Playing, Exploring, and Discovering: Figuring out how Electric Guitars Work

First things First:

What is the most basic physics of guitars?

They are generators

and generators transform motion into electricity

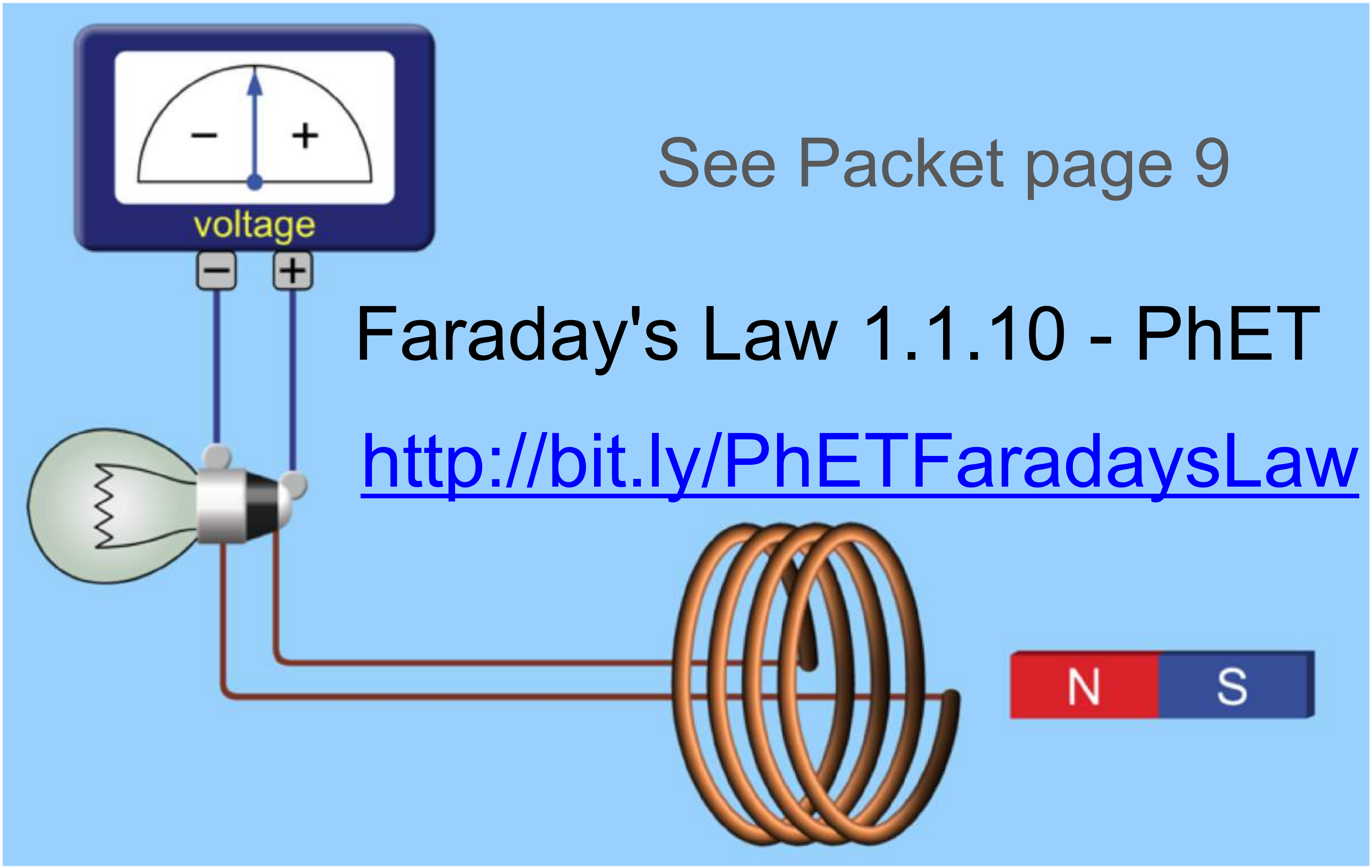
Playing, Exploring, and Discovering: Figuring out how Electric Guitars Work

Observe this…

What is happening?

How is this similar and different from the speaker?

Playing, Exploring, and Discovering: Figuring out how Electric Guitars Work



See Packet page 9

Faraday's Law 1.1.10 - PhET

http://bit.ly/PhETFaradaysLaw

Changing Magnetic Fields produces Electric Fields (current), the basis for generators, is definitely a Big Idea in Science.

Motors: Transform electricity into motion

Generators: Transform motion into electricity

A Speaker to Microphone
-- Motor to Generator --

Changing Magnetic Fields produces Electric Fields (current), the basis for generators, is definitely a Big Idea in Science.

Playing with this idea, what are wonderings that come to mind?

Let us brainstorm applications of this big idea in science? **How about charging a cell phone?**

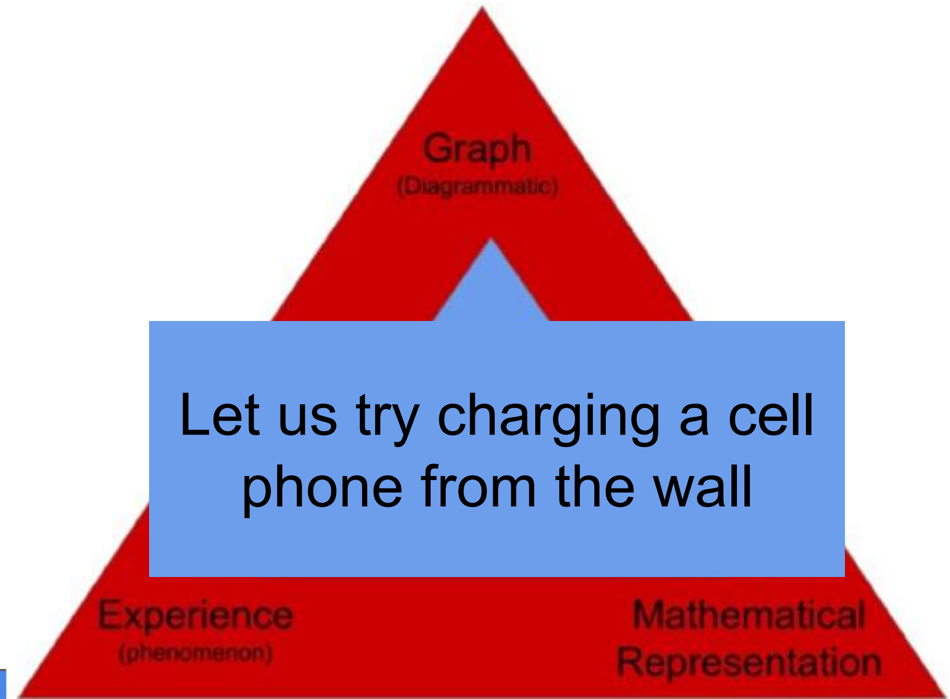
Design Solutions: How do you do this bigger and better?

Returning to our Inner Scientist Adventure

With this new knowledge, let us revisit our electricity model / water analogy to see how plugging in a cell phone to the wall to charge works.

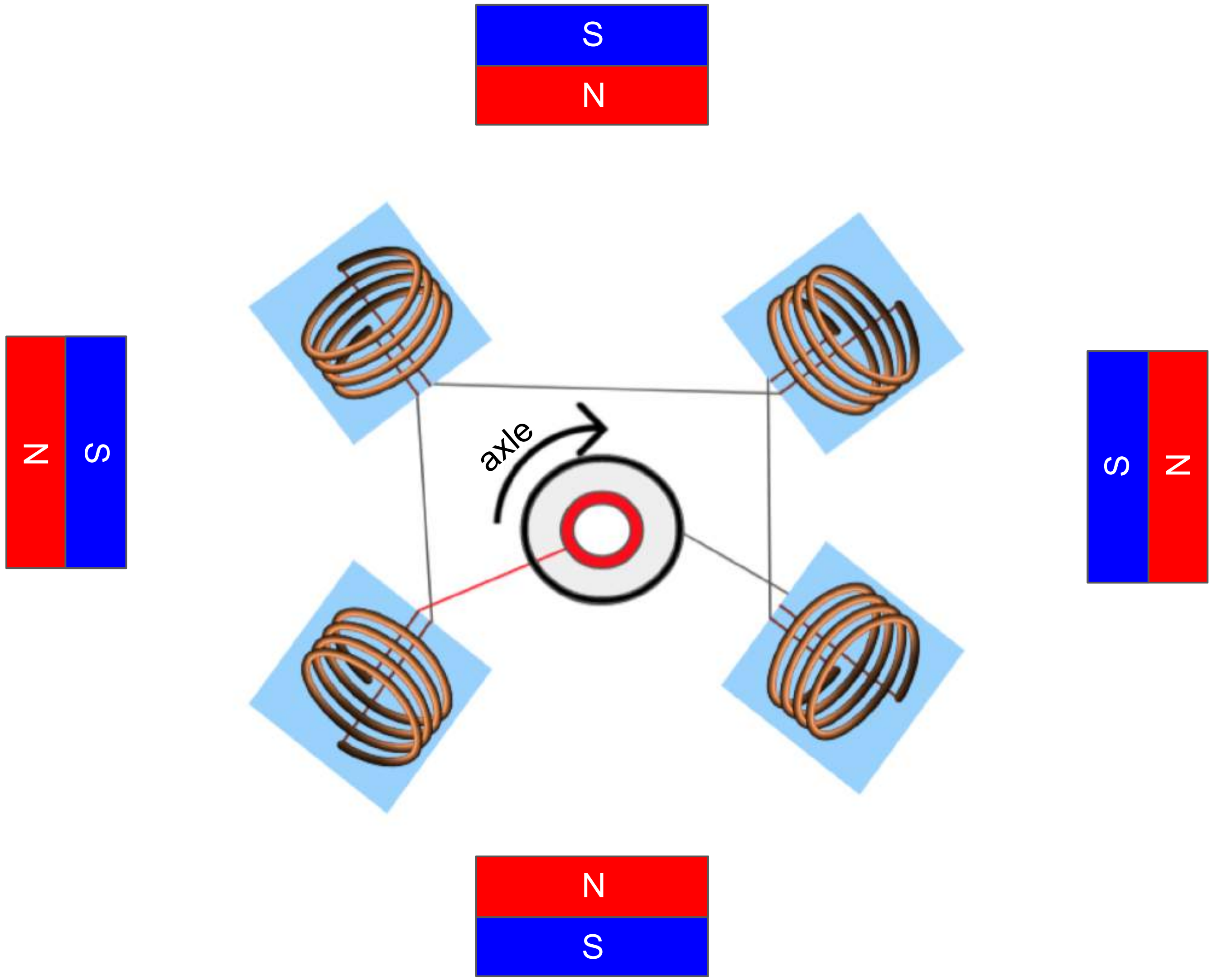
Focusing on:

- create useful diagrams

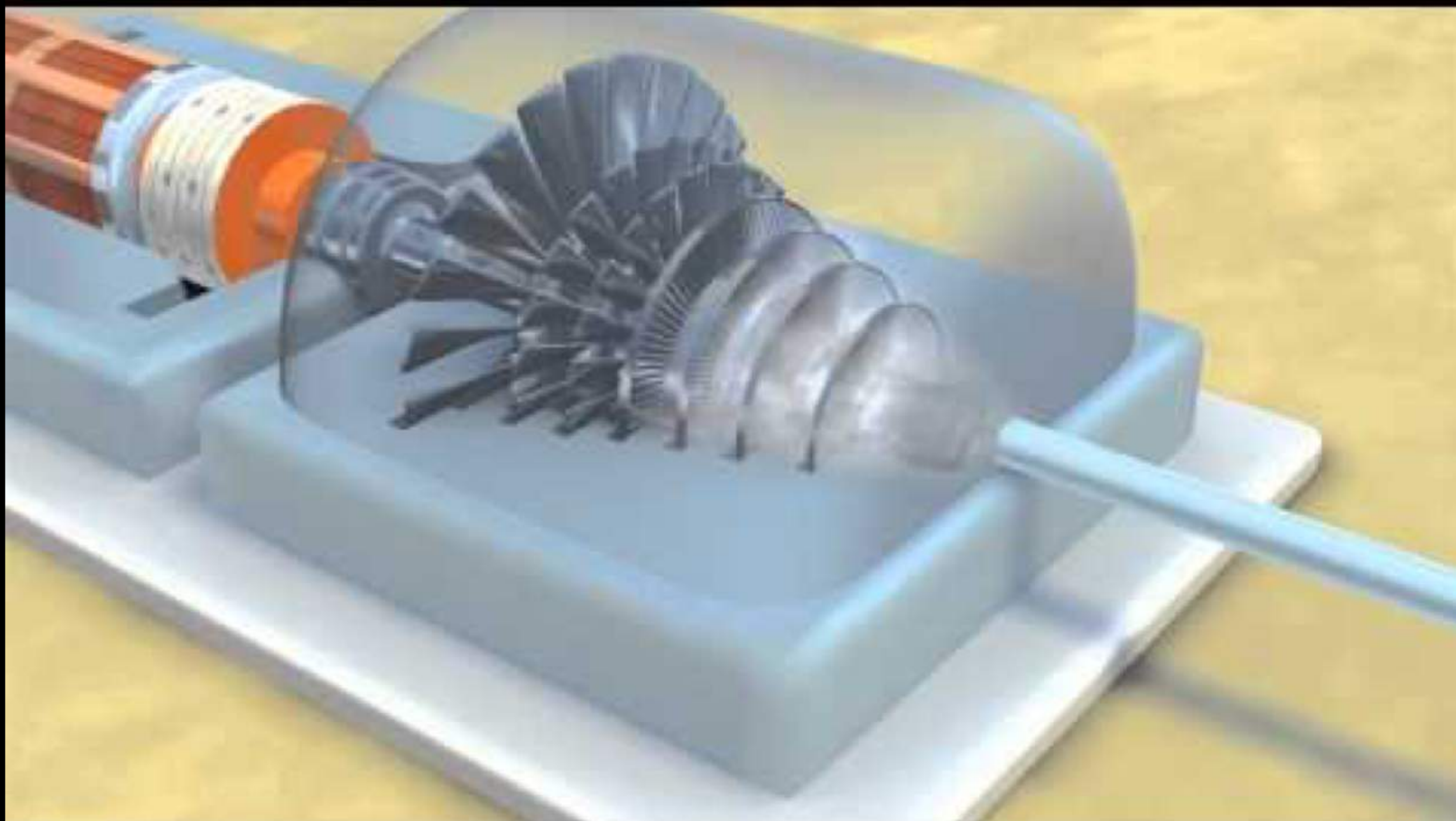


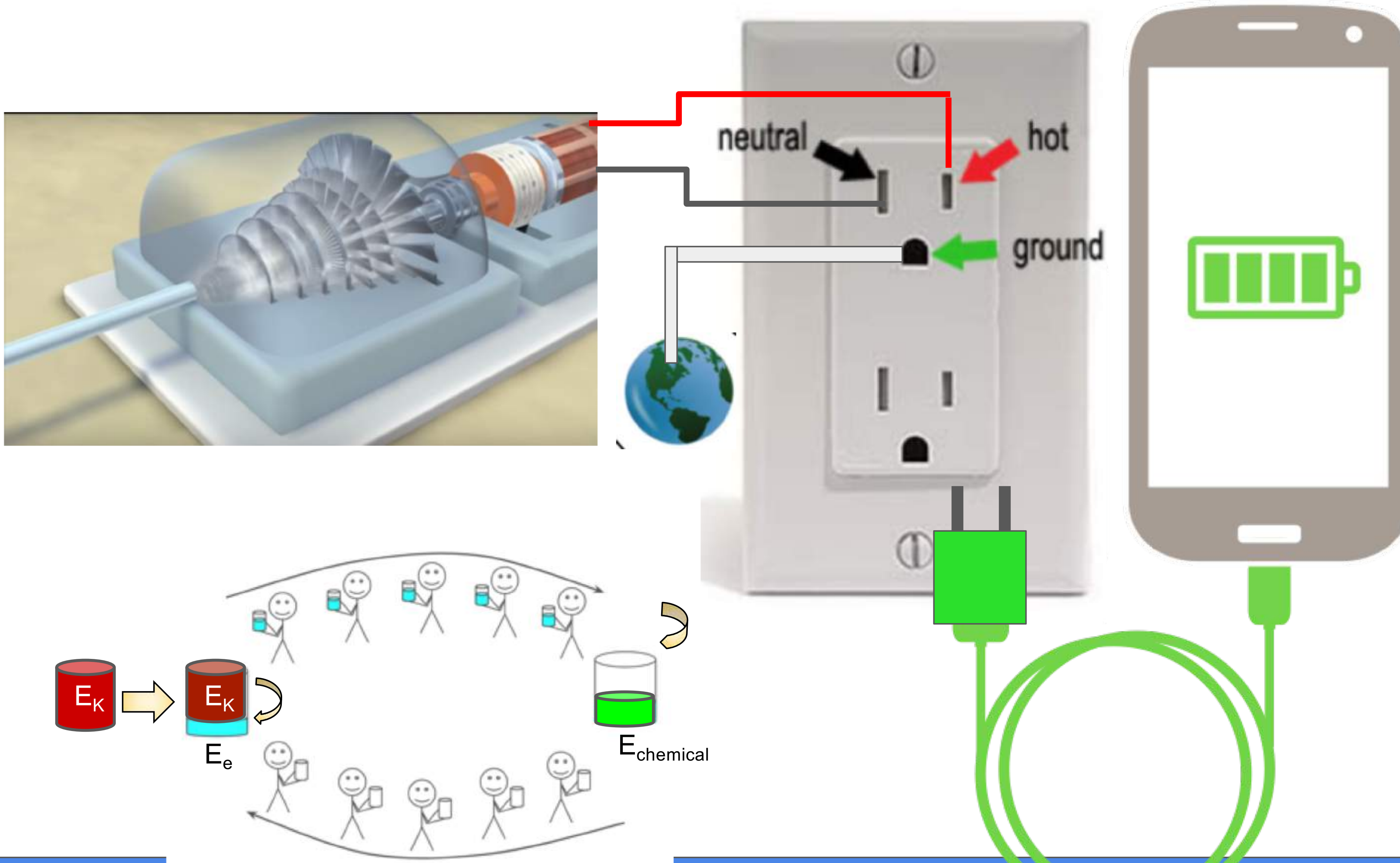
Let us try charging a cell phone from the wall

First, a step towards more efficiency



Then we need something to turn the axle US DoE: Geothermal powers Generators




neutral
hot
ground
E_K
E_K
E_e
$E_{chemical}$

By the End of this Activity You Should Be able to Answer:

Focus Question

How do electric guitars/generators work?

Language Focus

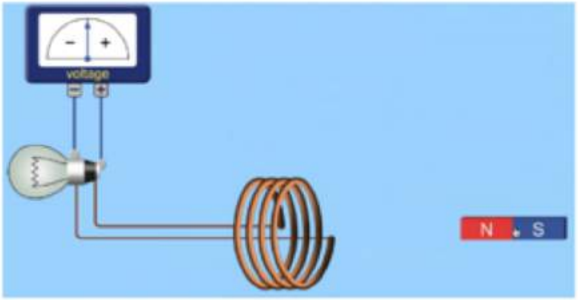
Be able to our technical terms from electricity and new ones we discover to explain the basic physics of how electric guitars/generators work.

We Need this in our 50 Year Energy Plan Report

*6EP

The Basic Physics of Electric Generators

The basics physics of electric generators ClickHereToType



Electricity, Magnetism, & Power Production - Day 5

Agenda:

Quiz on Basic Physics of
Motors & Generators

Scaling to Large Scale
Power Production

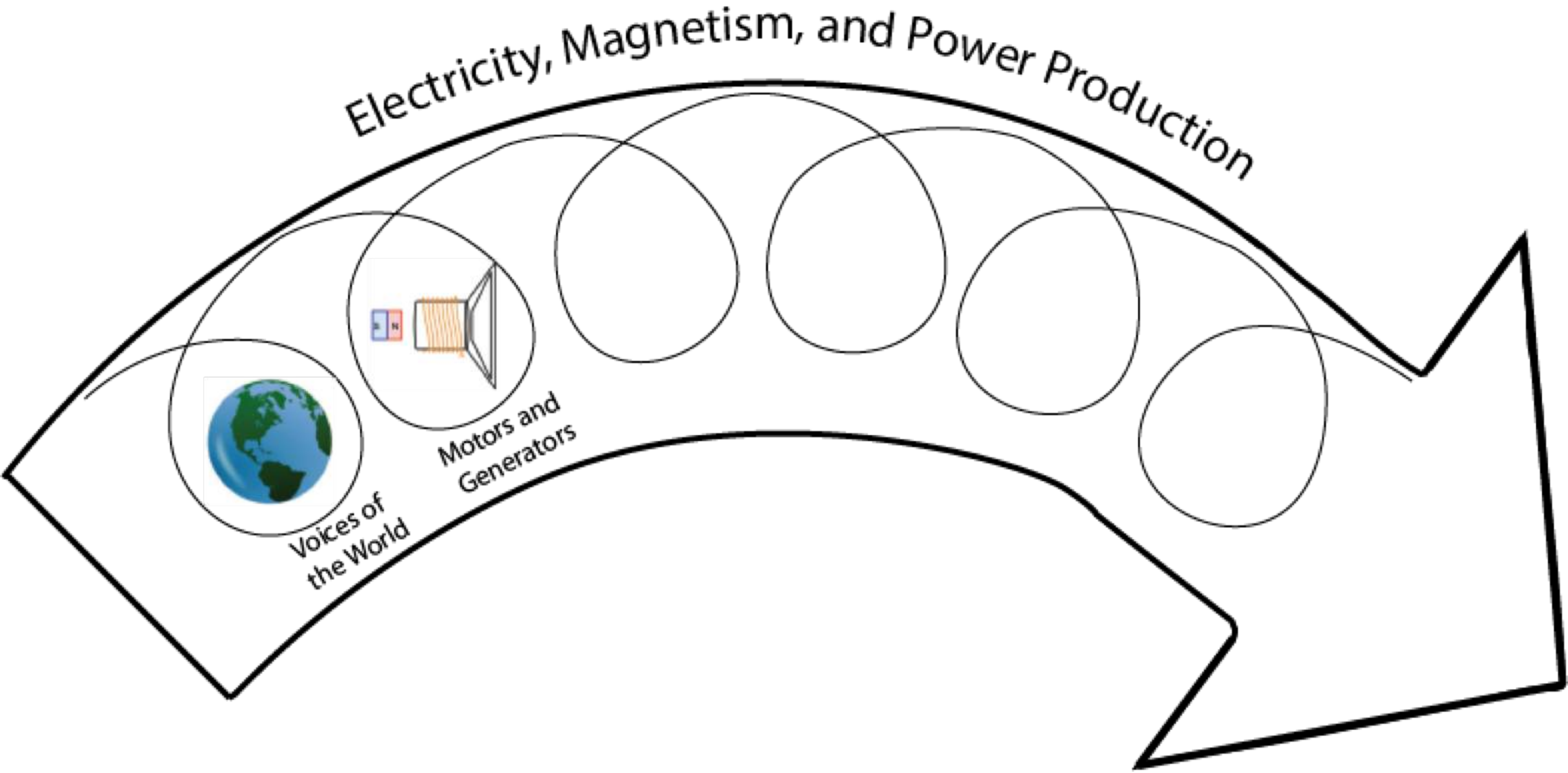
Due Next Class

Due This Class

Warm Up Question:

What are the key steps that must happen to force a motor to move?

What are the key steps that must happen to generate electricity?


Electricity, Magnetism, and Power Production
Voices of the World
Motors and Generators

6Q1 - Quiz on the Basic Physics of Motors & Generators

By the End of this Activity
You Should Be able to Answer:

Focus Question

Why is our large scale power production and distribution the way it is?

Language Focus

Be able to use the big ideas of electricity to explain the design of our large scale power grid.

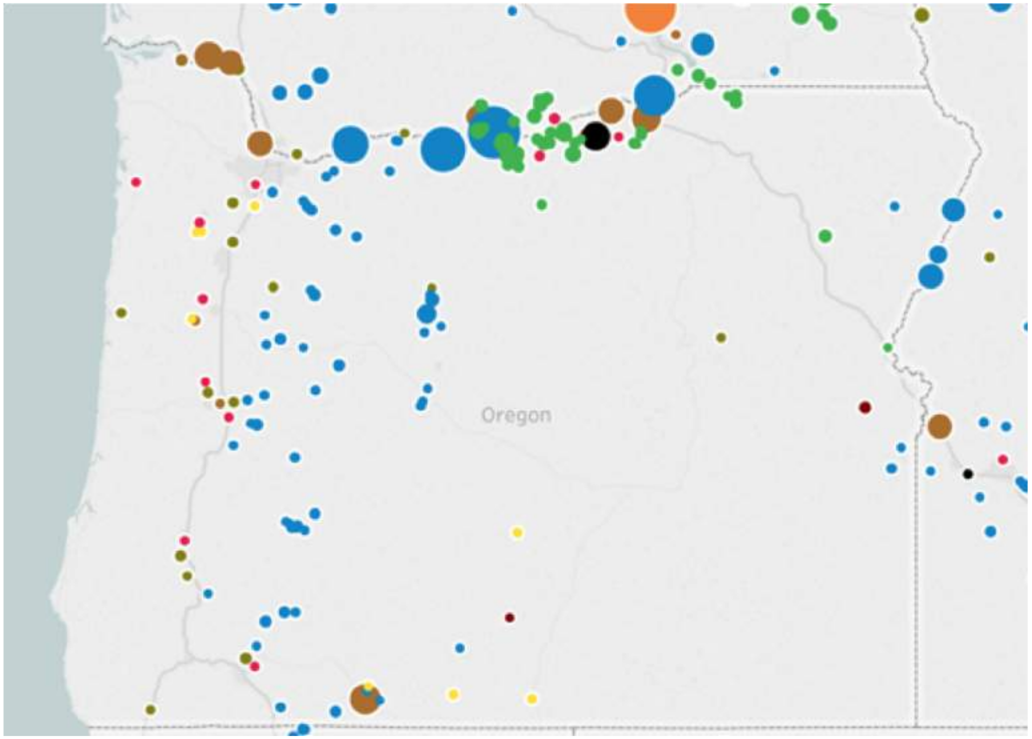
Large Scale Power Production is a Big, Complex Issue

At first you think putting a generator on every exercise bike and water downspout is going to supply us with enough electricity, until ….

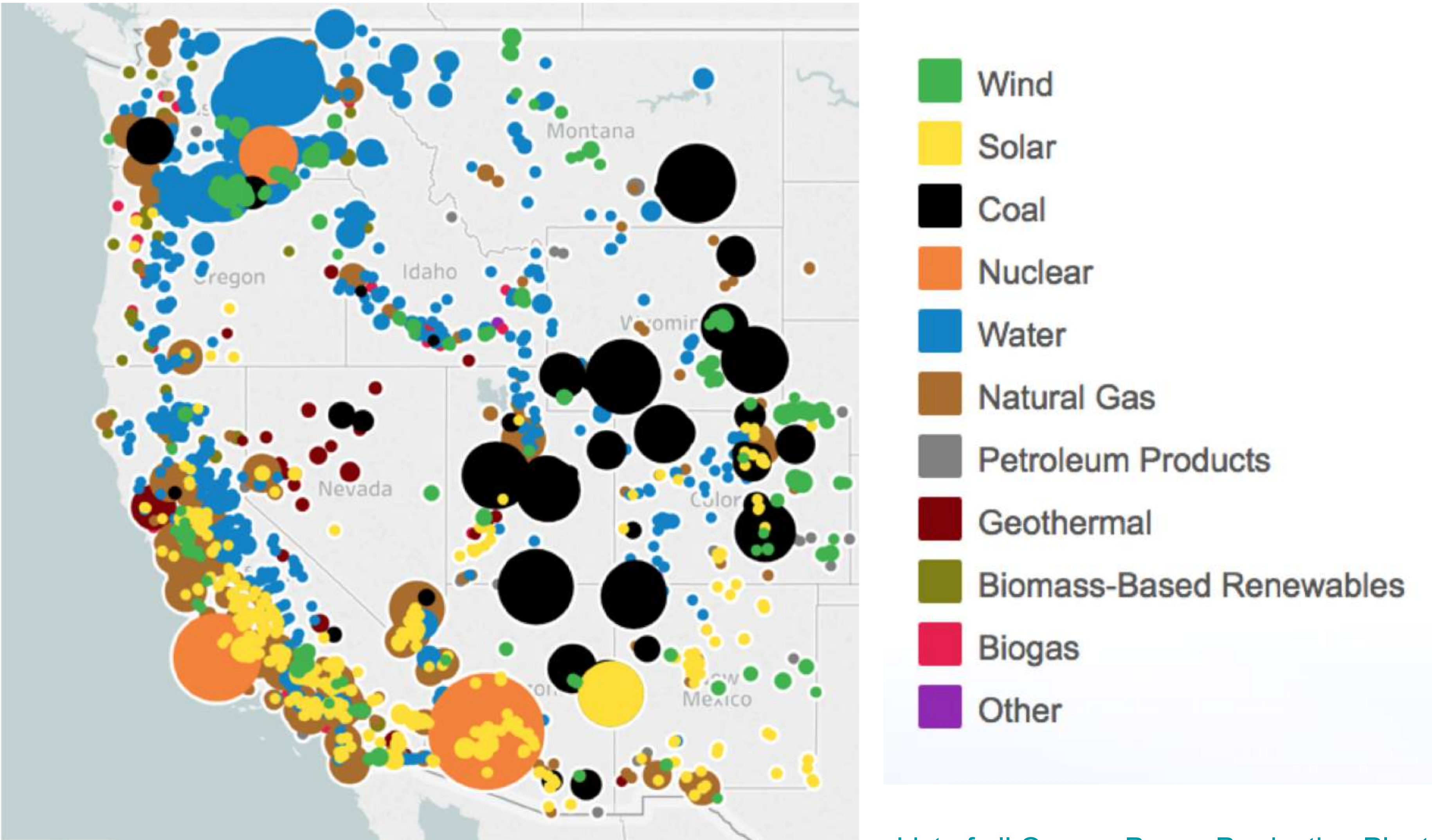
The need for Large Scale Power Production

But Big, Localized Power Production Creates its own Issues

What do you think?



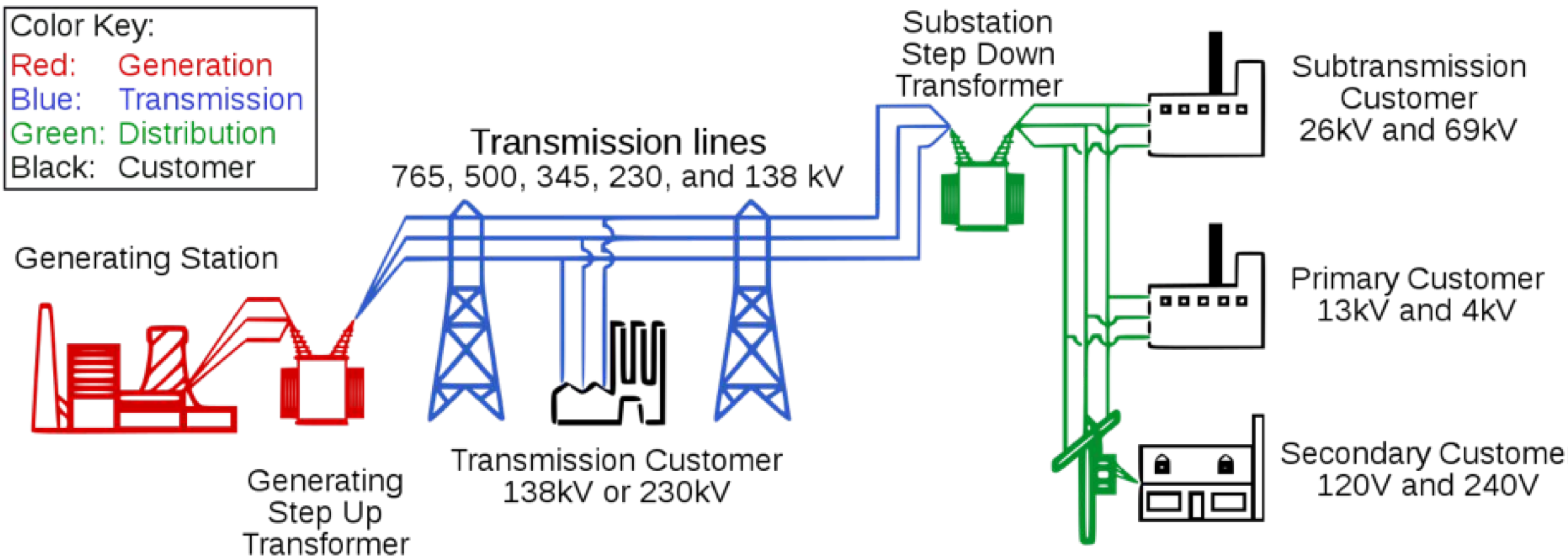
Power Production in the West (map linked)



List of all Oregon Power Production Plants

Other Considerations: A Better Grid

Power Production Distribution

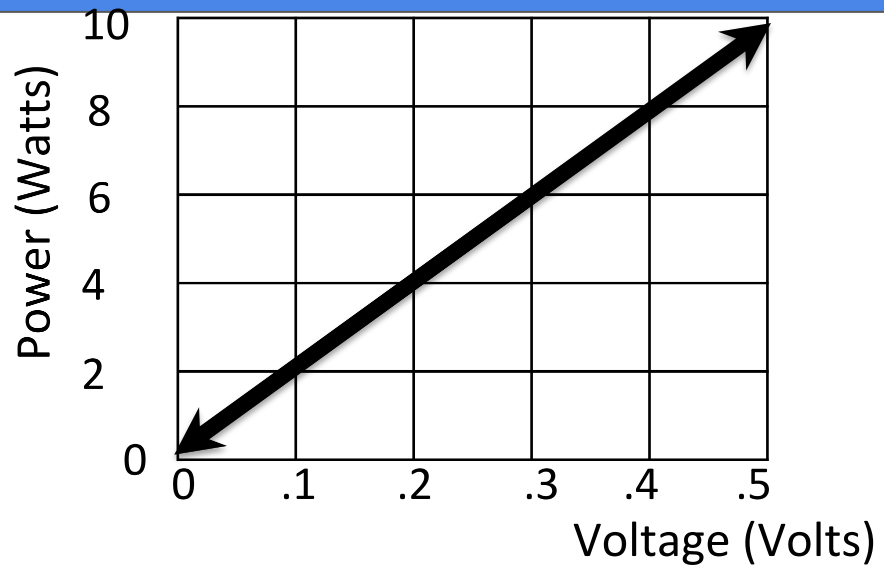


Source: http://www.ferc.gov/industries/electric/indus-act/reliability/blackout/ch1-3.pdf Page 13 Title:"Final Report on the August 14, 2003 Blackout in the United States and Canada" Dated April 2004. Accessed on 2010-12-25

Why use high voltage Power Lines?

With big localized power production you need to transfer the energy long distances, why the high voltage?

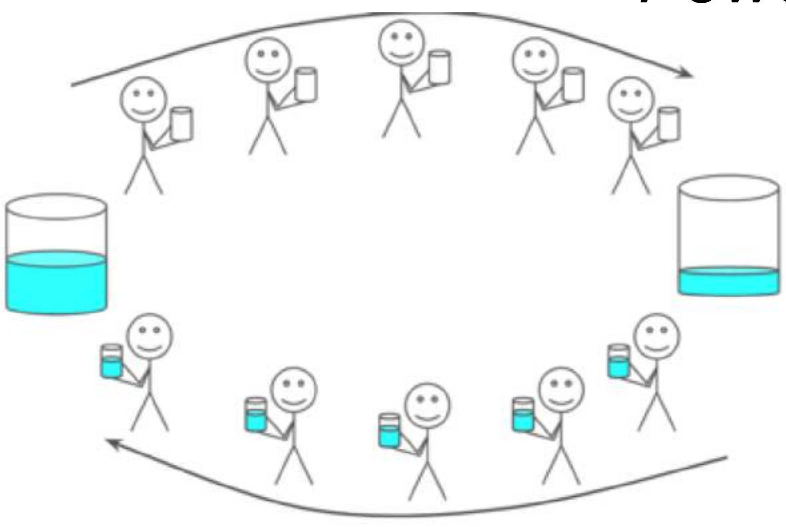
V	P
0.0	0
0.1	2
0.2	4
0.5	10



$P = IV$

Power

*Power = current * voltage*



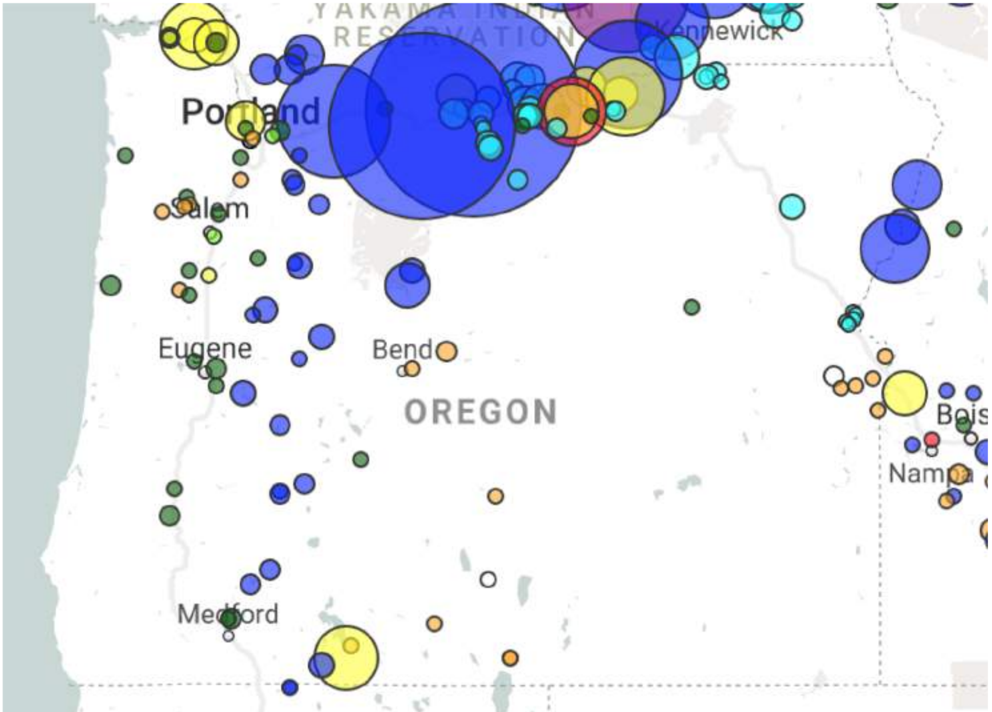
When:
voltage doubles
the energy per second doubles

Why use high voltage Power Lines?

With big localized power production you need to transfer the energy long distances, why the high voltage?

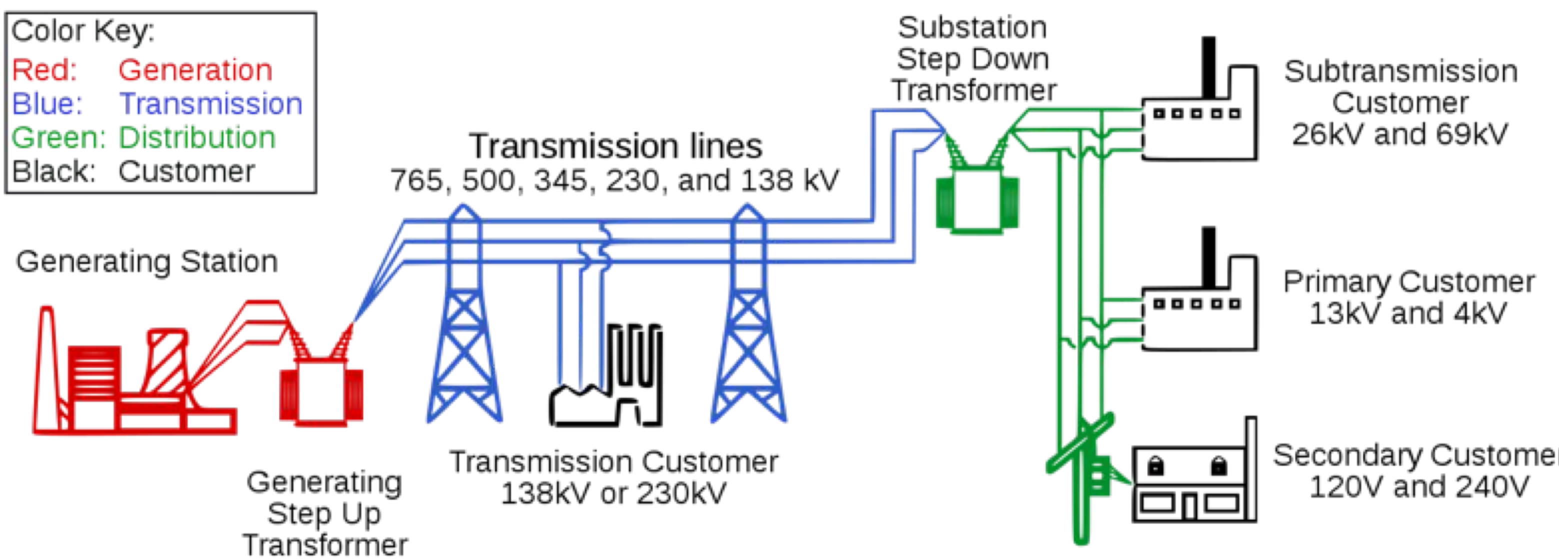
One consideration is that most wasted energy (dissipated energy) is heavily dependent on the amount of current (I) in the wires.

Second consideration is that supplying power is a combination of current and voltage from our P=IV.

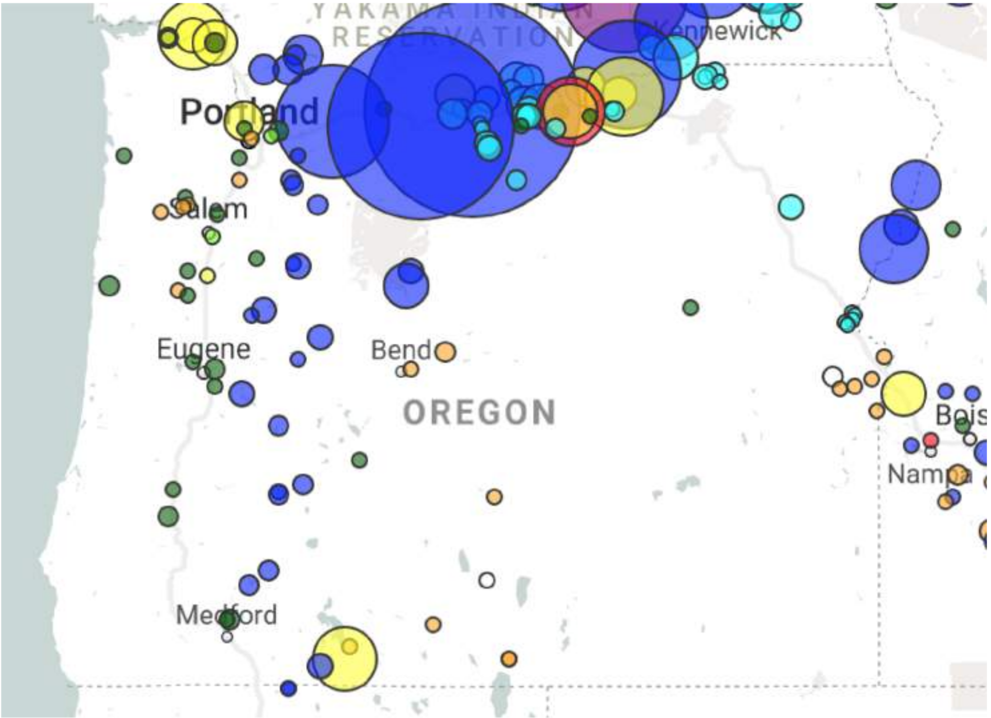


So to get Power, P the best solution is

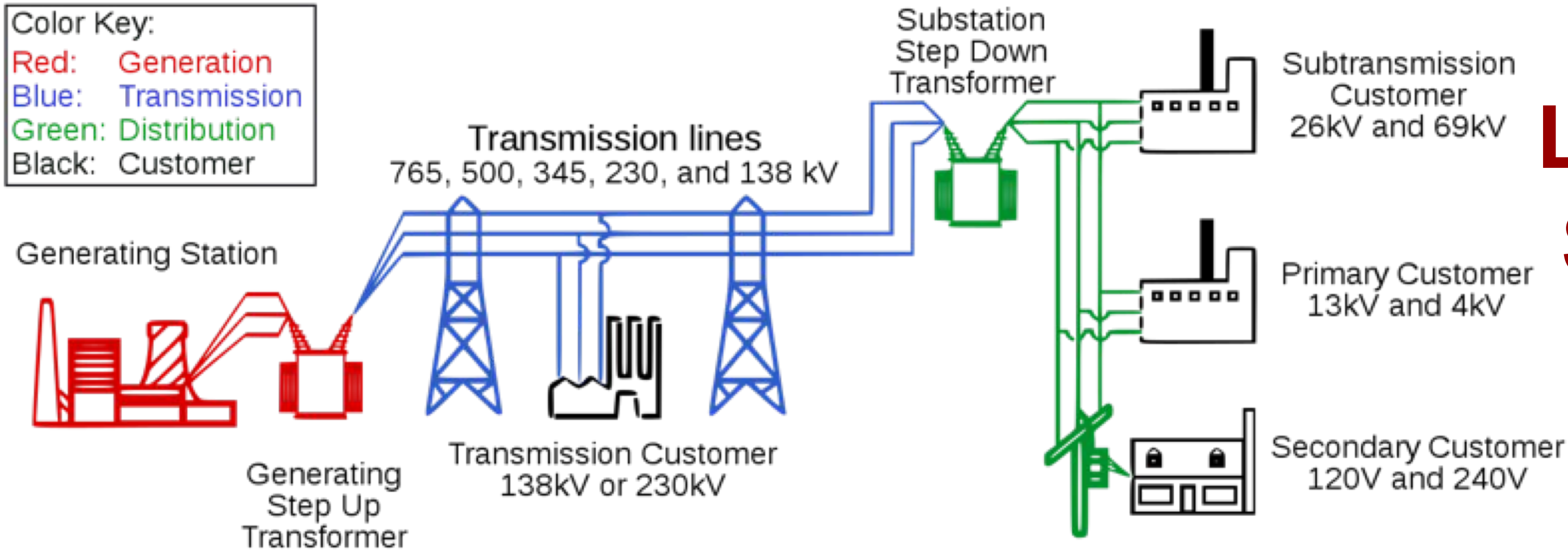
$$P = I V$$



Career Connection



So why use 120 V Power Lines?



Largely Safety

Check In:
You Should Be able to Answer:

Focus Question

What are the important considerations in large scale power production?

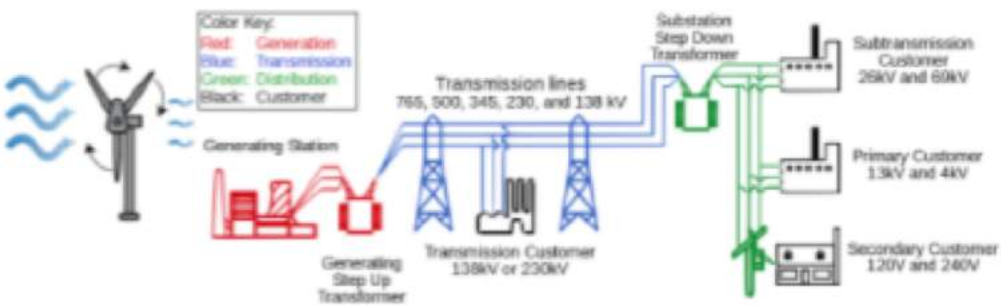
Language Focus

Be able to use the big ideas of electricity to explain the design of our large scale power grid.

We Need this in our 50 Year Energy Plan Report

Background on Large Scale Power Production, Distribution, and the Grid

Describe how our power grid works using the image as a guide. ClickHereToType



Challenge: Large Scale Power Production is Big, Complex Issue

[Watch Intro Video and Play NOVA's Energy Lab Simulation]

Electricity, Magnetism, & Power Production - Day 6

Agenda:

Finish Scaling to Large Scale
    Power Production

Engineering a Wind Turbine

Due Next Class

Data for Wind Turbine

Due This Class

Warm Up Question:

What are the three big ideas of the following video?

Other Considerations: Solving Storage

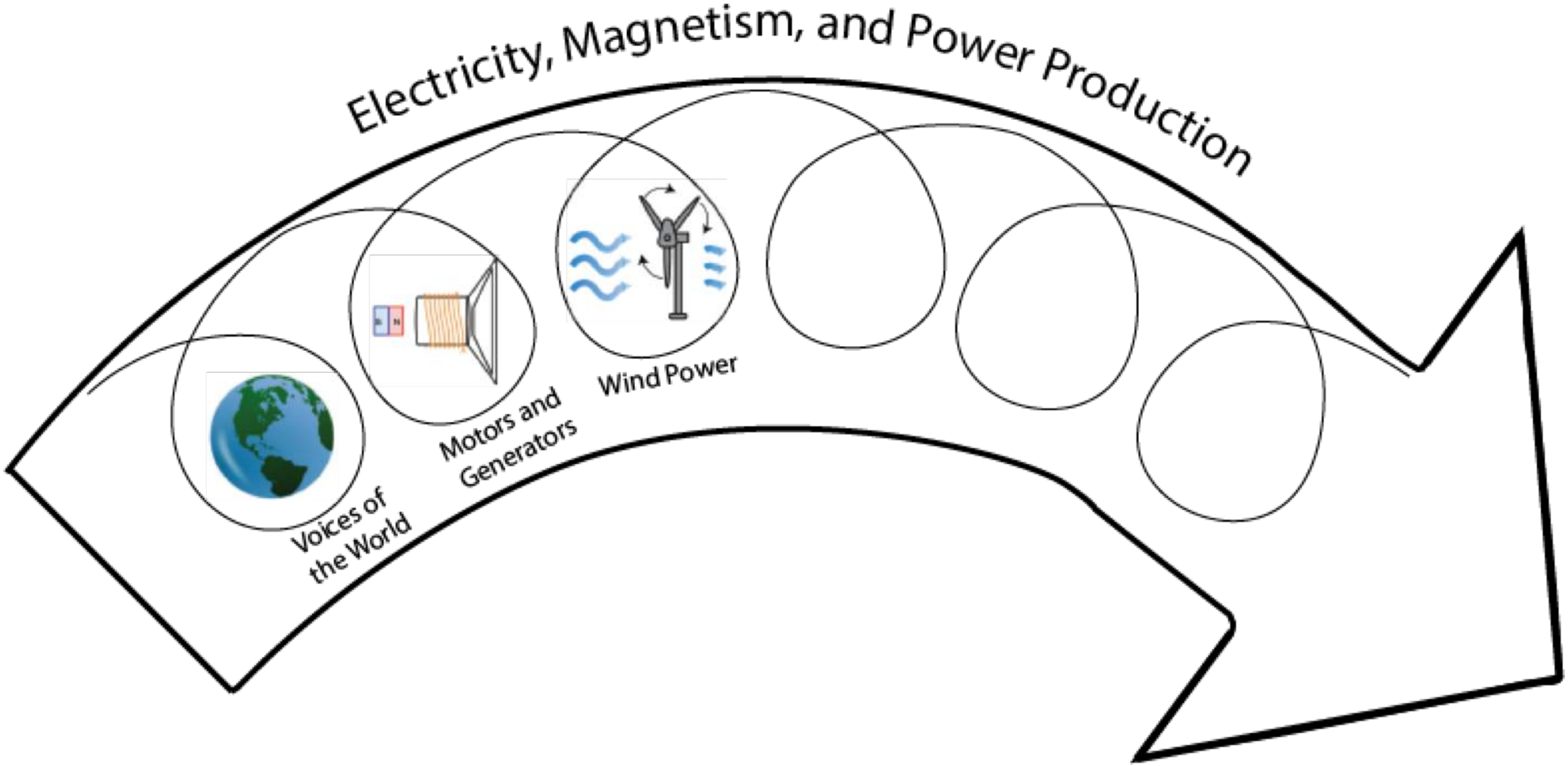
Finish Scaling to Large Scale Power Production

Some Quotes on Engineering

"I think one of the big challenges is actually cultivating beginners' minds and making sure you're still open to the world and continue to see new things. You can actually get jaded. You can stop seeing things that are new. You can start fearing failure. Those are the things an entrepreneur needs—an open mind and the ability to see the world with new eyes."

-- Caterina Fake, Co-Founder of Flickr and Hunch

The most important thing is to keep the most important thing the most important thing.


Electricity, Magnetism, and Power Production
Voices of the World
Motors and Generators
Wind Power

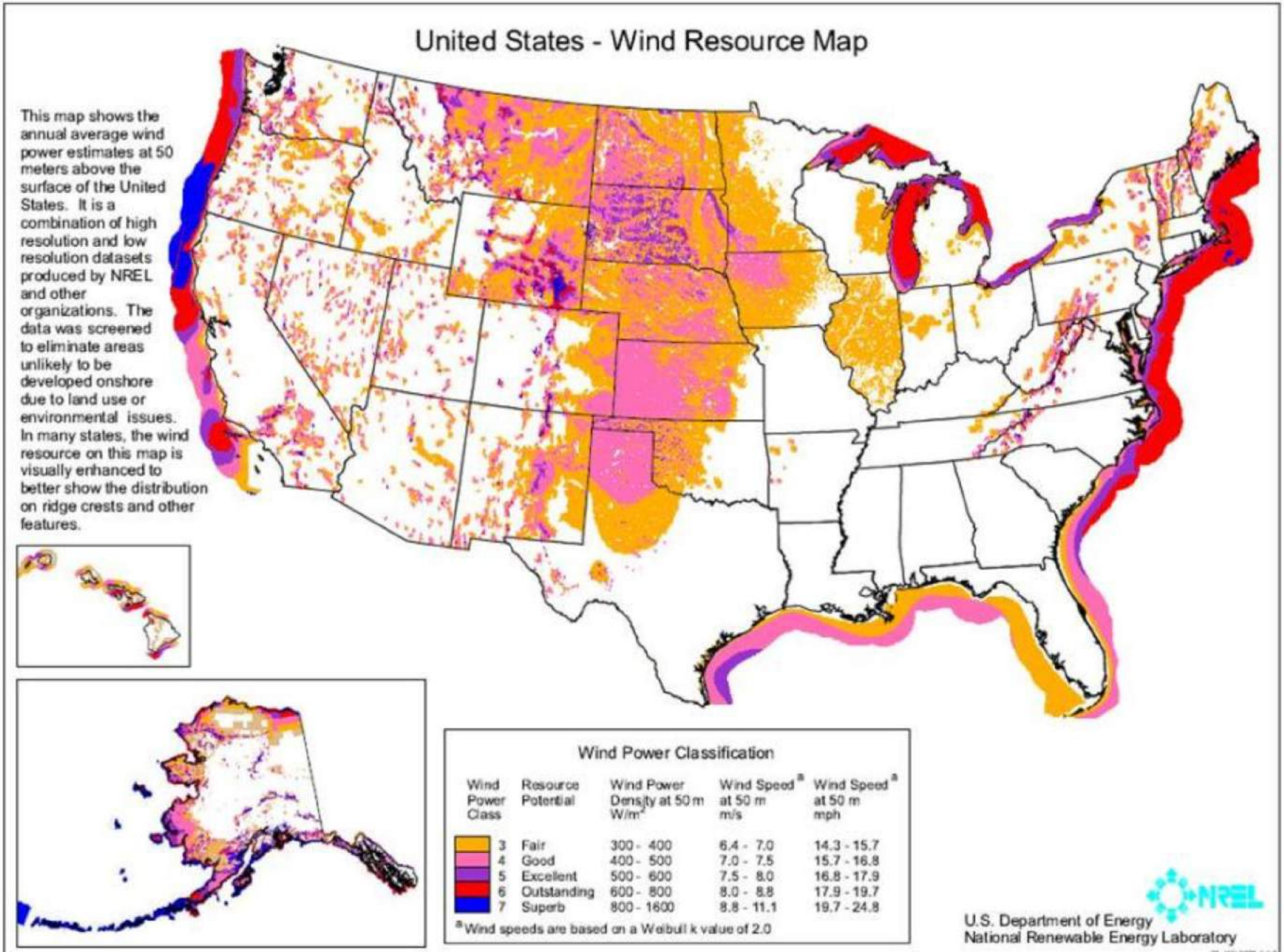
NOVA: Wind Power

Thinking through Wind Energy

Pros:

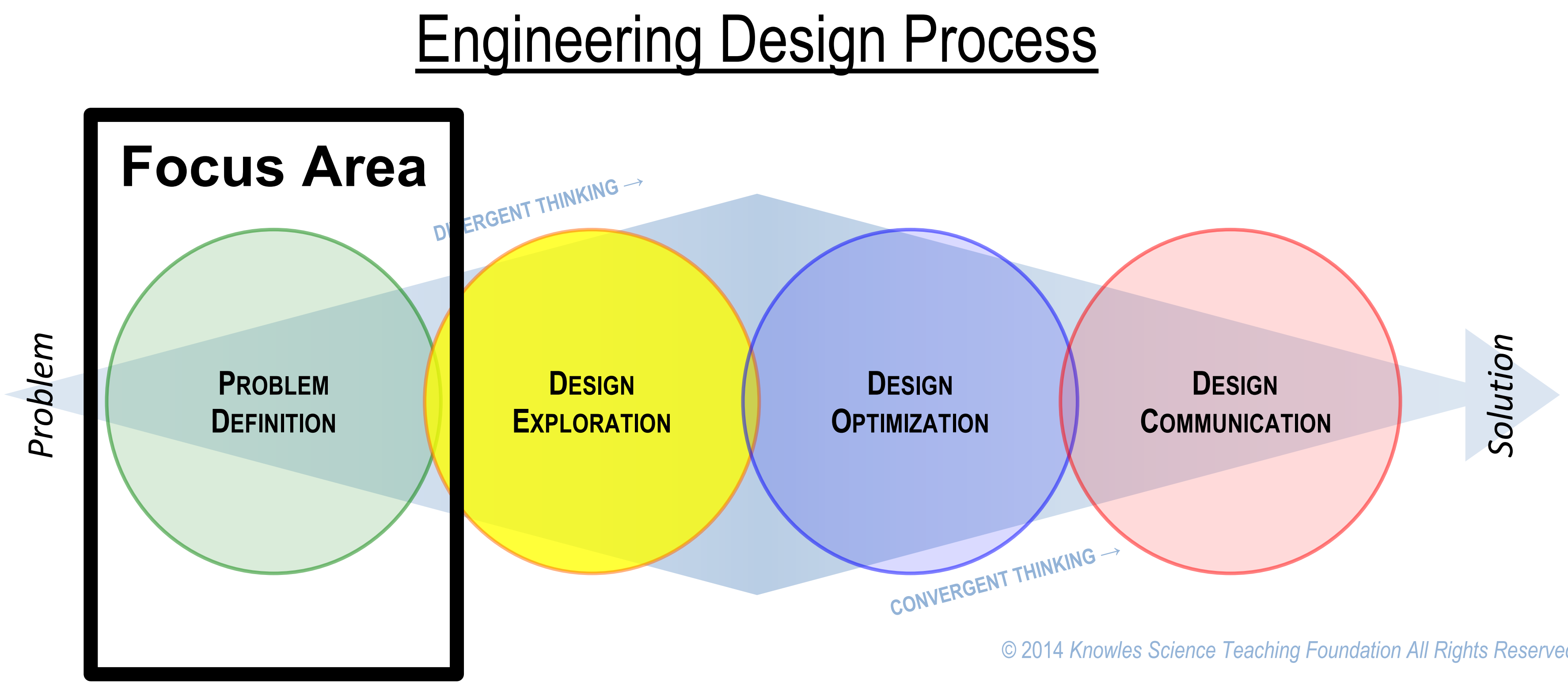
Cons:

write into your packet on bottom of Page 10


United States - Wind Resource Map
This map shows the annual average wind power estimates at 50 meters above the surface of the United States. It is a combination of high resolution and low resolution datasets produced by NREL and other organizations. The data was screened to eliminate areas unlikely to be developed onshore due to land use or environmental issues. In many states, the wind resource on this map is visually enhanced to better show the distribution on ridge crests and other features.
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m²
Wind Speed[a] at 50 m m/s
Wind Speed[a] at 50 m mph
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb 800 - 1600 8.8 - 11.1 19.7 - 24.8
[a] Wind speeds are based on a Weibull k value of 2.0
NREL
U.S. Department of Energy
National Renewable Energy Laboratory

Engineering a Wind Turbine

Cooper Mountain Nature Park Wind Turbine Project



Problem Definition
--Request for Proposal--

Check your comprehension:

1. Skim over Page 11
   - 3 sections – at least 3 big ideas
2. Now scan the rest of Wind Turbine documentation to make sure it makes sense.

1. Check In: Why 1 data table with graph, then 3 more graphs?

Cooper Mountain Nature Park Wind Turbine Project

Read on page 11 of Packet

Request for Proposal:

Beaverton Public Works is accepting bids, until ________, to refine the blade design of a wind turbine that increases power production for the Cooper Mountain Nature House within Cooper Mountain Nature Park. The wind turbine currently produces only 2 Watts (W) but to reach their energy goal of net neutral the wind turbine must generate at least 5 W. Additional production is desirable as a future cost saving measure.

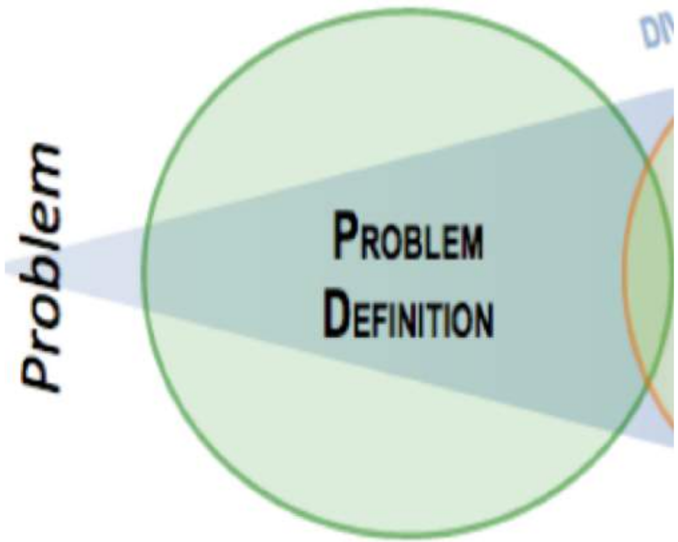
Cooper Mountain Nature Park Wind Turbine Project

Read on page 11 of Packet

Request for Proposal (Part 2):

Beaverton Public Works Engineers did an initial investigation of the site before the original installation, in which they measured a nearly constant wind speed of 8 (± 2) m/s from the west at the site of the wind turbine during operation times. Additionally, Beaverton Public Works Engineers have measured maximum wind gusts at this location of 14 (± 2) m/s from the southwest. To justify the redesign and ensure its success, the design recommendation report will need to display test data for the energy output for at least 4 different blade design parameters. The Beaverton City Council has approved $75,000 for the completed project and prefers that materials, as much as possible, be sourced locally to reduce the environmental impact of shipping materials long distances.

Getting a Handle on our Current Challenge



Write a clear, focused <u>statement of the design problem</u>:

We as (role) seek to (problem) that must address (goal) for (stakeholders).

Write on page 12 of Packet

Problem Definition
-- Request for Proposal --

Check your comprehension of the RfP:

1. Circle 4 constraints
   - rules or directions that must be followed
   - requirements that must be met
2. Draw a rectangle around a criterion
   - restrictions that prevent your turbine from being the best it can be
3. Get another criterion from your neighbor

Cooper Mountain Nature Park Wind Turbine Project

Request for Data:

Teachers' Data Co-op needs quality data on how various blade designs affect the max energy output of a wind turbine. Teachers' Data Co-op has defined max power output as the ability of the wind turbine to consistently produce the power for 5 continuous seconds. To simulate the constant wind speed found at the build site, data must be collected by placing the wind turbine 30 cm from the wind source which maintains a constant wind speed of 8 m/s. Teachers' Data Co-op has an open contract to pay out $40,000 for each quality data set and graph that helps to determine the effectiveness of different blade designs.

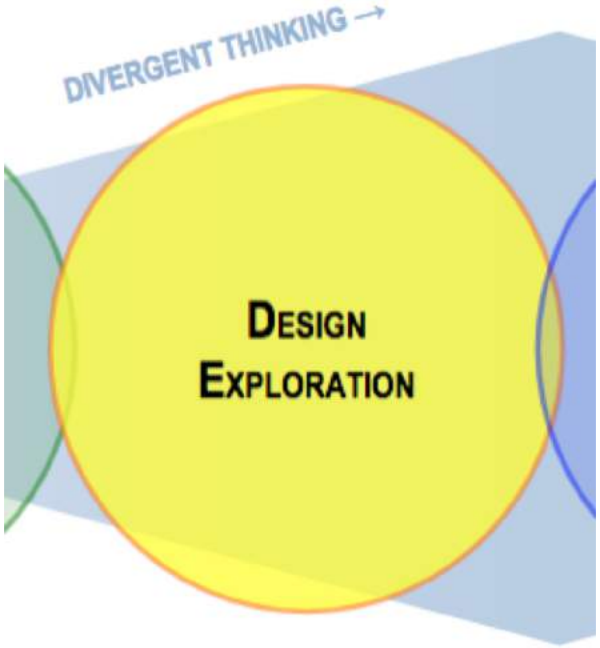
Additional criteria/constraints? Circle/rectangle!

Cooper Mountain Nature Park Wind Turbine Project

Paid Advertisement

Teachers' Data Co-op. is your source for data on wind turbine blade performance. We are your one stop shop for purchasing data on how different wind turbine blades will perform under different conditions. Contact us through our local representative: ________________@ ____________________.
Prices may vary but start as low as just $5,000.

Divergent Thinking & Brainstorming



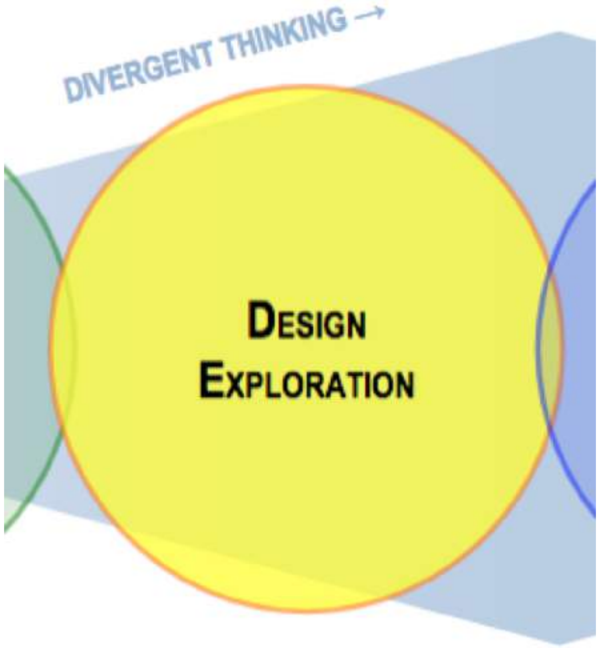
Brainstorm blade-related parameters that could affect the power output of a wind turbine.

Think. Pair. Share.

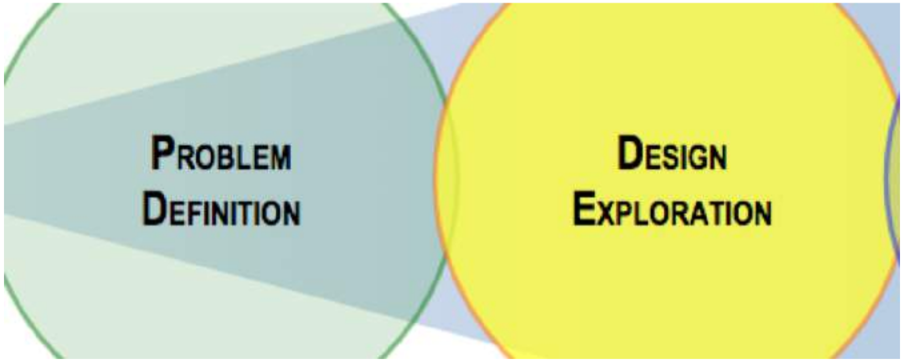
Record in your packet.

Circle the ones we will actually test!

Wild Guess an Initial Design

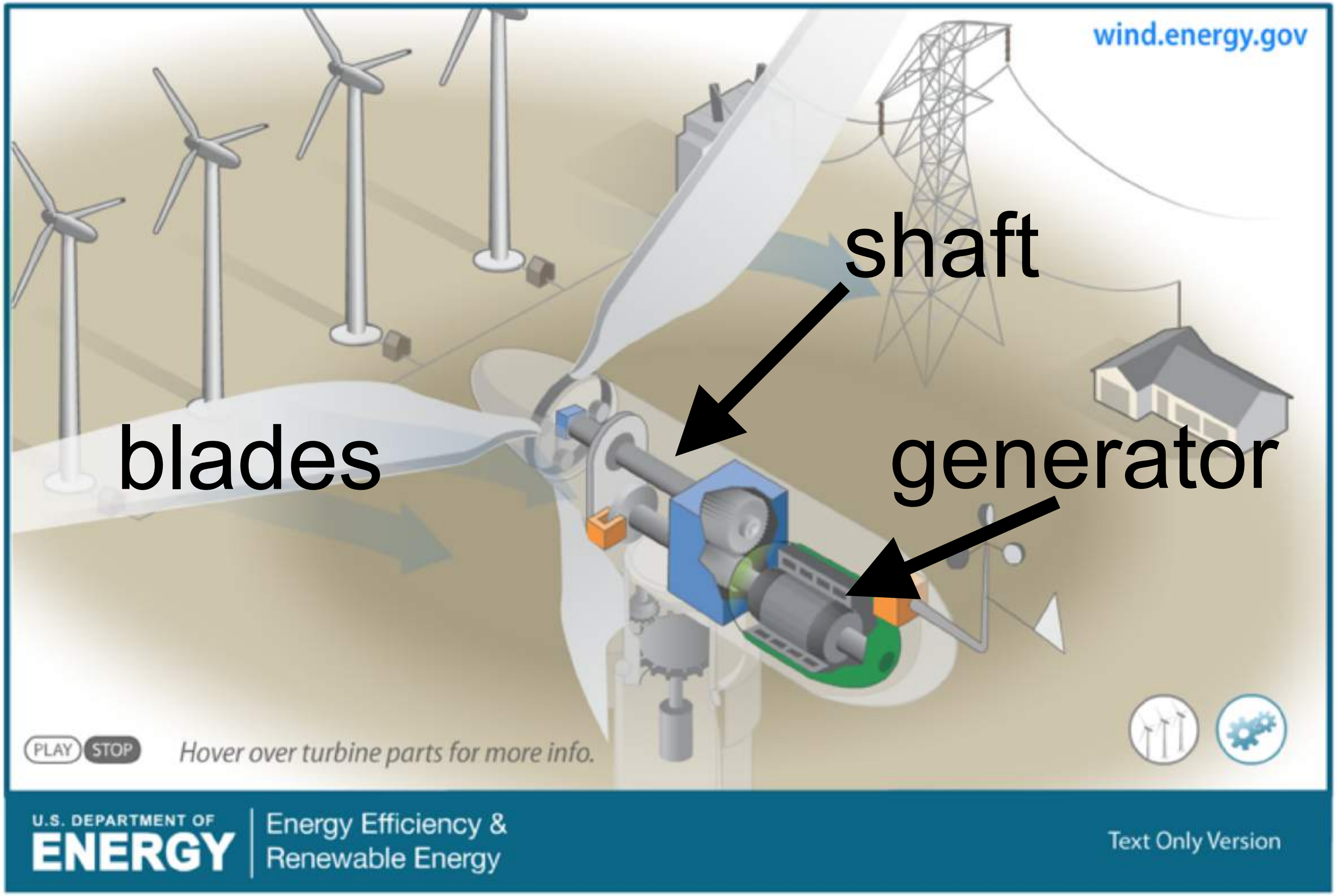


Based on the class discussion of the effects of different blade parameters, create an initial low-evidence design of a wind turbine and draw it in your packet.



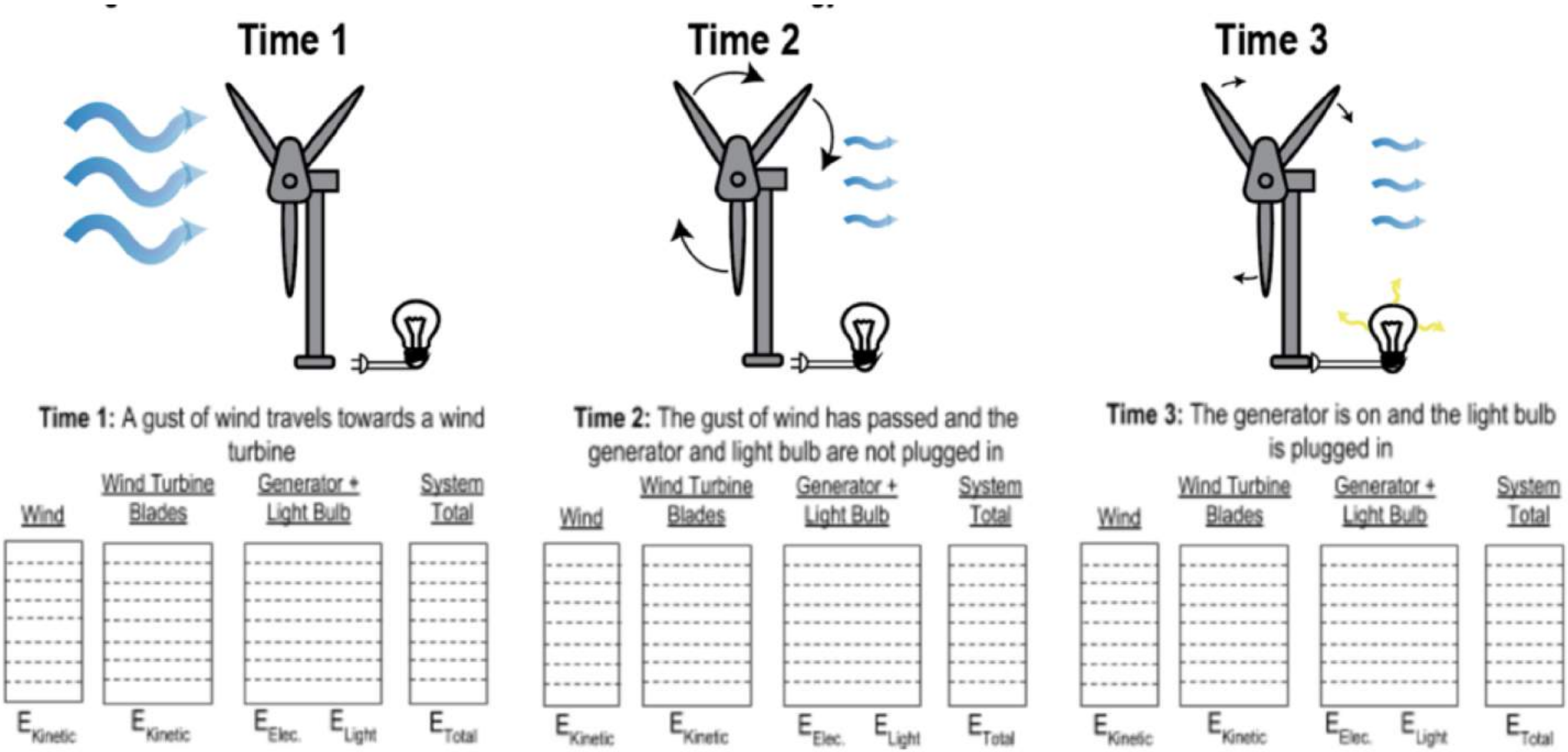
While we could have done it earlier, now is also a good time to think about the basic physics of how wind turbines work

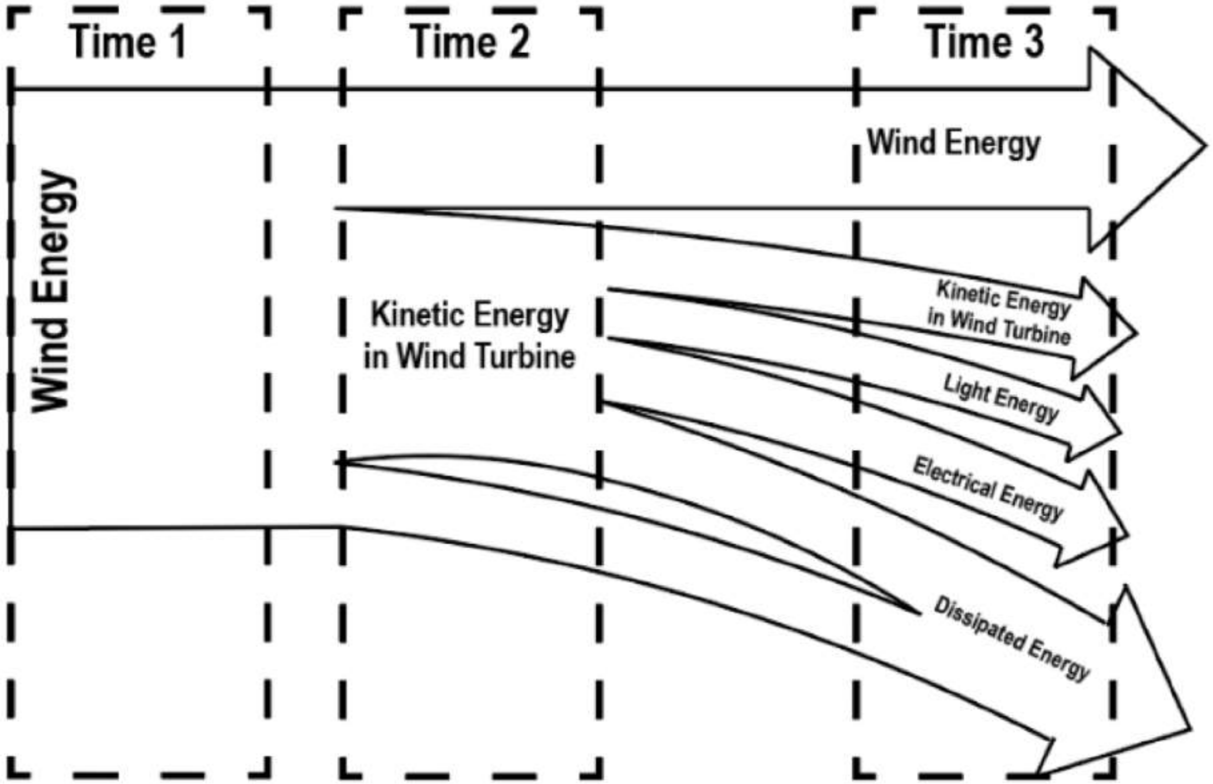
How does a wind turbine work?



[Animation from Department of Energy]

Tracking Energy Flow in a Wind Turbine with Energy Bar Charts





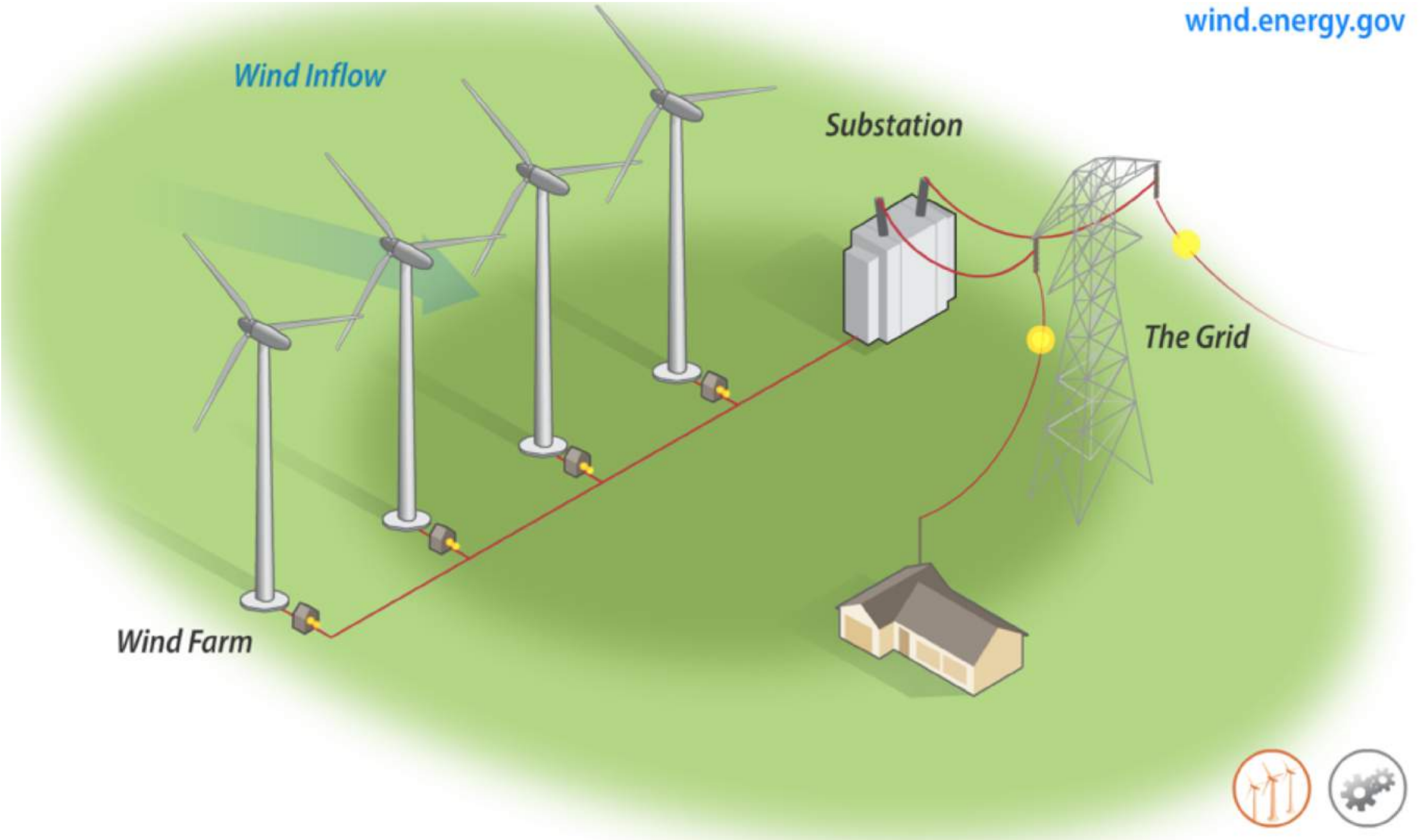
1. Place a [square] around the energy <u>initially</u> captured by the wind turbine
2. Place a {bracket} around the <u>useful energy</u> coming out of the wind turbine.
3. Estimate both the overall efficiency and the internal efficiency of the wind turbine.
4. Modify the arrows (with a + or a -) to show how overall and internal efficiency could be increased

The Basic Physics of How a Wind Turbine Works

Provide a written description of the basic physics of a wind turbine.

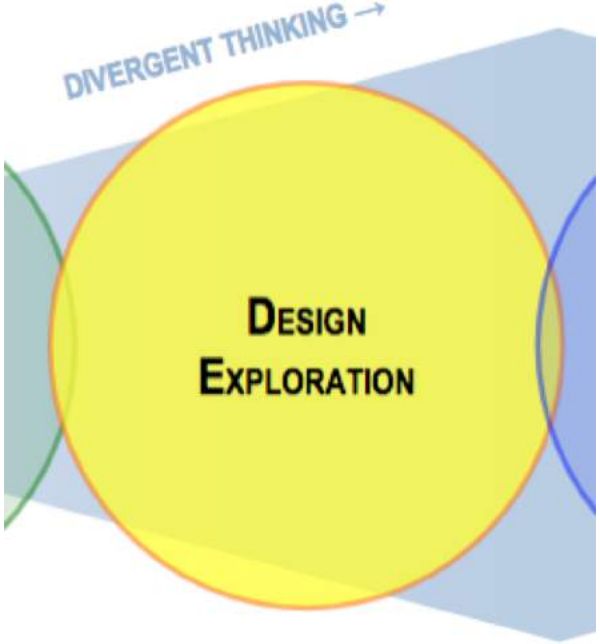
Use key terminology: wind, wind turbine, energy, energy transfer, energy transformation, kinetic energy, electric energy, light energy, dissipated energy, and overall efficiency.

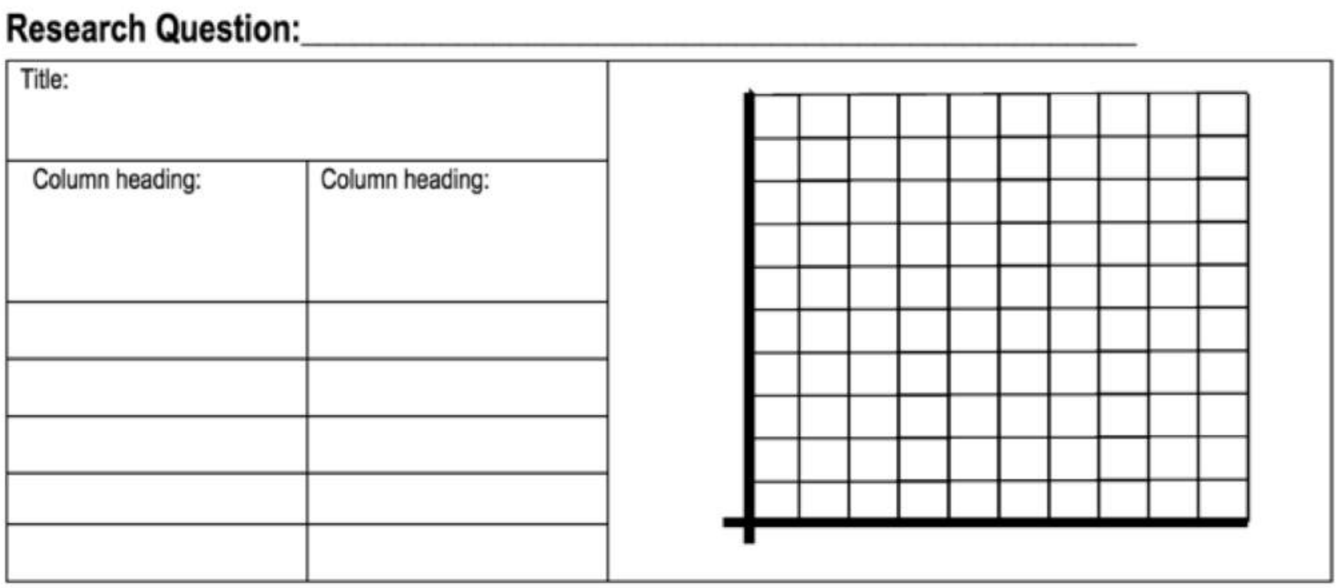
The Larger Picture



[Animation from Department of Energy]

We Need Data to Inform our Design





Research Question:____

Title:	
Column heading:	Column heading:

Our Initial Parameters to Investigate:

A) Shape of the Blade (12.8x5, 10x6.4, 8x8, 6.4x10)

Controls:

B) Angle of Blades to Wind (0, 30, 45, 60, 90)

Controls:

C) Number of Blades (2,4,6)

Controls:

D) Total Area of All Blades (0, 48, 75, 192, 300)

Controls:

Our Initial Parameters to Investigate:

A) Shape of the Blade (12.8x5, 10x6.4, 8x8, 6.4x10)

Controls: angle, number of blades, area of blades

B) Angle of Blades to Wind (0, 30, 45, 60, 90)

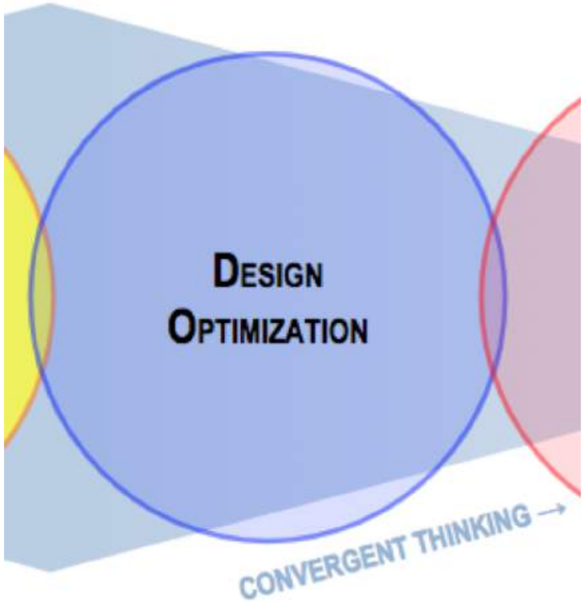
Controls: shape of blades, number of blades, area

C) Number of Blades (2,4,6)

Controls: shape of blades, angle, area of blades which for square blades sides: 9.8, 8, 7, 5.7

D) Total Area of All Blades (0, 48, 75, 192, 300)

Controls:shape of blades, angle, number of blades



For just $5000 per parameter, the Teachers' Data Co-op will connect you with other Engineers to have a Data Discussion on each parameter

If time - Go and take your data!

Electricity, Magnetism, & Power Production - Day 7

Agenda:

Finish taking data on wind turbines

Make beautiful graphs

Data presentation

Due Next Class

Due This Class

Data for Wind Turbine

Warm Up Question:

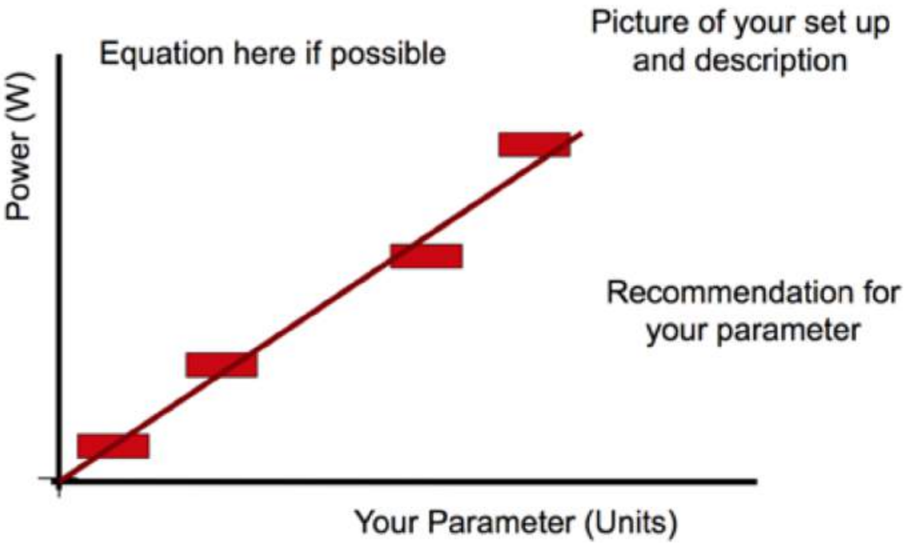
As we listen to this story, write two things that you found interesting.

NPR Island Wind Energy Story

Finish taking your data and make beautiful graphs

- When making your whiteboard you are trying to tell a story.
- This means that you must think how you want to effectively present your findings.
- Note: There are many ways to convey information!

Good Example of a Whiteboard

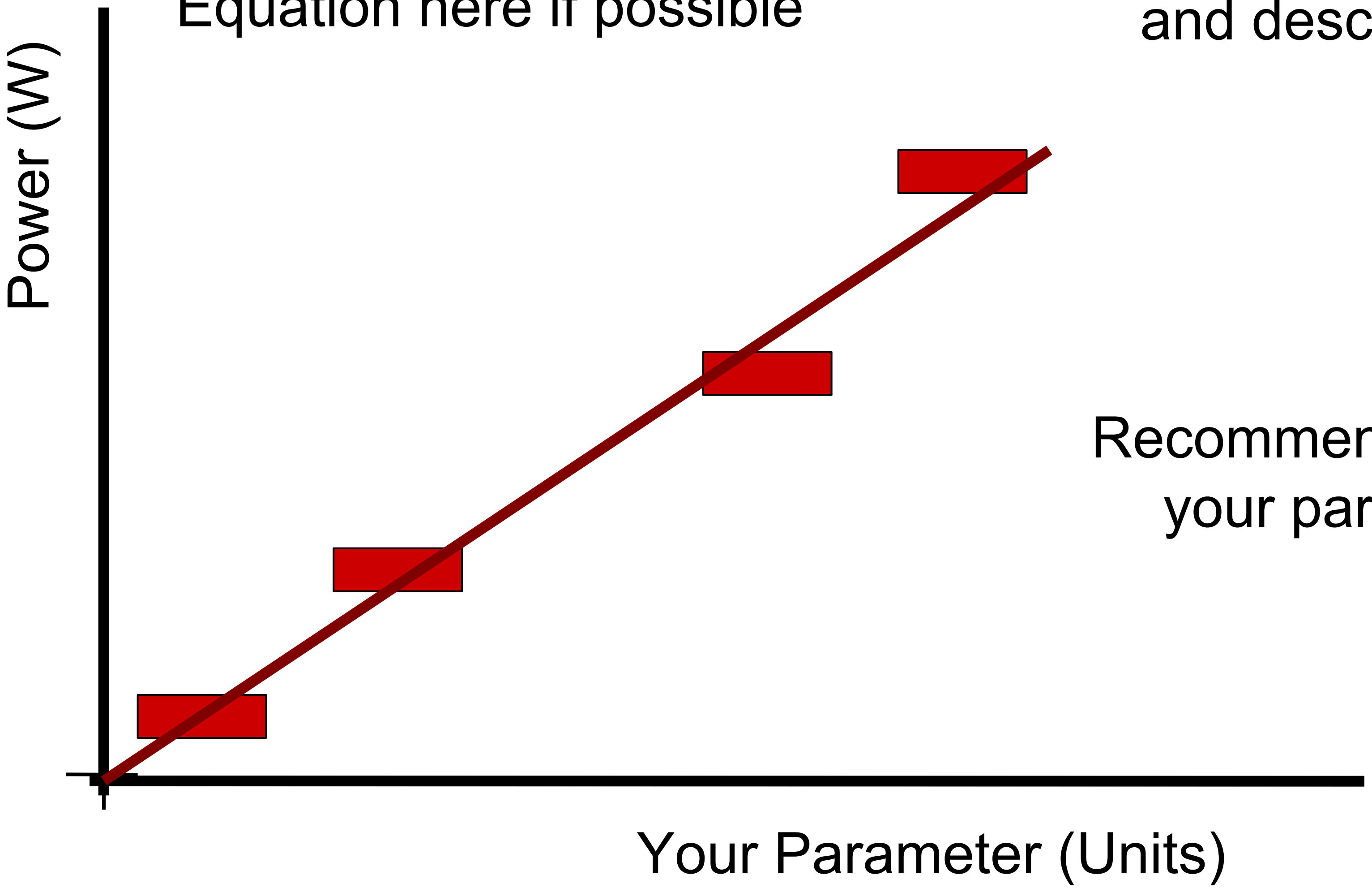


See next slide.

Good Example of a Whiteboard

Picture of your set up and description

Equation here if possible



Recommendation for your parameter

By the End of this Day You Should Be able to Answer:

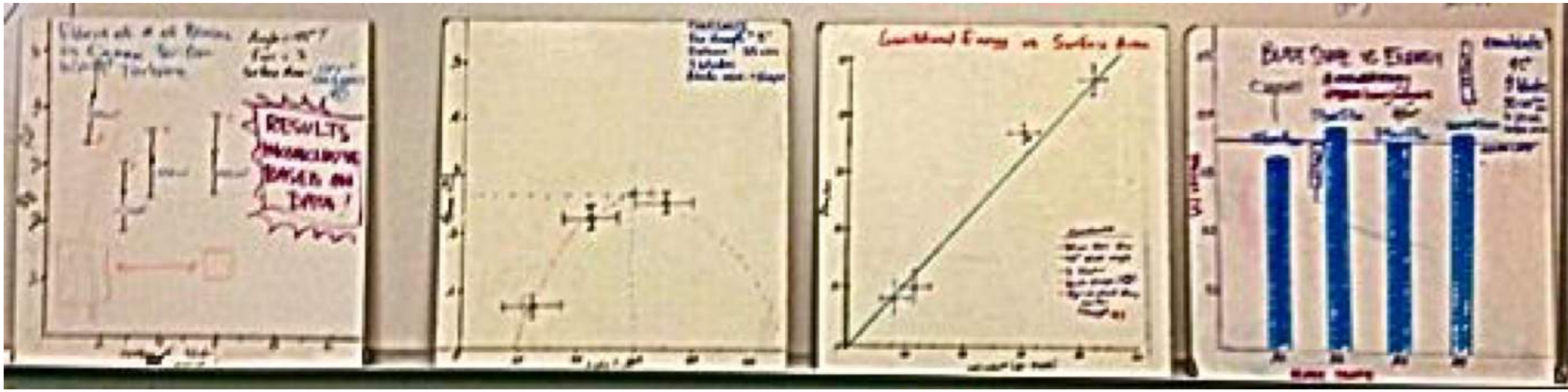
Focus Question

Be able to make a data-informed decision about how to best design your wind turbine to maximize its power production.

Language Focus

Orally communicate with the aid of graphs your experimental results of your wind turbine design.

Use Your Science Data Discussion Skills



Hot Shot Points

Now in the context of an engineering project what can you share that is "value-added"?

Now Use Your Engineering Data Discussion Skills to talk Trade-offs

Figure 1: Material Costs

Tower (Base Station)	Total Cost of Tower ($)
1	30,000

Blade Angle (degrees)	Additional Cost to Blade for the Angle ($)
20	0
40	0
60	0
90	0

Number of Blade Holders (# of Pegs)	Total Cost of Blade Holders ($)
2	10,000
3	15,000
4	20,000
6	30,000

Total Area of Paper on all Blades (cm^2)	Total Cost of Paper on Blades ($)
40	20,000
60	30,000
80	40,000
100	50,000

Check In:
You Should Be able to Answer:

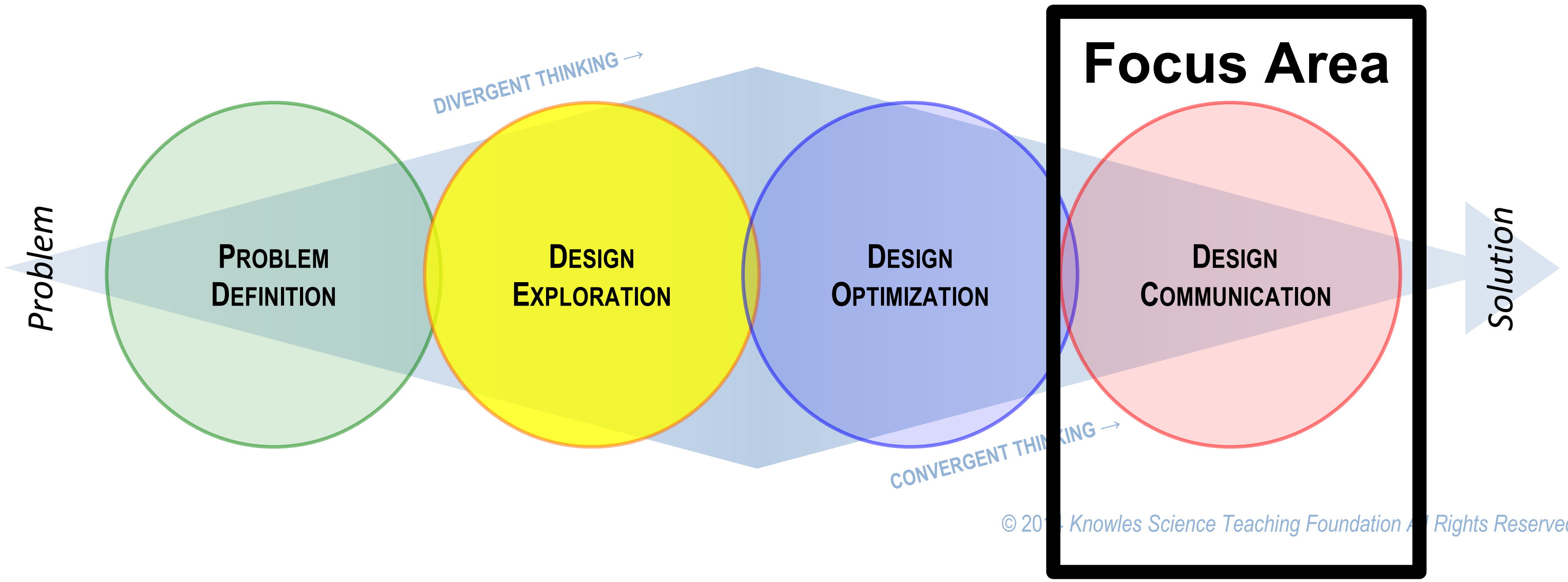
Focus Question

Be able to make a data-informed decision about how to best design your wind turbine to maximize the energy transferred.

Language Focus

Orally communicate with the aid of graphs your experimental results of your wind turbine design.

Engineering Design Process



Engineering Rationale for Final Design (page 15)

Claim: I claim the optimal design is ...

Evidence		Reasoning about Design Decision
Graph	**Graph Explained in Words**	
	My first piece of evidence is ... that shows ...	Since .... my design recommendation is ....
	My second piece of evidence is ... that demonstrates ...	Considering this and ... , I recommend building a wind turbine with ....
	Graph 3 indicates that....	Therefore the optimal design should have ...
	My final piece of evidence is ... which reveals a ... pattern between	Considering this pattern and the budget I recommend ...

Engineering Rationale for Final Design

Optional, helpful sentence starters…

I claim the optimal design is …

My first piece of evidence is … that shows …
Since …. my design recommendation is ….

My second piece of evidence is … that demonstrates ...
Considering this and … , I recommend building a wind turbine with ….

My final piece of evidence is … which establishes that ...
Therefore the optimal design should have …

Additional Optional, helpful sentence starters…

Under the given criteria and constraints the optimal design of the wind turbine is …

Graph 1 shows that, given all other parameters equal, the optimal ... , because ...
Considering this and the fact that ... my design recommendation for …

Graph 2 indicates that …
In light of this and ..., I recommend building the wind turbine with …

Graph 3 reveals a ... pattern between ….
Considering this pattern and the budget I recommend … so the overall design will transfer ...

Electricity, Magnetism, & Power Production - Day 8

Agenda:

Finish design rationale outline

Getting creative in optimizing your Design

If time test the efficiency of your wind turbine

Due Next Class

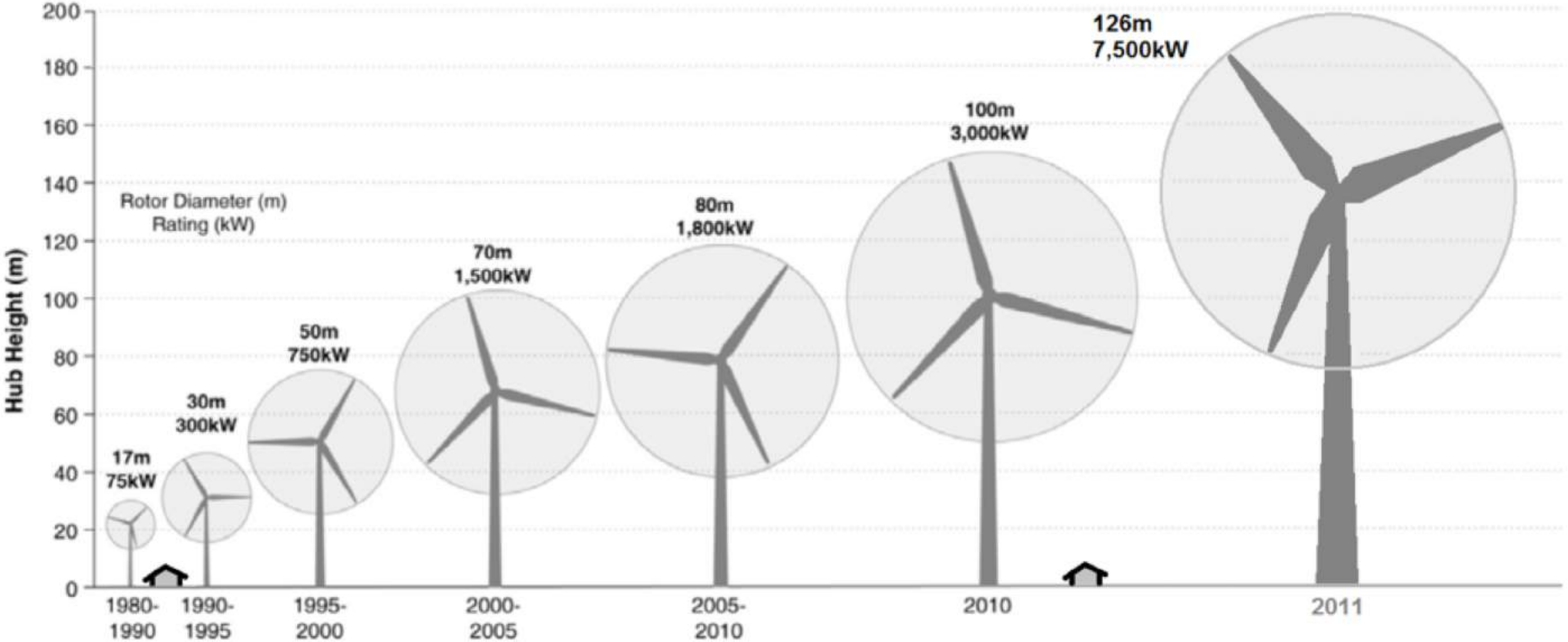
Rational outline (page 15) for quiz

Due This Class

Warm Up Question:

See next slide: Two part question

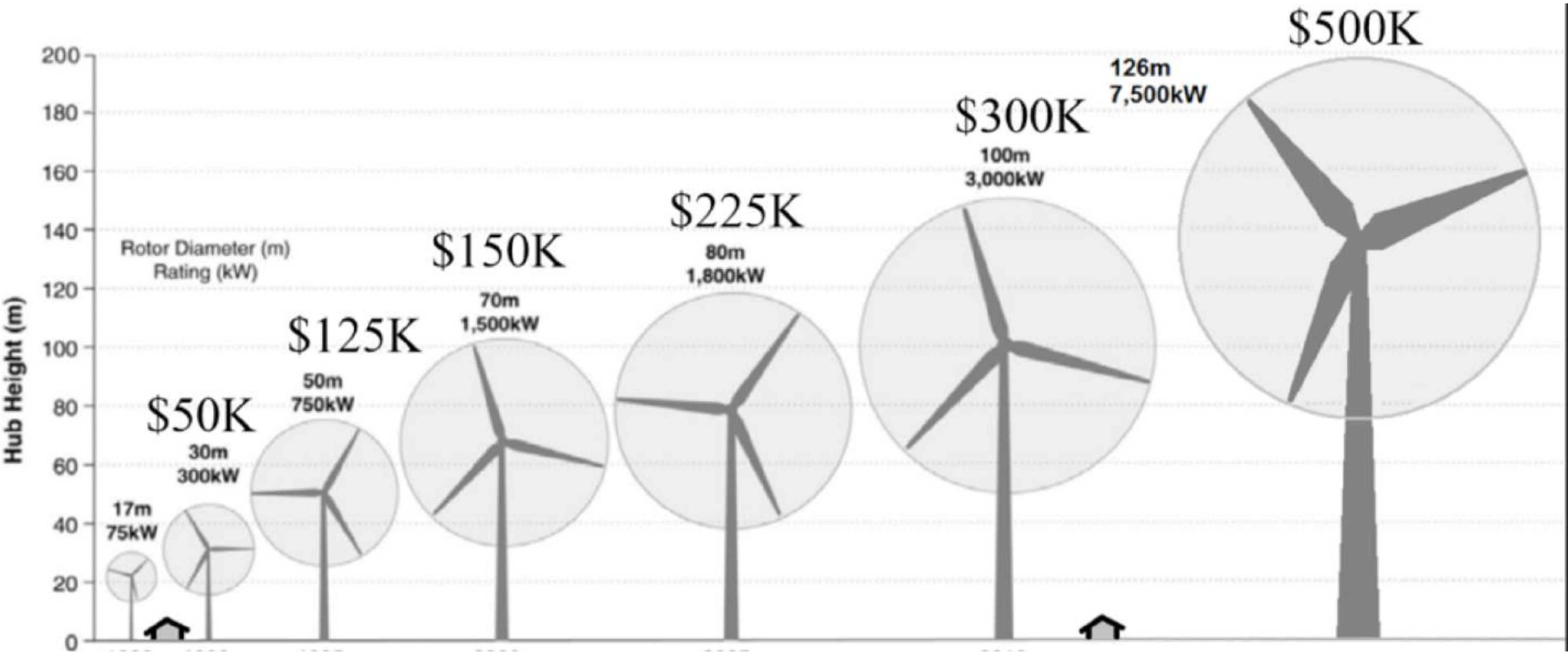
Analyzing Informational Graphics



What explains the trend in higher power output?

Use the technical terms energy transfer, energy transformation, E_k, $E_{electrical}$, Watt (W), which is a J/s.

A farmer is looking into buying wind turbines for his farm. He has space to put blades with a total diameter of 150m and a loan from the bank for $400,000 ($400K). Using the infographic above, write your claim, evidence, and reasoning for the wind turbine or combination of wind turbines that would work best.



Another Quote on Engineering

Life doesn't always present you with the perfect opportunity at the perfect time. Opportunities come when you least expect them, or when you're not ready for them. Rarely are opportunities presented to you in the perfect way, in a nice little box with a yellow bow on top. … Opportunities, the good ones, they're messy and confusing and hard to recognize. They're risky. They challenge you.

-- Susan Wojcicki, CEO of YouTube

-- Getting Creative --

It is time to build your Final Design, however, as you do you may find ways you could improve the wind turbine's performance on the construction site. So go for it.

Remember, that you will need to justify your decisions using evidence based arguments.

Describe how engineering a wind turbine benefits our community while decreasing costs

One more quote:

Engineering is a great profession. There is the satisfaction of watching a figment of the imagination emerge through the aid of science to a plan on paper. Then it moves to realisation in stone or metal or energy. Then it brings homes to men or women. Then it elevates the standard of living and adds to the comforts of life. This is the engineer's high privilege.

-- Herbert Hoover, Engineer and 31st POTUS

Electricity, Magnetism, & Power Production - Day 9

Agenda:

6Q2 - Quiz on Basic Physics of a Wind Turbine

Test the efficiency of your wind turbine

Due Next Class

Due This Class

Quiz!

Warm Up Question:

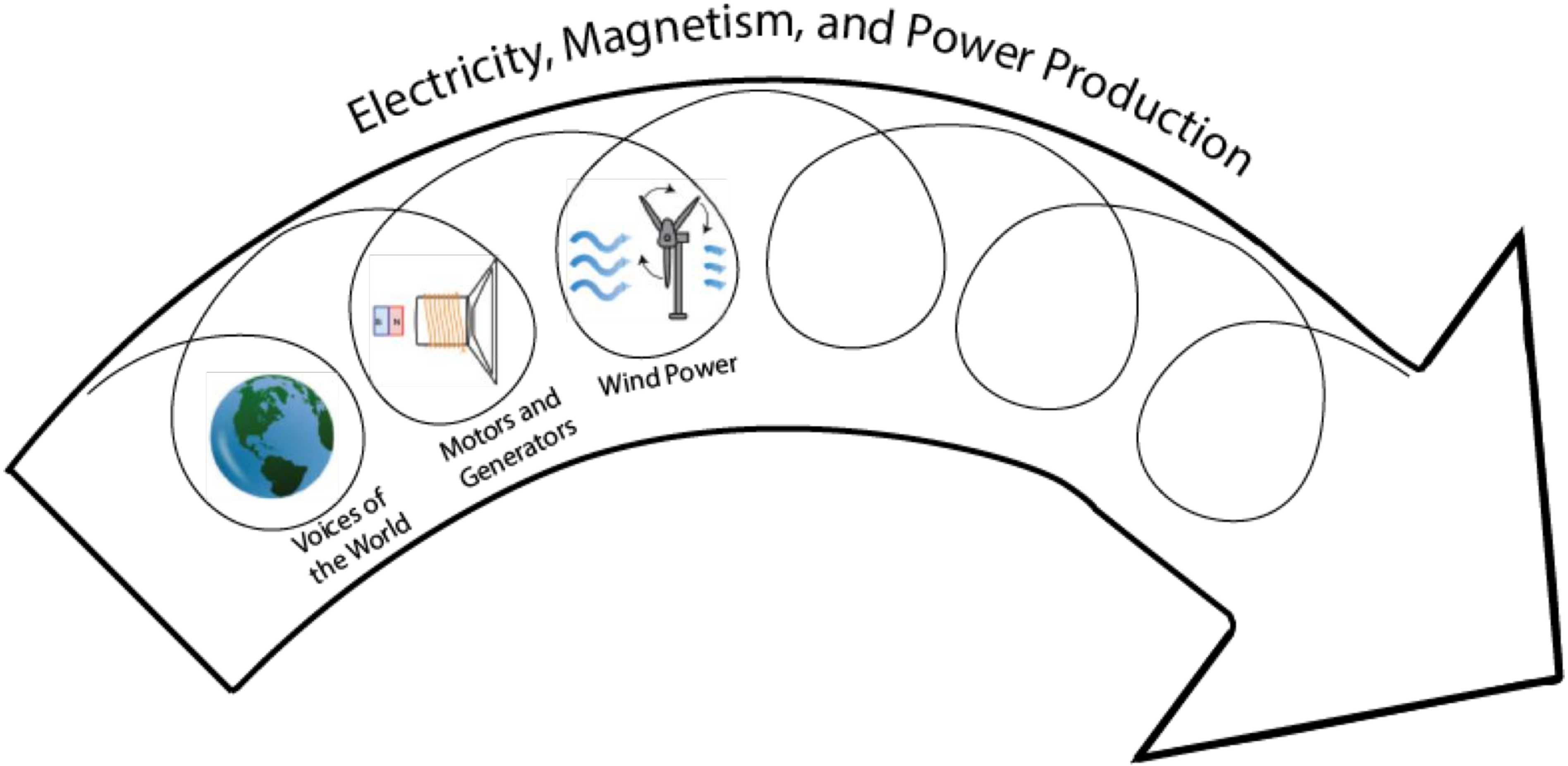
As we listen to this story, write two things that you found interesting.

NPR Island Wind Energy Story

6Q2 - Quiz on the Basic Physics of a Wind Turbine

Test the efficiency of your turbine

After you have finished, take additional data on other parameters. Get creative with this.


Electricity, Magnetism, and Power Production
Voices of the World
Motors and Generators
Wind Power

Electricity, Magnetism, & Power Production - Day 10

Agenda:

Optimizing a Solar Cell Lab

Warm Up Question:

Due Next Class

Optimizing a Solar Cell Lab

Due This Class

Electricity, Magnetism, & Power Production - Day 11

Agenda:

Data Discussion on

Optimizing a Solar Cell

Conclusion Writing

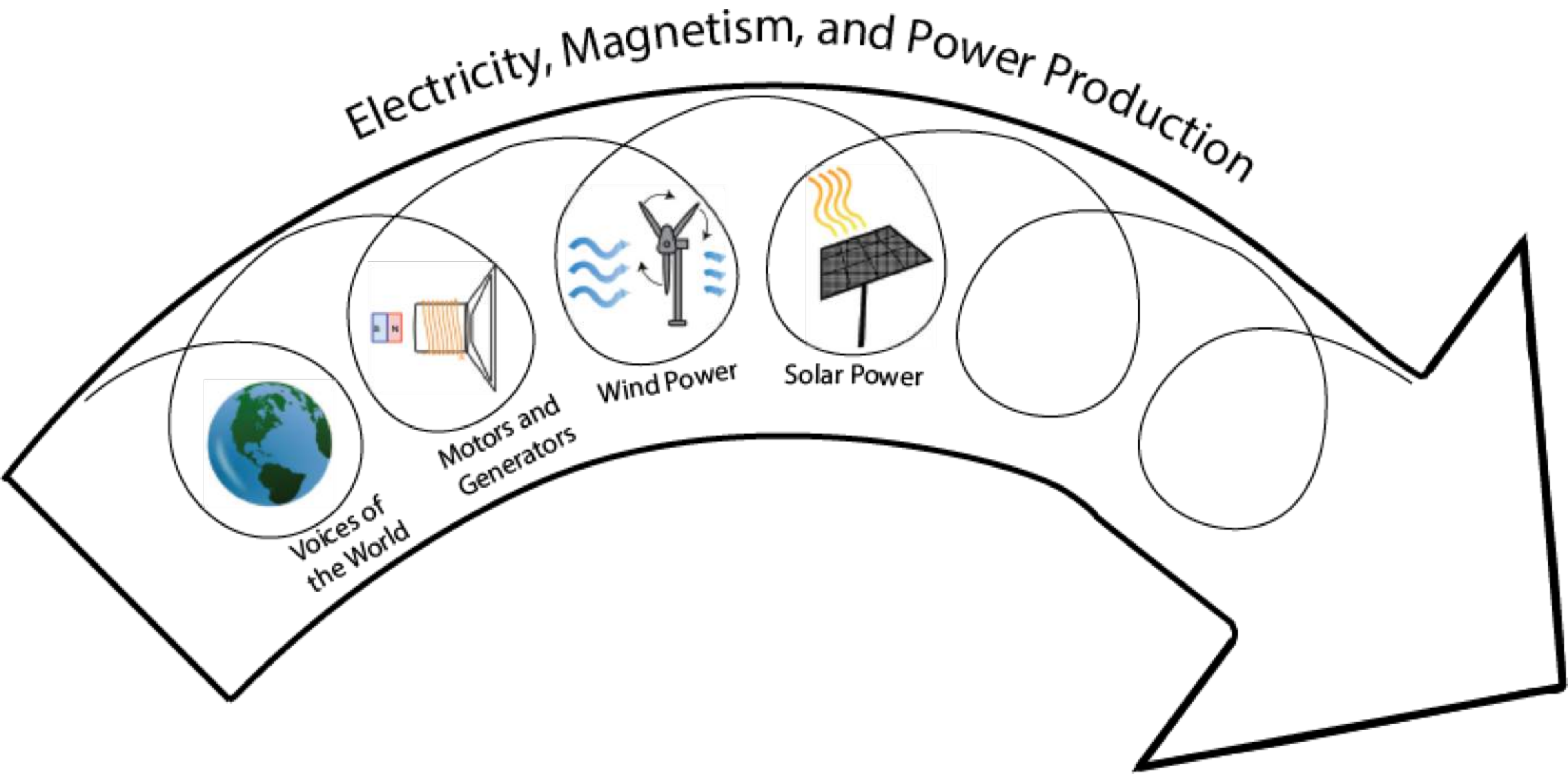
Energy City Check In

Due Next Class

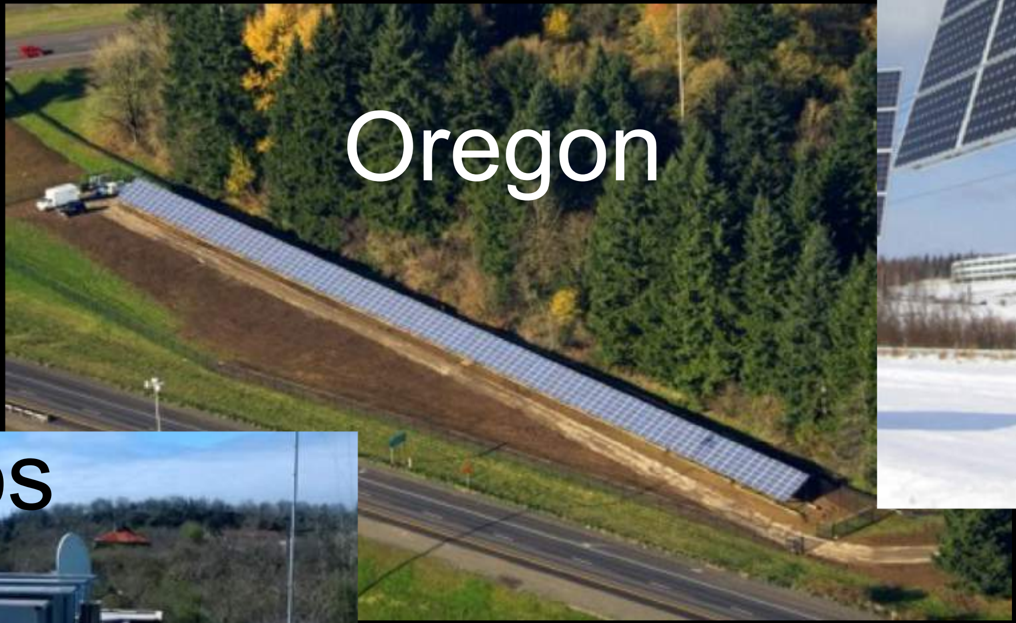
Due This Class

Optimizing a Solar Cell Lab Report

Warm Up Question:


Electricity, Magnetism, and Power Production
Voices of the World
Motors and Generators
Wind Power
Solar Power

The Phenomenon: Why the difference in mounting of solar cells?



The Phenomenon: Why the difference in mounting of solar cells?

Galapagos Science Center near the equator

The Phenomenon: Why the difference in mounting of solar cells?

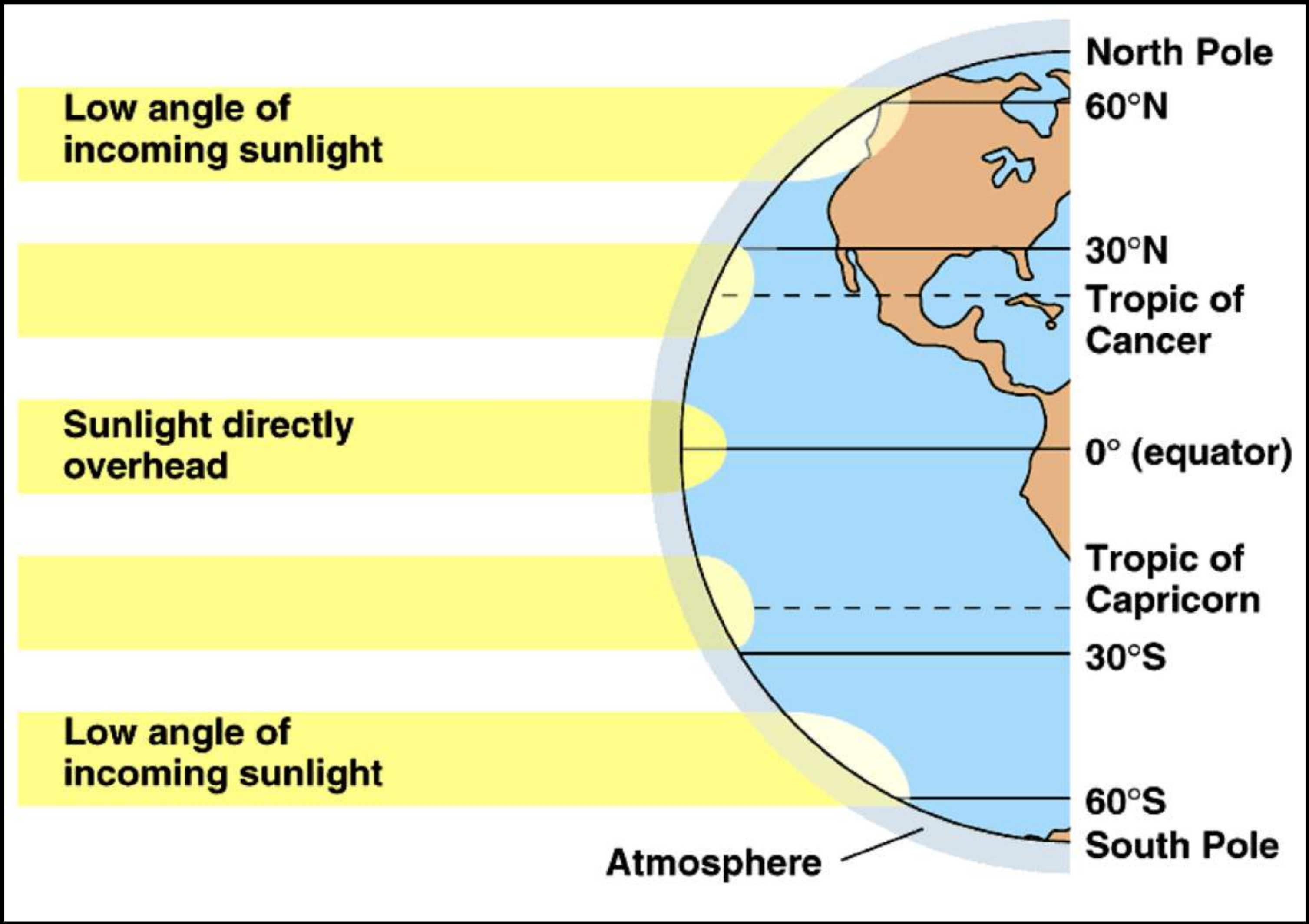
This is at the intersection of I-5 and I-205 near Tualatin

[(full story in the Oregonian)]

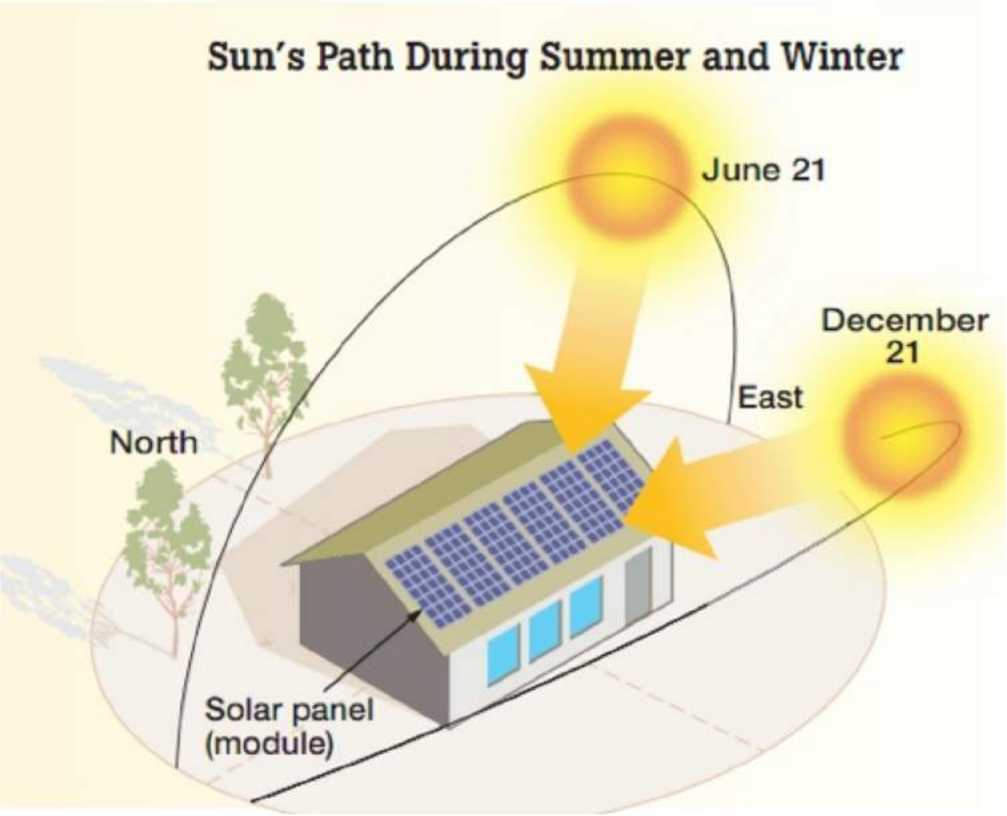
The Phenomenon: Why the difference in mounting of solar cells?

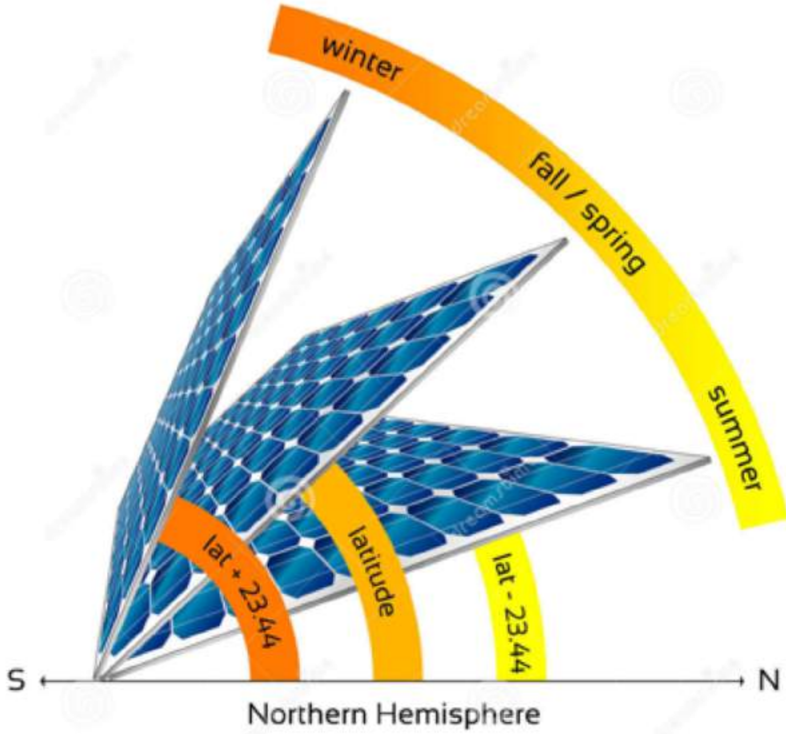
This is at the Cold Climate Housing Research in Alaska

The Phenomenon: Why the difference in mounting of solar cells?



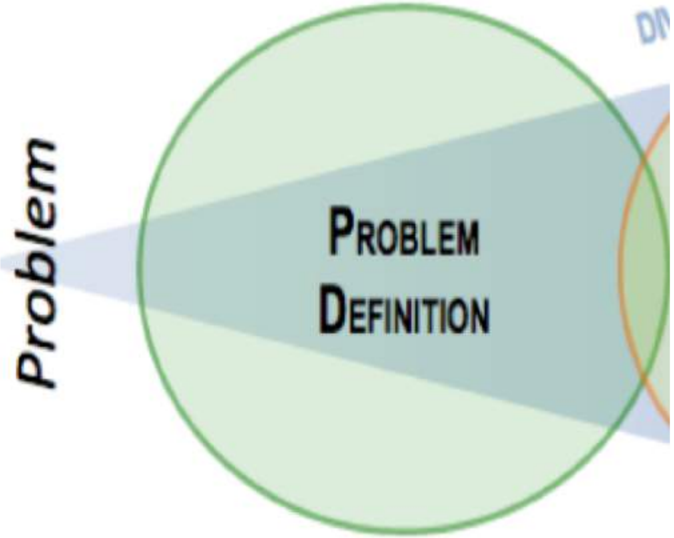
Follow up: Why the difference over a year for us in Oregon but not really for Ecuador?





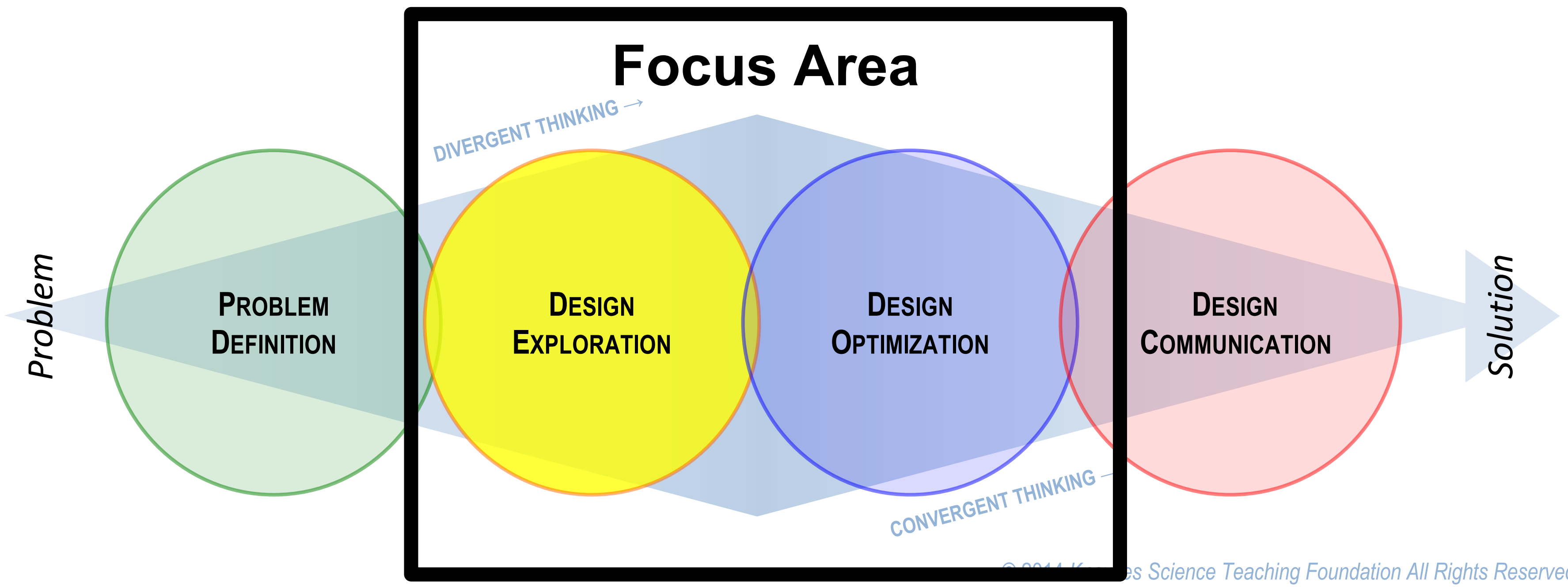
NOVA: Solar

A Slice of Engineering

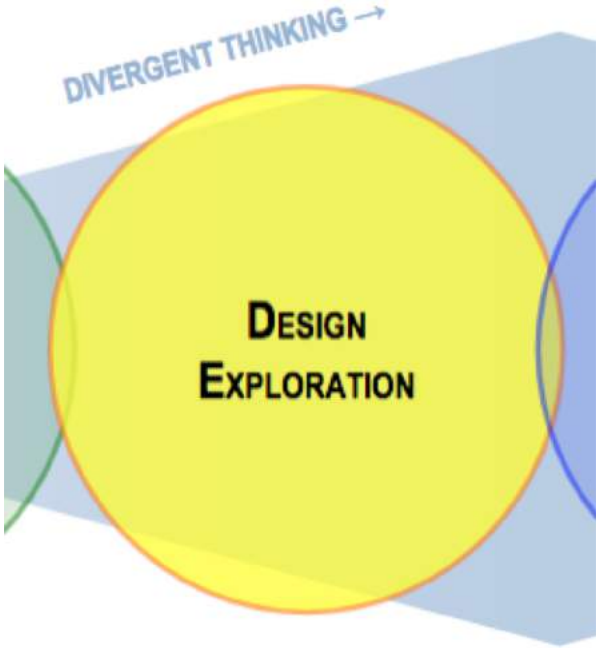


Many foundations and organizations will provide schools with a small array of solar cells (PV). We are considering writing an application for some. While most of the criteria, constraints, and supplies for this are predetermined, we need to determine the optimal angle and placement of them at our school.

Engineering Design Process

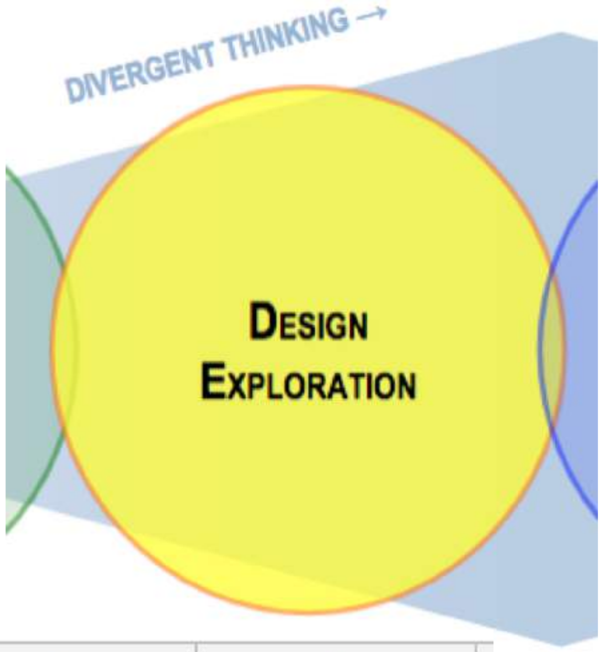


Location



What factors should we consider for selecting the location of the cells?

We Need Data to Inform our Design



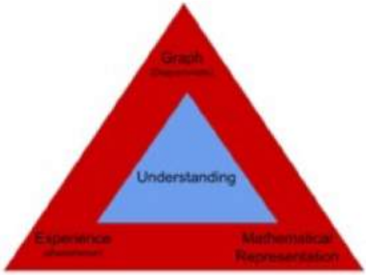
	A	B	C	D	E
1		DV: ClickHereToType			
2	IV: ClickHereToType	Trial 1	Trial 2	Trial 3	Average
3					
4					
5					
6					
7					
8					
9					

Data Discussion

6L2 - Interactive Notes for Data Discussion on Patterns in Solar Cells

Scientists present their explanations and critique the explanations proposed by other scientists.

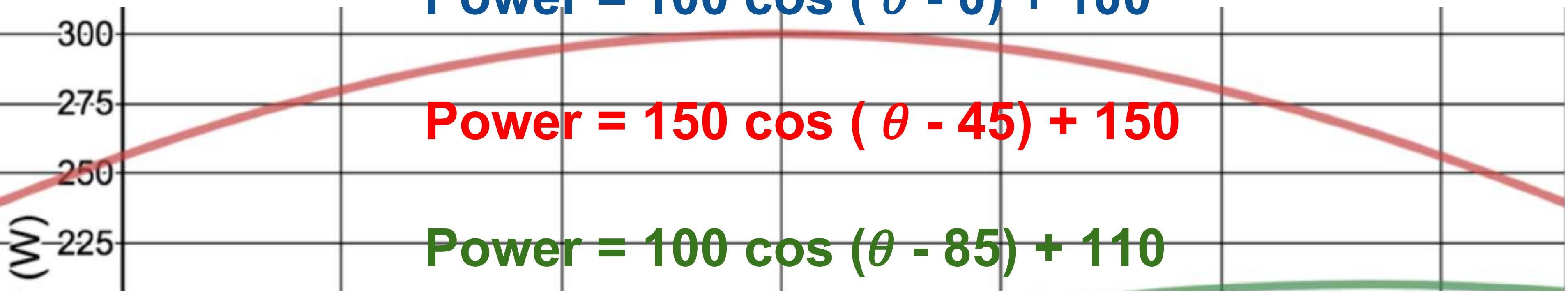
1 - Orient to the graph (axes, scale, pick a few data points)
2 - Compare and contrast
3 - Why are there similarities?
4 - What explains the differences?
5 - Experience → Graph → Mathematical Model



Power = 100 cos (θ - 0) + 100

Power = 150 cos (θ - 45) + 150

Power = 100 cos (θ - 85) + 110



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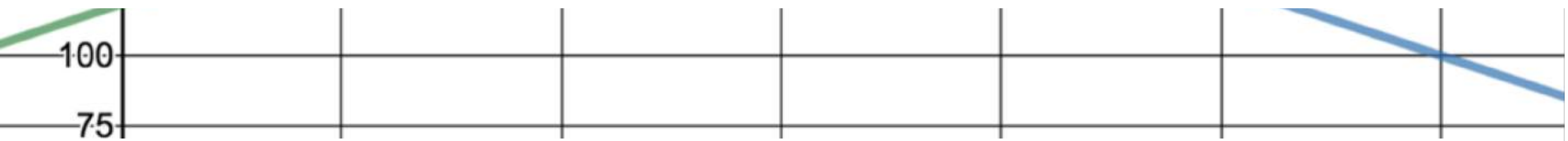

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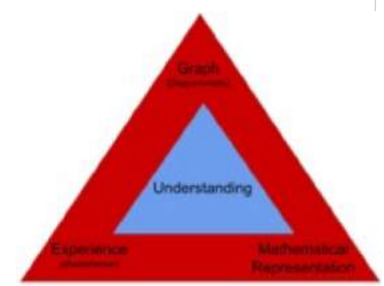
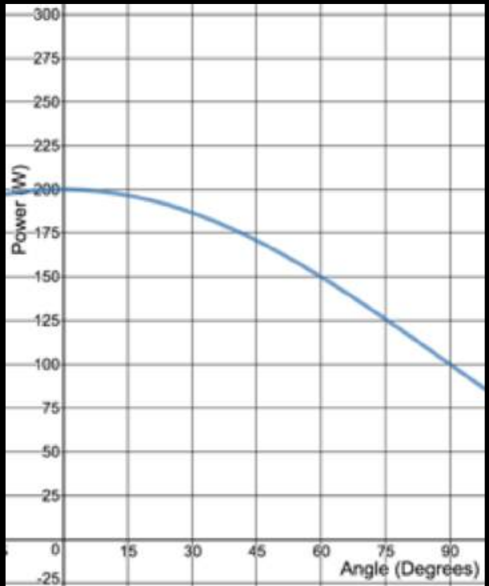
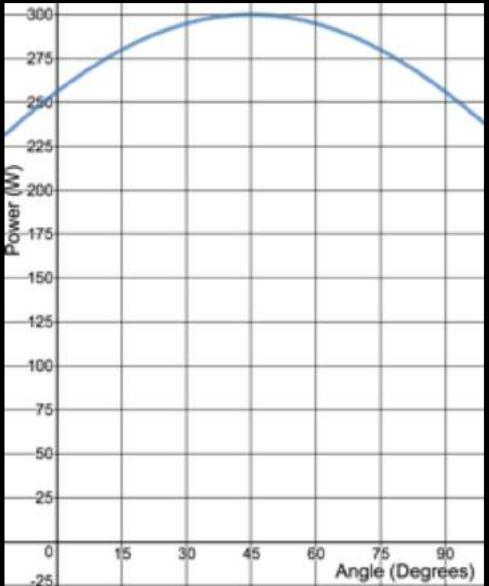
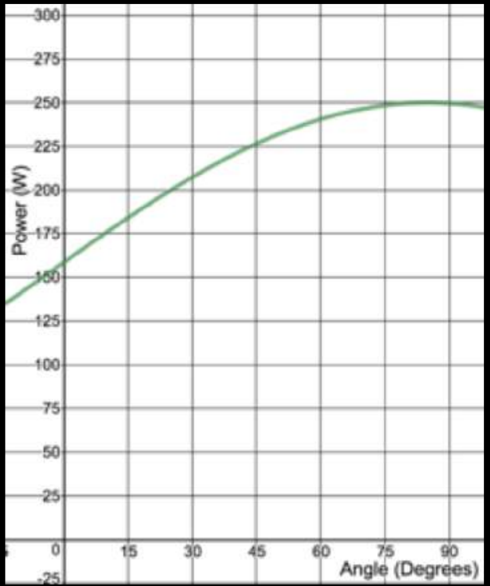


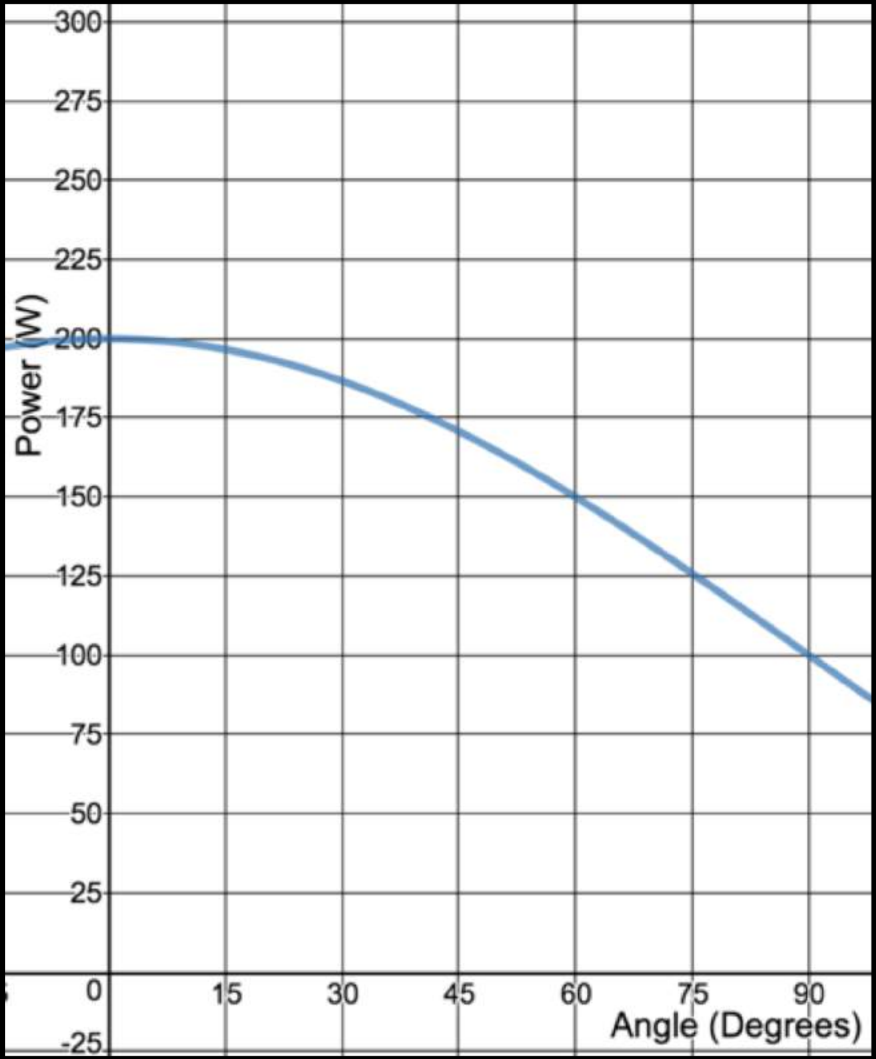
Back to the Phenomenon: Why the difference in mounting of solar cells?



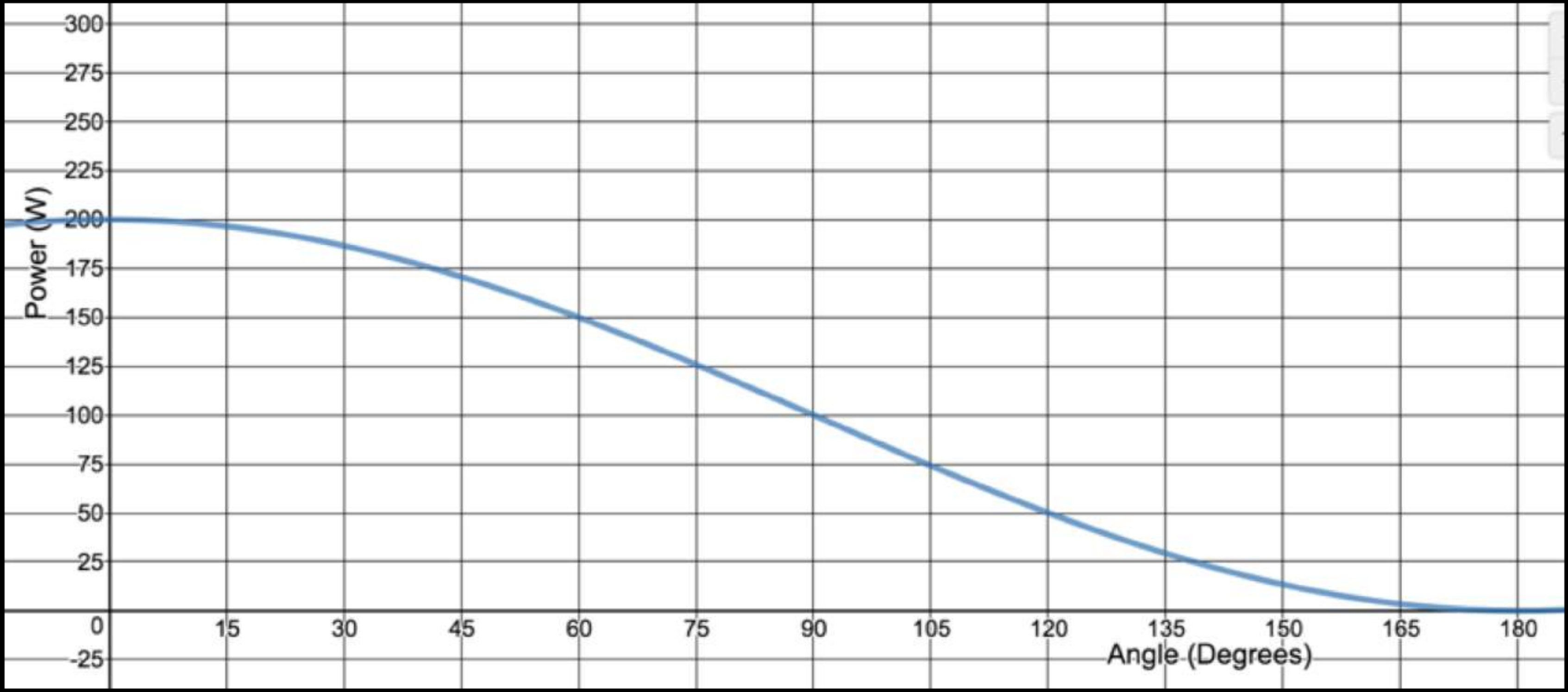




The Phenomenon: Why the difference in mounting of solar cells?



Prediction Question 1: For the Galapagos solar panel display, what would the power be if you turned it upside down on the roof, that is 180 degrees? Why does this make sense?



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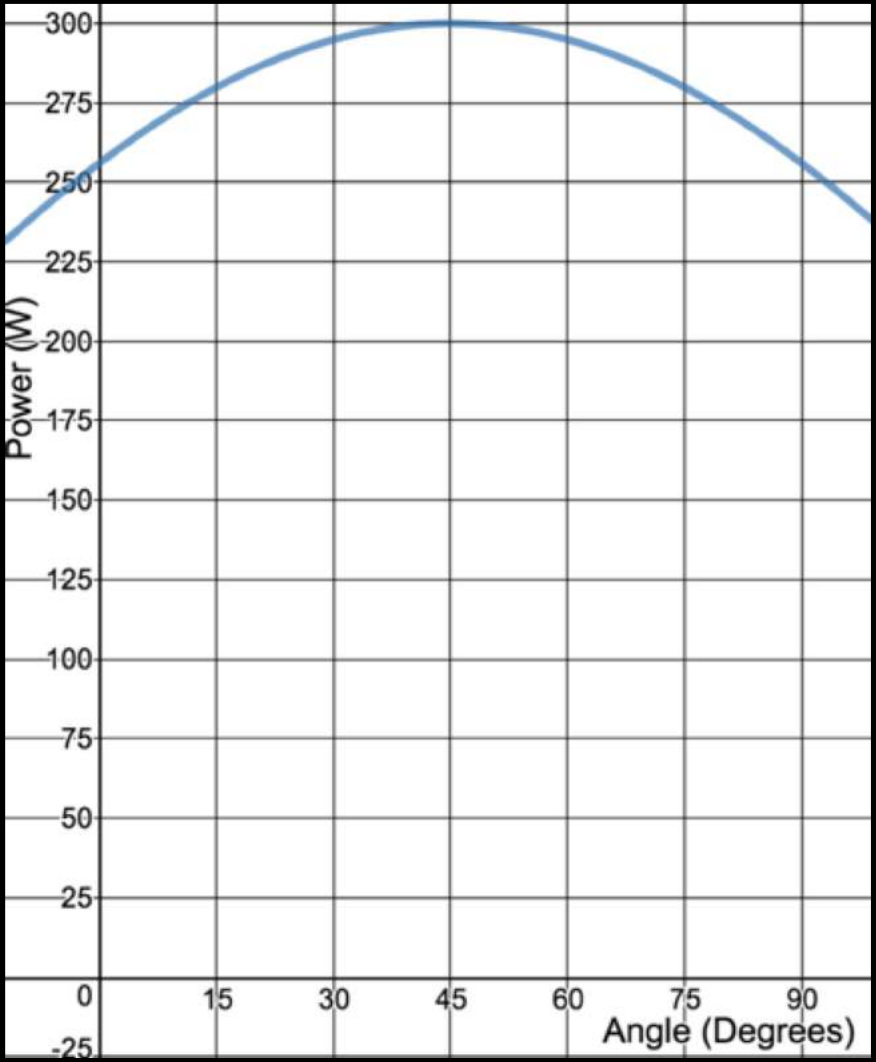

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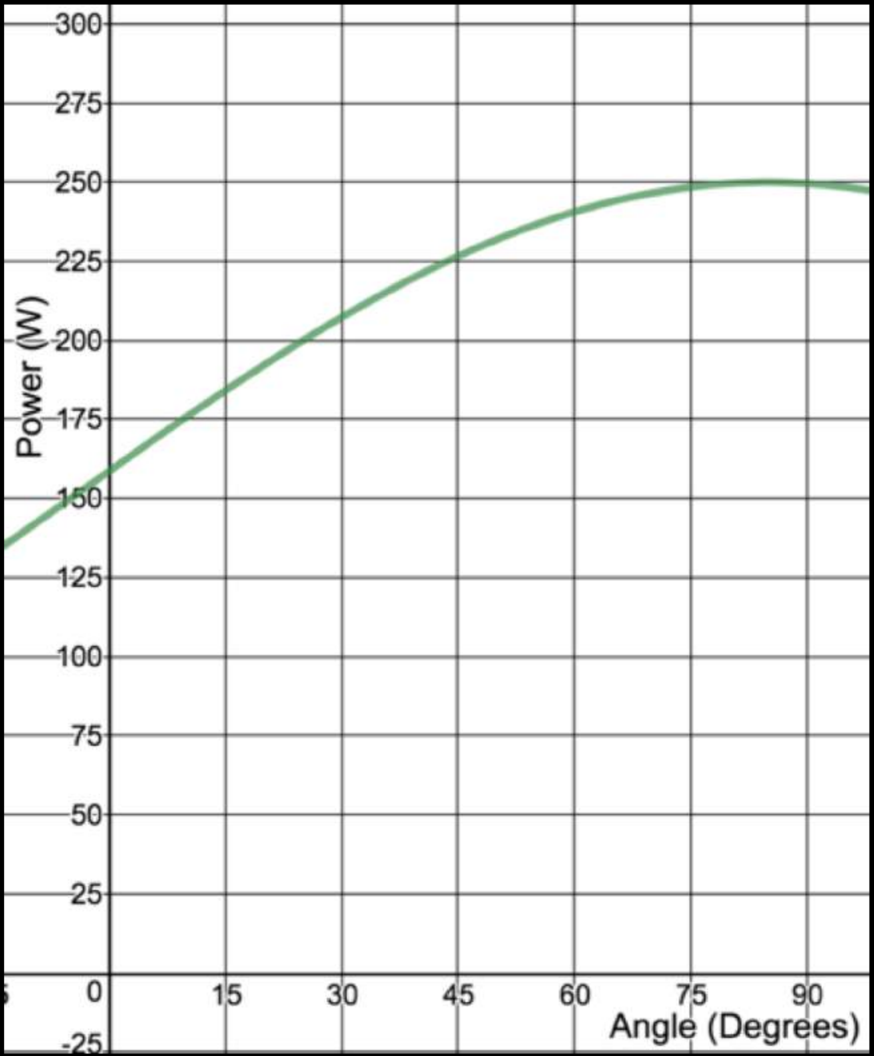
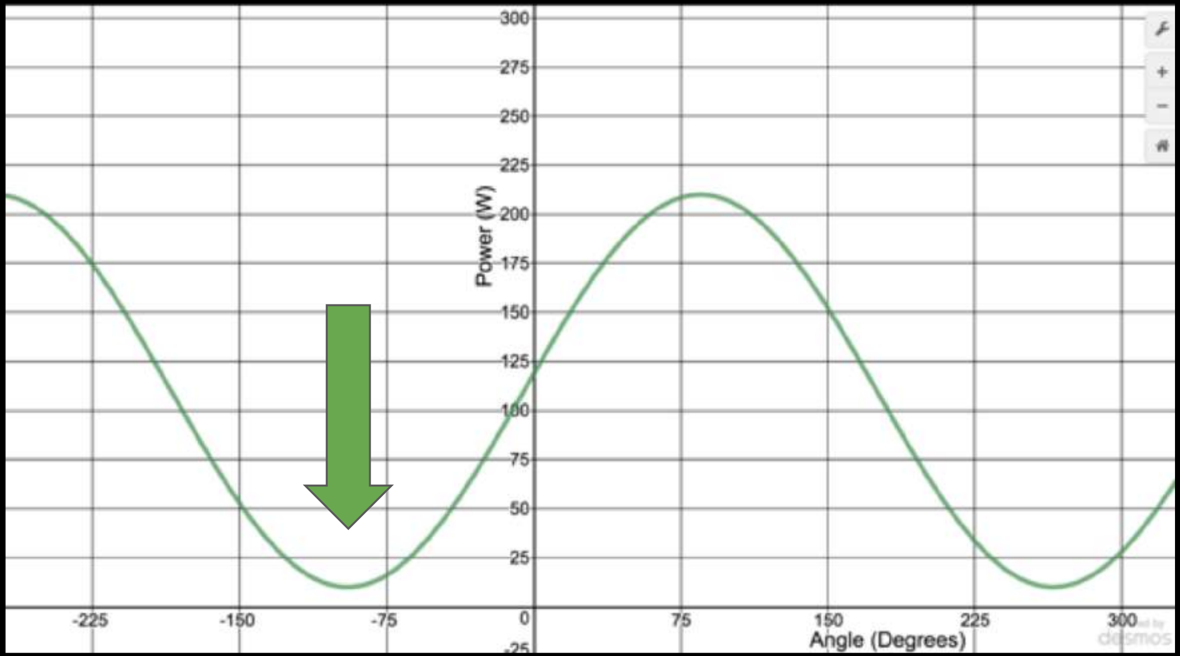


Prediction Question 2: For the Alaska solar panel, if instead of tilting it towards the sun you tilted it backwards away from the -95 degrees what would the power be? How could it still be generating a little power?



At their respective optimum angles, why is Oregon's solar panel producing more power than the Galapagos or Alaska solar panel?

Answer key

Helpful Desmos file to demonstrate effect of A, B, and C

A-Value: ½ harvestable direct light

= direct incoming light * efficiency

B-Value: starting angle to perpendicular direct sunlight

C-Value: ½ harvestable direct light + harvestable indirect light

= reflected light * efficiency