




Statistical Report on the Logicator Green Plug Trial

Report for Logicator Ltd prepared by Prof M.J. Crowder

13th January 2011



Introduction

The Green Plug is an innovative energy saving device pioneered by Logicor's research and development team. Logicor is developing a range of technologies that will help home owners and businesses to save money and reduce their carbon footprint. Logicor has already secured a number of worldwide patents and these ground-breaking concepts are anticipated to reach the market soon.

The Green Plug is powered by a novel air-driven timer that is easy to start and automatically switches off appliances to which it is connected after a predetermined time. This ensures that appliances in the home and office never again waste energy by being left turned on accidentally or placed on standby.

In 2010, a study by Professor Martin Crowder of Imperial College, found that on average wasted energy is costing UK households £365 per year. The energy saving Green Plug is precisely designed to minimise this cost and ultimately benefit the energy bill payer.

This report documents the findings about Logicor's Green Plug from the analysis of raw data generated in the sixty-eight house trial in West Yorkshire. The findings from the trial include:

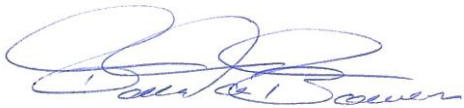
- The largest reduction of electricity consumption was achieved by attaching the Green Plug to printers. This obtained a 92.5% reduction in the amount of electricity this appliance used.
- The electricity consumption of game stations and TV's were reduced by 58% and 53% respectively after fitting a Green Plug to the appliances.
- The trial found that on average the Green Plug reduces the electricity consumption of appliances by 41%. If this energy saving technology is effectively installed in households this will reduce the electricity bill by up to £200.
- Data analysis of the results showed a statistically 'significant' reduction in the electricity consumption for nine appliances in the trial.
- The Green Plug can save over £20 when attached to four different electrical appliances. Larger household electrical appliances and the continuing rise in electricity bills will lead to even greater savings.

Logicor Green Plug trial

The Green Plug trial showed that this small device can make large electricity savings to help homeowners cut their electricity bills. The large sample size of the trial which included 415 household appliances ensures that these findings have not occurred by chance and represent real savings.

Fuel poverty has risen sharply over the last decade and around 4 million households are currently in fuel poverty (Annual report on fuel poverty statistics 2010 DECC). To help the UK reach its target of eradicating fuel poverty 'as far as reasonably practical' by 2016, devices such as the Green Plug will have an important role to play in the future. Coupled with this is the UK's legally binding carbon targets and many people's own desire to reduce their own carbon footprint. Saving electricity helps to reduce carbon dioxide emissions since 74% of electricity generated in the UK comes from power plants that burn fossil fuels and release greenhouse gases (DECC - Fuel mix disclosure data).

The Yorkshire trial of the Green Plug is a significant milestone in the development of this energy saving device. We are delighted that Professor Martin Crowder of Imperial College has been able to provide an independent statistical analysis of the results and these can be found below.



David Bowen
Managing Director, Logicor

The logo for Logicor, featuring the word "logicor" in a bold, black, sans-serif font. The letters "l", "o", and "i" are lowercase, while "g", "i", "c", "o", and "r" are uppercase. The logo is set against a yellow background that is split into two horizontal bars, one above and one below the text.

Logicor's Green Plug Trial

Logicor have developed an easy-to-use 'Green Plug' that switches off electrical appliances after a pre-set time. The rationale is that appliances are often left switched on when not in use, thus unintentionally wasting energy. The extent of such wastage has been assessed in an earlier survey commissioned by Logicor. The subject of this report is the West Yorkshire trial of Logicor's Green Plug device and a 'sister-product' of the Green Plug, the Green Adaptor, that differs only in the way the device is attached to the appliance. For the purpose of this trial, the Green Adaptor and Green Plug are referred to collectively as the 'Green Plug'.

In total, sixty-four households agreed to participate in the trial, in which ten different electrical appliances were monitored. In the run-in phase, that lasted four weeks, normal use was recorded as a baseline. In the following, experimental phase, also of four weeks, green plugs were fitted to the 10 appliances. Detailed round-the-clock automated records were compiled for each appliance of the times of switching on and off. For the purpose of the statistical analysis described below this data has been simplified to total weekly usage. So, for each household and each appliance, there are four totals of usage in the run-in phase plus four totals of usage in the experimental phase. Separate trials due to take place in 2011 will include an 'all appliances in the home trial' in addition to the ten appliances from this trial listed in the following table.

Summary results

	1	2	3	4	5	6
Lamp	50	0.94	0.56	40.2	19.8	10.7
Game station	34	1.18	0.49	58	35.9	19.5
Iron	51	0.8	0.66	17.3	7.3	4.0
Microwave	48	1.5	0.97	35.4	27.6	15.0
Mobile phone	58	0.03	0.02	26.4	0.5	0.3
PC screen	28	1.43	0.94	33.9	25.5	13.9
Printer	31	0.4	0.03	92.5	19.2	10.5
Hair appliance	41	0.07	0.05	26.7	1.0	0.6
Laptop	40	1.14	0.84	25.6	15.6	8.5
Bedroom TV	34	1.37	0.63	53.6	38.5	20.9

Key to table

1 Number of appliances tested

2 Electricity usage by appliances without the plug (kWh/pw)

3 Electricity usage by appliances with the plug (kWh/pw)

4 Electricity usage saving (%)

The electricity usage saving (4) are the percentage savings, e.g. For the lamp: $100 \times (0.94 - 0.56) / 0.94 = 40.2$ (subject to rounding).

5 Actual electricity saving (kWh/pa)

Figures given represent the difference between Column 2 and Column 3, multiplied by 52 for the annual figure.

6 Carbon saving (kgCO₂/pa)

The amount of CO₂ in kg that the Green Plug saves each year. Calculated using the Carbon Trust conversion factor of 0.544 kgCO₂/kWh

The largest percentage, 92.5%, suggests that printers do tend to be left switched on for substantial periods when not in use. This leads to a high amount of ‘electricity leakage’ which raises electricity bills and associated carbon emissions. In the table above the iron has the least saving, at 17.3%. This implies that irons tend not to be left switched on and unattended so much.

The average of column four is 41%. This shows that for all ten appliances listed in the left-hand column of the table, the average electricity saving achieved is 41%.

The finding that fitting just four plugs can make over £20 savings comes from applying the current average price of electricity 12.5p to the Actual electricity saving of four typical household appliances. These include a TV, game station, PC screen and microwave.

The reduction of electricity bills by up to £200 is obtained through applying the 41% average saving made by the Green Plug on household electrical appliances to the £520 average electricity bill in Dec 2010 (Ofgem – Electricity and Gas Market Report Nov 2010).

Appendix: detailed computations

Listed below are the results from running several statistical programs on the data generated from each appliance used in the trial. The format has been left exactly as output by the program (using the R statistical language), in spite of the unnecessarily large number of decimal places.

For each appliance the mean usages are listed for the four weeks in each phase: phase 1 comprises the four-week run-in, baseline period; phase 2 is the four-week experimental period. The main interest here is in the per cent reduction figure, reproduced in the table above. For a formal assessment of the statistical significance of the reduction a paired t-test has been performed. At the end of the line headed 'test on paired differences' appears 'pval'. This is the p-value for the test: it represents the probability of seeing a reduction as large as the one that happens to have occurred in the sample data when there is really no real reduction in the wider population. Thus, the smaller the p-value is, the more unlikely to see such a reduction in the sample. So, arguing inversely, if the p-value is very small, doubt is cast on the 'no-real-reduction' hypothesis. All but one of the p-values listed below are extremely small, so the evidence points strongly towards the reductions' being 'real'. The exception is that for appliance 4 which, at 0.025, is not overwhelmingly convincing: 0.025 means that such a sample reduction could occur once in 40 trials -- a sceptic could argue that the observed reduction was the 1 in 40 chance result. (On a technical point, the validity of the t-test depends on the distribution of the paired differences being normal. However, even with departures from this ideal, the marginal adjustments to the p-values listed below would not seriously affect the interpretation.)

It is possible that the members of a household, conscious of being under observation, might behave other than in their normal fashion. In the present context this might take the form of being more-than-usually conscientious about switching appliances off after use during phase 1; such a change of behaviour would have less effect during phase 2. So, the net result would be to decrease the observed usage reductions. It is difficult to assess this since the households were not observed without their knowledge. Perhaps, if there is such a self-conscious effect, it might wear off during phase 1. If so, an increase in usage over the four weeks of phase 1 should be observed. This is the subject of 'trends' in the lists below. The differences between weeks 1 and 2, between weeks 2 and 3, and between weeks 3 and 4, were subjected to a statistical test similar to the paired t-test described above; for completeness the results for phase 2 are also given, so there are 6 differences to be assessed. The results for the means, etc., are listed but suffice it to say that firm evidence of an effect is not forthcoming -- the p-values are not small so the observed differences between successive weeks could well have arisen by chance.

Numerical summaries

appliance 1 n2= 50

means

phase 1: 0.881456 0.804806 1.023104 1.063092 average 0.9431145

phase 2: 0.600586 0.494942 0.560952 0.601188 average 0.564417

per cent reduction: 40.15393

test on paired differences: mean,std,zval,pval 0.3786975 0.7099191 3.771973 0.0002184771

trends

av-diffs: -0.07665 0.218298 0.039988 -0.105644 0.06601 0.040236

sd-diffs: 0.7975445 0.7979437 0.6720747 0.6760446 0.5463244 0.3449078

zd: -0.6795826 1.934472 0.4207238 -1.104980 0.8543663 0.8248914

pvals: 0.7500166 0.02941995 0.3378982 0.8627178 0.1985300 0.2067155

appliance 2 n2= 34

means

phase 1: 0.9964588 1.107941 1.489921 1.118141 average 1.178115

phase 2: 0.5153529 0.4258059 0.6140647 0.4226088 average 0.4944581

per cent reduction: 58.02974

test on paired differences: mean,std,zval,pval 0.6836574 1.150368 3.465302 0.0007448781

trends

av-diffs: 0.1114824 0.3819794 -0.3717794 -0.08954706 0.1882588 -0.1914559

sd-diffs: 0.9760418 1.426913 1.255979 0.62319 0.8247677 0.6051802

zd: 0.6660045 1.560924 -1.726007 -0.8378578 1.330954 -1.84469

pvals: 0.2550187 0.06404083 0.9531503 0.7959309 0.09616358 0.9629627

appliance 3 n2= 51

means

phase 1: 0.727698 0.7970216 0.8980255 0.7844569 average 0.8018005

phase 2: 0.6777627 0.7851647 0.6070275 0.5825373 average 0.663123

per cent reduction: 17.29576

test on paired differences: mean,std,zval,pval 0.1386775 0.3095619 3.199215 0.001196727

trends

av-diffs: 0.06932353 0.1010039 -0.1135686 0.1074020 -0.1781373 -0.02449020

sd-diffs: 0.7929986 0.7639156 0.8729088 0.7772428 0.7457607 0.757979

zd: 0.6243 0.9442303 -0.929126 0.986826 -1.705848 -0.2307385

pvals: 0.2676345 0.1747963 0.821356 0.1642397 0.952879 0.5907703

Logicor Green Plug trial

appliance 4 n2= 48

means

phase 1: 1.486913 1.517604 1.470179 1.528152 average 1.500712

phase 2: 0.9325542 0.9942562 1.043335 0.9102562 average 0.9701005

per cent reduction: 35.35731

test on paired differences: mean,std,zval,pval 0.5306115 1.832051 2.006595 0.0252826

trends

av-diffs: 0.03069167 -0.047425 0.05797292 0.06170208 0.04907917 -0.1330792

sd-diffs: 0.4290198 0.6964303 0.5947795 0.9389112 0.9136781 0.7490856

zd: 0.4956371 -0.4717917 0.6752892 0.4552982 0.3721556 -1.230833

pvals: 0.3112301 0.6803707 0.2514005 0.3254956 0.3557249 0.8877453

appliance 5 n2= 58

means

phase 1: 0.03176379 0.02344655 0.02453448 0.02132414 average 0.02526724

phase 2: 0.01765172 0.02072586 0.01820172 0.01780517 average 0.01859612

per cent reduction: 26.40225

test on paired differences: mean,std,zval,pval 0.006671121 0.01571535 3.232874 0.001019699

trends

av-diffs: -0.008317241 0.001087931 -0.003210345 0.003074138 -0.002524138 -0.0003965517

sd-diffs: 0.03258364 0.01069374 0.01596140 0.01487094 0.01243676 0.00931603

zd: -1.943989 0.7747928 -1.531774 1.574342 -1.545680 -0.3241776

pvals: 0.9715807 0.2208322 0.934445 0.06047157 0.9361419 0.6265049

appliance 6 n2= 28

means

phase 1: 1.384054 1.346843 1.536768 1.444061 average 1.427931

phase 2: 1.020743 0.9858786 0.9617571 0.8073786 average 0.9439393

per cent reduction: 33.89463

test on paired differences: mean,std,zval,pval 0.483992 0.6161214 4.156721 0.0001460068

trends

av-diffs: -0.03721071 0.189925 -0.09270714 -0.03486429 -0.02412143 -0.1543786

sd-diffs: 0.5050089 0.8714055 1.235961 0.2902486 0.3306628 0.3801625

zd: -0.3898953 1.153296 -0.3969058 -0.6356084 -0.3860084 -2.148804

pvals: 0.6501636 0.1294484 0.6527215 0.7348087 0.6487423 0.9796122

Logicor Green Plug trial

appliance 7 n2= 31

means

phase 1: 0.4524903 0.4339968 0.3564839 0.3418032 average 0.3961935

phase 2: 0.03167419 0.03235806 0.01895161 0.03548387 average 0.02961694

per cent reduction: 92.52463

test on paired differences: mean,std,zval,pval 0.3665766 0.3520218 5.797971 1.227741e-06

trends

av-diffs: -0.01849355 -0.0775129 -0.01468065 0.000683871 -0.01340645 0.01653226

sd-diffs: 0.1924842 0.507575 0.2800503 0.06165392 0.08363603 0.09638159

zd: -0.5349413 -0.8502657 -0.2918704 0.06175815 -0.8924857 0.9550342

pvals: 0.7016832 0.7990437 0.6138027 0.4755825 0.810382 0.1735966

appliance 8 n2= 41

means

phase 1: 0.07987317 0.06771463 0.07403902 0.07300732 average 0.07365854

phase 2: 0.05220976 0.05516341 0.05355854 0.05500976 average 0.05398537

per cent reduction: 26.70861

test on paired differences: mean,std,zval,pval 0.01967317 0.03003124 4.194624 7.364386e-05

trends

av-diffs: -0.01215854 0.00632439 -0.001031707 0.002953659 -0.001604878 0.001451220

sd-diffs: 0.04409937 0.08082032 0.1007690 0.04373011 0.0399402 0.03375515

zd: -1.765391 0.5010603 -0.06555734 0.4324856 -0.2572905 0.2752866

pvals: 0.9574343 0.3095375 0.5259716 0.3338557 0.6008632 0.3922566

appliance 9 n2= 40

means

phase 1: 1.054642 1.186752 1.193395 1.107745 average 1.135634

phase 2: 0.7971575 0.7865775 0.884755 0.9089625 average 0.8443631

per cent reduction: 25.64829

test on paired differences: mean,std,zval,pval 0.2912706 0.7376258 2.497414 0.00841948

trends

av-diffs: 0.13211 0.0066425 -0.08565 -0.01058 0.0981775 0.0242075

sd-diffs: 0.4651197 0.807372 0.9139242 0.5071626 0.4039512 0.5045458

zd: 1.796391 0.05203408 -0.5927167 -0.1319376 1.537139 0.3034446

pvals: 0.04009069 0.4793836 0.7216039 0.552144 0.06616689 0.381582

Logicor Green Plug trial

appliance 10 n2= 34

means

phase 1: 1.228609 1.364118 1.405076 1.462482 average 1.365071

phase 2: 0.4957118 0.7405118 0.7100794 0.5870353 average 0.6333346

per cent reduction: 53.60429

test on paired differences: mean,std,zval,pval 0.7317368 1.517824 2.811078 0.004121991

trends

av-diffs: 0.1355088 0.04095882 0.05740588 0.2448 -0.03043235 -0.1230441

sd-diffs: 0.6451093 0.5579692 0.6938 0.8201836 0.4582792 0.4673844

zd: 1.224824 0.4280325 0.4824603 1.740363 -0.3872085 -1.535063

pvals: 0.1146564 0.3357041 0.316332 0.04555718 0.649456 0.9328492>