DOWN LISBURN TRUST

Lifelong Health & Care

ENERGY EFFICIENCY CASE STUDY

BY

THE DOWN AND LISBURN HSS TRUST

Evaluation of the M2G System
A boiler energy management load compensating sequence control

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INTRODUCTION

The Down Lisburn Health and Social Services Trust is part of the Government's National Health Service. The Trust, as a responsible Government Department, has a clearly defined energy and environmental policy with two main objectives. The first objective is to reduce its overheads, wherever possible, in order that patient care can be improved through more effective management of funds. The second objective is to reduce harmful CO_2 emissions in line with the Government's commitment to the Kyoto Protocol Agreement. Reducing our emissions helps to create a cleaner local environment by setting an example to the private sector and making them more aware about their responsibilities and the need to follow our example.

The Trust has an excellent record of reducing energy consumption having won many distinguished energy efficiency awards and certificates. As our record shows the Trust's energy policy has a high profile.

The Down Lisburn HSS Trust has 58 buildings ranging from general hospital services, acute hospital patient care, elderly care, mental care, GP centres, training centres and other associated type buildings.
As part of its commitment and drive to reduce energy, the Trust has specific guidelines for considering products that claim to reduce energy consumption. A product offered for our consideration must have acceptable supportive evidence before the Trust will consider it for short term tests. The Trust is bound by the Patients Charter and of utmost importance is the total welfare of our patients and the Trust's guidelines for trialling any product are very clear in this respect. A test on any product will immediately terminate if comfort levels are not maintained. A product must also have acceptable engineering logic to capture our full consideration.
If the Trust decides that there is conclusive evidence during initial test conditions that the product has performed well without any side effects, then the test is normally extended to a longer period, usually a twelve month period. At the end of this period if the Trust is completely satisfied with the energy performance results, it may then decide to bring the product to the attention of others in the form of a Case Study. This does not mean the Trust endorses the product but it is an indication for any other interested parties that the particular product tested by the Trust had demonstrated its ability to reduce energy consumption on our buildings and would have merit for their own applications.

In 1997 the Trust decided to evaluate boiler optimising units as part of its energy policy. Prior to that date, this type of control appeared to be fairly basic but advances, particularly in electronic technology, suggested that some of these controls had considerably advanced while others were just starting to enter the market. The Trust conducted a thorough assessment of these controls and divided them into two categories. Our first category included controls that had little or no intelligence which would make them suspect under heavy loading conditions that some of our hospitals demanded. Our second category included those controls that were more sophisticated having intelligence and engineering logic. The Trust decided to consider only those controls in the second category due to their ability to have at least some load demand logic. Within this category three units appeared to be worthy of extended consideration. The Trust decided to conduct initial tests on buildings that we could monitor through our BEMS (Building Energy Management System) and one particular control's performance stood out from the others. It appeared to have a much higher level of intelligence and consequently an advanced logic that included self learning features. It also had a system diagnostic facility which none of the others had. Under the Trust's testing guidelines it was decided to test this unit on two buildings over a much longer period.
In February 1998 the Trust purchased and installed four of the units that appeared to stand out from the others. Units were installed to the boilers of a hospital block. The heating demand for this hospital required a room temperature of 25°C due to the inactivity of the patients.
Units were also installed at the second selected site which was a GP Health Centre. Unit installation was carried out by an approved contractor and took less than 90 minutes per unit.
Although the Trust had purchased the units before starting the longer trial at the hospital, due to the welfare consideration of the elderly patients, the Trust repeated its stipulation that if there was any unacceptable variation in room temperature the test would be immediately abandoned. The Trust placed calibrated data loggers to monitor room temperatures every three minutes at different areas in the hospital. Calibrated data loggers also monitored ambient temperatures every three minutes.
The second test site was also monitored for room and ambient temperatures by calibrated data loggers every three minutes. Supportive evidence for both sites was supplied by our BEMS (Building Energy Management System). Daily consumption was read manually at the same time every day and confirmed by the BEMS. After confirming that there was no variation whatsoever in room temperature at the hospital, even during frost periods, the test was allowed to run its course over a full year. The Trust evaluated the test findings and established that energy was considerably reduced and room temperature was maintained at both sites. Even during frost levels reaching –5°C, room temperature was still maintained. The technical representative of this control unit was invited to explain in greater detail how the unit functioned and basically to go through the test findings.

M2G SYSTEM LOGIC

The unit under test was called the M2G System and was defined as a boiler energy management load compensating sequence control. The Trust keeps a record of how any device being tested functions so that we have at least a basic understanding of how it performs. While this energy efficiency Case Study makes an effort to briefly explain how the M2G System logic works, the Trusts understanding falls well short of explaining the full intelligence and self learning functionality of the unit software capabilities. That can only be best described by the unit suppliers. However, we can link the Trusts basic understanding with accurate consumption details under different ambient temperature conditions and this goes a long way to understand how the unit does in fact compensate for system loading demand and how it sequences loading demand over multi boilers, if multi boilers are installed.

The M2G System monitors flow and return water temperature as individual and totally separate software conditions to each boiler at 10 second intervals. This is a continuous process that provides ongoing system intelligence and picks up changing patterns in water temperatures indicating such things as modulating zone valves opening or closing or radiator thermostat valves opening and closing. Immediately on the termination of each burner fire, the M2G System software captures flow and return water temperatures in memory and uses this as a template for the next burner call. Using this memory template guide in conjunction with the ongoing 10 second interval readings from the flow and return temperature values, the unit software is able to build a "current picture" of system demand. With this detailed intelligence about current system demand, the unit software applies its advanced logic to effectively control burner firing. The advanced logic appears to be very unique because the Trust could not find any other control in the marketplace that applied the same degree of heat transfer intelligence throughout first and second stage firing.

Being able to accurately evaluate the current demand, and any sudden changes in demand pattern, the M2G System is able to take accurate decisions on how to deal with current demands. By monitoring flow and return water temperatures every ten seconds, the M2G System is able to establish how effective a burner is at raising water temperature during its first stage fire or at any given time during the firing cycle (all our boilers have two stage firing). Holding in its memory flow and return water temperature values when the burner terminated it's previous fire, the M2G System software is able to establish if the burner is making sufficient progress during its first stage fire by monitoring its progress and the software makes a calculation every ten seconds to establish at the current heat transfer rate how long it would take it to reach the previous burner fire set point (burner termination point). Every boiler with a single thermostat has a safety control device that sends a signal to the burner to release its second stage fire. When this signal is sent to fire the second stage, the M2G software has already a detailed evaluation how effective the first stage fire has been at raising water temperature. This signal would normally ignite the second stage fire after a predetermined time factor, which is unrelated to system demand or ambient temperature. The predetermined time period delay to the second stage fire varies with burner size and fuel type. The M2G System software having already applied its advanced intelligence once the call for the second stage fire has been made and is able to quickly establish if the second stage fire is necessary given the existing heat transfer rate. If the software decides the second stage fire is necessary it will make an accurate judgement at the exact moment to economically introduce it. The M2G System logic appears very effective in controlling the second stage firing as is demonstrated in later graphs. During the 12 month monitoring period there was factual evidence to prove that the M2G System introduced second stage firing with an obvious relationship to ambient temperature and loading demand. There were definite periods, especially from 10:00 or 11:00 in the morning to 15:00 or 16:00 in the afternoon, where second stage firing was greatly reduced and this not only reflected the general pattern of ambient temperature rising to its daily peak but also the rate of building heat loss slowing down. The M2G System responded to these situations effectively and maximum reduction in energy consumption occurred during these periods, although it was certainly not restricted by any means to these periods. Second stage firing of course consumes a lot more fuel than first stage fire and a reduction in second stage activity generates considerable savings despite longer first stage firing. On occasions when the ambient temperature was steadily rising, the M2G System decided that the second stage fire was not necessary due to either a higher level in return water temperature or a faster heat transfer rate from the first stage fire. Despite the reduction of second stage firing even through prolonged periods, room temperature was still maintained. In both buildings when two or three of the modulation valves closed greatly reducing the loading demand, the M2G System responded by preventing second stage firing. Equally so, when there was a significant loading demand the M2G System did not delay the second stage fire at all. A series of LED's on the unit panel indicates the current status of the unit and what function it is performing at any given moment.

The M2G System logic and its decision making functions are based on water temperature gain versus time for second stage firing control and water temperature loss verses time for first stage firing. Flow and return temperatures are monitored separately by digital sensing probes as two individual software conditions and their different characteristics produce patterns of temperature gain and loss versus time in a variation of ways. As each boiler must have a M2G System unit installed, the overall logical control becomes boiler specific as no two boilers have the same rise and fall temperature characteristics.

With an installed unit to each boiler in a multi boiler site, a communications cable from M2G unit to M2G unit passes flow and return water temperature information between each other. Additionally, if one boiler fires in a multi boiler site, the other boiler(s) will immediately be informed of its current and ongoing ability to raise water temperature given the current loading conditions. Even if the lag boiler(s) has called to fire, the M2G System will use its intelligence to take effective decisions if the boiler fire is necessary. If it decides that the call to fire is necessary, the M2G system will fire the burner in its first stage and then monitor its heat transfer progress before eventually making a further decision

whether it is necessary to fire its second stage which would fire anyway if left uncontrolled. The "chatting" procedure between units is a continuous process.

FURTHER EVALUATION

The Trust then decided to extend our initial trails on the M2G System to a further eight buildings and to monitor energy consumption performance over a full year comparing its performance to our 18 year historical consumption data records. The buildings were carefully selected to provide a good variation in operational activity. As this was to be an extended trial over twelve months it was important to reflect a variation of building types and operational requirements to include buildings having a high demand with 24 hour requirements and buildings less demanding but staff occupied between 08:00 and 18:00. The buildings selected for extended trials were further divided by fuel source. The buildings selected were as follows :

Laurelhill House
Laurelhill House is a patient care centre with 24 hour 7 day operational requirements. The boilers are natural gas fired.

Seymour House
Seymour House is a patient care centre with 24 hour 7 day operational requirements. The boilers are natural gas fired.

Lindsay House
Lindsay House is a residential disability centre with 24 hour 7 day operational requirements. The boilers are natural gas fired.

Lisburn Adult Training Centre
Lisburn Adult Training Centre is a special needs centre. The building is operational part time, between 08:00 and 17:30 Monday to Friday. The boilers are natural gas fired.

Hillsborough Health Centre
Hillsborough Health Centre is a GP Practice with extended facilities. These include speech therapy, child care, nursing care, special clinics and nursing administration in relation to nursing home visits and direct nursing treatment through GP referral. The building is heated from 06:00 to 18:00 each weekday and from 06:00 to 10:30 during weekends. The Centre has one evening clinic per week. Three of the heating zones have a room temperature requirement of 21°C. The boilers are oil fired.

Finniston House
Finniston House is a hospital catering for mental illness. It has 24 hour 7 day operational requirements. The boilers are oil fired.

Nurses Residence
The nurses' residence houses the nursing staff from three local hospitals in the general estate complex. Nursing staff operate 3 shifts per day. The site has very high hot water demands with nurses showering prior to commencing their shift and at the end of their shift. The boilers operate 24 hours 7 days per week and are oil fired.

Downshire Maternity
The Maternity Hospital has a very high demand for hot water as would be expected from such a building. The boilers are operational 24 hours 7 days per week and are oil fired.

Boiler capacity for these buildings varied from 115kW to 600kW output. Each building has two boilers per site. The buildings vary from single floor to four floor levels.

WEATHER CORRECTION

The weather correction method used for comparing one year of normal control with one year of M2G System control has been based on long term historical consumption records illustrating a consumption value per degree day. However, absolutely crucial for making an energy consumption comparison was selecting an appropriate and relevant base year. The Trust was very aware selecting a fair base year was important for an evaluation especially given the variety of buildings and operational use. After careful scrutiny and consideration, the Trust selected the year 2000 as the base year for making a comparison because its degree days closely reflected a five year average pattern, 1997-2001.

The year 2002, the period when the M2G system controlled the boilers at the named sites listed on the previous page, was a slightly milder year. The weather correction method as already defined, i.e. consumption rate per degree day, was used to make the appropriate weather correction. The buildings had the following consumption rates per degree day :

NATURAL GAS

BUILDING	CONSUMPTION RATE PER DEGREE DAY
Laurelhill House	**104.45 kWh**
Seymour House	**120.02 kWh**
Lindsay House	**32.96 kWh**
Lisburn Adult Training Centre	**182.00 kWh**

CLASS D OIL

BUILDING	CONSUMPTION RATE PER DEGREE DAY
Hillsborough Health Centre	**34.72 kWh**
Finniston House	**403.42 kWh**
Nurses Residence	**88.48 kWh**
Downshire Maternity Hospital	**296.00 kWh**

The following tables illustrate the before and after consumption rates weather corrected by the above consumption rates per degree day figures. Column 1 illustrates consumption for the year 2000 (prior to M2G System control) and the second column illustrates consumption weather corrected for the year 2002 (all boilers controlled by the M2G System). Column 3 illustrates the percentage reduction in fuel. Column 4 illustrates the payback on investment based on December 2003 energy prices. Column 5 illustrates the reduction in CO_2 tonnes emissions due to the M2G System control.

	Column 1	Column 2	Column 3	Column 4	Column 5
NATURAL GAS	**Year 2000 mWh**	**Year 2002 mWh**	**Percentage Saving**	**Payback in Years**	**CO_2 Tonnes reduced**
Laurelhill House	**557.30**	**412.99**	**25.9%**	**0.99**	**27.4**
Seymour House	**854.70**	**750.22**	**12.2%**	**1.36**	**19.9**
Lindsay House	**182.50**	**145.59**	**20.2%**	**3.86**	**7.0**
Lisburn ATC	**613.50**	**446.10**	**27.3%**	**0.85**	**31.8**

	Column 1	Column 2	Column 3	Column 4	Column 5
CLASS D OIL	**Year 2000 Litres**	**Year 2002 Litres**	**Percentage Saving**	**Payback in Years**	**CO2 Tonnes reduced**
Finniston House	**197621**	**162788**	**17.7%**	**0.30**	**94.1**
Nurses Residence	**70895**	**65667**	**7.4%**	**1.86**	**14.1**
Maternity Block	**172503**	**160145**	**7.2%**	**0.78**	**33.4**
Hillsborough Health Centre	**13005**	**8472**	**34.9%**	**2.14**	**12.2**

The eight sites listed above when controlled by the M2G System produced a reduction in energy consumption under very heavy load demanding buildings of 7% and up to 34% under less load demanding conditions. The Trust was aware that these buildings would produce the worst and best performance opportunities for the M2G System. The average reduction in energy consumption considering all the sites over one full year was 19.2%. The total reduction in CO_2 emissions for all the buildings was 240 tonnes. The average payback was very attractive. Using recent increases in gas and oil prices (January 2004) the average payback would be 0.81 years.

Room temperature at all the buildings was at least maintained and in some cases was slightly higher during M2G System control. Since purchasing and installing the first units in 1998 the Trust has never had a unit malfunction or a cause to complain.

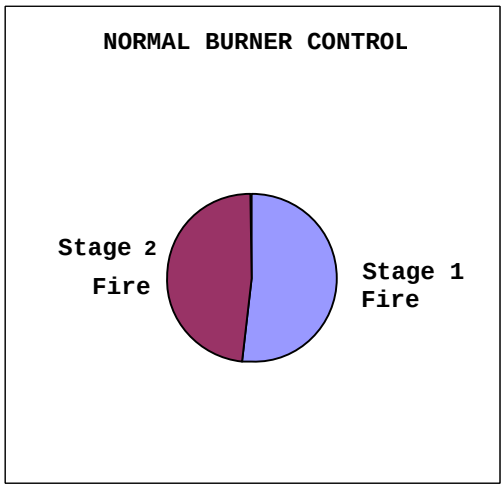
The Down Lisburn HSS Trust being completely satisfied with the M2G System control decided to purchase and installed these devices on all other suitable Trust Estate buildings. The Trust installed M2G System units on six buildings at the same time so that monitoring a group of buildings would be more meaningful. Six months have passed and these buildings are reporting the same kind of average percentage reduction in energy as the twelve month evaluation trials on the eight buildings.

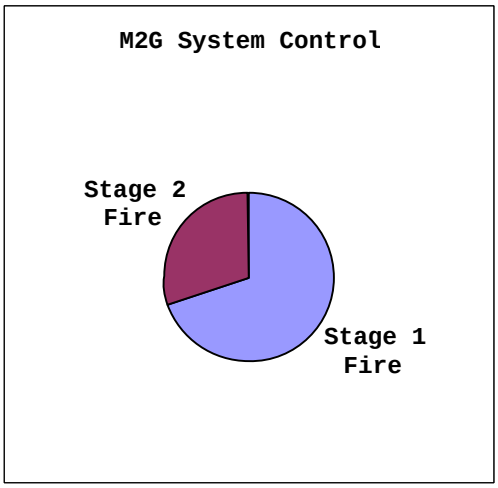
In January 2004 the M2G system had a software upgrade introducing more intelligence into second stage firing. The Trust has completed an initial test on the software upgrade on two buildings and there is an improvement in energy saving percentage. We are about to install M2G System units at another five buildings clearly illustrating the Trust's confidence and commitment in the control.

The following graphs and Tables have been produced from the test period for the Department of Elderly Medicine at the Lagan Valley Hospital complex. The first table illustrates two comparable ambient temperature days.

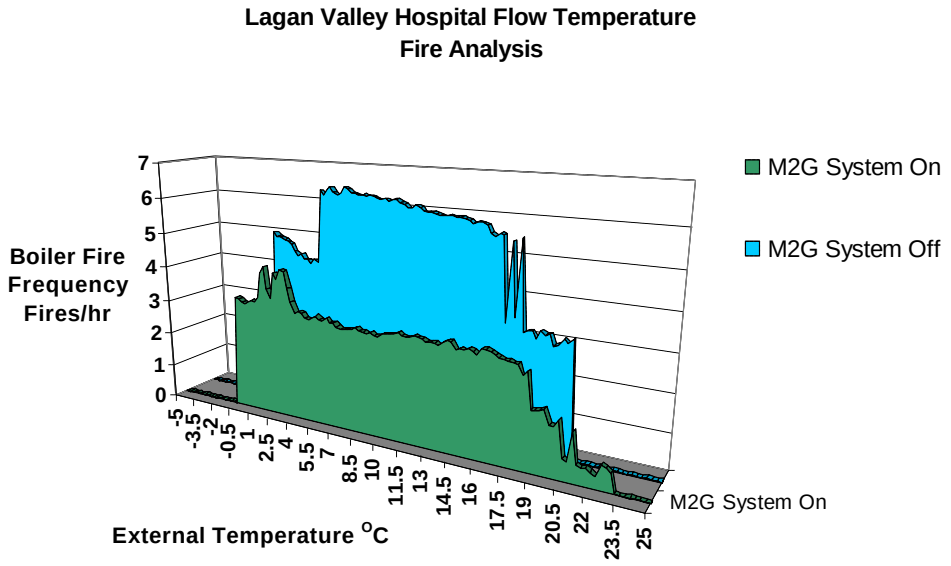
Mode	Average Ambient Temp	Max Ambient Temp	Min Ambient Temp	Average Room Temp	Max Room Temp	Min Room Temp	Total Burner Runtime (Minutes)	Lead Boiler Fires	Lag Boiler Fires	% Saving in Energy
Normal	9.73	15.66	7.47	25.38	25.78	25.09	737.47	102	37	
M2G Control	**9.20**	**15.38**	**7.21**	**25.48**	**25.78**	**25.09**	**517.43**	**83**	**27**	**29.8**

The pie chart below and the pie chart at the top of the next page illustrate a two hour gas consumption rate for Normal control and M2G System control in both stages of fire. The second pie chart, on the next page, M2G System control, shows less second stage firing. Second stage firing consumes considerably more fuel than first stage firing. During M2G System control there is longer first stage firing when the loading demand is below maximum. During very low demand periods when the ambient temperature was above 16°C (room temperature requirement of 25°C) and some zone valves had closed thereby raising the return water temperature, the M2G System prevented second stage firing altogether. The M2G System Control pie chart illustrates more fuel efficiency and therefore is more economical.

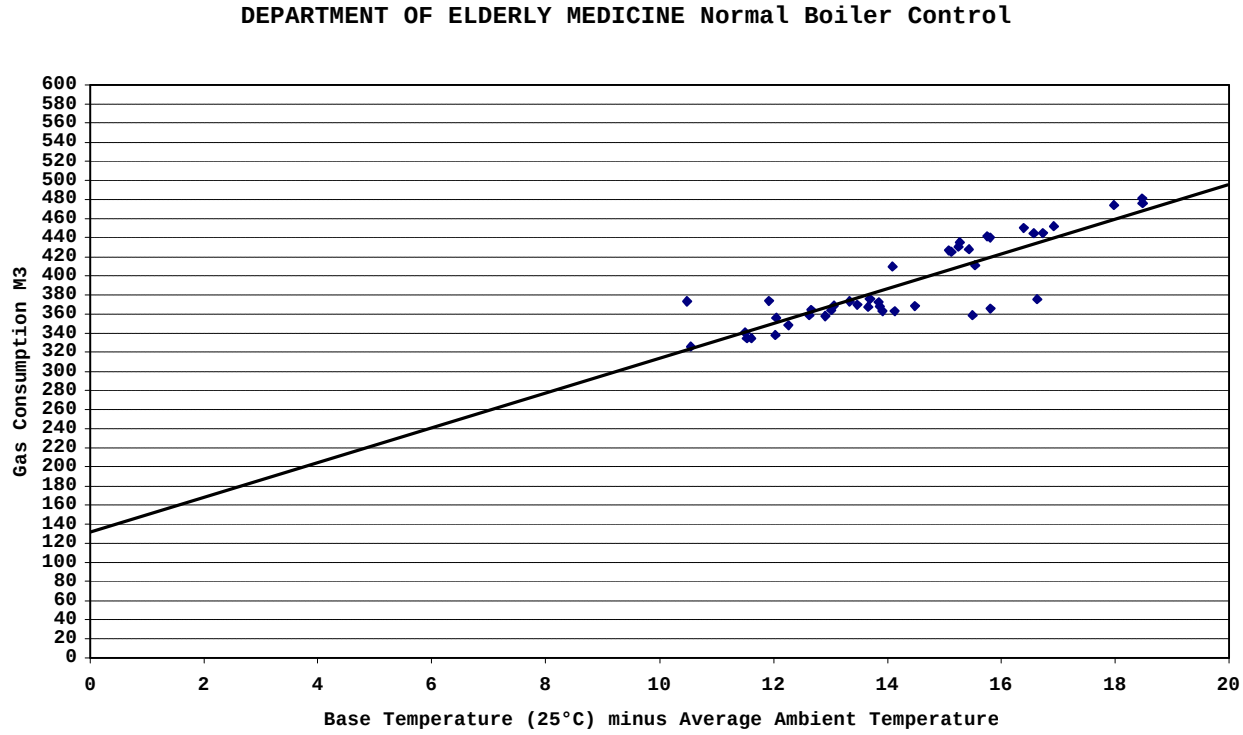




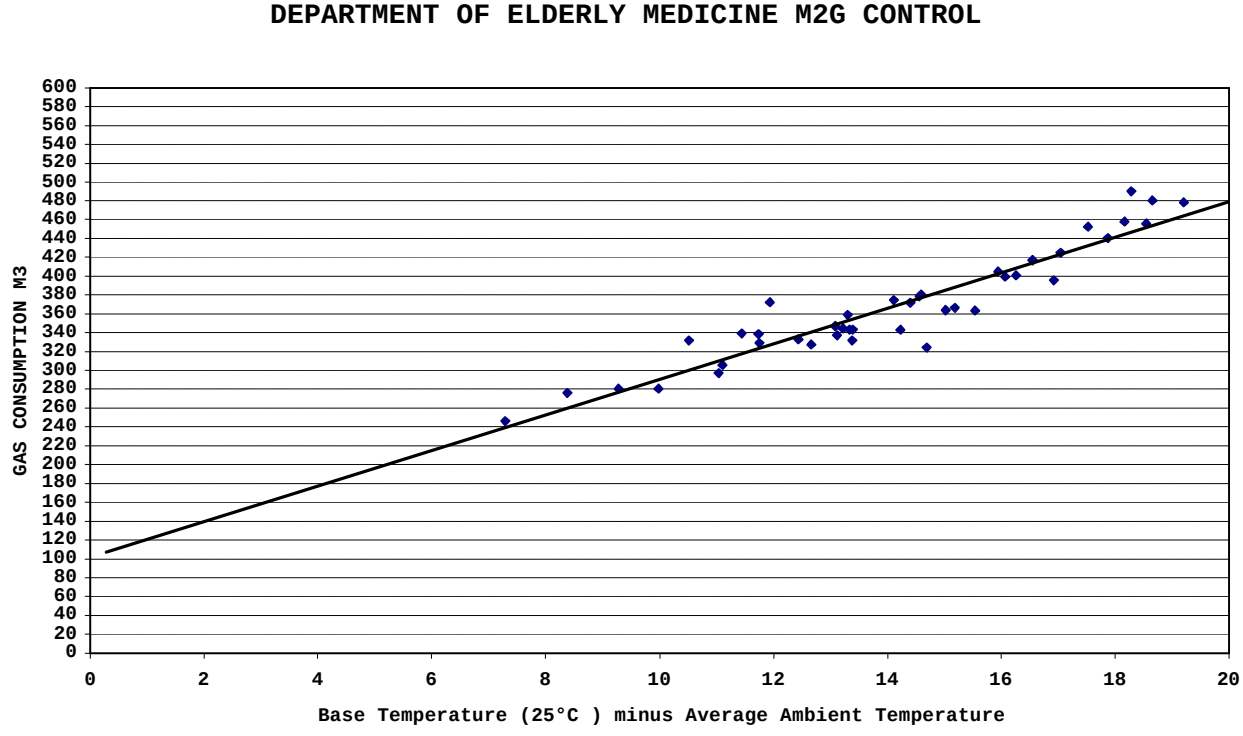
The graph below stretches over a four month period and illustrates boiler frequency firing per hour at varying ambient temperatures. This again confirms that the M2G System is a load compensating device by reducing the number of fires per hour as the load decreases. The demand for room temperature was 25°C.



The first graph on the next page illustrates fuel consumption plotted against degree days based on the difference between base load (room temperature) and the average ambient temperature during normal boiler control, (prior to M2G System installation). On first appearance the regression analysis trend line looks as if energy is generally tightly controlled and indeed this would be termed as well controlled. However, when the M2G System controlled the boilers, illustrated on the second graph on the next page, it was evident that we had been using too much fuel particularly when the ambient temperature was between 8-14°C. The result of this improved control was the weather unrelated energy consumption per day (the point where the trend line strikes the left hand axis, in this case just over 130m^3) was a little higher than it should have been.



Comparing the graph below, illustrating M2G System control, with the graph above, illustrating normal boiler control (prior to M2G System installation) it illustrates that the M2G System control has reduced gas consumption throughout the ambient temperature range. The regression analysis trend line on the M2G System control graph also shows better control of energy consumption at 8-14°C ambient temperature where under our normal boiler control there was an obvious waste of energy. During M2G System control the difference in this crucial ambient temperature band had the effect of reducing the daily weather unrelated consumption rate (the point where the trend line intersects the left hand axis which under M2G System control this figure was $100m^3$ compared to non M2G System control of $130m^3$)



SUMMARY

Boiler controls, boiler optimising units, sequence controls and load compensating controls fall under the same general category heading. The Trust has a minimum requirement for a boiler control and that is it should have intelligence and understandable engineering logic. Even within the selected definition of intelligence there is a wide variation. In our opinion the M2G System appeared the most advanced boiler control we could find. The engineering logic has been obviously well thought out. From short term and long term trials the Trust proved that the M2G System logic was very effective at reducing energy consumption while maintaining room temperature. Now having the benefit of the M2G system installed on some buildings over six years, the Trust can favourably report that on these buildings there has never been a single heating or hot water complaint. We can further report a similar experience on other buildings where units have been installed since. Room temperature at all the buildings has also been maintained, and in some cases has been slightly higher so the reduction in energy has not been at the expense of comfort. All the Trust's buildings have a BEMS and installation of the M2G system has proved to be an additional and complimentary control to the BEMS. The reduction in energy is certainly a major benefit with the M2G system but less energy consumption means less boiler activity which in turn has a number of other benefits. A reduction in electricity due to the fact that there is less burner motor activity and perhaps more important, if the burner functions less both it and the boiler should last longer which delays capital investment for boiler replacement. A reduction in energy means boiler servicing intervals can be extended.

In conclusion the Down Lisburn HSS Trust findings clearly illustrate that the M2G System significantly reduced energy consumption, maintained room temperature, had no side effects and offered a very attractive pay back on investment. Even in the buildings where very high levels of saving were achieved, up to 34%, room temperature was still maintained. This clearly illustrates that uncontrolled boilers do consume more fuel than they should compared to effective control by intelligence and self learning logic. The Down Lisburn HSS Trust proved that installing the M2G System control is good practice in energy conservation terms.