

CO₂ – BREWERY SELF-SUFFICIENCY AND BEST IN QUALITY.

Ir Jos Sloesen, Ivan Williams, Haffmans BV, Venlo, The Netherlands

INTRODUCTION

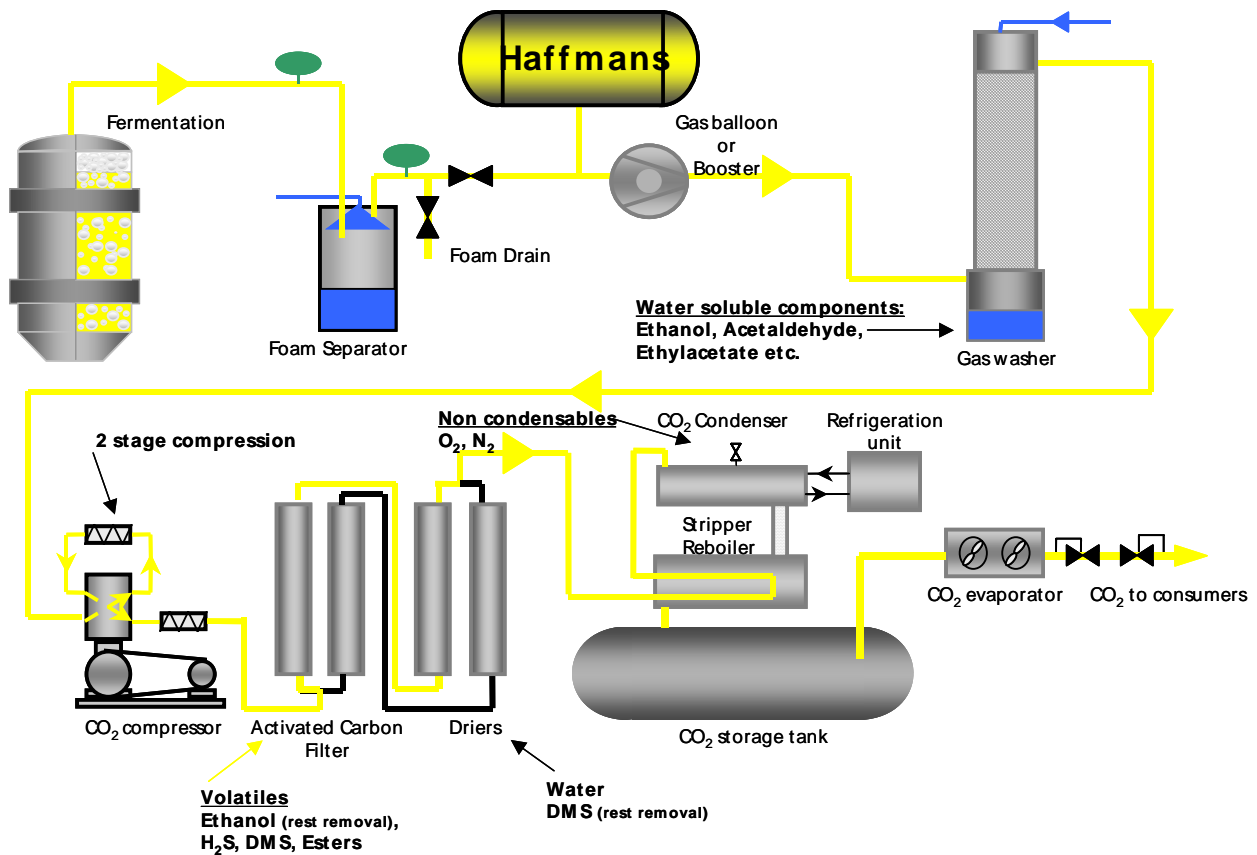
Within brewing, CO₂ Recovery is the process whereby the CO₂ emitted during the fermentation process is collected, purified, liquefied and stored prior to re-use within the brewing process or sold to a third party.

Energy recovery within the process of CO₂ Recovery is becoming ever more commonplace. Increasing costs in world energy mean that

breweries are investing significantly in energy saving and in more energy efficiency systems. The CO₂ Recovery process itself includes energy intensive processes. These are primarily:

1. The compression of CO₂ gas from atmospheric pressure to nominally 17 bar.g
2. The removal of odour and moisture from the CO₂ gas.
3. The liquefaction of the CO₂ and removal of non-condensable gases (O₂+N₂)
4. Vaporising liquid CO₂ prior to re-use within the Brewing process (bottling, canning, flushing, water-deaeration, carbonation etc.)

Of the above steps, 3 and 4 are two sides of a reversible process and allow recovery of the already added energy.



OBJECTIVES

Our objective is then to quantify the available energy, identify how we can best recover this energy and develop a suitable technology for its recovery. Specifically, this involves identifying how we link or couple the CO₂ recovery process with other processes within the brewery to recover this energy. Here we need to consider:

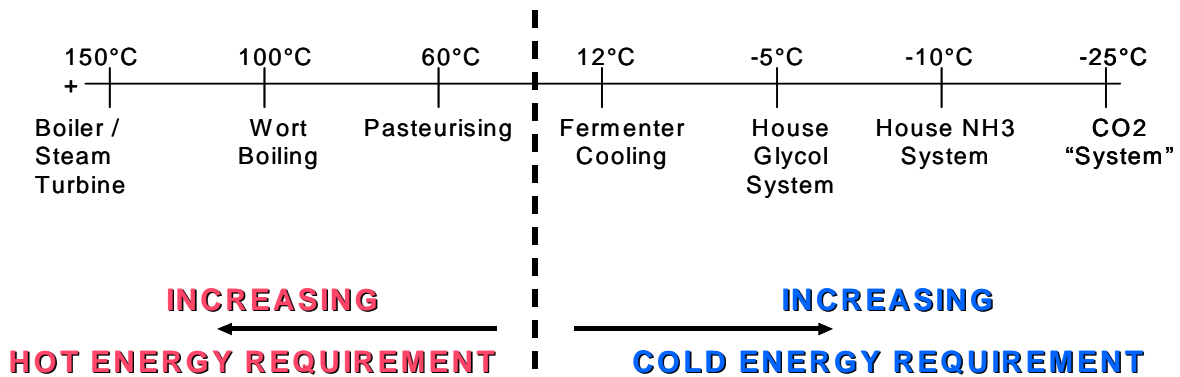
- Concurrency/Commonality of process operating times (thought given to batch versus continual processes)
- “Quality” of energy available - using it in the right place
- Simplicity of concept, ease of retro-fitting into existing concept
- Return on Investment (ROI) and Total Cost of Ownership

HOW MUCH ENERGY IS AVAILABLE?

CO₂ is typically stored in liquid form at 17 bar.g, -24°C. However, the CO₂ is circulating in the brewery for the re-use as a gas - typically this gas has 7-10 barg and an ambient temperature. From here we see that a chilling or refrigeration effect is available from the vaporising process. Importantly, this energy is available at a very low temperature making it ideal for “cold” processes within the brewery.

WHERE CAN WE BEST MAKE USE OF THIS ENERGY?

Firstly we need to have an appreciation of the processes within the brewing process and at what temperature these processes operate. We can best make a distinction between the type of processes present in a brewery by considering processes either “hot” or “cold”. “Hot” being those which require energy to raise the process or product above ambient temperature and “cold” being those which require energy to reduce the process or product temperature to below ambient temperature. (Figures given are nominal and given as a guide.)



It is clear that the colder the process is, the more energy input is required. This leads to the following conclusion:

“When cold energy is available, one should use this at the coldest point in a process in order to make most efficient use of it.”

Therefore we can simply conclude that the traditional method of vaporising CO₂ (using steam or electricity) is not desirable. Steam and CO₂ are at opposite ends of the “hot” and “cold” energy spectrum meaning that the maximum amounts of energy have been expended to provide them!

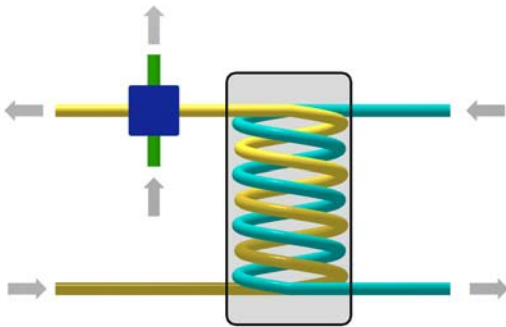
Considering the cold processes within the brewery, we need to determine which processes provide compatible/usable conditions so that we can couple the CO₂ vaporising process and develop energy known as “heat recovery system.”

THREE HEAT RECOVERY SYSTEMS

From a detailed investigation of the cold processes within breweries, we conclude there are three heat recovery systems or “HRS” which can be used to recover the cold energy from the CO₂ vaporising process.

DIRECT HEAT RECOVERY (“HRS-Direct”)

The HRS - direct system means the direct recovery of cold energy into the house secondary refrigerant (“glycol” or “brine”) system. In such a system, warm glycol/brine leaving the fermentation / process area is fed completely (or as a side stream) to a CO₂ vaporiser. Here the glycol/brine is chilled prior to return to the central house chillers. This saves energy on the central house system. On the other side, energy like i.e. steam or electricity for vaporization is saved. The CO₂ gas which is still cold should be superheated prior to use within the brewery - this can be done with cooling water providing a small amount of additional energy recovery.



ADVANTAGES & BENEFITS:

- Lowest capital cost system (equipment and installation) and good ROI
- Compact (minimal space requirements)
- No steam/electricity or vaporizing costs
- Medium availability of heat recovery process (glycol/brine system is nearly always in operation with sufficient load)

DISADVANTAGES:

- Not applicable with ammonia (cross-contamination possibility)
- Not most efficient use of available energy (use at only -5°C)
- Long term, less attractive Total Cost of Ownership
- Requires always a glycol/brine system tie-in (utility outage)

Application and performance will depend on available glycol/brine temperature and/or composition

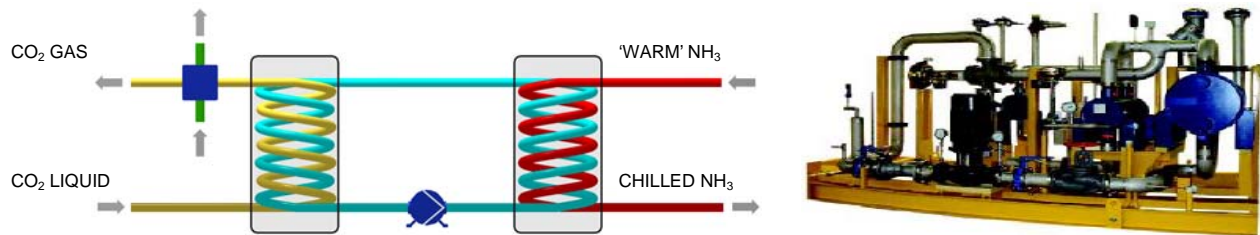
CASE STUDY:

- Annual Production: 800,000 HL
- Glycol chilling costs: € 0,027 / kW
- Steam costs: € 0,017 / kg

ROI = 19 MONTHS

INDIRECT HEAT RECOVERY (“HRS-Indirect”)

The indirect Heat Recovery System applies to those breweries using NH₃ to cool processes. NH₃ can also be used as an energy source in a Heat Recovery System. However, a cross-contamination between CO₂ and NH₃ - as for instance in case of a leak - and the resulting chemical reaction are to be prevented in any case. Therefore, an intermediate system with a second heat exchanger is used and forms a physical barrier between the CO₂ and NH₃.



ADVANTAGES & BENEFITS:

- Low capital cost (equipment and installation) and good ROI
- No steam/electricity or vaporising costs
- Can be used with NH₃ (avoids cross-contamination)
- High availability of heat recovery process (glycol/brine system is nearly always in operation)

DISADVANTAGES:

- More space required
- Not most efficient use of available energy (use at only -5°C)
- Long term, less attractive Total Cost of Ownership
- Requires a glycol/brine/NH₃ system tie-in (utility outage)

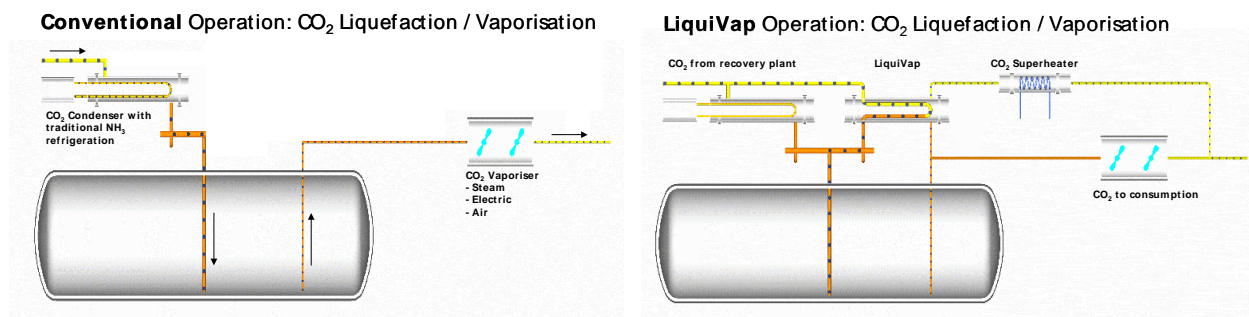
CASE STUDY:

- Annual Production: 3.2 million HL
- Glycol chilling costs: € 0,026 / kW
- Steam costs: € 0,019 / kg

ROI = 14 MONTHS

LIQUIVAP (“HRS-LiquiVap”)

The LiquiVap process follows the philosophy of using the cold energy at the most optimum point in the brewery. In this case the CO₂ vaporisation energy within the CO₂ plant is used to drive the liquefaction process. In comparison to the previous two heat recovery systems, the HRS-LiquiVap system provides significantly more efficient energy recovery and additional benefits to the brewery. While this is the most efficient use of CO₂ vaporisation energy, its effectiveness is relative to the “synchronicity” or overlap between the CO₂ recovery plant operation and the CO₂ vaporising process.



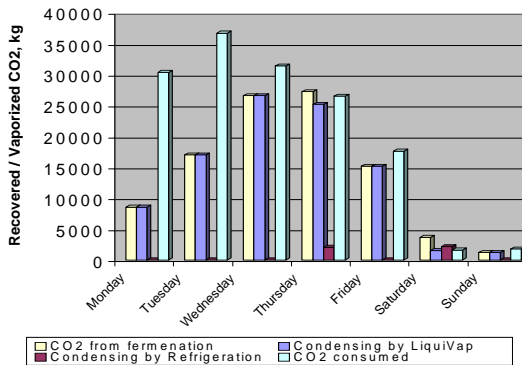
CONVENTIONAL OPERATION:

During conventional (normal) operation the CO₂ is liquefied by the refrigeration plant within the CO₂ plant. CO₂ is vaporised using a traditional vaporiser.

LIQUIVAP OPERATION:

During LiquiVap operation CO₂ is liquefied by vaporised CO₂.

WEEKLY HRS-LIQUIVAP HEAT RECOVERY PROFILE



ADVANTAGES & BENEFITS:

- Most efficient use of cold energy
- Medium capital cost system (equipment and installed), excellent ROI, best TCO
- Elevated location (no effect on engine room floor space)
- No steam/electricity or vaporizing costs
- Requires a CO₂ tie-in (no major utility outage)
- Allows additional CO₂ recovery (in conjunction with early fermenter turn-in and stripping technology.)

DISADVANTAGES:

- Strongly dependent on “same-time” processes (favours 5+ days/week brewing and bottling)

CASE STUDY:

- Annual Production: 2.0 million HL
- Glycol chilling costs: € 0,083 / kW
- Steam costs: € 0,019 / kg

ROI = 11 MONTHS

CONCLUSION: “Heat Recovery Systems can reduce operational costs by up to 60%”

Breweries place an increasing amount of importance on saving energy and the three concepts which have been developed by Haffmans are an excellent means of contributing to this. By thinking outside of the box and linking different steps in the process, Haffmans has been able to create opportunities to reduce the CO₂ plant operational costs by up to 60%. The concepts have already been successfully implemented in breweries and practice has shown that the time it takes for the systems to pay for themselves is economically attractive.

Which heat recovery system suits best will depend of various factors and will differ from brewery to brewery. These factors range from brewing volume, brewing days per week, bottling days per week,

energy costs (steam/electricity), economical ROI, long term TCO. With these in mind we can set up some basic *general* guidelines.

HRS-DIRECT:

Brewing volumes: < 1 million HL
Brewing / bottling week: overlap provides effect
Brewing days per week: min. 3 days per week (ROI)
Typical ROI: ~ 12 - 24 months

HRS-INDIRECT:

Brewing volumes: 1 - 2 million HL
Brewing /bottling week: semi-independent of bottling week
Bottling week: min. 5 days per week
Typical ROI: ~ 18 - 30 months

HRS-LIQUIVAP:

Brewing Volumes: > 1 million HL
Brewing / bottling week: overlap mandatory
Bottling week: min. 5 days per week (ROI)
Typical ROI: ~ 12 - 30 months

FOR MORE INFORMATION:

Ivan Williams
Product Manager - CO₂ Recovery
Haffmans BV, The Netherlands
E ivan.williams@haffmans.nl
I www.haffmans.nl

*The commercial viability of any heat recovery system associated with the CO₂ plant will depend greatly on the local costs of energy. The provided ROI's are based on actual projects executed in late 2004/early 2005 in Western Europe. The costs of energy (steam and electricity) at the breweries concerned have risen between 20-30%. (Jan 2006)