Emerging Energy Challenges and Opportunities
Dr. Anil Kakodkar

Indian Nuclear Scientist and Mechanical Engineer


Honorary Fellow, Indian Institute of Technology, Mumbai

Fellow, Institution of Engineers, India

Honorary Fellow, Institution of Electronics and Telecommunication Engineers, India

Former Chairman, Atomic Energy Commission of India

Ex-Secretary, Government of India

Former Director, Bhabha Atomic Research Centre, Trombay
“Emerging energy challenges and opportunities”

Anil Kakodkar
Emerging Global Scene
Non OECD countries growing faster and overtaking OECD countries

Fossil fuels would continue to dominate the energy scene

Unless OECD countries reduce their CO2 emissions, there may not be space to accommodate Non-OECD emissions. USA and China are the dominant players on either side.
Developing countries to be equally dominant players in energy market

Fossil energy prices would continue to rise.
Global average temperature over last one and a half century showing a more or less steady increase over the last fifty years or so. The fluctuations and their cycles can be correlated with various events like solar cycles.

We do not know how close we are to the tipping point. However we need to act now to secure survival of our future generations.
Emerging Indian Scene
Goa  2005

Bihar  117

All India  779

Ref. Data released by GoI – 18th May 2012

HDI unaffected by change in electricity use

HDI strongly dependent on electricity use

Source: Dr. Steve Chu, Department of Energy, US

Figure 5: Human Development Index and Electricity Consumption
Securing energy for India’s future is a major challenge

<table>
<thead>
<tr>
<th></th>
<th>World</th>
<th>OECD</th>
<th>Non-OECD (developing world)</th>
<th>India</th>
<th>India of our dream</th>
</tr>
</thead>
<tbody>
<tr>
<td>Population (billion)</td>
<td>6.7</td>
<td>1.18</td>
<td>5.52</td>
<td>1.2</td>
<td>1.6 (stabilised)</td>
</tr>
<tr>
<td>Annual av. per capita Electricity (kWh)</td>
<td>~2800</td>
<td>~9000</td>
<td>~1500</td>
<td>~780</td>
<td>5000</td>
</tr>
<tr>
<td>Annual Electricity Generation (trillion kWh)</td>
<td>18.8</td>
<td>10.6</td>
<td>8.2</td>
<td>0.835</td>
<td>8.0</td>
</tr>
<tr>
<td>Carbon-di-oxide Emission (billion tons/yr)</td>
<td>30</td>
<td>13</td>
<td>17</td>
<td>1.8</td>
<td>?</td>
</tr>
</tbody>
</table>

- India alone would need around 40% of present global electricity generation to be added to reach average 5000 kWh per capita electricity generation
We would need to import around 60% of primary energy supply by 2031-32.

Energy import bill increases much faster than economy.
➢ We need to enhance domestic energy production and ownership of energy assets to minimise energy import cost. (Both traditional as well as new resource types).

➢ We need greater thrust towards Renewables and Nuclear both to minimise imports as well as carbon dioxide emissions.

➢ We need greater thrust on transformation of renewable and nuclear energy into hydrogen and fluid hydrocarbons.

➢ Need to think of a policy shift to redeploy subsidy from natural hydrocarbons to renewable energy appliances and artificial hydrocarbons/hydrogen from renewable/nuclear and bio-methane from waste.
WHILE WE MUST MAKE FULL USE OF ALL AVAILABLE ENERGY RESOURCES ONLY THORIUM AND SOLAR ENERGY IS SUSTAINABLE IN THE LONG RUN (FUSION ENERGY NOT CONSIDERED FOR THE PRESENT)

<table>
<thead>
<tr>
<th></th>
<th>Coal</th>
<th>Hydro-carbon</th>
<th>Uranium once-through</th>
<th>Uranium recycle</th>
<th>Thorium</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of years</td>
<td>11.5</td>
<td>----</td>
<td>0.9</td>
<td>46</td>
<td>&gt;200</td>
</tr>
</tbody>
</table>

Electricity generation potential from renewable sources in India (as fraction of 8 trillion units)

<table>
<thead>
<tr>
<th>Energy Source</th>
<th>Hydro</th>
<th>Other renewables</th>
<th>Solar (wind+biomass)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0.075</td>
<td>0.0225</td>
<td>1.0*</td>
</tr>
</tbody>
</table>

* Would need ~45,000 sq.km which corresponds to a fourth of barren and uncultivable land in India.
Cumulative Generation Capacity - GW

Nuclear

Solar (peak)

- AHWR
- FBR
- LWR
- PHWR
- BWR

operational  |  opt+const  |  add 12 plan

<table>
<thead>
<tr>
<th>Year</th>
<th>2012</th>
<th>2017</th>
<th>2022</th>
<th>2027</th>
</tr>
</thead>
<tbody>
<tr>
<td>Solar</td>
<td>0</td>
<td>1</td>
<td>30</td>
<td>100</td>
</tr>
</tbody>
</table>
Limited initial import of Uranium backed up by domestic three stage strategy can meet the projected requirement without the need for additional uranium.

- LWR (Imported)
- Nuclear (Domestic 3-stage programme)
- Hydrocarbon
- Coal domestic
- Non-conventional
- Hydroelectric


* - Assuming 4200 kcal/kg
Ref. Energy Technology Vision 2035 (Draft TIFAC Report)

Around 34% energy imported
Cooking and lighting in households

Total number of households: 246,697,667

### Lighting
- Electricity
- Kerosene
- Solar
- No lights

### Cooking
- Firewood
- LPG/PNG
- Crop residue
- Cow dung
- Kerosene
NISARGRUNA developed by BARC is a robust biphasic biowaste digester that offers a decentralised urban solid waste management solution through 100% recycle to produce 70-80% pure methane and organic manure.

A staggering amount of waste is generated every day in every town and city, and the local bodies are grappling with logistics for its disposal. The government and individuals fail to see waste as a potential source of energy and agricultural input in the form of manure. At places where domestic piped gas network is available, the gas company could discharge significant corporate social responsibility through liquidating waste and marketing gas as well as organic manure. Create livelihood for people in the process.
Technology thrusts part - I

- Clean coal technologies (with Indian coal)
- Energy technology up gradations (for ex. UDC, use of DC appliances etc.)
- Special attention to India specific problems
- Hybrids with Solar thermal for power generation and air conditioning/refrigeration
- Gradual replacement of subsidy on kerosene and agriculture power supply with incentives for solar lights and solar pumps respectively
- Energy efficient building architecture with integrated renewable energy, water harvesting and waste recycle systems
Technology thrusts part-II

- New energy technologies
  - For energy production
    - Solar
    - Nuclear
  - For hydrogen production, storage / transportation, utilisation
  - For synthesis of fluid hydrocarbons

- Mobility
  - Electric
  - Hydrogen
Sustainable development of energy sector

TRANSITION TO FOSSIL CARBON FREE ENERGY CYCLE

GREATER SHARE FOR NUCLEAR IN ELECTRICITY SUPPLY

REPLACE FOSSIL HYDROCARBON IN A PROGRESSIVE MANNER

RECYCLE CARBON DIOXIDE

DERIVE MOST OF PRIMARY ENERGY THROUGH SOLAR & NUCLEAR

ENERGY CARRIERS
(In storage or transportation)

• Electricity
• Fluid fuels (hydrocarbons/hydrogen)

WASTE
• CO2
• H2O
• Other oxides and products

Nuclear Recycle
Sustainable Waste Management Strategies

Urgent need to reduce use of fossil carbon in a progressive manner
Given very different and limited choices for sustainable energy resources we need an India specific long term energy strategy and leverage Indian scientific community to work on it

Thank you
Food, Energy and Environment in India: Vision 2020

Dr. G. Thyagrajan

Fellow, Royal Society of Chemistry, London

Fellow, Indian National Academy of Engineering, New Delhi

Honorary Fellow, Indian Institute of Chemical Engineers

Former Director of North East Institute of Science and Technology, Jorhat (1974-80),

Former Director of Indian Institute of Chemical Technology, Hyderabad (1981-85) and

Director Central Leather Institute, Chennai (1984-94)

Ex-Chairman of Research Council of CFTRI, NISCOM, NEIST and CIMFR (1996-2009)

President of Madras Science Foundation