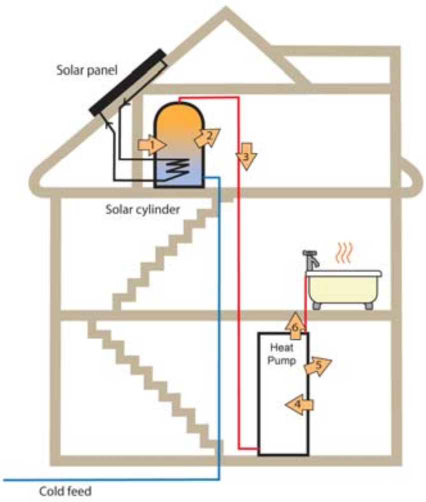
Technical Notes to Case Study 008

Useful Solar Heating Energy

The monitoring system implemented by BSRIA was aimed at assessing the whole house energy performance rather than an in-depth study of the solar energy performance.

The diagram shows the solar heating arrangement, with a 150 litre solar cylinder on the second floor pre-heating water feeding the exhaust air heat pump which heats the solar water further if necessary before supplying outlets (6). The solar heat contributes to reducing the electricity used by the heat pump (4) to heat the water for use at the outlets and to overcome standing losses from the integral cylinder in the heat pump (5)



Hot Water Heat Flows		
1	Solar Input	Measured
2	Solar cylinder standing loss	Manufacturer's Data
3	Useful solar input	Calculated
4	Electrical water heating	
5	Standing losses from heat pump store	
6	Hot water use	

The solar input energy (1) is measured by a heat meter. Because the hot water draw off from the solar cylinder (3) is not measured, the useful solar energy is calculated by estimating the cylinder standing losses (2) from manufacturer's data.

The manufacturer's declared cylinder standing loss measured at a constant through cylinder temperature of 60C is 1.41kWh/24 hours.

The standing loss from the solar cylinder is estimated to be 1.41 x 365 = 515kWh/year. This is felt to be a conservative (over) estimate of the losses because the solar cylinder will not spend the whole year at 60C.

For an energy balance in the cylinder, the useful solar input is therefore estimated to be:

Useful solar energy (3) = Solar Input (1) – Solar Cylinder Standing losses (3).

The solar cylinder standing losses were charged to each month in proportion to the solar energy input measured for that month.

For some of the year, heat losses from the solar cylinder contribute to reducing the requirement for space heating in the home. It was assumed for a heating season of November to February the cylinder standing losses were useful. The heating season is chosen to be short due to the highly insulated nature of the building.

Useful Solar Heating Energy					
Month	Measured Solar Input (kWh)	Apportioned Cylinder Loss (kWh)	Useful Cylinder Loss (kWh)	Useful Solar Energy (kWh)	Solar Electricity Use (kWh)
January	51	10	10	51	2
February	88	17	17	88	3
March	272	52	-	220	9
April	356	68	-	287	10
May	352	68	-	285	11
June	361	69	-	292	11
July	360	69	-	291	12
August	276	53	-	223	9
September	253	49	-	204	9
October	192	37	-	155	6
November	93	18	18	93	4
December	24	5	5	24	1
TOTAL	2,702	515	49	2,212	88

The useful solar energy reaches a limit based on either storage volume or household demand from April to July of around 290kWh/month or 9.7kWh/day. Assuming a water inlet temperature of 10°C and a use temperature of 60°C this corresponds to:

$E = mc\theta$
$9.7 \times 10^3 \times 3600$ (J) = m . 4200 . (60-10)
m = 166 kg or 166 litres/day of hot water

With five residents, this corresponds to 33 litres/person.day

The solar thermal system uses mains electricity for its circulator pump and electronic controller. The energy used for this was measured with an electricity meter and corresponds to a charge of only 4.0% of the useful heat energy generated by the system.

The government's SAP calculation predicts only 1,094kWh of solar input to the cylinder per year. The reason for this is that the occupancy of the dwelling assumed by SAP is driven only by the floor area and cannot be changed (even knowing the *actual* occupancy). SAP assumes only 2.78 people live in this house, using 106 litres per day. The actual occupancy is 5 people, using 166 litres/day. Solar hot water energy is a very strong function of hot water demand, and a change to SAP to allow a known occupancy to be entered is strongly recommended by this finding.

Solar PV Energy

The solar electric system comprised six Clearline PV15 solar panels of 225Wp, each connected to a dedicated micro-inverter. The output of the system as a whole was monitored through a single electricity meter, and data for each panel was available from an online portal provided by the micro-inverter manufacturer.

Carbon Dioxide Emissions Avoided

Since the solar pv system can export excess electricity production to the grid, then all generated energy offsets electricity consumption, and the emissions avoided is simply the measured energy multiplied by a carbon intensity factor of 0.591kgCO_2/kWh.

Solar PV Carbon Emissions Avoided						
Month	South Elevation Solar Energy (kWh)	South Elevation Carbon Saving (kgCO_2)	North Elevation Solar Energy (kWh)	North Elevation Carbon Saving (kgCO_2)	Combined Solar Energy (kWh)	Combined Carbon Saving (kgCO_2)
January	15	9	5	3	20	12
February	20	12	8	5	28	17
March	49	29	19	11	68	40
April	61	36	34	20	96	56
May	70	41	52	31	122	72
June	65	38	55	33	120	71
July	61	36	52	31	113	67
August	50	29	37	22	87	51
September	43	26	24	14	68	40
October	35	21	13	8	49	29
November	21	12	8	5	28	17
December	9	6	3	2	13	8
TOTAL	**499**	**295**	**310**	**183**	**811**	**478**

Solar thermal carbon reductions were stated assuming the more common situation of a house with a gas fired boiler.

The boiler is assumed to have a summer efficiency of 70% and winter (combined duty) efficiency of 80%. (Figures based on SAP 2009 technical support document). The summer efficiency was taken to run from April to October due to the high insulation levels in the house.

The carbon intensity factor for gas was taken to be 0.206 kgCO_2/kWh.

The carbon saving is calculated as follows:

{(Useful solar energy x 0.206) / Boiler efficiency } – {pump electricity x 0.591}

Solar Heating Carbon Emissions Avoided				
Month	Useful Solar Energy (kWh)	Solar Electricity Use (kWh)	Boiler Efficiency (%)	Carbon Saving (kgCO_2)
January	51	2	80	12
February	88	3	80	21
March	220	9	70	52
April	287	10	70	79
May	285	11	70	77
June	292	11	70	79
July	291	12	70	79
August	223	9	70	60
September	204	9	70	55
October	155	6	70	42
November	93	4	80	22
December	24	1	80	5
TOTAL	**2,236**	**88**	**49**	**582**