Annual Planning Outlook

Demand Forecast Methodology

December 2021

ieso

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1. Introduction

The IESO produces annual planning outlooks (APOs) for the province. The demand for electricity establishes the context for resource adequacy and transmission security assessments as it determines the amount of electricity that must be served.

2. Role of the Demand Forecast within the Bulk System Planning Process and the Annual Planning Outlook

The demand for electricity establishes the context for integrated planning as it determines the amount of electricity that must be served. The IESO updates the demand forecast to provide context for updated integrated plans, conservation program planning and supply procurement decisions. The demand for electricity establishes the context for integrated planning as it determines the amount of electricity that must be served. Electricity requirements are affected by many factors, including choice of energy form, technology, equipment purchasing decisions, behaviour, demographics, population, the economy, energy prices, transportation policy and conservation. The IESO monitors and interprets these and other factors on an ongoing basis to develop outlooks against which integrated planning can take place. The first step in the development of the APO is to determine a long-term demand forecast.

Figure 1: How the Demand Forecast Fits into Bulk System Planning Process
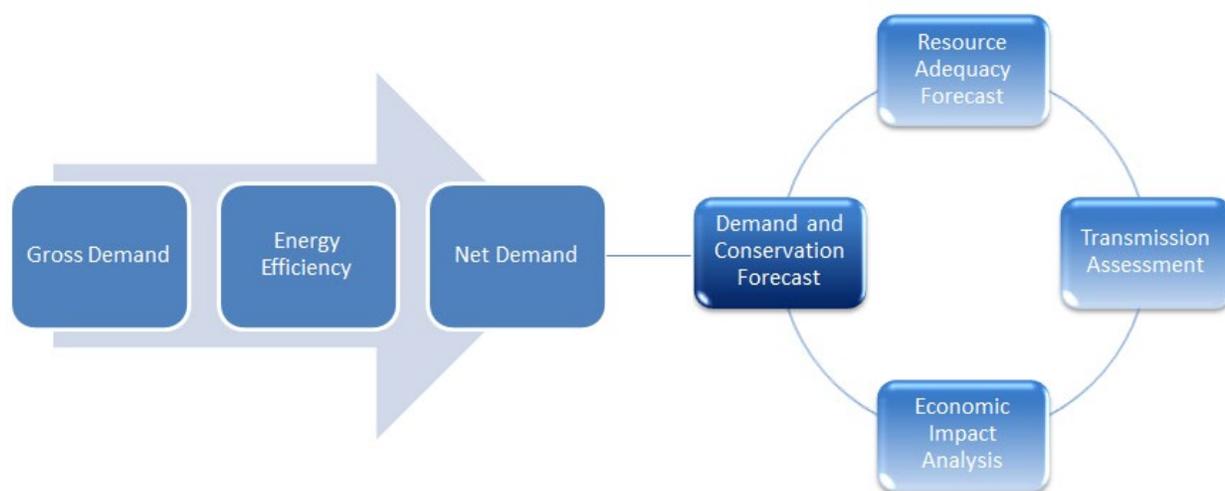
3. Demand Forecasting Process

Overview: the process used to develop the demand forecast is illustrated in Figure 2 below.

Figure 2: Demand Forecasting Process
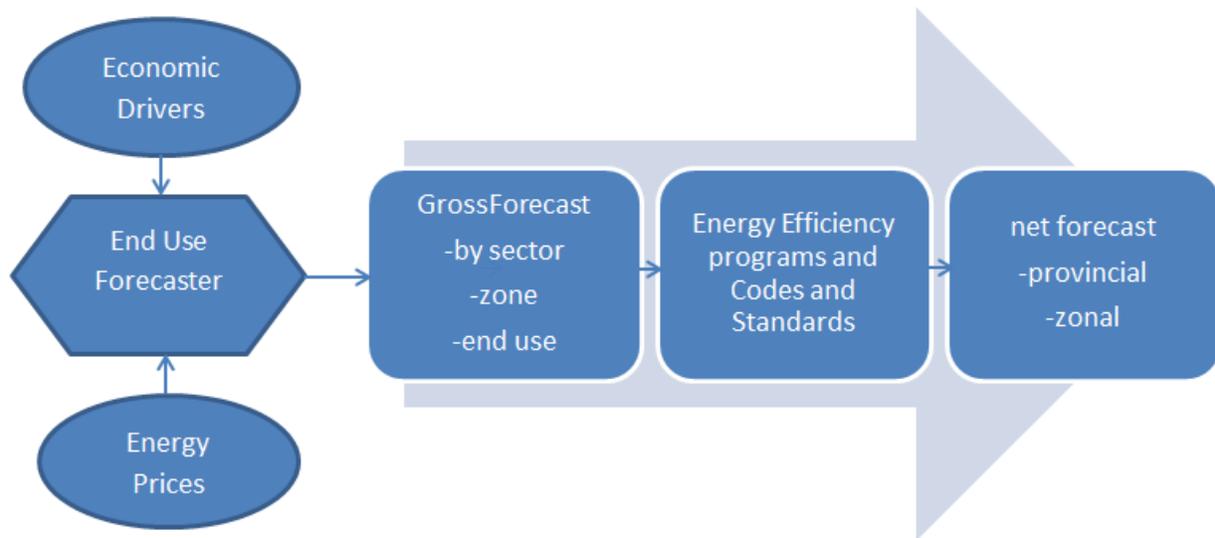
1. **Annual Gross Energy Demand Forecast**: the production of the IESO's planning forecast begins with the estimation of energy demand at the annual, zonal, sectoral, segment, end-use, efficiency, gross and end-user levels. Demographic and economic drivers are considered in the development of the annual gross energy demand forecast, including changes in household counts and building types, commercial floor space, industrial output and energy prices. Energy demand estimates are computed with the IESO's *End-Use Forecaster model* (EUF).. The IESO applies transmission and distribution line losses to convert these energy values from the end-user level to the generator level.

2. **Hourly Gross Energy Demand Forecast**: once completed, zonal, sectoral, segment, end-use, efficiency, gross and generator level energy demands are transformed from annual values to hourly values through the application of end-use level hourly load shape profile and then aggregated to the zonal hourly gross level energy demand forecast.

3. Hourly Net Energy Demand Forecast:

Conservation Programs and Regulations: the zonal hourly gross level energy demand forecast is then corrected for projected policy-induced conservation savings (i.e., savings from energy-efficiency incentive programs, appliance and products standards, and commercial building codes). The outcome of this derivation is the zonal hourly net level energy demand forecast.

Net Demand Forecast: once completed, the zonal hourly net demand forecast establishes the amount of electricity that is to be served and forms the starting point for resource adequacy, reliability and transmission security assessments and integrated planning analysis.

3.1 Annual Gross Energy Demand Forecast

3.1.1 End-Use Forecasting Model

The IESO's demand forecast is developed on an end-use level basis. An end-use forecasting approach was chosen for a number of reasons, including the need to:

1. Capture structural changes in the economy, including the growth and decline of specific zones, home types, businesses or industries and change in the relative strength of sectors;

2. Address the impact on demand of the penetration of new electricity using technologies;

3. Ensure linkages between conservation savings estimates and underlying assumptions of the demand forecast;

4. Specifically address the impact on peak demand of the growth of different end-uses;

5. Allow updates to the codes and standards.

The EUF is built at the IESO's transmission system electrical zonal level with all ten zones aggregating up to the Ontario provincial system total. The EUF is an end-use model that tracks equipment and building stocks over time and simulates technology acquisition in the economy. The residential, commercial/institutional and industrial sectors are each analyzed separately and independently.

A schematic of the EUF is shown in Figure 3.

Figure 3: EUF Modules and Structure
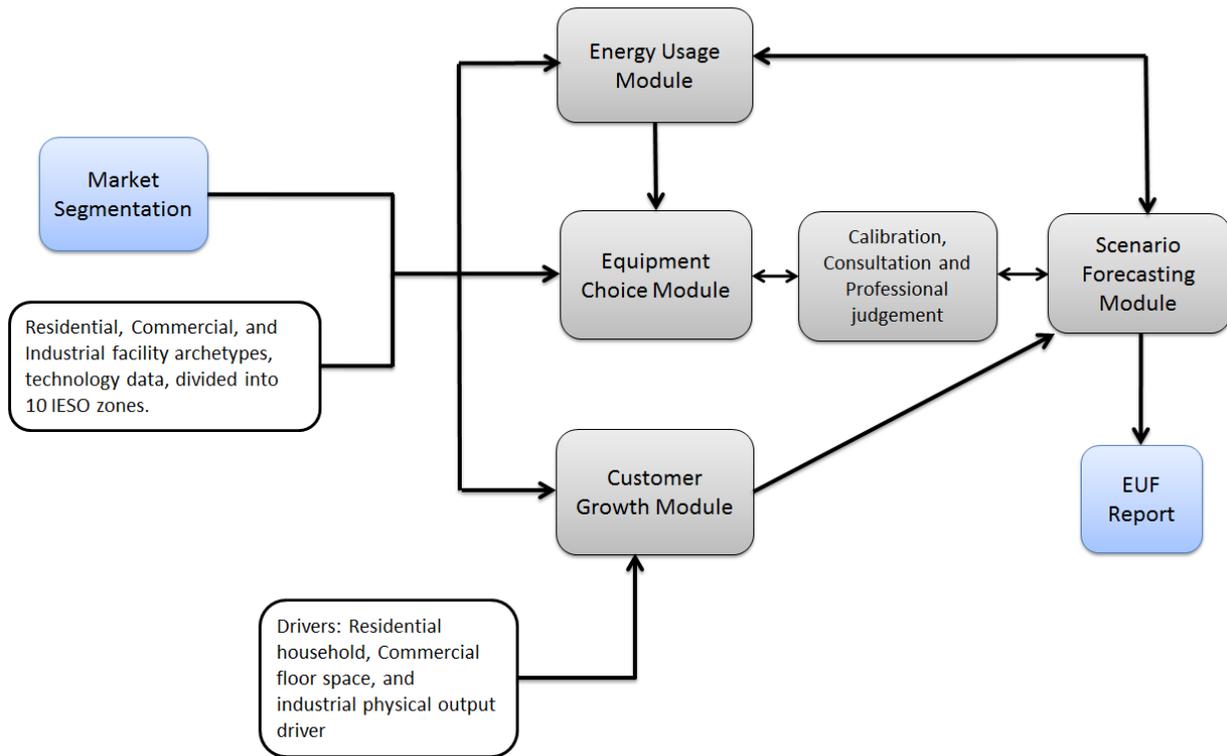
3.1.2 EUF Modules

Several primary modules form the heart of the EUF analytical framework. Figure 3 also depicts the relationships between these modules.

1. Market Segmentation Module
2. Energy Usage Module
3. Equipment Choice Module
4. Customer Growth Module
5. Scenario Forecasting Module

3.1.2.1 EUF Market Segmentation Module

The *EUF Market Segmentation Module* governs the development of customized market segmentation designs and the population of the model with the necessary data. A third-party consultant supplied the majority of the data characterizing the end-uses as they apply to Ontario and its zones. The data includes: building characteristics, equipment saturations, fuel shares, end-use equipment efficiency shares, replacement technology relative efficiencies and capital costs. The IESO has been in the process of updating the end-use information whenever updates become available. The market segmentation of the model, shown in Figure 4, contains sectors, zones, building types, end-uses, fuel types and efficiency levels.

Figure 4: EUF Market Segmentation Data Category
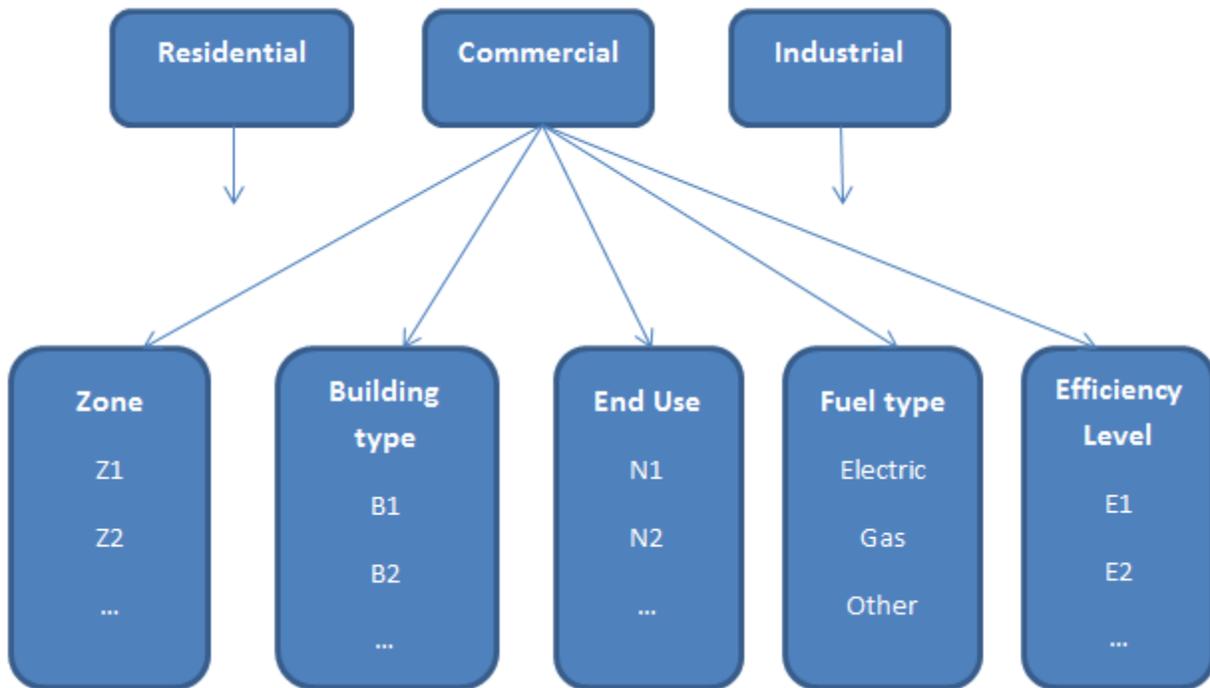
3.1.2.2 EUF Energy Usage Module

The *EUF Energy Usage Module* tracks equipment utilization given the stock of equipment, building characteristics, and customer behaviour at any moment in time over the forecast horizon. For example, single-family homes may have a discrete set of central air conditioner efficiency choices, with each efficiency level having an associated electric consumption for each year. That consumption can vary in the short run as customers modify behaviour that results in changes to equipment utilization without changing the equipment itself. Factors that can affect consumption in the short run include weather, non-weather seasonal factors, building and customer characteristics, energy prices, disposable income, and other user-specified attributes. These relationships are specified in the EUF *Energy Usage Module* by combining:

1. a forecast of consumption factors or drivers (independent or exogenous variables); with

2. a set of coefficients associated with each exogenous variable.

3.1.2.3 EUF Customer Growth Module

The *EUF Customer Growth Module* tracks the number of customers (facilities) within each vintage, geographic zone, and dwelling type or sub-sector from the market characterization. Customer growth varies over time through a range of factors, including forecasts of population (typically applicable to the residential sector) and square footage of different building types (typically applicable to the commercial sector). As with the *EUF Energy Usage Module*, these relationships are specified in the *EUF Customer Growth Module* by combining:

1. a forecast of customer growth factors or drivers (i.e., independent or exogenous variables); with

2. a set of coefficients associated with each exogenous variable.

The main drivers used in *EUF Customer Growth Module*, including residential households, commercial floor space and industrial physical drivers/activities, are provided by either third-party consultants or IESO internal analyses.

3.1.2.4 EUF Equipment Choice Module

Equipment stock changes in the EUF occur in response to new driver growth, as well as to end-of-life retirement and replacement of equipment. Increasing saturation and utilization is also considered (e.g., increasing or decreasing the number of computers per household). Equipment acquisition choices are governed by choice equations that consider energy operating costs, as well as capital costs. Different technologies are represented by five efficiency choice levels for each end-use. Discount rates by sector vary from 25 to 50 per cent. Recognizing that price and cost savings are not the only factors that determine consumer action, the choice equation is, therefore, a weighting of financial and non-financial factors.

The *EUF Equipment Choice Module* analyzes customer choice decisions among competitors and product options. For example, customers choose their end-use equipment based on fuel types and efficiency levels. Purchase decisions are represented by a nested structure of provider (fuel choices) and product (efficiency choices) choices. This is illustrated in Figure 5.

Choice equations are calibrated against base year new stock acquisition decisions across technology levels. For end-uses with a fuel choice (e.g., domestic water heating), purchase decisions are represented by nested fuel and efficiency choices.

Short-term behavioural response to price that reflects changes in equipment utilization without changing the equipment itself is captured through the use of behavioural price elasticity. The range of the elasticity is from -0.25 to -0.1 and captures behaviours, such as adjusting thermostat settings for lower HVAC utilization and turning off lights and computer monitors when not required.

The hierarchy of *EUF Equipment Choice Module* is shown in Figure 5.

Figure 5: EUF Customer Choice Module Hierarchy
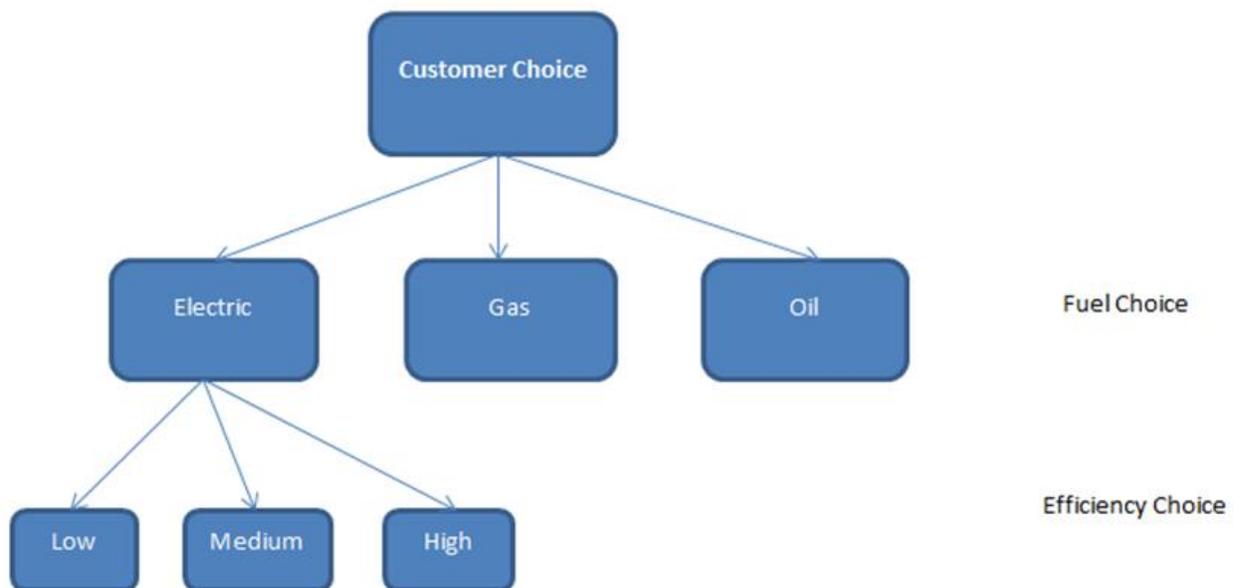
3.1.2.5 Scenario Forecasting Module

The *EUF Scenario Forecasting Module* combines the outputs from the EUF Energy Usage Module, EUF Equipment Choice Module and EUF Customer Growth Module. The EUF Scenario Forecasting Module then performs additional calculations regarding the turnover of equipment at the end of its useful life to produce forecasts for energy demand.

3.1.3 Calibration, Consultation and Professional Judgement

For calibration, the IESO's zonal residential energy forecasts are compared with the annual local distribution company (LDC) yearbook published by the Ontario Energy Board (OEB), which summarizes actual energy demand by rate class. The IESO's industrial forecast is also compared with IESO transmission-connected customer electricity demand trends and market intelligence based on research and consultation with IESO power system planners, industrial conservation program account managers and others.

Energy consumption trends from Natural Resource Canada's (NRCan) Office of Energy Efficiency are also used as check points with respect to provincial end-use energy and sector and sub-sector consumption trends. Information from NRCan's Survey of Household Energy Use and sales data from the Canada Appliance Manufacturers Association are used to check the IESO's equipment forecasts.

Other sources are used to check the energy demand forecast results, including but not limited to: The American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE); the Residential Energy Consumption Survey (RECS) and Commercial Building Energy Consumption Surveys (CBECS) conducted by the U.S. Energy Information Administration; and the Residential Energy Use Survey conducted by the IESO Energy Efficiency division.

The IESO undertook extensive testing and calibration during model development and implementation, work that continues today.[1]

3.2 Hourly Gross Energy Demand Forecast

In the "Bottom Up" method, individual sectoral, and segmental end-use level hourly load profiles are multiplied by the corresponding annual gross energy demand forecast determined in the process described in the previous section then aggregated to create residential, commercial and industrial sector level zonal hourly gross energy demand forecasts which are in turn aggregated to form the total Ontario provincial system level zonal hourly gross energy demand forecast. The advantage of this approach is that it provides detailed results that can assist with activities such as conservation planning and sensitivity analysis. The IESO has compared the result from the "Bottom Up" method to the available system level zonal hourly demand including weather-corrected 2019 demand data to ensure that it represents a reasonable depiction of the Ontario demand profile under normal conditions.

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[1] Over time the data that supports the demand forecast needs to be updated. Some of this data is updated by internal systems as they become available, while other inputs are procured through third-party resources and primary research. As technology and consumer behaviour evolves, end-use and other profiles require a refresh.

In the "Delta" method, the Ontario provincial system zonal hourly demand profile for a given base year is taken and used as a basis for the future energy demand forecast for the entire outlook period. The change in electricity use associated with a particular end-use over time is mapped to the corresponding end-use load shape, which is then after aggregation is added to or subtracted from the overall Ontario system profile.

If more electricity is to be used by an end-use over time, this constitutes an increment to the system profile. If less electricity is to be used by an end-use over time, this constitutes a decrement to the system profile.

Using a measured system demand profile as a base and adding only increments and decrements produces better alignment between the modeled and actual system profiles.

3.3 Hourly Net Energy Demand Forecast

In this process, conservation is deducted from the hourly gross energy demand forecast and results in the hourly net energy demand forecast.

3.3.1 Conservation

Conservation is the cleanest and most cost-effective resource for helping to meet Ontario's electricity needs. Ontario benefits from approximately 21 TWh of annual energy savings from conservation measures implemented from 2006 to 2020. These savings can be attributed to energy-efficiency programs and improved building codes and equipment standards regulations. Conservation has made a significant contribution to electricity service in Ontario and have been an integral part of reliable and sustainable electricity system in the province. New savings are forecasted separately by conservation programs and regulations.

3.3.1.1 Conservation Programs

In addition to persisted savings from previous conservation initiatives, new conservation programs are rolled out, planned, and anticipated. The planned and forecasted savings are included to derive the net demand forecast. On September 30, 2020, the Minister of Energy, Northern Development and Mines directed the IESO to implement a 2021-2024 Conservation and Demand Management Framework, starting in January 2021. The framework is centrally delivered by the IESO under the Save on Energy brand and includes incentive programs targeted to those who need them most, including opportunities for commercial, industrial, institutional, on-reserve First Nations, and income-eligible electricity consumers. The forecasted annual savings are 3 TWh in 2026 with a total budget close to $700 million.

Due to the pandemic and current market conditions, programs from previous frameworks have been extended. It is expected that about 0.6 TWh savings from Conservation Frist Framework Wind Down and the Interim Framework will be materialized in 2021 and 2022.

Besides the IESO administered programs, a few federally and municipally funded programs are in the market and expect to achieve electricity savings in Ontario. The Climate Action Incentive Fund is expected to result in over 1.1 TWh electricity savings in Ontario by 2024. Projects supported through the Green Municipal Fund, which is managed by the Federation of Canadian Municipalities, are forecasted to achieve electricity savings of about 0.01 TWh each year in Ontario. The Greener Homes Grants rolled out in 2021 having a budget of $2.6 billion over 7 years. The program target to provide 700,000 grants in Canada to help home owners do energy efficiency and emission reduction retrofits. The resulted electricity savings in Ontario is estimated as 0.3 TWh each year. These programs target the entire country and are not administered by the IESO. The savings are estimated with higher uncertainty as not all program details are currently available.

Beyond the energy conservation programs already in the market, it is anticipated that conservation efforts will continue from 2025 to 2042. New savings will materialize as a result of continued delivery of energy-efficiency initiatives. For planning purposes, incremental annual energy savings is assumed to be consistent with proportions of gross demand consistent with current levels, which is informed by the planned savings level of the 2021-2024 Framework Program Plan. The long term programs are expected to save 8.7 TWh in by 2042. This will be updated when a future policy decision is made.

Besides the aforementioned conservation program savings, there are potential to achieve incremental conservation energy savings as identified and quantified in the IESO and Ontario Energy Board Electricity and Natural Gas Conservation Achievable Potential Study completed in 2019.

3.3.1.2 Conservation Regulations

3.3.1.2.1 Ontario Building Codes

Building code regulations (hereinafter referred to "codes") set minimum energy-efficiency requirements for new and substantially renovated buildings.

New commercial buildings or buildings undergoing major renovations are subject to provincial and federal codes. The energy-efficiency requirements in codes are often defined as a reduction factor (e.g., 25% more efficient than a design conforming to Model National Energy Code for Buildings (MNECB)). Given the broad range of design and technology choices that can meet these requirements, the IESO codes analysis also uses reduction factors.

The codes analysis deals with Cooling, Lighting, and Ventilation end-uses. Collectively, they represent about 60 per cent of the gross energy consumed by the commercial sector in the EUF. Each end-use has an energy use intensity (EUI) measured in energy per unit floor space (kWh/ft^2) in the base year, which is used as its baseline performance. Estimated reduction factors set the minimum codes-compliant EUI relative to this baseline.

Floor space turnover: Each end-use has a retirement rate, defined as 1/EUL (effective useful life). For example, commercial chillers have an estimated lifespan of 40 years, so the annual retirement rate is 2.5 per cent. The demand forecast for each end-use is re-modeled by breaking the annual floor space value into annual values for:

1. Existing floor space;

2. New floor space; and

3. Renovated floor space.

Existing floor space decreases at the retirement rate. Renovated floor space for a given year is equal to the total floor space that was retired in the previous year. New floor space is estimated as the annual increase in total floor space. For each year, renovated floor space is subject to EUI reduction associated with federal building standards and new floor space is assigned an EUI based on the Ontario Building Code.

Reduction Factors: The reduction factors below were developed from estimates of the effect of existing codes on electricity-consuming end-uses. Planned future improvements to codes reflect a long-term trajectory of conservation policy with incremental improvements.

Figure 6: Ontario Building Codes Regulation

New

#	Regulation	Effective Date	Reduction from Baseline
1	2006 C-OBC Improvements	2006	24 %
2	2012 C-OBC Improvements	2012	30 %
3	2015 C-OBC Improvements (planned)	2015	35 %
4	2020 C-OBC Improvements (planned)	2020	38 %

Renovation

#	Regulation	Effective Date	Reduction from Baseline
1	ASHRAE 90.1-1999/MNECB	2000	19 %
2	MEPS - Federal Standards	2012	22 %
3	MEPS - Federal Standards (planned)	2015	24 %
4	MEPS - Federal Standards (planned)	2020	25 %

3.3.1.2.2 Equipment Standards

Equipment standard regulations (hereinafter referred to "standards") mandate the minimum energy performance standards (MEPS) required of select new equipment.

A third-party consultant was engaged by the IESO in 2015 to undertake an assessment of the electricity savings resulting from changes to energy-efficiency product performance standards for residential and select commercial equipment. The savings attributed to product standards were calculated relative to a reference case of energy consumption of each product. The reference case represents the baseline against which all future savings are compared. The third-party consultant developed a conservation savings forecasting model that includes the methodology used for the United States of America's Department of Energy rulemakings and customized the model to calculate the expected electricity savings achieved from standards for each product. The IESO estimates savings attributed to codes and standards by comparing the gross demand forecast to the forecast adjusted for the impacts of regulations.

The analysis incorporates new or updated standards that have a compliance date between January 1, 2013 and January 1, 2019 and also considered potential future standards beyond 2019 for each product. The IESO has reviewed each standard to ensure it is up to date.[2]

3.3.2 Industrial Conservation Initiative

The Industrial Conservation Initiative (ICI) is a function of Ontario Regulation 429/04 that allows for participants to determine their Global Adjustment rate for a given Adjustment period based on their Peak Demand Factor which is determined based on a customer's percentage contribution to the top 5 system peak day, system peak hour, in the preceding Base Period. ICI participants reducing their energy demand during these periods enables them to reduce their Global Adjustment rates.

The actual system peak days in the Base Period are determined retroactively, and it is observed that due to this uncertainty, ICI participants typically respond to system demand conditions in greater than the 5 top system peak days, to mitigate the risk of not responding in the resulting top 5 system peak days in the Base period. The forecasted hourly levels of ICI response included in the demand forecast are based on observed actual ICI participant response on system demand in the latest Base Period and have been stratified in to 2 strata: 1) the top 5 system peak days; and 2) the second top 5 system peak days. The level and profile of the ICI response is held constant for the outlook period, unless otherwise specified. The effect of the ICI impact forecast is applied to the observed top 5 and second top 5 system peak days of each year of the hourly net energy demand forecast.

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[2] Differences in the baseline demand forecast between the IESO and the third-party consultant have been addressed:

1. **Difference between natural efficiency assumptions**: The third-party consultant assumed little to no natural efficiency. Based on the assumption that people naturally choose more efficient products, the IESO's gross energy demand forecast includes the effects of naturally occurring conservation, but not the effects of new conservation interventions.
2. **Difference in method to analyze each end-use**: While the third-party consultant estimated the end-use energy consumption by product class, the IESO uses a maximum of five technology energy efficiency levels to represent overall end-use energy consumption.
3. **Difference in total forecasted consumptions**: The third party consultant forecasted energy consumption for end-uses of interest; the IESO forecasts energy consumption for the entire sector/province.

Ontario Regulation 509 was used as the reference when standards savings analysis was in development.

3.4 Embedded Generation

New in the 2021 APO is the included publication of a grid level energy demand forecast that incorporates the net level energy demand forecast as in past APOs and an *embedded generation* output forecast for the outlook period (2023-2042) in addition to the base year (2022). Embedded generation is defined as an electricity generating resource that does not participate in the IESO administered wholesale market, injects into the distribution system rather than offsetting load and is generally grouped by fuel type: solar, wind, hydroelectric, biomass and natural gas. Embedded generation is considered in developing the *net level demand base year* described in section 3.5.2 as well as producing the hourly grid energy demand forecast described in section 3.6.

As *embedded generators* are resources that are not market participants, it is challenging to obtain accurate data on: 1) actual resources; and 2) hourly data on actual energy production; where such resources are not contracted with the IESO. The *embedded generation* output forecast relies on the most credible data available, that is monthly energy by fuel type reported by LDCs through IESO's settlements.

Two of these fuel types are of particular interest to forecasting demand: solar and wind. The reason is twofold. First, these two fuel types are the most common type of embedded generation and account for over 2,000 MW of installed capacity. Secondly, the output from these two fuel types is correlated to weather in a manner similar to demand. For the solar and wind *embedded generation* output forecast and the normal weather base year forecast described in section 3.5.1, the same weather simulation models were run for both forecasts resulting in a consistent weather approach. For the remaining embedded generation fuel types, hourly output is calculated using hourly profile assumptions. The hourly profile is developed for the remaining fuel types by using available information from various sources, including: local distribution company data, IESO contracts information (capacity), and IESO settlements data (monthly energy).

The embedded generation output forecast is based on consistent hourly profiles for the fuel type and for each year, adjusted for expected changes in available capacity, operating conditions, and continued availability of existing resources, that is existing *embedded generation* resources continue to operate through the end of the outlook period, even in instances where a resources' operation contract with the IESO expire.

3.5 Delta Process

Two different methods are used to produce the final, calibrated, total Ontario provincial system zonal hourly net energy demand forecast for the outlook period. The first, the "Bottom Up" aggregation method has been described in the preceding sections 3.1 – 3.3. The second, the "Delta" method, uses a base year of demand data on which each subsequent year in the Bottom-Up demand forecast is applied, or added to. The base year forms the foundation of the forecast as it is used as the starting point within the succeeding demand forecasting tools.

Schematics of the Delta method is shown in Figure 7.

Figure 7: Converting Annual Energy to Hourly Peak
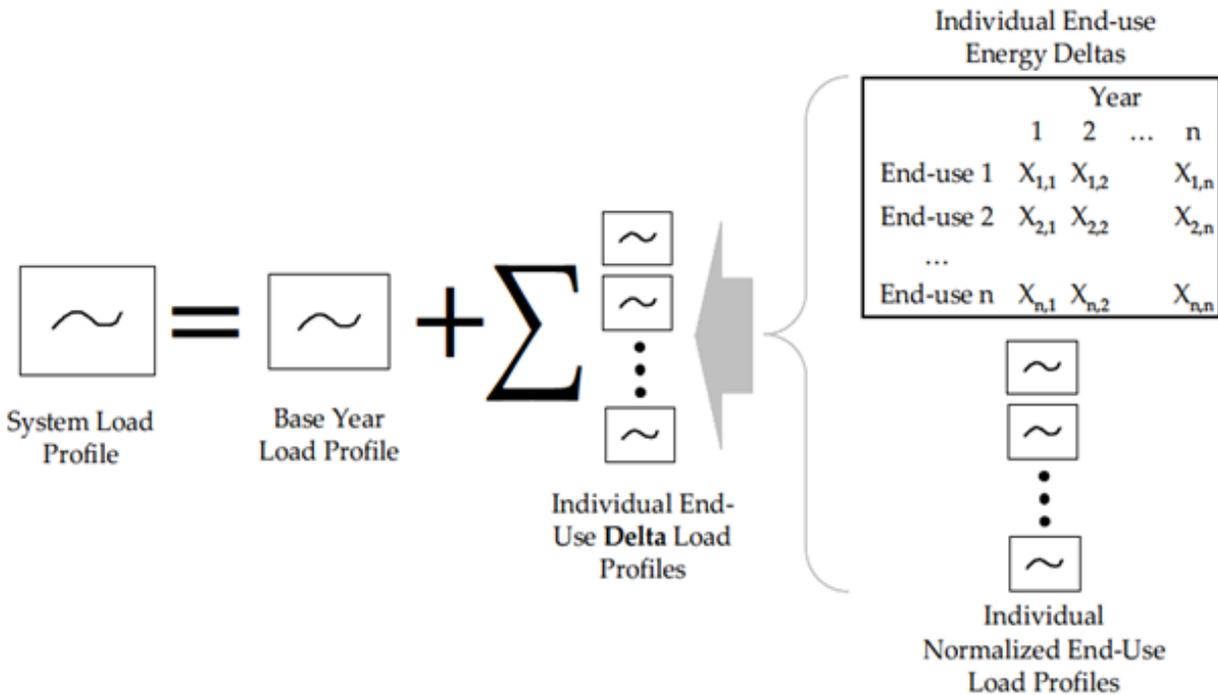
3.5.1 Grid Level Demand Base Year

In the 2021 APO energy demand forecast, a forecasted year 2022 zonal hourly grid demand forecast under normal weather conditions was generated for the *Delta Method* base year using simulations of energy demand incorporating weather sensitive demand and historical actual weather data developed via a linear regression model.

The base year was generated to present normal weather monthly peak demand and total energy demand. In this case, normal represents the concept that the monthly peak and total energy demand values have a 50/50, or equal chance of being higher or lower due to weather variability with all other inputs being constant. The base year output of the demand simulation weather model was produced at the grid level of demand.

3.5.1.1 Demand Simulation Weather Model Methodology for the Base Year

The *demand simulation weather model methodology* is utilized to generate the desirable properties of the base year which include capturing underlying trends and the totality of recent weather history instead of being tied to the vagaries in demand and weather of one historical year. The demand simulation weather model methodology uses a consistent set of economic, demographic and other inputs to create a forecast for the base year. Holding all these inputs fixed, weather for each of the latest available past 31 years (1989-2019) is run through the demand simulation weather model to calculate the resulting hourly electricity demand. Each year is run through the model again shifting the weather backward or ahead by a day. This allows for the interaction of the weather and calendar variables. In total, the weather is shifted +/- 7 days. This results in 465 hourly demand forecasts.

From this resulting dataset the base year is produced. For each month, the simulation that gave the monthly peak demand and total energy demand closest to the median values of all simulations was selected, with equal consideration given to the peak demand and total energy demand. Once the simulations for all 12 months have been chosen, the hourly profiles for each month are then joined together to make up the demand profile for the entire base year.

Additional detail regarding the *demand simulation weather model methodology* can be found in the IESO's Planning and Forecasting Methodology Changes Engagement Update on September 23, 2021.

3.5.2 Net Level Demand Base Year

To align with the *Bottom-Up* hourly net energy demand forecast the *grid level demand base year* is converted to the *net level demand base year*, by adding the e*mbedded generation output forecast*, described in section 3.4, for each hour in the base year (2022).

3.6 Hourly Grid Energy Demand Forecast

As with previous APOs the final product of the demand forecast is the hourly net energy demand forecast, on which resource adequacy and transmission security assessments are conducted, and is published as part of the Annual Planning Outlook.

As previously noted, new for the 2021 APO is the included publication of the hourly grid energy demand forecast in which the hourly embedded generation output forecast is subtracted from the hourly net energy demand for each hour in the outlook period. This new additional product of the demand forecast is being provided as a result of stakeholder engagement feedback from previous APOs and provides alignment with other IESO reporting and data including the demand forecast included in the quarterly Reliability Outlook.

3.7 High Demand Scenario Energy Demand Forecast

In the context of the 2021 APO, the future of electricity demand in Ontario is facing higher levels of uncertainty than in recent history stemming from a broad range of drivers including pandemic recovery, economic restructuring and expansion, climate change mitigation/decarbonization/electrification trends and policy implementation. As consumer and business markets evolve quickly and policies evolve to these uncertainty, the predictability of the timing and size of changes to electricity demand increase and become more challenging. To help identify how electricity demand in Ontario may change over the outlook period and provide a basis of initial and high level resource adequacy analysis in the form of a seasonal capacity requirement assessment in the 2021 APO Chapter 8 on Uncertainties, a *High Demand Scenario Energy Demand Forecast* was developed in which a limited number of electricity demand assumptions were reviewed and revised. The *High Demand Scenario Energy Demand Forecast* represents a set of reasonably potential increases in demand have been aggregated and integrated into the Reference Scenario Demand Forecast. Going forward, the IESO continues to monitor the state of electricity demand in Ontario and refines its demand forecasts in each year's APOs and assess the need for scenarios in the APO on an annual basis.

4. Drivers Used in the Demand Forecast

Residential household count is the main driver used in the residential sector forecast. Household counts have a direct relationship with electricity consumption, as end-uses are measured using households as the unit. The household count forecast is based on information provided by a third-party consultant.

Commercial floor space is the main driver used in the commercial sector forecasts. Similar to household counts in the residential sector, commercial floor space has a direct relationship with electricity consumption. The commercial floor space forecast is provided by a third-party consultant.

The major driver for industrial sector electricity demand is industrial sector activity. The relationship between industrial sector GDP output and industrial sector electricity demand use is often weak. A first effort at producing a set of physical drivers having a stronger connection with electricity use was made for each industrial sub-sector. Research, industry news, regional planning activities, and various analyses inform the development of physical drivers.

The agricultural sector's electricity demand is heavily affected by greenhouse growth light utilization associated with vegetables, flowers and cannabis in southwestern Ontario. Data provided by LDCs and direct-connect customers was used to conduct energy and peak demand analyses. Additional electricity demand in this sector is also outlined in the reference scenario in the IESO's *Need for Bulk System Reinforcements West of London* bulk study.

Electricity and natural gas rates also play an important role in the forecast. For example, higher electricity rates lead to greater energy efficiency measure uptake; lower natural gas rates lead to fuel switching (from electricity fueled to natural gas fueled measures), for example, space heating, water heating and cooking. The electricity and natural gas rate forecast assumptions are discussed in the 2021 APO Supply, Adequacy and Energy Outlook Module.

4.1 Market Segmentation

This section includes a listing of end-uses and building type for different sectors.

4.1.1 Residential Sector

Figure 8: Residential Sector End-Uses

#	Residential Sector End-Use
1	Air Conditioning - Central
2	Air Conditioning - Room
3	Baseboard Heating
4	Clothes Dryer
5	Clothes Washer
6	Computer
7	Cooking
8	Dehumidifier
9	Dishwasher
10	Domestic Hot Water
11	Elevator
12	Forced Air Central Heating
13	Freezer
14	Lighting
15	Lighting - Common Area
16	Miscellaneous
17	Other Consumer Electronics
18	Refrigerator
19	Set Top Box
20	Space Heating - Room
21	Swimming Pool Pump
22	Television
23	Ventilation and Circulation

Figure 9: Residential Sector Building Types

#	Residential Sector Building Type
1	Multi-Residential High Rise
2	Multi-Residential Low Rise
3	Other Residential Building
4	Row House
5	Single Family

4.1.2 Commercial Sector

Figure 10: Commercial Sector End-Uses

#	Commercial Sector End-Use
1	Commercial Electric Space Heating
2	Computer Equipment
3	Cooking
4	Cooling Chiller
5	Cooling - Direct Expansion
6	Domestic Hot Water
7	Elevator
8	Heating, Ventilation, Air Conditioning - Fans and Pumps
9	Lighting - Exterior
10	Lighting - General
11	Lighting - High Bay
12	Lighting - Interior Architectural
13	Miscellaneous Equipment
14	Other Plug Load
15	Refrigeration

Figure 11: Commercial Sector Business Types

#	Commercial Sector Business Type
1	Food Retail
2	Hospital
3	Large Hotel
4	Large Non-Food Retail
5	Large Office
6	Nursing Home
7	Other Commercial Building
8	Other Hotel, Motel
9	Other Non-Food Retail
10	Other Office
11	Restaurant
12	School
13	University and College
14	Warehouse Wholesale

4.1.3 Industrial Sector

Figure 12: Industrial Sector End-Uses

#	Industrial Sector End-Use
1	Compressed Air
2	Electro-Chemical
3	Heating, Ventilation, Air-Conditioning
4	Lighting
5	Motors - Fans and Blowers
6	Motors - Other
7	Motors - Pumps
8	Other
9	Process Cooling
10	Process Heating
11	Process Specific

Figure 13: Industrial Sector Sub-Sectors

#	Industrial Sector Sub-Sector
1	Chemical Manufacturing
2	Fabricated Metals
3	Food and Beverage
4	Mining
5	Miscellaneous Industrial
6	Non-Metallic Minerals
7	Paper Manufacturing
8	Petroleum Refineries
9	Plastic and Rubber Manufacturing
10	Primary Metals
11	Transportation and Machinery
12	Wood Products

4.2 Transportation

4.2.1 Electric Vehicles

The demand forecast of transportation electrification consists of the proliferation of electric vehicle (EV) charging demand and rail transit electrification projects. EVs are among the most important components of the drive towards climate change mitigation, decarbonization and electrification. In the recent past years, the EV market has been growing in Ontario, Canada, and around the world. By the end of 2020, there were approximately fifty-one thousand EVs on Ontario roads. Driven by strong government policy, manufacturer motivation, and evolving consumer preferences, it is projected that more EVs will replace internal combustion engine (ICE) vehicles. As a result, EV charging demand will increase significantly. EV charging demand, both energy and peak, have been included in the IESO's demand forecast and power system planning analyses.

EVs are a unique electricity end use with its own characteristics. Many factors can affect EV charging demand, including the number of EVs, vehicle size and mass, driving distance and pattern, battery capacity, time location of charging, and charger type. In order to avoid adding significant burden to electricity system, EV charging needs and can be managed. Technology such as grid-to-vehicle communication and Time-of-Use electricity rates can help to shift EV charging from system peak periods to off peak periods. Therefore the demand forecast of EV charging has a much higher uncertainty than many other end uses. In addition to carrying out its own research and analyses, the IESO has contacted the government, other planning agencies, and industry experts. For the demand forecast in the 2021 APO, the IESO's analysis focuses on two main categories and three key factors. Light duty electric vehicles (LDEV) and electric buses are analyzed separately. The number of EVs, driving distance, and fuel efficiency are three key factors largely determine electricity charging demand.

To date, LDEVs represents the majority of EVs in Ontario. It is forecasted that the same continues over the outlook period. The first step is to estimate how many LDEVs will be on Ontario roads over the next two decades. LDEV adoption is affected by many factors and there are a wide range of projections by various organizations. On June 29, 2021, the Canadian federal government set a mandatory target of 100% of car and passenger truck sales to be zero emissions by 2035 in Canada. The 2021 APO reference demand forecast assumes a moderate adoption in early years and fast ramp up after 2030. The projected number of EVs in Ontario will reach half million by 2030 and 6.6 million by 2042.

The next step is to estimate LDEV charging annual energy demand, which is determined by LDEV: 1) quantity as just described; 2) driving distance; and 3) fuel efficiency. The Canadian Vehicle Survey shows that an Ontario car on average is driven about 16,000 km per year. Natural Resources Canada manages a database of vehicle fuel efficiency including LDEVs. Based on data of dozens of LDEV models, an average of 0.2 KWh per km is estimated and used in the 2021 APO demand forecast. With calculated LDEV charging annual energy demand, LDEV charging hourly profiles are applied to arrive at the LDEV charging hourly energy demand forecast.

The LDEV charging hourly profile, which is determined by when and how LDEVs are charged, has a significant impact on power system peaks and capacity needs. Real-world charging data from the Charge the North project was used to develop the LDEV charging hourly profile and EV charging hourly energy demand forecast. The project collected LDEV charging data from about one thousand LDEVs in Canada over two years. The LDEV charging information and data of Ontario participants was aggregated and analyzed to develop the LDEV charging hourly profile.

Besides LDEVs, it is forecasted that most buses in the province will be electrified (e-buses) over the next two decades. Various government initiatives are in place to support e-bus adoption and a number transit agencies have plans to convert their bus fleet from ICE to electric. The aforementioned LDEV charging electricity demand forecast process is repeated to estimate e-bus charging electricity demand. Though projected to be tiny, electricity charging demands of other electric mobility, are estimated as a 10% adder and included in the overall EV demand forecast.

4.2.2 Rail Transit Electrification

A few rail transit electrification projects are at various stages in Ontario, including the Metrolinx GO Transit rail system, nine light rail transit projects, and subway lines in the Greater Toronto Area. These projects, when in operation, are expected to have an annual energy demand of nearly 2 TWh. The ION rapid transit project connecting Kitchener and Waterloo and the Confederation line in Ottawa have been in service since 2019. Another seven light rail transit projects are under construction or being planned. Early work on new subway projects, including the planned Metrolinx Ontario Line and two Toronto Transit Commission subway line extensions in the GTA, is underway. Electrifying Metroxlinx GO Transit rail corridors is a multi-year project and the procurement process is underway.

Electricity demand arising from rail transit electrification is estimated and included in the demand forecast based on most recently available plans and schedules. A couple of these projects are at the early planning stage with little information on electricity requirements. The IESO will update its rail transit electrification electricity demand projection, both in terms of magnitude and timing, when more information becomes available.

4.4 Other Electricity Demand

The "Other Electricity Demand" category of demand includes:

1. connection of remote communities

2. street lighting;

3. electricity generator demand; and

4. water treatment facilities

Demand forecasting methodologies vary for each of the *Other Electricity Demand* sub-sectors and reflect study results from third-party consultants, the IESO's regional resource planning, and consultations with LDCs.

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