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## Connecting Energy and Electricity Environmental Justice Issues

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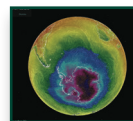


# Connecting Energy and Electricity Instruction to Local Environmental Justice Issues

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**E**nergy and electricity are major concerns for communities as well as being major topics in physics learning. My colleagues and I<sup>1</sup> are adapting our energy and electricity instruction to help students connect their learning to local environmental justice issues. An important goal is to help students understand that science is implicated in ethical decision-making that affects them and their communities.<sup>2,3</sup> In this way, we hope to better prepare students to both understand social problems as scientists<sup>4,5</sup> and address them as citizens.<sup>6</sup> The materials presented here are available for download from [energyandequity.org](http://energyandequity.org).

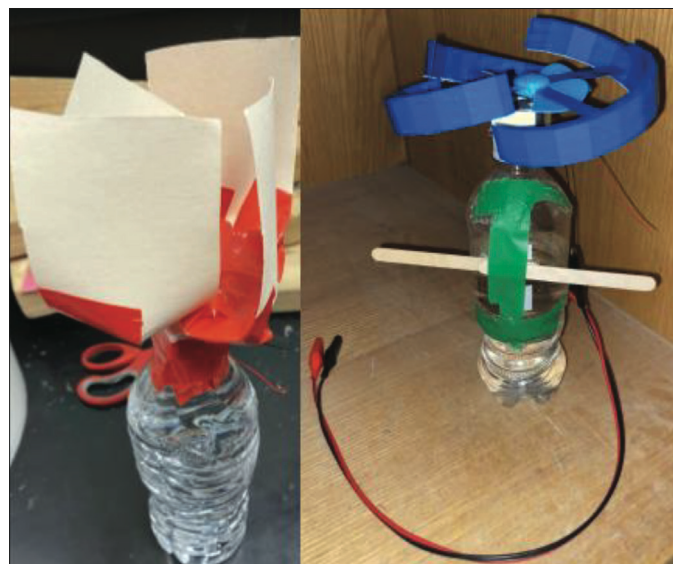
## Instructional sequence

The John D. O'Bryant School of Mathematics and Science is a public STEM-focused school in Boston, MA. The student population represents many neighborhoods of Boston and is 32% Black, 34% Latine, 20% Asian, and 12% White; 62% are designated as low income by the state of Massachusetts, and 51% have a first language other than English. Almost every student in the school takes non-tracked general physics, which is not tied to standardized assessments. In this course, the topic sequence is (1) Waves and Sound, (2) Mechanical Energy, (3) Electricity, (4) Energy Generation and Transformation, and (5) Work and Forces. This article will describe the Energy Generation and Transformation unit, which was taught by four different instructors simultaneously in 10 different sections of 11th and 12th graders.

## Electromagnetism and energy generation

Bridging from the previous unit (on electricity), students began the Energy Generation and Transformation unit by learning about electromagnetic induction, which is the basis for most energy production facilities. First, students demonstrated the electromagnetism of current-carrying wires by building simple speakers from copper wire, neodymium magnets, and plastic cups. To support further conceptual understanding of electromagnetic induction, students explored various topics at classroom stations, including (1) generating electric current by putting a magnet through coil; (2) observing simple motors; (3) operating crank and shaking flashlights; (4) inducing magnetism in a nail with an electric coil; and (5) observing the slowed motion of a magnet dropped through a metal tube. Students represented energy transfers and transformations in complex systems using Energy Tracking Diagrams<sup>7</sup> and the PhET simulation "Energy Forms and Changes."<sup>8</sup>

Students' thinking about energy generation began with an exercise from an engineering education organization that provides lab equipment and one remote class visit from an engineering mentor.<sup>9</sup> Students used the provided equipment to



**Fig. 1. Student-constructed model wind turbines.**

build miniature wind turbines to light a light-emitting diode and described the associated energy transfers and transformations (Fig. 1). Overall, this part of the instructional sequence brought together the students' understanding of mechanical energy, electricity, and electromagnetism to describe how a wind turbine generates electricity.

## Comparing methods of energy generation

In order for students to learn more about the advantages and disadvantages of methods of energy generation, students held a class debate. Students debated the question, "Which forms of energy should Massachusetts increase the use of?" One of the goals of this debate was to give students an impetus to research the types of energy generation used in Massachusetts and the impacts of these types of energy generation on local communities. Throughout this unit, we used an environmental justice lens to learn about these issues. Environmental justice addresses how environmental policies, land use, and air and water pollution impact communities that are already marginalized because of their identity, especially race, class, or ethnicity. Environmental justice was introduced to students using a video.<sup>10</sup> The Massachusetts legislature has defined Environmental Justice Populations based on communities' annual median income, racial makeup, and English fluency.<sup>11</sup> All of the local energy issues described in the section below are located in environmental justice communities. Students researched solar energy, hydroelectric energy, biomass, or natural gas. In addition to researching the topic they were presenting, each group also researched a second energy source so that they were prepared to question

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that group during the presentations. This encouraged students to become familiar with more than one form of energy generation. It also encouraged students to think critically about the impacts of energy generation rather than focus solely on the advantages of their own topic. This section of the unit culminated with students writing their own recommendation about which energy sources Massachusetts should increasingly use.

## Learning about local issues

To learn about how the physics of energy generation directly affected their local community, students researched four local environmental justice issues across Massachusetts and created posters about the issues (Fig. 2). Students researched what was being proposed and why, who was against it and why, and the science behind the energy generation or energy transformation of what was being proposed. Students learned from each other's research by viewing and discussing each other's posters. The posters were displayed in the hallways for other students to learn about these issues. The four issues that students researched were as follows:

- **A natural gas compressor station** in Weymouth, for which a natural gas pipeline was built through a densely populated neighborhood known for flooding that has been designated as an environmental justice community by the state.<sup>12</sup> Natural gas produces harmful emissions when burned to produce electricity or when leaks occur.
- **Proposed "peaker plants"** in Peabody, which were designed to only be used during times of peak demand for electricity and are often heavy polluters because they burn natural gas and diesel.<sup>13</sup> These plants are slated to be located in communities with vulnerable populations already facing other environmental health issues.
- **A biomass substation** in Springfield, which, as a result of a decade of environmental activism, was not built.<sup>14</sup> Biomass is wood and other plant-based material, which is burned to generate electricity. The particulates in the smoke can be harmful, especially in communities with high incidences of asthma, which is a particular public health concern in Springfield.
- **An electric substation** in East Boston, located in some students' home neighborhood.<sup>15</sup> These substations are known to catch fire easily but were being placed on tidal plains in a densely populated area and near the jet fuel storage for Logan Airport.

An organizer from a local environmental justice organization (which led the campaign against the biomass substation) spoke to our 11th and 12th graders about current community organizing efforts.<sup>16</sup>

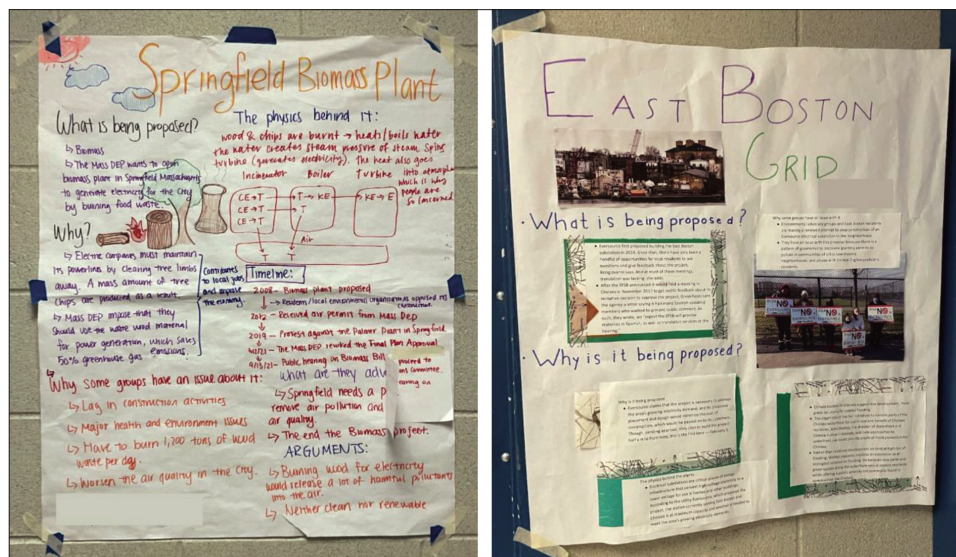


Fig. 2. Student posters about local energy justice issues.

Our hope was that students would connect the physics they had learned to issues that matter in their own neighborhoods. One student, "James," was reading an article about the Peabody peaker plant for his poster project and recognized a picture of a power plant he could see from his house in the Charlestown neighborhood of Boston. James started asking questions about the placement of power plants and peaker plants and why the power plant was so close to his home. When the guest speaker came to speak, James asked him about peaker plants and their relationship to the substation fight in East Boston. In this way, James was able to make connections between the physics he had learned, the neighborhood he lived in, and environmental justice issues in the greater Boston area.

While it is important for students to learn about the global impacts of climate change, in this unit, the focus was on local issues around environmental justice and climate change and what local groups are doing to fight these issues. The hope was that students could better understand ways that climate change impacts them and that they could have impacts on these issues.

## Moving toward action

The final part of the unit was meant to move students toward social action. Students learned about three current legislative or letter-writing campaigns that are tied to the environmental justice campaigns represented in their posters. Students had a choice to write letters to their legislators for one of three current campaigns. One campaign was a clean energy bill that would eliminate Massachusetts's natural gas use by 2050 and not allow biomass to count as a renewable energy source. The second was a bill about siting board reform, which would include environmental justice consideration when placing new substations and power plants. This campaign was led by the same group that is leading the fight against the substation in East Boston. The third campaign was not related to a bill but rather advocacy around stopping the Peabody peaker plants. Students wrote letters to their state legislators about the bills or campaigns. In addition to



making a request as part of the campaign, students talked about the physics behind the campaigns. Moving forward, this part of the unit needs to be further developed to include more student agency and choice so that students are more invested in the actions that they are taking.

## Reflections

As a physics teacher, I often hear, “Why do I have to learn physics?” I heard that sentiment much less this year after we did this unit. Many students liked the hands-on activities (building speakers and wind turbines). Others especially enjoyed the debate as a method of learning about the different types of energy forms, and the environmental justice posters as a way to creatively express what they learned about the issues, including the impacts on communities of color. In an after-unit reflection survey, students expressed all of these ideas:

- “I liked how we got to educate ourselves on minority communities and advocate for them through both the posters and letters.”
- “I really liked the environmental justice issue posters the most because I was able to learn about these real life issues around us that I didn’t know about before.”
- “The debate was really fun because we got to support, criticize and question how energy should be used. We also [got] to learn the pros and cons of all.”
- “I enjoy being able to research and learn about the problem our state is facing with environmental justice.”

The next time I implement this lesson, I plan to create a series of lessons in which students research a local power plant, track the energy transfers and transformations throughout its operation, and also track the plant’s sources and emissions. This will help students learn where the energy and material resources come from, and the impacts of extracting and disposing of those resources on the people and lands surrounding the plant.<sup>3</sup> Finally, I want to make the social action portion of the unit more meaningful to students, whether by helping them develop personal connections to the campaigns or by allowing more creativity in what they produce. Overall, my colleagues and I agree that this unit was a positive addition to our curriculum and look forward to continuing to develop it in the future. The current version is available on the Energy and Equity Portal,<sup>17</sup> an online resource for teachers to share lessons about energy and equity in physics.

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