and Sink.
- Benefit 1: Allows different refrigerants optimized for specific ranges.
- **Benefit 2**: Improves efficiency by **up to 30%**.
- Benefit 3: Enables combined heating and cooling.

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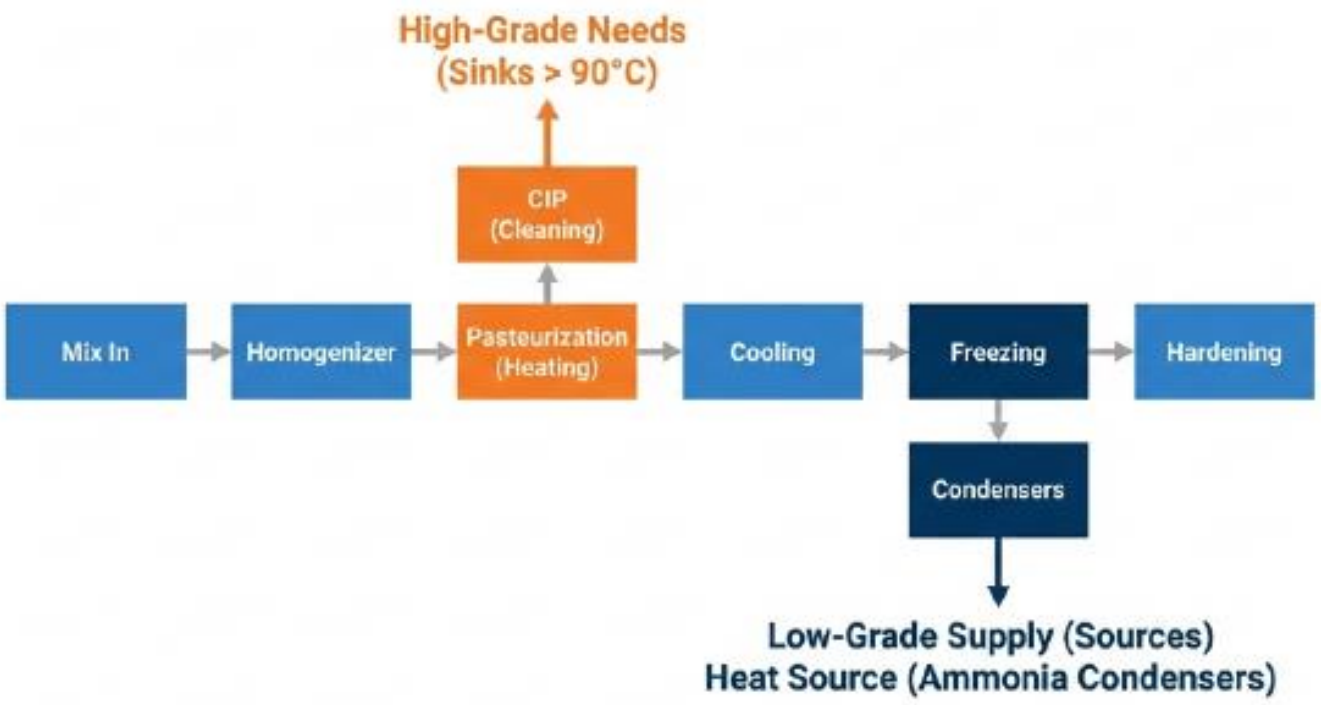
Case Study: Ice Cream Manufacturing



The Challenge:
Matching the abundant low-grade heat (35-45°C) from refrigeration to the high-grade heat (>90°C) needed for cleaning.

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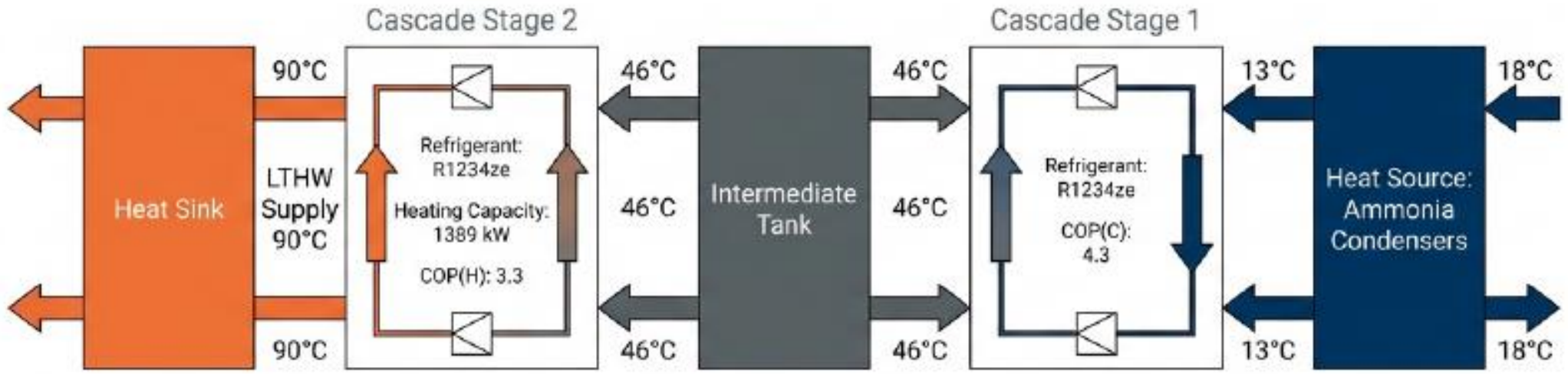
The Solution: Two-Stage Cascade Integration

- Technical Schematic of the Implemented System



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Results & Performance Impact

- Quantifying Efficiency and Decarbonization

Stage 1 Performance

Heating COP: **5.2**

Cooling COP: **4.3**

Stage 2 Performance

Heating COP: **3.3**

Target Temp: **90°C**

System Combined COP

Net COP: **~2.2 – 2.6**

Comparison: **>2x efficiency of Electric Boilers.**

- **Decarbonization:** Replaces fossil fuel boilers for high-grade heat.
- **Simultaneity:** Provides necessary cooling for the refrigeration plant while generating useful heat.
- **OPEX:** Significant operational savings.

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BETTED Three pillars

01

Capacity Building & Community: Build capacity for sustainable energy transition.

Easy-to-Use Tools: Implement user-friendly tools for companies within the same value chain to promote energy efficiency, sustainable practices, and cooperation

02

03

Policy Recommendations: Offer policy and regulatory recommendations to accelerate the energy transition.

Immage source: Pixabay

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Capacity building programme

1. Step 1: **interactive training sessions** with large companies and their value chain aiming at improving their skills, knowledge, awareness, know-how on the potential of sustainability through a collaborative approach.
   - Companies will also be supported in the assessment, implementation, and monitoring of the EEMs, RES and heat pumps with the support of the developed toolbox.
2. Step 2: 20 **workshops with different stakeholders** linked to the dairy sector (e.g., energy manager, non-energy experts inside companies, financial institutions, ...) on the energy and sustainability related topics and on the potential of coordinating the value chain showing also best practices and financial/funding opportunities.
3. Step 3: **e-learning** module.
4. Step 4: value chain **direct interviews and roundtable meetings**

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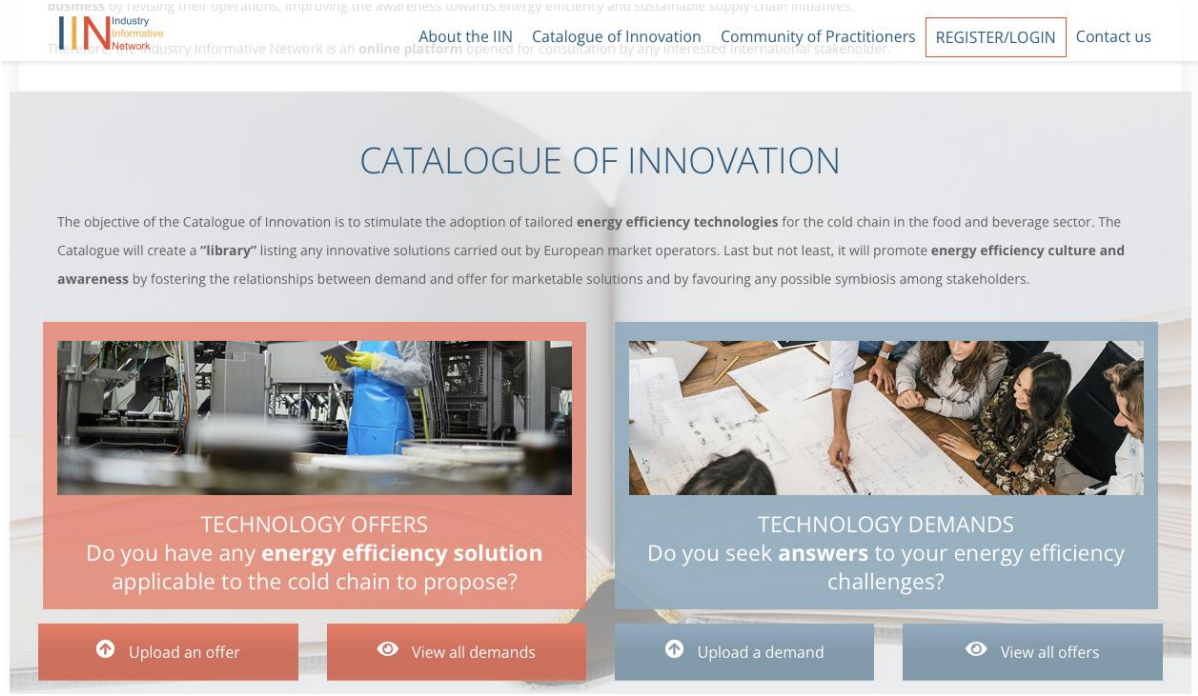
Industrial Informative Network (IIN)

IIN developed under the H2020 ICCEE project will be exploited and updated with further details for the dairy sector enabling learning across all EU Member States (MS) and fostering the relationship between various market stakeholders through the use of a platform that:

- combines demand and supply
- enables discussion among them and with other experts



https://iccee.eu/industry-informative-network/

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BETTED-Toolbox: Coverage from 7 angles

Tool #1: Dairy supply chain tool (DSC)
Do you want to analyze your DSC's energy consumption?

Tool #7: Non-energy benefit evaluator (NEB)
Do you wonder how to analyze non-energy benefits in a structured manner?

Tool #2: Life cycle assessment tool (LCA)
Do you want to understand the environmental impact of your DSC?

Tool #6: Dairy vendors' sustainability (DVS)
Are you interested in evaluating the sustainability readiness of your vendors?

Tool #3: Life cycle costing tool (LCC)
Do you wonder about the economic benefit from energy efficiency measures?

Tool #5: Heat Pumps for dairy (HPD)
Do you wonder about integrating a Heat Pump's potential economic and environmental benefits?

Tool #4: Biogas in the dairy chain (BDC)
Do you wonder about the potential economic and environmental benefits of integrating a Biogas plant?

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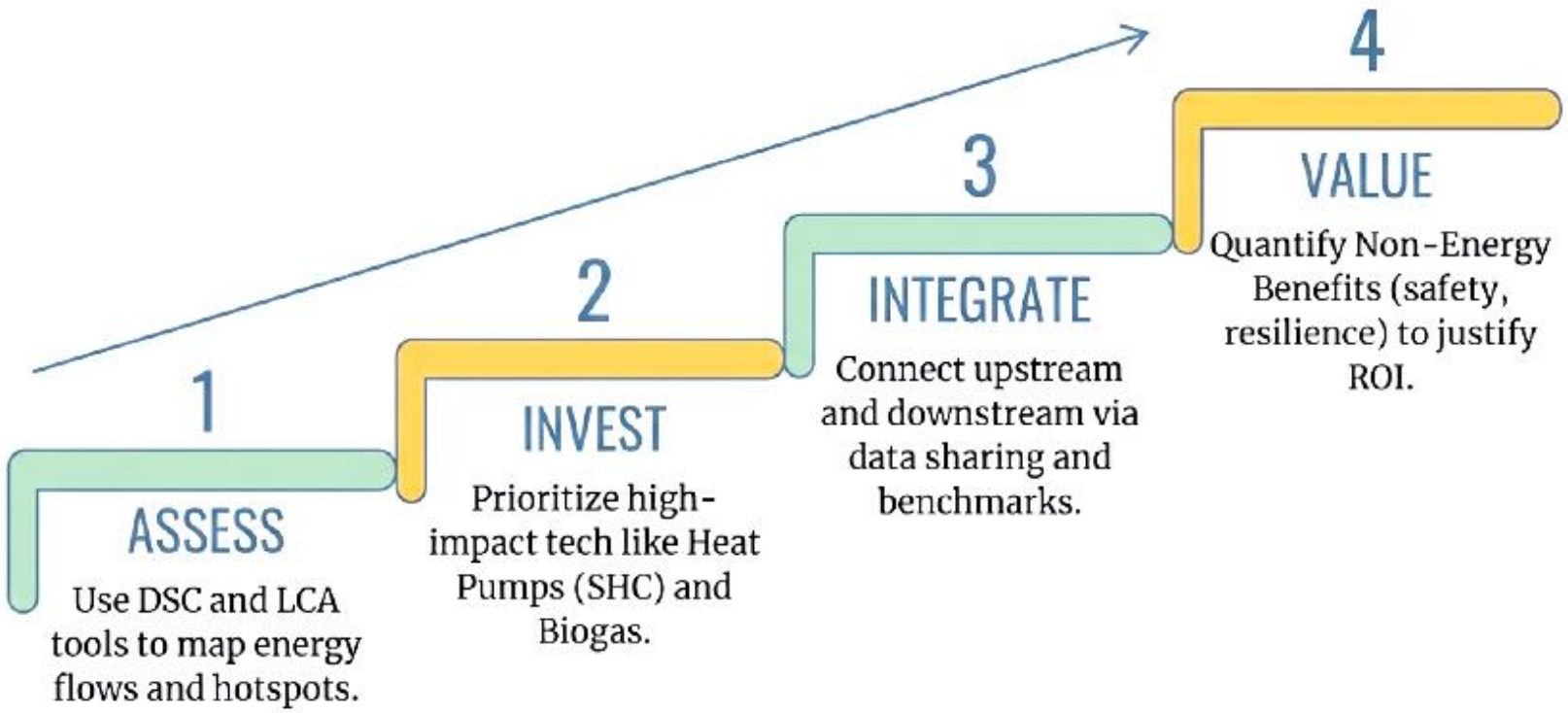
Strategic roadmap for a net-zero dairy sector

- Transitioning from Isolated Efficiency to Systemic Sustainability



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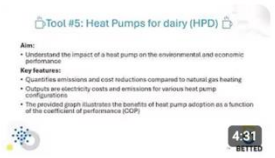

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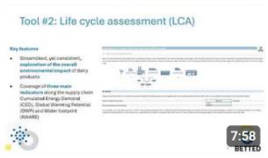

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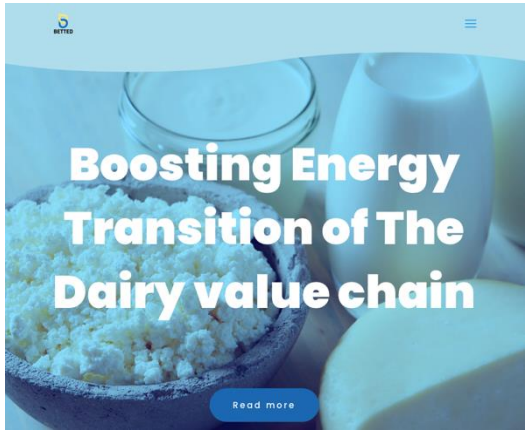

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