

R&D for Sustainable Development

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Talk will focus on following

- **DAY 1**
 - Existing energy and development problems in India.
 - How NARI's work is relevant to solving some of these problems.
- **DAY 2**
 - Design and philosophical issues
 - Collaboration between UF and NARI

- **Energy is basis of life. Lack of it produces economic stagnation and social upheavals.**
- **Energy situation in India is alarming. Average per capita consumption in India is 6% that in US. ~ 65% of India lives in rural areas and faces tremendous hardship.**
- **60% of rural population has no electricity.**
- **Mostly use kerosine for lighting and 180 million tons of biomass for cooking in inefficient and smoky stoves. Cooking and lighting constitutes 75% of total rural energy usage.**
- **India's petroleum imports (75% of total consumption) this year ~ \$ 25 billion. 50% of total exports. >15%/yr.growth.**
- **Electricity shortfall in India ~15000 MW/yr. Need to add 140,000 MW by 2010. Will require ~ \$ 130 billion. Where is the money?**

Introduction(contd.....)

- **1984 riots in Delhi and recently in Gujarat killed ~7000 people. Release of bottled-up emotions. Spark could be from any source.**
- **India spends 2-8% of GNP on medical costs related to environment. Around 52,000 premature deaths per year and 25 million asthma related cases. Cost ~ \$ 1 billion/yr.**
- **Renewable energy \Rightarrow better environment!**
- **Above events are direct result of lopsided development. Based on 50-100 year old centralized model of developed countries. Preference to cities over rural areas.**
- **Centralized production and control inherently leads to corruption and is antithesis of democracy.**
- **Decentralization leads to accountability.**

Introduction(contd.....)

- **Increased spread of electronic media has fueled increased aspirations for consumer goods.**
- **Resulted in increased use of energy. Automotive revolution. In 20 years India and China might surpass oil consumption of developed world. May lead to strifes and wars.**
- **50% of India's population is below 25 yr. age.**
- **Resulted in increased divide between haves and have-nots. This divide has increased worldwide.**
- **Today 3 billion people with income less than \$2/day. 1990 it was 2 billion.**
- **Our population wants developed country's life style. Will require inexhaustible supply of cheap energy.**
- **May not be available. Why?**

Introduction(contd.)

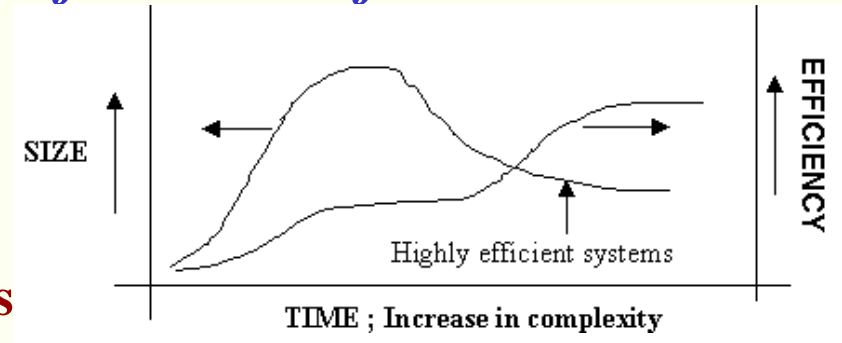
- **Energy consumption of any country is $E_I + E_{II}$**
- **E_I is the energy that goes in infrastructure building.**
- **E_{II} is energy consumption/capita per year.**
- **E_I is not available to DCs because of historical reasons. They were colonized during early 20th century.**
- **It is difficult to reach US or European quality of life even if E_{II} becomes somehow available. Is it desirable?**
- **Our consumptive lifestyle needs to be changed.**
- **Need for an alternative development model which is satisfying, decentralized and based upon renewable energy.**
- **The decentralized model should take into account the aspirations of rural population.**

- **Our model is based on concept of high tech. rural Taluka such that it becomes food and energy self sufficient and hence sustainable. Can also help in India's food and energy security.**
- **What is a Taluka?**
- **Administrative block of 90-100 contiguous villages.**
- **Area of ~ 1000-1500 sq. km. Like a US county. ~ 20 km radius.**
- **Population of 200,000-250,000. Town pop.~50,000**
- **Avg. consumption of 10-15 MW electricity and 10-15 million litres/yr. of petroleum products.**
- **Primary activity is agriculture. About 3350 talukas in India. Produce > 400 mT/yr. of agr. residues. Can produce > 53,000 MW of power. About 100 mT burnt in fields.**
- **Taluka as biomass and rain basin. Agricultural residues as raw material for fuel, feed and fertilizer.**

- **All its energy needs for 2005 AD could be met by:**
 - **Electricity via 2X10 MW biomass based power plants**
 - **Liquid fuel from sweet sorghum and pyrolysis oil**
- **With investment of \$70 million, creation of 30,000 jobs and \$ 45 million/yr. wealth in each taluka.**
- **For those talukas where there is not enough biomass, solar and wind can supplement energy production.**
- **Phaltan study became basis of National policy. MNES.**
- **Fifty power plants of 6-10 MW capacity set up. More are coming because of the new electricity act.**
- **Taluka Development can be truly sustainable and a middle path approach.**
- **Why Taluka model?**

Taluka Model(contd.)

- **Small villages are economic sinks. Big cities are cracking at seams and are ugly. *Middle path of Taluka is functional.***
- **Hallmark of evolution:**
 - size reduction; sustainability;
 - increased efficiency
 - equilibrium with the surroundings
- **Societies are like Prigogine's dissipative structures.**
- **Taluka can provide critical mass for development.**
- **With use of renewable energy it is possible that in future all societies may be decentralized, high technology and rural based.**
- **India is already rural based. Hence a good candidate.**
- **Taluka philosophy as guide to NARI's work**



Nimbkar Agricultural Research Institute (NARI)

- **NARI is working to produce technologies for sustainable development. Extension work.**
- **NARI is a small NGO in Phaltan Taluka. Phaltan is 100 km SE of Pune and 300 km SE to Mumbai.**
- **Has 125 acres of irrigated farm, ~2000 m² of buildings/workshops.**
- **Works in Agriculture, RE, AH & Sustainable Development.**
- **Use of best tools of S&T for solving rural problems. Focus on technology development.**
- **Total staff of 50 with 20 scientists. Working on shoestring budget.**



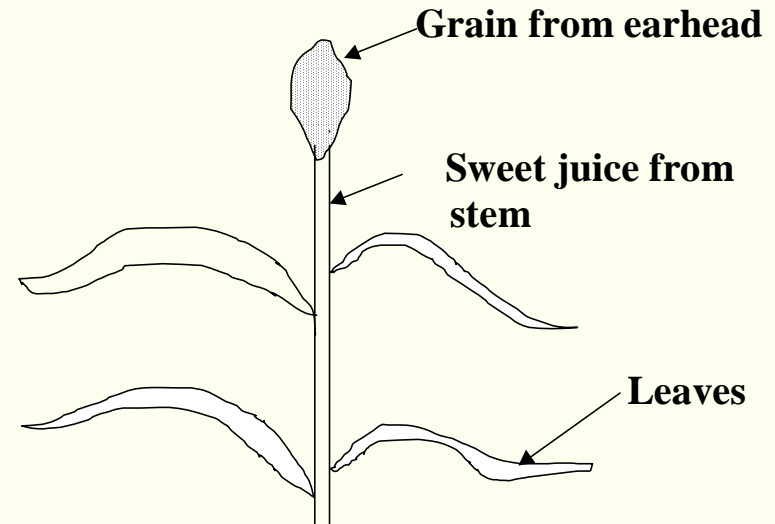
Agriculture (safflower)

- Have worked in cotton, sugarbeet, sunflower, grain sorghum etc.
- Present focus on higher yielding safflower and sweet sorghum var. and hybrids. Poor man's crops.
- Whole plant approach; safflower seed for oil, petals as herbal tea and residues for fertilizer and fuel in gasifier.
- Petals sell at \$ 9/kg. Seed sells at 25 cents/kg. Petals as main product.
- Herbal tea excellent for hypertension.
- Four hybrids and var. released.
- NARI hybrids and var. grown on 7000 ha in different states in India.
- ICAR funded.



Agriculture (sweet sorghum)

- **Introduced by NARI in India.**
- **Multipurpose crop. Grain for food, juice for syrup or ethanol and bagasse as fodder for animals or fuel for gasifier.**
- **Alternative crop to sugarcane. Uses less inputs.**
- **MADHURA hybrid released. Around 4 tons of Madhura seed sold last year to distilleries.**
- **Large scale plantation in India and abroad for ethanol production. 100 t/yr demand.**
- **NARI was member of EEC sweet sorghum group.**



Yearly output from 1 ha (2 crops)

- **2500-3000 l of ethanol (95% v/v)**
- **2-3 tons of grain for flour**
- **15-20 tons of bagasse as fodder or fuel**

Agriculture (agrochemical testing)

- Agrochemical testing for various national and multinational companies.
- Recognized by Central Insecticides Board of India.
- Bio-efficacy, compatibility and phytotoxicity testing.
- Comparative testing of different varieties of crops.
- Agricultural equipment testing.



Agriculture (greening of deserts)

- Growing of trees in semi - arid regions
- Soil water evaporation using solar energy.
- Pit size ~ 1m X 1m X 0.6 m
- 100% seedling survival. Five yr. data on 1000 m².
Leucaena, Prosopis and *Neem* grown.
- Avg. water prod. 300 ml/d per pit.
- Given to NDDDB. Need for large scale experiments.

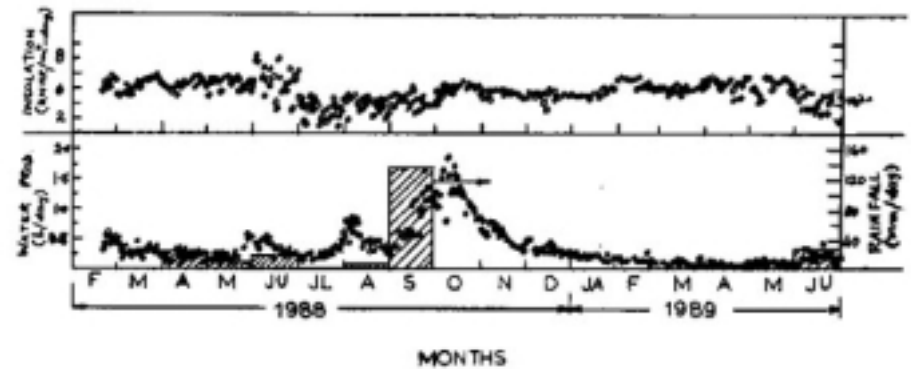
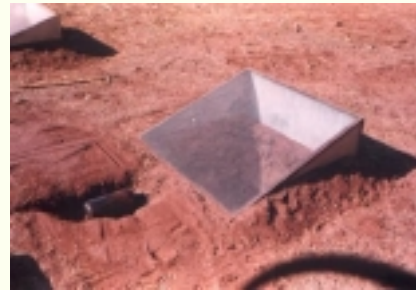


Fig. 2 Monthly Variation of Water Production from pits

Agriculture (animal husbandry)

- **Work in breeding of better sheep for milk and meat production. Awassi introduction in India.**
- **AI work for twinning, and worm resistance**
- **Extension work among local shepherds to improve profitability of sheep production**
- **Joint project between NARI, NCL, UNE**
- **Five year study funded by ACIAR, Australia**



Renewable Energy

- **Technology:**

- **Mostly biomass based. Agriculture can provide food and energy security for India**
- **Ethanol from sweet sorghum for cooking, lighting and automotive uses**
- **Multifuel lantern development**
- **Loose and leafy biomass gasifier**
- **Electric cycle rickshaws and motor assisted wheelchairs**
- **Solar detoxification of distillery waste**

- **Policy:**

- **Cooking and lighting energy strategy for rural areas**
- **Taluka energy plan**

Renewable energy (sweet sorghum)

- **Ethanol from Sweet sorghum. Work started in 1980's.**
- **Cooking stoves and lanterns developed.**
- **Solar distillation of 95%(v/v) ethanol; 50 l/day plant, 38 m² collectors, 2500 l tank.**
- **High sugar and grain yielding varieties and hybrids developed. Exported to Italy, France, Zimbabwe, Portugal and Zambia.**
- **Bagasse for gasifier and fodder.**
- **Our hybrid Madhura presently being tested in 6 distilleries in India.**



Alcohol stove

- **50% (w/w) ethanol**
- **0.7 - 2.5 kW_{th} capacity**
- **Controllable flame**



Renewable energy (lanterns)

- **60% of rural population in India have no electricity for lighting.**
- **Mostly use kerosene. Majority of it is imported.**
- **Frequent blackouts and brown-outs require alternative lighting.**
- **GOI is promoting costly PV lanterns.**
- **Multifuel NOORIE lantern developed. Very efficient and user friendly. Uses 50% less fuel than the existing Petromax (like Coleman lanterns).**
- **Produces light output of ~1350 lumens. 100 W light bulb equivalent. Is self cleaning, small and easy to light. Doubles up as a small cooking stove.**
- **Excellent for cold areas where both heat and light required.**
- **ABE and DST funded.**



Attributes of Noorie lantern

- Lightweight. 2 kg
- Light output ~ 1350 lm.
- Runs on diesel, kerosene or ethanol
- Low cost. \$10/-

Renewable energy (gasifier)

- **>100 m tons/yr of agricultural residues are burnt in fields in India.**
- **Multifuel low density biomass gasifier developed for thermal applications.**
- **Gasifier can run on sugarcane leaves and bagasse, sweet sorghum stalks and bagasse, safflower stalks, etc.**
- **1000 MJ/hr. thermal capacity and produces 24% w/w char. Hot gas combustion. Char briquettes useful as cooking fuel.**
- **Tested successfully in specialty ceramics factory for replacement of furnace oil.**
- **MNES and RF funded.**



Improved pedal rickshaw (IMPRA)

- **Air and noise pollution by petrol/diesel powered 2 and 3 wheelers. For India/DCs, rickshaws can provide environmentally sound transport.**
- **Estimates of 1-2 million cycle rickshaws in India, carrying 6-8 billion passengers - km/yr.**
- **Employment to 1-2 million poor/yr.**
- **Existing rickshaws have poor mech.design, poor aerodynamics and no quality control. No change in last 70-80 years.**
- **IMPRA has 3-gear system, backwheel braking, is light weight and easy to drive. Speed 10-15 km/h.**
- **IMPRA has life of 7-10 years and present cost is \$ 150/- in mass production. Wt ~ 75 kg.**
- **Exported to Europe and US.**
- **MNES and E+Co funded.**



Motor Assisted Pedal Rickshaw (MAPRA)

- **MAPRA is modified IMPRA. It has a small geared motor which runs on lead-acid deep discharge batteries.**
- **Geared motor assists rickshawpuller in pedaling. On/off motor switch.**
- **MAPRA can go at speeds of 15-20 km/hr to 45-50 km in one battery charge. Wt.130 kg. Cost ~ \$ 470/- in mass production. Present cost \$ 575/-(including batteries).**
- **Battery is charged overnight. Deep discharge batteries last ~2-3 years.**
- **Test marketed in Indian Univ. campuses and in Hampi. Logged > 10, 000 km.**
- **Need to set up rickshawpullers cooperative society. Program in Agra near Taj Mahal.**
- **Exported to US and Europe.**
- **MNES funded.**



Motor Assisted NARI handicapped Rickshaw (MANHARA)

- **There are close to 4 million physically handicapped persons (without use of legs) in India.**
- **Motor assisted hand pedaled rickshaw can help them.**
- **Based on MAPRA principles.**
- **Has a small PMDC geared motor, electronic drive and batteries.**
- **Can take one passenger 20-25 km in one battery charge with speed of 10-15 km/hr. Completely silent.**
- **Cost of MANHARA is \$ 250/-. Licensed out for manufacturing.**
- **Need for bank loans to handicapped persons for buying MANHARA.**

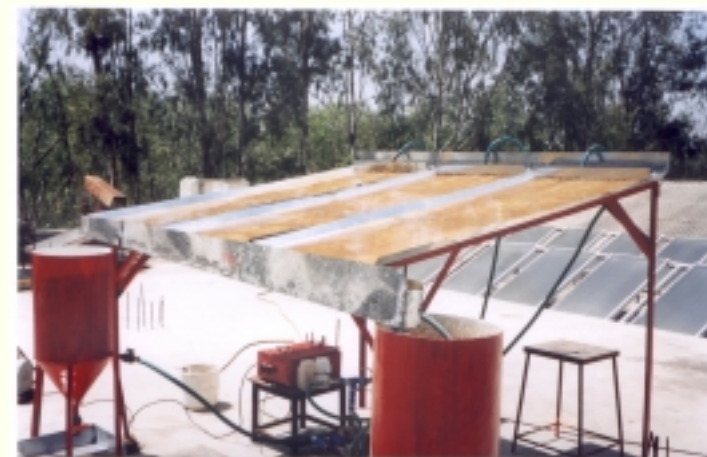


- **ELECSHA has lead-acid batteries, PMDC motor, 3-speed gear box, differential and soft start electronic controller.**
- **It can carry 2-3 passengers at 30-35 km/hr and can go to 60-65 km in one battery charge.**
- **Estimated cost is \$ 3500/. Running cost is 3 cents/km.**
- **ELECSHA consumes 40% less energy than petrol autorickshaw (power plant-to-traction).**
- **Can be a family vehicle. Logged more than 6500 km in trial run.**
- **All rickshaws developed at NARI are excellent for small distances in Taluka area. Development still continuing.**
- **MNES funded.**



Solar detoxification of distillery waste

- **Large amount of distillery effluent (DE) is polluting rural India.**
- **Anaerobically digested DE has COD of 25,000- 40,000 mg/L, is black in color and has foul odor.**
- **Tertiary treatments have not succeeded in reducing color.**
- **Solar detoxification using catalysts and chemicals is a possible solution. Dilution 4-5 times.**
- **T from 0 → 85-95%, COD ↓ to 250 mg/L and no smell. Two days treatment.**
- **Pilot plant for 100 L/day set up at NARI campus. 6 m² area; 4.5 kL/hr.**
- **Effluent as irrigation water.**
- **MNES funded.**



- **Technologies/Policies developed at NARI went in making National Taluka Energy policy.**
- **Around 50 biomass based power plants running. More to come because of the new electricity act.**
- **New decentralized power packs for rural areas for producing electricity and water simultaneously. NARI's suggestion.**
- **National ethanol program based on our sweet sorghum. Large areas in India planted under "MADHURA".**
- **Our safflower hybrids and varieties planted in ~ 7000 ha.**
- **NARI's work on cycle rickshaw has spurred development all over India and abroad.**
- **New strategy of high technology for rural areas.**

What can be done?

- **Technology intervention can help bring 3 billion poor people in mainstream development process.**
- **We all have responsibility to develop and deploy technologies specially for upliftment of these people.**
- **Tinkering approach has not helped. Need to develop technologies from ground up.**
- **Sophisticated technology needed. It allows very efficient energy and material conversions. Nature's way.**
- **Less resources and low grade energies available in rural areas. Need for high “conversion η ” systems.**
- **Decentralized energies \Rightarrow decentralized society.**
- **Three major areas for intervention; Lighting and cooking (75% of total rural household energy used in India); Clean drinking water.**

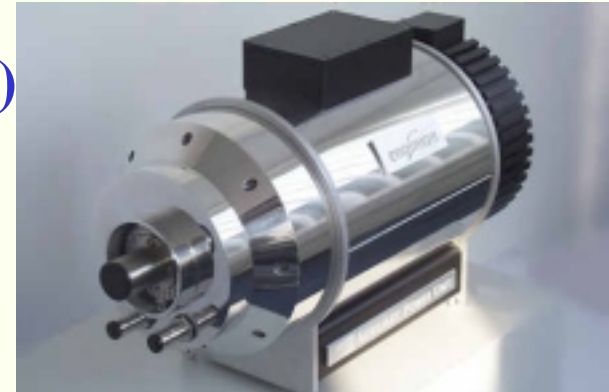
Strategy for lighting and cooking energy

Liquid fuel lighting strategy

- 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. With increased T&D losses PPL will further reduce.
- Present T/L mantles are 1880's vintage. Use 99% ThO₂ and 1% CeO.
- R&D required in developing new mixtures of rare earth or other oxides which can glow at lower temperatures (1000-1500 °C) with higher luminous efficacy. Superconductor and nanotechnology R&D may provide direction.
- R&D required in developing sturdier mantles. Could be ceramic cloth based, carbon-carbon composites etc.
- Need to copy bioluminescence technology of firefly.
- With grid electricity still a distant dream for major portion of rural areas, efficient liquid fuel lighting needs to be encouraged.

Distributed Electricity based lighting

- Taluka level plants (10-20 MW capacity)
- Small scale plants (10-500 kW_e range):
 - **R&D needed in:**
 - Gasifiers, space-age steam engines.
 - Stirling engines, biomass gas turbines, low cost PV, etc.
 - **Nuclear Power? Concept of microuilities in rural areas.**
- **Micro scale power units:**
 - **Thermoelectric elements for cookstoves. Can produce 40-50 W power. Need R&D in efficient batteries like ultracapacitors and LED units.**
 - **10-30 W nano engines? No batteries needed.**
 - **Human-powered small PMDC generators. Rare earth magnets. Gandhi's energy charkha.**



Cooking Energy Strategy

- Only liquid and gaseous fuels can provide clean cooking energy.
- Ethanol is excellent fuel for cooking. R&D required for pyrolysis oil and non-edible oil in stoves.
- Excise laws need to be modified for use of ethanol for cooking. Stove running on 7% ethanol ?
- R&D required in high tech biogas reactors and storage of biogas in hydrate, porous carbon, etc.
- Scenario of a small utility in rural areas which processes waste into biogas and supplies it in small gas cylinders lined with storage materials.
- Cooking and lighting energy industry based on liquid and gaseous fuels can be of the order of \$ 7-9 bn/yr.
- National technology mission on cooking and lighting.



- All the development efforts should also be accompanied by change in mindset.
- Curbing greed is the biggest challenge. Spirituality might help in creating a “contented” mindset.
- Maxim of *Simple living and high thinking* is a possible driving force.
- Mahatma Gandhi and Einstein as examples. With less energy and few needs they produced a very high quality of thought.
- Very difficult to impose in a democratic society. However for sustainable future we have to do it.
- Need for continuous education of children and college students regarding sustainability and love for natural systems.
- Biomimicry as mantra for all green design.

- **Few projects can be taken up**
 - T/L mantle development
 - Thermoelectric elements for wood or biomass cookstoves
 - Micro/Nano engines (10-30 W)
 - Liquid and gaseous fuels from biomass residues
 - Biogas storage structures and devices
 - Water purification via solar energy
 - Electricity and water production from IC power plants (200-500 kW)
 - Better catalysts for detoxification of industrial effluents
- **Students as future entrepreneurs in RE.**
- **Funding , intellectual property and manufacturing issues to be resolved.**
- **NARI can also provide internship opportunities.**
- **International Center for Sustainable Development.**

THANK YOU

- <http://nariphaltan.virtualave.net> (Institute)
 - <http://education.vsnl.com/nimbkar/criticalmass.html> (taluka)
 - <http://education.vsnl.com/nimbkar/swee.html> (water from soil)
 - <http://nariphaltan.virtualave.net/Gasifier.pdf>
 - <http://nariphaltan.virtualave.net/MAPRA.pdf> (rickshaw)
 - <http://pune.sancharnet.in/nariphaltan/housenergy.pdf> (cooking and lighting strategy)
-