August 15, 2017

The Honourable Jim Carr, MP
Minister of Natural Resources
Government of Canada
House of Commons
Ottawa, ON, K1A 0A6

Dear Minister,

I thank you for the opportunity to allow the Durham chapter of North American Young Generation in Nuclear (NAYGN) to share what Canada's energy sector could look like in 2050. NAYGN is a non-profit group which provides opportunities for a young generation of nuclear enthusiasts to develop leadership and professional skills, create life-long connections, engage and inform the public, and inspire today's nuclear technology professionals to meet the challenges of the 21st century. The founding principles of NAYGN includes: knowledge transfer, professional development, public information, recruiting & retention and networking. NAYGN has more than 15,000 members and is composed of over 110 chapters across North America, including 9 chapters located across Canada.

As a child, I spent many starry nights looking up in fascination at the seemingly infinite number of shiny specks in the sky. I remember learning in school that the light emitted from these stars may have been emitted millions or even billions of years ago, depending on their distance from Earth. I read about the discoveries of scientists which explained that these balls of hot plasma were continuously powered by a process of nuclear transmutation.

Perhaps my most astonishing personal discovery was finding out that the brilliant physicists and engineers of the 20th century had harnessed these same forces of transmutation here on earth, in the form of nuclear fission to produce electricity.

I was so inspired that I chose to pursue my university education in the field of nuclear science. Today, I am a nuclear engineering professional and I have a vision of the future of energy production in Canada that I would like to share with you.

Forecasting the future with any degree of certainty is an impossible task. I do not think anybody in the early 1900's could have foreseen the technological developments in the last century, let alone all the new scientific fields that were born as a result; biotechnology, computer science, and nuclear physics to name just a few. For this reason, my vision will not venture into the realm of unknowable future innovations. Instead, I dream of a Canadian energy sector 30 years from now, based predominantly on the amazing technologies of today. With present-day nuclear technologies it is currently possible to essentially eliminate harmful emissions, increase the number of highly skilled career opportunities, and propel Canada as a world leader in the energy sector.

I envision a future in which all Canadians enjoy cheap, clean, reliable electricity with minimal CO_2, NOx and sulfur oxide emissions. In the second half of the 20th century, nuclear power faced public opposition. However, with nuclear reactors now in their fourth generation of design, lessons and experiences from the past have been incorporated to make the plants safer and cleaner than ever before. Combined with the increased demand for clean energy, nuclear power presents the best option to achieve this vision.

Unlike the days of yore, when our parents graduated (mostly just high school) and then often obtained lifelong careers, the list of reliable permanent careers has been steadily decreasing. The nuclear power industry, however, has been providing clean, baseload electricity consistently since its introduction in Canada and has been supported by a highly educated and skilled workforce. Within the NAYGN Durham survey [1], 85% of members ranked the importance of job security in terms of starting a career as either important or very important. Within NAYGN the job satisfaction survey of members indicated 83% were either very satisfied or satisfied with their job [2]. Furthermore, of the members polled only 6% were seeking new employment outside of the nuclear industry [2]. The high job satisfaction combined with the high retention within the nuclear industry

clearly demonstrates the nuclear industry represents an attractive career opportunity for the young generation.

When fossil fuels are burned they produce nitrogen oxides and sulfur oxides which can cause smog, respiratory problems and acid rain. I believe that in order to reduce these nitrogen and sulfur discharges, and align with Canada's goal of being a global leader in the Paris Accord, there must be a greater emphasis on clean energy sources. Nuclear power is amongst the lowest carbon dioxide energy producer, with the lifecycle production of carbon dioxide similar to wind and solar [3]; while not producing sulfur or NOx emissions. Nuclear power also requires amongst the lowest area of land (i.e. high energy density) compared to energy produced, requiring up to 360 times less land than wind for the same electrical output [4]. To drastically reduce the use of fossil fuels, Canada will be left with an energy production deficit. If planned accordingly, nuclear energy is best suited to fill this void due to its inherent safety, reliability, and low cost; especially since hydroelectric is already a largely tapped resource and is therefore not a viable scalable option for rapid expansion.

Contrary to some public opinion, nuclear power generation is one of the safest forms of electricity production. Ontario Power Generation's public and employee safety record, for example, rivals or exceeds that of the industry leading major employers in the world. Using the worst-case Chernobyl numbers and Fukushima projections, uranium mining deaths, and using the Linear-Non-Threshold hypothesis, nuclear still ranks the best among energy sources in terms of mortality rate per unit power produced [5]. Reactor designs today are safer than they have ever been in the past. From the NAYGN Durham survey [1], 91.7% of members stated that they would either support or strongly support their children/grandchildren working in the nuclear industry. This poll result demonstrates the confidence young workers have in the safety within the nuclear industry. Furthermore, once capital costs are paid off, nuclear power also provides some of the cheapest electricity. One does not need to look further than Ontario, where hydroelectric power is the only energy source cheaper than nuclear. The Darlington refurbishment project demonstrates the feasibility of such large-scale infrastructure projects and brings with it huge economic benefits [6] to the residents of Ontario.

Newly developed technologies have the potential to provide even better outcomes. For example, recently proposed medium-sized modular reactors can significantly reduce capital investment costs and improve safety even further by being intrinsically safe against all accident scenarios. In anticipating the introduction of such new generation nuclear reactors, assistance will be required to transform our current rigid nuclear regulatory organizations into more nimble and flexible entities that can better respond to the nature of such future designs. Emergency safety systems may not even be required due to the innate safety design of future generation reactors, which make them physically unable to suffer catastrophic failures.

I believe that the greatest challenge we face is an exaggerated public fear of radioactivity and current doubt in the Linear-Non-Threshold (LNT) model for radiation. The LNT model was developed by principally studying large doses and calculating the biological damage (i.e. risk). This model, however, takes these data points and assumes the long term biological damage caused by ionizing radiation is directly proportional to the dose. This model uses the assumption of linear extrapolation from the high dose effects to zero dose thereby stating that all levels of radiation have a risk. With growing research the LNT is being challenged with such models as hormesis (low doses of radiation may be beneficial) and linear-quadratic (low doses of radiation do not have the same relationship to risk as high doses of radiation). We need greater efforts to educate and inform the public about the effects of radiation and to study the low dose and low dose-rate effects of radiation. The precautionary principle underlying the LNT model from can have dire consequences, both in terms of energy policy and on human life. One example of this consequence is that the evacuation area around Fukushima Daiichi was construed based on the LNT model and the evacuation process itself resulted in over 2000 avoidable deaths [7]. For nuclear power to be more widely accepted, the public must have a better understanding of how radiation works and a model which accurately reflects the risk based on dose rates must be adopted.

Another barrier for nuclear energy going forward is the public misconception involving the safe storage and disposal of spent nuclear fuel. Currently the “spent” fuel is placed in the spent fuel repository for around 10 years and then the fuel bundles are placed in casks on site indefinitely. I say “spent” since there still exists a large portion of usable energy which can be available for

reprocessing, such as is done in France. An alternative option may be the reutilization of spent fuel from pressurized light water reactors into CANDU reactors or reprocessing of used fuel from CANDU reactors. Furthermore, a final option must be determined for the disposal of used fuel in order to provide a safer option than simply storing the fuel on site, and to increase public confidence that the full lifecycle for nuclear can be achieved. Such disposal methods are already being explored in Finland and Sweden with evidence that the technical challenges can and have been reasonably and inexpensively solved.

To help achieve the vision proposed, I ask that you spare no effort in supporting fundamental public education and research. Our educational institutions in Canada are the envy of the world. A well-educated generation of Canadians will provide the human resources necessary for achieving and maintaining a skill advantage in leading-edge technology. Historically, Canadian research always seems to provide surprising technological answers to problems that previously appeared insoluble. A well-educated public is one that is more likely to make better informed decisions, which can only benefit Canada. From the NAYGN Durham survey [1], members stated that 73.3% of their family and friends became more supportive of nuclear power since they entered the nuclear industry showing that education can have a large impact on opinions going forward. The setting is ripe for our generation to rise to the challenge and make nuclear power technology a cornerstone of our national energy sector.

I dream of a future, 30 years from now, in which all electricity produced in Canada, 24 hours a day, 365 days a year, is powered by minimal CO_2, NOx and Sulfur Oxide emission sources while still being reliable and cost effective. Perhaps one day, children in Canada will learn that by harnessing the forces of nuclear fission, the global climate change catastrophe was averted. Who knows, one day a child might even marvel at the sun, bewildered by the intensity of the light radiation emitted and pondering the future of the most recent technological breakthrough of the day, nuclear fusion.

Sincerely,

Matthew Mairinger

President – NAYGN Durham

c.c.: Diane Cameron, Director – Nuclear Energy Division, Natural Resources Canada

Emily Pearce, A/Deputy Director, Nuclear Energy Policy – Natural Resources Canada

Attachment: M. Mairinger and K. Palinka, "NAYGN Durham – Survey for Generation Energy," NAYGN Durham, Durham, ON, Aug. 2017.

References:

[1] M. Mairinger and K. Palinka, "NAYGN Durham – Survey for Generation Energy," NAYGN Durham, Durham, ON, August 2017.

[2] NAYGN. (2016). *2016 NAYGN Career Report*. [Online] Available at: http://naygn.org/wp-content/uploads/2012/07/2016-NAYGN-Career-Report-Final.pdf [Accessed 27 Jul. 2017].

[3] WNA (2011). *WNA Report – Comparison of Lifecycle Greenhouse Gas Emissions of Various Electricity Generation Sources.* [Online] Available at: http://www.world-nuclear.org/uploadedFiles/org/WNA/Publications/Working_Group_Reports/comparison_of_lifecycle.pdf [Accessed 28 Jul. 2017].

[4] NEI (2015) *Land Requirements for Carbon-Free Technologies.* [Online] Available at: https://www.nei.org/CorporateSite/media/filefolder/Policy/Papers/Land_Use_Carbon_Free_Technologies.pdf?ext=.pdf [Accessed 28 Jul 2017].

[5] Forbes (2012) *How Deadly Is Your Kilowatt? We Rank the Killer Energy Sources.* [Online] Available at: https://www.forbes.com/sites/jamesconca/2012/06/10/energys-deathprint-a-price-always-paid/#6df3bb70709b [Accessed 08 Aug 2017].

[6] F. Bounajm and A. Pedro, **"**Refurbishment of the Darlington Nuclear Generating Station: An Impact Analysis on Ontario's Economy," The Conference Board of Canada, Ottawa, ON, 2015.

[7] A. Hasegawa et al., "Emergency Responses and Health Consequences after the Fukushima Accident; Evacuation and Relocation," Fukushima Medical University School of Medicine, Fukushima, Japan. Clinical Oncology, Volume 28, Issue 4, 2016, Pages 237-244, ISSN 0936-6555, January 2016.

ATTACHMENT

NAYGN Durham – Survey for Generation Energy

Issued: August 2017

Prepared by:

Matthew Mairinger – NAYGN Durham President

Karissa Palinka – NAYGN Durham Membership & Networking Chair

Introduction:

North American Young Generation in Nuclear (NAYGN) is a non-profit group which provides opportunities for a young generation of nuclear enthusiasts to develop leadership and professional skills, create life-long connections, engage and inform the public, and inspire today's nuclear technology professionals to meet the challenges of the 21st century. The founding principles of NAYGN includes: knowledge transfer, professional development, public information, recruiting & retention and networking. NAYGN has more than 15,000 members and is composed of over 110 chapters across North America including, 9 chapters located across Canada.

The Durham chapter has over 250 members and is composed of members at both the Darlington and Pickering nuclear generating stations (10 CANDU units operated by Ontario Power Generation) as well as the surrounding Durham area just east of Toronto, Ontario, Canada.

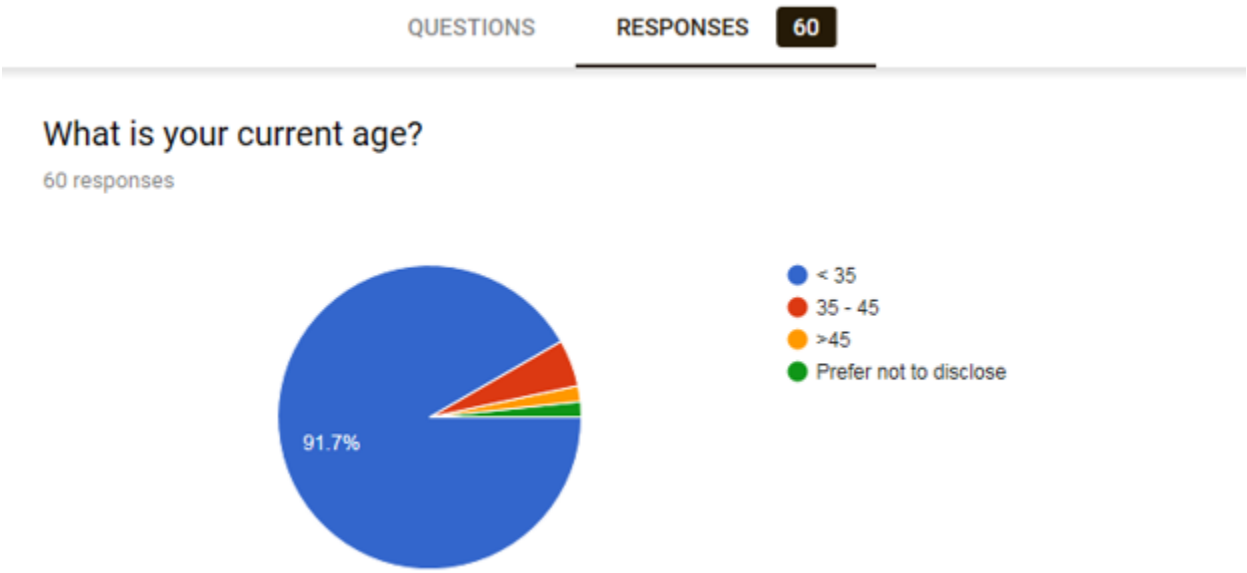
The purpose of this survey was to gauge members opinions of what the energy sector in Canada should look like in 2050 in support of the Generation Energy initiative which was launched by Canada's Minister of Natural Resources – Jim Carr.

Question 1: What is your current age?

Options:

- Under 35 years old
- 35 to 45 years old
- Over 45 years old
- Prefer not to disclose

Results:



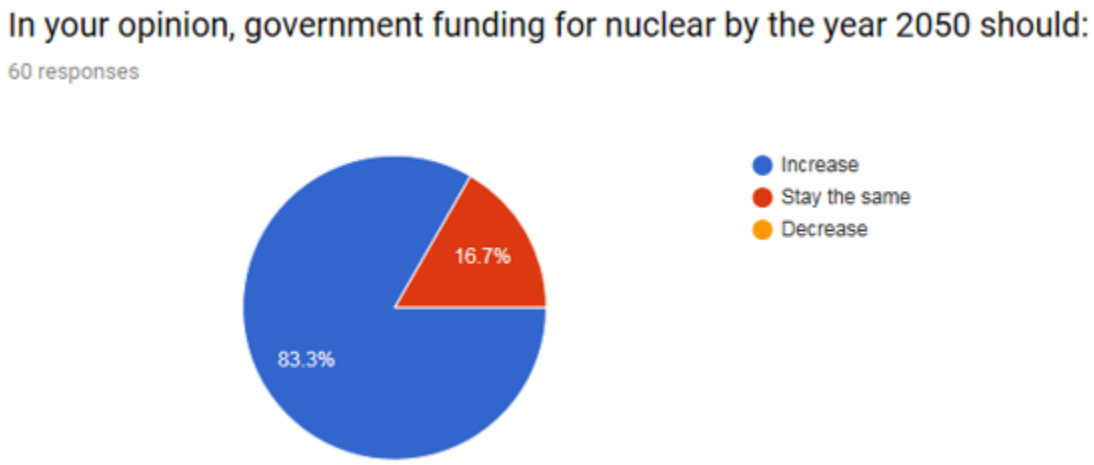
- Under 35 years old – 91.7%
- 35 to 45 years old – 5%
- Over 45 years old – 1.7%
- Prefer not to disclose – 1.6%

Question 2: In your opinion, government funding for nuclear by the year 2050 should:

Options:

- Increase
- Stay the same
- Decrease

Results:



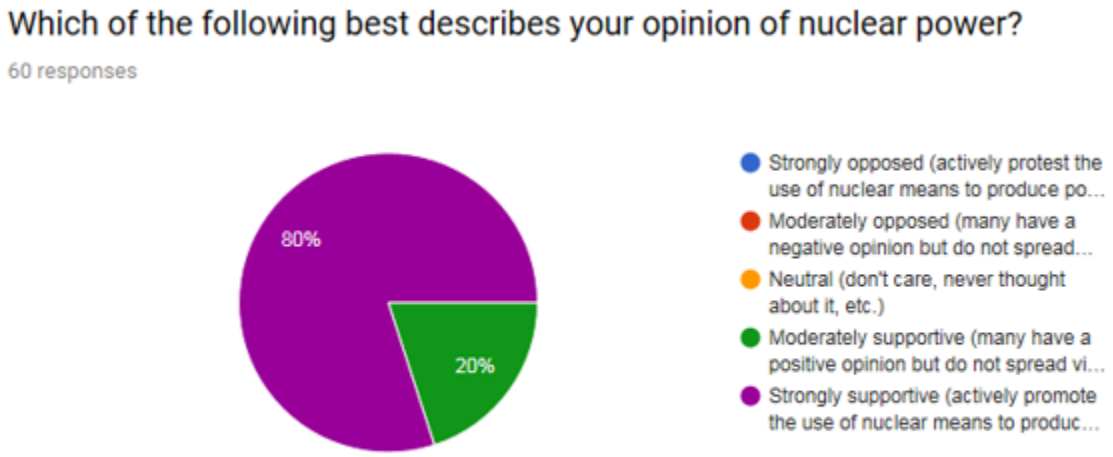
- Increase - 83.3%
- Stay the same - 16.7%
- Decrease – 0%

Question 3: Which of the following best describes your opinion of nuclear power?

Options:

- Strongly opposed (actively protest the use of nuclear means to produce power)
- Moderately opposed (many have a negative opinion but do not spread views to others)
- Neutral (don't care, never thought about it, etc.)
- Moderately supportive (many have a positive opinion but do not spread views to others)
- Strongly supportive (actively promote the use of nuclear means to produce power)

Results:



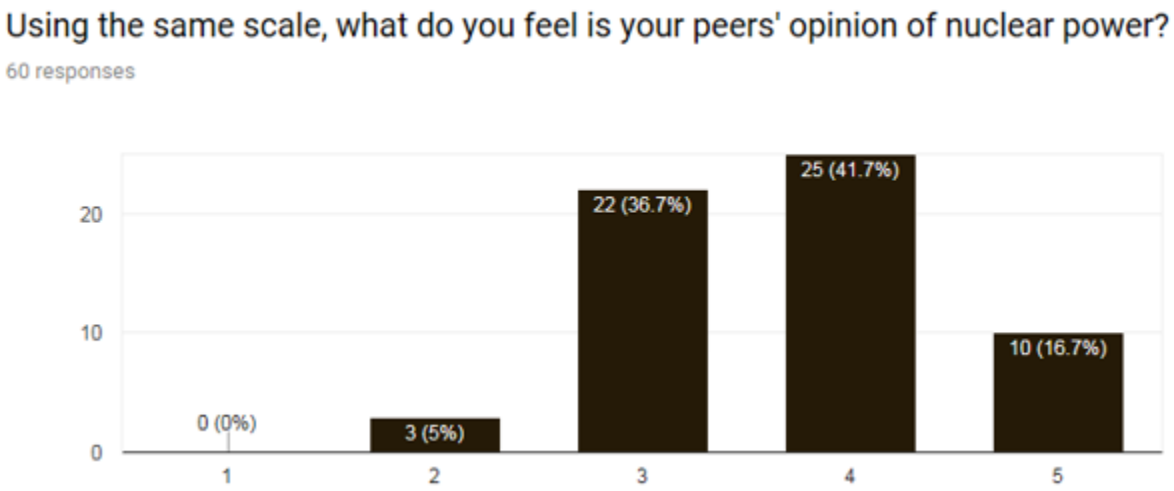
- Strongly opposed (actively protest the use of nuclear means to produce power) – 0%
- Moderately opposed (many have a negative opinion but do not spread views to others) – 0%
- Neutral (don't care, never thought about it, etc.) – 0%
- Moderately supportive (many have a positive opinion but do not spread views to others) – 20%
- Strongly supportive (actively promote the use of nuclear means to produce power) – 80%

Question 4: Using the same scale, what do you feel is your peers' opinion of nuclear power?

Options:

- 1 - Strongly opposed (actively protest the use of nuclear means to produce power)
- 2 - Moderately opposed (many have a negative opinion but do not spread views to others)
- 3 - Neutral (don't care, never thought about it, etc.)
- 4 - Moderately supportive (many have a positive opinion but do not spread views to others)
- 5 - Strongly supportive (actively promote the use of nuclear means to produce power)

Results:



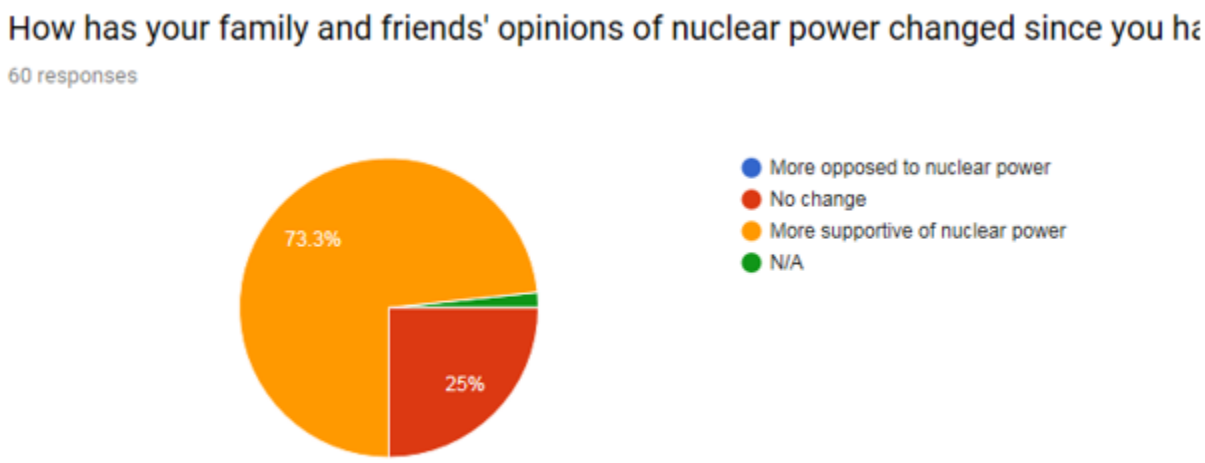
- 1 - Strongly opposed (actively protest the use of nuclear means to produce power) – 0%
- 2 - Moderately opposed (many have a negative opinion but do not spread views to others) – 5%
- 3 - Neutral (don't care, never thought about it, etc.) – 36.7%
- 4 - Moderately supportive (many have a positive opinion but do not spread views to others) – 41.7%
- 5 - Strongly supportive (actively promote the use of nuclear means to produce power) – 16.7%

Question 5: How has your family and friends' opinions of nuclear power changed since you have entered the nuclear industry?

Options:

- More opposed to nuclear power
- No change
- More supportive of nuclear power
- Not applicable

Results:



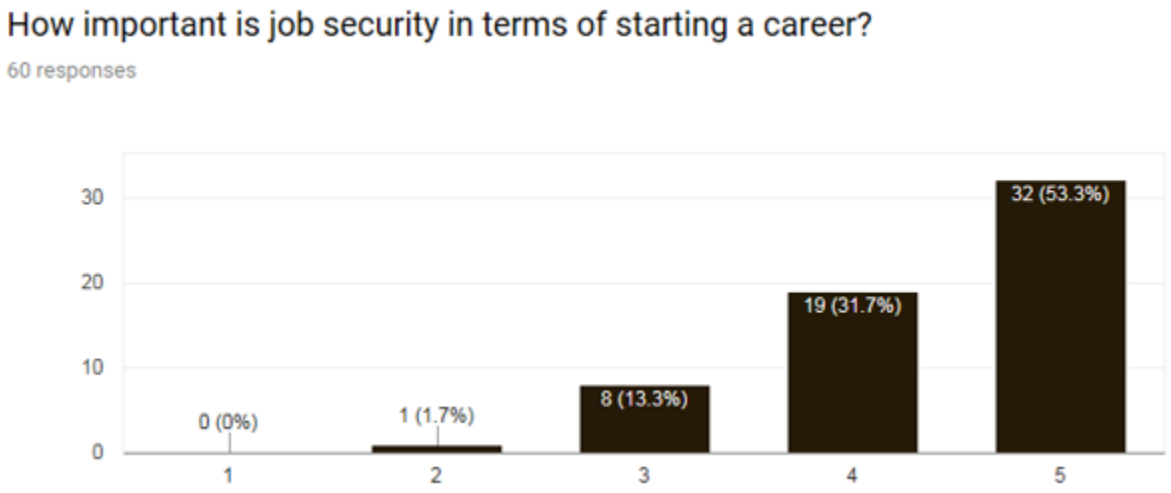
- More opposed to nuclear power – 0%
- No change – 25%
- More supportive of nuclear power – 73.3%
- Not applicable – 1.7%

Question 6: How important is job security in terms of a starting career? (1 being not important at all and 5 being very important)

Options:

- 1 (not important at all)
- 2
- 3
- 4
- 5 (very important)

Results:



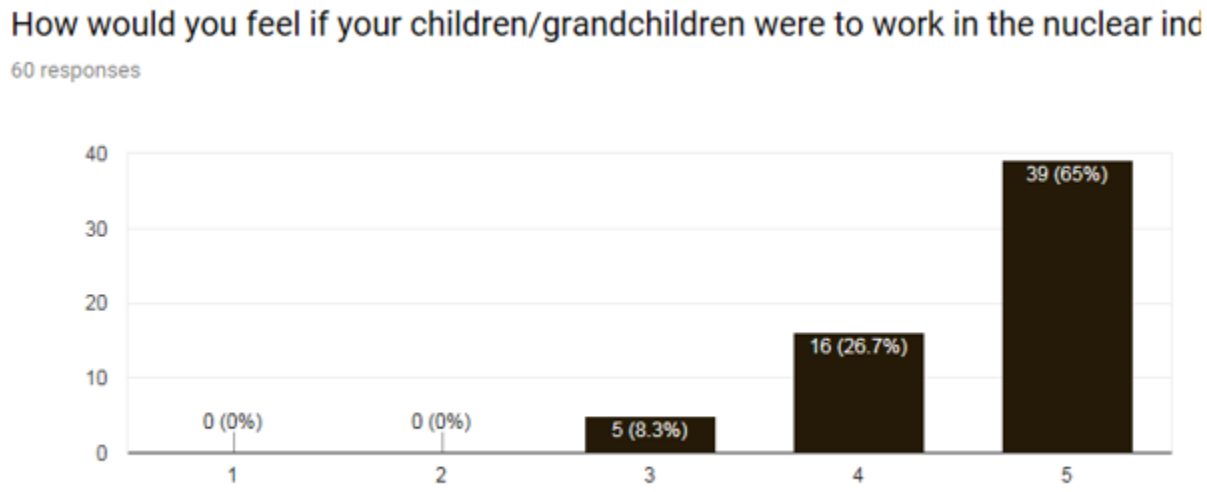
- 1 (not important at all) – 0%
- 2 - 1.7%
- 3 – 8.3%
- 4 – 31.7%
- 5 (very important) - 53.3%

Question 7: How would you feel if your children/grandchildren were to work in the nuclear industry? (1 being strongly opposed at all and 5 being strongly supportive)

Options:

- 1 (strongly opposed)
- 2
- 3
- 4
- 5 (strongly supportive)

Results:



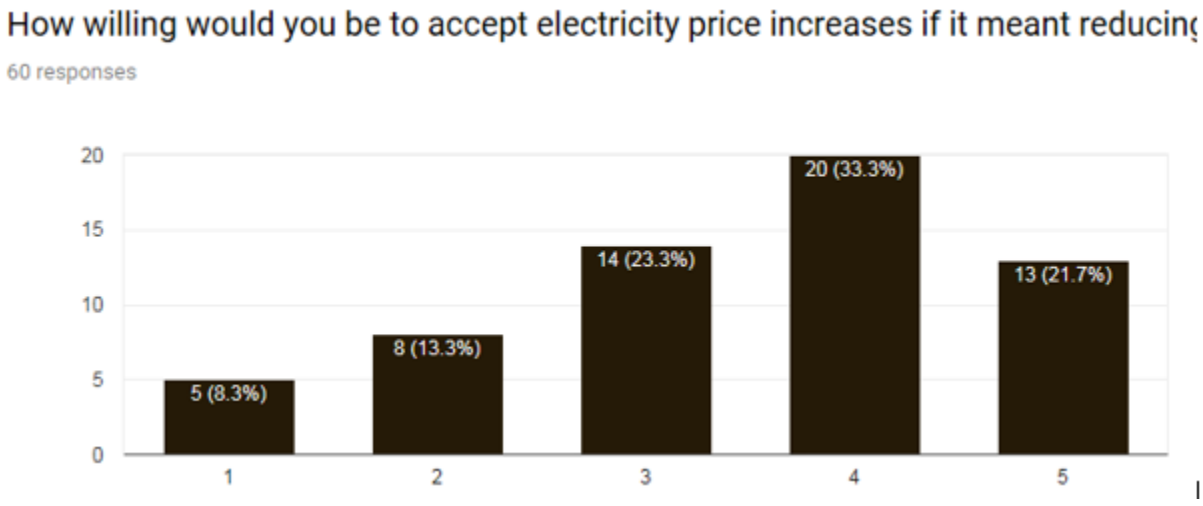
- 1 (strongly opposed) – 0%
- 2 – 0%
- 3 – 8.3%
- 4 – 26.7%
- 5 (strongly supportive) – 65%

Question 8: How willing would you be to accept electricity price increases if it meant reducing/eliminating carbon emissions? (1 being not willing at all and 5 being very willing)

Options:

- 1 (not willing at all)
- 2
- 3
- 4
- 5 (very willing)

Results:



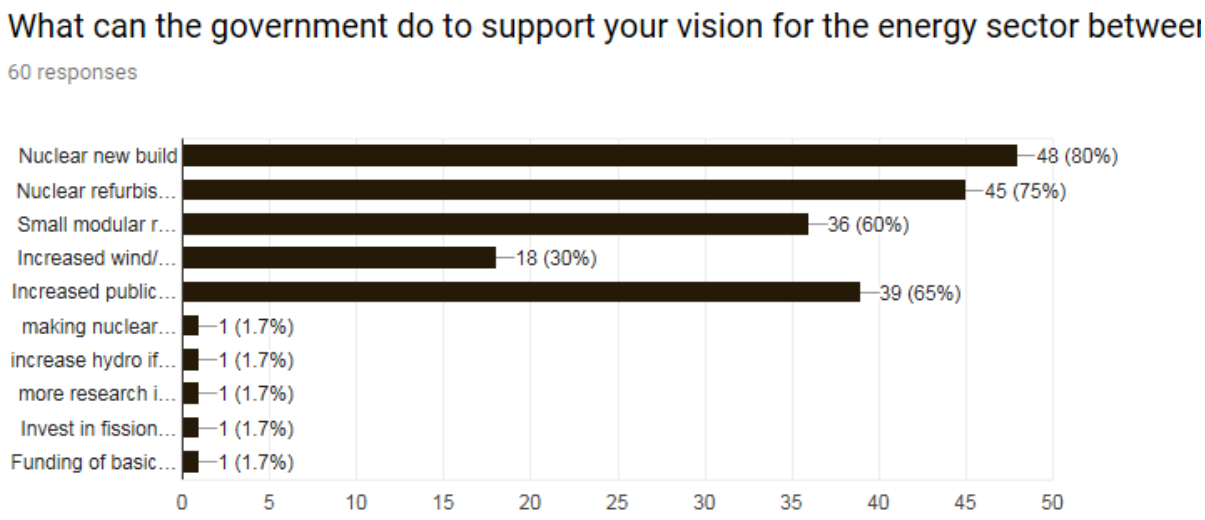
- 1 (not willing at all) – 8.3%
- 2 - 13.3%
- 3 – 23.3%
- 4 – 33.3%
- 5 (very willing) – 21.7%

Question 9: What can the government do to support your vision for the energy sector between now and 2050? (More than one option may be selected)

Options:

- Nuclear New Build
- Nuclear Refurbishment
- Small modular reactors
- Increase wind/solar
- Increased public awareness/education
- Other

Results:



- Nuclear New Build – 80%
- Nuclear Refurbishment -75%
- Small modular reactors – 60%
- Increase wind/solar – 30%
- Increased public awareness/education – 65%
- Other – 8.5%
    - making nuclear power available in remote communities to relieve their reliance on diesel generators (ex. microreactors ("U-Battery") or SMRs)
    - increase hydro if required
    - more research into nuclear waste and its implications
    - Invest in fission research
    - Funding of basic (fundamental / blue-sky) research for undergraduate and graduate students

Question 9: Are there any other opinions you hold on what Canada's energy sector should look like in 2050? What should be federal priorities to help realize these goals? (Long answer blank question)

Results:

1. “Complete elimination of coal across Canada. Increased hydrothermal (where available), increased garbage incineration, increased nuclear whether SMRs. Increased carbon taxes on businesses and individuals, and monetary incentives for businesses and individuals to reduce emissions.”
2. “I think that the biggest road block for more nuclear power in Canada is the public's education and awareness. There are so many people who are scared and against it, simply because they are unfamiliar.”
3. “People are cheap. Good things cost money. That makes things tough.”
4. “More research into renewables but in the meantime, nuclear should be the focus of producing clean energy”
5. “Diversity is good. I don't just support Nuclear but other generation sources as well. Nuclear just has the ability to support base load at a competitive price, with low carbon emissions. By 2050 I would like to see our energy sector be sustainable, but with a more competitive and open market. Ontario is more monopolized in the energy sector (which may be good from a government standpoint), which drives the costs up for the consumers. Encouraging private generation will drive the cost down with a more economic-load-dispatch based system. This can also promote more "green" energy”
6. “Energy sector should be focused to be "low or no carbon power" and doing so in the most efficient manner. Most suitable hydro locations are considered exhausted, space utilization can be an issue for solar farms, nuclear should be considered an ideal option for low carbon power. Climate action should be a federal priority; including aggressive targets for fossil fuel reduction and a strategy to attain them (low carbon power production, public transit improvements, incentives for green initiatives (electric cars, solar shingles/roofs, etc))."
7. “By 2050, large power plants will become mostly obsolete and households will be able to generate and store their own power.”
8. “Canada's energy sector should be further implementing the use of nuclear power. The federal government needs educate the public regarding the cost/benefit and stigmatized safety concerns involving nuclear power.”
9. “Wind and solar should play less roles in the future energy mix as they are intermittent generators. They increase overall cost to the grid as backups are needed from gas generators. We need to invest more in load-following nuclear power plants such as the ones found in France as well as developing more hydro-electric resources.”
10. “We need to jump on board with small modular reactors - we have the best security technology in the world to allow this to happen safely (thanks to Chalk River Laboratories). We also need to lead to world in re-processed fuel reactors. This will change the playing field, create jobs, and place Canada as a leader.”
11. “Nuclear to be a "norm" in society. I think it is really important to hold educational sessions to increase the public's knowledge of Nuclear power. With greater knowledge will come better understanding and realization of the importance nuclear power holds on everyone's daily life.”

12. “Finalize and have built the long term solution for used nuclear fuel, and more actively educate and advocate for the benefits of nuclear power”
13. “A system that prioritizes sustainability in an engineered way. Ensuring the correct energy portfolio that functions well together and is not competing with each other on the grid.”
14. “If there were more research into nuclear waste and the implications of storing growing amounts of it which came out with positive results I would be more supportive of nuclear. However, with such a large half life there is definitely a significant worry to having so much waste which must be monitored practically forever. Until then the focus should be on other green alternatives like wind and solar.”
15. “Nuclear ftw, unless solar energy becomes more cost-effective than nuclear by 2050.”
16. “Invest in research”
17. “Carbon Free Power. This should be a large baseload from Nuclear Power as it is reliable and secure. Natural Gas should not be an option to replace Coal as it is also a fossil fuel and produces greenhouse gases such as CO2. All coal plants in Canada should be phased out completely. There should be some Wind and Solar but less than 10% of the total power produced. Nuclear is cheaper than both of these options and also creates tens of thousands of good pay jobs. Workers invest their money back into the communities they live.”
18. “To help achieve these goals we need to further educate the public on the positive benefits of nuclear energy. This should begin by teaching courses at the high school level and promoting Nuclear Energy in the public to increase public awareness.”
19. “Nuclear R&D should also be ramped up to get Canadian made fusion reactor a reality, so that nuclear power can be almost completely waste free.”
20. “Northern communities could use reliable local power from SMR to minimize the requirements for distribution and the budget for maintaining/building new distribution lines between the northern portion of Ontario and southern Ontario would be reduced. This would reduce transmission costs for the northern communities and in the long term reduce bills and allow for more stable economic assessments for resource projects to occur.”
21. “The government should base their energy decisions on science and engineering (including full life cycle analyses and environmental, social, and economic impacts) rather than on public opinion.”
22. “Get rid of inefficient green power and invest in efficient clean power like nuclear. The wind and solar contracts in Ontario hurt consumers. Green is great, but there are better ways to apply the technology than overcharging consumers. Handing out contracts to wind and solar takes gets rid of the incentive to invest in developing a more efficient means of harnessing power from those sources”
23. “All future challenges that we are aware of are achievable with currently existing technology. Priorities should be to instill optimism and awareness in the public domain, and to seek guidance from disinterested scientists and technical experts (the facts and the physics are indisputable and should provide a foundational framework for future action)”
24. “I think by 2050, solar panel technology and battery technology will be more than capable to produce enough energy for most of Canada.”
25. “Electrification of transport infrastructure. Focus on developing economic forms of generation, including nuclear. Do not cripple the economy and drive businesses South by imposing opaque

carbon pricing schemes or overpriced "green" power that increase costs to ratepayers for generations.”

NAYGN

NORTH AMERICAN YOUNG GENERATION IN NUCLEAR

NA-YGN DURHAM

Email:
NAYGNDurham@opg.com
NAYGNDurham@gmail.com

Twitter:
@NAYGN_Durham

Facebook:
NAYGN Durham