Minnesota State Envirothon Current Issue Scenario 2024
Renewable Energy for a Sustainable Future in Minnesota

You work for a company called ***New Energy Minnesota (NEM)***. The NEM team specializes in helping Minnesota cities and businesses ***imagine a more sustainable future*** and explore new economic opportunities. The NEM team is small, but includes sustainability-specialists in energy, natural resources, policy, and community economics. Your team uses the United Nations Sustainable Development Goals (also called the SDGs) as their systemic framework for discussing the idea of "sustainability" – including its environmental, social, and economic dimensions. This framework is the international gold standard.

Your firm has been hired by business leaders on the Iron Range to work with them on a project called ***Energizing the Iron Range*****. They call their group of partners the "EIR team" – or "air" team, for short.**

NEM knows Minnesota is an ideal State to lead the industrial decarbonization transition because of its abundant wind and solar resources – and talented workforce. The world needs to make steel and cement with lower carbon emissions. Minnesota has many assets. But, it does not have any coal, oil, or natural gas. Western Minnesota has rich productive soils. And, northern Minnesota is a major producer of taconite ore, and iron ore pellets, which are used to make steel. Iron ore mining is a major economic driver in many communities in northern Minnesota.

Iron Range leaders are proud of their history. Cities like Mountain Iron pulled iron-rich ore out of the ground that was refined into steel and helped the Allies win World War II. But, times have changed. Today **lower-grade iron ore, called taconite (20-30% iron)** is mined. But, the global steel industry wants **raw ore or pellets to be above 65% iron**. The Iron Range has been working on how to use taconite, a lower-grade ore, for more than 50 years. People on the Iron Range keep writing a new story about their future, and this might be the next chapter. Researchers at University of Minnesota are also excited about these possible futures.

NEM doesn't have a ton of knowledge about northern Minnesota, so the team is doing background research to help inform their first conversations with the EIR team. NEM knows Minnesota has passed laws that could shape the State's future. In particular, a new state law

sets several goals, including 100% clean power in Minnesota by 2040 and 55% by 2035. NEM knows that Minnesota has made big progress on its clean power goals over the past decade.

NEM is preparing for two preliminary meetings with the EIR team. One in Babbitt, a mining town. Babbitt is located 15 miles away from Ely, the gateway to the Boundary Waters Canoe Area Wilderness. A second meeting is planned in Hibbing, another mining town – and where Bob Dylan grew up. Both cities get their power from Minnesota Power, which already gets 50% of their power from clean sources.

The federal government has also passed big laws, including the **Bipartisan Infrastructure La**w (BIL) and **Inflation Reduction Act** (IRA), which are having a huge influence on clean energy investment. This includes big financial incentives for utilities to develop new clean energy projects and huge incentives to produce hydrogen. Combining state and federal incentives could open up new economic opportunities for the Iron Range.

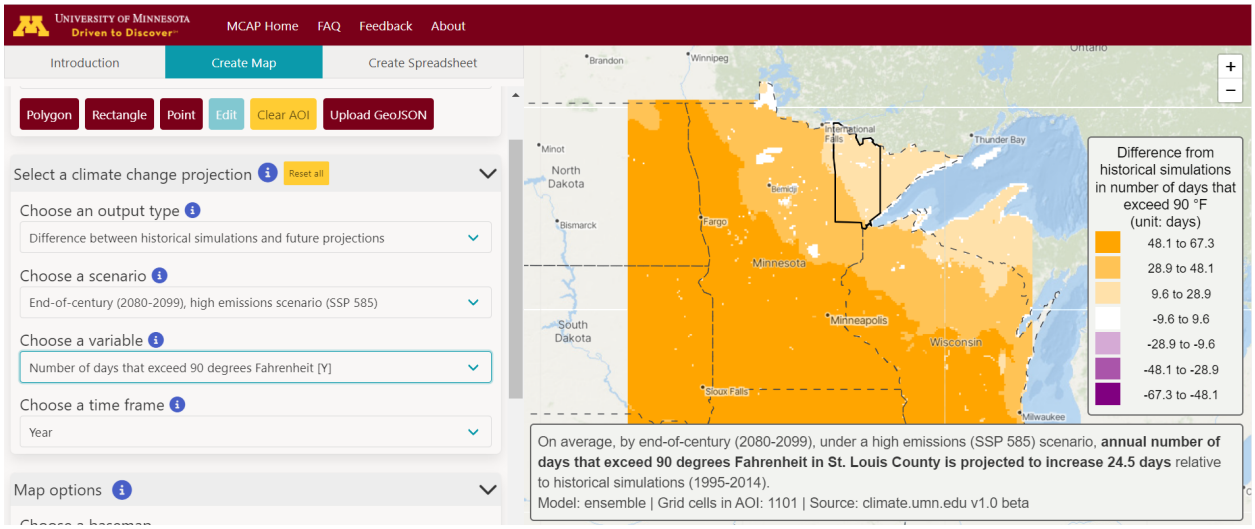
The EIR team has asked the NEM team to **provide a brief background on Minnesota's policy and greenhouse gas (GHG) emissions landscape.** Fortunately, the Minnesota Pollution Control Agency has prepared good information about our state GHG emissions. NEM also wants to make sure everyone understands why decarbonization work is important for the regional economy and regional climate. Tourism, trees, and lakes are also important to the region.

The University of Minnesota (UMN) just released a **new climate simulation tool, called Minnesota CliMAT**, which helps people to simulate how the climate may look under different GHG emissions scenarios depending on the choices that human societies make to lower emissions. Many hours of U of M supercomputer time enabled these results. One member of the EIR team has a 16-year-old kid, so you think it might be meaningful to consider what the climate might be like in northern Minnesota in 2080, when they would be 73-years-old, around their own grandparents' age.

To run the simulation, go to UMN's climate mapping and analysis tool. Scroll down, and click on "Go to the tool >". Follow the next few steps:

1) click on Create Map
2) click on "OPTIONAL: Define an Area of Interest (AOI)" then click on the dropdown menu and select "counties"
3) then you hover your cursor over St. Louis County and click it, it will become highlighted
4) then choose the output type, select "Difference between historical simulations and future projections"
5) then choose a scenario, "End-of-Century 2080-2099, high emissions scenario"
6) then choose a variable, in this case, "Number of degrees that exceed 90 degrees Fahrenheit."

The graphic automatically changes and reports that **St. Louis County is projected to have about 25 additional days above 90F in a scenario where humans drag their feet on climate action**. You run another simulation to compare results and see that Stevens County in western Minnesota may see up to 60 more days above 90F. You wonder if northern Minnesota might be a place where more people will want to live in a warmer Minnesota.



The Energizing the Iron Range (EIR) team has been thinking about the energy transition and the unique natural resources of the North Country. They know they have a lot of iron ore. They also know that copper-sulfide mining has been controversial in the region. EIR is interested in exploring other options, like green steel. Iron ore is basically an iron atom attached to a bunch of oxygen atoms. To make pure iron, the oxygen atoms attached to iron atoms have to be broken, leaving only iron atoms. Currently, the Iron Range makes iron ore pellets, which are shipped to other places and transformed into steel.

EIR is wondering if their industries could move up the value chain and produce their own "green" steel. EIR has explored two of the main "green" steel production options. The first is using hydrogen to get rid of – or reduce – the oxygen atoms. The second is using electricity to get rid of the oxygen atoms. Both ideas have some advantages. There are other options, too. EIR wonders if Minnesota, the home of iron, could become a global leader in advanced steel manufacturing and the jobs that would come with that change.

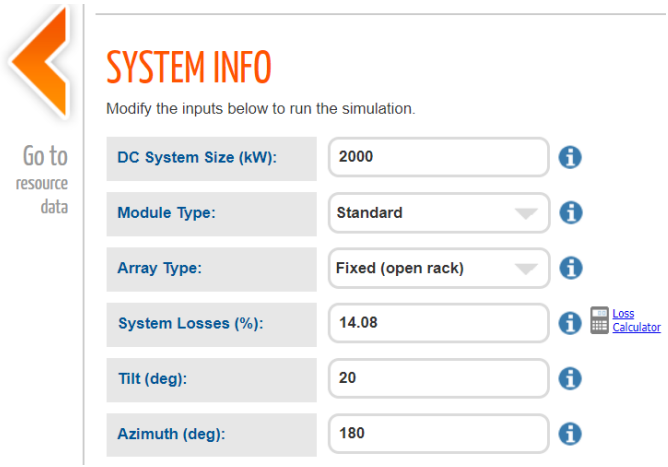
The Iron Range ships about 40 million tons of high-grade iron ore pellets each year, and remarkably, supplies the United States with most of its domestic supply – about 75-80%. NEM will need to do additional research on steel production. But, they like quick back-of-the-envelope calculations that help scope a challenge. It takes about 500 kilowatt-hours (kWh) to melt about 1 metric ton of scrap steel in an electric arc furnace.

The NEM team wonders: how much steel could one industrial turbine produce per day on the Iron Range – or elsewhere in Minnesota? Minnesota has wind maps. Vestas is a well-known

large wind turbine manufacturer in Denmark. Vestas makes 2MW (mega-watt) wind turbines that stand 80 meters or even higher! A 2MW turbine, in 6 meter-per-second average winds, will produce about 7M kWh per year. Roughly 20,000 kWh per day – if wind stayed the same every day, which it doesn't. So, maybe one turbine could produce roughly 40 tons of steel per day.

The University of Minnesota West Central Research and Outreach Center (WCROC) is already producing hydrogen from wind in Stevens County, located in west-central Minnesota. Two industrial wind turbines have been operating there for many years. University of Minnesota Morris, which is carbon neutral in electricity, partnered with WCROC to launch the Center for Renewable Energy Storage Technology to demonstrate wind-to-hydrogen-ammonia research and new battery storage technologies. There are areas in Minnesota with impressive wind resources – and North Dakota and South Dakota are basically the "Saudi Arabia of wind."

One member of the NEM team also wanted to do a quick check to see how much power a large solar photovoltaic (PV) field might produce in Hibbing. The National Renewable Energy Laboratory makes an easy-to-use tool, called PVWatts, to make an estimate. You launch the tool, enter Hibbing as your location, and enter 2000kW – which is the same as 2MW – and see that you could make about 2.5 million kWh per year. Also, solar panels being made in northern Minnesota could be used in northern Minnesota, too!



NEM knows that the energy transition and green steel will require a lot of clean energy. And, new ways to store that energy. It would be cool if iron could also be part of that solution. One of the energy storage experts on the team identified several emerging technologies that allow electricity to be stored with iron-based solutions. One technology is the iron-flow battery. And, the second technology is the iron-air battery. These ideas are already getting attention in Minnesota. NEM is excited about the idea that the Iron Range could lead on all things "iron-made" in collaboration with researchers at universities and industry partners. NEM is also watching new thermal energy batteries enter the market, for example, like Antora, which is basically a box of fancy rocks (like graphite) that can be heated up with electricity to over 1500C, which can reach temperatures required for steel manufacturing.

Of course, there is a lot of energy in just getting the iron ore out of the pits before it is crushed and turned into pellets. NEM wonders if electrifying the dump trucks might be one quick win that would demonstrate how electricity could improve mine operations and reduce the carbon footprint and spur more clean energy projects.

NEM decides that their preliminary meetings with the EIR team will focus on a few key areas. Their goal is getting Iron Range leaders excited about emerging possibilities. Your team brainstorms a basic outline to present. You know you will only have about ten minutes, so you will have to keep it brief.

1. Broadly describe the United Nations Sustainable Development Goals (SDGs) and why your team uses them to organize their work in communities: What are some examples of the SDGs that relate to this project?
2. Broadly describe the current clean energy policy goals of Minnesota: What are our clean energy targets?
3. Using a cutting-edge climate simulator tool – describe Minneosta's climate at the end-of-the-century without bold global action: What could Minnesota's summer weather look like in 2080? How would that affect society?
4. Broadly describe Minnesota's GHG emissions: What are our top emissions areas and how do they fit into this project?
5. Broadly describe how steel production fits into the global GHG emissions picture: How much does steel production contribute to climate change?
6. Broadly describe how Minnesota is decarbonizing its electricity sector: In particular, how is Minnesota Power, which supplies Iron Range communities, getting its power? How clean is it right now?
7. Broadly describe two of the approaches currently being researched to make green steel: How is hydrogen used to make steel green? How can electricity be used to make steel green?
8. Broadly describe how much iron ore Minnesota produces and how much energy might be needed to convert high-grade iron ore pellets into steel: How much ore does the Iron Range produce, and how could wind and solar help with the electricity demands?
9. Broadly describe other emerging opportunities around energy storage: What are examples of energy storage that use iron? How could thermal energy batteries help with steel production? How could electrifying trucks in mines help?
10. Broadly describe how renewable energy plays a role in creating a sustainable future in Minnesota: How can renewable energy help the Iron Range develop a new steel-making future?