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

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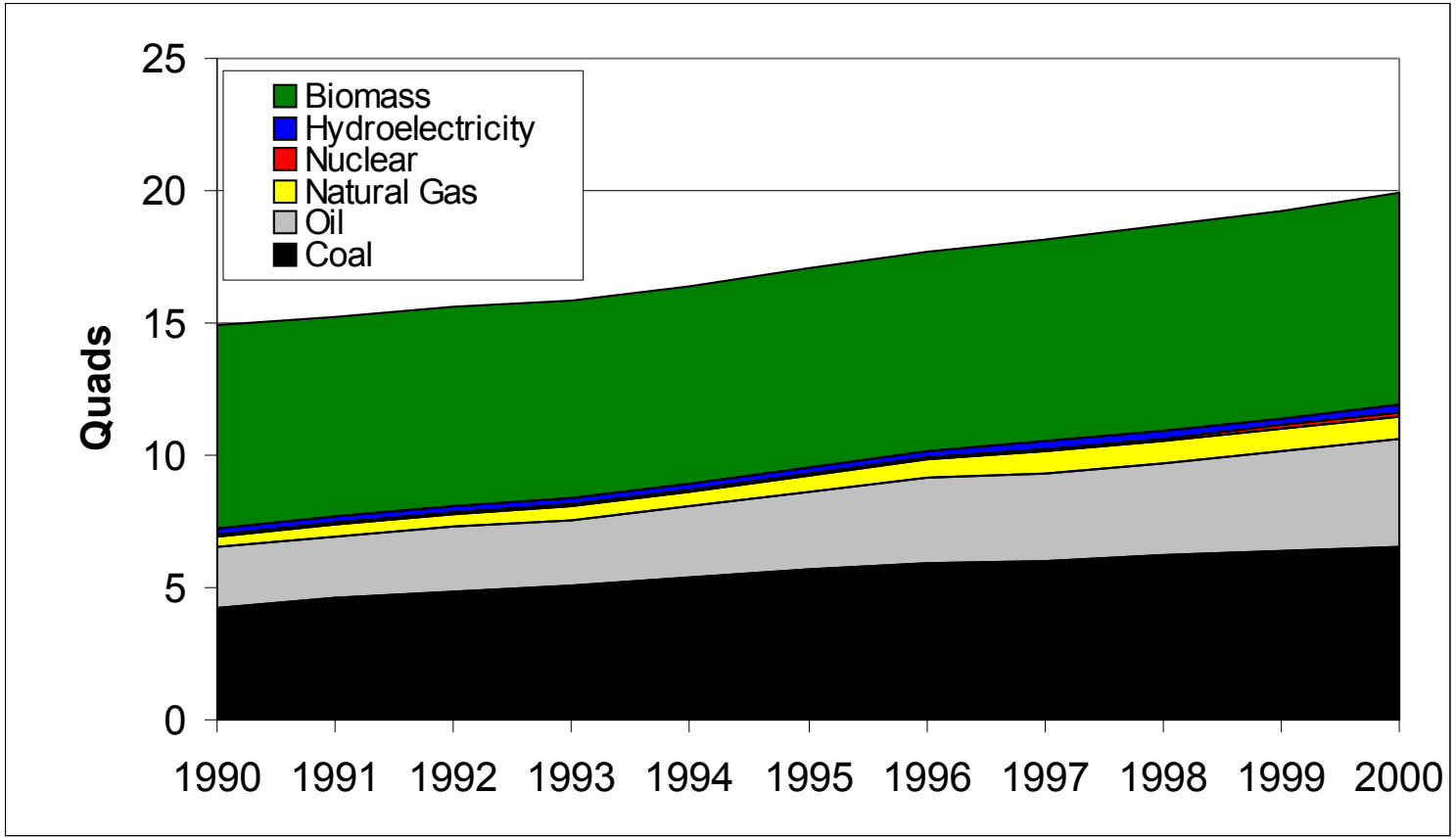
India's Energy Challenges

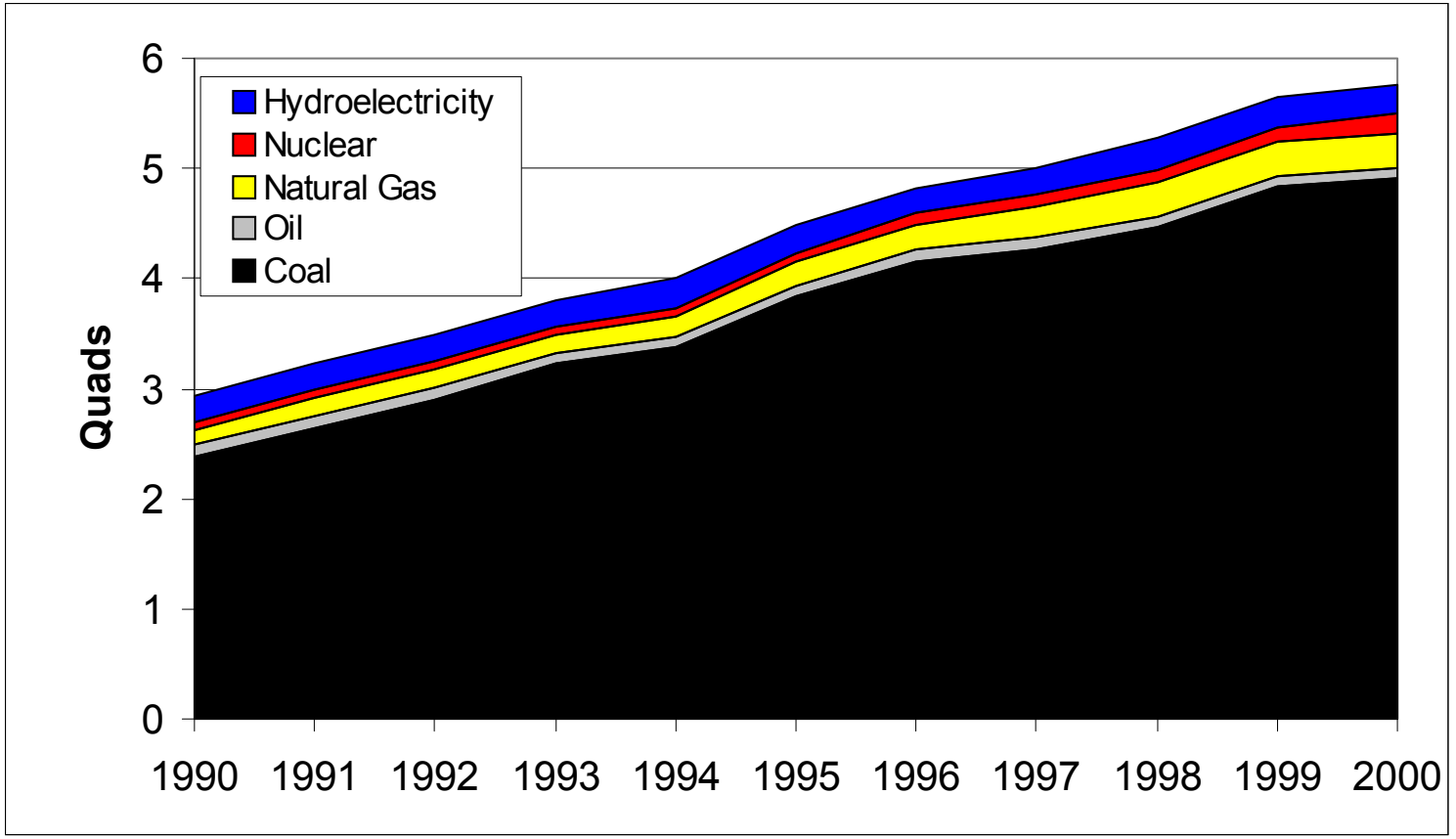
- **Expanding population**
- **Increasing demand for total primary energy**
- **The current and projected fuel supply mix may lead to:**
  - **Deteriorating local air quality**
  - **Increasing global carbon emissions**
- **Fuel imports may increase**

Total Primary Energy Demand in India



Source: International Energy Agency, 2002.

Electricity Generation Mix in India



Source: International Energy Agency, 2002.

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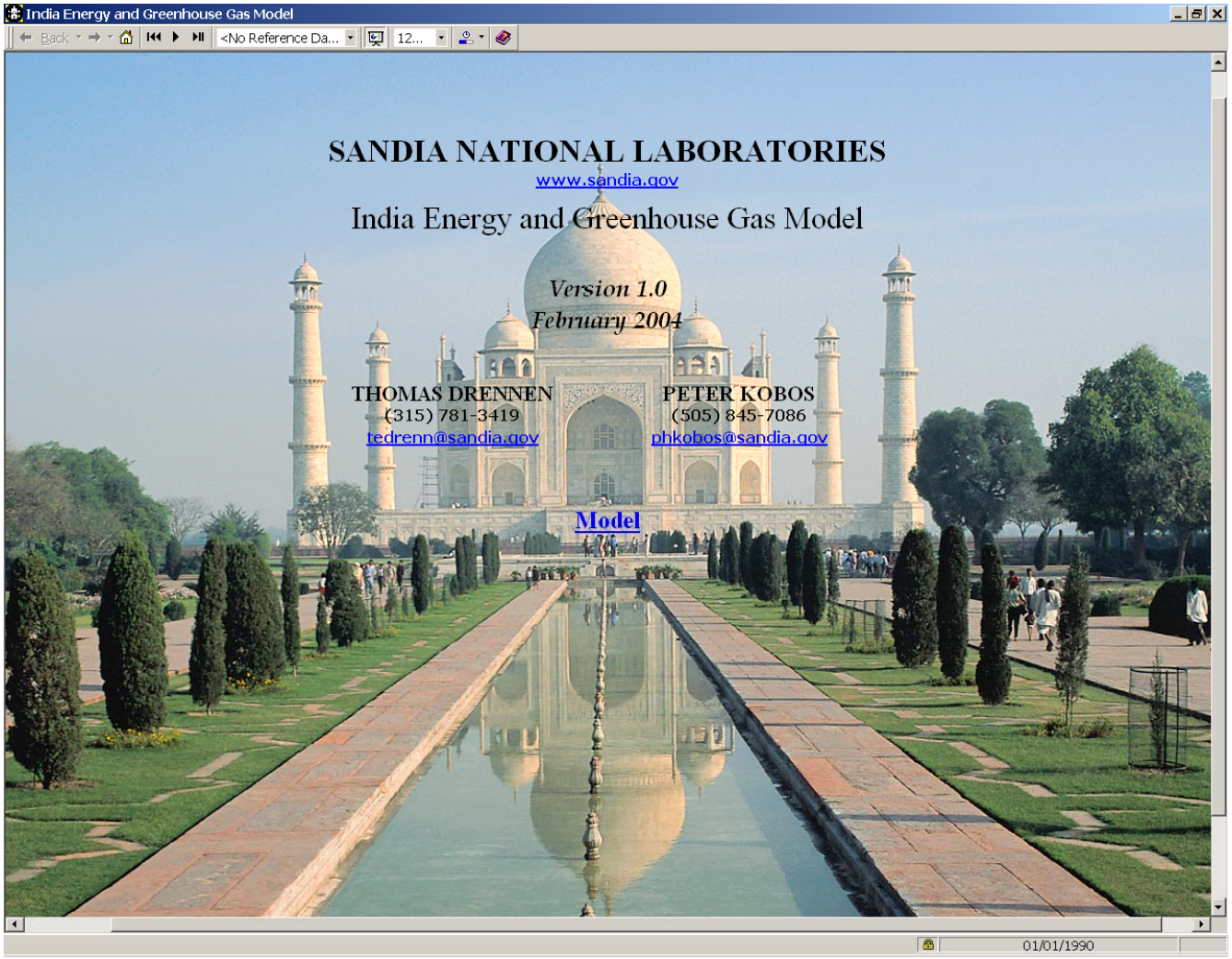

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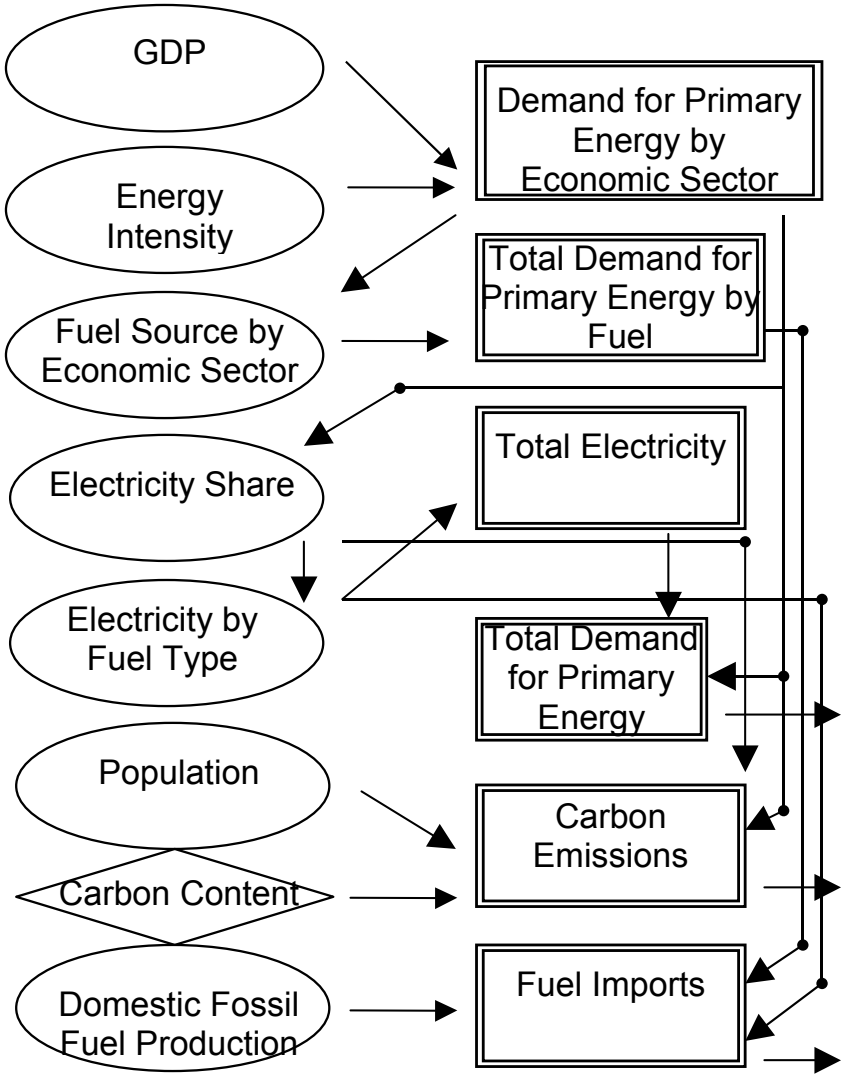

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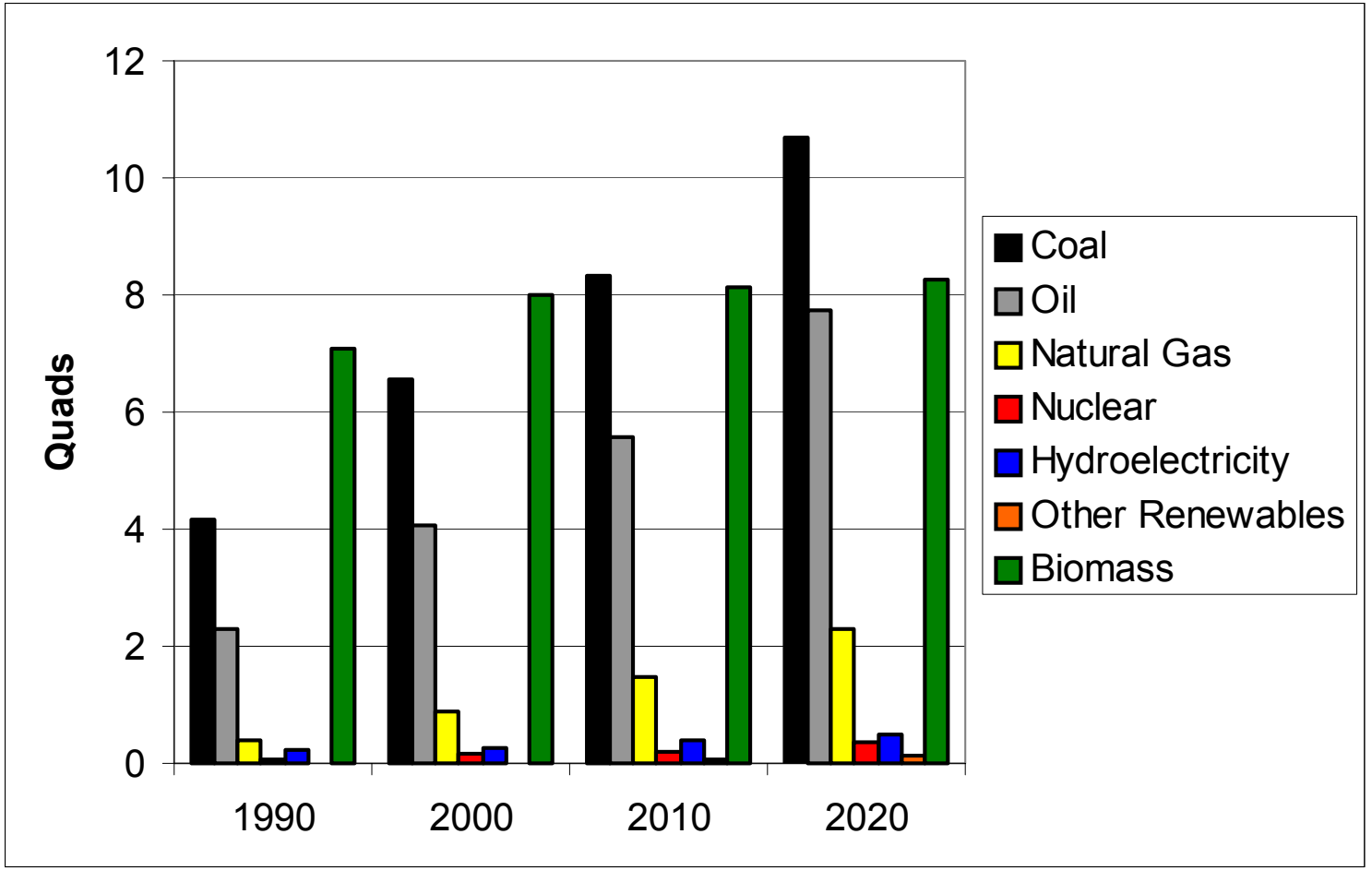
Model Input (1990 – 2020)

- **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**

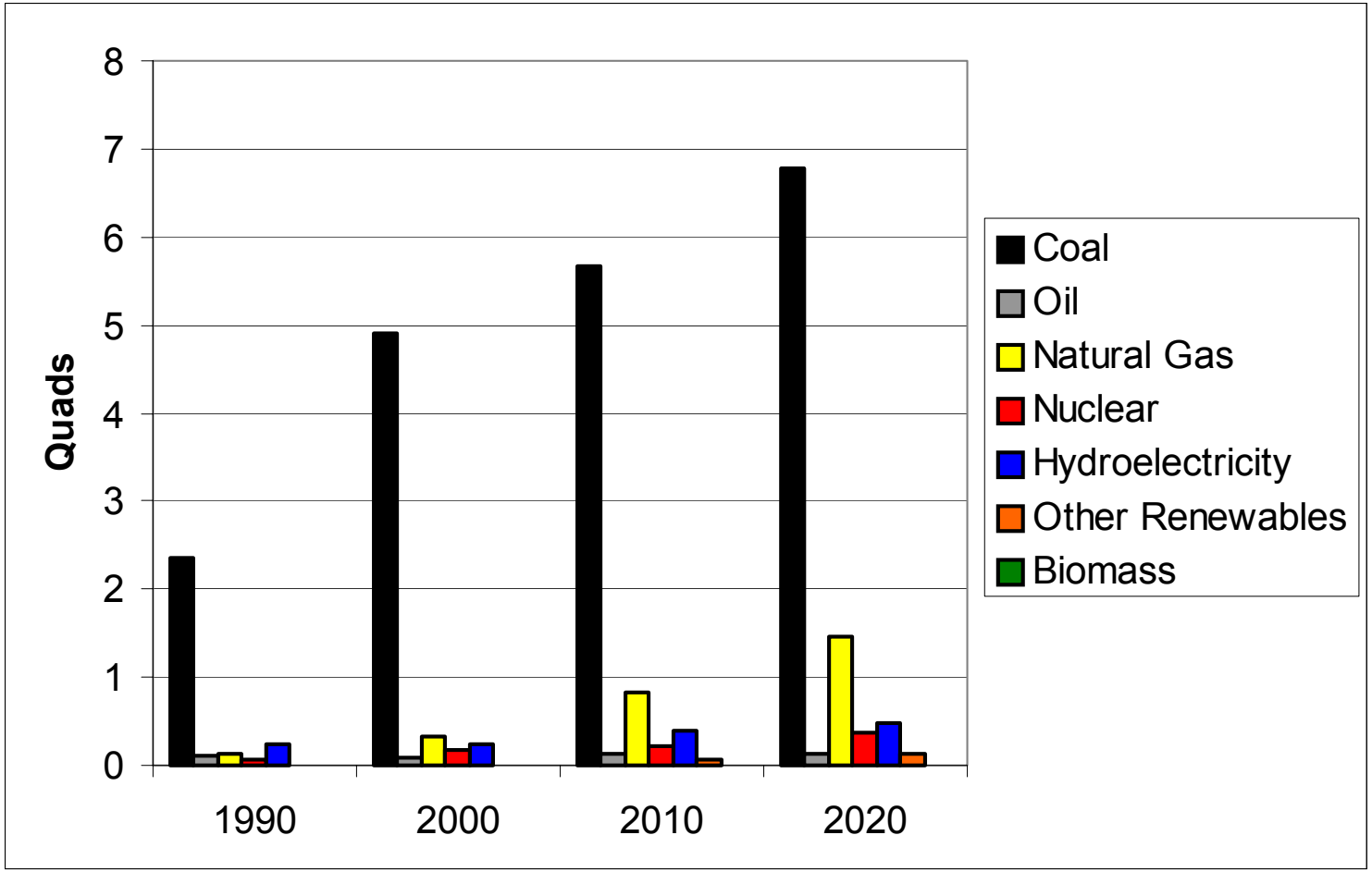
Model Outputs (1990 – 2020)

- 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

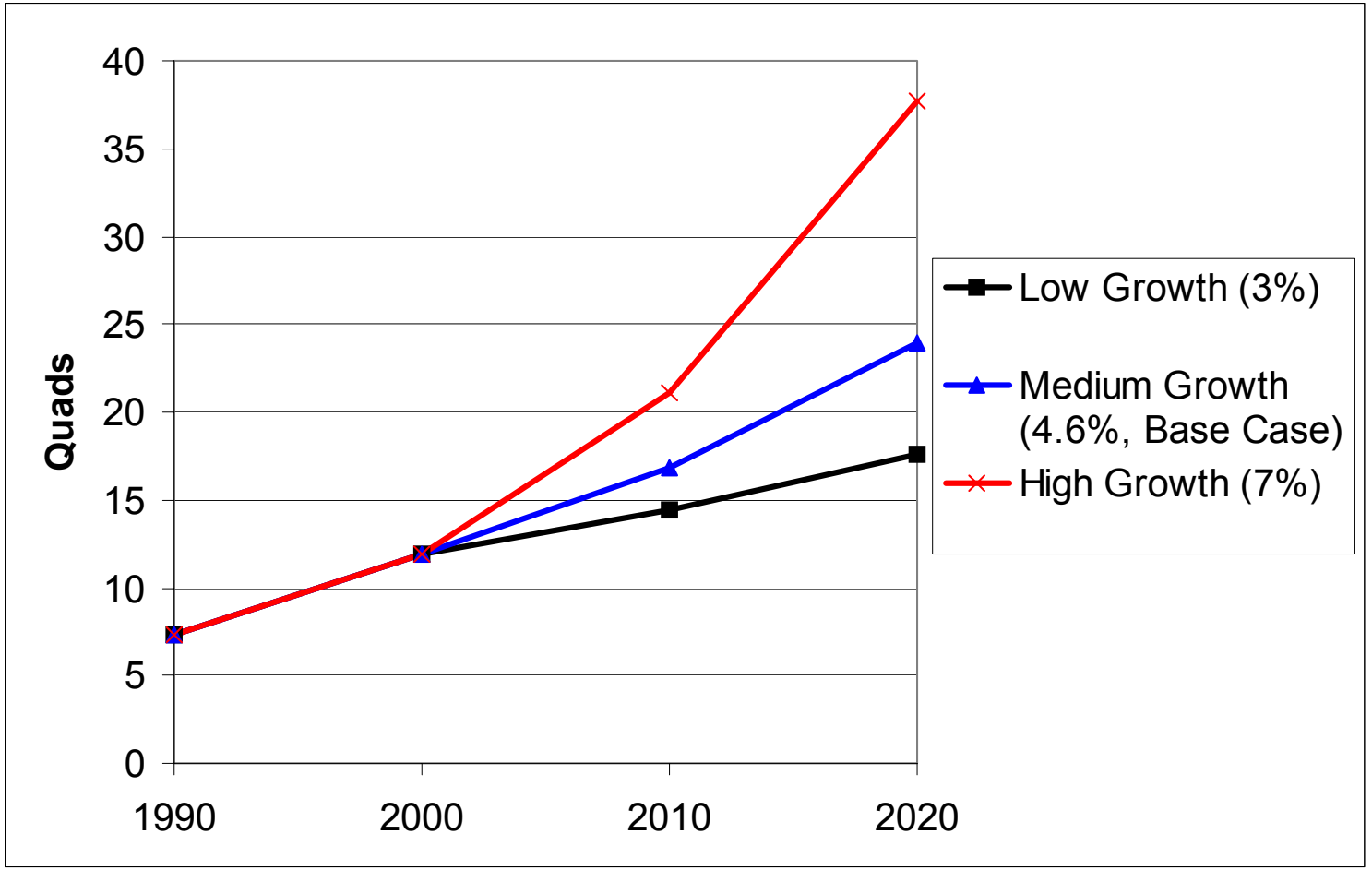
Base Case Results: Primary Energy



Base Case Results: Electricity by Fuel Type



GDP Growth Scenarios: Primary Energy



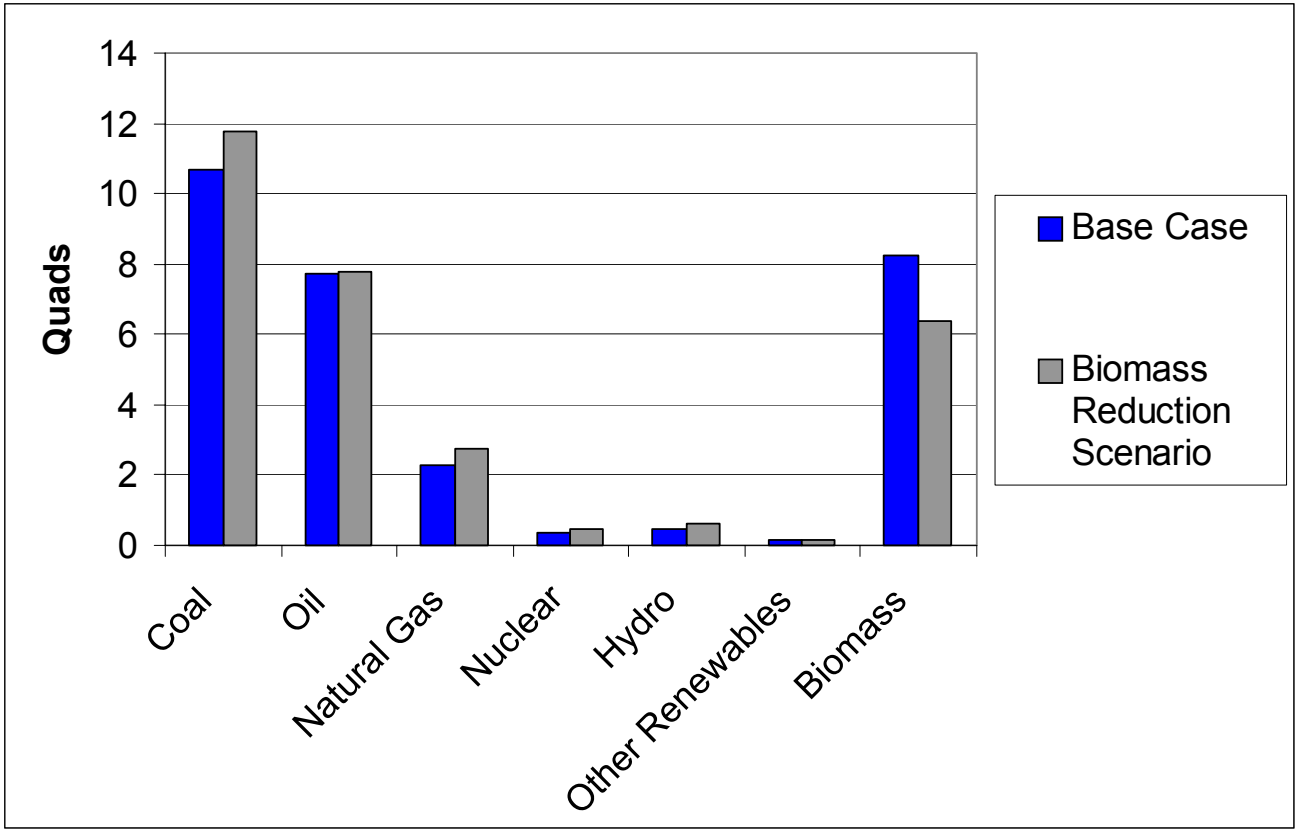
Primary Energy: Biomass

- 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.

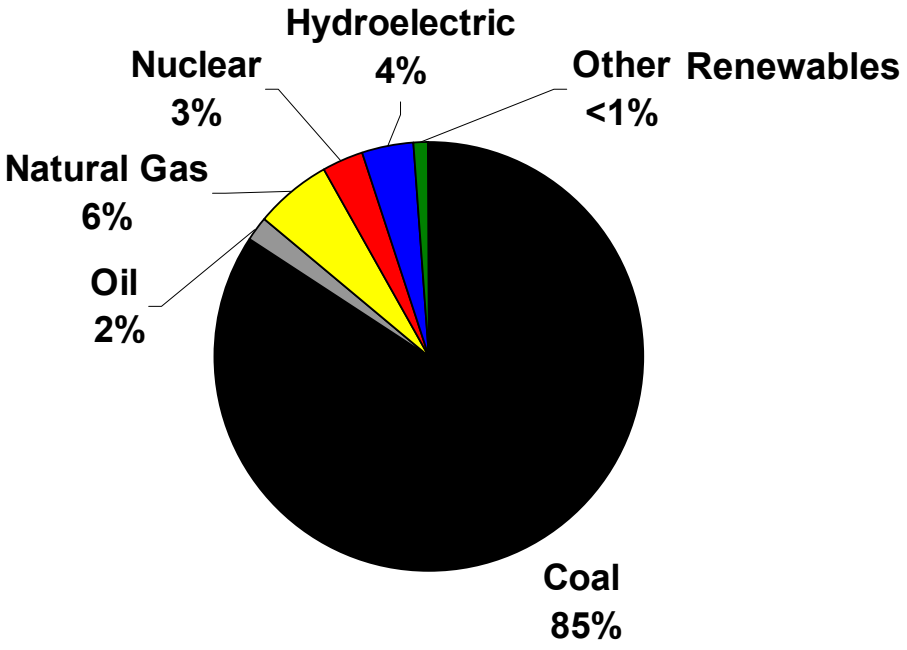


Electricity

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%

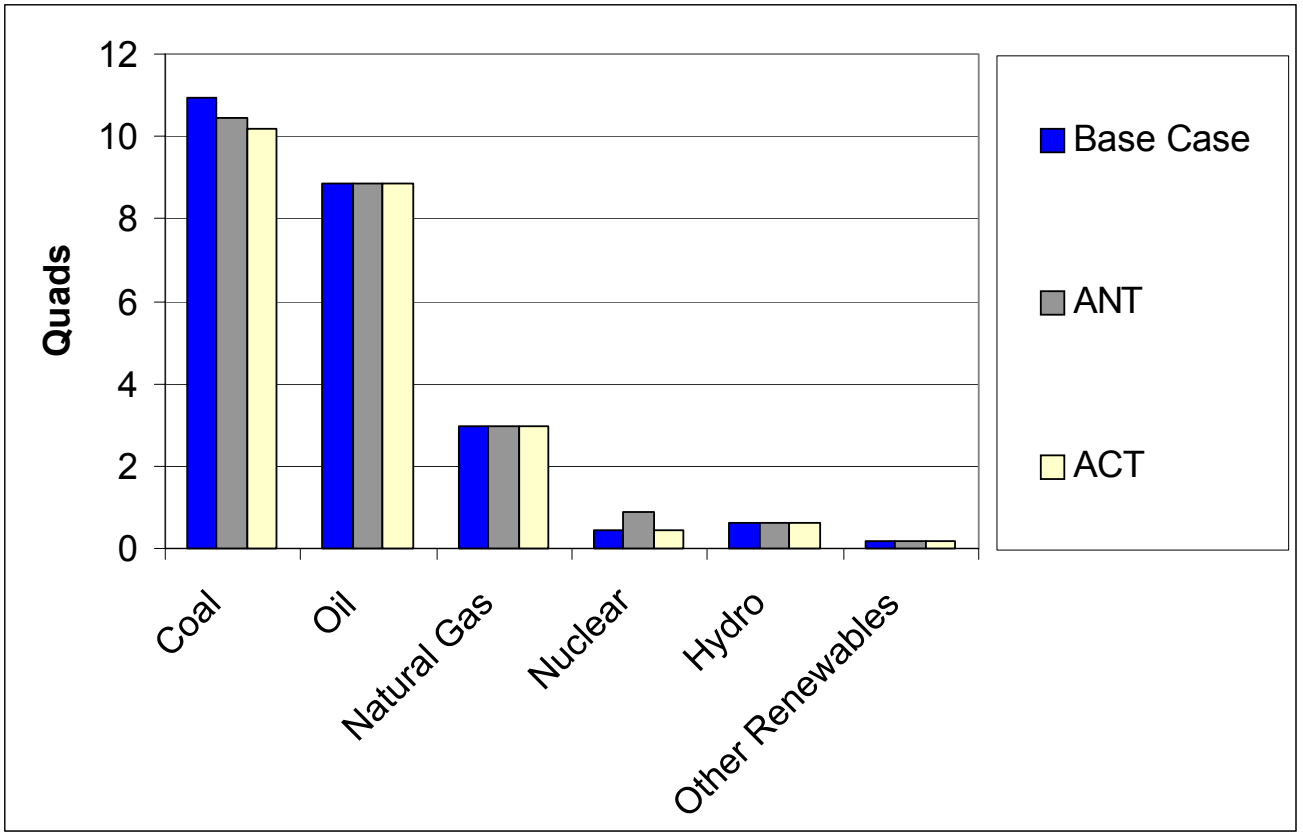
Electricity by fuel in 2000



Source: International Energy Agency, 2002.

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

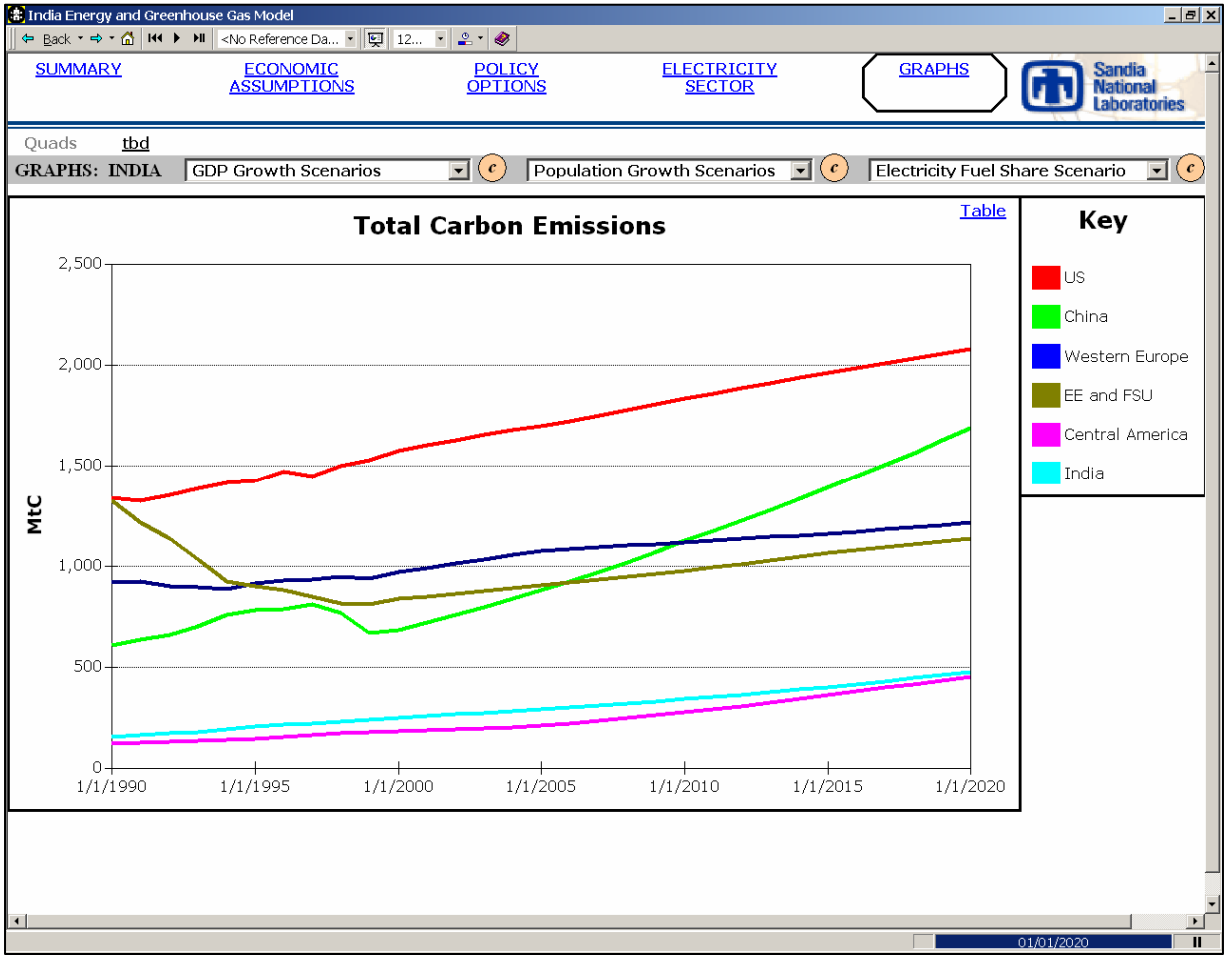
Carbon Emissions in 2020:
Base Case (476.2 MtC), ANT (464.9 MtC), ACT (457.7 MtC)



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**



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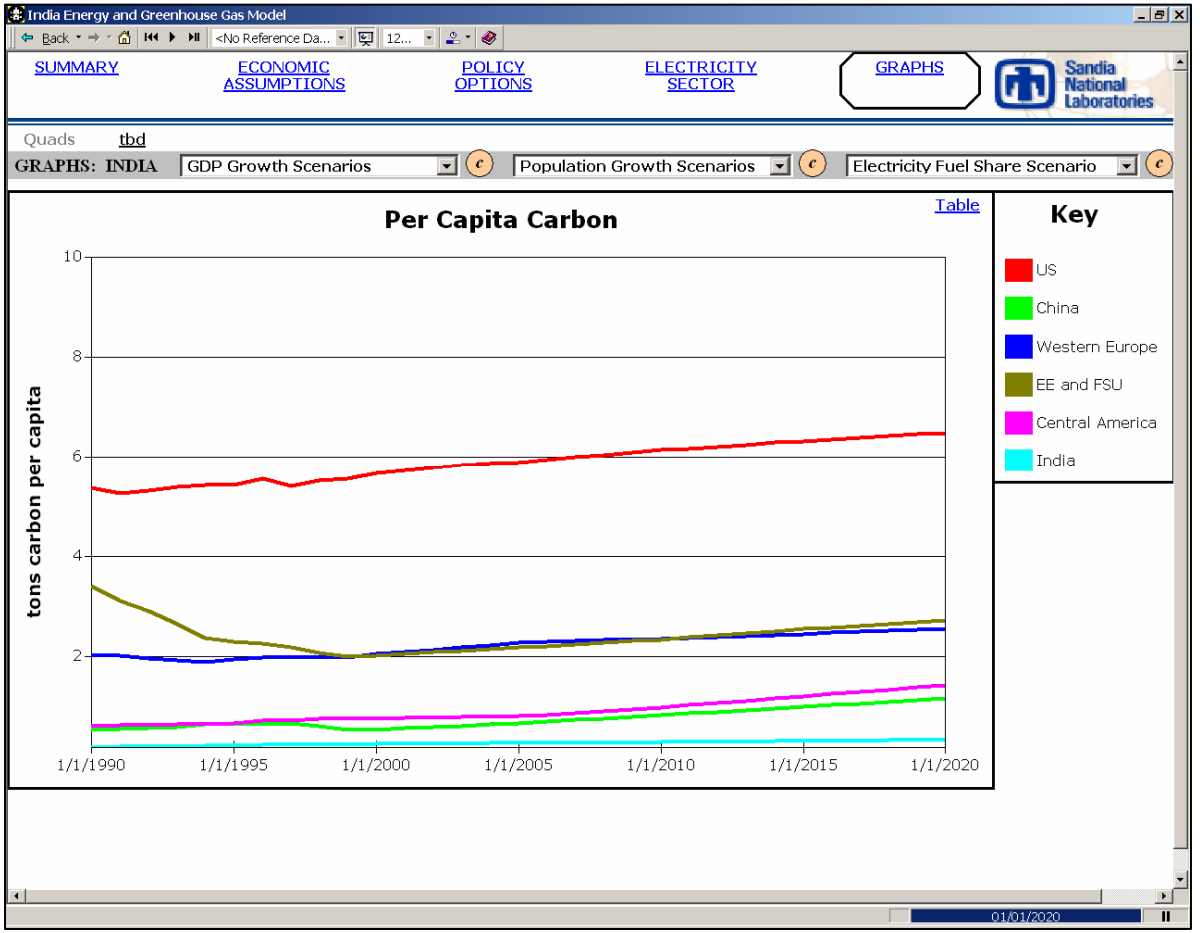
Per Capita Carbon Emissions

- **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.**



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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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