Towards a New Energy Paradigm
(using fuel cell technology to provide access to power)

Access is the key to enterprise. The developing world needs access; access to credit, information and power. These had always been crucial resources for wealth creation by individual initiative in the West. For too long market failures leading to lack of accessibility have prevented the people in the developing countries from utilizing these key resources of enterprise in breaking out of a vicious cycle of poverty.

Although some breakthrough has taken place in the area of credit in low-income economies, there has been little progress in accessing information or power. More than 50% of the country in many of these economies is still shrouded in darkness. The traditional approach of resolving the problem by providing electricity through the national grid has proven to have limitations in terms of time and costs. Can there be innovations outside the existing market paradigm, allowing people to access energy more easily and quickly in a cost effective manner? This article proposes the development of a new model based on recent progress in fuel cell technology to achieve that goal.

The central idea behind our proposed model is to shift the current focus from production to distribution. This calls for exploring the potential in what is now often known as the 'missing link' in the electricity value chain, i.e., energy storage. Whereas most of the development in the area of energy storage in the West was driven by the need to address issues of energy security or greater efficiency of the system, its applicability in bringing electricity to the poor, as an alternative to relying on the national grid, has been overlooked. We believe that existing technologies can make this a feasible option. What is required is re-engineering of existing products and inventions to serve customers in the developing world as a controllable demand side management option at the retail level.

The realization that energy storage at its heart is an economic decision is gradually gaining ground even in the context of developed economies. The White Paper published by Energy Storage Council states[1] *"without storage an industry must develop and maintain an entire delivery network capable of meeting the highest peak of the year at any given moment. Without storage, the industry must operate within a 'just-in-time' framework that is dependent on variable end-use demand. By supplying power when and where needed, energy storage will create a far more responsive market. It will:*

- *Reduce the need for additional transmission assets.*
- *Be the preferred supplier of ancillary services.*
- *Provide better integration of renewables into the system.*
- *Support more efficient use of existing assets.*
- *Improve reliability of electricity supply.*
- *Increase efficiency of existing power plants and transmission facilities.*
- *Reduce the investment required for new facilities.*

[1] Energy Storage: The Missing Link in the Electricity Value Chain – An ESC White Paper published by the Energy Storage Council, U.S.A.

It is difficult to not to see how relevant and appropriate all of the above is in the context of developing economies also, where the national grid based distribution system is yet to extend its reach in bringing electricity to the general population.

Take for example the case of Bangladesh. Only around 20% of the population of 120 million (25% in urban areas and 10% in rural areas) has access to electricity, and per capita energy consumption is among the lowest in the world. Non-commercial energy sources such as wood, animal wastes, and crop residues, are estimated to account for over half the country's energy consumption. Consumption of wood for fuel has contributed to deforestation and other environmental problems in Bangladesh.[2] The World Bank has estimated that Bangladesh loses around $1 billion per year in economic output due to power outages and unreliable energy supplies; And all this in the 21st century.

The existing energy paradigm has proved to be painstakingly slow in providing electricity to the people. Bangladesh's installed electric generating capacity is 4.6 gigawatts (GW) of which only two-thirds is considered to be 'available' at any given time. In the last twenty years access to electricity has increased less than 10%. Problems in the Bangladeshi power sector include high system losses (up to 40%), delays in completion of new plants, low plant efficiencies, natural gas availability problems, erratic power supply, electric theft, and blackouts, shortages of funds for needed maintenance at the country's power plants and other power infrastructure, and unwillingness of customers to pay bills (public sector organizations being the biggest defaulters). Overall, the country's generation plants have been chronically unable to meet system demand over the past decade. Bangladesh's Power System Master Plan (PSMP) projects a required doubling of electric generating capacity by 2010, although it is a known fact that 30-40% of the current generating capacity needs replacement due to aging infrastructure.

The issues involved here are two fold. Traditionally, providing electricity has been looked at as an infrastructure development issue with very little or no involvement of the individual at a micro level. Strong interest groups propagate this view. a) governments can use large infrastructure development schemes to get more international aid, b) private lobby groups benefit by being able to sell large power projects to the government as local agents of foreign companies, c) industrialized nations and their companies gain by selling large infrastructure projects to developing economies against foreign aid.

The other issue is of technology or the perception of it. The current fuel cell technology with the potential of challenging the existing energy paradigm is cutting edge and new even for developed economies. Commercial use of fuel cells has only recently come out of the realm of US Space Programme and DoD (Department of Defence). There still exists a general perception that advanced technology is inappropriate for underdeveloped economies. In reality the opposite may often be true. Breakthroughs in technology may offer the only real chance for these struggling economies to leapfrog the sequential stages of development. Also, these economies offer the ideal ground for implementing new technology free from being trapped by the predominance of an older one.

[2] Bangladesh: Country Profile, US Department of Energy

Concerted effort can help develop a business model based on breakthroughs in existing fuel cell technology to support an energy distribution system alternative to the national grid. This can be based on the development of the first prototype 'refilling station', in a small scale, to be replicated subsequently in different remote parts of the country. These refilling stations will be run by individual entrepreneurs on a franchising scheme that will use solid state fuel cells of a particular type as 'electricity carrier' which will be 'loaned' out to rural consumers. Consumers will pay not for the cost of the fuel cell itself, but for the cost of refilling, transfer and operation/management of refilling stations. On depletion of fuel in the cell (e.g., hydrogen, in the case of hydrogen fuel cells), the consumer will exchange it for a refilled one paying for the refilling cost. Using electricity to 'refuel' these cells to 'produce' electricity will, in effect, serve the function of energy storage. Cost of conversion will form part of the cost of storage. This cost can be referred to as the 'transfer cost'. Apparently, this cost may not compare favourably with the current cost of energy as it is traditionally measured. $/kw/hr assumes the accepted paradigm of continuous flow of energy. The new model will be based on use of power *as and when needed*. A proper comparison must take into account various factors, such as the opportunity cost of extending the grid based system to the hitherto unattended customer, savings to the consumer for use *as and when needed*, gains in accelerating progress (*opportunity now* against *opportunity deferred*), gains in engaging latent capital of private initiative, etc.

The diagram below goes towards illustrating the areas research is required to justify using electricity for the refuelling of energy cells in the proposed refilling station:

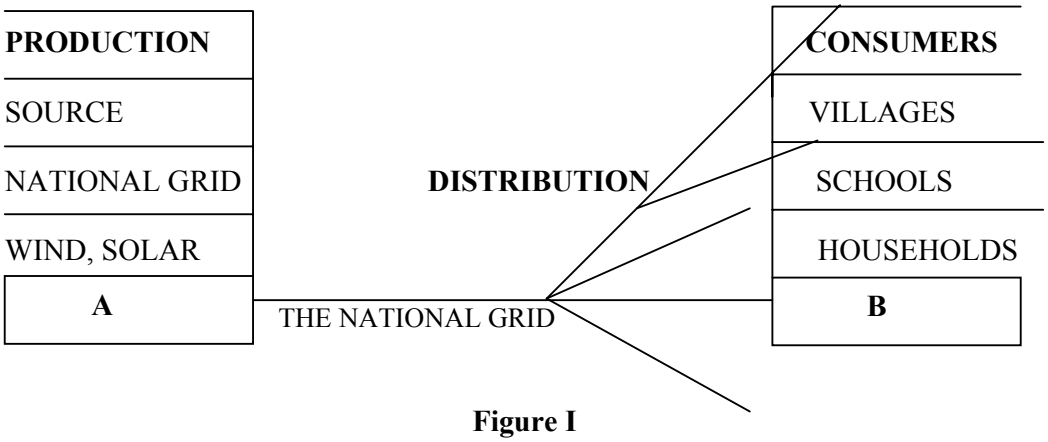

Figure I

Consider the cost of distribution from **A: Source of Production** to **B: End Use Consumers** by extension of the national grid. Some of this cost is direct, such as the cost of setting up of transmission lines and complex grid infrastructure of a fixed scale and load, even if there are only a few end use customers in some areas with low load demand. The cost is largely subsidized as a public undertaking. Our proposed model will justify substituting the *extension* of such a stationary structure by installing instead a *process*. The process will involve private enterprise. These are the refilling stations that will use as their source of energy either the end points of the

existing grid system or independent production sources such as solar or wind. This would be a new way of looking at the already installed national grid as a distribution *source* rather than as a distribution channel. Refilling stations can skim off excess load capacity from the system, which is not infrequent in the rural extensions (most often the end points) of the grid. Greater efficiency can be achieved by the refilling stations setting up their own independent source of renewable energy, such as solar or wind, as and when costs permit.

Hydrogen fuel cell yield is calculated to be approximately 1.75 kwh per litre of hydrogen which would cost 25 cents at current kwh prices. By adding on top of it other costs such as overhead, operating cost, depreciated cost of a single fuel cell plus profit would yield a price per kwh far higher than the current price of electricity, but would have to be less than the cost of energy derived from alternate energy materials currently used, such as diesel or gasoline.

The work towards creating the new energy paradigm can be summarized as follows:

1. **Distribution re-engineering:**

   - Developing the prototype model of an 'refilling/energy station' that can be run commercially where grid penetration has not taken place.

   - Investigating current fuel cell technology that would allow breaking continuous flow of energy into 'energy parcels' and developing storage solutions in terms of cost effective 'batteries'.

   - Factoring the national grid as an energy source alongside other production sources (e.g., renewable sources such as solar or wind) for the 'energy stations' to harness, store and distribute 'energy parcels' to remote consumers.

2. **Design innovations:**

   - Designing a 'refilling' system for the 'energy stations' for exchanging the exhausted fuel cells for recharged ones on payment of 'refilling' cost.

   - Re-designing the new generation of solid-state fuel cells in the form of cost effective 'batteries' cased in rugged insulation.

   - Designing standardization of a modular system for the manufacture, distribution and use of these fuel cells.

3. **Business modelling:**

   - Devising a business model based on existing technology.

- Securing involvement of social entrepreneurs to play pivotal role in running and managing 'energy stations' as viable commercial entities.

- Patenting and licensing the design concept by the primary company.

- Developing a franchising operation to pay for the development costs.

Mahakash Limited has taken up the initiative of setting up a research team in place, as the primary company who would work towards achieving this goal. The team would have ownership of the IP rights over the design of the prototype refilling station and the business model, which is to be licensed out on a franchising scheme. Collaboration with universities and research institutions are welcomed. Mahakash actively seeks funding for the initial research in exchange of commercial stake in the research output.

We feel the biggest bottleneck in wide scale use of fuel cell today eventually boils down to numbers, i.e., the industry's inability to reap the benefits of the economies of scale that can come from mass production. As with many new technologies, the industry is yet to emerge out of a classic cycle of **limited market—placing limits on mass production—resulting in high costs—restricting marketability.** It is only by shifting the current focus from production to distribution, and in seeking potentially new markets, that the industry can break out of this cycle. As in the case of production technology, it is innovation in distribution that can make this a reality.

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THE DIRECTORS

Farhad Mahmud (CEO)

In 1998 Farhad Mahmud set up the first terrestrial television station in the private sector in Bangladesh, known as Ekushey Television. In a country of 120 million with literacy rate is as low as 60%, Ekushey became the primary source of information for the people. With the technical collaboration of BBC Worldwide, Farhad grew the company from the drawing board stage to a 300 plus employee organization. With a turnover of $12 million per year growing at the rate of 30% per annum, Ekushey Television became a showcase of successful social entrepreneurship.

Mike Lovell (Director)

Mike Lovell worked as the Head of Business of the nuclear power plant, BNFL, between 1999 and 2000 and was in charge of Business Development from 1994 and 1999. He led a team of 70 staff involved in financial stewardship, strategic and operational business planning, major scheme management and IT. Prior to working in the nuclear energy sector, Mike Lovell worked for several years in senior engineering positions in the Electricity Supply Industry holding various appointments within oil and coal fired power plants with responsibility for managing its economic operation.

Raj Malhan (Director)

Raj Malhan co-founded Amber-Jade Investments, a day-trading investment company based in New York specialising in the trading of Technology stocks. The company managed funds for clients aggressive in their expectations of the returns to be made in technology shares. After the tech-bubble imploded in 2000, Rajesh decided to pursue a more 'meaningful' career where he could contribute the many years of business skills and experience that he has accumulated back into the community.

Nadia McMahon (Director)

Following a series of successful small business initiatives which included a selection and recruitment service, Nadia drew upon her experience and expertise to launch a consultancy service with the objective of developing and encouraging entrepreneurial skills in SMEs. In this role, Nadia has successfully supported the origination, formation and development of several small businesses in London and the South East, as well as providing business skill training across a wide range of disciplines.