Energy Efficiency and Conservation Authority
Te Tari Tiaki Pūngao

Technical Information Document

Electric thermal storage for low carbon building and process heating.

Technical Information Document 2019

New Zealand Government

Introduction

Thermal storage offers the ability to shift process heating demand to utilise lower cost off-peak electricity and manage network costs and manage peak heat demand to improve the overall energy efficiency of heating processes.

Thermal energy storage is increasingly used in industrial and commercial systems to manage energy supply capacity and costs, and variability in demand. By smoothing and matching supply and demand variability, energy storage allows a managed transition towards more sophisticated, higher-value heating processes where fossil fuels are replaced with cleaner and renewable energy sources.

Alongside batteries, thermal storage systems assist in maximising the value obtained from intermittent electricity generation sources such as solar and wind energy.

Thermal storage systems can operate at close to 100% efficiency if well insulated and appropriately controlled. When used with modern, intelligent controls, storage can closely match and respond to variable end-use requirements which reduces total operating costs.

The relative simplicity of thermal storage systems means they are generally easy to operate. Storage systems are often a good choice for process or space heating loads with variable or peaky heat demands.

Thermal storage systems provide inertia and resilience in energy supply systems and can be sized to address the recognised energy supply risks. In facilities where electricity or gas supply interruptions can be costly, thermal storage can help provide continuity of business operations. The main use of thermal energy storage in New Zealand is likely to be balancing continuous end-use energy demands with variable (time of use) energy supply prices.

This technical information sheet provides an overview of the range of thermal storage options and then focuses on relatively simple systems using lower cost minerals or water in storage tanks.

Strata ENERGY CONSULTING

Efficient Energy International Markets • Policies • Results

EECA commissioned Strata Energy Consulting and Efficient Energy International to produce this document which is one of a series on electrical heating.

Technical features

Thermal Storage Systems

Operation

Thermal storage systems are generally used to balance the energy demands of end-use applications with the constraints of energy supply. Thermal storage is already widely used in domestic hot water systems to balance intermittent hot water discharge rates with a need to utilise low-cost off-peak power. Simple insulated low pressure and mains pressure cylinders store hot water at 60°C over a daily charge -discharge cycle. The heat is supplied by an immersion element with simple control by a thermostat.

Using water as an energy storage medium is logical because of its high specific heat (4.2 kJ/kg/degC – higher than most other single-phase thermal storage materials) and the fact that it's safe, chemically stable, and creates no environmental risks.

Responsiveness and Efficiency

By building a store of heat over a long period and discharging the stored heat over a short period, thermal storage can provide a high heat discharge rate from a limited capacity energy input. The 'thermal mass' of thermal storage is essentially retaining a reservoir of energy which can be designed to discharge quickly to meet process needs. This is generally much more responsive to variable production process demands than that achievable by boilers.

The relationship between charge and discharge cycles is called recovery time. A thermal mass system that discharges its heat in one hour and recharges over the balance of a daily 24 hour recharge and would have a 23 hour recovery time. If it was recharged more frequently, its recharge rate would be a function of the rate at which it can be recharged. If the rate of recharge was ½ the rate of discharge, it would have a 2 hour recovery; if it was ¼ the rate of discharge, it would have a 4 hour recovery and so on.

Thermal storage is often required in heat recovery applications where the heat rejection from a process is not coincident with the use for the recovered heat.

Storage materials and options

A wide range of materials are used in thermal storage applications. Their suitability depends on a number of key factors:

- The thermal storage material must store heat at or above the required end use temperature
- The required storage density:
  - For sensible heat storage (no phase change) the key consideration is the material's specific heat (energy stored per unit of mass as measured in kJ/kg/degree C)
  - Where heat is stored by a material's phase change, the key consideration is the latent heat of fusion (energy required to melt or freeze) measured in kJ/kg and the temperature this occurs at.
- The available space – a large volume can store more energy at a lower temperature, or use a low specific heat storage material
- Environmental and safety considerations. A water leak may be annoying, but a leak of high temperature oil is dangerous and more difficult to clean up

Table 1 summarises thermal storage materials and their energy storage characteristics. This technical guide contains more information on the highlighted options as they have general and practical applications that can replace fossil fuel options within industry and commerce within New Zealand.

Output temperature	Application / storage medium	System	Specific heat	Status
0°C	Ice-based storage technology.	Ice brine slush or solid ice use latent heat of fusion of water for peak refrigeration and air conditioning storage	334 kJ/m^3 93 kWh/m^3	Commercialised, not widely used.
20°C	Heat storage in solids & masonry	Passive thermal storage designed into building structures and linings	1.5 kJ/kgK	Low cost, under-utilised
20°C to 50°C	Electric storage heaters	'Nightstore heaters' with high-density (3,900 kg/m^3) iron oxide bricks heated to a high temperature	0.9 kJ/kgK	Commercialised, widely used
-35-90°C	Organic Phase change materials	Employs latent heat of fusion of solidifying and melting oils like paraffin	170 to 278 kJ/kg	Commercialised, not widely used
15-390°C	Inorganic salt hydrates	Uses the chemical energy from hydrating or dehydrating a 50% sodium hydroxide (NaOH) solution	140 to 370 kJ/kg 1 GJ/m^3	Commercialised, not widely used
60°C	Super capacitor DHW line heaters	Capacitor discharged for short term hot water delivery		Not yet commercialised
82°C	Low temperature water storage	Low pressure and mains water pressure DHW storage cylinders and tanks	4.2 kJ/kgK	Commercialised, widely used
	Hybrid water storage heaters	Coil within tank provides high recovery	4.2 kJ/kgK	Commercialised, not widely used.
120°C	Medium temperature water storage	Pressurised insulated water storage vessels, typically on night rate power	4.2 kJ/kgK	Commercialised, not widely used
>100°C	Steam accumulator	Short term steam storage for demand surges or damping shocks in steam demand	Varies with storage and discharge pressures	Custom applications, not widely used.
>600°C	High temperature hot rocks	Higher temperatures overcome limited specific heat storage of rock	1.5 kJ/kgK	Limited projects internationally
300°C to 400°C	Molten-salts	Sensible and latent heat of molten salt storing solar energy at a high temperature	varies	Commercialised, not widely used.
1,400°C	Solid or molten silicon	Silicon offers high temperatures than salts, increasing capacity and temperature	1 MWh/m^3	Not commercialised

Table 1. Summary of heat storage media and systems

Maximising temperature differentials in fluid-based systems

Thermal storage devices using liquids operate between a higher output temperature and a lower return temperature. Maintaining the temperature differential is key to maximising the amount of energy stored. Mixing between the output and input flows should be avoided as it reduces the amount of stored energy.

Sensible liquid thermal storage systems generally use thermal stratification within the tanks that store the heat with the less dense hot layer of fluid ‘floating’ on top of the denser, colder fluid. As the storage tank is charged, hot fluid is pumped into the top of the tank, while cold fluid is discharged from the base to be heated. Hot fluid flows from the storage tank to discharge its energy and cooled fluid is returned to the base of the tank. The boundary or “thermocline” between the hot and cold fluid volumes travels down as the tank is charged, and up as the storage tank is discharged.

In larger thermal storage systems, the fluid heater is typically separated from the storage vessel so as to minimise internal mixing. Pipe entries to the storage vessel include distributers to minimise fluid velocities and prevent mixing.

Thermal heat storage for buildings using solid thermal media

Heat storage in solids & rock stores

Stone heat storage is effective for applications that heat air, such as in solar air-thermal systems, bricks or stone. This type of storage is widely used in regenerative heaters such as kilns, masonry structures or rock stores in passive solar homes.

Masonry floors and walls

These offer both heat storage opportunities and a low cost means for implementing low temperature radiant heating . This form of energy storage needs to be included at the time of building design. Masonry storage systems absorb energy from heat in the surrounding atmosphere; this stored energy is radiated as long wavelength radiant heat to the point where it is needed.

The benefits of masonry energy storage systems include:

- Self-regulating heat output. Heat flows naturally between the masonry surface and the heating space when there is a temperature difference between them
- Draft and noise free
- Unobtrusive, walls are left clear; low dust movement reduces cleaning requirements.

While masonry only has about one third of water’s specific heat capacity (1.5 kJ/kgK for concrete vs. 4.2 kJ/kgK for water), it can provide for thermal storage at negligible additional cost as part of the building structure and is then available at large volume. The performance depends on being well insulated from the external environment.

No fines concrete

No fines concreate is concrete typically made with 20 mm aggregate, and is a variant of rock storage. The absence of sand or finer aggregates in the mix creates a porous concrete through which air can flow, which allows more rapid heating and discharge cycles. No-fines concrete can be used as a structural element or sub-layer to floors, providing controllable thermal storage as part of the floor structure.

Electric floor systems

Improvements in electric floor energy storage systems from Scandinavia have led to increased interest in in-floor and in-ceiling electric heating. These electric systems rely on the building structure for thermal storage and can be built into the structure during construction. These energy storage systems provide reliable and controllable heating.

Smart controls can be used to actively manage heat input by learning how the building responds to outdoor temperatures and historical heat charge rates. The controls will adjust energy input to meet forecasted heat demand.

Floor energy storage system installations fall into two broad categories, fast and slow.

Fast-response systems have heating elements just under the surface, with little thermal storage.

A slow-response system has the heating elements embedded deeper (100 mm or more) within the structure. This method uses the building structure as a thermal mass storage system (see figure 1).

Figure 1. Under floor heat storage

Source: http://akapdx.com/44027/radiant-floor/fine-decoration-radiant-floor-heating-mike-s/

Hydronic heating and cooling systems use a circulating heat-transfer fluid in inside a floor. Modern hydronic underfloor heating passes low temperature water through plastic pipe in the floor instead of laying electric elements in the floor structure. The lower temperatures these applications operate at make them well suited to use with heat pumps as the thermal energy source.

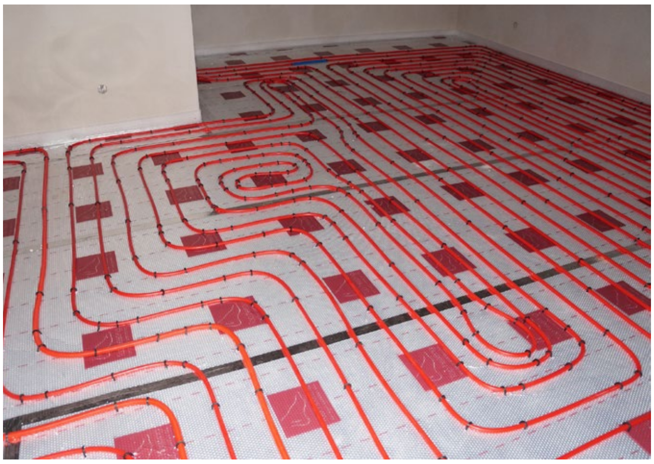

Figure 2. Hydronic floor storage heating options

Source: http://liquidtransition.com.au/hydronic-underfloor-heating-for-existing-homes/

Phase change (latent) heat storage

Phase Change materials can store a significant amount of energy in the latent heat that is absorbed or released during phase change (e.g. from ice to water). Heating a material from solid to liquid (e.g. melting wax) absorbs heat; conversely, cooling the heated liquid to return it to a solid recovers heat (e.g. solidifying melted wax). Commonly used phase change materials retain latent heat without significant changes in physical volume or chemical properties.

Phase change occurs at a constant temperature (the melting point or freezing point) and requires much more energy than changes in temperature without phase change. For example, heating 1 kg of water by 10°C requires 42 kJ whereas melting 1 kg of ice at 0°C requires 334 kJ. Vaporising or boiling water at 100°C requires 2230 kJ/kg. The ability to store and release phase change energy makes latent storage applications an important option where relevant.

One of the most common applications of phase change storage is using of freezing and melting of ice packs to minimise air conditioning demand peaks.

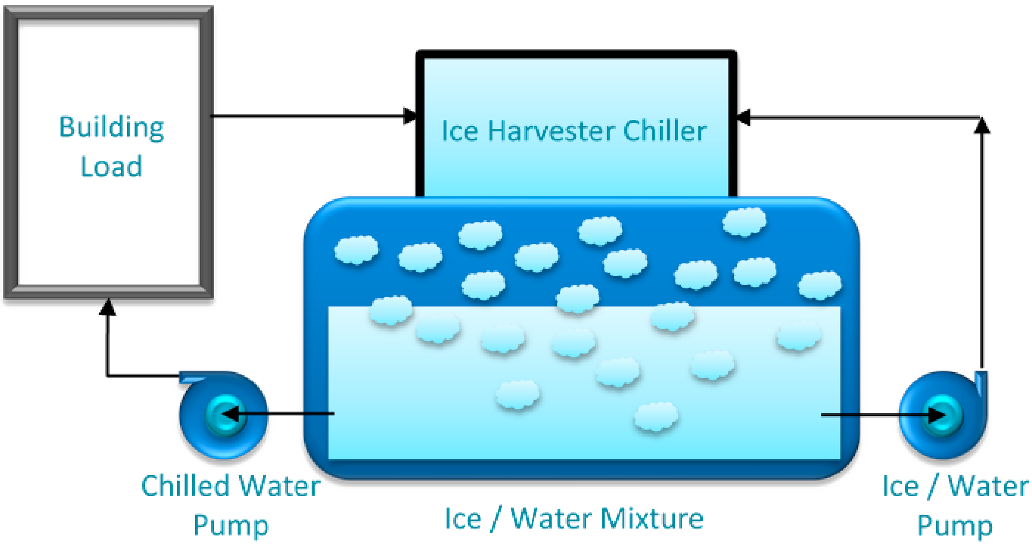

Figure 3. Ice Storage system

Source: https://energydesignresources.com/resources/e-news/e-news-67-cool-thermal-energy-storage.aspx and http://www.ncpisolutions.co.uk/service/renewable-energy-solutions

Commercially available phase change materials operate at temperatures between -35°C to + 90°C depending upon the chemistry of the medium and its applications.

Organic phase change materials

These are commercialised, but not widely used. This method uses natural, organic materials that melt at useable temperatures and include oils like paraffin which provide melting points from -35 to 90°C and latent heat of 170 to 278 kJ/kg. These materials are ideal as they are chemically stable and melt consistently. However, they are also flammable and have low conductivity in their solid phase which requires specific design strategies to overcome. They also have a lower specific heat storage capacity than many inorganic materials.

Inorganic salt hydrates

These include sodium sulphate (Glauber's salt), calcium chloride hexahydrate, sodium thiosulfate penthydrate, sodium carbonate decahydrate have phase change points from 15 to 390°C. These materials are low cost, readily available compounds with high energy storage density and relatively high thermal conductivity. However they can be corrosive, may decompose over time, and may be subject to inconsistent melting. Salt hydrate thermal storage is commercialised but not widely used.

Molten salts

Molten salts are suitable for storing heat at elevated temperatures greater than 100°C. They have high thermal stability, relatively low material costs, high heat capacity and high density. As they are non-flammable and have low vapour pressure, pressurized vessels are not required.

Challenges in using molten salts include corrosion and preventing the salts from solidifying during operation or storage. Auxiliary heating systems or the use of salt formulations with low melting temperatures may be required. For example, “Solar salt” is a mix of 60% (by weight) of sodium nitrate ($NaNO_3$) and 40% potassium nitrate (KNO_3) that is used for storing heat in solar thermal power plants. It melts at about 240°C and is stable up to about 550°C.

Domestic hot water storage

Most domestic electric hot water systems contain 180 to 270 litres of water and a 2.4 to 3.0 kW resistance heating element. Elements above 2.4 kW are available but require their own high current circuits and tend to be subject to demand controls, where they are turned off during peak electricity demand periods.

When choosing a hot water supply system, comparison should be made with the economics of a heat pump water storage system.

Hybrid storage system

In hybrid systems (Figure 4), a heat pump is used to create a high pressure heating system inside a low pressure tank, creating a lower-cost heat pump-driven hot water supply within an insulated storage tank.

Figure 4. Hybrid Hot water storage

Source: http://www.universalforces.in/Chemical_Equipments.html

Process heat water thermal storage

Low pressure hot water (LPHW) thermal storage

LPHW systems supply hot water at up to 82ºC and are widely used for heating buildings.

The construction cost of these storage tanks in these systems is fairly low as the same design tanks are widely used for storing different liquids. A 10,000 litre (1.8 m diameter x 4.0 m long) storage vessel operating at 82ºC can store 3.0 GJ (equivalent to 830 kWh) of heat.

Storage below 100ºC can be done at atmospheric pressure in a vented system. The vessel must be designed for the weight of the fluid and seismic loads and can be incorporated into a building's structure (basement voids) or in underground or in-ground tanks with insulated covers. In-ground storage systems suit large low-temperature storage systems, such as heat pump or warm water systems. One of the case studies covers an in-ground thermal storage system.

Medium temperature hot water (MTHW) thermal storage

The ability to store heat at higher temperatures can significantly increase the amount of stored energy as the temperature operating range is increased.

Figure 5 shows the amount of energy stored for different volumes and operating temperature ranges.

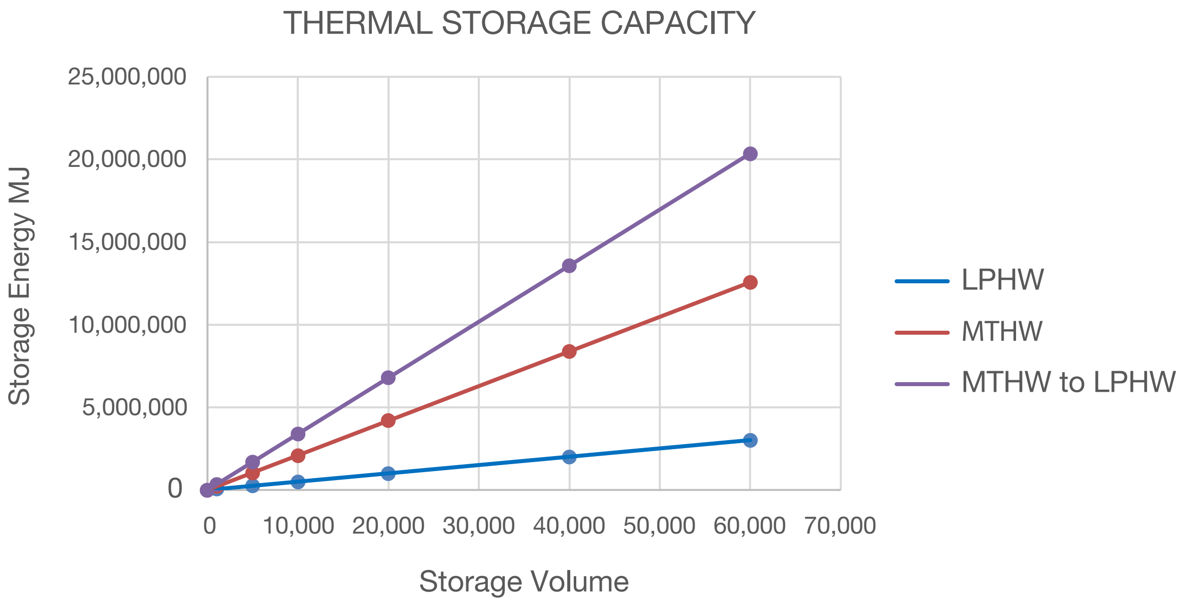

Figure 5. Energy storage at different temperatures

Pressurised hot water must be stored in specially designed pressure vessels. Unfired vessels are available in up to 200,000 litre capacities. A budget cost for a typical 20,000 litre vessel is NZD$90,000, installation costs depend on site conditions.

The required storage volume can be achieved using a single large vessel or multiple smaller vessels.

Pressurised storage vessels can be fitted with electric immersion elements, or used with a stand-alone electrode boiler, or added to an existing heat distribution system to smooth out heat demand.

In the 1980's a number of new commercial buildings in the South Island were fitted with electric thermal storage systems that utilised lower-cost night-rate electricity to generate and store heat. Changing energy prices and the availability of piped LPG altered these systems' economics of over time. Several thermal storage systems in Christchurch were destroyed with their buildings in the 2011 earthquake and replaced with heat pump based systems. More recently, thermal storage tanks have been widely used with biomass boilers to help meet peak winter heating demands and so minimise boiler size and capital cost. An example is included in the case studies.

Steam accumulators

A steam accumulator enables a system to supply periodic high steam demands that are greater than the boiler system's normal capacity. This can allow boiler size to be minimised and reduce capital costs.

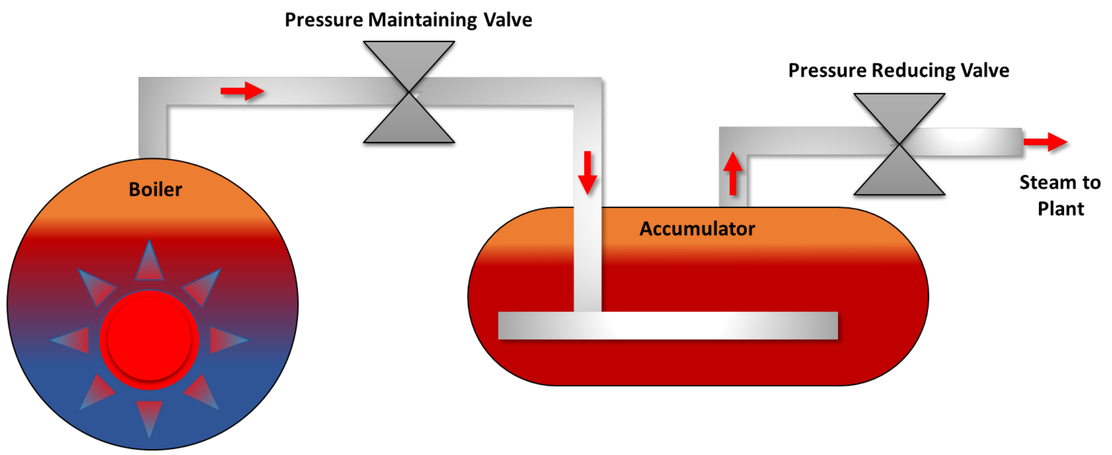

Figure 6. A steam accumulator and boiler system

Source: http://www.spiraxsarco.com/Resources/Pages/Steam-Engineering-Tutorials/the-boiler-house/steam-accumulators.aspx

A steam accumulator is an unfired pressurised vessel partially filled with water. Steam is injected into the accumulator's base through a valve until the water is at the required pressure and temperature. The boiler needs to have greater capacity than the average process demand so that it can recharge the accumulator between demand peaks.

Benefits of thermal storage

Low cost resilience

Often thermal storage is compact and easily installed. For buildings it may be able to be integrated into the structure. Storage at end use offers increased resilience for processes.

Highly efficient

With good insulation (at least 100mm of foamed, in-place insulant) and control, 93% to 99% of input energy is available for the end-use applications. Unused heat is retained for later use instead of being wasted. Technologies like phase-change storage can store a lot of energy.

There are no combustion losses, radiated heat losses or fuel storage, delivery or emission problems, and heat distribution losses are minimised.

Responsive to process requirements

Drawing heat as required from a thermal reservoir can improve controllability. Rapid load response and high turndown of the heat supply are also possible.

High durability

With few components, and only the storage medium at high temperature, there is little thermal stress or heat loss.

Advanced power industry integration

With future power grids demanding rapid demand response, thermal storage systems can offer electrical demand response capability.

Challenges

Energy costs

Off-peak electricity prices approach the wholesale price, but the economics of thermal storage depend on future relative energy price dynamics.

Capital Costs

Some specialised components of thermal storage systems, such as phase change materials, can be expensive depending on what is required. Similarly, some refrigerants and phase change materials can be corrosive and systems that use them may require regular maintenance or repair.

Connection capacity requirements

Thermal storage systems that use electricity may require significant increases in electricity supply capacity. The additional switch gear, metering and cabling costs can add significant installation costs.

Contribution to peak demand costs

To avoid exposure to high time of use and peak demand electricity charges, energy storage systems need to consider daily storage cycles in their design to minimise costs during peak demand periods.

Design complexity

Sophisticated materials and complex control systems, unless demanded by process requirements, may struggle to be economic against directly using relatively low cost fuels. Simple systems that use cheap minerals, or water in storage tanks embedded in the structure of buildings are more economic.

Good design information is needed

The economics of thermal storage systems depend on the life cycle return on investment. This requires good information on actual end-use heat demand patterns, minimising unnecessary process heat losses, and on current and future time of use energy prices, capacity charges, and demand charges.

Thermal Storage Systems suppliers in New Zealand

Thermal storage has been widely used for small-scale applications in New Zealand. Larger system require professional design. Suppliers identified in 2018 include:

New Zealand Suppliers

In-floor / building structure thermal storage systems

DEVI electric

Hydronic Systems

Air conditioning services
http://www.airconcentre.co.nz/underfloor-heating.html

Integrated boiler – solar – thermal storage systems

SparkEnergy
http://www.sparkenergy.co.nz

Storage vessel design and manufacture

ACME engineering
https://www.acme-eng.co.nz

CLE brew systems
http://www.clebrewsystems.com

Culham Engineering
http://culham.co.nz

Dispatch & Garlick Ltd.
http://www.dispatchgarlick.co.nz

Engex
http://engex.co.nz/

Fitzroy Engineering
http://www.fitzroyengineering.com

FMA
http://www.foodmachineryaustralasia.co.nz

Gilbert Engineering
http://www.gilbertengineering.co.nz

Gobal Stainless Industrial
http://www.globalstainlessindustrial.com

Hendle and Murray
https://www.hmengineering.co.nz

HSM Engineering
http://www.hsmeng.co.nz

Kauwerau Engineering
http://www.kaweraueng.co.nz

Lyttleton Engineering
https://lytteng.co.nz

MB Century
http://www.mbcentury.co.nz/

McKenzie & Ridley
http://mrk.nz

Mercer Stainless
http://www.mercerstainless.com/home.html

Mount Engineering
http://www.mounteng.co.nz

Napier Engineering
https://www.napierengineering.co.nz

NDA
https://www.nda.co.nz

Niven Engineering
http://nivenengineering.co.nz

Page McRae Engineering
http://www.page-macrae.co.nz

PFS Engineering
https://www.pfsengineering.co.nz

Rhodes Engineering
http://www.rhodeseng.co.nz

Scotts Engineering
http://www.scottsengineering.co.nz

SPI Industries
http://www.spi.co.nz

Stafford Engineering
http://www.stafford.co.nz

Stainless Design
http://www.stainlessdesign.co.nz

Stainless Engineering
https://stainlesseng.co.nz

Stewart and Cavalier
http://www.stewcav.co.nz

Taymac
http://www.taymacstainless.co.nz

Weldtrade
https://www.weldtrade.co.nz

Application Notes

Successfully applying thermal storage requires meeting some of the following criteria:

- The peak heat requirement is much higher than the average heat requirement
- There is a large enough difference between the on-peak and off-peak energy rates for storage to be economically viable
- Capital costs are able to be reduced by using storage – e.g. by enabling a smaller boiler to be installed
- There are electrical supply capacity constraints - thermal storage system can avoid the cost of new electrical capacity upgrades (e.g. transformers and switchboards)
- Resilient back-up heating systems are required, such as 24-7 facilities where continuity of services is essential, such as hospitals
- There is some other need for additional heat capacity.

Common applications include:

Food Processing

Process heat demands in food, dairy and meat processing plants vary significantly depending upon the type of process, whether batch or continuous processing, and the product characteristics.

For batch processes or changing product or shift patterns, thermal storage can reduce start-up fuel costs, idling fuel use and labour expenses of combustion boilers. Thermal storage systems can respond quickly to load changes, and offer precise temperature control, increasing the efficiency of existing heat systems under real operating conditions.

Thermal storage systems can be designed to meet food processing plant construction standards.

Health Care

Health care facilities have historically been shaped by hospital campus centralised steam systems based on a need for sterilisation steam and historically high heating intensities. As buildings become more efficient and local electrical steam generators take over sterilisation roles, there is scope to rationalise hospital heat services. Thermal storage may enable discrete end-uses of heat to be supplied using electricity and avoid the need for extending existing steam distribution systems or building new boilers. Smaller places such as outpatient facilities can avoid long steam mains and local use heat pumps or electric resistance boilers with thermal storage to avoid peak electricity demand costs. These are compact designs that require little supervision or maintenance.

Heat storage and heat emission for buildings.

The low cost and high effectiveness of thermal mass (e.g. masonry stone) in building structures is an important element to consider when designing smart air conditioning and heating systems.

It has large potential to minimise energy demand in buildings and is central to building low or zero energy or low carbon buildings.

The practice of heating floors in buildings has been around for over 2000 years, and masonry floors offer both heat storage and efficient low temperature radiant heat emission. Few buildings however are specifically designed to utilise the mass of the structure or an active mass storage system to minimise heat energy demand and spread heat and cooling energy demands. A useful design guide is Designing Comfortable Homes[1]. The principles in this guide can be applied to simple commercial buildings despite its focus on masonry homes.

Hydronic underfloor heating with heat pump

High energy efficiency is achieved as both the floor storage system and heat pump system operate under close to ideal operating conditions. The heat pump is delivering heat to a sink at the lowest temperature suitable for heat distribution in the building, and the floor heating system receives water at the right temperature. The floor energy storage is based on the floor's emission rate, typically in the range of 65 to 85 W/m^2 with floor surface temperatures limited to 27°C (or 5°C above room temperature) depending on floor construction and floor finishings. To achieve these conditions, hot water flow temperatures are limited to 30 to 40°C, well within the range of practical heat pumps.

Christchurch Bus Interchange Underfloor Heating

The underfloor heating system in the new Christchurch Bus Interchange Building distributes heat into a space with high foot traffic and constantly opening doors. Multiple manifold locations were required for the long thin heated areas in the waiting area where the buses enter the complex. As well as underfloor manifolds, there are 3000 meters of composite underfloor pipe.

1 http://www.ccanz.org.nz/page/Designing-Comfortable-Homes.aspx.

Designing for electric thermal storage installations

Thermal storage systems are designed to meet the specific characteristics of a process. Careful engineering design is required to effectively capture and store available heat, minimise heat loss, and maximise the amount of heat that can be utilised in each recharge-discharge cycle. A thermal storage system that is too large or too small will be less effective. Efficiency in thermal storage systems requires appropriately designed and selected components. The design must also ensure effective integration of the components and effective control strategies for each component, as well as for the system as a whole.

Heat loss from thermal storage systems needs to be managed carefully. With good insulation and control, 93 to 99% of input energy is available for end-use applications. At least 100mm of foamed in-situ insulation is required for hydronic systems, with careful detailing of all pipe, controls, and structural penetrations through the insulation. Higher temperature-rated and thicker insulation will be required for higher temperatures. With long discharge-recharge cycles and high temperatures, insulation becomes critical to system performance.

Where heaters or thermal storage are fitted in exterior elements of buildings, the R-value of the exterior insulation needs to be 10- times greater than that of the internal heat-emitting surfaces. In all cases, insulation must be carefully designed to minimise the heat losses that can erode the operational efficiency gains of storage systems.

Direct storage of the heating medium (e.g. water in hydronic systems) maximises efficiencies and minimises losses in heat exchangers, where typically, input temperatures need to be 5ºC higher than the outlet.

Basic steps to be followed when designing thermal storage systems are:

Step 1

Accurately establish the end-use heat demand requirements (not just current fuel-input or steam outputs). Establish what temperatures, heat loads and or flow rates are required, when and for how long.

Step 2

Determine the site's current electricity load profile, demand capacity and energy cost tariffs. The same degree of resolution as the electricity tariffs (e.g. ½ hourly) should be used.

Step 3

Identify and evaluate the opportunities to minimise heat system inefficiencies and losses and quantify the economics of alternative heating options:

- Identify building and process-heat losses and insulation solutions before considering new heat supply
- Identify the most appropriate heating medium for the product or process. Are direct electric heating methods (RF, IR) better suited to process requirements?
- Explore whether smaller distributed systems are better than a larger centralised system.
- Explore options to recycle or reclaim heat
- Explore options to change from using steam to other approaches.

Step 4

Explore options to spread heating loads and if storage can also cover heating start-up or other peak demands and so reduce the size and capital cost of the boiler. If a storage system makes economic sense, identify suitable storage options, establish capital, installation and transaction costs.

Step 5

Identify the heat source options and if you should install an electric boiler or heat pump as a standalone heat source, or in parallel with the thermal store to complement or replace existing heat sources. Retaining the existing heat sources may minimise construction demolition costs, and improve system resilience, and allows peak load reductions by operating the non-electric water heater. Conversely, retaining older plant also has higher O&M costs.

Safety

All pressure vessels are subject to the Health and Safety in Employment Act 1992 and the Approved Code of Practice for The Design, Safe operation, Maintenance and Servicing of Boilers. Generally designed to ASME codes. All pressure vessels must have correctly designed seismic restraints (these are part of the pressure vessel design itself) and be fixed to an appropriately designed seismic foundation.

http://www.worksafe.govt.nz/worksafe/information-guidance/all-guidance-items/acop-boilers/boiler-code.pdf

Electric storage systems may have special requirements for earthing and bonding

Where a water boiler is not piped to a water supply or in contact with any earthed metal, it is said to be 'insulated' and different requirements apply. Electrical design engineers should ensure these requirements are met.

Case studies

Case Study: Zealandia, Belfast

Zealandia uses biomass boilers in Auckland and Christchurch for heating glasshouses. The boilers sit beside 1 million litre, 10 metre tall hot-water storage tanks which operate so the water at the top may be close to boiling, while water near the bottom may just be warm. This enables efficient management of the heating requirements inside a glasshouse.

Case Study: Thermal storage enables switch to biofuel at Donovan School

Thermal storage enabled meant an existing boiler could be used for a new boiler to reduce costs. The biggest challenge was the constrained fuel store. Ideally, the bunker would have been enlarged, but there wasn't enough room.

Adding three 1650 litre thermal storage buffer tanks, enabled use of a smaller 220 kW boiler. The tanks fitted through the existing boiler room door to further reduce building costs. The storage tanks allow the boiler to manage peak heat-up on cold mornings (boilers are typically oversized with start-up margins) minimising boiler costs. Heating can continue economically for events such as parent-teacher meetings.

The system is highly automated, with remote management of the heating system via internet. It achieves lower whole of life costs across the fuel, boiler management and operations with the thermal storage system.

https://www.usewoodfuel.org.nz/documents/resource/CaseStudy-Donovan-Primary-WES.pdf

Case Study: Aro Ha Retreat near Glenorchy

Sustainable energy technologies, including PV panels, a micro hydro station to generate power, solar water heating panels and a 120 kW wide-body KOB Pyromat ECO gasification boiler with a thermal storage 'booster tank' provide energy services at Aro Ha. During summer, heat energy requirements can be met by the solar panels. The wood boiler is the principal heat source during winter months. The thermal storage is achieved with two tanks, a 6,000 litre tank, with two 9 kW booster elements and a 2,000 litres with a charging coil. Figure 7 shows the thermal storage booster tank behind the boiler.

Figure 7. Thermal storage booster tank and boiler

Technical Information Document

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