Integrating Energy, Equity, and Place in High School Physics

The energy story of a power plant

Day 3 | Wed Aug 11, 2021 | 12-2 PT / 2-5 ET
Session Slides

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Agenda

Purpose of this session

In this session we will

- **Analyze the energy dynamics of a power plant**
- **Consider the sources and emissions of energy for a power plant**
- **Recognize the sociopolitical origins of the energy concept**

This and subsequent lessons will provide us with:

- A shared vocabulary for energy in its sociopolitical context
- Recognition of how the physics model of energy is connected to the historic and current exploitation of land and people

Slide 4: Energy Tracking Diagram for Plant Scherer

Time: About 30 minutes
Task: Construct an energy tracking diagram for Plant Scherer, the largest coal-fired power production facility in North America.

1. Access information about Plant Scherer: A Coal-Fired Thermoelectric Power Plant
2. Access your group's electronic whiteboard at the links below, and **turn to page 3 to create your diagram.**
3. I suggest including only the following objects in your diagram as a first pass -- this will make your task less complex:
    - "Boiler": including Coal, Precipitator, and Stack
    - "Turbogenerator": Turbine + Generator as one object
    - "Cooling system": Condenser + Cooling tower as one object
    - "Electrical grid": Transformer + Transmission Lines as one object

Electronic whiteboards:

Group 1	Group 2	Group 3	Group 4

Rules for Energy Tracking Diagrams

- Objects are areas.
- Units of energy are letters;
  specific letters indicate forms of energy.
- Energy transfers and transformations
  are represented with arrows.

Slide 8: Plant Scherer sources and emissions

Time: About 10 minutes
Task: Research associations between Plant Scherer and historic or current exploitation of land and people. Take notes in your group space below. *Guiding questions:*

1. Who are the people and communities that the power plant impacts?
2. Who are the people and communities impacted by coal extraction in the Powder River Basin?
3. Is the ash safe? Is the ash pond contained, or does it connect to local groundwater? What bodies of water are nearby?
4. What gas(es) are exhausted from the plant? Are they greenhouse gases? Is a lot of gas emitted?

If you find valuable resources to help you answer these or other questions, please paste links below!

Group 1

- In 2006, Plant Scherer was "largest single point-source for carbon dioxide emissions in the United States"
- 2-5 trains (of up to 135 cars) deliver coal each day
- The power plant impacts the communities connected to its power grid (in a positive way by providing electricity), but has a negative local impact on the ash pond and those who rely on nearby water sources for drinking water, agriculture, marine life; a local/global impact through exhaust gases that pollute the air locally (can cause health issues and agricultural conditions) and facilitate climate change.
- Human impact of coal ash can be seen at: https://www.psr.org/wp-content/uploads/2018/05/coal-ash-hazardous-to-human-health.pdf
- Coal and the environment - US Energy Information Administration
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- A map of dumping sites in the US is available at: Mapping the Coal Ash Contamination
- Power plants are massive industrial complexes, with buildings, stacks, and other structures on a scale that often dwarfs everything nearby. Because of this, power plants can be seen from far away, and they can irreparably harm viewsheds that are highly valued by society. Nearby homes and sites of historic significance

Group 2

- Power plants use fossil fuels, such as coal, oil, and natural gas, which are finite in supply
- https://www.clearwater.org/news/powerplants.html
- Power plants cause water pollution. When water is discharged back to the river, thermal (heat) pollution occurs.
- The ash pond did not have the necessary protective lining which affected the drinking water near the plant.
- It affects marine life by killing newborn fish and other species. Heavy metals and chlorine have a negative effect on river life.
- https://www.sciencedaily.com/releases/2019/02/190219111718.htm
- https://docs.google.com/document/d/17eP3B4B8LEZKR2gDR3-N495ZOBdBse41U2AUozJhsOM/edit#heading=h.ss513zj9m9c9
- The power plant's close proximity to communities has a negative impact
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- Lawsuit Says Plant Scherer Is 'Poisoning' Locals | Georgia Public Broadcasting (gpb.org) Harmful effect of plant scherer
- Scherer Steam Generating Station - Global Energy Monitor (gem.wiki) environmental impact
- Plant Scherer is the U.S biggest greenhouse gas single contributor

Group 3

- Anyone on the watershed → people in that town or nearby town.
  a. Local communities have a higher rate of cancer.
  b. Census: https://www.bestplaces.net/people/zip-code/georgia/juliette/31046
- *Is the plant storing coal in land or ponds?*
- Use the ash to *displace* people.
- Coal ash contains arsenic, chromium, lead, mercury--hazards to human health. This can be stored in ponds as sludge and can then leach into the groundwater supply of communities over time poisoning the groundwater. Coal ash water from ponds is also allowed to be discharged into rivers and waterways polluting them.
- Plant's zip code: 31046
  a. Mvskoke lands

Group 4

- Gases include CO2, sulfer dioxide, ozone: from energy.gov Yes, these are greenhouse gases, although sulfer dioxide not exactly.It is horriible for lungs though.
- shut down roughly 30 ponds from the Appalachian foothills to the wetlands near the Georgia coast
- Hexavalent Chromium found in well water
- Legal action, 2020: Middle Georgians take legal action against Georgia Power over coal plant
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are devalued because of the plant´s inappropriate size, use, and architecture. • • • • • • •	• https://www.nwf.org/Our-Work/Environmental-Threats/Climate-Change/Fossil-Fuels/Coal/Powder-River-Basin • Coal in Powder River Basin • How Wyoming's Black coal miners shaped their own history		

Resources on Plant Scherer sources and emissions – please share what you find!

- The Coal Plant Next Door — ProPublica
- High carbon emissions costs measured in mortality // The mortality cost of carbon
- EPA Says Coal Ash isnt hazardous waste
- Coal Ash Storage and Discharge
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Slide 10: Energy is sociopolitical

Time: About 10 minutes
Task: After viewing this video together (4 min):

1. Share your thoughts 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.

- Perhaps also give a nod to the older terms, especially efficiency, as it would be wonderful if we, machines, etc were more efficient.
  - Efficiency is the subject of the next video we will show you!
- This is a very unique and innovative approach to thinking about science and energy and I appreciate that equity and new thinking can be applied to concepts which are considered the "law and testament" of science. Though not necessarily wrong it is interesting to see a new and fresh approach in which students and educators alike can reimagine and reframe what science is and how it is taught and understood.
- Maybe include an example(s) of how electricity would be intertwined with the other forms of energy had it been devised today.
- I felt that this video started with a sense of students as the intended audience, but at the end, it was clear that teachers were the audience. I wonder if it would be beneficial to have two different videos: one for the project as a whole, and one (or ideally a series) for students which illustrate how other physics concepts were sociopolitically constructed.+2
- I am curious about other concepts in physics and how the history in which they were formed impacted them. +1
- Current states of energy could be addressed. I appreciate the approach to thinking about these issues. Cool!
- Interested in learning more about the history in which the concept of energy was formed. Do you have specific resources that you would recommend? Maybe add them at the end of the video.
  - Our best sources have so far been kind of "heavy" - like this book: Science of Energy the Construction of Energy Physics nt he 19th Century
- "By learning how science concepts are shaped by the historical period in which they are constructed…" makes me want to learn more about the historical period in which every major concept in my intro physics class was constructed. It also is different from, but reminds me of, the part in *Disordered Cosmos* where **Dr. Prescod-Weinstein** talks about how we tell students certain concepts aren't intuitive because we experience them that way, but not every student will experience them in the same way. The connection to me is about the values embedded implicitly in the way we talk about things (and decide which things to talk about). (+1 Her book is amazing!!!) (+1!!!)+1 **See her book promo video! It dissects physics and race! https://twitter.com/IBJIYONGI/status/1359985570227892235?s=20**
- Energy means power
- It supports capitalist interest and colonialism
- I applaud this approach to our curriculum. This discussion and movement in ideas of physics education has been a long time coming! Nice Work!
- I think that showing the history of how and why things were developed is important so that students can see the context of when the science was being done/researched/studied.
- Energy uncovers power structures

- ^Yes! And if they learn the context of this science, they may have a better understanding of why we are currently focusing scientific research on the things we are
- Could we then ask students to extrapolate on the idea of energy currently (renewableness clearnliness etc)? In a classroom discussion around this video?? +1

- Science is a human endeavor to explain the natural world around us. As we evolve as a species our technology evolves and thus our understanding. I think it is important for us to articulate how the ideas of a period impact the beliefs of and that those models are constantly changing...which is the nature of authentic science. It is great we are being transparent on the origins of our understandings.
- Science as created by humans is an important idea. The video perhaps oversimplifies the existing physics concept of energy since it does encompass a lot already. Some more specific examples of how new concepts of energy might be incorporated into the traditional physics energy story would be interesting.
- I appreciate how explicit you were that physics is political.
- The video is short but very explicit that science is a structure within geopolitical structures.
- I think this is trailblazing work in physics education
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- I wish there were articles in *TPT* that were like this. +1
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Slide 12: Efficiency is sociopolitical

Time: About 10 minutes
Task: After viewing this video together (6 min):

1. Share your thoughts 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.

- This is great! I'm always trying to convince my students to take the bus to school instead of driving in their cars...I'm totally going to use the unit of people miles!

- Wow this was great. Wonderful way to have a meaningful discussion about efficiency and what does it mean in our practicality of life.
- In her session on the first day, Jessica's presentation referred to **efficiency as a theological concept with the ideal of maximizing the human use**. It was one of the most impactful "tidbits" of the day, and I highlighted it in my notebook. I wanted this video to have that same level of impact, and I think there's room for a stronger and deeper take in it. I also would have liked more historical connections (I know that's not a simple request). *(I also kind of zoned out in the middle, so it's really possible I missed important stuff. For the previous video, I watched it during the break so I could see it twice and miss less, but this one I've only seen once so far.)*
    - *(from Kara) The theological relationship to efficiency is something that I'm working to flesh out. These two concepts are very closely tied.*
    - *(from Jessica) I can try to go more in depth on this → my background is on Indigenous science and scholarship and I can discuss this further! I also thought an hour was not enough time to address everything I had to so thank you for this feedback.*
- What counts as input energy and what counts as output? This allows us to expand our ideas and connect to real life.
- I think this brings us back somewhat to the idea of positionality and understanding more of the human side and how we impact as well as interpret data in ways that we see fit.

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- It was very interesting how Kara expressed the different views of efficiency and how it **depends on the lens or definition or unit of efficiency in that definition.** I never considered a school bus being more efficient than a small car or an incandescent light bulb putting out more useful energy.
- Provide different perspectives how we define efficiency
- Great idea(s) in this video. Point of view or positionality completely affects the calculation. +1
- Works excellently as a video for any audience - demonstrates inherent sociopolitical nature of physics, which is a beneficial way of thinking to expose to everyone.
- LOVED this video. Kara problematized the historical definition of efficiency in multiple ways, and also gave modern examples that prompted further questions around how we could alternatively think about efficiency. I especially appreciated the discussion of how human labor to build, transport, and use machinery has typically *not* been taken into account when determining its efficiency. It is a surprising contrast to our work-oriented culture and how people may tie their self-worth to their productivity; I feel this could just as easily lead to a SEL conversation with students as an equity discussion.
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- I would show this to my students. → 11th/12th graders, not 9th/10th as it currently is
- I would love to be able to do a calculation of how much more food I would need to intake, and the land use and embodied energy associated with food, if I were to ride my bicycle everyday to work. +1
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- The idea of efficiency was tremendous. The rethinking of what is being characterized by the concept of efficiency is brilliant!
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- This is awesome. What a great way to approach this topic!
- I really liked all the different methods of thinking about efficiency. I wonder about making connections about valuing efficiency in engineering/physics and the value that white protestant culture puts of efficiency.
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- I was struck by the power of the idea of how **including humans into the calculation makes a big difference,** both in the example of the steamship and in the example of the bus.

- I think including the Earth and our environment into this as well as humans could add another interesting layer. Especially when it comes to power production, like we saw with the power plant previously. It is “efficient” if you ignore the increase in loss of life and damage to the environment…. +1
- Kara, I wonder if you have considered the idea that in many cases as efficiency increases, resource depletion increases. There are many examples throughout history, such as the steam engine’s impact on coal extraction. But as an example I use with students, if I have a gas guzzler car and a Prius, if gas is $1 per gallon I might drive the gas guzzler, but if it is $5 I might have stayed home if I only owned the gas-guzzler, but because I own the Prius, I can afford to keep driving at $5. On the production side, this means it becomes economically viable to keep extracting oil at $5 per gallon, whereas if everyone only owned gas guzzlers, oil production would collapse. This results in the counter-intuitive concept that higher efficiency causes more not less absolute depletion
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- I think the audience is intended for both students and teachers.

- What counts as efficiency? To whom? And why? Can it be measured and quantified? What is included and not included in this calculation of efficiency? Who makes the decisions what to include/exclude in the calculation of efficiency?
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- Kara's fuel efficiency lesson

Your questions and comments here!

- As a physics teacher, I really like the energy tracking diagrams. But as a chemistry teacher I find myself wincing a bit. If I ask my chemistry students "What makes a tree?", from a matter perspective it's made from regrouped atoms from CO_2 from the air and H_2O from the ground. But from an energy perspective it's made from transformed sunlight. The problem I have seen is that my chemistry students have a really hard time switching back and forth from thinking about matter to thinking about energy. My concern is that a very physical representation of energy will compound or exacerbate the problems differentiating these ideas. I don't know if this concern is valid because I have never taught energy tracking with a physical representation before. Maybe it all works out fine. I assume in your decades of working with physics and chemistry teachers that you would have insight into how to navigate this issue. I would greatly appreciate if you would share those insights
    - (from rachel) Yes! I completely agree that Energy Tracking Diagrams represent energy transfers at the expense of matter transfers. I have colleagues who have done ENERGY tracking diagrams *alongside* MATTER tracking diagrams for this reason, and they looooved it. I can look for a reference - I wonder if they published their work.
- 10 minutes is not enough to even settle into reading one article. I wish we would have actually spent time on the activity of learning about the power plant. 20 people pasting links into one document was overwhelming and made the 10 minutes feel even shorter.
    - I agree with the above comment on the energy tracking diagrams, as a chemistry teacher(in addition to physics) it did cause me some stress! I would love to see more on the matter tracking diagrams also.
    - Definitely need more time for the resources and sources of emissions research for the power plant
    - (from Rachel) Thank you for this feedback.
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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).