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Made-in-Ontario Pumped Hydro Storage

Economic and Social Value Benefits

Research Report | April 2024

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About this Report

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Executive Summary

Background

Ontario's electricity system is on the cusp of transformation. Faced with rising demand for electricity, due to population and industrial growth, and increased electrification, coupled with commitments to transition to cleaner sources of supply, Ontario's electricity system will grow significantly in the coming decades. The Independent Electricity System Operator (IESO) (2024) projects that total electricity demand in the province will increase by 60% over the next twenty five years. To support this growth, the province is diversifying its electricity mix to include incremental nuclear, hydroelectric, and renewable power. To balance these resources, the province is investing in energy storage solutions to reduce energy generation curtailment and ensure a stable supply during peak demand periods.

The Ontario Pumped Hydro Storage (OPS) Project, a prospective partnership between TC Energy Corporation and the Chippewas of Nawash Unceded First Nation and the Chippewas of Saugeen First Nation, collectively, the Saugeen Ojibway Nation, is a direct response to these needs. The prospective partnership aims to construct a 1,000-megawatt pumped hydro storage facility to enhance the reliability and efficiency of Ontario's electricity system. The Project is designed to store excess energy during low-demand periods and release it during high-demand times.

Objectives

This study focuses on the economic and social value of the OPS investment, with social value being the well-being pillar of Environmental, Social and Governance (ESG) investment principles. Together, these components of value combine to measure the total benefits supported by the Project. Additionally, to fully understand the benefits of any infrastructure investment, both the contribution (the overall significance of the Project in the economy and society) and the net benefit (how the Project compares to business-as-usual growth) of an investment must be considered. These key concepts are explained below.

OPS Contributions: The Gross Value Components of OPS

Economic Contributions: The economic contributions quantify the activity in Ontario and the increased capacity of its supply lines that result from OPS investments. This requires an understanding of the jobs and economic activity directly related to OPS construction and operations (direct contributions), the jobs and economic activity generated in the affected supply lines (indirect contributions) and the induced effects from the payment of wages which OPS will directly, or indirectly, support.

Social Value Benefits: The social value benefit quantifies the extent to which OPS will change the well-being of Ontarians. This captures all the positive and negative effects on the well-being of individuals against well-being in a business-as-usual baseline that would generate the same number of jobs as OPS would generate directly[1]. These changes in well-being are mapped to monetary equivalents using income changes that would result, all else equal, in the same changes in well-being for each unique individual in the analysis. This exercise requires an understanding of the people that OPS will impact through training, upskilling, increased Ontario supply capacity and the higher wages paid to higher-quality jobs.

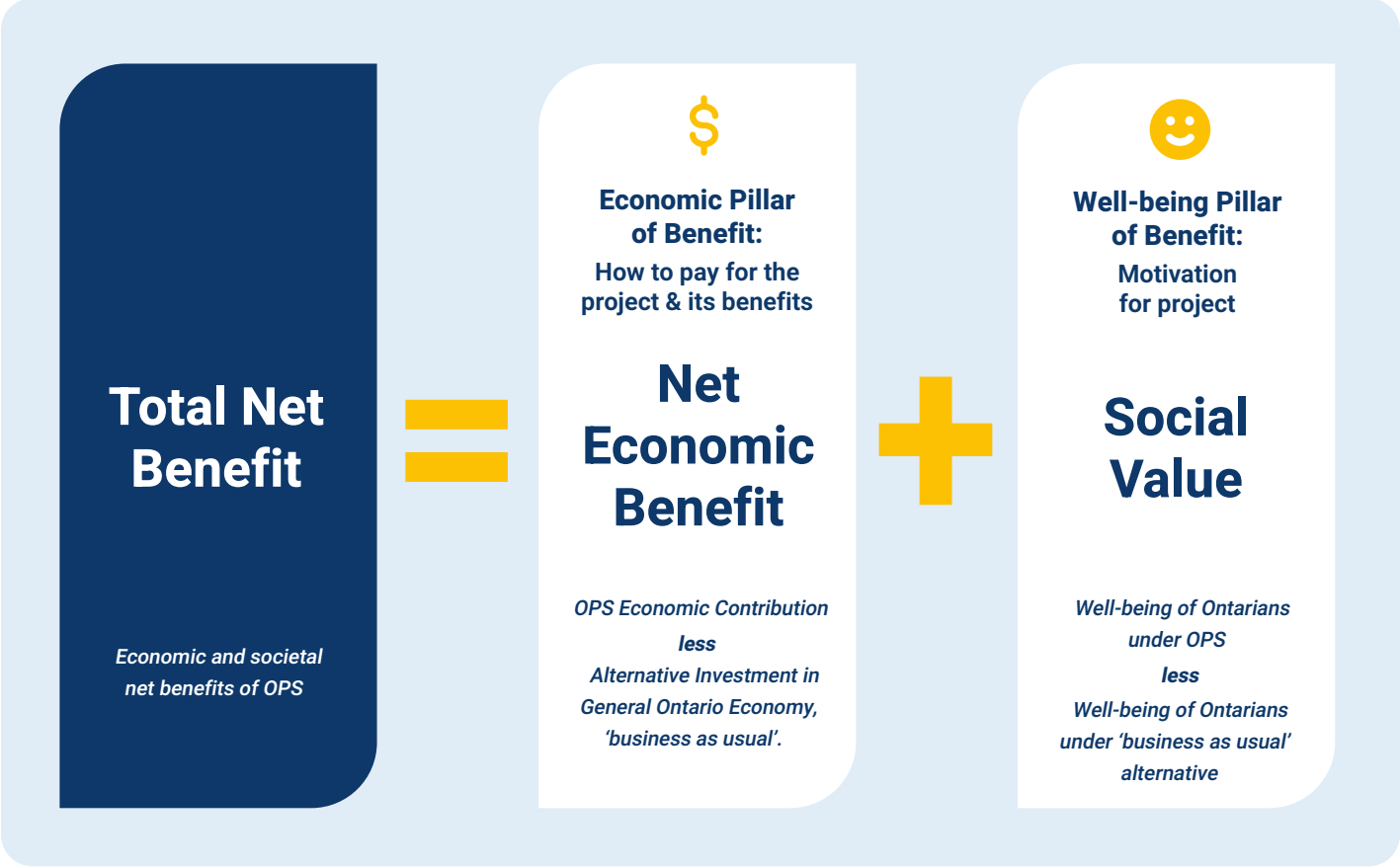
OPS Net Economic Benefit: The Net Economic Value Components of OPS

Economic Net Benefits: The net economic benefit of the project measures how much more valuable, in terms of the economic metrics analyzed, the OPS investment is over the business-as-usual baseline that would generate the same number of jobs as OPS would generate directly. This net benefit corresponds to the difference between OPS's gross economic contribution and the gross economic contribution of the baseline.

1 The motivation for this baseline scenario is that if an alternative investment were to have the same direct jobs impact, but the direct jobs reflected the general economy (rather than the specific jobs required for OPS) there will be differences in the overall economic contribution. In particular, when following the indirect and induced aspects in the 'business as usual' case, there might be different jobs required in the supply chain, and variation in the overall economic capacity of the province. The net result will reveal that even when starting with the same number of direct jobs, the effects of OPS on the supply chain and induced activity could be different to the 'business as usual case'.

Understanding the Net Social and Economic Benefit

With these concepts in mind, failing to compute social value estimates alongside economic contributions leads to an incomplete picture of the total value of a project. Given that the motivation for a project should be its impact on people, the social value of a project is an intrinsic aspect of its total value. In other words, while the net economic value indicates the financial viability of a project, the social value provides the reasons why a project should be undertaken in the first place. Therefore, the total net value of OPS is the sum of its net economic value and social value:



Using this assessment framework, this report provides two key findings. First, the report provides the total value proposition of OPS's investment and operations plans over the 50-year course of the Project. To this end, it assesses the total economic, labour, and social value contributions of the Project. **Our analysis concludes that the OPS Project has a net value of $3.4 billion**.

Second, the economic results of OPS are contrasted with the results from a stylized example of a Battery Energy Storage System (BESS) with comparable capacity. This comparison is conducted for both economic and social metrics, covering benefits to metrics such as GDP, employment, taxation revenues, and the number of affected Ontarians, households, and full-time jobs. The objective is to understand the differences in the economic and social contributions between OPS and BESS.

A positive social value indicates the project is worth considering.

Results

OPS Economic Contribution

The Ontario Pumped Hydro Storage Project is a multi-billion dollar investment by TC Energy and Saugeen Ojibway Nation into Ontario's electricity infrastructure. Over the next 50 years, the construction and operation of OPS would contribute, in present value terms, over $6.8 billion (2023 dollars) to the Canadian economy, with 90% of that activity remaining in Ontario and $3.9 billion in wages.

OPS expected to contribute $6.8 billion to the economy.

The OPS Project:

Generates high quality[2] jobs for Ontarians: The Project generates the equivalent of 41,000 jobs, of which 66% are full-time positions. Moreover, 77% of total generated employment is specific to OPS investments (from direct or indirect sources). During the 4-year peak construction period, over 1,700 construction jobs would be directly or indirectly supported each year, mostly with local employment.

Is built through provincial and national supply chains: Of the total capital investment, 83% remains in Canada of which 92% stays in Ontario. This ensures that Canadian and Ontarian individuals and businesses realize the biggest benefits from the Project, with over 110,000 Ontarians benefiting. In terms of both GDP and employment, the Ontario manufacturing and construction sectors benefit the most relative to other sectors.

Contributes to the prosperity of rural economies: Of the total employment and GDP benefits, 61% and 65%, respectively, are in more rural regions[3]. 59% of the total gross operating surplus and labour income benefits occur in more rural economies.

Benefits for immigrants: It is estimated that 35% of all employment benefits would support immigrants in Ontario. This has the potential to attract more immigrants to the province, and while many newcomers would settle in urban centres, over 1 in 7 rural jobs would support immigrants. This can help address demographic and labour force challenges faced by communities across the province.

OPS expected to affect 110,000 Ontarians.

2 High-quality jobs refer to well-paid, generally skilled, full-time jobs.

3 Throughout this report, "urban" refers to regions among the top census divisions that account for at least 60% of the total population. "Rural" regions are the remaining ones.

OPS Social Value

While the economic benefits of the Project support the financial viability of OPS, OPS would also have wide-ranging social value benefits, indicating that it could improve the well-being of Ontarians. In particular, OPS would have:

High impact on rural Ontarians: Of the 37,000 households benefited, 20,700 (56%) are in rural regions. The majority of benefited households are couples with children.

High impact on affordability challenges: A third of the jobs created by the Project are anticipated to be filled by individuals aged under 35, which compose the demographic most likely to be facing housing affordability pressures. Because the jobs generated by OPS are in skilled sectors with generally higher incomes than other industries, these jobs have the potential to improve the affordability of affected households.

High well-being impact for Ontarians: The $450 million social value contribution from OPS signifies a considerable improvement in aggregate well-being over the current levels of well-being in the Ontario population. It corresponds to the well-being that would be generated, all else equal, by a total income injection of $450 million in the Ontario economy.

Net Value of Ontario Pumped Hydro Storage to Ontario

To better understand the significance of OPS in the Ontario economy and society, it is useful to compare the effect of OPS relative to a business-as-usual baseline that would generate the same number of jobs as OPS would generate directly. In this case, the economic contribution of OPS was found to be 1.7 times higher than the contribution generated from Ontario's business-as-usual activity. That is, OPS is 1.7 times more beneficial than general investment in the Ontario economy. In addition, it benefits 20% more Ontarians.

Overall, OPS is expected to generate a total net value of $3.4 billion over the next 50 years, which arises from a net economic contribution of $2.9 billion relative to the general economy plus the social value contribution of $450 million.

OPS is 1.7 times more beneficial than an alternative investment in the Ontario economy

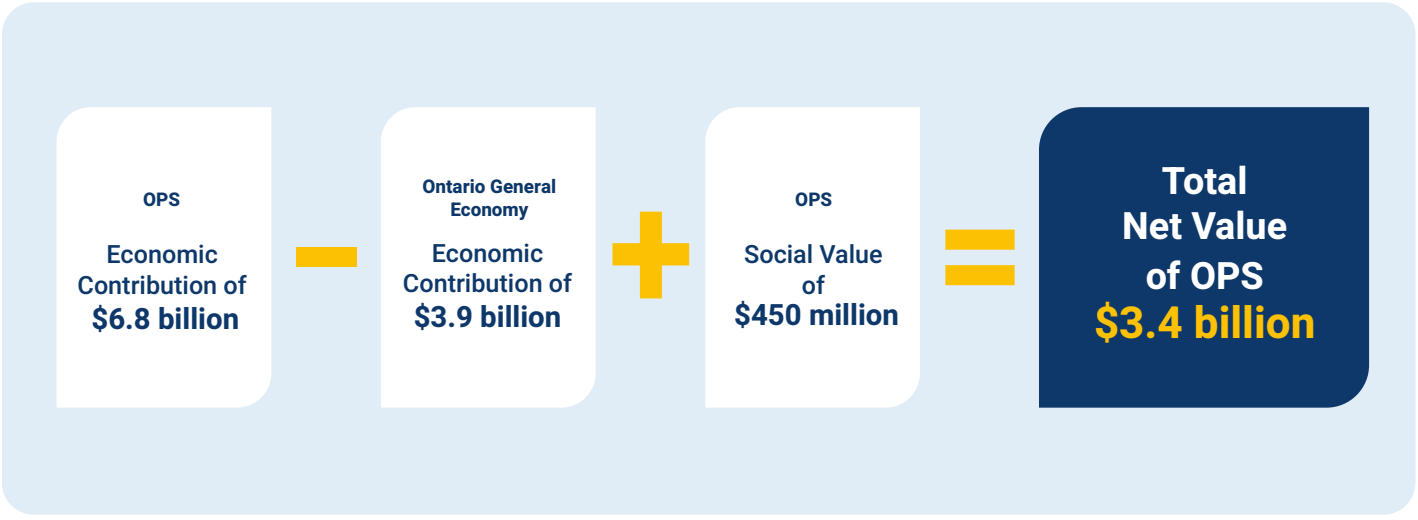


Table 1 Total value of Ontario Pumped Hydro Storage relative to the general economy

	OPS (over 50 years)	General Economy (business as usual) (over 50 years)	OPS benefit vs. general economy
Economic Contribution (GDP, 2023 dollars)	**$6.8 billion**	**$3.9 billion**	**1.7 times**
Gross operating surplus[4] (2023 dollars)	$2.9 billion	$1.5 billion	1.9 times
Private investment (2023 dollars)	$1.4 billion	$680 million	2.1 times
Jobs[5]	41,200	31,800	1.3 times
Labour income (2023 dollars)	$3.9 billion	$2.4 billion	1.6 times
Social Value (Ontarian's well-being)	**$450 million**	-	-
Ontarians benefited	110,000	89,500	1.2 times
Households benefited	37,000	29,000	1.3 times
Rural households benefited	20,700	11,500	1.8 times
Households with children benefited	16,800	15,100	1.1 times
One-parent families benefited	3,000	2,600	1.2 times
Jobs for Ontarians under 35 years of age, percentage of total	33%	34%	-
Total Value Relative to the General Economy	**$3.4 billion**		-

4 Gross operating surplus is approximately equal to business profits.

5 Jobs are measured in people-years, which correspond to the number of full-time employment equivalents over one year.

In addition, the strength of OPS relative to the general economy is seen through the fact that it:

Generates high-quality jobs for Ontarians: OPS would generate 1.4 times more high-quality full-time jobs for Ontarians.

Is built with Ontario/Canadian Supply Chain: For every job supported, the Project generates 2.3 times more construction and manufacturing jobs than the general economy.

Contributes to the prosperity of rural economies: OPS benefits 1.8 times more rural households than the general economy.

Has a high impact on affordability challenges: By generating 1.3 times more total jobs, OPS provides greater support to households affected by housing unaffordability challenges.

Has High well-being impact for Ontarians: OPS generates $450 million in social value, reflecting positive well-being changes on aggregate as a result of the Project.

Other Benefits of Ontario Pumped Hydro Storage

In addition to the economic and social benefits presented above, OPS has the potential to contribute positively to Ontario's emissions-reduction goals, to partner with Indigenous Nations, and benefit local communities.

Sector Emissions Reductions

In reducing the need for high-emitting sources at peak times, storage technologies, particularly long-duration (over 8 hours of supply) energy storage, play a crucial role in helping mitigate greenhouse gas (GHG) emissions. By ensuring that electricity generated from non-emitting sources during periods when supply exceeds demand is stored for later use, the overall efficiency of the electrical system can be maximized while mitigating GHG emissions.

Indigenous Partnership

As prospective co-owners of the Project, the Saugeen Ojibway Nation will earn proceeds from ownership, which will directly go back to investments in their communities. Further, the Nations will have access to priority employment, training, and contracting opportunities for their members. This represents a direct and meaningful economic reconciliation effort between industry and treaty partners and is aligned with the 92 Calls to Action from the Truth and Reconciliation Commission.

Benefit for Local Communities

As the Project is located within the Municipality of Meaford, Ontario, TC Energy is committed to working with the Municipality to define long-term benefits through a Community Benefits Agreement. This will take the form of a direct and sustained monetary contribution to the municipality. This contribution could support several community needs, programs and investments that contribute to the well-being of Meaford residents.

Given the Project's proximity to the City of Owen Sound and other key centres in Grey, Bruce and Simcoe Counties, and TC Energy's commitments to hire and buy local principles, these communities will benefit from Project construction and operation.

Comparison of Ontario Pumped Hydro Storage to Battery Energy Storage System

A primary alternative to pumped hydro storage is battery energy storage. While these technologies can provide similar utility to the electricity system, they can differ widely in their economic and social benefits. With this in mind, the economic and social benefits of the first 20 years of construction and operations of OPS are contrasted with those of a 20-year battery energy storage system (BESS) alternative. The exercise adopts a stylized BESS example that is of similar capacity and location to OPS. The total capital investment for this BESS example would be similar to OPS.

The net benefit of OPS relative to such a battery energy storage system is $3.5 billion, encompassing $3.2 billion and $190 million, respectively, in net economic and social value contributions over the next 20 years. In terms of GDP and social value, the OPS contributions are 2.5 and 2.1 times higher than those of BESS, respectively.

OPS is 2.5 times more economically beneficial than battery alternatives.

OPS is 2.1 times more beneficial to the well-being of Ontarians than battery alternatives.

Pumped Hydro Storage Relative to Battery Energy Storage System

Relative to the first 20 years of OPS, an investment in the equivalent capacity battery storage system would result in:

Fewer jobs for Ontarians: While OPS generates 34,700 jobs for Ontarians, BESS generates only 10,500. This means that OPS generates 3.3 times more jobs than BESS.

Greater reliance on foreign supply chains: While 83% of the direct spending from OPS would remain in Canada, that figure is only 20% for BESS. This reliance on foreign, as opposed to local, supply chains, is reflected in the significantly lower economic and social benefits generated for Ontarians by BESS.

Less economic value: OPS generates 2.5 times more GDP than BESS over the 20 years analyzed. Similar differences are observed for all metrics analyzed, including GDP in rural regions, gross operating surpluses, private investments, and jobs.

Less social value: OPS generates 2.1 times more social value than BESS over the 20 years analyzed. Across all social metrics analyzed, including the number of affected Ontarians, households, and full-time jobs, OPS generates at least 3.2 times as many benefits as BESS.

OPS generates more spending in Ontario, building important construction & manufacturing capacity.

Table 2 Net value of Ontario Pumped Hydro Storage relative to Battery Energy Storage System

	OPS (over 20 years)	Battery Alternative (over 20 years)	OPS benefit vs. BESS
Economic Contribution (GDP, 2023 dollars)	**$5.3 billion**	**$2.1 billion**	**2.5 times**
GDP in rural regions (2023 dollars)	$2.8 billion	$1.3 billion	2.2 times
Gross operating surplus[6] (2023 dollars)	$2.1 billion	$1.1 billion	2.0 times
Additional private investment (2023 dollars)	$820 million	$550 million	1.5 times
Jobs[7]	34,700	10,500	3.3 times
Jobs in rural regions	17,400	5,500	3.2 times
Social Value (Ontarian's well-being)	**$360 million**	**$170 million**	**2.1 times**
Ontarians benefited	47,600	14,600	3.3 times
Households benefited	15,600	4,800	3.2 times
Households in rural regions benefited	17,400	5,500	3.2 times
Households with children benefited	6,600	2,000	3.2 times
One-parent families benefited	1,400	420	3.3 times
Net Benefit of OPS compared to BESS	**$3.5 billion**		-

6 Gross operating surplus is approximately equal to business profits.

7 Jobs are measured in people-years, which correspond to the number of full-time employment equivalents over one year.

Conclusions

The OPS investment has several unique value drivers, including the use of Ontario supply chain lines and the skilled and trained labour required to build the facility. These value drivers result in OPS being 1.7 times more beneficial than general investment in the Ontario economy.

Over the next 50 years, the proposed investments in OPS stand to generate significant economic, labour, and social benefits for Ontario. By affecting more than 110,000 Ontarians, OPS would generate over $6.8 billion in economic activity, an increase of $2.9 billion over business-as-usual growth. It would also generate over 41,000 jobs, primarily targeting parts of the province that could benefit the most from them: rural regions, young people (under 35 years of age), and households with children. Overall, these benefits lead to a significant increase in aggregate well-being in the province, equating to $450 million in social value.

In comparison with a BESS of similar storage capacity, OPS would generate significantly higher economic and social benefits over 20 years, namely 2.5 times more economic benefits and 2.1 times more social value. BESS projects source construction resources primarily from abroad and the number of affected Ontarians would be 69% lower relative to OPS. As a result, fewer households would be affected, and significantly fewer full-time jobs would be generated.

1.0 Introduction

1.1 Background

1.1.1 General

Ontario's electricity system is at a critical juncture, needing to meet rising electricity demands while moving towards cleaner energy sources. This shift is essential as the province faces increasing industrial activity, a growing population, and a commitment to reducing greenhouse gas emissions. Pumped hydro storage can play a pivotal role in this context, aligning with Ontario's clean energy strategy and supporting the province's vision for a clean economy.

Electricity demand in Ontario is anticipated to increase significantly in the following decades. The Independent Electricity System Operator (IESO) (2024) forecasts that the demand for electricity will increase by 60% over the next twenty-five years. To support this growth, the province is diversifying its energy mix to include nuclear, hydroelectric, and renewable power. A critical component of this strategy is the development of energy storage solutions to reduce energy generation curtailment and ensure a stable supply during peak demand periods.

Ontario's electricity system often generates surplus energy, primarily from renewable and nuclear sources, during times of low demand (nights and weekends). It is therefore crucial that efforts made in the development of clean electricity sources are complemented by storage technologies, thereby further reducing reliance on emissions-producing generation and helping Ontario meet its growing electricity demand.

The Ontario Pumped Hydro Storage (OPS) Project, a prospective partnership between TC Energy Corporation and, the Chippewas of Nawash Unceded First Nation and Chippewas of Saugeen First Nation, collectively the Saugeen Ojibway Nation, is a direct response to these needs. The prospective partnership aims to construct a 1,000-megawatt (MW) utility-scale pumped hydro storage facility to enhance the reliability and efficiency of Ontario's electricity system. The facility is designed to store excess energy during low-demand periods and release it during high-demand times. By helping to optimize clean electricity generation resources, it is estimated that this initiative could lower CO2 emissions in the province by an annual average of 490,000 tonnes (Navigant, 2020).

Crucially, during construction and into operations, the Project will leverage a domestic supply chain, creating significant value for Ontario. Several of the necessary major suppliers have a strong presence in Ontario and have the necessary capabilities to support a pumped hydro storage project (Hatch, 2022).

1.1.2 Climate Change

By increasing the reliability and efficiency of the electricity system, storage technologies play an important role in helping mitigate greenhouse gas (GHG) emissions. To maximize the utility of non-emitting power generation technologies, such as wind, solar, and nuclear power generation, it requires pairing them with appropriate storage systems. By ensuring that electricity generated from these sources during low-demand periods is stored for later use, the need and dependence on traditional sources of power supply from carbon-heavy resources is reduced.

Evidence suggests that among many energy storage alternatives including pumped hydro storage, lithium-ion battery storage, compressed-air energy storage, and other forms of battery storage, pumped hydro storage delivers the lowest median life-cycle emissions and global warming potential (NREL, 2021; Timothy, et al., 2023). These benefits are maximized when pumped hydro storage involves the appropriate site conditions and electricity grid mix.

Therefore, by reducing reliance on high-emitting power generation, increasing the efficiency of non-emitting generation systems, and providing low life-cycle emissions, pumped hydro storage can be a key factor in the province's achievement of its emissions reduction goals.

1.1.3 Indigenous Partnerships

TC Energy has engaged in a prospective partnership with the Saugeen Ojibway Nation in the development of OPS. As the Project resides within the traditional territory of the Nation, TC Energy committed to only proceeding with the Project with Saugeen Ojibway Nation support.

As co-owners of the facility, the Saugeen Ojibway Nation will earn proceeds from ownership, which will directly support their Nations. Further, the Saugeen Ojibway Nation will have access to priority employment, training, and contracting opportunities for its members. With this in mind, TC Energy aims to support the Nations in their investment of skills and capacity-building programs necessary to ensure their members and businesses are ready to take full advantage of the Project's opportunities. Moreover, the Nations will play an ongoing and active role in asset management and environmental monitoring.

1.1.4 Community Benefits

The Project is located within the Municipality of Meaford, Ontario, and TC Energy will work with the Municipality on a

Community Benefits Agreement. This Agreement will take the form of direct monetary support provided to the municipality.

Beyond the economic benefits from the sourcing of goods, labour, and materials from local communities, the monetary support provided to Meaford through a Community Benefits Agreement, has the potential to positively impact the well-being of Meaford residents.

1.2 Objectives

This report focuses on the economic value and the social value of the proposed OPS investments. Central to this study is the concept of social value. Social value is a key element in the Environmental, Social, and Governance (ESG) framework, which emphasizes the augmentation of traditional economic indicators to offer a richer understanding of public well-being. Together, the economic and social values combine to measure the total benefits supported by the Project.

Additionally, to fully understand the benefits of any infrastructure investment, both the contribution (the overall significance of the project in the economy and society) and the net benefit (how the project compares to business-as-usual growth) of an investment must be considered. The key concepts underlying this analysis are explained below.

1.2.1 OPS Contributions: The Gross Value Components of OPS

1.2.1.1 Economic Contributions

The financial impact of investments in OPS can be measured through the increased economic activity and enhanced supply chain capabilities in Ontario stemming from the Project. This involves examining the direct economic benefits and job creation linked to the construction and operation of OPS, as well as the indirect benefits that occur within the supply chains affected by the project. Additionally, there are induced effects, which arise from the dispersal of wages that OPS directly or indirectly supports, further contributing to economic growth.

1.2.1.2 Social Value

The social value of OPS measures how it will improve the quality of life for people in Ontario, comparing the overall change of an individual's well-being with a business-as-usual scenario without OPS intervention. This evaluation translates changes in well-being into financial terms, equating them to the income adjustments that would lead, all else equal, to equivalent well-being improvements for each person considered in the study. This process necessitates an understanding of how OPS will impact individuals through training opportunities, upskilling, expanded supply capabilities in Ontario, and higher wages paid to higher-quality jobs.

1.2.2 OPS Net Economic Benefit: The Net Economic Value Components of OPS

The net economic value of the project measures how much more valuable, in terms of the economic metrics analyzed, the OPS investment is over a business-as-usual baseline that would generate the same number of jobs as OPS would generate directly[8]. This net benefit corresponds to the difference between OPS's gross economic contribution and the gross economic contribution of the baseline.

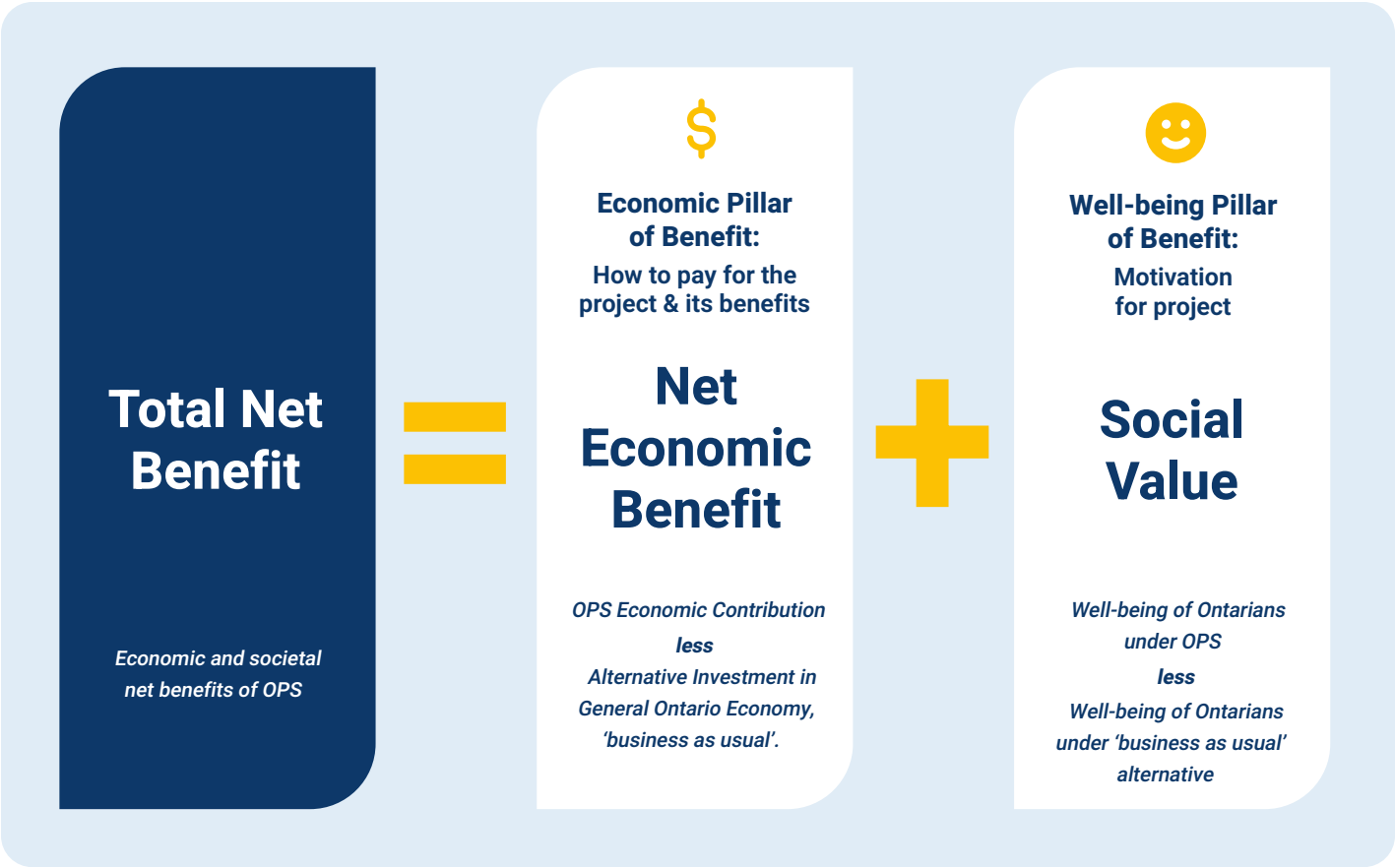
The computation of net benefits is crucial in underlining the significance of contributions. While contributions only refer to the gross benefits of a project, net benefits showcase how those benefits compare to the benefits that would be generated by a scenario that yields a similar number of jobs, with investments distributed broadly across the province. In this sense, net benefits display the extent to which the analyzed project is preferable to the status-quo general economy.

1.2.3 The Total Value of OPS

With these concepts in mind, this report combines the net economic value and the social value generated by

8 The use of direct jobs as a basis for comparison is motivated by a desire to base the computation of net benefits on the number of people primarily affected by the proposed intervention (OPS in this case).

OPS to yield the total net benefit of the project. This approach follows the idea that the motivation for a project should be its impact on people, such that a failure to compute social value estimates alongside net economic benefits leads to an incomplete picture of the total value of a project. In other words, while the net economic value indicates the financial viability of a project, the social value provides the reasons why a project should be undertaken in the first place. This approach is captured by the following expression:



Using this framework, this report first aims to showcase the contributions and the total net value proposition of OPS's investment and operations plans over the 50-year course of the project. To this end, it assesses the total economic, labour, and social value benefits of the project, both in gross terms (contributions) and relative to a business-as-usual general economy baseline (net benefits).

Measured labour and economic indicators include GDP, jobs supported, employment income, private investment, and taxation revenues, by industry and sub-region[9] of Ontario, and age group. Further, evaluated social value contributions quantify the changes, due to supported regional economic growth and job creation, in individual and aggregate well-being across the province. Social benefits are further analyzed by the number of affected Ontarians, households by region and type, and full-time jobs.

Secondly, the key economic results from the assessment of the OPS project are contrasted with the results from a stylized example of a Battery Energy Storage System (BESS) with comparable capacity. This comparison is conducted for both economic and social metrics, covering benefits to metrics such as GDP, employment, taxation revenues, and the number of affected Ontarians, households, and full-time jobs. The objective is to understand the differences in the economic and social contributions between OPS and BESS.

9 Throughout this report, "urban" refers to regions among the top census divisions that account for at least 60% of the total population. "Rural" regions are the remaining ones.

The report is structured as follows. The remainder of this section covers the methods adopted in the estimation of the economic and social value contributions of OPS, as well as an overview of the proposed investments and operations for the project. Section 2 presents the economic and labour contributions of OPS, including the additional productive capacity supported by the project. Section 3 displays the social contributions, including benefits to people and social value. Section 4 summarizes the results from sections 2 and 3 and presents the net contribution of the project. Section 5 compares OPS and BESS along key economic and social metrics. Finally, section 6 concludes.

1.3 Methods

1.3.1 Economic Contribution Estimation

This study utilizes CANCEA's agent-based modelling platform to analyze the economic and labour contributions of OPS investments.

CANCEA's agent-based platform is a detailed socioeconomic simulation platform designed to analyze policy and infrastructure investment scenarios across over 5,000 societal sustainability and prosperity topics. It performs calculations on the level of individual people, firms, and governments, which are modelled using extensive data inputs. For example, data inputs for individual households include, in addition to demographics, factors such as household structure, labour force participation, and finances. The economy is modelled using a structural approach, and individual businesses are modelled using a combination of Statistics Canada data and input/output tables at the local level. Importantly, the platform is geospatial and covers more than 56,000 dissemination areas across Canada.

The economic contribution from OPS investments arises from the increased economic activity induced by capital and operational expenses. The structure of CANCEA's model allows it to accurately trace out the widespread economic effect of these investments, hence producing figures regarding benefits to key economic metrics. Specifically, the contributions are identified from the following dissemination channels:

Direct effects: these include the economic activity generated by the construction of infrastructure and related maintenance, as well as operating wages.

Indirect effects: these include all economic activity that arises through business-to-business interactions within the supply chain. Indirect effects include input expenditures, as well as the follow-on expenditures that are generated

further up and down the supply chain in all sectors of the economy.

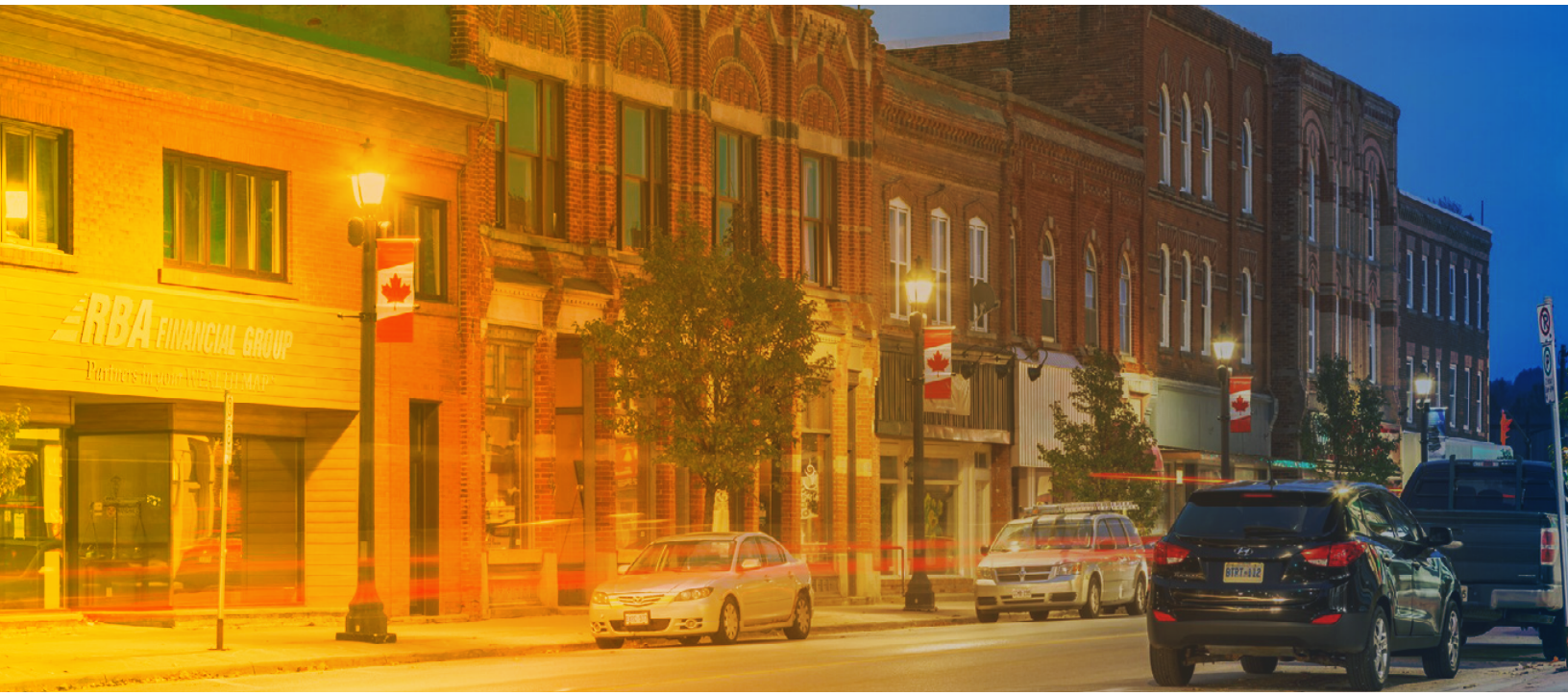
Induced effects: these include all economic activity generated through the spending of wages earned by employees working in either the targeted investment areas or related industry sectors. Induced effects also include expenditures on increased capacity or the replacement of depreciating capital stock that result from reinvesting business profits. These purchases or activities can lead to further hiring, resulting in income and tax revenues that reverberate throughout the economy.

Additionally, a key feature of CANCEA's modelling platform is its ability to evaluate and compare multiple scenarios. This capability underlies the computation of net benefits in this report, in that this computation involves a comparison between the benefits generated by OPS investments and those generated by a business-as-usual baseline scenario.

1.3.2 Social Value Evaluation

CANCEA conducts social value evaluation by combining statistical well-being estimation with agent-based modelling. In particular, the use of well-being estimation in economic impact research is supported by research in the social sciences, the OECD, and various G20 governments, all of which recognize the validity and reliability of life satisfaction measures in policy-supporting studies. Importantly, scholars emphasize the ability of well-being measurement to incorporate respondents' values and preferences, reflecting the outcomes of their choices, thus making it a valuable tool in social value evaluation (Diener, Inglehart, & Tay, 2013; Layard, 2010; Frey & Stutzer, 1999; Stutzer & Frey, 2010; Yang, 2018).

The methodology quantifies the monetary equivalent of well-being changes resulting from proposed interventions, such as a new infrastructure project (OMERS Social Value Report, 2021; Alberta PPP Social Value Report, 2022; Housing Crisis Social Value, 2024). The first step is to map the well-being of affected individuals to their traits, socioeconomic characteristics, environment, and connections, allowing for the estimation of well-being changes that result from the effects of the intervention. These changes can be either positive or negative, depending on the individual variables described. Links between a person's well-being across time and their characteristics and the community and environmental



circumstances they face have been identified in numerous studies (Lu, Schellenberg, Hou, & Helliwell, 2015; Helliwell & Wang, 2011; Chen & Hou, 2010; Kytta, Broberg, Haybatollahi, & Schmidt-Thome, 2016; Layard, Mayraz, & Nickell, The marginal utility of income, 2008).

The second step is to then draw, for each person, the change in individual income, all else being equal, that would result in the same change in well-being. The computed income change is defined as the monetary equivalent of the estimated well-being change (OMERS Social Value Report, 2021; Alberta PPP Social Value Report, 2022; Housing Crisis Social Value, 2024). Finally, monetary equivalents are aggregated across all individuals affected, yielding a total monetary equivalent, defined as the social value of the intervention. The translation of well-being changes into income adjustments and the subsequent aggregation of these adjustments into a social value estimate is a key feature of Murtin, Boarini, & Ripoll (2017) and Llena-Nozal, Martin, & Murtin (2019).

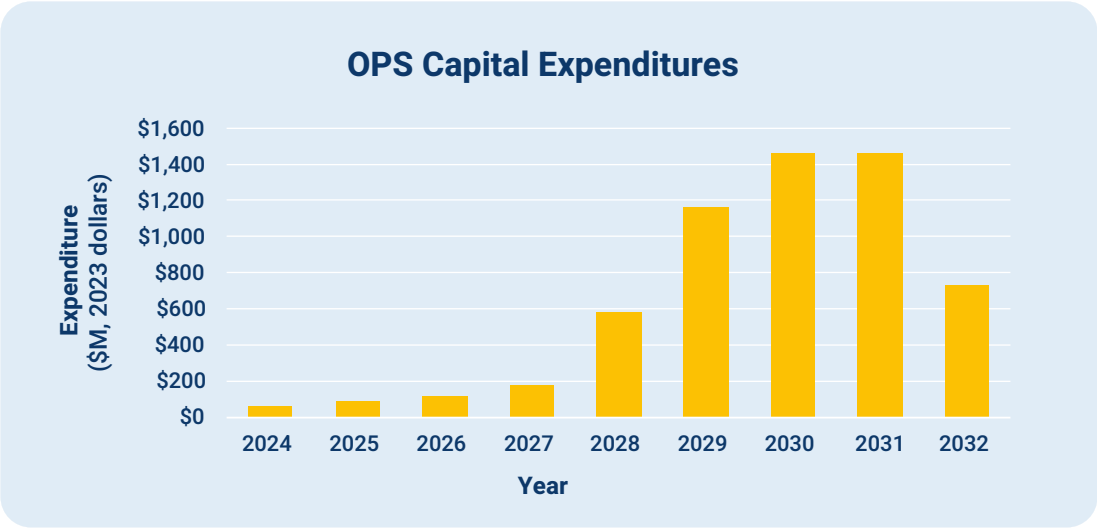
By combining well-being estimation with agent-based modelling, this approach considers the myriad factors influencing individual well-being, including demographic, socioeconomic, financial, and environmental aspects. These factors influence well-being through different channels, such as financial stability and community cohesion. The adopted methodology thus considers people's overall well-being changes in proportion to the improvement in their different well-being domains, such as health and community satisfaction, and measures it according to individuals' preferences over money. Ultimately, it offers a holistic view of the social value generated by proposed interventions.

For more details on the adopted methodologies, refer to Appendix B, CANCEA's previous reports (OMERS Social Value Report, 2021; Alberta PPP Social Value Report, 2022; Housing Crisis Social Value, 2024), or contact CANCEA at connect@cancea.ca.

1.4 Ontario Pumped Hydro Storage Investments and Operations

This report analyzes capital and operational investments proposed by TC Energy from 2024 to 2072. Capital investments, related to the preconstruction and construction phases of the project, span the 2024-2032 period. In total, the estimated capital investments amount to $5.8 billion[10], with 83% of this spending remaining in Canada. The majority of these investments occur during the construction phase from 2027 to 2032, as shown in Figure 1.

Figure 1 Estimated Capital expenditures (2023 dollars)



10 Given ongoing refinements to the project, the final project costs could differ from the estimates used for this analysis.

Following the construction phase, operational expenses span 2033-2072. The distribution of these expenses is assumed to be constant, amounting to $21 million per year. Of this cost, the wages of employees are the largest component.

2.0 Economic and Labour Contributions of Ontario Pumped Hydro Storage

The economic contributions of OPS include its effects on economic activity, businesses, and the labour market, over the 50 years of investments analyzed. The main results are summarized in Table 3. Between 2024 and 2072, the project is expected to contribute significantly to economic growth in Ontario, totalling over $6.8 billion in GDP in present-value terms. The total gross operating surplus, which relates to business profits in the province, amounts to $2.9 billion. Moreover, the Project incentivizes $1.4 billion in private investments, adding to the productive capacity of the province. Regarding the labour market, OPS is expected to generate approximately 41,200 jobs (people-years), with a total of $3.9 billion in labour income.

The remainder of this section further dissects these results, elucidating the parts of the province that will benefit most by this Project.

Table 3 Total economic and labour contributions of Ontario Pumped Hydro Storage, by source

Category	Total	Direct Components	Indirect Components	Induced Components
Economic Contribution (GDP, 2023 dollars)	**$6.8 billion**	$3.4 billion	$2.0 billion	$1.4 billion
Gross operating surplus* (2023 dollars)	$2.9 billion	$1.5 billion	$0.8 billion	$0.7 billion
Private investment (2023 dollars)	$1.4 billion	$0.7 billion	$0.5 billion	$0.2 billion
Jobs (people-years)	41,200	17,600	14,100	9,400
Labour income (2023 dollars)	$3.9 billion	$2.0 billion	$1.3 billion	$0.6 billion

* Gross operating surpluses are approximately equal to business profits.

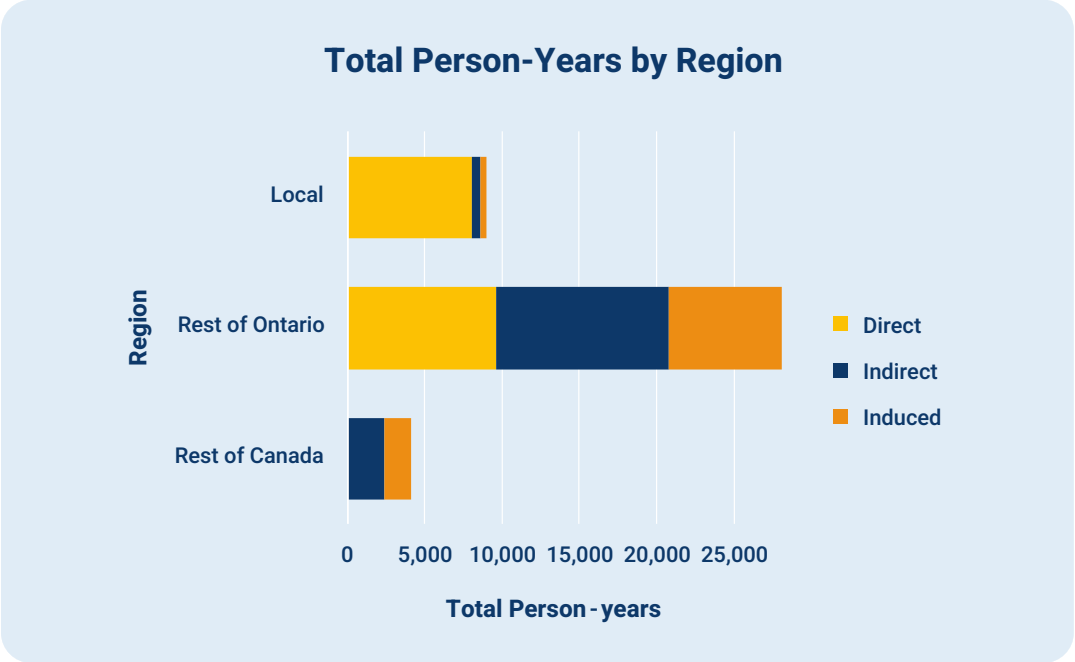
2.1 Labour Contributions

Of the total employment contribution of 41,200 jobs over 50 years, 17,600 are directly supported by the construction and operation of the facility. These are the jobs that are immediately supported by the Project. In addition, 14,100 are indirectly supported through effects on the supply chain, following the increased demand for resources generated by the Project. The remaining 9,400 jobs stem from induced sources—those generated by the increased spending supported by OPS. These numbers show that 77% of the generated jobs are specifically attributable to OPS investments (from direct or indirect sources). During the 4-year peak construction period, over 1,700 construction jobs would be directly or indirectly supported each year, mostly with local employment.

2.1.1 Employment by Region

Notably, 37,000 of the total jobs are generated in Ontario, with the remaining 4,100 across Canada. Locally—in the region of Grey, Bruce, and Simcoe—nearly 9,000 jobs are generated. These results are shown in Figure 2.

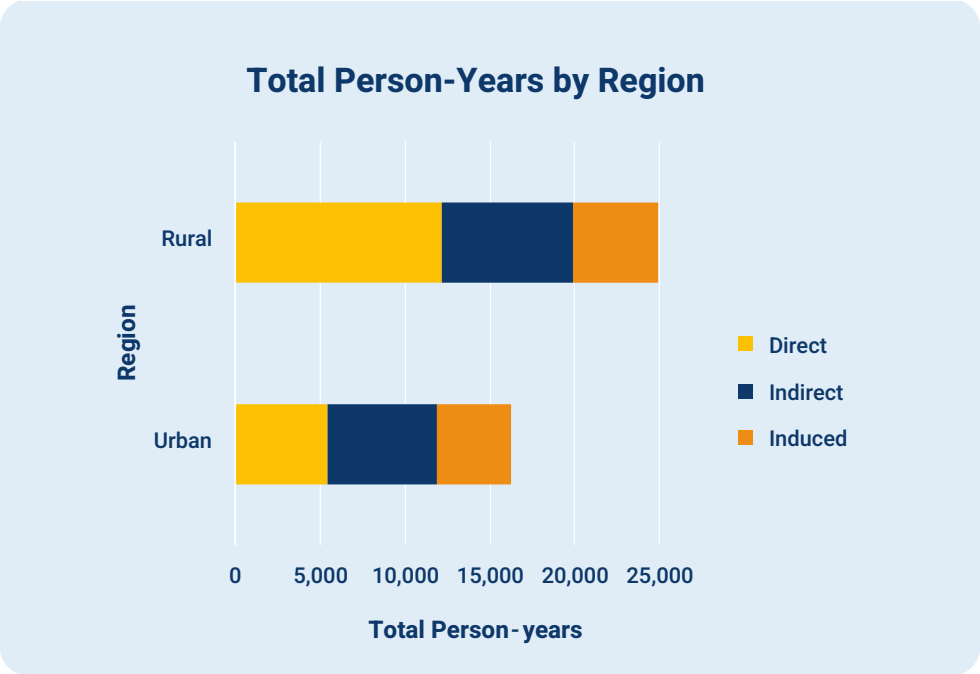
Figure 2 Total person-years by region, across Canada



OPS expected to generate 37,000 jobs in Ontario, including 9,000 locally.

Moreover, of the supported employment, 25,000, corresponding to 61% of the total, occur in rural regions, providing vital jobs to sustain and support rural areas. These results are shown in Figure 3.

Figure 3 Total person-years by region, rural and urban

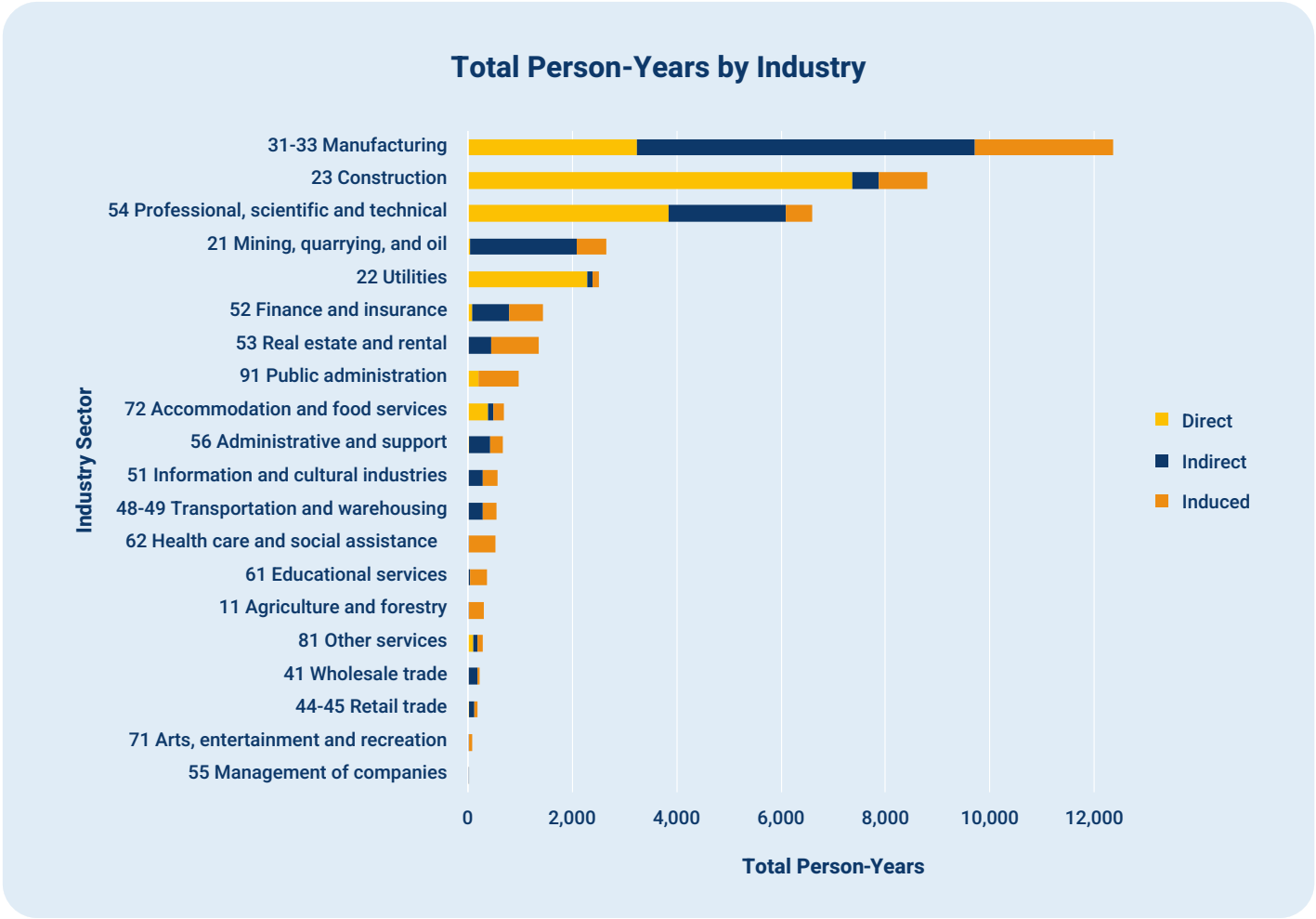


2.1.2 Employment by Industry

The total employment contributions for the 20 most affected industry sectors, categorized according to 2-digit NAICS codes, are shown in Figure 4. Notably, the manufacturing and construction sectors stand to benefit the most in terms of employment, receiving approximately 12,400 and 8,800 new jobs, respectively. This is expected, given that the 50 years of the Project's construction and operations will create significant demand for resources from these sectors. In fact, for every job supported, the Project generates 2.3 times more construction and manufacturing jobs than alternative investments in the general economy (further explored below), making an important contribution to the capacity of the Ontario economy through skilled trades.

Less intuitively, a variety of other sectors, such as accommodation and food services, cultural industries, and health care, also benefit from increased employment, albeit to a smaller extent. This corresponds with the ripple effects associated with the resulting economic expansion, which drives economic activity throughout the province.

Figure 4 Total person-years by industry

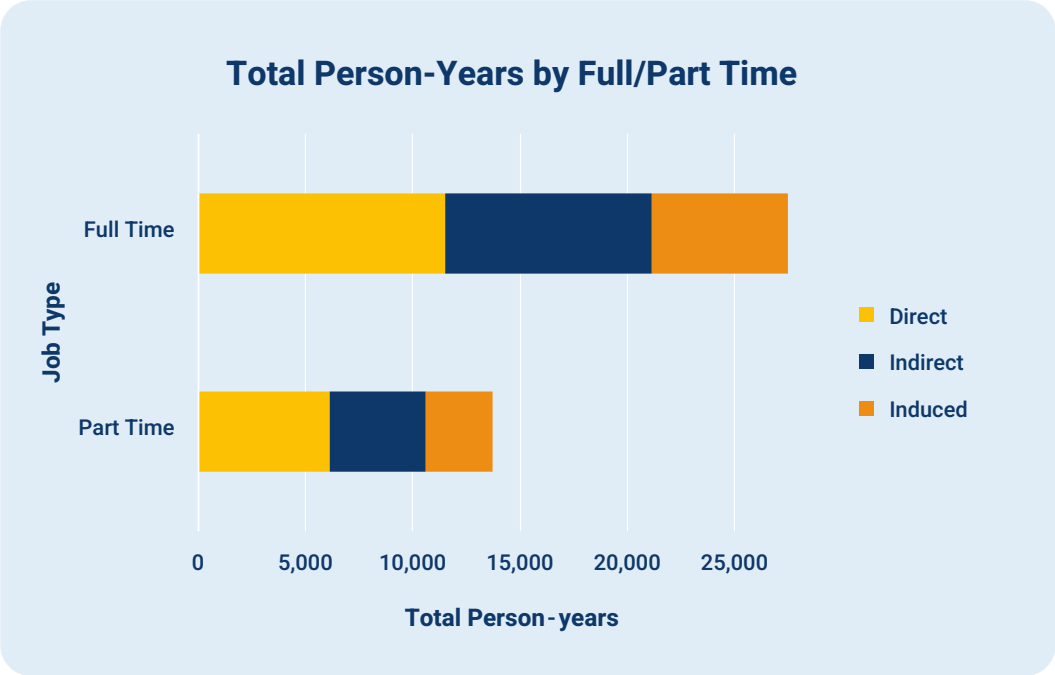


2.1.3 Employment by Type

Importantly, 27,000 (66% of the total) of the created jobs are full-time, providing well-paid, skilled employment opportunities. By contrast, in the overall Ontario economy, only 62% of the jobs are full-time. In line with this, every job supported by OPS generates 1.36 times more taxation revenue than the average job in the Ontario economy.

A breakdown of jobs by type is depicted in Figure 5.

Figure 5 Total person-years by job type, full-time and part-time



2.2 Economic Contributions

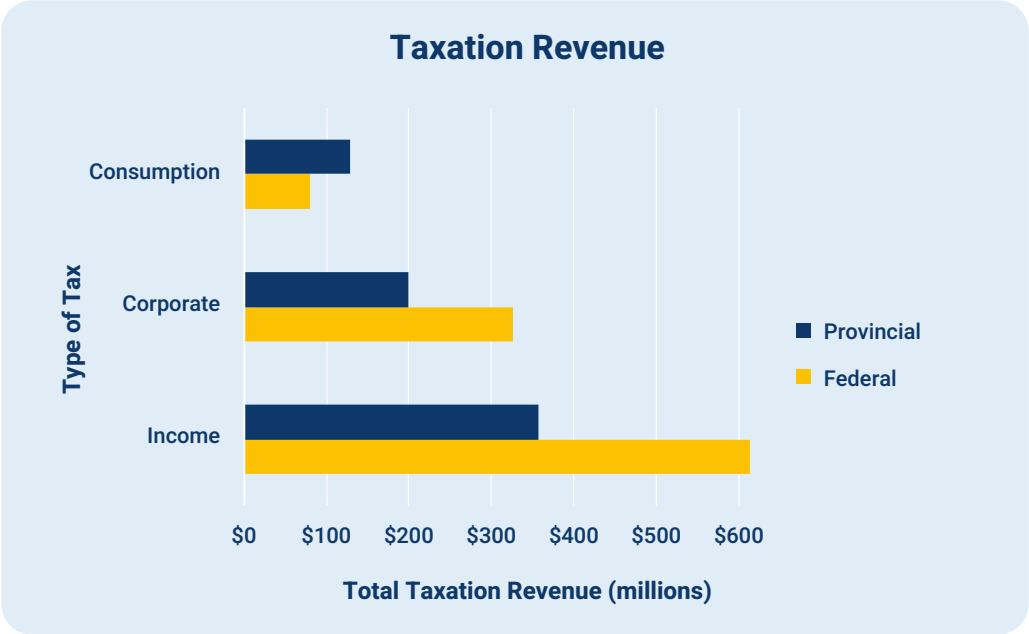
2.2.1 Contribution to GDP and Taxes

Of the total economic contribution of $6.8 billion in GDP for Canada, $3.4 billion stems from direct economic activity, that is, the activity directly generated by the construction and operations of the project. In addition, the indirect economic activity, relating to effects on the supply chain, amounts to $2.0 billion. The remaining $1.4 billion is associated with induced economic activity—the activity supported by the additional spending generated by OPS.

The supported economic activity drives over $1.7 billion in taxation revenue for the federal and provincial governments. In particular, the federal and provincial governments obtain $1.0 billion and $680 million, respectively, from income, corporate, and consumption taxes. For both levels of government, the bulk of additional revenues stem from income taxes, followed by corporate and consumption. Taxation revenue results are detailed in Figure 6.

OPS is expected to generate over $1.7 billion in taxation revenues for federal and provincial governments.

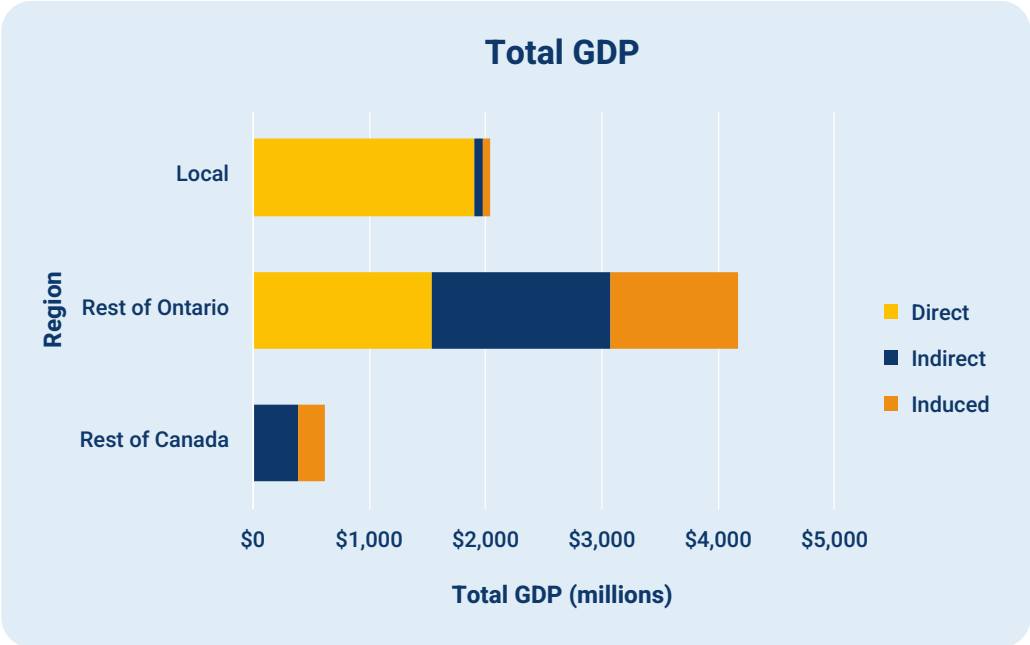
Figure 6 Taxation revenue (2023 dollars)



2.2.1.1 GDP by region

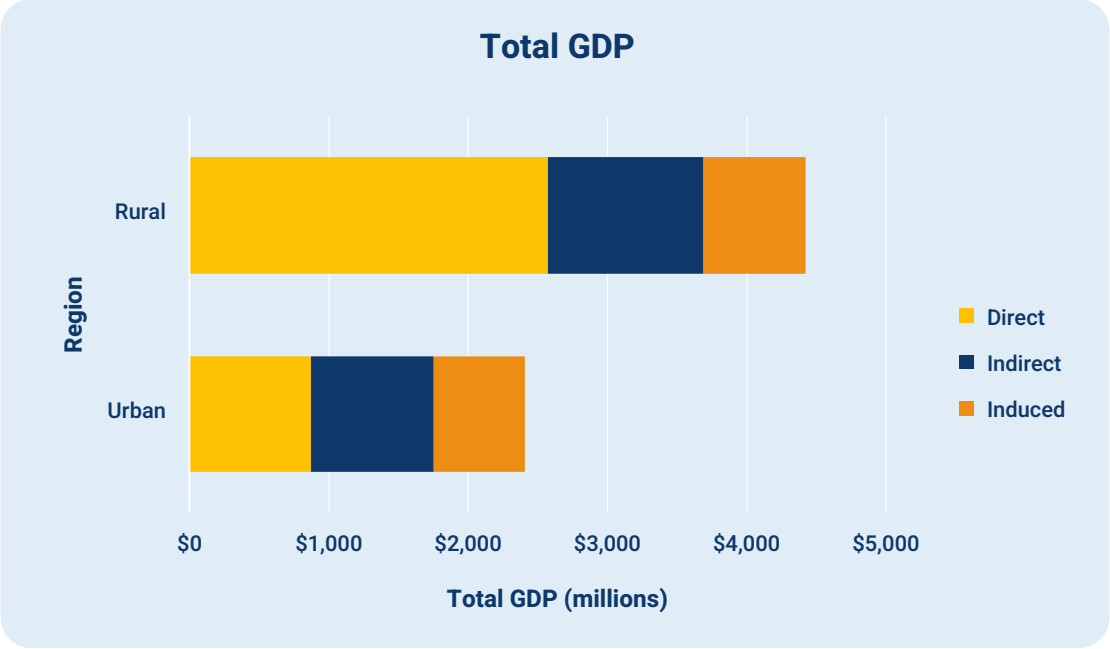
Significantly, more than 90% of the total economic activity of $6.8 billion (amounting to over $6.2 billion) occurs in Ontario, with 30% of the total remaining in the local regions of Grey, Bruce, and Simcoe. These results are shown in Figure 7.

Figure 7 Total GDP by region, across Canada (2023 dollars)



Additionally, of the supported economic activity, 65% (totalling $4.0 billion) occurs in rural regions of the province, aiding in the provision of vital income to sustain and support rural areas, with $1.7 billion of corporate profits generated in local rural regions. The rural-urban breakdown is shown in Figure 8.

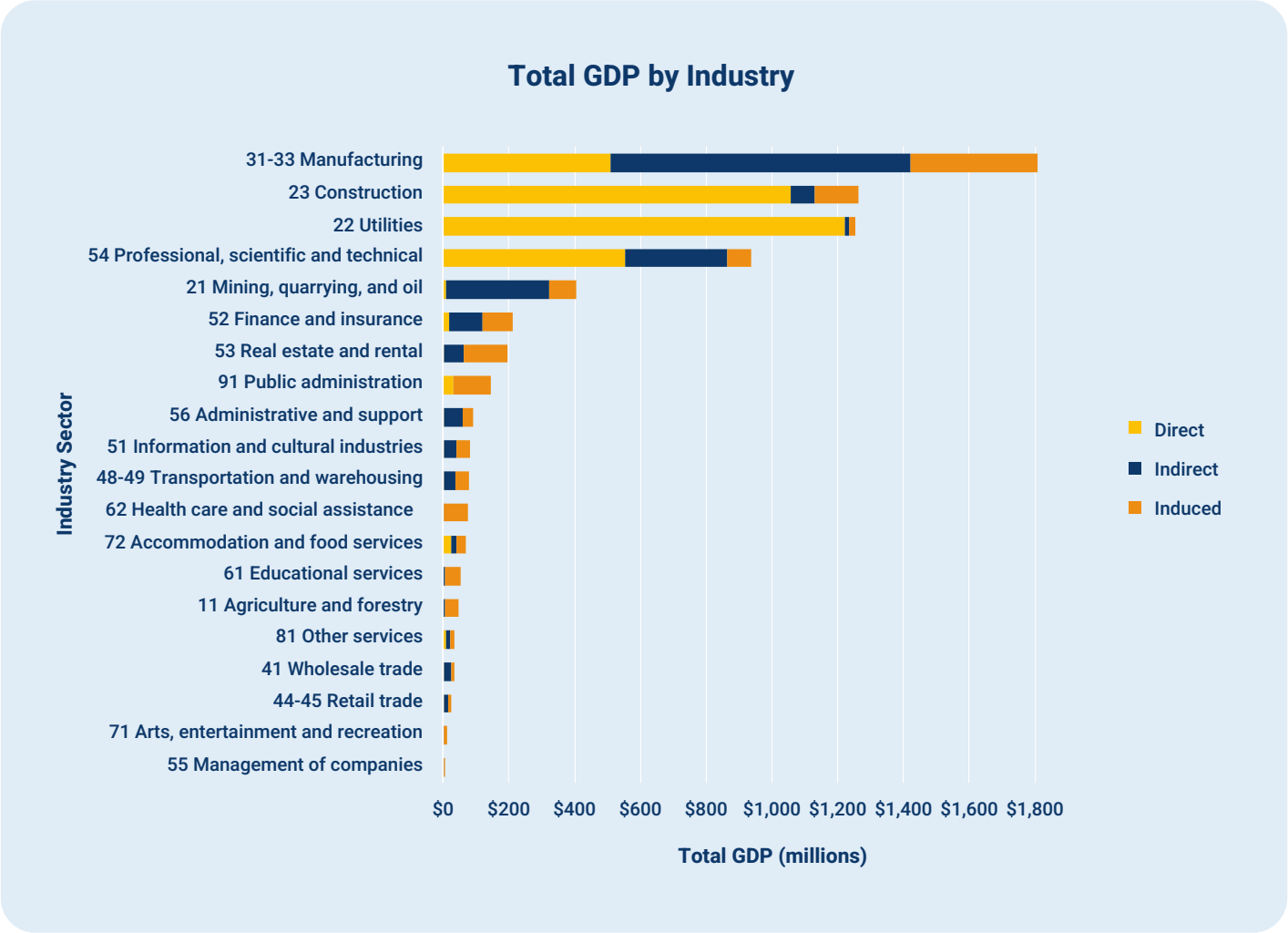
Figure 8 Total GDP by region, rural and urban (2023 dollars)



2.2.1.2 GDP by industry

The total economic activity generated for the 20 most affected industry sectors, categorized according to 2-digit NAICS codes, is shown in Figure 9. Similarly to employment, the manufacturing and construction sectors stand to benefit the most in terms of economic activity, followed by utilities and professional, scientific and technical services. While manufacturing experiences a boost of roughly $1.8 billion in economic activity, construction-related GDP grows by approximately $1.3 billion.

Figure 9 Total GDP by industry (2023 dollars)



2.2.2 Contribution to Gross Operating Surpluses

The cumulative contribution to gross operating surpluses, which are approximately equal to the profits of businesses affected, totals $2.9 billion (in present-value terms) over the 50 years analyzed. Of this total, $2.7 billion remains in the province, with almost $1.0 billion (34% of the total) occurring in the local region of Grey, Bruce, and Simcoe. Moreover, $1.7 billion (59% of the total) occurs within rural regions of the province. The results by region are shown in Figure 10 and Figure 11.

Figure 10 Total Gross Operating Surplus by region, across Canada (2023 dollars)

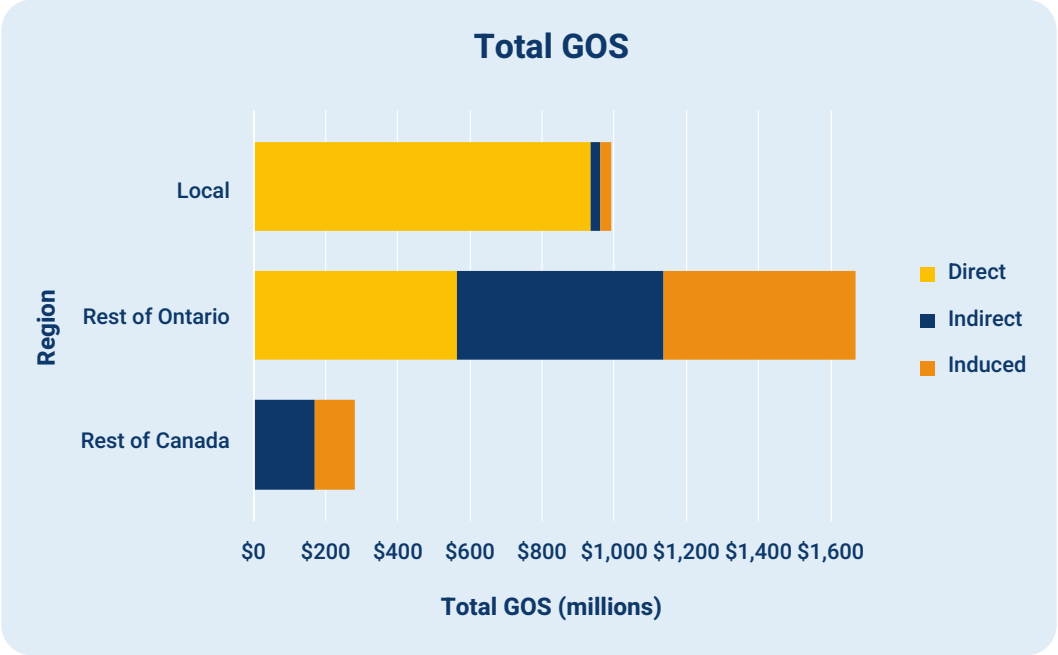
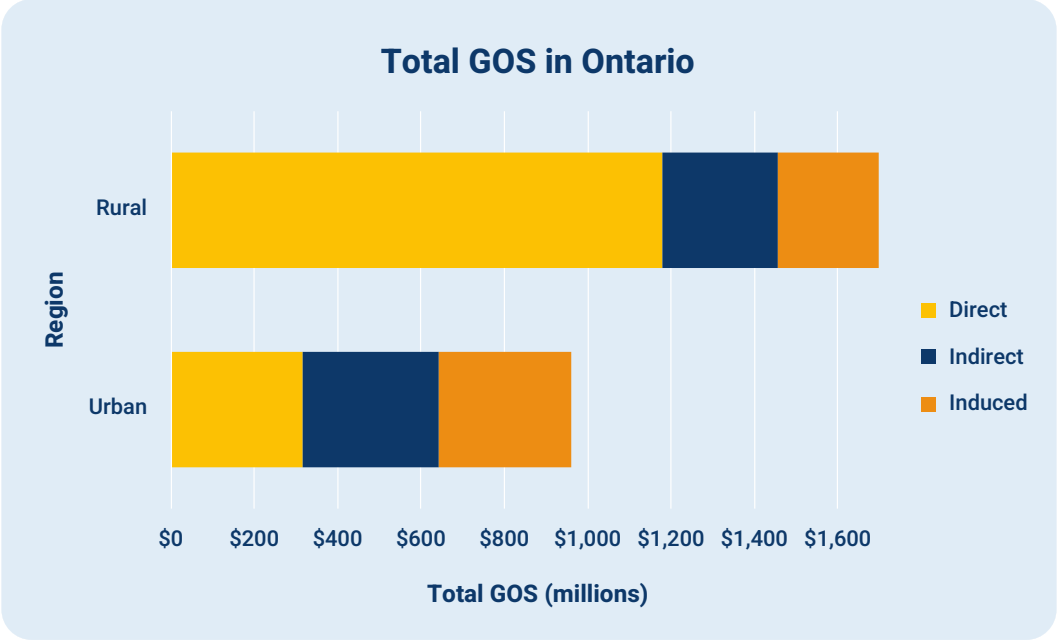
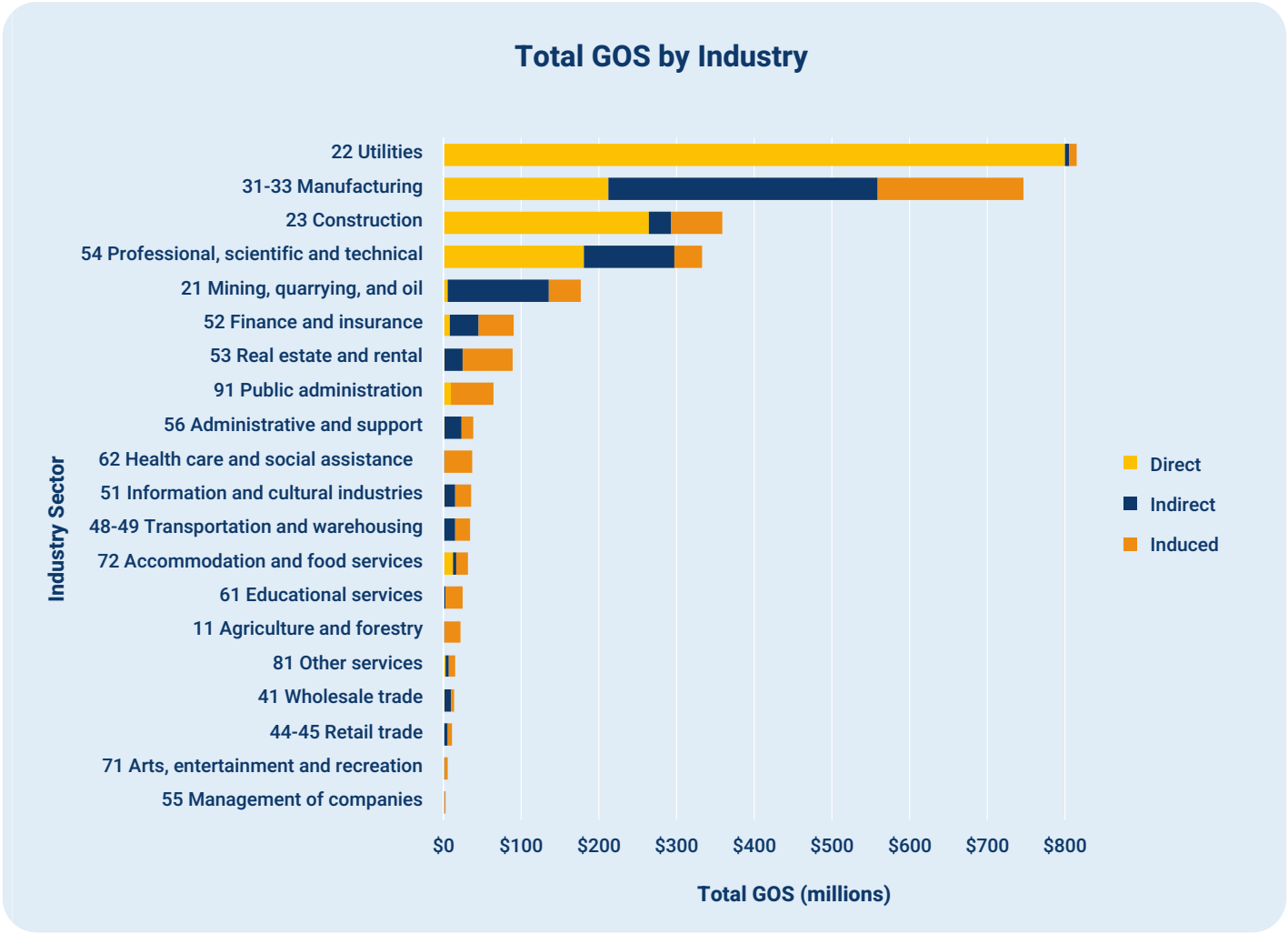


Figure 11 Total Gross Operating Surplus by region, rural and urban (2023 dollars)



The results by industry are depicted in Figure 12. The bulk of benefits are concentrated in the utilities and manufacturing sectors, followed by construction and professional, scientific and technical services. The size of benefits received by the utilities sector is expected, given that this sector directly benefits from the added flexibility and reliability that pumped storage provides , and includes the operation of OPS itself. Moreover, OPS can lead to significant cost savings for utilities in terms of reduced need for peaking power plants, which are typically more expensive to run. By providing a more cost-effective way to manage peak loads, the utility sector can improve its overall efficiency and profitability.

Figure 12 Total Gross Operating Surplus by industry (2023 dollars)



2.2.3 Contribution to Labour Incomes

In present-value terms, the total labour income supported by OPS amounts to $3.9 billion over the 50 years of investments analyzed. Of this total, $3.6 billion remains in Ontario, with $1.1 billion remaining in the local region and $2.5 billion in the rest of Ontario. Additionally, 59% of the total, or $2.1 billion, accrues in rural regions of the provinces. These results are detailed in Figure 13 and Figure 14.

Figure 13 Total labour income by region, across Canada (2023 dollars)

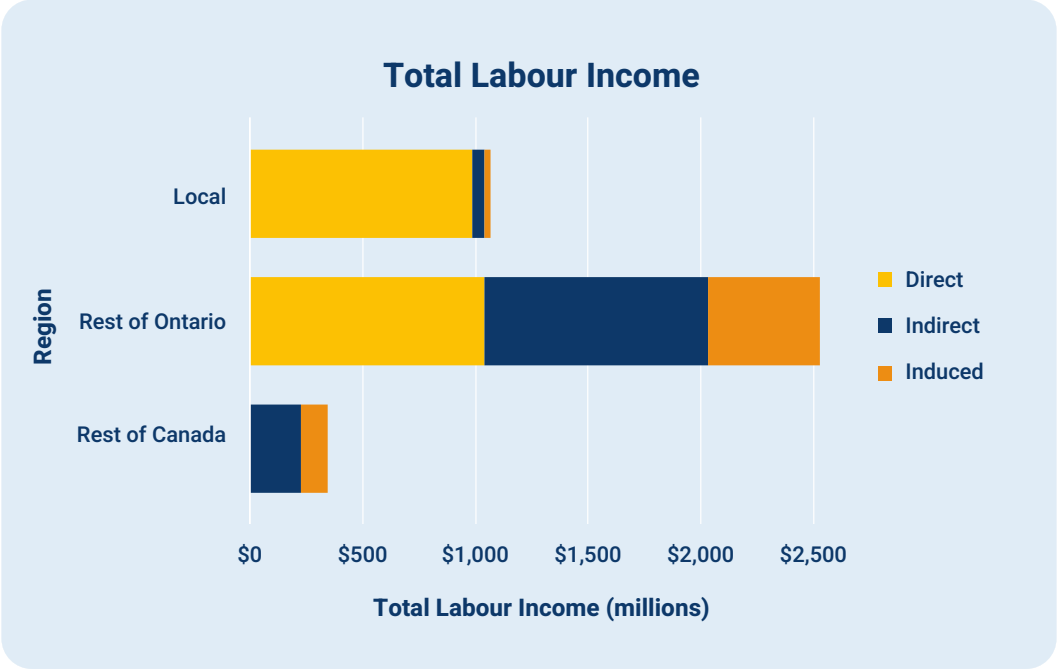
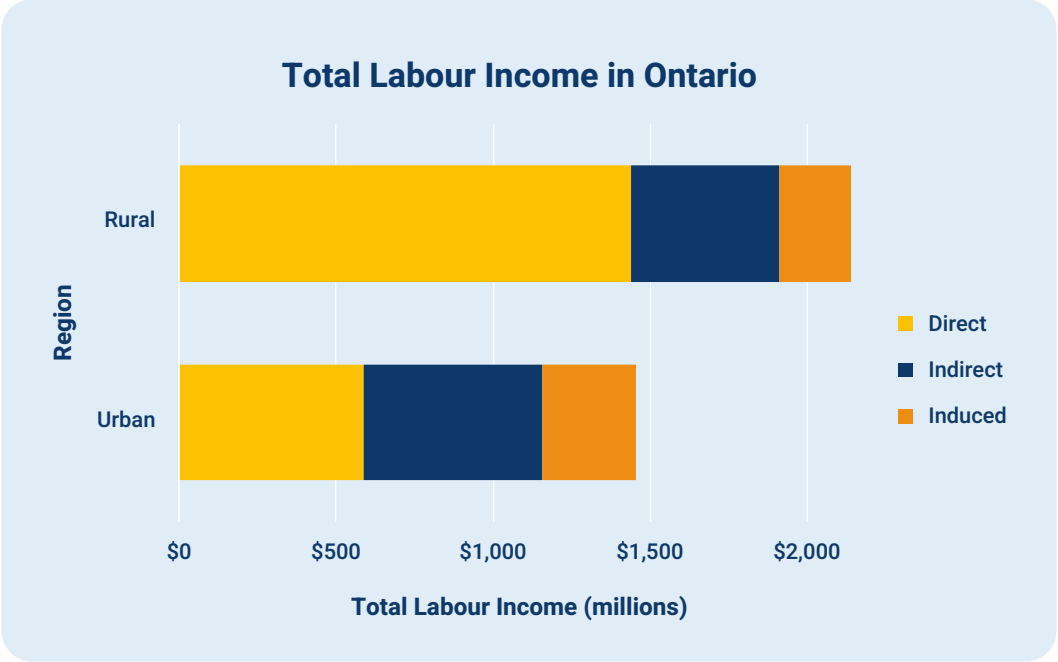
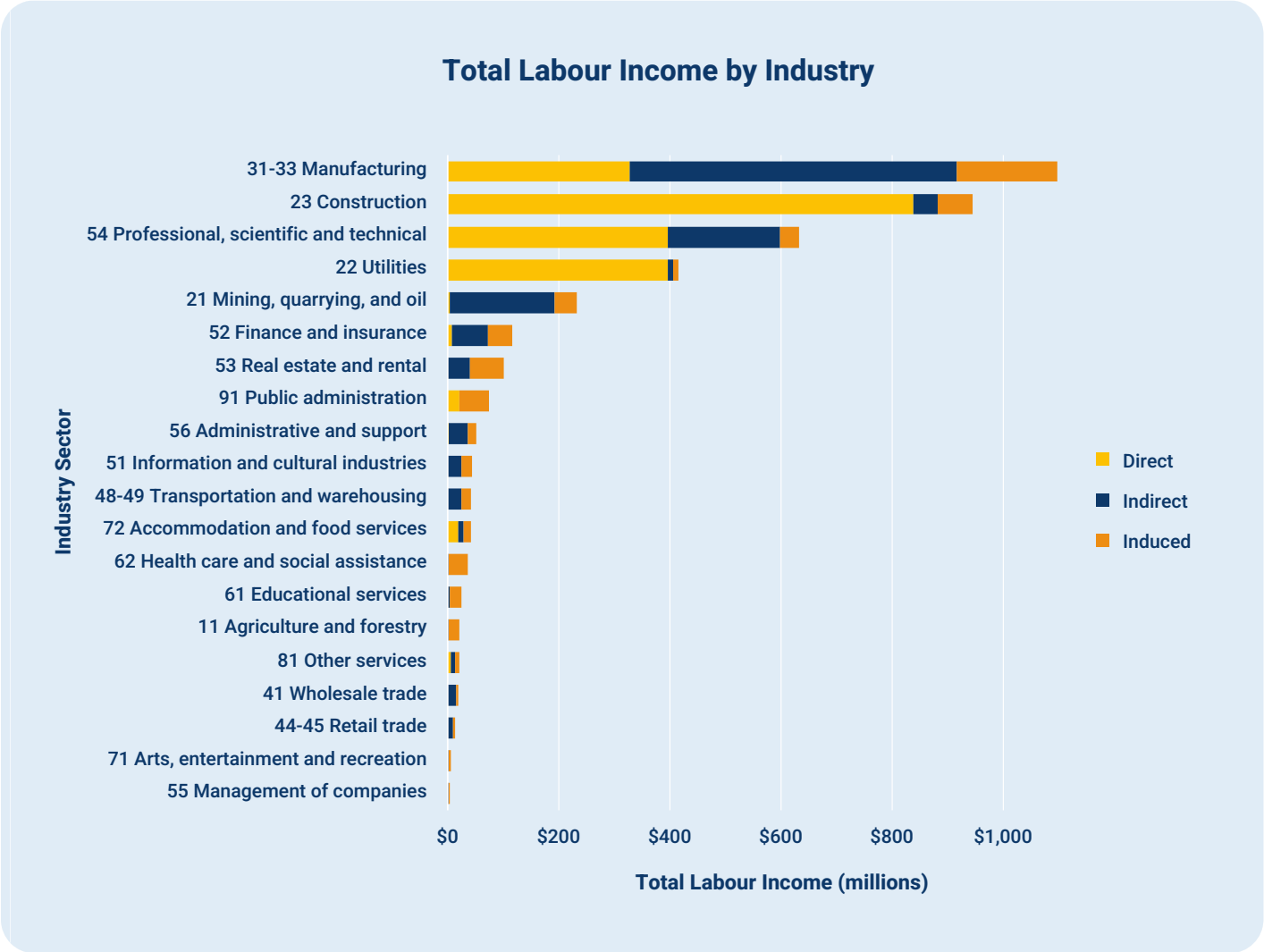


Figure 14 Total labour income by region, rural and urban (2023 dollars)



Across industries, the manufacturing and construction sectors obtain the biggest boost in labour income. This accords with the increase in total employment in these sectors, as explained in the previous section. It is also notable that induced effects spread across most industry sectors, including the retail and service sectors. The complete results are shown in Figure 15.

Figure 15 Total labour income by industry (2023 dollars)



2.3 Capacity of the Economy

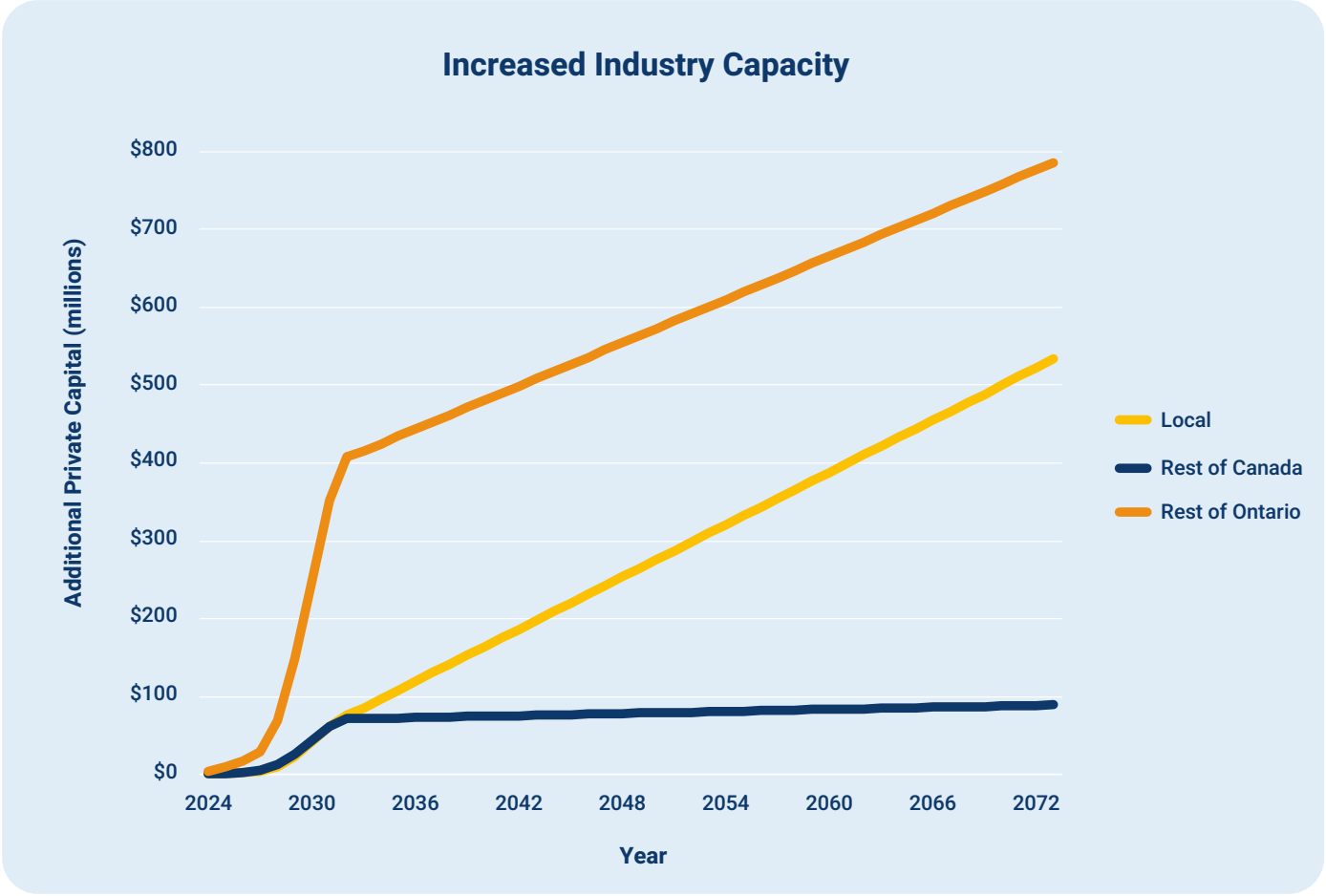
The OPS investment has several unique value drivers, one of which is a concentration on using Ontario supply lines and labour to build its pumped storage facility. The jobs and economic activity generated by OPS are enduring, with the private investment generated within Ontario supply chains supporting the continued growth and capacity of business throughout the Ontario economy. Moreover, by supporting the development of skilled trades, as well as training and upskilling, OPS stands to improve human capital in the province. These factors are linked to increased productive capacity in the economy.

2.3.1 Capital

With the additional demand for resources initiated by OPS, many businesses increase their investment in private capital. By 2073, the additional capital investment generated amounts to almost $1.4 billion in present-value terms.

The increased industry capacity is depicted in Figure 16. By 2073, the increased capacity will increase by almost $530 million locally, $800 million in the rest of Ontario, and almost $100 million in the rest of Canada.

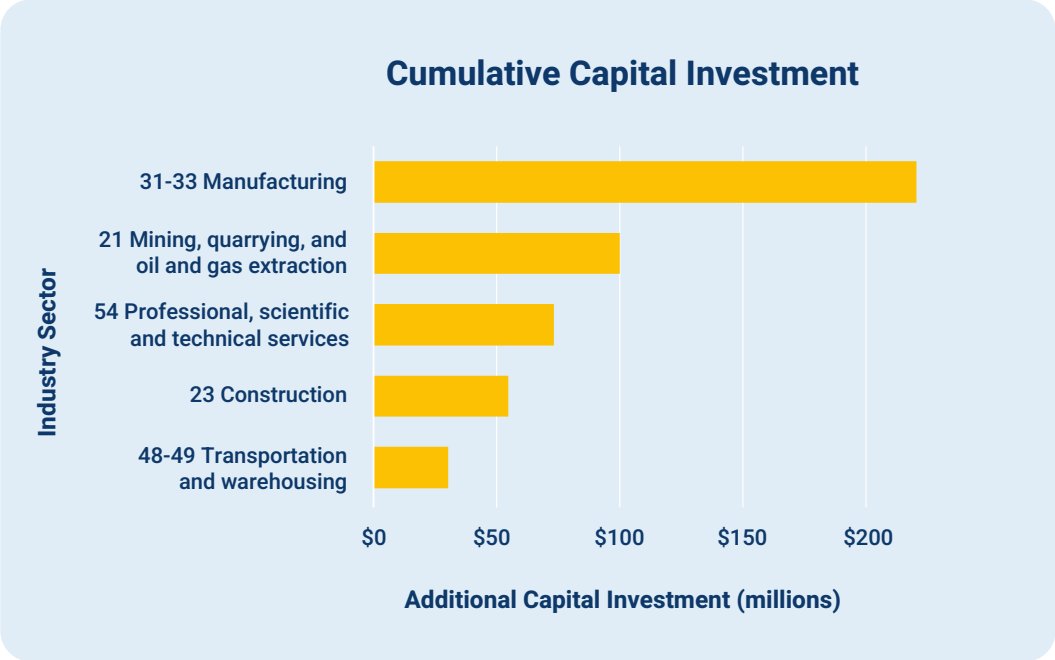
Figure 16 Increased industry capacity (2023 dollars)



Moreover, the Project enhances those industries that add to the productive capacity of the province, with the sectors that experience the biggest increases in investment (excluding electrical utilities) being manufacturing, mining and

quarrying, professional and technical services, construction, and transportation and warehousing. The cumulative capital investments throughout the Project for these top 5 industries are shown in Figure 17.

Figure 17 Cumulative capital investment (2023 dollars)



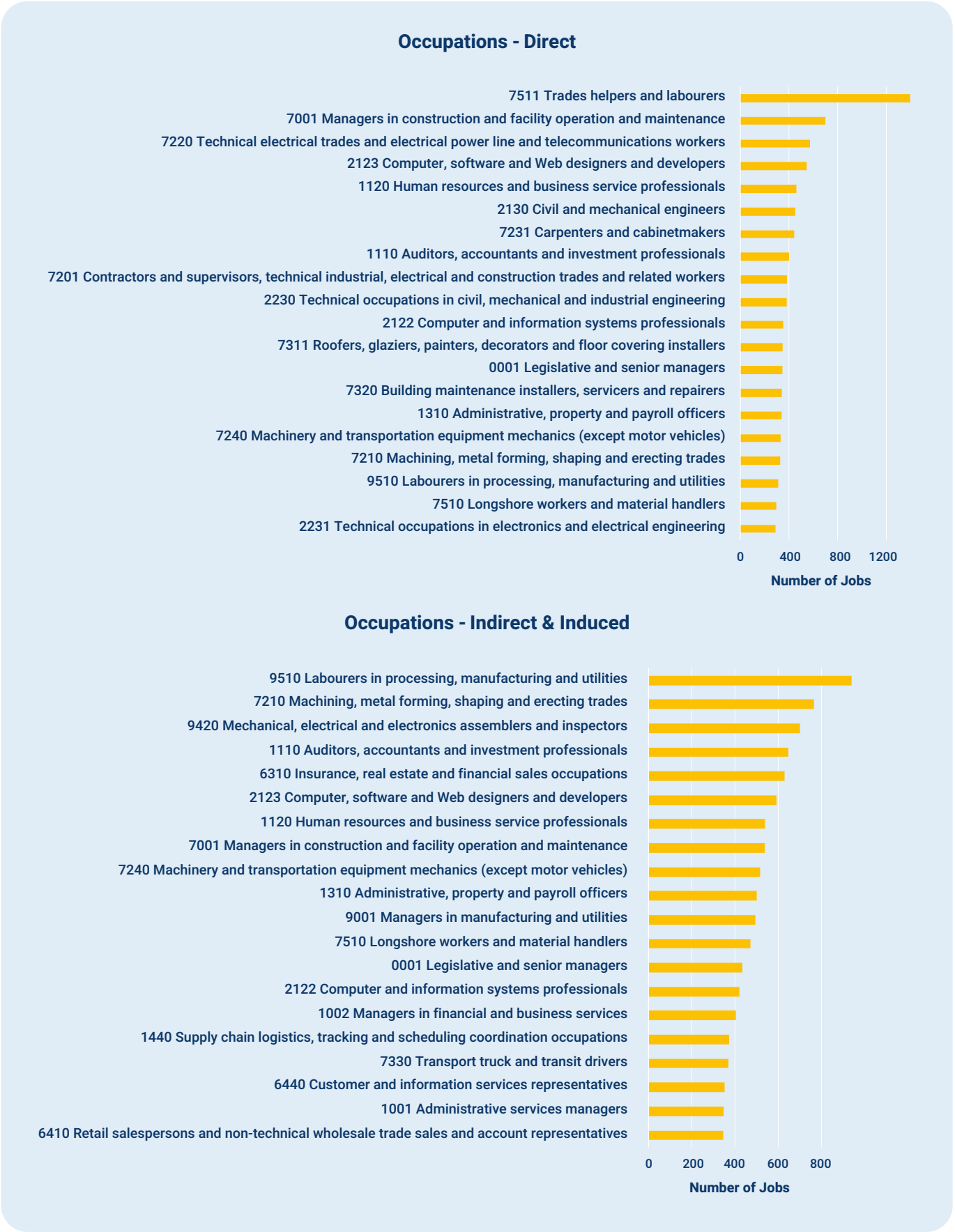
2.3.2 Skilled Labour

In addition to capital, the demand for skilled labour can improve worker skills. With a focus on Ontario supply chains and jobs, the Project will support 7,000 additional quality jobs across Ontario's manufacturing and construction supply chains. This represents an additional capacity in the labour market of between 2% to 8% for different skilled and construction occupations.

Notably, among the occupations directly supported by the construction of the facility, many skilled trades are required. Figure 18 shows the top 20 skilled occupations supported by each source[11].

11 Trades are occupation codes starting with 7.

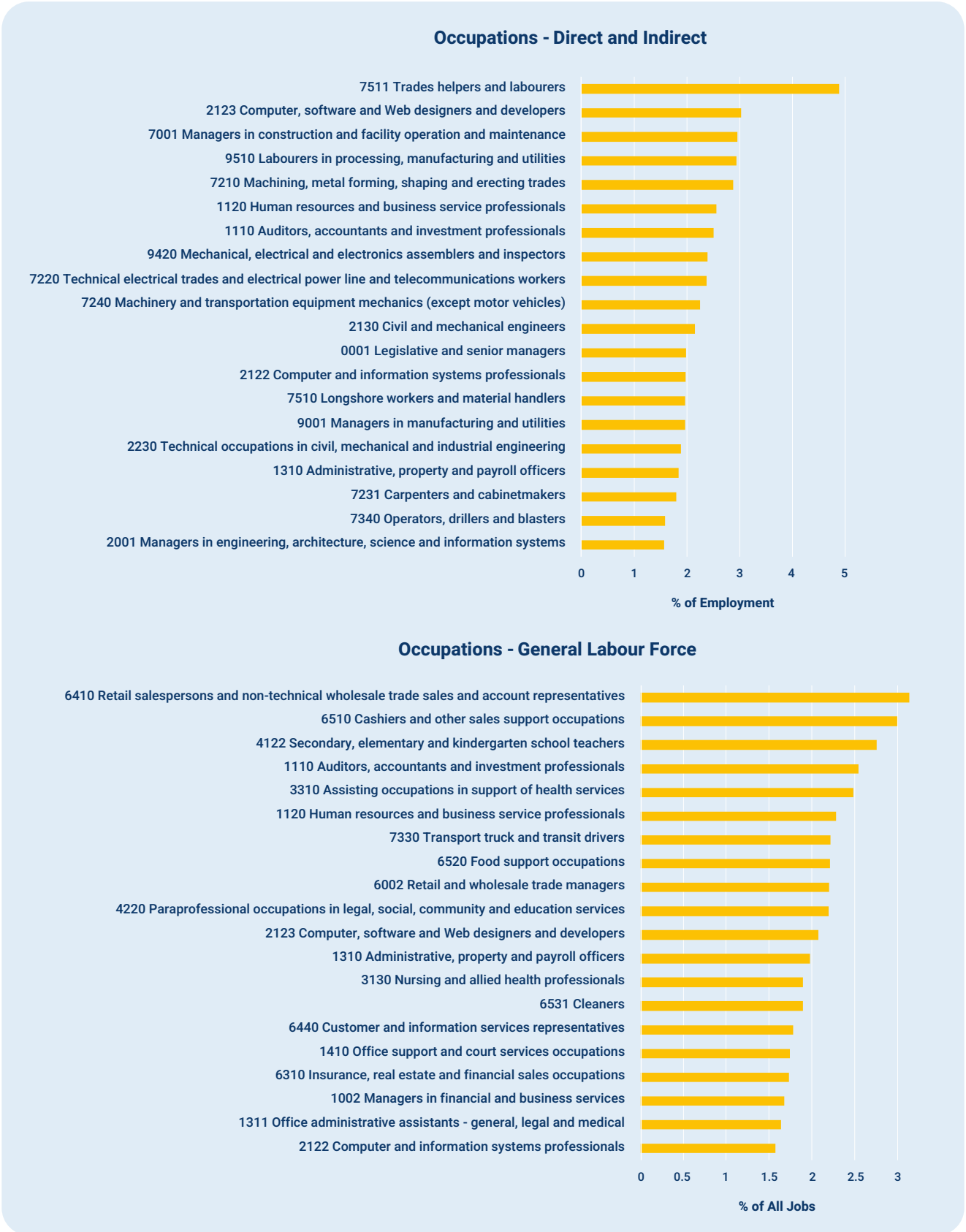
Figure 18 Occupations supported by source



To illustrate the extent of training and upskilling of the labour force supported by the Project, Figure 19 compares the occupations attributable to OPS investments (supported through direct or indirect sources) with the occupational structure of the general labour force in Ontario. Because the top skills and occupations required for OPS are significantly different than those in the overall labour force, appropriate training and upskilling will be required for the generated labour demand to be met.

Training and apprenticeships across OPS-related occupations will provide ongoing support to the Ontario economy beyond OPS. This not only boosts Ontario's productive capacity but also aids the province in meeting its required capital and infrastructure projects to achieve its climate policy goals. This is maintained by the fact that the jobs created by OPS are 65% more productive than if created across the general economy.

Figure 19 Occupations supported by Ontario Pumped Hydro Storage and in the general labour force



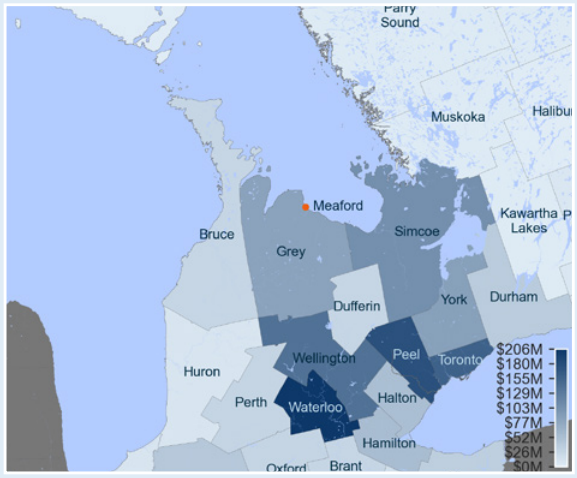
2.4 Contributions by Region

This section dives deeper into the GDP and employment contributions supported across the province. This is particularly important for elucidating the regions that will benefit the most from OPS's construction and operations.

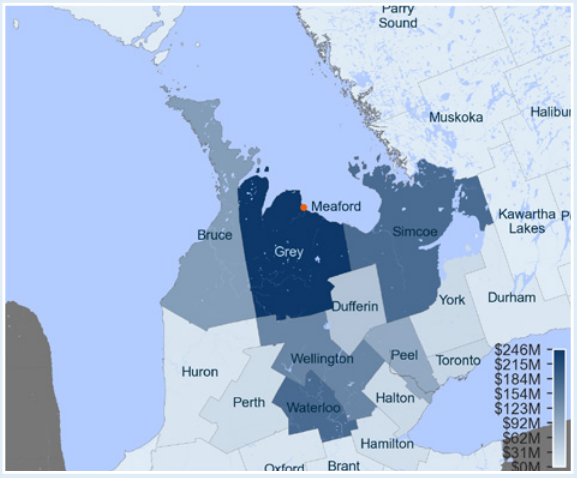
Figure 20 shows the GDP contributions for manufacturing, construction, professional and technical services, and finance and insurance sectors for the areas of the province most affected. Notably, economic activity in manufacturing grows primarily around the regions of Waterloo and Peel. Professional and technical services, many associated with manufacturing, are also centred around Waterloo. For construction, because it can be sourced closer to the construction site of the project, economic activity is centred around Meaford. By contrast, financial businesses have less geospatial restriction and are thus concentrated in Toronto.

Figure 20 GDP by region and industry

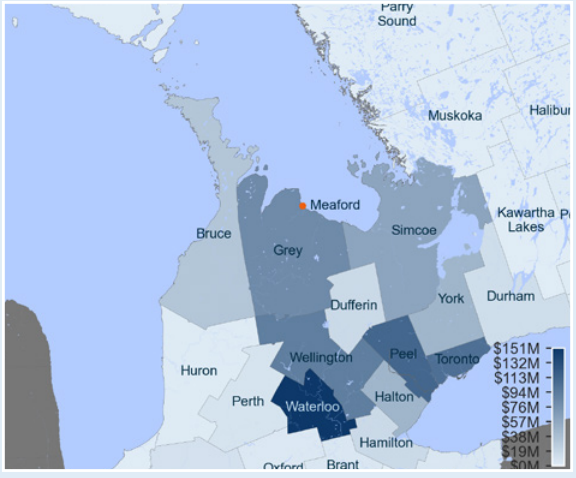
GDP: 31-33 Manufacturing



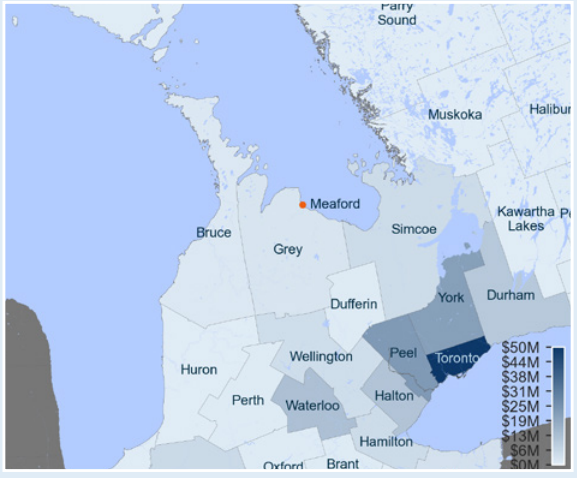
GDP: 23 Construction



GDP: 54 Professional, scientific and technical services



GDP: 52 Finance and insurance



Complementing these insights, Table 4 shows the 20 counties that receive the biggest employment contributions, alongside their GDP generated. Waterloo receives the biggest employment benefits, which are concentrated in the manufacturing and engineering sectors. Toronto, being a financial hub, experiences significant employment boosts in financial and professional services. Moreover, Grey County receives a large employment contribution to its construction sector. Nonetheless, economic activity and employment benefits extend across the province.

Table 4 Regional GDP (2023 dollars) and employment contributions

Municipality	GDP ($M)	Job-Years
Waterloo	$652.58	4,209.60
Toronto	$519.31	3,657.00
Peel	$520.91	3,511.80
Grey	$643.20	3,429.60
Wellington	$454.86	2,869.00
Simcoe	$455.04	2,858.90
Bruce	$939.68	2,704.60
York	$254.74	1,772.60
Halton	$194.52	1,294.50
Ottawa	$143.95	1,008.00
Hamilton	$134.08	917.8
Durham	$116.45	819.3
Dufferin	$124.05	777.6
Middlesex	$96.64	673.7
Essex	$88.93	627.8
Greater Sudbury / Grand Sudbury	$86.28	602.4
Niagara	$75.48	531.1
Perth	$74.04	482.4
Oxford	$55.37	368.1
Brant	$53.24	356.5

3.0 Social Contributions of Ontario Pumped Hydro Storage

The social contributions of OPS include both its benefits to people and social value generated, over the 50 years of investments analyzed. The following benefits to people cover the number of Ontarians and households (by region and type) impacted, as well as full-time jobs and jobs by age group and location. The goal is to track OPS contributions to specific groups of people, aligning the results with key demographics and areas impacted. Enriching these people-level benefits, the social value of OPS demonstrates the impact of the project on the well-being of all individuals affected. It reflects the equivalent change in income, all else equal, that would result in the same increases in well-being stemming from OPS.

The main results are summarized in Table 5. Between 2024 and 2072, the positive well-being impact of OPS is equivalent to an aggregate income injection of $450 million. This figure encompasses all the well-being impacts of OPS on over 110,000 Ontarians, spanning 37,000 households. Of these households, 20,700 are located in rural regions, 16,800 have children, and 3,000 are one-parent households. Moreover, a total of 27,000 full-time jobs are supported, and 33% of the total jobs supported are received by Ontarians under 35 years of age.

The remaining of this section further dissects these results.

Table 5 Total social contributions of Ontario Pumped Hydro Storage, by source

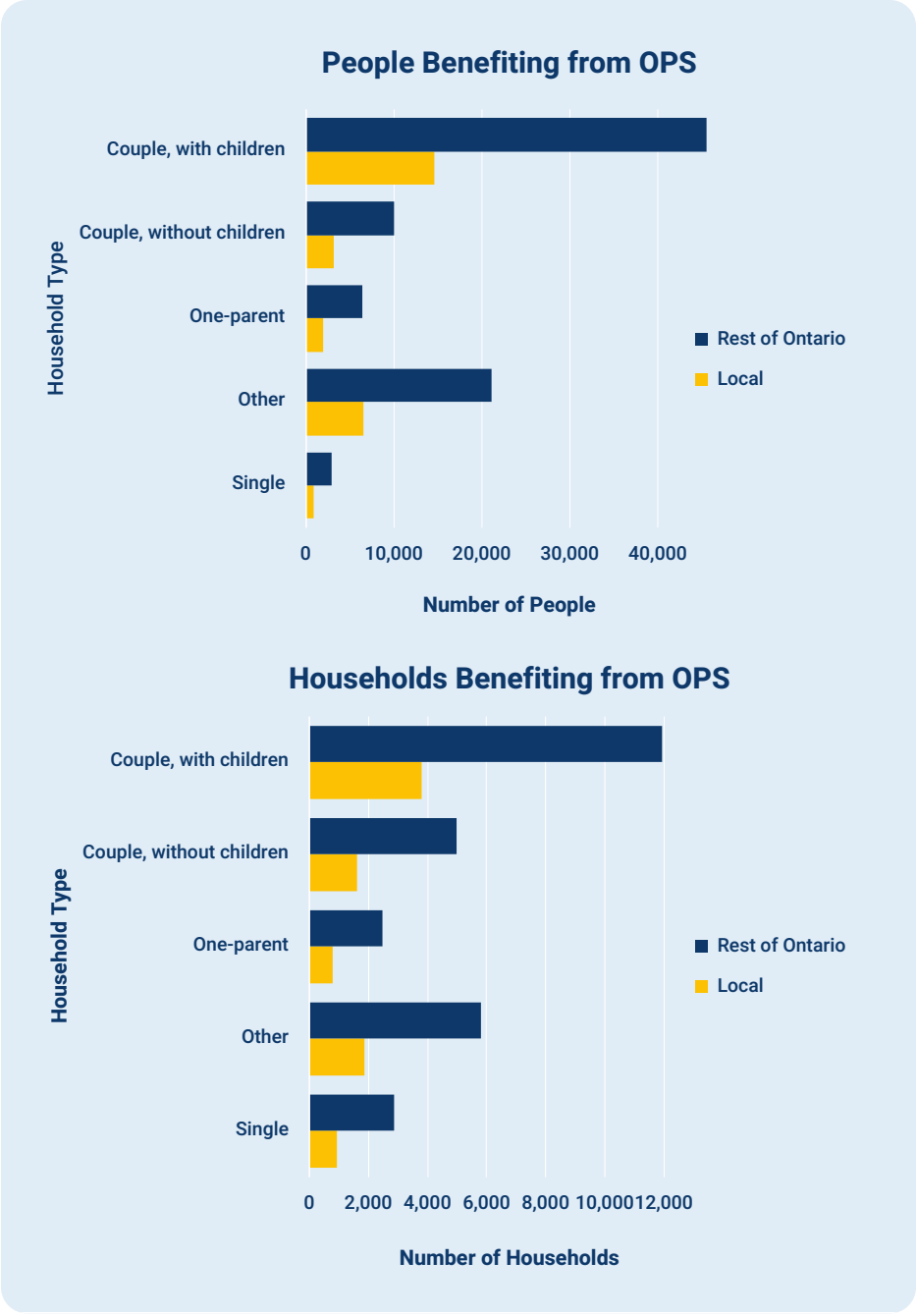
	Total	From Direct	From Indirect	From Induced
Social Value (Ontarian's well-being)	**$450 million**	$250 million	$180 million	$15 million
Ontarians benefited	110,000	54,000	36,000	24,000
Households benefited	37,000	18,000	12,000	7,700
Rural households benefited	21,000	12,000	5,300	3,400
Households with children benefited	19,000	9,100	6,000	4,000
One-parent families benefited	3,300	1,600	1,000	700
Full-time jobs	27,000	11,000	10,000	6,300
Jobs for Ontarians under 35 years of age, percentage of total	12,000	6,000	4,000	2,000

3.1 Benefits to People

3.1.1 By Household Type

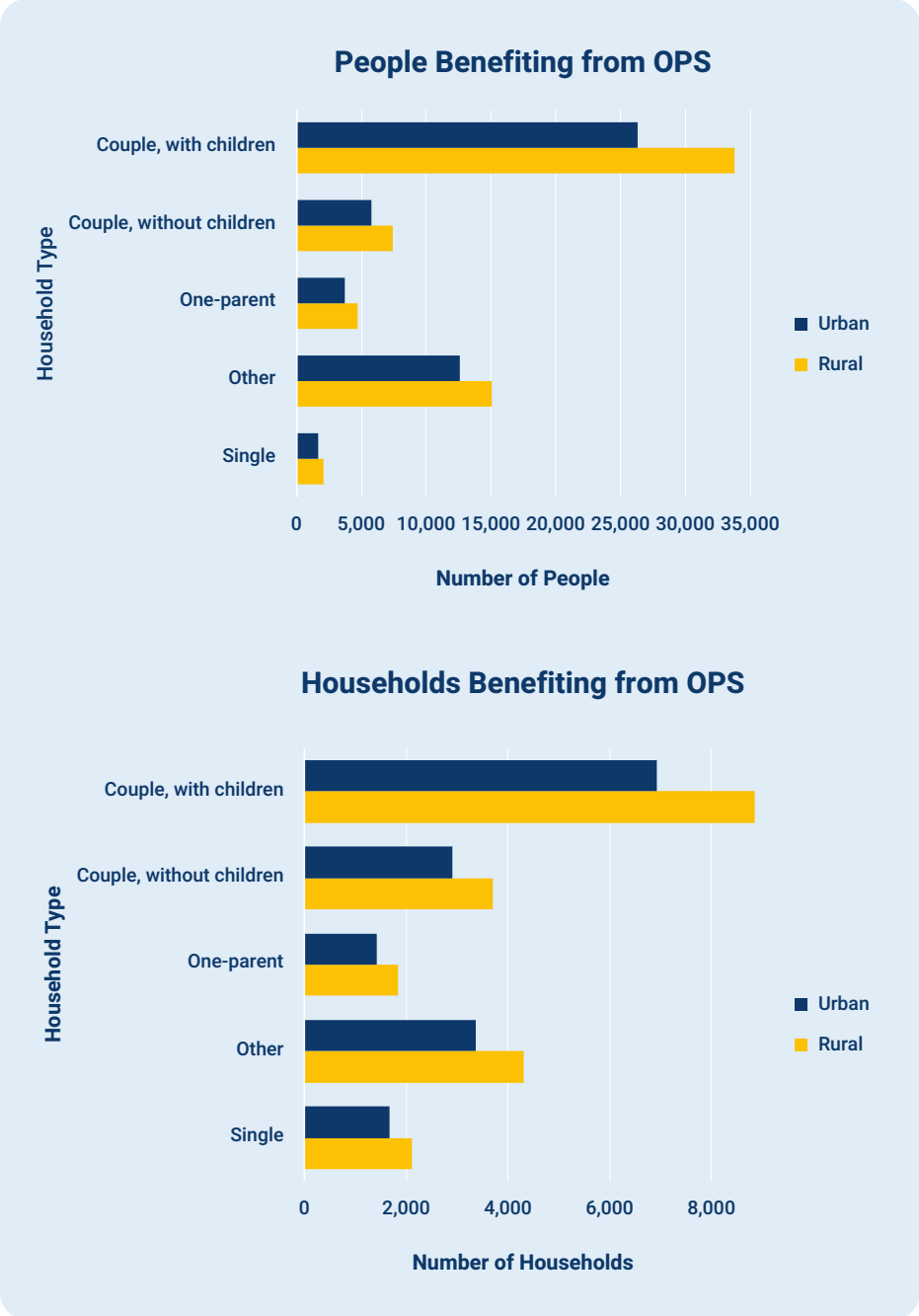
The over 110,000 Ontarians affected throughout the Project include those who are impacted either through supported employment or are family members who benefit from generated jobs (from direct, indirect, or induced sources). As Figure 21 shows, both locally and in the rest of Ontario couples with children benefit the most, followed by "other" households (which include multi-generational households, individuals living with roommates, etc.).

Figure 21 People and households benefiting from Ontario Pumped Hydro Storage, across Ontario



Furthermore, the majority of people affected by OPS reside in traditionally rural regions (outside the GTHA and major cities), amounting to 56% of the total. This is true for all household types, as shown in Figure 22.

Figure 22 People and households benefiting from Ontario Pumped Hydro Storage, rural and urban



3.1.2 By Region

With the reliance on local supply chains, the people who benefit from OPS are distributed across the province. Expectedly, many of them are in the local region of Grey, Bruce, and Simcoe. Moreover, due to the boost in professional services, a significant number of beneficiaries reside in Toronto and Peel. Due to being a manufacturing hub and the considerable benefits incurred by this sector, Wellington County is home to many people who benefit from the Project. These results are presented in Figure 23.

Figure 23 People benefiting from Ontario Pumped Hydro Storage across Ontario

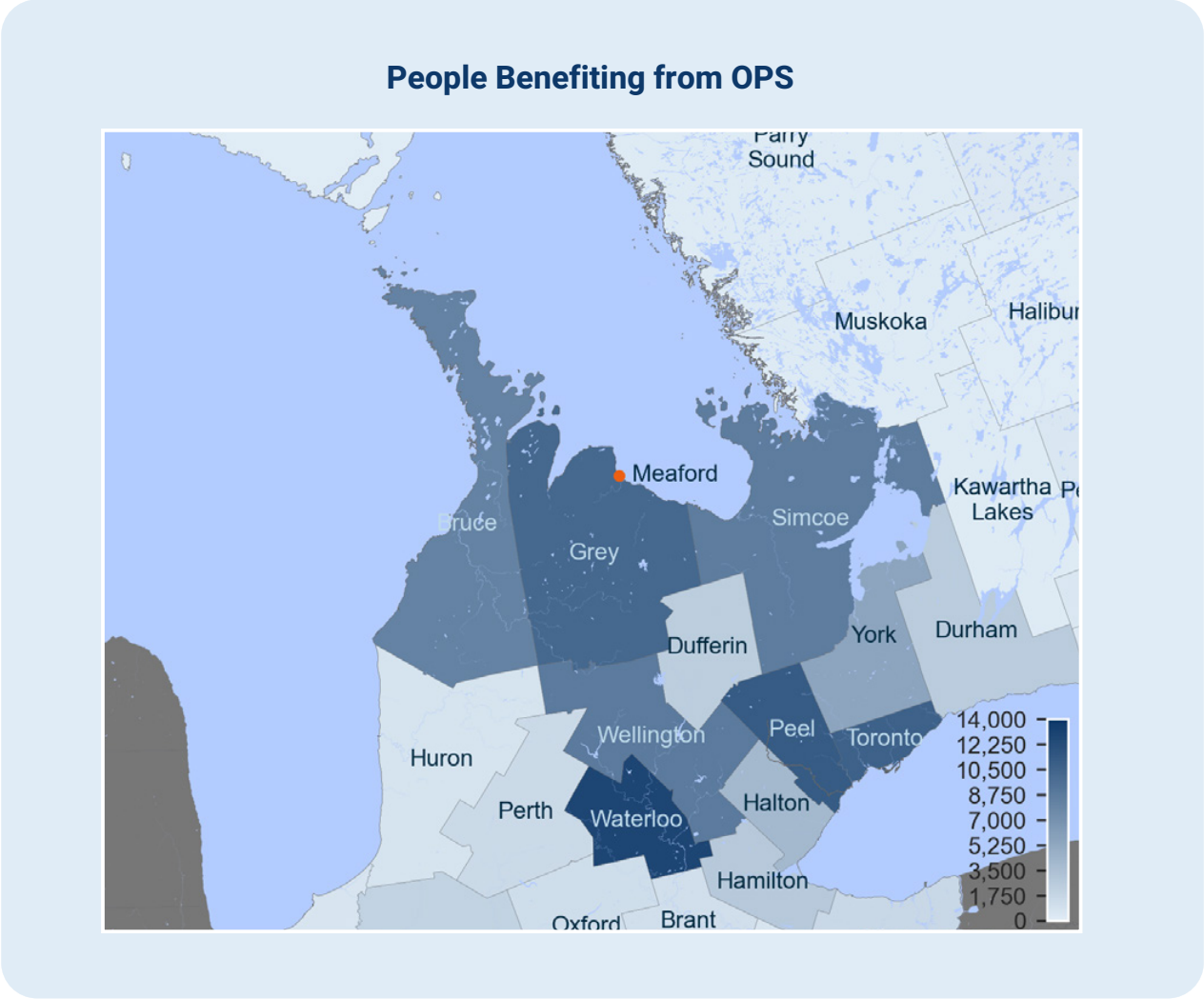


Table 6 accompanies the map shown in Figure 23 by showing the number of benefited people by region. Expectedly, the number of people benefited trails the employment contributions in each region.

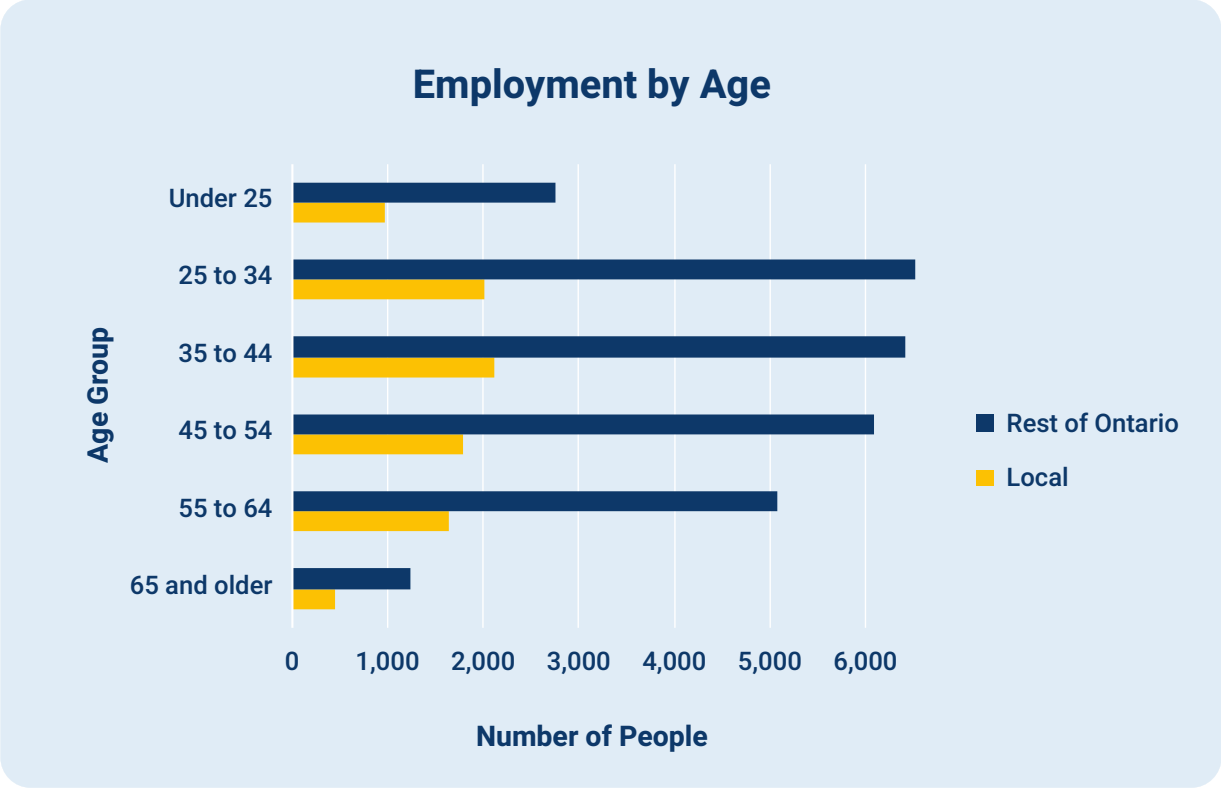
Table 6 People benefiting from Ontario Pumped Hydro Storage across Ontario

Municipality	# of People Affected
Waterloo	12,889
Peel	11,179
Toronto	10,847
Grey	10,294
Wellington	8,778
Simcoe	8,731
Bruce	8,214
York	5,515
Halton	4,059
Ottawa	3,029
Hamilton	2,793
Durham	2,555
Dufferin	2,436
Middlesex	2,023
Essex	1,931
Greater Sudbury / Grand Sudbury	1,782
Niagara	1,585
Perth	1,469
Oxford	1,132
Brant	1,091

3.1.3 Employment Benefits

This subsection adds to the employment contributions described in the labour contributions section. Notably, the employment benefits of OPS are felt across all age groups, as shown in Figure 24. A third of these benefits are received by individuals aged between 15 and 35, which compose a key demographic for learning skilled trades and who are the most likely to be facing housing affordability pressures. Indeed, almost 40% of households with people under 35 face affordability challenges. Because the jobs generated by OPS are in skilled sectors with generally higher incomes than other industries, these jobs have the potential to improve the affordability of affected households.

Figure 24 Employment by age



Additionally, it is estimated that 35% of all employment benefits would target immigrants in Ontario. This has the potential to attract more immigrants to the province, and while many newcomers would settle in urban centres, over 1 in 7 rural jobs would support immigrants. The importance of this point stems from the fact that the population and labour force of many rural communities are expected to start or continue to fall without immigration in the following decades. The jobs supported by OPS, either directly or indirectly, play a role in attracting and retaining skilled immigrants in these regions. The complete employment benefits by immigration status and region are depicted in Figure 25.

Figure 25 Employment by immigration status and location

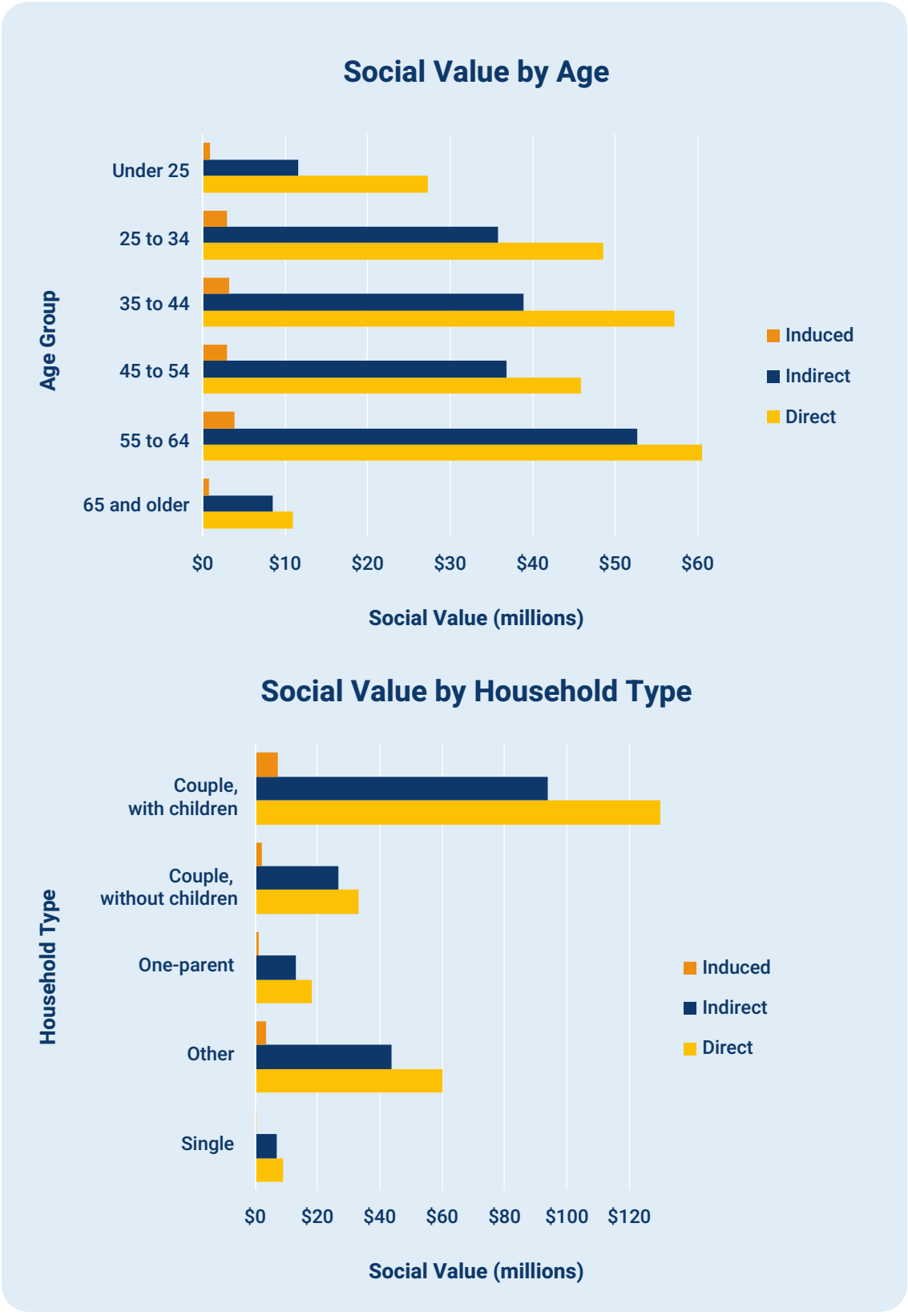
3.2 Social Value

Collectively, throughout the project, the OPS project generates $450 million (in present-value terms) in social value as a result of improved well-being for Ontarians associated with it. This corresponds to an average of $11,000 of social value per employment-year.

Trailing the distribution of benefits by household type, the majority of social value arises in families with children, followed by “other” households. Moreover, individuals aged between 55 and 65 experience the biggest improvement in social value from all sources. Nonetheless, because employment training and upskilling are “sticky”, and, as observed, young individuals obtain the biggest improvement in employment, social value benefits are expected to grow as the population ages.

Figure 26 shows the complete social value results by age and household type.

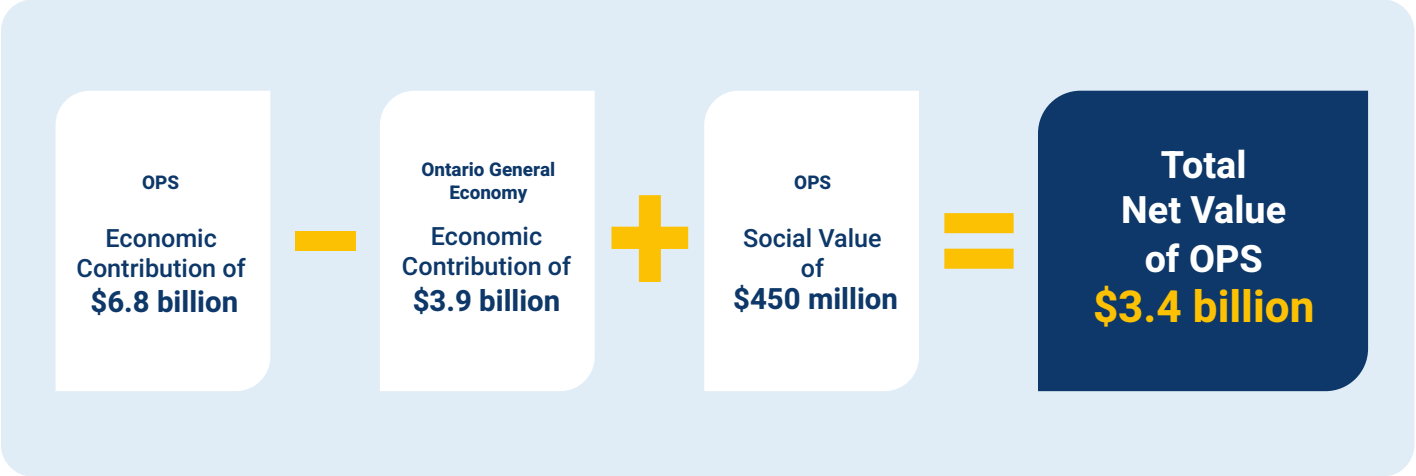
Figure 26 Social value by age and household type



4.0 Net Value of Ontario Pumped Hydro Storage

The complete picture of the contribution of OPS to the Canadian economy is captured by its net value, which corresponds to its total economic and social value benefits relative to a "general economy" baseline. This baseline corresponds to a scenario which generates the same number of direct jobs (by age and sex) as OPS in the general economy, across the province, rather than via OPS investments near Meaford[12]. This exercise is useful in elucidating the contributions of OPS relative to business-as-usual growth in the general economy.

Overall, OPS is expected to generate a total net value of $3.4 billion over the next 50 years, which arises from a net economic contribution of $2.9 billion relative to the general economy (1.7 times higher) plus the social value contribution of $450 million. That is:



The full economic net benefit and social value results are summarized in Table 7.

12 The motivation for this baseline scenario is that if an alternative investment were to have the same direct jobs impact, but the direct jobs reflected the general economy (rather than the specific jobs required for OPS) there will be differences in the overall economic contribution. In particular, when following the indirect and induced aspects in the 'business as usual' case, there might be different jobs required in the supply chain, and variation in the overall economic capacity of the province. The net result will reveal that even when starting with the same number of direct jobs, the effects of OPS on the supply chain and induced activity could be different to the 'business as usual case'.

4.1 Economic Net Benefit

Over 50 years, sizeable differences are notable for all the economic metrics analyzed, including GDP, gross operating surpluses, private investment, jobs, and labour income. Importantly, the OPS project:

Generates high-quality jobs for Ontarians: OPS would generate 1.4 times more high-quality full-time jobs for Ontarians relative to the general economy.

Is built with Ontario/Canadian Supply Chain: For every job supported, the project generates 2.3 times more construction and manufacturing jobs than the general economy.

Contributes to the prosperity of rural economies: OPS benefits 1.8 times more rural households than the general economy.

4.2 Social Value Benefit

While the economic benefits of the project support the financial viability of OPS, OPS would also have wide-ranging social value benefits, indicating its potential to improve the well-being of Ontarians. Importantly, OPS would have:

A high impact on affordability challenges: By generating 1.3 times more total jobs, OPS provides greater support to households affected by housing unaffordability challenges.

A high well-being impact for Ontarians: OPS generates $450 million in social value, reflecting positive well-being changes on aggregate as a result of the project.

The significant social value improvement stems both from the quality of investment impacts and the number of people affected: in total, 20% more Ontarians are affected by OPS than by equivalent investments in the general economy. This corresponds with 30% more households, 80% more rural households, 10% more households with children, 20% more one-parent families, and 40% more full-time jobs.

Table 7 Benefits of investments in Ontario Pumped Hydro Storage versus the general economy

	OPS (over 20 years)	General Economy (business as usual) (over 50 years)	OPS benefit vs. general economy
Economic Contribution (GDP, 2023 dollars)	**$6.8 billion**	**$3.9 billion**	**1.7 times**
Gross operating surplus[13] (2023 dollars)	$2.9 billion	$1.5 billion	1.9 times
Private investment (2023 dollars)	$1.4 billion	$680 million	2.1 times
Jobs (people-years)	41,200	31,800	1.3 times
Labour income (2023 dollars)	$3.9 billion	$2.4 billion	1.6 times
Social Value (Ontarian's well-being)	**$450 million**	-	-
Ontarians benefited	110,000	89,500	1.2 times
Households benefited	37,000	29,000	1.3 times
Rural households benefited	20,700	11,500	1.8 times
Households with children benefited	16,800	15,100	1.1 times
One-parent families benefited	3,000	2,600	1.2 times
Full-time jobs	27,000	18,300	1.4 times
Jobs for Ontarians under 35 years of age, percentage of total	33%	34%	-
Total Value Relative to the General Economy	**$3.4 billion**		-

13 Gross operating surplus is approximately equal to business profits

5.0 Comparison to Battery Storage

Among energy storage solutions, a primary alternative to pumped storage technology is battery energy storage systems (BESS). Although these systems provide some of the same utility to the electricity grid, they differ widely in their construction and maintenance requirements, sensitivity to economic shocks, and lifetime.

While most of the construction inputs for OPS would be sourced domestically, BESS would require significant amounts of critical minerals, such as lithium, to be sourced from abroad, particularly from China. This has the potential to expose a BESS project to significant price risk, given the forecasted global lithium supply deficit and the resulting price volatility. Additionally, China's dominance of battery metals, refining and battery manufacturing, could create geopolitical concerns (Hatch, 2022).

In terms of the system's lifetime, a BESS would have to be re-implemented several times to offer the same lifespan as a pumped hydro storage project, which could result in higher lifecycle emissions (Hatch, 2022).

This section of the report aims to showcase that OPS has the potential to generate significantly greater economic benefits than BESS, in addition to possessing superior longevity. To this end, the first 20 years of construction and operations of OPS are contrasted with a 20-year battery alternative. This follows a stylized BESS example that is of similar scope and size to OPS (i.e. 1,000MW, with approximately 10 hours duration), proposed by TC Energy. The total capital investment for this BESS example would be $5.1 billion.

5.1 Differences in Economic and Social Value Contributions

Over the analyzed 20 years, the economic profile of the two projects is significantly different, with BESS having a greater reliance on imported products rather than locally produced goods, services and jobs. While only 17% of capital spending would be devoted to foreign sources for OPS, this figure is almost 80% for BESS (4.7 times greater). Additionally, capital for augmentation would be largely sourced from abroad as well. Operating costs would be between $17 million and $35 million annually, with replacements of batteries after 8 years of operation.

When compared to the first 20 years of OPS operations, an equivalent battery storage investment would generate significantly lower economic and labour benefits. Namely, it would generate $3.2 billion less GDP, with $1.5 billion less GDP for rural regions, as well as 24,000 fewer jobs, with 11,900 fewer jobs for rural regions. Total taxation revenues would also be 63% lower at $860 million. Moreover, because OPS has the potential to operate for up to 100 years, the BESS alternative would only possess 20% of the lifetime of OPS.

The economic contributions from BESS are contrasted with those of OPS in Figure 27. Proportionally, among economic metrics, the biggest difference in contribution between the two projects is in labour income, with OPS generating 3 times as much labour income as OPS. However, notable differences occur for all metrics, including gross operating surpluses and private investments.

Regarding labour contributions, BESS creates significantly fewer jobs in Ontario relative to OPS, both locally and within the rest of the province. These differences reflect the greater reliance of BESS on foreign, as opposed to local, supply chains. These results are shown in Figure 28.

Figure 27 Economic comparison between Ontario Pumped Hydro Storage and Battery Energy Storage System (2023 dollars)

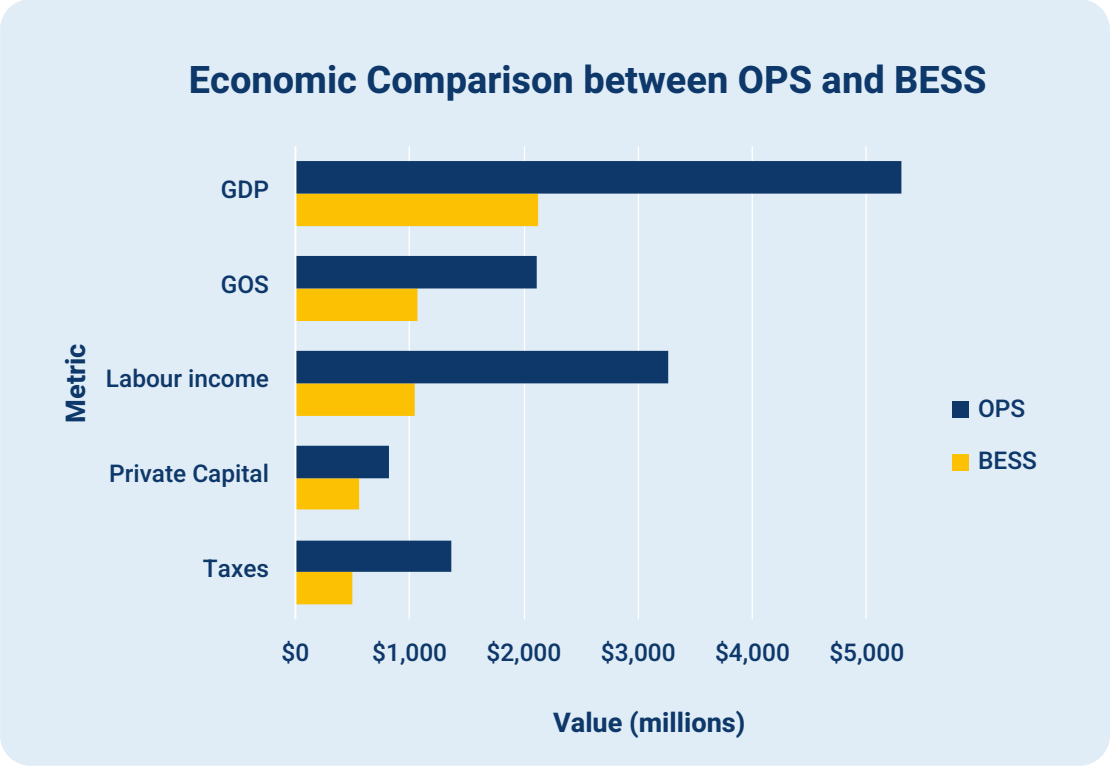
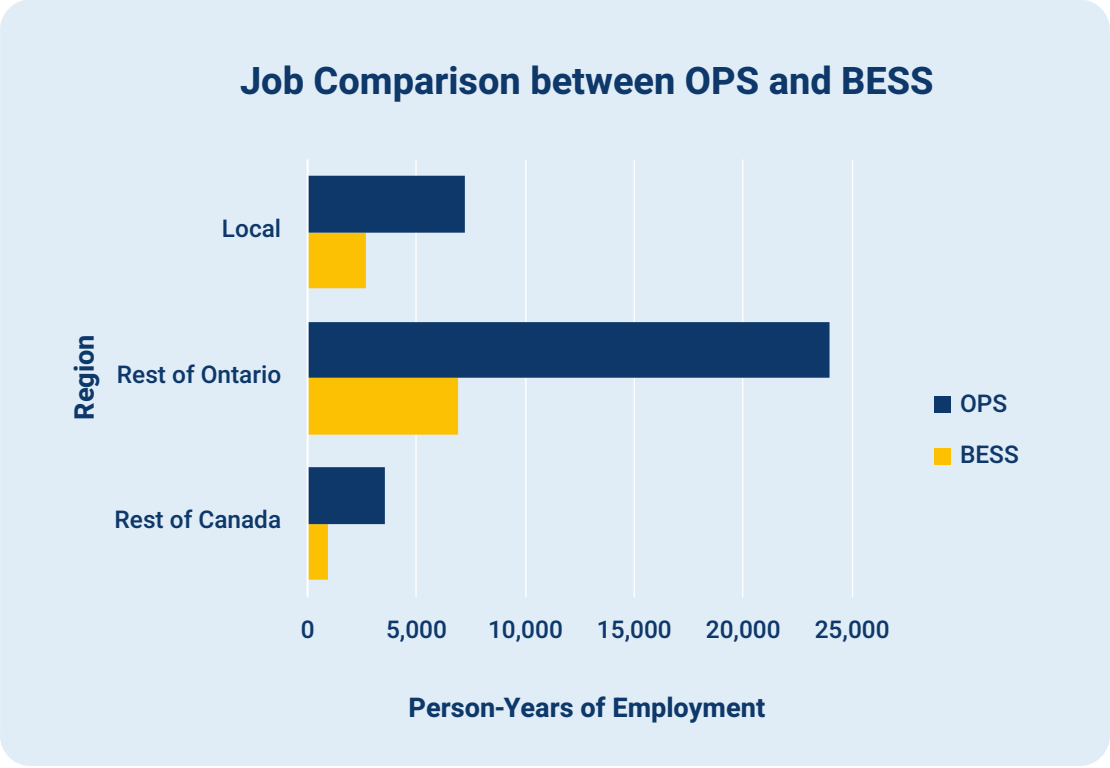


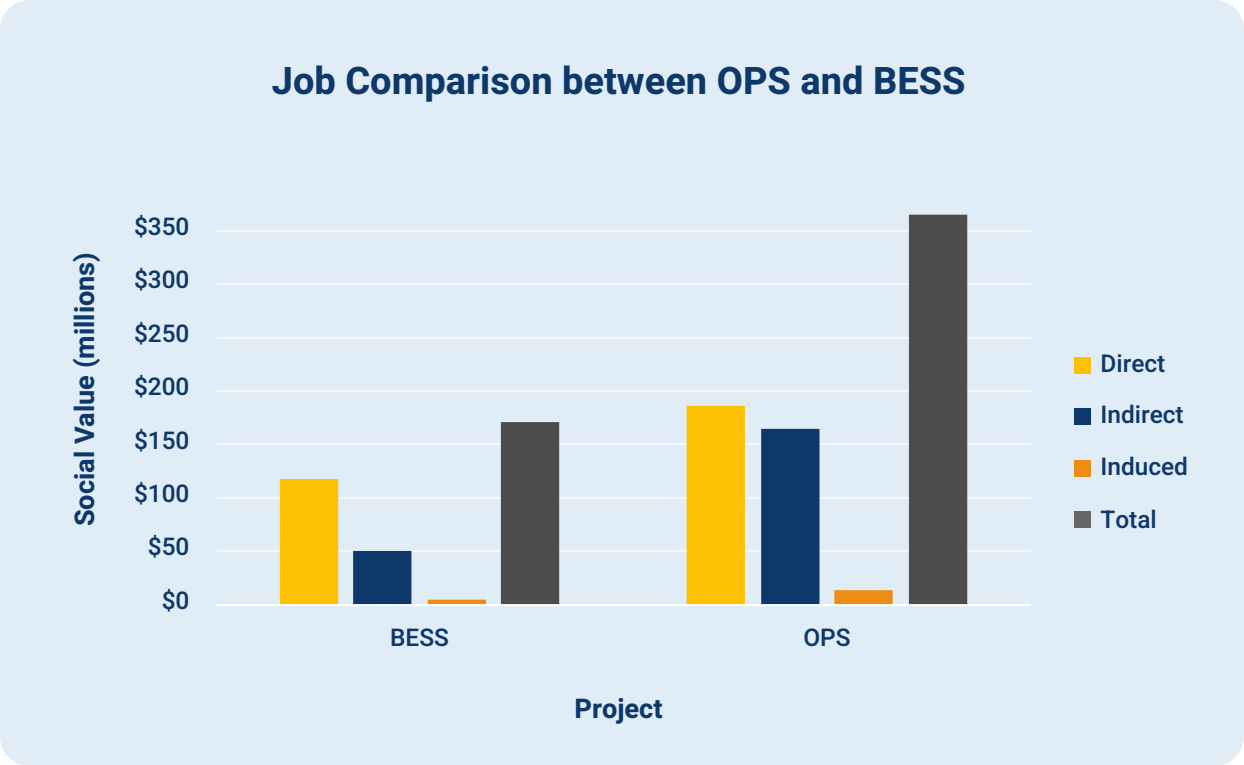
Figure 28 Labour comparison between Ontario Pumped Hydro Storage and Battery Energy Storage System



5.2 Difference in Social Value

In terms of social value, the contribution of OPS is over 2.1 times greater than of BESS for the first 20 years of operation, with the contribution being $360 million for OPS and $170 million for BESS. This total difference is shown in Figure 29, alongside differences in social value from direct, indirect, and induced sources. Expectedly, the stark differences between the direct and indirect social value benefits for the two projects highlight the import-heavy aspects of BESS: because most of the project's spending leaves the country, far fewer people benefit in Canada.

Figure 29 Social value comparison between Ontario Pumped Hydro Storage and Battery Energy Storage System



5.3 Net Value of Ontario Pumped Hydro Storage relative to Battery Energy Storage System

The net value of OPS relative to BESS is given by the sum of the differences in net economic and net social value contributions between the two alternatives. With the difference in GDP and social value contributions being $3.2 billion and $190 million, respectively, this net value amounts to $3.5 billion. In terms of GDP, the OPS contribution is 2.5 times higher than BESS's.

The complete comparison of the main metrics analyzed is given in Table 8. Among economic and labour metrics, the biggest differences are in jobs supported, with OPS supporting 3.3 times more total jobs and 3.2 times more jobs in rural regions. Again, this reflects the considerably greater reliance of OPS on Ontario's supply chain. The difference in gross operating surplus supported is also significant, being 2.0 times higher for OPS.

Regarding social benefits, OPS is significantly superior to BESS. The pumped hydro storage project supports 3.3 times more Ontarians than battery storage, as well as 3.2 times more total households, households in rural regions, and households with children. Considerably more full-time jobs are generated by pumped storage, with the figure being 3.2 times higher for OPS.

In conclusion, OPS is both more reliable (due to being less exposed to price risks and geopolitical disruptions) and more impactful than BESS at generating economic and social returns. In addition to being more beneficial to the Ontario economy as a whole, OPS generates more benefits for people, households, and businesses, and is significantly more likely to support sections of the population that can benefit the most from increased economic activity, such as rural regions, households with children, and one parent families. Additionally, by generating more jobs in all regions impacted, OPS is more efficient at incentivizing the upskilling of Ontario's labour force.

Table 8 Net value of Ontario Pumped Hydro Storage relative to Battery Energy Storage System

	OPS (over 20 years)	Battery Alternative (over 20 years)	OPS benefit vs. BESS
Economic Contribution (GDP, 2023 dollars)	**$5.3 billion**	**$2.1 billion**	**2.5 times**
GDP in rural regions (2023 dollars)	$2.8 billion	$1.3 billion	2.2 times
Gross operating surplus (2023 dollars)	$2.1 billion	$1.1 billion	2.0 times
Additional private investment (2023 dollars)	$820 million	$550 million	1.5 times
Jobs (people-years)	34,700	10,500	3.3 times
Jobs in rural regions (people-years)	17,400	5,500	3.2 times
Social Value (Ontarian's well-being)	**$360 million**	**$170 million**	**2.1 times**
Ontarians benefited	47,600	14,600	3.3 times
Households benefited	15,600	4,800	3.2 times
Households in rural regions benefited	17,400	5,500	3.2 times
Households with children benefited	6,600	2,000	3.2 times
One-parent families benefited	1,400	420	3.3 times
Full-time jobs	23,000	7,000	3.2 times
Net Benefit of OPS compared to BESS	**$3.5 billion**		-

The Net Benefit of OPS compared to BESS is equal to the sum of the differences in economic and social value contributions between the two alternatives.

6.0 Conclusions

The OPS investment has several unique value drivers, including the use of Ontario supply chain lines and the skilled and trained labour required to build the facility. These value drivers result in OPS being 1.7 times more beneficial than general investment in the Ontario economy.

Over the following 50 years, the proposed investments in OPS stand to generate significant economic, labour, and social benefits for Ontario. By affecting more than 110,000 Ontarians, OPS would generate over $6.8 billion in economic activity, an increase of $2.9 billion over business-as-usual growth. It would also generate over 41,000 jobs, primarily targeting parts of the province that could benefit the most from them: rural regions, young people (under 35 years of age), and households with children. Moreover, by targeting trades largely filled by immigrants, the growth induced by the project has the potential to increase immigrant attraction and retention. Overall, these benefits lead to a significant increase in aggregate well-being in the province, equating to $450 million in social value.

Relative to the general economy, a scenario corresponding to business-as-usual growth, OPS can generate 1.9 times more operating surplus, 1.3 times more jobs, 1.6 times more labour income, and 2.1 times more private investment. These benefits are supported by parallel advantages in the social contributions of OPS: the project affects 1.2 times more Ontarians, 1.8 more rural households, and creates 1.4 times more full-time jobs.

In comparison with a battery energy storage system of similar storage capacity, OPS would generate significantly higher economic and social benefits over 20 years, namely 2.5 times more economic benefits and 2.1 times more social value. By sourcing construction resources primarily from abroad, the number of affected Ontarians would be 69% lower relative to OPS. As a result, fewer households would be affected, and significantly fewer full-time jobs would be generated.

The Project also stands to aid Ontario in the achievement of its emissions-reduction goal by reducing the reliance of its electricity system on high-emitting power generation, increasing the efficiency of non-emitting generation systems, and providing low life-cycle emissions. Additionally, it can generate significant economic and social benefits for its prospective partners, the Saugeen Ojibway Nation.

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Social Value Evaluation

CANCEA's social value evaluation (SVE) approach couples agent-based modelling with statistical well-being estimation. Agent-based modelling is adopted to probabilistically track the socio-economic states and well-being of individuals longitudinally over time. The platform follows the individual evolution of each agent, such as a person, household, or business across time. Given starting states, individuals interact and face changing circumstances according to empirically-derived probability distributions. In this way, the dynamics of the model emerge stochastically. While each of the individual decision processes may be straightforward, the combined dynamics of millions of heterogeneous people and businesses, subject to limited resources, can yield complex non-linear results. The utilization of ABM in economic studies has been prescribed and supported by extensive research (Baptista, et al., 2016; Turrell, 2016; Haldane & Turrell, 2017; Farmer & Foley, 2009; Mazzucato, et al., 2020; UK HM Treasury, 2020; UK HM Treasury, 2020).

CANCEA's approach to SVE is rooted in the idea that subjective well-being valuation (Tesileanu, 2008; Dolan, Peasgood, & White, 2008; Carlsson, 2011) is an intrinsic part of SVE. Indeed, scholars emphasize the ability of well-being measurement to incorporate respondents' values and preferences, reflecting the outcomes of their choices, thus making it an indispensable tool in social value evaluation (Diener, Inglehart, & Tay, 2013; Layard, 2010; Frey & Stutzer, 1999; Stutzer & Frey, 2010; Yang, 2018; OECD, 2013). Moreover, when future well-being expectation changes are involved, the aggregation process requires discounting for future well-being expectations at the individual level before aggregation. Handling time and well-being preferences is important for long-term assets, addressing issues like inflation, risk and well-being expectations, as outlined in the UK Green Book (2018).

In light of this, CANCEA conducts SVE by combining modelled agent dynamics with a well-being function for each agent. These functions are supported by statistics derived from detailed well-being surveys. In our analyses of subjective well-being with data from Statistics Canada's General Social Survey (GSS) and Canadian Community Housing Survey (CCHS), for instance, we can uncover strong correlations between individual characteristics and their well-being levels. Primarily, these analyses entail the computation of linear regressions corrected for interactions between independent variables and for non-linear relationships between well-being and some individual characteristics. This is motivated by extensive research identifying links between a person's well-being across time and their characteristics and the community and environmental circumstances they face (Lu, Schellenberg, Hou, & Helliwell, 2015; Helliwell & Wang, 2011; Chen & Hou, 2010; Kytta, Broberg, Haybatollahi, & Schmidt-Thome, 2016; Layard, Mayraz, & Nickell, 2008).

Following this approach, SVE requires the separate specification of a baseline scenario, in which the status quo is maintained in the long run and no structural changes are introduced, and an alternative scenario, in which a proposed structural change is introduced. Each of these scenarios yields, for every individual analyzed, a probability distribution of outcomes regarding their well-being and socio-economic states. The expected value of these outcomes is then adopted as the representative measure of that scenario.

In the baseline, given status quo relationships that are derived from historical data, the number of possible journeys followed by an individual over the period analyzed is equal to the number of possible (reasonable and realistic) combinations of all demographic and socio-economic characteristics of the individual. Each of these combinations is a possible state of the individual at a given time. The probability of each such state occurring is equal to the probability that all variables of the individual have a given realized value, given the individual's preceding state. This yields a probability distribution of individual states.

Based on this distribution, the expected value of the well-being in the baseline scenario for this individual is equal to the expected value of that individual's well-being function. That is, given the individual's initial state, the expected value of their well-being at the end of the period is equal to the sum of all possible well-being values (defined over all possible states), weighted appropriately by the probability of each state occurring.

The expected well-being of the individual in the alternative scenario is computed similarly, with individual states and state changes being affected by the introduction of some change in circumstances, such as a policy or infrastructure project.

The difference between these expected well-being values for the baseline and alternative scenarios yields the well-being impact of the change in circumstances for the individual in question. Then, analysis is conducted to identify the income change over the analyzed period that would result in the same change in well-being for this individual, holding the remaining state variables constant. This income change, referred to as monetary equivalent, is then present valued using the yield curve for a zero coupon bond to obtain discount factors. These present-valued monetary equivalents are aggregated over all individuals affected by their change in circumstances in response to what is being evaluated, yielding the total social value. The translation of well-being changes into monetary equivalents and the subsequent aggregation of these adjustments into a social value estimate is a key feature of Murtin, Boarini, & Ripoll (2017) and Llena-Nozal, Martin, & Murtin (2019), for example.