



# Embedding Justice from the Beginning: JUST-R Metrics for Considering Energy Justice in Early-Stage Research

---

Liz Gill, Nikita Dutta, Bettina Arkhurst and  
Kate Anderson

March 30, 2023

# Objective

Develop metrics and methods for integrating energy justice from early research through deployment, to realize NREL's vision of clean energy for all.

Drive transformation of how we do clean energy research and deployment, at NREL and beyond.

Key Outputs		
<b>Need-finding survey:</b> Existing practices and barriers when researchers try to apply EJ to their work.	<b>Metrics for applying EJ to research:</b> Lit review on metrics for late-TRL & new metrics for early-TRL.	<b>Methods for applying EJ to research:</b> New methods for early-TRL & assessment of NREL case studies.



# Why consider energy justice in early-TRL work?

Can be costly & difficult to address energy justice issues later in tech development

**Example:** Cobalt in lithium-ion batteries poses both energy justice (resource depletion, unethical mining) & economic (expensive, unstable supply chain) challenges.

ARTICLE

<https://doi.org/10.1038/s41467-022-29022-z>

OPEN



Battery technology and recycling alone will not save the electric mobility transition from future cobalt shortages

Anqi Zeng<sup>1,2,3,8</sup>, Wu Chen<sup>2,8</sup>, Kasper Dalgas Rasmussen<sup>2</sup>, Xuehong Zhu<sup>1,3</sup>, Maren Lundhaug<sup>4</sup>, Daniel B. Müller<sup>4</sup>, Juan Tan<sup>5</sup>, Jakob K. Keiding<sup>5</sup>, Litao Liu<sup>6</sup>, Tao Dai<sup>7</sup>, Anjian Wang<sup>7</sup> & Gang Liu<sup>2</sup>

*Nature Communications* (2022).

*“Low-cobalt battery cathode technology development could alleviate, but not prevent, the supply crisis. The demand-supply gap would still occur around 2028-2033, even though cobalt-free LFP technology already penetrated the market in 2020 and it is predicted that the next-generation cobalt-free battery technologies will become commercialized by 2030.”*

→ Can we preempt these issues by considering energy justice earlier?

# Addressing the Lack of Early-TRL Energy Justice Resources

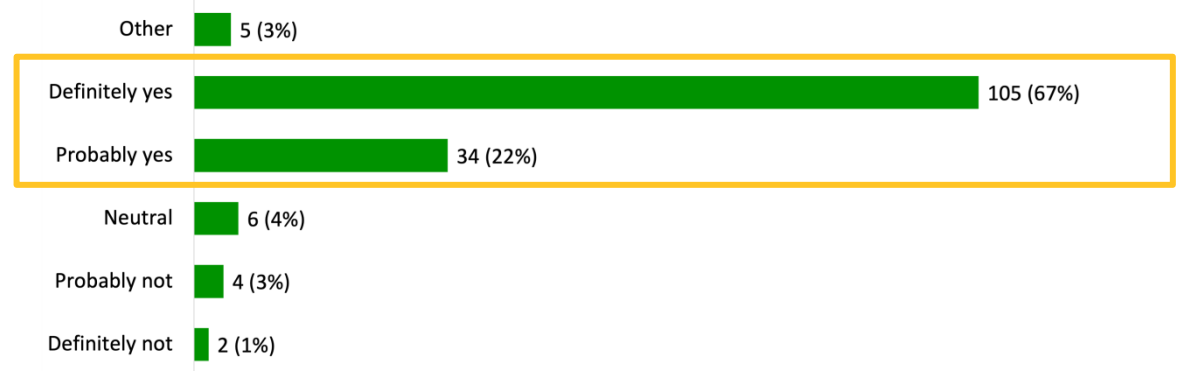
Literature reviews, surveys, and interviews showed a significant gap in knowledge on how to apply energy justice at early-TRL despite interest in doing so.

## Developing metrics for early-TRL:

Address lack of resources with metrics that...

- Incorporate justice into the process of early-stage research.
- Can be applied by individual researcher or project on an immediate timescale.
- Prepare an emerging technology to meet later-TRL metrics.

Do you believe aspects of energy justice should be incorporated into the energy technology design process?



Which of the following have been issues you have faced when attempting to apply energy justice to your work?



# Metrics

---

# New JUST-R Metrics for Early-TRL

## Breadth of pre-existing knowledge review:

- ↑ Number of social science papers reviewed
- ↑ Number of non-academic sources reviewed
- ↑ Diversity of authors of scientific papers reviewed

## Hidden process costs:

- ↓ Estimated cost of managing waste generated by research
- ↓ Estimated cost of energy consumed during research
- ↑ Projected cost savings from operating new tech vs. competing tech

## Identification of set vs. flexible parameters:

- ↑ Number of alternatives explored to waste-intensive processes
- ↑ Number of alternatives explored to energy-intensive processes
- ↑ Number of alternatives explored to hazardous or unethically sourced material
- ↑ Number of environmental parameters tested
- ↑ Number of non-tech solutions explored to solve key problems

## Distribution of hazard exposure during research life cycle:

- ↓ Hazard level of extracting or synthesizing material inputs
- ↓ Hazard level of laboratory processes
- ↓ Hazard level of managing waste
- ↓ Extent to which hazards would increase at industrial scale

## Distribution of research results:

- ↑ Proportion of results published open access
- ↑ Number of non-academic reports of results
- ↑ Number of non-academic oral presentations of results
- ↑ Diversity of audience reached
- ↑ Diversity of team members credited for & publicly presenting work

# Example 1: Consider the Whole Research Life Cycle

## Distribution of hazard exposure during research life cycle:

- ↓ Hazard level of extracting or synthesizing material inputs
- ↓ Hazard level of lab processes
- ↓ Hazard level of managing waste
- ↓ Extent to which hazards would increase at industrial scale

## Hidden process costs:

- ↓ Estimated cost of managing waste generated by research
- ↓ Estimated cost of energy consumed during research
- ↑ Projected cost savings from operating new tech vs. competing tech

**Asks of the researcher:** Consider the whole research life cycle, beyond what occurs in lab.

**EJ impacts:** Evaluating parts of life cycle individually gives insight into how costs, savings, & hazards may be distributed among communities on scale-up.

## Example thought process: Cobalt-containing lithium-ion batteries

- Hazard level of laboratory processes  
→ *Sufficiently **low** due to small scale & engineering controls at NREL.*
- Hazard level of extracting or synthesizing material inputs  
→ ***High** health hazards associated with artisanal & small-scale cobalt mining – **hazards distributed among individuals & communities who are not necessarily technology end users, an example of cosmopolitan justice.***

# Example 2: Broadening Use of Knowledge

## Breadth of pre-existing knowledge review:

- ↑ Number of social science papers reviewed
- ↑ Number of non-academic sources reviewed
- ↑ Diversity of authors of scientific papers reviewed

## Distribution of research results:

- ↑ Proportion of results published open access
- ↑ Number of non-academic reports of results
- ↑ Number of non-academic oral presentations of results
- ↑ Diversity of audience reached
- ↑ Diversity of team members credited for & publicly presenting work

**Asks of the researcher:** Reflect on knowledge that goes into or out of a research project – who is represented or benefits?

**EJ impacts:** Promotes public engagement, cultural compatibility, & earlier identification of social impacts.

## Example thought process: Heterogenous catalysis for fuel production

- Number of social science papers reviewed  
→ *Learn about **social impacts of precious metal extraction for catalysts.***
- Number of non-academic sources reviewed
- Diversity of authors of scientific papers reviewed  
→ *Learn about **feedstocks appropriate for different communities or geographies & social perception or impacts of their use.***



# Example 3: Expanding Solution Spaces

## Identification of set vs. flexible parameters:

- ↑ Number of alternatives explored to waste-intensive processes
- ↑ Number of alternatives explored to energy-intensive processes
- ↑ Number of alternatives explored to hazardous or unethically sourced materials
- ↑ Number of environmental parameters tested
- ↑ Number of non-tech solutions explored to solve key problems

**Asks of the researcher:** Combat the inertia of following what is normally done in the field, ask questions, & think creatively.

**EJ impacts:** Early insight into whether technology is likely to be deployable at scale in diverse environments without significant negative impacts.

## Example thought process: Wind resource modeling

- Number of alternatives explored to energy-intensive processes
  - *Incorporate **energy consumed by turbine/material transport** into analyses.*
- Number of environmental parameters tested
  - *Ensure models take into account **diverse boundary conditions/features relevant to different communities**, e.g. cultural differences in architecture, geographic differences in terrain.*

# Evaluation

---

# Case Study Evaluations: JUST-R Framework & Other Methods for Integrating Energy Justice

In case studies with 12 research teams, evaluated **appeal & effectiveness** of:

## **JUST-R Metrics Framework**

### **Increase Community Engagement**

Participate in public events targeted at non-scientific audiences

### **Improve JEDI in Research Implementation**

Internal workshops to discuss DEI and energy justice within project team

### **Linking Energy Justice Concepts from R&D to Deployment**

Use expand process hazards evaluations & research input-output maps to consider energy justice impacts

# Results: Enthusiasm for Engagement & Guidance for Further Improvement

**Enthusiasm around engaging with methods again.** Even with suggested improvements, the majority of researchers who volunteered to participate in this evaluation indicated they will be or would like to apply methods in the future

**Need for more resources to ensure successful method implementation.** Researchers thought it would be useful to have access to NREL-wide metrics around energy justice, time allotted for energy justice work, and facilitators for going through methods

**Need to better link methods with energy justice theories.** Researchers felt they still could not verbalize what exactly energy justice was and exactly how it related to their work.

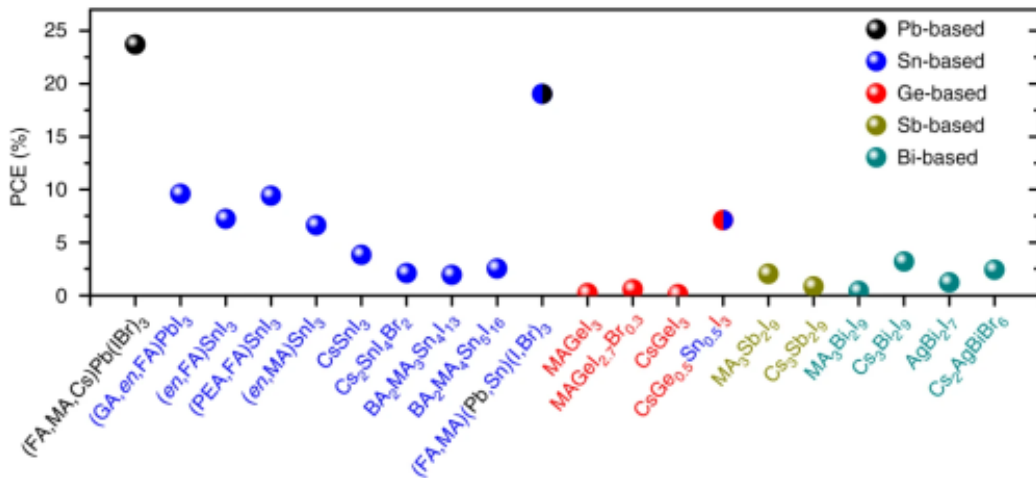
**Desire from researchers to see more specialized methods.** Methods and metrics better tailored to research could come from directorates/research centers and provide more specific guidance to researchers.

**Challenges impacting or changing research processes.** Although there were many discussions about changes in perspectives and thinking about particular metrics, concepts, and communities for the first time, we did not observe changes in research processes during this month-long evaluation.

# Challenges: Potential for tradeoffs between EJ & technical or economic metrics

**Example:** Perovskite photovoltaics

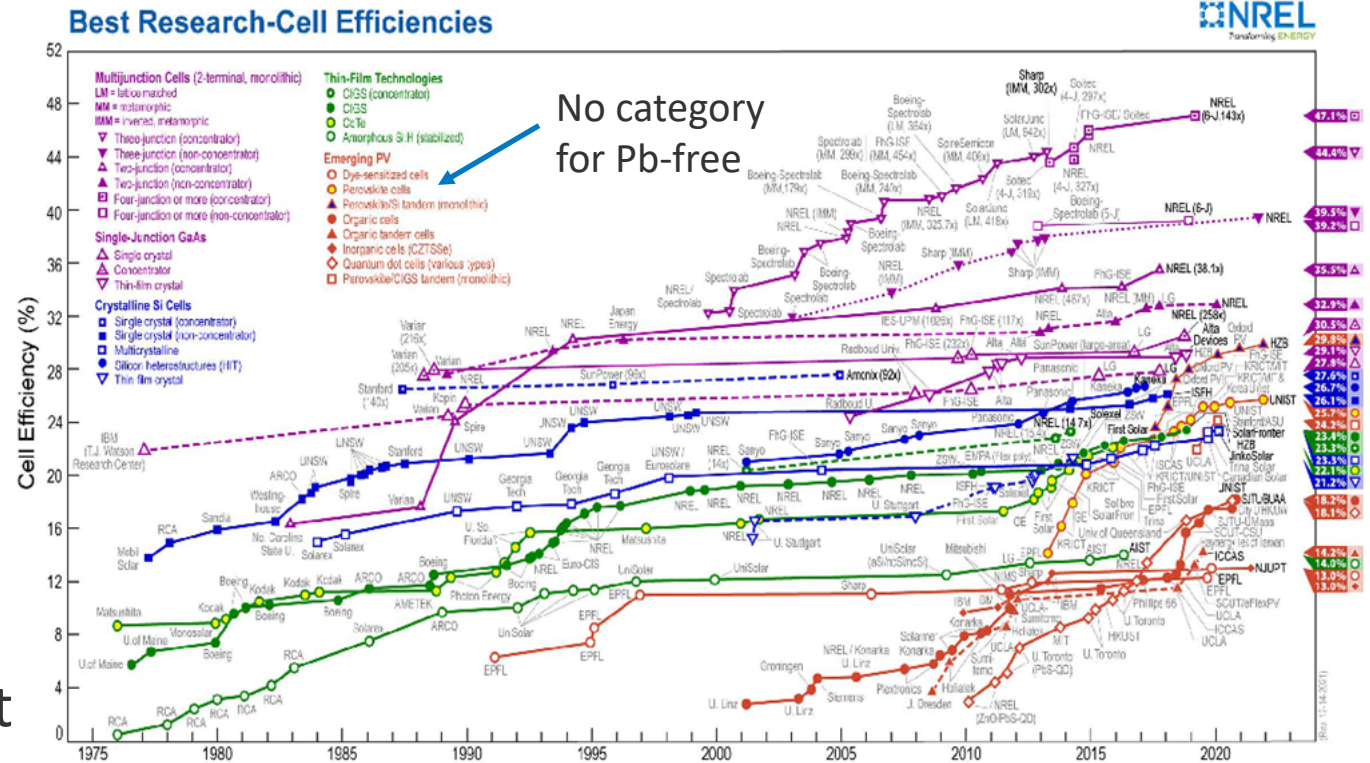
>25% of metrics improve with a Pb-free perovskite, at the expense of lower efficiency:



Ke & Kanatzidis, "Prospects for low-toxicity lead-free perovskite solar cells," *Nature Communications* (2019).

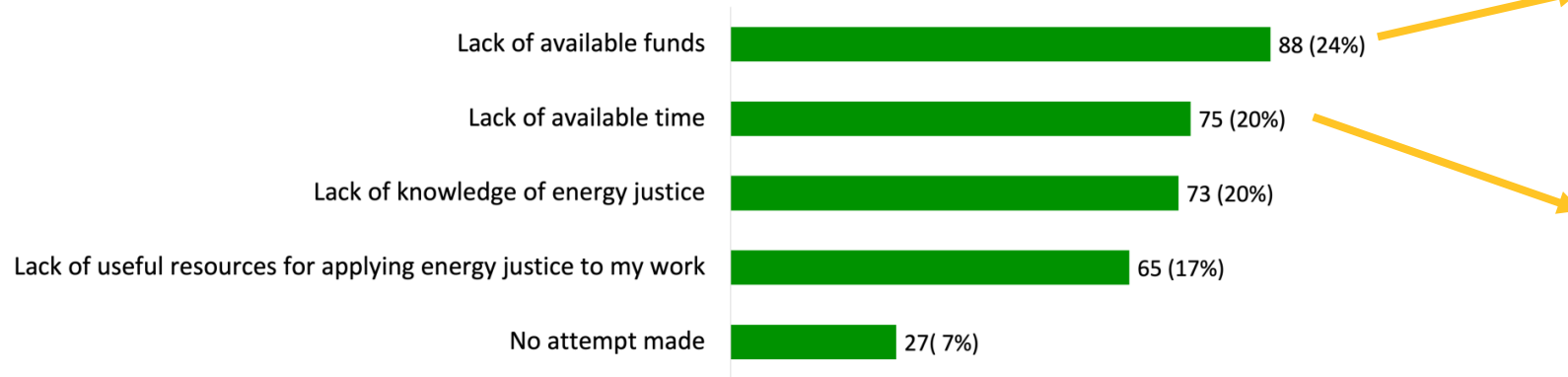
At early-TRL, energy justice is seen as a long-term incentive; unrealistic to expect it to compete with tangible, short-term incentives

(e.g. publishing, grants, career progression) without institutional support.



# Key takeaways & opportunities for future work

Which of the following have been issues you have faced when attempting to apply energy justice to your work?



Consider metrics at program level & incorporate energy justice-supportive language into funding calls.

Resources, policies, & dedicated staff to assist researchers with thinking through projects.

Researchers in case studies showed enthusiasm for engaging with developed metrics and methods again but highlighted need for future work:

**Specializing metrics** for individual research areas

Seeking feedback on potential for collaboration with ongoing projects

**Assessing long-term EJ impacts** of early-stage, low-TRL work

Connect back to research & process to demonstrate impact of considering EJ

## Journal Articles

[JUST-R metrics for considering energy justice in early-stage energy research \(Joule\)](#)

The Case for Energy Justice throughout Clean Energy R&D<sup>5</sup>  
(Submitted)

Thank You!

Questions & Comments

---

[elizabeth.gill@nrel.gov](mailto:elizabeth.gill@nrel.gov)