

VALUE ADDED NATURAL RESOURCES

John Temte, Rosie Berger, Mark Christiansen, Greg Hill, Cy Lee, Steve Russell, Michael Von Flatern



NATURAL RESOURCES A STRONG WYOMING SECTOR

In the U.S., Wyoming is:*

- 1st in coal, uranium, trona and bentonite production
- 1st in on-shore, high-capacity wind resources
- 2nd in rare earth minerals reserves and helium production
- 4th in natural gas production

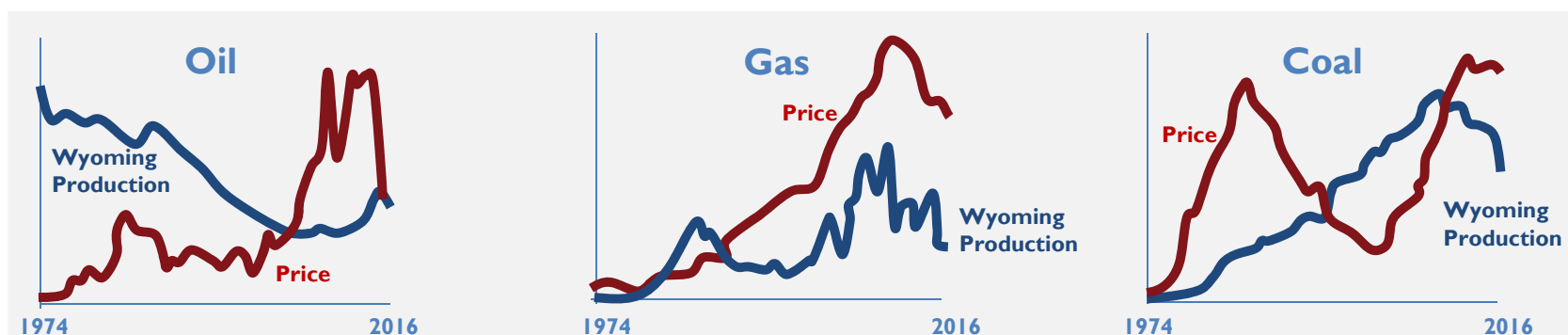
Mining, Quarrying and O&G account for

25%

of Wyoming's GDP, compared
to 2% Nationwide**

50%

of Wyoming's Total Locally and
State Assessed Valuation***



How can we leverage Wyoming's strength in natural resources to diversify Wyoming's economy?

*Wyoming Mining Association *BEA 2016. **Wyoming A&I Division, 2015



POTENTIAL TO LEVERAGE ALTERNATIVE RESOURCES

In the U.S., Wyoming ranks

#1

In land area with class 7 wind speeds*

#7

In solar index**

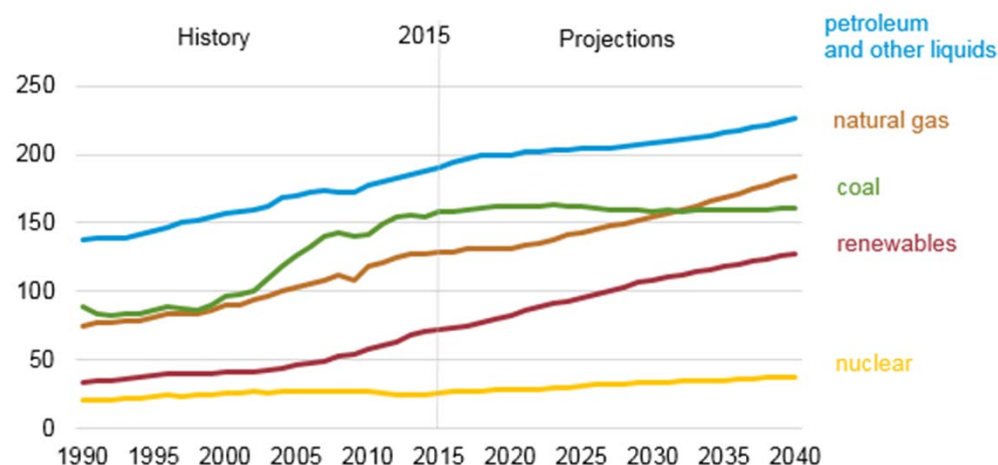
#15

In installed wind capacity***

#44

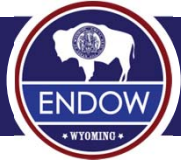
In solar production**

World energy consumption by energy source
Quadrillion btu



How can we leverage Wyoming's strength in natural resources to diversify Wyoming's economy?

*Godby, et. al, NREL **SEIA ***AWEA



LONG TERM OPPORTUNITIES ADDING VALUE TO RESOURCE BASES



Traditional

- Coal
- Oil & Gas
- Trona
- Uranium
- Rare earth elements
- Metals and gems
- Water



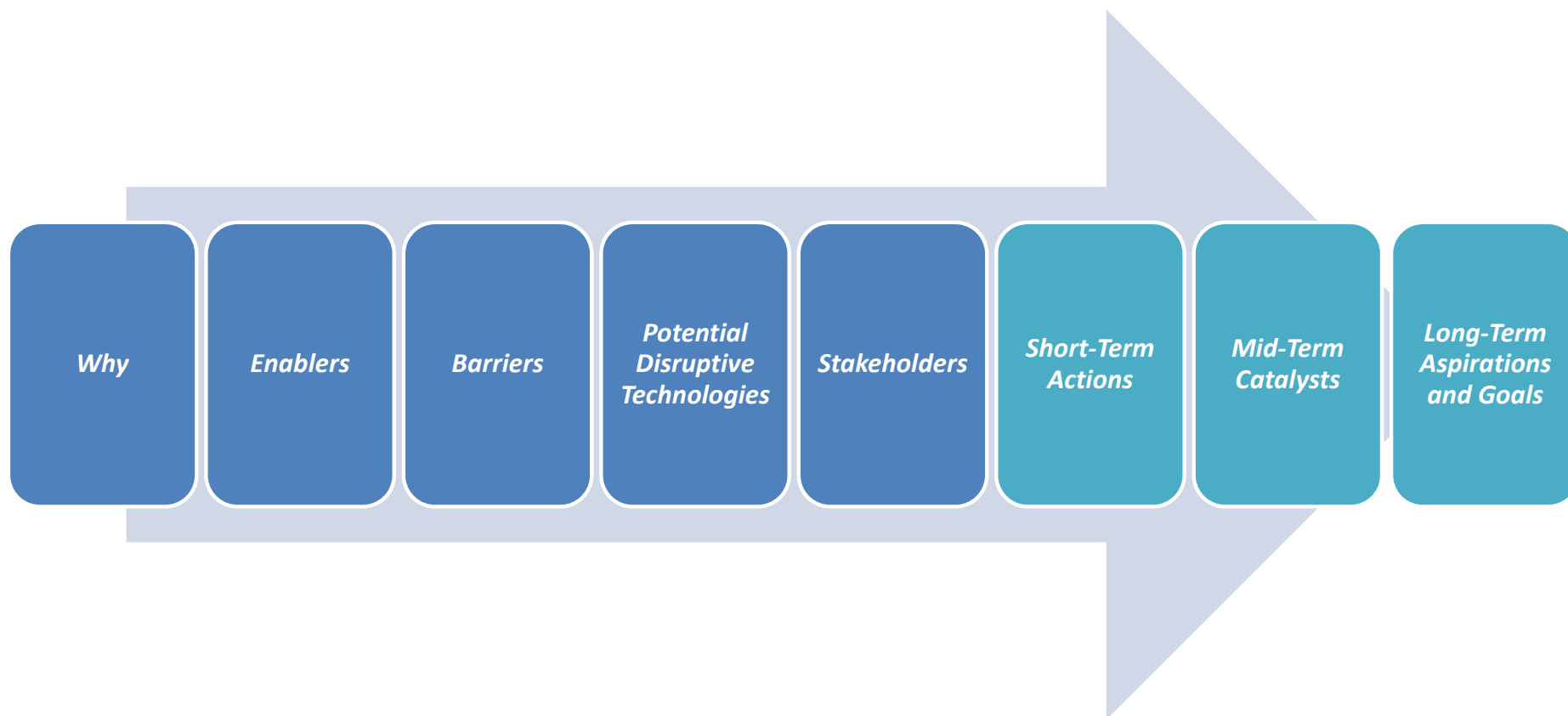
Alternative

- Wind
- Solar
- CO2 Tech



OPPORTUNITY TRACKER

AN ORGANIZED PROCESS TO DEVELOPING A STRATEGY





OPPORTUNITY TRACKER

AN ORGANIZED PROCESS TO DEVELOPING A STRATEGY

Resource Base	Why	Enablers	Barriers	Short-Term Actions	Mid-Term Catalysts	Long-Term Aspirations and Goals	Potential Disruptive Technologies	Stakeholders
CO2	<ul style="list-style-type: none"> • CO2 Tech (Carbon-to-Value) is a \$1T industry globally. • Potential to help to retain demand for fossil fuel energy in an increasingly CO2-averse global energy market 	<ul style="list-style-type: none"> • Abundant CO2 sources • State and UW prioritization • Extraordinary research and test facilities- Integrated Test Center, high bay facility, etc. • Section 45Q 	<ul style="list-style-type: none"> • Lack of training to turn promising ideas into commercial ventures • Potential investors and corporates lack clarity on potential opportunities • Unclear industry ecosystem • Room for improvement in reseach funding 	<p>Create a world class research environment to attract the industry's best CO2 innovators and foster technology development</p> <ul style="list-style-type: none"> • Increase research funding (increase applications for federal funding opportunities, NSF grant matching, other mechanisms) • Develop a consortium of stakeholders and researchers • Recruit leading researchers to UW or other institutes in Wyoming (keep this?) • Create industrial sites with access to CO2 sources • Pre-permitting and streamlined regulations in BDIZs • Improvements to existing research facilities, and additions of others as necessary • Expand permitted corridors for CO2 pipelines and other infrastructure • Focus on creating towns and cities with amenities that are attractive to science and tech innovators 	<p>Develop markets, infrastructure, workforce and businesses to transfer emerging tech to economic opportunities</p> <ul style="list-style-type: none"> • Develop and grow CO2 tech entrepreneurial ecosystem (building on Kickstart) • Develop public and private capital opportunities • Create demand and grow markets for CO2 tech by implementing policies like Buy Clean and Low Carbon Portfolio Standards • Develop workforce for industry by developing specific training and degree tracks • Maintain focus on creating towns and cities with amenities that are attractive to science and tech innovators 	<p>Wyoming is a leader in CO2 Technology and Carbon-to-Value businesses</p> <ul style="list-style-type: none"> • Wyoming leads the nation/world in number of CO2 innovators and companies • Wyoming leads the nation/world in CO2 tech patents • CO2 technology businesses contribute x to GDP, x jobs, x economic activity to Wyoming 	<ul style="list-style-type: none"> • Carbon Capture • Carbon storage • Enhanced oil recovery • Nanomaterials • Early technologies (including XPRIZE concepts) 	<p>Wyoming Infrastructure Authority, XPRIZE, School of Energy Resources, Western Research Institute, Center for Carbon Removal</p>



OPPORTUNITY TRACKER

AN ORGANIZED PROCESS TO DEVELOPING A STRATEGY

Resource Base	Why	Enablers	Barriers	Short-Term Actions	Mid-Term Catalysts	Long-Term Aspirations and Goals	Potential Disruptive Technologies	Stakeholders
Coal	<ul style="list-style-type: none"> • Short-term benefits of extraction and export (1333.5 Mt traded worldwide in 2016) • Potential to capture demand decreases and create more resilient mining sector by diversifying end uses • Potential to help to retain demand for fossil fuel energy in an increasingly CO₂-averse global energy market (See CO₂) 	<ul style="list-style-type: none"> • Proximity to resource • State and UW prioritization 	<ul style="list-style-type: none"> • Room for improvement in research funding • Competition with petroleum-based products • Large capital investment needed 	<p>Support and grow opportunity for extractors and exporters (keep this? too near-term?)</p> <ul style="list-style-type: none"> • Foster trade and research relationships with importers • Support development of ports and relationships with coastal states <p>Create a world class research environment to attract the industry's best coal- to-products innovators and foster technology development</p> <ul style="list-style-type: none"> • Increase research funding (increase applications for federal funding opportunities, NSF grant matching, other mechanisms) • Develop a consortium of stakeholders and researchers (is the SER doing this?) • Recruit and retain leading researchers to UW or other institutes in Wyoming (keep this?) • Create industrial sites near coal mines or coal handling facilities • Pre-permitting and streamlined regulations in BDIZs • Improvements to existing research facilities, and additions of others as necessary • Focus on creating towns and cities with amenities that are attractive to science and tech innovators 	<p>Support and grow opportunity for extractors and exporters (keep this? too near-term?)</p> <ul style="list-style-type: none"> • Maintain relationships with importers • Support development of ports and relationships with coastal states • Promote Wyoming coal to international importers <p>Develop markets, workforce and businesses to transfer emerging tech to economic opportunities</p> <ul style="list-style-type: none"> • Develop and grow coal tech entrepreneurial ecosystem (building on Kickstart) • Develop public and private capital opportunities • Create demand and grow markets for coal tech by implementing policies like Buy Clean and Low Carbon Portfolio Standards • Develop workforce for industry by developong specific training and degree tracks • Maintain focus on creating towns and cities with amenities that are attractive to science and tech innovators 	<p>Wyoming is a leader in international coal exports</p> <ul style="list-style-type: none"> • International coal exports increase by xx% by 2028 <p>Wyoming is a leader in Coal technology and coal-to-products businesses</p> <ul style="list-style-type: none"> • Wyoming leads the nation/world in number of coal innovators and companies • Wyoming leads the nation/world in coal tech patents • Coal-to-products businesses contribute x to GDP, x jobs, x economic activity to Wyoming 	<ul style="list-style-type: none"> • Coal to asphalt • Coal to soil amendments • Beneficiated Coal • Coal to fuel • Coal to carbon fiber • Coal composites (including for proppant) • Rare earth elements from coal • 0-emission carbon refinery 	Coal producers, UW SER, Western Research Institute



OPPORTUNITY TRACKER

AN ORGANIZED PROCESS TO DEVELOPING A STRATEGY

Resource Base	Why	Enablers	Barriers	Short-Term Actions	Mid-Term Catalysts	Long-Term Aspirations and Goals	Potential Disruptive Technologies	Stakeholders
Wind	<ul style="list-style-type: none"> • 8 GW of undeveloped wind energy in Wyoming • \$13B in potential investment • \$9B in new economic activity • \$4B in new labor income • 68k job-years • \$2.5B in new tax revenue • Potential to grow manufacturing 	<ul style="list-style-type: none"> • Excellent wind resource • State incentives for manufacturers 	<ul style="list-style-type: none"> • Tax uncertainty • Lack of transmission • Species concerns • Competition with other states • Competition with other sources of energy • Small workforce compared to nearby population centers (e.g. Loveland, the site of Vestas' new plant) 	<ul style="list-style-type: none"> • Reduce uncertainty in tax and regulatory environment to encourage wind energy development • Public statements supporting wind energy as a job creator, deemphasizing renewables-vs-coal sentiment • Public opposition to proposed increases in wind tax • Support legislation to eliminate deference to sub-surface lease holders in developing state lands • Develop a siting plan to address species protection, cultural considerations, land access • Pre-permitted transmission corridors 	<ul style="list-style-type: none"> • Develop manufacturing and other complimentary industries • Uphold manufacturing sales tax exemption • Support competitive state measures measures and local efforts to recruit businesses • Support research in storage mechanisms (should this be stronger-on par with CO2 research?) 	<ul style="list-style-type: none"> • Wyoming is a leader in wind energy development and manufacturing and renewable energy storage • 4 GW of developed wind energy in Wyoming by 2038 (currently at ~1.5 GW) • Wind energy manufacturing contributes xx to gdp, xx jobs, xx economic activity 	<ul style="list-style-type: none"> • Wind energy development • Wind energy manufacturing and other complimentary industries • Energy storage 	<ul style="list-style-type: none"> • Wyoming Wind Energy Research Center, School of Energy Resources, wind developers, Wyoming Infrastructure Authority, Wyoming Business Council



OPPORTUNITY TRACKER

AN ORGANIZED PROCESS TO DEVELOPING A STRATEGY

Resource Base	Why	Enablers	Barriers	Short-Term Actions	Mid-Term Catalysts	Long-Term Aspirations and Goals	Potential Disruptive Technologies	Stakeholders
Solar	<ul style="list-style-type: none"> • Potential to generate 72 million MWh/yr • \$x in potential investment • \$x in new economic activity • \$x in new labor income • x job-years • \$x in new tax revenue • Potential to grow manufacturing 	<p>Need more info here</p> <ul style="list-style-type: none"> • Good solar resource • State incentives for manufacturers 	<p>Need more info here</p> <ul style="list-style-type: none"> • Tax uncertainty • Lack of transmission • Species concerns • Competition with other states • Competition with other sources of energy • Small workforce compared to nearby population centers (e.g. Loveland, the site of Vestas' new plant) 	<p>Reduce uncertainty in tax and regulatory environment to encourage wind energy development</p> <ul style="list-style-type: none"> • Public statements supporting solar energy as a job creator, deemphasizing renewables-vs-coal sentiment • Public opposition to proposed increases in taxes on renewables • Support legislation to eliminate deference to sub-surface lease holders in developing state lands • Develop a siting plan to address species protection, cultural considerations, land access • Pre-permitted transmission corridors 	<p>Develop manufacturing and other complimentary industries</p> <ul style="list-style-type: none"> • Uphold manufacturing sales tax exemption • Support competitive state measures measures and local efforts to recruit businesses • Support research in storage mechanisms (should this be stronger-on par with CO2 research?) 	<p>Wyoming is a leader in solar energy development manufacturing and renewable energy storage</p> <ul style="list-style-type: none"> • x GW of developed solar energy in Wyoming by 2038 (currently at GW) • Solar energy manufacturing contributes xx to gdp, xx jobs, xx economic activity 	<ul style="list-style-type: none"> • Solar energy development • Solar energy manufacturing and other complimentary industries 	<p>Solar developers, Wyoming Infrastructure Authority, Sweetwater County</p>



OPPORTUNITY TRACKER

AN ORGANIZED PROCESS TO DEVELOPING A STRATEGY

Resource Base	Why	Enablers	Barriers	Short-Term Actions	Mid-Term Catalysts	Long-Term Aspirations and Goals	Potential Disruptive Technologies	Stakeholders
Oil and Gas	<ul style="list-style-type: none"> • Short-term benefits of currently successful extraction • Capture demand losses and create more resilient O&G sector by diversifying end uses 	<ul style="list-style-type: none"> • Proximity to petroleum resource 	<ul style="list-style-type: none"> • Distance to market (most successful petrochemical facilities are located near ports or endusers) • Large capital investment to enter market 				<ul style="list-style-type: none"> • Petrochemicals 	O&G producers, refiners, Petroleum Association of Wyoming
Trona	Grow manufacturing sector by leveraging globally unparalleled resource						<ul style="list-style-type: none"> • Glass fiber • Building materials from oil shale (byproduct of trona production) 	Trona companies, ...
Uranium	Create markets for U resources while providing clean baseload nuclear power		Onerous federal permitting process				<ul style="list-style-type: none"> • Uranium enrichment 	Uranium producers
Rare Earth Elements	Capture demand fueled by tech	Rumors of increased tariffs on metals	Chinese monopoly on REE market				<ul style="list-style-type: none"> • REE extraction and export 	Rare Earth Resources (company in Sundance who tried to open REE mine)
Precious Metals and Gems	Is there a large scale opportunity here?						<ul style="list-style-type: none"> • Extraction and export 	



NEXT STEPS CLEARING PATHWAYS TO SUCCESS

Enablers

- Abundant natural resources
- State support

Barriers

- Uncertainty—taxes, regulation, emerging industries
- Room for improvement in funding for research and tech transfer in the energy space

Support and grow
opportunity for
extractors and
exporters

Create a world-
class research
environment to
attract leading
innovators

Develop markets,
workforce and
businesses to
transfer emerging
tech to economic
opportunities

Reduce
uncertainty and
inefficiency in tax
and regulatory
environment

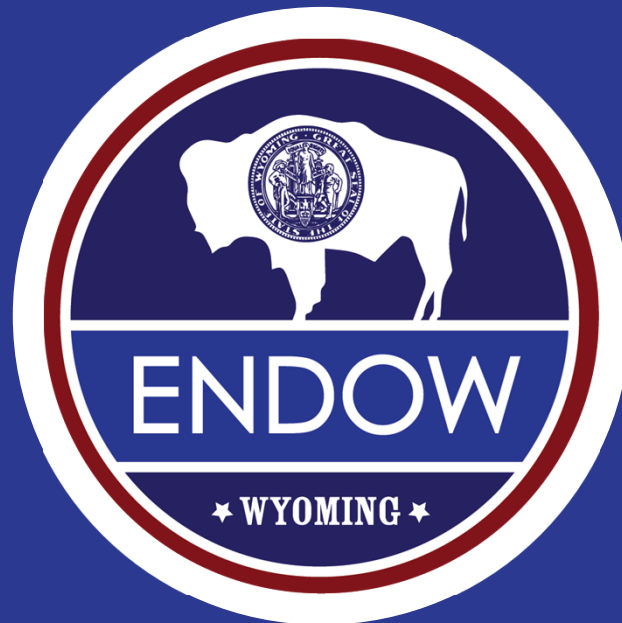
Develop
manufacturing
and other
complimentary
industries



The Big Idea...

Power Forward

(currently in stealth mode)



ENDOWyo.biz