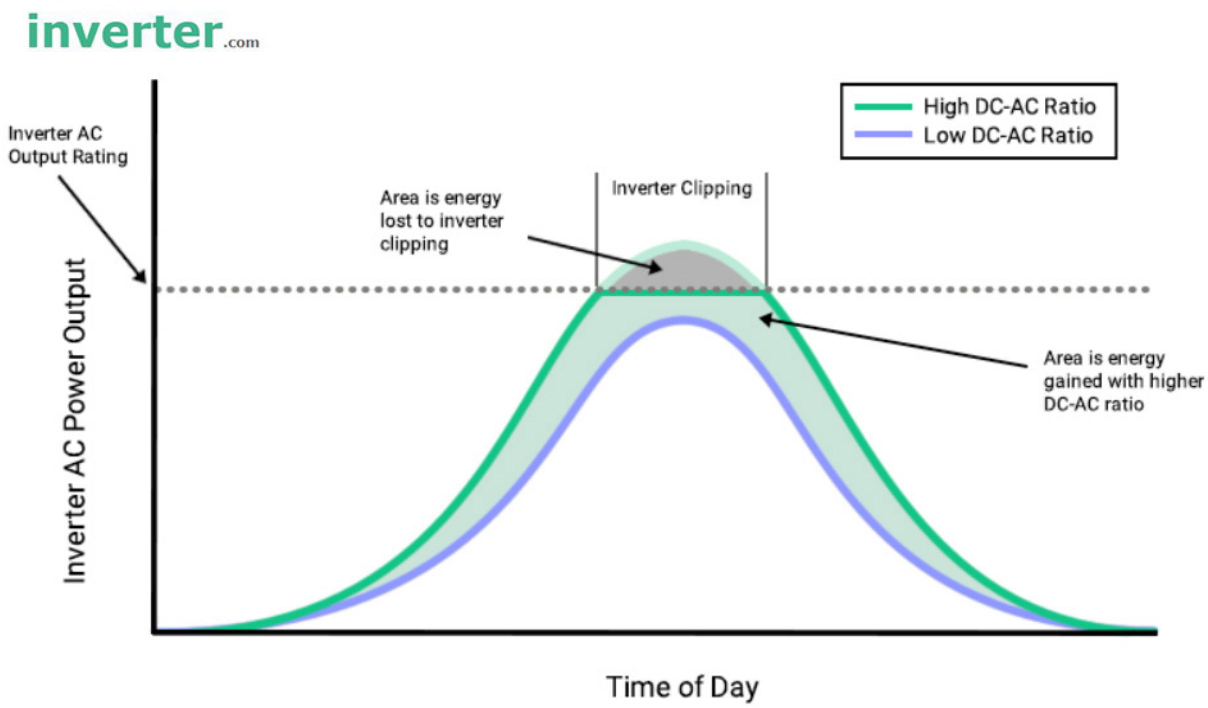
One Tree Hill Solar claim of number of homes powered is overinflated

To estimate the equivalent homes 'powered' by the output of a solar farm you need a) the best estimate of the solar farm annual generation and b) an agreed value of the average UK household's annual electricity usage.

<u>Firstly how to estimate the annual generation of a solar farm</u>:

The widely accepted approach is to multiply the total combined DC capacity of solar panels by a factor known as the kK factor. The calculation is: **Annual Solar Panel Energy Output (in kWh) = kK x system kWp**. The kK factor a function of orientation, shading and location …. typically 850-950kWh/kWp for the south of the UK. For the purposes of this study the solar farm dataset on the Greenmatch.co.uk website was used. However, the Greenmatch data table uses a mix of AC and DC capacity. It has become a controversial point that many solar farms have, or are, engaged in excessive so-called "overplanting". This is the practice of oversizing the DC capacity of the solar farms to maximise electricity generation while remaining within the local LPA threshold of 50MWac. The following figure illustrates how an elevated DC/AC ratio can increase overall generation. As more panels are added to a fixed power inverter, mid-day production on high irradiance days will max out the inverter's AC output rating, but this is typically more than compensated for with extra production coming in the mornings and afternoons.



Primary source data about each solar farm was obtained to give more insights into exact capacity values. As you can see from the attached table Wroughton, Llanwern, Scurf Dyke and Larks Green solar farms all have DC capacity (or MWp) much greater than their AC (inverter or export) capacity. West Raynham solar farm is likely to have a MWp greater than the quoted 49.9MW, but there is a lack of information in the public domain. Where available estimates of the annual generation in GWh were included, along with the estimates of eq. homes powered and farm size in acres. The farm sizes are broadly equivalent to the Greenmatch data but the Larks Green entry in the Greenmatch table was erroneously included in hectares, not acres.

	Greenmatch Data		Primary Source Data						kWh/kWp	Av. Use, kWh
Solar Farm	Capacity, MW	Size, acres	Capacity, MWp	Capacity, MWac	Annual Gen, GWh	Homes powered	BESS?	Size, acres		
Shotwick Solar Park	72.2	250	72.2			18,055		250		
Lyneham Solar Farm	69.8	213.3	69.8		66.31	17,455		213.3	950	3.8
Owl's Hatch Solar Park	49.9	200	51.9	49.9		12,600		213		
Wroughton Airfield	50	165	60.9	49.9		15,400		172		
West Raynham Solar Farm	49.8	225	49.9		48.2	14,000		225	966	3.4
Llanwern Solar Farm	49.9	260	75			20,606		300		
South Lowfield Solar Farm	49.9	231	49.9		42.7	12,929		231	856	3.3
Scurf Dyke Solar Farm	50	200	80	50	77.7	21,000	yes	245	971	3.7
Lark's Green Solar Farm	49.9	106	70	49.5		17,000	yes	262		
The Grange Solar Farm	49.9	207	49.9		44.3	13,441		207	888	3.3
Average									926	3.5

One Tree Hill	20.9	16.9		10,000		70

For solar farms that provided an estimate of annual generation, the kWh/kWp factor was back calculated. The factor used for West Raynham is high at 966 (again indicating that the actual kWp capacity of the farm is probably higher than 49.9MW). The value for Scurf Dyke is also high but might be down to the development having battery storage which would capture the clipping losses (see previous figure) for deferred export. The other factors are considered reasonable.

<u>How much electricity does an average household in the UK use</u>?

There are a range of estimates in the public domain from 2,900 kWh (Ofgem), through 3,100 kWh (BEIS) to 3,600 kWh (Dept of Energy Security and Net Zero).

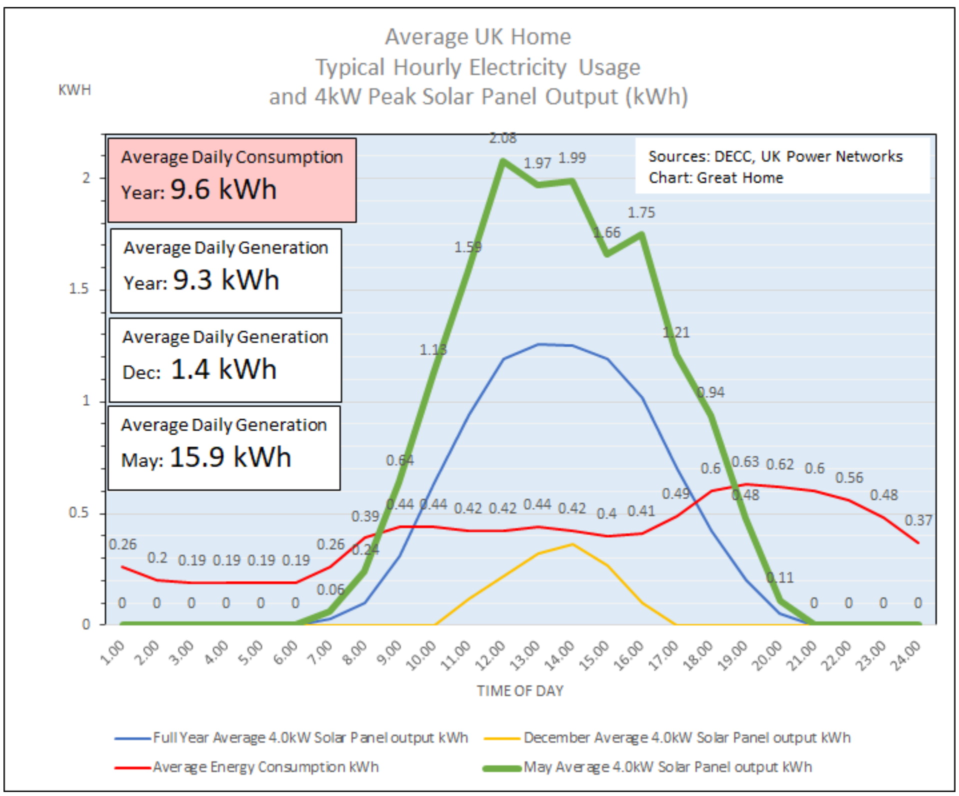
Government Department	Average annual usage	Average daily usage	Source
Ofgem	2,900 kWh	7.9 kWh	Ofgem: Average Gas and electricity use explained
BEIS	3,100 kWh	8.5 kWh	BEIS: Household energy consumption & affordability report
Department for Energy Security & Net Zero	3,600 kWh	9.9 kWh	Annual domestic energy bills publications

The annual average household electricity consumption was back calculated (for those solar developments that quoted an annual generation total). A range of 3,000 to 3,800 kWh, with an average of 3,500 kWh suggests the developers have used values in the right 'ball-park'.

HOWEVER, there are two further important factors to consider.

Firstly intermittency, both diurnal and seasonal, which makes the notion that a given number of households can be powered by solar based on annual averages totally absurd. This is well illustrated by the following plot showing the typical daily generating profiles of a domestic 4kW solar system, along with a typical average profile of a household's electricity usage (red line). The daily average totals are essentially the same at 9.3 and 9.6 kWh (representing circa 3,500 kWh annual usage, and the portion of annual solar generation that is being attributed to power the hypothetical average home). The blue average daily line shows that, although the daily total generation would satisfy the total daily electricity demand, the actual average generation profile would only provide enough electricity between 9am and 6pm. But it is worse than this. The yellow average line for December solar generation would only satisfy 15% of the daily need, and only in the middle of the day, and (on an average basis) at no time supply all the required electricity. The green line representing the average generation profile in May shows that typically during summer months the equivalent household would be fully supplied for around 12hours, but not supplied at all for the rest of the time. Yes, there is excess generation during some daylight hours but without other customers (or storage) this would lead to curtailment.

Even the average monthly generation profiles smooths the daily and hourly fluctuations associated with the varied British weather and irradiance levels. Significant investment in battery storage (something neither of the solar developments near Potterne are proposing) would mitigate much of the very short term and diurnal intermittency, but could never adequately alleviate the seasonal variation.



The growth in intermittent supply has led to an increasing need for so-called Capacity Market (CM) contracts for dispersed sites to provide standby power during extreme network “stress events” (or shortage of supply). This latent capacity is expensive to provide and can, for instance in the case of the

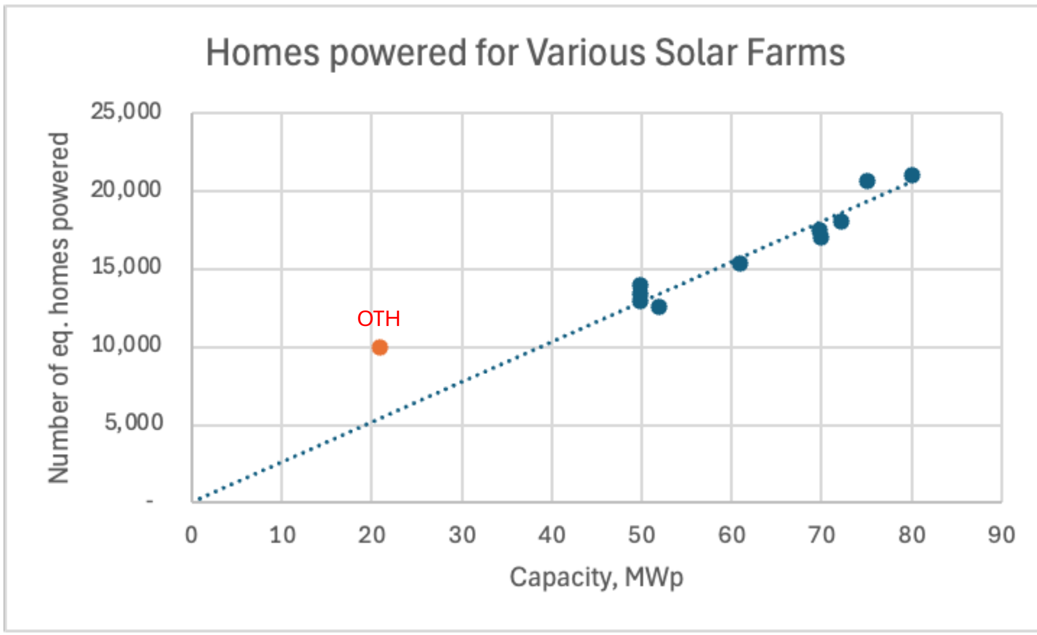
Roundponds site near Melksham, result in periods of excessive diesel consumption.

The second reason it is disingenuous to quote numbers of homes powered by an individual solar farm is because it implies the home is provided with all its energy needs. The following table gives the additional energy supply in the form of gas that is typically used for heating water and space heating in the UK. If the energy requirements of a typical home were furnished purely by electricity (as is the ambition by 2050), then the estimates of the number of equivalent homes supplied would need to fall by at least half. And the seasonal fluctuation of energy consumption for space heating makes the mismatch with seasonal solar generation intermittency even more extreme.

Government Department	Average annual usage	Average daily usage	Source
Ofgem	12,000 kWh	32.9 kWh	Ofgem: Average Gas and electricity use explained
BEIS	12,400 kWh	34.0 kWh	BEIS: Household energy consumption & affordability report
Department for Energy Security & Net Zero	13,600 kWh	37.2 kWh	Annual domestic energy bills publications

The One Tree Hill Solar application calls for the installation of 20.9MWp of generation capacity. Using a typical factor of 900 kWh/kWp gives an annual solar generation of 19GWh. Using the flawed methodology employed by other solar developers would suggest this energy is the equivalent to the annual electricity requirement of a little over 5000 homes. The One Tree Hill submission in fact quotes 10,000 homes.

The lack of consistency with assertions made by other solar farm developers is illustrated by the following plot of capacity, MWp, versus quoted equivalent homes powered. Most of the solar farms contained in table above fall on a consistent trend. One Tree Hill is an obvious outlier.



Conclusion: All the quoted "equivalent homes powered" by solar developers are disingenuous at best. The number claimed by the developers of the proposed solar farm at One Tree Hill is not only disingenuous, it is wrong.

John Peak
On behalf of Potterne Solar Action Group