SUSTAINABILITY AMBASSADORS

# Electrify Everything Series

## Localized Phenomena Lesson Ideas

## Heat Pumps are Hotcool

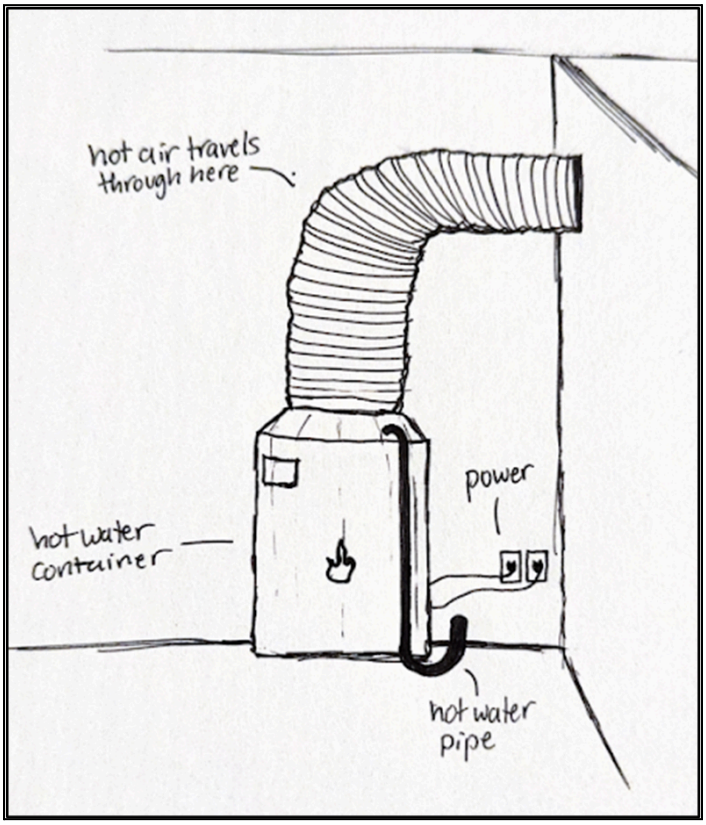
### How Does a Heat Pump Work and Where is it Working?

**The Problem**

In our region, 90% of homes are still heated by natural gas which is a major contributor to our collective carbon footprint. If we could find a way to heat our homes, apartments, and schools with equipment that runs on electricity instead of natural gas we could eliminate this source of greenhouse gas emissions.

Electric heat pumps are the answer. Plus, they not only can heat our buildings in the winter but the same machine can cool our buildings in the summer.

***How does that work?***




**Initial Model**

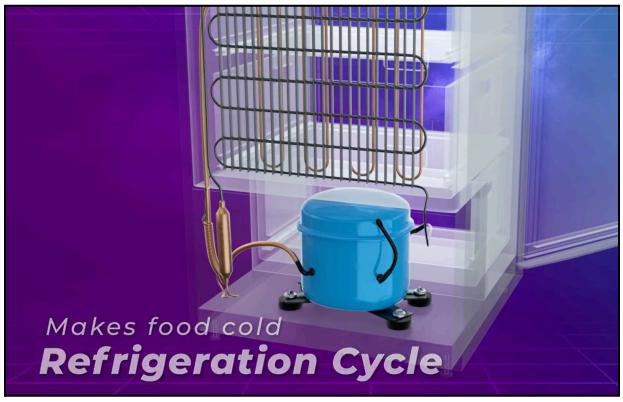
Students take out a blank sheet of paper and draw from scratch how they think a heat pump looks, where it goes in the house or apartment, the component parts, and the relationship among them to make the heat pump function.

They label their diagram to show their thinking and write down any questions they have if they are unsure, stuck, or curious.

Students pair and share to improve their initial models.

**Consider The Simple Refrigerator**

Open the door to your refrigerator and you will find cold air which helps you preserve fresh foods longer. Reach behind your refrigerator and you will notice some warm air coming out. Pull the refrigerator out far enough to look behind it and you will notice a whole system of coils protected by a metal grill. **Inquiry:** What is the relationship between cold air inside your refrigerator and warm air being expelled out the back side. Pair and share followed by classroom discussion.




**Analyze the Engineering of a Refrigerator**

This great little video, How Does a Refrigerator Work? [3:36] uses 3D animation to give a thorough breakdown of the engineering design of a basic home refrigerator. Watch it once with students taking notes. Watch it a second time without the audio and have students take turns in pairs narrating the main ideas as if they were the voice hired to explain the video for the millions of people on youtube.

**Inquiry:** How can we apply the engineering and chemistry principles of a refrigerator to the heating and cooling of our home, apartment, or school?


**It's working in New York City**

Analyze this inspiring video for how landlords are retrofitting older buildings in New York City with heat pumps. NOVA VIDEO [4:17]. The video includes an animated section that reinforces how a heat pump works. It shows how a compressor can change the pressure and therefore the temperature of a special refringent moving through a system of coils.

**A Student Explanation**

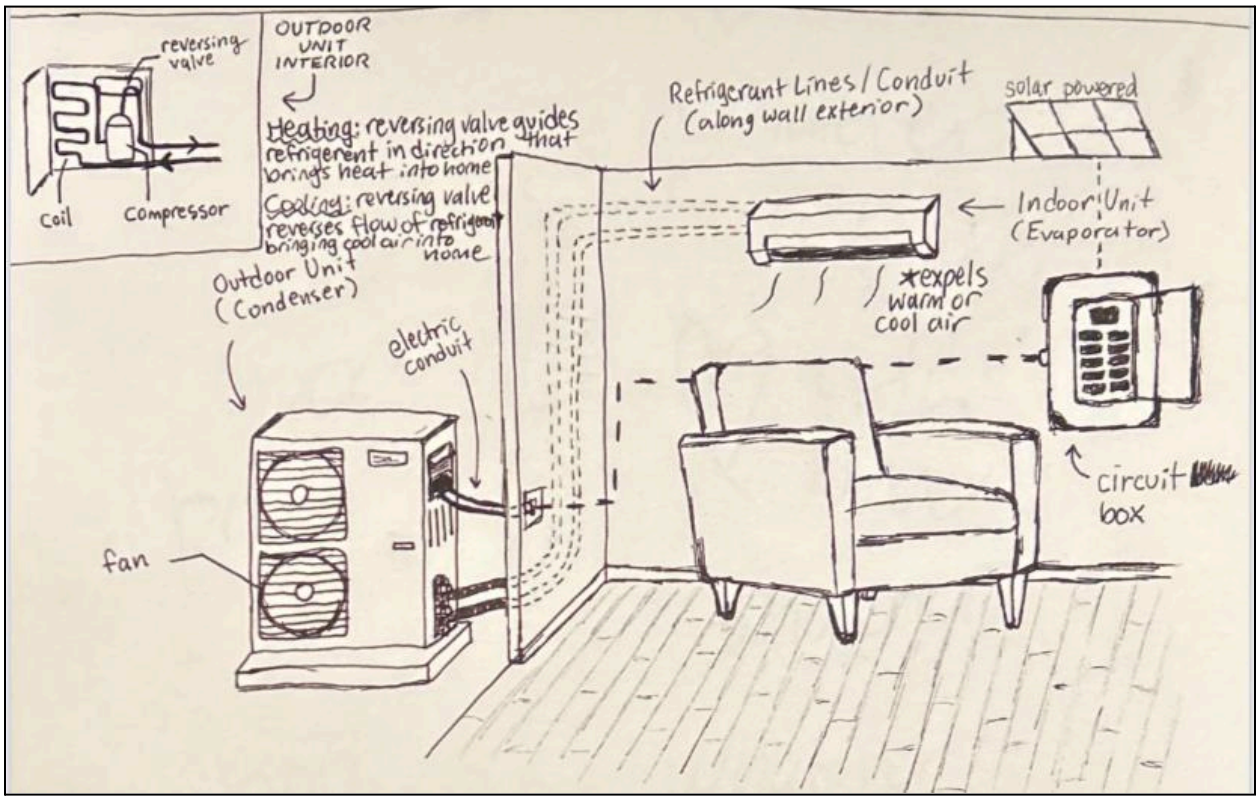
Analyze this video produced by student Sustainability Ambassador, McKenzie, What is a Heat Pump? [3:00] **Inquiry 1:** What are the main ideas here? **Inquiry 2:** How did McKenzie structure her video storyboard? What shots, storytelling techniques, and graphic devices did she use?

**Breaking it Down**

See this handy list of explanations for the **[16 Parts of a Heat Pump](#).** It was written by an installation company to help inform their customers.

IMAGE: [Aquarius Home Services](#)

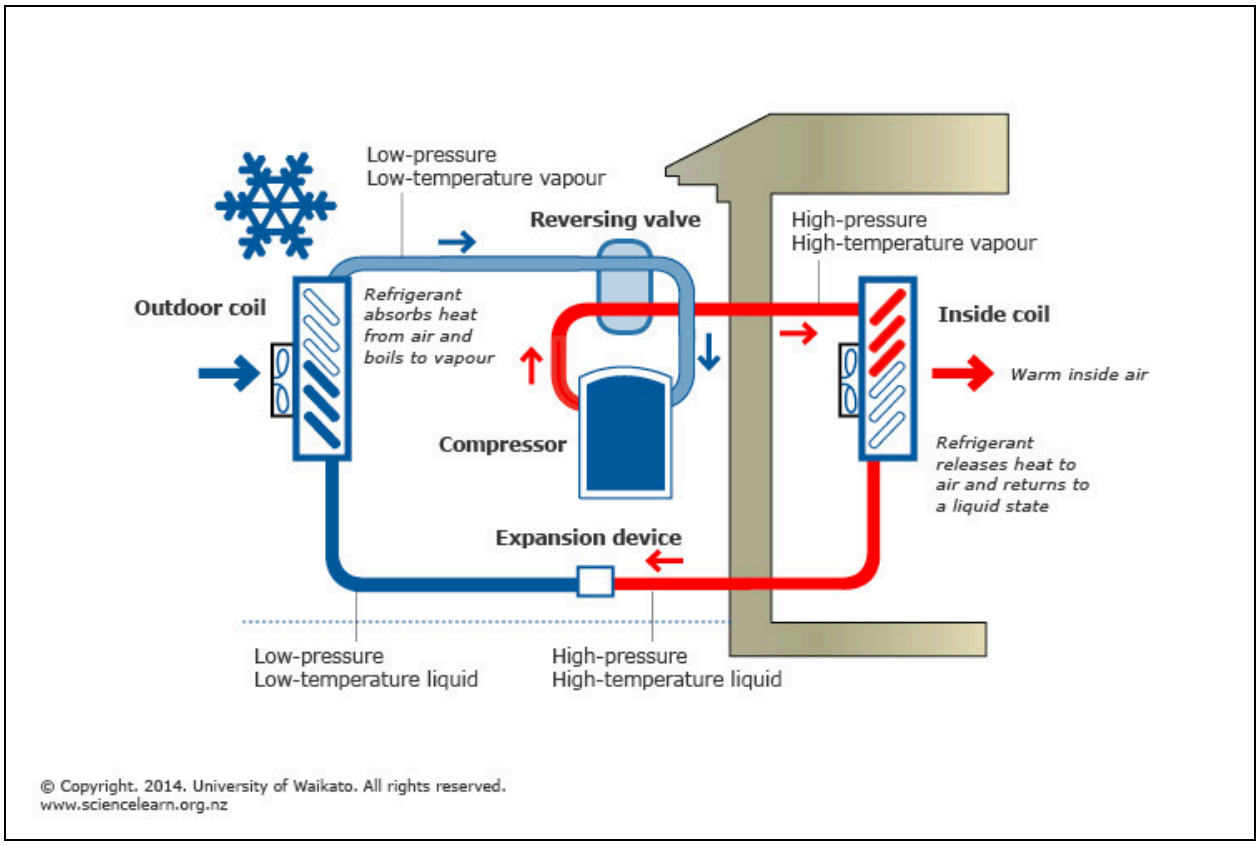
## Initial Model Revised with New Understanding



## What is the Chemistry behind how a Heat Pump Works?

Review or introduce the ideal gas law: **PV=nRT**

Heat pumps transfer heat from one area to another by exploiting the behavior of gases. They rely on cycles of compression and expansion to move heat efficiently. There are two phases, **compression and expansion**. Heat pumps contain a refrigerant that has a low boiling point and low heat of vaporization, this means the refrigerant can absorb heat and boil into gas. This gas is compressed, raising the temperature and pressure. Newly compressed, hot gas is sent through the inside coil to release heat into your home. This means the gas returns to its cooler, liquid form. The expansion device takes that liquid and expands its volume, cooling and de-pressurizing the liquid refrigerant. This is moved through the indoor coil and boiled into its vapor form, then sent to the compressor for the cycle to repeat.





**Label where each of these steps occurs on the diagram above:**

1. Gas is compressed, reducing its volume (V).
2. The increase in temperature (T) allows the gas to release heat to the surrounding area (your home!).
3. Gas is allowed to expand, increasing volume (V).
4. The lower temperature (T) allows the gas to absorb heat from its surroundings.

**True or False?**

If volume (V) decreases and amount of gas (n) is constant, pressure (P) and temperature (T) must increase. Explain why or why not using the properties of the ideal gas law (PV=nRT).

**Challenge #1:** What are the properties of the refrigerant in a heat pump?

**Challenge #2:** What are the environmental drawbacks to refrigerants? See blog post by HVAC Engineer, Miles Gribs: Facing the Heat: The Environmental Challenge of Refrigerants

**Challenge #3:** How can we apply chemical engineering to create a more sustainable refrigerant? See Project Drawdown - Alternative Refrigerants.

# APPLICATION

**Can My Family Get a Heat Pump?**

Students use the Impact Project Template to work through how switching from a gas furnace to a heat pump could benefit their family. Students will learn about the health, financial, and climate benefits of electrifying their homes, how to read their energy bill, how to calculate their carbon savings, and how to explore possibilities for local rebates and incentives.

# SCALING

**The Role of Heat Pumps in Reducing our Global Carbon Footprint**

Project Drawdown - High-Efficiency Heat Pumps. The Project Drawdown description for this action includes a brief introduction excerpted below, as well as the mathematical and economic thinking for scaling this solution world-wide as a strategy for drawing down carbon.

## *Excerpt…*

***"Buildings are responsible for a substantial proportion of energy use worldwide. Maximizing efficiency in heating and cooling could cut global energy use by 30 to 40 percent.***

***One efficiency-enhancing technology stands out from the rest: heat pumps. A heat pump transfers heat from a cold space to a hot one. In winter, it pulls heat from outside and sends it into a building. In summer, it pulls heat from inside and sends it out. The source or sink of heat can be the ground, air, or water.***

***While cost can be high and efficiency varies, heat pumps are easy to adopt, well understood, and already in use around the world. They can supply indoor heating, cooling, and hot water all from one integrated unit. When paired with renewable energy sources and building structures designed for efficiency, heat pumps could eliminate almost all greenhouse gas emissions from heating and cooling."*** *learn more*

**Curious?** For lots more solutions beyond heat pumps learn more about Project Drawdown, the world's leading resource for climate solutions

## China Heat Pump Case Study

China's buildings and industries account for one third of global emissions. Read this article breaking down China's potential carbon savings from data provided by the International Energy Agency. China has the largest market for heat pumps in the world and they have installed over 25% of heat pumps installed worldwide. China is a big country with different climate zones, see how heat pumps can tackle these diverse heating challenges from the Rocky Mountain Institute's analysis.

## Norway Heat Pump Case Study

Norway is leading the world with the highest percentage of heat pumps per household. See how these Nordic countries are busting the myth "heat pumps don't work in the cold". Read this article to understand why Norway leads the world in heat pumps. Learn more about the financial incentives in Norway and watch this video to learn about the technological developments that help Norway decarbonize their buildings. Watch VIDEO [5:00]

# *Making Connections….*

**Start with Energy Conservation**

Lesson Ideas: Students understand a range of opportunities for ensuring that we are conserving as much energy as possible before we seek clean energy production solutions.

**Electrification 101**

Lesson Ideas: Designed to expose students to the world of home de-carbonization–in other words–electrification! Students will learn about the environmental and health impacts of natural gas, where natural gas may be present in their homes, and what electric strategies are emerging to mitigate these impacts.

**Heat Pump HVAC Careers**

To be developed….

## Funder & Partner Acknowledgment