Decarbonizing the Intermountain West

(I-WEST: Intermountain West Energy Sustainability & Transitions)

Project LANL-AE-388-361

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LA-UR-22-28289

U.S. Department of Energy

National Energy Technology Laboratory
Carbon Management Project Review Meeting
August 15 - 19, 2022

Project Overview: DOE's I–WEST initiative is looking at strategies and pathways for equitable transition to carbon neutrality

Two Primary Objectives

- Develop a stakeholder-based roadmap to achieve carbon neutrality
- Build regional coalitions to deploy the roadmap

Place-based Approach

- Prioritize regional attributes and societal readiness first, and technologies second
- Explicitly consider non-technological aspects of region—policy landscape, revenue and jobs, workforce, equity, energy & environmental justice

Multiple Technologies and Multiple (Symbiotic) Economies

- Carbon capture, utilization, and storage; clean hydrogen; bioenergy; and low-carbon electricity

Phase I Team

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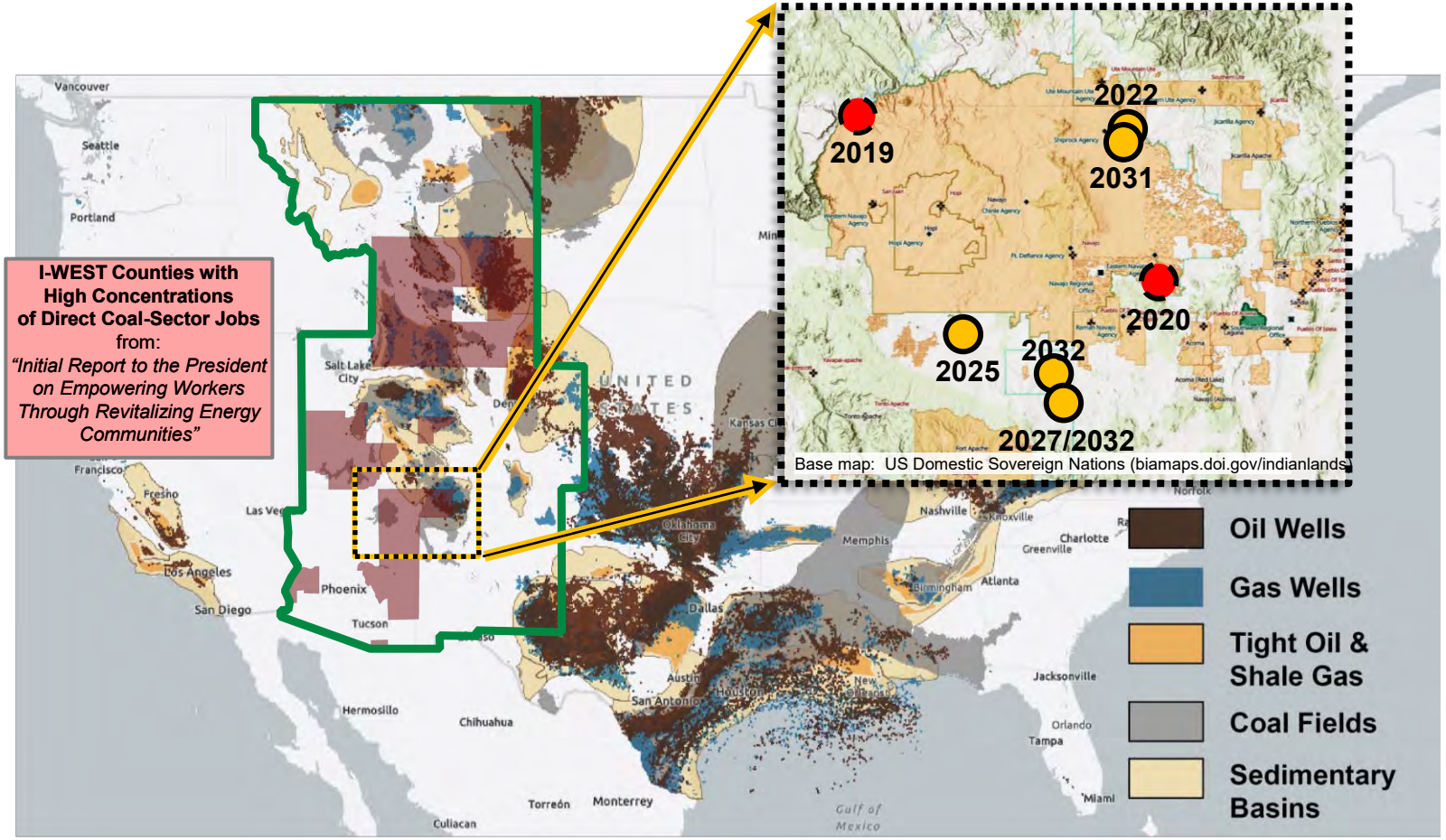
Visit iwest.org for more detail and archived material from workshops or email iwest@lanl.gov

Project Funding and Period of Performance

- DOE-FECM: $3,275.5k; DOE-EERE/BETO: $375k
- POP: 1 May 2021 through 31 December 2022

Project Overview: The I-WEST region is focused on communities dependent on fossil-based economies

The Four Corners area exemplifies the current impacts already occurring in the I-WEST region due to the closing of coal powerplants



Base map: U.S. Fossil Fuel Resources (atlas.eia.gov)

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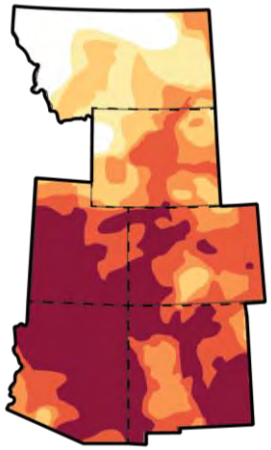
Project Overview: The I-WEST region has diverse attributes that inform energy transition strategies

U.S. Domestic Sovereign Nations

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

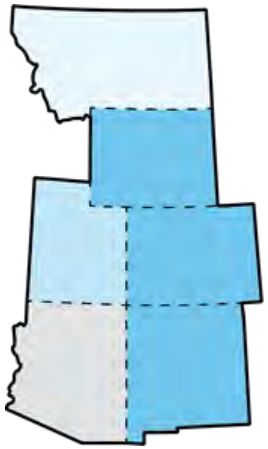
American Indian Tribes
Trust or Restricted Fee



Drying U.S. West

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

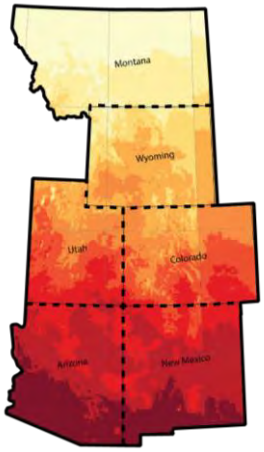
Drought Intensity
- Abnormally Dry
- Moderate Drought
- Severe Drought
- Extreme Drought
- Exceptional Drought



Annual Dry Gas Production

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

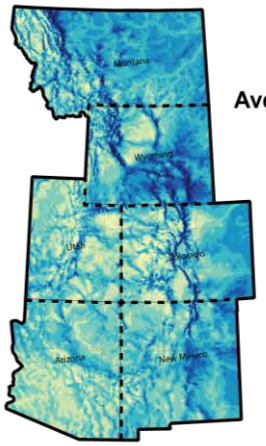
Dry Gas Production (BCF)
- 0
- <100
- 100–1000
- 1000–2000



Global Horizontal Solar Irradiance

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

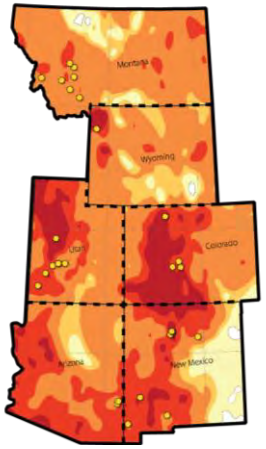
GHI (kWh/m²/d)
- ≥5.75
- 5.50–5.75
- 5.25–5.50
- 5.00–5.25
- 4.75–5.00
- 4.50–4.75
- 4.25 to 4.50
- 4.00 to 4.25



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)

4

The new energy infrastructure and economies must anticipate the evolution of the region in response to climate change.

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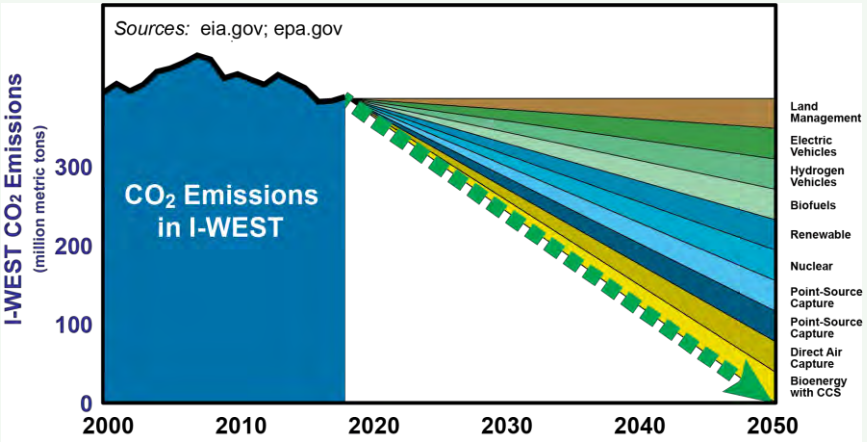
Background: I-WEST is pursuing a regional roadmap that can be described in two complementary ways

Pathways to carbon neutrality that are regionally relevant



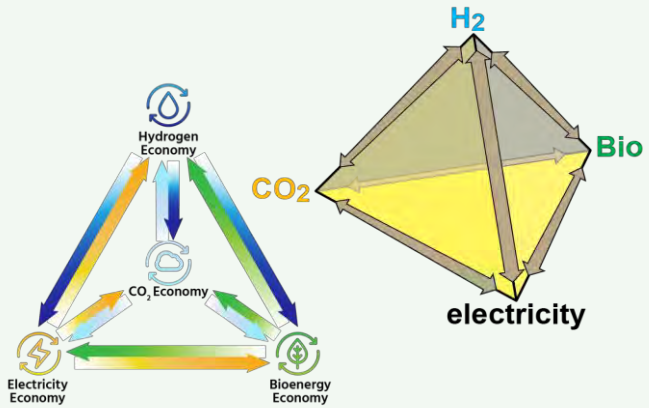
Multiple technologies (wedges) will be needed to achieve carbon neutrality in the I-WEST

- No single wedge is sufficient to achieve goal (similar conclusion as IPCC's on the global level)

Individual communities are each developing their own unique strategies

- I-WEST assessment is looking at wedges from both the bottom up and top down

Development of new, symbiotic economies that are regionally relevant



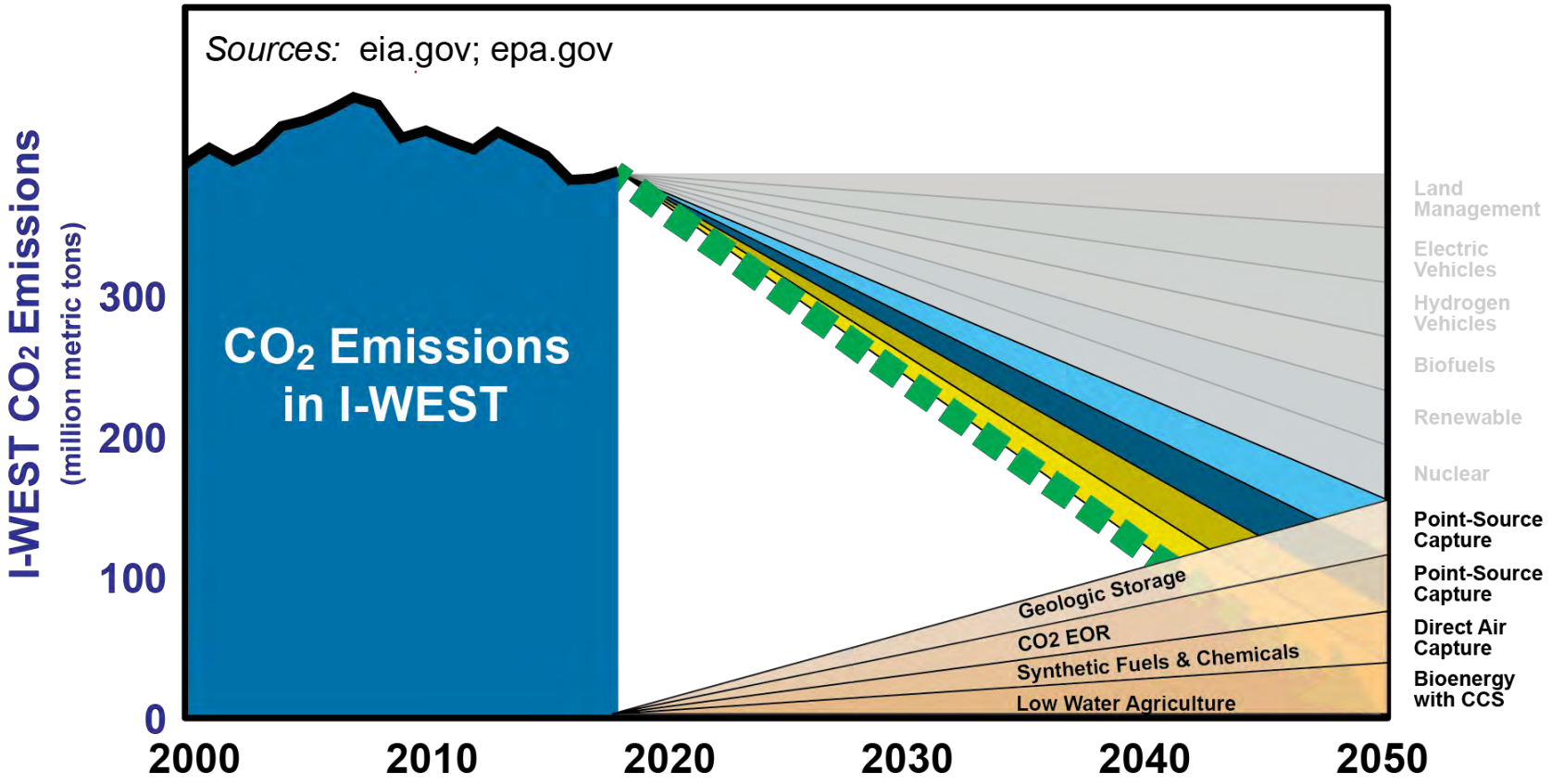
Potential new energy economies based on:

- Capture (supply) and utilization/storage (demand) of CO_2
- Production and generation of low-carbon H_2
- Production and distribution of low-carbon electricity
- Production and utilization of biofuels

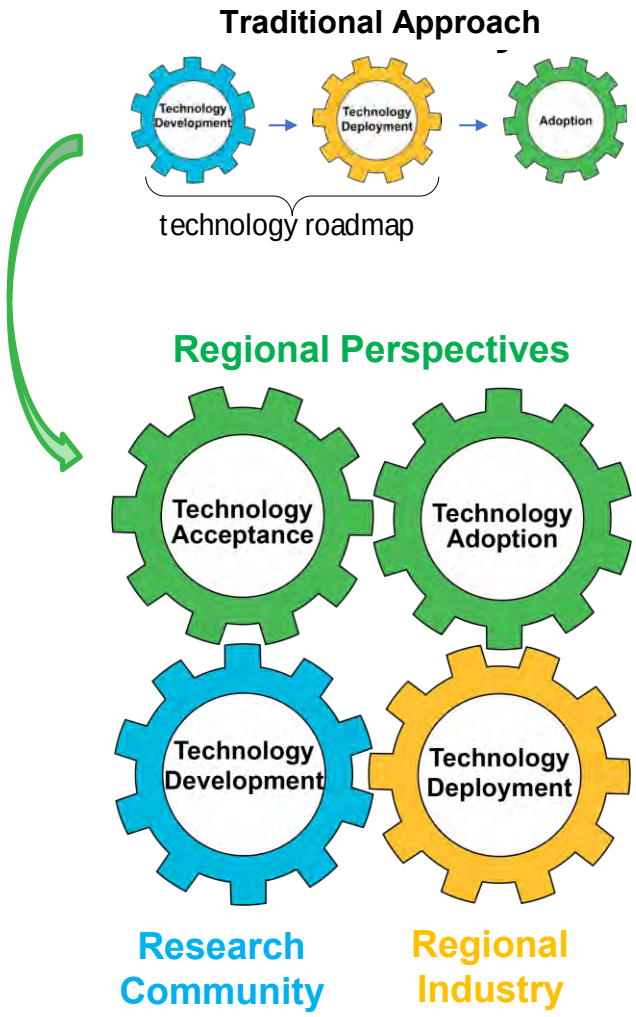
Why emphasize symbiotic economies?

- "Economic" narrative is resonant across region
- Symbiotic economies can accelerate deployment

Background: "Supply" must equal "demand" for each of the symbiotic economies



Approach: As a place-based initiative, I-WEST is rethinking the traditional approach to technology roadmapping



Areas of I-WEST Assessment

- **Economics Landscape**
- **Policy Landscape**
- **Energy, Environmental, & Social Justice Considerations**
- **Community Perspectives**

- **Low-Carbon Electricity**
- **Hydrogen Production and Utilization**
- **Bioenergy**
- **CO_2 Point Source Management**
- **Direct Air Capture**
- **CO_2 Utilization / Storage**

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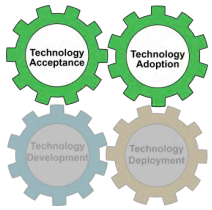
Approach: I-WEST is looking at several nontechnical considerations that impact the regional strategy for transition



J. Chermak
R. Ehrenfeucht

Coordination with other I-WEST partners to identify stakeholders, data, location specific information, and key communities.

Economics Landscape

- To develop a regional understanding of the current landscape of energy economics
- To assess the potential economic impacts to the region due to transition from fossil to carbon neutral

RESOURCES *for the* FUTURE

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Coordination with other I-WEST partners to identify stakeholders, data, location specific information, and key communities.

Energy-Policy Landscape

- Describe policy landscape supporting and impeding energy transition
  - Current landscape for States, Tribes, and Federal
  - Explore themes and ideas for future policies to enable/accelerate the transition

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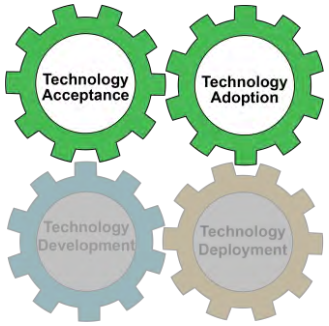
Energy, Environmental, & Social Justice Considerations

- To identify regional considerations important for an equitable transition to carbon neutrality
- To identify community issues re: historical and future impacts of energy economies
- To build justice and equity strategies that converge for the basis of a regional approach

Place-based Approach: I-WEST engaged a broad spectrum of stakeholders in the region to build a place-based understanding



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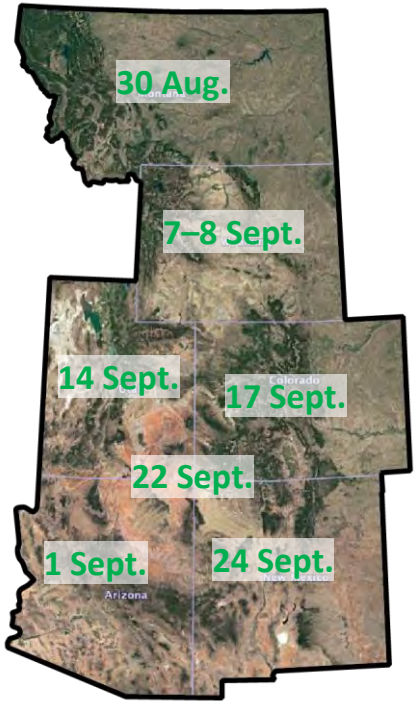
San Juan College	New Mexico Tech	NMSU
Alicia Corbell Steve Grey	Robert Balch	J. Chermak R. Ehrenfeucht

Community Outreach (Place-based)

- Engage stakeholders through workshops, surveys, and listening/learning sessions
  - Identify expectations—needs, goals, concerns; community through regional scale
- Workshops focused on states and Tribal Nations
  - Summer 2021
  - 8 workshops; ~300 participants
- Surveys, listening/learning sessions with individuals and focus groups
  - Ongoing
  - ~ 1100 participants
- Website to solicit input

Place-based Approach & Initial Outcomes: Our first step was regional engagement focused on States and Sovereign Nations

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



Community Outreach Strategy

- Engage stakeholders through workshops, surveys, listening sessions
  - Identify expectations—needs, goals, concerns; community through regional scale

Insights from Initial Workshops

- Negative impacts emerging now
- Commonality in carbon-neutrality goal, but diversity in perspectives on how to get there
  - Shifted from "decarbonization" to "carbon-neutral"
- Extensive emerging activity (projects; state-level)
  - Opportunity for coordination & coalition-building
  - **CO_2 and H_2 are particularly active areas of interest**
- **Focus on water is widespread**
  - Implications for technologies
  - Opportunity for integrating "water" as part of the strategy

Project Catalog
(www.iwest.org)

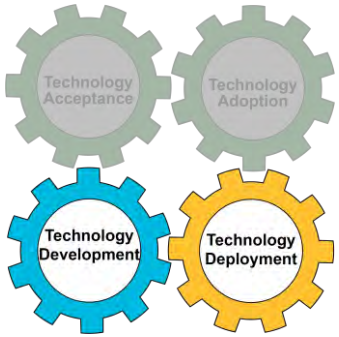
Biomass—Production,, Use/Conversion

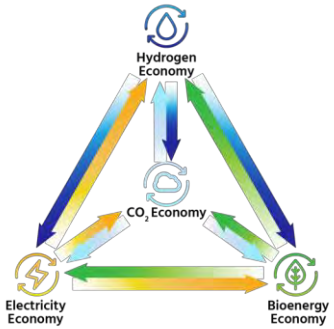
CO_2—Capture, Use, Storage

H_2—Production, Use

Low Carbon Electricity

Technology-pathways Approach: I-WEST engaged a broad spectrum of stakeholders in the region to build a place-based understanding





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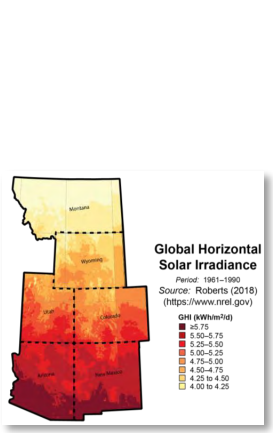
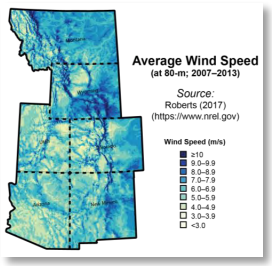
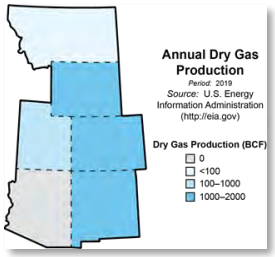
Technology Pathways

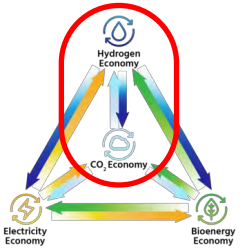
- Engage stakeholders through workshops and listening/learning sessions
  - Identify emerging projects, stakeholder needs/concerns, opportunities
- Workshops focused on pathways aligned with symbiotic economies—technology, policy landscape, economics
  - Initial workshop 11/20/21
  - 10 workshops to date; ~400 participants (not including I-WEST team)
- Listening/learning sessions—akin to Energy I-Corps "stakeholder discovery interviews"
- Preliminary data analysis
  - Scoping analysis of available data
  - Preliminary analysis of CO_2 point sources and CO_2 sinks
  - Leveraging analysis from other projects (e.g., SimCCS)
  - Semi-quantitative "wedge" analysis for emissions reductions—high, medium, low scenarios

Technology-pathways Initial Outcomes: The I-WEST region has a strong interest and emerging activity in both H_2 and CO_2









CO_2 capture is emerging

- Both blue hydrogen and retrofits
- Direct air capture also has strong regional alignment and interest
- **Will the region have sufficient storage capacity?**

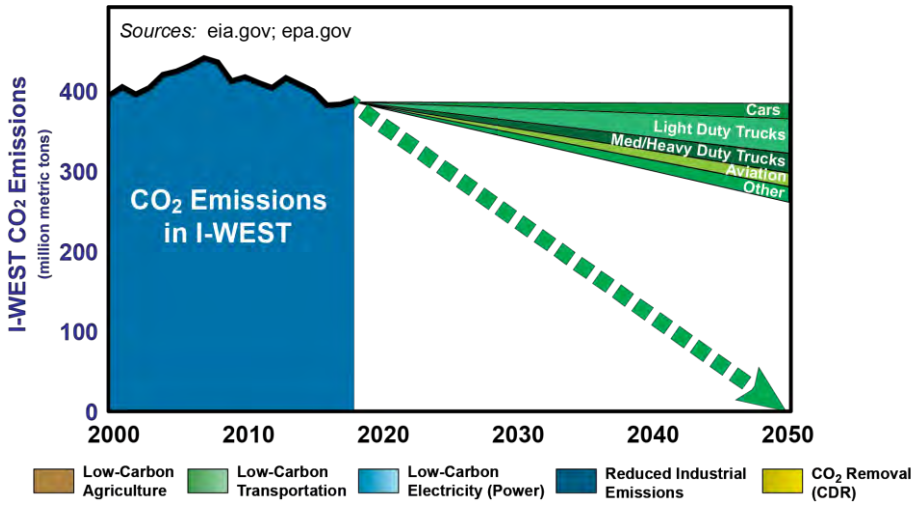
H_2 production is emerging

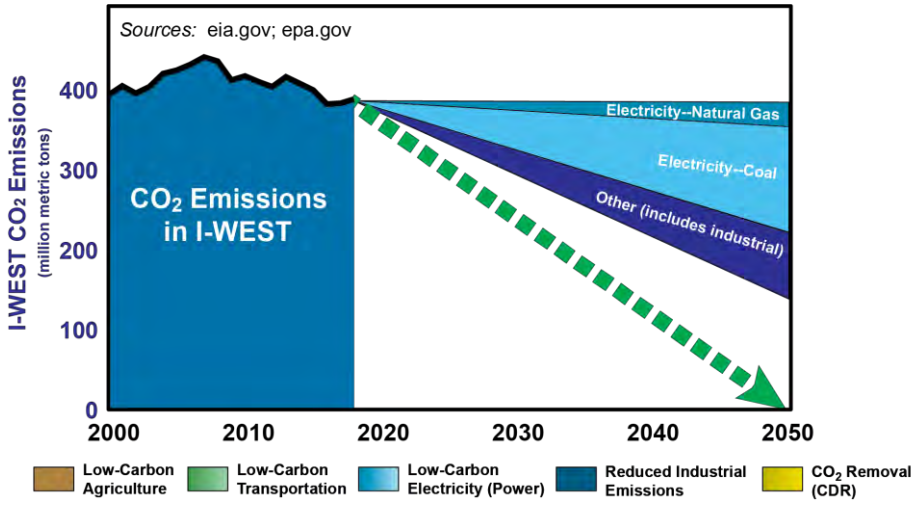
- The region has high potential for wind and solar
- Parts of the region have natural gas resources
  - Fugitive methane is a regional concern
- High solar potential could also be tapped through biomass
- Nuclear is being considered in parts of the region
- **Is blue hydrogen consistent with a regional strategy to lower CO_2 emissions?**

Water concerns are emerging

- **Will new energy technologies be limited by water needs?**

Technology-pathways Initial Outcomes: Our initial approach to technology pathways is to ask "How big could the 'wedges' become?"





Transportation

(Heidlage & Semelsberger, LANL)

- Based on EPA emissions data, analysis of fuel needs and emissions for registered vehicles in region, state highway department data on interstate highway traffic
- No life-cycle analysis (next phase)
- Possible regional pathways include battery electric vehicles, fuel-cell electric vehicles, biofuels

Point-source

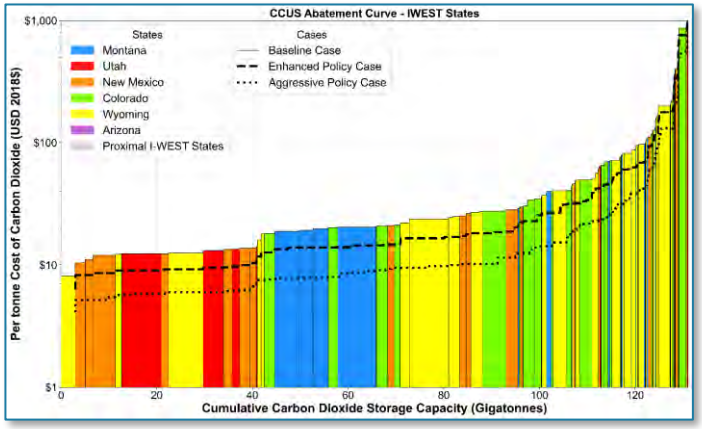
(Gattiker, Gilfillan, & Chen, LANL)

- Based on EPA emissions data, analysis of regional facilities; includes all facilities (shown) and 45Q compliant facilities (not shown)
- No life-cycle analysis (next phase)
- Possible regional pathways for electricity include retrofits with CO_2 capture, replacement with renewable, replacement with nuclear
- Pathway analysis for other sources in next phase

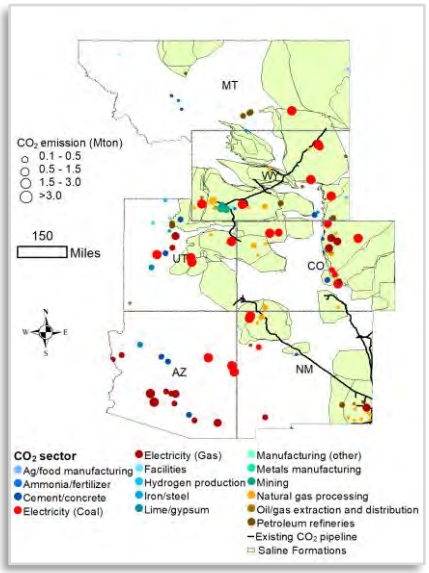
Technology-pathways Initial Outcomes: Given the potential size of the "wedges", will the region have sufficient capacity to store CO_2?

(Vikara, NETL, and broad contributions from across the I-WEST team)

Cost Curve for CO_2 Storage in I-WEST



Point Sources and Existing CO_2 Pipelines in I-WEST



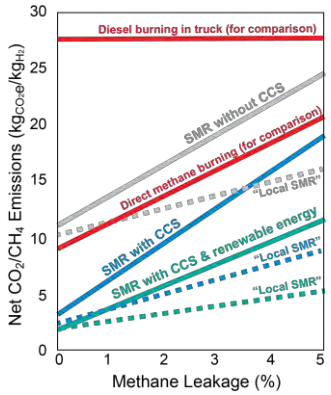
Observations from Stakeholder Outreach & Regional Analysis

- Ample storage capacity likely exists to handle point-source emissions (and likely DAC as well)
- Multiple ongoing and anticipated CCUS projects
  - Diversity in the types of those projects
  - 45Q is driving interest from industry
- Early-mover opportunities are emerging in the region
  - CO_2 EOR; acid gas disposal w/ 45Q under UIC Class II w/ MRV
- Other potential regional opportunities include:
  - Depleted reservoirs (oil/gas and natural CO_2 domes)
  - Diversity of saline formations
  - CO_2 enhanced geothermal?
- Enabling tech and policy clarifications could help to enable broader deployment:
  - Pore space rights clarity
  - Long-term liability
  - Primacy for EPA Class VI
  - Workforce: practitioners and permit oversight
  - Identification of viable storage sites (**State-level atlas**)

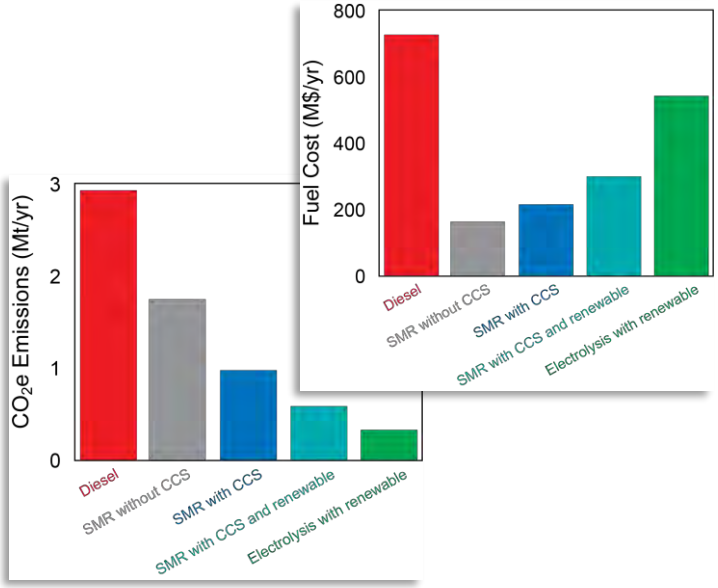
Technology-pathways Initial Outcomes: Is blue hydrogen a potential regional pathway to lowering CO2 emissions?

(Sharan, Dubey, Singh, & Semelsberger, LANL)

LCA of GHG Emissions for SMR Hydrogen



Comparison of Hydrogen vs Diesel for Truck Fuel



Managing methane-leakage emissions is central to an effective blue hydrogen strategy in I-WEST

- LCA assessments for SMR scenarios to identify key drivers in greenhouse gas (GHG) emission profile
  - Methane leakage is key driver life-cycle GHG emissions for blue hydrogen
  - Location of SMR near NG production ("Local SMR" could be an effective strategy for minimizing life-cycle emissions
  - Using renewable sources to drive the SMR process could significantly lower life-cycle emissions

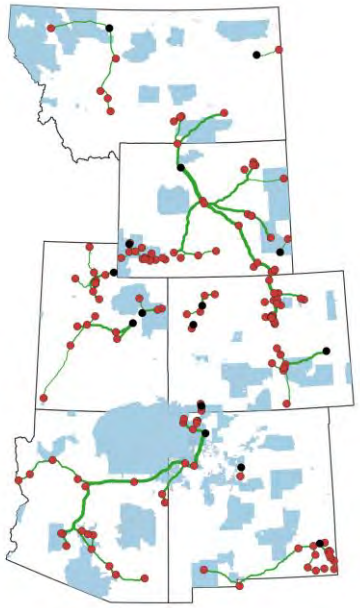
Switching trucks from diesel to hydrogen fuel cell is one potential option in I-WEST for transportation

- LCA assessment to assess anticipated GHG emissions and costs assuming heavy trucks
- All hydrogen scenarios outperform diesel in both costs and emissions
- A regional strategy could pursue an evolution from blue to green

Technology-pathways Initial Outcomes: How do EESJ considerations impact the infrastructure needs and strategies to deploy CCUS?

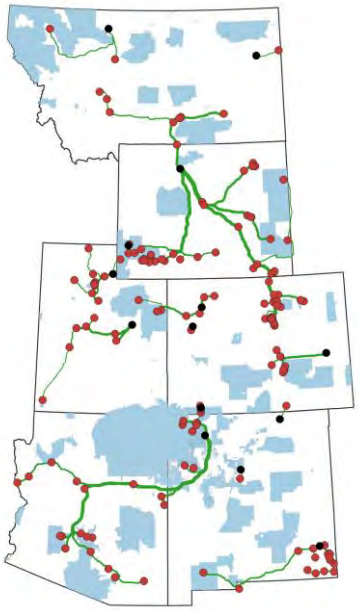
(Chen, Ma, & Pawar, LANL)

Saline storage only; no EJ considerations



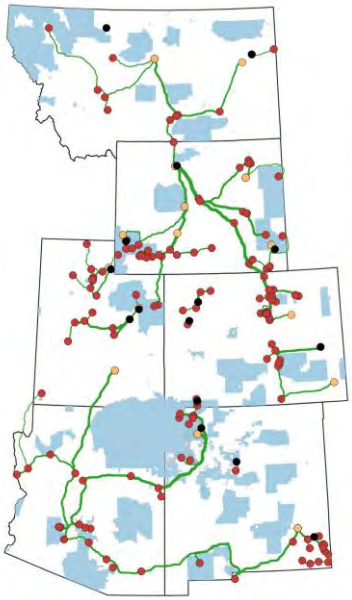
Pipeline length (miles) – 4882

Saline storage only; with EJ considerations



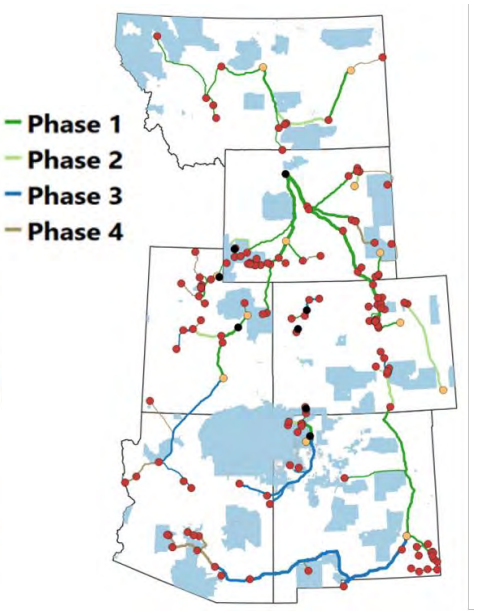
Pipeline length (miles) – 5433

Saline storage & CO_2-EOR; with EJ considerations



Pipeline length (miles) – 6836

Saline storage & CO_2-EOR; with EJ considerations; phased build out



Pipeline length (miles) – 6601

● = Existing CO_2 point source

▬ = Potential CO_2 pipeline

● = CO_2-EOR field centroid

● = Saline reservoir centroid

▬ = Disadvantaged community or tribal lands

I-WEST
iwest.org

Technology-pathways Initial Outcomes: What is the context for water demands to drive new energy technologies?

(Guthrie, LANL)

Water use is dominated by agriculture

- 40M acre-feet per year total
- 85% from surface water

Public water supply is 2nd highest usage

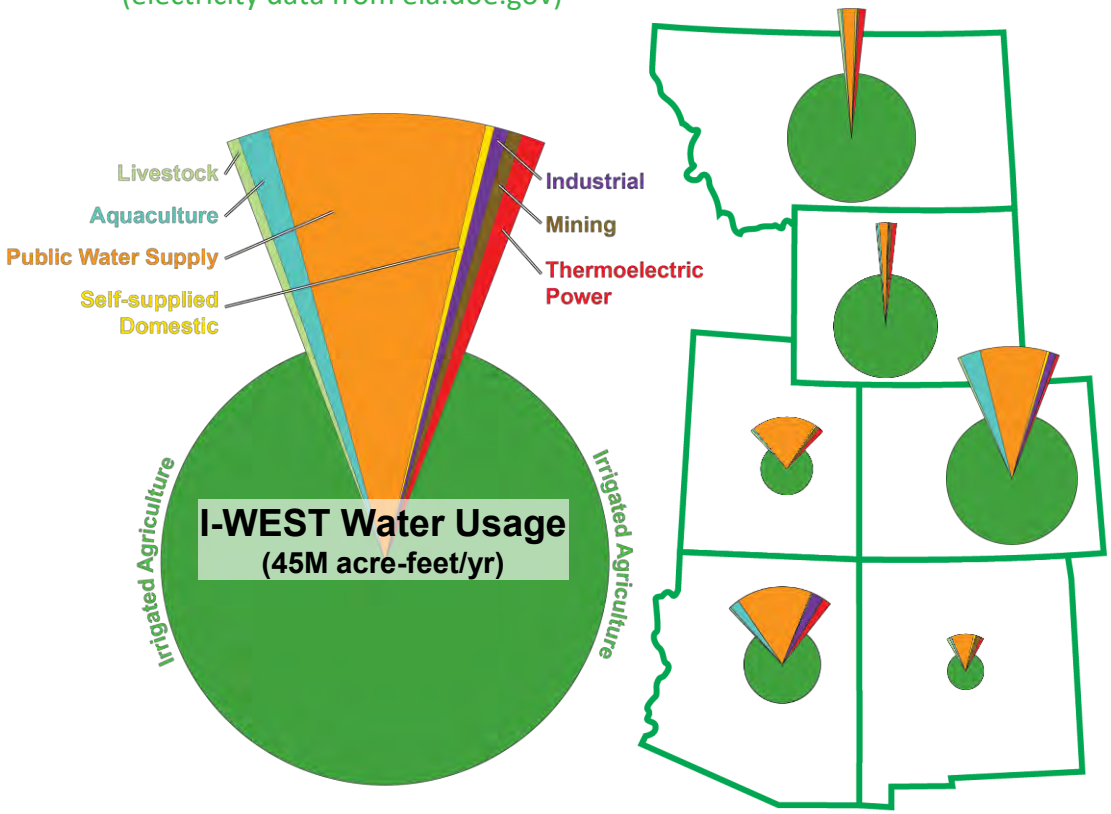
- 3.6M acre-feet per year
- 57% from surface water

Thermoelectric power generation currently uses a small fraction

- 0.4M acre-feet per year (~400k acre-feet/yr)
- 72% from surface water
- Accounts for ~87% of the 300 GW-hrs produced in region, of which ~24% is exported to other regions

Water Usage in the Intermountain West

(based on data from waterdata.usgs.gov)
(electricity data from eia.doe.gov)

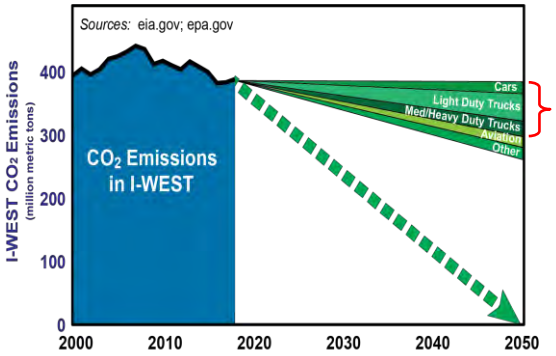


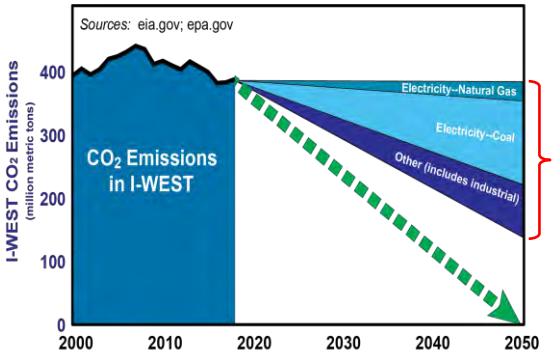
(Sizes of pie charts are scaled to volume of water used. The slices for usages other than irrigated agriculture have been expanded by a factor of two to facilitate viewing.)

I-WEST
iwest.org

Technology-pathways Initial Outcomes: What are the anticipated maximum levels of water needed for various energy technologies?

(Heidlage, Sharan, & Gattiker, LANL)





Converting all vehicles to hydrogen

- Producing enough hydrogen via steam-methane reforming to fuel all cars/pickups/trucks in region would require ~200k-300k acre-feet/yr [‡]
- Producing enough hydrogen via electrolysis [‡] to fuel all cars/pickups/trucks in region would require ~70k–80k acre-feet/yr
- Potable water needs [‡] for feedstock (part of total) are 25k-30k acre-feet/yr and 70k-80k acre-feet/yr for blue and green H2, respectively

Capturing all point sources of CO_2

- Capturing all large point sources of CO_2 in region would require ~200k acre-feet/yr based on water-cooled amine technology[fi]
- Using air cooling could reduce required water by ~90%[fi] (e.g., to ~20k acre-feet/yr)

Storing all captured point-source CO_2 in reservoirs

- Co-producing brine while injecting CO_2 (to manage pressure) could be a nontraditional water source
- Storing 200Mt CO_2/yr could result in ~200k acre-feet/yr water[§]

[‡] Calculated based on LCA of water needs for various processes on a per kg-H2 basis (Sharan et al.).

[§] Water co-produced during CO_2 storage assumes an equivalent volume of brine is removed for pressure management and the brine is desalinated to produce water; for comparison, Veil (2020) reported 411k acre-feet of produced water from oil/gas operations in the I-WEST region

[fi] Point source data from eia.gov. Water needs for capture based on analysis by Grol et al. (2018) NETL-PUB-22446.

Summary

I-WEST is a place-based initiative focused on regional deployment

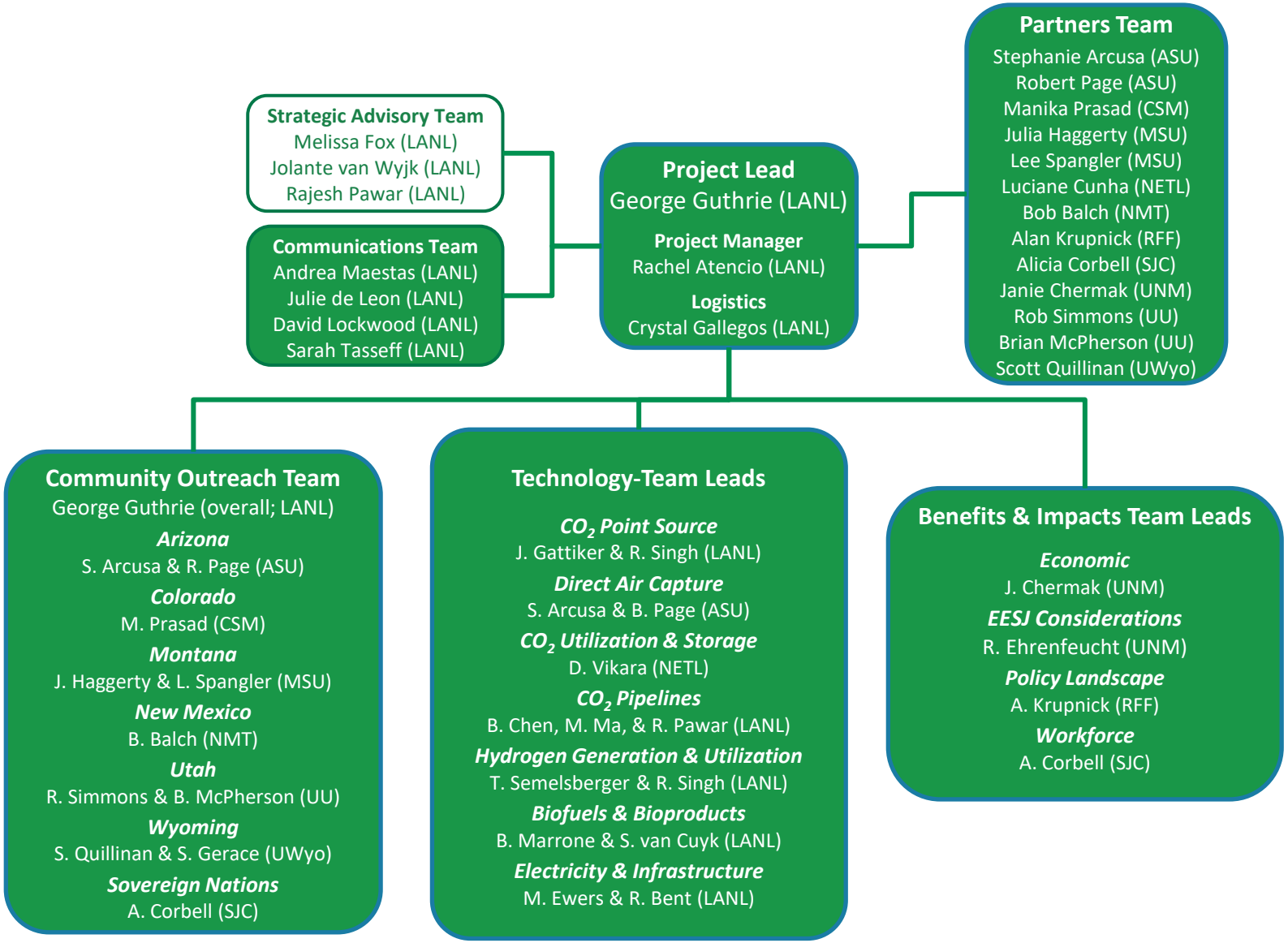
- Regional stakeholders' perspectives on needs/opportunities/concerns are central to understanding how a region is likely to proceed with transition and deployment
- In I-WEST, "communities" are many and diverse:
  - Cities and counties and economic development organizations
  - States
  - Sovereign Nations
  - Regional stakeholders in multiple business sectors
  - Citizens, advocacy groups, etc.
  - Regional experts in energy-technology
- Maintaining revenue and comparable jobs are a widespread concerns across at-risk communities in I-WEST

Multiple technologies will need to evolve in tandem for I-WEST to achieve carbon neutrality while developing new economies

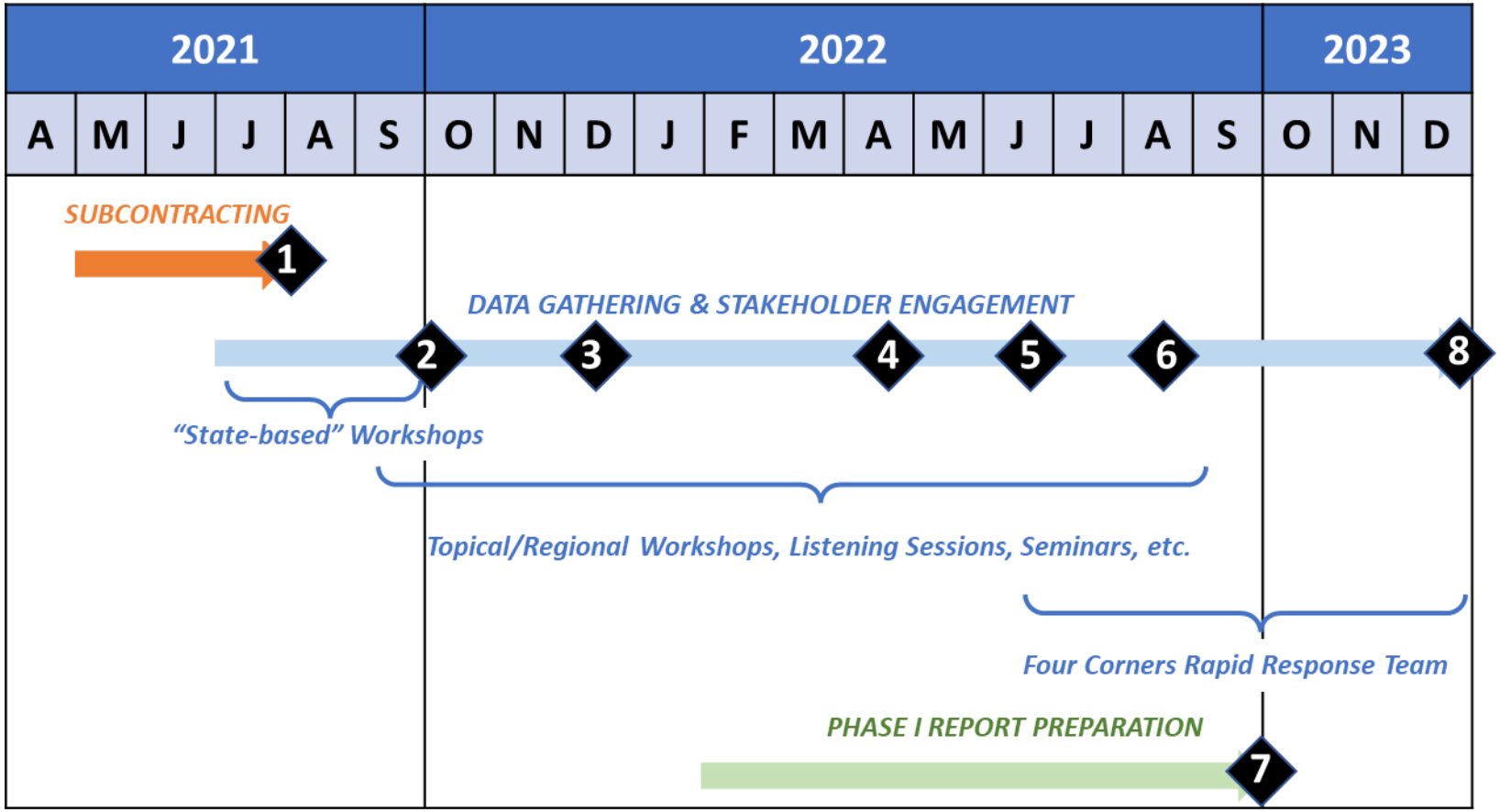
- Potential new economies are symbiotic
  - Capturing CO_2 (supply) and utilizing/storing CO2 (demand)
  - Producing/utilizing/storing low-carbon hydrogen
  - Producing/utilizing low-carbon (or even carbon-negative) biofuels
  - Producing/distributing low-carbon electricity

Appendix

Appendix: Organizational Chart for the I–WEST Initiative



Appendix: Gantt Chart for the I–WEST Initiative



1—Completion of subcontracts, kick off of team's work
2—Completion of initial set of state-focused workshops and other outreach engagements
3—First cross-office briefing for DOE (included attendees from FECM, EERE, OE, SC, S-4, S-1, OIE)
4—Second cross-office briefing for DOE (included attendees from FECM, EERE, OE, SC, S-4, S-1, NE)
5—Completion of initial round of data collection for regional technology assessment
6—Official launch of the Four Corners Rapid Response Team under the Interagency Working Group
7—Release of final public-facing report assessing regional pathways to carbon neutrality
8—Release of final technical report for phase I