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Electrification and Energy Transition Panel
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Open Call for Written Submissions 2023: The Electrification and Energy Transition Panel

The **Ontario Society of Professional Engineers (OSPE)** is the advocacy body and voice of the engineering profession. Ontario currently has over 85,000 professional engineers, 250,000 engineering graduates, 6,600 engineering post-graduate students and 37,000 engineering undergraduate students. OSPE is pleased to respond to the ***Open Call for Written Submissions 2023: The Electrification and Energy Transition Panel***.

Introduction

The establishment of the **Ontario Electrification & Energy Transition Panel (EETP)** and the initiation of the **Independent, Cost-effective Pathways Study (IC-EPS)** were direct outcomes of consultations conducted by the **Ministry of Energy Mines and Northern Development** regarding the **Long-Term Energy Planning Framework (LTEPF)** for Ontario. During this process, OSPE actively participated and submitted its own response to the LTEPF Consultation. You can access our submission at the following link: https://ero.ontario.ca/comment/54261

OSPE commends the Ministry for taking action on the proposed initiatives and appreciates the opportunity to submit this follow-up document in response to the invitation from the EETP. Our recommendations, advice, and comments are related to the following five themes:

1. Energy Planning
2. Governance and Accountability
3. Technologies
4. Community and Customer Perspectives, Affordability and Energy Sector
5. Facilitating Economic Growth

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Theme 1. Energy Planning

1. Energy Planning

The need for change

To reflect the transformation and transition occurring in the energy sector, changes are needed in the integrated long-term energy planning framework and processes, and the roles and responsibilities of key participants must be clarified. The major ongoing changes in the sector are:

· The growing trend for energy customers to be both consumers and producers of energy (prosumers). Customers must be included as active participants in energy planning.

· The decentralized/distributed nature of supply resources.

· The widespread availability of live system and equipment data to system control centres, providing increased opportunities for wireless solutions.

· The need for plans to be end-use market driven, not just supply-side production based.

· Digitization throughout energy systems.

· Decarbonization to mitigate climate change and reach associated emission targets.

· Interdependence of energy sources, transmission and distribution, and end uses.

· Electrification of the end uses of energy, particularly in the transportation sector and building heating.

· The new **low temperature district heating systems (LT-DHSs)** now being deployed in urban areas in Europe to the recover waste heat from electricity production and industrial / commercial operations

· New generation and information technology commercially available and in development.

· The intermittent nature of renewable resources requiring energy storage.

· Technical advances and cost reductions for energy storage and renewable energy.

· The evolution of transactive and flexible markets.

· The changing role of transmission and distribution.

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The energy planning framework and processes must change to accommodate these transformations and take advantage of the diverse opportunities and advantages they present, while ameliorating their disadvantages and disruption. These changes require improved collaboration and integrated planning of all energy sub-sectors (electricity, natural gas, thermal, diesel, propane, heating oil, and gasoline). Changes must also recognize the roles and expectations of energy stakeholders and end use customers.

Setting the Scene: Factors to Keep in Mind for Integrated Energy Planning

It is generally easier to decarbonize electricity production than other energy supplies. This has led to the common belief that we should completely decarbonize electricity production, and then electrify all energy use. Unfortunately, the engineering and economic facts do not support these two conclusions. There are at least 4 major reasons for this:

1. Zero-emission energy systems have higher fixed costs (capital and labour) and lower variable costs (fuel) than higher emitting technologies. Intermittent generation sources (like wind and solar) require additional equipment such as storage to better align production with demand, and synchronous condensers to maintain stability of the power system electrical parameters. This means zero-emission electricity systems produce electricity at a retail cost at least two times higher than fossil fuelled generation (excluding carbon taxes). Also, the highest 10 per cent of energy demand is infrequent and short lived. Therefore, decarbonizing the last 10 per cent of energy demand is very expensive in a zero-emission electrical system.

2. Production and distribution of electricity is several times more expensive than production and distribution of natural gas for heating. Ontario consumers use twice as much heat as electricity, so electrifying everything creates a significant increase in overall energy costs for the consumer. (This is true even if we use efficiency-boosting technologies like heat pumps, because these pumps cost more compared to natural gas furnaces and traditional air conditioners.)

3. Some zero-emission electricity production technologies produce clean waste heat as a byproduct of electricity production. Many industrial and commercial electricity-consuming processes (data centres, refrigerated storage, ovens, etc.) also produce clean waste heat as a byproduct of their operations. Therefore, it may not be cheaper to use electricity to provide consumers with their heating needs. If the energy consumption density of an area is high enough, other thermal technologies (like district heating) can be more cost-effective than using electricity to supply the heat. Europe is currently deploying low temperature district heating systems in urban areas as a means to harvest waste heat and supply it to consumers for their building and hot water needs. As carbon taxes and energy prices rise in North America, district heating systems in urban areas will become cost-competitive with electricity for the purposes of supplying heat.

4. The expansion of the electricity system to supply all heating demand will be difficult to implement (especially in urban) areas due to public resistance to expanding high-voltage transmission and distribution lines. In urban areas, it will likely be much easier to get public acceptance to deploy buried district heating systems (as opposed to overhead high-voltage lines). Also, most existing lower-voltage,

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buried distribution lines in urban areas are not sized to support the winter heating electrical load. These will need to be replaced at additional cost. Furthermore, as winter heating peaks exceed summer peaks, the main client for the additional installed electricity generation capacity will only be utilized for about 13 per cent of the potential energy supply from that additional capacity.

It is important to differentiate between conceptual energy planning activities needed for setting government energy policies, laws, regulations and financial incentives, and the detailed energy planning activities needed to deploy solutions for consumers' specific energy demands.

Conceptual Energy Planning

Conceptual energy planning for government purposes should be used to set direction for various energy sectors to help:

· Ensure cost-competitive energy options are available to consumers who can then select from those options to minimize their total annual energy cost based on their individual needs. This includes providing energy options that are more appropriate for the location being served and the applications requiring energy. By "location," we mean providing appropriate energy supply options for high-density urban areas, suburban areas, rural areas, and remote areas. By "applications," we mean providing appropriate energy supply options for low-temperature building space and water heating, high temperature industrial heating, and for various transportation needs (including heavy trucks, trains, planes, ships, offroad construction equipment, and personal use vehicles).· Ensure ample supply for each energy option that meets consumers reliability requirements and that supports economic growth and job opportunities.

· Ensure energy options collectively meet environmental requirements.

· Ensure treaty and other agreements with various parties are met.

· Ensure safe operation of all energy infrastructure.

· Prevent industry players or consumers from choosing energy options for specific applications that the government has decided are not compatible with the public interest (e.g., banning the use of coal for electricity production.)

Governments (who undertake conceptual planning) and other sector players (who undertake detailed planning) must share the results of their planning activities with each other. For example, useful conceptual planning studies must be informed by realistic implementation costs, and detailed planning studies must be informed by conceptual planning studies that suggest new energy supply options.

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Recommendations: Roles and Responsibilities of Key Participants

The Ministry's role should be confined to setting high level goals, policy and strategy, and should leave detailed planning and execution to the organizations best equipped to do so. These goals, policies and strategies must be long-term and enduring to avoid drastic redirection by changes in government administration. We must keep political philosophy out of energy planning and execution.

There has been a tendency in the past for the Ministry to micro-manage the various energy sub-sectors, even though it does not have the required engineering or economic expertise and analysis capabilities to execute the task effectively. Over the past 15 years, the Ministry has been issuing "Ministerial Directives" that are over-reaching into design details like supply mixes, detailed rules for pricing, etc. These should be left with the responsible sub-sector entities.

The **Independent Electricity System Operator (IESO)** should continue to have the lead role, responsibility, and expertise for the planning, acquisition, operation, and control of the Ontario power grid, its interconnections with neighbouring systems, and the associated wholesale electricity market. This includes the short-term and long-term planning and acquisition of facilities and contracts, to ensure forecasted consumer electricity demand is met in a safe, reliable, affordable, and environmentally responsible manner consistent with the goals, policies, directives, and strategies set by the Ministry. However, at present, the IESO is not explicitly required to meet the annual emission goals set for the electricity system. This obligation should be added to the IESO's roles and responsibilities.

The **Ontario Energy Board (OEB)** is the independent regulator of Ontario's electricity and natural gas energy sectors. As such, they should continue to have the primary responsibility to set retail rates and regulations that are fair, equitable, and affordable for consumers and that serve the public interest. However, the OEB should also be responsible to make available both firm and non-firm electricity in the retail market, similar to the wholesale market. Firm electricity incurs a global adjustment markup and non-firm electricity does not in the wholesale market. This change in the retail market is necessary to facilitate the introduction of new emission reduction technologies that currently cannot be economically justified (because of the lack of sufficiently large differential rates for the two types of electricity at the retail level). The OEB should also continue to have the role and responsibility of setting regulations, codes, and standards for the integration of **distributed energy resources (DERs)** to the grid. This is an urgent need.

The OEB and the IESO must work closely and co-operatively within their assigned mandates to ensure effective integration of the wholesale and retail markets and develop new innovative market options. Net metering and **EV to grid (V2G)** options are two examples. Throughout the planning process, the Ministry, the OEB, and the IESO must be open to and supportive of innovation. Innovation is critical for the future prosperity of Ontario's economy. Innovation is inherent in the work of engineers, and advice from the engineering community should be sought throughout the energy planning process.

The OEB and IESO should also continue to have the responsibility to provide input, advice, and recommendations to the Ministry to ensure consumers have an ample, reliable, safe, resilient, and affordable supply of energy to meet their needs.

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Local Distribution Companies (LDCs) should continue to have front-line access to consumers and responsibility to deliver energy efficiency and conservation programs and projects. They also should continue to have the lead responsibility for the connection and integration of DERs to their distribution networks, consistent with the regulations, codes, and standards set by the OEB. LDCs should also be required to facilitate the introduction of new technologies to improve the technical and economic performance of the power system including generation, transmission, and distribution.

Answers to most of the specific questions posed by the Panel on Theme 1 are given in Appendix 1.

Theme 2. Governance Policy & Accountability

It is important to differentiate between energy sectors that must operate as monopolies and those that can operate in competitive markets. Monopolies must be subject to more extensive regulations to protect consumers. Electricity distribution, natural gas distribution, and thermal energy distribution are natural monopolies. Monopolies will by their nature involve some form of central planning and contracting for the required infrastructure.

Governments have constrained themselves to options that are familiar and where capability is well-established. We have the systems that we do because of an overabundance of cheap natural gas and extensive hydro resources. Other countries have long-established electric, thermal, and fossil fuel distribution systems. In Canada, we have largely overlooked thermal distribution systems (such as district heating in urban areas) at the provincial level, even though the interest and implementation is increasing at the municipal level. Trying to decarbonize while ignoring significant options is like fighting with one hand tied behind our back. We must be comprehensive and include all cost-effective energy options.

We need to place a higher value on the government's role in establishing high-level goals for society. As Mark Carney suggested in his recent book *Value(s),* "once society has set a goal, it is profitable to be part of the solution and terminal to remain part of the problem." We must set out and commit to clear goals.

Competitive markets will not necessarily require central planning, but a central entity will still be needed to monitor competitive markets to ensure they are operating well and not creating either excessively high prices or a serious lack of supply. Competitive markets can be regulated only to the extent necessary to ensure fair competition, limit market power by any market player, and protect consumers from unfair business practices by market players.

Individual energy sector players will need to plan their business activities and infrastructure deployment in accordance with government policies, laws, regulations and financial incentives appropriate to each type of market (e.g. monopoly or competitive market) and each energy option recommended by conceptual planning studies (e.g., electricity, low temperature heat, high temperature heat, and various fuels).

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Recommendations

While the Minister of Energy has the ultimate responsibility to ensure energy markets are functioning properly, the Minister should not get involved in detailed design, deployment, and operating issues. Those are best handled by the appropriate market players and agencies responsible.

The Minister can and should provide energy markets with policies, targets, and appropriate regulations, with suitable enforcement for each energy sector. These need to be informed not only by what government and consumers want, but also what providers are realistically able to deliver. Energy integration goals and targets should also be included and assigned to the affected sectors.

Deployment plans should be prepared by the parties responsible for deploying various energy infrastructure solutions, and subject to approval by the Minister or a designated agency like the OEB if the plans require more extensive reviews and public participation.

On the regulatory front, including barriers to implementation of plans, we make the following recommendations:

1. There is an urgent need to develop and implement fast-track regulations for the permitting and approval of charging infrastructure projects. The current process can take two to three times the actual length of time to install the projects.

2. The current process for **Environmental Assessments EA** of the **right-of-way (ROW)** for overhead bulk transmission lines is cumbersome, time-consuming, and has uncertain outcomes. For ROW in rural areas, the approval process should be subject to time limits. In urban and suburban areas, undergrounding the lines should be considered where it is technically and economically practical. Although much more costly than overhead lines, there is much higher probability and certainty that the approval can be obtained in a timely manner.

Answers to most of the questions posed by the Panel on Theme 2 are given in Appendix 2.

Theme 3. Technologies

All commercially available technologies (and those forecast to be commercially available within the planning period) should be considered. Each has advantages and disadvantages, and some may be well-suited to solving problems in unique situations. This will require detailed analysis of alternatives to establish their affordability, reliability, and sustainability characteristics.

OSPE has prepared an analysis of the mix of generation technologies that can achieve net-zero goals for the electricity grid by 2035. The preferred mix to maintain a reliable, operable, and resilient grid, and keep rates affordable, involves a combination of new nuclear and pumped storage added to the existing nuclear, hydro-electric, solar **PV (photovoltaic)**, and wind turbine assets. Alternative supply mixes with a higher penetration of wind and solar technologies were found to result in significant additional cost to the consumer. This is due to the high cost of long-term energy storage facilities and the extra capacity

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required to integrate intermittent, weather-dependent generation while maintaining grid reliability, operability, and resiliency standards.

For all supply mix alternatives studied, it was found that there was a large quantity of low-temperature, zero-emission thermal energy discarded to the environment as a byproduct of electricity production. The opportunities to harness this thermal energy for building heating in urban areas (and avoid the need to expand the electricity system) should be seriously explored. The resulting higher efficiency of all energy use would help meet decarbonization goals in a more cost-effective manner.

The analysis also showed a large availability of surplus zero-emission electricity in all supply mixes. The opportunity to use this surplus electricity to produce hydrogen (by electrolysis) to replace fossil fuels used in industrial processes and heavy-duty transportation should be explored. Hydrogen, biomass, and heat can also be combined to manufacture synthetic zero-emission liquid fuels for applications like airplanes (which cannot economically use batteries or gaseous fuels).

The Executive Summary of the OSPE Electricity Supply Mix Study report is included in Appendix 6. The full report can be downloaded at: Ontario-Electricity-Supply-PRINT.pdf (ospe.on.ca)

Recommendations

The opportunity to apply the significant amount of thermal energy waste for building heating should be explored and analyzed. This will reduce the need for electrification of heating needs and produce a more efficient, less costly energy supply. Further information and recommendations on the synergies of electricity and thermal energy planning are contained in Appendix 7.

Complimentary to this, LDCs and municipalities should take the lead role in revisiting and re-evaluating the opportunities for implementing and operating district heating distribution systems.

The timely licensing, permitting, and approvals for the **Small Modular Reactor (SMR)** project at Darlington being undertaken by **Ontario Power Generation (OPG)** is critical to demonstrate that this is a sound, safe, and cost-effective technology for the decarbonization of the power grid. Full support to eliminate unnecessary delays in the approval process should be a priority of the federal and provincial governments.

Maintaining and strengthening cost-effective energy efficiency technologies and conservation programs in all energy sectors is strongly recommended. A unit of energy saved at the consumer's premises is a unit of energy that does not have to be produced, transmitted, and distributed, thus reducing power system costs. It also contributes to decarbonization, can improve industrial productivity, and reduces **transmission and distribution (T&D)** losses.

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It is important to support ongoing **Research and Development (R&D)** in Ontario to improve the performance, efficiency, and cost effectiveness of existing technologies and develop promising new technologies to commercial status.

Also, many other jurisdictions are much further advanced than Ontario in some aspects of the transformation and transition of their energy sectors. To avoid "reinventing the wheel," it is recommended to explore and learn from their experience as to what works (and, more importantly, what doesn't) in relation to technologies, plans, programs, and processes.

Answers to most of the questions posed by the Panel on Theme 3 are given in Appendix 3.

Theme 4. Community & Customer Perspectives, Affordability, and Energy Sector Objectives

Since Ontario requires energy projects on Indigenous lands to be conducted in partnership with the local communities, there is an opportunity for training and employment of local workers to the benefit of those communities.

Recommendations

It is recommended to address the disruptions resulting from the transformations in the energy industry, such as the expected decline in the oil and gas sector and accelerated growth in the electricity and district heating sectors. This will require the expansion, retraining, reskilling, and relocation of skilled trades, technologists, and engineers.

The role and input of stakeholders, customers and Indigenous communities must be included in the process through consultation, outreach, and engagement to educate, learn, and appreciate their needs, preferences, and expectations.

In the case of Indigenous communities, it is important that engagement be done at an early stage.

Answers to some of the questions posed by the Panel on Theme 4 are given in Appendix 4.

Theme 5. Facilitating Economic Growth

New energy and information technologies will provide ample economic stimulus and growth as they are deployed. However, transition plans will need to consider the phase-out of older high-emission technologies to avoid precipitating excessive costs from stranded assets in the rate base.

Recommendations

Maintaining reliable and affordable energy is critical for the retention and attraction of industrial, commercial, and manufacturing entities to ensure economic growth in the province.

Authorities must explore and assess supply chain sourcing, availability, and limitations. Ontario and Canada are blessed with an abundant availability of raw materials, mining know-how, and skills to resource, develop, manufacture, and build the assets and infrastructure needed to successfully implement energy plans. Preference should be given to "Made in Canada" facilities and solutions to boost the provincial and federal economies.

Answers to some of the questions posed by the Panel on Theme 5 are given in Appendix 5.

APPENDICES

Appendix 1.
Answers to the specific questions posed by the Panel on Theme 1 – Energy Planning.

Achieving Integrated, Long Term Energy Planning

Q1 – Energy flows need to be modelled on an hourly basis to properly capture the installed capacity requirements and energy requirements of consumers for each type of energy demand. Conceptual studies should include simulation studies with a goal of reducing the consumer's overall energy costs and emissions. The optimization process should be informed by detailed planning studies by market players of the estimated costs of each energy option being considered in the optimization studies.

Q2 – Deploying new technologies too early will increase consumer costs. Deploying new technologies too late will miss opportunities to lower costs and emissions. Therefore, close collaboration between the conceptual energy planning studies and the detailed planning studies must be part of the planning process to properly assess a realistic deployment strategy that can then be modelled for costs and emissions.

Q3 – Electricity use, thermal energy use, and transportation electrification requirements should be included in any integrated energy planning studies. The different locations (urban, suburban, rural, and remote areas) will have different energy solutions based on cost optimization. That degree of geographic fidelity in the analysis should be achieved.

Q4 – An hourly simulation of energy demand should be included in any conceptual analysis and optimization. The optimization results should inform government on what energy solutions to encourage and incentivize; however, the choice of what options to actually select should be left to the individual consumers. Each consumer has their own financial obligations and knows what financial resources they can allocate to their energy needs to meet government emission goals. Government incentives can be used to accelerate adoption if necessary.

Q5 – Cultural considerations are best provided by the affected groups.

Q6 – Energy conservation and energy efficiency should always be included in future demand studies, but the conceptual planning staff need to be aware that energy efficiency and conservation need to be cost-effective compared to supplying additional zero-emission energy. For example, there are economic

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limits to how much insulation can be used to reduce building envelope heat loss in winter or heat gain in summer. Also, some energy efficiency programs distort hourly energy use profiles, and those distortions should be included in the simulation analysis to ensure the conservation programs are cost-effective for the energy system as a whole.

In past years in Ontario, energy conservation programs that reduced nighttime electricity use ultimately increased the amount of clean electricity that was already being curtailed at night. In the future, the amount of curtailed clean electricity will rise dramatically as we approach zero-emissions. OSPE simulations suggest that at least 20 per cent of energy production capability will be curtailed compared to actual energy use, due to low energy demands at night. These amounts will be much higher if larger amounts of intermittent sources of electricity (such as wind and solar) are used in the future. The current cost of electrical storage is too high to economically reduce the level of curtailment.

It is important to recognize that if district energy systems are used to decarbonize space heating, thermal energy storage will be an available and important feature. Longer-duration low-temperature thermal energy storage is approximately 100 times cheaper than longer-duration electrical storage. Instead of curtailing renewable (or other) electricity production, surplus electricity can be converted and stored as low-temperature heat (or cold) to avoid wasting electricity through curtailment.

Q7 – The IESO's current planning process, with inputs from local utilities as part of the regional planning process for electricity demand, is effective for electricity demand only. What is missing is the need to recognize emission reduction targets as part of that planning process, and to include other forms of clean energy in competition with electricity (such as clean heat and energy carriers like hydrogen and renewable natural gas). Part of that gap can be reduced by making IESO responsible for meeting emission targets for the electricity system. However, to decarbonize the economy as a whole, some entity needs to be mandated with conducting conceptual planning and simulation analysis on total energy needs.

Currently the IESO and Enbridge are in competition for space, water, and cooking heating energy demand. The IESO is now in competition with the unregulated fuels sector for transportation energy demand due to electrification. It is likely better to have a new entity that works with all the competitors (IESO, Enbridge and non-regulated fuel providers) to conduct the conceptual planning studies and simulations to optimize energy use and recommend to what energy options should be encouraged or discouraged to reduce consumer costs and meet emission goals. Presently Ministry of Energy does not have the technical or financial analysis expertise to conduct hourly energy flow analysis and optimization studies. Nothing precludes the Ministry from performing the conceptual planning studies, and simulations but the required expertise will need to be acquired or contracted from private companies that perform such studies for other jurisdictions (Europe, USA, etc.).

Scoping such studies will be very important if the work is contracted out. Most contractors will respond to procurement specifications. If the specifications are flawed, the results could suggest technology deployment that is too expensive and ineffective at reducing emissions quickly. Early studies of various energy options in Europe and the USA were plagued with incorrect simplifying assumptions, such as averaging hourly energy use over several years, ignoring transmission constraints, and incorrectly using

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levelized cost of electricity (LCOE) data. These simplifying assumptions resulted in study recommendations that were incorrect. It took years to discover the errors. In the meantime, many government entities used those faulty recommendations to deploy energy policies and incentives that have resulted in operational problems for power system operators such as **PJM (Pennsylvania-New Jersey-Maryland Interconnection)**, **CAISO (California Independent System Operator)** and **ERCOT (Electricity Reliability Council of Texas)** in the USA, and that are now being reported in their more recent system assessment reports. Here in Ontario, we experienced our own problems after 2010 with significant curtailment of clean electricity, wholesale market price volatility and rapidly escalating retail rates. Policy changes and market rule changes were necessary to correct some of the problems. However, the contractual costs of the policy errors are now embedded into the Ontario provincial deficits until the contracts expire.

Q8 – Local distribution companies (electricity, natural gas, and unregulated fuels) and local municipalities can participate by inputting into the provincial conceptual energy studies, and later by performing detailed planning studies to deploy various energy options. Conducting conceptual energy planning studies at the local municipal level is problematic because most municipalities and small electrical distribution companies do not have the technical and financial resources to undertake such complex studies and simulations. Also, most local municipalities and associated distribution utilities are unfamiliar with emerging (and potentially less expensive) energy systems like district heating systems for space and water heating.

<u>Improving the Long-Term Planning Process and Outcomes</u>

Q1 – Reliability, affordability, and sustainability are core requirements and must all be met in the longer term. However, during the energy transition, the individual items should have different priorities.

Reliability should receive the highest priority from the beginning. Our energy systems operate our entire economy and keep us all safe during winter storms. Therefore, reliability cannot be compromised.

The next priority is affordability. Consumers are currently suffering from high inflation and wage increases which are lagging behind inflation. Decarbonizing will increase energy costs, so it is important to minimize the cost of emission reduction (so the government does not lose public support for decarbonization).

Sustainability should be last because Ontario is currently leading the world in electricity system decarbonization and is now deploying electric vehicles for personal use transportation. Ontario will still be a leader in decarbonization even if Ontario takes a little longer to achieve net zero across the economy. Major emitters such as China and India are not planning to fully decarbonize until 2060 or 2070, and Ontario is an insignificant contributor to total global emissions. Taking more time to achieve net-zero without imposing excessive costs on consumers is important because Ontario relies on trade for many domestic jobs.

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Furthermore, long-term planning needs to be more comprehensive. Many northern European (and increasingly, Korean and Chinese communities) have the option of either electricity or thermal networks for decarbonization of building heating. Because they lack a strong voice in planning consultations, thermal networks/district heating have been almost completely overlooked, even though such options could be less expensive than electrification when full costs are considered (especially for higher-density urban areas). For example, the heat rejected from the **Pickering Nuclear Generating Station (PNGS)** is sufficient to heat much of the **Greater Toronto Area (GTA)** if that heat was combined with a longer-duration low-temperature large-scale thermal energy storage system. Such a district heating system would reduce the need to expand the electricity system in the GTA. This could stabilize or even lower future electricity prices.

Q2 – Key outcomes for long-term energy plans will depend on the locations affected. Larger urban areas are likely best served when **district energy systems (DESs)** include community thermal storage systems, similar to Europe's larger cities. DESs will also minimize the amount of electrical system expansion in cities where it will be both difficult and expensive to add more electrical capacity.

Rural areas are likely better served by cold weather heat pumps with local thermal storage where space is not a problem. In the longer term, synthetic zero-emission liquid fuels may become economical and could be distributed like heating oil or diesel to rural homes and businesses.

Small remote communities are likely better served by integrated electric/heat energy sources like zero-emission, passively safe, micro modular reactors with district heating. There could be opportunities for remote community residents to operate and maintain these reactors with parts and fuel support from larger cities.

Individual remote residences could use biomass combustion to meet their heating and cooking needs. Electricity could be provided by solar panels and a modest amount of battery storage. In the longer term, synthetic zero-emission liquid fuels may become economical and could be distributed like heating oil or diesel to remote residences.

Some small communities can also use biomass heating systems. In Oujé-Bougoumou, QC, a biomass district heating system has served heating needs since 1992 using local sawmill residues.

Q3 – Energy demand in the future is impacted not only by population changes, but also by relative pricing (including government incentives). Short-term forecasts are more accurate than long-term forecasts because uncertainties increase the further out the forecasts are made. Therefore, some flexibility in deployment plans is necessary to avoid over- or under-building new infrastructure. Deployment plans need to be regularly reviewed, re-forecasted, and adjusted.

Q4 – Province-wide emission targets need to be established not by decree, but by rolling up deployment plans, monitoring progress, regularly reforecasting progress, and revising incentives and deployment plans which should result in revised annual emission targets.

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Policy change and regulation can also be important. Thermal electric power plants could be required to be located and sized so they can sell heat to a **district heating system (DHS)** where a DHS is economically attractive. Building more landfill sites should be the option of last resort, with preference given to using municipal waste for combined heat and power fitted with the latest state-of-the art emission controls. Forest resource planning can be enhanced by stimulating and encouraging the production of forest residues for use as fuel by thermal energy systems. Currently, Canada exports some forestry products to Europe for use as low-emission fuel in district energy systems. Such policy or regulation changes can send a powerful signal to energy planners and communities as to what options are desirable and effective for decarbonization. Some countries have even considered ways to discourage wasting heat from industries, possibly a tax on waste heat.

Q5 – Project approval timelines are much too long to meet 2050 net zero targets. If net-zero 2050 is that important to society, the associated implementation plans (including project approval timelines) need to be consistent with the 2050 goal. If project approvals cannot be streamlined, then we need to stop publishing goals that are unrealistic; otherwise, public support for the energy transition will disappear and the goal will not be met regardless of the date. We need to find more time-efficient engagement processes that balance societal needs with individual community needs. When timelines are very short, it is likely we will not be able to satisfy both societal and community requirements completely. Reasonable compromises by various parties will need to be part of the project approval processes.

Q6 – Projects are frequently delayed when there is no clear understanding of who should pay for unforeseen work. If project timelines are critical, then a mechanism to guarantee payment of unforeseen work must be established. That guarantor is often the public, via government subsidies during execution or cost recovery certainty when the project is completed. Also, electrification of heating options (demand reduction and heat pumps) is often looked at from the building owner perspective, and the costs to expand electricity generation and distribution systems are seen as “someone else’s responsibility.” Those costs are not included in project evaluations, thus distorting choices and undermining the planning process to achieve net-zero at an affordable cost.

Q7 – Indigenous equity participation suggestions should be provided by the affected groups. Cultural values and the importance of sustainability and self-reliance may lead to decisions that may be different from what others perceive.

Q8 – The current net-zero 2050 goal has been established by decree without analyzing historical data for energy infrastructure deployment, the associated human and natural resources necessary, and the availability of those human and natural resources to ensure we can achieve the 2050 goal. Simply throwing more money and people at a project generally results in project chaos, not improved progress. The past is littered with projects that failed when additional pressure and resources were applied to a project that was falling behind without careful analysis of the root causes of the delays.

Q9 – Some of the new technologies that can more rapidly reduce emissions at lower cost will involve steep learning curves. For example, if we want to rapidly build out district heating systems in higher-density urban areas, we need to find ways to speed up the process of approving easements for underground district heating pipes, create a new utility to market and supply heat without burdening

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the consumer with large upfront capital costs, and negotiate contracts with zero-emission heat providers to supply that energy to the district heating system. All this will likely need to be done in parallel with deploying the system, which means a party with financial means – likely government – will need to guarantee the various contractual arrangements.

Appendix 2.
Answers to the specific questions posed by the Panel on Theme 2 – Governance and Accountabilities.

Q1 – Currently, the IESO is not responsible for meeting emission targets. Currently, the OEB is not responsible to ensure that wholesale market pricing and retail market pricing are compatible with each other and provide similar behavioural incentives. For example, the wholesale market differentiates between firm capacity-backed electricity and spot market electricity that is not capacity-backed. The retail market only recognizes firm capacity-backed electricity. This creates a situation in which adjoining power systems can purchase Ontario spot market electricity at much lower rates than domestic consumers. The result is a growing amount of surplus clean electricity that is often curtailed because adjoining power systems cannot absorb the quantity available and domestic consumers cannot afford to use that surplus at the higher prices demanded by retail rate plans. The OEB must be held responsible for making sure the retail and wholesale markets are more effectively aligned with respect to price signals for both firm and spot market electricity.

Various other government goals and targets can also be included in directives to the OEB, IESO, Enbridge, and other market participants consistent with their mandates and contractual obligations. To the extent possible, governments should not mandate specific technology solutions, but instead implement the market design, price signals and access rules to ensure any technology can compete fairly in the market based on price and performance. Consumers or agencies who purchase technology can then chose the best combination of price and performance to meet their needs.

Q2 – Integrated planning is important because some technologies can supply more than one clean energy product. A consumer does not usually care if their heat comes from the electricity system or district heating system. However, where district heating systems can be built economically compared to electricity systems, a consumer cannot take advantage of that lower cost heat source if the district energy system has not been made available by the government. There is no business incentive for electrical utilities or natural gas utilities to offer district heating to consumers, because that would reduce their sales in electricity or natural gas. The provision of district heating systems, where they can be built economically, is initially the responsibility of government until a district heating utility is created, which can then compete for heating load with electric and natural gas utilities.

<u>**Accountability**</u>

Q1 – Success and failure will be determined based on whether government fully understands the technical and resource constraints of each technology to contribute to reliable energy supply and zero-emissions.

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For example, most policy makers do not fully appreciate that for every installed kW of zero emission generation capacity, the reduction in carbon dioxide emissions is directly proportional to the operating capacity factor of that generation technology. That means a nuclear plant operated as a base-load facility in Ontario can reduce emissions 6x more than the same installed capacity of solar PV plus storage and 2.6x more than wind turbines with storage and 1.6x more than hydroelectric. Nuclear and hydroelectric plants are well-suited to supply base load and intermediate load with zero-emission electricity. Solar PV and wind turbines with modest amounts of electrical storage are better suited to supply peak load with zero-emission electricity.

Alternatively, in communities where district heating or cooling schemes can be implemented cost-effectively, surplus energy can be much more economically stored as heat or cold. Large thermal electric plants (nuclear, biomass or municipal waste) serving those communities can be designed as **combined heat and power (CHP)** plants that can produce varying quantities of electricity and heat. When there is a need to produce more electricity, the heat load can be dropped and met from thermal storage at a cost less than one per cent that of electrical batteries.

Also, nuclear does not require additional synchronous condenser equipment to stabilize electrical parameters, whereas solar PV and wind turbines do. Nuclear can also supply zero-emission low temperature heat as a byproduct of electricity production if a low temperature district heating system is available to consumers near the plant for their space and water heating needs.

Several of the world’s major electricity systems (including Ontario) have already decarbonized their electricity system by more than 90 per cent using primarily hydroelectric or nuclear, or a combination of both. No major electricity system has been able to achieve 90 per cent decarbonization using primarily solar PV and wind turbines. This is primarily due to the need for an affordable zero-emission backup when the sunshine or wind is not present. Affordable zero-emission backup sources of electricity are not currently available. Most jurisdictions that have high penetration of solar PV and wind turbines have had to resort to natural gas or coal fired backup to keep electricity rates affordable and consequently their electricity system emissions are still much too high.

Q2 – The most important performance metrics are the annual emission profile and average cost per delivered kWh (or kJ) of energy compared to the annual targets. Emission targets should progressively fall to zero by 2050 if that is the net-zero goal for the economy as a whole. Cost targets should progressively rise until 2050 to accommodate the higher fixed cost of zero-emission energy systems.

Where district heating systems are economical, the demand for additional electricity capacity can be lowered and additional revenues can accrue to electricity generators, and industrial and commercial waste heat providers.

Q3 – Performance metrics for individual agencies and market participants can only be established after the detailed deployment plans have been established. There must also be a process to confirm performance metrics are reasonable and achievable, or else accountability cannot be enforced. Many of the processes involved in approving and deploying energy infrastructure are under the control of government or regulatory agencies (not market players). The 2050 net zero goal is very aggressive and

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inconsistent with current regulatory processes for project approvals. There is also a major concern about the availability of both human and natural resources to meet the 2050 net-zero goal, which is only 27 years away.

There is currently a lack of thermal energy system expertise in policy and other planning groups. Special efforts should be made to include such capability so that more comprehensive planning is possible.

Q4 – The timelines for the 2050 net-zero goal are so aggressive that it is unlikely normal contractual methods to ensure contract performance (like performance bonds, penalties, or contract cancellation) can be used. Companies will not bid on projects that are seen as no-win situations. New time-efficient processes must be developed to resolve contractual disputes and help keep projects on schedule.

Public Private Partnerships (P3s) are a way to advance implementation of some technologies where the scope of work is very clear and opportunities for unforeseen work are limited. A clear signal from government as to what it wants to do may see more P3s emerge that can accelerate implementation. Decreasing perceived risk is one of the most important roles that government can play in stimulating private (or indeed public) utility participation.

Q5 – Better alignment between provincial and federal goals and targets is important. Currently, targets are being established by both levels of governments without clear indication of an alignment with the deployment plans by the other government level and associated market players. More discussion and co-operation and better integration of the detailed planning data are required.

Appendix 3 - Answers to the specific questions posed by the Panel on Theme 3 - Technologies.

<u>The potential of emerging technologies</u>

Q1 – There are several emerging technologies that could contribute to decarbonization efforts and reduce transition costs. However, as Ontario learned from the premature deployment of solar PV, deployment before costs have fallen sufficiently can lead to high prices being locked into contracts for many years. Consequently, R&D and protype support from government is necessary for promising new technologies so they reach the commercialization stage. However, aggressive incentives to accelerate deployment should not take place until unit costs are sufficiently low to enable economies of scale to lower the unit costs to an affordable level. Integration of the planning of electricity and thermal systems may see much greater potential for efficient technologies such as **CHP (combined heat and power)** or thermal energy storage.

Q2 – In terms of carbon emission reduction, two effective emerging energy technologies are low-temperature district heating systems in combination with passively safe small modular reactors that can be deployed closer to electrical and thermal energy load centers. Another is electric vehicles for personal and ground-based mass transportation. A third is hydrogen-based fuels for heavy duty transportation needs with the hydrogen-based fuels produced using low-cost surplus zero-emission electricity.

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Q3 – Emerging technologies will take time to deploy so they are more suited to the medium and long term. **Electric vehicle (EV)** adoption has been well underway for about 10 years, so this option is suitable for short term timelines to 2035. One short-term option that is not an emerging technology is the redesign of our retail rate plans. The new plans can be used to incentivize electricity use to displace fossil fuels whenever a surplus is available. Ontario is currently deploying a new **Ultra Low Overnight (ULO)** price plan for EV owners to encourage overnight vehicle charging. However, the ULO price plan can be modified to allow fuel switching between electricity and fossil fuels. The current ULO plan sets the overnight rate at a level too high to displace natural gas economically. A reduction to the ultra-low overnight rate can make fuel switching economically attractive by ensuring the total effective volumetric rate for electricity overnight is lower than the volumetric rate for natural gas on an energy equivalent basis. Fortunately, zero emission electricity does have a volumetric rate lower than natural gas, but our retail price plans do not recognize and enable this opportunity to be exploited.

Q4 – The various emerging technologies have different equipment costs, capacity factors, production profiles, and integration costs. That is why it is important for some entity to perform simulation studies using hourly energy flows to determine the total retail cost to consumers to adopt those technologies.

Such simulations should integrate thermal and electricity demands so that synergies can be highlighted, such as higher efficiency from power (converted to CHP) plants, decreased curtailment of electricity production through thermal energy storage, and general load management (short-term to seasonal) using the thermal energy storage.

Q5 – Some emerging technologies come with social and community acceptance challenges. For example, high-voltage transmission is perceived as a threat by the public due to electromagnetic effects, and small modular nuclear reactors are perceived as a threat due to nuclear fuel waste and plant accidents. Both these technologies have excellent safety records, but the public perception of unacceptable risk still exists. Some public education will be necessary to inform the public of the true safety record and help the public become more comfortable with these technologies. Decarbonization will be more difficult and costly without those technologies.

Many technologies have been under-utilized because of outdated information or misinformation that is not corrected. Also, decisions are made on some energy distribution systems (e.g. district heating) by people without experience in the technology and its deployment.

<u>Role of the Province</u>

Q6 – The province should allow emerging technologies to participate in energy markets by removing regulatory barriers. The province can also support R&D and prototype work to help promising new technologies to reach commercialization status. When unit prices have dropped low enough to take advantage of economies of scale, then the province can incentivize early adoption and deployment.

Q7 – It is important to incorporate lessons from other jurisdictions on what to do and what not to do. For example, Europe is currently deploying low temperature district heating systems in cities to harvest industrial and commercial sources of waste heat for hot water and space heating. California is developing standards for better coordination of EV chargers with the available capacity of the electricity system. Several electricity systems have rapidly decarbonized by increasing the installed capacity of their nuclear plants. If we want to accelerate our decarbonization program, Ontario needs a proactive program to find solutions that have worked elsewhere and determine if they can be effectively deployed in Ontario.

Q8 – There are regulatory barriers that prevent new technologies from being deployed. These should be identified and removed where practical. One of the less-understood barriers is how electricity is priced at the retail level. For example, to simplify billing for small consumers, electricity is primarily sold on a volumetric energy basis with a modest fixed monthly charge (approximately 25% of the total bill). Time-of-use and tiered pricing is used to encourage efficient use of the electricity system. However, the resulting electricity rates do not reflect the true costs of providing an electric service to consumers. A zero-emission electricity system is primarily a fixed cost system because fuel costs are very low. Approximately 90 per cent of the cost of the electricity system is incurred to meet the peak power demand of consumers, not their energy demand. Therefore, the present retail rate design undercharges for power demand and overcharges for energy use. This price design does not provide consumers the opportunity to use new load management and fuel switching technology to better utilize low-cost surplus clean electricity when it is available.

Q9 – See response to Q8 immediately above.

Q10 – Many utilities in the USA are allowed to supply both electricity and natural gas. We can also envision a time in the future when a utility could supply electricity, heat, and zero-emission fuels like renewable natural gas to its customers. However, this would require a major change to how electricity and natural gas (and the associated companies) are currently regulated.

Ontario has allowed consumers to install their own generation behind their meters, and then be billed by net metering. Excess energy flows into the grid during an annual period are not compensated. With EVs now being sold with bi-directional chargers, a re-examination of system-avoided costs due to these behind-the-meter energy resources would be helpful to determine how best to compensate these self-generating consumers and encourage adoption of behind-the-meter resources such as generation, storage (both electrical and thermal), and bi-directional EV chargers.

Q11 – Deployment of new technology is cheaper for each jurisdiction if multiple jurisdictions co-operate in the deployment strategy. So, co-operation among provinces and the federal government should be encouraged.

Q12 – The development and deployment of the CANDU nuclear reactor was a joint collaboration of the federal government and Ontario government in the 1960s and 1970s. It is unlikely either government would have chosen to deploy the CANDU reactor alone because of the cost risk and because energy policy is a provincial responsibility, while nuclear energy is a federal responsibility.

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Q13 – Ontario has several examples where municipalities have supported and deployed small district energy systems in urban settings. The relatively low cost of natural gas has made deployment of district heating/energy systems less attractive in Ontario compared to Europe. However, with rising carbon taxes and zero-emission goals, district heating/energy systems will become increasingly attractive especially in higher-density urban areas. Ontario should seize this opportunity to reduce the size of the electricity system to meet heating needs and lower consumers' future overall energy bills.

Q14 – Many new energy technologies can be evaluated for effectiveness and affordability using simulation and analysis techniques that are currently used for engineered systems. What is needed is an organization with the appropriate systems modelling, analysis, and simulation skills. These skills can also be contracted using detailed specifications of what results and precision are needed.

Q15 – Many energy studies to date have not properly assessed the system integration aspects of new technologies when they are added to the energy system. For example, when solar PV and wind turbines were added to the electricity system, no detailed system impact assessment was done. Nor were the associated costs calculated to properly integrate those resources into the Ontario system to maintain reliability and resiliency of the electricity supply. Eventually, the additional backup and reserve generation, the resulting curtailment that needed to be paid for, the impact on transmission capacity upgrades, and the additional equipment to ensure electrical power system stability were identified and resulted in much higher annual increases in retail electricity rates.

The lesson for the future is that system integration studies should be done when any significant amount of new technology is proposed to be deployed.

Appendix 4

Answers to the specific questions posed by the Panel on Theme 4 - Community and Customer Perspectives, Affordability and Energy Sector Objectives

<u>Indigenous Communities</u>

Indigenous communities are diverse in the circumstances, skills available, access to the electricity grid, etc. "One size fits all" approaches will not be appropriate. Also, challenges are varied, and the quality and adequacy of housing stock is a major one, as is access to good drinking water. Accordingly, a comprehensive approach is important with community engagement and buy-in all along the way. Their energy needs vary, but it should be remembered that heating needs may be double or more than their electricity needs. While we cannot speak for the communities, a comprehensive approach may include considerations such as:

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1. Evaluate the housing stock. Increase housing to avoid overcrowding and examine building energy efficiency, because much housing is poorly insulated and leaky (with notable exceptions). If the community is on the electricity grid, focus on the heating requirements and options. District heating may enable the use of local resources, particularly biomass, and create local biomass fuel-related economic opportunities. Local wood fuel used directly in each building or cluster of buildings may also be an option; but the choice must be the community's.

2. Where the community is off the electricity grid, then heat and power needs might be integrated. Heat could be used from existing diesel generators to decrease the fossil fuel used for space heating. Renewable energy sources, where available, might be considered with electricity and/or heat storage. The options will be limited by economies of scale (local energy and peak loads), density of the community (particularly for district heating), and local fuel supplies. Future **CHP (combined heat and power)** options may include biomass with steam turbines for electricity or emerging SMR or MMR nuclear technology. All have local operator capacity and acceptance issues, and these must be articulated by the individual community.

3. In parallel, or preceding the above, it would be helpful to establish a sustainable community vision that reflects environmental performance, local energy and economic opportunities, and cultural values or priorities. Such a vision, established with/by the community (with assistance on technical options), may form the framework for today's planning. This may include changes to housing types or densities in ways that are more economic and sustainable, yet respect community values and priorities.

In conclusion, options can be elaborated, but Indigenous communities must be engaged at an early stage so they can articulate a process for decarbonization. However, if housing and water issues are overlooked, the attention to energy may be seen as a lower priority.

Given that Ontario regulations require energy projects on Indigenous lands to be done in partnership with the local community, this provides the opportunity for training and employment of local workers to the benefit of the community.

Appendix 5

Answers to the specific questions posed by the Panel on Theme 5 - Facilitating Economic Growth

Q1, Q2, Q3 (Combined Response) - The short and long-term economic opportunities for Ontario are substantial. Globally, countries are coupling new thermal electric power generation with heating loads so that up to 90 per cent of input energy can be used. CHP is becoming the norm. Some countries have policies to ensure new power generation is sized and located so as to maximize the ability to access both heat and electricity loads. This is facilitated by thermal energy storage to assist with load management in a more cost-effective way than electricity storage where possible. If Ontario (and Canada) are to participate in and sell products and services internationally, they should be leaders in such practices. Being followers means we will be *buying* international products rather than *selling*. Also, Ontario and Canada's industrial products may be penalized in the future if our emissions are perceived as excessive by other countries.

As we introduce new technologies, including district heating, there are economies of scale at play. If we are bold and enact policies and programs to advance new (or at least new-to-Ontario) technology, the market players will justify investment in local manufacturing. We have the capability and secure markets would lead to new opportunities.

We have major investments ahead, no matter what pathways we chose. If further analysis confirms our contention that thermal and electricity infrastructure planning should be integrated, we can make sure that future investments are the most cost-effective (i.e., they achieve decarbonization at the lowest cost) and stimulate new skills, services and products, and jobs from both domestic and international activity.

Future generations will regard us unkindly if we choose a path that is less environmentally friendly and cost-effective than the paths other progressive nations have already chosen.

To change direction, the biggest challenge is risk management. If we do not provide a comprehensive and workable roadmap or pathway to decarbonization, then private and public investors will perceive unacceptable risk and action will be slow and misguided. Accordingly, we have to generate a new pathway including both urban and rural requirements and opportunities, and then back it up with all the tools available to us (including policy, programs, and – where necessary – regulation and incentives). As Mark Carney said, “once society sets a goal, it is profitable to be part of the solution and terminal to remain part of the problem.” Let’s set a goal and be profitable.

Appendix 6

Executive Summary of the OSPE Supply Mix Analysis Report.

This report estimates the average retail electricity rate that Ontario consumers will pay using various generation supply technologies to achieve a net-zero emission goal by 2035. All the supply mixes that are presented are constrained by the need to meet the **North American Electric Reliability Corporation (NERC)** reliability criteria. The report examines various combinations of wind, solar, nuclear, pumped hydroelectric storage, and battery energy storage systems. Estimates are also provided of the amounts of curtailed production, generation nameplate over-build, and discarded thermal energy for each supply mix.

The lowest cost net-zero supply mix that reliably serves the 2035 high-demand load forecast is the 2021 Ontario supply mix with additional nuclear generation and a modest amount of pumped hydroelectric storage with natural gas plants repurposed to supply reserve generation using renewable natural gas (RNG) fuel.

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This study assumes that the additional generating capacity for each supply mix can be installed in time to meet the forecast load up to the 2035 time period. For severe weather events and other contingencies, it also assumes the availability of the necessary RNG fuel supply for the reserve generation. The time we refer to includes permitting, licensing, environmental approvals, financing, design, manufacture, site preparation, construction, and commissioning of each project.

Appendix 7
Synergies of Electricity and Thermal Energy Planning and Operation

To successfully determine the most cost-effective pathway to decarbonization, we must integrate electricity and thermal planning, and be prepared to move from familiar technologies and consider global practices successful elsewhere.

What is largely missing in the Electrification and Transition process is the integration of thermal energy requirements into the planning process and associated networks (district heating and cooling systems) that facilitate integration with the electricity system.

Without knowledge of how to integrate thermal and electricity requirements, many have settled for electrification of almost everything (including space heating and transportation). While this seems reasonable at the building or end-user level, the impact on the electricity system will be significant. Estimates suggest that electricity capacity may have to triple to meet 2050 emission goals. Such an electricity system expansion in 27 years is well beyond any ever undertaken in the past in Ontario. Electricity prices will also rise, and could more than double or triple their current cost depending on the generation technology choices we make. The consumer's total energy bill for heating, cooling, and electricity could rise significantly even if we use energy-improving technologies like heat pumps. By considering other options for heating and the integration of electricity and thermal systems, the future total cost of electricity, heating, and cooling could be at least stabilized (or, in the best case, significantly reduced).

In addition to electrification of demands, there is also the public desire to see more renewable energy as part of the solution – for both electricity and heat. The challenge here, particularly for electricity, is that renewable sources like solar PV and wind are 1) intermittent, 2) not dispatchable, 3) have low operating capacity factors (in Ontario), and 4) have periods of prolonged low output during severe weather events. To accommodate the characteristics of these renewable energy forms, there must be dispatchable zero-emission backup for these sources and/or sufficient long duration electrical storage. Thus, over-reliance on renewable energy sources (like solar PV and wind) is expected to drive up the future retail cost of electricity. This is not to minimize the importance of sustainable renewable energy – but we owe it to the public to make informed choices and be comprehensive in our analysis of various options. If the public wants to make a choice that is more sustainable but more expensive, that is the public's right – but they are entitled to accurate information on which to base their choice.

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Part of our duty, then, is to fully consider all energy uses (including transportation, heating, cooling, and electricity production) and explore the synergies that might lead to a more cost-effective and energy-efficient pathway to decarbonization. Importantly, by thinking "outside of the box," we can reduce the future increase in peak electricity demand (which affects the installed capacity of generation and distribution requirements), the amount of waste heat emitted to the environment, and consumers' total energy bills.

The attractive aspect of thermal systems is that they are very forgiving in terms of the temperature and availability of heat. Making heat is much less expensive than producing electricity, and is widely available as a byproduct from other processes (notably thermal electric power production, industry, data centres, etc.). Heat can be very cheaply stored compared to electricity, both hourly and even seasonally. Even though many see the cost of installing district heating pipes as prohibitively expensive, this cost is more than offset by the savings in generation and distribution system capacity increases. Fifty per cent of all space heating in Sweden is provided by district heating. Over 98 per cent of space heating in Copenhagen, Stockholm, Helsinki, and many other communities is met by district heating or thermal networks. The district heating systems increase the overall energy efficiency of the community by enabling access to renewable energy or non-GHG-emitting energy sources not otherwise possible by individual buildings alone. Importantly, these Scandinavian cities also fully integrate electricity and thermal network operation to great advantage.

Impact on the electricity system and costs:

To illustrate possibilities: if space heating in urban areas is electrified, it might be better to connect the buildings to a district heating system, and then provide the heat from large scale heat pumps. Such heat pumps can connect to sources that are always warmer than outside air, operate with water instead of air, and as a result, operate at higher efficiencies or **co-efficient of performance (COP)** throughout the year. To mitigate short peaks in consumer heating load, thermal energy storage can be installed to supply the peak loads and recover the heat during off-peak periods. The combination of higher energy efficiency and load management will substantially lower the peak electricity generation requirement at substantial cost savings. The lower generation requirements will also require less labour and fewer materials for electricity system expansion between now and 2050.

As district heating systems are expanded, we need to focus on CHP. If all non-GHG-emitting thermal electric generating stations (including nuclear, biomass and municipal wastes) were modified to produce both heat and power, the efficiency of the power plant would increase from about 35 per cent to typically 70 per cent (and even as high as 90 per cent). The heat can be used to displace the need for more electricity and air-sourced heat pumps as well as to reduce the dependency on natural gas. The generator might initially sell heat at a low price to ensure there is no loss, but as the district heating system becomes better established, the price for heat sold can be increased and revenues to the generator will increase (thus stabilizing or even lowering the cost of electricity).

For the CHP plants, when useful heat is generated, there will be a small decrease in electricity output. Depending on the temperature, the loss of electricity will be between 1 unit of electricity lost to make 6 to 14 units of formerly wasted heat useful at a slightly higher temperature. In heat pump terms, we

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would be producing useful heat at the power plant property boundary with a COP equivalent of between 6 and 14. (This is much greater than the best cold weather air source heat pump, which has a COP of less than 2 during the coldest winter days.) But importantly, if the CHP operator requires the full output of electricity, the heat load can be dropped, the power plant can operate at full electricity capacity, and the heat can be supplied from other industrial/commercial sources (or thermal storage) until the electricity demand subsides. This will enable more electricity and heat capacity at peak demand without installing additional generation.

The availability of the district heating system will allow the community to harvest and use other sources of low-grade energy like waste heat from data centers, industrial waste heat, and heat from sewer systems or sewage treatment plant effluents. This further lowers the need for electrification of space heating.

As noted earlier, excessive dependency on renewable electricity generation (solar PV and wind) will be costly, and surplus-generating output will be regularly curtailed. With an optimized mix of generation sources, including generation that produces heat like nuclear, renewable natural gas, solar PV, etc., surplus electricity can be stored as heat and used as required by district heating networks. This provides another source of revenue for the electricity generators.

The above measures illustrate how integrating thermal and electric systems can foster a more efficient electricity system, minimizing the need to electrify building space and water heating and lowering the need for (and considerable cost of) power system expansion.

Bio-energy

As a future source of largely GHG-neutral energy, and also as an economic development tool, Ontario must look more closely at biomass residues. Forest management and urban tree-trimming operations are constrained by lack of markets for residues. Ontario has established an **AAV (annual allowable volume)** for lumber harvesting at 30 million tonnes. This is double our current harvest of about 15 million tonnes. Typically, about 36 per cent of finished lumber is a residue with limited markets; ultimately about 10 million tonnes/year. There are about 4 or 5 pellet plants in northern Ontario, but these are constrained by market availability.

If there were a market for residues, this would provide revenues to the forest industry to improve forest management, clear damaged forests (from derechos or ice storms) and avoid piles of residue being left in fields to rot (and generate GHGs).

In Ontario, many communities could adopt biomass residue-based district energy (like Oujé-Bougoumou, QC), provide GHG-free heating, and further reduce the potential demand for increased electricity system capacity. In larger remote communities, the generation of electricity and heat would be feasible and further decrease the demands on the electricity system.

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As climate change advances, weather disturbances and forest fires will increase. Over the last 30 years, our forests have moved from being a net *sink* for GHGs to being a net *source*. In Canada in 2015, 2017 and 2018, forest net GHG emissions exceeded 250 **MT (mega-tonnes)** of GHG. This could be reduced through better forest management that would be facilitated by markets for residues for heat and electricity production.

Conclusion

The consideration of district heating, and the integration of electricity and heating networks, can provide great dividends to Ontario's electricity customers, support decarbonization of space and water heating, and lead to lower electricity and heat prices than would be possible through electrification alone.

Recommendations

1. Future net-zero emission thermal electric generation (e.g. biomass or nuclear) should be planned as CHP and sized and located to serve local heating and electricity requirements.

2. Electrification of space heating should be a last resort for urban areas, and – in rural areas and small communities – implemented as ground source heat pumps with thermal storage where other non-GHG emitting sources are unavailable.

3. Electricity system planning in urban areas must be integrated with thermal energy planning to lower the cost of both and to limit the substantial cost of the electricity system expansion (which might be required for electrification of space and water heating).

4. Thermal storage can load manage both space heating and electricity loads and provide a market for curtailed renewable energy production.

5. Biomass and municipal wastes are grossly under-utilized for both electricity and heat production. Biomass residue use, coupled with expanded district heating systems, would further reduce electricity system expansion needs and cost, and also provide a dispatchable source of heat and power to lessen the need for natural gas. Emission control systems for biomass and municipal waste combustion have improved substantially and can now meet stringent environmental emission limits.

6. District heating and thermal energy expertise should be integrated in future energy pathway planning exercises to generate more cost effective and resilient options for decarbonization. The expertise is available, and examples of best practices are widely available internationally (and increasingly in Canada).

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We look forward to working with you to further develop these recommendations. If you have any additional questions, please contact Paola Cetares, OSPE Public Affairs Manager, at pcetares@ospe.on.ca or 416-223-9961 ext. 225.

Sincerely,

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