

distribution utilities in six European countries that aims to illustrate the methodological and data issues encountered in the use of international benchmarking for utility regulation. The study examines the effect of the choice of benchmarking methods using DEA, COLS and SFA models. The report discusses what problems of international benchmarking are highlighted by the study and how they can be overcome.

04/01346 Lead-acid battery research and development – a vital key to winning new business

Bullock, K. R. *Journal of Power Sources*, 2003, 116, (1–2), 8–13.
Battery strings are operated in a partial-state-of-charge mode (PSoC) in several new and changing applications for lead-acid batteries, in which the battery is seldom, if ever, fully charged or discharged. The lead battery industry faces new challenges as additional failure modes become evident in these PSoC applications. Without overcharge, cell imbalances caused by variations in cell temperature will cause premature failures. Valve-regulated lead-acid batteries are especially susceptible because of the heat generated by oxygen recombination at the negative plate. Improved thermal properties are shown by a proprietary battery design that combines absorptive glass mat and gelled acid technologies. Well-designed power systems are also required to reduce cell-to-cell temperature variations and, thereby, increase battery life.

04/01347 Life cycle inventory analysis for electricity in Korea

Lee, K.-M. *et al. Energy*, 2004, 29, (1), 87–101.
A life cycle inventory (LCI) analysis database that encompasses the entire Korean electrical energy grid was developed. The CO₂ emission per functional unit of electricity, 1 kWh of usable electricity, was 0.49 kg/f.u. Contribution of direct emission of CO₂ to the total CO₂ emission was around 95%. In the case of emissions of SO_x, NO_x, and PM, contribution of the upstream processes including raw energy material extraction, transport, and fuel processing to the total emissions were 29%, 26%, and 43%, respectively. Emissions of air pollutants from power generation or direct emissions are much greater in quantity than those from the upstream processes. On the other hand, the opposite is true for the emissions of water pollutants. Bituminous coal was the largest source of emissions of air and water pollutants including CO₂. Natural gas was the best fuel and anthracite coal was the worst fuel with respect to the direct and upstream emissions of air and water pollutants and wastes.

04/01348 Pricing criterions in presence of intra- and inter-zonal constraints

Dicorato, M. *et al. Electric Power Systems Research*, 2003, 66, (2), 179–186.
Zonal partitioning is a method for solving the energy market, when network topology is taken into account. The reduction of the network to equivalent nodes representing zones, is unable to assess the intra-zonal flows. This could give rise to questionable and unreliable results. In this paper, a methodology for solving the energy market together with transmission service, when either inter- or intra-zonal congestions occur, is proposed. A double-side auction, where both customers and sellers bid prices and quantities, is considered. Test results are evaluated using the proposed approach on IEEE-118 bus test grid.

04/01349 Progress of electricity from biomass, wind and photovoltaics in the European Union

Jäger-Waldau, A. and Ossenbrink, H. *Renewable and Sustainable Energy Reviews*, 2004, 8, (2), 157–182.
The world market for renewable energies is continuously growing. In particular, the wind energy and photovoltaic markets show yearly growth rates between 20 and over 30% in the last few years. Despite the fact that there are still discrepancies between the European Union and the USA how to deal with climate change, renewable energies will play an important role for the implementation of the Kyoto Protocol and the worldwide introduction of tradable green certificates. Apart from the electricity sector, renewable energy sources for the generation of heat and the use of environmental friendly bio-fuels for the transport sector will become more and more important in the future. This article tries to give an overview about the progress of renewable energies in Europe.

04/01350 Prospects for lead-acid batteries in the new millennium

Razelli, E. *Journal of Power Sources*, 2003, 116, (1–2), 2–3.
The European lead-acid battery industry has been adversely affected by the collapse of the telecommunications and information technology expansion of the last several years and by general economic conditions in other sectors. This has had a substantial effect on the industrial battery market, particularly standby batteries, but the automotive business has been less affected. The industry has reacted to these continuing changes by consolidation and specialization within the

different sectors but this alone is insufficient to ensure future success. The industry faces significant challenges to improve efficiencies through better manufacturing systems, but the development of new products for both existing and future applications is the greater priority. Advanced automotive batteries for Powernet applications and for hybrid electric vehicles, new types of standby and traction batteries and improvements to automotive batteries can all be achieved with lead-acid technology. This is a system with enormous potential for further improvement building on current strengths. This is a challenge to which the industry must respond in order to underpin the lead-acid battery as the most important electrical energy storage system.

04/01351 Prospects of autonomous/stand-alone hybrid (photo-voltaic + diesel + battery) power systems in commercial applications in hot regions

Shaahid, S. M. and Elhadidy, M. A. *Renewable Energy*, 2004, 29, (2), 165–177.

Most of the world's energy consumption is greatly dependent on fossil fuel, which is exhaustible and is being used extensively due to continuous escalation in the world's population and development. This valuable resource needs to be conserved and its alternatives need to be explored. In this perspective, dissemination and utilization of renewables such as solar energy has gained worldwide momentum since the onset of the oil crises of the 1970s. Moreover, burning of fuels is the principal cause of air pollution, and possibly environmental warming. Saudi Arabia, being blessed with a fairly high level of solar radiation, is a suitable candidate for deployment of solar photovoltaic (PV) panels for power generation during crisis. Literature indicates that commercial/residential buildings in Saudi Arabia consume an estimated 10–45% of the total electrical energy generated/consumed. In the present study, hourly mean solar radiation data for the period 1986–1993 recorded at the solar radiation and meteorological monitoring station, Dhahran (26°32'N, 50°13'E), Saudi Arabia, have been analysed to investigate the potential of utilizing hybrid (PV+diesel) power systems to meet the load requirements of a typical commercial building (with an annual electrical energy demand of 620 000 kWh). The monthly average daily solar global irradiation for Dhahran ranges from 3.61 to 7.96 kWh/m². The hybrid systems considered in the present analysis consist of different combinations of PV panels/modules (different array sizes) supplemented with a battery storage unit and diesel back-up. The study shows that with a combination of 3700 m² PV together with 12 h of battery storage, the diesel back-up system has to provide 6% of the load demand. However, in the absence of a battery bank, about 56% of the load needs to be provided by the diesel system.

04/01352 Reliability of the Afam electric power generating station, Nigeria

Eti, M. C. *et al. Applied Energy*, 2004, 77, (3), 309–315.
Today's economic climate requires that each industry aims at achieving maximum production capability, while minimizing capital investment, e.g. in the maintenance function. This means finding ways to maximize equipment reliability and up-time and extend plant and equipment life through cost-effective maintenance. This paper surveys the performance of gas-turbine plants in Afam thermal-power station. The findings show that the financial impact of lost generation (through non-availability) exceeded within a few years, the initial purchase price of the power plants and associated equipment.

04/01353 Role of hybrid (wind+diesel) power systems in meeting commercial loads

Elhadidy, M. A. and Shaahid, S. M. *Renewable Energy*, 2004, 29, (1), 109–118.

The utilization of energy from renewable sources, such as wind, is becoming increasingly attractive and is being widely used for the substitution of oil-produced energy, and eventually to minimize atmospheric degradation. Literature shows that commercial/residential buildings in Saudi Arabia consume an estimated 10–40% of the total electric energy generated. In the present study, hourly mean wind-speed data for the period 1986–1997 recorded at the solar radiation and meteorological monitoring station, Dhahran (26°32' N, 50°13' E), Saudi Arabia, have been analysed to investigate/examine the role of hybrid (wind+diesel) energy conversion systems in meeting the load requirements of a typical commercial building (with annual electrical energy demand of 620 000 kWh). The monthly average wind speeds for Dhahran range from 4.1 to 6.4 m/s. The hybrid systems considered in the present analysis consist of different combinations of the commercial 10 kW wind energy conversion systems (WECS), supplemented with battery storage unit and diesel back-up. The study shows that with thirty 10 kW WECS and 3 days of battery storage, the diesel back-up system has to provide 19% of the load demand. However, in the absence of battery storage, about 40% of the load needs to be provided by the diesel system.