1 Load Forecast

Report by: C. Kellas

Newfoundland is Canada's easternmost province with a relatively small population of half a million residents. The Newfoundland economy has gone through some difficult times in the 1990's with the closure of the cod fishery and many people seeking out-of-province employment opportunities. Since 2000, the economy has improved significantly with the expansion of the off-shore oil fields and recovery of the inshore fishery. However, the pulp and paper industry has fallen on hard times, which has caused two of the three major mills to close. The economic hardship and recovery are reflected in the historical economic and demographic data.[1]

Newfoundland and Labrador Hydro (NLH) is a crown corporation and subsidiary of Nalcor Energy. NLH has 1,637 MW of installed generating capacity and is the primary generator of electricity in Newfoundland. NLH owns and operates most of the existing generation facilities on the island, but other utility generation and non-utility generation facilities exist and are included in the total interconnected system capabilities that are being reviewed in this project.

NLH currently serves three large industrial customers (a pulp and paper mill in Corner Brook, an oil refinery at Come-by-Chance and a copper mine at Duck Pond) and about 10% of the domestic and general service customers, who generally live in remote or rural areas. NLH also sells power at a wholesale rate to Newfoundland Power (NP), which is the dominant electric retailer on the island. NP is a privately owned electrical utility that distributes electricity to the vast majority (90%) of the island's domestic and general service customers. Since NP services the bulk of the domestic and general service customers, they retain most of the customer billing data. NP conducts customer surveys and load research analysis for their customer base. NP also provides NLH with summarized monthly sales by customer class for the domestic and general service sectors. The conservation demand management (CDM) programs are jointly designed by NP and NLH staff. These programs are available to all Newfoundland customers.

NLH is responsible for producing the long term forecast to assess future generation requirements on the island. NLH does not have access to the majority of customers on the island, which limits the company's ability to conduct detailed end-use analysis of customer billing information. NLH periodically conducts customer survey research of their domestic customer base. In 2010, NLH completed a survey of their domestic customers. In 2006, NLH conducted a two year load research program to measure hourly loads in the domestic and general service sectors.

This review examines the 2010 Planning Load Forecast (PLF) that was prepared by the Market Analysis Section of the NLH System Planning Department. This assessment and report was developed using information obtained during meetings with NLH staff as well as through formal Requests for Information (RFI). The load forecast analysis used information provided in Exhibits 1, 27, 45, 46, 58, 62, 63, 64, and 103, as well as responses to MHI-Nalcor 92 and Nalcor's Final Submission. The material was sufficiently detailed to allow a thorough review and the findings were developed based on complete data provided by NLH.

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[1] Exhibit 45 Rev.1, Nalcor, "Key Regression Equations"

The domestic and general service forecasts are based on econometric equations that are estimated over the 1969-2008 period. The industrial sector forecast is prepared through direct customer contact to assess power requirements on a case-by-case basis. The load forecast is prepared using an iterative process in which the initial forecast is passed through a process of generation expansion, capital, financial and revenue requirement models to determine the future marginal electricity price. The forecast is recalculated on updated marginal price and commercial business investment figures, until the updated load forecast does not substantially change the generation expansion sequence and future capital requirements.

For analytical purposes, the 2010 forecast year was replaced with weather-adjusted actual figures so the analysis could be based on the most current data available. The island load forecast is extended over the 2029-2067 period using an extrapolation of the last five forecast (2024-2029) years. This extrapolation is reduced in five to ten year intervals to reflect the maturing market saturation for electric space heat. The extended forecast will only be reviewed for total island energy requirements and the interconnected island system peak demand requirements.

The load forecasting process was evaluated using criteria that examined the reasonableness of the methodologies and assumptions used to prepare the 2010 PLF. Past forecast performance was measured by examining the accuracy of the last ten forecasts prepared by NLH. The 2001 PLF was compared to actual figures for each year from 2001 to 2010; the 2002 PLF was compared to actual figures for each year from 2002 to 2010, etc. In total, 55 different combinations of forecast value and actual year results were analysed to assess forecast accuracy. The accuracy analysis was conducted for the domestic sector, general service sector, industrial sector, line loss sector, total island energy requirements and interconnected system peak demand.

1.1 Domestic Sector

1.1.1 Overview and Methodology

The domestic sector is comprised of the customers served by NP and the rural customers served by NLH. Electric heat growth is the dominant domestic end-use and a significant factor in the overall island load growth[2]. The space heating market is made up of electricity (60%), oil (25%) and wood (15%). Electric heat and non-electric heat customers consume an average of 19,500 kWh and 9,500 kWh, respectively. During 1980-2000, about 70% of new homes installed electric heat. Since 2000, the new home electric heat saturation has reached 85% due to convenience and increasing oil prices.

The domestic forecast is prepared multiplying an average use forecast by the number of customers forecast. The NP portion of the domestic forecast is prepared through the estimation of two regression equations to predict average use and the number of customers. This methodology is used because the domestic sector is relatively homogeneous, which implies that the average use is representative of all customers in the domestic class. Another two equations forecast the penetration rate of electric space heat for new customers and the conversion rate to electric space heat for existing customers. These

[2] Exhibit 27, Nalcor, "Summary of Newfoundland and Labrador Hydro 2010 Long Term Planning Load Forecast", 2010

equations are used to develop a forecast for the saturation of electric space heat, which is a critical input variable to the NP average use equation.

The NLH portion of the domestic forecast is primarily prepared through the estimation of a regression equation explaining the average use of a rural NLH customer. The average use forecast is multiplied by a NLH customer forecast that is derived from the Department of Finance housing starts forecast.

The regression equations are derived from summarized NP and NLH customer billing data, electricity price data, and economic and demographic data supplied from the Newfoundland Department of Finance and Statistics Canada. Forecast assumptions for economic and demographic variables are prepared by the Department of Finance. The model specification and coefficients for the regression equations are shown in the Forecast Models section 1.10.

1.1.2 Comparison of Historical and Forecast Results

Figure 1 shows that the domestic sector grew rapidly over the 1969-1993 period and remained relatively flat during 1993-1999 due to the economic downturn. Since 1999, the domestic electricity consumption has grown steadily due to increasing levels of housing, income and electric space heat.

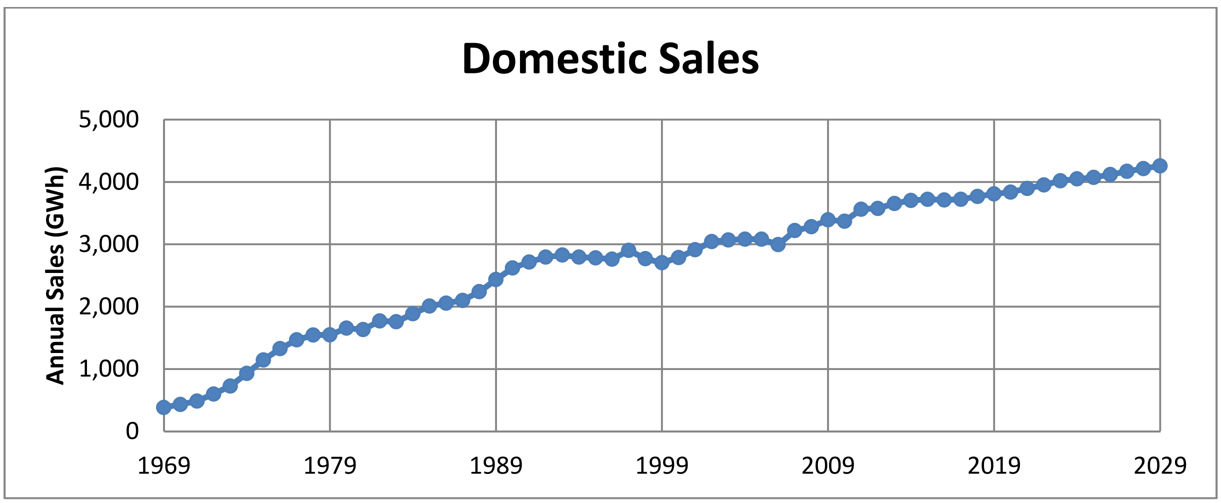

Figure 1: Domestic Energy Sales[3]

Table 1 shows that the domestic electricity forecast increases 38 GWh per year during the forecast period. This growth is 51% lower than the 78 GWh per year experienced in the last 40 years and 39% lower than the 62 GWh experienced in the last decade.

[3] Exhibit 1 - Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"

Table 1: Domestic Energy Growth per Year (GWh)[4]

Domestic Energy Growth Per Year (GWh)		
Last 40 Years	Last 10 Years	2010-2029
78	62	38

The primary components of the domestic forecast are the average use and customer forecasts. Table 2 shows that the average use forecast increases 19 kWh per year over the forecast period, which is 93% lower than the 261 kWh per year experienced in the last forty years and 82% lower than the 106 kWh per year experienced in the last decade. The lower average use forecast is the result of lower electric space heat growth, higher marginal electricity prices and continued efficiency improvement. The electric space heat saturation rate is forecast to increase 0.4% per year during the forecast, which is much lower than the 1.4% increase per year experienced in the last forty years or the 0.8% increase per year experienced in the last decade.

Table 2: Domestic Average Use Growth per Year[5]

Domestic Average Use Growth Per Year (kWh/Customer)		
Last 40 Years	Last 10 Years	2010-2029
261	106	19

Table 3 shows that the customer forecast increases by 2,133 per year. This is 40% below the 3,569 customers per year experienced in the last forty years and 19% below the 2,632 customers per year experienced in the last decade. The lower customer forecast is a result of a lower housing starts forecast provided by the Department of Finance, as shown in the Key Economic Assumptions section 1.7.

Table 3: Domestic Customer Growth per Year[6]

Domestic Customer Growth Per Year		
Last 40 Years	Last 10 Years	2010-2029
3,569	2,632	2,133

[4] MHI derived from Exhibit 1 Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"

[5] MHI derived from Exhibit 45 Rev. 1, Nalcor, "Key Regression Equations"
[6] MHI derived from Exhibit 45 Rev. 1, Nalcor, "Key Regression Equations"

1.1.3 Accuracy and Conclusions

Forecasting an uncertain future is a difficult task. Variation between actual and predicted results must be expected. Experience within the industry and results from Manitoba Hydro[7] and other utilities indicate that a reasonable performance measure for forecast accuracy is to expect a forecast deviation of one percent per year into the future. This means that a ten year old forecast should be within ten percent (plus or minus) of the actual load observed.

Table 4 shows that the domestic forecast meets this requirement because the accuracy level is similar to the age of the forecast (i.e. the number of years ago that the forecast was prepared). Therefore, even though the domestic forecast has consistently under predicted load growth, the forecast has met acceptable levels of accuracy and has performed reasonably well in the past. Based on past forecast performance, lower average use projections, lower customer projections and relatively conservative future assumptions, it is reasonable to assume that the long term domestic forecast will continue to under predict load growth, but at a rate of about one percent per future year.

Table 4: Domestic Energy Forecast Accuracy[8]

Forecast Accuracy Measured in Percentage of Deviation from the Actual Load										
Years of History	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Domestic Accuracy	-1.3%	-2.2%	-3.3%	-3.8%	-4.0%	-4.7%	-5.8%	-6.9%	-7.9%	-10.0%

The main concern is the frequency in which the domestic forecast has under predicted energy consumption. The accuracy analysis compared 55 combinations of forecast value to actual year-end sales. The results showed that in 53 of the 55 cases, the domestic forecast was low. This bias would indicate that the load is growing for reasons not identified in the model (i.e. other end-uses, not just electric space heating) and/or that the assumptions driving the model are consistently conservative. Virtually all growth in the domestic average use model is attributable to electric space heat and other end uses are not specifically identified or forecast to grow within the current modeling framework. The domestic forecast regression models do not have the explanatory power of end-use analysis.

End-use models are based on detailed customer billing and survey analysis. End-use models are calculated using a bottom up approach, meaning that the forecast is calculated by summing up the energy associated with each of the major domestic end-uses. A good end-use forecast would estimate the domestic energy requirements associated with specific end-uses such as: electric space heat, electric water heating, fridges, stoves, washers, dryers, dishwashers, televisions, personal computers and lighting, plus a miscellaneous component to represent all other electrical uses.

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[7] www.hydro.mb.ca/regulatory_affairs/electric/gra_2010_2012/Appendix_62.pdf (Pages 55 and 56)
[8] MHI derived from Exhibit 46, Nalcor, "PLF Key Forecast Units for Island Interconnected Systems 2001 - 2010" and Exhibit 64, Nalcor, "Actual NLH Rural Island Interconnected Loads and Customers"

The domestic sector represents about 50% of all electricity sales on the island; therefore the significance of the domestic load makes end-use modeling desirable for this sector. The recommendation to develop an end-use forecasting methodology for the domestic sector is primarily based on the ability of end-use models to quantify load growth by end-use, quantify energy-efficiency by end-use, incorporate new end-uses (e.g. electric cars), improve the design of CDM programs and improve the defensibility of the load forecasting process. Although the additional detail required to prepare an end-use forecasting methodology may likely improve forecast accuracy, increased accuracy is not guaranteed because any forecast is dependent on the accuracy of the assumptions on which it is based.

In summary, the domestic forecast methodology is acceptable, but does not meet the requirement of utility best forecast practice for this sector. The domestic forecast is entirely prepared using econometric modeling techniques. The domestic forecast model is primarily driven by electric space heat. Best utility practices would incorporate end-use modeling techniques into the forecasting process, so that electricity growth can be quantified for all major domestic end-uses of electricity.

1.2 General Service Sector

1.2.1 Overview and Methodology

The general service sector is also comprised of the customers served by NP and the rural customers served by NLH. Electric space heating is the most important component of this sector. The general service forecast is prepared through the estimation of four sub-groups: NP electric heat, NP small non-electric heat, NP large non-electric heat and NLH rural, which is primarily heated by electricity. The NP electric heat group is the most important sector, representing 54% of the total general service sales[9]. The NP electric heat and NLH rural groups are forecast using regression equations that predict total energy consumption. Average use is not forecast because the general service sector is comprised of many different business types (e.g. small industrials, offices, schools, hospitals, grocery stores, retail stores, restaurants, etc.) with significantly different usage patterns. The regression equations are derived from summarized customer billing data and economic data supplied by Statistics Canada, investment data supplied by the Department of Finance and furnace oil price data supplied by PIRA. The model specification and coefficients for the regression equations are shown in the Forecast Models section 1.10.

The NP forecast also consists of small non-electric and large non-electric groups. These groups are assumed to remain at constant levels of 300 GWh and 585 GWh, respectively, throughout the forecast period.[10]

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[9] MHI derived from Exhibit 46, Nalcor, "PLF Key Forecast Units for Island Interconnected Systems 2001 - 2010" and Exhibit 64, Nalcor, "Actual NLH Rural Island Interconnected Loads and Customers"
[10] Exhibit 46, Nalcor, "PLF Key Forecast Units for Island Interconnected Systems 2001-2010"

1.2.2 Comparison of Historical and Forecast Results

Figure 2 shows that the general service sector grew rapidly over the 1970-1990 period and remained relatively flat during the 1990's, as GDP and commercial business investment stalled. Since 1999, the general service load has grown at a steady, slow rate due to increasing levels of construction activity, GDP, commercial business investment and furnace oil prices, which make electric heat more desirable.

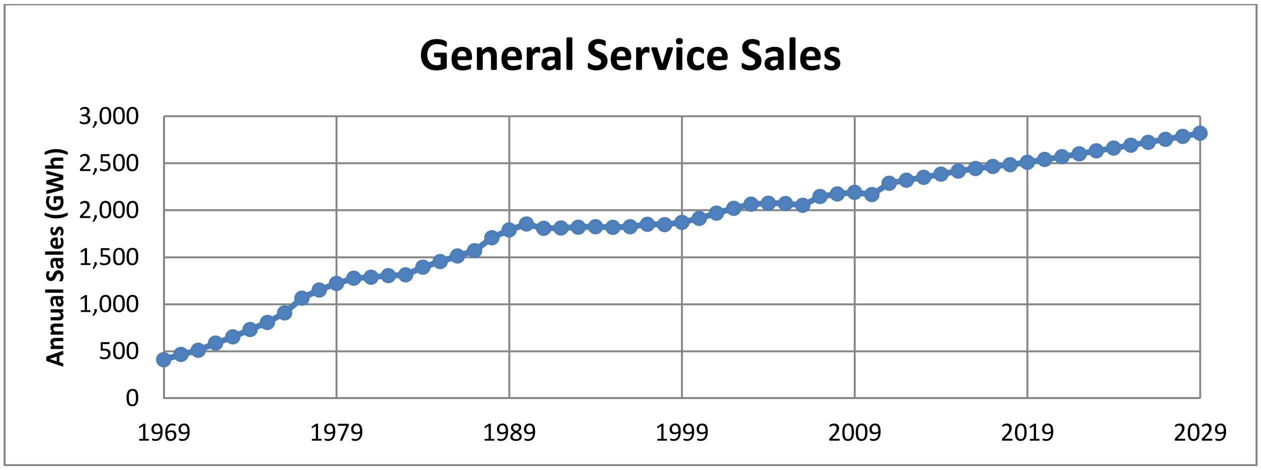

Figure 2: General Service Sales[11]

Table 5 shows that general service electricity consumption is forecast to increase 32 GWh per year. Forecast growth is 27% lower than the 44 GWh per year experienced over the last forty years or 23% higher than growth experienced in the last decade. The general service forecast is primarily based on slower levels of gross domestic product (GDP) growth and higher levels of commercial business investment growth provided by the Department of Finance and are shown in the Key Economic Assumptions section 1.7.

Table 5: General Service Energy Growth per Year (GWh)[12]

General Service Energy Growth per Year (GWh)		
Last 40 Years	Last 10 Years	2010-2029
44	26	32

1.2.3 Accuracy and Conclusions

Table 6 shows that the forecasting methodology for the general service sector has produced remarkably good results. Regression modeling and linear extrapolation techniques have worked extremely well. Implementation of an end-use forecasting model for the general service sector is not recommended at this time because the current models are performing very well and the additional allocation of resources required to implement an end-use methodology could not be justified based

[11] MHI derived from Exhibit 1 Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"
[12] MHI derived from Exhibit 1 Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"

on improvement in forecast accuracy. The complexity and diversity of the building stock make end-use modeling of the general service sector a difficult task. NLH should focus on developing an end-use model for the domestic sector, which represents a larger proportion of the load.

Table 6: General Service Energy Forecast Accuracy[13]

Forecast Accuracy Measured in Percentage of Deviation from the Actual Load										
Years of History	1	2	3	4	5	6	7	8	9	10
General Service Accuracy	-0.1%	0.0%	0.0%	0.1%	0.3%	0.4%	0.4%	1.0%	2.0%	6.0%

In summary, the general service forecast methodology is based on a combination of regression modeling and linear extrapolation techniques that have performed extremely well in the past. The general service forecast has produced accuracy levels within 1 to 2%, as far as eight to nine years into the future. The general service forecasting process is relatively unbiased. Under prediction of actual weather-adjusted energy consumption occurred 24 times and over prediction occurred 31 times of the 55 cases examined. NLH should continue using the current general service forecasting methodology.

1.3 Industrial Sector

1.3.1 Overview and Methodology

The industrial sector consists of only three existing large industrial customers: a pulp and paper mill in Corner Brook, an oil refinery at Come-by-Chance and a copper mine at Duck Pond. Contractual arrangements have been made to supply electric power to the new Vale hydrometallurgical processing plant being constructed at Long Harbour. The industrial forecast is prepared on an individual, case-by-case basis, with direct customer contact concerning future operational plans.

This forecast assumes that the pulp and paper mill and oil refinery will continue at current operational levels throughout the forecast horizon. The copper mine is forecast to cease operation in 2013. The load forecast includes new load based on contractual arrangements with Vale, which will be staged in over the 2013-2015 period. The industrial forecast does not include any further large customer additions throughout the forecast horizon. Conversely, the long term forecast does not include a probability for the potential closure of industrial customers.

The principal risk in the forecast is the long term viability of the pulp and paper mill. If the Corner Brook mill closes, there will be a large gap created between excess supply and demand. In the long

[13] MHI derived from Exhibit 46, Nalcor, “PLF Key Forecast Units for Island Interconnected Systems 2001 - 2010” and Exhibit 64, Nalcor, “Actual NLH Rural Island Interconnected Loads and Customers”

term, this gap will diminish as new industrial loads potentially locate on the island throughout the forecast horizon. The original load forecast covers a twenty year period and is extended out to 2067. Unforeseen events can and likely will happen during the forecast period and beyond.

1.3.2 Comparison of Historical and Forecast Results

Figure 3 shows that the industrial sector grew rapidly over the 1975-1984 period and fluctuated, but remained relatively constant throughout 1984-2005. Since 2005, the industrial load has declined sharply due to the closure of two Abitibi pulp and paper mills at Stephenville (2006) and at Grand Falls (2009).

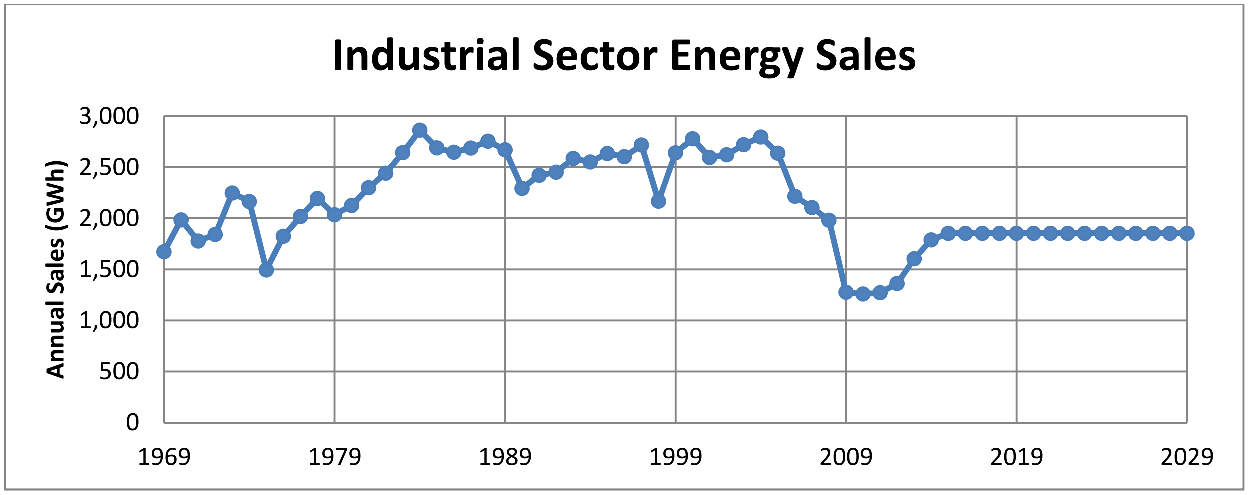

Figure 3: Industrial Sector Energy Sales[14]

Table 7 shows that the industrial forecast predicts that electricity consumption will grow 31 GWh per year. This growth is specifically associated with the Vale hydrometallurgical load coming online during the 2013-2015 period. The load remains constant after 2015. Industrial consumption decreased an average of 152 GWh per year in the last decade, primarily due to pulp and paper mill closures.

Table 7: Industrial Energy Growth per Year (GWh)[15]

Industrial Energy Growth Per Year (GWh)		
Last 40 Years	Last 10 Years	2010-2029
-18	-152	31

1.3.3 Accuracy and Conclusions

Table 8 shows that the industrial forecast has consistently over predicted load growth by a considerable amount, resulting from unanticipated mill closures.

[14] Exhibit 1 Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"
[15] MHI derived from Exhibit 1 Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"

Table 8: Industrial Energy Forecast Accuracy[16]

Forecast Accuracy Measured in Percentage of Deviation from the Actual Load										
Years of History	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Industrial	5%	14%	27%	37%	50%	67%	76%	92%	119%	124%

The customer specific methodology used to prepare the industrial forecast is reasonable, but in hindsight, the assumption of continued operation of the pulp and paper industry was too optimistic and has caused problems that have affected overall forecast accuracy. A method to potentially improve the industrial forecast accuracy could be to assign a probability of operation to the large industrial loads. This probability could increase or decrease over time, depending on the likelihood of expansion or contraction of business operations in the future. However, this may be difficult to implement given the limited size of the industrial customer base.

If the pulp and paper facility at Corner Brook stays operational throughout the forecast horizon, the industrial forecast should be about 90 GWh low, because the ongoing customer consultation process has recently upgraded consumption estimates of the Vale hydrometallurgical processing plant by 90 GWh. In the longer term, the industrial forecast runs the risk of being too low because no new industrial loads are forecast for the entire review period to 2067. Any new industrial load would increase industrial consumption above forecast levels.

If the Corner Brook operation closes, then the load forecast will be too high and the forecast errors of the past will be replicated. In the long term, it is likely that new potential industrial loads will eventually replace the load lost due to a Corner Brook closure. Any scenario that includes the closure of the pulp and paper mill will have to be evaluated in a sensitivity analysis because the facility is the island's largest customer and consumes a significant portion of all the electric generation on the island. The amount of variability due to potential industrial load changes is high and impacts the results of the cumulative present worth (CPW) analysis.

1.4 Line Losses and Other Loads

1.4.1 Overview and Methodology

This sector includes street lighting, distribution losses, transmission losses and company use. It represents 8% of the total island energy requirements.[17] Transmission and distribution losses comprise the majority of this sector's load. These losses increase proportionally as sales in the domestic, general service and industrial sectors increase. Distribution and transmission losses are forecast as a

[16] MHI derived from Exhibit 46, Nalcor, "PLF Key Forecast Units for Island Interconnected Systems 2001 - 2010"
[17] MHI derived from Exhibit 58, Nalcor, "Total Island Interconnected Load"

percentage of sales. Street lighting and company use are assumed to remain constant throughout the forecast period.

1.4.2 Comparison of Historical and Forecast Results

Figure 4 shows that the loss sector grew slowly in the 1989-2005 period. Actual line losses will vary based on the frequency and severity of outages and the proximity of generation to load centers. It should be noted that the forecast for transmission line losses is based on historical loss percentages.

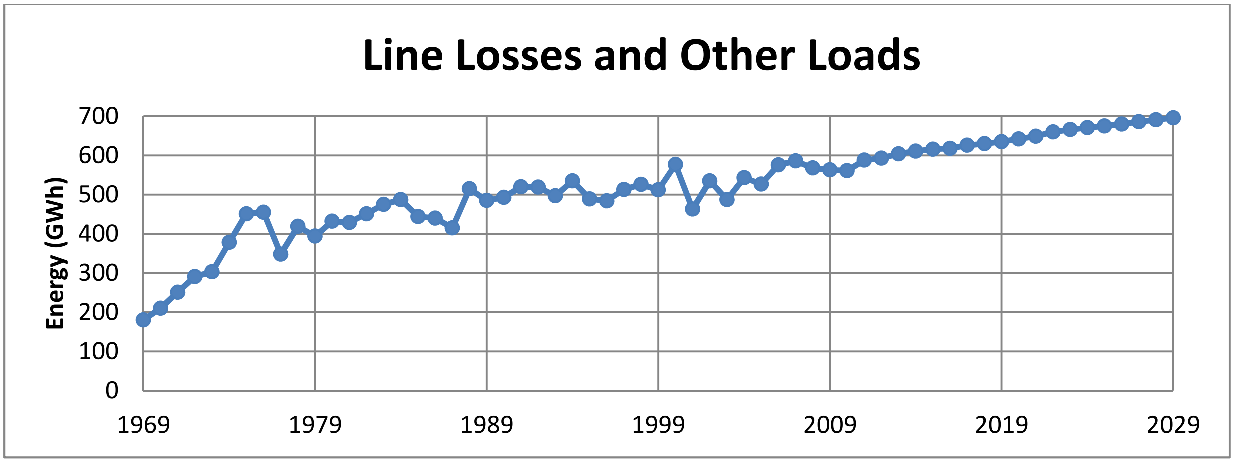

Figure 4: Other Load Forecast[18]

Table 9 shows that this sector is forecast to increase 6 GWh per year. Forecast growth is similar to the growth experienced in the last forty years.

Table 9: Line Losses & Other Loads Growth per Year (GWh)[19]

Line Losses & Other Loads Growth Per Year (GWh)		
Last 40 Years	Last 10 Years	2010-2029
9	0	6

1.4.3 Accuracy and Conclusions

Table 10 shows that the forecast methodology used to prepare the line losses and other loads forecast has produced reasonable results. Forecast accuracy results vary due to fluctuations in actual year-to-year line losses.

[18] MHI derived from Exhibit 1 Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"
[19] MHI derived from Exhibit 1 Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"

Table 10: Line Losses & Other Loads Energy Forecast Accuracy[20]

Forecast Accuracy Measured in Percentage of Deviation from the Actual Load										
Years of History	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Line Losses & Other Loads	-2.5%	-3.8%	-4.5%	-6.2%	-6.6%	-6.7%	-5.6%	-4.6%	-3.4%	-4.1%

1.5 Total Island Energy Requirements

1.5.1 Overview and Methodology

The total island energy requirements forecast is calculated by summing the domestic, general service, industrial and line loss forecasts.

1.5.2 Comparison of Historical and Forecast Results

Figure 5 shows that the domestic and general sectors have grown steadily throughout the historical period, except for the economic slowdown of the 1990's. Figure 5 also shows the decline in the industrial sector due to the pulp and paper mill closures in 2006 and 2009. Steady growth is expected in the domestic and general service sales. The Vale expansion stimulates growth in the 2013-2015 period.

[20] MHI derived from Exhibit 46, Nalcor, "PLF Key Forecast Units for Island Interconnected Systems 2001 - 2010", Exhibit 64, Nalcor, "Actual NLH Rural Island Interconnected Loads and Customers", and Exhibit 103, Nalcor, "Island Interconnected Requirments – Actual and Forecast"

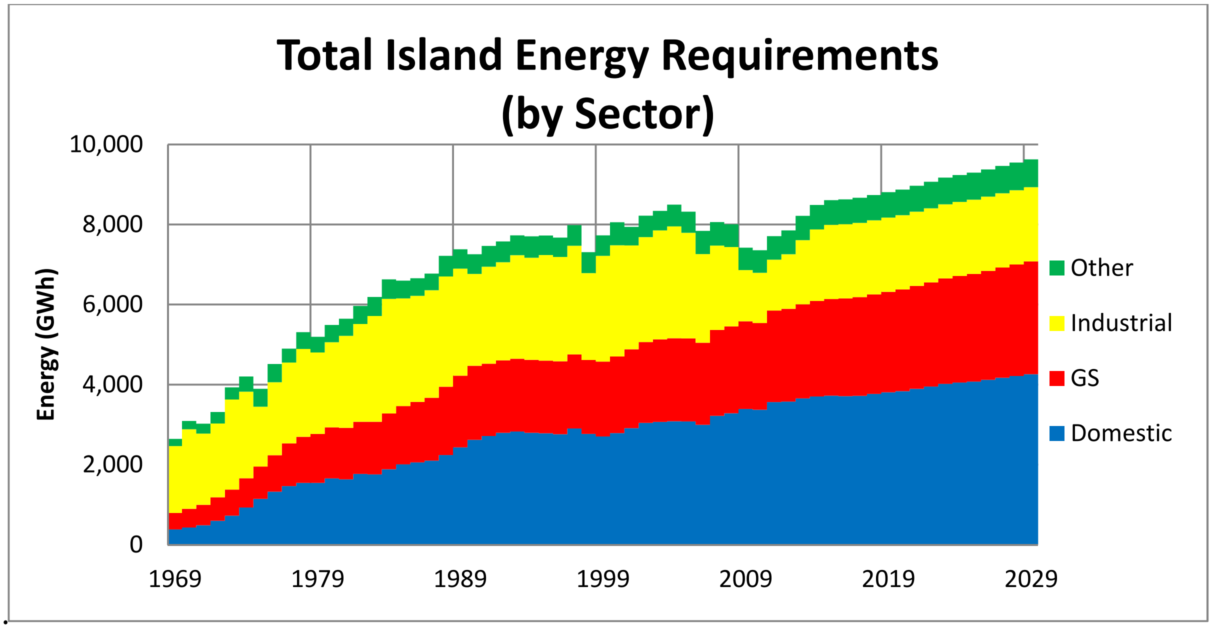

Figure 5: Total Island Energy Forecast by Sector[21]

Figure 6 shows the total island energy requirements forecast over the extended period of time. The extended forecast (2029-2067) is based on an extrapolation of the last five years (2024-2029) of the 2010 Planning Load Forecast.

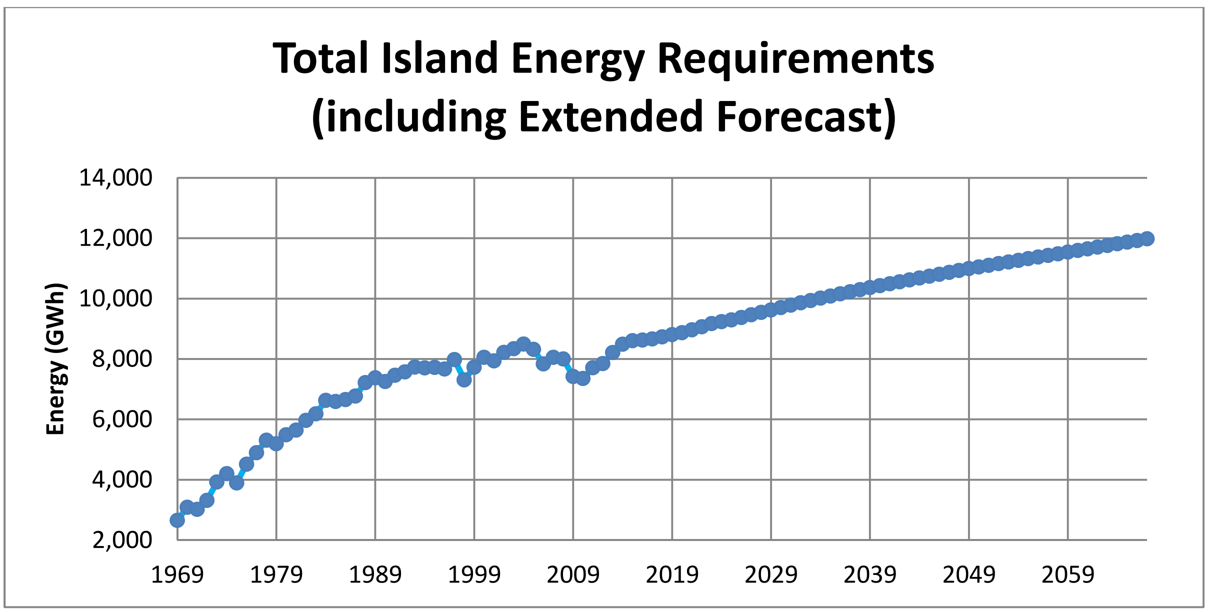

Figure 6: Total Island Energy Requirements to 2067[22]

[21] MHI derived from Exhibit 1 Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"

[22] Exhibit 1 Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"

Table 11 shows that the total island energy requirements decreased 63 GWh per year in the last decade. Total island energy requirements are forecast to increase 106 GWh per year in the 2010-2029 forecast period, which is 6% lower than the 113 GWh growth experienced in the last forty years. The lower load growth is primarily due to the lower domestic energy forecast. Total island energy requirements are forecast to increase 62 GWh per year over the extended period. The extended load growth is 45% lower than the growth experienced in the last forty years and 42% lower than the growth expected in the first forecast period (2010-2029). The lower growth in the extended period is a result of no industrial load increase and limited electric space heating growth in the domestic and general service sectors.

Table 11: Total Island Energy Growth per Year (GWh)[23]

Total Island Energy Growth Per Year (GWh)			
Last 40 Years	**Last 10 Years**	**2010-2029**	**2029-2067**
113	-63	106	62

1.5.3 Accuracy and Conclusions

Table 12 shows that in the last ten years, the total island energy requirements forecast has significantly over predicted load growth. The vast majority of the forecast deviation can be associated with the industrial forecast. Previous load forecasts assumed that the pulp and paper industry would continue operations at normal energy consumption levels, without any mill closures. The loss of load associated with the two pulp and paper mills caused an adverse effect on the overall forecast accuracy results.

Table 12: Total Island Energy Forecast Accuracy[24]

Forecast Accuracy Measured in Percentage of Deviation from the Actual Load										
Years of History	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Island Energy	0.4%	1.9%	3.7%	5.5%	7.9%	10.6%	11.4%	13.3%	16.6%	17.4%

Table 13 shows that the total island energy requirements forecast would have been exceptionally accurate, if the timing and magnitude of mill closures were accurately predicted in the previous load forecasts. For the purpose of this analysis, load forecasts prepared before 2006 were reduced by a maximum of 1,100 GWh and load forecasts prepared from 2006-2009 were reduced by a maximum of 600 GWh.

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[23] MHI derived from Exhibit 1 Addendum, Nalcor, "Planning Load Forecast Outline and Tables", and Exhibit 58, Nalcor, "Total Island Interconnected Load"
[24] MHI derived from Exhibit 103, Nalcor, "Island Interconnected Requirments – Actual and Forecast"

Table 13: Total Island Energy Forecast Accuracy Adjusting for Mill Closures[25]

Forecast Accuracy Measured in Percentage of Deviation from the Actual Load										
Years of History	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Island Energy	-1.2%	-1.4%	-0.8%	-0.6%	-0.3%	1.0%	1.0%	1.5%	2.0%	2.9%

1.6 System Peak

1.6.1 Overview and Methodology

The system peak is the maximum hourly demand placed on the interconnected island system. This maximum load is usually reached at 5:00-6:00 PM on a very cold winter day. The interconnected system peak demand forecast is prepared by estimating four peak demand forecast sub-groups: NP peak demand, NLH rural peak demand, industrial demand and NLH transmission peak demand.

The NP peak demand is the most important component of the peak forecast and is estimated using a regression equation. The model specification and coefficients for the regression equation is shown in the Forecast Models section 1.10. Since the NP peak forecasting methodology is prepared separately (i.e. separate regression equation) from the NP sales forecast, an adjustment is made to the NP peak forecast to ensure that changes to the NP load factor occur in a smooth and consistent basis. The results from the NP forecasting model were increased by 2.5 MW per year for each forecast year, which translates to a 50 MW increase over the twenty year forecast. This adjustment is based on the assumption that peak efficiency improvements will be 30% more difficult to achieve in the future because the most cost-effective improvements have already been done.

The NLH rural peak demand, industrial peak demand and NLH transmission peak demand forecasts are prepared by applying historical coincident load factors to the energy consumption forecast associated with each of these groups. The interconnected system peak demand forecast is prepared by adding the four peak forecasts together.

1.6.2 Comparison of Historical and Forecast Results

Figure 7 shows that the interconnected island peak demand grew rapidly over the 1970-1990 period as the NP electric heat saturation rate increased from 4% to 48%. The peak remained relatively constant throughout the 1990's as electric heat growth was offset by economic stagnation. When the economy recovered, the peak started to grow again, until the two mill closures in 2006 and 2009.

Figure 7 also shows that the NP peak forecast is the most significant (80%) contributor to the interconnected island system peak forecast and has accounted for almost all of the peak load growth

[25] MHI derived from Exhibit 103, Nalcor, "Island Interconnected Requirments – Actual and Forecast" and includes two plant closure assumptions

since 1999. The vast majority of the peak load growth (excluding the Vale expansion), is expected to come from the NP service area.

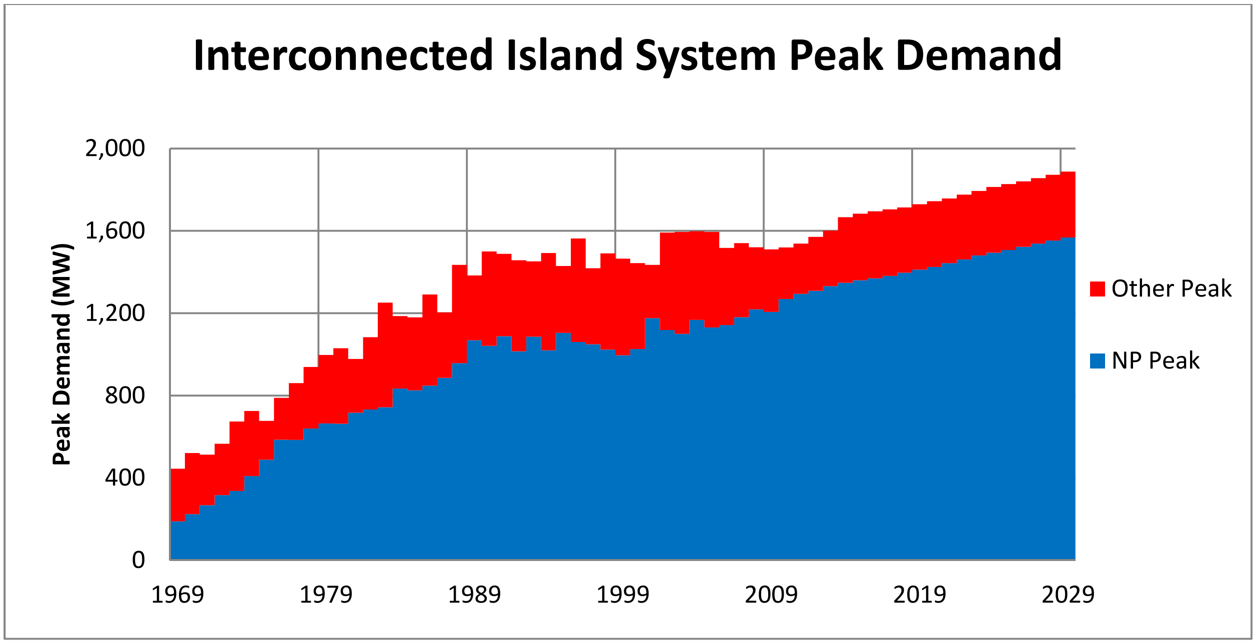

Figure 7: Interconnected Island Peak Demand[26]

Figure 8 shows the interconnected island peak forecast over the extended period of time. The extended forecast (2029-2067) is based on an extrapolation of the last five years (2024-2029) of the 2010 Planning Load Forecast.

[26] Exhibit 1, Nalcor, "NLH 2010 Planning Load Forecast (PLF) for the Island Interconnected System", Exhibit 45 – Rev. 1, Nalcor, "Key Regression Equations" and Response to RFI MHI-Nalcor-92

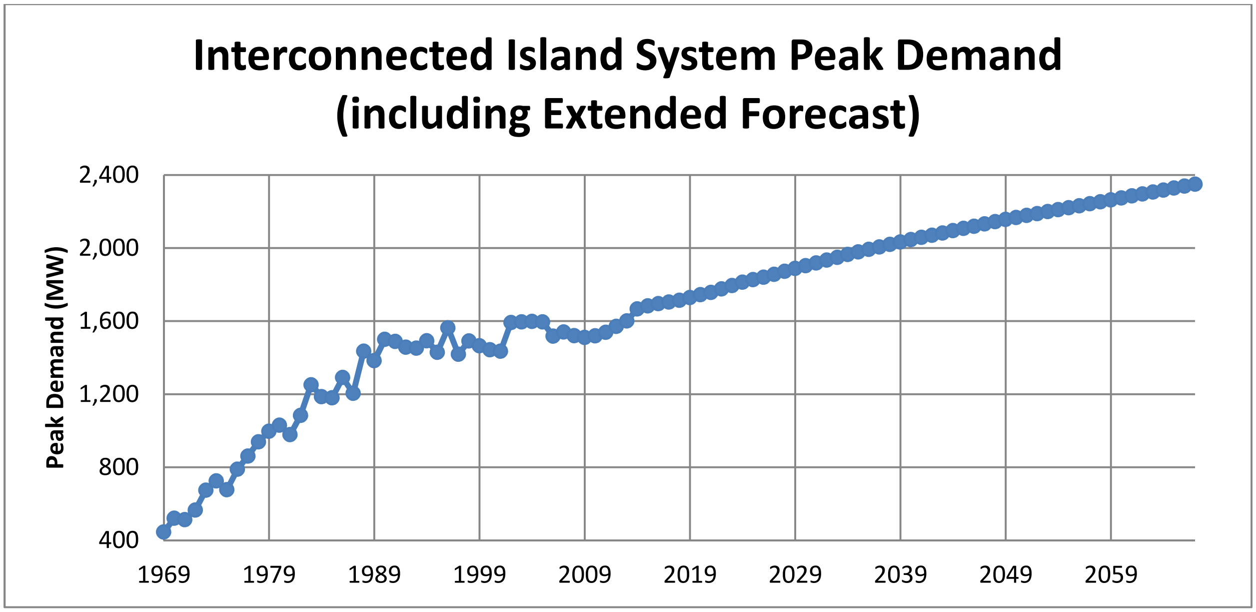

Figure 8: Interconnected Island Peak Demand to 2067[27]

Table 14 shows that the interconnected island peak load is forecast to increase 20 MW per year in the 2010-2029 forecast period. This growth is 20% lower than the 25 MW per year experienced in the last forty years. The forecast drops to 12 MW per year in the extended forecast period, which is 52% lower than the growth experienced in the last forty years.

Table 14: Interconnected System Peak Demand Growth Per Year (MW)[28]

Interconnected System Peak Demand Growth Per Year (MW)			
Last 40 Years	Last 10 Years	2010-2029	2029-2067
25	7	20	12

1.6.3 Accuracy and Conclusions

Table 15 shows that in the last ten years, the NP system peak demand forecast has performed exceptionally well. The "other" peak category includes peak demands associated with the NLH rural system, the NLH industrial customers and the NLH transmission system. The "other" peak and interconnected island peak forecasts have been adversely affected by the pulp and paper mill closures.

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[27] Exhibit 1, Nalcor, "NLH 2010 Planning Load Forecast (PLF) for the Island Interconnected System", and Response to RFI MHI-Nalcor-92

[28] MHI derived from Exhibit 1, Nalcor, "NLH 2010 Planning Load Forecast (PLF) for the Island Interconnected System", and Response to RFI MHI-Nalcor-92

Table 15: Interconnected System Peak Demand Forecast Accuracy[29]

Forecast Accuracy Measured in Percentage of Deviation from the Actual Load										
Years of History	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
NP Peak	2.1%	0.7%	1.0%	0.6%	1.0%	1.2%	1.3%	0.6%	0.2%	2.5%
Other Peak	-3.5%	-0.5%	5.3%	11.3%	15.7%	25.8%	28.1%	37.1%	43.8%	73.7%
Island Peak	0.6%	0.3%	1.8%	2.8%	4.1%	6.4%	6.8%	8.0%	8.6%	15.3%

Although the regression-based peak forecasting methodology has performed very well in the past, there is a possibility that continuation of this methodology may lead to under forecasting the peak in the future.

The electric space heat end-use has a very low load factor (probably in the range of 35-40% in Newfoundland), so the system load factor should decrease as electric space heating represents a larger proportion of the total island energy requirements. Since 1990, the overall system load factor has changed very little, fluctuating around 60%, even though the number of electric space heating customers has risen dramatically and the high load factor industrial load has declined sharply.

The peak forecasting adjustment assumes that the rate of technological change will continue at a rate of 30% lower in the future. This may not be enough of a reduction. If future efficiency gains from the existing building stock shell improvements (e.g. insulation upgrades, EE windows, caulking, etc.) become even more difficult to achieve, then the rate of future technological change could diminish more than 30%. This would have the effect of increasing the peak forecast (i.e. technological improvements reduce peak requirements). The key point is that the continued addition of electric space heating load should have the effect of lowering the future system load factor more than the current forecasted level of 58%.

The main concern with this methodology is that the system peak is being calculated separately from the energy portion of the forecast. This makes it necessary to calculate adjustments to the peak in order to ensure consistency with the energy growth and produce a smooth load factor for the island. The system peak forecasting methodology could be improved by incorporating domestic, general service, industrial and end-use (e.g. space heating) load research information into the forecasting process to develop an integrated energy and peak forecasting methodology. NLH staff should partner with Newfoundland Power to develop a coordinated load research program that is designed to develop load shape information by sector and by end-use. Sector or end-use energy forecasts could be distributed on an hourly basis throughout the year, using the hourly load shape profiles developed from the load research information. These hourly load forecasts could then be added together to produce an hourly forecast model for the interconnected system.

[29] MHI derived from Exhibit 46, Nalcor, “PLF Key Forecast Units for Island Interconnected Systems 2001 - 2010”, and Exhibit 103, Nalcor, “Island Interconnected Requirments – Actual and Forecast”

1.7 Key Economic Assumptions

Key economic and demographic assumptions provided by the Department of Finance (DOF) form the basis on which the domestic and general service forecasts are developed. A regression-based forecast can only be as good as the assumptions on which they are developed.

Table 16 shows that most of the key factors (i.e. income, population, housing, GDP) are assumed to grow at a significantly lower rate than experienced over the last ten or forty years. Using the personal disposable income (PDI) variable as an example, the line entitled "Forecast/Last 10" is derived by dividing the PDI Forecast value ($118) by the PDI Last 10 value ($241), which equals 49%. Thus, the forecast is assuming that PDI will grow at a much slower rate (49%) than it has in the last ten years.

The forecast assumptions of PDI, income, population and housing are all used in the domestic forecast models and contribute to the relatively conservative domestic forecast. The forecast assumption of GDP and commercial business investment are used in the general service forecast models and produce a good forecast.

Table 16: Key Economic and Demographic Assumptions[30]

History	Personal Disposal Income 2002$	Personal Income 2002$	Pop.	Housing Starts	Adjusted GDP 2002$	Commercial Business Investment 2002$
Last 10 Years	$241	$269	-2,443	2,467	$259	$340
Last 40 Years	$181	$235	-344	2,937	$233	$290
Forecast	$118	$147	-110	2,275	$151	$425
Forecast/Last 10	49%	55%	5%	92%	58%	125%
Forecast/Last 40	65%	62%	32%	77%	65%	147%

1.8 Conservation in the Load Forecast

It should be noted that the domestic forecast does not include any specific, exogenous adjustment for specific Conservation Demand Management (CDM) programs. The NLH method of capturing and estimating CDM effects is through the technological change variable contained in the regression equations.

For the NP domestic sector the technological change variable has a -35.37 coefficient, see the Forecast Models section 1.10. This means that the average use is forecast to decline (35.37*20) 707 kWh per

[30] MHI derived from Exhibit 45 Rev. 1, Nalcor, "Key Regression Equation"

customer over the 2010-2029 forecast period. When this figure is multiplied by the NP number of customers, the load forecast includes (707*251,131 customers) 178 GWh due to domestic CDM effects.

The NP general service forecast also captures CDM effects through the estimation of a technological change variable that has a -10.52 coefficient, as shown in the Forecast Model section 1.10. This means that the general service electricity consumption will decline (10.52*20) 210 GWh over the forecast period.

The industrial sector does not include any specific adjustment for CDM. The total sales forecast includes 388 GWh of load reduction for CDM effects. Assuming that system losses average 8%, the total island energy requirements forecast inherently includes 419 GWh of load reduction, which represents 20% of the total energy growth over the forecast period.

1.9 Comparison to Other Utilities

Table 17 was derived from reviewing load forecasts of Canadian electric utilities that were available on the web. Utilities may perform some of these tasks, but they were not observed in the forecast report. This is not intended to be a complete and exhaustive comparison, rather it is meant to provide some insight into the data collection, analysis and forecast methodologies that are used by other Canadian utilities.

The two key points to be made are that other utilities use end-use models to prepare the domestic (residential) forecast and hourly load shape modeling to prepare the peak forecast.

Table 17: Forecast Methods Used by Other Canadian Utilities

FUNCTIONS PERFORMED	RESIDENTIAL				COMMERCIAL				INDUSTRIAL			
	NLH	ON	MB	BC	NLH	ON	MB	BC	NLH	ON	MB	BC
Customer Billing Data	x	x	x	x	x	x	x	x	x	x	x	x
Economic/Price Data	x	x	x	x	x	x	x	x		x	x	x
Demographic Data	x	x	x	x	x	x	x	x		x	x	
Weather Data	x	x	x	x	x	x	x	x	x	x	x	x
Business Type Coding					x	x	x	x	x	x	x	x
Customer Survey Data	x	x	x	x		x	x	x		x		
Appliance/End-Use Data	x	x	x	x		x		x		x		
Commercial Floor Space						x		x				
Industrial Output										x		x
Load Research Data	x	x	x	x	x	x	x	x	x	x	x	x
Load Shape Data		x	x	x		x	x	x	x	x	x	x
Regression Model	x	x	x	x	x	x	x	x		x		x
End-Use Model		x	x	x		x		x		x		
Weather Adjustment Model	x	x	x	x	x	x	x	x		x	x	x
Hourly Load Shape Model		x	x	x		x	x	x	x	x	x	x

1.10 Forecast Models

1.10.1 NP Domestic Average Use Model

This model is the most important component of the domestic forecast. This model is based on the market share of electric heat (percentage of customers using electric space heat), degree days heating, marginal price of electricity, disposable income per customer and the population of Newfoundland. The regression has an R-squared of 99.8%. The R-squared measures the goodness of fit or the percentage of total variation explained by the model. The equation takes the following form:

Y= (3.072308*X1) + (7963.467*X2) + (-524.7547*X3) + (0.064911*X4) + (-35.36781*X5) + (0.008005*X6) + (-617.9116*X7)

Y=Domestic Average Use per Customer in the NP Service Area
X1=Domestic Market Share of Electric Heat *Degree Days Heating
X2=Domestic Market Share of Electric Heat
X3=Domestic Marginal Price of Electricity in the Previous Year (t-1)
X4=Personal Disposable Income per Customer in $2002
X5=Technological Change (<1981=0, 1981=1 increasing by 1 each year, 2010=30)
X6=Population of Newfoundland
X7=Recession Dummy for 1982 (1982=1, otherwise=0)

1.10.2 NP Domestic Customer Additions Model

This model is based on housing starts and personal income per customer. This regression has an R-squared of 93.4%. The equation takes the following form:

Y= (0.480831*X1) + (0.037441*X2) + (3802.905*X3) + (-1768.742*X4) + (-364.1837*X5) + -2029.571

Y=Number of Domestic Customer Additions in the NP Service Area
X1=Housing Starts & Completions
X2=Personal Income per Customer in $2002
X3=Dummy Variable (1972=1, otherwise=0)
X4=Dummy Variable (1976=1, otherwise=0)
X5=Economy Shift Change Variable (<1995=0, 1995 and on=1)

It should be noted that this equation is not as significant as the average use equation because a large variance of 1,000 customers would only create a 15 GWh variance to the electricity forecast because each domestic customer has an annual average use of 15,000 kilowatt-hours.

1.10.3 NP Penetration Rate of Electric Heat in New Homes Model

This model is based on the marginal relative price of electricity, the efficiency-adjusted price of furnace oil, the introduction of the rate stabilization plan and the ratio of urban to total housing starts. This equation has an R-squared of 88.5%. The equation takes the following form:

Y= (-0.41036*X1) + (0.016906*X2) + (0.862048*X3) + (1.014481*X4) + (-0.461892*X5) +0.803393

Y=Logit of the NP Penetration Rate of Electricity in New Homes
X1=Marginal Price of Electricity
X2=Efficiency-Adjusted Price of Furnace Oil
X3=Rate Stabilization Plan (<1986=0, 1986 and on=1)
X4=Ratio of Urban Housing Starts
X5=Dummy Variable for 1998-99 (1998=1, 1999=1, otherwise=0)

1.10.4 NP Conversion Rate of Non-electric to Electric Heat in Existing Homes Model

This model is based on the relative price of electricity compared to furnace oil on a gigajoule-equivalent basis and the market share of electric heat. This equation has an R-squared of 78.9%. The historical conversion rate can vary based on the stability in the price of oil. Most customers that converted to electricity, installed baseboards and retained their oil furnace. In effect, these are dual fuel customers that switch to or from oil heat depending on the relative price of oil versus electricity. In summary, new customers are separated into electric/non-electric classes based on the penetration rate and existing customers are separated into electric/non-electric classes based on the conversion rate.

Y= (-2.340087*X1) + (-2.650558*X2) + (-1.082214*X3) + (-0.804003*X4) + (0.543954*X5)

Y=Logit of the NP Conversion Rate of Non-electric to Electric in Existing Homes
X1=Relative Price of Electricity to Furnace Oil on an Equivalent Basis (GJ)
X2=Market Share of Electric Heat
X3=Dummy Variable for 1997 (1997=1, otherwise=0)
X4=Economy Shift Change Variable (<2000=0, 2000 and on=1)
X5=Moving Average Variable to Adjust Residuals

1.10.5 NLH Domestic Average Use Forecast

This model is based on the market share of electric heat in rural NLH areas, degree days heating, marginal price of electricity, disposable income per customer and the saturation of electric water heating. The regression has an R-squared of 98.1%.The equation takes the following form:

Y= (2.12482*X1) + (-181.8509*X2) + (0.127775*X3) + (41.23951*X4) + (-550.6892*X5) + (-385.9454*X6)

Y=Domestic Average Use per Customer in the NLH Service Area
X1=Rural NLH Domestic Market Share of Electric Heat *Degree Days Heating (Stephenville)
X2=Domestic Marginal Price of Electricity in the Previous Year (t-1)
X3=Personal Disposable Income per Customer in $2002
X4=Electric Hot Water Saturation Rate
X5=Dummy Variable (1995=1, otherwise=0)
X6=Dummy Variable (1987=1, otherwise=0)

1.10.6 NP General Service Electric Heat Load Model

The electrical energy requirement for NP general service customers with electric heat is forecasted based on gross domestic product, commercial building investment, weather data and furnace oil price data. The regression has an R-squared of 99.9% and all input (explanatory) variables are significant. The equation takes the following form:

Y= (0.021163*X1) + (0.084515*X2) + (0.030751*X3) + (0.639004*X4) + (39.24521*X5) + (31.57073*X6) + (-10.51975*X7) - 400.4815

Y=General Service Electricity Load (GWh) for NP Customers
X1=Gross Domestic Product Adjusted for Outflows in $2002
X2=Commercial Business Investment
X3=Degree Days Heating
X4=Efficiency-Adjusted Furnace Oil Price
X5=Economy Shift Change Variable (<1976=0, 1976 and on=1)
X6=Dummy Variable for 1996 (1996=1, otherwise=0)
X7=Technological Change (<1995=0, 1995=1 increasing by 1 each year, 2010=16)

1.10.7 NLH General Service Forecast

The electrical energy requirement for all NLH general service customers is forecasted based on personal income. The regression has an R-squared of 99.6%. The equation takes the following form:

Y= (0.004164) + (0.032726*X2) + (0.000464*X3) + (20.1808*X4) + (1.896473*X5) + (-1.889519*X6) + (7.209384*X7) – 18.77022

Y=General Service Electricity Load (GWh) for NLH Customers
X1=Real Personal Income in $2002
X2=Fishery Industry Variable
X3=Domestic Market Share of Electric Heat *Degree Days Heating (Stephenville)
X4=Dummy Variable
X5=Mining Industry Variable
X6=Dummy Variable for 1991 (1991=1, otherwise=0)

1.10.8 NP General Service Non-Electric Heat Forecast

This sector would include all general service businesses in the NP service area that do not use electricity as a primary heating source. This segment of customers is assumed to remain a constant 885 GWh per year throughout the forecast period. This sector is sub-divided into small (300 GWh) and large (585 GWh) classes. It is reasonable to assume that these classifications will not grow in the future because new general service customers primarily install electric heating systems and existing customers that convert to electric heat will be transferred into the NP electric heat group.

1.10.9 NP System Peak Forecast

The winter system peak forecast is prepared through the estimation of one regression equation. This regression equation is used to explain and predict the maximum hourly electricity demand requirements in a given year based on the number of NP domestic non-electric heat customers, the number of NP domestic electric heat customers, the NP weather-adjusted general service load, wind-chill and the marginal price of electricity. The regression equations are derived from NLH system load data, NP customer billing data and Environment Canada weather data. The wind chill variable is based on a twenty hour average temperature and an eight hour average wind. The wind chills are calculated for weather stations at St. John's, Gander and Stephenville and then weighted by the number of customers to calculate an island wind chill figure. The regression has an R-squared of 99.7%, has no auto-correlation effect and all input (explanatory) variables are significant. The regression model estimates that every regular NP customer contributes 1.5 kW and every all-electric NP customer contributes 6.7 kW to the NP system peak. These estimates are reasonable and similar to metered customer load research results of other utilities. The equation takes the following form:

$$Y= (0.001524*X1) + (0.006727*X2) + (0.157677*X3) + (-18.6309*X4) + (0.234852*X5) + (-8.347*X6) + (-11.25104*X7) + (30.44149*X8)$$

Y=Annual Maximum Hourly Demand (MW)
X1=Number of NP Non-Electric Heat Customers
X2= Number of NP Electric Heat Customers
X3=Wind-Chill Factor
X4= Marginal Price of Electricity in the Previous Year (t-1)
X5= Weather-Adjusted NP General Service Load (GWh)
X6= Technological Change (<1990=0, 1990=1 increasing by 1 each year, 2010=21)
X7= Non Supper Time (5:00=0, 6:00=0, otherwise=1)
X8=Dummy Variable for a December Peak (December=1, otherwise=0)

1.11 Conclusions and Key Findings

A load forecast predicts future electrical energy (GWh) and demand (MW) requirements, and is a critical factor in developing and evaluating future generation options. MHI has completed a comprehensive analysis of Nalcor's load forecasting methods, data sources, and data analysis techniques. MHI's review has developed the following key findings:

- A detailed analysis of Nalcor's load forecasting practices and methodologies confirms that the load forecast has been performed with due diligence and care using generally accepted practices, except as noted in the next key finding.

- The domestic forecast methodology is acceptable, but consistently under-predicts future energy needs at a rate of 1% per future year. The domestic forecast is entirely prepared using econometric modeling techniques. Although these techniques are acceptable, they are not the best utility forecast practices for this sector. Best utility practices would incorporate end-use modeling techniques into the forecasting process so that electricity growth can be quantified for all major domestic end-uses.

  The general service forecast methodology used by Nalcor is based on a combination of regression modeling and linear extrapolation techniques that have performed extremely well in the past. The general service forecast has produced accuracy levels within 1-2%, and as far as eight to nine years into the future.

  The industrial forecast is prepared on an individual, case-by-case basis, with direct customer contact concerning future operational plans. This methodology is reasonable considering the small industrial customer base on the island, but, in hindsight, the assumption of continued operation of two pulp and paper mills was too optimistic and has adversely affected the industrial forecast accuracy. The assumption of continued operation of the one remaining pulp and paper mill throughout the forecast horizon is optimistic and the assumption of no new industrial load additions after 2015 is pessimistic. The amount of variability due to potential load changes is high and could materially impact the results of the cumulative present worth analysis.

A detailed analysis of load forecasting practices, methodologies and results has led to the following recommendations:

1. Nalcor should develop an end-use forecasting model for the domestic sector. The best utility practice for preparing a domestic energy forecast is to use a combination of regression and end-use modeling techniques. NLH should partner with NP to develop and implement an end-use modeling methodology to predict future domestic energy consumption.

   The additional detail required to prepare an end-use forecasting methodology may improve forecast accuracy, but increased accuracy is not guaranteed because any forecast is dependent on the accuracy of the assumptions on which it is based. The current econometric process produces reasonable results, but it does not possess the explanatory power of an end-use methodology. The recommendation to develop an end-use forecasting methodology for the domestic sector is primarily based on improving the capability to:

   - Quantify load growth by end-use.
   - Quantify energy-efficiency by end-use.
   - Incorporate new end-uses (e.g. electric cars).
   - Improve the design of CDM programs.
   - Improve the defensibility of the load forecasting process.

2. Nalcor should develop a process to integrate the energy and peak forecasting methodologies. NLH staff should partner with NP to develop a coordinated load research program that is designed to develop load shape information by sector and by end-use. Incorporating domestic, general service, industrial and end-use (e.g. space heating) load research information could be used to integrate the energy and peak forecasting processes. Annual energy forecasts could be distributed throughout the 8,760 hours in a year, based on the hourly load shape profiles developed from the load research information. These hourly load forecasts could then be added together to produce an hourly forecast model for the interconnected system.