Kalam appointed Chairman, SACC

Through a memorandum of appointment issued by the Cabinet Secretariat on 25 November, A. P. J. Abdul Kalam has been appointed 'Principal Scientific Adviser to the Government of India', with Cabinet rank. (Cognoscenti will know that all recipients of the Bharat Ratna – awarded to Kalam in 1997 – enjoy Cabinet rank, along with former Prime Ministers, in that Gita of the pecking-order of officialdom: The Warrant of Precedence.)

In a subsequent circular of 15 December, the Cabinet Secretariat has notified that:

'It has been decided, with the approval of the Prime Minister that the Principal Scientific Adviser would be primarily responsible for:

(i) Evolving policies, strategies and missions for generation of innovations and support systems for multiple applications.

(ii) Generating science and technology tasks in strategic, economic and social sectors in partnership with Government departments, institutions and industry.

(iii) He would also be Chairman, ex-officio, of the Scientific Advisory Committee to the Cabinet.'

Random selections

Are clusters solids or liquids?

'Solid-like to liquid-like transition in small clusters of C_{60} molecules or transition metal atoms'
L. J. Gallego, J. Garcia-Rodeja, M. M. G. Alemany and C. Rey
Phys. Rev. Lett., 1999, **83**, 5258

The 13-member icosahedral C_{60} cluster contains a central molecule whereas the 7-member C_{60} cluster does not. Do both these types of clusters behave similarly (solid or liquid-like)? Molecular dynamics studies using Girifalco's spherical potential shows that the 7-member cluster achieves the liquid state contrary to what was observed earlier in the case of the 13-member cluster. In the latter case, as the central molecule reached the surface, sublimation occurred from the (icosahedral) solid-like phase without the cluster exhibiting melting. The paper deals with similar studies related to transition metal clusters also.

Orchestrated evaporation

'Cooperative evaporation in ordered arrays of volatile droplets'
C. Schafle, C. Bechinger, B. Rinn, C. David and P. Leiderer
Phys. Rev. Lett., 1999, **83**, 5302

Consider equal-sized droplets of a volatile liquid arranged in a quasi-one-dimensional pattern. Theoretical studies of Lacasta *et al.*, *Phys. Rev.*, 1998, **57**, 6198 had shown that the droplets in such a system evaporate in a cooperative manner and not independently of each other. This feature has been confirmed now experimentally and reported in this paper. Microcontactprinting technique was adopted to create an ordered array of diethyl glycol droplets on gold surface in a 'honeycomb pattern'. This pattern changed to a triangular superlattice under ambient conditions due to cooperative process of evaporation of one set of droplets, having the other set to survive. This direct experimental evidence, during the so-called Ostwald ripening, has bearing on other systems like binary metal alloys.

OPINION

Role of science, engineering, economics and environment in energy system of the 21st century*

Jyoti K. Parikh

Science is the foerunner of new ideas and fresh concepts for the energy system. Last few centuries gave us a framework that characterizes energy systems such as laws of motion, laws of thermodynamics, electro-magnetism and so on. Stalwarts like Newton, Boltzman, Maxwell, Faraday, Carnot and others gave us the foundation characterizing energy systems. In the 20th century, we have had new discoveries that could expand options for the energy systems such as photoelectric effect, which provides the basis for photovoltaic technology, nuclear chain reaction that gave us nuclear power, superconductivity which has the potential to advance every aspect of the power system, viz. generators, transmission and storage and so

*Keynote address given at the panel discussion on 'Science and Energy' at the World Conference on Science hosted by Hungarian Academy of Science at Budapest in June 1999.

on[1]. Which scientific ideas are realized in practice? Why? Techno-socio-economic and environmental criteria determine the choice of any energy system. We could observe that in some cases, the gap between discovery and commercialization of technology was small, say 10 years and in some cases nearly half a century.

Energy system and market penetration of technologies

The energy system begins with primary energy sources which may be gift of nature such as sun, wind, fossil, fuel resources and so on. The conversion technologies give us options to convert from one energy form to the other such as solar, hydro or nuclear energy to electricity and so on. Transportation and transmission have gone through major changes over the century. There are a host of innovations in end-use devices that have come into the market that increase useful energy derived from energy input. Due to technological progress, every aspect of the energy system, from primary energy to useful energy is changing rapidly with time, reducing losses and expanding options for energy systems. Technologies which have bottlenecks in any of the above steps are not likely to penetrate fast. For example, up to now, hydrogen has been difficult to store and transport. At times, two technologies together succeed better than one alone. For example, lighting with photovoltaics penetrates faster after the advent of compact fluorescent lamp technology which consumes less energy.

New technological and engineering acumen transform scientific concepts into tangible products and processes. However, increasingly socio-economic criteria are playing a major role in selection of energy alternatives. Energy prices, howsoever arrived at, determine social choices. Much of the desirable changes such as improving efficiency of conversion or end-use devices take place only if the energy resources are correctly priced. Recently, financing energy expansion is a major problem, especially in the developing countries where capital is scarce.

Environmental concerns and role of energy efficiency

In the last two decades, local environmental concerns became important issues in making choices. To this, one adds global environmental concerns that calls for reduction in use of fossil fuels to reduce greenhouse gases so as to mitigate climate change.

Decarbonization of energy systems may gradually become a major criterion for choosing various elements of energy systems as the implementation of Framework Convention of Climate Change progresses. Pollution, whether local or global, depends on type of energy used and pollution emitted per unit energy use, energy used per GDP (Gross Domestic Product), GDP per capita and pollution[2].

$$\text{Pollution} = \frac{\text{Pollution}}{\text{Energy}} \times \frac{\text{Energy}}{\text{GDP}} \times \frac{\text{GDP}}{\text{Population}} \times \text{Population}\,.$$

Since all countries wish to increase their income, reduction in pollution therefore, can be done mainly by the first two factors, viz. reducing pollution intensity and energy intensity of GDP. When population stabilizes, there is more scope to arrest or reduce growth rates of pollution and energy consumption. Technological progress combined with economic considerations reduce energy used per value added. As shown by Nakicenovic *et al.*[3], during the initial process of development, commercial energy substitutes non-commercial energy, viz. fuel wood and agriculture residues and therefore commercial energy appears to increase but when both commercial and non-commercial (traditional) energy are combined, energy intensity goes down with time even in developing countries due to technical progress.

To reduce the first two factors, a number of initiatives have been commenced such as demand side management to reduce energy demand, fuel switching to reduce pollution, new technologies and processes that require less energy and so on. Here, science and engineering play a major role. Power plant efficiencies which are still in the range of 20% to 30% in developing countries, have reached 40% to 60% in the developed countries for new generation of power plants which recover and reuse waste heat.

Table 1. Per person annual energy use (direct and indirect) 1989–90*

Income group	Coal (kg)	Oil (kg)	Electricity (kWh)	Carbon (tonne)
Rural				
Bot 50%	74	22.5	95	0.054
Mid 40%	127	39.7	152	0.093
Top 10%	262	89.8	284	0.204
Urban				
Bot 50%	130	45.6	164	0.101
Mid 40%	302	118.6	366	0.246
Top 10%	765	332.3	858	0.656
EDR'	10.3	14.8	9.0	12.0

*Excluding energy used directly and indirectly to make deliveries to other than private consumption.
'EDR, Extreme disparity ratio in capital annual energy consumption between the richest class and the poorest class.

Energy and equity

Parikh *et al.*[4] showed that distribution of energy across countries and income groups is far from equitable, 75% energy resources are used by 25% of the world population in the developed countries. Within low income developing countries also, rural poor use much less energy out of which a large portion comes from locally available biomass. In particular, a poor woman who gathers wood/dung fuel, processes or converts it, transports it and cooks using these fuels represents a single person energy system[5].

Murthy *et al.*[6] have shown that in India carbon pollution arising from rural poor and urban rich persons is 0.054 t and 0.656 t of carbon per person respectively (Table 1).

It is indeed unfortunate that even in the 21st century, millions of women will be spending hours gathering biofuels travelling many kilometres carrying them, suffering health effects due to smoke arising in the process of use of biofuels and exposing also their children to these ill effects[7].

Economic imperatives and institutional changes

Along with engineering efficiencies, economic efficiency needs to improve. For this purpose, energy system institutions have seen evolutionary changes, especially in the last decade or so where government involvement in coal, petroleum and power sector on a large scale is paving way to private sector enterprises. Erstwhile vertically integrated utilities may now be reinforced by distributive energy systems. Power generation, transmission, distribution, marketing and banking may be done by separate companies. Exploration, production, distribution and retail marketing of fossil fuels may follow the same pattern.

Energy system in 21st century

From the above discussion, it is expected that the transition of energy system in the next century could be characterized as follows:

- Transition from low or medium efficiency to high efficiency;
- Fossil fuels based systems to decarbonized systems;
- Environmentally damaging to environmentally friendly systems;
- Inequitable to equitable consumption (?)
- Public sector and government to private sector undertakings.
- Highly centralized system to one with reinforcement distributed energy system.

One hopes that once again science and engineering would come forward to meet the challenges envisaged above.

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From the archives

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Unemployment among the Educated Classes

Addressing the graduates at the Convocation of Agra University in 1931, Sir Ross Barker is reported to have observed, 'You are like apprentices who have collected the tools of your craft. You will be judged by the way in which you will use them in after life and as you are judged the University which has equipped you will be judged'. In his very commendable exhortation Sir Ross Barker evidently assumes that there is a reasonable scope for the employment of the labourer and the exercise of his tools and therefore the responsibility of using them for a high and honourable purpose belongs to the young men. The significance of these pregnant words, had they been spoken thirty years ago, might have been understood by the graduates, when the harvest was rich enough to provide employment for tools and labourers of all description. Everyone knows that to-day the output of graduates from the Universities in India is out of all proportion to the expansion of public service, industrial organizations and other big employing agencies, and the rate at which the volume of unemployment among the educated young men is increasing must fill all thoughtful minds with apprehension. It is true that the acuteness of unemployment among the labouring communities is already straining the resources of statesmanship and possibly, in this case, at least partial relief may be given by rationalizing industries and by balancing agriculture and manufactures: but surely none of these palliatives can convey hope to the educated youth whose distress is as acute as it is widespread. That a compulsory restriction of the growth of population may be relied upon to bring succour, is, in our opinion, a suggestion more facetious than feasible and no far-sighted statesman can deem his stewardship fully and satisfactorily discharged until he has contributed to the solution of the problem which sooner or later is bound to become a menace to the stability of society... .