

Renewable energies and virtualization in vogue

Eco-friendly data centers get the go-ahead

The coal and oil era is irrevocably drawing to a close: "green" electricity and energy production is set to supersede fossil fuels in the foreseeable future. Data center operators and those in charge of IT (CIOs) can become pioneers in this respect by committing to energy-efficient hardware and resource-conserving energy sources, such as the fuel cell, for their electricity supply. T-Systems is already involved in one such innovative project at its Munich data center.

Large data centers with entire server parks can easily consume as much power as a small town. And as long as this electricity continues to be produced on the basis of fossil fuels, IT will remain an environmental "bad guy". According to calculations by management consultants A.T. Kearney, information technology worldwide produces CO₂ emissions of around 600 million metric tons per annum – the equivalent of approximately 320 million small cars. In Germany alone, according to A.T. Kearney, the CO₂ emissions produced by corporate IT systems are set to increase by 60 percent to 31 million tons by 2020. However, this scenario is preventable. In the future, a "green CIO" will have a range of options at his disposal for limiting and reducing carbon dioxide emissions.

Virtualize and consolidate your hardware

Energy-efficient hardware and server virtualization can contribute to green IT. For example, super-slimline computers tailored to the actual work requirements and equipped with electricity-saving fans help to improve a company's eco-balance sheet directly at the employee workstations (see the box on "PC services from the Net"). The servers on which a company's applications and systems are stored can also be outsourced to specialist suppliers, who use virtualization to achieve more efficient capacity utilization of the systems, which in turn saves electricity.

Although only 10 to 30 percent of the available computing capacity is normally utilized, most server systems consume roughly the same amount of electricity as if they were operating at full load. Creating a number of virtual servers on one machine allows capacity utilization to be significantly increased, while the amount of hardware overall may be reduced and consolidated.

Virtualization should not exceed a capacity utilization level of 80 percent in order to prevent overloading, which would ultimately lead to increased electricity consumption.

Fuel cell in constant use

In order to safeguard electricity supplies and improve his company's CO₂ balance sheet, the "green" CIO can also make use of the four elements: solar power, windpower, geothermal heat, hydroelectric power, utilization of waste heat and energy-efficient cooling are the buzzwords here. Some of these technologies are still in their infancy, while others need a further 20 years or more to reach maturity, but an innovative project in Munich, in which an entire data center room operated by T-Systems is supplied with electricity by a fuel cell, is already a reality.

For data centers, this could provide a much-needed bridge between eco-friendly technology on the one hand, and high availability and reliable operation on the other. The Munich project uses a new fuel cell developed by CFC Solutions called "Hot-Module", comprised of a gas preconditioning system, a carbonate fuel cell, and a control cabinet with inverter.

This Hot Module is currently undergoing load testing in the T-Systems data center room. The fuel cell will be in continuous operation around the clock, seven days a week. A data center with a constant energy consumption and no peaks is ideal for this new operating form, the first of its kind to be tested anywhere in the world.

Use CO₂-neutral biogas to generate electricity

The fuel cell is supplied with biomethane from a plant in Pliening near Munich. During cultivation, the energy crops absorb precisely the same quantity of CO₂ that is later released by the plant. (See the boxes on biogas and biomethane).

The Hot Module itself is comprised of three parts:

- In the gas preconditioning system, the gas is usually prepared for fuel cell use by means of desulfurization, heating and humidification. Desulfurization is not required for the T-Systems plant, because this stage is carried out by the biogas plant operator.

- The central fuel cell module integrates all hot parts inside one enclosure. There are no flames and no large moving parts such as rotating turbine paddles or driving pistons. The energy from the gas is electrochemically converted into electricity and heat. No pollutants such as nitrogen oxides or sulfur compounds are produced. Only water vapor, nitrogen and residual oxygen are released.
- Finally, the electrical control cabinet of the plant houses the inverter, which converts the DC current produced by the fuel cell into AC current.

In total, the Hot Module covers a length of 8 meters, a width of 2.5 meters, and a height of 3.2 meters, and produces an electrical power output of 245 kilowatts. Its overall efficiency is more than 90 percent.

A system of pipes transports the hot air, which can reach temperatures of up to 400°C, away from the central fuel module. The hot air can either be converted into cold air for air-conditioning systems, or used to generate additional electricity via a steam turbine connected downstream. At T-Systems, the waste heat from the fuel cell is used to cool the computers in an absorption cooling cycle, and therefore embodies the principle of using waste heat for energy-efficient cooling systems.

Optimum distribution of the energy yield

The on-site use of fuel cell technology offers a host of other benefits. With an overall efficiency of around 90 percent, it helps to minimize the line and transmission losses found in conventional energy supply systems. Furthermore, distribution of the energy yield from the fuel cell is ideal for use in the data center, where around half of the energy is needed for climate control purposes.

As the conversion of biogas into electricity in the fuel cell does not entail any combustion processes, no climate-damaging exhaust gases are produced. The use of biomass therefore produces the desired ecological effects: it protects the climate by using renewable raw materials, and avoids unnecessary energy transportation because the crops are grown close to where they are needed. A further beneficial side-effect is that the residues from the biogas system may be used as valuable fertilizer.

Never squander resources

The biogas-powered fuel cell is just a short step away from the "green data center", which produces its own electricity as well as supplying electricity and heat for other consumers. In winter, for example, the waste heat from the fuel cell that is not required for climate control could be sold to neighboring residents. Provided the Hot Module lives up to the operator's expectations, the next stage will be to develop a fuel cell with a constant electrical output of one megawatt.

PC services from the Net: Slimline, energy-saving computers

So-called thin clients are kind to the environment, because they only consume around one-quarter of the electricity of their "fatter" relatives. Gartner analysts rate this virtualization of the IT infrastructure among the top ten technology strategies. T-Systems offers companies a comprehensive thin client solution with the "workstation from the Net": Whether in the office, in the home office, at the airport or in the hotel, this solution allows users to access their own data and applications any time, anywhere. In the office, they use thin clients to access their data from a T-Systems data center, rather than full PCs. Companies pay a fixed price for each client. All services, such as software and data memory, are payable according to usage. This produces potential savings of up to 30 percent compared with conventional desktop operation. Whilst traveling, employees only need carry a USB (Universal Serial Bus) stick to securely access their personal work interface and all programs from any Internet terminal, anywhere in the world.

How the fuel cell works

The fuel cell principle has been around for more than 160 years. It was discovered by the chemist Christian Friedrich Schönbein – who is also credited with discovering ozone – in 1839, when he immersed two platinum strips in an electrolyte solution with hydrogen and oxygen, respectively, and noticed an electrical voltage. The subsequent development of the combustion motor and the dynamo eclipsed his discovery, and the fuel cell principle was forgotten until the 1950s, when it underwent something of a renaissance, initially in connection with space travel.

The cell has a sandwich-like structure. It produces electricity and heat when the anode is supplied with hydrogen and the cathode is supplied with atmospheric oxygen. An electrolyte made from lithium and potassium carbonate is situated between the anode and the cathode. If methane and water are added to the fuel cell, it releases hydrogen. The hydrogen reacts with the carbonate ions of the electrolytes to form water and carbon dioxide, during which electrons are released. The carbon dioxide is added to the cathode together with atmospheric oxygen. As the electrons are used, new carbonate ions are constantly formed, which in turn releases heat. The carbonate ions migrate through the electrolyte to the anode, thus closing the electrical circuit.

Using waste heat for energy-efficient cooling

At T-Systems, the waste heat from the fuel cell, at temperatures of more than 400°C, is used to cool the computers in an absorption cooling cycle. The absorption refrigeration machine is characterized by a two-substance system. In many cases, this is a mixture of water and ammonia. When heat is added, the ammonia becomes gaseous and escapes from the mixture. It is subsequently liquefied. In the evaporator coil, the ammonia – now in liquid form – absorbs heat from the environment during its transition back to the gaseous phase. At this point, the apparatus cools. The water subsequently re-absorbs the gaseous ammonia and the whole cycle begins again.

How is biogas obtained?

Biogas is essentially composed of methane and carbon dioxide. It is produced by microorganisms which convert the organic material into biogas. In nature, biogas is created in the stomachs of ruminants, during the rotting of organic waste, in rice paddies, and in bogs. Depending on its origin, biogas is categorized either as landfill gas created on landfill sites, sewage gas which is produced in sewage treatment plants, and biogas of plant and animal origin which is produced in biogas systems for use as energy.

Small systems have been used by farmers for more than twenty years to supply energy to their farms, and particularly to improve the fertilizing quality of animal slurry. More recently, we have seen the emergence of large-scale industrial plants for targeted energy extraction which run on corn, cereal or grass. A biogas plant optimizes the natural conversion process by creating ideal living conditions for so-called methane bacteria. The initial substrate is fermented over a defined period – usually between two and five weeks – in a fermentation container at an average temperature of 37°C, with the exclusion of oxygen.

The microbiological process occurring inside a biogas plant has yet to be fully researched. A water ratio of at least 50 percent is required in order to obtain methane, which is the part of biogas that may be used as energy. Depending on the initial substrate, biogas contains between 45 and 70 percent methane, between 50 and 25 percent carbon dioxide, as well as water vapor, oxygen, nitrogen, ammonia, hydrogen and hydrogen sulfide. Before being used as energy, the aggressive substances ammonia and hydrogen sulfide need to be removed via desulfurization, while CO₂ must be removed from the biogas via gas washing. If the biogas is fed into an existing natural gas network, it is subsequently compressed after cleaning.

Biomethane – the "noble" biogas

Biomethane is the name for purified biogas. Whereas biogas e.g. from fermented waste in the organic waste bin is usually only half to two-thirds methane, biomethane has the same degree of "purity" as natural gas, with approximately 96 percent. It therefore lends itself to being mixed with natural gas and transported in the same network, and can be traded in the same way as eco-electricity.

When used in the Hot Module, this produces two benefits: Firstly, this CO₂-neutral energy carrier may be produced anywhere, so that biogas production and consumption may be geographically separate from one another; and secondly, the cost of gas purification in the Hot Module may be considerably reduced, since biomethane and natural gas contain far fewer sulfur compounds than biogas. Sulfur is harmful to the nickel catalytic converter in the Hot Module and needs to be filtered out in a gas preconditioning system where biogas or sewage gas are to be used directly.

The biomethane for the Hot Module at the T-Systems data center is produced in a plant operated by Aufwind Schmack GmbH Neue Energien in Pliening, which processes energy crops. This facilitates a CO₂-neutral energy supply, since during cultivation, the crops absorb exactly the same quantity of CO₂ as is later released by the system. This is the first plant in Germany to supply biomethane to the gas network under the terms of the Renewable Energy Sources Act.

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