Energy Scenarios for India

Atul Kumar

The Energy and Resources Institute

Conference on Balancing Growth and Environmental Sustainability

June 12, 2014, New Delhi

India: Current Energy Status

Creating Innovative Solutions for a Sustainable Future

- Coal is the major source of energy (~ 50% of commercial energy supply)
- Very high import dependency of crude oil (~ 70%)
- Per capita consumption of electricity of 884 kWh/annum (2011/12)
  - **World average: 3044 kWh/annum**
- Suffering from huge power shortages (2012/13) of
  - **8.7% in energy terms**
  - **9% in peak energy**
- ~ 80 million households with no access to electricity (out of 247)
- ~ 32,000 villages are yet to be electrified
- 80% of rural India dependent on traditional fuels for cooking

Increase in Energy Needs – an Inevitability !

Creating Innovative Solutions for a Sustainable Future

- Economic growth
  - **Poverty eradication and development goal**
- Increasing urbanization
- Provision of adequate and equitable access to basic amenities and services
  - **Infrastructure expansion (already stressed)**
- Daily need of energy services
  - **Cooking, lighting, and space cooling, etc.**

Implying massive increase in energy requirements

Future Challenges

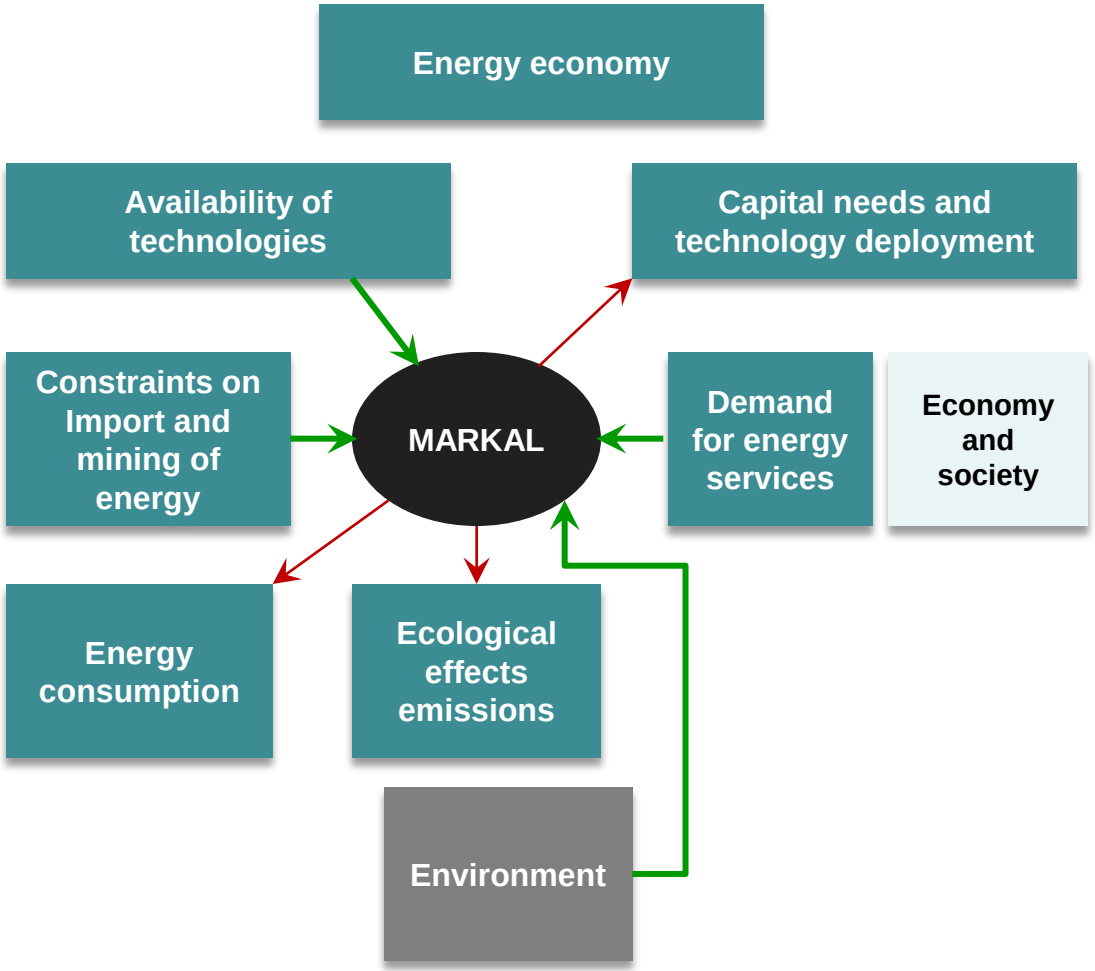
- Concerns of:
  - **Energy access**
  - **Energy import vulnerabilities**
  - **Climate change**
- What then are the options & what are the implications of adopting alternative choices to fuel the country's energy needs?
- Scenario based analysis

TERI's MARKAL Modeling Framework

Creating Innovative Solutions for a Sustainable Future

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

Economy-Energy-Environment linkages

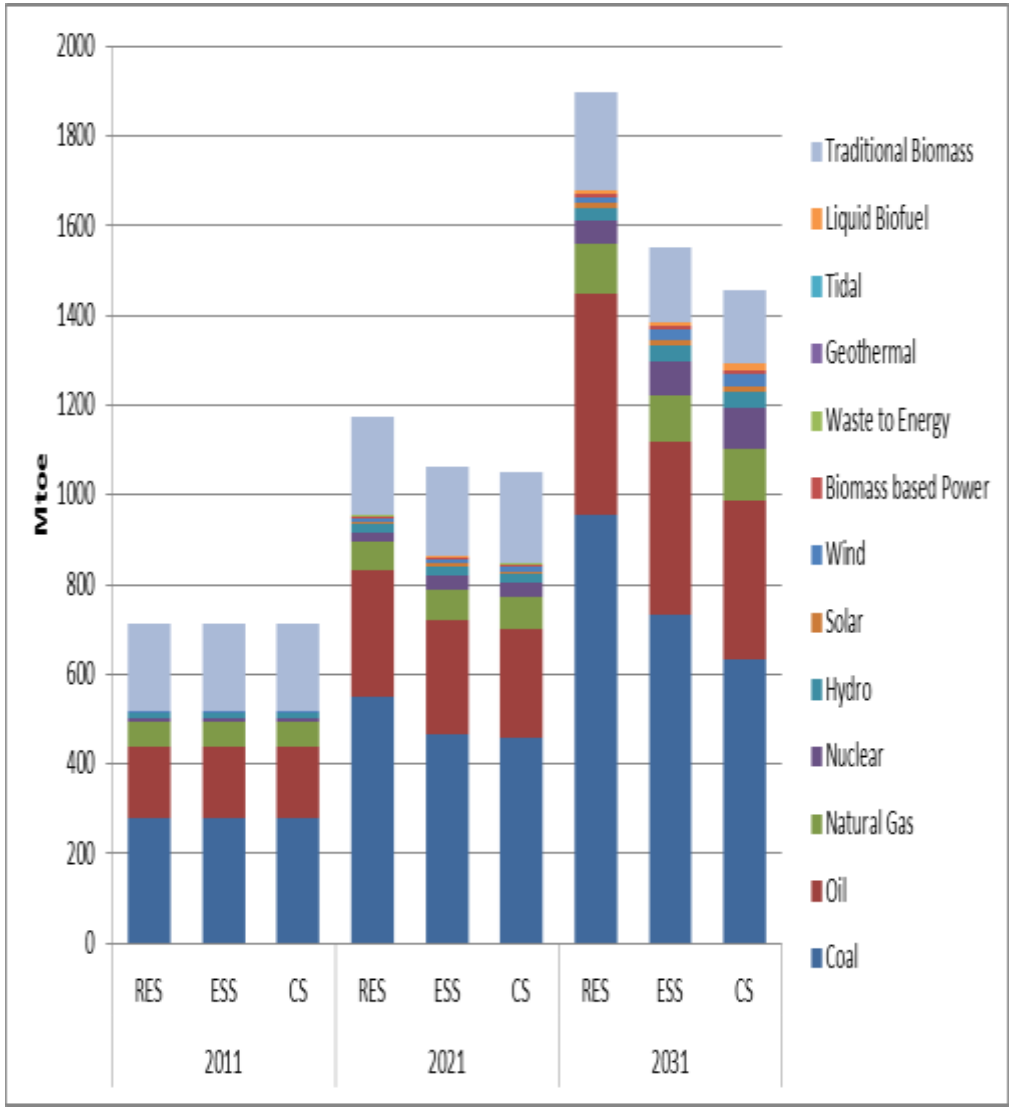


Possible Future Energy Scenarios

Creating Innovative Solutions for a Sustainable Future

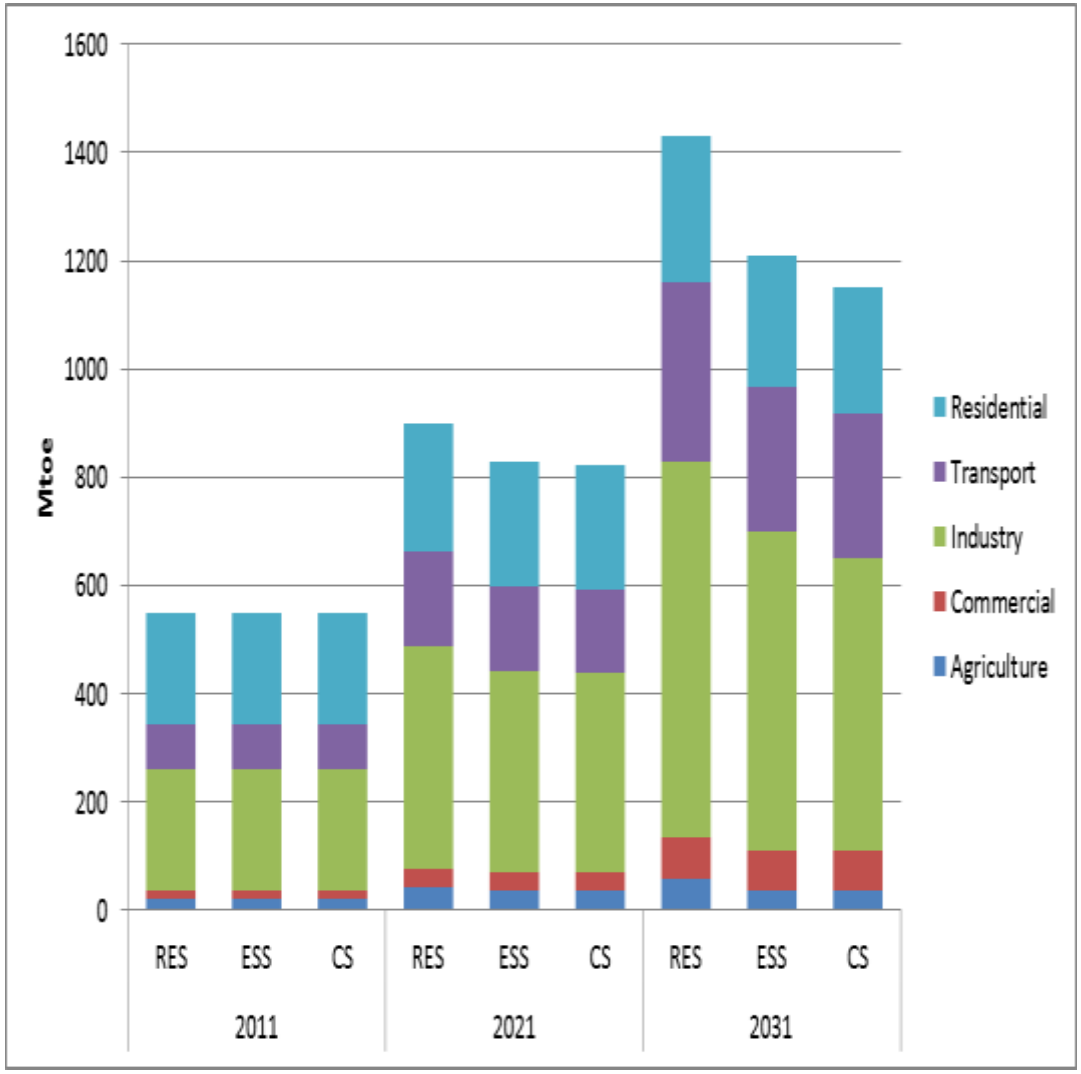
Scenario Name	Storyline
Reference Energy Scenario (REF)	Current policies are implemented & improvements in efficiency continue at the current pace
Energy Security Scenario (ESS)	A determined effort is provided here for efficiency improvements both on the supply and demand sides, an accelerated push diversifying the energy mix & increasing renewables and penetration of new technologies. Energy Security concerns are paramount in this scenario & efforts are made to increase domestic production & use of energy.
Climate Scenario(CS)	This is an extremely aggressive scenario geared towards reducing the carbon footprint. Broadly, this is in line with TERI's Carbon Budget Approach where in order to limit the temperature increase to 2^0C, emissions are constrained to entitlements of around 2.2 tonnes per capita CO_2 based on equal emissions per human year basis

Primary Energy Supply



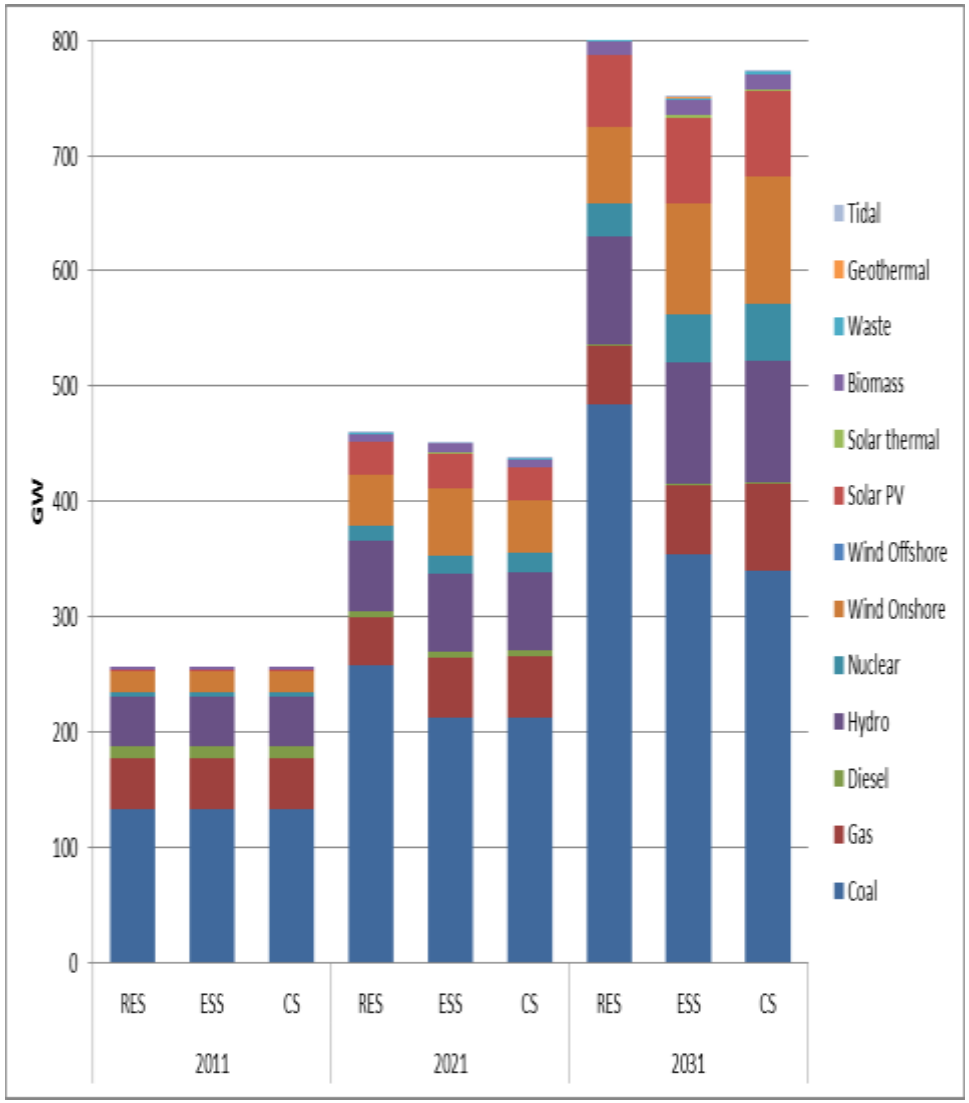
- The primary energy supply increases from 714 Mtoe in 2011 to 1897 Mtoe in 2031 in the REF scenario (CAGR: 5%)
  - **Coal : 39% (2011), 50% (2031)**
  - **Biomass: 27% (2011), 12 % (2031)**
  - **Oil: 22% (2011), 26% (2031)**
- Reduction of primary commercial energy supply in ESS and CS
  - **ESS in 2031: 1533 Mtoe (18% reduction)**
  - **CS in 2031: 1457 Mtoe (23% reduction)**
- Coal (2031) – ESS: 47%, CS: 44%
- Renewable & Nuclear (2011): 2%; 2031 REF: 5%, ESS: 8%, CSS: 11%

Final Energy Demand



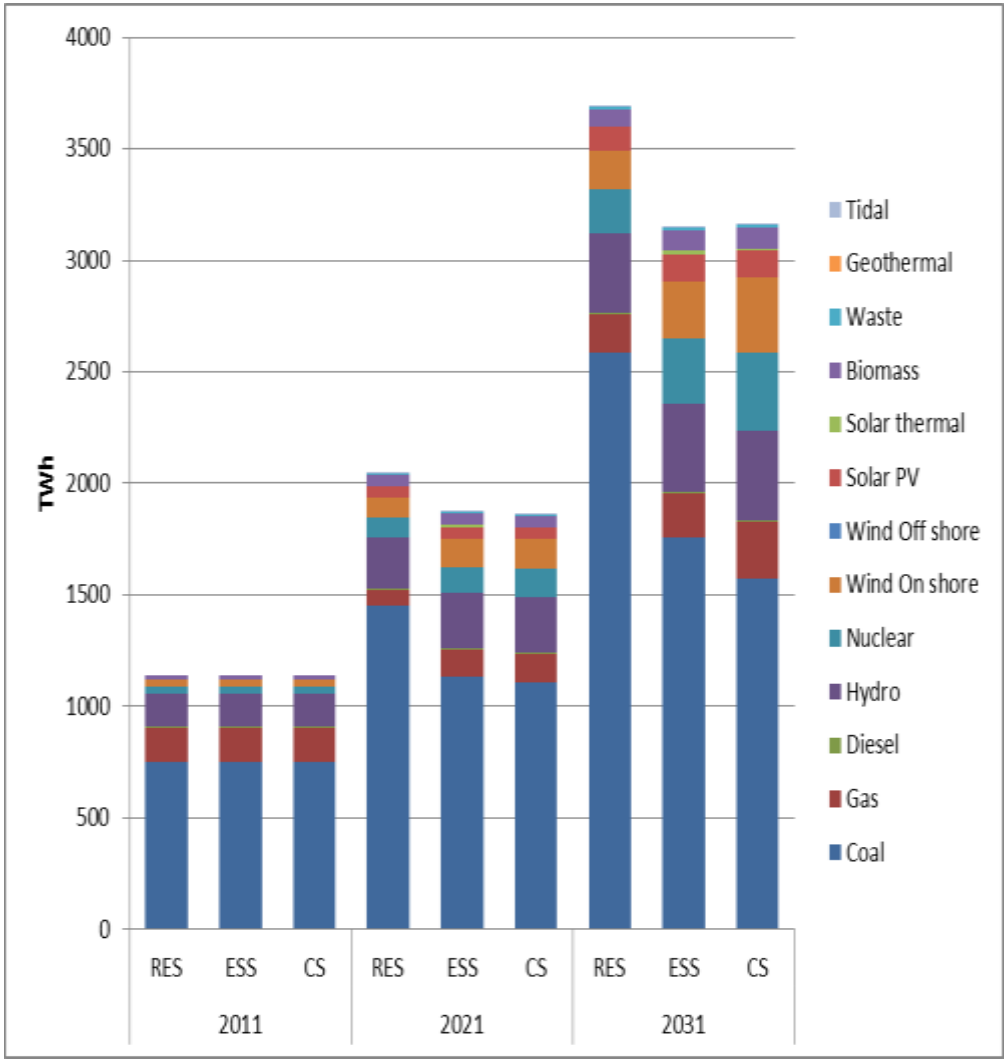
- Final Energy Demand in the REF grows from 558 Mtoe (2011) to 1430 Mtoe (2031) at a CAGR of 4.9%
- ESS in 2031: 1209 Mtoe (2031) showing a reduction of 15% as compared to REF
- In CS it drops further to 1152 Mtoe in 2031 (19% reduction)
- Sectoral share in REF
  - **Industry 41% (2011), 48% (2031)**
  - **Residential:38% (2011), 19% (2031)**
  - **Transport: 15% (2011), 23% (2031)**

Power Generation Capacity (Centralized & Decentralized)



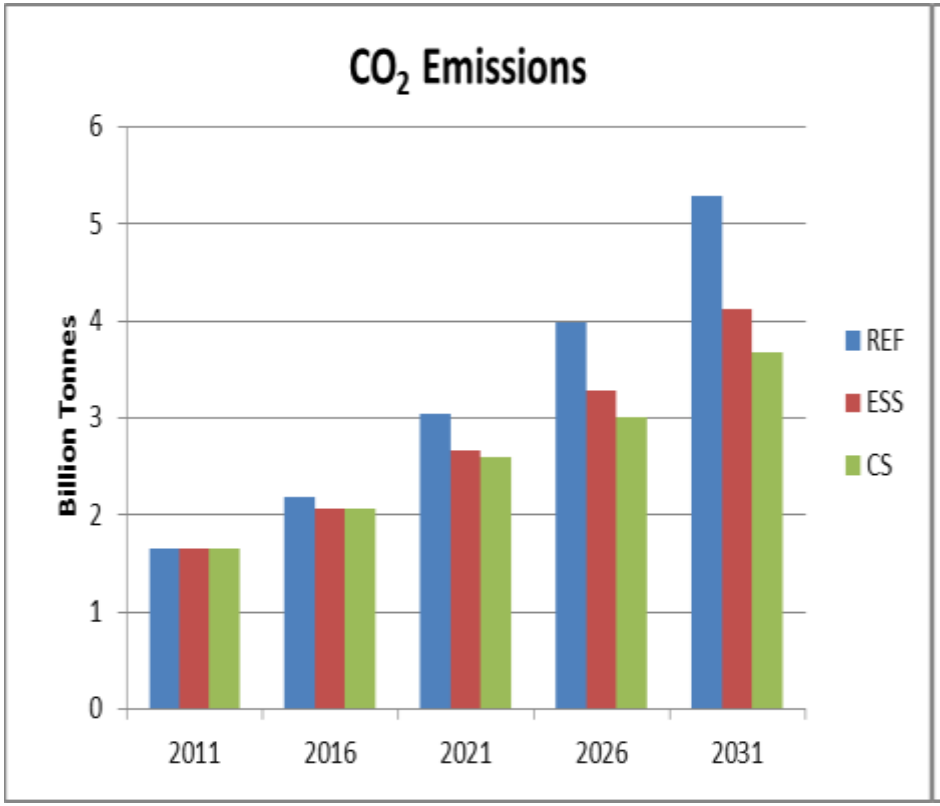
- The generation capacity increases significantly from 257 GW in 2011 to 800 GW in 2031 in the REF scenario.
  - **ESS in 2031: 750 GW**
  - **CS in 2031: 772 GW**
- In 2011: 50% was coal based capacity while renewables formed 9% capacity.
- In 2031 in the REF, coal based capacity contribute to 60% while renewable based generation capacity is 18%
- In 2031 in ESS and CS scenario however coal based generation drops to 47% and 44% respectively while renewable based generation increases to 25% and 26% respectively

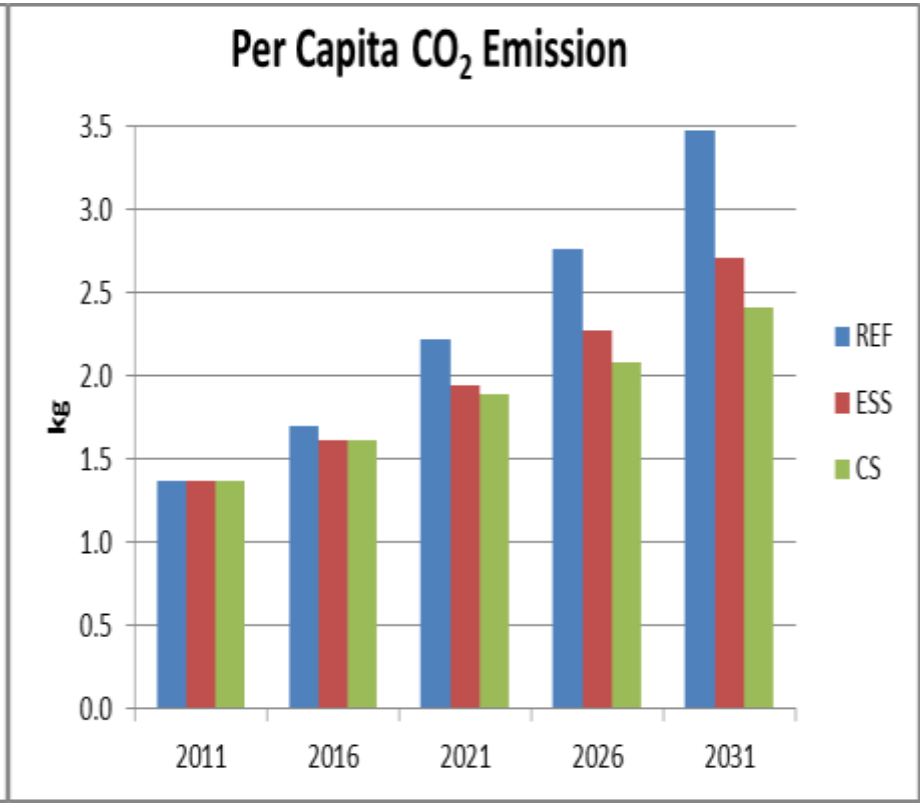
Electricity Generation (Centralized & Decentralized)



- The total annual power generation increases from 1141 TWh in 2011 to 3689 TWh in the REF (CAGR: 6%),
- Power generation drops in the ESS and CS scenarios compared to the REF scenarios.
- This seems contrary to the capacity addition, due increase in renewable in the energy mix which has a lower availability factor.

CO_2 Emission





- CO_2 emission in the REF: 1.6 billion tonnes (2011), 5.3 billion tonne (2031)
  - **ESS in 2031: 4.1 billion tonne (22% reduction from REF)**
  - **CES in 2031: 3.7 billion tonne(31%)**
- Per capita CO_2 emission in 2011: 1.7 kg
  - 2031- REF 3.5 kg, ESS: 2.7 kg, CS: 2.4 kg

Sectoral directions

Creating Innovative Solutions for a Sustainable Future

- Residential & Commercial sector
  - **Electricity requirements expected to increase rapidly**
  - **Efficient lighting (CFL, LED)**
  - **Efficient appliances**
    - BEE initiative already exists: (Lighting ; Refrigerators, AC)
  - **Building design**
    - Day lighting integration in design
    - Natural ventilation / thermal comfort
    - Efficient building envelop design
  - **Progressive improvement of standards/norms**
- **Agriculture sector**
  - **Efficiency of irrigation pumpsets**
  - **Impact of subsidised electricity on electricity use in agriculture**

Sectoral directions

Creating Innovative Solutions for a Sustainable Future

- Transport sector
  - **Modal shifts towards rail based movement, public transportation efficiency improvement of vehicle**
- **Industry sector**
  - **Significant efficiency improvements in SMES**
  - **Recycling and reuse**
- **Power sector**
  - **Advanced coal generation technologies**
  - **Renewable**
  - **Nuclear**

Major directional findings

Creating Innovative Solutions for a Sustainable Future

- Several directional synergies in the energy security and climate driven scenarios
- Need for energy efficiency to play a key role – several ”win-win” options that may be tapped immediately
- Renewables would eventually need to play a much larger role in India’s energy scene
- Local resources, infrastructure and environmental considerations important to plan for

For more detail

Creating Innovative Solutions for a Sustainable Future

TERI's Forthcoming Publication

ENERGY SECURITY OUTLOOK

Defining a secure and Sustainable Energy Future for India

DFID-TERI Partnership on Clean Energy Access and Improved Policies for Sustainable Development

UKaid
from the British people

Thank you !