Running Costs of Conventional Electric Space Heating Systems

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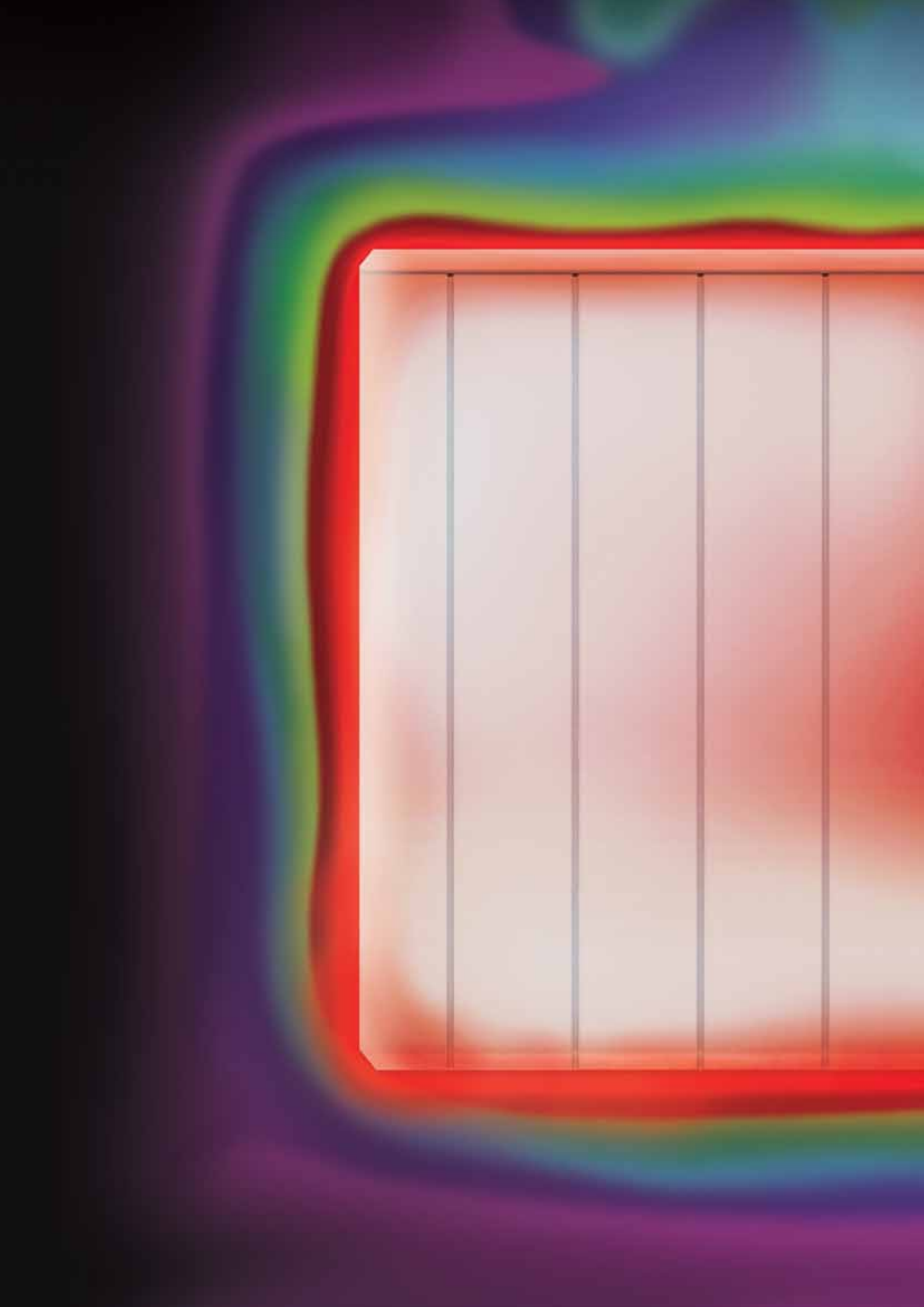


Content's

Introduction

The purpose of this information paper is to provide a publicly available document for professionally informed decisions regarding the running costs of various conventional electric heating systems installed in UK homes, and their running costs.

The report has been prepared by Dr John Counsell who is an independent researcher with over 20 years of experience in the design, development and performance assessment of electric heating systems and their controls. The running costs used in the comparison study described in this paper have been estimated using the UK Government's calculation method: Standard Assessment Procedure 2012 (SAP). SAP is a compulsory calculation required to comply with Part L of the England & Wales and Section 6 of the Scotland & Northern Ireland building regulations. The study uses the full SAP calculation and the latest BRE published revision SAP2012 (2012 Edition rev Feb2014) [1]. The fuel costs used are also from SAP published in Table 12 [1].

A typical High Heat Retention Heater made by Dimplex.

SAP has expanded its coverage of energy use in homes since its introduction to Part L in 1994 to cover the whole house energy use including the use of renewable energy sources. The energy prediction method/calculations for Space and Domestic Hot Water heating energy consumption have been calculated in SAP based on the BRE Domestic Energy Model (BREDEM). In the comparison of electric heating system running costs in this paper, only space heating (i.e. excluding Domestic Hot Water) energy running costs are used. The type of electric heating systems to be compared in their running cost performances have been confined to conventional types of electric heating. These systems are based on resistive heating elements and do not include more complex electric heating systems such as heat pumps and underfloor electric heating systems. The SAP/BREDEM modelling parameters for the heating systems used are given and fully explained in the report and the attached Appendix A.

Running Cost Estimation using SAP

BREDEM which is the core estimation method for predicting the energy consumption in UK homes is, still to date the only known energy prediction method that has been extensively calibrated across the UK with a wide range of real occupied homes.

This calibration was carried out with accurately monitored annual and minute-by-minute data from real occupied homes. The data from the monitoring contained information on; occupancy times, house temperatures, space heating and hot water energy use and outside weather conditions.

This unique calibration has established BREDEM and thus SAP as the Government and Building industry's trusted de facto standard for predicting energy use in a UK home. The BREDEM method is a combination of empirically derived standard occupancy patterns in two zones in the home; the first for the main living area and secondly the rest of the home.

The SAP calculation procedure in this study uses outside weather conditions specified monthly and also allows the UK regional weather to be specified if required. In this study the SAP region used is the "UK Average" [1] as it fairly represents the average weather conditions for space heating energy use calculations in the UK.

The BREDEM method uses these outside weather conditions to calculate the monthly space heating energy required to meet the empirically derived standard occupancy times and comfort temperatures of 21°C in the main living area and 18°C in the rest of the rooms. The energy use calculation is based on the conservation of energy principle that requires the average internal temperatures for the house to be derived for the different heating systems whilst satisfying the required comfort temperatures during the standard (on average) occupancy times.

The running costs of electric heating systems in this paper are calculated using energy consumptions derived using SAP2012 energy use estimation methods. This energy use is combined with a standard electric heating tariff and an Economy 7 tariff with kWh use unit rates as stated in SAP2012 Table 12 [1]. With these assumptions the SAP2012 calculation procedure has been used in the comparison study described in this paper to predict the space heating running costs for 3 types of homes with two levels of insulation.

The three types of home considered are typical of homes where electric heating is commonly used.

Home 1

The first home type used is a 1 Bedroom, 40m^2 in floor area, ground floor flat with an originally designed minimum SAP space heating energy requirement of 6840kWh.

Home 2

The second home used is a 2 Bedroom, 65m^2 in floor area, ground floor flat with an originally designed minimum SAP space heating energy consumption of 10610kWh.

Home 3

The third home type used is a 3 Bedroom, 90m^2 in floor area, semi-detached home with an originally designed SAP minimum space heating energy consumption of 15910kWh.

For all three types of property two types of construction were assumed; first the originally built based on 1960s building regulation levels of insulation and air tightness (Tables 1 to 3) and secondly a refurbished level of insulation typical of building regulations in the 1990s (Tables 3 to 6).

The physical parameters used for these constructions are described in Appendix A and were taken from the Energy Saving Trust's report "Northern Ireland: assessing U-values of existing housing" [2].

Different Types of Electric Heating and their SAP performance models

In the study three types of **100% efficient** electric heating systems have been modelled using SAP2012, they are as follows:

Direct Acting (Direct):

Direct acting heating in SAP is defined as an electric heating system that has a responsiveness of 1 and perfect tracking of room temperature. A responsiveness of 1 usually describes a heating system that can go from zero heat output to maximum heat output with time constant response of less than 5 minutes.

Perfect tracking of room temperature requires a room by room thermostat, i.e. a thermostat fitted to each heater. The heaters that SAP considers to be of Direct acting type include, but are not confined to; Panel convector heaters, radiant panel heaters (oil or ceramic filled), fan heaters and aluminium/oil filled radiators. In SAP modelling all these heaters have the same responsiveness and controllability and there is **NO** variation in running cost predictions in SAP2012 between these systems.

Manually Charged Storage and Secondary Direct Acting Heaters (Storage):

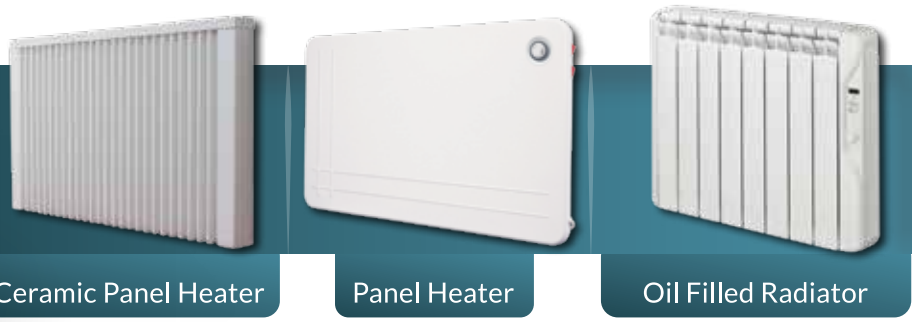
This heating system consists of traditional manually charged (i.e. no automatic charging of the store) static storage heaters (i.e. no fan or integrated radiant panel heater) in the home with secondary direct acting heaters (such as panel convector heaters) in, for example, bedrooms and bathrooms.

High Heat Retention Storage and Secondary Direct Acting Heaters (High Ret):

This heating system is defined in SAP2012 and consists of the modern high heat retention, digitally controlled fan assisted storage heaters with secondary direct acting heating (such as panel convector heaters).

Heating System Type

Direct Acting using Standard Rate Tariffs **[1] (Direct)**



Ceramic Panel Heater | Panel Heater | Oil Filled Radiator

Manual Storage & Secondary Direct Acting Heaters using an E7 Tariff **[1] (Storage)**

Static Storage Heater

High heat retention Storage Heaters & Secondary Direct Acting using E7 Tariff **[1] (HHRS)**

HHRS Heaters

Electric heating system types and examples used in this SAP2012 comparative study

Relative Heating Systems' Performances

The SAP results for the three heating systems described in Table 1 were calculated assuming; SAP standard occupancy and thermal comfort requirements; "UK Average" regional weather conditions and electricity tariffs described in SAP2012 Table 12 [1]. For the three case study homes as originally built these results are shown in the following tables:

Table 1 - 40m² 1 Bed Flat as built with typical 1960s Building Regulations (refer Appendix A)

Heating System	Tariff	Running Cost (£)
Direct Acting Convectors or Electric Radiators	Standard	£902
Manual Charge Storage & Convectors	E7	£664
High Heat Retention storage & Convectors	E7	£494

Table 2 - 65m² 2 Bed Flat as built with typical 1960s Building Regulations (refer Appendix A)

Heating System	Tariff	Running Cost (£)
Direct Acting Convectors or Electric Radiators	Standard	£1399
Manual Charge Storage & Convectors	E7	£985
High Heat Retention storage & Convectors	E7	£745

Table 3 - 90m² 3 Bed Semi-detached Home with 1960s Building Regulations (refer Appendix A)

Heating System	Tariff	Running Cost (£)
Direct Acting Convectors or Electric Radiators	Standard	£2099
Manual Charge Storage & Convectors	E7	£1542
High Heat Retention storage & Convectors	E7	£1124

The original homes have been assumed to be of a fabric and glazing typical of the 1960s building standards. This was when many of the UK's social housing and flats were built. Within a reasonable budget it is feasible to upgrade these homes with new UPVc double glazed windows, draught proofing and internal or external insulation to bring homes up to insulation standards typical of the 1990s building fabric standards.

All the key parameters for areas and insulation for the original and refurbished homes used in this comparative study are given in Appendix A. The same three homes assumed to be refurbished to the equivalent of 1990s insulation levels according to SAP calculations again using tariffs described in SAP2012 [1] gave the following SAP results in Tables 4 to 6:

Table 4 - 40m² 1 Bed Flat as refurbished with typical 1990s Building Regulations (refer Appendix A)		
Heating System	**Tariff**	**Running Cost (£)**
Direct Acting Convectors or Electric Radiators	Standard	£523
Manual Charge Storage & Convectors	E7	£371
High Heat Retention storage & Convectors	E7	£291

Table 5 - 65m² 2 Bed Flat as refurbished with typical 1990s Building Regulations (refer Appendix A)		
Heating System	**Tariff**	**Running Cost (£)**
Direct Acting Convectors or Electric Radiators	Standard	£849
Manual Charge Storage & Convectors	E7	£575
High Heat Retention storage & Convectors	E7	£455

Table 6 - 90 m² 3 Bed Semi-detached with typical 1990s Building Regulations (refer Appendix A)		
Heating System	**Tariff**	**Running Cost (£)**
Direct Acting Convectors or Electric Radiators	Standard	£1248
Manual Charge Storage & Convectors	E7	£857
High Heat Retention storage & Convectors	E7	£663

In both the original and the refurbished case studies it can be observed from Tables 1 to 6 that the High Heat Retention Storage (HHRS) heating system achieves a running cost on an Economy 7 (E7) tariff **almost half that** of direct acting heating on a standard tariff.

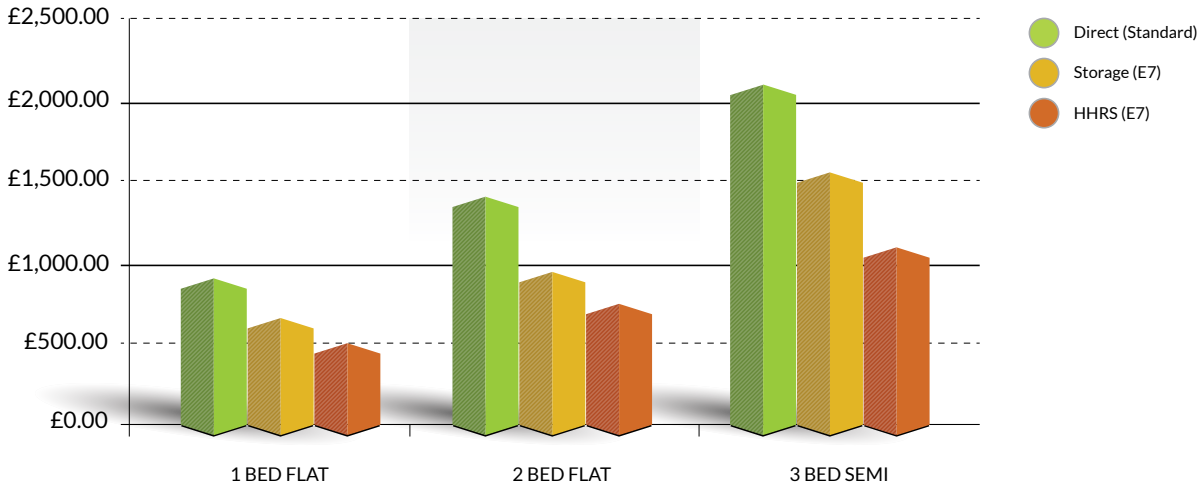
The advantage of the HHRS heating system running costs is achieved by utilising 90% of the electricity at the E7 off-peak rate. SAP2012 and other price research such as the Sutherland tables (April 2014 SE England) which is a reputable and established source of independent and impartial information on domestic heating costs, state that the E7 off-peak electricity unit price to be less than 40% of the standard electricity tariff unit price.

The HHRS heating system is a revolution in storage heating as it achieves 90% E7 off-peak electricity use without over-heating the home which results from poor temperature control normally associated with older storage heating systems. Even more modern storage convectors with manual charging shown in this comparison study overheat according to SAP by an average of 0.7°C. According to SAP, the results shown in Tables 1 to 6 indicate that modern convective storage heating systems typically use 25% more energy than HHRS heating systems and cost over 35% more to run in some poorly insulated homes.

Potential Impact of Electric Heating Choices on Fuel Poverty

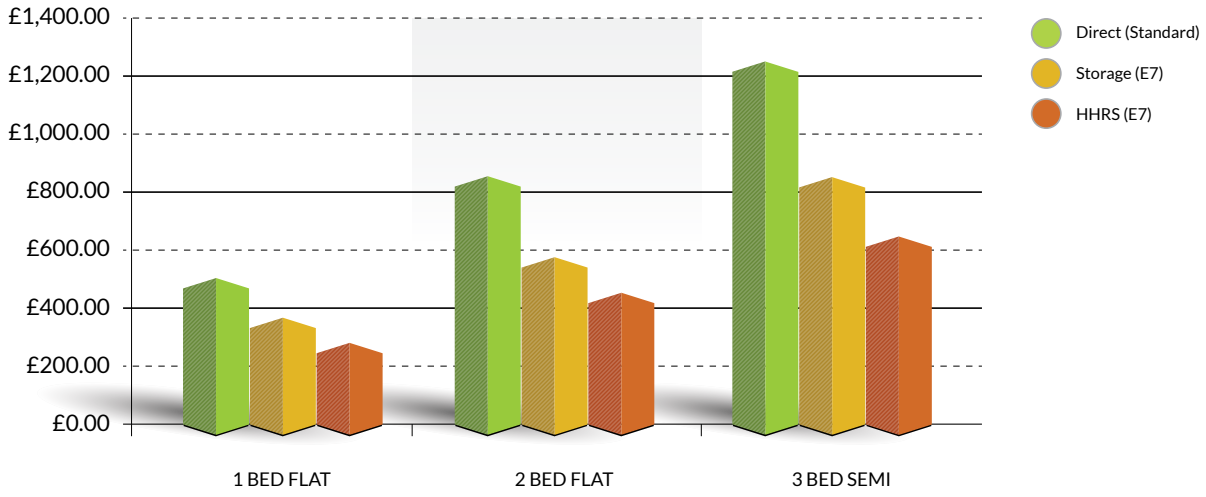
The running costs for the three homes as they were built (assumed to be in the 1960s) for the three heating systems as estimated by SAP are shown in the column chart Figure 1 below:

Figure 1: Annual space heating running costs (£) for all heating systems in the three original homes



The running costs for the homes refurbished to insulation standards typical of 1990s building regulations for the three heating systems are shown in column chart Figure 2 below.

Figure 2: Annual space heating running costs (£) for all heating systems in the three refurbished homes



It is clear from both Figures 1 and 2 that the most cost effective of the heating systems in this study in terms of running costs is the HHRS heating systems operating on an Economy 7 tariff. With its vastly improved controllability and its superior running costs the modern HHRS heating system using Economy 7 [1] compared with the Direct acting system using a Standard Electricity tariff [1] presents the best conventional electric heating solution for homes aiming to reduce running cost and fuel poverty.

These running costs are also predicted by assuming that the SAP's standard occupancy comfort conditions are achieved (e.g. The average expected comfort conditions of a UK homes) and thus present a high level of confidence that the running costs will be achieved with thermal comfort conditions at levels expected by all in a modern UK society.

The relative percentage savings by HHRS heating systems improves slightly as a home is refurbished with better glazing, draught proofing, building fabric and roof insulation. There is a lot of confusion with government bodies, architects, heating system designers, installers and users to why storage based heating systems can deliver much lower running costs whilst using more energy, improve thermal comfort and reduce building fabric and glazing condensation.

The energy increase especially from modern HHRS heating systems is very small compared with the benefit of using 90% of the heating energy required using electricity which is less than half the price of that of Standard Rate electricity, i.e. off-peak electricity generally available between midnight and 7am in the morning every day of the week and throughout the year.

Any claims of significant energy saving due to more accurate digital control of room temperatures by direct acting heating is considered negligible (i.e. less than 1 or 2%) in the SAP2012 model.

In SAP2012 the energy waste due to poor temperature control using Direct acting systems and HHRS heating systems is modelled as being identical, i.e. Zero!

Conclusion

In conclusion using the de facto model SAP2012 for prediction of space heating energy consumption in UK homes, this comparison study showed that HHRS heating systems using an E7 tariff [1] on average reduce running costs compared with Direct Acting systems using a Standard Rate tariff [1] by between 45 and 47%.

Author's Biography

Dr John Counsell is the Managing Director of Advanced Control Partnerships Limited and a BRE Trust Fellow sponsored by BRE at the University of Liverpool where he is an active member of BRE's and DECC's SAP scientific integrity group. He was previously the R&D group manager for advanced domestic electric heating for the electricity industry at EA Technology and the holder of the BRE. Chair in Energy Utilisation at the University of Strathclyde.

Author's signature.

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Table A1 - Home SAP parameters as originally built, assumed to be in the 1960s [2]	
House Parameter / Description	**Value / Units**
Wall Fabric U value	1.7 W/K/m^2
Roof U value	1.5 W/K/m^2
Suspended sealed Floor U value	0.6 W/K/m^2
Non sealed, Wooden Frame Single Glazing U value	4.84 W/K/m^2
Living area fractions	1 bed = 0.5 2 bed = 0.4 3 bed = 0.3

Table A2 - Home SAP parameters as refurbished to 1990s insulation levels [2]	
House Parameter / Description	**Value / Units**
Wall Fabric U value	0.55 W/K/m^2
Roof U value	0.35 W/K/m^2
Suspended sealed Floor U value	0.45 W/K/m^2
Non sealed, Wooden Frame Single Glazing U value	3.1 W/K/m^2
Living area fractions	1 bed = 0.5 2 bed = 0.4 3 bed = 0.3

Table A1 - Heaters' SAP2012 Parameters		
Heating System Type and Control	**SAP Parameters**	**Value**
Direct Acting using Standard Rate Tariffs [1] (Direct)	SAP Heating Type: SAP Responsiveness (R): SAP Percentage from Secondary Direct-acting heaters	1 1 0%
Manual Storage & Secondary Direct Acting Heaters using an E7 Tariff [1] (Storage)	SAP Heating Type: SAP Responsiveness (R): SAP Percentage from Secondary Direct-acting heaters	5 0.2 15%
High heat retention Storage Heaters & Secondary Direct Acting using E7 Tariff [1] (High Ret)	SAP Heating Type: SAP Responsiveness (R): SAP Percentage from Secondary Direct-acting heaters	2 0.8 10%

References

1. BRE (Published on behalf of DECC), "SAP2012, The Government's Standard Assessment Procedure for Energy Rating of Dwellings", 2012 Edition, rev February 2014.

2. Energy Savings Trust, "Energy Efficiency Best Practice in Housing, Northern Ireland: assessing U-values of existing housing", March 2005, CE127.


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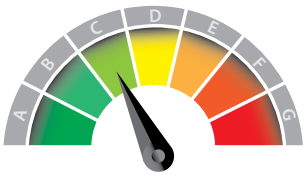

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