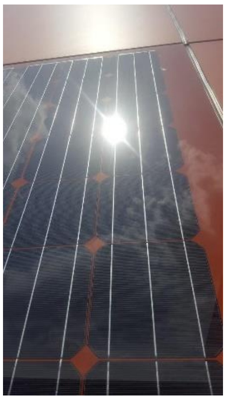
   

Q-Air – the solution for CO_2 emissions in northern countries – executive summary

In the EU there is rapidly growing concern for seasonal renewable power supply intermittency. Summer offers excess power, whereas, winter has a shortage. Winter shortage is almost entirely due to building heating demand. To compensate for this an energy buffer of staggering proportions would be required. For Germany alone, this buffer would need to be 43 TWh. This is 17-times more than the whole EU geo-potential for hydro-pumping energy storage, which would be impossible to build anyway as many national parks would need to be flooded. This problem has decisively derailed Germany's energy transition to the point that it has given up on its climate targets. Q-Air offers a uniqe solution to this problem. It can be demonstrated that with U-value of less than 0.4 W/m^2K, a zero heating building can be achieved. This is of profound importance to the problem of seasonal buffering as the source for the buffering need (building heating) gets eliminated. Such a zero heating building can syphon the excess summer PV power for cooling, thus generating zero CO_2.

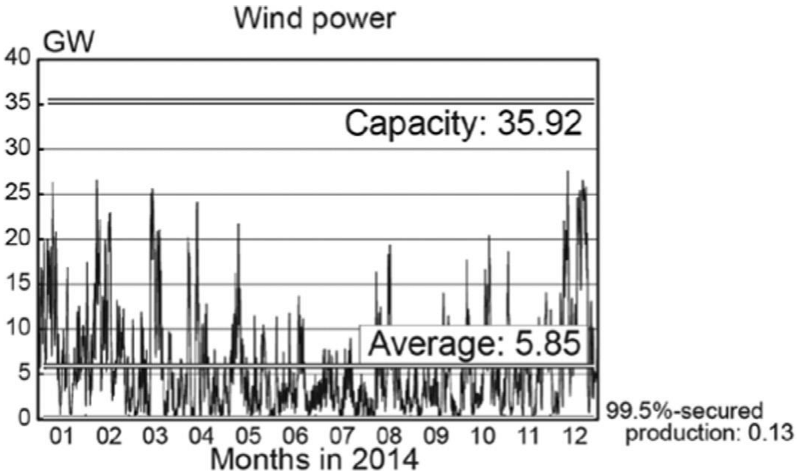
REFLEX

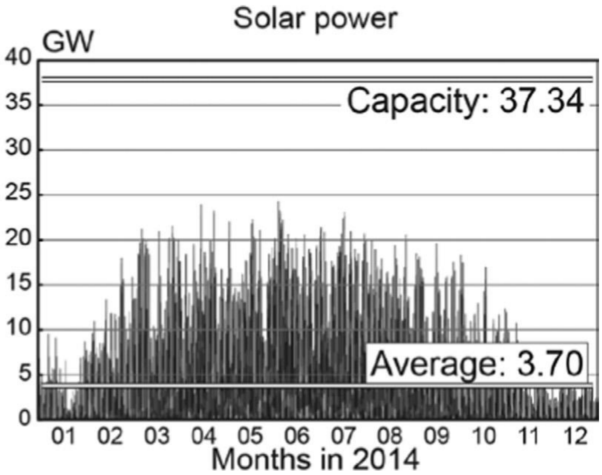
Q-Air

Table of contents

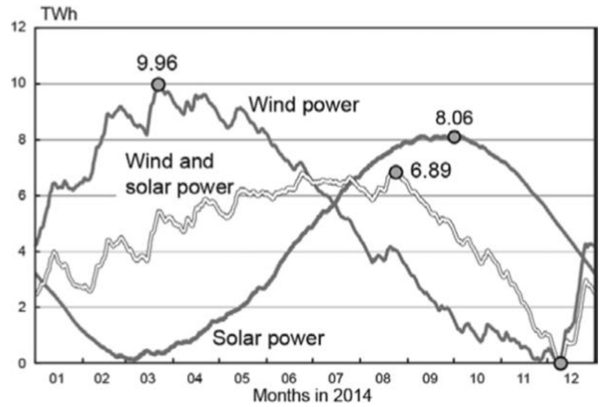
The European CO_2 problem: renewable intermittency 3
Standard glazing vs multipane (6-pane) 4
Appendix A - the new paradigm explained 5

The European CO_2 problem: renewable intermittency





As shown for Germany above, (2014 hourly data[1]), renewable power needs energy buffering. On the scale of the whole year ensuring seasonal buffering capacity is so huge that it cannot be technically achieved by any of today's or foreseeable near-future means[1]. Diagram on the right shows seasonal buffering capacity requirement for Germany to be about 7 TWh[1]. Should renewable power expand to encompass the whole electricity production in Germany, the buffering requirement increases to the staggering 43 TWh[1]. This is equivalent to 40.000 pumping hydro-power plants. The whole of western Europe could sport less than 3 TWh pumping storage capacity if all geological availability were exploited. Obviously, even this would be difficult as many national parks would need to be flooded. Other proposed solutions such as smart energy use (consumption smoothing) and interconnected EU grids for power production smoothing would offer only minor improvement[1]. Batteries such as electric car batteries could not be used due to prohibitive cost and inability to work as seasonal storage, E-gas, methane is energy inefficient method due to inefficient double conversions[1].

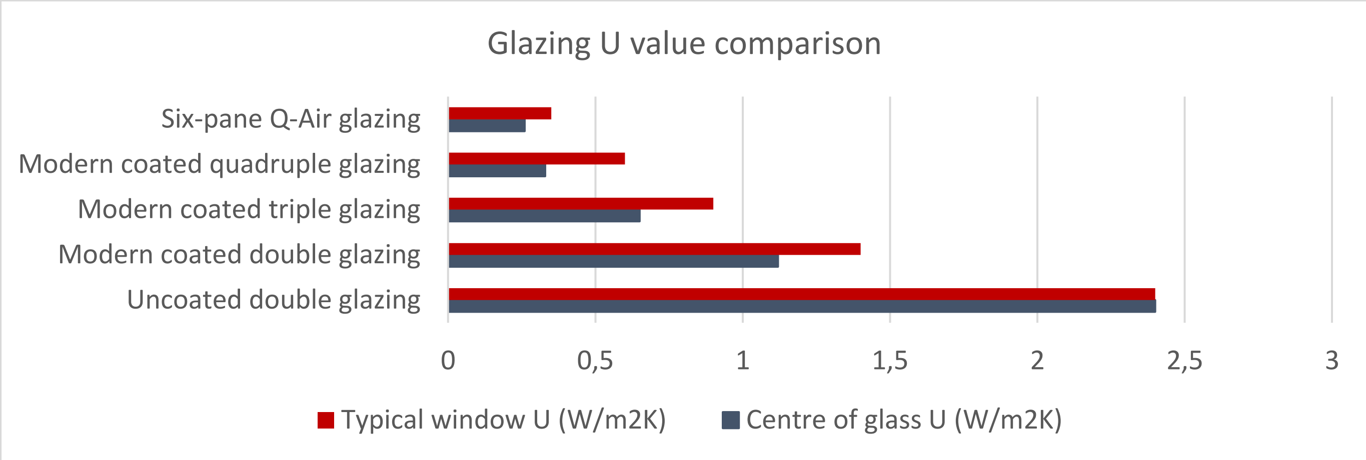


Observing the above, one could see an obvious summer electricity power surplus. The need to waste this surplus will increase with the further expansion of renewable power. Why not utilising this "free" surplus for cooling buildings and at the same time removing the need for winter heating which is the main cause for the needed seasonal buffering?

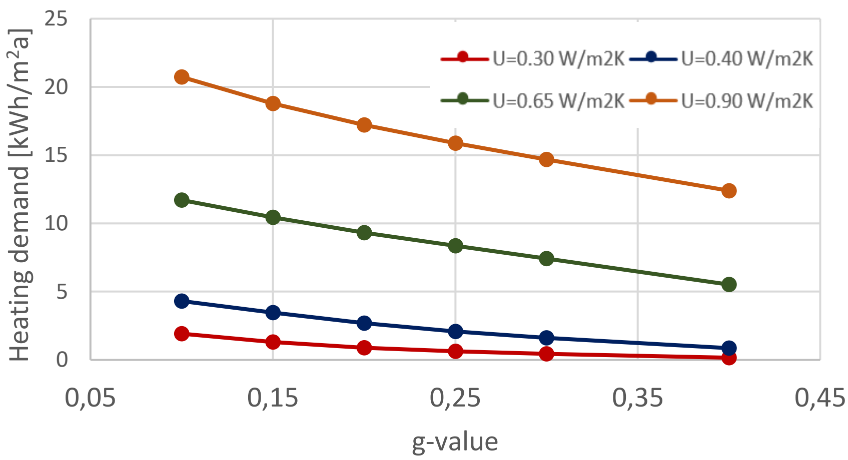
This can be achieved by using appropriately designed buildings with glazing with U value less than 0.4 W/m^2K.

[1] Sinn, Hans-Werner. "Buffering Volatility: A Study on the Limits of Germany's Energy Revolution." *European Economic Review* (2017).

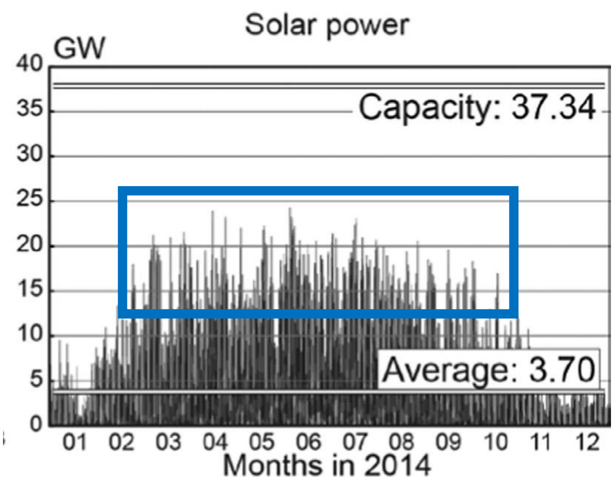
Standard glazing vs multipane (6-pane)



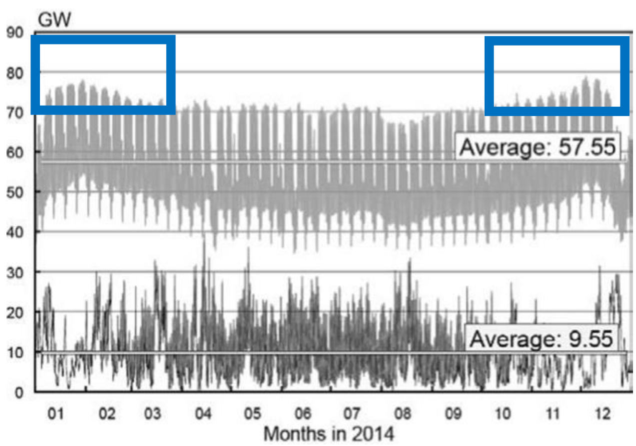
It is only when overall window U value sinks below 0.4 W/m^{2}K, does the building heating requirement approach zero (right diagram, for Oslo, Norway). At such a low U value glazing becomes net positive even in winter. This means that northerly oriented glazing with U value lower than 0.4 W/m^{2}K, on an average winter, cloudy day, collects more heat into the building than it dissipates over the whole 24hr period.



With Q-Air we can simultaneously use summer surplus PV power and eliminate winter power shortage without adding any additional cost to newbuild or renovated building.



Summer power surplus



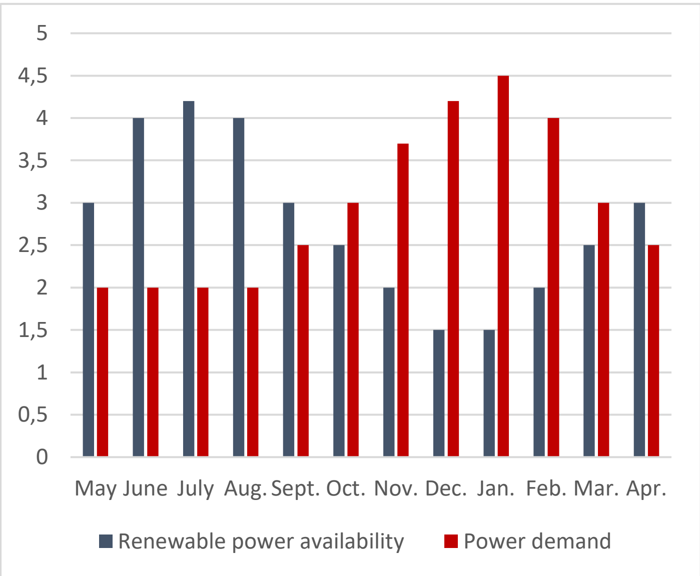
Winter power demand increase

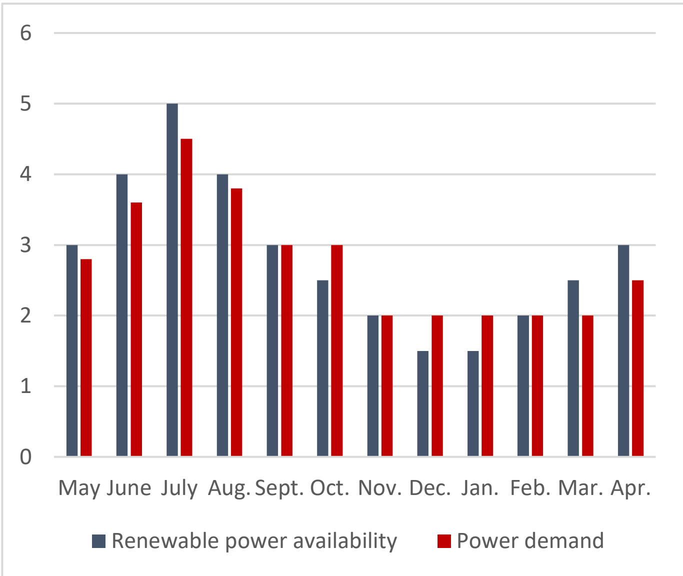
Appendix A - the new paradigm explained

Typical building with dominated heating demand has an annual energy profile which looks like the one on the chart below left. It has prominent summer renewable power availability either through the grid or installed on the building itself, and notable winter power requirement. There is an evident mismatch, which drives the need for the grid fossil power reserve. Hydropower plants must be used according to the water table; nuclear cannot be turned on and off on demand. There are no economical means to store summer surplus power “into the grid”, as obviously wires cannot store electricity. Surplus energy is simply wasted[2].

Cooling dominated building, as you can see on the chart below right, synchronises renewable power availability almost perfectly with the cooling demand. This is possible as summer cooling demand largely coincides with solar power generation.

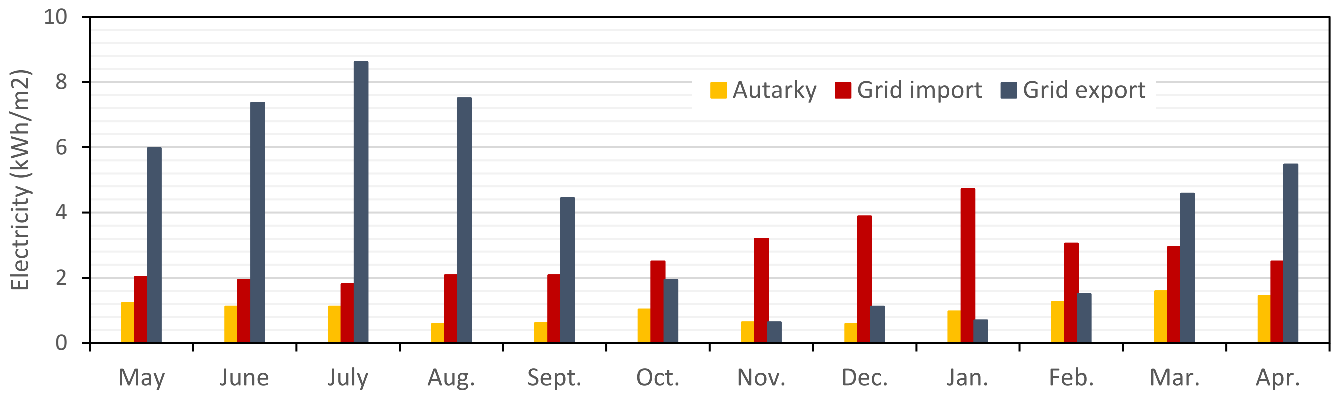
In this way, the need for fossil winter power reserve is removed entirely. This does not mean that such cooling dominated building does not need grid power. It does mean, however, that such building has even grid energy demand throughout the year.



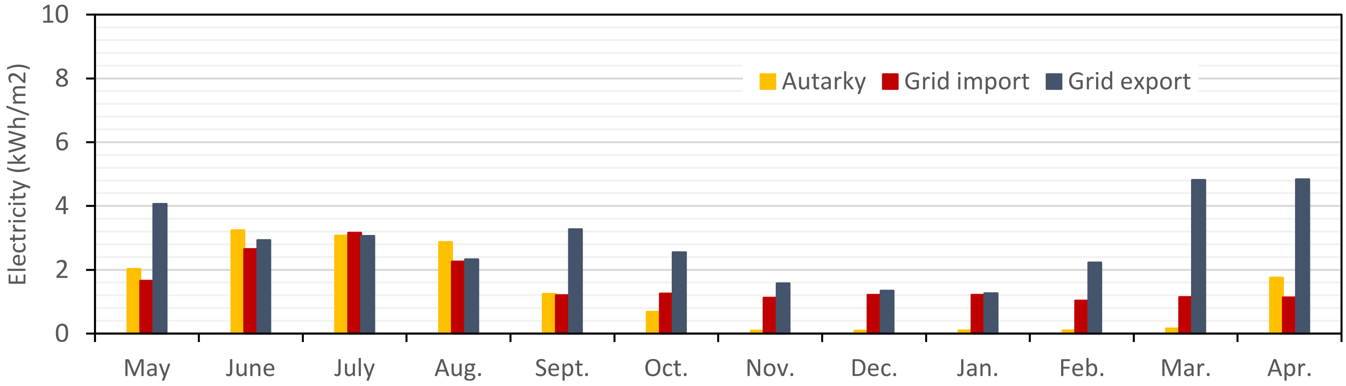


[2] Sinn, Hans-Werner. "Buffering Volatility: A Study on the Limits of Germany's Energy Revolution." *European Economic Review* (2017).

Let us now compare two realistic buildings. The first one is scientific literature reported[3] Swiss, two-storey home, nearly zero energy building, where the smart use of electric loads was used to optimize available solar power (middle chart). This precludes building occupants to use some equipment such as dishwasher for example at will. Building facilitates external dynamic sun shading, and as it is a habit in Swiss building design, no air-conditioning. There is some cooling through reversing the heat pump. Such arrangement caused the upper floor apartment to experience high humidity temperatures of above 25°C throughout the summer. In our opinion, these present intolerable conditions.



The second building (chart below) with energy results below is simulated Q-Air 70% glass to wall ratio building with 12x10 m ground floor. Here, the building was simulated without any smart technologies, so occupants could use any powered apparatus at will. The building is air-conditioned and thus in the summer temperature never exceeded 24.6 °C. A small 3 kW auxiliary heater is featured to prevent any departure from comfort range in extreme winter. Glass façade was exterior shading free with g value of 0.15. Even with g value this low, the Q-Air glazing with U_{cw} of 0.3 W/m^{2}K still functions as a net energy positive window, which means that it uptakes more light energy than there are heat losses in winter. Combined with building internal heat sources of 12 occupants, this is sufficient to eliminate heating almost completely. The remaining cooling demand is easily provided with renewable power through roof PV system. In this way, almost no CO_2 emissions are generated for the heating and cooling.



Conclusions:

In this way grid load is evened-out throughout the year, export to the grid is minimized in the summer and the autarky ratio (self-sufficiency ratio) is greatly improved. All this will additional benefit of all-time thermal comfort.

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[3] Hall, Monika, and Achim Geissler. "Different balancing methods for Net Zero Energy Buildings-Impact of time steps, grid interaction and weighting factors." *Energy Procedia* 122 (2017): 379-384.