

“How Energy Efficient is our Campus?”

Assessing the energy efficiency of the university campus using a benchmarked Campus Energy Use Statistical Analysis Method

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by

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Introduction

Why does energy management matter?

Energy is our largest operational cost, after staff

Manawatu campus = 450 buildings; 10,500 people on campus, on a typical semester weekday; 274,000m² gross floor area

Energy usage and cost
= 41 million kW/h electricity and gas (equivalent to 4,500 houses)
= NZ\$ 3,900,000 per year



Introduction

The problem:

- University campuses are large users of energy.
- Senior executives require reports on key budgets such as energy to be accurate - but also succinct.
- There is a need for a method of summarising the energy performance of the university estate, at a whole-campus level, in comparison to industry benchmarks.
- No single method for whole-site, rather than building- or infrastructure system-level, assessment of university campuses currently exists.



Introduction

- Universities are unusual energy client organisations.
- They contain all the major building purpose groups, on the same physical site and served by the same energy infrastructure.
- This differentiates them from, for example, local authorities and large industrial and commercial installations.

Some examples follow...



Science buildings





Libraries





Lecture theatres and classrooms





Accommodation (old and new)



Student centre and catering





Sports and outdoor floodlit areas





Administration





Commercial





Agricultural, Horticultural and Veterinary





New buildings, often climate-controlled



Buildings due for refurbishment





Heritage buildings





**Old but not “heritage”, energy-inefficient
and less fit for purpose**





Existing buildings altered and refurbished - adds complexity



Objectives

Objectives of the project:

- Find better ways of measuring energy efficiency of the university campus
- Gain some insights into energy management at Massey University's Manawatu campus.
- Commentary on energy efficiency performance of whole campus, for the last 10 years.
- Suggest strategies for energy efficiency and savings.



Methodology

- Literature Review and interviews. Identify current best practice and published benchmarks
- Statistical analysis of Manawatu Campus data.

Literature Review

Examined:

- peer reviewed academic papers
- industry literature such as: AS/NZ Standards; web sites and publications of industry or governmental organisations
- including TEFMA
- policy of universities and similar complex installations such as hospitals, and reports on their departmental projects and initiatives



Literature Review

Focus was on:

- University estates or facilities.
- Whole-site (not building level) and strategic.
- Australasian/ NZ material and comparable overseas sources such as UK, US and EU.
- New Zealand climatic zone or similar where possible.



Interviews

- Current state of development of benchmarking energy efficiency within the Australasian university facilities management sector was investigated by a survey, consisting of a questionnaire and telephone interview based around a brief set of questions.
- Interviewees were some of the leading persons in the field of energy management of tertiary education facilities. They were identified through TEFMA; the FM departments of New Zealand and Australian universities; and personal contact.
- TEFMA Carbon Foot Printing Workshop 2009 included a benchmarking discussion forum.



Interviews

Consensus:

- All organisations have either an official Policy or a written plan in place
- All used some form of benchmarking of energy efficiency performance.
- Comparisons between different organisations were seen as needing to be treated with caution.
- The ideal method for the measurement of energy performance would allow comparisons to be made, taking into account the many factors that influence energy consumption.
- All respondents stated that the methods developed by TEFMA were quite good and were useful.



Interviews

Methods of benchmarking of energy efficiency performance most commonly used are:

- Participation in the annual TEFMA benchmark survey.
- GJ or KWh energy consumption measured per square metre Gross Floor Area, with all types of space treated the same (m² GFA/ year). Considered basic but a good starting point.
- In-depth monitoring of selected buildings' operational parameters.
- Measuring energy use per equivalent full time student (EFTS).
- Measuring energy use per facility hour of use and utilisation rates.
- Carbon footprint and greenhouse gas emissions.



Interviews

Obstacles(s) to using that ideal method included:

- Lack of information and data such as metering, hours of operation and lack of similar buildings to make comparisons.
- Lack of understanding of the technical issues by senior university staff that do not have an engineering background.
- Lack of a national standard or protocol for energy management performance monitoring and benchmarking.



New Benchmarking Methods

Two main benchmarked methods identified:

1. Major factors driving campus energy consumption, to inform policy and programming.
2. Ratio of actual energy consumption to a benchmarked target for the campus, to track progress year-on-year.

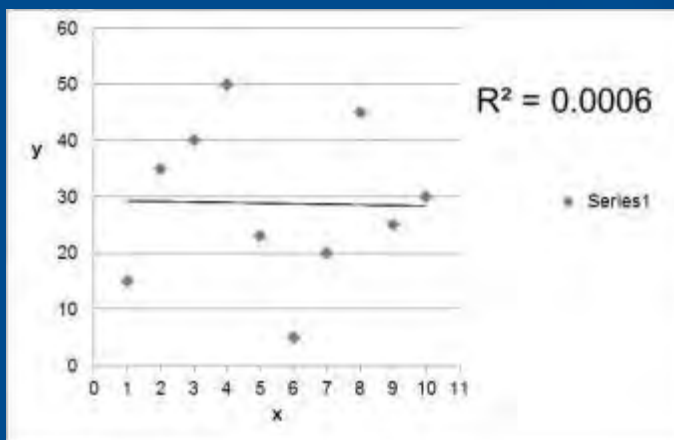
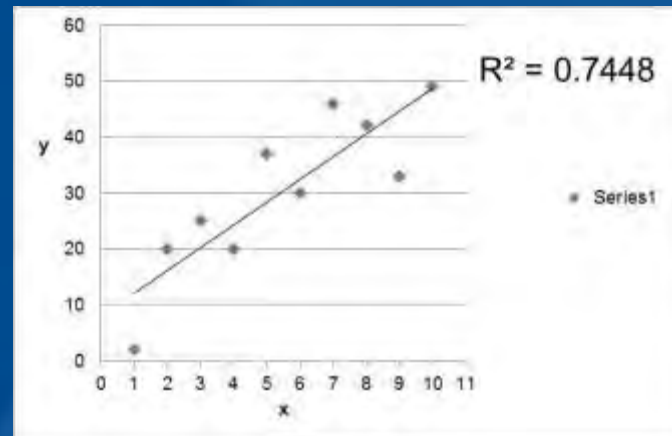
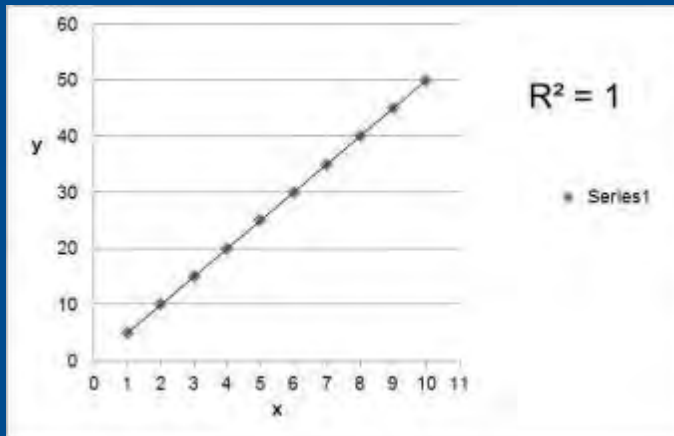


Data Examined

- Years 1999-2009 (11 years)
- Energy consumption: gas and electricity from utilities records
- Buildings: m2 GFA, space types (39 nr); changes in built environment of campus over time
- Climate: local temperature, rainfall
- Massey data: staff and student numbers



Regression Analysis: Method

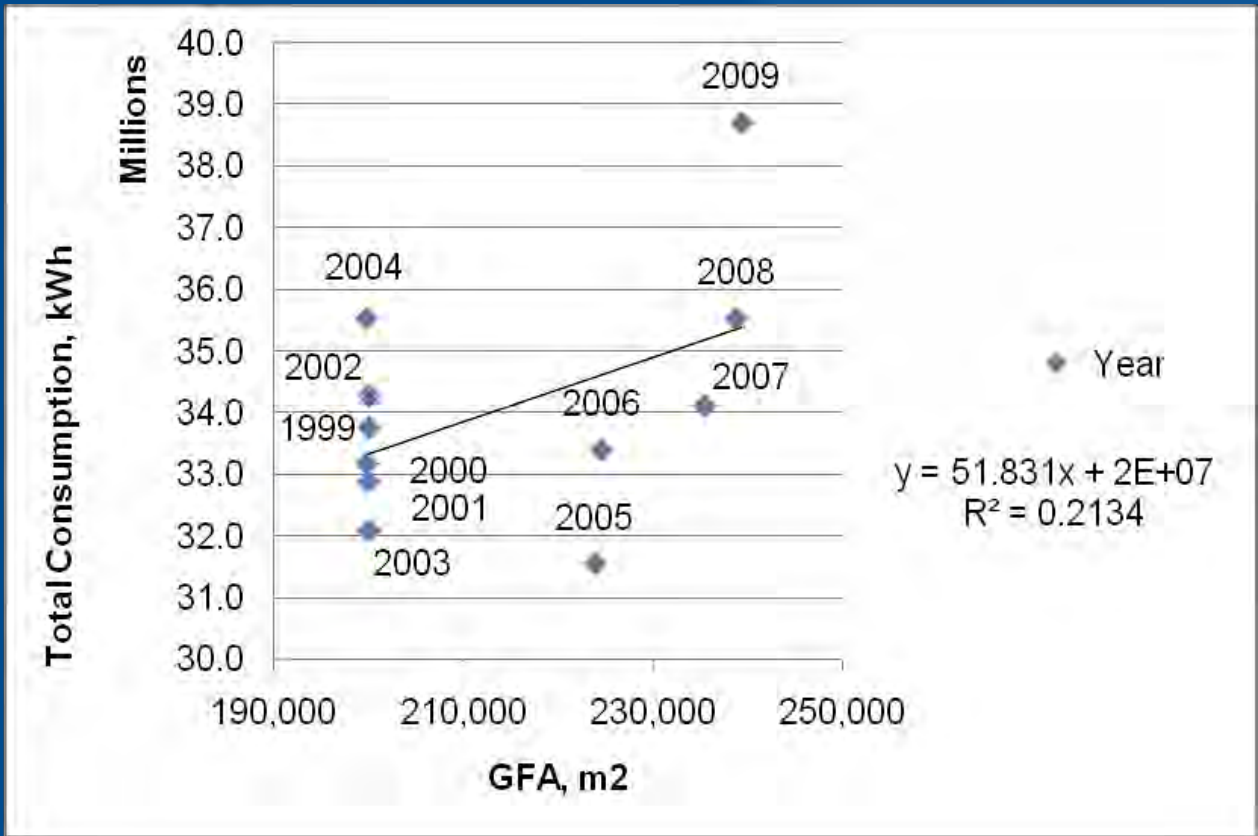


An R squared value over 0.58 – 0.77 usually indicates a connection.



Results

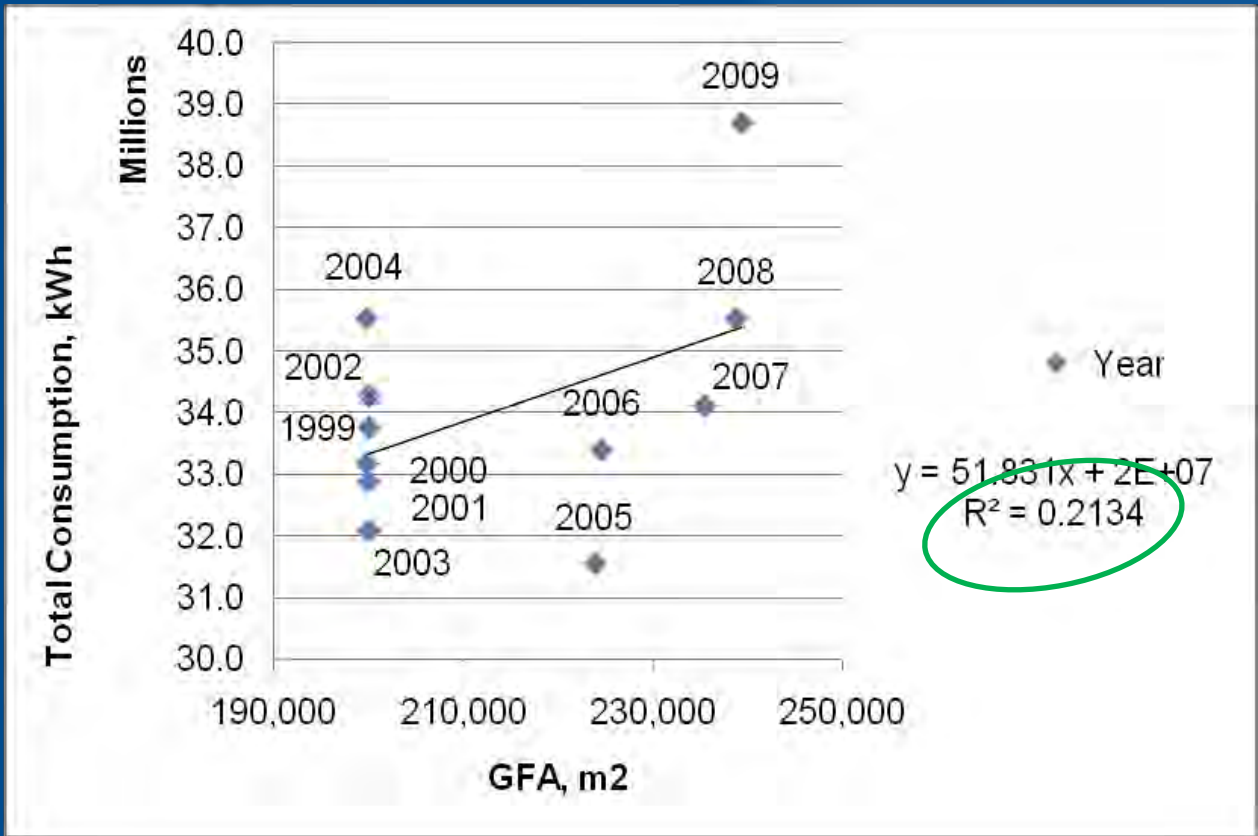
Factors that don't have a major effect on campus energy consumption



Gross Floor Area m2 of buildings
(If you take no account of space type)

Results

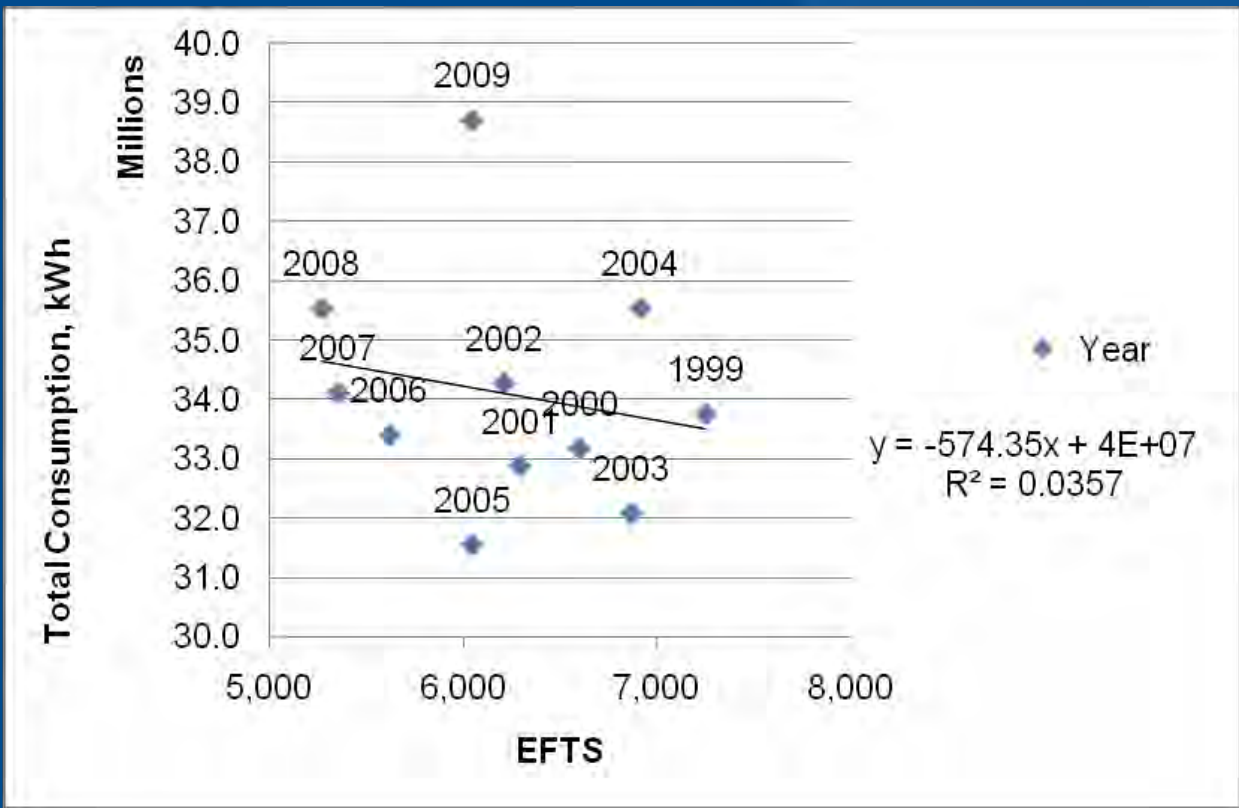
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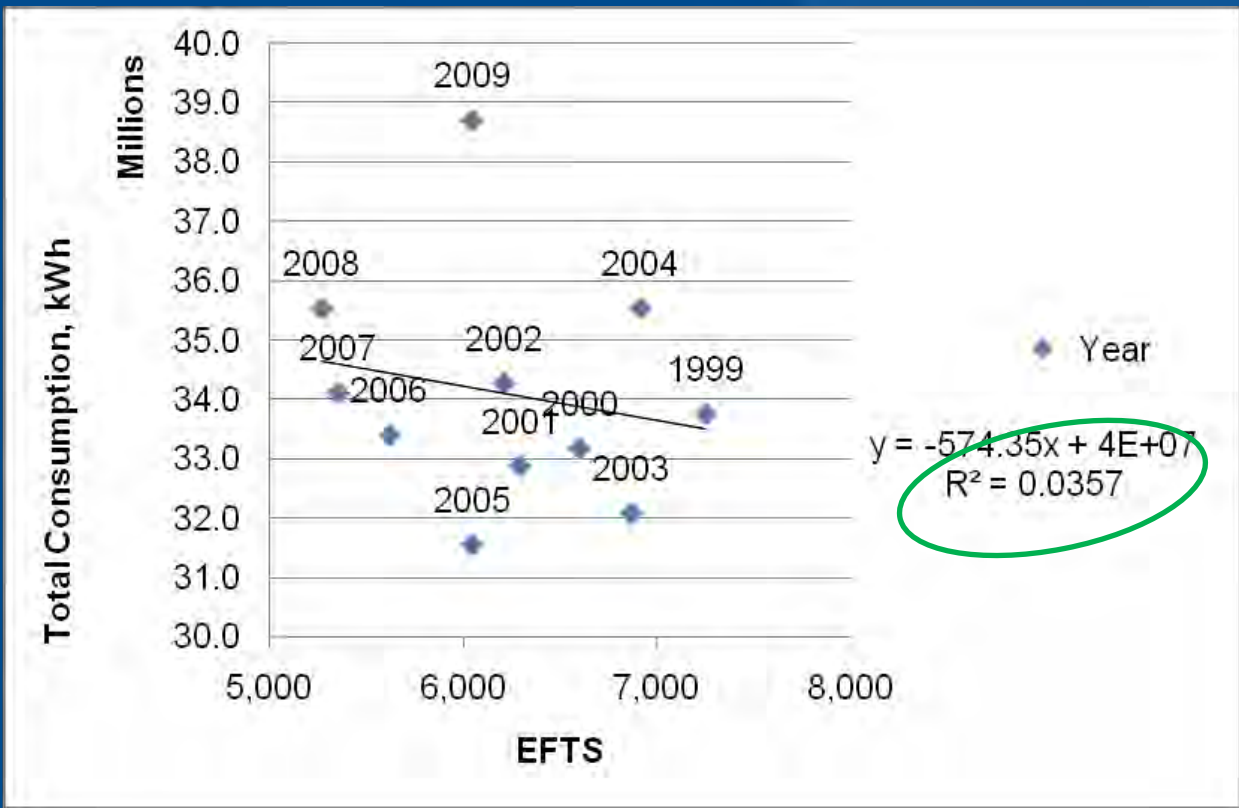
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Numbers of people on campus

Results

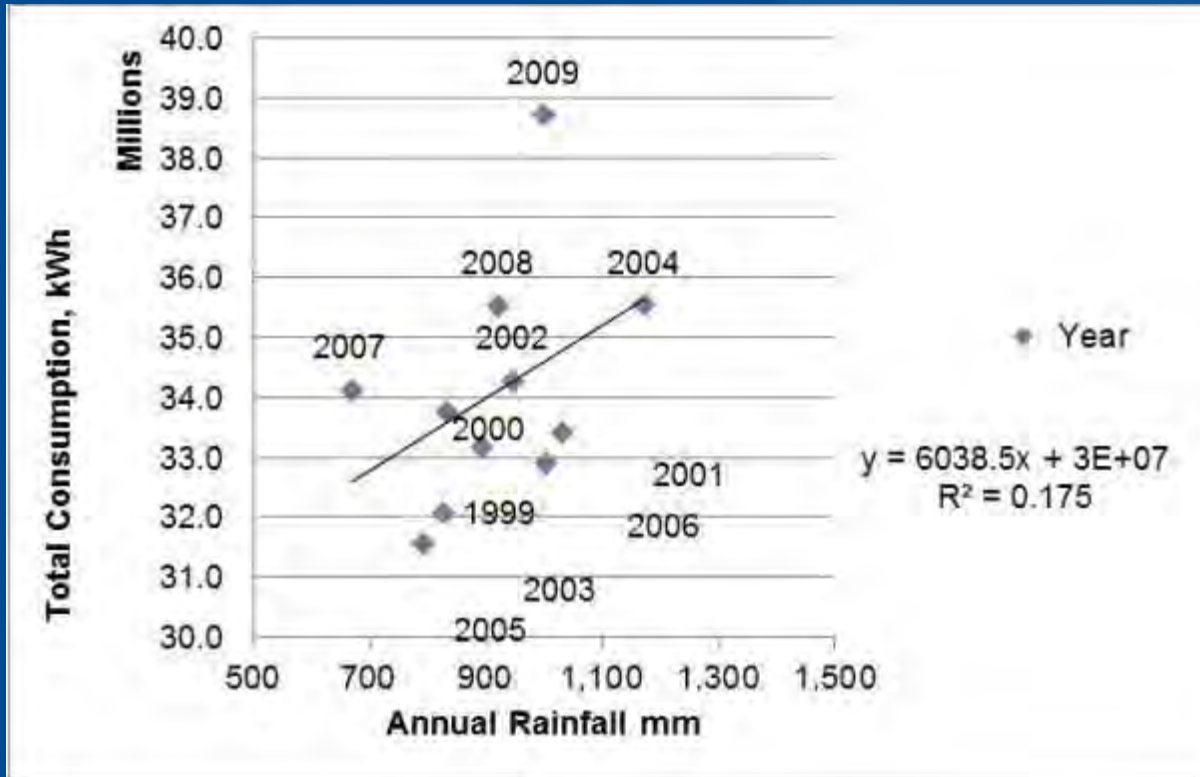
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Numbers of people on campus

Results

Factors that don't have a major effect on campus energy consumption

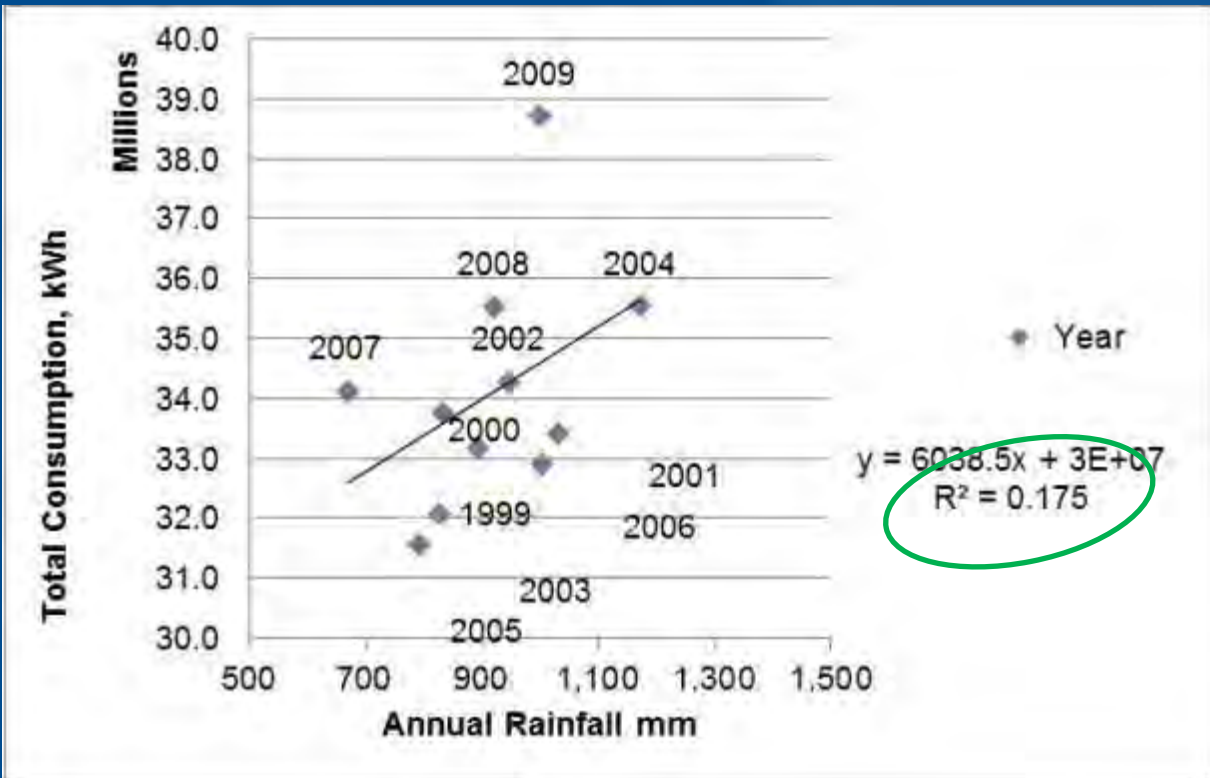


Rainfall, in a cooler climate

(Humidity makes air conditioning work harder = more energy)

Results

Factors that don't have a major effect on campus energy consumption



Rainfall, in a cooler climate

(Humidity makes air conditioning work harder = more energy)

Benchmarked Model



Science Tower A:
4,500m²

Consumes say
1.3M kWh per year

= 289 kWh/ m²

Is that high, low or
about right?



Benchmarked Model

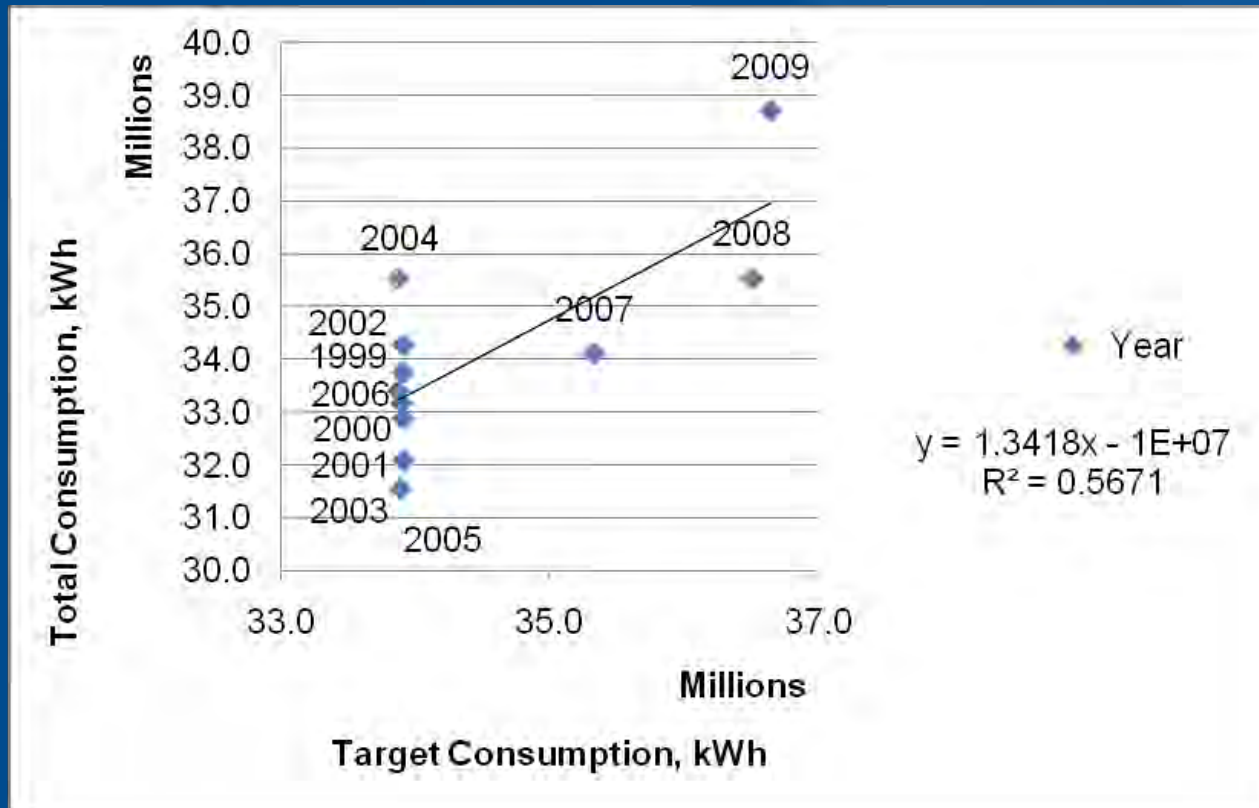
Space Type	Area, m2:	Benchmark kWh/ m2/ year:	Benchmark kWh/ year
Lecture Room, science	150	189	28,350
Office space: naturally ventilated, cellular	2,500	248	620,000
Teaching Laboratory, standard	1,500	200	300,000
Teaching Laboratory, controlled environment	250	1,553	388,250
Stores	100	150	15,000
	4,500		1,351,600

- The model identifies the benchmarked target energy consumption for the building in a given year.
- From this we can see that the consumption of 1,300,000 kWh per year is close to the benchmark model.
- This can be aggregated for all buildings on campus, to form a total annual campus energy consumption target.
- This value would evolve over time as the campus changes due to redevelopment.



Results

Major factors driving campus energy consumption: 1 of 2

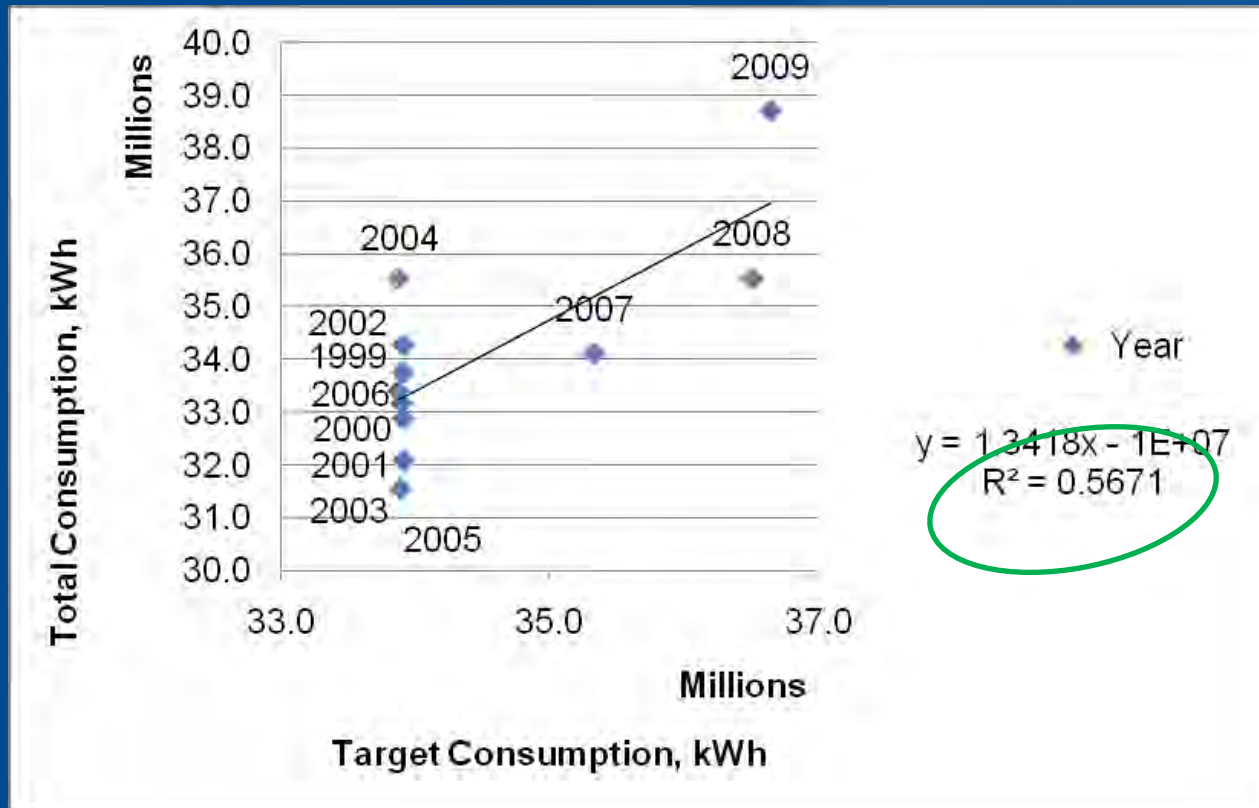


Amount and types of space used.

(Climate-controlled laboratories use more energy per m2 than naturally ventilated classrooms)

Results

Major factors driving campus energy consumption: 1 of 2

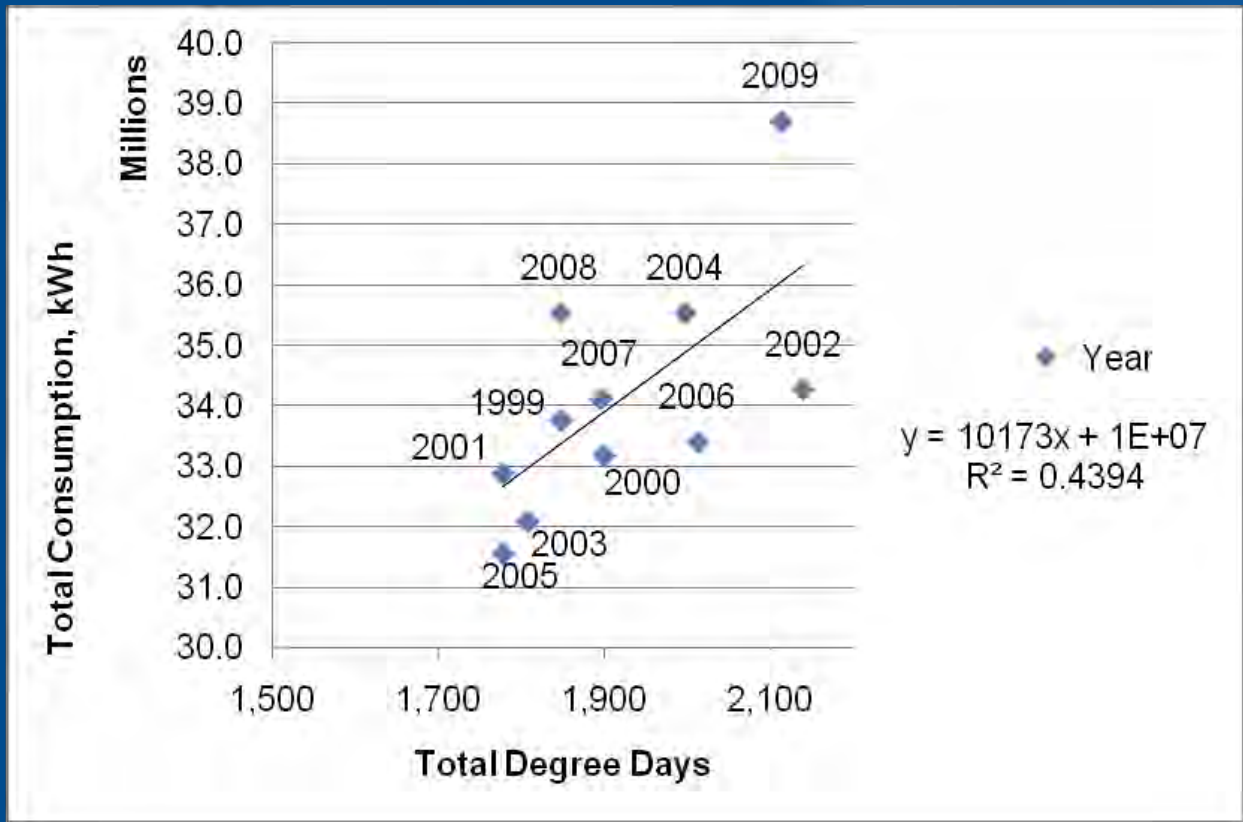


Amount and types of space used.

(Climate-controlled laboratories use more energy per m2 than naturally ventilated classrooms)

Results

Major factors driving campus energy consumption: 2 of 2

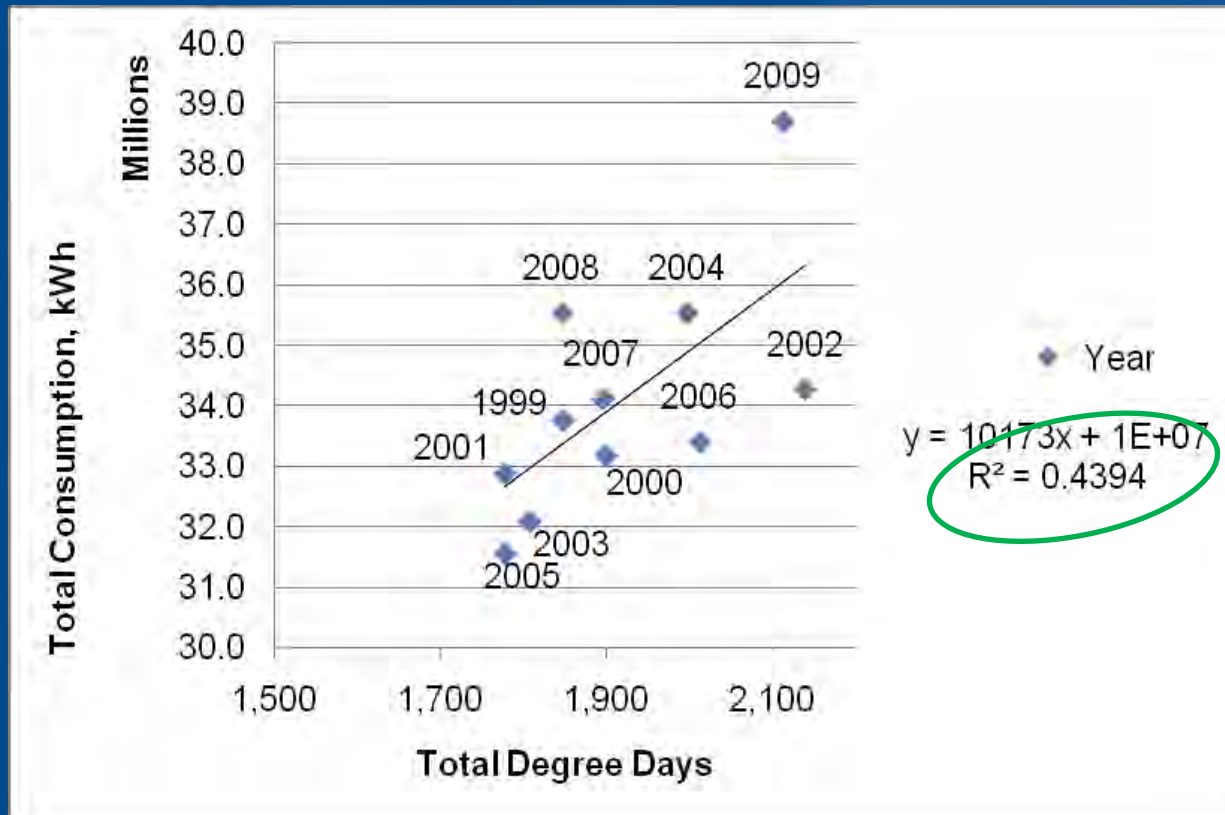


The weather.

(Hot summers and cold winters use more energy than mild years)

Results

Major factors driving campus energy consumption: 2 of 2



The weather.

(Hot summers and cold winters use more energy than mild years)

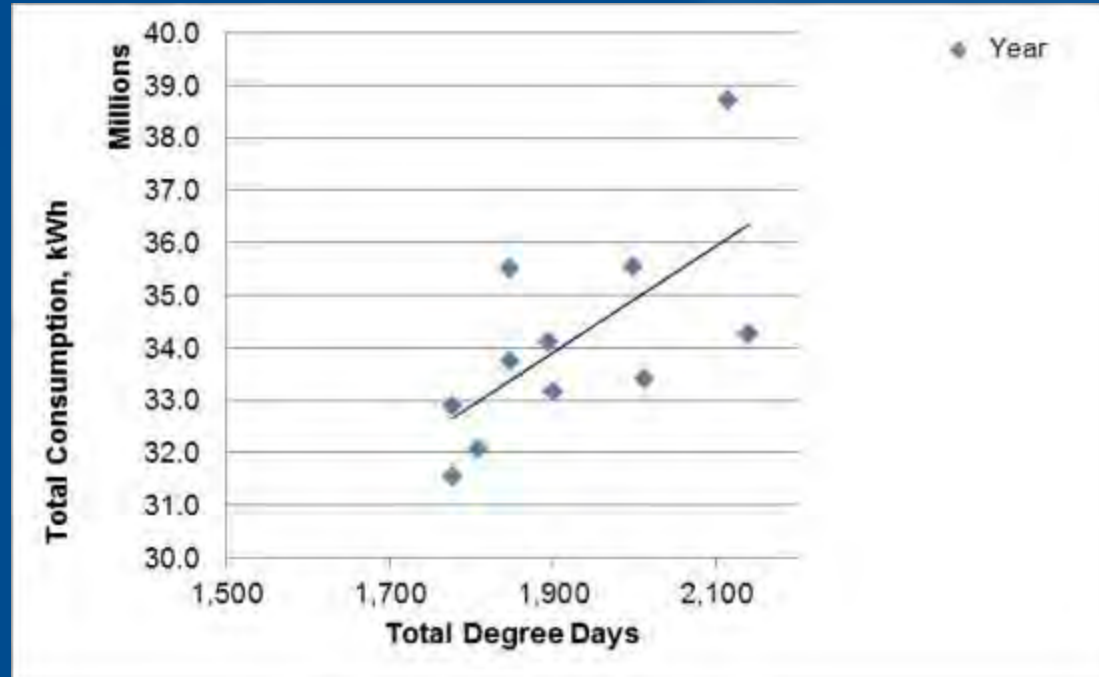
Multi-factorial regression analysis

Results

	Total energy consumption, kWh
Target Energy Consumption, kWh	0.5671
Total Degree days/year	0.4394

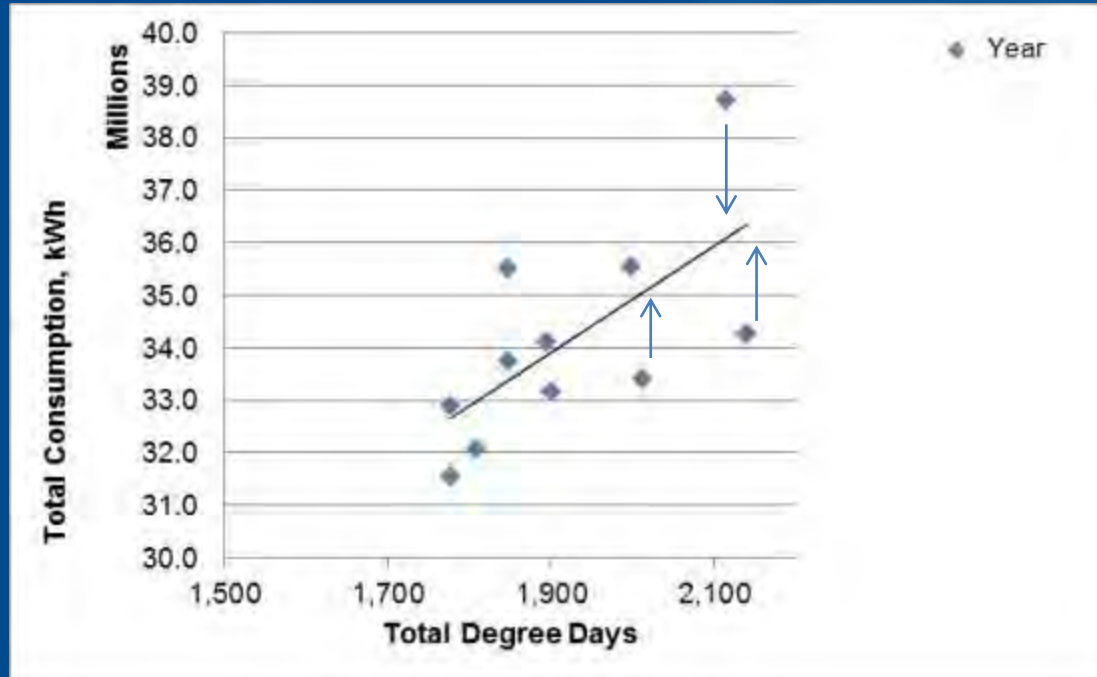
- R squared = **0.7883**
- This suggests that if we can normalize the annual effects of the weather, we will have a robust benchmarked model to compare annual energy consumption to.

Weather-adjustment



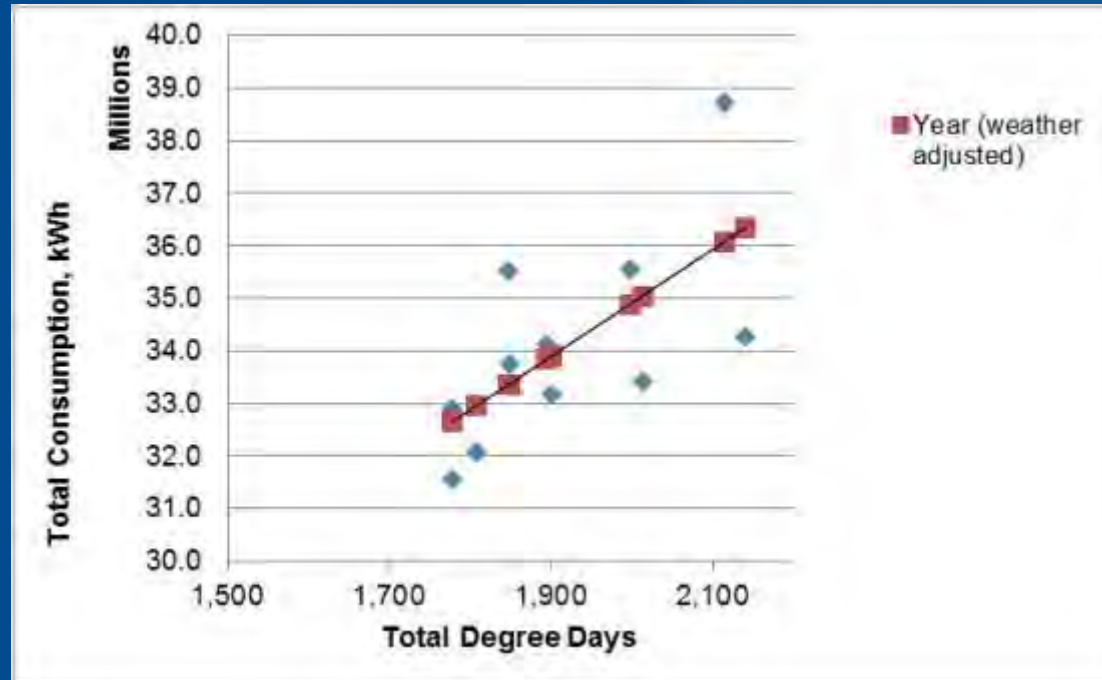
- Method first suggested by APPA in 1994.
- Remove the difference between the trend line and the actual value for each year (the residual).

Weather-adjustment



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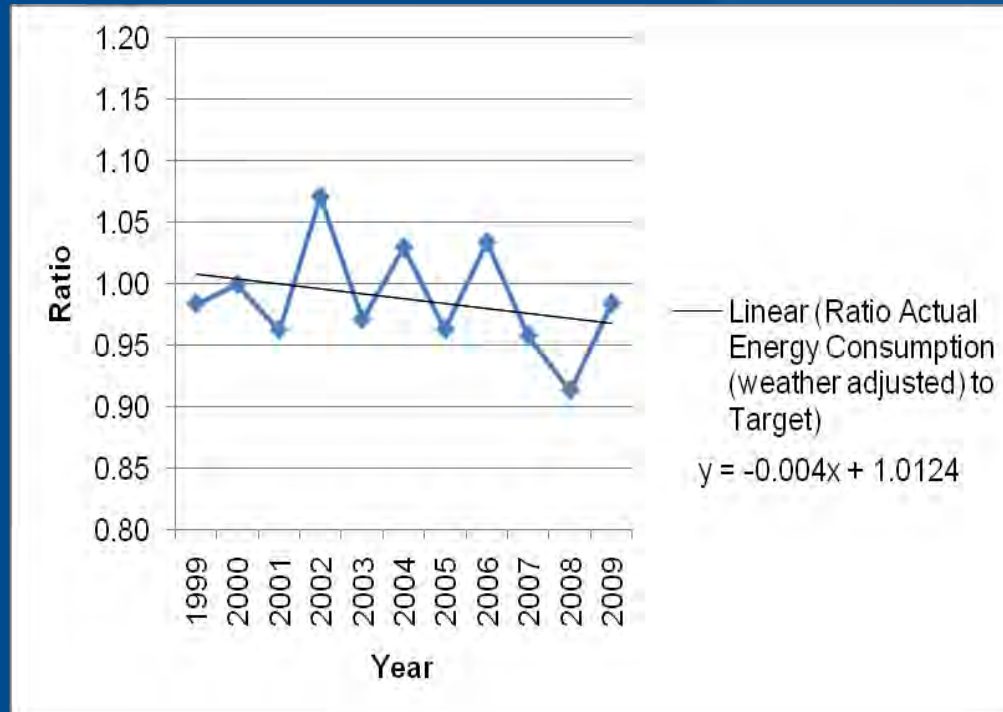
Weather-adjustment



- Method first suggested by APPA in 1994.
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4. Energy Management

Ratio of actual energy consumption to benchmarked target



Total energy consumption is decreasing in relation to the target energy consumption. In other words although energy consumption kWh is increasing year on year, the campus is becoming more energy efficient.

Conclusions

Major factors driving campus energy consumption

The most significant influences on campus energy consumption, in order of statistical significance, are:

1. The amount (m^2) and type (energy intensity kWh/ m^2) of space in use on campus.
2. Weather effects, measured in total degree-days.

For the year 2009 these in total accounted for 98.40% of energy consumed on Manawatu campus.

The remaining 1.60% was due to operational factors not yet identified.



Conclusions

Strategy – first priority:

- Maximise utilisation of the space we do have. Energy consumption is driven by buildings, not people.
- Have a strategy of keeping space usage rates as high as possible, particularly in highly energy-intensive areas such as climate-controlled laboratories. The timetable software is useful for monitoring this also.
- Rationalise buildings over time. Have a smaller number of larger, fit for purpose buildings and get rid of all the less compact energy-inefficient buildings.



Conclusions

Strategy – second priority:

- Recognise coping with the effects of the weather is an inevitable function of campus energy consumption. One cannot control the weather, but one can have some control over the effects of weather on the functional environment of the facility. Therefore the effects of weather should not be dismissed as “unavoidable” and the cost of consumption written off.
- Make use of low or nil operating cost measures such as passive solar design and super-insulation.
- Invest in more efficient climate control systems, use energy efficient equipment, lighting controls and day lighting technologies.



Conclusions

Implementing Strategy:

- The two points above will seem intuitively sensible; however it is essential they should be made strategic priorities.
- Consider space management even before one considers which buildings should have energy efficiency retrofits.
- This should be considered as a campus-wide strategy, particularly for using passive solar design in new build projects when they are most cost-effective to implement.
- This strategy has the additional advantage of being readily understandable to senior university staff that do not have an engineering background.



Conclusions

What does this mean for Manawatu campus?

- Manawatu campus is becoming more energy efficient over time, due to campus redevelopment.
- Not a cause for complacency – we still have an energy bill to pay! (\$3,900,000 budget in 2012).
- Space rationalisation and modernisation programme over past 10 years has been beneficial for energy management, and should continue actively.
- An example is redevelopment of science buildings 2005-2010, where a large amount of older less energy-intensive science space was replaced with newer climate-controlled laboratories. The trade off was, we brought in timetabling systems that resulted in the lab space being used more intensively.



Thank You

Thank you for your time.
Any questions?

