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HVAC
ENERGY EFFICIENT EQUIPMENT TOOLKIT

CONTENTS AND PARTNERS

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INTRODUCTION

Heating, ventilation and air conditioning (HVAC) systems deliver cool or warm air, to many spaces, including offices, factory floors, warehouses, store rooms, and plant rooms. HVAC systems contribute 5-15% of the total site energy use, usually as electricity, though some demand is seasonal.

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 OPERATING SETTINGS

Air conditioning power decreases with increasing width of the temperature band (the difference between the lowest highest acceptable requested temperature settings).

ADJUST TEMPERATURE SETTING

Reduce air conditioner power use by using the widest acceptable temperature setting, especially during non-production and non-occupied periods. A temperature band of 19-26°C could be acceptable.

POTENTIAL ENERGY SAVINGS
Savings vary depending width of temperature band and operating conditions.

OTHER BENEFITS
- Lower maintenance costs
- Longer operating life of air conditioner equipment

EQUIPMENT/MATERIAL
- None needed

Reduce air conditioner power use by using the economy cycle during cool periods, such as at night. The economy cycle of an air conditioner circulates air from outside using only the fans.

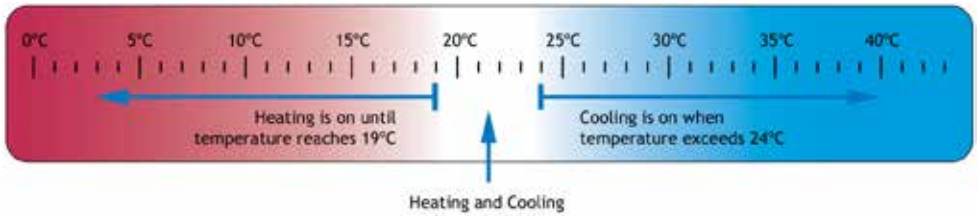
USE THE ECONOMY CYCLE

It requires less power because the air is not cooled.

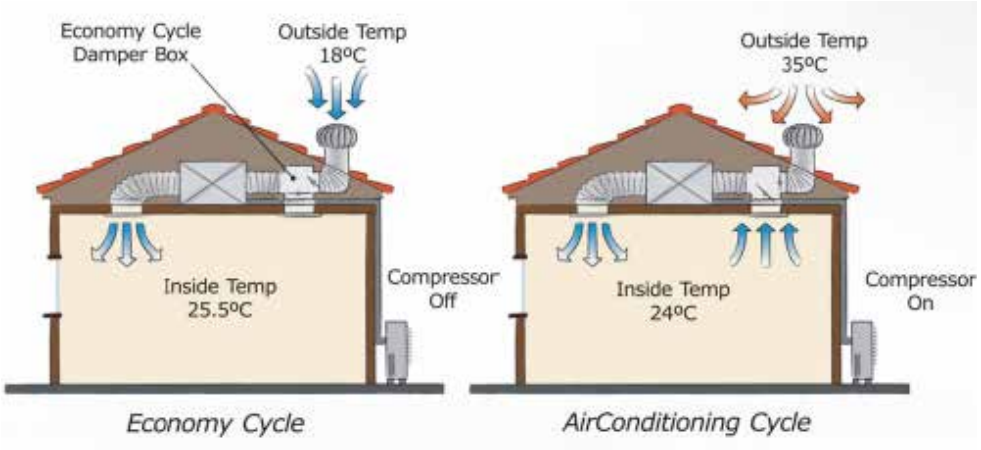
POTENTIAL ENERGY SAVINGS
- Savings vary depending average outside temperatures, which governs how often the Economy Cycle can work to draw cooler air from the outside

OTHER BENEFITS
- Lower maintenance costs
- Longer operating life of air conditioner equipment

EQUIPMENT/MATERIAL
- None needed



Increasing temperature band decreases energy consumption



Economy cycle vs air conditioning cycle

SEAL THE BUILDING

Unconditioned air infiltrates spaces through unsealed and open doors and windows, increasing the load on air conditioners.

INSTALL SEALS

Avoid some of this infiltration by installing tight seals, and by implementing proper door and window management.

This includes training staff to close doors and windows after use, and installing automatic door closers.

POTENTIAL ENERGY SAVINGS

- Savings depend on existing circumstances and choices made

OTHER BENEFITS

- Higher air conditioning capacity

EQUIPMENT/MATERIAL

- Door and window seals/sealants
- Automatic door closers

REARRANGE AIR CONDITIONING DUCT NETWORK

A fan must generate air-flow at a rate and pressure that meets the demands of the end-use and overcomes the friction losses (pressure drop) in the duct network.

MINIMISE THE PRESSURE DROP OF THE DUCT NETWORK

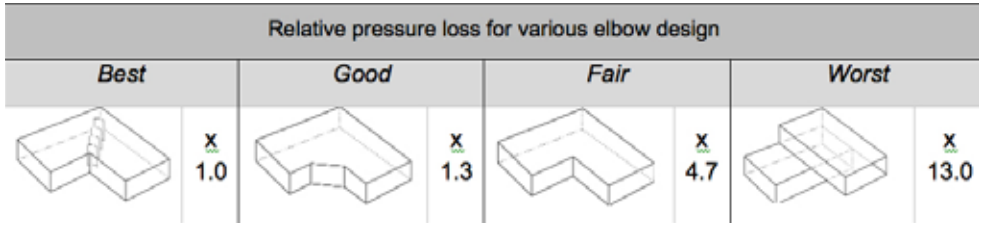
You can reduce pressure drop:

- Even a small increase in duct width will lead to a relatively large improvement in air flow because duct friction is inversely proportional to the fifth power of internal duct width (for square ducts)
- Smooth, rigid ducts have much less friction than rough or flexible ducts and can therefore transfer air more efficiently. Internal duct roughness depends on the construction material, including internal insulation, and finish
- Friction within ducts increases with increasing length. Duct networks can be unnecessarily long due to bypass loops, bend components, bends in flexible ducts, and the location of the fans and end-uses
- Each duct component adds friction losses. Reduce loss of pressure by eliminating bends, branches, and joins or keeping them gradual (large radius) and using the minimum number of dampers

POTENTIAL ENERGY SAVINGS
- Savings vary depending on choices made

OTHER BENEFITS
- Lower capital cost of fans, which can be smaller if the duct network has less friction
- Lower maintenance costs
- Longer operating life of air conditioning system equipment

EQUIPMENT/MATERIAL
- Variable depending on choices made



Relative pressure loss for various elbow designs

HVAC compressors and condensers operate more efficiently in cooler surroundings.

RELOCATE HVAC UNIT

Increase HVAC efficiency by locating units in areas that are cool, well ventilated, and out of direct sunlight (shaded, enclosure with reflective paint, or underground).

POTENTIAL ENERGY SAVINGS
- Savings vary depending on conditions and choices made

OTHER BENEFITS
- Lower maintenance costs and longer operating life of HVAC equipment, due to less stress placed on HVAC unit to deliver the same level of space heating/cooling

EQUIPMENT/MATERIAL
- Variable depending on choices made

INSTALL NEW HVAC COMPONENTS

All types of active HVAC equipment use energy even on standby.

INSTALL CONTROLS TO OPERATE HVAC ONLY WHEN REQUIRED

Reduce HVAC power use by installing automatic control systems or time switches to turn equipment off when it is not needed for long periods (outside of business hours). Installing zone control to isolate areas that do not need to be heated or cooled will also help reduce running costs. You may also be able to turn off the unit for the last hour of the business day without losing comfort.

POTENTIAL ENERGY SAVINGS

- Savings vary depending on conditions and choices made

OTHER BENEFITS

- Lower maintenance costs
- Longer operating life of HVAC equipment

EQUIPMENT/MATERIAL

- Zone control unit if required

Insulation prevents heat transfer into cooling fluids.

INSTALL INSULATION ON HVAC AND DUCT NETWORKS

It can often be cost-effectively installed or improved on ducts and fittings that are located outside of the air-conditioned space (in the ceiling or outside).

POTENTIAL ENERGY SAVINGS

- Savings vary depending on conditions and choices made

OTHER BENEFITS

- Lower maintenance costs and longer operating life of HVAC equipment, as less load is required by the HVAC unit to deliver the same level of space heating/cooling

EQUIPMENT/MATERIAL

- Insulation and fittings

Installing insulation on HVAC ducts

(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)

INSTALL NEW HVAC COMPONENTS *CONT.*

Variable speed drives (VSDs) are well suited to components (compressor or fan) that operate at part-load for up to 95% of the time.

INSTALL A VARIABLE SPEED DRIVE ON HVAC COMPONENTS

At full-load, VSDs are about 3% less efficient than constant speed drives and should therefore be avoided where full loads are required most of the time.

VSDs continually adjust the motor speed to match the component output to the load profile. Even a small reduction in speed will lead to a relatively large reduction in power use (because component power is proportional to motor speed cubed).

A VSD eliminates the need for flow-control devices, such as valves and bypass loops. As a flow-on benefit, pressure drop in the duct network can then be reduced by removing unnecessary flow-control devices.

VSDs only reduce component power as well as the controls implemented. To find the best control method, you need an appropriate control signal and an iterative procedure to find the optimal settings.

Capital cost is $200-$500/kW (2013), about the same as the motor depending on size, number and use patterns. The capital cost per kW decreases with increased motor size.

POTENTIAL ENERGY SAVINGS

- Savings can be 10-60% (20% average) of motor power use, depending on number, and use patterns of the motor

OTHER BENEFITS

- Lower maintenance costs
- Longer operating life of HVAC equipment

EQUIPMENT/MATERIAL

- VSDs for each group of components (some components have multiple fans but would only need one VSD)
- Sufficient programming capability in the control system

REPLACE HVAC UNIT

Many food businesses use refrigerative air conditioning units to supply their space cooling needs.

REPLACE REFRIGERATIVE COOLING UNIT WITH EVAPORATIVE COOLING

These units operate in a similar fashion to refrigerators – they provide the highest levels of cooling in all climates, but consume high amounts of electricity and are therefore expensive to run.

Evaporative coolers on the other hand use the process of evaporation to cool-down warm air and provide a similar level of performance to refrigerative air conditioning. Under the right conditions, evaporative coolers consume much less energy than air conditioners – in some cases, up to 75% less electricity.

POTENTIAL ENERGY SAVINGS

- Savings can by up to 75% less electricity consumption than refrigerative air conditioners of similar size

OTHER BENEFITS

- Improved indoor air quality
- Easy to install
- Recirculates stale inside air

EQUIPMENT/MATERIAL

- Purchase and installation

Seeley International ClimateWizard Evaporative Cooler

Advantages vs Disadvantages of evaporative coolers.

ADVANTAGES OF AN EVAPORATIVE COOLER

- Operating costs are typically lower than those of a central air conditioner
- System uses as much as 75% less electricity than refrigerative air conditioning
- Costs about half as much as an air conditioner that will cool the same sized area
- System operates on 240-volt electricity, which means they don't need special high-voltage circuits (unlike some air conditioners)
- The moist pads from an evaporative cooler are relatively efficient air filters, trapping some dust and pollen
- Evaporative cooling requires simple installation and is relatively compact
- An evaporative cooler can cool outside air and blow it into your building, thereby re-circulating stale inside air

DISADVANTAGES OF AN EVAPORATIVE COOLER

- During periods of high humidity and high temperature, the effectiveness of evaporative coolers is limited
- An evaporative cooler reduces control over temperature and comfort
- The air from an evaporative cooler is not "cleaned" as well as with an air conditioner
- An evaporative cooler needs to have open windows or vents to outside
- An evaporative cooler adds moisture to the air and damp air can cause doors and wood furniture to swell
- An evaporative cooler requires more maintenance than an air conditioner

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 settings			
	Adjust temperature setting			
	Use the economy cycle			

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
	Seal the building envelope			
	XXXXXXXX see request for sub-header in the toolkit copy			
	Rearrange duct network			
	Minimise the pressure drop of the duct network			
	Relocate HVAC unit			
	Install new HVAC components			
	Install controls to operate HVAC only when required			
	Install insulation on HVAC and duct networks			
	Install a variable speed drive on HVAC components			
	Replace HVAC unit			
	Replace refrigerative cooling unit with evaporative cooling			

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 HVAC SYSTEM(S)

IDENTIFY THE FOLLOWING END-USES

Tick those that apply to your business

- ○ Offices
- ○ Factory floor
- ○ Warehouses
- ○ Store rooms
- ○ Plant rooms
- ○ Other

COMPILE A HVAC INVENTORY

COMPILE A LIST OF THE FOLLOWING EQUIPMENT

Tick those that apply to your business

- ○ Compressors: number, make, model, type(screw or reciprocating), power rating (kW), efficiency (%), flow rate (l/s), speed (rpm), and number of pump stages
- ○ Condensers: number, make, model, type (air cooled, water cooled or evaporative), and age (y)
- ○ Pumps: number, make, model, type, power rating (kW), efficiency (%), flow rate (l/s), speed (rpm), and number of pump stages
- ○ Fans: number, make, model, type, power rating (kW), efficiency (%), flow rate (l/s), speed (rpm), and number of pump stages
- ○ Ducts: diameter of main high-pressure refrigerant liquid line (m)
- ○ HVAC unit: time in use (h/y)
- ○ Electric heaters: number, make, model, type, power rating (kW), efficiency (%), time in use (h/y)
- ○ Other

CHOOSE AN APPROACH TO ESTIMATE TIME IN USE

Tick those that apply to your business

- ○ Record readings on the hour-run meter (h) at regular intervals
- ○ Divide the hour-run meter reading (h) by the total time (h) that the HVAC unit has been installed
- ○ Compare the energy (kWh) and power readings (kW) (if the system has an electricity meter)
- ○ Examine electricity meter load profiles (kW)
- ○ Use existing control systems and manual procedures
- ○ Check control settings (if the system has controls)

DETERMINE VARIATION IN COOLING, HEATING, AND VENTILATION LOADS UNDER THE FOLLOWING CONDITIONS

Tick those that apply to your business

- ○ Seasonal variation in ambient temperatures (°C)
- ○ Variation in occupancy
- ○ Variation in vehicle movement

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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ESTIMATE THE COOLING AND HEATING LOADS

COMPILE A LIST OF THE FOLLOWING INFORMATION

Tick those that apply to your business

- ○ Major end-uses (which comprise at least 70% of the total cooling and heating loads (kW))
- ○ Specific cooling and heating requirements (temperature (°C), and cooling and heating times (h)) for each end-use

CHOOSE AN APPROACH

- ○ For an initial estimate of theoretical cooling requirements (kW), review equipment manuals and process specifications
- ○ If budget and time allow for a more-accurate estimate of actual cooling and heating requirements (kW), which include undesirable heat gains and losses (kW), then install metering and monitoring equipment, such as data-loggers

THIS LIST ENABLES YOU TO:

- Estimate the cooling and heating loads (kW), including the base load (kW)and peak load (kW)
- Identify the spaces that dominate the cooling and heating loads (kW)
- Identify the conditioning of spaces that can be rescheduled from peak times to off-peak times

ESTIMATE THE HVAC UNIT PERFORMANCE

MEASURE INDICATORS OF HVAC UNIT PERFORMANCE AND CHOOSE AND APPROACH

Tick those that apply to your business

- ○ For an initial estimate, measure the following parameters, and compare them to their design values:
  - ○ Condensing temperature (°C) at the inlet
  - ○ Condensing temperature (°C) at the outlet
  - ○ Evaporator temperature (°C) at the inlet
  - ○ Evaporator temperature (°C) at the outlet
  - ○ Compressor pressure (kPa) and temperature (°C) at the inlet
  - ○ Compressor pressure (kPa) and temperature (°C) at the outlet
  - ○ Power to the compressor (kW)
  - ○ Ambient temperature (°C)
- ○ For a more-accurate estimate, perform an energy consumption assessment. For this procedure, log the energy use of the HVAC unit and/or specific components against the ambient temperature (°C), and cooling and heating loads (kW). Then compare these graphs to the design values
  - ○ HVAC unit
  - ○ Compressors
  - ○ Pumps
  - ○ Fans
  - ○ Other

THESE INDICATORS ENABLE YOU TO:

- Identify inefficient equipment and processes
- Assess the effectiveness of the energy efficiency measure implemented
- Monitor for unexpected changes in the performance of equipment and processes

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).

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

DETERMINE THE BUSINESS PARAMETERS OF THE HVAC SYSTEM

QUANTIFY OR QUALIFY THE FOLLOWING VALUES

Tick those that apply to your business

- ○ Energy price(s) ($/kWh)
- ○ Capital budget ($)
- ○ Targets for running costs ($/y)
- ○ Required level of redundancy in the system
- ○ Acceptable payback period or return on investment
- ○ Acceptable level of risk for new technologies
- ○ 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 HVAC PERFORMANCE

CHECK THE FOLLOWING CONDITIONS

Tick those that apply to your business

- ○ The HVAC unit meets the peak cooling and heating loads (kW)
- ○ The HVAC unit is optimised for the most common cooling and heating 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).

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

SELECT A SERVICE PROVIDER

SELECT AN AIR COMPRESSOR SERVICE PROVIDER THAT CAN PROVIDE THE COMBINATION OF SERVICES THAT YOU SEEK

Tick those that apply to your business

- ○ Measurement and analysis of the compressed air requirements profile; and power (kW) of compressors, dryers, and end-uses
- ○ Reporting on equipment and process performance
- ○ Optimisation of the pumping system, including: optimisation of the control system, flow rates (l/s), and pressure levels (kPa), management of air leaks, minimisation of the compressed air requirements at end-uses, appropriate treatment of air and assessment of heat recovery potential
- ○ Design of a compressed air system that aims to minimise losses from the end-use to the compressor
- ○ Supply, service, and installation of compressed air system equipment (compressors, filters, drains, and pipes) 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
- ○ Emergency rental compressors
- ○ Remote monitoring
- ○ 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

The following references were used in the development of the *Heating, Ventilation & Air Conditioning* section of the Food SA BCEEE toolkit. We encourage you to access these references as they may provide additional useful information for your business in evaluating energy efficiency opportunities.

Food SA's Your Guide to Sustainable Business in Food

Architectural Energy Corporation, Design Brief: Integrated Design for Small Commercial HVAC, Energy Design Resources, p 13

California Energy Commission, Small HVAC System Design Guide: Design Guidelines

Carbon Trust - Heating, ventilation and air conditioning overview

Carbon Trust: How to implement process thermal insulation

Department of Resources, Energy and Tourism: Energy Efficiency Exchange

Department of Climate Change and Energy Efficiency: Electric motors

Lawrence Berkeley National Laboratory: Improving Fan System Performance - A Sourcebook for Industry

Lawrence Berkeley National Laboratory: Energy Efficiency Improvement and Cost Saving Opportunities for the Fruit and Vegetable Processing Industry

South Australian Government, Energy Efficient Cooling

Working Group for Cleaner Production: Eco-Efficiency Resources for the Queensland Food Processing Industry