

Incorporating Sustainability, Justice, and Resilience Into R&D Thinking

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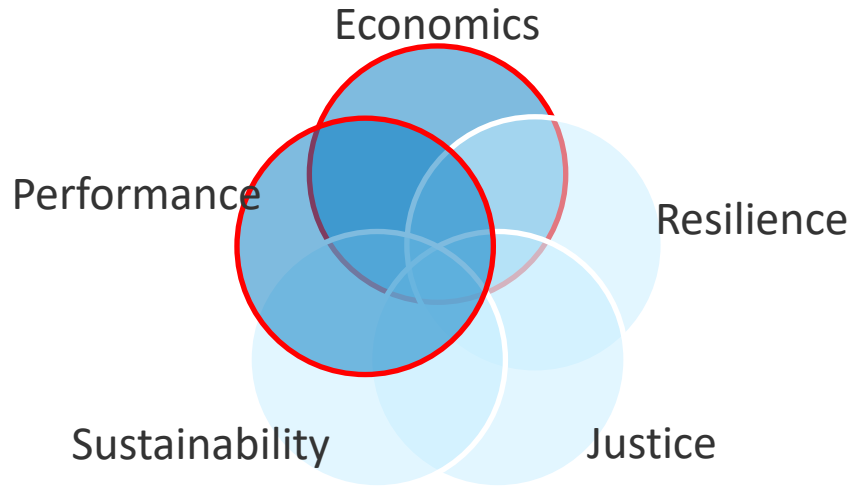


NREL's Energy Analysis and Decision Science

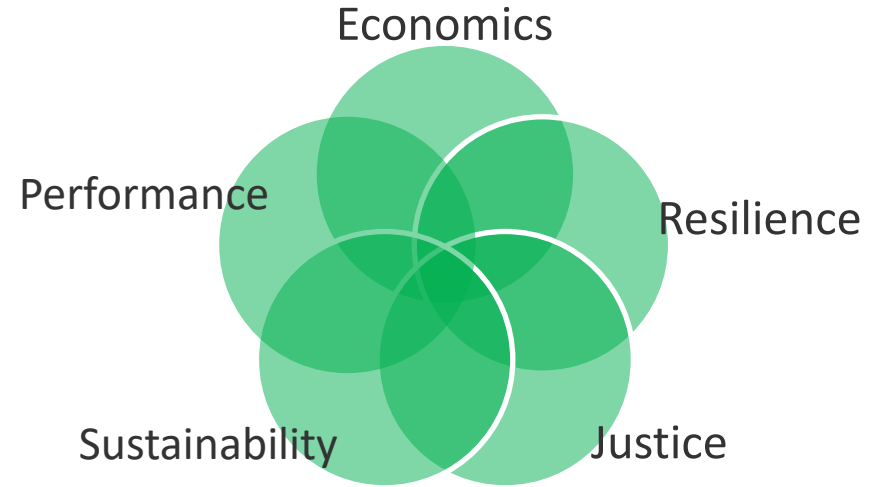
The National Renewable Energy Laboratory's (NREL's) **state-of-the-art decision science** drives understanding of **complex system dynamics, equity, and transformation**—from communities to states to entire continents.

A Holistic Approach to Research Objectives

Traditional Research Agenda



Target Research Agenda



How Is NREL Incorporating **Sustainability** Into R&D?

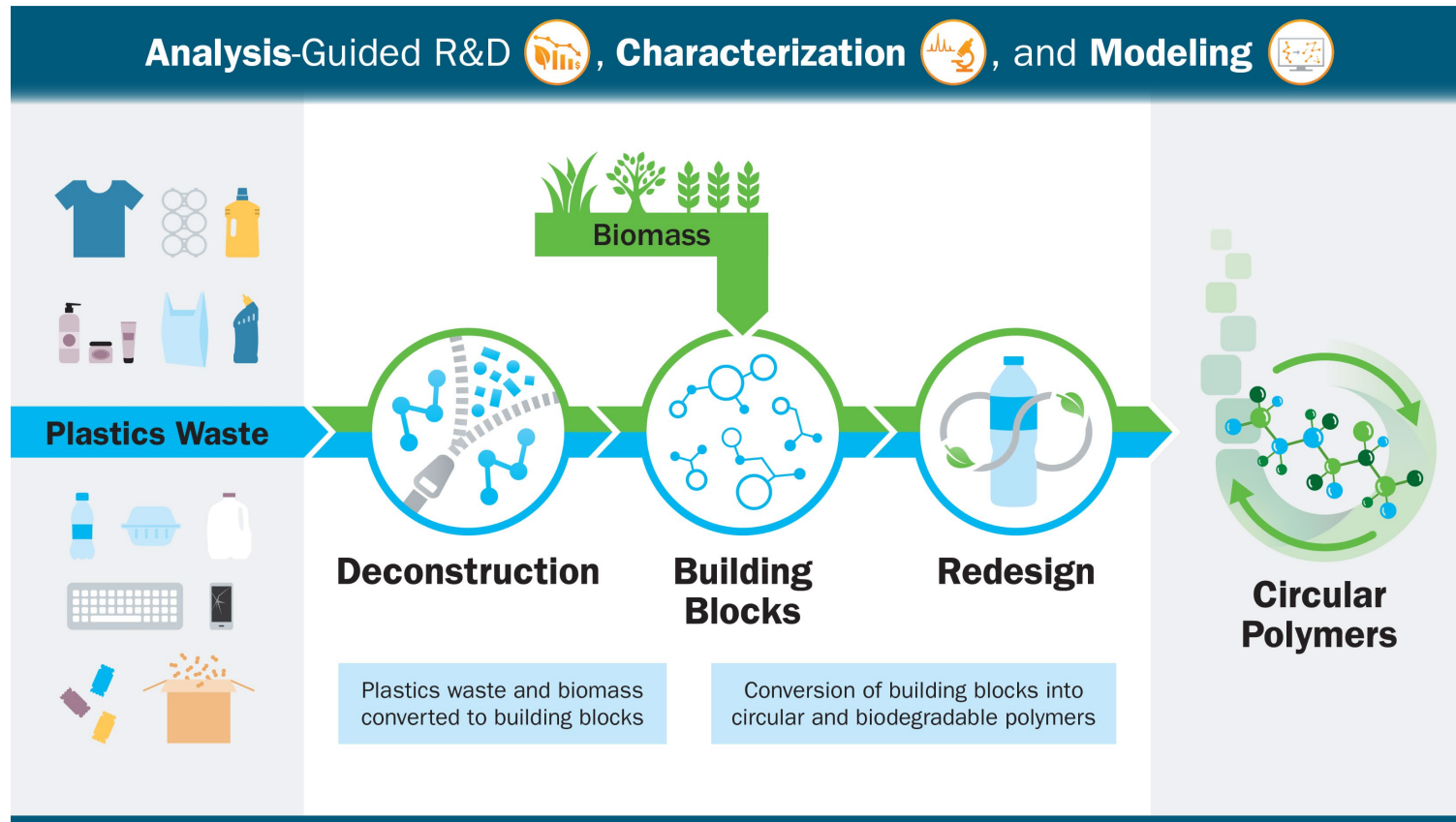
Defining Sustainability

Sustainability is defined globally as **“meeting the needs of the present without compromising the well-being of future generations”** (United Nations General Assembly 1987).

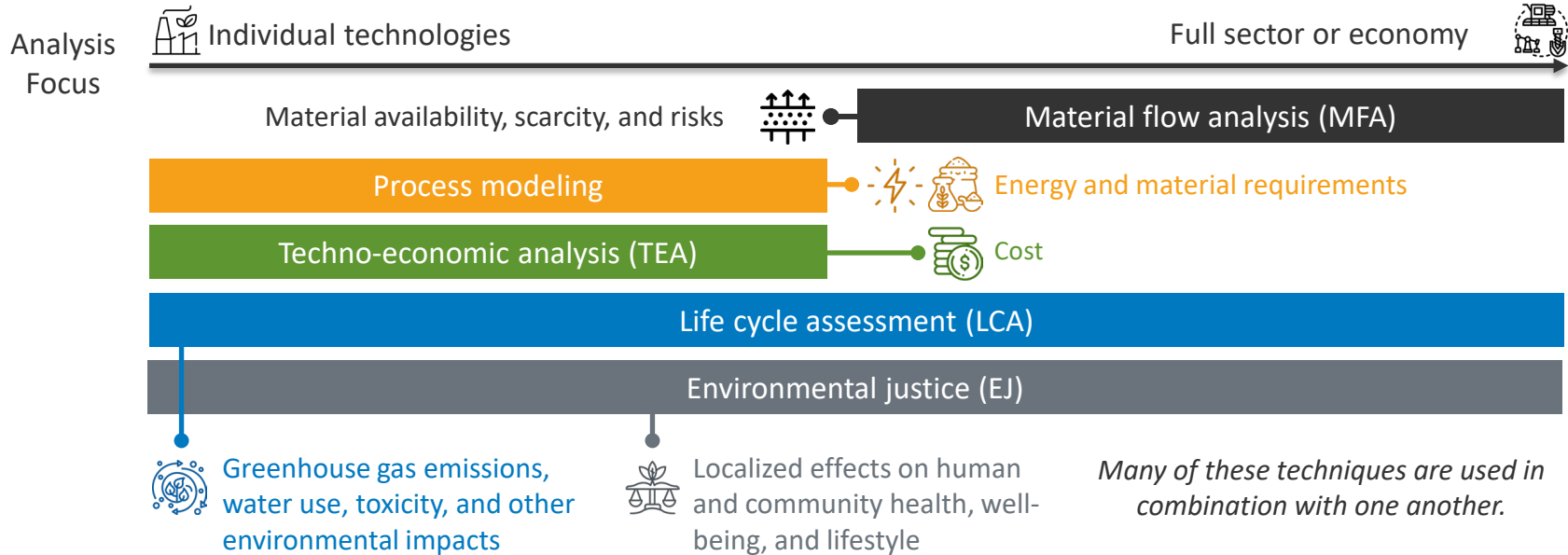
For the United States, sustainable development means a commitment **“to create and maintain conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations”** (U.S. National Environmental Policy Act 1969).



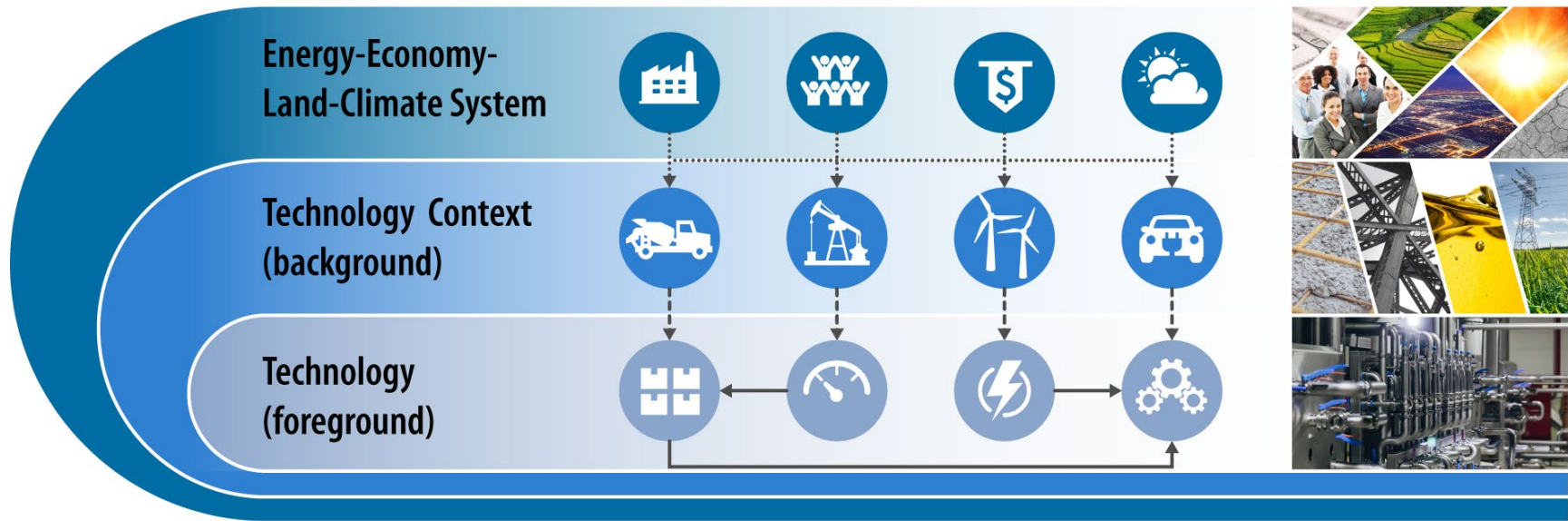
Example: Bio-Optimized Technologies to keep Thermoplastics out of Landfills and the Environment (BOTTLE™) Consortium



Overview: Analysis and Its Role in BOTTLE



Example: Lifecycle Analysis Integration into Scalable Opensource Numerical Models (LiAISON)

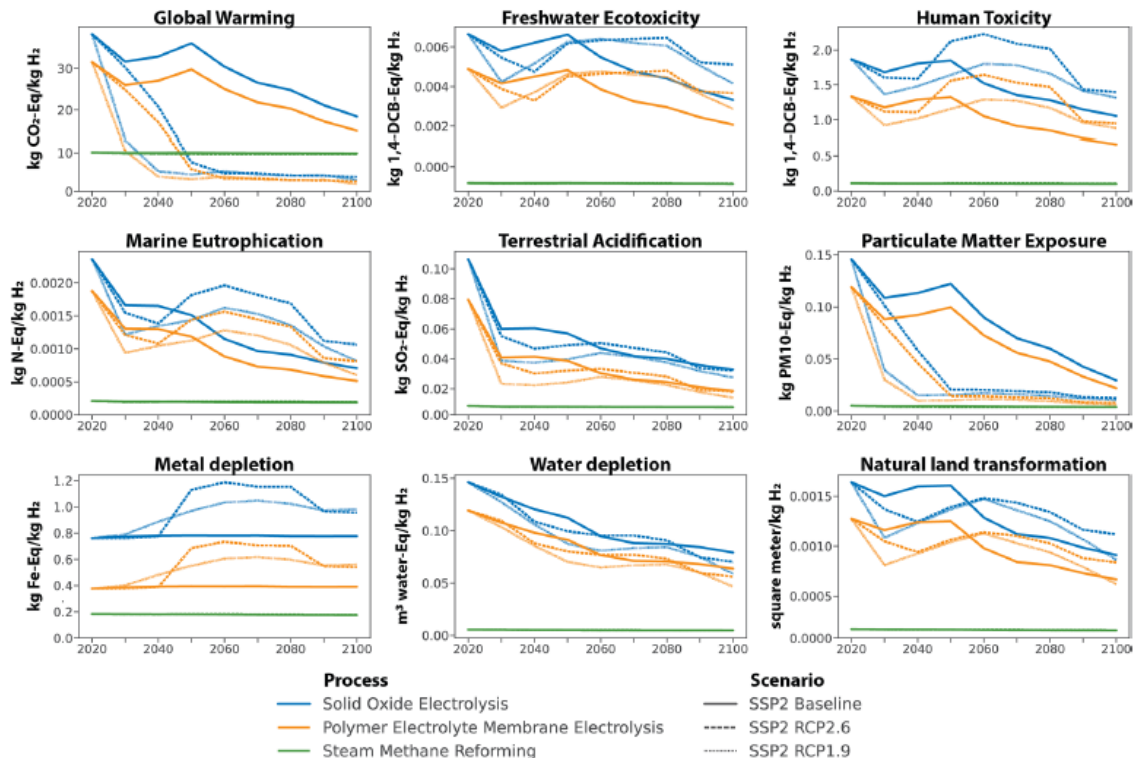


LiAISON Process and Data

Environmental Science & Technology

pubs.acs.org/est

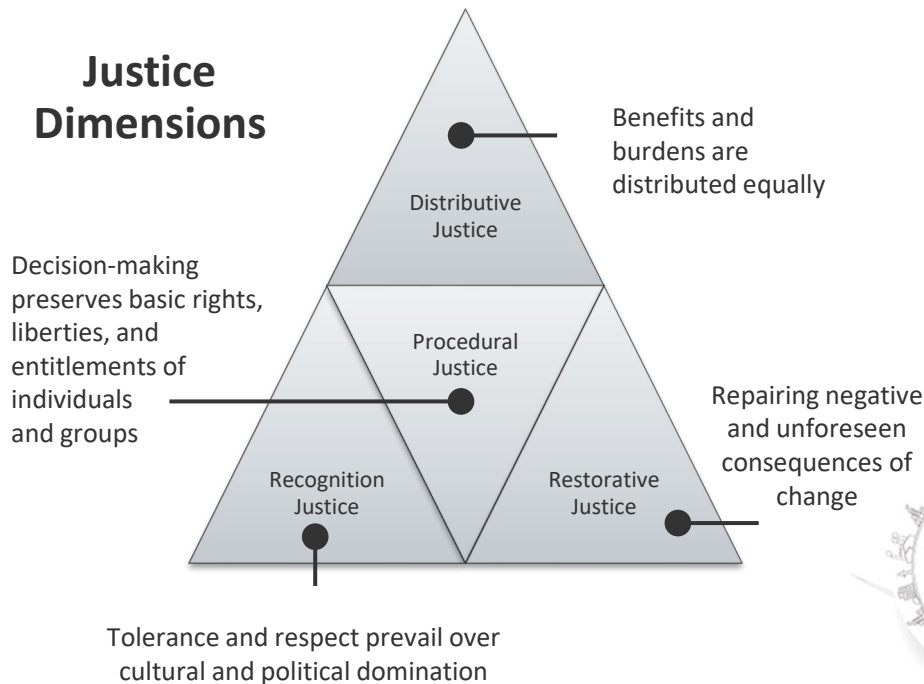
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How Is NREL Incorporating **Justice** Into R&D?

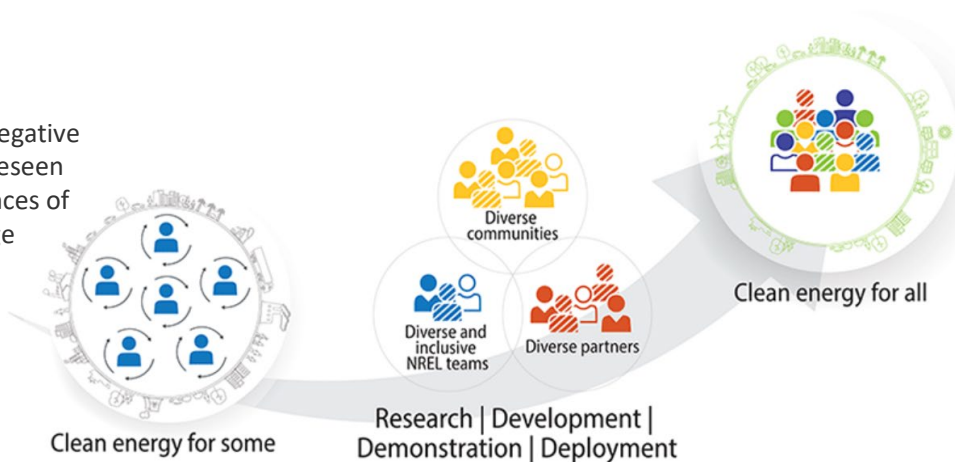
Defining Justice

Justice Dimensions



Consideration of these dimensions leads us to ask:

- **How** did we get here?
- Who is **included** and who is not? Who experiences burdens or benefits?
- What is the **context** of our work? What impacts do we expect it to have in the **future**?
- What **trade-offs** are we making?



Why Should We Care About Justice?

- Justice is a **basic human right** → allows everyone to have agency over decisions that impact their lives.
- Without justice, technologies may:
 - Jeopardize people’s lives and sustainability
 - Cause damage that must be mitigated or repaired
 - Face social acceptance issues
 - Face practical barriers such as “lock-in” or scaling challenges.

Can we preempt these issues by considering justice early in R&D?

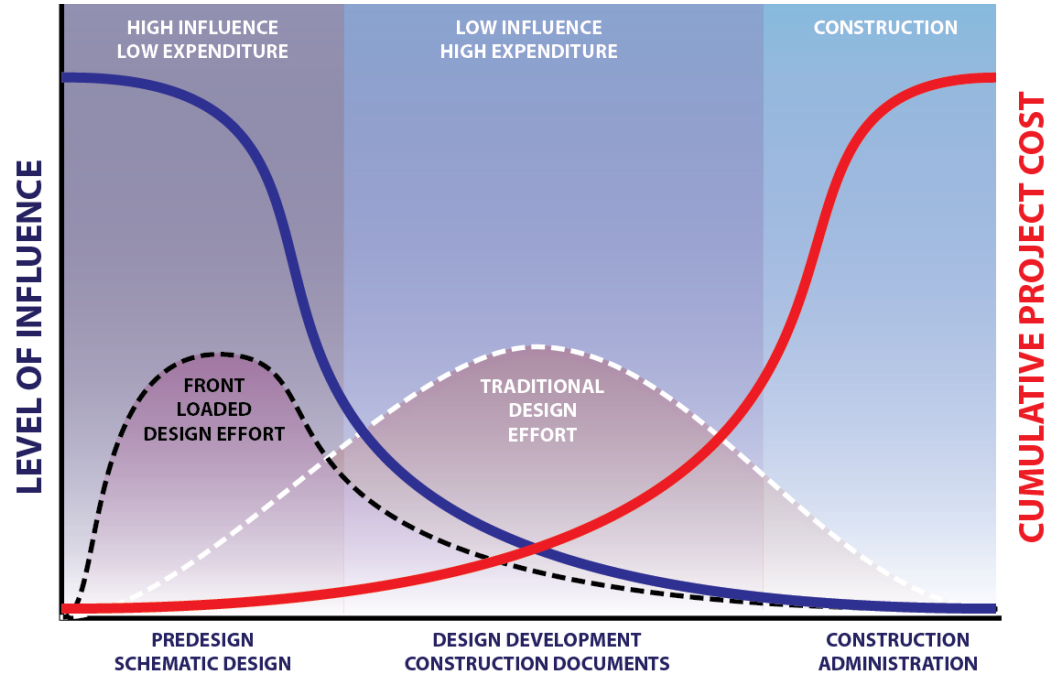


Image by Wheeler Kearns Architects; Paulson, 1976

A Starting Point for Incorporating Justice Into R&D

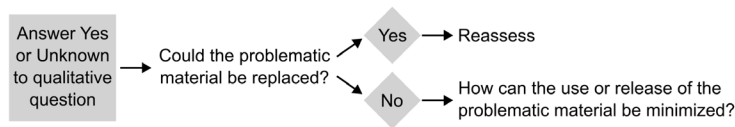
Step 1: Determine the Technology Readiness Level (TRL) of the solution to be evaluated.



Step 2: Answer the following justice questions.

<p>Qualitative Assessment*</p> <p>Environmental Impacts:</p> <ol style="list-style-type: none"> 1. Are any toxic materials used? 2. Are any of the used materials known to cause social or environmental issues? 3. Are any hazardous waste streams produced? <p>Worker Impacts:</p> <ol style="list-style-type: none"> 4. Are any of the used materials associated with forced or child labor? <p>Supply Chain Impacts:</p> <ol style="list-style-type: none"> 5. Will existing infrastructure be unable to manage the solution's end-of-life? 	<p>Quantitative Assessment</p> <p>Environmental Impacts:**</p> <ol style="list-style-type: none"> 6. Using life cycle assessment, what are the impact scores for smog formation, respiratory effects, and human toxicity? <p>Worker Impacts:</p> <ol style="list-style-type: none"> 7. What are the health and safety occupational hazards for workers? <p>Economic Impacts:**</p> <ol style="list-style-type: none"> 8. What are the number and types of jobs that will be created? 9. What are the economic impacts of the solution? 10. Will consumers be able to afford this solution? 	<p>Qualitative Assessment</p> <p>Worker Impacts:**</p> <ol style="list-style-type: none"> 11. Will workers along the material supply chain receive an unfair salary? 12. Will workers along the material supply chain work an unfair number of hours? 13. Will collective bargaining rights of workers along the material supply chain be disrespected? <p>Community Impacts:**</p> <ol style="list-style-type: none"> 14. Will the solution perpetuate historic problematic impacts or land use in the community where it will be deployed? 15. Is the community engagement plan lacking? 16. Are the land-use permits lacking? 17. Are the community preferences for the use of land being ignored?
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Step 3: Reflect on the answers. How can the results be taken into consideration when designing the technology?



Step 4: Communicate results and repeat.

* Qualitative questions should be answered with "yes," "no," or "unknown."

** These questions may require additional expertise, such as a life cycle assessment expert, a techno-economic analyst, or a social scientist.

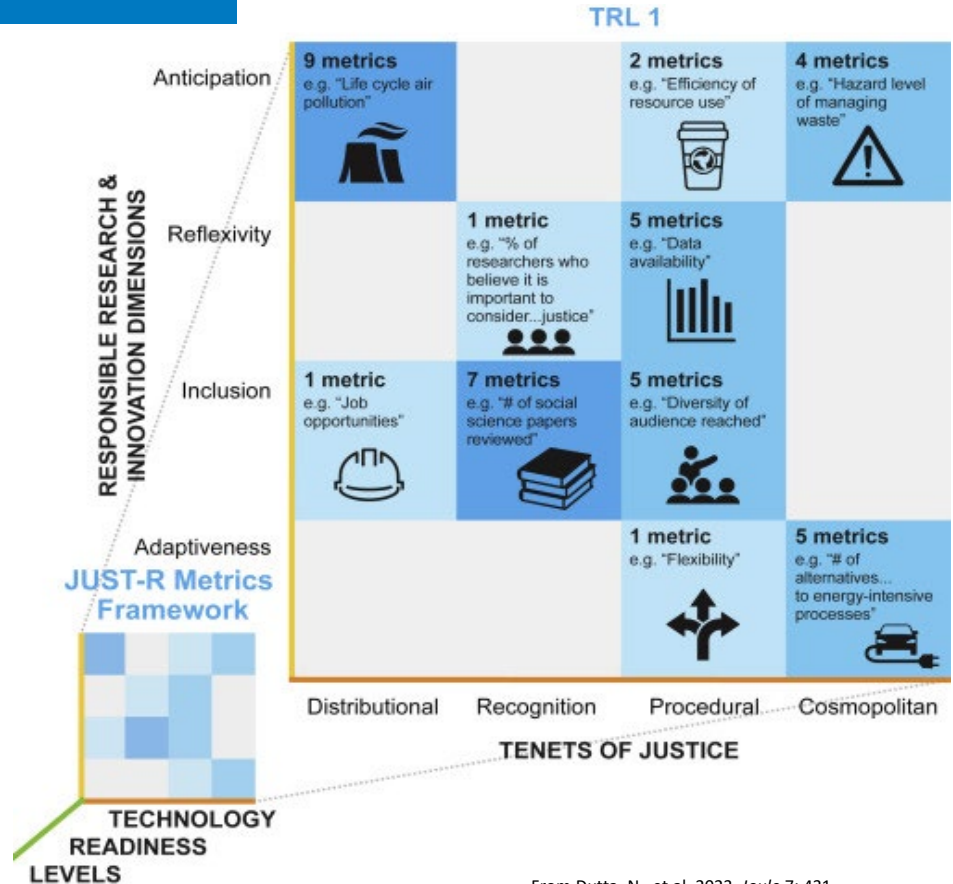
Goal: An inquiry-based, action-oriented, and easy-to-use framework for considering EJ early in the R&D process.

EJ Worksheet



JUST-R: Expanding for More Comprehensive Evaluation

Ongoing work is combining this action-oriented approach with the comprehensive metrics of Justice Underpinning Science and Technology Research (JUST-R).



Example: LA100 Equity Strategies



In 2021, NREL's LA100 study found that reliable, 100% renewable energy is achievable and can provide significant environmental and health benefits.



But improving energy equity requires intentionally designed strategies.

LA100 Equity Strategies Framework



LA100 Equity Strategies is groundbreaking in its methodology that centers equity throughout the project. The project integrated community engagement and guidance with robust modeling and analysis organized around three tenets of justice:



Recognition justice: Seeks to understand and address past and current energy inequities within LA.



Procedural justice: Ensures Angelenos are actively engaged partners throughout the project, co-design the analysis, and shape the resulting equity strategies.



Distributional justice: Ensures a just and equitable distribution of benefits and burdens of the clean energy transition.

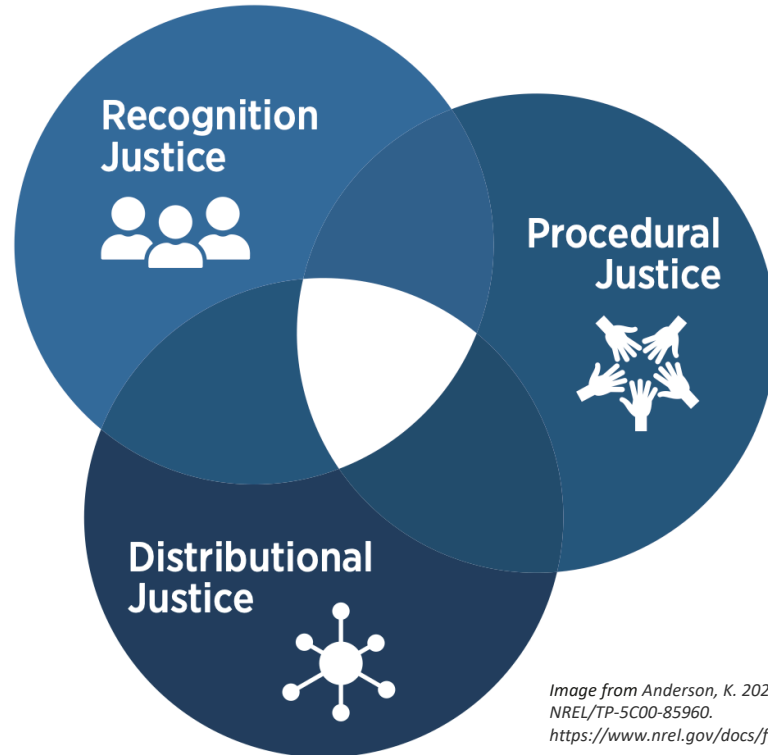


Image from Anderson, K. 2023. LA100 Equity Strategies. NREL/TP-5C00-85960. <https://www.nrel.gov/docs/fy24osti/85960.pdf>

The benefits of The Los Angeles Department of Water and Power (LADWP) programs are **not equitably distributed** across communities.

LADWP RESIDENTIAL INVESTMENTS 1999–2022

SOLAR INSTALLATION (1999–2022)



Net Energy Metering Programs



\$340,604,541



Non-DAC

White

Non-Hispanic

Owners

Above



Home Energy Improvement Program



\$3,378,869

\$3
\$2



DAC

Hispanic

Owners



Refrigerator Turn-In and Recycle Program



\$2,667,307



Non-DAC

White

Non-Hispanic

Owners

Above

ENERGY EFFICIENCY (2013–2021)



Consumer Rebate Program



\$93,248,144

\$64
\$74



Non-DAC

White

Non-Hispanic

Owners

Above



Other Non-Low-Income-Targeted Programs



\$36,343,548

\$178
\$196



Non-DAC

White

Non-Hispanic

Owners

Above



Energy Savings Assistance Program*



\$7,897,260

\$11
\$1



DAC

Non-White

Hispanic

Renters

Below

ELECTRIC VEHICLES (2013–2021)



Incentive Programs



\$5,361,426

\$41
\$64



Non-DAC

White

Non-Hispanic

Owners

Above

CUSTOMER DISCOUNTS (2006–2021)



Low-Income Program*



\$173,633,204

\$195
\$64



DAC

Non-White

Hispanic

Renters

Below



Lifeline Program*



\$313,424,782

\$302
\$164



DAC

Non-White

Hispanic

Renters

Below

Image from Anderson, K. 2023. LA100 Equity Strategies. NREL/TP-5C00-85960. <https://www.nrel.gov/docs/fy24osti/85960.pdf>

LA100 Equity Strategies identified community-informed, energy-just, and implementation-ready outcomes across a range of scenarios.

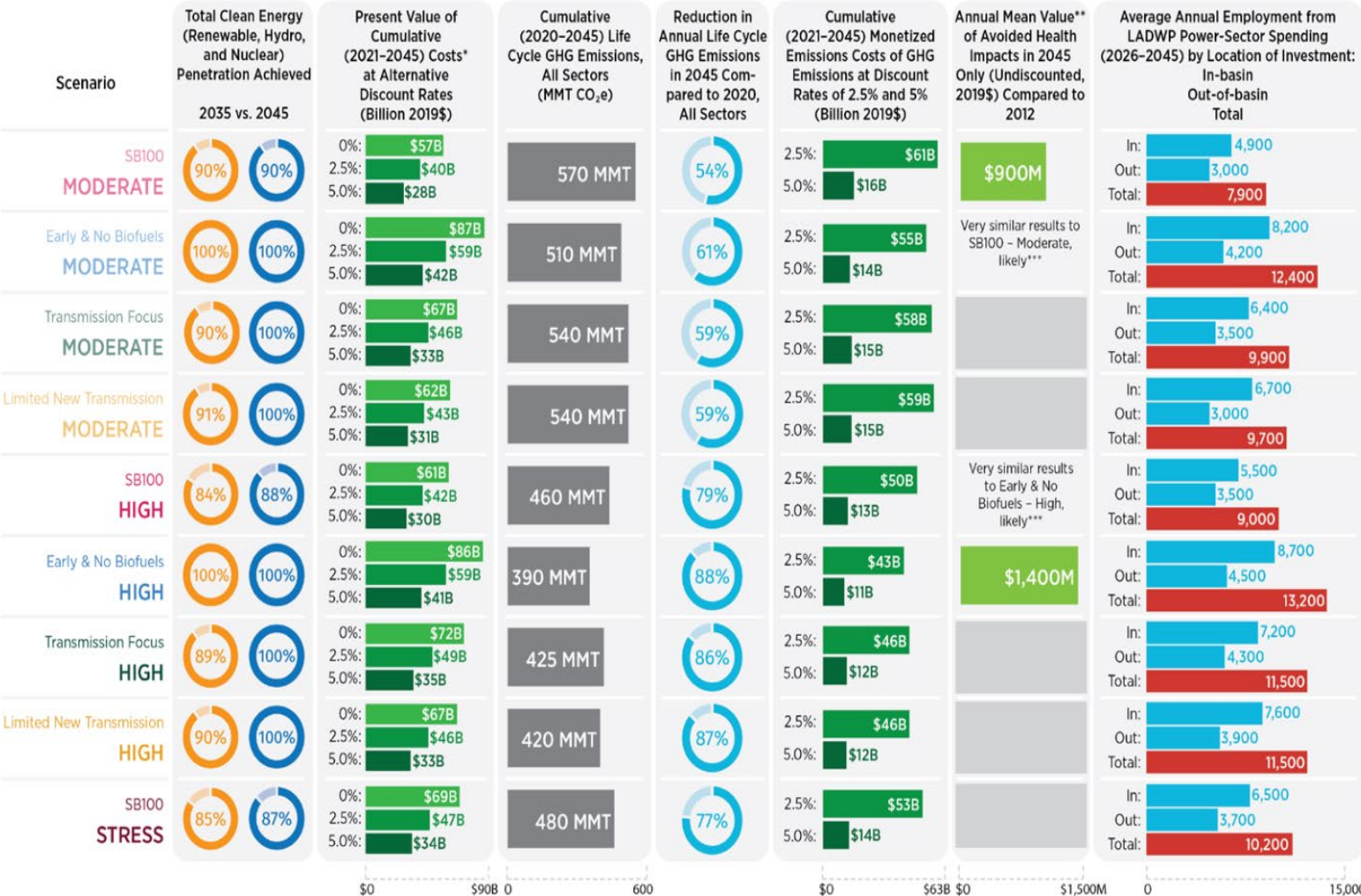


Image from Anderson, K. 2023. LA100 Equity Strategies. NREL/TP-5C00-85960. <https://www.nrel.gov/docs/fy24osti/85960.pdf>

LA100 Equity Strategies Research Outcomes

The final report provides **data** and **actionable strategies** to enable the City of Los Angeles to make effective and educated decisions about its energy future.



<https://maps.nrel.gov/la100/equity-strategies>



How Is NREL Incorporating **Resilience** Into R&D?

Tenets of Energy Security & Resilience



Cybersecurity

The **capability to address today's most critical energy security challenges**—like the exponential increase in grid-connected devices, split incentives for robust cyber defense, and control of the technology supply chains that directly impact grid services

System Resilience

The ability to **anticipate, prepare** for, and **adapt** to changing conditions and **withstand, respond** to, and **recover** rapidly from disruptions



Strategic Energy Security

The **uninterrupted availability of energy sources** at an affordable price to minimize negative consequences from energy use, including efficiency, environmental, social, and geopolitical factors

What Drives Resilience R&D at NREL?

DRIVING PROBLEM:

Climate change and a growing human threat environment are causing increasing risks to energy systems.

As we drive toward a more equitable clean energy future, energy systems are becoming *more* important to human life, the economy, and national security.

What is needed to address this problem?



Advanced Capability: Industry and partners don't have the advanced technical capabilities to achieve a resilient and decarbonized future.



The Resilience Externality: This problem won't solve itself because industry is not incentivized to solve it.



The Role of Clean Energy: Clean energy technologies provide a guaranteed secure fuel supply, alongside the challenges of variable availability.

Grand Challenges



Rapid growth of secure, clean energy technologies changes **market dynamics and supply chain** considerations

Absence of **quantifiable frameworks** for uncertainties reduces accuracy of risk identification and management

Outdated **standards implementation** creates new threats and vulnerabilities in distributed technologies and systems

Lack of **mature incentives or policies** for optimal resilience and security for infrastructure owners

Resilience Research



Decision Support



Transition to Practice



Threat



Device
Performance



System
Performance



Consequence



Technology Innovation

Questions?

www.nrel.gov

NREL/PR-6A20-92334

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