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The Northern Way

Hybrid Micro-Grids: Improving Energy Security through a Northern Alternative to Carbon Pricing

Northerners suffer disproportionately from the impacts of climate change. Energy insecurity exists in too many Northern communities and industries because they are almost totally dependent on electricity that is generated through burning fossil fuels. The introduction of a carbon price intended reduce fossil fuel use will worsen that lack of security. Further, Northerners face an extremely high cost of living and a carbon price will only make that worse.

The solution is support for hybrid micro-grids in each diesel-powered community or industry site. Instead of pricing carbon out of the market, it is eliminated directly. These systems increase energy independence, reduce risk from climate impacts, cost much less, can be built quickly and will result in immediate reductions in carbon emissions.

September 2016

Image: Colville Micro-grid Installation Courtesy of AEC

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FACING REALITY: A PRICE ON CARBON IS HERE

The Status Quo

Context

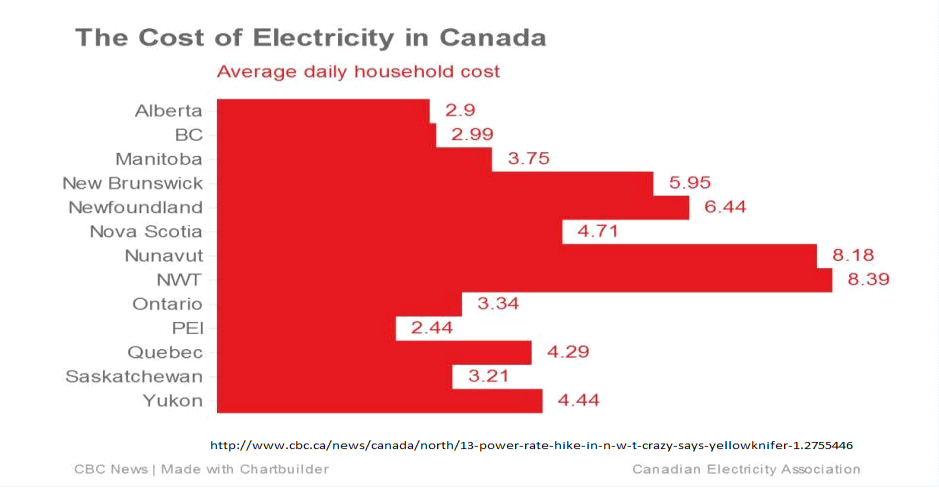
The NWT energy policy has been to provide a mix of reliable, affordable and sustainable energy that currently includes:

- 2 aging, high maintenance hydro micro-grids with diesel backup;
- 24 remote diesel-fuelled community micro-grids (with small amounts of solar photo-voltaic (PV) and natural gas);
- 1 solar-diesel-battery hybrid micro-grid (Colville Lake)[1]; and
- 3 large diesel-fuelled micro-grids at remote diamond mines (one mine is supplemented by a wind farm that produces approximately 10% of its electricity).[2]

This mix is referred to as the "status quo". This mix produces about 430 kilotonnes (Kt) of greenhouse gases from the electricity sector each year (out of an NWT total of 1500 Kt).

Energy cost is a major contributor to the crushing cost of living. Electricity generation contributes almost 30% of NWT greenhouse gas emissions.[3] The other 70% of NWT greenhouse gas emissions are generated from transportation and heating.[4] Breaking the dependency on diesel fuel has been a frequently stated objective for at least 15 years.[5] However, the frequency of power outages, continuing reliance on diesel and the fact that customers in NWT pay the highest cost for electricity in Canada (a cost which continues to spiral higher) would suggest that the "status quo" policies have not achieved their goal.

Figure 1: Average electricity Costs in Canada



Dangerous climate change is being caused, in large part, by the burning of fossil fuels. In September 2016, "375 of the world's top scientists, including 30 Nobel Prize winners...report that the evidence is

[1] Toom, Paul. NTPC Power System Plan 2016. 281p.
[2] http://www.pws.gov.nt.ca/pdf/EnergyCharrettePresentations/Diavik%20Wind%20Farm%20Project%20-%20Liezl%20van%20Wyk.pdf
[3] http://www.enr.gov.nt.ca/state-environment/62-trends-electrical-generation
[4] http://www.enr.gov.nt.ca/state-environment/63-trends-nwt-greenhouse-gas-emissions
[5] http://www.enr.gov.nt.ca/sites/default/files/strategies/greenhouse_gas_strategy_final.pdf

clear: humans are causing climate change. We are now observing climate change and its affect across the globe. The seas are rising, the oceans are warming, the lower atmosphere is warming, the land is warming, ice is melting, rainfall patterns are changing and the ocean is becoming more acidic."[6] The impacts of this climate change are at crisis levels. Northern jurisdictions are already heavily impacted.[7]

All of this combines to decrease the energy security of NWT communities and industries. Examples of this already abound. In 2006, extremely warm weather drastically shortened the Tibbitt to Contwoyto winter road season, costing the diamond mines millions to airlift in fuel, freight and supplies.[8] In 2014 and 2015, deliveries of dry goods and fuel were significantly delayed due to low water levels on the Mackenzie River.[9] In 2015, GNWT paid $29.7 M to NTPC so a 25% rate hike on electricity – due to low water levels on the Snare and Bluefish hydro system - could be avoided.[10]

The Global Commitment

To combat this, Canada has joined with governments around the world in signing the Paris Accord which sets a goal to limit the global average temperature rise to well below 2°C and pursue efforts to limit the increase to 1.5°C.[11]

Along with the G7 and G20 partners, Canada has committed to eliminating "fossil fuel subsidies...that distort energy markets" by 2025.[12] On October 3, 2016, Canada announced a nation-wide price on carbon pollution starting at a minimum of $10/tonne in 2018 and rising by $10 a year to reach $50/tonne in 2022.[13] If successful, these measures will direct market forces to reduce and eliminate carbon emissions.

Unless NWT is exempt from contributing to the global effort (which it is not), the diesel-dependent electricity systems of the NWT are now obsolete. Displacing diesel-generated electricity with carbon neutral electricity is a clear opportunity to significantly reduce NWT greenhouse gas emissions.

The Fiscal Impact in the NWT of the Price on Carbon

In a normal year, the NWT emits a total of 1500 Kt of CO2. Of this total, the diamond mining industry emits approximately 500 Kt. At $10/tonne (2018 price) NWT carbon price would be approximately $15M/year and the diamond mining industry share of the carbon price would be approximately $5M/year. At $50/tonne (2022 price) the NWT carbon price would be approximately $75M/year and the Diamond mining industry share would be approximately $25M/year. Over the five years (2018-2022), the NWT total cost of carbon pollution would be approximately $225M and the diamond mining industry approximately $75M. These revenues could be available to invest in emission reductions and these costs could be reduced with reduced emissions. If emission reduction targets are not being met, the price of carbon will likely increase after 2022.

While a price on carbon will achieve reductions of greenhouse gas emissions, it will also harm those who have no alternatives. Without the ability to choose any immediate alternatives, communities and businesses will be hit with increases to the cost of living and cost of doing business that may well be unsustainable.

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[6] https://www.theguardian.com/environment/climate-consensus-97-per-cent/2016/sep/21/375-top-scientists-warn-of-real-serious-immediate-climate-threat?CMP=share_btn_tw
[7] https://www.opencanada.org/features/north-americas-climate-action-plan-why-arctic-matters-beyond-its-borders/
[8] http://www.nnsl.com/frames/newspapers/2008-01/jan23_08rd.html
[9] http://www.cbc.ca/news/canada/north/ntcl-moves-barge-traffic-earlier-to-avoid-low-water-1.3170697
[10] http://www.cbc.ca/news/canada/north/n-w-t-avoids-power-rate-hike-with-29-7m-to-cover-diesel-costs-1.3213456
[11] http://www.climatechange.gc.ca/default.asp?lang=En&n=24700154-1
[12] https://www.theguardian.com/environment/2016/may/27/g7-nations-pledge-to-end-fossil-fuel-subsidies-by-2025
[13] http://news.gc.ca/web/article-en.do?nid=1132149

Canada has acknowledged that other actions must be taken to address these issues, and achieve further emission reductions. A number of actions are proposed in this paper including:

- Eliminating fossil fuel subsidies;
- Avoiding mega-projects; and,
- Refining or addressing ineffective policy.

This paper also sets out an plan ("Plan B") focused on addressing the need for immediate, effective, lower cost solutions to reducing emissions while meeting the needs of vulnerable communities.

Current Fossil Fuel Energy Subsidies are Counter Productive

The purpose of putting a price on carbon is to make it less affordable to emit greenhouse gases. However, energy subsidies make diesel electricity much more affordable, and work directly contrary to the goal behind a price on carbon.[14] This is why, along with its G7 partners, Canada has committed to eliminating "fossil fuel subsidies...that distort energy markets" by 2025. In NWT, the following are the types of energy market distortions that Canada has committed to eliminate in the next decade:

Benefits to Industry:

- Tax relief (non-motive diesel fuel gets a $0.06/litre tax break) @300 M litres/year = $18 M/year.[15]
- Business rates are set approximately 1/3 below full cost in the thermal (e.g. diesel) zone.

Benefits to NTPC:

- Publicly funded logistical support (i.e. Petroleum Products Division).
- The requirement for a regulated return on invested (ROI) capital has been removed for capital assets in the thermal zone.
- 2012-15 GNWT paid a direct subsidy to NTPC of $35 M to offset a revenue shortfall caused by an unpredicted spike in diesel fuel price.
- 2014-16 GNWT paid a direct subsidy of $50 M to NTPC to offset unpredicted fuel costs caused by low water in the Snare - Bluefish hydro systems.

Benefits to the Customers:

- Thermal zone customers pay no share of NTPC Headquarters costs.
- Residential rates in thermal zone are subsidized by public to Yellowknife retail rates for first 700 kWh in summer, 1000 kWh in winter. (e.g. >95% of residential sales in thermal zone are subsidized >50%).

The concept of **"affordability" is the product of policy choice and not the driver.** Diesel electricity is made "affordable" by subsidies. Without the current subsidy package, the price of residential diesel electricity could easily triple in the thermal communities and increase significantly at the mines. Adding additional cost by pricing carbon will make diesel electricity even less affordable. However, if carbon pricing and removal of fossil energy subsidies are successful, diesel electricity will no longer be an option. In the post - Paris Accord world, arguments about the relative affordability of high carbon energy are moot.

Mega-Projects will not Reduce Greenhouse Gas Emissions in the Desired Timelines

In the last forty years, investment in the NWT has focused on large–scale energy projects. Hundreds of millions have been spent on the proposed Mackenzie Gas Project; the NWT Hydro Strategy; the Deze

[14] https://www.theguardian.com/environment/2016/may/27/g7-nations-pledge-to-end-fossil-fuel-subsidies-by-2025
[15] http://www.fin.gov.nt.ca/document/taxation-policy-and-rates-fuel-usage.pdf

Energy project; and the promotion of a hydro development on the Bear River, none of which have been realized.

While hydro development can be considered renewable depending on the scale of the initiative, there is current interest in accessing Federal dollars to expand the Taltson hydro generation output and interconnect it with new transmission capability to Saskatchewan. This could also allow for other generation capability. The profits from the sale of Taltson (or new generation) power to southern customers would fund renewable energy projects in the NWT. However, while considering the feasibility of this mega-project, the following is worth noting:

- As Table 1 illustrates, major hydro projects in similar terrain in Canada are costing upwards from $11/watt to construct. At that rate, the Taltson expansion to 200MW would cost upwards of $2.2 B (more than the entire Federal $2 billion Low Carbon Economy Trust created to fund projects across Canada that reduce greenhouse gas emissions).[16]
- Transmission lines in remote Canadian Shield terrain are estimated to cost $1.0 million/km.[17] Transmission from the half dozen or more generation dams to an interconnect point could easily cost another $0.5 B.
- Paying for a project of that magnitude would add more than $60,000 to the territorial debt load of every resident of the NWT. There would be little if any benefits generated along any timeline that would be important to meeting terms of the Paris Accord.
- The result would be a system exposed to the same climate change risks of drought and wildfire that are currently ravaging the Snare system.
- The reservoirs created to feed hydro dams may well become significant sources of new greenhouse gas emissions.[18]
- This huge capital outlay would do nothing to relieve the dependency on diesel - or reduce greenhouse gas emissions - in the thermal communities and the mines for the next decade or longer.
- The GNWT has no headroom in its debt limit so it cannot self-finance any part of these costs.

Table 1: Comparison of Affordability of Large Scale Hydro

Current Large Hydro Projects in Canada					
Project	Province	Capacity MW	Cost estimate	$/watt installed	Reference
Muskrat Falls	NL	824	$11.4B	$13.8	http://www.theglobeandmail.com/report-on-business/rob-commentary/muskrat-falls-has-become-a-114-billion-boondoggle/article31165739/
Keeask	MB	695	$6.5B	$9.8	https://www.hydro.mb.ca/projects/keeyask/
Tazi Twe	Sask	50	$630M	$12.6	http://tthp.ca/
Site C	BC	1100	$8.8B	$8.0	https://www.sitecproject.com/
				$11.1	

[16] http://www.climatechange.gc.ca/default.asp?lang=En&n=72F16A84-1
[17] NT Energy Directors Report Sept.16, 2014. p.3
[18] http://www.sciencemag.org/news/2016/09/hundreds-new-dams-could-mean-trouble-our-climate

We Need to Move in the Right Direction

Consider how different the cost-benefit analysis would be if even a fraction of the subsidies currently applied to fossil energy were redirected to carbon neutral energy. Consider further what a difference it would make if energy development policies focused on distributed carbon neutral projects rather than costly mega-projects that do not clearly and immediately reduce carbon emissions.

GNWT energy policy decisions were heading in the right direction:

- Moving aggressively on conservation, improving building standards, moving to energy efficient appliances and lighting and setting up rebate and incentive programs to assist and encourage Northerners to move off fossil fuels and improve energy efficiency.
- Initiating a program to switch all the streetlights to LED lights.
- Developing progressive strategies for biomass[19], solar[20] and reducing greenhouse gases[21], and starting to demonstrate them.
    - A 105 kW array of solar PV was installed in Fort Simpson.[22]
    - A solar-battery-diesel hybrid micro-grid was installed in Colville Lake.[23]
    - A 35 kW solar array was installed in Lutsel K'e.[24] Wind studies were begun in Inuvik and Tuktoyaktuk.
- Studying small hydro potential at Lutsel K'e and Deline.
- Assessing grid interconnection of the Snare and Taltson system.
- Issuing a call for expression of interest in developing 10 MW of solar and/or wind for Yellowknife.
- Conducting two energy charrettes in Yellowknife.[25]

As the same time, the mining industry installed a 9.2 MW wind farm development at Diavik.[26] [27]

Meanwhile, renewable solar and wind technologies have entered the North American mainstream.[28] The Northwest Territories Power Corporation (NTPC) expressed a clear, future-oriented and powerful vision:

[19] http://www.grrb.nt.ca/pdf/forestry/NWT_Biomass_Energy_Strategy.pdf
[20] http://www.pws.gov.nt.ca/pdf/ParkingLot/Solar_Energy_Strategy_2012-2017_0.pdf
[21] http://www.enr.gov.nt.ca/sites/default/files/strategies/ghg_strategy_2011-2015.pdf
[22] https://www.ntpc.com/smart-energy/how-to-save-energy/fort-simpson-solar-energy-project
[23] http://www.cbc.ca/news/canada/north/colville-lake-solar-power-1.3604310
[24] http://www.bullfrogpower.com/wp-content/uploads/2015/09/Lutsel_Ke-Solar.pdf
[25] http://www.pws.gov.nt.ca/pdf/Energy/charrette_report_fnl_web.pdf
[26] http://www.pws.gov.nt.ca/pdf/EnergyCharrettePresentations/Diavik%20Wind%20Farm%20Project%20-%20Liezl%20van%20Wyk.pdf
[27] http://www.enr.gov.nt.ca/sites/default/files/final_4-nwt_greenhouse_gas_summary_report_2015.pdf
[28] http://www.greentechmedia.com/articles/read/the-us-has-10-gw-of-utility-scale-pv-projects-under-construction
http://www.progressalberta.ca/alberta_solar_boom

> Excerpt from NWT Power System Plan Toom 2016.
>
> NTPC envisions a sustainable energy future based on clean and renewable energy sources. The past practice of using diesel and other fossil-fueled prime generation will no longer be acceptable in a climate-changed world, particularly given the Paris 2050 carbon balance commitments, carbon pricing and the increasing accessibility or economical sustainable alternatives. New technologies are emerging and the cost of renewable energy is decreasing. Solar demonstration projects have provided valuable learning experience. Going forward, the opportunity to build a sustainable energy future for the NWT has arrived. Alternative energy prices have decreased, and technology has matured and become more robust and dependable. These generation options have been slow to emerge in the north for a number of reasons, yet the people of the north, community leaders, GNWT, the federal government and NTPC all have a desire to see this happen. New technology and renewable energy options can be integrated using a Hybrid Power Plant style of micro grid that includes storage. Page iii.

However, how and when the vision noted above will be implemented is still unclear. At the same time, a number of missed opportunities have been identified:

- Commit to decarbonizing energy in the thermal communities;
- Convene a meeting with NWT mines to plan how to reduce their reliance on diesel fuels;
- Build on successful demonstration projects and increasingly obvious external trends, and create a program to decarbonize the NWT electricity sector;
- Reinstate the call for Expression of Interest in developing a large wind and or solar project in Yellowknife;
- Reinstate the planned Battery Energy Storage System (BESS) designed to improve the reliability and efficiency of the Yellowknife grid; and,
- Commit to support for renewable solar and wind projects in hydro communities.

It is not a future-oriented strategy to maintain the "status quo" which has been identified as unsustainable. Efforts to decarbonize should be maintained.[29] [30] Status quo efforts, especially those that are mega-project related, will not result in a reduction of carbon emissions. Billions could be spent, without direct reductions. These large projects may create regulatory approval processes that alienate Indigenous peoples through impacting their rights, lands and waters. As a result, this is unlikely to be supported by federal funding.

A BETTER APPROACH: PLAN B

Making Renewable Energy Work

Carbon Neutral Electricity Opportunities in the NWT

Canada has targeted the electricity sector to be the first sector to decarbonize. "The basic recipe goes like this: cut energy waste as much as possible, and clean up your electricity supply so that it's as low carbon as possible. Then use that clean electricity as your source of energy for activities that we largely power with fossil fuels today".[31]

By setting a price on carbon, the Federal Government will be creating a revenue stream for investment by provinces and territories as the revenue is returned to its original jurisdiction. This revenue could be

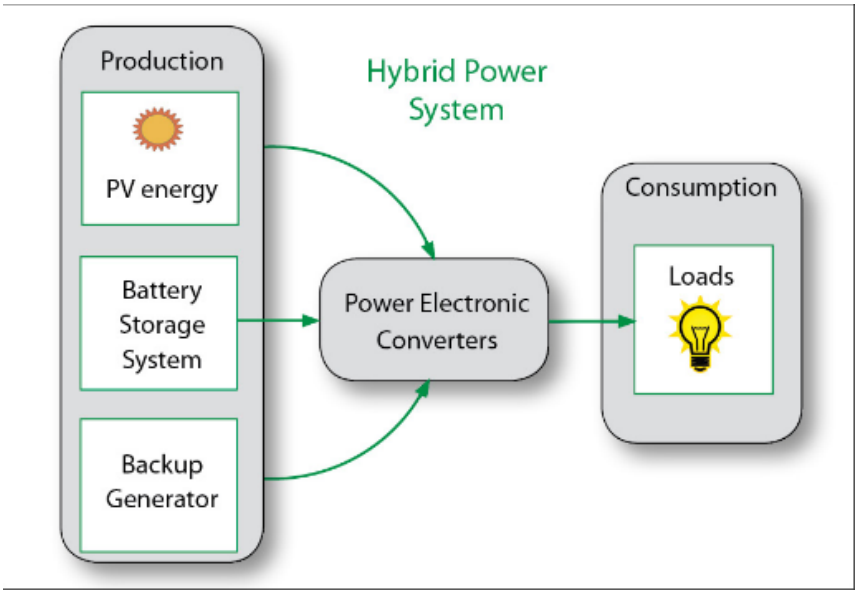
[29] http://www.pws.gov.nt.ca/pdf/Energy/North%20Slave%20Resiliency%20Study%20Final%20Report.pdf
[30] http://www.cbc.ca/news/canada/north/diesel-wind-solar-backup-nwt-1.3628433
[31] http://cleanenergycanada.org/electrification-matters-now/

used for renewables investments that are cost-shared with the provinces and territories.[32] If the "status quo" is not an option, and mega-projects are unrealistic, then the NWT needs aggressive targets to decarbonize the electrical sector and to create a program of distributed carbon neutral energy opportunities.

The vision of reducing diesel use for electricity in NWT by 50% (e.g. reduction by 50% of 430 Kt = 215 Kt) has been identified by the NTPC.[33] Proven technologies are available for investment and they have been demonstrated as successful in NWT systems.

For example, Figure 2 below illustrates a simple solar-diesel-battery hybrid micro-grid.[34] Solar and diesel generators charge a battery bank that supplies power to the loads. This is the new paradigm for high penetration renewable electricity generation in remote off-grid locations, worldwide. This model has been demonstrated at Colville Lake and can be applied in all of the remote communities and mines[35] in the NWT that are currently relying on diesel generation. Well-designed hybrid grids using variable speed generators can achieve renewable energy penetration up to 90% of energy.[36]

Figure 2: Solar-Diesel-Battery Hybrid Micro-Grid



As these hybrid micro-grid systems enter mainstream deployment they are becoming more modular, efficient and cost effective.[37]

Increasing Energy Security in NWT Communities

Eliminating dependency on diesel in remote communities, replacing it with locally-produced and stored energy, increases that community's energy security. Increased local control and production can also

[32] http://www.climatechange.gc.ca/default.asp?lang=En&n=72F16A84-1
[33] NTPC 2017 Corporate Plan.
[34] http://www.solarindustrymag.com/online/issues/SI1310/FEAT_03_Multiport-Converters-Enable-Grid-Integration-Of-Hybrid-Solar-Power.html
[35] http://www.huffingtonpost.ca/joseph-kirschke-/the-global-mining-industry-renewables_b_11459560.html
[36] http://www.innovus-power.com/
[37] http://www.mining.com/web/a-new-cost-efficient-compact-hybrid-system-for-solar-diesel-microgrids-targets-the-mining-industry/

decrease costs (as set out below) and protect a community from the vagaries of volatile markets. Recent reports from Alaska and Nunavut show that a strong business case can be made for displacing diesel generation with solar energy in hybrid micro-grid systems[38] [39]. Notably, these reports predict cost savings from renewable energy even without a price on carbon and in areas that have much less solar potential than the NWT. Even if cost savings were not attainable (which is highly unlikely), the increase in energy security that could be realized through local systems (as described in this paper) is a critical climate adaptation strategy.

Net Metering

The cost of electricity is so high that some people and businesses are abandoning their community grid and supplying their own electricity. Many independent "studies consistently show having solar on the grid is a net benefit to everyone[40]. Yet, an effective "net metering" program that would assist customers to self-generate their own renewable energy does not yet exist.[41] The following challenges continue:

- There is no need to insist on a maximum size limit (currently set at an arbitrary maximum 5 kW per application).
- There needs to be a clear long term commitment to the Power Purchase Agreement (currently there is no firm commitment to the length of the agreement with the utility) and self-generators need to be fully compensated for any surplus energy they contribute to the grid.
- The concept of "standby charges", where NTPC charges a net metering applicant an amount intended to address the costs of maintaining backup capacity needs to be removed from the application.[42] It is a great disincentive to engaging in the net metering program.

In their 2012 Solar Strategy[43], the GNWT set a target of 20% of average generation in the thermal communities. This was a modest target that required only 2% of actual generation to come from solar PV. With less than a year left in the five-year strategy, the thermal communities have reached less than 10% of that target.[44]

Quantifying Diesel Displacement Opportunities

In the following calculations, diesel generators at typical efficiency produce 3.5 kWh/liter of fuel and emit approximately 0.75 kg CO^2/kWh.[45] Combustion of one liter of diesel fuel produces 2.66 kg of CO^2 emissions.[46] Total NWT greenhouse gas emissions average approximately 1500 Kt/year.[47]

Mining Industry Opportunities

Mining industry estimates for a large underground diamond mine suggest annual generation of 170 GWh/year[48] emitting 127.5 Kt/year of greenhouse gas emissions. Two large underground mines (Ekati and Diavik) and one large surface mine (Gahcho Kue) could generate 425 GWh emitting 318 Kt/year of greenhouse gases (21% of NWT total).

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[38] http://awsassets.wwf.ca/downloads/summary_and_prefeasibility_report.pdf
[39] http://www.nrel.gov/docs/fy16osti/65834.pdf
[40] http://www.renewableenergyworld.com/articles/2016/09/studied-to-death-solar-customers-don-t-harm-non-solar-ratepayers.html?cmpid=enl_REW_SolarEnergyNews_2016-10-01&jack.vancamp@gmail.com&eid=291172174&bid=1544165
[41] https://www.ntpc.com/customer-service/net-billing
[42] http://www.ntpc.com/docs/default-source/default-document-library/ntpc-application-form-13-08-14.pdf?sfvrsn=2
[43] http://www.pws.gov.nt.ca/pdf/ParkingLot/Solar_Energy_Strategy_2012-2017_0.pdf
[44] http://www.ntpc.com/docs/default-source/default-document-library/net-metering-capacity-by-community-v1.pdf?sfvrsn=2
[45] http://www.ec.gc.ca/ges-ghg/default.asp?lang=En&n=ac2b7641-1
[46] https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69554/pb13773-ghg-conversion-factors-2012.pdf
[47] http://www.enr.gov.nt.ca/state-environment/63-trends-nwt-greenhouse-gas-emissions
[48] http://www.pws.gov.nt.ca/pdf/EnergyCharrettePresentations/Diavik%20Wind%20Farm%20Project%20-%20Liezl%20van%20Wyk.pdf

In a normal year, the diamond mining industry emits approximately 500 Kt CO_2, which accounts for 34% of the NWT total.[49] Diesel electricity generation accounts for 75 - 85% of mine generated greenhouse gas emissions. The 9.2 MW wind farm installed at the Diavik Diamond Mine in 2012 generates 17 GWh/year and reduces diesel generation by 10%. It saves approximately 8.3 M litres/year and reduces carbon footprint by 12 Kt (6%). The project has already paid for itself in fuel cost savings. This was achieved without any storage.[50] Ekati Diamond Mine produces approximately the same amount of greenhouse emissions as Diavik but it has no installed renewable energy capacity. The Snap Lake closure and the Gahcho Kue opening will roughly offset their greenhouse emissions. Gahcho Kue represents another 25 MW ($75 M) opportunity for wind generation.

Displacement of 50% of diamond mine diesel generation represents an opportunity to develop up to 200 MW of solar energy or 75 MW of wind energy or a combination of the two. At a cost between $220 - $580 M, diesel consumption could be reduced by 60 M litres/year and greenhouse gas emissions could be reduced by 159 Kt/year.

Utility Opportunities

Opportunities in Yellowknife Snare/Bluefish - Jackfish System

In a low water year, Yellowknife can require 20 M litres of diesel fuel to generate 70 GWh, emitting 53 Kt of CO_2, and adding approximately 3.5% to NWT total. Low water in the Snare-Bluefish hydro system can nearly double NTPC emissions from diesel generation. Yellowknife needs extra generation capacity and is a prime location for up to 30 MW of solar or 12 MW of wind or a combination of the two tying into the current hydro/diesel system, creating a sustainable, practical, and affordable hybrid system. At a cost between $36 - $95 M, diesel consumption could be reduced by 10 M litres/year and greenhouse gas emissions could be reduced by 26 Kt. Alternatively, imposing a low water charge for extra diesel, hoping for increased precipitation, and planning to spend potentially hundreds of millions of dollars on more dams and more diesel generators[51] is not sustainable, either environmentally or financially.

Opportunities in the Large Thermal Communities

Inuvik

The second largest community in the NWT, Inuvik, is a 100% fossil fuel-powered community. It has excellent solar for eight months of the year and a world-class wind site. It is also a world-class location for burgeoning remote sensing industry, where affordable energy is critical. High Point, a site close to Inuvik, has been identified as the best site for a 9 MW wind farm. The wind is good and the location requires a minimal transmission line, greatly enhancing the affordability of the project. Inuvik is the premier renewable energy site in the NWT, where there will be the greatest impact in the reduction in diesel use, greenhouse gases and downward pressure on the cost of energy and living. To achieve a 50% reduction in fossil fuel use would require approximately 4 MW of wind or 11 MW of solar or some combination of the two. At a cost of between $14 - $34 M, diesel consumption could be reduced by 3.6 M litres/year and greenhouses gas emissions could be reduced by 9.5 Kt/year.

Fort Simpson

Fort Simpson has 100 kW of solar already installed. To reach the 50% reduction target, it would require an upgrade to 3 MW of solar or 1.4 MW of wind, plus storage to form a hybrid generation system modeled on the Colville lake demonstration. At a cost of $3.7 - $9.8 M, diesel consumption could be reduced by 1 M litres/year and greenhouse gas emissions could be reduced by 2.8 Kt/ year.

[49] http://www.ec.gc.ca/ges-ghg/donnees-data/index.cfm?do=facility_info&lang=en&ghg_id=G10101&year=2014
[50] http://www.pws.gov.nt.ca/pdf/EnergyCharrettePresentations/Diavik%20Wind%20Farm%20Project%20-%20Liezl%20van%20Wyk.pdf
[51] http://www.pws.gov.nt.ca/pdf/Energy/North%20Slave%20Resiliency%20Study%20Final%20Report.pdf

Priority (Small) Thermal Communities

NTPC has identified diesel generators in the thermal communities that are old, inefficient and will require replacement in the coming years.[52] Some of the thermal communities are in more urgent need of major maintenance or replacement and should be the first to be upgraded to hybrid generation systems. To reach 50% diesel reduction in these communities would require 2.5 MW wind or 6.5 MW of solar or some combination distributed among the priority communities. At a cost between $7.5 - $19.6 M, diesel consumption could be reduced by 2 M litres/year and greenhouse gas emissions could be reduced by 5.4 Kt/year.

Other Thermal Communities

In the rest of the thermal communities, at a cost of $16 - $42 M, diesel consumption can be reduced by 4.4 M litres/year and greenhouse gas emissions could be reduced 11.5 Kt/year.

Table 2 Solar and Wind Opportunities

Scale of Opportunities	50% of Current Diesel Generation GWh/year	Diesel fuel displaced Million Liters	Potential GHG reduction kT/year	Solar MW*	Cost of Solar $M ***	Wind MW **	Cost of Wind $M ***
Inuvik	12.6	3.6	9.5	11.5	$34.4	4.8	$14.4
Fort Simpson	3.6	1.0	2.7	3.3	$9.8	1.2	$3.7
Yellowknife Low Water	35	10.0	26.3	31.8	$95.5	12.1	$36.3
Priority Small Thermal Utilities	7.2	2.1	5.4	6.5	$19.6	2.5	$7.5
Other Small Thermal Utilities	15.3	4.4	11.5	13.9	$41.7	5.3	$15.9
Diamond Mines	212	60.6	159.0	192.7	$578.2	73.3	$220.0
total	285.7	81.6	214.3	259.7	$779.2	99.3	$297.8
* @ 12.5% capacity							
** @ 30% capacity							
*** @ $3/watt							

Conclusion

A reduction of 214.3 Kt/year achieves the target of 50% reduction of electricity sector emissions in NWT, and costs less than other options under consideration. The “status quo” diesel fuelled electricity systems of the NWT are not sustainable. High cost, high risk, hydro-electric mega-projects are an unrealistic distraction in that they could cost at least three to ten times more than the solar and wind options discussed in this paper, but would still result in no reductions to carbon emissions in any meaningful timeline (if at all).

However, practical hybrid micro-grid opportunities can be found wherever electricity is now generated with diesel. Every GWh of diesel-fuelled electricity that can be displaced with carbon neutral

[52] Toom, Paul. NTPC Power System Plan 2016. 281p.

alternatives eliminates 0.75 Kt/year of greenhouse gas emissions. As subsidies are redirected and the cost of carbon increases incrementally, the business case for diesel is weakened and the business case for renewables is strengthened.

Now is the time to aggressively transition to state of the art hybrid systems. There are opportunities to displace 50% of all diesel electricity generation in the NWT by developing up to 260 MW of solar or 100 MW of wind or a combination of the two. The scale of investment required is in the range of $300 to $780 M. This level of investment could reduce diesel fuel consumption by more than 80 M litres/year and reduce NWT greenhouse gas emissions by nearly 15%.

A STRATEGY FOR FUNDING CRITICAL RENEWABLE ENERGY INFRASTRUCTURE

The Federal government is firmly committed to implementing their election promises on protecting the environment, fighting global warming and climate change and has put a price on carbon. The GNWT is doing its part but has to do more with both the diamond industry and the thermal communities.

In the NWT, as the transition from diesel to renewable energy sources continues, there are a number of actions that can be undertaken to assist and help fund the transition even in a time of fiscal restraint. This requires the Federal government, GNWT, industry and municipal and Indigenous communities to work collaboratively to address Northern needs.

- The Federal government should commit to establish a $500 M/year northern-remote hybrid micro-grid fund, to assist Northern communities to transition to this new technology over a five-year period. The fund could be topped up to $700 M by the territories to achieve a 70%/30% federal/territorial cost-sharing. Through an agreed formula, each territory would be eligible for a certain amount of the Federal fund. It should be a Northern fund targeted at the NWT, Yukon, Nunavut and Nunavik. In the NWT, a share of this fund would allow the acceleration of the move to hybrid micro-grid technology, starting with Inuvik, followed by the other six priority thermal communities identified in this paper. This would also allow the planning work to be done on the other 13 thermal communities. The initial goal should be 50% displacement of diesel use for electricity, within five years.

- An industrial incentive program for large Northern emitters should be created to encourage the acceleration to hybrid micro-grid technology. The initial goal is 50% displacement of diesel use for electricity within 5 years. Achievements in emission reductions should be credited against their carbon payments. For example, if a diamond mine spent 2 M building a local renewable energy grid that displaced diesel use by 10%, an equivalent offset (e.g. depreciation, credit) should be granted.

- A working committee, comprised of representatives from the GNWT, the Federal government, Indigenous governments, industry and the NWT Association of Municipalities, should be created to advise within six months, on 1) the most efficient, effective and economical way to move forward on priority northern/remote hybrid micro-grids (e.g. Inuvik) and other strategies that increase remote community energy security and resilience, and 2) current subsidies for diesel, both federal and territorial that should be staged for elimination (as committed to by Canada) and transfer to support renewable energy sources that can demonstrate reduction of greenhouse gas emissions.

- GNWT should conclude negotiations with the Federal government on the definition of “borrowing” to have their self-financing debt accounted for separately from their operational borrowing limit. This will give the GNWT borrowing room to cost share renewable energy projects with the Federal

Government, as part of dealing with an NWT appropriate response to the national price on carbon initiative.

- GNWT should revamp NTPC's capital planning process to bring it in line with the GNWT process, making it more transparent and removing disincentives to renewables e.g. charging HQ operational costs to wind and solar capital projects.

- GNWT should remove the current restrictions and limits on the net metering policy to encourage the private installation of solar-wind across the NWT. This will greatly lessen the burden on NTPC of lack of capital dollars for renewable projects.

- GNWT should have NTPC actively pursue Power Purchase Agreements with the private sector to have hybrid micro-grid systems built in the diesel communities. For example, the Lutsel K'e model can be improved upon by fairer displaced cost of diesel that recognizes the significant subsidies for diesel artificially mask the true cost of diesel.

Michael is the principal of North Raven. His interests are water protection and governance, working collaboratively on environmental protection, renewable energy development, building efficient government, expediting land claims, and strategic planning. He works with Aboriginal and Crown governments, ENGO's, industry and the private sector providing strategic political advice. Prior to his current work, he spent 20 years as MLA in the NWT Legislature, 14 of those years as Minister of the Environment and Natural Resources, Minister of Finance, Minister of Health and Social Services and the Minister Responsible for the Northwest Territories Power Corporation. He is Metis and lives in Fort Smith, NWT.

Merrell-Ann Phare is a lawyer, writer and the founding Executive Director of the Centre for Indigenous Environmental Resources (CIER), a national First Nation charitable environmental organisation. She is the author of the book '*Denying the Source: the Crisis of First Nations Water Rights*' and '*Ethical Water*'. As Chief Negotiator for the Government of the Northwest Territories, Merrell-Ann lead the negotiation of transboundary water agreements in the Mackenzie River Basin and the creation of Thaidene Nene, a national and terrritorial park in the east arm of Great Slave Lake. She is legal counsel and advisor to a number of First Nation and other governments and organisations and regularly speaks on water issues and First Nations.

Jack VanCamp is an Environmental Scientist and Planner. His 45 year career began in 1972 as a research technician at Washington University St Louis, Center for the Biology of Natural Systems. His graduate studies at University Calgary included wildlife planning for Fish Creek Provincial Park, Bison research with Canadian Wildlife Service in Elk Island National Park and field work as a consultant on the CAGSL project during the Berger hearings. His career has included jobs with; Alberta (Kananaskis Country planning); GNWT (Wildlife Biologist - Hook Lake Bison / Wolf Project); Aurora College (Instructor and Program Coordinator - Renewable Resources and Natural Resources Technology Programs); and Canada (Executive Director- Mackenzie River Basin Board). He has also worked for an NGO (Nature Conservancy - NWT Protected Areas Strategy) and as a private consultant on mining projects and government policy development. He has a business interest in renewable energy (Stand Alone Energy Systems Ltd.). His public service includes appointments to the Mackenzie Valley Land and Water Board and recently the Board of Directors of the NWT Power Corporation. He understands that environmental problems are best solved by the people most affected. His career has focused on capacity building and the transfer of information and ideas to local and indigenous communities. He has four adult sons and lives in Fort Smith, NWT.