The India Energy and Greenhouse Gas Model: Model Overview and Results

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India’s Energy Challenges

- Expanding population
- Increasing demand for total primary energy
- The current and projected fuel supply mix may lead to:
  - Deteriorating local air quality
  - Increasing global carbon emissions
- Fuel imports may increase
Total Primary Energy Demand in India

Electricity Generation Mix in India

The India Energy and Greenhouse Gas Model
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- GDP
- Energy Intensity
- Fuel Source by Economic Sector
- Electricity Share
- Electricity by Fuel Type
- Population
- Carbon Content
- Domestic Fossil Fuel Production
- Demand for Primary Energy by Economic Sector
- Total Demand for Primary Energy by Fuel
- Total Electricity
- Total Demand for Primary Energy
- Carbon Emissions
- Fuel Imports
Model Input (1990 – 2020)

- GDP growth scenarios

- Energy consumption by fuel type
  - Coal, oil, natural gas, nuclear, hydroelectric, other renewables, combustible renewables
  - Derived and user defined scenarios

- Electricity consumption share by fuel type
  - Coal, oil, natural gas, nuclear, hydroelectric, other renewables
  - Derived and user defined scenarios
Model Outputs (1990 – 2020)

- Gross Domestic Product
- Population
- Energy consumption share by fuel type
  - Coal, oil, natural gas, nuclear, hydroelectric, other renewables, combustible renewables
- Electricity consumption by fuel type
  - Coal, oil, natural gas, nuclear, hydroelectric, other renewables
- Carbon emissions (total and per capita)
- Implied fuel import requirements
Base Case Results: Primary Energy

The chart depicts the primary energy sources from 1990 to 2020.

- **Coal**
- **Oil**
- **Natural Gas**
- **Nuclear**
- **Hydroelectricity**
- **Other Renewables**
- **Biomass**
Base Case Results: Electricity by Fuel Type

- Coal
- Oil
- Natural Gas
- Nuclear
- Hydroelectricity
- Other Renewables
- Biomass

Quads

- 1990
- 2000
- 2010
- 2020

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GDP Growth Scenarios: Primary Energy

- Low Growth (3%)
- Medium Growth (4.6%, Base Case)
- High Growth (7%)
Primary Energy: Biomass

• There is still a strong reliance on biomass in the residential sector (76% of residential energy demand in year 2000 was biomass).

• A biomass reduction scenario considers the gradual shift from this heavy reliance on biomass to electricity.
  – Biomass share decreases in the residential sector from 76% to 50%
  – Electricity share increases from 12% to 38%
Biomass Reduction Scenario, 2020

The substitution increased projected carbon emissions by 34 million metric tons carbon (MtC) (8%) in 2020.
Electricity Development Scenarios

- **Aggressive Nuclear Technology (ANT)**
  » Doubles 2020 nuclear capacity, 6 to 12 GW

- **Advanced Coal Technology (ACT)**
  » Increases future coal plant efficiency by 5%

Electricity by fuel in 2000

- Coal 85%
- Natural Gas 6%
- Oil 2%
- Nuclear 3%
- Hydroelectric 4%
- Other Renewables <1%

Nuclear and Coal Electricity Scenarios: Total Primary Energy Demand, 2020

Carbon Emissions in 2020:
Base Case (476.2 MtC), ANT (464.9 MtC), ACT (457.7 MtC)

Aggressive Nuclear Technology (ANT), Advanced Coal Technology (ACT)
Carbon Emissions

- India represents 5.6% and 6.8% of world carbon emissions in 2000 and 2020, respectively.

- Limited fuel switching opportunities from coal to cleaner sources exist.
Per Capita Carbon Emissions

- Per Capita carbon emissions in 2000 were 0.25 tC/person in India, 0.54 in China, and 5.67 in the U.S.

- Projected per capita emissions in 2020 are 0.33 tC/person in India, 1.17 in China, and 6.47 in the U.S.
Energy Imports will Likely Increase

• Oil
  – Imports in 2000 were 1.3 million barrels per day, 65% of the total oil demand
  – Imports by 2020 may reach 3.2 million barrels per day, 88% of the total oil demand

• Natural Gas
  – India was self-sufficient in 2000
  – Imports by 2020 may reach 3.1 billion cubic feet per day, 39% of the total natural gas demand.
Conclusions

- India’s primary energy demand is projected to increase from 19.9 to 30.0 Quads (50%), and carbon emissions 250.0 to 440.4 MtC (76%) between 2000 and 2020.

- Substitution from biomass to electricity would increase carbon emissions

- Large scale adoption of advanced nuclear or coal technologies will have only minimal impacts on reducing carbon emissions
Conclusions
(continued)

• Carbon emissions are relatively low compared to industrialized countries and China

• Energy imports will likely increase for oil by 1.9 million barrels per day, and natural gas by 3.1 billion cubic feet per day
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