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electronics enabling efficient energy usage

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Saving Energy with Electronics

Successful answers of power electronics to the

energy efficiency challenge

Efficiency is Possible

Using electrical energy more efficiently than today is essential if we want to reach the ambitious goals for the reduction of green house gases in Europe and also for remaining competitive internationally. Recent advances in power electronics and information technology make them key technologies for harvesting the enormous potential to save electrical energy in households, transportation, industry, and consumer products.

The examples in this brochure document the success of research and development in power electronics and information technology. Investments in electronics and IT research help saving energy, developing eco-friendly products, creating value-added services and adding dynamics to European economies.

Electronics Enables Efficient Energy Usage

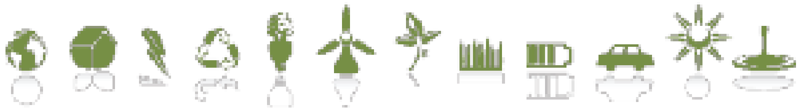
New information technologies improve the measurement, communication, and control of electrical energy. Together with novel power electronics solutions IT can create energy saving solutions where energy is wasted today.

Power Electronics is a cross functional technology covering high Giga Watt (GW) power in energy transmission lines down to very low milliWatt (mW) power needed to operate a mobile phone. It is responsible for the reliability and stability of the whole power supply infrastructure in Europe from the sources, the transmission and distribution, up to the huge variety of applications in industry, transportation systems, and the home. Power electronics is the key technology to control the flow of electrical energy from the source to the load precisely according to the requirements of the load.

If Europe aims to reap the enormous potential of new technologies for energy efficiency, it must invest in its excellence research and technology base.

The examples in this folder provide an overview of how power electronics facilitates saving energy. The examples range from power supplies to the power grid and e-mobility, include buildings and lighting and the important area of electric drives.

These are but a few examples for what IT and electronics can achieve in advancing the state-of-the-art in energy efficiency.



The Vision 2020

- *We will live in a ´More Electric World´: the share of green electricity of the overall energy significantly increases.*
- *Information processing, power processing, and sensors & actuators will converge to enable smart energy efficient systems.*
- *Smart Energy Grids will be able to handle more than a 20% share of fluctuating renewable energy in an economic and efficient way.*
- *We will see Zero-emission e-mobility in megacities.*
- *Life-cycle costs of buildings including lighting and climate conditioning will be halved.*
- *There will be energy on demand for ICT and wireless energy supply for mobile applications.*

Investments in power electronics research and technology development supports European universities and research centres as global leaders in research and innovation in electronics enabling efficient energy usage. This will make it possible for European industry to become a leader in smart energy efficient products and services.

The Scenario

About 60% of world oil is consumed in the transport sector. The development of the Electric Vehicle (EV) will lead to a great improvement in energy efficiency and pave the way to an emission-free and sustainable solution for mobility and transport. Estimates vary, but the cost of electricity/km for an EV is 3-4 times lower than petrol/km for combustion engine cars. One of the reasons is that the electric drive train has much higher efficiency than the combustion engine drive train.

The Technological Challenge

Battery technology plays a crucial role in the rise of the Electric Vehicle. An important milestone in the EV development is the 2nd generation Lithium-ion batteries with high power density, leading to lower weight and smaller volumes. Furthermore, they can be charged fast, within minutes instead of hours thus offering potential to overcome one of the major obstacles in the wider penetration of EVs: long charge times of 4 hours up to 12 hours. To facilitate ultra-fast charging, advanced power electronics solutions are required. Together with batteries and intelligent control systems, power electronics is an enabler of ultra-fast battery charging.

The Solution: NRGspot - a Public Ultra-Fast Charging Infrastructure

The NRGspot system[1] is part of a public ultra-fast charging infrastructure for electric vehicles enabling clean transportation in cities across Europe. The NRG spot is an initiative of the utility company Eneco in co-operation with RCI (Rotterdam Climate Initiative) and TNT and can be used to fast-charge electric vehicles, ranging from delivery scooters and electric bicycles to electric cars and delivery trucks. The charging systems are provided by Epyon, a spin-off company of the Delft University of Technology, and the only European company currently providing advanced ultra-fast charging solutions for electric vehicles used in critical business processes such as material handling, delivery of goods and transportation of people.

The NRGspot system can be used by subscribers and is accessed through an intelligent interface. After a quick log-in the system can be used to charge the electric vehicle of the user within 15-30 minutes. The fast charging functionality is compatible with a whole range of electric vehicles with special lithium-ion battery technology. The charge points will exclusively supply green electricity. The systems will be placed initially in large cities at strategic places near shopping centres. The NRGspot can be used by fleet owners such as delivery services, taxi services and individual consumers. Two pilot NRG spots have already been placed in the city of Rotterdam, The Netherlands. In the near future more charging points suitable for built-up areas will be

[1] NRGspot, Epyon B.V., Rijswijk, The Netherlands

deployed. Many municipalities and companies have already expressed their interest.

Epyon develops and produces Ultra Fast Charging stations that are used to charge EVs in between 5 and 60 minutes for example during coffee and lunch breaks thus minimizing the disruption in the business operation. They are especially designed to meet the needs of professional users of electric vehicles such as owners of forklift fleets, cleaning machines, delivery vehicles and taxi fleets enabling a significant reduction of total cost of ownership in these industries.

The Scenario

Although the environmental impact of mobile communications is relatively low, it deserves attention due to the rapid growth of this sector. Ericsson, for example, has conducted lifecycle assessments of mobile networks for more than ten years and issued a White Paper on "Sustainable energy use in mobile communications"[2]. These studies show that power consumption in radio base stations (RBSs) during operation is the most significant environmental burden. RBS sites are responsible for more than 90% of the power consumption within a 3G network (including mobiles). Optimizing energy efficiency not only reduces the environmental impact, it also permits considerable savings of operational expenditure.

The Technological Challenge

A typical RBS with an output power of 120W has a power consumption of more than 10kW. This translates into a system efficiency of 1,2%. Fig. 1 illustrates the losses in the various subsystems[3]:

- More than 4kW are consumed by the power amplifier and an additional 2.2kW by base band signal processing. This results in only 6% combined efficiency.
- The power supply runs at only 85% efficiency, due to the low efficiency of the rectifiers.
- Climate equipment is responsible for additional losses of more than 2.5kW.

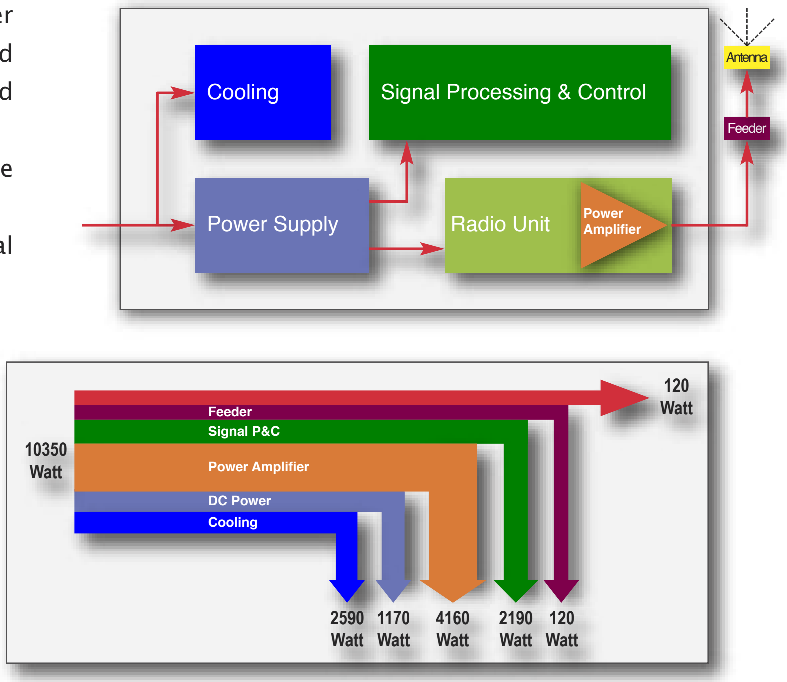


Fig. 1: Power losses in a typical radio base station[3].

[2] Cf. Sustainable energy use in mobile communications. Ericsson White Paper, August 2007
[3] P. Gildert: Power System Efficiency in Wireless Communications. APEC 2006

The Solution

Efficiency of the power transmitter is barely 6%. The use of Envelope Elimination and Restoration techniques can significantly improve the efficiency of the transmitter since it can be based on a high efficiency non-linear RF amplifier with a highly efficient envelope power supply to implement a high efficient linear RF amplifier (see Fig. 2). The use of conventional switched power converters for the envelope amplifier requires switching frequencies around five times the bandwidth of the envelope signal, penalizing the efficiency of the converter.

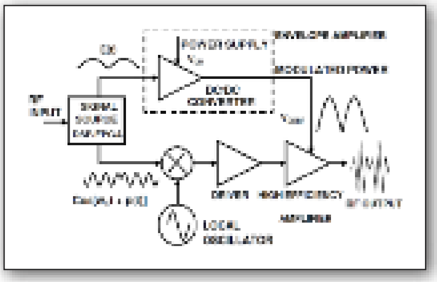


Fig. 2: Block diagram of a transmitter with Envelope Elimination and Restoration technique

Innovative solutions like the use of multilevel converters and a linear regulator allow using a switching frequency equal to the bandwidth of the envelope signal. Compared to an ideal linear amplifier, the efficiency can be increased from 29% to 43,7% which means that the total energy required is reduced by 35%[4]. The efficiency can be pushed even further by improving device technology, especially promising are wide band gap semiconductor technology (SiC or GaN).

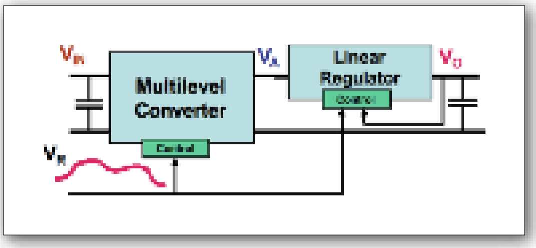


Fig. 3: Block diaram of a transmitter with Envelope Elimination and Restoration technique

Another way in which radio equipment can be managed to reduce overall energy consumption is through stand-by modes. RBS sites are dimensioned to cope with peak hours. By introducing advanced power management schemes the power consumption can be reduced during quieter periods as illustrated in Fig. 4. Ericsson recently introduced its Base Transceiver Station (BTS) Power Savings feature which, depending on network traffic patterns, permits overall energy savings of up to 25% without any impact on service quality. Vodafone Germany became the first operator to use the BTS Power Savings feature, in December 2007. If the entire installed base of Ericsson GSM base stations was to apply this software-upgradeable feature, CO2 emissions could be cut by 1 million tons per year – the equivalent of the emissions from 330.000 cars each traveling 16.000km per year.[5]

Emerson Network Power carried out an analysis of the losses in wireless networks and proposes a so-called Energy Logic concept, applying technologies and best practices that exhibit the highest savings potential. If all proposed measures are implemented, total savings of nearly 60% are possible.[6]

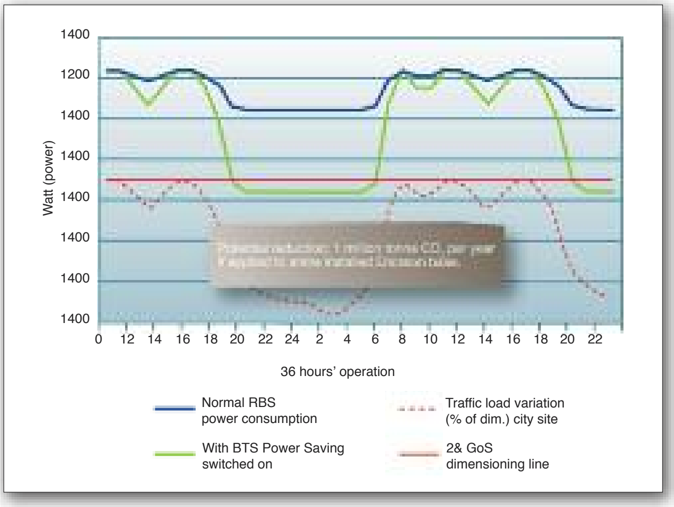


Fig. 4: RBS consumption over 36 hours. Source: Ericsson[6]

[4] M. Vasic, O. Garcia, J. Oliver, P. Alou, D. Diaz, and J. Cobos, "Multilevel Power Supply for High Efficiency RF Amplifiers" IEEE Applied Power Electronics Conference and Exposition 2009
[5] Ericsson Press Information, June 2008
[6] Steve Roy: Energy Logic for Telecommunications. Emerson Network Power White Paper, September 2008

The Scenario

Buildings account for more than 40% of energy use in the developed countries and hold great potential for cost-effective energy savings[7]. Between 50 and 60% of this energy consumption is electrical. In office buildings, energy costs (lighting, HVAC, lifts, etc.) during the building life cycle are double the construction costs, and account for 40% of the total life cycle costs. However, barriers such as split incentives between owners and tenants, lack of awareness of energy-efficient options, and high initial investments hamper the implementation of energy savings measures.

Lighting represents around 20% of electricity consumption. According to the International Energy Agency, at least 38% of global lighting energy consumption could be saved cost-effectively by greater use of efficient lighting technologies[8]. Furthermore, it has been shown that an additional reduction of 43% in energy consumption be realized by using intelligent dimming and automatic lighting controls[9]. Fluorescent lamps use smart electronics to convert and then regulate the flow of electricity and consume approximately one fourth of the energy of equivalent incandescent bulbs. Even higher efficiency can be achieved with recent solid-state lighting (SSL) technology like silicon carbide light-emitting diodes (LEDs) or organic light-emitting diodes (OLEDs). The U.S. Department of Energy has defined, together with its SSL partners, a multi-year R&D plan to stimulate technological research and to accelerate market introduction of high-efficiency, high-performance SSL products[10].

The Technological Challenge

Constructing energy-efficient buildings or – even more so – improving the efficiency of existing buildings involves several technical, economical, and political issues. Good solutions require deep knowledge and expertise from diverse fields. To give an example, Siemens Building Technologies invested about 30 person-years in training and market preparation before offering their service to the European market[11]. In technical terms, building automation and control systems are the key to efficient energy use. Particularly advantageous are those integrated solutions which combine several functions like heating, air conditioning, cooling, and lighting, but also fire and security systems. From an economic point of view, it is crucial to overcome the so-called user-investor dilemma. With respect to political frameworks, public authorities need to address market failure by standards, regulation and awareness initiatives, such as the EU GreenBuilding Programme.

[7, 8] Cf. Energy Efficiency Policy Recommendations. In support of the G8 Plan of Action. International Energy Agency, © OECD/IEA, Paris, 2008
[9] Cf. The quest for the ideal office control system. Lighting Futures Vol.3 No.3. Lighting Research Center, Rensselaer Polytechnic Institute, Troy, NY, 1998
[10] U.S. Department of Energy Efficiency and Renewable Energy (EERE)
[11] Siemens Switzerland Ltd, Building Technologies Division

The Solution

Energy performance contracting is a promising approach to realize energy savings in buildings by providing the required technical expertise, thorough life-cycle analysis, and guaranteed cost-effectiveness at the same time.

For the construction of the new Moevenpick Hotel in Frankfurt's new "Europa Quarter", real estate company Vivico and the Hochtief/Bilfinger Berger joint venture have opted for an "everything from one source" concept proposed by Siemens Building Technologies. This featured the abandonment of the conventional separation of electrical engineering and building automation systems in favor of a total solution package. The advantage for the owner of the building: this bundling enabled Siemens Building Technologies to offer the functions being bid for at an economical all-in price. At the same time the owner of the building obtains a unified, overall concept based on the latest systems engineering and current design for switches, sockets and room automation. Furthermore, synergies within the high-voltage and low-voltage current systems and building automation make additional optimization potential available, benefiting both the owner of the building (Vivico) and the hotel's tenant and operator (Moevenpick). The solution offered by Siemens Building Technologies therefore fulfills the investor's requirement for a life cycle concept that takes into account the ecological and economic optimization of the technical systems throughout the building's lifetime.

For this example, Siemens reports the following savings: In this case the resulting pay-back time is less than three years[12].

	Savings €/a	Investment €
Optimized lighting (400 fluorescent tubes with electronic ballasts)	14.700,-	46.500,-
Variable speed drives and demand controlled ventilation (6 air-handling units)	35.200,-	110.000,-
Heat recovery of kitchen exhaust air to room supply air	34.100,-	53.000,-
	84.000,-	***209.500,-***

[12] Source: P. Vanlombeek: Maximize Efficiency! A Critical Strategy towards Making Buildings Green. Energy Week 2008, Brussels

The Scenario

Electric motors and drive systems are widely present. Their applications range from the low power area e.g. in home appliances over medium power in industrial and automotive up to the large MW power in the field of generation. Over half of all electricity is consumed by electric motors. In the EU, electric drives account for around 65% of industrial electricity consumption. The market of industrial drives has been experiencing a continuous growth all over the world. Currently, the vast majority of these motors do not have electronic controls. By converting such simple electric motors to variable speed, it is possible to cut power consumption by almost half. Energy saving and improved energy efficiency are major objectives for drives and generator systems development, and power electronics provides the key for energy efficient variable speed drives.

The most important area of application of motors with variable speed drives is for pumps and fans. Compared to conventional flow control by means of throttling, speed reduction provides dramatic energy savings of up to 80%, as illustrated in Fig. 3.

The following exmple is from ABB[13]. It is taken from Pietarsaaren Vesi, the water utility which serves the town of Pietarsaari in Finland.

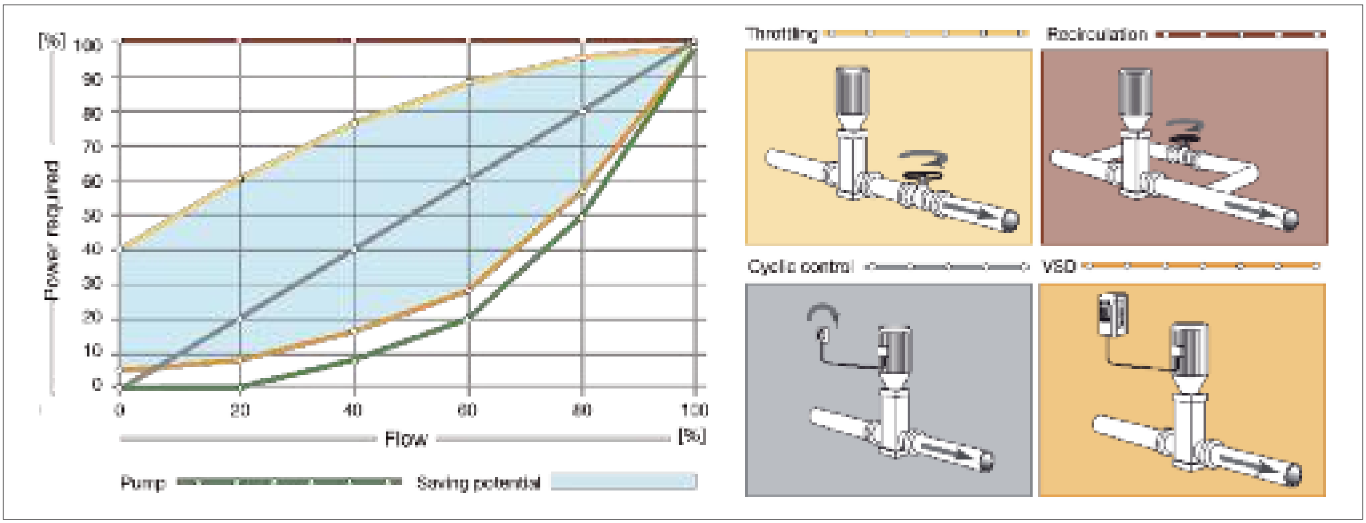


Fig. 3: Power consumption of pumps for various control methods

[13] Sustainability Guide No. 12, ABB

The Technological Challenge

Pietarsaari's water supply is taken from a local river. Following treatment, the water is pumped to a 1.500 cubic meter above-ground storage tank and pressure boosting station. In this application, pressure control is crucial, as the pressure boosting station supplies water directly to the distribution system. The station is equipped with two 75kW and one 37 kW electric pumps, with a diesel-powered pump as back-up.

Fig. 4: The pressure boosting station in Pietarsaari's water utility[12].

The Solution

The drives at the pressure boosting station feature intelligent pump control (IPC), an optional software package for ABB drives which incorporates all the functions required by pump users. The Pietarsaari installation, depicted in Fig. 4, uses IPC's multipump control, pump priority, and flow measurement functions. Multipump control is used to operate several pumps together. Each pump is controlled by its own drive, with one being speed adjusted and the rest running at constant speed. This permits smooth control with no pressure peaks. This reduces pipeline stress and results in fewer leaks and reduced maintenance requirements. At the same time, the use of drives avoids the disturbance to the electrical network that is often caused by direct on-line starting.

According to Pietarsaaren Vesi, the upgrade has resulted in significant energy savings over the previous direct-on-line configuration: "Together with our new pumps, the drives have enabled us to reduce our energy consumption by about 30 percent. The pressure in the system is much more stable, which has reduced leaks, reduced maintenance needs, and increased end-user satisfaction," says Jan Snellman, Automation Engineer.

[14] ABB Oy Drives, Helsinki

E4U initiative project partners

eutema Technology Management GmbH, Austria

eutema is a strategic research and technology consultancy based in Vienna, Austria. eutema designs and implements research strategies for EU member states and manages RTD projects and programs. Its customers and partners include the European Commission, Austrian ministries, research councils, funding agencies, universities as well as global industry players, small companies and private research organisations.

European Center for Power Electronics e.V., Germany

Leading power electronics industries have founded the European Center for Power Electronics (ECPE) in 2003 in order to promote research, education and technology transfer in this field. ECPE aims at promoting the importance of power electronics to the public. For an efficient realisation two legal bodies have been founded, the registered association ECPE e.V. and the limited company ECPE GmbH.

Universidad Politécnica de Madrid, Spain

Universidad Politécnica de Madrid is the oldest and largest of the Spanish Technical Universities. The Centro de Electrónica Industrial (UPM-CEI) is mainly devoted to power conversion systems, Embedded systems design, and power quality. All these research lines have horizontal activities in common, such as design and integration of electronic systems and advanced techniques for modelling and simulation.

University College Cork (Tyndall Institute), Ireland

The Tyndall National Institute was created in 2004 at the initiative of the Department of Enterprise Trade and Employment and University College . The strengths of the institute at the present time lie in the area of photonics, electronics, materials and nanotechnologies and their applications for life sciences, communications, power electronics and other industries.

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