Justice **U**nderpinning **S**cience and **T**echnology **R**esearch **(JUST-R)** Offline Tool

A Tool for Guiding Researchers in Addressing Energy Justice Considerations in Early-Stage Research

Clara Houghteling, Bettina K. Arkhurst, Nikita S. Dutta,
Liz Gill, Taylor Uekert, Sara Murillo, and Evan Savage

NREL is a national laboratory of the U.S. Department of Energy
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User Guide
NREL/OT-7A40-88710
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Accessing the JUST-R Tool

The JUST-R Tool can be found here: https://www.nrel.gov/analysis/just-r.html

What Is the JUST-R Metrics Framework?

The JUST-R Metrics Framework is a set of metrics for assessing the energy justice implications of technologies that are currently under research and development (R&D). Though many interventions focus on tracking energy justice at the point of deployment (Tarekegne et al. 2021), there has been relatively little attention on developing practical techniques for integrating energy justice considerations into the development of emerging technologies, especially from the earliest stages of R&D. The JUST-R Metrics Framework addresses this gap by guiding researchers through an analysis of the many facets of their research processes, from material inputs and outputs to knowledge sources, that may contribute to energy injustice both during the research period and when the technology is scaled. The framework enables researchers to **1) consider the potential energy justice implications of their research, 2) develop justice-oriented changes to the research process, and 3) track the implementation of proposed changes.** The metrics included in the framework are sorted into five aspects of research:

- Team dynamics
- Sources and inputs
- Processes and protocols
- Waste and hazards
- Results and dissemination

More information on each of these topic areas is provided later in the guide.

Using JUST-R in Leadership and Management

Leaders and managers can play a vital role in supporting energy justice in research (Arkhurst et al. 2023). Though managers may not be as directly involved in the day-to-day research activities and processes covered in the JUST-R metrics, engaging with the metrics framework may help in developing institutional policies that can advance justice from basic science research through deployment. Managers and decision-makers can impact R&D projects by:

- **Allocating time and funding** to activities and goals that center justice
- **Collecting and sharing best practices** for integrating justice across project teams, especially as researchers develop innovative approaches
- **Undertaking institutional initiatives**, such as collecting data on information needed for JUST-R assessments (e.g., data associated with hazards, material sourcing, waste disposal, and energy use)
- **Expanding performance metrics** to consider efforts to better incorporate energy justice in research work.

To build a culture that prioritizes energy justice in research and innovation, leaders may want to consider focusing on incentives, support, and positive approaches. Though energy justice is distinct from diversity, equity, inclusion, and accessibility (DEIA), efforts to promote DEIA in the workplace have shown that voluntary tactics are more effective than strict requirements and reporting (Dobbin and Kalev 2016). A lack of clear energy justice thinking or evaluation should not be viewed as a shortcoming on researchers' part. Instead, think of it as a challenge to be solved together through voluntary collaboration.

Consider questions such as:

- How can researchers and managers "opt in" to tackle energy injustices together?
- What systems, processes, and incentives can be put in place to enable researchers and managers to effectively tackle energy injustices?
- What opportunities and experiences can boost understanding of energy justice for researchers, managers, and leadership alike?

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Why Integrate Energy Justice Into Your Research?

The growth of the global energy system over the last few centuries has not benefited all equitably. As of 2020, unequal access to affordable, reliable energy leaves nearly 760 million people without electricity and many more—2.6 billion—without clean cooking fuel (IEA et al. 2023). Exposure to the hazardous air pollutants released by fossil energy combustion is a leading cause of illness globally, accounting for as many as 1 in 5 premature deaths (Vohra et al. 2021). The approximately 2,500 gigatons (Gt) of carbon pollution released into the atmosphere since 1850 have created a global climate crisis that threatens to disproportionately harm people in frontline communities[1] and the Global South[2], who have contributed least to (and benefitted least from) fossil fuel consumption (Friedlingstein et al. 2020; Sultana 2021). For these reasons and more, broad decarbonization, including through transitions to clean energy generation, has emerged as a justice imperative.

> Clean energy development does not necessarily lead to a just energy system.

Clean energy development will not necessarily lead to a just energy system. If energy justice is not a central focus of clean energy research and deployment, some existing sources of energy injustice may persist or even intensify, and new injustices may emerge (Carley and Konisky 2020; Marino et al. 2023). Increased demand for raw materials, new manufacturing practices, changes in land and water use, the production of waste and hazardous materials, and the evolving needs of communities that live near or depend on energy sources are considerations in building a just clean energy system.

For example, though lithium batteries are important components of electric vehicle production and renewable energy storage, increased lithium mining in the U.S., where reserves are often located near tribal lands, can expose Native communities to toxic leaching, environmental disruption, and the destruction of sacred land (Duque 2023; Holzman and Waldman 2022). Biofuels could potentially reduce petroleum-based carbon emissions, but, depending on feedstocks and production methods used, they could also affect global hunger and malnutrition if agricultural land used for food production is converted into land used for fuel production (Gonzalez 2016). Solar energy is a key component of the clean energy transition, but decommissioning a solar plant can create electronic waste that has the potential to burden rural communities and future generations (Sovacool et al. 2022).

These issues are complex and extend well beyond the research stage, but R&D can still play a critical role in pursuing a more just clean energy system. In many cases, technological sources of energy injustice are "locked in" from the point of early research and design, meaning that researchers are well positioned to influence energy justice outcomes beginning at the earliest stages of R&D (Arkhurst et al. 2024; Dutta et al. 2023). As energy justice gains greater traction in scientific and governmental institutions, the ability to consider and articulate the energy justice impacts of their research may help researchers secure funding for their work and create more impactful research projects. When energy justice considerations are integrated from early research through deployment, the clean energy transition can provide opportunities to address embedded energy injustices.

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[1] Frontline communities are "those communities who are the most vulnerable to and will be the most adversely affected by climate change and inequitable actions because of systemic and historical socioeconomic disparities, environmental injustice, or other forms of injustice" (NOAA 2021). They include communities living with high levels of pollution, exposure to industrial and waste sites, and environments endangered by climate change.

[2] The Global South refers to "regions of Latin America, Asia, Africa, and Oceania" that are often marginalized in global economic or political relationships. (Dados and Connell 2012).

How to Use This Guide

This guide provides an introduction to key energy justice concepts, step-by-step instructions for working through your JUST-R assessment, directions for using the JUST-R Excel tool, examples for applying JUST-R metrics in different research areas, and an overview of the metrics in the JUST-R framework. Though both the guide and the JUST-R framework are primarily geared toward use by energy researchers, other audiences—including policymakers, manufacturers, and developers—may find that both are useful in evaluating the energy justice implications of their work. See p. 2, Using JUST-R in Leadership and Management, for more guidance on non-research applications.

In this guide, you'll find the following:

1) Some background on energy justice: If you would like some background information (or maybe just a refresher) on energy justice before using the framework, start with the Introduction to Energy Justice, which offers a brief overview of some of the core principles of energy justice.

2) A step-by-step process for using JUST-R: This guide accompanies the JUST-R Excel tool, which is what you will use to select and track the energy justice metrics that you want to apply to your research. Using JUST-R: The Recommended Process outlines steps for creating research flow diagrams, using the Excel tool, and targeting metrics to help form an action plan. Both the Excel tool and this guide may be found here: https://www.nrel.gov/analysis/just-r.html.

3) Examples from different research areas: How each of the JUST-R metrics applies to your research will depend on your research area. The JUST-R framework does not enable comparison between energy technologies; it is a brainstorming tool to help researchers integrate energy justice-centered thinking into their areas of expertise. This guide provides four example research projects to demonstrate application of the metrics in different research areas, and the Excel tool includes columns demonstrating how each metric applies to each of the example research projects.

4) The JUST-R metrics categories: The metrics in the Excel tool are sorted into five categories according to the aspect of research they correspond to: team dynamics, sources and inputs, processes and protocols, waste and hazards, and outcomes and dissemination. This guide provides an overview of what each of those categories means and the metrics they include, starting with team dynamics.

> JUST-R is a brainstorming tool for researchers.
>
> The framework does not provide energy justice "scores" or rankings and is <u>**not**</u> meant to compare energy justice between energy technologies.
>
> Instead, focus on how the metrics can help make your specific technology area the best it can be.

Introduction to Energy Justice

Defining Energy Justice

The concept of energy justice in the United States emerged from the broader environmental justice movement of the second half of the twentieth century (Baker 2019), which itself came from the Civil Rights Movement (McGurty 2000). Like these foundational movements, energy justice is about restructuring unjust systems to avoid inflicting future harm while addressing past harms. Energy justice is closely related to the concept of equity, but it provides a deeper lens for both critiquing the past and envisioning the future of our energy system. Take, for instance, the Energy Justice Initiative's definition of energy justice:

> Energy justice refers to the goal of achieving equity in both the social and economic participation in the energy system, **while also remediating social, economic, and health burdens on those historically harmed by the energy system** ('frontline communities'). [emphasis added] (2019)

Because of its broad perspective, energy justice includes a wide range of topics related to the human consequences of how we produce and consume energy, including energy access, cost burdens, and security; economic participation/exclusion and job impacts; pollution, environmental degradation, and climate impacts; and human health and illness (Lackton and DeVar 2021). The statistics in the Figure 3 below provide a snapshot of some of the most direct effects of energy injustice in the United States today.

The scope of energy justice stretches all the way from oil rigs and cobalt mines to your nearest power plant, the vehicle used for your daily commute, or even your kitchen stove. The energy system generates many economic and health *benefits* that are not (and for many generations, have not been) distributed equitably to all people. Effectively engaging with the full array of benefits and burdens affecting diverse energy producers and consumers is a core component of energy justice.

Statistical snapshots of energy justice in the U.S.

Cost Burden

Low-income households in the U.S. spend almost 3x more of their income on energy than wealthier households.

(NCSL 2024)

Clean Energy Access

Black and Latino communities in the U.S. have 69% and 45% less rooftop solar, respectively, than other communities.

(Sunter et al. 2019)

Energy Insecurity

About 25-30% of U.S. households struggle to meet their energy needs in a given year.

(EIA 2022)

Health Concerns

In the U.S., Black, Asian, and Hispanic people are more likely to live in areas with high air pollution than White people.

(Lui et al. 2021)

Types of Energy Justice

Energy justice requires structurally changing the energy system to ensure that we can produce and consume the energy we need and better distribute the benefits of the energy system without sacrificing the health, wellbeing, security, environment, or political autonomy of any community. Energy justice therefore encompasses each of the following types of justice:

Type of Justice		Definition	Example
Distributional		Equitable distribution of benefits and burdens across a population	Ensuring a technology does not negatively impact the health of one community while lowering the electric bill of another community
Procedural		Equitable engagement, fairness, and transparency when allocating resources and reconciling disputes	Working with a community when deploying a new technology in that community
Recognition		Respect for the rights, needs, values, understandings, and customs of a population	Including and highlighting underrepresented voices and perspectives in research
Restorative		Acknowledging, ameliorating, and addressing previous negative impacts that caused inequities	Building accessible renewable energy sources on historically polluted lands to benefit the community
Intergenerational		Considering past and future generations when evaluating changing effects of energy technologies over time	Ensuring natural materials that may be needed today are available for future generations to use
Cosmopolitan		Ensuring the wellbeing of persons rather than communities or nations across the energy life cycle	Considering mining practices and the health implications on mining communities along a global supply chain
Epistemic		The systemic inclusion of diverse forms of knowledge and ways of knowing	Respecting Traditional Ecological Knowledge and Indigenous Knowledge about land and natural resources

Healy, N., Stephens, J. C., and Malin, S. A. 2019; Sovacool, B. K., Martiskainen, M., Hook, A., and Baker, L. 2019; Sovacool, B. K., Bell, S. E., Daggett, C., Labuski, C., Lennon, M., Naylor, L., Klinger, J., Leonard, K., and Firestone, J. 2023; Tsosie, R., 2012.

The Scope of the JUST-R Framework

The Role of Researchers

Reorienting our current energy economy to be more just will depend on a broad range of systemic factors both large and small. What role can an energy researcher play in this context? The answer is not that researchers can fully solve energy injustice through technological innovation; the problem is much too complex to be solved by technology alone (Geels 2017). However, technology will certainly be an important part of improving the energy system. By working to align energy research with energy justice, researchers can help ensure existing systemic biases are not embedded in the technologies they help create.

JUST-R's Limited Scope in a Global System

Energy justice is a global concern. Though many inequities are visible on a smaller scale—down to the level of how energy is produced and accessed in a single community—those inequities exist within a larger dynamic of global supply and waste chains, continuing legacies of colonialism, and disparities in access to reliable, clean energy between a minority of Western countries and the majority of the world. Though researchers may certainly incorporate global considerations into the JUST-R framework, it is important to note that the framework was not designed to guide researchers through a comprehensive account of global energy justice impacts.

In part, the limited scope of the framework is because of the large scale and complexity of energy justice as a topic. Adhering to a mostly domestic analysis provided a method for defining a scope for the initial JUST-R framework. More importantly, the JUST-R team also recognizes that, as members of federally funded, mainstream institutions in the Global North, we are not positioned to create a framework that reflects a comprehensive understanding of energy justice concerns around the world. Such an effort would require leadership from scholars in other places and with other expertise, perspectives, and experiences. Such a collaboration was not possible in the initial stages of developing the JUST-R framework, but forming global collaborations is a goal of future JUST-R work.

Distinguishing Energy Justice from DEIA

While using the JUST-R framework, it is important not to confuse energy justice with other initiatives happening in research institutions, including diversity, equity, inclusion, and accessibility (DEIA) strategies for mitigating exclusion and underrepresentation. Though DEIA primarily focuses on ensuring equitable treatment and opportunities *within an institution*, energy justice takes a broader, systems-focused consideration of energy technologies' life cycles, and the related range of inputs, outcomes, and impacts at every stage. Working toward energy justice requires us to think about the many human and environmental outcomes and decision-making processes happening beyond any one institution. Therefore, although there may be some overlap, the frameworks used to advance energy justice will be different from, but often complementary to, those used to improve workplace DEIA.

Using JUST-R: The Recommended Process

1. Create Block Flow Diagrams

Drafting block flow diagrams that visualize the inputs and outputs of your research project can make the entire JUST-R process easier—from determining the scope of your JUST-R assessment through brainstorming action items to integrate energy justice considerations into your research. Our quick, step-by-step guide on creating block flow diagrams addresses the physical components of research as well as knowledge use and production. The Assessment Examples section provides example block flow diagrams.

2. Begin Using the JUST-R Excel Tool

Once you've captured a broad view of your research in block flow diagrams, you're ready to begin your JUST-R assessment. This guide provides detailed instructions on how to use the JUST-R Excel Tool to complete your initial and subsequent assessments.

3. Target Metrics for Action

After completing your initial assessment using the JUST-R Excel tool, we recommend targeting the metrics that are most relevant to your efforts to integrate energy justice into your work. This guide offers tips and examples of how to choose which metrics to target, including how to use your flow diagrams to determine which metrics could have the biggest impact on energy justice in your research. The JUST-R Excel tool instructions also walk you through how to "select" and "deselect" metrics to display in the tool during re-assessments.

4. Develop an Action Plan

The specific actions you will take to integrate energy justice into your research will depend on your research process. However, the Assessment Examples section provides a few examples of action plans that other research teams have developed across diverse research areas. This section includes examples in each of the JUST-R metrics categories.

5. Continue Using the JUST-R Excel Tool for Reassessment

The JUST-R Tool is supposed to be used over time to critically assess and adapt your research process. The JUST-R Excel tool provides space to reassess your selected metrics over the course of your project timeline.

Using JUST-R: How to Create Block Flow Diagrams

To help you evaluate the JUST-R metrics, we recommend that you draw two simple block flow diagrams for your research project. A block flow diagram can be drawn by hand or in your preferred software. *These diagrams do not have to be perfect* — we suggest spending no more than 30 minutes per diagram.

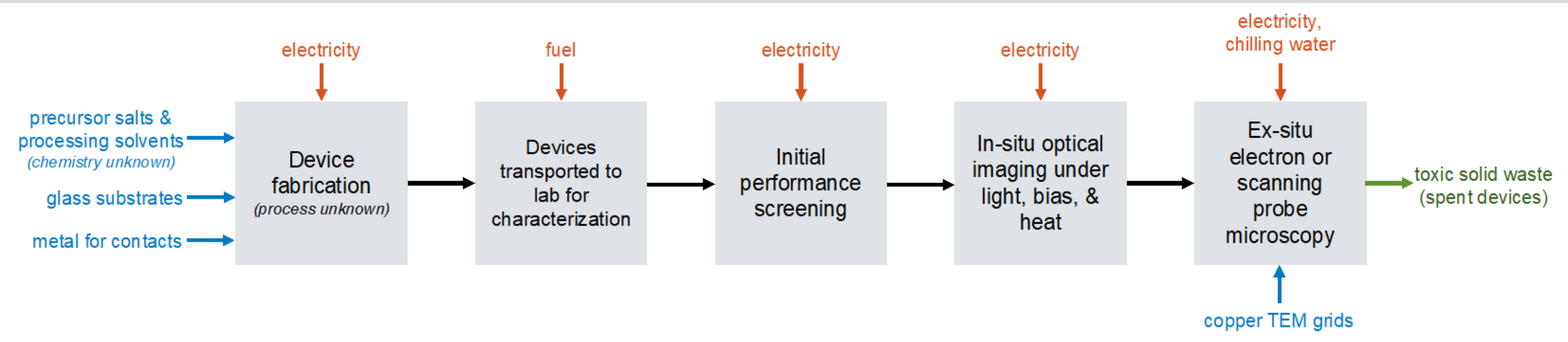
The purpose of these diagrams is to visualize all of the steps, inputs, and outputs in your research process that affect the JUST-R metrics that you will use the Excel Tool to evaluate. After you have completed your first JUST-R assessment, you will want to return to your diagrams to help determine which metrics you should focus on and brainstorm actions you can take to improve energy justice in your research process.

The example diagrams in this section are from Assessment Example A: Wet Lab and Characterization. More examples of physical flow diagrams are included in the Assessment Examples section.

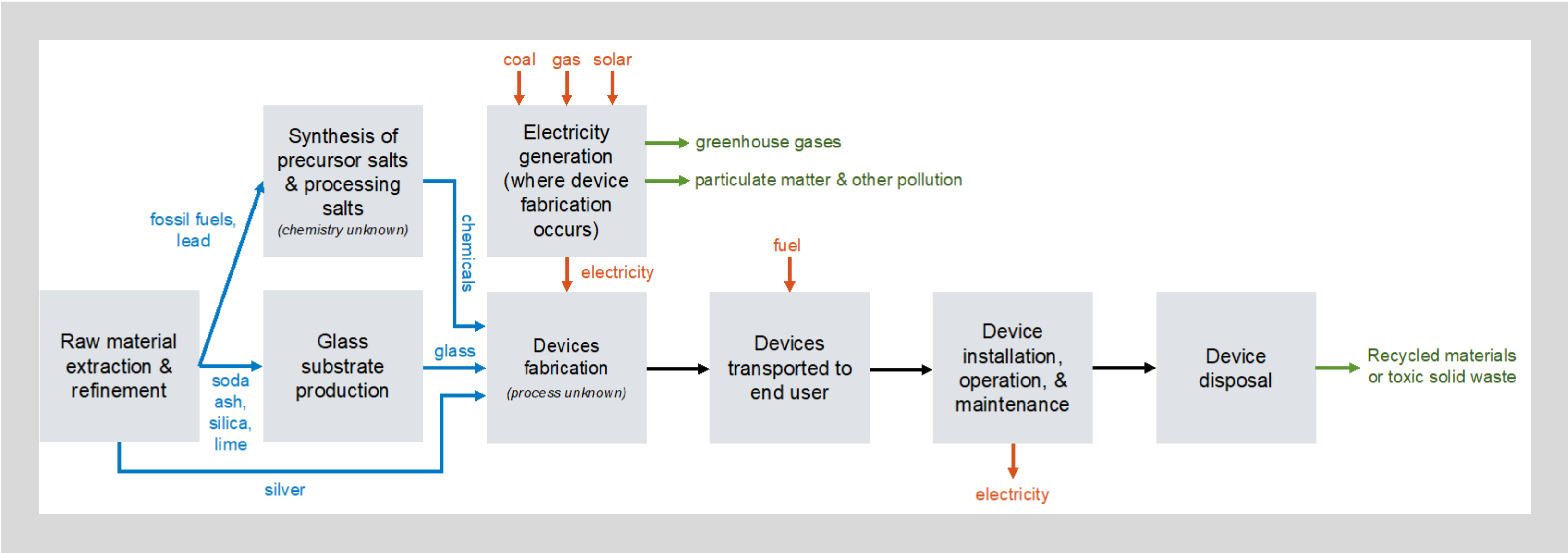
Relevant Metrics
- Sources & Inputs
- Processes & Protocols
- Waste & Hazards

1. **Physical flow diagram:** For the first block flow diagram, which is focused on physical flows, draw one block per major process step in your research project and list any material and energy inputs and outputs (no quantification necessary). For particularly complex material inputs, it may be helpful to identify simplified proxies that can be more easily evaluated. When developing the physical flow diagram, it is important to decide on a system boundary — or the process steps that will be evaluated — to maintain consistency. Two potential system boundaries include:

   - Project: This system boundary is most relevant if you are asking: "How can I incorporate justice into my laboratory procedures?" It should include all research steps (e.g., material synthesis, characterization, model development, etc.) and their corresponding material and energy flows for the research project of interest.



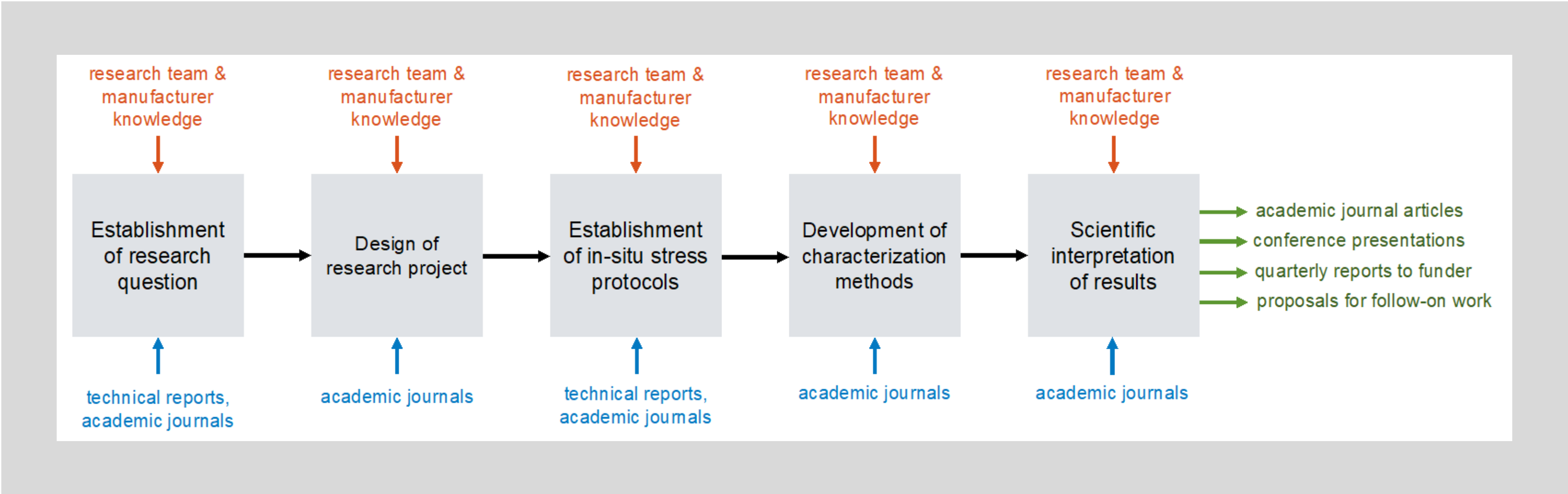
- Technology: This expanded system boundary is most relevant if you are asking: “How can I design my technology for just outcomes?” It should imagine how the technology or innovation of interest would be produced, used, and disposed in a real-world application.



2. Knowledge flow diagram: For the second block flow diagram, which is focused on information flows, draw one block per step of the scientific method (e.g., observation, hypothesis, experiment, analysis, and report, or similar) and list the following:

- Documented knowledge inputs – journal articles, data repositories, etc.
- Experiential knowledge inputs – lived experience from team members, focus groups, etc.
- Information outputs – presentations, publications, open-source data, etc.

Relevant Metrics
- Team Dynamics
- Sources & Inputs
- Outcomes & Dissemination



After you have completed these diagrams, you are ready to begin using the JUST-R Excel tool to assess your research.

Using JUST-R: How to Use the JUST-R Excel Tool

The JUST-R Excel tool is designed to enable you to select, assess, and track JUST-R metrics over the course of your research project. While not required, we recommend creating block flow diagrams of your research project before beginning your assessment in the Excel tool.

Initial Assessment

Set the parameters of your project and complete a baseline assessment of energy justice metrics.

1. Open the JUST-R Excel tool found at https://www.nrel.gov/analysis/just-r.html.

2. On the **Introduction** sheet (Sheet 1), enter basic information about your project (i.e., project title, description, and timeline).

Project Title:	
Project Description:	
Project Time Remaining: (At Start of Assessment)	0 - 2 Years Remaining
JUST-R Start Date:	=DATE(2024,10,1)
Project End Date:	10/1/25

   a. Select the Project Time Remaining (i.e., how much time you have remaining in the project you're assessing) from the drop-down menu.
      i. For example, if your project is planned to end 3 years from today, select "2–4 years remaining."
      ii. A project endpoint could be determined in multiple ways. For students, it could be defined as the expected end of a degree or internship; for national laboratory researchers, it could be the end of the project funding period; and for industry researchers, it could relate to internal or client-set deadlines. If your project doesn't have a clear endpoint, we recommend choosing the end of a discrete research stage defined in your proposal, scope of work, or operating plan. The point is to use the "end date" to set a timeline for assessment and re-assessment. Aiming for a project timeline lasting between 6 months – 3 years is a good rule of thumb.
   b. Enter a JUST-R Start Date (i.e., the day you will begin assessing your project; likely today's date) by double-clicking on the cell and following the format =DATE(year,month,day)
      i. If you have not yet started your project, this date will be when you expect to assess the project in the future.
   c. Enter a planned Project End Date
   d. Based on these inputs, a set of recommended metrics assessment deadlines will populate under the Recommended Auto-generated (Re)assessment Deadlines. These dates will populate deadlines for (re-)assessing metrics in the JUST-R Assessment sheets.
      i. Note: The deadline for Assessment 1 will default to one week after your JUST-R Start Date, giving you a week to complete your initial assessment.
      ii. If the project is finished, all deadlines will read "Project Completed."

   e. Using the dates provided, we recommend that you take a moment to create calendar reminders to revisit the JUST-R Tool in the week leading up to the deadlines.

3. Before you begin to assess your research, familiarize yourself with the **Metrics Overview** sheet (Sheet 2).
   a. Ignore Metric Selection (column A) for now.
      i. Note the default choice in this column is "Selected" and rows of selected metrics are highlighted in green. You will have the option to select/deselect metrics in the **JUST-R 0-2 Year Assessment** and **JUST-R 2-4 Year Assessment** sheets.
   b. To the right of each Metric (column B) is a longer description of the metric (column C), recommendations for ways to assess or measure that metric (Assessment Form), units of measurement for the metric (Units), and the aspect of the research process to which the metric best applies (Metric Category), tips and resources for assessing the metric (Assessment Resource), and a space to consider why a metric should or should not be selected for assessment (Reasoning Behind Metrics Selection).
      i. More information about the metric categories is provided in this guide, pp. 32–41.

A	B
Selected	Project Team Defined Metric: Local clean energy disparities
Selected	Project Team Defined Metric:
Selected	Project Team Defined Metric:
Selected	Project Team Defined Metric:
Selected	Project Team Defined Metric:

   c. You may add extra metrics specific to your project in rows 36–40 (column B).
   d. The Assessment Examples (columns I–P) provide examples of how each metric could apply to research projects in four different research areas: Wet Lab and Characterization; Engineering Design and Demonstration; Modeling, Analysis, and Software; and Fundamental Science.
      i. Summaries of each of the projects used in these examples are provided in this guide, pp. 19–31.

4. After browsing through the metrics, move to the appropriate sheet based on the length of the project you selected, **JUST-R 0-2 Year Assessment** (Sheet 3) or **JUST-R 2-4 Year Assessment** (Sheet 4), to begin an initial evaluation of your research.
   a. The JUST-R metrics are listed under Metric (column C). The Units column contains each metric's unit of measurement. Column E indicates the direction in which each metric should change (increase or decrease) to improve the metric over the course of the project.
   b. By the deadline indicated in the top row, column L, complete an initial assessment of your research project using the Initial Assessment section (columns K–N).

i. Use the Assessment 1 column (column K) to assess your project by each metric (column C).[3]
    1. This assessment could be qualitative or quantitative.

ii. In the Action Plan column, brainstorm strategies to improve your project according to that metric.

iii. Record potential obstacles you may encounter (or have already encountered) in the Potential Barriers column.

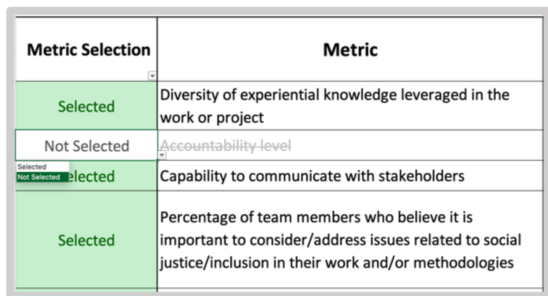
iv. The Notes column can be helpful for recording how a metric was evaluated, especially for metrics assessed qualitatively.

Broad and creative thinking is encouraged, especially during your initial assessment. Try to assess each metric for your project before deselecting metrics (see the following section on Metrics Targeting for instructions on how to select or deselect metrics in the Excel tool). You may refer to the examples in the **Metrics Overview** tab if you get stuck.

Metrics Targeting

Select the metrics you want to target for improvement over the course of your project. See advice for choosing which metrics to target in Targeting Metrics for Action.

1. Once you have completed the initial metrics assessment, stay on the **JUST-R 0-2 Year Assessment** or **JUST-R 2-4 Year Assessment** sheet to decide which metrics your research team will target for improvement and will continue evaluating for the remainder of the project.

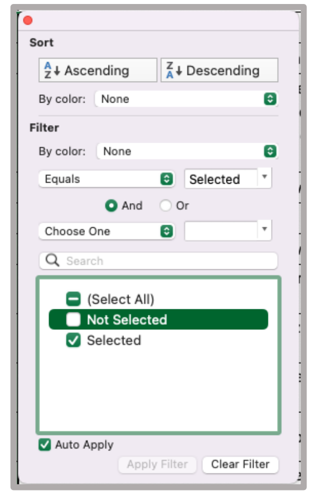


Metric Selection	Metric
Selected	Diversity of experiential knowledge leveraged in the work or project
Not Selected	~~Accountability level~~
Selected	Capability to communicate with stakeholders
Selected	Percentage of team members who believe it is important to consider/address issues related to social justice/inclusion in their work and/or methodologies

   a. Review your assessment.
      i. Which metrics have the most room for improvement? Which metrics do you have the most control over? Are there metrics your team finds particularly insightful?
   b. Determine which metrics make the most sense for your team to target, in terms of both impact and feasibility. See how you can use block flow diagrams to aid in this process on pp.17-18.
   c. Use the drop-down menus in each row of the Metric Selection column (column A) to deselect (i.e., choose "Not Selected" option) each metric you will not be targeting.
   d. You may indicate why you have selected or deselected a metric in the Notes column corresponding to that metric.
   e. Note that you may reselect/deselect a metric at any time.

[3] Note that columns F-J are hidden. If you unhide these columns, you will see an optional planning section. This section can be used for project or proposal planning before carrying out the initial assessment.

2. Return to the appropriate **JUST-R [0-2 Years or 2-4 Years] Assessment** sheet.
    a. Deselected metrics will now appear grayed and crossed out. If you would like to hide deselected metrics while working on this sheet, use the drop-down filter option at the top of column A (Metrics Selection cell) to uncheck the box next to "Not selected" and then press "Apply Filter." Excel may automatically apply the filter if "Auto Apply" is checked.



Continual Assessment

As you work to integrate energy justice considerations into your research project, reassess the metrics periodically, using the dates generated in the **Introduction** sheet for guidance. When you start developing an action plan for improving your metrics between assessments, you may refer to the action plan examples in the Assessment Examples.

1. Once you have established an actionable plan to change the metrics you're targeting, return to the **JUST-R [0-2 Years or 2-4 Years] Assessment** sheet at the deadlines listed in the top row.
    a. Use the appropriate assessment section (e.g., initial, midterm, etc.) to re-evaluate each of your selected metrics. Be sure to keep the units of measurement consistent from one assessment to the next.
        i. As before, use the Assessment, Action Plan, Potential Barriers, and Notes columns to (re-)evaluate and record your project.
        ii. Again, make sure to use calendar entries or another reminder to keep track of these deadlines.

Summary

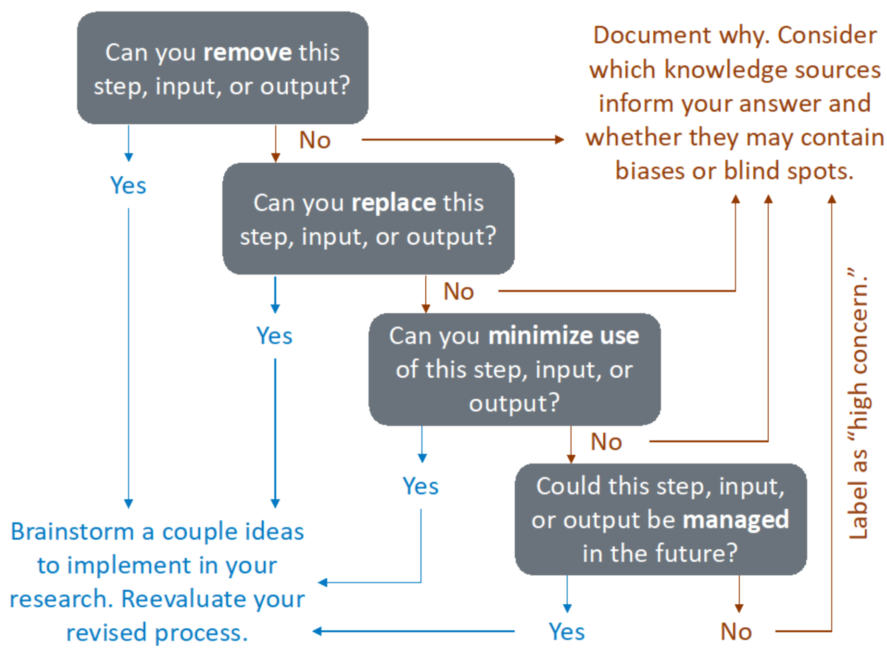
Review the results of your assessment.

1. In columns AB–AI in the **JUST-R 0-2 Years Assessment** sheet and in columns AJ–AQ in the **2-4 Years Assessment** sheet, you'll find a summary of the changes in the metrics used to evaluate your project over time. Use this summary to consider lessons learned, project conclusions, and goals for future research.

Using JUST-R: Targeting Metrics for Action

After using the JUST-R metrics to complete an initial assessment of your research project, you may be wondering, "What now?" The next step is to determine which metrics you will target to address some of the key energy justice considerations identified in your initial assessment. Targeting a metric means that you will develop an action plan to improve that metric and will continue to include the metric in future JUST-R assessments. In addition to this section, the Assessment Example sections include examples of metrics targeting by research teams in diverse research areas.

Begin by returning to your physical flow diagram and marking which steps, inputs, or outputs affect problematic "sources & inputs," "processes & protocols," and "waste & hazards" metrics identified in your initial JUST-R assessment. Similarly, return to your knowledge flow diagram and mark which steps, inputs, or outputs affect problematic "team dynamics," "sources & inputs," and "outcomes & dissemination" metrics. Using your updated flow diagrams as a visual guide, proceed through the following structured reflection for any steps, inputs, or outputs that are flagged as particularly impactful (e.g., linked to multiple metrics). For each question, make sure to document why you answer "yes" or "no," including any assumptions that led to your answer.



1. **Can you remove this step, input, or output?**
   If no, document why. Referring to your knowledge flow diagram, consider which knowledge sources inform your answer and whether these sources might contain biases or blind spots. Proceed to question 2.
   If yes, brainstorm some ideas for how you could remove the step, input, or output, using additional sources of knowledge where possible. Reevaluate your revised process.

2. **Can you replace this step, input, or output?**
   If no, document why. Referring to your knowledge flow diagram, consider which knowledge sources inform your answer and whether these sources might contain biases or blind spots. Proceed to question 3.

If yes, brainstorm some ideas for how you could replace the step, input, or output, using additional sources of knowledge where possible. Reevaluate your revised process.

3. **Can you minimize use of this step, input, or output?**
If no, document why. Referring to your knowledge flow diagram, consider which knowledge sources inform your answer and whether these sources might contain biases or blind spots. Proceed to question 4.
If yes, brainstorm some ideas for how you could minimize use of the step, input, or output, using additional sources of knowledge where possible. Reevaluate your revised process.

4. **Could this step, input, or output be managed in the future?**
If no, document why. Referring to your knowledge flow diagram, consider which knowledge sources inform your answer and whether these sources might contain biases or blind spots. Make sure to label this step, input, or output as of high concern going forward.
If yes, brainstorm some ideas for how you could manage (e.g., process controls, specific wastewater treatment, etc.) this step, input, or output, using additional sources of knowledge where possible. Reevaluate your revised process.

After answering these questions, consider which ideas excited you. Why? How much time and resources might be required to work on these ideas? Reflect on major data or knowledge gaps and uncertainties that could affect your answers to the above questions (e.g., were you unable to evaluate certain metrics or inputs/outputs due to missing data?) and how you might fill these gaps going forward (e.g., certain measurements that could be taken during experiments, certain types of social science or non-academic literature that could be reviewed). Be sure to also take a moment to consider what things you and/or your process do well from a justice perspective. How could you incorporate more of that positive aspect? To summarize, the following principles are useful guidelines for determining which metrics to target.

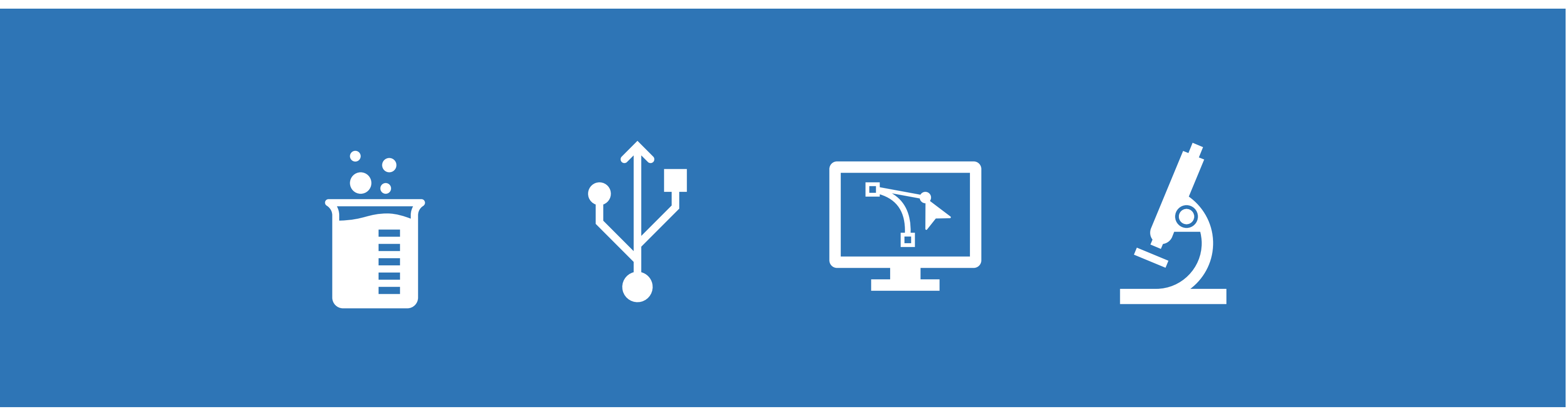
Principles for Targeting Metrics

Impact – Which metrics are likely to lead to the biggest energy justice improvement?
After your initial assessment, you may notice that certain components of your research process, inputs, or outputs seem to be "hot spots" of potential energy injustice. Which metrics prompt you to investigate these big energy justice concerns? Which are most likely to lead you toward real-world actions to improve your research process? Impact should be the first rule in choosing metrics to target.

Capacity – How many metrics does your team have the time to assess?
Depending on your team's staffing and workloads, you may need to select fewer metrics to make a rigorous assessment feasible. Quality is more important than quantity when selecting metrics to target. If you find that you are unable to allocate the time needed to assess all the metrics you have initially targeted, you may need to down-select again. Similarly, some metrics may be impossible to change in later stages of a project.

Data Availability – Which metrics could you find or collect data to assess?
Because energy justice assessments have not been a standard component of energy research, the data needed to assess some of the JUST-R metrics may not be readily available. Think creatively about how you may be able to integrate JUST-R data collection into your research process, or who you may be able to contact to attain the necessary data. Keep in mind that gathering these data and demonstrating their application may also be novel contributions you can make to your field.

Assessment Examples



Assessment Example A: Wet Lab and Characterization

Please note that this example is inspired by real research that has been fictionalized and anonymized.

Example Overview: Solar Cell Degradation

Metal-halide perovskites have attracted significant attention as next-generation solar cell materials. Their name comes from their shared "perovskite" crystal structure, but their flexible chemical compositions allow researchers to tune important properties such as band gap. As solar cells, their promising efficiencies have rapidly increased in less than a decade of research, showing much quicker improvement than competing materials. Moreover, they can be solution processed into thin films and devices—an inexpensive process that could drastically reduce solar cell fabrication costs compared to standard technologies such as silicon solar cells.

Unfortunately, perovskite solar cells are hampered by short lifetimes due to material instability, with research cells showing projected lifetimes up to 3 years (Luo et al. 2024), compared to the 25+ year lifetimes of commercial silicon photovoltaics ("Crystalline Silicon Photovoltaics Research."). They degrade quickly with exposure to air, heat, or moisture, and this degradation is often made worse by light exposure or electrical bias conditions. Understanding this material degradation so it can be mitigated is therefore extremely important to commercializing perovskite solar cells and is a very active area of research in the photovoltaics community.

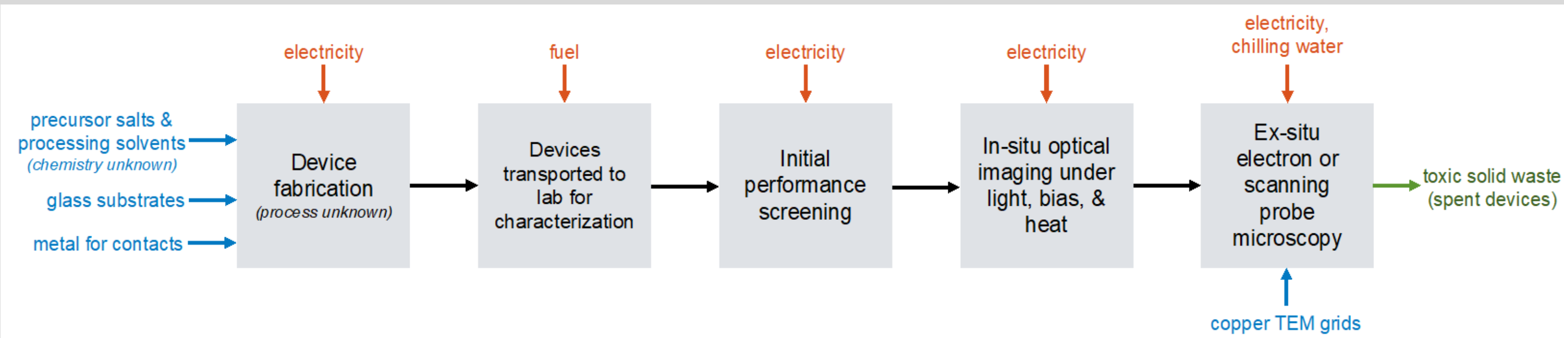
This project is a collaboration between material researchers and a solar cell manufacturer. The manufacturer is working to develop commercial metal-halide perovskite solar cells, and the researchers are studying degradation of the constituent materials under light, heat, and electrical bias using a variety of materials characterization techniques. The goal of the project is to use multimodal characterization—combining in-situ optoelectronic characterization with ex-situ electron beam and scanning probe microscopy—to understand the fundamental causes of device degradation. This mechanistic understanding can inform improvements to solar cell fabrication processes, and the multimodal characterization methodology can be used to understand degradation in other photovoltaic systems.

The research team decides to apply the JUST-R metrics framework to their project to better understand the potential energy justice implications of their work and to ensure they provide the solar cell manufacturer with a more holistic view of the research results.

Assessment Example A:
Wet Lab and Characterization

Physical Flow Diagram for Assessment Example A

This flow diagram shows the physical inputs of the solar cell degradation project. The research team used the diagram to determine which metrics they should target and then developed action items.



Targeting Metrics for Assessment Example A

The following example shows one of the metrics that the research team chose to target and one the team decided not to target, as well as the rationales behind those decisions. Both metrics are from the [Outcomes and Dissemination](#) metrics category.

Selected	Diversity of audience reached

Rationale: The team chose this metric because performing the initial JUST-R assessment made them realize their research results have so far only been shared with a very narrow group of photovoltaics specialists, which has likely limited the potential impact of this project. A key goal of this project is to develop methodologies for multiscale characterization of solar cell degradation; however, these techniques could potentially be used to investigate degradation in other kinds of device materials as well. The team recognized that sharing these methodologies with a broader community of researchers who might employ them in their work could greatly increase the impact of this project. In addition, the environmental stressing conditions applied to samples in this project have been informed by perovskite PV literature, but sharing results with more diverse stakeholders (for instance, individuals involved in PV install & maintenance from a variety of geographies) could generate feedback on other relevant conditions to incorporate into the research to expand its relevance to broader communities.

Not Selected	Percentage of open data published

Rationale: The team chose not to target this metric because there are limitations on the data that can be shared from this project due to the need to protect the company's intellectual property. The research team does not have control over what data the company is or is not willing to share; thus, the team believed it would be more impactful to focus their efforts on how to share their method development with broad audiences, such as developing materials to help other researchers apply the methods.

Action Items for Assessment Example A

This table provides examples of some of the action items the research team developed after their first JUST-R assessment. The table reproduces a section of the spreadsheet found in the assessment tabs (Tab 3 or Tab 4, depending on the length of your project) of the JUST-R Excel Tool.

Initial Assessment		
Metric	**Assessment 1**	**Action Plan**
Percentage of team members who believe it is important to consider/address issues related to social justice/inclusion in their work and/or methodologies	About 20% of the project team engaged in the JUST-R evaluation. Others may also believe it is important, but this has never been discussed in a project meeting.	1. Present results of initial JUST-R assessment in a full project team meeting. Discuss the assessment as a group. 2. Allot the first 5 minutes of future project meetings for team members to share reflections, literature, or other research ideas related to justice, to incorporate these topics more regularly into team discussions.
Estimated health cost of managing waste generated by project	Low, but with open questions about where waste from the project ends up and what communities are impacted.	1. Speak to the lab waste management team to understand where hazardous solid waste is disposed and/or what contractor manages the lab's hazardous solid waste. 2. Research what communities neighbor the hazardous solid waste disposal site and how it affects them, particularly leveraging community-based knowledge sources from advocacy groups, the local news, etc. 3. Incorporate this context into the next JUST-R assessment to establish a clearer understanding of impacts for this metric and inform future action items.

Assessment Example B: Engineering Design and Demonstration

Please note that this example is inspired by real research that has been fictionalized and anonymized.

Example Overview: Software Tool for Industrial Decarbonization

Industrial emissions represent close to one-quarter of U.S. greenhouse gas emissions (EPA 2021). A large share of these emissions comes from on-site combustion of fossil fuels (e.g., coal and natural gas) for heat and power generation. Pathways to reduce and/or eliminate these emissions include energy efficiency, direct electrification, carbon capture and storage, green hydrogen, and concentrated solar thermal (CST) technologies. However, the economic opportunity and technical feasibility are difficult for industrial owners to assess. Therefore, this project aims to develop an open-source, web-based solar+storage decision support tool; a bilingual (English and Spanish) interface will improve the tool's accessibility.

The tool's main objective is to ease the barrier of entry to considering solar+storage solutions (i.e., solar photovoltaics [PV], CST, thermal energy storage [TES], and batteries) for industrial decarbonization goals. The tool will optimally size a hybrid PV+CST+TES+Battery system to meet industrial heat and power loads given local renewable resource availability, land availability, temperature requirements, decarbonization goals, and so on. The resultant optimal hybrid system's economic value to the industrial facility will be presented to the user with comparisons to alternative decarbonization options and suggestions for the next steps (e.g., contacts for technical experts and contractors). The aim of this project is to deliver the first-generation of the tool to users, with the intention of supporting future iterations with subsequent funding.

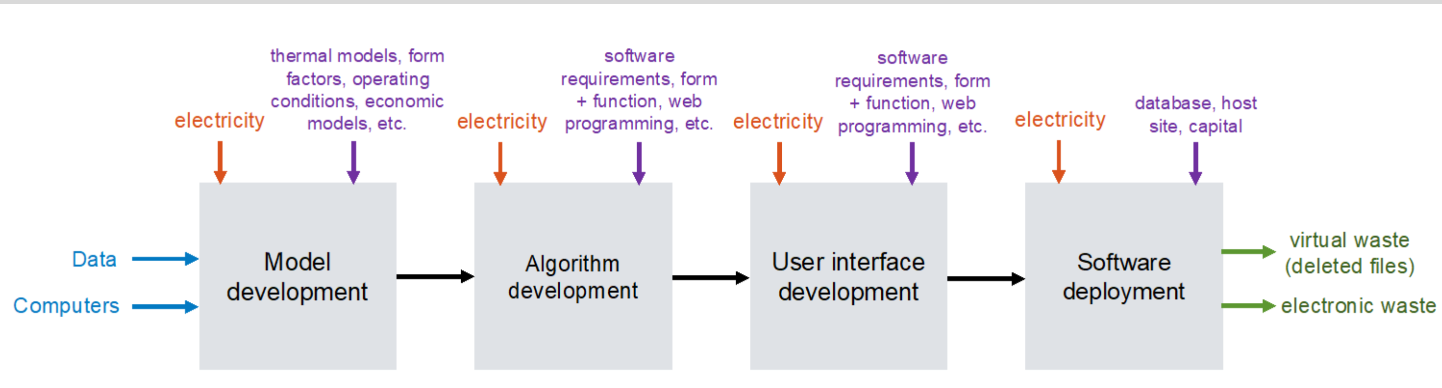
Using the new tool, the project team also seeks to conduct a nationwide analysis of the economic competitiveness of solar+storage solutions for industrial decarbonization. The analysis will evaluate the costs of solar+storage for industrial decarbonization in comparison to other prominent decarbonization pathways. This study will highlight locations in the United States where solar+storage is most cost-competitive and how much that correlates with the geospatial distribution of industrial demand in the United States. The study will also evaluate cost targets for emerging solar+storage technologies, i.e., CST and TES, and the greenhouse gas emission reductions that are economically viable. The project team expects to publish findings from their study as open access either directly through their institution or through a peer-reviewed journal article. The study results will inform funding agencies; researchers; local, state, and federal governments; and community leaders about the economics of using these technologies in communities across the country.

The project team uses the JUST-R framework to evaluate the direction, aims, and methodologies proposed to complete the project successfully. The JUST-R framework provides an actionable lens through which to view the project and improve its outcomes for a wider range of stakeholders. The industrial sector's emissions are not only a large share of the country's greenhouse gas emissions, but they are also a leading cause of the inequity in exposure to air pollutants, such as harmful $PM_{2.5}$, between racial groups in the United States (Tessum et al. 2021). The JUST-R framework helps the project's outputs be informed by and accessible to the communities most impacted by these emissions.

Assessment Example B: Engineering Design and Demonstration

Physical Flow Diagram for Assessment Example B

This flow diagram represents the physical inputs of the industrial decarbonization project. The research team used the diagram to determine which metrics they should target and then developed action items.



Targeting Metrics for Assessment Example B

The following example shows one of the metrics that the research team chose to target and one the team decided not to target, as well as the rationales behind those decisions. Both metrics are from the Sources and Inputs metrics category.

Selected	Diversity of authors of scientific papers reviewed

Rationale: The research team chose to target this metric for several reasons. First, obtaining the data to track this metric requires a low level of effort as the data can be gathered through a simple internet search. The team is comprised of less than 10 researchers and the literature search is targeted, therefore, the list of papers reviewed is not unreasonable to track. When the team first assessed the diversity of authors of the scientific papers they had reviewed, the results showed very low diversity – even for papers that focused on environmental injustices. This fact stuck with the team and motivated the team to track/target this metric going forward. Industrial decarbonization is also a rapidly growing area of interest with only a few researchers and/or groups that have been focusing on it for more than the past few years. However, in recent years, there has been a dramatic increase in the research, development, and deployment of technologies in this sector. Therefore, the metric seems appropriate to track such that the team can actively choose to feature and learn from a wide range of authors from less-traditional groups (e.g., diverse university professors and community groups versus only DOE offices). At a time of growth, it is more impactful/important to seek researchers who have been doing this work without as much recognition and/or amplify diverse authors who have experience in adjacent/supportive fields (e.g., environmental justice groups). The smaller size of the team also means learning from a wider range of authors is important to make the specific, technical team members more well-rounded; therefore, the team can more effectively realize the goals of the project.

Not Selected	Number of alternatives explored to hazardous materials

Rationale: As a software development-focused project, this metric seemed less directly relevant to the team's work than others and, therefore, was not chosen as a metric to target going forward. There are material hazard considerations in the supply chain of the renewable thermal technology the software tool is modeling that are important for users to understand. However, the project is focused on software development so there are no hazard materials being directly used, procured, and/or disposed of during this project. Additionally, the comparison of the hazardousness of the technologies modeled and/or suggested by the tool is not clear, with different technologies having their own unique advantages and disadvantages. The opaque comparison between alternatives in this field would be difficult, especially given the number of unknowns. Thus, the team has chosen not to target this metric given the removed relevancy and large level of effort to compare. With the system/project boundaries the team chose to use, this metric was not prioritized but did provide a potential area of future exploration.

Developing Action Items for Assessment Example B

This table provides examples of some of the action items the research team developed after their first JUST-R assessment. The table reproduces a section of the spreadsheet found in the assessment tabs (Tab 3 or Tab 4, depending on the length of your project) of the JUST-R Excel Tool.

Initial Assessment		
Metric	**Assessment 1**	**Action Plan**
Diversity of authors of scientific papers reviewed	The initial examination found a very low diversity of authors in the scientific papers used as part of the project's proposal.	1. All literature reviewed (even minorly) is stored in the project's OneNote for referencing. A precursory examination of the author's diversity is done. 2. Literature/resources from HBCU partnership used as a good starting point. 3. The full literature review will be compiled at the end of the project and the metric will be updated and compared to the original review.
Percentage of code or software published open source, open access, or free	No code published yet.	1. The tool being developed is a free web tool such that a user does not need to know coding languages nor pay for this initial TEA analysis. 2. The code behind the tool is going to be released open source.
Multi-lingual resources, outputs, etc. (*Project Team Defined Metric*)	No outputs yet. Current similar tool suite is only in English.	1. A bilingual interface for the tool has been developed such that both English and Spanish speakers will be able to use the tool.

Assessment Example C: Modeling, Analysis, and Software

Please note that this example is inspired by real research that has been fictionalized and anonymized.

Example Overview: Cyber Resilience for a Distributed Energy Grid

The adoption of clean energy resources is fundamentally changing the nature of the energy grid, which is becoming distributed, highly interconnected, and autonomously operated. These changes are emerging with the increasing penetration of distributed energy resources (DERs) and smart homes with highly controllable loads as well as with the interconnection of bulk renewables. All these changes rely on a rapid increase in dependence on communication infrastructure and independent third parties for control and operation of the grid. Though the evolution of the grid enables innovation in how energy is produced and used, it also exposes the grid to new cyber resilience hazards.

Among the key cyber resilience challenges facing the evolving grid are 1) a distributed cyberattack surface because of increasing influence of DERs and smart load on grid stability; 2) multiple entry points for cyberattack because of the diminishing of traditional information technology/operational technology (IT/OT) airgap driven by internet-connected loads and DERs; 3) the increasing possibility of cascading failures caused by a cyberattack because of the hierarchical and coordinated nature of new grid control and operation algorithms such as unified protection and control schemes; and 4) the need for autonomous decision-making in response and recovery of the grid at the cyber layer because of increasing autonomous control at the physical layer, especially considering the fast timescales that are required to maintain grid stability.

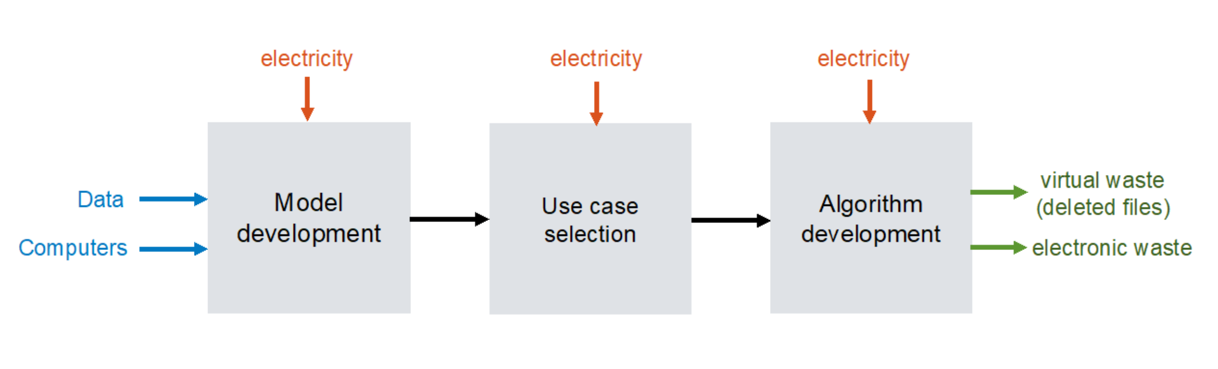
This project is aimed at developing algorithms, engineering approaches, and technologies to integrate cyber resilience into the future grid. This includes preparing and adapting the system at the design level, defending the control layer, anticipating cyberattacks by assuming a zero-trust posture at the device and network layer, and withstanding and recovering from attack by leveraging autonomous decision-making at the cyber layer—providing autonomous response without sacrificing threat intelligence and attack characterization.

The researchers focus on the development of methods for quantifying the impact of design on system cyber resilience, selection of use cases for control architecture and algorithm vulnerability analysis such as control of rooftop photovoltaics, automated energy systems (AES), wind plants, building automation, and transportation, along with investigation into formal verification and reverse engineering methods for device and software vulnerability analysis. After these analyses, the researchers will focus on developing novel algorithms for searching and developing a more cyber resilient network design and a self-healing, self-optimizing communication system coupled with novel methods for cyber deception and decoy for gathering threat intelligence. The JUST-R framework equips the researchers to consider otherwise "hidden" social and environmental costs associated with different pathways to cyber resilience.

Assessment Example C: Modeling, Analysis, and Software

Physical Flow Diagram for Assessment Example C

This flow diagram represents the physical inputs of the industrial decarbonization project. The research team used the diagram to determine which metrics they should target and then developed action items.



Targeting Metrics for Assessment Example C

The following example shows one of the metrics that the research team chose to target and one the team decided not to target, as well as the rationales behind those decisions. Both metrics are from the Team Dynamics metrics category.

Selected	Capability to communicate with stakeholders

Rationale: The research team chose to target this metric because the initial assessment showed that, while the team has made efforts to communicate findings with industry, government, and academic stakeholders, there was no plan to communicate findings and research to other community-level stakeholders through externally facing, plain language resources. Team members felt that developing such resources would be an interesting challenge that could open new perspectives on the research. Additionally, while there is no capacity to bring on additional team members with different areas of expertise at the current stage of the project, addressing this metric would likely require having conversations with staff and external experts who have experience with other stakeholder groups.

Not Selected	Accountability level

Rationale: The research team decided not to target this metric because of the high security level of much of the information involved in the research. For this reason, there are several intensive reporting and accountability protocols already in place, and creating any additional accountability involving end-users would likely not be permitted by the project funders. However, working through this metric in the initial assessment led to interesting discussions in the research team about how to integrate the priorities and concerns of end-users in project development.

Developing Action Items for Assessment Example C

This table provides examples of some of the action items the research team developed after their first JUST-R assessment. The table reproduces a section of the spreadsheet found in the assessment tabs (Tab 3 or Tab 4, depending on the length of your project) of the JUST-R Excel Tool.

Initial Assessment		
Metric	**Assessment 1**	**Action Plan**
Number of nonacademic sources reviewed	From a poll of the research team, majority of the team members (88%) used fewer than 5 nonacademic sources in their research, with half of those being 0 nonacademic sources. Nonacademic sources also often came from industry partners. There is room to consider other nonacademic sources in the future, such as news sources and firsthand accounts to better incorporate broader implications of cyberattacks on DERs.	1. Add a folder to the team's shared citation manager 2. Compile non-academic resources that team members have already read 3. Add a biweekly "reading discussion" to the regular team meeting to add more non-academic sources to team discussions. One team member "assigns" a relevant source to the team beforehand, presents a short summary slide with main points and discussion questions, and facilitates a (approximately 15 minute) discussion on the piece and how it factors into the team's research.
Hazard level of extracting or synthesizing material inputs	No materials were extracted or synthesized. At demonstration and deployment stage, may be worth considering hazards from extraction and manufacturing of hardware related to cyber-resilient DERs.	1. Research analogous cyber scale-up processes in other use cases and the specific hazards associated with technology used in project-related hardware. 2. Propose the development of health and safety metrics to capture the lifecycle impacts of hardware used in DER. Incorporate these metrics into cyber-resilience modelling outputs.

Assessment Example D: Fundamental Science

Please note that this example is inspired by real research that has been fictionalized and anonymized.

Example Overview: Hybrid Organic-Inorganic Nanostructures

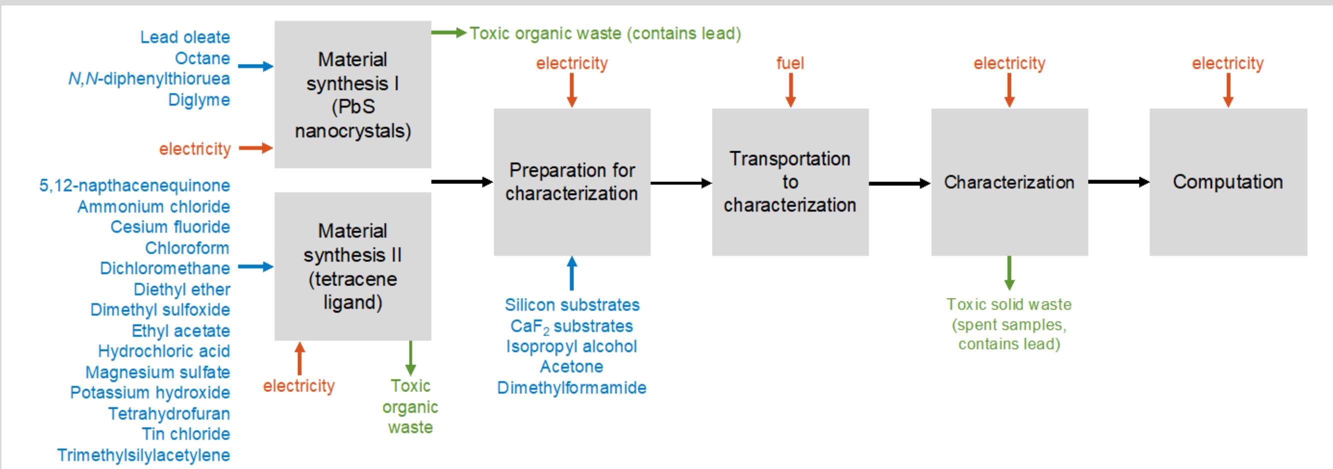
In this project, the researchers study a variation on a prototypical material used in fundamental research of solar energy harvesting systems. The material is a hybrid organic-inorganic nanostructure that combines the advantageous properties of both components to produce a material with enhanced solar harvesting properties. These nanomaterials are made by chemically attaching organic dyes (tetracene derivatives) to the surface of semiconductor nanocrystals, called quantum dots (QDs), about 3–7 nm in diameter. Although this system has been studied with different nanocrystal sizes and organic dye molecules, there is still a lack of understanding on the nature and type of interactions that can occur between surface-bound molecules and QDs. This study aims to fill the gap in the fundamental understanding of QD-dye interactions through intentional molecular design and QD size and material selection. The tasks of designing and synthesizing the tetracene derivative, preparing and characterizing the hybrid films, conducting transient absorption, carrying out X-ray scattering experiments, and performing computational modeling are shared among national laboratory researchers and university Ph.D. students.

The optical and structural measurements are used to provide detailed insight on the way the tetracene attaches to the QD surface and how the changes in the angle between the molecule and QD surface affect the optical and electronic properties. The main findings have been that the molecular structure and orientation of the tetracene with respect to the QD surface facilitates a strong electronic interaction with the PbS nanocrystals and that the electronic interaction depends on the concentration of the molecular solution used when exposing it to the nanocrystal. This is a new finding that will have strong implications on the behavior and fate of photo-generated excited states in this hybrid material as well as our understanding of the QD-molecular interface. Using the JUST-R framework enables the researchers to critically reflect on their collaborative team dynamics and evaluate how status quo laboratory protocols may embed sources of energy injustice in fundamental science research.

Assessment Example D: Fundamental Science

Physical Flow Diagram for Assessment Example D

This flow diagram represents the physical inputs of the synthesis and characterization of the hybrid organic-inorganic nanostructures project. The research team used the diagram to determine which metrics they should target and then developed action items.



Targeting Metrics for Assessment Example D

The following example shows metrics that the research team chose to target and metrics that the team decided not to target, as well as the rationales behind those decisions. The metrics are from the Processes and Protocols and Waste and Hazards metrics categories.

Selected	Number of alternatives explored to waste-intensive processes

Rationale: The research team selected this metric for further assessment and investigation because it suggested clear action items that could be applied more broadly than only the fundamental science research involved in this project. Because this project could potentially encourage the adoption of new material uses, exploring how waste processes related to the materials can be adapted for lower negative social impact could also benefit future research and development processes.

Not Selected	Extent to which hazards would increase at an industrial scale

Rationale: Because the industrial application of this research is not yet evident, the team could not accurately assess the hazard levels of the technology at an industrial scale. The team thus decided that it would be more impactful to focus their attention on options for reducing wastes and hazards directly associated with the materials used in the laboratory context, as any alternative processes they developed could be useful in future technology development and demonstration that uses these materials.

Selected	Number of alternatives explored to energy-intensive processes

Rationale: The team chose this metric because while they focused on their laboratory energy consumption in their initial JUST-R assessment, this project also has a computational aspect, and they were interested in thinking more into the energy requirements of their computing and if these could be reduced by using more efficient computing practices. The project team plans to connect with computing experts at their institution to learn more about energy consumption and green computing strategies to see if they can come up with some alternatives to potential energy-intensive processes in their work. Alongside this course of action, they will look for opportunities—however small—to reduce energy consumption in their material synthesis and film fabrication, as these process improvements could be impactful down the line as the materials are further developed for potential applications.

Not Selected	Number of environmental parameters tested

Rationale: The team chose not to target this metric because they believed it is too early in development of these materials to introduce new environmental parameters. While environmental stability will be important if these materials are ever employed in solar energy harvesting, this project is focused on understanding fundamental QD-dye interactions. It is important to first characterize these molecular interfaces in a controlled environment before researching how interactions evolve under different environmental stimuli. Thus, the team felt this metric would be more appropriate to target in later work.

Developing Action Items for Assessment Example D

This table provides examples of some of the action items the research team developed after their first JUST-R assessment. *The table reproduces a section of the spreadsheet found in the assessment tabs (Tab 3 or Tab 4, depending on the length of your project) of the JUST-R Excel Tool.*

Initial Assessment		
Metric	**Assessment 1**	**Action Plan**
Capability to communicate with stakeholders	Low – no presentations outside of academic conferences	1. Develop a summary briefing that could be used to share the research with nonacademic audiences.
Number of alternatives explored to waste-intensive processes	1 – reusing chemical containment	1. Connect with other chemical labs at the institution that may be using similar solvents. 2. Develop a system to share/consolidate excess solvents with these groups, so that one project's excess does not get disposed if they could be used by another project. This is particularly feasible for this project since such small volumes of solvent are used.

Team Dynamics

Team Dynamics Metrics

- Diversity of experiential knowledge leveraged in the work or project
- Accountability level
- Capability to communicate with stakeholders
- Percentage of team members who believe it is important to consider/address issues related to social justice/inclusion in their work and/or methodologies

Overview

The Team Dynamics metrics recognize the importance of the research team's perspectives, skillsets, and priorities in improving energy justice in early-stage research. Though the JUST-R framework includes many metrics that will guide you in analyzing specific points of intervention in your work, there may be other, unplanned opportunities to support energy justice as you make decisions and solve problems in the lab that are not reflected in this framework. A research team that is equipped to identify and act on those opportunities is an important asset.

Applying Team Dynamics Metrics: Guiding Questions

Does your research team reflect a diversity of identities and life experiences? How are different team members valued and recognized in the work?

Does your team have the skills necessary to engage with the implications of your research beyond the lab? Are your team members eager to learn about and improve energy justice in your research?

What types of experiences have your team members had interacting with the energy system outside of the lab, as energy consumers or neighbors to energy generation? Do these experiences reflect a wide range of contexts?

Example: Targeting Team Dynamics Metrics

How do you choose which Team Dynamics metrics to focus on? The following examples come from Assessment Example C: Modelling, Analysis, and Software and are also reproduced in that section.

Selected	Capability to communicate with stakeholders

Rationale: The research team chose to target this metric because the initial assessment showed that, while the team has made efforts to communicate findings with industry, government, and academic stakeholders, there was no plan to communicate findings and research to other community-level stakeholders through externally facing, plain language resources. Team members felt that developing such resources would be an interesting challenge that could open new perspectives on the research. Additionally, while there is no capacity to bring on additional team members with different areas of expertise at the current stage of the project, addressing this metric would likely require having conversations with staff and external experts who have experience with other stakeholder groups.

Not Selected	Accountability level

Rationale: The research team decided not to target this metric because of the high security level of much of the information involved in the research. For this reason, there are several intensive reporting and accountability protocols already in place, and creating any additional accountability involving end-users would likely not be permitted by the project funders. However, working through this metric in the initial assessment led to interesting discussions in the research team about how to integrate the priorities and concerns of end-users in project development.

Sources and Inputs

Sources and Inputs Metrics

- Number of social science papers reviewed
- Diversity of authors of scientific papers reviewed
- Number of nonacademic sources reviewed
- Hazard level of extracting or synthesizing material inputs
- Number of alternatives explored to hazardous materials
- Number of alternatives explored to unethically sourced materials

Overview

The Sources and Inputs metrics account for both the intellectual and material inputs of the research process. Metrics evaluating the hazards and ethics implications of materials used in your research invite you to consider what happens to those materials before they enter the lab (mining and supply chain) and after they leave the lab (disposal, safety, and exposure). The knowledge source metrics encourage you to consider what types of knowledge are framing what you know about your research field and how it impacts different people and places.

Applying Sources and Inputs Metrics: Guiding Questions

How are you evaluating the materials you use? Are you prioritizing efficiency above safety?

What knowledge sources are you using to formulate the questions that your research addresses? Could they be missing some of the impacts that your research/technology area has beyond the lab?

What do you know about where the materials you're using come from and how they get to your lab?

Example: Targeting Sources and Inputs Metrics

How do you choose which Sources and Inputs metrics to focus on? The following examples come from Assessment Example B: Engineering Design and Demonstration and are also reproduced in that section.

Selected	Diversity of authors of scientific papers reviewed

Rationale: The research team chose to target this metric for several reasons. First, obtaining the data to track this metric requires a low level of effort as the data can be gathered through a simple internet search. The team is comprised of less than 10 researchers and the literature search is targeted, therefore, the list of papers reviewed is not unreasonable to track. When the team first assessed the diversity of authors of the scientific papers they had reviewed, the results showed very low diversity – even for papers that focused on environmental injustices. This fact stuck with the team and motivated the team to track/target this metric going forward. Industrial decarbonization is also a rapidly growing area of interest with only a few researchers and/or groups that have been focusing on it for more than the past few years. However, in recent years, there has been a dramatic increase in the research, development, and deployment of technologies in this sector. Therefore, the metric seems appropriate to track such that the team can actively choose to feature and learn from a wide range of authors from less-traditional groups (e.g., diverse university professors and community groups versus only DOE offices). At a time of growth, it is more impactful/important to seek researchers who have been doing this work without as much recognition and/or amplify diverse authors who have experience in adjacent/supportive fields (e.g., environmental justice groups). The smaller size of the team also means learning from a wider range of authors is important to make the specific, technical team members more well-rounded; therefore, the team can more effectively realize the goals of the project.

Not Selected	Number of alternatives explored to hazardous materials

Rationale: As a software development-focused project, this metric seemed less directly relevant to the team's work than others and, therefore, was not chosen as a metric to target going forward. There are material hazard considerations in the supply chain of the renewable thermal technology the software tool is modeling that are important for users to understand. However, the project is focused on software development so there are no hazard materials being directly used, procured, and/or disposed of during this project. Additionally, the comparison of the hazardousness of the technologies modeled and/or suggested by the tool is not clear, with different technologies having their own unique advantages and disadvantages. The opaque comparison between alternatives in this field would be difficult, especially given the number of unknowns. Thus, the team has chosen not to target this metric given the removed relevancy and large level of effort to compare. With the system/project boundaries the team chose to use, this metric was not prioritized but did provide a potential area of future exploration.

Processes and Protocols

Processes and Protocols Metrics

- Estimated energy consumed during project activities
- Estimated water consumed during project activities
- Estimated land use during project activities
- Number of alternatives explored to resource-intensive processes
- Number of environmental parameters tested
- Number of nontechnological solutions explored to solve key problems in a project

Overview

The Processes and Protocols metrics ask you to think about the impact of your day-to-day work in your laboratory or research facility. Like the Sources and Inputs metrics, this category has both material and intellectual dimensions: In addition to measuring the energy and environmental impacts of your work, you will need to reflect on how you define problems and develop solutions during the research process.

Applying Processes and Protocols Metrics: Guiding Questions

In addition to optimizing the "ends" (outcomes) of your research for efficiency, can you find ways to optimize the "means" (processes and protocols) for efficiency?

What factors are you considering when developing your research processes? Are there lower-impact alternatives that you haven't tried?

Are there opportunities for innovation in your processes—perhaps to reduce waste or energy use or to improve safety?

Example: Targeting Processes and Protocols Metrics

How do you choose which Processes and Protocols metrics to focus on? The following examples come from Assessment Example D: Fundamental Science and are also reproduced in that section.

Selected	Number of alternatives explored to resource-intensive processes

Rationale: The team chose this metric because while they focused on their laboratory energy consumption in their initial JUST-R assessment, this project also has a computational aspect, and they were interested in thinking more into the energy requirements of their computing and if these could be reduced by using more efficient computing practices. The project team plans to connect with computing experts at their institution to learn more about energy consumption and green computing strategies to see if they can come up with some alternatives to potential energy-intensive processes in their work. Alongside this course of action, they will look for opportunities—however small—to reduce energy consumption in their material synthesis and film fabrication, as these process improvements could be impactful down the line as the materials are further developed for potential applications.

Not Selected	Number of environmental parameters tested

Rationale: The team chose not to target this metric because they believed it is too early in development of these materials to introduce new environmental parameters. While environmental stability will be important if these materials are ever employed in solar energy harvesting, this project is focused on understanding fundamental QD-dye interactions. It is important to first characterize these molecular interfaces in a controlled environment before researching how interactions evolve under different environmental stimuli. Thus, the team felt this metric would be more appropriate to target in later work.

Waste and Hazards

Waste and Hazards Metrics

- Hazard level of project processes
- Hazard level of managing waste
- Number of alternatives explored to waste-intensive processes
- Estimated environmental cost of managing waste generated by project
- Estimated health cost of managing waste generated by project
- Extent to which hazards and costs would increase at industrial scale

Overview

The unintended hazards produced by energy technologies have long been a source of energy and environmental injustice (Ottinger 2013). The Waste and Hazards metrics present different perspectives from which to evaluate the waste produced by your research process, including its economic, environmental, and human health impacts. Though you will generally be able to measure the waste and hazards only generated by your own research process, it can be valuable to think through how these might scale when a related technology is deployed.

Applying Waste and Hazards Metrics: Guiding Questions

Does the waste created by your research process have the potential to harm communities near disposal facilities? If so, what process and protocols can be put in place to protect or even benefit these communities?

Is it clear to you where waste created during your research ends up? Would the answer change once the technology is scaled for deployment?

Are there established protocols for handling any hazards created during your research process? How successfully have these protocols been applied at scale?

Example: Targeting Wastes and Hazards Metrics

How do you choose which Wastes and Hazards metrics to focus on? The following examples come from Assessment Example D: Fundamental Science and are also reproduced in that section.

Selected	Number of alternatives explored to waste-intensive processes

Rationale: The research team selected this metric for further assessment and investigation because it suggested clear action items that can be applied more broadly than the fundamental science research involved in this project. Because this project could potentially encourage the adoption of new material uses, exploring how waste processes related to material can be adapted for lower social impact could also benefit future research and development processes.

Not Selected	Extent to which hazards would increase at an industrial scale

Rationale: Because the industrial application of this research is not yet evident, the team could not accurately assess the hazard levels of the technology at an industrial scale. The team thus decided that it would be more impactful to focus their attention on options for reducing wastes and hazards directly associated with the materials used in the laboratory context, as any alternative processes they developed could be useful in future technology development and demonstration that uses these materials.

Outcomes and Dissemination

Outcomes and Dissemination Metrics

- Projected cost savings from operating the new technology vs. competing technologies
- Proportion of results published open access
- Number of nonacademic reports of results
- Number of nonacademic oral presentations of results
- Diversity of audience reached
- Percentage of funding sources disclosed
- Percentage of code or software published open source, open access, or free
- Percentage of open data published
- Number of accessible materials provided to replicate a project

Overview

Who has access to information generated by research—and in turn, whose voices are heard in feedback and decision-making processes—is critical to ensuring energy justice efforts succeed in the long term. Ensuring all stakeholders have information about technologies that may be used in their communities supports informed decision-making and effective energy justice advocacy. The Outcomes and Dissemination metrics focus on making the results of energy research transparent and accessible.

Applying Outcomes and Dissemination Metrics: Guiding Questions

Does your institution have options for sharing the results of your research in plain language?

Are there creative ways to share your work with a nonacademic/institutional audience?

If you were describing your research at a family gathering (assuming that not everyone in your family is an energy researcher!), what would you say? Can you make a similar sort of description available to a general audience?

Does your institution have options for sharing the results of your research in other languages?

Are there creative ways to share your work with a non-academic/institutional audience?

Outcomes and Dissemination

Example: Targeting Outcomes and Dissemination Metrics

How do you choose which Outcomes and Dissemination metrics to focus on? The following examples come from Assessment Example A: Wet Lab and Characterization and are also reproduced in that section.

Selected	Diversity of audience reached

Rationale: The team chose this metric because performing the initial JUST-R assessment made them realize their research results have so far only been shared with a very narrow group of photovoltaics specialists, which has likely limited the potential impact of this project. A key goal of this project is to develop methodologies for multiscale characterization of solar cell degradation; however, these techniques could potentially be used to investigate degradation in other kinds of device materials as well. The team recognized that sharing these methodologies with a broader community of researchers who might employ them in their work could greatly increase the impact of this project. In addition, the environmental stressing conditions applied to samples in this project have been informed by perovskite PV literature, but sharing results with more diverse stakeholders (for instance, individuals involved in PV install & maintenance from a variety of geographies) could generate feedback on other relevant conditions to incorporate into the research to expand its relevance to broader communities.

Not Selected	Percentage of open data published

Rationale: The team chose not to target this metric because there are limitations on the data that can be shared from this project due to the need to protect the company's intellectual property. The research team does not have control over what data the company is or is not willing to share; thus, the team believed it would be more impactful to focus their efforts on how to share their method development with broad audiences, such as developing materials to help other researchers apply the methods.

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