RENEWABLE POWER FOR LEAN DESKTOPS IN MEDIA APPLICATIONS

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ABSTRACT

An integration of solar microgeneration to supply a low-power IT desktop, using the Power over Ethernet standards IEEE 802.3af/at as a low power distribution network avoiding transformer losses from DC generation to mains power AC and back to low-voltage DC and hence maximising efficiency.

The resulting design points to applications in media technology where reducing grid power consumption is critical for improving sustainability, or where there are supply constraints, and indicates new directions in how we manage and consume power for IT devices.

INTRODUCTION

Enterprises are actively working to reduce their environmental impact, reduce carbon emissions and improve energy efficiency. IT equipment is recognised as a significant contributor to the environmental footprint of an enterprise from the total lifecycle cost in energy and materials. Estimates range between 2% and 5% (or higher in some European countries) and is comparable with figures for the aviation industry. Datacentres have been the major focus of attention, especially for technology service providers, but the ubiquity of desktop IT equipment presents a different set of environmental challenges for enterprises.

This paper describes an innovative approach to efficiently using on-site renewable microgeneration to directly power networked IT hardware, and the prototype developed by collaboration between Siemens, the University of Strathclyde and the Buildings Research Establishment, part-funded by the UK Government Technology Strategy Board under the "Low Carbon Technologies" programme and supported by the BBC. It provides a client-side counterpart of datacentre optimisation, and fits into the Siemens "IT for Sustainability" strategy to provide holistic solutions to mitigate carbon emissions and utilise IT to enable further savings.

Background

Photovoltaic (PV) panels generate electricity as low voltage direct current (DC). IT hardware consumes low voltage DC. The challenge is to remove the losses and inefficiencies due to power transformation between low voltages DC power to 220-240V AC mains and back again, and deliver reliable renewable power to the desktop. In this design, solar photovoltaic power and existing Power over Ethernet standards are integrated with low power IT equipment and novel control systems to manage and optimise the highly variable demands placed upon the system. Together these can reduce carbon emissions, energy costs and total cost of ownership. It also provides an alternative power source for use in situations where the local grid power supply is uncertain, such as in remote sites or on location.

The media industry, broadcasters and content producers are acutely aware of environmental issues and there are early adopters of strong carbon and energy mitigation strategies in the media industry. The BBC's own Environment strategy sets out targets, especially a 25% reduction in energy usage by 2013, working towards the Carbon Reduction Commitment and further regulatory and economic drivers are expected from governments and the EU. At the same time, structural changes in the power industry, declining generating capacity, adoption of renewable sources and pricing driven by real-time demand throughout the day all add pressure from the supply side. Therefore enterprises are now taking practical steps to manage energy use on the demand-side, where choices are more under their own control. This is an area where the IP network infrastructure can be used to reduce the direct impact of IT, for example through adoption of unified communications deployed and managed at the BBC with expertise from Siemens, and support indirect savings through sensing and monitoring energy demand.

BUSINESS CONTEXT

The business questions within an environment strategy must include how to minimise the direct energy consumption from widely distributed IT equipment, how to minimise heat competition between office IT equipment and air conditioning yet, still maintain thermal comfort, and how to cope sustainably with anticipated power shortages or brown-outs as the power grid suffers increasing demand and declining capacity.

Direct energy consumption from IT equipment

IT manufacturers are making efforts to reduce the power consumption of their products, but the peak power rating of typical desktop machine is still in the region of 100W. Under normal workload a desktop PC would be using less than that, but most is turned into heat by the power supply unit inside the machine. Laptops fare slightly better, but power supply units ("bricks") are still dissipating of their power as heat. A workstation intended for heavy graphics processing (as in video editing) may consume 500W at times, but these machines are exceptional and comparatively few in number. For broadcasting applications in the field, power availability and consumption and heat gain are design and operational challenges. There is still work to be done improving the performance of low power IT to the level where it can be used in high-end media production although Apple Computers are making some progress in this direction, we may soon see machines capable of high quality video editing which we can integrate with renewable microgeneration.

Heat gain and competition

For much of the year, the heat produced by power supply units competes with office air conditioning, which has to compensate to maintain a comfortable working environment. In temperate climates, (between Paris and Edinburgh) modern, well insulated buildings require cooling for more than they need heating. For every 100W used by IT equipment and lighting, we can add an additional 60% for extra cooling to compensate and in Mediterranean climates, that figure is closer to 100%. At the northern end of the range, between London and Edinburgh, the most efficient building designs can make very significant savings through using passive cooling techniques instead of conventional air conditioning, giving large benefits in installation and operational energy costs. As more of the building stock is refurbished to high standards, such as the BREEAM "Excellent" rating, the heat gain due to office equipment becomes a significant factor, which needs to be minimised.

Continuity of grid power

Over the next ten years, increasing demand for electricity and decreasing generating capacity in the UK (as end-of-life power stations are decommissioned) are expected to increase the chance of power shortages and brown-outs, during hot summer afternoons, when the cooling loads are greatest. If this becomes a frequent occurrence, a sustainable alternative to diesel back-up generators (which detract from carbon emissions audits) would become very attractive.

Renewable power sources

Considering how on-site microgeneration might be applied to reduce the demand and dependency upon grid power, micro-wind turbines can only deliver adequate power in a very few exposed locations and are usually not cost-effective in built-up areas. Microgeneration from water power (tide, wave or river) has very few suitable locations.

Power generation from biomass or combustible waste may be used to mitigate power shortages, but it also requires significant infrastructure investment and transporting fuel and residues may reduce the overall effectiveness.

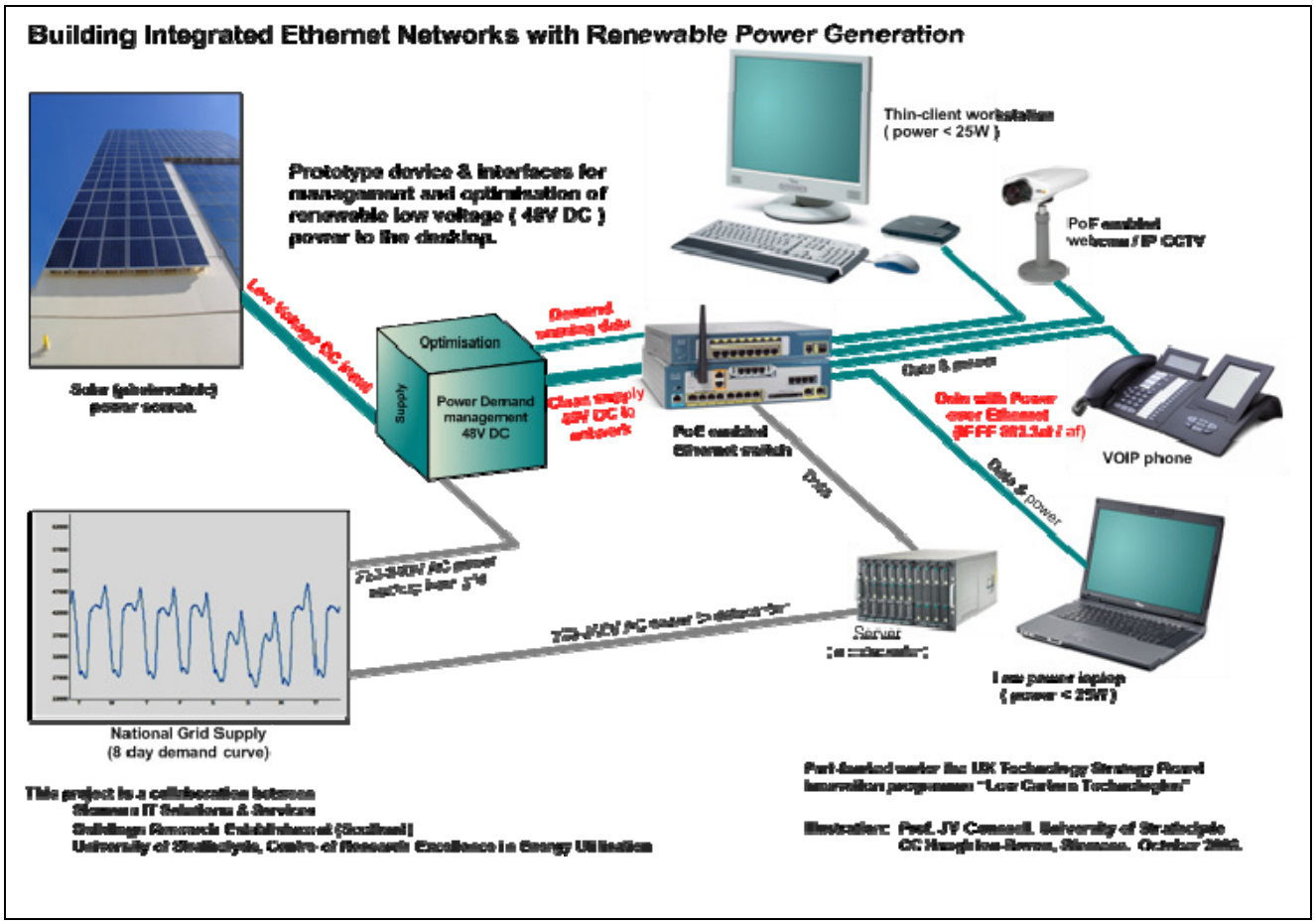
The price/performance of solar photovoltaic technology is steadily improving. Recent Siemens installations are operating at 18% solar efficiency in Germany. Siemens has shown

prototypes of semi-transparent photovoltaic polymer films intended for application to large glass windows. Whilst only about 10% solar efficient today, the widespread application of this technology will be a big step forward in cost effective solar microgeneration when it reaches commercial production.

At present, solar photovoltaic power is viable if the low voltage direct current generated (around 48V DC) can be put to use at very high efficiencies.

Therefore this project has concentrated on using solar microgeneration to generate a relatively small amount of power and then design for this power to be distributed and consumed by desktop IT equipment with the minimum of end-to-end losses.

The technical challenge then becomes how to make the best possible use of low-voltage direct current photovoltaic power to replace grid power in the enterprise?



TECHNICAL DESIGN

Concept

A proof-of-concept prototype has been designed and built from an original idea by Professor John Counsell, Director of the BRE Centre of Research Excellence in Energy Utilisation, at the University of Strathclyde.

It generates low voltage DC power from photovoltaic panels, uses the Power over Ethernet (PoE) standards (IEEE802.3af & at) to distribute the power at 48V DC over the office IT cabling infrastructure to desktop IT equipment over a distance of tens of metres. This is particularly efficient as it avoids the inherent losses as magnetism and heat in converting

between DC and AC. The design required new control systems for mediating between the variable supply from the solar panels and the variable demand from the network are implemented. These are represented by the green cube in the schematic diagram (Figure 1).

Power over Ethernet, standards and networks A modest amount of power can be carried over conventional CAT5 network cabling from a PoE enabled network switch. This is widely used for VOIP phones, IP-based CCTV cameras and a few models of thin-client workstations. It avoids the need to have a separate mains power supply unit built into to the device. As it is a single cable solution it is often used in places where providing mains power would be difficult, expensive or even hazardous. There are military implementations where secure "field networks" are deployed from trucks and tents for mobile command and support centres. The current standard (IEEE 802.3af) delivers up to 12W over each PoE enabled network connection. Cisco Systems also have a proprietary extension, PoE+, which delivers a bit more power.

The new standard, 802.3at, is awaiting ratification, but does allow up to 25W to be delivered by using more strands of the CAT5 cable to carry power.

The enormous advantage of this architecture is that CAT5 and subsequent versions of structured network cabling have been standardised for data networking since the early 1990's and have been specified in the vast majority of office refurbishments since then. It is expected to remain the metal cabling of choice for many years to come and is also becoming common in hotels and in broadband enabled homes. This installed base means renewable microgeneration installations can be integrated with an existing distribution network throughout a building, as combined data and power to, PoE enabled devices.

PoE already has a well established user base in communications and security, until now, its low power has been an obstacle to widespread adoption in IT. Industry estimates by VDC Group (2008) show 47 million out of 237 million Ethernet ports (18%) are PoE enabled in 2007, rising to 132 million out of a total of 432 million by 2012. This becomes a strong enabler for the business benefit of renewable microgeneration with photovoltaic power. The BBC has already deployed PoE in newer sites, mostly for VOIP telephony, which is in turn the technical enabler for environmental savings through unified communications. Most of the current BBC network infrastructure is progressively upgradeable to support PoE as and when the business requires it.

The Lean Desktop With this in mind, the requirement was to be able to operate laptops running complete operating systems and real applications, instead of thin-client workstations and phones; therefore effective power management and control strategies are needed to cope with heavy loads during startup and battery recharging, when the machine first joins the network, followed by lower demands in normal use later on.

The Lean Desktop configuration is a model for IT within the workplace, specifically optimised for minimising carbon emissions, energy consumption and heat gain whilst maximising flexibility and providing full functionality to the end users. It is an interdisciplinary approach, covering total product lifecycle management and design for electrical efficiency, thermal comfort (from building technology) and flexible working practices.

The Lean Desktop optimises desktop IT to fit regulatory requirements as emissions reduction legislation takes effect and economic issues as the cost of energy increases and issues arise over continuity of the power supply at peak demand. It is the desktop counterpart to progress in energy efficient datacentres and distributed (cloud) computing.

For practical purposes, the Lean Desktop is identified with an end user platform capable of

performing the normal operations expected in a PC environment, without compromising usability, but staying within the power constraints imposed by the PoE standards. It was recognised from the outset that some graphically intense functions, such as video editing, would fall outside this range and until suitable low-power graphics processors become available, high resolution video editing must remain outside the scope. Less graphically intense applications, such as office applications, publishing or audio editing, still accounts for a fairly large proportion of IT use in the media industry, should still be well within the capability of this model.

Demonstration

For the demonstration configuration, Samsung NC10 netbook computers were chosen, along with a wireless keyboard and early production examples of a low-power LED external monitor, which together make a practical workstation. As the network interface of the NC10 is not currently PoE enabled, an inexpensive splitter box is used to take the combined power and data input and produce a conventional 19V DC output separated from the data network connection. Using splitter boxes of this type reduces the dependency on computer manufacturers to manufacture PoE enabled products before renewable powered IT networks can be deployed. This gadget can be modified to incorporate USB to allow recharging of mobile phones and to power other small desktop devices.

A single solar panel, mounted on the roof of the University of Strathclyde in Glasgow, with an area less than $2m^2$ was sufficient to continuously power a desktop in this configuration, running Windows XP, MS-Office applications and viewing the BBC iPlayer content, in extended load testing. This installation was chosen to take advantage of an existing facility in a location that is not only less sunny than average, but also has wider variation in day length through the seasons, giving more opportunity to study the limits of solar microgeneration and power storage over the course of the project.

There is still back-up power provided from the grid, for when there is too little light available, and similarly, there are batteries around the network to store pre-loaded power from early morning, anticipating the arrival of staff.

Experimentation is continuing with control regimes to optimise the balance between re-charging batteries and supplying the network. Devices have different use profiles and a key capability of the control system is the ability to sense the demand from the network and automatically adjust the power available to meet immediate needs or stored for later use.

Workplace flexibility The demonstration also shows it is no longer an absolute necessity to have 220-240V mains power at every desk. This means the potential for electrical hazard from mains electricity is eliminated and the desk itself no longer needs to be a heavy construction which cannot be moved without qualified electricians and help from Facilities Management. Project teams can configure and reconfigure desk arrangements to suit their needs for co-located workgroups and the only cabling required is standard data network cable, carrying less than 50V, below the threshold for Health and Safety rules.

This is a step change for companies embracing flexible working practices and multi-purpose buildings. As projects progress, their working areas can evolve with them, growing and changing use as their needs change. A sustainable technology expert, independently assessing this design pointed out that for a new building, the money spent on solar power and networking capability yields a strongly positive return on investment because of the savings in mains cable installation and subsequent facilities management costs.

APPLICATIONS IN THE MEDIA INDUSTRY

Alternative Desktop economics

Renewable microgeneration could be broadly applied in the media industry to provide power for most business support and production management functions. Almost all “normal” use of IT in the enterprise could be competently executed with a netbook type machine. In use, the NC10s were judged to outperform a four year old premium laptop.

Netbook computers are now commodity items at the lower end of the IT price range. Concerns about robustness in everyday use and size of keyboards and screens are dealt with by external monitors and keyboards, though end-users may sometimes choose to work wirelessly in meetings or cafes and return to the wired network for a recharge. In conjunction with integration with renewable power, the total cost of ownership calculation shifts in favour of the smaller, lighter devices and away from large desk side computers.

Factoring in the reduction in heat gain in the office during the warmer months of the year and the additional benefits of supporting greater mobility and flexible use of the work space (enabling another BBC strategic goal) through longer battery life and reduced weight, there is a sound financial case as well as an environmental one.

Remote working and on location A PoE network can be easily deployed to support work in a remote site or on location. Adding solar microgeneration to this network would give a silent source of power and minimise the drain on other power sources, reducing the overall power budget for working in the field. Adding PoE wireless networking products, a self-contained power and data hub could be established around a vehicle to provide wireless coverage around it.

The feasibility of incorporating this design into an MPV sized radio car and as a making a contribution to the higher power demands of the truck based fleet is being assessed. Despite the limited roof space for generating power and vying for space with roof-mounted antennae, an all-digital recording and broadcasting vehicle could make use of this technology as a silent source of power, save weight in batteries and avoid the need to use generators, or the vehicle engine whilst recording. This may translate into enabling smaller and more efficient outside broadcast vehicles.

New builds and refurbishments Integrating solar microgeneration into the early stages of the facilities design and build process allows for the full benefit of the concept to be realised. It fits squarely with the objectives for flexible and multi-purpose workspaces and helps the new or refurbished sites achieve higher ratings in environmental assessments. In many cases, retrofitting to existing facilities is a matter of installing solar panels and upgrading the network switch modules inside the office building to PoE types; these are now standard products for leading switch manufacturers, and then deploying the system controller and low-power desktop hardware. The total amount of power generated and saved compared to using the grid would also be precisely measured and audited from the system controller logs.

FUTURE DIRECTIONS

Suitable workplaces

Comparing the area of solar panel required for each desktop with the industry benchmarks for space per person in modern office design, the demonstrated design works best in low-rise buildings and depends on how much of the roof can be used for solar panels.

The future availability of photovoltaic films on windows will open up opportunities for adoption in tall glass buildings. This indicates there is potential for widespread adoption of renewably powered IT networks.

Our continuing research with field trials of renewable powered networks will incorporate human factors and measuring and modelling user behaviour. We need to understand more about how people use lightweight and mobile IT equipment when they know it is on a renewably powered network and any unexpected consequences. The detailed total lifecycle costs for energy and materials, including build, installation, operation, longevity and disposal need to be worked through, using Siemens analytical methods for product lifecycle management, which can then become input to IT management roadmaps and enterprise architecture planning.

Overcoming inhibitors

PoE networks have until now been held back by the limited power available and by the long refresh cycles of data network infrastructure, which can be several years between major upgrades. Integration with renewable power and the improvement in power capacity will re-incentivise technology managers to implement PoE enabled switches in their network roadmaps and low power desktop devices in their hardware strategies. As reasons for not adopting PoE, VDC Group also reports IT managers' concerns over heat build-up and higher power consumption inside the dry-riser cupboards where switch equipment is operated. This heat comes from additional power transformers used to convert power from mains to low voltage DC. In our implementation, using power from renewable DC sources, removes the need for those transformers, so that heat problem is avoided.

For the full impact of demand-side energy management to be realised, there must be a combined effort between IT infrastructure management and buildings and facilities management. The traditional boundaries of these functions need to be overcome with an overarching cause, as is the case with the BBC Environment strategy. The Siemens "IT for Sustainability" structure and partnership with BRE provides the tools, methods and expertise to optimise both the building and the technology within it, to provide an efficient and effective workplace.

Target, 25W

The new PoE standard IEEE 802.3at is expected to carry 25W per connection. Within two or three years, the up-rated standard is expected to converge with the downward trend of device power consumption for a much wider variety of computer hardware and desktop equipment. This timescale should coincide with the commercial availability of improved solar photovoltaic devices. These three key technologies, of efficient solar microgeneration, effective delivery over the IT infrastructure and sufficiently low power devices will together reach a tipping point and we recommend that building and technology strategies consider

this design as an architectural option.

It is also reasonable to anticipate the adoption of renewable PoE networks in the home, enabling low power devices, set-top-boxes, OLED screens, IPTV devices and chargers with combined power and data cables, all driven from efficient domestic photovoltaic power sources. This could then be an enabler for widespread demand-side energy efficiency and development of smart buildings technology in the home.

In conclusion, the challenges of providing innovative solutions to the environment targets adopted by a large media organisation, has opened up the potential for a seismic change in how we manage and consume power in many different contexts, both at work and in our homes.