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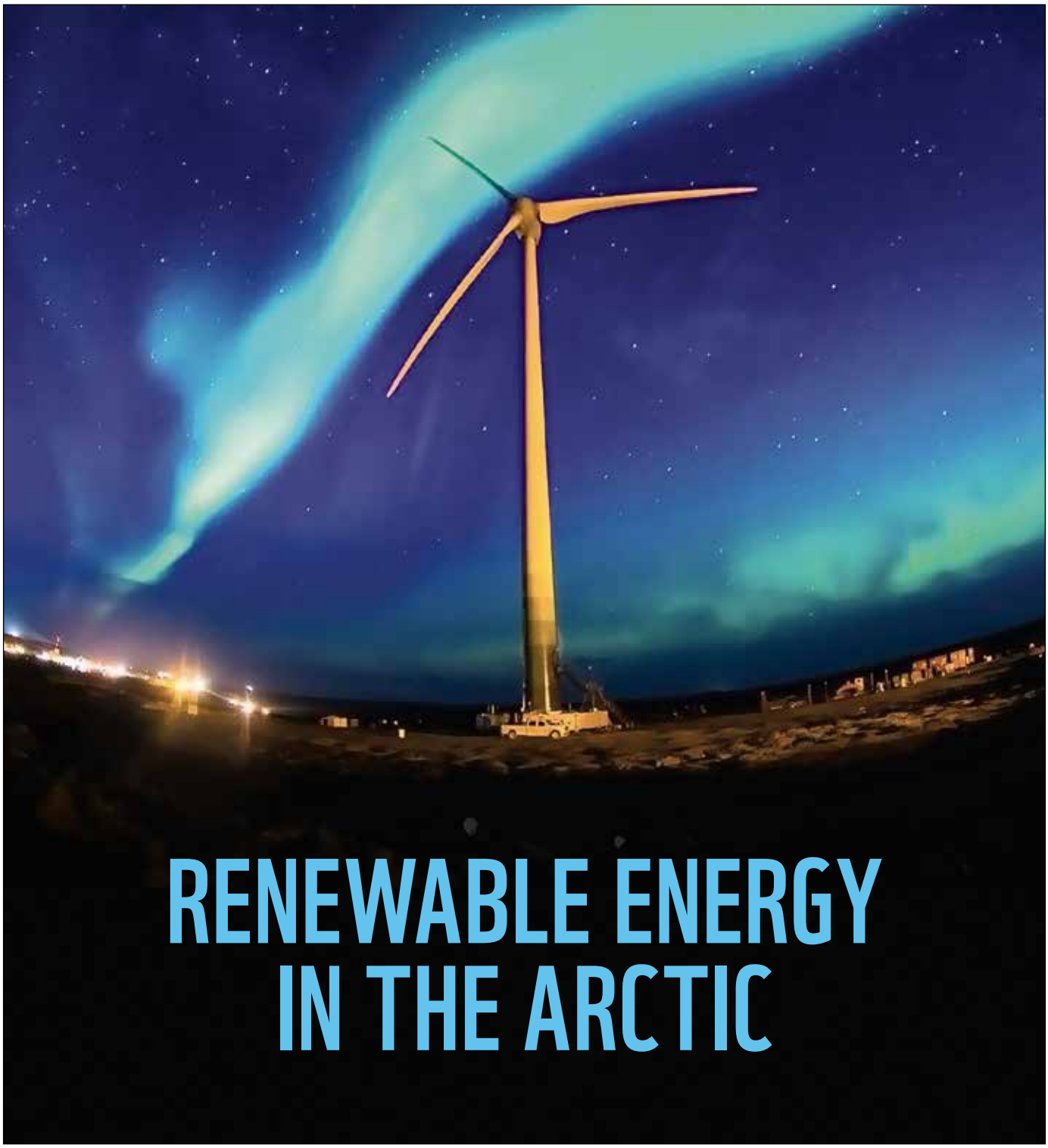

RENEWABLE ENERGY IN THE ARCTIC

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Contents

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COVER: Northern lights behind wind turbine at Raglan Mine, Quebec, Canada.
Photo: Glencore Group

ABOVE: Boreholes at Hellisheiðavirkjun geothermal powerplant, Iceland.
Photo: Jesús Rodríguez Fernández, flickr.com/Creative Commons

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Time to get real on renewables

THE FIRST International Renewable Energy conference in Bonn, Germany just over a decade ago heralded many successes. Attending governments, civil society organizations, academics and businesses agreed renewable energy deployment and investments needed to more than triple in the decade to come. This edition of *The Circle* looks at just some of the success stories and advances for renewable energy in the Arctic which are part of a global trend. Since 2004, global renewable energy investments have grown six-fold from about $US 50 billion to approximately $US 300 billion worldwide by the end of 2014.

Solar and wind power has also grown since 2006, now providing about 6 per cent of all electricity in the world.

For the first time, renewable energy additions in 2014 for new electricity capacity were higher than all fossil fuels combined worldwide.

And compared to a decade ago, there are now over four times more countries with numerous renewable energy policies in place.

Climate change is just one of the drivers along with erratic and high fossil fuel import prices. More jobs from renewables compared to the incumbent fuels; less air, land and water pollution and less demand on fresh water particularly in drier countries all add to the argument for renewable energy.

India recently committed to revolutionize its domestic coal-based energy system and targets 170 gigawatt (GW) renewables by 2022. China has a similar plan to boost renewables to 400 GW by 2020. This is the equivalent of up to half of the power generated by coal in India and almost one quarter of all coal consumed in China today.

Surprisingly, the latest large solar plant in Dubai provides cheaper energy than subsidized fossil fuel power. The irony that this plant is in the heart of OPEC (Organisation of Petroleum Exporting Countries) domain cannot be missed.

But I am not naïve. The dire truth is that overall investments in fossil fuels and nuclear are still about three times those of renewables and energy efficiency combined. The recently assessed subsidies to fossil fuels and externalities of unaccounted air pollution and carbon emission costs by the International Monetary Fund amount to more than $US 5 trillion annually. So the renewable energy spring is comparatively small, but as this edition of *The Circle* underscores, it is hardy.

The clean energy revolution is already a big wedge in the rather conservative incumbent energy system. Recent coal divestment moves by the Norwegian Sovereign Wealth Fund, the largest of its kind globally, and by AXXA, one of the largest global reinsurers, send a strong message. But as you will read in the following pages, smaller companies are also making global inroads in the renewables sector. Green Sun Rising in Canada recently installed the largest solar project to date in the Northwest Territories and the largest anywhere north of the Arctic Circle to significantly reduce one remote community's dependence on diesel fuel. Iceland is already in an enviable situation with nearly 100 per cent of its energy consumption fuelled by emission-free hydro-and geothermal energy. Yet, Páll Tómas Finnsson says that country is going even further with plans to harvest wind and solar power.

STEPHEN SINGER is the Director, Global Energy Policy, WWF International

THE REAL DEBATE CANNOT BE ABOUT WHETHER WE ACHIEVE A FULLY RENEWABLY POWERED ECONOMY, BUT WHEN.

Jon Kahn with Sweden's Ministry of Environment and Energy also urges Observer states to the Arctic Council to do their part in the southern hemisphere where many pollutants originate and which contribute to despoiling the unique Arctic environment.

The real debate cannot be about whether we achieve a fully renewably powered economy, but when. WWF says 100 per cent renewables by 2050. That would be great. With recent trends, however, that might be overly conservative. It's time to get real on renewables and its economics. ○

A better fuel for Arctic shipping

RISKS ASSOCIATED with using heavy fuel oil for shipping could be greatly reduced by switching to liquid natural gas according to a study on marine fuel alternatives commissioned by WWF-Canada.

"Of all the marine fuel options, heavy fuel oil is the most polluting and will cause the most damage in the event of a spill," says David Miller, President and CEO of WWF-Canada.

The study, *Fuel Alternatives for Arctic Shipping* assessed the environmental impacts of heavy fuel oil (HFO), diesel, and liquid natural gas (LNG), and compared ship design, fuel consumption, and the economic aspects of each marine fuel option.

It found that the use of LNG reduced pollutants by up to 97 per cent. Greenhouse gas emissions were reduced by up to 25 per cent. There was also a significant reduction in the risk of environmental damage from spills, since LNG dissipates almost immediately. Moving to diesel fuel was also found to have environmental advantages, but to a lesser extent.

Photo: Education Specialist, flickr.com/Creative Commons

Growth of Arctic shrubs may accelerate global warming

ONE OF THE LARGEST studies to date on how climate change is altering the Arctic has found that shrubs are gradually taking over the tundra and are likely the cause of their own climate feedback.

In the publication, *Nature Climate Change*, Dr. David Hik says shrub roots, which penetrate deeper into the soil than grass roots, will also likely break up permafrost and allow water to trickle down into it.

"All of the evidence is that this leads to the release of stored carbon into the atmosphere," he says. Dr. Hik and his colleagues completed a study of nine Arctic countries using data collected over 60 years. Scientists have known for some time that shrubs are gradually moving north. However, the rate at which the "shrubline" is moving in different parts of the Arctic has been a mystery. This study suggests the changes are happening faster in northern Europe and Russia than in North America.

The slow shift from grassy to shrubby landscapes could have profound consequences for Arctic peoples and animals. Caribou, for example, require the lichens found in the open tundra and can't eat shrubs. Moose, on the other hand, graze on shrubs and their population has been growing in the North. Arctic permafrost is considered one of the globe's great storehouses of greenhouse gases such as methane, which is much more potent in its climate-changing effects than carbon dioxide.

WWF staffer wins prestigious Arctic scholarship

WWF-SWEDEN'S Arctic mammal expert, Tom Arnbom, has been awarded the prestigious Fulbright Arctic Initiative Scholarship. His work will focus on researching and developing an international agreement on walrus management.

Norway rejects drilling near Barents Sea ice

IN A RARE MOVE, Norway's Parliament has rejected an offshore drilling proposal from its own Ministry of Climate and Environment. WWF and major scientific institutions criticized the Ministry for putting politics over science to extend offshore drilling. The proposal would have moved the northern limit for offshore drilling in the Barents Sea to the edge of the sea ice, well beyond the recommended limit set by scientific advisors. The marginal ice zone is the Arctic's biological engine, and an oil spill there could have enormous adverse consequences. When Arctic sea ice retreats northward in spring and summer, an explosion of life from plankton to polar bears follows, making the ice edge the most important marine area in the Arctic.

Veteran researchers lost in Arctic

AN EXPEDITION to study ice conditions in the Canadian Arctic ended in tragedy for two men from the Netherlands in April. Marc Cornelissen and Philip de Roo were skiing across sea ice about 1,500 kilometres from the North Pole as part of the "Last Ice Survey" for their organization, "Cold Facts" when they went missing. In his last posted message, Cor-

nelissen noted the presence of thin ice. A risky recovery operation by local volunteers and Canadian experts found Cornelissen's body, but a further extensive search at the scene failed to find Philip de Roo. The two experienced polar explorers have been involved with WWF for many years. Marc Cornelissen was WWF Netherlands' ambassador for the Arctic, and Philip de Roo was active from an early age as a WWF Ranger. WWF extends deepest sympathies to their families.

New Arctic fishing deal needs more signatories

A MORATORIUM on central Arctic fishing has been signed by five Arctic states. It is a promising sign that these countries are taking seriously the sustainability of fishing in this increasingly ice-free region. However, the agreement only covers the international waters of the Central Arctic and does not affect fishing boats from other states. WWF is calling on the Arctic Council observer states with large fishing fleets such as China, Japan, Korea, and Spain, to also sign onto the moratorium. Research indicates that climate change is driving huge stocks of fish such as cod north at a rate up to 160 kilometres per decade.

Polar bear, young bear in freezing water during autumn freeze up, Bernard Spit, 1002 area of the Arctic National Wildlife Refuge, North Slope, Alaska, Beaufort Sea

Photo: naturepl.com / Steven Kazlowski / WWF

New plan for Alaskan bears

WHILE A NEW polar bear conservation plan for the United States is moving in the right direction by addressing climate change, WWF says the plan still falls short of addressing the immediate threat posed by offshore drilling in Alaska.

The Polar Bear Conservation Management Plan calls for the US to commit to emissions reductions, as well as sustainable co-management of subsistence harvest, protection of denning habitat, human-polar bear conflict management, and research on polar bear populations.

Over 30 polar bear experts – including WWF staff – collaborated with the US Fish and Wildlife Service on this roadmap for collective action by US government agencies toward recovery of polar bear populations.

"The greatest long-term threat to polar bears is the loss of their sea ice habitat in a warming Arctic. Reducing greenhouse gases is the only way to curb that threat," said Margaret Williams, managing director of the WWF-US Arctic program. "By calling for emissions reductions in the conservation plan, the Obama Administration is moving in the right direction."

However, Williams cautioned that the US must take into account a more immediate threat to polar bears: potential spills from offshore oil and gas development. Oil spills can travel for miles in harsh Arctic waters and foul key polar bear habitat, further stressing the Arctic ecosystem.

The plan is part of an Arctic-wide conservation action plan being developed by the five polar bear "range states" (United States, Canada, Denmark, Norway, and Russia). At the first International Forum on Polar Bear Conservation, held in 2013 and supported by WWF, all five range states pledged to create a comprehensive international plan for polar bears by 2015.

See more at:
http://wwf.panda.org/what_we_do/where_we_work/arctic/news/?248758/WWF-United-States-government-moves-to-reduce-climate-change-threat-to-polar-bears#sthash.C56sxG3S.dpuf

PHOTO: GWEN HOLDMANN

GWEN HOLDMANN is the Director of the Alaska Center for Energy and Power

Caribou and Nome Wind Turbines, Banner Peak, Alaska

COMMUNITY PERSPECTIVE

Alaska – the microgrid frontier

It was a blustery day in March when I drove up to the Banner Peak wind farm near Nome, Alaska with John Handeland, manager of Nome Joint Utilities. Nome is a community of 3600 residents located on the edge of the Bering Sea – a stronghold of humanity in a vast expanse of rolling hills, tundra, and taiga. Traditional subsistence hunting and fishing are still very much a way of life here.

MY FIRST TRIP to Nome was 15 years ago, as a competitor in the Iditarod Sled Dog Race. I placed 30th after 12 days traversing 1600 kilometers of Alaska wilderness – including the Alaska Range – hundreds of miles of headwinds up the Yukon River, and a scary crossing of sea ice at Norton Sound. The experience gave me an intuitive feel for the land, the vast distances and challenging terrain. It was also the start of my love affair with the Arctic, including a deep and abiding admiration for the people who call it home.

On this trip, as John and I approached Banner Peak, we could see a crew of workers braving the wind chill to fix the tip brakes on several older model wind turbines that are notorious for having issues in the cold, dense arctic air. Dwarfing these older turbines were two larger, 900kW units better suited to arctic conditions, including direct drives and permanent magnet generators, and black blades designed to absorb heat during the short daylight hours and reduce formation of ice on the blades.

The wind farm represents a partnership between Nome Joint Utilities and Bering Straits (regional) and Sitnasuak (village) Native Corporations, which used private funding to install the original wind farm six years ago. The newer turbines were installed in 2014, supported in part through the Alaska Renewable Energy Fund. This program has funded about three quarters of Alaska's 70-plus, community-scale renewable energy systems. More than half are wind projects but include small hydro, wind, geothermal, biomass and solar.

Back in the office, John proudly showed me a screenshot from their SCADA (supervisory controller and data acquisition system) that had been taken the previous week. It had been a windy day, and showed that at the moment the screen shot was taken, 50 per cent of Nome's power was being produced by wind power. For a utility operator in most places, to achieve 50 per cent of

Repairing Banner Peak turbine.

PHOTO: GWEN HOLDMANN

their power produced from a variable renewable resource such as wind would be a scary proposition. But in Alaska, this is a common occurrence and necessitated by the fact there is no transmission grid connecting the roughly 250 remote communities in the Alaska 'bush'. The energy must be consumed where it is produced, and when it is produced. No small feat and John needed to balance a number of both technical and regulatory factors to do it. For example, he can't run his largest diesel units below 50 per cent of their rated capacity or he could risk being out of compliance with EPA emissions standards – resulting in the ironic situation where John needs to spill wind power and burn diesel when his loads are low and wind speeds high.

The Alaska Center for Energy and Power is working with John to assess how he can optimally manage his diesel fleet, and possibly add a small amount of energy storage, to maximize use of the wind resource. In addition, we conducted a multi-year resource evaluation of a local geothermal resource with over a dozen local partners to determine whether it could supply base load power to the Nome grid. The result was Nome's second Power Purchase Agreement signed with a private developer, to commit to purchasing 2MW of base load power if (or when) the resources is developed.

THE ALASKA CENTER FOR ENERGY AND POWER IS WORKING TO DEVELOP AN ORGANIZED STRATEGY WE HOPE WILL LEAD TO A NEW SORT OF ALASKA EXPORT ECONOMY – ONE BASED ON KNOWLEDGE EXPORT, RATHER THAN EXPORT OF NON-RENEWABLE RESOURCES

Other communities in Alaska are pushing the envelope even further – to the point of being able to turn off the diesel generators entirely when adequate renewably generated power is available. This is accomplished in part by demand management – in particular, dumping excess wind energy into heating loads such as space heating or hot water heating to maintain power quality and that perfect balance between power generated, and power consumed.

The innovation required to design, develop, operate and maintain these high penetration renewable energy systems has led Alaska to quietly become a leader in the development and operation of microgrids – especially microgrids integrating renewable generation. Today, Alaska is home to 12 per cent of the world's microgrids powered by renewable energy systems, and has more than 2 million hours of continual operating experience for these types of systems. Over 100 small businesses, as well as the Alaska Center for Energy and Power, have gained expertise in this sector and are now venturing out to test global markets for renewably-powered microgrids. Alaskans are now working in such far-flung locations as the South Pacific, Antarctica, and Africa. The Alaska Center for Energy and Power is working with these businesses to develop an organized strategy we hope will lead to a new sort of Alaska export economy – one based on knowledge export, rather than export of non-renewable resources such as crude oil and natural gas. ○

What's in a megawatt (MW)?

A megawatt measures the size of the particular electricity generator (say, a hydropower project) running at peak capacity, as measured in millions (mega) of watts. To scale this down to human terms, if you use a 100-watt light bulb for 10 hours, then you have consumed one kilowatt hour of electricity (one thousand watts per hour).

The difficulty in working out how much power a generator will provide is that they do not always run at peak capacity – especially with renewables because the sun does not always shine, the wind does not always blow, nor does water always run at the same volume. Therefore, the number of homes or businesses that can be powered by that plant will vary according to conditions. It is also hard to compare the number of homes powered by each megawatt of generating capacity because homes are not created equal in terms of their energy efficiency and usage. There is a big difference in electricity consumption between a home that uses electricity for heating and one that does not.

The Solar Energy Industry Association estimates that one megawatt of solar generating capacity will power 164 homes. According to the European Wind Energy Association, an average offshore wind turbine of 3.6 MW can power more than 3,312 average EU homes. So although a megawatt is a standard measure, variations in project efficiency and home consumption levels make it difficult to work out exactly how many homes can be powered by a new renewable energy project.

Wind turbine at Raglan Mine, Quebec, Canada.

FROM SEPTEMBER 1ST 2014 TO JUNE 30TH, 2015, RAGLAN MINE SAVED 4,838 TONNES OF GREENHOUSE GAS (GHG) AND 1,734,000 LITRES OF DIESEL

Raglan Mine's wind power

Mines in the far north also need power, and some are starting to turn to renewables to help fuel their needs. Raglan Mine is part of the Glencore group, one of the largest global diversified natural resource companies. At the northernmost limit of Québec, Canada, Raglan is one of the richest base-metal mines in the world. The Raglan Mine property stretches 70 kilometres from east to west, and encompasses a series of high-grade nickel and copper ore deposits. JEAN-FRANÇOIS VERRET outlines how his company strives to produce nickel safely and in a cost effective manner while showing respect for the environment and their host communities.

JEAN-FRANÇOIS VERRET, Director, Projects and Exploration, Raglan Mine, Québec, Canada

OUR SITE includes four underground mines, a concentrator, an accommodation complex and administrative buildings. It has all the infrastructures of a small municipality (a source of freshwater supply, fuel tanks, a water treatment plant, a power plant, etc.). A network of all-season roads links our mining site to the Donaldson airport as well as to the Deception Bay warehouses and seaport facilities. The ore extracted from our mines is crushed and processed on-site to produce a nickel-copper concentrate.

Raglan Mine strives to be a model in the mining industry in terms of human resource development, equity towards its multicultural workforce and respect for the local communities and the environment. To fulfill this mission, Raglan is based on sustainable development principles.

The facilities of Raglan Mine are neither connected to hydro nor natural gas networks. As a result, we must produce our own electricity from diesel generators. To decrease our greenhouse gas (GHG) emissions and reliance on fossil fuels we have, over the past few years, explored various ways of gradually introducing green energies in our power production portfolio. In 2009, the vision put forward by Raglan Mine on wind energy started to materialize through wind measuring, engineering and environmental impact studies as well as numerous consultation meetings with our host communities and other stakeholders. The four-year process revealed eye-opening results: the average wind speed in the area exceeded our expectations. In December 2013, follow-

ing successful findings, with our partner TUGLIQ energy – a company that specializes in energy-generation solutions in northern environments – we purchased the wind turbine. This was the official kick-off of the pilot project.

The first step of our pilot project was completed in August 2014 with the erection of a three megawatt wind turbine that is expected to offset the mine's diesel dependence by 5 per cent, amounting to approximately 2.4 million litres annually. This could decrease our GHG emissions by 7,200 equivalent tonnes of CO_2 per year, which is comparable to removing 1,516 vehicles from the road. The second step of this pilot project involves integrating an energy storage system with the energy network to enable maximum energy penetration from the wind turbine. This should be complete this summer and would be the first of its kind in the Canadian Arctic. By twinning the wind turbine with this storage system, we should be able to capture wind power surpluses and save them for times when there is less wind.

We believe our investments in this pilot project will allow us to innovatively decrease our reliance on fossil fuels, maximize our energy efficiency, but more importantly, reduce our carbon footprint and preserve the environment in which we operate. It is our hope that the expertise that we gain related to this pilot project will provide a future benefit to the surrounding Inuit villages. ○

Specifications of the wind turbine:

- E82-E4 Enercon wind turbine, 3 MW, certified for cold climates
- Heated blades
- Total height (with blades): 120 meters – equivalent to a 30-storey building
- Customized steel foundation structure, 15 metres in diameter
- Total weight (foundation included): 1200 tonnes

Colville Lake captures the sun

Colville Lake is a small, remote community in the Northwest Territories (NWT) of Canada, north of the Arctic Circle – not the first place one might think of for solar power. As KLAUS DOHRING writes, the climate in Colville Lake is typical of the far north with challenging winters, but sun-rich summers.

THE ONLY overland connection to Colville Lake – a community of about 160, mostly Dene First Nation residents – is the seasonal winter ice road, open about six weeks each year. We travelled to Colville Lake in June 2015 to install what we believe is the most advanced renewable energy project in the north to date. At that time of year, it doesn't get dark at all. The sun intensity all summer is remarkable, and the sun hours are plentiful.

Electrical power in Colville Lake has been provided by diesel generators in a stand-alone micro-grid. It is one of the most expensive diesel generation communities in the Northwest Territories which is why it was chosen for a new power plant concept combining solar power with large scale battery storage and new diesel generators. The goal is to supply the community exclusively with solar power and eliminate diesel generation during the summer. Surplus solar energy will be directed into the batteries, with the battery bank alternating between generation and consumption day and night.

In winter, when the sun rarely shines, the community will continue to be supplied with diesel-powered generators although the operators are hoping to reduce generation time with the new power plant by up to 50 per cent. Shutting down diesel generation for extended periods benefits the community through noise reduction and emissions elimination, cost avoidance, autonomy from total dependence on diesel and greatly improved quality of life. Maintenance requirements are being reduced, and the diesel generator lifespan will be extended, thus reducing operating and replacement costs. In shoulder months solar power can still reduce the need for diesel generation.

To achieve this, we added an 82.5 kW AC solar system, alongside an existing phase-1 50kW solar system which had been installed in 2014. The finished generating system will have a total of 132.5 kW AC solar generation capacity, and over 200 kWhs of battery storage capacity. Monitoring systems allow for remote internet-based monitoring and recording of solar generation data. Our solar system is ground-mounted, using local ballast to avoid disturbing the permafrost because it "floats" on the ground above the permafrost.

Materials were prepared, pre-machined and pre-assembled in Ontario over the winter, packaged and crated up in custom-made crates for protection during transportation. The winter ice roads are rough and very challenging

Colville Lake solar project.

Photo: Klaus Dohring

so sturdy crating is important to avoid transport damage. We safely delivered over 15 tons of solar materials into Colville Lake via winter ice road in February/March 2015, without any transport damage.

On June 1st we were greeted by a still-frozen lake, snow , frost, and a few very sunny days which brought out a bountiful crop of mosquitoes. Due to the preparation work in our shop over the winter, the on-site work was mainly assembly of pre-machined parts, allowing us to install this project in less than 10 working days. This project was the largest solar installation in NWT in 2015, and to the best of our knowledge the Colville Lake solar system is the largest solar system anywhere north of the Arctic Circle. It is interesting to note that the International Space Station is also powered by an 82 kW solar system, in continuous operation for roughly 12 years.

Our solar system is fixed-angle and maintenance free. Whenever sunshine reaches a module the photovoltaic effect kicks in, and free electrons are generated to provide free and clean electricity to the micro-grid. There are no moving parts and – other than the slow and limited solar cell degradation – no wear and tear. The solar cells are warranted to generate at least 80 per cent of rated output after 25 years. Solar generation is directly linked with sunshine availability. It will still occur with scattered and diffuse light and low light conditions, but to a lesser degree.

Solar cells become more efficient at lower ambient temperatures, so the low air temperatures in the North actually benefit solar generation. Dry air has less water vapour, and allows for more sun energy to penetrate the atmosphere to reach the solar cells. With about 1/3 of the inbound solar energy being absorbed in the atmosphere before reaching the ground, the dryer air in the North allows for noticeably more sun energy to reach the surface. Data for northern communities shows excellent solar energy availability in the summer months. We are monitoring solar systems in NWT, and can compare the data to similar size solar systems in southern Canada. While the solar harvest in NWT in winter is very low to zero, the best solar months in NWT greatly outperform the best solar months in the south. The seasonality in the North is more pronounced, which is what the weather data has been telling us all along.

We hope the power plant concept of a combination solar generation/battery bank will be embraced by many other remote communities to reduce and eliminate diesel generation as much as possible. The perfectly quiet and clean, emission- and noise-free operation of a solar system with or without battery storage, offers such an improvement in quality of life for the community, and affords them independence and autonomy, to the degree that sunshine is available and clean energy can be stored. The winter diesel supply truck or barge may not make it, but the sun will always rise with the seasons to provide free and clean energy. ○

KLAUS DOHRING is president of Green Sun Rising, a Canadian company that develops and supplies solar systems to generate clean electricity and heat.

Reducing black carbon and methane

Carbon dioxide is the usual culprit named in forcing global climate change. But JON KAHN says there are other climate pollutants too. Reducing them will also help reduce Arctic warming.

JON KAHN is director of the Ministry of Environment and Energy, Sweden

KNOWN AS short-lived climate pollutants, black carbon, hydroflurocarbons, methane and tropospheric ozone are contributing to global warming and directly warming the Arctic. These pollutants have a relatively short lifetime in the atmosphere – anywhere from a few days to a few decades. They have a warming influence on climate, are dangerous air pollutants and cause numerous detrimental health effects such as respiratory and heart disease, as well as impacting agriculture and ecosystems. Black carbon in the Arctic also affects the albedo – the reflection of light off snow and ice. As black carbon is deposited, snow and ice absorb more heat resulting in faster melting. Since these are short-lived climate pollutants with a brief life span, reducing them results in fast, positive results for both climate and health – a good reason to act immediately.

The sources of black carbon and methane emissions affecting the Arctic are: the oil and gas sector; waste; domestic burning; shipping and other modes of transportation; agricultural burning; other industry and agricultural sources and natural sources including wildfires and wetlands. It is very positive that during its chairmanship the US will look more closely at flaring – the burning of natural gas that cannot be processed or sold. Flaring disposes of the gas but releases emissions into the atmosphere. The potential for reducing emissions in this sector is also high, but we need a better understanding of these emissions.

WHILE ARCTIC COUNTRIES ARE ESTIMATED TO BE RESPONSIBLE FOR 30 PER CENT OF ARCTIC WARMING DUE TO BLACK CARBON, OBSERVER STATES TO THE ARCTIC COUNCIL ARE ALSO CONTRIBUTORS

Great gains can be made in reducing pollutants in all sectors through better combustion techniques and technologies, better controls and higher standards. However, a lot can be achieved through existing technology. If the maximum technologically feasible mitigation of black carbon and ozone precursors are applied globally, the Arctic Monitoring and Assessment Programme – one of the working groups of the Arctic Council – estimates Arctic warming could be reduced a quarter degree by 2050.

The Arctic Council has studied this problem for many years. The ministerial meeting in Kiruna, 2013 during the Swedish chairmanship, appointed a special task force to develop a framework to reduce black carbon and methane emissions in the Arctic. As co-chairs, France Jacovella from Canada and I helped task force nations agree on a framework that will result in more intense action from all Arctic countries to limit emissions. These countries are asked to report on emissions and efforts biannually. A special expert group will make policy conclusions based on this and other data for further consideration by the Arctic Council. Based on these conclusions the Arctic Council will also consider setting quantitative targets by the next ministerial meeting in 2017. The US chairmanship is now advancing this work.

While Arctic countries are estimated to be responsible for 30 per cent of Arctic warming due to black carbon, observer states to the Arctic Council are also contributors. These 12 non-Arctic observer states are therefore invited to join the effort to combat climate change and reduce short-lived climate pollutants. The Nordic Environment Finance Corporation (NEFCO), financed by Arctic countries, has now started to fund projects such as black carbon reduction in Karelia, Finland including replacement of diesel generators and wood gasification, and a wind turbine diesel project at a reindeer herding collective in Murmansk.

When it comes to reduction of black carbon and methane emissions, renewable energy such as wind can play a key role. Replacement of old equipment and stricter emission limit values are also needed to reduce black carbon emissions from domestic burning of biomass. Reducing black carbon and methane emissions could go hand in hand with the promotion of renewable energy provided the best technology is used. ○

Prioritizing renewables

In April, 2015, U.S. Secretary of State John Kerry traveled to Iqaluit, Canada, to assume Chairmanship of the Arctic Council. Since its inception in 1996, the Arctic Council has been a valuable international forum in addressing environmental, scientific, and societal issues that affect the four million people who live in the circumpolar region. The threat from climate change affects everything we do, especially in the Arctic where temperatures are rising twice as fast as the rest of the world. AMOS HOCHSTEIN says the U.S. Chairmanship intends to prioritize renewable energy in remote Arctic communities.

VILLAGES IN ALASKA are burdened by some of the highest energy costs in the Unites States. Rural Alaska is home to about 140,000 people spread over an area twice the size of Texas, or seven times the size of the United Kingdom. Many of these communities are not road-accessible, which means they are almost solely reliant on diesel fuel either shipped or flown in via barges or airplanes. This added transportation can make the cost for electricity, home heating, and transportation exponentially higher. While many parts of the North American Arctic have great access to wind, hydro, and geothermal resources, growth in the renewable sector has been slow, largely due to small markets and immense technical hurdles.

For many people in the Arctic, renewable energy access isn't just about climate change; it impacts their very survival and the survival of their communities. Black carbon emissions from diesel electricity and home heating are a public health risk. At the same time, the high cost of shipping or flying in diesel fuel has created energy migrants – people forced to leave their ancestral homes because they can no longer afford to live there. Developing renewable energy resources is directly tied to economic development in the Arctic – good paying jobs for local residents, keeping more money in the villages and spending less on the diesel barge, and creating more sustainable, healthier villages.

The Arctic Council is not just about what national governments can do for Arctic communities, but what the people of the region can teach us. The focus of the U.S. Chairmanship on renewable energy in the Arctic will add further momentum to other excellent efforts already taking place in the sector. To support improving clean energy access for Arctic communities, we are including the Remote Community Renewable Energy Partnership (RCRE) as part of our robust Arctic Council agenda. Through RCRE, a joint research project between the Department of Interior and the Department of Energy's National Renewable Energy Lab, scientists and engineers hope to ease integration of high levels of wind power into diesel micro grids. This research could have positive implications throughout the world for those who live in remote areas, from islands in the Pacific and Caribbean to Sub-Saharan Africa.

DEVELOPING RENEWABLE ENERGY RESOURCES IS DIRECTLY TIED TO ECONOMIC DEVELOPMENT IN THE ARCTIC

Our Arctic neighbors have a wealth of expertise to share on renewable energy in harsh climates. From hydropower in Norway, geothermal in Iceland, and energy efficiency in Finland, there is a lot we can learn from each other. The Arctic Energy Summit to be held in Fairbanks in September 2015 is a great example of how we can coordinate and share best practices from around the North Pole. The Department of State and our embassies in the Arctic also hope to tap into local know-how through our proposed Arctic Clean Energy Innovation Prize. Anyone from students to community leaders will be invited to submit business plans that promote clean energy and reduce dependence on diesel fuel. The best teams from each country will be invited to present their proposals, and the overall winner will receive a cash prize.

AMOS HOCHSTEIN is Special Envoy and Coordinator for International Energy Affairs at the U.S. Department of State.

To support rural Arctic communities as they transition towards clean energy, we must act as One Arctic, the theme of our Chairmanship, even as conditions vary from country to country and town to town. Each nation has something to share across the Pole and with the rest of the world. We thank Canada for its tremendous work in supporting sustainable development of Arctic communities during their Chairmanship and we look forward to carrying on their great work over the next two years. Through our Chairmanship, we hope to bring attention to this magnificent place, its people, and its renewable energy potential. ○

Hellisheiðavirkjun geothermal power plant.

DR. GUÐNI A. JÓHANNESSON is the Director General of Iceland's National Energy Authority

Iceland – renewables as a national project

The imminent threat of climate change has governments around the world attempting to set targets for increased energy efficiency, energy saving and the transition from fossil fuels to fuels with a low carbon footprint. GUÐNI JÓHANNESSON notes that Iceland's provision of one hundred per cent of space heating and electricity through hydropower and geothermal energy was not an accident of nature, but a national goal.

Photo: Jesús Rodríguez Fernández, flickr.com/Creative Commons

IT IS TRUE that Iceland has abundant resources in hydropower and geothermal energy but so have many other countries. The difference is that development of Iceland's renewable resources occurred through publicly financed initial research and development. This was followed by the introduction of renewables on a large scale supported by a strong national policy to create necessary market conditions and a viable business environment. It was recognized that factors such as energy security, lower pollution and CO_2 emissions plus long term impact on the balance of trade must be given a price tag for the transition to take place.

In Iceland, extensive research was carried out with government support in order to identify and develop new geothermal sources. The first projects were usually in areas where geothermal sources were obvious and in the vicinity of populated areas. A brilliant move by the government in the 1930s also saw the building of new centres for education and regional services close to known geothermal sources. A considerable development of greenhouses owned by private entrepreneurs was also fostered where geothermal water was available.

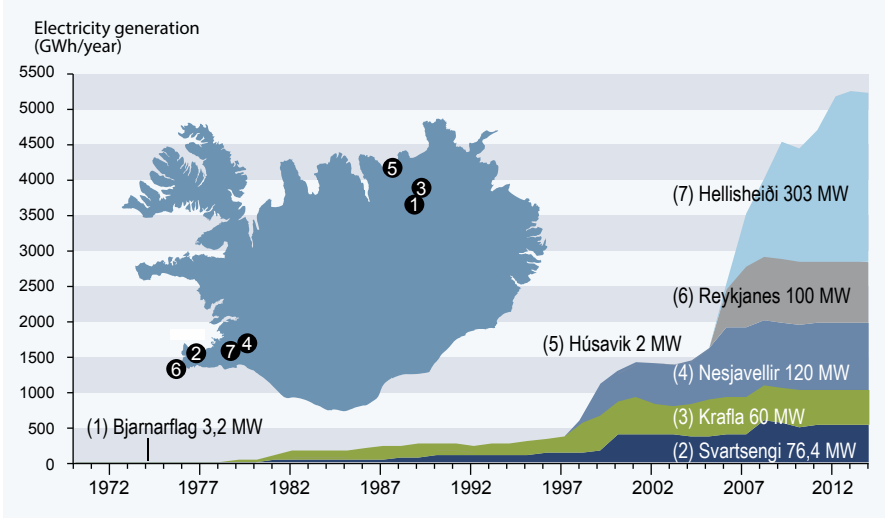
IN ICELAND, EXTENSIVE RESEARCH WAS CARRIED OUT WITH GOVERNMENT SUPPORT IN ORDER TO IDENTIFY AND DEVELOP NEW GEOTHERMAL SOURCES.

Photo: Jó Ragnarsson

Geothermal energy plant in Iceland.

In the 1960s about forty per cent of space heating was geothermal energy, with the remainder provided mainly by oil. A search for sources

Generation of electricity from geothermal energy, 1970-2013



where little or no surface indications were available had to take place. Since district heating systems in smaller communities and less densely populated areas would be more difficult to finance with sales revenues, state aid at that time included a risk mitigation fund sharing the risk for drilling and direct support for the build up of district heating in remote areas. In places where geothermal energy was yet to be found, district heating systems running on low priority electricity in combination with oil were built. However, many houses in the sixties were built with direct electrical heating which made it less lucrative for these homeowners to convert to district heating than for those who had an oil burner with a hydronic heating system which uses water or another liquid heat transfer medium. The government also guaranteed loans in US dollars which enhanced the investments but put a heavy strain on the economy of the district heating companies when the Icelandic currency was devalued.

The district heating companies are in most cases owned by municipalities and run on a cost plus basis as a service to the inhabitants. This means that as the financing has been paid off over time and since operational costs are low, the cost for heating can be down to 1-2 US cents per kWh. This makes a huge difference in the cost of living in a country with heating demands over the entire year.

Generating electricity with geothermal energy has increased significantly in recent years. As a result of a rapid expansion in Iceland's energy intensive industry, the demand for electricity has increased considerably.

The figure shows the development from 1970-2013. The installed generation capacity of geothermal power plants totaled 665 MWe (megawatt electric, the electric output of a power plant in megawatts) in 2013 and the production was 4,600 GWh, or 24.5% of the country's total electricity production. The construction and operation of the power plant Krafla was challenging due to difficult chemistry and volcanic activity in the region. However, once technical problems were overcome and operation secured, geothermal resources developed rapidly in the late 1990s.

The Iceland Deep Drilling Project (IDDP) is a long term study of high-temperature hydrothermal systems in Iceland. It is a collaborative effort by a consortium of Icelandic power companies and the Icelandic government to determine whether geothermal fluids would improve the economics of power production from geothermal fields. Over the next several years the IDDP expects to drill and test a series of boreholes beneath three currently exploited geothermal fields in Iceland. This will require drilling to a depth of about 5 km in order to reach hydrothermal fluids at temperatures ranging from 450°C to ~600°C.

Further outreach includes the Geothermal Training Programme of the United Nations University (UNU-GTP), established in Iceland in 1978 when Orkustofnun – the National Energy Authority of Iceland – became an Associated Institution of the UNU. Since 1979, a group of professional scientists and engineers from the developing and transitional countries have come to Iceland annually to spend six months on highly specialized studies, research, and on-the-job training in geothermal science and engineering. ○

Reykjanes geothermal power plant.

Photo: National Energy Authority

The first two windmills in Iceland by the river Þjórsá, southern Iceland.

Photo: Jesús Rodríguez Fernández, flickr.com/Creative Commons

GREEN GROWTH

The currency of power – renewables to hydrogen

Many communities in the Arctic and its surrounding regions are located in remote places with harsh weather conditions. Yet experts agree renewable energy should be an integrated part of all development plans. PÁLL TÓMAS FINNSSON says renewables are already working in the Arctic, with a new push to integrate them with hydrogen.

ICELAND is in a privileged position when it comes to energy supply, with almost 100 per cent of its energy consumption deriving from emission-free renewable energy sources such as hydro- and geothermal energy. Despite the country's abundant wind resource, wind energy has only recently been harvested here. In 2013 Landsvirkjun, the national power company, started operation of two 900 kW wind turbines near the Búrfell hydro power station in southern Iceland. Both have been a great success, according to Margrét Arnardóttir, Project Manager for Wind Power at Landsvirkjun. "There have been very few operational disturbances and an absolute minimum of maintenance. The efficiency rate has exceeded all expectations and was 44 per cent in the first year of operation, which is well above the global average of 28 per cent."

Despite the cold, snowy climate, the operational availability of the two turbines in 2014 was around 99 per cent and 97.5 per cent respectively.

"The turbines operate with a storm control feature that allows them to generate electricity in winds of up to 34 metres per second," Arnardóttir explains. "Moreover, they're equipped with a de-icing system that blows hot air onto the blades when there's risk of icing."

Based on these initial results, Landsvirkjun is designing a 200 MW wind farm in Iceland, aiming to increase efficiency to over 50 per cent. Arnardottir has no doubts that renewable energy is a viable option in the Arctic.

"Absolutely. Wind power is a relatively low-cost energy option and the environmental effect is minimal, provided it is carefully planned with respect for nature."

Solar energy is another renewable technology that has proven its worth in the cold climate of the north. In Piteå, Sweden, just 100 kilometres south of the Arctic Circle, a 20 kW solar panel test facility has produced impressive results.

"The system in Piteå gives the highest yield of all solar energy systems in northern Europe," says Professor Tobias Boström of the Arctic University of Norway. "It produces 1500 kWh per year per installed kW of solar panels, which is really good."

"It's a tracking system that follows the sun," he says. "It uses two different technologies, astronomical calculations

PÁLL TÓMAS FINNSSON is an Icelandic communications writer specialising in innovation, sustainability and Nordic culture. www.nordicway.org.

that track the sun's position and sensor technology that senses the brightest spot in the sky."

And conversely, cold climate improves the yield and efficiency of the solar panels.

"When the temperature drops 20 degrees Celsius – for example from 10 degrees to minus 10 – and lower, efficiency increases by 10 per cent," Boström explains. "The challenge is of course that the sun mostly shines in the summer and the further north you get, the less sun you have during winter. The issue of energy storage thus becomes more and more important the further north you get."

Energy storage is a key issue in order to react efficiently to fluctuations in electricity production and ensure balance between supply and demand. This is complicated in isolated, off-grid communities with limited access to backup energy. These communities often rely on diesel generators as the only source of electricity, and in many cases, the fuel is delivered by helicopter.

Replacing these costly, fossil fuel-based systems with renewable technologies requires development of new energy storage solutions. Systems combining wind energy and hydrogen storage are currently being tested on the islands of Ramea, Newfoundland in Canada and in Stóra-Dímon in the Faroe Islands.

"The objective of these projects is to make the islands energy self-sufficient by utilising wind power and storing surplus energy as hydrogen. The hydrogen is then converted into electricity when there is no wind," says Jón Björn Skúlason, Director of Icelandic New Energy.

The demonstration projects will show whether it's economically and technically feasible to start implementing such systems in remote communities in the north.

"This would release a vast potential," says Skúlason. "Most of these communities have wind all year round, and in summer, there's sunlight 24 hours a day. A robust, small-scale hydrogen storage solution would allow them to become fully self-sufficient with renewable energy." ○

THE DEVELOPMENT CHALLENGE

Overcoming diesel dependence in Nunavut

The North faces enormous developmental challenges. In the last fifty years, many northern communities abandoned their previously nomadic and historically sustainable lifestyles to embrace life in settled communities. They have also developed a complete dependence on imported diesel fuel. JOSHUA PEARCE says that now threatens the sustainability of these communities socially, environmentally and economically.

DIESEL CREATES substantial air pollution which has been linked to health impacts such as high rates of asthma due to poorer air quality. Diesel combustion also releases greenhouses gases contributing to the negative effects of climate change plaguing the North. There are also a number of economic issues associated with diesel use. The Government of Nunavut, for example, estimates it spends about one fifth of its annual budget on energy each year, thereby limiting the resources available for other community problems such as underfunded education programs, inadequate health services and overcrowded substandard housing. Meanwhile, the price of diesel is both volatile and expected to rise in the long term, further hamstringing northern communities. Yet little has been done to integrate renewable energy technologies (RET) to replace the use of diesel fuel in the Arctic. While a handful of renewable energy pilot projects were started in the 1980s, they provide little electricity.

However, there is a solution. Three studies explored various facets of RETs in Nunavut to assess their technical viability in isolated Northern communities, gauge the perspectives of local people on renewable energy use, and analyze government policy-makers' perspectives on integrating RETs into the North.

In case studies, technical analysis found that wind and solar photovoltaic technology were technically viable. In all cases, by matching peak power of existing systems, the RET systems could reduce diesel dependence substantially and in some cases, with modest storage, replace 100 per cent of the diesel-generated electricity in a community. In addition, it is clear that existing costs of RET

THE GOVERNMENT OF NUNAVUT ... ESTIMATES IT SPENDS ABOUT ONE FIFTH OF ITS ANNUAL BUDGET ON ENERGY EACH YEAR, THEREBY LIMITING THE RESOURCES AVAILABLE FOR OTHER COMMUNITY PROBLEMS

Photo: Josha Pearce

Diesel tanks for power plant, Nunavut.

systems would be economical on a life cycle basis because of extraordinarily high costs of energy in the North.

The two interview studies uncovered challenges, including capacity gaps, awareness gaps regarding the potential environmental and economic benefit of RET for a community as well as bureaucratic barriers and cost-related barriers. Bureaucracies waste resources and slow progress. In addition, the high up-front capital cost of RET is worsened by the general lack of investment capital and lack of economies of scale due to the remote nature and small populations in Northern communities.

The awareness gap for RETs can be addressed with large-scale community consultations on renewable energy. These can open discussion on the current energy situation in the north, expose community members to RETs and provide residents with an opportunity to have questions answered by RET specialists. Renewable energy can also be integrated into school curricula to bring information from children to their parents. By exposing students to RETs, children obtain strong lessons in applied science and learn the benefits of renewable energy, the need to be energy efficient and become more aware of the impact of diesel energy on health and the environment.

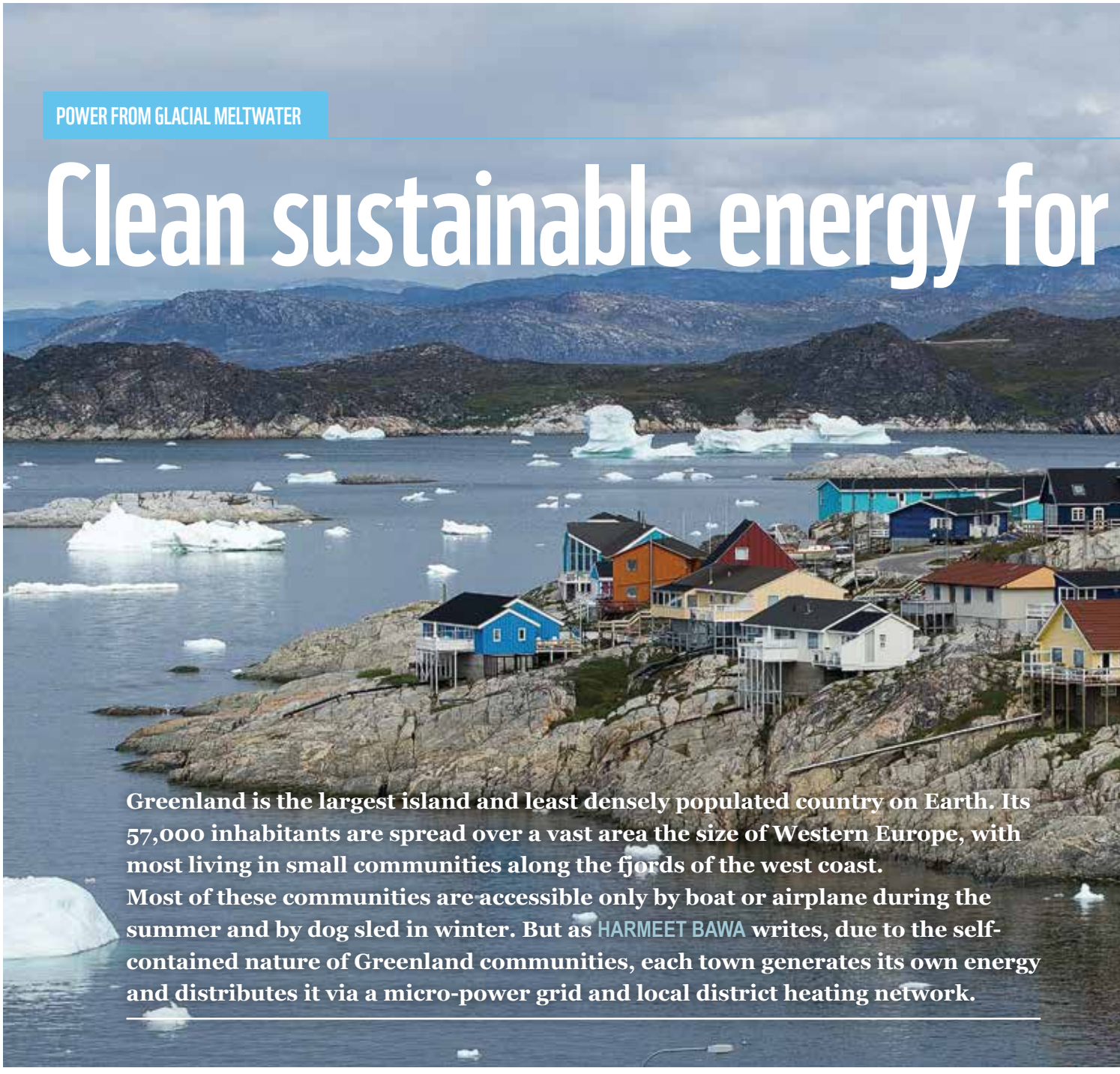
Once a foundation exists within the region regarding the viability of renewable energy and community awareness of the technologies, it will be essential for the various levels of government to explore opportunities to build partnerships with businesses and non-profit organizations to support northern RET research, provide appropriate incentives and to develop a structure to support renewable energy related jobs and RET deployment.

It is inevitable that the north will face a number of sustainable development challenges in the coming decades. However, if addressed properly, shifting to a sustainable energy plan won't be one of them. Given the strong renewable resources in the North, alternative energy sources such as solar power hold substantial technical and economic promise for communities that wish to reduce their diesel dependence. ○

JOSHUA PEARCE holds a PhD in Materials Engineering. His research concentrates on the use of open source appropriate technology to find collaborative solutions to sustainability and poverty reduction

POWER FROM GLACIAL MELTWATER

Clean sustainable energy for



Greenland is the largest island and least densely populated country on Earth. Its 57,000 inhabitants are spread over a vast area the size of Western Europe, with most living in small communities along the fjords of the west coast. Most of these communities are accessible only by boat or airplane during the summer and by dog sled in winter. But as HARMEET BAWA writes, due to the self-contained nature of Greenland communities, each town generates its own energy and distributes it via a micro-power grid and local district heating network.

HARMEET BAWA is head of communications for ABB's Power Products and Power Systems

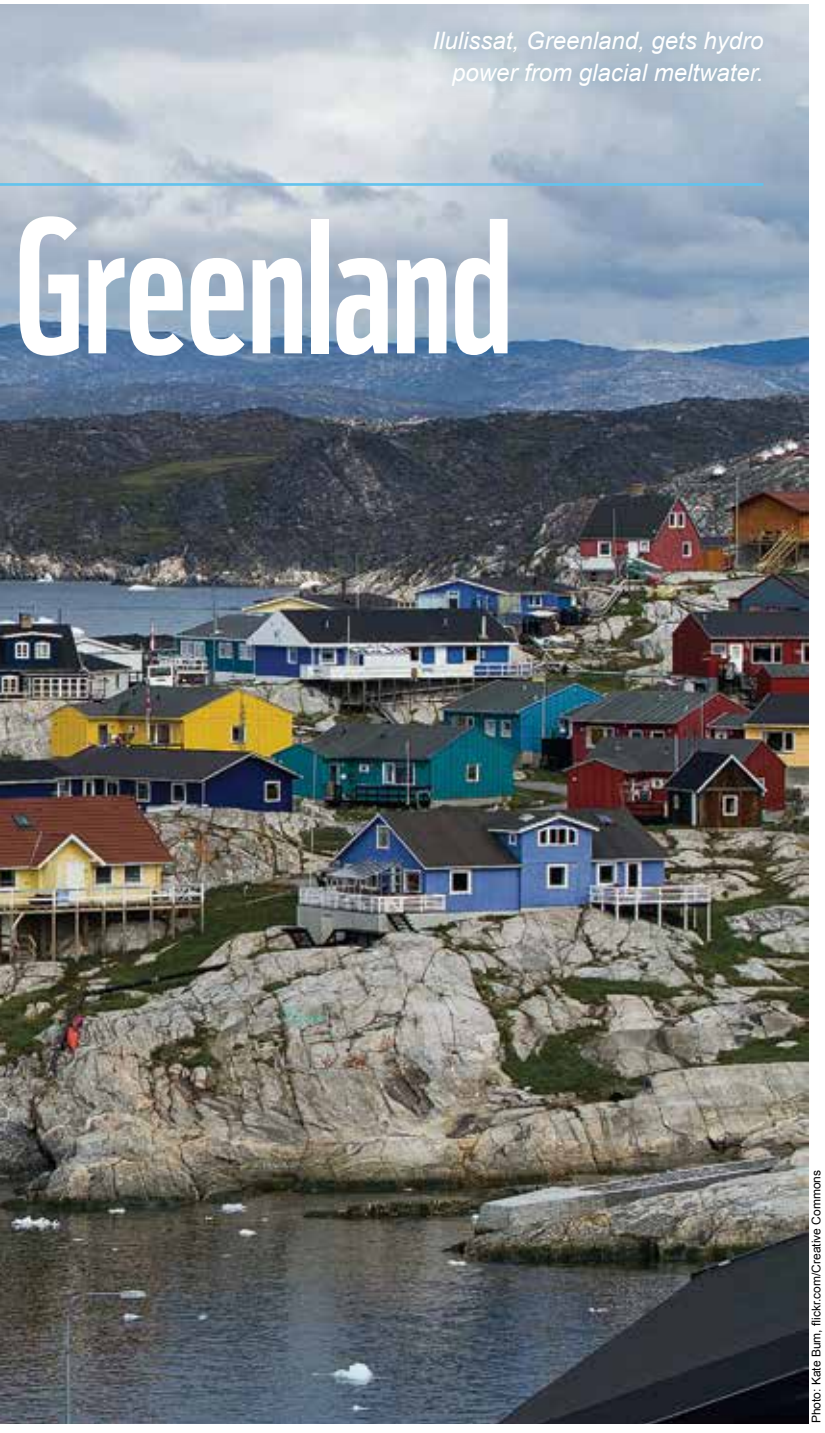
HISTORICALLY, this energy has been generated in Greenland by diesel-driven power plants, which require costly imports of fossil fuel and are the biggest single contributor to the island's greenhouse gas emissions.

In recent years, however, Greenland has been replacing its diesel power plants with hydropower plants – using its vast resources of glacial meltwater to generate lower cost hydropower and reduce the country's fuel imports and greenhouse gas emissions.

The latest of these renewable energy projects is a 22.5 megawatt (MW) hydropower plant for the town of Ilulissat on the west coast, the third largest community in Greenland with a population of 4,541 as of 2013. The plant replaces an existing diesel-driven power plant and will provide electricity for the town and the local district heating network.

Asea Brown Boveri (ABB), a global leader in power and automation technologies, was selected to supply a complete electrical and control solution for the hydropower plant by the Iceland-based engineering, procurement and construction contractor, Ístak.

Operational reliability is critical for the plant owner, Nukissiorfiit, the gov-

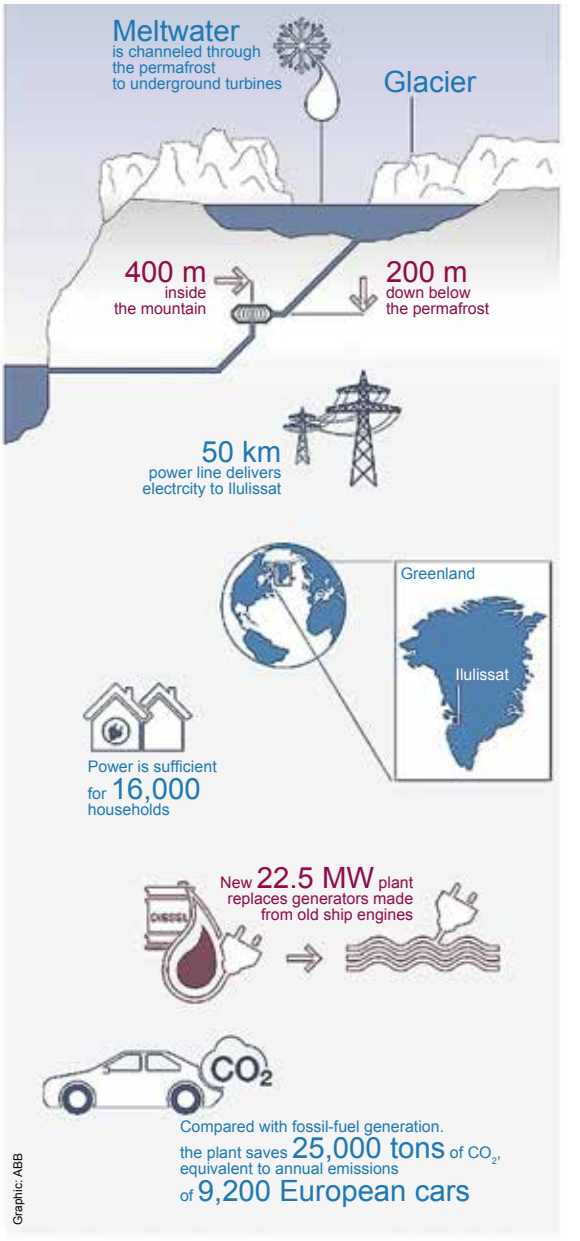


Ilulissat, Greenland, gets hydro power from glacial meltwater.

Photo: Kate Bum, flickr.com/Creative Commons

Greenland

On the west coast of Greenland, the town of Ilulissat is switching to emmision-free electricity produced by a hydro-power plant beneath the ice cap.



ALMOST 70 PERCENT OF GREENLAND'S ELECTRICITY IS NOW GENERATED BY EMISSION-FREE HYDROPOWER

ernment-owned energy provider. The plant is unmanned and located in an isolated fjord 45 km from Ilulissat. If a fault were to occur during harsh winter storms, access would not be possible for days or weeks and the old diesel-driven power plant would have to be restarted at great inconvenience and extra cost.

This is the third complete power and automation solution that ABB has supplied for Greenland's ongoing push to renewable energy. In 2010, ABB supplied a similar solution for a new 15 MW hydropower plant that supplies Sisimiut, the island's second largest town, with clean electric power. Prior to that in 2007, ABB completed the delivery and commissioning of the communication and control system for the 9 MW Qorlortorsuaq hydropower plant.

As a result of these and other hydropower projects, almost 70 percent of Greenland's electricity is now generated by emission-free hydropower. ○

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THE PICTURE

Harvesting the wind

Photo: Diavik Diamond Mines

The Diavik Mines wind farm, operational to minus 40 degrees Celsius, began delivering power to the mine's grid in 2012. Diavik operates the world's largest wind-diesel hybrid power facility at its diamond mine at Lac de Gras, Northwest Territories. The site is remote with no year-round all weather roads. The NWT's first large scale wind farm, it delivers 10 per cent of the mine's power needs. Diavik produces about seven million carats of gem quality rough diamonds per year from its underground mine.

WWF

Why we are here
To stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature.

www.panda.org/arctic