Appendix 4.2 Yukon Macroeconomic Model 2016-2035



Executive Summary

The Yukon Macroeconomic Model (MEM) is a tool for generating future economic and demographic indicators for the Yukon. The Model outputs are then a key input into Yukon Energy's (YEC) electricity demand forecasting model, which provides a long-term outlook of YEC's electricity demand needs. This demand forecast ultimately informs the YEC 2016 Resource Plan (RP), which will present desirable supply options for meeting future customer electricity requirements.

The MEM is the first step of several towards the successful issuance of the RP. The economic and demographic indicators produced by the MEM are a critical step in forecasting future supply requirements.

This appendix provides an overview of the MEM, which is used to generate forecasts of key economic variables such as Gross Domestic Product and population. The time period for the MEM is 20 years (2016 to 2035); which is consistent with the demand forecast period, and the mandated planning period of the 2016 YEC RP.

A number of historical economic and demographic variables are used as inputs to the MEM, including: economic output by industry, labour productivity, employment, wages and other income, population, consumption of goods and services, exchange rates, commodity prices, and capital investment.

Model runs were undertaken for 14 economic scenarios; these scenarios were developed to represent a range of Yukon economic activity over the planning period. The scenarios primarily consider a range of industrial activity, mining in particular, and in addition, a range of government spending levels. Sensitivity analysis with respect to future activity in Yukon's smaller economic sectors (such as tourism) were also modeled. The 14 scenarios cover a wide but plausible range of potential outcomes.

Values of the key economic variables with relevance to electricity consumption and therefore, future electricity demand, are presented in the Table 1. These are for the base economic case (Scenario 3). The minimum, maximum and base key economic variables from all 14 scenarios are presented in the body of this report in Table 2.

Table 1: Yukon Macroeconomic Model Outputs - Base Case

	Current (2015)	Year 2025	Year 2035
Population (000's)	37.4	41.2	41.1
Households (000's)	17.7	17.7	17.8
Employment (000's)	19.7	21.0	20.6
Real Dollar Disposable Income (\$M)	1,351	1,638	1,802
Real Dollar Gross Domestic Product (\$M)	2,226	2,682	2,789

The appendix concludes with a discussion of the results generated by the Yukon MEM. It also includes an explanation of the improvements resulting from the forecasting approach adopted, relative to efforts in YEC's previous resource plans.

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C4SE Firm Profile

The Centre for Spatial Economics (C4SE) was formed in 2000 as a partnership between two consulting firms, Stokes Economic Consulting and Strategic Projections Inc. The intent of the C4SE partnership is to improve the quality of quantitative economic research in small Canadian jurisdictions available to public and private organizations. Over its first fifteen years of operations, C4SE has developed an extensive client base. Public sector clients include provincial finance departments in Alberta, British Columbia, New Brunswick, Newfoundland and Labrador, Ontario and Saskatchewan. C4SE has also developed macroeconomic models for BC Hydro. A complete client list can be found here: (http://www.c4se.com/clients.html).

Robert Fairholm Economic Consulting joined the C4SE partnership in 2003 to increase C4SE's capacity and scope of services. In addition to the staff of these corporations, the C4SE draws from a list of academics and research consultants on an as-needed basis.

Robert Fairholm, Partner at C4SE and President at Robert Fairholm Economic Consulting Inc., was responsible for preparing the economic forecasts for the Yukon economy used in the YEC RP. Fairholm holds an MA in Economics from the University of Toronto and a BA in Economics from Queen's University. He has over 20 years of experience in economic analyses, modelling and forecasting. Prior to joining the C₄SE, Fairholm was the Managing Editor of the International Bank Credit Analyst from 2001 to 2003, and provided a monthly forecast of interest rates, equity markets, commodity prices, economic trends and currency movements in the world's principal economies. From 1993 to 2001, Fairholm directed the Canadian forecasting operations of Standard & Poor's Data Resources Incorporated. He was responsible for all the Canadian macro, industrial and provincial forecasts and related services. The C4SE model runs were facilitated on behalf of YEC by staff from the Business and Economic Research Branch, Yukon Economic Development.

Yukon Macroeconomic Model Specifications

The multi-sector MEM used to inform YEC's long-term demand forecast was initially developed by C4SE for the Yukon Government in 2010. The MEM has been regularly maintained and updated by C4SE since. The Yukon MEM is similar to those developed by the C4SE for its forecasting for other provincial governments and agencies. These models are categorized as "fixed-price" general equilibrium models. They are made up of a series of mathematical equations which together describe the linkages and dependencies between sectors in an economy. As the equations are executed in parallel during runs, this type of model is also known as a simultaneous equation model.

Quantity adjustments rather than price adjustments clear markets in the short to medium term. Examples of quantity adjustments used in the model include changes in a) the utilization of capital b) the utilization of labour and c) changes in the movement of labour. A fixed price structure is used because firms are price takers in the small open economies for which the models are designed. An example of this reality is the price of mine output such as copper and gold. The mining output of the Yukon does not significantly influence the global price for metals.

A distinction is made in the MEM between industries that primarily export and sectors that primarily serve the local economy. Rest-of-world forces largely influence investment decisions by sectors that focus on exports; whether national or international. Assumptions with respect to export-driven investment are set exogenously. The investment decisions made by non-export driven sectors are driven largely by economic activity and demographics within the local economy.

Investment in industries that are primarily export oriented (mining) are set based on views regarding growth in the rest of the world and economic policies that influence the cost of investment and profitability. Investment is determined by the expected amount of capital that will be needed to achieve a target level of output. The target is determined by growth in demand for the particular industry's product, which depends on the growth in the other industries in the local economy and domestic demand along with capital costs.

Model Operation

The MEM operates on a year-by-year basis. It attempts to achieve an internally-consistent and stable solution for the first year of the forecast; once this achieved, it then increments to the next year.

The list of MEM input and output variables is provided below:

Yukon Macroeconomic Model Inputs:	Yukon Macroeconomic Model Outputs:	
 Global economic indicators (historical and forecast real GDP, inflation and interest rates); Historical government economic policies; Historical production capacity by sector and capacity utilization rates; Historical real economic output by industry; Historical labour productivity; Historical population; Historical employment, wages and other income; Historical net population inmigration; Historical consumption of goods and services by individuals, companies and government; Historical investment; 	 Production capacity by sector and capacity utilization rates; Real GDP and inflation; Consumption of goods and services by individuals, companies and government; Labour productivity; Employment, wages and other income; Population; Net population inmigration; and, Real economic output by industry. 	

- Exchange rates;
- Commodity prices;
- Mineral production; and,
- Capital spending and employment associated with export-oriented projects.

Economic Scenarios

Notwithstanding the challenges of economic forecasting in a small jurisdiction where economic output can be significantly altered by the opening or closing of a single mine, the C4SE Yukon MEM represents a robust attempt to forecast a reasonably wide range of economic activity in the Yukon over the forecast period.

A total of 14 economic scenarios were conceived for Yukon economic activity over the forecast period. The development of the economic scenarios was seeded via a planning session with two engineers from YEC, two economists from Yukon Economic Development and an independent economist from Vector Research. The choice of scenarios is intended to cover a wide but plausible range of possible economic activity in the Yukon.

The draft scenarios were considered by a panel of business and institutional leaders at a one day economic retreat hosted by YEC in Whitehorse on September 2015. The session was facilitated by Dr. Mark Jaccard of Simon Fraser University. Feedback received at the session was used to refine the economic scenarios which were then presented to the Technical Advisory Committee for inclusion into the RP. The scenarios were further refined on the basis of RP Technical Advisory Committee feedback and advice from the Yukon Minerals Advisory Board.

Historically, and currently, mining is the largest non-government entity in the Territory. Due to the relatively large electricity demand of a single typical mining customer, this sector is a key uncertainty and risk in the YEC RP. The Yukon economy is small; in 2015, the Gross Domestic Product of Yukon accounted for 0.13% of total Canadian Gross Domestic Product. Any Yukon mine of economic scale would have a significant influence on overall Yukon economic output, therefore, mining is a key factor for consideration in all of the 14 scenarios developed by YEC. This is not to infer that future mines were included in every scenario, but mining was a key consideration in the development in all of the scenarios.

Uncertainty in the YEC demand forecast is not just from direct electricity demand from a mine, but also due to the secondary economic spin-off activity of mining. The potential influence of mining on the demand for electricity would occur even if a mine is not served by YEC from the electricity transmission grid. All mining activity has an impact on overall economic activity in the Yukon, including overall employment, the need for commercial services, and ultimately government services. These secondary linkages then drive future demand for electricity.

Mining project parameters were informed by publically available information including company presentations, technical reports and news releases. Key assumptions incorporated into the scenarios include estimates of development costs, timing and length of the mine development phases (construction, operation and reclamation).

While designing the industrial activity scenarios, assumptions were made in relation to the future of commodity prices. The Very Low Industrial Activity scenario assumes that commodity prices (particularly refined mine products such as gold and copper) would remain at currently low levels, or follow a decreasing trend over the next 20 years. In contrast, the Very High Industrial Scenario assumes commodity prices will rebound from current levels and increase over subsequent years, thus creating a favorable investment environment for the advancement of mining projects. The following four projects were selected to serve as proxies for mining activity of the forecast period: Eagle Gold, Coffee Gold, Wellgreen Platinum, and Casino (gold and molybdenum). Selection of the four projects was based on the current placing of each project with respect to mine permitting, feasibility assessment and the environmental assessment process.

Mining and the public sectors combined dominate the Yukon economy; the influence of Yukon's smaller economic sectors (tourism, agriculture, forestry and fishing) on total territorial economic output is relatively smaller. To explore the effects of changes in economic activity in Yukon's smaller economic sectors on potential electricity demand, sensitivity analyses were carried out by doubling input variable ranges to test the effects.

Federal transfer payments to the Yukon Government have significant influence on the Yukon economy. In the 2014/15 fiscal year, transfers from the Federal Government accounted for 83% of total Yukon Government revenues. As 39% of total Yukon Gross Domestic Product was attributable to the public sector in the 2015 calendar year, changes in growth rates and levels of federal transfers to the Yukon will have material effects on overall economic activity in the Yukon. For this reason, sensitivities were undertaken to determine the economic effects of changes in Federal transfer payments.

Federal transfer payments to the Yukon Government grew steadily and significantly during the 2000 to 2015 period, increasing by an average of 6.5% per annum. In all of the constructed scenarios, Federal transfers are expected to increase until at least 2019, at which the scenarios branch. In some scenarios, such as Low Industrial Activity with tapering government spending, Base Case with tapering government spending, and Low Mining Activity with Minto Mine ending production in 2017 and sensitivity analysis of government spending, transfers are expected to be flat from 2020 to the end of forecast period. It was assumed that government spending was capped on a real per person basis. In the remaining scenarios, the transfer payments, and government spending consequently, are assumed to grow on the average at a real rate of 0.5% per year per capita.

A total of 14 scenarios were modelled and they are described in the following paragraphs.

1. Very Low Industrial Activity

- Production at the Minto Mine ends after 2017.
- No new mines over the forecast period.
- Government spending is assumed to continue to grow beyond 2019.

2. Low Industrial Activity

- Production at the Minto Mine continues to the end of current productive life in 2022.
- One new medium-sized mine is brought into production. The Eagle Gold project is used as the proxy mine. Eagle Gold development begins in 2019 followed by full production from 2021 to 2035 with production tapering off and the mine closing in 2036.
- Government spending is assumed to continue to grow beyond 2019.

3. Base Case (Medium Industrial Activity)

- Production at the Minto Mine continues to the end of current productive life in 2022.
- Two new medium-sized mines are brought into production. The Eagle Gold and Coffee projects are used as proxy mines:
 - o Eagle Gold development begins in 2019 followed by production from 2021 to 2036.
 - o Coffee development begins in 2022 followed by production from 2023 to 2036.
- Government spending is assumed to continue to grow beyond 2019.

4. High Industrial Activity including a new Large Mine

- Production at the Minto Mine continues to the end of current productive life in 2022.
- Three new medium-sized mines are brought into production. The Eagle Gold, Coffee and Wellgreen projects are used as medium proxy sized mines:
 - o Eagle Gold development begins in 2019 followed by production from 2021 to 2036.
 - Coffee development begins in 2022 followed by production from 2023 to 2036.
 - o Wellgreen development begins in 2020 followed by production from 2022 to 2046.
- One new large mine is brought into production. The Casino project is used a large proxy mine. Casino mine development begins in 2018 and mine production begins in 2019, with operations continuing until 2043.
- Government spending is assumed to continue to grow beyond 2019.

5. Low Industrial Activity with tapering government spending

- Production at the Minto Mine continues to the end of current productive life in 2022.
- One new medium-sized mine is brought into production. The Eagle Gold project is used as a proxy mine. Eagle Gold development begins in 2019 followed by production from 2021 to 2036 with production beginning to taper off in 2035.

• Government spending is assumed to continue to grow only until 2019 after which time government spending growth is flat, i.e., government spending levels remain constant from 2020 to end of the forecast period.

6. Base Case with tapering government spending

- Production at the Minto Mine continues to the end of current productive life in 2022.
- Two new medium-sized mines are brought into production. The Eagle Gold and Coffee projects are used as proxy mines.
 - o Eagle Gold development begins in 2019 followed by production from 2021 to 2036 with production beginning to taper off in 2035.
 - o Coffee development begins in 2022 followed by production from 2023 to 2036.
- Government spending is assumed to continue to grow only until 2019 after which time government spending growth is flat, i.e., government spending levels remain constant from 2020 to end of the forecast period.

7. Base Case with sensitivity analysis of smaller economic sectors (agriculture, forestry and fishing)

- Production at the Minto Mine continues to the end of current productive life in 2022.
- Two new medium-sized mines are brought into production. The Eagle Gold and Coffee projects are used as proxy mines:
 - o Eagle Gold development begins in 2019 followed by production from 2021 to 2036.
 - o Coffee development begins in 2022 followed by production from 2023 to 2036.
- Government spending is assumed to continue to grow beyond 2019.
- Yukon's other economic sectors hold potential to influence economic output, though not at the same scale as the mining sector. Sensitivity analysis was undertaken to better understand the combined influence of the agriculture, forestry and fishing sectors on the MEM variables. This sensitivity analysis was executed by running the MEM with input variable ranges doubled compared to the base case to demonstrate the economic impacts.

8. Base Case with sensitivity analysis of natural gas projects

- Production at the Minto Mine continues to the end of current productive life in 2022.
- Two new medium-sized mines are brought into production. The Eagle Gold and Coffee projects are used as proxy mines:
 - o Eagle Gold development begins in 2019 followed by production from 2021 to 2036.
 - Coffee development begins in 2022 followed by production from 2023 to 2036.
- Government spending is assumed to continue to grow beyond 2019.
- Yukon's oil and gas sector holds potential to make a significant contribution to economic output. To understand the potential influence of this sector on the MEM variables, a sensitivity analysis was undertaken on one medium-sized natural gas project. Based on the limited data on gas projects available, a project with production estimated to last 15 years at a gas extraction

rate of 100 Mmcf/day was considered. The project related data were sourced from a feasibility study prepared by the Mines and Resources Oil & Gas Branch of the Yukon Government.

9. Base Case with later start of production for new Large Mine

- Production at the Minto Mine continues to the end of current productive life in 2022.
- Two new medium-sized mines are brought into production. The Eagle Gold and Coffee projects are used as proxy mines:
 - o Eagle Gold development begins in 2019 followed by production from 2021 to 2036.
 - o Coffee development begins in 2022 followed by production from 2023 to 2036.
- One new large mine is brought into production, two years later than in Scenario 4. The Casino project is used a proxy large mine. Casino mine development begins in 2020 and mine production begins in 2021, continuing until 2045.
- Government spending is assumed to continue to grow beyond 2019.

10. Base Case with induced mining "bust and boom cycle"

- Production at the Minto Mine continues to the end of current productive life in 2022.
- Two new medium-sized mines are brought into production. The Eagle Gold and Coffee projects are used as proxy mines. To illustrate to effects of a potential boom and bust cycle, the start of both projects is delayed to represent a bust period in the near term and both projects begin production at the same time to represent a boom period:
 - o Eagle Gold development begins in 2028 followed by production from 2030 to 2041.
 - o Coffee development begins in 2029 followed by production from 2030 to 2041.
- Government spending is assumed to continue to grow beyond 2019.

11. Base Case with advanced mine production timing

- Production at the Minto Mine continues to the end of current productive life in 2022.
- Two new medium-sized mines are brought into production. The Eagle Gold and Coffee projects are used as proxy mines. The base case scenario is modified by bringing the two proxy mines into production two years earlier:
 - o Eagle Gold development begins in 2017 followed by production from 2019 to 2034.
 - o Coffee development begins in 2020 followed by production from 2021 to 2034.
- Government spending is assumed to continue to grow beyond 2019.

12. Low Mining Activity with Minto Mine ending production in 2017

- Production at the Minto Mine ends after 2017.
- One new medium-sized mine is brought into production. The Eagle Gold project is used as a proxy mine. Eagle Gold development begins in 2019 followed by production from 2021 to 2036.
- Government spending is assumed to continue to grow beyond 2019.

13. Low Mining Activity with Minto Mine ending production in 2017 and sensitivity analysis of government spending

- Production at the Minto Mine ends after 2017.
- One new medium-sized mine is brought into production. The Eagle Gold project is used as a proxy mine with development starting in 2019, followed by production from 2021 to 2036.
- Government spending is assumed to continue to grow to 2019 after which time growth in government spending is frozen.

14. Base Case with sensitivity analysis of tourism

- Production at the Minto Mine continues to the end of current productive life in 2022.
- Two new medium-sized mines are brought into production. The Eagle Gold and Coffee projects are used as proxy mines:
 - o Eagle Gold development begins in 2019 followed by production from 2021 to 2036.
 - o Coffee development begins in 2022 followed by production from 2023 to 2036.
- Government spending is assumed to continue to grow beyond 2019.
- Yukon's smaller economic sectors hold potential to influence economic output, although not at the same scale as the mining sector. To understand the influence of these sectors on the model output, a sensitivity analysis was undertaken across the industries which comprise the tourism sector including retail trade, accommodation, food services and transportation. The rate of tourism growth was doubled compared to the base case.

Yukon Microeconomic Model Results

The C4SE model generates outputs for an extensive list of economic variables. Output ranges and average values for the key economic variables with relevance to electricity consumption and therefore, future electricity demand, are presented in Table 2 below. To illustrate the range of key economic variables which inform the demand forecast, minimum, maximum and base values drawn from all 14 scenarios are presented for two future dates. Note that demographic parameters are much less variable than the economic parameters. The latter are heavily impacted by mining assumptions.

Table 2: Yukon Macroeconomic Model Outputs - Including Scenario Results

	Current (2015)	Year 2025	Year 2035
Population Base Case (000's)	37.4	41.2	41.1
Highest Scenario		43.1	42.6
Lowest Scenario		40.0	38.5
Households Base Case (000's)	17.7	17.7	17.8
Highest Scenario		18.4	18.4
Lowest Scenario		17.2	16.8
Employment Base Case (000's)	19.7	21.0	20.6
Highest Scenario		21.9	21.6
Lowest Scenario		20.4	19.0
Real Dollar Disposable Income Base Case (\$M)	1,351	1,638	1,802
Highest Scenario		1,781	1,912
Lowest Scenario		1,548	1,611
Real Dollar Gross Domestic Product Base Case (\$M)	2,226	2,682	2,789
Highest Scenario		4,238	4,459
Lowest Scenario		2,407	2,480

Descriptive charts for key economic variables which inform the electricity demand forecast are presented in the following sections. To avoid potential confusion that can be caused by 14 sometimes overlapping lines presenting 14 scenarios, the charts show 5 major scenarios (Very Low Industrial Activity, Low Industrial Activity, with Early Minto Closure, Medium Industrial Activity, and Very High Industrial Activity) and the range of the remaining scenarios as a shaded area. The 5 major scenarios are selected due to their higher probability of realization compared to that of the rest of the scenarios.

Forecast Yukon Gross Domestic Product

Figure 1 illustrates forecast of Yukon Gross Domestic Product (Real dollars) over the forecast period for the economic scenarios. Growth in real GDP fall within a relatively narrow band except for the High Mining Activity including a new Large Mine scenario (scenario 4) and the Base Case with later start of production for new Large Mine scenario (scenario 9).

Figure 1: GDP including Mining Forecast

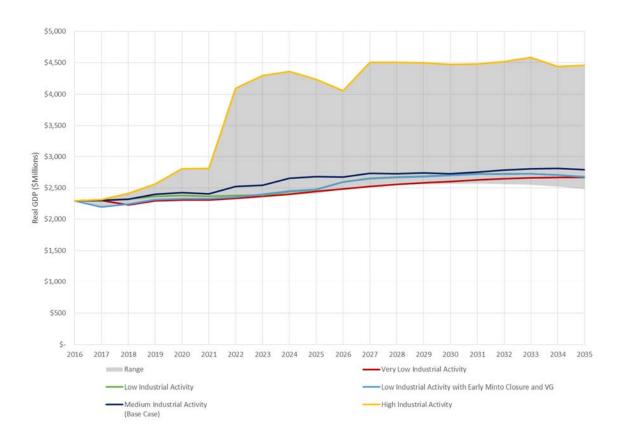
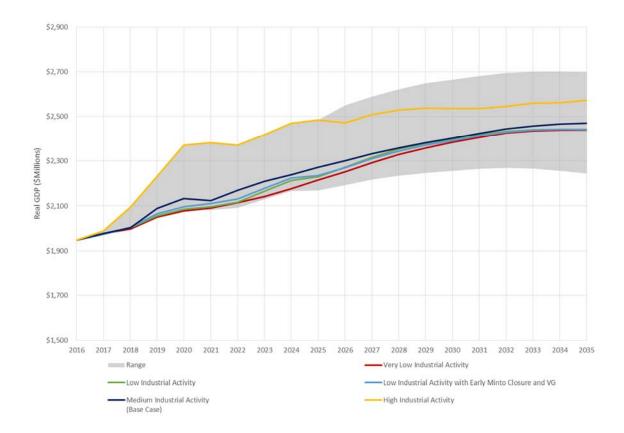


Figure 2 below illustrates a forecast of Yukon Gross Domestic Product (Real dollars) over the forecast period for the economic scenarios without the contribution of the mining industry. Growth in real GDP generally fall within a relatively narrow band except for the High Mining Activity including a new Large Mine scenario (scenario 4) and the Base Case with sensitivity on natural gas development (scenario 8).

Figure 2: GDP excluding Mining Forecast



Forecast Yukon Population

Figure 3 below illustrates forecast of Yukon population over the forecast period for the economic scenarios. As Figure 3 shows, the population changes fall into a relatively narrow for all the scenarios. The direct connection between population growth and economic activity that is implicit in the YEC MEM by the slight decline in Yukon's population for the period after 2030. The MEM forecasts indicate an accelerating decline in the natural population growth rate, from 0.6% per annum currently to zero growth by 2030. After 2030, the difference between the number of deaths and births per year is expected to widen each year. The decline in the natural population growth rate will be compounded by an increasingly aging population. Whereas the 65+ age cohort represented only 11% of the total population in the Territory in 2015, by 2035 the 65+ age cohort is predicted to account for 23% of the population. This will translate into fewer people of working age. Further impacting Territory employment, the assumption is made that mineral production activities in the Yukon will become more automated, as a competitive measure. This will result in less operational employment opportunities in Yukon mines.

The small population of Yukon makes it a challenge to forecast long-term population. Nevertheless, changes in the Yukon population over the next 20 years will have a significant influence on YEC electricity demand, as residential and commercial sector electricity requirements tends to follow trends in population and housing starts.

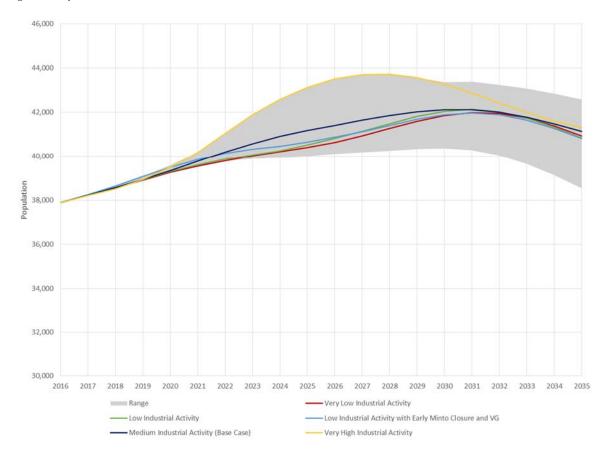


Figure 3. Population Forecast

The simplest approach to forecast the future is by extrapolation; this could include population projections. This approach implies that the past is the primary determinant of the future, and that recent trends will persist. Given inescapable demographic facts (i.e. the aging of the baby boomer generation), this approach will miss likely strategic outcomes, such as naturally declining employment levels or the need to import workers in the event of a domestic construction boom.

Forecasts of future population levels based on demographic trends (such as fertility and migration rates) are the basis of the C4SE and the Conference Board of Canada's population forecasts. As the fertility rate in Canada has been declining steadily for many years, and is expected to decline further, the forecast population growth in the Yukon is largely driven by assumptions regarding net in-migration. In contrast to the C4SE approach to long-term population forecasting, the Next Generation Hydro or previous forecasts done for YEC resource plans, were not directly informed by forecasts of economic activity. A comparison of recently developed population forecasts is illustrated in Figure 4.

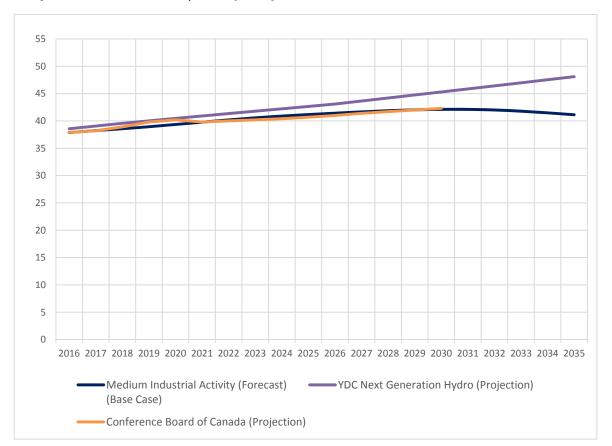
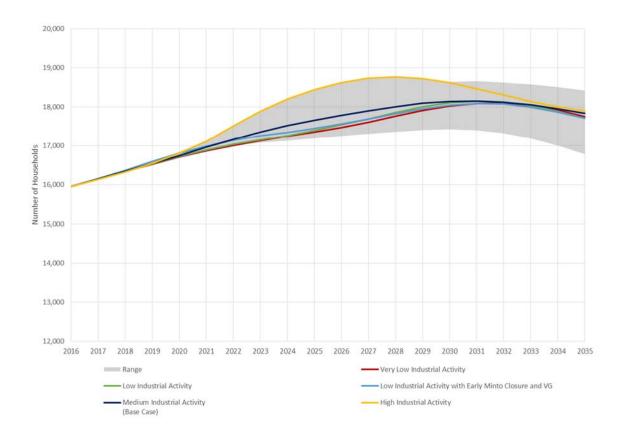


Figure 4. Projected and Forecast Yukon Population (in '000)

Forecast Number of Yukon Households

Figure 5 illustrates number of Yukon households forecast over the forecast period for the economic scenarios. As shown in Figure 5, growth in the number of households is forecast to be relatively steady over the forecast period. Consistent with the population forecast, the number of Yukon household peaks in the late 2020's before a gradual decline.

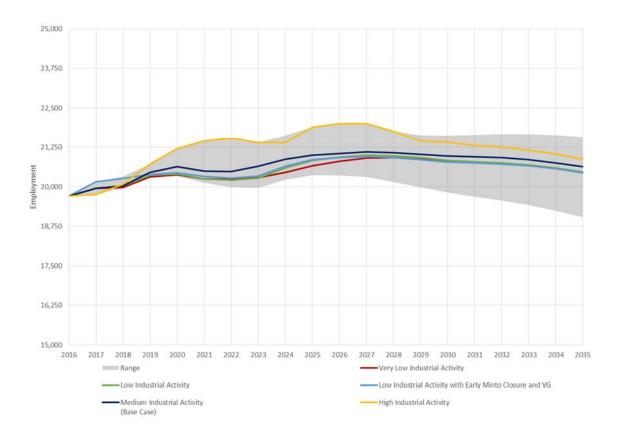
Figure 5. Number of Household Forecast



Forecast Yukon Employment

Figure 6 illustrates the forecast of total Yukon employment over the forecast period for the economic scenarios. The employment forecast is used to estimate commercial electricity demand over the forecast period, with the level of total employment directly related to electrical sales. As the level of total employment increases, electrical sales will also increase. Overall, total Yukon employment is forecast to grow until 2030 before beginning to decline slightly, a pattern consistent with the forecasts for population and the number of households as generated by the MEM.

Figure 6. Employment Forecast



Forecast Yukon Per Capita Disposable Income

Figure 7 illustrates the forecast of total Yukon employment over the forecast period for the economic scenarios. Yukon per capita disposable income (Real dollars) is used to forecast electrical sales to residential customers and is directly related to sales. As disposable income increases, residential electrical demand will correspondingly increase. As shown in Figure 7, the MEM results indicate a relatively narrow range of variations in per capita disposable income over the forecast period. In contrast to the forecasts for population, number of households and employment, per capita disposable income is expected to steadily increase under all scenarios through to the end of the forecast period in 2035.

Figure 7. Real Per Capita Disposable Income Forecast

