

Electric **Eco Hero**

The Costs of Electricity Student Activity Packet



PENINSULA
CLEAN ENERGY



YOU'RE AN ELECTRIC ECO HERO!

Climate change has had unprecedented effects on the environment, including extreme heat waves, wildfires and rising sea levels. As these effects become more extreme, it's important that we are all a part of the solution.

Climate change is caused mostly by humans burning oil, gas and coal for energy to travel, power buildings, grow food and make the stuff we use.

The good news is you are already helping the environment by using electricity from cleaner sources! In San Mateo County, Peninsula Clean Energy supplies you with electricity that comes from greener sources such as the sun, wind and water. Together, we are acting locally to be a part of the global solution.

Don't believe it? Let's do the math! This activity packet covers some basic calculations you need to know to understand your electricity usage and its cost, in terms of money and impact on the environment. You'll also learn how you are already helping to fight climate change.

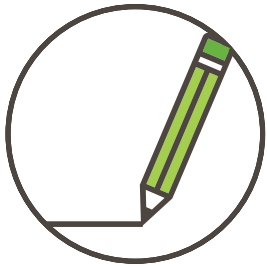
While you're at it, learn what your electricity bill means!

TABLE OF CONTENTS

Introduction	2
How to Use this Activity Packet	4
Definitions and Acronyms	5
Part I: The Scientific Context	6
• Electricity and Its Sources	8
• Electric Power and Energy	10
• Economic Cost of Electricity (Money)	11
• Environmental Cost of Electricity (Greenhouse Gas Emissions)	11
Part II: What Does Electricity Cost You?	12
• Electricity in San Mateo County	13
• Read Your Electricity Bill	14
• Life Skill: Learn How to Calculate Your Savings	15
• Calculating the Costs of Electricity	16
Part III: Let's Put It All Together	23
• Let's Scale It Up	24
Reflection	25
Notes	26
Citations	27

HOW TO USE THIS ACTIVITY PACKET

Make sure to read the instructions and passages carefully. If you see any of the following icons in the activity guide, here's what they mean:



You will need to record your thoughts and/or calculations here.

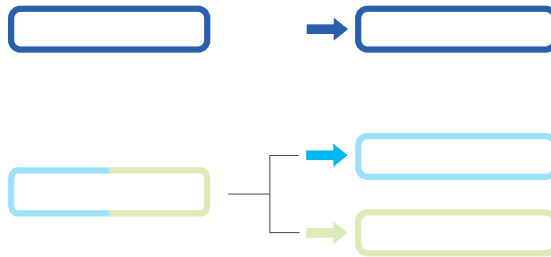


You will need to do some more serious thinking on this prompt.



You will need to do some research if you don't know this already.

Throughout this packet, there are worksheets that walk you through various calculations. When you see an arrow pointing to a colored box, you will need to find a number you have already written and copy it into that box. Look for a box with the same color and rewrite the number from that box in the box with the arrow.



Example: It takes Mark 90 seconds to install a light bulb. How many minutes does it take Mark to install 30 light bulbs? 72 light bulbs?

$$\frac{90 \text{ seconds}}{1 \text{ light bulb}} \times \frac{1 \text{ minute}}{60 \text{ seconds}} = \boxed{1.5} \frac{\text{minutes}}{\text{light bulb}}$$

→ 1.5 $\frac{\text{minutes}}{\text{light bulb}} \times 30 \text{ light bulbs} = 45 \text{ minutes}$
→ 1.5 $\frac{\text{minutes}}{\text{light bulb}} \times 72 \text{ light bulbs} = 108 \text{ minutes}$

DEFINITIONS

- **Electric Delivery:** Transmitting electricity to homes and businesses. Electric Delivery Charge is a charge for maintaining wires, infrastructure, and delivering electricity to homes and businesses
 - **Electric Energy:** Energy used over time
 - **Electric Generation:** Producing electricity. Electric Generation Charge is a charge for producing the amount of electricity customers used
 - **Electric Power:** How fast electric energy is produced or consumed
 - **Emission Factor:** Amount of carbon dioxide released from an amount of electricity generated
 - **Energy Mix:** The combination of energy that electric providers buy
 - **Greenhouse Effect:** Trapping of sunlight and heat caused by an increase in greenhouse gases, like carbon dioxide
 - **Non-Renewable Source:** Resources that cannot be replaced after they have been used
 - **Power Rating:** Energy consumed by an appliance
 - **Rate:** A fixed price set by companies for each kilowatt-hour of electricity used
 - **Renewable Source:** Energy from a source that is not depleted when used
 - **Tiered System:** Your electricity provider may charge a higher rate if more than a certain amount of electricity is used
 - **Vampire Draw:** Electricity used by appliances that are left plugged in, even when they are not in use
-

ACRONYMS

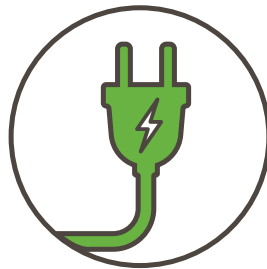
- **CO₂:** Carbon dioxide
- **GHG:** Greenhouse gas
- **kW:** Kilowatt
- **kWh:** Kilowatt-hour
- **lbCO₂:** Pounds of carbon dioxide
- **MTCO₂:** Metric tons of carbon dioxide
- **MW:** Megawatt
- **MWh:** Megawatt-hour
- **PG&E:** Pacific Gas and Electric
- **W:** Watt
- **Wh:** Watt-hour

PART I: THE SCIENTIFIC CONTEXT

By the end of Part I of the activity packet, you will be able to:



1. Understand the effect of greenhouse gas emissions as an environmental cost of electricity generation.



2. Define electrical power, electrical energy, economic and environmental costs, and the corresponding units.

CLIMATE CHANGE

HEAT WAVES

The September 2017 heat wave hit an all time high in the Bay Area, with the highest temperature at the San Francisco International Airport at 104°F and many other cities hitting a century record with temperatures in the 100s and 110s.¹

WILDFIRES

Wildfires in the western U.S. have been occurring more frequently, lasting longer and burning larger areas, causing more property damage and causing breathing difficulties from air pollution. Even when fires are far away, you may still smell the smoke-filled air, and it may be harder to breathe.

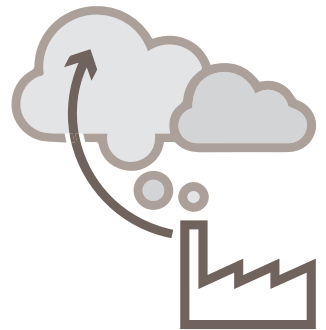
UNDERWATER

According to Sea Change San Mateo County, sea levels in San Mateo County are expected to rise around 6 inches by 2030 and around 1-2 feet by 2050. Many places we love, including tens of thousands of homes, community centers, roads and other infrastructure could be flooded.²

Human activities such as transporting people and products, growing food, manufacturing products and generating electricity impact our environment. A consequence of many human activities is the release of greenhouse gases in the process of burning fossil fuels for energy.

What are some greenhouse gases you can name?

What do you already know about greenhouse gases?



Carbon dioxide is a major contributor to the **greenhouse effect**. In the past 100 years, sharp increases in greenhouse gases like carbon dioxide have created a stronger greenhouse effect by trapping more sunlight and heat. This causes global warming.

What can you find out about the greenhouse effect? Write a brief explanation of the greenhouse effect.



ELECTRICITY AND ITS SOURCES

One of the major sources of greenhouse gas emissions is the generation of electricity. Let's think a little bit about what you already know about electricity:



1. What do you already know about where electricity comes from? Write two facts:

- _____
- _____

2. What are the pros and cons of using electricity? Write two ideas.

- _____
- _____

How we generate our electricity makes a big difference to our health and the health of the planet. Energy sources are categorized as **renewable** and **non-renewable**³.

ELECTRIC ENERGY SOURCES

Renewable Sources:

Resources that can be used repeatedly and replaced naturally.



Solar Energy



Wind Energy



Small Hydroelectric Energy



Tidal Energy



Biomass Energy



Geothermal Energy

Non-Renewable Sources:

Resources that cannot be readily replaced after they have been used.

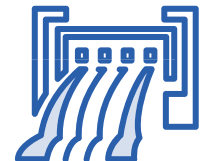


Fossil Fuels: Oil, Gas and Coal

Sources that are non-renewable, but are Greenhouse Gas Free and do not contain fossil fuels:



Nuclear Energy



Large Hydroelectric Energy

Use the graphic in the previous table to help you complete this table. Write the type of electricity source and mark it as renewable or non-renewable.

Definition	Source	Renewable	Non-Renewable
Power plants burn this to make steam, which turns turbines and generators to make electricity. It releases a lot of greenhouse gases.			
Heat from the earth is used to make steam, which turns turbines and generators to make electricity.			
Moving air turns generators to make electricity.			
Energy from the sun's rays gets captured by cells made from materials that convert this energy to electricity.			
Nuclear reactions make steam, which turns turbines and generators to make electricity.			
Large bodies of water, like rivers, flow from higher to lower altitudes. The moving water is used to move turbines in structures like dams.			
Small bodies of water flow from higher to lower altitudes. The moving water is used to move turbines.			
The movement of tides is used to make electricity.			
Wood and other organic matter is burned to make steam, which turns turbines and generators to make electricity.			

DID YOU KNOW?

Electric companies have the choice of buying their energy from various sources. The higher the percentage of renewable and greenhouse gas free energy in the mix, the fewer emissions are associated with it. In 2018, **Peninsula Clean Energy's** energy mix was as follows:

Source of Energy	ECOplus	ECO100
	Percent of Energy Purchased from Source	
Renewable	51%	100%
• Biomass & Biowaste	5%	0%
• Geothermal	2%	0%
• Small Hydroelectric	5%	0%
• Solar	7%	50%
• Wind	33%	50%
Coal	0%	0%
Large Hydroelectric	35%	0%
Natural Gas	0%	0%
Nuclear	0%	0%
Unspecified	14%	0%
TOTAL	100%	100%

You are part of the solution with Peninsula Clean Energy because the energy you use will be 100% greenhouse gas free by 2021! Go you! Go even further with ECO100 to have 100% renewable energy for your home right now:
www.peninsulacleanenergy.com/opt-up/

For the latest energy mix go to
www.peninsulacleanenergy.com/energy-sources/

Percentages may not total 100% due to rounding.

ELECTRIC POWER AND ENERGY

Electric power is how fast electric energy is produced or consumed. It is measured using the unit **watt**, abbreviated by the symbol **W**. More watts means faster consumption or production of electric energy.



What is a **kilowatt** and a **megawatt**?

- One **kilowatt (kW)** equals one thousand **watts**.
- One **megawatt (MW)** equals one thousand **kilowatts**, or one million **watts**.

To **convert** between watts and kilowatts, and between kilowatts and megawatts:

$$\text{kW} = \text{W} \times \frac{1\text{kW}}{1000\text{W}} \quad \text{or} \quad \text{kW} = \frac{\text{W}}{1000}$$

$$\text{MW} = \text{kW} \times \frac{1\text{MW}}{1000\text{kW}} \quad \text{or} \quad \text{MW} = \frac{\text{kW}}{1000}$$

Find an example of electrical power in your real life. Electrical appliances usually have labels that display their **power ratings**. Power ratings tell you the energy consumed by that appliance.

For example, the following label for an air conditioner unit shows that its electric power is 1,550 W. This tells us that the air conditioner consumes electrical energy very quickly.



Find an appliance near you and look for the power rating. Compare it to the air conditioner's power rating. *What do you notice?*

Electric energy (or **usage**) is the energy used over time. It is measured using the unit **watt-hour**, abbreviated by the symbol **Wh**.

Formula: energy = power × time

Units: watt-hours = watts × hours



How many watt-hours (Wh) do you think a kilowatt-hour (kWh) is?

What about a megawatt-hour (MWh)?

If you run an appliance for a number of hours, you can find the electric energy used by multiplying according to the formula. Assume an air conditioner uses **1,550 W**. If someone uses it for **3 hours**, the energy used would be **4,650 Wh**.



DID YOU KNOW?

The unit "watt-hour" is the product of multiplying power by time, meaning: **Wh = W × h**
Here's an analogy to help us better understand electrical power and energy:

- Electrical power (watts) is like the speed of a car – more power is like driving faster.
- Electrical energy (watt-hours) is like the distance you cover after driving for an hour at that speed.

The larger the speed, the more distance you can cover in an hour. Similarly, the larger the power, the more energy is produced or consumed in an hour.

ECONOMIC COST OF ELECTRICITY (MONEY)

Electricity costs money. Companies set a fixed price for each kilowatt-hour of electricity we use. We call this the **rate**.

To calculate how much your electricity usage costs, the general rule is to follow the formula:

Formula: cost = rate × energy usage

$$\text{Units: } \$ = \frac{\$}{\text{kWh}} \times \text{kWh}$$

Electric companies usually charge **by kilowatt-hour (kWh)**, rather than by watt-hour (Wh). So, to calculate usage for appliances that use watts, it is important to remember to **convert** to kilowatts.

A typical household in San Mateo County uses around **425 kWh** of energy in a month.

Converting Wh to kWh:

$$\text{kWh} = \frac{1 \text{ kWh}}{1000 \text{ Wh}} \quad \text{or} \quad \text{kWh} = \frac{\text{Wh}}{1000}$$

DID YOU KNOW?

Some electric providers charge using a **tiered system** for electricity rates. This means that the provider may charge you a higher rate if you use more than a certain amount of electricity. While it is important to find and use this information to calculate more accurate charges, for our calculations in this packet, we will assume a constant rate.

ENVIRONMENTAL COST OF ELECTRICITY (GREENHOUSE GAS EMISSIONS)

The amount of greenhouse gas released for each kilowatt-hour of electricity we use depends on the sources of the electricity, or the **energy mix**. We call this the **emissions factor**. To calculate how much your electricity usage costs the environment in terms of greenhouse gas emissions, we can use the formula:

Formula: CO₂ emissions = emissions factor × energy usage

$$\text{Units: } \text{lbCO}_2 = \frac{\text{lbCO}_2}{\text{MWh}} \times \text{MWh}$$

The amount of carbon dioxide emissions may be communicated in terms of **lbCO₂** (**pounds of carbon dioxide**) or **MTCO₂** (**metric tons of carbon dioxide**). A metric ton of carbon dioxide (MTCO₂) is roughly equivalent to 2204.62 pounds of carbon dioxide (lbCO₂). You may find conversion necessary – use the following equations:

Convert between pounds (lbs) and metric tons (MT):

$$\text{MT} = 2204.62 \text{ lbs}$$

$$\text{MT} = \frac{\text{lbs}}{2204.62}$$

How Do We Compare Different Greenhouse Gases?

Carbon dioxide equivalent is a measure used to compare the emissions from various greenhouse gases, like methane, carbon dioxide, and nitrous oxide, based upon their global warming potential. For example, the global warming potential for methane over 100 years is 21. This means that emissions of one million metric tons of methane is equivalent to emissions of 21 million metric tons of carbon dioxide.

PART II: WHAT DOES ELECTRICITY COST YOU?

By the end of this part of the activity guide, you will be able to:



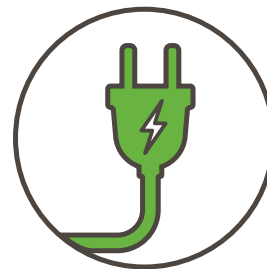
1. Calculate costs for sample scenarios of electrical appliance usage.



2. Compare differences in the costs of using various appliances.



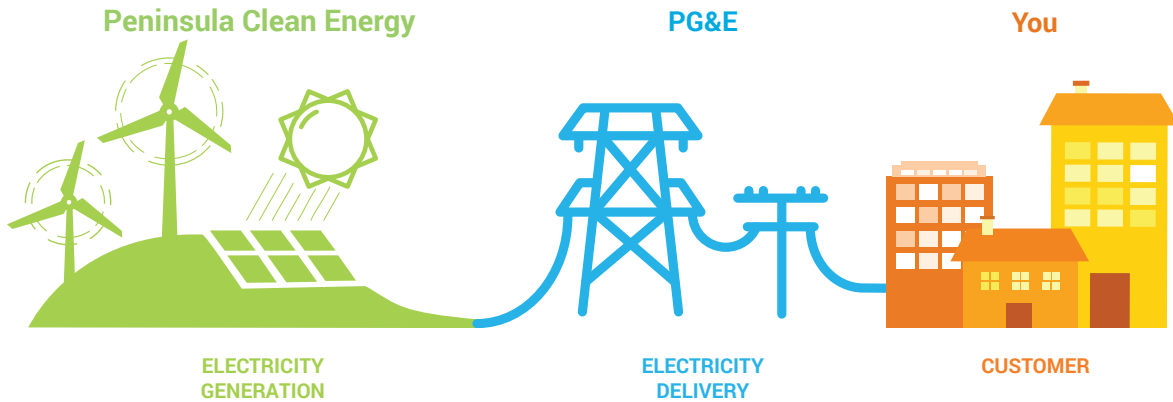
3. Identify the economic and environmental impacts of electricity usage in a home.



4. Understand the costs of electricity of San Mateo County.

ELECTRICITY IN SAN MATEO COUNTY

How It Works



In 2015, San Mateo County communities voted to form Peninsula Clean Energy, a new local agency to provide cleaner energy to help address climate change. Peninsula Clean Energy buys electricity, and PG&E maintains the poles and wires that deliver it. Peninsula Clean Energy serves as the automatic electricity service. Residents may choose to get electricity generation either from PG&E or from Peninsula Clean Energy.

CHARGES FOR ELECTRICITY ON YOUR PG&E BILL ARE NOW SIMPLY DIVIDED INTO TWO PARTS:



Peninsula Clean Energy Electric Generation Charges for creating the electricity you use. Customers receive a 5% savings for Peninsula Clean Energy's default energy mix ECOplus compared to PG&E's electricity generation rates. ECOplus comes from at least 50% renewable energy sources and 90% GHG-free, or you can pay a little more for 100% renewable energy for ECO100.



Current PG&E Electric Delivery Charges for maintaining PG&E's wires, infrastructure, and delivering electricity to your home. These rates are the same for Peninsula Clean Energy and non-Peninsula Clean Energy customers.

You receive a credit on your bill from PG&E for electricity generation, since Peninsula Clean Energy is now generating your electricity instead of PG&E. Learn more at peninsulacleanenergy.com/residents



READ YOUR ELECTRICITY BILL

Let's start by focusing on electricity usage at home – starting with reading a bill. Bills can be complicated, but with a little clarification, they will tell you how much electricity was used in kWh, and the rate in dollars (or cents) per kWh.

Peninsula Clean Energy



RENEWABLE ENERGY
Electric Generation

PAGE FOUR

ENERGY STATEMENT
www.pge.com/MyEnergy

Details of Peninsula Clean Energy Electric Generation Charges

05/03/2018 – 06/01/2018 (30 billing days)
Service For: 1234 Sample Road
Service Agreement ID: 0123456789 ESP Customer Number:

05/03/2018 – 06/01/2018

Rate Schedule: E-1

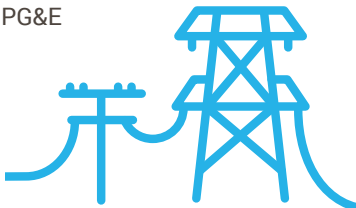
GENERATION – TOTAL	335.000000 kWh @ \$0.06840	\$22.91
NET CHARGES	22.91	
Local Utility Users Tax		1.15
Energy Commission Surcharge		0.10

Peninsula Clean Energy is San Mateo County's official electricity provider
You're getting cleaner energy at low rates!

Total Peninsula Clean Energy Electric Generation Charges **\$24.16**

This is what you pay Peninsula Clean Energy for the generation of your electricity from greener, more renewable sources.

PG&E



SAME RELIABLE SERVICE
Electric Delivery

PAGE THREE

ENERGY STATEMENT
www.pge.com/MyEnergy

Details of PG&E Electric Delivery Charges

05/03/2018 – 06/01/2018 (30 billing days)
Service For: 1234 Sample Road
Service Agreement ID: 0123456789
Rate Schedule: E1 T Residential Service

05/03/2018 - 06/01/2018	Your Tier Usage	1	2	
Tier 1 Allowance	210.00 kWh (30 days x 7.0 kWh/day)			
Tier 1 Usage	210.000000 kWh @ \$0.21169			\$44.45
Tier 2 Usage	125.000000 kWh @ \$0.27993			34.99
Generation Credit				-36.11
Power Charge Indifference Adjustment				11.21
Franchise Fee Surcharge				0.18
Daly City Utility Users' Tax (5.000%)				2.73

Total PG&E Electric Delivery Charges **\$57.45**

PG&E rates include generation and delivery. Then PG&E credits Peninsula Clean Energy customers the cost of generation so you just pay delivery.

This is what you pay PG&E for the delivery of your electricity.

Your home



YOUR COMMUNITY CHOICE
Cleaner Energy, Lower Rates

FRONT PAGE

ENERGY STATEMENT
www.pge.com/MyEnergy

Account No: 0123456789-1
Statement Date: 06/07/2018
Due Date: 06/28/2018

Service For:
William Sample
1234 Sample Road
Daly City, CA 94015

Your Account Summary

Amount Due on Previous Statement	\$77.65
Payment(s) Received Since Last Statement	\$77.65
Previous Unpaid Balance	0.00
Current PG&E Electric Delivery Charges	\$57.45
Peninsula Clean Energy Electric Generation Charges	24.16
Current Gas Charges	3.11
Total Amount Due by 06/28/2018	\$84.72

Questions about your bill?
Monday-Friday 7 a.m.-9 p.m.
Saturday 8 a.m.-6 p.m.
Phone: 1-866-743-0335
www.pge.com/MyEnergy

What you pay for the month

LIFE SKILL: LEARN HOW TO CALCULATE YOUR SAVINGS

Peninsula Clean Energy provides electric generation at 5% lower rates than PG&E. Use the electricity bill from the previous section to calculate the savings below.

You are a Peninsula Clean Energy ECOplus customer! Here's how to calculate your savings:

Step 1	<p>Enter "Generation Credit", usually found on Page 3 of your bill.</p> <p>This is a credit from PG&E because we are now getting electricity generation from Peninsula Clean Energy.</p>	CREDIT FROM PG&E
Step 2	<p>Enter additional charges from PG&E: Power Charge Indifference Adjustment and Franchise Fee Surcharge on Page 3.</p> <p>These cover the cost of energy purchased by PG&E on your behalf before you joined Peninsula Clean Energy.</p>	PCIA + FRANCHISE FEE
Step 3	<p>Enter charges for Peninsula Clean Energy's greener power, "Net Charges" on Page 4.</p> <p>Other fees found here, which may include an Energy Commission Surcharge and sometimes a Local Utility Users Tax, are paid by all customers, regardless of their electricity generation provider.</p>	+ NET CHARGES
Step 4	<p>Add the amounts from Steps 2 and 3.</p>	TOTAL CHARGES
Step 5	<p>Subtract the amount in Step 4 from the PG&E credit in Step 1 to see your savings.</p> <p>A typical ECOplus customer will save about \$1.50 to \$2.00 per month.</p>	SAVINGS

Having trouble with the calculation?

Contact our helpful call center representatives at 1 (866) 966-0110 during regular business hours, or watch the short instructional video on our website at peninsulacleanenergy.com/residents.

Video tutorial: https://youtu.be/4syCD_SkJww

An important note about rates:

A common confusion customers have about their electricity bills is the different rates. Rates change throughout the year depending on many factors, such as the season. Also, there are different rates for generation, delivery and different service charges. For simplicity of calculations in Part II, we are using an average rate from throughout the year, while also accounting for other fees (Power Charge Indifference Adjustment, Franchise Fees). Note this sample shows rates from June 2018.

CALCULATING THE COSTS OF ELECTRICITY

What are the rates and emissions for our electricity sources?

To calculate the economic and environmental costs of your electricity usage, you will need to know how much you are charged (**rates**) and how much carbon dioxide your energy sources release (**emissions factor**).

You will need the following information for the next part of the activity packet. For the most recent data, visit www.peninsulacleanenergy.com/activitypacket.

Table 1: Electricity Choices in San Mateo County and Their Rates/Emissions Factors

Electricity Provider/Plan	PG&E Regular	PG&E Solar Choice	Peninsula Clean Energy ECOplus	Peninsula Clean Energy ECO100
2019 Rate (\$/kWh)	0.24992 $\frac{\$}{\text{kWh}}$	0.26994 $\frac{\$}{\text{kWh}}$	0.24432 $\frac{\$}{\text{kWh}}$	0.25432 $\frac{\$}{\text{kWh}}$
Greenhouse Gas Emissions Factor ⁴ (lbCO ₂ /MWh)	210 $\frac{\text{lbCO}_2}{\text{MWh}}$	0 $\frac{\text{lbCO}_2}{\text{MWh}}$	130 $\frac{\text{lbCO}_2}{\text{MWh}}$	0 $\frac{\text{lbCO}_2}{\text{MWh}}$

Note: These rates are based on Res-1/E-1 rate schedule as of May 1, 2019 and includes the PCIA and Franchise Fee Surcharge. Peninsula Clean Energy emissions factor is for 2018, PG&E is for 2017.

Pick a Plan:

For PART II, you will use these rates and emissions factors from Table 1 for your calculation. Let's pick one of the following electricity plans (circle one):

PG&E Regular

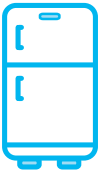
Peninsula Clean Energy ECOplus

What is the **rate** for this plan? _____ $\frac{\$}{\text{kWh}}$

What is the **emissions factor** for this plan? _____ $\frac{\text{lbCO}_2}{\text{MWh}}$

To learn more about what the CO₂ emissions mean to the environment, check out the Environmental Protection Agency's Greenhouse Gas Equivalencies calculator: <https://www.epa.gov/energy/greenhouse-gas-equivalenciescalculator>

Example 1: Refrigerator



Fernando has a refrigerator at his apartment, that has a power rating of **500 W**. A refrigerator runs for **8 hours each day** to keep its contents at a cold enough temperature for the entire day. What are the economic and environmental costs of running his refrigerator for **a month of 30 days**?



Total energy used by Fernando's refrigerator:

$$\frac{\text{Power}}{\text{W}} \times \frac{\text{Hours used per day}}{\text{Hours}} \times \frac{\text{Days per month}}{\text{days}} = \frac{\text{Total energy used}}{\text{Wh}} \frac{\text{Wh}}{\text{month}}$$

Convert total energy used to kWh: $\frac{\text{Wh}}{\text{month}} \times \frac{1\text{kWh}}{1000\text{Wh}} = \frac{\text{kWh}}{\text{month}}$

Economic cost:

$$\frac{\text{Total energy used}}{\text{kWh}} \frac{\text{kWh}}{\text{month}} \times \frac{\text{Rates from provider}}{\text{\$/kWh}} = \frac{\text{Total cost}}{\text{\$/month}}$$

Environmental cost:

Convert total energy used to MWh:

$$\frac{\text{kWh}}{\text{month}} \times \frac{1\text{MWh}}{1000\text{kWh}} = \frac{\text{MWh}}{\text{month}}$$

Calculate CO₂ emissions:

$$\frac{\text{Total energy used}}{\text{MWh}} \times \frac{\text{Emissions factor from provider}}{\text{lbCO}_2/\text{MWh}} = \frac{\text{Total CO}_2 \text{ emissions}}{\text{lbCO}_2/\text{month}}$$

Example 2: Lamp



Marie's room has a lamp with an LED light bulb that has a power rating of **10W**. If she uses her lamp every evening for **3 hours**, what are the economic and environmental costs of running the light for a **month of 30 days**?



Total energy used by Marie's lamp:

$$\frac{\text{Power}}{\text{W}} \times \frac{\text{Hours used per day}}{\text{Hours}} \times \frac{\text{Days per month}}{\text{day}} \times \frac{\text{days}}{\text{month}} = \frac{\boxed{}}{\text{Total energy used}} \frac{\text{Wh}}{\text{month}}$$

Convert total energy used to kWh: $\rightarrow \boxed{} \frac{\text{Wh}}{\text{month}} \times \frac{1\text{kWh}}{1000\text{Wh}} = \boxed{} \frac{\text{kWh}}{\text{month}}$

Economic cost:

$$\frac{\boxed{}}{\text{Total energy used}} \frac{\text{kWh}}{\text{month}} \times \frac{\text{Rates from provider}}{\frac{\$}{\text{kWh}}} = \frac{\$}{\text{Total cost}} \frac{\$}{\text{month}}$$

Environmental cost:

Convert total energy used to MWh:

$$\rightarrow \boxed{} \frac{\text{kWh}}{\text{month}} \times \frac{1\text{MWh}}{1000\text{kWh}} = \boxed{} \frac{\text{MWh}}{\text{month}}$$

Calculate CO₂ emissions:

$$\frac{\boxed{}}{\text{Total energy used}} \frac{\text{MWh}}{\text{month}} \times \frac{\text{Emissions factor from provider}}{\frac{\text{lbCO}_2}{\text{MWh}}} = \frac{\text{lbCO}_2}{\text{Total CO}_2 \text{ emissions}} \frac{\text{lbCO}_2}{\text{month}}$$

DID YOU KNOW?

An LED bulb can light up a room 21 times longer than a standard incandescent light bulb.

A single LED bulb can last for 50,000 hours.

Check out the "Check-It-Out!" kit from your local library, which was put together by the San Mateo County's Energy Watch program. It includes energy and water saving tools, and an LED light bulb you can keep!

Example 3: Air Conditioner

Andrew's three-bedroom house has a window air conditioner in each of the bedrooms, and another one for the living room. If each air conditioner has a power rating of **750 W**, how much does it cost Andrew and the environment to use the air conditioners for **a month** during the summer? Use Table 2 to think about the number of hours the air conditioners would be used, then calculate the costs.

Real-life calculations require making some assumptions about details. Consider the following questions before moving on to Table 2:

- Do you think Andrew runs all the air conditioners in each room at the same time?
- How many hours does each air conditioner get used? Make an estimate for each one.
- Do you think the number of hours the air conditioners get used differ between weekdays and weekends?

Table 2: Usage of Air Conditioners in Andrew's House

	Hours per day an air conditioner is used in each room					Days per month	Total hours per month
	Bedroom 1	Bedroom 2	Bedroom 3	Living room	Total hours each day		
Weekday						x 22 (Weekdays/month)	
Weekend						x 8 (Weekend days/month)	
						Total	

Total energy usage of the appliance for four weeks:

$$\frac{\text{Power}}{\text{W}} \times \frac{\text{Total hours used}}{\text{month}} = \frac{\text{Total energy used}}{\text{Wh}} \frac{\text{Wh}}{\text{month}}$$

Convert total energy used to kWh: $\frac{\text{Wh}}{\text{month}} \times \frac{1\text{kWh}}{1000\text{Wh}} = \frac{\text{kWh}}{\text{month}}$

Economic cost:

$$\frac{\text{Total energy used}}{\text{kWh}} \times \frac{\text{Rates from provider}}{\text{\$/kWh}} = \frac{\text{Total cost}}{\text{\$/month}}$$

Environmental cost:

Convert total energy used to MWh:

$$\frac{\text{kWh}}{\text{month}} \times \frac{1\text{MWh}}{1000\text{kWh}} = \frac{\text{MWh}}{\text{month}}$$

Calculate CO₂ emissions:

$$\frac{\text{Total energy used}}{\text{MWh}} \times \frac{\text{Emissions factor from provider}}{\text{lbCO}_2/\text{MWh}} = \frac{\text{Total CO}_2 \text{ emissions}}{\text{lbCO}_2/\text{month}}$$

Example 4: Computer

Compare the following estimates of energy usage of a typical desktop computer, both while in use and in standby mode (commonly called “vampire draw”). **Vampire draw** is the electricity used by appliances that are left plugged in, even when they are not in use.

In use	Vampire draw
Power: 170 W	Power: 2.4 W

Calculate the total electricity usage for the desktop computer for **one month**, assuming it stays plugged in even when not in use. You will need to estimate the number of hours you use your computer.

Table 3: Typical Usage of Your Computer for One Month

Usage	Weekday usage (hours per day)	Weekend usage (hours per day)	
Total usage for typical day			
Multiplied by number of days	× 22	× 8	Grand Total (hours per month)
Total usage for one month			<input type="text"/>

You left the computer plugged in for the remaining hours. Let's calculate the number of hours in the month the computer performs vampire draw:

$$720 \frac{\text{hours}}{\text{month}} - \frac{\text{Total energy used}}{\text{month}} = \frac{\text{Total hours for "vampire draw"}}{\text{month}}$$

Example 4: Computer (continued)



Total energy usage of the appliance for one month:

Calculate for “in use” power usage:

$$\frac{\text{Power}}{\text{W}} \times \frac{\text{Hours used per month}}{\text{hours}} = \frac{\text{Total energy used}}{\text{Wh month}}$$

Convert to kWh

$$\frac{\text{Wh}}{\text{month}} \times \frac{1\text{kWh}}{1000\text{Wh}} = \frac{\text{kWh}}{\text{month}}$$

Calculate for “vampire draw”:

$$\frac{\text{Power}}{\text{W}} \times \frac{\text{Hours of vampire draw per month}}{\text{hours}} = \frac{\text{Total energy drawn}}{\text{Wh month}}$$

Convert to kWh

$$\frac{\text{Wh}}{\text{month}} \times \frac{1\text{kWh}}{1000\text{Wh}} = \frac{\text{kWh}}{\text{month}}$$

Economic cost of usage:

$$\frac{\text{Total energy used}}{\text{kWh month}} \times \frac{\text{Rates from provider}}{\text{\$/kWh}} = \frac{\text{Total cost}}{\text{\$/month}}$$

Economic cost of “vampire draw”:

$$\frac{\text{Total energy used}}{\text{kWh month}} \times \frac{\text{Rates from provider}}{\text{\$/kWh}} = \frac{\text{Total cost}}{\text{\$/month}}$$

According to the U.S. Census Bureau⁶, there are 278,074 homes in San Mateo County as of 2017. Assuming there is 1 desktop computer that gets used like your computer each month in each home, calculate the costs of using the computer and for the vampire draw:

Usage cost for the whole county:

$$\frac{\text{\$/month}}{\text{month}} \times 278,074 = \frac{\text{\$/month}}{\text{month}}$$

Vampire draw cost for the whole county:

$$\frac{\text{\$/month}}{\text{month}} \times 278,074 = \frac{\text{\$/month}}{\text{month}}$$

Wondering just how much electricity your TV is sucking out in standby mode? What about that computer that’s “sleeping”?

Check out the “Check-It-Out!” kit from your local library, which was put together by the county’s Energy Watch program. It includes a Kill-A-Watt meter that helps you keep track of how much electricity your appliances are using. Ask your local librarian for more information about the “Check-It-Out” toolkit.

Example 5: Car

Did you know that the average American drives about **1,000 miles per month**? All that driving could be done using a gas car or an electric car. Gas cars are typically powered by burning gasoline obtained from gas stations. According to the U.S. Energy Information Administration (EIA), gasoline has a **19.60 lbCO₂/gallon emissions factor**⁷. Electric cars, on the other hand, are powered by electricity, and can be charged using charging stations installed at your home or at public locations. The emissions from using an electric car depend on the electricity provider.

Compare the costs of driving a gas car and an electric car for a month (1,000 miles driven).

Driving a gas car (Honda Civic) for a month:

Gasoline usage:

$$\frac{\text{Total miles traveled}}{\text{Total usage of gasoline}} = \frac{\text{miles}}{\text{month}} \div \frac{33 \text{ miles}}{\text{gallon}}$$

Average miles the car can travel with a gallon of gas
↓

$$= \frac{\text{gallon}}{\text{month}}$$

Economic cost:

$$\frac{\text{Total usage of gasoline}}{\text{Total cost}} = \frac{\text{gallon}}{\text{month}} \times \frac{\text{Estimate the current gas price in the Bay Area}}{\text{gallon}} = \frac{\$}{\text{month}}$$

Environmental cost:

Calculate CO₂ emissions:

$$\frac{\text{Total usage of gasoline}}{\text{Total CO}_2 \text{ emissions}} = \frac{\text{gallon}}{\text{month}} \times \frac{\text{Emissions factor from EIA}}{19.6 \text{ lbCO}_2/\text{gallon}} = \frac{\text{lbCO}_2}{\text{month}}$$

Driving an electric car (Chevy Bolt) for a month:

Electricity usage:

$$\frac{\text{Total miles traveled}}{\text{Total usage of electricity}} = \frac{\text{miles}}{\text{month}} \div \frac{3.8 \text{ miles}}{\text{kWh}}$$

Average miles the car can travel with a kWh of energy
↓

$$= \frac{\text{kWh}}{\text{month}}$$

Economic cost:

$$\frac{\text{Total usage of electricity}}{\text{Total cost}} = \frac{\text{kWh}}{\text{month}} \times \frac{\text{Add rate from provider}}{\text{kWh}} = \frac{\$}{\text{month}}$$

Environmental cost:

Convert total energy used to MWh:

$$\frac{\text{Total usage of electricity}}{\text{Total energy used}} = \frac{\text{kWh}}{\text{month}} \times \frac{1 \text{ MWh}}{1000 \text{ kWh}} = \frac{\text{MWh}}{\text{month}}$$

Calculate CO₂ emissions:

$$\frac{\text{Total energy used}}{\text{Total CO}_2 \text{ emissions}} = \frac{\text{MWh}}{\text{month}} \times \frac{\text{Emissions factor from provider}}{\text{MWh}} = \frac{\text{lbCO}_2}{\text{month}}$$

1. How much more does it cost in dollars to drive a gasoline car? _____
2. How much more does it cost in pounds of CO₂ to drive a gasoline car? _____

PART III: LET'S PUT IT ALL TOGETHER

Instructions: Go back to where you calculated costs for Fernando's refrigerator, Marie's lamp, Andrew's air conditioners, and the Chevy Bolt. Enter those numbers in this chart so we can look at the big picture. Pay attention to the units if you are unsure which numbers to put here.



Table 4: Comparison of Total Cost in Dollars and Pounds of CO₂ from One Month of Appliance Usage.

	Total Hours or Mileage	Total Energy	RATE	Total \$	Total Energy	EMISSIONS FACTOR	Total Emissions
Appliance	$\frac{\text{Hours or Miles}}{\text{month}}$	$\frac{\text{kWh}}{\text{month}}$	$\frac{\$}{\text{kWh}}$	$\frac{\$}{\text{month}}$	$\frac{\text{MWh}}{\text{month}}$	$\frac{\text{lbCO}_2}{\text{MWh}}$	$\frac{\text{lbCO}_2}{\text{month}}$
500W Refrigerator							
10W Lamp							
750W Air Conditioner							
Chevy Bolt							
Totals		$\frac{\text{kWh}}{\text{month}}$		$\frac{\$}{\text{month}}$	$\frac{\text{MWh}}{\text{month}}$		$\frac{\text{lbCO}_2}{\text{month}}$

Which provider and plan did you use to do the calculations above? Circle one: PG&E Regular Peninsula Clean Energy ECOplus

Now, find the RATE and EMISSIONS FACTOR for the plan you did not use. Write the new rate and emissions factors in the chart below and recalculate the costs using the other plan. Copy the total kWh/month and MWh/month from the chart above.



	Total Hours or Mileage	Total Energy	RATE	Total \$	Total Energy	EMISSIONS FACTOR	Total Emissions
Appliance	$\frac{\text{Hours or Miles}}{\text{month}}$	$\frac{\text{kWh}}{\text{month}}$	$\frac{\$}{\text{kWh}}$	$\frac{\$}{\text{month}}$	$\frac{\text{MWh}}{\text{month}}$	$\frac{\text{lbCO}_2}{\text{MWh}}$	$\frac{\text{lbCO}_2}{\text{month}}$
500W Refrigerator							
10W Lamp							
750W Air Conditioner							
Chevy Bolt							
Totals		$\frac{\text{kWh}}{\text{month}}$		$\frac{\$}{\text{month}}$	$\frac{\text{MWh}}{\text{month}}$		$\frac{\text{lbCO}_2}{\text{month}}$

LET'S SCALE IT UP

Let's do some estimation for the total cost of energy usage by residents in our whole county (San Mateo County). According to the U.S. Census Bureau, as of July 2017, there are **278,074 homes** (housing units) in San Mateo County. If each housing unit uses a typical amount of energy each month, **425 kWh**, what is the total economic and environmental cost of all homes in San Mateo County?



Total energy usage of all homes in San Mateo County:

$$\frac{\text{Typical energy usage per home}}{\text{home}} \frac{\text{kWh}}{\text{month}} \times \frac{\text{Total number of homes}}{\text{homes}} = \frac{\text{Total energy used}}{\text{Total energy used}} \text{ kWh}$$

Calculate using PG&E regular rates:

Economic cost:

$$\frac{\text{Total energy used}}{\text{Total energy used}} \frac{\text{kWh}}{\text{month}} \times \begin{matrix} \text{Rates from PG\&E} \\ \downarrow \\ 0.24992 \end{matrix} \frac{\$}{\text{kWh}} = \frac{\text{Total cost}}{\text{Total cost}} \frac{\$}{\text{month}}$$

Environmental cost:

Convert total energy used to MWh:

$$\frac{\text{Total energy used}}{\text{Total energy used}} \frac{\text{kWh}}{\text{month}} \times \frac{1 \text{ MWh}}{1000 \text{ kWh}} = \frac{\text{Total energy used}}{\text{Total energy used}} \frac{\text{MWh}}{\text{month}}$$

Calculate CO₂ emissions:

$$\frac{\text{Total energy used}}{\text{Total energy used}} \frac{\text{MWh}}{\text{month}} \times \begin{matrix} \text{Emissions factor} \\ \text{from provider} \\ \downarrow \\ 294 \end{matrix} \frac{\text{lbCO}_2}{\text{MWh}} = \frac{\text{Total CO}_2 \text{ emissions}}{\text{Total CO}_2 \text{ emissions}} \frac{\text{lbCO}_2}{\text{month}}$$

Now let's repeat the calculations. This time, use Peninsula Clean Energy's ECOplus rates:

Economic cost:

$$\frac{\text{Total energy used}}{\text{Total energy used}} \frac{\text{kWh}}{\text{month}} \times \begin{matrix} \text{Rates from Peninsula} \\ \text{Clean Energy} \\ \downarrow \\ 0.24432 \end{matrix} \frac{\$}{\text{kWh}} = \frac{\text{Total cost}}{\text{Total cost}} \frac{\$}{\text{month}}$$

Environmental cost:

Calculate CO₂ emissions:

$$\frac{\text{Total energy used}}{\text{Total energy used}} \frac{\text{MWh}}{\text{month}} \times \begin{matrix} \text{Emissions factor} \\ \text{from provider} \\ \downarrow \\ 130 \end{matrix} \frac{\text{lbCO}_2}{\text{MWh}} = \frac{\text{Total CO}_2 \text{ emissions}}{\text{Total CO}_2 \text{ emissions}} \frac{\text{lbCO}_2}{\text{month}}$$

What are the differences in environmental and economic costs between the two different electricity providers?



Why do you think it matters?



1. Which of the appliances you examined in this activity packet cost the most to use? Why?
2. What are some strategies that you might use in your home to reduce the economic and environmental costs of energy usage?
3. What do you think we can do, as a society, to reduce the economic and environmental costs of energy usage?
4. Home electricity usage on average spikes in the morning and evening when people are home. However, solar energy production is highest midday. What do you think we can do about this as a society?

Learn more about strategies to reduce the costs of energy usage with the San Mateo Office of Sustainability. One way to get involved is to get your school certified through the Green Star Schools program!

CITATIONS

1. <https://www.mercurynews.com/2017/09/01/bay-area-weather-scorching-temperatures-will-produce-hottest-days-in-a-decade/>
2. <http://seachangesmc.com/about/>
3. Refer to California Energy Commission's Renewables Portfolio Standard (RPS) Eligibility Handbook at <http://www.energy.ca.gov/renewables/documents/index.html#rps>
4. The emissions factor is updated with 2017 information for PG&E and updated with 2018 information for Peninsula Clean Energy.
5. A projected value based on the publicly shared emissions factor from 2013. Found here: https://www.pge.com/includes/docs/pdfs/shared/environment/calculator/pge_ghg_emission_factor_info_sheet.pdf
6. <https://www.census.gov/quickfacts/fact/table/sanmateocountycalifornia,ca/PST045217>
7. https://www.eia.gov/environment/emissions/co2_vol_mass.php



Peninsula Clean Energy, a community choice aggregator (CCA), is San Mateo County's official electricity provider. Formed in February 2016, Peninsula Clean Energy is a joint powers authority, consisting of the County of San Mateo and all twenty of its towns and cities. Peninsula Clean Energy provides cleaner and greener electricity at lower rates. Peninsula Clean Energy is also developing programs that include advancing the adoption of electric vehicles and transitioning building fossil fuel uses to low-carbon electricity. For more information on Peninsula Clean Energy, please go to www.peninsulacleanenergy.com.

Peninsula Clean Energy is committed to protecting customer privacy. Learn more at peninsulacleanenergy.com/privacy