Energy for the rural poor – Challenge for the global community†

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The dismal situation and poor quality of life in rural India is because of unavailability of energy. It is shown that sophisticated technology can help solve this and other problems of rural areas. A call is made to the global technological community to help provide such technologies. Finally issues of how much energy is needed for sustainable development are discussed.

Keywords: Energy, global community, rural poor.

THIS article related to globalization is divided into three parts. The first part reports the plight of the rural poor. In the second part we will discuss the technologies that might help in alleviating their poverty. The last part will focus on how the global community can participate in lighting up the lives of the rural poor, especially focused on those in India. However, the methodology developed can be used in any part of the developing world.

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

(1) About 60% of the rural population or almost 400 million people live in 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 the 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 are 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 the 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 one-fourth of the population who live on one dollar per day or less[4]. Except for barely filling their stomach, this meagre amount of money allows them neither the acquisition of material goods like utensils and clothes, nor any quality products like light or decent cooking fuel. These low wages also prompt the 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 by 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 have 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 for 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% of that in the US[6]. As we all know, without electricity very little

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development can take place and this is reflected in these areas. In Maharashtra, which is one of the most industrialized states of India, about 5000 MW peak shortfall exists[7]. Blackouts and brownouts are a regular feature of daily life. In rural Maharashtra where I live, around 12–15 h 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 the 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 it 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 the 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 the 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 biodiesels. Presently the high-speed diesel engines require tailored biodiesel.

Pyrolysis oil on the other hand, is produced by rapid combustion of biomass and then condensing rapidly the ensuing vapours 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. The 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 $50–100/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. The 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 should farming be treated differently? Thus unless and until the farmer gets remuneration for his entire produce, farming will never become economically viable.

About 600 million tonnes of agricultural residues is 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 the total installed capacity of India. Alternatively, they can produce 156 billion litres of ethanol, which can take care of 42% of India's oil demand for the year 2012. Similarly, the residues can also produce about 400 billion kilograms of pyrolysis oil, which is equivalent to 80% of the 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 ten 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 the US. 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 the 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 the world over and this technology will be very useful for rural areas of the world[14].

I strongly feel that when the farmers are neglected, 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 programmes taking shape in the US, 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 than 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 diarrhoea.

With the 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 metres of rainfall, whereas the present yearly water consumption is only 650 billion cubic metre or 16% of the 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 programmes.

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 rainwater, 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, the 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 the 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 potable water can be delivered at affordable price.

Development of efficient energy devices

The 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 the poor people. And often, the introduction of these technologies brought other problems such as increased workload 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 the system take place[15]. Some of our designs and technologies are following the size reduction route. For example, computer chips, cellphones, 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 are 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.

A few examples where high technology intervention can provide a quantum jump in the quality of life of the rural population are given below. These examples are for lighting and cooking, since they constitute 75% of the total energy used in the 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 is without electricity. They use a simple but very inefficient hurricane kerosene lantern for lighting. Similar is the story of the rural poor in other parts of the world. For example, in some parts of Africa, around 80% of rural population has no electricity.

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 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 the 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 the 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 the 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 light is produced from this mixture. For example, the 1500–2000°C flame produces light as if it is coming from a 3600°C blackbody. I feel that the emerging field of nanoscience can help in developing materials, which can glow efficiently even at low temperatures of 1000–1500°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 photocatalyse 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 the global community. With grid electricity still a distant dream for a major portion of the 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 to perfecting it.

NARI has pioneered the strategy of biomass-based power plants for providing energy self-sufficiency at the 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 the US, 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 programme 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 the global community.

On a micro scale, in the range of 10–20 W, there are exciting possibilities for lighting. For example, there are indications that a new class of materials is being researched, which can produce three 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 stove 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 four years back and Philips International last year has produced such a stove.

Work is also in progress in the 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 lamp.

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. NARI has 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 positive and almost all the rural women who have tried it, compare it favourably 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. The 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 programme 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 the rural areas of India. However, it is produced inefficiently in fixed and floating dome systems 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. Biogas, which is a mixture of methane and carbon dioxide, cannot be liquefied and requires 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 is to develop appropriate storage materials which could store biogas at medium pressures.

Research is in progress 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 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 sophisticated science and technology input has to be brought to bear on the problem for optimizing 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 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 fuel.

Role of the global community

There are two ways in which the global community can help in improving the lives of the rural poor around 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 detail below.

In recent years many rural development experts, especially C. K. Prahalad of University of Michigan have 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 Nobel 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 the rural poor.

In this era of globalization, the whole world is one global village where the actions of one part directly affect those of the others. Thus global warming, environmental pollution and migration of a large number of people from one country to another for better opportunities are all a result of the 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 the North to help the South, so that wealth is created in its rural areas and poverty removed. This can happen when the 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 US 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 the 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 lifestyle. The North, especially the US is the role model for the world. The citizens of the world try to copy the US lifestyle, even though it is totally unsustainable. For example, if every citizen of this earth follows it, then we will need the resources of four earths to sustain it[23]. Recent reports have shown that last year there were 1 billion obese people (mostly in the developed world) as against 600 million malnourished ones in the developing world[24]. For global sustainability this consumptive lifestyle has to change. In this age of instantaneous communication, whatever happens in New York, London or Paris is immediately copied by the elite of the developing world. Hence if the 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 lifestyle. I believe such a lifestyle is possible with much less energy than is consumed by an average US citizen. For example, in the US the per capita energy consumption is 350 GJ/yr, whereas in India it is a low[25] of 10 GJ/yr. I feel energy consumption of 50–70 GJ/person/yr or one-fifth that of the US can provide a decent and emotionally satisfying lifestyle[26]. This type of energy consumption will put much less pressure on the 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 the 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 the 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 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 great joy and satisfaction.

Finally, the 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 the North a lesson or two in sustainability.

I will end this article by telling you a 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 mountain-tops of the Himalayas, that is when the night ends and the dawn begins'. The sage says, 'No, my sons. When two travellers 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 the North light up the lives of residents of the South through technology and resources, then it will bring in the dawn of a new age for the civilization and promote global harmony.

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