

# A framework to centre justice in energy transition innovations

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Patricia Romero-Lankao <sup>1,2</sup>✉, Nicole Rosner <sup>1</sup>, Christof Brandtner <sup>3</sup>,  
Christopher Rea <sup>4</sup>, Adolfo Mejia-Montero<sup>5</sup>, Francesca Pilo <sup>6</sup>,  
Fedor Dokshin <sup>2</sup>, Vanesa Castan-Broto <sup>7</sup>, Sarah Burch <sup>8</sup> & Scott Schnur <sup>9</sup>

The important role of justice in energy transition technologies has been a topic of increasing interest in recent years. However, key questions remain about how inequities influence energy transition innovations (ETIs) from their design to their widespread use, which ETIs receive more funding, and who controls ETI research, prototyping and deployment. Here we propose a framework to centre justice in energy transition innovations (CJI) and examine how three tenets of justice (recognition, procedural and distributional justice) influence each level of ETI, including niche, regime and landscape levels. We examine wind energy in Mexico and multiple ETIs in Los Angeles as use cases to show how our CJI framework can help reveal the specific inequities undermining just energy transitions at crucial analytical levels of ETI in practice. Our CJI framework offers a path for promoters, practitioners and underserved communities to target the problems these groups face and create ETIs that better address their specific aspirations, needs and circumstances.

Justice is important to energy transitions at all levels of energy transition innovation (ETI). The intersection of socioeconomic, institutional and environmental factors generates inequities in energy transitions. This has been demonstrated through much recent work. For example, solar panels, wind turbines, electric vehicles (EVs) and other ETI processes intended to enhance energy quality and reduce negative energy impacts<sup>1</sup> (re)produce injustices in accessibility<sup>2,3</sup>. Procedural and recognition injustices, such as pre-existing social relations and structures of production and consumption, produce the unequal distribution of benefits, environmental harm, exclusion and ill-health<sup>4–7</sup>.

Critical environmental justice (EJ) scholars<sup>8,9</sup> are calling for greater attention on how multiple social categories of difference from race to gender, sexuality, income and ability are entangled in the production of environmental injustice<sup>10</sup>. There are dangers, however, in transposing environmental justice approaches from the Global North onto the Global South, emphasizing a need to adapt frameworks to local

histories, as well as lived realities<sup>1–3</sup>. Furthermore, a critical gap remains in understanding how inequities play out in the design and diffusion of ETIs: which innovators receive more funding, and who controls the research, testing and deployment of ETIs.

ETIs range from large-scale infrastructure such as ethanol plants, wind farms and utility-scale solar energy, to small-scale consumer-facing innovations such as EVs, rooftop solar, smart metering and household appliances<sup>11,12</sup>. However, a comprehensive framework for understanding how inequities influence ETIs, from their design to their widespread use, is yet to be established. Such a structured approach to investigating the social impact of ETIs would create the conditions for examining who controls, benefits or is burdened by ETI research, prototyping and deployment.

Here we will utilize wind energy in Tehuantepec, Mexico and multiple ETIs in Los Angeles, United States as use cases to suggest a framework to centre justice in energy transition innovations (CJI). Our

<sup>1</sup>National Renewable Energy Laboratory, Golden, CO, USA. <sup>2</sup>Department of Sociology, University of Toronto, Toronto, Ontario, Canada. <sup>3</sup>Emlyon Business School, Lyon, France. <sup>4</sup>Department of Sociology, Ohio State University, Columbus, OH, USA. <sup>5</sup>School of Social and Political Sciences, University of Edinburgh, Edinburgh, UK. <sup>6</sup>Department of Human Geography & Spatial Planning, Utrecht University, Utrecht, Netherlands. <sup>7</sup>Department of Geography, Sheffield University, Sheffield, UK. <sup>8</sup>Department of Geography and Environmental Management, University of Waterloo, Waterloo, Ontario, Canada. <sup>9</sup>Anthropology Department, Emory University, Atlanta, GA, USA. ✉e-mail: [paty.romerolankao@utoronto.ca](mailto:paty.romerolankao@utoronto.ca)

CJI framework is directed to a wide audience of practitioners working on energy transitions. It critically engages with existing approaches to ETI development<sup>1,3</sup>, and connects three justice tenets—procedural, distributional and recognition justice—with transitions scholarship<sup>14,15</sup>. It reveals the specific inequities that undermine just energy transitions at crucial analytical levels of ETIs in practice. Building on both theoretical scholarship and our own applied research, the framework provides guiding questions for practitioners to adapt this approach to each local context by embedding ETIs in local histories and lived realities<sup>12</sup>.

## Tracing key strands of scholarship Energy equity and just energy transitions

Scholars have emphasized the need for rigour in the application of equity, equality and justice, given that these concepts are often mistakenly used interchangeably<sup>16,17</sup>. The liberal account of justice by Rawls<sup>18</sup> linked it to distributive outcomes, with equity being the normative principle for assessing this distribution. Equity implies facilitating access to different (not equal) benefits or actions that rectify past and/or existing injustices. Although equality refers to distributing the same to all, equity recognizes previous and current differences in experiences and outcomes between people, groups and communities to rectify those imbalances<sup>19</sup>. For example, single-capacity EVs may not be feasible for many residents of underserved communities, where investment in public transit or community electric bikes could provide a more accessible option<sup>20</sup>. Equity is about redistributing resources and decision-making power and reducing harm to underserved communities, given their historically uneven allocation.

Justice has interconnected threads within the fields of energy, climate and the environment<sup>21</sup>. It initially highlighted the unequal distribution of environmental harms<sup>5,6</sup> and emphasized questions such as who benefits, who bears the burdens, and how benefits and burdens are distributed through time and space. Beginning in the early 1990s, relational understandings of justice argued that a sole focus on distributional aspects ignored the unequal power of different actors<sup>5,21</sup>, hence increasing attention on procedural and recognition justice. The former focuses on the sociocultural and institutional actions and processes (for example, infrastructural investments and regulations) through which distributional injustices are (re)produced. The latter aims to understand and redress historical and ongoing inequalities that produce disproportionate distributions of ETI benefits and burdens.

For recent work connecting justice with transitions scholarship, just energy transitions connote transformations that, at a minimum, yield equity in distribution, process and recognition but also raise other dimensions such as restorative justice, cosmopolitan justice and justice towards the non-human<sup>6,7,22,23</sup>. Restorative justice targets the harm done to nations, populations and nature by calling attention to the root causes of human activity and restoring them back to their original state prior to damage<sup>24</sup>. Cosmopolitan justice highlights the importance of applying energy justice principles to all humans, not just those living in wealthy nations, and recognizing Global South understandings of energy justice<sup>25</sup>. Considering the negative impacts of the human energy system suffered by non-humans widens the lens of accountability in justice processes and outcomes.

In this Perspective we embed these tenets (that is, restorative and cosmopolitan) into our conceptualization of procedural, recognition and distributional justice. Although we recognize each tenet's distinctiveness, our approach emphasizes their interrelated importance across all levels of ETI. By embedding the cosmopolitan and restorative tenets within the three tenets of procedural, recognition and distributional, we underscore the ETI significance of these justice tenets for our CJI framework. Restorative, cosmopolitan and non-human justice relate to the spatial and temporal consequences of the reproduction of inequity. Recognizing those historical inequities reveals ongoing harm not only in one nation, but within and across nations; it evinces a need to consider local understandings of justice rather than impose

concepts from more powerful external decision-makers—whether that be theorists, engineers and politicians from the Global North or entrenched energy practices from the past.

Our CJI framework weaves the principles of energy justice such as those proposed by Sovacool and colleagues<sup>26</sup> into procedure, recognition and distribution, adding the principle of self-determination to centre the agency of underserved communities in decision-making. By so doing, we hope to strengthen the practical significance of each principle/tenet so that both impact the ETI process and people's quality of life. Scholars have examined justice in relation to development projects for decades. These findings can direct attention to the entanglements between power, history and cultural context during the ETI process.

## Our approach to just ETIs

ETIs entail the series of processes by which improvements in energy technology—from refinements of previously existing technologies to their replacement by substantially different ones—are designed, tested, built, demonstrated and refined (from the laboratory to the marketplace) and diffused into widespread use<sup>1</sup>. We understand ETIs as not only technically constituted, but also socially and politically<sup>27,28</sup>. Energy transitions depend on the socio-institutional arrangements, expectations and actions that influence how people design, produce and use ETIs. ETIs are composed of technologies, infrastructures supporting their use, specific business and financing models, social practices, and policy instruments and regulations<sup>14,29</sup>. We use the multilevel perspective (MLP) framework<sup>30</sup> as an entry point to introduce our CJI framework.

Multilevel perspective proponents use three analytical levels—niche, regime and landscape—to examine the socio-technological dynamics of ETIs<sup>31,32</sup>. At the niche level, novel ETIs are designed, prototyped, tested<sup>29,32</sup> and funded through public and private monies. Policymakers may support an emerging ETI, protecting it until it is competitive. Business actors, civil society groups, policymakers and potential users become change agents with the potential to promote (or contest) ETIs<sup>33,34</sup>. The ETI's contribution to advancing procedural, recognition and/or distributional justice can be criteria for evaluating its desirability and feasibility. For example, by examining who is innovating, and with what values, priorities and understandings, we can glean some understanding of which populations will be served by a technology and which will not.

Regime refers to the incumbent energy system organizing the uses of ETIs and structuring relationships among actors such as producers, regulators and utilities, whose priorities and understanding of appropriate ways to develop ETIs are intertwined with their understandings of the expectations and practices of users (for example, range anxiety or cultural identity)<sup>31,35</sup>. An ETI is extended and replicated through supply and demand, and, in time, can become part of the stable configuration emerging from the niche. ETI development is incremental, with implications for justice. The primary focus is on cost reduction, which increases accessibility, but other decisions may make a stable product accessible, affordable and appropriate to diverse needs. Examples include where raw materials are sourced (for example, lithium and silicon) and whether prevailing financing models provide access to underserved groups (for example, leasing versus purchasing of rooftop, solar versus community solar). An equity lens can also shed light on the consequences of ETIs—past, present and future—including (re) distributions of benefits and burdens, winners and losers, tradeoffs and synergies<sup>36,37</sup>, and unintended or unanticipated outcomes from an incompatibility with community realities and aspirations.

Landscape comprises the broad economic trends, climatic, environmental and social processes, and normative values and visions that structurally influence ETIs. From an equity perspective<sup>30,38</sup>, this level becomes a crucial context for multilevel actor interactions intended to create pressure upon the other levels through social, political and economic channels. Here, we bring new elements and actors to bear on

**Table 1 | A framework connecting justice tenets and multilevel perspective**

Centring justice in ETI	Procedural (nature of involvement)	Distributional (benefits and negative impacts)	Recognitional (root causes of inequity)
<p><b>Niche (research and development)</b> What is the nature of the ETI getting funded, how do actors link different elements/ practices, and who backs what politically?</p>	<p>Who is in control or involved in (1) setting the vision and (2) deciding on the nature of the ETI? What values and motivations underlie ETI development? Are these transparent in the public interest?</p>	<p>Which ETIs and teams of innovators receive funding? Who loses/wins in the transition period and how are negative impacts and benefits considered? Who will take responsibility if things go wrong?</p>	<p>Is the ETI designed with an understanding of historical and current determinants of inequities? Does it only consider market value or also social, cultural and environmental values?</p>
<p><b>Regime (mature ETIs)</b> What does the ETI do, and how do actors and processes interact to diffuse it?</p>	<p>Who is excluded from ETI-related decision-making? How are underserved actors involved? Who is involved in implementation and evaluation?</p>	<p>What is the distribution of benefits/risks? What is the distributional influence of policies (for example, economic incentives, regulations) and of prevailing practices? Does the ETI create new problems or unintended consequences?</p>	<p>Does the ETI address the root causes of energy, hardship or exacerbate them? How are historically entrenched inequities targeted? Does the ETI recognize some users over others?</p>
<p><b>Landscape</b> What are the equity implications of broader trends and events, and the institutional, socioeconomic and environmental context within which actors and institutions are embedded?</p>	<p>Who is in control of larger cultural paradigms/shifts (for example, in business or state intervention)? Whose knowledge (for example, on climate change) influences ETI development?</p>	<p>What are the distributional consequences of cultural paradigms/ shifts? What are the distributional impacts of climate change, political, market and other dynamics?</p>	<p>How do cultural paradigms/shifts embed and/or balance market forces vis-à-vis equity values, realities and priorities?</p>

the discussion (for example, by including underserved communities) besides the traditional actors in equitable ETI development. Only in this way will governance of ETIs in the present take care of past, current and future energy inequities and injustices.

**A CJI framework**

Across tenets and levels, energy justice has wide-ranging effects on the equitable design and deployment of ETIs. Table 1 presents a series of questions for practitioners (such as ETI developers and/or promoters) to use as a scaffold for a more equitable process. Distributional justice at the niche level raises questions about which ETIs get more funding, or public support, and who controls or contributes during the early stages of ETI research and design. Procedural and recognition justice implications relate to questions such as who is involved or included, how promoters and developers anticipate the changing distribution of benefits and negative impacts, and how the design process acknowledges and responds to past and current inequalities (Table 1).

The regime raises procedural questions about who encourages the ETI deployment, who is excluded, and how principles of equity are embedded in technology-design decisions throughout the supply chain and at the deployment stage. Distributional questions about ETI impacts attend to the principles of availability, accessibility, affordability, intersectionality and due process within and across cities and nations (Table 1). Finally, it raises recognition questions about the ETI's effectiveness in tackling the problem, its causes and its socioeconomic and environmental consequences that have historically burdened underserved communities across generations. Variations in access to technologies like rooftop solar, wind and charging infrastructure, for example, depend on root determinants of social inequality playing out differently across contexts. These determinants include the legacies of land-use planning, infrastructure investment, and mechanisms of exclusion such as restrictive covenants, zoning ordinances and informal land-tenure and housing practices<sup>39</sup>.

As for the landscape level, an equity lens focuses on the implications of broader trends (for example, market and climatic dynamics) and events (for example, wars, economic and climatic shocks) on the other two levels. It also targets the wider socioeconomic, cultural and environmental contexts within which actors and technologies operate (Table 1). ETIs are part of broader narratives shaped by those who design and advance their visions of more equitable and sustainable futures. Equity considerations help analyse how broader cultural paradigms embed and balance market forces versus other values and priorities

(Table 1)<sup>27,40,41</sup>. Procedure questions aim to restore and redistribute due process to historically underserved communities by looking to changes across the ETI process that prioritize transparency, accountability and self-determination.

Through our CJI framework, we analyse the context-specific interplay between ETI levels and energy justice tenets. Scholars argue, however, that transposing frameworks from their original contexts (for example, in industry, government and/or the Global North) onto distinct local communities ‘may render claims conflicting with the very idea of environmental distribution [as a method of achieving equity] invisible’<sup>42</sup>. The negative impacts of solar, for example, are left unquestioned, provided their harm is evenly distributed across society. Therefore, energy justice scholarship<sup>22,25</sup> emphasizes the need to include cosmopolitan justice to avoid imposing singular understandings of justice on the rest of the world. We recognize the importance of cosmopolitan and restorative justice by embedding them within each of the three justice tenets that help structure our CJI framework. As such, our framework understands the significance for any process of socio-technical ETI to first recognize local voices and conceptions of energy inequity for each community impacted by the process before beginning to define the actors and steps needed to begin innovating. Adapting justice-oriented frameworks, such as CJI, to local histories, cultures and realities is also indispensable.

**Applying CJI to two case studies**

Our look at wind energy in a rural Indigenous setting retrospectively traces the long history of ETIs and how their impact in the Global South today echoes legacies of the past and points to future inequities that need to be addressed. In the case of the Los Angeles 100% Renewable Energy Study (LA100) Equity Strategies, we prospectively map a process under way in Los Angeles, a Global North city embarking on a community-guided process intended to replace conventional top-down approaches to ETI development.

**Wind energy in Mexico**

Our CJI framework shows how dimensions of cosmopolitan justice underlie the procedural, recognition and distributional aspects of past and current energy inequities in wind energy development in Oaxaca, Mexico.

The early development of wind power turbines reveals niche-level experiments made possible through the allocation of funding and its associated human and material resources (procedural and distributional

justice). A Danish scientist, Poul la Cour, and his team built the first wind turbines in 1891<sup>42</sup>. Seed funding from the Danish government enabled la Cour's niche-level experiments to successfully create small wind power turbines (25 kW) by the end of World War I<sup>43</sup>. Experiments helped to develop technologies like the three-blade horizontal-axis wind turbines that still enable electricity generation across the world<sup>44</sup>.

Over a century later, firms based in Denmark (Vestas) and the United States (General Electric) dominate the human, financial and institutional resources around the design and development of wind power<sup>45</sup>. This concentration generates inequities that unfold during the regime level, building on historical injustices flowing from government, industry and the Global North to local communities<sup>46,47</sup>. For example, the economic benefits of wind power are unequally distributed between the wind power manufacturing hubs in Global North countries and Global South communities.

The case of Oaxaca, Mexico shows how recognition and procedural considerations can help account for past harms within and across nations and help wind promoters target the intersectional and inter-generational needs, barriers and aspirations of local impacted communities. From 2000 to 2005, the Mexican federal and Oaxaca state governments organized six colloquia in Huatulco to promote the development of utility-scale wind power in the Indigenous region of the Tehuantepec Isthmus<sup>48</sup>. The colloquia brought together wind companies, federal and state public institutions, and local actors to overcome barriers to wind power development. However, rather than fostering the participation of local peasant and Indigenous communities, the investment and knowhow of transnational companies became the main force behind these developments<sup>46</sup>. Participants agreed on regulatory reforms predominantly based on techno-economic considerations<sup>49,50</sup>, financial incentives and additional transmission infrastructure to carry future electricity for Mexican areas of heavier energy consumption<sup>48</sup>.

This approach resulted in strong opposition from local peasant and Indigenous communities, who claimed that wind energy promoters neither recognized their Indigenous rights and autonomous governance (self-determination), nor did they engage in a proper, prior consultation process<sup>47,51</sup>. Procedural injustice fomented local resistance and caused the cancellation of one of the largest wind farm projects in 2012 and the delay of several other regional projects<sup>46,52</sup>. Intra- and inter-community conflicts are likely to affect the region for years to come<sup>53</sup>, illustrating why voicing and centring the local communities' needs, priorities and autonomy is essential for ETIs.

In 2014, the Mexican government introduced legal changes to make local consultation obligatory for all energy developments in Indigenous areas, ensuring local consent and equitable distribution of benefits. Although some local resistance groups and academics criticized them, these regulations operationalized the international principle of 'Free, Prior and Informed Consent' of Indigenous and tribal people<sup>54,55</sup>.

Utility-scale wind power in Mexico has had negative impacts, including increased corruption, social criminalization, job insecurity and the violation of the rights of Indigenous peoples<sup>44,47,48,53</sup>. Wind power development has had socio-environmental impacts (for example, noise and shadow flicker) and led to increased socioeconomic disparities between landowners and the population<sup>56</sup>. Community benefits from wind power projects are rarely institutionalized and, if they are, they tend to be conditional on the acceptance of additional wind energy projects<sup>57</sup>.

### A just transition to clean energy in Los Angeles

'LA100: The Los Angeles 100% Renewable Energy Study', published by the National Renewable Energy Laboratory (NREL) in March 2021 and commissioned by the Los Angeles Department of Water and Power (LADWP), modelled diverse paths for Los Angeles to achieve 100% renewable energy through decarbonization programmes and the rapid deployment of wind, EVs, solar and battery storage<sup>58</sup>. To shed light on

how to ensure the transition to 100% clean energy while fulfilling the needs of underrepresented and underserved populations, in July 2021, LADWP, NREL and UCLA launched the 'LA100 Equity Strategies' (LA100 ES), a high-social-impact project involving a community-informed analysis. Here we map our CJI framework onto a collaborative strategy analysis with the proposed goal of 'lifting all Angelenos so that everyone will share in the benefits of clean energy'<sup>59</sup>.

Recognition justice questions guided our examination of how historical practices, such as zoning, renting and lending practices like redlining<sup>60,61</sup>, have become embedded in current distributional energy inequities<sup>19</sup>. The legacy of redlining still undergirds infrastructural disinvestment and neglect, the siting of major freeway construction<sup>62</sup> and the health effects of extreme heat<sup>63</sup>. Indeed, formerly redlined neighbourhoods have higher than average summer temperatures, which can lead to increased cooling loads and higher mortality risk during heat waves<sup>63</sup>. Poor construction quality, and old, unsafe and inefficient housing stock in underserved communities also limit equal installation of rooftop solar and EV-charging infrastructure<sup>19</sup>.

Recasting the established decision-making process, we partnered with community-based organizations in underserved neighbourhoods to co-design listening sessions centring participants' experiences and expertise in equity strategy development. We used procedural justice questions to guide listening sessions with the active involvement of underserved Angelenos to understand how and why past policies and practices have failed to address energy equity and foster an inclusive process necessary to achieve a more just transition in Los Angeles. Participants referred to structural barriers preventing them from benefiting from the transition<sup>64</sup>. For example, factors limiting EV access include limited financial capital to purchase any car, or to upgrade home electric panels, and insufficient local EV-charging infrastructure. These factors create the perception that EVs are simply inaccessible for underserved communities<sup>64</sup>.

We also examined the wider institutional context (landscape) within which Los Angeles actors operate. Promoters can use institutional opportunities, offered by the federal Inflation Reduction Act and the Bipartisan Infrastructure Law, to finance subsidies for building weatherization, investments in community solar, or public EV-charging infrastructure. Yet, they face regulative constraints, such as California Propositions 26 and 218, under which LADWP rates are considered taxes, and rate increases to finance the transition requires taxpayer consent through a ballot initiative.

### CJI moving forward

The two cases illustrate how a CJI framework integrating the interplay among multilevel perspective and justice tenets can help us learn from the past and navigate the complexity of inequities of ETIs in current and future energy transition processes.

At the niche level, the normative goals underpinning ETIs have implications for their nature and the distribution of associated benefits and burdens. The failure to integrate recognition and procedural justice at the niche level or when launching city-wide ETIs shapes multiple distributional issues. For example, subsidies directed at homeowners have been an effective policy tool for accelerating the diffusion of distributed solar photovoltaic, but such policies systematically exclude non-homeowners in cities such as Los Angeles and contribute to the uneven access to the technology<sup>65,66</sup>. Solar community projects benefits, in contrast, have been more effective at reaching non-homeowners and underserved groups<sup>67</sup>, but require subsidies, investments and other policy supports. Considering dimensions of justice throughout different levels helps target critical questions, laying the socio-technical foundations for a just energy transition.

Alongside distribution, the two cases show how questions of procedure and recognition also apply to ETIs. Democratizing ETIs through this integrative approach opens opportunities for actors such as users and underserved communities to have a voice in ETI development<sup>67,68</sup>.

In market economies, technological innovators like wind-turbine or EV manufacturers regularly seek out well-heeled consumers to support their business models<sup>3</sup>. Technological innovators are responding to institutionalized incentive structures and taking ‘ways of doing business’ for granted, often reproducing inequity. At the landscape level, scholarship<sup>69</sup> describing epistemic injustices is useful to examine how certain yet unheard actors in society could influence future narratives. Distributional injustices are often beyond individual control because ETIs are embedded within larger social, political and economic institutions. Recognizing and critically addressing these entanglements through a CJI lens could help legislators, regulators and social activists reshape these market dynamics, reworking the ETI process at all levels.

At the niche level, practitioners such as community-based organizations, social movements, and change agents within firms and government institutions can call attention to the aspirations, needs or problems of the underserved<sup>70</sup>. They can reshape the economic and moral calculus of pushing the energy transition in renewable and other industries in specific directions<sup>71</sup>. For example, participatory processes such as citizen assemblies, listening sessions and committees<sup>72</sup> can help elicit aspirations and identify barriers and tradeoffs in ETIs. Legislators and regulators can devise procedural means for empowering constituents and including otherwise marginalized groups in early conceptualization and planning processes aimed at anticipating, reflecting and preparing to responsibly prevent future inequities<sup>73</sup>.

At the regime level, governments at all jurisdictions—but especially national—can offer subsidies, pay-as-you-go schemes, leasing programmes or cooperative models of community solar and wind, designed to level economic playing fields and promote unprofitable but socially beneficial ventures often favoured by groups excluded from decision-making processes<sup>74</sup>. Examples include mass transit or shared EVs in the United States and shared or rented single-family home solar panels in the United States and Zambia<sup>75,76</sup>. States and local entities can provide tax breaks for investors to produce lower-cost solar panels and multimodal electric mobility that address regional inequities<sup>35</sup>. Compensation and assistance schemes can redress transitional impacts in areas shifting to wind, solar and other decarbonized energy systems.

At the landscape level, movements and regulators can exert pressure to shift broader visions to redress existing inequities in creative and indirect ways. Legislators can empower constituencies with ‘citizen regulation’ (for example, citizen law suits<sup>77,78</sup>), and public servants can retool the regulatory process that typically lags behind technological development to make them deliberative<sup>79</sup>. When exogenous shocks like wars, pandemics, disruptive technologies and economic crises create opportunities for regime realignment, policymakers can promote visions that incorporate principles of equity and justice in ETIs<sup>80</sup>.

In summary, our CJI framework can light a path for promoters, practitioners and underserved communities to co-define the problems communities currently face and develop the capacity to create CTIs that target their specific aspirations, needs and circumstances.

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## Competing interests

The authors declare no competing interests.

## Additional information

**Correspondence** should be addressed to Patricia Romero-Lankao.

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