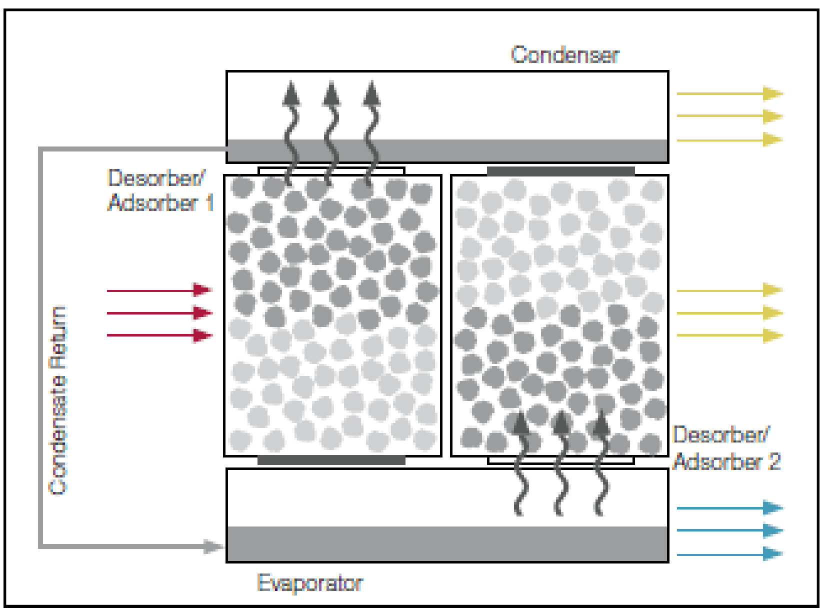
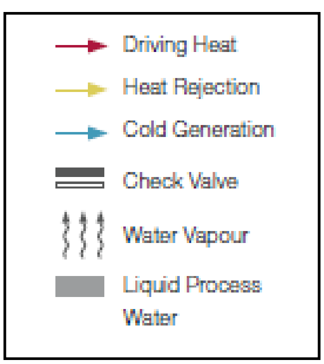
Solar Thermal Cooling

The basic principle behind solar thermal cooling is the thermo-chemical process of sorption: a liquid or gaseous substance is either attached to a solid, porous material (adsorption) or is taken in by a liquid or solid material (absorption). This process relies on the principle that water molecules bind more efficiently to certain sorbent materials than to other water molecules. So, if two separate bowls – one containing water, and the other containing a sorbent - are put into a closed space, the water will evaporate to get to the sorbent which absorbs or adsorbs the water. If the closed space is in a state of vacuum, the water will start boiling in order to produce vapor at the same speed that it is sorbed. Boiling water requires a lot of energy. If the energy is not supplied from outside the system it will be taken from the water itself, which, as a consequence, gets colder. In essence the evaporation process transports heat from the water to the sorbent. The temperature difference increases until the sorbent is no longer able to take more water.

A cooling cycle can be created if the chilled water is used to provide air conditioning and the sorbed water is liberated from the sorbent by boiling it out with the heat from a solar heated fluid. The heat transferred to the sorbent also needs to be removed, typically with a wet or dry cooling tower.





Adsorption Cooling

Commercially available adsorption chillers typically use water as the refrigerant and a desiccant like silica gel or zeolite as the adsorbent. SolarNext AG, a German company, makes an adsorption chiller that illustrates the process. The adsorption chiller consists of four main components: the condenser, the evaporator, and two desorbing/adsorbing chambers.

Desorber/Adsorber 1

The adsorbent (silica gel) is dried out by applying heat from solar heated water. Vapor is generated and flows into the condenser. When the material is sufficiently dried out, the heat input into the adsorbing chamber stops.

Condenser

Water vapor is condensed by rejecting excess heat to a cooling tower. The resulting liquid water flows into the evaporator.

Evaporator

In the low pressure of the evaporator, water is induced to boil by the attraction of the desiccant in the second adsorbing chamber. This cools the water in the evaporator which is used to provide chilled water for air conditioning.

Desorber/Adsorber 2

The water vapor is adsorbed in the second adsorbing chamber. During the adsorption process heat is being produced, which also has to be removed by the cooling tower.

A continuous cooling cycle is created by using two adsorbing/desorbing chambers so that while one chamber is adsorbing water vapor the other one is desorbing water vapor. Valves on the chambers are then reversed, and the chambers work in the opposite direction.

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Absorption Cooling

Commercial absorption chillers have been used for a long time, typically as part of a district heating and cooling plant or on refrigeration trucks and RV's. Some systems use water as a refrigerant and a hygroscopic salt as the absorbent while other systems use ammonia as the refrigerant and water as the absorbent.

Yazaki Energy Systems, Inc. makes a water fired chiller that illustrates the absorption cycle. It is energized by a heat medium (hot water) at 158°F to 203°F and the condenser is water cooled through a cooling tower. The Yazaki absorption chiller uses a solution of lithium bromide and water, under a vacuum, as the working fluid. Water is the refrigerant and lithium bromide, a nontoxic salt, is the absorbent.

Generator

When the heat medium inlet temperature exceeds 158°F, the solution pump forces dilute lithium bromide solution into the generator. The solution boils vigorously under a vacuum. After separation, refrigerant vapor flows to the condenser and concentrated solution is pre-cooled in the heat exchanger before flowing to the absorber.

Condenser

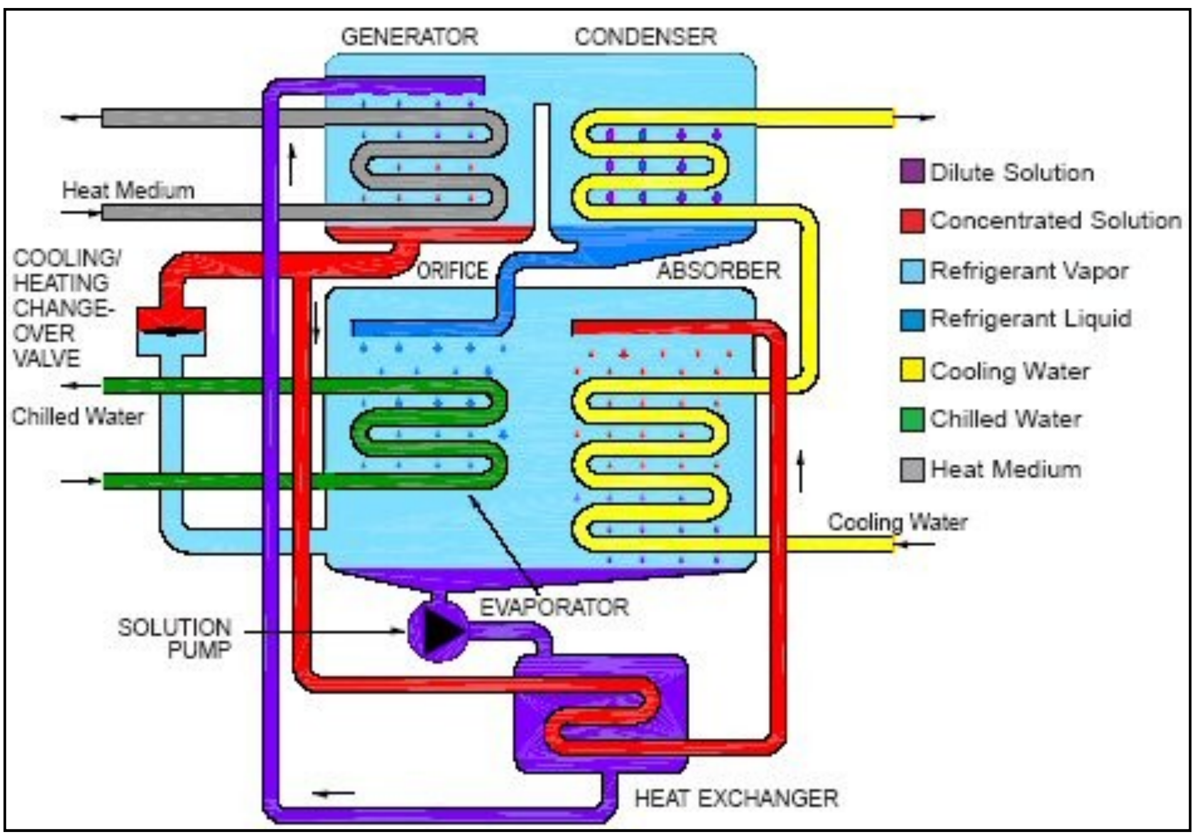
In the condenser, refrigerant vapor is condensed on the surface of the cooling coil and latent heat, removed by the cooling water, is rejected to a cooling tower. Refrigerant liquid accumulates in the condenser and then passes through an orifice into the evaporator.

Evaporator

In the evaporator, the refrigerant liquid is exposed to a substantially deeper vacuum than in the condenser due to the influence of the absorber. As refrigerant liquid flows over the surface of the evaporator coil it boils and removes heat from the chilled water circuit. The chilled water for air conditioning is cooled to 44.6°F and the refrigerant vapor is attracted to the absorber.

Absorber

A deep vacuum in the absorber is maintained by the affinity of the concentrated solution from the generator with the refrigerant vapor formed in the evaporator. The refrigerant vapor is absorbed by the concentrated lithium bromide solution flowing across the surface of the absorber coil. Heat is removed by the cooling water and rejected to a cooling tower. The resulting dilute solution is preheated in a heat exchanger before returning to the generator where the cycle is repeated.



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