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The bright side of snow cover effects on PV production - How to lower the seasonal mismatch between electricity supply and demand in a fully renewable Switzerland

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One of the major problems with solar PV in the context of a fully renewable electricity production at mid-latitudes is the trend of higher production in summer and lower production in winter. This trend is most often exactly opposite to demand patterns, causing a seasonal mismatch that requires extensive balancing power from other production sources or large storage capacities. Which possibilities do we have to bring PV production into closer correlation with demand? This question motivated our research and in response we investigated the effects of placing PV panels at different tilt angles in regions with extensive snow cover to increase winter production from ground reflected short wave radiation.

The aim of this project is therefore to quantify the effect of varying snow cover duration (SCD) and of panel tilt angle on the annual total production and on production during winter months when electricity is most needed. We chose Switzerland as ideal test site, because it has a wide range of snow cover conditions and a high potential for renewable electricity production. But methods can be applied to other regions of comparable conditions for snow cover and irradiance.

Our analysis can be separated into two steps:
1. A systematic, GIS and satellite-based analysis for all of Switzerland: We use time series of satellite-derived irradiance, and snow cover characteristics together with land surface cover types and elevation information to quantify the environmental conditions and to estimate potential production and ideal tilt angles.
2. A scenario-based analysis that contrasts the production patterns of different placement scenarios for PV panels in urban, rural and mountainous areas. We invoke a model of a fully renewable electricity system (including Switzerland's large hydropower system) at national level to compute the electricity import and storage capacity that will be required to balance the remaining mismatch between production and demand to further illuminate trade-offs between the different placement scenarios.

Our results show that in regions with extended periods of snow cover the winter production can be 10% higher without sacrifices on the annual total production. This helps significantly in reducing the energy gap mentioned above; annual required import can be lowered by 10%-20% and forced export due to overproduction during summer months reduces to less than half.