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Policy Forum: The Future of Energy Markets

Energy Markets: From the Dawn to the Present

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The use of energy has been an essential element in the supply of food, physical comfort, and the development of an organised society since the dawn of human existence some 4 million years ago. For most of this period energy requirements were relatively modest, generally limited to the use of fire for warmth, cooking and basic materials. In addition, wind and human 'energy' permitted transportation by water, whilst the invention of the wheel gave similar advantages on land. However, it is only in comparatively recent times (that is, the last 2000 years) that wind and water power have been harnessed to provide significant sources of power.

Perhaps the first significant increase in energy requirements came with the dawn of the Neolithic revolution. This period witnessed the change from a dependence on hunting and gathering to the development of primitive agriculture, involving interrelated developments such as cultivation of plants, domestication of animals, settlement of communities, and the development of pottery and improved toolmaking. However, with a relatively small human population and modest per capita consumption of heat and power, it was generally possible to maintain an approximate balance between renewable energy sources and demand.

The development of mechanical equipment based upon water and wind power led to a substantial increase in the power that could be harnessed. Water mills were used initially for irrigation and for grinding cereals, but by Roman times their use had been extended to other mechanical tasks such as driving saw mills. Windmills were used for similar tasks, although their value was limited by their intermittent operation. However, the energy component in the final product was very low, and it was not until the development of metal technology that power supply sufficient for the output of 'energy intensive' products was required.

Copper was the first metal to come into widespread use. Although it is not very abundant, its reduction temperature is relatively low and the metal can be separated from its ore with relative ease. Iron, whilst being more abundant than copper, is much more difficult to 'win' from the ore due to the much higher reduction temperature that is required. Furnaces based upon charcoal as a fuel that could be used to smelt iron were not developed until about 1100 BC. However, the new high-temperature technology, combined with widespread availability of iron ore and forests to provide charcoal, made it possible for the use of the metal to develop on an unprecedented scale. New tools made from iron transformed farming practices across Europe, although not without significant environmental impacts in England, the prime supplier of iron and iron products.

By the early Middle Ages, the forests of England had become badly depleted and production of iron ore declined for a period of time. Domestic consumption of wood also declined, as a result of increasing prices brought about by its relative scarcity. Its place in household use was taken by coal, despite resulting pollution from impurities in the coal (the same impurities that made it unsatisfactory for use in iron smelting). Rising household demand for coal stimulated the development of coal mines and

mining technology, and production increased dramatically in England during the 16th and 17th centuries. By 1800 annual production amounted to 10 million tons, the vast majority of which was consumed in households. Demand for coal was further stimulated in the early 18th century by the discovery that coal's impurities could be removed by heating, making the resulting product (coke) ideal for reducing iron ore.

Expansion of the coal mining industry and the requirement to continuously pump water out of coal mines raised an urgent need for a new form of mechanical power. The subsequent development of the coal-fired steam engine formed the basis of Britain's industrial revolution of the 18th century, and witnessed the development of an energy-based technology that was to greatly influence the economic and social development of the world.

Development of another energy-based technology of global significance came about in the mid-19th century with the evolution of the internal combustion engine. Development of the automobile and other road transport was associated with corresponding growth in the petroleum industry, and oil rose to join coal as the dominant fuels of the 20th century.

Development of coal-fired generators in the 1890s witnessed the growth of a market for electricity. Electricity provided a new way of generating power, heat and light. Initially electricity was very expensive, limited to small areas on the network, supplied of varying standards and subject to interruptions. However, technological developments led to the creation of a very homogeneous, reliable and time-saving energy carrier. This new form of energy supply initially extended the importance of coal, but in the last quarter of the 20th century nuclear power and natural gas grew in importance. Thus, despite the thermal losses associated with transforming fossil fuels into electricity, households and many forms of economic activity have tended to become increasingly electricity-intensive.

The 20th century also witnessed growing public concern over the impacts of large-scale energy use on the environment, although many of the concerns were evident in more localised areas for many hundreds of years. Ancient Rome burned wood and Emperor Nero's tutor, Seneca, complained of the bad effect that smoke had on his health and of smoke damage to temples, whilst anecdotal evidence indicates that air pollution had been a concern in England as early as 1352 when a ban was introduced on coal burning in London (hanging being the punishment for transgressors).

Historically, regulatory instruments have been the basic mechanism for enacting environmental policy throughout the industrialised world. Environmental quality has been regarded as a public good that the state must secure by preventing private agents from damaging it. Direct regulation involves the imposition of standards (or even bans) regarding emissions and discharges, product or process characteristics, etc., through licensing and monitoring. Legislation usually forms the basis for this form of control, and compliance is generally mandatory with sanctions for non-compliance.

The proposal to impose taxes on pollution, whilst more recent, is also far from new, having been proposed in the early years of the last century by the famous British economist Professor Arthur Cecil Pigou as a means of reducing London's famous fogs (or smogs). Pigou observed that pollution imposed uncovered costs on third parties that were not included in ordinary market transactions. His proposal was to tax pollution by means of a so-called externality tax in order to internalise within ordinary market transactions the damages caused by pollution. At the time Pigou's proposal was regarded as an academic curiosity, but several generations later it was rejuvenated as the core of the 'polluter pays principle'.

More recently, the use of tradeable permits for addressing a number of environmental concerns has risen to prominence. Ironically, the very mechanism that has encouraged excessive environmental damage in much of the world, and hence contributed significantly to its accompanying high social costs—*the market place*—is now seen as an important avenue by which environmental objectives and targets could possibly be met at a lower cost than by traditional regulatory or taxation measures.

Contemporary energy policy issues are dominated, directly and indirectly, by major concerns at both local and global levels of environmental degradation arising from combustion of fossil fuels. Even countries with relatively modest fossil fuel requirements, such as the poorer nations of Africa, Asia and the South Pacific, could experience significant adverse consequences if the world's requirement for energy from fossil fuels does not abate within a relatively short time-frame.

The three articles that follow this introduction address key energy market issues, at both global and domestic Australian levels, in the context of environmental constraints arising from the combustion of fossil fuels.

Fatih Birol gives an overview of the latest *World Energy Outlook*, focusing specifically on oil and gas markets. Although there are adequate reserves of oil and gas to meet projected world demand to 2030, he notes that major financial, environmental, and energy security concerns must be addressed if the uncertainties that have led to current price volatility are to be minimised.

Australia's projected levels of energy consumption, and associated emissions of greenhouse gases, are the subject of the article by Melanie Ford et al. Specifically, the article focuses on an Australian perspective on current international options for addressing the potential conflict of substantially enhanced levels of fossil fuel use with the requirement to mitigate emissions of the pollutants that give rise to global climate change.

In the final article in this forum, Anthony Owen considers the prospects for the growth of environmentally benign renewable energy technologies. This article investigates why, despite the apparent environmental attractiveness of renewable energy, with the exception of hydropower its market penetration has been very limited to date.

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