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From Ice to Energy: Greenland's Hydropower Bonanza

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Greenland, the world's largest island, is home to some of the most extensive and untouched natural landscapes on the planet. Its abundant water resources, including vast glaciers and numerous rivers, make it an ideal location for large-scale hydroelectric power projects. These projects not only have the potential to provide significant amounts of clean energy but also open up new opportunities for power to X production, with cheaper energy than from anywhere else on the planet. In this article, we will explore green hydrogen and ammonia production powered by hydroelectric power from Greenland as key strategic investment objects for US and European companies.

Greenland, a part of the Kingdom of Denmark, has a population of just over 56,000 people, making it one of the least densely populated places on Earth. Had it been its own independent country it would be the world's 12th largest. Its electricity demand is currently met through a mix of diesel generators and small-scale hydropower. However, the country's vast hydroelectric potential remains largely untapped.

The "power" scale of things

In recent years, there has been growing interest in large-scale hydroelectric power projects in Greenland, driven both by political ambition to become 100% green in 2030 and by the need to reduce the country's reliance on fossil fuels and the potential for export to neighboring countries. Putin's war in Ukraine has only fueled this sentiment, both in Greenland and most other Western countries. Out of more than 60 cataloged hydropower potentials, the most significant potential being offered for tender is large-scale potentials near Maniitsoq, and the Upper Nuuk fjord potentials. The Government of Greenland is cautious and does not overpromise, so mostly the collective capacity is mentioned as 800 MW.

However recent conclusions by GreenLead on the last 20 years of hydrology studies show that the increase in global temperature and the dramatic increase in Arctic temperature has increased the water flowing to these massive hydropower potentials. Today these giants will likely deliver between 1.5 GW to 2.0 GW producing some 7 – 10 TWh of energy in one massive hydropower system. Only 200 miles of transmission would be needed to combine this into one big system with all the backup and redundancy benefits this would bring. Calculations done by energy specialists from GreenLead indicate LCOE levels as low as 15 USD / MWh continuously for decades to come. The crazy part is, that with more global warming, the potentials will just keep increasing in size. The projects are being offered into tender, and the Government of Greenland is looking for investors. However, the Greenlandic government is small and has limited resources, so not a lot of noise has been made to alert the world to these unique possibilities.

These potentials are a group of just 5 potentials out of more than 60 relevant potentials with 30 years' worth of hydrology data. Concerning the remaining potentials, GreenLead has developed pre-feasability studies of many of the major potentials which show that there are lots of other attractive large-scale potentials with very low costs of energy. The Government of Greenland practices an "open door" policy, but it is unlikely that anybody is aware of this, and the possibilities this entails – Mind blowing!

What's the use of abundant energy with no consumers

The potential for large-scale hydroelectric power in Greenland doesn't stop at electricity generation. It must be converted into some other medium to be put to good use in other places around the world. One logical step is to combine the country's abundant clean water resources with hydroelectric power and make Power-to-X, such as green hydrogen and ammonia. These fuels can then be used as a clean alternative to fossil fuels in transportation, industry, and heating all over the world, substituting fossil fuels, and avoiding carbon emissions. However, this use of the energy, would not utilize all the value streams efficiently, as heat and oxygen would be valuable biproducts going to waste. Therefore GreenLead has detailed energy-intensive output concepts in the form of industry hub structures including Power-to-X, which utilizes the collective value streams to a much higher degree, thereby improving the feasibility of future Arctic hydroelectric Power to X projects.

Despite modest exposure, Greenland's potential for Power-to-X applications has attracted the interest of several companies and investors, including the Danish energy company and renewable energy developer Ørsted and other large companies with Power-to-X ambitions. Ørsted has been exploring the feasibility of a green hydrogen production facility in Greenland, and if this is done at full scale the 5 mentioned tender potentials could produce beyond 100,000 tons of hydrogen annually using renewable energy. Other companies exploring further refinement will be looking into green ammonia production. The production of ammonia requires nitrogen, and since air consists of 78% nitrogen, there is no shortage of supply of this ingredient.

Methanol – not a likely solution

While Power-to-X applications such as green hydrogen and green ammonia hold significant potential for large-scale hydroelectric power in Greenland, the production of green methanol may be less attractive due to the lack of abundant CO2 sources in the country. Methanol production requires a significant amount of carbon dioxide, which is typically sourced from industrial processes, large-scale waste processing, or from fossil sources. However, in

never been done to the scale required in this project and would require a lot of energy.

Moreover, the transportation of CO2 from other countries to Greenland for methanol production would result in significant carbon emissions, thus defeating the purpose of producing green fuels. Therefore, it only makes sense to ship CO2 to Greenland for Power to X production into methanol, and further refinement into DME and jet fuel, in the case where carbon capture in other countries lacks proper destinations, and the emission of ship transportation is solved.

As such, green hydrogen and ammonia hold greater potential for the sustainable development of large-scale hydroelectric power in Greenland.

Lakes, batteries and ice – what's not to like?

One of the significant advantages of large-scale hydropower in Greenland is the presence of natural lakes acting as reservoirs for hydropower generation. These reservoirs provide year-round

generation, these reservoirs act as batteries with a capacity measured in Terawatt hours (TWh), a number that is by two orders of magnitude larger than current technologies like lithium batteries. This will ensure a steady supply of electricity, both across seasons and in some cases across years. Not a bad feature when compared to solar, wind, or reliance on natural gas or oil from autocratic nations around the world.

Despite being located in an Arctic climate, the reservoirs in Greenland do not freeze completely during the winter. The ice on the reservoirs only freezes down to around two meters, leaving a layer of liquid water beneath the surface down to the bottom of the lakes, usually some 50 – 200 meters deep. This means that hydropower plants can continue to operate even in the coldest months, providing a reliable source of electricity throughout the year, despite everything being covered in snow and ice.

The presence of ice *does* present some challenges, particularly with regard to ship access to dispatch the Power-to-X during the winter months. Shipping is an essential component of the export of Power-to-X production, but the problem is less of an issue regarding the transportation of equipment, materials, and personnel to remote project sites. Experience from the national utility company, Nukissiorfiit, which owns and operates 5 hydropower stations in these conditions, show, that 8-10 ice-free months during the year is sufficient, and personnel swaps can be done with helicopters all year round. To address the remaining challenge, innovative solutions are required, and maybe the use of icebreakers or the development of alternative transportation methods will be the right solution. The oil and gas industry has long been using pipes across large tracks of land, and maybe this will also apply to the new green energy logistical setup. In addition, careful planning and management of project timelines can help ensure that necessary materials and equipment are delivered before the onset of winter, minimizing the impact of ice on shipping routes.

Building Power to X in Greenland – Low impact with the reindeer being the most likely visitor to the construction sites

One significant advantage of large-scale hydropower development in Greenland is the scarcity of population in the areas surrounding the hydropower potential sites. As mentioned, Greenland has a population of only about 56,000 people, with the majority of the population concentrated in coastal towns and settlements. The remote and sparsely populated nature of much of the country means that there are few settlements close to potential hydropower sites.

This population scarcity provides significant advantages for hydropower development, as it means that there are minimal negative consequences to the population. In many other regions of the world, large-scale hydropower development has faced significant opposition from local communities due to concerns about the impact on local ecosystems, displacement of communities, and other social and environmental issues. However, in Greenland, the lack of settlements near potential hydropower sites means that such concerns are largely absent.

As the world looks to transition to a low-carbon economy, the development of large-scale hydropower in Greenland offers a significant opportunity to meet growing energy demands sustainably.