India’s Energy Challenges

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Energy Prior to Electricity

- For all known human history, man used solar energy for drying food for storing; for drying clothes, etc.
- Humans all over the world used wind energy for transportation in rivers and seas, through sails
- For thousands of years, people in the sub-continent, like elsewhere, used cattle for activities such as ploughing, threshing, oil-pressing, transportation, etc.
- Vegetable oil from various seeds used for lighting and other needs

Electricity in the Sub-Continent

- 1879: First demonstration of Electricity in India conducted in Calcutta by P W Fleury & Co
- 1882: Mumbai saw electric lighting demonstration for the first time in Crawford Market
- 1897: First Hydro-electric Generating installation set up in a tea-estate near Darjeeling for Darjeeling municipality
- 1905: Bombay Electric Supply & Tramways Company (BEST) set up a generating station to supply electricity for the tramways
- 1925: First electric train run between VT and Kurla stations of Bombay
- 1931: Electrification of suburban train track carried out between Beach and Tambaram stations in Madras (Chennai)

Electricity Generation Capacity in India Over the Decades

- 1947 (after independence): 1,362 MW
- 1956: 2,886 MW
- 1966: 9,027 MW
- 1979: 26,680 MW
- 1990: 63,636 MW
- 2002: 105,046 MW
- June 2014: 249,488 MW

Uniqueness of Electric Power

- Modern life is almost unimaginable without electricity
- It touches almost all facets of human life, from birth to death
- The only exceptions could be those who are living deep in jungles, untouched by modern civilization
- The food we eat, clothes we wear, the medical and health care we get, from the most simple to the most complex gadgets we use, are either made using electricity, or run on them, or both
- Availability of electricity, is almost taken for granted, in the current day's way of living

Uniqueness of Electric Power

- Electricity, though is an economic good, similar to food, clothes, etc., is unique and different from almost all other goods in one sense
- Electricity cannot be stored (except in very small scale, in batteries)
- Electricity is generated, transmitted, and consumed, simultaneously at the same fraction of second
- However, the demand for electricity is different at different points of time in a day, or in different seasons
- Peak electric power demand between 6 pm to 10 pm daily for lighting; in winters in cold countries (for heating); in summers in hot countries (for cooling)

India’s Electricity Scenario

- India’s current installed electricity generating capacity is over 250,000 MW; an additional 40,000 MW is captive capacity
- India is world’s third largest producer of electricity with 4.8% share
- In 2013, India produced about 1100 billion kWh (Units) of electricity
- 59% of generating capacity is coal-based thermal; Hydro 17%; solar, wind and other renewable sources 12%; natural gas 9% & nuclear 2%
- Availability /Plant Load / Capacity Factor of power high in coal (75%), nuclear (80 to 90%); CSP Solar has potential up to 90%
- Low in hydro (25 to 40%; higher in Himalayan rivers); Solar PV (11 to 30%); and Wind (~40%)

India's Electricity Scenario

- India has about 300 million people without power (20% of the world)
- A large % of those who have access to electricity, do not get quality power (issues of voltage, interruptions, etc.)
- 80% of villages have power, but only 52.5% of villagers have access to power
- Substantial regional variations (Western region had surplus of 14.5%, northern & eastern (-3% each), northeastern (-17%) and Southern (-12.7%) regions had deficit
- Gujarat has highest surplus capacity (1600 MW), and erstwhile AP had highest deficit (3200 MW)

India’s Electricity Scenario

- Current electricity consumption patterns in India:
- Agri – 21%; Industrial – 35%; Household – 28%; Commercial – 9%
- Est of per capita electricity consumption p.a. in India: 684 kWh in 2011 & 883 kWh in 2012
- Compares with (kWh): Iceland-52300; US - 13250; Japan - 7850; France – 7290; Russia - 6500; UK - 5516; China – 3300; Iran – 2650; Egypt – 1740; Pakistan – 450; Bangladesh – 260; World avg: ~3000
- Large regional variations: Dadra & NH: 13800; Punjab – 1800; Gujarat – 1660; Haryana – 1630; Maharashtra & TN – 1200; Rajasthan – 930; WB – 560; UP – 450; NE – 260 & Bihar - 134

India’s Problems in Power

- Current Transmission & Distribution losses at 32%; (world avg. 14%)
- In a 2004 study, theft of power was valued at Rs.28,000 cr.
- Current pending power bills to PSU power producers by States estimated at Rs.3 lakh cr.
- In a recent experience, the NTPC’s proposal to stop supply of power to the Delhi power distribution co. was stayed by the Courts
- Promises of free power to the farmers; State Governments do not compensate the State PSU power producers for the free power
- Lack of requisite country-wide capacities in transmission and distribution

Growth Projections: How much Electricity does India Need?

- If India were to aim to reach even the current world avg., it needs four times its current power generation capacity, ~ 10 lakh MW
- In 2012, 51% of India's work force (40 cr.) was employed in Agri; 27% in Services sector; and 22% in Industry; Every year, 130 lakh new youth join the work-force
- New jobs, in any sector (industry or services) need addl. power
- Only 7% of India's work force is in organized sector (280 lakhs); of this, 150 lakh are in Govt., & 130 lakhs in organized industry (3%)
- Sustainable employment can be achieved only when a larger % (~25) of total work-force is employed in organized manufacturing sector

Growth Projections: How much Electricity does India Need?

- Assuming half of current power consumption in industry to be of organized sector (i.e., 18%), it would be 45,000 MW
- Thus, an addl. 360,000 MW would be required to power the manufacturing sector & support such level of employment in organized industry
- The unorganized industrial and the services sectors would also need commensurate growth to support the organized manufacturing sector & would need addl. power; overall economic growth would also vastly increase the household sector's incomes and demand for power
- International Energy Agency estimates that India would need to add between 6 to 12 lakh MW of additional power generation capacity by 2050; the above estimates broadly support this range

India's Power Options: Coal

- Coal and lignite based power plants account for 57% of the country's installed capacity & 65% of the generated power output
- Low calorific value and high ash content are constraints with Indian Coal (Indian coal: 0.7 kg per kWh; US coal: 0.45 kg per kWh)
- By-product of Ash in coal-based power plants, a huge problem; severe opposition from local population and environmental groups for location of new coal-based power plants
- Ash content estimated at 40% of coal burnt; @ 65% of total power output of 1103 billion kWh (2013), and 0.28 kg of ash per kWh, up to 200 million tons of ash is generated EVERY YEAR in India as of now (Contrast: India's food production in 2012-13 was 255 million tons)
- Could be marginally lower, due to better quality coal being imported from Indonesia, Australia, etc.

Problems with Coal

- Coal ash is feared, because of its fine size (up to 0.5 micrometers – 1/1000 of a mm - in dia); can easily percolate into the sub-soil strata and permeate the underground water aquifers permanently
- Coal ash contains (ppm): barium-806, strontium-779, boron-311, vanadium-252, manganese-250, chromium-220, zinc-176, copper-112, nickel-77, lead-56, arsenic-43, cobalt-36, fluorine-29, and trace proportions of radio-active elements such as molybdenum, thorium, uranium, radium, etc.
- 100% safe disposal and utilization through fly-ash bricks, etc. is the only way to allay public's fears
- However, would increase the cost of power, if ash-based brick-making and utilization is made a compulsory part of every coal-based power project (which only can address the issue)

The Future of Coal

- India’s total coal reserves are currently estimated at 301,560 million tons (proven reserves: 125,910 million tons; indicated reserves 142,510 million tons; and inferred reserves 33,150 million tons)
- Production of coal in 2013-14 was 566 million tons
- Even if we assume that power production using coal would go up substantially, and coal usage per year would go up four-fold to 2000 million tons, the country’s estimated reserves as on date would be good for the next 150 years
- It could also reasonably be assumed that with time, more reserves of coal would be identified
- And, other alternate sources of power would also be identified

India's Power Options: Natural Gas

- Current natural gas-based installed capacity is 18,900 (7.6% of total)
- Gas-based thermal power plants do not have pollution problem of ash, & their CO2 emissions are half as of Coal-based plants
- Natural Gas-based plants are ideal as "Load following Plants"
- However, anticipated quantities of gas have not been confirmed, off-shore and inland, in the country
- Issues of pricing (questions of international parity)
- As in 2010, India had 1437 billion cubic meters of confirmed natural gas inland and off-shore
- At 7.86 cu.ft requirement per kWh, estimated gross power capacity is 736,500 MW for one year

India’s Power Options: Natural Gas

- Alternately, if 100,000 MW capacity is added using natural gas, the country’s current confirmed natural gas reserves would last for about seven and half years
- However, India has substantial off-shore areas that are yet to be explored; It may be reasonably assumed that many times more reserves would be identified and exploited
- Therefore, the potential of major power generation using natural gas, is quite substantial
- Added advantage of less pollution problems, compared to coal
- The consumers would however, have to be prepared to pay the market price for its commercial exploitation

India’s Power Options: Nuclear Power

- India’s current nuclear power generation capacity is 4780 MW in 18 Pressurized Heavy Water Reactors
- Kudankulam-I Nuclear Power Station has commenced full-scale power production with 1000 MW capacity; if synchronized with Grid, nuclear capacity to go up to 5780
- Prototype Fast Breeder Reactor (PFBR) of 500 MW expected to be completed by Sept 2015
- Kudankulam-II 1000 MW plant under advanced stage of construction
- Four nuclear power plants of 700 MW each are under progress at Rawatbhata, Kaiga; will add 2800 MW additional capacity by 2017
- Nuclear power generation capacity to increase to 10080 MW by 2017

India’s Power Options: Nuclear Power

- New Nuclear Power Plants Sanctioned at Gorakhpur, Haryana (1500 MW)
- New Nuclear plants proposed with international cooperation at Jaitapur, Maharashtra (1650X2 MW); & Mithivirdi, Gujarat (2X1000 MW)
- NPCIL has plans to expand the nuclear power capacity to 27,000 MW by 2023
- India’s three phase nuclear power programme
- Second stage: Fast-Breeder Reactors; Potential
- Third Stage: thorium-based reactors

Issues with Nuclear Power

- Availability of Uranium fuel in India; quantity, grade issues
- Problems with Land Acquisition
- Opposition from public and environmental groups
- Fear of Nuclear Incidents; Fukushima scare
- The positives of nuclear power: No CO2; no emissions; no global warming
- Issues with storing of spent fuel and decommissioning of plants
- International denial regime for essential equipment and technology

India’s Power Options: Hydro-Power

- Current capacity in Hydro-power in the country is 40,660 MW, against a total potential of 84,000 MW; 97% of this power is in public sector
- Disadvantages: low availability factor of Hydro-power; in southern states, it could be two or three months in a year only
- Hydro-power is completely pollution free; though, if the deforestation caused through construction of the dams and the submergence of forests and other tree cover is considered, there is some degree of indirect pollution
- A substantial portion of the untapped Hydro-power potential is in the Himalayas; issues of risk of earthquakes with storage of large bodies of water in these regions

India's Renewable Power Options: Solar

- The potential of solar power for humanity is almost limitless
- It is estimated that at the outside edge of ozone layer covering our planet, about 174 billion MW equivalent of solar radiation reaches every moment
- 30% of this is reflected back into the outer space; balance is absorbed by the earth; and causes movements of wind, evaporation of sea water and creation of clouds, rains, photosynthesis, and the crops we depend upon for food
- Solar energy received by earth in one year, is twice that would be realized by burning all the fossil fuels present in the earth's crust
- Electricity that could be generated from solar energy received on earth in one hour is equal to the power being currently generated by the whole world in one year

India's Renewable Power Options: Solar

- Many methods of converting sun's rays into electricity
- Two main methods: Photo-voltaic (PV) cells and Concentric Solar Power (CSP) plants
- PV plants require 2.4 ha per MW; 1 sq.km (100 ha) can yield 40 MW
- 1% of India's land area (total 32 lakh sqkm; 1% = 32,000 sqkm) can yield 12.8 lakh MW generation capacity of power
- One acre of land could yield through solar power, Rs.5.5 lakhs net revenue per year, assuming 7 hours of power generation per day for 245 days a year (accounting for rainy season, etc.); and a profit of Rs.2 per kWh, after providing for cost of capital and operating costs

Renewable Power: Concentric Solar Power

- CSP units do not require land like PV solar farms; can also store heat (thro' molten salt) and generate power when required
- Upon a single Christmas tree-like structure, many parabolic reflecting dishes are arranged, to reflect the sun's light on to a single container
- Molten salt is used in this container, to absorb and retain the heat so reflected by the concentric solar panels
- Molten salt has the ability to retain the heat for a long time; can generate power using such heat, later in the night
- Andasol power plant in Spain: first commercial CSP Plant successfully generating 19.9 MW round the clock, using molten salt as the thermal reservoir
- Huge potential for future

India’s Current Status in Solar Power

- 2005: 6.4 MW; 2010: Grid-connected solar power was 10 MW
- By 2014 Jan, grid-connected solar power capacity rose to 2208 MW
- JNN Solar Mission set up in 2010; target 20000 MW by 2022; R&D to reduce cost; domestic production of PV panels; achieve tariff parity
- Gujarat the leader in solar power; Asia’s biggest solar power park set up at Charanka village to ultimately generate 500 MW solar power
- Rajasthan a natural choice for India’s solar power program; Jodhpur, Jaisalmer & Bikaner in forefront;
- 4000 MW Ultra-Mega Green Solar Power Project being built near Sambar Lake; 1st phase of 1000 MW to be on by 2016; at Rs.7 cr. per MW, capital cost compares well with Coal-based thermal (Rs.5 cr)

Solar Power: Other options

- Some Innovative ideas: Govt of Gujarat is setting up PV panels on the Narmada canals; power is generated and evaporation prevented
- PV panels can be placed over the water spread area of multi-purpose reservoirs; another smaller reservoir created downstream; hydro power is generated 6 to 10 pm; water is pumped back to the higher level reservoir in the day time, using solar power
- PV panels could be made mobile, set up on land in off-crop season; In summer, when the demand for power is highest, and farmers do not have crops, PV panels placed on such land and power generated
- All buildings could by law be forced to set up PV panels on roof-tops and side walls to generate solar power, and such power connected to the Grid; Alternately, incentive for domestic use (done in Germany)

India's Renewable Power Options: Wind

- MNRE estimated India's wind power potential at 103,000 MW in 2012
- India has 5th largest wind power generation capacity in the world; 21000 MW capacity of wind power in 3/2014
- Tamil Nadu, Gujarat, Maharashtra, Karnataka & Rajasthan have large potential of wind power
- Availability of wind power is low; 20 to 40% maximum;
- Developed countries have successfully experimented with major off-shore wind power units of up to 3 MW each; with its long coast line, India could also aim at tapping this potential
- Issues: high capital cost, compared with coal-thermal power

Other Renewable Power Options

- Bio-mass power, using bagasse, agro-residues such as rice husk, crop stalks, wood chips, etc. are used through gasification; total potential estimated at 24,000 MW
- Bio-gas based power generation units using the vast amounts of bio-gas potential that India has
- Geo-thermal Energy: India has 340 hot springs; those with power potential being identified
- Tidal wave energy: at research stage

Challenges in India's Power Sector

- Everyone wants quality, uninterrupted power; but no one wants a power plant in their neighbourhood
- Farmers and green activists oppose coal and nuclear power plants as being polluting, and taking away useful cultivable land
- But, coal & nuclear plants are inevitable, since solar, wind and other renewables cannot supply dependable power
- What are the options: give preference to locals in jobs created in the power plants
- Set apart certain % of power to be distributed within a certain radius around the power plants, to encourage industries being set up

THANK YOU