LIFE THE TOUGH GET GOING PROJECT

LIFE TTGG

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Action B4

Summary report

"PEF reduction measures: description"

DEPARTMENT OF ENERGY – POLITECNICO DI MILANO

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ENERSEM S.r.l.

INTRODUCTION

To limit global warming, in the coming decades, the reduction of Greenhouse Gas (GHG) emissions will have to be substantial and should cover all productive sectors. In this regard, the energy sector holds the main responsibility for direct global emissions, while the agricultural sector is responsible for 10-12% of total GHG emissions worldwide. Based on actual population growth projections, food consumption will increase, and the GHG emissions from agricultural activities will rise without action.

The European dairy sector represents one of the principal players globally in terms of importation and exportation. It is a crucial creator of wealth and jobs in the European Union. However, if we consider its environmental impacts, GHG emissions, water consumption, land use, etc., should not be underestimated.

Solutions are needed to improve cheeses' supply chain efficiency and to analyze and reduce their environmental footprint. More sustainable production and consumption is achievable only considering the whole supply chain of products, including waste management. According to some studies, the waste of food products for human consumption touches very high percentages, and up to one-third of edible food produced is lost every year. The European Commission sets aspiring targets to reduce GHG emissions and environmental degradation as a part of the European Green Deal. In line with the Farm to Fork strategy, the heart of the European Green Deal, the project LIFE 16 ENV/IT/000225 - LIFE The Tough Get Going (meaning "tough" the hard and semi-hard cheeses covered by the project) arises from the collaboration among universities, start-ups, manufacturing companies, Italian and French institutions, and research organizations. Through this synergy, the partners aim to improve the cheese production processes efficiency of Grana Padano and Comté, transfer the findings to Europe, reduce environmental impact, and thus achieve more sustainable production and consumption. Italy and France are significant European cheese producers (France takes second place after Germany, and Italy takes sixth place after Germany, France, the UK, Poland, and the Netherlands). In this context, Grana Padano and Comté undoubtedly are vital representatives of the two countries concerning Protected Designation of Origin (PDO) productions.

As well-known, Life cycle assessment (LCA) is increasingly required representing one of the reference methods for the European environmental policies and helps in analyzing supply chains to achieve environmental sustainability objectives. It consists of a comprehensive analysis that accounts for the material and energy inputs and emissions associated with each stage of a product life cycle, from resource extraction through processing to final use and disposal, to assess the environmental load quantified on specific impact categories. The European Commission, since 2013, has developed its LCA method called Environmental Footprint.

The authors with this document present some of the solutions identified related to the production phase of raw milk and milk processing, thanks to the project, applying the Environmental Footprint methodology to the supply chain of Grana Padano PDO. The document presents a first section in which the contributors to the environmental impact of cheese are shown; after it, the identified solutions are presented and discussed.

WHERE DO THE POTENTIAL ENVIRONMENTAL IMPACTS FOR CHEESE PRODUCTION COME FROM?

In this section, the environmental results achieved by the LIFE TTGG project are presented in summary. The outcomes obtained thanks to the project (for the Grana Padano DOP supply chain) highlighted that the raw milk production phase is responsible for about 90-92% of the environmental profile of cheese. The dairy and packaging phases are responsible for 6-7% of the total impact, while the distribution and end-of-life phases are responsible for the remaining 2-3%. In this regard, 68 dairy farms, 20 dairy plants, 20 ripeners, and 20 packers were audited. The results were assessed applying the Life Cycle approach through Product Environmental Footprint methodology, developed by the European Commission.

Figure 1 shows the most important contributors for (a) the raw milk production phase and (b) the dairy processing phase (excluding the production of raw milk, packaging, and distribution of the final product). For the farm phase, the hot spots, as shown, were feed purchased (34%), own production of feeds (25%), manure handling (16%), and enteric fermentation (12%).

For the dairy processing phase, the results underline how the most impacting factors were the consumption of heat (34%) and electricity (26%). Therefore, most of the effort was allocated to estimating energy consumption and defining potential energy savings.

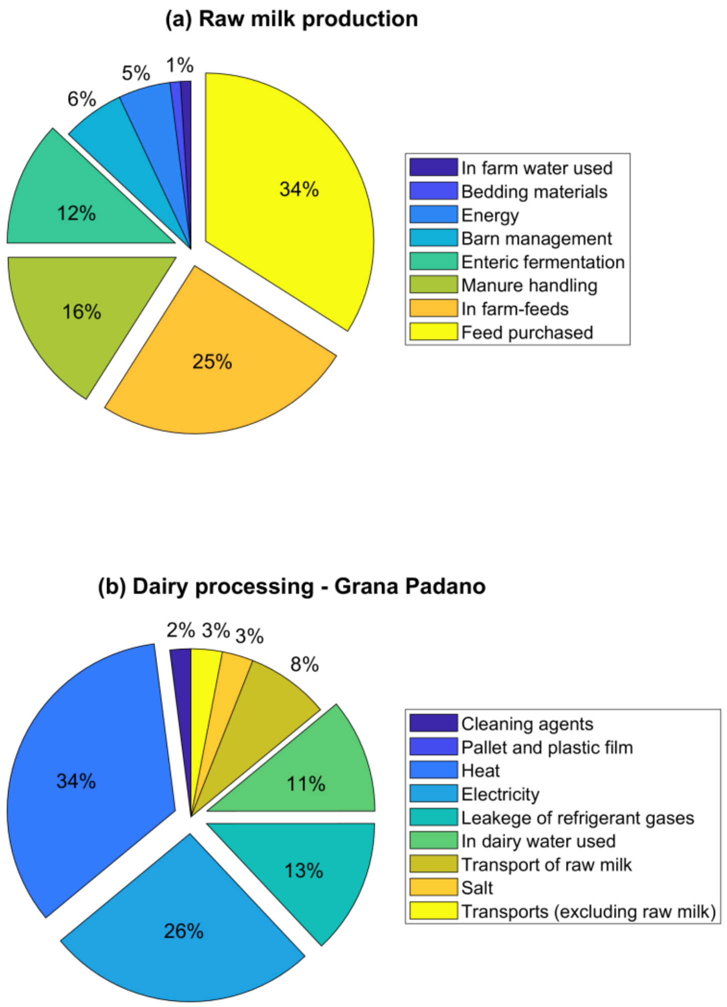
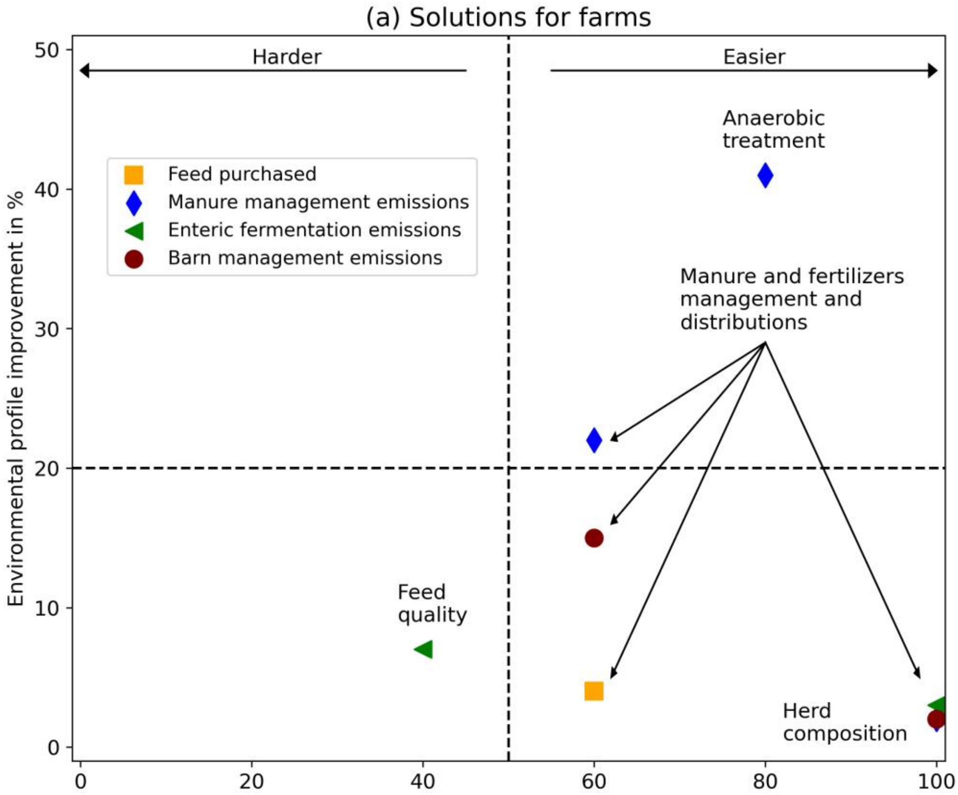


Figure 1. Contribution in terms of potential environmental impacts of materials, direct emissions, and energy for (a) raw milk production – (b) Transformation of raw milk in Grana Padano PDO.

HOW TO OPTIMIZE THE SUPPLY CHAIN?

This section lists some solutions to make the raw milk production and the dairy processing phase more efficient. For each proposed intervention, both the environmental effects and the reduction potential were highlighted. In Figure 2, a summary of the solutions presented was given underling the efficiency in terms of feasibility and (a) potential impact reductions and (b) primary energy consumption non-renewable (nren).



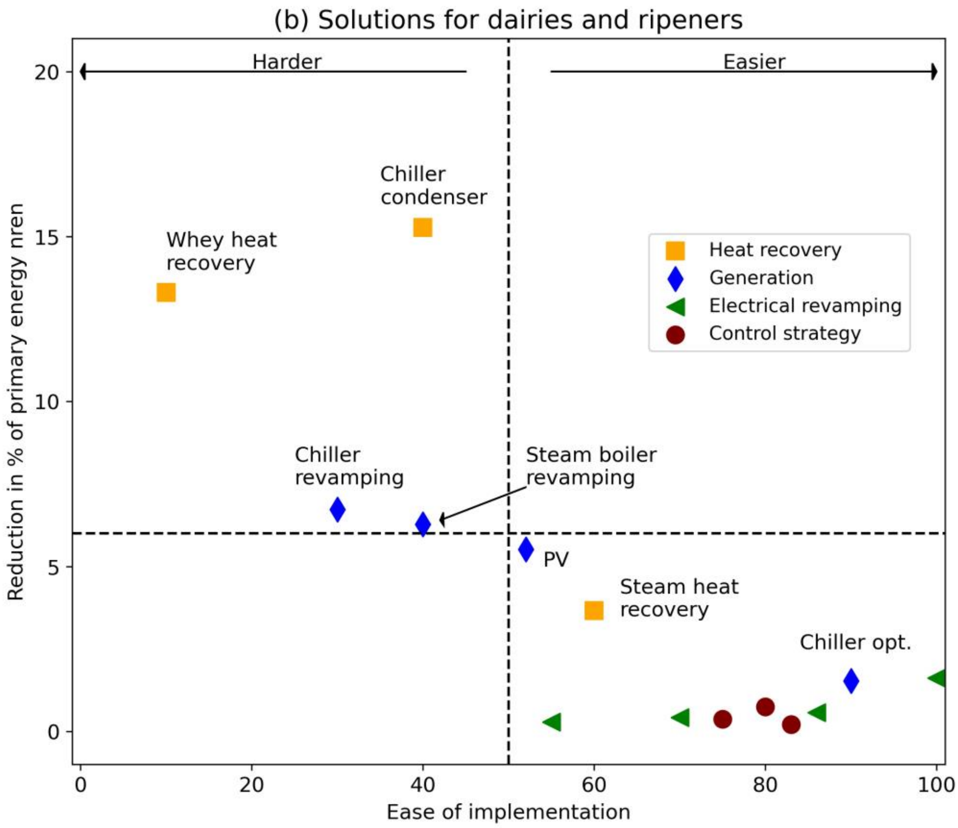


Figure 2. Solutions for (a) farms, (b) dairies and ripeners

HOW TO IMPROVE THE ENVIRONMENTAL PROFILE OF YOUR FARMS?

The authors in this section explained the interventions with higher potential impact reduction and easy implementation, presented in Figure 2 (a).

1) Management and distribution of livestock manure and distribution of mineral fertilizers

Livestock manure storage and subsequent distribution are central issues for many environmental impacts on air and water quality. Correct management and distribution of livestock manure and correct use of mineral fertilizers can reduce ammonia (NH_3), nitrous dioxide (N_2O), and nitrogen oxide (NO_x) emissions. It has positive effects on climate change, particulate matter, eutrophication, and acidification impact categories.

How does it affect the environmental impact?

When manure is improperly handled, nitrogen (N) could be easily lost via gaseous emissions in the form of ammonia (NH_3), nitrous dioxide (N_2O), and nitrogen oxide (NO_x). The NH_3 emitted is a threat to human health by forming fine particles (PM2.5), while Ammonia-N deposited to land or waters leads to acidification and eutrophication of natural ecosystems.

Which solutions can be implemented?

This section presents some solutions to manure management and fertilizer distribution that can lead to a potential environmental impact reduction of 3 and 7% of the environmental profile of raw milk.

a) Manure management system solutions (NH_3 emission reductions)

The implementation of low emission manure storage systems creates a physical barrier between manure and air.

Reliability (High), cost (High), and impact reduction (High)

- **Rigid lid or roof - impermeable:** solid/concrete lid very reliable;
- **Flexible cover - impermeable:** this system includes a tent cover or domed-shaped cover installed over round stores with the use of steel components and bolted joints;
- **Replace lagoons with tanks - open or covered, permeable or impermeable:** existing lagoons should be gradually replaced by deeper tanks to reduce the surface per unit volume.

Reliability (Medium), cost (Medium), and impact reduction (Medium)

- **Floating plastic bodies/foil - impermeable:** impermeable floating covers can include both floating plastics or suspended plastic bodies. Storage of the manure can be covered with a plastic sheet (usually a flexible, reinforced, high-density polyethylene membrane) or floating geometric plastic bodies in which the vertical ribs in the bodies prevent the elements from being pushed one on top of the other.
- **Storage bag:** it usually suitable for small farms.

Reliability (Low), cost (Low), and impact reduction (Low)

- **Natural crust - permeable:** natural floating covers are those formed by the fibrous material in the manure. Encouraging crusting is possible by minimizing stirring of stored slurry or introducing new slurry below the surface. Suitable natural cover for farms that do not have to mix manure for frequent spreading.

b) ***Manure spreading techniques (NH_3 and N_2O emission reductions)***

The manure application method significantly affects NH_3 potential losses. Improving infiltration and incorporation of manure into the soil reduces contact between manure and air.

Reliability (High), cost (Low), and impact reduction (High)

- ***Band Spreading:*** This method reduces the surface area of slurry exposed to the air, lowering ammonia emissions as well as nutrient losses
- ***Injection:*** can be described as shallow (closed slot) or deep injection.

c) ***Nitrogen fertilizers spreading techniques (NH_3 and N_2O emission reductions)***

The NH_3 emissions from fertilizer applications are dependent on fertilizer type, weather, and soil conditions. Best agricultural practices for nitrogen fertilizers spreading rely on either slowing the hydrolysis of urea or encouraging the rapid transfer of fertilizer into the soil.

Reliability (Medium), cost (Low), and impact reduction (Medium/High)

- **Incorporation into the soil:** made after fertilization by a tillage operation should occur as soon as possible.
- **Injection into the soil:** shall be adopted carefully since an improper slot closure led to very high emissions due to a rise in pH within the band when the urea hydrolyses. It more effective than shallow incorporation.

- **Urease inhibitors** are chemical compounds that block the activity of the enzyme urease, reducing and slowing the rate at which urea is hydrolyzed—valuable tools for controlling gaseous losses of ammonia.
- **Irrigation of the field after fertilizer application:** irrigation at the appropriate timing and rates (at least 5 mm water) can mitigate NH_3 emissions. It is a mitigation action to be considered just where there is a water need for irrigation. Vice versa, the risk is to increase nitrate leaching.

d) Slow-release urea-based fertilizers (CO_2, NH_3, and N_2O emission reductions)

Controlled-release nitrogen fertilizers are characterized by releasing nutrients at a slower rate, extending N availability for plant uptake. Consequently, crop yields can be effectively enhanced and raise the efficiency of nitrogen fertilizer in agroecosystem with the overall effect that approximately 20% less fertilizer is needed.

2) Anaerobic treatment of livestock manure

Manure storage emissions are a central issue for the environmental impact related to climate change. Manure storage is an important source of methane as a consequence of organic matter decomposition. Methane has a significant global warming potential and, therefore, a high impact on climate change.

How significant can be the impact reduction?

Anaerobic livestock manure treatment would allow emission reductions for raw milk production from 3% to 9%.

Reliability (High), cost (High), and impact reduction (High)

Anaerobic digestion provides a promising practice for mitigating Greenhouse Gas emissions from collected manure and stabilizing the organic carbon in the feedstock by reducing easily degradable C in manures and increasing plant availability of nitrogen when the digestate is spread as a fertilizer.

3) Heard composition

Strategies linked with heard composition are adopted to minimize the number of unproductive animals in the herd and consequently increase farm management efficiency. It helps to make efficient use of the farm's available resources and contributes to reducing methane emissions.

How considerable can be the impact reduction?

Reliability (Medium), cost (Low), and impact reduction (Medium)

Combination of different strategies that increase water use efficiency on farms, farm feeds; manure management emissions, enteric fermentation emissions, and barn Management Emissions.

- **Dry period:** milking is best stopped at 220 days of pregnancy to ensure a 60-day rest period for the animal.
- **Age at first calving:** the optimal choice when planning a heifer's first calving, concerning the Holstein breed, is 24 months of age. First calving at 24 months would maximize milk production and minimize breeding costs for the heifer.
- **Average Number of lactations per cow:** The optimal number of lactations per productive cow career should be at least 2.8. This parameter means that a cow should complete at least 2.8 lactations during her productive life on the farm.
- **Calving interval:** represents the interval between two successive births. The optimal interval should be about 376 days and is influenced by the detection of oestrus, the rate of conception, and the voluntary waiting time between calving and when the farmer decides to inseminate the animal for the first time after calving.
- **Average calving per year:** in dairy cattle breeding, the optimal number of births per year should be 0.97. It would be the result of the best fertility management of the herd.
- **% of a calf born female per year:** assuming that the number of lactating cows remains constant, every year as many females must enter production as are culled for various reasons such as reduced productivity or fertility, aging, disease, accidents, to keep the stock in balance over time.

The optimization of the reared herd's composition leads to a reduction of the total average dairy farm impact in the range of 0.09 to 5%.

HOW TO IMPROVE THE ENVIRONMENTAL PROFILE OF YOUR DAIRY?

This section explains the efficiencies with higher potential impact reduction and easier to implement, presented in Figure 2 (b). All the solutions described in this section significantly reduce the environmental impacts linked with energy consumption; thus, primary energy, climate change, acidification, etc., regarding the energy vector used to supply the appliances.

1) Heat recovery from whey

The heat recovery from whey solution is related to the recovery of heat from the whey cooling process. The whey represents 80-90% of the milk mass at the inlet of the cooker. The whey must be cooled down soon after the cooking phase to be directly sold or concentrated. The existing process consists of multiple-stage cooling in a dedicated heat exchanger. The possible cooling sources are i) cooling tower, ii) well water, and (iii) icy water. This cooling process is highly energy (electrical) and water consumption.

For implementation, the heat recovery system needs two tanks for technical water storage, and additional heat exchangers. The number of new heat exchangers depends on the number of users of the recovered heat, as generally, one heat exchanger is installed for each intended user.

The utilities potentially affected by recovered heat from whey are as follows:

- preheating of milk entering the compartments;
- preheating of the washing water of the whey concentrator;
- preheating of washing fluids of CIP (Clean In Place) plants;
- preheating of hot water for environments sanitizing;
- heating of milk in the activation line.

How significant can be the impact reduction?

Reliability (High), cost (High), and impact reduction (High)

Heat recovery from whey results in both thermal and electrical energy savings. The saving of thermal energy is strictly dependent on the number and amount of heat recovery users available in the dairy and compatibility with the recovery system. On average, savings range from 7 to 28% of the total heat consumption of dairies. Electricity savings, on the other hand, depending on the combination of sources used for whey cooling. In general terms, the more significant the proportion of chilled water used, the greater the saving, which on average is between 1% and 5% of the electricity bill.

2) Heat recovery from chiller condenser

Chiller units are generally air- or water-cooled (via a cooling tower). The proposed intervention consists in recovering the condensation heat from the steam compression cycle. The temperature level of the recovered heat is relatively low (25-35°C); therefore compatible with users characterized by the same thermal level. A user particularly indicated for the exploitation of the heat recovery is the Air Handling Unit (AHU) serving the ripening warehouses. The heat demand of the warehouses is continuous during the year because of the high dehumidification requirements, and the necessary temperature is compatible with that obtainable from the chiller condenser, provided that the exchange circuits of the AHU are adequately sized. This solution is particularly effective if there is a centralized cooling production system.

How significant can be the impact reduction?

Reliability (High), cost (High), and impact reduction (High)

The heat recovery from the chiller condenser allows a considerable saving of thermal energy, as it can potentially cover the heat requirements of the ripening warehouses entirely. The saving is between 9%-43% of the total heat consumption of dairies. It strictly depends on the size of the ripening warehouses present in the dairy.

3) Revamping cooling production

If there is a need to upgrade the cold production system (due to obsolescence or insufficient cooling capacity), two approaches are possible:

- replacement of the chiller, connection to present ice storage;
- replacement of the chiller, ice storage disposal, and direct cooling production.

The first approach means lower investment costs but lower overall efficiency improvement. The efficiency improvement is due only to the new chiller's higher EER (Energy Efficiency Ratio) compared with the old one. The second approach requires higher investment costs but leads to higher savings. These savings are due to the higher EER of the new chiller (at the same operating conditions as the old one) and higher cooling production temperature, meaning even higher EER values and lower thermal losses.

How significant can be the impact reduction?

Reliability (High), cost (Medium/Low), and impact reduction (High)

In general terms, savings depend on how inefficient the current generation system is and the extent of the dairy's refrigeration needs.

Replacing the refrigeration unit with retention of the ice tank (first approach) can increase overall cooling generation efficiency by 60% (e.g., EER from 2.75 to 4.40); that is, electricity savings of between 5% and 27% of total dairy electricity consumptions.

Replacing the refrigeration unit with the elimination of the ice tank (second approach) can improve performance by an additional 30% over the first approach, leading to savings of between 7% and 37% of the electricity bill.