Annual Planning Outlook

Demand Forecast Methodology

March 2024

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1. Introduction

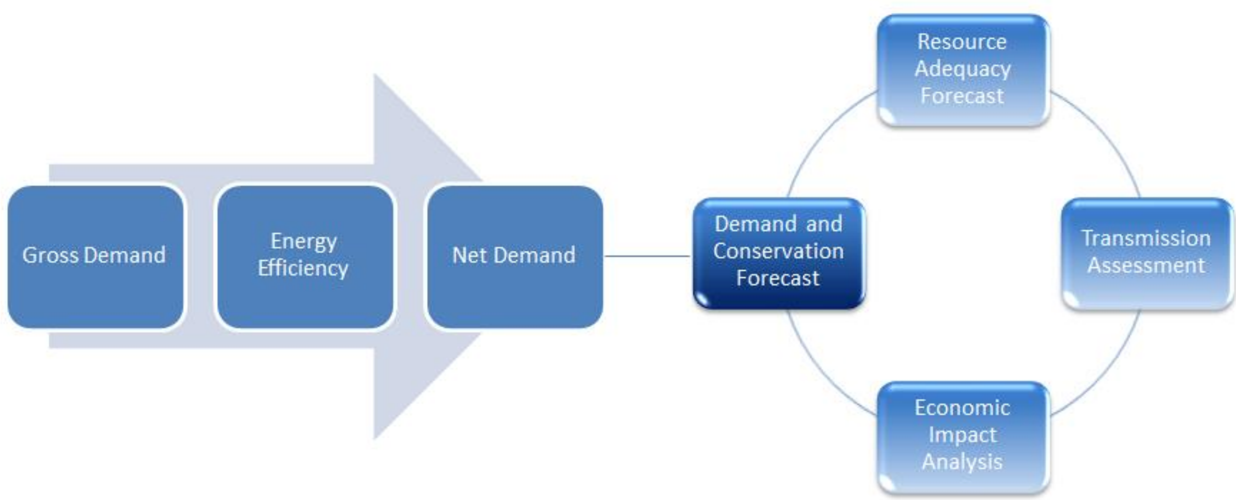
The IESO produces Annual Planning Outlooks (APOs) for the province for the purpose of informing stakeholders about the state of the electricity system, and any necessary investment required over the course of the outlook period. The demand for electricity, together with the supply outlook, establishes the context for resource adequacy and transmission security assessments, as the demand forecast determines the amount of electricity that must be served.

The APO 26-year long term demand forecast is produced at an hourly and zonal resolution and at the net-level, generator-level demand, under a normal weather scenario and is based primarily on a sector/sub-sector/zonal/end-use/efficiency level/fuel-type/annual and an 8,760 hourly load profile model, with additional adjustments for special sectors such as agriculture, transportation, other sources of demand, conservation and demand management (CDM) programs and regulations (including the residential demand response program), the Industrial Conservation Initiative, and embedded generation. The forecast is calibrated with actual historical demand data and aligned with the IESO's regional electricity planning initiative activities findings. The methodology of the development of the demand forecast is covered herein.

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, CDM program planning and supply procurement decisions. Electricity requirements are affected by many factors, including consumer's choice of energy form, technology, equipment purchasing decisions, behaviour, demographics, population, the economy, energy prices, and government policy on transportation, conservation and other sectors. 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.

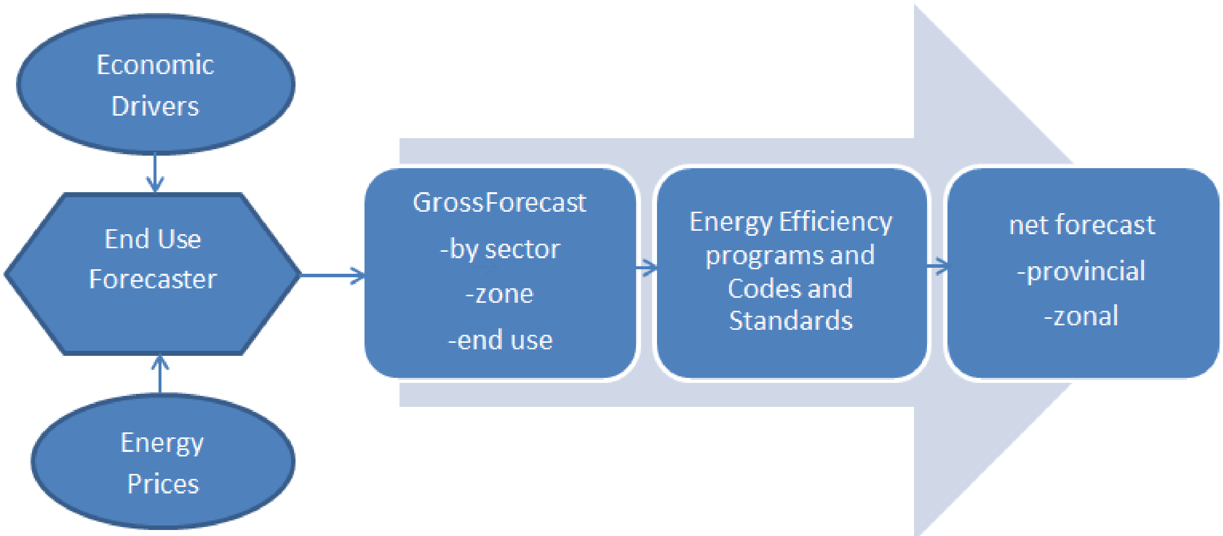
Figure 1 | How the Demand Forecast Fits into Bulk System Planning Process



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). As a final step in this process, 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, the zonal, sectoral, segment, end-use, efficiency, gross and generator level annual energy demand data are transformed from annual values to hourly values through the application of end-use level hourly load shape profiles and then aggregated to the zonal hourly gross level energy demand forecast.

3. Hourly Net Energy Demand Forecast:

The hourly gross energy demand forecast is then converted to the hourly net energy demand forecast by the following adjustment:

CDM Programs and Regulations: projected policy and regulation induced conservation and demand management savings (i.e., savings from energy-efficiency incentive programs, appliance and products standards, and commercial building codes) are identified at hourly resolution and subtracted from the hourly gross energy demand forecast.

Once completed, the zonal hourly net demand forecast establishes the amount of electricity that will need 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

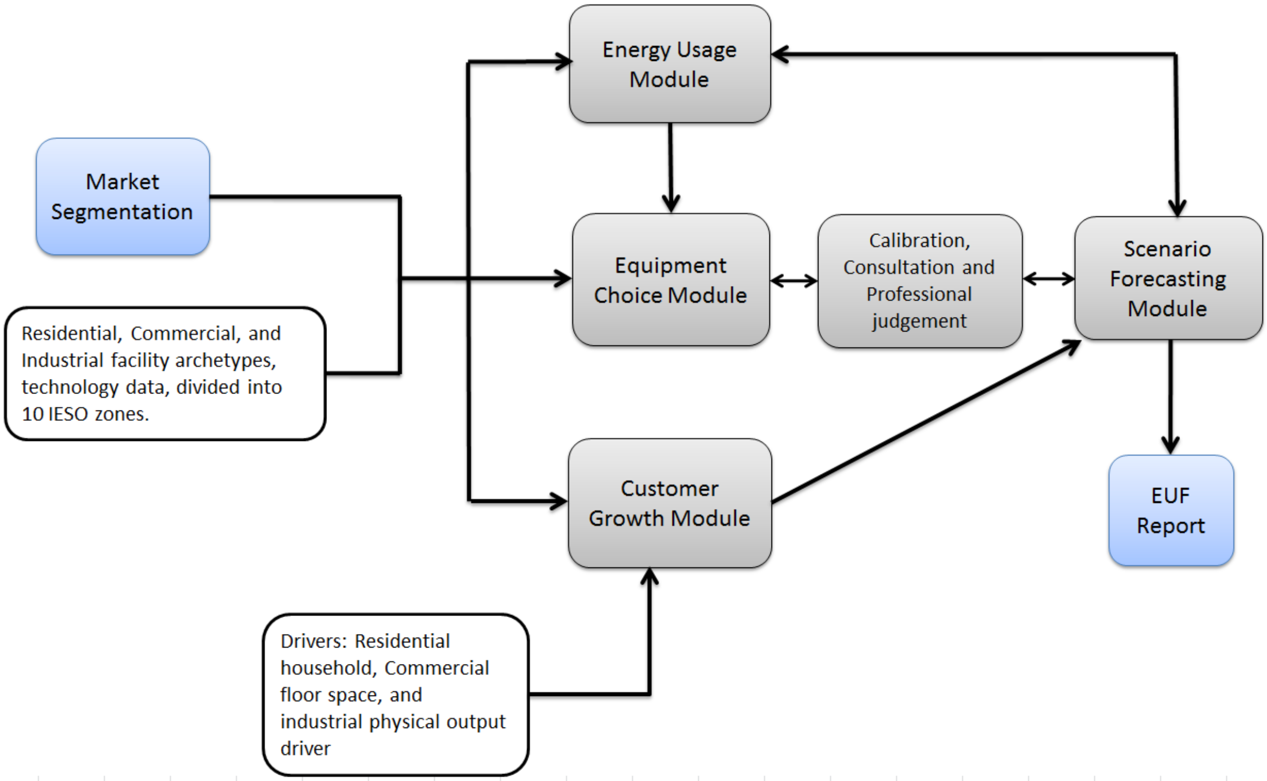
3.1.1 End-Use Forecasting Model

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 CDM 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

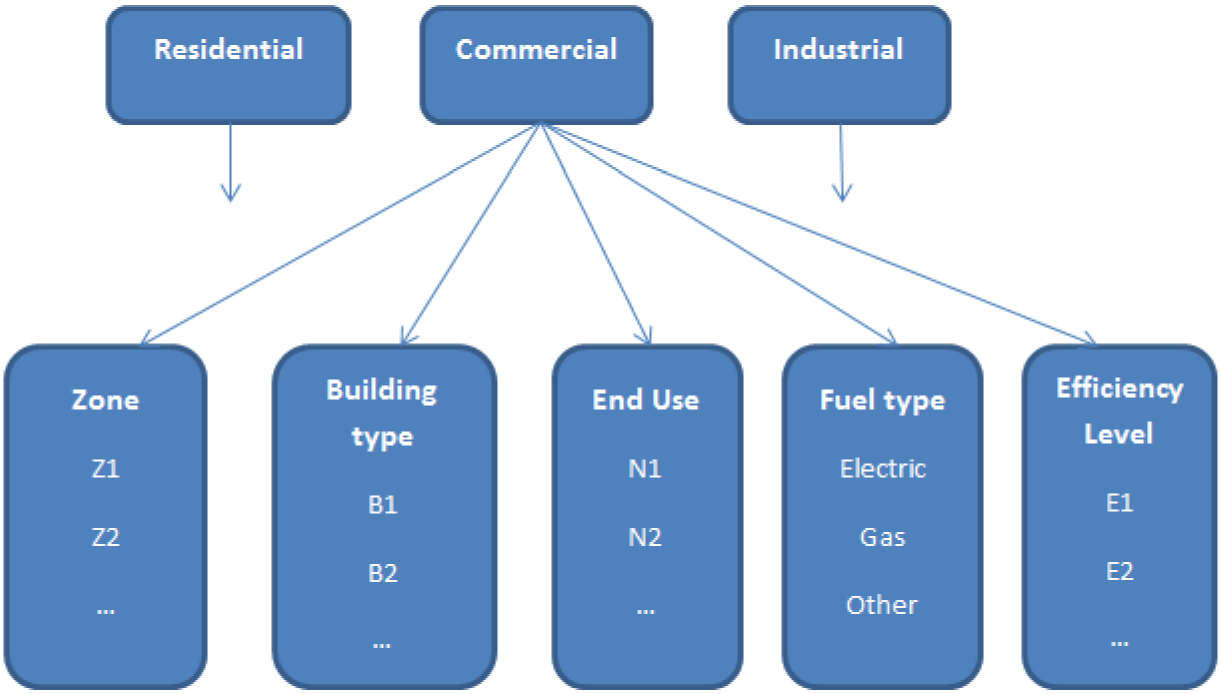
Several primary modules form the heart of the EUF analytical framework. Figure 3 also depicts the relationships between these modules.

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 updates 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. 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.

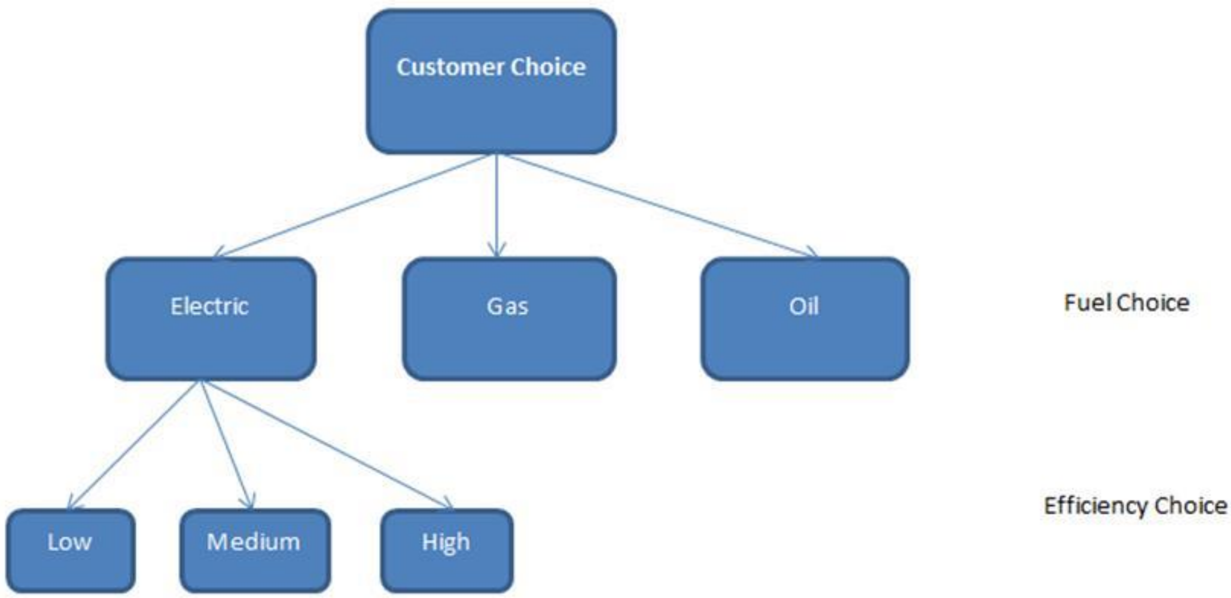
The *EUF Equipment Choice Module* analyzes customer choice decisions among competitors and product options. For example, customers choose their end-use equipment based on fuel types and efficiency levels. Purchase decisions are represented by a nested structure of provider (fuel choices) and product (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 annual gross energy demand forecasts determined in the process described in the previous section are multiplied by the corresponding end-use level hourly load profiles then aggregated to create residential, commercial and industrial sector level zonal hourly gross energy demand forecasts which are in turn aggregated to form the Ontario provincial residential, commercial and industrial sectors zonal hourly gross energy demand forecasts. The advantage of this approach is that it provides detailed results that can assist with activities such as CDM planning and sensitivity analysis. The IESO has compared the result from the "Bottom Up" method to the available system level zonal hourly demand data to ensure that it represents a reasonable depiction of the Ontario demand profile under normal conditions.

[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.

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 and Demand Management

CDM is the reduction of electricity use achieved primarily through two distinct methods: 1) resource acquisition through energy efficiency initiative frameworks; and 2) market transformation through building code and equipment standard regulations. These CDM savings, both persisting savings from historical activity and forecasted savings from future program delivery, would not otherwise occur in the absence of policy. These savings are deducted from the bottom up gross energy demand forecast.

For further details on how the CDM forecast is derived, see Section 4.5.

3.3.2 Industrial Conservation Initiative

A final adjustment that is applied to result in the hourly net energy demand forecast is the incorporation of the forecasted impacts from the Industrial Conservation Initiative, which enables program participants to reduce their Global Adjustment charge obligations by reducing their respective individual contributions to the actual top 5 daily system peaks during the respective ICI season, thus benefiting the electricity system in a capacity requirement basis.

For further details on how the Industrial Conservation Initiative forecast is derived, see Section 4.6.

3.4 Embedded Generation

Embedded generators are generators that are not registered participants in the IESO Administered Market and are typically connected to the distribution system and represent the variance between net-level demand and grid-level demand. Grid- level demand is the level of energy supplied by market participant generators, while net-level demand is the level of energy supplied by both market participant and non-market participant generators and is the level that is consistent with subsequent resource adequacy and transmission security assessments. Embedded generation is categorized as either fueled by: 1) solar; 2) wind; 3) hydro; 4) bio-fuel; or 5) combined heat & power. Embedded generator output is based on a database of known generators and their respective characteristics and assumed hourly production profiles. Embedded generation is considered in the demand forecast in the formation of the base year and the grid-level demand forecast, which are each discussed in the later sections.

3.5 Delta Process

Two different processes 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 process has been described in the preceding Sections 3.1 - 3.3. The second, the "Delta" process, 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.

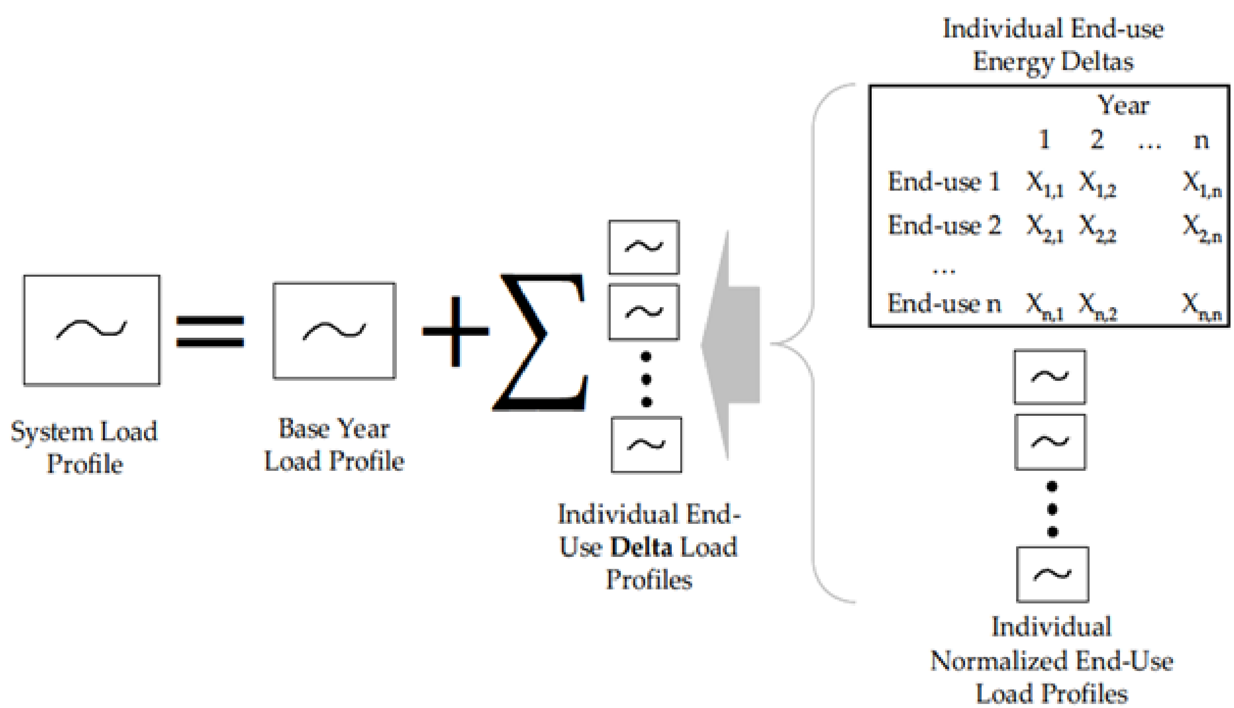
In the "Delta" method, the Ontario provincial system zonal hourly demand profile for a given base year is identified and used as a basis for the future energy demand forecast for the entire outlook period. The change in electricity use associated with a particular end-use over time is mapped to the corresponding 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.

Schematics of the Delta method are shown in Figure 6.

Figure 6 | Converting Annual Energy to Hourly Peak



3.5.1 Grid Level Demand Base Year

In the 2024 APO demand forecast, a forecasted year 2024 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 monthly peak demand, monthly minimum demand and total energy demand, by varying weather inputs. In this case, normal represents the concept that the monthly peak, minimum and total energy demand values have a 50/50, or equal probability 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, thus allowing for it to be calibrated to available actual historical demand data.

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 (1990-2020) 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, monthly minimum demand, and total energy demand closest to the median values of all simulations was selected, with equal consideration given to each metric. 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 4.9, to each hour in the base year (2024).

3.6 Hourly Grid Energy Demand Forecast

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.

In addition, since the 2021 APO, an 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 is now included in the APO supporting data. This 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.

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 was also informed by 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 2024 APO Supply, Adequacy and Energy Outlook Module.

4.1 End Use Forecaster Market Segmentation

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

4.1.1 Residential Sector

Table 1 | 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

Table 2 | 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

Table 3 | 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

Table 4 | 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

Table 5 | 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

Table 6 | 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 Agricultural Sector

Historically agriculture has been a sub-sector of the industrial sector, but with the emergence of significant growth in greenhouses producing fruits, vegetables, flowers and cannabis particularly in the West of London area, and with a distinct combination of end-uses, including lighting, space heating and ventilation, and output specific seasonality profiles, agriculture has been allocated a status as a distinct sector.

The IESO's West of London area greenhouse electricity demand forecast has been informed by multiple sources including: 1) information received from local distribution companies in the area, mainly Hydro One Distribution, including customers who have requested or inquired about connections as well as projections based on available natural gas supply capability from Enbridge Gas' Chatham pipeline expansion; 2) information received from IESO connection applicants or inquiries; and 3) historical acreage expansion rates for vegetable greenhouse growers in the area obtained from the Ontario Greenhouse Vegetable Growers Association. Further supporting segmentation, seasonality, hourly load profile and other information, data and projections have been sourced from the IESO's 2019 Windsor-Essex Integrated Regional Resource Plan Appendix B, and the findings of the IESO's 2021 West of London Bulk Power System Study Section 4.

Three main pockets of greenhouse demand growth have been identified consisting of: 1) Kingsville-Leamington; 2) Chatham-Kent, specifically the community of Dresden; and 3) Lambton-Sarnia. In each pocket, a demand forecast has been developed and informed by existing greenhouse loads, facilities for which IESO System Impact Assessment requests have been received, and with growth rates aligned with connection customers. Further incremental demand is forecasted once enabled by required transmission infrastructure implementation in 2026, as well as when a separate load growth from the Kingsville-Leamington customer queue (AgriPark) begins to be connected in annual stages.

Seasonal and hourly demand profiles are based on greenhouse crop output product segmentation and greenhouse end-use saturations in which the IESO obtains updates on a regular basis, from its market research and consultant findings.

Existing agricultural sector demand from sources other than greenhouses in the West IESO zone, as well as the rest of the province in general, has been maintained and updated with standard modelling processes similar to the industrial sector, as appropriate.

4.3 Transportation

4.3.1 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. The quantity of EVs on the road and the associated charging electricity demand are fast growing and projected to increase significantly over the next decades. The EV demand forecast is done outside of the End Use Forecaster model. The annual energy demand, peak impact, and hourly demand forecast over the planning horizon are estimated and fed into subsequent power system planning analyses.

EVs are a unique electricity end use with particular characteristics. Many factors can affect EV charging demand, including the number of EVs, vehicle size and mass, driving distance and pattern, battery capacity, fuel efficiency, time and location of charging, and charger type. EVs are also a flexible end use in terms of time and location. EV demand is relatively new, fast growing, and evolving. Therefore, the demand forecast of EV charging has a much higher uncertainty than many other end uses. The IESO analyzes the EV demand with available information, such as government policies and targets, market trends, studies, and other organizations' forecasts, in addition to making informed assumptions and professional judgements. EV charging can and should be managed to avoid adding significant burden to the electricity infrastructure. The IESO carries out studies and updates its forecast when new information is available.

For the EV demand forecast of 2024 APO, the IESO's analysis leverages on a recent consultant study and utilizes a multi-step process. The analysis focuses on Light duty electric vehicles (LDEV), which represent the majority of EVs. Medium and heavy duty EVs (M/HDEV) are also analyzed.

The first step is to estimate the quantity of EVs, which is the most important factor. A stock and flow model is utilized. As EV new sales continue to grow, more EVs are on the road in Ontario each year. The LDEV adoption aligns with federal government targets, with new sales achieving 60 per cent by 2030 and 100 per cent by 2035. There are 151 thousand EVs registered in Ontario today. The projected quantity of LDEVs in the province will reach 8.1 million by 2040 and 11.5 million by 2050.

Medium and heavy duty vehicles have their unique characteristics. Combined, they represent nearly 3% of today's total vehicles in the province. A variety of competing technologies and options are available to decarbonize them. It is generally agreed that the battery powered electrification of medium and heavy duty vehicles will lag behind light duty vehicles. Given a wide range of operation characteristics and small number of these vehicles, it is more challenging to forecast M/HDEV than LDEV. To develop the electricity demand forecast of M/HDEV, the IESO refers to the forecast of other provinces and relies on a consultant study. It is projected that the number of M/HDEV in the province will increase from nearly one thousand in 2025 to 90 thousand in 2050.

The next step is to estimate EV charging energy demand, which is the product of EV quantity, vehicle-kilometers travelled, and fuel efficiency. Annual vehicle-kilometers travelled (VKT) is another critical factor, which represents how much EVs are used. Data from the Canadian Vehicle Survey is incorporated into the model. Fuel efficiency, kWh per km, varies by vehicle size, mass, and driving conditions. Fuel efficiency is sourced from a database managed by the Natural Resources Canada. The annual charging energy demand of LDEVs is estimated to grow from 1.5 TWh in 2025 to 37 TWh in 2050. The annual charging energy demand of M/HDEVs will increase from nearly 0.1 TWh in 2025 to 5 TWh in 2050.

The last step is to develop hourly charging demand for subsequent power system analyses and modelling purposes. The EV charging profile, which is a representation of when and how EVs are charged, is applied to the annual energy demands from the preceding step to arrive at the hourly demand forecast. EVs are a flexible end use that practically can be charged any time when not on the move, which represents over 90% of time. Customer preference, battery size and status, driving conditions, time-of-use electricity rate, and active EV charging load management programs are among factors affecting charging profile. The flexibility of EV charging load makes it possible to manage the load. To avoid the needs of significant additional generation and transmission capacity, EV charging must be managed. As such, the APO adopts a managed charging profile constructed in a recent consultant study. Conceptually, EV charging demand is characterized into two portions, manageable demand and unmanageable demand. It is assumed that manageable demand only occurs outside system peak periods. The complete hourly charging profile is developed and applied to derive the hourly demand forecast. The EV charging profile carries an inherent high uncertainty and has a big impact on power system peaks and capacity needs. More studies on EV charging will inform the updates in future APOs.

4.3.2 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 2.4 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 rail projects, including the planned Metrolinx Ontario Line and two Toronto Transit Commission subway line extensions in the GTA, is underway. The electrification of Metroxlinx GO Transit rail corridors is another multi-year project for which the procurement process is underway.

Electricity demand arising from rail transit electrification is estimated and included in the demand forecast based on the most recent 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 in future APOs, 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.

4.5 Conservation and Demand Management

CDM is a clean and cost-effective resource for helping to meet Ontario's electricity needs. Ontario benefits from approximately 22 TWh of annual energy savings from CDM measures implemented from 2006 to 2021. These savings can be attributed to conservation and demand management programs and improved building codes and equipment standards regulations. CDM 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 programs and regulations.

4.5.1 CDM Programs

CDM programs have been funded and/or delivered by the IESO and predecessor organizations since 2006 based on committed provincial government program framework funding policy. Demand savings from programs delivered in the past have been verified with expected finite persistence lives and it is assumed that in the post committed framework period starting in 2025, that CDM program frameworks will continued to be delivered through the end of the outlook period.

4.5.1.1 CDM Programs – Historical Frameworks

Historical CDM program frameworks that continue to deliver savings include: 1) the 2019-2020 Interim Framework for the delivery of Energy Efficiency Programs; 2) the 2015-2019 Conservation First Framework; Industrial Accelerator Programs and their respective wind-downs; and 3) earlier conservation program frameworks.

4.5.1.2 CDM Programs – Current Frameworks

Current CDM program frameworks are forecasted distinctly based on the following program designs and funding sources.

4.5.1.2.1 CDM Programs – Current Frameworks – IESO Funded

In addition to persisted savings from previous CDM initiatives, new CDM 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. In September 2022, the Minister of Energy amended the Framework directive by increasing the budget for additional CDM programming. As a result, four new or enhanced programs were launched in 2023. The forecasted annual savings of the enhanced framework are 4 TWh in 2026 with a total budget close to $1 billion. One of new programs, the Peak Perks program, is discussed separately in section 4.7 Residential Demand Response.

4.5.1.2.2 CDM Programs – Current Frameworks – Federal Government Funded

Besides the IESO administered programs, a few federally funded programs are in the market and expect to achieve electricity savings in Ontario. This includes the Canada Greener Homes Grant program rolled out in 2021, which has a budget of $2.6 billion over 7 years. The program target is to provide 700,000 grants in Canada to help home owners perform energy efficiency and emission reduction retrofits. The resulted electricity savings in Ontario are estimated as 0.3 TWh each year when fully implemented. The Canada Greener Homes Loan program helps Canadians make their homes more energy efficient and comfortable by offering interest free financing in addition to Canada Greener Homes Grant. It is estimated that the program will reduce electricity consumption by 0.04 TWh in Ontario each year. 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. Together these programs target a variety of fuel types across the entire country and are not administered by the IESO. These savings are estimated with higher uncertainty as not all program details are currently available. The IESO is monitoring federal announcements regarding the evolution of the Canada Greener Homes Grant program and relevant changes will be reflected in future APOs.

4.5.1.3 CDM Programs – Future Frameworks

Beyond the CDM programs already in the market, it is anticipated that conservation efforts will continue over the planning horizon. New savings will materialize as a result of continued delivery of conservation and demand management initiatives. For planning purposes, incremental annual energy savings are assumed to be consistent with proportions of gross demand the current program frameworks deliver, which is informed by the planned savings level of the 2021-2024 CDM Framework Program Plan. The long term programs are expected to save 14 TWh in by 2050. This assumption will be updated in future APOs when a future policy decision is made.

Besides the aforementioned CDM program savings, there is potential to achieve incremental conservation energy savings as identified and quantified in the IESO's 2022 Achievable Potential Study.

4.5.2 CDM Regulations

CDM regulations savings are based on the expected improvement in building codes and specified end use equipment standards and are an effective energy efficiency tool that embeds energy savings in buildings and equipment upgrades through federal and provincial regulation and requires no incremental ratepayer investment.

4.5.2.1 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 heating, cooling, ventilation and lighting 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 CDM policy with incremental improvements.

Table 7 | Ontario Building Codes New Regulations

#	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 %

Table 8 | Ontario Building Renovation Regulations

#	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 %

4.5.2.2 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]

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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.

4.6 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. For a given Base Period, the actual system peak days 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.

For the long term demand forecast, forecasted ICI responses are based on maximum single hour system level ICI response observed from the latest 12 months available at the time of the development of the demand forecast (April 2022 – March 2023), and is identified separately at the seasonal (summer and winter) and IESO Zonal levels. ICI responses are forecasted to change on an annual basis on based on forecasted changes to industrial sector gross annual energy demand and at the IESO Zonal level. Based on the same latest observations ICI responses are forecasted to occur on the top 15 grid level system peak days (ICI Days). ICI Days are forecasted on a calendar year basis; each ICI Day's peak ICI response is forecasted based on the forecasted maximum annual seasonal ICI response and is adjusted corresponding to the ICI Day's system peak demand relative to the forecasted annual system peak demand. ICI Day Hourly ICI response is forecasted to 'follow' the ICI day's hourly demand, and occur only on hours of peak demand levels and to be always non-negative in terms of demand savings.

4.7 Residential Demand Response

In response to the Ministerial Directive dated September 29, 2022 and received October 4, 2022, the IESO launched a new Residential Demand Response program in summer 2023 branded as Save on Energy Peak Perks. Peak Perks is a demand response program that gives families more ways to lower their energy bills and provides residential consumers a financial incentive in exchange for lowering their energy use at peak times during the summer. Peak Perks aims to lower system demand during peak periods and allows the province to reduce electricity sector emissions, by reducing the need for electricity generation facilities that only run at times of peak demand such as natural gas.

The Residential Demand Response program has been added to the 2021-2024 CDM Program Framework committed to the end of 2024, but is assumed to be delivered in perpetuity, consistent with the long term demand forecast's long term CDM assumption. Peak Perk's activation criteria consist of:

1. June 1 to September 30 activation period;
2. Weekdays only;
3. Up to 10 activations per year
4. A maximum of 1 activation per day
5. An activation period of 3 contiguous hours
6. An activation day trigger of either:
    a. An forecasted grid level peak demand greater than 22 GW on or after noon;
    b. An IESO Emergency Procedure declared; or
    c. IESO's discretion;

For the purposes of the APO demand forecast, it is assumed that the Residential Demand Response program is activated on each of the top 10 June 1 – September 30 weekday grid level peak demand days each year, centred on the system peak hour and adjacent hours, at the forecasted demand savings level in the reference year and forecasted savings changes each year based on forecasted changes in residential sector air conditioner unit installed count and zonal response based on forecasted zonal residential air conditioner annual energy demand. Adjustments factors include discounted capacity factors on an system basis as well as initial and final hours of the 3-hour activation period.

4.8 Fuel Rates

The IESO's electricity demand forecast is based on forecasted annual fuel rates for: 1) electricity; 2) natural gas; and 3) other fossil fuels (heating oil/propane); for each of the a) residential; b) commercial; and c) industrial; sectors over the course of the outlook period. The inclusion of fuel rate forecasts for electricity alternatives plays an important factor in the calculations of the equipment choice module highlighted in Section 3.1.2.4.

4.9 Embedded Generation

Since the 2021 APO, 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 (2025-2050) is included. 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).

For the purposes of the embedded generation forecast for the grid-level long term demand forecast, the embedded generation output forecast is based on: 1) consistent hourly profiles for the fuel type and for each year, adjusted for expected changes in available capacity and operating conditions; 2) and reflects assumptions of discontinued availability of existing embedded generation resources in each resource's post contract expiry period. With this assumption, embedded generation production forecasts decrease steadily over the outlook period.

4.10 Regional Planning Alignment

Regional planning[3] is a continual process, with electricity reliability evaluated at minimum every five years in each region with local distribution companies, transmission system providers and customers. The IESO's long term demand forecast takes into accounts specific learnings from each assessment's latest findings in terms of forecasted demand.

Table 9 | IESO Regional Planning Regions

#	Region	Sub Regions			
1	Burlington to Nanticoke	Brant	Bronte	Hamilton	
2	Chatham-Kent / Lambton / Sarnia				
3	East Lake Superior				
4	Greater Bruce / Huron	Southern Huron-Perth	Southern Huron-Perth		
5	Greater Ottawa	Ottawa			
6	Greater Toronto Area East	Pickering-Ajax-Whitby	Oshawa-Clarington		
7	Greater Toronto Area North (York)				
8	Greater Toronto Area West (Peel & Halton)	Northwest GTA	Southwest GTA		
9	Kitchener-Waterloo-Cambridge-Guelph				
10	London Area	Greater London	Alymer-Tillsonburg	Strathroy	Woodstock
11	Niagara				
12	North / East of Sudbury				
13	North of Moosonee				
14	Northwest Ontario				
15	Peterborough-Kingston				
16	Renfrew				
17	South Georgian Bay / Muskoka	Barrie / Innisfil	Parry Sound / Muskoka		
18	St. Lawrence				
19	Sudbury / Algoma				
20	Toronto				

[3] https://www.ieso.ca/en/Get-Involved/Regional-Planning/About-Regional-Planning/How-the-Process-Works

#	Region	Sub Regions
21	Windsor-Essex	

4.11 IESO Electrical Zones

Table 10 | IESO Electrical Zones

#	Zone
1	Bruce
2	East
3	Essa
4	Niagara
5	Northeast
6	Northwest
7	Ottawa
8	Southwest
9	Toronto
10	West

Independent Electricity System Operator
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