Montana Climate Solutions Council

Technology innovation and Transitions Committee

White Paper: Montana's Innovation Landscape

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Key Issue

Responding to the impacts of climate change in Montana will require new technological approaches to agriculture, energy systems, infrastructure, and carbon mitigation and storage, among others. Developing and commercializing new technological approaches can generate opportunities for Montana to create new jobs, private investment, public funding, and businesses.

The Technology Innovation and Transitions Committee is tasked with helping Montana understand how to support technology innovation. The approach the Committee has followed is to define and identify existing elements of the "innovation landscape," or the systems, networks, and partnerships that align the state's unique skills, assets, and institutions to support technology and policy innovation. The focus on the innovation landscape is consistent with emerging economic development literature and practice in the changing U.S. economy.

First, this whitepaper defines the innovation landscape, drawing on literature and the experience of Committee members. Next, the Committee identifies key components of Montana's innovation landscape by exploring several case studies of innovation clusters and university partnerships. Finally, the Committee offers several recommendations to bolster current networks and capacity of the innovation landscape, and specific technology clusters that can be supported and grown by drawing together the resources and capacity the innovation landscape offers.

Defining Concepts of the Innovation Landscape

Innovation: Innovation is defined as new combinations of existing knowledge, capabilities, and resources that contribute to social and economic change. Innovation does not necessarily require new invention but is focused on implementation or putting new or existing ideas, processes, and technologies into practice in novel or new ways. In the context of climate change, using existing technologies will be critical for implementing immediate to short-term climate solutions. New invention will also be important, as our state looks to develop technologies for decreasing global warming gases applicable not only in our state, but nationally and internationally, as well.

Innovation Landscape: The innovation landscape is the networks, systems, and institutions that can be aligned to define and act on strategic priorities. Elements of the innovation landscape include the institutions (universities, government, non-governmental organizations, industry associations, and labor unions), the policy environment and culture among these institutions that allow them to collaborate and leverage unique strengths and skills, financing (e.g., venture capital, government grants, private foundations), physical assets and materials, and human capital.

Figure 1 provides a graphical depiction of building the innovation landscape critical to supporting Montana-based climate solutions. We define each element in the text that follows, beginning from the bottom of the figure.

· *Institutional Entities:* The research capacity within the Montana University System is a central institutional asset for the state. State agencies, philanthropies, non-profit organizations, business associations, and labor unions also are important institutions that bring capacity, experience, and resources to Montana's innovation landscape.

· *Innovation Environment:* The innovation environment includes local qualities of place such as proximity to research institutions, institutions of higher education, local social processes as well as competitive business and regulatory environments, and policy environments that foster effective fiscal incentives, government policies that support business, and financial and infrastructure incentives to promote business growth. The design of the policy environment in particular can support innovation in market formation (for example, energy balancing markets).

· *Culture:* Describes leadership from public and private institutions critical to developing an atmosphere (i.e., a "culture") that encourages the creation, support, and dissemination of innovation. A culture of innovation encourages ideas and welcomes new approaches to solving critical challenges Such leadership can take the form of helping seed and grow relationships, networks, and even business partnerships among institutional entities.

· *Funding Capital:* Substantial and sustained public funding is fundamental to realizing the innovation potential of a community. Public financing of basic research and funding that supports and accelerates innovative solutions to market. New technology markets can emerge

around novel technology areas driving the formation of innovation clusters. Innovation clusters create new value in local state economies and attracts private and philanthropic investments.

· *Sustained Material Resources:* Physical research facilities, infrastructure, and access to natural resources offer Montana competitive advantages in advancing energy, climate science,- and technology-related industries.

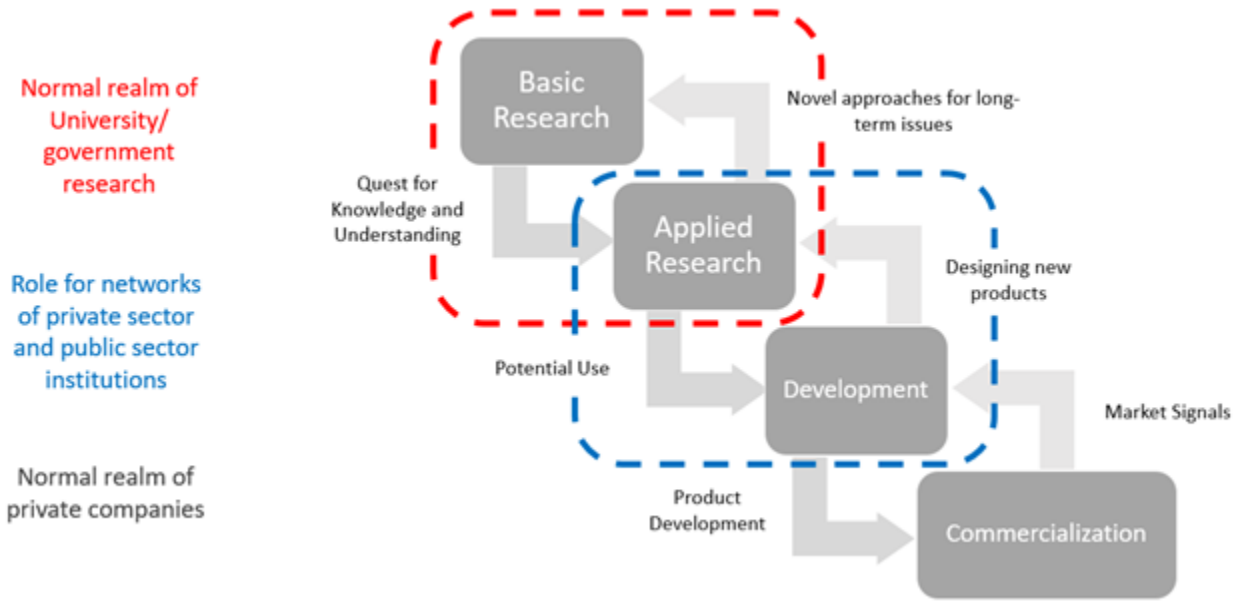
· *Human Capital:* A robust and adaptable workforce with appropriate knowledge, skills, and abilities is required to establish, grow, and sustain innovative businesses in Montana.

Figure 1: Elements of an Innovation Landscape

Assessing Montana's Innovation Landscape: Strengths and Assets

Employing an innovation landscape approach will help Montana stay nimble given the market uncertainties. Such uncertainties, including new technologies and legislation, are abundant given the rapidly warming climate. What new technologies and innovations are on the horizon that remain unknown today? How will the state anticipate and address unintended consequences of new technology innovation? Accepting uncertainty shifts the focus on how to navigate and create the landscape to allow technologies to emerge rather than select favored existing technologies to promote. Montana should focus not only on innovative technology but *effective* technology. That focus must begin at the beginning, with an assessment of Montana's current innovation landscape.

Assessing the capacity of Montana's innovation landscape draws on existing models of how innovation often occurs. The innovation process is commonly described as a series of steps, from basic research through to commercialization. The innovation process is rarely linear, however. Knowledge and hard lessons are learned at each step, which leads to better understanding and advancement in research, product development and ultimately commercialization (see Figure 2).



Adapted from NRC, 2013.[i]

Figure 2: Model of Innovation Landscape Feedback

For the purposes of the Montana Climate Council, a critical opportunity for capacity building evident in Montana's success stories and those of other existing state innovation initiatives is that realizing the fruits of innovation most often requires collaboration and support from public and private institutions. A review of state and regional innovation initiatives in the U.S. reports that "continuous public investment has been critical in training a large number of people over many years and in creating the necessary environment to foster new technology-based businesses."[ii] Basic and applied research, for example, benefit from public investment and informal or formal collaboration networks among public universities, government, and the business community. Public investments and partnerships remain important throughout the product development and commercialization process. Integrating public, philanthropic, non-governmental, and private institutions is a basic requirement of a functional innovation landscape.

In order to fuel effective cross-sector collaboration, a clear policy vision for an integrated, collaborative innovation landscape is required as well as understanding of the innovation process. Sustained resources and a mandate to apply public policy, funding, and capacity at

government agencies in order to support and advance the innovation landscape are needed in Montana.

The rest of this white paper uses a case study approach to assess Montana's current innovation landscape. The case studies demonstrate existing assets and strengths and gaps. The case studies are intended to help identify recommendations that could support Montana's efforts to better integrate existing components of the innovation landscape and suggest direction actions to build needed capacity in Montana institutions as well as address gaps in other elements of the state's innovation landscape.

The committee will also work to identify nascent technology and innovation clusters important to mitigating and adapting to climate change. The goal of assessing and strengthening Montana's innovation landscape is to advance innovations necessary to first address climate change, and second to position Montana as a leader in new technologies and business model development that can lead to new economic opportunities for our state, increased competitiveness, and job growth.

Case Studies and Gap Analysis

Assessing Montana's innovation landscape benefits from exploring case studies of existing research, product development, and commercialization efforts to understand why they succeeded or failed in practice. Case studies serve multiple purposes: concrete examples of actual projects will help communicate how the innovation landscape is defined and elements function as well as the interplay between the elements; case studies focus on what is actually happening in Montana and can help assess why some projects succeed or fail; and case studies can help identify opportunities to adapt the innovation landscape and explain how new opportunities can be leveraged.

Case Study: Absaroka Energy's Gordon Butte Pump Storage Project

Background and description

Absaroka Energy Expects to break ground soon on a closed loop pumped hydro energy storage project. The project will construct an upper and lower water reservoir on private land on Gordon Buttes in Meagher County. The installed generation capacity will be 400 MW with estimated storage of 3400 MW-hrs. It will utilize 3 pairs of pumps and turbines to allow rapid switching (or simultaneous) pumping and generation. The rapid response combined with large power and energy capacity will mean the facility can be used for peaking, firming, frequency control, and a variety of other ancillary benefits that can allow utilization of a larger percentage of variable renewable energy in the state's power portfolio. This will be the largest pump storage facility in the US and the first built in approximately 40 years. It will also be one of the few utility scale storage facilities in the country. Planning, permitting and financing of the project has taken over 10 years with 7 years devoted to permitting. Job creation estimates are about 450 workers for construction and about 24 permanent jobs (with relatively high wages).

Elements of Montana's innovation landscape

The project takes advantage of both Montana's inherent topography, geography, and existing infrastructure.

· *Sustained Material Resources:* The project demonstrates Montana's energy assets and existing infrastructure that offer advantages in renewable energy generation and supply to major West Coast markets. Gordon Butte utilizes some of Montana's steep topography with a 1000 ft vertical drop in a horizontal run of only 3000 ft. The project is located within 6 miles of existing large transmission lines that will have capacity to deliver power to Western states when Colstirp's Units 1 and 2 are retired. Montana also has good wind resources and increasing installation of wind power facilities. It will utilize spring run-off for filling the reservoirs.

· Workforce and human capital: The project will utilize existing highly trained construction professionals as well as provide for an additional 24 new permanent jobs in energy generation and operation.

Gaps in Montana's innovation landscape

· *Policy Environment:* Planning, permitting and financing of the project has taken over 10 years with 7 years devoted to permitting. Mitigating and adapting to climate change will likely require large industrial scale energy, carbon storage, and infrastructure investments and construction. Finding efficiencies in the planning, permitting and financing process are desirable.

Case Study: Montana's Photonics Cluster

Background and Description

Photonics is to photons (light) as electronics is to electrons and is critical to lasers, sensors, measurements and automated vision, medical technologies, defense technologies and other sectors. The first photonics company in the Gallatin Valley was Orionics (fiber splicing equipment) in 1980 (ended operations in 1987) followed by Big Sky Laser in 1981, Toomay-Mathis and Associates (TMA, light scattering measurement) in 1984, ILX Lightwave (Diode laser and fiber optic equipment) in 1986, and Scientific Materials Corp (Laser Crystals) and Lattice Materials (infrared optical materials) both in 1989. Five of these six companies had connections to either Montana State University (MSU) or the Gallatin Valley. MSU faculty began collaborations with TMA, ILX, and Scientific Materials and in 1992 four MSU faculty members wrote a proposal to the National Science Foundation's Experimental Program to Stimulate Competitive Research (EPSCoR), that strengthened these collaborations. EPSCoR funding coupled with institutional resources resulted in five additional faculty hires in photonics and the Optical Technology Center (OpTeC) received formal Board of Regents center status in 1995. There are now over 30 companies with about 600 employees in photonics in Montana, largely located in Gallatin County. Approximately 15 were spun out of MSU research and others were attracted by the desirable location, access to a strong research university, and availability of a high quality workforce. Montana Photonics Industry Alliance formed in 2013.[iii] The Montana

Photonics cluster is the fourth largest photonics cluster in the nation, the largest per capita, and a major contributor to the Montana economy.

Elements of Montana's Innovation Landscape

· *Innovation Environment:* Montana's high quality of life and desirable location attracted the first few photonics companies and is a factor in spin-outs where students want to remain in Montana and create their own jobs to do so. Access to recreation, cultural amenities, and a clean environment are important components of Montana's environment that attracts and retains entrepreneurs and businesses.

· *Institutions and Culture:* University-Industry partnership played a huge role in moving research to commercialization fundamental to the success of photonics in Montana. Both research faculty and private sector personnel were willing to meet "half-way" to learn how to work together. This resulted in successful SBIR and STTR proposals, students transitioning to existing companies with technologies to develop into products thus creating their own jobs (and others as well). Direct interaction among faculty, students and the private sector facilitated by the institutional relationships that generated an entrepreneurial spirit in graduate students helped generate spin-off companies and fuel the local innovation culture.

· *Sustained Material Resources:* Local industry tours potential clients through collaborating university labs allowing the small start-up to "show bigger" and help land additional investment dollars. Public investments in physical buildings, machinery and equipment helped accelerate these investments and foster the photonics innovation cluster in Gallatin County.

Gaps in Montana's Innovation Landscape

· *Human Resources:* Local industry is growing at a rapid pace. To keep up with the pressing workforce demands of the growing innovation cluster, Gallatin College has stood up training and certificate programs. Montana State University Bozeman is beginning to offer MS and PHD courses.

· *Sustained financial resources:* Stable research funding is needed to continue to advance the optics and photonics cluster as well as to maintain state of the science.

Case Study: Hydrogen-based Storage of Renewable Energy

Background and Description

Converting waste water into a renewable energy battery system presents an emerging economic opportunity for several components of Montana's innovation landscape. Mitsubishi-Hitachi is in the early stages of a proposal to produce hydrogen gas in Montana, store it in Utah, and deploy new technologies to generate electricity for western utilities by burning 100 percent renewably sourced hydrogen. Montana's competitive advantage for this multi-state concept is to utilize treated waste water from the Berkeley Pit in Butte and potentially from Silver Lake as a water source for electrolysis that splits water molecules into hydrogen and oxygen. Electrolysis

is an energy-intensive process that can be turned on and off to utilize excess renewable energy when the sun is shining, the wind is blowing, and electricity demand is relatively low. The Berkeley Pit is a scarce source of water in the western U.S. where many basins are closed to new water development and climate projections indicate increasing stress on water supplies.

Renewably sourced hydrogen potentially could serve as the foundation for a clean energy hydrogen economy that includes hydrogen fuel cell technology development and commercialization for transportation and other uses in addition to utility-scale production of electricity. This sector could create many jobs and businesses in wind and solar energy development, in construction, electrical trades, and engineering. Restoration job opportunities also may exist as treated water from the Berkeley Pit may also have beneficial in-stream uses, which may require a sophisticated balancing to accommodate both ecosystem restoration objectives and clean energy development. Combustion of H2, initially blended with fossil gas and eventually 100% H2, to generate electricity in Montana would produce water vapor that could be captured and put to beneficial use.

Elements of Montana's Innovation Landscape

Sustained Material Resources: Access to water resources and available transmission capacity position the Butte area to participate in an emerging hydrogen economy. Building a pipeline between Butte and Utah along the I-15 corridor appears feasible and would enable storage of H2 in salt dome caverns in central Utah.

Funding Capital: A shared commitment by private industry and state and federal governments would help develop a hydrogen technology cluster and facilitate commercialization and deployment in Montana.

Institutions and Culture: Montana's university system and economic development organizations are motivated to collaborate with private industry to help develop these technologies and maximize ecosystem benefits.

Gaps in Montana's Innovation Landscape

Policy Environment: Developing a clean energy hydrogen production system in the Butte area may require a policy shift in management of water rights to provide for beneficial uses of treated water from the Berkeley Pit. Development of this sector also will require aggressive build out of wind, solar and geothermal resources, which will hinge on development of policies that require utilities to prefer renewable energy sources to fossil fuel combustion. Lacking that, the economic benefits of a potential clean hydrogen sector may accrue to states that prioritize clean energy sources. Development of a hydrogen energy sector will also benefit from labor policies that support workforce training, recruitment and retention.

Case Study: Montana Emergent Technologies Commercialization of BioSqueeze, MSU's Well Sealing Technology

Background and description

Montana Emergent Technologies (MET) is commercializing a technology developed by Montana State University's Energy Research Institute (ERI) and Center for Biofilm Engineering (CBE). This technology uses bacteria that catalyze formation of calcium carbonate (calcite, the same substance as "boiler scale") which can be used to plug small aperture seeps in wells (typically outside the production casing in the cement between the casing and the formation rock) that can cause methane emissions to the atmosphere. Because the bacteria and other required materials can be delivered in low viscosity water solutions, this method works well for small seeps that are difficult to seal by pumping cement which is higher viscosity. MSU developed this technology at bench scale, tested it at an intermediate scale and performed four field pilots with MET involvement. MET is now commercializing in the DJ basin in Colorado and in 2019 has sealed nine wells owned by two different companies with a 100% success rate. These include 4 wells that were being plugged and abandoned, one of which the company spent in excess of $1M trying to remediate, and 5 active production wells.

Elements of Montana's innovation landscape

· *Sustained Material Resources:* The research enterprise and existing facilities at MSU enabled initial development of this technology.

· *Innovation Environment:* MSU research centers existence and enthusiasm for working with the private sector, the private sector's interest in guiding technology development, and Montana mall business's interest in commercialization all are playing key roles in this opportunity. Policy, albeit outside of Montana, is also a driver. Colorado has recently implemented regulations that bradenhead pressure (surface casing vent pressure) has to be zero on plugged and abandoned wells. (This is the pressure between the production casing and the formation rock for most of the well depth. This area is cemented, but the cement can develop small seeps.) Additionally, Colorado has implemented regulations that wells still in production have bradenhead pressures below a specified level. This policy driver aimed at reducing greenhouse gas emissions in another state is creating economic opportunity for Montana.

· *Institutions and Culture:* University-Industry partnership played a huge role in moving research to commercialization fundamental to this technology. The Center for Biofim Engineering provided the core expertise in microbial science and how it can be engineered for beneficial uses that are the basis for the technology. The Energy Research Institute helped identify the key application, generated Department of Energy interest, and guided proposal preparation. ERI also identified key industry partners to assist in field tests, provide initial test wells, and provide valuable oil and gas industry input that helped guide technology development. MET provided engineering support for designing the delivery system and on-site support for field trials which not only helped guarantee success at the research stage, but also reduced development cycles in the process of commercialization.

Gaps in Montana's Innovation Landscape

· *Funding Capital:* This technology attracted significant funding from both state and federal sources in the R&D phase, but lack of state sources of capital for commercialization has been a challenge. MET is in the process of attracting investment from an out-of-state company.

Case Study: Emerging Markets for Climate Smart Agriculture

Heavy precipitation events, unusual seasonal weather patterns, and a trend of hotter, drier summers are driving growing interest in climate-resilient agriculture among farmers, consumers, food companies, and state and federal agencies. Institutional and venture investors, philanthropic foundations, and state governments are now stepping up to provide financial incentives for farmers and ranchers to adopt such practices, especially soil health practices that build and retain organic matter, maintain continuous cover, and minimize tillage and chemical disturbance. A marketplace has emerged to reward farmers for increasing and sequestering soil carbon. Market players include California's Climate Smart Agriculture program funded through the state's carbon cap-and-trade program and Indigo Agriculture, a start-up company funded by more than $850 million in venture capital, which aims to sequester one trillion tons of carbon dioxide from the atmosphere by incentivizing farmers to adopt regenerative agriculture practices.

Given its vast agricultural landscape and breadth of innovative farmers and ranchers, Montana is well positioned to tap into this emerging market for carbon-rich soils. Western Sustainability Exchange (WSE), a non-profit based in Livingston, is collaborating Montana ranchers and state and national partners in a pilot project that does just that through its Montana Grasslands Carbon Initiative. Partners include Montana State University, NativeEnergy (a Vermont-based company that develops carbon projects and sells verified carbon offset credits), Soils for the Future (a soil science organization based at Syracuse University), and Xanterra Parks and Resorts (the country's largest park concession management company and Yellowstone and Glacier National Parks' primary concessionaire). The grasslands carbon program incentivizes ranchers to improve their grazing and thereby sequester large amounts of carbon. For doing so, ranchers will be compensated with carbon offset payments based on the additional amount of carbon they sequester each year. The sequestered carbon becomes the basis for verified carbon offset credits which NativeEnergy sells to companies committed to reducing their carbon footprint.

<u>Elements of Montana's Innovation Landscape</u>

Sustained Material Resources: Montana's vast agricultural landscape provides ample opportunities for innovative farmers and ranchers to tap into the emerging market for soil carbon sequestration.

Funding Capital: As demonstrated by corporate investments in WSE's carbon grasslands initiative, investors inside and beyond Montana are stepping up to fund soil health practices that increase climate resilience and sequester carbon.

Institutions and Culture: Montana producers and farm organizations appear to be receptive to new management practices that increase soil carbon, improve water retention, and bolster climate resilience. Montana State University researchers, extension, USDA-NRCS, producer organizations and non-profit organizations like WSE and the National Center for Appropriate Technology, based in Butte, provide technical support to farmers and convene diverse stakeholders around soil management. Local, state and national soil health conferences are being hosted in Montana in 2020, featuring innovative Montana and national producers and other diverse stakeholders.

Gaps in Montana's Innovation Landscape

Policy Environment: Dozens of state legislators have passed or are considering state-level soil health policies. Montana has not yet taken that step, although interest is growing across the state's agricultural landscape. In partnership with producers, NRCS, and other stakeholders, Montana's Department of Agriculture is well positioned to help develop a Montana Soil Health Program. Western examples include New Mexico, which passed legislation in 2019, following a stakeholder consensus process, which establishes a voluntary incentives program and robust support system. Land managers are offered access to soil health testing, education and training opportunities, as well as financial and technical assistance. Colorado currently is engaging stakeholders in development of a state soil health program that aims to create a base-line soil health inventory and engages producers by creating demonstration plots, farmer-to-farmer training, outreach and educational programming. The Colorado Department of Agriculture intends to provide grants and technical assistance to help producers advance soil health practices. A similar stakeholder process and program in Montana will help producers position themselves for a more resilient future and the emerging soil carbon marketplace.

Stakeholders

Stakeholders are addressed as appropriate for each recommendation below.

Recommendations

An important task the Committee will be to conduct asset mapping that can identify real opportunities in Montana to leverage existing partnerships and opportunities into actual projects. One of the primary goals of the committee work is to build a strategy around technology research, development, and commercialization.

Recommendations for technology innovation are required beyond the energy sector and across multiple geographies. The urban/rural divide is widening and solutions are required for all types of communities, particularly rural communities. Focusing on rural landscapes and communities

may also provide unique opportunities to leverage resources, partnerships, and innovation that may be overlooked as most efforts and attention are typically focused on cities where investments theoretically return a higher “bang for the buck.” Technology innovation in agriculture, timber, manufacturing, and other sectors are an important focus for the Committee.

Recommendation 1: Montana, led by the Montana Science and Technology Committee and the Office of the Commissioner of Higher Education, should identify key opportunities for technology-led economic development, prioritizing areas that assist with climate change transitions and mitigation

Revise and update Montana’s Science and Technology plan with particular focus on industry linkage opportunities and opportunities to foster and sustain competitive industry/university collaborations in basic and applied research.

Within identified areas of strength, charge and fund key networking organizations (i.e. industry organizations, university research centers, or state agencies) with regularly convening key university/industry/society players.

Within the Montana University System, institute seed-granting opportunities and research capacity building efforts to grow the state’s university expertise and competitiveness in each identified area of strength.

Recommendation 2: The Montana Legislature should invest in initiatives that build university/industry/society innovation linkages to address key Montana challenges, including climate change.

Institute a state-funded grant program to further develop research capabilities and user facilities at Montana’s public universities, with a goal of leveraging these facilities to grow innovative Montana-based technology development companies and clusters.

Develop a recruitment and retention funding pool for strategic growth in research capabilities in key areas of state need.

Appropriate further rounds of funding for the Montana Research and Economic Development Initiative to encourage applied research addressing Montana Problems.

Set aside a match-funding pool to increase Montana researcher’s competitiveness when pursuing federal grant dollars.

Develop / Identify and appropriately fund a research center or institute charged with networking and organizing university research and university/industry linkages statewide in the area of energy innovation. Key areas of focus based on Montana’s industry and existing research expertise may include biofuels, energy storage, transportation grid electrification, and energy related agricultural practices.

Recommendation 3: To the extent possible and prudent, implement the recommendations contained in the 2017 project report -- The Montana Jobs Project, A Guide to Photonics and Advanced Energy Job Creation.

Create a task force consisting of appropriate state agency personnel with representatives of the Montana University System and the Montana Photonics Industry Alliance (MPIA) to review *The Montana Jobs Project* report recommendations and advance them as deemed appropriate.

Recommendation 4: State agencies with regulatory authority should review and evaluate all regulations under their jurisdiction related to carbon emissions / climate issues to determine ways these regulations can be revised, streamlined or otherwise modified to remove barriers that may hinder innovative projects designed to reduce carbon emissions or mitigate, facilitate or adapt to issues related to climate change. The following recommendation exemplifies this and could be implemented immediately:

Montana DEQ and/or the Montana Board of Oil and Gas Conservation should seek primacy for Class VI deep injection wells.

Section 1421 of the Safe Drinking Water Act requires EPA to develop UIC program requirements that protect underground sources of drinking water from endangerment. EPA has developed underground injection control (UIC) program requirements that are designed to be adopted by states, territories, and tribes.

Primary enforcement authority, often called primacy, refers to state, territory, or tribal responsibilities associated with implementing EPA approved UIC programs. A state, territory, or tribe with UIC primacy, or primary enforcement authority oversees the UIC program in that state, territory, or tribe.

Class VI wells are used to inject carbon dioxide (CO2) into deep rock formations. This long-term underground storage is called geologic sequestration. Geologic sequestration refers to technologies to reduce CO2 emissions to the atmosphere and mitigate climate change. EPA has finalized requirements for geologic sequestration, including the development of a new class of wells, Class VI, under the authority of the Safe Drinking Water Act's UIC program. These requirements, also known as the Class VI rule, are designed to protect underground sources of drinking water.

North Dakota is the only state with primary enforcement authority for UIC Class VI wells. EPA directly implements the Class VI program in all other states, territories, and tribes.

Recommendation 5: Continue the state's efforts to evaluate, expand existing or recruit new industries to Montana that reduce carbon emissions or sequester carbon while providing well-paying jobs and increasing tax base.

Recommendations 1 through 4 propose actions that public institutions can take to help entrepreneurs attract, build, or increase capacity of Montana climate-smart businesses.

The primary benefit of this recommendation is to leverage existing efforts and successes in sectors where Montana exhibits comparative and competitive advantages. The following are examples of existing efforts by the state to develop industries that will help address climate change:

· Advanced Energy Storage – efforts being advanced by the Governor's Office of Economic Development and Department of Commerce, Department of Natural Resources and Conservation:

- Several companies are developing technology to produce advanced batteries or battery components including REC Silicon in Butte that has the potential to facilitate the manufacture of lithium ion batteries with increased storage capacity.

- The Gordon Butte pumped storage hydroelectric project (case study noted previously) is designed to balance variable power and could firm over 2GW of renewable energy generation.

- The Mitsubishi-Hitachi renewable hydrogen storage and energy generation project (case study noted previously) is a bold regional energy storage proposal that would invest billions of dollars in the state. The project would make use of treated water from Butte's Berkeley pit, thus capitalizing on mandated, long-term environmental remediation practices to facilitate renewable energy generation.

- Key areas where assistance is needed to facilitate advanced energy storage include:

§ Increasing access to capital (public and private) such as loans through the Montana Board of Investments and USDA Rural Development and the Small Business Administration

§ Assuring timely regulatory processing and streamlining where possible

§ Assuring Montana is an active participant in regional energy planning entities such as WECC, NWPCC and NTTG, BPA, WAPA, etc.

§ Increasing awareness of available tax incentives such as the New and Expanding Industries state property tax abatement and federal incentives such as Opportunity Zones and New Market tax credits

§ Assuring timely regulatory processing and streamlining where possible

§ Facilitating funding assistance through state programs such as the Big Sky Economic Development Trust Fund and Work Force training grants

- Agriculture - continue efforts led by the Montana Departments of Agriculture, Livestock, and Commerce along with the Governor's Office of Economic Development to develop

agricultural practices / projects to increase soil carbon (case study noted previously). Montana should continue with efforts to facilitate the emerging market for carbon-rich soils, such as the Western Sustainability Exchange's Montana Grasslands Carbon Initiative. State agriculture leaders should coordinate with producer groups, nonprofits, university researchers, and USDA-NRCS to develop a state soil health program, similar to the consensus-based process to develop a soil health policies in Colorado and New Mexico. At the same time Montana should build on its existing successful and emerging Montana agricultural practices that enhance soil health such as:

- Develop value-added processing, such as protein fractionation, to augment Montana's success with pulse crops (dried beans, chickpeas, lentils and peas). Montana farmers have incorporated pulse crops into their crop rotations to reduce the amount of land left fallow (idle). Pulse crop acres have increased from 350,000 in 2009 to over 800,000 in 2015 (#1 nationally). Pulses are a leguminous crop that are harvested solely for the dry seed. They play a huge role in healthy diets in countries all over the world. They are also a powerful versatile crop that Montana farmers can use to promote biodiversity, improve soil health, and generate income from local and global markets. Pulse crops utilize soil moisture efficiently. These crops require little (if any) nitrogen fertilizer; instead they fix nitrogen from the air into the soil. Pulse crops help break disease and pest cycles in wheat and barley. When a wheat or barley crop follows a pulse crop it can experience substantial rotational benefits, improving yield and quality. Less fossil energy is used to produce pulse crops. Pulse crops use water efficiently, which can enable more intensive crop rotations in dryland farming systems or reduce water consumption in irrigated farming systems. Dry peas, lentils, and chickpeas are typically grown in rotation (i.e., alternating years) with cereal grains. In contrast to dry beans, the cooler weather preferred by pulses during the growing season, especially at bloom, fits well with the climates conducive to small grains like wheat or barley.

- Monitor innovative technologies to increase soil carbon such as Accelergy Corporation's biological carbon capture utilization technology being tested in Montana. This technology utilizes algae to produce fertilizer that removes up to 30 tons of CO_2 from the atmosphere for every ton of CO_2 utilized in the original cultivation of algae. According to the company, the leveraging effect of the process yields a profitable terrestrial CO_2 sequestration solution.

- Maximizing the use of technology such as that produced by Montana's industry leading optics / photonics cluster to practice precision agriculture that help to optimize the efficient use of farm inputs such fossil-based fuels and fertilizers.

- Key areas where assistance is needed to facilitate improved soil health practices include:

§ Increasing access to capital (public and private) such as loans through the Montana Board of Investments, USDA Rural Development and the Small Business Administration

§ Increasing awareness of available tax incentives such as the New and Expanding Industries state property tax abatement and federal incentives such as Opportunity Zones and New Market tax credits

§ Assuring timely regulatory processing and streamlining where possible

§ Facilitating funding assistance through state programs such as the Growth Through Agriculture grant program, the Big Sky Economic Development Trust Fund and Work Force training grants

· Biofuels - the Departments of Commerce, Natural Resources and Conservation and the Governor's Office of Economic Development should evaluate ongoing efforts of the Northwest Advanced Renewables Alliance (NARA) to produce aviation jet fuel from woody biomass.

○ A developing project in Mississippi may provide an example that Montana could replicate to boost the timber industry and reduce greenhouse gas emissions. Biofuel company Velocys recently announced a project to produce negative emission fuels after signing a carbon capture, usage**,** and storage agreement with Oxy Low Carbon Ventures. Integrating carbon capture, usage**,** and storage into the biorefinery boosts certain targeted revenue streams, such as those derived from the California Low Carbon Fuels Standard and US 45Q tax credits, to incentivize the installation of carbon capture equipment on industrial facilities. The company hopes its proposed CCUS solution can be replicated at other sites, including a UK project that recently submitted a planning application to build Europe's first commercial scale waste-to-jet fuel facility

· Mass timber construction and small-diameter utilization - Mass timber construction with materials such as cross-laminated timber produced by SmartLam in Columbia Falls, reduces dependence on carbon-intensive steel and concrete and reduces carbon emissions. Cross laminated timber manufacturing that utilizes small-diameter timber can help sequester carbon that otherwise may be burnt in logging slash piles. The University of Montana is helping develop new products and plans to utilize mass timber construction to build a new "state-of-the-art" headquarters facility for the College of Forestry and Conservation. Craig Rawlings, the president and CEO of the Missoula-based Forest Business Network, says, "Everybody's concerned about trying to draw down carbon, and construction is such a huge contributor with concrete and steel. The growth trajectory (of mass timber construction) has been tremendous. The demand seems to be there."

· Restoration forestry and forest conservation – Montana's private and public forest owners can contribute to carbon sequestration by conserving and restoring healthy forests across millions of acres in which large-diameter trees were previously logged out and selective logging

can boost young tree growth while producing small-diameter logs that can be utilized in mass timber construction. Montana tax laws and land-use policies can support forest conservation by reversing taxpayer subsidies that currently contribute to residential conversion of forest lands in the fire-prone wildland-urban interface. Conservation of well-managed forests that are vulnerable to residential conversion prevents significant carbon emissions, as documented in the 2018 City of Whitefish Climate Action Plan. Residential development plays a significant role in increasing the cost and risk of western forest fires, according to studies by Bozeman-based Headwaters Economics. Montana has successfully partnered with private landowners, conservation groups, and federal agencies to conserve tens of thousands of acres of forest at risk of residential conversion.

- Support the efforts of the Montana Department of Environmental Quality to build out electric vehicle charging infrastructure. Montana, along with Arizona, Colorado, Idaho, Nevada, New Mexico, Utah and Wyoming have signed the Regional Electric Vehicle Plan for the West memorandum of understanding to create an Intermountain West Electric Vehicle (EV) Corridor that will make it possible to seamlessly drive an EV across these States' major transportation corridors. These States are committed to:

    - Create best practices and procedures that will enhance EV adoption by promoting EV consumer acceptance and awareness by addressing range anxiety, coordinating on EV charging station locations, and leveraging economies of scale;

        - Create minimum standards for EV charging stations, including standards for administration, interoperability, operations, and management;
        - Identify and develop opportunities to incorporate EV charging stations into planning and development processes such as building codes, metering policies, and renewable energy generation projects;
        - Encourage EV manufacturers to stock and market a wide variety of EVs within the Regional Electric Vehicle Plan for the West signatory states; and
        - Identify, respond to, and collaborate on funding opportunities to support the implementation of the Regional Electric Vehicle Plan for the West.

As a result of the Volkswagen settlement from Dieselgate, Western states have received over $241 million from the Environmental Mitigation Trust that can be spent on transportation decarbonization strategies. Funds from the Environmental Mitigation Trust alone will not be enough to build a network capable of supporting interregional EV travel.

The State should create a multiagency task force to work with the MDEQ to determine the best way to leverage Environmental Mitigation Trust funds to expand EV charging infrastructure.

[i] https://www.nap.edu/catalog/18364/best-practices-in-state-and-regional-innovation-initiatives-competing-in

[ii] https://www.nap.edu/catalog/18364/best-practices-in-state-and-regional-innovation-initiatives-competing-in

[iii] (See Education and Training in Optics and Photonics: Proc. of SPIE Vol. 9793, 97932J · © 2015 SPIE, IEEE, OSA, ICO · doi: 10.1117/12.2223218).