TUTCO HEATING SOLUTIONS GROUP

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Electrifcation and Decarbonization

Thermal Energy Storage

A Review and Exploration of Existing Literature and Systems

by Logan Hedrick

Across the globe, there has been a major push for green/renewable energy. This is especially true in the United States. Electrification, decarbonization, and renewable energy have been the focus of many different states, and various large companies as well. One of the pushes within renewable energy has been how to solve the problem of storing energy for output during high demand, and off-peak generation hours. The two best sources of renewable energy (wind and solar), both have this problem. Neither source of energy is capable of max output, 24 hours a day. Sensible heat, latent heat, thermochemical heat, and district heat schemes are all different approaches to solve this problem, to varying degrees of success and efficiency. An example of a sensible heat system is calculated below, as well as some different ways to optimize the system. The system examined below was found to have a round trip efficiency of nearly 40%. Various companies that manufacture these systems are working to create real world affordable systems that can be applied in many different sectors of the energy consuming and generating market.

One of the biggest problems currently facing the solar energy and green energy initiative, is how to solve the problem of inconsistent power generation via renewable energy [2]. As global and national decarbonization efforts continue to ramp up in the coming 10-20 years, the need for consistent renewable power generation will continue to increase. Unfortunately, there is no effective way to harness the power of the sun, during nighttime and cloudy days. Wind energy also has the inconvenience of not being able to generate electricity when there is no wind. Natural gas and coal were both very effective sources of power in the twentieth and early twenty first century, but the need to reduce carbon/CO2 emissions has driven these technologies to be phased out across the globe. This has not fully taken effect yet though. The United States, and the EU, are currently leading the charge with phasing out the burning of fossil fuels, but it has taken time, and will continue to take years to be phased out, due to the lack of a suitable alternative.

So how does society move forward and be prepared to effectively handle the phasing out of burning of fossil fuels for power generation? Numerous different ways of solving this problem have already been tried, are currently being evaluated, or have been hypothesized. Unfortunately, nearly all these methods and alternative ways to solve this problem involve some number of drawbacks. However, one very promising method of allowing renewable energy to be a consistent reliable source of power, is the use of thermal energy storage (TES).

Thermal energy storage can be used in a variety of ways. It can be used to store electrical energy in both short term and long term, it can be used to store heat or cooling for use in industrial processes, it can also be used in district heating schemes. There are many uses and applications for this technology, but the premise of the technology, is to store excess energy in the form of thermal energy and output the energy it has stored back into whatever process requires it. This can be used on many different scales, from the use of it in concentrated solar plants (CSP), to providing heat to buildings and facilities, to even being used at the residential scale in individual homes. The possibilities are virtually endless with TES. The main drawbacks of it though are its space requirements, and a sometimes-prohibitive cost.

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Energy Storage - continued

The concept of thermal energy storage has been around for many years and has seen effective industry use in various forms over the last 10-20 years. However, it has never been cost effective, or people just had not previously been willing to spend the money necessary to implement it. However, with the new decarbonization/electrification initiatives, and the phasing out of fossil fuels, this method has seen a renewed interest in research, and industry implementation. With all this renewed interest and research that has been performed, TES is becoming more and more viable as a solution to solve some if not most of the problems with current renewable energy sources.

There are three main types of thermal energy storage: sensible heat, latent heat, and thermochemical heat. All three methods of TES have their pros and cons, but all are potentially viable sources of storage, and likely all three will be implemented in the ways and methods that make the most sense given their known limitations and strengths. Sensible heat has the benefit of being the cheapest of the 3 methods, and the oldest and most established method. The downside of this method though is it suffers from low energy volume and density and significant system efficiency problems [2]. Latent heat has a much higher energy storage density, and greater efficiency, but has some major drawbacks, due to the phase change materials' (PCM) highly corrosive nature [2]. Latent heat also requires much more space from a system standpoint than sensible heat. Thermochemical TES (TCES) has both the highest energy storage density, as well being a smaller footprint. TCES does have some major drawback though. TCES can involve toxic chemicals and nasty cleanup operations after the lifespan of the system has been reached. While not as concerning as nuclear fission cleanup, it does suffer from some of the same concerns, and would likely face more political and environmental pressure than the other two methods. An illustration of TES in terms of each type's potential for heat storage capacity, is shown in Figure: 1.

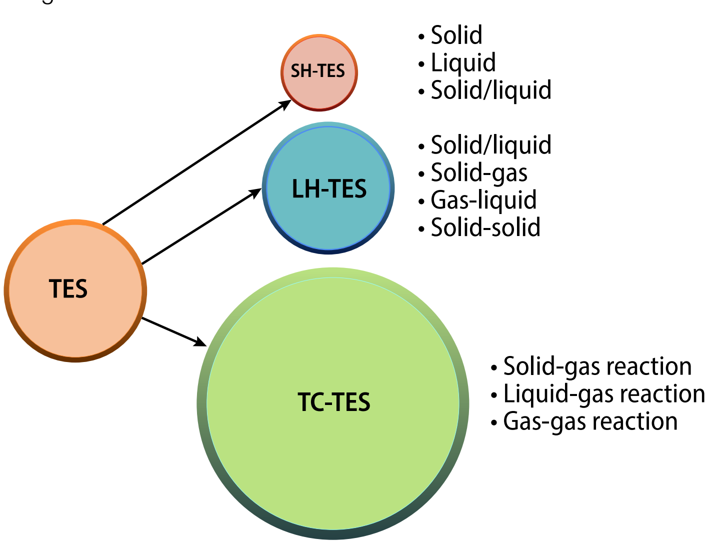

Figure. 1: TES Methods in Terms of Heat Storage Capacity. [2]

TES in the sensible and latent heat versions are typically supplied heat via solar power, wind energy, or waste heat capturing from industrial processes, IE capturing heat from flu gas from the burning of fossil fuels, and other various industrial burning processes. TES can receive heat in a couple different ways. The first way is to pump the heat into the storage system via a heat transfer fluid, this can be liquid or gas form, and transfer the heat to the storage media. Waste heat and solar thermal collectors operate much in this fashion. Heat can also be fed to the TES, via converting electrical energy into heat. This involves the use of a heat pump, or an electrical resistance heater. Heat pumps tend to be more efficient from a thermodynamic standpoint, but resistance heaters, are much more cost effective, and easier to install and replace. Solar panels, and wind energy would both use these two methods of converting electricity into thermal energy.

Sensible Heat

Sensible heat is one of the three main forms of thermal energy storage. This method is the most basic form of thermal energy storage. It utilizes the concept of temperature difference to store energy. The sensible heat method of thermal energy is comprised of a storage media or several, and a heat transfer fluid. The storage media, described further in Materials, can be comprised of many different materials, but concrete and rock are two of the more common materials. The heat transfer fluid can be composed of air, liquids, or gases that allow for high rates of heat transfer. For sensible heat to be effective, there must be a large temperature difference or ΔT, between the storage media and the heat transfer fluid [1].

Sensible heat has a purely linear relationship between the temperature of the storage media, and the amount of power stored. Equation 1 below shows the governing equation for the sensible heat storage method [1]. This equation shows that there are only 4 main variables that effect the sensible heat storage, hence its simplicity [1]. The density ρ and the material specific heat Cp, are both material properties of the storage media [1]. So, changing the storage material can have large effects on the amount of power capable of being stored by the system [1]. V is the volume of the storage system [1]. This can range from large to very small, but the smaller the volume, the lower the amount of power that is capable of being stored [1]. T1 and T2 both refer to the upper and lower temperature bounds of the systems capability [1]. The material min and max temperature ratings, or the system's ability to put temp and high or low temps could each contribute to these temp values on the bounds of the integral.

$$Q_{SHM} = \int_{T_1}^{T_2} \rho C_p v dT$$

Equation 1: Sensible Heat [1]

READ THE COMPLETE STORY

Feature Video

TUTCO Expands with Acquisition of WATTCO

TUTCO, one of the world's largest manufacturers of heating elements, proudly announces the acquisition of WATTCO, a leading electric heating company based in Montreal, Canada. This acquisition strengthens TUTCO's leadership in the global electric heating market, while enhancing its product offerings and furthering its commitment to innovation, quality, and customer satisfaction.

"We produce more than 38,000 heating elements per day across our global manufacturing facilities, which include three U.S. locations, as well as operations in China, Mexico, and Canada," said Dane Owen, TUTCO VP/General Manager. "Our capacity to deliver custom electric heat solutions around the globe sets us apart. Whether it's for industrial processes, manufacturing facilities, or global destinations like Dubai and Mexico, TUTCO's reach, and capability ensure we can meet any heating need."

Beyond our innovative products and expansive manufacturing network, TUTCO's true strength lies in its people. From a highly skilled production team to forward-thinking engineers, the TUTCO workforce drives the company's relentless pursuit of industry leadership. "It's not just our buildings or quality products that make us a global leader; it's our people—the precision, expertise, and passion they bring to work every day," added Angela Bruce – Human Resources.

With the acquisition of WATTCO, TUTCO broadens its technological capabilities while embracing WATTCO's strong leadership and shared commitment to customer service. "WATTCO is the perfect expansion of what makes TUTCO best in class. Their expertise in electric heat, combined with a family culture built on trust, makes them a valuable addition to the TUTCO family," Owen commented.

TUTCO and WATTCO will continue to serve customers around the globe with unmatched expertise, high-quality electric heating products, and a shared dedication to meeting the most demanding needs of the industry.

WATCH THE ACQUISITION VIDEO

Your One-Stop Shop

There is a world-famous fast-food restaurant that isn't part of a major chain, located in downtown Atlanta. It serves up some of the best quick burgers, hot dogs, fries, and onion rings you can find anywhere, and you can customize them any way you want—including adding their world-famous chili. You can also pair your meal with their frosted orange drinks and peach pies to satisfy your sweet tooth. When you approach the counter, the first thing they enthusiastically shout is "What'll ya have, What'll ya have, What'll ya have?" to get your order started.

Here at TUTCO, we share the same philosophy: "What'll you have?" We offer a wide range of commercial and industrial heating options and can also customize our standard offerings to fit your specific application, including special requests. It's not uncommon for us to add brackets, supports, additional controls, controllers, or even full control panels. If you provide us with a concept, we will do our best to find a way to supply it. We're happy to go beyond the basics, just like adding chili and cheese to create chili cheese dogs, chili cheeseburgers, or chili cheese fries.

While we mentioned a few of the common additions we provide, the sky's the limit. Our engineers will work with you to deliver a turnkey package tailored to your needs. Our Value-Added program can save you both time and money.

At TUTCO, we can provide as little or as much as you need. With our commercial and industrial divisions working together, many of your special requests and additions are readily available. No job is too small or too large for us to handle. Simply put, we can offer a package that checks all the boxes to meet your specific requirements. Give us the opportunity to evaluate all your electric heat system needs.

MORE THINKING OUTSIDE THE BOX

Kilowatts, Megawatts, Gigawatts: What Do They Mean?

by Ian Renwick

We've all seen these expressions, but what do they actually mean? The prefixes are simply multipliers of the unit they describe, grouped in increments of 1,000.

For example, one kilowatt equals 1,000 watts. This means you could refer to a 1,000-watt heater as a 1-kilowatt heater. Both are different ways of describing the same thing. Decimals work too. 2,700 watts can be stated as 2.7 kilowatts if you prefer.

Common Prefixes and Their Meanings:

- **kilo** = 1,000 (a thousand times)
- **mega** = 1,000,000 (a million times or a thousand thousand times)
- **giga** = 1,000,000,000 (a billion times or a thousand million times)
- **tera** = 1,000,000,000,000 (a trillion times or a thousand billion times)
- **peta** = 1,000,000,000,000,000 (a quadrillion times or a thousand trillion times)
- **exa** = 1,000,000,000,000,000,000 (a quintillion times or a thousand quadrillion times)
- **zetta** = 1,000,000,000,000,000,000,000 (a sextillion times or a thousand quintillion times)
- **yotta** = 1,000,000,000,000,000,000,000,000 (a septillion times or a thousand sextillion times)
- **ronna** = 1,000,000,000,000,000,000,000,000,000 (an octillion times or a thousand septillion times)
- **quetta** = 1,000,000,000,000,000,000,000,000,000,000 (a nonillion times or a thousand octillion times)

As of now, these are the official prefixes that are recognized. Many proposals have come and gone, including some amusing ones like names that sound similar to the Marx brothers. But as of 2022, this is the list.

Larger Numbers Without Prefixes

Ignoring the prefixes for a moment, what comes next as numbers increase by factors of 1,000? There are names for them too.

Starting with nonillion, the list includes:

• decillion	• sexdecillion
• undecillion	• septendecillion
• duodecillion	• octodecillion
• tredecillion	• novemdecillion, and finally
• quattuordecillion	• vigintillion
• quindecillion	

That last number equals 1 followed by 63 zeros.

Real-World Example: Power Plants

To use these prefixes in a real-world context, consider a power station. A generator with a capacity of 100 megawatts (MW) running continuously for 24 hours generates 2,400 megawatt-hours (MWh) of electricity. This can also be stated as 2.4 gigawatt-hours (GWh). Both terms are correct, but when comparing outputs between plants, using the prefix helps make numbers easier to compare.

A Fun Pop Culture Reference: Back to the Future

In the 1985 movie Back to the Future, Doc Brown is amazed when he watches a video of himself stating that 1.21 gigawatts of power are needed for his invention to work. Marty McFly famously asks, "What the hell is a gigawatt?" They mispronounced it as "jiggawatt," but we know what they meant. Giga means a billion, so 1.21 gigawatts equals 1,210,000,000 watts. That's a lot of power, about 1.62 million horsepower! That's what his flux capacitor was for*.

Prefixes for Smaller Numbers

Prefixes are also used when numbers get smaller. For example, a thousandth of something is a milli. Shrinking by a factor of 1,000 each time, the list goes like this:

• milli	• pico	• zepto	• quecto
• micro	• femto	• yocto	
• nano	• atto	• ronto	

Interestingly, some of these prefixes are similar to the ones used for larger numbers, which can make them easier to remember.

Continued on next page

Ask Ian - continued

Practical Applications

When it comes to electric heaters, these prefixes are used frequently in various contexts:

- Insulation resistance is often measured in the mega-ohm or giga-ohm range. Some testers can even measure up to 1 TΩ (tera-ohms), which is a trillion ohms!
- Test voltage for high-potential testing (hypot testing) is often in the kilovolt range.
- Low resistance measurements use milli-ohm meters, which are highly sensitive and can measure with great precision.
- Leakage current is typically measured in milliamps (mA). For safety, most electrical heaters are designed to keep leakage below 3.0 mA. Some advanced equipment can even measure down to microamps.

Prefixes in Everyday Language

These prefixes pop up in our everyday language too. For example:

- Millimeter: A thousandth of a meter.
- Piccolo: A tiny flute (not quite a "pico" flute, but close enough!).
- Megaphone: A device that makes a big noise!
- The Italian phrase "mille grazie" translates to "a thousand thank yous."

Fun Fact: MOSFET Transistors

Here's an interesting bit of trivia using a really large number. The most abundant man-made object in history is the MOSFET (Metal Oxide Semiconductor Field Effect Transistor), used in integrated circuits. Invented in 1959, by 2018 it's estimated that 13 sextillion MOSFETs had been produced. That's 13,000,000,000,000,000,000,000! Now that's a big number.

Understanding the prefixes like kilo, mega, and giga helps simplify the vast world of measurements, from power generation to everyday terms. Whether discussing massive power outputs or tiny electrical currents, these prefixes make large and small numbers easier to grasp. Their widespread use in science, engineering, and even casual language shows just how essential they are in helping us navigate the complexities of the world around us. So the next time you hear "gigawatt" or "megaphone," you'll know exactly what it means!

* You can get your very own flux capacitor from O'Reilly Auto Parts (part number 121g), if they ever get them back in stock again. It must be a hot item. *https://www.oreillyauto.com/flux-capacitor*

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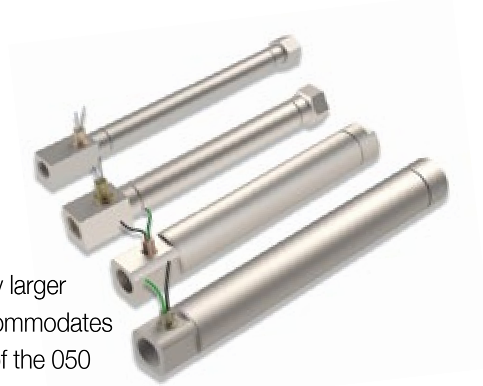
Feature Product

TUTCO Farnam's Heat Torch™ Heaters



TUTCO Farnam's Heat Torch™ family of air heaters offers a range of high-performance, precision-focused solutions designed for industrial heating applications. These heaters are ideal for heating compressed air and non-combustible gases across a wide variety of processes such as drying, curing, heat shrinking, sterilization, and more.

Heat Torch™ 030: The smallest in the lineup, with a 0.313" diameter, offers precision heating with airflow ranging from 0.3 to 1.0 SCFM and up to 300 watts of power. It can achieve temperatures of up to 900°F (482°C), making it perfect for applications requiring fine, focused heating control.

Heat Torch™ 050: With a 0.5" diameter, this compact heater handles moderate airflow (1 to 10 SCFM) and offers power ratings from 100 to 500 watts. It reaches output temperatures of up to 1300°F (704°C) making it ideal for tasks like curing, drying, and adhesive activation.

Heat Torch™ 075: Slightly larger at 0.75" in diameter, it accommodates twice the airflow capacity of the 050 model (1.3 to 25 SCFM) and power up to 1000 watts. This heater delivers higher temperatures and greater airflow for medium-duty applications such as sterilization and heat shrinking.

Heat Torch™ 150: Featuring a 1.5" diameter, the 150 model is built for high reliability and substantial airflow, ranging from 4.8 to 70 SCFM. With power options up to 5000 watts, it's ideal for larger-scale applications like air scrubbing, drying, and air knives.

Heat Torch™ 200: The largest Heat Torch, a 2" diameter, this heater can handle demanding tasks requiring airflow from 9.6 to 100 SCFM and power up to 12,000 watts. It's perfect for high-capacity processes such as wafer drying, semiconductor applications, and air knives.

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