Identifying best practices in cost-benefit analysis in the context of the Ontario Market Renewal Process

prepared for the Association of Power Producers of Ontario ("APPrO") by London Economics International LLC ("LEI")

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LEI was asked by APPrO to consider best practices for cost-benefit analysis ("CBA") in the context of electricity policy initiatives. A thorough CBA requires clear delineation of alternatives with respect to the status quo. All relevant benefits and costs must be quantified using transparent and replicable analysis based on current Ontario-specific data. This should be further supported by sensitivities which go beyond load growth and fuel prices to consider variables such as distributed energy resource ("DER") penetration. Qualitative factors to be examined include the potential for government intervention. While quantitative studies from other jurisdictions may be appropriate to determine the magnitude of potential benefits prior to commencing consideration of a market design change, they are not a substitute for detailed, Ontario specific quantitative analysis prior to making a final determination of whether to proceed once a policy direction has been chosen for consideration.

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London Economics International LLC
390 Bay Street, Suite 1702
Toronto, ON M5H 2Y2
www.londoneconomics.com

1 Context

1.1 Scope of work

London Economics International LLC ("LEI") was asked by the Association of Power Producers of Ontario ("APPrO") to prepare a high level discussion of best practices in cost-benefit analysis with specific application to comparing Ontario electricity policy options in the future. This paper is intended to assist in building a consensus regarding necessary components of CBA that meet high practical tests of rigor and relevance from a system and societal perspective. [1]

1.2 Methodology and organization of this paper

To explore approaches to CBA, LEI first reviewed the academic literature with regards to recommended CBA practices. Next, LEI examined recent electricity market design related CBA reports to assess how the approach to analysis there differed from what has been performed to date in Ontario. Finally, LEI presented an approach for performing CBA. The approach presented by LEI takes into account practices observed elsewhere as well as practical realities of the nature of the Ontario hybrid market.

2 CBA in academic literature

Cost-benefit analysis ("CBA") is grounded in welfare economics and is the principal analytical framework used to evaluate expenditure decisions. While CBA can be focused on an individual or firm's perspective, this paper discusses CBA more broadly – in consideration of all the costs and benefits to society as a whole. As put forward by Dréze and Stern in *The Theory of Cost-benefit Analysis*, a cost-benefit test is a decision rule which only accepts projects which have a positive net effect on social welfare. [2] To evaluate a project from the point of view of its consequences, it is crucial to have a model which predicts the total effect on the state of the economy. The determination of this net effect therefore involves a comparison of the economy "with" the project and the economy "without" it. This may be measured by the discounted stream of social benefits expressed in terms of a common metric – usually money in present value terms.

As summarized by Florio et. al., the basic principles of cost-benefit analysis include:

- ***shadow prices*** to capture social costs and benefits beyond the market or other observable values;
- a ***counterfactual scenario*** to ensure that all costs and benefits are estimated in incremental terms relative to a 'without project' world;
- ***discounting*** to convert any past and future value in their present equivalent; and

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[1] As the scope of this engagement was to provide support for an ongoing dialogue on CBA methods, this document is not intended for use in any regulatory or legal proceeding; further detailed research and analysis would be necessary for any such proceeding.

[2] Dréze, J. and Stern, N. *The Theory of Cost-Benefit Analysis – Chapter 14 of the Handbook of Public Economics.* 1987.

- a ***consistent framework to identify social benefits*** by looking at the different categories of agents.[3]

The process of conducting a CBA may be broken down into nine (9) major steps, as shown in Figure 1, which are as follows:

1. ***Define the set of alternative projects:*** This step involves defining the set of alternatives to be compared to the displaced project or counterfactual. This counterfactual is typically the status quo and assumes there is no change in the current policy. The calculation of benefits, costs, and net social benefits of a particular alternative relative to the status quo allows for these amounts to be deemed incremental;

2. ***Determine which benefits and costs are within scope:*** At this stage, a determination must be made on whose benefits and costs have standing, and are within the scope of the study. Depending on the nature of the project and the underlying issues it aims to solve, the relevant perspectives of a CBA could be set as municipal, provincial, federal or global; in this paper, we assume the focus is on the province of Ontario. In some cases, a combination of perspectives may be used to address the contribution of salient stakeholders. This may take the form of a municipal project including the wider provincial impact to reflect impact of provincial funding or a global perspective to account for climate change-related impacts;

3. ***Identify the impact categories and select metrics for their evaluation:*** Here, the potential impact categories of the proposed alternatives are identified and catalogued as benefits or costs. For each impact, a metric for evaluation must be selected. The identification of impact categories must focus on those which affect the utility of individuals or parties with standing. Impacts therefore flow from physical outputs of a project and are based on an underlying cause-and-effect relationship;

4. ***Predict the impacts quantitatively over the project timeframe:*** This step involves quantifying all of the impacts for each year in the lifetime of each project, and across all of the alternatives;

5. ***Monetize all impacts:*** Next, the impacts must be valued in dollars. Ideally, these value estimates should be specific to the location of the project under review using current data;

6. ***Discount benefits and costs to obtain present values:*** Future benefits and costs must be discounted relative to present benefits and costs to facilitate their aggregation into a single measure.

7. ***Calculate the net present value of each alternative:*** The net present value ("NPV") of an alternative is the difference between the PV of the benefits and the PV of the costs. For the evaluation of a single project relative to the status quo, the basic rule is to adopt the project if the NPV is positive or where the benefits exceed the costs. For an analysis

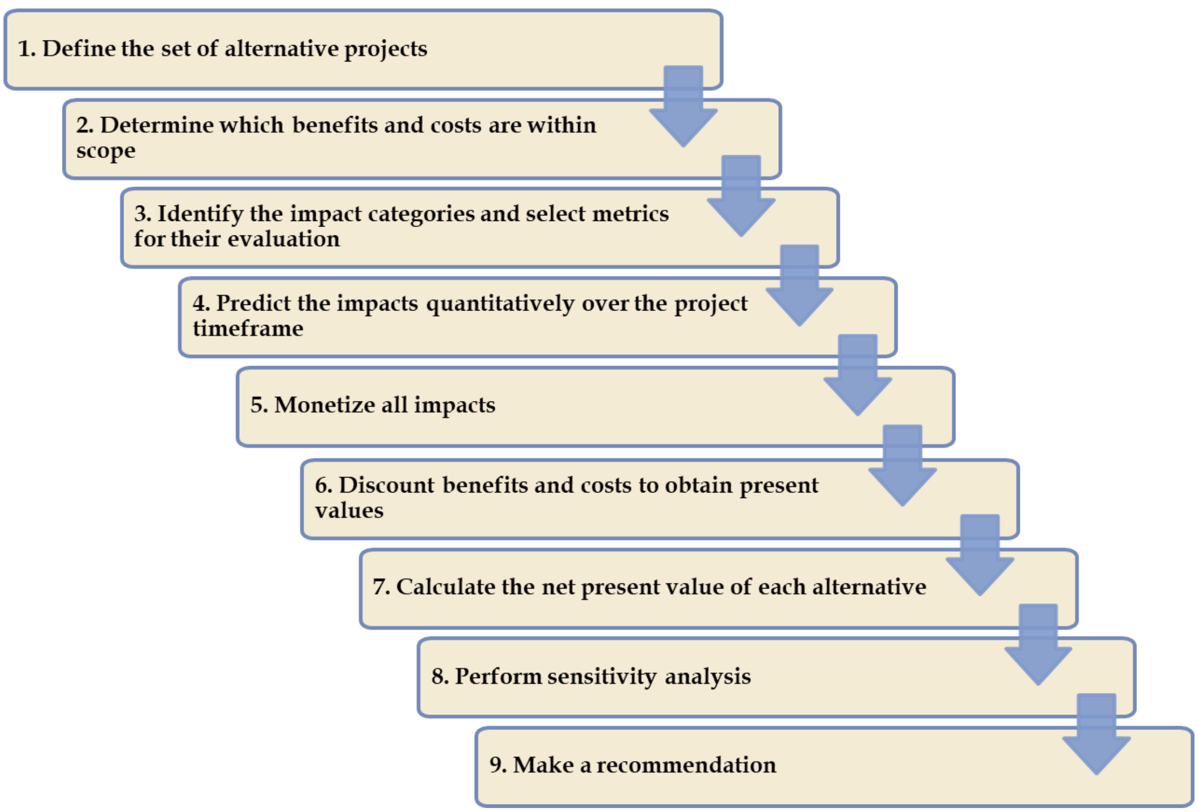
[3] Florio, M. et. al. *Exploring Cost-benefit Analysis of Research Development and Innovation Infrastructures: An Evaluation Framework.* February 2016.

involving multiple alternatives with positive NPVs, select the project with the largest NPV. Naturally, if none of the NPVs evaluated are positive, then the status quo should remain in place;

8. *Perform sensitivity analysis:* As the calculated NPVs are estimates, sensitivities around their values should be conducted before making a final recommendation. Uncertainty about the valuation of the predicted impacts, the appropriate social discount rate, and the appropriate level of standing are areas which may be explored by a sensitivity analysis. The variation of results under different sensitivities provides insight to the weight of particular assumptions on the final result; and

9. *Make a recommendation:* While generally the recommendation of choice would be to adopt the alternative with the largest NPV, this may not be the best solution in all circumstances explored in the sensitivity analysis. The choice of recommendation therefore involves consideration of the estimated NPVs, as well as the impact of a change in assumptions or perspective.

Figure 1. Major steps in CBA



Source: Boardman, A. et. al. Cost-Benefit Analysis: Concepts and Practice. 2017.

3 Examples of recent electricity market CBA calculations in other jurisdictions

To provide a practical understanding of how CBA has been applied elsewhere once details of proposed design changes are known, LEI reviewed two case studies. While LEI does not advocate the use of the ***results*** of studies from other jurisdictions to make a final policy decision ("FPD"), LEI believes a review of the ***approaches*** is instructive. The two studies reviewed are Puget Sound Energy's ("PSE") 2014 *Benefits Analysis of Puget Sound Energy's Participation in the ISO Energy Imbalance Market* and the UK's Department of Energy & Climate Change's ("DECC") 2014 *Impact Assessment on the Capacity Market*. Critically, each deployed recent, market specific data in performing forward modeling of the relevant jurisdiction.

3.1 EIM participation benefits study

Following the launch of the Western Energy Imbalance Market ("EIM") in 2014, Puget Sound Energy ("PSE") and the California Independent System Operator ("CAISO") retained Energy and Environmental Economics, Inc. ("E3") to estimate the economic benefits of PSE's participation in the EIM.[4] This study focused specifically on sub-hourly dispatch benefits and savings from reductions in flexibility reserve requirements. Defining this scope in this way addresses the steps one and two from Section 0 regarding the alternatives to be reviewed and the types of benefits to be examined and quantified.

To assess sub-hourly dispatch, the analysis employed a sub-hourly production cost model using actual day-ahead and hour-ahead forecasts of expected load, wind and solar output, as well as actual load, wind and solar output 10-minute interval for the real-time simulation. The study also defined other key assumption parameters such as real-time transmission transfer capability informed by capacity rights owned or controlled by the current EIM participants and hurdle rate adders based on charges for the interfaces between balancing authority areas. For real-time transmission transfer capability, high transfer and a low transfer scenarios were defined and assessed.

With respect to flexibility reserve requirements, the study employed a statistical analysis to estimate the quantity of flexibility of reserve reductions from participation in the EIM. This was followed by an examination of historical flexible ramping constraint shadow prices from 2013 to determine the avoided cost of flexibility reserves. To estimate the total EIM reserve savings, the study applied the average shadow price from 2013 to the flexibility reserve quantity reductions.

With respect to each of the basic principles noted in Section 0, the study:

- estimated societal costs through the use of a production cost model and historical flexible ramping constraint shadow prices;
- modelled PSE's production costs in the Western Interconnection and flexible reserve needs with and without PSE as an EIM participant;

[4] Puget Sound Energy and California ISO. *Benefits Analysis of Puget Sound Energy's Participation in the ISO Energy Imbalance Market.* September 2014.

- discounted implementation costs incurred, production cost savings, and flexibility reserve savings using the utility's after-tax weighted average cost of capital ("WACC"); and
- based analysis on system level impacts to overarching measure of benefits and costs to be shared between the utility and its customers.

Figure 2 presents the key design parameters of the PSE's EIM participation CBA. For the two alternatives considered, sub-hourly dispatch benefits and reduced flexibility reserves were modelled over a 20-year period from 2016 to 2035.

Figure 2. CBA parameters for PSE's EIM participation CBA

CBA parameter	Puget Sound Energy EIM participation CBA
Alternatives under consideration	1. **Base case:** no EIM participation (status quo) 2. **PSE EIM participation:** commencing in 2016
Quantitative impacts	EIM participation will be assessed based on the following: • sub-hourly dispatch benefits; and • reduced flexibility reserves
Study period	20 years (2016-2035)
Discount rate	WACC of 6.7%
Sensitivities	Expected levels of real-time transfer capability between PSE and current EIM participants

Source: Puget Sound Energy and California ISO. Benefits Analysis of Puget Sound Energy's Participation in the ISO Energy Imbalance Market. September 2014.

3.2 Capacity market design cost-benefit analysis

Noting increasing pressures from its transition away from fossil fuel generation towards more intermittent and less flexible generation, United Kingdom ("UK") policy makers acknowledged the risk that the energy-only market would no longer provide adequate levels of electricity supply. The evaluation of alternative options – in particular a centralized capacity market – led to the UK's Department of Energy and Climate Change ("DECC") conducting a CBA in 2014 to evaluate which policy option would best serve its objectives including:

- ***Security of electricity supply:*** to incentivize sufficient investment in capacity to ensure security of the electricity supply;
- ***Cost-effectiveness:*** to minimize the cost to consumers; and

- ***Avoid unintended consequences:*** to minimize design risks and complement decarbonization policies.[5]

This study examined energy system costs, business administrative costs and institutional costs. For the energy system costs, DECC employed a dynamic dispatch model of the Great Britain power market which enabled the assessment of new build, retirements, security of supply, wholesale energy prices and emissions under different policy decision scenarios. This energy market model was paired with a capacity auction model following a descending-clock, pay-as-clear format in which all successful suppliers are paid the market clearing bid. Alternative structures such as sealed bid, pay-as-bid, and first-rejected bid formats were not examined. Business administrative costs were estimated as a function of the number of power producers with more than 5 MW of capacity and cost of two full-time staff. Institutional costs were based on National Grid's estimates for capacity market administration as the energy market reform delivery body.

Figure 3 presents the key design parameters of the UK's capacity market design CBA. To explore variation around the base inputs, the study involved a sensitivity test on the assumed value of lost load ("VOLL").

Figure 3. CBA parameters for UK capacity market CBA

CBA parameter	UK DECC capacity market CBA
Alternatives under consideration	1. **Base case:** no capacity market; retains existing policies of feed-in tariff contract for differences, emissions performance standard and carbon price support; continuation of supplemental balancing reserve and demand side balancing reserve 2. **Capacity market:** technology neutral capacity auctions open to all existing and new forms of capacity (including demand side resources)
Quantitative impacts	The capacity market will be assessed based on the following: • modelled energy system impact • institutional impacts; and • impacts on businesses such as administrative costs
Study period	19 years
Discount rate	3.5% consistent with government guidance
Sensitivities	VOLL pricing ranging between £10,000 and £30,000/MWh

Source: UK Government Department of Energy & Climate Change. Electricity Market Report – Capacity Market Impact Assessment. September 2014.

[5] UK Government Department of Energy & Climate Change. *Electricity Market Report – Capacity Market Impact Assessment.* September 2014.

With respect to each of the basic principles noted in Section 0, the study:

- estimated societal costs through the use of a production cost model and capacity auction model;
- modelled the energy system costs needs with and without a capacity market in place;
- discounted energy system cost savings, business administrative and institution incurred using the UK government set social discount rate; and
- based analysis on market level impacts to overarching measure of benefits and costs to be shared between the market participants and end consumers.

4 Proper approach to CBA in Ontario

The standard of analysis for making a final decision to proceed with a particular option is higher than that needed to determine whether to proceed to investigate a series of options. Below, we first highlight how we would approach CBA in the context of a decision to proceed; this approach is broadly similar to that from the academic literature surveyed. However, after describing the approach, we set forth a number of key issues which we believe are necessary to address in performing a CBA related to making a final policy decision. Properly performed CBAs subject to peer review, comment, and response can aid in achieving stakeholder acceptance, improved decision-making, and durability of proposed market design changes.

4.1 Principles of CBA in the context of electricity market reform

Best practices for CBA require at the onset a clear delineation of alternatives with respect to the status quo, the selection of all relevant benefits and cost metrics quantified using transparent and replicable analysis using current Ontario-specific data. This should be further supported by sensitivities which go beyond load growth and fuel prices to consider variables such as DER penetration. Qualitative factors to be examined include the potential for government intervention.

The principles and process above may be adapted to the context of evaluating wholesale market report reforms. As seen in Figure 4, LEI's approach to conducting a CBA is comprised of six steps. These steps are broadly consistent with the nine steps presented in Figure 1 from the academic literature:

- First, the CBA should begin with clear definitions of the scope of market design changes being considered and how these compare to the status quo. However, the description of the status quo also needs to be carefully developed, so that the baseline is well understood. Furthermore, the CBA should also justify why these are the only options to consider.

- Second, for the identified market design changes, all material potential costs and benefits within the boundaries of Ontario should be identified.

- Third, metrics for each of these items must be determined. Examples include, but are not limited to, total wholesale market system costs, capacity procurement costs, changes in emissions, and market administration costs. At this stage it is also important to set the study period for evaluating the alternatives as well as the social discount rate to be applied.

- For step four, all of the metrics identified must be quantified. This stage would involve modelling of Ontario's wholesale market under the defined alternatives, as well as analysis of total lifecycle costs under the differing structures. For each metric, the difference between the outcome under the proposal and status quo alternatives should be calculated in order to uncover the underlying incremental benefits and costs.
- In step five, these incremental benefits and costs are discounted to an NPV.
- Lastly, sensitivities around the key assumptions including the social discount factor and study period should be examined.

Figure 4. LEI-recommended CBA process

LEI-adapted principles of CBA for assessing market design	MRP benefits-cost assessment (2017)	EIM participation study (2014)	Capacity market benefits study (2014)
1. Define the scope design changes to be examined as well as the counterfactual scenario	✓	✓	✓
2. Identify all potential costs and benefits for the province of Ontario	✓	✓	✓
3. Determine the metrics to be modelled and bounding assumptions (i.e. total wholesale market system costs, capacity procurement costs, market administration costs, study period, social discount rate)	✗	✓	✓
4. Perform modelling of project and counterfactual scenarios and calculate the differences with respect to total wholesale market system costs, capacity procurement costs, and market administration costs between the two scenarios. Where project costs are lower than the counterfactual, these differences represent incremental benefits.	✗	✓	✓
5. Calculate the NPV of the incremental benefits and costs	✓	✓	✓
6. Perform sensitivities around key assumptions	✓	✓	✓

As shown above, assessment can be enhanced through the development of Ontario-specific measures of the potential impacts. While proxies from neighboring jurisdictions may be useful in providing a range of expectations, these should not be used for an FPD when it is possible to model the impact of the proposed market design changes directly. Although there are costs in time and money in performing the modeling exercises, the magnitude of the potential negative impact of getting the market changes wrong far outweighs these costs. The need for and use of market-specific modeling is demonstrated in the EIM participation and capacity market benefits case studies described in Section 3.

London Economics International LLC
390 Bay Street, Suite 1702
Toronto, ON M5H 2Y2
www.londoneconomics.com

4.2 Critical issues to explore

Previous CBA of market design changes in Ontario used common sense analogies to provide an indication of potential benefits. While such analysis can provide an indicative view of potential costs and benefits, it is less appropriate to use such an approach once design details are known and proper market specific quantitative analysis can be performed. A more robust approach for undertaking future Ontario electricity market-related CBAs should involve the following:

- ***Clearly describe status quo*** – analysts need to carefully define what is it that we are benchmarking against, and avoid false comparisons; assuming policymakers behave foolishly in the status quo but wisely in the design change scenario is not a plausible narrative. For example, assuming that capacity mechanisms result in less over-procurement is questionable, given that the reserve margin targets in both central procurement and a capacity mechanism design are in either case the result of policy decisions. Furthermore, as we have observed in other jurisdictions, the presence of a capacity mechanism does not prevent policymakers from instituting out-of-market mechanisms to favor particular technologies.

- ***Use market specific analysis*** – while inferences based on prior studies in other markets may provide context and a range of possible values, these calculations are more useful when deciding whether to analyze a change than they are for making a final decision about making the change that has been analyzed. Market specific, detailed modeling is necessary before making an FPD;

- Make sure that the analysis reflects ***current conditions;***

- Assure all calculations are ***transparent and replicable.*** Ideally, the calculations would be subject to independent peer review through a quasi-judicial process;

- ***Appropriately incorporate transitional costs for all participants;*** these should not be assumed away or underestimated, and may be disproportionately large for smaller market participants;

- ***Examine a range of discount rates;*** given that the benefits relate to investment in a specific market, and that there are significant uncertainties related to the change in market rules, using discount rates well below the weighted average cost of capital for the sector may exaggerate potential benefits. Using a range of discount rates will help policymakers better understand the impact of the timing of potential benefits on perceived value;

- ***Distinguish between scenarios and sensitivities***; explore at least three scenarios; these scenarios may need to incorporate more variables than simply load and fuel prices. Examples of additional scenario drivers include more rapid technological change, alternative nuclear fleet performance drivers, and potential out-of-market programs designed by the government of the day to support favored technologies. However, load

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390 Bay Street, Suite 1702
Toronto, ON M5H 2Y2
www.londoneconomics.com

sensitivities remain important – results may be significantly less favorable in an environment of little to no load growth;

- ***Don't ignore emerging variables such as DERs*** – market designs may have very different outcomes if decentralized generation driven partially by delivered prices begins to become a significant supply source, and should be explored in detail in at least one of the scenarios;

- ***Acknowledge potential for government interference***; test how both the new market design and the status quo perform with regards to various types of government interference, and explore the triggers for such interference. For example, if short term price spikes are the most likely cause of intervention, then the market design that is most likely to produce volatility may also result in such intervention, meaning the design may not be durable; and

- ***Be clear that analysis is assumptions driven***, and more useful for directional guidance rather than absolute values; there tend to be fallacies of misplaced precision in such studies, and it is better to identify these in a transparent fashion.

5 Concluding remarks

Any new report analyzing market design or other energy policy options leading to a recommendation should incorporate CBA using Ontario-specific modeling, produce results under multiple scenarios and sensitivities, and be part of a structured peer review process.

Policymakers, whether in the Ministry, the Premier's office, or IESO, should consider hiring an independent reviewer, in a process somewhat analogous to the "fairness review" process that has existed in the past for RFPs at the former Ontario Power Authority. The independent reviewer would assess whether the CBA provided met best practices, was performed in a holistic and unbiased way, provided for transparency into assumptions and modeling, and addressed appropriate sensitivities and scenarios. If deficiencies were found, the independent reviewer would make recommendations about how to address them in the analysis.

Such an independent review need not be unduly long, but the outcomes would provide for more informed decision-making, better system planning, and potentially improve stakeholder satisfaction with the critical energy sector related policies.