SOLARCOOLING WORKSHOP
2014 Brisbane

AIRAH

Venue host

CSIRO

Adaptive Solar Thermal Systems.

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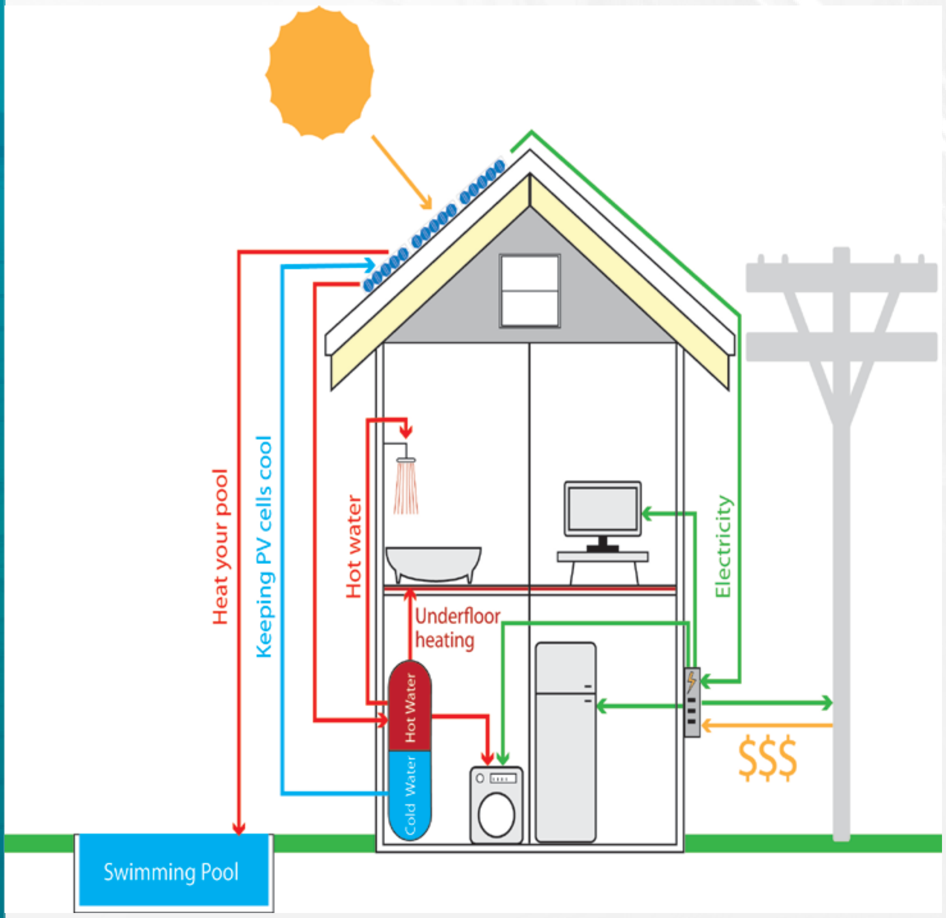
Objective.

- To provide low carbon heating and cooling to a typical occupied space.
- To provide the highest fraction of the heating and cooling load requirement as possible.
- Renewable energy.
- Low impact.
- Repeatability.
- Pathway to cost effective solutions.

Hybrid solar systems.



* Picture courtesy of Sun Drum

- Typical modern space with some of todays requirements.
- Solar thermal systems can operate in conjunction with photovoltaic collectors.
- Solar thermal collector efficiencies are typically more than three times solar photovoltaic collectors.
- Efficient use of precious roof space is an important factor.
- Conversion efficiency rates from electricity to heat is poor, heat pump efficiencies drop sharply with low ambient use.
- A combination provides a more balanced approached.

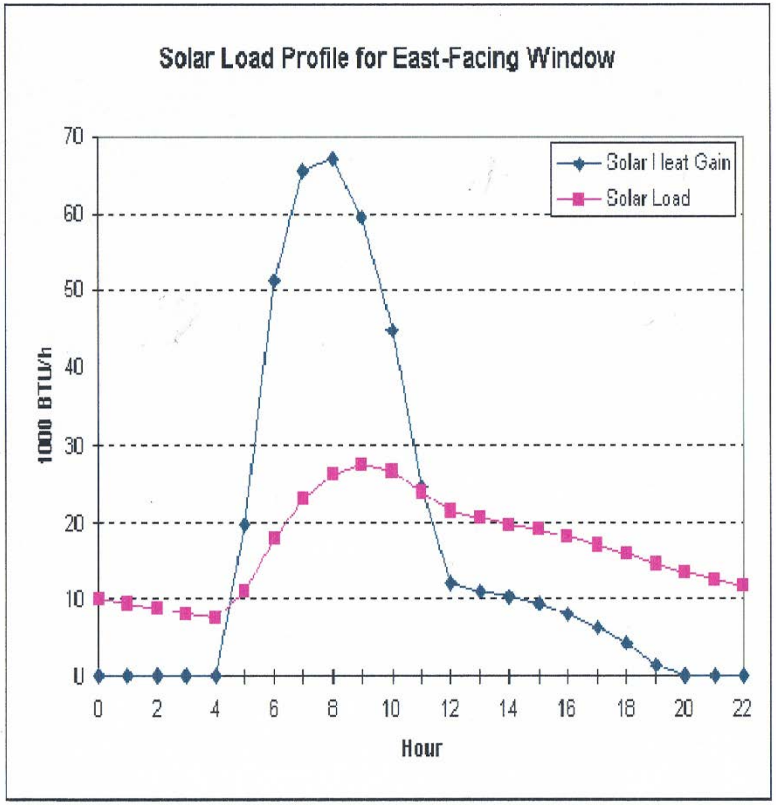
Local site constraints.

- Aspect and area available for equipment.
- Structural limitations of the existing building.
- Local government restrictions, planning and building approval.
- Includes new roof extension.
- Low budget.
- Electricity feed in tariffs are not economically viable.
- Electrical usage tariffs are penalised when solar photovoltaic system are included.
- Therefore the total system must use what it produces and not rely on the electrical power grid.

The building.

- Older style strip shop, converted for use as Air Engineers Pty Ltd office.
- Sun Exposure, north rear wall, east side roof &wall, and west roof area (narrow deep building of 110 M^2 per floor).
- Existing structure was not able to accommodate tracking solar collectors without major structural alterations, it was more cost effective to include more solar collectors.
- Limited roof availability, therefore adapted to variable flow multiple solar thermal and photovoltaic collectors.
- Heavy weight construction, smaller windows, retrofit double glazing, included shading where possible.

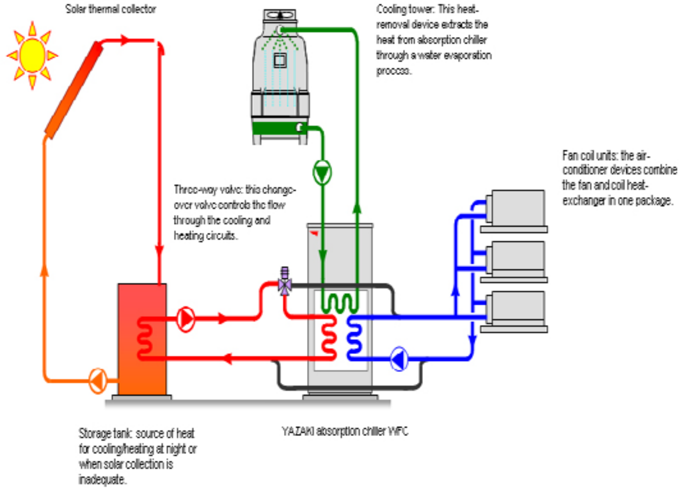
Building heat storage factor.



- The Building's storage capacity has the ability to be defer heating and cooling needs.
- Provide inertia to reduce peak loads.
- Objective is to maintain as close to steady state conditions as possible.
- "U" values included meeting requirements of climate zone 6 within the BCA.
- The system included has a total cooling capacity of 12kw, based on diversity within the zones.
- Detailed assessment was conducted using Carriers HAP energy modelling program and applying various building changes to optimise the outcome.

* Reference graph courtesy of the Carrier Corporation

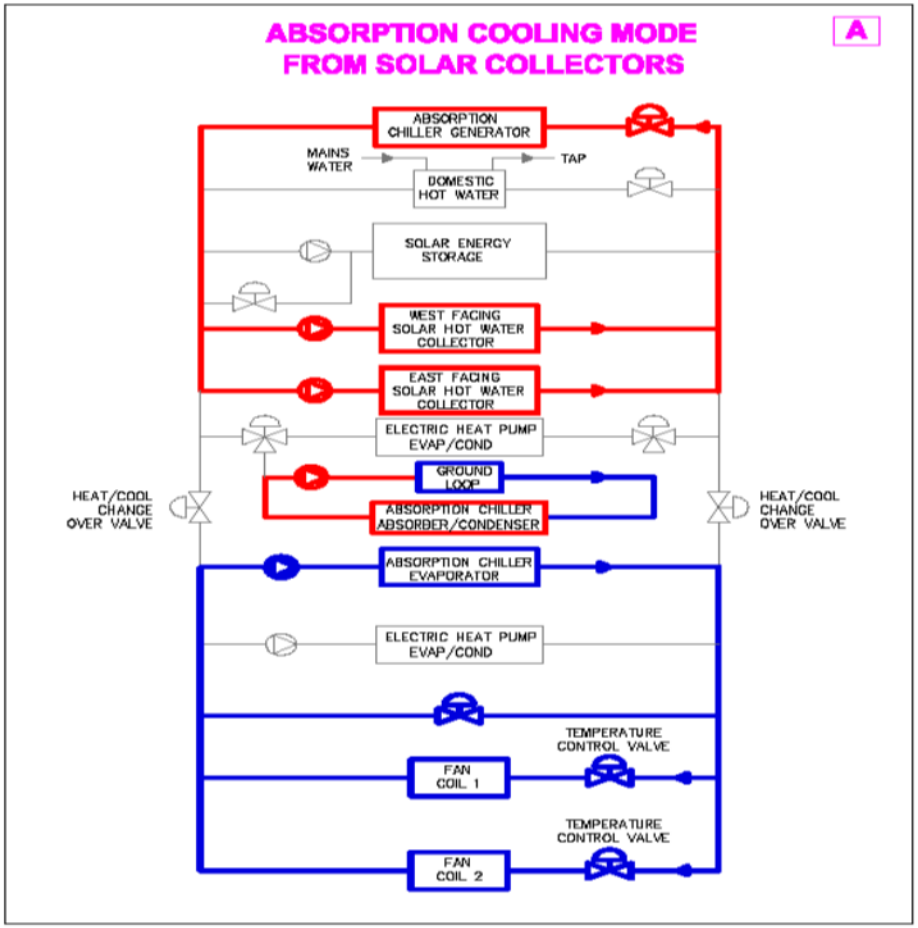
Solar thermal systems.



* Reference picture courtesy of the Yazaki Corporation.

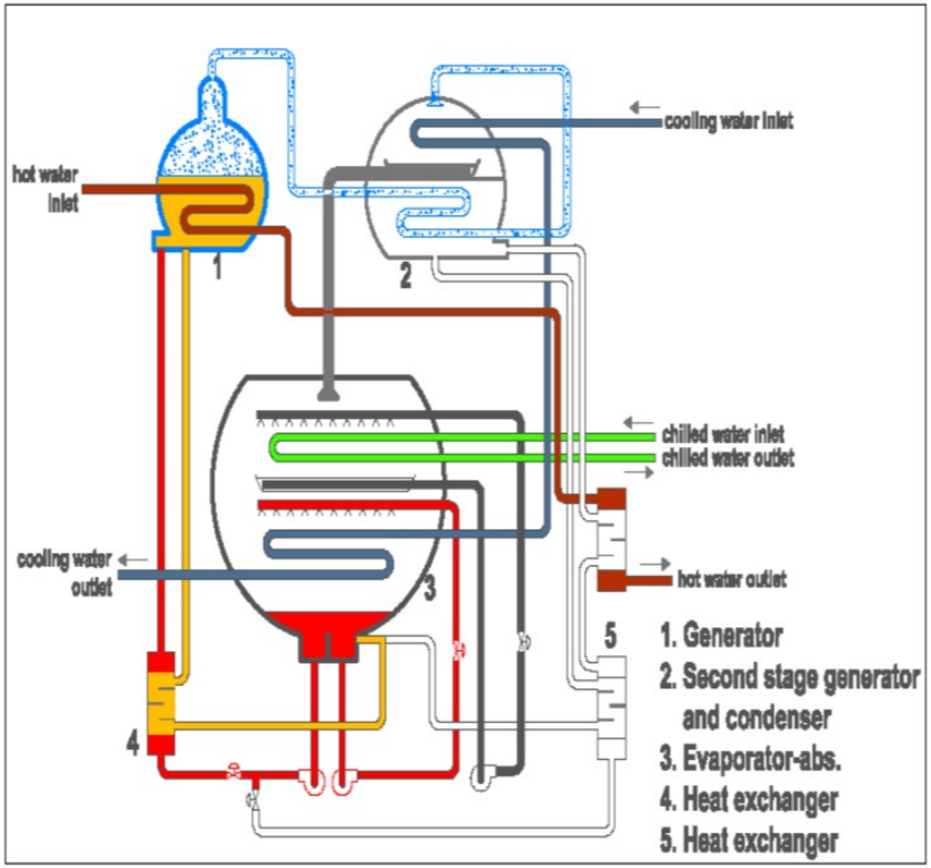
- Typically Solar thermal systems are not cost effective and lack the ability to provide consistent performance required.
- Solar storage provided increases initial start up time due to heat loss at night and storage mass warm up requirements.
- Stored energy is only useful when it can be released at sufficiently high temperatures (cold return water mixing causes lower average temperatures).
- Cooling tower is undesirable due to water consumption, possible health risk, and maintenance requirements.
- Single effect chillers have a large total heat rejection requirement, solar energy input + absorbed space cooling.
- Double and triple effect chillers provide high efficiency at high temperatures limiting their actual available solar operation.

Single effect solar cooling.



- We are designing and constructing our own chiller.
- Optimising heat collected by solar array to capture maximum energy.
- Sun rise start up and sun set shut down to maintain internal space conditions to average load requirements and reduce pull down or warm up needs providing maximum solar operation.
- Variable chilled water circuit incorporating a chilled water by-pass to prevent chiller freezing during minimum flow operation.
- Coldest water enters condenser first during single effect mode, causing a low pressure within generator, therefore lowest possible operating temperature.

Single effect solar cooling.

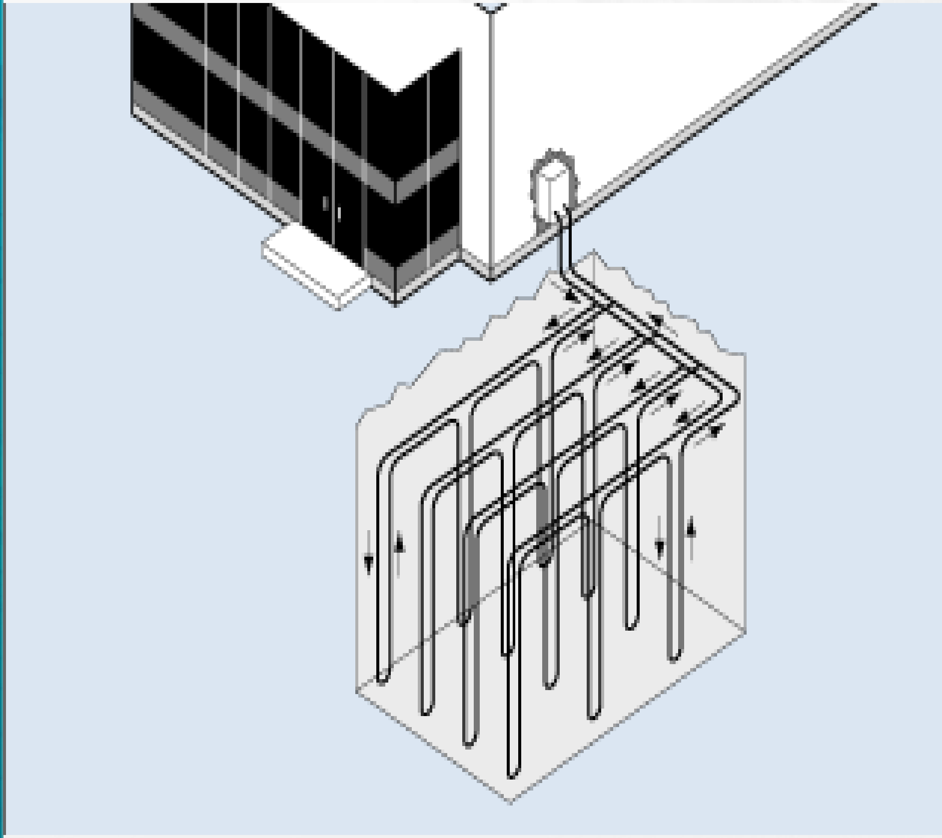


- Single effect operation is achieved by turning off solution flow to the second effect generator.
- Reduced solution concentrations are maintained by the increased solution flow through the first effect temperature generator
- Cooling water lower than 20˚C is available during cooling operation from geothermal heat exchange.
- Cooling water temperatures are precisely controlled providing reliable chiller operation.
- This provides part load cooling operation with solar heat input as low as 60˚C increasing available solar cooling.

The water circuit.

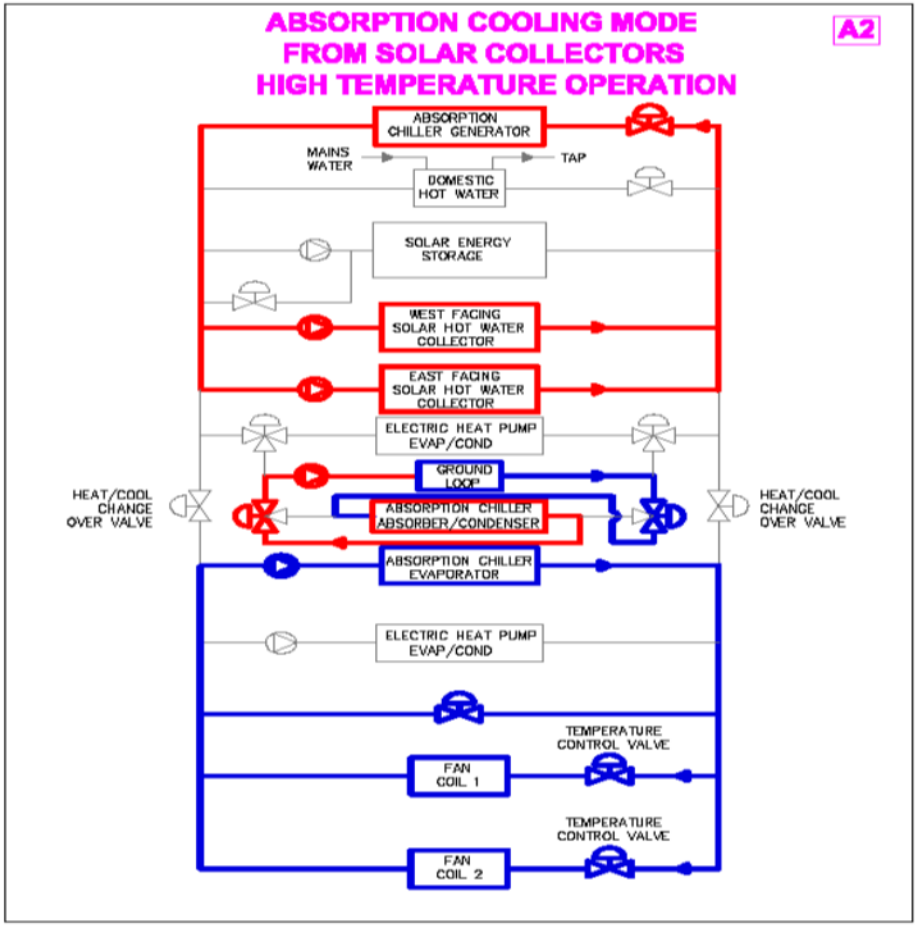
- Careful consideration was required for pump efficiency, water loop volume at each stage, noise and aesthetics.
- Variable flow pumps.
- Separate circuits to improve efficiency by isolating circuit not in use.
- Balance between low velocity piping/ low frictional loses and large system volume causing slow start up characteristics or night time heat loss.
- Building automation system (DDC open protocol, powerful algorithms).

Geothermal heat exchange.



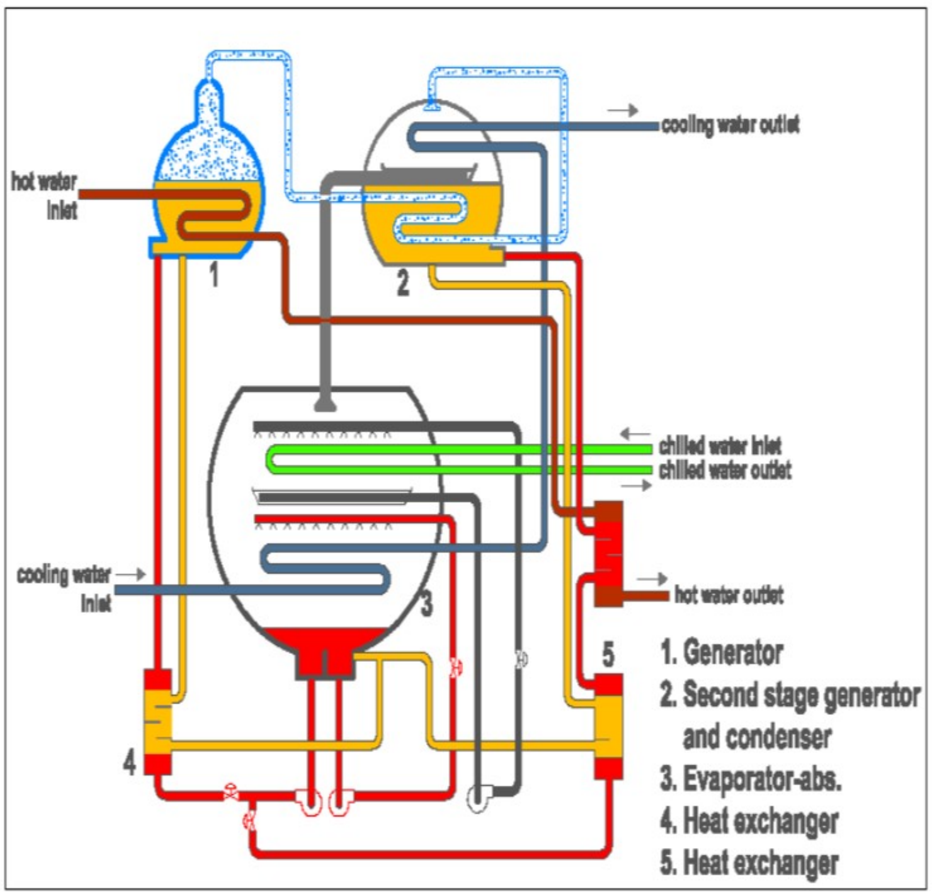
- Provides consistent temperatures
- Provides lower temperatures than a cooling tower during warmer months.
- Provides warmer water during colder months.
- No legionella.
- No air entering system to promote corrosion.
- No scale or fouling of heat exchangers.
- Enables flexible operation reliably.
- Less maintenance.

Double effect operation.



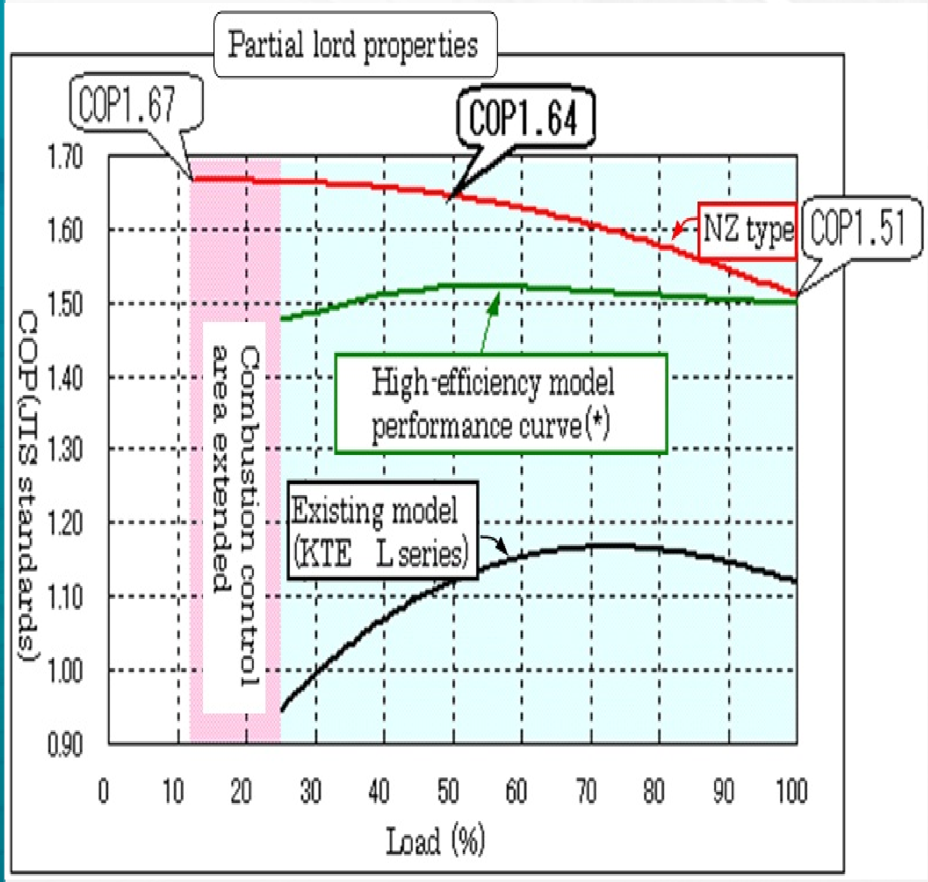
- Double effect operation is possible when there are clear sky's and the system has stabilised.
- Cooling water from the ground loop is reversed for high temperature operation, higher efficiencies with greater operating solution concentrations without crystallisation.
- Heat rejection requirements reduce improving cycle efficiency and initial installation cost.
- Solution flow rates, refrigerant flow rates, cooling water flow rates, solar hot water flow rates and chilled water flow rates all increase as the double effect cycle increases in capacity.

Double effect generator enabled.



- Double effect absorption chillers are typically twice the efficiency of a single effect chiller because the energy provided to separate the refrigerant vapour from the solution in the first effect generator is carried over to the second effect generator via the refrigerant vapour from the first stage where it is used a second time to produce more refrigerant vapour whilst condensing.
- Precise electronic control and powerful processors make reliable efficient operation possible.

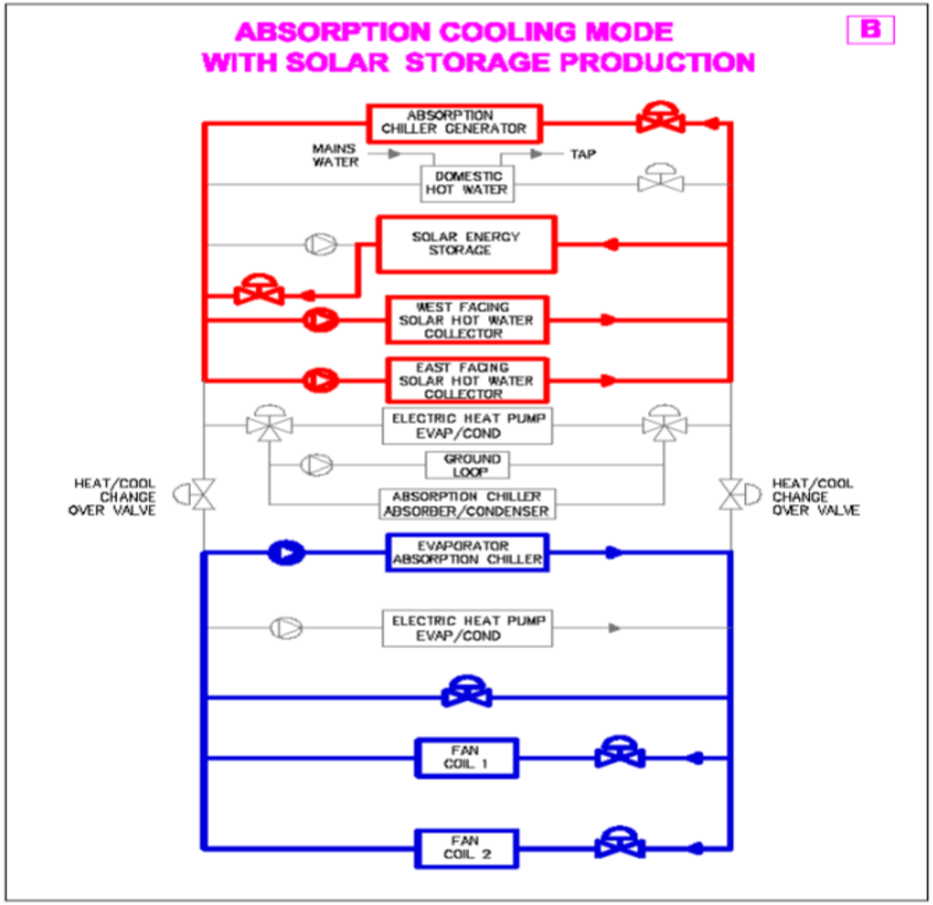
Efficiencies of absorption chillers.



* Reference chart courtesy of Kawasaki Thermal Corporation.

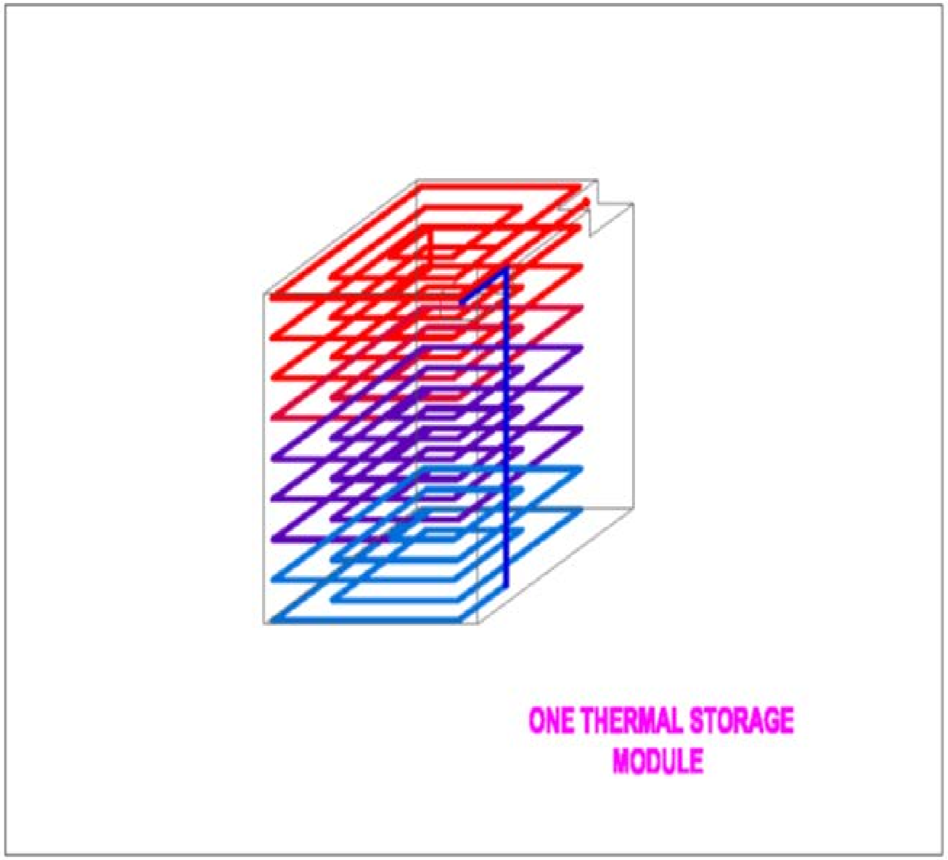
- This chart shows the improvement of COP's of absorption chillers.
- The part load efficiencies are greater with modern chillers due to the ability to regulate solution and refrigerant flow rates accurately.
- This is reducing chiller and cooling water cost by reducing equipment size requirements.
- Salt based absorbents provide highest COP's, low risk, low environmental impact.
- Fully welded and hermetically sealed chillers with palladium cells provide trouble free operation.
- Crystallisation inhibitors have been developed in recent years to further improve operating reliability of salt based absorption chillers.

Solar energy storage.



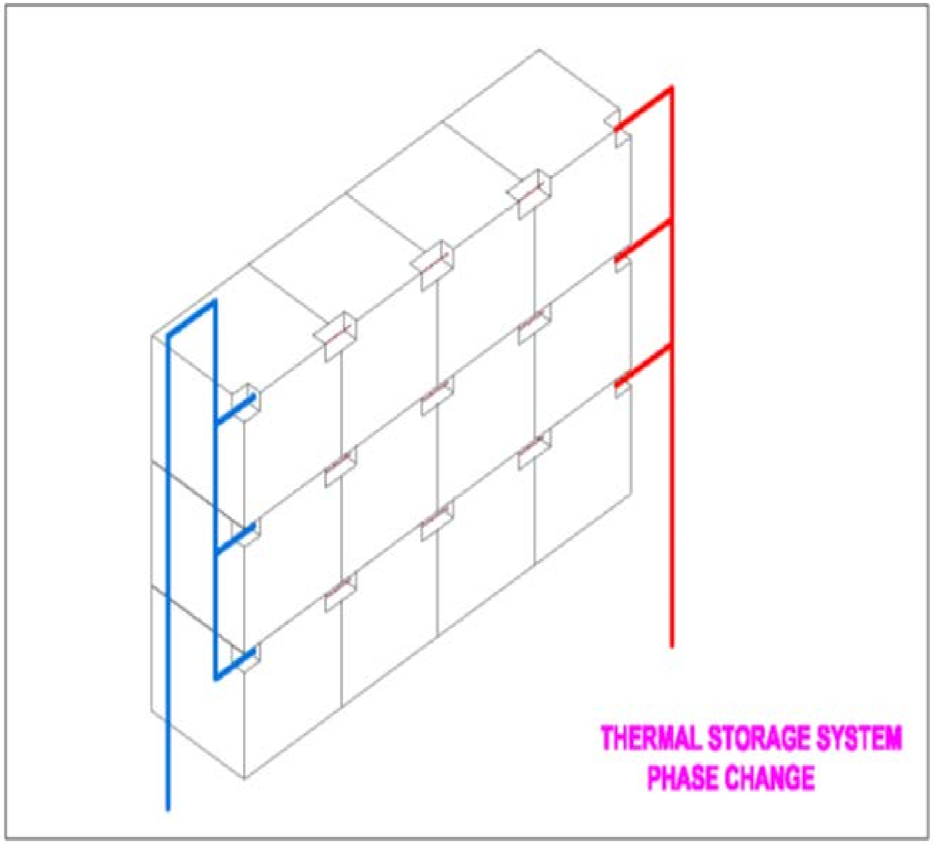
- Large capacity energy storage without large volume was required.
- Phase change was adopted firstly to reduce overall size, and secondly to provide a consistent supply temperatures when used in the storage mode.
- Once the absorption chiller has achieved its required operating temperature the energy storage valve opens by passing the chiller to accommodate the surplus of solar energy available.
- No drain back cycle required within solar collectors to prevent over temperature/ pressurisation, less corrosion within system due to no air entering collectors.

Thermal module.



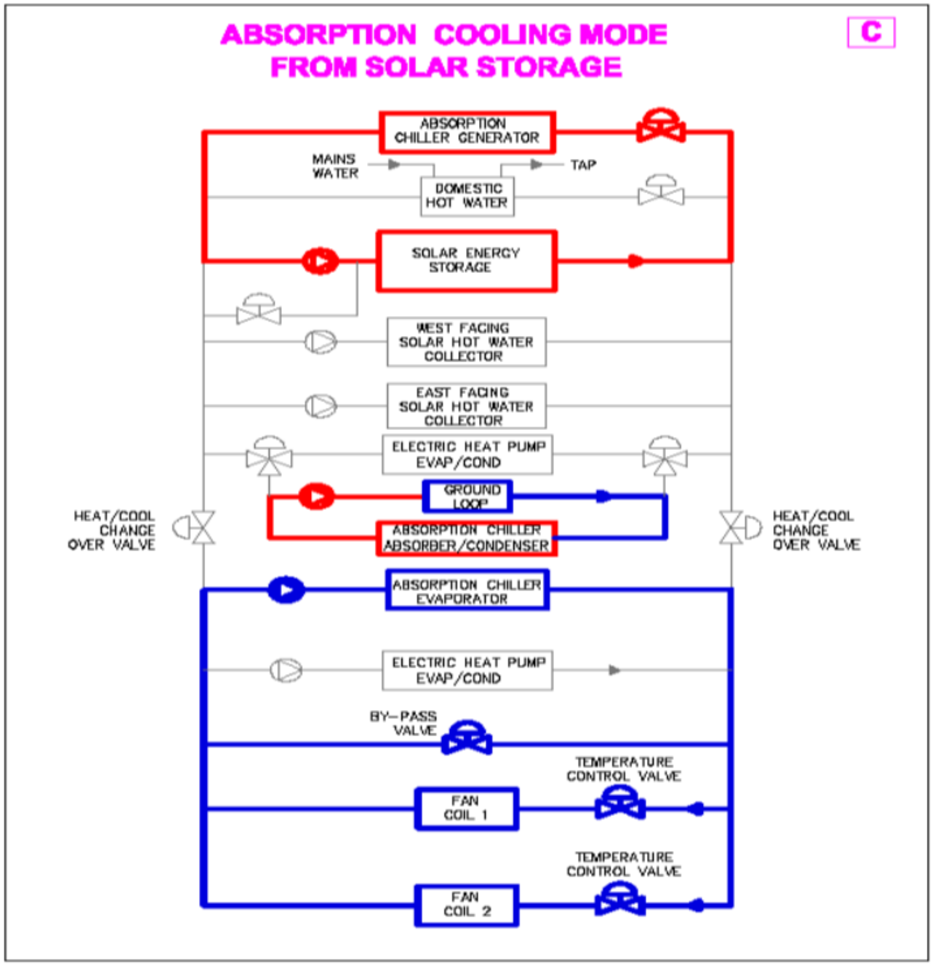
- Low cost modular system.
- Serpentine heat exchanging coil
- Filled with rice bran wax
- Wax melting / solidifying point approximately 86˚C.
- Tube bundle ensures rapid conduction of heat present.
- Optimised to prevent partial solidification or loss of energy.
- Sustainable
- Safe.
- Non toxic.
- Renewable

Thermal storage modules.



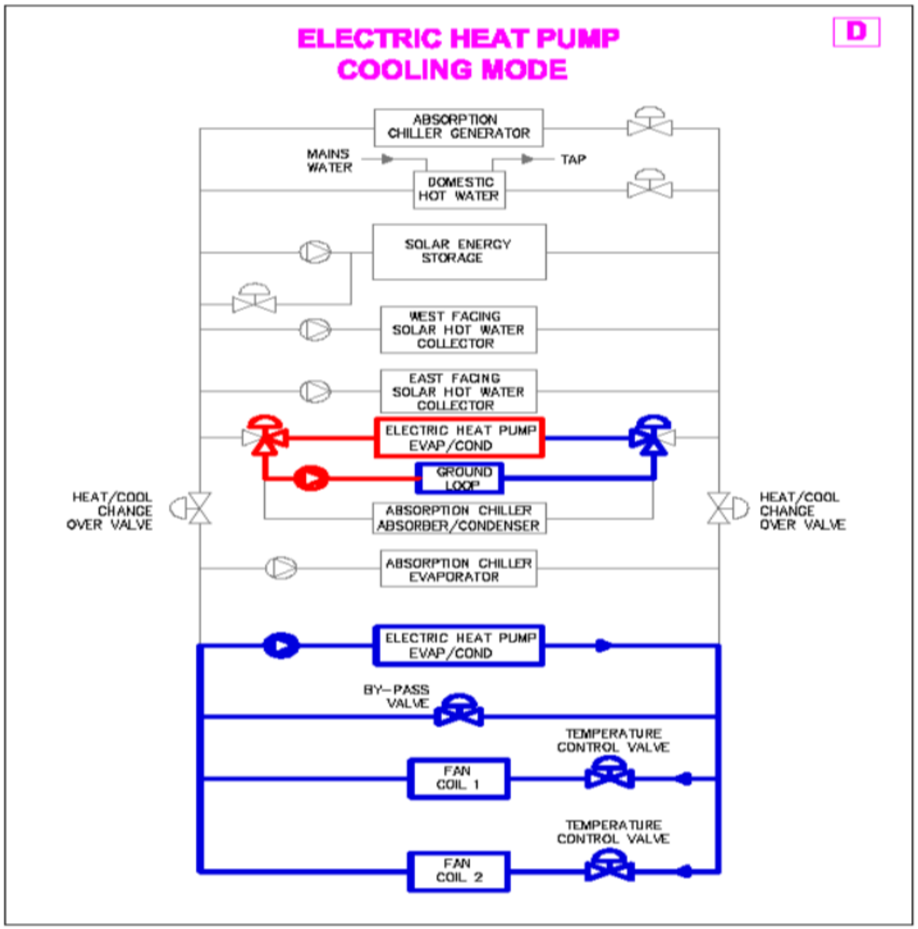
- Reversed return piping to ensure balanced distribution.
- Located within apex of gable roof to reduce heat loss / gain and reduce piping lengths.
- Modular system provides flexibility with installation.
- Various multiple configuration arrangements possible (size and or shape).

Thermal storage operation.



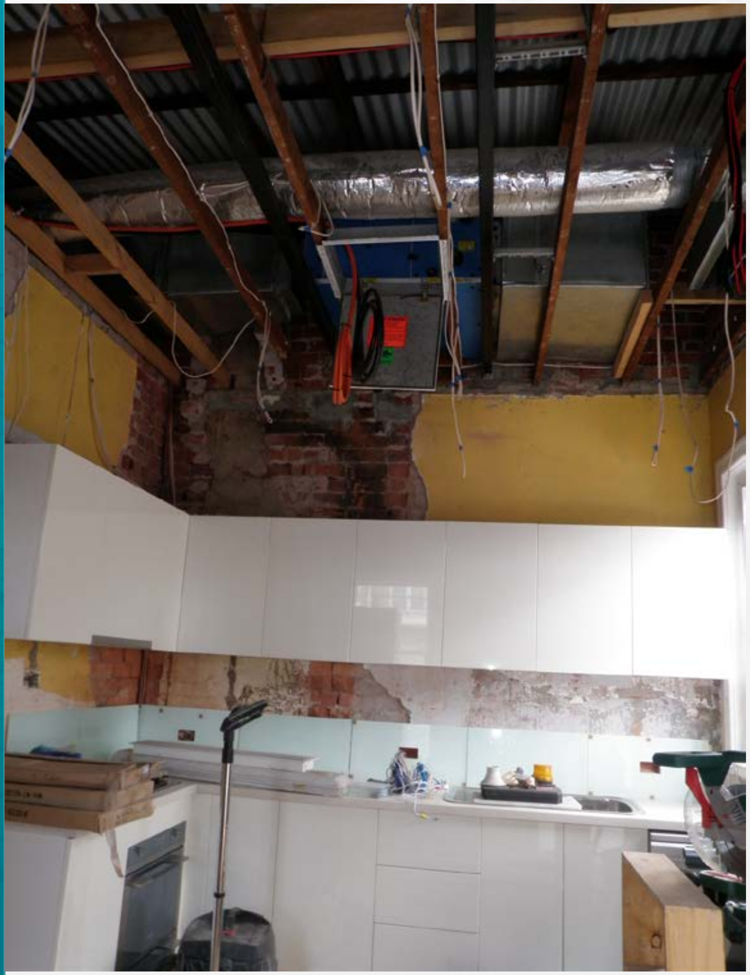
- During solar storage use the dedicated storage pump is activated and pumps water in the opposite direction. This ensures the energy released is at the highest possible supply temperature from the storage system.
- Due to stored latent energy the storage system releases most of the stored energy at a more useful point.

Back up cooling system.



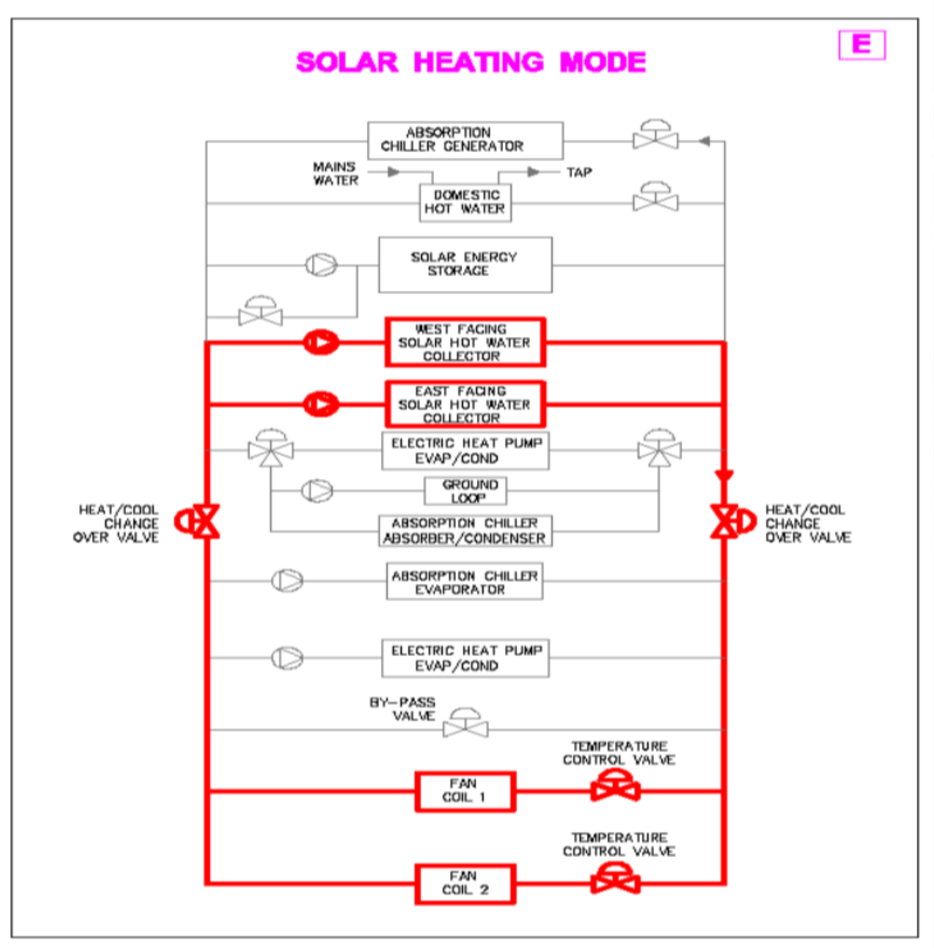
- A water source heat pump has been included to back up the absorption chiller.
- No fossil fuels required.
- Minimal operation required in Melbourne, allowing for cloudy humid days.

Air distribution.



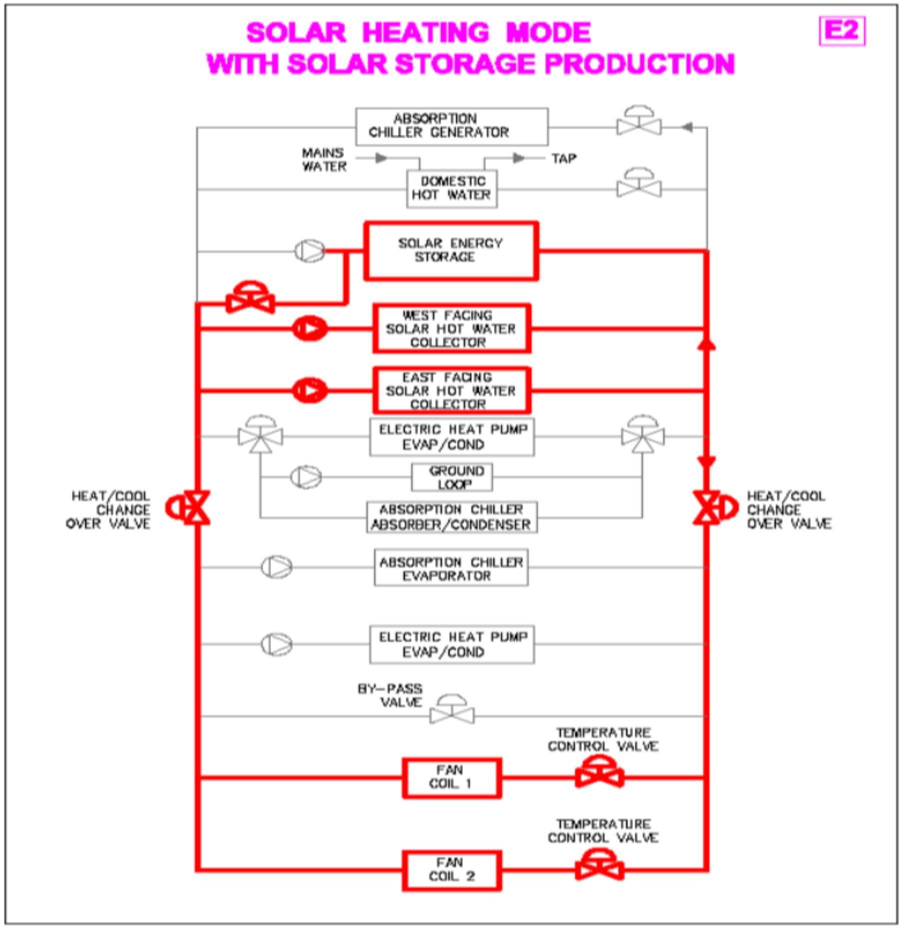
- Open-able windows within the building fabric eliminate the need for introduced outside air to comply with AS1668-2, 2012 ventilation standard. However ventilation outside air is introduced through a supply air to exhaust air heat exchanger into the building and is regulated to maintain building pressurisation to minimise outside infiltration.
- Fans speeds are controlled and regulated according to supply air temperatures and supply water temperatures.
- Low velocity air distribution with minimal air throw requirements to reduce air drafts and fan power consumption.
- The heat exchanging coil within the fan coil unit is sized for the cooling requirement. The larger size coil required for cooling provides greater heating operating range.
- Complex control algorithms included are to ensure stable temperature operation.

Solar heating mode.



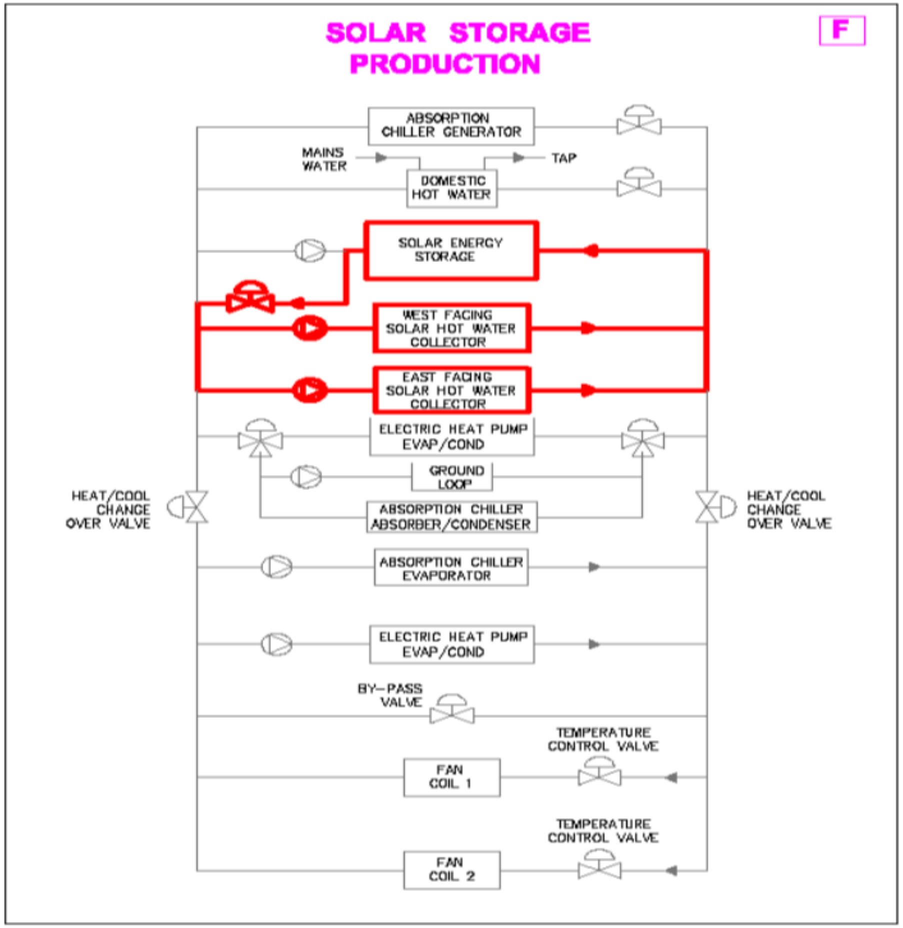
- Heat /cool change over valves open to allow solar hot water to enter directly into the heat exchangers within the fan coil units.
- Other field valves close to prevent heat entering excluded areas.
- Modulated air and water flow rates provide gradual warm up.

Solar heating with storage mode.



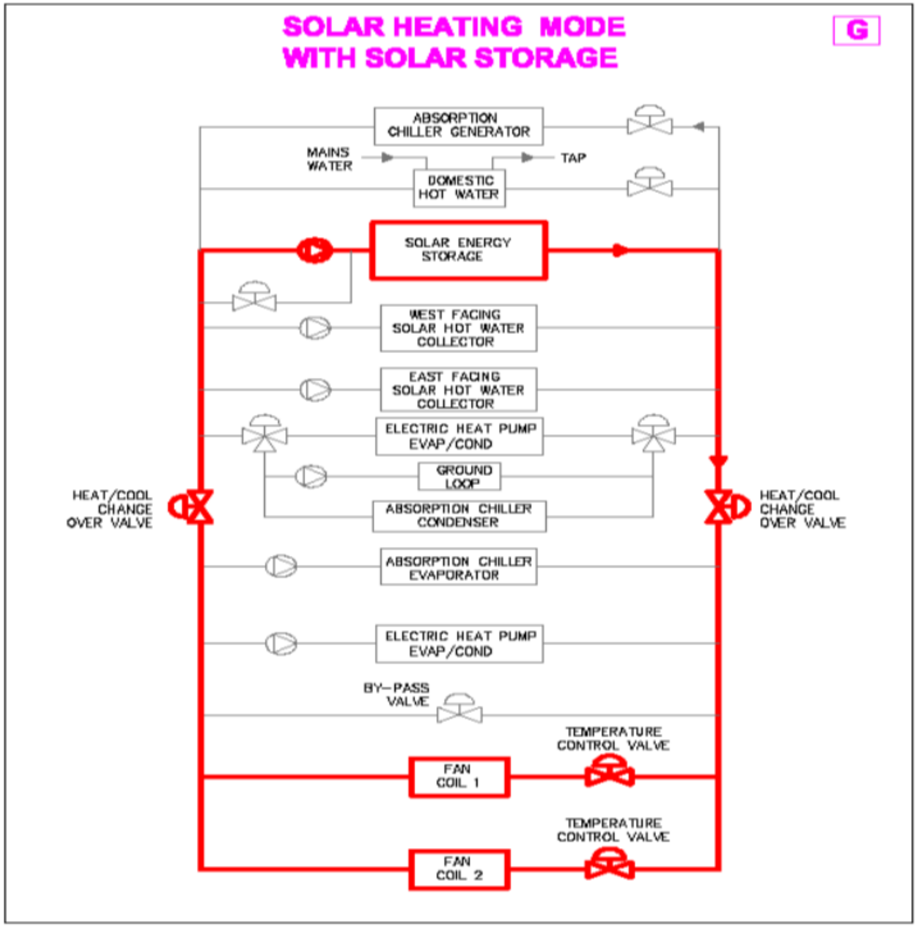
- The solar storage system is included once the zone temperatures are satisfied, it acts as a by-pass to the temperature controlled zones.
- Similar to the cooling storage mode.

Storage only mode.



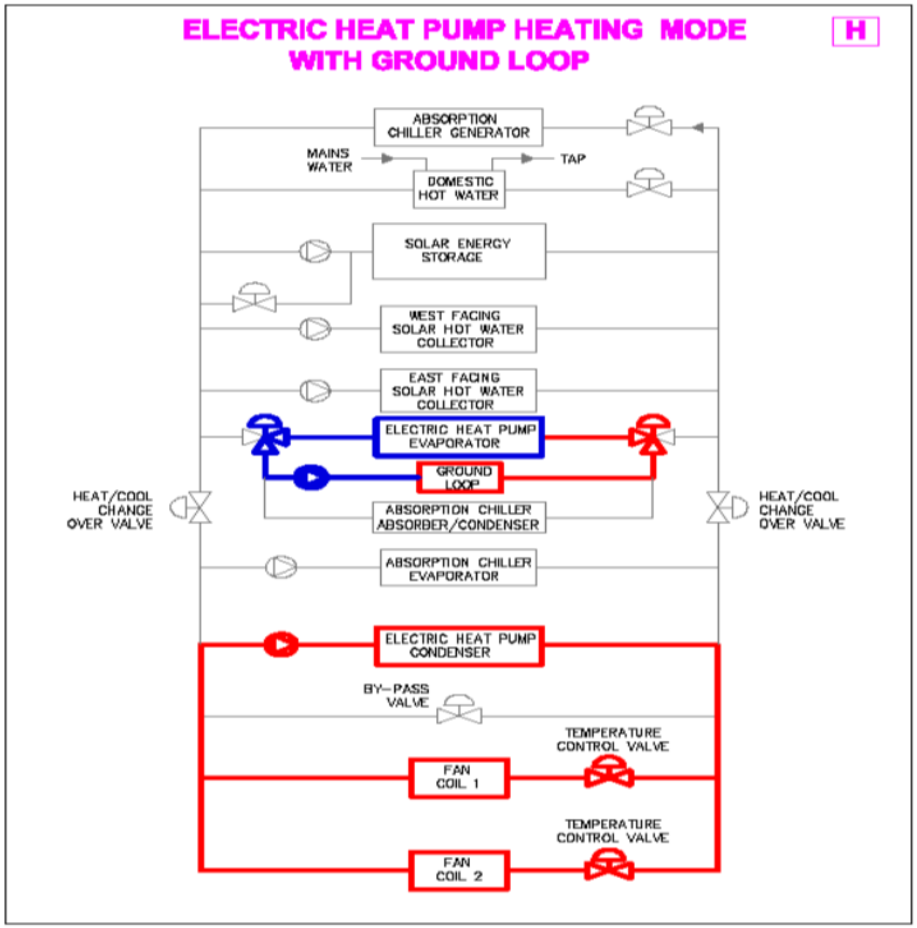
- When the temperatures within the occupied spaces are satisfied the system reverts to storage mode only.

Heating from solar storage.



- Heating from solar storage is again similar to cooling from the storage, except the heat is supplied directly to the heat exchangers within the fan coil units.
- Pressure relief valves, expansion tanks and other included accessories have been excluded from these schematic drawings.

Back up heating.

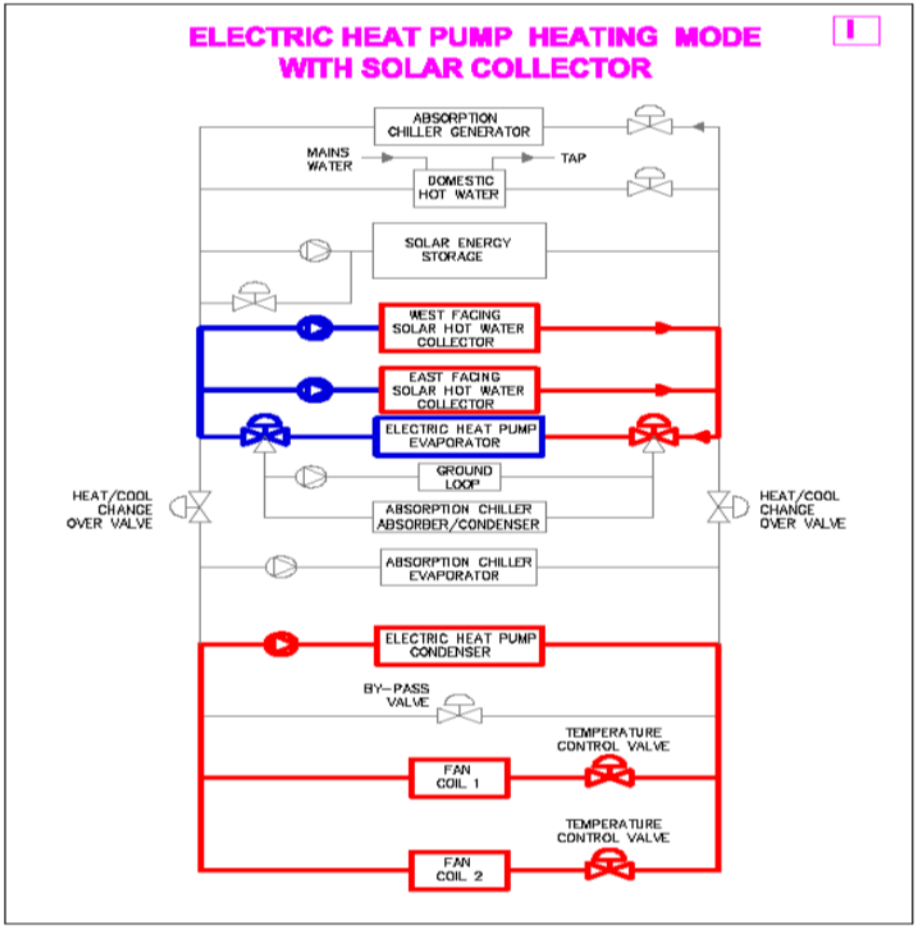


- The back up heating is provided by the same water source heat pump used for the cooling back up, only in reverse.
- Heat is absorbed from the ground loop and pumped into the fan coils.

Water source heat pump.

- Pictures illustrate our water source heat pump photographed during construction.
- The water source heat pump is located under an existing staircase.
- Acoustic and vibration isolation have been included.
- Local Council required that no visible external equipment or piping shall be included.

Solar hybrid heat pump.



- This type of water circuit is flexible enough to include many modes of operation
- Careful operation of the solar collectors and heat pump is required whilst its heat source is solar.
- Inclusion of refrigerant crank case pressure regulator prevents heat pump from pressure or temperature over load.
- Reduced water pumping required.
- Highest COP possible.
- Maximum efficiencies available during very cold sun lit morning warm up, prior to sufficiently hot solar water is present.

Conclusion.

- Expensive and complicated compared with carbon producing system.
- Electric back up could be excluded for some applications.
- Has the potential to harness more energy than most systems.
- Safer than storing hydrogen in built up areas.
- Data logging to record operating parameters to provide more detailed assessment.
- Needs to be an out of the box solution to have a viable future.