APPENDIX J - Guideline Project GHG Options Analysis Methodology

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Guideline - Project GHG Options Analysis Methodology

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November 26, 2020

The Federal Sustainable Development Strategy (FSDS) 2016-19 and the Greening Government Strategy: A Government of Canada Directive (GGS) emphasize that reductions in greenhouse gas (GHG) emissions are a Government of Canada priority. Therefore, PSPC must consider GHG emission reductions when evaluating design options for projects. This guideline describes a methodology to evaluate project options based on their GHG emission reductions opportunity. The methodology was developed to incorporate greenhouse gas emissions reduction and their financial impact into Real Property Investment Decisions.

Project leaders are to consult with the Greening Government Directorate within the Technical Services Service Line (TSSL) of Real Property Services (RPS) at the beginning of Investment Analysis Report (IAR) development for each project. RPS TSSL's Greening Government Directorate (RPS TSSL GGD) will determine if the GHG options analysis should be undertaken as part of the writing of the IAR. Alternatively, RPS TSSL GGD could determine that it is more appropriate to do the GHG options analysis within the design, after Expenditure Authority (EA) is received for planning and design. Regardless, RPS TSSL GGD services will be engaged by the project leader to make sure climate change considerations are covered within the IAR. The GHG options analysis was approved for full application by the Real Property Operations Committee in March 2017. IARs that are presented to the Real Property Investment Board (RPIB) or Regional Investment Management Boards (RIMB) for Project Approval must comply with this guideline.

As part of the FSDS, the Government of Canada committed to reducing GHG emissions by 40% by 2030 when compared to the 2005-06 baseline. The GGS sets a reduction of 90% in GHG emissions by 2050, compared to the 2005-06 baseline. In addition, Real Property Services has committed to initiating measures to achieve a carbon neutral portfolio by 2050, with an aspirational target of 2030. All other sustainability commitments and targets, at this time, are unchanged. If and when other sustainability commitments change, this options analysis methodology may require adjustments.

Scope

This guideline is to be followed for projects in Crown-owned buildings. It currently does not apply to leases or sale-lease-back as PSPC does not have operational control of this space. The guideline does apply to the construction of built to lease and lease purchase assets since these facilities are being built specifically for the Government of Canada and PSPC has control over their design.

Energy Modelling and Simulation

This methodology relies on building energy modelling and simulation to estimate the annual energy consumption and GHG emissions of each design option. Building energy modelling and simulation provides the ability to quantify the energy savings, energy cost savings and GHG emission reductions of the energy conservation measures that are considered for each design option. This section provides a background on building energy modelling and simulation.

A building can be considered as a whole system composed of elements that interact with one another. These elements include: building envelope, mechanical systems, lighting, people, plug and other equipment loads and the external environment, including weather and site.

Energy modelling and simulation is a virtual representation of the building, specifically of the elements that make up a building. The energy, air and moisture flows into and out of the building and its elements are considered in order to predict the building's annual energy requirements. Energy modelling and simulation is commonly performed to verify a building's compliance to an energy code and to estimate the building's annual energy consumption, annual energy costs and annual GHG emissions.

A major project is defined as a project that is multi-disciplinary in nature, i.e. the project impacts more than one building element. Newly constructed buildings, acquisitions and major renovations are major projects and thus require that building energy modeling and simulation be done to assess the energy and GHG performance of design options. Building energy modelling and simulation is the only accepted tool that is capable of accounting for the interaction between different building elements and of analyzing multiple energy conservation measures simultaneously. Energy modelling and simulation supports an integrated design process among building professionals: architects designing the building envelope, mechanical and electrical engineers designing the heating, ventilation and air-conditioning (HVAC) and lighting systems, and other members of the design and project teams.

Simple projects are defined as projects that are single-disciplinary, that is they affect one building element in isolation. Because simple projects are non-complex in nature, they do not necessarily require whole building energy modeling and simulation. Examples of simple single-disciplinary projects are the replacement of a pump, small chiller, small boiler or a window replacement project.

Emission Factors

PSPC reports the GHG emissions from its real property operations annually, in accordance with the GGS and the FSDS. PSPC follows the *Federal GHG Accounting and Reporting Guidance* for accounting and reporting GHG emissions. Annex A of the *Federal GHG Accounting and Reporting Guidance* provides emission factors for fuel, biomass, electricity and district heating and district cooling. These emission factors should be used to calculate the GHG emissions of project options.

Environment and Climate Change Canada (ECCC) has provided RPS TSSL GGD with projected future emission factors for electricity based on planned activities and policies by the Provinces and Territories. Project teams should use the projected electricity emission factor for the estimated year of occupancy of the completed project. Alternatively, an average value can be calculated, based on a 40 year lifecycle period, starting on the estimated year of occupancy of the completed project. The latest projection available (the 2040 projected value) can be used to represent years beyond 2040. Finally, if project teams deem it necessary, they can apply the annual projected electricity emission factor throughout the lifecycle, using the projected value for the year 2040 to represent years beyond 2040. Which approach to use is the responsibility of the project team and should be based on what provides accurate GHG accounting. Please refer to question 7 in the Q and A section if more details are required.

The projected electricity emission factors from ECCC and the emission factors for combustion sources provided in Annex A of the *Federal GHG Accounting and Reporting Guidance* are provided at this link.

Please consult with RPS TSSL GGD to obtain the emission factors for the modernised district energy system in the National Capital Area. Also, please flag to RPS TSSL GGD any project options that include biomass combustion. The federal government has yet to finalize how to properly account for biogenic emissions from the combustion of biomass.

Approach for projects that are single disciplinary (affect one building element in isolation) and non-complex in nature

This approach will apply to projects that are single disciplinary and that have an impact on GHG emissions. For example, the replacement of HVAC equipment (boilers, chillers, etc.). In this case, the consultant will evaluate the energy savings, associated GHG emission savings and net present value (NPV) over 40 years for each analyzed option, compared to the baseline (status quo) option. Among the options that have returns on investment within 40 years, i.e. a positive incremental NPV over the 40 years, the option that generates the largest GHG emission savings compared to the baseline option will be selected. For an option where the incremental NPV is slightly negative and GHG emission reductions are significant, the option should not be automatically discarded. An energy manager must be consulted to review all of the analyzed options and evaluate which option makes the most financial sense in comparison to GHG emission savings. For example, if there is an option that results in a return on investment that is close to cost-neutral (NPV not positive for all 40 years) but that generates a significant amount of GHG emission savings, it may still be recommended. This recommendation will be based on the importance of the asset for PSPC to meet its goal of a carbon neutral portfolio.

The GGS directive states that a lifecycle cost analysis will use a period of 40 years and a carbon shadow price of $300 per tonne. Shadow carbon pricing is a method of decision analysis that adds a surcharge for carbon dioxide that would be released. Although a carbon shadow price of $300 per tonne is included in the options analysis for decision-making, it is not a cost that will be incurred by the project.

Projects in which the up-front cost of the recommended option is 20% greater than the capital cost of the baseline option (option that would have normally been recommended before the implementation of this methodology) are to be flagged and reviewed by RPS TSSL GGD. This will help determine the impact of the methodology on the capital cost investment required for single disciplinary projects. This requirement may be adjusted or removed in the future once sufficient data is collected to better understand the financial impact these greener options have on funding.

Fuel switching from electricity to a combustion fuel is not permitted at the project level because of PSPC’s commitment to purchase 100% of its electricity consumption from clean energy sources by 2025.

Approach for multi-disciplinary projects, new buildings, acquisitions and major renovations

The GGS mandates departments to ensure that all new buildings and major building retrofits prioritize low carbon investments and that investment decisions are based on the total cost of ownership. The application of this guideline ensures that PSPC complies with the GGS requirement.

The GGS also states that all new federal buildings should be constructed to be net-zero carbon, unless a lifecycle cost-benefit analysis indicates that a net-zero carbon ready construction is more feasible. The application of this guideline provides the business case for a net-zero carbon or a net-zero carbon ready design. A net zero carbon ready building is one that could operate as net-zero carbon in the future (for example, no fossil fuel combustion on site).

The GGS states that all major building retrofits require a GHG reduction life-cycle cost analysis to determine optimal GHG emission savings.

The life-cycle cost approach must use a period of 40 years and a carbon shadow price of $300 per tonne. Shadow carbon pricing is a method of decision analysis that adds a surcharge for carbon dioxide that would be released to market prices for projects that involve significant carbon emissions. Although a carbon shadow price of $300 per tonne is included in the options analysis for decision-making, it is not a cost that will be incurred by the project.

The application of this approach is mandatory to all multi-disciplinary projects. It is to be applied to the recommended procurement option and to any other option within 10% of the lifecycle cost of the recommended one. The project leader is to contact TSSL’s GGD at the start of the Investment Analysis Report development for guidance on how and when to apply the methodology. TSSL’s GGD will advise whether the methodology is to be applied in the IAR and the results incorporated into the project costing before Project Authority (PA)/

Expenditure Authority (EA) is granted. Alternatively, RPS TSSL GGD may advise that the methodology be incorporated within the planning and design after PA and/or EA is granted. A cost allowance, supported and approved by RPS TSSL GGD, will be applied for projects that are not incorporating the methodology into the IAR. The IAR must clearly specify what costs have been included within the PA to account for the reduction of GHG emissions and that amended PA, if required, will be sought with EA for implementation.

Each IAR will analyze the following four design options:

Option 1: Design to Meet Minimum Departmental Commitments (Baseline option)

This option will require the building design to meet the most recent minimum departmental design commitments.

Every project team should reference and provide the design team the "PWGSC – Real Property Sustainability Framework and the Technical Reference for Office Building Design. Table 1 presents the key sustainability and energy performance commitments in the PWGSC – Real Property Sustainability Framework.

Table 1: Project Design and Delivery

Building Project Type	Threshold[1] ($ or m²)	Assessment Tool & Target	Energy Efficiency Target	Lifecycle Assessment
1. **New office buildings**	All projects	LEED Gold or 4 Green Globes	28% more energy efficient than NECB performance and/or 35% more energy efficient than the building being replaced.	Athena EIE/EC (>$5M, location restrictions)
2. **Other types of newly constructed buildings[2]**	All projects	LEED Silver or 3 Green Globes	24% more energy efficient than NECB performance and/or 35% more energy efficient than the building being replaced.	Athena EIE/EC (>$5M, location restrictions)
3. **Long-term lease office buildings (including build-to-lease, lease-to-purchase, sale- leaseback)**	All projects ≥500 m²	LEED Gold or 4 Green Globes	24% more energy efficient than NECB performance and/or 35% more energy efficient than the building being replaced.	No
4. **Building acquisition**	All projects	LEED Silver or 3 Green Globes	24% more energy efficient than NECB performance.	No
5. **Buildings undergoing Major Renovations[3]**	All projects	LEED Silver or 3 Green Globes	24% more energy efficient than NECB performance.	Athena EIE/EC (>$5M, location restrictions)
6. **Space Fit-Up and Retrofits**	≥1000 m² (Office)	LEED Silver or 3 Green Globes		No

The National Energy Code for Buildings (NECB) referenced in Table 1 refers to the latest edition of the NECB. The energy efficiency targets in Table 1 were established for office buildings. The energy efficiency target to meet the Minimum Departmental requirement may need to be adjusted for projects that have process loads that are atypical of office buildings (for example, buildings with data centres or labs). Building projects that include process loads should be flagged and reviewed by RPS TSSL GGD. A major renovation is defined as

[1] This only includes buildings where PWGSC is the custodian or leases where PWGSC is the lease holder.

[2] This does not include special purpose buildings for which no appropriate green assessment tool is available.

[3] Heritage buildings undergoing major renovations are subject to the Sustainable Heritage Guide

a project that has a construction value greater than 50% of the building's assessed value; the assessed value is based on Payment in Lieu of Taxes (PILT).

The purchase of clean energy via renewable energy certificates (RECs) or carbon offsets is not to be considered as a measure to reduce GHG emissions.

A shadow carbon price of $300 per tonne is applied to determine the lifecycle cost of Option 1 over 40 years.

Option 2: Design to Achieve GHG Emission Reductions that are Cost-neutral (40 years)

Option 2 will meet all of the Departmental commitments in Option 1.

In addition, the consultant will assess measures that improve energy performance and reduce the GHGs emitted by the facility, if the facility were designed to Option 1. Energy modeling and simulations will be performed on bundled measures until the best option is identified. The best option results in a bundle of measures that provides the most GHG savings and has a positive NPV on the incremental cost (compared to option 1), when calculated over the life cycle of the project (40 years to meet GGS requirement). Priority should be given to energy conservation, before fuel switching alternatives are considered for reducing GHG emissions. For example, switching a building component's fuel source from natural gas to electricity in a province with a clean grid will reduce the facility's GHG emissions but will not necessarily improve the building's energy efficiency. The priority should be to reduce the building component's energy use, no matter its fuel source. Once the building energy performance has been optimized, fuel switching and on-site renewable energy generation should be evaluated. The purchase of clean energy via RECs or carbon offsets is not to be considered as a GHG emission reduction measure.

Fuel switching from electricity to a combustion fuel is not permitted at the project level because of PSPC's commitment to purchase 100% of the electricity it consumes from clean energy sources by 2025.

A shadow carbon price of $300 per tonne is applied to determine the lifecycle cost of Option 2 over 40 years.

As Option 2 will lead to a positive, or very close to positive, incremental NPV over the project's lifecycle, it should always be recommended over Option 1 if funding is available. Option 2 provides the Crown the best option for deep GHG emission reductions at no additional cost over the investment horizon.

Option 3: Design to Achieve Maximum GHG Emission Reductions

Option 3 will meet all of the Departmental commitments to sustainability, and environmental performance standards, as identified in Option 1.

In addition, the consultant will evaluate the measures required for the project to reduce the carbon emissions footprint to as close to or beyond carbon neutral as possible, when compared to Option 1. The purchase of clean energy via RECs or carbon offsets is not to be considered. The consultant should focus on reducing the building's GHG emissions through improved energy efficiency first, followed by the selection of less-emitting fuel sources. The production of on-site renewable energy generation should be evaluated and presented.

Fuel switching from electricity to a combustion fuel is not permitted at the project level because of PSPC's commitment to purchase 100% of the electricity it consumes from clean energy sources by 2025.

A shadow carbon price of $300 per tonne is applied to determine the lifecycle cost of Option 3 over 40 years.

This option will provide PSPC with two key pieces of information: (1) the maximum GHG emission reduction potential of the project, and (2) the cost associated with this Maximum GHG Emissions Reduction Design Option. The term Maximum GHG Emission Reductions is used instead of net zero carbon for this design option because there are some instances where projects will be able to produce on-site renewable power that is greater than the facility's demand. In such a case, power can be exported to the utility grid as a net benefit.

Option 4: Hybrid GHG Emissions Reduction Design

The consultant, in consultation with the PSPC project team (champion, director, leader, manager and Regional Centre of Expertise Specialists) will be asked to evaluate and propose an optimized design option, based on the information collected and calculated in the three options defined above. This hybrid optimized design option balances GHG emissions with construction and building operating costs. The hybrid optimized design option will likely be a newly bundled combination of individual measures that were investigated in Options 2 and 3. The individual measures themselves can be evaluated in terms of cost, cost avoidance, energy savings and GHG emission reductions. The modeling and simulation of different energy conservation/GHG emission reduction measure combinations will be required to determine the combination of measures that provides the best value for the Crown. In other words, the Crown is requesting that the professional consortium use their expertise to determine a fiscally responsible option that optimizes GHG emission reductions versus additional lifecycle costs (compared to Option 1). In most cases, it is expected that this hybrid optimized design will incorporate all of the measures selected for Option 2 and individual conservation measures that were identified in Option 3 that are cost-effective and/or lead to significant GHG emission reductions. The purchase of clean energy via RECs or carbon offsets is not to be considered as a GHG emission reduction measure. A shadow carbon price of $300 per tonne is applied to determine the lifecycle cost of Option 4 over 40 years.

Final Remarks

The project requirements, asset characteristics and its geographical location will dictate what must be included in each design option to provide best value for the Crown. The project options investigated in this methodology provide PSPC with information on the cost and GHG emission reduction potential of each design option. Thus, PSPC can make an informed decision on which project option to recommend, that is the option that provides best value, financially and environmentally, to the Crown.

Frequently Asked Questions

Question 1. What escalation and discount rates should be used in the calculation of net-present-value?

Answer 1. PSPC's Finance and Administration Branch (FAB) publish up to date interest rates and amortization factors on PSPC's intranet. Inflation rates and long-term escalation rates for operations and maintenance (O&M) costs are provided. Please note that the discount rate is equal to the cost of borrowing for the Government of Canada and is a function of the life expectancy of the investment. The discount rate is equal to the annual effective interest rate at year 25. In the future, FAB will provide a longer term discount rate to match the 40 year lifecycle period used for this analysis.

Question 2. Should a carbon charge be included in the lifecycle cost analysis?

Answer 2. Yes. The Greening Government Strategy requires that lifecycle and total cost of ownership assessments incorporate shadow carbon pricing. Shadow carbon pricing is a method of investment or decision analysis that adds a surcharge, for carbon dioxide that would be released, to market prices for projects that involve significant carbon emissions. A shadow carbon price of $300 per tonne is applied in the lifecycle cost analysis. The annual carbon cost is discounted to present dollars when determining the net present value or total lifecycle cost, however the annual carbon cost is not escalated for inflation during the 40 year lifecycle period. Although a carbon shadow price of $300 per tonne is included in the options analysis for decision-making, it is not a cost that will be incurred by the project.

Question 3. Should the residual value of building components be considered in the calculation of Net-Present-Value (NPV)?

Answer 3. Yes. The NPV calculation is done over a 40-year lifecycle and the residual value of building components and equipment at year 40 should be taken into account. This applies to the approach for single disciplinary and multidisciplinary projects.

Question 4. Is there a particular order that the options for the multidisciplinary projects should be investigated?

Answer 4. There is no particular order. However, generally option 1 (design that meets minimum departmental standards) and option 3 (maximum GHG emission reductions) will be developed first since they describe the baseline and maximum potential, respectively, for the project. It is expected that several iterations of bundling measures (which necessitates building simulations and cost analyses for each iteration) will be required to determine option 2 (cost neutral over 25 years). Finally, it is expected that the individual measures investigated in options 2 and 3 will be combined to arrive at option 4 (hybrid optimized design); this will necessitate several iterations of bundling measures.

Question 5. Should fuel switching from electricity to fossil fuel ever be considered?

Answer 5. In some provinces and territories, the emission factor for electricity is greater than the emission factor for a fossil fuel (for example, natural gas). This is the case if the fossil fuel is cleaner than the energy source that is used to generate electricity in the province or territory. Thus, fuel switching from electricity to fossil fuel would reduce GHG emissions. However, fuel switching from electricity to fossil fuel is discouraged as it is forecast that every electrical grid in Canada will be cleaner by 2040. As well, the Government of Canada has made a commitment to purchase 100% of its electricity from clean energy sources, starting in 2025. Therefore, fuel switching from electricity to fossil fuel is discouraged.

Question 6. What energy simulation software tool should be used for multidisciplinary projects to model the building, determine the impact of energy conservation measures and develop the different options?

Answer 6. A whole building hourly energy simulation software tool that complies with *ASHRAE Standard 140-- Standard Method of Test for the Evaluation of Building Energy Analysis Computer Programs* should be used. Examples of software tools that are widely used by industry and that comply with ASHRAE Standard 140 include IESVE, eQUEST, CAN-QUEST, OpenStudio/EnergyPlus and Design Builder. The professional performing the energy modelling should have experience with the tool selected and understand the tool's assumptions, validate the inputs provided to the tool and perform quality assurance of simulation results.

Question 7. How do I take into account ECCC's projected electricity emission factors in the calculation of annual GHG emissions?

Answer 7. There are three different ways to account for projected changes in Canada's utility grids when calculating GHG emissions. ECCC provides projected emission factors up to 2040. Depending on the project location, annual electricity emission factors can vary significantly from present day to 2040. For example, the 2020 emission factor for electricity in New Brunswick is 323.0 eCO2/kWh, and drops to 103.9 eCO2/kWh in 2040. In Ontario, the emission factor for electricity ranges from 35.5 eCO2/kWh in 2020 to 43.9 eCO2/kWh in 2040. In Québec, the emission factor for electricity ranges from 0.8 eCO2/kWh in 2020 to 1.8 eCO2/kWh in 2040. Taking into account the variance in emission factor will have a bigger impact on the estimated annual GHG emissions of a project in New Brunswick versus a project in Québec or Ontario. Project teams have three options for electricity emission factors:

(1) use the electricity emission factor projected for the estimated year of occupancy of the completed project;

(2) use the average emission factor for electricity, calculated as the average value over the 40 year lifecycle starting in the year the project is completed;

(3) use the emission factor projected year over year over the 40 year lifecycle.

Note that the projected value for the year 2040 is to be used to represent years beyond 2040.

For a fictitious project completed in 2025, the projected electricity emission factor in 2025 is compared to the average emission factor for 2025-2064, for New Brunswick, Québec and Ontario:

Location	Electricity Emission Factor 2025 eCO2/kWh	Average Electricity Emission Factor 2025-2065 (eCO2/kWh)
New Brunswick	320.6	116.7
Ontario	53.2	43.1
Québec	1.4	1.6

Project teams will use the approach that best represents true GHG emission production and should consult RPS-TSSL-GGD if there is uncertainty in which approach to use.

Worked Example 1. Options analysis for new building construction in Québec

This example provides information on how the Project GHG Options Analysis Methodology was applied to a new building construction in Québec. The Project GHG Options Analysis Methodology was a component of the project's Investment Analysis Report. The analysis defined the different design options available and determined the best value to the Crown, considering capital costs, lifecycle costs and GHG emissions.

A new building construction is a multidisciplinary project requiring that four design options be investigated. As Québec's electricity grid is clean, the maximum GHG emission reductions option for the project is a carbon neutral, or zero carbon, building. The analysis showed that there were in fact three different paths to a zero carbon building. Furthermore, two sub-options were investigated for the hybrid option in order to present a complete picture of different design scenarios.

Table 2 presents the different options investigated by the project team, and is a good example of the information that should be presented to decision makers. Table 2 includes a description of each design option, the capital and lifecycle costs of each design option and the estimated annual GHG emissions of each design option. Table 2 should be used as a template of how to present the results of the GHG Options Analysis in an Investment Analysis Report. The significant energy efficiency measures that are bundled for each option are described, with the significant differences from one option to the next highlighted in bold font (in the description row). The advantages and disadvantages of each design option are also defined by the project team.

The minimum departmental design option 1 sets the baseline to which all of the other options are compared. The cost neutral option 2 results in a lower lifecycle cost than the baseline option, at a minimal $288K incremental capital cost. However, the project team felt that because the building will be in Québec, a carbon neutral building is achievable without a significant increase in cost. In fact, option 3a shows that a carbon neutral building is achievable with a minimal increase in capital cost ($296K) and a decrease in lifecycle cost ($228K). The only difference between option 2 and option 3a is that the natural gas boiler is replaced with an electric boiler. The project team investigated two other options (3b and 3c) to achieve a carbon neutral building, with the goal of improving the building's energy performance and reducing its annual utility costs. Specifically, the building fenestration was changed from double glazed to triple glazed, recognizing that triple glazed windows allow the design to meet the Canadian Green Building Council's (CaGBC) requirement for the Thermal Energy Design Intensity (TEDI). A low TEDI reduces a building's heating and cooling loads and increases occupant comfort. The hybrid design option 4a reduces annual GHG emissions beyond the cost neutral design option 2 but does not lead to a carbon neutral building. The analysis demonstrates that hybrid option 4a is not best value for this project, since carbon neutrality can be achieved at a lower capital cost. Finally, option 4b was investigated to demonstrate the impact of reducing the fenestration to wall ratio to the prescriptive requirement in the National Energy Code for Buildings (NECB) for the building location. Although option 4b leads to a lower incremental capital cost and slightly lower lifecycle cost than option 3b, the project team notes that reducing the fenestration area and access to natural daylight risks reducing occupant wellbeing. Based on the analysis, the project team recommends option 3b, as the incremental capital and lifecycle costs are reasonable to achieve a carbon neutral building that meets CaGBC best practice and addresses occupant comfort.

Table 2: Worked Example - Presentation of Results

				Recommended Option			
Options	**1: Design to Meet Minimum Departmental Commitments (Baseline option)**	**2: Design to Achieve GHG Emission Reductions that are Cost Neutral (40 years)**	**3: Design to Achieve Maximum GHG Emission Reductions**			**4: Hybrid GHG Emissions Reductions Design**	
			a	**b**	**c**	**a**	**b**
Description	Condensing natural gas boiler Thermal wheel heat recovery Double glazed fenestration 40% fenestration to wall ratio Envelope insulation meets NECB presriptive requirements 29% better than NECB	Condensing natural gas boiler **Off-peak electric boiler** **Dual core heat recovery** Double glazed fenestration 40% fenestration to wall ratio **Envelope insulation exceeds NECB prescriptive requirements by R4** Free cooling	**Electric boiler** Dual core heat recovery Double glazed fenestration 40% fenestration to wall ratio Envelope insulation exceeds NECB prescriptive requirements by R4 Free cooling	**Electric boiler** Dual core heat recovery **Triple glazed fenestration** 40% fenestration to wall ratio Envelope insulation exceeds NECB prescriptive requirements by R4 Free cooling	**Electric boiler** **Geothermal heat pump** Dual core heat recovery **Triple glazed fenestration** 40% fenestration to wall ratio Envelope insulation exceeds NECB prescriptive requirements by R4 Free cooling	**Option 2 with geothermal heat pump and triple glazed fenestration**	**Option 3b but with 33% fenestration to wall ratio (prescriptive requirement in NECB for building location)**
Annual GHG Emissions (tonnes of CO2e)	130	60	-	-	-	32	-
Initial capital cost	110,000,000 $	110,288,000 $	110,296,000 $	111,021,000 $	111,724,000 $	111,735,000 $	110,738,000 $
Incremental capital cost	- $	288,000.00 $	296,000.00 $	1,021,000.00 $	1,724,000.00 $	1,735,000.00 $	738,000.00 $
Annual energy cost	292,000.00 $	277,000.00 $	306,000.00 $	297,000.00 $	288,000.00 $	274,000.00 $	290,600.00 $
Annual carbon shadow cost	39,000.00 $	18,000.00 $	- $	- $	- $	9,600.00 $	- $
40 year life-cycle cost	123,316,230.96 $	122,380,082.99 $	123,088,702.06 $	123,437,446.12 $	123,764,190.17 $	123,189,903.15 $	122,886,886.33 $
Incremental NPV compared to option 1 (includes escalation and residual value)	- $	936,147.97 $	227,528.90 $	(121,215.16) $	(447,959.21) $	126,327.81 $	429,344.63 $
Increase in lifecycle cost	N/A	-0.76%	-0.18%	0.10%	0.36%	-0.10%	-0.35%
Advantages	-Minimum departmental commitment met	-Best value in terms of energy reductions and energy costs.	-Carbon neutral at an acceptable cost.	-TEDI complies to CaGBC best practice -Better occupant comfort - Carbon neutral at a reasonable cost	-TEDI complies to CaGBC best practice -Better occupant comfort -Exemplary energy performance	-Operational advantage of having 2 energy sources -Exemplary energy performance	-TEDI complies to CaGBC best practice -Better occupant comfort -Reduced capital cost
Disadvantages	-Does not comply to GHG emission reduction commitments.	-Does not comply to PSPC's commitment to achieve a carbon neutral portfolio and to GC Greening Government Strategy.	-Thermal Energy Density Intensity (TEDI) does not comply to CaGBC best practice to achieve carbon neutral and to guidance from Greening Government	-Minor increase in cost	-Higher cost	-High cost of increased energy performance to achieve maximum reduction of GHG emissions	-Negligible reduction in energy costs over 40 years -Reduction of occupant wellbeing because of reduced fenestration area

Discount rate:	1.782%
Utility inflation rate:	2.000%
Maintenance inflation rate:	1.900%
Construction inflation rate:	2.400%

Representative rates used in this worked example.

APPENDIX K –Template Scope of Work Climate Risk Vulnerability Assessment (CRiVA)

Services publics et Approvisionnement Canada

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SCOPE OF WORK (SOW)

Climate Risk Vulnerability Assessment (CRiVA) on Potential Climate and Weather Impacts on Crown Assets – Laboratories Canada

Requested by:

The Science and Parliamentary Infrastructure Branch of Public services and Procurement Canada

National Capital Region

Project No. R.xx

October 2021

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9 ADDITIONAL INFORMATION ..... ERROR! BOOKMARK NOT DEFINED.

9.1 Terms and conditions ..... **Error! Bookmark not defined.**

9.2 Availability of personnel ..... **Error! Bookmark not defined.**

9.3 Ownership of information ..... **Error! Bookmark not defined.**

10 TECHNICAL AUTHORITY .... ERROR! BOOKMARK NOT DEFINED.

1 BACKGROUND AND OBJECTIVES

1.1 Background

Under the Federal Sustainable Development Strategy (FSDS),[1] the Government of Canada has made a commitment to "take action to understand the wide range of climate change impacts that could potentially affect federal assets, services and operations across the country." In addition, as stated in the FSDS, "All major real property projects will integrate climate change adaptation into the design, construction and operation aspects."

In addition, the Greening Government Strategy: A Government of Canada Directive states that "Consistent with the Federal Adaptation Policy Framework, departments will:

- by 2021, and at regular intervals thereafter, take action to improve understanding of the risks posed by the impacts of climate change to federal assets, services and operations across the country;
- by 2022, and following each subsequent climate risk assessment process, take action to reduce climate change risks to assets, services and operations, which could include:
  - incorporating and/or strengthening the consideration of climate change in business continuity planning, departmental risk planning or equivalent processes, and program design and delivery considerations;
  - integrating climate change adaptation into the design, construction and operation aspects of all major real property projects;
- apply climate-resilient building guidance being developed by National Research Council Canada;
- increase training and support for public service employees on assessing climate change impacts, undertaking climate change risk assessments, and developing adaptation measures, and facilitating the sharing of best practices and lessons learned."

It is in this context that the Science and Parliamentary Infrastructure Branch (SPIB) of Public Services and Procurement Canada (PSPC) is seeking the services of the Consultant to identify and assess potential site vulnerabilities and make infrastructure engineering design recommendations for climate change and extreme weather. This study is to be carried out using the Public Infrastructure Engineering Vulnerability Committee (PIEVC) protocol or equivalent in accordance with ISO 31000.

The study will look at the following Crown property:

1) Transportation Safety and Technology Science Hub, NRC Campus, Montreal Road, Ottawa, Ontario

[1] Federal Sustainable Development Strategy {FSDS} 2019–2022.

1.2 Objective

This study will be carried out in order to provide recommendations for the new infrastructure to be more resilient to sudden or protacted present and future climatic events. These recommendations will be taken into account during the design of the new infrastructure. This will facilitate decision-making on possible interventions to protect and sustain Labs Canada's asset and the development of future projects in the asset's management to account for sudden or protracted climatic events.

Another objective is to assess the suitability of the methodology selected for this study for the evaluation of ESAP's real property assets in order to optimize future climate risk and vulnerability studies at other sites.

Specifically, the assessment has the following objectives:

1. Review the available documentation on the property, which may include, but is not limited to, feasibility study, functional and technical program, emergency measures or business continuity plans etc.

2. Identify changes in key climate parameters that could affect the property over a 60-year time horizon.

3. Identify future infrastructure elements that are at risk of failure, damage and/or deterioration due to more frequent and intense severe climate events or significant changes from a baseline climate scenario considered in the design development process;

4. Determine the nature and relative levels of climate risk in order to set priorities for adaptation measures. These risk studies should be carried out according to the guidelines in the Public Infrastructure Engineering Vulnerability Committee (PIEVC) engineering protocol (the Protocol) or equivalent, which include the following:

a. Estimate the likelihood that significant climatic events will affect infrastructure;

b. Estimate the effects of significant climatic events on infrastructure;

c. Hold a vulnerability assessment workshop involving subject-matter experts, the project advisory committee and other stakeholders to quantify the risks associated with the identified events;

5. Make recommendations on to be taken into consideration when designing the new infrastructure and prioritize adaptation measures to address the facilities' climate change risks;

6. Document and submit the results in the form of a report and presentation.

The results of each study are intended to inform investment and asset management decisions made by the owner and operators.

2 METHODOLOGY

The Consultant will work with representatives of PSPC and ESAP, the “work team.” All decisions required to ensure that the work goes smoothly must be made in close collaboration by the Consultant and the work team.

2.1 Kick-off and other meetings

Following the contract award, the work team will schedule a kick-off meeting with all project stakeholders to ensure that each party understands their role in the project, that there is good collaboration between parties and that all parties understand the project scope. The meeting will also serve to validate the work schedule proposed by the Consultant, including the planning and completion of deliverables, and to clarify the mandate. In addition, the meeting will provide an opportunity to discuss the available data and to define the type of input data needed to carry out the study. The meeting will be by conference call.

Within two weeks of the kick-off meeting, the Consultant will provide PSPC and ESAP with the following:

- the minutes of the kick-off meeting;
- a list of all documentation on the properties needed to carry out Step 1 of the Protocol (Project Definition);
- a list of all project stakeholders that PSPC will be responsible for contacting and coordinating;
- a communications plan, including communication channels for any request from the Consultant to PSPC;
- any other requests, as discussed at the kick-off meeting.

Subsequent follow-up meetings will be scheduled when required and will be conducted by electronic means (conference calls, videoconferences or web conferences).

2.2 Scope of services

2.2.1 Assessment of the infrastructure engineering vulnerabilities to potential climate- and weather-related impacts

The scope of the assessment will include the design, construction, operation and management of the building(s).

The study must address the potential impacts of current and future climate over a global time horizon of 60 years.

The nature and relative levels of risk must be determined in order to set recommendations for the design and operations the building . The assessment must be performed using the most current version of the PIEVC engineering protocol or an equivalent protocol that follows the guidelines of ISO 31000, Risk Management.

For the purposes of this study, "engineering vulnerability to climate change" is defined as the shortfall in the ability of infrastructure to absorb the negative effects, and benefit from the positive effects, of changes in climate conditions; this expression is used in infrastructure design and operation. Engineering vulnerability is determined as a function of the following:

1. the character, magnitude and rate of change in the climatic conditions to which infrastructure is predicted to be exposed;
2. the sensitivities of infrastructure to the changes, in terms of positive or negative consequences of changes in applicable climatic conditions; and
3. the built-in capacity of infrastructure to absorb any net negative consequences from the predicted changes in climatic conditions.

The engineering vulnerability assessment will entail assessment of all three elements above.

2.2.1.1 Step 1 – Project Definition

In this step, the Consultant will provide a general description of the infrastructure, including design, construction, management, operation and maintenance based on the available information. The description will include the following:

- the site;
- historical climate conditions;
- pre-design information, if available;
- life cycle;
- upkeep and maintenance anticipated;
- departmental operations (if any);
- third-party easements that serve the study site, such as energy suppliers (electricity and others, if applicable), telecommunications, and municipal water supply and wastewater systems;

- any other important factor.

The final list of infrastructure components to be assessed must be prepared by the Consultant. The Consultant will also mention important documents and sources of information.

A site visit may be arranged at this stage (subject to approval by SPIB) if the available infrastructure information is insufficient and if COVID-19 conditions permit.

2.2.1.2 Step 2 – Data Gathering and Extensiveness of Data

In this step, the Consultant will define the following in more detail:

1. the infrastructure components that will be assessed;
2. the specific climatic hazards that will be taken into consideration, i.e., those likely to interact with infrastructure component(s);

There are two main activities in this step:

1. Identifying the characteristics of the infrastructure that will be considered in the assessment:
   - the infrastructure's physical components: the number of physical components and their location;
   - other important engineering/technical considerations: construction materials, age, regional importance, and physical condition;
   - current and archived operation and maintenance practices;
   - infrastructure operation and management: insurance and legal considerations, policies, guidelines, and regulatory framework;
   - components of third-party delivery of essential services such as water, energy and telecommunications.

2. Identifying site-specific climate data, including extreme and repetitive events. For example, for assets located in coastal and riparian zones, coastal erosion and flooding hazards or riparian erosion and flooding hazards must be included in the study. Sources of climate data include, but are not limited to, the National Building Code of Canada, Appendix C – Climatic Information; Intensity-Duration-Frequency (IDF) curves; floodplain mapping; climate models and development of region-specific scenarios (Intergovernmental Panel on Climate Change, CCCSN.ca); thermal units (e.g., degree days); the Institute for Catastrophic Loss Reduction; and other sources as appropriate.

No new climate modelling or downscaling of climate predictions is expected here. However, the Consultant is expected to identify, access and compile historical and projected future climate information on relevant climate factors for locations at or near the infrastructure from Environment and Climate Change Canada and other reliable sources. The climate information must be compiled in a manner that is scientifically defensible and complies with scientific and industry standards. Other sources of information about future climate include Ouranos, the Pacific Climate Impacts Consortium, the Canadian Climate

Data and Scenarios (CCDS) network, local municipalities, and any other climate studies that may have been conducted in the region. The assumptions and limitations of the future climate information must be included in the final report and be as scientifically defensible as possible. The Consultant can use the climate data from the "Identification of Climate-Related Hazards for Real Property Assets in the National Capital Area" Study as a starting point. The Study report will be provided at the contract awarding.

As this step is a multidisciplinary process, involving expertise in engineering, climatology, operations, maintenance and management, the Consultant must ensure that the right mix of expertise is applied, either on the assessment team or through consultations with other professionals during the assessment. In this step, SPIB - PSPC expects the Consultant to plan one or more workshops that will bring together the key individuals involved in the project, including but not limited to: personnel responsible for the planning, engineering, operation and maintenance of the building, representatives of the occupying client department(s), the Consultant's project team, climate experts, and any other relevant stakeholders.

2.2.1.3 Step 3 – Risk Assessment

In this step, the Consultant will identify the interactions between infrastructure, climate and other factors that could lead to vulnerability, including the following:

- certain infrastructure components;
- certain climate parameter values;
- certain minimum performance targets.

The risk assessment requires the Consultant to determine which infrastructure components (including occupant operations components) are likely to be sensitive to changes in certain climate parameters. The Consultant must assess this sensitivity against performance expectations and other requirements placed on the infrastructure. Infrastructure performance can be influenced by a variety of factors and even by the combined effect of certain factors. In other words, the Consultant must consider the infrastructure's overall environment.

It is recommended that the Consultant measure risk on a scale of 1 to 5 (5 x 5 matrix) that is consistent with other risk management approaches used by the Government. This method is also consistent with Infrastructure Canada's Climate Lens – General Guidance, as follows:

Risk Assessment Matrix							
Impact' Severity	Very Severe	5	5	10	15	20	25
	Severe	4	4	8	12	16	20
	Moderate	3	3	6	9	12	15
	Minor	2	2	4	6	8	10
	Measurable	1	1	2	3	4	5
			1	2	3	4	5
			Very Low	Low	Moderate	High	Very High
			Likelihood				

Risks Levels	
Risk (R) = Likelihood (L) x Severity (S)	
R < 5	Negligible
3 < R < 4	Low
R = 5	**Particular Case**
6 < R < 9	Moderate
10 < R < 16	**Significant**
R > 20	**Major**

Where:

Major Risk: Immediate controls required
Significant Risk: High priority control measures required
Moderate Risk (Yellow): Some controls required to reduce risks to lower levels
Low Risk (Blue): Controls likely not required
Negligible Risk (Green): Risk events do not require further consideration
Particular Case (R=5): corresponds to an extreme climatic event having a low probability of occurring but which would cause very serious damage or to a negligible climatic event which occurs frequently, which can cause premature wear of the physical components

The final risk matrix format will be confirmed with the work team.

In this step, the Consultant will conduct a risk assessment of the infrastructure's vulnerability to climate change. The assessment team will use its professional judgement in assessing the identified interactions, taking into account the risk tolerance scale previously established with representatives of the client department(s) and re-validated following the exercise. The risk assessment will identify areas of major concern. The Consultant will organize a risk assessment workshop. It is expected that the key people attending the workshop will be at least the same as those present at the Step 2 workshop.

The Consultant will identify the interactions that require further analysis. Interactions that do not clearly establish vulnerability may require further engineering analysis or additional study as a result of the assessment.

In this step, the Consultant will also assess data availability and quality. If the Consultant, in its professional judgement, identifies a potential vulnerability that requires data not available to the assessment team, the Consultant must go back to Step 1 or Step 2 and obtain and improve the data that is needed for a risk assessment. The Consultant may determine that this process requires further work outside the scope of the assessment. This must be reflected in the recommendations set out in Step 5.

This step is the key step in the vulnerability assessment, as the Consultant must determine the following:

- the interactions that require further assessment;
- aspects requiring data improvement;
- initial recommendations for further research or for immediate remedial action, or a finding that the infrastructure is not vulnerable.

Maintaining the infrastructure's operations and services and the time required to return to normal are major factors in assessing risks and identifying mitigation measures.

2.2.1.4 Step 4 – Recommendations and Conclusions

In this step, the Consultant will make recommendations based on the work carried out in the above steps. In general, recommendations will be divided into the following main categories:

- Adaptation measures will be required to improve the infrastructure;
- Management action will be required to address changes in infrastructure capacity;
- No further action is required;
- Identification of deficiencies in data availability or quality requires further work.

The Consultant may also provide additional conclusions or recommendations regarding the robustness of the assessment, the need for further assessment, or areas that were not part of this assessment.

2.2.1.5 Study reports

The Consultant will prepare a report that clearly documents and summarizes the work completed and that includes an executive summary, a description of the baseline and projected climate parameters, a list and description of the infrastructure components, and the assessment of the engineering vulnerabilities and recommended adaptation measures.

2.3 Site access (optional)

In the event of a site visit, the Consultant will be responsible for its own transportation, with no support from PSPC, and will incur all travel costs. Any visit will be subject to the approval of SPIB - PSPC and will depend on COVID-19 conditions at that time.

2.4 Materials and equipment

The Consultant will provide all of the materials and equipment required to perform the work and ensure that the equipment is in proper working order.

2.5 Guidelines

The guidelines to be observed by the Consultant include, but are not limited to, the following:

- the most recent version of the PIEVC Protocol (if the PIEVC Protocol is used);
- the climate change resilience principles described in Annex F of Infrastructure Canada's (IC's) Climate Lens – General Guidance;
- the National Building Code of Canada.

The Consultant will be responsible for obtaining the most recent version of the PIEVC Protocol, if applicable.

2.6 Additional requirements

If the PIEVC Protocol is used, the Consultant will be required to sign a confidentiality agreement with PSPC and Labs Canada regarding the use of the Protocol, which is the intellectual property of the partnership consisting of the Institute for Catastrophic Loss Reduction (ICLR), the Climate Risk Institute (CRI) and the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. The agreement covers non-disclosure to third parties or internal personnel who are not involved in the project. In addition, the Consultant undertakes to maintain the confidentiality of all other documents provided (e.g., similar studies provided by other departments).

Once the project is completed, the Consultant will be required to return the Protocol to the owner/operator and destroy and not retain any electronic or hard copies.

3 DOCUMENTATION PROVIDED AND REFERENCES

The Consultant must perform the work in accordance with the applicable federal, provincial or municipal acts, regulations, codes, guides and standards.

In the context of this mandate, the following is a partial list of documents that may be provided to the Consultant as required:

- Site plans
- Equipment specifications
- The NCA Climate Study
- Other documents as required (to be discussed at project outset)

If applicable, the Consultant will also contact the municipality and the energy and telecommunications distributors to obtain a history of incidents related to climatic events reported in the vicinity of the property under study in at least the last five years.

4 DELIVERABLES

For this project, the Consultant is required to provide the following deliverables. Comments from SPIB – PSPC and Labs Canada are to be incorporated into the deliverables.

All oral and written communications during this mandate must be in English.

4.1 Summary of kick-off meeting and description of activities in the work plan

Based on the discussions at the kick-off meeting, the Consultant will submit a work plan for approval by the SPIB-PSPC Project Manager. The work plan will contain the following information:

- further details on the technical experts on the Consultant's team who will take part in the project and their duties and responsibilities (e.g., structural engineering, paving, climate – data gathering and analysis, and property management and operation);
- further details on the technical approach outlined in the Consultant's proposal and any possible/predicted deviations. This includes, but is not be limited to, the data/information gathering procedures the Consultant will follow;
- a listing of potential issues that will require decisions by SPIB – PSPC and Labs Canada;
- a listing of infrastructure and climate data/information requirements and a preliminary assessment of significant data deficiencies;
- a proposed project schedule that includes key milestones (e.g., workshops, required travel, and meetings);
- a detailed description of how the project will operate (e.g., meetings, teleconferences, and summaries of action items for subsequent meetings).

4.2 Monthly progress reports

The Consultant will provide a monthly progress report by email. The report will

- describe monthly progress in relation to the work plan;
- document technical issues and key decision points; and
- identify any technical, financial or management issues that require resolution and/or were resolved during the reporting period.

The reports are to be submitted to the SPIB-PSPC Project Manager by email.

4.3 Vulnerability study report

The Consultant will produce a Climate Risk and Vulnerability Assessment Report which will include, but not be limited to, the following:

- an executive summary (a section summarizing the entire study, including the recommendations);
- an introduction that describes the background and objectives and the main steps in the study based on the protocol used;
- the methodology used and the work team involved;
- the project definition, including a list of assumptions, technical judgements, analysis limitations, the time horizon, and the geographical and administrative context;
- data gathering and extensiveness of data, including a description of the infrastructure components considered; current and projected climate parameters of interest that are relevant to the infrastructure's design, development and operation; and the information sources used and their evaluation (quantity and quality);
- a summary of the site visit, if applicable;

- risk assessment and results of the engineering vulnerability analysis, including the vulnerability analysis matrices (current and future climate);
- a listing of potentially vulnerable infrastructure components and a description of climate parameters affecting those components;
- a detailed engineering analysis, if applicable (optional work);
- recommendations regarding risk management and adaptation measures: a description of recommended remedial measures for strengthening potentially vulnerable future infrastructure components. The recommendations must be quantified wherever possible (for example, removing snow from the roof when it reaches a given thickness in cm);
- recommendations and comments on the application of the protocol used or suggestions for improvement;
- a conclusion, including a statement regarding the infrastructure's overall vulnerability/resilience, if applicable;
- references used and citation of the PIEVC Protocol (if applicable) in accordance with the requirements of the agreement providing access to it.

Deliverables will be produced only in English.

4.3.1 Draft (pre-final) report

The report must be provided in draft form, electronically. The draft report must have the same quality of presentation and content as a final report. Special attention must be paid to the writing style (clear, concise and well-organized) and the quality of the English (spelling mistakes, syntax, etc.). The Consultant should also note that more than one set of comments may be made depending on the quality and accuracy of the information provided in the draft report.

4.3.2 Final report

A complete final document, following acceptance by the authorities responsible for changes to the draft report, must be submitted electronically. The complete final report must be provided in PDF (including appendices), and all files must also be submitted in their original format (Word, Excel or other). The Consultant must sign the PDF version of the report.

To summarize, format and number of copies:
One (1) electronic copy of the draft report in MS Word and MS Excel (for the spreadsheets for each step).
One (1) signed electronic copy of the final report in Adobe PDF with no restrictions on printing or copying and pasting. This copy will constitute the original version of the study.
One (1) electronic copy of the final report in MS Word and MS Excel.

4.3.3 Spreadsheets and forms from the PIEVC Engineering Protocol

If the PIEVC Protocol is used, the Consultant will duly complete MS Excel spreadsheets and forms documenting the results of each step in the PIEVC Engineering Protocol. The spreadsheets and forms are to be submitted as appendices to the reports.

4.3.4 Presentation of the project

The Consultant will provide a PowerPoint presentation summarizing the entire study, including key findings and recommendations for the properties included in the project for use by PSPC and ESAP or other project stakeholders. This deliverable will be produced in English.

The visual aids used during the presentations will be provided to PSPC as contract deliverables.