Rocket Science for Rural Development [1]

Anil K Rajvanshi
Nimbkar Agricultural Research Institute (NARI)
Maharashtra, India
nariphaltan@gmail.com

I must really thank Dr. Navin Singhi for proposing my name and his colleague Prof. Satyanarayana at ASET for inviting me for this colloquium. I am honored to join the distinguished list of past speakers which has included Dr. E. C. Sudarshan, Mr. Sam Pitroda, Dr. Mashelkar among others. It will be a difficult act to follow since I live and work in rural area but still I will do my best.

Dr. Homi Bhabha was one of the pioneer and visionary scientist of India. You know much more about him than I do. He set up the tone of scientific temper in India and being a visionary and interested in all round inclusive growth I am quite sure that had he been alive today he would have used the might of his Institutes for rural development.

I do hope that my talk may make some of you interested in rural development and with tremendous talent and resources available in TIFR would like to explore how NGO like us and you can work together.

My talk is divided into three parts. The first is tell you little bit about the existing problems in rural areas, the second part is about some of the solutions to these problems. The problems of rural India are almost infinite since they are basically the problems of humanity. Thus I will restrict myself to talking about rural energy since energy is the basis of life and from

[1] An invited talk given at TIFR, Mumbai on 30 April 2010 in ASET Colloquium to celebrate Dr. Homi Bhabha's birth centenary.

which flows all other aspects of development. I will also talk about some high tech solutions in cooking, lighting energy and provision of potable water – the three most basic and pressing problems of rural India. These will be in the light of our work at NARI. And in my last section of the talk, I will touch on how TIFR and NGO's like us can work for rural development.

AKR delivering the talk

View of the audience

Rocket Science for Rural Development

Anil K Rajvanshi
Nimbkar Agricultural Research Institute (NARI)
Phaltan, Maharashtra
www.nariphaltan.org

ASET Lecture, TIFR, Mumbai. April 30, 2010

Structure of talk

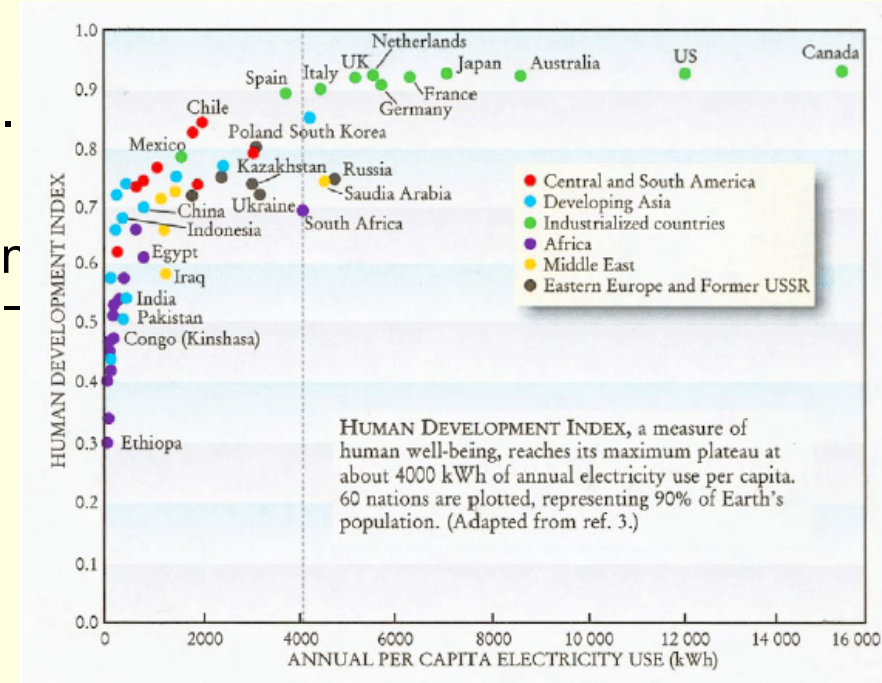
- Rural scenario and problems
- Possible high tech solutions
  - Energy from agriculture
  - Water issues
  - Cooking and lighting. 75% of total rural household energy.
- How TIFR and NARI can collaborate in solving some of them

Rural scenario

- 65% of our population is rural based. 20,000 villages have never seen electricity. 60% of rural population (~ 400 million) has nearly non-existent electricity. Sad state even 62 years after independence.
- Mostly use kerosene for lighting and 180-200 million tons/yr of biomass for cooking in inefficient, primitive and smoky stoves. Unclean drinking water.
- Around 300,000 deaths/yr because of indoor air pollution and 1.5 million because of polluted drinking water. Modern technology has not touched their lives. Other India has aspirations of sending man to the moon.
- 25% (~260 million) of rural population survives on less than Rs. 100/day.

Rural energy scenario

- Energy is the basis of life. Lack of it produces economic stagnation and social upheavals.
- Energy situation in India is alarming. Average per capita consumption is 18 GJ/yr. or 5% that in US (350 GJ/yr.). Rural electricity consumption per capita is just 60 kWh/yr (~ 7 W) - the lowest in the world.
- HDI is directly linked to electricity consumption. In India there is a shortfall of 60,000 MW. In Maharashtra ~ 5000 MW shortage. 10-12 hours daily blackouts in rural areas.
- With slight increase in electricity usage, tremendous increase in HDI.



General energy scenario

- India's petroleum imports (80-85% of total consumption) last year ~ Rs. 3 lakh crores. (6% of GDP). Serious outflow of foreign exchange. Need fuel for 8-9 %/yr. growth.
- Automotive usage >15% p.a. Poor roads $\Rightarrow$ more energy/km and increased pollution.
- In 15-20 years India and China might surpass oil consumption of developed world. May lead to strife/wars.
- Planning Commission's estimate of electricity shortfall is 150,000 MW by 2016. Will need Rs. 6 lakh crores! Where is the money? PP partnership has no yielded good results.

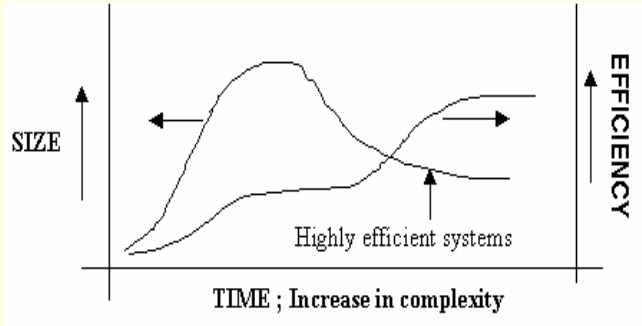
Rural energy strategy

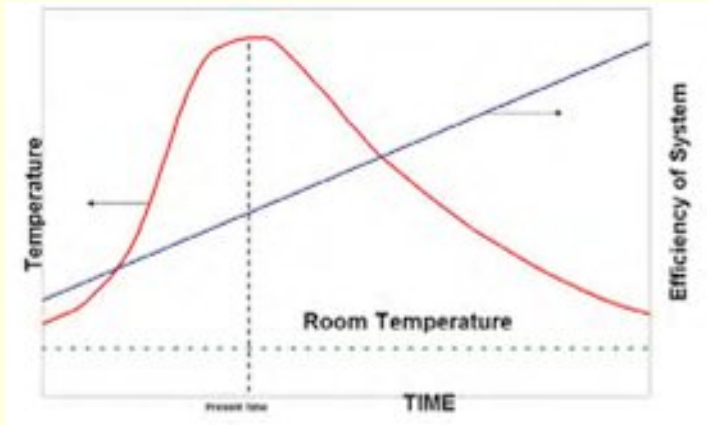
- Energy from agriculture can solve the twin problem of electricity and liquid fuel shortage and will provide rural wealth and create employment.

- 54% of India's population < 25 years of age. Mass communication has raised their expectations.
- With 60% of these rural poor coming in mainstream development, huge intellectual capital will be available. India then can become an economic super power.
- Scientists, technologists, corporate world and GOI should work together in solving the rural energy problems.

Strategy of rural development

- High technology needed for rural development.
- It allows maximum extraction of materials and energy from dilute locally available resources .
- Hallmark of evolution: size reduction; sustainability; increased efficiency; room temperature processes; equilibrium with surroundings and robustness.
- Most of our designs are following this route. Biomimicry as mantra for design. Is also spiritual !
- Societies as Prigogine's dissipative structures. Decentralized high tech energy solutions $\Rightarrow$ softer sustainable decentralized societies .





Energy from agriculture

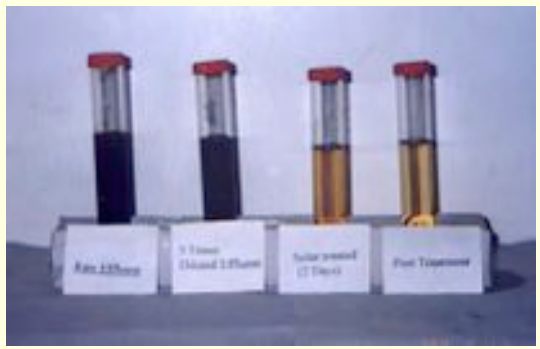
- India produces ~ 600 million tons of agri. residues per year. Waste disposal problem and hence mostly burned in fields . Creates environmental pollution and loss of energy.
- From residues we can produce three types of fuel
  - Liquid fuels like ethanol or pyrolysis oil.
  - Gaseous fuel like methane (biogas).
  - Electricity via biomass-based power plants.
- Theoretically these residues can produce 156 b l/yr of ethanol which is 42% of India's oil demand in 2012; or 80% of oil demand via pyrolysis oil; or 80,000 MW of electric power (50% of presently installed capacity).
- Can take care of major fuel requirements of India. NARI's contribution in biomass power.
- Biodiesel and ethanol from special crops.

Energy production (cont..)

- In any agriculture 25-40% of produce is food and rest are residues. No remunerations from residues, hence farming is uneconomical. No industry can survive on such norms.
- Residues for energy can give an extra income of Rs. 2000-4000/acre per year to the farmers. Insurance against distress sale. Increased agriculture will result in increased residues.
- Energy from agriculture can provide 50 million jobs and could be Rs. 200,000 crores/yr industry.
- With increased industrial demand for fuel and electricity large tracts of farmland may come under fuel crops only.
- Food vs. fuel debate. Need to do R&D on multipurpose crops. Sweet sorghum is one of them.

Sweet Sorghum

- NARI's pioneering work on ethanol from sweet sorghum.
- Solar distillation and detoxification.



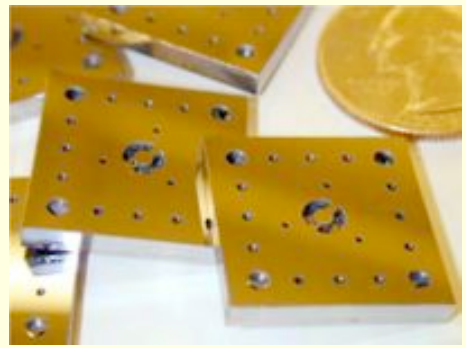
NARI

Farming and water issues

- Sophisticated technology needed in farming. Lacking in India. Best brains needed in agriculture.
- Small land holdings fit for precision agriculture. Need for developing small and high tech farm machinery.
- Increased farming will require adequate water supply.
- Rainwater harvesting provides the best solution. Need for setting up micro rural water utilities.
- Issue of ownership of water bodies needs to be resolved. Water Act similar to Electricity act needed.
- Use of flue gases from power generation can provide clean potable water. Combined electricity/water plants.

Lighting strategy

- Around 75% of total energy is used in rural cooking and lighting. Innovations in these areas can improve the quality of life.
- No rural connectivity and grid in sight. Need for decentralized energy lighting. Electricity or liquid fuel based.
- Decentralized electricity based lighting
  - **Taluka level plants (10-20 MW capacity).**
    - **Biomass, coal based or even nuclear.**
  - **Small scale plants (10-500 kW_e range):**
    - **Gasifiers, space-age steam engines.**
    - **Solar thermal, low cost PV, etc.**
    - **Nuclear power for micro utilities.**
  - **Micro scale power units:**
    - **Thermoelectric elements for cook stoves. Can produce 40-50 W power. R&D in batteries, ultracapacitors and LED units.**
    - **10-30 W micro engines? No batteries needed.**
    - **Human-powered small PMDC generators. Real play radios.**
    - **Solar antennas, nano radios**



Liquid fuel based lighting

- Simple hurricane lanterns used presently. Very poor light output. <100 lm.
- Noorie lantern a major improvement.
- Presently mantle efficacy~2-3 lm/W; light bulb~10-15 lm/W and CFL ~ 50-70 lm/W. Need to match mantle efficacy with that of light bulb.
- Power plant-to-light efficiency (PPL) point of view liquid fuel lighting can be superior to electric lighting. PPL of CFL is ~ 12-14 lm/W. 70% loss in power plant and 20% T&D losses. With increased T&D losses PPL will further reduce.

Noorie lantern

- Lightweight. 2 kg
- Light output ~ 1350 lm
- Runs on kerosene, diesel or low conc. ethanol
- Lighting and cooking
- Low cost. Rs.1000/-

Strategy for lighting (cont..)

- Present T/L mantles are 1880's vintage. Use 99% ThO_2 and 1% CeO.
- Nanotechnology can help in developing new mixtures of rare earth or other oxides which can glow at lower temperatures (1000-1500 ^{0}C) with higher luminous efficacy.
- NARI's work in improving mantle. Yt, Mg and Co salts.
- R&D required in developing sturdier mantles based on ceramic cloth and carbon-carbon composites etc.
- Need to copy bioluminescence technology of firefly.
- Dream of Solar $\Rightarrow$ liquids $\Rightarrow$ light!
- With grid electricity still a distant dream for major portion of rural areas, efficient liquid fuel lighting needs to be encouraged.

Cooking/lighting on ethanol

- 50-60% ethanol/water mixture. Easy to distill and very safe household fuel. Pressurized cylinders.
- Lantern output =100 W bulb light.
- Stove 2.5-3 kW capacity. Like LPG stove with high and simmer settings.
- Lanstove capacity ~ 1 kW. Provides cooking, lighting and clean drinking water. 2.5-3 times more efficient than electric lighting and cooking.
- Pyrolysis reaction need to be reduced. Additives?
- Need to change draconian excise laws.

Lanstove

Biogas cooking energy strategy

- Existing biogas systems in India are very inefficient.
- Need agricultural residues biogas plants.
- R&D required in high tech biogas reactors. Sophisticated controls, biochemical engg. And enhanced gas production bacteria needed.
- In Europe ~ 6000 MW electricity from biogas. About 130,000 cars running in Sweden.
- New materials for storage of biogas at medium pressures. Nano structures and materials needed.
- Scenario of a small utility in rural areas which processes waste into biogas and supplies it in small gas cylinders lined with storage materials.

Biomass gasification for cooking

- Loose leafy biomass gasifier.
- 500-800 kW (thermal) capacity. Controllable flame. CO + H_2
- Excellent for process heat and community cooking applications. Good airflow needed.
- Cleaning of gas for power still a problem. Excellent chemical eng. needed to do so.

Availability of devices in rural areas

- Excellent R&D should be backed by mass availability of its products.
- “Cell phone model” to be used.
- Provides an important function for communication in rural areas. Is robust, very high tech, low cost and good after sales service. So are human beings!

- Future manufacturing will be desktop (rapid prototyping) with locally available raw materials.
- Will lead to sustainable rural communities with high standard of living. Gandhi’s dream village.

Working together

- Need for corporate world, civil society (S&T NGOs) and R&D institutes like TIFR to work together. Sensitization of corporate world and R&D institutes regarding rural problems.
- NARI can help through its center of sustainable development.
- Mantra of biomimicry leads to fundamental S&T solutions to rural problems. TIFR can help in it.
  - Solar thermal – new working fuels
  - PV systems – one photon to many electrons!
  - Solar + $CO_2 \Rightarrow$ ethanol or diesel fuel; mimic photosynthesis
  - Mathematical modeling needed for distributed networks both in decentralized electricity generation and water storage

Working together….

- Urban elite as role model? Need to live sustainably.
- A very decent lifestyle is possible with energy consumption of 50-70 GJ/person-yr. In India average consumption is 18 GJ/person. US is 350 GJ/p/y.
- If every citizen of India follows US lifestyle we will need all the resources of the world to sustain it.
- Spirituality can help in curbing the greed for resources and making us sustainable. High technology with spirituality should be the mantra of development.
- Becoming sustainable in our personal lives and giving something back to the society is very satisfying and will help India become a holistic and sustainable country.

Thank You

Useful sites

- www.nariphaltan.org
- www.nariphaltan.org/ncsd (Sustainable center site)
- www.nariphaltan.org/writings.htm
  (articles on spirituality, technology and sustainability)
- www.nariphaltan.org/langmuirrural.pdf
  (an article on use of high technology for rural areas)

Email: nariphaltan@gmail.com