WHITE PAPER

Convergent Clean Energy Research in Support of Sovereign and Prosperous Tribal Nations

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Executive Summary

This white paper, titled *Convergent Clean Energy Research in Support of Sovereign and Prosperous Tribal Nations*, presents the outcomes of a two-day workshop held on March 12-13, 2024, at the Hyatt Regency Tamaya Resort on the Santa Ana Pueblo in New Mexico. The workshop aimed to develop a research and workforce development agenda supporting clean energy transitions in Tribal communities.

Background and Motivation

Tribal Nations in the United States hold significant potential for clean energy development, with an estimated resource potential of 9 TW. However, this potential remains largely untapped due to a range of technical, socio-economic, and cultural compatibility challenges within the clean energy sector. Many Tribal communities face severe energy poverty, with access to reliable and affordable electricity being significantly lower than the national average. This white paper emphasizes the need for culturally informed, collaborative, transdisciplinary research to address these challenges, integrating Tribal knowledge into energy planning, and supporting Tribal energy sovereignty—an emerging concept that seeks to align energy systems with Tribal cultural values, economic goals, and self-determination (Schelly et al., 2020).

Workshop Objectives

The workshop was organized by a committee representing the Rochester Institute of Technology, Navajo Technical University, Seattle University, the Microgrid Systems Laboratory, and Sandia National Laboratories. The primary objective was to craft a convergent research and workforce development agenda to support clean energy transitions in Tribal communities. This agenda aimed to:

- Understand Tribal opportunities, goals, and aspirations for energy development and sovereignty.
- Identify technical and non-technical barriers to clean energy development on Tribal lands.
- Develop socio-technical systems approaches for successful clean energy project implementation.
- Identify critical workforce training and education needs to support these goals.
- Foster collaboration between Tribal Colleges and Universities (TCUs), non-Tribal research institutions, and other stakeholders.

Key Findings

The workshop identified several challenges and opportunities in advancing clean energy development within Tribal communities:

- **Technical Challenges:** These include the need for advanced, climate-appropriate technologies, improved infrastructure, and accurate weather and energy models tailored to the unique conditions of Tribal lands. Participants emphasized the importance of developing flexible, scalable clean energy solutions that can be adapted to the diverse needs of different Tribal Nations.
- **Non-Technical Challenges:** Cultural compatibility, energy sovereignty, and community engagement emerged as critical factors. Clean energy projects must align with Tribal values and practices to gain community support and be sustainable. Financial and policy frameworks also need to be tailored to the unique Tribal context, with an emphasis on innovative financing models and capacity building within Tribal communities.
- **Workforce Development:** There is a significant gap in the availability of trained Native professionals and vocational workers necessary to support clean energy development. The workshop highlighted the need for targeted educational and training programs that are culturally relevant and accessible to Native communities. Building internal technical, administrative, and financial capacity within Tribes is crucial for achieving energy sovereignty.

Proposed Research Agenda

The research agenda proposed in this white paper prioritizes the following areas:

1. Integrated planning of clean energy infrastructure with complementary infrastructures and services and establishment of Tribal utilities
2. Trust building between Tribal and non-Tribal energy sector actors
3. Stakeholder engagement frameworks and education of non-Natives on effective collaboration with Tribes
4. Innovative finance solutions for unique Tribal needs and challenges
5. Siting of transmission and distribution infrastructure accounting for complex land tenure situations and cultural heritage
6. Affordable software for system design, simulation, and feasibility studies
7. Technical training of the Native workforce
8. Quality, high-resolution weather data and localized subsurface energy models
9. Hardware maintenance, upgrade, and replacement for aging infrastructure in changing climates
10. Weatherized hardware design for harsh environments found in many Tribal lands

Pathways to Overcome Structural and Institutional Barriers

A prominent outcome of the workshop was to delineate the work that needs to be done to alleviate systematic structural and institutional barriers to implementing the agenda outlined in this white paper. Recommendations for researchers, universities, and research funders include:

- **Provide Patient and Contextualized Funding:** Offer funding that recognizes the unique challenges of working in Tribal contexts, including the historical context leading to trust deficits. Allocate seed funding for the initial relationship-building phase between external researchers and Tribal partners.
- **Support Native Graduate Students:** Earmark funding for Native graduate students involved in Tribal research projects to ensure culturally relevant research and develop skilled Native researchers.
- **Establish Best Practices and Training:** Develop and implement best practices for research with Tribes, including comprehensive Tribal Institutional Review Board (IRB) training, to ensure ethical and respectful research aligned with Tribal protocols.
- **Allocate Funding for Tribal Participation:** Dedicate funding for Tribal participation throughout the research process, including long-term follow-up and implementation, to ensure community benefits and stakeholder engagement.
- **Facilitate Researcher-Tribe Relationships:** Establish organizations to act as intermediaries, facilitating collaboration between researchers and Tribes, and ensuring alignment with Tribal priorities and values.
- **Strengthen Research Infrastructure at TCUs:** Support the development of physical and institutional research capacities at Tribal Colleges and Universities (TCUs) independent of specific projects. Provide resources for Native early-career researchers to return to TCUs and build their research portfolios.
- **Create University Tribal Relations Offices:** Establish Tribal relations offices and programs at non-Tribal universities to support Native students, promote cultural awareness, and foster an inclusive academic environment that respects Native American heritage.

Conclusion

The workshop underscored the need for transdisciplinary research that integrates technical, cultural, and social perspectives to support clean energy transitions in Tribal communities. By addressing the identified challenges and leveraging the unique opportunities within Tribal Nations, this research agenda aims to foster sustainable, culturally aligned energy systems that enhance Tribal sovereignty and prosperity. The white paper serves as a foundational document for future collaborative efforts between Tribes, TCUs, research institutions, and other stakeholders in the clean energy sector.

1. Introduction

Native American communities in the United States hold a unique status as sovereign, self-governing nations. Tribal lands possess immense clean energy resource potential, estimated at 9 TW by the National Renewable Energy Laboratory (NREL) (Milbrandt et al., 2013). However, this study did not consider current land uses of Tribal land, neglecting traditional land uses and culturally significant sites. This highlights the need for culturally informed investigations into clean energy potential on Tribal lands. Concurrently, many tribes experience high levels of energy poverty. A 2000 report by the Energy Information Administration found that 14.2% of Native American households on reservations lacked access to electricity, 10 times higher than the national average (Energy Information Administration, 2000). A more recent Department of Energy report to Congress indicated that 47% of respondents reported that households in their Tribal communities lacked access to grid or microgrid-based electricity (United States Department of Energy, 2023b). Tribes, often located in remote rural areas with harsh climates, also suffer from significantly less reliable and lower-quality electricity services (Narum et al., 2016). Moreover, Tribal communities are among the most vulnerable to climate change, which is largely driven by conventional energy generation technologies. Improving access to and the quality of electricity services in Tribal communities is crucial to enhancing health, well-being, and economic opportunities in a population where one in four lives in poverty (Creamer et al., 2022).

Despite these challenges, there are opportunities for innovation and leadership in the transition to clean energy. Because Tribal communities are poorly served by legacy systems, they are less bound to them, presenting the potential for these communities to lead the energy transition. A growing dialogue within Tribal communities focuses on achieving energy sovereignty (Lee et al., 2023). While the meaning of energy sovereignty varies among tribes, there is a growing consensus on the importance of renewable energy technologies in building an energy system that aligns with Tribal cultural values, supports economic goals, and reinforces Tribal self-determination (Necefer et al., 2015). Significant financial resources are being directed toward tribes, notably through the Inflation Reduction Act, which includes $300 million for Tribal energy initiatives and $20 billion for loans and loan guarantees for Tribal Nations (The White House, 2023).

While the potential is immense, convergent, collaborative research is necessary to overcome technical challenges, integrate Tribal knowledge and values into energy planning, and understand the complex socio-technical systems in which clean energy technologies are embedded in the context of Tribal communities. Preliminary data from an ongoing study at the Rochester Institute of Technology on Tribal energy sovereignty

shows near-universal recognition of the need to train a Native American workforce at all levels, from technicians to professionals and academics, to lead this transition.

This white paper reports on the outcomes of a two-day workshop held on March 12-13, 2024, at the Hyatt Regency Tamaya Resort and Spa on the territory of the Santa Ana Pueblo in New Mexico. The workshop aimed to develop a convergent, prioritized research agenda to support clean energy transitions in Tribal communities and address the education and workforce training needs to achieve ambitious Tribal aspirations. The 32 conference participants were selected to represent the diversity of domains and stakeholders necessary to foster the collaborative relationships needed to pursue this research agenda. The workshop program was designed around creating this agenda, including these elements:

- Understanding Tribal opportunities, goals, and aspirations for energy development and energy sovereignty.
- Identifying key technical barriers to the development of clean energy technologies and systems in Tribal communities.
- Developing socio-technical systems approaches for the successful implementation of clean energy projects on Tribal lands.
- Identifying critical workforce training and education needs, and the roles of Tribal and non-Tribal educational institutions, as well as Federally Funded Research and Development Centers (FFRDCs).
- Frameworks to foster research collaboration between Tribal Colleges & Universities, non-Tribal research universities, and FFRDCs.

Workshop Design and Implementation

Objectives of the Workshop

On March 12th and 13th, 2024, an Organizing Committee composed of Nathan Williams (Rochester Institute of Technology, PI), Peter Romine (Navajo Technical University, co-PI), David Breecker (the Microgrid Systems Laboratory, co-PI), Henry Louie (Seattle University, co-PI), Stanley Atcitty (Sandia National Laboratories, Office of Electricity's Tribal Energy Storage Program), and Sandra Begay (Sandia National Laboratories, Indian Energy Program) convened key stakeholders for the inaugural Energy Sovereignty Research Workshop. With primary funding from the National Science Foundation and additional support from the New Venture Fund and Remy's Good Day Fund, 32 participants representing academia, Tribal governments and agencies, Federally Funded Research and Development Centers, and energy sector organizations gathered at the tribally-owned Hyatt Tamaya at Santa Ana Pueblo in New Mexico. The event was designed to create research agendas aimed at supporting clean energy transitions and associated workforce needs in Tribal communities.

While the potential for clean energy in Tribal communities is immense, the Committee members had previously identified a need for convergent, collaborative research to overcome technical challenges, integrate Tribal knowledge and values into energy planning, and understand the complex socio-technical systems in which clean energy technologies are embedded in the context of Tribal communities. The workshop aimed to address this need and advance practical actions toward meeting these challenges. The central workshop objective was defined as: “Craft research agendas in support of clean energy and Tribal sovereignty.”

Target Audience and Participants

Participants were invited based on their experience and achievements in the domain, with the goal of maximizing diversity along the dimensions of Native/non-Native individuals, and Tribal/non-Tribal organizations and universities, as well as geographic region, demographics, and sector (i.e., academic, NGO, private sector, National Laboratories, Tribal staff/government, finance). Inclusive of the organizers’ institutions, participating organizations included:

- Arizona State University
- Blackfeet Community College
- Grid Alternatives
- Indigenized Energy
- Menominee Tribe
- Microgrid Systems Laboratory
- National Science Foundation
- Rainstorm Consulting
- Native Renewables
- Navajo Technical University
- Navajo Tribal Utilities Authority
- Picuris Pueblo
- Rochester Institute of Technology
- Sandia National Laboratories
- Seattle University
- Seneca Environmental
- Sovereign Energy
- Sustainable Native Communities Design Lab
- U.S. Department of Energy
- University of Alaska, Fairbanks
- University of Illinois, Urbana-Champaign
- University of North Dakota
- University of Oklahoma

- Ute Mountain Ute Tribe

In total, nine Native American Tribes were represented by participants at the workshop, with participants drawn from twelve states, as depicted in Figure 1.

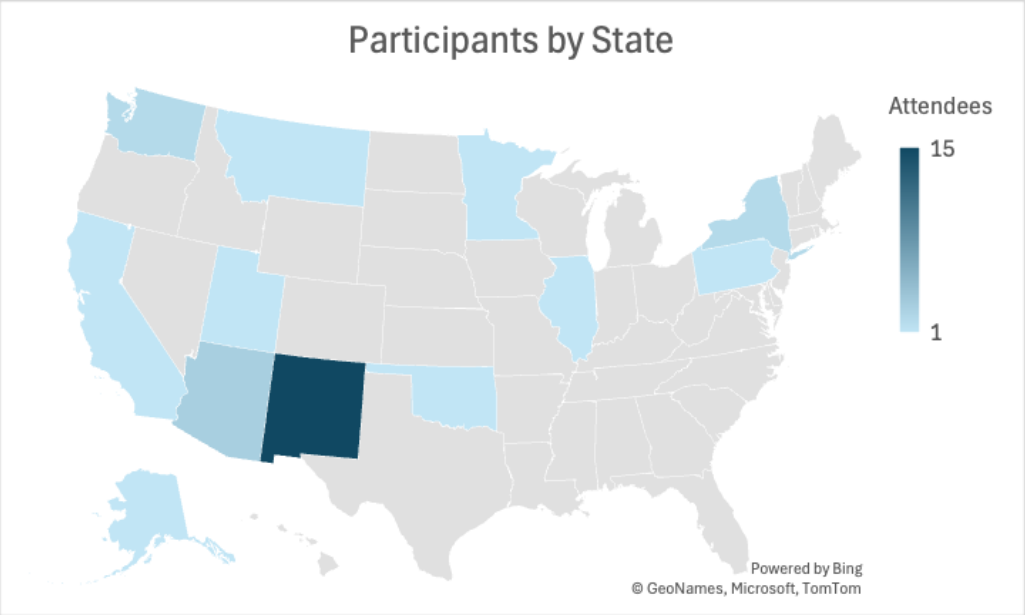

Figure 1 Workshop participants by state of residence.

Workshop Design and Format

The workshop structure included keynote speakers, participant presentations, plenary discussions, and hands-on breakout groups. The full workshop agenda can be found in Appendix A. Workshop Agenda. The sequence was designed to provide a broad shared understanding of current challenges, issues, and solutions in the domain, leading into small, focused sessions for participant input and dialogue. Google Docs were utilized as a collaborative note-taking and comment platform to ensure that all participants had unfettered ability to contribute detailed input to this white paper (hardcopy input was available as an option), along with online polls at critical junctures throughout the proceedings.

The workshop design and process architecture utilized a systems innovation approach, beginning with a foundational understanding of system contours and factors, leading to discussions of challenges and potential solutions, and then determining priorities for research in support of these goals. The general process followed this sequence:

Information (keynotes & plenaries)
Ideation (breakout groups)
Input (to subsequent discussions)
Impact (on practical applications)

Keynote presentations were delivered by Jacob Moore, Vice President and Special Advisor to the President for American Indian Affairs at Arizona State University, focusing on issues related to energy sovereignty and tribal sovereignty; and Elmer Guy, President of Navajo Technical University, focusing on recent and current technical research at NTU. Breakout groups addressed Technical and Non-Technical Challenges, Developing a Professional and Vocational Native Workforce, and Technical and Non-Technical Research Agendas. Additionally, unstructured time during meals and breaks allowed for secondary objectives of supporting networking, informal information sharing, and building collaborative relationships.

The primary outcomes of the workshop are the research agendas to advance clean energy technology and project development, professional and vocational workforce development, and collaboration between Tribal and non-Tribal research institutions and other stakeholders in the domain.

Workshop Objectives and White Paper Structure

The primary outcomes of this workshop are a prioritized clean energy research agenda in support of prosperous and sovereign Tribal Nations, an outline of workforce development needs and challenges to support clean energy development on Tribal lands, and a discussion of structural and institutional barriers that must be addressed to enable the realization of this agenda. The white paper is structured as follows:

- Section 2 provides an overview of the technical, non-technical, and workforce challenges and opportunities that Tribes encounter.
- Section 3 proposes a research agenda to address the challenges and take advantage of the opportunities described in Section 2.
- Section 4 elaborates on the structural and institutional challenges that impede progress on the priorities in Section 3, including recommendations on strategies to overcome them.
- Section 5 summarizes the white paper findings.

2. Understanding the Challenges and Opportunities

The first day of the workshop focused on establishing a shared understanding of the challenges and opportunities in advancing clean energy development within Tribal communities. The day featured two sets of parallel breakout sessions.

In the morning, participants were divided into groups to discuss the following:

- Technical challenges to Tribal clean energy development.
- Non-technical challenges to Tribal clean energy development.

In the afternoon, a plenary session was held where the two groups reported back on their session outcomes and discussed challenges holistically, including the interplay between technical and non-technical barriers. This was followed by a second set of breakout sessions focused on the professional and vocational training needs required to build the Native workforce essential for achieving Tribal clean energy goals.

To set the stage for these discussions, a plenary session on Tribal sovereignty and the motivations for pursuing clean energy was conducted. Key motivators include addressing energy poverty and high energy costs, building infrastructure to improve energy access—particularly in rural areas—promoting economic development while preserving language and culture, achieving more just and equitable energy systems, and striving for greater resilience, energy independence, and self-sufficiency. However, it was emphasized that Tribes are not homogeneous; their motivations vary according to their unique needs, cultures, histories, and contexts.

The diverse nature of Tribes also influences their views on energy sovereignty. While some Tribes seek greater self-sufficiency as part of their energy sovereignty agenda, it was recognized that energy sovereignty and energy self-sufficiency are distinct yet related concepts. One participant described energy sovereignty as a verb or practice rather than a noun, emphasizing the agency of Tribes. However, some lamented that true energy sovereignty remains elusive, citing external approvals required for projects on Tribal lands and the lack of Tribal ownership of energy assets on their lands as significant obstacles. Central to realizing Tribal agency is the creation of the skills and knowledge within Tribes that enable them to develop energy plans aligned with their values, community needs, and the needs of future generations. This section summarizes the findings on the challenges and opportunities for clean energy development and workforce training by Tribes, with an eye toward identifying research and workforce initiatives that can foster these essential skills and knowledge.

Clean Energy Development Challenges

Technical Challenges and Opportunities

The technical challenges breakout session focused on several key areas, including perceptions of the cleanliness of various energy sources, the importance of different scales of clean energy in the Tribal context, the unique technical challenges faced by Tribal communities, and the technical developments needed to advance clean energy projects. This section synthesizes the session's insights and highlights the critical technical factors influencing clean energy development on Tribal lands.

Perceptions of Clean Energy Sources

The term "clean energy" can hold different meanings for different individuals and Tribes. This was explored through Likert-scale polling, where participants rated the perceived cleanliness of various energy sources, followed by discussions. Figure 2 provides the average results of these ratings, where 5 represented "very clean" and 1 represented "very dirty."

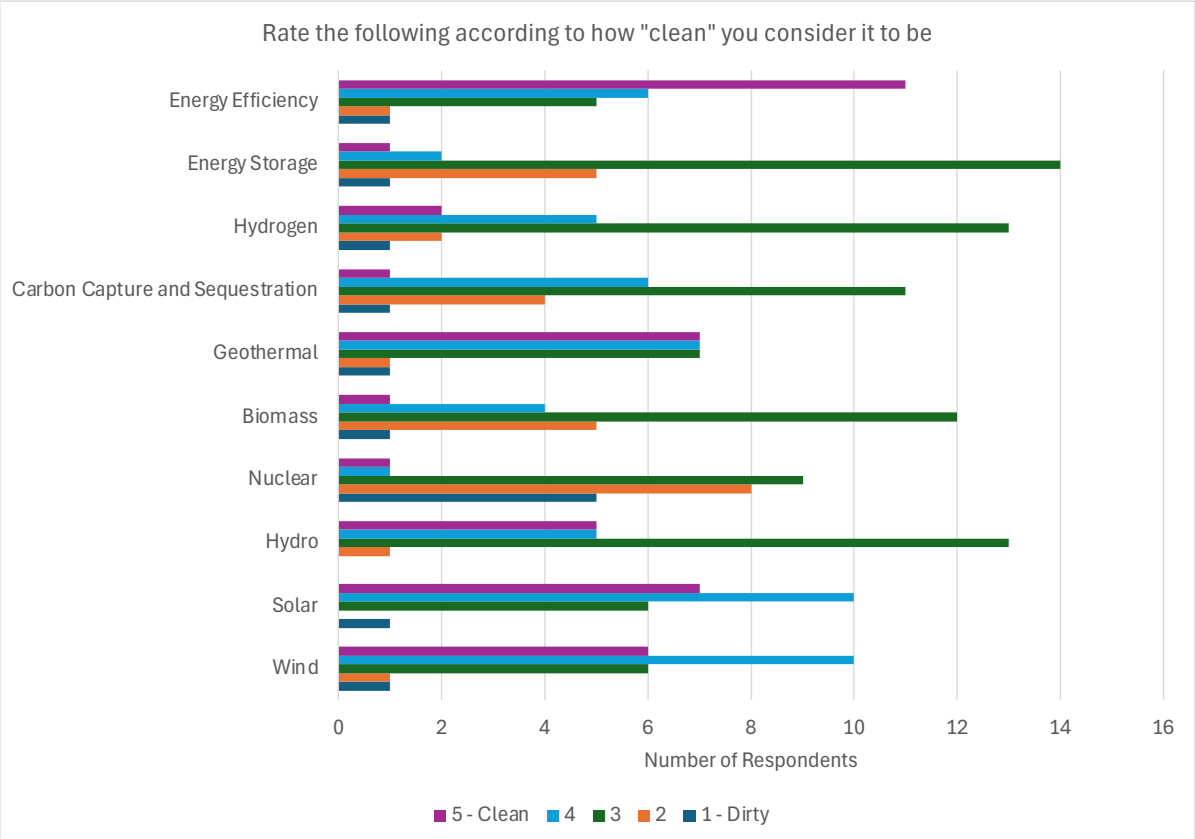

Figure 2 Workshop participant responses to the prompt, "Rate the following according to how "clean" you consider it to be." Responses are for both the technical and non-technical breakout groups. Responses are on a 1 to 5 scale with 1 being dirty and 5 being clean.

Workshop participants held varied opinions on the cleanliness of different energy sources, including wind, solar, hydro, nuclear, biomass, geothermal, carbon capture and sequestration, hydrogen, energy storage, and energy efficiency. Among the highest-rated were hydro, solar, wind, and geothermal. Nuclear power, the lowest-rated option, raised significant concerns regarding uranium extraction and the disposal of fuel rods. It was widely acknowledged that no energy source is entirely clean or dirty. Even hydropower, which received the highest rating, was criticized for its impact on aquatic life, ecological damage associated with impoundment structures, and the environmental cost of concrete use.

The perceived cleanliness of an energy source often depends on the timescale considered and the specific technology employed. For instance, different types of hydro and wind turbines have varying environmental impacts. This topic also arose in the non-technical breakout session, particularly regarding the cultural compatibility of different clean energy technologies. Participants emphasized the need for a lifecycle approach to assessing the environmental impacts of technologies, taking into account resource extraction, manufacturing, and the end-of-life of technologies like batteries. Tribes must not only be equipped to operate new clean energy technologies but also plan for their disposal and recycling at the end of their life cycles. This nuanced understanding underscores the need for careful evaluation of energy technologies on a technology-by-technology and tribe-by-tribe basis.

Importance of Different Scales of Clean Energy

Participants discussed the importance of various scales of clean energy—utility-scale, community-scale, residential-scale, grid-connected, and off-grid (both community and residential)—in the context of Tribal clean energy development. The discussions highlighted the unique needs and preferences of Tribal communities, which can vary significantly. For some communities, utility-scale projects may offer the most significant benefits, typically through bulk sales of energy to non-Tribal off takers for revenue generation. Others might prioritize community-scale or off-grid solutions to enhance energy access, independence, and resilience. This variability necessitates flexible approaches to clean energy development that can be tailored to the specific contexts of different Tribal communities. Figure 3 shows participant ratings of the importance of different scales of clean energy. All scales were rated highly, with community-scale clean energy being rated the most important.

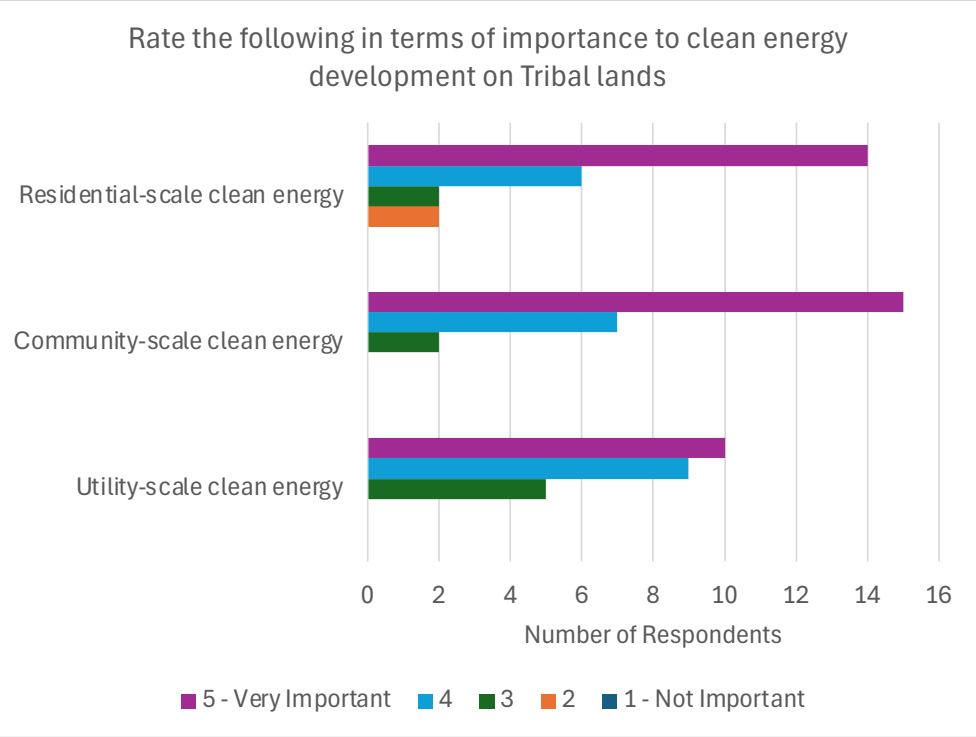

Figure 3 Workshop participant responses to the prompt, "Rate the following in terms of importance to clean energy development on Tribal lands." Responses are for both the technical and non-technical breakout groups. Responses are on a 1 to 5 scale with 1 being not important and 5 being very important.

Technical Challenges on Tribal Lands

Clean energy development on Tribal lands often presents greater challenges than on non-Tribal lands due to a range of technical, regulatory, logistical, territorial, and environmental issues (Beshilas et al., 2023). Participants noted that layers of federal laws and Tribal government regulations, such as the National Environmental Policy Act (NEPA) and rights-of-way (ROW) requirements, can complicate project development, increase costs, and extend timelines. Additionally, remote locations with difficult transportation access and extreme climate conditions pose significant challenges for the implementation, operation, and maintenance of clean energy technologies. The lack of high-quality weather stations on many Tribal lands further impedes the development and operation of clean energy systems, particularly in the cases of solar and wind, which are highly sensitive to weather patterns and require accurate forecasts for optimization.

Another critical issue is the reliance on non-Native consultants for decision-making and workforce development in project implementation. This dependence can hinder the development of local expertise and workforce capacity, which are essential for the sustainable operation of clean energy systems. It also challenges Tribal sovereignty by placing significant influence in the hands of non-Native individuals who may not fully

understand or share Tribal values and objectives. Non-Tribal companies may prefer to hire a Native workforce; however, they often employ non-Natives due to a lack of existing skilled labor. This challenge is not insurmountable, with Native Renewables cited as a successful example of a Native-owned clean energy company aligned with Tribal policy and values. This foreshadowed much of the discussion in the workforce sessions. Additionally, the interaction between the community and the technology, as well as the impact on cultural and traditional practices, must be carefully managed to ensure community buy-in and support.

Tribal communities often face additional challenges, such as dispersed population centers lacking existing grid infrastructure, difficulties in selling excess energy back to the wider grid, and outdated infrastructure requiring significant investment for upgrades. Limited transmission and distribution infrastructure is a particularly significant issue for large clean energy generation projects, where most of the power generated is sold to customers off Tribal land. The "checkerboarding" or "doughnutting" of Tribal lands further complicates the siting of generation assets and transmission lines. These challenges are compounded by limited internal resources, such as electrical engineers and technicians, and the need to navigate complex relationships with monopoly power utility companies, state utility regulations, and public utility commissions (PUCs). Reliance on external utility companies and consequent regulation by PUCs also limits the nature and scale of clean energy development on Tribal lands.

Tribes often contend with extreme climates, including arctic tundra, alpine mountain settings, and hot deserts, posing unique technical challenges. An example was cited of solar deployments on the Navajo Nation that did not sufficiently account for the effects of the dry and dusty environment. Poor design decisions led to six of ten inverters catching fire, which ultimately resulted in the project’s failure. Subsequent projects have learned from this experience and have overcome the challenge through improved system designs. Participants also noted the effects of climate change, coupled with often lacking building codes and strategic energy planning, as factors that further complicate clean energy advancement on Tribal lands.

Technical Development Needs

To better enable clean energy development on Tribal lands, workshop participants identified several key technical developments and activities:

- R&D of New Hardware: Innovations such as drones for examining distribution and transmission lines and Arctic-grade, weatherized, and dust-resistant hardware for extreme climates are essential for improving the reliability and efficiency of clean energy systems.

- R&D of New Software: Developing tools for microgrid feasibility analysis and free software for clean energy design and analysis can empower Tribal communities to take greater control of their energy planning and implementation processes.
- Technical Data Collection: Collection of and access to more accurate and higher spatial and temporal-resolution weather data, along with data verification, is critical for optimizing the performance of clean energy systems. Tribal data sovereignty and internal capacity to collect and analyze data are key enabling factors.
- Models and Analyses: Free microgrid modeling software, boundary layer real-time modeling for wind energy, and geologic assessments for CO2 capture and storage reservoirs are necessary for designing and implementing effective clean energy solutions.
- Infrastructure Upgrades: Upgrading transmission lines, repurposing discontinued oil and gas wells, and developing enabling infrastructure are vital for expanding clean energy capacity on Tribal lands. These technical challenges intersect with non-technical barriers such as cultural aspects of land use and infrastructure siting, as well as determining who should bear the costs of upgrades.

Barriers and the Role of Research Institutions

Several barriers have prevented the realization of these technical activities, including regulatory hurdles, funding limitations, and the need for capacity building within Native communities. The scarcity of technical skills and reliance on non-Tribal entities for essential energy services limit Tribes' ability to pursue energy sovereignty. Participants observed a generational gap within Native communities, with younger Native people more open to new technology than their elders, who may be skeptical of new technology and non-Tribal sources of technical knowledge. Universities can play a significant role in providing technical knowledge and training in support of clean energy projects through the development of long-term, trusting relationships. However, as discussed in Section 4 of this white paper, many barriers must be addressed to achieve this.

Non-Technical Challenges and Opportunities

The non-technical challenges and opportunities breakout session aimed to describe the institutional and cultural context in which clean energy development takes place in Tribal communities, identify the unique aspects of Tribal clean energy development, and uncover non-technical barriers and solutions to successful clean energy development.

At the beginning of the session, participants were asked to share their views on the importance of different motivators for Tribes to pursue clean energy. Broad categories of motivators included cultural compatibility of clean energy, energy self-sufficiency,

environmental protection, and economic development. As shown in Figure 4, all these factors were viewed as important; however, cultural compatibility and energy self-sufficiency were rated as the strongest motivators. This reflects much of the subsequent discussion, which highlighted the importance of pursuing energy sovereignty.

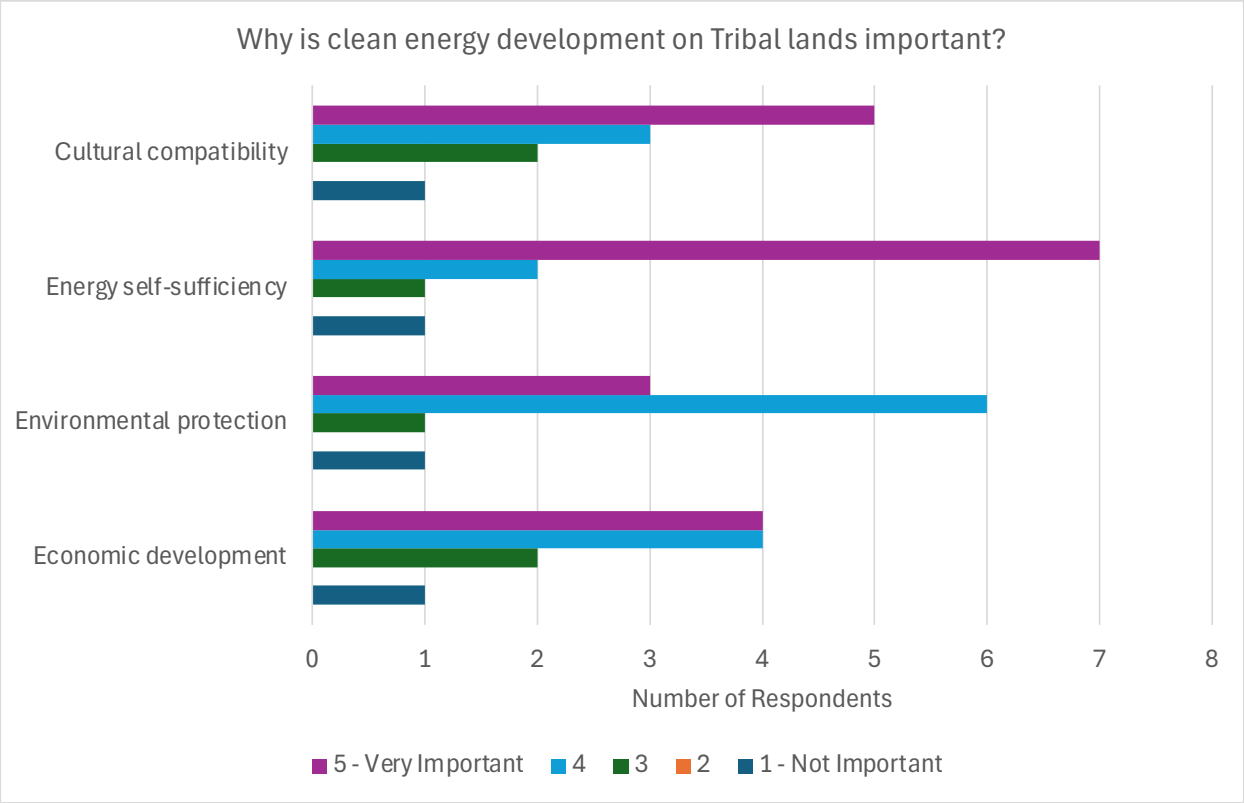

Figure 4 Workshop participant responses to the question, "Why is clean energy development on Tribal lands important?" Responses are for the non-technical breakout group.

The discourse during the session emphasized the need to understand the underlying Tribal motivations for pursuing clean energy, align clean energy development with Tribal cultural values and goals, enhance energy literacy among decision-makers and community members, and ensure that Tribes maintain sovereignty and control over their energy resources. It also underscored the need for stable funding, supportive policies, and collaborative efforts to overcome the unique challenges faced by Tribal communities in clean energy transitions. All these concepts are interconnected, and a common theme of the session was the need for transdisciplinary, collaborative work employing a systems-thinking approach.

This section synthesizes the key themes and discussions, highlighting the critical aspects of cultural compatibility, energy sovereignty, community engagement, and the financial and policy frameworks necessary for successful clean energy transitions in these communities.

Cultural Compatibility

One of the fundamental requirements for clean energy development on Tribal lands is cultural compatibility. The discussions underscored the necessity of aligning clean energy projects with the cultural values and practices of Tribal communities. This alignment is vital for ensuring that projects are not only accepted but are also actively supported by the community. Concepts of user-centered design during the planning and design of energy projects can help achieve these goals. Participants emphasized the importance of increasing energy literacy within Tribes, enabling Tribal leaders and community members to make informed decisions about energy development and planning. This involves communicating the benefits and implications of clean energy in a culturally relevant manner.

While participants agreed that clean energy development was generally aligned with many Tribal communities' values around environmental stewardship, examples were given of clean energy technologies that conflict with cultural values and beliefs. One participant noted ongoing discussions about Navajo fundamental law (The Fundamental Laws of the Diné, 2002) and concerns about how and if the sun should be monetized. Other conflicts, such as Tribes that place great cultural significance on eagles, which are negatively impacted by wind turbine development, demonstrate the unique and diverse context of clean energy development on Tribal lands. Concerns were raised about the misalignment of values between Tribal communities and non-Tribal partners and governments, particularly with respect to balancing financial gain with family, cultural, and community priorities.

Energy Justice and Resilience

The concept of "energy justice" was highlighted as a means to ensure that the transition to clean energy is equitable and beneficial to all members of the community. This involves framing clean energy discussions within the cultural context and languages of the Tribes, allowing for deeper and more meaningful engagement with the concept of clean energy. Part of energy justice also involves improving the resilience of vulnerable and energy-poor communities. Climate change is exacerbating vulnerability in many Native communities due to wildfires and extreme weather events. A need was identified for resilience hubs at the community level and economic resilience through clean energy development at a Tribal Nation level. Tribal governments need support in developing hazard assessment and mitigation, as well as climate change adaptation and climate action plans. These are deeply intertwined with energy and Tribal sovereignty. Furthermore, economic opportunities from clean energy development can benefit communities that have historically been limited to a role of consumers of energy, but now have the opportunity to be producers and sellers of energy.

Energy Sovereignty vs. Energy Self-Sufficiency

Energy sovereignty was a central and framing theme of the workshop. Tribes are increasingly seeking to exert control over and benefit from their energy resources. A critical distinction made during the session was between energy self-sufficiency and energy sovereignty. Energy self-sufficiency refers to the ability of a community to generate and consume its own energy independently. In contrast, energy sovereignty involves having control over energy resources and the ability to make decisions that align with the community's cultural and societal values. Ownership of energy resources alone does not confer true sovereignty. True energy sovereignty means that Tribes have the agency to decide how energy is produced, managed, distributed, and used in ways that support their broader goals of self-determination and cultural preservation. While some Tribes are pursuing greater energy self-sufficiency, complete self-sufficiency is often neither possible nor desirable due to economic and workforce-related limitations.

Land Use and Siting Challenges

Tribes face a range of unique challenges related to land use and infrastructure siting in clean energy development. Rights of way for energy infrastructure are complicated by the checkerboarding of Tribal lands. Checkerboarding, primarily a legacy of the Dawes Act, which resulted in the allotment of Tribal land to settlers, refers to noncontiguous Tribal land interspersed with non-Tribal and privately owned land. Crossing these checkerboards introduces a plethora of policy and administrative challenges that can be difficult to navigate (Lavallie, 2023). Additionally, Tribal lands that may appear unused to outsiders can hold high cultural value and serve social purposes that are not apparent to non-Tribal members. Therefore, siting infrastructure requires careful consideration of both technical and non-technical factors. Finally, the value of Tribal land and the sovereignty of Tribal governments must be respected in any negotiations for transmission siting. Any rights of way through Tribal lands should be fairly compensated and beneficial to Tribes. Tribal sovereignty in weighing the costs and benefits of rights of way must be respected.

Financial and Socio-Technical Challenges

Access to finance is a significant barrier to clean energy development on Tribal lands. Funding needs differ at various stages of planning, with resources for early-stage planning often lacking compared to those available for mature projects ready to break ground. Access to federal funding programs and alternative financing options is crucial for the success of these projects, but Tribes face challenges in meeting cost-share requirements for federal funding. Philanthropy has shown some interest in granting and providing low-interest loans for Tribal energy projects, but longstanding funding shortfalls remain. Tribes also face unique challenges in raising private capital for clean

energy projects. While there are several forms of Tribal land tenure, most Tribal lands are held in trust by the federal government. This introduces additional bureaucracy and limitations, increasing transaction and finance costs. The lack of homeownership among households limits their ability to finance home solar systems. Community-based financing schemes, through institutions such as the Community Development Finance Institutions Fund, were suggested as a potential solution to this problem. However, this would require the development of local capacity to vet projects and distribute funds.

Moreover, non-Tribal partners often expect Tribes to waive their sovereign immunity as a condition of financial and business cooperation. These requests directly conflict with the concept of energy sovereignty and have proven to be sticking points for some Tribal Nations. Views on waivers of sovereign immunity are mixed, with some Tribes seeing benefits in limited waivers with a narrow scope for specific projects. However, Tribes have diverse financial resources, and inter-Tribal finance arrangements could address some of the aforementioned challenges. Financial innovation will be crucial to unlocking the clean energy potential of Tribes. These financing challenges are not limited to energy development, and Tribes often have to make difficult decisions about how to allocate scarce resources to address many pressing challenges and basic needs.

Technological opportunities abound for Tribes, including the potential for leapfrog technology due to the lack of legacy infrastructure in certain regions. This means that Tribes can adopt advanced technologies without the constraints of outdated systems in some cases. However, this requires careful planning and the involvement of Tribal communities in the siting and design phases of projects to ensure that the technologies meet the community's needs and values. Participants noted the risk of Tribes being used as testbeds for unproven technologies, which could lead to unforeseen risks. Therefore, it is essential to ensure that Tribes are not merely testing grounds for new technologies and that adequate financial support and guarantees are provided for the risks taken.

Community Engagement and Education

Effective community engagement is paramount for the success of clean energy projects on Tribal lands. Participants highlighted the need for frameworks that define just and fair community benefits and development, and for developers and utilities to have plans for meaningfully engaging with Tribal communities. The example of Grid Alternatives' outreach process, which includes Tribal liaisons, was cited as a model for fostering meaningful engagement.

Education and capacity building within Tribes are also crucial. Enhancing financial literacy and providing educational support for Tribal members can empower

communities to take charge of their energy futures. Programs tailored to those working with Tribes should ensure cultural sensitivity and understanding, fostering trust and collaboration between Tribes and external partners.

Community benefits plans emerged as an important area for research in light of new federal policies such as the Justice40 Initiative (United States Department of Energy, 2023a). Communities need to have a better understanding of the implications of hosting clean energy projects and how they can benefit from them. Tribes must carefully balance the benefits and burdens of clean energy projects to ensure equitable and just outcomes.

Policy and Collaboration

Stable funding, supportive policies, and effective collaboration are essential to overcoming the unique challenges faced by Tribal communities in their transition to clean energy. Ensuring continuity in federal programs and policies can provide the necessary support for long-term success. Continuity of policy and leadership, as well as Tribal representation in important decision-making bodies, was cited as a prerequisite for success. Building trust with external partners and ensuring that Tribes choose the right collaborators is also critical.

Participants emphasized opportunities for Tribes to form their own utilities to enhance their agency and control over energy resources. This would allow Tribes to develop their own policies and regulations to achieve their energy goals, such as implementing net metering policies. This area holds great potential for innovation, including Tribally-owned microgrids and renewable energy generation. Where Tribal utilities are absent, relationships with non-Tribal utilities are crucial. As sovereign entities, Tribes have significant agency to demand better performance and reliability from utilities, but they are often unaware of their leverage or how to exert it. For example, utilities need rights of way from Tribes in order to cross Tribal lands. As one participant put it, Tribes are playing poker with utilities but don’t know what cards they are holding.

Collaboration among Tribes and with external social movements can also support shared clean energy goals. Inter-Tribal solidarity and collaboration can amplify the impact of clean energy initiatives, fostering a collective approach to overcoming common challenges. Inter-Tribal collaboration and co-investment in energy assets may be a pathway to financing, with initial efforts already underway.

Tomorrow's Professional Native Workforce

In the afternoon of the first day of the workshop, participants reconvened in breakout groups to focus on the professional and vocational workforce needs essential for clean energy development on Tribal lands. As illustrated in Figure 5, both breakout groups agreed that the current workforce is not adequately prepared to support clean energy development in Tribal communities. Figure 6 further shows that participants generally found the size of the workforce to be insufficient, though opinions varied. This section outlines the outcomes of these discussions.

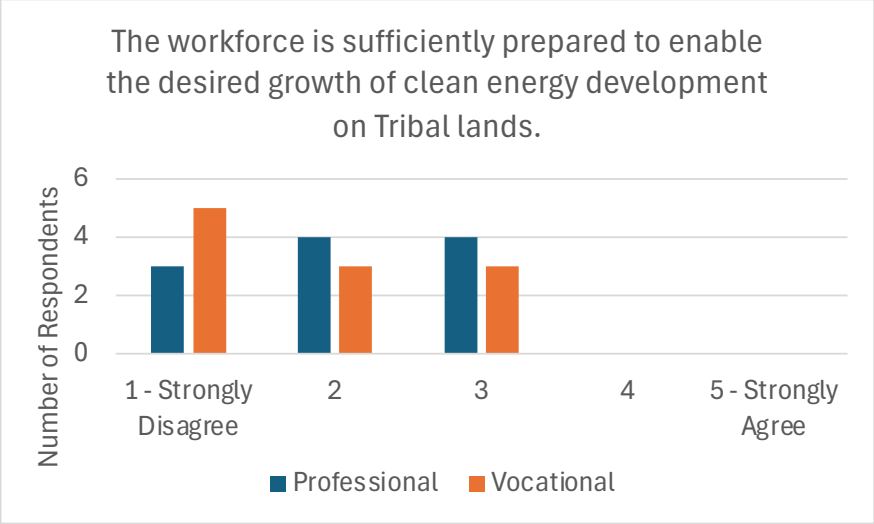

Figure 5 Workshop participant responses to the prompt, "The workforce is sufficiently prepared to enable the desired growth of clean energy development on Tribal lands." Responses are for both the professional and vocational breakout groups.

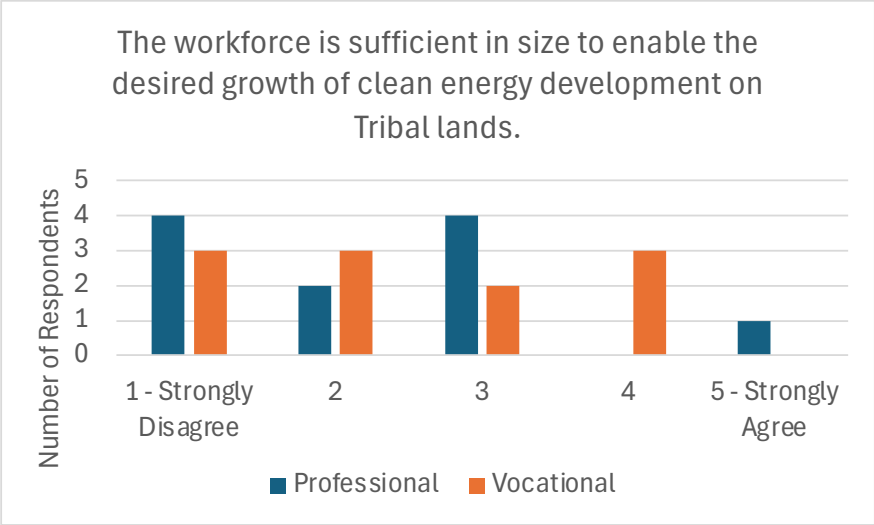

Figure 6 Workshop participant responses to the prompt, "The workforce is sufficient in size to enable the desired growth of clean energy development on Tribal lands." Responses are for both the professional and vocational breakout groups.

Professional Training

The professional workforce development session aimed to assess the current state of the Native clean energy workforce, identify future workforce and skills needs, and explore barriers to meeting those needs. The energy sector demands a diverse set of skills, often requiring advanced degrees or specialized training, and there is a significant gap in the availability of trained Native professionals (Yazzie et al., 2024). Tribal departments managing energy projects are typically small and understaffed relative to the number of active projects, which often encompass various forms of infrastructure and public works. This situation leads to missed opportunities when Tribes are unaware of, or unable to respond to, grant opportunities.

Workforce Needs and Gaps

The need for a professional workforce spans a wide range of fields and sectors. A fundamental aspect of Tribal energy sovereignty is the ability of Tribes to make informed decisions about their energy futures. Non-Tribal energy professionals, on whom Tribes often rely, may lack a deep understanding of Tribal values and goals for energy development, potentially prioritizing non-Tribal interests. Building internal technical and financial capacity is crucial for project development, implementation, and operation. Roles such as grant writers and project managers are critical to securing funding and executing projects. Additionally, technical skills in energy system design and analysis, as well as policy analysis, are in high demand. The hydrogen economy was identified as an emerging opportunity for workforce and economic development within Tribal communities.

Workforce development is also crucial for fostering entrepreneurship and the growth of Tribal clean energy enterprises. For example, Seneca Environmental, a renewable energy investment and development company owned by the Seneca Nation, prefers to hire Native employees but faces a skills gap in project finance, renewable energy development, and entrepreneurship. Business skills related to the development of Tribally owned companies that address various aspects of climate action—such as renewable energy production and sales, carbon management, forestry/reforestry, and agrivoltaics—must be cultivated to position Tribally owned companies as leaders in climate action.

Bridging the Gap in Professional and Technical Workforce

There is a recognized gap in the technical professional workforce among Native communities, exacerbated by traditional engineering and science education structures that often do not align with the cultural and educational needs of Native students. Conventional engineering programs typically focus narrowly on technical and economic outcomes rather than addressing the broader societal challenges that Native

communities face, which can deter Native students from pursuing these fields. Tribal Colleges and Universities (TCUs) have made progress in addressing these contextual issues, but their engineering programs are limited in number and in scope. Approaches to STEM education at TCUs could be beneficial for non-Tribal communities as well. Collaborative curriculum development and student exchange programs between TCUs and non-Tribal universities can enhance professional workforce development, but these partnerships must be based on mutual respect and meaningful engagement. Challenges in establishing such relationships are discussed in Section 4 of this white paper.

To better align engineering education with the needs of Native students, it is essential to integrate social and cultural context into the curriculum. This includes discussing the socio-cultural significance of engineering projects and emphasizing community benefits alongside financial gains. Native students are often highly aware of how climate change impacts their communities. Focusing education on practical problem-solving rather than theoretical knowledge can motivate students to pursue STEM fields and lower entry barriers.

Participants also noted that STEM subjects are often intimidating for many Native students, who may lack role models in these fields within their families and communities. Investing in organizations like the American Indian Science and Engineering Society (AISES) can help increase the visibility of Native professionals. Initiatives like "stealth STEM," where students are introduced to problems and then taught the necessary math and science tools to solve them, can make STEM subjects more accessible and engaging. There was a strong consensus on the need to rethink the current approach to science and engineering education specifically for Native students and, more broadly, to engage students in STEM fields starting at the middle school level. Creating pathways to professional STEM careers through technical vocational training could also help build the professional workforce. Vocational training is seen as more accessible for those lacking traditional academic preparation and could be used to build confidence and guide talented students into professional programs.

Pathways and Filling Gaps

Establishing trust between Tribal and non-Tribal colleges is vital for creating educational pathways for Native students. This includes the equitable distribution of grant funds and the provision of training programs tailored to the needs of Native communities. Additionally, leveraging online education can make STEM programs more accessible to students in remote communities, provided there is adequate internet infrastructure, which helps maintain cultural ties and reduces dropout rates among Native students.

A key issue is the lack of awareness about career opportunities in the energy sector among Tribal communities. Moreover, the preference for hiring Native individuals creates a dilemma when there is an urgency to fill positions with candidates who may not yet be fully qualified. This issue is compounded by the unpredictability of job openings, making it difficult to time training programs effectively. To address this, a proactive approach to workforce training is essential. Training programs should be developed and implemented well in advance of project start dates to ensure that a pool of qualified candidates is ready when needed. However, many jobs related to clean energy projects are concentrated in the construction phase, and without a consistent pipeline of projects, the jobs created may be temporary. Additionally, once these skills are obtained, they often attract higher salaries outside the Tribal community, leading to brain drain and reducing the return on investment in professional training. Creating well-paid, long-term career prospects is crucial to retaining critical skills within Tribal communities.

This gap can be bridged through targeted outreach and education initiatives. For instance, promoting certificate programs as a quicker alternative to lengthy degree programs could encourage more Native individuals to enter the field.

Integrating Community Culture with Workforce Development

A recurring theme in the session was the need to closely engage host communities as critical stakeholders. This connection is essential for the success of clean energy projects, as it ensures community buy-in and long-term sustainability. Projects must be designed with the cultural and environmental values of the community in mind, which can be achieved through early and ongoing community engagement. Project developers must also recognize the contributions of community members and compensate them for their time and efforts.

For instance, embedding internships within projects and creating Tribal companies can foster a sense of ownership and empowerment among Tribal communities. Additionally, addressing the economic motivations for students to stay in their communities by providing well-paying jobs and career advancement opportunities can help retain talent within the community.

Vocational Training

Similar to the professional workforce session, the vocational workforce development session sought to understand the current state of the Native American clean energy workforce in the trades (including general trades like electricians and surveyors, as well as specific trades like solar installers and wind turbine technicians), future vocational workforce needs, and barriers and solutions to meeting those needs. Key themes

included engaging youth, creating educational and training pathways, generating jobs within Tribal lands, and overcoming barriers to workforce retention.

Current State and Future Workforce Needs

Polling participants revealed divergent views on whether the size of the Native vocational workforce is sufficient to support the desired growth of clean energy development within Tribal Nations. However, no participant believed that this workforce is adequately prepared for this growth, pointing to a skills gap within the Tribal workforce related to clean energy projects.

While emphasis is often placed on the need for solar installers, many other skills are required, including operations and maintenance (O&M) technicians, electricians, administrators, and finance personnel. As noted in the professional workforce breakout, clean energy projects often generate significant short-term employment during installation, particularly for large projects, but there is also a need to create longer-term employment opportunities. While there is a common desire for individuals to stay on their Tribal land, in many cases, the more a worker specializes, the less likely a job requiring that skillset will be found in their home community. Challenges also exist in attracting youth to clean energy jobs, providing appropriate educational pathways, and retaining them within Tribal communities.

Engaging Youth and Educational Pathways

One of the primary challenges identified was the need to inform and engage younger generations about opportunities in clean energy jobs. This involves educating them about the types of jobs available, such as construction and renewable energy-related positions, and creating partnerships that provide hands-on experience and mentorship. Participants emphasized the importance of engaging youth at a young age to nurture an interest in clean energy, particularly in STEM fields.

Ensuring that investments in clean energy jobs align with industry needs and providing support systems for students are vital. For instance, job shadowing, mentorship programs, and incorporating cultural elements into training can enhance the appeal and effectiveness of these programs. Emphasizing the cultural significance of clean energy projects and integrating sovereignty concepts can further motivate young people to pursue careers in this field. For example, the concept of seven-generation thinking encourages a long-term perspective, inspiring youth to consider the impact of their career choices on future generations.

Additionally, targeted outreach and education at the middle and high school levels are crucial. Programs like the Solar Futures initiative at Sherman Indian Boarding School,

where students gain practical experience through solar installation projects, serve as a model, though transportation and access to broadband for virtual training remain significant barriers. Creating campuses that offer hands-on training, dormitories, and other facilities can bridge these gaps. Opportunities for high school students to job shadow or intern at Tribal utilities are effective ways to attract future talent into the clean energy workforce. As in the professional workforce session, early intervention, even at the middle school level, was identified as critical.

GRID Alternatives also provides examples of outreach methods to attract local talent for clean energy opportunities, including the use of social media, flyers, and presence at conferences. Tribes may also have unique hiring requirements that must be accounted for when recruiting, such as Tribal Employment Rights Ordinances (TEROs), which give preference to Tribal members in businesses operating on reservations (Guedel & Viles, 2024).

A challenge for photovoltaic (PV) projects is their relatively short installation time, which may make traditional two-year credentialing or training programs unsuitable for meeting workforce needs. Micro-credentialing was highlighted as a promising approach to training, offering a quicker path to certification compared to traditional degree programs. This method can attract more individuals to the workforce by providing them with the necessary skills in a shorter time frame. This may allow for more consistent employment opportunities within a Tribal community, as a worker, such as an electrician, could quickly be credentialed to work on a solar plant installation and then on an energy storage installation.

Addressing Brain Drain and Workforce Retention

Once individuals are trained, retaining them within the Tribal workforce presents another challenge. The issue of brain drain, where trained individuals leave their communities for better-paying jobs off Tribal land, is a significant concern. Participants noted that while off-reservation jobs often offer higher wages and better benefits, they can result in a loss of skilled labor within Tribes. To counter this, there is a need to create competitive, long-term job opportunities within the community, particularly in O&M roles. Requests for proposals for clean energy projects can include mandatory workforce training requirements to support job creation.

Moreover, developing Tribal utilities to manage electrical systems locally can help retain skilled workers. Providing on-the-job training and accredited online courses that allow individuals to work under a master electrician within the Tribe can overcome barriers to more traditional training programs. Such initiatives not only help retain talent but also build local capacity and expertise.

While many workforce challenges exist, participants also pointed to success stories that provide models and inspiration for solutions. Programs like GRID Alternatives' Tribal Program, which focuses on Tribal program development and local hiring, demonstrate the potential for successful implementation of training programs designed to address unique Tribal contexts. Investing in community-driven projects and building long-term relationships with TCUs can also foster a sense of ownership and commitment among participants.

Summary of Clean Energy Development and Workforce Challenges

The discussions from the technical challenges breakout session illuminated the multifaceted issues and opportunities associated with clean energy development on Tribal lands. It became clear that perceptions of "clean energy" vary widely among Tribal communities, influenced by cultural values, environmental impacts, and technological nuances. While some sources like hydro, solar, wind, and geothermal are generally viewed as cleaner, others, such as nuclear power, raise significant concerns due to environmental and cultural impacts. The need for a nuanced evaluation of each energy technology on a case-by-case and tribe-by-tribe basis was emphasized, ensuring that cultural compatibility and long-term sustainability are prioritized.

The importance of developing clean energy projects at various scales—utility-scale, community-scale, residential-scale, grid-connected, and off-grid—was underscored as vital to addressing the unique needs and preferences of different Tribal Nations. The discussions highlighted the necessity of flexible, tailored approaches to clean energy development that can adapt to the diverse contexts of Tribal Nations. Participants also detailed the technical, regulatory, logistical, territorial, and environmental challenges that often complicate clean energy projects on Tribal lands. These include stringent federal and Tribal regulations, remote locations, extreme climates, and limited local expertise. Addressing these challenges requires targeted technical developments, such as advanced hardware and software, improved weather data collection, and significant infrastructure upgrades.

Insights into the non-technical challenges underscored the critical importance of cultural compatibility, energy sovereignty, community engagement, and financial and policy support. Ensuring that clean energy projects align with Tribal values and practices is essential for gaining community buy-in and support. Energy sovereignty emerged as a key theme, emphasizing the need for Tribes to have control over their energy resources and decision-making processes. Overcoming financial and regulatory barriers,

enhancing community education and capacity building, and fostering collaborative efforts are crucial for the successful transition to clean energy in Tribal communities. Tribes must achieve their clean energy goals in ways that respect their cultural heritage, enhance their sovereignty, and support their long-term sustainability.

3. Setting a Research Agenda

On day two, participants set out to chart research agendas based on the challenges and opportunities identified on day one. They divided initially into technical and non-technical breakout sessions and subsequently reported back to the entire group of participants, discussing overall findings and interdependencies between technical and non-technical research agendas. This section describes the outcome of that activity.

Research Priorities from Technical Breakout Session

This section examines key technical research areas identified by workshop participants. They are presented in order of descending priority as determined by the breakout session participants.

Weatherized and Climate-Appropriate Technology

Many Tribes are located in remote areas, some with extreme climates ranging from the arctic regions of Alaska to the dust-blown high desert plains in the Southwest. Further, some locations experience rapid swings in temperature and weather. These conditions present unique challenges to reliably operating and maintaining power system equipment, and some participants cited examples of premature and catastrophic failure due to dust storms, microbursts, and icing. Participants saw potential for additional research, development, and analysis of clean energy equipment purpose-built for these extreme environments.

Potential areas of research include:

- Designing and adapting components resilient to extreme environmental conditions, such as cold, wind, dust, smoke, and wildfires.
- Analyzing the impacts of acute short-term temperature fluctuations on the performance, reliability, and life span of equipment.
- Developing techniques for snow and dust removal and mitigation on solar arrays.

Research should consider present and future climate conditions. Research quantifying the scope of these extreme environmental conditions is also needed.

Infrastructure Maintenance, Replacement, and Upgrades

Maintenance of a host of existing infrastructure assets, such as transmission and distribution lines, substations, and control and communication equipment, is needed to

enable a clean energy transition. While this is true of any power system, the unique context of Tribal systems requires additional consideration. Many participants felt that the electrical infrastructure on their Tribal land was nearing or past the end of its service life, and limited funding, harsh environmental conditions, and remoteness have left many components inadequately maintained.

There are research opportunities related to the maintenance, replacement, and upgrades of electrical infrastructure. Examples include increased use of real-time condition monitoring and predictive maintenance practices; development of optimized repair and replacement strategies, including considerations of cybersecurity vulnerabilities; and identifying practices for future-proofing equipment, including the selection of components such as battery chemistries.

Geospatial Planning and Infrastructure Siting

Effective transmission siting (to connect large-scale clean energy generation with distant load centers) is another critical research area. This involves utilizing advanced mapping techniques and considering cultural, environmental, and logistical factors in the planning process. Enhanced mapping of Tribal lands using Geographic Information Systems (GIS) and 3D mapping can identify optimal locations for transmission and renewable energy generation resources. This approach also helps avoid culturally significant sites and endangered species habitats.

Tribal lands present unique opportunities for the co-development of energy, water, transportation, and communication infrastructure to currently unserved or underserved locations. Algorithms and approaches to co-optimize the routing and installation of power lines, water lines, roads, and communication systems may reduce costs and reduce time while improving and extending service.

In locations with low electrification rates, novel approaches to economically connecting remote and sparsely populated homes to the grid or otherwise providing electricity are needed. Policy analysis at state, federal, Tribal, and company levels is necessary to streamline transmission siting decisions.

System Design and Feasibility Software

A barrier to clean energy adoption on Tribal lands is the availability of appropriate feasibility and design software. Although commercially available software exists, participants felt that it was prohibitively expensive, unfamiliar, and not customizable to unique Tribal conditions. Participants suggested modifying existing free or open-source software to meet localized needs. Creating community-specific software programs and

keeping them within the community for future use ensures sustainability and self-reliance.

A companion area of research is satisfying the data requirements of feasibility and design software. The availability of specific or representative datasets of load and system parameters reflecting Tribal lands is limited. Collecting and utilizing large-scale data, while ensuring cybersecurity, is vital for this effort.

Improved Weather Data and Energy Models

Most clean energy technologies require highly accurate climate and weather data for their development and operation. However, participants noted that generally, high-quality, high-resolution weather data was unavailable for Tribal communities. This presents issues in determining the feasibility of clean energy projects, generating accurate and reliable forecasts for power generation, and making informed operational decisions. In one case, a participant shared that a microburst damaged a clean energy facility, but they were unsuccessful in collecting insurance as there was no nearby weather station to corroborate the cause. This dearth of accessible data also includes geologic and subsurface conditions, which are needed for some clean energy technologies.

Research in this area includes developing optimal placement strategies for weather stations, the development of hyper-localized weather forecast models, and devising remedial action schemes for extreme weather events.

Research Priorities from Non-Technical Breakout Session

The non-technical breakout session on research priorities focused its discussion on Tribal capacity building, equitable and innovative finance solutions, education of Tribal communities and non-Tribal partners, trust-building and relationships, stakeholder engagement approaches, and integrated energy planning, including the development of Tribal utilities.

Tribal Capacity Building

One of the primary focuses of the session was on building the capacity of Tribes to manage and benefit from renewable energy projects. This goes beyond workforce development discussed in other sessions. The GRID Alternatives Tribal Accelerator Fund (TSAF) is at the forefront of this effort, developing programs like the Tribal Capacity Building Grant Program and the Tribal Energy Plan Grant (*Tribal Solar Accelerator Fund – GRID Alternatives*, 2024). These initiatives aim to bridge financial

gaps and support Tribal leaders in addressing the challenges and opportunities related to energy sovereignty.

Capacity building also involves creating organizational structures that facilitate equitable access to finance and ownership models in renewable energy development. Inspiring and supporting young Native Americans to establish clean energy-focused businesses is an important pathway to achieving both climate and economic development goals for Tribal Nations. Participants stressed the need for culturally sensitive energy literacy programs that align with Tribal values and traditions. This approach ensures that Tribal members are well-informed and capable of making decisions that benefit their communities in the long term.

Equitable and Innovative Finance

Access to equitable finance is a significant barrier for many Tribes in pursuing renewable energy projects. Traditional financing models often do not align with the unique needs of Tribal communities, leading to what participants described as "bad finance." To address this, the participants proposed exploring alternative financing mechanisms, such as combining New Market Tax Credits, DOE Loan Programs, and philanthropic contributions. These models can de-risk pre-development work and provide necessary project financing.

A case study approach was suggested to demonstrate effective financing models and educate Tribes about their potential benefits. For example, leveraging justice-inspired renewable energy credits (RECs) and exploring concepts like "Tribal Renewable Energy Credits" (T-RECs) can provide additional financial incentives for Tribal renewable energy projects. Understanding the true value of renewable energy generation in Native communities is essential for creating these markets. Additionally, understanding the spectrum of business models, from leasing to full Tribal ownership, and addressing tax issues are key considerations for developing viable renewable energy projects.

There is a need for research on innovative financing solutions that are culturally compatible and suited for unique Tribal needs and circumstances.

Community Education and Tribal Partners

Effective community education is critical for advancing sovereignty. Educational materials must be culturally relevant, accessible across generations, and free from jargon and acronyms. Participants noted the importance of involving Native messengers to convey cultural perspectives authentically. This approach ensures that the community fully understands the implications and benefits of renewable energy projects. Research

is needed to understand and document Native perspectives on clean energy and energy sovereignty (Schelly et al., 2020).

Education of non-Tribal partners is equally crucial. Researchers and funders must respect Tribal sovereignty and understand the broader responsibilities of Tribal leaders. Moving at the Tribe's pace, respecting confidentiality, and recognizing the unique cultural contexts of each Tribe are essential practices for fostering productive and respectful partnerships.

Stakeholder Engagement, Trust Building, and Relationships

Developing effective stakeholder engagement frameworks is essential for advancing energy sovereignty. Cultural training for researchers and educating non-Natives on how to work with Tribes can improve collaboration and project outcomes.

Building trust between researchers and Tribal communities is fundamental for successful collaborations. The workshop emphasized the need for genuine engagement, where researchers prioritize relationship-building over pursuing research agendas. This involves spending time in the community, sharing meals, and engaging in open conversations without an extractive intent.

Understanding the reasons behind the existing trust deficit is crucial. Researchers must recognize their historical roles in perpetuating exploitative practices and work toward mitigating these issues. Training programs that sensitize researchers to the unique contexts and needs of Tribal communities can help build sustainable and respectful partnerships. Research is needed to develop these training programs and resources.

Integrated Planning for Tribal Energy Infrastructure and Utilities

Tribal communities need to translate their values and visions into strategic plans that include the development of Tribal energy infrastructure and utilities (Lavallie, 2023). Understanding the interplay of technology, financial constraints, culture, and economic goals is vital for effective planning. Staged approaches that adapt to increasing Tribal capacity can help achieve these goals incrementally and sustainably. Many Tribes are approaching energy planning with a view toward improving resilience, which addresses vulnerability to climate change and advances Tribal sovereignty. Research is needed to understand the costs and benefits of forming Tribal utilities and to draw lessons and best practices from Tribes that have pursued this path.

For all Tribal energy infrastructure, more work needs to be done to understand the impact of energy projects—both positive and negative—on Tribes and Tribal communities that host these projects. Government initiatives, such as Justice40 (United

States Department of Energy, 2023a) aim to direct significant benefits from investments in clean energy toward underserved communities, including Tribes. It is critical to understand how Tribal communities are affected by clean energy projects, and how projects can be designed to mitigate negative externalities, align with community needs and goals, and advance energy equity and justice. There is much to be learned from Tribes that have led the way in deploying clean energy projects, such as the Navajo Nation, Ute Mountain Ute, Picuris Pueblo, Moapa Band Paiute Indians, and the Blue Lake Rancheria, to name a few.

Structural and Institutional Research Challenges

Participants noted various structural and institutional barriers that impede positive collaboration between researchers and Tribes, both at academic institutions as well as within funding agencies. This topic arose throughout the workshop and thus deserves a deeper discussion in this white paper. The collaborative principles discussed in this session—including developing research questions collaboratively, setting clear expectations for deliverables, and ensuring funding to act on research findings—are essential steps for meaningful engagement. Creating educational opportunities for Native students and connecting them to their communities can help retain talent and build local capacity.

Each Tribe is unique, and cookie-cutter solutions are ineffective. Research must often be tailored to the specific needs and contexts of each community, focusing on practical outcomes that benefit the Tribe. Funder expectations that research will generalize to all Tribes do not recognize the diverse nature of Tribal Nations. New methods of listening and informal interaction can help overcome survey fatigue and build genuine relationships.

Assessment of Cross-Cutting, Transdisciplinary Research Needs and Opportunities

Following these breakout sessions, participants reconvened in a plenary session to report on breakout session outcomes and discuss cross-cutting themes that transcend the technical and non-technical boundary. Participants were asked to rank the research priorities that emerged from the breakout sessions, resulting in the following list:

1. Integrated planning of clean energy infrastructure with complementary infrastructures and services and establishment of Tribal utilities
2. Trust building between Tribal and non-Tribal energy sector actors
3. Stakeholder engagement frameworks and education of non-Natives on effective collaboration with Tribes
4. Innovative finance solutions for unique Tribal needs and challenges

5. Siting of transmission and distribution infrastructure accounting for complex land tenure situations and cultural heritage
6. Affordable software for system design, simulation, and feasibility studies
7. Technical training of the Native workforce
8. High-quality, high-resolution weather data and localized subsurface energy models
9. Hardware maintenance, upgrade, and replacement for aging infrastructure in changing climates
10. Weatherized hardware design for harsh environments found in many Tribal lands

It is notable that weatherized hardware design, which was rated as the highest priority in the technical breakout group, was ranked at the bottom of the list by the larger group. There was consensus that if non-technical challenges are not overcome, technical advancements will have limited impact. However, many of the high-ranking priorities require an integration of technical and non-technical knowledge. For example, Tribal utility and integrated cross-sectoral planning emerged as the highest priority, with an emphasis on incorporating unique Tribal values and objectives into the planning process, recognizing the interconnectedness of energy planning with other social, cultural, and infrastructure goals. Tribal utilities were viewed as an important tool for achieving Tribal energy sovereignty. However, setting up Tribal utilities requires careful technical, financial, and policy planning. Embedding energy sovereignty goals into energy planning requires careful consideration of trade-offs.

While there is a clear preference for embedding internal capacity to implement clean energy projects within Tribes, there was also recognition that collaboration with non-Tribal partners is critical. Bridging the trust deficit between Tribes and non-Tribal actors presents a significant stumbling block. Related to this, participants recognized the need for better frameworks to engage Tribal stakeholders in clean energy project development and to educate non-Native partners about Native culture and values to ensure the success of these projects.

Other top priorities include innovative finance and transmission and distribution planning. Both of these activities require careful consideration of the interplay between technical, policy, and socio-cultural factors. A common thread in the discussions about research needs was the structural and institutional barriers that hinder research and workforce development projects in Tribal communities. Addressing these barriers will require active, intentional efforts by non-Tribal researchers and partners to ensure that their work supports Tribal sovereignty and aligns with Tribal goals.

4. Structural and Institutional Barriers to Research and Workforce Development in the Tribal Context

Ethical Challenges and Concerns in Research with Tribes

While research with Tribal communities is vital and can yield significant benefits, the current academic research model often fails to incentivize ethical practices and the translation of research into practical impacts. When Tribes are treated as subjects of research rather than active participants, the research can become extractive, reflecting negative colonial legacies.

Ethical research practices require that Tribes be engaged from the very beginning of the research process, starting with identifying research needs and defining research questions. Incorporating Tribal knowledge throughout the research process is critical, but it is equally important to acknowledge the sources and owners of that knowledge. Whenever possible, Tribal partners should be recognized as co-authors and co-owners of the work, acknowledging the challenges and limited resources many Tribes face. Their contributions should also be recognized and compensated through grant budgets.

Institutional Review Boards (IRBs) within both academic institutions and Tribal communities play a crucial role in ensuring ethical practices in research with Tribes. There is a recognized need for IRB training specifically tailored for researchers and students engaging with Tribal communities. Existing examples from health research, such as the Research Ethics Training for Health in Indigenous Communities (rETHICS) program at the University of Washington, were noted as valuable models (Pearson et al., 2019).

However, there is a need to balance policies designed to protect Tribal interests with avoiding administrative burdens that may inhibit critical research. Concerns were raised that new NSF policies requiring Tribal approval of research before grant submission could make research with Tribes impractical under current funding models. The Tribal research approval process can be time-consuming and resource-intensive, often infeasible without grant resources.

Impediments to Participation of Tribes and TCUs in Research

Tribes are critical research partners but often face resource constraints and competing priorities. Tribal Colleges and Universities (TCUs) frequently have limited physical and

administrative research infrastructure and staffing, presenting significant obstacles to establishing robust research portfolios. Overcoming these challenges requires dedicated, long-term funding. TCUs face a “chicken-and-egg” problem: funding research infrastructure from grant indirect costs requires a steady stream of funded projects, but successfully securing these grants requires the supportive systems to already be in place.

In the short term, some challenges can be mitigated through partnerships with non-Tribal research universities with greater resources and infrastructure. However, TCU participants noted that they are often approached by these institutions late in the grant-writing process. This limits TCUs’ ability to shape the work with their technical and cultural knowledge and expertise, often leading to perceptions that their inclusion is intended to boost Diversity, Equity, and Inclusion (DEI) metrics rather than foster meaningful engagement. Additionally, resources allocated to TCUs in grant budgets are often small compared to non-Tribal university collaborators. Increasing Tribal representation in policymaking bodies is crucial for ensuring that Native American voices are heard and respected.

Cultural and Institutional Challenges within Non-Tribal University Settings

U.S. research universities are largely driven by externally funded research projects from public and private organizations, including the National Science Foundation (NSF). Tenured and tenure-track faculty are evaluated based on the volume of external funding secured, the number of graduate students supported, and the quantity and quality of resulting publications. This system incentivizes faculty to focus on securing large grants, recruiting students with strong academic credentials, and quickly moving on to new research after publications are produced.

However, these productivity metrics are often incompatible with work that engages Tribes, which requires patience, relationship-building, time-intensive co-creation, involvement of Native students who may not have had the same opportunities to develop research skills, and a commitment to translating research into practical outcomes for Tribal communities. For pre-tenure faculty, pursuing ethical, impactful, and meaningful research with Tribes can present significant professional risks.

Additionally, universities often lack the infrastructure to support research with Tribes. Training on ethical research practices in Tribal contexts is generally insufficient, and many universities lack systematic engagement with the Tribes on whose traditional territories they operate. Support for Native students and Native American culture on

campuses is frequently inadequate, resulting in environments that are not always welcoming or supportive of young Native graduate students. Non-Native faculty, while generally well-meaning, may lack the cultural knowledge and sensitivity needed to effectively advise Native students. Educational programs that help university faculty and staff understand the needs and cultural perspectives of Native students are often lacking.

There are only a few MS programs, and no STEM PhD programs at TCUs. Addressing this gap requires training future Native faculty and researchers to establish these programs at TCUs. In the near term, Native students must seek academic training outside their home communities. To successfully attract and train the next generation of Native researchers, universities need to create welcoming, supportive environments, and faculty and funders must provide opportunities for graduate research on projects meaningful to young Native scholars. Furthermore, once these students have completed their degrees, resources must be available to ensure they have opportunities to return to their home communities and build their research portfolios.

Challenges to Collaboration between Research Institutions and Tribes/TCUs

Universities can be powerful tools for knowledge creation, workforce development, and capacity building within Tribal Nations. However, achieving these goals requires fostering genuine relationships with Tribal communities and TCUs. High-level university leadership is crucial in facilitating these relationships, including establishing offices of Tribal relations and creating environments that support long-term, mutually beneficial partnerships with Tribes that are not solely tied to grant funding cycles (Gardner-Vandy et al., 2021).

To succeed, it is essential to involve Tribal communities and institutions from the very beginning of the research process to ensure that projects are relevant to Tribal needs and integrate Tribal knowledge and values. Embedding internal capacity within Tribal institutions empowers them to take ownership of the research and its outcomes. Additionally, it is important that the findings and benefits of the research are returned to the communities, ensuring that they see tangible benefits and retain ownership of their Tribal knowledge. Some participants noted that research projects completed on their lands did not provide resources to act on the outcomes or that the results were never communicated back to the participating Tribes.

Supporting the implementation of projects even after research is completed is vital for long-term success but is often not supported by research funders. This leaves Tribes

with few resources to translate research into practical action. Workshop participants emphasized the need for in-person interactions with diverse stakeholders to build trust and recognize the contributions of Tribes and TCUs. It is important to ensure that TCUs are meaningfully integrated into projects and are not treated as mere add-ons or tokens. Funders should ensure that Tribal partners are well-integrated into the research team and well-resourced to fulfill their roles in the project. Where possible, proposals should be led by Tribal and TCU leadership to ensure that the work aligns with Tribal values and priorities, recognizing that not all Tribes and TCUs have the internal resources to lead large projects.

Barriers Related to Funding Models and Expectations

Effective collaboration between Tribes and researchers requires patience, relationship-building, and establishing trust and a common understanding of research needs from the Tribal perspective. However, the nature of typical academic funding programs means that these prerequisites must often be established before submitting research proposals to funding agencies. These processes are time- and resource-intensive for both Tribes and researchers and require travel and interaction without an underlying agenda tied to a specific funding opportunity. When researchers approach Tribes to partner on grant proposals, the timelines are often too short to engage Tribes effectively in the early stages of research conceptualization. As a result, researchers may present Tribes with pre-existing ideas, seeking Tribal support for an agenda that lacks sufficient Tribal input.

Proposed Solutions to These Challenges

To foster meaningful and sustainable research partnerships with Tribal communities, it is essential to provide patient funding that recognizes the unique challenges of working in a Tribal context and the historical context that has resulted in trust deficits. Funders should consider providing seed funding for the initial relationship-building phase for both researchers and their Tribal partners. This seed funding would enable a deeper understanding of the unique challenges faced by Tribal communities and the co-generation of research questions that address their specific needs. Additionally, earmarked support for Native graduate students working on Tribal research projects is crucial. This approach ensures that research is culturally relevant and builds a pipeline of skilled Native researchers. Establishing best practices for research with Tribes, including comprehensive Tribal IRB training, ensures that research processes are ethical, respectful, and aligned with Tribal protocols and priorities.

Funding should also be allocated specifically for Tribal participation in research, including long-term follow-up and implementation phases. This ensures that the benefits

of the research are realized within the communities and that they have a stake in the ongoing application of research findings. Establishing organizations that facilitate relationships between researchers and Tribes can streamline collaboration and ensure that research efforts are consistently aligned with the priorities and values of Tribal communities. These organizations can serve as intermediaries, helping to bridge cultural and institutional gaps between academia and Tribal entities.

To strengthen the research infrastructure at TCUs, there must be support for building both physical and institutional research capacities that are not tied to specific research projects. This allows TCUs to develop robust and sustainable research environments that can support a wide range of initiatives. Additionally, providing support for Native early-career researchers to return to TCUs and build their research portfolios is vital for nurturing a new generation of Native scholars. Establishing university Tribal relations offices and programs at non-Tribal universities can further support Native students and culture, creating a more inclusive and supportive academic environment. These offices can play a crucial role in advocating for Native students, promoting cultural awareness, and fostering a campus environment that respects and celebrates Native American heritage.

5. Summary of Findings

The primary outcomes of this workshop include an agenda for basic and applied collaborative research to support clean energy development on Tribal lands, workforce development priorities to enable this progress, and a series of recommendations for creating an enabling environment for effective partnerships between Tribes, Tribal Colleges and Universities (TCUs), and non-Tribal universities.

The research priorities highlight the need for transdisciplinary approaches that bridge the unique social, political, and cultural contexts of Tribal Nations with diverse fields such as finance, entrepreneurship, science, engineering, data science, policy, and social sciences. There is a need to develop new approaches tailored to Tribal needs, values, and objectives for integrated energy planning that considers the cross-sectoral impact of energy systems. These approaches must be adaptable to the diverse priorities and capabilities among Tribes. While one-size-fits-all solutions may seem appealing, each Tribe's unique circumstances require bespoke solutions. Therefore, planning tools and methods must be flexible to capture these nuances. A particular focus is understanding the costs and benefits of Tribal utilities, best practices for establishing and operating them, and how they fit into broader discussions around energy planning, energy self-sufficiency, and Tribal energy sovereignty. Another critical area is the need for improved approaches to siting transmission and distribution infrastructure, considering traditional land uses, cultural heritage, and the complex regulatory environment surrounding rights of way on Tribal lands. Better geospatial data for planning, including climate and weather data, are also essential enablers of improved planning. Accessible, user-friendly software for energy system design and planning was also highlighted as a key need.

A significant barrier to clean energy development is the lack of trust that often exists between Tribal governments, Tribal communities, and non-Tribal public and private entities. This mistrust is deeply rooted in a history of negative outcomes from the exploitation of Tribal energy resources. Even when intentions are good, non-Tribal actors working on Tribal lands often fail to engage stakeholders effectively at both the Tribal government and community levels. Similar issues can arise within Tribal governments and communities. There is a pressing need for research on effective engagement strategies in the Tribal context. Additionally, educational resources are needed for all actors seeking to engage with Tribes, including researchers, to better understand Native cultures and values, facilitating more positive interactions and outcomes. Tribal governments and communities need to fully comprehend the

implications of clean energy development on their nations and communities to make informed decisions.

Within the planning framework, there is a specific need for innovation in clean energy finance and business models tailored to the unique Tribal environment. Tribes face unique challenges related to land tenure, Tribal sovereignty, and a mix of Tribal, state, and federal policies, creating a complex landscape where traditional finance models may not be well-suited.

The remote environments and harsh, changing climates that many Tribes occupy demand innovation in weatherized hardware design. Aging infrastructure on many Tribal lands increases the urgency for hardware upgrades and replacements that are well adapted to these operating environments.

There was broad agreement that both the professional and vocational workforce is not adequately prepared to enable Tribes to achieve their clean energy goals. The need for skills is urgent and wide-ranging. Vocational skills are needed for trades involved in clean energy system installation, operations, and maintenance. There is also an acute need for administrative and finance personnel to manage clean energy projects.

The demand for professional skills is equally strong. Beyond technical skills in engineering, there is a need for business and entrepreneurship expertise to build Tribal clean energy enterprises, as well as project management and grant writing skills to develop and execute projects.

For both the professional and vocational workforce, it is essential to make training more accessible to Native American workers. Opportunities for training at local TCUs or through e-learning platforms allow individuals to stay connected to their cultures and communities, which provide critical support structures. When students must leave their communities to obtain training and education, it is crucial to ensure that these students find supportive environments that provide space for and celebrate their culture. It is also important for there to be a viable career pathway leading back to their community.

Early intervention is necessary to attract young people to clean energy fields, starting as early as middle school. For technical fields in particular, which are often perceived as challenging and inaccessible, students need opportunities to engage from a young age and understand how clean energy intersects with and serves their needs and values as Native people. Approaches to technical education that emphasize problem-solving and the intersection of science with society, rather than pure theory, are important for lowering entry barriers and building internal workforce capacity within Tribes.

Equally important as attracting individuals to the Tribal clean energy workforce is retaining them. Jobs outside of Tribal communities often offer higher salaries and can entice Native workers to seek opportunities elsewhere. Many clean energy jobs, particularly during the installation phase, are short-term and do not lead to long-term employment within Tribal communities. Therefore, workforce development efforts must be thoughtfully paired with strategies to create attractive, long-term career opportunities within Tribes. This includes improving compensation packages, including benefits. Smaller, residential, and community-scale renewable energy projects can lead to more sustained demand for installation jobs. Creating more local job opportunities for project development and during the operation of clean energy projects also helps retain skills within Tribal Nations.

Finally, the workshop identified several structural and institutional barriers that impede partnerships between researchers, academic institutions, Tribes, and TCUs. Although this topic was not a primary focus in the planning of the workshop, it emerged as a major issue that warrants emphasis in this white paper. Success in realizing this research and workforce development agenda hinges critically on addressing these broader issues.

Workshop participants noted that trust issues extend to research institutions and universities. Establishing trusting relationships between researchers, academic institutions, Tribes, and TCUs is a process that requires time and patience. Through this process of relationship-building, a mutual understanding of challenges and opportunities for collaboration can develop, leading to work that is firmly grounded in Tribal needs and goals.

However, it was noted that current funding, tenure, and promotion models often incentivize extractive practices by researchers who need to secure funding to support graduate students and publish their work within relatively short timeframes. This pressure to produce can short-circuit the process of relationship-building, resulting in work that is not well-informed by Tribal needs and therefore does not translate into practical change. It may also lead to extractive research that places a burden on research participants in Tribal communities with little gain. Patient funding is required to facilitate this process of trust and relationship-building between Tribes and universities.

One solution is to increase funded research activities at TCUs. However, TCUs often lack the physical and administrative infrastructure to support large research portfolios. More investment is needed to develop this infrastructure, which should not be tied to funding cycles. Partnerships with non-Tribal research universities can help build

capacity, but these relationships must be built on mutual respect. TCUs have experienced many instances where research universities approached them late in the proposal development process to improve the perception of diversity in their proposals while allocating few resources to TCU partners. Meaningful, long-term partnerships between research universities, Tribes, and TCUs require sustained high-level engagement between university and Tribal leadership.

Building capacity at TCUs also means training and retaining Native faculty members. Few TCUs have PhD programs, which means that future Native faculty members must complete their academic training at non-Tribal institutions. Research universities need to create supportive environments for Native graduate students, providing space for them to gather and celebrate their cultures, offering training to faculty and staff on Native American culture, and respecting Tribal knowledge and ways of knowing within environments dominated by Western scientific traditions. Funding is also crucial to ensure that new Native PhDs have the resources and environment within TCUs to continue their academic careers.

This white paper outlines the outcomes of this initial workshop on energy sovereignty, self-sufficiency, and Tribal economic development research and workforce needs in support of prosperous and sovereign Tribal Nations. Workshop participants expressed a strong desire to continue this discussion, with some noting that the time allocated for the workshop was too short. We hope that this workshop represents the beginning of this important dialogue, not the end. Much work remains to be done to realize the immense benefits of clean energy development in support of Tribal sovereignty and prosperity.

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Appendix A. Workshop Agenda

Workshop on Convergent Clean Energy Research
in Support of Sovereign and Prosperous Tribal Nations
PROGRAM
Hyatt Regency Tamaya Resort, Santa Ana Pueblo, New Mexico
March 12, 2024

Time (MST)	Duration (mins)	Session ID	Session	Speaker(s)	Room
7:30-8:00	30	N/A	Registration		**Eagle**
8:00-9:45	105	1A	**Opening Plenary** Keynote address and dicussion: *Energy Sovereignty and Tribal Sovereignty*	**Jacob Moore, Arizona State University; Wayne Yazza, Picuris; Mayane Baurdin, Sovereign Energy; Dr. Nathan Williams, RIT**	**Eagle**
9:45-10:15	30	1B	**Morning Refreshment Break**		**Eagle**
10:15-12:30	135	1C	**Breakout Sessions** *Clean energy development challenges:* Technical and Non-Technical Issues	**All attendees**	**Eagle, Bear A, Bear B**
12:30-1:30	60	1D	**Working Lunch** *Videos from the Tribal Energy Field*		**Eagle**
1:30-2:30	60	1E	**Afternoon Plenary** *Overcoming challenges and related workforce needs*	**Dr. Peter Romine, Navajo Technical University; Stephanie Bostwick, Dept. of Energy; Melissa Weatherwax, Blackfeet Community College**	**Eagle**
2:30-5:00	150	1F	**Breakout Sessions with Informal Refreshment Break**	**All attendees**	**Eagle, Bear A, Bear B**

			Tomorrow's professional and Technical Native workforce		
5:00-5:15	15	1G	**Wrap-up Plenary** *Looking ahead to the role of research*		**Eagle**
7:00-9:00	120	1H	**Group Dinner** with Cultural Presentations	**Joseph Kunkel, MASS Design**	**Wolf**

Workshop on Convergent Clean Energy Research

in Support of Sovereign and Prosperous Tribal Nations

PROGRAM

Hyatt Regency Tamaya Resort, Santa Ana Pueblo, New Mexico

March 13, 2024

Time (MST)	Duration (mins)	Session ID	Session	Speaker(s)	Room
8:00-9:00	60	2A	**Opening Plenary** *Keynote address and discussion: The Role of Research in the Real World*	**Dr. Elmer Guy, Navajo Technical University; Dr. Stanley Atcitty and Sandra Begay, Sandia National Laboratories**	**Eagle**
9:00-10:15	75	2B	**Breakout Sessions** *Where's the data? Designing Technical and Non-Technical Research Agendas*	**All attendees**	**Eagle, Bear A, Bear B**
10:15-10:45	30	2C	Morning Refreshment Break		**Eagle**
10:45-12:00	75	2D	**Breakout Sessions Continued** *Where's the data? Designing Technical and Non-Technical Research Agendas*	**All attendees**	**Eagle, Bear A, Bear B**

12:00-1:00	60	2E	**Report-outs and Discussion** *Refining the Agendas*	**All attendees**	**Eagle**
1:00-2:00	60	2F	**Working Lunch** *Videos from the Tribal Energy Field*		**Eagle**
2:00-3:30	90	2G	**Panel and Plenary Synthesis** ***Use-Inspired and Applied: Research meets Practice***	**Arash Moalemi, Navajo Tribal Utility Authority; Sherry Sneezer, Rochester Inst. of Tech; David Riley, Indignized Energy; Beth Klemetsrud, Univ. of North Dakota; Scott Clow, Ute Mountain Ute; Nathan Williams, Rochester Inst. of Tech.**	**Eagle**
3:30-4:00	30	2H	Afternoon Refreshment Break		**Eagle**
4:00-5:00	60	2I	**Closing Plenary** *Key Learnings and Conclusions* **Presentation** *Funding Opportunities and Resources*	**Mara Schindelhotz, National Science Foundation; Nathan Williams, Rochester Inst. of Tech.**	**Eagle**