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# The Application of Solar Photovoltaic (PV) Generation Technology to Data-Centre Facilities

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Ark Continuity delivers high integrity data centres for Government and Corporate occupiers. Ark is now building data centre campus locations at Spring Park, Wiltshire and Cody Park, Hampshire. Data Centre SQ17, module one, is now operational. All facilities are designed to be the most secure, available and sustainable in Europe.

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## Background

As electrical power costs climb and corporate entities wish to advertise their 'green' credentials the application of sustainable power generation to data-centre facilities has gathered pace. Although the application of on-site generation using renewable technologies is usually limited by available land, rooftop space or fuel logistics an option that increasingly attracts attention, and publicity headlines, is that of solar photovoltaic panels.

This paper attempts to clarify the practicalities of applying PV to a typical data-centre.

## Technology

Current technology is based upon encapsulated wafers of silicon PV cells that convert solar radiation to a low voltage DC. The voltage output is proportional to the strength of the radiation falling onto the cell. The cells are generally built into 12V or 24V panels and those panels can be daisy-chained to a relatively high DC voltage suitable for inverter conversion to AC (for example to 230V) or applied to a low voltage DC load to avoid conversion losses. At low voltage the distribution distance has to be relatively short to avoid large cross-section copper conductors, $I^2R$ losses and volt-drop.

To produce maximum power the panels must be tilted to face the 'brightest' part of the sky. In the UK this means tilted 30-35° from the horizontal and facing south. The cells should not be overshadowed by structures, buildings or vegetation for the entire daily cycle of the sun across the sky in every season.

Contrary to common perception the cells need daylight not sunshine – but the clearer the sky the higher the level of radiation that reaches the silicon-cell face.

It is not that uncommon to see solar-PV panel built into the vertical walls of buildings, some even not south facing, but this clearly limits the effectiveness of energy collection and is only a form of architectural gimmick.

## Intermittence

The obvious limitation of solar PV is the daylight (strictly speaking, 'radiation') hours per day and intensity that the PV panels are exposed to - the 'intermittence' of the output being in common with other renewable energies such as wind, tidal, wave etc.

The intermittence raises the first design issue – energy storage. With data-centre loads being virtually constant the choice is between a dedicated (separate) load and an energy storage system to bridge the dark hours (e.g. lead-acid batteries) or to parallel the output of the PV system with the mains supply and simply use the power collected to reduce the demand on the grid.

In the first case you have to accept the charge/discharge losses of the battery system and in the second case the losses in the voltage boost converter and DC/AC inverter. Clearly in both cases the fuel is 'free' so classic 'efficiency' issues should not apply – but the capital cost of plant and a Return on Investment (ROI) is a factor in the choice.

## Insolation

At the latitude of the UK the peak solar radiation is around 1kW/m² and the daily/seasonal cycle will aggregate to a gross value of around 3,000kWh/m²/year given ideal installation and alignment conditions.

## Energy conversion efficiency

The average conversion efficiency using the current silicon based technology has been in the order of 15% with a peak of up to 20%. Only a radical change in the material technology will enable future conversion efficiencies higher than 20-25%.

## Deployment and space availability

The ideal location is on the flat roof of the data-centre, assuming that the heat rejection plant is not already occupying the space, tilted to 30-35° and facing south (in the UK). We can relate the space available on the roof to the space taken up by a single IT cabinet – which is around 5m² of gross floor area when combining raised floor & plant-room space.

To allow for service access and the panel-tilt the maximum solar cell surface area in a 5m² roof footprint will be around 3m². This is for a single storey facility – with proportionately less for multi-storey facilities.

## On-site power generation

It is simple arithmetic to calculate the kWh/year produced by a 3m², 15% efficient, PV array with a gross insolation of 3,000kWh/m²/year. The result is 1350kWh – equivalent to a constant load of just above 150W.

## Generation capacity Vs demand

The single IT cabinet consumes 5m² of roof space onto which we can fit 3m² of PV array which generates 1350kWh/year. Without considering high-density facilities and ignoring the cooling load altogether, the constant electrical load of the average IT cabinet is in the order of 4kW (a modest power density of around 1500W/m²) which is equivalent to 35,000kWh/year.

It can be seen that a PV array of current silicon technology will produce no more than 4% of a modest IT load even if the entire roof space of a single storey facility is covered. A more practical solution will reduce this to 2-3%.

Another way of considering the power generated is to compare it with a Blade-Server chassis, typically occupying only 7U of a single 42U high IT cabinet, whose average demand is 5.5kW. The PV array will contribute less than 3% of a load occupying 1/6$^{th}$ of a cabinet.

If a separate load is planned for the PV installation then a 100% rooftop coverage array could be relied upon to generate sufficient power for high efficiency motion-detected aisle lighting in the raised floor space (requiring about 50W per cabinet predominately during the hours of daylight) and the security-access/BMS/EMS systems.

## Embedded Carbon & ROI

It is worthy of note that the embedded carbon (from the energy used in manufacture) in the silicon based cells is not recovered through power generated in service for at least four years. It is anticipated that new technology using more exotic materials will improve both the conversion efficiency and reduce the embedded carbon.

Without government subsidy for the kWh produced (via demand side reduction) the capital cost of PV currently prohibits any financial Return on Investment. Generally the cost of electricity would have to double and the capital cost of the cells halve before a sub-10 year ROI will be possible.

## Conclusions

The high and continuous load found in data-centre facilities is not conducive with the low power and intermittence of solar photo-voltaic on-site power generation.

Demonstration projects, especially those aided by government subsidies for installation and generation, are possible and could reduce the typical load by 2-3% if the entire roof space of a single storey facility is utilised. A Return on Investment is not currently available and $CO_2$ emission savings are marginal in the service period beyond 4-5 years after installation. However, all, if any, emission savings depend upon the power-generation fuel mix in the country of installation or any special national contracts in place to purchase ‘green’ power from sustainable sources.

For IT power densities of c10kW/cabinet the proportion of sustainable PV derived energy falls to less than 0.6% when the cooling system energy (at a PUE=1.5) is taken into account.

## End