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Solar energy for information technology: challenges and possibilities

Shrisha Rao and Pragati Agrawal

Information technology (IT) equipment is already estimated to account for about 2% of the global energy consumption, and this figure is only expected to rise. However, the use of solar power for IT is yet to receive the attention it deserves from researchers, and there is a vast array of important problems to be addressed to enable the use of solar and other alternative energy sources in IT. In this note, we take the view that a broad systems perspective of solar power generation and utilization (rather than looking only at component technologies such as PV, solar-thermal, etc.) is essential, and mention major directions which in our opinion merit attention in this regard.

With the worldwide increase in both solar energy production as well as in the consumption of energy by information technology (IT) systems, especially large data centres and such, it appears inevitable that these two seemingly disparate trends will soon interact in a much more significant way than at present. It is therefore necessary for us to understand the likely manner of such an interaction, and prepare to meet the challenges that come with it. Some obvious points may be noted in this regard:

- IT loads often have stringent availability requirements, coming to 'five-9s' (i.e. 99.999% uptime) or more.
- IT equipment and services cannot be easily shut down or restarted, but unlike other systems, IT jobs can sometimes be (re-)located across great geographical distances.
- Solar energy is subject to known variations (hourly, seasonal, latitudinal) that can be taken into account in some cases.

It is thus of interest to consider how solar generation systems (regardless of the specific technologies used) can be tuned to meet the needs of IT systems, and how IT systems in turn can be built to work with solar power. It could be thought that networked systems such as data centres are not in the proper purview of studies of solar energy consumption, but it should also be noted that with new technologies and concepts such as the 'Internet of Things', many systems that were not commonly considered networked are becoming so. Therefore, studies based on concepts involving networked systems can and do apply in the analyses of large systems (even conventional, non-IT systems) that are not usually thought of as being networked.

State of the art

It has been more than 50 years since the first efficient solar cell was developed.

Starting from satellites back then, solar electricity is now used in many sectors like household lighting, automobiles and even aircraft. Big solar electricity power plants have also been constructed which supply power to regular electricity grids. After much delay it has been realized that solar power is also relevant to the IT sector.

These days, some IT companies have started using solar energy, mostly in the form of solar electricity to supply some power to their data centres. Apple has built a large solar array next to its new data centre in Maiden, North Carolina[1]. This array is the largest such installation for a data centre and provides 20 MW of electricity at its peak. Many other companies like McGraw-Hill, Phoenix IT and Facebook have also begun to equip their data centres with solar cell arrays. IBM in India has initiated the installing of solar arrays on the roofs of their data centres which will fulfil up to 20% of their energy requirements[2]. In Africa, solar cells are installed in some schools in villages to provide power for computers and Internet connections[3]. This has a good social impact, as these areas suffer from shortage of electricity. In addition to PV, other technologies like solar thermal can also be used in connection with these data centres.

Surprisingly, there is a dearth of scientific publications in this field, and the confluence of solar energy and IT has received little serious attention from researchers in either discipline. We believe that the intersection of IT and solar power should be analysed in depth, rather than merely counting on the ongoing solar energy research efforts to come up with better electricity generation technologies and expecting IT to use electricity as it always has. We propose two major directions in which studies can be made: (i) the analyses and creation of solar power systems that are specifically suited to serve IT loads; and (ii) the modifications needed to IT systems to enable them to effectively use solar energy.

Solar power systems for IT loads

The methods and approaches that will be needed to make solar and other alternative energy sources viable on a massive scale will require 'systems thinking' and approaches on a similarly large scale, rather than being merely confined to specific tools and technologies (like PV, solar thermal, etc.) for solar power production. The development of such specific technologies is surely an important aspect of solar energy research, but it is by no means the sole one. The development of specific technologies for solar energy production should be complemented by systems research that examines larger systems issues pertaining to solar energy that may be orthogonal to the specific choice of solar-generation technology. One such issue obviously is the development of methods of solar generation that suit IT loads, such as by connecting geographically spread solar power plants to produce power at a more uniform rate than any plant would individually[4]. Given that IT systems often have stringent availability requirements, this type of study is absolutely essential when it comes to designing and building solar power systems to supply energy to IT systems on a massive scale.

There is around 14% loss in conversion from grid electricity (AC) to the power required by IT systems (DC), whereas the loss is only about 4% in conversion from solar electricity (DC) to IT loads[2]. Hence a significant gain can be achieved if solar electricity is used in place of grid electricity. Though solar electricity is presently costlier than grid energy (often powered by coal), its production cost is declining. In many countries, grid power is expensive during peak hours. Though solar energy is not available throughout the day, it is often available at peak hours. Hence planning can be done to use solar electricity in conjunction with grid power in IT systems to reduce energy costs.

Designing IT systems for solar energy

Large IT systems (such as large data centres used in cloud computing) can consume power at the rate of megawatts[5], just like any other large systems, and we will surely, before long, see such systems using solar power on a significant scale. It is therefore prudent to wonder how consumption practices of large systems, such as those in IT, need to evolve in order for such systems to become effective consumers of solar energy. Some specific ideas or hints can be suggested in this regard. One is to come up with general principles of systems design to achieve demand-side management (also known as demand–response) in the specific context of solar energy supply, i.e. to create demand–response systems that take particular note of the characteristics of solar energy supply[6]. Another is to create algorithms that permit large jobs (such as those arising in cloud computing) to be geo-located (possibly in near-real time) to take advantage of solar energy availability in particular locations at particular times[7]. A third is to find ways to schedule heterogeneous computing jobs (e.g. in cloud computing) to take opportunistic advantage of solar energy availability.

Conclusion

We have argued for the need of a specialized interdisciplinary study of solar energy and IT. We believe that the interaction of solar energy with IT is important and that such study is a necessity that will, in future, appear inevitable.

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