Enhancing Energy Efficiency in Dairies

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Contents

Dairies: Introduction

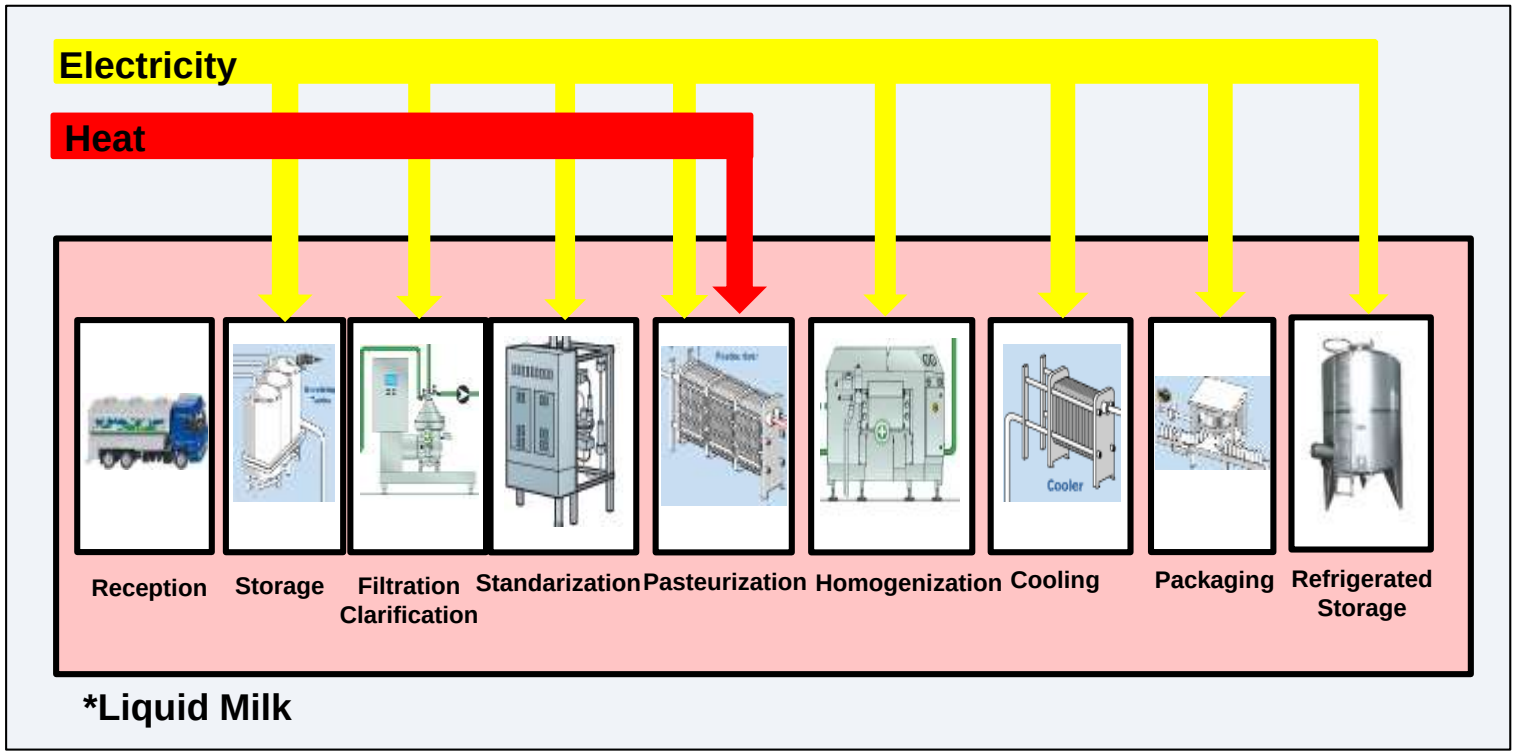
- Dairy: Processing of animal milk
- Dairies are typically located in a dedicated farm
- Energy intensive process
- Energy accounts for 2-3% of production costs
- Focus on minimised use of energy
- Possibility for Cogeneration and Trigeneration
- Product purity and energy security is a must

Milk and powder milk

Cheese products

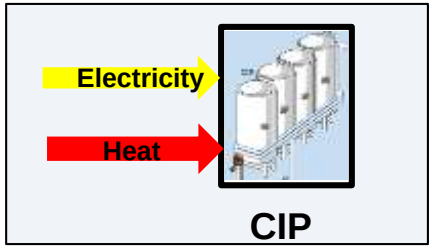
Fresh products

Dairies: Manufacturing Process



Other product can be:

- **Butter and cream.**
- **Cheese.**
- **Powdered milk.**



Reception
- Delivery from the farm

Storage
- Temporary storage in refrigeration tank

Filtration
- To eliminate impurities
- To eliminate foreign particles

Standardization
- To preserve quality
- To ensure proper fat content

Pasteurization
- Heating milk to kill bacteria
- UHT, heating for short time at high temperature

Homogenization
- Fat globules broken reducing the cream formation
- Improving the flavor

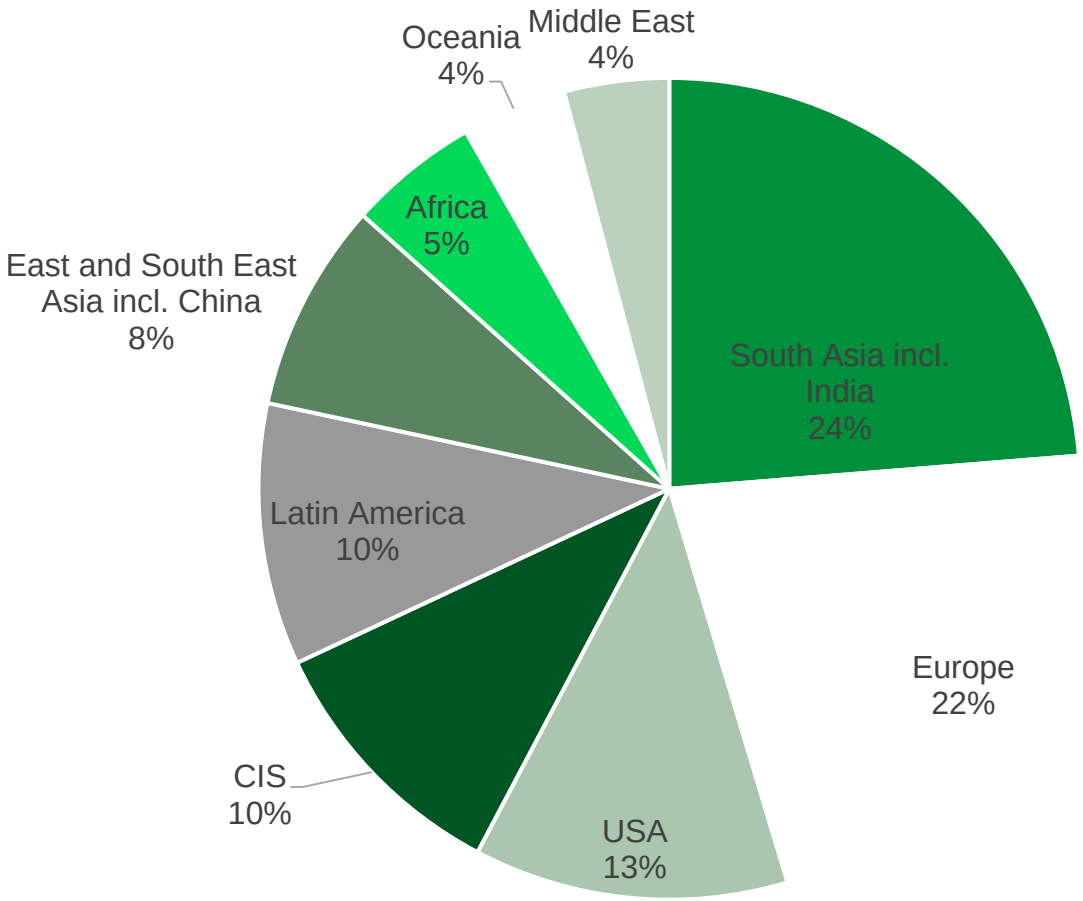
Cooling
- To reduce the milk temperature
- To prevent physical changes

Packaging
- The cooled milk is packaged

Refrigeration
- To delay growth of microorganism
- To prevent physical changes

Dairies: Market Distribution

- Worldwide production 800 million tons per year,
- Increase by 50% in 30 years
- Worldwide leaders are USA, EU, China, India and Brazil
- European leaders are Germany and France



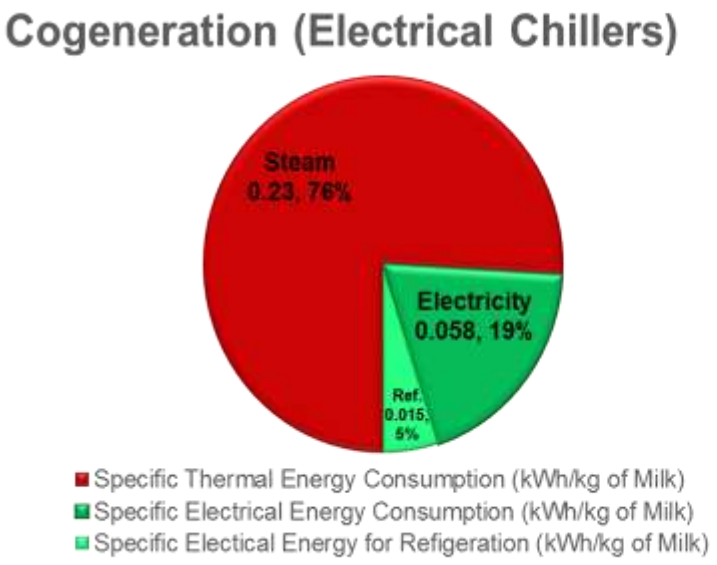
Milk produced by region

* Source: http://www.fao.org/docrep/012/i1522e/i1522e02.pdf

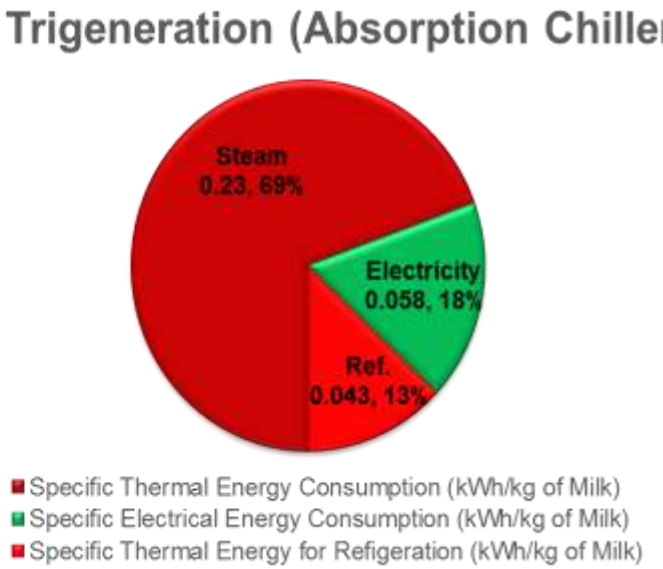
Dairies: Energy Distribution

- Specific Energy Consumption:
  - Amount of energy required to produce 1kg of milk
- Heat to Power ratio favorable for Combined Heat & Power

Utilities	Energy level
Steam	Low Pressure Saturated Steam (217 Psi [15 Bar] @ 388^{0}F [198^{0}C])
Chilling	Cooling at temperatures between 42^{0}F [6^{0}C] to 77^{0}F [25^{0}C]



Heat to Power Ratio= 3.1:1



Heat to Power Ratio= 4.7:1

*Assuming COP=4 for electric chillers
*Assuming COP=1.4 for absorption chillers

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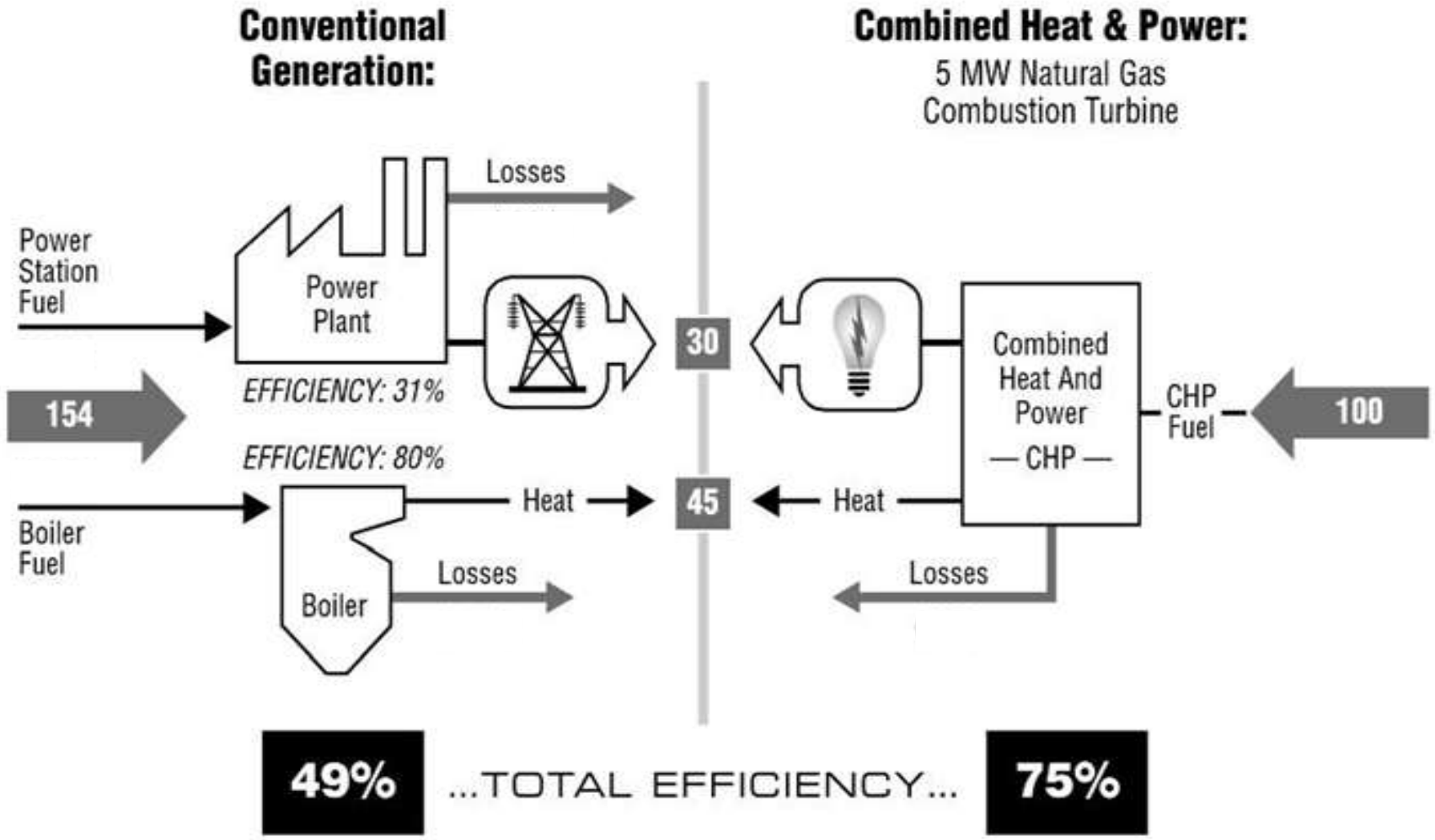
Dairies: Energy Consumers

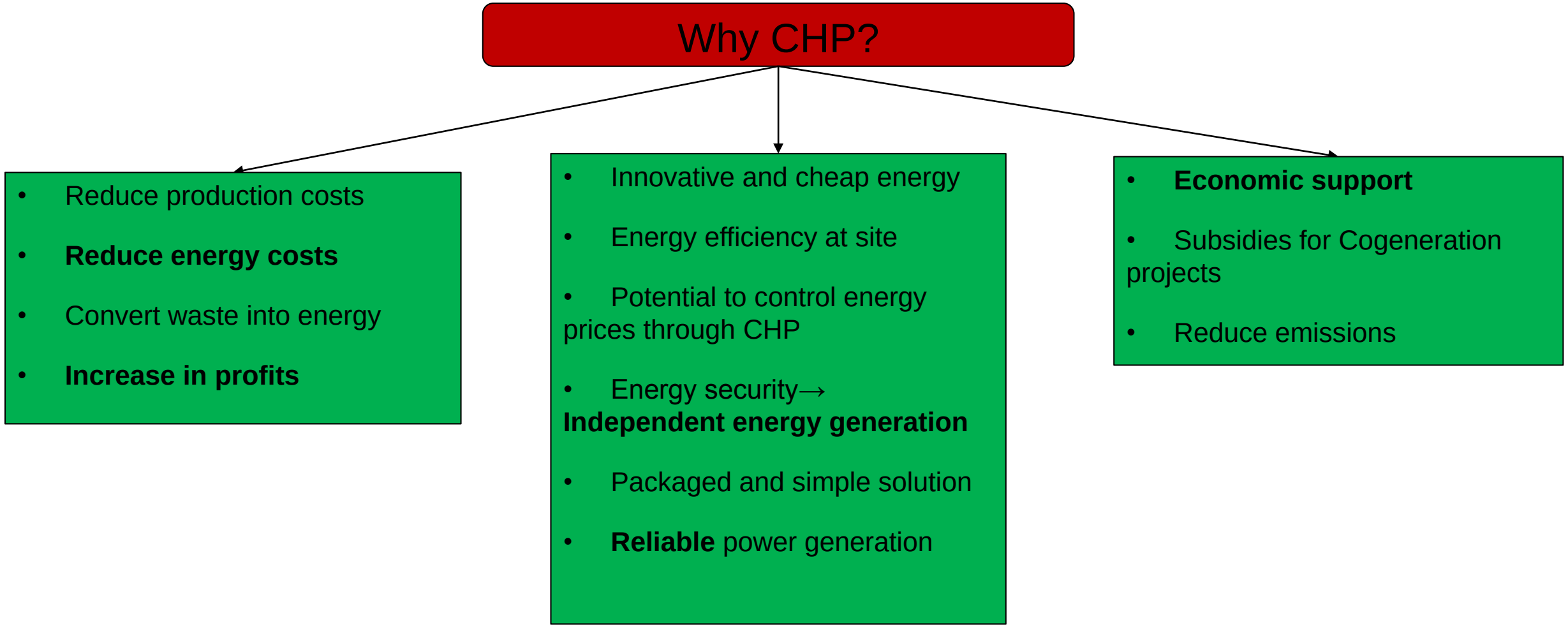
- High thermal energy consumption → natural gas:
  - Evaporation and Spray Drying: Milk powder production
  - Cleaning In Place (CIP)
- High electricity consumption → grid:
  - Refrigeration
  - Compressed air
  - Auxiliaries
- Anaerobic wastewater treatment
  - Digester gas/ Biogas (Siloxanes & H2S)
  - Free fuel

Combined Heat and Power (CHP) increases efficiency



Source: U.S. EPA: Combined Heat and Power Partnership

Combined Heat and Power: Key Benefits



Independency, Reliability, Availability & Profitability

OP16 integration in dairies

Cogeneration

Electricity (utilities)

Electrical chiller

1.8 MW

70,600 pph at 1058F

Hot water

WHRB

14,000 pph steam

Legend

- GT Exhaust
- Water/Steam
- Electricity
- Ambient air
- GT Fuel

Trigeneration

Fuel

Electricity (utilities)

1.8 MW

70,600 pph at 1058F

Hot water

WHRB

14,000 pph steam

Absorp-tion Chiller

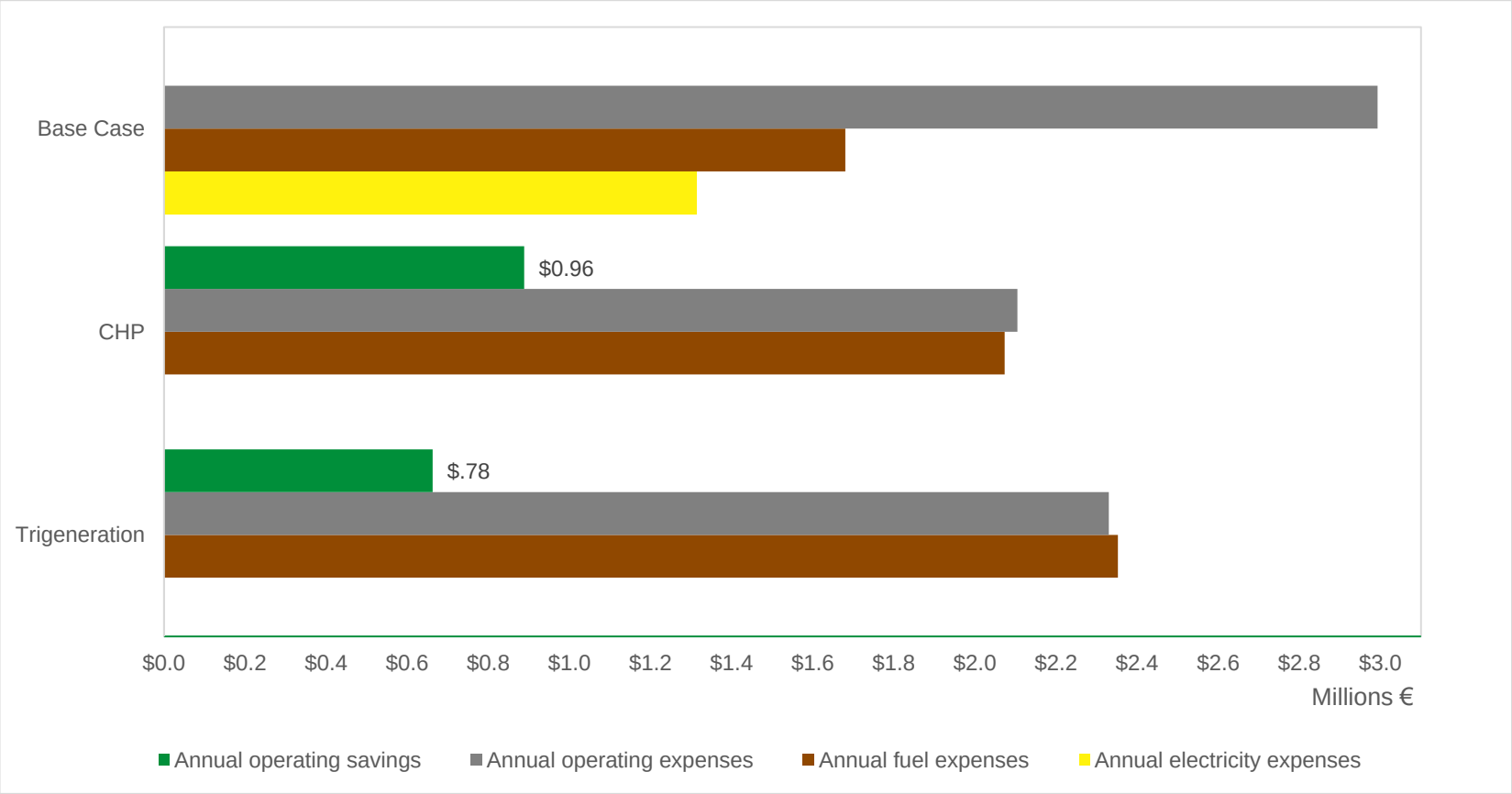
Cold air

References & Feedbacks

- OP16 already implemented in German Dairy Industry
  - Käserei Champignon Hofmeister GmbH & Co. KG: Manufacturer of high-quality dairy products
  - Annual production capacity: 423 M kg milk and 568 M kg annually whey processed

- OP16 used in cogeneration mode
  - OP16-3B operating on 24/7 grid mode
  - Exhaust used for steam generation using supplementary firing
  - Steam generated at 40 bar in heat recovery boiler

Dairies: Feasibility Study



Dairy Size	210 million kg milk
Electricity Demand	1,876 kWe
OP16 Exhaust Heat	15 MMBTU [4,500 kWt]
Sat. Steam production	14,000 lb/hr [6 tph] 174 Psia [@12bar]
Natural Gas Price	3.3 $/MMBTU
Electricity Price	0.08 $/kWh

- ✓ **High Operational Savings: 22 to 30%**
- ✓ **Quick payback: 3.6 years**

- Dairies ≤ 210 M kg of annual milk production is good fit for 1 OP16
- Dairies > 210 M kg of annual milk production is good fit for 1 or 2 OP16

*Trigeneration calculations are including the investment cost of absorption chiller.
** All calculations for Cogeneration and Trigeneration includes complete turnkey costs i.e. CAPEX and OPEX.

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Thank You

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