Weather Files and Their Influence on Energy Consumption in Commercial Buildings

A Comparison Between TMY and TRY Weather Files Within New Zealand Climates

Assignment 2

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Executive Summary

This research report has determined that the energy consumption of a commercial building differs significantly with changing the weather file used in the computer calculation.

The two weather files used are the TMY and TRY which a both standard files used to represent a typical year. The TMY was developed in 2009 and the TRY in the 1970's. Both have been developed through using monitored data of actual weather patterns. The focus has been in New Zealand with an investigation into the three climate zones as define in NZS 4218:2004 – Energy Efficiency. Therefore the three main centres, Auckland, Wellington, and Christchurch were used in the calculation on energy consumption.

The greatest difference in energy consumption is in the warmer months when greater cooling is needed. Up to 19% difference was calculated with the TMY weather file being less than the TRY weather results. In cooler months, the difference between the two files is marginal, ranging from 3% and -4%. The positive percentage represents the TMY file consuming greater energy than the TRY weather, and a negative percentage is the TRY consuming greatest energy.

A-

Quick & dirty study. Replication difficult as the process of generating the epw files not well documented. Excellent methodology & results. But, justification of the significance of the outcome not attempted; and more importantly you signal the issues around using a heavyweight test case without any reference to the literature or evidence for your statement(s). Good report structure; good graphics; but simplistic analysis. Summer/winter differences not mentioned; temperature profiles inside & out could have been interesting given the summer/winter services behaviour

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1.0 - Introduction

This report documents the process and analysis that has been undertaken to determine if two different standard weather files of the same location produce similar results of calculated energy consumption. The energy consumptions have been calculated per month over a single year time frame using the same building model for each of the calculations. The building model that this method is being tested on is a commercial building which has been calibrated to an accuracy of +/-5% of actual energy consumption values.

The weather files that are used are the TMY (Typical Meteorological Year) and the TRY (Test Reference Year) which was developed in 2009 and 1993 respectively. The three main centres in New Zealand have been the focused for this research as this is a pilot study to identify the differences of the weather files and will therefore determine if there is a need to have further research.

1.1 - Background Information

Weather files are used in conjunction with computer programs when calculating and predicting the performance of buildings. By including weather files during a calculation, the accuracy of the predicted results increases due to the influence the climatic conditions have on the building. This is most commonly used in the calculation of the thermal performance of buildings as well energy consumption; however it is not limited to these applications. Daylight is also known to use weather files to improve the accuracy of the results. In terms of energy consumption calculations, a weather file effects the required heating, cooling, and ventilation requirements of the building to maintain a comfortable set temperature for the occupants.

When a computer program is used in the calculation of the building's performance, the process is commonly referred to as a simulation within the construction industry. Through out this report, the simulations are referred to as calculations as this is the underlying process being performed. The calculation of a program replicates reality and building performance to the best of the program's ability through a series of complex algorithms which otherwise would have to be done by hand.

"Users of energy simulation programs often have a wide variety of weather data from which to choose – from locally recorded, measured data to *typical* data sets" (Crawley and Huang, 1997:1). Standard weather files are used when calculating the energy consumption of buildings; they take into consideration aspects such as solar radiation and outside ambient air temperature which influence the energy consumption of a building. In New Zealand there are currently two typical weather files which are available for use in energy simulation programs. Both provide an typical yearly representation of the hourly climatic conditions that can be expected in different areas within New Zealand.

One file is a TMY (Typical Meteorological Year) which was developed in 2009 using climatic data over the last 30 years. It uses monthly data from multiple years to produce a year's worth of data which is representative of a typical year. The second typical weather file is a TRY (Test Reference Year) which was developed in 1993; this uses a single year from the data dating back to the 1970's which represents a typical year (Amor et al., 1993).

As well as the types of weather files available, there is also a large amount of locations available; a list of the available locations can be seen in Appendix A. Theoretically there is an unlimited amount of weather files that are accessible as custom files can be created providing that the raw weather data is available. Custom weather files are not used within this research, only standard TMY and TRY weather files that have been developed by the Energy Research Group or Centre for Building Performance Research whom are both connected to the school of architecture at Victoria University of Wellington. The three main centres within New Zealand; Auckland, Wellington, and Christchurch, these locations effectively represent a hot, moderate, and cold climates respectively.

we only produced the TRY data!

? which? related to what?

The New Zealand Standards and other related documents regarding the consumption of energy and thermal performance of buildings have been developed using the 1993 weather files. As the weather files are now outdated, this report documents the investigation untaken to determine the differences between the two weather files when applied to a building energy calculation.

1.2 - Research Question

The research of this report is based on the following question.

Is the calculated energy consumption of a commercial building using the recently (2009) developed TMY weather file produce results that are significantly different from the results produced when using the TRY (1993) weather file?

This report answers this question by calculating the energy consumption using the two types of weather files for the three main centres defined within the climatic zones of New Zealand using the same computer model building.

2.0 - The Importance of this Study

Tools (simulation programs) in which energy calculations are performed are continually being developed. The quality and depth of analysis capability over the past 35 years has improved considerably. Now, other than operator input errors, there is one other aspect that can have a significant impact on the resulting calculations; weather data (Hand et al., 2008).

In New Zealand, the current Building Code, Standards, and Compliance Documents that regard the energy and thermal performance requirements of a building have been developed through calculations which have been done using the 1993 TRY weather files. In 2009, new generic weather files were developed to represent a typical year in the current climatic conditions. These files are based on the historic weather data over the previous 30 years and provide a 'typical' years worth of data. As “energy consumption and thermal comfort is directly influenced by the climatic context” (David et al., 2010), it is known that the weather file has a significant effect when doing calculations.

The importance of weather data and the use of it in computer calculations is identified by many. One example of this is seen in a case study building; “the effects of humidity and radiation on energy consumption are less significant than those of external temperature for the building” (Neto and Fiorelli, 2008:2176).

Also within the same report, a sensitivity study of the effects of the weather conditions acting on the building was performed. This involved adjusting the weather parameters to determine the influence it has on the energy consumption of the building. The results of which can be seen in Appendix B. In brief summary, the change of +/- 1°C in air temperature can result in a +/- 1.2% change in building energy consumption; or a +/- 20% variation of the internal loads, eg.lighing loads will result in a +/- 12.4% change in the building’s energy consumption.

As the research was performed in Sao Paulo, Brazil, the variations seen will be directly applicable to a New Zealand context but this provides an understanding of the importance of the weather file and correct internal loads.

2.1 - Computer Calculation Program

For this research, the program that was selected for doing the energy calculations was EnergyPlus. “EnergyPlus is a simulation program designed for modelling buildings with all their associated heating, ventilating, and air conditioning equipment” (EnergyPlus, 2009). The program provides detailed output of the modelled building performance with regards to energy consumption and thermal performance.

EnergyPlus was selected as the simulation program to use for this study due to being a superior energy simulation program in comparison to many others as identified within (Crawley et al., 2001). Also, as a calibrated building model in the EnergyPlus format was available to the author at the time of the research, the program was the best choice and most suitable for this research topic.

2.2 - The Test Building

The building model that was available at the time needed for the author has been calibrated to an accuracy of 5% of the actual energy consumption for the year 2009. Because of the reliability of the building model by having a high accuracy of the produced results, the selection of the model was a suitable choice for the completion of this research.

The building is a concrete structure commercial building with a commercial end use. Because of both the size and construction of the building, the climatic conditions are expected to have little influence on the buildings overall energy consumption.

For a heavy weight commercial building, the weather file will typically have less influence on the overall energy consumption. For this reason, the test building can be noted to not be ideal for determining the difference of energy consumption for different weather files.

The layout of the building consists of three storeys, the ground and first floor consist of general office use and operations while the basement level is exclusively car parking. The basement car parking is half the longitudinal dimension of the other levels. In total, the building consists of a gross floor plan area of 2,851 square metres. The building is wholly occupied by a single company which eliminates any uncertainties caused by unbalanced energy consumption for different companies.

2.3 - Weather Files

The purpose of using weather files in conjunction with energy calculation programs is so they provide an increased detailed results of energy consumption and thermal performance of buildings with the influence of weather on the building. Ideally this "helps architects and engineers during early stages to design energy efficient buildings" (Westphal and Lamberts, 2004).

As previously mentioned, there are currently two standard weather files for locations around New Zealand; the TMY (Typical Meteorological Year) and TRY (Test Reference Year) files. The latest file is the TMY file which was developed in 2009, the TRY was developed in 1993.

An explanation of what a TMY weather file is is best summed up by the following quote:

> In 1978, Hall et al. developed a TMY method that is one of the most commonly accepted methods for generating typical weather years. The method used to select a TMY for a given location involves selecting, by statistical methods, one typical meteorological month (TMM) for each of the 12 calendar months from a period of years of data and concatenating the 12 months to form a TMY.
>
> (Jiang, 2010:88)

The method of creating a TRY weather file is a lot more simplistic than the TMY. Out of the range of years that the weather data is available, a single year is selected that best represents a typical average year. There are also whole years selected for representing other conditional years (Amor et al. 1993). These are seen in Appendix C.

The TMY weather files were already in a format that is supported by EnergyPlus so there was no need to convert the files to use them. In contrast to this the TRY weather files are not able to be directly used in EnergyPlus so that they had to be converted to a supported format.

The requirement of having to convert weather files so that different programs can use them one of the greatest identified issues with using weather files in energy calculation programs. The procedure in converting the files can be seen in Section 3.1.

2.4 - Climate Zones

The New Zealand Building Standards "provide a minimum number of climate zones so that component designs need not change radically throughout New Zealand". (Isaacs et al., 1996:29). The country is divided into three climate zones; one, two, and three. Each consisting of one of the main centres Auckland, Wellington, and Christchurch respectively. The division of the three zones can be seen in Appendix D which has been extracted from the New Zealand Standard 4218:2004 – Energy Efficiency. These three zones have primarily been divided up in relation to a geometric division; the division also provides a broad climatic division. As a result, in particular the south island, different micro climate areas are required to comply with other areas which may consist of colder or warmer weather patterns. An example of this is how Nelson has to perform with equal minimum insulation value as Dunedin which is known to be significantly colder during winter.

For the purpose of this research, Auckland, Wellington, and Christchurch weather files are used as they are the main centres which are within the zones.

3.0 - Method

A calculation was performed for each of the identified weather files and climate zones. In total this is six calculations. Three TMY and three TRY - one file per climate zone. Each calculation produced the predicted energy consumption for each month over a single year period of testing.

The following sections are the processes that were undertaken to perform the energy calculations and produce results.

3.1 - Converting TRY Weather files into .epw Format

To overcome the problem of weather file not being able to be read by EnergyPlus, a series of steps were taken to convert the files to a format that is supported by EnergyPlus. To ensure the accuracy of the conversion process, the method explained in Henninger et al., 2003 was followed when applicable.

> In order to create an EnergyPlus compatible weather file, the TMY file was first converted to BLAST format using the BLAST weather processor (WIFE). An EnergyPlus translator was then used to convert the weather data from the BLAST format to EnergyPlus format. (Henninger et al., 2003:468).

In situations where the translator process as described by Henninger was not applicable, the following procedure was undertaken.

The binary .TRY weather files are opened as fixed delimited values into a spreadsheet. The column values are described in Appendix E.1. As some vital information was found to be missing to create a valid weather file, the missing values are obtained from another TRY file which in the SUNREL format. The same opening procedure into a spreadsheet in used for the SUNREL files but a different column range is used; these can be seen in Appendix E.2.

With the raw data in the spreadsheet, identified issues need to be resolved before creating an EnergyPlus weather file (.epw). The first issue is to correct decimal places. Pressure and solar radiation are imported are whole values. They need to be divided by 100 and 10 respectively. For example, value of pressure will be 2983 when imported, by dividing by 100, the correct value of 29.83 is obtained. The dry bulb temperature that is obtained from the SUNREL weather files are a three figure values. They must be divided by 10 to achieve the correct decimal placing. Further information regarding the parameters of the files can be seen in Werff et al., 2005 and Deru et al.,2002.

Another issue that is encountered with the TRY weather files is that due to their age, the many of the values are empirical units; these need to be converted to metric SI units in order to make the EnergyPlus weather file. In order to do this, the conversion calculations can be seen in Appendix F; this includes temperatures, relative humidity, and solar radiation.

When all TRY files are correctly formatted and are in a metric unit format, any EnergyPlus weather file (.epw) needs to be converted to a Comma Separated Values (CSV) file. This is done through the native weather converter within EnergyPlus. The CSV file is then opened in a spreadsheet. This spreadsheet is a template that is used for inserting the TRY values.

TRY weather values are copied from one spreadsheet to the CSV template spreadsheet. Once all the values are input, the CSV document can be converted back to a .epw using the same native weather file convertor in EnergyPlus.

4.0 - How do the Calculation Results Differ Between the Two Generic Weather Files?

This chapter of the report contains the results and corresponding analyses of the computer calculations. It is divided into four sections; the first covers the overall energy consumption per month for each of the climate zones and weather file type; and the other three sections are a breakdown of the equipment showing the energy consumption for each of the climate zones.

All of the percentage differences between the two weather files are the reduction or increase that the TMY energy consumption is in comparison to the TRY energy consumption. For example, if the TMY weather file produces results of energy consumption being 10,000 kWh and the TRY file produces a result of 9,000 kWh; the percentage difference is 10% as the TMY is greater that the TRY results. When the TMY results are less than the TRY file the percentage difference is a negative number unless stated that they are less.

4.1 - Comparing the Energy Consumption in the Three Main City Centres in New Zealand

As previously explained, New Zealand has been split into three climatic zones within the New Zealand Standards and other building regulation documents. This section of the report compares the results of the monthly energy consumptions that have been calculated on the test building for the three identified climates.

The total monthly energy consumption for a year with respect to the three climate zones and two standard weather files can be seen in Figure 1. As the graph indicates, there is a significant difference between the weather files for all three climate zones; especially throughout warmer months (October to March). Up to 19% less kWh (kilo Watt hours) are being used by the TMY weather files in comparison to the TRY files.

Because the difference of up to -19% is during the summer months, it is an indication that the TMY weather files have lower air temperatures and less solar radiation which would therefore result in less cooling energy required to maintain a comfortable internal temperature. To confirm this, a breakdown of the equipment that is using energy and is subjective to climate conditions can be seen within the subsequent sections.

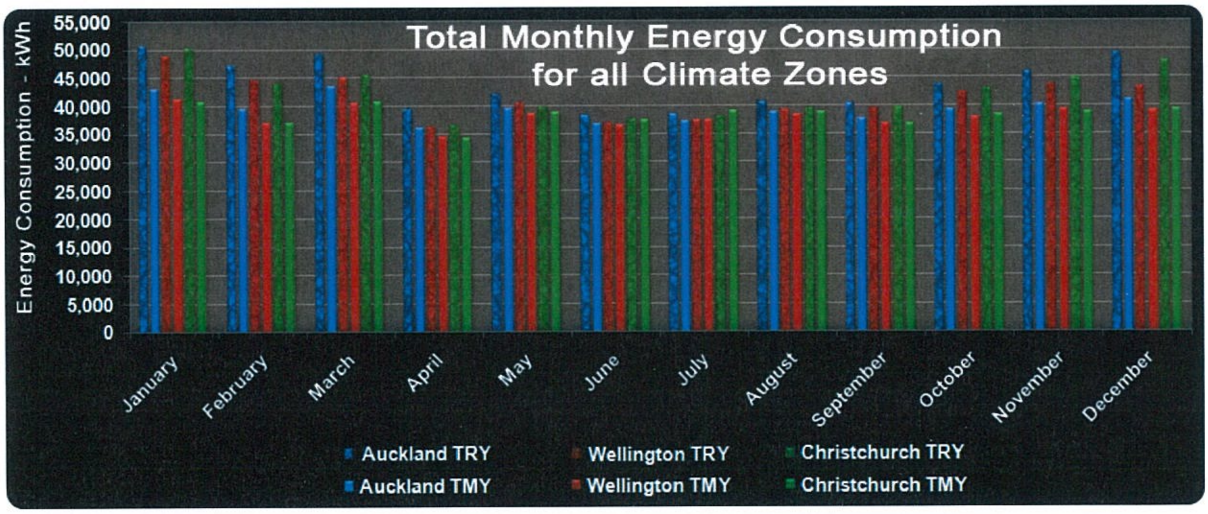

Figure 1. Total Energy Consumption per Month for TMY and TRY Weather Files.

In comparison to the warm months, the typically colder months throughout winter are seen to have significantly less variation between the TMY and TRY weather files; in particular June, July, and August. For these months, the difference between the TMY and TRY weather files range between 3% and -4%. Absolute energy consumption values per month, weather file, and climate zone can be seen in Appendix F.

The only time that monthly TMY energy consumption values are greater than the TRY values is in June and July for the Christchurch climate. No other climate zone or month has a variation like this. Further analysis on Christchurch can be seen in Section 4.4.

When considering the total energy consumption for the year for each of the climate zones, the TMY weather files are 10%, 8%, and 9% less than the TRY weather files for Auckland, Wellington, and Christchurch respectively. The majority of this difference has previously been identified as being a result of months that require cooling being largely different. Further analysis on this is done on this for each of the zones in Sections 4.2, 4.3, 4.4.

The following sections show a breakdown of the aspects which are consuming the energy to identify how the weather files are influencing the performance of the building. The focus of the breakdown is the HVAC (Heating, Ventilation, and Air Conditioning) equipment as this is influenced by the climate conditions of the weather file data.

4.2 - Auckland Energy Consumption Analysis.

The equipment that is affected by the climatic conditions and as a results consumes more or less energy depending on the conditions is the HVAC system. For simplicity, this has been split into the three categories of cooling, heating, and fans as shown in Figure 2. A total breakdown for all of the electrical equipment within the building, including lighting and plug loads, can be seen in Appendix H.1.

To eliminate any uncertainties that are present with the difference in energy consumption between the weekdays and weekend, the total monthly energy consumption per aspect is divided by the number of days in the corresponding month. This means that the energy consumption values shown on the Y-axis of Figure 2 are the average kWh that is consumed per day (kWh/day).

Auckland in comparison to the other two climates is the hottest; this is reflected in the energy consumption calculated as there is very little heating being used during the winter. The maximum heating is used in July. This is the case for both the TMY and TRY weather files. Although heating is being used, the cooling is still the greatest consumer of energy out of the equipment that is affected by the climatic conditions at this time of year. The heating energy consumed is 10 kWh/day for the TMY weather files and 5.5 kWh/day for the TRY weather files at the largest consumption in July.

The minimum value for cooling with the TMY weather file is 94 kWh/day, this is in July. The TRY weather file also has the lowest cooling energy consumption in July; however at 134 kWh/day, it is still greater than the cooling in July for the TMY file.

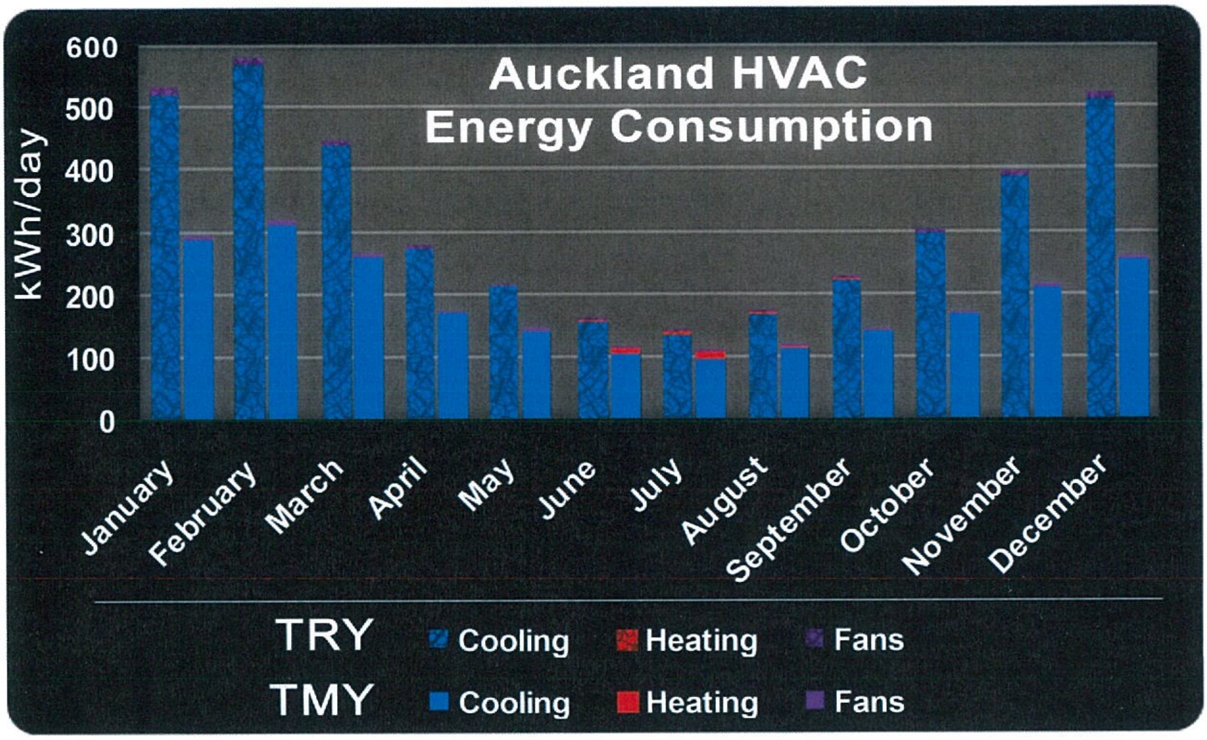

Figure 2. Comparison of TMY and TRY Weather Files in Auckland.

Continuing with exploring the cooling, the greatest consumption during the year for both the TMY and TRY weather files is in February. This is 310 kWh/day and 566 kWh/day respectively. The remainder of the energy is used by the fans to ventilate the building and circulate the conditioned air within the building. In both weather files, the heating energy used can be seen to be significantly less than the cooling energy

4.3 - Wellington Energy Consumption Analysis.

As with Auckland, to eliminate any uncertainties that are present with the difference in energy consumption between the weekdays and weekend, the total monthly energy consumption is divided by the number of days in the corresponding month. Leaving the average kWh per day.

As with the calculated results previously seen with Auckland, the Wellington results show a similar trend, Figure 3. The highest energy consumption is from the cooling loads of the building, the summer months have a significantly higher consumption than winter months, and heating is present in more months. This is the case for both TMY and TRY weather files.

If this is the case, why pad the report by putting them in separate sections?

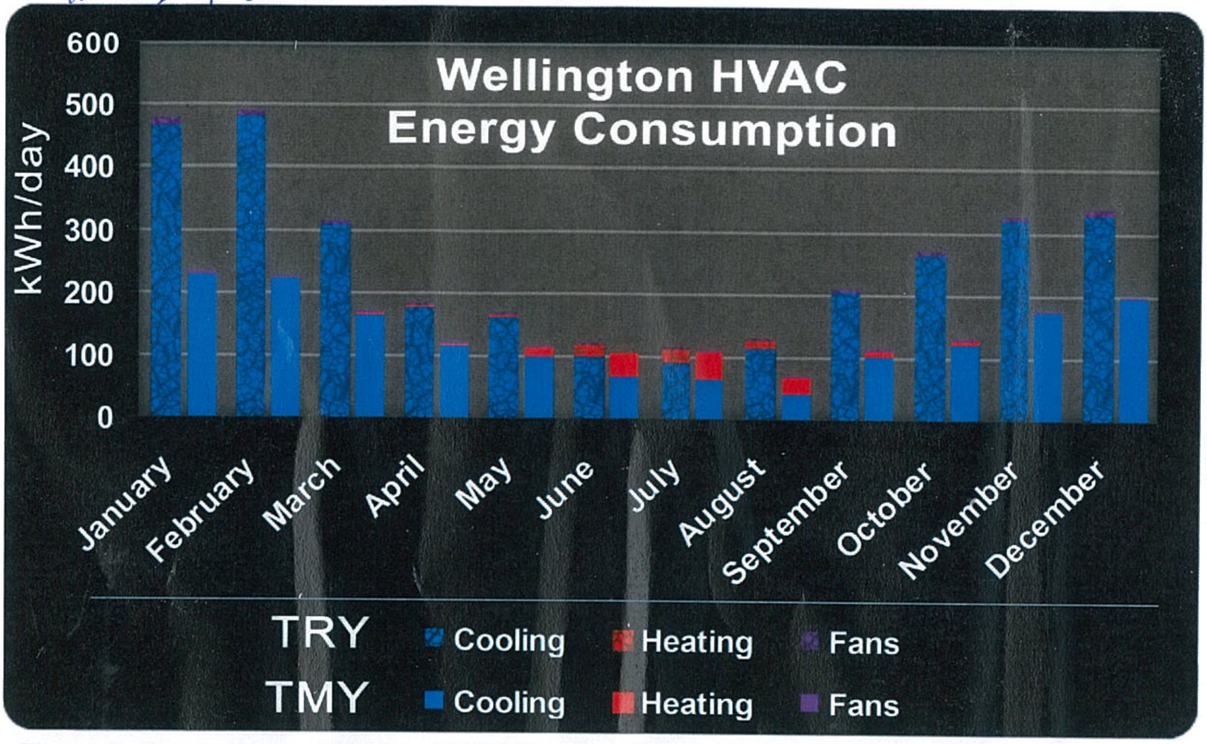

Figure 3. Comparison of TMY and TRY Weather Files in Wellington.

The trend of the TRY weather file consuming greater energy in comparison to the TMY file as previously seen in the Auckland results is once again confirmed by this breakdown of equipment energy consumption results.

ENGLISH!

Due to Wellington experiencing some colder conditions during the winter time, the energy required for the heating can be seen to have greater energy consumption. This is a clear influence of how the external temperatures are influencing the energy consumption of the building to provide a comfortable indoor environment.

AWKWARD phrasing

The greatest energy consumption is in the month of February, this is only for the TRY weather file, the TMY file results show that the greatest energy use is in January. In comparing a high energy consuming month for each file (February) an indication of the differences between the two file types is provided. The TRY weather file produced energy consumption results which are 482 kWh/day for cooling; 0 kWh/day for heating; and 11 kWh/day for the fans in February. In comparison to this, the TMY energy consumption for cooling is 220 kWh/day; heating is 0 kWh/day and the fans are 5 kWh/day. The total difference for this month is -17%.

The results show that for the February, the TRY weather file uses approximately twice as much energy to obtain a comfortable internal temperature, as opposed to the TMY weather file.

In addition to the previously shown graph, a total breakdown of all of the energy consumed by the building per month can be seen in Appendix H.2. This includes the energy used in the operation of the occupying businesses equipment such as plug loads and lighting.

4.4 - Christchurch Energy Consumption Analysis.

Like the previous data presented for Auckland and Wellington, the Christchurch data is presented with the average daily energy consumption (kWh/day) in relation to the months of the year and the two different weather files.

Out of the three climate zones investigated, Christchurch required the greatest heating loads during the winter period. The heating loads are also required for an extended period of time in comparison to the other climate locations, this indicates that weather conditions of Christchurch is significantly colder than Auckland and Wellington. This is assumed to be a result of a lack of solar gains and lower air temperatures that are within the weather files. Further analysis on the raw weather data would be required to confirm this.

really?

The following graph, Figure 4, shows the breakdown of the climate influenced equipment for each month of the year.

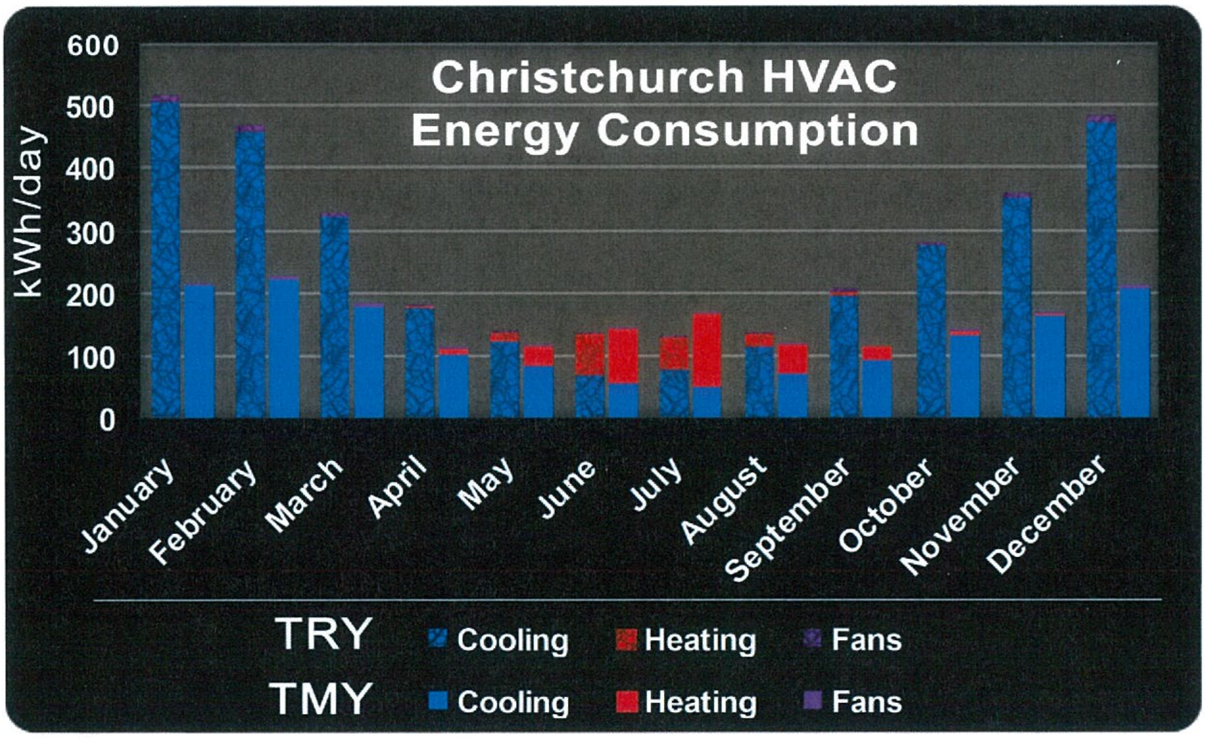

Figure 4. Comparison of TMY and TRY Weather Files in Christchurch.

As with the other climate locations, the energy consumption of the TMY weather file heating energy is seen to be greater in contrast to the heating of the TRY weather file. In July, the TMY file requires the building to use 113 kWh/day while the TRY file is only 49 kWh/day in July for the heating energy. For June and July, the heating energy outweighs the energy required for cooling the building. This is the only climate that this happens in.

The cooling that is done within the building during this period of the year is in areas with very high internal gains which are needed to be cooled such as the computer systems sever room.

In January, an average of 515 kWh/day is calculated to be consumed for the TRY weather file, this includes the operation of the fans at 12 kWh/day. The TMY weather file results for January show an average energy consumption of 222 kWh/day (fans account for 5 kWh/day). In comparing the greatest average energy consumption per day, the TRY weather file can be seen to be over twice the TMY weather file.

As with the other climates, a total breakdown for all of the electrical equipment can be seen in Appendix H.3.

4.5 - Summary of Results

Out of the equipment that is affect by the climatic conditions, cooling consumes the greatest energy all year round. This has been identified for both the TMY and TRY weather files, and for all three climate zones. This identifies that heavy weight, high mass, commercial buildings contain a large amount of internal gains, and have only a slight influence from external weather conditions.

Generally, the difference of the calculated energy between the TMY and TRY weather files are fairly similar for each climate zone. The greatest differences are seen in the warmer months when greater cooling energy loads are required. Up to a difference of -19% has been identified between the TMY and TRY weather files.

within a month? or annually?

5.0 - Conclusion

From the simulated results, comparisons have been made between the TMY and TRY weather files, this has been done for the three main centres that are within the classified climate zones. The results successfully answered the research question that was raised at the start of this research. Simply put, yes there is a significant difference of energy consumption between the TRY and TMY weather files

what did you do to avoid mistakes?

Although the process of making the files are different, as previously discussed within the report, this should not result in the calculated energy consumption data being as different as they are due to both files being representative of a typical year. Because the same building model was used and just the input weather file was changed, the change in energy consumption is purely a result of the influence of climatic conditions. Therefore this identifies that there has been a change in weather patterns which have been collected by the monitored data and the typical year data has been made form this.

Overall, the greatest changes to the energy consumption of the building have been seen to be during the warmer months. This has resulted in the amount of cooling energy in the TMY weather file to be significantly less than the TRY weather files. Without having analysed the raw weather data, it is assumed that this reduction in energy consumption for cooling loads is due to there being less solar gains, more cloud cover, and apparent cooler air temperatures. This conclusion of the TMY weather files of being generally cooler is reinforced by the fact that during the winter months, greater heating loads are used in comparison to the TRY weather files. These outcomes have been consistent through all three climate zones that have been tested.

As a result of this significant difference being identified, the New Zealand Standards and relevant documents that have been developed through using the old TRY weather files should be reviewed. Prior to the documentation being reviewed, prior information and testing should be performed to confirm the results and findings of this report aw well as investigate other variables that have not been included in the scope of this research. Examples of which are in the following section.

6.0 - Further Investigation

The previous analyses of the energy consumption on the three main centres shows how there is a significant difference between the TMY and TRY weather files. To confirm that this is true for all available weather file locations, further investigation will be required. Not all of the TMY and TRY weather file locations match. A list of the available locations for each file type can be seen in Appendix A.

Another investigation that has been identified within this report but has not been explored due to the limited scope of this project is the validity of the three climate zones within New Zealand based on the TMY weather files. A breakdown showing which microclimates correspond to the main centres can be seen in Appendix I. The outcome of this particular research would be to determine if the three main centres represent the microclimates that are classified within New Zealand standards as being in zones one, two, or three.

As this study has been on a heavy weight (concrete structure) building, a study using the same methodology but using a light weight residential building will be able to identify further differences in the weather files. This is due to light weight buildings being more influenced by weather conditions.

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8.0 - Appendices

Appendix A - Available Weather Files

The following table identifies what locations are available for each weather file type.

Location	TMY Weather File	TRY Weather File
Auckland	✓	✓
Christchurch	✓	✓
Dunedin	✓	✓
Hamilton	✓	✗
Hokitika	✓	✓
Kaitaia	✓	✓
Napier	✓	✗
Nelson	✓	✓
New Plymouth	✓	✗
Turangi	✓	✗
Wellington	✓	✓

Appendix B– Sensitivity Study

The following table is a sensitivity study that has been performed by NETO ?? showing the influence that weather has on the energy consumption of buildings.

Note that the study has been done in Brazil so the Figures will not produce the same variations in New Zealand.

Sensitivity analysis results for building energy consumption for a variation on the weather parameters

Weather parameter	Uncertainty	Building energy consumption variation (%)
Dry-bulb temperature	±1.0 °C	±1.2
Daily range	±1.4 °C[a]	±1.2
Relative humidity	±5%	±0.8
Global solar radiation	±20 W/m^2	±1.2

[a] Observation: the daily range uncertainty is calculated based on the ±1.0 °C uncertainty of the maximum and minimum dry-bulb temperature.

Sensitivity analysis results for building energy consumption for a ±20% variation on the internal loads values

Internal load	Building energy consumption variation (%)
Occupancy	±6.2
Lighting	±12.4
Electrical equipment	±10.6

Appendix C – TRY Weather File Types

The following table lists the TRY file types that are available. The type is identified by the code which is used for naming the file. For the purpose of this research, only the AV – Average Year TRY weather files were used.

TRY File Type	Description
LO	Cold Year
HI	Hot Year
NW	Cold and Windy Year
NN	Cool, Clam, and No Sun Year
NS	Cool, Calm, and Sunny Year
TW	Hot and Windy Year
TN	Hot and Calm Year
AV	Average Year

Appendix D - Climate Zones

New Zealand is divided up into three climatic zones as shown in the following image sourced from NZS 4218:2004 – Energy Efficiency.

Appendix E – Fixed File Format Weather

Appendix E.1 – TRY Weather File

For TRY format weather files, the following table identifies the columns that are used to divide the binary weather file into a readable format when importing to a spreadsheet as fixed format values.

<table>
<tr><th>Variable</th><th>Column</th><th colspan="2">Description</th></tr>
<tr><td>Station Number</td><td>1-5</td><td colspan="2">A unique number to represent the weather station data was collected from</td></tr>
<tr><td>Dry-bulb Temperature</td><td>6-8</td><td colspan="2">Whole degrees in Fahrenheit. Ranges from -80 to 140 ^{o}F. 999 indicates missing data.</td></tr>
<tr><td>Wet-bulb Temperature</td><td>9-11</td><td colspan="2">Whole degrees in Fahrenheit. Ranges from -80 to 140 ^{o}F. 999 indicates missing data.</td></tr>
<tr><td>Dew-point Temperature</td><td>12-14</td><td colspan="2">Whole degrees in Fahrenheit. Ranges from -80 to 140 ^{o}F. 999 indicates missing data.</td></tr>
<tr><td>Wind Direction</td><td>15-17</td><td colspan="2">Direction from which wind is blowing in whole degrees. Ranges from 1 to 360, a value of 0 indicates calm. 999 indicates missing data.</td></tr>
<tr><td>Wind Speed</td><td>18-20</td><td colspan="2">In whole Knots. Ranges from 1 to 230, a value of 0 indicates calm. 999 indicates missing data.</td></tr>
<tr><td>Station Pressure</td><td>21-24</td><td colspan="2">In inches and hundredths of Hg. Ranges from 1900 to 3999 (ie 19.00 to 39.99). 9999 indicates missing data.</td></tr>
<tr><td rowspan="2">Weather Type</td><td rowspan="2">25-25</td><td colspan="2">At time of observation. Where a combination of these types of weather may occur in a single hour, the following priorities were assigned: code 7 the code 8 then codes 1, 2, 3, 4, 9 then code 5 , 6.</td></tr>
<tr><td>0</td><td>No weather or obstructions to vision</td></tr>
</table>

		1	Fog
		2	Haze
		3	Smoke
		4	Haze and Smoke
		5	Thunderstorm
		6	Tornado
		7	Liquid precipitation
		8	Frozen precipitation
		9	Blowing dust and sand
Total Sky Cover	26-27	In tenths. Ranges from 0 to 10, 99 indicates missing data.	
Amount of Lowest Cloud Cover	28-29	In tenths. Ranges from 0 to 10, 99 indicates missing data.	
Type of Lowest Cloud	30-30	Types of clouds are defined by the following codes.	
		0	Clear
		1	Fog or other obstructing
		2	Stratus or Fractus Stratus
		3	Stratocumulus
		4	Cumulus or Cumulus Fractus
		5	Cumulonimbus or MAmmatus
		6	Altostratus or Nimbostratus
		7	Altocumulus

		8	Cirrus
		9	Cirrostratus or Cirrocumulus
Height of Base of Lowest Cloud	31-33	In hundreds of feet, ranges from 0 to 760, 777 indicates clear sky, 888 indicates Cirroform clouds of unknown height, 999 indicates missing data.	
Amount of Second Cloud Layer	34-35	In tenths. Ranges from 0 to 10, 99 indicates missing data.	
Type of Cloud, Second Layer	36-36	Refer to Type of Lowest Cloud.	
Height of Base of Second Cloud Layer	37-39	In hundreds of feet, ranges from 0 to 760, 777 indicates clear sky, 888 indicates Cirroform clouds of unknown height, 999 indicates missing data.	
Summation of First Two Layers of Cloud Amount	40-41		
Amount of Third Cloud Layer	42-43	In tenths. Ranges from 0 to 10, 99 indicates missing data.	
Type of Cloud, Third Layer	44-44	Refer to Type of Lowest Cloud.	
Height of Base of Third Cloud Layer	45-47	In hundreds of feet, ranges from 0 to 760, 777 indicates clear sky, 888 indicates Cirroform clouds of unknown height, 999 indicates missing data.	
Summation of First Three Layers of Cloud Amount	4849		
Amount of Fourth Cloud Layer	50-51	In tenths. Ranges from 0 to 10, 99 indicates missing data.	
Type of Cloud, Fourth Layer	52-52	Refer to Type of Lowest Cloud.	
Height of Base of Fourth Cloud Layer	53-55	In hundreds of feet, ranges from 0 to 760, 777 indicates clear sky, 888 indicates Cirroform clouds of unknown height, 999 indicates missing data.	
Solar Radiation	56-59	Total solar radiation in Langleys to tenths. Ranges from 0 to	

		1999 (ie 0 to 199.9). 9999 indicates missing data.
Blank Field	60-69	Reserved for future use
Year of Data	70-73	The year of recorded data.
Month	74-75	1=Jan, 2=Feb, etc.
Day	76-77	Ranges from 1 up to 31.
Hour	78-79	In local standard time, ranges from 0 to 23.
Blank Field	80-80	Reserved for future use

Appendix E.2 – SUNREL Weather Files

For SUNREL format weather files, the following table identifies the columns that are used to divide the binary weather file into a readable format when importing to a spreadsheet as fixed format values.

Variable	Column	Description
Month	1-2	1=Jan, 2=Feb, etc.
Day	3-4	Ranges from 1 up to 31.
Hour	5-6	In local standard time, ranges from 0 to 23.
Global-horizontal Radiation	7-10	In whole values of Watt hours per square metres. (Wh/m^2).
Direct Normal Radiation	11-14	
Dry-bulb Temperature	15-19	Tenths of degrees in Celsius. (ie 15.5 ^{o}C).
Dew-point Temperature	20-24	Tenths of degrees in Celsius (ie 15.5 ^{o}C).
Wind Speed	25-28	Tenths of metres per second.
Wind Direction	29-31	Direction from which wind is blowing in whole degrees. Ranges from 1 to 360, a value of 0 indicates calm. 999 indicates missing data.

Appendix F - Conversions

The SI Units that are used in the EnergyPlus weather files are metric. Due to the units within the TRY weather files being imperial, they had to be converted before the TRY EnergyPlus weather could be made. The following calculations were required to convert the units.

All formulas have been obtained from *http://www.csgnetwork.com/convfactorstable.html* unless otherwise stated.

F.1 - Temperature

Degrees Fahrenheit (^{o}F) to degrees Celsius (^{o}C)

(^{o}F-32) / 1.8 = ^{o}C

F.2 - Distance

Feet (ft) to metres (m)

ft x 0.3048 = m

F.3 - Speed

Knots (kt) to metres per second (m/s)

kt x 0.514444 = m/s

F.4 - Pressure

Inch of mercury (hg) to Pascals (Pa)

hg x 3386.389 = Pa

F.5 - Solar Radiation

Formula sourced from: http://www.sutron.com/customerservice/Conversions_Calcuations/radiant_exposure.htm

Langleys (Ly) to Watt hours per square metres (Wh/m^2)

(Ly x 41840) / 3600

F.6 - Relative Humidity

Formula sourced from: http://www.gorhamschaffler.com/humidity_formulas.htm

Where: E = Actual Vapour Pressure

Es = Saturation Vapour Pressure

Db = Dry bulb

Dp = Dew Point

RH% = Relative Humidity Percentage

Es = 6.11 x 10 x (7.5 x Db / (237.7 + Dp))

E = 6.11 x 10 x (7.5 x Dp / (237.7 + Dp))

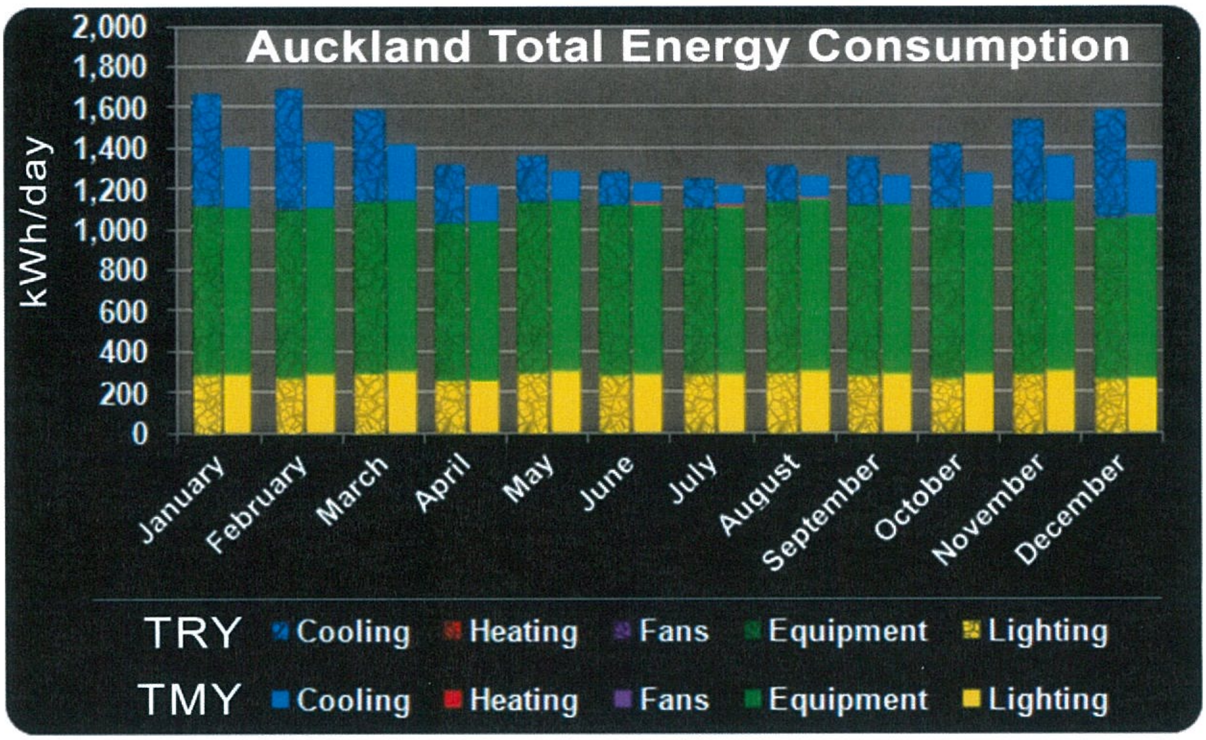
RH% = (E / Es) / 100

Appendix G – Raw Energy Data

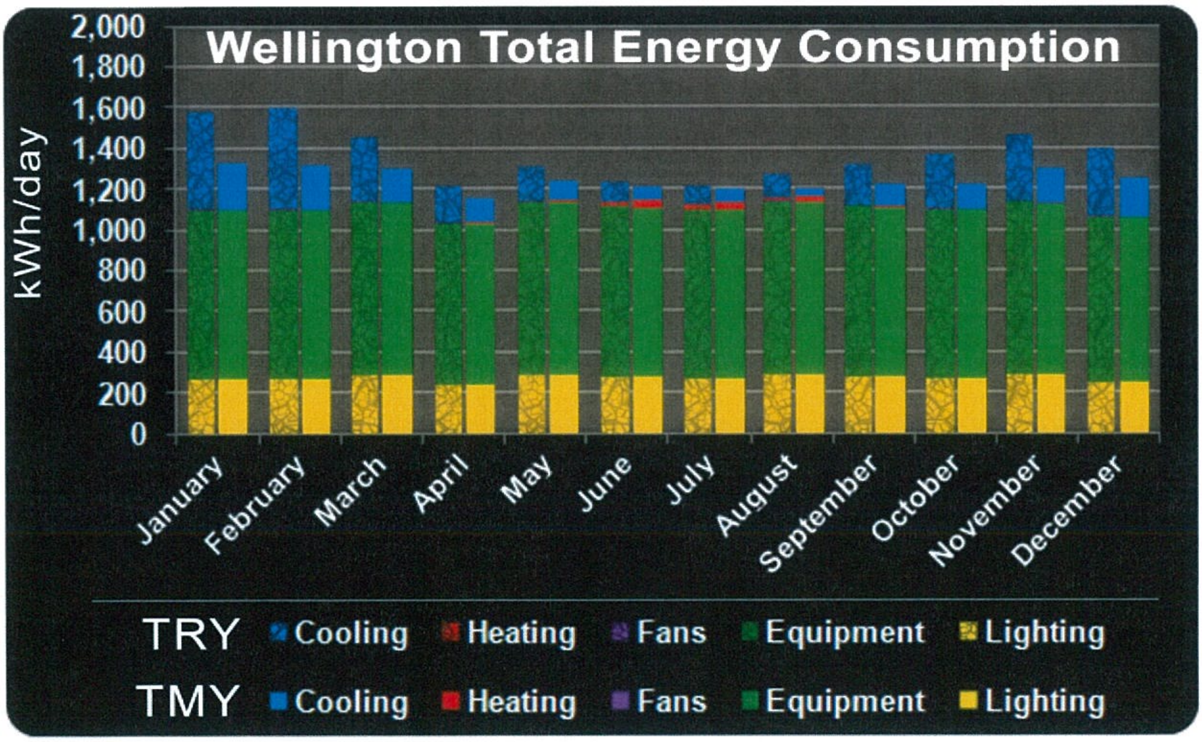
	Auckland			Wellington			Christchurch		
	TMY	TRY	Difference	TMY	TRY	Difference	TMY	TRY	Difference
January	43,071	50,476	-15%	41,269	48,889	-16%	40,632	49,989	-19%
February	39,639	46,968	-16%	37,068	44,571	-17%	36,991	43,781	-16%
March	43,388	49,076	-12%	40,480	45,020	-10%	40,803	45,347	-10%
April	36,069	39,260	-8%	34,580	36,441	-5%	34,271	36,351	-6%
May	39,657	41,971	-6%	38,753	40,443	-4%	38,779	39,539	-2%
June	36,729	38,166	-4%	36,472	36,944	-1%	37,602	37,393	1%
July	37,354	38,465	-3%	37,417	37,572	0%	39,147	38,018	3%
August	38,881	40,577	-4%	38,475	39,246	-2%	38,863	39,435	-1%
September	37,617	40,154	-6%	36,698	39,630	-7%	36,729	39,462	-7%
October	39,250	43,404	-10%	38,010	42,391	-10%	38,334	42,676	-10%
November	40,327	45,828	-12%	39,238	43,789	-10%	38,908	44,658	-13%
December	40,877	48,975	-17%	39,007	43,327	-10%	39,293	47,673	-18%

Appendix H - Energy Consumption Breakdown Graphs

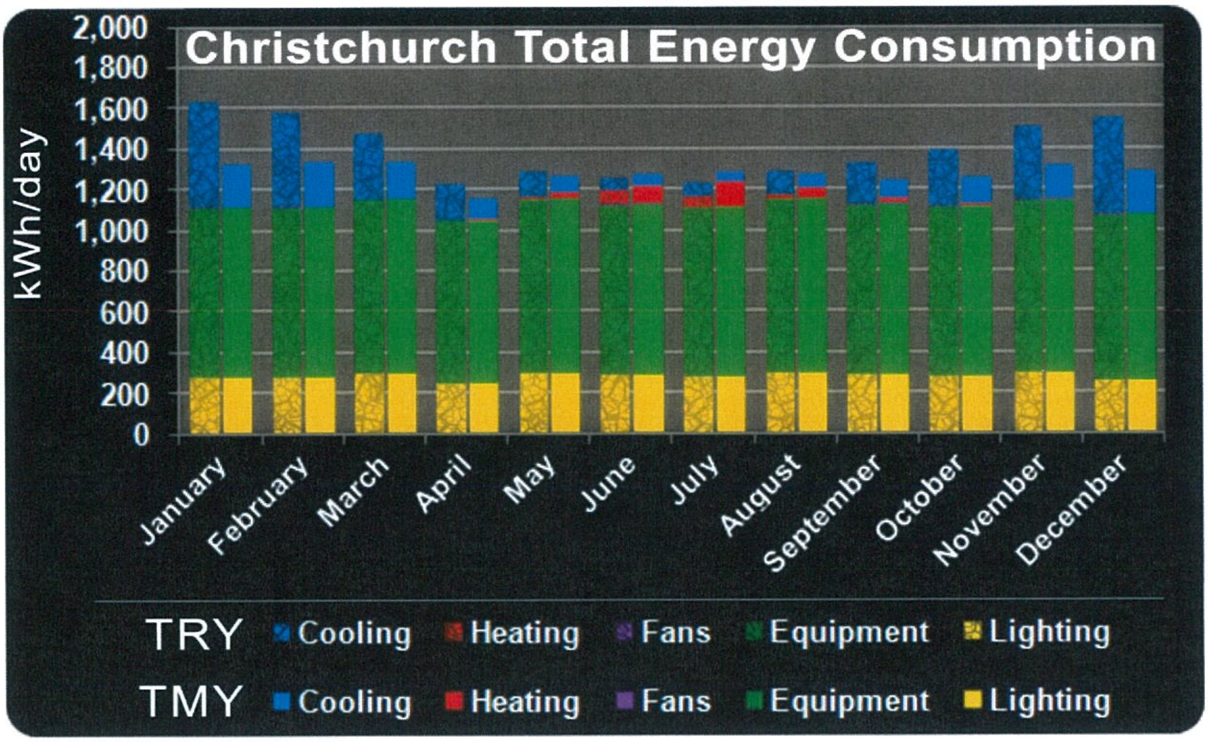
H.1 - Auckland monthly energy consumption breakdown



H.2 - Wellington monthly energy consumption breakdown



H.3 - Christchurch monthly energy consumption breakdown



Appendix I - Micro Climates in relation to main centres

The following table identifies which micro climates in New Zealand relate to the main centres.

Main Centre	Micro Climates
Auckland	Kaitaia
Wellington	Hamilton *
	New Plymouth
	Napier *
Christchurch	Dunedin
	Hokitika
	Nelson
	Turangi *

* TRY weather files are not available for these locations