

“One year in the Colourworks”



Arcola Theatre-Energy Report

April 2011-March 2012

April 2012

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Executive Summary

This report presents the energy profile of Arcola Theatre from March 2011 to March 2012 when it moved into the Colourworks building in Hackney. Given Arcola's commitment to environmental sustainability, many efforts have taken place to monitor and reduce energy use and carbon footprint. As expected, this first year in a new building has been characterised by many challenges in terms of data collection and energy management. Hence, in this report, several significant assumptions have been considered in order to be able to present a complete image of the theatre's energy efficiency. These assumptions are mostly concerned with the time period of water consumption metering, the exact amount of LPG consumed for heating and the amount and composition of waste produced in the theatre. As far as the CO₂e calculation is concerned, the amount of CO₂ due to the waste produced and managed has not been taken into account because of the variety in its composition.

In these terms, according to the energy monitoring over the year, the total electricity use was 71,694 kWh and LPG consumption 32,379 kWh, resulting in total energy use of 104,074 kWh. Total CO₂e emissions, taking into account the water use as well, were 41.8 tonnes. Finally, the amount of waste generated was 16.3 tonnes throughout that year.

Timeline

Since the first day when the theatre moved in the new building, many changes have been done to improve its efficiency. On that basis, and in order to be able to evaluate better the present report, it is important to present the most basic actions that took place, concerning energy and sustainability.

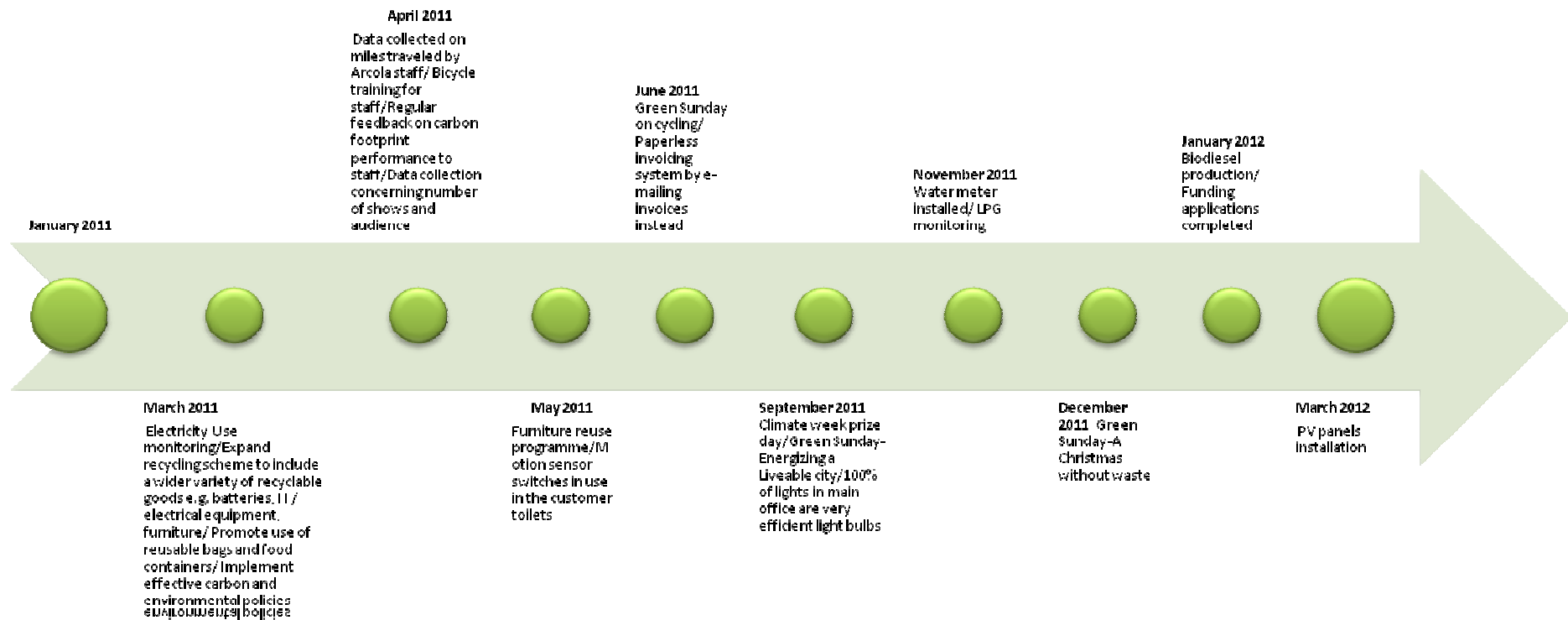


Figure 1: Timeline

The timeline above indicates that the first effort was **electricity consumption monitoring**. This task took place in three different ways, developed over the year. March 2011: meter readings from the central building meters (2 meters installed covering different areas of the building), November 2011: Current Cost monitors, monitoring electricity consumption in three areas (Bar, Offices, Front of House), December 2011: meter readings from Wattson meter which monitors the electricity consumption of one of the two central meters all the time. Regarding metering water use, a **water meter** was installed in November 2011. The data collected is partial and significant assumptions have to be considered to estimate the total amount of water used during that year. The monitoring of the energy used to meet the theatre's heating demand, started on November 2011, collecting data on the **LPG** consumed. The LPG was supplied in canisters containing 25Kg LPG each, and the data collection on that contains a significant percentage of uncertainty.

Apart from energy monitoring, significant initiatives concerning the promotion of sustainable energy and environmental sustainability took place including staff training on sustainability and behavioural change and Green Sundays where the theatre's audience was informed about clean energy, recycling, environmental activism, cycling and local environmental initiatives.

Electricity

Arcola's energy use in terms of electricity during the first year in Colourworks is presented in Table 1 and demonstrated in Figure 1.

| Ending Week | Electricity (kWh) | CO ₂ e (kg) | Cost (£) |
|--------------|-------------------|---------------------------------|---------------|
| 19/03/2012 | 1,368 | 659 | 163 |
| 12/03/2012 | 1,350 | 650 | 161 |
| 05/03/2012 | 1,380 | 664 | 164 |
| 27/02/2012 | 1,397 | 673 | 167 |
| 20/02/2012 | 1,507 | 726 | 180 |
| 13/02/2012 | 1,724 | 830 | 206 |
| 06/02/2012 | 1,886 | 908 | 225 |
| 30/01/2012 | 1,838 | 885 | 219 |
| 23/01/2012 | 1,827 | 880 | 218 |
| 16/01/2012 | 1,666 | 802 | 199 |
| 09/01/2012 | 826 | 398 | 99 |
| 02/01/2012 | 826 | 398 | 99 |
| 26/12/2011 | 826 | 398 | 99 |
| 19/12/2011 | 1,670 | 804 | 199 |
| 12/12/2011 | 1,879 | 905 | 224 |
| 05/12/2011 | 1,725 | 831 | 206 |
| 28/11/2011 | 1,814 | 873 | 216 |
| 21/11/2011 | 1,339 | 645 | 160 |
| 14/11/2011 | 1,621 | 781 | 193 |
| 07/11/2011 | 1,188 | 572 | 142 |
| 31/10/2011 | 1,325 | 638 | 158 |
| 24/10/2011 | 1,461 | 703 | 174 |
| 17/10/2011 | 1,037 | 500 | 124 |
| 10/10/2011 | 1,037 | 500 | 124 |
| 03/10/2011 | 1,438 | 692 | 171 |
| 26/09/2011 | 1,498 | 721 | 179 |
| 19/09/2011 | 1,567 | 754 | 187 |
| 12/09/2011 | 1,340 | 645 | 160 |
| 05/09/2011 | 1,251 | 602 | 149 |
| 29/08/2011 | 949 | 457 | 113 |
| 22/08/2011 | 1,133 | 545 | 135 |
| 15/08/2011 | 1,214 | 585 | 145 |
| 08/08/2011 | 1,064 | 512 | 127 |
| 01/08/2011 | 1,173 | 565 | 140 |
| 25/07/2011 | 1,257 | 605 | 150 |
| 18/07/2011 | 1,293 | 623 | 154 |
| 11/07/2011 | 1,559 | 751 | 186 |
| 04/07/2011 | 1,221 | 588 | 146 |
| 27/06/2011 | 1,151 | 554 | 137 |
| 20/06/2011 | 1,324 | 637 | 158 |
| 13/06/2011 | 1,497 | 721 | 178 |
| 06/06/2011 | 1,238 | 596 | 148 |
| 30/05/2011 | 1,272 | 613 | 152 |
| 23/05/2011 | 1,305 | 628 | 156 |
| 16/05/2011 | 1,278 | 615 | 152 |
| 09/05/2011 | 1,310 | 631 | 156 |
| 02/05/2011 | 1,340 | 645 | 160 |
| 25/04/2011 | 867 | 418 | 103 |
| 18/04/2011 | 1,444 | 695 | 172 |
| 11/04/2011 | 1,140 | 549 | 136 |
| 04/04/2011 | 1,212 | 584 | 144 |
| 28/03/2011 | 1,272 | 612 | 152 |
| 21/03/2011 | 1,569 | 756 | 187 |
| Total | 71,695 kWh | 34,521 kg CO₂ | £8,546 |

Table 1: Electricity use/CO₂ emissions/Cost

Note: The data concerning CO₂ emissions and cost has been provided by www.smeasure.co.uk, where the electricity use readings have been uploaded.

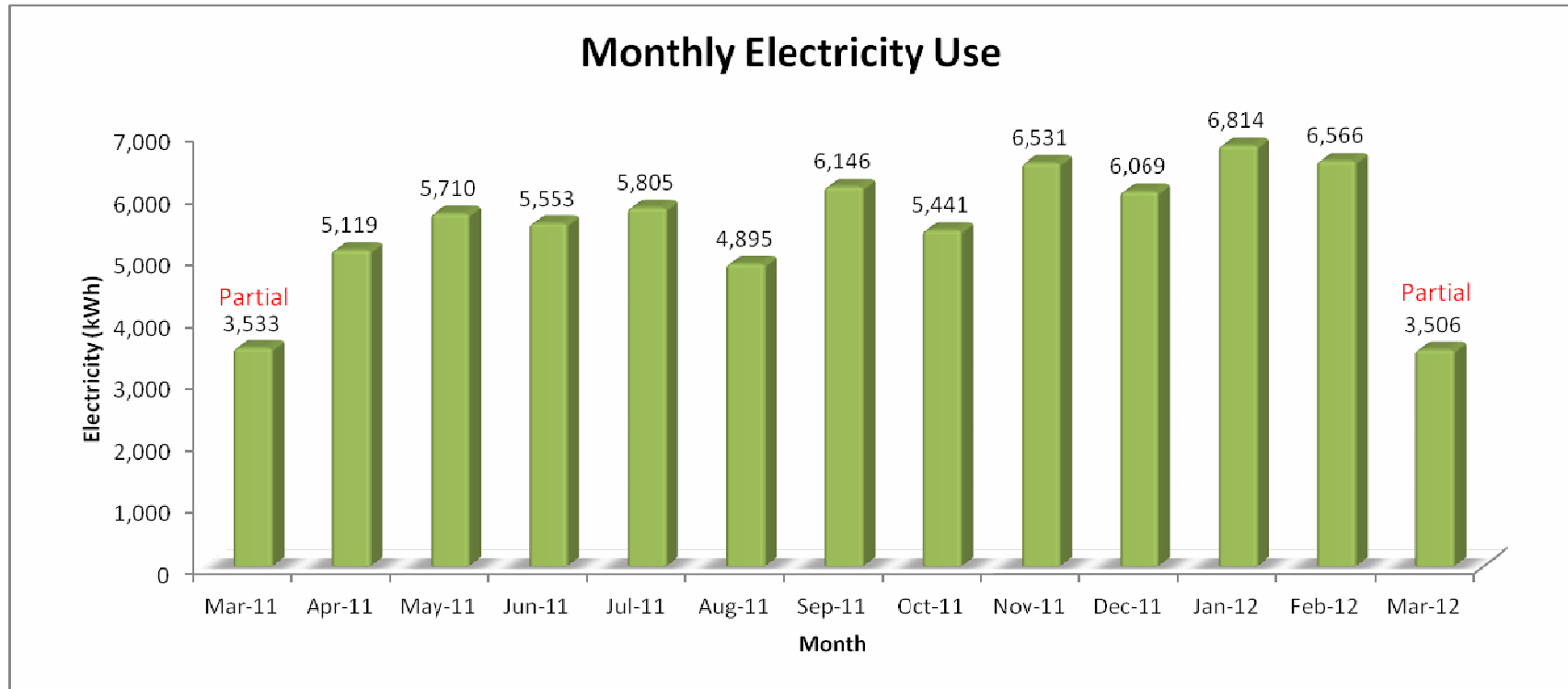


Figure 2: Monthly Electricity Use Graph

A high electricity use can be noted during November, December, January and February. The highest value occurs during February 2012, but with a very small difference between December and January whilst the lowest occurred on August 2011. The average electricity use per week has been 1,353kWh whilst the average monthly consumption 5,409 kWh.

Based on the data above, the total annual electricity use is **71,695 kWh** whilst the corresponding cost is **£8,546** and the relevant CO₂ e emissions are **34.52 tonnes**.

Tim Atkinson conducted an energy analysis as part of the Ecovenue project, using a Wattson electricity meter. This found that the base load during the Christmas period when the theatre was closed was 250 Watts for the areas covered by the Arcola meter 1 and 450 Watts for the areas covered by the Arcola meter 2 (areas covered by different meters are detailed in the Appendix). Hence, the total building's total base load has been 700 Watts. Whilst the base load of meter 1 is sufficiently low, the base load of meter 2 has to be researched to identify the reasons for that high value. Possible reasons according to the Tim's report might be pre-heat for dimmers, static lighting load or intruder/fire systems monitoring equipment.

The results of the electricity monitoring using the current cost monitors are demonstrated in the graph below. It demonstrates the results of one month electricity monitoring for three parts of our building: the Bar, the Office and the Front of House. It can be noticed that the highest consumption takes place in the bar, which is normal since fridges are in operation there. The Front of House (FOH) is characterised by low electricity consumption, and one of the main reasons is the LED Lighting that is in use there. The office's consumption has to do mainly with the electrical appliances and the electric heaters that are used during the winter. The average electricity usage in these areas is approximately 111kWh/day.

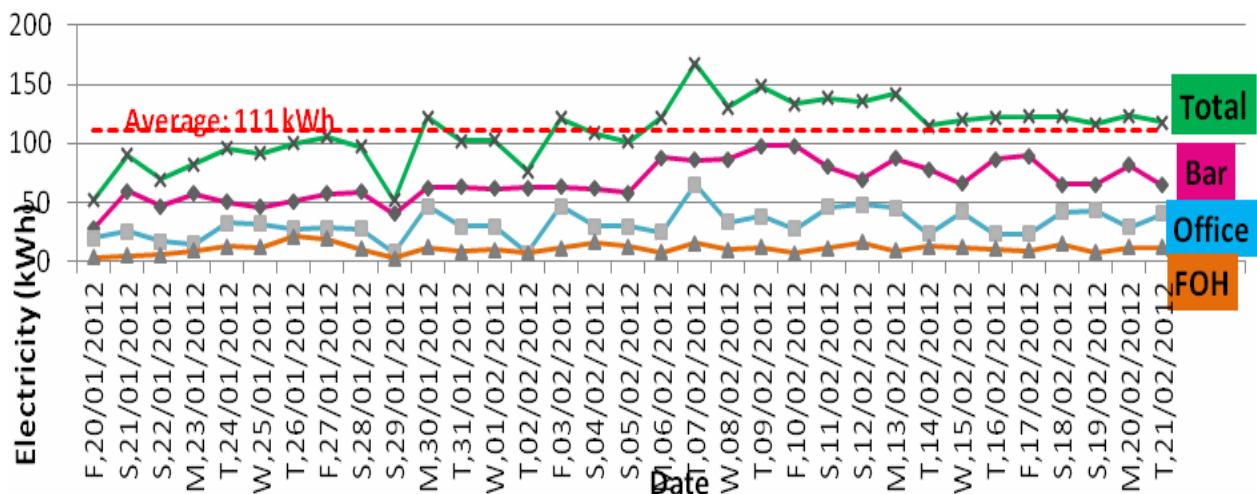


Figure 3: Energy Monitoring (Office-Bar-FoH)

Heating

The calculation of the energy used for heating is a difficult task for this building, at least at the moment, since there is no central heating. The heating demand is covered by electric and LPG (Liquefied Petroleum Gas) heaters. However, there is a significant lack of data on the amount of LPG used every month and the operating hours of electric heaters. For the purpose of this report, the results of the energy consumed for heating are based on significant assumptions.

Note: Due to the electric heaters operating in the building, a percentage of the energy needed for heating reasons has been covered by them. However, since there is no monitoring data for their operation, it has been assumed that for heating only the LPG heaters have been taken into account. The electricity used from the electric heaters has been included in the total electricity use, but it is not feasible to determine exactly their percentage.

Heating Degree Days

In order to estimate the energy consumed for heating demand, it is important to present the Heating Degree Days (HDD) for London. "*Heating degree days*", or "*HDD*", are a measure of how much (in degrees), and for how long (in days), outside air temperature was *lower* than a specific "*base temperature*" (or "*balance point*"). They are used for calculations relating to the energy consumption required to *heat* buildings." ¹ This data has been retrieved from RETScreen software where the weather data has been provided by NASA. In the following table the HDD for the period examined are presented.

| London Heating Degree Days (Base Temperature 16°C) | |
|--|--------------|
| Mar-11 | 287 |
| Apr-11 | 112 |
| May-11 | 96 |
| Jun-11 | 40 |
| Jul-11 | 8 |
| Aug-11 | 10 |
| Sep-11 | 21 |
| Oct-11 | 94 |
| Nov-11 | 169 |
| Dec-11 | 302 |
| Jan-12 | 319 |
| Feb-12 | 363 |
| Mar-12 | 246 |
| Annual Total | 2,067 |

Table 2: London Heating Degree Days

¹ <http://www.degreedays.net>

LPG consumption data is available only for three months (November 2011, December 2011 and January 2012). Based on this data and the HDD, the amount of LPG consumed potentially throughout the year will be calculated through a regression analysis, assuming that the LPG consumption and the HDD are proportional.

The regression analysis resulted to the equation $y = 1.1352x$, where y the LPG amount in kg and x the HDD.

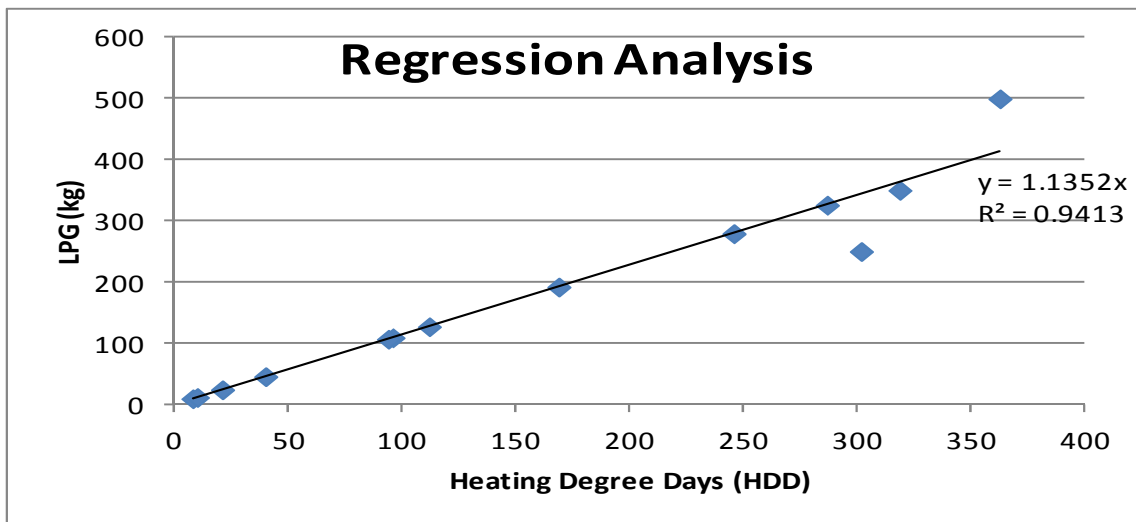


Figure 4: Regression Analysis (Heating)

The results are presented in Table 3.

| Month | HDD | LPG (kg) | Energy (kWh) | CO2e (kg) |
|--------------|--------------|--------------|---------------|--------------|
| Mar-11 | 287 | 326 | 4,529 | 972 |
| Apr-11 | 112 | 127 | 1,767 | 379 |
| May-11 | 96 | 109 | 1,515 | 325 |
| Jun-11 | 40 | 45 | 631 | 136 |
| Jul-11 | 8 | 9 | 126 | 27 |
| Aug-11 | 10 | 11 | 158 | 34 |
| Sep-11 | 21 | 24 | 331 | 71 |
| Oct-11 | 94 | 107 | 1,483 | 318 |
| Nov-11 | 169 | 192 | 2,667 | 573 |
| Dec-11 | 302 | 250 | 3,475 | 746 |
| Jan-12 | 319 | 350 | 4,865 | 1,045 |
| Feb-12 | 363 | 500 | 6,950 | 1,492 |
| Mar-12 | 246 | 279 | 3,882 | 833 |
| Total | 2,067 | 2,329 | 32,379 | 6,952 |

Table 3: LPG consumption

As demonstrated in the Table above, the amount of LPG that has been consumed through the year, based on significant assumptions, is **2,329 kg**, (equivalent to 93 bottles) which in terms of energy is **32,379 kWh** and CO₂e is **6,952 kg**.

Note: Conversion factor LPG 1.1352 and CO₂e 0.2147 ²

Water

The Colourworks building did not have a water meter when Arcola theatre moved in and data concerning the water consumption was based on a rough estimation. A water meter provided by Thames Water was installed in November 2011 providing accurate readings. The estimated water consumption before the meter installation was 575m³ per month. After the water meter installation, the readings were around 113m³. Hence, by assuming that the monthly water consumption has been 113m³, the total water consumption for one year is approximately 1,356m³. The CO₂ emissions corresponding to the amount of water consumed, is **374kgCO₂e**, using a conversion factor of 0.276kgCO₂/m³ provided from DEFRA and it incorporates the full life cycle.

Waste

As far as the waste produced is concerned, Arcola theatre has managed to prevent its transfer to landfill, by promoting recycling and energy from waste procedures. More particularly, the average amount of waste produced per month was 1,356 kg. From this amount, 800kg of waste went to energy from waste plant; 520 kg of general waste was sent for recycling and 36 kg for composting. Based on the numbers above, the total amount of waste during that year was 16.3 tonnes approximately, considering 12 months.

² <http://www.carbontrust.com/resources/reports/advice/conversion-factors>

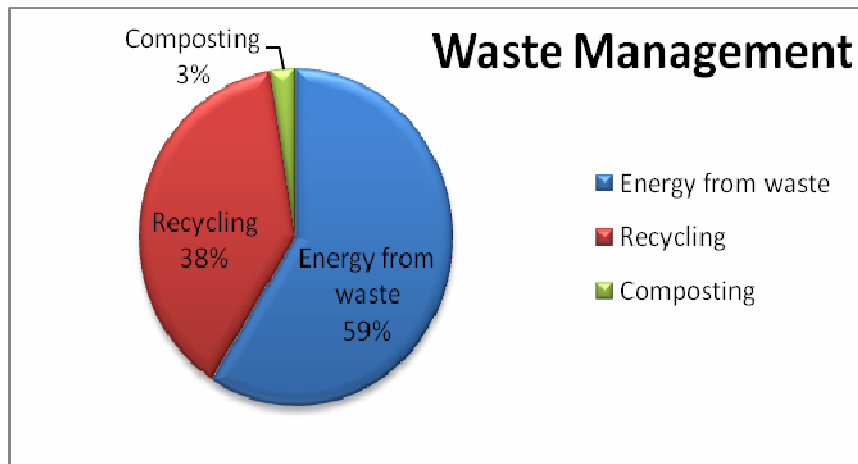


Figure 5: Waste Management

Conclusion

The theatre's total energy use (including electricity and heating) during this first year in the Colourworks has been 104,074 kWh. Electricity's contribution to this amount of energy has been 68.9% whilst heating 31.1%.

| | Electricity | LPG | Total |
|-------------------------------------|-------------|----------------------|---------|
| Annual Energy Use (kWh) | 71,695 | 32,379 | 104,074 |
| Annual Energy Cost (£) | 8,546 | 2,790 | 11,336 |
| Unit Cost | £0.012/kWh | £30/25kg canister | |
| kWh/m² floor area | 68.7 | 31.04 | 99.74 |

Table 4: Total Energy Use and Cost

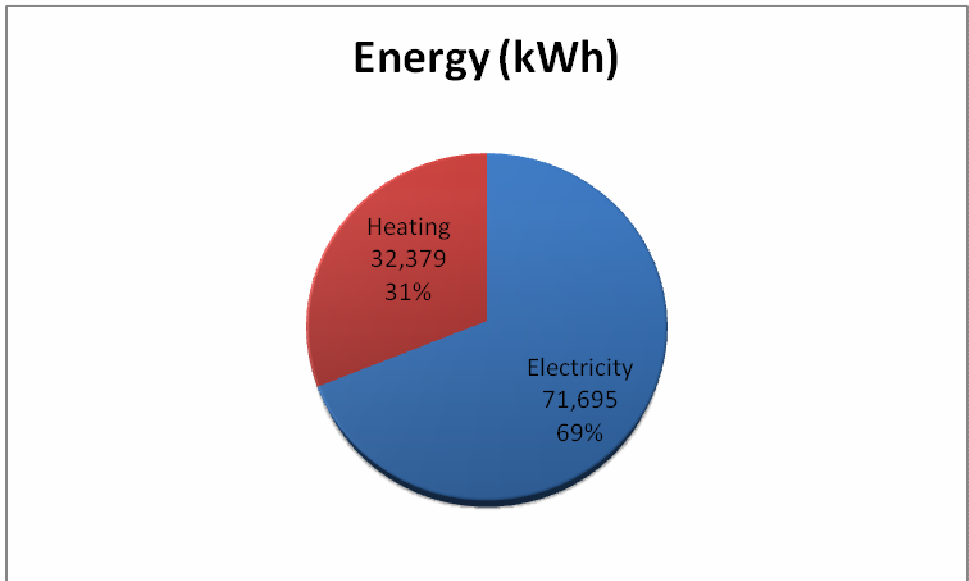


Figure 6: Total energy use

In terms of CO₂ emissions, the total equivalent amount has been 41.8 tonnes.

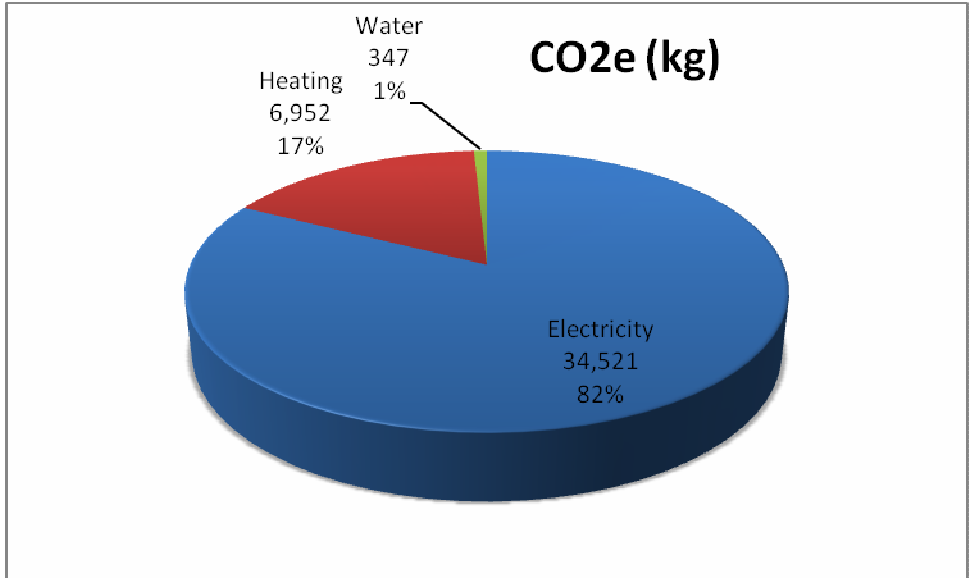


Figure 7: Total CO₂e emissions

The theatre’s target is to reduce its carbon footprint by 10% in 2012. Towards that aim, Arcola theatre has begun to apply significant changes to the building, beginning with the installation of 6.44kWp PV panels on its roof, providing clean electricity of 4,796 kWh per year. That means that a percentage of 6.7% of the electricity provided by the grid in the previous year will be replaced by

green electricity provided by the PV panels. The corresponding CO₂ savings will be 2,302 kg CO₂e (5.51%).

Moreover, according to a thermal modelling report conducted by Paola Valencia, the main heat loss for the building occurs in the following order:

- Walls
- Infiltration
- Windows
- Roofs

Based on these results, the author proposed the following suggestion: “Double glazing in windows + 0.2 ac/h infiltration+ insulation in external walls (50mm. Polyurethane)+ insulated roof 75mmPUR)= double glazing in roof” which could lead to 45.4% savings to heating demand, equivalent to energy savings of 14,700kWh (14.12%) and 3,156kg CO₂e (7.5%).

The total CO₂ reduction, as a result of the suggestions above, will be 12.5% in a year.

APPENDIX

The meter readings presented in Table 1 have been retrieved by the building’s electricity meters. The building has two meters where each one covers a different part of the building. The areas covered by each meter are presented in the following Table.

| | Fuses on Arcola Meter 1 | Fuses on Arcola Meter 2 |
|----|--------------------------|---|
| 1 | 32a Studio 1 Socket (10) | - |
| 2 | 16a Studio 1 Socket (11) | - |
| 3 | 16a Studio 1 Socket (12) | - |
| 4 | Studio 1 Extractor | - |
| 5 | 32a Studio 1 Socket(8) | - |
| 6 | 32a Studio 1 Socket(7) | Bar |
| 7 | Studio 1 Lights Back | - |
| 8 | Studio 1 Lights Front | Studio 3 Emergency |
| 9 | 16a Studio 1 Socket (10) | Energy Lab |
| 10 | 16a Studio 1 Socket (9) | Studio 3 Sockets |
| 11 | 16a Studio 1 Socket (8) | 1 st Floor Hall Lights (nr lift) |
| 12 | 16a Studio 1 Socket (7) | Toilets/Basement |
| 13 | 16a Studio 1 Socket (6) | Fire Alarm |
| 14 | 16a Studio 1 Socket (5) | Studio 2 Working Lights and Disabled |
| 15 | 16a Studio 1 Socket (4) | - |
| 16 | 16a Studio 1 Socket (3) | Studio 2 Sockets Ceiling |
| 17 | 16a Studio 1 Socket (2) | - |
| 18 | 16a Studio 1 Socket (1) | FOH |
| 19 | 32a Studio 1 Socket(16) | Studio 1 Heater Sockets |

| | | |
|----|------------------------|------------------------------------|
| 20 | 32a Studio 1 Socket(5) | - |
| 21 | 32a Studio 1 Socket(4) | Studio 2 Control Sockets and Light |
| 22 | 32a Studio 1 Socket(3) | Office Sockets |
| 23 | 32a Studio 1 Socket(2) | Studio 1 Dressing Room Lights |
| 24 | 32a Studio 1 Socket(1) | Bar Dishwasher |
| 25 | - | - |
| 26 | - | - |
| 27 | - | - |
| 28 | - | Studio 2 Dimmer 1 |
| 29 | - | Studio 2 Dimmer 1 |
| 30 | - | Studio 2 Dimmer 1 |
| 31 | - | Studio 2 Dimmer 3 |
| 32 | - | Studio 2 Dimmer 3 |
| 33 | - | Studio 2 Dimmer 3 |
| 34 | Studio 1 | Studio 3 Dimmer 2 |
| 35 | Studio 1 | Studio 2 Dimmer 2 |
| 36 | Studio 1 | Studio 2 Dimmer 2 |
| 37 | Studio 1 Dimmer 8 | Studio 2 Dimmer 4 |
| 38 | Studio 1 Dimmer 8 | Studio 2 Dimmer 4 |
| 39 | Studio 1 Dimmer 8 | Studio 2 Dimmer 4 |
| 40 | Studio 1 Dimmer 7 | Studio 1 Dimmer 3 |
| 41 | Studio 1 Dimmer 7 | Studio 1 Dimmer 3 |
| 42 | Studio 1 Dimmer 7 | Studio 1 Dimmer 3 |
| 43 | Studio 1 Dimmer 6 | Studio 1 Dimmer 2 |
| 44 | Studio 1 Dimmer 6 | Studio 1 Dimmer 2 |
| 45 | Studio 1 Dimmer 6 | Studio 1 Dimmer 2 |
| 46 | Studio 1 Dimmer 5 | Studio 1 Dimmer 1 |
| 47 | Studio 1 Dimmer 5 | Studio 1 Dimmer 1 |
| 48 | Studio 1 Dimmer 5 | Studio 1 Dimmer 1 |

The detailed data concerning the two different meters are presented in the Table below.

| Week | Arcola Meter 1 (kWh) | Arcola Meter 2 (kWh) |
|--------------|----------------------|----------------------|
| 19/03/2012 | 161 | 1,207 |
| 12/03/2012 | 130 | 1,220 |
| 05/03/2012 | 183 | 1,197 |
| 27/02/2012 | 147 | 1,250 |
| 20/02/2012 | 157 | 1,350 |
| 13/02/2012 | 136 | 1,588 |
| 06/02/2012 | 193 | 1,693 |
| 30/01/2012 | 252 | 1,586 |
| 23/01/2012 | 159 | 1,668 |
| 16/01/2012 | 190.17 | 1,475.83 |
| 09/01/2012 | 96.67 | 729.7 |
| 02/01/2012 | 96.67 | 729.7 |
| 26/12/2011 | 96.67 | 729.7 |
| 19/12/2011 | 242 | 1,428 |
| 12/12/2011 | 268 | 1,611 |
| 05/12/2011 | 314 | 1,411 |
| 28/11/2011 | 379.3 | 1,434.3 |
| 21/11/2011 | 192.7 | 1,146.7 |
| 14/11/2011 | 184 | 1,437 |
| 07/11/2011 | 163 | 1,025 |
| 31/10/2011 | 176 | 1,149 |
| 24/10/2011 | 242 | 1,219 |
| 17/10/2011 | 177.92 | 859.57 |
| 10/10/2011 | 177.92 | 859.57 |
| 03/10/2011 | 389.11 | 1,049.04 |
| 26/09/2011 | 376.4 | 1,121.2 |
| 19/09/2011 | 384.4 | 1,182.3 |
| 12/09/2011 | 295 | 1,045.2 |
| 05/09/2011 | 319.5 | 931.5 |
| 29/08/2011 | 263.43 | 685.07 |
| 22/08/2011 | 277.38 | 855.31 |
| 15/08/2011 | 286.77 | 927.27 |
| 08/08/2011 | 177.4 | 886.8 |
| 01/08/2011 | 169.66 | 1,002.84 |
| 25/07/2011 | 220.6 | 1,036.1 |
| 18/07/2011 | 308.6 | 984.7 |
| 11/07/2011 | 365.17 | 1,193.97 |
| 04/07/2011 | 257.51 | 963.81 |
| 27/06/2011 | 289.4 | 861.7 |
| 20/06/2011 | 329.5 | 994 |
| 13/06/2011 | 392.7 | 1,104.5 |
| 06/06/2011 | 234.2 | 1,003.8 |
| 30/05/2011 | 168.1 | 1,104.2 |
| 23/05/2011 | 181.4 | 1,123.7 |
| 16/05/2011 | 156.8 | 1,121.3 |
| 09/05/2011 | 179.4 | 1,130.7 |
| 02/05/2011 | 219 | 1,120.9 |
| 25/04/2011 | 110.6 | 756.5 |
| 18/04/2011 | 156 | 1,288.1 |
| 11/04/2011 | 132.2 | 1,007.9 |
| 04/04/2011 | 114.8 | 1,097.1 |
| 28/03/2011 | 119 | 1,153 |
| 21/03/2011 | 156.1 | 1,413.3 |
| Total | 11,545.15 | 60,149.88 |