Energy for Rural Poor – Challenge for Global Community

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Good evening Ladies and Gentlemen,

I am delighted and honored to be here to give a talk in the Globalization series at the prestigious Patel Center.

My talk will be divided into three parts. The first part will be to sensitize you to the plight of rural poor and in the second part we will discuss the technologies that might help in alleviating their poverty. The last part of my talk will focus on how global community can participate in lighting up the lives of rural poor.

Since I live and work in rural India my talk will be focused on India. However the methodology developed can be used in any part of the developing world.

Introduction

Just to give you some idea regarding the plight of rural poor in India consider the following:

1) 60% of the rural population or almost 400 million people live in very primitive conditions[1]. They have no electricity and their lives are in darkness. They use inefficient kerosene lanterns for light and primitive and ancient biomass cook stoves for cooking. Modern technology somehow has not touched their lives. Besides, the poor quality of these devices creates tremendous household pollution. Thus there are estimates that around 300,000 deaths every year are attributable to inhaling smoke from these inefficient and primitive stoves [2].
2) Around 54% of India's population is below 25 years of age and most of them live in rural areas and are unemployed. Creation of rural based enterprises is the best way

to create wealth, improve their quality of life and bring these people into mainstream of development. Our national leaders are talking about making India the third biggest economy by the year 2012. Unless the lives of this population is improved this will not be possible. The so-called “India poised” slogan which the western and Indian English media harp on is not reflected in the lives of the rural population.

3) There is tremendous poverty in rural areas. According to World Bank estimates around 3 billion people live on less than 2 dollars per day [3]. In India alone there are around 260 million people or 1/4th of the population who live on one dollar per day or less [4]. Except for barely filling their stomach this much money allows them neither the acquisition of material goods like utensils and clothes nor to get any quality products like light or decent cooking fuel. These low wages also prompt rural poor to have a large family so that each member can earn one dollar per day and increase the daily family income.

4) Because of poverty there are continuous suicides of farmers. In the last 10 years about 100,000 farmers have committed suicide [5]. This is according to the government figures. I am sure the actual figures are much higher. Farming is presently non-remunerative. This is partly because of the policy of low support price for farm produce by the Government of India which is the biggest buyer of agricultural commodities. Secondly, increased aspirations of farmers to improve their quality of life has made them get into a never ending debt of loan sharks. Thus no amount of soft financial packages will prevent the farmers’ suicides or help the marginal farmers. These are all short-term solutions. There is an old Chinese saying “You can feed a person for a short time by supplying him fish, but if you teach him how to catch fish he will feed himself the rest of his life”. Thus there is a need to create a long term agricultural policy which brings in wealth to the countryside without much government support. This will automatically improve the farmers’ lot.

5) There is a serious energy crisis in rural India. In various states there is a tremendous shortage of electricity. For example, per capita consumption of electricity in rural areas is only 250 kWh/yr or about 2% that in U.S.[6] As we all know without electricity very little development can take place and this is reflected in these areas. In my state of Maharashtra which is one of the most industrialized states of India, about 5000 MW peak shortfall exists[7]. Blackouts and brownouts is a regular feature of daily life. In rural Maharashtra where I live, around 12-15 hours of daily blackout takes place. This has created havoc in the lives of people. Besides it has spawned a whole industry of small and inefficient fossil-powered electric gensets of 1-10 KVA capacity which produce huge pollution in rural areas.
6) Last year India imported about 45 billion dollars worth of petroleum products. With ever increasing price of crude this number will increase in coming years and will put a heavy burden on balance of payment account [8]. Besides the uncertainty of supply from various countries can play havoc with the energy security of India.

I feel most of these problems have come because of non-governance. In a corrupt society which unfortunately India is, the first casualty is governance and we are seeing the effects. Part of this non-governance has been a very poor energy planning which has resulted in unavailability of adequate energy in rural areas.

Energy is the basis of life. All other activities flow from it. Therefore availability of affordable energy in rural areas is the only way to improve the quality of life of its inhabitants.

I believe that one of the best solutions to the above problems is energy production via agriculture and the development of high technology devices to provide the basic needs of cooking, lighting and clean water to rural areas. Energy production via agriculture can produce rural wealth by providing energy, creating employment, increasing wages and providing services to improve people's quality of life. In the development of a viable energy technology and in producing devices, the role of global technological community becomes important and I will discuss in detail what they can do.

Production of Energy

Three types of fuels can be produced easily via agriculture. Liquid fuels such as ethanol, pyrolysis oil, or biodiesel; gaseous fuels like methane; and production of electricity. Though the basic technology for their production exists, much more R&D is needed for increasing their efficiency and making them affordable. This is the challenge for global technological community.

Ethanol fuel can easily be produced from agricultural crops like sweet sorghum, sugarbeet, sugarcane, corn etc., However to produce it in an affordable and environmentally sound manner will require tremendous inputs of biotechnology and good engineering. Thus research is being done in US and all over the world in converting agricultural residues into ethanol via the enzymatic hydrolysis process.

Similarly biodiesel can be produced from a horde of oil producing crops like Jatropha, Soybean, Pongamia, Castor etc. Though the production of biodiesel is quite easy, there is a need to increase the yield of oil bearing plants and to develop internal combustion engines which can run on a whole bouquet of the biodiesel. Presently the high speed diesel engines require tailored biodiesel.

The pyrolysis oil on the other hand is produced by rapid combustion of biomass and then condensing rapidly the ensuing vapors or smoke to yield oil which is nearly equivalent to diesel. Pyrolysis oil still requires much more R&D in terms of producing it economically, improving its keeping quality and making it suitable for use in existing internal combustion engines. Nevertheless recent experiments in Sweden on running a 5 MW diesel power plant on pyrolysis oil have been successful [9].

In any agriculture only 25-40% of the produce is food. Rest 60-75% forms the agricultural residues. It is these residues which can produce electricity via biomass-based power plants or pyrolysis oil or ethanol fuel. Any marginal farm can produce agricultural residues even if the main food crop fails. Our calculations show that on an average a farmer in India can get an extra income of $ 200-300/acre per year from the residues alone if they are used for producing energy [10]. This income can give him benefits even in case of a distress sale of his crop. Farmer is a multipurpose industrialist producing a variety of outputs from the same piece of land. We do not know of any other industry which can exist or can survive selling only 25-40% of its produce with the rest being wasted. So why the farming should be treated differently. Thus unless and until the farmer gets remuneration for his entire produce, farming will never become economically viable.

About 600 million tons of agricultural residues are produced annually in India [11]. Most of these residues are burnt in the fields as a solution to the waste disposal problem. This not only wastes the precious biomass resource but also produces tremendous air pollution.

Theoretically these residues can produce about 80,000 MW of electric power year round through biomass based power plants. This power is nearly 50% of total installed capacity of India. Alternatively they can produce 156 billion liters of ethanol which can take care of 42% of India's oil demand for year 2012. Similarly the residues can also produce about 400 billion kg of pyrolysis oil which is equivalent to 80% of total Indian oil demand for 2012. Thus the agricultural residues if properly utilized can take care of a huge chunk of India's energy needs.

A part of these agricultural residues can also be used via the bio-digester route to produce fertilizer for the crops and methane gas to either run rural transport, irrigation pump sets or for cooking purposes. Another stream can also be used for producing fodder for animals. Thus the residues can produce fuel, fodder and fertilizer. Which stream of residue conversion technology is eventually followed will depend upon the existing market forces.

The production of electricity in India via residues or the use of wood from fast growing tree species will require an investment of about 35 billion dollars [12]. However it will bring about 10 times more money to rural areas in terms of revenues from electricity generation. Besides it can potentially create almost 120 million extra jobs in these areas [12].

As the industrial demand for fuels and electricity increases, we might see large tracts of farmland coming under fuel crops and food production may suffer. People who have cars have money and when they give good money for the homegrown fuel the farmers will put majority of their land under fuel crops. This is already happening in India and will happen in almost any country including U.S. Thus there is a need to seriously debate the food vs. fuel issues.

Consequently R&D needs to be done on crops which produce both fuel and food from the same piece of land. Sweet sorghum is one such crop. Our Institute NARI has pioneered the development of this crop in India [13]. We introduced it in the country in early 1970s. Sweet sorghum produces food (grain) from its earhead, fuel from its stem (the sweet juice can be fermented to produce ethanol) and bagasse and leaves make an excellent fodder for animals. Alternatively they can also be used as fuel in power plants. Sweet sorghum is a thrifty crop and produces maximum sugar per unit of water of any crop known to man. Presently our hybrid MADHURA produces 2000 – 3000 l/ha of ethanol per year. It is presently planted in large areas of India and has been exported to various countries including US.

Similarly if the agricultural residues can be broken down by suitable enzymes to produce ethanol then both food and fuel can be produced from all food crops. Extensive research in this field is being done by universities and industry world over and this technology will be very useful for rural areas of the world [14].

I strongly feel that when the farmers are forgotten the long term sustainability of the country is threatened. When farms produce both food and fuel then their utility becomes manifold. Now with the ethanol and biodiesel programs taking shape in U.S., I feel it will again become a land of farmers. In India 65% of its population depends upon farming and with energy from agriculture as a major focus India has the potential of becoming a high tech farming community.

Water Issues

However for farming to increase so that it can take the load of food and energy production, adequate water supply has to be assured. To my mind supply of adequate water to poor regions of the world is a much bigger challenge then even energy availability and where the global technological community can play an important role. Not only is there a water shortage but lack of clean potable water results in millions of deaths every year due to diarrhea.

With green revolution in India there has been an extensive use of water resulting in shortage in some parts of the country. This is despite the fact that there is enough rainfall. Every year India receives ~ 4000 billion cubic meter of rainfall whereas the present yearly water consumption is only 650 billion cubic meter or 16% of total rainfall. Thus theoretically we have enough water, but the rainfall is not evenly distributed over India and it comes in short spells thereby pointing to the need for rainwater harvesting and storage programs.

However the issues of rainwater harvesting and its supply to the community in rural areas raise a question of who will own the water bodies. This is a touchy issue and quite a few developing countries are grappling with it. I feel there is a need for the local governments to develop policies so that rural water utilities can be set up which can harvest the rain, store it and then supply this water to a village throughout the year. These water utilities may also be able to buy water from the government through the existing canal system. Presently all the water utilities in India are owned by the government and this leads to corruption in supply of water and its very inefficient usage. In 2003 Government of India passed an electricity act allowing for the first time the private players to produce, sell and distribute electricity anywhere in the country. This act has allowed power producers to break free from the clutches of inefficient and corrupt government power utilities. I feel a similar water act will help in supply of water to rural areas.

Two most important issues for rural development are supply of clean water and electricity. NARI has developed a strategy whereby it is shown that a microutility producing 500 kW power for rural areas can easily use the heat of the flue gases of the engine to boil or distil water to make it potable[15]. The 500 kW power plant is sufficient for a village of 2000-3000 people. The combined cycle of electricity and water production will increase the efficiency of the power plant to almost 65-70% from the existing low of 35%. Nevertheless R&D is needed in improving the distillation process and developing a compact water treatment plant so that the potable water can be delivered at affordable price.

Development of Efficient Energy Devices

Rural population has the same aspirations as you and I have. With increased exposure to mass media their desire to improve their lot has also increased. Thus technology intervention is required in using local resources to provide products and services to these people. Filtering down approach of urban goods to rural areas will not work in the long run because of lack of infrastructure, resources and different local situations.

This is a technological age. Whatever we do is governed by technology and thus technology plays an extremely important role in our lives.

Most of the technological efforts in the past for providing basic facilities to rural areas have been based on a “tinkering” approach, meaning a small adjustment here and there, and using “low” or appropriate technology. This approach, which has been used by various agencies, normally resulted in incremental changes like development of improved chulhas (cook stoves) or better bullock carts. Tinkering, however, has barely made a dent in the quality of life of poor people. And often, the introductions of these technologies brought other problems such as increased workloads for women.

I therefore believe that sophisticated – or “high” – technology is needed to convert efficiently the locally available resources and materials into useful products. This is the hallmark of evolution where natural systems evolve into very efficient materials and energy converters. In this process, size reduction and increased complexity of system takes place[15]. Some of our designs and technologies are following the size reduction route. For example, computer chips, cell phones, power plants, etc. have reduced in size, increased in complexity and become more efficient. Technology developers should follow this strategy in developing rural technologies. In fact, much more sophisticated thought and “high” technology is required for solving rural problems since the materials and energy resources available are limited and often in "dilute forms". Thus the strategy of high technology allows maximum energy and materials to be extracted for useful end products.

I will now show you few examples where high technology intervention can provide a quantum jump in the quality of life of rural population. These examples are for lighting and cooking since they constitute 75% of total energy used in rural households.

Strategy for lighting

The history of civilization is the history of lighting. Lighting allowed mankind to extend daylight hours and hence increase productivity and commerce. It is a sad state of affairs in India that nearly 60 years after independence around 60% of the rural population are without electricity. They use a simple but very inefficient hurricane kerosene lantern for lighting. Similar is the story of rural poor in other parts of the world. For example in some parts of Africa around 80% of rural population has no electricity.

Our Institute NARI has therefore developed a very efficient lantern called Noorie [16]. This lantern produces about 1350 lumens (lm) of light which is equivalent to that from a 100 W electric bulb and runs either on kerosene, diesel or with slight modification on low concentration ethanol. It is reasonably priced at US$ 10, is very light weight, efficient and also doubles up as a cooking device.

However in developing the lantern we became aware that the stumbling block in improving its efficiency was the thermoluminescent (T/L) mantle which is what produces light. Presently these T/L mantles have an efficacy of 2-3 lm/W. In comparison a 100 W light bulb has an efficacy of 10-13 lm/W and a compact fluorescent lamp (CFL) ~ 50-70 lm/W. If by R&D we can match the mantle efficacy with that of a light bulb then the liquid fuel lighting can become better than the electricity-based lighting. How can this happen?

Consider the power plant-to-light efficiency (PPL) or the amount of energy that you finally get in your household socket. The PPL of CFL is only 10-14 lm/W or nearly that of light bulb. This is so since 70% of the energy from the thermal power plant is lost as heat and further 30-33% energy loss takes place in transmission and distribution (T&D). The T&D losses in developing countries are high because of electricity theft. Thus only 20% of total fuel energy is available as electricity in the household socket. Research in producing better T/L mantles therefore can provide very efficient decentralized liquid fuel lighting.

These T/L mantles have not changed since early 1860s when Welshbach in Germany made them out of radioactive Thoria/Ceria mixture. Many people have tried to improve them but have not succeeded. We still do not understand how the light is produced from this mixture. For example the 1500-2000^{0}C flame produces light as if it is coming from a 3600^{0}C black body. I feel that the emerging field of nanoscience can help in developing materials, which can glow efficiently even at low temperatures of 1000-1500^{0}C. Besides R&D is necessary in making these mantles out of sturdier materials like carbon composites, ceramic-based thermoluminescent materials etc. Presently these mantles are very fragile and break easily.

Ultimately for decentralized light based on chemical fuels we should try to copy the bioluminescence mechanism of a firefly where visible light is produced very efficiently and at room temperatures. Similarly it is possible that mankind one day will develop a strategy where sunlight will photo catalyze two liquids which when mixed together will produce brilliant light. The time is now to work on this strategy and that is the challenge for global community. With grid electricity still a distant dream for a major portion of rural areas, efficient liquid fuel lighting needs to be encouraged.

Simultaneously we have to continue exploring decentralized, electricity-based lighting, since 100 years of R&D has gone in perfecting it.

We at NARI pioneered the strategy of biomass based power plants for providing energy self-sufficiency at taluka level [12]. Taluka is an administrative block in India consisting of a town and about 100 contiguous villages and is equivalent to a county in U.S both in terms of land area and population. The taluka strategy was based on producing power from agricultural residues and wood from fast growing trees. Thus the biomass available in a taluka could easily support two 15 MW biomass based power plants. This strategy became a national policy and was implemented by the Government of India from 1996 till 2002. Consequently 40-50 biomass-based plants of 6-10 MW capacity each were set up in different talukas, but the whole program had a mixed success. This was because the Electricity Act of 2003 had not come into being. With the advent of this act there are indications that there will be an explosive growth of such biomass power plants all over the country.

In the range of 10-500 kW power, R&D is needed in biomass gasifier-based plants, steam engines, sterling engines or biogas-based gas turbines. There is a whole array of technologies to be developed so that power is generated from renewable fuels, which are biomass-based, environment-friendly and produced locally. This is the challenge for global community.

On micro scale in the range of 10-20 W there are exciting possibilities for lighting. For example there are tantalizing indications that new class of materials are being researched which can produce 3 electrons per photon thereby providing a quantum jump in the efficiency of solar cells [17]. These type of solar cells together with ultra capacitor batteries (instead of regular lead-acid batteries) can revolutionize rural lighting.

Similarly there has been a quantum jump in the efficiency of thermoelectric elements – a device which converts heat directly into electricity [18]. These elements can be incorporated into any biomass cook stoves and about 40-50 W of power can be produced. This power is enough to run a small fan so that the combustion efficiency of the cook stove is nearly doubled and part of the power can be stored in ultra capacitors for lighting. We recommended such a strategy about 4 years back and are delighted to inform you that Philips last year has produced such a stove.

Work is also going on in US in producing 10-20 W micro engines [19]. These engines can run on ethanol or methanol and hence can eliminate the need for heavy storage batteries since the energy is stored in the fuel. Thus an extremely efficient, compact and light weight decentralized lighting system can be thought of which consists of a micro engine powering a light emitting diode (LED) or CFL lamps.

Cooking energy strategy

Only liquid and gaseous fuels produced renewably can provide clean cooking energy. Two fuels fall into this category. Liquid fuels like ethanol or biodiesel and gaseous fuel like biogas.

Ethanol is an excellent fuel for cooking. At NARI we have developed a stove which runs on 50% ethanol-water mixture [20]. This mixture is very safe and can be easily distilled in a backyard still with much less energy than that required to distil high concentration of ethanol. The stove has a maximum thermal capacity of 2.5-3 kW and has a flame control for simmer and high settings so that it works just like an LPG stove. Large scale testing in the field has been very positive and almost all the rural women who have tried it compare it very favorably with an LPG stove. However in order that ethanol can be used as a rural household fuel, the presently tough excise laws have to be modified. Our Noorie lantern also works on 50% ethanol-water mixture. Thus we have developed high tech, environmentally sound cooking and lighting systems which can run on homegrown fuel.

Biodiesel is another fuel which can be grown locally. Various governments all over the world are embarking on a major program of using biodiesel for running automobiles. However R&D is required in improving its yield per ha and also its use in cooking stoves. Presently there are no reliable cooking and lighting devices which can run on biodiesel.

A clean gaseous fuel that can be produced from the existing biomass sources is biogas. Biogas has been used extensively in rural areas of India. However it is produced very inefficiently in fixed and floating dome systems as shown in the slide and requires considerable amount of cowdung and other nitrogenous material. It is not suitable for a household with less than 3-4 cattle. Besides there are problems of gas production during winter and improper mixing of mixed inputs like biomass, night soil, cowdung, etc. The biogas which is a mixture of methane and carbon dioxide cannot be liquefied and requires very high pressure of more than 100 atmospheres to compress it so that it can be used over extended periods.

Thus R&D is necessary in two areas. One is in the development of extremely efficient biogas reactors so that the production per unit of biomass inputs could be maximized. The second area is to develop appropriate storage materials which could store biogas at medium pressures.

Research is also being done world over in methane storage and recently experiments have been conducted in storing it at medium pressures of less than 40 atmospheres in hydrates, porous carbon and porous organic structures [21]. There is thus a need to develop low cost storage materials so that biogas could be stored in them for usage in households. New materials developed through nanoscience and nanotechnology can be used for this purpose. Thus a scenario can be thought of where a micro-utility company in rural areas will buy locally available raw materials like cowdung, biomass, etc. and will use them in a very high tech biogas reactor to generate biogas efficiently. This gas can be stored in small cylinders lined with gas-absorbent materials and transported to households just like the present LPG cylinders. This will revolutionize the cooking system in rural India and other parts of the world.

Optimization of biogas production from a reactor requires sophisticated electronics based controls and biochemical engineering technology. A small utility can afford to do it whereas for a household it might be too costly. Tinkering around with existing biogas reactors will not solve the problem. A very sophisticated science and technology input has to be brought to bear on the problem for optimizing the biogas production in rural areas.

The use of high technology in lighting and cooking energy can result in considerable economic development in rural areas. Our estimates show that this energy industry both for fuel and device production can be of the order of 10 billion dollars per year in India alone [21]. Since the fuel production will be rural-based, it can bring in substantial wealth to these areas both in terms of biomass production and also in processing it to produce the fuel.

I hope these examples have given you a feel for the need of using very sophisticated technology for solving the rural problems.

Now I will come to the last part of my talk namely how the global community can participate in the development outlined above ?

Role of Global Community

There are two ways in which the global community can help in improving the lives of rural poor round the world. One is by providing liberally the technologies, knowledge, intellectual property, funds etc, on extremely soft terms and secondly by putting their own house in order. I will discuss these in details below.

In recent years many rural development experts especially C. K. Prahalad of University of Michigan has talked about the bottom of pyramid approach to development [22]. They contend that helping the rural poor makes good business sense and the example of Mohammad Yunus who last year won the Noble Peace Prize for his micro credit work in Bangladesh attests to that. What Prahalad says makes sense since we saw that the energy industry for rural areas in India could be of the order of 10-20 billion dollars per year and that empowering the rural poor to produce energy through agriculture could improve their lot. However, I feel that we should look beyond the issues of business and getting financial gains from rural poor.

In this era of globalization the whole world is one global village where the actions of one part directly affect those of others. Thus global warming, environmental pollution and the migration of large number of people from one country to another for better opportunities are all a result of globalization process.

One of the impacts of globalization has been the rise of international terrorism. In fact poverty breeds terrorism which ultimately affects all of us. It is therefore in the interest of North to help the South so that wealth is created in its rural areas and poverty removed. This can happen when North, which has the resources to produce new ideas, technologies and financial instruments, uses them for providing services to rural areas as outlined above. In this process the U.S. universities, corporations and businesses will need to work with developing country NGOs and businesses in a meaningful and cooperative relationship. I also feel that the governments of both North and South should have a minimal role in such ventures.

The second way in which the global community especially those in the North can help the world is by reducing their consumptive life style. North especially US is the role model of the world. The citizens of the world try to copy the U.S. life style, even though it is totally unsustainable. For example if every citizen of this earth follows it then we will need the resources of 4 earths to sustain it [23]. Some recent reports have shown that last year there were 1 billion obese people (mostly in developed world) as against 600 million malnourished ones in developing world [24]. For global sustainability this consumptive life style has to change. In this age of instantaneous communication whatever happens in New York, London or Paris is immediately copied by the elite of developing world. Hence if North shows the way towards sustainability then it will have a great impact on the rest of the world.

Every citizen of this earth aspires to a decent life style. I believe such a life style is possible in much less energy than is consumed by an average U.S. citizen. For example in U.S. the per capita energy consumption is 350 GJ/yr whereas in India it is a low of 10 GJ/yr [25]. I feel energy consumption of 50-70 GJ/person/yr or 1/5th that of US can provide a very decent and emotionally satisfying life style [26]. This type of energy consumption will put much less pressure on earth's resources besides reducing substantially the environmental pollution. However it can only happen if we follow the maxim of "simple living and high thinking". This is the genesis of spirituality which helps us become internally secure and less greedy for materials and resources [27].

To my mind the highest spiritual work for mankind is to help poor people improve their quality of life. As engineers and scientists we can do it by providing right-sized technologies at the right "price" to the poor. It is a doable goal. What is needed is the direction and will of leaders in both North and South to make the life of poor people better.

Once our basic needs are satisfied, all of us long for some meaningful existence. Even very rich are looking for some meaningful actions and purpose in their life. Happiness cannot be obtained by money alone. It only comes when there is some meaning to the life.

That meaning, I feel comes from helping other less fortunate people and by giving back something to the society. I believe that the whole purpose of our existence is to increase personal and societal infrastructure. Personal infrastructure includes our health, happiness and general well being. By improving our personal "infrastructure" we become better human beings and it helps in our emotional growth and evolution. By giving back to the society so that its "infrastructure" increases we help in mankind's evolution. Both these activities when carried out simultaneously can give us a great joy and satisfaction.

Finally I would like to point out that rural population of the world has a great strength of being satisfied with fewer material comforts. Partially this is because they never had many material goods in the first place and partly because they have not been corrupted by the so called notions of "good life". Thus I believe that the provision of high technology for meeting the basic needs of rural poor together with their spiritual strength may provide a new model of sustainable development and in the process may teach North a lesson or two in sustainability.

I will end my talk by telling you an Indian story, a tale from our ancient scriptures, the Puranas [28]. It is a typical Indian story of a sage and his disciples. The sage asks his disciples, "When does the night end?" And the disciples say, "at dawn, of course." The sage says, "I know that. But when does the night end and the dawn begin?" The first disciple, who is from the tropical south of India which is similar to South Florida replies: "When the first glimmer of light across the sky reveals the fronds on the coconut trees swaying in the breeze, that is when the night ends and the dawn begins". The sage says "no," so the second disciple, who is from the cold north, ventures: "When the first streaks of sunshine make the snow gleam white on the mountaintops of the Himalayas, that is when the night ends and the dawn begins." The sage says, "no, my sons. When two travelers from opposite ends of our land meet and embrace each other as brothers, and when they realize they sleep under the same sky, see the same stars and dream the same dreams - that is when the night ends and the dawn begins." I feel that when the citizens from North light up the lives of residents of South through technology and resources then it will bring in the dawn of a new age for the civilization and promote global harmony.

Thank you very much.

References

1. Rural Energy – India country gateway; www.incg.org.in/countryGateway/RuralEnergy/Overview/Ruralenergy.in/ India.htm

2. ITDG. Smoke – the killer in kitchen; www.itdg.org/html/smoke/smoke_ report _ 1.htm.

3. World Bank. Overview of World Poverty. www.worldbank.org/poverty.

4. IFAD. Rural Poverty in India, 2007. www.ruralpovertyportal.org/english/ regions/asia/ind/index.htm.

5. S. Narain. Why do farmers have to die? *Down to Earth*, Center for Science and Environment, New Delhi. June 15, 2006.

6. Planning Commission. Draft Report of the Expert Committee on Integrated Energy Policy. Govt. of India. December 2005. pg. 1.

7. No power cuts for now but user curbs on. *News item in Indian Express*. April 5, 2007.

8. India's oil import bill shoots to $ 44.64 bn. http://US.rediff.com/money/2006/may/10 oil.htm? q=bp&file.htm.

9. Solantausta, Y. *et. al*., Use of pyrolysis oil in test diesel engine to study the feasibility of diesel power plant. *Biomass Bioenergy*, 1994, 7, 297-306.

10. Rajvanshi, A. K. Agriculture Policy for Energy Security. http://nariphaltan.virtualave. net/agri.htm.

11. K. S. Jagdish. Bioenergy for India: Prospects, problems and tasks. *Energy for Sustainable Development*. 2003, Vol. VII No. 1. pp. 28-34.

12. Rajvanshi, A. K., Talukas can provide critical mass for India's sustainable development. *Curr. Sci.,* 2002, **82**, 632-637.

13. Rajvanshi, A. K. *et. al.*, Sweet Sorghum R&D at NARI. http://nariphaltan.virtualave. net/sorghum.htm.

14. Commercial-scale wood-based ethanol production begins in Japan. www.japanfs.org/db/ 1674-e. 28 March 2007.

15. Rajvanshi, A. K., Strategy for Rural Electrification. *REPSOVISION*, Vol. 33, January-March, 2006. Winrock International, New Delhi.

16. Rajvanshi, A. K. 1989. Development of Improved Lanterns for Rural Areas. http://nariphaltan.virtualave.net/lantern.htm.

17. Basic Research Needs for Solar Energy Utilization. Workshop Report, Office of Science, U. S. Dept. of Energy April 18-21, 2005. pg. 235. www. sc.doe.gov/bes/reports/files/SEU_rpt.pdf.

18. Rama Venkatasubramania, *et. al*., Thin film thermoelectric devices with high room temperature figures of merit. *Nature*, 2001, **413**, 597-602.

19. MIT news. Engine on a chip promises to best the battery. http://web.mit.edu/newsoffice/2006/microengines.html.

20. Rajvanshi, A. K., et*. al*. Low concentration ethanol stove for rural areas of India. *Energy for Sustainable Development.* 2007, Vol. XI No. 1. pg. 94-99.

21. Rajvanshi, A. K., R&D strategy for lighting and cooking energy for rural households. *Curr. Sci.*, 2003, Vol. 85, No. 4, 25 August 2003.

22. C. K. Prahalad and S. L. Hart. The Fortune at the Bottom of the Pyramid. www.changemakers.net/library/temp/fortunepyramid.cfm.

23. Edward O. Wilson, The Future of Life. Alfred A. Knopf, 2002.

24. CBS News (2006). Obesity an International Scourge. www.cbsnews.com/stories/2006/09/03/health/main1962961.shtml.

25. Planning Commission. Draft Report of the Expert Committee on Integrated Energy Policy. Govt. of India. December 2005. pg. 31.

26. V. Smil. Energy at the Cross Roads. MIT Press, 2003. pg. 352.

27. Rajvanshi, A. K., Spiritual Counsel for Rio plus ten. *Editorial article in Times of India*, 26 August 2002.

28. Shashi Tharoor, Ultimately what is India? www.rediff.com/republic/2000/apr/07shashi.htm.