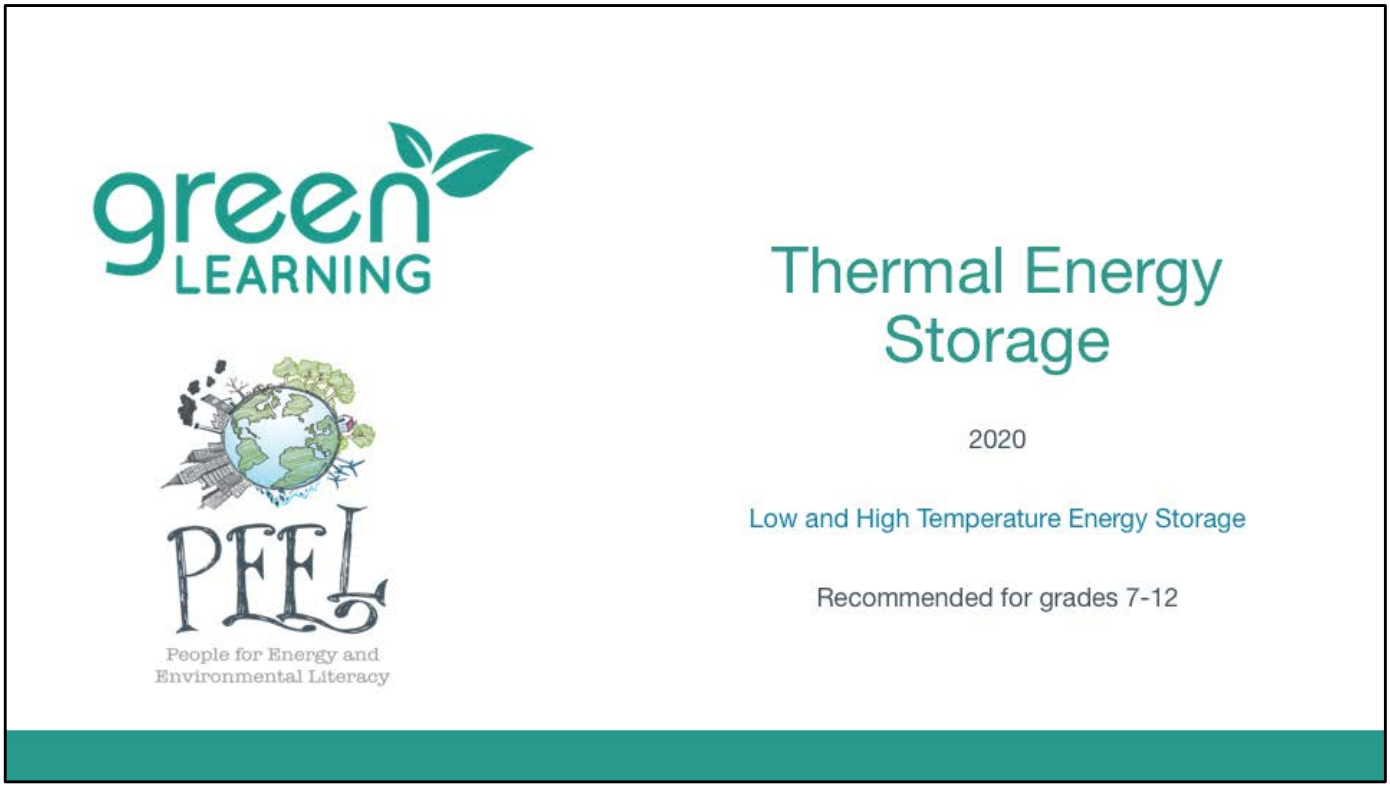
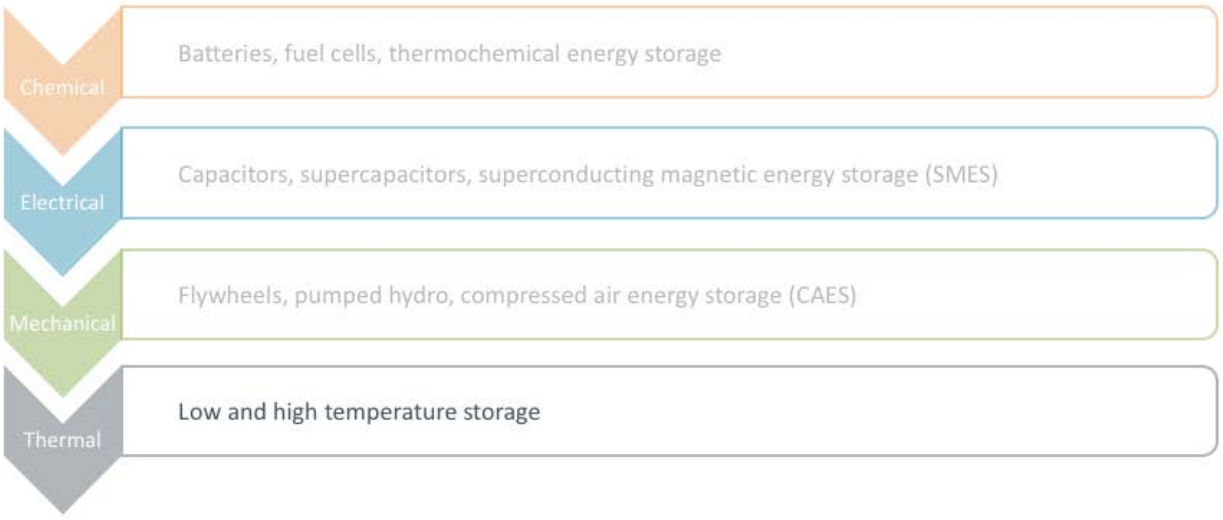
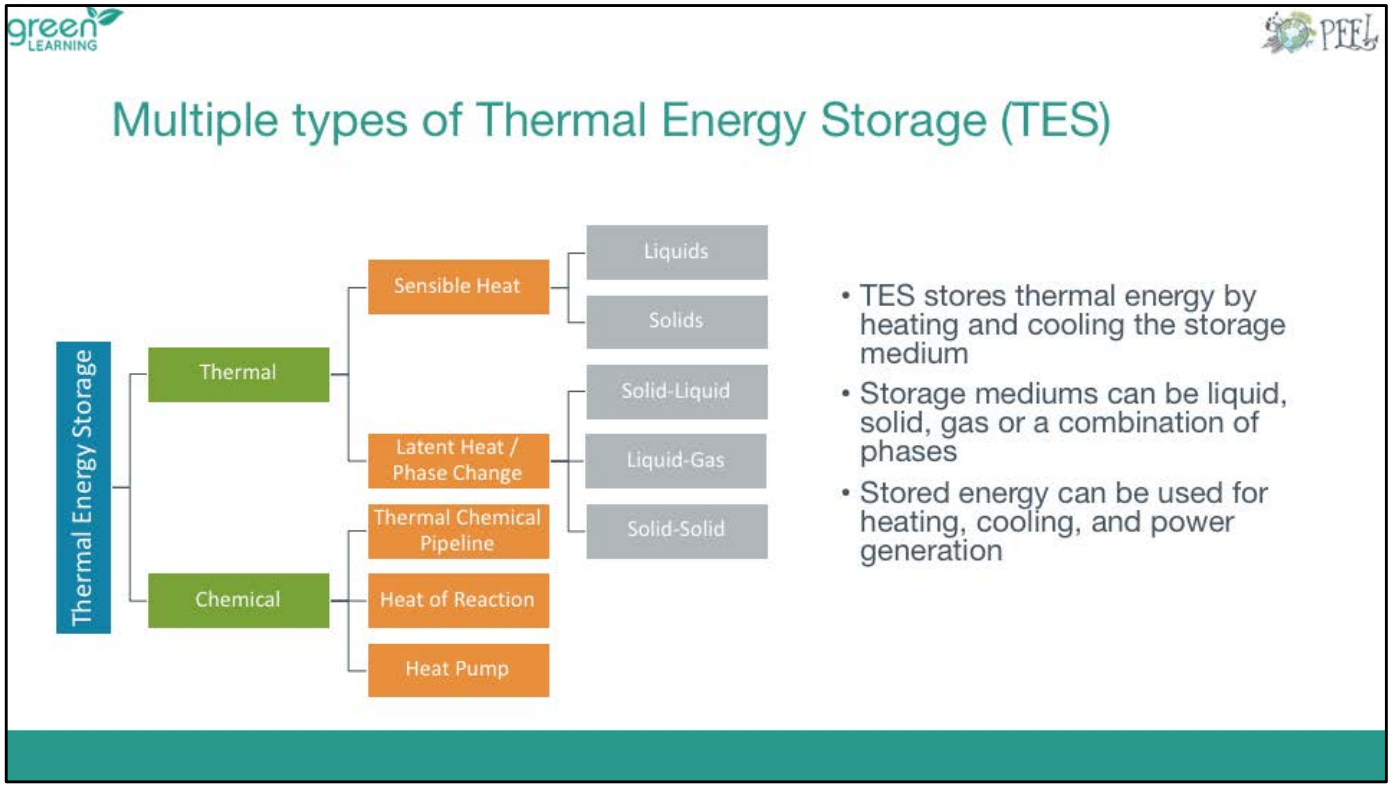


This lesson in aligned with the Alberta curriculum. See the lesson plan for more details.

Thermal Energy Storage

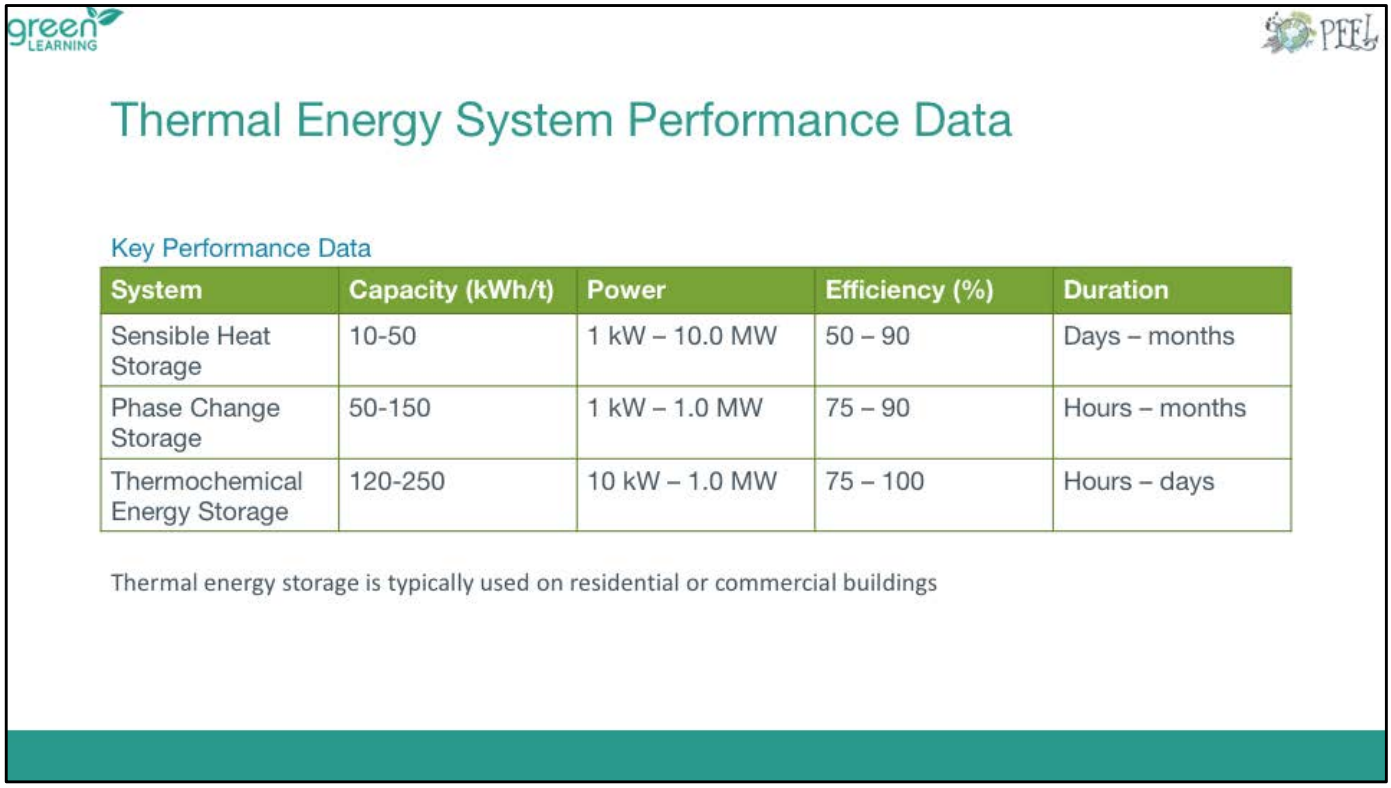




The fourth type of energy storage is Thermal Energy Storage (TES). TES is based on the conduction of heat to release energy (Fourier's Law: The law of heat conduction. "The time rate of heat transfer through a material is proportional to the negative gradient in the temperature and to the area.")

The graphic on this slide shows the different technologies that are available under thermal energy storage. This presentation is going to focus on sensible heat and latent heat storage. This presentation will not discuss chemical thermal energy storage, but students should be aware of the other types.

https://www.mdpi.com/2071-1050/10/1/191/htm



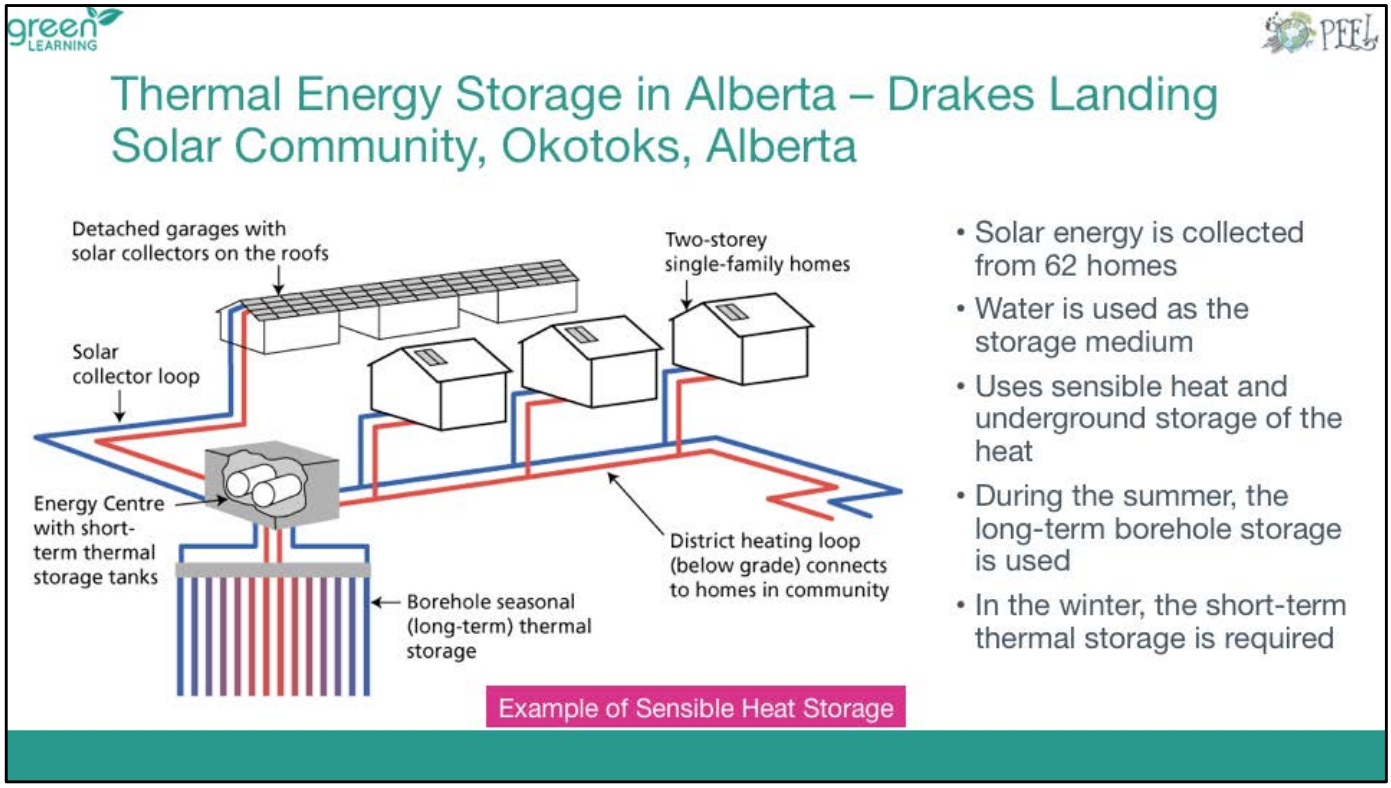
Data courtesy of MDPI –

I. Sarbu and C. Sebarchievici. *A comprehensive Review of Thermal Energy Storage*. MDPI. Jan 14, 2018. Polytechnic University of Timisoara.

Sensible Heat Storage

- Sensible heat storage uses the heat change of a material without changing its phase to store energy
- The temperature of the storage material (solid or liquid) rises when energy is stored (charging) and cools when the energy is released (discharged)
- The charge and discharge process is reversible, and can undergo an unlimited number of cycles
- Water is commonly used. Other storage media include sand, molten salts, and rocks
  - Water has a high specific heat capacity and is therefore ideal for storage
- Sensible heat storage is **low cost** and does not emit toxic chemicals

Specific heat capacity: the amount of heat required to raise the substance's temperature by 1 unit (K) per unit mass (g)



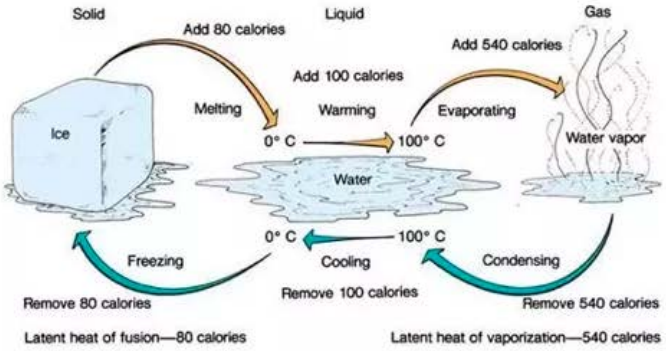
A community in Okotoks, Alberta sources its heat from solar collectors located on the detached garages. The solar collectors heat water, which is used as the storage medium. The heated water is transported to underground storage tanks (for long term storage i.e., in the summer) or to an above ground storage tank (for short term storage i.e., in the winter). When heat is required, the water is transported to the home for heating.

Reference: https://www.dlsc.ca/how.htm

Drakes Landing Solar Community – Video (9 min 44 sec)

This project is located in Okotoks, Alberta

Latent Heat / Phase Change Storage

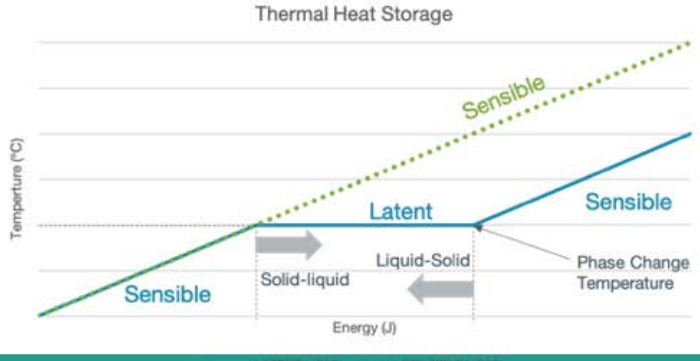


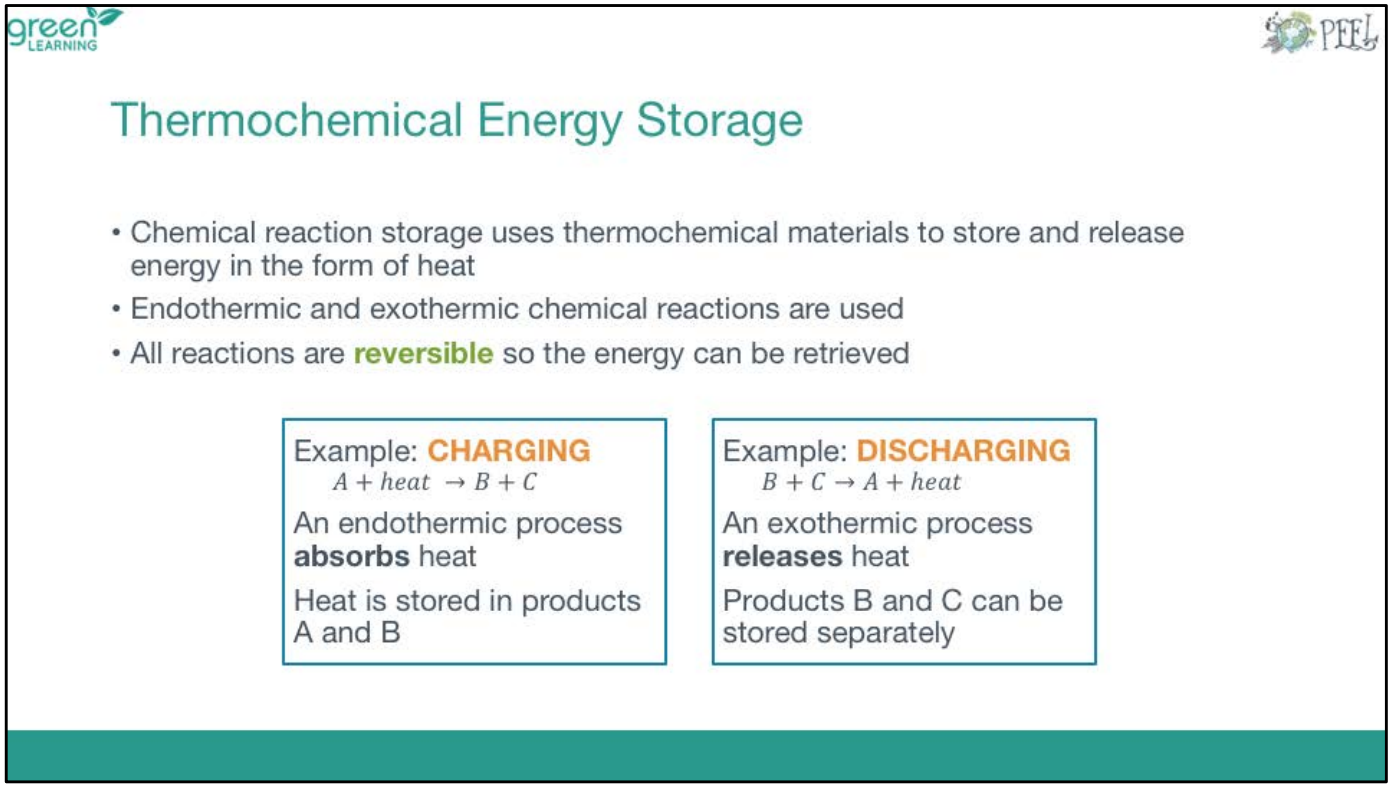
- Latent heat storage, also known as phase change storage stores thermal energy through a phase change such as liquid-gas, solid-liquid, liquid-liquid
- The temperature remains **constant** during process

Latent heat: the heat required for a substance to undergo a phase change without a change in temperature

Latent Heat Storage

- Latent heat is more advantageous over sensible heat because temperature can stay constant
- Latent heat behaves like sensible heat to start, until temperature is constant
  - The temperature released is equal to the temperature absorbed





Thermochemical energy storage is a newer technology compared to latent and sensible heat, and is still in the experimental stage.

Thermochemical energy storage (TCES) stores energy based on the heat released from chemical reactions.
The chemical reactions used in the TCES system are all reversible. The stored energy is proportional to the **enthalpy** of the reaction.

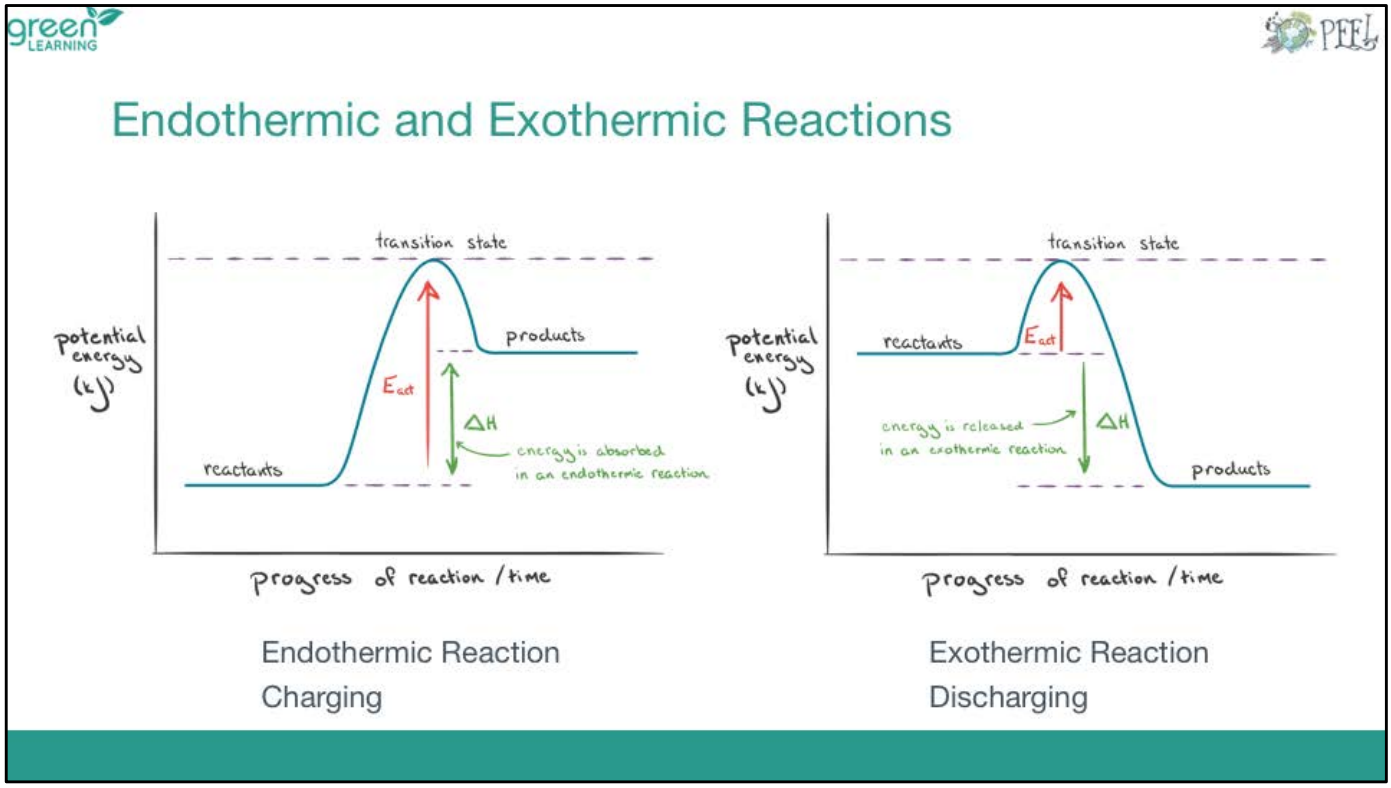
Enthalpy: the total heat content of a system. "Enthalpy is equal to the internal energy of the system plus the product of pressure and volume."

Reactions that have a heat change are called **endothermic** or **exothermic.** Endothermic absorbs heat, while exothermic releases heat. Endothermic reactions create the charging process. Heat reacts with compound *A* to produce compound *B* and *C*. These two compounds can be stored separately until required for discharge. The separation is best accomplished when one product is a solid, and the other is a gas.

During discharge, *B* and *C* react and release the stored heat in an exothermic reaction.

Storage capacity is maximized if a small molar volume is used with a large reaction enthalpy. It is also key for side reactions to not occur.

https://www.mdpi.com/1996-1073/12/6/1086/htm



This is an energy diagram of endo- and exothermic reactions. The y-axis measures the energy, in the form of heat that is stored. As you see in an endothermic reaction, the reactants are lower in energy than the products. This is because endothermic reactions absorb heat to form the products. In this case, products are less stable (because of the higher energy content. Species prefer to reside at a lower energy. The higher energy, the more prone the species are to reaction). Endothermic reactions are non-spontaneous. The reaction proceeds because energy is input into the reaction and is then stored.

In an exothermic reaction, the reactants are at a higher energy than the products. The species are more willing to undergo a reaction, and are spontaneous. During this process, energy is release, which can be used for other applications.

https://www.khanacademy.org/test-prep/mcat/chemical-processes/thermochemistry/a/endothermic-vs-exothermic-reactions

Endothermic and Exothermic Reactions Activity

- This activity will test if you can differentiate between an exothermic and and endothermic reaction
- See the activity hand out for instructions

Exothermic

Endothermic

Thank you!

This is a project of GreenLearning offered in partnership with PEEL thanks to funding support from the Alberta Energy Efficiency Education Grant Program.