Wasted Energy: how money and carbon dioxide could be saved in schools

A report by the

South West London Environment Network

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Contents

1. Purpose

This paper reports on an analysis of gas consumption by 20 schools (60% primary, 40% secondary) in the Royal Borough of Kingston upon Thames, London, throughout a full year with the aim of encouraging more schools to become involved in energy saving and to promote energy saving more widely. It has been prepared by the charity South West London Environmental Network (SWLEN) to offer suggestions on how schools might make significant reductions in energy consumption, along with lower costs and carbon emissions, by relatively easy and inexpensive changes to heating timers and to manual heating operation. It also describes SWLEN's attempts to discuss these findings with individual schools

The analysis was possible due to the "half-hourly" meter reading service, an automatic system, previously known as Automated Meter Reading (AMR), which is now mandatory for larger energy users and is available to schools through their energy suppliers or from independent Meter Operators. Although we have focused on gas, the recommendations of this report can also apply to schools heated by electricity.

As a result of our analysis, we also describe some methods by which schools without access to half-hourly energy consumption data can take advantage of the potential saving opportunities identified, by manually reading energy meters.

This paper will be sent to a wide audience to create interest and awareness in both schools and the wider community.

2. Summary of recommendations

The overriding finding of the analysis is that many schools are heated to varying degrees when they are unoccupied. Therefore our main recommendation is that by analysing energy use through a school year, energy saving opportunities can almost always be identified. Then, by manually turning off heating for example during the winter holidays or by adjusting heating timers, energy use and hence costs and carbon dioxide emissions can be reduced. As one participant put it: *"Turning off the heating at 3pm on the last day of term in December and turning it on again an hour early on the first day of term in January could save £1000 per year – that's about £100 per minute of effort!"*

Turning off heating when buildings are unoccupied is only one of many opportunities to save energy in schools. Although upgrading building fabric is expensive and disruptive, there are many other low cost and low disruption opportunities to save energy. We recommend that schools undertake a wider energy audit to identify such opportunities - for schools in south west London, SWLEN can provide this as a free service (See Section 9 for details).

Achieving such reductions in cost and carbon emissions can prove challenging in the face of other, more pressing objectives in schools. We found that the best results occurred when several staff members took an interest in energy saving, with support from senior management and governors. We therefore also recommend that specific responsibilities for energy saving and environmental issues is allocated to appropriate staff. The ideal is for the head teacher, bursar, premises manager and a governor to all give support.

3. Background

SWLEN is a charity that aims to build community capacity to protect and enhance the environment. One of its activities is to help people save energy. Working with schools is a huge opportunity to help them save energy, educate their pupils in energy saving and renewable generation and motivate staff and parents.

In 2015, SWLEN was given access to AMR data for the 20 Kingston schools. A full year (12 months) of half-hourly gas consumption data was captured for them in Oct/Nov 2015 and updated data captured for several more in late 2016.

The half-hourly data was analysed using a spreadsheet, with the intention of trying to find out if gas was being used when the buildings were unlikely to be occupied. Gas consumption was calculated for the following times:

- Term time weekday "daytime" (4AM to 10PM)
- School holidays
- Term-time weekends
- Term weekday nights (10PM to 4AM)

We selected a 4AM start and 10PM end time to allow time for the buildings to heat up by about 7AM for early opening, and to allow for after school clubs and other possibly evening use.

This data, including relevant charts of daily and hourly gas use, was used to prepare reports for consideration by some of the schools. For a few of these schools, full or partial updated data was captured in late 2016, demonstrating some reductions in energy use as a result of the first report and follow-up energy audit.

This paper generalises our analysis of the data from all 20 schools and makes suggestions that may help other schools save energy based on our findings. Our experience shows that analysis of energy consumption at a school almost always uncovers some opportunities for energy saving through behavioural change, often achievable through relatively easy and inexpensive changes to heating timers and to manual heating operation. Many school buildings are old and poorly insulated and upgrades to the building fabric to save energy are expensive and often inconvenient. Therefore low-cost, relatively easy behavioural changes become an important way to save energy.

To preserve the anonymity of the schools involved, we have used data from several different schools and have not shown the exact data and as a result, the charts do not have a vertical scale.

4. Findings

4.1 Gas usage at times when unoccupied

The overriding finding of the analysis is that many schools are heated when they are unoccupied. Simply by manually turning off heating for example by switching to "holiday" / "frost-protection" mode during the winter holidays, or by adjusting heating timers, energy use, and hence costs and carbon emissions, can be reduced.

The heating systems in even smaller schools can be complex and it is difficult to monitor energy use without good, easily accessible data. That is what half-hourly consumption data can provide. Careful analysis and comparison of the data with actual school building use patterns can reveal opportunities for significant savings. To put this in perspective, we identified possible savings of over £10,000 in some schools, representing up to 40% of annual gas use. Practically achievable savings should be expected to be somewhat lower, as there may be some use of school buildings outside of the times we used for the analysis, for example in school holidays and weekends. Many schools may not even need to use all their buildings every weekday evening and so for them potential savings may be understated.

Table 1 shows the distribution of gas use during periods when the buildings may not be occupied, for the schools studied. Note that no school has the lowest (or highest) consumption in every category, and even for the "best" school more than 10% of annual energy was used during school holidays, most of this during the winter holidays.

Table 1: Distribution of gas use (percentages of total annual use)	**Term weekday night (10PM to 4AM)**	**Term weekend**	**School holidays**
Lowest value in sample	Less than 0.5%	Less than 1%	12%
Average value in sample	6%	10%	19%
Highest value in sample	14%	22%	26%

We looked for correlation between total energy use (per square metre) and the level of "out of hours" use, both in aggregate and for each column in the table above, but found none. Our conclusion is that the possible savings identified are not linked to the energy efficiency of the buildings.

The dataset also included enough church schools to draw reasonable conclusions. We looked for correlation between out-of-hours use in church schools and non-religious schools, on the assumption that church schools might be used more often outside of normal school hours than non-religious schools - but again found none.

The most common and significant use of gas outside of normal school hours was during the Christmas and spring half term (February) holidays, together ranging from 3% to 15% of annual gas use.

4.2 Engagement with school staff

SWLEN tried to contact those schools out of the 20 analysed where the largest and easiest savings could be made. Contact was tried by cold calling, through a parent, through local council staff or by a referral from another school.

Enquiries were made at 10 schools but only 5 resulted in an invitation to visit. This was at first surprising, as SWLEN offered a free service with an opportunity to make cost savings with little or no investment. It is likely that the low uptake was because most schools have no-one with a specific

responsibility for energy management and energy reduction. Although staff recognised this is an important topic, more pressing everyday needs took priority.

Whilst schools appreciate they need to save energy in a cost effective way, it was found that many do not have time to proactively pursue energy saving recommendations. We suggest this is because energy saving is not a specific objective for which any staff member has responsibility nor forms part of any cost reduction initiative. Energy saving covers many aspects of school life and should be part of education. The best result occurred when several staff members supported energy saving. The ideal is for the head teacher, bursar, premises manager and a governor to all give support.

4.3 Follow-up visits to conduct an energy audit

SWLEN arranged several visits to schools to perform an energy audit, covering energy usage, insulation, lighting and behaviours by staff and pupils. Although the half-hourly analysis formed a starting point for discussions, many other issues were found. Recommendations that had appeared to be straightforward when each school was given a list of “quick wins” often became difficult to carry out.

Section 9 provides details of SWLEN energy audits and summarises the findings from the audits of the schools in this exercise.

5. Detailed recommendations

5.1 Gas usage at times when unoccupied

These recommendations are presented in order of priority - with the first suggestion being, in our opinion, the easiest change that is most likely to achieve a significant reduction in energy use.

Where we cite "average savings" this represents the likely average saving across a number of schools, based on our analysis - actual savings in individual schools may be greater or smaller.

5.1.1 School holidays

Manually set the heating and hot water systems to "frost protection" mode (sometimes helpfully called “holiday” mode) when the buildings are unoccupied during school holidays. The greatest potential savings will be during the winter holidays - October half term, the Christmas holidays and February half-term. Average savings of around 15% of annual gas use might be expected if this is achievable. If the buildings are part-occupied, investigate opportunities to turn off heating in unoccupied areas (see also Section 7).

Identifying energy saving opportunities during the winter school holidays does not necessarily require access to half-hourly energy consumption data. Any school could manually read the gas meters at the start and end of school holidays, and compare this with readings for the term-time weeks before and after the holidays. In this way gas use in school holidays can be quantified, and compared with actual building occupation, potentially identifying savings.

5.1.2 Weekends

Investigate weekend gas use, to see if this is correlated with actual use of the school. Adjust heating and hot water timers such that the buildings and water are not heated during unoccupied periods at weekends. Average further savings of around 10% of annual gas use might be expected if this is

achievable. If the buildings are part-occupied, investigate opportunities to turn off heating in unoccupied areas (see also Section 7).

Again as noted above, manual gas meter readings can provide partial information on weekend gas use and may also identify energy saving opportunities.

5.1.3 Winter out of hours gas use

Investigate winter evening/night-time/ early morning gas use. During the period 10PM - 4AM, we would normally not expect the heating to be operating, apart from frost protection on very cold nights. Adjust heating and hot water timers to avoid unnecessary pre-heating. Average further savings of around 5% of annual gas use might be expected if this is achievable. In addition to the 10PM to 4AM period used in your analysis, we recommend that schools also look at the period 6 pm - 10 pm. Gas use should be compared to actual building occupation times, to determine if there are further opportunities to save energy by adjusting timers and manual procedures.

5.1.4 Hot water

Investigate hot water timers and ensure that hot water is turned off along with heating when the buildings are unoccupied, particularly during school holidays. Average further savings of around 2% of annual gas use might be expected if this is achievable.

5.2 Barriers to adjusting heating timers

We are aware of barriers to these actions, primarily that heating system controls and timers in even smaller schools can be quite complex to adjust. However, adjusting heating timers to better reflect building occupancy and pre-heat requirements should not need to be done often. If it is not possible for in-house staff to make these changes, they could be made by the normal heating maintenance company, probably at relatively low cost.

If only some rooms are in use after school hours, then programmable radiator valves can be installed, which set the temperature depending on occupancy (See also Section 7).

However, the best opportunity for savings is usually from improving heating management during school holidays - this is typically achieved through manual operating of the heating controls, which in our experience is possible using in-house staff in most schools.

What is important is to analyse gas consumption to identify opportunities for energy savings. Section 6, Detailed Analysis gives examples of how this might be achieved, based on our analysis of the data from the 20 schools in the sample.

5.3 Engagement with school staff

For any suggestions to be carried out, a school needs to have a culture which embraces energy saving and environmental protection. In some schools we have worked with this culture already exists, but in others it will only be created gradually. We found the best results where SWLEN remained in touch with each school permanently and, as an opportunity arises to carry out a “quick win”, to help ensure that it is taken. Once an energy saving culture is adopted, its benefits should ensure that it continues to grow.

Several staff members need to support energy saving including the head teacher, bursar, premises manager and a governor. A staff member needs to have responsibility for energy saving and its promotion, objectives and targets for annual savings and a budget. When several schools have this culture in place, there is scope for them to collaborate.

As AMR meters are no longer available, schools must be encouraged to contact their energy suppliers to request "half-hourly" metering services, which will provide the same data and opportunities for analysis as AMR meters. SWLEN can help with this analysis.

6. Detailed analysis

6.1 School holidays

As noted earlier, gas use in school holidays is the greatest potential saving opportunity in the schools in our sample. We believe that this is likely to also be the case in many other schools.

Only two out of the 20 schools in the sample used less than £500 worth of gas during school holidays during the year, but 15 used more than £1,000 worth. Two schools used over £5,000 worth and the average gas use during school holidays was nearly £1,800 during the year, representing over 10 tonnes of carbon dioxide emissions.

The biggest opportunity for saving energy is during the winter holidays, particularly Christmas and the February half-term. Table 2 shows the distribution of energy saving opportunities in the schools in our sample (figures are rounded to the nearest percent). As can be seen, the winter school holidays represent, on average, almost 10% of annual gas use.

Table 2: Distribution of gas use (percentages of total annual use)	**Christmas holidays**	**February half-term**
Lowest value in sample	1%	1%
Average value in sample	5%	4%
Highest value in sample	10%	7%

Earlier we noted that we could not find any correlation between out-of-hours gas used and school status - in support of this, the highest and lowest Christmas holiday gas use in the sample are both in church schools.

Figures 1 and 2 show the results of typical analysis of half-hourly gas consumption data. Figure 1 shows a school where the heating was clearly turned off during the Christmas holidays. Figure 2 shows an example of a school where the heating seems to have been left on.

Unless schools are actually occupied during the holiday periods, gas could be saved if the heating and hot water system were to be turned off, with the heating set to a "frost protection" setting (usually 10 degrees or less) in colder months. This will likely be a manual operation. Most heating control systems incorporate automatic frost protection, which operates when the main heating is set to "off".

Figure 1: Christmas holiday gas use

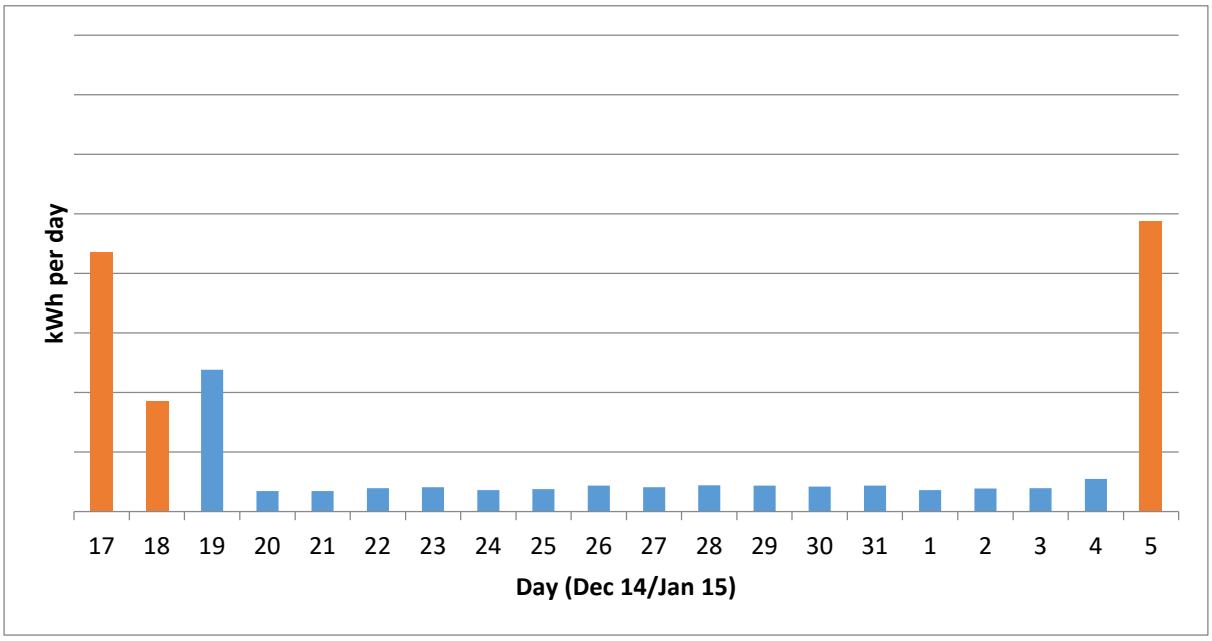


Figure 2: Christmas holiday gas use

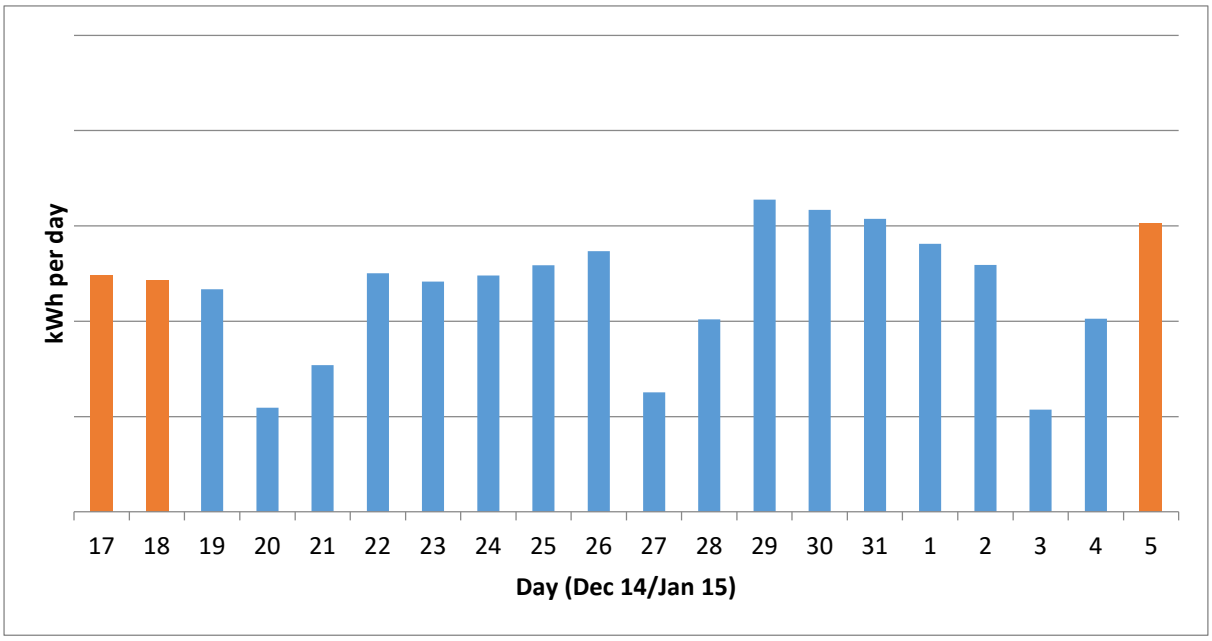
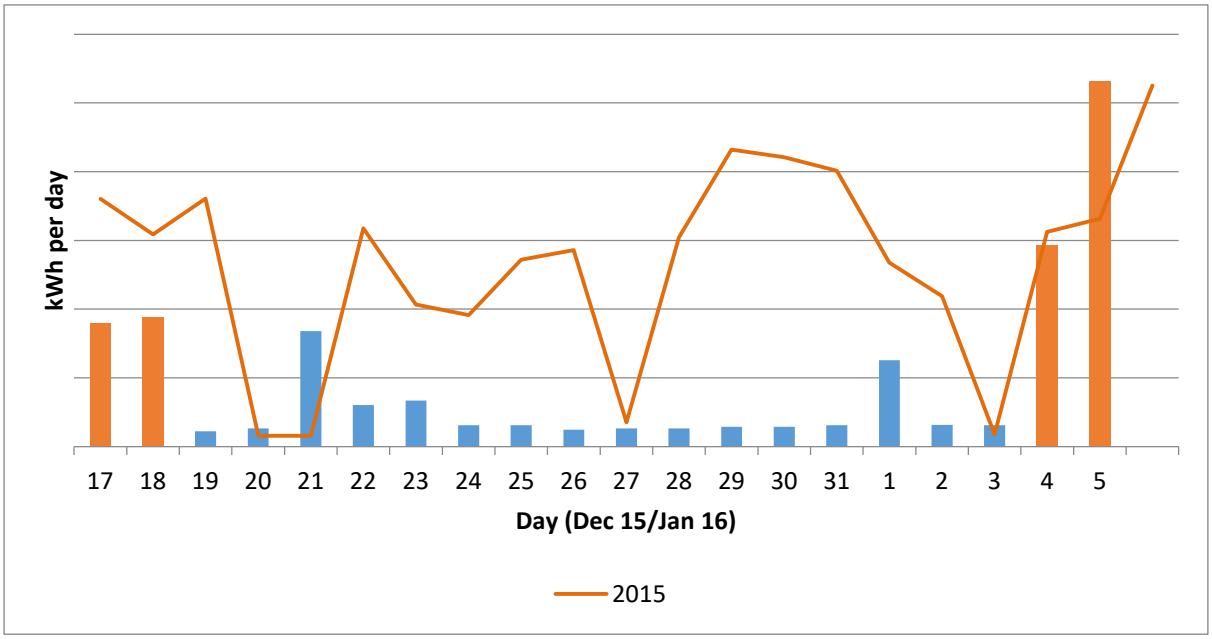


Figure 3 shows the impact of our initial report in one school. The line shows the "before" gas consumption and the bars represents the "after" consumption the following year. In this school, following the advice in our report, the heating was manually turned on to the "frost protection" setting at the beginning of the Christmas holiday and then turned back on at the end of the holiday. These actions resulted in savings of about £500 and 2.5 tonnes of carbon dioxide emissions for the school.

Figure 3: Christmas holiday gas use



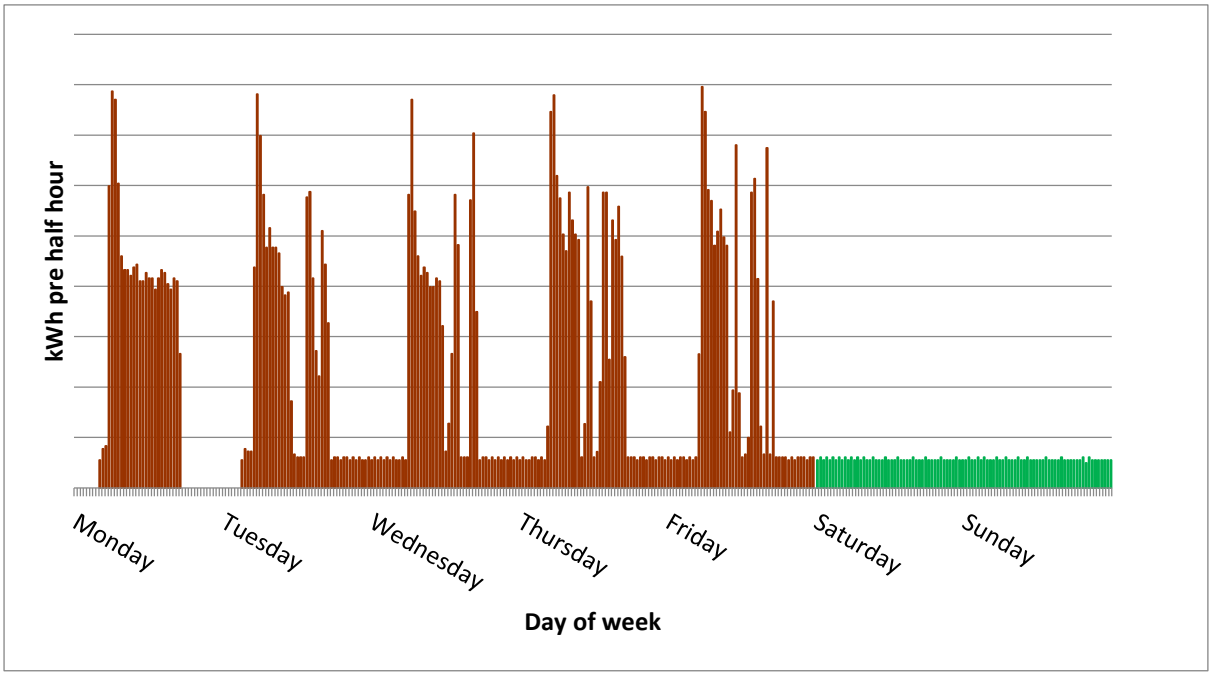
6.2 Weekly gas use analysis

Weekend gas use is the second largest potential saving opportunity identified in our analysis. On average, schools in the sample used 10% of their annual gas at weekends, with the highest using over 20%, but the lowest well under 1%. This may represent differing use of school buildings at weekends, but we believe that in many schools, the buildings may be un-necessarily heated at the weekend.

Figures 4 and 5 give an example: these are both for a week during winter, in different schools. Figure 4 shows a school that is clearly not used at the weekend, when the heating is turned off. The constant low-level use of gas is, we believe, for hot water (see also later) - which could probably be turned off at the weekend as well.

Figure 5 shows a school which may be in use at weekends, but note that the use of gas is actually higher than during the week. We have observed this pattern of gas use in a number of schools and it may be that, unbeknown to the school management, a different timer setting is used at weekends, meaning that buildings may be heated when not in use.

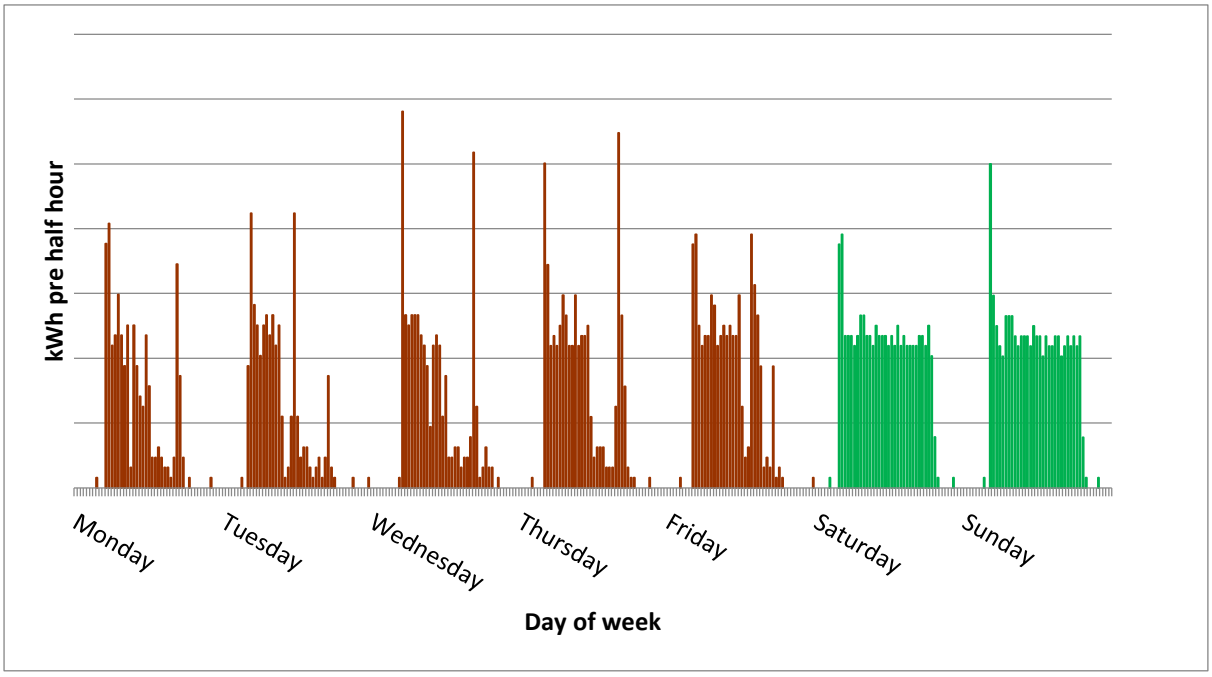
Figure 4: Weekend gas use



If school buildings are not used at weekends, or are used for only part of the weekend, gas could be saved by adjusting the timers so that heating and hot water are turned off when the buildings are unoccupied. Should weekend use not be regular, manual intervention may be required to avoid heating the buildings when not occupied.

Please also refer to Section 7.

Figure 5: Weekend gas use



6.3 Daily gas use analysis

Our analysis also uncovered opportunities to save gas by reviewing night-time gas use in schools. While smaller than the holiday and weekend opportunities, there is less likely to be a good reason that schools need to be heated during the night, so the savings may be more easily achievable. The average use of gas in schools in the sample during term time, weekday nights (10PM to 4 AM) was 6% or annual gas use, ranging from *less than half a percent* to 14%.

We feel that it is very unlikely that school buildings are in-use between 10PM and 4AM, so we would expect to see very low gas use during this period. Any gas used would represent only frost protection, and only be used on the coldest nights. The frost protection setting on most heating controllers usually maintains buildings at between 5 and 10 degrees Celsius, much lower than the typical 18 degree daytime setting. We would expect that even on the coldest nights, residual heat in the building fabric would result in gas consumption under frost protection conditions of less than half of the rate the day before or after.

Figure 6 shows the daily gas use for a cold winter day in a school where the heating is clearly turned on at 5:30AM and off at 10:00AM. Figure 6 shows the gas use for the same day, in another school within 15 miles of the first one. The external temperature for both schools can therefore be assumed to be the same, but Figure 6 shows much greater use of gas. Interestingly, the heating is turned off or down at 5:30PM, but comes on again at around 9:30PM. This may be due to evening use of the schools buildings (although it seems rather late in the evening), but then the heating remains on all night. The night-time level of gas use is slightly lower than the daytime level, but we think the thermostat setting is probably the same - the lower gas use at night is probably because doors are not being opened at night. We have observed this pattern of gas use in a number of schools, suggesting that it is perhaps a function of the heating control system rather than of manual intervention.

Some early-morning use of gas is to be expected, to preheat the buildings ready for the morning opening of the school. We have worked on the assumption that the earliest occupation of a school would not be before 6 AM - in many schools opening time may be later. While the pre-heat requirements do depend on the nature of the buildings, the data suggests that 2 hours is sufficient in most cases to bring the buildings up to normal temperature, even on cold nights, suggesting an earliest switch-on time of 4AM.

Should schools find this pattern of gas use, it is an area for further investigation and monitoring. Pre-heat requirements can be assessed by measuring the actual temperature from midnight to opening time to determine if too much pre-heat is being applied. If this is the case, existing time controls could be adjusted accordingly.

Alternatively, pre-heat requirements can be deduced from the half-hourly gas consumption data. Figure 6 shows a large switch-on peak at 6AM, but with gas consumption dropping to a level similar to the average for the rest of the day by about 7:30AM. This suggests that the target temperature has been reached by 7:30AM. Schools can compare the time at which the target temperature is reached with actual opening times and adjust the switch-on time accordingly. This is sometimes called “optimum on” and may be slightly earlier for a Monday (after a weekend’s cooling off) than during the remainder of the week.

Figure 6: Daily gas use (term time weekday)

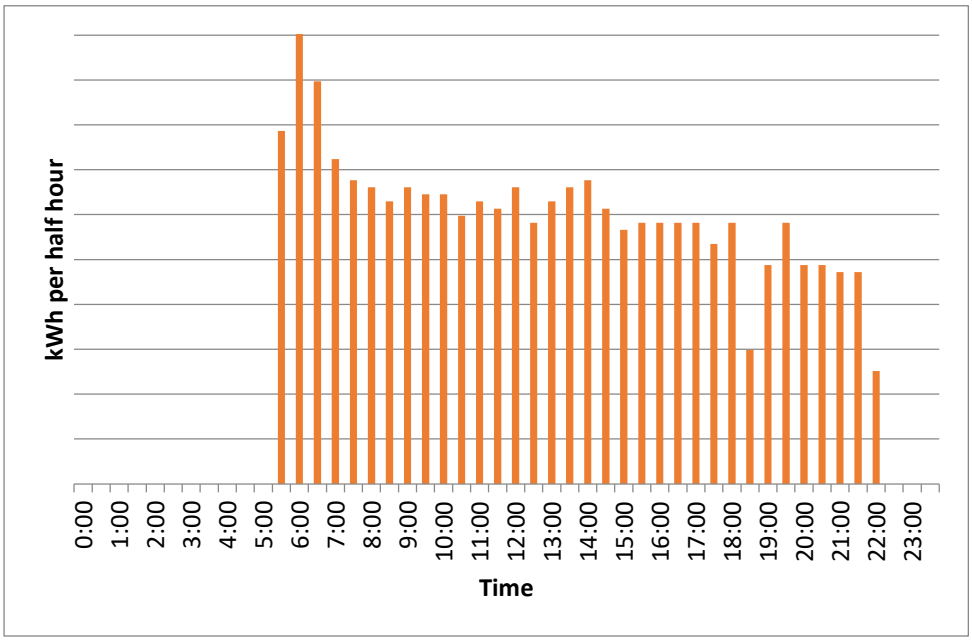
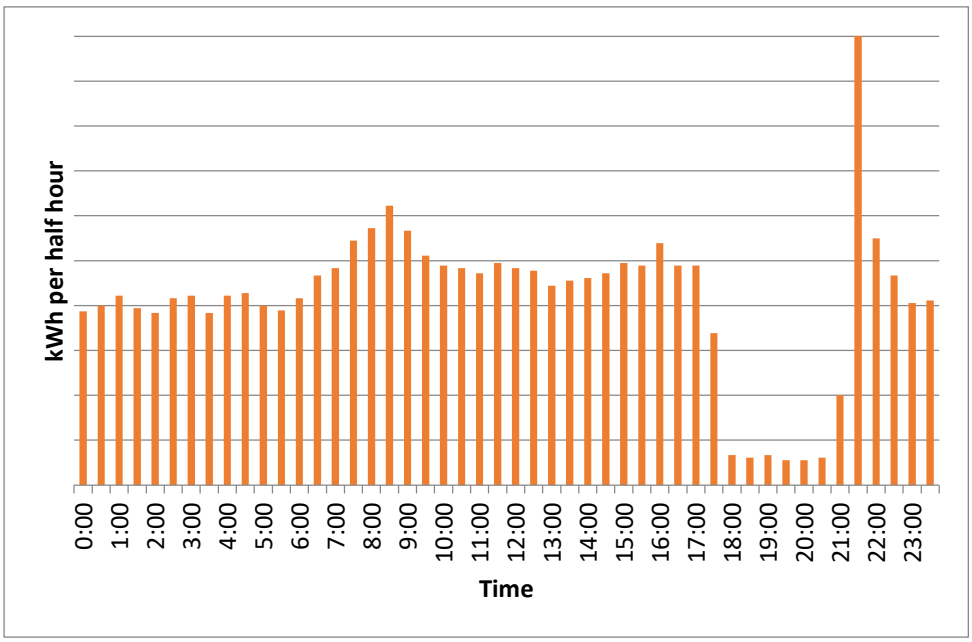


Figure 7: Daily gas use (term time weekday)



In the data for several schools, including many of schools with highest night time gas use, we observed that the heating appeared to have been left on all night, for periods ranging from a few days to several weeks. Sometimes, it seemed to be turned off or down at the end of the schools day (Figure 7) but then to come back on later in the evening and stay on all night. While this usually occurs in the winter, there is no clear correlation with particularly cold days.

We can imagine two possible explanations for this. Either the heating was turned to "continuous" for an evening event and not turned back to timer operation for some time, or perhaps the heating controller or frost thermostat is malfunctioning of incorrectly adjusted. Schools can determine if the

heating is left on all night through analysing "half-hourly" gas consumption data, or perhaps even through manual checks.

6.4 Hot water

Our analysis of the data suggests that the low-level, fairly constant summer holiday gas use often observed suggests that in many schools the hot water is left on during schools holidays. Although we estimate that this typically only represents about 2% of annual usage, it is still another opportunity to reduce gas use. Some schools in the sample used virtually no gas in August, an indication that at least in some circumstances the hot water and heating systems can both be turned completely off during the summer holidays.

Should hot water be required for staff working during holidays, a small over-sink electric hot water system may be more cost-effective than heating large tanks of water by gas for only occasional use. However schools should ensure that any changes to hot water timers or temperature do not compromise health and safety.

7. Part-occupation of buildings

Part-occupation of school buildings outside of normal school hours, for parents' evenings, concerts, and events run by other organisations using the school premises can be problematic when it comes to minimising wasted heating energy.

The problem with most of these events is that only a few rooms, perhaps a main hall or a few classrooms, are used. Ideally only these rooms should be heated, but few school heating systems we have seen provide good zone control. Where it is even possible this usually requires manually turning off thermostats or thermostatic valves in potentially a very large number of un-used rooms. This may be viable for school holidays, but can be an onerous task for evening and weekend use of school buildings.

One method which SWLEN is trialling is to replace the thermostatic radiator valve (TRV) "heads" in rooms that are not used outside of normal hours with electronically programmable units. These can be programmed to shut down the heating in these rooms outside of normal school hours, allowing the main heating to be turned on and to only heat the occupied rooms. Changing TRV "heads" does not require any changes to the plumbing system, and can probably be done by regular maintenance staff. The new programmable "heads" cost around £30 each.

8. Obtaining and working with half-hourly energy data

Obtaining half-hourly energy consumption data is not always straightforward. For this reason, we have tried to include suggestions on how some of the energy-saving opportunities highlighted in this paper can still be achieved through manual energy consumption monitoring. However, the maximum benefits will be obtained from half-hourly energy consumption data or even shorter intervals.

From April 2017, half-hourly meter readings became mandatory for larger energy consumers (with Profile Class 05-08 meters). We believe that most schools will have Profile Class 03 meters, but may be eligible for voluntary half-hourly metering.

Schools in a number of local authority areas across the UK were able to access AMR half-hourly data through a British Gas web portal in 2015 and 2016. It is not clear if this service is currently available - SWLEN was authorised to access this service for schools in Kingston but the service ceased at the end of 2016. We also believe that several energy suppliers, including Laser Energy Buying Group, may offer AMR/ half-hourly metering.

Some suppliers offer analysis tools, but we have found that these do not address the particular needs of schools, such as separate analysis of term-time and holiday energy use. SWLEN has put together an in-house spreadsheet-based analysis tool that can work with the "raw" half-hourly consumption data and produce reports tailored top school energy needs. In some cases, access to the "raw" data is less expensive than using the supplier's analysis tools.

We suggest that schools approach their energy supplier to find out what is available and at what cost. SWLEN has not been successful in obtaining sample pricing, but, from publicly available information, we believe that the cost is likely to be less than £200 per year for each energy meter.

9. SWLEN energy audits

9.1 Method

SWLEN offers schools a full energy audit. (This is a service offered by SWLEN not only to schools, but also to community centres and to individual homes.)

Our approach for schools is for the first visit to consist of a short meeting between two SWLEN energy advisors and the school's bursar or an admin staff member to explain what SWLEN needs to know, followed by a tour of the school by the premises manager. Although many classrooms may be in use, it is important to visit 1 or 2 that are unoccupied. This tour must cover each boiler room and the areas heated by them so that for the purposes of the energy audit, the school can be separated into zones each with its own heating controls. Each zone will often comprise buildings of similar construction, age and thermal efficiency and will have its own characteristics.

An infra-red (IR) camera can demonstrate where heat is being lost in a very graphic way and the colourful images will often impress staff. However the IR camera can only be used on a cold day with the heating on. From the tour, it should start to become clear where simple improvements can be made, whether by insulation, adjustment of heating timers or behaviours by occupants. For each zone, the heating timer settings should be compared with the schedule of occupancy outside school hours.

A follow up visit can be used to discuss initial findings, what may be "quick wins" and what needs further discussion. Each school visited is usually found to have a different combination of issues and some issues combine into quite difficult challenges. Examples are:

- Many staff remain working after the school day has finished and spread themselves around several zones, so that heating and lighting must be kept on for the whole school;
- Out of hours lettings may only use a few rooms or a hall but the whole school is heated and lit;

- Heating timer settings are complex to change and changes may be forbidden, because of the risk that the heating fails to come on the next day and the whole school has to close until the problem is resolved;
- Staff members are initially interested but pressure of work means they are unavailable to discuss recommendations; and
- Tampering by staff or pupils, such as adjusting radiator valves or thermostats or opening doors or windows when the heating is set too high, may nullify simple improvements.

9.2 Response to recommendations

Each school was given a list of actions with the offer of help to implement them. In many cases, no immediate action was taken because no-one had any clearly assigned responsibility for saving energy. Where larger energy saving improvements were identified, SWLEN produced rough costs, likely benefits and the payback period. SWLEN also advised that there are opportunities to apply for interest free loans from UK government sources where the loan repayments never exceed the reduction in energy costs, so that no investment by the school is needed. Again, these opportunities have not yet been pursued by the schools and a follow-up survey may identify the reasons. The feeling was that budgets are tight or being reduced and the idea of a loan, even where no investment is needed, has negative connotations.

9.3 Successful energy saving actions

We found two types of measure most likely to succeed. Firstly, simple measures which need little action by school staff are more likely to succeed, such as:

- setting heating timers to a “frost setting” on the last day of term;
- installing an electricity monitor to highlight unexpected usage in real time; and
- installing programmable radiator valves which adjust the temperature depending on occupancy.

Secondly, actions taken by SWLEN, examples are:

- Reflective radiator foil: SWLEN energy advisors visited several schools and fitted foil behind radiators on outside walls. Many schools have 50 or 100 such radiators. The average saving per radiator is £8 per year.
- Curriculum: in one school, SWLEN assisted with the introduction of energy generation and energy reduction into the curriculum of year 4 with the help of two parents. This consisted of four lessons given by school staff with practical demonstrations and one session run by the two parents.
- Reminders by SWLEN about turning off heating: one school reminded to turn the heating to a frost setting over the Xmas / New Year holiday period saved around £500.