FOODSA

Feeding connections

STEAM & HOT WATER
ENERGY EFFICIENT EQUIPMENT TOOLKIT

CONTENTS & SUMMARY

PARTNERS

This Toolkit is brought to you the following partners.

FOODSA Feeding connections

Australian Government
Department of Resources, Energy and Tourism

Government of South Australia
Zero Waste SA

INTRODUCTION

Steam and hot water systems deliver heat to many pieces of equipment, including pasteurisers, sterilisers, spray dryers, dehydrators, evaporators, blanchers, steam peelers. They also deliver hot water for end uses. They comprise boilers (steam or hot water), pipe networks, and controls. Steam and hot water systems contribute 10-30% of the total site energy use, usually as combustion fuels, but some hot water boilers run on electricity.

EQUIPMENT & PROCESSES

By using your equipment settings more efficiently you can reduce your energy consumption.

UPGRADE EQUIPMENT

You can evaluate what energy reduction benefits your organisation could gain from upgrading to more efficient equipment and/or adjusting combinations of equipment. Consider adopting a selection of the following opportunities according to available resources.

SELECT & PRIORITISE

Learn how to get the best from your equipment and processes and whether you need to upgrade.

COLLECT & CHECK

Learn how to collect data and engage with your suppliers.

OPTIMISE AND MAINTAIN BOILER OPERATION

Boiler power use decreases with decreasing hot water temperature.

USE MINIMUM SAFE TEMPERATURE SETTING

Reduce boiler power use by using the lowest acceptable temperature setting (refer to equipment specifications).

POTENTIAL ENERGY SAVINGS
- Savings vary depending the required hot water or steam temperature and volume, but possible to achieve up to 5% of boiler energy consumption

OTHER BENEFITS
- Lower maintenance costs
- Longer operating life of refrigeration equipment

EQUIPMENT/MATERIAL
- None needed

Boiler temperature control setting

Effective water treatment and water analysis can minimise scale build up on boiler tubes and heat exchangers that reduces heat transfer efficiency.

MAINTAIN WATER TREATMENT TO REDUCE SCALING

POTENTIAL ENERGY SAVINGS
- Varies depending on how much scale is removed – for example, removing boiler tube scaling of 1.6mm thickness can reduce fuel consumption by almost 4%

OTHER BENEFITS
- Lower maintenance costs
- Longer operating life of refrigeration equipment

EQUIPMENT/MATERIAL
- Maintain water treatment practices and use of appropriate chemicals dosage to remove impurities
- For removing scale, boiler cleaning equipment such as a steel brush– or contact a suitably qualified boiler maintenance service provider

Maintaining steam traps reduces energy loss from traps that fail to effectively close or open.

MAINTAIN STEAM TRAPS

A trap that doesn't close allows steam to escape while a trap that doesn't open allows the system to become water-logged thereby reducing the heat output.

POTENTIAL ENERGY SAVINGS
- Energy savings varies depending on size of boiler system and existing state of steam trap

OTHER BENEFITS
- No other significant benefits identified

EQUIPMENT/MATERIAL
- None needed – maintain daily/weekly inspection of steam traps

Leaks in the pipe network require the boiler to produce more hot water or steam than required.

INSPECT FOR LEAKAGE

Encourage staff to monitor the pipe network and report leaks.

POTENTIAL ENERGY SAVINGS
- Energy savings of up to 3% of boiler power consumption

OTHER BENEFITS
- Cost savings from longer equipment life and lower maintenance costs

Recirculated boiler water often results in the build-up of contaminants that result in fouling, corrosion and scale – the most boiler systems remove these contaminants through 'blow down' (bleeding-off some of the recirculated water, typically between 4-10%).

REDUCE BLOW DOWN

Excessive blow down results in the waste of hot-water, and hence reduces boiler energy efficiency. To reduce excessive blowdown, a conductivity probe can be used to measure the salt level within the water and only blowdown when that level exceeds a set value.

POTENTIAL ENERGY SAVINGS
- Reducing blow down can reduce boiler energy required to heat-up feedwater by 2-5%

OTHER BENEFITS
- Reduced costs associated with water consumption
- Reduced costs associated with water treatment

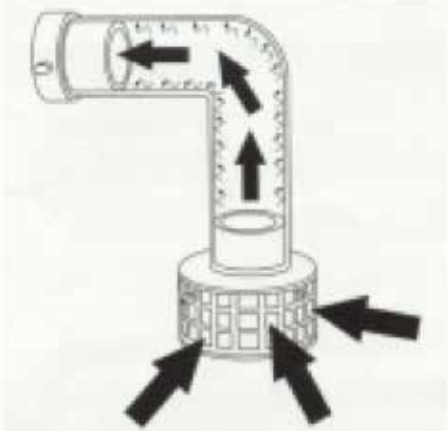
EQUIPMENT/MATERIAL
- None needed

REARRANGE BOILER NETWORK

Rearranging the pipe network, especially installing larger-diameter pipes, is best suited for new or replacement networks due to the capital cost required.

MINIMISE THE PRESSURE DROP OF THE HOT WATER PIPE NETWORK

In a hot water system, a pump usually needs to generate fluid flow at a rate and pressure that both meets the demands of the end-use (the end point where heating is needed) and overcomes any friction and gravitational flow losses (*pressure drop*) in the pipe network.



Boiler temperature control setting

You can reduce pressure drop and improve the energy efficiency of your hot water pumping system in the following ways:

- Increasing pipe diameter. A small increase in pipe diameter will lead to a relatively large reduction in friction, and therefore, help to reduce flow losses. Pipe friction for circular pipes is inversely proportional to the fifth power of internal pipe diameter
- Making the internal surface of pipework smoother. Smooth pipes have much less friction than rough pipes and can therefore transfer water more efficiently. Internal pipe roughness depends on the material and finish, and the amount of fouling and corrosion
- Reducing pipe length. Pipe friction increases with increasing length. Pipe networks can be unnecessarily long due to bypass loops, bend components, and the location of the pumps and end-uses
- Reducing bends and other restrictions. Each pipe component adds friction. Reduce loss of pressure by eliminating bends or smoothing out any sharp bends, keeping inlets rounded and constrictions gradual and using minimal valves and restrictors. Throttling valves should be eliminated. Even a fully open valve can add 70 kPa of pressure drop
- Increasing pump elevation. Positioning the pump higher than the end-use eliminates pressure drop due to gravity. The higher the end-use above the pump, the greater gravitational loss. A gravity feed arrangement can eliminate the need for a pump altogether

When determining which of these features to include, consider the combined costs of the pipe network, pump, and energy.

POTENTIAL ENERGY SAVINGS
- Savings can be 5-20% of pump power use (from changing to larger diameter pipes only)

OTHER BENEFITS
- Lower capital cost for pumps because smaller sizes will do the task
- Lower maintenance costs
- Longer operating life of pump system equipment

EQUIPMENT/MATERIAL
- Variable depending on choices made

REARRANGE BOILER NETWORK *CONT.*

MINIMISE THE PRESSURE DROP OF THE HOT WATER PIPE NETWORK *CONT.*

In addition to the points mentioned in the *Minimise the pressure drop of the hot water pipe network* improvement, the pressure drop of the steam pipe network can be reduced (and energy efficiency improved) by considering the following:

- Pipes must slope down in the direction of flow, ideally at a slope of at least 1:100. Install a vertical relay point to direct a pipe near the floor to a higher elevation
- The maximum steam velocity should be limited to about 40m/s in general, to 15-25m/s in main distribution lines, and to even lower velocities in very long pipes (since pipe friction increases with the cube of fluid velocity). Install nozzles to generate higher velocities at end-uses
- Each steam pipe component adds friction losses so consider the following:
  - Control valves should usually be 1-2 sizes smaller than the diameter of the (large) pipes
  - Valves should be installed on outlets of the distribution headers (the vessel into which steam from all boilers converge before entering the distribution system) to allow unused boilers to be turned off easily
  - Bellows-sealed valves, rather than gland-sealed valves, do not leak and do not require maintenance
  - Efficient nozzles and taps, if required, should be installed at end-uses
  - Automatic air vents should be installed on terminal ends and remote or high points along the pipe network
  - Relay points and other low points, where condensate could accumulate, should be a pocket-shape of the same diameter as the pipe. Steam traps should be installed on these pockets, at a maximum of 50m apart, to automatically drain condensate
  - Steam separators should be installed when steam quality might be lower than required or when the maximum boiler output is needed to remove water droplets. Baffle-type separators are well suited over a wider range of flow rates and pressures

POTENTIAL ENERGY SAVINGS
- Savings vary depending on the extent of the pipe network rearrangement. Increasing pipe diameter alone can result in 5-20% reduction in pump power consumption

OTHER BENEFITS
- Lower maintenance costs – less friction on the pipework means less stress and wear-and-tear on the hot water pumping system

EQUIPMENT/MATERIAL
- Variable depending on choices made regarding re-arrangement

For more information on improving pumping efficiency, refer to the Pumping section of the BCEEE Toolkit.

Friction and heat losses increase with pipe length.

RELOCATE BOILER

Increase boiler system efficiency by locating the boiler near the major end-uses for the hot water and steam.

POTENTIAL ENERGY SAVINGS
- Savings can be 5% of boiler power use. Total costs savings depend on the layout of the pipe network and works required for relocation

OTHER BENEFITS
- No other significant benefits identified

EQUIPMENT/MATERIAL
- Variable depending on choices made

RETROFIT BOILER SYSTEM AND COMPONENTS

New boilers usually have sufficient insulation, but older boilers might need additional or replacement insulation. Inefficiency due to degraded or insufficient insulation can be up to 10%.

INSTALL INSULATION ON PIPE NETWORKS AND BOILER

Insulation prevents up to 90% of potential heat loss from steam. It can often be cost-effectively installed or improved on boilers, pipes, heat exchangers, valves, flanges and other fittings, and on areas of thermal bridging, such as bolts and brackets.

Decrease heat loss by installing insulation on any surface that heats to above 50°C.

Good insulation has:

- Low thermal conductivity
- Dimensional stability under temperature change
- Resistance to water absorption
- Resistance to combustion

Other important characteristics, depending on the application, include tolerance of wide temperature variation and system vibration, and compressive strength where insulation is load bearing. Reduce degradation by eliminating sources of moisture.

POTENTIAL ENERGY SAVINGS

- For insulation on pipework, you can achieve a saving of 3-13% of boiler power use (lower savings for hot water boilers; higher savings for steam boilers) and equivalent to an approximate 2-year payback or better

OTHER BENEFITS

- Shorter time to reach the temperature setting on start up

EQUIPMENT/MATERIAL

- Insulation
- A thermographic camera to find where existing insulation is degraded, if required

Insulation jacket for boiler/water heater

Insulation on steam pipe

(Table 1) Insulation materials and their typical applications.

TYPE OF MATERIAL	MAXIMUM TEMPERATURE (°C)	APPLICATION
Insulation		
Polyethylene	80	Internal and external locations (joints sealed)
Synthetic rubber	105	Internal and external locations (joints sealed)
Ball blankets		
Polypropylene	110	Metal treatment tanks
High density polypropylene	230	External freezing prevention, UV stabilised
Glass mineral fibre, aluminium foil faced, preformed	230	Internal, concealed surfaces
Glass mineral fibre, aluminium clad	230	Surfaces exposed to damage and external surfaces open to the weather (joints sealed)
Rock mineral fibre aluminium foil faced, preformed	830	Internal, concealed surfaces
Rock mineral fibre aluminium foil faced, preformed, aluminium clad	830	Surfaces exposed to damage and external surfaces open to the weather (joints sealed)

RETROFIT BOILER SYSTEM AND COMPONENTS *CONT.*

Downsize or use multiple boiler systems to match demand and reduce energy use.

REVISIT BOILER SIZE TO MATCH DEMAND

The boiler may be oversized and producing more steam than required if it continually cycles (turning off and on a number of times in a relatively short period).

Consider whether two or more smaller boilers can meet a variable load of different steam pressures at different locations and times during production.

POTENTIAL ENERGY SAVINGS
- Energy savings vary depending on steam/hot water demand

OTHER BENEFITS
- Improved flexibility of hot water/steam supply

EQUIPMENT/MATERIAL
- Multiple boilers and supporting infrastructure to interconnect boilers with common end-uses

Economiser systems work by recovering waste heat from the flue for preheating boiler feedwater.

INSTALL ECONOMISERS TO REUSE WASTE HEAT

Direct-contact economisers spray water directly into the flue gas, which also remove particles and acid gases such as sulphur dioxide.

POTENTIAL ENERGY SAVINGS
- Energy savings of up to 5% of boiler energy consumption

OTHER BENEFITS
- No other significant benefits identified

EQUIPMENT/MATERIAL
- Purchase and installation of economiser unit

EQUIPMENT AND PROCESSES

Use the following table to select which energy efficiency opportunities your business would be interested in pursuing, as well next steps in terms of actions and responsibilities.

Tick the box if you plan to pursue an Energy Efficiency Option.

X	ENERGY EFFICIENCY OPTION	NEXT STEPS & TIMING	WHO RESPONSIBLE	NOTES
	Optimise operating conditions			
	Use minimum temperature setting			
	Maintain water treatment to reduce scaling			
	Maintain steam traps			
	Reduce blowdown			
	Inspect for leakage			

UPGRADE EQUIPMENT

Use the following table to select which energy efficiency opportunities your business would be interested in pursuing, as well next steps in terms of actions and responsibilities.

Tick the box if you plan to pursue an Energy Efficiency Option.

X	ENERGY EFFICIENCY OPTION	NEXT STEPS & TIMING	WHO RESPONSIBLE	NOTES
	Rearrange boiler network			
	Minimise the pressure drop of the hot water pipe network			
	Minimise the pressure drop of the steam pipe network			
	Relocate boiler			
	Retrofit boiler system and components			
	Install insulation on pipe network and boiler			
	Revisit boiler size to match demand			
	Install economisers to reuse waste heat			

CHECKLIST TO ENGAGE WITH SUPPLIERS

By gathering the information suggested in this supplier checklist, you can build a complete picture of your equipment and energy uses.

This will help you to identify which actions are likely to benefit your business so that you can establish a business case to support decision making now and planning for the future. Some of the information you can collect within your own business resources, but some may need you the help of suppliers or experts (e.g. an energy audit).

Note: This checklist can be used by either the food business or the supplier.

DETERMINE THE END-USES OF YOUR BOILER

CHECK THE FOLLOWING END-USES

Tick those that apply to your business

- ○ Pasteurisers
- ○ Sterilisers
- ○ Spray dryers
- ○ Dehydrators
- ○ Evaporators
- ○ Blanchers
- ○ Steam peelers
- ○ Other

COMPILE A BOILER INVENTORY

COMPILE A LIST OF THE FOLLOWING EQUIPMENT

Tick those that apply to your business

- ○ Boilers: number, make, model, type (water tube or fire tube, condensing), fuel, power rating (kW), efficiency, flow rate (kg/s), pressure (kPa), and time in use (h/y)
- ○ Pipes: diameter (m)
- ○ Valves: number, make, model, type
- ○ Other

CHOOSE AN APPROACH TO ESTIMATE TIME IN USE

- ○ Divide the total fuel use (kWh) by the total time (h) that the boiler has been installed
- ○ Use existing control systems and manual procedures
- ○ Check control settings (if the system has controls)

ESTIMATE THE STEAM OR HOT WATER LOAD

COMPILE A LIST OF THE FOLLOWING INFORMATION

Tick those that apply to your business

- ○ Flow rates (kg/s) required now
- ○ Flow rates required in the future
- ○ Location of end-use
- ○ Operating times or events that require steam or hot water fluid
- ○ Reason the end-use requires steam or hot water
- ○ Flow rates required in the future

THIS LIST ENABLES YOU TO:

- Estimate the steam and hot water load (kW), including the base load (kW) and peak load (kW)w
- Identify the end-uses that dominate the steam and hot water load (kW)
- Identify the end-uses that can be rescheduled from peak times to off-peak times
- Group together end-uses that require similar heating temperatures (°C)

CHECKLIST ENGAGE WITH SUPPLIERS *CONT.*

By gathering the information suggested in this supplier checklist, you can build a complete picture of your equipment and energy uses.

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ESTIMATE THE EFFICIENCY OF YOUR EXISTING BOILER SYSTEMS

MEASURE INDICATORS OF REFRIGERATOR PERFORMANCE

Tick those that apply to your business

- ○ For an initial estimate, measure the following parameters, and compare them to their design values:
  - ○ Flow rate (kg/s)
  - ○ Pressure (kPa)
  - ○ Fuel energy use (l/kg)

DETERMINE THE BUSINESS PARAMETERS OF THE BOILER SYSTEM

QUANTIFY OR QUALIFY THE FOLLOWING VALUES

Tick those that apply to your business

- ○ Energy price(s) ($/kWh, $/l gas/fuel)
- ○ Capital budget ($)
- ○ Targets for running costs ($/y)
- ○ Required level of redundancy in the system
- ○ Acceptable level of risk for new technologies
- ○ Acceptable payback period or return on investment
- ○ Equipment constraints, such as specific brands of equipment, specifications for electrical wiring, compatibility with existing infrastructure or floor space, and adaptability to future upgrades

If the existing equipment needs to be replaced, then calculate the payback period (y) based on the extra (rather than total) costs ($) (if any) of the efficient equipment.

CONFIRM EQUIPMENT PERFORMANCE

CHECK THE FOLLOWING CONDITIONS

Tick those that apply to your business

- ○ The boiler meets the peak steam and hot water load (kW)
- ○ The boiler is optimised for the most common steam and hot water loads (kW)

CHECKLIST TO ENGAGE WITH SUPPLIERS *CONT.*

By gathering the information suggested in this supplier checklist, you can build a complete picture of your equipment and energy uses.

This will help you to identify which actions are likely to benefit your business so that you can establish a business case to support decision making now and planning for the future. Some of the information you can collect within your own business resources, but some may need you the help of suppliers or experts (e.g. an energy audit).

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SELECT A SERVICE PROVIDER

SELECT A BOILER SERVICE PROVIDER THAT CAN PROVIDE THE COMBINATION OF SERVICES THAT YOU SEEK

Tick those that apply to your business

- ○ Measurement and analysis of the steam and hot water load profile (kW), and power (kW) of the boiler and end-uses
- ○ Reporting on equipment and process performance
- ○ Optimisation of the boiler system, including the control system, flow rates (kg/s), and pressure levels (kPa), management of steam and hot water leaks, assessment of heat recovery potential, location of the boiler, and compatibility of the boiler with the existing heating system
- ○ Design of a boiler system that aims to minimise losses from the end-use to the boiler, including the selection of the most appropriate fuel
- ○ Supply, service, and installation of steam and hot water equipment (e.g. boilers, pipes, and valves) for optimal energy efficiency
- ○ Supply of spare parts, including shipping/transport
- ○ Guarantee of minimum efficiency (%) of the proposed system
- ○ Guarantee of maximum running costs ($/y) of the proposed system
- ○ Technical support and after sales service
- ○ In-house repairs and onsite service
- ○ Emergency service
- ○ Appropriate removal and disposal of old equipment
- ○ Other

NEGOTIATE A CONTRACT

DETERMINE YOUR PREFERRED TYPE OF CONTRACT

Tick those that apply to your business

- ○ Service contract - the supplier performs certain actions for a fixed price ($)
- ○ Energy performance contract - the supplier performs certain actions that meet certain levels of energy reduction (kWh) for a lower upfront price ($) and a share of the cost savings ($/y)

REFERENCES

By gathering the information suggested in this supplier checklist, you can build a complete picture of your equipment and energy uses.

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Note: This checklist can be used by either the food business or the supplier.

Food SA's Your Guide to Sustainable Business in Food

Carbon Trust: How to implement process thermal insulation

Department of Resources, Energy and Tourism: Energy Efficiency Exchange

Lawrence Berkeley National Laboratory: Energy Efficiency Improvement and Cost Saving Opportunities for Breweries

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Queensland Government, Eco-efficiency opportunities in Queensland Foundries – Boiler Efficiency (F7) Fact sheet

Sustainability Victoria: Energy Efficiency Best Practice Guide– Steam, Hot Water and Process Heating Systems

Tyco: Industrial Steam Trapping Handbook

US Department of Energy (US DOE), 2001, Green Federal Facilities An Energy, Environmental, and Economic Resource Guide for Federal Facility Managers and Designers - 5.2.1 Boilers

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