BETTER BUILDINGS PARTNERSHIP

THERMAL RETICULATION NETWORK CONSIDERATIONS

Find out if your building can connect to a Thermal Reticulation Network (TRN)

September 2013

Acknowledgments

80% of the City of Sydney's greenhouse gas emissions come from coal-fired power plants. Thermal reticulation networks are twice as energy efficient as coal-fired power stations due to their use of waste heat from electricity production. These networks that both locally create electricity and heating could reduce greenhouse gas pollution in buildings by 40-60 per cent compared to this coal-fired power. These savings delivering large economic and environmental savings for our commercial buildings, in line with Local, State and Federal commitments of greenhouse gas emissions reductions.

Recognising these benefits, the Better Buildings Partnership has created this checklist to provide actionable tools for asset and facilities managers to determine whether thermal reticulation network connections are technically feasible solutions for their own buildings.

This checklist was developed with the expertise of the Better Buildings Partnership energy technical working group members and the external engineering specialist firm WSP Group.

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Introduction

Purpose of document

This document is intended to assist facilities managers who are interested in connecting their building to a thermal reticulation network (TRN). It offers practical advice and outlines technical considerations to facilitate ready connection.

This document provides checklist tools to assess the potential to connect to a TRN and is intended to provide initial guidance. A detailed analysis is required to fully identify the technical implications of connecting to a TRN.

Structure of document

A range of technical considerations are discussed within this document to allow facilities managers to check and verify potential issues of and opportunities for connecting to a TRN. The document has been split into the following chapters:

1. **Summary Checklist** – key building attributes required in order to connect to a TRN.
2. **Network Considerations** – TRN connection options that may be available.
3. **Building Considerations** – key considerations to assess if your building is capable of connection.
4. **Mechanical Integration** – key mechanical equipment that may be required to connect.
5. **Electrical Integration** – key electrical equipment that may be required to connect.

Other useful resources

If you are considering connecting to a TRN, the following documents may also be useful (webpage links provided at bottom of page):

- *Community Energy: Planning, Development and Delivery*, International District Energy Association, 2012.
- *District Heating and Cooling Connection Handbook*, International Energy Agency.
- *Guidelines for District Heating Substations*, Euroheat & Power.
- *Cogeneration Opportunity Assessment Guide*, Office of Environment and Heritage.

Energy efficiency

Connection to a TRN should not preclude investigation and implementation of other energy efficiency initiatives, such as:

- Lighting upgrades.
- Control optimisation.
- Heating, ventilation and air conditioning (HVAC) equipment upgrades.
- On-going energy monitoring and tracking.

What does a precinct approach offer?

A TRN connection offers a low or zero carbon energy solution, where natural (or renewable) gas is combusted in an energy centre to supply:

- Electricity.
- Heating hot water for space heating and domestic hot water services.
- Chilled water for comfort cooling.

A TRN connection reduces the reliance on coal-fired power stations to provide electricity to supply some or all of these services. This approach also offers energy efficiency improvements and greenhouse gas (GHG) emissions savings benefits.

Additional environmental and economic benefits may apply if a building can host cogeneration or trigeneration plant as then they have the ability to export heating hot water or chilled water at certain times of the day.

Connection to a TRN should not preclude other energy efficiency initiatives.

Webpage Links

- http://www.aeieng.com/images/services/USCommunityEnergyGuide_LR.pdf
- http://dedc.dk/sites/default/files/programme_of_research_development_and_demonstration_on_district_heating_and_cooling.pdf
- http://www.euroheat.org/Technical-guidelines-28.x?PID=52&M=NewsV2&Action=1&NewsId=70

Chapter 1 | Summary checklist

Purpose of summary checklist

The summary checklist provides a high level overview to identify the typical building attributes that are required in order to connect to a TRN.

The items in the checklist are in relation to a 'typical' or representative commercial building with a retail stratum in a major Australian city centre.

Using the summary checklist

All 'Essential' criteria must be met for a TRN connection to be viable. 'Desirable' criteria are preferred but are not mandatory.

Summary checklist

Essential criteria

- **Does your building have water-based systems for domestic hot water and air conditioning?*** (See Chapter 3) ☐
- **Is there at least 35m² of available plant space?** (See Chapter 4) ☐
- **Is there adequate access to remove old plant and install new plant?** (See Chapter 4) ☐
- **Have you undertaken all practical energy efficiency measures?** ☐

*Or are you considering an upgrade or overhaul to your existing air conditioning and domestic hot water systems?

Desirable criteria

- **Is your building > 10,000m² GFA?** ☐
  Buildings <10,000m² can be connected to a TRN where there are opportunities, for example: If the building is adjacent to a TRN route, and if the building can host cogeneration or trigeneration plant.
- **Is your building close to a proposed TRN route?** ☐
- **Have you undertaken an assessment of the building's space heating loads?** ☐
- **Have you undertaken an assessment of the building's comfort cooling loads?** ☐
- **Have you undertaken an assessment of the building's domestic hot water loads?** ☐
- **Looking at hosting an energy centre? Does your building have plant space for cogeneration (≥100m²) and potentially trigeneration plant (an additional 100m²)?** ☐

Chapter 2 | Network considerations | What is a TRN?

What is a TRN?

A Thermal Reticulation Network (TRN) is a district network which supplies heating hot water (HHW) and/or chilled water (CHW) to buildings via flow and return pipework infrastructure. An Energy Transfer Station (ETS) is the interface between the TRN and building. HHW and/or CHW is supplied from an energy centre, which consists of a combination of generators, boilers and heat rejection equipment, plus absorption and/or electrical chillers (where CHW is supplied). The TRN is a closed loop system; therefore there is no direct contact between the TRN fluid medium (water) and the building fluid medium (water).

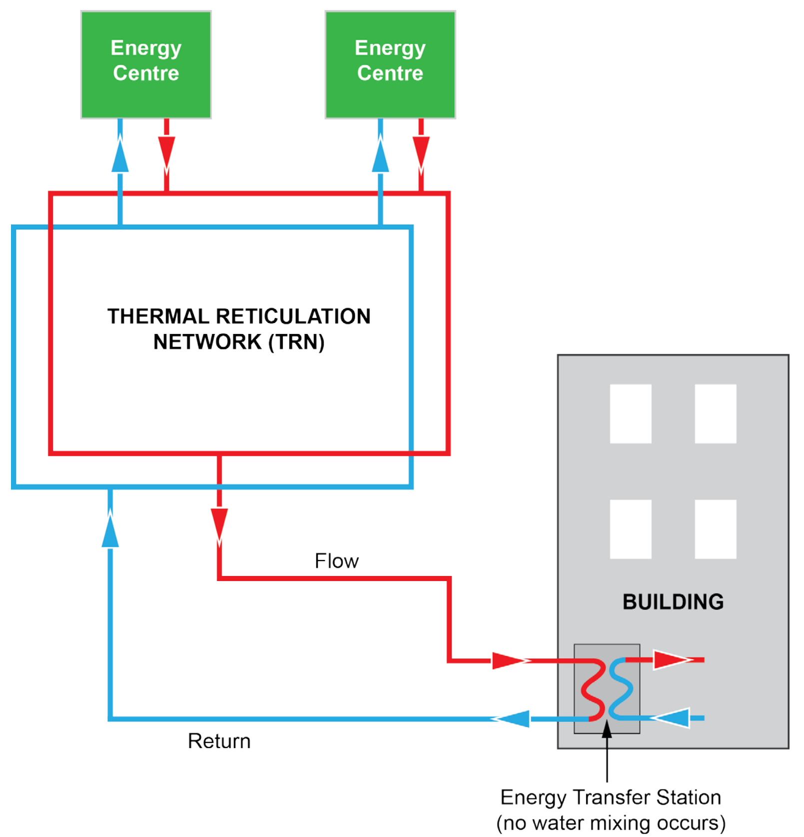
Reliability

The TRN will ultimately be designed with multiple energy centres feeding into the network. In the unlikely scenario that an energy centre were to fail, the TRN would still be supplied through other energy centres. The network will also have back-up boiler plant and thermal storage at the energy centres or at customer buildings, which will be used to supplement the day time or any night time thermal load should any generator downtime be experienced. This provides an inherent level of redundancy within the TRN. A TRN should provide the same or better security of supply as that offered by the electricity and gas supply networks. In addition, these traditional utility supply networks can continue to provide a further level of redundancy to the building.

Reticulated water quality

Reticulated water within the TRN will be centrally treated and tested. Due to the closed loop configuration, in the unlikely event of contamination, the building will not be impacted.

Figure 1: Simple TRN example



A TRN is a district network which supplies HHW and/or CHW to buildings.

The connection to a TRN should provide the same or better security of supply as that offered by the utility networks.

Reticulated water within the TRN will be centrally treated, tested and monitored to ensure supply is not interrupted.

Chapter 2 | Network considerations | TRN connection scenarios

There are multiple TRN connection scenarios available. Two scenarios are discussed in this document as broad examples; namely Consumers; and Producers and Consumers.

Scenario 1: Consumers

Under this scenario, HHW and/or CHW is supplied to the building via an energy transfer station (ETS). The building's heating, ventilation and air conditioning systems are hydraulically separated from the TRN, and can have different operating temperatures and pressures.

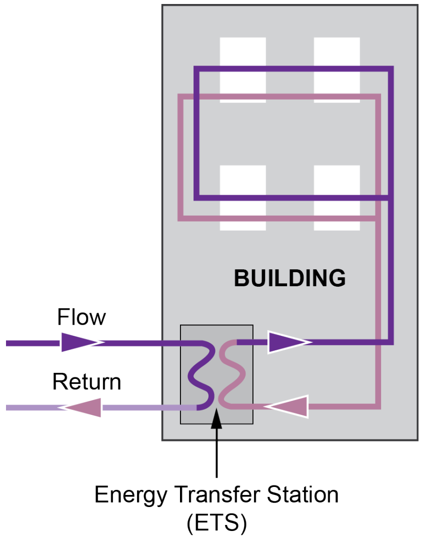
Scenario 2: Producers and Consumers

Under this scenario, the building can be both a consumer and producer of energy. There are two options (each option has an ETS to allow direct connection to a TRN):

1. Cogeneration to produce heating hot water for use within the building and/or export to a TRN.
2. Trigeneration: as option 1 plus an absorption chiller to generate CHW for use in the building and/or export to a TRN.

1 Consumers

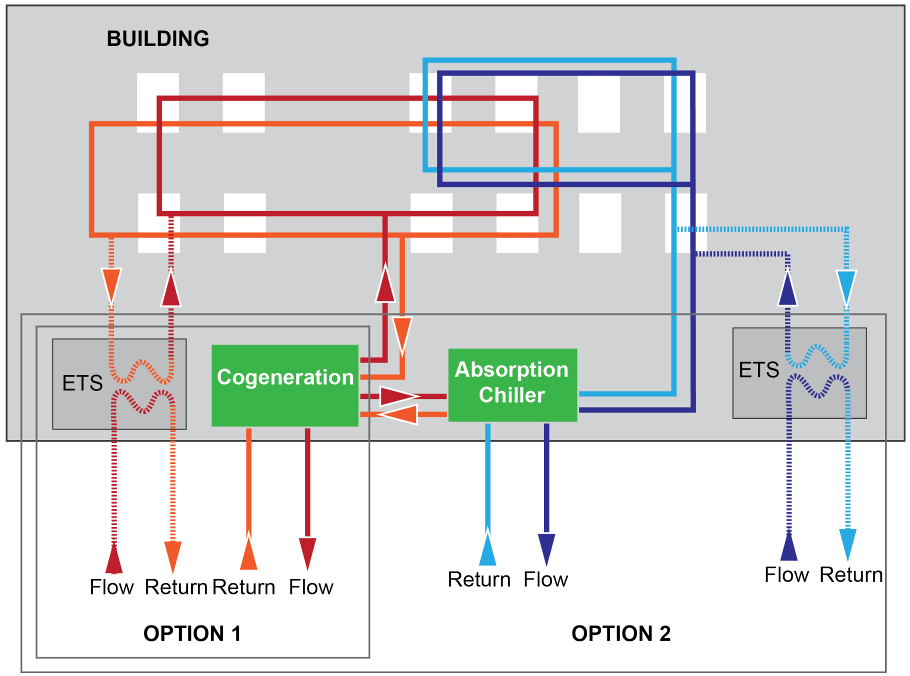
Figure 2: Consumer illustration



HHW and/or CHW is supplied to the building via an Energy Transfer Station (ETS).

2 Producers and Consumers

Figure 3: Producers and consumer illustration



The building can be both a producer and consumer. There are two main options available:

1. Cogeneration

2. Trigeneration

Chapter 3 | Building considerations | Size and systems

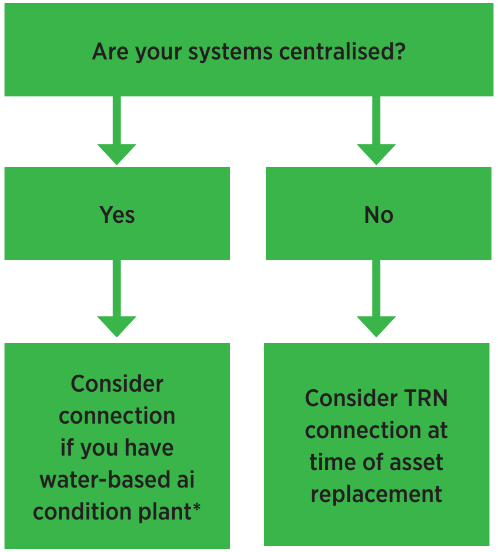
Building size

Buildings of any size can connect to a TRN. However, as a guide, it is generally easier to justify connection if buildings have a GFA of at least 10,000m^2.

>10,000m^2 GFA

Buildings <10,000m^2 can be connected to a TRN where there are opportunities, for example: If the building is adjacent to a TRN route, and if the building can host cogeneration or trigeneration plant.

Are your systems centralised and water based?



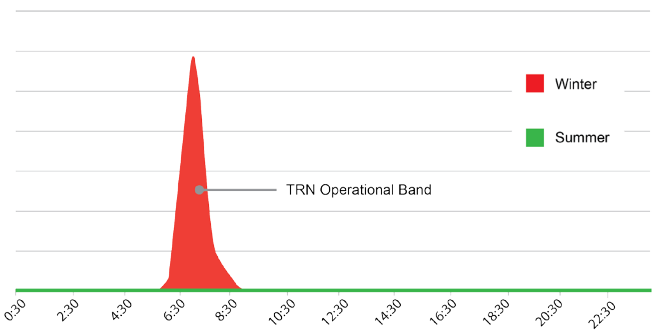
Electrical based systems cannot connect to a TRN. So, if you have unitary split systems or VRF/VRV systems, consider moving to water based systems at time of asset replacement or where there is an economic or environmental reason to do so.

*These systems include those which have chiller plant, cooling towers etc. that serve on floor equipment such as Variable Air Volume (VAV), Fan Coil Units (FCUs), Chilled Beams, Packaged Air Conditioning (PAC) Units, etc.

Buildings can be any size in order to connect to a TRN but, as a guide, >10,000m^2 GFA is preferred.

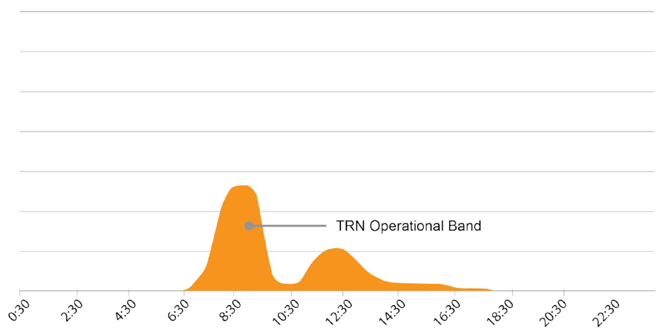
A building must have centralised, water based building services for comfort cooling, space heating and domestic hot water in order to connect to a TRN, or to potentially provide ancillary services to a TRN.

Figure 4: Typical daily space heating profile for a commercial building



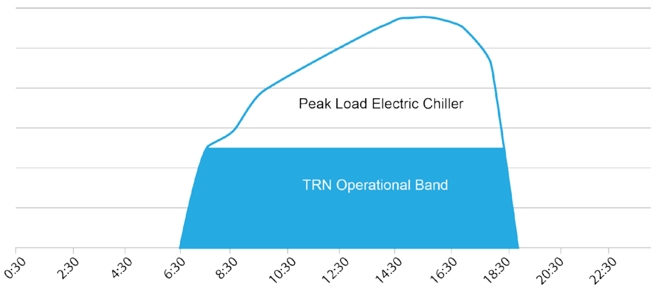
Commercial building space heating demand

Figure 5: Typical daily domestic hot water profile for a commercial building



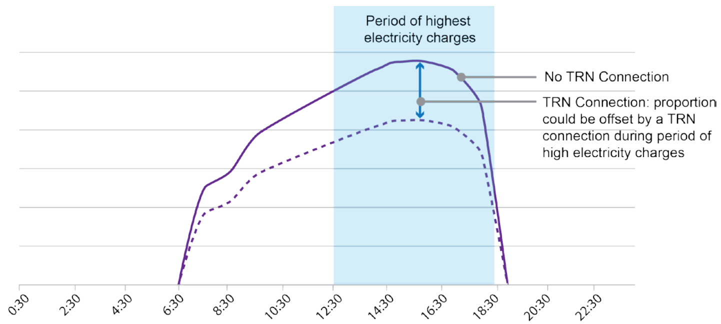
Commercial building domestic hot water demand

Figure 6: Typical daily comfort cooling profile for a commercial building



Comfort cooling demand – summer

Figure 7: Indicative electricity displacement



Indicative electricity displacement

Commercial building space heating demand

Space heating is generally required in commercial buildings in winter during morning pre-heat period. The space heating demands could be fully met through a TRN connection.

Commercial building domestic hot water demand

Domestic hot water heating is generally required in commercial buildings throughout the day for showers and general hot water use. The domestic hot water heating demands could be fully met through a TRN connection.

Comfort cooling demand – summer

Comfort cooling is generally required from 6.30am to 7pm in commercial office buildings during summer. A TRN connection could meet the base load cooling demand. There will always be the requirement for peak load electric chiller plant or other on-site air conditioning equipment to meet peak cooling demands.

Indicative electricity displacement

The use of a TRN for comfort cooling means that there is a reduced requirement to source electricity from the grid; reducing operating costs associated with network charges. This is especially important during the period of highest network charges, currently between 2–8pm.

Big kit—locations

Available plant space will vary from building to building.

Scenario 2 is the most space critical (dependent on size and configuration option). It should be noted that existing plant may be removed, as it could be redundant after TRN connection, although it may want to be retained to provide an additional level of redundancy.

1 Consumers

Figure 9: Example of a heat exchanger

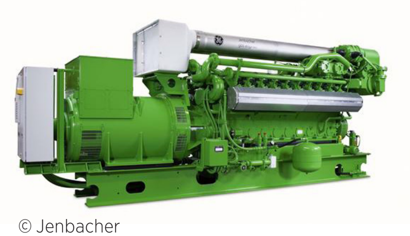
A consumer will require a heat exchanger to transfer thermal energy from the TRN to the building.

The heat exchanger will form part of an Energy Transfer Station (ETS), which will also include meters, valves and other equipment. An ETS is housed within customer buildings and demarcates the TRN and customer building equipment.

Ideally, an ETS should be located near to the CHW and HHW primary circuits to avoid running excessive lengths of pipework; which result in heat losses/gains. An ETS should also be located close to the building boundary at basement or ground level.

2 Producers and Consumers

Figure 10: Example of a generator



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Cogeneration

A producer will typically have an electricity generator (gas-fired reciprocating engine) and/or gas-fired boiler or other thermal generator plant to produce heating hot water.

The generator should be located where ventilation can be readily introduced and where the equipment can be adequately maintained. The structure of the building should also be able to support the weight of the equipment.

Figure 11: Example of an absorption chiller

Trigeneration

The building may also have an absorption chiller, which produces chilled water from waste heat off the generator.

The absorption chillers should be located in a space where the equipment can be adequately maintained . The structure of the building should also be able to support the weight of the equipment.

Chapter 4 | Mechanical integration | Energy Transfer Station (ETS)

General guidance

An Energy Transfer Station (ETS) is one of the major components that assists in a TRN connection, and consists of a heat exchanger, meters, valves and other ancillary equipment. The purpose of the heat exchanger within the ETS is to allow efficient heat transfer between the TRN and the building; ensuring that the building and TRN are physically separated to eliminate undesirable hydraulic interaction between the two entities.

Heat exchanger selection

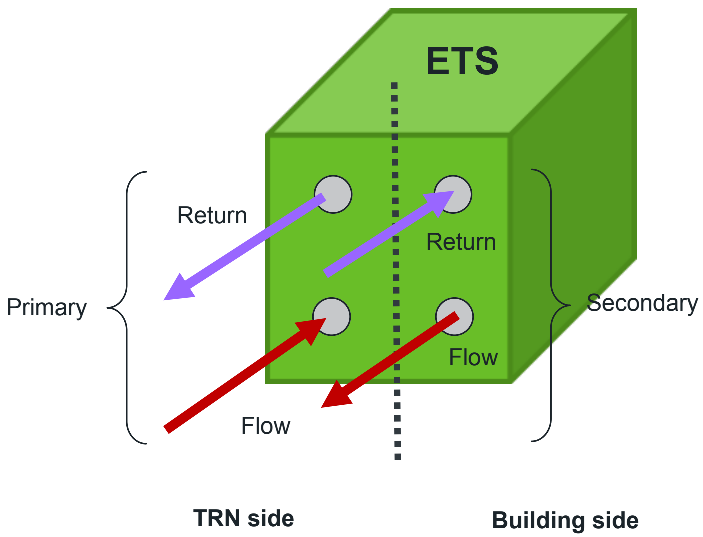
Careful selection of the heat exchanger is very important to convey the correct amount of energy into the building. It is recommended that plate heat exchangers (PHXs) are used in lieu of other heat exchanger styles, such as a shell-and-tube style. These heat exchangers require less space for installation and are generally cheaper.

ETS ownership and maintenance

The ETS will be provided, owned, operated and maintained by the TRN operator. As general guidance:

- The secondary thermal energy network that conveys the building side fluid medium should be kept and maintained by the building owner. This includes any building side controls and devices.
- The primary thermal energy network that conveys the TRN side fluid medium will be owned and maintained by the TRN operator. This includes any TRN side controls and devices.

Figure 12: ETS illustrating building side and network side flow and returns of water



The ETS will be provided, owned, operated and maintained by the TRN operator.

The secondary thermal energy network from the ETS must be maintained by the building owner.

The primary thermal energy network to and including the ETS will be maintained by the TRN operator.

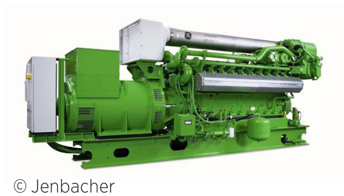
	1 Consumers	2 Producers and Consumers
ETS size	There are two ETS size options for a consumer: 1. CHW base load demand—a set size to cater for the base cooling load AND/OR 2. HHW demand—a set size to cater for the full space and domestic hot water heating load	ETS size will be dependent on the size of the central plant and the desired capacity to export ■ The ETS should allow for the full thermal output of the co/trigeneration provision regardless of building demand.
Building side items	**Import connection** ■ Control valves and sensors ■ Pumps	**Import/Export connection** There will be both an import and export connection: **Import connection** as described in Scenario 1 AND **Export connection**, consisting of: ■ Control valves and sensors ■ Pumps ■ Expansion equipment to provide export ability to the TRN (normally provided by the Energy Centre in collaboration with the TRN operator)
TRN side items (provided by TRN operator)	■ 1 x ETS	■ 1 or 2 ETS, including heat exchangers, pumps and ancillaries

1 Consumers

Figure 13: Example of a heat exchanger

2 Producers and Consumers

Figure 14: Example of a generator



© Jenbacher

Figure 15: Example of an absorption chiller

	1 Consumers	2 Producers and Consumers: Cogeneration		2 Producers and Consumers: Trigeneration
Plant space	$35m^2$	$\geq 100m^2$	+	$100m^2$
Heat rejection space at roof level	None	$\geq 25m^2$	+	$\geq 35m^2$
Riser space	None: utilises existing building services infrastructure	$\geq 2.5m^2$	+	$\geq 1m^2$
Structural needs Indicated mass for total thermal load of system (including pipes, energy transfer stations, etc.)	1MW ~ 1,500kg (based on Alfa Laval data)	1MWe ~ 25,000kg (based on Jenbacher data)	+	1MWth ~ 24,000kg (based on Broad data)
Access needs	Access required to maintain components in ETS. This can generally be undertaken through a goods lift but is dependent on the size of thermal connection.	Access required to adequately maintain plant by trained personnel.		
Connection pipes Each site is unique based on efficiency, age, layout, etc. of the building.	$10,000m^2$ building chilled water Import: 200Ømm and/or hot water Import: 100Ømm	500kW Export: 80Ømm		500kW Export: 125Ømm
	$20,000m^2$ building chilled water Import: 300Ømm and/or hot water Import: 125Ømm	1MW Export: 100Ømm		1MW Export: 200Ømm
	$30,000m^2$ building chilled water Import: 350Ømm and/or hot water Import: 150Ømm	2MW Export: 150Ømm		2MW Export: 250Ømm

Chapter 4 | Mechanical integration | Thermal meter

Thermal meter

A thermal meter is required to measure how much energy is imported/exported from/to the TRN.

The meter generally consists of two key components:

1. Magnetic flow meter is a device that measures the volume of fluid past a point.
2. Temperature sensors establish the temperature difference across the flow and return circuits. These devices allow for remote monitoring by the TRN operator to ensure the network is operating as intended and for troubleshooting purposes.

The thermal meters will be included as part of the ETS. They will be provided, owned, operated and maintained by the TRN operator.

1 Consumers

TRN Operator | **Building Owner**

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One thermal meter located on TRN side of the ETS

- The building owner should only be charged for the energy used within the building.
- Locate in a position where easy access can be maintained for the TRN operator.

2 Producers and Consumers

TRN Operator | **Building Owner**

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One thermal meter located on each side of the ETS

The building owner may also want to meter their own thermal supply to establish their own thermal energy use.

Differential pressure sensors

Differential pressure sensors monitor the pressure difference across an ETS and are required for two reasons:

1. The differential pressure sensor allows the TRN operator to determine if the ETS is operating as intended. Over time, scale and dirt will build up on the plate heat exchanger surfaces. The differential pressure sensor will indicate when maintenance needs to be undertaken.
2. The differential pressure sensors allow the TRN operator to proportionally and dynamically control the pressure and flow in the circuit of the TRN and ensure that HHW and/or CHW is delivered to the areas in the networks that require it, and reduce energy wastage from excessive pumping power.

Figure 16: Example of a differential pressure sensor

© Linear Instruments

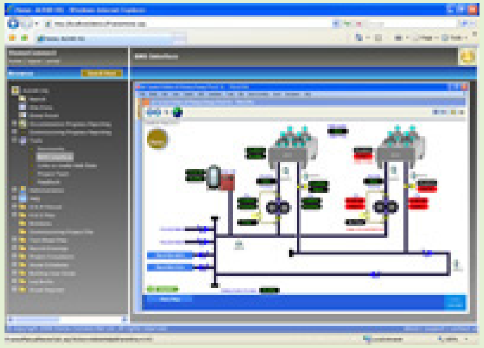
Pressure sensors reduce energy wastage from excessive pumping power.

Controls

The HHW/CHW flow on the building side will be controlled by the building's Building Management System (BMS); therefore the building has no point of connection control to the TRN. The base building system will need to be expandable and ideally open protocol to allow additional functionality.

Controls strategy is consistent regardless of which TRN connection option is pursued.

Figure 16: Example of a BMS interface



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Controls strategy is consistent regardless of which TRN connection option is pursued.

	1 Consumers	2 Producers and Consumers
Connection to electricity network The impact on the electrical supply is dependent on the connection scenario. Key considerations include: ■ If the building is a HV/LV customer. ■ Tariff arrangements. ■ If connecting embedded generation, agreements need to be in place with the relevant distribution authority.	Impact on electrical supply will be minimal if TRN is used for a HHW supply only. If the TRN will be used for a CHW supply, this will generally involve the replacement of electric chiller capacity; reducing network capacity charges. Consider re-addressing connection agreements and tariffs for reduced installed electrical plant capacity.	As per Scenario 1, plus: ■ A connection agreement is required with the distribution authority for embedded generation, as the generation will impact the network fault levels and protection. ■ If the building is a HV customer, Ausgrid may require the generator to be connected at HV to assist with synchronisation to the grid. ■ Connection should be made behind the meter so that electricity is first supplied to the host building before export and to deliver the full financial benefit of embedded generation. ■ Consideration required for stand-by capacity/redundancy to account for any potential engine downtime. ■ Export agreements required and system of operation to be in place with distribution authority.
Building electrical distribution The existing building system capacity will need to be considered and distribution system modified to integrate new/modified plant.	Impact on electrical supply will be nominal if TRN is used for a HHW supply only. If the TRN will be used for a CHW supply, this will generally involve a reduction in the electrical distribution system although the integration of new plant will need to be considered.	As per Scenario 1, plus: ■ Capacity of the system to handle the existing load and fault levels plus those introduced by embedded generation. ■ Consider how electricity is to be distributed within the building, including any on-selling to tenants. ■ Connection point – modifications will be required to the electrical distribution system. ■ Ensure that the correct protection measures are in place to enable the connection of embedded generation and methods to synchronise supplies.

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