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Submission to the Federal / Provincial / Territorial Working Group on Clean Technology, Innovation and Jobs

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Executive Summary

The COP 21 Paris Agreement and the Vancouver Declaration reflect the global and Canadian consensus that business-as-usual is no longer an option, and there are now clear signs that the world is transitioning to disruptive clean energy technologies at an accelerating pace.[2]

I am pleased to provide this submission (in response to the public request for suggestions on clean technology, innovation and jobs) for consideration by the federal Minister of the Environment and Climate Change and the Federal / Provincial / Territorial Working Group (the Working Group). This submission contains suggested observations and recommendations concerning some proposed changes, policies and programs which could assist Canada to participate more effectively in the clean energy transition. This submission is intended to complement and respond to the July 2016 Backgrounder (the Backgrounder) prepared by the Working Group to summarize the results of its initial research (which identifies many valuable best practices, with which I agree).

Observations

1. Public education is the most important enabler of clean technology (cleantech) innovation and jobs in Canada.[3] Comprehensive public education and outreach about climate change, greenhouse gas (GHG) emissions,[4] and cleantech opportunities may be expected to play an important role in persuading Canadians to obtain the requisite skills and to make other investments to support the clean energy transition to a low carbon economy.
2. As discussed in the "Context" section, a global clean energy transition would appear to be well underway, and to be gradually reshaping the global markets within which Canada sells its exports.

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[1] Toronto, Ontario. While I have benefitted from the input and valuable suggestions of many others, the views and recommendations expressed in this submission are mine alone and are not made on behalf of my partners, clients or any others.

[2] For example, Stanford Professor Tony Seba has mapped out the technical basis for the ongoing replacement of a number of fossil fuel technologies with renewable and digital technologies in his book "Clean Disruption" and has summarized his thesis in the following video: https://www.youtube.com/watch?v=Kxryv2XrnqM.

[3] I have concurrently prepared and plan to provide separate submissions with suggestions on "How and Where to Reduce Emissions" and on "Putting a Price on Carbon".

[4] In this submission "climate change" and "global warming" are used interchangeably to refer to the impacts on the global climate and environment caused by anthropogenic GHG emissions. "Climate change" refers to the broader range of environmental impacts, most of which are caused by "global warming". References in this submission to pricing or putting a price on carbon or on GHG emissions should be read as referring to putting a price on manmade GHG emissions. More generally, all other references to "carbon" should similarly be read as referring to GHG emissions (the term carbon is commonly used as a short form for carbon dioxide (CO_2), which is widely referred to as a proxy for all GHG emissions). CO_2e refers to the global warming impact of GHGs in terms of the mass of carbon dioxide required to produce an equivalent global warming impact; for example the emission of 30 kg of CH_4 (methane) equals one Tonne CO_2e (as CH_4 has 34 times the global warming potential (GWP) of CO_2 measured over 100 years).

3. Access to scale is very important to technology companies. The relatively small size of the Canadian economy increases the importance of the public policy environment in facilitating access by Canadian cleantech firms to opportunities to achieve the requisite scale.

Recommendations

In addition to the best practices identified in the Backgrounder, changes, policies and programs which could be implemented to assist Canada to participate more effectively in the clean energy transition include the following:

1. Appointing a federal Minister of Economic Transformation, who would be responsible for coordinating support for and advocating for cleantech innovation and the clean energy transition to a low carbon economy.
2. Endowing high profile prestigious chairs in cleantech innovation and economic transformation at leading universities.
3. Supporting the creation of further university-based centers of cleantech research excellence, and the development of strong cleantech industry clusters.
4. Supporting Canadian leadership in the development of cleantech technical standards.
5. Measuring, reporting on and applying energy and GDP/TCO2e productivity measures as key metrics for and objectives of government policies.[5]
6. Implementing and expanding programs to assist Canadian cleantech companies to obtain the required funding, including:
    a. backstopping investment pools for early stage cleantech investments;
    b. further tax incentives for cleantech investments; and
    c. further coordinated federal and provincial government funding through grants, co-investments, guarantees and other low carbon finance mechanisms.
7. Expanding markets for Canadian cleantech products and services, including through:
    a. greater and more focused federal and provincial government procurement of such products and services;
    b. further tax incentives for cleantech adoption by Canadians;
    c. a steadily and predictably increasing price on GHG emissions and a pollution surcharge on prescribed GHG emitting durable goods;
    d. other economic incentives for cleantech adoption by Canadians;
    e. regulatory actions to create markets for Canadian cleantech products and services; and
    f. expanded support for Canadian cleantech export sales.

[5] GDP/TCO2e refers to Gross Domestic Product (GDP) per Tonne of CO2e emissions.

Discussion of and Rationale for Observations and Recommendations

Context and Background

The markets for energy (both clean and fossil-based) and related products, of which Canada is a part, are global in their scale and are substantially affected by three closely related factors.

First and foremost is the ongoing information technology and manufacturing revolution, which through its various progeny (including solar PV, energy storage, electric vehicles, autonomous navigation and the internet of things) promises to displace and replace fossil powered energy systems with more efficient and cost-effective clean technology alternatives (the Cleantech Transition).[6] While a number of elements of the Cleantech Transition had their roots in development of silicon and battery technologies in Silicon Valley, regulatory actions and economic incentives (such as the renewable energy feed-in tariff programs under the Ontario Green Energy Act, in Germany and in other jurisdictions) have substantially diversified and accelerated the exponentially falling costs and growing volumes of solar and wind power generation and other clean technologies.

The second and third considerations, namely: (i) the global commitments made in Paris, including by Canada, to reduce GHG emissions substantially and rapidly, and (ii) the related recognition that a price must be put on GHG emissions to reflect the damage they are causing, are expected to further accelerate both the pace and the scale of the Cleantech Transition.

The high speed and exponential growth with which the Cleantech Transition is advancing (in accordance with variants of Moore's Law[7]) poses a significant challenge and necessitates decisive action if Canada is to participate more effectively in the Cleantech Transition. As noted by the Working Group in the Backgrounder [emphasis added]:

> *Clean technologies provide the pathway for emissions mitigation and more sustainable growth of all areas of the economy, including transportation, natural resources development, manufacturing, construction, utilities and others. Canada's strong industrial base and natural resource endowments can serve as a catalyst for new, sustainable clean growth, but* ***Canada must act quickly and decisively to seize these opportunities to participate in and grow the global market****.*

Quick action is critical due to the exponential growth of the global markets for clean technologies. Many key clean technologies have achieved, or are achieving the critical mass, and are seeing the continuing exponential declines in cost and increases in volume required to make the rapid replacement of fossil energy sources with renewable and clean technology alternatives inevitable in the relatively near future. As noted by Stanford Professor of Innovation, Tony Seba, the author of Clean Disruption:

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[6] As noted in the Blackrock Investment Institute "*Adapting Portfolios to Climate Change Risk: Implications and strategies for all investors*", Global Insights, September 2016 "*Technological advances and cost declines in renewable power and electric grids, EVs and batteries pose a threat to incumbent industries and demand for fossil fuels*". See: https://www.blackrock.com/investing/literature/whitepaper/bii-climate-change-2016-us.pdf.

[7] Moore's Law predicted that computing would dramatically increase in power, and decrease in relative cost, at an exponential pace, which it has done on a consistent basis for more than 50 years. See: http://www.intel.com/content/www/us/en/silicon-innovations/moores-law-technology.html

> *The Stone Age did not end because humankind ran out of stones. It ended because rocks were disrupted by a superior technology: bronze. …*
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> *The horse and carriage era did not end because we ran out of horses. It ended because horse transportation was disrupted by a superior technology, the internal combustion engine, …*
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> *The age of centralized, command-and-control, extraction-resource-based energy sources (oil, gas, coal and nuclear) will not end because we run out of petroleum, natural gas, coal, or uranium. It will end because these energy sources, … will be disrupted by superior … new technologies such as solar, wind, electric vehicles, and autonomous (self-driving) cars …*
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> *The clean disruption is about digital (bit) and clean energy (electron) technologies disrupting resource-based (atom-based) industries. Clean energy (solar and wind) is free. Clean transportation is electric and uses clean energy derived from the sun and wind. The key to the disruption of energy lies in the exponential cost and performance improvement of technologies that convert, manage, store, and share clean energy.* …[8]

The book "Clean Disruption" sets out the author's thesis, with which I agree, that the continually declining costs of clean technologies (with costs driven down by the increasing returns to scale and network effects provided by these technologies), will disrupt resource-based energy sources (with their decreasing returns to scale, based on conventional extraction energy resource economics). As noted by Professor Seba:

> *Solar photovoltaic (PV) companies have decreased their costs by a factor of 154, a classic technology cost curve. Technology companies have an unparalleled record of lowering costs exponentially while increasing quality exponentially. The same economics that governed digital cameras, disk drives, microprocessors, routers, and mobile phones now govern solar PV technology development.*
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> *The electric vehicle is already better, faster, and safer than the internal combustion engine (gasoline) vehicle. Electric vehicles (EVs) are also cheaper to operate and maintain. An electric vehicle is still more expensive to purchase upfront, mainly due to battery costs. However, like other technology products, the technology cost curve of EVs points to a disruption soon; innovative business models will only accelerate the transition from gasoline vehicles to electric vehicles. …* [9]
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> *Increasing investments in electricity storage technologies in the automotive industry have led to more innovation and a subsequent drop in the cost of batteries like Lithium-Ion. As Li-on batteries become cheaper, they can increasingly be used — and economically be used — for solar and wind energy storage. … which in turn pushes down the cost of EVs, solar, and wind. The increasing demand for electric vehicles and solar will attract even more investment in these technologies. … This virtuous cycle of increasing demand, increasing investment, and increasing innovation will dramatically lower costs; …*

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[8] Tony Seba, *Clean Disruption of Energy and Transportation: How Silicon Valley Will Make Oil, Nuclear, Natural Gas, Coal, Electric Utilities and Conventional Cars Obsolete by 2030* ("Clean Disruption") (Silicon Valley: Clean Planet Ventures, 2014), Chapter 1. Since the publication of Clean Disruption, solar prices have continued to fall to the current record low, unsubsidized price of under US$0.03/kWh, see: http://cleantechnica.com/2016/05/02/lowest-solar-price-dubai-800-mw-solar-project/.

[9] The Tesla Model S P100D which was announced on August 23, 2016, is the quickest production car in the world, has an EPA range of over 300 miles and an EU range of over 600 km. See: https://www.tesla.com/en_CA/blog/new-tesla-model-s-now-quickest-production-car-world

> *Extraction economics is about decreasing returns: The more you pump, the less each well produces. The more you pump, the less the neighboring well gets. The more you pump, the more each unit of energy will cost in the future. …*
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> *Solar, electric vehicles and the clean disruption are about increasing returns. Solar photovoltaic (PV) panels have a learning curve of 22 percent. PV production costs have dropped by 22 percent with every doubling of the infrastructure. … Every large solar power plant in the desert benefits not only the people who buy its power, but everyone who buys solar power in the future. The higher the demand for solar PV, the lower the cost of solar for everyone, everywhere. … All this enables more growth in the solar marketplace, which, because of the solar learning curve, further pushes down costs. This mutually beneficial arrangement is the opposite of extraction industries like oil and gas. When China's demand for oil surged in the last decade, world prices for oil went up by a factor of ten. The higher the demand for oil in Beijing, the higher gasoline prices are in Palo Alto and Sydney. This is not just a theoretical framework. Solar PV has improved its cost basis by more than five thousand times relative to oil since 1970 (see Chapter 7). By 2020, as the market for solar expands, solar will improve its cost basis relative to oil by twelve thousand times (see Chapter 7). The economics of energy resource extraction, based on decreasing returns, just cannot compete with the economics of technology industries and its increasing returns.*[10]

As the cost of electricity from utility scale wind and solar installations continue to decrease and consistently falls below the price of fossil fuel and nuclear alternatives, renewables are comprising an increasing majority of new generating capacity. As noted in a Bloomberg report earlier this year:

> *While two years of crashing prices for oil, natural gas, and coal triggered dramatic downsizing in those industries, renewables have been thriving. Clean energy investment broke new records in 2015 and is now seeing twice as much global funding as fossil fuels.*
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> *One reason is that renewable energy is becoming ever cheaper to produce. Recent solar and wind auctions in Mexico and Morocco ended with winning bids from companies that promised to produce electricity at the cheapest rate, from any source, anywhere in the world, said Michael Liebreich, chairman of the advisory board for Bloomberg New Energy Finance (BNEF).*[11]

Solar power has been growing exponentially for the past 20 years and is projected to become the world's largest source of electricity by 2050.[12] As costs have fallen by a factor of more than 150 times, the total installed capacity has increased by a factor of 115,000.[13]

The current, relatively low prices for oil reflect the recognition by leading oil producers, to quote Ali al-Naimi, Saudi Arabia's petroleum minister, that "Demand will peak way ahead of supply".[14] The low prices are expected to enable low cost producers such as Saudi Arabia, to maintain their market

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[10] Clean Technology, Chapter 1.

[11] See: http://www.bloomberg.com/news/articles/2016-04-06/wind-and-solar-are-crushing-fossil-fuels.

[12] See: https://en.wikipedia.org/wiki/Growth_of_photovoltaics and for information about the market in the U.S. see: http://www.seia.org/research-resources/solar-industry-data.

[13] See: http://www.bloomberg.com/news/articles/2016-04-06/wind-and-solar-are-crushing-fossil-fuels.

[14] See: http://www.bloomberg.com/news/articles/2015-04-12/saudi-arabia-s-plan-to-extend-the-age-of-oil.

share while deterring further investments in high cost oil production and somewhat reducing the rate at which customers switch from oil to energy alternatives.[15]

Renewable energy is already disrupting petroleum energy markets and is increasingly replacing the use of oil to generate electricity, for example, in the U.S., despite dramatically lower oil prices, the modest share of U.S. electric power production supplied by petroleum liquids fell by more than half, from approximately 0.8% to less than 0.4% in the past year, from Q1 2015 to Q1 2016.[16] Since a majority of petroleum is used for ground transportation, a transition from gas to electricity as the principal fuel for vehicles would have a major impact on demand for oil. In Clean Disruption, Tony Seba outlines a number of reasons why he expects electric vehicles will rapidly disrupt transportation markets, including the following:

1. *the electric motor is five times more energy efficient;*
2. *the electric vehicle is ten times cheaper to charge;*
3. *the electric vehicle is ten times cheaper to maintain;*
4. *solar and electric vehicles are four-hundred times more land efficient; and*
5. *electric vehicles can contribute to grid storage and other services.*[17]

In this context, the Canadian focus on the development of fossil energy reserves over the past decade has adversely impacted Canada's participation in international markets for clean technology products and services[18] and further depressed Canada's GDP/TCO2e performance relative to that of its OECD peers.[19] We need to make substantial changes in order for Canada to participate more effectively in the increasingly important Cleantech Transition.

Turning briefly to the other considerations, the human and economic costs of the global warming resulting from manmade GHG emissions have led to a clear global recognition and agreement (in Paris) that business as usual is not an option. As noted by the Working Group in the Backgrounder:

> *A guiding factor in our Working Group discussions and activities is an understanding that climate change is one of the greatest long-term challenges facing the world today. Tackling climate change requires a serious and sustained global response – economies around the world must transform how they use and produce energy. A dramatic and transformative step change in global innovation and adoption of clean technologies will be essential to meet this challenge.*

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[15] See: http://www.mepc.org/articles-commentary/speeches/saudi-arabia-and-oil-price-collapse?print.

[16] See: http://cleantechnica.com/2016/05/31/renewables-99-new-electricity-capacity-q1-2016-usa/.

[17] See Clean Disruption, Chapter 4. As noted in the August 22, 2016 article "*Electric vehicles – It's not just about the car*" by Michael Liebreich, Chairman of the Advisory Board and Angus McCrone, Chief Editor of Bloomberg New Energy Finance: EV battery costs have fallen 65% in the past 5 years; global electric car sales grew 57% in the first half of 2016 (with 285,000 new vehicles sold), in spite of low oil prices; there are now more than 200 million electric bikes in China alone; and by 2040 more than 35 percent of new car sales are expected to be electric. See: https://about.bnef.com/blog/liebreich-mccrone-electric-vehicles-not-just-car/.

[18] See: Analytica Advisers, *2016 Canadian Clean Technology Industry Report* (2016).

[19] See Figure 1 in Backgrounder at Page 12.

Climate change action plans, to mitigate GHG emissions, and the imposition of a price on carbon[20] may be expected, on a global basis, to further accelerate the Cleantech Transition and should be employed strategically by Canada to facilitate Canadian participation and leadership in the Cleantech Transition. In particular, the consistent imposition across Canada of a significant, and steadily increasing minimum price on GHG emissions[21] would enable a variety of Canadian cleantech businesses to grow and succeed by creating the streams of guaranteed savings required to raise funding and to grow their businesses. This would also increase the expected value of research and innovation and could provide Canada and Canadian cleantech business with a competitive advantage (relative to jurisdictions where there is a higher degree of uncertainty as to the future price on GHG emissions).[22] The consistent imposition across Canada of a significant, and steadily increasing minimum price on GHG emissions has the further advantage of creating consistent streams of revenues which may applied to support the Cleantech Transition (whether through agency-managed "Green Banks" or by the public in the case of a fee and dividend or other similar models, or some combination of both). Assuming that the revenues from the price on GHG emissions are fully and transparently returned to the economy (whether through investments in low carbon technologies or through the return of funds to the public through a dividend or tax reductions), the increasing energy efficiency and productivity,[23] increasing investments in declining marginal cost technologies (which are continually growing exponentially), and local investments in energy conservation, generation and storage projects should be substantially stimulative to the Canadian economy.

The following observations and recommendations are intended largely to complement and supplement those made in the Backgrounder and to address some areas not specifically addressed in the Backgrounder, with a particular focus on innovation and leadership, and the effective communication to the public of the economic and employment opportunities afforded by the Cleantech Transition.

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[20] Discussed in my separate submissions on "How and Where to Reduce Emissions" and on "Putting a Price on Carbon".

[21] The benefits and the proposed mechanics of this approach are discussed in greater detail in my submission on "Putting a Price on Carbon".

[22] As noted in the September 2014 *New Climate Economy Report* by The Global Commission on the Economy and Climate (see: http://newclimateeconomy.report/TheNewClimateEconomyReport.pdf) at page 18: "*The current vacillating and mixed signals on climate policy in many countries, especially in terms of a predictable carbon price, pose a significant dilemma for investors. … many low-carbon investments are riskier and less profitable than they might be with strong climate policies. This uncertainty has raised the cost of capital and encouraged investors to hedge their bets between high- and low-carbon assets. Investment, jobs and growth all suffer as a result.*"

[23] Resulting from the increasing penetration of high efficiency, electric-powered and digitally controlled clean technologies at continually decreasing prices.

Observations

1. <u>Public education is the most important enabler of cleantech innovation and jobs in Canada. Comprehensive public education and outreach about climate change, GHG emissions, and cleantech opportunities may be expected to play an important role in persuading Canadians to obtain the requisite skills and to make other investments to support the clean energy transition to a low carbon economy.</u>

   The Canadian public is generally very poorly informed[24] (and is regularly misinformed[25]) about the causes and expected impacts of manmade global warming, and about the measures which may be taken to effectively mitigate the emissions of GHGs. Public education about manmade global warming, and the boundless business opportunities in the low carbon economy, is critical to public support for effective action to combat climate change, including support for the development and adoption in Canada of clean technologies. Education should be given top priority as a key part of the federal government's climate action plan. It needs to provide the public with sound information about climate change, and the policy and clean technology options to achieve greater productivity and prosperity; educate the public about new programs and opportunities; and provide the skills and entrepreneurship training and support required for Canadians to take full advantage of the opportunities in the clean energy economy. Public education is critical to cleantech innovation in the following ways:

   a. To assist potential investors and the broader investment community to better understand and value the opportunities to invest in cleantech businesses and to participate in the Cleantech Transition.

   b. To assist the public to better understand the benefits of purchasing cleantech products and services (and the harm caused by polluting alternatives), thereby driving greater demand for cleantech products and services, and creating greater opportunities for Canadian cleantech businesses and entrepreneurs.

   c. To assist Canadians to obtain the skills, information, training and educational qualifications relevant to the low carbon economy, in order for them to capitalize on the opportunities to innovate and to build cleantech businesses.

   d. To drive public support for government action to address climate change, and the transition to the low carbon economy (including government support for cleantech innovation and the procurement of cleantech products and services).

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[24] For example, the 2016 Yale Climate Opinion Map reports that only 44% of Canadians are of the opinion that the Earth is getting warmer mostly because of human activities. See: http://environment.yale.edu/ycom/canada/2016/

[25] See: http://www.ecojustice.ca/pressrelease/leading-canadians-call-for-investigation-of-climate-change-denier-groups/

e. To assist the public to effectively discount and disregard ongoing campaigns which are intended to: (i) raise doubt about climate change; and (ii) impede meaningful action to respond effectively to it.[26]

2. <u>As discussed in the "Context" section, above, a global clean energy transition would appear to be well underway, and to be gradually reshaping the global markets within which Canada sells its exports.</u>

The Canadian economy of the future is going to be dramatically different than it is today. Effectively addressing and improving Canada's current low rate of CO2 productivity through the Cleantech Transition will involve massive redeployments of capital, and human and other resources. Proactive engagement by the federal government in skills training and transitional support should help to minimize the social and economic impacts of the transition to low carbon employment, and assist with the development of new export markets to replace those lost as a result of the foreseeably declining demand for fossil fuels.

3. <u>Access to scale is very important to technology companies. The relatively small size of the Canadian economy increases the importance of the public policy environment in facilitating access by Canadian cleantech firms to opportunities to achieve the requisite scale.</u>

Cleantech industries must achieve a critical mass and need access to global scale in order to remain competitive in exponentially growing markets (with exponentially falling prices). Canadian government procurement, incentive programs, international aid programs, export development, and other programs to support Canadian participation will in many cases be critical. Canadian businesses will also need to make a clear-eyed assessment of the areas which have the most potential, (which may exclude markets for products which have already become deeply internationally commoditized). Areas in which Canadian geography or historical engagement may provide Canadian firms with a sustainable competitive advantage in cleantech products and services, could include automotive supply chain, information technology, mineral extraction, and cold weather operations.

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[26] Historical information about the climate change counter movement may be found at: http://drexel.edu/now/archive/2013/December/Climate-Change/ and http://www.amazon.ca/Merchants-Of-Doubt-Naomi-Oreskes/dp/1596916109. For a video of Naomi Oreskes speaking about the book see: http://www.youtube.com/watch?v=XXyTpY0NCp0 Please cut and paste the following link to updated article: http://www.nature.com/nclimate/journal/v6/n4/full/nclimate2875.html?WT.feed_name=subjects_climate-change-policy

Recommendations

Policies and programs which could be implemented to enable Canada to lead the transition to low carbon economy of the future include the following:

1. Appointing a federal Minister of Economic Transformation, who would be responsible for coordinating support for and advocating for cleantech innovation and the clean energy transition to a low carbon economy.

   The scope of the implications of the Cleantech Transition are so broad as to merit the appointment of a Minister responsible solely for advocating and working with the private sector to help coordinate the energy transition to a low carbon economy. This new Minister would, both outside and inside government, serve as an advocate for the required transformational changes. He or she would also help to coordinate the required changes with the private sector, the provinces and territories, and all affected Ministries. (The energy transition and the transformation of the economy to sustainable growth have implications for virtually every other Ministry.)

   The Minister of Economic Transformation, with the support of the Prime Minister and the Cabinet, would work closely in consultation with the private sector and leading academics[27] to clearly articulate, to the Canadian public and other stakeholders, potential roadmaps to a technology-based, sustainable, low carbon Canadian economy. The roadmaps will integrate a coherent vision which brings together technology and innovations in energy and storage with the required changes to computing and telecommunications, buildings, transportation and logistics, and the corresponding changes to education, resource extraction, and other relevant fields.[28]

   While it would be premature to anticipate the outcome of such consultations and the resulting roadmaps, the increasing electrification and use of renewable energy, electric and autonomous vehicles, heat pumps and internet integration may be expected to result in an order-of-magnitude step change increase in the aggregate energy efficiency and productivity of the Canadian economy, and to position Canada to effectively compete in the low carbon global economy.

2. Endowing high profile prestigious chairs in cleantech innovation and economic transformation at leading universities.

   In order to help overcome the inertia associated with our energy and economic status quo, and to assist the Government, and the Minister of Economic Transformation to work with the private sector and the provinces to develop and

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[27] Such as the individuals identified as potential endowed chairs in cleantech innovation and economic transformation in the following section.

[28] As briefly discussed in my submission on "Putting a Price on Carbon", Bill McKibben has characterized the battle against global warming as World War III, and has called for the same level of industrial mobilization to fight this battle as was mustered in the previous World Wars. See: https://newrepublic.com/article/135684/declare-war-climate-change-mobilize-wwii?utm=350org.

articulate the key elements of the roadmap for the energy transition, prestigious chairs in subjects relevant to cleantech innovation and the economic transformation to a low carbon economy, should be endowed at leading Canadian Universities.

Canada should recruit top-ranked academics and thought leaders[29] to fill these chairs to support the economic transformation, and to lead research programs, outreach, consultation, communications and the work of the associated centers of excellence with a view to facilitating the development of clusters of leading cleantech firms in Canada, and to contribute to the further development and implementation of the cleantech roadmaps referred to in the previous section.

3. Support university-based centers of cleantech research excellence and the development of cleantech clusters.

In order to assemble the critical mass of expertise in key clean technologies which is required to create successful and sustainable cleantech clusters, the federal and provincial governments need to engage with post-secondary educational institutions and the private sector to build globally leading research programs (including hiring top-ranked international researchers) in relevant fields[30] and centers of excellence which are focused on leadership in key areas of cleantech research and development. (Studies of clusters of leading cleantech firms have demonstrated that there is a very high correlation between the number of top research programs and the number of leading cleantech start-ups.[31]) The cleantech centers of excellence, in consultation with the leading researchers, chairs, and private sector leaders could provide further advice to the federal and provincial governments with respect to specific policies which would best facilitate the growth and success within the centers' particular domains.

4. Supporting Canadian leadership in the development of cleantech technical standards.

The technical standards which will enable and ensure the interoperability and security of the emerging internet of things (within which cleantech energy production, storage and use, autonomous vehicles, building systems, and other logistical and delivery systems are to interoperate) will underpin the operating

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[29] Examples of such individuals could include Jeremy Rifkin of the Wharton School, Jeffery Sachs of Columbia, and Tony Seba and Mark Jacobson of Stanford. Further information may be found at: http://www.foet.org/JeremyRifkin.htm, http://jeffsachs.org/about/, http://cleandisruption.com/author/cleann/, and http://news.stanford.edu/pr/2015/pr-50states-renewable-energy-060815.html.

[30] Fields that are particularly relevant to the clean economy include: Mechanical Engineering; Materials Science; Material Engineering; Civil and Environmental Engineering; Earth Science; and Oceanography, Atmospheric Science, and Meteorology.

[31] See: https://www.brookings.edu/2011/02/24/the-role-of-leading-academic-programs-in-cleantech-innovation/

system of the emerging clean energy economy and will therefore be critically important to its development.

The cleantech research centers and clusters, together with the leading international researchers would provide the opportunities (and the credibility) for even greater Canadian involvement in and leadership of the development of such technical standards. The further involvement of Canadian industry in such development work would help to ensure that the Canadian private sector is fully up-to-date with the emerging standards and in a position to bring forward products and services which utilize and comply with such standards. (As a leading OECD economy with very close historical, social and economic ties to both Europe and the United States, but is independent of both and is a smaller economy, Canada is uniquely positioned to lead in the development of such highly valuable technical standards.)

5. Measuring, reporting on and applying energy and GDP/TCO2e productivity measures as key metrics for and objectives of government policies.

The timely collection and dissemination by the government of authoritative information about key performance metrics such as GDP/TCO2e productivity will assist the private sector and government to better develop and implement the policies required to succeed in the clean energy transition. In order to meet the key objectives of enabling economic growth while cutting GHG emissions, Canada needs to focus on the development of technologies and industries which will substantially increase Canada's GDP per Kg of CO2 emitted. (In order to meet its current international commitments to reduce GHG emissions while growing its economy and population, over the next fifteen years Canada needs to dramatically improve its average carbon productivity from its current US$2+ per Kg of CO2 to around US$5 per Kg of CO2.) To this end Government policy should focus support and resources on innovations and industries which can best improve Canada's GDP/TCO2e productivity, and improve energy efficiency and productivity.

6. Implementing and expanding programs to assist Canadian cleantech companies to obtain the required funding.

The raising of early stage and venture capital financing for cleantech businesses in Canada has proven challenging. In addition to the suggestions outlined in the Backgrounder, steps that the government could take to assist cleantech companies to obtain the required funding would be further developed through the steps outlined above and could include:

a. backstopping investment pools for early stage cleantech investments;

The provision of a federal or provincial guarantee of the principal amount in pooled investments in cleantech companies could facilitate the application of less onerous securities law requirements for a prescribed class of investment vehicles subject to such a guarantee, and broaden the universe of prospective investors beyond the current class of accredited investors. Such a program could include a number of reasonable safeguards (such as a minimum number of investments, e.g., 20, in a fund and a cap, e.g., 10%, on

the percentage of the fund which may be invested in any one company), protections against conflicts of interest, and other reasonable fiduciary and commercial safeguards such that there should be very little likelihood of a call on the guarantee. The guarantee could also, for example, allow investors to sell their units to the government for the principal amount after a certain period (e.g., three or five years), or otherwise facilitate an exit through sales to other unit holders. The prescribed investment vehicles would have to satisfy a number of prudential criteria and safeguards, including with respect to the qualifications of those establishing and managing them.

b. <u>further tax incentives for cleantech investments; and</u>

In addition to existing programs which support scientific research and development work and renewable energy, further study needs to be made of the opportunities to provide tax incentives for cleantech investments. Options could include preferred treatment of earning from green bonds, the ability to write off, against income, investments in early stage cleantech companies with the full amount of any proceeds being taxed as capital gains, exclusion of capital gains taxes on gains in early stage cleantech companies, and other similar incentives.

c. <u>further coordinated federal and provincial government funding through grants, co-investments, guarantees and other low carbon finance mechanisms.</u>

Such programs need to be constantly reviewed, in consultation with industry leaders, to obtain the greatest innovation, and development value for each dollar invested.

7. <u>Expanding markets for Canadian cleantech products and services.</u>

The development of robust markets for Canadian cleantech products and services, both at home and abroad, is the key to the achievement of the critical mass of sales activities and revenues required to accelerate the virtuous cycle of technology development in Canada. (As discussed in the "Context" section, virtuous technology cycles result from positive network effects, and the continuous learning and exponential growth of technologies, once they achieve the required critical mass. Increasing output drives learning, innovation, better technologies and greater economies of scale, enabling yet better products at lower prices, driving further increases in output, and so on.)

Steps the government could take to assist cleantech companies to obtain the required critical mass of sales are discussed in greater detail in the submission on "How and Where to Reduce Emissions". The specific mix of policies should be engineered to achieve the greatest value and impact, and could include:

a. greater and more focused federal and provincial government procurement of such products and services;

The federal and provincial governments represent massive (in the Canadian context) potential markets for a number of cleantech products and services which may be leveraged (as noted in the Backgrounder) to facilitate the financing of cleantech businesses and to assist them to achieve the required critical mass.

Government procurement can also play a critical role in kick starting networks effects, for example, with respect to electric vehicle charging infrastructure, and in demonstrating the feasibility and advantages of clean technologies. In order to assist early stage cleantech businesses, consideration should be given to the use of a small business set-aside to assist small businesses to win certain government contracts.[32]

b. further tax incentives for Canadian cleantech adoption in Canada;

Deductions and refunds of income and/or consumption (GST/HST) taxes have been used to spur the adoption of renewable energy and other clean technologies (such as electric vehicles) to good effect in a number of jurisdictions (including some in Canada), and could be used to a greater extent in Canada.

c. a steadily and predictably increasing price on GHG emissions and a pollution surcharge on prescribed GHG emitting durable goods;

As discussed above and in my submission on "Putting a Price on Carbon", the consistent imposition across Canada of a significant, and steadily increasing, minimum price on GHG emissions will assist Canadian cleantech businesses by creating the streams of guaranteed savings required to raise the funding. This would also increase the expected value of research and innovation and could provide Canada and Canadian cleantech business with a competitive international advantage (relative to jurisdictions where there is a higher degree of uncertainty as to the future price on GHG emissions).

d. other economic incentives for cleantech adoption by Canadians;

Programs to assist with the costs of energy retrofits, heat pump installations, smart thermostats, electric vehicles and other technologies have been and are currently being used in a number of provinces and other jurisdictions to encourage adoption. The learnings from the cumulative experience with these programs should enable focused programs which provide the highest value (in terms of reductions of GHG emissions, and the development of the cleantech industry).

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[32] For a description of the program operated in the U.S., see: https://www.sba.gov/contracting/government-contracting-programs/what-small-business-set-aside.

e. regulatory actions to create markets for Canadian cleantech products and services; and

Regulatory actions can be highly effective in driving demand for cleantech products. Building code, minimum efficiency, maximum emissions, energy and emissions disclosure requirements, warning labels, and other regulations may be used to help drive adoption of clean technologies in Canada.

f. expanded support for Canadian cleantech export sales.

Export markets are critical to the development and growth of Canadian cleantech products and services, and ultimately to the long term prosperity of the country. Export sales may be supported through initiatives such as the active involvement and support of sales through consular activities, trade missions and other similar events, support for the financing of export sales, and the provision of Canadian cleantech products and services as part of the aid provided to assist less developed countries to adapt to climate change and to mitigate their own emissions.

Questions of the Clean Technology, Innovation and Jobs Working Group

On the website, the Working Group on Clean Technology, Innovation and Jobs posed a series of questions which submissions were invited to address. My responses to these questions follow:

1. How can all Canadians work together to make Canada a world leader in the development and use of clean technologies? What more can governments, industry, academia, consumers and other stakeholders do to support this goal?

   The above observations and recommendations set out some specific suggestions for actions. For all of the reasons articulated in the "Context" section of this submission and the corresponding section of my submission on "Putting a Price On Carbon", this challenge is perhaps the single greatest one faced by this country. It is for this reason that I have recommended the appointment of a new Minister to focus principally or exclusively on the clean energy transition. As suggested above, Canadians need to be fully educated about the climate change problem, the technological developments which are underway and the opportunities for Canada. As a country which is heavily involved in the extraction of fossil fuels the transition is inevitably going to be disruptive to Canada and needs to be coordinated with strong and clear sighted leadership. This is not a transition which can be successfully completed through half measures.

2. What are our national and regional strengths in clean technology? How can we build on these strengths to support clean growth and sustainable development across the Canadian economy?

   The 2016 Canadian Clean Technology Industry Report by Analytica Advisors reports on clean technology companies in Canada in terms of ten technology areas.[33] This represents the base upon which Canadian cleantech companies are positioned to build. We should focus on domains in which Canadian geography or our historical involvement provides a comparative advantage. These could include areas such as electric vehicle supply chain, information technology services, mineral extraction, and cold weather structures and operations. In order to employ clean technologies to substantially eliminate Canadian GHG emissions, extensive investments will be required in the areas of renewable energy generation, electrification of individual and mass long range and local transportation, storage systems for electrical and thermal energy, low energy building construction and retrofits, cold weather heat pump systems, smart grid and energy management systems, and control systems of all types. There will be business opportunities to participate in all of these areas and to develop export businesses around particular areas of expertise (as further enhanced by cleantech clusters).

[33] Report available at: http://analytica-advisors.com/publications.

3. Are there barriers to innovation or shortages of particular skills needed for greater clean technology development, commercialization and adoption in Canada? What are the international best practices from which Canada can learn?

   Canadians face a number of barriers, many of which are attitudinal and educational, which will need to be overcome. The Canadian identity has been closely tied to resource extraction, and with a particular focus, for the past few decades, on the extraction and sale of fossil fuels. It will take a substantial educational effort for Canadians to understand and accept that there is no long-term future in the fossil fuel industry, that technology is the path of the future, and that our skills, training and technology (together with other natural resources) are now our most valuable assets. Research, science, engineering, technical and business skills are among those required for Canada to lead in the Cleantech Transition. Germany would seem to be amongst the leaders in the training of its population to develop, commercialize and export products and services relevant to the low carbon economy.

4. What are the greatest opportunities for accessing global markets, participating in global value chains, and international collaboration?

   The product and service areas identified in the response to question #2, above, would seem to hold the greatest potential for international collaboration. There may be particular promise in areas such as electrical vehicle supply chain, water treatment systems, low temperature heat pumps, thermal energy storage and low energy building systems for cold climates, and smart grid and control systems (among others).

5. How can Indigenous peoples' involvement in, and benefits from, clean technology be improved?

   The development, installation, operation and maintenance of standalone distributed renewable energy generation, storage and management systems, and associated microgrids in remote communities would seem to be an area in which Indigenous Canadians may have a particular comparative advantage. There may similarly be opportunities to specialize in low energy construction and retrofit work, and the installation of heat pump and thermal storage systems.