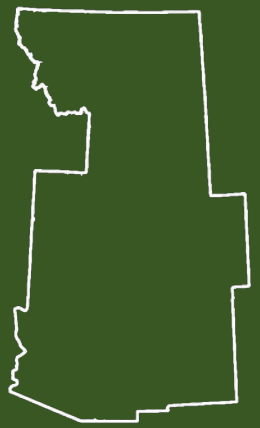

I-WEST

Intermountain West Energy Sustainability & Transitions

The Road to Decarbonizing the Intermountain West

Science, Technology and Telecommunications Committee

New Mexico State Legislature

22 July 2021

George Guthrie & Rajesh Pawar

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LA-UR-21-26715

Los Alamos Applied Energy Programs

Melissa Fox (program director; mami@lanl.gov)
George Guthrie (deputy PD; geo@lanl.gov)

Los Alamos has a tradition of innovation in clean energy technology

- **Fuel-cell R&D—dating to 1977—introduced the world to the potential to use hydrogen for transportation**
  (every fuel cell vehicle relies on technology developed at LANL)
- **Long history in genomics and biotechnology—including helping to introduce human genome to the world**
- **Hot Dry Rock—dating from late 1970s—introduced enhanced geothermal systems (EGS) to the world**

DOE's Applied Energy Offices and Program Areas

Advanced Research Projects Agency-Energy (ARPA-E)
- Transformational energy projects/concepts

Cybersecurity, Energy Security, and Emergency Response (CESER)
- Cyber for Energy Delivery
- Infrastructure Security & Energy Restoration

Energy Efficiency and Renewable Energy (EERE)
- Bioenergy Technologies
- Hydrogen & Fuel Cells Technologies
- Vehicle Technologies
- Geothermal Technologies
- Solar Energy Technologies
- Wind Energy Technologies
- Advanced Manufacturing

Office of Fossil Energy (FE)
- Carbon Storage
- Carbon Capture
- Unconventional Gas
- Critical Materials
- Materials in Extreme Conditions

Office of Electricity (OE)
- Advanced Grid R & D
- Energy Storage
- Microgrid R & D
- Grid Modernization

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Hydrogen

- Fuel-cell R&D—dating to 1977—introduced the world to the potential to use hydrogen for transportation (every fuel cell vehicle relies on technology developed at LANL)
  - ➢ Now opening new pathways to deployment for transportation

Bioenergy

- Long history in genomics and biotechnology—including helping to introduce human genome to the world
  - ➢ Now exploring pathways to algae-based biofuels

Carbon Dioxide

- Hot Dry Rock—dating from late 1970s—introduced enhanced geothermal systems (EGS) to the world
  - ➢ Now discovering new pathways to store & utilize CO_2 , e.g., CO_2-EGS, direct air capture, 1st CO_2 storage demo, …

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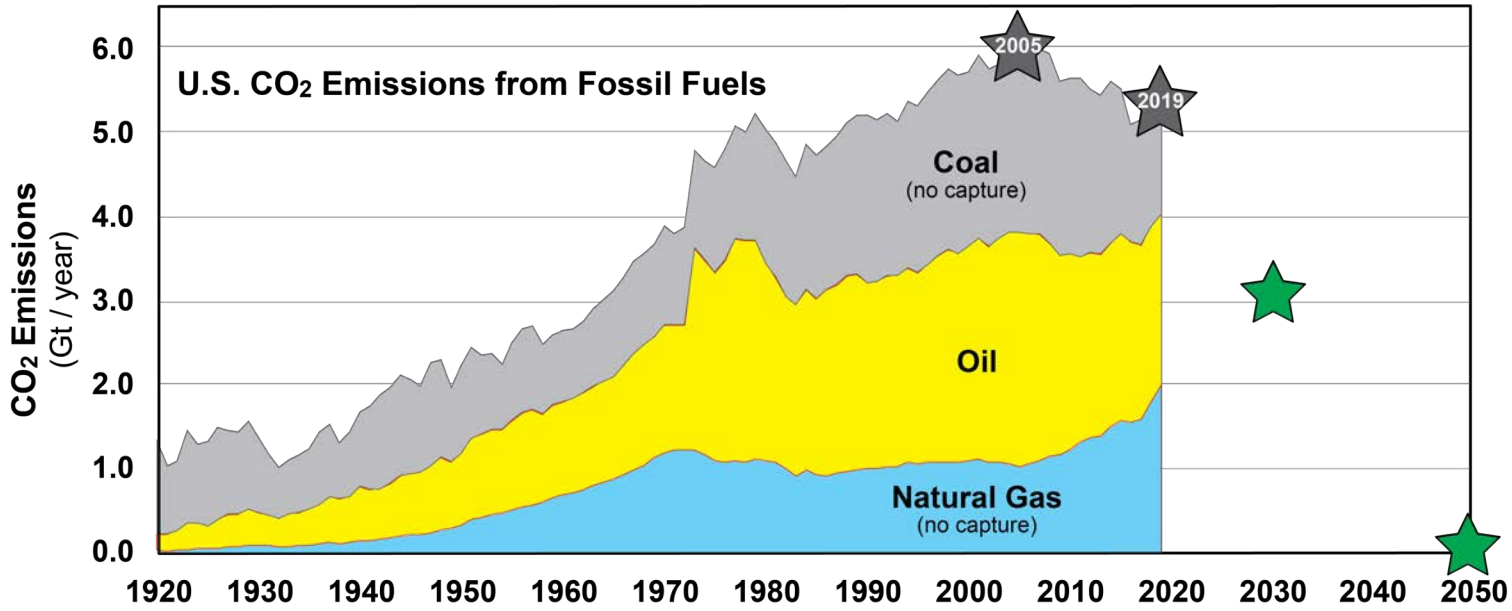
Environmental Benefits



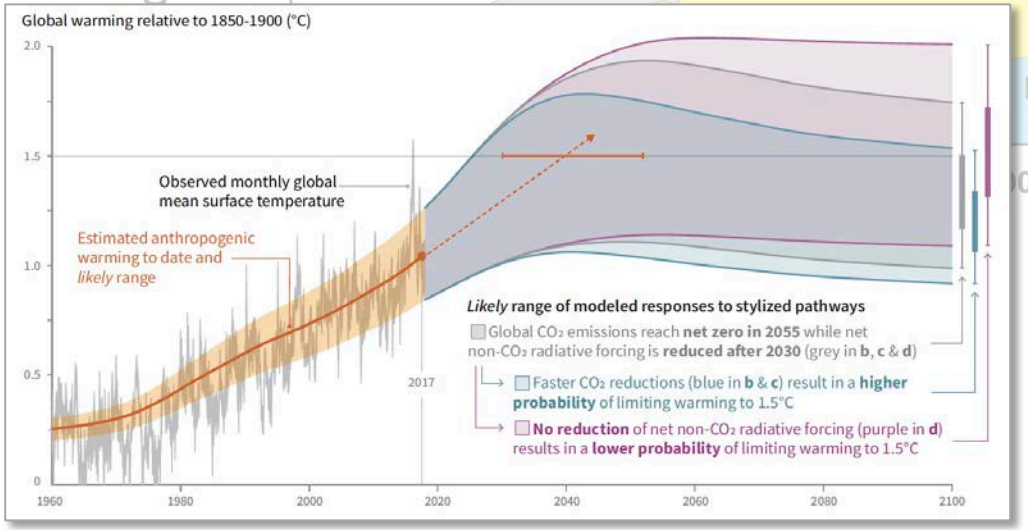
Economic Opportunities

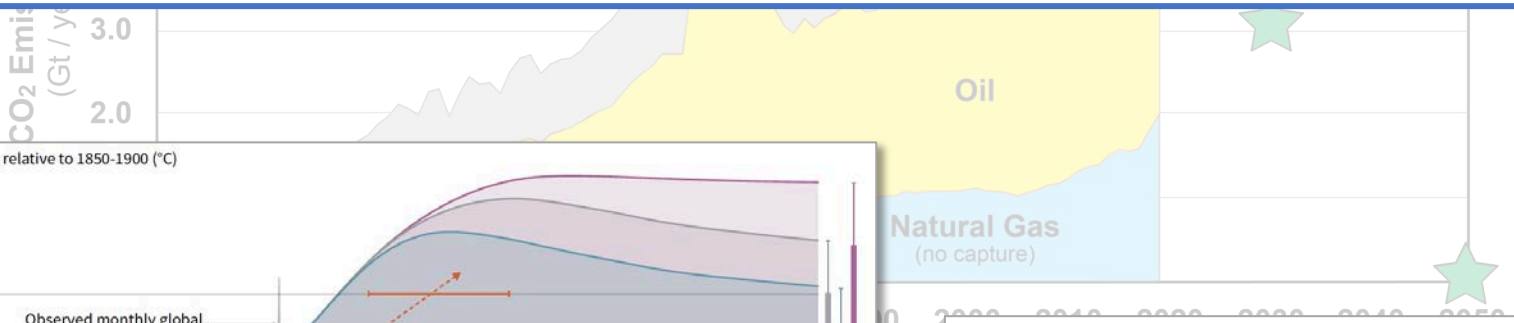
Environmental Benefits

Intergovernmental Panel on Climate Change (IPCC, 2018) has identified reductions in CO_2 emissions that would be required to keep temperature rise to 1.5 °C (US equivalent is shown by green stars).

IPCC (2018) also identified numerous benefits of keeping rise to 1.5 °C (versus 2 °C), including:

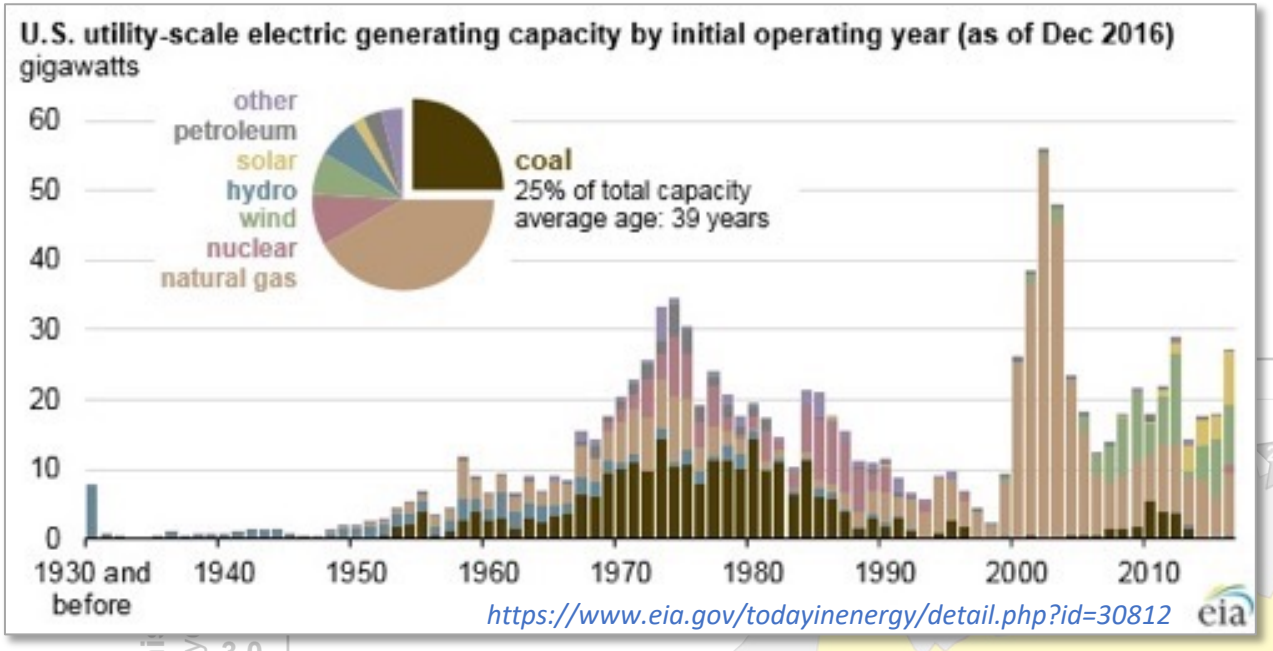
- Arctic Ocean free of sea ice in summer once per century (compared with at least once per decade with 2°C);
- Coral reefs remain—decline of 70–90 percent (whereas virtually all would be lost with 2°C).
- Smaller changes in regional climate characteristics—smaller increases in hot extremes and drought frequency





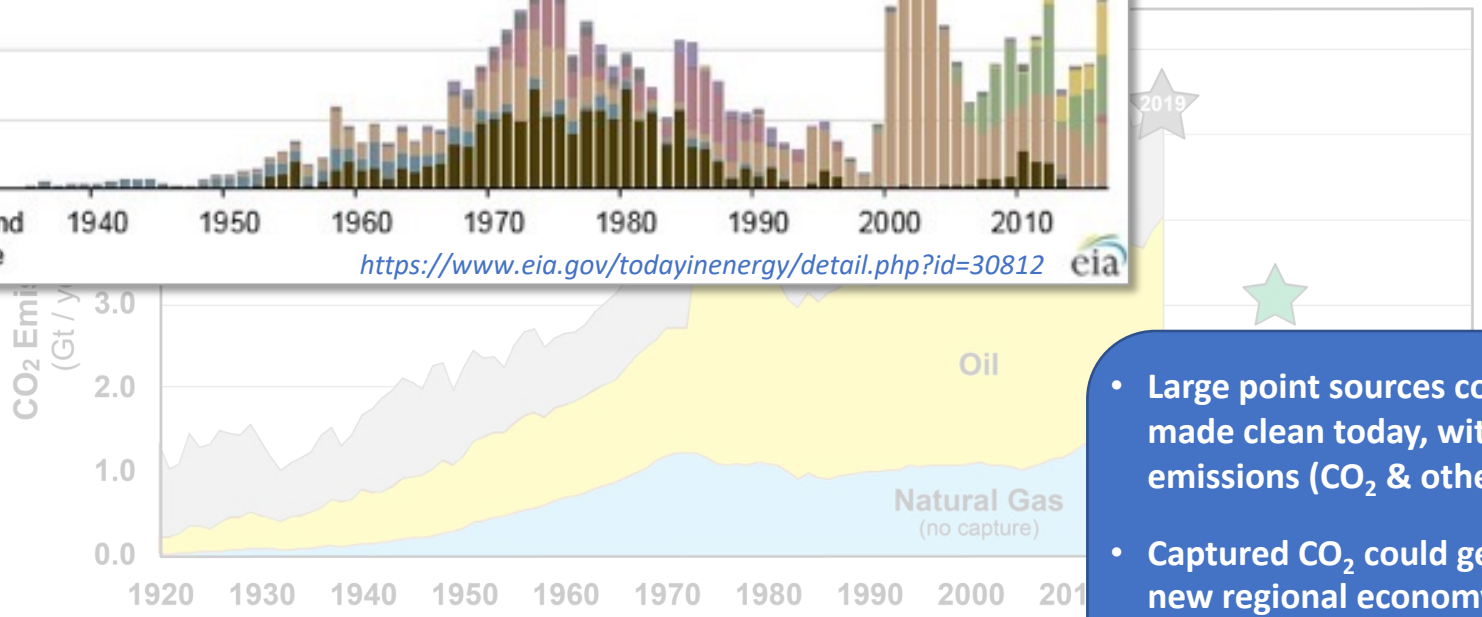
"Human activities are estimated to have caused approximately 1.0°C of global warming above pre-industrial levels, with a likely range of 0.8°C to 1.2°C. Global warming is likely to reach 1.5°C between 2030 and 2052 if it continues to increase at the current rate."
(IPCC, 2018; "Summary for Policy Makers")

Los Alamos NATIONAL LABORATORY



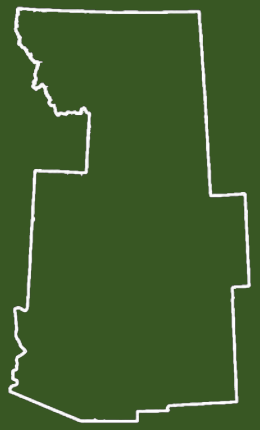
New coal generation declined in the 1980s, largely replaced by natural gas build out in the 2000s.

Coal-power did not respond adequately to projected shifts—*CO_2 capture was & is critical.*



- **Large point sources could be made clean today, with very low emissions (CO_2 & otherwise)**
- **Captured CO_2 could generate a new regional economy, with point-source capture today and direct air capture tomorrow**

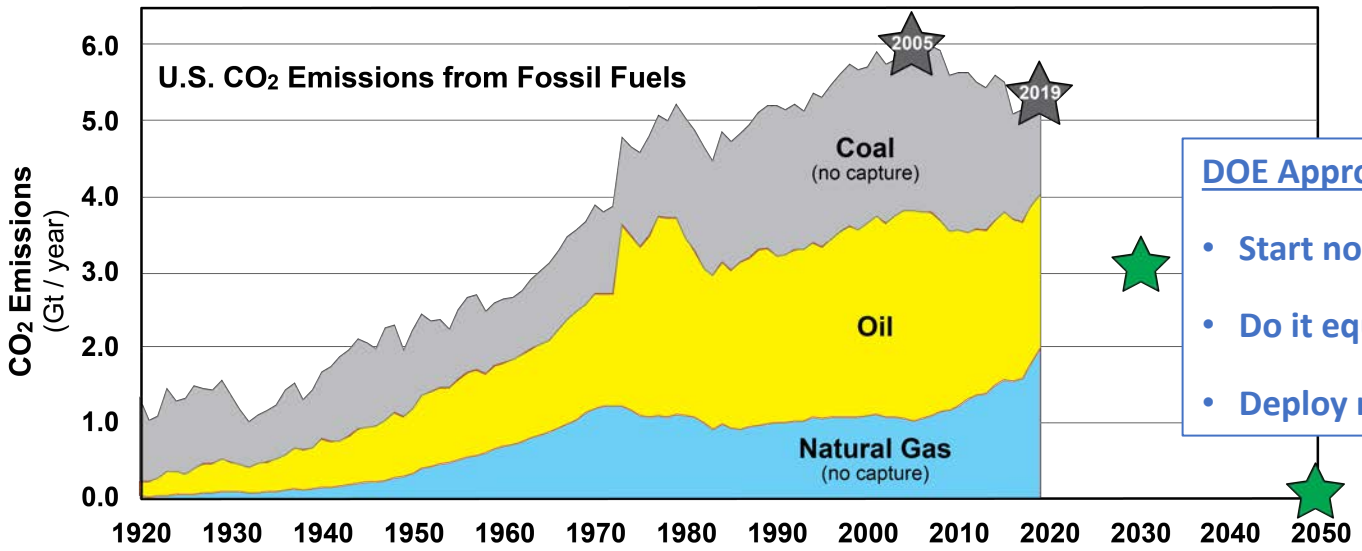
Economic Opportunities



I-WEST

Regional Action

National Goal



DOE Approach to Transition

- **Start now**
- **Do it equitably**
- **Deploy regionally**

I-WEST is a place-based initiative—the options will be defined by regional needs.

Place-based Principles to Accelerate Deployment of New Carbon-neutral Technologies

Research/technology portfolio is **driven by community needs** and includes innovative use of low-tech solutions

↓

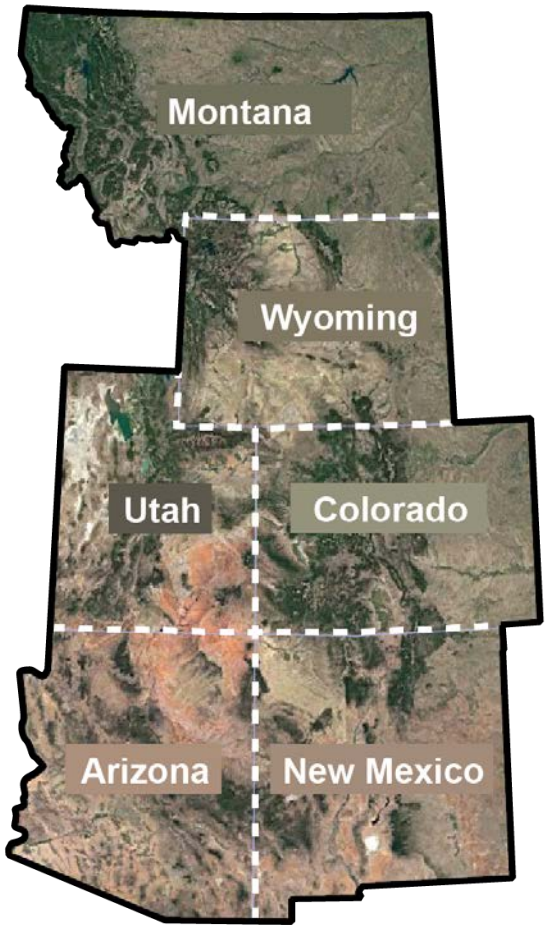
Community integrated, de-risked technology demonstrations—**driven by community needs**, not by technology

↓

Expanded impact in response to the needs of a broader set of communities

From Liz Doris (NREL/DOE-EERE)—Workshop on Place-Based Activities held for National Lab Directors' Council

A placed-based approach translates national goals to community goals, needs, and expectations.



- National Goal:
  Rapid transition to carbon-neutral economies.

- Local-to-Regional Goals and Needs: ?

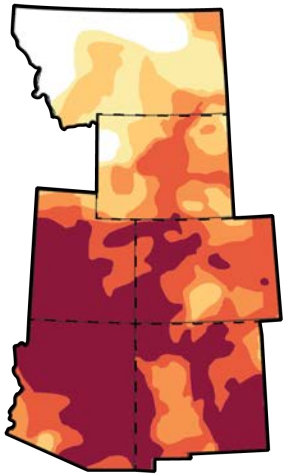
  I-WEST will identify the diversity of goals/needs at the community to state levels, integrating these into a regional perspective.

Intermountain West region has a diversity of attributes.

U.S. Domestic Sovereign Nations

Sources:
Bureau of Indian Affairs
Office of Trust Services
2017
(https://biamaps.doi.gov)

- American Indian Tribes
- Trust or Restricted Fee

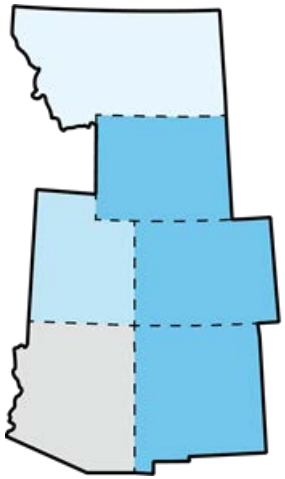


Drying U.S. West

Period: 2020
Source: NASA
Earth Observatory
(http://earthobservatory.nasa.gov)

Drought Intensity

- Abnormally Dry
- Moderate Drought
- Severe Drought
- Extreme Drought
- Exceptional Drought

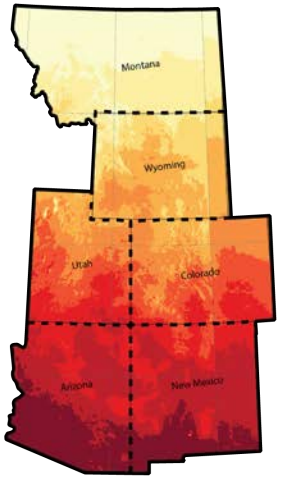


Annual Dry Gas Production

Period: 2019
Source: U.S. Energy Information Administration
(http://eia.gov)

Dry Gas Production (BCF)

- 0
- <100
- 100–1000
- 1000–2000

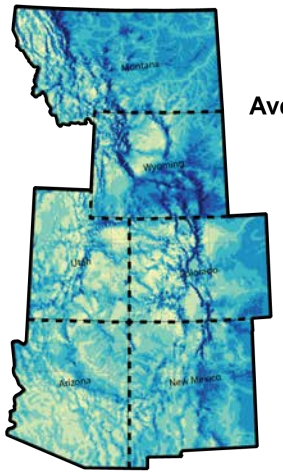


Global Horizontal Solar Irradiance

Period: 1961–1990
Source: Roberts (2018)
(https://www.nrel.gov)

GHI (kWh/m²/d)

- ≥5.75
- 5.50–5.75
- 5.25–5.50
- 5.00–5.25
- 4.75–5.00
- 4.50–4.75
- 4.25 to 4.50
- 4.00 to 4.25

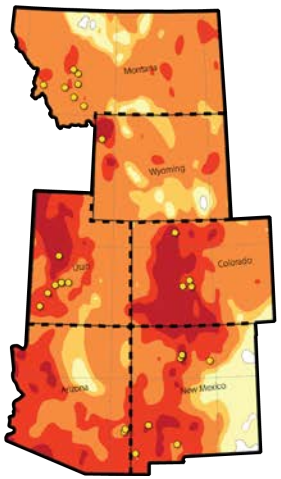


Average Wind Speed
(at 80-m; 2007–2013)

Source:
Roberts (2017)
(https://www.nrel.gov)

Wind Speed (m/s)

- ≥10
- 9.0–9.9
- 8.0–8.9
- 7.0–7.9
- 6.0–6.9
- 5.0–5.9
- 4.0–4.9
- 3.0–3.9
- <3.0



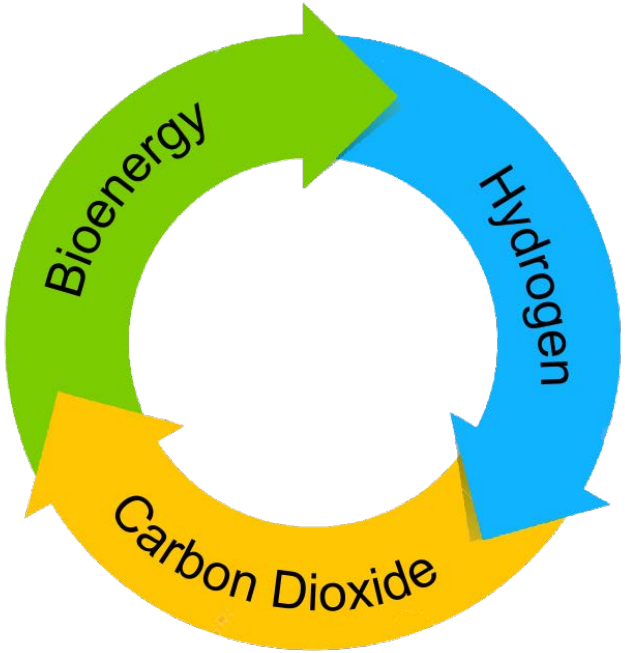
Geothermal Resource Potential

Source:
Roberts (2009)
(https://www.nrel.gov)

Favorability of Deep Enhanced Geothermal Systems

- Most Favorable
- Least Favorable
- N/A (T<150°C @ 10-km depth)
- Identified Hydrothermal Site (≥90°C)

The symbiosis between CO_2, H_2, & bioenergy can accelerate transition to clean-energy economies.



The intermountain west has a diverse set of opportunities tied to CO_2, H_2, and bioenergy.

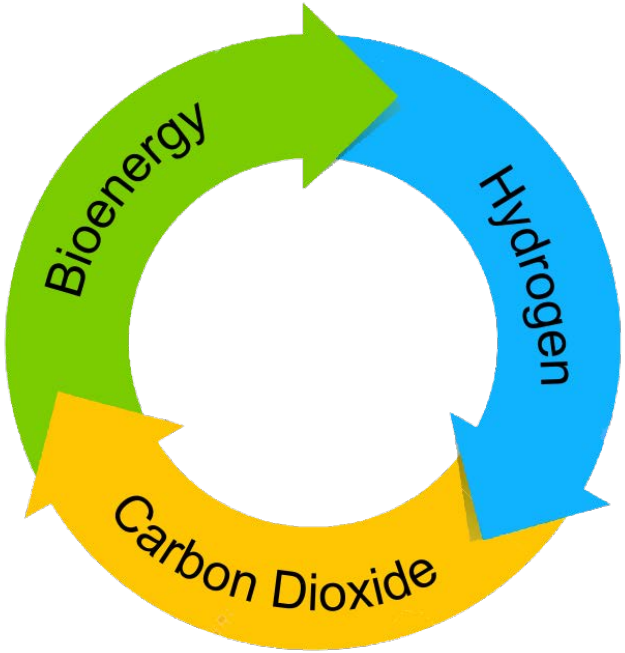
Why Carbon Dioxide?

Why Hydrogen?

Why Bioenergy?

Why highlight symbiosis?

The symbiosis between CO_2, H_2, & bioenergy can accelerate transition to clean-energy economies.



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Why Carbon Dioxide?

- Capturing CO_2 is essential to achieving carbon neutrality, even with rapid deployment of renewables.

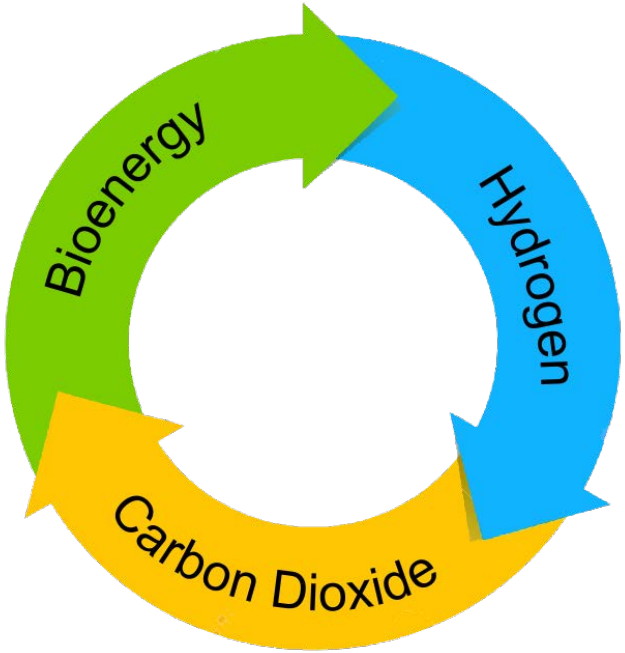
Why is it essential?

- **Transition may develop at slower rates in other countries**
- **Transportation fuels may transition more slowly** (particularly for some applications)
- **Natural gas power is needed for near-term deployment of renewables**
- **Need to address historical emissions** (e.g., via direct air capture)
- **Point source capture is a near-term option—existing facilities could be made clean quickly** (2030 goal vs. 2050 goal)

Opportunity

- **Capturing CO_2 can generate a new economy and could enable hydrogen & biofuels** (symbiotic economies)

The symbiosis between CO_2, H_2, & bioenergy can accelerate transition to clean-energy economies.



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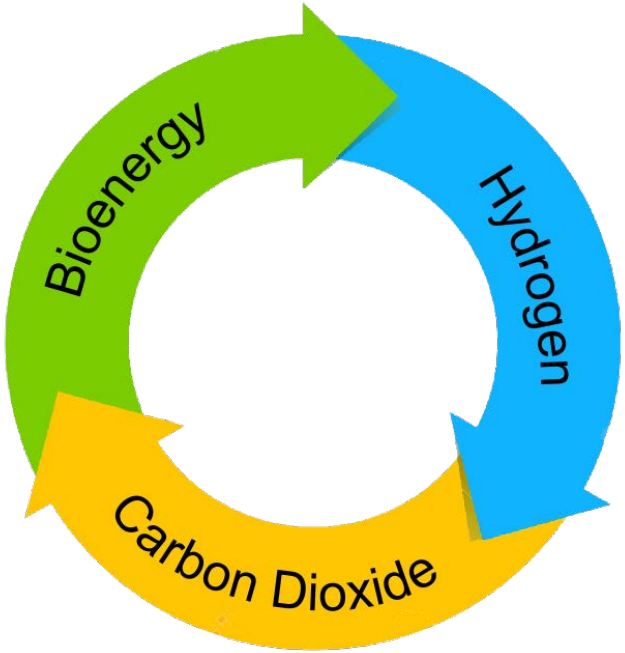
Why Hydrogen?

- Production of carbon-neutral H_2 from various sources enables sustainable end uses—power, transportation, products

We can't use sun's energy (photon) directly.

photon → **electron** (electricity) + **proton** (hydrogen)

The symbiosis between CO_2, H_2, & bioenergy can accelerate transition to clean-energy economies.



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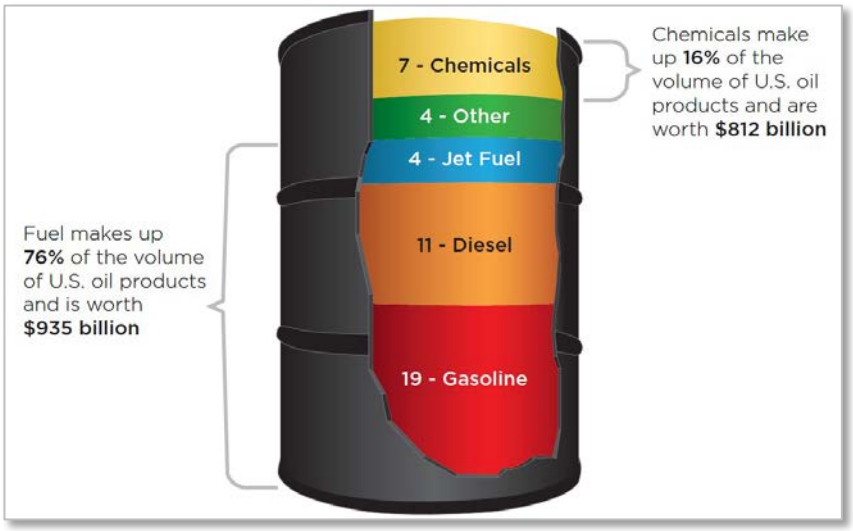


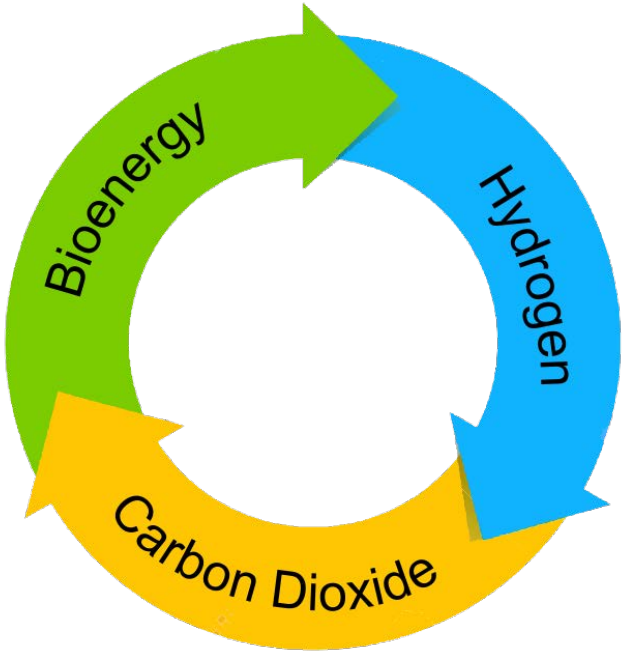
*

Why Bioenergy?

- Biological pathways (e.g., via algae) can lead to carbon-neutral replacements for many fossil-derived fuels and products.

*Figure from DOE Workshop on "Bioproducts to Enable Biofuels Workshop in Westminster, Colorado", July 2015

The symbiosis between CO_2, H_2, & bioenergy can accelerate transition to clean-energy economies.



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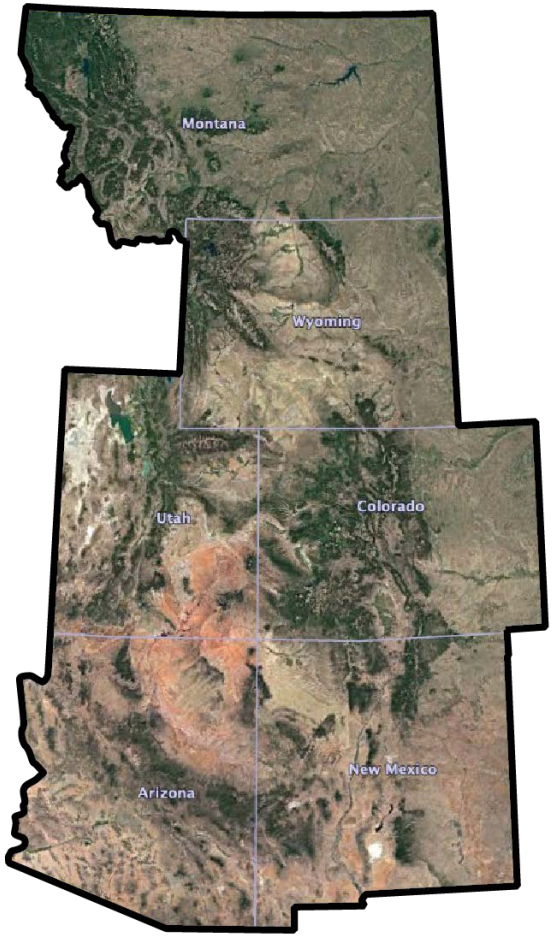
- Biological pathways (e.g., via algae) can lead to carbon-neutral replacements for many fossil-derived fuels and products.

Why highlight symbiosis?

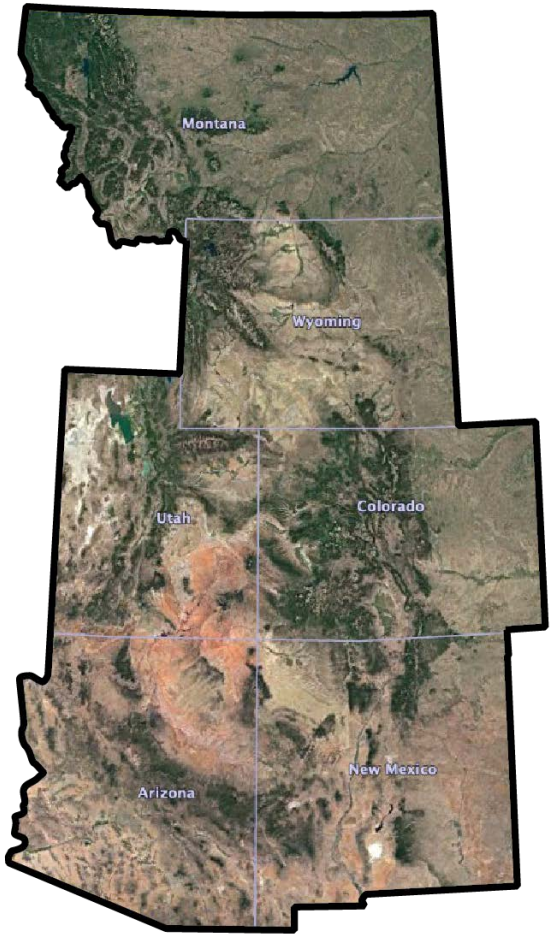
- Energy systems are interdependent. Exploiting symbiotic economies can accelerate deployment.

Our first step is to build a regional perspective on options for transitioning to carbon neutrality.



- Objectives
  - To develop a stakeholder-informed regional technology roadmap that transitions the Intermountain West to a carbon-neutral and sustainable energy economy.
  - To build a regional coalition that can facilitate and implement deployment of the roadmap within the next 15 years.
- Focus
  - Outreach and engagement (communities, states, sovereign nations)
  - Regional technology options
  - Regional impacts
  - Integration

Comprehensive regional outreach is central to our Phase 1 objectives.



Community Outreach Strategy

- Engage stakeholders through workshops, surveys, and other outreach to identify expectations—needs, goals, concerns—at the community through regional scales (summer through fall 2021).
- Develop stakeholder coalitions to explore regional technology solutions that align with expectations. Coalitions will be developed through topical workshops and other outreach (fall 2021 through spring 2022).
- Actively seek/explore other regional outreach opportunities.
- Communication facilitated through I-WEST website (www.IWEST.org to be launched late July).

Anticipated Outcomes from Phase 1

- Deployment timelines are assessed for various relevant technology options for CO_2, H_2, biofuels/products. Key component will be options that can deploy near-term (today!) while *en route* to an ultimate goal.
- Regional capacity is built, as needed, for rapid deployment.
- Public report is released, detailing options, timelines, R&D gaps, etc.

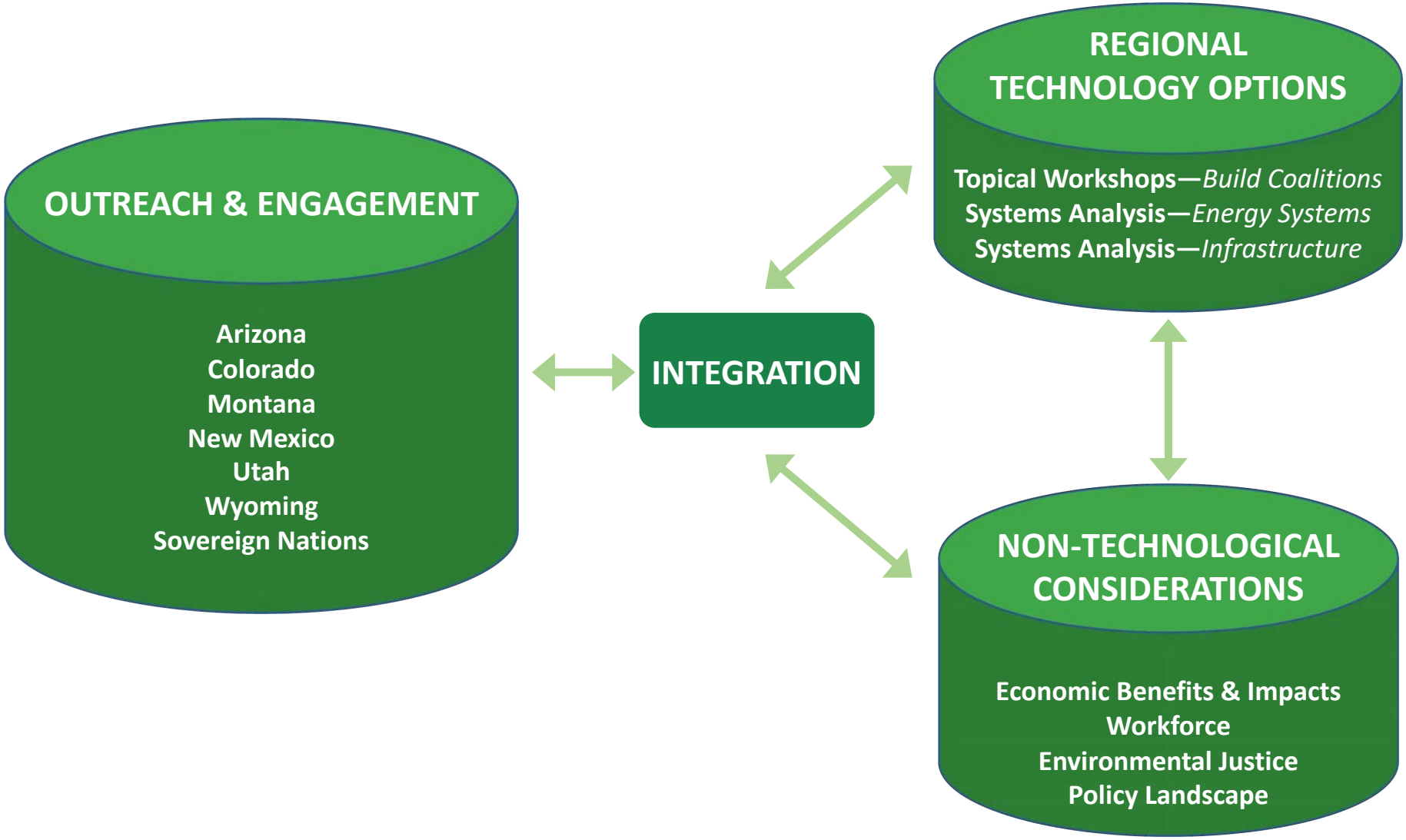
*Example Timeline (draft) for a CO_2 Economy**

	5-year	10-year	15-year
Goal	**30 Mt CO_2/yr**	**100 Mt CO_2/yr**	**300 Mt CO_2/yr**
Capture	• 5–10 point sources deploy (amine-based) • Biomass co-firing at selected point sources deploys • Algae ponds deploy	• 30–50 point sources deploy (amines plus new technology) • Biofuels/bioproducts deploy	• Point sources continue (amines plus new technology) • Direct air capture deploys (at >100 $MtCO_2$/yr)
Utilization	• Vertical agriculture deploys • Geologic storage deploys • Brine recovery deploys • CO_2-EOR deploys	• Biofuels/bioproducts deploy • Compressed gas (CO_2) energy storage deploys	• Synthetic fuels/feedstocks deploy • Mineralization deploys with CM recovery • CO_2 geothermal deploys

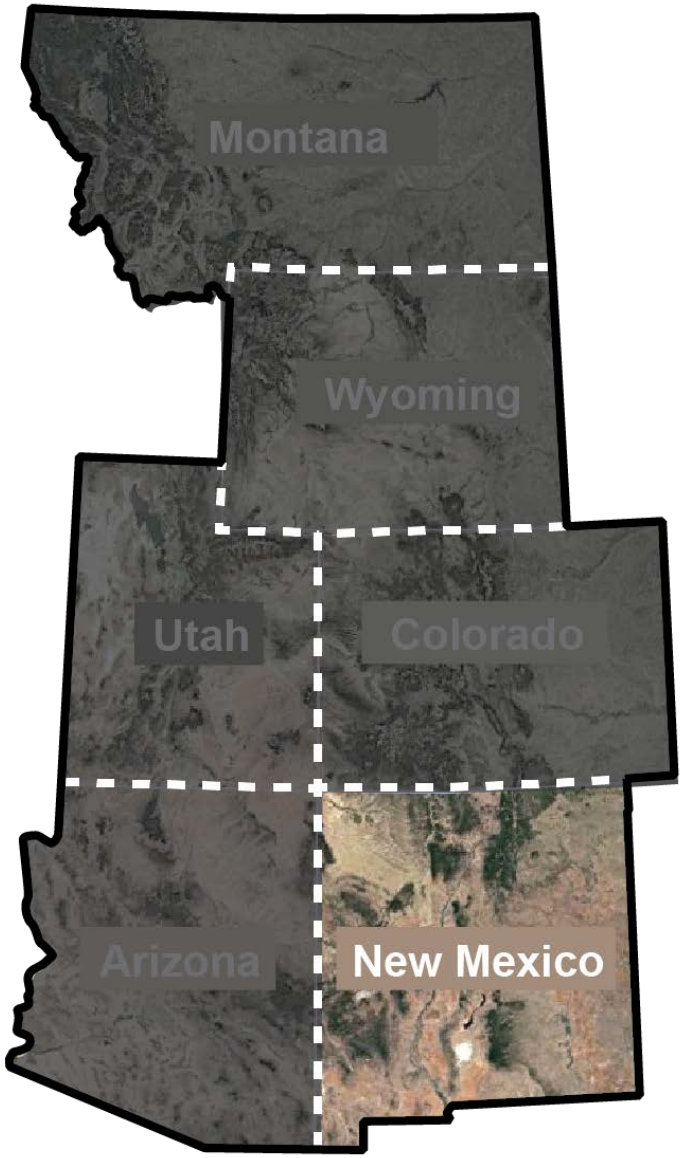
**Based on LANL's preliminary analysis of the Four Corners states (AZ, CO, NM, UT).*

Preliminary Table of Contents for Public Report

The I-WEST phase I assessment will be organized around three pillars for a regional strategy.



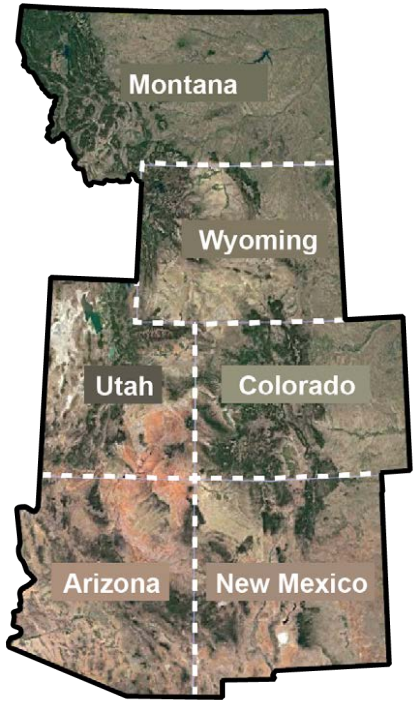
New Mexico and I-WEST



- Diversity of energy resources
- Impacted communities
- Diverse energy leadership
- Opportunity to drive transition

I-WEST wants to engage stakeholders broadly.

- Immediate inquiries may be sent via email to iwest@lanl.gov
- Online presence coming soon at www.iwest.org



I-WEST TEAM

States / Nations

- Arizona State University
- Colorado School of Mines
- Montana State University
- New Mexico Tech
- University of Utah
- University of Wyoming
- San Juan College

Benefits and Impacts

- Resources for the Future
- University of New Mexico
- National Energy Technology Lab.

Topical/Technical Workshops

- Los Alamos National Lab.