I-WEST

Phase One Final Report | Detailed Chapter

# Regional Overview

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# About this report

The Intermountain West Energy Sustainability & Transitions (I-WEST) initiative is funded by the U.S. Department of Energy to develop a regional technology roadmap to transition six U.S. states to a carbon-neutral energy economy. I-WEST encompasses Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming. Each state is represented in this initiative by a local college, university, or national laboratory. Additional partners from beyond the region were selected for their expertise in applicable fields. In the first phase of I-WEST, the team built the foundation for a regional roadmap that models various energy transition scenarios, including the intersections between technologies, climate, energy policy, economics, and energy, environmental, and social justice. This chapter presents work led by an I-WEST partner on one or more of these focus areas. A summary of the entire I-WEST phase one effort is published online at www.iwest.org.

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# Introduction

Energy production and distribution are critical components in the state-based economies across the Intermountain West. Collectively, the region contributes to approximately one-fifth of the nation's energy production,[1] with regionally abundant fossil resources being dominant contributors. Dependence on fossil-based resources is increasingly becoming a challenge for the region as demand for a carbon-constrained energy economy rises. Economic impacts of this transition are already affecting many energy communities and sovereign nations whose economies are structured around fossil fuel industries. While each Intermountain West state is managing the challenge differently, a regional plan will be critical to achieving an accelerated transition and mitigating regional economic impacts. Furthermore, a place-based approach that leverages the region's strengths and considers its constraints and challenges must be part of the strategy to deploy and implement a regional energy transition plan on an accelerated timeline.

# Place-based approach

A place-based approach focuses on effectively utilizing regional resources. A collaborative approach is required, along with coordinated efforts by regional stakeholders, including sovereign nations, federal and state governments, private industries, policy makers, educational entities, non-governmental organizations, and the general public. The two fundamental tenets of a place-based approach are:

1) Geographical context of a region, including its social, cultural, and environmental characteristics.
2) Interactions between industry, local communities, and government with information and knowledge sharing.

A place-based approach leverages existing physical advantages, specialties, and capabilities to develop new industries and economies. This inherently builds on the region's geography, culture, and history—emphasizing societal readiness first and technologies second. A place-based approach uses local characteristics, complexities, and partnerships to spur inclusive technology deployment and industrial growth. Most of the knowledge needed to fully realize the true growth potential of a region is not readily available to large industries; federal, state, and local governments; or policy makers. Rather, it must be developed through a deliberate dialogue and interactions among internal and external stakeholders. The place-based approach combines key theories that highlight the characteristics of a location, available resources and institutions, and additional elements such as collaboration, adaptability, resource management capability, and the interactions of various local elements. As local

[1] EIA's State Profile and Energy Estimates website (last accessed 01/30/2022).

conditions determine the competitiveness of resources and ensure its persistence over time, space becomes an active factor in development. Thus, the specificity, complexity, and interconnectedness of a territory are essential parts of a place-based strategy. In this sense, place-based strategies are different from top-down approaches—often identified as place-neutral approaches—that prioritize technologies.

There are three key elements of a successful place-based approach:

**Define local comparative advantages.** This involves defining the technology development and deployment pathways based on the existing and potential new comparative advantages of a region. According to the place-based approach, each region has unique industries that provide the local economy with different comparative advantages. Determining the comparative advantages means identifying which specific industries need to be deployed. These, in turn, are dependent on human and physical capital, which are related to workforce, raw materials, and energy resources. A place-based approach aims to improve the quality of the local workforce as well as investments in research, development, and innovation. Without investing in local human capital and research and development, investment in infrastructure may be useless, although such investments increase accessibility, especially for remote areas. While the effects of these may not be evident over the short term, they can create conditions for sustained long-term growth.

**Identify regionally applicable technologies and industries.** There is no one-size-fits-all approach for a place-based strategy. Local specificity is highly desirable to develop the strength of an industry within a region. What works in one place cannot be transferred context-free to another, regardless of the similarities. Therefore, a place-based regional strategy for industries requires the understanding of the specific sectoral constraints and capabilities in a particular area. An industrial regional strategy identifies the path for industrial technology deployment based on the existing comparative advantages. On one hand, place-based regional strategies can foster industrial specialization by enhancing traditional sectors where local industry already has a comparative advantage and existing strengths. On the other hand, they strive for supporting enterprises to move toward more dynamic technology sectors.

**Identify effective policies to facilitate regional deployment.** The place-based approach assumes that each territory has different resources and institutional settings to develop. Thus, no single policy setting can be applied. Delivering policy change is highly context-specific and depends on institutional, administrative, legal, and organizational conditions. Institutional weaknesses at the federal, state, and local levels can act as barriers to the successful realization of each region's potential.

A place-based approach to facilitate accelerated transition of the Intermountain West region toward carbon-neutral energy systems will have to take into consideration the regional geography, existing energy economies, policies, and stakeholders' perspectives on energy transition. The subsequent part of this report focuses on the regional geography and stakeholder perspectives based on extensive outreach efforts.

# Regional attributes

The Intermountain West has a unique mix of extremely diverse geography that includes high mountain ranges (e.g., the Rocky Mountains), spectacular canyons (e.g., the Grand Canyon), river valleys, forests, plains and grasslands, large salt flats (e.g., Bonneville Salt Flats) and deserts (e.g., the Great Salt Lake and Sonoran Desert). The six states are among the 13 largest in the country by land area (Figure 1).

Despite this large land area, most of the population is concentrated in four major urban corridors in Arizona (Phoenix-Tucson), Colorado (Fort Collins-Denver-Colorado Springs), New Mexico (Albuquerque-Santa Fe), and Utah (Ogden-Salt Lake City-Provo). This leaves a large portion of the region with some of the lowest population densities in the US (Figures 2 and 3). One unique aspect of the region is the presence of approximately 60 federally recognized tribal nations (Figure 4), the majority of which are located in Arizona and New Mexico, with a combined population of around 470,000.

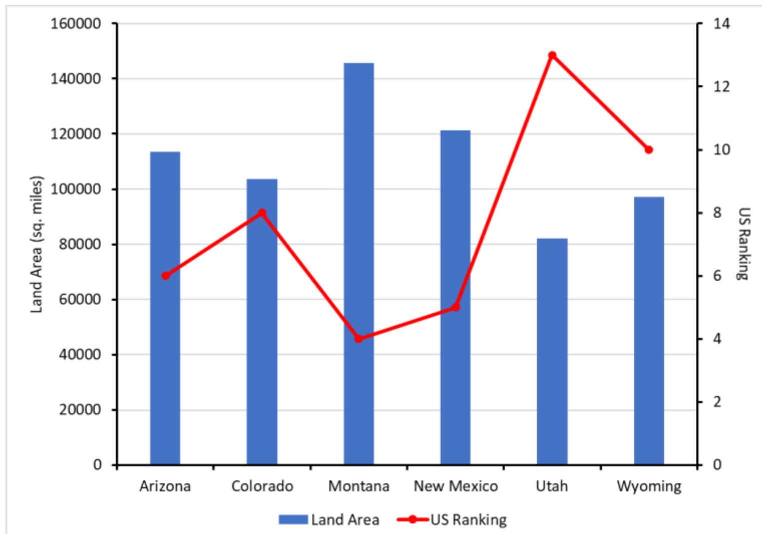


**Figure 1. Land area of the states and their U.S. rankings.**

Land ownership in the Intermountain West is complex, with various combinations of federal and state government, tribal government, and private ownership (Figure 5). On one end of the spectrum are states such as Arizona and Utah where almost 80 percent of the land is non-private and is owned by state or federal governments or tribal nations. On the other end of the spectrum are states such as Wyoming and Colorado where about 60 percent of the land is privately owned. Tribal nations own close to 30 percent of the land in Arizona and approximately 10 percent of the land in New Mexico.

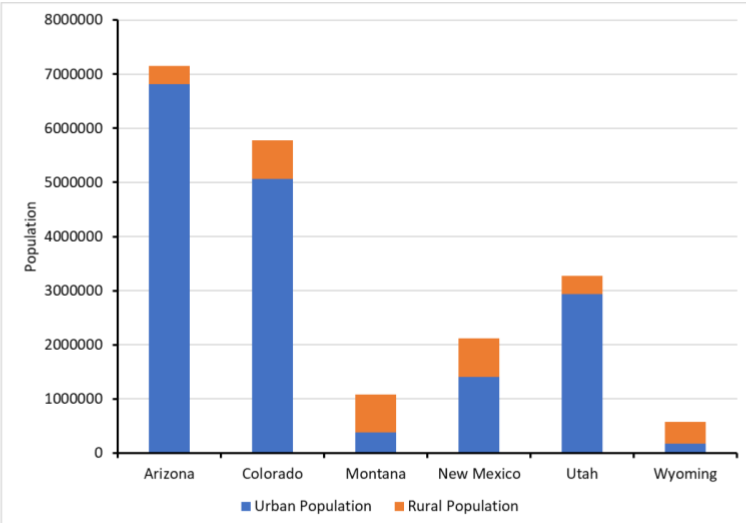


**Figure 2. Urban and rural population.**

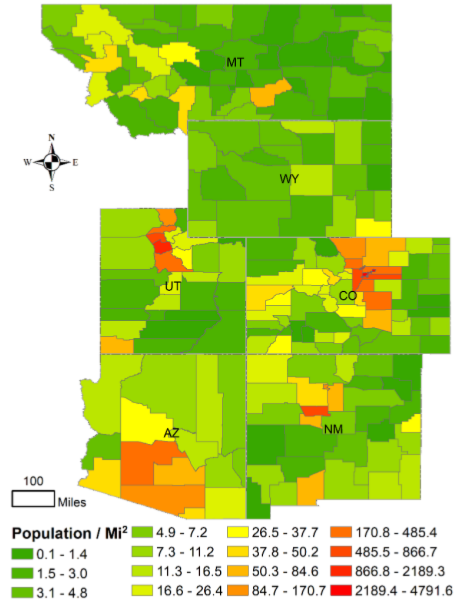


**Figure 3. Population density.**

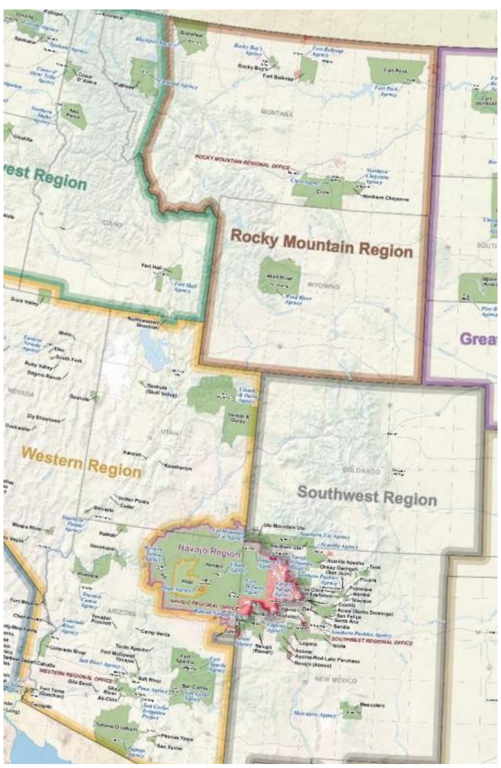


**Figure 4. Native American lands of federally recognized tribes located in the region.**

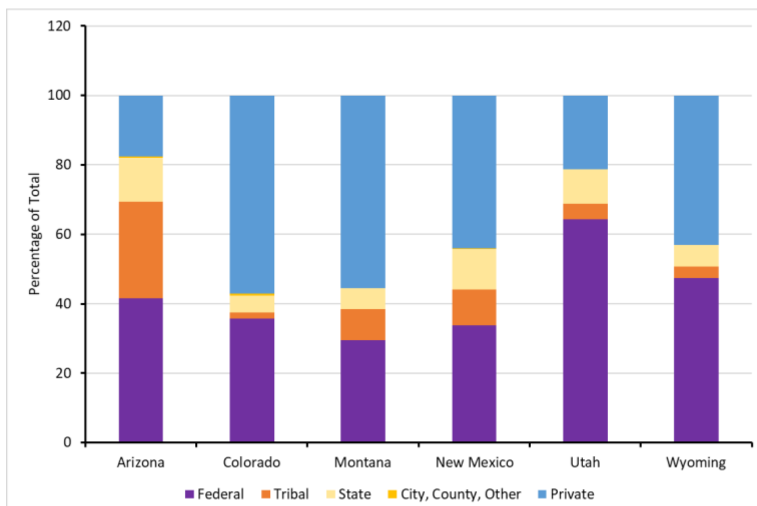


**Figure 5. Make up of land ownership.**

## Regional climate

The climate in the Intermountain West ranges from semi-arid to arid in the northern states to hot and dry in the southern states. The regional climate varies within each state due to variations in topography and geography. For example, eastern and central Montana are part of the Great Plains and have warm summers and cold winters, while the western side of the state is part of the Rocky Mountains and have snowy and cold winters. Arizona, however, has some of the hottest and driest climates in the country in its southern deserts, a cooler climate in the northeast, which includes part of the Colorado Plateau, and heavier precipitation and significant temperature variations in the mountain ranges that extend from northwest to southeast. The mountains of the Intermountain West are home to the headwaters of major rivers that supply water to numerous states, including the Colorado River, Missouri River, Rio Grande, Arkansas River, and Platte River.

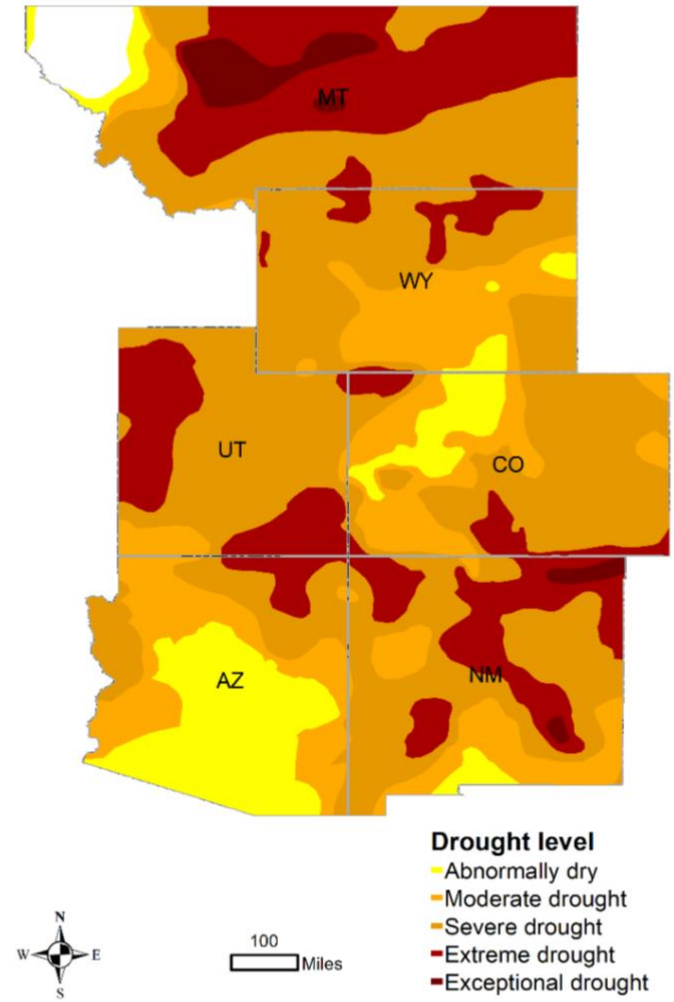


**Figure 6. Current drought levels.**

Climate change has shifted the Intermountain West's regional climate. Temperatures in the region have increased by 2–2.5 °F since the beginning of the 20th century. Almost the entire region is extremely dry or in moderate to extreme drought (Figure 6). The latest long-term climate predictions for the region indicate severe impacts of climate change, including 1) historically unprecedented increases in annual average temperature during this century, 2) potential for more extended droughts posing major challenges to environmental, agricultural, and human systems, 3) high risk of very large wildfires, 4) high variability in monsoon rainfall, 5) decreased winter snowfall leading to reduced water in major rivers, 6) increased potential for flooding due to heavier spring precipitation combined with a shift from snow to rain, and 7) increased rate of soil moisture loss due to higher temperatures and decreased summer precipitation leading to increased intensity of naturally occurring droughts[2,3,4,5,6,7].

## Regional geology

The geology of the Intermountain West is marked with sedimentary basins, mountain ranges, rift valleys, volcanic cones, and basaltic deposits. A number of major sedimentary basins in the region are rich in fossil-based resources including coal, oil, and natural gas (Figure 7). Additionally, the region has other mining resources such as gold, copper, silver, and a number of rare earth elements. In fact, nine of the top ten US copper mines—including the largest—are located in either Arizona, Utah, or New Mexico. One unique feature of the region is the presence of numerous natural $CO_2$ reservoirs (Figure 8), which are primarily located on the Colorado Plateau. These reservoirs have been used to supply $CO_2$ primarily for enhanced oil recovery operations in the Permian Basin in New Mexico and Texas. The regional sedimentary basins also contain major saline formations that have been identified as potential targets for geologic storage of $CO_2$.

## Regional energy resources, production and infrastructure

The Intermountain West encompasses some of the biggest energy-producing states producers in the nation (Figure 9), primarily due to abundant fossil resources in the region. Five of the six states (excluding Arizona) are in the top 15 for coal, oil, and gas production, with Wyoming being the top coal producing state in the country. In terms of electricity generation, all but Arizona rank in the bottom half of state rankings. However, five of the six states (all but Colorado) are net exporters of electricity, primarily to the more populous western states. Arizona and Wyoming rank in the top seven of the net electricity exporting states, while New Mexico (18), Montana (21), and Utah (25) rank in the top 25. Almost 68 percent of the electricity generated in the region is derived from fossil fuels, primarily coal

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[2] Frankson, R., K.E. Kunkel, L.E. Stevens, D.R. Easterling, T. Brown, N. Selover, and E. Saffell, 2022: Arizona State Climate Summary 2022. NOAA Technical Report NESDIS 150-AZ. NOAA/NESDIS, Silver Spring, MD, 5 pp.

[3] Frankson, R., K.E. Kunkel, L.E. Stevens, D.R. Easterling, N.A. Umphlett, C.J. Stiles, R. Schumacher, and P.E. Goble, 2022: Colorado State Climate Summary 2022. NOAA Technical Report NESDIS 150-CO. NOAA/NESDIS, Silver Spring, MD, 5 pp.

[4] Frankson, R., K.E. Kunkel, S.M. Champion, D.R. Easterling, K. Jencso, 2022: Montana State Climate Summary 2022. NOAA Technical Report NESDIS 150-MT. NOAA/NESDIS, Silver Spring, MD, 5 pp.

[5] Frankson, R., K.E. Kunkel, L.E. Stevens, and D.R. Easterling, 2022: New Mexico State Climate Summary 2022. NOAA Technical Report NESDIS 150-NM. NOAA/NESDIS, Silver Spring, MD, 5 pp.

[6] Frankson, R., K.E. Kunkel, L.E. Stevens, and D.R. Easterling, 2022: Utah State Climate Summary 2022. NOAA Technical Report NESDIS 150-UT. NOAA/NESDIS, Silver Spring, MD, 5 pp.

[7] Frankson, R., K.E. Kunkel, L.E. Stevens, D.R. Easterling, B.C. Stewart, N.A. Umphlett, and C.J. Stiles, 2022: Wyoming State Climate Summary 2022. NOAA Technical Report NESDIS 150-WY. NOAA/NESDIS, Silver Spring, MD, 5 pp.

and natural gas (Figure 10). **The reliance on fossil fuels for electricity generation may have future implications for Intermountain West states exporting electricity to other western states that are increasingly demanding carbon-neutral electricity.** The share of renewable resource-based electricity is currently at 28 percent, with Arizona ranking fourth in the nation in terms of solar electricity generation capacity and Colorado ranking ninth for wind electricity generation capacity. Given the abundance of wind (Figure 11) and solar (Figure 12) resources in the northern and southern Intermountain West states, respectively, the share of regional electricity generated from renewable resources is expected to grow in the future. In addition to the traditional renewable energy resources such as wind and solar, the region has geothermal energy potential that has not been fully exploited (Figure 13).

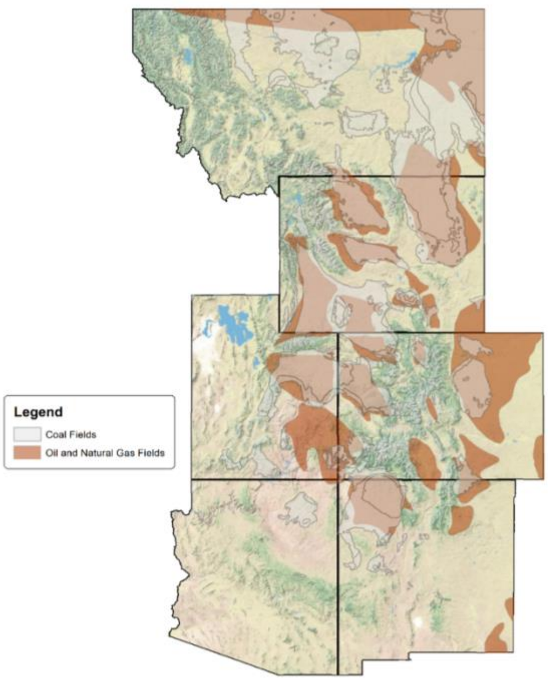


**Figure 7. Coal, oil, and natural gas fields.**

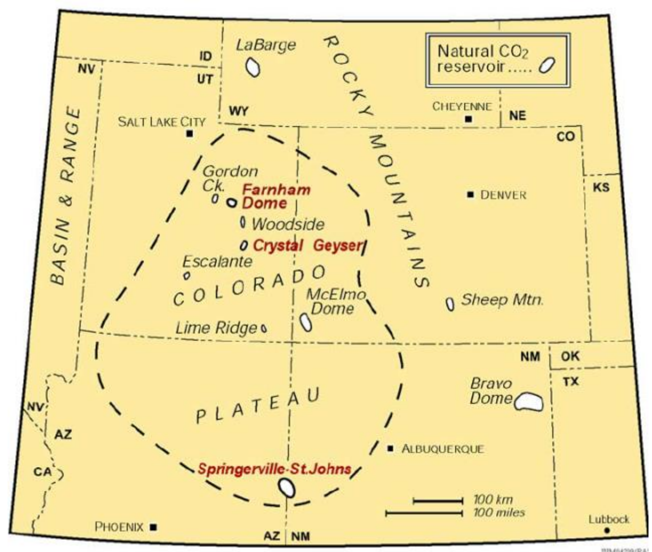


**Figure 8. Natural $CO_2$ reservoirs on Colorado Plateau.**[8]

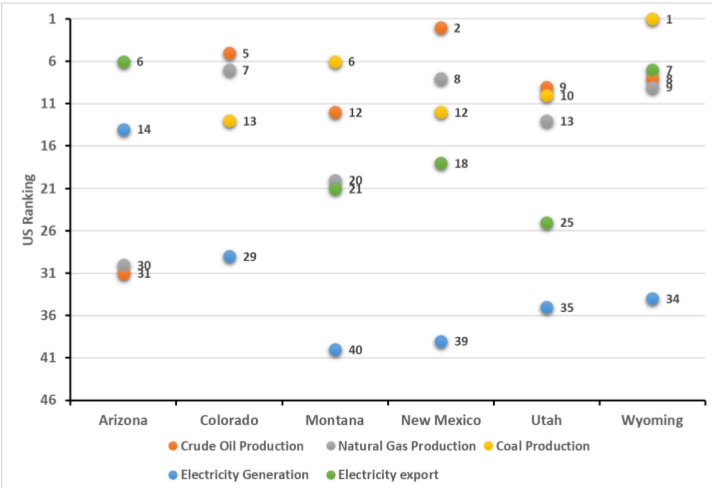


**Figure 9. State rankings in terms of production of fossil fuels, electricity generation, and electricity export.**

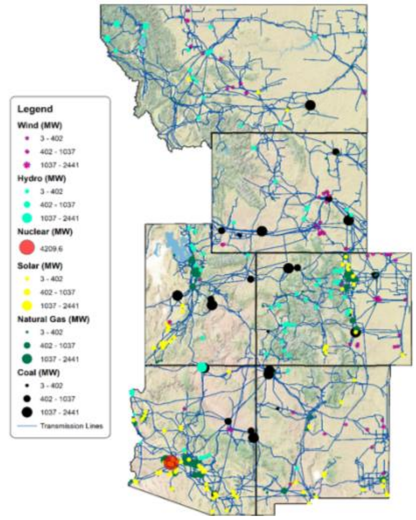


**Figure 10. Locations of power plants and electricity transmission lines.**

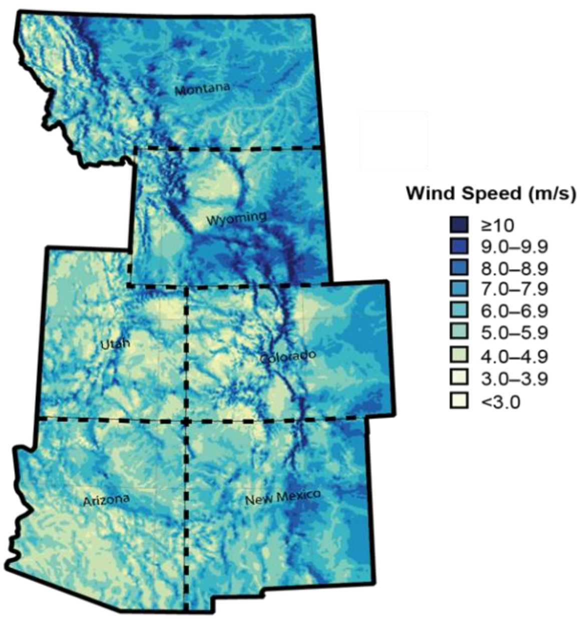


**Figure 11. Wind potential in terms of wind speed. (Source: [NREL](NREL))**

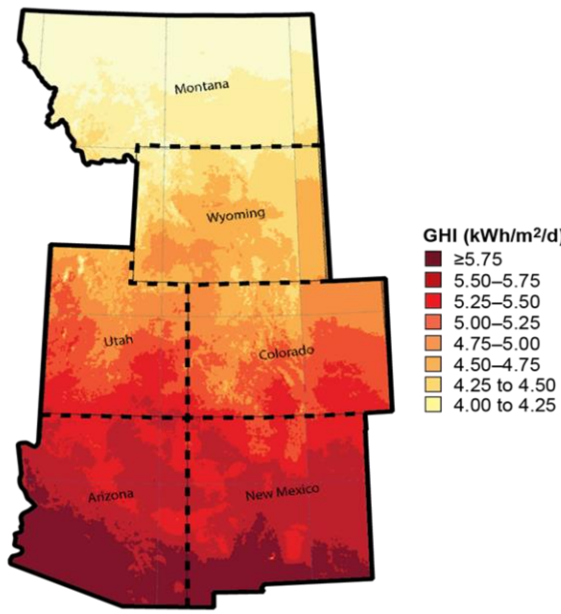


**Figure 12. Solar potential in terms of global horizontal solar irradiance (GHI). (Source: [NREL](NREL))**

Regional fossil-fuel based energy production has led to the development of significant regional infrastructure for conversion and transport of energy products, including oil refineries; gas processing plants; and oil, gas, and $CO_2$ transport pipelines (Figure 14). **The fossil and non-fossil energy resources—combined with a) existing energy extraction, conversion, processing, and transportation infrastructure and b) growing future low-carbon energy economies—indicate that there is potential for deploying multiple regionally relevant energy technologies to transition the Intermountain West to carbon neutrality.**

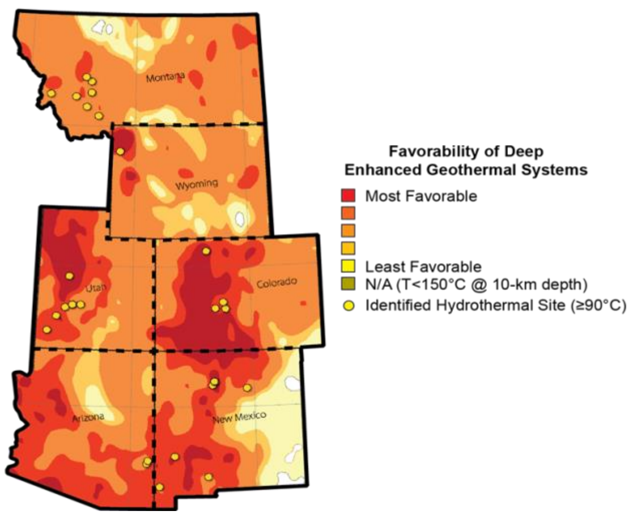


**Figure 13. Geothermal energy resources. (Source: [NREL](NREL)).**

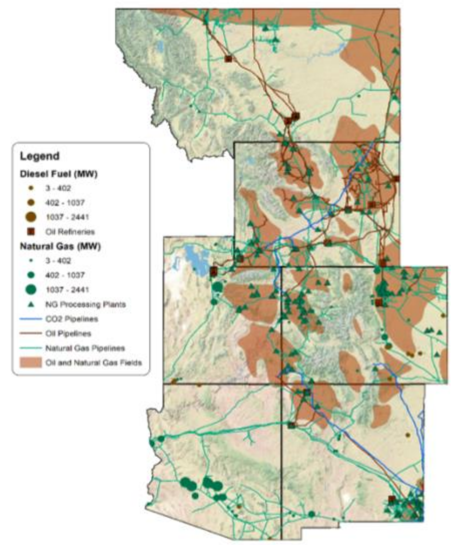


**Figure 14. Locations of oil- and gas-related infrastructure.**

## Stakeholder perspectives on energy transition

As indicated earlier, a place-based approach necessitates knowledge sharing among the regional communities, industries, government, and non-governmental organizations to identify regionally relevant context and considerations to develop an effective technology deployment plan. To facilitate development of a regionally relevant technology roadmap and its implementation, the I-WEST team performed extensive outreach to regional stakeholders to identify their needs, goals, and expectations related to energy transition. We utilized various outreach approaches, including eight state-based workshops (one exclusively focused on the sovereign nations), multiple public surveys, and focus group discussions. Through these efforts, we engaged with more than 1400 regional stakeholders representing local communities, the public, non-governmental organizations (NGOs), and educational institutions. Our outreach efforts led to several key insights into regional stakeholders' perspectives on issues associated with energy transition and carbon neutrality.

**There are diverse motivations for energy transition among regional stakeholders.**

- Enthusiasm for energy transition depends on numerous things, including how permanent or temporary a community perceives it to be, and whether or not it believes energy transition will present opportunities or barriers for economic growth.
- Energy transition means different things to different people, and decarbonization is often thought of on a spectrum—carbon neutral, net zero, absolute zero, climate positive, etc. There is support for various scenarios across the region, and all stakeholders are wary of what each scenario will equate to in terms of impact on environment, economies, workforce, and revenues.
- Within the Intermountain West region, there are diverse motivations for energy transition, which impact the attitudes, enthusiasm, and acceptance for energy transition. This emphasizes the importance of communication among local governments, technology developers, technology deployers, and communities. Ultimately, all stakeholders across the region are interested in new energy economies that can represent opportunities.

**Stakeholders identify with energy transition opportunities but are concerned with risks**

- New energy economies have the potential to help reduce regional carbon emissions and create new opportunities. The impact of energy transition is already being felt across the region and a desire to stay competitive in changing markets is a unifying motivation for energy transition acceptance—the region does not want to get left behind. But the new opportunities need to be weighed against the risks.
- The energy transition will lead to increased economic and job opportunities but there are risks associated with the viability of new energy technologies over the long term. Past experience with boom or bust cycles, especially those associated with fossil fuels, have made regional communities cautious about adopting new technologies. Additionally, local communities are skeptical about the long-term commitment of "out of region" project developers given past negative experiences. Deployers of new technologies will be expected to build relationships with local communities and work with them over the long term to overcome the skepticism and ensure community buy-in and support.
- The energy transition has the potential to positively impact the environment and public health, but there are concerns of unforeseen impacts new energy technologies might have within the region and beyond.

## Regional perspectives on future energy technologies

- Motivations for energy transition impact attitudes toward energy technologies, which emphasizes the importance of communication among technology developers, technology deployers, and communities. Traditionally, technology adoption and community acceptance are afterthoughts, but I-WEST has found that doing things in parallel will help accelerate deployment.
- Technologies must be regionally relevant and conducive to the geological, environmental, and natural resources available, as well as considerate of existing economies, infrastructure, and workforce.
- Communities are more likely to accept technologies that leverage existing frameworks and/or present viable and realistic options for building new economic frameworks.
- Overall, there is a high level of support for renewable energy, while technologies for hydrogen and CCUS require more explanation and assessment to address questions and concerns about environmental impacts and if these pathways extend the use of fossil fuels.
- Existing infrastructure may be limited to accommodate the new energy technologies; significant investments will be required to develop required infrastructure.
- Risks associated with new energy technologies are not things that communities ignore, and technology developers and deployers should not assume that communities are ignorant about potential impacts to water, ground, air, and health; in fact, many regional stakeholders prioritize these issues over economic opportunities.

## Sustained pursuit of energy justice within the region is important to stakeholders

- Energy justice is multi-pronged and involves ensuring affordable energy for all, protecting natural resources, ensuring job security, and mitigating the impacts of climate change for disadvantaged communities that most suffer from a combination of economic, health, and environmental burdens.
- The Intermountain West region is especially critical due to the high number of sovereign nations who have a long history of dealing with environmental and economic impacts as a result of unjust energy decisions. Across the board, governments at all levels and technology deployers must build trust with tribal stakeholders and make decisions that inspire their confidence.

- A just energy transition is something that must be pursued in a sustained manner. Stakeholders from sovereign nations emphasized that there must be an ongoing dialog and not a one-time "check the box" exercise.
- Opportunities related to new energy technologies may increase regional population and temporarily stress infrastructure, but could also lead to better education and services in the long term.

### Government's role in energy transition

- Regional stakeholders want state and local governments to take a more proactive and holistic approach to facilitate effective energy transition. The lack of coordination across state-based approaches, policies, and regulations related to reducing $CO_2$ emissions and strategizing for energy transition is slowing the pace for an effective transition.
- To facilitate deployment of new energy technologies, gaps in policies and regulations need to be addressed immediately. Furthermore, timelines to obtain permits need to be shortened drastically. New and existing energy technologies fall under the jurisdictions of multiple federal and state agencies that are not necessarily on the same page in terms of what is needed to facilitate rapid energy transition. Certain agencies may have limited or no flexibility to modify the existing regulations in the near future.
- On average, local communities and sovereign nations are typically unfamiliar with the process required to pursue various funding and financial assistance opportunities related to energy transition. Due limited in-house technical expertise, and limited resources for grant/proposal writing, they need assistance to pursue federal and state opportunities.

### Workforce needs for future energy technologies

- While future energy technologies may result in job opportunities, the current regional workforce may not be able to meet the needs of new industries for various reasons, including lack of technical expertise. This may limit timely deployment of new energy technologies.
- Historically, energy-related jobs have paid well and offered good benefits. Similar financial benefits will be needed from future energy pathways in order to maintain a normal standard of living for energy communities—this will also help drive the desire to develop the required technical skills through training.

- Local communities want regional educational and vocational institutes to create and offer curricula to develop the technical skills needed for jobs associated with new energy technologies.

**Stakeholders expect to have a voice in the transition, be engaged in the decision-making process, and remain informed**

- The public expects greater transparency in the deployment of new energy technologies than it has had in the past. Members of the public also expect to be better educated about the positive and negative aspects of new energy technologies so they can make informed decisions. Numerous public debates over challenging issues have shown that concerned members of the public are proactive in gathering information from public domain resources. Overcoming unfavorable public opinions will be a significant challenge and will require a transparent approach.

Outreach efforts help provide a comprehensive understanding of the regional stakeholders' mindsets related to energy transition, their expectations, and their values associated with a range of related issues that are important to consider while developing a technology roadmap.

# Summary

Transitioning the Intermountain West to carbon-neutral energy systems within a 15-year timeframe is a tall order. Successful transition will require a nontraditional approach that is both just and effective in meeting the regional carbon emission reduction goals. A traditional technology-centric approach may be effective in meeting emission reduction goals but likely will not be effective in meeting the regional stakeholders' expectations and buy-in, which in turn may delay technology deployment. A place-based approach, which emphasizes leveraging regional physical and human capital, engaging regional stakeholders to inform decision making, and forming regional coalitions can be an effective alternative to facilitate accelerated energy transition.

Given the range of natural resources—fossil and non-fossil alike— combined with significant energy generation and distribution infrastructure, there is significant potential to deploy multiple low-carbon or carbon-neutral energy technologies in the Intermountain West. Insights gained from I-WEST outreach efforts demonstrate that regional stakeholders expect energy transition to meet diverse motivations by prioritizing regionally applicable technologies, reducing economic hardships faced by energy-dependent communities, offering new sustainable economic opportunities, and ensuring energy justice.