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# sand-battery-thermal-storage-device-up-to-1000-c-for-waste-heat-to-energy-by-

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## Sand Battery Thermal Storage Device up to 1000 C for Waste Heat to Energy

This webpage QR code

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Sand battery features include no oxidation and fantastic heat retention as compared to water

## PDF Version of the webpage (first pages)

https://infinityturbine.com/sand-battery-thermal-storage-device-up-to-1000-c-for-waste-heat-to-energy-by-infinity-turbine.html

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# Sand Battery Basics

A sand battery is simply a thermal storage device that accepts and rejects heat. While its current use is primarily heating, it can also be used for cooling. Silicon dioxide (sand) is thermally stable up to around 1000 C, and has a high heat capacity.

The goal is a cost effective method of storing energy. With properly insulated storage containment, thermal energy can be stored for months.

The basic setup is a insulated container of sand, with a arrangement of conduit (pipes) embedded in the sand. That simple. The commercial prototype in Finland projects a investment cost of less than 10 Euros per kWh of storage capacity.

The concept of a sand battery is similar to using geothermal cooling (putting fluid conduit, including liquid or gas in the ground) but in this case, it's using sand instead of Earth.

Other forms of using Earth materials for thermal storage:

Ocean Thermal Energy Conversion (OTEC) has been used commercially for air conditioning (commonly referred to as Sea Water Air Conditioning or SWAC). It is used at The Brando Resort in Tahiti where the temperature of sea water is 4 -5 C at 960 meters down. In Switzerland Lac Leman (Geneva) and Lake Walensee (Densitas AG) are utilizing 6 C deep lake cooling.

A commerical ice storage method called CalMac has been used for decades which uses off peak evening power to make ice, which is stored in huge insulated tanks, for later use as air conditioning.

## Payback

The decision for most home owners boils down to payback (investment cost versus cost savings). A financial decision along with less grid (utility) reliance may provide the best reason for consideration. Current huge gas and electrical cost increases in the UK are driving alternative considerations.

IT10 Revenue based on gross sales or grid savings, not including cost of acquiring waste heat flow or pumps.

Revenue from IT10 (24 hours x 365 days per year x 10 kWh = 87,600 kWh per year):
at $.20 per kWh = $17,520 USD per year
at $.40 per kWh = $35,040 USD per year
at $.80 per kWh = $70,080 USD per year

IT50 Revenue based on gross sales or savings, not including cost of acquiring waste heat flow or pumps.

Revenue from IT50 (24 hours x 365 days per year x 50 kWh = 438,000 kWh per year):
at $.20 per kWh = $87,600 USD per year
at $.50 per kWh = $219,000 USD per year
at $1.00 per kWh = $438,000 USD per year

IT250 Revenue based on gross sales or savings, not including cost of acquiring waste heat flow or pumps.

Revenue from IT250 (24 hours x 365 days per year x 250 kWh = 2,190,000 kWh per year):
at $.20 per kWh = $438,000 USD per year
at $.40 per kWh = $876,000 USD per year
at $.80 per kWh = $1,752,000 USD per year

IT1000 (1 MW) Revenue based on gross sales or savings, not including cost of acquiring waste heat flow or pumps.

Revenue from IT250 (24 hours x 365 days per year x 1000 kWh = 8,760,000 kWh per year):
at $.20 per kWh = $1,752,000 USD per year
at $.40 per kWh = $3,504,000 USD per year
at $.80 per kWh = $7,008,000 USD per year

## How to charge a sand battery

The sand battery can be thermally charged by many different methods, including some of the most popular:
-electricity to heating element
-induction heating by magnets
-liquid thermal from solar, wood heat, electric heating element, or heat pump

A sand battery is simply a thermal storage device that accepts and rejects heat. While its current use is primarily heating, it can also be used for cooling.

## Compared to a Lithium Ion Battery Bank

To realize the advantages of a thermal sand battery, we can compare it to a LiOn battery back. While a electrochemical battery back has a small footprint, and multi-use, it has a huge financial investment cost and limited life.

The question of affordability may come down to payback. That is, investment versus cost savings.

The quick payback on a sand battery (for home heating applications) is a significant factor.

## Wood Fired Sand Battery

For those who have water boilers that are wood fired, an interesting alternative would be a sand filled vessel, using a wood burner. A hot water or air coil can be used to extract the thermal energy for use.

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## Best Thermal Storage Media

Sand is one of the best media for storing heat.

Sand has a low heat transfer coefficient of 0.06 watts per square meter degree Celsius. This means it can retain heat for very long periods of time and explains why the sand on the beach of a hot country remains warm hours after sunset. A 1-kilogram container of sand will cool from 104 degrees F to 68 degrees F in 5 hours, 30 minutes.

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# How to Calculate Heat Release

To calculate the amount of heat released in a chemical reaction, use the equation $Q = mc\ \Delta T$, where Q is the heat energy transferred (in joules), m is the mass of the liquid being heated (in kilograms), c is the specific heat capacity of the liquid (joule per kilogram degrees Celsius), and $\Delta T$ is the change in temperature of the liquid (degrees Celsius).

Temperature is a measure of how hot something is, measured in degrees Celsius or degrees Fahrenheit, while heat is a measure of the thermal energy contained in an object measured in joules.

Thermal energy can be stored as sensible heat in a material by raising its temperature.

The heat or energy storage can be calculated as

$q = V\ \rho\ cp\ dt$

$\quad = m\ cp\ dt$

Note: 1 kJ/(kg K) = 0.2389 Btu/(lbm degree F)

where

q = sensible heat stored in the material (J, Btu)

V = volume of substance (m3, ft3)

ρ = density of substance (kg/m3, lb/ft3)

m = mass of substance (kg, lb)

cp = specific heat of substance (J/kg C, Btu/lb F)

dt = temperature change ( C, F)

Specific heat is how much heat energy is needed raise the temperature of a substance. Water has a very high specific heat. That means it needs to absorb a lot of energy before its temperature changes. Sand and asphalt, on the other hand, have lower specific heats.

Specific heat of the sand, quartz, is 830 J/Kg. degree C
Thermal conductivity of water is 0.25 W/(m·K).

Specific heat capacity of water is 4182 J/kg degree C
Thermal conductivity of water is 0.598 W/(m·K).

Specific heat capacity of $CO_2$ is 840 J/g K
Thermal conductivity of Carbon Dioxide is 0.0166 W/(m·K).

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## Advantages of Sand

Sand is cheap, widely available, and easy to store. It can also be heated to higher temperatures than other battery mediums, such as water — with the right insulation, it could go higher than 980 degrees Celsius (1,800 degrees Fahrenheit).

Sand batteries could be built essentially anywhere and they can even be constructed underground to save land.

When used in a thermal application (stored as heat and used as heat) the process is 99 percent efficient.

Low investment cost estimated at less than 10 Euros per kWh.

Since there are no hazardous materials (just sand), it has health and safety advantages.

Has no emissions, minimal operating costs (pumping), no consumables, and fully automated.

# What About Water

Water is another fantastic storage medium, but has some limitations.

The first is the limitation of temperature, since water boils at 100 C.

While this makes it perfect for home consumer use (hot water space heating and domestic hot water), it becomes problematic for commercial energy storage for utility energy storage.

While water is available, most commercially available water has chemicals in it to make it potable (i.e. chorine or flouride).

Water can develop algae and other growth, which can foul pipes and valves.

Water oxidizes and depending on pH and types of metal valves or piping, can oxidize pipe fittings through electrolysis.

There is a maintenance factor involved with using water as a storage thermal method.

Pressure gaskets and waterproofing insure that the water is contained and don't leak.

## Compared to a Traditional Solar Thermal Storage Hot Water System

A thermal sand battery is lower in cost than a solar thermal system which is commercially purchased (since most of the cost is profit in the system). If you build your own solar thermal hot water system, the costs may be comparable. This is what we will address in a thermal cost savings application available soon from Infinity Turbine.

Average price of a commercially available thermal collector is around $2,000 to $4,000.

Add to that a solar water heater tank for storage, which will be another $1,500 to $2,900.

Add to that, piping, pumps, installation and other items, which will total more than $1,000.

To assess a payback, compare your existing hot water costs using gas or electricity, to solar. If the payback is beyond 10 years, it may not be worth installing a solar thermal system.

As is the case of huge gas and eletricity swings (like in the UK in 2022), off grid solar alternatives may become an attractive option, if not a necessity. Installing a solar thermal system allows you to avoid utility rate hikes and uncertainty.

## Seasonal thermal energy storage with heat pumps and low temperatures in building projects

Heat pumps are an energy saving and energy efficient technol- ogy for supplying both heating and cooling demand [48,49]. Heat pumps usually deliver more useful energy than the required energy to operate them [50]. In heating mode the heat source of the heat pump normally uses renewable energy stored in ground, groundwater, ambient air, or exhaust air. In heat pumps this low grade energy is converted to high grade by putting in the required amount of work, e.g. by electrical energy. In cooling mode this cycle is reversed and the indoor air acts as an evaporator for the heat pump.

The efficiency of a heat pump in heating mode is determined by the coefficient of performance (COP). The COP of a heat pump indicates the ratio of produced energy to used energy. Presently the average COP of an efficient heat pump can be up to 4.

## Solar Thermal to Sand Battery

Evacuated solar tubes (Sunda Solar, Beijing, China, part Sunda with two collector arrays are placed in series at a tilt angle of 75 degrees on the southern wall. with two collector arrays are placed in series at a tilt angle of 75 on the southern wall. The test data from Solartechnik shows a rated efficiency curve based on a flowrate of 300 L/h and The test data from Solartechnik shows a rated efficiency curve based on a flowrate of 300 L/h and solar irradiance of solar irradiance of 800 W/m2.

Solar collectors heat a water-glycol solution that, during normal operation, passes through a heat exchanger to a domestic hot water tank. When the domestic hot water tank is not calling for heat, the excess heat is sent to the sand-bed under the garage floor for heating.

Conclusion: The measured garage and sand-bed temperatures suggest that such types of solar thermal storage systems are viable options for climates in regions with long periods of freezing temperatures.