Department of Health

NHS Energy Efficiency Fund

Final Report – Summary

February 2015

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1 Summary

This executive summary reports on the preliminary outcomes from 117 energy efficiency projects delivered through 2013-14 in 48 NHS organisations in England, funded through the Department of Health NHS Energy Efficiency Fund (NHS EEF). The projects alone are on track to save 100.6Mkg of carbon dioxide per year and some 2.4%[1] of the entire 2012 NHS building energy related carbon footprint, delivering annual energy savings of 160.5MkWh, equivalent to boiling some 3.34 billion cups of tea a year[2]. The NHS generates 18% of all emissions deriving from the UK non-domestic building stock, at a metered energy cost of £600 million in 2011, a figure which excludes the multiple dis-benefits[3] accompanying the excessive use of energy in the NHS.

1.1 Program Aims and Objectives

The Aim of the NHS EEF Programme is to accelerate current NHS measures to mitigate the effects of climate change by improving energy efficiency across the NHS estate.

The Objective is to retain the resulting benefits within the NHS organisations to be re-invested directly into frontline patient services.

£49.3m of Public Dividend Capital was distributed competitively amongst successful NHS applicants in mid-2013, requiring projects to be completed by 31 March 2014, a tight timeframe. The Fund was heavily over-subscribed. 365 NHS organisations submitted bids totalling £200m, revealing a latent demand for energy efficiency improvements across the NHS Retained Estate amounting to at least four times the budget available. Discounted savings add up to £69.8m in the first five years of operation, equivalent to 63,800 Tonsillectomies, or 39,900 abdominal hernia procedures, or 27,100 cardiac arrest treatments or 9,000 coronary heart bypass grafts.

The Fund outcomes really are *'the gift that keeps on giving'* until major re-investment in equipment or fabric is required in, say, 15-20 years. NHS EEF savings are projected to each £118.7m within ten years and continue to accrue thereafter.

1.2 The Benefits available

A 'Benefits Framework' devised with the Department of Health is the common vehicle for identifying and evaluating immediately cash-releasing and less quantifiable, but no less significant, health and sustainability benefits accruing from the original investment. Benefits have proved to be very diverse, from increasing patient throughput with the purchase of new diagnostic equipment (Royal Marsden) to the removal of a now defunct underground oil tank, releasing land for a new Pathology laboratory (Homerton) at city centre land prices.

A wide variety of energy efficiency project types was proposed and implemented: from improvements to building fabric; upgrades to mechanical and electrical services; low energy lighting schemes; switching away from fossil fuels and the on-site generation of energy. **Figure**

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[1] NHS SDU records NHS carbon emissions related to building energy to be 17% of total NHS carbon footprint of 25MtCO_2, some 4.25MtCO_2 (w.sduhealth.org.uk/policy-strategy/reporting/nhs-carbon-footprint.aspx, accessed 23Nov2014)

[2] Using the research team's 2.5kW rated kettle to boil 1 litre of water in 2mins. 20 secs. comfortably yielding 2 mugs of tea.

[3] *Dis-benefits of the unnecessary use of energy include such things as excess carbon emissions, environmental impacts of the use of fossil fuels and excess water usage.*

1 shows the relative distribution of funding across project types. CHP schemes scooped 40% of the Fund.

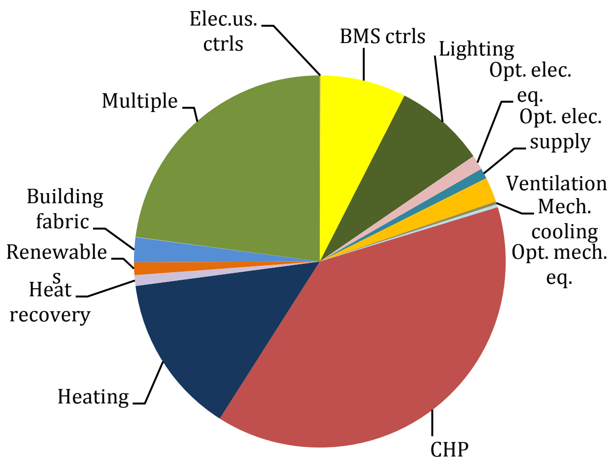

Figure 1 Allocation of funding according to project type [4] - (Total value £49m)

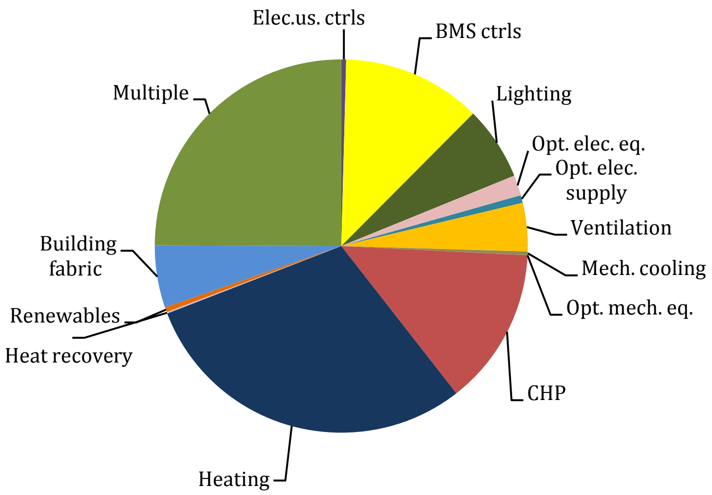

Figure 2 Predicted energy savings in kWh per project type in first year - (Total 160 million kWh)

However, marked differences in the relative benefit and ease of implementation of projects emerge, with important implications for policy-makers who may be contemplating similar funding initiatives and for NHS organisations developing energy efficiency strategies. **Figure 2** depicts the relative energy savings anticipated, suggesting significant differences in relative Value for Money. **Table 1** explores these differences in more detail on the basis of original projections reinforced where possible by actual measured data on the performance of schemes in use. Some very simple one-hit projects yield disproportionate benefits, in one case[5] £22m invested in electrical usage controls delivers £254k in five years, £472k in 10 years. £3.7m invested in Building Management System controls are projected to deliver £5.6m in five years and £10m in ten; Lighting upgrades are on track to deliver £5.19m in five years and £9m in ten from £3.9m initial investment, whilst others, notably some Combined Heat and Power (CHP) schemes, have variable outcomes, in aggregate a £19.1m investment delivers only £23.2m of benefits within five years, but rather more is predicted over ten years, some £38.9m. Well organised Trusts securing multiple inter-linked projects should realise £17.97m in five years out of their combined £11.3m of initial investment and £29.4m in 10 years. There is a huge premium available in joined up thinking and planning ahead.

[4] Some NHS organisations supplemented EEF funds from other sources to deliver their projects. These figures are strictly based on EEF investment.

[5] St Helens & Knowsley Teaching Hospitals

Table 1: Review of predicted energy savings and VfM according to project type
(a more detailed breakdown is provided in Appendix II and III)

KEY: EEF funds invested (£) / Expected returns (total discounted value over 5 / Expected kWh saved pa

Project type	Predicted energy savings against EE funds invested	No. of contracts	VfM-range[6]	Comments
BMS	£3,688,000 £5,588,437 (5yr) 19,352,491 KWh pa	3	1.47 – 1.94	
CHP	£19,105,000 £23,243,690 (5yr) 21,927,944 KWh pa	15	0.55 - 2.06	Further analysis carried out through case study.
Electrical usage controls[7]	£22,000 £253,650 (5yr) 676,560 KWh pa	1	7.61	Project ran pilot prior to submission. Note: limited number of project examples.
Heat recovery	£453,000 £714,646 (5yr) 195,048 KWh pa	1	1.57	Difficult to make any generalisations due to limited number of project examples.
Heating upgrades	£6,841,000 £10,311,882 (5yr) 47,685,074 KWh pa	9	0.91 - 7.58	
Lighting internal/external	£3,907,200 £5,186,552 (5yr) 10,256,388 KWh pa	10	1.20- 1.80	Further analysis carried out through case study.[8]
Mechanical cooling	£125,000 £245,014 (5yr) 505,274 KWh pa	2	1.53 - 2.23	Difficult to make any generalisations due to limited number of project examples.
'Multiples'	£11,296,000 £17,971,739 (5yr) 40,048,606 KWh pa	13	0.88- 5.39	Large variance can be attributed to the range of initiatives, CHP for example.
Optimising electrical equipment	£628,000 £1,095,353 (5yr) 2,817,119 KWh pa	5	1.13 – 5.61	Further analysis carried out through case study.
Optimising electricity supply	£446,000 £430,612 (5yr) 1,070,000 KWh pa	1	0.97	
Optimising mechanical equipment[9]	£126,000 £466,715 (5yr) 0 KWh pa	1	3.70	Difficult to make any generalisations due to limited number of project examples.
Renewable energy[10]	£550,000 £458,843 (5yr) 696,212 KWh pa	1	0.85	
Upgrading building fabric	£1,065,000 £1,692,237 (5yr) 8,642,602 KWh pa	4	0.40 – 1.75	
Ventilation plant upgrade	£1,059,000 £2,164,967 (5yr) 6,717,994 KWh pa	3	1.27- 3.53	

[6] VfM assuming a 5 year period.

[7] Trust confident of predicted figure, derived from pilot prior to submission, introducing PC management software reducing idle time and inactivity by shutting computers down, payback predicted in 5 months. Note: this is a small project of £22,000.

[8] Evidence of detailed calculations with reasonable assumptions have been provided. Some monitoring data available although savings not always directly seen in energy bills due to other changes happening on site.

[9] Project reported £0 energy savings expected at submission however since implementation £7,000 savings have been seen in the first month.

[10] Figures based on original wind power project but due to planning refusal for a turbine, solar panels were substituted and are in place.

Case studies

Thirty one case studies were selected in order to provide richer insights into the implementation of the Fund.

- **Singular cases:** Four case studies in total, three of which involved significant investment into multiple initiatives. The fourth project involved a unique EEF project combination covering: electrification of the vehicle fleet, purchase of tele-conferencing facilities and installation of solar photovoltaic panels to completely reform the outreach activities of that Trust.
- **Lighting improvement case study**: a catch-all case study capturing all 20 projects involving lighting improvement. These were universally effective, yielding a wide sweep of collateral benefit, in some cases equaling the raw energy saving benefit.
- **CHP case study**: Analyses three CHP-related projects in detail out of the 15 supported by the EEF, revealing generic benefits but yielding points to note for NHS organisations contemplating CHP .
- **Electrical optimisation case study**: Another catch-all case study analyses four out of the seven EEF projects involving electrical optimization.

The case by case exploration involved interviews, ongoing conversations and site visits with key members of Trust estates staff who have led project implementation. For some of these cases, Trust estates staff supplied significant detail behind predicted savings calculations and/or energy metering data, helping to validate the likelihood of achieving the predicted savings. However, for most of the 117 projects in the EEF, savings data is based on estimates provided by the Trusts through their original submissions and subsequent revisions or re-confirmations provided through project updates.

For clarity, it is important to note that “five year estimated savings” are based on the discounted total savings[6] from the reduction in costs and consideration of other quantitative benefits (predominantly savings associated with the “social cost of carbon”). These savings were obtained from VfM analysis provided by the Trusts in the EEF application process. The calculation considers savings from 2014/15 to 2018/19, which equates to five financial years (this excludes any savings reported for 2013/14, which was the year in which projects were implemented). Discounting future savings means that reported annual savings do not directly multiply up to the reported savings over five years.

1.3 Southend University – multiple projects

Southend University Hospital NHSFT was well prepared to bid with an energy masterplan. The Trust won funding of a £1.607m for 17 separate but interconnected projects under the EEF scheme. The projects covered many aspects of building energy performance, including works on the heating, ventilation and air conditioning (HVAC) systems, thermal insulation of the envelope, and lighting. The Trust included works to reduce the water consumption of the site with consequent energy benefits, by installing low-water use showers, and replacing an existing leaky water main. The hospital used the EEF works as an opportunity to make wider improvements to patient areas, in the restaurant, and in several wards, contain disruption and economise on contractor preliminaries costs.

The total expected impact will be an annual reduction in energy use of almost 5,600 MWh, and in water consumption of 82,000m^{3}. Managing so many separate projects presented some complications. In particular, the use of an external short-term contracted project manager led to some difficulties during the handover stage when the contract ended. Following the allocation of

[6] DH Economic appraisals require that future costs and benefits are discounted at a rate of 3.5% each year.

funding, the scope of two of the projects was changed. The detailed design process revealed that the financial benefits of the original proposals were unlikely to be as good as promised.

One EEF project originally planned was an improvement to the renal dialysis unit, to incorporate reuse of effluent reverse osmosis water. This would have reduced the water consumption on site, and is understood to generally be a fairly common and cost-effective means of reducing water consumption in hospitals. However, after examining the potential improvement in detail, including carrying out a survey of the existing kit, the team found that the water efficiency of the existing system was better than expected. This impacted on the five year payback period, and it was decided not to go ahead with this work although it would have yielded longer term benefit. The funds were instead used for improving the amount of low-energy lighting in the site.

The hospital noted the difficulty of getting access to the different patient-occupied areas of the hospital, and highlighted the need to engage with the different stakeholders early in the process to agree on shutdown periods, notwithstanding unforeseen pressures. Southend is one of the few hospitals to have formal post-project evaluation procedures in place, comprising surveys across hospital staff over the 24 months following the completion of the works, currently in progress. Many hospitals highlighted the importance of the hospital staff in the smooth running of the EEF scheme works in terms of organizing shut-downs and works. Furthermore, many of the projects require buy-in from the staff to be effective. For example, new lighting controls or IT systems will only achieve energy reductions if used appropriately by the medical staff and/or patients.

1.4 Cornwall

The Cornwall Partnership NHS Trust serves a wide area, requiring staff to cover many miles to attend to local patients. In order to address this, the Trust identified electrification of its vehicle fleet as a priority to reducing energy costs and GHG emissions and applied successfully to the NHS EEF for funding for new electric vehicles. The scheme includes 40 kW of solar PV panels, an online booking system and teleconferencing equipment as priorities for reducing energy costs and meeting its 15% GHG emissions reduction target by 2015. The booking system and teleconferencing equipment reduces staff travel time and yield payback periods of two years and six months, respectively. The Trust informs that since their introduction in late 2013, the electric vehicles have traveled more than 50,000 miles, 4,000 litres of traditional fuels were thus displaced by 15.9 MWh of electricity. 40 kW of solar panels across two PV farms have been installed to charge car batteries through a new charging infrastructure for the electric vehicles. The total declared mileage has reduced from 2011/12 5million miles by 1.4 million to 3.6 million at the end of 2013/14. 2014/15 trends are positive but will not be reported in this format until summer 2015. The entirety of the measures is expected to generate ~£325K p.a. of direct savings, and ~£300K p.a. of other benefits.

An interesting conundrum has arisen. To this point, roughly 50% of electricity generated was fed back into the grid. It is still a matter of debate as to whether this is the best use for the solar electricity being produced, and it is anticipated that further investigation will be made on the economics of on-site storage of generation for use in either the electric vehicles or in the NHS facilities. This conundrum comes up across a number of NHS EEF projects. It should be highlighted that the exploration of these types of forward-looking scenarios would not have been possible in the absence of EEF grants.

Important lessons emerge for future similar projects: the requirement of a full planning application for the PV farms introduced delays. It emerged that existing electrical transmission infrastructure could not accommodate the original design and so the PV array was split across two sites. Electrical infrastructure constraints also impacted the installation of the electric vehicle charging infrastructure, as there was an unforeseen issue concerning the earthing threshold, with some charging posts requiring re-earthing.

Another unforeseen issue with the electric vehicles is the minor incompatibility between the charging posts and the vehicles. The French manufactured vehicles and the English 45 kW charging systems have different power ratings, which could potentially impact charge quality. The reason that was not foreseen by the electric vehicle supplier was that the 45kW systems used at Cornwall NHS are well beyond the voltage used by this particular supplier to charge their vehicles. However, the selected make of electric vehicle is still seen as the best option based on its superior charging rate.

1.5 Southampton

University Hospital Southampton NHSFT received EEF grants for nine different proposals taken from their pre-existing masterplan, including upgrades to building fabric, air handling unit (AHU) controls, heating system and ventilation upgrades, air infiltration control (through automatic doors), and lighting improvements.

Building envelope improvements have been undertaken where maintenance had been due, predominantly in the 1960s era neurology building. The single-glazed windows in the West Wing are retrofitted with modern double-glazed replacements. Refurbishments are currently underway in certain wards; the installation of LED lighting has been focused in these areas to reduce incremental costs.

New high-efficiency chilling units have been installed. The main steam duct was also scheduled to be reinsulated although this has been delayed due to the unanticipated presence of asbestos, a recurring theme across the NHS EEF scheme. Sensors were installed in all of the operating theatres to turn off air handling units when not in use. The doors in the B-level corridor have now been automated to reduce the rate of air leakage from the building. It had been described as a quarter mile long wind tunnel, a very simple but very effective intervention into the building fabric.

Many of these improvements have positively impacted patient/staff thermal comfort and the overall quality of the hospital environment. Direct cost savings are expected to amount to £625k/pa and £215k/pa savings in other benefits. Energy savings are expected to be 18,406,000 kWh/pa, yielding an emissions reduction of 5,611,000 kg CO_2e within five years.

It is of interest to note some issues with an existing CHP at Southampton, even though this was not an EEF project. At present, energy from on-site production at an existing CHP plant can be exported at around 4.5p/kWh (in comparison, imported electricity from the grid costs approximately 8-9p/kWh). The cost of generation on-site is approximately 6.5p/kWh, which means it costs the Trust/contractor to export to the grid. As a result, CHP plant operators have no natural incentive to support on-site energy demand measures that would reduce on-site power consumption, as their responsibility is strictly supply/generation. Southampton's 2MW CHP plant, which cost £2.5m to build, has an expected payback of 5-6 years based on the operator's estimates. However, changes in demand may alter the economics.

In addition to this, other contractual arrangements affect the efficiency of the CHP operation. The condition in the original contract for the delivery of specified levels of Low Temperature Hot Water to the site could not be met, but there was no compensation allowed for this in the contract, resulting in retrospective negotiation. Another issue the Trust faced with the CHP system is that the grid management in the area occasionally interrupts CHP feed-in to prevent frequency/voltage variation outside of specifications (related to regulation G59, which prevents electricity from being sent to the grid that does not match parameters dictated by the district network authority[7]). This can occur several times per day and is seen to compromise the CHP's financial return.

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[7] http://www.connectingindustry.com/ElectricalEngineering/what-is-g59.aspx

Institutional knowledge is in danger of being lost at Southampton due to pending retirement of energy management staff. One opportunity that may yet be exploited to partially address this is the leverage of local university research capacity. This is an issue across a number of NHS EEF projects.

1.6 Salisbury

The Salisbury NHSFT was awarded £800,000 through the NHS EEF program for improvements to its campus of low-rise brick buildings, which include LED lighting, three 250kW high efficiency chillers, and solar panels, all delivered to schedule due to careful pre-planning. By October 2014, LED fixtures had been installed. The quality of the patient environment has improved, due to the changes to the building envelope and improved lighting from the LED retrofits. The Trust's staff have also commented positively on the improvements to the work environment provided by the LEDs. One area in which the LED retrofit has been particularly appreciated is the main production kitchen, where the quality of lighting can have implications for food safety as well as staff satisfaction. The Lighting upgrade alone delivers estimated annual savings of £40,500 and 37 tonnes of CO_2e[8]. Considerable additional savings related to maintenance are also expected, as LED fittings are expected to have a lifespan that is roughly six times greater than fluorescent tubes and disruption to patients and staff. At the Royal Marsden for example, maintenance cost savings are of the order of the energy cost saved.

The heat obtained from the CHP facilities is partially used to improve the temperature within the pool (used for therapy, exercise and classes), which is especially useful since it is a non-seasonal use for the benefit of patients.

The new PV panels have generated 80% of the electricity expected (112 MWh versus 140 MWh), while solar thermal panels had been delayed due to renovations to the pool (the intended recipient of the energy converted), but are expected to be completed in autumn 2014. The retrofits are anticipated to save £158,000, 1,200,000 kWh, and 12,000,000 kgCO2e annually. The Trust has committed to encouraging environmental stewardship among its staff and throughout its facilities, investing over £3m over the past five years, including the installation of a 850kW CHP plant. To 2013/14, it is estimated that the trust has saved 1,800,000 kWh through these investments.

1.7 Lighting projects

Twenty projects within the EEF scheme contained lighting upgrades. This included relatively large projects that only involved lighting, such as the Royal United Hospital Bath NHSFT £1.7m lighting upgrade involving 7000 lamps. It also included projects where lighting was a component of a wider programme, such as the Ashford and St Peter's NHSFT upgrade of approximately 500 lamps. The total investment into lighting has been approximately £8m, of which £5.9m is expended in combination with other projects, either within the same contract, or through separate contracts. **Table 2** provides a summary of the schemes in terms of size and expected return on investment.

While it is expected that LEDs return significant energy savings in a like-for-like comparison with previous energy use of existing lamps, several factors influence the cost-benefit analysis of these schemes. Such factors include, but are not limited to, the auxiliary costs associated with the project such as wiring upgrades, replacement of fittings, removal of asbestos and other ceiling improvements. In places, occupancy sensors have been fitted at additional cost, where they increase expected savings per lamp through reducing hours of use. Finally, the retrofit may require adding extra lamps in order to improve lux levels to meet current standards. Although

8 As reported by Head of Estates, Salisbury NHS.

these lighting projects are all in the same sector, there is no reliable uniform cost-benefit ratio. It all depends on the context.

The key cash-releasing benefit of the lighting schemes is the reduction of energy use associated with the reduction in wattage of the lamps and reduction in hours of use. However, while not always explicitly accounted for, lower maintenance costs associated with using the longer-life LEDs provides additional benefits. This benefit is partly guaranteed through replacement warranties provided by suppliers (warranty periods range in length). Other efficiencies can also be gained through streamlining the lighting scheme across the site. For example, one Trust reported reducing the number of lamp types from over 100 down to 20. The main non-cash releasing benefit is the improved lighting quality and lux levels. This provides improved conditions for both patients and staff. This is demonstrated in photos provided below from St Peter's Hospital. Also, there are potential improvements in safety through, for example, better illumination of trip hazards in car parks and reducing the frequency of replacing lights at a height where an extension ladder is required.

A key constraint of implementing these projects was the tight timescales placed on the schemes by the short timeframe stipulated by funding criteria. Replacing lighting in patient areas is intrusive and the logistics of transferring patients from wards can be challenging. Some Trusts have managed this through partnering lighting upgrades with other refurbishment work.

Table 2: Summary of lighting projects

	NHS Trust	Trust awarded other projects? SC = under same contract OC = through other contracts	Discounted cost to benefit ratio (VfM) - 5 yrs (as per Appendix III)	External lighting	Internal lighting	Lamps or luminares replaced	EEF funded capital expenditure	Expected annual savings in kWh	Expected annual savings in £ (mostly based on energy savings only. Some values include e maintenance savings)
1	Ashford and St Peter's	Yes - OC	1.55	Y	Y	500	£224,200	381,351	£45,495
2	Brighton & Sussex University Hosp.	Yes - SC	1.73	Y	Y	270	£214,994	310,560	£37,268
3	Central North West London	Yes - SC	1.51	N	Y	40	£40,000	n.a.	n.a.
4	Chelsea & Westminster	Yes - OC	1.20	?	Y	3500	£1,378,000	3,541,000	£304,300
5	Ealing	Yes - SC	1.51	Y	Y	4500	£600,000	1,400,831	£85,170
6	Heart of England	Yes - SC	0.88	?	Y	8300	£1,741,000	3,182,257	£299,000
7	Luton and Dunstable	Yes - OC	1.36	Y	N	n.a.	£42,000	n.a.	£15,290
8	Northumbria	No	1.74	Y	Y	371	£52,000	103,250	£13,361
9	Nottinghamshire	Yes - SC	1.17	Y	Y	396	£105,525	n.a.	n.a.
10	Royal Devon & Exeter	Yes - SC	1.34	N	Y	757	£247,000	236,070	£39,900
11	Royal Free London	Yes - SC	1.46	N	Y	470	£225,000	61,022	£7,700
12	Royal Liverpool & Broadgreen	Yes - OC	1.80	N	Y	3078	£190,000	543,821	£48,941
13	Royal Marsden, Chelsea	No	1.49	?	Y	3000	£168,000	253,761	£49,523
14	Royal United Hospital, Bath	No	1.36	Y	Y	7000	£1,673,000	1,260,127	see notes
15	Salisbury	Yes - SC	1.03	N	Y	n.a.	£120,000	371,572	£40,452
16	Shropshire community health	No	n.a.	Y	Y	1070	£77,000	150,000	£20,500
17	Southend University	Yes - SC	1.80	?	Y	1404	£221,000	603,035	£55,599
18	Stockport	Yes - SC	2.0	Y	Y	2075	£558,168	n.a.	n.a.
19	University Hospital South Manchester	Yes - OC	1.47	N	Y	247	£40,183	120,718	£12,555
20	University Hospital Southampton	Yes - OC	1.47	N	Y	300	£68,000	n.a.	£17,520
	Additional sum given unavailable estimates for some projects:					500		1,228,100	£216,000
			TOTAL:			**37,778***	**£7,985,070**	**13,700,000**	**£1,300,000**
					Projects under the same contract as other initiatives		£4,072,687		
					Projects initiated alongside other contracts		£1,942,383		
					Lighting only projects		£1,970,000		

n.a. = data not available for reporting

***Note: this is an estimate figure. Some Trusts reported on lamps replaced while others reported on total fittings or luminaires.**

1.8 Combined heat and power case studies

Across the EEF, 15 Combined Heat and Power (CHP) schemes were carried out. These works included new installations, as well as efficiency improvements to existing units. Case study interviews were carried out at three sites; Frimley Park, Homerton University, and Milton Keynes. Although actual data was limited, the case studies suggested a reasonable potential for carbon savings from CHP installations, especially when used in conjunction with fuel switching. The complexity of these systems resulted in some early teething problems, and highlighted the difficulty of achieving actual savings that meet with the design intentions. In one hospital, systematic errors were found in the methodology for calculating the emissions savings potential, highlighting the need for clear guidance to be available for dealing with complex system installations such as CHP and renewables. The time needed for dealing with the different external stakeholders, compared with more traditional building refurbishment measures, was also noted by the hospitals, and obtaining a G59 agreement led to delays in at least one hospital.

Table 3: Summary of each of the CHP case study projects, from the EEF application forms

Hospital	Project Type	CHP Duty and Fuel	DH Funding	Estimated Impact	Discounted Cost:Benefit Ratio
Frimley Park	Improvement of existing CHP	Gas-fired 1,370kWe	£380k	-6.5% (gas)	2.45 (10 years)
Homerton	New CHP (and full heating refurb)	Gas-fired 320kWe	~£3.0M*	-50% (CO_2)**	2.36 (10 years)
Milton Keynes	Replacement of existing CHP	Gas-fired 229kWe	£292k	+4.3% (gas) -5.1% (elec)	1.72 (10 years)

* At the time of the interview, the final project precise cost has not been confirmed.
** The results have been presented as a change in emissions, rather than in energy consumption, as the project involves a change in fuel (from oil to gas).

Figure 3: The Homerton CHP installation (right), and the new boilers (left)

1.9 Electrical optimisation case studies

Seven electricity supply optimisation projects were undertaken as part of the EEF scheme. These included installation of voltage optimisation and the replacement of existing transformers with more efficient units. Case study interviews were carried out at four sites; Great Western, Southend University, Stockport and University Hospital of South Manchester. The sites suggested a reasonable reduction in electricity use through the measures. Furthermore, the high carbon intensity of mains electricity compared with gas means that the impact on the sites' emissions was typically higher than the impact on energy use. The metered data suggested reductions in electricity use of around 5% and upwards, although the amount varied from installation to installation, including one showing a small increase (possibly attributable to variations in use). The case study hospitals noted the improvement potential of voltage reduction on the lifetime of kit through reduced wear and tear. However, several highlighted the need for installations to take care to ensure that sensitive medical and building equipment would not have an increased risk of failure.

Table 4 Summary of each of the electrical optimisation case study projects, from the EEF application forms

Hospital	Project Type	Project Budget	Estimated Annual Electricity Use Reduction		Benefit:Cost Ratio
Great Western	Installation of VO	£446k	1,200 MWh	~7%	1.8 (10 years)
Southend*	Installation of VO	£45k	187 MWh	1.3%	3.25 (10 years)
Stockport*	Transformer Replacement	£300k	682 MWh	5.7%	2.89 (20 years)
Uni. S. Manchester*	Transformer Replacement	£316k	701 MWh	3.2%	2.06 (10 years)

** These hospitals had multiple projects under the EEF scheme, but only those relating to improvements to the electricity supply are listed here.*

2 Recommendations

Recommendations to policy-makers contemplating the launch of future similar funds include:

- Energy efficiency knowledge and skills available to Trusts vary dramatically from evangelical in-house energy managers, to external consultants, to in-house staff with only an elementary understanding of energy-efficiency.

  NHS organisations, currently without in-house skills in energy efficiency, should review the relative cost of bringing in external expertise for even the simplest tasks, against the savings available from an in-house capacity to diagnose Trust energy performance and deliver effective strategies, procurement specifications and contracts.

- The current Fund is reactive, successful Trusts pick from pre-existing energy efficiency masterplans, whilst weaker organisations with little expertise in the field are at the mercy of contractors' and suppliers' marketing skills. However it is in the latter organisations researchers suspect the real energy efficiency dividends lie.

  Less 'successful' Trusts should be empowered to collect data, diagnose their performance and devise their own masterplans.

- Existing data at the useful scale of individual buildings is almost totally absent, ERIC data is too high level to permit meaningful building diagnostics and post-intervention comparison.

  Trusts need to be enabled to collect more detailed and specific data, monitoring equipment is increasingly affordable and the digital tools to download and analyse recorded data increasingly user-friendly.

- There is a need for informed bottom-up strategy to yield the most effective proposals within each NHS organisation's own context.

  Trusts should be encouraged to bid in a preliminary round for advice in identifying needs and opportunities and the development of meaningful projects for persuasive 2nd stage bids.

- This implies the process needs more time to unfold to ensure successful outcomes. The current EEF timetable rendered all applications requiring a chain of external permissions unviable. For example, Trusts have been unable to secure the necessary Development Control permissions for renewables installations in the timescale of the current EEF programme and have then found they were refused.

  If policy-makers intend to encourage the use of renewable energy sources across the NHS Estate, they need to permit adequate time for negotiations with local planning authorities.

- Energy Efficiency improvement schemes require very good data to identify genuinely beneficial measures and expose the less productive but fashionable 'solutions', at least through a full summer and winter.

  The full seasonal cycle should be available for reporting post-implementation performance, a summer and a winter.

- Recent research shows that the need to establish and boost resilience is pressing now. Building resilience to current and future summer hot spells, however, barely figured in the successful proposals.

Pursue adaptive as well as mitigatory schemes. This would require higher level advice in interpreting climate change predictions and the likely performance of their building stock.

- The participating NHS organisations all seemed to be re-inventing the wheel in parallel with each other with few examples of shared expertise and experience.

  Cluster projects by type, say all Combined Heat and Power schemes, and coordinate procurement, CHP engines for example. Pool intelligent specifications for kit developing out of fast-changing technologies, for example LED lighting, and in the negotiation of the most beneficial warranties and guarantees.

- Make the whole greater than the sum of the parts (as achieved at Southend, Salisbury, Southampton). This requires sustained expert input.

  Encourage the timely clustering of interconnected projects to exploit synergies, maximise returns, and minimise disruption to patients.

- The Fund became self-fulfilling as 33 of the 48 organisations awarded contracts were Foundation Trusts with carefully pre-prepared energy efficiency masterplans. But it is highly likely that the poorer performing organisations will yield the most 'low-hanging fruit'.

  Focus on Trusts within the remit of the Trust Development Authority, install an expert team to gather performance data, conduct the diagnoses, implement simple mitigatory measures with coincident adaptation benefits, train Trust staff and leave in place a knowing, reliable and rigorous monitoring exercise.

- The expertise might very well be available within the greater organisation. Research colleagues will be very keen to see their work impact on the real world. It's an open door for the NHS.

  Engage with University building science research departments and marry their expertise with NHS organisations, after all, many Trusts are University Hospital Trusts.

2.1 Health and Social Care system recommendations

If the NHS, accounting for 25% of all public sector emissions, halves its built environment carbon emissions, some 18% of NHS emissions, it could save 2.25% of all public sector emissions in the UK, deliver savings back into healthcare and, therefore, trigger a step change in NHS organisational behaviour. There is an exciting potential to factor the EEF programme findings up to the scale of the entire NHS estate. The Programme is delivering a sizeable sample of real data covering almost the full range of customary UK hospital building types. The authors believe that it is feasible to assess the energy efficiency and thereby the mitigation potential and the adaptation challenge of the NHS estate as a whole. An overview of current and future performance of the NHS England acute hospital estate would yield powerful insights to inform the NHS Carbon Reduction Strategy and would contribute materially to the national public sector carbon reduction target.

There is also the potential for supplying the NHS Strategic Health Asset Planning and Evaluation (SHAPE)[9] database, a nationwide locational tool, with specific NHS organisation site project data to a standard format: the project type, initial investment, returns as measured, the cash and non-cash benefits accruing over what timescales, and lessons learnt in implementing

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9 SHAPE is a web enabled evidence based application that supports and informs the strategic planning of healthcare assets and services. It supports key national policy and provides both a national and local perspective on health needs and service planning.

the particular project/projects. The benefits and perils of implementing the whole palette of energy efficiency initiatives would be immediately evident at the click of a mouse.

Policy driving the scheme is focused entirely on the mitigation of carbon emissions but inevitably some of the content of the projects will yield adaptation benefits to the host institutions. Future funding initiatives should incorporate measures to deliver adaptive benefit but NHS organisations will require guidance in analysing climate change scenarios and predicted effects. That level of expertise may not be readily available. The NHS is not generally well equipped to monitor and diagnose its own energy use. Reliance on external consultants is expensive and their inputs necessarily limited whilst direct reliance for advice on equipment suppliers raises issues of conflict of interest. Hospitals would need to collect very significantly more data at a finer grain in their building stock. A policy which aimed to empower NHS organisations to deliver sound energy efficiency strategies for their own estates would set the foundations for highly effective future EEF initiatives. NHS organisations should be mindful of the effects of predicted climate change but will certainly need specialist help to interpret predictive material and model the implications. That specialist but disinterested advice may reside in University research teams across the country, perhaps coupled with a regional network of consulting environmental engineers. NHS organisations should receive guidance on appropriate forms of appointment to achieve productive longer term framework agreements in which to collect data, diagnose current usage and devise energy efficiency Trust-wide masterplans.

3 Conclusion

If the NHS halves its built environment carbon emissions it could save 9% of NHS total emissions, some 2.25 Million tonnes of CO_2 annually, deliver the cash savings directly back into healthcare and, therefore, trigger a step change in NHS organisational behaviour. Very crudely, simply factoring up the outcomes of the NHS EEF project to save 2.25 Million tonnes, some £330m of benefits may be available annually across the whole estate, £165m annually for a cut in emissions of only 25%. The successful formula is to collect data; understand the building stock; improve the building fabric, improve the lighting, improve controls and then, and only then, pursue renewable energy sources to satisfy the healthily reduced demand. There is everything to play for.

ANNEX A

Page 4, description of Figure 1

PIE chart indicating allocation of funding according to project type (total value £49m)

In descending order:

CHP
Multiple
Heating
Lighting – internal/external
BMS controls
Ventilation plant upgrade
Upgrading building fabric
Optimising electrical equipment
Renewable energy
Heat recovery
Optimising electricity supply
Optimising mechanical equipment
Mechanical cooling
Electricity usage controls

Page 4, description of Figure 2

PIE chart indicating predicted energy savings in kWh per project type in first year (total 160 million kWh)

In descending order:

Heating
Multiple
CHP
BMS controls
Lighting – internal/external
Upgrading building fabric
Ventilation plant upgrade
Optimising electrical equipment
Optimising electricity supply
Renewable energy
Electricity usage controls
Mechanical cooling
Heat recovery
Optimising mechanical equipment

Page 5, Table 1 with figures only

Table 5: Review of predicted energy savings and VfM according to project type
(a more detailed breakdown is provided in Appendix II and III)

Project type	Predicted energy savings against EE funds invested			No. of contracts	VfM-range[10]	Comments
	EEF funds Invested (£)	Expected returns (total discounted value over 5	Expected kWh saved pa			
BMS	£3,688,000	£5,588,437	19,352,491	3	1.47–1.94	
CHP	£19,105,000	£23,243,690	21,927,944	15	0.55-2.06	Further analysis carried out through case study.
Electrical usage controls[11]	£22,000	£253,650	676,560	1	7.61	Project ran pilot prior to submission. Note: limited number of project examples.
Heat recovery	£453,000	£714,646	195,048	1	1.57	Difficult to make any generalisations due to limited number of project examples.
Heating upgrades	£6,841,000	£10,311,882	47,685,074	9	0.91-7.58	
Lighting internal/external	£3,907,200	£5,186,552	10,256,388	10	1.20-1.80	Further analysis carried out through case study.[12]
Mechanical cooling	£125,000	£245,014	505,274	2	1.53-2.23	Difficult to make any generalisations due to limited number of project examples.
'Multiples'	£11,296,000	£17,971,739	40,048,606	13	0.88-5.39	Large variance can be attributed to the range of initiatives, CHP for example. predominance of CHP.
Optimising electrical equipment	£628,000	£1,095,353	2,817,119	5	1.13–5.61	Further analysis carried out through case study.
Optimising electricity supply	£446,000	£430,612	1,070,000	1	0.97	
Optimising mechanical equipment[13]	£126,000	£466,715	0	1	3.70	Difficult to make any generalisations due to limited number of project examples.
Renewable energy[14]	£550,000	£458,843	696,212	1	0.85	
Upgrading building fabric	£1,065,000	£1,692,237	8,642,602	4	0.40–1.75	
Ventilation plant upgrade	1,059,000	£2,164,967	6,717,994	3	1.27-3.53	

[10] VfM assuming a five year period.

[11] Trust confident of predicted figure, derived from pilot prior to submission, introducing PC management software reducing idle time and inactivity by shutting computers down, payback predicted in five months. Note: this is a small project of £22,000.

[12] Evidence of detailed calculations with reasonable assumptions have been provided. Some monitoring data available although savings not always directly seen in energy bills due to other changes happening on site.

[13] Project reported £0 energy savings expected at submission. However since implementation £7,000 savings have been seen in the first month.

[14] Figures based on original wind power project but due to planning refusal for a turbine, solar panels were substituted and are in place.

Page 12, description of Figure 3

Images depicting the Homerton CHP installation (right) and the new boilers (left)