



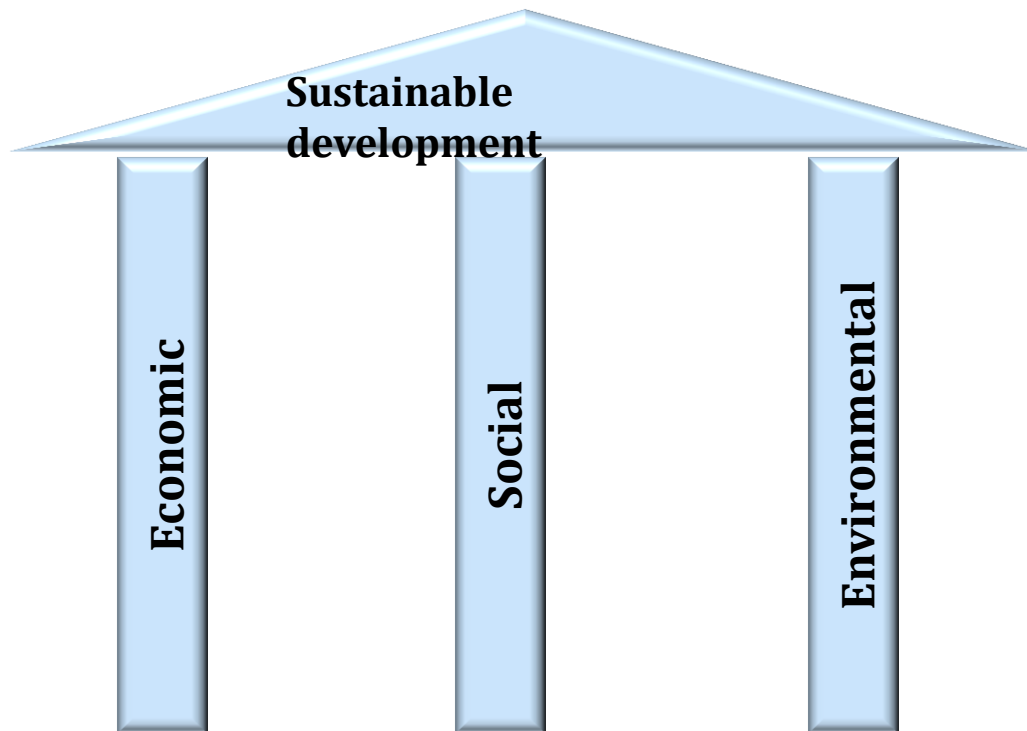
Sustainable Energy

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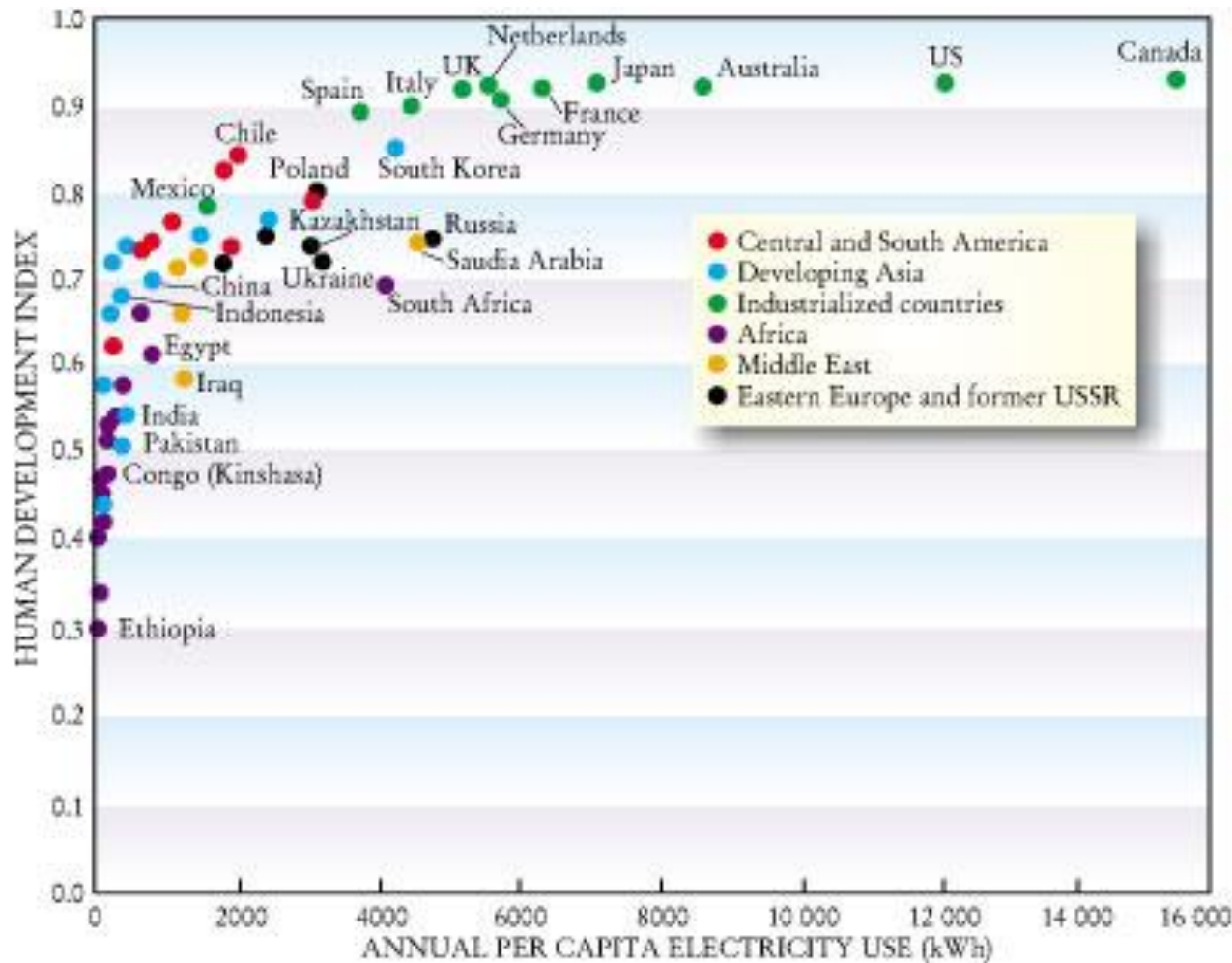
Components of Sustainable Development: Dominant View



Inspired by Our Common Future, 1987

- Three pillars of sustainable development
 - Economic
 - Social
 - Environmental
- Achievements
 - policy mainstreaming and consensus building
 - Responsible corporate conduct
 - Formal and informal institutions working together
- Criticisms
 - Compartmentalized – Leading to Isolated actions?
 - An oxymoron?
 - Fuzziness?

Quality of Life is Question of Power



The HDI is an index combining normalized measures of **life expectancy**, **literacy**, **educational attainment**, and **GDP per capita**



Increase in Energy Needs – an Inevitability!

- Economic growth and development goals
- Provision of adequate and equitable access to basic amenities and services
- Daily need of energy services
 - Cooking,
 - Lighting,
 - Space cooling, heating, etc

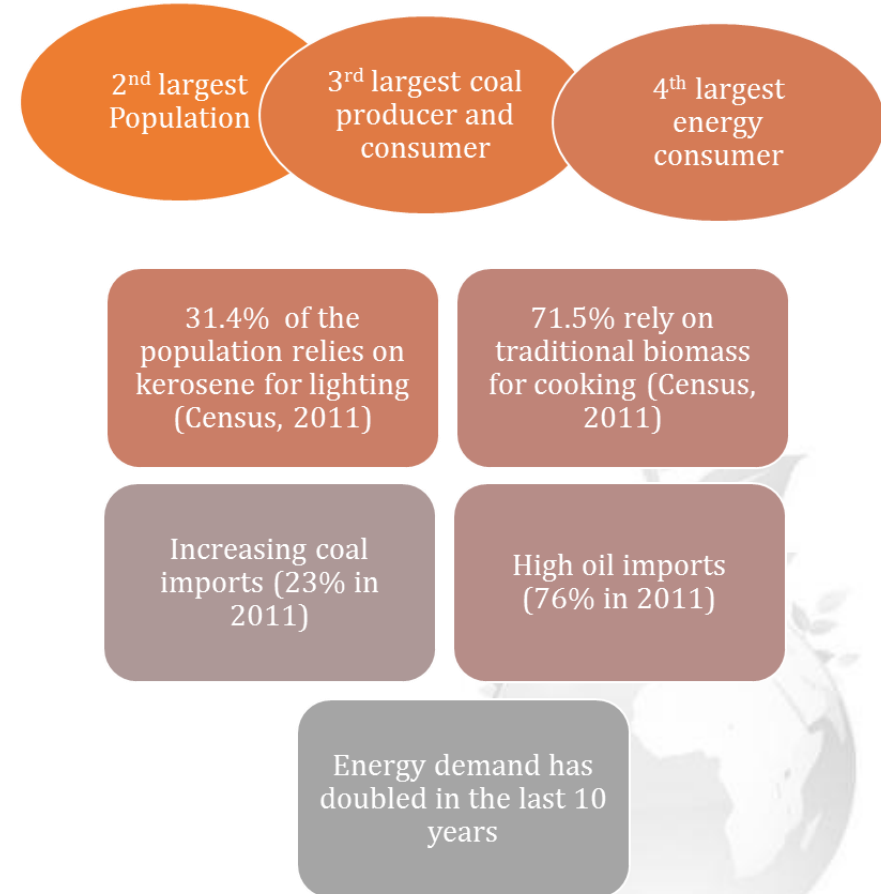
Implying massive increase in energy requirements



India's Energy Snapshot



- Low per capita primary commercial energy consumption: 506 kgoe (2011/12) (World average 1802 kgoe per capita)
- Per capita consumption of electricity 884 kWh/annum (2011/12) (World average: 3044 kWh/annum)
- 80% of rural India dependent on traditional fuels for cooking
- Fossil fuels account for about 70% of the primary energy supply



Sustained economic growth and social development require increasing energy use

Energy Access



Lighting

- It has been estimated that the annual expenditure on kerosene for lighting by off-grid and under-electrified households is around USD 2.2 billion. Out of this, around USD 1.8 billion is spent by rural households

Cooking

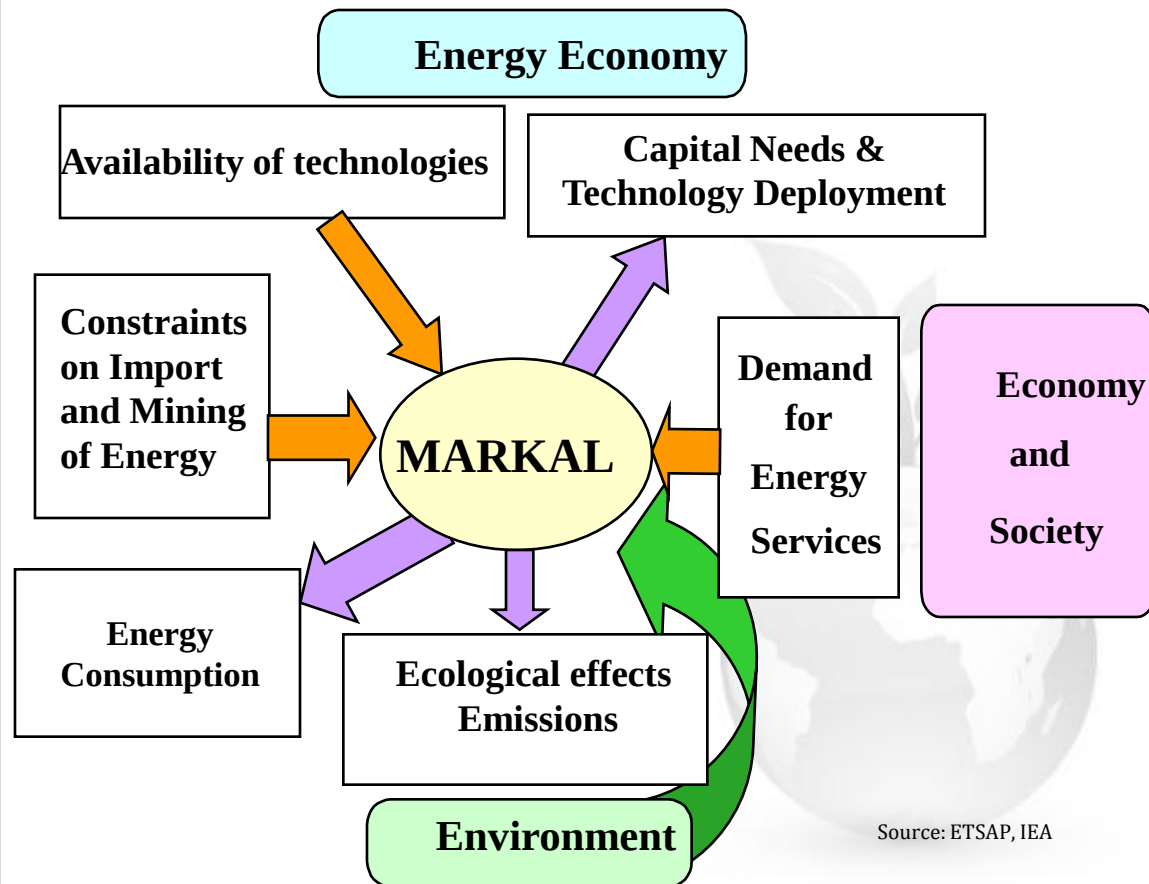
- Inefficient burning of biomass in traditional cookstoves requiring higher quantities and leading to pollution
- Indoor air pollution from burning of solid fuels increases health risks

Lighting		Cooking	
Source	Percentage	Source	Percentage
Electricity	67.3	Firewood	49
Kerosene	31.4	Crop residue	8.9
Solar energy	0.4	Cowdung cake	8.0
Other oil	0.2	Coal, Charcoal	1.5
Any other	0.2	Kerosene	2.9
No lighting	0.5	LPG	28.6
		Electricity	0.1
		Biogas	0.4
		Any other	0.5

Methodological Approach



- Detailed bottom-up technological representation of the energy system: over 300 technologies & ~ 100,000 variables
- Multi-time period, dynamic LP model extending from 2001/2-2051/52
- Objective function minimizes total energy system costs while incorporating elements of sustainable development i.e. risk minimization, energy access, self sufficiency, emissions reduction

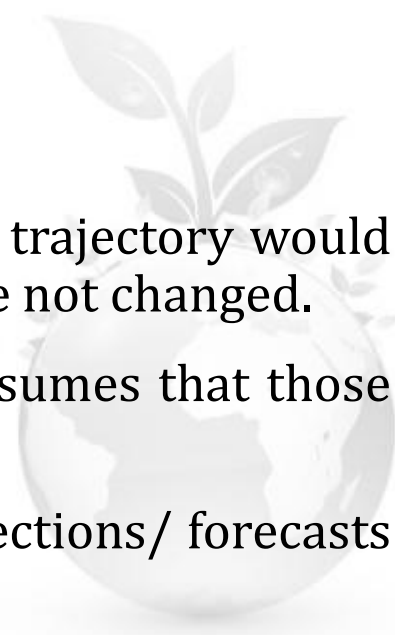


Key Assumptions

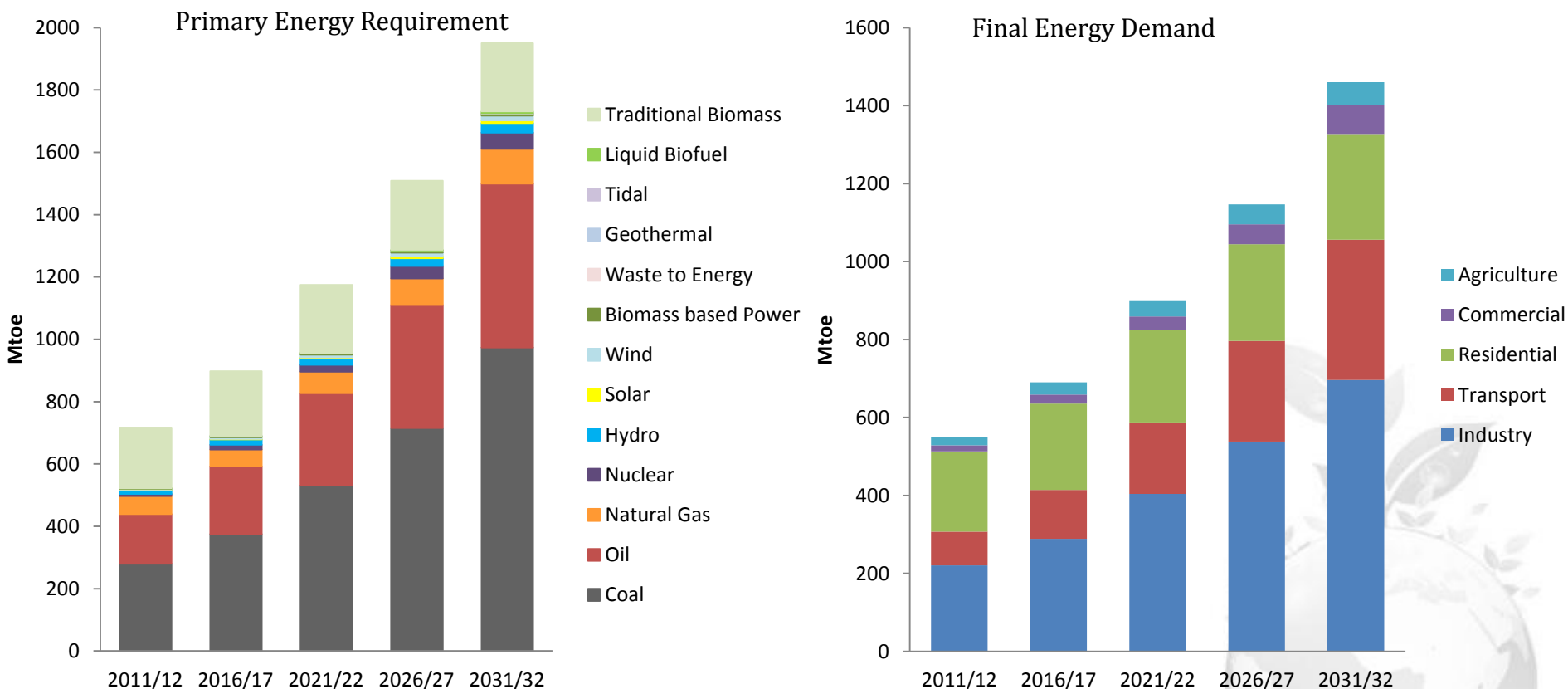
- GDP growth rate of about 8 % per annum till 2031/32
- Structural shift towards services
- Population of 1.5 billion in 2031/32
- Electricity to all & lifestyle improvements over time

Reference Energy Scenario (RES)

- Provides a baseline that shows how the nation's energy trajectory would evolve if current trends in energy demand and supply are not changed.
- Takes into account existing policy commitments and assumes that those recently announced are implemented
- Wherever necessary, a diversion from Government projections/ forecasts has been assumed



An Unambitious, Unsustainable Future



- Primary energy supply increases from 717 (2011/12) mtoe to 1950 mtoe (2031/32); coal followed by oil remain the two dominant energy sources
- Final energy demand rises from 549 mtoe (2011/12) to 1460 mtoe (2031/32), an increase of about 2.7 times in 20 years
- Industry sector continues to remain the major energy consumer (40%- 48%), and the share of transport sector rises from 16% (2011/12) to 25% (2031/32)

Why Unsustainable?

Parameter	Current Status (2011/12)
Import dependence - Oil	76%
Import dependence - Coal	23%
Import dependence - Natural Gas	21%
Total energy import dependence for fossil fuels (energy terms)	40%

- Oil imports alone would be around 10 million barrels per day by 2031/32 (from around 2.5 million barrels per day in 2011/12)
- Annual coal imports rise from around 100 MT in 2011/12 to 1012 MT in 2031/32
- Import bill rises to Rs. 33.5 trillion in 2031/32 (net import bill at 2011 prices)
- A rise by about 5.9 times of the current amount!

Source: TERI's MARKAL Model Results

Why Unambitious?

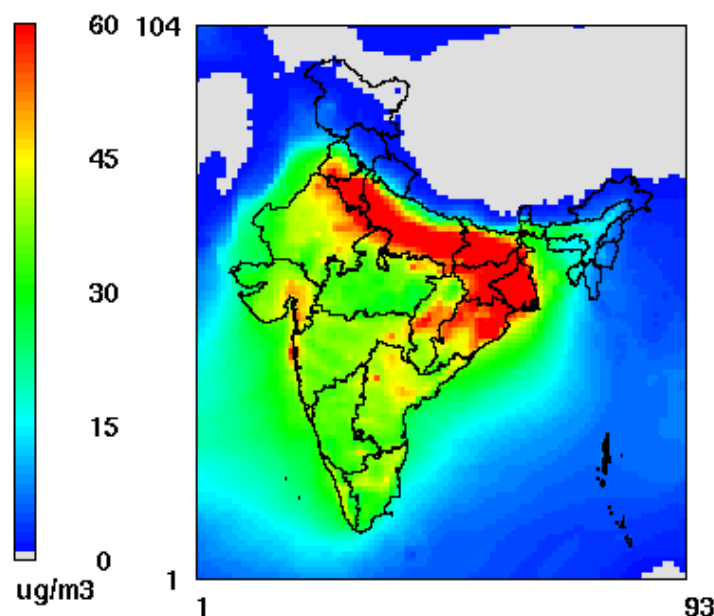
- Inadequate exploitation of locally available renewable energy resources
- Not promoting energy efficiency adequately
- Not taking advantage of available degrees of freedom in defining future pathways
- Not informing people about choices



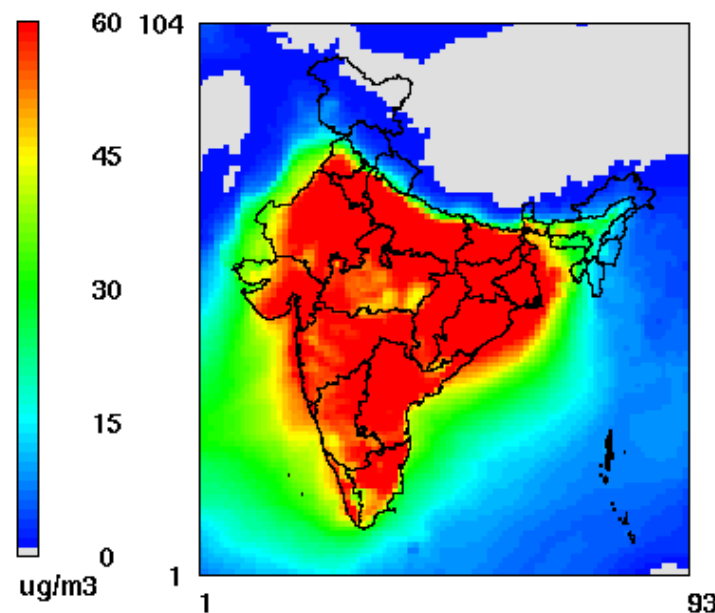
Deteriorating Air Quality

Regional scale air quality in India -2011 and projections for Reference Scenario 2031

PM2.5 (2011: Winter)



PM2.5 (2031: Winter)



Source: TERI's Integrated MARKAL, WRF, CMAQ Models Results

- By 2011/12, most cities in the country had already exceeded the ambient air quality standard
 - In 2011/12 mortality from PM 2.5 was 5.73 lakhs
 - In future, the air quality worsens increasing the mortality to 10.45 lakhs (2031/32)



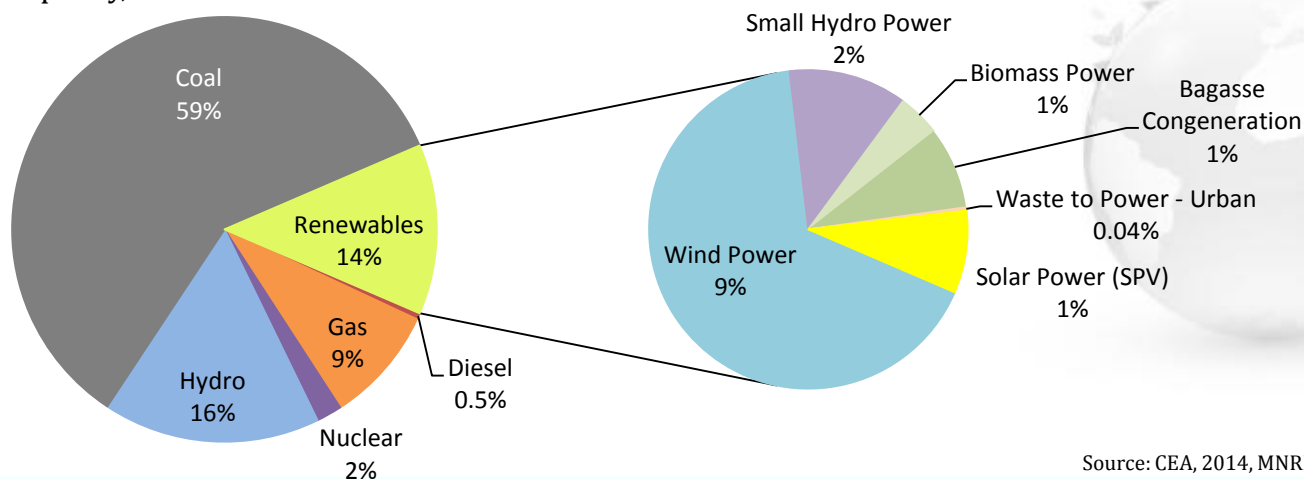
Sector Outlook



Electricity Sector: Present Situation

- High share of coal in the generation capacity mix
- Shortage of fuel availability resulting in loss of generation
- Infructuous investments due to unavailability of fuel
- Issues related to large-scale integration of renewable energy
- High R&D losses
- Poor financial health of the utilities

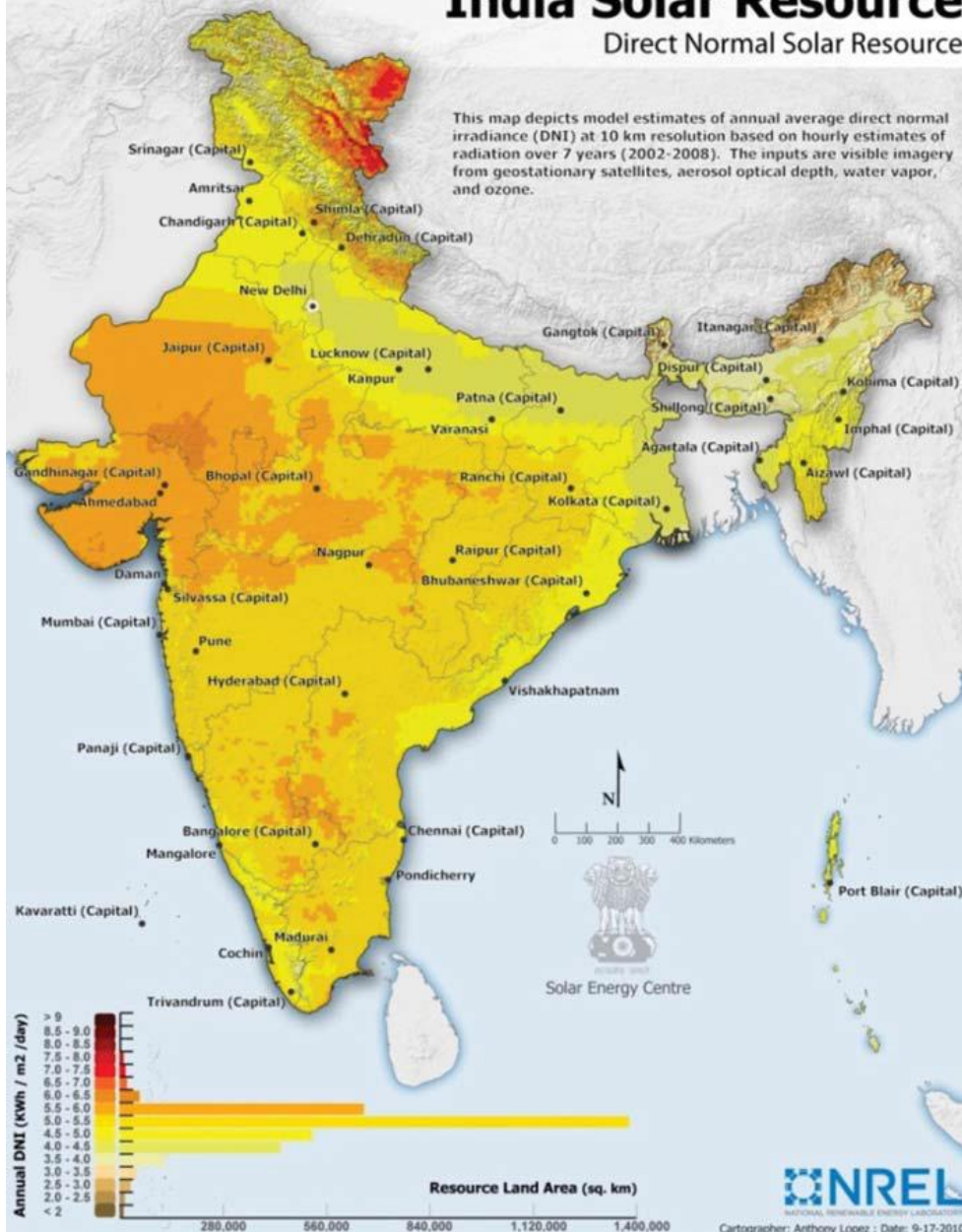
Installed Power Generation Capacity, 2014



India Solar Resource

Direct Normal Solar Resource

This map depicts model estimates of annual average direct normal irradiance (DNI) at 10 km resolution based on hourly estimates of radiation over 7 years (2002-2008). The inputs are visible imagery from geostationary satellites, aerosol optical depth, water vapor, and ozone.



On shore Potential of Wind Power in India

Source	Estimated potential (GW)	Hub height (m)	Other assumptions
C-WET	49	50	2% land availability for all states except Himalayan states, North-eastern states and Andaman and Nicobar Islands
C-WET	102	80	
LBNL	2,006	80	Based on GIS data on topography and land use, the study found a significantly high availability of land (7%) that can potentially be used for wind power development. The study excluded land with low-quality wind, slopes greater than 20 degrees, elevation greater than 1,500m and certain other unsuitable areas such as forests, water bodies and cities.
LBNL	3,121	120	
Low Carbon Working Group (Twelfth Five-year Plan)	500	80	6% land availability

Transport: Present Situation



- Rapid growth in transport demand was seen in the last decade
- Rapid motorization across the country (increase in registered vehicles from 52m veh. in 2000-01 to 145m veh. in 2011-12)
- Growth driven by population growth, economic growth, urbanization and motorization
- Huge requirement on imported crude to meet this demand
- Emergence of road sector as the predominant means of passenger and freight travel
 - 86% of total passenger-km
 - 65% of the freight-km
- Decline in the share of Railways
 - 1950 – 74% (Pass.) – 80% (Freight)
 - 2010 – 12% (Pass.) – 35% (Freight)
- Declining share of public transport
- Air transport gaining momentum as an inter-city travel mode
 - Witnessed 8 times growth in the last decade



Key interventions for end use efficiency improvement : Transport Sector



- Continuous vehicle efficiency improvement
- Increase share of rail in freight movement (50% by 2031, as compared to 30% in REF)
- Increase share of rail in passenger movement (20% by 2031 as compared to 15% in REF)
- Enhancement in the share of public-mode based passenger movement to (75% by 2031 as compared to 59% in REF)
 - Expand the Dedicated Freight Corridors across the country's quadrilateral (around US\$ 50 billion investment requirement)
 - Introduce High Speed Rail services across select corridors to retain railway passenger shares (for 12 routes around US\$ 100 billion investment requirement)
 - Metro rail network in all million plus cities by 2031 (60 cities) (around US\$ 150 billion investment)

Industry Sector: Present Situation



- Industry sector accounts for about 50% of total commercial energy consumption in India (2010/11)
- Large Industry sector
 - New plants: Mostly adopt energy efficient/state of the art technological options as per the global standard on their own. e.g. cement, paper, etc.
 - Existing/old plants: Options exist for energy efficiency improvements
- Medium and small scale industries
 - 26 million enterprises
 - Existence of many energy intensive industrial clusters
 - Manufacturing 6000 products and employing 60 million people
 - Majority of units use obsolete technologies and unskilled manpower
- Efficiency improvement in the medium and small scale industries is a key challenge
 - Availability of technology and finance



Residential and Commercial: Present Situation



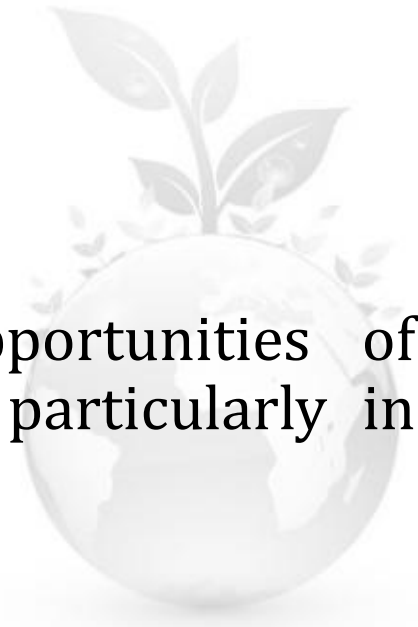
- Household electricity consumption due to appliances is expected to increase significantly in the future due to growth in per capita income.
- Electricity consumption by buildings has been growing over the years, from 15% (1970/71) it has grown to 34% of the total consumption in 2010/11.
- There is going to be huge demand for real estate space in India in the coming years and the electricity consumption by buildings is likely to grow even more with this construction boom in India
- Upcoming commercial buildings are highly energy intensive. If they are built and operated in the conventional manner, their energy demand will increase enormously
- There is a significant potential for electricity savings by buildings sector in India

*Efficient lighting alone has **50%** electricity saving potential*

Key Recommendations

- Recognise the synergistic interdependence between energy sector development and other sectors
 - Urban
 - **Health**
 - Water
 - Food

- Importantly, recognise the job creation opportunities of decentralised, distributed energy generation, particularly in support of energy access and the SME sector



Energy policies are usually much more effective and readily accepted if they are integrated into broader development plans



Thank You

