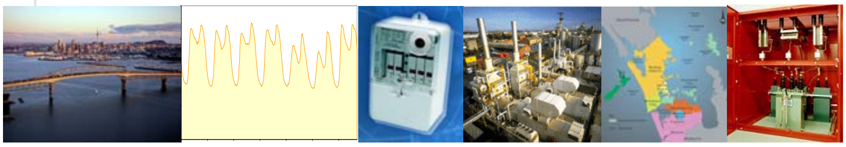
Auckland's Electrical Demand Characteristics and Applicability of Demand Management



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Contents

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Executive Summary

Introduction

Auckland is the largest load centre for the New Zealand electrical transmission grid and is remotely located in comparison to most of New Zealand's generation sources. As load in Auckland and those regions to the north of Auckland (North-Isthmus) increases the existing 220kV/110kV transmission supply is projected to become increasingly constrained.

This report examines the characteristics of the electrical demand in the Auckland/North-Isthmus region, highlights those international demand side management examples that SKM believes are applicable to the region, and outlines a selection of solutions available for managing major commercial and industrial demand.

The objective of SKM's investigations have been to provide additional information in relation to demand side management that will support the Electricity Commission's consideration of how demand side management should be encouraged in the Auckland region where it results in efficient outcomes.

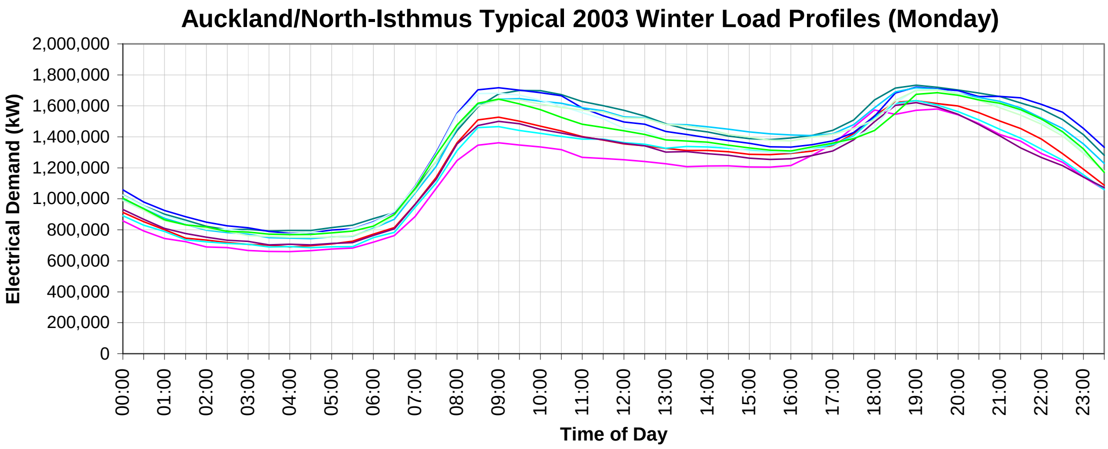
In undertaking this work SKM recognises that there are number of New Zealand organisations that are actively working towards the responsible management of the demand for electricity in New Zealand. These organisations include the Energy Efficiency and Conservation Authority (EECA) and New Zealand Climate Change Office. Given that these organisations are based in New Zealand and their activities are relatively well understood SKM has not specifically referenced their work.

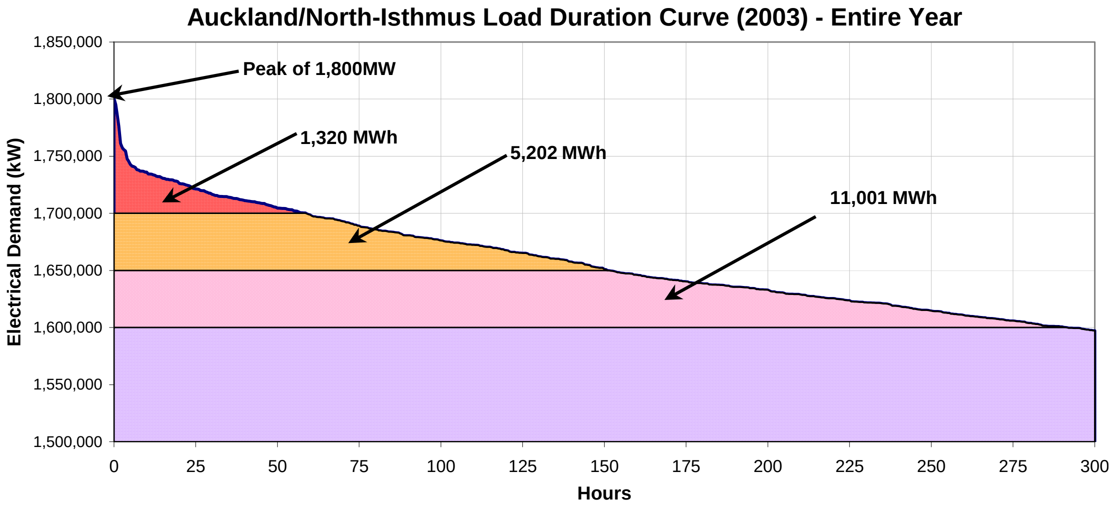
Characteristics and Components of Demand

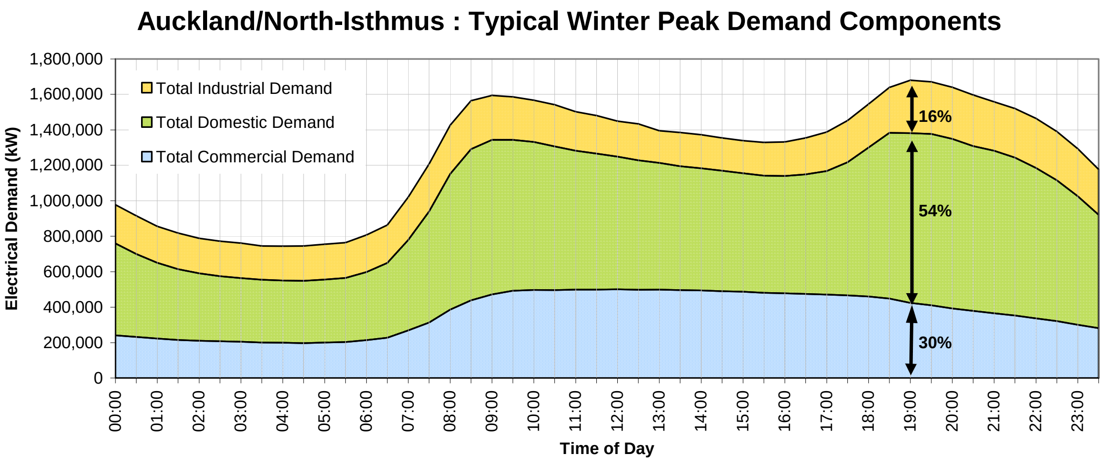
Winter

The following are the key features associated with the Auckland/North-Isthmus regions winter demand (refer to the charts that follow):

- The existence of a predominant evening peak with a significant domestic consumer component.
- A relatively small peak demand contribution due to industrial consumers. This is due to the fact that in comparison to the New Zealand average (or many other jurisdictions) the industrial base is small.
- The existence of a "mid-day trough" into which demand could be shifted.
- A peak demand that generally occurs during weekday evenings between the hours of 5pm and 9pm. A winter morning peak also exists that is marginally smaller than the evening peak.
- The top 100 MW of demand typically represents 6% of the total peak demand but is only required for 0.7% of the year (60 hours). The total energy usage during this period is typically 1,300 MWh.
- The top 100 MW of demand (60 hours) typically occurs during Monday through Thursday evenings on roughly 33 different winter days. On some of these days winter morning peaks also enter the top 100 MW of peak demand.


Auckland/North-Isthmus Typical 2003 Winter Load Profiles (Monday)
Electrical Demand (kW)
Time of Day

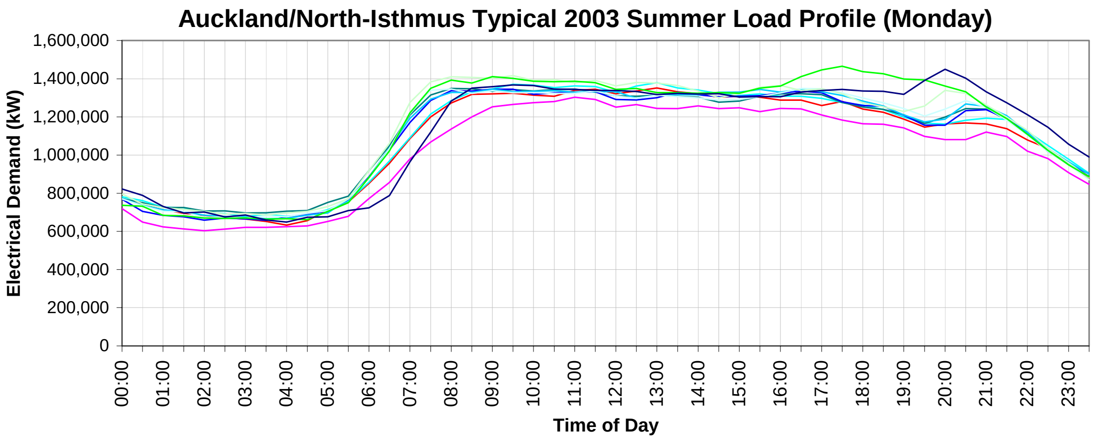

Auckland/North-Isthmus Load Duration Curve (2003) - Entire Year
Peak of 1,800MW
1,320 MWh
5,202 MWh
11,001 MWh
Electrical Demand (kW)
Hours

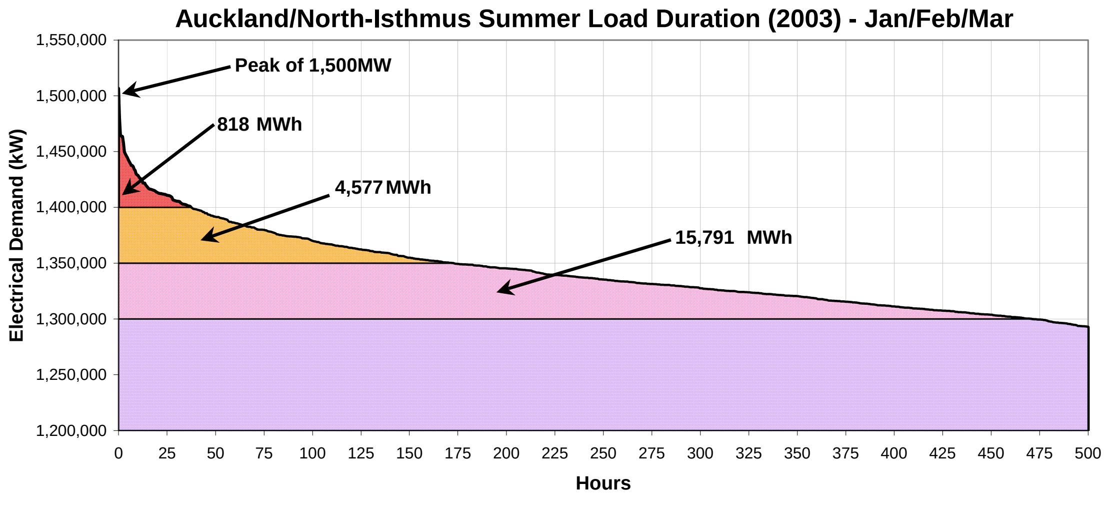

Auckland/North-Isthmus : Typical Winter Peak Demand Components
Total Industrial Demand
Total Domestic Demand
Total Commercial Demand
16%
54%
30%
Electrical Demand (kW)
Time of Day

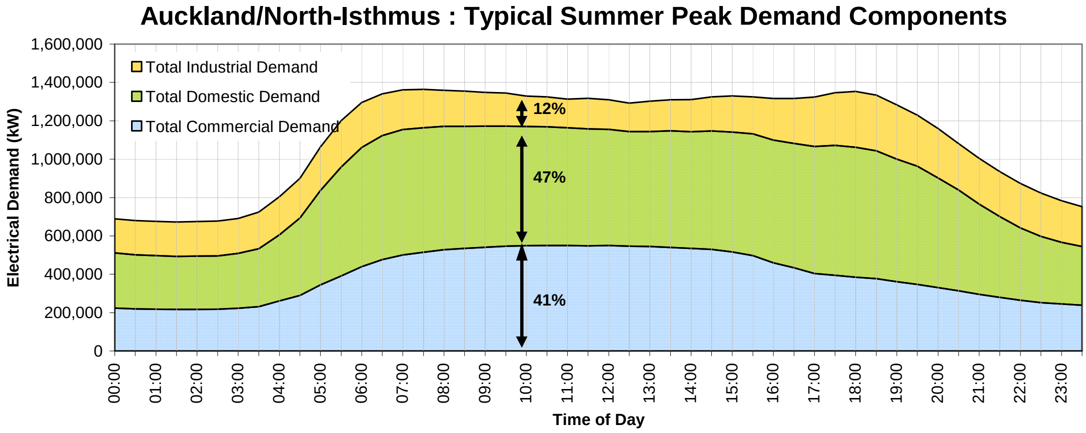
Summer

The following are the key features associated with the Auckland/North-Isthmus regions summer demand (refer to the charts that follow):

- A relatively constant flat MW demand over the period 8am through 6pm.
- A relatively significant contribution due to commercial & industrial consumers.
- The top 100 MW of demand typically represents 7% of the total peak demand but is only required for 0.5% of the year (30 hours). The total energy usage during this period is typically 800 MWh.
- The top 100 MW of demand (30 hours) typically occurs during Monday through Friday daytime on roughly 16 different summer days.







Applicability of Other DSM Examples

SKMs review of local and international demand side management (DSM) practices has uncovered a number of DSM practices/programs that are applicable to the Auckland/North-Isthmus region. However, it should be noted that DSM practices vary widely from jurisdiction to jurisdiction. The reasons for this are numerous, and are often linked to historical ownership structures, preferred industry practices and the general industry environment.

The following table outlines the DSM initiatives that SKM believes are generally applicable to the Auckland/North-Isthmus region coupled with examples of countries in which they have been implemented. The complexity of the subject matter means that SKM is not currently in a position to take a view on the economics of the initiatives.

DSM Subject Area	Jurisdiction
Efficient lighting (including Compact Florescent Lights)	Argentina, Australia, Belgium, France, Mexico, New Zealand (Canterbury), Spain Thailand, Vietnam
Mass market interval metering	Australia (Victoria), Canada (Ontario), Japan, US (California)
Special/System Protection Systems (load tripping)	Australia (Tasmania)
Regulator initiated DSM framework	Australia, Brazil Denmark, Italy, Netherlands, US (Texas)
Legislated energy efficiency / building standards	Australia, US (California), UK
Tax rebates and financial incentives	Ireland, Singapore, Korea, Taiwan, UK
Thermal Storage Systems (Space Heating)	New Zealand (Orion, Christchurch), Scotland, US (Minnesota)
Thermal Storage Systems (Space Cooling)	UK, Taiwan, Hong Kong, US (Minnesota)
Distribution voltage/loss optimisation	US (Georgia)
Load curtailment under contract	US (Iowa,, Wisconsin, New York State)
Back-up Generators/Diesels (BUGs)	New Zealand (Orion, Christchurch)

Specific Demand Reduction Options

Commercial

Transmission constraints in the Auckland/North-Isthmus region are most severe during winter evenings. The peak is predominantly the result of domestic demand due to cooking, lighting, heating etc. and commercial demand is generally in decline at this time of day. However there are potential areas for demand management that can be addressed in the commercial sector.

The reduction of commercial electrical demand during peak transmission periods can be initiated using the following indirect methodologies:

- financial incentives
- electrical tariffs
- building standards
- peer comparisons / competition
- market forces / energy education

Each of the above methods will trigger different technical solutions which are generally only suited to implementation at the construction/refurbishment stage of a commercial building.

A typical commercial building consumes roughly 100 watts per m^2 of floor area. The major contributors to the demand are lighting, air conditioning and ventilation. The technical solutions available for demand management in commercial buildings are numerous, but tend to be closely linked to energy efficient design practices. The following are the major technical options for demand management within commercial buildings:

- Lighting; the installation of efficient lighting and lighting control systems.
- Back-up Generators (BUGs); this involves the operation of BUGs for peak load lopping.
- Heating, Ventilation and Air Conditioning (HVAC); the replacement, modification or control of existing HVAC equipment. HVAC plant is used to manage both air temperature and humidity in a commercial building (during winter and summer).
- Computers; the use of computers during winter evening peaks could be managed more intelligently by placing inactive computer workstations into hibernation.

The costs associated with the above technical options are site specific and are difficult to estimate. SKM has provided guidance regarding costs of these items in the main body of the report but the determination of more accurate costs is complex.

Industrial

SKM undertook a survey of several major industrial consumers in the Auckland/North-Isthmus region. The survey involved brief meetings with seven major industrial consumers located within the region. The meetings involved discussions regarding their ability and willingness to curtail demand during peak transmission periods. The conclusion from those meetings was that opportunities do exist to manage, trip and or curtail industrial demand. The accurate evaluation of the capital/operating costs associated with industrial plant enhancements that will deliver electrical demand reduction is an extensive task. SKM has thus not attempted to do this. However, SKMs investigations indicate that specific major industrial consumers would move to reduce demand once electricity prices reached NZ$0.5/kWh. The exact prices would depend on the length of time for which curtailment is required and the number of times curtailment is requested. SKM thus concludes that if financial incentives of around NZ$1/kWh are offered widely to industrial consumers at times of peak network loading there will be some response.

Depending on the DSM methodology adopted the following systems would need to be implemented to facilitate demand reduction:

- *A Special/System Protection System/Schemes* (SPS); this type of system would be used to trip large industrial loads (under contract) in order to allow the transmission system into the Auckland/North-Isthmus region to operate beyond the (N-1) level. This solution would be novel. SKM estimates that, excluding communication links, the capital cost to install such a scheme would be around NZ$1M. This would include the installation of a centralised control system coupled with eight sets of remote load tripping terminal equipment (with each additional load tripping terminal costing around NZ$30k). The costs of communication links would be very site specific and would be significant.
- *A Demand Exchange System*; this type of system relies on industrial consumers volunteering to curtail demand on the basis that they will be paid to do so (the system would also be applicable to commercial consumers). The cost of such a system can generally be broken down into (i) the technology, (ii) system set-up, and (iii) day to day operation. SKM understands that the indicative costs for an exchange for 50 MW of curtailable load with 50+ customers would be in the region of NZ$150-250k (for technology and a section of the set-up costs). However, these costs would not include the significant costs associated with negotiating agreements, visiting customers, and the operational costs (these costs are difficult to estimate).
- *Direct Load Control Systems;* a number of technologies are available that may be used to centrally manage sheddable industrial electrical load, and which are presently relied upon by many electrical network operators to manage sheddable electrical demand. Examples include mains borne ripple control systems, pager systems or radio wave teleswitching systems. In all cases these systems are proven technologies that can, if acceptable, be used to facilitate (i) the direct control of specific industrial equipment, and (ii) the start-up and connection of back-up diesel generators. The exact capital costs of these systems is usually linked to functionality. However, by way of example, the installation of a mains

borne ripple injection system (injecting into a single transmission substation supplying 100 MW) would typically cost in the region of NZ$0.5M, with the installed receivers costing around NZ$150. SKM is of the view that, if acceptable, the use of existing ripple injection equipment for controlling small scale industrial/commercial demand/generation would be cost effective.

Conclusions

The high level conclusions reached by SKM during the investigations are as follows:

- There is not one particular compelling demand management initiative that is applicable to the Auckland/North-Isthmus region. SKM is of the view that DSM involves a wide range of initiatives that evolve with time and there is no "silver bullet".
- It is difficult to segregate the general topic of electrical demand management (ie. energy efficiency) from that of peak demand management. The prime focus of many reported demand side management (DSM) programs is energy efficiency, although SKM understands that many programs are shifting their focus to energy savings at times of peak network loading.
- The extent to which the Auckland/North-Isthmus region (and New Zealand) has implemented traditional electrical load management technology (ie. domestic hot water load control) is relatively high. There are a number of examples of comparable countries where little in the way of consumer load control has been implemented.
- Peak winter electrical demands in the Auckland/North-Isthmus have a significant domestic contribution. This sector of the consumer base currently has little incentive to reduce demand. Initiatives in this sector are key to achieving demand reductions.
- When one considers the entire electricity delivery chain the installation of demand management equipment may be economic at the time of the installation of houses/buildings/plant and the associated electrical distribution system. However once the assets are installed the elevated cost of retrofitting the equipment coupled with the inability to capture the benefits of the entire delivery chain often reduces the viability of demand management schemes. For this reason many jurisdictions who have not historically installed demand management equipment have difficulty in motivating to retrofit the equipment. This is further complicated by the separation of vertically integrated power supply companies (as is the case in New Zealand).
- There are examples of other jurisdictions where demand control is more compelling than is the case in Auckland. These examples generally experience summer peaking demands that are driven by air conditioning load. For these cases the number of extremely hot days are relatively small. Furthermore the increased temperatures that result in higher electrical demands are exacerbated by a corresponding decrease in transmission equipment ratings. This is not the case in the Auckland/North-Isthmus region during winter.

- In comparison to other jurisdictions (ie. specific locations in Europe and the US) the region experiences a relatively small amount of energy efficiency and "new age" demand side initiatives. A significant reason for this is the relative low cost of electricity and the relative temperate climate. Examples do exist (ie. California) where relatively intensive energy demand management programs have been in existence for more than a decade and have achieved reductions in electrical demand.
- The industrial sector in the Auckland/North-Isthmus region is relatively buoyant and many industries are planning expansions. These new developments create opportunities for the supply sector to work together with industry to ensure new build has an appropriate level of energy efficiency.
- Opportunities for demand management do exist within the industrial and commercial sector. However there will be a time lag before they can be implemented and any results achieved. Numerous examples exist that highlight this fact.
- There does exist the opportunity to trip industrial load under contract. This would only apply to a handful of large industrial consumers.

In summary : *Numerous applicable demand side initiatives exist for the commercial and industrial sectors. However, previous experience indicates that these initiatives generally take some years to implement, and in some cases have only yielded results after 5-10 years.*

It should also be noted that the relatively limited extent of the demand reduction initiatives coupled with the regions demand growth mean that DSM initiatives are unlikely to take the place of transmission upgrade or the addition of appropriate generation, but will simply serve to defer these supply options. This does not mean that DSM initiatives should not be undertaken. In fact given the energy issues facing the Auckland/North-Isthmus region it would seem pragmatic to take a pro-active stance regarding DSM initiatives.

1. Introduction

Auckland is the largest load centre for the New Zealand electrical transmission grid and is remotely located in comparison to most of New Zealands generation sources. As load in the Auckland/North-Isthmus region has grown the existing 220kV/110kV transmission grid that supplies the region has become increasingly constrained and its ability to deliver electricity into the region will continue to be eroded.

There are a number of ways of relieving the problem, one of which is transmission reinforcement. It is for this reason that Transpower has proposed that a 400kV transmission grid be built, with one of the first legs of that grid being a double circuit 400kV line between Whakamaru and Otahuhu.

In the broader sense the alternatives to Transpower's proposed transmission reinforcement plan generally fall into the following categories:

- generation located close to the Auckland/North-Isthmus electrical load; this includes both small distributed generators (DG) and large power stations
- the management of existing and future electrical loads within the Auckland/North-Isthmus region; including demand side management and energy efficiency
- other electrical transmission methodologies; including 220kV reinforcement or HVDC.

During September 2004 Transpower released a document (Ref 1) that outlined the transmission issues that the Auckland/North-Isthmus region faces, and requested information in relation to alternatives to transmission reinforcement.

In addition the Electricity Commission (EC) commissioned Sinclair Knight Merz (SKM) to investigate the alternatives to transmission reinforcement into the region (Ref 2). Following this work the EC commissioned SKM to undertake more detailed investigations in relation to demand side management in the Auckland/North-Isthmus region. These investigations are the subject of this report and include consideration of:

- the different consumer loads that exist during peak electrical demand periods
- the appropriateness or otherwise of applying overseas demand management examples to the region
- the technical options and costs associated with demand reduction within the large industrial/commercial consumer sector.

The objective of SKMs investigations has been to provide additional information in relation to demand side management that will support the Electricity Commission's consideration of how demand side management should be encouraged where it results in efficient outcomes.

2. Characteristics & Components of Auckland's Demand

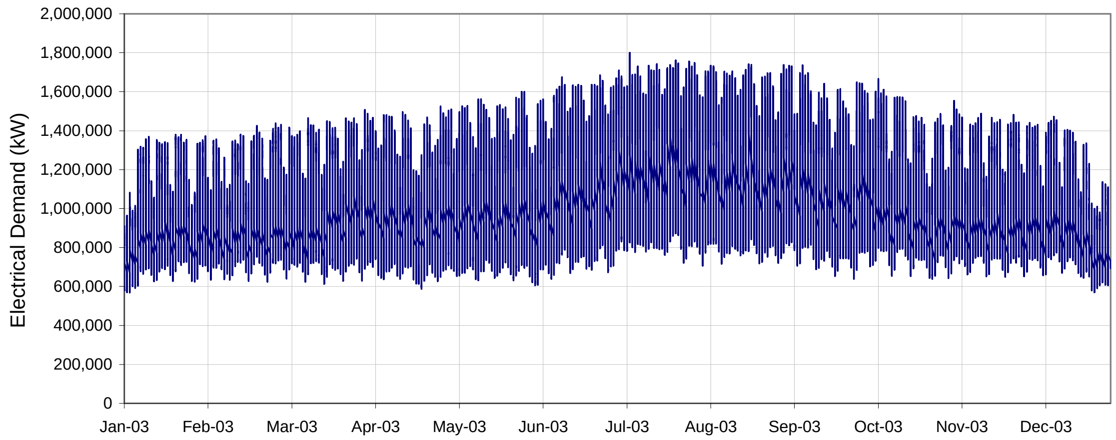
The following sections outline those issues, components and characteristics of the electrical demand within the Auckland/North-Isthmus region that are pertinent to implementing demand side management programs.

2.1 Demand Characteristics

The electrical demand of consumers within the Auckland/North-Isthmus region varies with time significantly, but is relatively predictable and closely linked to the time of day and the season.

Figure 1 illustrates a typical annual electrical demand curve for the Auckland/North-Isthmus region. The curve is based on grid exit point (GXP) metering and thus includes distribution system losses and does not consider the effects of embedded generation sources. Examination of Figure 1 shows that the load is predominantly winter peaking and that summer peaks are roughly 75% of winter peaks.

Figure 1 Auckland/North-Isthmus Annual Demand (2003)



Transmission equipment ratings vary with weather conditions

It is also worth noting that during winter months the colder temperatures and prevailing winds result in transmission line ratings that are significantly higher than during summer months. Typical transmission line rating ratios for summer to winter are around 75% (the exact ratio depends on specific line constructions and the associated weather conditions). As a result whilst the transmission system into the Auckland/North Isthmus region is predominantly winter constrained the summer constraints should not be ignored. This fact is outlined by Transpower in Ref (1) who indicate that summer constraints are becoming an increasing issue due to the increasing amounts of air conditioning plant that is being installed in the region. For this reason, in the long term, any initiatives that reduce demand during both winter and summer peaks will likely deliver double the value in comparison to those that reduce only winter or summer peaks. SKM understands that the current transmission pricing regime is based on a set number of peak demands for the entire year and thus there is currently no incentive for distribution companies to reduce peak summer demands. Given this fact there may be some scope for using hot water load control during summer periods, but this will impact on consumer hot water supply.

Figure 2 illustrates the % of time for which the loads in the Auckland/North-Isthmus region exceeded specific loading levels during 2003 (commonly referred to as a load duration curve). The curve shows that during 2003 for 100% of the time the regions load exceeded a value of roughly 600 MW and that the 1,600 MW level was only exceeded for around 3% of the total time.

Figure 2 Auckland/North-Isthmus Load Duration Curve (2003) - Entire Year

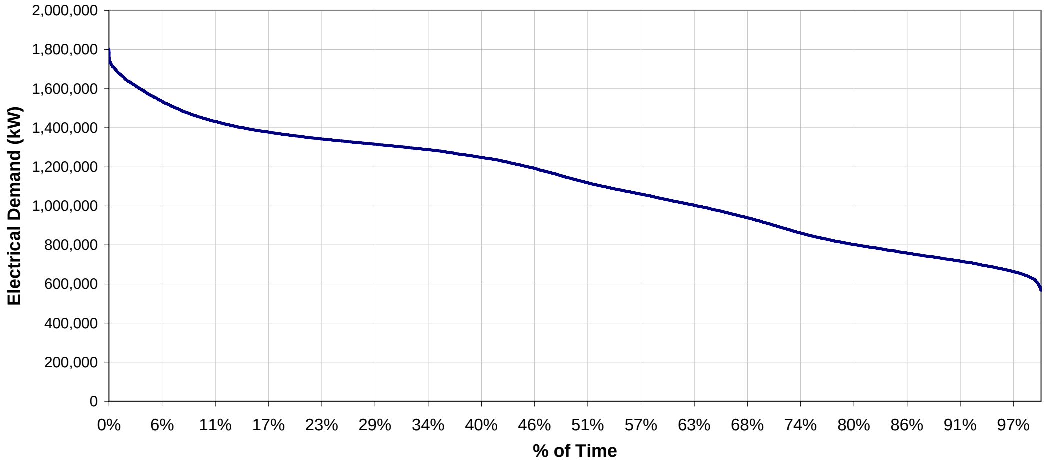


Figure 3 is a more detailed illustration of the peak 2003 loading periods for the Auckland/North-Isthmus region and which shows that the region peaked at 1,800 MW. This detailed load duration curve can be sliced into the following three areas that are indicative of the electrical energy that is consumed during peak times:

- a period of 60 hours during which the regional demand exceeded 1,700 MW and a total of 1,320 MWh was consumed (red area)
- a period of 150 hours during which the regional demand was between 1,650 MW and 1,700 MW, and a total of 5,202 MWh was consumed (orange area)
- a period of 290 hours during which the regional demand was between 1,600 MW and 1,650 MW, and a total of 11,001 MWh was consumed (pink area)

Periods of peak demand are relatively short

The above periods illustrate the extent to which energy consumption would need to be managed/curtailed to reduce peak loading levels in the region. It is worth noting that if a demand response market existed, and the market value was $1/kWh, the annual costs associated with reducing demand during the three periods would be in the region of $1.3M, $5.2M and $11.0M, with respective load reductions of 100 MW, 50 MW and 50 MW (i.e. a total load reduction of roughly 10%).

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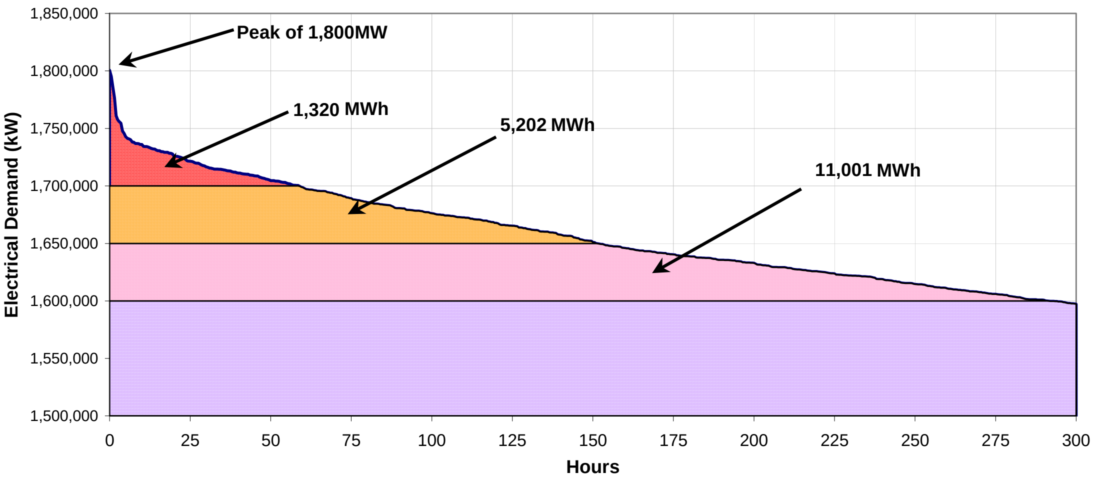
■ **Figure 3 Auckland/North-Isthmus Load Duration Curve (2003) - Entire Year**

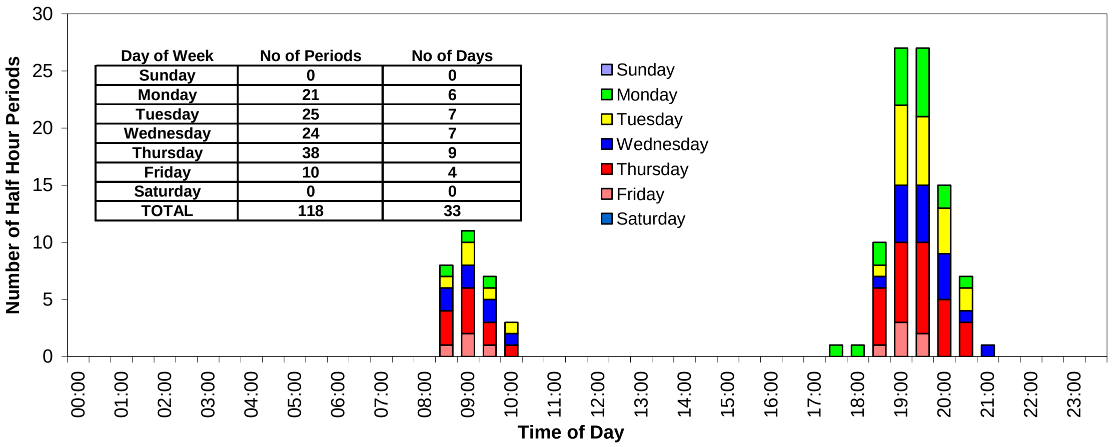


By way of illustration Figure 4 shows the half hourly periods and week days during which the regions load exceeded the 1,700 MW level during 2003. The months during which the periods occurred were July, August and September (i.e. a three month period). During this period the 1,700 MW level was exceeded on 33 days, with most periods occurring during the evenings and none occurring during weekends. The worst case consecutive period during which load exceeded 1,700 MW was for 4.5 hours.

Figure 4 is presented as an illustration of the extent to which load curtailment/management would be required to reduce the Auckland/North-Isthmus regions load by 100 MW during winter.

■ **Figure 4 Half Hourly Periods Exceeding 1700 MW (red region in Figure 3) - Entire Year**

Weekday electrical demands are the highest



Day of Week	No of Periods	No of Days
Sunday	0	0
Monday	21	6
Tuesday	25	7
Wednesday	24	7
Thursday	38	9
Friday	10	4
Saturday	0	0
TOTAL	118	33

Figure 5 is a detailed illustration of the peak 2003 summer loading periods for the Auckland/North-Isthmus region (for the months of January, February and March). Figure 5 shows that the regions summer demand peaked at 1,500 MW. As per that for Figure 3 the summer load duration curve can be sliced into three areas as follows:

- a period of 30 hours during which the regional demand exceeded 1,400 MW and a total of 818 MWh was consumed (red area)
- a period of 160 hours during which the regional demand was between 1,350 MW and 1,400 MW, and a total of 4,577 MWh was consumed (orange area)
- a period of 460 hours during which the regional demand was between 1,300 MW and 1,350 MW, and a total of 15,791 MWh was consumed (pink area)

Comparison of winter and summer load duration curves (Figure 5 and Figure 3) shows that the highest summer demand periods (red area) are of relatively small duration (likely to be a particularly hot day), but that in general peak summer demands are of relatively high duration (pink area). These characteristics are typical of summer based electrical demand.

Figure 6 shows the half hourly periods and week days during which the regions load exceeded the 1,400 MW level during the summer of 2003. During this period the 1,400 MW level was exceeded on 16 days, with all periods occurring during daylight hours and none occurring during weekends. The worst case consecutive period during which load exceeded 1,400 MW was for 6.5 hours.

Figure 6 is presented as an illustration of the extent to which load curtailment/management would be required to reduce the Auckland/North-Isthmus regions summer load by 100 MW during summer.

- **Figure 5 Auckland/North-Isthmus Summer Load Duration Curve (2003) - Jan/Feb/Mar**

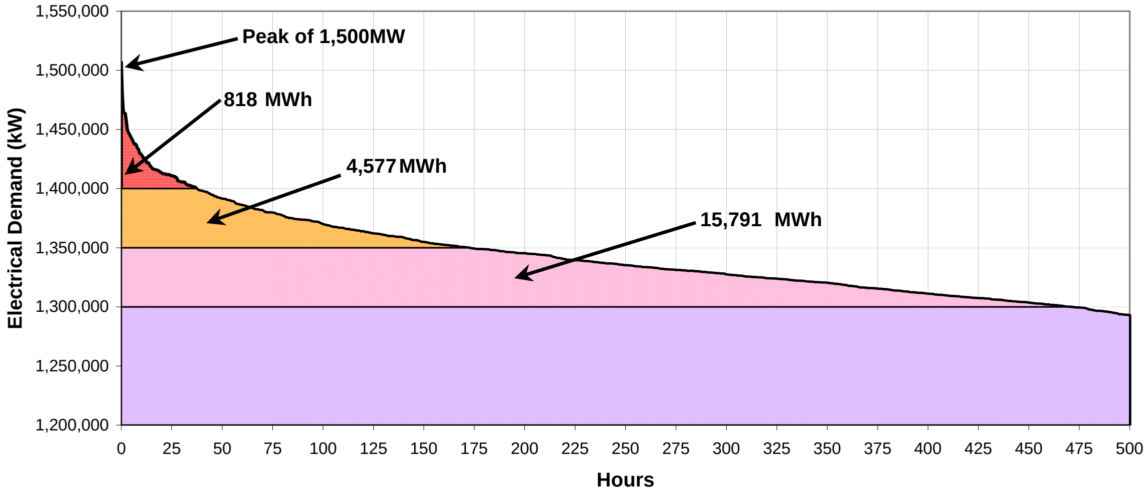
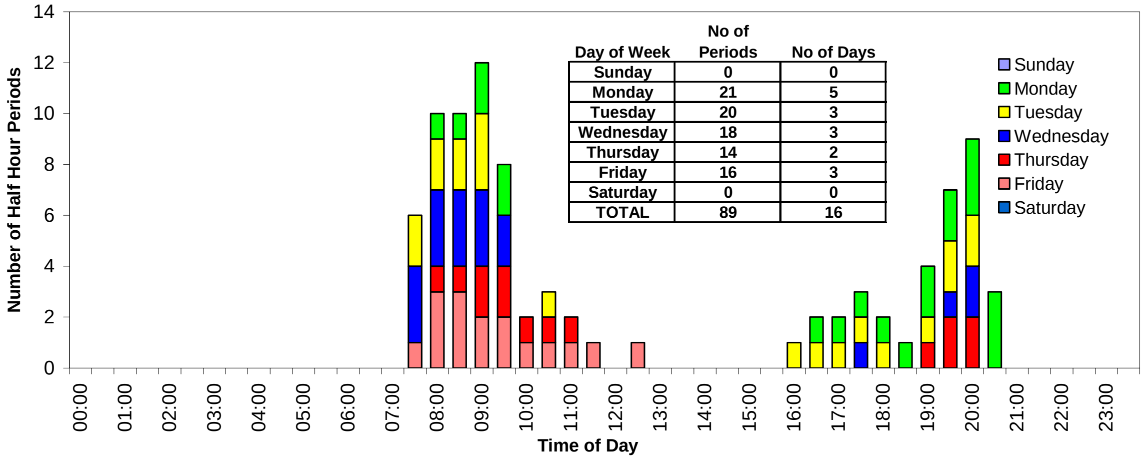


Figure 6 Half Hourly Periods Exceeding 1,400 MW (red region in Figure 5) - Jan/Feb/Mar



Day of Week	No of Periods	No of Days
Sunday	0	0
Monday	21	5
Tuesday	20	3
Wednesday	18	3
Thursday	14	2
Friday	16	3
Saturday	0	0
TOTAL	89	16

2.1.1 Winter Demand

Figure 7 illustrates the typical weekly winter profiles for the Auckland/North-Isthmus region. SKMs experience is that winter loading levels are reduced during weekends and peak loading levels predominantly occur on Monday through Thursday evenings. This fact is corroborated by Figure 7. It is SKMs understanding that the weekday winter evening peaks are largely driven by domestic consumer behaviour.

Figure 7 Auckland/North-Isthmus Typical 2003 Winter Profiles (Weekly)

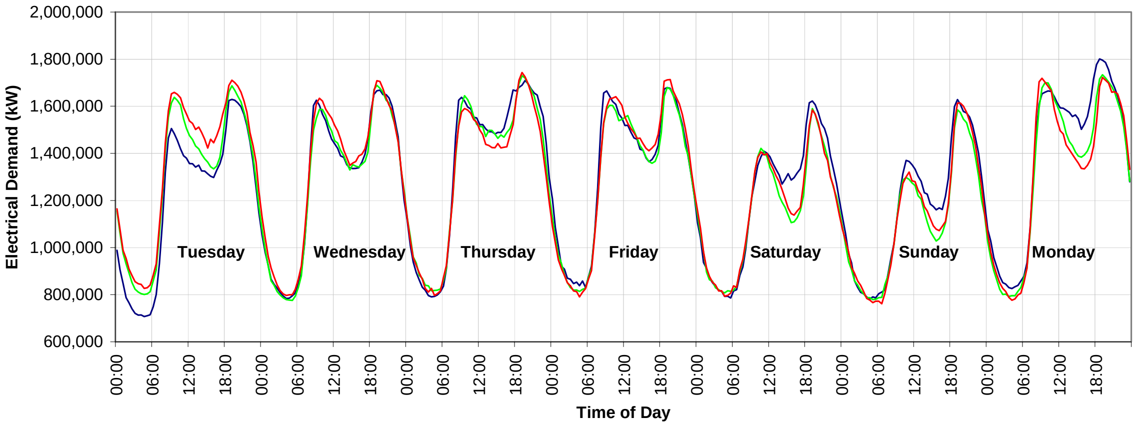
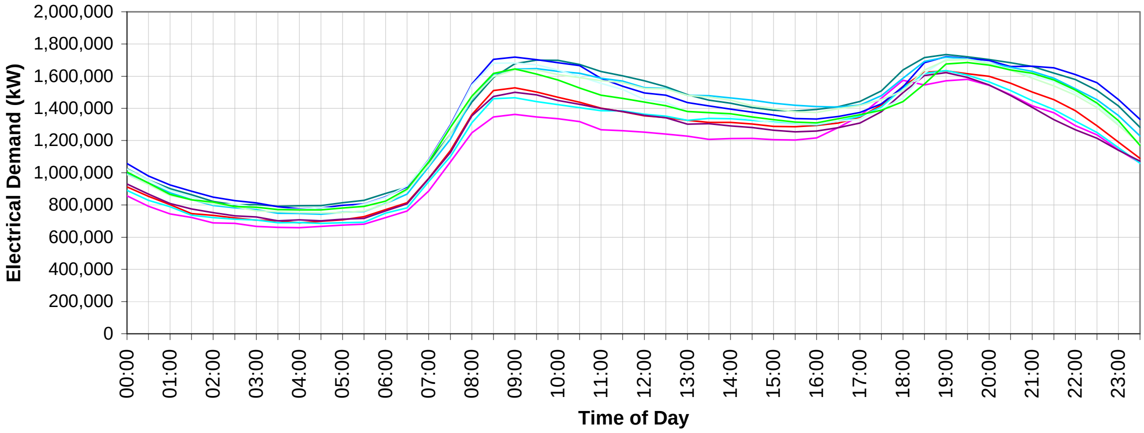


Figure 8 illustrates typical daily winter electrical demand profiles for the Auckland/North-Isthmus region. Examination of Figure 8 shows the existence of two predominant peaks that occur in the morning and evening. The evening peaks are marginally higher than the morning peaks by an amount of roughly 100 MW (or 5% of the peak demand). The reduction of winter evening peaks by more than 5% will shift peak loading periods to winter mornings. SKM understands that it is unusual for distribution companies to initiate significant hot water load control during winter morning peaks and there is thus potential to reduce morning peak demand levels using existing hot water load control systems. However, this would have an impact on consumers hot water supply systems but could be managed by installing bigger hot water cylinders.

The regions electrical demand has a midday trough

The morning and evening peak periods are typically between 8:30am/10:00am and 6:00pm/ 9:00pm respectively, with a midday trough occurring between roughly 11:00am and 5:00pm. The midday trough typically has a depth of around 250 MW and there exists an opportunity to shift peak evening loads into it.

▪ **Figure 8 Auckland/North-Isthmus Typical 2003 Winter Profiles (Monday)**



2.1.2 Summer Demand

Figure 9 illustrates the typical weekly summer profiles for the Auckland/North-Isthmus region. As per that for winter the weekend loadings are significantly lower than weekday loads.

▪ **Figure 9 Auckland/North-Isthmus Typical 2003 Summer Profiles (Weekly)**

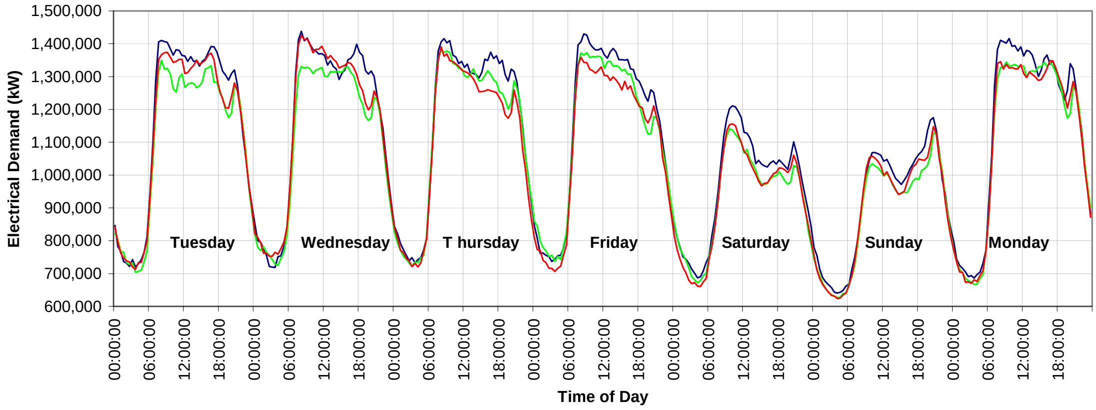
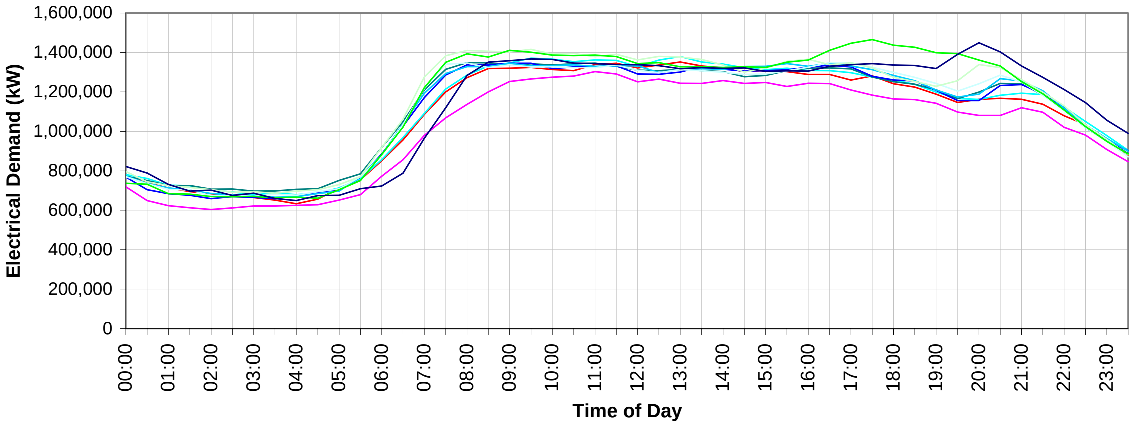


Figure 10 illustrates the typical daily summer electrical demand profiles for the Auckland/North-Isthmus region. Examination of Figure 10 shows that summer demands remain relatively constant throughout the daylight hours. It is worth noting that transmission line ratings reduce with higher temperatures. As a result transmission constraints would be higher during the middle of the day.

■ **Figure 10 Auckland/North-Isthmus Typical 2003 Summer Profiles (Monday)**

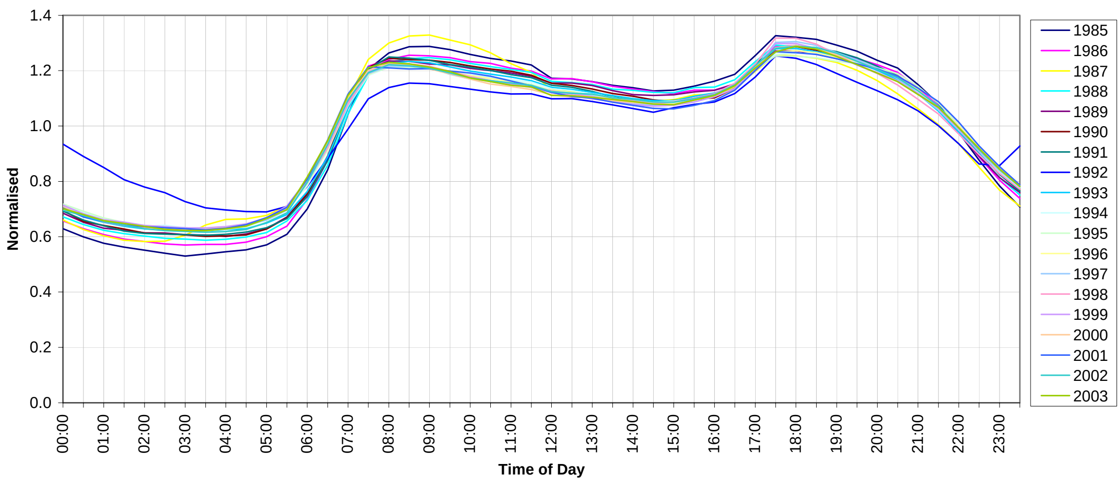


2.2 Historical Demand Characteristics

Peak winter daily profiles have not changed significantly

Figure 11 illustrates the normalised winter peaks for the period 1985 through 2003. In order to produce the curves for each year the weekday demands (Monday through Thursday) for a twelve-week winter period (in each case from mid-May) have been used. In each case the curves have been normalised such that, on average, each of the curves delivers 48 units for the entire day (the area under each curve is the same). This methodology has been used to demonstrate the relative peakiness of each of the winter demands. Figure 11 illustrates that, on average, there has been no significant change in the Auckland/North-Isthmus regions demand profile. One exception is that exhibited by the 1992 profile which corresponds to the '1992 Hydro Crisis' (a dry year).

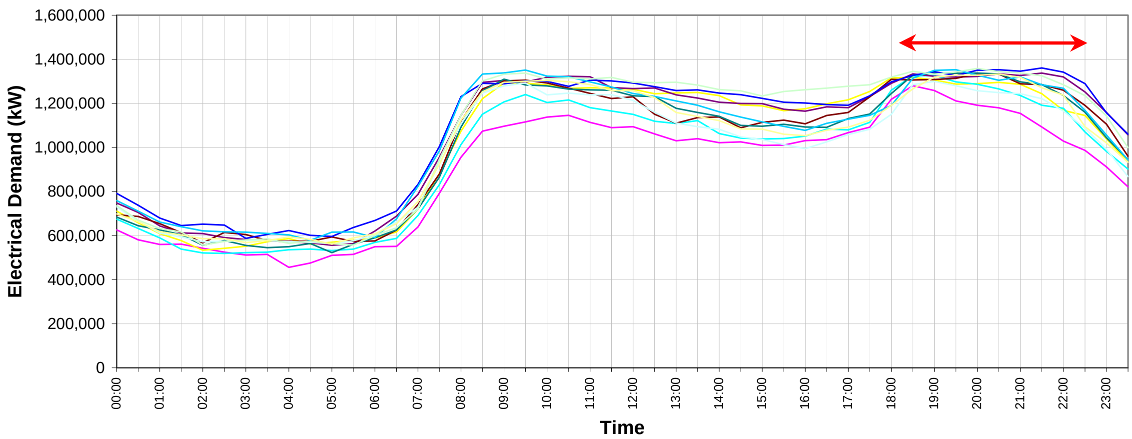
■ **Figure 11 Normalised Winter Demand Curves (1985 to 2003)***



* Normalised data such that each curve delivers 48 units of electricity per day

SKM has discovered some evidence of changing load management practices in the region over the last two decades. Figure 12 illustrates typical 1990 Auckland/North-Isthmus regional demand profiles for Mondays for the same seasonal period as that for Figure 8. Comparison between the two sets of data clearly indicates the existance of a flatter regional profile during winter evenings in 1990 (indicated by a red arrow). SKM believes the differences are largely due to the fact that during 1990 winter evenings distribution companies used hot water load management systems to manage the system-wide peaks. Load management equipment is currently used to manage individual grid exit points. This is due to the present transmission pricing methodology. Some industry commentators are of the opininion that a return to system wide peak management will deliver an overall demand reduction. There may be some truth in this assertion but given the results of Figure 11 SKM has not examined this issue in further detail.

■ **Figure 12 Auckland/North-Isthmus Typical 1990 Winter Profiles (Monday)**



2.3 Components of Demand

The demand for electricity in the Auckland/North-Isthmus region results from the time based demands of a number of different consumer groups (ie. domestic, commercial, retail, etc.). The determination of the exact demands of each of these consumer groups during peak network loading periods is not a simple task. However, it is possible to estimate the demands using energy consumption data and typical consumer group profiles. The following sections outline the energy consumption for the region and provide estimates of the major consumer group demands during peak loading periods.

2.3.1 Consumer Energy Demand

Ref (3) contains annual data (not time of use data) in relation to the electrical consumption of different consumer groups within specific regions in New Zealand. Table 1 illustrates the annual consumption figures for the Auckland/North-Isthmus region for 1993.

Table 1 Annual Auckland/North-Isthmus Consumption by Sector (1993)(Ref 3)

		Annual Energy Consumption		
Category	**Sub-Category**	**GWh**	**% of Total**	**% of Total**
Domestic	Domestic	2,983	46.5%	46.5%
Commercial	Wholesale & Retail Trade	916	14.3%	32%
	Business & Financial Services	615	9.6%	
	Community, social & personal services	373	5.8%	
	Transport, storage and communication	120	1.9%	
	Electricity, gas and water	24	0.4%	
Industrial	Manufacturing	1,194	18.6%	22%
	Mining and quarrying	48	0.7%	
	Agricultural, hunting, forestry and fishing	119	1.9%	
	Construction	17	0.3%	
Total		**6,409**	**100%**	**100%**

Ref (3) ceased recording regional energy usage figures subsequent to 1993. The collection of an updated set of data from individual energy retailers would be relatively exhaustive. However, SKM is of the view that the 1993 data is relatively representative of the 2004 consumption components for the region.

Industrial load is relatively small in the region

Table 2 illustrates the most recent electrical energy consumption figures for New Zealand (from Ref (3)). A comparison between Table 2 and Table 1 illustrates that the Auckland/North-Isthmus region has a significantly higher commercial and domestic energy consumption than the national average, and a corresponding lower industrial energy consumption. Another factor affecting the region is that industrial load generally has a high load factor (24/7 operation) which means that, in comparison to commercial/domestic loads, the associated percentage contribution to peak demand is smaller than the figures outlined in Table 1 and Table 2. Given the relatively small amount of industrial load in the Auckland/North-Isthmus region the opportunities for demand management are relatively small.

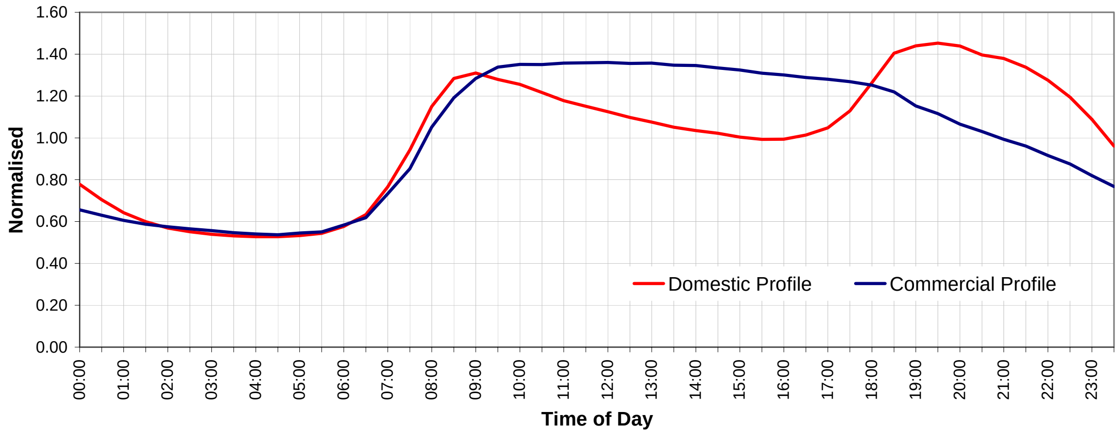
Table 2 Annual New Zealand Consumption by Sector (2004)(Ref 3)

Category	**Annual Energy Consumption (MWh)**	**Percentage**
Domestic	11,723,124	34%
Commercial	7,734,088	22%
Industrial	15,431,297	44%
Total	**34,888,509**	**100%**

2.3.2 Typical Consumer Demand Profiles

Figure 13 illustrates typical demand profiles for domestic and industrial consumers in the Auckland/North-Isthmus region. The curves are based on the respective Albany and Penrose 110kV points of supply (POS), which have significant domestic and commercial consumer bases. The curves have been normalised in the manner outlined in Section 2.2 (the areas under the curves are equal).

■ **Figure 13 Typical Winter Domestic and Commercial Electrical Demand Profiles***



*Normalised data such that each curve delivers 48 units of electricity per day (equal areas)

No typical industrial demand profiles are presented because industrial load is industry specific. However, it is worth noting that industrial processes tend to be continous and thus electrical demand profiles tend to be relatively flat (constant) throughout the day.

2.3.3 Consumer Loads During Peak Loading Periods

Winter peaks are dominated by domestic load

Figure 14 and Figure 15 illustrate SKMs estimate of the typical daily electrical demands for domestic, industrial and commercial consumer groups during respective peak winter and summer demand periods. These diagrams have been created using the annual energy consumption figures for the region coupled with typical annual commercial and residential profiles (half hourly data). The figures clearly illustrate the dominance of domestic consumer demand during winter peaks.

■ **Figure 14 Typical Winter Peak Demand Components**

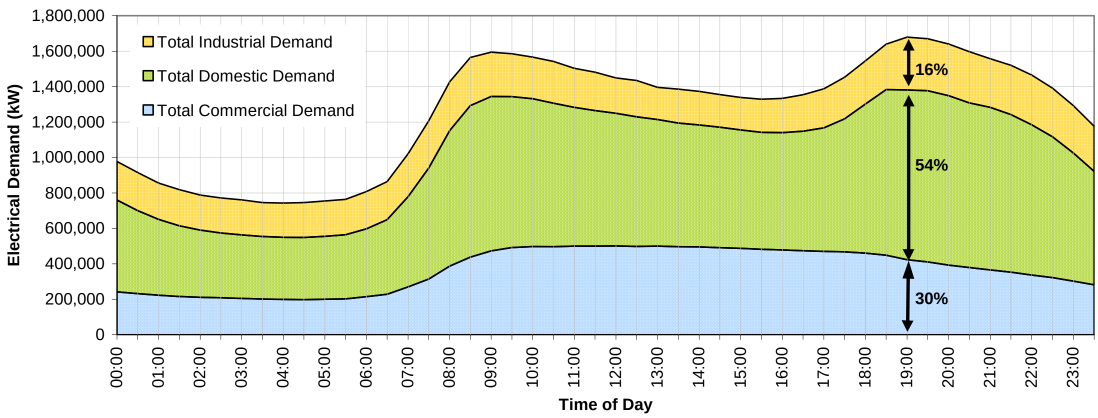
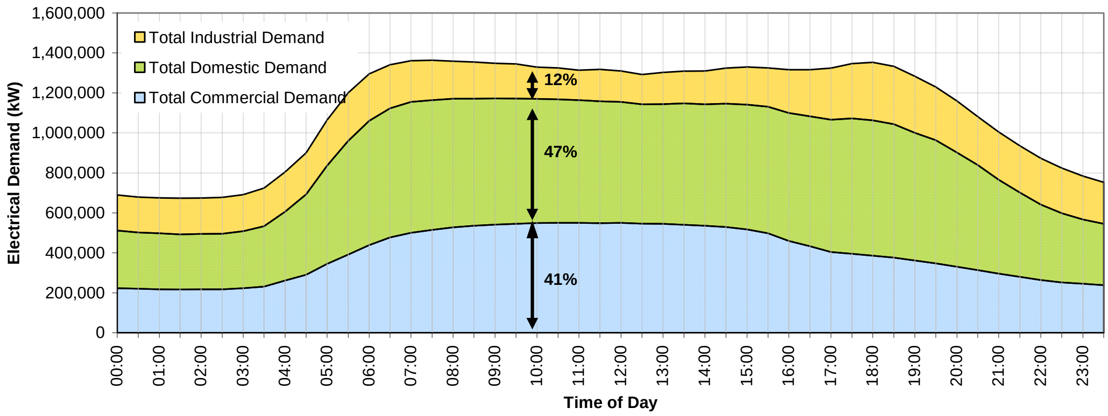


Figure 15 Typical Summer Peak Demand Components



Motors contribute significantly to electrical demand

2.3.4 Static Load vs Motor Based Demand

The use of electricity can effectively be split into two components. That demand due to motors (fans, air-conditioners, pumps etc.) and that due to devices that are static (lighting, radiant heating, etc). SKMs experience is that the static/motor load split for the Auckland/North-Isthmus region during times of system peak would be that outlined in Table 3. The large motors would likely be located within industrial premises.

Table 3 Static vs Motor Load During Peak Loading Conditions

	Static	Small motors	Large Motors	Total
Winter Peak (MW)	1,100	600	100	1,800
Summer Peak (MW)	500	700	200	1,400
Winter Peak (%)	61%	33%	6%	100%
Summer Peak (%)	36%	50%	14%	100%

The above information is included to demonstrate the extent to which motor load contributes to the electrical demand in the Auckland/North-Isthmus region, and reinforces the need to consider (i) managing motor loads or (ii) incentivising the installation of high efficiency motors.

2.4 Load Tripping

Specialised load tripping schemes exist

Transmission security (during high loading periods) has in some jurisdictions been managed by installing Special Protection Systems (SPS) (sometimes called System Protection Schemes). These schemes involve the use of a highly reliable protection system that trips specific electrical loads in the event of specific network events. These systems typically only "arm themselves" (become active) once the transmission loading exceeds a preset level. In the case of the Auckland/North-Isthmus region the specific network events would likely be (i) the loss of major generation plant in the Auckland area, or (ii) the loss of an incoming 220kV line. The key issue associated with these types of schemes is the frequency and duration of load tripping (particularly given that consumer loads are involved).

The supply to the Auckland/North-Isthmus region is a complex mix of transformers, circuit breakers, transmission lines and generators and SKM has not been in a position to undertake exhaustive work in relation to the frequency of transmission/generation events. However the following paragraphs are indicative of the extent to which load tripping might occur if such an SPS were implemented.

Table 4 illustrates the forced outage rate for 220kV transmission lines in New Zealand, and indicates an average forced outage rate of 1.6 events per annum per 100km of line. Based on this information and the fact that there are six 220kV supply lines supplying Auckland (roughly 200km in length) it can be summarised that there might be roughly $1.6 \times 2 \times 6 \approx 20$ forced outages per annum on the 220kV lines supplying the Auckland region. However the chances of these outages occurring during peak network loading conditions (as per the periods outlined in Figure 4) are relatively slim.

The subject of transmission reliability into Auckland requires further detailed investigation but it is worth noting that the internationally recognised organisation CIGRE (Ref 5) undertook global surveys of SPS schemes during 1987 and 1996. These respective surveys indicated that load shedding SPS schemes typically operated 0.8 and 0.1 times per annum. Whilst these values would not specifically apply to the Auckland/North-Isthmus case it would seem that the assumption that SPS operation might occur once per annum would be relatively conservative. Furthermore should an SPS be implemented to trip 100 MW of industrial load during times of peak electrical demand the duration of each event would likely be limited to a 4.5 hour period (as per that illustrated in Figure 4).

- **Table 4 220kV Transmission Line Forced Outage Rates : Transpower**

Period	Annual Forced Outage Rate Per 100km of 220kV line
1994-95	2.3
1995-96	2.5
1996-97	1.5
1997-98	1.1
1998-99	1.3
1999-00	1.2
2000-01	2.0
2001-02	1.8
2002-03	1.4
2003-04	1.4
Average Last 10 Years	**1.6**

3. Applicability of Other DSM Examples

3.1 General

An extensive amount of information is available in relation to the management of electrical demand. A simple Internet search using the words 'Electrical Demand Side Management' results in excess of one million hits. The variations in the reported demand reductions resulting from demand side initiatives are significant. These variations are generally driven by local conditions, consumer preferences and the types of technologies/schemes that have been implemented. In most cases it is difficult to make meaningful comparisons between the demand side management methodologies (and the associated economics) employed in different jurisdictions, and with those employed in New Zealand.

New Zealand has a relatively high penetration of traditional load control

However, SKM's investigations indicate that the extent to which load management has been exercised in New Zealand is relatively high in comparison to many other jurisdictions. For example, SKM understands that New Zealand has the highest number of installed ripple control receivers per head of population. These devices are primarily used to control hot water load and were installed by historical "Power Boards". Their installation was in response to the strong pricing signal provided by the "Bulk Supply Tariff" which recovered both energy and transmission costs based on the measurement of annual peak demand. In addition to the widespread use of hot water management systems New Zealand has a number of additional demand side management initiatives that are reported to have resulted in significant success. Some of these initiatives are reported in Section 3.3

There is evidence that similar conditions to that in New Zealand existed in other jurisdictions, and which has resulted in the adoption of relatively similar amounts of load management technology. For example, SKM's research indicates that those US utilities that have historically been run as co-operatives have generally had a long history of installing demand management equipment (refer to Ref 17). SKM understands that this is not the case for many mainstream USA electrical utilities that have historically had no effective incentives to manage electrical demand. As a result traditional mains borne ripple control systems are not widely installed in the US.

Furthermore, SKM understands that extensive hot water load management systems are installed in New South Wales and Queensland (Australia). In contrast South Australia, Victoria and Tasmania have little in the way of hot water load management. Again the installation of these systems has been the result of historical conditions and decisions.

In some cases hot water load management systems have only been partially deployed. For example, South Africa currently only has control equipment installed on 30% of consumer's hot water cylinders (refer to Ref 6).

A major factor associated with the economics of installing demand management equipment is that a significant amount of the costs associated with electrical infrastructure lie within the distribution system (11kV and 400V).

It thus becomes difficult to justify installing load management equipment or energy efficient equipment as an alternative to a single transmission or subtransmission project unless the impact on the overall value chain is considered. This is reflected in the fact that the replacement cost of the entire distribution system in New Zealand is estimated to be around NZ$12 billion while transmission replacement would be around $6 billion (reported ODV replacement costs). The savings associated with demand management equipment can generally only be justified in terms of the long run cost of the entire electrical delivery system (generation, transmission and distribution). This means that in many cases the retrofitting of load management equipment into an existing network becomes difficult to justify unless a significant number of elements of the electrical network have constraints. For this reason many utilities that have relatively little load control continue with the status quo and opt to construct new transmission/distribution lines rather than retrofit a load management solution.

DSM most economic when considering the entire delivery chain

Another factor that significantly affects the general activity of demand side solutions (ie. the installation of heat pumps, solar hot water systems) is electricity prices. In numerous other jurisdictions the electricity prices are significantly higher than that in NZ which naturally stimulates activity in this sector.

There is also evidence of situations where demand management has received significant focus but generally under the guise of energy efficiency. An example of this are the DSM programs that have evolved in California since 1975 under the management of the California Energy Commission (CEC). SKM understands that the CEC programs faltered during the restructuring of the power industry during the 1990's. However, given the power supply security issues California experienced during the early 2000's the CEC has renewed focus and particular attention is being devoted to reducing peak network demands.

3.2 Comparison of Demand Characteristics

The characteristics of the demand for electricity in different jurisdictions vary significantly, as does the economics of different demand side management technologies in these jurisdictions. The following sections compare the Auckland/North-Isthmus electrical demand with that in a number of international locations. The comparisons made are limited by the extent to which information is publicly available, but SKM believes the data is sufficient to demonstrate a number of pertinent issues.

3.2.1 Load Duration Curves

The economics associated with managing electrical demands are usually a function of the extent and duration to which demand needs to be curtailed. An indication of the relative economics associated with demand curtailment in different jurisdictions can be obtained by comparing load duration curves. Figure 16 compares the Auckland/North-Isthmus load duration curve with a select number of other jurisdictions (note that the load duration curves have been normalised).

Generally speaking, the quicker a load duration curve falls away the more scope there is to curtail electrical demand during peak periods. This is due to the fact that the area under a load duration curve is reflective of the amount of energy consumed and which needs to be shifted or curtailed.

Figure 16 Load Duration Curves for Different Jurisdictions

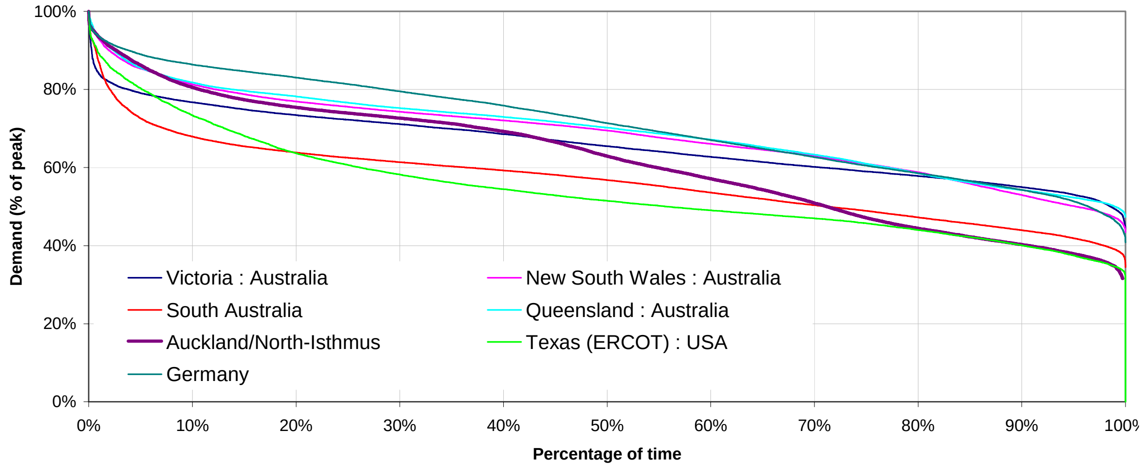
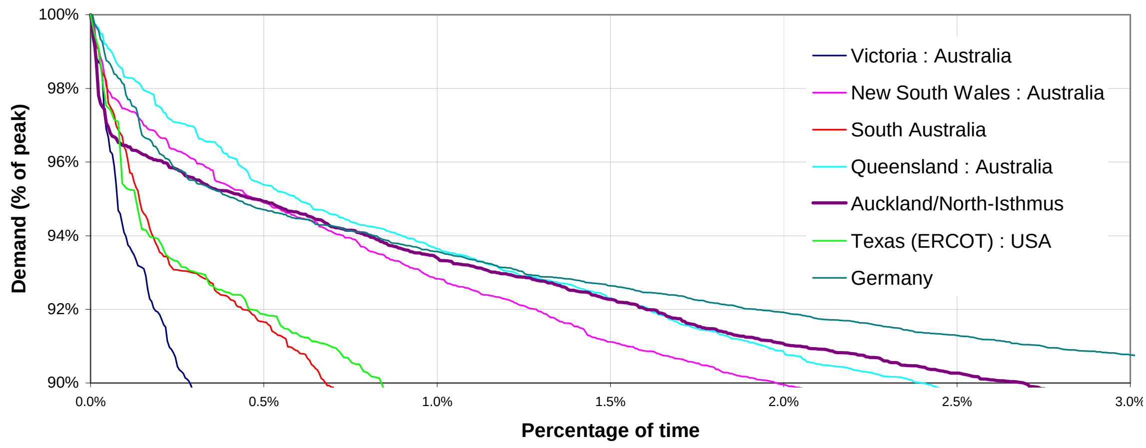


Figure 17 is a magnified version of Figure 16 and illustrates the same load curves for peak loading periods. The areas under the curves illustrated in Figure 17 are representative of the kWhs of electrical demand that would need to be curtailed to reduce electrical demand in each jurisdiction by 10%. Clearly Texas, Victoria and South Australia require comparatively little kWh curtailment and thus are likely to be well suited to implementing peak load curtailment. However, note that these regions have significant summer loads and are generally constrained during summer periods. These curves also reinforce SKM's assertion that Queensland, New South Wales and New Zealand have relatively extensive load management systems (although other factors may exist).

Figure 17 Load Duration Curves : Peak Loading Periods



3.2.2 Daily Profiles

Another indicator of the opportunities associated with demand reduction is the shape of a regions daily electrical demand profile.

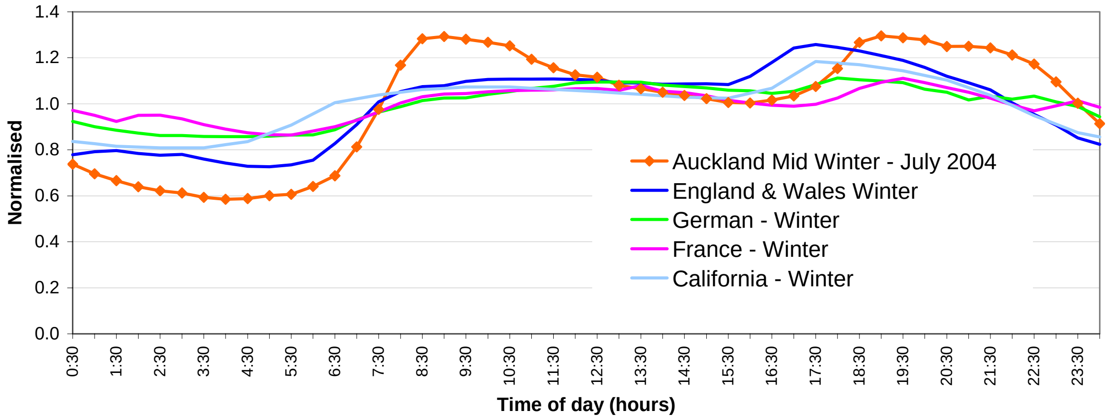
SKM's investigations indicate that the demand profiles from country to country vary considerably but that general trends can be identified. SKM makes the following observations that are substantiated by the data illustrated in Figure 18 and Figure 19 (which compare the Auckland/North-Isthmus winter and summer demand profiles with that of other jurisdictions):

- Summer demand profiles in most jurisdictions tend to be relatively flat during daylight hours, but with the demand for electricity rising sharply in the early morning and peaking around midday. The demands are usually driven by air conditioning load and as such networks that have summer peaking loads are particularly precarious given that as the temperatures increase electrical demands increase and at the same time network equipment ratings decrease. As a result network margins are more quickly eroded with temperature increases and have a large affect on the ability of an electrical network to deliver electricity to demand centres.
- The summer demand profile for the Auckland/North-Isthmus does not differ significantly from other jurisdictions. Given that demand reduction for a significant portion of a summer day is usually prohibitive a substantial number of summer peaking DSM programs focus on energy efficient equipment (as opposed to peak shifting technologies).
- Winter demand profiles in many jurisdictions are relatively peaky in nature, with peaks occurring in the mornings and/or evenings. Given this fact winter peaks tend to lend themselves to load shifting. It is also worth noting that as temperatures decrease both electrical demand and network equipment ratings increase, and thus network margins are not eroded that quickly with marginal decreases in temperature.

Midday winter trough may provide an opportunity for load shifting using domestic storage heating

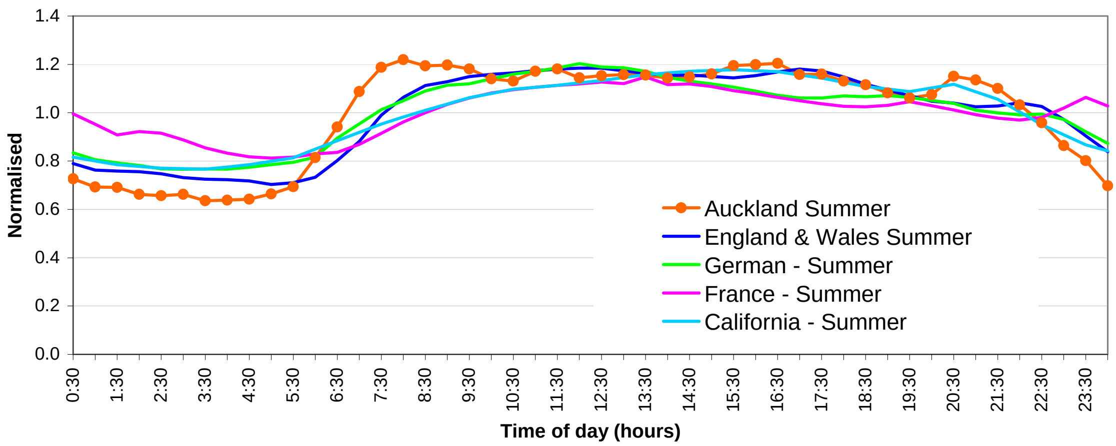
- A particular feature of the winter Auckland/North Isthmus demand is the existence of both morning and evening peaks and a midday trough. In many jurisdictions a midday trough does not exist. For example The England & Wales winter profile exhibits increasing loads at the start of the working day (around 6am) followed by a plateau during the working day (primarily commercial & industrial demand), before rising to a peak in the evenings (due to increased lighting and domestic demand). In the Auckland/North-Isthmus case there is an opportunity to shift evening winter loads to the midday trough and morning peaks to the early hours of the morning.

■ **Figure 18 Winter Demand Profile Comparison***



*Normalised data such that each curve delivers 48 units of electricity per day

■ **Figure 19 Summer Demand Profile Comparison***



*Normalised data such that each curve delivers 48 units of electricity per day

3.3 Demand Management Programs In Different Countries

The following sections investigate international Demand Side Management (DSM) practices with the objective of highlighting those situations that are of relevance to the Auckland/North-Isthmus situation.

In order to develop this section SKM has made use of numerous references, the most significant of which are listed in Section 6. In a number of cases the references are not recent, but this does not mean that the initiatives are not pertinent. It is worth noting that the restructuring of the world wide power industry during the 1990's (energy market evolution) resulted in a significant number of DSM initiatives being either discontinued or shifted to focus on energy savings. Recent blackouts have resulted in the power industry focusing more intensively on energy savings at times of system peak.

3.3.1 Efficient Lighting

The use of efficient lighting to reduce demand and energy consumption is well established and numerous countries have undertaken or are undertaking lighting programs that provide consumers with incentives to install efficient lighting equipment. Examples include:

- Argentina; In 1999 participated in a multi-country Efficient Lighting Initiative (ELI). This was a three-year program funded by the International Finance Corporation (IFC) and the Global Environment Facility (GEF).
- Australia; Greenlight Australia is a national strategy for improving the efficiency of lighting in Australia during the period 2005 though 2015, and is actively being promoted by the Australian Government. The aim is, through the introduction of mandatory measures, to attain a 20% reduction in lighting energy consumption by 2015, (Ref 67). The European Green light program is similar and has published case studies for the Retail sector which indicate that considerable success can be achieved by changing the lighting and lamp types in large car park and retail outlets. Projects have achieved 20% to 36% reductions in energy consumption, and approximately 3 to 4 year pay back periods (Ref 66).
- EU; The European Commission and the Union of the Electricity Industry (EURELECTRIC) sponsored a European-wide initiative in 1999 to promote compact fluorescent light bulbs (CFLs) in households. The campaign was chosen because savings could be realised quickly due to the rapid turnover of light bulbs and was undertaken by ENEL (Italy) and ESB (Ireland). The ENEL campaign ran from March 2001 to June 2001 where 100,000 CFLs were sold to provide an estimated saving of 7,200 MWh/year. The ESB campaign ran from Sep to Oct 2000 with 60,000 CFLs sold to provide an estimated saving of 4,200 MWh/year (Ref 23).
- France; Nineteen regional and three national DSM pilot programs are reported. The programs promote energy efficient appliances and compact fluorescent light bulbs, energy efficiency audits in industry, public lighting and efficient industrial motors. Guadeloupe achieved a 20% decrease in peak load through an efficient lighting campaign (Ref 74).
- Indonesia; The Directorate General of Electricity and Energy Utilisation (DGEEU) is implementing programs to install efficient lamps in homes and street lighting and to improve public awareness of DSM. The expected savings over five years are 955 million kWh/ year and equivalent to 160 MW avoided capacity.
- Mexico; With support from Global Environmental Facility (GEF), the national electric utility of Mexico (Comision Federal de Electricidad, or CFE) executed a successful efficient lighting program. CFE set up an independent trust fund to purchase high quality CFLs at a significant discount and sell them directly to consumers at a reduced price. The utility set specific performance criteria that ensured high quality lamps at a price comparable to those of lower quality lamps. Results of this project indicate that DSM programs can deliver a large number of CFLs, distribution through utility officers is feasible, bulk procurement can lower costs, and large programs can spur further replication of DSM programs.

- New Zealand; The Line Trust South Canterbury in conjunction with Energy Mad Ltd initiated a compact florescent light (CFL) program in South Canterbury (Ref 32). The project is reported to have sold a total of 62,000 Ecobulbs at discounted prices and achieved a peak network load reduction of 3.8 MW at a cost of roughly $29,000 per MW ($29/kW).
- Peru; The country has participated in a Global Environment Facility (GEF) lighting program and a product certification program involving national standards, and as a result the transmission system load factor substantially improved and system losses reduced to approximately 10%. Distribution companies are seen as needing to be active entities to help address customer problems and improve their energy utilisation.

3.3.2 Interval Metering and Peak Pricing Tariffs

In many jurisdictions the use of appropriate metering coupled with tariffs that are reflective of peak network congestion are deemed to be effective for managing consumer demand. The following are typical examples:

- Australia; The Victorian regulator has recently decreed the mandatory installation of interval meters over an extended period (refer to Ref 10). In this case the regulator is of the opinion that the disparate structure of the industry would not result in the widespread installation of interval metering. Also that if one considers the wider benefits associated with interval meters their installation is economic and is key to delivering demand side response.
- Canada; The Government of Ontario has established targets for the installation of 800,000 smart electricity meters by December 31, 2007 and installation of smart meters for all Ontario customers by December 31, 2010 (refer to Ref 18). The Board received a directive from the Minister of Energy under Section 27.1 of the Ontario Energy Board Act, 1998 (the Act) on July 16, 2004 (the Directive). In it, the Minister directed the Board to consult with stakeholders to identify options and address issues with regard to the targets.
- Ireland; The Electricity Supply Board (ESB) has implemented a peak demand reduction program (Ref 27) referred to as the Winter Demand Reduction Incentive (WDRI). This program pays industrial and commercial consumers between €10 and €20 per kW (NZ$20/kW to NZ$40/kW) to reduce demand during the winter evenings. The payment is made on an assessment of historical consumer demands.
- Taiwan; Taiwans total installed capacity grew an average of 6.5%/annum from 1990 to 2001, while peak load grew by an average of 5.6%/annum during that time period. Load management programs enabled Taiwan to reduce its peak load by 4336 MW in 2000 (Ref 36). Taiwan provides a variety of financial incentives for investments in energy conservation equipment, including tax credits, low interest loans and accelerated depreciation. To balance the system load and improve the system load factor and power efficiency the transmission company, Taipower, has undertaken a number of load management options. As a result they have increased the difference between peak and off-peak hour electricity rates such that the summer season ratio between peak and off-peak rates is typically 7-1 (Ref 37).

- UK; The introduction of advanced (smart) meters in the United Kingdom is being trialed. A key facet of the technology employed involves the display of energy consumption to consumers, particularly during times of peak load (high cost) (Ref 42). The technology, which is semi-mature, including display meters, remotely read meters and Internet meters is estimated to be capable of reducing energy consumption in the United Kingdom by 5-10% (Ref 44).
- US (California); the Californian Electricity Commission (CEC) and the Californian Public Utilities Commission (CPUC) have set a goal to introduce smart metering to consumers such that appropriate critical peak pricing (CPP) and/or time of use (TOU) tariffs can be introduced to all consumers. The goal is to achieve an additional 1% of load response per annum (Ref (82)). In January 2005 the California Public Utilities Commission (PCUC) authorised funding to distribution utilities to complete advanced metering installations for customers with monthly demand over 200 kW.

3.3.3 Energy Efficient Equipment and Programs

Numerous electrical DSM initiatives exist in the form of generalised energy efficiency programs that serve to reduce the demand for electrical energy and are applicable to the Auckland/North-Isthmus region. Typical examples are as follows:

- Belgium; Tax abatements exist whereby 13.5% of energy saving investments can be deducted from the taxable income of companies or private persons (refer to Ref 14).
- EU; The European Parliament and the Council in June 2003 adopted the Intelligent Energy – Europe program (EIE) which supports programs of a non-technological nature with a particular focus on energy efficiency and renewable energy sources. EIE supports the European Unions Green Paper on Security of Energy Supply and Community legislation on renewable electricity, energy performance of buildings and biofuels. The program is running from 2003 to 2006 and involves €250M for programs that increase the proportion of energy generated from renewable sources and the efficient use of energy (Ref 24).
- Germany; The utility RWE Energie implemented a program to promote the use of energy-efficient appliances in the home which included refrigerators, freezers, dishwashers, and washing machines. The utility paid an incentive of 50 euro to each customer buying an energy-efficient appliance with an RWE label. The program recorded 1 million of the 1.8 million eligible taking advantage of the scheme and energy savings totalled 453,000 MWh with a cost-saving ratio of 0.1695 euro/kWh (Ref 16).
- International Energy Agency (IEA); This organisation is an autonomous body which was established in November 1974 within the framework of the Organisation for Economic Co-operation and Development (OECD) to implement an international energy program (Ref 28). It carries out a number of programs among twenty-five of the OECD's thirty member countries. The IEA began an international database on Demand-Side Management Techniques and Programs (INDEEP) database in 1994. The database was implemented as an international tool to inspire the design and planning of new DSM and energy efficiency activities. In 2004 the database contained information on 229 DSM programs implemented in 14 member countries. The programs cover a broad range of energy-saving technologies that have been

implemented. The primary objective of the majority of programs is energy efficiency, which are implemented largely by utility companies (84%), central governments (7%), and regional governments and energy service companies (3%).

- Netherlands; An environmental tax, Regulerende Energie Belasting (REB) [Regulating Energy Tax] is imposed. Energy efficient domestic appliances are subsidised with money raised from REB with a budget for the domestic sector in excess of 100 million Euro per year for A-label appliances and efficiency measures in buildings. The Energy Savings Action Program was implemented in 1999 and set an energy efficiency improvement target for appliances in households of 1.8% per year for the period 1995 to 2010.
- Philippines; A national DSM energy program exists that is projected to deliver an estimated cumulative potential energy savings of 1.2 MMBFOE (million barrels of fuel oil equivalent). The energy efficiency programs in the power sector are predicted to defer the construction of 450 MW of additional plant capacity (Ref 34).
- Singapore; In addition to a voluntary green labelling scheme, Singapore has an accelerated depreciation tax initiative. The focus is on replacing primary building equipment such as cooling systems, boilers and pumps. Businesses can accelerate the depreciation of this equipment and thus enjoy significant tax savings.
- South Korea; The government provides tax incentives for energy efficiency investments. From 2001, a 10% income tax credit is provided for the replacement of old industrial kilns, the installation of energy-saving facilities, alternative fuel-using facilities and other facilities which are assessed as being able to deliver more than 10% of energy-saving effects (Ref 35).
- UK; The Enhanced Capital Allowance (ECA) scheme enables businesses to claim 100% first year capital allowances on investments in energy saving technologies and products, ranging from energy efficient lighting systems to combined heat and power systems (subject to achieving certain ‘quality’ (heat to power) ratios). Businesses are able to write off the whole cost of their investment against their taxable profits of the period during which they make the investment. The scheme was based upon the model operating in the Netherlands.
- US; Over the last two decades many states have used Integrated Resource Planning (IRP) to compare the benefits and costs of DSM with the costs of additional generation. These IRP programs have led many states to generate a network of utility DSM programs that together have avoided the need for about one hundred 300 MW power plants. It is estimated that by 2020, changes to energy standards already enacted will save/reduce peak electric demand by 120,000 MW (more than a 10% reduction) (Ref 47).

3.3.4 Energy Efficient Standards

Many countries have modified/introduced standards that improve the energy efficiency requirements of buildings, appliances etc. Some typical examples include:

- Australia; The Australian government has developed a strategy to reduce stand-by power consumption that supports international co-operative programs, and to undertake programs to help reduce stand-by power in domestic and imported appliances. Australia has a national end-use energy efficiency program (Ref 11).
- Germany; In recent years Germany has become aware of stand-by power consumption and the federal government and local authorities in Berlin have issued resolutions to reduce stand-by power losses. The government supports a 1-watt goal for stand-by power and recommends the principle that "off is off". The Association of Municipal Public Utilities for Energy Efficiency (ASEW) members offered DM50 for the purchase of appliances with low stand-by power losses (Ref 12).
- Japan; The Top Runner program in Japan is a regulatory program for stand-by power to reduce energy consumed by the growing number of electrical devices that are drawing power while in stand-by mode. The program was established in March 1999 under Japan's framework legislation on energy efficiency with targets for 11 products including air-conditioning, heaters, fluorescent lamps, television receivers, copying machines, computers, VCRs, refrigerators and freezers. Studies indicate that stand-by power is responsible for between 3 and 13 per cent of residential electricity used by the Organisation for Economic Co-operation and Development (OECD) members. The replacement of existing appliances with new appliances that have a lower stand-by power have been estimated to reduce the total stand-by power consumption by over 70 per cent (Ref 12).
- US (California); The California Energy Commission (CEC) (California's primary energy planning and policy agency) oversees an annual expenditure of US$250M on energy efficiency programs. The CEC has existed since 1975 and claims to have had a significant impact on the per capita energy usage within California over the period 1975 through 2004. During 2005 the CEC approved new regulations governing stand-by power to make appliances sold in the state more energy efficient, saving some 100 megawatts of generating capacity every year. The regulations go into effect on a staggered schedule beginning in January 2006. The new energy standards regulate appliances such as incandescent lamps; audio and video equipment; residential pool pumps and portable electric spas; evaporative coolers; ceiling fans, exhaust fans and whole house fans; commercial ice makers, refrigerators and freezers; vending machines; commercial hot food holding cabinets and water dispensers, among others (Ref 83).

3.3.5 Special Protection Systems (load tripping)

The tripping of specific loads during contingency situations has been used in some jurisdictions. An example includes that employed in Tasmania where a system/special protection system (SPS) was developed by the Hydro Electric Corporation of Tasmania (HECT) to extend power transfer limits of interconnecting lines between southern and northern Tasmania (Ref 19). The implementation of the SPS scheme was accepted as an interim solution before a new 220kV transmission line could be constructed.

The scheme is triggered by the status of a circuit breaker. A computer system checks the pre-event power flow and trips generation and load based on a set of look-up tables. The scheme is installed in a substation and has dedicated two-way communication with 8 generators and 10 loads and the tested operation time was 270 ms. The scheme was commissioned in 1997 using Abbey Systems (NZ) hardware.

A more extensive, permanent SPS is currently being commissioned for Hydro Tasmania to support the operation of the Basslink interconnection with mainland Australia. This SPS has an economic driver (rather than supply reliability) and avoids the need for significant grid investment at a substantially lower cost. This system supervises the loading of 17 transmission circuits and has the capability to disconnect remote hydro generation to maintain intact transmission circuits within rated capacity following forced outages.

3.3.6 Regulated DSM Frameworks

In a number of jurisdictions regulators have moved to codify what levels of DSM are expected of industry participants. Examples include:

- Australia; The National electricity Code that defines the operation of the NEM requires a “regulatory test” be carried out prior to making significant transmission network investments. This test is essentially an economic benefits test, and requires demand management and embedded generation alternatives to be considered alongside traditional supply side options. A number of these tests have been conducted to date, with no instances where demand management was the preferred solution (Ref 60). Under the New South Wales (NSW) Electricity Supply Act 1995 distribution companies in NSW are required to investigate and report on demand management strategies where demand management options may be expected to be cost effective in avoiding or deferring the expansion of the distribution network (Ref 61). This requirement has been codified in a Demand Management code of Practice, requiring distributors to publish an annual planning statement outlining areas facing future capacity constraints, and to seek public expressions of interest to provide DM alternatives, prior to investing in network augmentations.
- Australia; A consent condition for a new 330kV cable to supply the Sydney CBD in 1999, EnergyAustralia and Transgrid (distribution and transmission respectively) were required to establish a A$10M fund to investigate the potential for demand management to reduce peak network demands. This project commenced in 2003, and there are currently a number of studies being undertaken aimed at quantifying the practical and commercially viable potential of demand management (Ref 72).
- Belgium; A Rational Use of Energy (RUE) public service obligation exists. The RUE obligation has placed on grid controllers the need to guarantee a yearly energy saving of 1% of primary energy of delivered electricity.
- Brazil; In 1998 the federal regulatory agency for the electric sector announced measures to improve distribution and end-use efficiency. All distribution utilities were required to spend at least 1% of their revenues on energy efficiency improvements and that a quarter of this amount (representing approximately $50 million per year) should be spent on end-use efficiency projects. As a result Brazil has seen an expansion of energy efficiency programs.

- Denmark; Grid companies are obliged to plan and perform DSM activities directed at all types of consumers including households, industry, service and public administration. The grid companies are obliged to present information about the development of electricity consumption and undertake comparisons on consumer's electricity bills. The grid companies assign a budget of approximately 0.6 EURO/MWh on demand side management activities (Ref 20).
- Hong Kong; Both CLP Power and HEC have entered into DSM agreements with the SAR Government. Both of these companies are integrated power companies (owning generation, transmission and distribution). HEC reports that a total of HK$37.5M (NZ$7M) was spent on demand side initiatives over the period of 2000 through 2003 to achieve a saving of 50.2GWh or 9.8 MW (roughly NZ$700/kW).
- India; The Indian government has concluded that investment in energy efficiency/conservation is highly cost effective and enacted the Energy Conservation (EC) Act 2001 in 2002. (Ref 25). The Act provides the legal framework, institutional arrangement and regulatory mechanism at central and state level to drive energy efficiency throughout the country.
- Italy; Distribution companies are required to implement end-use efficiency improvement measures in order to reach quantitative energy saving targets. The targets become progressively tighter over a five-year period, ranging from 0.3 Mtoe (million tonnes of oil equivalent) of energy savings in 2002 to 1.60 Mtoe in 2006. These targets apply to all distribution companies providing electricity to more than 100,000 end-users. The quota of energy savings to be achieved by a single distributor is proportional to the ratio between the electricity it distributes at the local level and the total electricity distributed at the national level. Distributors who do not achieve their assigned energy savings targets must pay fines.
- Norway; To establish the implementation of energy efficiency Norway created Enova SF, which became operational in 2002. Enova is a public enterprise owned by the Royal Norwegian Ministry of Petroleum and Energy and the aim was to create a pro-active agency that has the capacity to stimulate energy efficiency by motivating cost-effective and environmental sound investment decisions. The Enova program is funded by the Norwegian Parliament which established an energy fund and indicated grants within a framework of up to NKr5 billion (NZ$1B) over a ten-year period. A levy on the electricity distribution tariffs and government to finance the energy fund. Enova manages the energy fund and finances programs and initiatives that support and underpin national objectives.
- UK; The Energy Efficiency Commitment (EEC) was implemented under the Energy Efficiency Obligations Order 2001. For 2002 to 2005 (proposals are in place for EEC 2005-2008) the EEC placed a requirement on electricity and gas suppliers to achieve targets for the promotion of improvements in domestic energy efficiency. Suppliers were obligated to encourage and assist their domestic consumers make energy savings through installing measures such as cavity wall and loft insulation, energy efficient boilers, appliances and light bulbs. At least 50% of energy savings is focussed on low-income consumers, specifically those in receipt of certain benefits and tax credits.
- US (Texas); The Public Utility Commission of Texas has developed an Energy Efficiency Implementation Project in order to achieve the mandated energy efficiency equivalent to 10% of each years growth in electricity demand.

- US (California); The California Public Utilities Commission (PCUC) and the California Energy Commission (CEC) jointly sponsor an "Energy Action Plan" which has as the primary goal of decreasing the per capita energy use and greenhouse gases through increased conservation and efficiency. The plan includes three fundamental tools (i) Energy Efficiency Programs, (ii) building codes and standards and (iii) demand response programs and pricing. The impact of the plan has been monitored since 1975 and claims to have reduced peak electrical demands in California by up to 10,000 MW. As proof of its effectiveness CEC indicates that during the period 1975 through 2005 the per capita energy usage in California has remained relatively constant at roughly 7,500kWh/annum whilst the US average has climbed from 8,000kWh/annum to 12,000kWh/annum.
- US (California); In January 2005 the California Public Utilities Commission (PCUC), in its ongoing efforts to ensure electricity supply and reliability for the state, approved electricity DSM programs for the 2005 summer. The program includes critical peak pricing, demand bidding, demand reserves partnerships, commercial/residential demand management programs and educational/awareness programs. Through authorisation of these programs, the commission has estimated that the additional demand response capacity available to the utilities state wide during the 2005 summer will be approximately 600 MW. The anticipated demand reduction would be around 1% given that California's maximum summer electricity demand is around 35,500 MW. In total all the demand response programs that are active are expected to reduce the electrical demand in California by 5% during the 2005 summer.

3.3.7 Specific Demand Reduction Initiatives

The following are examples of companies/communities/organisations that have claimed success using DSM. The methodologies employed would be applicable to the Auckland/North-Isthmus region (although economic applicability requires further investigation).

- New Zealand; The Canterbury based distribution company Orion reports that it has achieved significant success managing the demand for electricity supply in the Christchurch region. Orion's DSM are reported to include the use of an existing ripple management system coupled with a decade long demand management plan that incorporated critical pricing tariffs, stand-by diesels, fuel substitution and night storage heater initiatives (Ref 31).
- US; The Peak Load Management Alliance (PLMA) was formed by a group of organisations with business interests in dealing with the tremendous price fluctuations experienced in the electricity supply markets during the last few years of the twentieth century (Ref 33). These price fluctuations resulted from the markets inability to either generate or transmit a supply of electricity sufficient to meet the demand at certain times. The PLMA has made a number of awards to companies who have achieved success in the area of managing electrical demand.
- US (California); A typical example of the DSM programs being introduced in California is illustrated by that proposed by the Pacific Gas and Electric Company (PG&E) who outline a budget of US$176M during 2006 for the reduction of 170 MW of peak demand (roughly US$1000/kW) (Ref 80).

- US (Florida); Florida Light & Power (FPL) (peak summer demand of 19,000MW) reports that its DSM programs have been active since 1978 and include cost-effective energy conservation and load management. Ref (86) indicates that FPL's DSM efforts through 2004 have resulted in a cumulative summer peak reduction of approximately 3,418 MW and an estimated cumulative energy saving of 29,050 GWH (both calculated at generator terminals). In particular FPL uses a bi-direction load management system called TWACS (Two Way Automatic Control System) that also provides automatic meter reading facilities. FPL offers numerous load management program to its consumers, including credits for the control of major domestic appliances/household equipment and commercial/industrial equipment. An overview of FPL's systems is reported in Ref (85).
- US (Georgia); Georgia Power (Ref 50), A Southern Company, included in its January 1998 Integrated Resource Plan (IRP) a program for equalising voltage along selected distribution feeders via the installation of switched capacitor banks. Ref 75) details how the additional capacitors coupled with zone substation tap changer reduction improves system efficiency and allows for load reduction during peak and shoulder peak conditions. SKM understands that the demand reduction is persistent and that during 2000 Georgia Power had installed equipment on 314 feeders and 153 substations with a load reduction of roughly 200 MW.
- US (Iowa); The MidAmerican Energy Company is the largest utility in Iowa and is strategically located in the middle of several major markets in the Midwest. The company is reported to have (Ref 49) 156 MW of interruptible load, with 125 participating commercial and industrial customers. The minimum customer participation load is 250 kW. This contract-based curtailment program is designed so that when a curtailment alert is issued, usually on hot summer days when high electricity usage is expected, the programs 125 customers agree to shed load in return for a capacity payment.
- US (Minnesota); The Otter Tail Power Company supplies roughly 130,000 consumers in the states of Minnesota and North/South Dakota. The company provides numerous rebates to consumers who are prepared to have specific equipment controlled or for the installation of specific equipment (Ref 51). This targeted approach to managing peak demand is typical of numerous vertically integrated utilities in the USA. The rebates offered are for new and retrofitted equipment and include residential demand control, thermal storage, commercial cooking, commercial refrigeration, commercial/industrial lighting, high efficiency motors and finance programs.
- US (New York); New York State has three load management programs that offer different terms and payments, and are open to all types of consumers (Ref 78). One of the programs participants receive payments for an agreement to curtail demand during times when the grid could be in jeopardy. To register consumers commit to a minimum 100 kW load reduction, subject to a one -hour verification determined by the NYISO (system operator). During 2003 payments ranged from US$1/kWh to US$11/kWh (in New York City).
- US (Washington, Oregon, Montana & Idaho); Bonneville Power Administration (BPA) has implemented a full-scale regional DSM program that provides incentives to Pacific Northwest aluminium smelters, encouraging them to invest in electric energy efficiency improvements. The incentive is offered to

aluminium smelters only. The smelters are paid 0.005 USD/kWh saved over a 10-year period, based on the differences between a baseline kWh per pound electrical usage and current kWh per pound electrical usage (Ref 16). BPA are also actively working on a number of other "Non-Wires Solutions". One example involves the use of the Internet to manage peak electrical demands (air conditioning) in commercial buildings (Ref 77).

- US (Vermont); Burlington Electric Department (BED) is Vermont's largest municipally owned electric utility serving 19,600 customers. Over the last decade more than $24 million has been invested in efficiency in Burlington. BED has spent about half of this amount directly on energy efficiency measures, while customers own investment accounts for the other $12 million. As a result of this investment demand for electricity has declined 2% since 1989, saving customers over $5 million annually. Put another way, it is estimated that 13% of the city's electric energy needs are now served by energy secured through BED's efficiency measures (Ref 55). This is an example where a community owned company adopted a demand management policy that became central to its mission. It gave the community an opportunity to save money and keep the environment cleaner by reducing the town's overall demand.
- US (Wisconsin); Wisconsin Electric Power Co., Milwaukee offers a diverse mix of load management programs to help the company manage system integrity under the most severe conditions (Ref 56). It is reported that in 1995 the summer peak demand was 5368 MW. At the time the company reported 164 MW served on one of the various load management rates and 25,000 participants. Many of these participants opted for different options for controlling air conditioning. The industrial and commercial customers are reported to have a choice of three load management rates, all of them receive a personal computer with software as well as a load control relay and signal light stack. They're notified of pending curtailments through electronic mail as well as by triggering an alarm via the light stack. The company reports having accessed curtailable and interruptible load for up to 8 hours during some periods. However, the actual relief achieved is relatively modest and reported at 123 MW.

4. Specific Demand Reduction Options

The following sections outline specific electrical demand reduction options in relation to commercial and industrial consumers.

4.1 Commercial Sector

Transmission constraints in the Auckland/North-Isthmus region are most severe during winter evenings (5pm through 9pm). The peak is predominantly the result of domestic demand due to cooking, lighting, heating etc. (refer to Figure 14) and commercial demand is generally in decline at this time of day. However there are potential areas for demand management that can be addressed in the commercial sector.

When considering the electrical demand of commercial buildings there is a need to consider both new and existing buildings. Opportunities for demand reduction in existing buildings effectively only consist of those with planned refurbishment or those who are close to being refurbished (if sufficient economic drivers exist). In both cases new and existing buildings can be further split into those that are owner occupied or are speculative. Speculative developers may be influenced by market forces but they tend to focus on short term capital gains and in many cases do not consider the long term economics associated with energy consumption. In contrast owner-occupiers tend to invest in equipment that is energy efficient and capable of managing peak electrical demands (owner-occupiers, for example, include tertiary organisations like the University of Auckland). Because of the above issues numerous governments have chosen to address this issue via legislation.

The reduction of commercial electrical demand during peak transmission periods can be initiated using the following indirect methodologies:

- financial incentives
- electrical tariffs
- building standards
- peer comparisons / competition
- market forces / energy education

Each of the above methods will trigger different technical solutions which are generally only suited to implementation at the construction or refurbishment stage of a commercial building.

4.1.1 Indirect DSM Methodologies

Financial Incentives

Financial incentives could be introduced as per that being offered in a number of ways by different government bodies as outlined in Section 3. Examples of which are rebate schemes for the purchase of energy efficient equipment for a refurbishment program or as part of the capital expenditure for new build.

Schemes of this nature do exist and include the Enhanced Capital Allowances promoted by the UK government. Such a scheme allows a business to write off 100% of the capital expenditure on energy efficient equipment in the first year against the profits of the business instead of it being written off over a number of years.

This type of incentive need not be solely aimed at new developments but can be part of a business's planned maintenance scheme (ie. for re-lamping or chiller replacement).

The UK Energy Saving Trust is providing grants from a £50 million fund until March 2008 to encourage community heating schemes, those being from a central source to supply multiple buildings such as homes, schools, hospitals or offices. Each with differing demand profiles over a 24/7 cycle, thus providing a demand profile that is more linear and which typically utilises CHP production equipment (Ref 64).

"Clear skies" is a further example of grants being made available, with £10.0 million being provided by the UK government (Ref 65) to schools, trusts and communities for the installation of wind turbines to reduce energy consumption. A recently completed business plan demonstrates that a wind turbine installed at a school in Dunstable UK will save on average £1,200 per annum. The capital cost of the project is £20,000 and with a 50% grant from Clear Skies there is a pay back period of 8.5 years, if electricity prices remain constant.

The Energy Savings Trust has also made available £30 million in grants for commercial and residential PV applications, or general energy improvement measures, such as improved glazing and insulation.

They also offer to undertake free energy audits for commercial and industrial premises, providing a report and developing an effective energy policy in accordance with the Good Practice Guide 186, which has been well received.

Electricity Tariffs

A dual/multiple tariff structure could be implemented throughout the Auckland region, similar to that introduced by Orion (Ref 31), thus encouraging the use of off peak electricity. This could be structured to offer, for example, preferential tariffs for electricity from say 12pm to 4pm during winter.

Many commercial consumers already have multiple tariff meters. However the introduction of dual/multiple tariffs to all consumers would need to be mandated (as per that mandated by the regulators in Victoria and Ontario. Refer to Section 3).

Building Standards

Building Standards could be modified to ensure that minimum standards of material and energy performance are achieved. For example they could set the required thermal criteria for the building skins and also set targets for energy usage (kW/Annum/m^2). The latter target would mainly effect new build schemes rather than promoting efficient refurbishment works.

The UK government in conjunction with the Building Research Establishment (BRE), the Department for Environment, Food and Rural Affairs (DEFRA) and the Department of Local Government Regions (DTLR) have developed a Standard Assessment Procedure (SAP), for energy rating of dwellings. SAP rating is then linked to the approval process of "Building Control" which then has the ability to refuse to issue a certificate of completion until the ratings are completed and are approved.

The system penalises high ratios of glass to wall areas in a building facade, and considers construction quality and energy systems.

The above rating is in a similar vein to the benchmarking procedure being established for white goods carrying the Energy Efficiency Recommended Logo, where appliances are given a rating A-G.

In a book entitled "Scotland in 2020 – Agenda for a new Scotland" the former environment minister calls for the Scottish Executive to make it a planning condition that all newly-built Scottish homes should have solar power or wind vanes as standard to provide an element of renewable energy.

The Mayor of London Ken Livingstone has made it a requirement for developers to identify the best types of energy usage solutions for any new development in London whether they are commercial or residential (Ref 68).

ASHRAE (American Society of Heating, Refrigeration and Air Conditioning Engineers) are currently reviewing the guidelines and design standards to incorporate a good design practice section within each guide. It is also setting up a series of sub committees and sponsoring projects.

One option that is closely linked to building standards is the use of passive systems, where possible, for building environmental control. An example of which is to use the mass of a building for thermal storage. Fabric Energy Storage (FES), the "Pre-cooling" of structures so that it takes less power to cool the buildings has been tested by firstly Purdue University on a four floor 1.4million square foot Ameritech Corp. office building. The result was an estimated 41% reduction in electricity running costs. A second example is that of CCANZ and UK's Concrete Centre who commissioned research to model Canterbury University's existing Maths and Computer Science building. This work demonstrated that the thermal mass helped stabilise temperature fluctuations and resulted in energy savings of up to 20%.

Another tool to provide incentives that is currently being discussed in Europe and applies to Carbon Index Rating. This would involve introducing an energy efficiency review of existing and new buildings which applies a factor to the rateable value. The better the efficiency the nearer to 1 the factor would be. This could be reviewed every number of years (say 5) or when requested by the occupier (ie. following building modifications).

In the UK Air Leakage Testing is now a statutory requirement under Part L2 of the Building Regulations for buildings over 1000 m² gross internal floor area. Smaller buildings have to prove compliance with Part L2 via the use of appropriate construction techniques and the use of suitable materials. In addition a 'Competent Person' is required to certify that the building achieves the appropriate level of air tightness. For buildings incorporating many complex details, an Air Leakage Test is becoming a common option to demonstrate compliance

Testing can only be carried out once the building facades and the external envelope and internal finishes are completed. For the test, designed apertures including the doors, windows and other elements of the building envelope are closed as normal. Ventilation ducts and natural ventilation openings are temporarily sealed. Lift shaft ventilation openings remain unsealed, the objective of the tests is to demonstrate that minimum standards of build quality and workmanship are attained thus ensuring that heat, and therefore energy is not wasted to overcome fabric leakage.

The US Solar power industry has developed "Our Solar Power Future" as a road map through 2030 and beyond, with an objective of providing 50% of the US electricity generation by 2025, via solar power, with similar schemes being reiterated in both Germany and Japan.

Peer Comparisons / Competition

Buildings of any type have always been compared and judged against their peers, and up until recently this has generally been in terms of aesthetics, physical size, shape and interior finishes. In the US, UK and Europe another factor has come to the forefront in recent times and is that of energy efficiency. This approach could be further emphasised in New Zealand.

For a number of years the US has had tools such as "LEED" (Leadership in Energy and Environment Design), the UK "BREEAM" (Building Research Establishment Environmental Assessment Method) and more recently GREEN STAR in Australia. These are the countries individual tools for benchmarking a building's performance in terms of energy efficiency and sustainability.

Within these countries both designers and developers have embraced the use of such tools and recognise that their peers and potential occupiers in terms of energy consumption and sustainability judge the developments. The effect has been to stimulate competition between design teams and a new marketing tool has opened up for the agencies. Public awareness of energy performance has improved and R & D development has increased. All resulting in a positive move away from what was the norm.

Whilst EECA is currently working towards this end in New Zealand the level of industry participation has not reached the level seen in many other countries. A recent New Zealand example of this type of activity would be the Landcare Research Campus at Tamaki, where the building's life cycle costs were analysed against the initial capital expenditure resulting in an energy efficient and sustainable building.

The energy agency of Frankfurt organised an Energy Benchmark Pool for commercial buildings. Users, owners and investors of buildings were invited to analyse and optimise the energy use of their buildings in small groups of maximum ten participants. The results are published in an anonymous way. The aim was to enforce competition of energy efficient buildings in Frankfurt and to give owners and investors clear figures to describe energy efficiency for their planners.

On average the results achieved were a reduction of 25% of the total demand of the buildings with a pay-back-time less than 5 years. Typically 10 to 15% of the total demand could be saved only by optimising the running time of the equipment without any investment. For the first time the electricity demand in 10 big office buildings in Frankfurt was analysed in every detail (parts of lighting, HVAC, office equipment etc.) showing large deviations in specific demands as well as high saving potential. The implementation of the defined saving potential is still in process (Ref 70).

Similarly Sustainable Energy Ireland (SEI) have undertaken case studies within the education and commercial office sectors. The results demonstrate that by holistic design measures between Architects and engineers the building orientation, fabric and external shading can maximise the use of daylight whilst minimising the solar gains, this process linked to automatic control of energy efficient lighting dramatically reduces energy consumption. The new headquarters building (7,884 m^2) for Limerick County Council is recorded as having an 87% improvement in performance (Ref 69).

Market Forces / Energy Education

The introduction of schemes like BREEAM (UK), LEED (US) or GREEN STAR (Australia) has created an increased level of expectation from occupiers and owners in relation to energy performance and efficiency.

The marketeers, agents and now financiers have further advanced this by their long term yield predictions of the commercial sector, by linking the rental returns, saleability and capital appreciation to the Green Star or equivalent rating thus impacting on business plans and valuations.

4.1.2 Technical Options and Costs

A typical commercial building consumes roughly 100 watts per m^2 of floor area. The major contributors to the demand are lighting, air conditioning and ventilation.

The technical solutions available for demand management in commercial buildings are numerous, but tend to be closely linked to energy efficient design practices. It is important to note that the ability to affect maximum demand reduction benefit is when commercial buildings are constructed or refurbished, and in some cases technical options are only available when the building is designed and built (for example maximising the use of natural light). Typical refurbishment intervals for buildings would be around 10 years for shopping centres and 30 years for large office blocks. This means that any reductions in existing commercial electrical demand will not be achieved quickly.

Lighting

Section 3 contains numerous examples where initiatives have been implemented to reduce lighting loads. Specific examples include the Nasher Sculpture Centre in Dallas, which utilises 100% daylight to illuminate specific works of art, or the office space at the Tamaki College that has a daylight factor of 5%.

The reduction of lighting demand in commercial buildings can be implemented using the following methods:

- automatic lighting control to reduce the number of lights utilised in a building, by:
  - photocell switching of the perimeter lights within buildings ("daylight linkage"). That is those spaces adjacent to windows that rely on natural light. This would not reduce peak winter demands (5pm to 9pm)
  - movement sensors to turn lights off after peak hours of occupancy
  - cleaning staff to have swipe cards to allow limited control of lighting
  - toilets, store rooms and other low occupancy rooms are fitted with PIR sensors and/or timers
  - reducing lighting output using specialised lighting control systems coupled with florescent lighting that can be dimmed.

  The costs associated with automatic lighting systems are relatively insignificant (NZ$50k) in comparison to other costs when a building is constructed or refurbished. However it is not possible to implement an automatic lighting control scheme without re-configuring the building wiring and in most cases replacing the physical lights (at significant cost).

  With automatic lighting controls installed and daylight linkage provided SKM is of the view that during daylight hours approximately 20W/m^2 could be saved. Assuming a typical 10,000 m^2 office development, with a 50% effective lighting control system (due to cellular offices) the energy consumption could be reduced by 100 kW. Ref (63) reports a total of 1.1 million m^2 of primary and secondary office space within the Auckland CBD. Hence if the above theory were applied to 50% of the buildings the peak demand reduction would be around 5.5 MW.

- a program for improving the efficiency of lighting equipment, lamps, ballasts, transformers and luminaries (similar to the Greenlight Australia scheme). The costs associated with upgrading commercial lighting are around $50/m^2.

Back-up Generators

The operation of back-up generating (BUG) equipment for peak load lopping. In many cases this solution would require the installation of synchronisation equipment such that BUG's can connect to the distribution system. More intensive maintenance regimes would be required to make use of BUG's and a centralised control system would be required to synchronise the units during times of peak demand. It is worth noting that the use of BUG's during 5pm-9pm winter peaks would be when building occupancy rates are low, if not zero.

The costs associated with installing synchronisation equipment are estimated by SKM to be around $40k per generator. However, these costs do not include other issues that may need consideration when connecting to the distribution network (ie. fault level mitigation, fuel tank capacity, emission control and noise).

Potable Hot Water Systems

The installation of (or replacement of electric hot water storage systems with) high efficiency gas instantaneous heaters. The capital costs associated with gas hot water systems are generally twice that of electricity hot water systems, and this does not include gas pipeline connection costs. Fuel substitution in the commercial sector would not provide significant reduction to winter peak loads. Fuel substitution would be more appropriate for domestic space heating (this issue is the beyond the scope of this report).

Heating, Ventilation and Air Conditioning

The air quality within a commercial building is controlled by heating, ventilation and air conditioning plant (HVAC). The equipment is available in different forms, sizes and costs. Generally speaking the more expensive plant is more energy efficient. The ventilation plant effectively consists of fans that circulate air around, and in/out of, the building. The air-conditioning plant heats or cools air for distribution around the building. In its cheaper form air conditioning plant simply uses a large number of distributed compressors to effect cooling via evaporation (in the same manner as a fridge) which cools air and is blown around the building. This type of plant is well suited to small buildings and because of its relatively cheap capital cost is often utilised around commercial buildings. In the case of large buildings HVAC plant often consists of a central air conditioning plant that chills water. This water is then used to cool air in the Air Handling Unit (AHU) for distribution within the building. During winter mornings heating is achieved by introducing heat into the AHU generated by a hot water element (water is heated by gas or by electric heating elements). This type of HVAC plant incurs a higher capital cost than distributed HVAC systems but is significantly more energy efficient.

Air conditioning plant is operational in winter to control humidity

HVAC plant is used to manage both air temperature and humidity in a commercial building. Given this fact it is not unusual for HVAC to have relatively high amounts of air conditioning (cooling) load during winter. This is due to the HVAC system attempting to remove moisture from the building that is due to the building occupants. SKM understands that many of the Auckland CBD commercial buildings would have relatively significant HVAC demand due to chillers (compressor motors) during both winter and summer peaks.

The reduction of electrical demand due to HVAC can be achieved by:

- the replacement of smaller "old style DX (distributed) systems" with new variable air volume systems (VRV)
- the replacement of larger "old style DX (distributed) systems" for chilled water systems
- the use of variable speed fan drives to create variable air volume (VAV) ventilation systems instead of constant volume type systems (based on inefficient damper throttling)

- the reduction of electric reheat loads via the use of direct gas heating (fuel substitution)
- the conversion of larger systems to use fresh air economiser systems (maximising the use of external air)
- altering the controls on existing systems to use temperature only control rather than enthalpy (temperature and humidity) during specific times. Whilst this would allow humidity levels to rise it is SKM's experience that this would not significantly affect personal comfort levels for commercial buildings in Auckland
- reducing specifications for internal temperature and humidity control by say 1 – 2 degrees ^{o}C.
- the replacement of existing low efficiency motors with equivalent high efficiency types. Particularly given that a large portion of electricity used by HVAC plant is due to motor load
- turning off or cycling of HVAC chillers between 5pm and 9pm on winter evenings and relying on thermal inertia for this period. This is based on these systems inherently having a relatively large amount of chilled water storage thereby acting as a reservoir of otherwise unused cooling. This could be controlled using existing mains borne ripple control systems at relatively little cost (SKM estimates a capital cost to install of around NZ$500) or using existing HVAC control systems. Cycling would only be pragmatic in those systems that are fitted with variable speed drive systems. The use of cycling for those with direct-on-line motor starting (DOL) would likely result in higher demands. If one considers a 10,000 m^2 building (say built over 6 floors) and the HVAC system in each floor is consecutively switched off for 10 minutes in every hour the resultant saving would be 1/6th of the normal energy consumed. Assuming on average HVAC is around 50W/m^2 the reduction would be approximately 8.5 kW. Ref (63) reports a total of 1.1 million m^2 of primary and secondary office space within the Auckland CBD. Hence if the above theory were applied to 50% of the buildings the peak demand reduction would be roughly 5 MW.
- installing reservoirs to store chilled water (in the case of chilled water HVAC systems) for use during the 5pm to 9pm peak winter loading period, and turning off HVAC compressors during this period
- consider ice storage in conjunction with off peak electricity, where the electricity is used over night to make the ice, then the water for the chillers is cooled via the ice during the day, these systems have successfully been completed in the UK
- use “airhandling luminaires” to reduce load on air supply for air conditioning, utilising ceiling space as a return air plenum (heat from lights is directly removed by effectively installing extraction ducts above lights).

If is worth noting that the costs associated with basic low efficient HVAC plant are around NZ$200/m^2, while high energy efficient HVAC plant would be as much as NZ$400/m^2.

Computers

The issue of computer efficiency requires additional focus given are a relatively high number of computers are operational in the commercial sector during 5pm-9pm winter evening peaks, but the operators have left the office. The management of computers could be managed more intelligently by placing inactive computer workstations into hibernation (Ref 79). SKM's experience is that there is the risk of data loss/corruption and hence computer energy management tends to be left as a manual exercise (staff requested to turn off computers before leaving the office).

Combined Heat and Power (CHP)

The installation of combined heat and power plant is only economic for those commercial consumers who require large amounts of heat. In terms of reducing peak winter electrical demands (5pm-9pm) this would include hospitals, hotels and swimming pools. Given the high capital costs associated with CHP, coupled with the relatively low electricity prices and the fact that the Auckland/North-Isthmus region is relatively temperate there is little incentive for commercial consumers to convert to CHP.

New commercial buildings should be incentivised to install gas fuelled CHP plant (where economic).

4.2 Industrial Sector

The electrical equipment located within industrial plants tends to be site specific and varies significantly from site to site. It is thus difficult for SKM, without undertaking a significant survey, to deliver an accurate assessment of the potential for demand reductions in the industrial sector and the associated costs.

However, SKM has undertaken a sample survey of a handful of major industrial consumers in the Auckland/North-Isthmus region. This survey has not enabled SKM to come to a definitive conclusion regarding the entire amount of industrial demand response that is available in the Auckland/North-Isthmus region. However, it has established the fact that demand management opportunities do exist in the industrial sector and that these opportunities can be accessed if the right environment is created.

As expected the extent to which demand can be reduced is closely linked to economics. Furthermore the issue (as a whole) is relatively complex due to a number of less tangible issues that are difficult to quantify when considering the entire industrial base. These issues include:

- staff working hours (ie. weekend/late-night shifts interfere with family life)
- specific industry market conditions that change from time to time (ie. supply and demand for plant output)
- the ability to stockpile plant output
- the long-term effects of process disruption due to both planned and unplanned demand reduction
- electrical supply contracts (ie. each industrial consumer has specific electrical supply contracts, which have varying degrees of exposure to the electricity spot market. In a number of cases historical hedge contracts exist that mean industrial consumers are currently not exposed to increases in electricity prices)

4.2.1 SKM's Industrial Survey Results

SKM undertook a survey of major industrial consumers in the Auckland/North-Isthmus region. The survey involved brief meetings with seven major industrial consumers that are located within the region. The meetings involved discussions with major consumers regarding their ability and willingness to curtail demand during peak transmission periods. As an introduction to the meeting SKM used the diagrams presented in Section 2 of this document to illustrate the periods and durations during which electrical demand reductions are required.

Table 5 and Table 6 illustrate SKM's findings in relation to discussions with industrial consumers A through G.

▪ **Table 5 Industrial Consumer Demand Characteristics and General Comments**

	Site Demand Characteristics	General Comments
Consumer A	Heavy industrial Energy intensive 24/7 constant operation	Significant on-site generation. Space for more. Planning expansion of around 20 MW
Consumer B	Heavy industrial 24 hour weekday operation Plant off-line during weekends Significant load variations	Land area available for generation
Consumer C	Medium industrial Labour intensive 24/7 operation	Electricity ≈5% of operating costs
Consumer D	Medium industrial 24 hour weekday production Off-line during weekends	Electricity ≈10% of operating costs Energy costs entirely hedged 7pm-8pm peak network charges managed
Consumer E	Large distributor 24/7 operation Infrastructure based	Exposed to energy spot market Demand growth linked to population growth
Consumer F	Large petrochemical 24/7 constant operation Energy intensive	Outages result in H&S risks
Consumer G	Heavy industrial 24/7 constant operation	Exposed to energy spot market Planning expansion of around 6 MW

The results illustrated in Table 5 and Table 6 illustrate the following:

- opportunities do exist for demand reduction
- the majority of opportunities have maximum durations of 2-4 hours, after which plant operation is severely affected
- advanced warning of load curtailment/tripping is preferred and in many cases is a requirement

Table 6 Industrial consumer demand reduction potential (independent opportunities)

	Demand Reduction	Duration	Affects/Issues/Source
Consumer A	8 MW	> 4 hours	Additional generation from heat source
	60 MW	≤ 2 hours	Trip possible with no H&S risks Limited to ≈2 per annum Currently bid into reserves market
Consumer B	12 MW	< 4 hours	Trip possible with advanced warning Production delay
	45 MW	< 2 hours	Trip possible with no H&S risks Significant production delay
		> 2 hours	Significant production delay & product loss
Consumer C	0.5 MW	< 0.5 hours	Trip possible with advanced warning Production delay
Consumer D	4 MW	< 2 hours	Production delay
Consumer E	1 MW	< 2 hours	Production delay
	2.5 MW	< 8 hours	Existing diesel generation
Consumer F	1 MW	< 8 hours	Existing diesel generation
Consumer G	3 MW	< 3 hours	Trip possible with advanced warning 24 hour warning preferred Production delay
	8 MW	< 24 hours	24 hour warning required Significant production delay

4.2.2 General Survey Comments/Issues

It is worth noting the following issues that were highlighted during discussions with industrial consumers:

- electrical demand reductions (in some cases) are already occurring during periods of high spot prices. These reductions are generally being requested by electrical retailers and industrial consumers are not always compensated for the service. Recent industrial demand reductions have occurred when high electricity prices resulted from grid constraints during the 2005 summer months (with the Huntly power station being constrained off due to high Waikato river temperatures)
- a number of industrial consumers recalled that during the 1970-1980 period industrial consumers received signals to reduce electrical demand via a system of red/green lights. These lights indicated grid congestion and the fact that pricing tariffs had changed. Industrial consumers saw this form of tariff signalling as being sensible, and the philosophy is relatively similar to that promulgated by Orion (Ref 31) and EDF (France). The system in the Auckland/North-Isthmus region was discontinued as the market based electricity industry evolved

- in many cases electricity costs constitute a relatively small part of the overall plant production costs. As a result in some cases electricity reductions/savings will not receive significant focus unless costs become a significant portion of operating costs
- the perception that, on balance, the incentives to manage electrical demand are significantly higher in the domestic sector given that the cost of domestic energy is around $0.12/kWh compared to $0.04/kWh for the industrial sector
- the perception that there is no mechanism for industrial consumers to be rewarded for demand response. This view is, in part, driven by those industrial consumers who have electricity hedges, but also by those industrial consumers who have the ability to reduce demand at times of peak grid loading but currently can see no clear path to be rewarded, despite understanding that they might be penalised in the future by higher electricity prices
- all consumers had taken advantage of EECA energy audits. Most were of the view that energy savings opportunities in their businesses had been maximised
- those industrial consumers consulted were of the view that the demand reduction requirements outlined in Figure 4 (33 days per annum for as much as 4 hours) were significant and if they curtailed demand during all of these periods it would have a significant impact on their business
- in most cases industrial consumers indicated a preference to have the final decision regarding whether to reduce demand.

4.2.3 Cost of Demand Reduction Incentives

The evaluation of the capital/operating costs associated with industrial plant enhancements that would deliver electrical demand reduction is an extensive task. SKM has thus not attempted to do this. However, SKM's investigations indicate that specific major industrial consumers would consider implementing demand reductions once electricity prices reached NZ$0.5/kWh. This figure is of the same order as that assumed in Section 2.1 that projected a cost of NZ$1.3M/annum to reduce the Auckland/North-Isthmus region's demand by 100 MW. The exact prices would depend on the length of time for which curtailment is required and the number of times curtailment is requested. It is worth noting that these $/kWh figures were readily quoted by some industrial consumers due to the fact that they are already managing their demand due to their exposure on the electricity spot-market.

SKM thus concludes that if financial incentives of around NZ$1/kWh are offered widely to industrial consumers there will be some response.

4.2.4 Technical Demand Management Systems

The following sections outline a selection of systems that could potentially be used to facilitate demand reductions.

Special/System Protection Systems/Schemes

It would be possible to trip large industrial loads (under contract) in order to allow the transmission system that supplies the Auckland/North-Isthmus region to operate beyond the (N-1) level. This solution would be novel as it is not an approach typically used by utilities. However, its implementation may be desirable in order to manage the regions increasing demand until a suitable new transmission line or generation station is built. SKM estimates that, excluding communication links, the capital cost to install such a scheme would be around NZ$1M. This would include the installation of a centralised control system coupled with eight sets of remote load tripping terminal equipment (with each additional load tripping terminal costing around NZ$30k). Load tripping terminal equipment would need to be installed close to each of the industrial loads to enable tripping and secure communication links would need to be set up between the centralised control system and each of the load tripping terminals. The costs of these communication links would be very site specific and would be significant.

In some cases industrial demand that is already being bid into the existing spinning reserves market could potentially be "redirected" to manage electrical demand in the Auckland/North-Isthmus region (or could play a dual role).

Demand Exchange Systems

It would be possible to facilitate the curtailment of industrial loads by implementing a Demand Exchange System. This type of system relies on industrial consumers volunteering to curtail demand on the basis that they will be paid to do so (the system would also be applicable to commercial consumers).

The cost of such a system can generally be broken down into three stages:

- *The technology.* This would involve a web-based platform on a secure server that sends the alerts, posts prices and accepts the demand curtailment offers/trades. Other features and functionality like building customer groups for special events, counter-offering, on-line data graphing to help customers through events and on-line settlement are all possible but at additional cost.
- *Set-up.* The enrolment of customers and training them (along with traders or network operators) to participate on the exchange. The set-up costs would be significant given that consumers need to be visited by account managers or consultants. There would also be a cost to establish legal agreements surrounding the curtailment of demand.
- *Day to Day Operation.* The maintenance of the exchange for the period of operation and the settlement of the trades against each customers baseline. The access to 1/2 hourly metering data for each site subsequent to each trade is important. If the trades are infrequent, a fund is usually required to "fire drill" customers to ensure they are ready for real events.

SKM understands[1] that it is possible to obtain existing Demand Exchange platforms at prices that are commensurate with the smaller New Zealand consumer base. SKM also understands that the indicative costs for an exchange for 50 MW of curtailable load with 50+ customers would be in the region of NZ$150-250k (for technology and a section of the set-up costs). However, these costs do not include the significant costs associated with negotiating agreements, visiting customers, and the operational costs (these costs are difficult to estimate).

Direct Load Control Systems

If required there are a number of technologies available that may be used to centrally manage sheddable industrial electrical load, and which are presently relied upon by electrical network operators to manage sheddable electrical demand. Examples include mains borne ripple control systems, pager systems or radio wave teleswitching systems. In all cases these systems are proven technologies that can, if acceptable, be used to facilitate (i) the direct control of specific industrial equipment, and (ii) the start-up and connection of back-up diesel generators.

It is worth noting that in more recent times the use of the Internet for direct demand control has been considered (Ref 62).

The exact capital costs of direct load control systems is usually linked to functionality. However, by way of example, the installation of a mains borne ripple injection system (injecting into a single transmission substation supplying 100 MW) would typically cost in the region of NZ$0.5M, with the installed receivers costing around NZ$150. SKM is of the view that, if acceptable, the use of existing ripple injection equipment for controlling industrial demand/generation would be cost effective. The reliability of these systems in NZ is well establshed.

[1] Discussions with Demand Response (http://www.demandresponse.co.nz/)

5. Conclusions

The high level conclusions reached by SKM during the investigations are as follows:

- There is not one particular compelling demand management initiative that is applicable to the Auckland/North-Isthmus region. SKM is of the view that DSM involves a wide range of initiatives that evolve with time and there is no "silver bullet".
- It is difficult to segregate the general topic of electrical demand management (ie. energy efficiency) from that of peak demand management. The prime focus of many reported demand side management (DSM) programs is energy efficiency, although SKM understands that many programs are shifting their focus to energy savings at times of peak network loading.
- The extent to which the Auckland/North-Isthmus region (and New Zealand) has implemented traditional electrical load management technology (ie. domestic hot water load control) is relatively high. There are a number of examples of comparable countries where little in the way of consumer load control has been implemented.
- Peak winter electrical demands in the Auckland/North-Isthmus region have a significant domestic contribution. This sector of the consumer base currently has little incentive to reduce demand. Initiatives in this sector are key to achieving demand reductions.
- When one considers the entire electricity delivery chain the installation of demand management equipment may be economic at the time of the installation of houses/buildings/plant. However the elevated cost of retrofitting the equipment coupled with the inability to capture the benefits of the entire delivery chain often reduces the viability of demand management schemes. For this reason many jurisdictions that have not historically installed demand management equipment have difficulty in motivating to retrofit the equipment. This is further complicated by the separation of vertically integrated power supply companies (as is the case in New Zealand).
- There are examples of other jurisdictions where demand control is more compelling than is the case in Auckland. These examples generally experience summer peaking demands that are driven by air conditioning load. For these cases the number of extremely hot days are relatively small. Furthermore the increased temperatures that result in higher electrical demands are exacerbated by a corresponding decrease in transmission equipment ratings. This is not the case in the Auckland/North-Isthmus region during winter.
- In comparison to some jurisdictions (ie. locations in Europe and the US) the region experiences a relatively small amount of energy efficiency and "new age" demand side initiatives. A significant reason for this is the relative low cost of electricity and the relative temperate climate. International examples exist (ie. California) where relatively intensive energy demand management programs have been in existence for more than a decade and have achieved reductions in electrical demand.

- The industrial sector in the Auckland/North-Isthmus region is relatively buoyant and many industries are planning expansions. These new developments create opportunities for the supply sector to work together with industry to ensure new build has an appropriate level of energy efficiency.
- Opportunities for demand management do exist within the industrial and commercial sector. However there will be a time lag before they can be implemented and any results achieved. There are numerous examples that highlight this fact.
- There does exist the opportunity to trip industrial load under contract. This would only apply to a handful of large industrial consumers

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