Influence of the orientation of solar systems

Most solar systems on existing buildings are planned such that the total annual yield is as large as possible and this is at the same time realised with the simplest possible installation. In unshaded locations in much of Switzerland, this results in a southern exposure with an inclination of about 35°. See for example figure 1 showing my first solar installation. The angle is however not exactly 35°, because this configuration is not completely unshaded and other factors also apply. E.g. snow (steeper is better) and neighbours (flatter is better).

Figure 1: This solar installation in Frenkendorf BL is oriented exactly to the south even though the building points south-southeast.

However, this arrangement leads to reduced yields in winter. In order to increase these, it is better to orient the panels steeper or even vertical on south facades instead of on roofs. The morning and evening yields are also smaller. In order to increase these, it is better to either use east and west roofs, or to mount the panels very flat.

In order to maximize the yield for each day of the year, two-axis tracking can be used, as shown in Figure 2.

Figure 2: This installation in Schwendibach, Homberg, BE, always points directly to the sun.

Such tracking systems are rare because of the considerable expense. Another option is single-axis tracking and/or seasonal adjustment. The cost is smaller than for two-axis tracking, especially if the seasonal optimum angle is adjusted by hand. On my system in Frenkendorf, the latter was possible. But after two years the motivation to climb onto the roof diminished and the panels were fixed in a central position. Presumably therefore, only automatic systems would provide an effective advantage in comparison to fixed systems.

With regard to energy policy, it would be desirable to increase yields in the winter and also during certain hours of peak usage. However electricity payments to private producers are not varied in time in order to motivate towards this goal. Today there is thus no incentive to abandon the type of income maximization which results in high summer and noon peaks.

However it is likely that this will change. On the one hand, photovoltaics are becoming cheaper, on the other hand, a "smart grid" would allow even the smallest producers to profit from time-differentiated electricity rates - but only if policy makers and legislators decide this way.

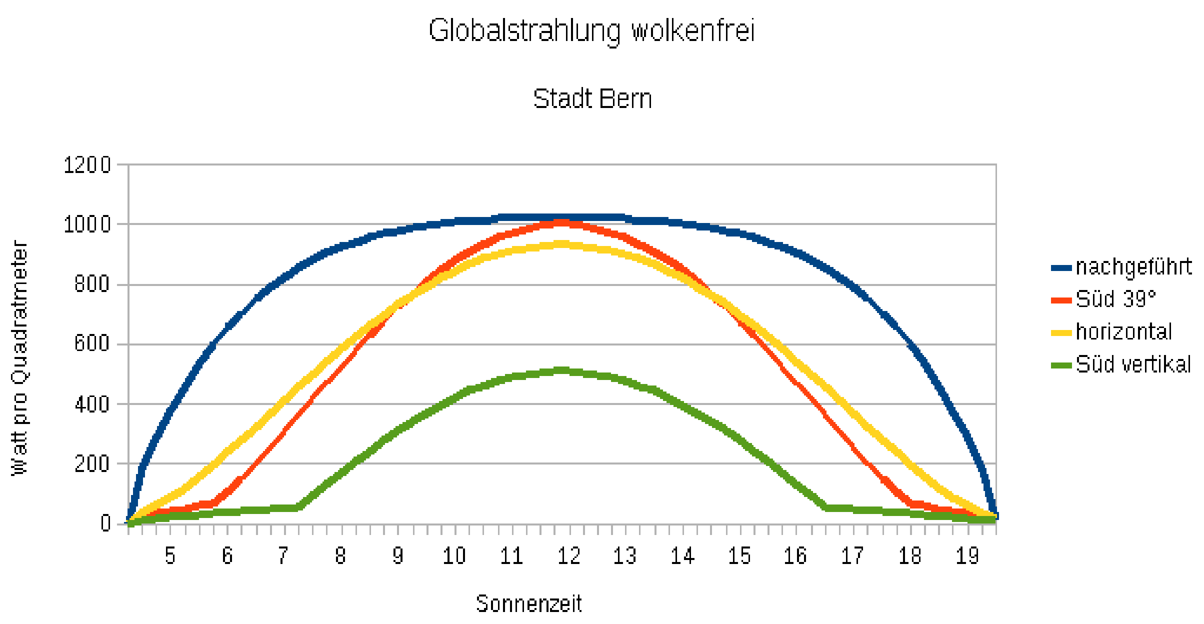
Once the producers of solar power are reimbursed for the quickly varying electricity prices instead of annual averages, it might be worthwhile for them to try to fill morning, evening, and winter "holes" rather than to maximize total return. The technical possibilities are already here: "smart meters", which - calibrated and certified - record the momentary grid-feed via the internet or by data-logging for later comparison and remuneration. The technology exists, the legal basis does not.

This development could be accelerated as long as financial incentive instruments still exist. For example, east and west panels could be reimbursed more than south panels.

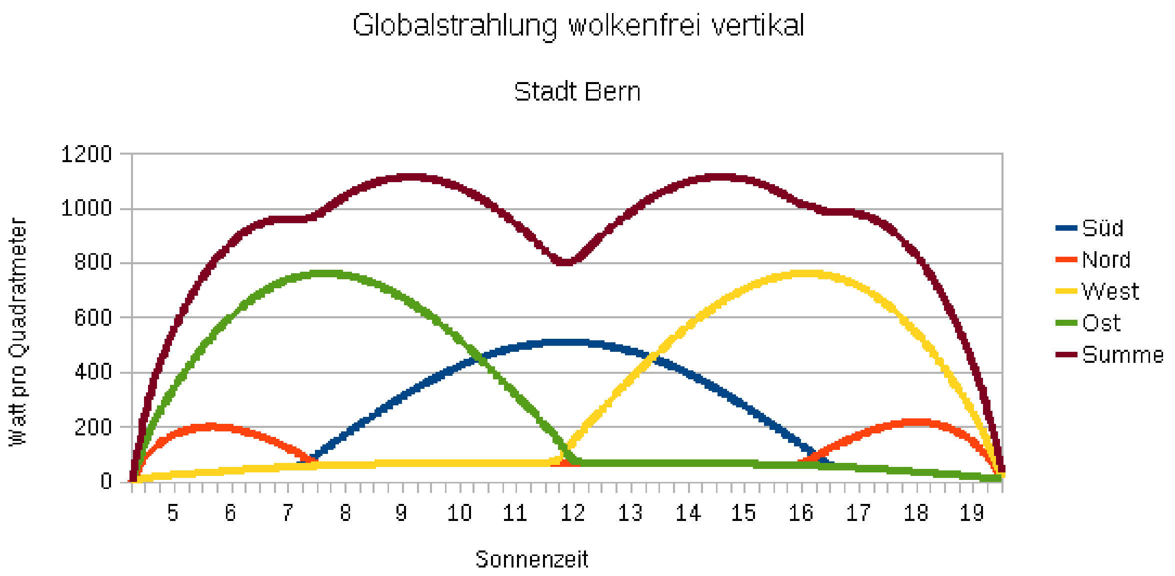
Eventually solar cells will be only slightly more expensive than conventional roofing and facade materials and windows. Then it may be advantageous to equip all roof surfaces, facades and perhaps also windows with PV, and in addition to the south facing surfaces, also the east, west and even north surfaces. Today, this is already done for architectural reasons, e.g. on high-rise buildings at the Sihlweidstrasse in Zurich. See http://www.pvtest.ch/fileadmin/user_upload/lab1/pv/publikationen/PV-Duennschichtfassaden.pdf .

How then do the yield curves of the different arrangements look like? This can be answered by using PV calculators such as the online tool offered by the Euopean Commission. See http://re.jrc.ec.europa.eu/pvgis/apps4/pvest.php?lang=de&map=europe . Such tools combine geometric calculations, real weather data and the horizons (natural skylines) at any location.

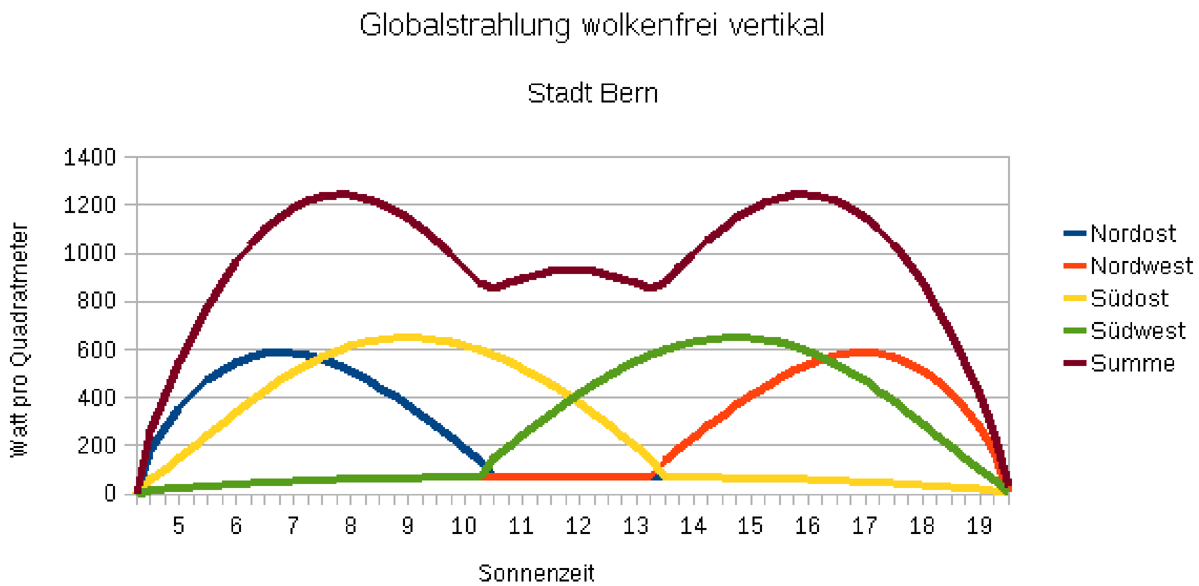
A diagram of such data is shown for the city of Bern (unobstructed location). It shows the global radiation - not the electrical output of the solar cells - in June under a cloudless sky, for 2-axis tracking ("nachgeführt"), for a horizontal surface, for a vertical south-pointing surface, and for a south-pointing surface with an inclination of 39°. So the usual south orientations bring the familiar midday peaks and a horizontal surface can give a slight but valuable contribution around an hour after sunrise and before sunset.



Now we come to the curves of buildings, of which all four vertical facades are solarised, as with the high-rise building in Zurich mentioned above. The next diagram shows the value of a house with same size south, north, east and west facades. Also indicated is the sum of all of these areas. At noon there is a small valley but the performance in the morning and in the evening is even higher than for a tracked system, but at four times the solar surface (i.e. to compare, the scale for this curve must be divided by four).



The next diagram showns the situation if the house is oriented diagonally. Here we have morning and evening peaks e.g. useful for powering the trains of commuters, and the midday valley compensates the peaks of other solar installations.



Conclusion: It is possible to provide useful power from PV systems from morning to evening and not just around midday. Tracking systems are not required, as it can alternatively be done by covering of all facades with cheap solar panels. Not treated here are the other seasons, e.g. winter, where south pointing vertical facades are particularly advantageous. However vertical surfaces should not be used instead of flat or horizontal ones on roofs, but in addition to these.