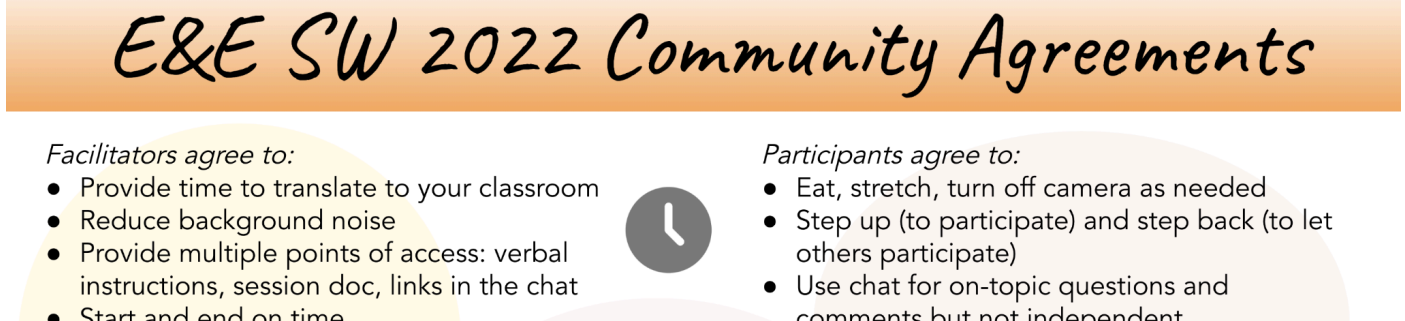
Integrating Energy, Equity, and Place in High School Physics

Energy tracking

Day 2 | Tue Aug 2, 2022 | 12-2 PT / 3-5 ET
[Session Slides]



Agenda

Purpose of this session

In this session we will

- **Represent energy with an Energy Tracking Diagram**
- **Recognize the sociopolitical values embedded in energy concepts**

Energy tracking

Introduction

Time: About 10 minutes
Format: Brief lecture

Slide 14: Energy tracking diagram for tissue box

Time: About 15 minutes
Format: Breakout rooms.

- New groups! You choose where to go.
- Groups 1-4: 4 participants each + facilitator. Group 5: 5 participants + facilitator.

Task: Construct an **energy tracking diagram** for a tissue box that slides to a stop. (See detailed instructions below.)

Electronic whiteboards:

Group 1	Group 2	Group 3	Group 4	Group 5
Maajida, Nifemi, Andy, Vincent Facilitator: Jaime	Heather, Asher, Rachel, Kate Facilitator: Nora	Mark, Gareth, Julie, Shawn Facilitator: Jim	Paul, Rory, Liz, Emily Facilitator: Trà	Jolai, Ariel, Ari, Kristin, Adrien Facilitator: Kara

Rules for Energy Tracking Diagrams	**Instructions for creating Energy Tracking Diagrams**
• Objects are areas (boxes). • Units of energy are letters; specific letters indicate forms of energy. • Energy transfers and transformations are represented with arrows.	- Draw boxes to represent the objects in the scenario, and label them. - Show which forms of energy are involved in this scenario. (What observable indicators of energy are there?) Create a key showing which letters indicate which forms of energy. - Show the energy transfers and transformations that are involved in the scenario. (Where does the energy come from? Where does it go?) - For each energy transfer or transformation (each arrow), label the energy transfer or transformation process. See suggestions below.

Some possible labels for arrows are below (this is not an exhaustive list):

Transfers: Processes that cause energy to cross the boundary of an object or system	**Transformations:** Processes that change energy from one form to another
• Shoving • Warming (thermally conducting) • Electrically conducting • Radiating (shining) • Eating • …	• Melting, freezing • Squeezing, stretching • Metabolizing • Lifting, lowering • Rubbing/warming • Glowing • …

Slide 22: Energy tracking diagram for steam-powered light bulb

Time: About 15 minutes (until 1:10)
Format: Breakout rooms
Task: Construct an energy tracking diagram for a steam-powered light bulb.

1. Access the PhET sim: Energy Forms and Changes
2. On the “Systems” screen, put the teakettle on the left and the incandescent light bulb on the right.
3. Check the “Energy Symbols” box.
4. Increase the heat under the teakettle to make it produce steam and light the bulb.
5. Advance to **page 2** of the electronic whiteboard (linked below), then collaborate to construct the energy tracking diagram for this scenario.

Electronic whiteboards:

Group 1	Group 2	Group 3	Group 4	Group 5
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Break

1:10-1:20 / 4:10-4:20

Sociopolitical values embedded in energy concepts

Energy is sociopolitical

Time: 15 minutes
Format: Video and discussion

1. Please respond to the video at one of the bullet points below.
2. When you're done, please read what others have written.
3. Highlight, bold, +1, or comment on others' comments that stand out to you.

- I love the emphasis on how the idea of energy would be differently focused if our students were **developing it now**
    - +5
- It is interesting to see how others may perceive the focus of energy- coal vs. electrical vs. … +1
- I love that it's like a conversation, it doesnt feel dry or formal, while also being powerful and salient ++3
- It is fascinating to think of how we would frame it today in terms of environmental and renewables! I also wonder how it would be framed in a matrilineal hunter-gatherer society? I could see a lot of student interest with new possibilities, especially if they were to set the framework! +3
- **Efficiency, work, heat, and power are main concepts of energy - this stems from energy being developed as a scientific concept during the Industrial Revolution +1**
- The study of electricity goes back hundreds of years**. I think of Laura Bassi whose physics salons were attended by Voltaire** and the fact that she had many children while doing physics and lecturing in physics, and I wonder what would have happened if voices like hers had been magnified the way men's voices were. If history had taken a more equitable path starting even so recently as then.+1
    - Yes, and Emilie du Chatelet! **Love showing students huge concepts by scientists other than Newton, Einstein**.+1
- Really cool to place energy in the time period of the ideas. **The economic systems that enable/privilege a certain way of thinking about things.** +2
- **I would love to elicit student ideas about what energy would be called / perceived today if it were a brand new concept in terms of what it's for, who it benefits, how we can make its usage equitable, and how we can make sure we're being good stewards of the only home we have**. +8
    - This is also one of many answers to my students' questions about why we teach & learn history and its connection to EVERYTHING
- Interesting to consider how energy would be approached today from a different perspective involving responsibility, relevancy, resistance, and responsiveness.
- interesting to look at how the context in which terms and ideas in science are fleshed out are in tune with the challenges and industry at the time
- The relationship between **physics and the military** is as strong as the relationship between **physics and capitalism**.you can pair physics with the environment of the student just as well. All it takes is an open mind!
    - Very good point! Physics has a very military history at least back to Galileo who I believe was working for the italian army, to help them predict where their cannonballs would land +1
- Love love loved this video and how it presented how culture and social values are embedded in science concepts. **I was especially struck by how it imagines a world where we define energy today because that gives the agency to students now to see how embedding values doesn't need to be a negative (that trying to be abstract is not possible and doesn't need to be seen as a negative). +5**
    - Yes! Values can be aligned or not aligned with your own values, but they are surely someone's values, and maybe for a good reason
- It seems like I should have thought of the industrial revolution connection before but putting that perspective into what we put our time into based on what is going on is interesting and is a good transfer of knowledge for many topics
    - Right?? How did I get so far in physics and never be supported to make that connection? Or care about it? +3
    - I was taught about like the dates that scientists were alive, but I always thought that was stupid and boring - I would've seen more value in being taught about the environment they were developing the concepts in (yes, I could've gotten that from history class, but I hated history and I'm really bad with dates and chronological order)
- I think a good way to see how energy as a concept would be thought of today would be to ask students before teaching it. +2
- I appreciate tying the development of the energy concept to a very specific time, place, and situation. +1,
    - -> comment: I agree with this completely, history and society shapes science is a key framework and idea I want to convey to my students.
- Would be interesting to think about nonwestern depictions of of energy might are different
    - +3
- I think the idea of electrical energy not being a focus is an interesting angle for someone who might be resistant to these ideas
    - +1
- Energy is at the root of all of our current conflicts and war.(+3)
- I notice that the recognition of positionality and privilege becomes part of the positive messaging of social change and empowerment, by using science education as a method and process towards the greater good.
- In Kenya when the price of fuel increases people go hungry. +1
    - I wonder how this compares to how people lived pre-colonization, is it actually an improvement? I wonder as well, what would life be like without the colonial rule?

- The poor suffer the most with lack of access to cheap energy
- The second law of thermodynamics can be used to match energy sources to applications
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- The video suggests not to throw out these concepts of energy. Is that true? Should they be rethought? Is it just a reworking of the context?
    - Very interesting question! Maybe the answer depends on what you think energy “is”?
- Is the whole idea of physics as a pursuit an arm of capitalism/industrialism? What is the application of physics in a de-industrialized world?
    - THIS IS SUCH A QUESTION.
- Climate change! We would spend so much time thinking about the energy implications of climate change if it were a fresh idea today +!
    - So right!!!

Efficiency is sociopolitical

Time: 20 minutes
Format: Video and discussion

1. Please respond to the video at one of the bullet points below.
2. When you’re done, please read what others have written.
3. Highlight, bold, +1, or comment on others’ comments that stand out to you.

- **Mind blown! I always tell my students that units are important but this adds a whole new dimension to that! – YES! I think it gives them a personal stake in units** (beyond helping them get the equation right). +3
    - Makes me think about how when I teach ratios to students, they often think of “ratio” as a verb where someone’s tweet gets more negative feedback than support. This speaks to the importance of units and how that affects the value of a number. (aka high engagement of a tweet does not equate to support.)
- Economics discusses this type of thinking all the time, being creative in the definitions and identification of costs/benefits is difficult, but fascinating.
- I love this. I have not spent much time on teaching efficiency at all until recently. It is part of an introductory course I teach but purely in terms of how high a ball continues to bounce with each bounce. To me this is pointless to the students and disconnected from most of what they care about. **THIS FEELS REAL. +1!!**
- Excellent connection between efficiency calculations and subjectivity. This makes for an easy discussion regarding what we can do to reduce carbon emissions and fight climate change. +1
- Love thinking bout how efficiency cannot be simplified into that singular calculation without including some context as well. Being able to include subjectivity is very relevant to the real world.
    - And the subjectivity was already there but we maybe weren’t seeing it!—So true!
- “Efficiency” is weird and potentially misleading. Different stakeholders can present efficiency data that works for them. +2
- **This is an excellent case against throwing formulas at our students! I can see this opening up a chance for them to discuss what to include first when considering how to quantify efficiency.** Very thought-provoking! It will allow for good arguments and creativity! (+3)
    - Could even be something where you start by throwing the efficiency formula at them and have them rank systems based on efficiency (without knowing anything about the system), then introduce other factors about the systems and have them change their rankings. Like “wow you ranked system A really high for efficiency and system A is actually [something really dangerous or exploitative etc.]. Does that change how you think about it?” +1
- A great example to asking what is effenct to you? Is it the output in the environment? Or Is it the about of pollution left from the output. Efficiency is a not a formula from nature, it is a man-made ratio.
- Thinking about what the focus object (bulb/car/etc.) and how the efficiencies can change when the intended uses change… interesting! Positionality in action.
- I liked how the video continues to speak to the idea that values are embedded in our models and **calculations that claim to be “value-free,”** and how that doesn’t need to be a bad thing. This understanding pushes us to avoid searching for that “one ultimate equation” and instead have an open discussion about our values. (+2)
    - Yes to becoming more conscious of hidden values!
- Love thinking about efficiency in different ways. I think this video had some great visuals and examples that would really open up my students mind on how to think about a variety of topics. This would be a great connection to different projects trying to be passed in the state.
- This video makes me think about arguments against things like public transportation and high speed rail and how the decision was made between subways or highways. The Fords and GMs and oil companies and the like were thinking one way, but in terms of people you can move more efficiently with less fuel, that calculation looks very different. I really love the breakdown of what you consider valuable applied to a math equation here because math is another subject people assume is objective. Depending on what you think is valuable output and to whom versus what is valuable input changes the calculus of what it means to be efficient. +2
    - I think this applies to a lot of things - like in my small neighborhood we would likely all only need one lawn mower, but all of us have our own. We could have created a system where people share more, but then it cuts down on how much people consume.
- Similar issues of what to include or ignore come up in other parts of physics, such as whether to include friction, or to assume a spherical cow. Energy does seem to be a place where these decisions run into our values more often than other concepts. +2
- So very thought provoking! It makes me think about people working in a system that is made to extract the most out of every person to maximize profit…it certainly seems more efficient from the perspective of a business owner to pay workers less. +2
- Placing the concept of efficiency high up the hierarchy of importance is not always a good thing. +1
- A great cautionary tale about cherry-picked/deliberately misleading statistics. I like the idea of encouraging students to become critical consumers of facts and data as presented. +5

- It would be interesting to have students analyze one system in multiple ways to get them thinking about how the definition of efficiency can be adapted to a specific desired outcome. +2
- I love this!!! I feel like I mention it to my students but don't take the time to let them really unpack it, this video was so inspirational. It also got me thinking about externalities in economics. Who flips the bill for oil spills? (not oil companies), who suffers the most from energy choices and who's "bottom line" is largest? +2
- This is what I've tried to capture with my final energy project with my students, but not effectively or *efficiently* conveyed in a good summary that helps them tackle the project, that the process of learning physics is about thinking critically at problems, and shifting our perspective, not just the physics concept itself. +4
    - I'm curious what your energy project is
- I think the difference between useful and nonuseful energies comes down to context which is of course dependent on our positionalility. Everything is coming together! +3
    - Great connection!!
- (I like bringing this wider lens to efficiency - the calculations can tell us something, but what else do we know? How do those calculations change when we include or exclude things?) The three main questions to consider when discussing efficiency: (1) What counts as the input? (energy in when using it? Manufacturing? Human energy? Transportation?) (2) What is useful energy? (this depends on the situation) and (3) What other factors are we ignoring? (What else determines the usefulness or benefit of this item/machine/system?)
- Efficiency helps compare and choose, the definitions are critical for the tool to be useful. Good video
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"Exit ticket"

(5 min) Please complete this feedback form to let us know how things are going for you.

Further reading about Energy Tracking Diagrams and other representations

- Representing Energy – The site provides resources to support learners in co-constructing a flexible, interdisciplinary, energy model through the process of representing the "energy story" of diverse, real-world, scenarios.
- "Energy Tracking Diagrams," by R. E. Scherr, B. W. Harrer, H. G. Close, and A. R. Daane, *Phys. Teach.* 54(96), 2016 (PDF here)
- Drawings of energy: Evidence of the Next Generation Science Standards model of energy in diagrams
- Phys. Rev. ST Phys. Educ. Res. 8, 020114 (2012) - Representing energy. I. Representing a substance ontology for energy
- Phys. Rev. ST Phys. Educ. Res. 8, 020115 (2012) - Representing energy. II. Energy tracking representations
- Energy Tracking Diagrams are actually my second favorite energy representation -- my favorite favorite is Energy Theater (PDF)! But it only works in person.
- We also love Energy Cubes (PDF) and Energy Animations (PDF).