Direct Testimony Presentation

PUBLIC SESSION

Load Forecast Review

PREPARED BY: DAYMARK ENEGY ADVISORS
PREPARED FOR: MANITOBA PUBLIC UTILITIES BOARD
DATE: JANUARY 2018

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Agenda

1. Load Forecasting Concepts and Background
2. Daymark Scope of Work
3. Key Findings
4. Daymark Review Process
5. Manitoba Hydro Load Forecasting Methodology and Daymark Review
6. Load Forecast Changes (2014 to 2017)
7. Summary and Conclusions

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1. Load Forecast Concepts and Background

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Load Forecast - Uses

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- What is a load forecast?
- What is load?
- Why is the load forecast important?

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A Load Forecast is a Key Business Planning Tool

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- Supports short- and long-term **resource planning** including distribution planning
- Supports **financial planning** (revenues from sales)
- Provides a way to investigate "**alternative futures**" and enhances **flexibility** in responding to industry changes, such as
  - Economic growth
  - New technologies for energy consumption
  - Policy changes
  - New generation technologies (distributed energy resources, energy storage, utility scale technologies)
  - Early warning system (how soon must a commitment be made?)

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Load Forecasts Rely on Historical Information and "Drivers"

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- Historical usage **informs** future usage
- **Drivers** are used to explain consumption patterns
  - Price of electricity and substitute products
  - Economic variables (GDP, CPI) and population variables
  - Customer counts
  - Weather variables
- History is **not always an accurate predictor**, such as in the following examples
  - New technologies substituting for central station generation
  - Policies designed to increase energy efficiency or storage technology adoption
  - Sudden shifts in economic growth

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Load Forecast - Terms

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- Sectors
- Total Consumer Sales
- Common Bus Load
- Gross Firm Energy
- Total Peak Demand

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Manitoba Hydro Load Forecast Method

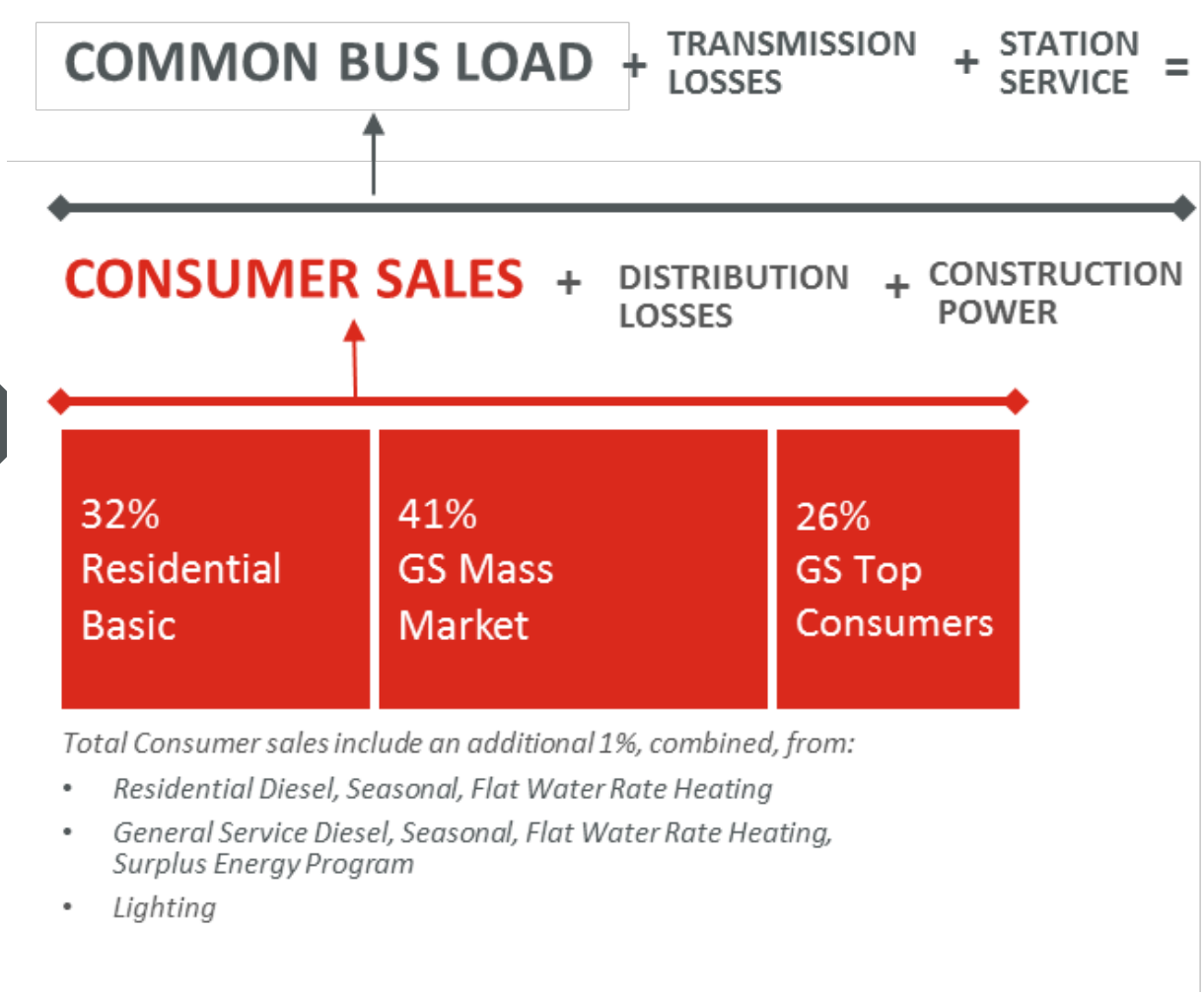

Figure Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 10, Figure 1. [*emphasis added*]

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Four Common Load Forecasting Approaches

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1. Time-series
2. Cross-sectional via econometric regression modeling

   ↑ This is the primary approach used by Manitoba Hydro
3. Engineering “bottom-up” approach
4. Statistically adjusted end-use method

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Key Concepts in Load Forecasting Methods

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- Econometric modeling
- Regression analysis
  - Regression Equation
    - Simple Example: $Y = \beta_o + \alpha X + \varepsilon$
  - Regression coefficient
- Price elasticity
- Step-wise regression
- Statistical terms (multicollinearity, significance)

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2. Daymark Scope of Work

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Daymark Scope of Work

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- Assess Manitoba Hydro's load forecasting methodologies for **residential**, **general service mass market**, and **top consumer** sectors
- Assess other aspects of the load forecasting methodology, including transmission and distribution losses
- Evaluate **historical performance** of Manitoba Hydro's load forecasting methodology
- Identify and assess **changes between Manitoba Hydro's 2017 and 2014** load forecasting methodologies.

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3. Key Findings

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Key Findings

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- Manitoba Hydro's load forecast methodologies, which develop its projections of future energy and demand, **are reflective of industry practice**

- Review of Manitoba Hydro's load forecasting process shows that there are **areas where improvement may have an impact on the base load forecast and enhance the load forecasting methodology**

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Directional Impact on Base Load Forecast

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TOPIC	IMPACT ON LOAD FORECAST
Use of conservative PLIL* methodology	Conservative PLIL method used in 2017 forecasted 523 GWh less load than using the 2014 method and 2017 data over the 20-year forecast period
Use of historically under-forecasted population	Lower-than-actual customer count and residential customer forecast will result in lower residential and GSMM load forecasts
Fuel switching not fully considered	Load forecast may change without considering potential alternative energy source substitution that may occur due to the proposed rate increase
Short term impact of rate increase not considered for top consumers	Top Consumer sector could reduce 185 GWh of load in short-term due to proposed rate increase

* PLIL stands for "Potential Large Industrial Loads."

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Price Elasticity

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- Estimated price elasticity for all three sectors may not be reliable due to
  - **Statistical concerns**
  - **Use of predictor variables**, which may have suppressed price elasticity value as shown by regression model
  - **Use of conservative PLIL methodology**, which has a lower price elasticity than the method used in 2014

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Suggestions to Enhance MH Methodology

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- Considering **informed sensitivities and scenario analysis**
- Considering a more robust approach to **understanding load uncertainty** by evaluating inherent characteristics of each fundamental variable with the help of probabilistic (i.e., stochastic) risk assessments
- **Weather normalization process**
  - Period used for estimating the relationship between weather and usage and
  - "Normal" year weather considerations
- Testing for statistical issues

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4. Daymark Review Process

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Daymark Review Process

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- Daymark team reviewed public and commercially-sensitive information regarding Manitoba Hydro's load forecast methodology, including
  - Discussion with Manitoba Hydro load forecast team during site visit in September and regular conversation thereafter
  - Review of commercially-sensitive information shared by Manitoba Hydro via SharePoint as requested by Daymark
  - Review of publicly available Manitoba Hydro annual Load Forecast Reports and peer-reviewed journal articles
  - Running Manitoba Hydro's various load forecast models independently and making changes based on the review, such as PLIL methodology, step-wise regressions, and checking for statistical issues

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5. Manitoba Hydro Load Forecasting Methodology and Daymark Review

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Manitoba Hydro Load Forecast Overview

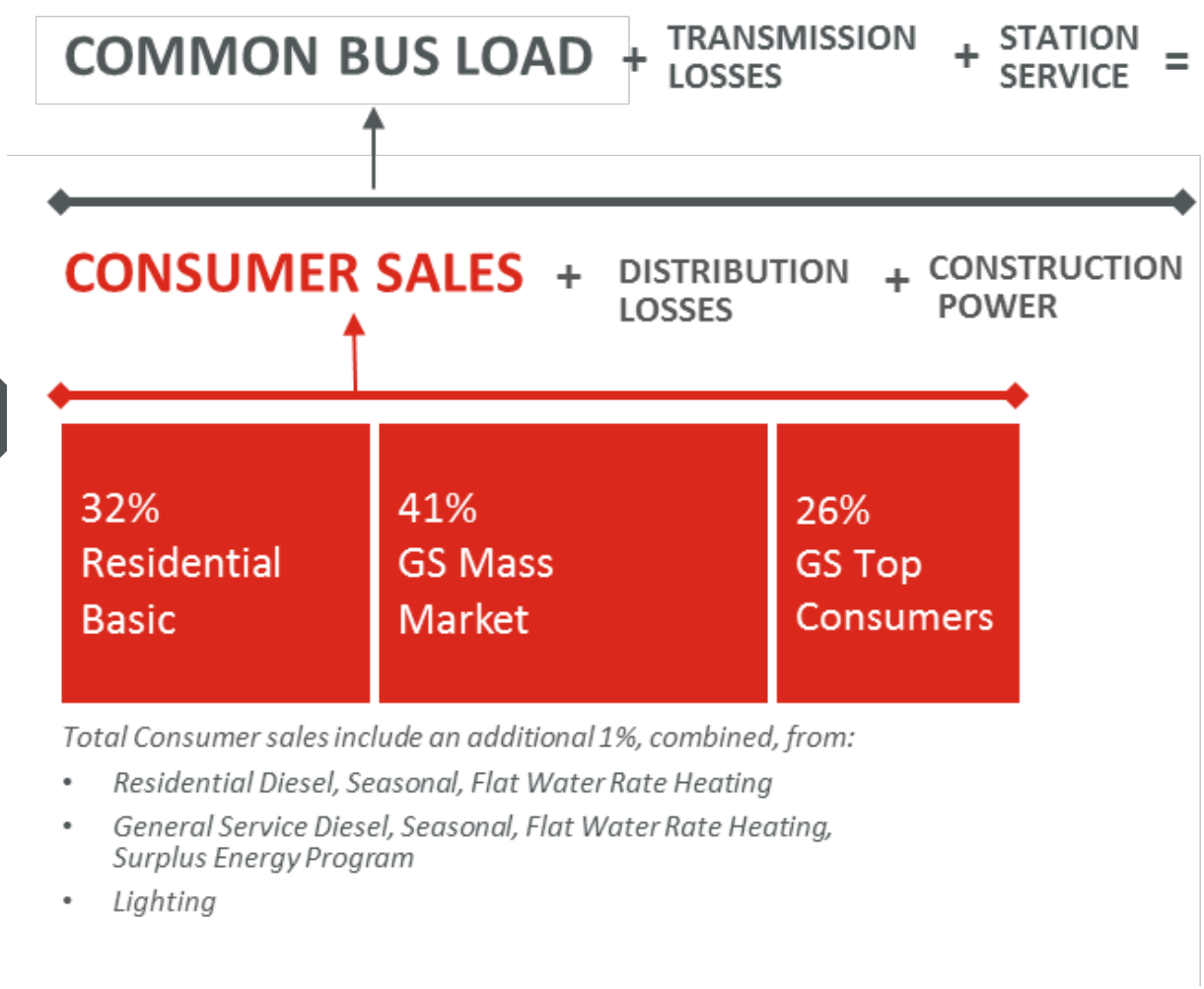

Figure Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 10, Figure 1. [*emphasis added*]

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Residential Methodology

- **Two** key forecast components
  1. **Average usage** per residential customer
  2. **Number** of residential customers or dwellings
- End-use forecast method also developed, but limited in use.

1. **Average usage per residential customer forecast** uses regression method
   - **Key variables**: Electricity price, Income, Saturation (ratio of electric heat customer count to total customer), and trend variable.
   - Log-log regression model

2. **Number of residential customers or dwellings forecast** is based on several third-party Manitoba population forecasts and a Manitoba Hydro-estimated ratio of total population to total residential customers

Residential Basic Components

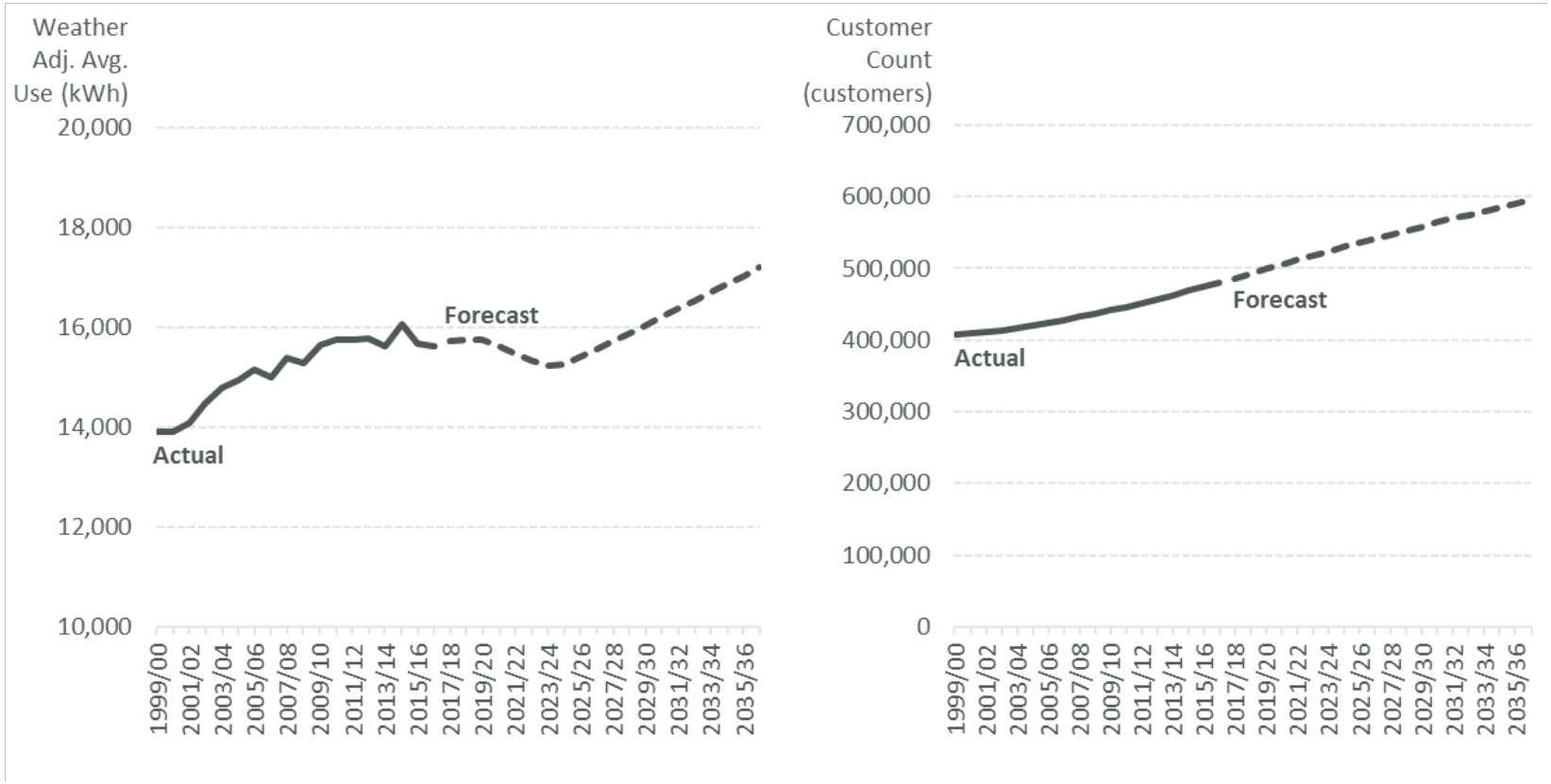

Figure Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 12, Figure 2.

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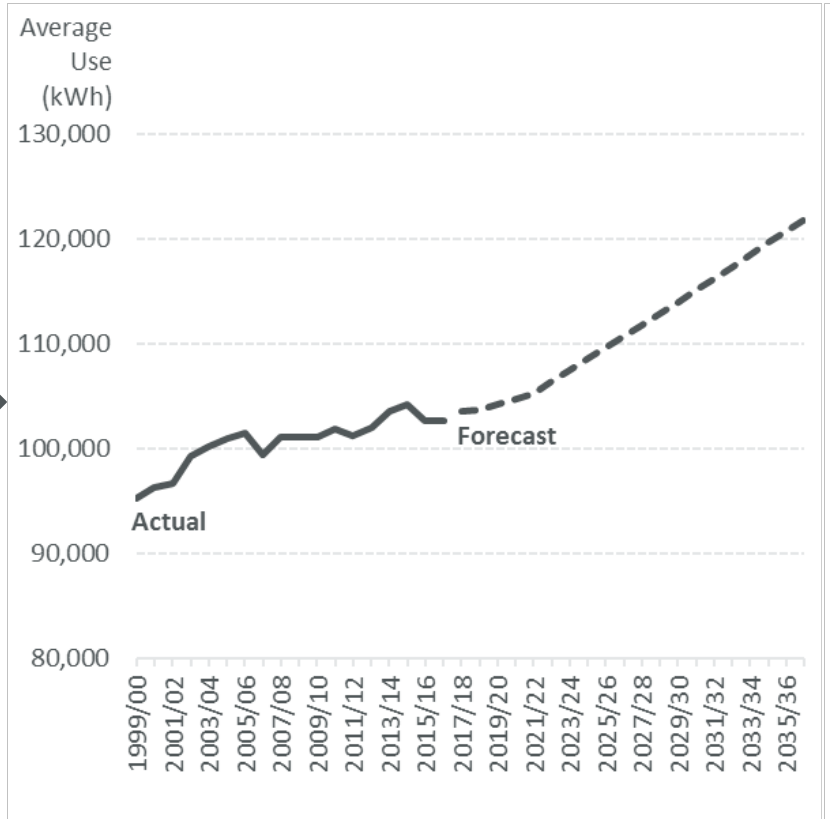
General Service Mass Market Methodology

- Same method as Residential Basic - forecasting **average usage** and **number of customers** to get the total usage
  - Regression models used to forecast both components.
- GSMM is further divided into two subgroups:
  - Small Non-Demand, Small Demand, and Medium customers
  - Large Customers

1. **Average usage** is modeled as a function of electricity price, GDP, and a dummy variable to account for billing reclassification
2. **Number of customers** is modeled as a function of GDP and number of residential customers
   - Manitoba GDP for small, medium customer model
   - Manitoba/Canada/US blended GDP for large customer model

GS Mass Market Components – *Small, Medium Customer Category*



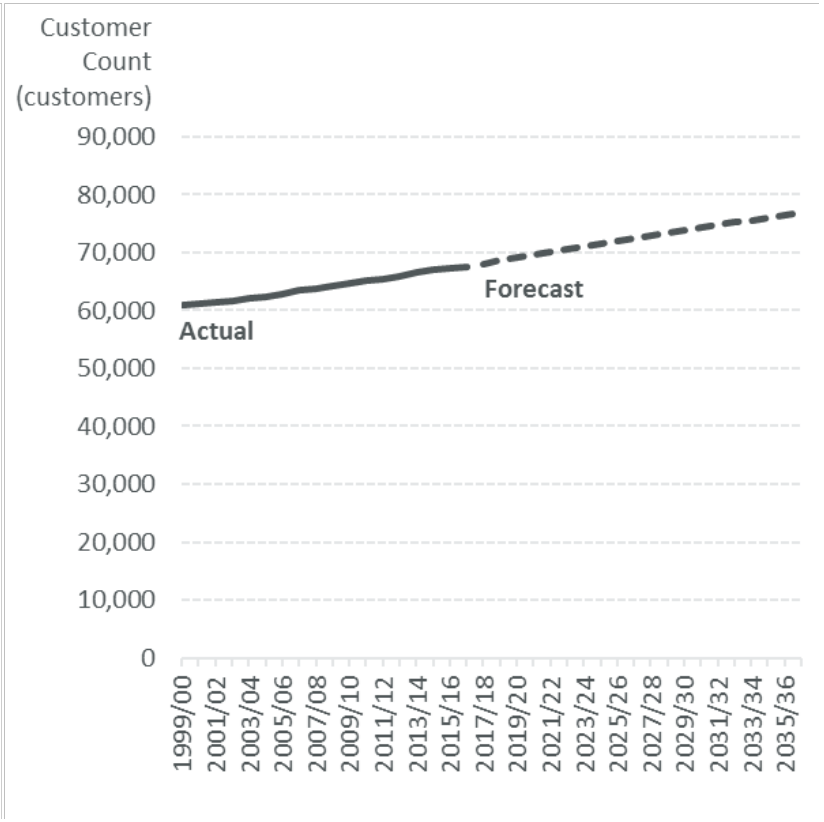


Figure Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 15, Figure 3.

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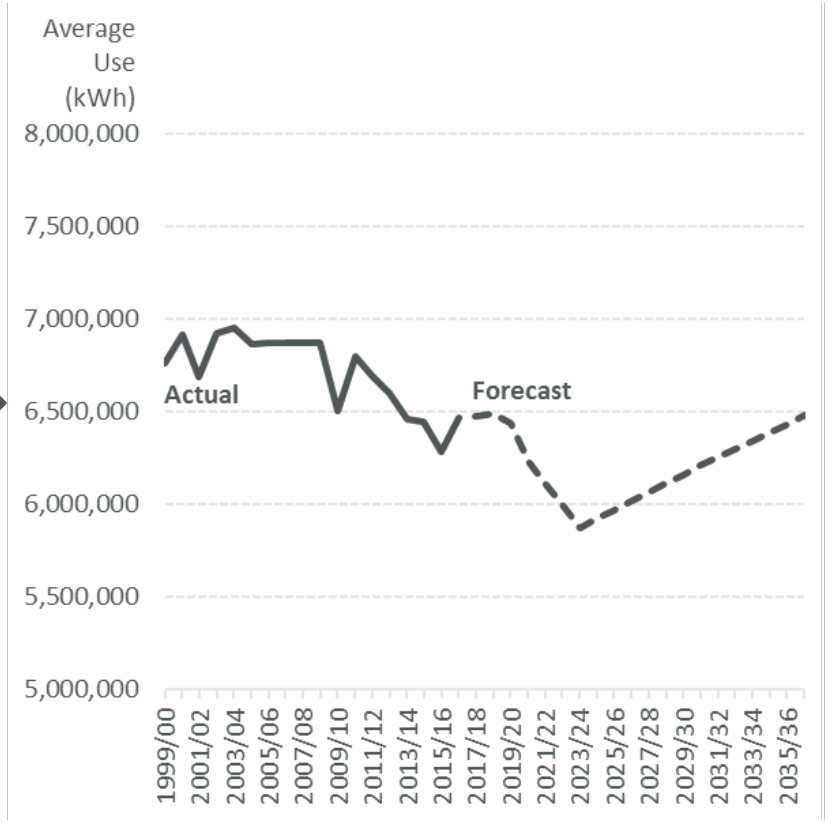
GS Mass Market Components - *Large Customer Category*



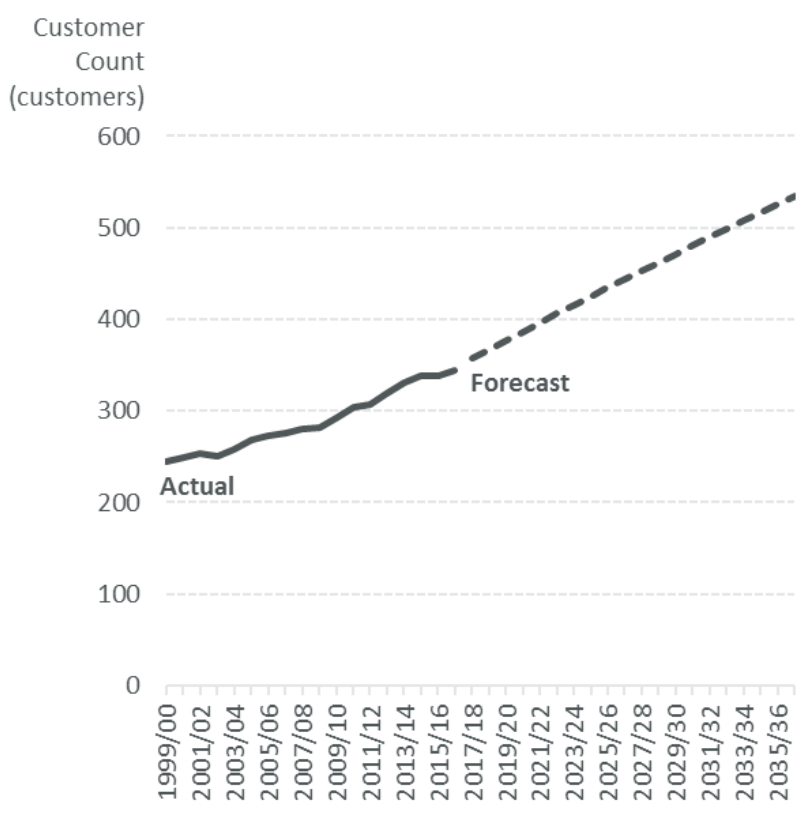


Figure Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 16, Figure 4.

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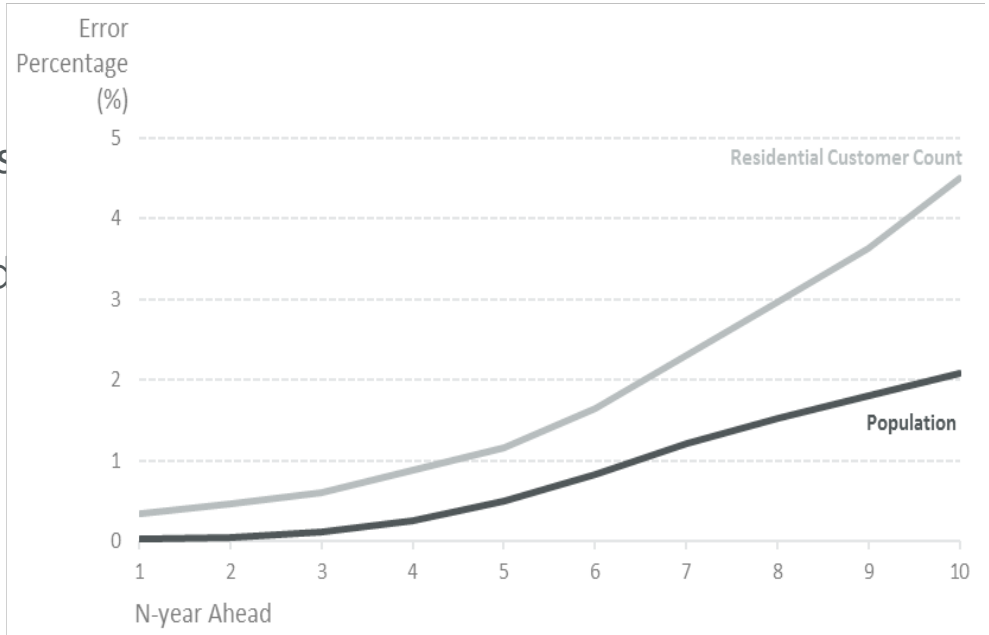
Use of Population Forecast

- Historically, MH's own evaluation of population and residential customer forecasts error analysis shows that MH has typically under-forecasted population values.
- The figure shows that the average percentage error varies, on average, from 0.033% in 1-year ahead comparisons to 2.01% in 10-year ahead forecasts.



- Lower-than-actual customer count and residential customer forecast **result in lower residential and GSMM load forecasts**
- MH mentioned that Manitoba Provincial Nominee Program (MPNP) may have impacted population forecast to be lower than actual. (MH Rebuttal Evidence of Daymark Energy Advisors, Page 20 of 37)

Figure Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 31, Figure 10.

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GS Top Consumers Methodology

- Forecast broken down by time-periods
  1. **Short-term,** customer-level forecast
  2. **Long-term** forecast includes Potential Large Industrial Loads (PLIL)

1. **Short-term, customer-level forecast** is used for the first five years and is based on customer-specific information such as operating plans, including short-term expansion plans or contraction plans.

2. **Long-term forecast** is used for years 6 through 20, which builds on fifth year forecast and includes a growth pattern modeled using PLIL category.
   - The growth regression model is a function of electricity price and blended GDP
   - There is a change in PLIL methodology in 2017 as compared with the method used in 2014

GS Top Consumers Components

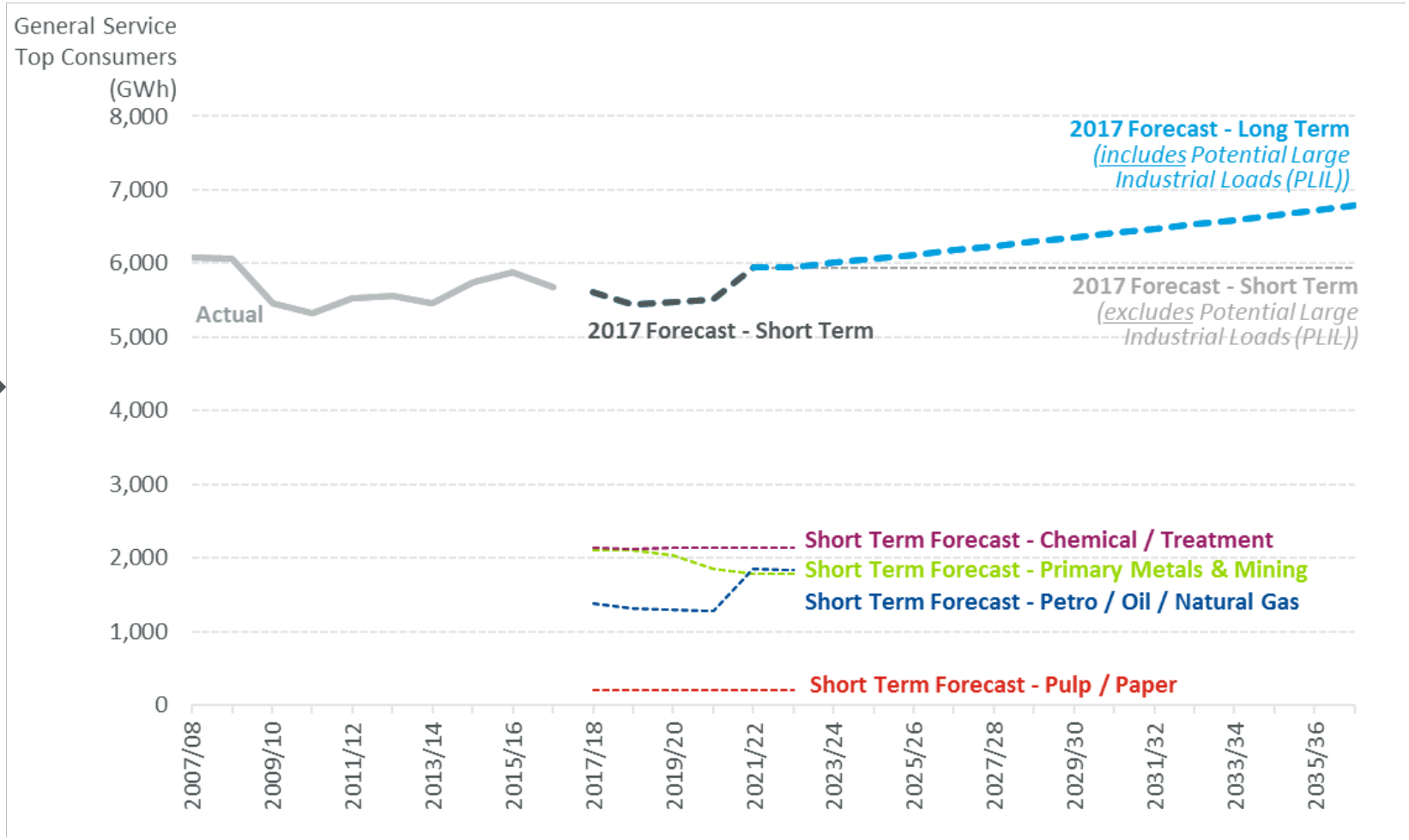

Figure Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 18, Figure 5.

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Use of Conservative PLIL Methodology

- PLIL methodology is used to forecast load changes in the top consumer sector as a whole, over the long-term
- The **2017 PLIL method** used a more conservative approach by **excluding** start-up load of companies that became part of the Top Consumers category after 1983/84
  - In comparison, the **2014 PLIL method** considered historical load of **all customers** that were part of the Top Consumers category
  - The **conservative 2017 PLIL model** did not consider the possibility of new customers joining Top Consumers category in the future; note, three customers joined the group since 1983/84
- Daymark estimated that the new conservative **2017 PLIL method** forecasted **523 GWh less load** than would have been forecasted using the 2014 method over the same forecast period (2017/18 to 2036/37)

PLIL stands for "Potential Large Industrial Loads."

PLIL Methodology on Rebuttal Evidence

- MH discussed that it is reasonable to exclude the start-up load of customers that became part of the Top Consumers category, citing that four of its current ten customers would be part of GS Mass Market with the change in definition of "Top Consumers" customer. (Page 2 of 37)

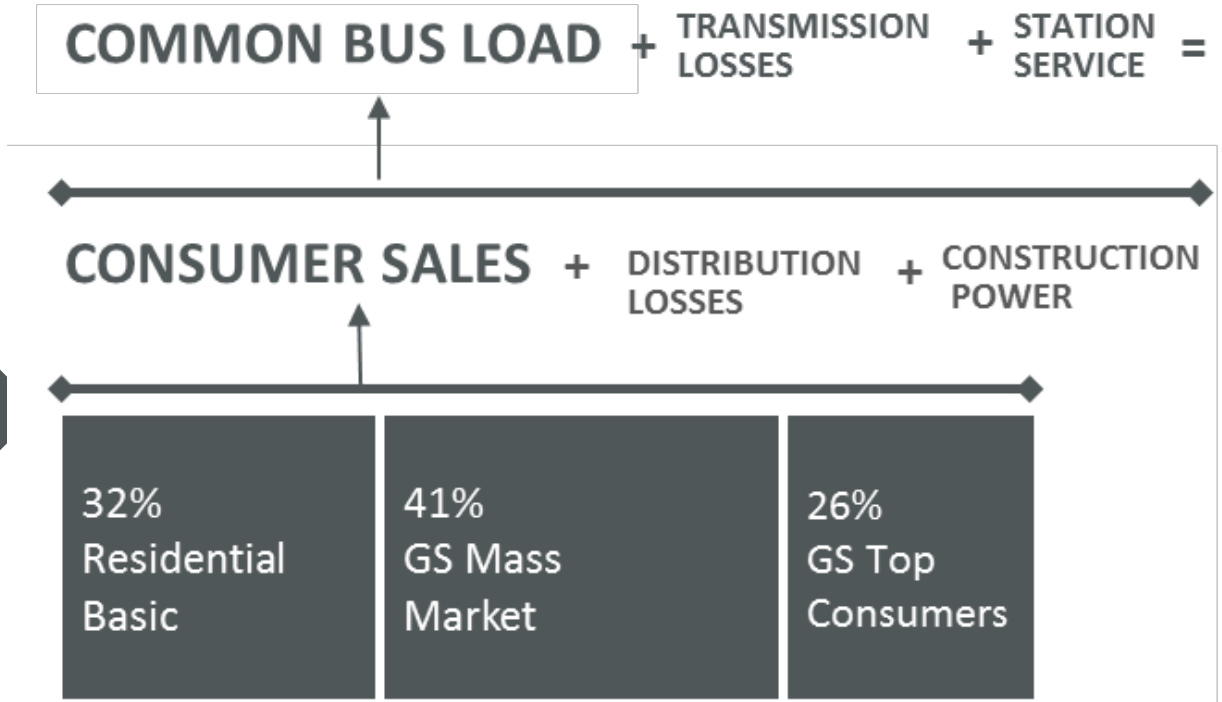
Effect of Proposed Rate Increase on Top Consumers

- The short-term Top Consumers forecasts were created for **each individual customer** using information about their operating plans and short-term expansion/ contraction
- These short-term, individual forecasts **do not consider** potential changes in load in the first five years as a result of the proposed rate increases
- Daymark estimated a **potential reduction of 185 GWh** in the short-term load by using
  1. Price elasticity estimated by MH from PLIL methodology,
  2. Difference between proposed rate in GRA 2017/18 & 2018/19 and previously-proposed 3.95% rate increase (GRA 2015/16 & 2016/17)
  3. Annual short-term Top Consumers load

Potential Fuel Switching by GSMM and Top Consumers

- MH **did not entirely consider** potential substitution effects on load due to the proposed rate increase.
- Fuel switching is considered in the residential sector average usage regression model through use of saturation variable (ratio of electric heat customers to total customers).
  - Note that a natural gas price variable is also used in the forecast of heating system in MH's End-Use forecasting method which is used in MH forecast on a limited basis.
- Fuel switching is not considered explicitly in GSMM and GS Top Consumers sectors load forecast models, which together comprise 68% of total consumer sales in 2016/17.

Sector-level Forecasts to Gross Firm Energy Forecast



Total Consumer sales include an additional 1%, combined, from:

- *Residential Diesel, Seasonal, Flat Water Rate Heating*
- *General Service Diesel, Seasonal, Flat Water Rate Heating, Surplus Energy Program*
- *Lighting*

GROSS FIRM ENERGY

Gross firm energy is then adjusted for **DSM-related energy savings** by subtracting forecasted annual program-based DSM savings.

The DSM-adjusted annual load forecast becomes the **basis for financial analysis to forecast reve**

Figure Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 10, Figure 1. [*emphasis added*]

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Estimation of Gross Peak Demand

- Monthly peak loads are estimated using **monthly gross firm energy** and **monthly load factors**
  - Monthly gross firm energy is calculated using annual Common Bus Load forecasts and the average of historical monthly Common Bus Load percentages as compared to annual load.
  - Load factor is the ratio of average hourly energy usage to the peak hourly load.
- According to a 2010 survey of utility companies' forecasting methods conducted by Itron,
  - 8% of utilities used the method similar to MH.
  - 59% of surveyed companies were using econometric modeling and
  - 26% used load shapes to develop the monthly peaks.

Manitoba Hydro Methods Similar to Industry Practice

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- MH's sector-level, regression model-based load forecast is **consistent with industry practices.**
- Predictor variables used in load forecast models, such as electricity price and economic and demographic variables, are similar to the variables used in other load forecasts in the industry.
- Weather normalization considerations, DSM treatment, electric vehicle adoption are similar to industry practice.
- However, review of Manitoba Hydro's load forecasting process shows that there are **areas where improvement may have an impact on the base load forecast and enhance the load forecasting methodology.**

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Price Elasticities

	PRICE ELASTICITY	REAL INCOME ELASTICITY	REAL GDP ELASTICITY
Residential Basic	-0.28	0.30	
GS Mass Market Small/Medium	-0.13		0.55
GS Mass Market Large	-0.46		0.29
GS Top Consumers	-0.37		0.62
Gross Firm Energy	-0.27	0.10	0.36

- MH price elasticities may be incorrectly estimated even though they are within industry "ranges"
  - **Multicollinearity** is present in Residential Average Usage Models
  - Step-wise regression results show that use of trend and dummy variables may have **suppressed the magnitude of price elasticity**
  - Conservative PLIL method estimated **lower price elasticity** for Top Consumers category than the method used in 2014

Table Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 33, Table 1.

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Scenario Analysis and Informed Sensitivity Analysis

- Manitoba Hydro's base load forecast is a simple point forecast that provides a **single view of the future**
  - Investigating the potential differences that could occur using alternatives, or ranges, affords the utility the ability to plan more effectively by understanding the direction and magnitude of uncertainty around the drivers
- Manitoba Hydro's methodology could use scenario analysis to estimate **alternative load forecast values** by considering different possible trends in key input variables to the base load forecast
  - For example, such scenarios could consider key uncertainties by representing different assumptions for economic and population growth, electricity and fuel commodity prices, and CO_2 prices

Robust Probabilistic Method for Risk Assessment

- Manitoba Hydro's method of considering load forecast uncertainty
  - Evaluating **P10 and P90 levels** of base (P50) load forecast
- Daymark's suggestion is to enhance MH's risk analysis by considering inherent characteristics of key variables using stochastic risk assessments
  - Stochastic risk assessment method would allow MH to estimate potential outcomes by incorporating underlying uncertainties of key input variables

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Weather Normalization Process

- Load forecast is adjusted to reflect what is considered to be **"normal" weather**
- Weather Normalization process occurs in two steps
  - **Step 1:** Estimate the **relationship** between temperature (HDD and CDD) and usage → MH uses two years of data
  - **Step 2:** Determine **weather-dependent load** for a particular year using
    - HDD and CDD relationships with usage (estimated in **Step 1**),
    - The difference between:
      - Particular year's HDD and CDD,
      - "Normal" year's HDD and CDD → MH uses a rolling 25-year average
- Weather-dependent load is subtracted from or added to actual, observed annual load to calculate historical weather-adjusted load, which is used for load forecasting

Weather Normalization Discussion - MH Rebuttal Evidence

- Daymark did not advocate step-wise regression for Weather Normalization, as mentioned in MH Rebuttal Evidence
  (p. 14 of 37, line 28, and p. 15 of 37, line 26)
- The following statements, made in MH Rebuttal, do not have supporting evidence
  - There is no evidence to show that the increase in "*Total kWh/HDD*", as shown in Figure 1.6, using 10 years of historical data would result in lower HDD coefficients
  - It is not clear how lower weather-dependent regression coefficients would under represent weather-related impacts, as mentioned in MH Rebuttal Evidence: "*…lower HDD coefficients would under represent the impact of weather as more customers have chosen to heat their homes with electricity.*" *(p. 17 of 37, lines 6-7)*

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Enhancing the Weather Normalization Process

- Using **more** than two-years of monthly energy and degree days to estimate the **weather-dependent relationship** *(see **Step 1** in slide 35)*
  - Regression models usually produce **robust estimates** when **more data points** are used
- Using a **shorter** period to calculate the "**normal**" **year** weather variables *(see **Step 2** in slide 35)*
  - MH used a 25-year rolling average to get normal year weather parameters for CDD and HDD

DSM Treatment

- MH added back historical DSM savings to the actual measured energy use prior to estimating its average use per customer for residential, GSMM, and top consumers sectors
- Comparing MH's DSM forecasting method to those used by other utilities, a 2013 survey of utility forecasting methods (Itron, 2013 Forecasting Benchmark Survey) found that:
  - **38%** of utilities surveyed subtract DSM savings from their **forecast**
  - **Around 22%** of utilities surveyed estimate a model with historical DSM and then subtract past and future DSM savings. This is the method used by MH.
  - **11%** of those surveyed capture DSM impacts through statistically-adjusted engineering (SAE) model specification

6. Load Forecast Changes (2014 to 2017)

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Comparison between 2014 and 2017 LF Methodology

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- **Most methods are similar** between 2014 and 2017.
- **Key methodology differences** between 2014 and 2017 are:
  1. Models used for forecasting general service mass market customer count is different between 2014 and 2017.
  2. The PLIL method used for capturing long-term forecasts for the top consumers category. The change in 2017 methodology is the primary reason for the difference in gross firm energy forecast estimated in 2014 and 2017.
  3. Economic and population assumptions used in the analysis.
- The 2017 method generated a **lower long-term forecast** than the 2014 method.

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Annual Gross Firm Energy (GWh) Forecast Comparison

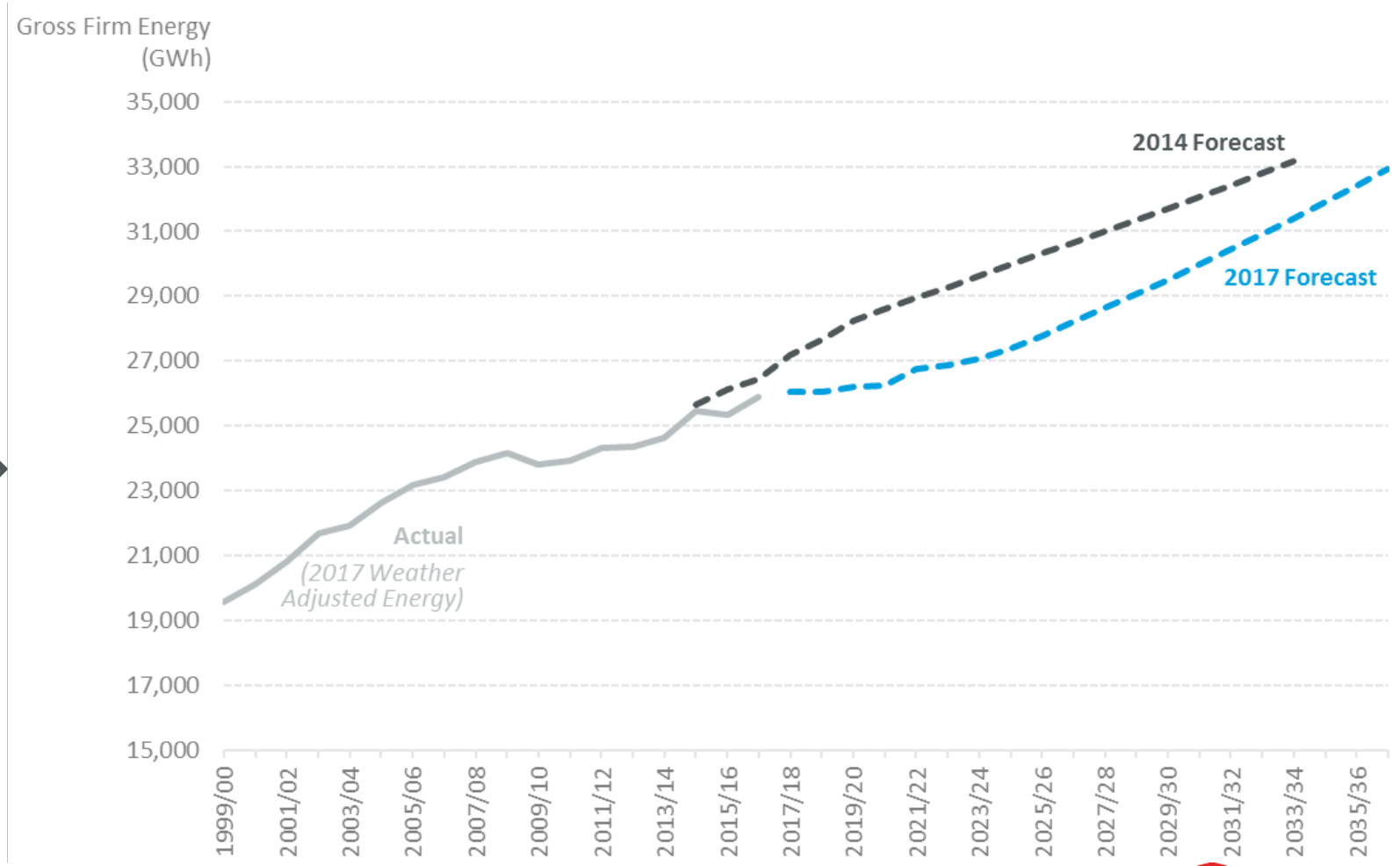

Figure Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 50, Figure 17.

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Annual Gross Total Peak (MW) Forecast Comparison

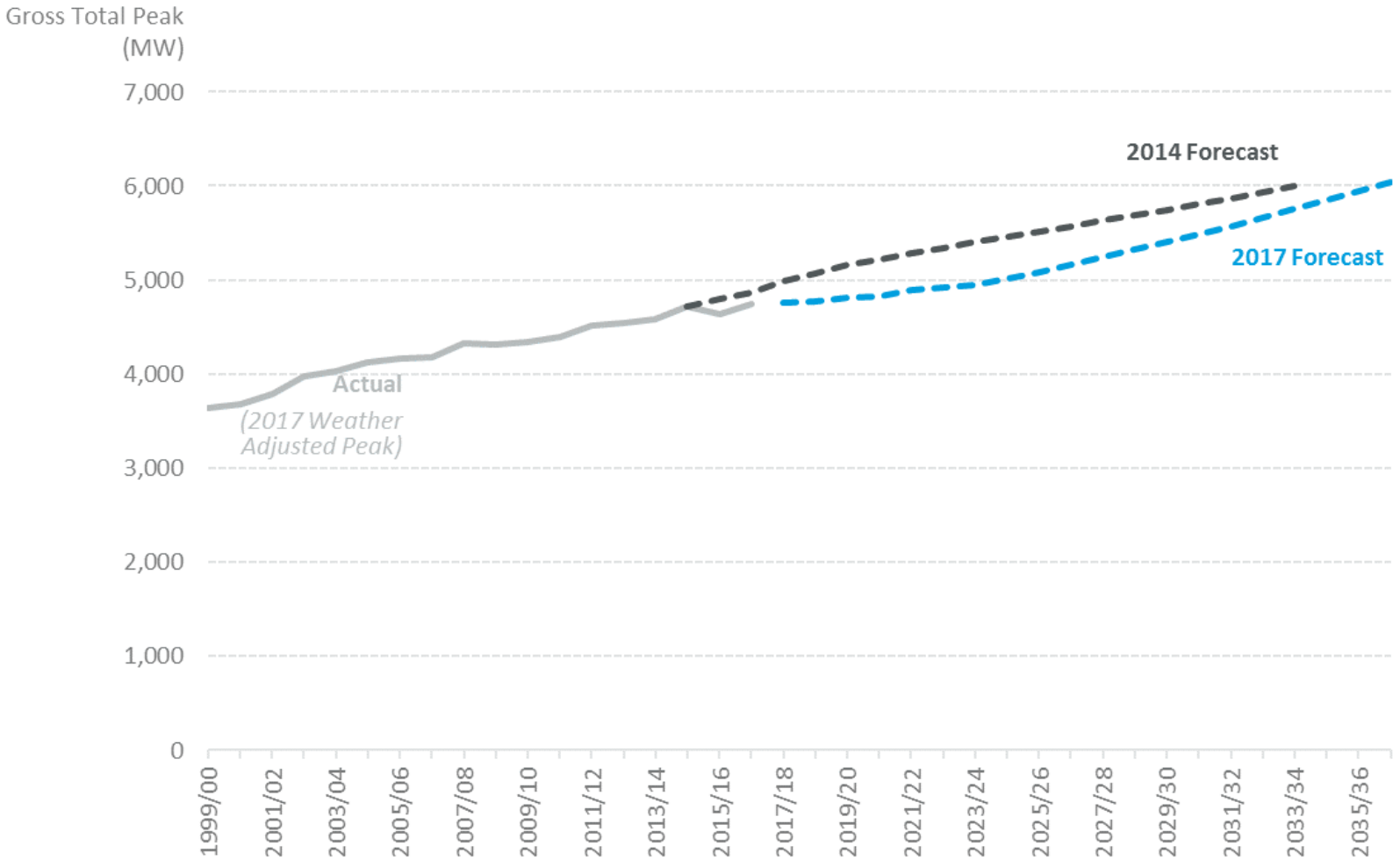

Figure Source: Daymark, "*Independent Expert Consultant Report: Load Forecast Review*," p. 51, Figure 18.

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7. Summary and Conclusions

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MH Load Forecast Methodology

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- **Sector-level forecasts** estimate total annual load, primarily residential, general service mass market, and general service top consumers
- The load forecast models are mainly **econometric, regression analysis-based**
- Manitoba Hydro's load forecast methodologies, which develop its projections of future energy and demand, **are reflective of industry practice**

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Directional Impact on Base Load Forecast

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TOPIC	IMPACT ON LOAD FORECAST
Use of conservative PLIL* methodology	Conservative PLIL method used in 2017 forecasted 523 GWh less load than using the 2014 method and 2017 data over the 20-year forecast period
Use of historically under-forecasted population	Lower-than-actual customer count and residential customer forecast may result in lower residential and GSMM load forecasts
Fuel switching not fully considered	Load forecast may change without considering potential alternative energy source substitution due to the proposed rate increase
Short term impact of rate increase not considered for top consumers	Top Consumer sector could reduce 185 GWh of load in short-term due to proposed rate increase

* PLIL stands for "Potential Large Industrial Loads."

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Key Findings

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- Estimated price elasticity for all three sectors may not be reliable due to
  - **Statistical concerns**
  - **Use of predictor variables**, which may have suppressed price elasticity value as shown by regression model
  - **Use of conservative PLIL methodology**, which has a lower price elasticity than the method used in 2014
- **Process changes will enhance** MH's load forecast methodology
  - Considering **informed sensitivities and scenario analysis**
  - Considering a more robust approach to **understanding load uncertainty** by evaluating inherent characteristics of each fundamental variable with the help of probabilistic (i.e., stochastic) risk assessments
  - **Weather normalization process:** (1) period used for estimating the relationship between weather and usage, and (2) "normal" year weather consideration
  - Explicitly testing and reporting on statistical issues and potential implications

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End of Presentation

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