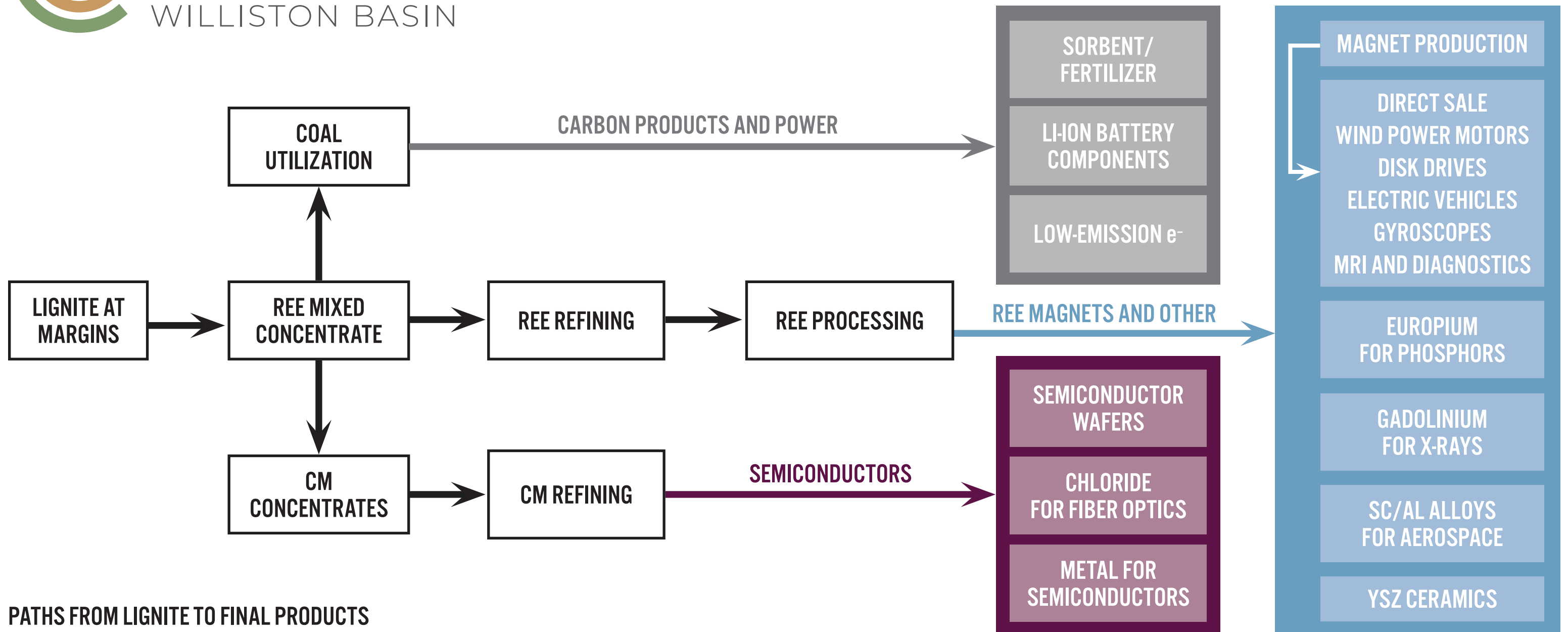


# PREVIEW: WHAT IS THE OVERALL PICTURE?



## PATHS FROM LIGNITE TO FINAL PRODUCTS

Everything starts with the lignite at the margins of coal seams, which is where critical minerals (CMs) and rare-earth elements (REEs) tend to concentrate. This lignite could be taken to a plant for processing—usually physical and/or chemical—into three products:

**MIXED RARE-EARTH OXIDE CONCENTRATE** | This powder can eventually be separated into each of the REEs, although this takes a great many steps. As shown on the back, REEs are typically split into five categories: REEs used to make magnets; heavy REEs; light REEs; samarium, europium, and gadolinium; and scandium and yttrium. Some of these, like the magnet REEs, are extremely important for making a whole host of products, while others, especially light REEs lanthanum and cerium, are overproduced.

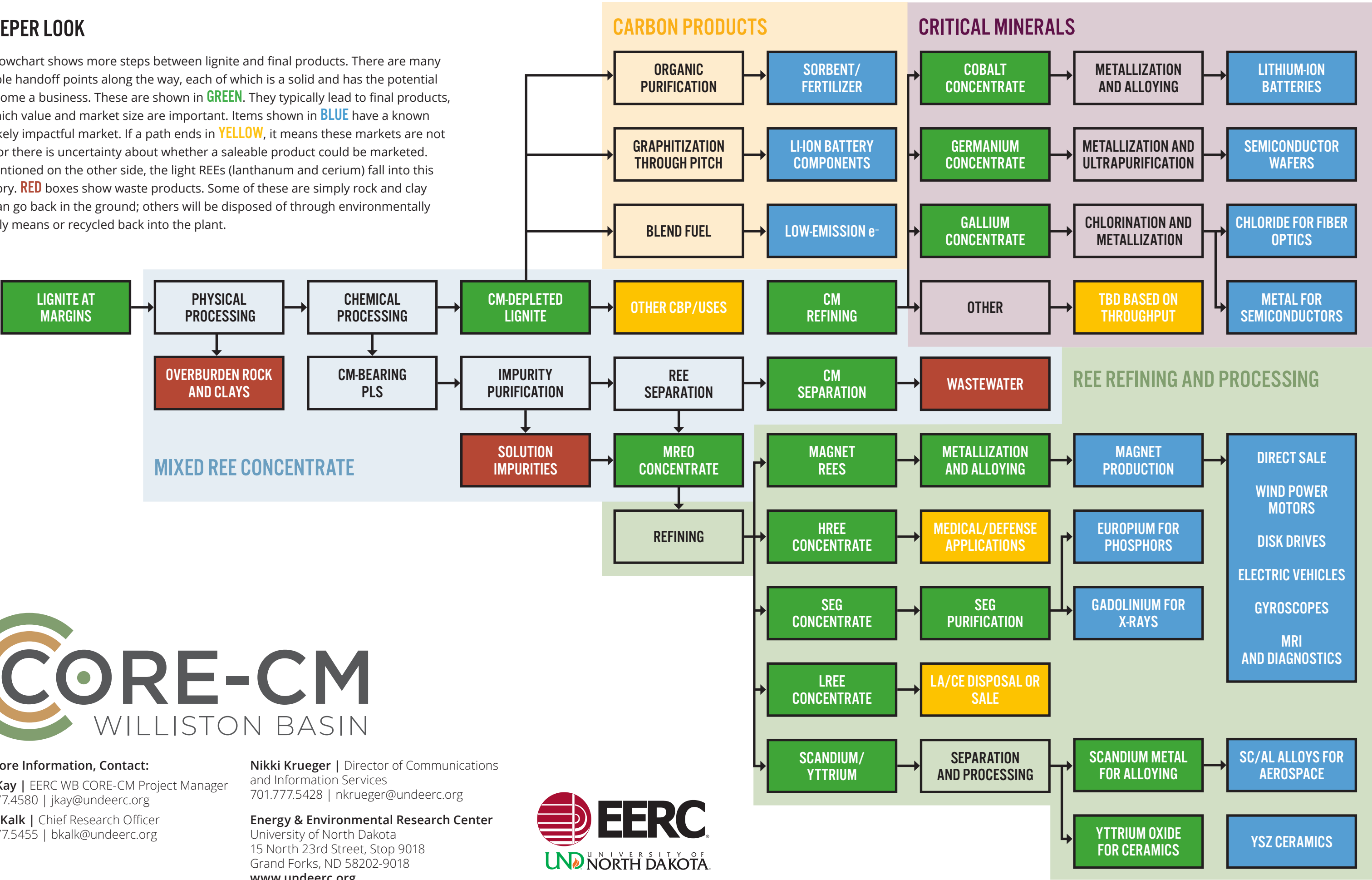
**CM CONCENTRATES** | These include the CMs that are not REEs. Typically, CMs also need to undergo processing. Two important CMs are germanium and gallium, which are semiconductors. Cobalt is a primary constituent of the cathodes (positive side) in a lithium-ion battery. Elements like lithium and nickel are also among those important to daily life.

**CM-DEPLETED LIGNITE** | In addition to being burned to produce electricity, carbon ore can be used to make graphite, battery components, or any number of different products. Graphite and CM cobalt account for half the cost of a lithium-ion battery. Other processes lead to the production of a better burning, lower-emission fuel.

**This is the advantage of lignite: It can be used to produce REEs, CMs, or carbon products.** Thinking of coal as an ore useable for manufacturing goods will be a change for many, but it also ensures that the Williston Basin continues to make the most of its enormous lignite deposit and existing coal mines.

A DEEPER LOOK

This flowchart shows more steps between lignite and final products. There are many possible handoff points along the way, each of which is a solid and has the potential to become a business. These are shown in **GREEN**. They typically lead to final products, for which value and market size are important. Items shown in **BLUE** have a known and likely impactful market. If a path ends in **YELLOW**, it means these markets are not large or there is uncertainty about whether a saleable product could be marketed. As mentioned on the other side, the light REEs (lanthanum and cerium) fall into this category. **RED** boxes show waste products. Some of these are simply rock and clay and can go back in the ground; others will be disposed of through environmentally friendly means or recycled back into the plant.



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