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# Redefining Energy Justice in Physics Classrooms

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## ABSTRACT

Energy is one of the fundamental topics taught in high school physics. However, energy continues to be taught as an abstract concept that removes itself from the social implications energy systems have on society, in particular toward Indigenous communities. Given the importance of integrating discussions around equity into our science courses, in this study we propose a way in which energy justice can be redefined and included in physics classrooms. Redefining energy justice into physics classrooms allows us to connect energy justice to existing energy physics curriculum and lessons plans. In Summer 2020, 22 physics teachers participated in a professional development that centered on discussions around energy and equity. We analyzed and coded teachers' dialogues and conversations around energy and equity to identify energy justice pillars. The energy justice pillars we identified formed the basis of an energy justice framework that redefines energy justice for physics classrooms. This energy justice framework allows us to bridge the separation between physics and social justice, as they continue to be viewed as two separate schools of thought in the field of physics.


**Keywords:** energy, equity, energy justice, professional development, social justice, physics

## ENERGY IN PHYSICS EDUCATION

Energy is one of the most important and fundamental topics taught in physics high school curriculum.[1] However, energy continues to be defined in physics classrooms as an abstract concept that can also not be perceived directly.[2] Despite the tremendous advances in energy technologies since the nineteenth century, when the model of energy originated, the concept of energy as it is taught in most physics courses has not changed since. For example, energy as taught in physics foregrounds work, heat, efficiency, and power, because the original purpose of the energy concept was to improve factories and steamships in the British Industrial Revolution and advance the capitalism and colonialism that characterized that period.[3,4] At the same time, many physicists are pushing to adapt this concept to a more modern-day concept that supports teaching and learning methodologies more relevant today.[5]

It is also important to redefine the concept of energy because most science teachers are being asked to make their lessons culturally relevant to both their students and the twenty-first century.[6] The Energy Literacy

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[1]Lane Seeley, Kara Gray, and Amy D. Robertson. "Energy Cubes." *The Physics Teacher* 59 (2021): 89–93.

[2]Ibid.

[3]Crosbie Smith. *The Science of Energy: A Cultural History of Energy Physics in Victorian Britain*. (University of Chicago Press, 1998).

[4]E.A. Wrigley. "Energy and the English Industrial Revolution." *Philosophical Transactions of the Royal Society of London. Series A: Mathematical, Physical, and Engineering Sciences* 371 (2013): 20110568.

[5]Eugene Hecht. "Understanding Energy as a Subtle Concept: A Model for Teaching and Learning Energy." *American Journal of Physics* 87 (2019): 495–503.

[6]Josef De Beer. "Cultural-Historical Activity Theory (CHAT) as a Practical Lens to Guide Classroom Action Research in the Biology Classroom." *The American Biology Teacher* 81 (2019): 395–402.

Framework states that energy learning is the foundation for informed decision making about sustainable and just use of energy resources, and presses teachers to recognize that energy issues are not only issues of science and technology, but must be integrated with ''civics, history, economics, sociology, psychology, and politics.''[7] This is to help students understand and learn how to solve modern energy problems. Without doing so, the curriculum for the energy unit fails to reach and serve diverse students, especially those whose communities are the most impacted by our society's high dependence on extractive energy resources.

This reliance on extractive energy sources such as fossil fuels is accelerating climate change at a higher rate than our society can curb, thus inappropriately impacting Indigenous communities.[8,9,10,11] To address these disparities that result from extractive energy resource dependence, we argue that the concept of energy needs to be redefined to also include the injustices it results in. One way this can be done so is by integrating and redefining energy justice in physics classrooms. This will merge the need for equity with energy, a foundational physics concept.

## THE ROLE OF ENERGY IN CLIMATE CHANGE

Climate change is a natural phenomenon that is accelerating more rapidly than our world can adapt because of our high dependence on fossil fuels.[12] Our inability to curb climate change is resulting in severe impacts toward Indigenous peoples.[13] For example, in the Pacific Northwest, climate change is warming the oceans, causing them to become more acidic.[14] This is resulting in the high mortality rates of Pacific salmon, an important cultural species to the Coast Salish tribes and people of this region.[15,16] In North Carolina, climate change is resulting in more droughts, ultimately impacting the groundwater and other water reservoirs the Lumbee Tribe depends on.[17] This makes energy a political issue despite being taught as an apolitical and abstract concept that is governed by physical and mathematical laws (thermodynamics, kinetic energy, etc.) in physics.[18] This is because our dependence on energy systems is resulting in sociopolitical issues that are linked to Indigeneity (Indigenous identity). Climate change is one of those sociopolitical issues because the introduction of colonialism, capitalism, and industrialization severely impacts the original caretakers of these lands, Indigenous communities.[19] Energy is deeply rooted in colonialism, capitalism, and industrialization as energy systems in the United States focus on the extraction, conversion, delivery, and usage of energy.[20] This energy system is not abstract and intersects with ecological, political, economic, and social systems.[21] Given the relationship between climate change, energy, and social injustices, we contend that energy can be taught through the lens that emerges from climate and environmental justice to energy systems. This relationship or nexus is known as energy justice, which integrates theories of little-e (energy) and Big-E (energy).[22,23]

Lohmann et al.[24] and Lennon[25] have theorized that energy can be conceptualized in terms of little-e (energy) and big-E (energy). The big-E refers to energy that can be transported in large quantities and long distances that uphold capitalism and our fossil fuels dependence.[26,27] The big-E is thus responsible for the energy injustices that continue to primarily impact communities of color.

[7]Energy Literacy. Essential Principles for Energy Education. Energy.Gov. (2017). <https://www.energy.gov/eere/education/energy-literacy-essential-principles-energy-education>. (Last accessed on March 2, 2021).

[8]Donna Green, Ursula King, and Joe Morrison. ''Disproportionate Burdens: The Multidimensional Impacts of Climate Change on the Health of Indigenous Australians.'' *Medical Journal of Australia* 190 (2009): 4–5.

[9]James D. Ford. ''Indigenous Health and Climate Change.'' *American Journal of Public Health (1971)* 102 (2012): 1260–266.

[10]Michael Paolisso, Ellen Douglas, Ashley Enrici, Paul Kirshen, Chris Watson, and Matthias Ruth. ''Climate Change, Justice, and Adaptation among African American Communities in the Chesapeake Bay Region.'' *Weather, Climate, and Society* 4 (2012): 34–47.

[11]Michael S. Spencer, Taurmini Fentress, Ammara Touch, and Jessica Hernandez. ''Environmental Justice, Indigenous Knowledge Systems, and Native Hawaiians and Other Pacific Islanders.'' *Human Biology* 92 (2020): 45–57.

[12]M.J. Burke and J.C. Stephens. ''Political Power and Renewable Energy Futures: A Critical Review.'' *Energy Research & Social Science* 35 (2018): 78–93.

[13]J. Hernandez. ''Indigenizing Environmental Justice: Case Studies from the Pacific Northwest.'' *Environmental Justice* 12 (2019): 175–181.

[14]C.C. Funk and M.E. Brown. ''Declining Global Per Capita Agricultural Production and Warming Oceans Threaten Food Security.'' *Food Security* 1 2009: 271–289.

[15]R.J. Beamish and C. Mahnken. ''A Critical Size and Period Hypothesis to Explain Natural Regulation of Salmon Abundance and the Linkage to Climate and Climate Change.'' *Progress in Oceanography* 49 (2001): 423–437.

[16]C. Jacob, T. McDaniels, and S. Hinch. ''Indigenous Culture and Adaptation to Climate Change: Sockeye Salmon and the St'át'imc People.'' *Mitigation and Adaptation Strategies for Global Change* 15 (2010): 859–876.

[17]R.E. Emanuel. ''Climate Change in the Lumbee River Watershed and Potential Impacts on the Lumbee Tribe of North Carolina.'' *Journal of Contemporary Water Research & Education* 163 (2018): 79–93.

[18]Myles Lennon. ''Decolonizing Energy: Black Lives Matter and Technoscientific Expertise Amid Solar Transitions.'' *Energy Research & Social Science* 30 (2017): 18–27.

[19]Kyle Whyte. ''Indigenous Climate Change Studies: Indigenizing Futures, Decolonizing the Anthropocene.'' *English Language Notes* 55 (2017): 153–162.

[20]B.A. Garrett. ''Evolving the Nation's Energy Infrastructure: A Challenging System Issue for the Twenty-First Century,'' (2007 IEEE International Conference on System of Systems Engineering, 2007), 1–6.

[21]Ibid.

[22]Larry Lohmann, Hildyard Nicholas, and S. Sexton. *Energy Alternatives: Surveying the Territory*. (*The Corner House* 20, 2013).

[23]Lennon. (2017). *Op. cit.*

[24]Lohmann et al. (2013). *Op. cit.*

[25]Lennon. (2017). *Op. cit.*

[26]Lohmann et al. (2013). *Op. cit.*

[27]Lennon. (2017). *Op. cit.*

Owing to environmental racism, communities of color are more likely to live near power plants that cause pollution, resulting in energy injustices that impact their overall wellbeing and livelihoods.[28,29] In contrast, the little-e (energy) refers to energy that cannot be transported in large quantities or long distances, such as energy required to make wood from trees.[30,31]

We contend that both the big-E and little-e need to be integrated in high school physics curricula. The big-E has become a dominant narrative in our society, so we can no longer ignore fossil fuels and the energy industry when discussing energy through a physics lens. The big-E and little-e create an energy and equity nexus that allows us to look at how inequities and energy are related and intersect. This is because energy systems focus on the extraction, conversion, delivery, and usage of energy.[32] This energy system is not abstract and intersects with ecological, political, economic, and social systems.[33] Integrating both big-E and little-e also allows physics teachers and physicists to link social justice to the concept of energy within this energy-equity nexus that is not visible within physics education.

## SOCIAL JUSTICE IN THE CONCEPT OF ENERGY

Energy justice and racial justice are closely connected. In the Blackfeet nation, atomic waste has been dumped in their ancestral lands, making the Amskapi Piikani Nation (Blackfeet) extremely vulnerable to certain cancers, respiratory diseases, and so on.[34] In the Navajo nation, abandoned uranium mines, to which many of their tribal citizens worked for, have resulted in high cases of cancers and kidney diseases.[35] These examples, among many others that exist, make energy a concept—both big-E and little-e—deeply rooted in racial injustices that are primarily impacting Indigenous communities. However, physics continues to promote that it is a scientific discipline free from bias, meaning that it is not responsible for any of the racial and social injustices taking place in our environments and communities.[36] This is one of the reasons why issues of racism, sexism, and other forms of oppression are often not discussed in physics classrooms, further excluding people of color and women from the field of physics.[37,38,39] Given the racial hierarchies and other intersectionalities that determine who has power and privilege, we do not and cannot operate in an abstract world and thus we must start having more discussions about justice within physics. Integration of science and social justice is also called for by many physicists, including physics teachers.[40,41] Teaching students about social justice, for example, how energy injustices are manifested among Indigenous communities, can help students apply the problem-solving they learn in physics to real-world problems.[42] Some of these real-world problems may be directly impacting their own communities. This is another way of making physics more culturally relevant and responsive while building community resilience from within the classroom.

Given that physics is one of the scientific fields with a large racial disparity,[43] these conversations are important to bring to the forefront of physics education, which primarily begins in high school. It can also help students understand, especially those from Indigenous communities that both racial and economic disparities are factors that determine the quality of education they can obtain and are offered. Silence when it comes to social justice does not serve Indigenous people, as it continues to center and comfort whiteness.[44] Thus, energy justice is a social justice concept that is deeply relevant to physics. Research has shown that physics integrating social justice into physics classrooms can help students bridge the notions that exist in physics and redefine what it means to be a physicist who is also passionate about social justice issues.[45] Several professional organizations and grassroots efforts—for example, National Society of Black

[28]Dorceta Taylor. *Toxic Communities: Environmental Racism, Industrial Pollution, and Residential Mobility*. (NYU Press, 2014).

[29]Laura Pulido. ''Geographies of Race and Ethnicity II: Environmental Racism, Racial Capitalism and State-Sanctioned Violence.'' *Progress in Human Geography* 41 (2017): 524–533.

[30]Lohmann et al. (2013). *Op. cit*.

[31]Lennon. (2017). *Op. cit*.

[32]Garrett. (2007). *Op. cit*.

[33]Ibid.

[34]Kimberly L. Paul and Laura B. Caplins. ''Narratives of Injustice: An Investigation of Toxic Dumping within the Blackfeet Nation.'' *Human Biology* 92 (2020): 27–35.

[35]Tommy Rock and Jani C. Ingram. ''Traditional Ecological Knowledge Policy Considerations for Abandoned Uranium Mines on Navajo Nation.'' *Human Biology* 92 (2020): 19–26.

[36]Monwhea Jeng. ''A Selected History of Expectation Bias in Physics.'' *American Journal of Physics* 74 (2006): 578–583.

[37]Marcus Anthony Hunter. ''Racial Physics or a Theory for Everything That Happened.'' *Ethnic and Racial Studies* 40 (2017): 1173–1183.

[38]Chanda Prescod-Weinstein. ''Making Black Women Scientists Under White Empiricism: The Racialization of Epistemology in Physics.'' *Signs: Journal of Women in Culture and Society* 45 (2020): 421–447.

[39]Danielle Dickens, Maria Jones, and Naomi Hall. ''Being a Token Black Female Faculty Member in Physics: Exploring Research on Gendered Racism, Identity Shifting as a Coping Strategy, and Inclusivity in Physics.'' *The Physics Teacher* 58 (2020): 335–337.

[40]Kevin K. Kumashiro. *Against Common Sense: Teaching and Learning Toward Social Justice*. (Routledge, 2013).

[41]Christopher Emdin. ''Citizenship and Social Justice in Urban Science Education.'' *International Journal of Qualitative Studies in Education* 24 (2011): 285–301.

[42]Elizabeth Whitelegg and Malcolm Parry. ''Real-Life Contexts for Learning Physics: Meanings, Issues and Practice.'' *Physics Education* 34 (1999): 68.

[43]American Physical Society (APS). ''Minority Physics Statistics.'' (2018). *American Physical Society*, <aps.org/programs/minorities/resources/statistics.cfm>. (Last accessed on May 4, 2021).

[44]Carolyn M. Shields. ''Dialogic Leadership for Social Justice: Overcoming Pathologies of Silence.'' *Educational Administration Quarterly* 40 (2004): 109–132.

[45]Daniel Lee Reinholz, Adriana Corrales, and Amelia Stone-Johnstone. ''The Access Network: Supporting the Construction of Social Justice Physics Identities Through Student Partnerships.'' *International Journal for Students as Partners* 3 (2019): 44–61.

Physicists, the Society for Advancement of Chicanos/Hispanics and Native Americans in Science, the Physics and Astronomy Anti-Racism Coalition—are working to make change along these lines.

## ENERGY JUSTICE

Energy justice is an interdisciplinary approach that integrates policy, technology, and philosophies[46] that can be adapted and tailored to fit students' lived experiences or their communities. Energy justice is a social justice approach that also seeks justice in relation to energy systems, production, and consumption[47] that is very relevant to discuss in physics classrooms. Energy injustices continue to exist in many low-socioeconomic communities, in particular communities of color. This is due to environmental racism, which is one of the main determinants of which communities will face the highest rates of pollution, waste, and other environmental impacts. Education, livelihoods, and health are all sociocultural indicators that determine who benefits from societal advancements such as energy developments.[48] For example, pollution from energy-driven plants (i.e., fossil fuel plants) determine who has better health outcomes.[49] Communities who live closer to fossil fuel plants experience many health disparities from the pollution that these energy plants generate.[50,51] In this sense, environmental racism is ultimately energy racism under the energy justice lens. Environmental racism is the reason why low socioeconomic communities and people of color tend to live closer to pollution than white people.[52] This ultimately transcends to educational opportunities, as property taxes in neighborhoods are lower, which then translates to lower funding for local public schools. Energy justice is a social justice approach that also seeks justice in relation to energy systems, production, and consumption[53] that is very prevalent to discuss in physics classrooms.

There are two identified dimensions of energy justice: (1) production and consumption and (2) distribution and procedure.[54] These dimensions bring to the forefront of energy justice the energy systems that produce and consume energy and the policies that determine the process by which these energy resources will be distributed within our local society.[55] Energy justice, similar to climate and environmental justice, can be framed from the global lens to the local or regional lens as well. For the purposes of our argument made in this study and its applicability to physics education in the United States, we are framing energy justice from the classroom and local lens. Ultimately, energy injustices translate to educational injustices, which are important to make students aware of.

## METHODOLOGY: SUMMER PROFESSIONAL DEVELOPMENT FOR PHYSICS TEACHERS

The Energy and Equity team—a partnership between the University of Washington Bothell, Seattle Pacific University, American Association of Physics Teachers, and Alder Science Education Association—hosted a summer professional development (PD) for high school physics teachers. This summer PD was hosted virtually over the course of 1 week. A total of 22 high school teachers participated in this PD in Summer 2020, for 30 hours of instruction. Over the course of the week, equity topics such as intersectionality, justice, antiracism, and others were incorporated into the lesson plans and discussions. These topics were interconnected to energy in physics classrooms. The main goal of this PD was to understand what it means to incorporate issues around equity and issues around place in our energy instruction, and particularly in energy instruction at the high school level. To ensure participants' confidentiality and anonymity, we use pseudonyms to refer to each participant in our data analysis. This research project is administered by the Seattle Pacific University Institutional Review Board (#18190700ZR).

### *Physics teacher dilemmas between physics and social justice*

One of the dilemmas that kept presenting itself as teachers discussed energy and equity was the difficulty of connecting social justice and physics. Many teachers said that these have been treated separately in their own education or in their teaching, as we have discussed previously in this study. This is because they are situated and trained as physics teachers to follow the logic of physics that concepts such as energy are abstract and thus not applicable to sociopolitical issues such as energy justice. Following are two exchanges, common among all physics teachers participating in the summer PD. In various conversations participants kept referring to social justice and physics as two separate schools of thoughts.

[46]Xiaojing Xu and Chien-fei Chen. "Energy Efficiency and Energy Justice for US Low-Income Households: An Analysis of Multifaceted Challenges and Potential." *Energy Policy* 128 (2019): 763–774.

[47]Kirsten Jenkins, Darren McCauley, Raphael Heffron, Hannes Stephan, and Robert Rehner. "Energy Justice: A Conceptual Review." *Energy Research & Social Science* 11 (2016): 174–182.

[48]Ankit Kumar. "Justice and Politics in Energy Access for Education, Livelihoods and Health: How Socio-cultural Processes Mediate the Winners and Losers." *Energy Research & Social Science* 40 (2018): 3–13.

[49]Robert D. Bullard. *Dumping in Dixie: Race, Class, and Environmental Quality*. (Avalon Publishing-(Westview Press), 2008).

[50]Robert D. Bullard. "Environmental Justice for All: It's the Right Thing to Do," *Journal of Environmental Law and Litigation* 9 (1994): 281.

[51]Clifford Rechtschaffen. "Fighting Back Against a Power Plant: Some Lessons from the Legal and Organizing Efforts of the Bayview-Hunters Point Community." *Hastings W.-Nw. J. Envt'l L. & Pol'y* 3 (1995): 407.

[52]Taylor. (2014). *Op. cit.*

[53]Jenkins et al. (2016). *Op. cit.*

[54]Sara Fuller and Darren McCauley. "Framing Energy Justice: Perspectives from Activism and Advocacy." *Energy Research & Social Science* 11 (2016): 1–8.

[55]Jenkins et al. (2016), *Op. cit.*

We listed two exchanges titled conversation #1 and #2 hereunder to clarify their dilemmas.

*Conversation #1:*

> Rebecca: ''I feel like I'm woefully ignorant in [social justice and physics] and it's always been something that I've been wanting to do. Like I think often I teach [physics] content and then social justice is kept almost separately.''
> Lisa: ''Yeah. I feel the same in terms of having social justice and physics as two separate schools of thought in my mind. And I feel like I don't know why I never thought to put them together.''
> Tim: ''Yeah, similar. I feel very comfortable with giving them exposure to women in physics so that they have those role models. But I don't know how to bring it into the lesson plan as you said.''

*Conversation #2:*

> Tanya: ''I feel like it [physics and social justice] is almost like a forced connection a little bit. Like [some topics] are really kind of like environmental, social justice stuff. And I feel like it's almost like less connected to physics for me.''
> Judy: ''I'm actively thinking about how hard it can be to broaden my view of what social justice means, especially when, so often we [physicists] hide behind objectivity…[physics] feels kind of like a thing that's happened or like history deals.''

Both conversations demonstrate how physics teachers view social justice separate from physics. However, despite these common dialogues, teachers were able to articulate social justice issues that intersect between energy and equity throughout the PD, when asked questions by PD instructors that emerged from both physics and social justice. This suggests that it may be the separation between physics and social justice—integral to the mythology of physics as objective, apolitical, and acultural—that is causing physics teachers to believe that their conceptions of social justice issues in physics are not there or cannot be formulated from a physics lens. That is, dialogues throughout our PD show us that physics teachers are not naive to the societal issues around injustices and inequities and in fact articulate a number of pillars of energy justice that could be brought forward in their classrooms. It is just that social justice theories, concepts, and issues are not traditionally connected to physics topics such as energy.

It is our position that physics should not detach itself from social justice, especially in topics such as energy for reasons already stated in this study. In the context of energy that is taught in physics classrooms, its extraction, conversion, delivery, and usage continues to result in injustices that primarily impact Indigenous and other communities of color. To bring forward a model of energy justice that emerges from and is relevant to high school teaching and learning, we coded teachers' dialogues and conversations around energy and equity from the entire week of the PD. Coding these dialogues allowed us to identify major themes and topics that we are referring to as pillars. Our coding scheme allowed us to also define these identified energy justice pillars.

## RESULTS: ENERGY JUSTICE PILLARS

Our coding scheme allowed us to also define and identify 12 energy justice pillars. These energy justice pillars include energy production, consumption, security, vulnerability, racism, democracy, policy, economics, poverty, responsibility, and burdens (Fig. 1). Hereunder we list a participant's quote that corresponds to each pillar and its definition to conceptualize what each pillar is referencing within physics education and the concept of energy. It is important to note that in our coding scheme there were several statements and quotes that corresponded to each pillar but are only listing one in this study.

> *Energy Vulnerability:* Not having access or the needed energy resources or severely being impacted by the energy emissions that one is not responsible for.
> Josh: ''It is interesting that the countries that seem to have the least negative impact in terms of agriculture are the ones with major emissions these days, and strict regulations limiting immigration to their countries.…people leave their countries due to an increase in their increased vulnerability to these same emissions done by the same countries that limit their immigration.''
> *Energy Production:* The sources and processes that generate energy.
> Riley: ''I might add… energy [equity] requires incorporating production and pollution.''
> *Energy Consumption:* The usage of energy sources.
> Judy: ''… in terms of [energy] usage and benefits…I think about renewable energy, and how that is the solution right? [But] to me I ask, where is [renewable energy] coming from? And where's it going?…devastation of rerouting of rivers, it's such a, it's such a big deal.''
> *Energy Representation:* Allowing for all communities to be represented in energy-related discourses.
> Megan: ''…the student and community voice is important in differentiation and making sure that [energy] is relevant to their lives.''
> *Energy Democracy:* Integrates the social and cultural aspects that govern energy policy.
> Brenda: ''I look at energy and equity [not through] culturally responsiveness because I prefer it to be culturally relevant…where cultures are respected within social policies.''
> *Energy policy:* Policies, rules, and regulations established by the government to determine how energy is distributed, used, and consumed.
> Erica: ''…energy and equity policies absolutely need more science and equity minded people as well as educators to inform policy.''
> *Energy Economics:* the capital supply of energy resources.
> Tanya: ''I'm going to actually be looking for the economic advantage of using this [energy] resource that has been there for a while.
> *Energy Burdens:* When the use of energy resources dramatically impacts or marginalizes a specific group of people.
> Chris: ''I mean…there are definitely power plants…think there's a nuclear plant somewhere upstream…. the stuff from the textiles [is] burning coal or oil…I feel like we've, we've shipped most of that stuff overseas now. So they're all dealing with that pollution.''

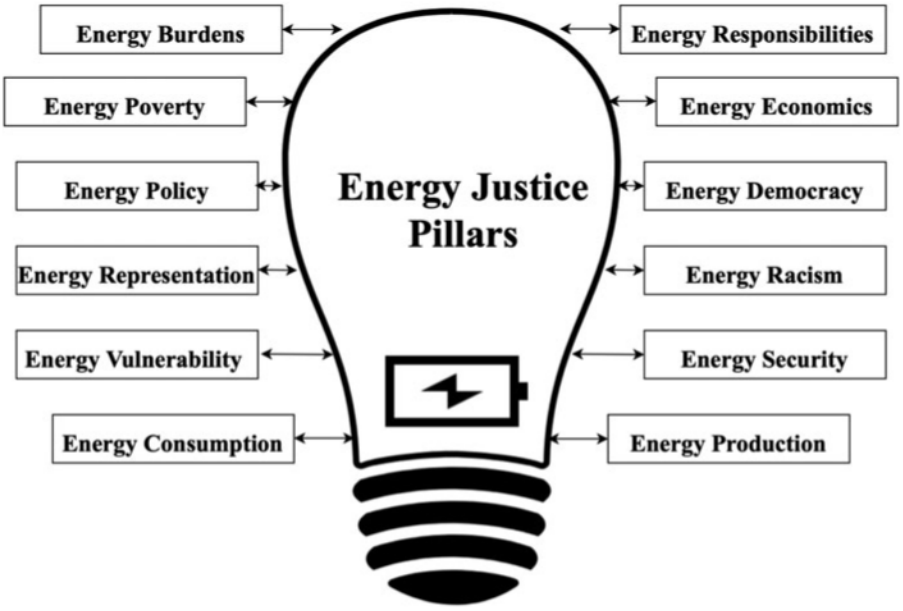


**FIG. 1.** Energy justice pillars.

*Energy Poverty:* lack of capital or power to access energy resources and decision making of their construction.
Maggie: ''I'm up in Northern California and there's …. a natural gas pipeline that [travels] from Colorado through the Oregon coast…when you look at which town they picked to build it in…it's a poor community… the usual criteria that you figure of who's on the margins…communities that aren't as respected by the people who make those decisions.''
*Energy Security:* The availability of the needed energy resources.
Judy: ''A particular form of energy [I think of] is food energy. I think about resource allocation and food resource allocation…in terms of food deserts and what that looks like and what that means.''
*Energy Responsibility:* Taking conscious approaches to how one or society consumes energy.
Josh: ''It is interesting that the countries that seem to have the least negative impact in terms of agriculture are the ones with major emissions these days…they don't want to be held responsible for their emissions.''
*Energy Racism:* Operating under systematic racist structures that leave certain communities out from energy-related discourses.
Judy: ''[Energy] and physics data doesn't really see race, but that's not true. We see that certainly in who we celebrate, who we worship, they all tend to be white men… everyone knows Marie Curie as the one amazing woman, right? But like, what about…all the people of color? Where are they in terms of energy and equity? We do know they are the most impacted by energy extraction and pollution, but where are they at the table?''

Coding physics teachers' dialogues and conversation to identify energy justice pillars is supporting the development of a teacher-centered energy justice framework. Energy justice by physics teachers is redefined as energy production, consumption, security, vulnerability, racism, democracy, policy, economics, poverty, responsibility, and burdens. This allows us to redefine energy justice from ''[promoting] happiness, welfare, freedom, equity, and due process for both producers and consumers''[56] into promoting equal and just energy production, consumption, security, vulnerability, racism, democracy, policy, economics, poverty, responsibility, and burdens. Including physics in the discussions and applications of energy justice is important because as Jenkins et al.[57] stated, ''The emerging field of energy justice is at a critical juncture; after years of productive scholarship and activism, and growing interdisciplinary interest, it is time to take stock, reflect on all that has been achieved, and look towards a future of greater impact and transdisciplinary methods.'' Transdisciplinary methods are primarily crucial in physics because as we continue to emphasize, physics is one of the fields in science that continues to separate itself from social justice. Owing to this, physics teachers believe that they cannot formulate social justice topics in physics, despite our data showing otherwise. Redefining energy justice in physics classrooms allows us to conceptualize energy justice in physics.

## CONCLUSION

A summer PD for physics teachers focusing on energy and equity made visible to us that physics teachers agree that equity is an important topic to start integrating in physics. We need to continue bridging the gap between social justice and physics; they are not separate since

[56]Benjamin K. Sovacool and Michael H. Dworkin. ''Energy Justice: Conceptual Insights and Practical Applications.'' *Applied Energy* 142 (2015): 435–444.
[57]K.E. Jenkins, J.C. Stephens, T.G. Reames, and D. Hernández. ''Towards Impactful Energy Justice Research: Transforming the Power of Academic Engagement.'' *Energy Research & Social Science* 67 (2020): 101510.

there are inequities and injustices present in physics. Energy may be defined as an abstract concept in high school physics, but this does not excuse it from the social injustices the energy system creates. Pellegrini-Masini et al.[58] have advocated that integrating equity into energy justice allows us to formulate justice between the present and future generations. This further explains the importance of having discussion around equity in many discourses, such as physics, as these conversations allow us to formulate discussions that will not just benefit us in the present but also our future generations. This is crucial for building community resilience in the time of climate change. Given that high school students are our future, integrating energy justice in physics classrooms allows us to support students in developing an identity as physicists who are invested in social justice issues.[59] We want to use our findings to continue providing PD to physics teachers and support them in both (1) challenging the common notion that physics and social justice are two separate schools of thoughts, they are not and (2) recognizing the ways that they are already merging these two. Conversations around energy and equity can help us redefine community resilience through physics education.

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[58]G. Pellegrini-Masini, A. Pirni, and S. Maran. ''Energy Justice Revisited: A Critical Review on the Philosophical and Political Origins of Equality.'' *Energy Research & Social Science* 59 (2020): 101310.
[59]Reinholz et al. (2019). *Op. cit.*