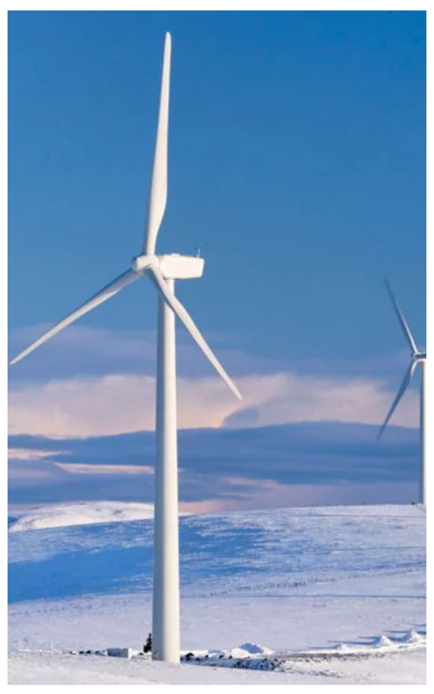


Research and Development

Scottish Passive Houses as wind-energy buffers

The idea

In a future electricity grid dominated by renewable energy, balancing supply and demand will become a key challenge. Previous research has shown that Passivhaus standard buildings can maintain comfortable conditions for long periods without supplementary heating, and suggested that electrically-heated Passivhaus buildings could be used as buffers to variable renewable electricity generation – turning electricity into heat when it is abundant and storing that heat in order to need less heating during periods of undersupply. This study seeks to quantify the degree to which heating in a Scottish Passivhaus could be shifted to periods of wind-energy oversupply, and the additional energy cost associated with different strategies to achieve this.

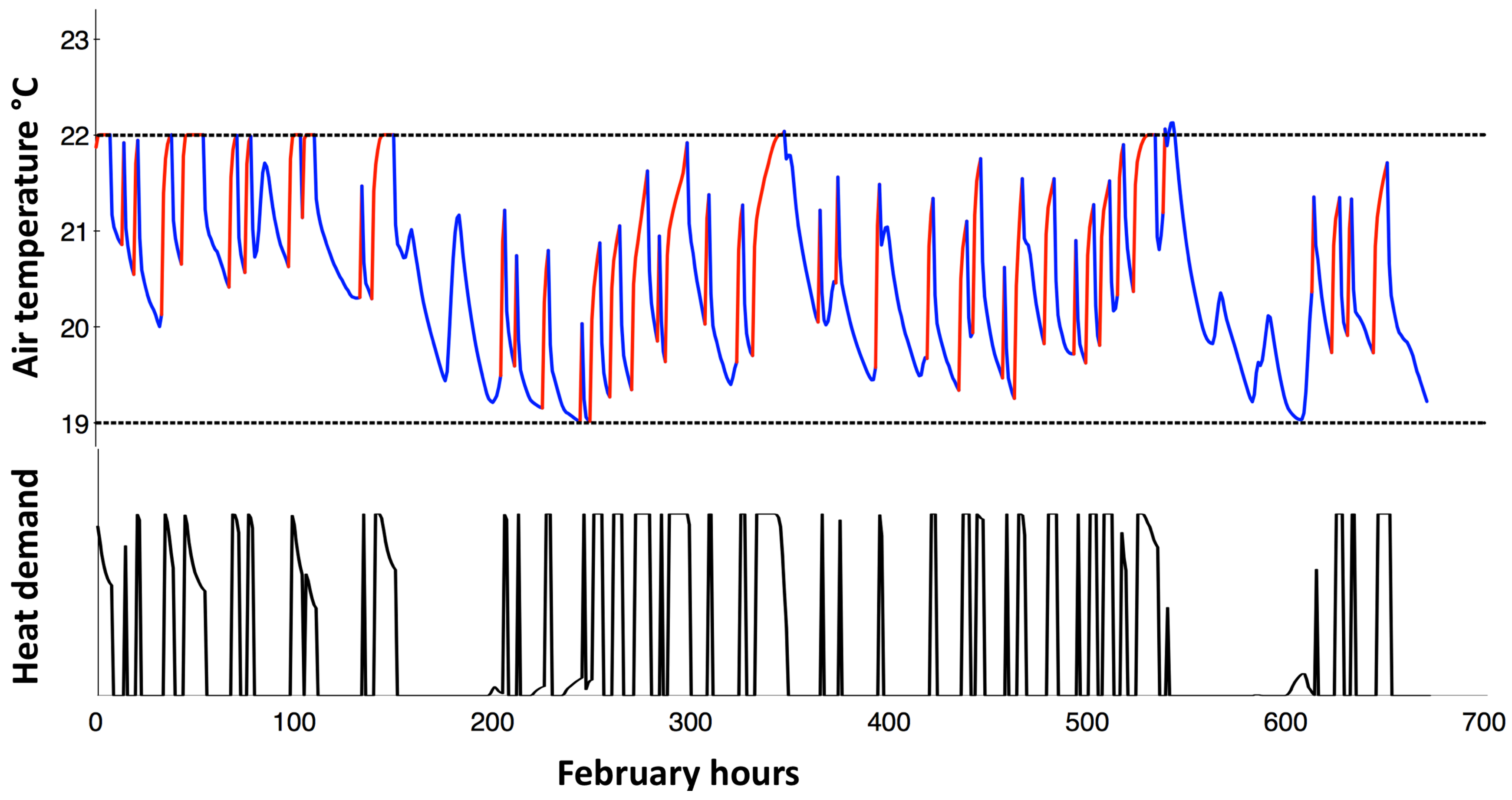
Method

A 100m^2 TFA Passivhaus, located in Oban on the west coast of Scotland, was designed using PHPP. The same building model was then built in DesignBuilder, a dynamic simulation tool.
Using half-hourly synthetic weather data a schedule of differential thermostat setpoints was created that heated to a higher temperature when wind speeds were above 4.4 m/s *and* outside of peak hours (1500 – 2000). Scottish wind turbines operate close to peak capacity for approximately 1/3 of the year, and wind speeds above 4.4 m/s represent the windiest 1/3 of the year.
Four different temperature setpoint scenarios were tested:

Scenario	Low temperature (undersupply) setting	High temperature (oversupply) setting
A	19	22
B	20	21
C	20	22
D	20	23

Results and discussion

The effect of these strategies on the supply of heating to the building can be seen below for scenario A, for the month of February. Red temperature lines indicate a period of wind over-supply, blue a period of under-supply. Implementing differential thermostat set-points allows most of the heating to take place during periods of over-supply.



The larger the difference between setpoint temperatures the more heating could be shifted to windy periods, with scenario A and D shifting 97% and 93% respectively, whereas scenario B shifted only 71%. However, these strategies also carry an energy cost with them, compared to a constant 20°C setpoint strategy, since the building spends considerable amounts of time warmer than usual. The higher the upper thermostat temperature, the higher the extra energy cost. This extra energy cost was small for scenario A (7% extra energy required), since the lower setpoint was actually below 20°C and for scenario B (6%) because the upper setpoint was only 1°C higher than the lower. Scenarios C and D required 13% and 20% extra heating energy respectively.
Scenarios A and B compare favourably, in efficiency terms, to more conventional means of managing renewable energy supply and demand such as batteries and pumped hydro and to less-conventional methods such as smart charging of electric vehicles and power-to-gas. The total amount of energy absorbed using these methods is comparable to the amount of energy required by an electric car over the same winter period; even for highly energy efficient buildings the size of the prize, in domestic terms, is quite big.

Future work

Having a large difference between upper and lower thermostat setpoints presents adaptive-comfort problems (will occupants be happy at 19°C a few days after having adapted to 22°C?) and increases total energy use. Heating to the upper setpoint is not always necessary to last out the next calm period. Future work will model a smarter thermostat that can see a weather forecast and adjust the temperature in anticipation of coming gaps in renewable generation.

Highland Passive

Author: Dr Esmond Tresidder
Director Lean Green Consulting and Highland Passive.
Es@HighlandPassive.com

Lean Green Consulting