Yukon Renewable Electricity Panel

REPORT TO THE MINISTER OF ENERGY, MINES AND RESOURCES

January 2020

MESSAGE TO THE MINISTER

Dear Minister Pillai,

Please accept the enclosed report as the culmination of our assignment to advise the Government of Yukon on future directions for renewable electricity generation in the territory. Our week of discussions with the public, energy stakeholders, First Nation groups, students, and government and utilities staff underscored both the scope of the clean energy challenge and a broadly shared vision and commitment to meet it. We learned an immense amount from our time with Yukoners, and hope that our perspectives and "best advice" serve as useful contributions to this vital conversation.

Sincerely,

John Maissan | Christopher Henderson | Michael Ross | Ravi Seethapathy

From left to right: Panel members John Maissan, Chris Henderson, Michael Ross, and Ravi Seethapathy (Credit: Vince Federoff, Whitehorse Star)

ACKNOWLEDGEMENTS

The Yukon Renewable Electricity Panel would like to thank all of the individuals and organizations that shared their valuable time and ideas during its November sessions. The Panel would also like to thank Jane Koepke of Groundswell Planning for providing facilitation and secretariat support.

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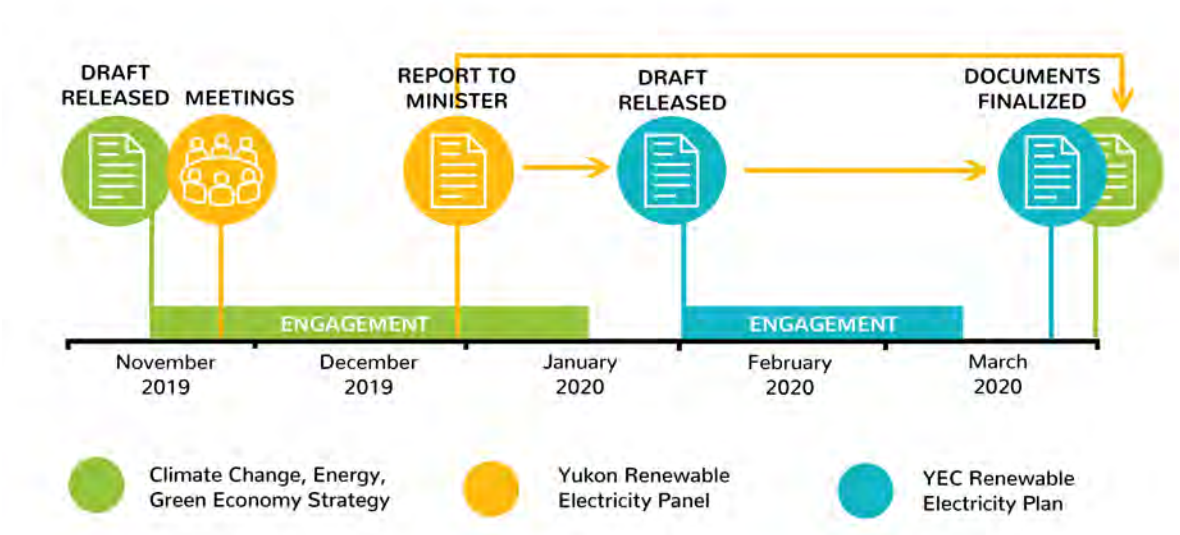
INTRODUCTION

The Yukon Renewable Electricity Panel ("Panel") was established in November 2019 to advise the Minister of Energy, Mines and Resources (EMR) in regards to meeting the Government of Yukon's target of providing at least 93% of Yukon's electricity demand through renewable sources, recently articulated in *Our Clean Future: A Yukon Strategy for Climate Change, Energy, and a Green Economy*. The four panelists – Chris Henderson, John Maissan, Michael Ross, and Ravi Seethapathy – brought a diversity of local and Outside technical, policy, research and project-based experience in the areas of renewable energy, community and First Nation energy projects, Smart Grid, and energy integration in small, remote jurisdictions[1].

During the week of November 18-22, 2019, the Panel visited Whitehorse, Watson Lake, and Haines Junction to share information with and hear from the public, energy stakeholder groups, and students[2]. The panel was also briefed by staff from EMR, Yukon Energy Corporation (YEC), Yukon Development Corporation (YDC), and ATCO Electric Yukon (ATCO). These conversations, along with a review of relevant background information, helped the Panel ultimately formulate its "best advice", contained in the following report, to the Minister. This document is intended to serve two purposes:

1. Assist the Yukon public and stakeholder groups in understanding challenges and opportunities and support active and informed input into Our Clean Future and YEC's pending plan; and,
2. Provide an impartial, third-party, expert perspective to be factored into the draft and final versions of the aforementioned documents



YREP and Associated Government of Yukon Processes

[1] Panel bios are included in Appendix A.

[2] The complete list of participants is included in Appendix B. The Panel was scheduled to visit four communities but inclement weather prevented the Team from traveling to Dawson City.

WHAT WE REVIEWED

Institutional History

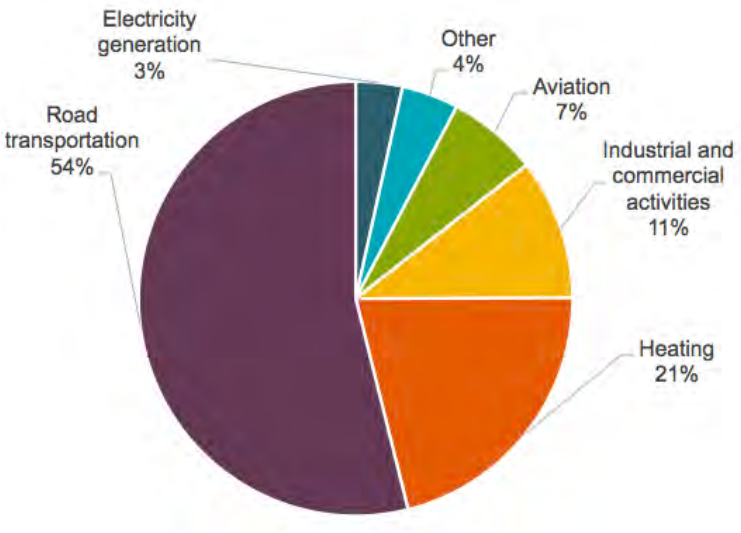
The origins of Yukon's electricity generation dates back to the establishment of the Yukon Electric Company (now ATCO) in 1901 in Whitehorse. The Northern Canada Power Commission (NCPC) spearheaded Yukon's legacy hydro infrastructure, starting in the 1950s with the Mayo hydro plant and followed up by the Whitehorse Rapids and Aishihik plants and associated transmission lines.

YEC was established in 1987 with the intention of operating at arms-length from government. YEC reports to YDC, a Crown Corporation established to hold NCPC's assets. Today, YEC sells wholesale power to ATCO for retail distribution and serves industrial customers (with electrical demand greater than 1 MW) directly. YEC also has retail distribution in the communities of Mayo, Dawson City, and Faro as well as some outlying areas. ATCO provides its own thermal (diesel) generation in off-grid communities in Yukon and owns the 1.4 MW capacity Fish Lake hydro facility in Whitehorse.

Yukon's electrical utilities have always been subject to regulation by the Yukon Utilities Board (YUB), a quasi-judicial board established under the *Public Utilities Act*. The Act (and YUB) provides for economic (i.e., price) regulation of both ATCO and YEC electricity rates.

Current Yukon Energy Context

Currently, 95% of the territory's population is connected to Yukon's hydroelectric grid. More than 90% of electricity generated on the Yukon grid is renewable, coming primary from hydro resources generated at YEC's Whitehorse, Mayo and Aishihik facilities. This high renewable component has helped keep the greenhouse gas (GHG) emission contributions from electricity generation at 3%, significantly lower than those of road transportation and heating. *Our Clean Future* commits to achieving 93%[3] renewable electricity through to 2030 as part of the territory's strategy to reduce emissions.



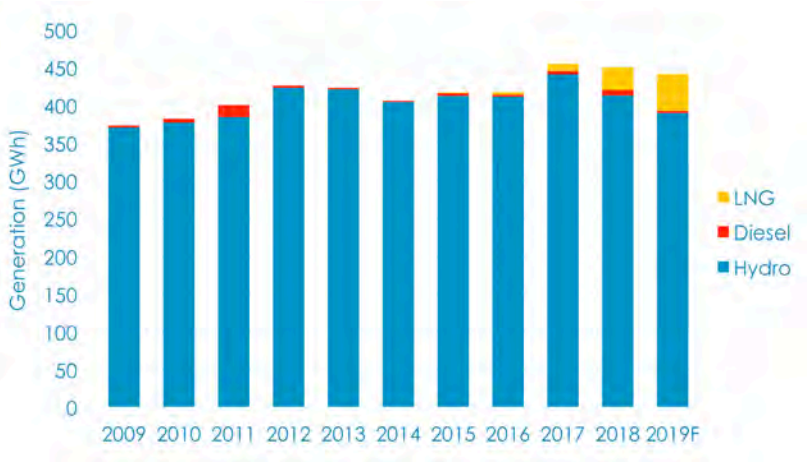
Yukon's Source of GHG Emissions (2017) (Source: YG)

However, recent and future anticipated trends raise the question of whether this 93% target is realistic. YEC's use of thermal (i.e. the fossil fuels diesel and liquefied natural gas) inputs to add firm capacity to the hydroelectric grid has steadily increased over the past several years. This is due to a

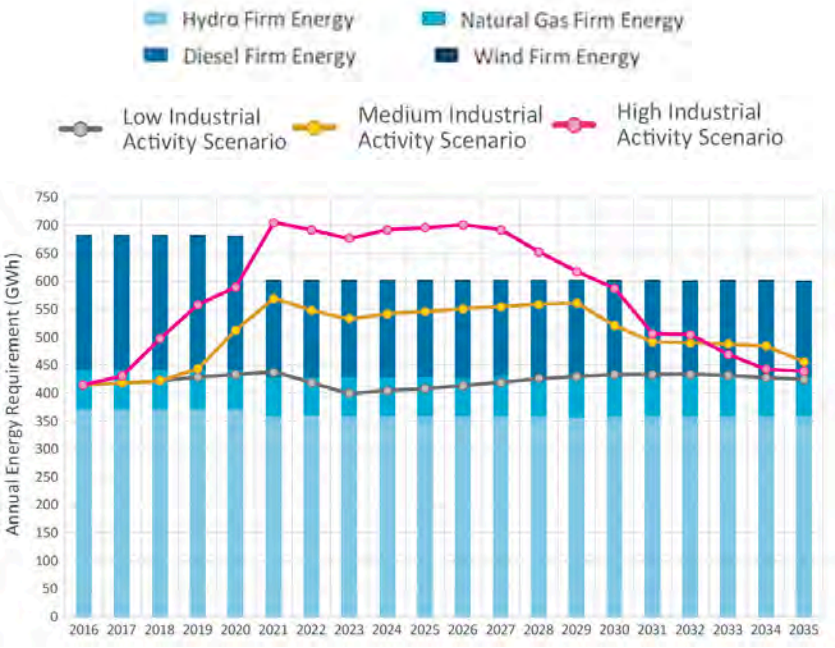
[3] This goal is stated as a long-term rolling average versus annual target.

combination of factors, including:

- Population growth;
- Increasing electrification of energy sources for the residential, commercial and institutional heating sector;
- The system's inherent mismatch between renewable energy capacity and demand (wherein demand peaks in colder winter periods when firm capacity is at its lowest level);
- Variability in generating capacity due to drought conditions in recent years;
- The addition, as well as the variability of large "lumped" loads from larger-scale mining projects; and,
- A lack of substantive progress on new renewable energy supply over the past several years.



2009-2019 YEC Generation Profile (Source: YEC, 2019)



2016-35 YEC Forecast - Energy (Source: YEC 2016 Resource Plan)

Looking to the next several decades, the trend line of relying on is fossil fuels for the supplying new electricity demand may persist due to:

- Continued shifting of energy sources away from fossil fuels and towards electrification, particularly in heating and the transportation sector;
- Continued steady population growth resulting in a projected 45,500 residents by 2025, up about 11% from 2018[4]; and
- Potential new mining projects.

[4] Yukon Bureau of Statistics. 2018. "Population Projections 2018". http://www.eco.gov.yk.ca/stats/pdf/Projections2018.pdf

Over the past five years, YEC, YDC and the Government of Yukon have undertaken several major planning exercises aimed at adding renewable firm capacity to the grid through new large-scale hydro and enhanced storage of lakes that supply existing hydro generation facilities, among others. The Panel concludes however that there is a high social license for these and other energy projects and initiatives. Passing the test of social license is clearly very challenging and may well require a new way of developing, leading and implementing energy projects to achieve Yukon's clean electricity vision.

Given all of these factors, it is the Panel's observation that there is a very daunting pathway by which Yukon can secure a reliable, affordable, and renewable electrical energy future in the next 10-15 years. Overcoming such challenges should consider that achieving a clean electricity future is a means to an end: a more prosperous, cleaner, competitive and climate-friendly Yukon economy and society. As such, relegating clean electricity to an energy "box" or "silo" would be limiting, and effectively compromise the attainment of multiple social, environmental and economic objectives that reflect a profound embrace of sustainable development for Yukon. It may be more powerful and likely more impactful to realize a vision of a 21st century clean energy infrastructure for Yukon with such a broader, more strategic and multi-dimensional strategy.

YEC's Liquified Natural Gas (LNG) electrical generating plant

WHAT WE HEARD: YUKON PERSPECTIVES

Who We Met With

During the week of November 18-22, 2019, the Panel met with a broad spectrum of Yukoners and Yukon organizations. Grassroots energy advocacy groups, First Nation, environmental and business non-governmental organizations, high school students, and members of the public in Watson Lake, Whitehorse, and Haines Junction[5] – all provided us with a deeper understanding of Yukoners' hopes, concerns and priorities for renewable electricity and energy.

The format for each session was adapted to meet the particular circumstances of the group and/or audience involved. Typically, the sessions involved a two-way exchange of knowledge; Yukoners providing local context, information, and – in some cases – positions to panelists, and the Panel offering information and/or clarification around various aspects of renewable electricity. A complete

The Panel meets with representatives from Council of Yukon First Nations and Assembly of First Nations – Yukon Region in Whitehorse.

[5] A fourth community meeting was scheduled for Dawson City but was canceled due to weather.

Top to bottom: Sessions with Watson Lake residents, Vanier Catholic Secondary School students, and Yukoners Concerned.

list of organizations, sample questions and answers from the public session, and written submissions to the Panel are included in the appendices.

Session Highlights

Public

Whitehorse (~65 people)

After a Q&A round, audience members were tasked with small group discussion around "renewable, reliable, and affordable" electricity. Participants reiterated the challenge of achieving all three, with some concluding that a multitude of approaches - including policy and new fiscal tools (i.e., carbon tax revenues) - will be required. A diversity of energy sources in terms of type and scale (i.e., from grid to household) were viewed by some as being central to the solution.

There was general agreement that there should be more pressure on the affordability front to achieve the levels of renewable and reliable desired, with energy efficiency and incentivization of independent power production cited as key tactics. The need for major capital investments and associated cost implications was seen as both inevitable and necessary.

Watson Lake (8 people)

Residents of Watson Lake shared their desire for local clean energy solutions but noted some unique challenges from the rural Yukon context, including affordability, capacity, and isolation (i.e., inhibiting adoption of electric vehicles). Better public education around the relationship between electricity generation and fossil fuels, along with rates that reflect the "true" cost of power, were seen as necessary ways to help Yukon households make better choices. Attendees stressed that the potential impact of local energy generation is very different in rural Yukon; new employment for a half dozen

people could have significant positive benefits. Biomass was seen as a logical fit for Watson Lake and there is precedent for it; however, government forestry policy was cited as a major impediment to harvesting at the scale required.

Haines Junction (12 people)

Haines Junction residents also emphasized the importance of local action and cited past examples of price-oriented regulatory policy hindering community efforts. Government financial support to adopt expensive clean energy technology was seen as necessary. The proposition of biomass as a potential solution garnered mixed reactions; while some felt that it would be an ideal fit with local skills and capacity, others commented that spruce beetle killed wood was largely unsalvageable now and cited the long growth period of Yukon forests and limited government management capacity as constraints.

Top to bottom: Haines Junction and Yukon Conservation Society sessions.

Schools

In Whitehorse, the Panel met with a large group of Grade 9/10 students relatively new to energy issues and a smaller group of Grade 11/12 students with experience in renewable energy technology and a high energy "literacy".

The Panel used an interactive challenge to introduce renewable energy concepts and get the larger group thinking about what an ideal future energy mix might look like. The smaller group utilized the Panel's expertise to better understand some of the technical issues and future career opportunities related to the clean energy sector. Both sessions highlighted the importance of early education around energy, and the enthusiasm and aptitude young people show for the topic.

First Nations

First Nations organizations told the Panel that their efforts and capacity are "ramping up" in the clean energy arena, reflecting its growing importance to Canada and Yukon's Indigenous peoples. Food security, wildfires, alienation from traditional subsistence areas, drought, and invasive species – all

were cited as key concerns for Yukon First Nations people. Negative experiences from past energy projects is a barrier to participation for Elders, in particular, and the broader question of how the energy regulatory environment meshes with the Umbrella Final Agreement needs careful consideration. Limited capacity, particularly in rural areas, was acknowledged as an ongoing challenge but some First Nations are making substantive progress on the housing and energy production fronts. Youth training is an another positive development but longer-term, hands-on leadership and mentoring opportunities are needed to ensure these efforts aren't one-offs.

Environmental NGOs

Environmental organizations challenged the cultural/philosophical underpinnings of the climate crisis and a perceived attitude among some residents and leaders that the Yukon is too small to "make a difference". Biomass and wind were cited as the "low hanging fruit" of renewable energy options available to Yukon and priority areas for action. Local economic opportunities, training, and capacity building were seen as integral elements of a clean energy future. Some viewed the institutional culture within government and energy agencies as an impediment and opined that First Nation ownership and management of renewable energy infrastructure was vital to making progress. The government's carbon tax rebate was questioned, and there was a desire for stronger action from the mining industry.

Business/Consumer NGOs

The Panel heard that Yukon's strong economy is driving power demand, but "Not In My Backyard" attitudes and a lack of political will to make difficult and/or unpopular decisions has resulted in little substantive progress. Government policy promoting electric heat was felt to be an avoidable contribution to the problem. The need for combined energy-economic development solutions was stressed, with a local biomass industry seen as an obvious starting point with the potential for 120-150 direct jobs. Clean energy innovation involving key industries (i.e., transportation and mining) was also envisioned. Utilities were felt to be less suited to leading cost-effective energy conservation than government due to their "bottom-line" mandate. Consumer protection and an updated regulatory framework that reflects the cost of carbon and levels the playing field for renewables were felt to be simultaneously achievable. Tactics such as DSM and potential income-geared carbon tax rebates would require careful review from a cost-effectiveness and administrative standpoint before adoption.

Our Big "Takeaways"

During our numerous discussions, it became very evident to the Panel that Yukoners are firmly committed to a clean energy future. We found a deep and broad desire for concerted action and consensus that future energy needs should be met in a fashion that protects Yukon's abundant natural wealth. Further, we heard a desire among Yukoners, and their household, community, commercial and institutional entities, to be active partners in shaping and contributing to this clean energy future.

Public and stakeholder consultations also revealed deep frustration among Yukon residents and stakeholders with the current energy policy and planning system. There is a prevailing view that the

goal of a clean, affordable and sustainable electricity system cannot be realized through a "business as usual" approach. The Panel would describe the dimensions of this energy "disconnect" as follows:

- Genuine concern that existing regulatory, policy and fiscal tools and instruments for energy planning and engaging and empowering Yukoners, including Yukon First Nations, are insufficient to forge a robust pathway for a renewable energy future. This is not to say that the government and energy agencies lack commitment or have not made commendable efforts, but rather that the planning and implementation framework needs redesign and additional tools and resources;
- The potential fallacy trap in promoting "clean" electric baseboard heat when the power is increasingly sourced from thermal generation (rather than renewable energy) in the winter (see Appendix E for further discussion);
- Insufficient attention being given to energy efficiency, especially with regards to heating, and the potential of moderating the demand peak for electric heating during winter;
- Advocacy for energy objectives to be achieved in a holistic manner that advances social and economic development and job and enterprise creation across the territory, but particularly in smaller and remote communities;
- Frustration with the perceived lack of real progress on stated renewable projects with needs being met by "temporary" thermal generation that instead becomes long-term;
- Pent-up unease with the lack of progress on developing a new renewable energy baseload and a desire to "break the logjam" on a long list of projects lacking a clear path to implementation;
- Absence of an ongoing and collaborative process that would accommodate public inputs more meaningfully and unlock the potential and passion of Yukoners, Yukon businesses and institutions to be part of the clean energy "solution". As just one example, Yukon youth possess the skills and talent to be clean energy innovators, and are forthright in calling for real climate action; and,
- The critical need for consultation with First Nations as a pre-condition to exploring technical feasibility of renewable energy projects and leadership and collaborative inclusion with First Nations governments and entities in actually constructing new clean energy capacity.

November 18th public session in Whitehorse

OUR BEST ADVICE

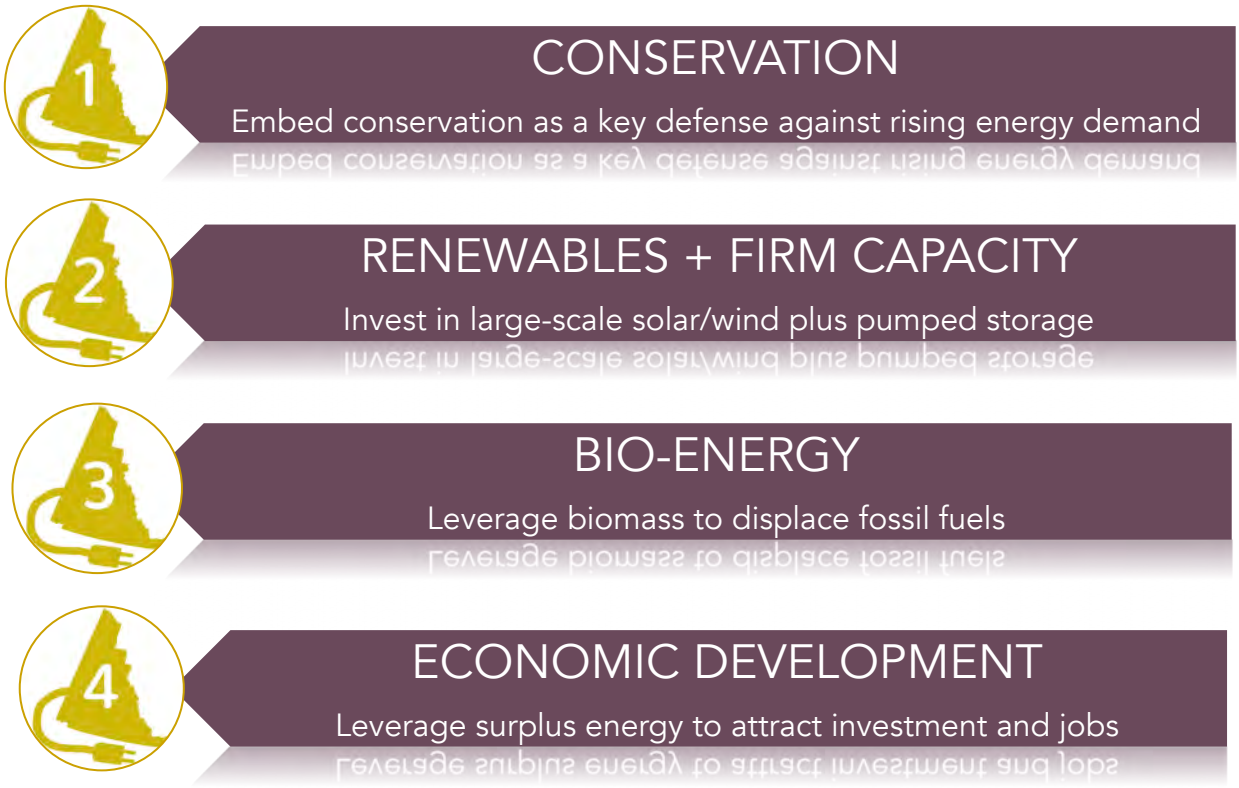
After careful review and consideration of the information and perspectives gleaned from stakeholder and public meetings, briefings, and relevant documentation, the Panel has elected to present its "best advice" to the Government of Yukon in four strategic, "cross-cutting" areas. This approach attempts to reflect the intersecting and strategic policy, regulatory and technical elements at play and address issues at a higher level than is typically afforded by Yukon's regulatory electricity/energy rate framework.

In formulating these four key areas, the Panel kept numerous key intertwining policy and strategic issues "top of mind", including:

- Cost implications versus economic opportunities;
- Electricity rates versus taxation effectiveness;
- Carbon tax revenue uses;
- Territorial-federal dialogue; and
- High-level energy planning that balances the broader, long-term needs of Yukon, versus a focus on short-term necessities and a cost-oriented regulatory framework.

> *"The greatest thing in this world, is not so much where we stand, as in what direction we are moving."*
> Oliver Wendell Holmes

Our four broad areas and their respective objectives encompass the broader energy situation (i.e., electricity, heat, and transportation) and are as follows:



AREA #1. CONSERVATION

Objective: Embed conservation as a key defense against rising energy demand

Steadily rising demand for electricity in the territory is being addressed increasingly with fossil fuel based supply-side options. Such theoretically short-term measures could indeed become long-term baseload generation for several reasons:

1. The regulatory approach of comparing future generation costs with the least expensive present alternatives (i.e. thermal generation);
2. The reactionary "chasing" of load growth[6] as it emerges is only possible with quick asset additions such as thermal generation; and
3. Many renewable energy sources, such as wind and solar, can not be counted on for firm or dispatchable capacity without storage.

> *"Energy efficiency is not just about saving energy, it's about tackling economic, environmental and social issues at the same time."*
> Harry Verhaar

This increasing baseload fossil fuel generation trend could see Yukon move below the government's 93% target in the coming years. We feel that the only short-term way to reverse this trendline is to embed conservation as the key line of defense against rising demand. Our rationale is two-fold: first, in our experience, conservation is the least expensive way to defer future supply; and second, it makes additional investments in renewable energy attractive due to the resulting smaller demand/energy footprint.

We believe the Government of Yukon recognizes the importance of conservation and demand side management (DSM), and applaud its continued efforts to this end. The following points provide further guidance on how to embed Conservation in resource planning efforts:

1. Set an ambitious target of 15% demand reduction and 25% energy reduction over 10 years.

While this effort should be focused primarily on residential, commercial and government buildings, a significant payoff could also come from green mining efforts[7]. After this goal is reached, all future load growth should have an embedded component of 25% energy deferral – in effect, embedding conservation in future supply planning.

Both energy and power play a role in a broader conservation strategy. Energy conservation factors in as the total renewable energy stored in the hydro facilities is limited and subject to variability from climate change. Conversely, power conservation - specifically at peak consumption times - will have a significant impact on reducing the required capacity to meet that peak. When "power in" must equal "power out" at all times, not only does reducing the peak through conservation reduce the power system infrastructure required to meet that peak, but it also reduces the size of the fossil-fuel based peaking generators.

[6] Current load growth planning does not seem to employ probabilistic factors, fearing overbuild conditions to ratepayers
[7] Potential pending policy on reducing the energy intensity of mines.

There are some jurisdictions that have "negawatt" incentives for retrofits at 50% cost sharing valued at $400/kW reduced[8]. The best payoffs are in the following order for both new and retrofitted buildings:

1. Broad based Energy Efficiency and DSM improvements across all customer segments;
2. "Behind the meter" automation in demand/energy management for Commercial & Industrial customers;
3. "Behind the meter" automation in electric heat demand/energy management for residences; and,
4. Utility-offered subscription-based Demand Reduction programs.

Conservation and Demand Side Management

Energy efficiency and demand-side management (DSM) are two major components of conservation. Energy efficiency entails reductions in the amount of energy required to provide products and services. For example, insulating a home allows it to use less heating energy to achieve and maintain a comfortable temperature. DSM is the modification of consumer demand for energy through various methods such as financial incentives and education. The goal of DSM is often encouraging the consumer to use less energy during peak hours, or move the time of energy use to off-peak times such as nighttime and weekends. Both energy efficiency and DSM are relevant to broader conservation and can reinforce one another.

2. Factor in both demand and energy reduction as well as cost/benefit

Some loads offer both demand/energy reductions simultaneously while others are separated. For example, LED lights simultaneously offer a 60% reduction in both for all customer segments. Such a reduction would pay off well during winter months when the demand and energy consumption is high due to shorter daylight hours. Commercial, Industrial and Residential customers and street lights in high load areas such as Whitehorse should be targeted first. While the YUB may have declined such efforts in the past (as not being utility appropriate), the government should make continued attempts using other agencies/directives.

Other logical electricity demand/energy reduction candidates (drives, compressors, fans) should be targeted based on favourable "pareto analysis" results for quick payoffs.

3. Target specific segments and customers

Residential and General Service customers with electric baseboard heating should be included in this incentivization. Since there are no time-of-use rates in Yukon, a tax incentive (or rebate such as in the government's Good Energy Programs) may be needed for energy-efficient appliances, Electric Thermal Storage (ETS) and battery energy storage. Such combinations are good for diurnal load leveling.

[8] Based on avoided generation at $1,000/KW nameplate

4. Use incentives and bulk procurement

Many jurisdictions outside Canada have used their bulk procurement strength to lower unit costs in this area. Within Canada a few jurisdictions have offered long-term attractive financing, embedded as a part of property tax or utility bills. Others have simply offered discount coupons.

5. Promote Community Energy Planning (CEP) efforts

Yukon communities, especially First Nations and rural, would benefit greatly from a community-centered engagement to determine how to reduce energy consumption and peak demand and make energy more affordable. Collective versus fragmented collaboration can be very effective in smaller, more socially connected communities.

6. Consider existing and new financial and DSM instruments

Yukon's electricity rates are roughly on par with those of southern Ontario, and significantly (about 50-400%) less than those of Northwest Territories and Nunavut. The Yukon Interim Electrical Rebate was introduced several decades ago to buffer the impacts of the Faro mine closure on Yukon ratepayers and warrants reconsideration in the context of conservation. The rebate could be gradually phased out altogether, with the resulting revenues directly reinvested in Conservation initiatives. In addition, the introduction of market facing tariffs such as Time-of-Use in larger grid connected communities (Whitehorse, Dawson, Mayo) that have both diurnal and seasonal variations should be considered. Such efforts have been implemented in Quebec whereby customers can opt-in to a rate structure that can reduce their standard electricity rate by 28%, except during cold spells (that occur a few days per year), when rates increase by 585% for those specific days[9]. Smart meters and in-home notification equipment/systems are required for its implementation.

Downstream view of the Whitehorse Rapids hydroelectric facility and Rotary Centennial Bridge

[9] http://www.hydroquebec.com/residential/customer-space/rates/rate-dt.html

AREA #2. NEW RENEWABLE TECHNOLOGY + FIRM CAPACITY

Objective: Invest in larger-scale solar and wind technology combined with pumped storage to meet long-term demand growth.

The projected need for an additional 20 MW of thermal generation capacity through to 2035[10] to meet demand growth, winter peak and N-1 contingency on a current non-industrial peak load of about 75 MW conflicts with Yukoners' values and compromises the government's own 93% target. The only way to reverse this problematic trend and provide the necessary public assurance is for the government, in addition to reducing demand through conservation, is to embark upon a serious investment in enhanced hydro generating efficiency, pumped hydro storage, augmented clean energy supply through new transmission capacity, and larger-scale solar and wind technology over the next five years.

In such an undertaking, given that it represents an accelerated timeline for development, we feel that the Government of Yukon would fulfill the role of the "initiating" stakeholder. However, the federal government and Yukon First Nations would need to be partners upfront.

The following points capture our initial thinking towards the technical aspects of this undertaking:

1) The wind, solar and pumped hydro plants need not be co-located geographically if connected by transmission, allowing for the preferential site selection for each. The pumped storage system should serve as both a firm capacity and adequate seasonal storage. Pumped storage would ideally be situated in central Yukon to "stiffen" the upper transmission system and avoid the hydrological challenges anticipated in southern Yukon due to climate change. However, the geography and transmission (i.e., 69 kV) in central Yukon may not be conducive to cost-effective pumped storage, forcing a southern Yukon location closer to the 138 kV transmission backbone.

2) A systems approach to a requisite scale/size should be adopted (likely 25 MW), based on all the three components enabling a combined "system optimized" system with blended Levelized Cost of Energy (LCOE)[11] and this will attract major EPC players, infrastructure investors and others[12]. It is imperative that the federal government supports this initiative with grant assistance.

3) Subject to the necessary integration infrastructure (possibly including YEC's proposed 8 MW battery) being in place to maintain stable grid voltage and frequency through operating reserve, some level of solar power infrastructure could be liberally sized to capture high summer solar irradiation and generate adequate surplus to prime the pumped storage system to meet winter peaks. A wind plant designed to produce energy predominantly in winter could be located on mountain ridges accessible to Whitehorse for easier transportation/maintenance access. The projected high-water variability (during freshet season) due to climate change[13], at both Aishihik and Mayo, could then be stored by this pumped storage (as opposed to spilling).

[10] YEC 2016 Energy Resource Plan, issued March 2017

[11] YEC's study in the past for pumped storage alone was estimated at 30 cents/kwh

[12] Smaller size systems and individual separate IPP builds, will have much higher LCOEs due to high EPC overheads.

[13] YEC 2016 Energy Resource Plan, March 2017

The development of renewable firm capacity that is dispatchable during the winter season would negate the need for additional diesel capacity beyond the implementation timeframe; however, it could remain a stable standby power supply. Indeed, the Panel would be remiss if it did not highlight that as it will take time to effect broad-based energy conservation, and bring on board new renewable energy supply, reliance on fossil fuel electricity generation will likely continue for the short term, or in other words, the Panel recognizes that the situation may get worse before the actions proposed can make things better.

The unique circumstances of off-grid communities in Yukon merit specific consideration. The Vuntut Gwich'in First Nation's solar-storage project in Old Crow, in partnership with ATCO Electric Yukon, has national relevance and is projected to come on line in 2020. Efforts to accelerate plans for wind energy in Burwash Landing would be similarly positive. Watson Lake should be the focus of a biomass or solar energy project to reduce diesel reliance.

The Panel further contends that the development of larger-scale new renewable energy supply need not be subject to a Request for Proposal (RFP) and/or through Independent Power Producer (IPP) contracting. We envision a more cooperative, "Made in Yukon" approach be taken on targeted, high-priority projects which would require direct involvement by YEC but provide tangible opportunities to First Nations and local community/entities for investment, economic development and joint decision-making.

We believe that such a foundation for new renewable energy development would promote collaborative versus combative project planning and construction, while also ensuring that operational control and power dispatch continues to be managed by YEC for Yukon as a whole.

Wind turbines on Haeckel Hill (Credit: J. Maissan)

AREA #3. BIO-ENERGY

Objective: Leverage local biomass to displace fossil fuels

Oil/propane space heating is the second largest contributor to GHG emissions at 16%[14]. Space heating is vital to the territory given its climatic conditions. Currently, about 13,000 cords (30,000 m^3) of wood are harvested annually to heat homes and buildings (amounting to 17% of Yukon's total heat) [15]. Much of this supply is harvested in the Haines Junction area from beetle-killed trees and trucked to the Whitehorse area[16]. This harvest level is well within the 0.1% of the Yukon's forested land base identified for harvest, and represents a tiny fraction (1/200) of the 112,000 hectares consumed by forest fires each year[17].

The EnerGuide Report[18] predicts that biomass is likely to play an increasing role in the Yukon's residential heating market. About 25% of homes heat with wood. There has been a significant increase in clean burning cord wood and pellet stove installations over the past several years (based on the Good Energy rebate applications). Both cord wood and wood pellets cost significantly less than conventional heating sources, including electricity. Pairing biomass with electric heating could be incentivized to improve seasonal load, with electric heating during spring/fall, and biomass heating in winter months (during periods of high electricity demand).

The current market value of the 13,000-cord supply chain at $250/cord[19] is about $3.25 million dollars annually. We believe this supply chain could easily be scaled up to convert half of the 69% of homes that heat[20] with oil to biomass. This would comprise a supply increase of 200% (fed by existing beetle-killed and forest fire affected trees) and a resulting annual market valuation of $9.75 million dollars. Further, this would translate to about 130 net new jobs across Yukon[21] generating about $6.5 million in direct wages[22] and total tax revenues of $1.0 million annually[23]. Please refer to Appendix D.

> *"The relationship between renewable energy sources and the communities we expect to host them must be appropriate, sustainable and above all, be acceptable to local people."*
>
> *Owen Patterson*

In addition to possible direct consumer-level benefits such as lower heating costs (as compared to oil), the conversion from oil heating to biomass has indirect benefits, such as avoiding long-haul oil transportation, the US dollar exchange rate, and global price volatility. Over the longer term, Yukon could potentially expand its supply chain to other areas such as power and/or standby generation or

[14] Overall 21% adjusted for only oil (69%) and propane (7%) heating
[15] Vector Research, "Yukon Energy State of Play", Updated December 2018
[16] The Panel heard in Watson Lake that logs from BC were being harvested due to limited/delayed permitting in Yukon
[17] Vector Research, "Yukon Energy State of Play", Updated December 2018
[18] EnerGuide for Homes, Yukon 2015 Report
[19] Retail rates for commercially cut and delivered cord-wood in 3-cord loads or higher is about $250 per cord
[20] Rising insurance requirement for fuel tanks/home safety
[21] Gathered in the various interviews (loggers themselves and others knowing the industry)
[22] Estimated at $50,000 per job annually
[23] Based on a blended tax rate of 15%

other geographic markets. Furthermore, forest fires pose a serious concern in many Yukon communities and are in themselves a source of GHG emissions.

We propose that Yukon advances a "Yukon Bio-Energy Trifecta" comprised of three key elements:

- **Procurement, policy and regulatory demand drivers** for a Bio-Energy Economy, including incentives for energy consumers;
- **"Smart Forest" management practices** that protect ecosystems and promote advanced silviculture, while utilizing forest resource and waste to reduce forest fire likelihood; and
- **Development of a Biomass Supply Chain** that drives local employment and provides secure feedstock availability.

To advance this Trifecta, we offer the following specific recommendations:

1) Convert space heating in all government buildings and schools from oil to biomass to offer a stable large offtake for biomass harvest and supply chain. For the time being, defer (except for a few trials) on electricity production (i.e. gasifier technologies) and transport fuel production (i.e., cellulosic ethanol) to allow for the space heating supply chain to develop and subsequently stabilize;
2) Review potential regulatory and/or other policy impediments to harvesting Yukon fire-killed and beetle-killed trees[24];
3) Promote a star-rated system for biomass boilers and furnaces (both chip-based and pellet-based) including filter designs down to 2.5-micron particulate matter (for public health benefits). Pilot a few hybrid trials in communities pairing biomass heating with electric heat systems in homes to reduce peak electricity demand in the winter, while reducing overall annual home heating costs. Such efforts could build on the Energy Solutions Centre's current $300 to $800 subsidies to homeowners who purchase efficient wood (including pellet) heating stoves.
4) Develop a biomass-oriented forest management regime addressing key aspects of the forest life cycle such as mitigating potential fires, clearing fire and beetle-killed trees, and planting of mixed forests for bio-resilience as well as future biomass harvest. The Nordic countries (particularly Finland) are well advanced in this area.

We note there is a project under development for a biomass generation plant using Organic-Rankine Cycle (ORC) in northern British Columbia[25], which if successful, could be used as a model for further such unitized distributed development from biomass sources, notably for remote, off-grid communities.

[24] The Panel heard in Watson Lake that BC offers larger permits and that logs are being harvested there and brought to Yukon market

[25] Mentioned at the public meeting at Watson Lake

AREA #4. ECONOMIC DEVELOPMENT

Objective: Leverage surplus clean energy and tax revenues to attract investment and create jobs

If the previously discussed "best advice" areas (listed above) are implemented successfully, there is a future possibility of surplus clean power (both firm and energy) being available from renewables. A renewable energy dominant situation, assuming Yukon incorporates the full costs of carbon in fossil fuels[26] for energy production (currently exempted), allows the territory to offer incentives to attract new, diverse industries. Carbon tax revenue is another strategic lever for government to deploy. We offer the following specific ideas towards creating new economic opportunities:

1) Prioritize sectors that generate new jobs, especially in rural communities. Areas with strong potential include food security and agro/animal production, health care, and information technology. Larger "plays" could include green mining, biofuels, and electric vehicles;
2) Allow a higher "carbon adjusted" IPP SOP price for smaller community based projects (i.e., below 100 kW) that are not currently viable under the SOP, by increasing rates for smaller renewable energy alternative projects to make them more attractive. An increased pricing methodology could allow for a more holistic lifecycle cost comparison by including a carbon price and a variable O&M cost, as opposed to variable fuel costs only. The carbon adjustment also serves as a means test, as the territory does not account for any carbon tax on its fossil fuels (exempted);
3) Bolster the territory's wilderness tourism brand with the major highway Fast Charging Infrastructure (FCI) outlined in 'Our Clean Future';
4) Engage the industrial (particularly mining) and freight sectors and academia to incubate Yukon-based innovation in alternative fuels for long-haul transport and mine operations;
5) Consider re-allocating 50% of carbon tax revenues towards investment in local renewable energy technology and/or conservation efforts, versus rebates;
6) Once the heating-oriented biomass industry is established, explore the following uses for excess:
    a. Strategic deployment of mobile biomass-gasifier electric generators (up to 250 kWe) in the remote communities along with diesel generators;
    b. Production of compressed biogas for use as distributed clean fuel instead of propane; and,
    c. Biomass pellet production plant for home, industrial and export uses.

There are other clean technologies on the horizon that could present new alternatives for Yukon to consider. They have been excluded from our discussion, given that they are subject to pending federal government investigations and pilot efforts, market timing, and stabilized commercial costs. These technologies include hydrogen energy, Small Modular Nuclear Reactors (SMR) energy, and Concentrated Solar energy.

[26] Fuel rebates could be extended in non-grid connected diesel power to keep rates affordable

PATHWAYS TO ACTION

The Panel reflected on the veracity of the themes presented in earlier sections of this report as the basis for promoting a Yukon electricity system that is virtually 100% renewable. In this regard, we asked ourselves: "How?" How can the recommendations be implemented with the highest likelihood of success? Deliberating on this fundamental question led the Panel to make a further recommendation we have labeled "Pathways to Action".

In essence, we have concluded that unless the Government of Yukon and energy agencies, along with Yukon stakeholders - notably First Nations - but also industry, commercial and institutional interests, move forward in a dramatically different way than in the past, the pursuit of a clean energy future will be fraught with discord and unrealized outcomes.

Good public policy is indicated by the public saying:

- "I see it, I believe it, and I support it"
- "Tangible project benefits are visible in my community"

We thus recommend that Yukon's clean energy and clean electricity future planning and realization be based on the principle and practice of what we tentatively label the "Collaborative Leadership for Energy Advancement Network" working model, or CLEAN. The CLEAN initiative could embody a collective Yukon drive towards a clean energy future and serve as a model that could be replicated in other parts of Canada. There will be a need for initial co-creation and ongoing curation of CLEAN; the Panel believes that numerous Yukon organizations, public, industry and communities have a vested interest in providing leadership and passion to this undertaking.

The Yukon CLEAN framework we propose would be inclusive, transparent and, above all, Outcomes Oriented, and could potentially incorporate the following key components:

a) ***Yukon Government Energy Planning Structure:*** A working group of senior officials from major Government of Yukon departments including Energy Mines and Resources, Finance, Highways and Public Works, Justice, and Education which would report to a Cabinet Committee on Energy Futures through the Minister of Energy, Mines and Resources.

b) ***Regulatory Reform for Clean Energy Development:*** A review of major regulatory provisions related to energy, and revision to regulations to promote Yukon's clean energy future including: the *Public Utilities Act*[27] (and the terms and operating parameters of the Public Utilities Board), *Territorial Lands Act*, and other pertinent pieces of legislation.

c) ***Yukon-Canada Joint Clean Energy Cooperation:*** A proposed 3 year agreement between Yukon and Canada to provide funding resources for: CLEAN, energy futures planning, energy conservation incentives, First Nations and local Community Energy Planning (CEP), targeted

[27] We note that a commitment has been made to update the *Public Utilities Act* in 'Our Clean Future'.

renewable energy generation/transmission feasibility and capital financing, and clean energy human resources skills development for employment and enterprise creation.

d) ***Yukon Energy Conservation Directives:*** The revision of land use and building regulations to require advanced building code construction and use of biomass for heating, including thermal storage, based on the goal of "Zero Energy Waste".

e) ***New Generation Partnership – First Nations, YEC and Local Communities:*** Examination of which new generation and transmission projects to pursue through collaborative project implementation and co-ownership partnerships, supported with substantive resources to assess technical and economic viability for high-priority projects through a "quick turnaround" approach.

f) ***Industry Leadership for Clean Energy:*** Drawing on the leadership of organizations such as the Yukon Chamber Commerce, Yukon Chamber of Mines, and mining companies, development and promotion of a Best Clean Energy Mining Practice standard for existing and new mines and operations.

g) ***Bio-Energy Trifecta Collaboration:*** A working group of the Government of Yukon, Bio-Energy supply chain players and biomass consumers to build the territory's Bio-Energy Economy.

h) ***Clean Energy for Clean Tourism:*** Attracting more sustainable and eco-tourism to the Yukon based on: electrification of highways for EVs and clean energy for grid and non-grid connected tourism operations.

i) ***Clean Energy Skills and Education:*** Working through Yukon College (soon to be Yukon University), development of hands-on curriculum and programs to build clean energy skills of young people, First Nations, and tradespeople in a range of areas, such as energy auditing, energy conservation and buildings, etc.

j) ***Annual Yukon CLEAN Conference:*** An open gathering for the CLEAN process focused on progress on Yukon's clean electricity future, including updates from energy agencies such as YEC and project partners, tracking of Yukon's GHG emissions, and briefings on the latest clean energy innovations. During the year an online platform could allow for updates on major clean energy developments.

APPENDIX A. Panel Biographies

Christopher Henderson

As Canada's pre-eminent Clean Energy Advisor to Indigenous communities, Chris Henderson treasures his deep relationships with First Nation, Métis and Inuit peoples across this vast and beautiful Land. He has played a key role in developing over 35 medium-large sized Indigenous renewable energy projects across Canada as head of Lumos Energy. Chris focuses on strengthening First Peoples clean energy leadership through the Indigenous Clean Energy (ICE) Social Enterprise platform which includes the ground-breaking 20/20 Catalysts Program, the ICE Network and a Global Hub. ICE's programming covers renewable energy, energy efficiency and conservation, advanced energy systems and green energy infrastructure. Prior to leading Lumos and ICE, Chris was the Founder and CEO of The Delphi Group, Canada's leading corporate sustainability, Cleantech and climate consultancy. Chris is Author of the book *Aboriginal Power*, and an honorary member of several Indigenous communities. Chris lives in Ottawa.

John Maissan

John Maissan was formerly a professional engineer with experience ranging from 15 years in the mining industry, 14 years with Yukon Energy Corporation, and spent 12 years running his own small consulting business. During his 14 years in a senior YEC engineering position, he was involved in the hydro reconnaissance program of the early 1990s, the wind energy development program on Haeckel Hill, the rebuild of the Whitehorse hydro plant and office building following a fire, and the Mayo to Dawson City transmission line. In his consulting business John served a wide variety of clients in renewable and non-renewable energy, with wind energy, solar PV, and small-scale hydro comprising the bulk of this work. Through John's experience with wind energy he has developed a niche expertise in dealing with cold temperatures and rime icing issues. Although mostly retired he remains involved in Yukon's energy picture and contracts part time in the renewable energy sector.

Michael Ross

Dr. Michael Ross is the NSERC Industrial Research Chair in Northern Energy Innovation at the Yukon Research Centre, Yukon College. His applied research program addresses the needs of the northern energy industry through academic partnerships with all three colleges in the territories, and through industry-driven direction and support from all four territorial electric power utilities. The pertinent engineering research areas for the program focus on integrating a high penetration of renewable generation in remote communities, diesel efficiencies, demand-side management, and market disruptors. Dr. Ross received his Master's and Ph.D. degrees in Electrical Engineering at McGill University, focusing on microgrid control and multi-objective optimization, and his Bachelor's of Applied Science at the University of Toronto focusing on electric power systems. He was an author and active contributor to international working groups on "Hybrid Systems for Off-grid Power Supply", "Microgrids, and "Rural Electrification". Along with his numerous local, national, and international professional affiliations, Michael is currently the President and Director of the Yukon Science Institute, and is a Level 1 electrician apprentice.

Ravi Seethapathy

Ravi Seethapathy retired in 2014 after a 31-year career in Hydro One/Ontario Hydro, where he managed leading portfolios in R&D, Innovation, Smart Grid, Energy Storage, and Renewable Energy Integration, among others. Ravi is now an advisor to the utility industry and an invited speaker throughout the EU, Latin America, Asia, and the Middle East. With a Masters of Engineering with a Masters of Business Administration, he has co-authored over 50 technical papers and served over 9 years as an adjunct Professor in Canadian universities in the area of Energy Systems. He is currently the Executive Chairman of Biosirus Inc. and is a corporate director of two India-based transmission/distribution and smart grid enterprises. Ravi's many corporate directorships include Smart Grid Canada, Ryerson University, Engineers without Borders, and the Indo-Canada Chamber of Commerce. His numerous honours and citations include the Queen Elizabeth Diamond Jubilee Medal. Ravi lives in Toronto.

APPENDIX B. List of Participating Organizations

Assembly of First Nations Yukon Region
Council of Yukon First Nations
FH Collins Senior Secondary School
Vanier Catholic Senior Secondary School
Yukoners Concerned
Yukon Conservation Society
Yukon Chamber of Commerce
Yukon Utilities Consumer Group

APPENDIX C. Selected Panel Q&A

From November 18th meeting in Whitehorse – (near) verbatim

Q: Energy storage is needed for intermittent (sun and wind) sources at the utility level? What are the technologies that are sufficiently advanced to fulfill this need and what is the timeline needed to get them to the permit stage?

JM: There are two kinds of storage – first short term to stabilize fluctuations so that we can maintain stable voltage and frequency on our system, and this is where flywheels and battery storage systems have a useful niche. Kodiak, Alaska has a battery and two fly wheel system to manage short-term fluctuations. Our load is more challenging in the variability aspect (temperature and season). Most of our needs come in the wintertime, when wind is more abundant – but it comes and goes. Solar is least available in the periods when electrical loads are highest and we need heat. The obvious solution that works best is pumped storage, which functions like a hydro plant and takes in the manner of 5-10 years to bring it online. Battery systems take a few years to bring online. YEC has a battery energy storage system under development. Tesla provided 100 MW battery system to South Australia in 90 days from contract signing; the capacity is really building out there.

CH: Your question is probably the most important energy system one Yukon has. Looking at the demand side function is important. When you look at peak cold days with LNG and diesel use; driving the energy demand function is important. If we can manage that peak down lower in certain conditions then we can manage that capacity more easily and may make renewables more workable and economic. That's why you have to have an integrated approach. There isn't going to be just one renewable source that meets all your winter peak needs. Be conscious and open to opportunities for distributed energy resources and distributed approaches to reducing demand and the policy and incentives that facilitate that while demand is still growing will offer a better rate of return on investment for everybody.

MR: I would suggest that you flip the question around to, "what problem are you trying to solve"? There is the range of technology – capacitors, super magnetic energy storage, etc. – if you scale too large it gets too expensive. The longer-term solutions are the seasonal storage (versus diurnal) such as pumped storage, compressed air, etc. You have to look at it in Northern context – which means not only climate but also logistical issues. If you want to install a storage component in remote communities you have to be able to get them on a plane. And how are you going to control it? The technology has to be there to help support it.

RS: The best examples work where energy storage works at the last mile – close to your home or community. You see the trend today where people pay far more than the electricity cost for convenience – cordless drills, lawnmowers, etc. If you do demand reduction your so-called rationalization for the premium becomes less challenging. That's the first part. The second part is that your ROI (or relative ROI) starts to improve because you have partly addressed your capacity issue. For example, during my time with Ontario Hydro we had all these boom trucks on diesel that were switch to electric and resulted in big diesel savings. If you think along niche lines and where projects will pay off, it's far better to work at that scale and in the end the cumulative impact is large. Costs of batteries and so forth have dropped dramatically. Where do you want to catch it? Do you want to anticipate it at the "millionth chip" (i.e. cheaper) level? How does Asia manage this? There is 40,000 MW of solar going into rooftops in India; requires almost 25% of energy storage in district-ized form. The

rationalization of going smaller and discrete allowed for better acceptance by the public than would have been possible in pursuing large energy storage projects.

Q: Now that we have a carbon tax, how would you advise the government to spend it?

C: When you look at how the carbon tax is going to be used, it's a political and policy question that we haven't been asked to consider closely. However, the reality is I would hope it will partly assist with the energy transition process. If you're going to return less to the tax or rate payer it means you're using those funds for something else so that's a trade-off that has to be considered. We haven't looked at that closely. Will say that the kinds of ratios that have been used are in the range of 90% going back to citizens in the form of rebates and 10% going to transition; I would like to see more going towards transition.

MR: Put it in research!

JM: I have not been asked to advise on this specifically in my role on the panel. My personal opinion is that the government should use it to reduce emissions. I prefer to not receive the money back; there are better uses for it.

RS: The best signals that can be sent out are market, or price, signals. So if I price carbon in, how do I achieve import substitution? How am I going to eliminate imported fossil fuels. If you price carbon in and then do a comparator, it might send the right price signal for people to adopt other technology.

Q: How big is the policy framework you're looking at? It seems like electricity isn't a big piece of our GHG emissions? How much are you able to comment on other contributions to the GHG emissions pie? What are we doing about all the other fuels?

RS: Clearly your heating and transportation are big areas. Why is electricity brought in? Even though it's only a small portion of energy use and emissions now it is the clearest pathway to a clean future. But clearly your short-term goal is heating and transportation whether electric cars, trucks, etc. That will get your GHGs down. The question is: how do you get your economy up to pay for it? That is what other countries have done successfully – occupying that space and using clean energy as the basis for economic development. If you don't do that the alternative is to pay for it or keep receiving subsidies.

CH: This is all about change, and it's hard to do. It's all combined and we're considering energy writ large. Electricity is the pathway so it's highly pertinent.

Q: If a small nuclear plant can run a battleship or submarine why can't we put in a 10 or 20 MW small facility here? It seems there are new technologies coming online that we should be looking at.

CH: I'm contacted regularly by people from various utilities in the east who say they have small modular reactor (SMR) solutions. I have two questions for them: where is it working at that scale and what does it cost? To date, nobody has been able to answer those questions for me. Why would you buy anything when you can't answer those questions? Is this potentially part of the solution here? Maybe. Should you study it as a possibility? Yes. Is this something to look at in the next 5-10 years? Highly likely no – simply because of the current lack of answers to those two questions. In the long-term it could be a play but in the shorter-term it's probably not realistic.

RS: I would agree and disagree. Your question is valid. Your best strategy is always an arbitrage of technologies. Take Ontario for example. We went big on gas and the price spiked in the 1990s and all the gas plants shut down. The key question is: are you going to keep only a few sliver of technologies or are you going to keep alternatives? There are several nuclear technologies – some look like a new plant, you have to refuel them, 100 MW size - while there are others at the 8/10/15 MW level where you fuel

them for life and then you don't have to tinker with them on the operations side. You also get heat. The small nuclear reactors are catching people's eyes around the world and they are giving thought to what piece they would consider for their systems. There may be a future possibility of Yukon following other jurisdictions, maybe not soon. That holds true for hydro, wind, solar, other options – you have to have a battery of options.

MR: It's technological maturity. I've been part of some working groups with the Canadian Nuclear Association and Chalk River Laboratories and they're projecting to have reactors as small as 5 MW in 5-10 years. It seems to be a rolling 5-10 years though. The North isn't the logical place to test new technology; it makes more sense to test it in less extreme environments first. But going back to identifying the problem you're trying to solve, nuclear submarines were invented because diesel submarines had to resurface too often, so it's meeting that particular need. One characteristic of nuclear technology is that it's baseload; you set it and it's you leave it. Ontario has a lot of nuclear and if you look at the Independent Electricity System Operator that regulates the electricity markets in Ontario. there are times when the market electricity price is negative; they will pay bulk power producers to buy electricity. Hydro Quebec gets paid to consume that electricity because Ontario can't ramp up and down as quickly. We don't have that flexibility in the North but that being said, nuclear is a technology I'm keeping a close eye on because it may have some potential role to play in the future.

CH: One concern I have when I look at the Yukon grid is its essential vulnerability to catastrophic events be it drought issues or major outage issues that could require Aishihik or Whitehorse to be out for months. One of those is sort of OK, two means you would have a huge reliance on fossil fuels coming in. I do think that in order to meet the goal of renewable energy in a growing electrification context you need to start doing the homework behind those projects so you can understand if you've got social license, the environmental issues are looked at, the feasibility issues are looked at, so when you go to build you have answers. You manage technology options by understanding what those options are so that your switch/turn off timeline is that much faster when in fact you need it. That's part of the strategic planning that's useful; spending $4, $5 million dollars to be taking these things to feasibility level so that you can turn around faster. Now what you see is a demand load coming on board in an isolated grid or vulnerability in supply and the automatic default option is LNG or diesel. So therefore planning for potential load acceleration is a really good strategy.

Q: What are some of the things we should be looking to invest in for renewables and challenges we should be aware of? What kinds of things do we need to change or be aware of to facilitate this energy transition?

CH: Any investment looks for some degree of certainty and clarity. The fact that the Yukon is going through the planning it is right now is a really good thing; when there is a clear pathway investment tends to be more interested. Second, investment looks at risk and return. Given the size of the Yukon grid, my counsel would be to look at Yukoners leading on solutions and not expecting major IPP players to come in. For one thing it's a small market and many of them won't come in. If the investment hurdles are such that organizations - private, state, community and First Nation – can see that there's a pathway, then you start seeing investment. Investment capital is not the issue – it's more running down the risks of development. The cost of capital if you have a clear off-date for renewable energy is quite stable – in fact, it's better than it has ever been. So the issue is clarity on the policy and project framework and then really building the Yukon response to this.

RS: At times in the energy supply questioning when we forget about the delivery. The strength of your generation lies in the strength of your wires, and that

get's forgotten all the time. We talk about the price of energy assuming it's almost free or there is no hindrance to get where it needs to go. Wrong! Typically what we have found is that as you move towards the medium and lower voltages the pain is extremely high. You'd better know what you are doing before you start putting anything on the edge of the grid simply because all kinds of issues around power quality come up. And so when you have a weak feeder, to use that term, which is typically where renewable energy resides because they are always where the land is available or rural-type feeders, they are the most vulnerable for not allowing the value of that generation to be transported to a delivery point. So in my career I have seen a lot of strengthening needing to be done wherever you had wind or solar farms in medium or low voltage grids. So don't just look at energy; you need to look at delivery points as well.

Transmission connected renewable energy in my view is the easiest. As you come closer to community-based systems the level of engineering available may be different; so the "handholding" from the electricity grid provider has to be better and the level of cost has to be absorbed in the wires to enable that project to come through, and that has to do with the rate base. So the question is what are the rate regulations? In Ontario, we had two classes. When the benefit of a project was only due to the connections, the cost was borne only by them; but whenever the benefit of strengthening the wire went to potential renewable energy projects it was kept as a part of the system development and was shared across the province. So the hard questions would have to be answered based on what you think the projects might be at the various levels of transmission.

From November 20th/21st meetings in Watson Lake and Haines Junction (paraphrased)

Q: Isn't bird kill a serious problem with wind mills?

JM: Not necessarily. The Haeckel Hill windmill was monitored for five years but there was actually only one bird kill recorded during its operation. It was a grouse that flew into the fencing versus the turbine blades.

Q: Is new hydro really GHG neutral? What about methane released from killed trees?

CH: These have historically been impacts from hydro but the standard has evolved. Generally, you now have to remove the biomass from the future reservoir prior to flooding it.

Q: Is carbon sequestration factored into things like the Paris Accord?

CH: Yes, but it's not fully accounted for in carbon accounting.

Q: What is the hydro lifespan? What about river turbines?

CH: Hydro is the longest capacity renewable technology available right now. JM: River turbines can be a bit challenging with ice cover; they are proven but not always effective in the North.

Q: What are other "islanded" grids doing that we can learn from?

RS: Yukon is not unique in its situation; there are thousands of islands and similar circumstances. The first and most important measure is conservation, which starts to improve the economics of renewables. In cold climates, the back-up power has to be perfectly reliable. Put in extra "gear" to ensure that you are never stranded; this creates extra costs at the time. If you move to the edge of the grid, it gets compared to the price of the cheapest supply. If you're always chasing load, diesel/LNG will always win. You have to plan a decade ahead.

APPENDIX D. Written Submissions to Panel

1. **Yukoners Concerned**
2. **Yukon Conservation Society**
3. **Wildlife Conservation Society (WCS) Canada**

COMMENTS TO THE YUKON ENERGY PANEL
- November 18-19, 2019

Yukoners Concerned would like to thank Yukon Energy, Mines and Resources, specifically Ms. Shirley Abercrombie, for inviting our group to share with you our recommendations for future energy initiatives.

Yukoners Concerned is an activist group formed in 2012 in reaction to proposals to open up the Whitehorse Trough to oil and gas exploration and to the very real possibility of fracking being permitted in Yukon. We educated ourselves and Yukoners about the dangers of fracking, visiting every Yukon community with our presentations. Our petition to ban fracking and the construction of an LNG plant was signed by more than 8000 Yukoners and submitted to the Yukon legislature. When the Yukon Liberal government assumed office in 2016 they declared there would be no fracking in Yukon, and put in place a moratorium.

Always concerned about greenhouse gas emissions and the impact of fossil fuels on our environment, we also focused on Yukon's energy future and the need to develop renewable energy - wind, solar, geothermal, small hydro or biomass - as demonstrated by our pamphlet dated November 7, 2016.

We have continued to advocate for renewable energy. In 2018, we developed our renewable energy pamphlet titled "Yukon Leading the Way" where we outlined specific strategies to help us achieve a sustainable Yukon, reliant upon renewable energy. This was delivered to every household in Yukon. It included suggestions such as incentivizing homeowners to retrofit their homes, allowing businesses and local development corporations to sell power to the grid, and funding a task force and technical committee to collaborate with stakeholders and government to create a renewable energy economy.

Meanwhile, the Auditor-General's Report in 2017 slammed the Yukon Party government for their failures to "set timelines or reasonable milestones" with regard to climate change during their time in government. This was an indictment of that administration and a clear signal that Yukon must act to address climate change.

So, here we are in 2019. Old Crow, the City of Whitehorse and the Yukon legislature have all declared a climate emergency, recognizing that we are running out of time to take action to

reduce GHGs and keep the planet warming **under** 1.5 degrees Celsius, as established by the Paris Agreement.

We recognize that the Yukon Liberal government has taken some specific steps to address climate change, including introducing the Independent Power Production Policy, supporting First Nations' governments in developing renewable energy projects and empowering the Energy Solutions Centre to assist households through renovation upgrades. These are all worthwhile strategies but much remains to be done.

Because Yukon has a small population, many Yukoners believe we should be able to put in place a model renewable energy system. And so, yes, we are encouraged by last Thursday's Climate Change Secretariat's draft policy that sets a 30% reduction in GHGs by 2030 and proposes a dramatic increase in the number of electric vehicles. However, to achieve those intentions, Yukon would need to significantly boost renewable energy development, by which we mean a few renewable energy projects, be it wind, biomass or small hydro.

To reach that level, Yukoners Concerned have suggested that the government of Yukon establish a working technical committee to work with FNs, communities and NGOs to devise a comprehensive renewable energy plan.
Dr. J.P. Pinard will briefly explain what this could be. Dr, Pinard will also comment on Additional Renewable Steps for Yukon (Please see attached ITEM # 3)

Yukoners Concerned also recommends that YG establish a regulatory regime that better reflects present realities with a review of YUB, YEC, YDC and addresses climate change, which avoids internal disputes such as that between the Yukon Utilities Board and Yukon Energy over Demand Side Management.

A third recommendation would be to disband the Department of Oil and Gas Resources, recognizing the Intergovernmental Panel on Climate Change's warning that undeveloped oil and gas resources must remain in the ground in order **not** to contribute to rising GHG emissions, and replace it with a Department of Renewable Energy. This would be a clear expression of where Yukon's emphasis must be.

In conclusion, Yukon's Liberal government has undertaken and supported positive initiatives toward realizing a green energy future. We hope that the recommendations you present to government in December will actually lead to further action in the very near future, rather than result in vague, unrealizable goals used only as a prop in the next election. Concrete action on climate change and renewable energy is what we and our youth are demanding. After all, they will live with the consequences of our failures to act.

Thank you for your attention.

Donald J Roberts
Chair, Yukoners Concerned

Renewable Energy Steps for Yukon (ITEM #3) – Yukoners Concerned

The Yukon has more than enough small hydro and wind potential to meet future needs of switching from fossil fuels to electrical. Time to begin planning for renewable energy was yesterday/is now.

- Step one… every Yukon building using a fossil fuel for heating will need to be converted to electrical heating and/or renewable biomass and every family and business changed to an EV (electric vehicle). Calculate the future electrical needs of Yukon.
- Redirect Federal "Roads to Resources" funding to fund Renewable Energy.
- Yukon match Federal incentive grant for purchase of an EV (electric vehicle).
- Provide grants for energy storage appliances, biomass heating systems, and all building retrofits.
- Change building code to require SOLAR installation, 4-ply windows and super insulation
- Establish a SMART GRID in Whitehorse
- Eliminate 2MW limit on Yukon IPP policy
- Immediately begin building a (minimum) 50MW WIND farm on Sumanik
    - -integrate 8Mw battery (proposed)
    - -Aishihik lake is a battery
    - -implement a conversion program to switch home and business owners from oil heat to ETS (electric thermal storage)

-Implement a BIOMASS industry

- -establish a central collection and storage facility for biomass products in the Whitehorse area
- -establish a distribution network for biomass products
- -identify and convert suitable buildings in Whitehorse to biomass heating
- -copy Teslin's biomass program in all Yukon communities

-Explore

- -BIOMASS to steam electrical generation
- -THERMAL ENERGY CONVERSION using a low boiling point "working fluid" such as ammonia or propane in a closed circuit to drive a turbine to generate electricity

-Continue implementing the SOLAR panel installation program

Yukon Conservation Society INC. 1968

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Yukon Conservation Society

Key Points for Yukon Renewable Energy Expert Panel – 21 November 2019

1. Utilities Act needs to be redone
    a. Ecosystem services must be included.
    b. Carbon pricing must be included (methane/propane CO_2 equivalents specified).
2. IPPs are currently set up to fail, the power purchase rate is too low (based on subsidized capex and dumped fuel pricing). Must be reformed.
3. Why do we have two utilities (YEC and Atco Electric)? – given the population and amount being generated/distributed it's not efficient.
4. Panel's proposal should include assessing the wildlife impacts (trade-offs usually mean bad things for wild things).
5. YCS is opposed to big new hydro (the Next Generation Hydro initiatives) due to ecological impacts.
6. CCEGE Draft Strategy proposes at least 93% renewable…why not 100% (or as close as feasible).
7. Energy storage is an essential component.
    a. In the short-term combining wind and ETS makes sense.
    b. In the medium term (5-10 yrs) pumped hydro offers low cost high capacity seasonal storage.
8. Must think holistically – if introducing high capacity renewable sources, must create a demand for it (eg. Build a lot of wind turbines, and as they come on line have increasing numbers of Yukon households get off home heating oil and onto ETS units).
9. Connection to the main BC grid may be too expensive for Yukon needs.
    a. Connecting to the Atlin system would be fine.
    b. Connecting to the Skagway system would be fine.
10. YCS is opposed to mini-nukes – technology is unproven, the Yukon will not be a testing ground.

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11. Mines – those connected to the grid should fund renewable sources elsewhere on the grid to offset their electrical demand.

    a. Offgrid mines should also be 100% renewable…size the mine to the energy they can generate.

    b. Placer mining should be included in this requirement.

12. Biomass – good but should be limited by sustainable yields in appropriate areas (will only provide about 10% of Yukon renewable).

13. Geothermal – has potential, particularly for heat pumps.

14. DSM (demand-side management) is an essential component.

15. Increase incentives, decrease disincentives for renewables energy sources.

Yukon Conservation Society

Thoughts on Remote Community Energy Futures

We have been asked by the Yukon Renewable Energy Expert Panel to comment on the potential energy options for remote communities in the Yukon. YCS has a 20-year history of researching and advocating for the final goal of a fossil-fuel free energy system in the Yukon but most of this consideration has been focussed on the Yukon electrical grid and, in particular, the Whitehorse area.

To suggest a pathway to renewables for the future energy system for remote communities we make the following assumptions.

1. There are no large industrial loads. Mines are dealt with separately.
2. Barring significant changes in infrastructure, technology and cost, ICE vehicles will continue to provide most or all of the transportation needs.
3. Given 2., the largest energy demand is for space heating.
4. Electrical supply needs will remain modest but essential.
5. Affordability will continue to be a key consideration.
6. This concerns off-grid communities.

Acknowledging that many of these communities have a majority of First Nations residents who should be part of deciding the pathway, we suggest that the following components make up the future low carbon energy system in remote communities.

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1. **Space Heating** – given the proximity and low cost of biomass energy sources, wood-based heating will continue to make sense as a renewable energy source. However, the increased use of low particulate producing systems should be encouraged. If a reliable local supply of wood pellets is developed, pellet stoves can offer both low particulate emissions and lower maintenance than conventional wood stoves.
   In situations where wind power has been introduced to complement diesel, there may be potential for the use of ETS units.
   Related to the requirements for space heating, improvements in the thermal efficiency of existing buildings should be part of building for the future.

2. **Lighting and Appliances** – given the constraint of affordability and lack of capital, diesel powered generation will remain a mainstay. However, the introduction of small-scale wind and solar with related storage to reduce the use of diesel fuel will be key to reducing GHG emissions and should be encouraged.

3. **Transportation** – in many of these communities, transportation includes both on and off-road vehicles all of which use diesel or gasoline. It is unlikely that these vehicles will transition to electricity or other renewable resource within the next 20 years.

30 November 2019

Members of the Renewable Electricity Panel
of Yukon Government and Yukon Energy Corp.

By email: renewableelectricitypanel@gmail.com

Dear Panel Members:

Please accept this letter as input as you prepare your advice on options for providing renewable electricity within Yukon's future system of energy supply. We will also make a submission to the public review process for the Yukon Government's "Our Clean Future" document that includes strategic direction for energy supplies in the light of climate change. However, there are a few points we would concurrently like to emphasize in this letter, given the role of the Panel in advising the Government and Yukon Energy Corporation.

WCS Wildlife Conservation Society Canada is a non-profit, charitable organization working at a national scale in Canada. Our mission is to save wildlife and wild places through science, conservation action, and inspiring people to value nature. WCS Canada scientists have been working in Yukon since 2004 on land use and protected areas planning, land and water management, and wildlife conservation research and policy applications. Our role is to provide long-term site-based research and syntheses of science that inform policy and practice and support the implementation of effective conservation measures by providing technical advice and by engaging relevant decision-makers at all levels, from local to federal. We are interested in renewable energy because the capture of energy from any source will result in some environmental effects including impacts on fish and wildlife and their habitats, and because dealing with the climate crisis is particularly required to stem loss of biodiversity. An understanding of these effects and impacts has to be brought into decision-making.

Hydroelectricity

Electricity generated from hydro-power will continue to be an important, and hopefully growing, part of Yukon's energy supply. There are crucial questions of scale when thinking about this source.

There is accumulating evidence pointing to the conclusion that large-scale hydroelectric dams, with generating facilities, are not a suitable way forward from an environmental point of view. Such an approach was proposed in Yukon as recently as 2015 with the Next Generation Hydro initiative. At that time we published a synopsis of the impacts and risks to fish and aquatic

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ecosystems of a large dam on a major Yukon river: "Potential Impacts and Risks of Proposed Next Generation Hydroelectric Dams on Fish and Fish Habitat in Yukon Waters"[1]. The blockage of fish movements, creation of large new bodies of water as reservoirs, and disruption to the seasonal patterns of water flow in a river, all produce major negative impacts on aquatic ecosystems and fish populations, many of which cannot be mitigated, with few to no ancillary ecological benefits. We strongly recommend that large-scale hydroelectric development not be considered again in the potential portfolio of renewable electricity sources.

Small-scale hydroelectric power developments can play a substantial role in providing new sources of electricity. Fairly local examples such as the generating facilities associated with Surprise Lake and Pine Creek near Atlin, British Columbia, and with Dewey Lakes near Skagway, Alaska, are good examples. Yes, the ecological character of subalpine and alpine lakes and their outflow streams in headwater circumstances (often first or second order streams) will be impacted by such developments. However, for any one development, the spatial scale of ecosystems affected, the diversity of species impacted, and the intensity of the negative impacts are all likely to be far less than those resulting from a large dam on a major river.

At the same time, care will need to be taken in assessing cumulative impacts of such developments when more than one is planned for a specific drainage. Once again, this is an issue of scale of the overall impacts, a topic which cannot be considered in customary piecemeal decision-making, one project at a time. We can expect impacts, but how these accumulate, and result in indirect effects, will need to be made clear and judged accordingly, as proactively as possible.

You, the Panel members, are already well aware of some of the opportunities in Yukon for such small-scale hydroelectric development. We recommend further exploration, careful watershed-based planning, and hopefully development of some of these options for small-scale hydroelectric development, as relatively "clean" or "green" sources of electricity in the mix of renewables.

Biomass

We focus the remainder of our comments on biomass energy because, in our analysis, it is incorrectly lumped with other renewables in the "low carbon" set of energy sources publicized in Yukon Government's draft strategic plan for climate change and energy: "Our Clean Future"[2]. In our analysis, biomass energy does not, in many cases, qualify as low carbon, as we discuss below.

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[1] von Finster, Al and Donald Reid, 2015. Potential Impacts and Risks of Proposed Next Generation Hydroelectric Dams on Fish and Fish Habitat in Yukon Waters. Wildlife Conservation Society Canada Conservation Report No. 8. Toronto, Ontario, Canada. Available at: https://www.wcscanada.org/Publications/Conservation-Reports.aspx

[2] Yukon Government 2019. Our Clean Future: A Yukon strategy for climate change, energy and a green economy. Draft for public review. Available at: https://yukon.ca/en/draft-our-clean-future

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This issue may not seem relevant to the Panel's work, because, in Yukon, biomass (wood residue, wood waste, and whole logs) is primarily used for space heating, not electricity generation. However, it is relevant, first because biomass could conceivably be used to generate electricity in some circumstances. We recommend that biomass not be used for electricity generation. Second, biomass is being promoted to replace use of fossil fuels in space heating and thereby lessen demand for electricity for the same purpose. Yes, burning biomass can lessen the short-term pressure to develop new electricity supplies. However, we recommend that biomass not be encouraged to take up a greater share of the space heating needs than it currently holds, but, instead, that new supplies of electricity that are more aptly termed "low carbon" be sought and implemented with greater haste.

The carbon cycle context. The scientific consensus is that overheating of the atmosphere is caused by large increases in greenhouse gases, especially carbon dioxide. Before the industrial revolution and the exponential growth of human population in the last four centuries, carbon dioxide concentrations in the atmosphere were mostly between 180 and 280 parts per million throughout the ice ages of the Pleistocene and Holocene. They are now around 410 ppm and have been increasing fast in parallel with our massive burning of fossil fuels. It is clear that absorption of carbon dioxide in the planet's oceans and lakes, and into plants, is not keeping up with what we send into the air from the various fuels we burn, the huge numbers of animals we raise, and our continued removal of native vegetation. This imbalance is the heart of the climate crisis, and leads to two principal policy imperatives: (i) reduce and stop the net emissions of carbon dioxide to the atmosphere and (ii) find ways to remove carbon from the atmosphere more quickly.

What is the carbon budget of burning biomass for energy? Biomass energy is created by burning organic materials that have quite recently been alive. These can range from annual crops, to the annual growth increment of perennial crops, to the standing crop of long-lived plants such as canopy trees. All of these contribute substantial carbon dioxide to the atmosphere by burning alone, let alone through other emissions as a result of the harvesting, transportation, and processing of the biomass. So all forms of biomass are immediately suspect as "low carbon" fuel sources.

The effect of this burning on the carbon budget depends on the time and spatial scales of accounting; that is, a full life-cycle analysis. When all of the carbon dioxide released from burning can be absorbed by new growth of plants *at the same sites in the same annual cycle*[3], there is not net contribution to the atmospheric carbon pool from the burning (i.e., the energy source is carbon neutral). This can be achieved only when one year's worth of growth is burnt in the annual cycle (i.e., carbon payback time of one year). In this case, the benefits of the biomass are evaluated based on the carbon emissions incurred during its harvest, transport and

[3] An annual accounting period should be applied to biomass as this is the accounting period applied to all other forms of human activity that create carbon emissions, such as burning of fossil fuels and raising livestock. New growth of plants "at the same sites" is required because carbon absorption at all other sites is already maximized given that the atmospheric carbon pool keeps increasing.

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processing relative to emissions from alternative fuel sources. This is not achieved, however, when the biomass fuel stock has many years and often decades of carbon accumulation through growth. Such is the case with burning whole trees (whether green or already dead), or wood residue and slash, as we do in Yukon. New plant growth, on sites where the fuel trees previously grew, cannot absorb all of the many years and often decades of tree growth in one annual cycle. The net effect is a large net contribution of carbon dioxide to the atmosphere annually, creating a "carbon debt" that has to be recovered in the future[4], with carbon payback time of many years and even many decades[5]. This is in direct contradiction to the major policy imperative to reduce such contributions year by year.

Policy direction towards biomass globally and in Yukon. Jurisdictions as large as the European Union and the USA have promoted biomass energy as carbon neutral[6]. Policy initiatives here in Yukon such as the Biomass Energy Strategy (2016) and the draft Whitehorse and Southern Lakes Forest Resources Management Plan (2019) have also made this assertion. The most recent Yukon Government action plan to deal with energy in the context of climate change – "Our Clean Future"[7] – has dropped the word "neutral" and now labels biomass as "low carbon", lumped in a category with solar, wind, hydro, and geothermal.

The notion that burning biomass for energy is carbon neutral is increasingly challenged by scientists and policy makers[8]. The Scientific Advisory Board to the U.S. Environmental Protection Agency stated in March 2019 that emissions created by burning recently living wood stocks cannot be assumed to be carbon neutral[9]. The Science Advisory Council of the European Academies warned the European Commission in 2017 and 2018[10] that burning wood harvested from forests cannot be considered carbon neutral for the purposes of meeting carbon emissions targets, and that classifying biomass energy as carbon neutral was actually inducing major increases in conversion of the carbon in mature forests to carbon dioxide in the atmosphere at a time when exactly the reverse is required.

Although biomass energy is not promoted as carbon neutral in Yukon Government's latest policy document (*Our Clean Future*), the fact that it is labelled as "low carbon", in the same category as wind, solar, and hydro, implicitly assumes this to be the case. The kinds of feed stocks (waste wood, live and dead trees) we have in Yukon to fuel biomass installations, and individual homes, require years if not decades to grow back. The carbon debt happens in the current year; the carbon payback is many years and often decades into the future, varying with factors such as

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[4] Fargione et al. 2008. Science 319:1235-1238.
[5] Birdsey et al. 2018 Environmental Research Letters 13. https://doi.org/10.1088/1748-9326/aab9d5
[6] For example: https://www.scientificamerican.com/article/congress-says-biomass-is-carbon-neutral-but-scientists-disagree/
[7] Yukon Government 2019. op.cit.
[8] Booth. 2018. Environmental Research Letters 13. https://doi.org/10.1088/1748-9326/aaac88 and https://www.euractiv.com/section/energy/opinion/need-for-a-scientific-basis-of-eu-climate-policy-on-forests/
[9] https://yosemite.epa.gov/sab/sabproduct.nsf/0/B86C81BACFAF9735852583B4005B3318/$File/EPA-SAB-19-002+.pdf
[10] EASAC 2017. Multi-functionality and sustainability in the European Union's forests. https://easac.eu/fileadmin/PDF_s/reports_statements/Forests/EASAC_Forests_web_complete.pdf and in 2018 https://easac.eu/fileadmin/user_upload/180108_Letter_to_President_Juncker.pdf

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decay rates of dead wood left on site[11]. By analogy, when one accrues debt year after year it will take longer and longer into the future to pay it off. Balancing the account (i.e. stabilizing atmospheric concentrations of carbon dioxide by getting rid of sources of emissions) is exactly what we have to do as a first step in dealing with the carbon crisis. Burning biomass in Yukon goes directly against that need to balance the account by getting rid of major sources of emissions.

Consequently, we recommend that the policy direction put forward by Yukon Government of investing in new biomass energy infrastructure[12] be dropped from the government's priorities, and that the equivalent financial and other resources be directed towards development of energy from renewables that are more aptly described as "low carbon", such as wind, geothermal, hydro, and solar.

Burning biomass for energy can also create considerable additional environmental impacts. These make it suspect as a "clean" or environmentally-friendly source of fuel. Depending on the wood type and combustion process, it can produce higher carbon emissions per unit energy obtained than some fossil fuels[13]. Burning wood, especially as cord wood, generally produces other emissions, such as particulates and volatile organic compounds, which are already creating negative health impacts in Whitehorse[14]. Salvaging of fire- or beetle-killed wood can have negative impacts on biodiversity[15], and an industrial-scale application of salvage logging for dead wood in Yukon would make these risks higher.

Burning wood for space heating is well established in Yukon, and will continue to contribute to our energy supply and annual emissions. These emissions from biomass need to be in the Yukon Government's reporting of annual emissions; they cannot be ignored as being "low carbon" or "carbon neutral". However, biomass is best viewed as a "bridging" form of energy supply, to be phased out as we progress to truly cleaner sources of energy[16]. To hasten this phase out, incentives are needed to make cleaner electricity a more favourable source of heat than burning wood, so that carbon emissions from burning wood can gradually be eliminated.

Thank you for the opportunity to provide input to your Panel.

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[11] Mansuy, N. et al. 2018. Salvage harvesting for bioenergy in Canada: From sustainable and integrated supply chain to climate change mitigation. WIREs Energy Environ. 2018;7:e298. https://doi.org/10.1002/wene.298

[12] Yukon Government 2019. op.cit. and Renewable Energy and Energy Efficiency Update (2016-2018) http://www.energy.gov.yk.ca/pdf/emr-energy-strategy-update-2016-2018.pdf

[13] Mäkipää, R. et al. 2015. Canadian Journal of Forest Research **45**: 217–225 dx.doi.org/10.1139/cjfr-2014-0120

[14] Yukon Initiative for Healthy Air. http://www.yukoncmoh.ca/files/YIHA-CMOH-Recommendations_2019.pdf and Yukon Government 2019. Actions 50 and 103. op.cit.

[15] Cooke, H. et al. 2019. Fire and Insects: Managing naturally disturbed forests to conserve ecological values. Conservation Series Report No. 12, Wildlife Conservation Society Canada, Toronto, ON.

[16] Project Drawdown. https://www.drawdown.org/solutions/electricity-generation/biomass

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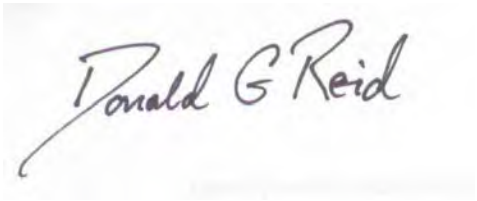
Yours sincerely,



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APPENDIX E. Supporting Technical Information

Topic 1. "Fallacy" of Clean Electric Heat

Table 3.4-1 from Yukon Energy's 2017-2018 General Rate Application (included on the following page) illustrates how the proportion of thermal generation increases with increasing electrical load with long-term average hydro generation available. This table reflects the nature and composition of the load as it existed when it was prepared. The connection of the Victoria Gold mine to the grid would change the calculations if the table were to be updated today; nonetheless, it serves to illustrate some important points.

Heating a home or other building directly with a fossil fuel usually has a seasonal efficiency of about 80% (i.e., 80% of the energy contained in the fuel is converted to useful heat). Electric power generation with a fossil fuel in new equipment is around 40% efficient, but transmission and distribution losses of about 15% will reduce that efficiency to about 34% at the point of use. In other words, heating a building with fossil fuel generated electricity consumes about 2.35 times as much fuel (80/34). Another way to look at this is that when about 42.5% of the electricity used for electric heat is derived from fossil fuels the fuel usage, and associated GHG emissions, are the same as direct fossil fuel heating.

Considering Table 3.4-1 along with the calculations above, we can derive some important conclusions:

1. At a YEC grid load of between 450 and 455 GWh/yr. the YEC renewable energy target of 93% is achieved (lines 17 & 18 in the table). In this load increment 63% of the marginal load is served with thermal (fossil fuel) generation.
2. If the desire is to meet the 42.5% fuel usage break-even point between fossil fuel heating and electric heating then the renewable energy portion of the grid load would need to be about 96.62% (line 11 in the table).
3. These figures show how desperately short of winter renewable energy the grid is.
4. These figures support the use of biomass as a heating solution, particularly in larger buildings where it is easier to do.
5. These figures also support the case for air source heat pumps and other approaches such as ETS and measures to reduce diurnal variations in electrical loads.
6. If solar PV dominates the IPP SOP program the winter shortage of renewable energy will be exacerbated unless a pumped seasonal storage hydro project is installed.

Table 3.4-1: Expected YEC Thermal Generation with LTA YEC Hydro Generation

Line Number	YEC Grid Load Net of Wind (GWh)	YEC Hydro Generation (GWh)	YEC Thermal Generation (GWh)	Increase in Load (GWh)	Increase in Thermal Generation (GWh)	Thermal as % of Increased Load
	Column A	Column B	Column C	Column D	Column E	Column F = E/D
1	370.0	369.337	0.663			
2	375.0	373.626	1.374	5.0	0.710	14%
3	380.0	377.800	2.200	5.0	0.826	17%
4	385.0	381.845	3.155	5.0	0.955	19%
5	390.0	385.750	4.250	5.0	1.096	22%
6	395.0	389.503	5.497	5.0	1.246	25%
7	400.0	393.098	6.902	5.0	1.405	28%
8	405.0	396.528	8.472	5.0	1.570	31%
9	410.0	399.789	10.211	5.0	1.739	35%
10	415.0	402.877	12.123	5.0	1.911	38%
11	420.0	405.793	14.207	5.0	2.084	42%
12	425.0	408.537	16.463	5.0	2.256	45%
13	430.0	411.111	18.889	5.0	2.426	49%
14	435.0	413.521	21.479	5.0	2.590	52%
15	440.0	415.772	24.228	5.0	2.748	55%
16	445.0	417.874	27.126	5.0	2.898	58%
17	450.0	419.836	30.164	5.0	3.038	61%
18	455.0	421.669	33.331	5.0	3.167	63%
19	460.0	423.388	36.612	5.0	3.281	66%
20	465.0	425.007	39.993	5.0	3.380	68%
21	470.0	426.545	43.455	5.0	3.462	69%
22	475.0	428.019	46.981	5.0	3.525	71%
23	480.0	429.452	50.548	5.0	3.567	71%
24	485.0	430.865	54.135	5.0	3.587	72%

Topic 2. Biomass Potential

Description	Annual Biomass	Annual Fuel Oil Displaced	Annual Economic Savings
Current biomass home heating	13,000 cord ($3.25 million)	4.17 million litres ($5.5 million)	$2.25 million
Current biomass home heating + 50% conversion of oil heated homes	39,000 cord ($9.75 million)	12.5 million litres ($16.5 million)	$6.75 million
Current biomass home heating + 100% conversion of oil heat homes	65,000 cord ($16.25 million)	20.85 million litres ($27.5 million)	$11.25 million
25% fire-killed and beetled-killed biomass (likely all Commercial & Industrial properties)	650,000 cord ($162.5 million)	208.5 million litres ($275.2 million)	$112.7 million
100% fire-killed and beetled-killed biomass (Max. potential)	2600,000 cord ($ 650 million)	834 million litres ($ 1,100 million)	$ 450.0 million

The annual fuel oil displaced by biomass is estimated below:

- Weight of seasoned 85% dry spruce or pine at about 1,000 kg/cord
- Net calorific value of seasoned (85% dry) Biomass at 17 MJ/kg or 17,000 MJ/tonne;
- Calorific value of Fuel oil at 48 MJ/kg (or 48,000 MJ/tonne or 53,000 MJ per 1,000 litres)
- Retail cost of fuel oil delivered estimated at $1.32 per litre (average)