Ferguson, Thomas (ENE)

From: Grid <grid@masscec.com>
Sent: Monday, January 29, 2024 9:56 AM
To: Ferguson, Thomas (ENE)
Subject: FW: [EXTERNAL] Charging Forward: Energy Storage in Net Zero Commonwealth.
Attachments: Michaud 5.pdf

Good Morning Thomas,

My name is Ben Levinson; I am in the new Fellow on the Net Zero Grid Team at MassCEC!

We received the following email this weekend containing feedback on the energy storage study you are managing.

Best,

Ben

Ben Levinson (He/Him)
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MASSACHUSETTS CLEAN ENERGY CENTER®

From: Marcia Young <marciamey5@gmail.com>
Sent: Sunday, January 28, 2024 2:00 PM
To: Grid <grid@masscec.com>
Subject: [EXTERNAL] Charging Forward: Energy Storage in Net Zero Commonwealth.

This report fails to mention that Renewables (specifically wind and solar) are impossible without adequate storage. Adequate storage will to need consider the very real possibility that we will need many weeks of storage in winter when successive storms will not allow the recharging of batteries. In addition, no consideration is given to the enormous quantity of critical minerals required globally to meet the 2050 Roadmap goals. Professor Simon Michaud of the Geological Survey of Finland has done a quantitative evaluation of the amount of backup needed and the quantity of minerals required to meet these goals. His main question is “Can the mining industry deliver?” His answer is “No”. There are not enough of the critical minerals on the planet to satisfy these needs, and the intensive mining required will have an enormous negative impact on the ecology of the Earth. Data supporting his conclusions are attached in a summary of some of his findings. A link to his full presentation is provided.

I urge you to consider Nuclear Power as the most reasonable clean energy alternative. Nuclear power is strong, reliable, dispatchable energy that <u>requires no backup</u>. Because of its energy density, a very small quantity of starting material produces an enormous amount of energy. Thus, it is kind to the planet both in its supply chain and its waste products. It produces no CO_2 and can solve so many of our problems in addressing climate change. If we are truly sincere in “Charging Forward”, we must add Nuclear Power to our energy mix.

Marcia Young
Westford, MA

Excerpts from Simon Michaud Presentation

The Green Energy Transition Will Not Work As Planned, What Might We Do Instead?

by Simon Michaud, Assoc. Professor of Mineral Processing & Geometallurgy, Geologica Survey of Finland

For the complete presentation, follow this link: https://www.youtube.com/watch?v=YbnXMv19Hck

Professor Michaud has conducted a through and detailed assessment of the mineral requirements to achieve the targets set by the International Energy Agency (IEA. 2021) *Net Zero by 2050 - A Roadmap for the Global Energy Sector.* According to this plan, renewables are expected to supply 88% of our energy needs by 2050, with all vehicles being electric or hydrogen-fueled, aviation using synthetic and bio-fuels and shipping relying on ammonia or biofuels.

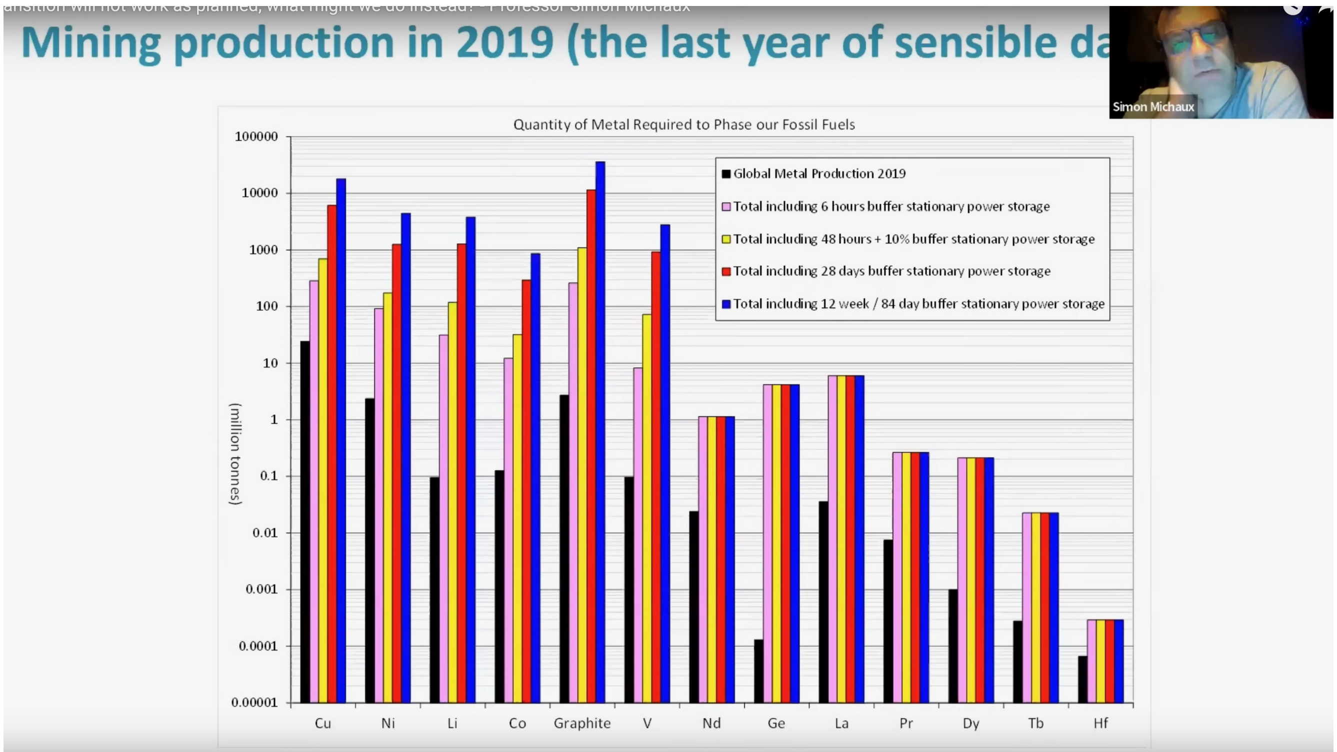
Professor Michaud's objective is to answer the question "Can the mining industry deliver?" He quantitatively maps the minerals required for various systems to meet this global goal, including Renewables, Transportation, Carbon Capture, Hydrogen and Ammonia, Unabated Fossil Fuels, Nuclear Power, and Infrastructure. His calculations reveal the need for an additional 796,210 new power plants of average capacity.

The intermittent nature of wind and solar necessitates a buffer to assure reliable delivery. Professor Michaud calculates the requirements for the current proposed 6-hour backup, as well as potential backup times of 48 hours, 28 days and 12 weeks. His investigation suggests that the likely amount of backup required is closer to 12-weeks. The 6-hour backup is not even enough to carry us through one night. Unfortunately, wind and solar underperform at the worst times of the year. In winter, there are typically successive periods of bad weather that will not allow sufficient recharging of battery storage. His conclusion is that solving the buffer problem is the biggest challenge facing us in meeting the 2050 goals. In fact, he says, **"Until we resolve the ability to deliver buffer, wind and solar are not viable for primary energy systems."**

Figure 1 depicts Global Mining Production in 2019 (the last year of sensible data due to Covid19) compared to mineral requirements for the four different buffer scenarios. Note that this is a log scale graph. The 2019 Global Metal Production (black) is compared with the needs for a buffer of 6 hours (pink), 48 hours (yellow), 28 days (red) and 12 weeks (blue). The graph illustrates the significant scale of demand with some scenarios requiring production time extending well beyond the 2050 timeframe. For example, for copper, the 12 week scenario would take 744.7 years to produce.

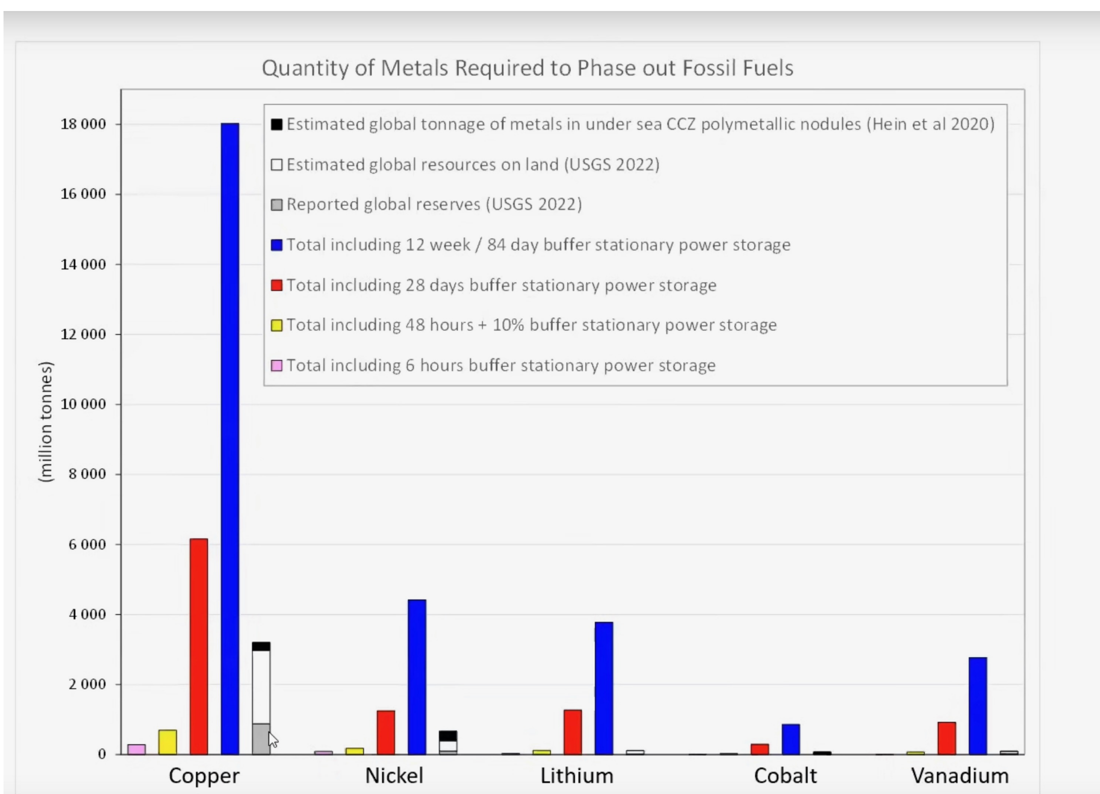
Figure 2 provides a linear scale graph of the requirements of six critical minerals across the four scenarios, compared with reported global reserves (grey), estimated global resources (white), and estimated undersea tonnage (black). It becomes evident that the Earth's current and estimated future mineral availability falls short of meeting demand for a realistic buffer and raises concerns about the environmental impact of intensified mining.

Figure 1. Global Mining Production in 2019 (log scale)



* tonne = metric ton

Figure 2. Quantity of Metals Required to Phase Out Fossil Fuels (linear scale)



Michaud asserts that the past 50 years have seen policy decisions proceed without adequate consideration of numerical realities. He advocates for a new energy paradigm grounded in reality, one that provides a comprehensive engineering assessment that considers the entire lifecycle of each energy option, including supply chain and production issues, operational impacts, waste burdens, mining repercussions, pollution effects on the Earth's ecology, and the impact on global prosperity and lifestyles. When we do this kind of analysis, Michaud concludes that, to save the planet and meet the need for abundant and reliable energy, high energy density is essential. We need to get a lot of energy from a small amount of source material.

To address the need for high energy density, Michaud suggests we focus on Thorium Breeder Reactors as a promising existing option due to their small environmental footprint. This nuclear reactor design has been around since the 1960's at Oak Ridge TN. Unlike standard Light Water Reactors that use solid uranium fuel rods that must be cooled by water, the Thorium Molten Salt Reactor employs a liquid fuel that is not radioactive prior to processing in the reactor and requires no water cooling. The table below demonstrates the benefits of the Thorium Molten Salt Reactor design over the standard Light Water Reactor with regard to starting materials and resulting waste.

	Thorium Molten Salt Reactor	**Light Water Reactor**
Starting Materials	280 metric tons of monazite mineral sands	123 million metric tons of uranium-rich ore
Electricity Produced	10,000 GWh in 365 days	10,000 GWh in 365 days
Waste	4-5% 53.84 kg	96% 31,584 metric tons

The overall impact on Earth is significantly smaller with the Thorium Molten Salt reactor - and minuscule when compared with the mineral requirements of Renewables. Since nuclear energy does not have the intermittency problems of Renewables, no buffer is needed. The energy produced is not impacted by the weather, the season or the time of day. Strong, steady reliable energy is produced with no CO_2 emissions and no need to cut trees or impinge on whale territory.

Currently, China is pioneering Small Modular Reactors (SMRs) using the thorium technology, and Copenhagen Atomic, a Danish company, plans to demonstrate similar reactors by 2025.