02/02948 The Sudetic geothermal region of Poland

Dowgiallo, J. *Geothermics*, 2002, 31, (3), 343–359.
Natural thermal springs were known from time immemorial in the Polish part of the Sudetes Mts at Cieplice and Ladek. Discharge temperatures of these springs are 44 and 29°C, respectively, and bathing is their traditional use. Drilling performed during the last three decades in the above-mentioned and other localities revealed considerable amounts of thermal waters occurring in tectonically disturbed zones of Sudetic metamorphic rocks and granitoids. The existence of thermal waters may also be expected in numerous areas of the Sudetes where carbonated waters occur. CO_2 connected with Tertiary and Pleistocene basic magmatism may be an indicator of regional rock heating. Another potential area of geothermal interest is the Fore-Sudetic block, where thermal carbonated water was discovered in the vicinity of a cluster of Tertiary basaltic cones and where hydrothermal activity of Tertiary to mid-Quaternary age took place.

Wind energy

02/02949 Dependence of power law index on surface wind speed

Hussain, M. *Energy Conversion and Management*, 2002, 43, (4), 467–472.
A study of the monthly wind speed τ near the ground surface and the power law index for 22 stations in India and Bangladesh has led to relations of the form $\alpha = Ae^{-b\tau}$ for each of the stations, where A and b are station dependent. A collective fit for the equation for three stations in the coastal plains is $\alpha = 0.43e^{-0.19v}$, and for three stations in the inland plains, it is $\alpha = 0.71e^{-0.34v}$. These correlations have been found to give estimates of the monthly α for different stations in the plain lands with the rms error of 0.05. The same fits are found to predict the annual α from the annual average of wind speed with rms error of 0.025, while the annual α ranges between 0.14 and 0.54. For the correlations computed, the α values for v around 5 or 6 m/s agree with the figure 0.14 of the 1/7 power law, but for lower speeds, these differ strongly. Therefore, the 1/7 power law may be considered as a special case of the exponential relations for high surface wind speeds. The collective fits show that the wind speed gets remarkably larger with height for low surface winds. Hence, for locations having low winds, large hub heights are recommended for wind machines.

02/02950 Determination of Weibull parameters for wind energy analysis of Izmir, Turkey

Ulgen, K. and Hepbasli, A. *International Journal of Energy Research*, 2002, 26, (6), 495–506.
In this study, the two Weibull parameters of the wind speed distribution function, the shape parameter k (dimensionless) and the scale parameter c (m s^{-1}), were computed from the wind speed data for Izmir. Wind data, consisting of hourly wind speed records over a 5-year period, 1995–1999, were measured in the Solar/Wind-Meteorological Station of the Solar Energy Institute at Ege University. Based on the experimental data, it was found that the numerical values of both Weibull parameters (k and c) for Izmir vary over a wide range. The yearly values of k range from 1.378 to 1.634 with a mean value of 1.552, while those of c are in the range of 2.956–3.444 with a mean value of 3.222. The average seasonal Weibull distributions for Izmir are also given. The wind speed distributions are represented by Weibull distribution and also by Rayleigh distribution, with a special case of the Weibull distribution for $k = 2$. As a result, the Weibull distribution is found to be suitable to represent the actual probability of wind speed data for Izmir (at annual average wind speeds up to 3 m s^{-1}).

02/02951 Dynamic performance assessment of an isolated wind–diesel power system with superconducting magnetic energy storage unit under turbulent wind and load disturbances

Mufti, M. D. *et al. International Journal of Energy Research*, 2002, 26, (3), 185–201.
This paper presents modelling and control aspects of an isolated wind–diesel system equipped with a superconducting magnetic energy storage (SMES) unit. The SMES unit is located at the induction generators' terminal bus, for exchanging real and reactive powers in four quadrants, with the wind–diesel system. The system components are modelled by non-linear equations for accurate dynamic performance assessment and the SMES unit is modelled as a controllable current source. The control of the SMES unit is exercised through a multi-input–multi-output (MIMO) self-tuning regulator (STR). The STR uses the local voltage and frequency measurements and generates appropriate signals for the control of the SMES unit. The SMES coil current deviation forms a part of one of the regulated variables of the STR for achieving a continuous control. The complete model of the hybrid system is developed and the parameters of the STR are adjusted for quality improvement of the power supply under turbulent wind. The scheme is then tested for load disturbances. The simulation results show the positive impact of the proposed scheme on the quality of the power supply both under turbulent wind as well as load disturbances.

02/02952 Optimum autonomous wind–power system sizing for remote consumers, using long-term wind speed data

Kaldellis, J. K. *Applied Energy*, 2002, 71, (3), 215–233.
The usage of autonomous power-systems is one of the most successful ways to treat the electrification requirements of numerous isolated consumers, not only in Greece but also world-wide. Such an autonomous system comprises a micro-wind converter and a battery storage device, along with the corresponding electronic equipment. Considering the high wind potential of several regions in our country, an integrated study is carried out, based on long-term wind-potential experimental measurements, in order to determine the optimum configuration of a stand-alone wind power system. The proposed solution "guarantees" zero load rejections for all the 4-year period examined. For this purpose, two separate calculation approximations are developed, presenting almost similar results. Of course, the application of the "WINDREMOTE II" numerical code based on detailed measurements, gives almost analytical results concerning the energy autonomy and the operational status of the autonomous system components. Finally, by introducing preliminary financial aspects, it is possible to determine the optimum system dimensions on a minimum first-installation cost.

02/02953 Using conjoint analysis to quantify public preferences over the environmental impacts of wind farms. An example from Spain

Álvarez-Farizo, B. and Hanley, N. *Energy Policy*, 2002, 30, (2), 107–116.
This paper focuses on the effect on people's utility of the potential environmental impacts of wind farm developments. It reports on research designed to provide insight into their preferences, and illustrates how two alternative choice modelling techniques can be used to estimate them. The results show that significant social costs in the form of environmental impacts can be associated with wind farm developments. As relative environmental values are revealed by these methods, it would be possible to develop wind farms in such a way that minimizes the total social costs of the investment and which maximizes its net benefits.

Others, including development, economics

02/02954 A critique of renewables policy in the UK

Helm, D. *Energy Policy*, 2002, 30, (3), 185–188.
The contribution of renewables to the reduction of CO_2 emissions is hampered by the operation of NETA in two ways: by its reflection of the high balancing costs within the context of the existing generation and network capacity; and the scarcity of long-term contracts in traded markets. The government's approach of imposing contracts through the Renewables Obligation is inferior to the development of a carbon tax, and risks "picking winners" from existing technologies rather than exploiting the full range of options.

02/02955 A uniform definition and quantitative basis for industrial ecology

Seager, T. P. and Theis, T. L. *Journal of Cleaner Production*, 2002, 10, (3), 225–235.
Industrial ecology (IE) has been characterized by a fragmented approach encompassing a number of different perspectives and analytical techniques. A uniform framework has yet to be established or proposed. This paper partially addresses this shortcoming by tracing some of the historical and intellectual antecedents of the field, providing a clear and concise lexicon of the biological analogue, and contrasting the two most promising analytical methods by which IE research may be carried out: life cycle assessment (LCA) and systems analysis. Although a number of comparative environmental metrics may be employed in cost-minimization or thermodynamic efficiency studies, no single measure is sufficiently developed to prioritize among qualitatively disparate types of environmental impacts. It is argued herein that the concept of *chemical exergy of mixing* may be the most promising basis for the development of a uniform, broad-based measure of chemical pollution, and that such a measure could significantly advance a scientific approach to IE. Some theoretical background is presented, although the reasoning herein is intended to be accessible to an interdisciplinary audience.

02/02956 Biomass energy surveying and techno-economic assessment of suitable CHP system installations

Papadopoulos, D. P. and Katsigiannis, P. A. *Biomass and Bioenergy*, 2002, 22, (2), 105–124.

This paper presents a developed general computer program, which is a flexible computational tool for biomass energy surveying of an interested wide geographical area (wga) and its properly selected interior zones for the purpose of identifying possible cogeneration or combined heat and power (CHP) unit installations in proper site locations, which in turn are fully assessed in techno-economic terms. In addition the program, based on the available in the wga forms of solid biomass and the geographic distribution of the pertinent feedstock, makes a hierarchical order of these taking into account their quantities and energy characteristics, which ultimately leads to definite combinations and thus to desired mixed solid biomass fuel for steady annual contribution (or with seasonal preference in order to reduce the storage costs) of the participating solid biomass residues to be used for the fuel supply of the associated CHP unit. Last the program is conducive to performing reliable sensitivity analysis work as function of key system parameters or quantities. As a case study a wga, belonging to the north-east part of Eastern Macedonia-Thrace Region of Greece, is thoroughly analysed taking into account the specific techno-economical constraints applicable (due to national energy and development laws, etc.) to this area and the pertinent practical results are presented.

02/02957 CO$_2$ abatement policy with learning-by-doing in renewable energy

Rasmussen, T. N. *Resource and Energy Economics*, 2001, 23, (4), 297–325.

This paper analyses the implications of CO$_2$ abatement when there is endogenous technological change in renewable energy. A multi-sector numerical general equilibrium model for Denmark is proposed to reflect two basic assumptions about technological progress in renewable energy. First, there is learning-by-doing and unit costs of production are a decreasing function of cumulated output. Second, technological progress only benefits new vintages of capital. The learning-by-doing process is calibrated to match current projections for technological progress in wind-based electricity. The implications are a marked reduction in the total and marginal cost of abatement and a decline in the optimal level of near-term abatement.

02/02958 Dye biosorption sites in *Aspergillus niger*

Fu, Y. and Viraraghavan, T. *Bioresource Technology*, 2002, 82, (4), 139–145.

Aspergillus niger is capable of removing dyes from an aqueous solution. In the study, the roles played by three major functional groups: carboxyl, amino and phosphate, and the lipid fraction in the biomass of *A. niger* in biosorption of four dyes, Basic Blue 9, Acid blue 29, Congo Red and Disperse Red 1, were investigated. These functional groups in *A. niger* were chemically modified individually to determine their contribution to the biosorption of dyes. It was found that biosorption of dyes was influenced by the functional groups in the fungal biomass and the chemical structure of the dyes.

02/02959 Encapsulated phase change materials for thermal energy storage: Experiments and simulation

Hawlader, M. N. A. *et al. International Journal of Energy Research*, 2002, 26, (2), 159–171.

In the present study, encapsulated phase change materials (PCMs) were used for the storage of thermal energy. Both experiments and simulation were performed to evaluate the characteristics of encapsulated PCMs. Tests were conducted in a packed bed to determine the performance of the encapsulated PCM. In the preparation of encapsulated PCMs, the coacervation technique was used. The performance of the encapsulated PCM was evaluated in terms of encapsulation ratio, hydrophilicity, and energy storage capacity. The experiments were designed, based on surface response method, to optimize the processing conditions. It was found that a higher coating-to-paraffin ratio led to a higher paraffin encapsulation ratio. The hydrophilicity value of encapsulated paraffin depended mainly on the ratio of paraffin to coating. The higher the ratio, the lower was its product hydrophilicity. When the paraffin-to-coating ratio was constant, the higher concentration of HCHO led to a lower hydrophilicity of the product. The encapsulated paraffin has shown large energy storage and release capacity (20–29 J g^{-1}) during its phase changes depending on different ratios of paraffin to coating. Thermal cyclic test showed that encapsulated paraffin kept its geometrical profile and energy storage capacity even after 1000 cycles of operation. In the experiments and simulation of fluid heating process in encapsulated PCM charged packed bed, results showed that Eulerian granular multiphase model in FLUENT 4.47 is suitable for simulation of such a system.

02/02960 Investment cost for geothermal power plants

Stefánsson, V. *Geothermics*, 2002, 31, (2), 263–272.

Stepwise development strategy is considered a suitable method for securing a cost-effective way for the development of geothermal power plants. This strategy has been in use in Iceland for the last decade.

Geothermal high-temperature fields are developed in steps of 20–30 MW. About 6 years are required for each step in the development. Parallel development of several fields in a country might be preferable, especially when a rapid increase of the generation capacity is required in that country. The capacity factor of geothermal power plants depends on the mix of power plants serving the electricity grid. Where geothermal power plants can be operated as base load, the capacity factor is usually in excess of 0.9. The investment cost of geothermal power plants is divided into the cost of surface equipment and activities and the cost of subsurface investment. The surface costs include the cost of surface exploration, and the plant and steam-gathering system, while the cost of subsurface investment is that of drilling. Surface equipment costs can be estimated with the same accuracy as other construction works at the surface (buildings, roads, bridges), whereas higher uncertainty might be associated with the cost of drilling. Analyses of the surface costs of five power plants in Iceland show that the investment cost of the surface equipment is linear with size, in the range 20–60 MW. Surface costs were found to be about 1000 USD/kW with a relative error of 10%. In an earlier publication the author detailed a statistical study of the drilling results in 31 high-temperature fields in the world. Using these results, it is possible to estimate the expectation value and its limits of error for the subsurface investment in an arbitrary geothermal field.

02/02961 National patterns of research output and priorities in renewable energy

Uzun, A. *Energy Policy*, 2002, 30, (2), 131–136.

This paper attempts to compare the research output and priorities of 25 major countries in renewable energy research. The main objective is to assess the research priorities of the major countries in frontier areas/subjects of renewable energy using some bibliometric measures based on renewable energy literature. Subjects of high activity and subjects of low activity are identified for two time periods (1996–1997 and 1998–1999). The findings show that the output of publications including articles, reviews, letters, notes, editorials, and book reviews of India, Greece, and Belgium declined between 1996–1997 and 1998–1999. All measures indicate that in the USA all subjects of renewable energy received more or less the same priority. The rest of the countries had differentiated high- or low-priority profiles in different subjects. Among the main research subjects of renewable energy only photovoltaic technology (PV) had a fairly homogenous profile for all countries.

02/02962 New renewable energy developments and the climate change issue: a case study of Norwegian politics

Christiansen, A. C. *Energy Policy*, 2002, 30, (3), 235–243.

It is widely agreed that the search for cleaner energy technologies is central to any long-term response to the threat of global climate change. Many countries are thus promoting the adoption of new renewable energy (NRE) sources and technologies within the context of energy and climate change policies. The scope of this paper is to unfold linkages between public policies and NRE developments using Norway as a case in point. The aims are firstly to assess the impacts of policy design and public priorities in terms of technology and industrial development dynamics, and secondly to discuss the role attributed to the climate change issue. The primary conclusion is that in spite of long-lasting public efforts, NRE sources represent only a pitiable fraction of the energy produced, delivered, and consumed in Norway, and only modest industrial development dynamics have taken place. Among the most important reasons for this poor outcome are: (i) weak demand-side policies, (ii) fluctuating patterns in public priorities, and (iii) low electricity prices. The Norwegian experience substantiates claims that effective public strategies should be firmly based upon long-term commitments, employ a combination of policies and measures conductive to technical change and innovation, and be capable of guarding against path dependence.

02/02963 Scope of fertiliser solar ponds in Indian agriculture

Murthy, G. R. R. and Pandey, K. P. *Energy*, 2002, 27, (2), 117–126.

Fertilizer salts are considered in the place of sodium chloride for operating solar ponds. A study was conducted to identify the potentially viable candidate fertilizer salts for Indian conditions. Muriate of potash, a potassic fertilizer, is found to have properties comparable to that of sodium chloride, and can generate energy at cheaper cost than urea.

02/02964 Strategic sustainable development – selection, design and synergies of applied tools

Robèrt, K.-H. *et al. Journal of Cleaner Production*, 2002, 10, (3), 197–214.

The number of tools and approaches to develop sustainability is growing rapidly. Sometimes they are presented as if they are contradictory or in competition. However, a systems approach consistent with basic principles and the requirements of sustainability shows that these tools are complementary and can be used in parallel for strategic sustainable development. In fact, it is only when using these approaches outside of the systemic context of sustainability that they become contradictory. This paper is a collective effort of scientists who have

pioneered some of these tools and approaches. The paper maps essential elements for developing sustainability and documents how these elements relate to the application of the respective tools. The objective is to show how these tools and approaches relate to each other and build on each other when used for planning for sustainability.

02/02965 Sustainable development and the challenge of innovation

Vollenbroek, F. A. *Journal of Cleaner Production*, 2002, 10, (3), 215–223.
Innovation does not automatically lead to societal progress, as is implicitly assumed in *technology push*-oriented policies. This assumption is an inheritance of the Enlightenment; i.e. the belief that science will automatically lead to a better quality of life. The strive for sustainable development needs an approach towards innovation that can be characterized as *society pull*: the society has to decide which (balance of) economical, ecological and social goals are to be met. Society pull can be organized by developing shared perspectives for the future, which are inspiring for public and private policy-makers and investors. In this paper this is worked out as transition management: a process approach directing innovation towards sustainable development. A crucial aspect of transition management is that innovation is no longer driven by the past, but attracted by the future.

02/02966 Too hot to handle? Benefits and costs of stimulating the use of biofuels in the Swedish heating sector

Brünnlund, R. and Kriström, B. *Resource and Energy Economics*, 2001, 23, (4), 343–358.
This paper evaluates the impact of changes in current Swedish energy taxation by analysing a panel of approximately 150 district heating plants in Sweden. Plant-specific production functions were estimated and the economic repercussions of changing the energy tax system derived. The resulting changes of emissions of sulfur, NO_x, particulates and CO_2 were also estimated. The results raise the issue of whether or not the Swedish tax system needs to be complemented with additional environmental taxes, covering, say, emissions of particulates. Because the geographical variation of damages is likely to be substantial, an overall re-assessment of current regulatory schemes seems preferable.

02/02967 Windfarming in India – the desired policy recast

Sasi, K. K. and Basu, S. *Energy*, 2002, 27, (3), 241–253.
The Indian wind energy programme suffered a recent setback after being placed third in terms of total installed capacity of wind electricity in the world. This paper submits, based on analysis of field performance data, that the falling profitability of private windfarm operation in the country today can hardly attract large-scale investment in the private sector. It further suggests that a right choice of wind electric generators with an optimum rated wind speed will improve the windfarm performance. The steps to be adopted by the government agencies in order to ensure the desired growth of the wind industry in the country have also been suggested. These in turn invite certain changes in the present windfarm development policy of the country.

08   STEAM RAISING

Boiler operation/design

02/02968 Boiler having waste gas cleaning unit with reduced size and simple structure

Inatsune, Y. *et al.* Jpn. Kokai Tokkyo Koho JP 2001 272,001 (Cl. F22B37/00), 5 Oct 2001, Appl. 2000/91,723, 29 Mar 2000. 6. (In Japanese)
In the boiler, waste gases generated by combustion of fuels, e.g. coal, are led to a duct for heat recovery and removal of NO_x through a NO_x removal unit having a NH_3 inlet and catalysts. The duct is vertically placed and ≥ 1 heat exchanger unit selected from a superheater, a reheater, an evaporator, and an economizer, the NO_x removal unit, and an air heater are successively placed along with the duct perpendicularly. The boiler shows a rare air, reduced pressure loss, uniform stretching of the duct, and reduced dust deposition to improve driving efficiency and to reduce driving costs.

02/02969 Investigation of the flow, combustion, heat-transfer and emissions from a 609 MW utility tangentially fired pulverized-coal boiler

Yin, C. *et al. Fuel*, 2002, 81, (8), 997–1006.

A numerical approach is given to investigate the performance of a 609 MW tangentially fired pulverized-coal boiler, with emphasis on formation mechanism of gas flow deviation and uneven wall temperature in crossover pass and on NO_x emission. To achieve this purpose and obtain a reliable solution, some different strategies with the existing researches are used. Good agreement of simulation results with design parameters and site operation records indicates this simulation is pretty reasonable and thus the conclusions of the gas flow deviation, emissions, combustion and heat transfer are reliable. These conclusions can be used to guide the design and operation of boilers of similar types.

02/02970 Second law analysis and optimization of a combined triple power cycle

Marrero, I.O. *et al. Energy Conversion and Management*, 2002, 43, (4), 557–573.
In this investigation, a combined triple (Brayton/Rankine/Rankine)/ (gas/steam/ammonia) power cycle is analysed. In the triple cycle, the exhaust of the Brayton gas topping cycle is used in a heat recovery steam generator (HRSG) to produce steam for a Rankine steam middle cycle followed by an ammonia Rankine bottoming cycle. The ammonia bottoming cycle provides a practical and more efficient hot and cold streams thermal matching for the triple cycle HRSG as compared to the HRSG of a conventional combined power cycle. Through exergy analysis of the cycle, the exergy of the exhaust streams and the irreversibility of each component in the cycle are determined, using reasonably practical constraints for the system components. These constraints are mainly due to the size of components and are conveniently parameterized and analysed. The triple cycle was analysed and optimized with respect to important system parameters, such as the gas topping cycle pressure ratio, gas turbine inlet temperature, HRSG pinch point, gas/steam approach temperature difference, rate of steam injection into combustion chamber and the effectiveness of the heat exchangers. One goal of the study is to find what configuration will achieve a thermal efficiency of 60% when reasonably practical constraints for system parameters are used.

02/02971 Thermochemical study of mercury oxidation in utility boiler flue gases

Widmer, N. C. *et al. Proc. Air Waste Manage. Assoc. Annu. Conf. Exhib., 93rd*, 2000, 1601–1610.
Previous studies of mercury capture in wet scrubbers reported that over 80% mercury control was achieved for certain Municipal Waste Combustor configurations utilizing acid gas scrubbers. In general it was noted that high levels of mercury capture were observed in waste processing systems that did not employ a rapid flue gas quench directly after the primary combustion chamber. The performance data suggested that the rapid quench was interfering with the conversion of elemental mercury to the soluble $HgCl_2$ form, and therefore, the acid gas scrubber could not effectively capture the mercury. A series of simple experiments were run to examine the impact of thermal quench rate on mercury oxidation by chlorine species under MWC exhaust conditions. The results permitted development of a global reaction rate constant for mercury oxidation Subsequent analysis of these data and the rate constant using thermochemical principles led to the development of a kinetic mechanism describing the reactions of mercury in the presence chlorine-containing molecules and radical species. This mechanism predicts that the rate-limiting step in mercury oxidation by chlorine is the Cl radical attack on elemental mercury. Subsequently the HgCl radical can react quickly with even small concentrations of molecule chlorine. Although reactions of HgCl with HCl, Cl, or HOCl are possible, they appear to be significantly slower in the temperature range of interest. The predicted rate constant for the initial attack of Cl on mercury was in the expected range of about $10^{16} cm\, mol^{-2} s^{-1}$. Under coal-fired utility conditions, however, HCl concentrations are orders of magnitude lower than in MWCs, so that observed rates of mercury oxidation are much slower. Application of the kinetic model to coal combustion conditions suggests limitations as well as opportunities for cost effective enhancement of mercury capture in utility boilers.

09   COMBUSTION

Burners, combustion systems

02/02972 A dynamic continuum of nanostructured carbons in the combustion furnace

Johnson, M. P. *et al. Carbon*, 2002, 40, (2), 189–194.