ELECTRIFICATION DECARBONIZTION AND THE QUEST FOR NET ZERO IN CANADA 2050

ELECTRIFICATION, DECARBONIZATION AND THE QUEST FOR NET ZERO IN CANADA 2050

FOREWARD:

Firstly is the admission that this is or can be an overly complex topic with numerous moving parts and variables. To be naïve enough to think that any one paper or person could write the definitive paper on this subject is probably wildly delusional.

Further disclosure, I am not a scientist, engineer or trained researcher so this will not be an academic paper rather it is an attempt to look at this subject from a lay person's perspective and to try and make sense of why this subject matter is so important, what needs to be done, where we are currently, and what it will take to achieve stated goals. In preparation for this paper I have used the resources noted in the addendum. Additionally, numerous journals, articles and of course, the internet were used. Throughout the paper sources will be noted where appropriate.

It is not the purpose of this paper to delve into the state of Federal-Provincial relationships or the constitutionality of the impact of some of the strategies required to achieve desired outcomes. However, it does need to be stated at the outset that there is an urgent need for national leadership and a national strategy as this paper will show. This does not diminish, in any way, the need for federal, provincial and municipal plans to be developed and implemented but these should be seen as complementary and supportive to a national strategy.

EXECUTIVE SUMMARY

Based on the information reviewed for this paper I feel that the conclusions to be drawn from this paper and the research involved come down to these 9 critical points:

1. Climate change is real and we are in for the fight of our lives if we, the inhabitants of planet earth, want to save it. If we lose this battle nothing else matters!
2. There is a pathway, actually multiple pathways and they all must be used to achieve Net Zero by 2050.
3. There is general agreement on what is needed, when it is needed (NOW!) and how to get there.
4. Canada has competitive advantages that will create new opportunities in pursuit of net zero and it is the responsibility of all of us especially our political leaders to ensure we do not squander these advantages.
5. Canada is not yet on track to meet even the interim 2030 goals.
6. Sacrifices will have to be made in the near term for many peoples around the globe and perhaps for the longer term but it is nothing compared to what we will have to do if we don't start making the necessary changes today.
7. It will cost a lot of money. As the World Bank forecasted, some $90T that is $90,000,000,000 will have to be spent globally by 2030 to just meet interim goals. And while this is certainly not chump change it too will pale in comparison by what it will cost if we don't achieve these goals.
   (For more read Nicholas Stern 2006 review of the economics of climate change)
8. It will take political guts, clarity, focus and a willingness to drive necessary change.
9. Yes it is a gamble with no absolute guarantees of success but not to do so will result in a 100% guarantee of uncountable turmoil and tragedy.

DEFINITIONS

Since words like electrification, decarbonization and net zero will be used liberally throughout this document it seems logical that a basic understanding of what these words mean is a good place to start. As well other words are used in this paper that are defined for clarity purposes.

Carbon capture, utilization and storage (CCUS) is the process of capturing CO2 emissions from fuel combustion, industrial processes or directly from the atmosphere, these emissions can then be stores usually in underground geological formations, onshore or offshore or used as input or feedstock to create products.

Direct Air Capture (DAC) is a process that uses industrial sized fans to direct air through a chemical process that then strips away carbon which is then stored or sold.

Decarbonization: literally means the reduction of carbon emissions but perhaps more precisely it is the conversion to an economic system that sustainably reduces and compensates the emissions of carbon dioxide with the long term goal to create a carbon (CO2) free global economy.

Electrification: simply means to charge with or supply with electricity rather than fossil fuels.

EVs_ electric powered vehicles or BEV, battery electric or PHEV, plug in hybrid vehicles

Geothermal: heat derived from the subsurface of the earth.

GHG: green house gas or gasses

ICE: internal combustion engine

Off-grid systems: stand alone systems for individual households or groups of consumers.

Net Zero: means achieving a balance between the carbon emitted into the atmosphere and the carbon removed from it. The ultimate goal being, to no longer add heat trapping greenhouse gases (GHG) into the atmosphere.

Petajoule: equals 277,778 Mwh

Renewables: includes bioenergy, geothermal, hydropower, solar, wind, and marine (tide and wave) for electricity and heat generating purposes.

Terrawatt (Twh): 1,000,000,000 megawatts or 3.6 petajoules.

WHY IS THIS IMPORTANT?

Simply stated, it is the only way to stop climate change. Unfortunately, for many, climate change is an abstract threat that does not readily appear to impact our everyday lives. Of course we may complain about some sort of weather phenomenon or about unusual temperatures or the high price of fuel but then we go about our normal lives as they still look and feel unchanged. Since carbon pollution is an invisible foe, many people including political leaders of all types, we don't think it is real but make no mistake, this is a fight for our collective future and for the world as we now know it.

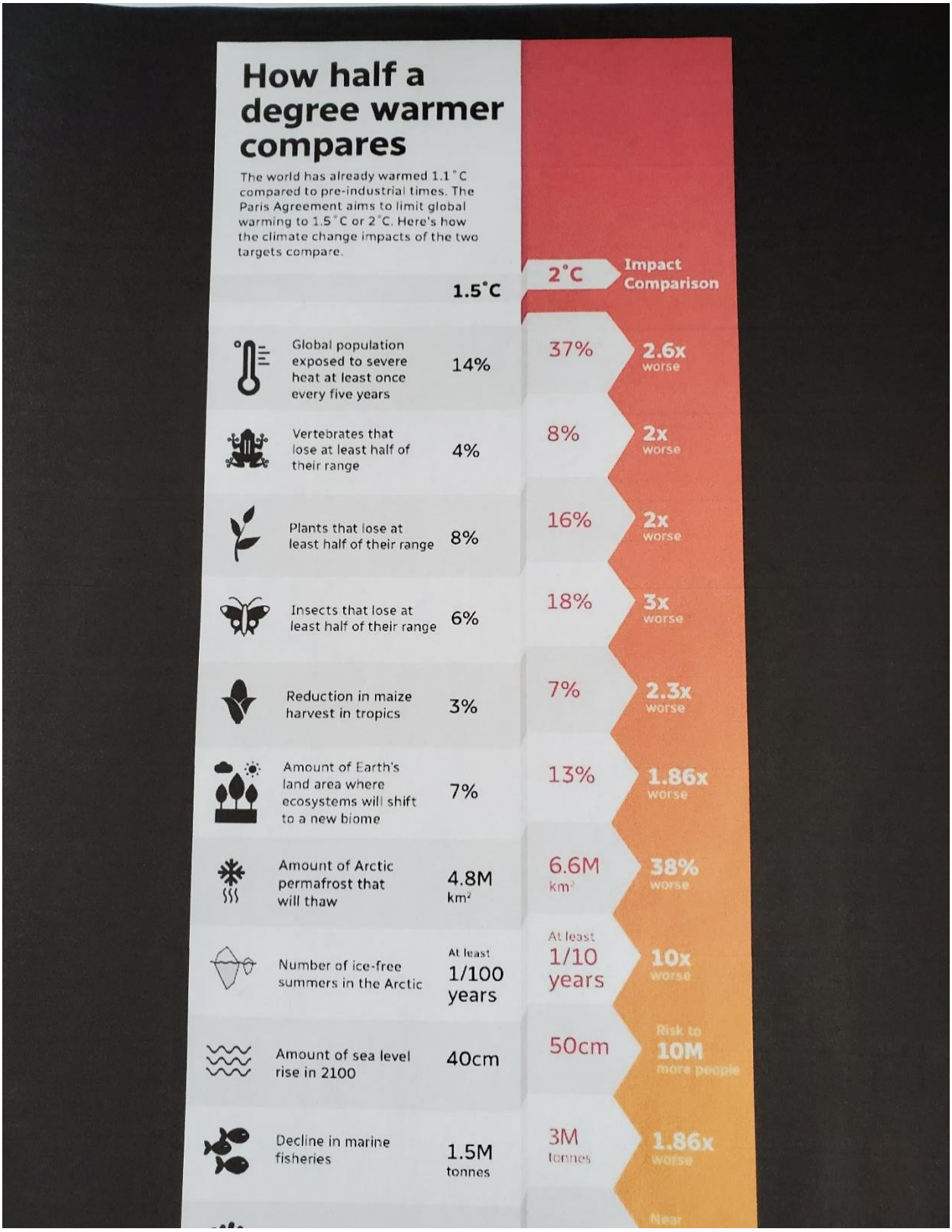
This paper will not delve into detailed arguments for or against climate change so let's just agree that the science is clear and overwhelming, climate change is an emergency!

The only way to stop climate change is to stop greenhouse gases from being added to the atmosphere. If this is not done than average global temperatures will continue to rise and the results will be catastrophic. For example:

- Massive disruptions to food systems, both on land and sea, with related losses of biodiversity, species and ecosystems, the breakdown of whole food chains and mass die-offs of coral reefs with resulting threats of starvation for some, food shortages and huge run ups in food prices for others;
- More extreme heat events with deadly consequences for the most vulnerable among us at home and abroad;
- Many more major weather events, form forest fires to floods and hurricanes and droughts resulting in billions of dollars in damage to property as well as massive disruptions to agriculture, devastating environmental impacts and countless lives lost;
- Greater and faster sea level rise threatening coastal communities globally flooding major cities forcing billions of dollars to be spent on defensive infrastructure and in some cases, the loss of entire island nations;
- Lost water sources with incalculable impacts on food supply and human health potentially resulting in new geopolitical tensions and wars;
- Spikes in illness carried by insects that thrive with global warming;
- Mass human climate displacement and migration with again, incalculable impact on our global societies.

So why 2050 and 1.5C? This is in response to climate science showing that in order to halt climate change, carbon emissions have to stop, not just reduced. If the question is why CO2, that is because CO2 is the only greenhouse gas that can be easily absorbed from the atmosphere. The Intergovernmental Panel on Climate Change (IPCC) modelled different scenarios and all the simplest paths to 1.5C required the world to cut emissions to 45% below 2010 levels by 2030 and reach net zero by 2050. And this is what was agreed to at the Paris Agreement and subsequently in Scotland in 2021.

The chart below provides a clear picture of what the impact of a 1.5C and 2C rise in temperature means”



The only logical conclusion that can be made here is that climate change is real and we are in for the fight of our lives. If we don't rise to the challenge than the human, ecological and economic will be devastating. Public intellectual and MIT professor, Noam Chomsky has recently been telling his classes that they have a choice to make that no one in human history has ever had to make.. "They have to decide whether organized human society is going to survive!"

According to Seth Klein in his book, A Good War, effectively tackling climate change is not a technical or policy problem. His feeling is that we know what is needed to transition to a zero carbon society, and the technology required is largely ready to go. Rather the challenge we face is a political one. Climate solutions persistently encounter political brick walls with the prevailing assumptions within political parties being that if political leaders actually acted on what the climate scientists say is necessary than that would be political suicide and so the necessary actions needed are not taken.

As to whether we can successfully align our politics with climate science remains to be seen. Nevertheless there is a way forward as this paper will show.

WHAT WILL IT TAKE

The good news is that there is a general consensus by climate scientists and other experts who have identified what will be required to get to the net zero goal by 2050. In fact the best case scenario is that 70% of today's global greenhouse gas emissions can be addressed by clean electrification. But according to a report prepared by IBM in May 2021, entitled "Sustainably Fueling the Future, which states " enabling clean electrification at scale for consumers will require leaders and businesses to come together in new ways to rethink how electrical systems operate. As more parts of our global economy rely on electricity to run, electricity ecosystems will become more complex and diversified. The number and scale of non-utility owned and operated resources to the grid will need to increase exponentially."

In its simplest form the quest to achieve Net Zero by 2050 requires 4 main strategies:

1. Generate electricity without emissions: using sources such as wind, solar, nuclear, and water power.
2. Use vehicles and equipment that are powered by electricity (and/or hydrogen) instead of fossil fuels: many of the biggest sources of GHG can be replaced with equipment powered by electricity in particular.
3. Use energy more efficiently: more efficient technologies and processes that reduce energy can also reduce emissions significantly as well as improves efficiency. Also, smart technologies, which sense when energy is needed and when it is not, can help to optimize how electricity is generated and used, helping to minimize waste.
4. Remove carbon dioxide from the atmosphere: to offset emissions that are too costly or difficult to avoid.

Existing technologies can support all of these strategies but they will need to be implemented rapidly and on a very large scale. This will require new policies and investments (World Bank calculates that some $90T will need to be spent by 2030 globally to meet interim goals) as well as careful attention to the social and economic trade offs that will be necessary. (National Academies of Science, Engineering and Medicine).

According to IBM, in their May 2021 report, Sustainably Fueling the Future, the key to moving forward with these strategies is in digital transformation. " Digital solutions that apply AI, IoT and block chain will support new energy marketplaces while enabling more resilient physical infrastructure, more efficient and reliable utility generation and better customer service.

For example, utility asset management solutions can help keep critical assets running at optimal efficiency, improve equipment operations, provide a complete view of asset health, mitigate the cost of vegetation management, enhance outage predication, and optimize asset inventory. Advanced Metering Infrastructure (AMI) solutions can help utilities adopt to changing customer demand, including wide spread distributed energy and increased adoption of EVs.

The next generation of utility networks competing over 5G networks will enable streaming analytics to digest and process usage data and millions of messages to assess grid conditions in real time. Hydro One uses such data to help them predict the impact of future storms and to proactively prepare for incoming weather events by mobilizing personnel and equipment in advance thereby reducing the time to restore power outage by as much as 50%. The City of Copenhagen uses this technology to help them achieve their goal of becoming the first carbon-neutral capital by 2025. They developed the "Utility Flexibility Platform which dynamically adjusts heat and power consumption especially for high end users, commercial buildings, shopping malls, etc. By leveraging this technology, Copenhagen avoids relying on their fossil fuel reserve power plants and thereby reduces or eliminates GHG emissions.

The International Energy Agency (iea.org) has written a 224 page report entitles "Net Zero by 2050 – A Roadmap for the Global Energy Sector. This paper outlines very clearly what it will take to achieve net zero by 2050 and pulls no punches with their opinions. A great deal of the paper focuses on global issues as can be expected from the title but there are critical generic themes that apply universally.

According to their report "The energy sector is the source of around 75% of GHG emissions today and holds the key to averting the worst effects of climate change, perhaps the greatest challenge humankind has faced. Reducing global CO2 emissions to net zero by 2050 is consistent with the efforts to limit the long term increase in average global temperatures to 1.5C. This calls for nothing less than a complete transformation of how we produce, transport and consume energy.

The growing political consensus on reaching net zero is cause for some optimism but the reality is that the changes truly required to reach net zero globally are poorly understood. A massive amount of work is needed to turn today's ambitions into reality. Furthermore, the commitments made to date fall short of what is required to achieve net zero. While the number of countries that have pledged to achieve net zero covers nearly 70% of the globe and at the COP26 climate change conference nearly 500 global financial firms agreed to align some $130T (about

40% of the world's financial assets) with the Paris Agreement goal of limiting global warming to 1.5C, the reality is still that most of these pledges are not yet supported by any meaningful policies, measure or actions. The reality is even if the pledges committed to so far are successfully fulfilled it would still leave 22B tonnes of CO2 emissions worldwide and that trend would be akin to raising temperature around the world by 2.1C.

The IEA forecasts the world economy will be some 40% larger in 2030 than it is today but will use 7% less energy. It is therefore essential, in their opinion, that a worldwide push to increase energy efficiency is absolutely necessary. IEA believes that energy intensity improvements need to average 4% annually between now and 2030 and that is about 3X the average achieved over the last two decades.

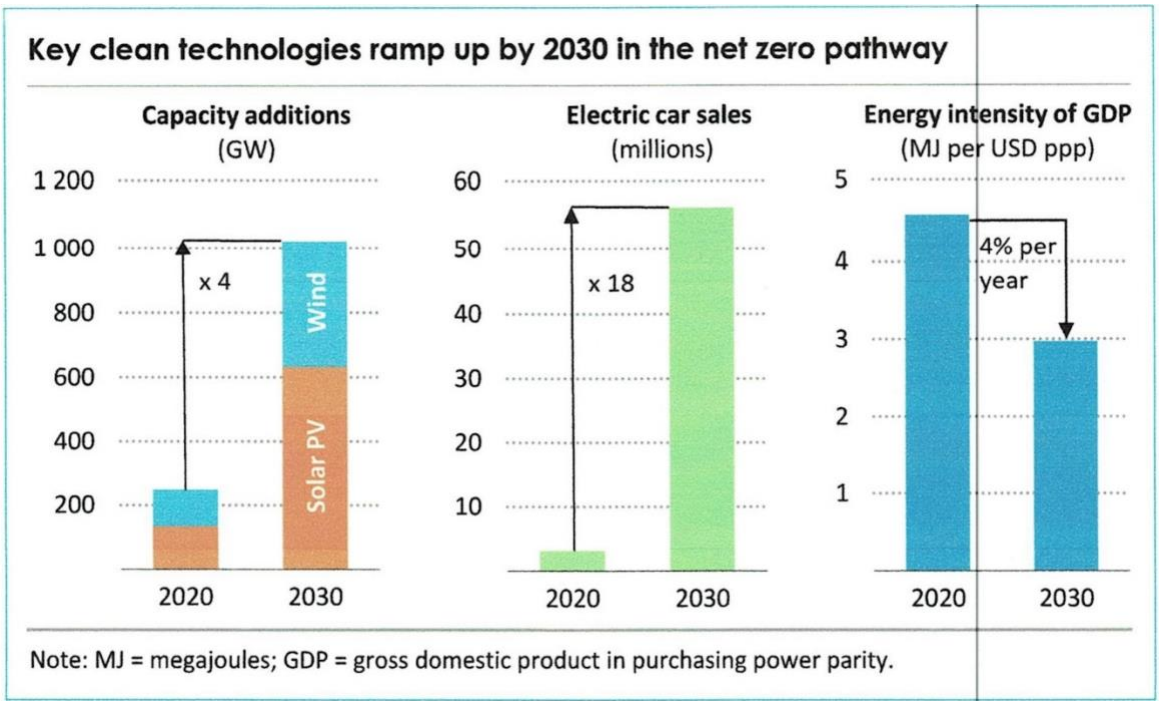
Targets IEA feel are required if we are to limit global warming to 1.5C:

- Reduce methane emissions from fossil fuels by 75% over the next 10 years;
- Scale up solar and wind generated power by 630 GW annually of solar photovoltaics and 390GW of wind (this is 4X the level achieved in 2020 and is equivalent to installing the world's largest solar plant roughly every day!)
- EVs to go from 5% (1 million vehicles) of global car sales to 60% (40 million) by 2030;
- Battery production for EVs to grow from 160GWh today to 6,600 GWh by 2030 (equivalent of adding almost 20 gigafactories each year for the next 10 years);
- End sales of ICE vehicles by 2035;
- Close coal plants by 2040 unless retrofitted with no new coal plants to be commissioned;
- No new oil/gas fields;
- Decrease fossil fuel use from its current 80% to 20% by 2050;
- Ban fossil fuels boilers in buildings starting by 2025;
- Investment in CO2 pipelines and hydrogen enabling infrastructure to increase from $1B today to $40B in 2030;
- Total annual energy investment to grow to $5T by 2030, triple the forecast needed by 2030;
- Market size of critical materials like copper, manganese, lithium, etc forecasted to grow 7X between 2020 and 2030;
- Taxes on diesel, gasoline and other fossil fuels consumption, including items such as road and highway taxes are expected to fall by 40% between 2020 and 2030;
- By 2050 almost 50% of reductions in emissions are expected to come from technologies that are now in demonstration or prototype phase while by 2030 most CO2 reductions will come from technologies readily available today. The biggest opportunities fore
- The biggest opportunities for innovation are likely to come from advancements in battery technology, hydrogen electrolysis and direct air capture and storage.

IEA concludes their report with 7 critical priorities, 5 of which are noted here:

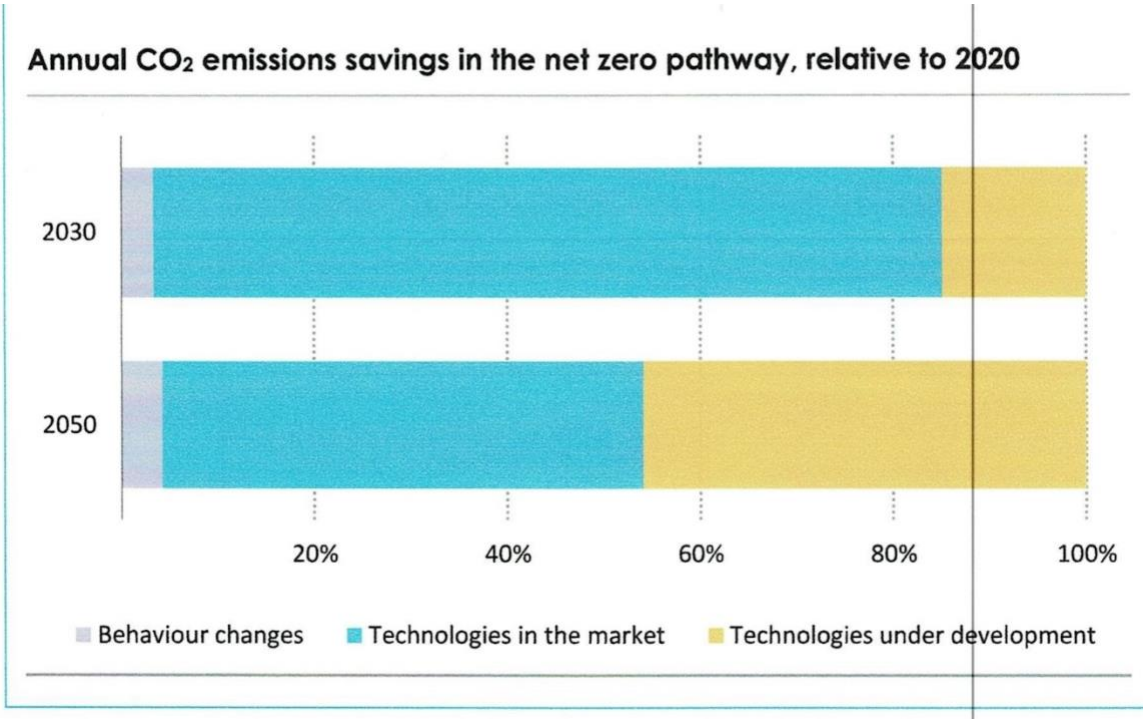
Priority 1

Make the 2020s the decade of massive clean energy expansion. All the technologies needed to achieve the necessary deep cuts in global emissions by 2030 already exist and the policies that can drive their deployment are already proven. Policies should and need to be strengthened to speed the development of clean and efficient energy technologies. Mandates and standards are vital to drive consumer spending and industry investment into the most efficient technologies. Targets and competitive auctions can enable wind and solar to accelerate the electricity sector transition. Fossil fuel subsidy phase-outs, carbon pricing and other market reforms can ensure appropriate price signals. Policies should be used to limit or provide disincentives for the use of certain fuels and technologies such as coal fired power stations, gas boilers and conventional internal combustion engines. Perhaps most importantly governments must lead the planning and incentivizing of the massive investment that will be required for smart transmission and distribution grids.



Priority 2

Prepare for the next phase of the transition by boosting innovation. Clean energy innovation must accelerate rapidly with governments putting R&D, demonstration and deployment at the core of energy and climate policy. Critical areas such as such as electrification, hydrogen, bioenergy and carbon capture, utilization and storage need a massive boost in investment to achieve the interim goals set for 2030. Support is also needed to accelerate the roll out of demonstration projects to leverage private investment in R&D. Around $90B of public money is required globally as soon as possible to complete a portfolio of demonstration projects before 2030. As of the date of this report only $25B is budgeted for this period. The chart below shows what the IEA believes is required in investment for the net zero pathway.

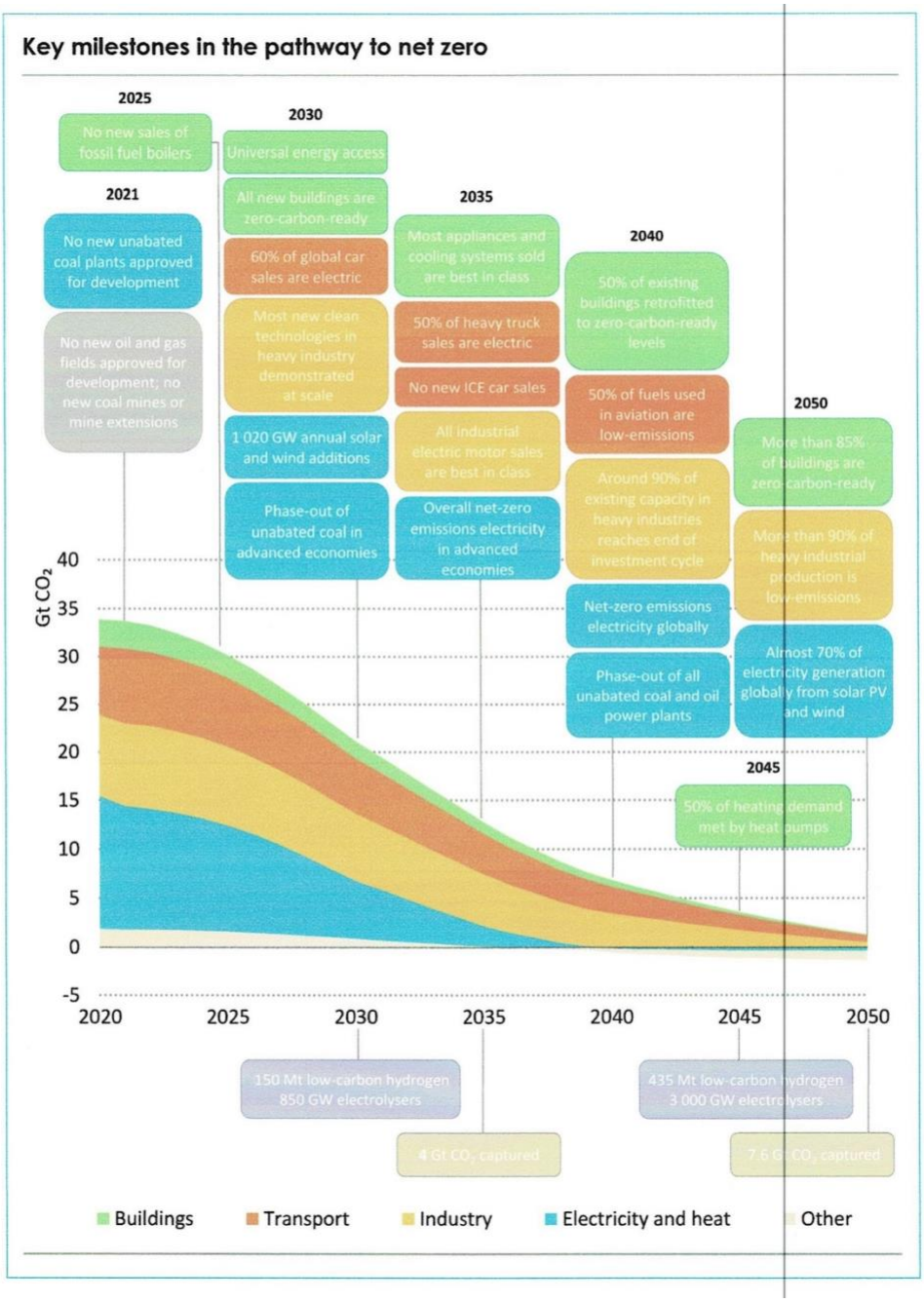


Priority 3

Clean energy jobs will grow strongly but must be widely spread. 14 million jobs are expected to be created by 2030 thanks to new activities and investments in clean energy. Spending on more efficient appliances, electric and fuel cell vehicles and building retrofits and energy efficient construction will require a further 16 million workers but during this transition period some 5 million jobs are expected to be lost. This means that careful policy planning to address the employment losses, retraining needs, relocation services, etc is absolutely vital.

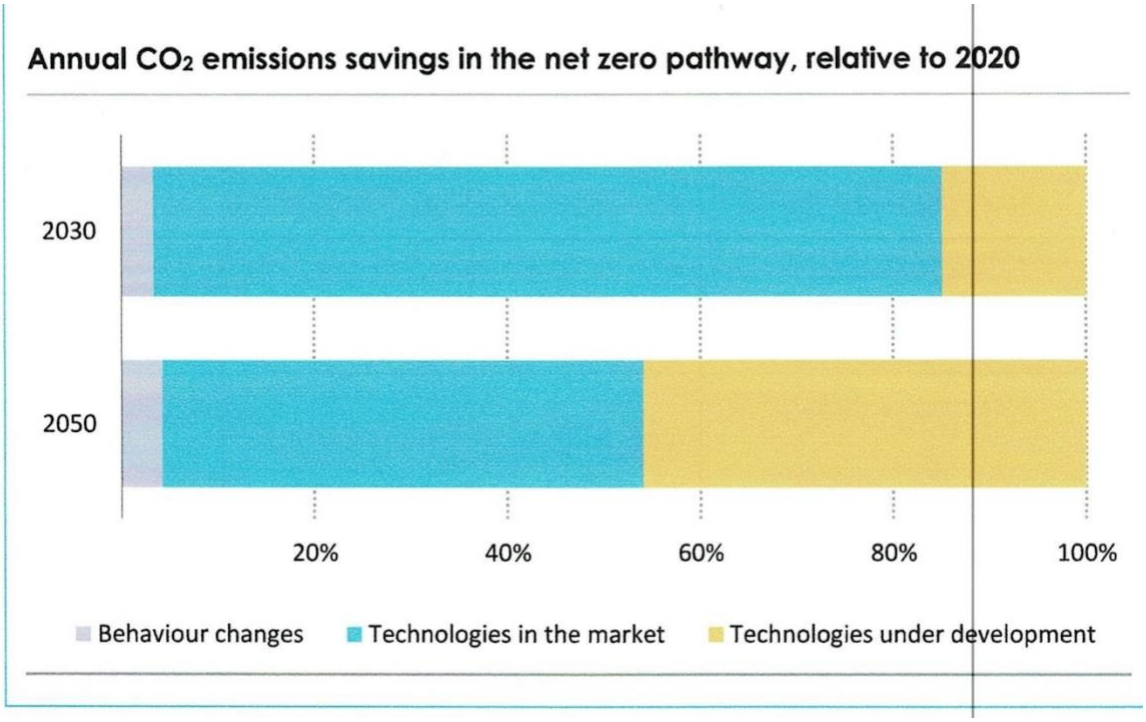
Priority 4

Set near term milestones to get on track for long term targets. Governments need to provide credible step by step plans to reach their net zero goals and build confidence among investors, industry, citizens and the global community.



Priority 5

Drive a historic surge in clean energy investment. Policies need to be designed to send market signals that unlock new business models and mobilize private spending but ultimately the private sector will need to finance most of the extra investment that will be required. In short, making net zero emissions a reality hinges on a singular, unwavering focus from all governments – working together and with businesses, investors and citizens.



WHAT DOES THIS MEAN FOR CANADA

First the good news. Currently 63% of our electricity is generated by hydroelectric power and only 15% generated from conventional steam (coal and natural gas) and a roughly equivalent amount generated by nuclear.

Canada has committed to achieving 90% of its electricity from zero emission sources by 2030. But as of 2021, renewable energy provides only 18.9% of Canada's total primary energy supply. (Data sourced by Natural Resources Canada). Alberta, Saskatchewan and Nova Scotia currently generate 85%, 74% and 90% respectively from coal and gas resources (NEB). Experts generally agree that in order for Canada to meet its zero emissions target by 2050, Canada will require significantly more electrification.

The other good news is that in the Direct Air Capture (DAC) market Canada is an emerging leader in this technology. This technology is still in its infabncy and progress is contingent on the scale and progress of technology as well as pricing factors. Canada also has the second largest CCUS capacity in the world. As the IEA report concluded these two areas are expected to be critical growth areas on the pathway to zero emissions.

It seems clear from the information presented thus far that multiple pathways are key to reach net zero by 2050 and Canada is no exception.

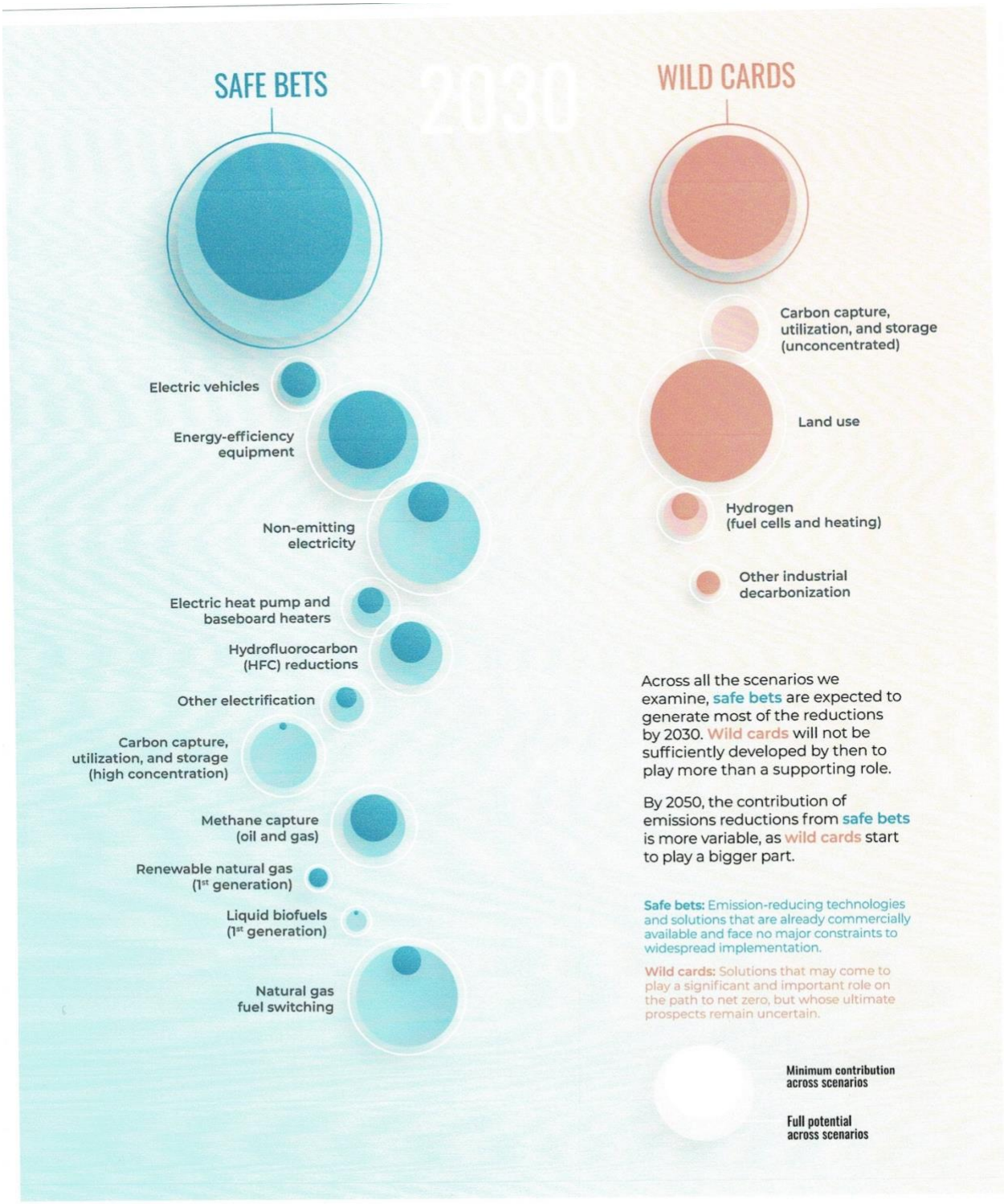
In the report entitled, " Canada's Net Zero Future" prepared by the Canadian Institute for Climate Change (CICC), four areas were identified that they believe will be critical to how Canada navigates this transition. The four areas are: Buildings, Transportation, Industry and Negative Emissions Solution. For brevity, these are summarized as follows:

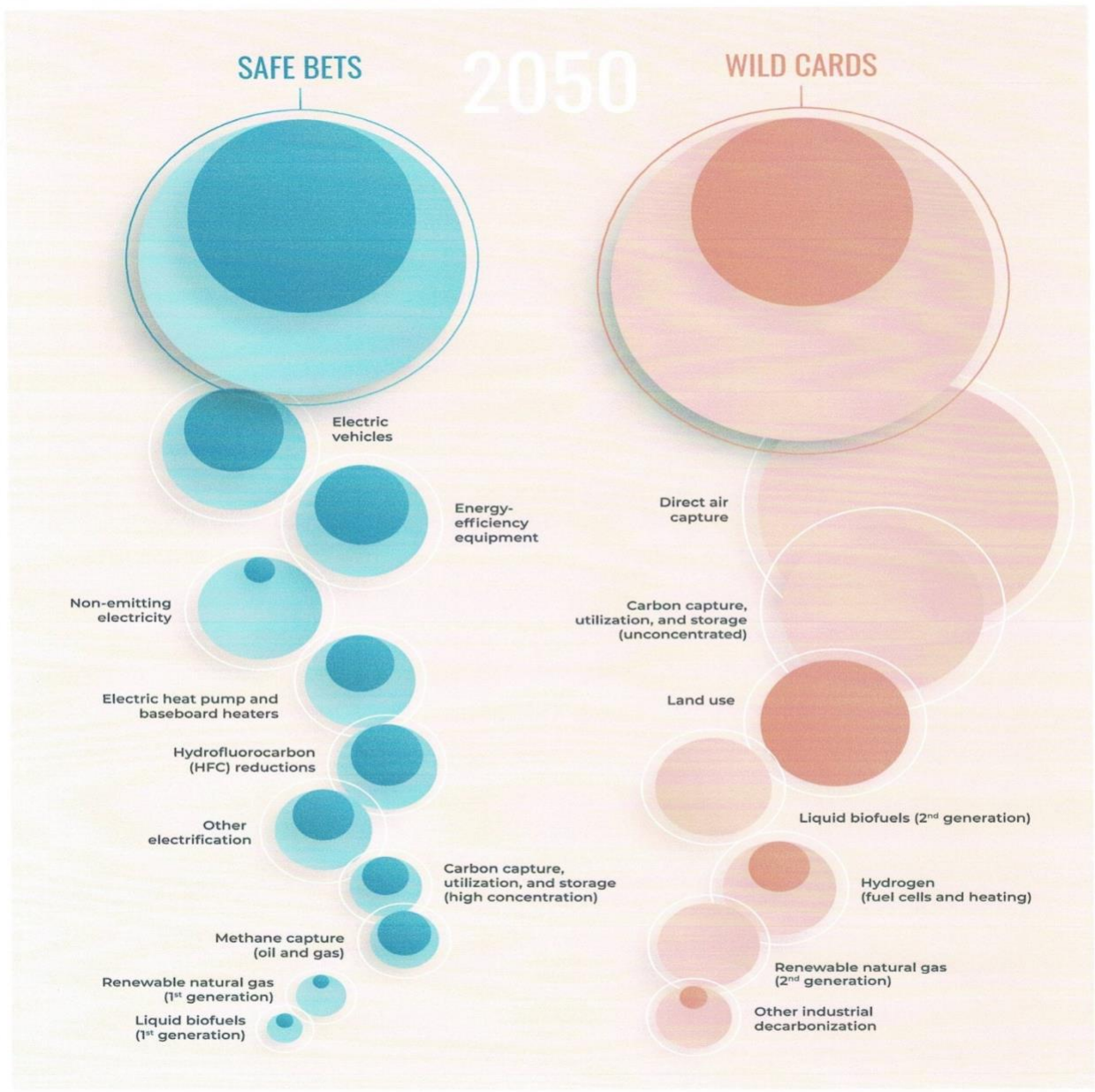
A. Buildings
    - Increase energy efficiencies
    - Switching to electric heat pumps
    - Switching to clean gases
    - Installation of smart thermostats
B. Transportation
    - Increase use of public transit
    - Transition to EVs

C. Industry
    - Methane management

D. Negative Emissions Solutions
    - Carbon capture, utilization and storage

Further they based their conclusions on what they called "Safe Bets" and "Wild Cards". They felt that the "Safe Bet" choices are critical to short term results and "Wild Cards" are important for unlocking the deeper, more cost effective reductions that can get Canada to net zero. CICC forecasts that at least 2/3 of emission reductions in 2030 will come from their "Safe Bet" solutions and less than 1/3 by the "Wild Cards" but by 2050 these proportions will switch. Findings that are quite similar to those contained in the IEA report citied earlier.


2030
SAFE BETS
WILD CARDS
Electric vehicles
Energy-efficiency equipment
Non-emitting electricity
Electric heat pump and baseboard heaters
Hydrofluorocarbon (HFC) reductions
Other electrification
Carbon capture, utilization, and storage (high concentration)
Methane capture (oil and gas)
Renewable natural gas (1st generation)
Liquid biofuels (1st generation)
Natural gas fuel switching
Carbon capture, utilization, and storage (unconcentrated)
Land use
Hydrogen (fuel cells and heating)
Other industrial decarbonization
Across all the scenarios we examine, safe bets are expected to generate most of the reductions by 2030. Wild cards will not be sufficiently developed by then to play more than a supporting role.
By 2050, the contribution of emissions reductions from safe bets is more variable, as wild cards start to play a bigger part.
Safe bets: Emission-reducing technologies and solutions that are already commercially available and face no major constraints to widespread implementation.
Wild cards: Solutions that may come to play a significant and important role on the path to net zero, but whose ultimate prospects remain uncertain.
Minimum contribution across scenarios
Full potential across scenarios



CICC believes Canada has more promising options than most in transitioning to net zero. To support that conclusion, CICC analyzed three distinct energy systems that could emerge in Canada's net zero future. The following charts illustrate those systems and the factors that will likely influence them:

3 distinct net zero energy systems are possible in Canada.

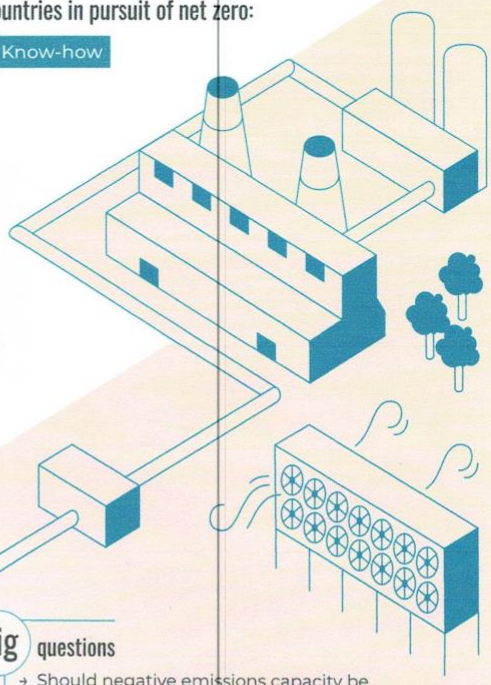
One could eventually dominate, or a mix of systems could emerge.

FACTORS affecting how our energy systems will evolve:

Within Canada's control	Outside Canada's control
Domestic policy	Technology adoption abroad
Infrastructure	Global market trends
Land-use priorities	Global climate policy
Research, development and demonstration	Technological innovation

Canada has more ADVANTAGES than other countries in pursuit of net zero:

Resources | Land mass | Infrastructure | Know-how



SYSTEM 1

Fossil fuels + negative emissions

Fossil fuels continue to provide much of our energy

Emissions are offset by negative emissions solutions, requiring both engineered and nature-based solutions

Upsides

- **Avoids need to replace** existing fossil fuel infrastructure
- **Less structural change** in the economy

Downsides

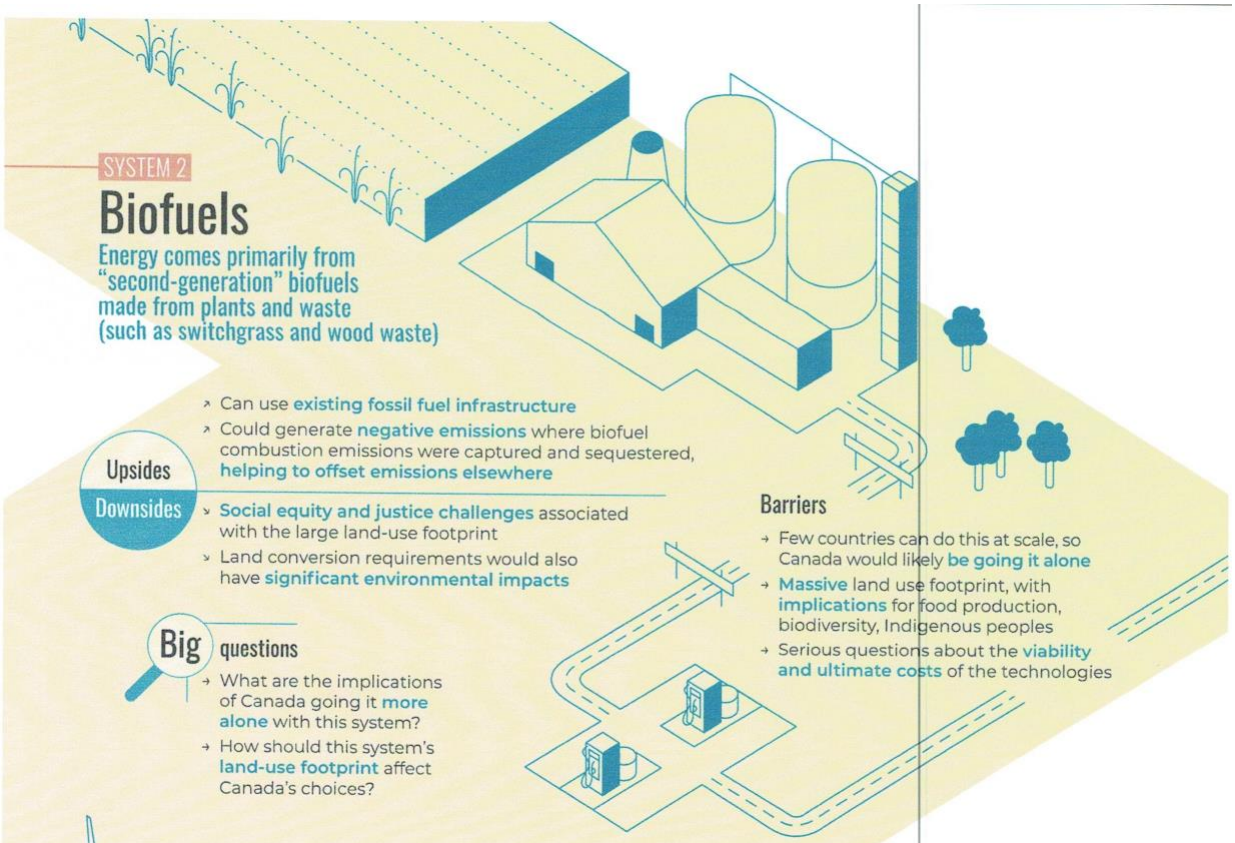
- Burning fossil fuels has **negative health and environmental consequences**
- May only **delay the transition** to another system (may need the negative emissions for other uses later)
- Avoiding structural change may mean **lost opportunities**

Barriers

- Technology is only at **demonstration stage**, would need to prove cost-effective and scalable; other countries' investment in it is still uncertain
- Would require **a massive build out** of negative emissions facilities and infrastructure
- Would require development of **a large and complex** offset trading system
- Public sees solution as **risky**

Big questions

- Should negative emissions capacity be reserved for the net negative emissions many global assessments say is necessary in the latter part of this century **to avoid severe climate change?**
- How should health impacts from air pollution in this system **affect Canada's choices?**



SYSTEM 2

Biofuels

Energy comes primarily from "second-generation" biofuels made from plants and waste (such as switchgrass and wood waste)

Upsides

- Can use **existing fossil fuel infrastructure**
- Could generate **negative emissions** where biofuel combustion emissions were captured and sequestered, **helping to offset emissions elsewhere**

Downsides

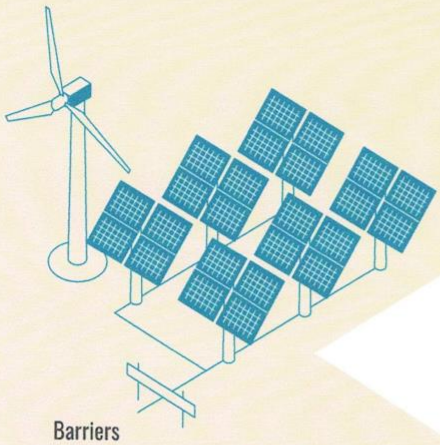
- **Social equity and justice challenges** associated with the large land-use footprint
- Land conversion requirements would also have **significant environmental impacts**

Barriers

- Few countries can do this at scale, so Canada would likely **be going it alone**
- **Massive** land use footprint, with **implications** for food production, biodiversity, Indigenous peoples
- Serious questions about the **viability and ultimate costs** of the technologies

Big questions

- What are the implications of Canada going it **more alone** with this system?
- How should this system's **land-use footprint** affect Canada's choices?



SYSTEM 3

Electrification + hydrogen

Emissions-free electricity is the dominant form of energy, with hydrogen used in areas that are difficult to run on electricity

Upsides

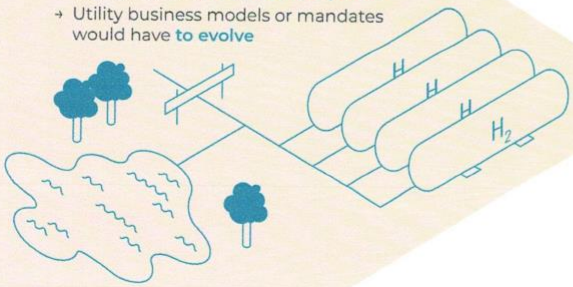
- **Lower air pollution** than in other systems
- **Potential export opportunities**, as this will be the type of net zero energy system most commonly adopted abroad

Downsides

- **Big departure** from the status quo
- Some types of electricity generation and transmission infrastructure may be **more vulnerable** to effects of climate change

Barriers

- Highly complex **to build and operate**
- Utility business models or mandates would have **to evolve**



Big questions

- What implications does **the logistical complexity** of realizing this system have?
- What could **affect Canada's ability** to compete globally for export opportunities?

In Seth Klein's book, A Good War, 20 key takeaways that Canada could and should implement to achieve our goal of net zero and are paraphrased below:

1. The first step is to fundamentally shift our mindset and to truly acknowledge and treat this as the emergency that it is. It is clear that what we have been doing up to this point is not working and we simply can't keep doing more of the same and expect anything to change for the better. This mindset change applies to all aspects of our society not just government.
2. Changes at the household, community and industrial level must be mandated, not voluntary or merely incentivized. The regulatory fiat is needed to order changes that have to happen and arguably a better choice for the Emergency Measures Act.
3. Clear and ambitious targets must be legislated both for overall GHG emission reductions and for various sectors. For example, ban the sale of gas powered vehicles by 2025 and ban the use of fossil fuels in all homes and buildings by 2040.
4. Ensure all institutions and machinery of government are focused on this national task. Appoint, a Climate Emergency Cabinet Committee, embed a Climate Emergency Secretariat in the PM's office and each premier's office.
5. Rally the public at every turn. In frequency and tone, this needs to look and sound like an emergency. Ban the advertising of fossil fuel vehicles and gas stations; require that all media companies divest from fossil fuels to ensure they are not compromised and marshall the cultural and entertainment sectors by supplying public funding for educational and arts initiatives that will rally the public.
6. Take on the fossil fuel corporations. Make them part of the solution not the problem. Think how automakers were made to change to war production from commercial production.
7. Spend what is necessary because as CD Howe, Canada's wartime minister said ever so succinctly, "If we lose the war, nothing else matters". That message holds true here, today, right now and for all the same reasons. Undertake massive public investments in needed climate and social infrastructure.
8. Sell Green Victory Bonds.
9. Create the economic institutions needed to get the job done, including new crown corporations as needed.
10. Conduct a national inventory of conversion needs. Determine how many heat pumps, solar panels, wind turbines, Evs, etc will be needed, plan for how those items will be produced and deployed.
11. Ensure visionary and creative people are in key leadership positions in the civil service; bring in outside experts, entrepreneurs, business and civil leaders as needed to drive change and oversee the necessary scale up.
12. Ensure a rigorous and just transition plan is in place. Match, retrain workers to new opportunities.
13. Establish a new federal Climate Emergency Just Transition Transfer to fund the work of provincial transition agencies especially the provinces that will do the heavy lifting.
14. Respect Indigenous communities and nations as full partners in this quest.
15. Establish a Youth Climate Corps open to all high school grads who wish to get involved.
16. Ensure Canada is willing and prepared to welcome tens of thousands climate refugees.

A Good War has taken the lessons learnt by Canada prior to, during and immediately after World War ll and adapted them to this global crisis. I found the analogies used in this book were so good because it shows in simple, straightforward ways what and how Canada did so successfully then and if we adopted the tools, methods now we will be successful in achieving net zero. In essence what this book provides is the roadmap to our future success.

WHAT IS BEING DONE IN CANADA NOW?

For simplification purposes, the actions in play or proposed are listed below:

- In 2012 Canada introduced regulations requiring coal fired power facilities to achieve a performance standard of 420 tonnes of CO2e/GwH when they reach the end of their 50 year life cycle;
- In 2018 Canada introduced carbon pricing starting at $10/tonne and rising to $50/tonne by 2022. Natural Resources Canada determined that a $50/tonne carbon price could decrease GHG in the electricity sector by 20-21% below 2005 levels but if the 30% target is to be met than carbon pricing must continue to rise beyond the 2022 price of $50/tonne.
- In June 2021, the Canadian Government passed the Net Zero Emissions Accountability Act. The Act establishes a legally binding process to set five year national emissions-reduction targets as well as develop credible, science based emissions-reduction plans to achieve each target. It establishes a GHG emissions reduction target of 40-45% below 2005 levels by 2030. However, details beyond 2030 through 2050 are basically non existent. Numerous experts feel that the interim plans Canada has set to reach 2030 targets are woefully insufficient. In fact it is forecasted that Canada needs to double their production of electricity by 2050 yet no plans are in place to accomplish this. To meet the goals identified in this act, Canada needs, at the bare minimum, to invest in a national clean energy electricity strategy and streamline the approval process for new clean energy projects.
- The federal government and Government of New Brunswick have committed funding for the development of SMRs (Small Modular Reactors) which are considered ideal for powering remote communities and off grid industrial projects. Commercialization of SMRs is probably at least a decade away.
- Smart Energy Project 2019 wherein the Governments of NB and NS joined together to pilot a new digital energy project at a cost of $108M.
- Collaborative Grid Innovation for Atlantic Smart Energy Communities has started a pilot smart grid infrastructure and renewable energy into the electricity grid in Shediac NB and Amherst NS. (See other projects in chart on page 27)
- The BC Government introduced their Clean BC program in 2021. Highlights of the program call for raising public awareness of driving EVs, expanding BC Hydro's fast charging network, provide financial incentives for electrification of busses, ferries and fleets. The BC Government plans to invest $260m over the next 5

years to advance electrification in 3 key segments – buildings, transportation and industry as well as commit to reducing GHG by 40% by 2030.

- Marine Energy; Sustainable Marine is set to demonstrate a project that shows how NS can produce vast amounts of clean and predictable energy from the tide power of the Bay of Fundy (renewable energy Magazine February 2022). The Canadian Government is also funding various efforts to explore wind and tidal power options and supporting industries;
- Others: Projects such as Saint John Energy and their Birch Hill Wind Project are in various stages in several locations throughout Canada.

WHAT ABOUT THE GRID?

With the desired goal of electrification clearly agreed upon, what does it actually mean for our electrical system? And this is where it gets a little bit tricky or at least confusing as there are various reports by various entities citing differing numbers in terms of capacity and forecasted need.

For example, Stats Canada said in their 2014 report Canada generated 375 Terrawatt hours (TWh) of hydroelectric electricity. Another report stated Canada generated 681 Twh of electricity in 2018 and total useage was 503 Twh of electricity in 2016 which leaves an approximate surplus capacity of 178 Twh.

Staying with Stats Canada and their 2014 report on Canada's grid capacity they showed the following table:

Installed Capacity: 140GW (0.14 Twh)

Annual Generation (all sources) : 639 Twh

Annual Consumption: 550 Twh

Annual Exports: 68.4 Twh

Annual Imports: 8.7 Twh

Average household Usage: 11,135 Kwh/year or 1.11 Twh

In 2021 Stats Canada updated their information as follows:

Primary energy production (all sources): 21,414 petajoules or 5948 Twh (Crude Oil: 50.1%, Electricity: 8.5%, Coal: 5.3%, Natural Gas: 4.3%);

Energy Consumption: 8,882 petajoules or 2467 Twh (all sources 2019)

Retail Pump Sales account for 62.6% of energy consumption with road transportation and urban transportation accounting for 13.3%, airlines 11.2%, Pipelines 6.6%, railways 3.5% and marine 2.9%.

Ontario, Alberta and Quebec account for the majority of energy consumed in Canada at 74.2% with Quebec, BC, and Manitoba with the lowest rates in the country.

Looking at these numbers it shows that Canada only generates 54.3 Twh from electricity yet consumes more than 10 X that amount.

As of 2020 Canada had an estimated installed capacity of 81.4 gw or 0.08 Twh from hydro, wave and tidal sources. Wind provided an additional 0.001 Twh, solar 0.0028 Twh, and 0.0125 Twh from nuclear for a total 0.0963 Twh.(Energy and Environment Canada).

The breakdown is noted as follows:

PRODUCTION OF HYDROELECTRICITY BY PROVINCE (EnergyRates.ca)

Manitoba 97%

Quebec 95.3%

Newfoundland and Labrador 94.3%

Yukon 93.7%

BC 89.4%

NWT 37.4%

Ontario 22.3%

NB 21.5%

Saskatchewan 13.3%

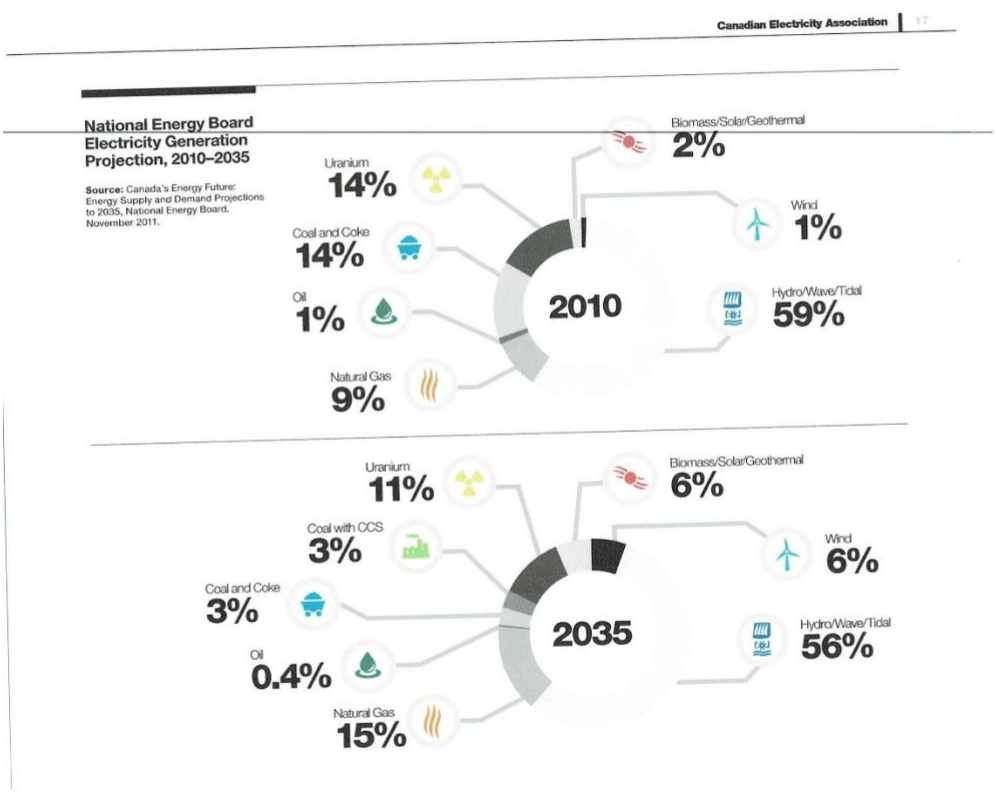
NS 8.7%

Alberta 2.8%

So if Canada consumes 550 Twh yet only produces 54.3 Twh from electricity and current hydroelectric capacity is at 0.08 Twh, (0.0963 from emissions free sources) we have a long, long, ways to go. No doubt these numbers have changed but it does allow one to draw the conclusion that while, at present, Canada has a surplus of electric capacity from all sources but once you eliminate the sources that are not emissions free you begin to see the problem. As Canada currently only generates 8.5% of its total output from electricity the road to 2030 and beyond is going to take a massive undertaking and investing starting now. In fact, the Conference Board of Canada estimates that Canada will need to invest some $350B over the next 20 years and that is just to maintain the reliability of the existing system.

The International Energy Agency found that global demand for energy surged 6% in 2021 with China's demand increasing by nearly 10%. Electricity generated by renewables also grew by 6% last year but coal fired electricity rose by 9% and C)2 emissions from power generation increased by 7%. Clearly these numbers show how far off track we currently are to achieving net zero emissions by 2050. If nothing else it underscores the massive changes needed for electricity sector to fulfill its critical role in decarbonizing the energy sector.

The following table outlines the National Energy Board's projections for electricity generation through 2035.



Other experts have made claims to say that for every 100 mw of wind or solar power there is a need to builkd an equal amount of stand by power to take its place at night or at times of low wind velocity or cloud cover. For example, they cite the fact that Australia plans to generate 10,000 mw of solar power on a 58 square mile of solar panels and transmit 2600 miles undersea to Singapore by 2027. The projected cost is $22B and is expected to provide 15-20% of Singapore's electric power demand.

It also must be said that renewables clearly must be part of the equation to get to carbon neutrality. In a report by The Future of Electrification in Canada by Adovision, they felt there was a need to generate 290 Twh of renewable energy power, which is equal to the output of 50,000 wind turbines. There seems to be general agreement by those who know that, for

Canada, electrification with renewables could reduce emissions by as much as 90% if and only if Canada starts moving rapidly with the actions required to achieve our goal of carbon neutrality.

We cannot escape the fact and it bears repeating, that our goal of net zero will cost a massive amount of money but two things mitigate in favour of moving ahead; (1) it will be far cheaper to invest now than it will be later by a huge margin and (2) cost effectiveness will prove itself overtime as industry, transportation, buildings and consumer use become more efficient and effective.

Fortunately, Canada is currently ranked 2/42 countries globally for our ability to meet future electricity needs from renewable resources (eg solar, wind) according to Clean Energy Canada. We are the 6th largest energy producer in the world (all sources), the 5th largest net exporter and the 8th largest consumer, surely with the resources we have available we can achieve net zero as long as we have leadership willing and able to commit for the long term. Interestingly, the Indigenous communities in Canada are the largest single owner of clean energy assets in Canada after the Crown and private utilities and there is no federal authority regarding the production of electricity in Canada as this is a matter of provincial jurisdiction. How these two factors play out in the near as well as long term will be vitally important to achieving net zero.

WHERE WE STAND TODAY/CONCLUSION

We are living in a time of deep disconnection, a gaping void between what is scientifically/ecologically necessary and what is considered politically impossible. For example the Canadian Government passed the Net Zero Accountability Act but doubled down on Trans Mountain pipeline and fossil fuel production. In 2015 the Alberta Government permits a 40% increase in oil sands emission and BC produces a Clean Air Climate Plan but then pursues LNG and ramps up natural gas fracking and the list goes on. Is it any wonder Canadians have little trust in their governments to actually make the tough decisions. Policy Options magazine did a survey and reported that only 12% of Canadians trust their provincial governments when it comes to decisions about climate change. The federal government fared better with 29%, but I'd be willing to bet that after issues relating to the recent Freedom Convoy, that rating has no doubt decreased.

Looking at this list, and recognizing that this subject matter is in a constant state of motion with many, many moving parts it still seems like a safe bet to say that Canada has a long way to go in order to meet their stated objectives for 2030 let alone 2050. When I look at what Canada is currently doing and appreciating the recommendations made in A Good War as well as the recommendations made throughout this paper I reluctantly conclude that Canada is not nor does not seem ready to actually do what is necessary. The truly sad part is we have the knowledge and the resources but not the will at least not yet. The 80% reduction target by 2050 seems most unlikely given what is known as of today. The reality is that this target objective will require technologies that not yet commercialized along with intense public, private and inter-industry cooperation and we are simply not there yet!

The CCIC in their report entitled Canada's Net Zero Future summarized it this way:

- A net zero future is possible but requires strong policy and that requires the federal Government to take the lead role;
- Big transitions are inevitable;
- Canada does have competitive advantages and these will create new opportunities but like all such transitions it won't be easy or inexpensive.

By now, we all understand the basic formula for success and it goes like this: cut energy waste as much as possible, clean up our energy supply so it is as low carbon as possible, then use that clean energy to power what we now power with fossil fuels. Simple, right? So instead of fueling cars with gasoline, power them with clean energy. Build super efficient homes and buildings and then use heat bumps or fossil free boilers, solar power to heat and cool them. Design cutting edge industrial processes that run on renewable power.This is what is called electrification.

A report entitled " Exploring Energy Use and Widespread Electrification and Power Sector Decarbonization (2017) concluded "electrification of end uses, when coupled with power sector decarbonization, has the potential to substantially reduce economy wide emissions of CO2, associated with fossil fuel combustion. Specifically, by 2050, electrification and simultaneous power sector decarbonization can achieve reductions of nearly 74% below the 2005 level of economy wide fossil fuel combustion emissions."

I'll close with the thoughts of Stephen Poloz, former Governor of the Bank of Canada who has written a new book, The Next Age of Uncertainty (release date February 22, 2022). In his book, Mr. Poloz believes there will be 5 meta trends that are about to collide in potentially violent ways that will reshape the economy and society as we now know it.

Poloz thinks perhaps hopes is a better word that companies and their leaders will fill the void left by politicians, especially when it comes to dealing with inequality and climate change. "…it is time for executives and investors to pay as much attention to environmental, social and corporate governance (ESG) as they do to profits." The growing importance of ESG in the corporate world represents the failure of politics to deliver the right balance of policies says Mr. Poloz in an article by the Financial Post (February 21, 2022). Poloz goes on to say that the coming tectonic stresses will prove too much for the capacity of existing fiscal and monetary stabilization tools and that policy makers will not be able to absorb all of the increase in risk that the tectonic forces will deliver.

In short, Poloz is skeptical that the people whose job it is to keep us out of trouble are up to the task. He thinks inequality issues have so badly polarized society to the extent that the compromises required to do the big and necessary things will be unachievable in the future and if that is not a scary wake up call, I don't know what is.

As much as I reluctantly agree with Mr. Poloz's conclusions, I do remain hopeful because the pathway is clear, the methods are known and proven. We have everything to lose if we don't act now as if our very future depends on it. May our leaders listen, react and lead as we want and need them to do. There is the old cliché about not wasting a good crisis, well we have a good one now, so let's not screw it up!

RESOURCES/LINKS

UN's Intergovernmental Panel of Climate Change (IPCC)

Canadian Institute for Climate Change – Canada's Net Zero Future

Clean Energy Canada

Canadian Electricity Association

Government of Canada: Stats Canada, NEB, NRC, Canadian Net Zero Emissions Accountability Act

Conference Board of Canada

Electric Power Research Institute

Climate Solutions

BC Hydro

Deep Decarbonization Pathways Project

California Council of Science and technology

Electrifying Canada

International Energy Association

World Data Bank

Lawrence Berkely National Laboratory

Acadis Center, EnergyVision Report

David Suziki Foundation – Clean Power pathways

Seth Klein, A Good War

Naomi Klein:This Changes Everything, On Fire:


NRCAN SMART GRID PROGRAM
LEGEND
Project by Program Stream:
Demonstration Projects
Deployment Projects
Hybrid Projects
1. Whitehorse, Yukon Energy
2. Edmonton, EPCOR
3. Red Deer, EQUS REA
4. Calgary, ENMAX Power
5. Waterton, FortisAlberta
6. Lethbridge, City of Lethbridge
7. Regina, SaskPower
8. Sault Ste. Marie, PUC Distribution
9. Thamesville, Entergrus Powerlines Inc.
10. Parry Sound, Bracebridge Generation
11. London, London Hydro
12. 13. Markham, Alectra Utilities
14. Toronto, Independant Electricity System Operator
15. Cobourg, Lakefront Utilities
16. Nunavik, Hydro-Québec
17. Lac Mégantic, Hydro-Québec
18. Saint John, Saint John Energy
19. Shediac, NB Power
20. Amherst, NS Power
21. Slemon Park, PEI Energy Corporation
6
NRCan Smart Grid Program Overview
NRCan Smart Grid Program Overview
7