# The Renewable Cornwall Project; The Heat, Light & Power Simulator

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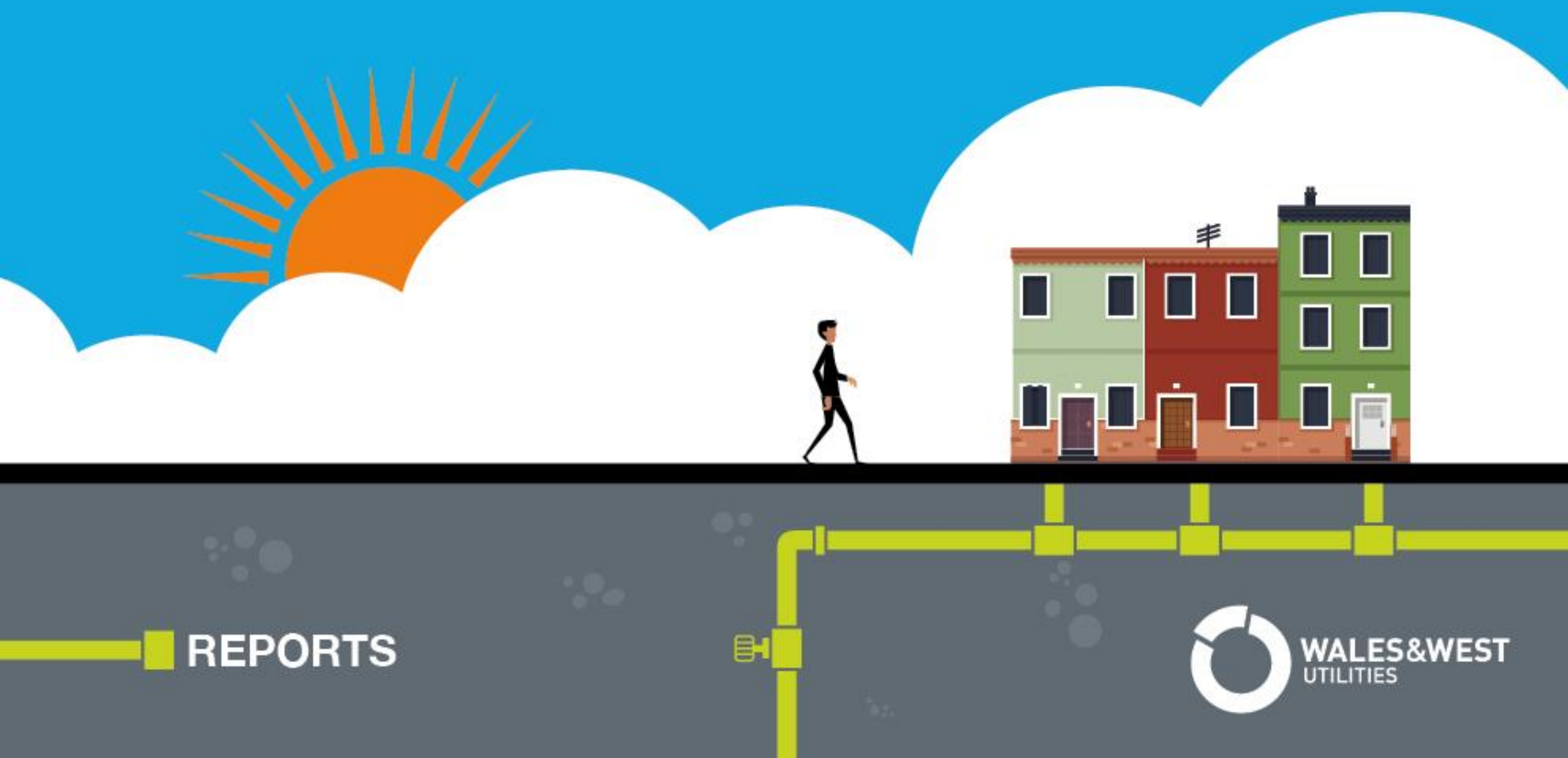
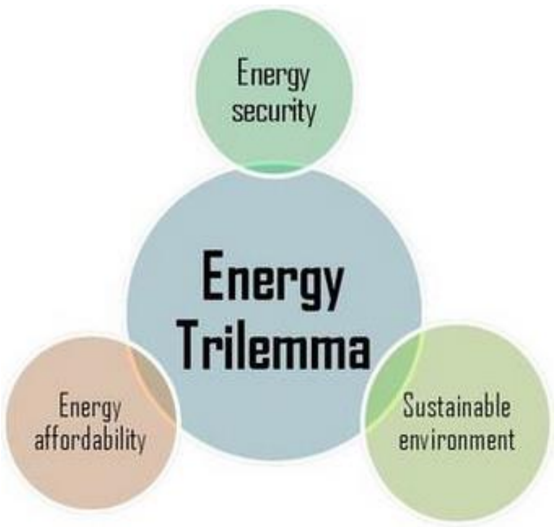


## 1. Background




The UK Government is committed to addressing an energy trilemma – keeping houses warm and lit at an affordable price, but with a very significant reduction in carbon emissions. Many solutions have been suggested, but most have lacked analysis to identify if they actually meet the "energy trilemma" conditions (I.e. secure energy at low cost and low carbon). Research conducted by Wales & West Utilities (Bridgend Phases 1-3 (www.smarternetworks.org)) revealed serious flaws in some of the main proposals for future heat solutions - such as electric heat pumps, which proved unaffordable to 80% of consumers and not practicable for a number of house types that are poorly insulated.

An objective way of assessing alternative energy proposals ability to provide heat, light and power is essential to demonstrate their value and indicate their likelihood of benefitting customers long into the future.

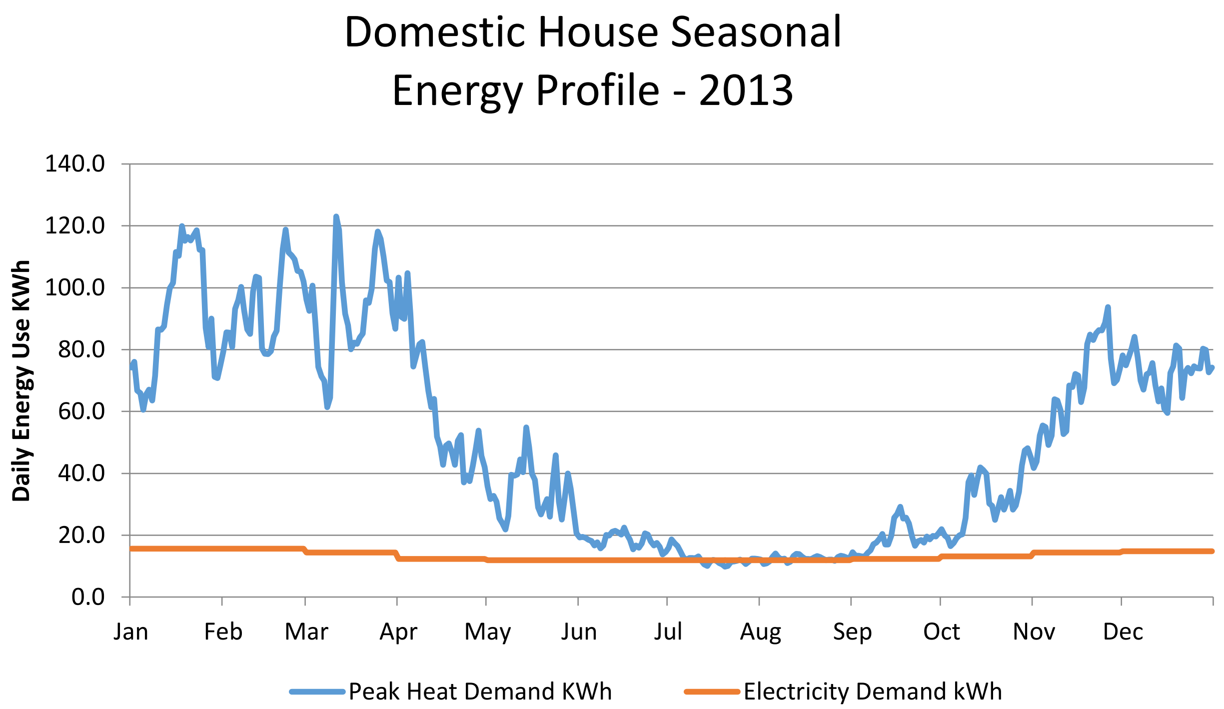
## 2. Forward

Wales & West Utilities has supported a study to create a detailed energy supply/demand simulator in order to understand the impact of investment requirements in the gas network. We used the premise of creating a "renewable Cornwall" as a model to set out what the future would look like, using the outputs from workshops with local people. Using these outputs, the simulator started by charting hourly usage (demand) for heat, light and power over the period January to December 2015. It then added the available energy supply profiles, e.g. for wind, solar and geothermal. (Geothermal energy is heat from hot rocks deep underground). When the two charts were combined, the simulator was able to identify the balance (or imbalance) of supply and demand, and look at real time data.

The simulator enables investment needs to be identified, including generation costs and storage costs and then can estimate the resultant cost to the consumer for various options. Any mix of renewable energy sources can be simulated, along with options related to the availability of storage. The simulator was used to model two future scenarios: a storage option, in which storage could be used to balance seasonal, daily or hourly demand; and an over-generation option, where generation could be scaled up to meet winter demand without the need for significant storage. This report provides a summary of the results.

## 3. Demand results

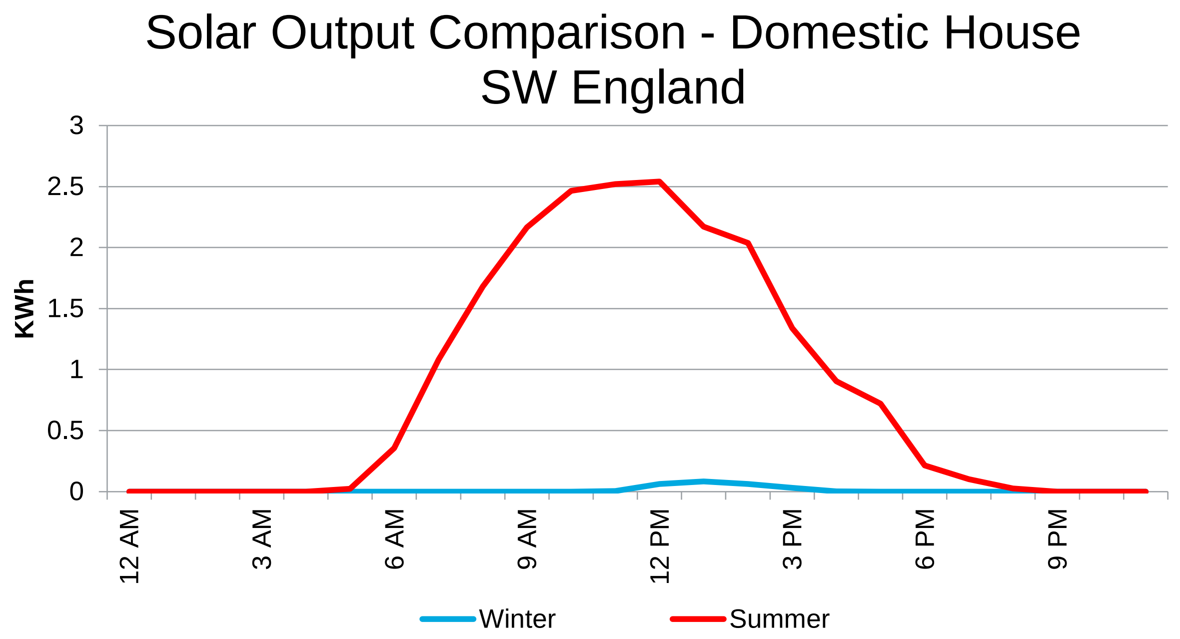
Electricity demand is thought to be peaky but, compared to heat, is seasonally flat (Figure 1, domestic daily heat and electricity demand). Heat is very seasonal, with many peak days. Providing heat to the profile illustrated is the main challenge facing the future of energy.



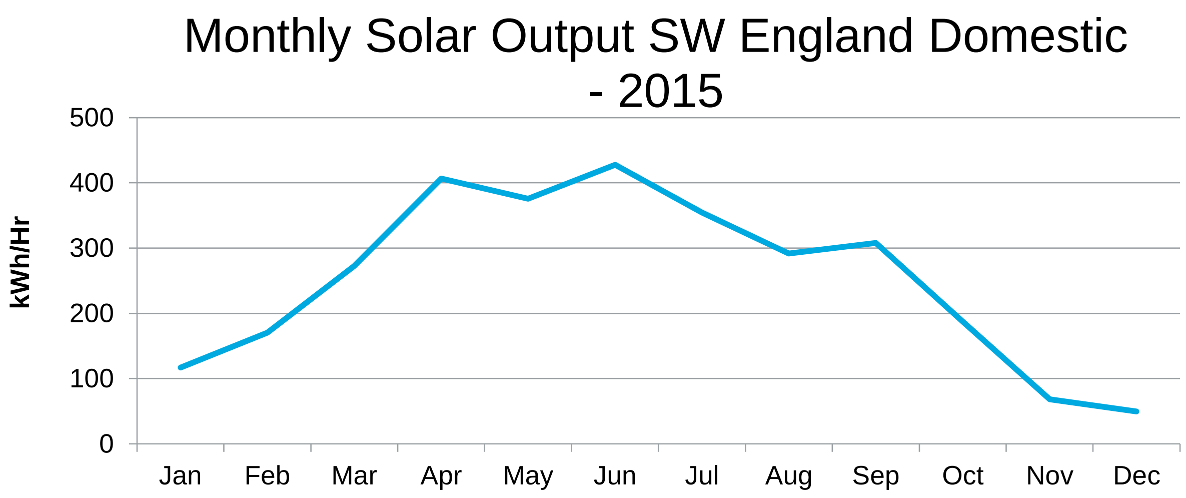
## 4. Supply Results

### 4.1 Solar

Solar power is much more variable than anticipated between summer and winter days. Daily winter solar output is typically 100 times less than summer due to shorter day length and lower sun angle:

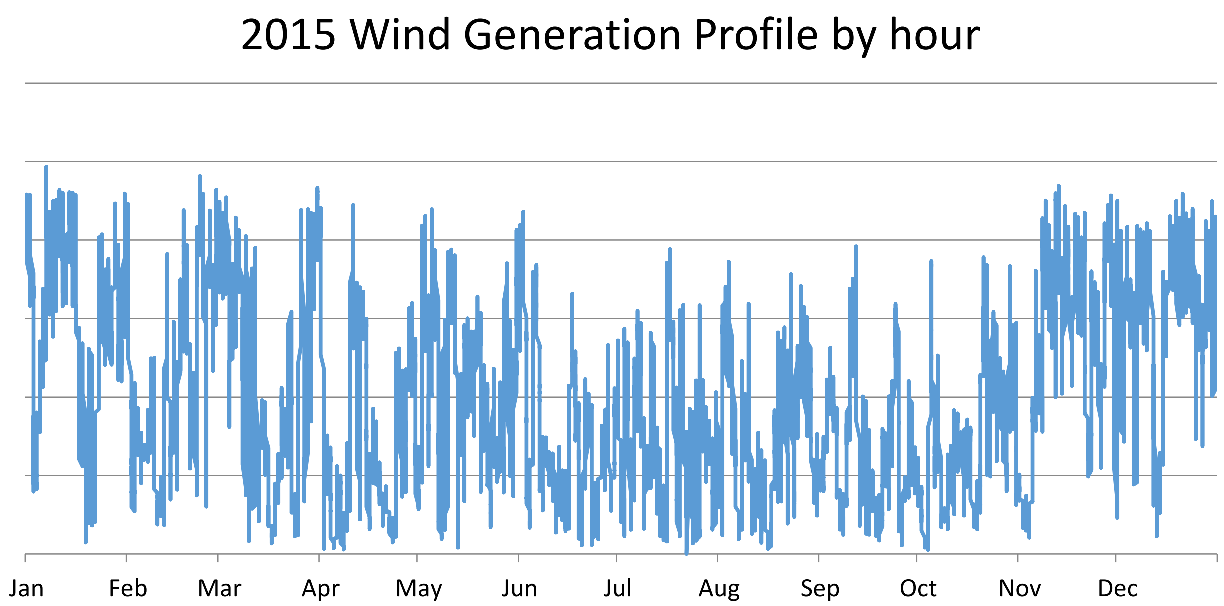



Solar, on a seasonal basis, is diametrically opposed to heat requirements and hence would provide little contribution to low carbon heat balancing in winter.

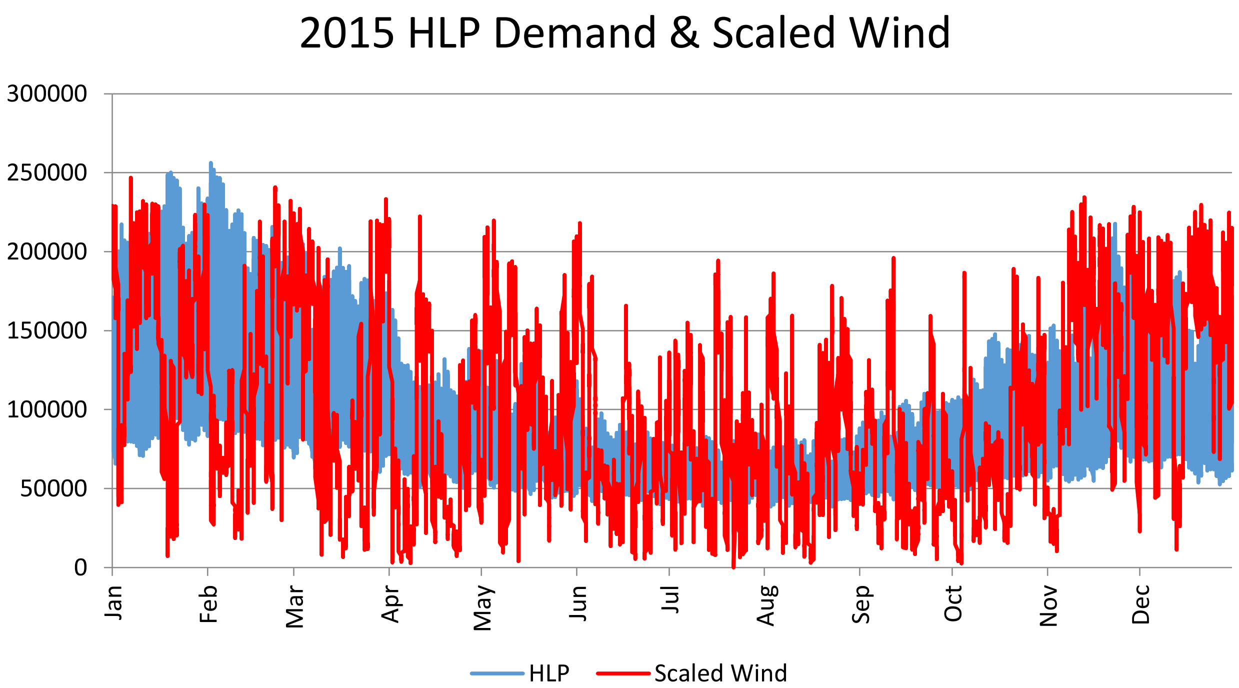


## 4.2 Wind

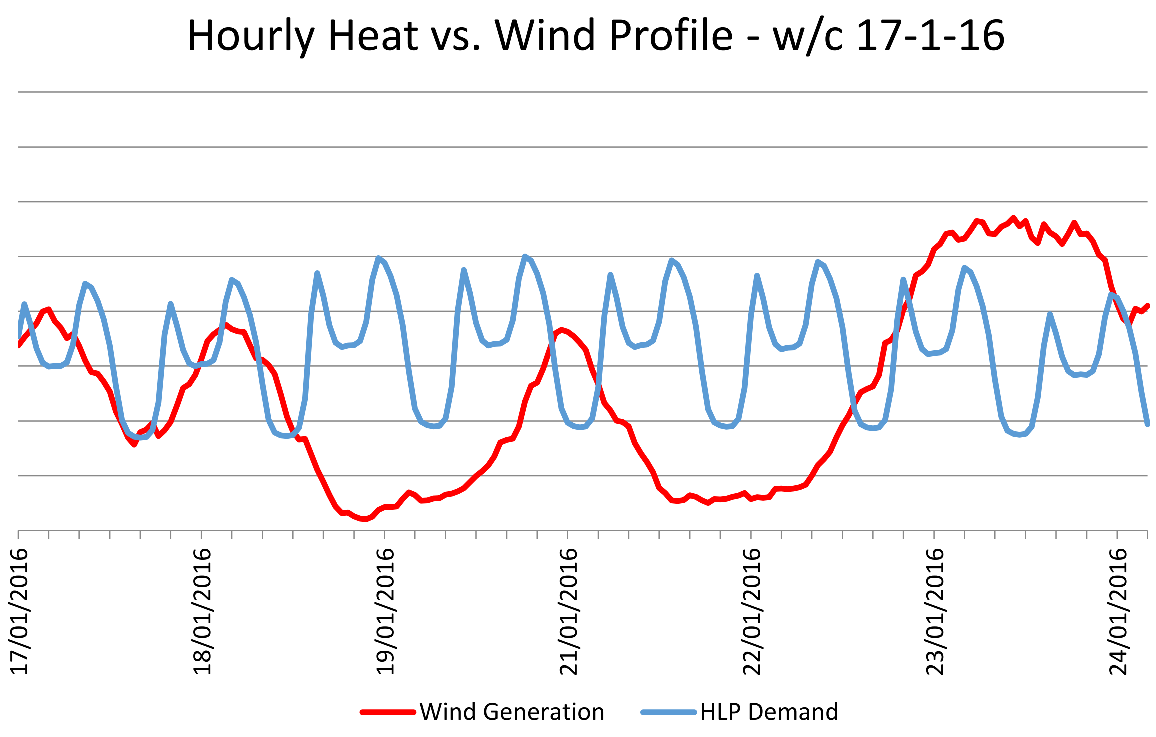
The wind profile from 2015 was entered into the simulator, with wind providing generation without much seasonality, but proving to be intermittent:




By overlaying heat, light and power demand onto supply, the gap between energy generation and energy demand on an hourly basis can be identified, in this illustration, wind:



Zooming in to look at a week indicates the requirement to balance supply and demand goes beyond the daily profile:




## 4.3 Deep Geothermal

For the purposes of the simulation, a flat profile of energy delivery was utilised aligned to the case study profiled in the DECC report regarding geothermal in Cornwall:

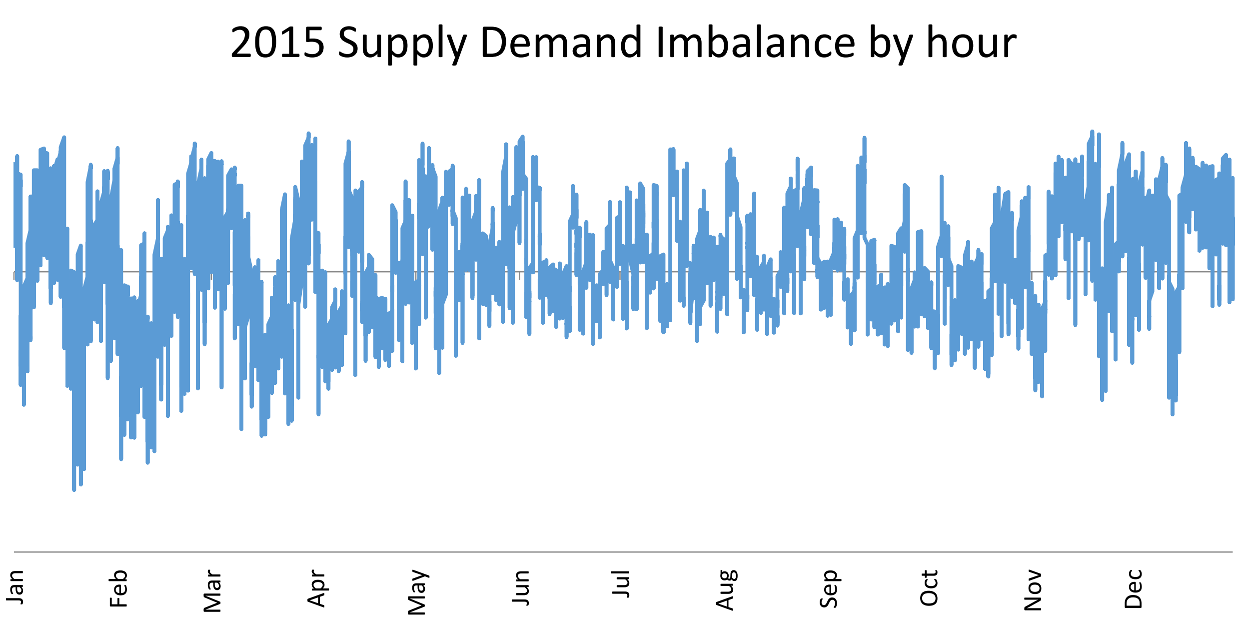
*In order that a large proportion of the available heat from the geothermal plant can be used it would need to be matched close to the base load available throughout the year, with the peak winter demand being met by conventional heating plant.* **(Cornwall case study - Atkins** Deep Geothermal Review Study | Version 5.0 | 21 October 2013)

## 5. Balancing Demand and Supply

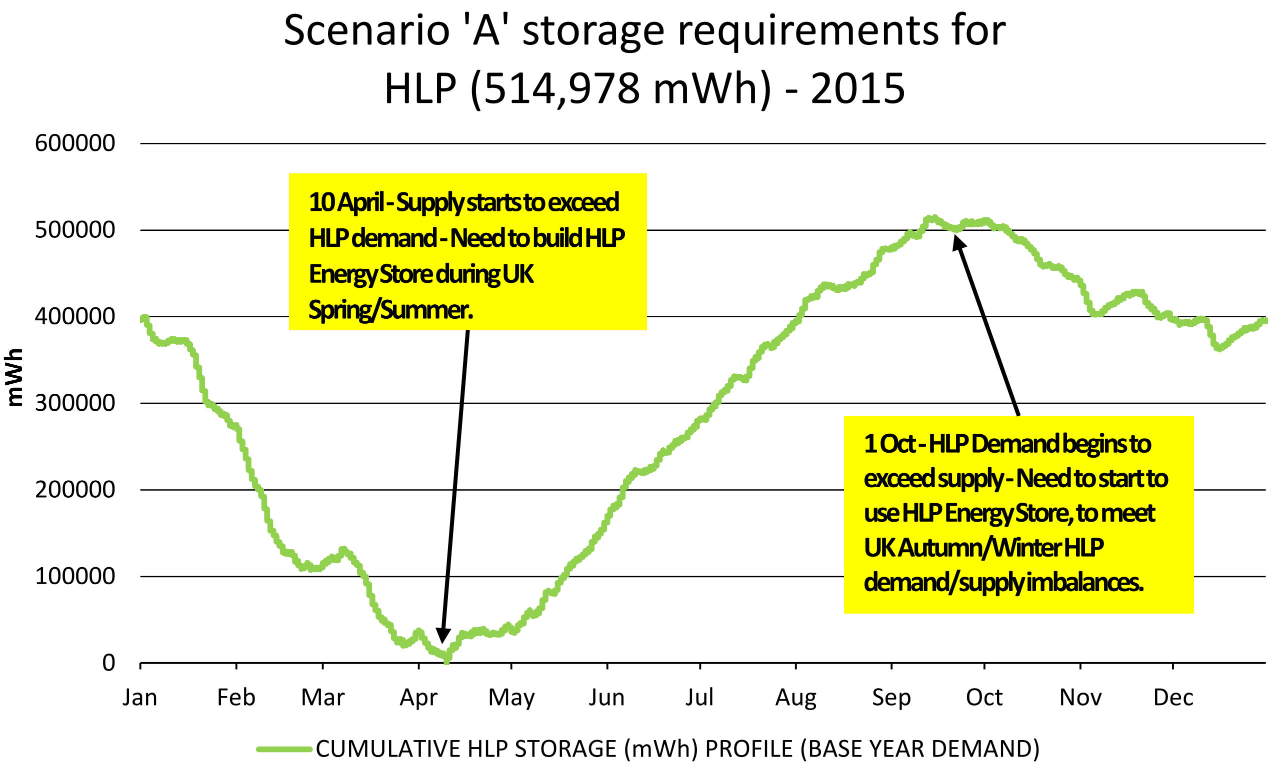
Having acquired the profile of energy supply for the mix chosen by the workshop participants (principally 50% wind; 25% solar and 25% geothermal/other) the simulator was programmed. It was programmed and run using two scenarios, one using storage to balance supply and demand, the other using over-generation to meet peak demand:

### 5.1 Simulation A - Annual Balance using storage

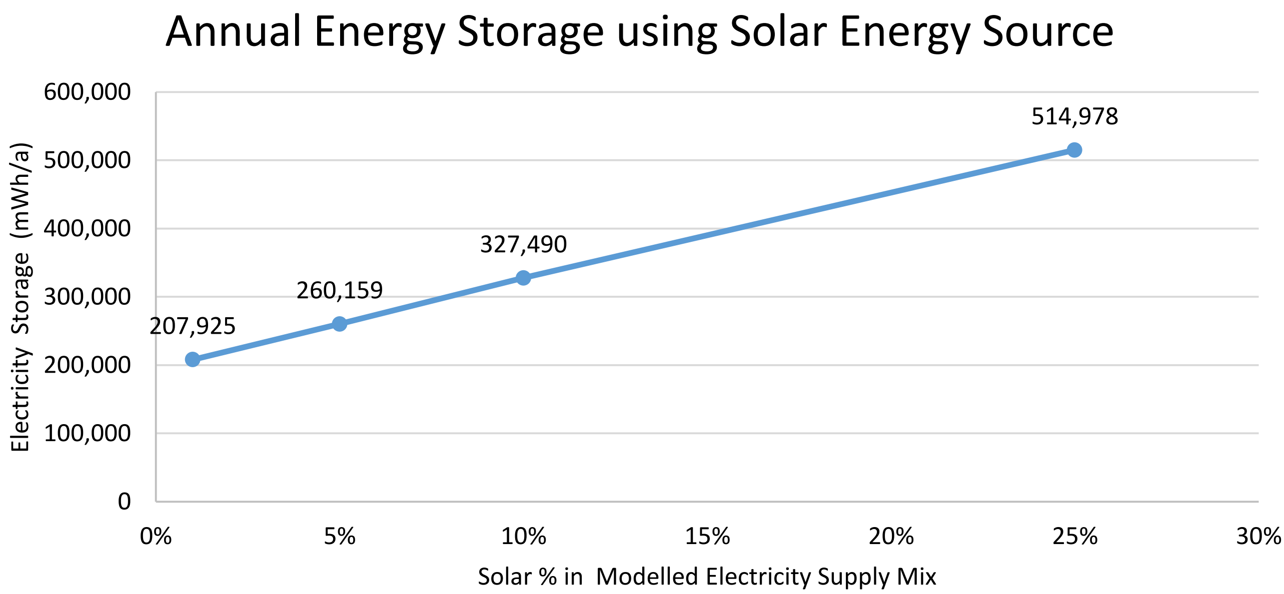
If sufficient low carbon generation (Solar/Wind/Geothermal) is provided to meet heat, light and power requirements for Cornwall on an annual basis, overlaying seasonal demand profiles with the supply profiles provides the imbalance:




This indicates a supply/demand imbalance most days of the year. The balance was proposed to be achieved via battery storage. By accumulating the hourly requirements into and out of storage, a seasonal profile is generated by the simulator. The results show a seasonal storage need of 500,000 Mwh. The capital costs of electrical storage in the UK has been estimated at £1m/MWh (UKPN – Smarter Network Storage (*innovation.**ukpowernetworks**.co.uk/innovation*)), suggesting an investment need of £500bn for such a scenario.

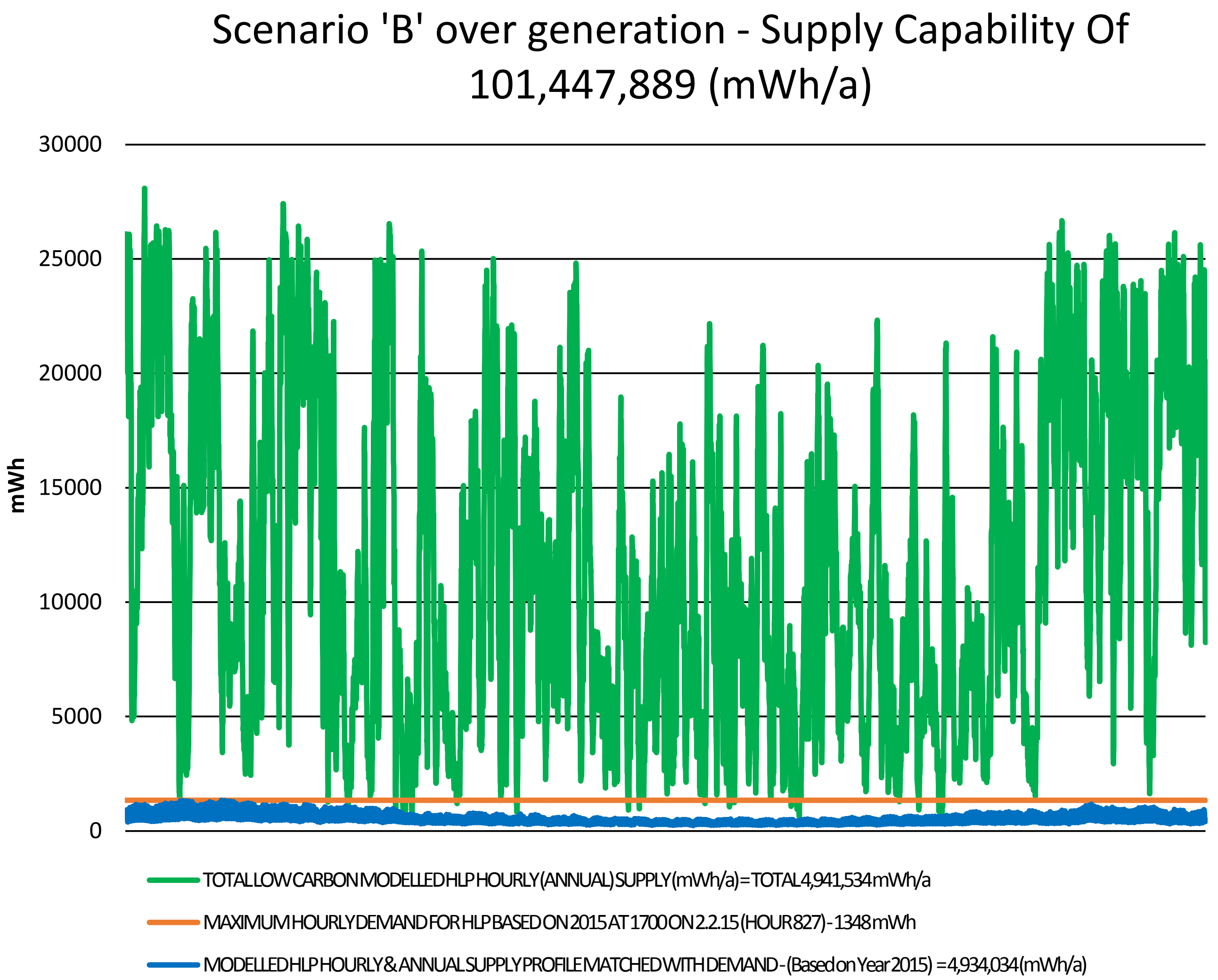



It was evident that the solar supply and heat, light, power demand created significant imbalance, so the simulator was run to provide a sensitivity analysis using reducing solar supply. It indicated that 60% of the storage requirement (above) came from the 25% of solar in the mix.



## 5.2 Simulation B – meeting seasonal peak demand using excess generation

Storage could be eliminated if supply was scaled up to meet peak demand. This would lead to significant over generation the rest of the time, with 95% of the generation under-utilised. Clearly, the cost of such over-generation would be a challenge for consumers to fund.



## 6. Impact on the consumer – next steps

To model the effects of different scenarios, a cost model, which has been independently reviewed, has been developed to take account of all aspects of the supply linkages, including generation; transmission/distribution; appliances and storage:

Storage → Generation → Storage → Distribution → Storage → Use

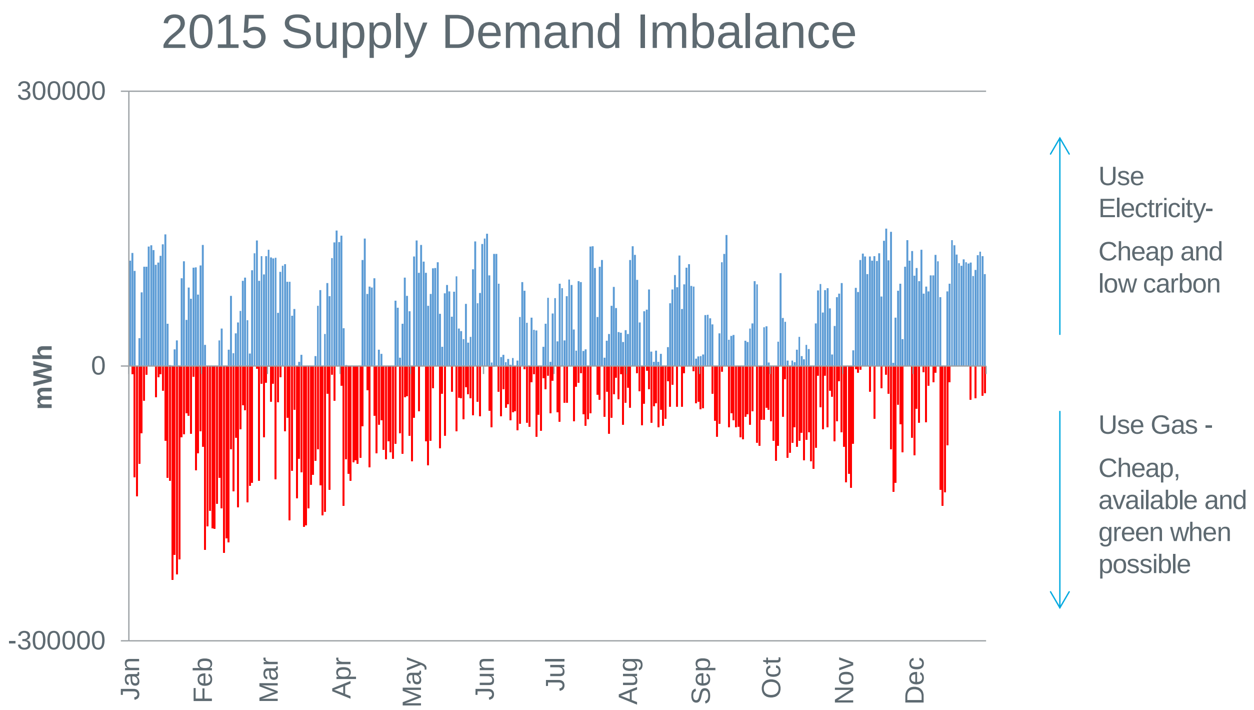
The hypothesis for a renewable Cornwall is that reduction in fossil fuel costs would offset any additional costs involved. However, electricity storage is very expensive, as is the facility for over generation. The model will be run using the outputs of the simulations to assess costs to the consumer. In addition, a cost comparison will be run utilising biomethane as a renewable source. This was not considered by local people in the workshops to determine how they saw the creation of a renewable Cornwall. Whilst biomethane production is more costly than natural gas, it would act as a useful cost comparator.

The initial results indicated that in all circumstances, costs to the consumer will rise substantially, with those using intermittent sources (solar & wind) being the most expensive:

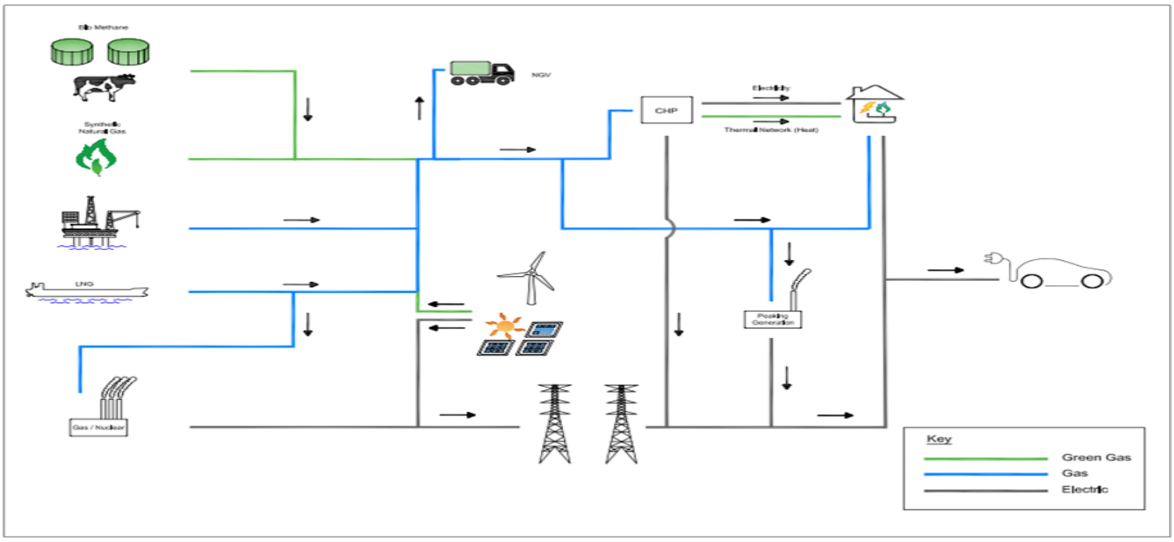
## 7. Conclusions

All of the above options simulated and costed have a significant impact on the consumer and whilst low carbon and secure, do not meet the affordability test, without utilising a gas network. It was evident from the background research for the project that no credible seasonal storage solutions are available to support anything but a modest penetration of renewable heat.

The simulator points towards more complex solutions being required that would support a multi-vector approach, including gas and utilising both the gas and electricity grid, using each vector to its maximum benefit. Wind powered generation would be utilised when the wind is blowing, and gas powered peaking electricity generation plants and Combined Heat & Power (CHP) produced heat and electricity when it is not:




Heat could be provided in the same multi-vector approach, with heat generated from renewable electricity when low cost and available, and a mix of green and natural gas when not available. This type of approach would support the current direction of travel with renewable electricity being supported with gas generation when renewable generation is not producing:




Finally, it is recommended that further research is conducted utilising the simulator to assess both the cost and renewable credentials of the above approach along with the technology needed to implement it, most notably hybrid heating systems, micro CHP and full scale green gas production/storage.