

Green Steel: Clean Energy and Iron-based Industries - Jobs for Northern Minnesota AND the Environment

**MN Northland Chapter of the
Citizens' Climate Lobby**

November 8, 2023



Slide 1:

Thank you for this opportunity to address the Mineland Vision Partnership today. I know that your organization focuses on the local Vision for dynamic minescapescapes...sustaining current and future mining... and enhancing the natural environment of the area that is so important to the Range Communities.

I'm Mike Overend, representing my colleagues from our Northland Chapter of Citizens' Climate Lobby, and we want to share five important opportunities of the clean energy economy that can help fulfill your vision for Northern Minnesota.

The bipartisan Infrastructure bill and the Inflation Reduction Act created immense Federal funding opportunities for communities to transform to a clean-energy future. On October 13th the Department of Energy made history with the announcement of \$1 billion in funding for the Heartland Hydrogen Hub based in Minnesota; powered by clean, renewable electricity. This Hydrogen Hub was the crucial financial and technology "missing piece" for the vision we will share with you today.

Right now, the stars have aligned for the Range, creating a “once-in-a-lifetime” opportunity using Minnesota’s unique resources to support Range families and communities far into the future.

As concerned citizens we believe that the people in this room must act swiftly, and with purpose, to seize this moment, and bring these Jobs, built from Clean-Energy and Iron, to your Range communities.

We Are Citizens' Climate Lobby:

- Volunteer-driven, Non-partisan
- 400+ US Chapters with 220,000+ Volunteers
- Nationally: Advocating for important Climate Solutions through bipartisan legislative policy
- Locally: promoting clean energy and iron-based opportunities for sustainable jobs in N. Minnesota

CCL: “Creating Political Will for a Livable World”



Citizens' Climate Lobby

Slide 2

CCL is focused on creating political will for a livable world by supporting important Climate Solutions. Our presentation shows five unique opportunities for Northern Minnesota which are important, environmentally safe, Clean-Energy Climate Solutions offering sustainable jobs in our region. CCL is focused on four national Climate Solutions:

1. Pricing Carbon with the Energy Innovation and Carbon Dividend Act: Gradually increasing Carbon Pricing combined with an equal monthly citizen Dividend and a Carbon Border Adjustment Mechanism (CBAM).
2. Healthy Forests: including best management practices for both rural and urban forests
3. Building Electrification and Energy Efficiency by implementation of the Inflation Reduction Act (IRA)
4. Clean Energy Permitting Reform to modernize our electric grid.

Climate Change: It's Real...It's Us...It's Bad...and it's Urgent

But there's **hope**...if we **act**!

Over 60% of power for global Industry comes from burning Fossil Fuels:

- Steel production = 7% of global GHG
- **“Beneficial Electrification”**
 - “Green” the Grid with Clean Energy
 - Electrify Everything
 - Stops 80% of GHG



Slide 3

Climate Change: Its Real, Its Us, Its Bad, and its Urgent BUT There's Hope, IF we Act Now!

Our global energy system has a major problem:

- Over 60% of our industrial power comes from burning fossil fuels, creating economic loss, pollution and health issues.
- Industry causes 30% of global Greenhouse Gas Emissions (GHG) and Global steel production creates 7% of GHG.
- Transitioning to Clean Energy to power 100% of our lives, including industry, is the primary solution to global warming and can reduce GHG by 80%.

This is termed “Beneficial Electrification” which will save us money, create jobs and dramatically reduce pollution.

Huge Opportunities In Front of Us



“This is the largest wealth creation opportunity of our lifetimes... There will be nothing else that will produce more wealth, more jobs, more work...”

-Jigar Shah: in charge of \$400 Billion in DOE funding for Climate Innovation

-January 20, 2021

Slide 4

The opportunities are enormous for those who choose to ACT! Jigar Shah, successful solar industry entrepreneur and now in charge of \$400 Bn in DOE funding for Climate Innovation has said:

“This is the largest wealth creation opportunity of our lifetimes... There will be nothing else that will produce more wealth, more jobs, more work...”

Why not HERE on the Iron Range?

- Natural Resources offer global market “Clean Energy” Solutions
- Skilled workers and training
- Strategic Energy and Transportation grids
- Access to Vast Clean-Energy
- Range Communities adapt & succeed
- A rich and strong culture of family, community, work and pride



Slide 5

Our opportunities to create important “Added Value” from mining iron have historically disappeared “down the lake” on ore-boats to other states and communities.

- The steel industry originally developed close to fossil fuel energy: coal, coke and natural gas.
- Primary Steel Markets now are asking for low-carbon intensity and 100% GHG emission-free “Green” Steel
- Clean Energy is cost-effectively replacing Fossil Fuels

Minnesota’s Iron Range is located at the intersection of cost-effective clean energy and vast iron resources.

AND

The future of decarbonized, green iron, green steel and green industry CAN come here!

Iron Range mining communities have the people and the resources to make this happen right HERE!

Resources For Our MN Future

**1. Federal and
State Funding**

**2. Academia:
U of M: NRRI and
Morris WCROC**

**3. Clean Energy:
Hydro, Wind and
Solar**

**4. DOE Heartland
Hydrogen Hub**

**5. New Ore and
Steel
Technologies**

**6. Energy Storage
Technologies:
Abandoned Mines
& Batteries**

Slide 6

Department Of Energy studies have shown that this set of critically important resources is unique to Northern Minnesota and gives us a window of opportunity, for 10 years, to create decarbonized industries that offer a Clean Energy and Iron-based future for the Range.

Funding is Available NOW!

- **Bipartisan Infrastructure Bill** (IIJA): \$1.2 Tn
 - **Inflation Reduction Act** (IRA): \$ 375 Bn - up to >\$1 Tn
+ \$400 Bn DOE Innovation Loans
 - **Heartland Hydrogen Hub**: \$1 Bn
 - **Federal “Buy Clean” Program**
 - **MN State “Buy Clean, Buy Fair” Program**
 - **MN Climate Innovation Finance Authority**
- “Steel in the Ground” Investments must happen by 2032 to capture these incentives!**

Slide 7

Massive government funding incentives are available until 2032 to spur innovation and jobs on the Range. However, “Steel must go in the ground”, soon, for the Range to “lock in” these incentives for sustainable job-creating opportunities. This government funding is designed to leverage private capital for the benefit of our communities.

Clean Energy Resources Available to the Range

Wind, Solar and Hydro:

Cost-effective Power without Pollution

- Growing Clean Energy Production and Transmission:
- Lowest-Cost Energy with No GHG emissions or Air Pollution
- Opportunities for large-scale Energy Storage including:
Green Hydrogen, Mechanical and Battery Energy Storage
- Congress is focused on increased Clean Energy Permitting to triple our grid.

Clean Energy Creating New Solutions for Global Needs

Slide 8

Our access to increasing Wind, Solar and Hydro Clean Energy is growing rapidly and expected to triple in 10 years, while their costs continue to decline. The potential for Direct Reduced Iron (DRI) production and our abandoned mines on the Range offer unique opportunities for developing utility-scale Energy Storage technologies to fully utilize this clean energy which can directly benefit our region and utilities across the US.

Heartland “green” Hydrogen (H₂) Hub

- **Opportunity to Decarbonize MN Industry including:**
- Steel, Cement/Concrete, Fertilizer and E-fuels:
- Key to decarbonization of our Minnesota Industries
- Heartland Hydrogen Hub: \$1 Billion DOE funding awarded to MN: One of 7 of 79 proposed US hubs funded.
- \$3.00/kg green hydrogen production tax credit ending 2032
- **IRA tax credits for Hydrogen investments until 2032**
- **NREL: MN is most cost-effective state for Hydrogen Industries and has diverse Regional Markets: for hydrogen-based products across multiple sectors**
- Sector-Coupling: Using resources from one industry to support the next: cost-efficiency and expanding multi-industry opportunities

Slide 9

The MN Heartland Hydrogen Hub includes MN ,WI, ND, SD and Montana.

- It offers up to \$1 Bn in DOE funding to create innovations in clean energy manufacturing
- It makes green hydrogen cost-competitive with fossil-fuel energy.
- It makes decarbonization of our Minnesota industries possible: including fertilizer, cement/concrete, iron and steel, and Electro-fuels (E-fuels).

On November 1st, 2023, 100 leaders from across Minnesota, many in this room today, convened at the U of M in Minneapolis to learn about this amazing opportunity for decarbonization of Industry in Minnesota. The message from the many experts there was clear; Minnesota is the best place in the nation for decarbonization of industries, but we must act quickly to capture these opportunities before competing states take them away from us.

Iron and Steel: Evolving Resources, Technologies and Economics

- **Iron Ore Resources are evolving:**
 - Massive reserves of lower-grade ores from hematite are available to help meet increased demands for steel
 - Advances in ore extraction, separation, concentration and metallurgy
- **Innovations in Steel Production Technology:**
 - Blast Furnace , BOF and Electric Arc Furnace Steel-making
 - DRI production with Hydrogen
 - Green Steel production with DRI or Molten Oxide Electrolysis (MOE)
- **Domestic and Global Markets**
 - Increasing demand and competition for low-carbon steel production
 - Carbon Border Adjustment Mechanisms: Bipartisan Congressional support for CBAM to protect US low-carbon steel production and “levelize” international competition

Slide 10

Our Resources, Technologies and the Economics of Iron and Steel are Evolving:
The demand for steel, including low-carbon and green, 100% carbon-free steel is growing!

-Massive reserves of taconite and low-grade non-taconite ores exist on the Range

-Innovations in Blast Furnace, Basic Oxygen and Electric Arc Furnace technology can decarbonize steel production now.

-100% “green” steel is possible now with clean energy, hydrogen and Direct Reduced Iron (DRI).

-100% “green” steel using Molten Oxide Electrolysis technology is ready for proof-of-concept pilot plants.

Beneficial Electrification creates strong demand for steel to build our dramatically growing solar, wind and electric-grid infrastructure.

-Steel is needed to “re-shore” our US manufacturing industries being incentivized by the IRA and bipartisan Infrastructure Acts.

-Demand for low-carbon steel is increasing dramatically for cars and consumer goods.

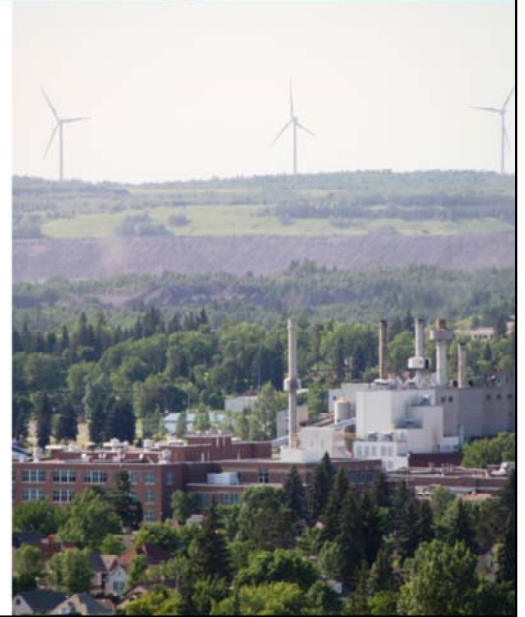
Ex\$di\$ril}iev\$errmziwev}\$sjs\$di\$WE\$ i\$Lezi\$wiir>\$(6;<\$fmsr\$errsyrgih\$rr{i{ \$
twzxi\$grier\$riw}\$rziwq irw2Tvnigw\$errsyrgih\$eggsyrxrk\$sw\$5;4@44\$ri{

nsfw\$erh\$viexrk\$irsvq syw\$hiq erh\$sv\$wygyve\$wiip\$ VM

-There is also growing bipartisan Congressional support for protecting US decarbonized steel markets and producers with Carbon Border Adjustment Mechanisms (CBAM) to “level the playing field” of international steel production.

Five Clean-Energy and Iron-Based Opportunities for the Iron Range

- 1 Green DRI Production: Hydrogen
- 2 Green Steel: DRI and MOE
- 3 Abandoned mine Energy Storage: Pumped Hydro & Compressed Air (CAES)
- 4 Manufacturing of Iron-Air Batteries
- 5 Mitigation of Sulfate-Impaired Water



Slide 11

Our CCL group has identified Five Unique Clean-Energy and Iron-based Economic Development Opportunities for the Iron Range

- Hydrogen-based green DRI production
- Green steel production with DRI and Molten Oxide Electrolysis
- Using abandoned Mines for Pumped Hydro and Compressed Air Energy Storage
- Iron-Air Battery Manufacturing on the Range...AND
- Technology to cost-effectively address mine-water impaired with Sulfate from iron-mining operations.

These are “Jobs For People AND the Environment!”

These are Jobs For People AND the Environment!

#1: Direct Reduced Iron: Opportunities

Near-Term:

- Green DRI Pellet Manufacturing:
- HERE, using hydrogen electrolyzed on-Site
- Hydrogen Hub makes hydrogen infrastructure cost-competitive with methane.

Mid-Term:

- DRI Pellet Utilization:
- Green Steel Manufacturing in Minnesota
- -made with Green Hydrogen and Clean Electricity
- -use for manufacturing Iron-Air Battery as the primary component



Slide 12

Manufacturing of DRI is our next logical step on the Range towards decarbonization. The DR-Grade feedstock is available in Minnesota and with the addition of cost-competitive hydrogen, co-located with the DR grade pellet plants, existing technology can make “green” DRI production possible here.

- Currently DRI technology represents approximately 6.7% of world steel production.
- “Green” DRI represents < 0.25% of world steel production.

Low-carbon and “green” DRI production “opens the door” for the next value-added process... manufacturing MN low-carbon and 100% “green” steel.

Low-carbon and “green” DRI production also “opens the door” for manufacturing of Form Energy Iron-Air batteries with DRI pellets as their main component, and they want “green” DRI to build their batteries!

#2: Decarbonized “Green” Steel Production

- US steel industry can reach Net Zero GHG by 2050
- Using current steel technology would increase GHG by 25%
- 70 new carbon-free steel plants needed in US by 2030
- IRA and Bipartisan Infrastructure Act have created increased demand for massive US infrastructure buildout requiring MORE steel by 2030 to build renewables, grid infrastructure and reshore industries
- Projected annual US green steel demand = 9.4 M tons by 2030
- We must make green steel here, or import it!



Slide 13

Our 2050 GHG goal of NET ZERO for US Industry includes 100% Decarbonized Steel Production.

-To meet this 25-year goal analysts say we will need 70 new carbon-free steel plants in the US by 2030!

Future demand for steel production is STRONG!

- The IRA and Bipartisan Infrastructure Act have dramatically increased demand to build our new clean-energy grid infrastructure, including wind turbine towers, solar farms, transmission lines and towers; all needing steel.
- New factories for our decarbonized transportation sector, manufacturing sector and consumer goods all need steel.

Consumers want green products and steel consumers want green steel to make them with...

If we don't make decarbonized Steel here it will be imported to meet market demand!

Mid-term Green Steel Opportunity: MOE

- **Molten Oxide Electrolysis (MOE) – Boston Metal**
- **Modular and Flexible – potential mouth-of-the-mine location and value-added manufacturing**
MOE uses electricity to selectively extract valuable metals from materials that are currently considered waste
- **High value metals recovery: uses low-grade ore without concentrating or pelletizing + cost-effective electrolysis with clean energy**
- **Turns mining waste — into an asset.**
- **Commercialization expected in 2025**



Slide 14

Green Steel with Molten Oxide Electrolysis from Boston Metal:

- It is Modular, Flexible technology and clean.
 - The only by-product from this process is Oxygen.
 - These schoolbus-sized furnaces can be located at the mouth of the iron mine
 - Connect them to adequate clean electricity and you can make 100% Green Steel directly from crushed lean ores.
 - Our massive, stockpiled lean-ore reserves can be used with minimal processing...
- AND
- Concentrated ores should improve cost-efficiency.
 - Commercialization of MOE is expected in 2025.

Utility Scale Energy Storage – Solution to Intermittency of Renewables

- **Challenge for Clean Energy:**
- **Cost of Wind and Solar has continuously declined**
- **-Production and Access is expanding**
- **-Intermittency of Wind and Solar remains a problem**
- **-Current utility energy storage is 4 hours**
- **Solutions:**
- **- Mechanical Storage locally with MN geographic features**
- **- Multi-Day Battery Storage for ALL utilities globally**



Slide 15

Wind and Solar are clean and low in cost, but they are Intermittent; the sun doesn't always shine and the wind doesn't always blow.

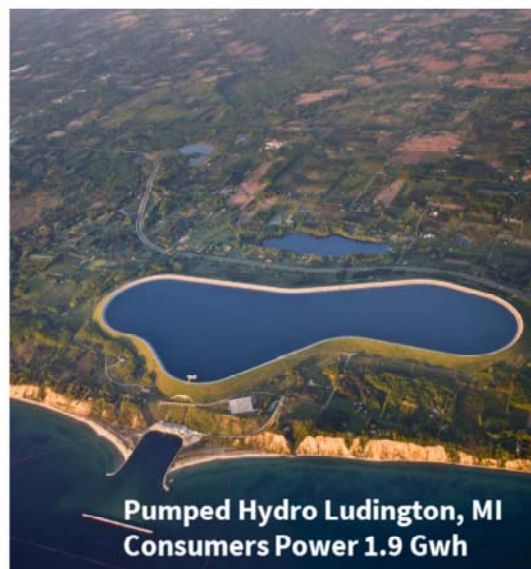
Utility-Scale Energy Storage solves the intermittency of solar and wind making it 24/7 reliable for residential and industrial customers. Storing clean energy allows it to be used when we need it, not just when it is being produced by sun and wind.

Northern MN has unique geographic resources, abandoned mine pits, that can store energy mechanically with Pumped Hydro or Compressed Air Energy Storage to make wind and solar 24/7 reliable.

Long duration utility-scale batteries are another way to make wind and solar 24/7 reliable for homes and industry. Another opportunity, if we produce DRI pellets here is to diversify our economy by MANUFACTURING new utility-scale batteries on the Range.

#3: Geographic-feature Energy Storage

- Large capacity storage technologies
- 24/7 “Firm” clean energy for severe weather & daily peak energy demands
- NRRI has identified 9-sites on the Range for Pumped Hydro:
- Proven technology for 100 years
- Compressed Air Energy Storage (CAES): additional opportunities for N. MN
- Inflation Reduction Act and MN CIFA Incentives
- Optimize use of renewable energy available from increased hydro, wind and solar e.g. Manitoba Hydro has potential for 4,300 MW of undeveloped hydroelectric



Slide16

NRRI has identified multiple locations on the Range where Pumped Hydro and Compressed Air Energy Storage can use abandoned mine sites to mechanically store large amounts of excess wind and solar energy for later use. These technologies can use Northern Minnesota’s unique geography to store clean power cost-effectively and optimize the benefits of wind and solar for both industrial and residential electric utility customers. As more sources of clean energy become available, large-scale storage provides the 24/7 solution to reliably power our lives with clean electricity.

#4: Form Energy's Iron – Air Battery Utility-Scale Solution to Wind and Solar Intermittency

- “Reversible Rusting” Chemistry of DRI
- Abundant and Safe: non-flammable, non-toxic, recyclable, wide operating temperature range
- 1/10 the cost of current utility battery technologies
- Reliable and scalable with flexible siting of batteries on the grid creating a massive market
- Expands grid capacity without additional transmission
- Increased grid resilience for severe weather with long-duration storage: 100 hrs. vs. 4 hrs. existing technologies
- US and Global massive market demand
- First manufacturing facility in West Virginia, creating 750 new jobs with a \$760 million investment.



Slide 17

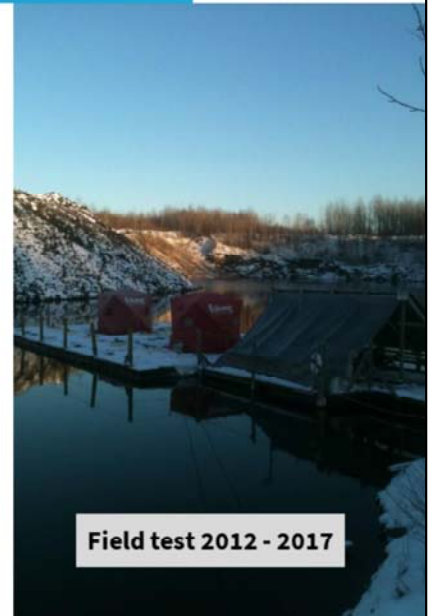
Multiple-day duration battery storage for utilities is also an important way to make wind and solar a 24/7 “Firm” power resource. Current lithium-based batteries last 4-hours and are expensive. Utilities want long-duration cost-effective batteries to meet the demands of severe weather events. Form Energy’s Iron-Air battery lasts 100-hours and uses safe, abundant DRI pellets, air and water in a “rust and un-rust” battery cycle to make wind and solar 24/7 reliable. This is a modular technology is easily scaled and is safe and recyclable. These batteries can be placed anywhere on the grid to improve resilience without building more transmission, and they are 1/10 the cost of current battery technology.

Their first factory is being built in West Virginia and is creating 750 jobs with \$760 Million in investments. These Iron-Air batteries will have massive utility market demand and will likely need additional manufacturing capacity soon. If the Range can make DRI this factory and battery manufacturing can come to Northern Minnesota.

#5: Sulfate mitigation Reduces Environmental Impact



- **Low-cost system to remove Sulfate**
- **Natural Sulfate Reducing Bacteria and Direct Reduced Iron (DRI) convert Sulfate to Iron Sulfide.**
- **Iron Sulfide is removed removed & has value**
- **No harmful chemicals added**
- **Reduces Sulfate to < 10 mg/L**
- **Improving our waters and offering important regional Environmental Justice**



Slide18

The final opportunity I will share is Clearwater Biologic's technology using DRI pellets to treat sulfate-impaired waters in iron mine pit lakes and tailing basins. This sulfate can be removed cost-effectively with natural bacteria from soil which convert sulfate to hydrogen sulfide. DRI pellets bind with and remove the sulfide which can then be used as a valuable by-product. No harmful chemicals are used and this process reduces water sulfate levels to < 10 mg/L meeting the safety standards for wild rice. This technology provides an important opportunity for environmental remediation and justice for all the communities which depend on our clean waters.

Clean-Energy + Iron-Based Technology: Connect the Dots for Opportunity and Jobs:

- **RESOURCES:** Skilled Labor + Clean Energy + Green Hydrogen + Iron Ore + Mining Technology
- **INFRASTRUCTURE:** Grid and Transportation + Energy Storage
- **TECHNOLOGY:** DRI + Green Steel including MOE, Energy Storage (NRRI + UMM) + Mitigation of Sulfate Impaired Water
- **FUNDING:** Federal and State money leverages Private Capital Clean Energy and Iron-based Opportunities .
- **= Jobs for Range Families and Communities**

Slide 19

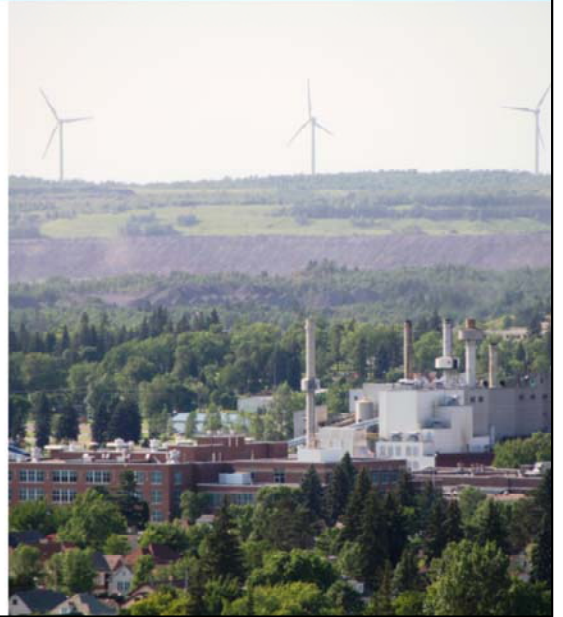
If we “Connect the Dots” we can see a great Clean Energy Vision with decarbonized Industry and Jobs for the Range.

Combining our Workers, Natural Resources and Infrastructure with our access to vast Clean Energy, Technology and Innovation; then adding strong new funding incentives to create a new Vision for the Range creates a formula for:

Jobs for Range Families and Communities that also serve as important Climate Solutions.

A Once-in-a-Lifetime Opportunity for the Iron Range

- IRA incentives for 10 years, but steel must go in the ground to get funding
- These sustainable jobs from clean-energy and iron-based industries offer important Clean Energy Solutions for MN
- We can create MN Green Steel to Put in the Ground all across the US to build our Clean Energy Economy!



Slide 20

This truly is a Once-In-A-Lifetime Opportunity for the Iron Range, we have a 10-year window to leverage government incentives with private capital.

These are clean-energy and iron-based jobs that will create important growth and a sustainable future for Northern Minnesota while offering important Clean Energy Solutions to the US and the world.

Northern Minnesota is blessed to have these unique resources. Our leaders and citizens must work together to “Plant our Minnesota GREEN Steel in the Ground” and Harvest the future that our Range families and communities have dreamed of for so long!

Thank You!

18 MINUTES

Thank You For Your Time!

- **Contact:**
- **Mike Overend drmoverend@gmail.com**
- **CCL MN Northland**

THANK YOU!

Please reach out to me at this contact information for questions.

End of Slide Presentation
Following Slides are available for longer
presentations.

Iron and Steel Industry CHALLENGES

- Changing Iron-resources: Taconite vs. Hematite
- Climate Change and Pollution Issues: Greenhouse Gas Emissions and Air and Water Pollution
- Growing market demand for decarbonized Primary and Secondary Steel
- Intense international Steel Market Competition
- Emerging pricing of carbon emissions
- Adequate access to low-cost clean energy to reduce Scope 2 emissions

PP Topics after introduction:

1. Renewable Energy: Increased availability and transmission
2. Green Hydrogen: Key to decarbonization and DOE and IRA funding
3. Green Primary Steel Market demand: DRI process, MOE and others
4. Energy Storage: Mechanical Pumped Hydro and CAEs
5. Energy Storage: Electrochemical Iron Air This is the largest wealth creation opportunity of our lifetimes...
There will be nothing else that will produce more wealth, more jobs, more workBatter
6. Sulfide Mitigation: ClearwaterBiologic

Iron and Steel Industry Opportunities

- Growing market demand for decarbonized Primary Steel
- Steel needed for 300% expansion of clean energy and grid infrastructure by 2050 to meet Clean Energy goals
- Decarbonization and Value-Added iron and steel technologies: DRI, Gaustec, MOE and other emerging techs
- Clean Energy Storage Technologies
- Iron-based industries Manufacturing
- Green Hydrogen-based industrial development in: Cement, Fertilizer, E-fuels, Green Ammonia
- Sulfate Pollution Mitigation

RESOURCES: Clean Energy

- MISO Inter-regional grid connectivity is best in the US
- Existing Electric Transmission infrastructure in NE MN
- Access to growing Wind energy in NE MN
- Current plans for grid expansion to renewables for NE MN
- Minnesota's directive: Clean Electricity by 2040
- Interest in Clean Energy Permitting Reform at Federal and State levels

RESOURCES: Iron-ore reserves and existing iron ore infrastructure

- Current taconite reserves
- Vast hematite reserves on the Range: a long-term iron supply
- New investments in DR Grade processing by Cliffs and US Steel
- MidRex green hydrogen DRI technology is available and scalable to rapidly integrate DRI process locally
- Gaustec separation offers a pathway to cost-effectively concentrate non-magnetite ore
- MN state pilot grant for electrification of haul trucks
- Mineland Vision Partnership and IRRR advocacy for the industry

RESOURCES: Renewable Energy Storage

- Heartland Green Hydrogen Hub

- Geologic Feature Energy Storage:

 - Pumped Hydro and CAES

- Battery Energy Storage:

 - Iron based utility scale BESS: Flow and Iron Air technologies

RESOURCES: Funding

- IIJA Infrastructure Investment and Jobs Act
- IRA Inflation Reduction Act
- DOE Heartland Hydrogen Hub
- DOE Loan Programs Office
- Federal Buy Clean Initiative
- Minnesota's Buy Clean Buy Fair Law

Challenges, Opportunities, Resources and Solutions!

- The coming decade is a once-in-a-lifetime confluence of these elements for Northern Minnesota.
- Minnesota's unique position for green hydrogen, clean-energy, iron resources, new ore and metallurgy technologies, incentive funding, evolving steel markets, grid expansion, geologic features, international trade and demand for Climate Solutions.
- Many other communities want these opportunities.

Steel Must Go In The Ground SOON to Make This Happen!

Innovation: The Key to our Future

The Iron Range must innovate to meet market demands

- ADOPT technological innovations in ore processing and steel production methods.
- EXPAND electricity transmission and
- UTILIZE opportunities for vast energy storage capacity
- EMBRACE innovations in mitigation technologies for existing mining including water sulfate impairment
- USE the massive Federal and State innovation and deployment incentives for reductions of greenhouse gas emissions with Green Hydrogen and Clean Energy

Minnesota: The potential of cost-effective clean energy, iron-ore and funding incentives

National Renewable Energy Laboratory analysis:

- Minnesota has the most cost-effective resources in the nation for decarbonization of industry “Supercharged” by financial incentives

U of M Morris and NRRI research shows Minnesota can meet the demand for green industrial development with: Green Steel, Cement, Fertilizer, Green Ammonia, E-Fuels and value-added manufacturing

- “Sector Coupling” + co-location of projects, allows benefits of one investment to creating cost-efficiencies for multiple industries

IIJA, IRA and DOE funding combined with MN State incentives offer a 10-year window of opportunity, but “Steel Must Go In The Ground” to qualify for these powerful incentives!

Our unique Iron Range Assets position us for Success.

- Vast iron and water resources
- Strong existing iron mining technologies
- Skilled workforce and training infrastructure
- Access to abundant renewable energy
- Strategic access to electric transmission and transportation grids
- Strong legacy of adapting to market demands
- U of M and NRRI partnering with integrated research solutions for Green Industry
- New access to new Heartland “green” hydrogen hub

SUMMARY:

-Citizens concerned about the Climate Crisis and our Region's Future

-Opportunities with clean energy and iron resources.

- Sustainable jobs
- Environmental Protection
- Reduce GHG
- Create global Climate Solutions

The Iron Range:

Unique and cost-effective resources

Sustainable, environmentally safe, mining, construction and manufacturing jobs for Range communities.

Create important Climate Solutions

No requirement for controversial resources or unreliable supply chains.

Clean Energy: Access to Hydro, Wind and Solar

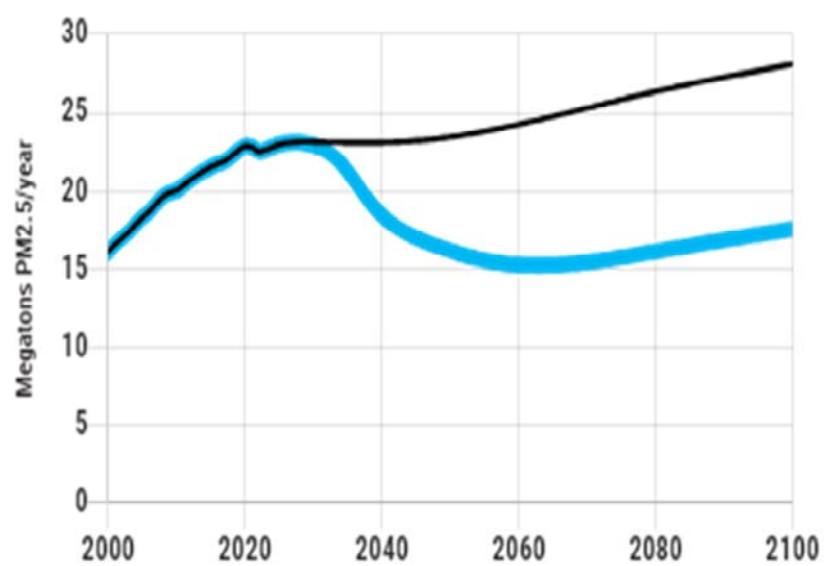
Beneficial Electrification:

- Increases Demand for Clean Electricity Generation and Transmission

Clean Energy Permitting Reform is a Congressional Priority

- Grid Modernization Needed: Improvements for Affordability, Reliability, Efficiency

Beneficial Electrification Impact on Global Air Pollution



Northern Minnesota Transmission Capacity

Existing: HV Transmission Capacity: 5,000 MW

Future: HV Transmission Capability: 7,500 MW

(MN Power plans to triple HVDC transmission to 1,500 MW)

(GRE is planning on adding 1000 MW)

Data from Minnesota Power, GRE, Manitoba Hydro and MISO(Mid American Independent System Operator)

DRI Pellet Production in MN

Dr. Weberg's topic

MN makes DR-Grade pellets now

-Precursor to DRI Steel production

-Major energy loss in shipping hot pellets

-DRI process requires massive energy inputs, currently supplied by natural gas, new technology can use hydrogen

DRI is Cost-Competitive with Clean Energy plus IRA incentives:

-For MN DRI pellet production

-For MN "low-carbon" steel production with natural gas

Now Hydrogen is available with IRA incentives

-Cost-competitive Green Steel production

Steel Technology is Changing

Blast Furnaces (BF): “Dinosaurs” of the “Rust Belt” are retiring

- Taconite pellets plus fossil fuels with large GHG.
- BF turn “on” and STAY “on” for 30 years
- Less cost-competitive steel
- Expensive maintenance

Electric Arc Furnaces (EAF): “Mini-mills” popping up globally

- DRI and scrap steel plus clean electricity with 75% less carbon
- Start and stop cycles to reduce energy loss.

Potential for Value-added to Minnesota’s iron ore still goes to other states!

EAF Steel Production can happen on the Range!

How Can We Help?

What can CCL do to help MVP create the support and political will to create this future for Northern Minnesota?

18 min mark

“Beneficial Electrification”

The Clean Energy Solution to Climate Change and the Sustainable Future of the Range

100% Renewable Energy can power the Range

Eliminates 80% of GHG and significantly reduces air pollution

This is an “ALL HANDS ON DECK” time in our lives.

We Need Innovation and Action to find the solutions to this challenge.

U of M's NRRI + Morris WCROC

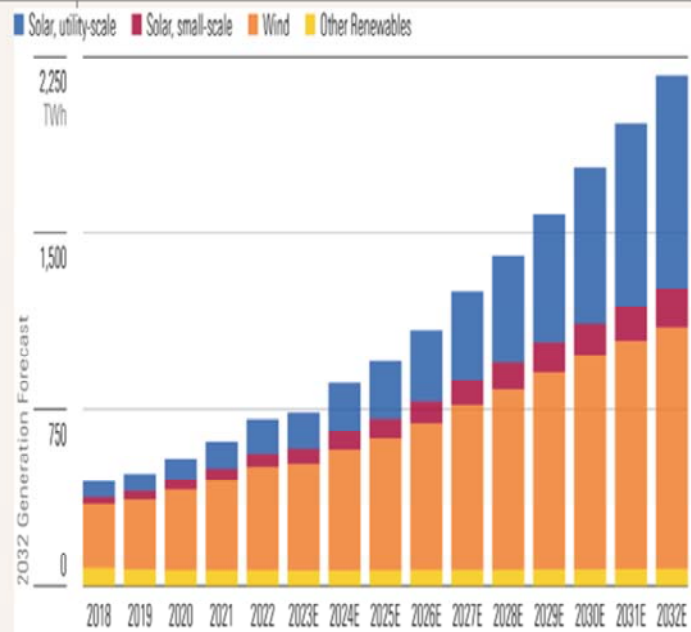


Projected Growth of Renewables

RENEWABLE ENERGY TO
TRIPLE BY 2032

MORNINGSTAR

19 OCTOBER 2023



US Must Make Green Steel!

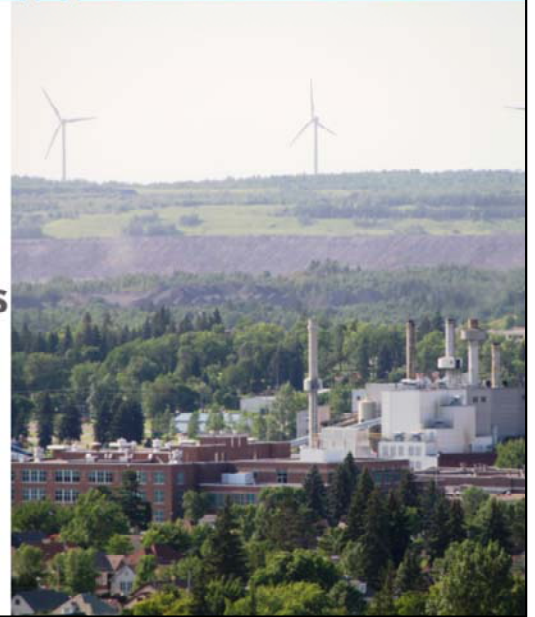
- Swedish SSAB is shipping green steel now!
- It takes 4 to 6 years to build new steel plants.

START NOW, HERE!



Five Clean-Energy and Iron-Based Economic Development Opportunities

- 1 Hydrogen-based DRI production
- 2 Green steel with DRI, MOE, etc.
- 3 Pumped Hydro and Compressed Air Energy Storage + Hydrogen Electrolysis
- 4 Iron -Air Battery Manufacturing
- 5 Sulfate Mitigation to cost-effectively address water impairment



Five Clean-Energy and Iron-based Economic Development Opportunities for the Iron Range

Hydrogen-based DRI production

Green steel with DRI, MOE, etc.

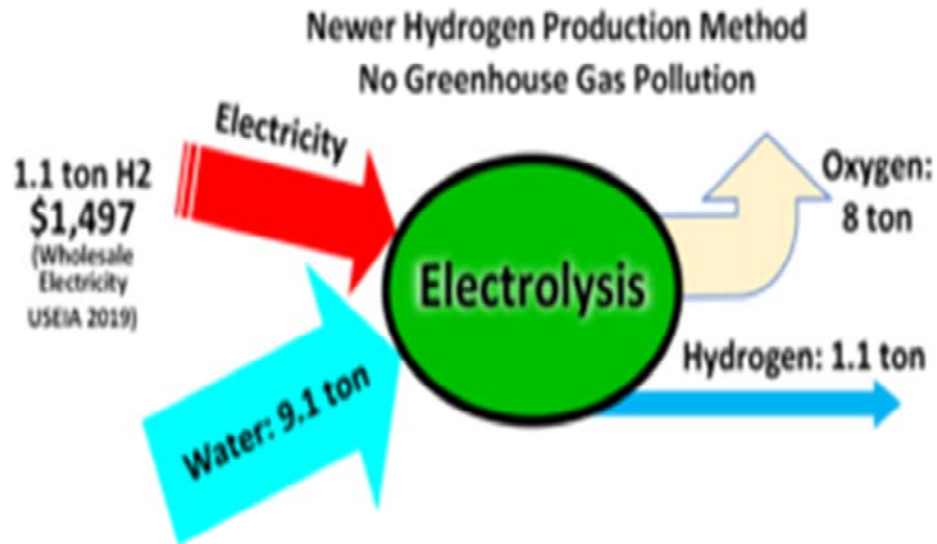
Pumped Hydro and Compressed Air Energy Storage

Iron -Air Battery Manufacturing

Sulfate Mitigation to cost-effectively address water impairment

Jobs For People AND the Environment!

Electrolysis of Water for Green Hydrogen



1.1 tons (1,000 Kg) of Hydrogen using wholesale electricity = \$1,497 in 2019
IRA Green Hydrogen production tax credit = \$3.00/Kg