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GREENHOUSE CHALLENGE PLUS

ENERGY AUDIT TOOL
CHILLERS

03

Australian Government
Department of the Environment and Heritage
Australian Greenhouse Office

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Contents

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01 OVERVIEW

Effective management of your organisation's energy usage is good business sense. It can produce both environmental and economic benefits – and importantly reduce your greenhouse gas emissions.

The Greenhouse Challenge Plus Energy Audit Tool has been developed to assist non-technical or semi-technical energy managers in small to medium organisations:

→ identify actions to improve energy efficiency through the use of a simple but detailed audit checklist; and

→ develop plans for implementing energy efficiency actions.

The checklist contains notes supplying the auditor with further explanation or hints on how to compete the tasks. It should be possible to complete the majority of tasks through simple observation.

The energy efficiency action plan – can also be utilised in the preparation of or alternatively form part of your organisation's annual progress report to the Greenhouse Challenge Plus programme—which details abatement actions.

The energy audit tool has been designed as a modular system. This means that you can utilise each of the volumes as stand-alone independent units or in combination with the other units.

This is *Volume 03 — Chillers* of the Greenhouse Challenge Plus Energy Audit Tool, which includes the following 11 volumes:

Volume 01 — Lighting (indoor and outdoor)
Volume 02 — Lighting control
Volume 03 — Chillers
Volume 04 — Boilers and steam systems
Volume 05 — Ventilation systems
Volume 06 — Airconditioning systems
Volume 07 — Office equipment
Volume 08 — Domestic hot water
Volume 09 — Building insulation
Volume 10 — Infiltration (air leakage into buildings)
Volume 11 — Compressed air

Your challenge to reduce energy consumption and greenhouse gas emissions starts now!

Need more information?

If you require additional information about the Greenhouse Challenge Plus Energy Audit Tool, contact your Industry Adviser on 02 6274-1229 or at email greenhouse@greenhouse.gov.au. Additional copies of the Greenhouse Challenge Plus Audit tool can also be downloaded from www.greenhouse.gov.au/challenge

A:
BACKGROUND INFORMATION

Chillers are cooling equipment that produce chilled water to cool air for a variety of applications, ranging from space cooling (air conditioning or refrigeration) to process cooling. The term 'chiller' is very broad and is used in this audit tool to describe an overall system that includes the refrigeration plant, the water chiller and condensers.

The two most common types of chillers are mechanical compression chillers and absorption chillers.

The basic components of a mechanical compression chiller include an electric motor, refrigerant compressor, condenser, evaporator, associated piping and controls. Mechanical compression chillers are classified based on the type of compressor used. Common compressor types include centrifugal, screw and reciprocating.

Absorption chillers have an evaporator, absorber, generator and condenser, along with the associated piping and controls. In both the absorption and mechanical compression cycles, the refrigerant evaporates at low pressure and low temperature to absorb heat, and then condenses at higher pressure and higher temperature to release heat to the atmosphere.

The refrigeration or chiller system in food industries such as dairies and food processing is typically responsible for between 50% and 80% of the total electricity consumed in the refrigeration plant and therefore is the major energy consumer in this industry. This volume highlights measures to do with the operation and structure of your chiller system to improve the energy efficiency of the system. Some of the measures include: installing a variable speed drive (VSD) on the electric pump which drives the chiller, insulating system pipes and valves, and shifting cooling loads away from periods of high energy demand.

Each question in the energy audit checklist that follows has a space where you can write your energy efficiency improvement ideas. You should refer to the explanatory notes when considering what can be done to improve energy efficiency. You may need to take additional notes and attach them to the checklist, or attach other relevant documentation (such as instruction sheets and site plans) in order to support your improvement ideas and completely document your audit.

Remember these are ideas, not decisions. When you have completed the energy audit checklist, select the energy efficiency improvements that are viable and enter them into the energy efficiency action plan in section C of this volume.

B: ENERGY AUDIT CHECKLIST

03

OPERATION AND USE

QUESTION 1: What type of chiller does your organisation have? Tick the appropriate boxes and indicate the number of each type.

- ☐ Compression chiller — Number: .....
- ☐ Absorption chiller — Number: .....
- ☐ Other..... Number: .....

Improvement ideas and notes:.....

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→ A chiller is a refrigeration system that cools water using a vapour-compression or absorption cycle. Chillers are classified based on whether or not they use a compressor to cool the water and if they do, the type of compressor they use. The chilled water has a variety of applications from space cooling to process uses.

→ Match number, size and type of chillers to the cooling load required taking into account the load profile. Replacing electrical chillers with gas absorption chillers may be more economical.

MAKE SURE YOU: Consult maintenance or engineering personnel if needed.

QUESTION 2: Are any chiller systems more than 10 years old?

☐ Yes ☐ No

If yes, indicate which chiller systems:.....

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Improvement ideas and notes:.....

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→ Consider replacing the chiller when equipment is older than ten years. This can increase efficiency by 30% to 40%. Undertake a life cycle cost analysis if needed.

MAKE SURE YOU: Consult maintenance or engineering personnel, or the asset or purchasing records.

B:
ENERGY AUDIT CHECKLIST

QUESTION 3: How are chiller compressor units operated? Please tick the appropriate box below.

- ☐ Automatically
- ☐ Semi-automatically
- ☐ Manually
- ☐ Combination
- ☐ Other: .....

Improvement ideas and notes:.....

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→ Computer controls should be installed to allow automatic sequencing of compressors, making sure they operate at their highest efficiency points. This involves each compressor in the system only being switched on when necessary. Automatic controls may also result in labour savings.

MAKE SURE YOU: Consult operational personnel or maintenance or engineering personnel if needed.

QUESTION 4: Is the chiller compressor unit and motor drive compatible with the cooling loads required by your organisation?

☐ Yes ☐ No ☐ N/A

Improvement ideas and notes:.....

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→ Because of production increases, the load on the compressor and motor drive can exceed the capacity of the actual installation. Ensure the compressor and motor drive are of suitable size and type to match the cooling loads required, thus achieving energy savings and longer equipment life.

MAKE SURE YOU: Obtain output capacity (check operating manual) and required cooling load of the chiller compressor unit. Consult maintenance or engineering personnel if needed.

QUESTION 5: Does the electric pump used to drive the chiller have variable speed drive (VSD)?

■ Yes ■ No

Improvement ideas and notes:.....

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→ A variable speed motor drive for the electric pump will allow the pump speed to be reduced when cooling loads are lower, therefore improving energy efficiency.

MAKE SURE YOU: Consult maintenance or engineering personnel or the operating manual for the units.

QUESTION 6: Do evaporator and condenser fans have 2-speed or variable speed drive (VSD)?

■ Yes ■ No

Improvement ideas and notes:.....

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→ Chiller systems have an evaporator, a compressor (except for an absorption chiller), and a condenser. Evaporator fans move air across refrigerant coils to condition the space. Condenser fans remove the heat generated during compression of the refrigerant. Consider the installation of two-speed or VSD controls on condenser and evaporator fans, allowing control over the speed at which the fans operate. The fan motors' energy consumption is reduced significantly by adjusting the fan speed to the cooling load needed.

MAKE SURE YOU: Consult maintenance or engineering personnel or the operating manual if needed.

QUESTION 7: Are evaporator and condenser fans cycled where possible?

■ Yes ■ No

Improvement ideas and notes:.....

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→ Cycling of fans refers to switching them on and off at varying times according to when they are needed. Consider installing timers on primary evaporator and condenser fans. Cycling fans will reduce the amount of energy used by the fans and the compressor.

MAKE SURE YOU: Consult maintenance or engineering personnel or the operating manual.

B:
ENERGY AUDIT CHECKLIST

QUESTION 8: Do the chiller compressor/s operate at low suction pressures?

■ Yes ■ No ■ N/A

Improvement ideas and notes:.....

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→ Compressors operate at a certain suction pressure to maintain production rates or to maintain the desired storage temperature. They are most energy efficient when operating at maximum suction pressure. Cooling loads with similar suction requirements should be consolidated and piped to a single compressor. This avoids excessive energy use resulting from multiple compressors operating at low suction pressures.

→ Alternatively, ensure the size of the evaporator is suitable for the cooling load and that the evaporator is clean. Undersized or dirty evaporators often require lower suction pressure and so waste energy.

MAKE SURE YOU: Consult maintenance or engineering personnel or the operating manual.

QUESTION 9: Does the chiller have a bypass system?

■ Yes ■ No

Improvement ideas and notes:.....

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→ Consider installation of a bypass system for the chiller. This system will allow the chiller to be switched off when outside air temperatures are cool enough to be used, or if cooling towers can provide chilled water.

MAKE SURE YOU: Consult maintenance or engineering personnel or the operating manual if necessary.

QUESTION 10: Can the timing of heavy process or other cooling loads be distributed more evenly?

■ Yes ■ No

Improvement ideas and notes:.....

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→ Energy demand fluctuates during the day and many energy suppliers will charge more for periods of high-energy use. Consider shifting cooling loads away from those periods, for example by shifting thermal storage to periods of low energy use, reducing the total energy demand.

MAKE SURE YOU: Consult maintenance, engineering or accounts personnel.

QUESTION 11: Can the defrost time of evaporator coils be adjusted?

■ Yes ■ No

Improvement ideas and notes:.....

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→ Evaporator coils must be free from ice for maximum heat transfer and energy efficiency. An evaporator defrost control may allow the time of defrosting to be adjusted. Reduce the defrost times of the evaporator coils if possible. Warm fluid such as refrigerant gas or water is commonly used to defrost evaporator coils and will often warm the space in the coils even after the ice has melted. Airflow sensors and thermocouples can stop the defrost system as soon as the ice has melted to ensure maximum energy efficiency is achieved.

MAKE SURE YOU: Consult maintenance or engineering personnel.

QUESTION 12: Is heat recovery undertaken?

■ Yes ■ No

If yes, please specify.

Heat recovery activity:.....

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Improvement ideas and notes:.....

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→ Heat recovery refers to the utilisation of any heat given off (waste heat) from the chiller system during operation. Heat recovery from the condenser water should be undertaken so that waste heat can be used to preheat process water, domestic hot water, or for space heating.

MAKE SURE YOU: Consult maintenance or engineering personnel if necessary.

B:
ENERGY AUDIT CHECKLIST

STRUCTURE

QUESTION 13: Does the chiller system have an extensive piping network?

☐ Yes ☐ No

Improvement ideas and notes:.....

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→ Reduce the length of pipe work associated with chiller systems wherever possible to minimise heat gain. Pump efficiency as well as pipe work energy losses are associated with the length of pipe run.

→ As centralised chiller systems often have extensive pipe work reticulation which may give rise to large scale heat gain, those systems should be designed as modular units where possible, with isolation points which allow independent operation of different parts of the system.

→ Consider using a number of smaller chillers located nearer to the cooling loads instead of a centralised system. Alternatively, if the site has a number of smaller chiller units located close together, consider utilising a single centralised chiller unit depending on the load profile.

MAKE SURE YOU: Consult maintenance or engineering personnel.

QUESTION 14: What components of the chiller system are insulated? Please tick the appropriate boxes

☐ Pipes
☐ Valves
☐ Cooler or freezer area
☐ None
☐ Other: .....

Improvement ideas and notes:.....

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→ The cooler or freezer area and all of the pipes and valves of the chiller system should be insulated to avoid unnecessary heat gain into the system. Insulation may be polystyrene or polyurethane. Both are foam type materials, which are suitable to be used as insulation for cool rooms, refrigerated transports, deep freezers and refrigeration piping.

MAKE SURE YOU: Consult maintenance or engineering personnel. Refer to the resource page for more information.

MAINTENANCE

QUESTION 15: Are all components of the chiller system regularly serviced and maintained as recommended by the manufacturer?

☐ Yes ☐ No

If yes, indicate the tasks undertaken along with your maintenance schedule by filling out the table below.

Maintenance task	**Maintenance schedule* (monthly for example)**
Check evaporator and condenser coils for fouling	.....
	.....
Check compressor motor temperature per manufacturer's specifications	.....
	.....
Check compressor motor assembly and oil system	.....
	.....
Check water treatment prior to it entering condenser	.....
	.....
Purge non condensable gases from condenser	.....
	.....
Test for leaks on all joints, fittings and valves	.....
	.....
Check insulation	.....
	.....
Check refrigerant level and condition	.....
	.....
Clean condenser tubes	.....
	.....
Clean evaporator tubes	.....
	.....

SOURCE: Resource No. 2

B:
ENERGY AUDIT CHECKLIST

Improvement ideas and notes:.....

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* Provide work order number or other information to verify the scheduled maintenance activity if possible.

The entire chiller system should be regularly inspected, serviced and maintained as per manufacturer's instructions. This includes the following tasks:

- Checking evaporator and condenser coils for fouling and cleaning them if required. This will ensure the coils are free from scale and organic build up.
- Checking compressor motor temperature every month ensuring it is the temperature recommended by the manufacturer.
- Checking the compressor motor assembly and oil system annually to ensure it is operating at maximum efficiency.
- Monthly checking and treating cooling water entering the chiller system to reduce scale, corrosion, and biological growth. This ensures heat transfer is efficient.
- Purging non-condensable gases from the chiller system. Air or carbon dioxide reduces the effective surface area of the condenser, which is used to condense refrigerant vapour. This decreases the efficiency of the heat exchanger and wastes energy. Automatic purging controls are readily available or the system can be purged manually when an operator notices an increase in the discharge pressure. A refrigeration log will help to identify changes in operating conditions.
- Monthly checking all oil pump and compressor joints and fittings and all relief valves in the chiller system for leaks.
- Monthly checking all insulation of pipes, valves and cooler or freezer areas for condition and appropriate thickness.
- Checking refrigerant levels and adding refrigerant as required. Record amounts and address leakage issues. Refrigerant top-ups should be undertaken annually.
- Cleaning evaporator and condenser tubes at least once annually during shut down.

MAKE SURE YOU: Consult maintenance or engineering personnel to obtain your maintenance schedule for the chiller system.

C: ENERGY EFFICIENCY ACTION PLAN

Note: As an alternative to using this action plan, you can also enter your energy efficiency actions as objectives and targets in an environmental management system, as a work order in your maintenance management system, or in another process that ensures nominated personnel complete the actions.

GOALS AND METHODS FOR ENERGY EFFICIENCY

Your energy efficiency goals

Example: "Reduce the energy use for lighting by 10% compared to last year's consumption." Be specific where possible taking into account technical, financial and operational inputs. Goals should be measurable where practicable.

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Your preferred energy efficiency options

Chosen from 'Improvement ideas and notes' in section B.

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Target completion date .....

Person responsible .....

Goal(s):.....

ACTION STEPS TO BE TAKEN *Specific steps needed to implement the preferred energy efficiency actions stated under 'goals and methods'.*

No.	Action	Person responsible	Due date	Date completed	Initials

COMPLETION *To be signed by person nominated under 'goals and methods'.*

Signature.....

Print Name .....

Title ..... Completion Date.....

Please photocopy this form if additional action steps are required. Complete the page numbering and action numbering on all forms.

Page:..... of.....

National Energy Efficiency
A comprehensive guide to the latest Commonwealth, State and Territory regulations, standards and guides on energy efficient appliances
www.energyrating.gov.au

A SELECTION OF OTHER USEFUL LINKS

1. Building Technologies Program — Chillers.
US Department of Energy.
Contains general information about chillers and provides links to an energy efficiency checklist and new chiller technologies. http://www.eere.energy.gov/buildings/info/components/hvac/cooling/chillers.html

2. Operations and Maintenance Best Practices Guide (Chapter 9.4, pp9.29-9.35).
Federal Energy Management Program, US Department of Energy.
This section describes the different types of chillers, their various components, maintenance requirements and energy efficiency options.
http://www.eere.energy.gov/femp/operations_maintenance/om_best_practices_guidebook.cfm

3. Energy Efficient Products - Chiller Information Page.
Federal Energy Management Program, US Department of Energy.
Provides information about how to buy energy efficient water-cooled chillers. Includes links to a comparative cost calculator. http://www.eere.energy.gov/femp/technologies/eep_wc_chillers.cfm

4. Business Information Sheets.
Sustainable Energy Authority Victoria (SEAV).
Includes links to selection criteria, energy performance and description of different chilled water systems.
http://www.sea.vic.gov.au/advice/business/infosheets/refrigeration.asp

5. Case Study of Energy Management for a Refrigeration Plant at Inghams Enterprises, Summerville, Victoria.
Sustainable Energy Authority Victoria (SEAV).
http://www.sea.vic.gov.au/ftp/advice/business/case_studies/InghamsCasStudy0_a.pdf

6. Working Energy Program Toolkit.
Department of the Environment and Heritage, Australian Greenhouse Office.
Provides concisely arranged measures which can be undertaken to improve the energy efficiency of your water chiller system.
http://www.greenhouse.gov.au/lgmodules/wep/toolkit/hvacsavings/chiller.html http://www.greenhouse.gov.au/lgmodules/wep/toolkit/hvacsavings/water.html

7. Energy Smart Allies Directory.
Directory of suppliers of energy services and products including information regarding chiller systems: www.energysmartallies.com/esa/middlesub.asp

8. Information Sheet: Energy Saving With Insulation.
Sustainable Energy Authority of Victoria (SEAV).
Recommends the types of insulation suitable for different process equipment in industry (such as industrial ovens, boilers, high temperature pipes, refrigeration piping, cool rooms and deep freezers).
http://www.seav.vic.gov.au/ftp/advice/business/info_sheets/EnergySavingInsulatio_0_a.pdf

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