Strategies for the Future Development of Energy Systems

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The cheap-oil era is a short anomaly in the Earth's history. In this short period, practically unlimited access to the hitherto unimaginable physical power which oil so easily provides has changed the world and transformed modern man's concepts of the economic and ecological conditions of life. As this era is now coming to an end, we face global technological, ecological, economic, and, hence, political challenges unparalleled to those of any other cultural transition in the history of mankind. The technological and ecological nature of these challenges cannot be apprehended within the framework of concepts inherent in the mind-set of the cheap-oil era. In particular, the concept of "energy" as tradeable commodities must be revised in order to establish a rational conceptual framework for the analysis of feasible strategies for the future development of energy systems.

I. THE ORIGIN OF THE COMMERCIAL ENERGY CONCEPT

After World War II when the military and civilian use of atomic energy became a political issue in the West, the US Atomic Energy Commission of 1946 and similar administrations in other countries were created to take charge of atomic energy programmes. However, "energy" was not generally used as a political and economic term before the mid-1970's when the oil crisis unveiled the Western economies' crucial dependency on oil and the needs for coal, natural gas and nuclear power as substitutes for oil. Instead of the explicit but awkward term "fossil fuels and nuclear power", the term "energy" was introduced in the naming of institutions and governmental departments, e.g. the International Energy Agency (1974), the US Department of Energy (1977), and energy agencies in many countries.

Thus, as a result of the Opec-staged oil crisis in the mid-1970's, "energy" became the general term for tradeable commodities: fuels and electric power - a simplistic concept only vaguely related to the thermodynamic meaning of the term. This concept contrasted with several physical and biological analyses of energy flows in natural and industrialised ecosystems, published in the 1960's and early 1970's, in which energy (and entropy) is defined as a thermodynamic systems property (e.g. Odum 1971, [1]).

II. THE ENERGY BOOKKEEPING OF A WASTEFUL ENERGY ECONOMY

In the cheap-oil era, oil - the precious resource for the powering of vehicles on land, at sea and in the air - has been cheap enough to be burned in simple boilers for low-temperature heating or, wasting even more of its thermodynamic potential, in thermal power stations whose contribution to sustaining the electric potential (voltage) of the power grid is annihilated in electric resistance coils (mere entropy generators) for room heating and warm water.

Because such waste of the thermodynamic potentials of oil, gas and coal has not been an important economic issue, energy statistics generally make no thermodynamic distinction between the different forms of energy. Energy statistics are simple bookkeeping accounts of chemical, electric and thermal energy, denominated in calorimetric values. For example, the potential power of one kilogram of oil or 11 kWh of electric power is equalled to the heat from a solar collector raising the temperature of 1 cubic metre of water by 10 degrees C.

Such simplistic bookkeeping of energy supply and demand conforms to the pecuniary bookkeeping accounts in which the supply and demand for all sorts of various goods and services is measured in some currency. It requires no insight in the basic principles of thermodynamics and is therefore easily grasped and applied in general economic theories.

The simplistic energy bookkeeping method was adopted also by the advocates of "renewable energy", a term introduced into the vocabulary in the 1980's as an expression for any source of power or heat other than fossil fuels or nuclear power. Renewable energy is thought of as something which can replace fossil fuels and nuclear power within the fossil-fuel infrastructure framework, not as endogenous energy flows in new energy systems which facilitate the efficient utilisation of various scarce resources with very different properties. Thus, in 2001 the European Union formally approved a directive on renewable energy which required member states to ensure that 12% of gross internal energy consumption and 22% of electricity consumption would come from renewable sources by 2010. [2]

Such percentage accounting is ostensibly easy to grasp but makes little sense with respect to the formulation of a goal-directed policy aiming at reducing dependency on fossil fuels. First, if energy consumption according to the simplistic bookkeeping grows by 10%, the dependency on fossil fuels is only insignificantly reduced if this growth is covered by renewables. Second, and more importantly, it does not make sense to replace heat from oil or gas boilers by heat from solar absorbers or biomass fuelled boilers as long as the resource economy of replacement by heat from cooling circuits of power generating units (cogeneration) is much better.

III. ECONOMIC THEORY VERSUS CONCRETE COST ANALYSES

It is a general assumption of economic equilibrium theories that the market ensures that demand and supply is balanced at minimum costs and that, therefore, any politically regulated shift away from the state of equilibrium will be costly. Accordingly, macroeconomic analyses such as Nordhaus & Zili-Yang [3] show that the transition to new energy systems which fulfil the needs of industrialised societies at substantially reduced fossil fuel consumption and CO_2 emission will be costly. However, these results are not confirmed by the results of cost computations in specific cases of concretely specified technological investment programmes which lead to substantially reduced fossil fuel consumption.

On the contrary, computations based on models which in detail represent the physical properties of national or regional energy systems as a whole - including energy sources, the energy conversion and transmission system, and the end-use complex - show that under any reasonable assumption as to future fuel prices, the well-engineered technological transition to energy systems much less dependent on fossil fuels is economically advantageous for the community as a whole. This is demonstrated by comparative economic cost analyses for concretely specified transition scenarios (investment programmes) for Denmark and the Nordic Countries, [4], [5].

IV. BUSINESS AS USUAL IS NOT AN OPTION

The history of the industrialised world powered by fossil energy sources, which begins when Thomas Newcomen set up the first successful steam engine in 1712, has culminated in the all-embracing cheap-oil technological complex upon which all functions of our societies now depend. The transformation of the energy systems of this complex to systems much less dependent on fossil energy sources is a task of engineering of a magnitude never before encountered by mankind. The time available may be too short but in the Western civilisation the barriers for change are cultural and institutional rather than technical. Coherent technological strategies for the transformation of energy systems in the affluent industrialised countries can be spelled out. But in the political economies based on the consumerism culture and liberalised markets extended to the basic energy infrastructures upon which the economy depends, there is little scope for the political pursuance of technological strategies for the common good.

However, business as usual is not an option. Either energy policies based on coherent technological strategies for the reduction of oil and gas consumption and CO_2 emission are formulated and forthwith pursued in order to sustain the welfare of our societies. Or the basis of our economy will be eroded when the supply of oil and gas can no longer meet the demand.

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