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Intermountain West Energy Sustainability & Transitions

A Place-based Approach to Achieving Carbon Neutrality in the Intermountain West

USEA Workshop on Models for Deployment of CCUS Hubs

30 September 2021

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In 2019, Los Alamos initiated a study for DOE-FE on the potential of a CO_2 economy to accelerate capture in the Four Corners states.

Key conclusions:

- **Develop/exploit a CO_2 economy (i.e., supply–demand)**
  - A portfolio of CO_2 use (demand) in the region could create a "pull" for CO_2 capture (supply)
  - A sustainable economy will require a portfolio of capture that goes beyond point sources
- **CO_2 economy is <u>symbiotic with a hydrogen economy</u>**
  - ★ Production of low-carbon liquid fuels could provide a demand for direct air capture of CO_2 (CO_2 acts as a "carrier" for hydrogen…i.e., hydrogen storage platform)
  - ★ Production of hydrogen from methane requires CO_2 capture low-carbon liquid fuels could provide a demand for direct air capture of CO_2

Potential "Conventional" CO_2 Economy in Four Corners (@ 300 Mt/yr)

$15B

CO_2 Supply ⟷ **CO_2 Demand**

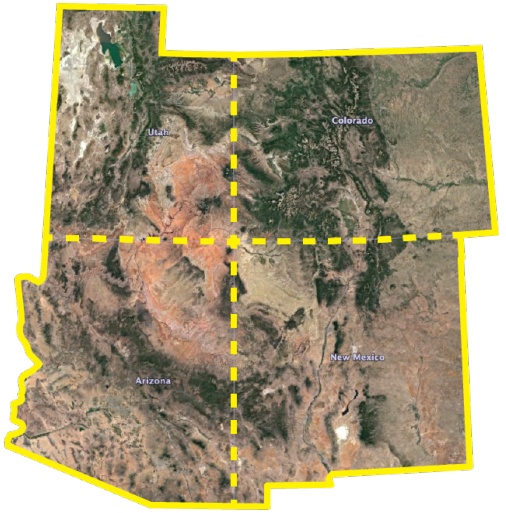
★ Point source capture

- Geologic storage

$75B

- Enhanced oil recovery
- Low-water agriculture
- CO_2 enhanced geothermal
- Direct air capture
- ★ Low-carbon fuels/products

Potential Expanded CO_2 Economy in Four Corners (@ 300 Mt/yr)



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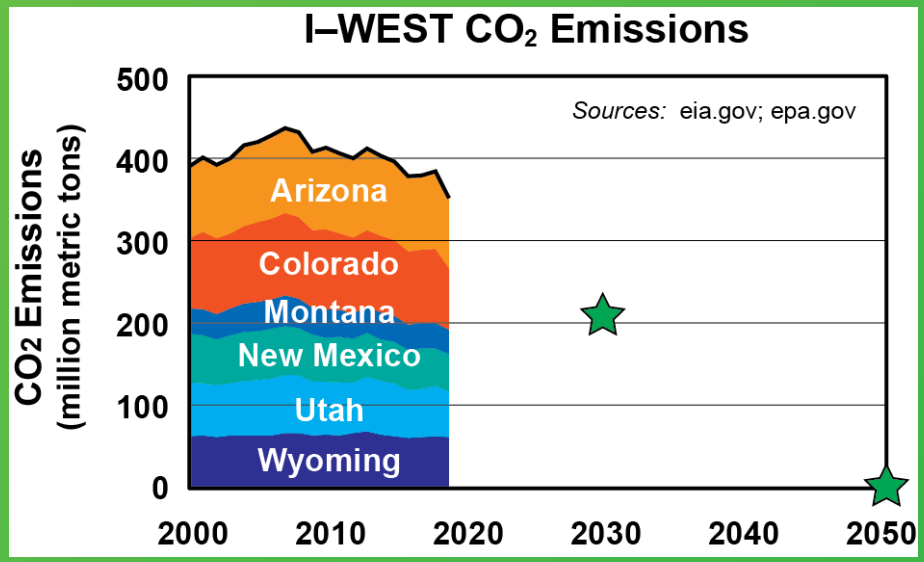
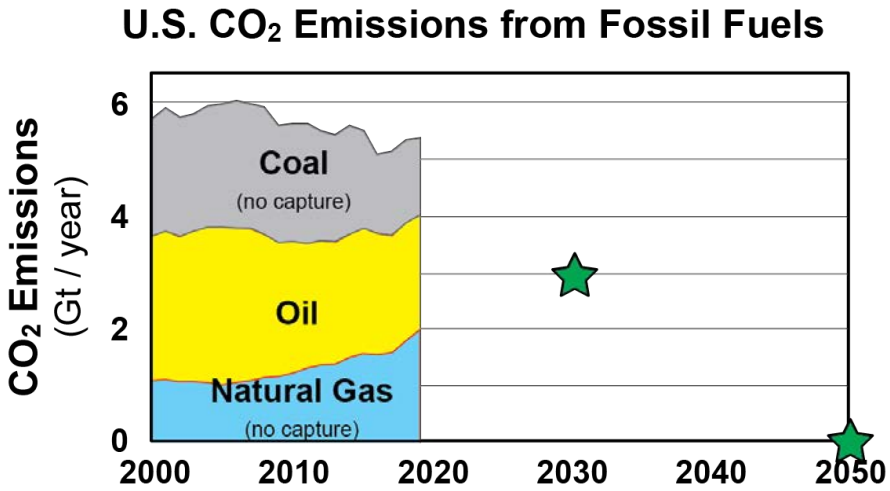


Regional Action

↑ *Place-based*

National Goal



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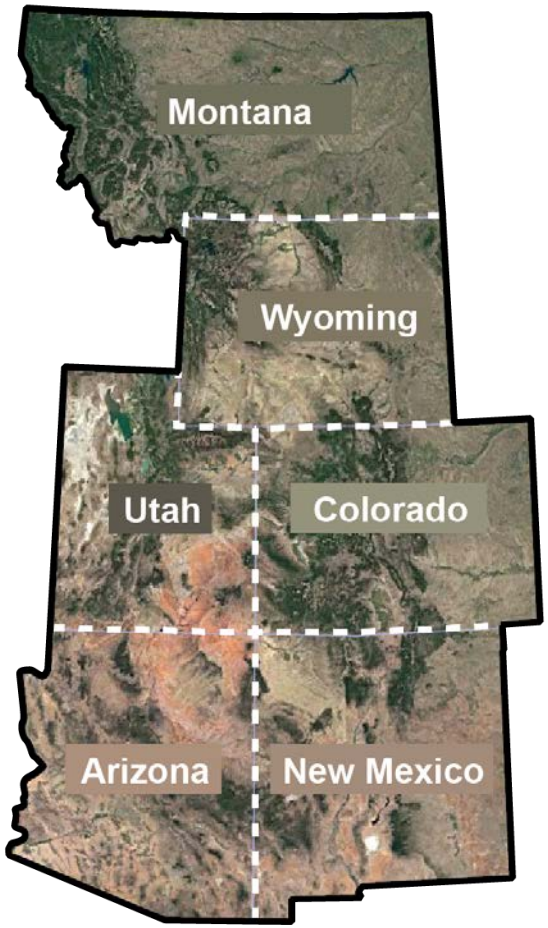
A placed-based approach translates national goals to community goals, needs, expectations, & action.



National Goal:

Rapid transition to carbon-neutral

Local/Regional Action Plan: ?

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

- **"Place-based" lets regional characteristics drive technology solutions**
  - Starts with region not technologies
  - Includes an innovative use of low-tech options

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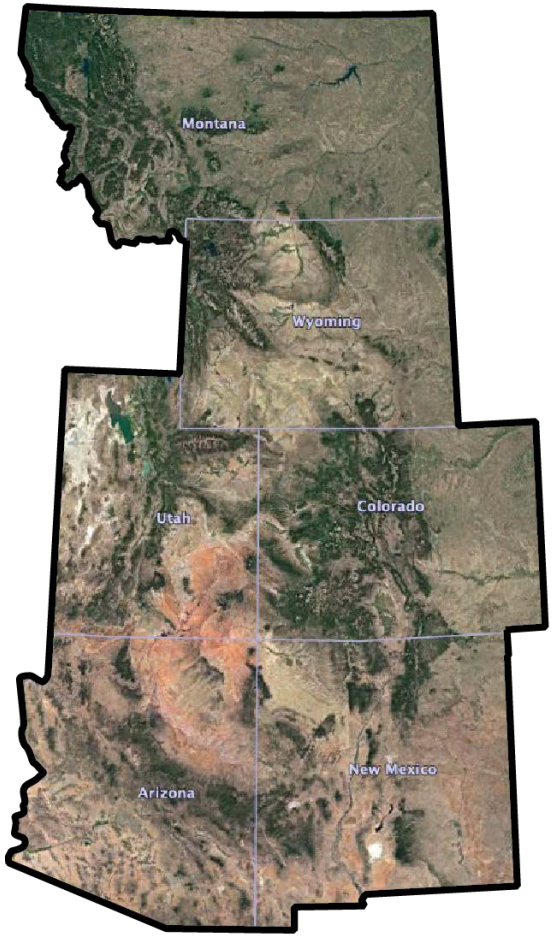
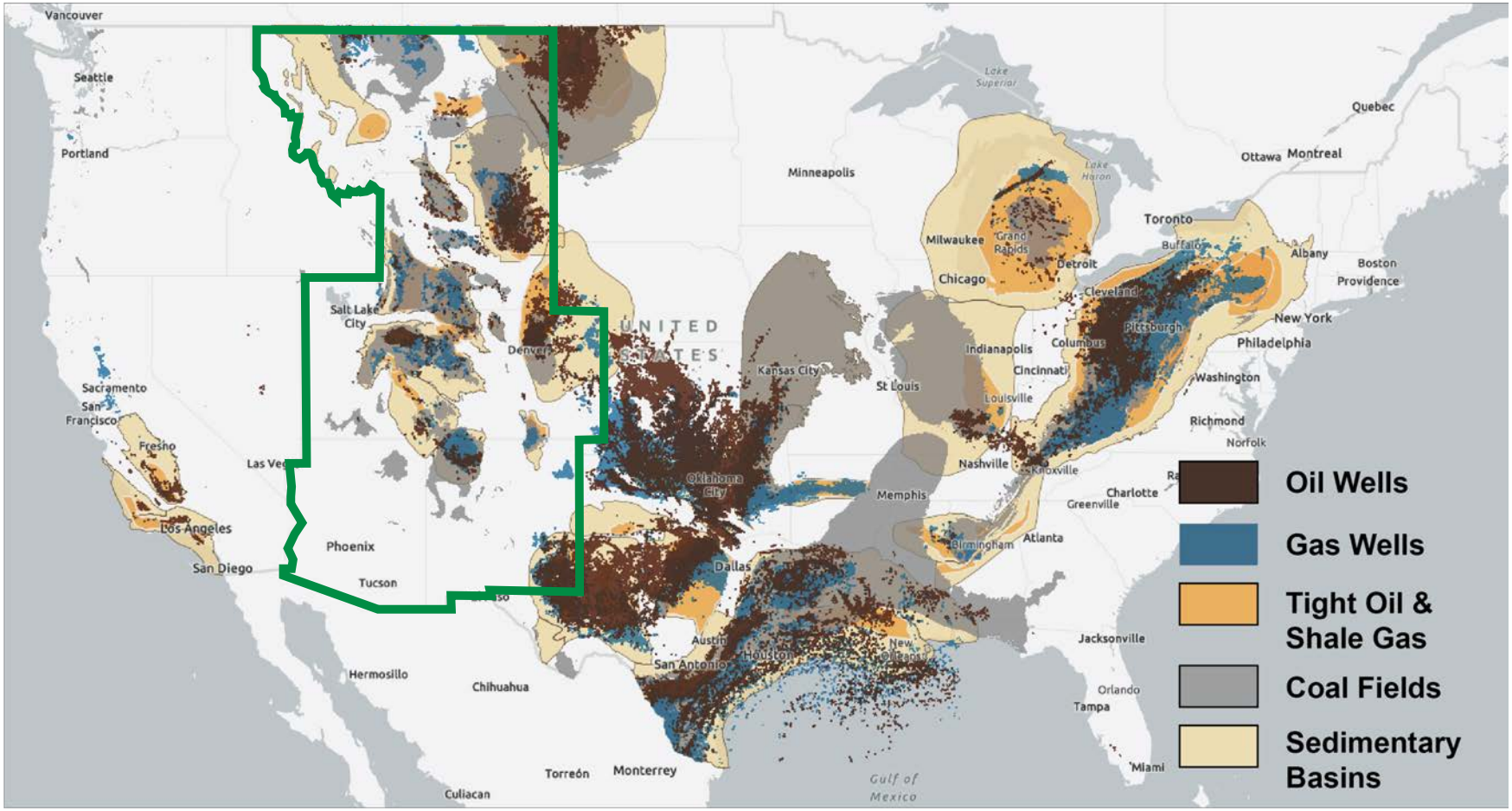
Our first step is to build a regional perspective on options for transitioning to carbon neutrality.



- **Objectives**
  - To develop a stakeholder-informed regional technology roadmap that transitions the Intermountain West to a carbon-neutral and sustainable energy economy.
  - To build regional coalitions 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

I-WEST is a region with communities dependent on fossil-based economies.



U.S. Fossil Fuel Resources (atlas.eia.gov)

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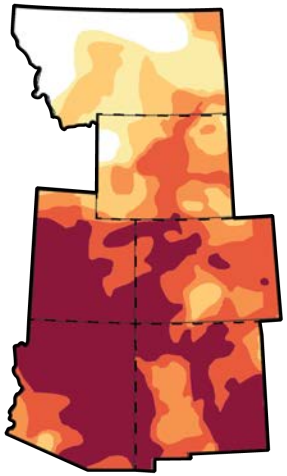
Intermountain West region has a diversity of attributes.

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

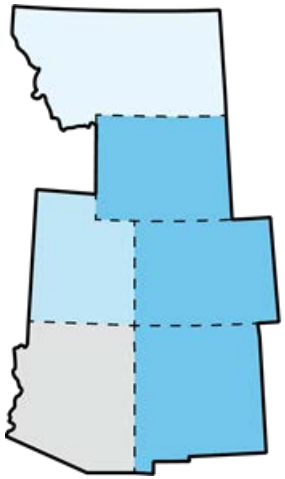


Drying U.S. West

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

Drought Intensity

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

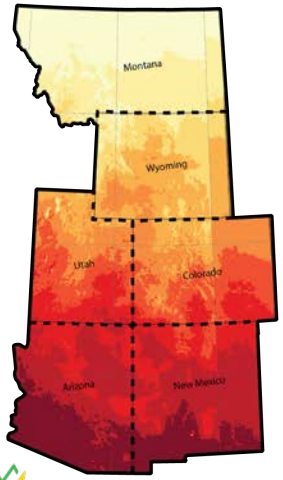


Annual Dry Gas Production

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

Dry Gas Production (BCF)

- 0
- <100
- 100–1000
- 1000–2000

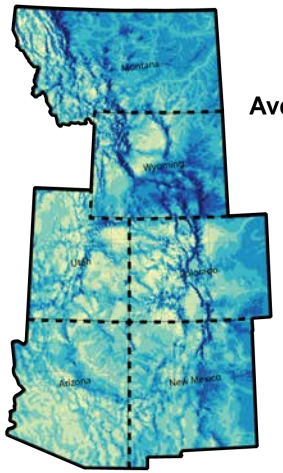


Global Horizontal Solar Irradiance

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

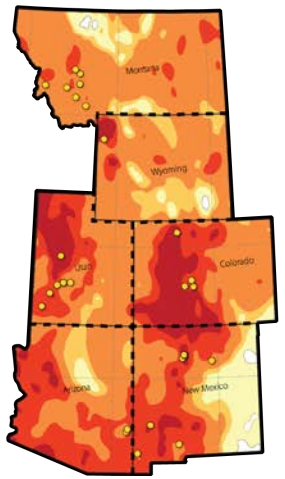


Average Wind Speed
(at 80-m; 2007–2013)

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)

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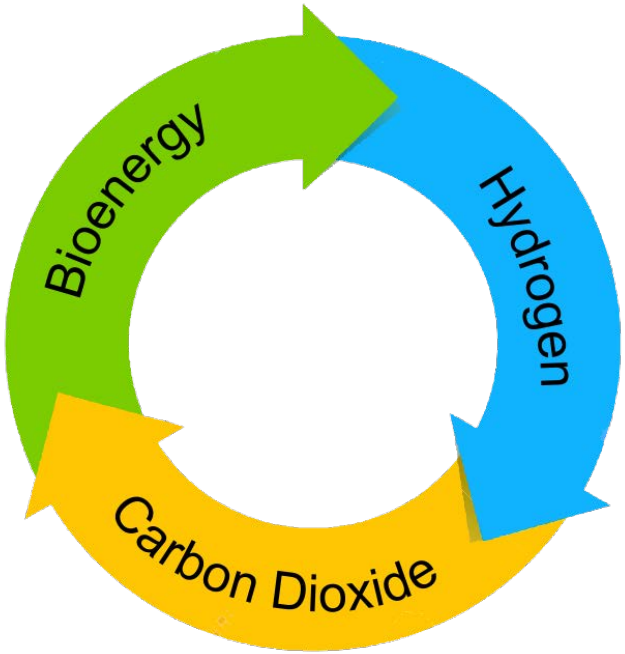
The symbiosis between CO_2, H_2, bioenergy, and electricity can accelerate transition to clean-energy economies.



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?

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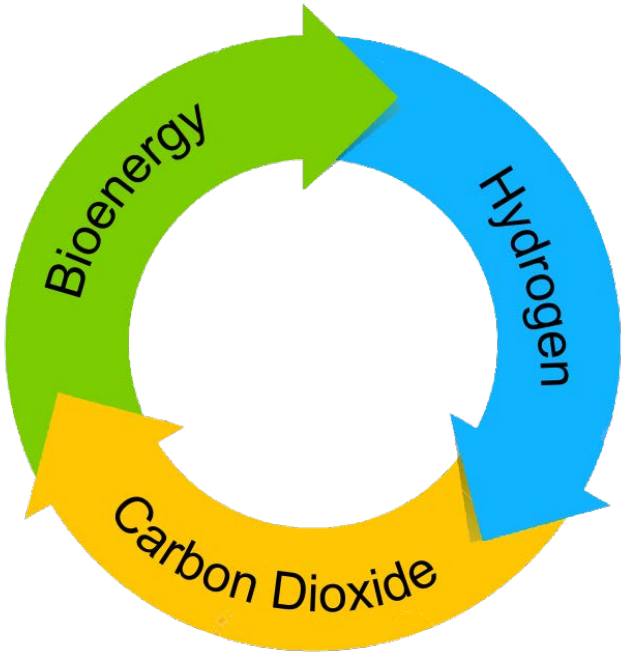

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Why Carbon Dioxide?

- 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)

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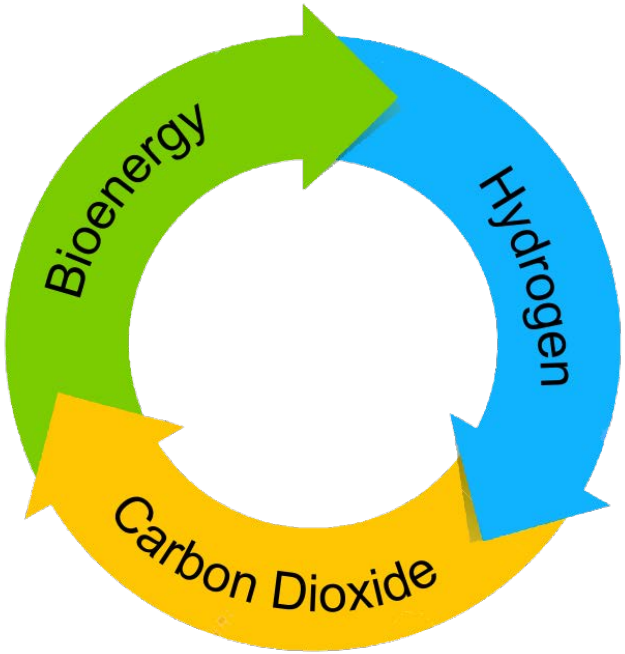

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Why Carbon Dioxide?

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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)

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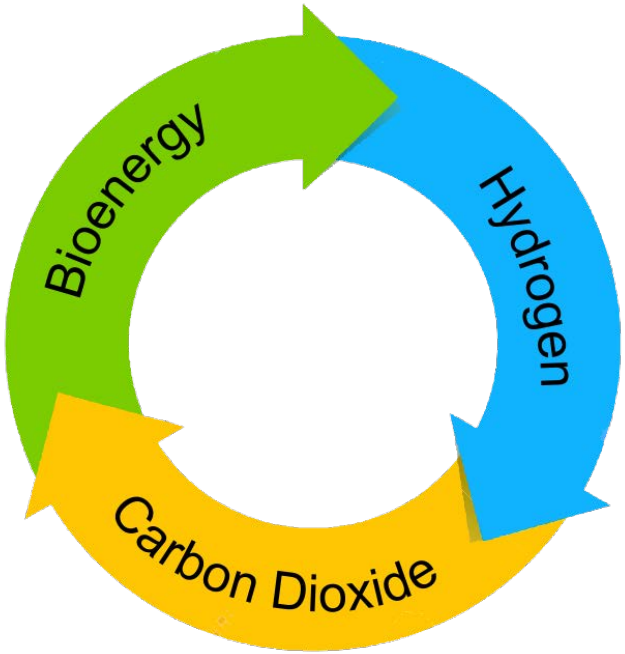

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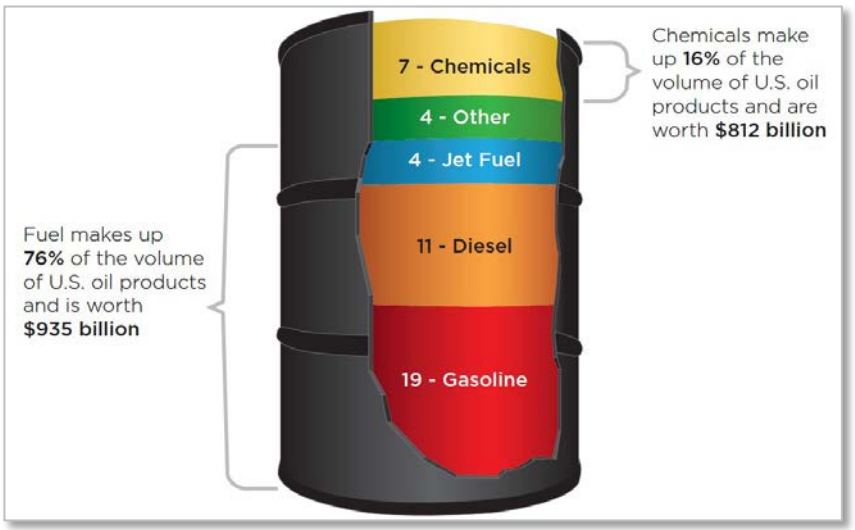

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Why Bioenergy?

- 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

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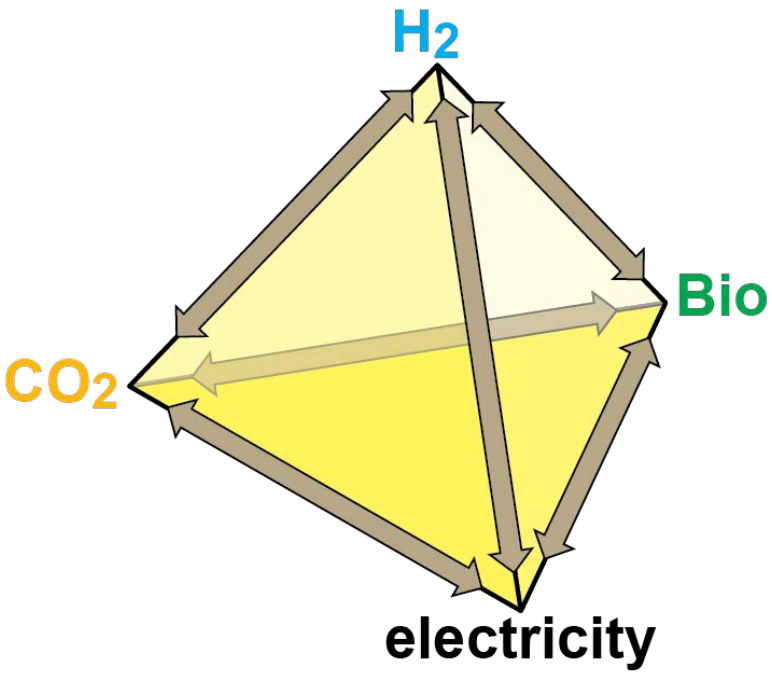

Electricity generation is also central to the I-WEST energy strategy.

Why Carbon Dioxide?

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

Why Hydrogen?

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

Why Bioenergy?

- 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.

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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.

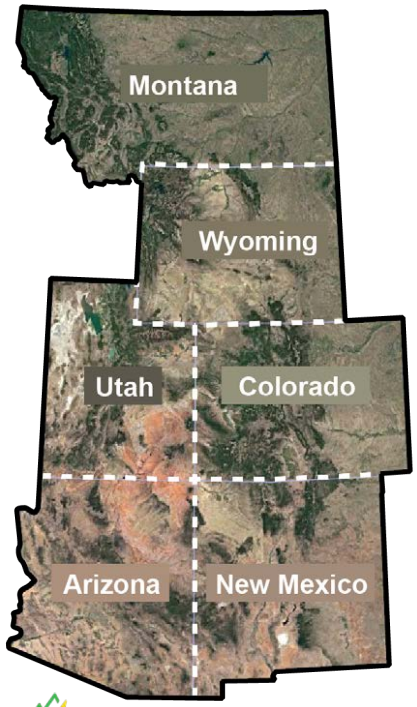
*Example Timeline (draft) for a CO_2 Economy**

	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).*

I-WEST wants to engage stakeholders broadly.

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



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I-WEST TEAM

Leads for States & Tribal Nations

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

Leads for Benefits and Impacts

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

Lead for Topical/Technical Workshops

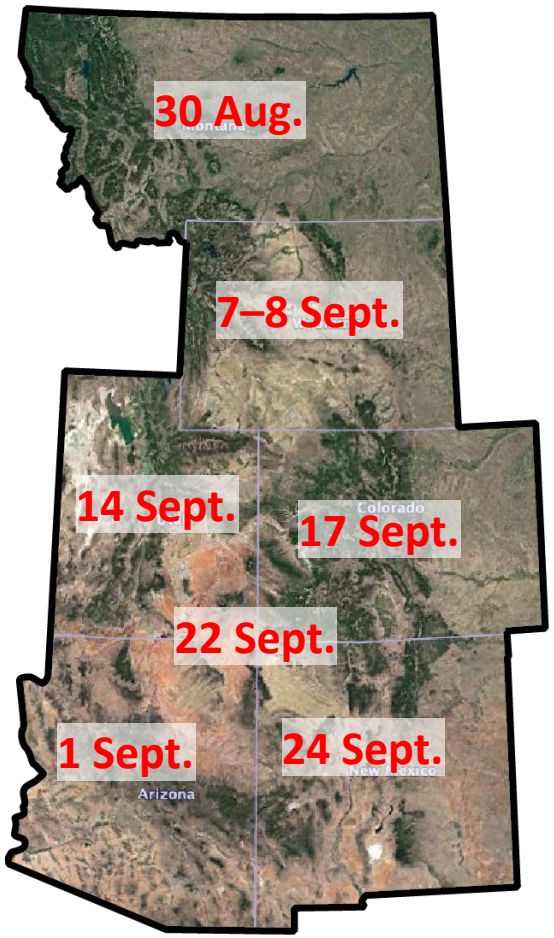
- Los Alamos National Lab.

I-WEST Sponsor

- U.S. Dept. of Energy

Comprehensive regional outreach is central to our Phase 1 objectives.

Initial state-focused workshops were held in late summer 2021.



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).

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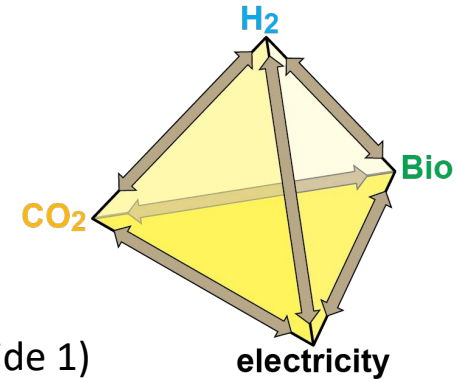
I-WEST Summary



- ***Project Scope—***Phase I assessment and coalition-building (slide 4); intermountain west (slides 3, 6, 7); 62 Sovereign Nations and other impacted rural communities; symbiosis between CO_2 , H_2 , bio, e^- (slide 8)
- ***Partners—***LANL (lead), ASU, CSM, MSU, NMT, RFF, SJC, UNM, UU, Uwyo (slide 1)
- ***Financing—***DOE (Office of Fossil Energy & Carbon Management; EERE, OE)
- ***Timeline—***Summer 2021 through fall 2022 (slide 15)
- ***Are you leveraging existing infrastructure?—***Assessment will explore existing and new infrastructure
- ***Are you pursuing Class VI well permitting, if so how far along are you?—***Several projects within the I-WEST region are exploring field efforts and permitting. I-WEST assessment will look at existing policy landscape, including class VI and primacy.
- ***What are your plans for community engagement—***Community input and coalition building via workshops (slide 15), surveys, interviews, etc.
- ***What are the EJ concerns?—***Numerous Sovereign Nations and other rural communities that have fossil-based economies (workforce/jobs and revenue/tax base); historical environmental impacts and water availability pose EJ considerations that will be incorporated into transition strategy.
- ***Have you estimated job creation?—***Workforce impacts will be part of the assessment.