Department of Energy

Energy efficiency guidance for the food & beverage sector

Introducing energy saving opportunities in distillation, drying and evaporation

UK Government
UK-ASEAN ENERGY EFFICIENCY ACCELERATOR
CARBON TRUST
EY Building a better working world
iMC worldwide

Distillation, Drying and Evaporation

Distillation, drying and evaporation are all separation techniques common to many of the sub-sectors within the food and beverage industry.

Technology overview:

Distillation

Distillation is a commonly used separation process for fluids. It uses the different vapour-liquid equilibrium concentrations of components in a mixture to achieve separation.

Major uses of distillation in the food industry are for concentrating essential oils, flavours, cola based beverages, and in the deodorization of fats and oils.

Energy losses can occur for many reasons including poor insulation, excessive reheating, generation of excessively pure products, poor control strategy and non-optimum feed conditions.

Drying

Drying is a process by which a liquid (commonly water) is removed from a material. This is usually achieved by applying heat and/or the flow of warm air through or over the surface of the material.

The objective of drying is to form a product that meets a water-content specification, so the amount of water removed depends on the desired product. Drying accounts for a high proportion of energy consumption in the food and beverage industry.

Microwave drying, or in combination with conventional drying techniques, allows for better control of the process and a reduction in the cycle time required. Typical applications include;

- **Preheating**: Microwave energy is applied to bring all moisture content to the surface of the product. This product is then sent to a conventional drier or oven where the moisture flashes off.

- **Booster drying**: Microwave energy is applied once the surface moisture has been removed and the drying rate of conventional systems begins to drop. The microwave is used to bring the remaining moisture to the surface and remove it.

- **Finish drying**: Microwave energy is applied at the last stage of the drying process, as material leaves the conventional oven. In finish drying, the microwave takes over just as the conventional system's efficiency drops.

Finish drying is the most common of the hybrid systems. An additional benefit is that, provided appropriate temperatures are used, the product in its final stage will be pasteurised as well as dry.

Typical savings are <50% over conventional drying methods.

Evaporation

The evaporation process is distinct from drying in that the remaining residue is usually a liquid or slurry.

A large percentage of the vapour generated can be recondensed and recovered. Evaporation is widely used in the food and beverage industry – examples of such processes include removing excess water to make fruit juice concentrate, the concentration of corn syrups and the production of salt from brine.

Dewatering product before drying or evaporating whether by mechanical means or reverse osmosis is best practice and has the potential to provide significant energy savings. A reduction of just 5% in moisture content will save 20% on drying/evaporation costs.

Homogenisation

Primarily used in the milk and soft drinks industry.

The liquids to be combined are forced through a homogenising valve or 'head' under pressure so breaking down the mixture to ensure there is no separation during transport or storage.

The energy used in the process is proportional to the pressure required to achieve the desired level of homogenisation. Upgrading to modern, more efficient design of head (allowing a reduction from 180 bar to 120 bar) will reduce electricity use by <33%.

For milk there is an opportunity to improve efficiency further.

Partial homogenisation: reducing the homogeniser throughput by homogenising only the fat-enriched (cream) from the separator, and mixing this with the low-fat milk.

Throughput reduces by 20% allowing for smaller equipment to be used. Typical saving from best practice designs have seen savings of 55% in investment costs and 73% in annual running costs.

Pasteurisation

Pasteurisation is a process in which water, milk, wine and fruit juices are treated with heat (usually <100°C) to destroy pathogens and extend product shelf life.

Energy losses can occur for many reasons including poor insulation, excessive heating temperatures and times, poor control strategy and non-optimum feed conditions.

Moving to a continuous pasteurisation process can provide <14% energy savings with immediate payback over a batch system.

There is significant scope for heat recovery as the product is cooled after pasteurisation with typical heat recovery projects providing a 6% saving.

Cleaning-in-Place (CiP)

CiP is required to maintain a hygienic process/manufacturing environment to ensure product quality and safety. It allows the cleaning of pipelines, vessels and other process equipment without the requirement to disassemble.

A typical cycle includes:

- Pre-rinse (removal of remaining product in process)
- Cleaning wash (60-140^{o}C)
- Intermediate rinse
- Final and sanitise rinse

Typical energy losses occur due to excessive water temperatures, prolonged cycle times and poor dosing – all of which highlight the importance of a best practice controls strategy.

For example, with turbidity monitoring, the cleaning solution can be checked and if found not to be too soiled can be reused, saving on dosing chemicals and hot water.

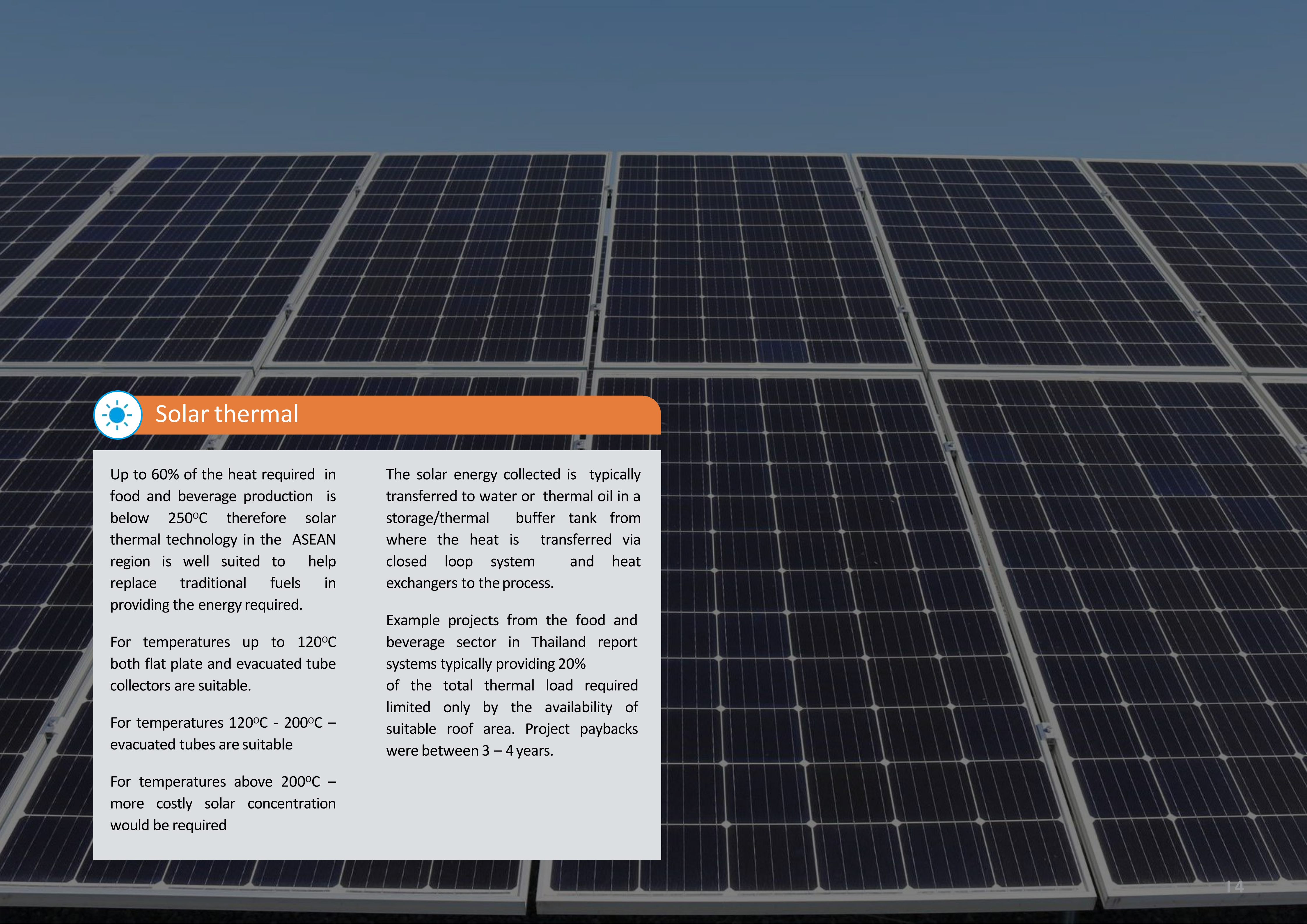
Also, depending on the water temperature required there are heat recovery opportunities from the cleaning washes.

Pigging is a system that is incorporated into CiP system that allows a flexible plug (pig) to be put into the pipe to separate residual product from the pre-rinse water – the pig is forced along the pipe by the pressure of the water behind it. The pigging process allows valuable product cleared from the system, and significantly reduces the volume of hot water required for the initial cycle.

Traditionally plastic pigs have been used which were only effective in relatively simple linear pipe runs and struggled to navigate bends and changes in pipe diameter or valves which limited the volume of product recovered and the impact on the potential energy savings.

The use of crushed ice in water (ice pigging) significantly improves the pigging process with no restrictions due to bends, pipe diameter changes or valves and can recover up to 99% of the product in the systems.

The resulting reduction in hot water used is <85%.



Solar thermal

Up to 60% of the heat required in food and beverage production is below 250°C therefore solar thermal technology in the ASEAN region is well suited to help replace traditional fuels in providing the energy required.

For temperatures up to 120°C both flat plate and evacuated tube collectors are suitable.

For temperatures 120°C - 200°C – evacuated tubes are suitable

For temperatures above 200°C – more costly solar concentration would be required

The solar energy collected is typically transferred to water or thermal oil in a storage/thermal buffer tank from where the heat is transferred via closed loop system and heat exchangers to the process.

Example projects from the food and beverage sector in Thailand report systems typically providing 20%
of the total thermal load required limited only by the availability of suitable roof area. Project paybacks were between 3 – 4 years.

Energy saving opportunities in distillation, drying and evaporation

Check that equipment is well insulated and maintained

Regularly check for damaged, missing or wet insulation indicating unnecessary loss of energy. Distilling, drying and separation equipment is often susceptible to these kinds of problems. Repair insulation promptly.

Investigate whether waste heat from separation equipment could be used elsewhere on the site

All of these processes generate waste heat. Consider where waste heat can be recovered and reused elsewhere on-site, for example, as space heating in a warehouse or workshop.

In addition, more specific actions for distillation and drying are below.

Distillation

Regularly check and record product yield against energy use

Use this data to identify anomalies in energy use that may suggest that the system is working inefficiently. Contact an equipment supplier if energy use rises above the expected parameters.

Consider an alternative process or operating regime such as reduced pressure distillation

Reduced pressure distillation allows separation to be carried out at lower temperatures, also reducing the heat load. A supplier or a distillation consultant will be able to advise on the suitability of alternative designs and operation regimes.

Reduced pressure distillation is a process which could generate energy savings within whisky distilleries.

Drying

Consider using less water in the initial product mixture

Drying is widely used in the food and drink industry to remove water from the product mixture. If less water can be used in the initial mixture, then the process will require less energy for drying. Check how much water is actually needed in a process.

Investigate mechanical water removal

Water can often be removed by mechanical means earlier in the process, resulting in the use of less energy for drying. The suitability of mechanical extraction is dependent on the water content of the mixture and therefore it is advisable to contact the product's quality manager for further guidance.

A range of mechanical filtration techniques are possible such as micro and ultra filtration, and centrifugation.

These techniques are used in soft cheese making to separate out the liquid milk or whey, or to separate out water in the milk-drying process.

Checklist and tips for efficient operation of distillation, drying and evaporation systems

This checklist summarises the key criteria and characteristics of energy efficient distillation, drying and evaporation system. If you are unable to indicate “YES” to all questions, it is likely that the efficiency of your system could be improved, saving you money and reducing your carbon emissions.

Checklist and tips

Ref	Best practice criteria	Response	Feedback
1	**Have you considered microwave as a means of heating and drying product?**	[yes]/[no]	Microwave drying or in combination with conventional drying techniques allows for better control of the process and a significant reduction in the cycle time required. Typical savings are <50% over conventional drying methods.
2	**Is your pasteurisation carried out in batches?**	[yes]/[no]	Moving to a continuous pasteurisation process offers <14% energy saving and immediate payback over a batch process. Where batching is necessary pasteuriser hibernation offers 65-85% reduction in both heating and cooling demand during periods of no throughout for a payback < 6 months.
3	**Has your pasteurisation process been reviewed for improvement opportunities?**	[yes]/[no]	Significant improvements to the efficiency of a pasteuriser can be made through the use of higher efficiency heat exchangers. Typical efficiency improvement of 6% give a project payback of 3.5 - 4 years.
4	**Has the homogenisation process been optimised? [Dairy]**	[yes]/[no]	Partial homogenisation - reducing the homogeniser throughput by only homogenising the fat-enriched phase [cream] from the separator, and mixing this with the low-fat phase. Flow through the homogeniser reduces to 20% meaning much smaller equipment is required. Typical cost savings from best practice design are 55% in investment costs and 73% in annual running costs giving project paybacks < 1 year.
5	**Has the homogenisation head pressure been optimised?**	[yes]/[no]	Energy used in homogenisation is proportional to the pressure required. Upgrading to modern more efficient design of head (180 bar to 120 bar) will reduce electricity use by 33%.
6	**Does your CiP process include 'pigging'?**	[yes]/[no]	Pigging is a system that is incorporated into a pipe system that allows a flexible plug (pig) to be put into the pipe to separate product from rinsing water. The pigging process allows valuable product to be retained and reduces the hot water consumption required by < 85%. Typically, systems pay back in < 1 year.
7	**When drying do you dewater before product enters the dryer?**	[yes]/[no]	Whether by mechanical means or reverse osmosis dewatering product before entering the dryer will save significant amounts of energy. Even a modest reduction of 5% moisture content will save 20% on drying costs. Associated savings from reverse osmosis including water and treatment savings support a project payback < 1 year.
8	**Have the options for utilising solar thermal been assessed?**	[yes]/[no]	Sector specific projects typically provide 20% of the total thermal load required - limited only by the availability of suitable roof area. Project paybacks are between 3 – 4 years [Thailand – non subsidised].
9	**Have the options for utilising thermal oil over steam systems, etc, been fully assessed?**	[yes]/[no]	With an 80% thermal efficiency, compact footprint, no flash steam, blowdown or condensate losses thermal oil boilers offer up to a 31% energy saving over steam systems.