The Value of Solar Heat

The Role of Solar and Storage in the Decarbonisation of Heat

Solar Energy UK

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About Us

As an established trade association working for and representing the entire solar and energy storage value chain, Solar Energy UK represents a thriving member-led community of over 300 businesses and associates, including installers, manufacturers, distributors, large-scale developers, investors, and law firms.

Our underlying ethos has remained the same since our foundation in 1978 – to be a powerful voice for our members by catalysing their collective strengths to build a clean energy system for everyone's benefit. Our mission is to empower the UK solar transformation. Together with our members, we are paving the way for solar to deliver 40GW by 2030 by enabling a bigger and better solar industry.

Foreword

Richard Hauxwell-Baldwin, MCS

MCS Charitable Foundation is delighted to have been the principal funder for this important research by Solar Energy UK.

The research provides robust evidence on the significant contribution that solar heating technologies can make to the UK's net zero goals. The need to advance low carbon heating solutions has never been greater given the growing concern about the climate emergency and rising energy costs. This report clearly highlights that installing small-scale renewables provides a direct solution to these concerns.

As a charity, we work to decarbonise homes, heat and energy. The Value of Solar Heat report is yet another example of the excellent work Solar Energy UK has contributed towards achieving those goals.

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Solar Energy UK Policy Recommendations

Decarbonising the UK's heat at low cost will require significant policy action. Solar Energy UK's recommendations to deliver this are as follow.

The Westminster and devolved Governments should:

- Design the Future Homes Standard and Future Buildings Standard so that that solar technology is installed as standard on all new homes and non-domestic property, with the system specified to the size that will deliver the maximum carbon and cost benefit for the building. The Westminster and devolved Governments should enable an affordable transition to low carbon heating for UK homes and businesses by adding solar PV or thermal to the heat pump specification in the new building regulations.
- Ensure that relevant statutory bodies – such as Local Authorities – deliver as many new homes as possible with solar energy technologies included as standard. Local planning authorities should use their powers under the Planning and Energy Act (2008) to mandate the highest energy standards for new homes in their area.
- Facilitate access to low-cost finance, as outlined in the British Energy Security Strategy. This should include working with the solar and other low carbon technology industries to establish a long-term retrofit support scheme for homeowners and renters. All zero carbon technologies should be eligible, including solar PV, thermal, energy storage and other carbon heat technologies. The priority should be to support low-income and vulnerable householders to help combat fuel poverty levels caused by high energy prices. This could include, for example:
  - A zero-interest loan scheme.
  - Grant support for social landlords and renters.
  - Enabling green finance products such as property-linked finance.
- Update the standard parameters of Energy Performance Certificates and other building documents to provide detailed information on the presence and energy and financial performance of low carbon heating technology, such as solar generation.
- Include all low-carbon heat technologies and batteries on the Energy Saving Materials list that encourage low-carbon home upgrades, ensuring that these qualify for zero-rated VAT.

The Royal Institute of Chartered Surveyors should:

- Update its valuation models for homes in line with Solar Energy UK's evidence that solar technologies increase the value of homes and provide major running cost benefits to homeowners and occupiers.

The property and consumer finance industry should:

- Flag the financial benefits of solar heat technologies to borrowers at key financial decision points – for example, existing homeowners who are remortgaging their properties.
- Develop and bring to market consumer finance and green mortgage products that reward investment in properties which include solar and other low carbon technologies.
- Record and present information on the presence of solar generation systems as part of the standard description of a home (for example, on sales and lettings websites).
- Ensure that financial advice and guidance are based on up-to-date solar system cost assumptions sourced from the solar industry

The energy, housebuilding and construction industry should:

- Design homes and non-domestic property to meet new building regulations based on the inclusion of solar technologies.
- Design show homes with integrated solar and energy storage systems as standard, providing home buyers with the opportunity to discuss the benefits of onsite generation and energy storage as part of the buying process.
- Coordinate skills, training, and professional development programmes to expand the workforce and supply chain capacity needed to ensure that all new homes are equipped with solar from 2023.

Report Context

This document fits into a broader suite of reports produced by Solar Energy UK to evidence the financial and system-wide benefits of residential solar and storage technologies. Together they demonstrate the energy, financial and climate change benefits of installing solar, which is a hedge against the rising cost of living, promotes energy security, and contributes to the UK's net zero targets.

Our Smart Solar Homes publication is the first in the series, followed by The Value of Solar Property.

Smart Solar Homes

Our smart home energy analysis outlines the individual and system level benefits delivered by 4.4 million smart solar homes in the UK. Together, these could generate and store enough electricity to help eliminate the winter peak in demand on the electricity grid. There are already a million solar homes in the UK, reflecting consumer demand for solar's benefits. But many more are needed to help the UK meet the increased demand for electricity that will arise from decarbonising heat, transport, and the wider economy. The emergence of smart solar homes will reduce bills for consumers, increase energy security, and enable the UK to address climate change.

The Value of Solar Property

Our 2021 report on demonstrates the financial benefits of installing a residential solar system. Solar Energy UK analysis of more than five million properties shows that homes fitted with solar PV achieve a higher sale price than comparable homes without them. A typical solar home could increase its value by more than £2,000 or more – potentially equivalent to half the installation cost alone. Combined with the running cost benefits of installing solar, this means a residential solar system is a powerful investment.

Key findings

For a typical gas-heated home, installing a solar system could reduce energy bills by £1,276 annually. Meaning a payback period of just 5.9 years

In a typical heat pump heated home, installing solar would mean annual savings of £1,454, which despite a longer pay back period of 14 years, delivers a significantly higher NPV (net present value) and a decarbonised home

In a best-case scenario, annual savings could reach more than £2,997 in a gas-heated home, and £3,089 in a heat pump heated home

These running cost savings will ensure an affordable consumer transition to clean heat, particularly with rising energy costs.

Deploying solar to deliver clean heat would also to support the decarbonisation of a huge proportion of carbon emissions

Solar heat technologies are versatile and can be used across a wide range of building types, including for commercial and industrial heat demand

The financial and carbon benefits of the four case studies presented in this report are shown below. Full details of eight case studies are included in the Annex, which accompanies this report.

Location	House type	Effective annual running cost savings using solar technologies (30 years)	Lifetime emissions saved (TCO2)
Midlands	Terraced	£43 - £4,572	9.62 -18.20
Southwest England	Detached	£2,997 - £3,164	13.45
Northeast Scotland	Semi-detached	£382 - £1,419	9.94 - 16.62
London	Terrace	£1,200 - £3,545	9.94 - 16.56

Executive summary

This report demonstrates that using solar to decarbonise a home could cut bills by up to £4,572 per year.

Solar Energy UK's The Value of Solar Heat report explains the carbon and financial benefits of using solar energy to decarbonise residential and commercial buildings in the United Kingdom.

For a typical home, installing solar PV with a heat pump could save £1,454 and deliver a decarbonised home, whilst a gas heated home could save £1,276. In a best-case scenario, annual savings could reach more than £2,997 in a gas-heated home, and £3,089 in a heat pump heated home.

These findings are based on a comprehensive cost model initially developed for Solar Energy UK's groundbreaking research, the Value of Solar Property. This showed that in addition to the running cost savings, installing solar on a home can increase its value by more than £2,000. This is a vital benefit, showing that while cutting carbon to address climate change, solar homes also help consumers to face the cost-of-living crisis. There are also major benefits for commercial property, as case studies included in this report demonstrate.

What is needed now is coordinated action to deliver solar homes and solar buildings. The UK has a legally binding commitment to achieve a net zero economy by 2050, and this, compounded by the urgency of the energy crisis, must serve as the foundation for heat policy.

The Westminster and devolved governments must ensure that existing property owners and occupiers have the support they need to retrofit their property. Key building regulations – such as the Future Homes Standard and Future Buildings Standard – must also be designed so that solar comes as standard on new domestic and non-domestic property. Doing so will enable the UK to reduce bills, cut carbon, and increase its homegrown energy supply. This is the value of solar heat.

Solar Energy UK is available to discuss these and the other recommendations in the Value of Solar Heat report in detail.

Introduction

Heat plays a crucial role in our daily lives; it is essential to our health and comfort. It also represents a significant cost, and, at present, generates major carbon emissions: space, water and industrial heating together account for more than a third of UK greenhouse gas emissions.1

As part of its climate goals, the UK has a legally binding commitment to achieve a net zero economy by 2050. To achieve this, it will need to drastically reduce its dependency on fossil fuels and expand the volume of heat it generates from renewable sources such as solar. Meeting these climate commitments will require the near-complete decarbonisation of heat in buildings and industrial processes. Solar technologies must and can make a significant contribution to heat decarbonisation. Doing so will ensure that consumers and businesses benefit from a clean, affordable, and reliable heat supply.

Despite the severity of the climate crisis, gas remains the predominant heating source in our buildings and industrial processes. The need to transition away from gas was made clear in 2022, with an energy price crisis and rise in consumer bills directly driven by the price of gas. The UK's reliance on fossil fuels has meant that British consumers are at the mercy of global fluctuations in commodity prices. The lack of ownership over energy is contributing to the fact that an estimated 8.2 million homes will be in fuel poverty by 2023. 2

While welcome progress has been made on decarbonising the grid electricity supply, developments in decarbonised heat have lagged significantly. For the UK to meet its zero targets, the government must place heat decarbonisation on equal footing with power decarbonisation. There is, at present, a risk that government policy intended to achieve clean heat will focus narrowly on grid decarbonisation. This does not recognise the direct benefits that can be realised by installing solar technologies directly on homes and businesses.

Government and broader utility stakeholders must understand the relationship between clean and onsite solar heat generation. Recently, low carbon technologies have played an increasingly important role in the UK's heat supply; heat pumps, for example, are central to government policy for gas displacement. Solar and storage technologies are vital to enabling existing low-carbon heat technologies to achieve their potential for decarbonisation.

This report examines the benefits of a range onsite solar and storage technologies in decarbonising heat. The findings are based on a comprehensive quantitative model which has produced new evidence on the carbon and cost savings solar heat technologies. The research is intended to support improvements in the design and installation of renewable and low carbon energy projects into the UK's building stock, helping to advance environmental protection and improvement.

First, it outlines the methodology used to generate the quantitative evidence on the cost and carbon savings of solar heating technologies for consumers and the energy system. Next, it highlights the potential benefits of installing a range of solar heating technologies on four different property types. Then, it outlines the benefits solar heat technologies can provide to the energy system as a whole, looking at residential and commercial scale applications. Finally, it summarises the findings and conclusions.

Methodology[1]

The research for this project included generating a fully modifiable running cost model taking into account an extensive range of variables. This enables the financial and carbon impact of a range of solar technologies to be assessed, explaining the role each can play in decarbonising heat within the UK housing stock.

The model's low carbon technologies (LCT) are solar PV, solar thermal, solar PVT and home storage. Each LCT option is applied to four different heating systems[2] – gas boiler, direct electric heating, heat pump and infrared – for a given property type. This means the costs and benefits of each option can be compared. The baseline for each property type is the same home with no solar technology installed.

The model allows for the selection of individual technologies or combinations of technologies, resulting in more than 20 input variables for a solar heating system to be altered, including:

- **The type, combination, size and direction of solar systems**
- **The cost of the solar system and battery, including operation and maintenance**
- **Property type, location and age**
- **The cost of gas and electricity tariffs**
- **Level of energy efficiency enhancements (EEE), e.g., wall and roof insulation**

The consumption profiles for different housing typologies are generated using the Standard Assessment Procedure (SAP) for each housing typology and property age. Depending on the selections, energy consumption and generation are calculated for the relevant typology, region, EE level, etc., irrespective of the LCT.

The model employs certain assumptions for capital and running costs for each option. These have been validated using real-world data from sources including government and industry. Operational costs cover the running costs for the different technologies. For example, the price for a solar PV system includes the cost of replacing the inverter after 15 years.

The model is designed to provide the following key outputs to present the cost benefits of different combinations of LCTs and the potential case for investment:

- **Annual consumption (annualised) – before & after application of technologies**
- **Capital expenditure (investment costs) and operating expenditure (running costs) - before and after the installation of relevant technologies**
- **Annual income**
- **Annual running costs**
- **Cumulative income**
- **Capitalised savings**
- **Return on investment**
- **Payback period**

The challenge of decarbonising heat

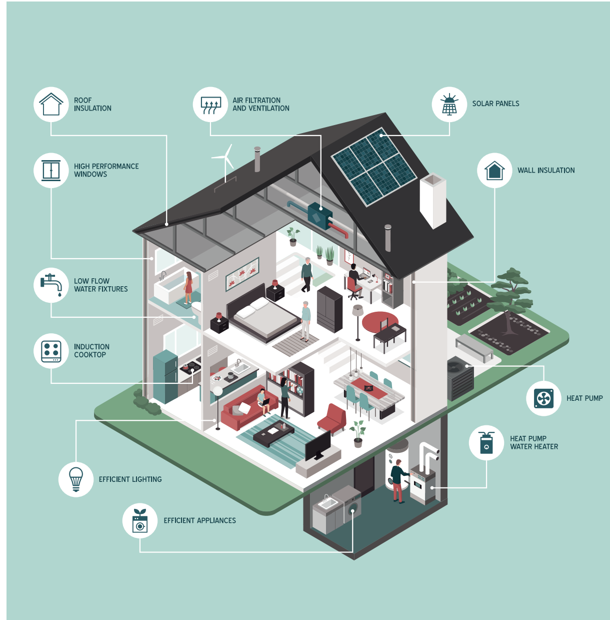
The Department for Business, Energy and Industrial Strategy (BEIS) has noted that "heating is arguably the most difficult of the major energy consuming sectors of the economy to decarbonise."[3]

This is largely due to scale: there are millions of domestic and non-domestic buildings, as well as industrial applications, which have significant heat demand. While the transition to clean heat is challenging, traditional solutions tend to focus on direct heating technologies – primarily gas boilers – while ignoring the significant contribution that clean technologies such as solar can make.

It is generally understood that the most effective way to reduce carbon emissions from heat is to push for the widespread use of electric heating. Currently, UK policy intends to address this via the decarbonisation of the national electricity grid, with clean electricity then powering technologies such as heat pumps. Indeed, the British government has declared a target of more than 600,000 heat pump installations a year by 2028, as noted in the Heat and Buildings Strategy.[4]

Heat pumps are an effective way to decarbonise heating if powered by low-carbon sources of electricity. To realise the full potential of this technology, the deployment of renewable energy generation needs to keep up with the speed of electric heat deployment. Without this, the increased electricity consumption caused by heat pumps would lead to higher electricity bills for consumers, at a time when many are already contending with skyrocketing energy prices. The cost of decarbonisation is likely to feature prominently in debates about how the UK achieves net zero.

The transition to low-carbon heat will therefore require a major shift in our traditional heat production and distribution; we will need to rely on a significant expansion



of low-carbon heating technologies to keep up with demand. One of the main barriers to the uptake of clean heat technologies is the initial upfront cost.

However, the cost of remaining on fossil fuels is high, as the energy crisis has shown. Low carbon heat is more affordable and free from the price volatility of traditional energy sources, as articulated in the case studies below. Onsite technology such as solar enables energy generation at a lower cost than grid electricity, helping to ensure the affordability of heating. It therefore makes sense to support the deployment of onsite renewable heating and electricity generation technologies such as solar PV, solar thermal, and heat and power storage technologies, in addition to supporting the decarbonisation of the grid. However, present government policy does not adequately acknowledge or plan for the contribution of solar and storage in reducing the costs and carbon emissions of fossil-fuelled heating.

An overview of solar technologies and how they work

Solutions for clean heat will vary. The most suitable technology will depend on various factors such as property type, space and water heating demand, and the building's current heating system. Solar is a versatile technology which can complement other heat sources, allowing a significant portion of our heat requirements to be met emissions-free, at zero cost and source. This section provides an overview of solar technologies and other low-carbon heating solutions and how they work.

Solar Technologies

Solar Photovoltaic (PV)

Solar PV systems convert light into power. A typical 3 kW to 4 kW system will likely include 10-14 solar panels, connecting directly to a house's electricity system. Solar PV can produce clean heat by directing electricity for an electric heat technology in the home. This includes heat pumps and direct electric systems.

Solar systems can be installed on flat or sloping roofs. Panels can be installed on a mounting rack fixed to the roof or integrated as part of the roof by replacing roof tiles. Solar can be installed on multi-occupancy properties, although this may entail more complex connection arrangements. Residential solar systems do not usually require planning permission. Any power that is not used can be sent to the national grid, helping to power other homes as well. Homeowners can receive payments from their energy suppliers for this power. Alternatively, most new PV systems are also installed with a battery, meaning surplus power can be stored and used later.

Solar Thermal

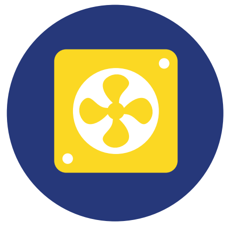
Solar thermal technologies use the sun's thermal energy to provide space and water heating. Solar thermal collectors heat a fluid used to transfer heat around the building, working with a boiler, immersion heater or another system to pump the fluid to where it is needed. Solar thermal can also provide hot water during the winter months or on a cloudy day. An antifreeze solution circulates the loop of an indirect solar thermal system protecting it from sub-zero temperatures. It can also significantly contribute to space heating, usually through an under-floor heating system, which works at a lower temperature than traditional wall-mounted radiators. Solar thermal systems can suit multioccupancy properties with centralised heat and hot water systems. Solar thermal systems can replenish ground heat in ground source heat pump systems built with ground areas that would otherwise be too small.

PV-Thermal (PVT)

Solar thermal collectors can be combined with photovoltaic (PV) modules to produce hybrid PV-thermal (PVT) collectors. These hybrid solar systems combine PV cells mounted on an integrated heat exchanger (or pipes) with circulating fluid. Sunlight is then absorbed by the PV cells within the solar thermal collector to generate electricity and heat. This delivery of heat and electricity simultaneously from the same installed area can provide a higher overall efficiency compared to individual solar-thermal and PV panels installed separately since the fluid can be warmed for useful heat and cool PV cells to make them more efficient. Hybrid PV-T technology provides an up-and-coming solution when roof space is limited or when heat and electricity are required simultaneously.

Low carbon heating solutions

Air Source Heat Pump



Air source heat pumps take heat from the outside air and upgrade it to a higher temperature to provide heating for homes and hot water. Heat pumps are powered by electricity, which can, in turn, be provided by solar. Most heat pump systems in the UK connect to a conventional radiator system and a hot water cylinder and are controlled much like a traditional central heating system. There are also air-to-air systems that distribute warm air through the house. Heat pump efficiency varies considerably and is affected by many factors, such as insulation and the size of radiators. Nevertheless, the efficiency of heat pumps is significantly higher than a gas boiler - it only takes around 1kW of electricity to power the pump to generate around 3kW of heat. Air source heat pumps are suitable for most houses and ground floor flats with a small amount of outdoor space.

Ground Source Heat Pump

Ground source heat pumps (GSHPs) take heat from the ground and upgrade it to a higher temperature to provide heating for homes and hot water. The heat may come from a horizontal loop, buried a metre or more below the surface in a field or large garden, or from vertical boreholes drilled typically 50 to 150 metres down. Ground source heat pumps may also operate using a shared loop, where the heat pumps of multiple households are connected to a network of pipes, which draw heat from several boreholes. These shared loop systems can lead to even greater efficiencies and allow for a phased installation over a larger geographical area. Ground-source heat pumps require more outdoor space than air-source heat pumps but generally exhibit a higher coefficient of performance. Solar thermal systems can replenish ground heat in GSHP systems built with ground areas that would otherwise be too small.

Infrared Heater

Infrared heaters work by converting electricity into energy-efficient radiant heat. With a solar system, infrared heaters can provide an environmentally friendly energy solution. Infrared heaters heat walls and objects directly, releasing heat slowly back into space, making it highly efficient. Infrared is the direct transfer of heat from the heater to the object (people and the room around them) without heating the air. Infrared produces warmth at lower air temperatures, resulting in having to heat less. Infrared heat is the same feeling of warmth as the winter sun on your face and is safe and natural.

The Value of Solar Heating

Case studies

This section presents the financial and carbon benefits of installing a range of low carbon technologies on four different homes around the UK. They are intended to represent the variety of carbon and financial performance which could be expected depending on where the home is located, the financing used to pay for the system, and the property's typology and occupancy characteristics. The figures are produced from the carbon and running cost model developed for this research. Full details on a further eight case studies are presented in the Annex which accompanies this report.

Case study 1

Existing Homeowner; Loan Finance; Mid-terrace; Midlands

This case study represents a typical case of the financial and carbon benefits which could be achieved by installing a range of solar technologies system in a home in the UK; the case study assesses the contribution that solar PV, solar thermal and a PVT system could make to several heating types.

It represents a typical Victorian mid-terraced located in the middle of the UK with no energy efficiency improvements and high energy consumption levels. The home receives an average level of daylight hours. The same house is compared on a like by like basis, using a 2kWp solar PV system, a 6.25m2 aperture solar thermal system and a 6.4m2 & 0.74kWp PVT system. The installation is funded using cash.

The solar PV system generates 2,052kWh/yr of carbon free electricity, which delivers an effective annual saving of £1,276 - £3,530 per year depending on which fuel this offsets.

While the solar thermal system produces 2821 kWh/yr of hot water, which generates an effective annual saving of -£39 to £1,983 a year. Relatively, the PVT system generates 759kWh a year of electricity and 1,305 kWh/yr of heat, which saves £1,249 to £4,572 a year. It's clear from this case study that there is a strong investment case to retrofit a home with any solar heat technology. In this scenario each solar technology produces a positive NPV and saves the homeowner a significant sum of money.

PV

Energy Tariffs		Electric 52p/kWh		Gas 15p/kWh	
Property and system details		1a	1b	1c	1d
Property characteristics	Heating fuel	Gas	Direct electric heating	Heat pump	Infrared
	Location	Midlands		Midlands	
	Property type	Mid-terrace		Mid-terraced	
	Energy efficiency	Baseline		Gas	
	Occupancy	In half day		In half day	
System characteristics	Onsite generation type	PV		PV	
	Annual energy costs (before LCTs)	£2,320	£4,275	£2,736	£4,018
	Annual energy costs (after LCTs)	£1,882	£3,697	£2,183	£3,440
System costs	LCT Capex	£2,505	£3,555	£7,934	£5,622
	Annual Opex (yr1)	£521	£81	£586	£81
System financing	Type	Cash			
	Interest rate (%)	0	0		
	Loan term (years)	0	0		
Financial benefits (running cost)	Annual revenue (year one)	-£83	£498	-£33	£498
	Annual revenue (year ten)	£253	£811	£394	£811
	Net present value (lifespan)	£38,292	£106,978	£43,622	£105,928
	Payback period (years)	5.9	1.5	14.0	2.1
	Effective annual saving (lifespan)	£1,276	£3,565	£1,454	£3,530
Lifetime emissions saved (TCO2)		15.34	9.50	7.99	9.78

Solar Thermal

Energy Tariffs		Electric 34p/kWh		Gas 10.3p/kWh	
Property and system details		1a	1b	1c	1d
Property characteristics	Heating fuel	Gas	Direct electric heating	Heat pump	Infrared
	Location	Midlands		Midlands	
	Property type	Mid-terrace		Mid-terraced	
	Energy efficiency	Baseline		Gas	
	Occupancy	In half day		In half day	
System characteristics	Onsite generation type	Solar Thermal			
	Annual energy costs (before LCTs)	£2,320	£4,275	£2,736	£4,018
	Annual energy costs (after LCTs)	£1,995	£3,316	£2,286	£3,059
System costs	LCT Capex	£5,396	£5,396	£16,474	£6,446
	Annual Opex (yr1)	£597	£157	£662	£157
System financing	Type	Cash			
	Interest rate (%)	0	0		
	Loan term (years)	0	0		
Financial benefits (running cost)	Annual revenue (year one)	-£272	£803	-£212	£803
	Annual revenue (year ten)	-£36	£1,306	-£124	£1,306
	Net present value (lifespan)	£1,307	£60,567	-£1,150	£59,517
	Payback period (years)	29.3	5.1	31.9	6.0
	Effective annual saving (lifespan)	£43	£2,018	-£39	£1,983
Lifetime emissions saved (TCO2)		5.609	5.302	5.609	5.609

PVT					
Energy Tariffs		Electric 52p/kWh		Gas 15p/kWh	
Property and system details		1a	1b	1c	1d
Property characteristics	Heating fuel	Gas	Direct electric heating	Heat pump	Infrared
	Location	Midlands		Midlands	
	Property type	Mid-terrace		Mid-terraced	
	Energy efficiency	Baseline		Gas	
	Occupancy	In half day		In half day	
System characteristics	Onsite generation type	PVT			
	Annual energy costs (before LCTs)	£2,320	£4,275	£2,736	£4,018
	Annual energy costs (after LCTs)	£1,944	£3,580	£2,235	£3,323
System costs	LCT Capex	£5,865	£5,865	£16,944	£6,915
	Annual Opex (yr1)	£607	£167	£615	£167
System financing	Type	Cash			
	Interest rate (%)	0	0		
	Loan term (years)	0	0		
Financial benefits (running cost)	Annual revenue (year one)	-£121	£833	-£67	£833
	Annual revenue (year ten)	£206	£1,356	£354	£1,356
	Net present value (lifespan)	£37,463	£138,223	£44,405	£137,173
	Payback period (years)	10.2	2.7	15.4	3.1
	Effective annual saving (lifespan)	£1,249	£4,607	£1,480	£4,572
Lifetime emissions saved (TCO2)		20.25	9.62	6.54	9.88

Additionally, we ran a sensitivity test to assess the future implications of high energy prices. The tariffs used are based on Ofgem's own figures prior to the announcement of the Energy Price Guarantee; electricity at 51.9p kwh and gas at 14.8 kwh. Although it is unlikely that prices will remain this high for the decades to come, it is unknown how prices will behave once the Government subsidies come to an end in 2024. This scenario therefore represents what could happen if prices return to the predicted 2022 levels. It's clear that the economics for each solar technology improve and return staggering NPVs between £12,208 - £218,398 and depending on which technology and heating fuel is used. This scenario therefore represents the true price of remaining dependent on gas and the opportunity cost of the inaction of investing in renewables.

Energy Tariffs:	**Gas 14.8 (p/kWh)**	**Electricity 51.9 (p/kWh)**		
LCT option	**Gas heated**	**Electric heating**	**Heat pump**	**Infrared**
PV – NPV	£64,524	£166,255	£92,459	£166,255
SWH – NPV	£12,208	£99,420	£28,149	£99,420
PVT – NPV	£66,009	£218,398	£98,126	£218,398
PV – payback yrs	3.2	1.0	2.2	1.0
SWH – payback yrs	19.3	3.4	12.6	3.4
PVT – payback yrs	6.2	1.8	4.4	1.8

Case study 2

Existing homeowner, cash buyer, Detached; South England

This case study represents what may reasonably constitute a best-case scenario for the financial and carbon benefits of installing a solar and battery system. This scenario demonstrates a more recently constructed detached property with prior improvements to its energy efficiency levels. The home is located in Southern England, which has the highest irradiation levels in the UK. This detached house is fitted with a south-facing solar photovoltaic system and a home storage battery; the solar PV array is fitted at an angle of 30 degrees and generates 4,921kWh of electricity per year. The system is paid for with cash, this means there are no costs associated with borrowing money. The solar PV system has been maximised and paired with a larger battery, meaning the consumer can self-consume as much of the energy produced by the solar as possible.

Because the home is energy efficient, it has a relatively low heat demand, and reduced heat loss. This is ideal for low-temperature heating systems like heat pumps. As a result, the heat pump operates at a high efficiency resulting in lower energy demands for heating and hot water where this system is used.

Overall, the system could be expected to save consumers of a heat pump heated home over £3,089 annually and 13.45 of carbon over its lifetime. This combination delivers an impressive payback period of just 9.2 years. Comparatively, a home heated with gas generates a longer payback period of 9.8 years and returns less each year at £2,997. This highlights that transitioning away from gas to low carbon heating technologies not only delivers significant environmental benefits but is also a sound financial decision. This case study emphasises the positive relationship between heat pumps and onsite generation and storage.

Infrared heating also saves energy use with significantly less capital investment required for this form of heating. The solar PV and home battery systems also deliver high self-consumption rates for homes using electricity to meet the heating and hot water demand. This scenario's financial and carbon savings are impressive irrespective of the heating fuel used, with effective annual savings between -£2,997 - £3,164 on running costs, once again highlighting the crucial role of solar in delivering affordable low carbon homes.

Energy Tariffs		Electric 34p/kWh		Gas 10.3p/kWh	
Property and system details		1a	1b	1c	1d
Property characteristics	Heating fuel	Gas	Direct electric heating	Heat pump	Infrared
	Location	Southern England		Southern England	
	Property type	Detached		Detached	
	Energy efficiency	EE5		EE5	
	Occupancy	Home all day		Home all day	
System characteristics	Onsite generation type	PV + battery			
	Annual energy costs (before LCTs)	£2,536	£4,090	£2,520	£3,859
	Annual energy costs (after LCTs)	£629	£2,294	£603	£2,063
System costs	LCT Capex	£13,078	£13,078	£13,078	£13,078
	Annual Opex (yr1)	£1,246	£706	£1,121	£706
System financing	Type	Cash buyer			
	Interest rate (%)	0%			
	Loan term (years)	0			
Financial benefits (running cost)	Annual revenue (year one)	£660	£1,090	£796	£1,090
	Annual revenue (year ten)	£2,188	£2,442	£2,292	£2,442
	Net present value (lifespan)	£89,897	£94,905	£92,666	£94,905
	Payback period (years)	9.8	8.3	9.2	8.3
	Effective annual saving (lifespan)	£2,997	£3,164	£3,089	£3,164
Lifetime emissions saved (TCO2)		13.45	13.45	13.45	13.45

Case study 3

Homebuyer, Green Mortgage, Semi-detached, NE Scotland

This case study represents a sub-optimal scenario for the financial benefits of installing solar heat technologies. The semi-detached house, built between 1996-02 in Northeast Scotland, has some modest energy efficiency enhancements. The home buyer opts to install a solar thermal system, a solar photovoltaic system, and a home storage battery at the point of purchase. The low carbon technologies are procured at an interest rate of 2% over the 25-year mortgage term. The point of purchasing a home is often seen as a catalyst for investing in improvements to the home since this coincides with opportunities to borrow additional funds to pay for the enhancements.

The home's orientation is not ideal (facing East/West), and daylight levels are lower than in most other parts of the UK. The solar thermal system has an aperture of 5m2, which offsets ~30% - 40% of the home's hot water demands. The 3kWp PV system generates 2,367 kWh/yr, and the 8kW battery facilitates a high self-consumption rate of 88% - 95%. Although this is not considered an optimised scenario, the combined low carbon technologies still generate significant savings in energy costs compared to the same home without any low carbon technologies.

In this scenario, the capital costs for any energy efficiency improvements are excluded since they come with the home as they were. Overall, this scenario shows that installing solar technologies remains a sound financial decision. Despite varying payback periods, every investment in a solar heating system returns a positive net present value, even where a loan is used to buy the system. Annual savings vary between £575- £1,419 depending on the heating system used. Gas boilers and heat pumps have higher operational and maintenance costs than direct electric/infrared heating systems, which impact the investment. Nevertheless, they are still higher than the upfront capital and lifetime operating costs.

Energy Tariffs		Electric 34p/kWh		Gas 10.3p/kWh	
Property and system details		1a	1b	1c	1d
Property characteristics	Heating fuel	Gas	Direct electric heating	Heat pump	Infrared
	Location	NE Scotland		NE Scotland	
	Property type	Semi detached		Semi detached	
	Energy efficiency	EE2		EE2	
	Occupancy	Out all day		Out all day	
System characteristics	Onsite generation type	PV + solar thermal + battery			
	Annual energy costs (before LCTs)	£2,066	£3,210	£2,082	£3,050
	Annual energy costs (after LCTs)	£831	£1,776	£809	£1,616
System costs	LCT Capex	£28,337	£28,337	£36,037	£29,687
	Annual Opex (yr1)	£1,210	£690	£1,126	£690
System financing	Type	Green mortgage			
	Interest rate (%)	2%			
	Loan term (years)	25			
Financial benefits (running cost)	Annual revenue (year one)	-£1,426	-£707	-£1,698	-£776
	Annual revenue (year ten)	-£407	£312	£678	£243
	Net present value (lifespan)	£17,263	£42,559	£11,469	£40,830
	Payback period (years)	26.0	14.8	28.0	16.0
	Effective annual saving (lifespan)	£575	£1,419	£382	£1,361
Lifetime emissions saved (TCO2)		16.62	11.31	9.94	11.57

Case study 4

Social landlord and tenant, Loan finance, End-terrace, London

In this scenario, a housing association finances a solar thermal and PV system for a tenanted dwelling as part of its portfolio to improve the energy efficiency of its housing stock. A solar thermal system with an aperture of 5 m2 is installed, and a 2.5 kWp solar PV system, where the solar thermal system offsets 40% - 55% of the hot water consumption, and the PV system generates 2,647 kWh each year. The property is an end terrace home located in the London and fitted with a solar thermal and PV system.

This scenario provides an example of how costs and benefits can be split between a social landlord and their tenant, where the initial investment in the property is made by the housing association, which is assumed to own and manage it.

In this case, the tenant would not be liable for the capital cost of installing the system. However, the housing association could choose to recover all or some of the capital outlay through increased rent or a service charge. The tenant would receive the benefits of the reduction in electricity costs in total, while the housing association would receive any payment for exported electricity via the Smart Export Guarantee. The housing association would also be liable for any ongoing operational costs. Under the split benefit arrangement, the tenant receives a reduction in energy costs of £472 to £878 per year, and the social landlord derives a benefit of £70 to £90 per year.

While the export payments would comfortably repay the finance costs associated with the investment, the social landlord might not fully recover its costs. However, the landlord owns the asset and would ultimately benefit from investing in future proofing the property and ensuring tenants can reside with lower energy costs and therefore less risk of defaulting on their rent.

Energy Tariffs		Electric 34p/kWh		Gas 10.3p/kWh	
Property and system details		1a	1b	1c	1d
Property characteristics	Heating fuel	Gas	Direct electric heating	Heat pump	Infrared
	Location	Thames		Thames	
	Property type	End terrace		End terrace	
	Energy efficiency	EE4		EE4	
	Occupancy	Home all day		Home all day	
System characteristics	Onsite generation type	PV + solar thermal			
	Annual energy costs (before LCTs)	£2,825	£4,882	£3,284	£4,657
	Annual energy costs (after LCTs)	£1,822	£2,984	£1,814	£2,759
System costs	LCT Capex	£7,591	£7,591	£11,862	£8,641
	Annual Opex (yr1)	£722	£242	£622	£242
System financing	Type	Secured loan			
	Interest rate (%)	2%			
	Loan term (years)	3			
Financial benefits (running cost)	Annual revenue (year one)	-£2,326	-£952	-£3,226	-£1,312
	Annual revenue (year ten)	£903	£2,672	£1,696	£2,672
	Net present value (lifespan)	£35,996	£106,350	£64,041	£105,268
	Payback period (years)	12.4	4.3	10.1	4.9
	Effective annual saving (lifespan)	£1,200	£3,545	£2,135	£3,509
Tenant benefit	Annual reduction in energy costs (yr1)	£876	£1,845	£1,394	£1,845
	Annual reduction in energy costs (yr10)	£1,374	£2,898	£2,189	£2,898
HA cost-benefits	Annual SEG payments (yr1)	£128	£52	£75	£52
	Annual SEG paments (end of life)	£489	£201	£288	£201
	Payback	>40yr	>40yr	>40yr	>40yr
Lifetime emissions saved (TCO2)		16.56	11.30	9.94	11.55

The system wide benefits of solar heat

The findings presented in this report are clear: residential solar heat technologies deliver significant financial and carbon benefits.

First, the installation of a solar system leads to direct savings on energy bills, because of the reduced amount of electricity which needs to be bought from the national grid. Second, solar systems reduce the amount of carbon a home generates. Homes can therefore become active contributors to the UK's net zero objective, rather than simply being passive consumers of gas and electricity.

In a best case-case scenario, solar heat technologies can offer an effective annual saving of £2,997 - £3,164, depending on which heating system is used. This means the system would pay for itself in around nine years and save 13.4 tonnes of carbon dioxide over its lifetime. The effective annual benefits are also impressive under a typical scenario, with savings varying between £44 - £ 4,572.

The running cost savings apply across the board, including for households on lower incomes and social tenants, all of whom will benefit from the improved affordability of running a home with lower energy bills. What is clear under every scenario tested is that a home with a modern form of heating – such as a heat pump, or infrared heating – delivers the best financial performance. This means the investment case for transitioning away from gas to onsite heat generation has never been greater. Doing so is in the national economic and environmental interest.

To demonstrate the benefits of residential solar heat technologies to the UK overall, we aggregated the financial and carbon benefits that solar can deliver to UK homes. Our analysis shows that if every home currently dependent on gas, oil or LPG for its heating installed a heat pump, and combined this with solar thermal, solar PV and a battery, it would save an estimated 21 million tonnes of carbon dioxide overall per year, and £41 million in energy costs.

This provides further proof that the best way for the UK reduce domestic energy bills, and increase energy security, is to reduce its dependency on gas, by installing solar technologies in combination with a low carbon heating system.

The commercial application of solar heat

Surging energy prices are also affecting UK businesses. To help businesses contend with rising costs the Government has announced the Energy Relief Bill support scheme, but it's important to note that this support will run on a six-month basis initially. This poses the question of businesses will do when the support scheme comes to an end? Without support businesses will be left to bear the brunt of volatile wholesale gas prices, Cornwall Insight analysis has predicted that the price cap will remain significantly above £3,000 a year until at least 2024.[5]

Prior to the announcement of the support it was reported that gas prices are predicted to contribute to two-thirds of UK pubs closing this winter.[6] Similarly, 79% of public leisure facilities said they were extremely likely to face closure within the next 6 months without support.[7] Businesses are particularly vulnerable to volatile wholesale prices, and there is no guarantee that the Energy Bill Relief Scheme will be extended, leaving businesses in the same catastrophic position as Autumn 2022. It is now even clearer that the swift decarbonisation of heat and electricity supplies is in the national economic interest.

Solar heat technologies' carbon and financial benefits expand beyond residential applications. Solar is a diverse technology which can be applied at all scales, and solar thermal technologies can meet even commercial and industrial heat and hot water needs. On-site and commercially sized solar technologies offer businesses a unique opportunity to significantly reduce their heat costs for the system's lifespan, typically 35 years. This is because producing heat and power on-site is much more affordable than buying it from the grid. On-site heat and power generation is done at a fixed cost, meaning businesses can avoid exposure to further increases in energy bills. As we move to greater levels of electrified heating

Additionally, solar energy is zero-carbon at the point of generation. This improves the environmental performance of any building on which it is installed. Developing on-site generation capacity now also means they have a clean, affordable energy source for other commercial scale low carbon technologies, such as heat pumps, which are rapidly being installed. These benefits are widely recognised by businesses around the UK, which is why the UK's commercial-scale solar sector is going from strength to strength. The section below describes 4 case studies where solar has successfully contributed to larger projects' space and water demand.

Case study 1

Bristol City Council
– Solar thermal for hot water demand

Location: Easton Leisure Centre, Bristol

Installer: Solarsense, May 2021

Technology: Solar thermal

System size: 840 tubes

Area size: 80 sq. meters

Solar thermal is especially well suited to the hospitality sector and public buildings such as leisure and health centres, given their available roof space, and typically high hot water demand for cooking, cleaning and facilities such as swimming pools.

This installation of this solar thermal system in a public leisure centre in Easton, has significantly reduced their heating bills. The leisure centre has reported that their heating bill has now been brought down to zero, and the addition of solar thermal has also saved nearly 13 tonnes of CO_2 each year. The installation consisted of 800 solar thermal tubes flat on the flat roof, which transfer the heat generated into the existing hot water storage.

Councillor Kye Dudd, Cabinet Member for Climate, Ecology, Waste and Energy at Bristol City Council said: "It's exciting to see such a vital and visible part of the community as Easton Leisure Centre taking action to reduce their emissions and support Bristol's climate ambitions. Our clean energy programme has saved the city millions of pounds through reduced energy bills, whilst making a massive reduction in our carbon emissions and reinforcing Bristol's position as one of the UK's most sustainable cities."

Case study 2

Naked Energy
– Solar thermal and solar PVT for hot water demand

Location: University of Westminster

Installer: Solar thermal and Solar PVT

Technology: Solar thermal

System size: 135 VirtuHOT and 60 VirtuPVT solar collectors

Area size: 139 m2

Based in North London in the UK, the University houses over 10,000 students for up to 12 months of the year across their student accommodation, with 3,000 located in their Harrow Campus. The University selected Naked Energy's technology as part of an integrated approach to tackle its Scope 1 and Scope 2 emissions and reach net zero CO_2 emissions by 2025. Improving student experience by enabling students to engage with renewable generation onsite was also a high priority for the University. The University of Westminster needed to supply hot water for 3,000 students on its Harrow Campus. They required a high energy density solution with limited roof space on the city campus.

The installation generates 44,100 kWh/year of annual thermal output and 3,487 kWh/year, resulting in 4981 kg of carbon saving each year.

"Naked Energy's VirtuPVT collectors provide simultaneous solar heat and power by combining PV and solar thermal elements in the same evacuated tube. The sister product, VirtuHOT, provides only solar heat in higher quantities. Both can supply heat well above 60 ºC, which is ideal for domestic hot water. Using the combination of both collectors, the University could balance heat and power provision to suit the project."

Case study 3

Silkeborg – Solar district heating with inter-seasonal storage

Location: Denmark

Technology: Solar thermal

System size: 12,436 solar thermal collectors

Area size: 156, 694 m2

Solar heat technologies' flexibility means they can successfully feed into district heating networks. Solar thermal is highly successful in other European countries. Denmark, for example, has a well-established solar district heating network. Solar heat networks, powered by PV and solar thermal, deliver a cost-effective way of reducing carbon emissions from heating at scale.

Silberberg, Denmark, hosts a 156,700 m² (110 MW) plant where solar-thermal delivers 20% of the annual district heating demand.9 "Solar collectors have been the most cost-effective technology to supply 22,000 households with renewable heating and help the area reach the goal of 100% carbon neutral heat by 2030." 10 The installation also includes inter-seasonal storage, meaning surplus heat is stored in tanks for later use.

Solar thermal now plays an essential role in Denmark's extensive district heating systems. The Climate Change Committee estimated that by 2050 heat networks and district heating will need to meet around 18% of the UK's heat demand. Solar is a complimentary technology, as articulated in the case study above.

Case study 4

Greater London – Communal Energy

Location: Greater London Planning Authority

Technology: Solar PV, heat pump

System size: 400 kWp PV system &

Area size: 550 flats across 14 multi-storey blocks of 2-8 storeys

This case study represents a communal energy system, with a central plant room providing heat and hot water via a network of pipework to all dwellings in the development. The following case study is taken from a proposed development in Greater London where the Local Planning Authority and the Greater London Planning Authority. The proposed development is for ~550 flats across 14 multi-storey blocks of 2-8 storeys with some small commercial space on the ground floor of two blocks.

The block of flats utilises large-scale heat pumps to supply heating and hot water to each apartment and commercial space. A large solar PV array of ~400 kWp is located on the roof of all blocks (except the block hosting the heat pump condenser units). It is designed to directly supply the central energy-generating plant with power generated from the solar array. The use of solar PV, in this way, ensures the carbon intensity of the heat delivered is reduced further by using renewable energy at the point of generation to power the heat pumps.

Using renewable electrical generation from solar PV to supplement the heat pumps' electrical demands would help alleviate high electricity supply costs and ensure more of the local generation is consumed at the point of use. A notional calculation for the resultant reduction in the carbon intensity of the heat supplied by the proposed system, assuming 100% of the PV output is supplied to the Energy Centre, is provided below for information.

- SAP 10.0 carbon intensity for electricity – 0.233 kgCO2/kWh
- Carbon generated by heat pumps – 193,254 kgCO2/yr (829,418kWh electricity required)
- Carbon intensity of heat delivered by a heat pump – 86.3 grams CO2/kWh
- PV supplements electrical demands of heat pump – 282,338 kWh/yr.
- Resultant carbon intensity of heat delivered = 56.9 grams CO2/kWh

Conclusion

The evidence is clear: there has never been a stronger case for a decisive move towards using solar technology for heating. Solar can reduce the impact of the cost of living crisis while enabling the UK to make progress on its net zero targets.

British consumers are now facing significant uncertainty due to global fluctuations in commodity prices. The UK's reliance on fossil fuels has created the energy price crisis. The fastest and easiest way to address this is to deploy more solar technology on homes and buildings around the country. Doing so will cut costs, displace fossil fuels, reduce carbon, and increase our energy security.

This report demonstrates that homes fitted with solar heat technology create huge consumer savings. Installing different combinations of solar heat technologies on residential properties also delivers significant reductions in carbon emissions.

What is needed now is coordinated action to deliver solar homes and solar buildings. As part of its climate goals, the UK has a legally binding commitment to achieve a net zero economy by 2050. This, compounded by the urgency of the energy crisis, must serve as the foundation for heat policy. The Westminster and devolved governments must ensure that existing property owners and occupiers have the support they need to retrofit their property. Key building regulations – such as the Future Homes Standard and Future Buildings Standard – must also be designed so that solar comes as standard on new domestic and non-domestic property. Doing so will enable the UK to reduce bills, cut carbon, and increase its homegrown energy supply.

Solar Energy UK is available to discuss these and the other recommendations made in this report.

Solar technologies can ensure that consumers and businesses benefit from a clean, affordable, reliable heat supply. We must not miss the opportunity.

Glossary

Battery storage – A type of rechargeable energy storage. Batteries are used to store surplus power produced by a solar energy system for later use

CCC – Climate Change Committee. This an independent an independent statutory body established under the Climate Change Act 2008 to advise the UK and devolved governments on emissions targets and preparing for and adapting to the impacts of climate change

Electrification – The use of electricity (supported by solar heat) instead of fuel (such as gas) to provide energy for heat and transport. The source of electricity should be renewable (such as solar power) and not fossil fuels (such as coal or gas) to ensure the climate benefits of electric technology are realised

Energy Performance Certificate – This is a statement of information about a property's energy use and costs. It is required whenever a property is built, sold, or rented. It provides an energy efficiency rating from A to G, where A is the most efficient

Heat pump – Heat pumps take energy from a relatively low temperature source and forces that heat to a higher temperature making it more useful. Sources of heat include the ground, water and air (19).

The grid – The interconnected network of cabling and other equipment which transports electricity around the country

kW – kilowatt. A measure of electric or thermal power

kWh – kilowatt hour. A measure of electric or thermal energy. The provision of one kilowatt of electric or thermal power for an hour. A typical home in the UK uses around four kWh of electricity and 33 kWh of heat per day.

MCS – Microgeneration Certification Scheme. The quality assurance and standards body for residential renewable technologies in the UK

MW – megawatt. A measure of electric power equivalent to 1,000 kilowatts

MWh – megawatt hour. The provision of one megawatt of electric power for an hour

Net zero – this means that any carbon or other emissions produced by an economy are balanced by the equivalent number of emissions being taken out of the atmosphere. Achieving net zero requires both reducing absolute emissions, and offsetting any that remain

NPV – net present value. This is an investment metric which refers to the lifetime cost or benefit of an investment, accounting for the cost of borrowing money and other factors relating to how the value of money changes over time. An NPV above zero means that over its lifetime, an investment will provide a positive return. For example, if a project has a total NPV of £4,000, the person or organisation which paid for the project will be £4,000 better off

PV – photovoltaic. A type of solar energy system which converts light into electricity

Running costs – where this is included in a table in this report, this refers to the assumed annualised cost of ensuring a solar system is kept clean and maintained. This includes a calculation to reflect the cost of replacing the system's inverter, and any battery equipment, where relevant.

Solar property – A home which includes one or more of a solar PV system, an energy storage system such as a battery, and intelligent controls, such as a smart meter, which allows its technology to interact with the electricity grid

Solar PVT (Photovoltaic Thermal) – a type of solar energy system which converts light into usable heat and power

Solar Thermal – a type of solar energy system which converts light into usable heat, e.g., for hot water or industrial processes

References

1 This is a condensed summary of the methodology and assumptions underpinning this quantitative model. More detail is provided in the Annex which accompanies this report.

2 Since heating still comprises a large proportion of energy costs in UK housing it is useful to understand the relative cost-benefits of different LCTs when applied to homes heated using different systems.

3 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/766109/decarbonising-heating.pdf

4 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1044598/6.7408_BEIS_Clean_Heat_Heat___Buildings_Strategy_Stage_2_v5_WEB.pdf

5 https://www.cornwall-insight.com/press/price-cap-to-remain-significantly-above-3000-a-year-until-at-least-2024/

6 https://www.morningadvertiser.co.uk/Article/2022/08/23/Three-quarters-of-pubs-likely-to-close-in-energy-crisis

7 https://www.ukactive.com/news/sector-leaders-call-for-urgent-action-from-government-as-energy-costs-put-leisure-facilities-and-pools-at-risk-of-closure-within-six-months/