

CORE-CM: Carbon Ore, Rare Earth and Critical Minerals Initiative

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2022 AGNC

7th Annual Economic Development Summit



School of
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Acknowledgement and Disclaimer

Acknowledgment: This material is based upon work supported by the Department of Energy under Award Number DE-FE0032047

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Our Project Team

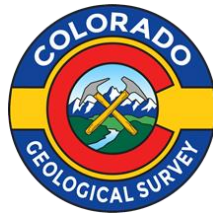
University of Wyoming

School of Energy Resources
Center for Economic
Geology Research

School of Energy Resources
Center for Energy Regulation
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School of Energy Resources
Center for Carbon Capture
and Conversion

College of Business
Center for Business
and Economic Analysis



Coalgeo, LLC



Our Partners and Project Supporters

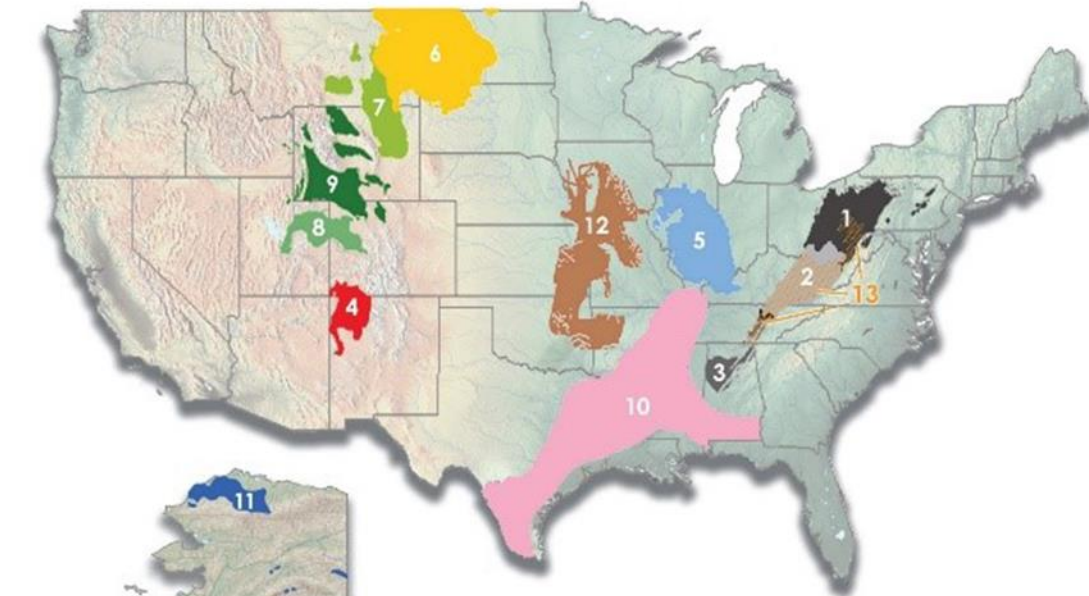
Current Partners & Supporting Stakeholders:

U.S. Congressional Delegation of Barrasso, Lummis, and Cheney; Wyoming Governors Office; Colorado State Land Board; Colorado Division of Reclamation, Mining and Safety; Wyoming Mining Association; Wyoming Representative Donald Burkhart; Wyoming Representative Mike Greear; Wyoming County Commissioners Association; Associated Governments of Northern Colorado; Wyoming Business Council; Wyoming Small Business Development Center; Impact 307; Wyoming Counties of Sweetwater, Sublette, Fremont, Carbon, and Uinta; Routt County, CO Economic Development Office; Moffat County; Kemmerer Operations, LLC; Tri-State; NTEC; Peabody Energy; PacifiCorp; Trapper Coal Mine; Colowyo Coal Mine; Black Butte Coal; Bridger Coal Company; Sweetwater Economic Development Coalition; Southwest Wyoming Manufacturing Partnership; Central Wyoming College; Mango Materials; Ur-Energy Inc.; City of Rock Springs; City of Green River; The University of Texas at Austin; Concurrent Technologies Corporation: Tetra Tech; Novex, LLC; Disa, LLC

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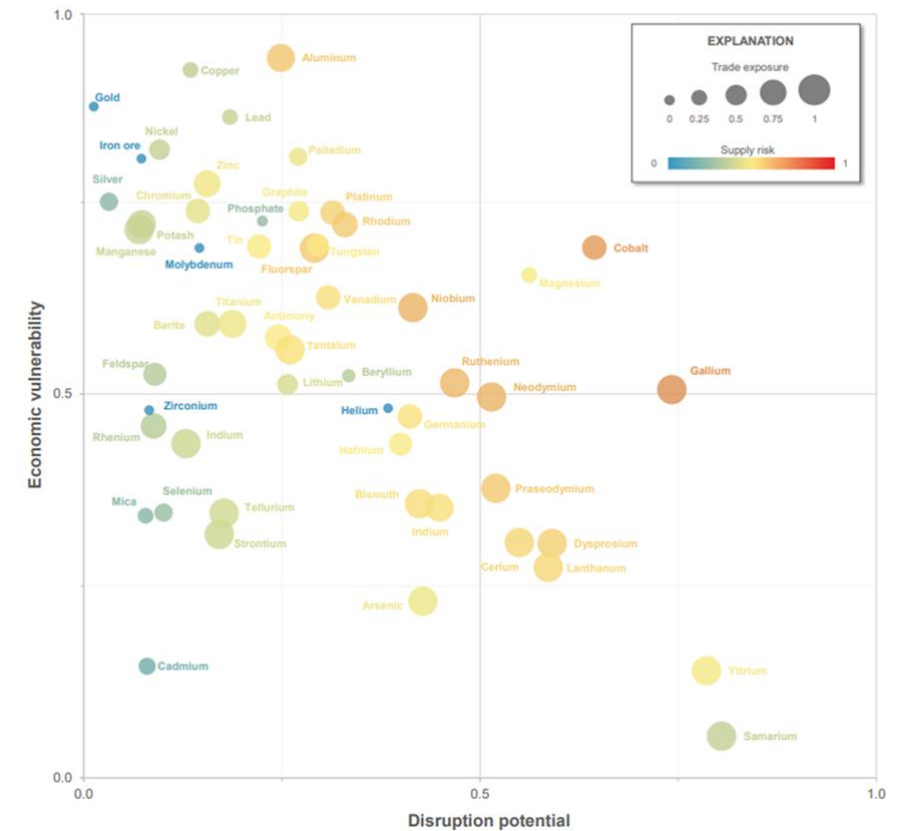
CORE-CM INITIATIVE

<https://netl.doe.gov/node/11045>



US BASINS

- | | |
|------------------------------|--------------------------------|
| 1 Appalachian Basin, North | 7 Powder River Basin |
| 2 Appalachian Basin, Central | 8 Uinta Basin |
| 3 Appalachian Basin, South | 9 Green River-Wind River Basin |
| 4 San Juan River-Raton Basin | 10 Gulf Coast Basin |
| 5 Illinois Basin | 11 Alaska Basin |
| 6 Williston Basin | 12 Cherokee-Forest City Basin |
| | 13 Mid-Appalachian Basin |



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CORE-CM in The Greater Green River and Wind River Basins

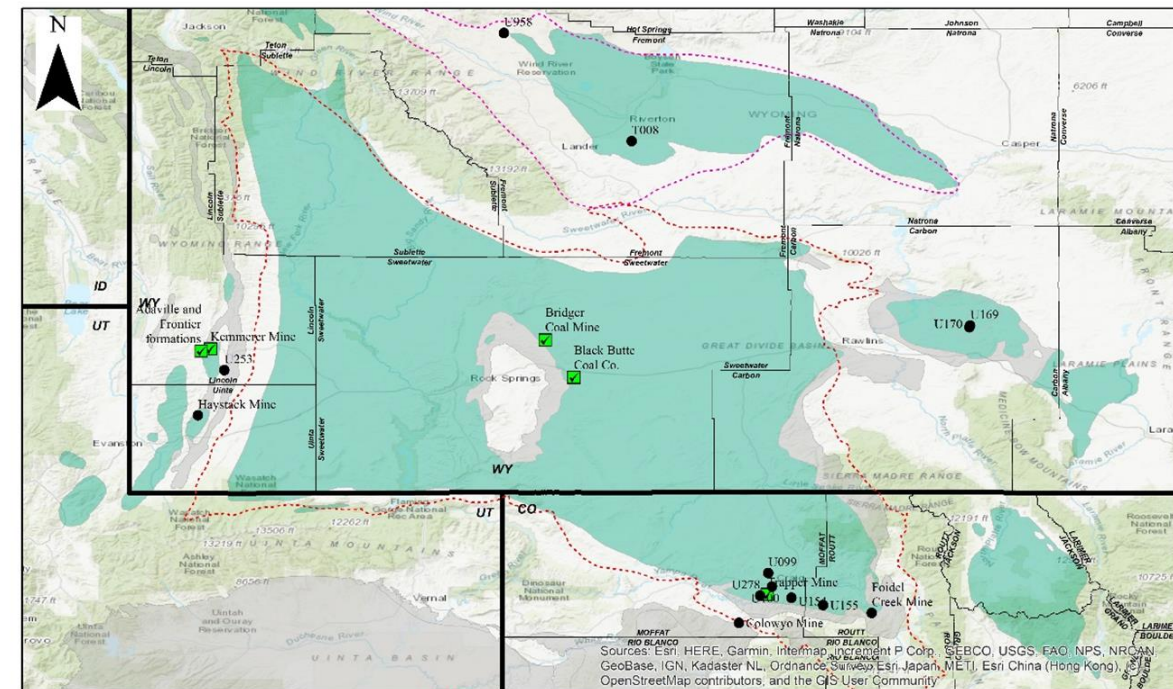
Objectives

Complete detailed assessments, including State of The Art DATA (SOTA) acquisition of potential CORE-CM materials across U.S. coal basins.

Leverage highly trained workforces, existing and novel coal technologies, and energy infrastructure in development of CORE-CM supply chains.

Bring together a committed network of stakeholders, gaining acceptance of new energy technology within coal regions and across communities.

Establish strategic plans to maximize the development of potential carbon ore, rare earth elements, and critical minerals (CORE-CM); within the creation of public-private partnerships.



Coal Samples

STATUS

- Collected
- Pending

- Wind River Basin
- Greater Green River Basin
- County Boundary
- State Boundary

Coal Fields

RANK

- Medium and High Volatile Bituminous
- Subbituminous

0 20 40 80 Miles

Technology Innovation Centers

Overall Goals

- Primary: to recover REE's and Critical Materials of specific interest.
 - Counter anticipated supply shortages (scarcity)
 - Reduce foreign dependence
- Secondary: manage feedstock residual carbon, in case of carbon-ore.
- Tertiary: manage & use remaining mineral matter.

Minimal or no waste to manage

Targeted Rare Earths*

Cerium
Dysprosium
Erbium
Europium
Gadolinium
Holmium
Lanthanum
Lutetium
Neodymium
Praseodymium
Samarium
Scandium
Terbium
Thulium
Ytterbium
Yttrium

Other Critical Minerals**

aluminum (bauxite)
antimony
arsenic
barite
beryllium
bismuth
cesium
chromium
cobalt
fluorspar
gallium
germanium
graphite (natural)
hafnium
helium
indium
lithium
magnesium
manganese
niobium
platinum group
metals
potash
rhenium
rubidium
scandium
strontium
tantalum
tellurium
tin
titanium
tungsten
uranium
vanadium
zirconium

* Per DOE-NETL's Feasibility of Recovering Rare Earth Elements Program

** Additional critical minerals identified in Executive Order 138172

Technology Innovation Centers

Decision Criteria for Selecting Technology Decision Areas

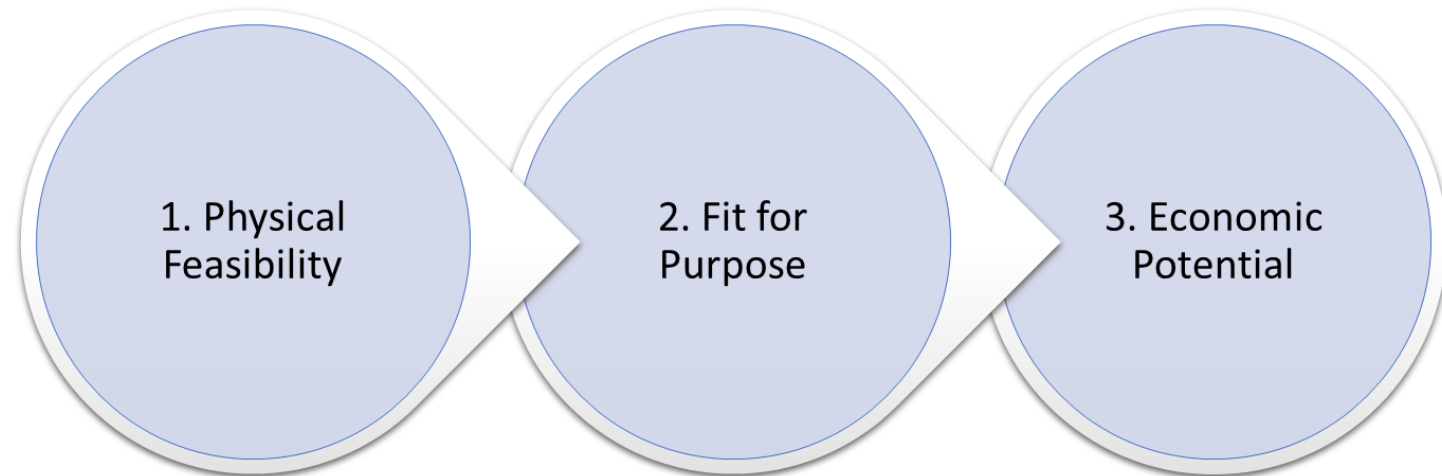
- Potential technology solutions studied must be sustainable.
- Leverage geographic, geological and resource strengths of the basin.
- Has potential to deliver competitive advantage.
- Addresses local water availability & management concerns
- Prospect for local economic development and job creation.
- Associated with a degree of novelty and newness.
- Outwardly techno-economically sound

Technology Innovation Centers

Different Extraction & Process Options Considered

- Burning
- Synthesis
- Gasifying
- Pyrolyzing
- Flotation
- Solvent Extraction
- Electrochemical
- Bio-leaching
- H₂ Production
- etc.

Preliminary Assessment Of Extraction And Process Options



1. Burning with CCS
2. Burning without CCS
3. Coal Ash Synthesis
4. Coal Bed Methane
5. Coal Fires (Geothermal Heat)
6. "Coal to Dirt"
7. "Coal to Liquids"
8. "Coal to Solids"
9. Coal Fires
10. Fly Ash Synthesis
11. Gasification
12. H₂ Production
13. Metals Production
14. Pyrolysis
15. Solvent Extraction

1. Burning with CCS
- ~~2. Burning without CCS~~
3. Coal Ash Synthesis (renamed to Concentration and Separation of Rare Earths from Coal Ash)
- ~~4. Coal Bed Methane~~
5. Fly Ash Synthesis (renamed to Concentration and Separation of Rare Earths from Metal Ore)
6. Gasification with H₂ Production
- ~~7. Gasification without H₂ Production~~
- ~~8. Metals Production~~
9. Pyrolysis
10. Solvent Extraction

1. Burning + CCS
2. Pyrolysis
3. Gasification + H₂ Production
4. Solvent Extraction + Pyrolysis of Graphene Oxide, Activated Carbon, Char Bricks and Soil Conditioner from Mined Coal
5. Concentration and Separation of Rare Earths from Coal Ash
6. Concentration and Separation of Rare Earths from Metal Ore

Technology Innovation Centers

Preliminary Analysis Has Yielded 5 Pathways for Economic Evaluation

1. Pyrolyzing
2. Gasifying
3. Solvent Extraction
4. Concentration & Separation:-
 - a. from metal ores
 - b. from coal ash,
 - c. bio-leaching (both)

Preliminary Assessment Of Extraction And Process Options

Criterion →		Energy Independence (per EO 13817)	Feed Available	Feed Quality (fit for purpose)	Process Developed at Scale	CO2 Emission without CCS	Other Undesirable Waste Products
Scale → Process Name ↓		1=None 10=Many	1=None 10=Plentiful	1=Unusable 10=Rich	1=Never 10=Commonly	1=CO2 10=No CO2	1=Multiple 10=No Wastes
Use the Coal to Produce Carbonaceous Products	Pyrolysis	1	10	9 ¹	10	5	8 ²
	Gasification + H ₂ Production	5 ³	5	9 ⁴	10	2	8 ⁵
	Solvent Extraction + Pyrolysis of Graphene Oxide, Activated Carbon, Char Bricks and Soil Conditioner from Mined Coal	6	10	9 ⁶	1 ⁷	7	5 ⁸
Extract the Rare Earths from Ores & Waste Streams	Concentration and Separation of Rare Earth from Metal Ores	10	6 ⁹	4 ¹⁰	5 ¹¹	8 ¹²	4.5 ¹³
	Concentration and Separation of Rare Earths <u>From</u> Coal Ash	10	10 ¹⁴	4 ¹⁵	4 ¹⁶	8 ¹⁷	6 ¹⁸

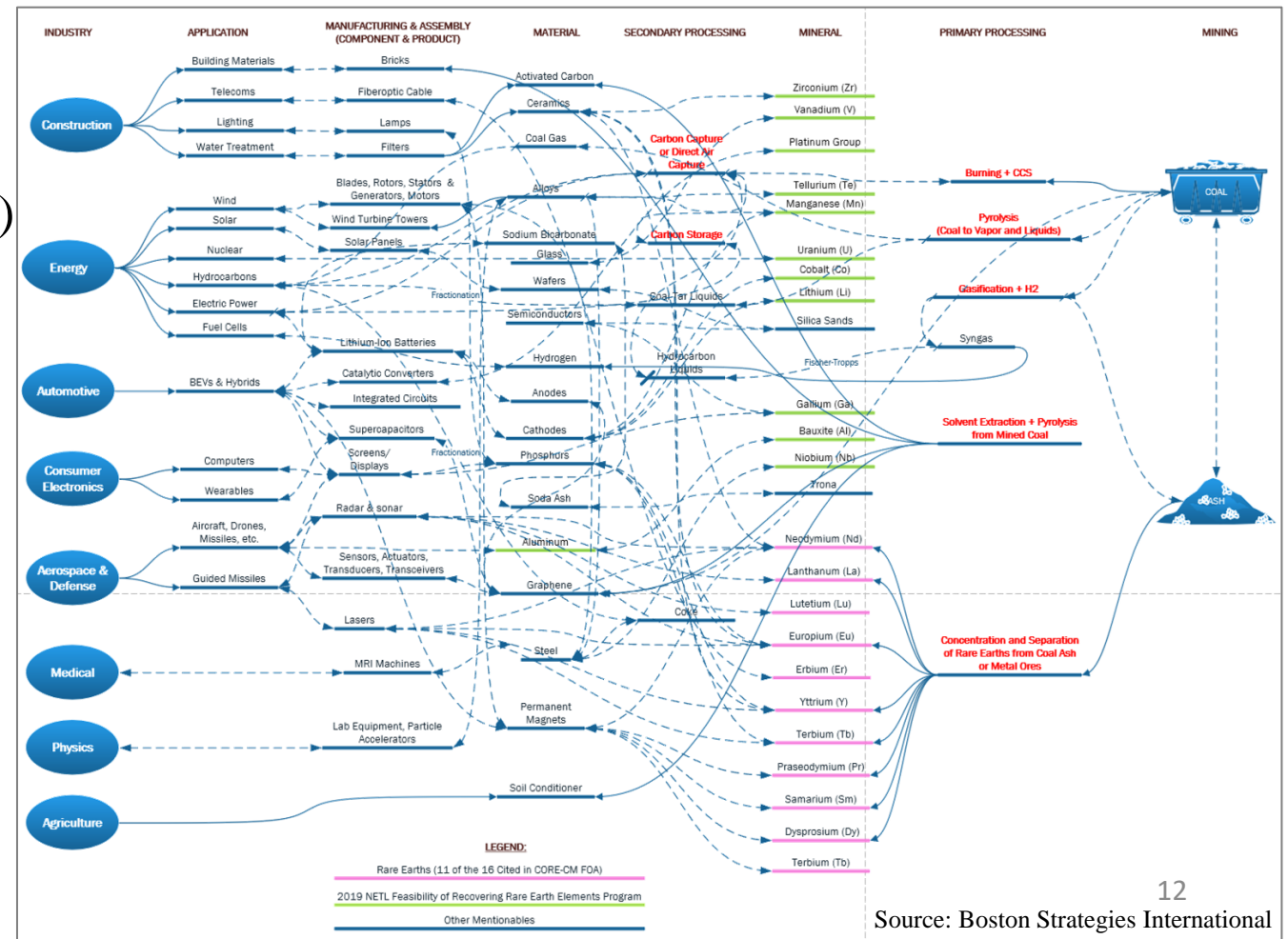
Technology Innovation Centers

Potential Supply Chain Pathways to Be Analyzed versus Project Goals

Preliminary Economic Evaluation Criteria

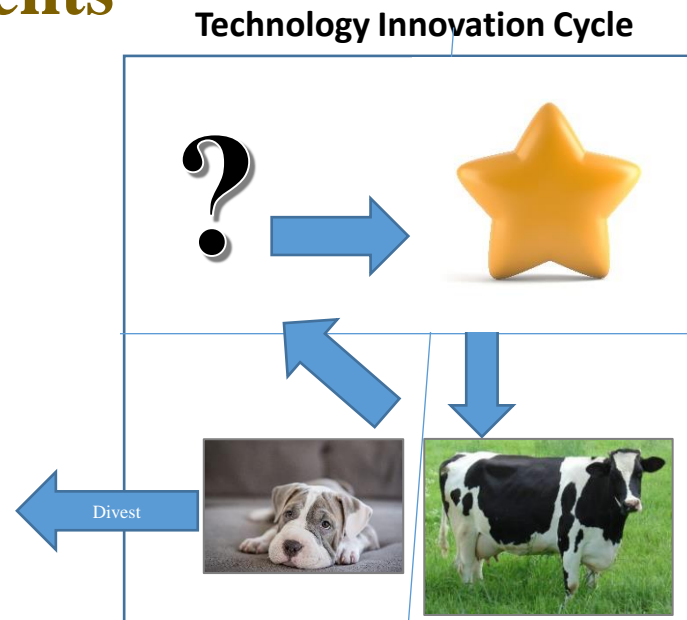
- End-market Size (societal and economic impact)
- Local Capital Expenditure (near-term job creation)
- Labor Intensity (long-term job creation)
- Local Operating Expenditure (tax revenues)
- CO₂ Footprint (sustainability)
- Sales per Head (knowledge intensity)

Value Chains for Economic Analysis (Jobs, etc.)

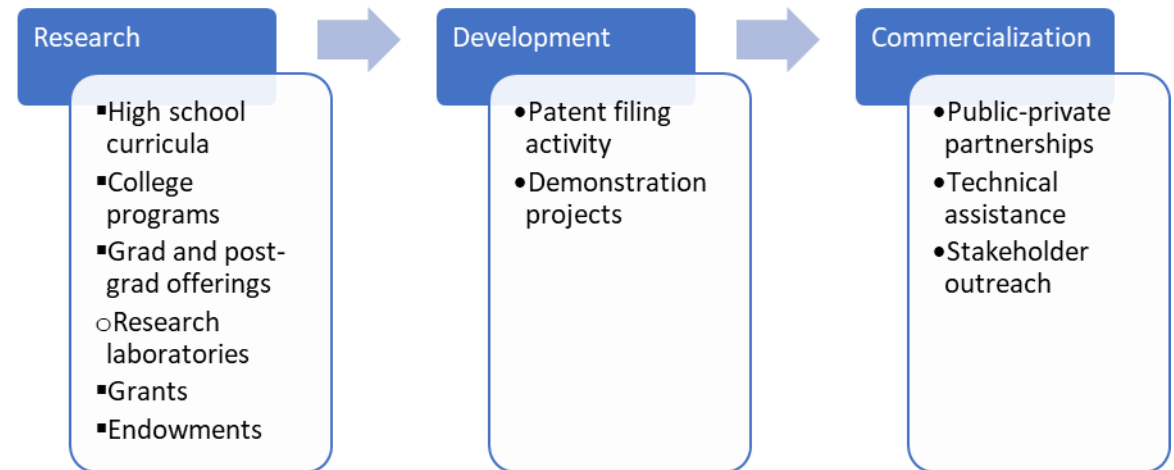


Technology Innovation Centers

Technologies That Best Fit the Goals Will Be Prime Innovation Center Investments



Likely Components of Technology Innovation Center Investments



Source: Boston Strategies International

Siting & location of Technology Innovation Center(s) based upon leveraging existing research strengths & infrastructure

Thank You

Project Details & Information

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To be added to stakeholder updates

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