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Chairman Bowman, Ranking Member Weber, and members of the Subcommittee, thank you for this opportunity to discuss energy technologies research, development, demonstration, and deployment (RDD&D) efforts that benefit all Americans.

My name is Bruno Grunau, and I serve as the Regional Director of NREL's Cold Climate Housing Research Center, or CCHRC. Sitting in the northernmost LEED Platinum building in the world, CCHRC's Building and Infrastructure Research and Testing Facility is a world-class model for energy efficiency and renewable energy technologies in the arctic and subarctic climate.

In 1999, CCHRC was formed by Alaska builders and researchers to create solutions to unique northern building challenges such as energy efficiency, mold, degrading permafrost, and other impacts of climate change. Our mission was to develop healthy, durable, sustainable shelter for people in extreme climates. Last year, CCHRC joined the U.S. Department of Energy's (DOE's) National Renewable Energy Laboratory, or NREL, to better address the energy, housing, and economic challenges. As one of 17 national laboratories, NREL is DOE's primary national laboratory for renewable energy and energy efficiency research and development. The CCHRC-NREL partnership has expanded mission impact in the Arctic and sub-Arctic and strengthened the focus on sustainable, equitable technology.

Our core focus at CCHRC includes energy and building technology research for extreme climates, social and economic analysis, and community-driven design. This research is applied through demonstration projects across Alaska, featuring everything from adjustable foundations for thawing permafrost to experimental solar-thermal storage systems. We have designed and helped construct more than 20 high-performance buildings in rural communities using advanced building technology, local labor, and traditional knowledge. The entire research, development, demonstration, and deployment process is aimed at improving the performance of buildings for all.

I began my adventure at CCHRC as a research engineer before serving as chief programs officer, president, and now regional director. In recent years I also served on the U.S. Arctic Research Commission *Arctic Renewable Energy Working Group* and sat on the Board of Directors of Alaska Center for Appropriate Technology. In each of these capacities, I have testified at U.S. Senate Energy Committee hearings as an expert on energy efficiency and cold climate design and building—first in 2017 and then in 2019.

As NREL's interim energy justice coordinator and a member of the NREL Senior Managers Energy Equity Committee, I recently presented, along with my colleagues Elizabeth Doris, LP.D., and Roderick Jackson, Ph.D., to DOE Office of Energy Efficiency and Renewable Energy Deputy Assistant Secretary, Kelly Speakes-Backman. Our presentation covered NREL's philosophy of and deep experience including equity from early in the R&D process all the way through demonstration and deployment—and highlighted how prioritizing inclusion from the very beginning can help achieve equitable energy transformation in the long run.

I am testifying before this Subcommittee today because of the deep, layered perspective NREL brings to this growing area of focus at DOE and across the federal government.

Energy Equity Starts Below the Surface

NREL has worked with more than 2,000 communities, utilities, and businesses representing a wide range of state, local, and tribal jurisdictions pursuing energy transitions. The research, analysis, and technical assistance NREL delivers through these partnerships informs holistic, community-driven energy and infrastructure solutions that address policy, technology, economic, environmental, and social issues.

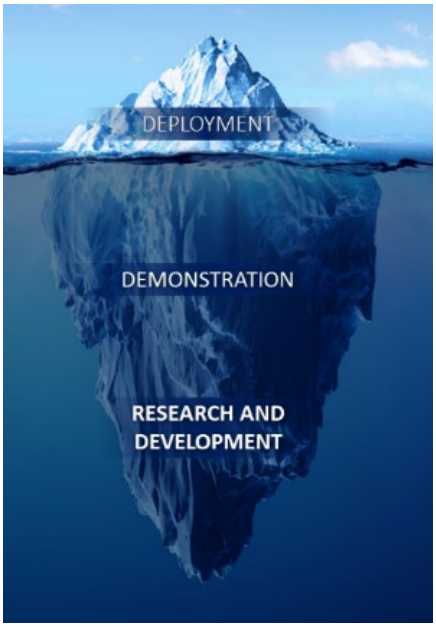

Figure 1: RDD&D iceberg

But technology deployment is only the tip of the iceberg. Equitable energy transitions must embed environmental, energy, and climate justice every step of the way.

Collaborative, inclusive development of culturally responsive and adaptive technologies, strategies, and solutions enables communities to harness transformative technologies and innovations to best fit community needs. In turn, the lessons and insights emerging from these successes inform early-stage research that gives rise to new equity-centered innovations.

Along with highlighting examples of equitable energy transitions, my testimony will demonstrate how the equity-centered clean energy deployment and demonstration at the tip of the iceberg feed back into equity-centered technology research and development at its base.

This **positive feedback mechanism between codeveloped deployment and equity-informed technology development is what will deliver the benefits of clean energy to a broader set of stakeholders**. We've made significant progress on that front—and we have learned enough to know we have a long way to go.

Systemic Inequities Limit Impact and Reach of Energy Innovations

The energy industry is no exception to the social inequities that permeate society. As one example, the American Council for an Energy-Efficient Economy's 2020 assessment of energy burdens across the United States revealed the median energy burden of Black households—that is, the percentage of income spent on energy costs—is 43% higher than that of White households.[1]

While public investment in clean energy innovation has catalyzed significant progress toward a modern energy system and strengthened American economic leadership, not everyone has benefited. This is perhaps clearest in the transportation sector, where our success in solving technical challenges related to electric vehicles has contributed to dramatic shifts in market share:

[1] American Council for an Energy-Efficient Economy. 2020. "Report: Low Income Households, Communities of Color Face High 'Energy Burden' Entering Recession." Accessed July 2021. https://www.aceee.org/press-release/2020/09/report-low-income-households-communities-color-face-high-energy-burden.

- The least affluent 20% of households spend twice the share of their income on transportation than do the most affluent 20%.[2]
- 70% of American households live in neighborhoods where combined housing and transportation costs are not affordable.[3]
- Since 2006, 90% of electric vehicle income credits were received by the top income quintile.[4]
- Renters and those living in multifamily housing often lack access to home charging locations, where 80% of electric vehicle charging occurs.[5]

Statistics on solar energy adoption and capacity expansion tell a similar story. For example, households in Black-majority census tracts installed 69% less rooftop photovoltaic (PV) systems than no-majority tracts of the same household income,[6] and less than half of U.S. community solar projects include low-income households.[7] In 2018, nearly 60% of all new U.S. solar capacity was utility-scale PV, expanding access to clean, renewable energy.[8] Yet economic benefits such as lower costs are rarely transferred directly to customers who need them most.

Nor are the burdens associated with clean energy innovation and the energy transition always distributed evenly. Certain communities have raised complaints and even filed lawsuits over perceived inequities in clean energy development and waste disposal.

For example, studies have found small, rural populations bear the brunt of negative impacts associated with wind development, such as loss of view shed, noise pollution, and shadow flicker.[9] A recent article in *Honolulu Civil Beat*[10] offers a case in point, highlighting the objections Kahuku residents have raised to perceived aggressive and excessive wind development in their small, rural North Shore community. Their complaints include lack of consultation with local stakeholders and disregard for the community members' wishes, such as limited wind farm size, restricted wind turbine height, and imposed setbacks.

Examples of centering equity in energy technology innovation and the energy transition are most often focused on the deployment phase of the RDD&D spectrum. While important and essential, deployment

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[2] Transportation Spending by Quintiles of Income Transportation table, p.20 (Source: Consumer Expenditures Survey 2018) shows spending ≈30% of income for the lowest quintile and closer to 15% for the highest quintile. Feen, Gidon, Amitai Bin-Nun, and Anthony Panasci. 2020. *Fostering Economic Opportunity through Autonomous Vehicle Technology*. Washington, D.C.: Securing America's Future Energy (SAFE). https://2uj256fs8px404p3p2l7nvkd-wpengine.netdna-ssl.com/wp-content/uploads/2020/07/Fostering-Economic-Opportunity-through-Autonomous-Vehicle-Technology.pdf.

[3] Ibid, p.28

[4] Borenstein, Severin and Lucas W. Davis. 2016. "The Distributional Effects of U.S. Clean Energy Tax Credits." *Tax Policy and the Economy* 30 (1). https://doi.org/10.1086/685597.

[5] The U.S. Department of Energy. 2017. "Fact #958: January 2, 2017 Sixty-three percent of all Housing Units have a Garage or Carport." Accessed July 2021. https://www.energy.gov/eere/vehicles/fact-958-january-2-2017-sixty-three-percent-all-housing-units-have-garage-or-carport.

[6] The authors define "no-majority tracts" as those "where no single racial or ethnic group comprises more than 50 or 75% of the population are categorized as no majority and no strong majority, respectively." Sunter, Deborah et al. 2019. "Disparities in rooftop photovoltaics deployment in the United States by race and ethnicity." *Nature Sustainability* 2: 71-76. https://doi.org/10.1038/s41893-018-0204-z.

[7] Gallucci, Maria. 2019. "Energy Equity: Bringing Solar Power to Low-Income Communities." *Yale Environment 360.* April 4, 2019. https://e360.yale.edu/features/energy-equity-bringing-solar-power-to-low-income-communities.

[8] Bolinger, Mark, Joachim Seel, and Dana Robson. 2019. *Utility-Scale Solar*. Berkeley, CA: Lawrence Berkeley National Laboratory. https://emp.lbl.gov/sites/default/files/lbnl_utility_scale_solar_2019_edition_final.pdf.

[9] Carley, Sanya, and David M. Konisky. 2020. "The justice and equity implications of the clean energy transition." *Nature Energy* 5: 569–577. https://doi.org/10.1038/s41560-020-0641-6.

[10] Yerton, Stewart. 2021. "This North Shore Community Has Had Enough of Towering Wind Turbines." *Honolulu Civil Beat*. June 24, 2021. https://www.civilbeat.org/2021/06/this-north-shore-community-has-had-enough-of-towering-wind-turbines/.

represents one of the final stages of technology innovation and adoption. In many cases this makes it more difficult to equitably deploy technology that was developed without regard to equity.

As an alternate approach, the R&D community should follow NREL's lead in taking the additional step of centering equity in the earlier stages of energy technology research, development, and demonstration. Doing so will increase the impact and effectiveness of attempts to equitably distribute the benefits of the clean energy transition. Moreover, it is essential to achieving the prosperity and energy security that the nation's overall clean energy goals support.

Due to historical underinvestment, the challenges frontline communities face in transitioning to safe, affordable, reliable, and resilient clean energy systems are different and, in most cases, distinctly more difficult to overcome than those on which energy technology research has traditionally focused. As a result, the need for science, engineering, and innovation to address these challenges now is all the more pressing.

Traditional Approaches Fall Short

Technology deployment is a combination of market pull, where early-stage consumers create a demand, and scientific push, where the developer actively promotes the technology. Experience is gained in the market when innovators and early adopters willingly take new technology risks and encourage more risk-averse consumers that the technology is worth the investment.[11] As the adage goes, "everyone wants to be the first to be the second to adopt a new technology."

Market growth is often illustrated through a diffusion curve showing demand for a technology increasing as early adopters start building on the experience of innovators. Market mechanisms, such as learning-by-doing and learning-by-using, bring new technologies to the inflection point on the curve where demand increases rapidly.

But this status quo market transformation model does not foster a just or equitable energy transition. When we don't infuse energy justice throughout the innovation pipeline, we develop clean energy technologies that favor first adopters instead of seeing to it that those who have suffered the most are the first to benefit, as prescribed by Energy Secretary Jennifer Granholm.[12]

For example, demonstration and development platforms have helped accelerate multiple R&D 100 award-winning advanced building technologies' paths to market. However, many of these technologies realized a significantly reduced impact in marginalized communities, where systemic inequities such as lack of access to traditional financing diminish opportunities for investment in new homes and buildings.

According to the 2021 Snapshot of Race and Home Buying in America released by the National Association of REALTORS,[13] 81% of home sales in the United States in 2019 were purchased by Whites compared to 7%, 6%, and 11% for Black, Asian, and Hispanic Americans respectively.

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[11] Mathur, Ajay, Ananth P. Chikkatur, and Ambuj D. Sagar. 2007. "Past as prologue: an innovation-diffusion approach to additionality." *Climate Policy* 7(3): 230-239. https://www.tandfonline.com/doi/abs/10.1080/14693062.2007.9685651.

[12] The U.S. Department of Energy. 2021. "Promoting Energy Justice." Accessed July 2021. https://www.energy.gov/promoting-energy-justice.

[13] Yun, Lawrence, Jessica Lautz, Nadia Evangelou, et al. 2021. *2021 Snapshot of Race and Home Buying in America*. Washington, D.C.: National Association of REALTORS. https://cdn.nar.realtor/sites/default/files/documents/2021-snapshot-of-race-and-home-buyers-in-america-report-02-19-2021.pdf.

A Framework for Energy Equity

NREL's expertise in renewable energy, energy efficiency, sustainable transportation, and energy systems integration makes us uniquely qualified to codevelop place-based solutions for equitable clean energy transitions—and the direct economic, social, and environmental impacts of our integrated, collaborative approach to advancing our partners' ambitious energy goals are profound and far-reaching.

Accessible, Relevant Tools and Resources

With DOE's support, NREL has built first-of-their-kind tools that give local stakeholders access to detailed, jurisdictionally resolved data to support and inform their decision-making. For example, NREL's:

- **State and Local Planning for Energy, or SLOPE**, platform provides county-level renewable energy generation potential, efficiency potential, and electric vehicle adoption potential.[14]
- **Low-Income Energy Affordability Data, or LEAD**, tool provides census tract-level data on energy burden, or the percentage of household income spent on energy bills.[15]
- **Regional Energy Deployment System, or ReEDS,** is a state-of-the-art energy capacity planning model that empowers users to explore optimal pathways of large-scale power sector transformation through 2050.[16]

Any local jurisdiction can use these free tools for clean energy education and planning—letting them tap into an abundance of data represented by compelling visualizations that help them understand what the data mean for their community.

Community-Engaged Demonstration

Demonstration is an important part of the innovation cycle, and community involvement during this phase benefits process and outcomes greatly. With NREL's Advanced Research on Integrated Energy Systems (ARIES) research platform, stakeholders can evaluate and validate complex options at scale through emulation and demonstration. This immersive experience de-risks implementation through experimental validation in a virtual environment and prevents surprise issues upon deployment.

Decades of Community Partnership

And NREL doesn't just provide data—we also have a long history of working directly with more than 2,000 local governments, utilities, and businesses to codevelop context-sensitive, culturally responsive, and adaptive solutions to wide-ranging energy and infrastructure challenges. From remote Alaska Native villages to the largest cities in the United States and beyond, NREL partners with communities on:

- Building back cleaner, greener, and more efficiently during disaster recovery
- Resilience planning
- Renewable energy land use planning

[14] National Renewable Energy Laboratory. "SLOPE: State and Local Planning for Energy." Accessed July 2021. https://maps.nrel.gov/slope.
[15] The U.S. Department of Energy. "Low-Income Energy Affordability Data (LEAD) Tool." Accessed July 2021. https://www.energy.gov/eere/slsc/maps/lead-tool.
[16] National Renewable Energy Laboratory. "Regional Energy Deployment System Model." Accessed July 2021. https://www.nrel.gov/analysis/reeds/.

- Transportation electrification modeling
- Equitable clean energy transitions.

As the only national lab dedicated exclusively to clean energy research and development, demonstration, and deployment, NREL is well-positioned to partner with communities charting their course to a clean energy future. As NREL succeeds in advancing goals on the ground, the experiential learnings support our own mission-driven goal of embedding environmental, energy, and climate justice every step of the way.

Equitable Energy Transitions Prioritize Local Perspectives, Needs

Unalakleet, Alaska: Villagers Codevelop Culturally Responsive Modular Home Solutions

One of the most challenging places in the world to live is Unalakleet, Alaska, a remote Inupiat village in the Arctic, with conditions typical of many communities in western Alaska: housing shortages, high overcrowding, and some of the highest rates of upper respiratory disease in the nation. Unalakleet is not alone; there are hundreds of other villages like it in Alaska.

Like most of these rural villages, Unalakleet relies on high cost imported diesel for space heating and electricity. As a result, the average household in Unalakleet spends nearly four times the national average on energy costs. Located on the rapidly warming Arctic coast, Unalakleet is also facing severe erosion and permafrost thaw, threatening homes, infrastructure, and food security.

Traditionally, the Inupiaq people built sod homes in the winter and lived in tents in the summer. Their homes were warm and safe, and supported their seminomadic subsistence lifestyle. The modern housing imported in the 1970s, however, was not appropriate for the Arctic climate or subsistence culture.

Today those 1970s-era homes are cold, moldy, and extremely overcrowded. Due to high shipping costs and lack of local labor, the cost of building new housing in the community is prohibitively expensive. Elders and young families who cannot find adequate shelter are forced to move to urban areas, a great loss to the social fabric of the community.

In 2020 the village of Unalakleet partnered with NREL to create a demonstration home that would be affordable, energy efficient, and healthy. Seeking to avoid the mistakes of the past, NREL researchers engaged the local community from the outset to ensure the new home accommodated the villagers' needs while reflecting Inupiaq culture and environment.

Figure 2: Unalakleet community meeting

Working hand-in-hand with community stakeholders and local partners, the NREL team developed a semi-modular home, built partly in the lab to save money, and partly in the community–to create as many local jobs and economic benefits as possible. Over the past year, the tribe was involved in every step of the RDD&D process—informing the design, iterating the construction documents, and ensuring the technology stayed true to cultural values.

Last winter, my team at the Cold Climate Housing Research Center constructed the modular portion of the home. It consisted of a kitchen, bathroom, and mechanical room built *inside* a shipping container. Because we assembled the most expensive portions of the home (plumbing and wiring) inside NREL's Fairbanks-based lab, we're on track to cut construction costs by 40%. Meanwhile, 75% of new jobs

remained *within* the community, with a local crew led by NREL instructors building the rest of the home on-site.

The container will be shipped via barge to Unalakleet, a three-week journey around the Gulf of Alaska and up the Bering Sea coast. The shipping container will simply "plug in" to the newly constructed home to provide healthy air and modern amenities to a new family. As the final piece of the RDD&D process, the occupants will participate as live-in researchers, sharing data on energy usage, home performance, and critical feedback with NREL researchers so we can learn and improve on this design for other villages.

Figure 3: Furnished container plugs in

As our partnership with Unalakleet demonstrates, **equity in advanced building design and construction is achieved by including occupants not at the end of the process, but from the start.** This technology was not developed *for* the community; it was developed *by* the community.

Navajo Nation and Hopi Tribe: Engaging Stakeholders Early and Often Eases Transition from Coal to Clean

Unalakleet is the story of one house creating a proof of concept for a region. NREL also guides entire communities through energy transitions, balancing what is physically possible with what is practically acceptable and accessible to those on the ground. Our multiyear partnership with two tribal communities nearly 3,000 miles south of Unalakleet in Arizona and New Mexico offers an example.

As the Navajo Nation and the Hopi Tribe prepared for the imminent shuttering of the Navajo Generating Station (NGS), both saw renewable energy as an important path to a transforming economic future, and the tribes sought NREL's expertise to guide their path.

For more than four decades, the Navajo Reservation was home to NGS, the largest coal-fired power plant in the West. The mine that fueled the plant spanned the border between Hopi and Navajo lands. For both communities, NGS and its mine provided jobs and prosperity. But they also created economic dependence on a plant that had ceased to be economically viable.

Seeking to ameliorate the devastating economic impact NGS' closure could have on their communities, Navajo and Hopi tribal leaders looked to NREL for technical assistance and decision support as they explored economic development strategies consistent with their values. Subject matter experts from the lab attended tribal council meetings and community-led workshops, briefing stakeholders on the available options.

Navajo tribal leaders relied on NREL's insight as they explored standing up a tribal Energy Office that would advance the tribe's goal of cultivating their indigenous institutional expertise in energy. Hopi tribal leaders looked to NREL for support in assessing the market opportunities for solar development on Hopi land holdings. Both tribes sought assistance with a geospatial assessment of renewable energy potential that could take advantage of the transmission capacity made available by NGS closure.

Projects are set up for success when NREL gains a seat at the stakeholders' table early in conversation. Their impacts are amplified when we incorporate stakeholder feedback as energy transitions progress. Iterative stakeholder engagement enables us to be responsive to communities' needs as conditions and priorities change over time.

The technical work NREL did with the Navajo and Hopi tribes over the roughly half-decade partnership **stood up to significant shifts in priorities from various stakeholders** because of the **breadth of core technical and stakeholder engagement capabilities we brought to the table every step of the way.**

Puerto Rico: Checklists Support Islanders' Efforts To Bolster PV System Resilience

The same complementary set of capabilities that allowed NREL to be responsive to the Navajo and Hopi communities' needs over the course of a multiyear energy transition enabled us to address Puerto Rican stakeholders' priorities in the aftermath of two major disasters.

Following Hurricanes Irma and Maria in 2017, NREL was among the DOE national laboratories called to help restore Puerto Rico's devastated infrastructure and grid system and support resilient recovery goals. The first round of DOE support to FEMA included stakeholder engagement to determine what future lab support was needed to enable a resilient power system.

NREL led one such effort focused on solar PV as a potential solution to enhance resilience. Several stakeholder groups prioritized checklists for readying PV arrays for approaching storms, as well as guidelines for repowering PV systems after disruptive events. NREL developed the requested checklists leveraging our extensive research related to PV-system failure modes during storms and storm hardening and mitigation options.

These checklists are enabling the rapid dissemination of actionable PV research that bolsters resilience of on-site and distributed energy systems in Puerto Rico and directly meets communities' needs as identified through stakeholder engagement. This is just one of the many ways NREL's support for long-term disaster recovery efforts in Puerto Rico has applied equitable project development strategies for resilient energy systems.

As another example, NREL hosted several webinars and workshops in April 2019 to demonstrate the modeling tools available to stakeholders. Participant surveys revealed Spanish-language versions would better support users on the ground. In response, NREL developed and published a Spanish-language user guide for our System Advisor Model and is now translating the PVWatts tool to Spanish.

Our collaborative and integrated approach focused on connecting what is physically possible to what is practically acceptable and accessible to those on the ground in Puerto Rico. That **enabled traditional and nontraditional stakeholders to see each others' concepts and provide feedback**. It was also pivotal to NREL's ability to **codevelop solutions that prioritize equity to broaden the reach and impact** of the territory's investments in **reliable, affordable, resilient** clean energy systems.

City of Kingston: Analysis Supports Goal To Grow Jobs, Build Resilience on Path to 100%

In Kingston, New York, NREL provided rigorous analysis and modeled optimized efficiency and renewable solutions for individual buildings, then scaled findings to demonstrate potential impacts at the district and community-wide level for a community seeking to broaden the benefits and expand the impact of transitioning clean energy.

The City of Kingston placed equity front and center as it mapped out a strategy for achieving 100% clean energy by 2050. It was an audacious goal for a community where low-income residents can spend one-third of annual household income on power and heating bills.

For Kingston, reaching the city's 100% target was equally as important as lessening low-income residents' onerous energy burden. Stakeholders sought to maximize the local impact of the city's investment in clean technology through the creation of jobs. Early site visits enabled NREL researchers to learn directly from community members and leaders about place-based values critical to success.

Partnering with the CADMUS Group, NREL provided analysis that supported city leaders in evaluating strategic pathways for meeting city-defined objectives. Prioritizing stakeholder-defined values, NREL and partners deployed the lab's broad suite of modeling tools, focusing on the potential for community renewable energy generation, energy efficiency measures, and opportunities to create jobs, lower energy costs, and build resilience.

NREL's analysis identified optimized solutions that packaged rooftop solar with energy efficiency measures, including mini-split heat pumps to reduce bills and improve comfort in affordable housing; city building retrofits to deliver emergency services, resilience, and savings; and new clean energy jobs in a key revitalization area.

The analysis provided Kingston city leaders with a **business case for prioritizing energy efficiency to drive local clean energy jobs**. More broadly, NREL's analysis demonstrated that **small communities can meet green power goals while maintaining energy affordability and bolstering resilience**.

Equity-Centered Demonstration and Deployment Expands Local Empowerment To Advance National Goals

Equity is foundational to the kind of responsive RDD&D approach that has addressed the unique needs and goals of communities as diverse as Unalakleet and Kingston.

Working in partnership with community stakeholders, NREL draws upon its diverse research team, broad spectrum of capabilities, and world-class facilities to catalyze innovation, provide multidimensional perspective, and lower the actual and perceived risks associated with transitioning to new energy technologies.

But we are not doing it enough, and we have a long road ahead to realize the nation's goals.

NREL's target for energy transformation is clean energy for all. As such, we focus on developing and delivering solutions that allow everyone to participate in and benefit from a clean energy economy.

Equity-centered demonstration and deployment enable near immediate and long-term on-the-ground impact for America's communities. Each of these success stories I have shared illustrate this by highlighting different facets of the framework NREL has applied successfully for more than a decade.

NREL's experience-based **philosophy is that if we can expand effective local engagement, we can empower local energy infrastructure decision-making at a fast enough pace and volume to meet national goals.**

DOE Partnership Project Expands Community Energy Resilience

Communities across the nation have navigated energy and infrastructure challenges for generations. Although communities are increasingly prioritizing equitable, resilient, and affordable energy systems, the resources and capacity to fully evaluate options and implement solutions are often in short supply,

particularly in remote, island, and islanded communities. Because of their geographic isolation, these communities face unique energy and infrastructure risks that leave them particularly vulnerable.

Frequent blackouts and disruptions challenge residents, utilities, and governments to rapidly adapt. The impacts of climate change reverberate dramatically—from chronic environmental degradation to extreme weather events and natural disasters—affecting remote and island communities more significantly in many cases. Dependence on imported fossil fuel for energy generation results in some of the highest utility rates in the nation. Higher energy costs strain household finances and local economies.

DOE's Energy Transitions Initiative Partnership Project (ETIPP) aims to arm remote communities with resources and technical support to bridge the gap between risk and resilience. Eleven competitively selected communities are leveraging ETIPP's network of national laboratories and regional partner organizations to mitigate local challenges and risks through codeveloped, community-driven solutions that integrate building performance, critical facility hazards, distributed energy resources, hydropower, microgrids, solar, storage, tidal energy, and transportation.

While each community's route to resilience will be unique, all share common goals: enhanced ability to withstand and recover from energy disruptions, improved energy reliability and access, and reduced energy costs.

Sharing and applying lessons learned, innovations, and best practices furthers NREL's broader goal to tailor, scale, and advance resilient energy transitions to a broader range of geographic regions, communities, and organizations.

NREL Aims To Accelerate Clean Energy at Scale

To reduce risks, bolster resilience, strengthen local economies, and address inequalities, businesses and communities are pursuing ambitious clean energy initiatives at an unprecedented rate. And because of NREL's depth and breadth of applied research experience, we are well-positioned to bolster this momentum.

Accelerating Clean Energy at Scale (ACES) applies NREL's experience, expertise, and capabilities to illuminate pathways for businesses and communities rapidly transitioning to clean, affordable, equitable, secure, and resilient energy systems on a broader scale than ever before. Through customized, holistic modeling and analysis, we uncover insights and codevelop energy transition strategies that address communities' unique energy-system goals and diverse stakeholder priorities.

Rooted in inclusive community engagement, ACES develops partnerships, accelerates pivotal decisions, and shares resources for technology innovations, capacity building, and commercial solutions. We provide support—including workforce development—to implement solutions, leveraging public and private funds to enable infrastructure and other investments.

Harnessing learnings from successful community energy transitions, NREL leverages best practices and proven methodologies to enable more communities to achieve their clean energy goals quickly and effectively. ACES can support diverse and wide-ranging ambitions—from small communities to regional collaboratives—building momentum toward a nationwide clean energy economy that benefits everyone.

City of Los Angeles: 100% Renewable Energy is Possible—Equity Must Be Intentional

NREL's multiyear partnership with the City of Los Angeles demonstrates the efficacy of scaling our established energy transition framework to expand clean energy benefits nationally while feeding the lessons learned back into our innovation cycle.

Approximately 47% of Angelenos are members of a disadvantaged community in need of reduced energy burdens, increased access to cooling, clean and affordable mobility, and improved air quality. As in many cities nationwide, disadvantaged communities' lack access to clean energy solutions, effectively locking them out of participating in the clean energy economy and reaping its benefits.

Released in March 2021, NREL's Los Angeles 100% Renewable Energy Study, or LA100 Study, found that LA can achieve reliable, 100% renewable power as early as 2035. By helping ensure all communities in LA will share in the benefits of the clean energy transition, the study also demonstrated that improving equity in participation and outcomes requires intentionally designed policies and programs.

Now the City of Los Angeles has asked NREL to build on the insights from LA100's three years of stakeholder engagement and groundbreaking modeling and analysis by embarking on an exciting new community-driven study examining how to best achieve just and equitable transitions. The new phase of the study, LA100 Equity Strategies, bring together environmental justice communities and other key LA stakeholders to identify pathways for achieving just and equitable stakeholder-driven outcomes, particularly for those in disadvantaged communities. LA100 Equity Strategies picks up where LA100 left off, building on NREL's deep ties to LA to expand and improve upon our cutting-edge modeling and analysis and social science-based methodologies.

In continuing to work directly with a broad and diverse set of community stakeholders, we can further tailor our analysis to LA's needs to ensure 100% renewable energy benefits for 100% of people. Along with informing our iterative, community-responsive energy transition road map for LA, the resulting insights will be free and accessible to other U.S. cities seeking to replicate LA's successful approach as the city strives for equity in realizing its own energy goals.

On a broader level, NREL intends for our groundbreaking work on LA100 to help advance the administration's goals of realizing an equitable energy transition for the nation by ensuring federal clean energy investments—and their impacts—flow to disadvantaged communities.

Completing the LA100 Study and ramping up for LA100 Equity Strategies has highlighted for NREL specifically where and how we can better center equity in our existing framework and tools, and also develop new data, tools, and capabilities in a concerted effort to infuse equity throughout the iceberg.

Along with scaling our collaborative, integrated energy transition framework nationally, NREL is using our on-the-ground learnings to inform equity-centered R&D in the lab—feeding a self-sustaining cycle that supports impactful and equitable energy technology research innovation, demonstration, and deployment on the path to a clean, prosperous, and secure energy future for all.

Learnings Inform Innovation Cycle

NREL's mission-driven work to transform energy depends on integrating best practices from each of the projects and initiatives I have highlighted into an evolving, laboratory-wide framework for energy equity and environmental justice that guides our RDD&D efforts.

The traditional RDD&D model for technology innovation is flawed in that it suggests a linear process from research to a technology's widespread adoption in the marketplace. In practice, the technology innovation process is an iterative process with multiple feedback loops that depend on the interaction between stakeholders, policy, technology, and markets.[17] If communities from Los Angeles to Kingston and beyond are to realize a resilient, affordable, secure, and clean energy future, engineering is just one step in an iterative cycle.

As an applied DOE laboratory, NREL serves as a conduit of knowledge and information in the critical feedback loop that exists between the lab and the marketplace. This pivotal role demands that we apply, learn from, and contribute to the deep analysis and technology research capabilities across the lab and beyond.

Our on-the-ground technical support of and partnership with communities pursuing aggressive energy goals inform and advance NREL's fundamental research and energy analysis in an era of increasingly complex challenges and rapidly changing systems. In turn, our deep insight into the lab's technologies, tools, and analysis informs communities' and our partners' decisions and strategies, advancing toward local goals.

Through this cyclical model that connects our applied research and sustained community engagement to our basic scientific research, NREL continues to gain invaluable lessons and insights from communities that drive innovation and support the technical feasibility of community-centric energy transitions.

This innovation cycle will become increasingly important as the energy transformation continues to accelerate. Along with advancing science and engineering, the lab provides the analysis and decision support to integrate and optimize energy systems. It is the core focus of our mission-driven work to help our partners meet ambitious climate and energy goals.

The positive feedback mechanism connecting codeveloped deployment and demonstration to equity-informed technology development is **essential to extending the benefits of clean energy to a broader set of stakeholders** and thus to realizing our vision.

By bridging the gap from concept to market, NREL links research and development with real-world demonstration and applications. To accelerate the transformation of the global energy landscape, we must learn from each success and share our experience in the marketplace to inform the ongoing technology research and analysis of the laboratory.

A path to center equity at early-stage R&D is to connect scientists, researchers, and technology developers through the entire RDD&D pipeline. The foundation of successful early-stage equity begins with engaging stakeholders and end users. Their active involvement in prioritizing needs and initiating a solutions-based agenda is critical to fostering respect and generating a sense of personal ownership in

[17] Rubin, Edward S. 2005. "The Government Role in Technology Innovation: Lessons for the Climate Change Policy Agenda." Presented at 10th Biennial Conference on Transportation Energy and Environmental Policy, Pacific Grove, CA. Carnegie Mellon University, Pittsburg, PA. https://www.cmu.edu/epp/iecm/rubin/PDF%20files/2005/2005ti%20Rubin,%2010th%20Conf%20Asilomar%20(b&w).pdf.

the process. Lessons-learned through the codevelopment of technology at the demonstration and deployment phases that are fed back to early-stage researchers inform and shape the approaches taken by R&D teams. The types of lessons learned at demonstration and deployment stages include understanding the impact of the developed technology on people and society and mitigating the negative or unintended consequences on people. Including social scientists on the research team to develop energy technology provides opportunities at each step to objectively quantify the human impacts at social and community levels.

The Whole Iceberg

We must continue to build on our successful efforts to expand access to clean energy technologies to underserved and frontline communities. How we **accelerate equity-centered clean energy demonstration and scale deployment at the tip of the iceberg** is of critical importance.

Of greater importance to fostering equity in energy innovation is how we **thoughtfully feed learnings into equity-centered technology research and development at the iceberg's base**. We are laser-focused on the need to expand and improve efforts to integrate end-user and community needs into the R&D pipeline so we develop technologies that are not only appropriate for and beneficial to all communities but also result in fewer negative health, environmental, and economic impacts for certain communities.

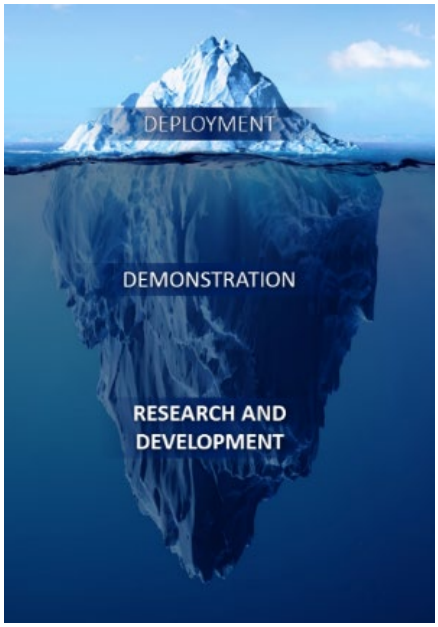

Figure 4: RDD&D iceberg

This also means connecting scientists, researchers, and technology developers throughout the entire RDD&D pipeline. Social scientists need to be at the table every step of the way. Likewise, technical researchers should be at the table with social scientists throughout the pipeline.

These approaches will help ensure lessons-learned through the codevelopment of technology at the demonstration and deployment phases will in turn inform and shape the approaches taken by early-stage research and development teams. The types of lessons learned at demonstration and deployment stages include understanding the impact of the developed technology on people and society and mitigating the negative or unintended consequences on people.

Prioritizing collaboration between social scientists and research teams from the earliest stages of technology development and at each step along the way embeds ongoing opportunities to objectively quantify the human impacts at social and community levels.

An Equitable Clean Energy Future Demands Commitment, Focus, and Accountability

NREL's target for energy transformation is clean energy for all. As such, we focus on developing and delivering solutions that allow everyone to participate in and benefit from a clean energy economy.

To remediate the social, economic, and health burdens placed on some through our energy system, NREL strives to advance prosperity, security, and energy resilience for all. We do this through scientific research and development, energy analysis, decision support, and technology demonstration and deployment.

Our framework for advancing energy transitions engages underserved communities in developing and deploying community-driven strategies that address the full spectrum of local energy challenges and priorities. We place the resilience and energy security of all people at the center of the research, tools, strategies, and solutions we apply to transforming energy.

We intend to stay on course in our support of energy and environmental justice by applying a rigorous accountability framework structured to reveal gaps, identify solutions, and gauge progress on the path to a secure and sustainable energy future for all.

Onward and Upward: Diversity, Equity, and Inclusion Begin Within

Our success in transforming energy rests on a foundation of inclusion we are building from within. Our commitment to achieving clean energy for all is embedded in our ethos and reflected in the actions we take to promote diversity, equity, and inclusion at NREL. Transformative change demands that we lead by example. This means that along with leading an inclusive energy transition in which benefits are equitably distributed, we must prioritize diversity and center equity at every stage of our innovation pipeline.

We recognize that to achieve our vision, we need everyone's contributions. Understanding that diversity, equity, and inclusion are crucial to our success, we are proactively working to create a community that empowers people to be upstanders and exercise inclusivity in all they do.

To ensure that we do this well, NREL is committed to cultivating talent and including people from the entire social spectrum. When we avail ourselves of insights borne of diverse experiences and backgrounds, we are better equipped to view scientific innovation and progress through the lens of people in underrepresented or historically marginalized communities. Just as engaging diverse stakeholders at the community level empowers our efforts to advance communities' energy goals equitably, so bringing diversity of experience and background to our research teams enriches our work to develop equitable advanced technology solutions.

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