Conventional economic growth theory assumes that technological progress is exogenous and that resource consumption is a consequence, not a cause, of growth. The reality is different and more complex. A 'growth engine' is a positive feedback loop involving declining costs of inputs and increasing demand for lower priced outputs, which then drives costs down further, thanks to economies of scale and learning effects. In a competitive environment, prices follow. The most important 'growth engine' of the first industrial revolution was dependent on coal and steam power. The feedback operated through rapidly declining fossil fuel and mechanical power costs. The advent of electric power, in growing quantities and declining cost, has triggered the development of a whole range of new products and industries, including electric light, radio and television, moving pictures, and the whole modern information sector. The purpose of this paper is to reformulate the idea of the 'growth engine' in terms of the service provided by energy inputs, namely 'useful work', defined as the product of energy (exergy) inputs multiplied by a conversion efficiency. This study attempts to reconstruct the useful work performed in the US economy during the twentieth century. Some economic implications are indicated very briefly.

03/01556 Financial risks for green electricity investors and producers in a tradable green certificate market

Lemming, J. *Energy Policy*, 2003, 31, (1), 21–32.

This paper analyses financial risks in a market for tradable green certificates (TGC) from two perspectives; existing renewable producers and potential investors in new renewable electricity generation capacity. The equilibrium pricing mechanism for a consumer-based TGC market is described and a market with wind turbines as the sole renewable technology is analysed. In this framework, TGC prices and fluctuations in production from wind turbines will be negatively correlated and, as a result, TGC price fluctuations can actually help decrease the total financial risk. Based on this recognition, analytical expressions for revenue-variance-minimizing trading strategies are derived and an analysis of the demand and supply for financial hedging is used to show that forward contracts will be traded at a risk premium.

03/01557 Financial subsidies to the Australian fossil fuel industry

Riedy, C. and Diesendorf, M. *Energy Policy*, 2003, 31, (2), 125–137.

A common claim during international greenhouse gas reduction negotiations has been that domestic emissions cuts will harm national economies. This argument fails to consider the distorting effect of existing financial subsidies and associated incentives to fossil fuel production and consumption provided by governments in most developed countries. These subsidies support a fossil fuel energy sector that is the major contributor to global greenhouse gas emissions and conflict with attempts to expand the role of sustainable energy technologies. Reform of these types of subsidies has the potential to provide substantial gains in economic efficiency as well as reductions in carbon dioxide emissions – a 'no regrets' outcome for the economy and the environment. This paper examines financial subsidies to fossil fuel production and consumption in Australia and estimates the magnitude of the subsidies. Subsidies and associated incentives to fossil fuel production and consumption in Australia are similar to those in the United States and the other countries that have pushed for increased 'flexibility' during international negotiations.

03/01558 Framework for formulating a performance-based incentive-rebate scale for the demand-side-energy management scheme for commercial buildings in Hong Kong

Lee, W. L. and Yik, F. W. H. *Applied Energy*, 2002, 73, (2), 139–166.

Many, but not all, rebate-type demand side management (DSM) programmes worldwide have met with success. The rebate rate offered is a critical factor to success but a rational rebate scale determination method that would help strike a proper balance between the incentive offered and the effectiveness of the programme is lacking. For the DSM programmes recently launched in Hong Kong, the rebate rates are disproportionate to the cost and performance of the promoted energy-saving measures, resulting in diverse participation rates among the programmes. This paper presents a conceptual framework for formulating the rebate scales for incentive-based DSM programmes for commercial buildings, which would attract participation of building owners and boost electricity saving. The establishment of the scale starts from developing a performance curve that relates the cost effectiveness and the long-term benefits of different energy-saving DSM measures. The rebate scale is set based on the premise that a proportionally higher rebate rate should be offered for the adoption of each additional measure, which would yield a diminished marginal rate of return. Analysis showed that replacing the current rebate scale by the proposed scale would lead to benefits, both to the building owners and the utility companies.

03/01559 Fuel poverty, thermal comfort and occupancy: results of a national household-survey in Ireland

Healy, J. D and Clinch, J. P. *Applied Energy*, 2002, 73, (3–4), 329–343.

Fuel poverty is perhaps the strongest adverse social impact resulting from the inefficient consumption of energy in the domestic sector. Despite considerable research examining the plight of those affected, there has been very little empirical work examining the relationship between fuel poverty and thermal comfort and the extent of indoor cold strain resulting from inadequately heated housing. Furthermore, the effects of fuel poverty on household occupancy have not been addressed formerly. This paper employs a new national household survey of Ireland – a country with a level of fuel poverty similar to Britain – to examine these key issues. Both self-reported and objective measures of thermal comfort are utilized, and the study pays particular attention to the age profile of those affected by thermal discomfort. The results show, inter alia, that two-thirds of fuel-poor householders demonstrate cold strain, and over half of elderly households endure inadequate ambient household temperatures during winter.

03/01560 Fuel processing for low-temperature and high-temperature fuel cells. Challenges, and opportunities for sustainable development in the 21st century

Song, C. *Catalysis Today*, 2002, 77, (1–2), 17–49.

This review paper first discusses the needs for fundamental changes in the energy system for major efficiency improvements in terms of global resource limitation and sustainable development. Major improvement in energy efficiency of electric power plants and transportation vehicles is needed to enable the world to meet the energy demands at lower rate of energy consumption with corresponding reduction in pollutant and CO_2 emissions. A brief overview will then be given on principle and advantages of different types of low-temperature and high-temperature fuel cells. Fuel cells are intrinsically much more energy-efficient, and could achieve as high as 70–80% system efficiency (including heat utilization) in electric power plants using solid oxide fuel cells (SOFC, versus the current efficiency of 30–37% via combustion), and 40–50% efficiency for transportation using proton-exchange membrane fuel cells (PEMFC) or solid oxide fuel cells (versus the current efficiency of 20–35% with internal combustion (IC) engines). The technical discussions will focus on fuel processing for fuel cell applications in the 21st century. The strategies and options of fuel processors depend on the type of fuel cells and applications. Among the low-temperature fuel cells, proton-exchange membrane fuel cells require H_2 as the fuel and thus nearly CO-free and sulfur-free gas feed must be produced from fuel processor. High-temperature fuel cells such as solid oxide fuel cells can use both CO and H_2 as fuel, and thus fuel processing can be achieved in less steps. Hydrocarbon fuels and alcohol fuels can both be used as fuels for reforming on-site or on-board. Alcohol fuels have the advantages of being ultra-clean and sulfur-free and can be reformed at lower temperatures, but hydrocarbon fuels have the advantages of existing infrastructure of production and distribution and higher energy density. Further research and development on fuel processing are necessary for improved energy efficiency and reduced size of fuel processor. More effective ways for on-site or on-board deep removal of sulfur before and after fuel reforming, and more energy-efficient and stable catalysts and processes for reforming hydrocarbon fuels are necessary for both high-temperature and low-temperature fuel cells. In addition, more active and robust (non-pyrophoric) catalysts for water–gas-shift (WGS) reactions, more selective and active catalysts for preferential CO oxidation at lower temperature, more CO-tolerant anode catalysts would contribute significantly to development and implementation of low-temperature fuel cells, particularly proton-exchange membrane fuel cells. In addition, more work is required in the area of electrode catalysis and high-temperature membrane development related to fuel processing including tolerance to certain components in reformate, especially CO and sulfur species.

03/01561 In search of sustainable values

Partridge, E. *Int. J. Sustainable Development*, 2003, 6, (1), 25–41.

Fundamental to policies of sustainable development is the assumption that values will not depreciate through time. This assumption is inconsistent with the economic approach to policy-making. Economic analysis, by interpreting social values in terms of money, necessarily discounts values in the future. Accordingly, if the interests of future generations are to be served, moral and economic values must be shown to be essentially incommensurable, and moral values must predominate in policy analyses. The distinction between economic and moral values is enumerated with 12 contrasting characteristics, five of which are given careful elaboration: (a) 'economic man' (a utility maximizer) vs the moral agent (rule-oriented evaluator); (b) the marketplace vs the community; (c) ecocentric vs 'spectator' point of view; (d) non-moral values vs moral values; and (e) time preference (discounting) vs time neutrality.