AUTHOR(S): ABU-BAKAR, S.H., MUHAMMAD-SUKKI, F., RAMIREZ-INIGUEZ, R., MUNIR, A.B., YASIN, S.H.M., MALLICK, T.K., MCLENNAN, C. and RAHIM, R.A.

TITLE: Financial analysis on the proposed renewable heat incentive for residential houses in the United Kingdom: a case study on the solar thermal system.

YEAR: 2014

Publisher citation: ABU-BAKAR, S.H., MUHAMMAD-SUKKI, F., RAMIREZ-INIGUEZ, R., MUNIR, A.B., YASIN, S.H.M., MALLICK, T.K., MCLENNAN, C. and RAHIM, R.A. 2014. Financial analysis on the proposed renewable heat incentive for residential houses in the United Kingdom: a case study on the solar thermal system. Energy policy [online], 65, pages 552-561. Available from: http://dx.doi.org/10.1016/j.enpol.2013.10.018

OpenAIR citation: ABU-BAKAR, S.H., MUHAMMAD-SUKKI, F., RAMIREZ-INIGUEZ, R., MUNIR, A.B., YASIN, S.H.M., MALLICK, T.K., MCLENNAN, C. and RAHIM, R.A. 2014. Financial analysis on the proposed renewable heat incentive for residential houses in the United Kingdom: a case study on the solar thermal system. Energy policy [online], 65, pages 552-561. Held on OpenAIR [online]. Available from: https://openair.rgu.ac.uk.

Financial Analysis on the Proposed Renewable Heat Incentive for Residential Houses in the United Kingdom: A Case Study on the Solar Thermal System.

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Abstract: This short communication paper focuses on the renewable heat incentive (RHI) scheme in the United Kingdom (UK); and in particular, on its implication to domestic installations of solar thermal systems (STSs). First, a short review on the STS in the UK is provided. Then, a detailed description of the RHI is discussed. A financial analysis is presented afterwards, analysing the impact of the RHI scheme on the applicants, in terms of the net present value and the internal rate of return. From the financial analysis it has been found that the RHI scheme for domestic installation is only generating desirable scenario if a longer period of RHI payment, i.e. 17 years, or a higher RHI rate i.e. £0.32 per kWh is implemented. The current proposal from the UK government is not financially viable, and as a result, may hinder the penetration of domestic solar thermal systems in residential sector in the UK.

Keywords - Solar energy; solar thermal system; renewable heat incentive

1. Introduction

From 1970 until 2011, the total energy consumption in the UK varies between 1,628 and 1,861 TWh, which was mainly supplied by petroleum, gas, electricity and solid fuel (Department of Energy and Climate Change (DECC), 2012a). Although the energy consumption do not vary much, significant changes can be seen in terms of total expenditure on energy, i.e. from about £5 billion in 1970 to about £134 billion in 2011 (Department of Energy and Climate Change (DECC), 2012a) mainly due to the increase in the fossil fuel price. Specifically in the domestic sector, the data from 1990 until 2011 indicates that the consumers consumed roughly around 80% of the total energy for space heating and hot water, as illustrated in Figure 1.

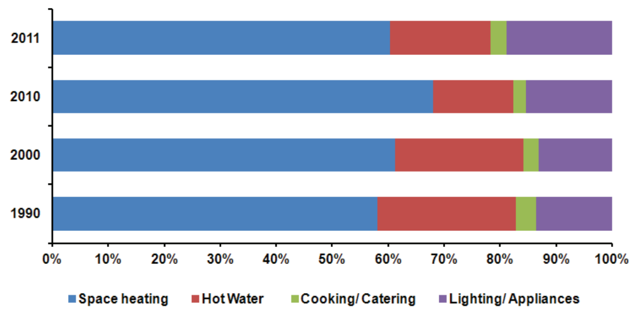

Figure 1: The breakdown of energy usage in domestic sector. Adapted from (Department of Energy and Climate Change (DECC), 2012a).

The rising trend in population, plus other factors such as fossil fuel dependency, energy security and energy cost caused the UK Government to elevate the usage of renewable energy in the country. In terms of solar energy, the UK receives a moderate amount of sunlight, with an insolation of between 800 and 1,300 kWh/m^2 per year (Jardine and Lane, 2003) depending on location, with an average of around 1,000 kWh/m^2 (Energy Saving Trust (EST) UK, 2005). One of the potential solutions in providing heat to buildings via solar energy is by installing a solar thermal system (STS). The report by the European Solar Thermal Industry Federation (ESTIF) has seen an upward trend in the installation of STS in the UK. The total capacity installed in the UK grew from 74 MW_{th} in 2001 to about 460 MW_{th} in 2011 (European Solar Thermal Industry Federation (ESTIF), 2012). Figure 2 shows estimated performance of STSs[1] installed in selected locations in the UK. In general, the output from the STS is higher throughout the March-September period.

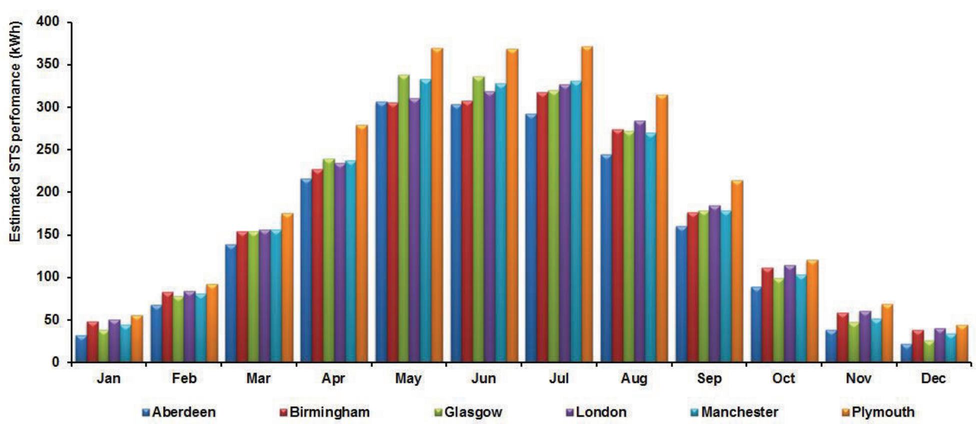

Figure 2: Estimated performance of STS in selected locations in the UK.

[1] It is assumed that an AES flat plate collector with an area of 5m^2 is used in all installations, and the collectors are placed at the optimum position - mounted on a south facing rooftop (Thomas et al., 1999).

2. Renewable Heat Incentive for Domestic Sector

The Renewable Heat incentive (RHI) is a financial incentive that aims at encouraging uptake of renewable heat technologies in the UK (Energy Saving Trust (EST) UK, 2012b). The UK government projected that the RHI will contribute to ensure that 12% of the heating will come from renewable sources by 2020 (Department of Energy and Climate Change (DECC), 2011a). This scheme covers a number of heat technologies namely biomass boiler, heat pump, STS and biomethane and biogas combustion (Department of Energy and Climate Change (DECC), 2011a). Prior to the RHI, there were other measures that have been implemented in the UK related closely to the STS, and the major ones are tabulated in Table 1. Detailed descriptions about these measures have been covered by the authors in Abu-Bakar et al. (2013).

Table 1: Summary of measures that relate to the STS (Abu-Bakar et al. (2013)).

Item	Regulatory	Policies	Programme	Financial Incentive
Energy Saving Trust (1992-to date)			/	/
Energy Efficiency Commitment (2002-2008)				/
Energy Act (2004)	/			
Climate Change and Sustainable Energy Act (2006)	/			
Microgeneration Strategy (2006)		/		
Low Carbon Building Programme (2006-2011)				/
Carbon Emission Reduction Target (2008-2012)				/
Climate Change Act (2008)	/			
Energy Act (2008)	/			
The UK National Renewable Energy Action Plan (2010)		/		
Renewable Heat Premium Payment (2011-2013)				/
Renewable Heat Incentive (2011-to date)				/
Microgeneration Strategy (2011)		/		
Energy Act (2011)	/			
Green Deal (2012)				/

Initially, the RHI only covers the non- domestic installation of renewable heat technologies – which is the Phase 1 of the RHI (Department of Energy and Climate Change (DECC), 2011a). However, the government proposed to include financial payment for the deployment of these technologies for domestic usage (which is the Phase 2 of the RHI) to promote more uptakes in the household sectors following a consultation in September 2012 (Department of Energy and Climate Change (DECC), 2012b). Similar to the feed-in tariff (FiT) scheme, the RHI will guarantee a fixed payment per kWh of heat generated by renewable heat technology for a particular contract duration. For the domestic installation, the government proposed a rate of £0.0173 per kWh paid for a contract period of 7 years (Department of Energy and Climate Change (DECC), 2012b). The scheme is expected to be announced in summer 2013, with the funding projected to commence in early 2014.

The RHI rate is index-linked and the yearly rate will be determined in proportion to the change in the Retail Price Index (RPI) of the previous year (Department of Energy and Climate Change (DECC), 2011a), e.g. if the RPI is 3%, the RHI rate per kWh for that year will be increase by 3%. The government projected that by 2020, the domestic sector will contribute approximately 3.3 TWh annually with a projected number of installations totalling to roughly 380,000 (Department of Energy and Climate Change (DECC), 2012b).

The announcement of the RHI scheme received mixed responses from various groups. The Renewable Energy Association welcomed the scheme by saying that they are "delighted that the government has published these proposal" (Clark, 2012), but many agreed the RHI scheme for domestic sector requires more review to determine the right tariff and payment duration. Solar Trade Association commented that "the tariff level proposed for solar thermal will concern many of our members" and is campaigning for a higher RHI rate (Clark, 2012). Another comment from Micropower Council indicates that "the tariff levels for biomass and solar are problematic and will probably not provide adequate returns to help this technologies flourish" (Clark, 2012).

3. Financial Analysis

In order to evaluate the profitability and the economic aspects of an STS installation in the domestic sector, it is useful to use the following widely accepted investment appraisal methods (Feibel, 2003; Khan 1993): the net present value (NPV) and the internal rate of return (IRR). The nomenclature needed for the financial analysis is presented in Table 2. Based on these nomenclatures, the relations between the financial parameters are given in Equations (1) to (6).

Table 2: Nomenclature for the financial analysis.

Item	Symbol	Amount	Unit
Annual Maintenance Cost	M		£
Annual RHI Income	R_{RHI}		£
Annual Revenue	R_A		£
Annual Saving from Onsite Usage	R_{SAV}		£
Annual Solar Insolation	S_T	800-1300	kWh/m^2
Annual STS Output	Q_S		kWh
Average Annual Return on Investment	ROI		£
Duration	T	20	year
Discounted rate	r_d	3.5	%
Installation Cost	C		£
Internal rate of return	IRR	≥ 6	%
Net present value	NPV	> 0	£
Overall Collector's Efficiency	E_c		
Positioning Factor	K_P	0.95	
RHI rate	r		£
Solar Collector Area	A		m^2
Utility Rate (Gas or Electric)	u		£

$$Q_S = E_c * K_P * S_T * A * 0.46 \quad (1)$$

$$R_{RHI} = Q_S * r \quad (2)$$

$$R_{SAV} = Q_S * u \quad (3)$$

$$R_A = R_{RHI} + R_{SAV} - M \quad (4)$$

$$NPV = -CF_0 + \sum_{T=1}^{20} \frac{CF_T}{(1+r_d)^T} \quad (5)$$

$$IRR = -CF_0 + \sum_{T=1}^{20} \frac{CF_T}{(1+IRR)^T} = 0 \quad (6)$$

The NPV is a measure which involves a series of cash flows for the lifetime of the STS, which enables the 'profits' to be seen (Sudtharalingam et al, 2010; Muhammad-Sukki et al, 2012). It adds up the discounting future cash flow (CF), (in this case the net annual revenue, (R_A)), for the whole period (T), before deducting the initial capital investment (C), as illustrated in Equation 5. The discounted rate, (r_d) chosen for this is selected to be 3.5% (Department of Energy and Climate Change (DECC), 2012c). A positive value of NPV indicates that the investment is feasible while a negative value implies that the investment should be discarded (Sudtharalingam et al, 2010; Muhammad-Sukki et al, 2012). An example of the cash flow is presented in Table 3.

Table 3: An example of cash flow from implementing an STS in the UK (S_T = 1300 kWh/m^2).

Duration (year)	Panel performance actor (%)	Annual STS Output (kWh)	Annual RHI Income (£)	Annual Saving from Onsite Usage (replacing gas boilers) (£)	Annual Maintenance Cost (£)	Annual Revenue (£)	Cash flow (£)
0							-3900.00
1	100.0	2,840.50	491.41	127.54	64.00	554.94	-3,345.06
2	99.5	2,826.30	503.62	137.05	65.92	574.75	-2,770.30
3	99.0	2,812.10	501.09	147.27	67.90	580.46	-2,189.84
4	98.5	2,797.89	498.56	158.25	69.93	586.87	-1,602.97
5	98.0	2,783.69	496.03	170.04	72.03	594.04	-1,008.93
6	97.5	2,769.49	493.49	182.71	74.19	602.01	-406.92
7	97.0	2,755.29	490.96	196.32	76.42	610.86	203.94
8	96.5	2,741.08		210.93	78.71	132.22	336.16
9	96.0	2,726.88		226.62	81.07	145.55	481.71
10	95.5	2,712.68		243.48	83.51	159.97	641.68
11	95.0	2,698.48		261.58	86.01	175.57	817.25
12	94.5	2,684.27		281.02	88.59	192.43	1,009.67
13	94.0	2,670.07		301.89	91.25	210.65	1,220.32
14	93.5	2,655.87		324.31	93.99	230.32	1,450.64
15	93.0	2,641.67		348.38	96.81	251.58	1,702.22
16	92.5	2,627.46		374.23	99.71	274.52	1,976.74
17	92.0	2,613.26		401.98	102.70	299.28	2,276.03
18	91.5	2,599.06		431.78	105.78	326.00	2,602.03
19	91.0	2,584.86		463.78	108.96	354.82	2,956.85
20	90.5	2,570.65		498.13	112.22	385.90	3,342.75

As for the IRR, this can be defined as the growth rate of the project, which is found when the NPV value is equals to zero. For any solar STS installation, the proposed IRR value should be at minimum 6% - as estimated by the UK government (Department of Energy and Climate Change (DECC), 2011b). In general, the higher the IRR, the more desirable the project becomes (Investopedia, 2011). The formula for the IRR is shown in Equation 6 and the equation can be solved either by using the Newton-Raphson method or by linear interpolation (Think&Done, 2011).

To ease the calculation, these assumptions are taken into account:

1. The financial analysis is conducted on domestic buildings, using different values of solar insolation (800-1,300 kWh/m^2/year).
2. For the domestic installation, the typical size of solar collector is used, i.e. 5m^2, and the installation cost of this system is estimated to be £3,900 (McLennan, 2012). It is assumed that AES flat plate collector is used in all installations, and the collectors are placed at the optimum position - mounted on a south facing rooftop on a 35^o pitch from horizontal (Thomas et al., 1999).
3. The overall efficiency of the collector degrades by 0.5% annually (Cassard et al., 2011).
4. The annual maintenance cost is £64 (McLennan, 2012), and increases by 3% each year due to inflation.
5. The calculation is done for the duration of 20 years (which is the average lifespan of the STS).
6. In each location, two cases are analysed: Case (i) the utility bill savings when replacing gas heating, and Case (ii) the utility bill savings when replacing electric immersion heating. According to the EST, the average gas price is £0.049/kWh and the average electricity price (standard rate) is £0.1439/kWh (Energy Saving Trust (EST) UK, 2012a).
7. The RHI rate is £0.0173 paid for a duration of 7 years (Department of Energy and Climate Change (DECC), 2012b). However, each year, the price is also adjusted by 3% due to inflation Department of Energy and Climate Change (DECC), 2011).
8. It is assumed that the annual utility cost increases by 8% per year (Cherrington et al., 2013).

The cash flows obtained from the financial analysis are presented in Figure 3, while the NPV and the IRR analysis are presented in Table 4. It is found that for Case (i), only installation of STS in a location that receives solar insolation of minimum 1200 kWh/m^2 is feasible since it generates a positive NPV and an IRR of more than 6%. As for Case (ii), all installations are feasible, generating an NPV of as high as £9,163.34 and a maximum IRR of 22.35% annually. It is observed that an STS that replaces electric immersion heating generates a higher return than the one that replaces gas heating, owing to the fact that the average cost of electricity is three times the cost of gas heating.

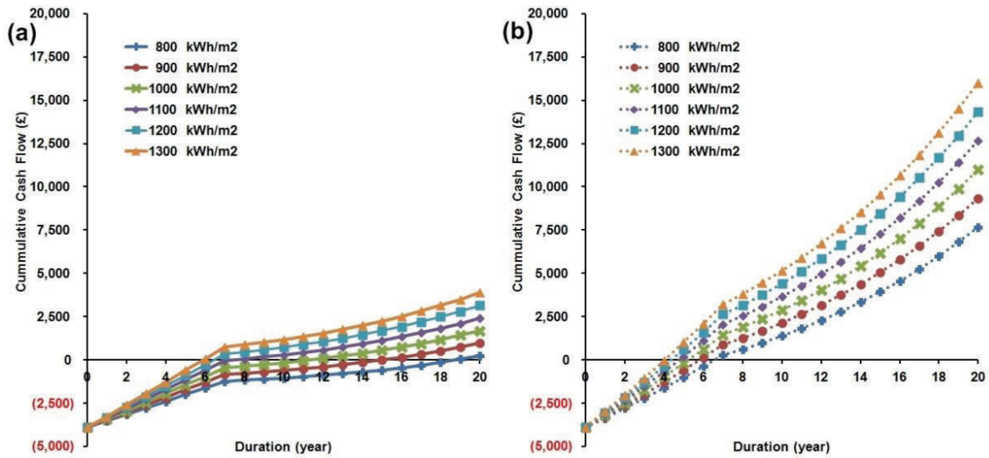

Figure 3: Cash flow of installing an STS in a domestic building in (a) Case (i), and (b) Case (ii).

Table 4: The NPV and the IRR of installing the STS in the UK under the RHI scheme.

Case	Case (i): Reducing dependency on gas heating						Case (ii): Reducing dependency on electric immersion heating					
Solar Insolation (kWh/m^2/year)	800.00	900.00	1,000.00	1,100.00	1,200.00	1,300.00	800.00	900.00	1,000.00	1,100.00	1,200.00	1,300.00
NPV (£)	*-965.48*	*-472.45*	*20.58*	*513.60*	1,006.64	1,499.67	3,750.62	4,833.17	5,915.71	6,998.25	8,080.80	9,163.34
IRR	*-0.32*	*1.70*	*3.58*	*5.34*	7.03	8.66	12.13	14.28	16.36	18.40	20.39	22.35

*The italic font indicated the unfeasible installation.

4. Proposal for more reasonable incentive in the UK

From the previous analysis in Section 3, it has been found that the current RHI framework is not attractive especially to those living in the northern part of the UK, which could deter the adoption of the STS in that area. To ensure that the RHI scheme is attractive and appealing to investors and homeowners, a more reasonable framework is proposed.

4.1 RHI rate of £0.173 paid for longer period of time

Figure 4 shows the analysis of implementing a fixed rate of £0.173 per kWh paid for the period of between 7 and 20 years. From the analysis, the RHI will only be feasible if the payment is made for a minimum 17 years – unlike the current proposal of 7 years. This will allows the participants to generate an NPV ranging from £1039.63 to £12,180.75 and an IRR of between 6.01% and 24.78% annually depending on their locations.

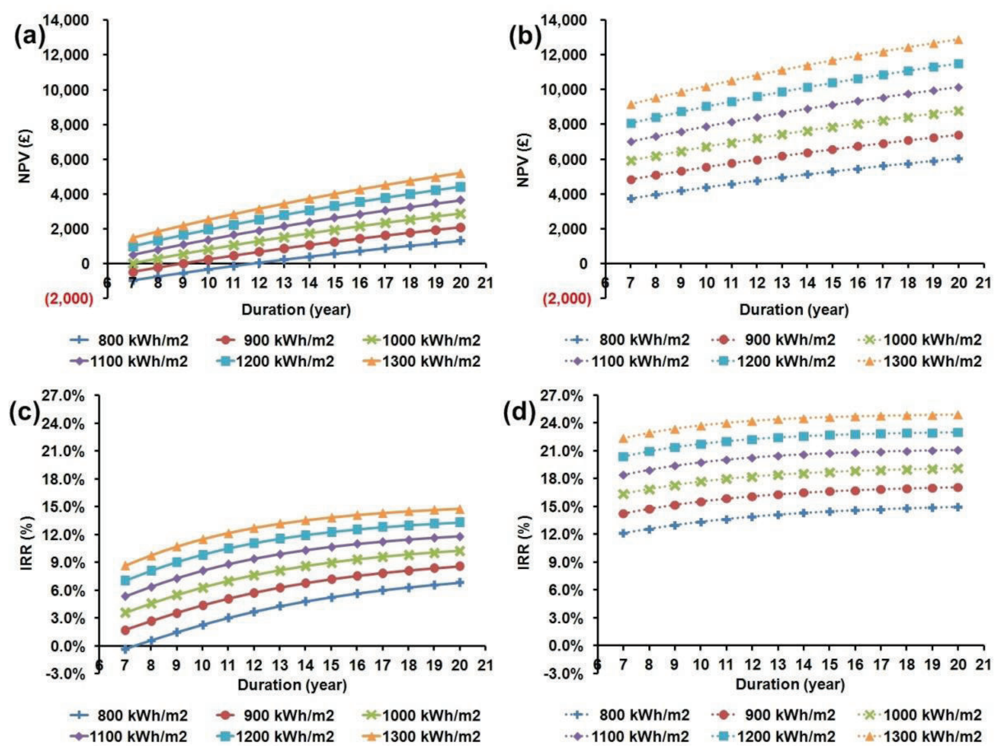

Figure 4: Financial analysis of installing an STS in the UK by fixing the RHI rate at £0.173 and varying the payment period where (a) The NPV for Case (i); (b) The NPV for Case (ii); (c) The IRR for Case (i), and (d) the IRR for Case (ii).

4.2 Higher RHI rate paid for the duration of 7 years

Figure 5 shows the analysis of implementing a higher RHI rate per kWh paid for the period of 7 years. From the analysis, the RHI will only be desirable if the RHI rate is at a minimum £0.32 per kWh paid for a duration of 7 years. This will allow the participants to generate an NPV ranging from £568.52 to £11,656.10 and an IRR of between 6.06% and 31.82% annually depending on their locations.

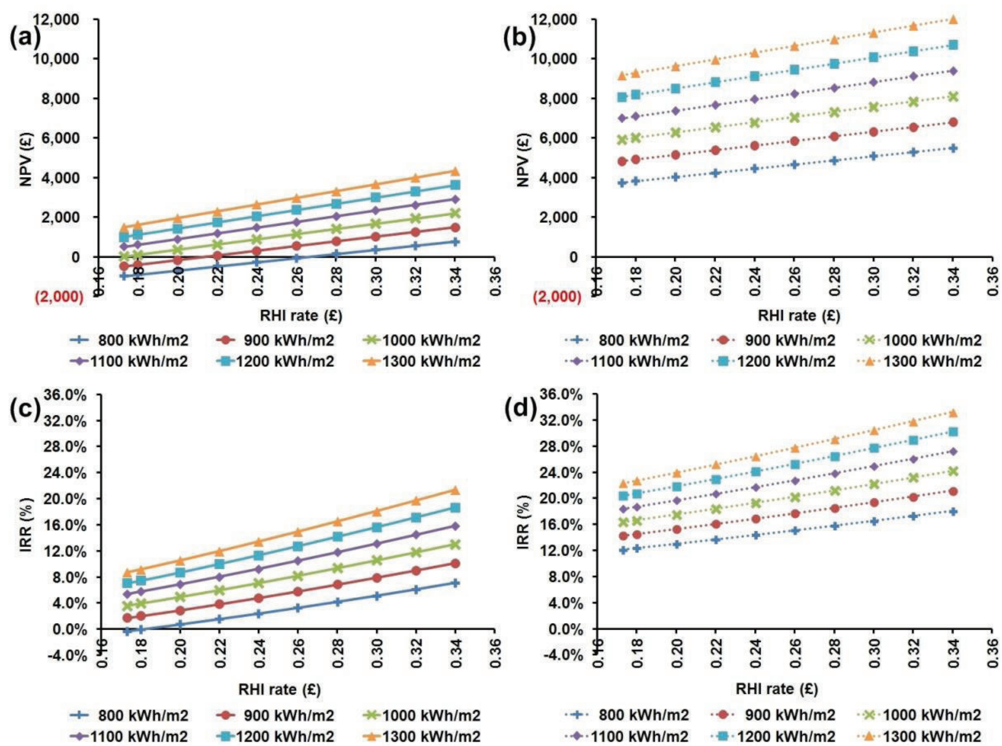

Figure 5: Financial analysis of installing an STS in the UK by varying the RHI rate paid for 7 years where (a) The NPV for Case (i); (b) The NPV for Case (ii); (c) The IRR for Case (i), and (d) the IRR for Case (ii).

4.3 Loan financing

Another possible option is to introduce a loan financing option for installing the STS in a building. It has been demonstrated in various countries that a loan option helps to accelerate the uptake of renewable technologies (see (Dusonchet and Telaretti, 2010); (Muhammad- Sukki et al., 2012); (Roulleau and Lloyd, 2008); (Stryi-Hipp, 2004). In an ideal situation, a loan scheme with a low interest rate and a short loan tenure is desirable, but in a normal scenario, a low interest is offered with a longer loan tenure. This section analyses the impact of interest rate ranging from 0 to 10% with a loan tenure of between 2 and 10 years on the NPV and the IRR. It is assumed that a 100% loan is taken up to finance the installation of an STS. For Case (i), the NPV and the IRR are presented in Figures 6 and 7 respectively and for Case (ii), the NPV and IRR are illustrated in Figures 8 and 9 respectively[2]. Interestingly, even a 0% interest with a loan tenure of 10 years does not generate desirable return for all locations. In the best case scenario, any installation that has an insolation of minimum 900 kWh/m^2/year could benefit from a 0% interest with the loan tenure of 10 years. However, this type of loan is unrealistic since the majority of the schemes available in the UK impose a loan interest rate of minimum 5% with a tenure of up to 30 years (Money.co.uk, 2013).

[2] Please note that some of the IRR could not be calculated since the value is exceeding 100%.

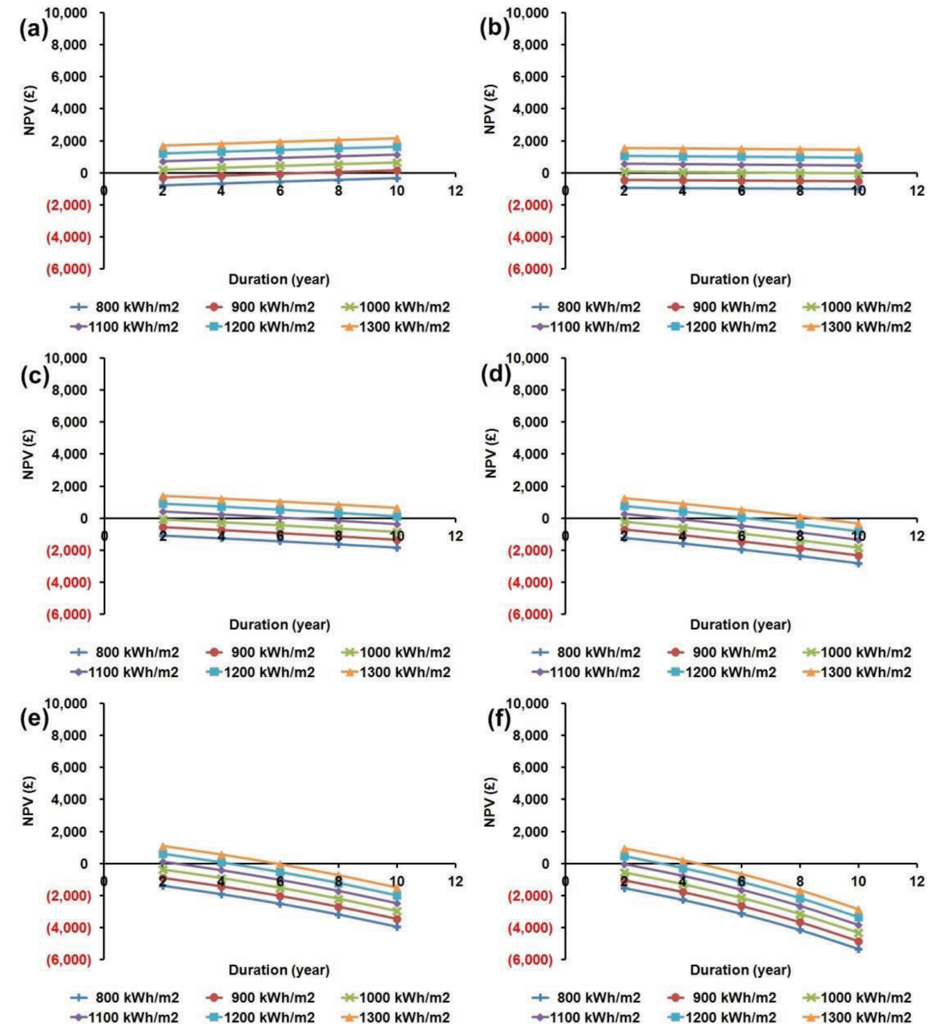

Figure 6: The NPV analysis of installing an STS in the UK by varying the interest rate and the loan tenure for Case (i) where the interest rate is (a) 0%; (b) 2%; (c) 4%; (d) 6%; (e) 8%, and (e) 10%.

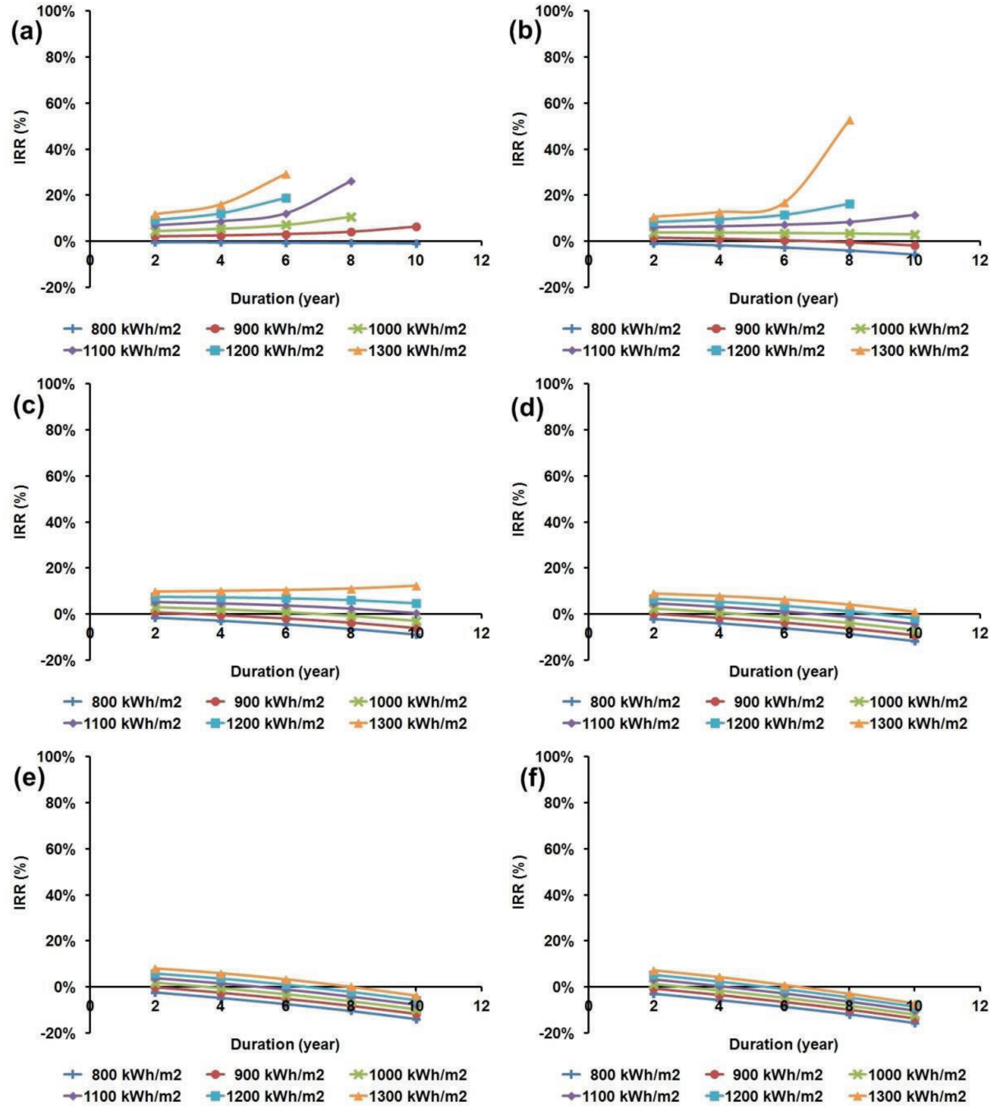

Figure 7: The IRR analysis of installing an STS in the UK by varying the interest rate and the loan tenure for Case (i) where the interest rate is (a) 0%; (b) 2%; (c) 4%; (d) 6%; (e) 8%, and (e) 10%.

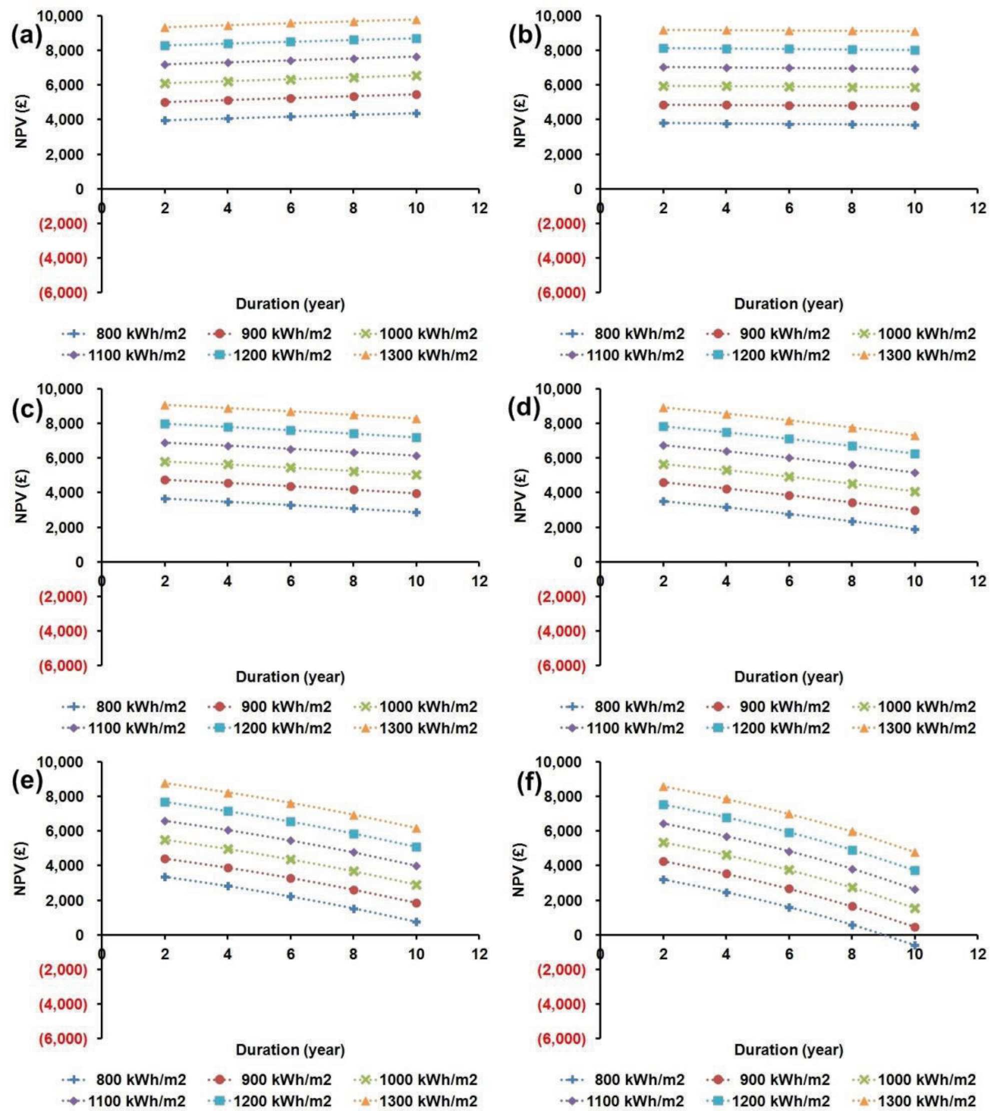

Figure 8: The NPV analysis of installing an STS in the UK by varying the interest rate and the loan tenure for Case (ii) where the interest rate is (a) 0%; (b) 2%; (c) 4%; (d) 6%; (e) 8%, and (e) 10%.

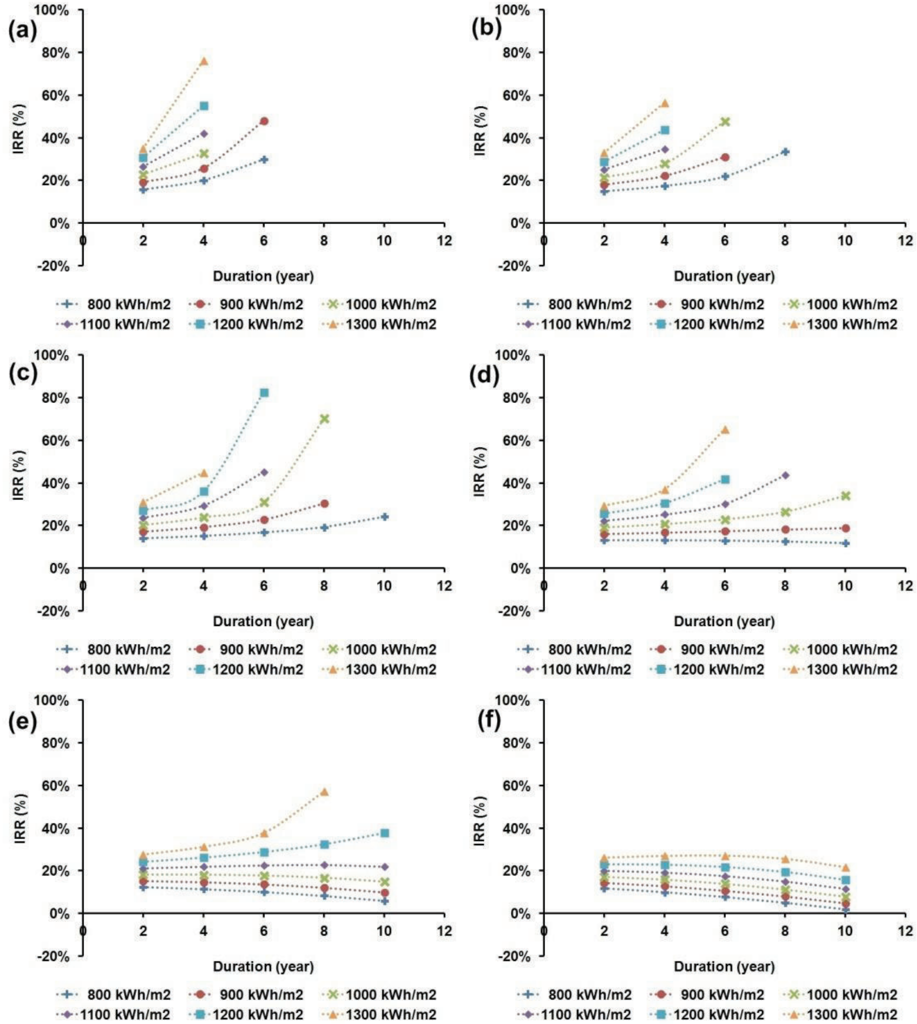

Figure 9: The IRR analysis of installing an STS in the UK by varying the interest rate and the loan tenure for Case (ii) where the interest rate is (a) 0%; (b) 2%; (c) 4%; (d) 6%; (e) 8%, and (e) 10%.

Conclusions

Solar energy has significant potential in the UK. The installation of renewable heat technologies has grown considerably in this country – including the STS. This is mainly due to the introduction of various policies, regulation and programmes by the government, as well as strong supports from the R&D sectors. The recent introduction of the RHI scheme could become the key driver to boost the solar thermal industry in the country. However, based on a number of assumptions, it is calculated that the proposed RHI scheme for the domestic sector in the UK (with an RHI rate of £0.173 per kWh paid for a duration of 7 years) is not desirable especially to the northern part of the UK due to the lower solar insolation. As a result, it could hinder the penetration of domestic solar thermal systems in residential sector in the UK. This paper proposes some improvement to the scheme that could generate good investment return to all consumers, which are:

- If a fix rate of £0.173 per kWh is used, the period of RHI payment has to be extended, i.e. 17 years.
- If the payment period is fixed at 7 years, a higher RHI rate i.e. £0.32 per kWh should be introduced.
- As for the loan financing scheme, no suitable scheme is available to satisfy the requirement of a feasible investment. To ensure the loan scheme is viable, the capital cost of an STS must be reduced. One alternative is to introduce an incentive that covers a fraction of the capital cost of installation (between 10% and 30%), which could result in a more desirable return to the potential investors when choosing the loan financing scheme.

However, all the suggestions will depend on the government's capability to financially sustain the scheme to ensure that the renewable energy could prosper in the UK.

Acknowledgment

This project is funded by the Glasgow Caledonian University (GCU), Scotland's Energy Technology Partnership (ETP) and Majlis Amanah Rakyat (MARA), Malaysia. However, the views expressed here are those of the authors alone, and do not necessarily reflect the views or the policies of the funding bodies.

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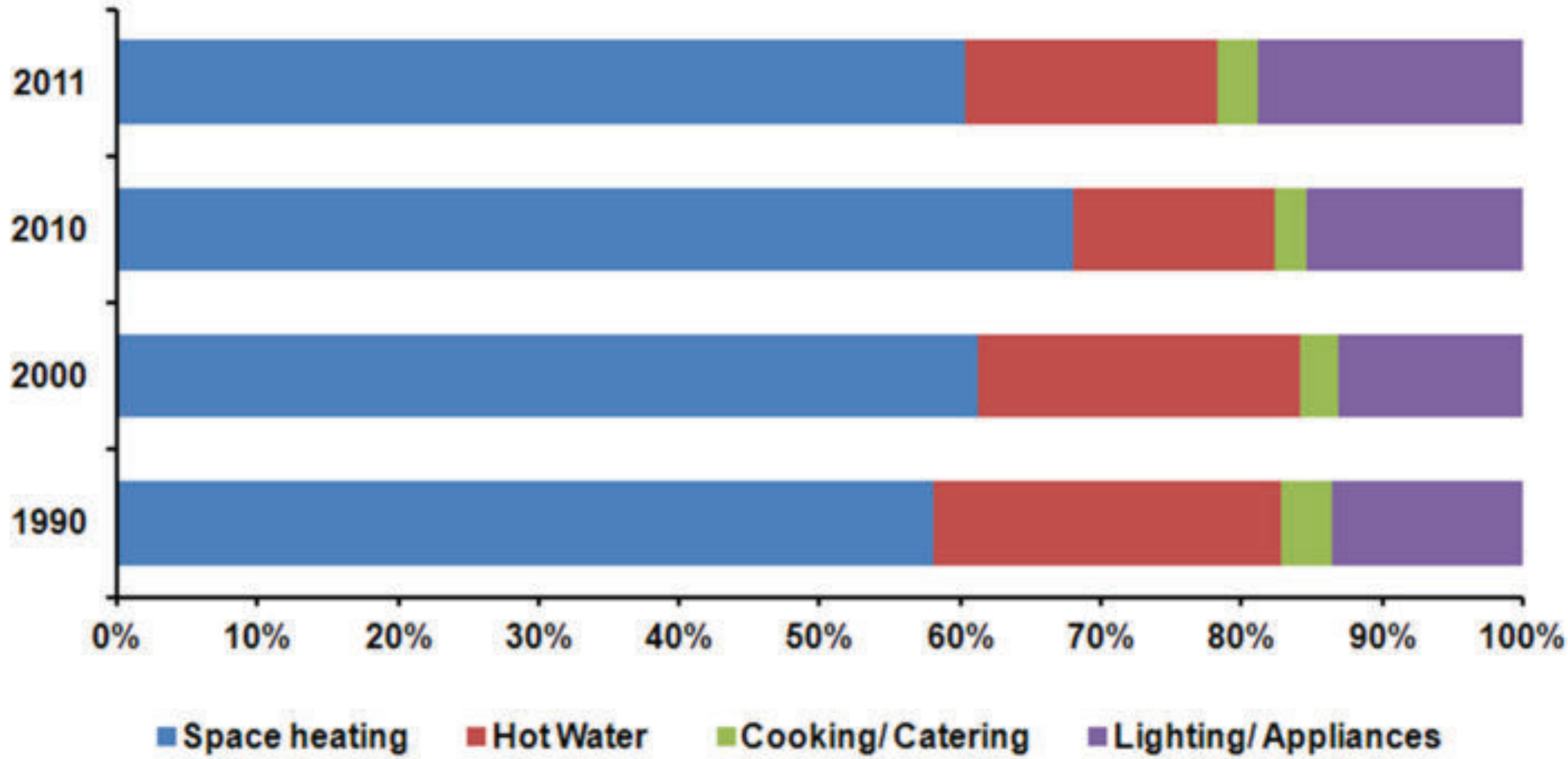
Figure1


2011
2010
2000
1990
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Space heating
Hot Water
Cooking/ Catering
Lighting/ Appliances