Modeling Emissions Policy Options for Beijing

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Overview

- Like all dynamic economies, China faces a wide variety of resource and environment challenges.
- Among these, the long term challenges posed by residential energy use from electricity and transport demand are among the most prominent.
- In this research, we use a new resource and environment CGE model to evaluate policies toward long term energy use.

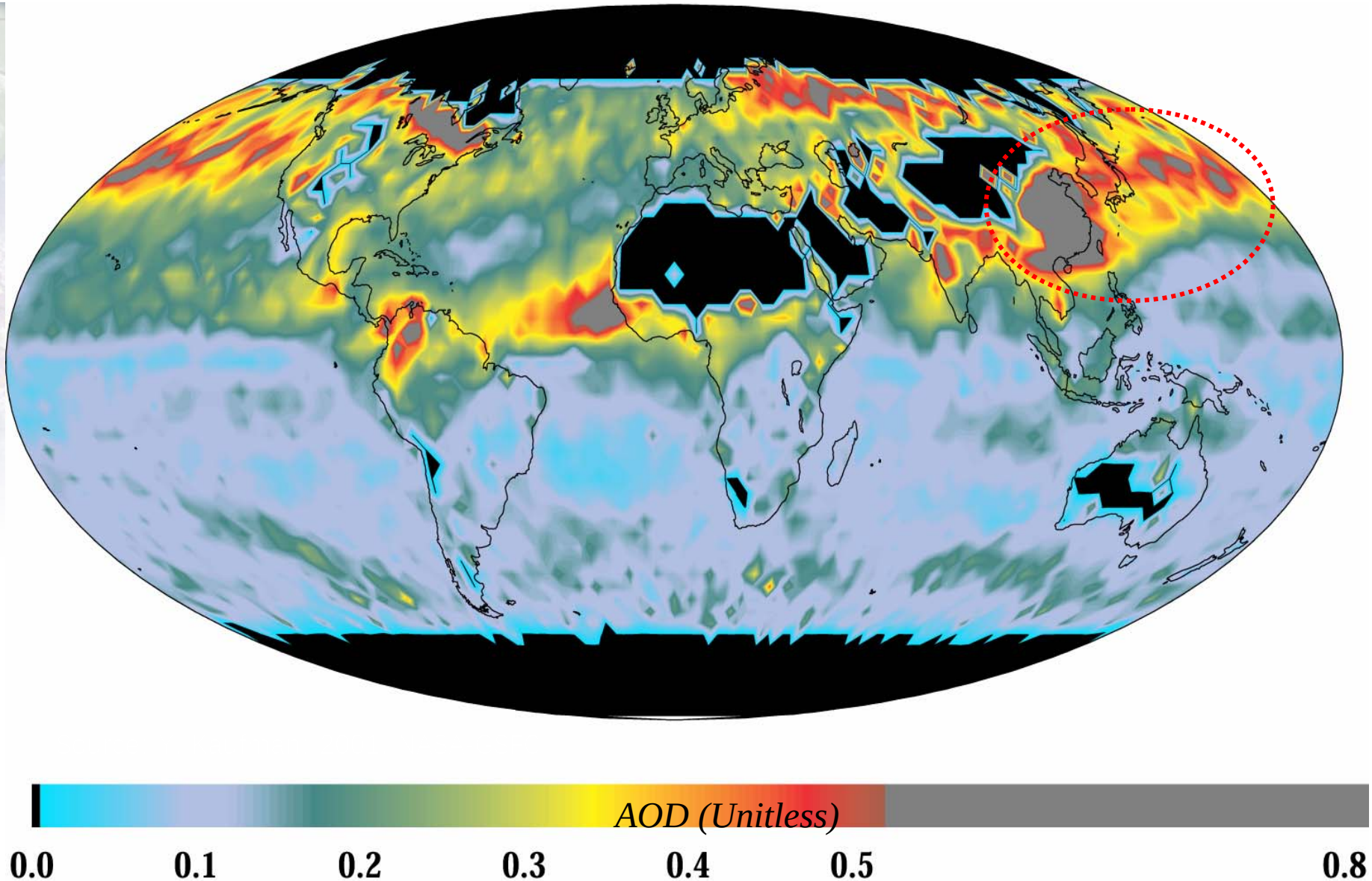
Motivation

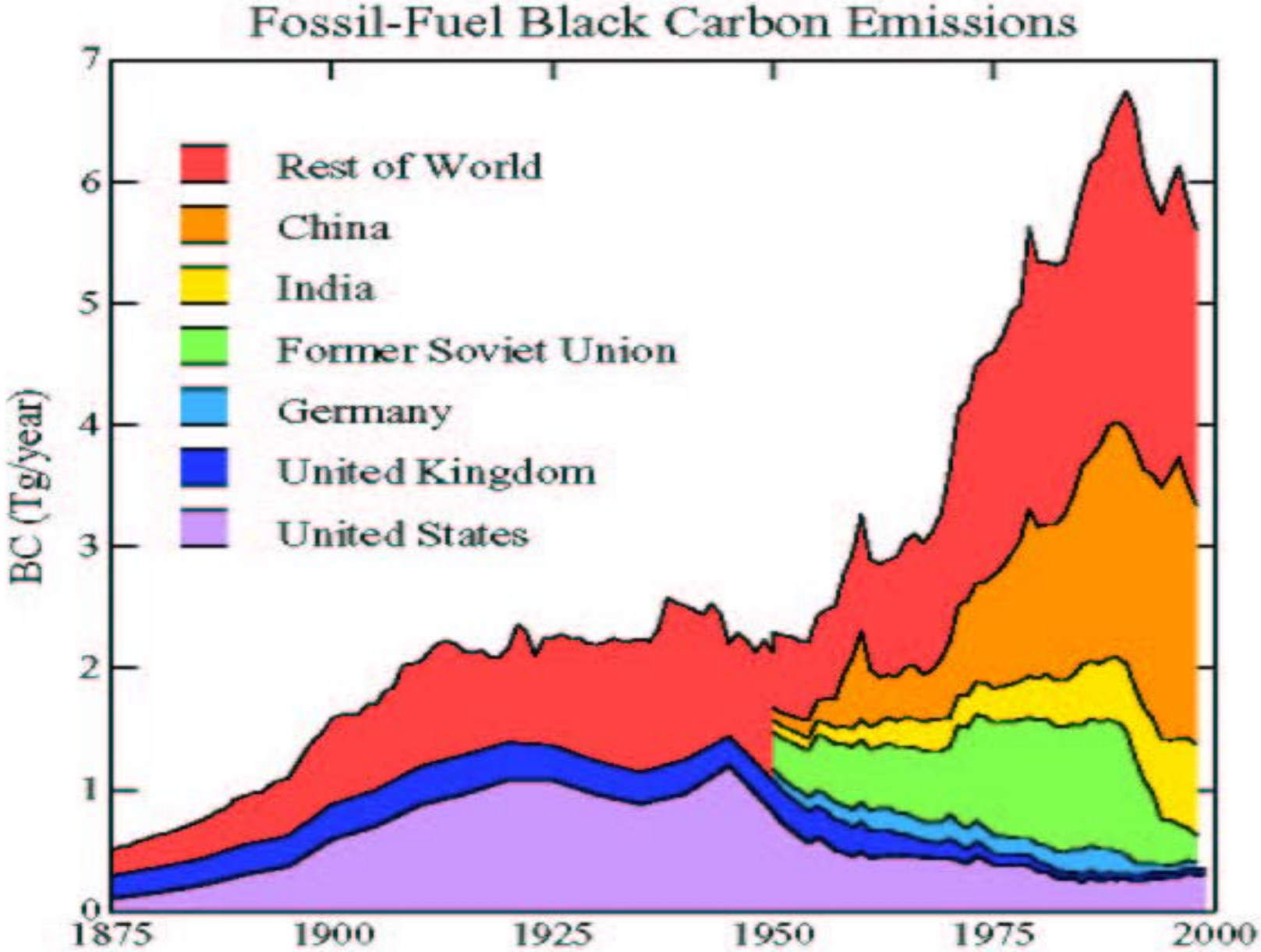
Why we should care about this:

1. Chinese GHG emissions are already a significant regional externality and could be decisive on a global basis.
2. China's energy demand is "rocking the tanker."
3. Because of its status as a populous DC, what happens in China in terms of sustainable living is of special significance.

China's Carbon Challenge

Aerosol Optical Depth (2001) NASA-TERRA Satellite





Source: Novakov, Ramanathan, Hansen, .. Sathaye, GRL, 2002

Three Focal Points

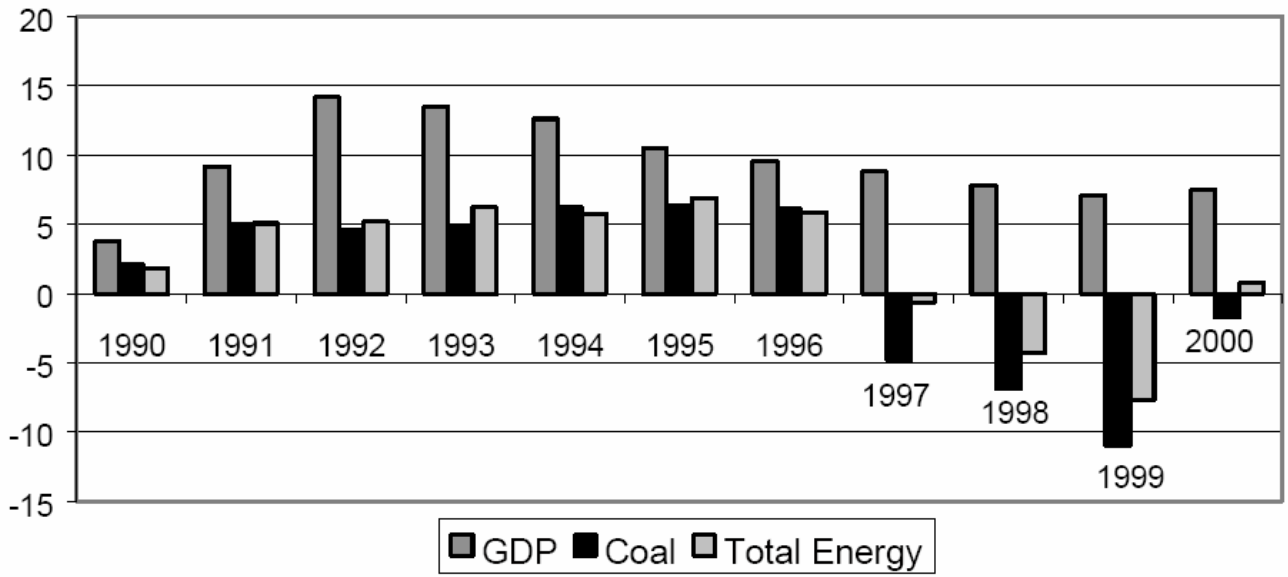
1. Where is China along the path of energy dependence?
2. How might energy prices and policies influence its course?
3. How can we decompose the ensuing environmental effects?

Energy and GHG Trends in China

Two contending perspectives:

1. Optimists point to falling coal intensity in the late 1990s and massive technology infusion across the economy.
2. Others see resurgence of coal and overwhelming demand shifts in recent years, driven mainly by final consumption and completion of the process of modernization.

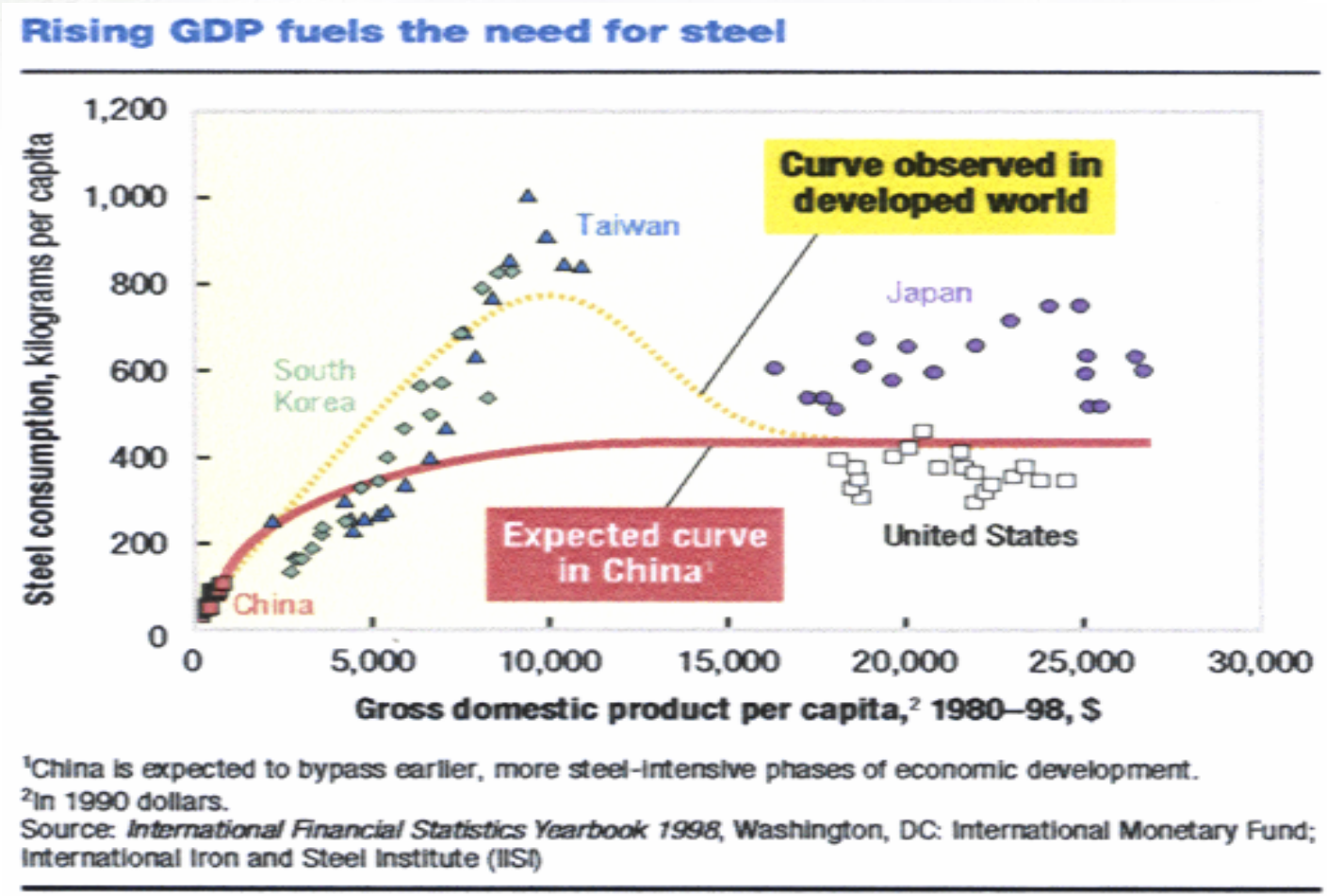
Reported Growth Rates of GDP and Commercial Energy Use in China



Source: *China Statistical Abstracts 2000* [Zhongguo Tongji Zhaiyao], Beijing: State Statistical Bureau, 2000. Energy data for 2000 are estimated by author.

Source: Logan:2001

Chinese Steel: An Optimistic View



The Energy Challenge

Not industrialization, but rising living standards.

Annual Kilograms Per Capita

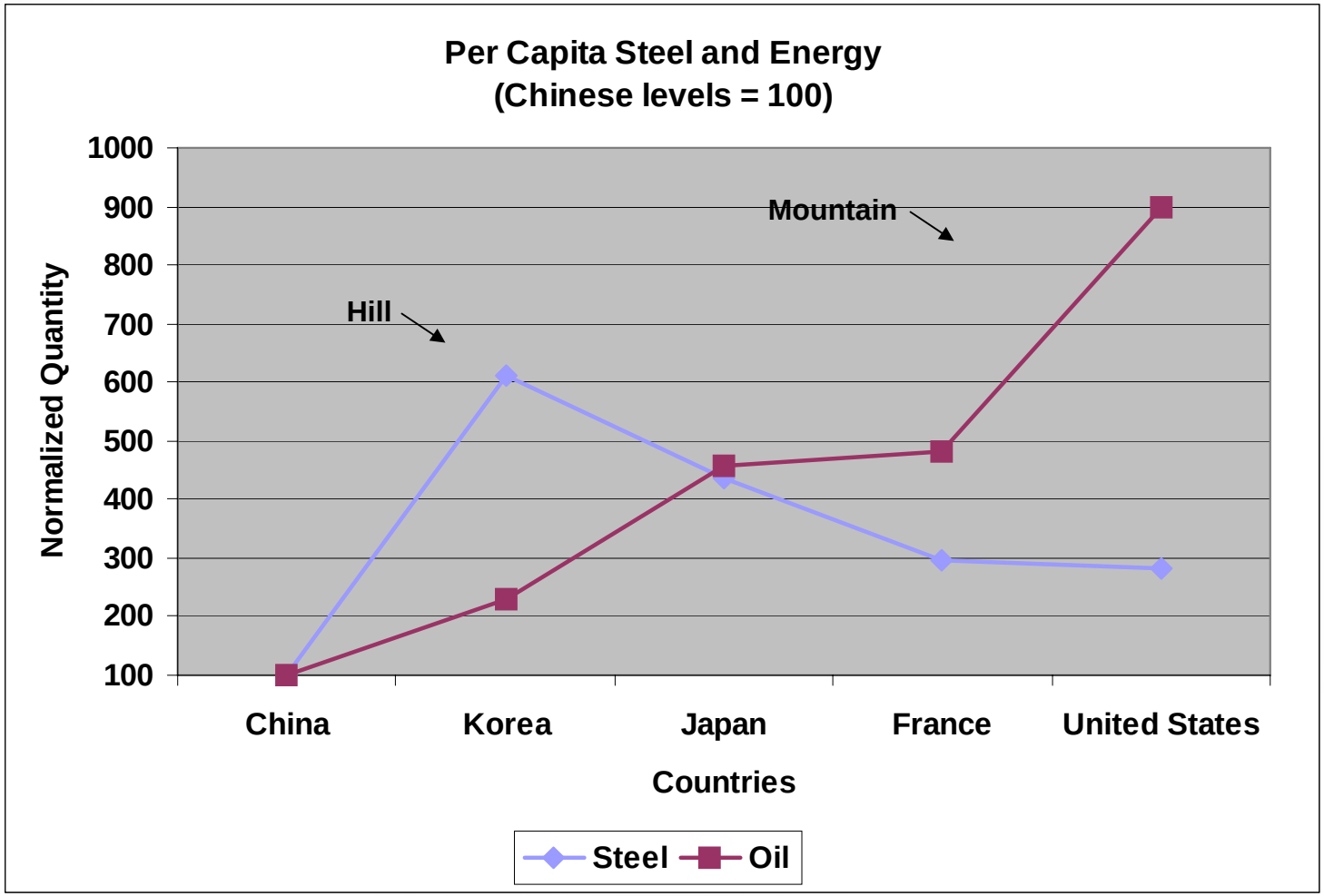
Country	Steel Production 1992	Steel Production 2001	Oil Consumption 2000
China	59	132	905
Korea	499	809	2071
Japan	635	575	4136
France	382	390	4366
United States	330	373	8141

INDUSTRIAL

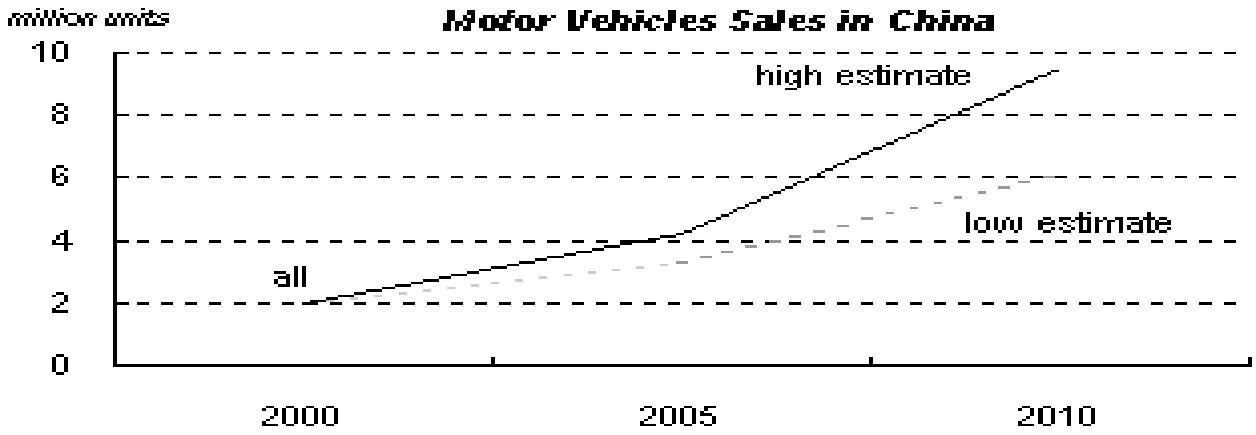
POST-INDUSTRIAL

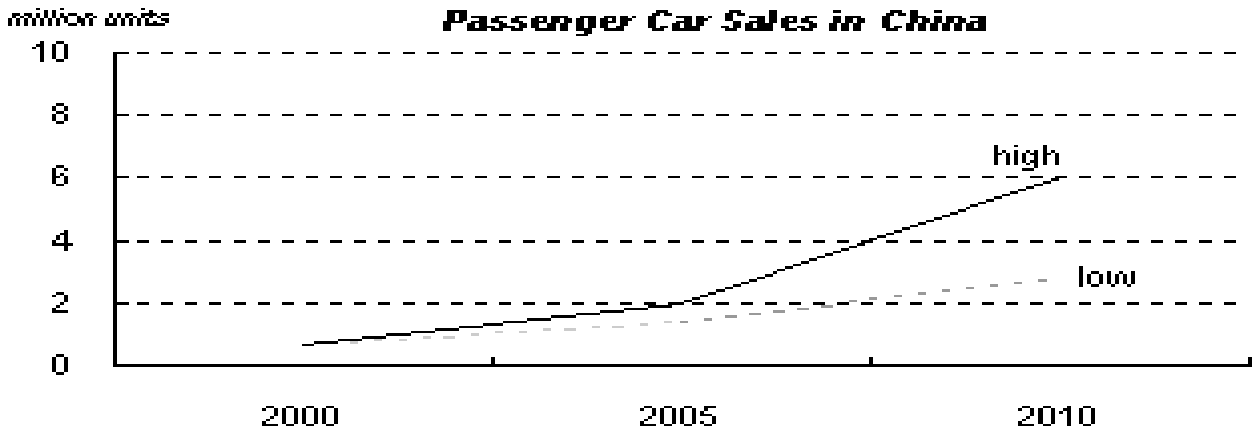
Industrialization may be energy-intensive, but affluence is much more so.

The "mountain" of industrialization is only a hill.
The real mountain for China to climb is post-industrial energy demand.

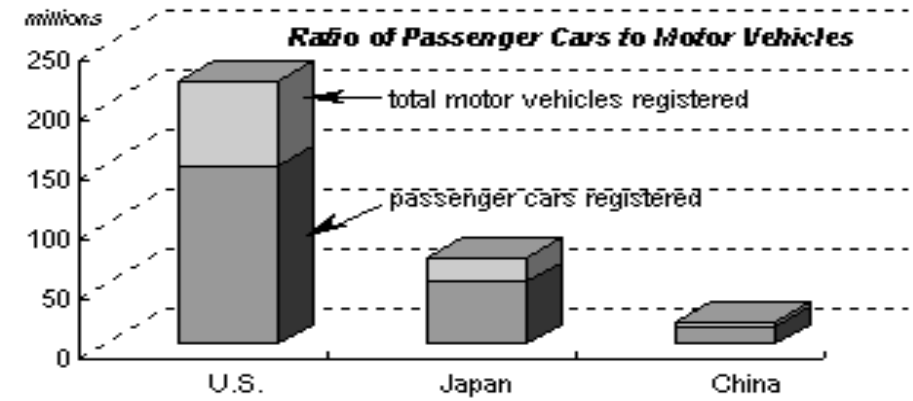


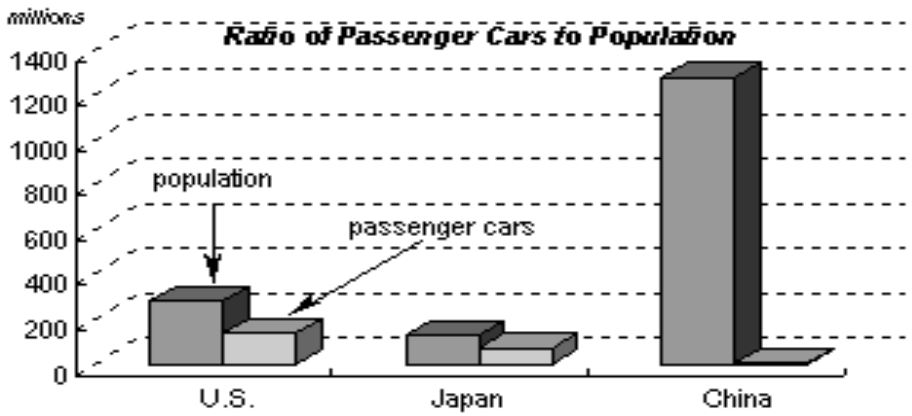
China: The Worlds 3rd Largest Car Market by 2010





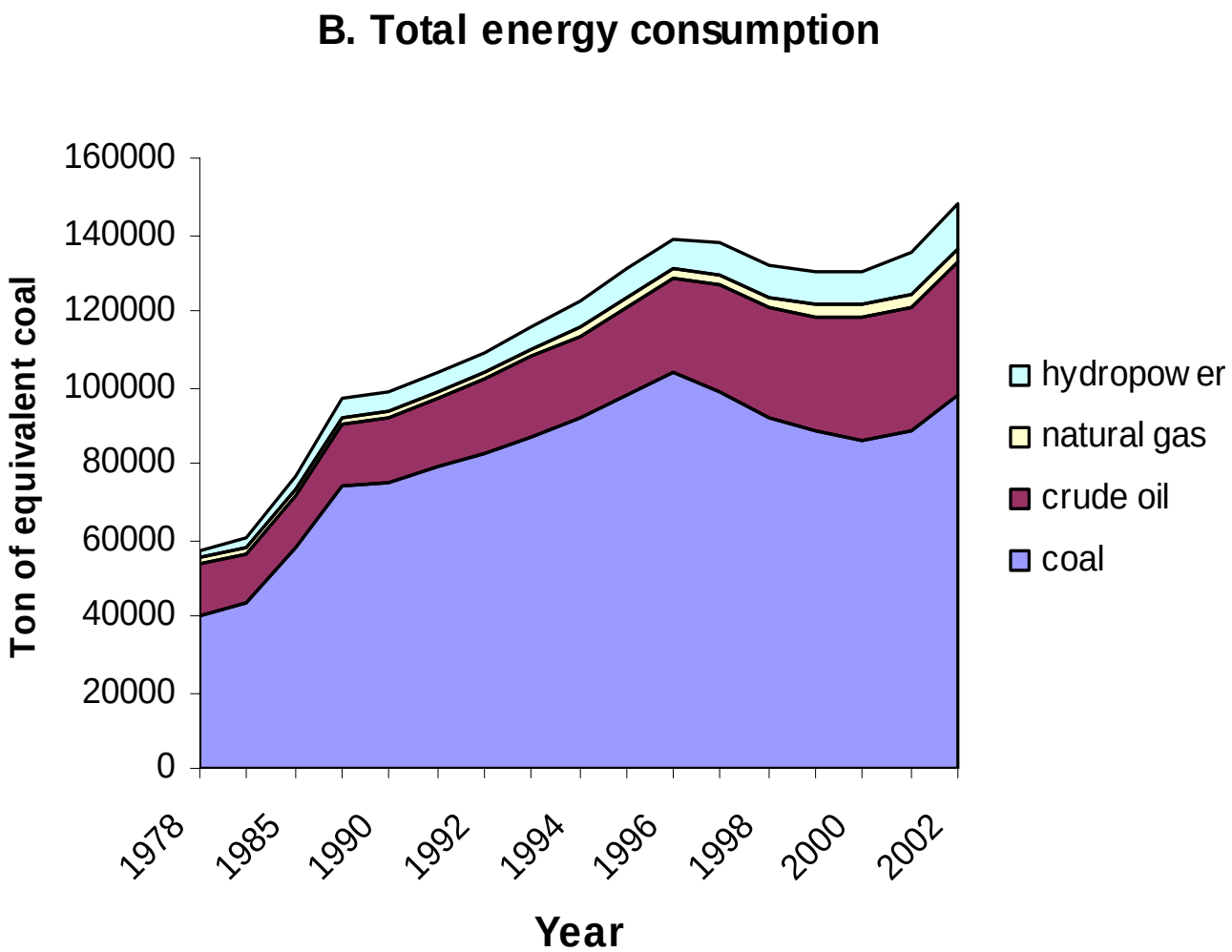
Demographics of Vehicle Demand



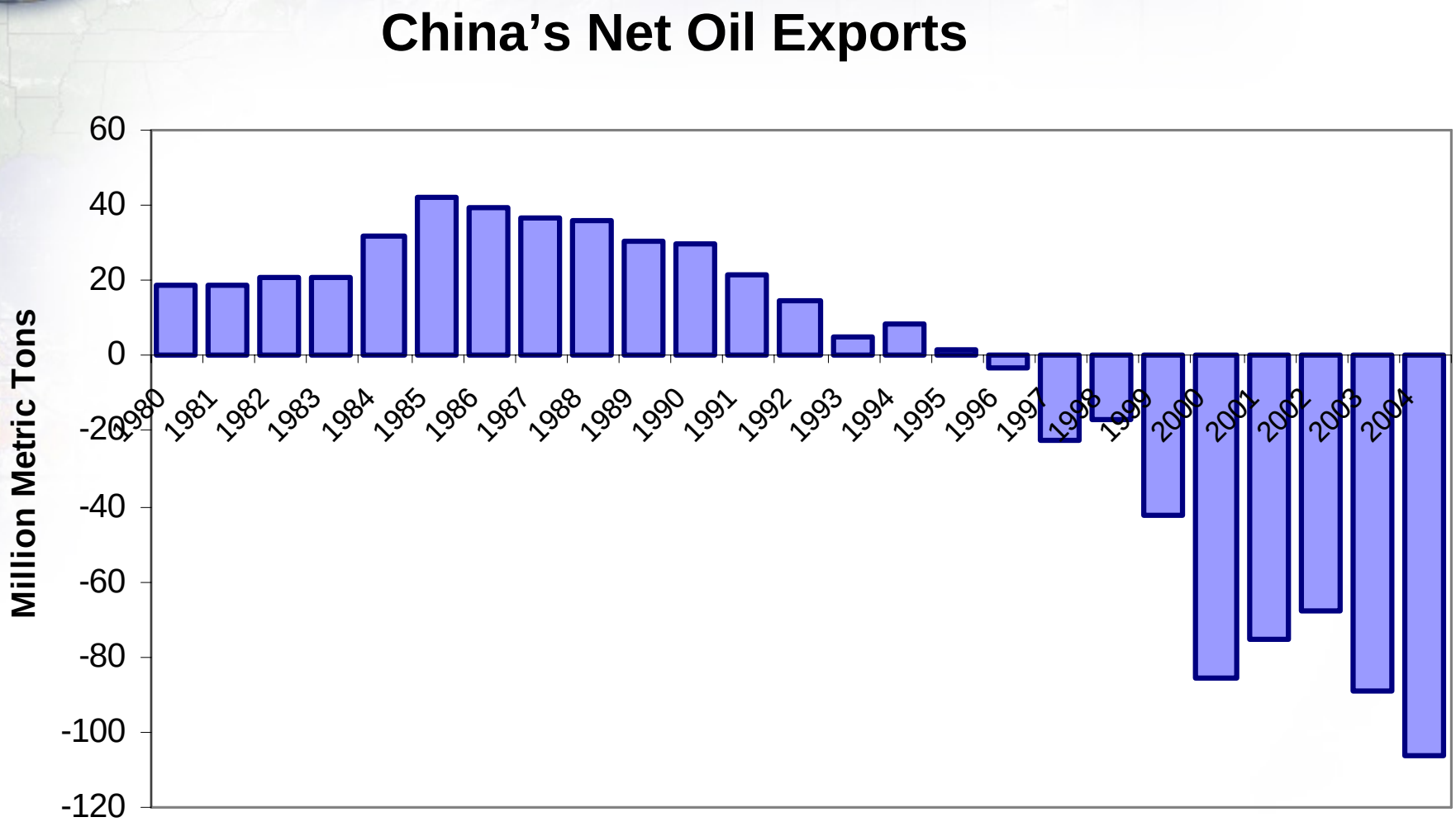


Sources: U.S. Census Bureau, Japan Association of Automobile Manufacturers, World Markets Research Centre

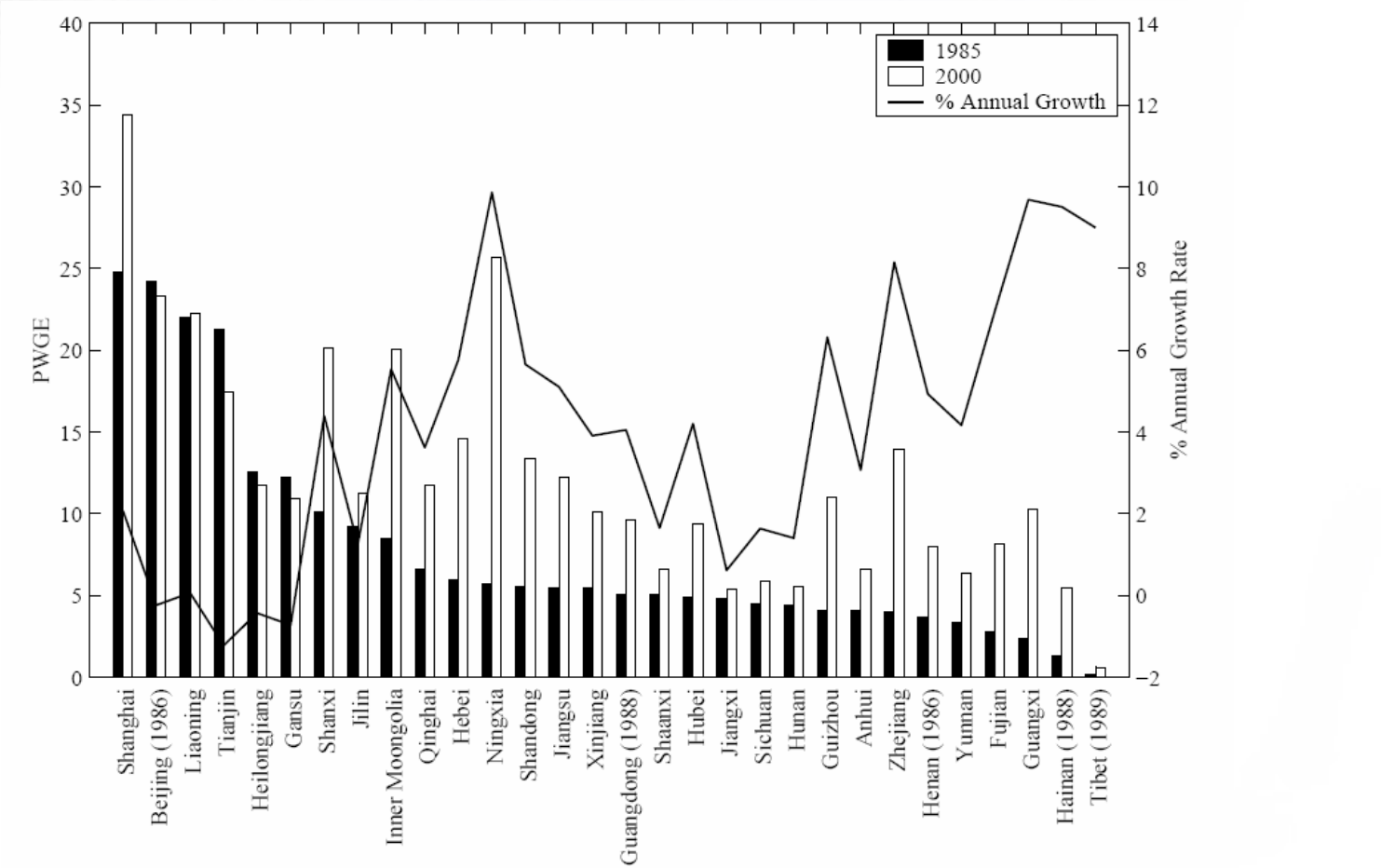
Coal at the Foundaton, Oil at the Margin: Energy Composition by Type



Tipping the Trade Balance



China: Per Capita Waste Gas Emissions
(1,000 cubic meters)

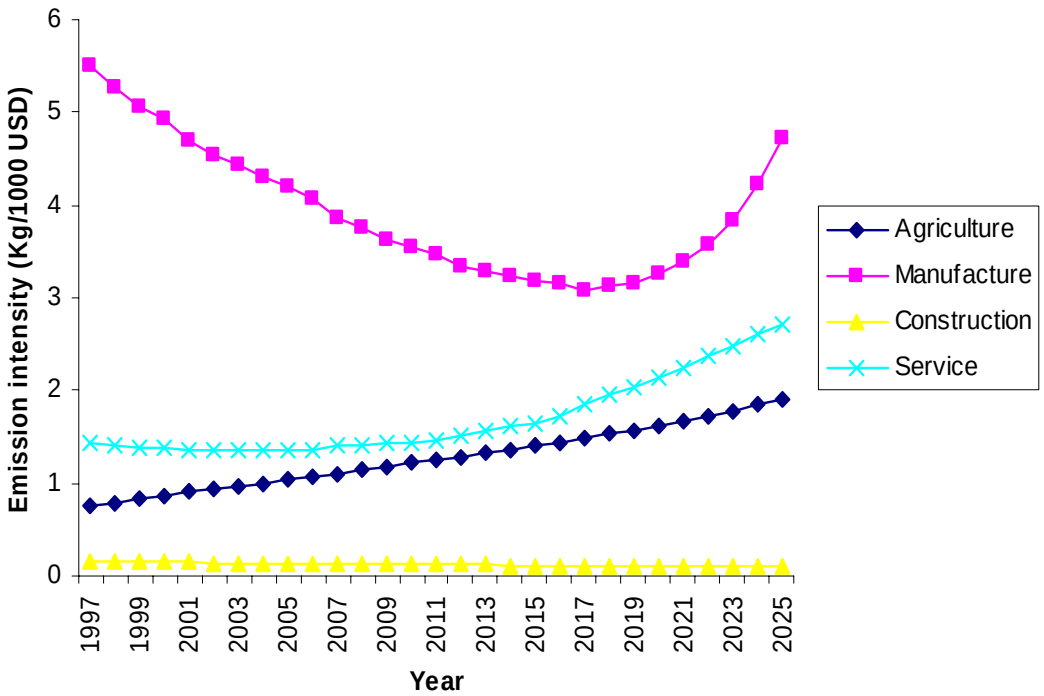


Source: Aufhammer et al: 2003

Projections to 2025

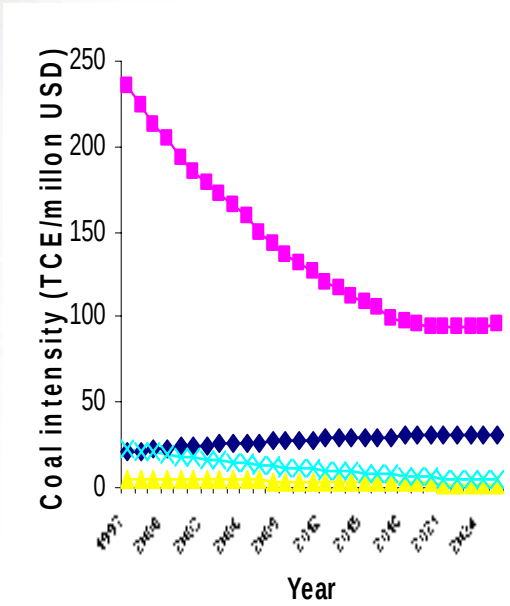
- We use a recursive dynamic CGE model to forecast trends for China over the next two decades.
- Around a calibrated baseline of consensus GDP growth, we evaluate the effects of rising oil prices.

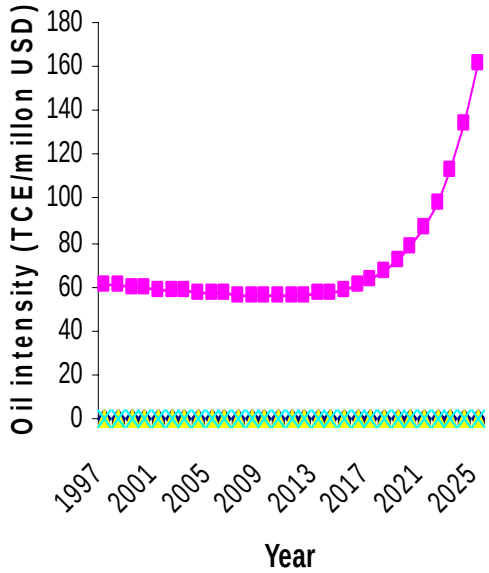
Ills of Affluence

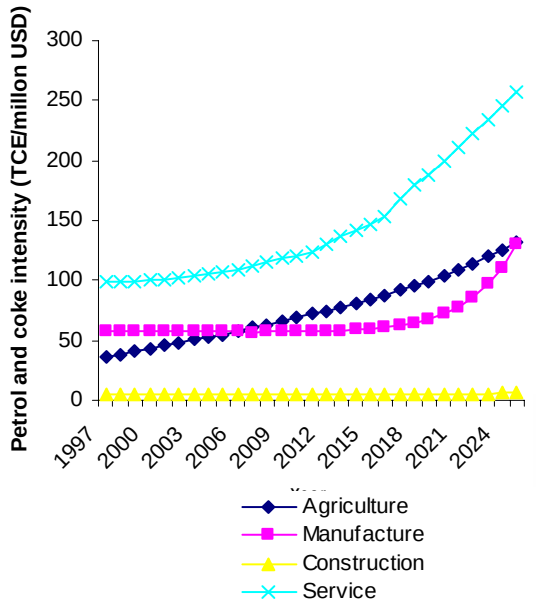


Mfg reverses course because of electricity production.
Services are about transportation.

Real Sources Of Emission Intensity







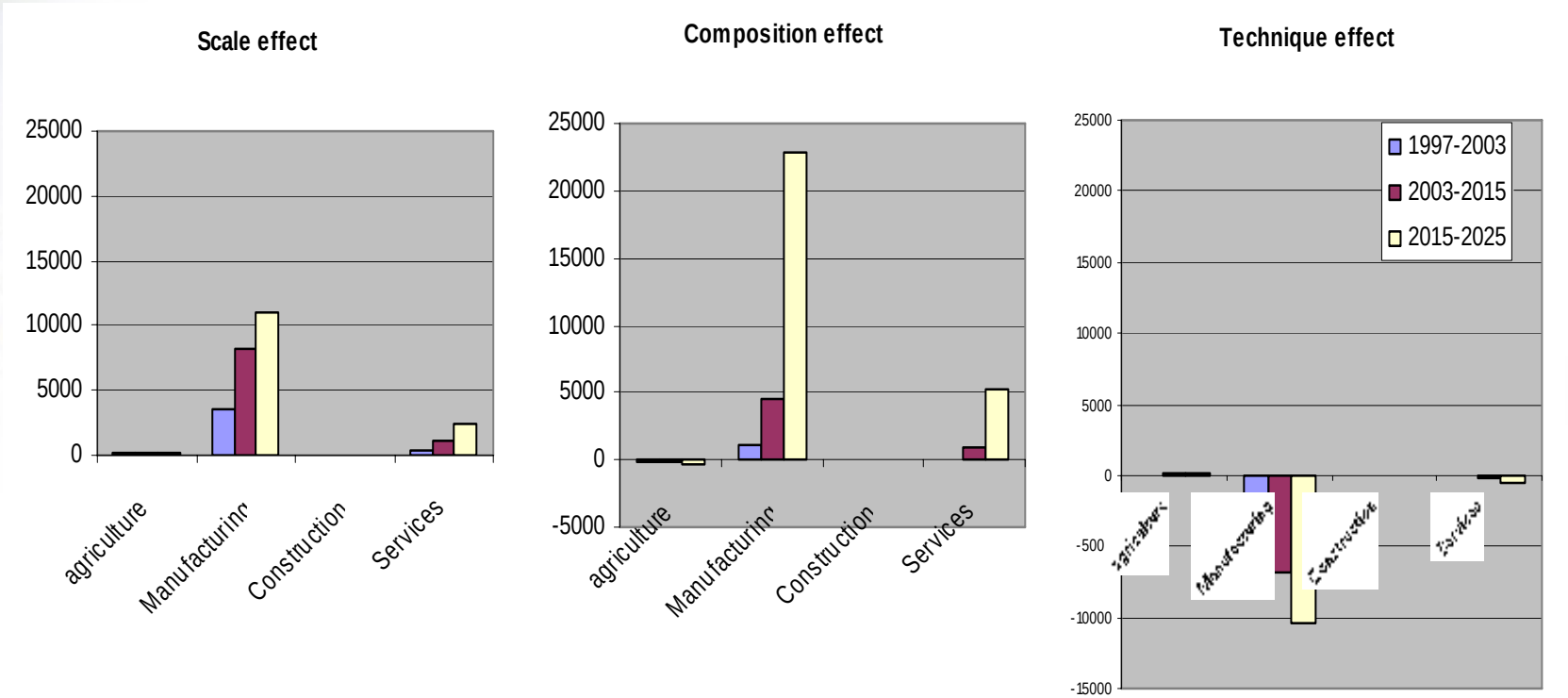
Composition of Environmental Incidence:The Pollution Troika

Economic sources of pollution can be decomposed into three parts:

1. Growth effects – expanding the envelope of economic activity. China's successes here are now legendary, and becoming almost surreal.
2. Composition effects – shifting patterns of supply and demand around the surface of the envelope. Things will get much worse before they get better.
3. Technological change – efficiency gains, bending the envelope. Here is the only unequivocally good news, driven mainly by coal use/distribution constraints and technology transfer.

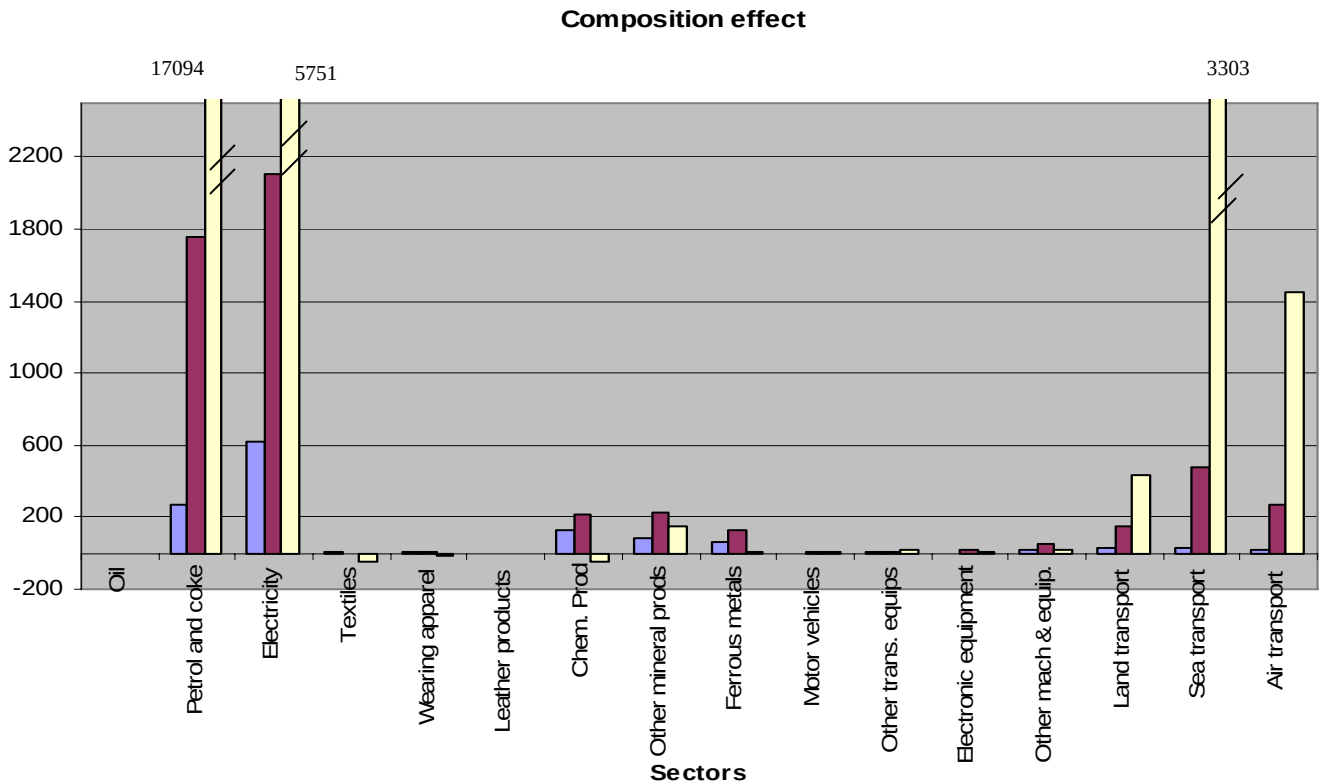
Divisia Decomposition Results

- CO2 emission variation during 1997-2025.

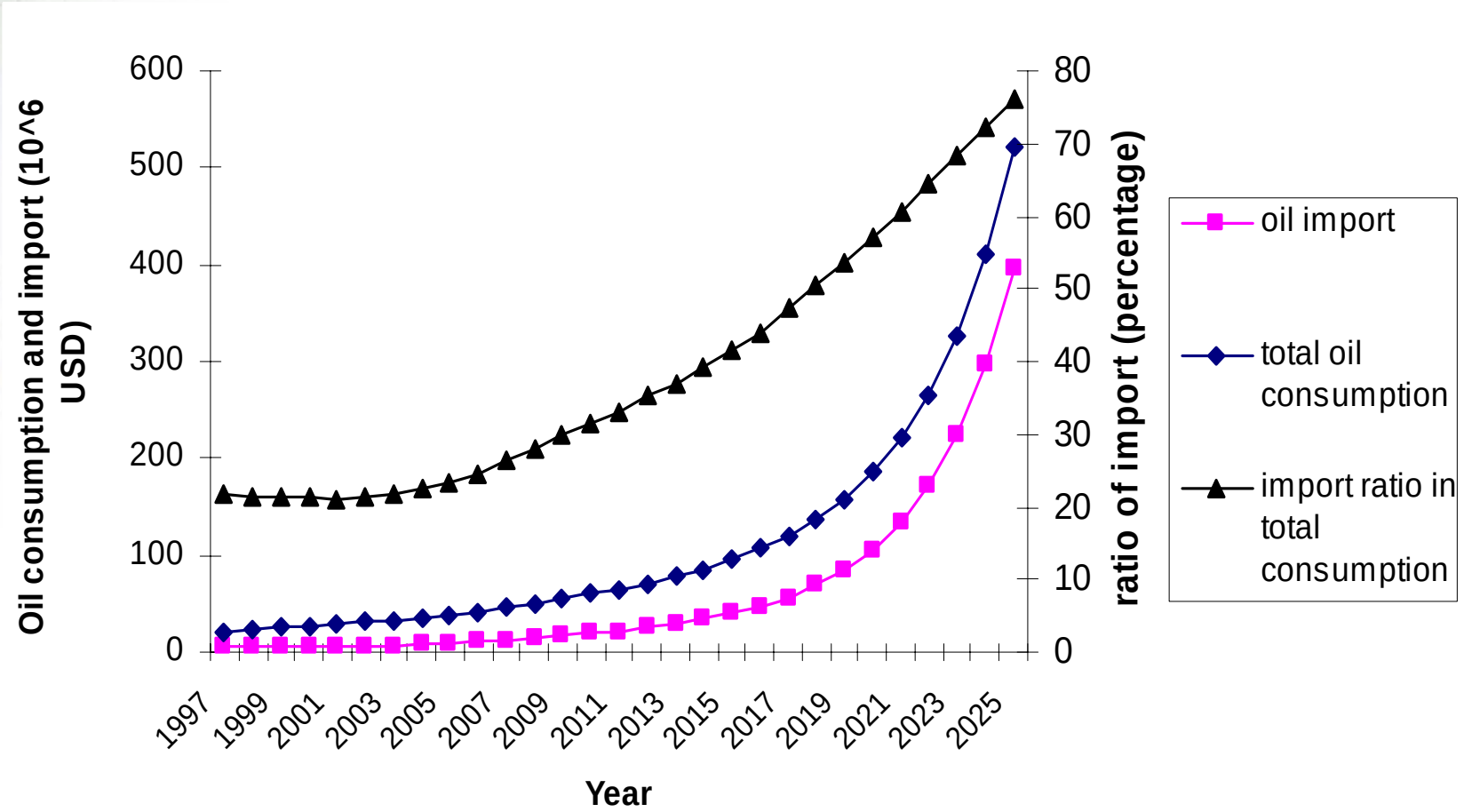


Divisia Decomposition

CO2 emission changes for some manufactures



Oil Absorption Trends



Observations

China has attained levels of growth and modernization that seemed beyond imagining only a generation ago. Along with its many successes in improving material living standards, however, have come new risks to sustainability and environmental quality.

- Without more effective emission control policies, China's economic growth will give rise to very significant CO_2 emission problems, especially in the period of 2015-2025.
- After a period of industrialization, structural transformation induces rapid expansions of energy-intensive final demand, mainly private electricity, heating, and transport services.
- To meet the needs of a consumer society, CO_2 emissions shift from the other manufacturing and service sectors into intermediate energy generation (electricity generation and petrol and coke sectors), and petroleum refining.
- Coal will be significantly replaced by relatively cleaner intermediate energy sources such as electricity, oil products and natural gas in manufacturing.

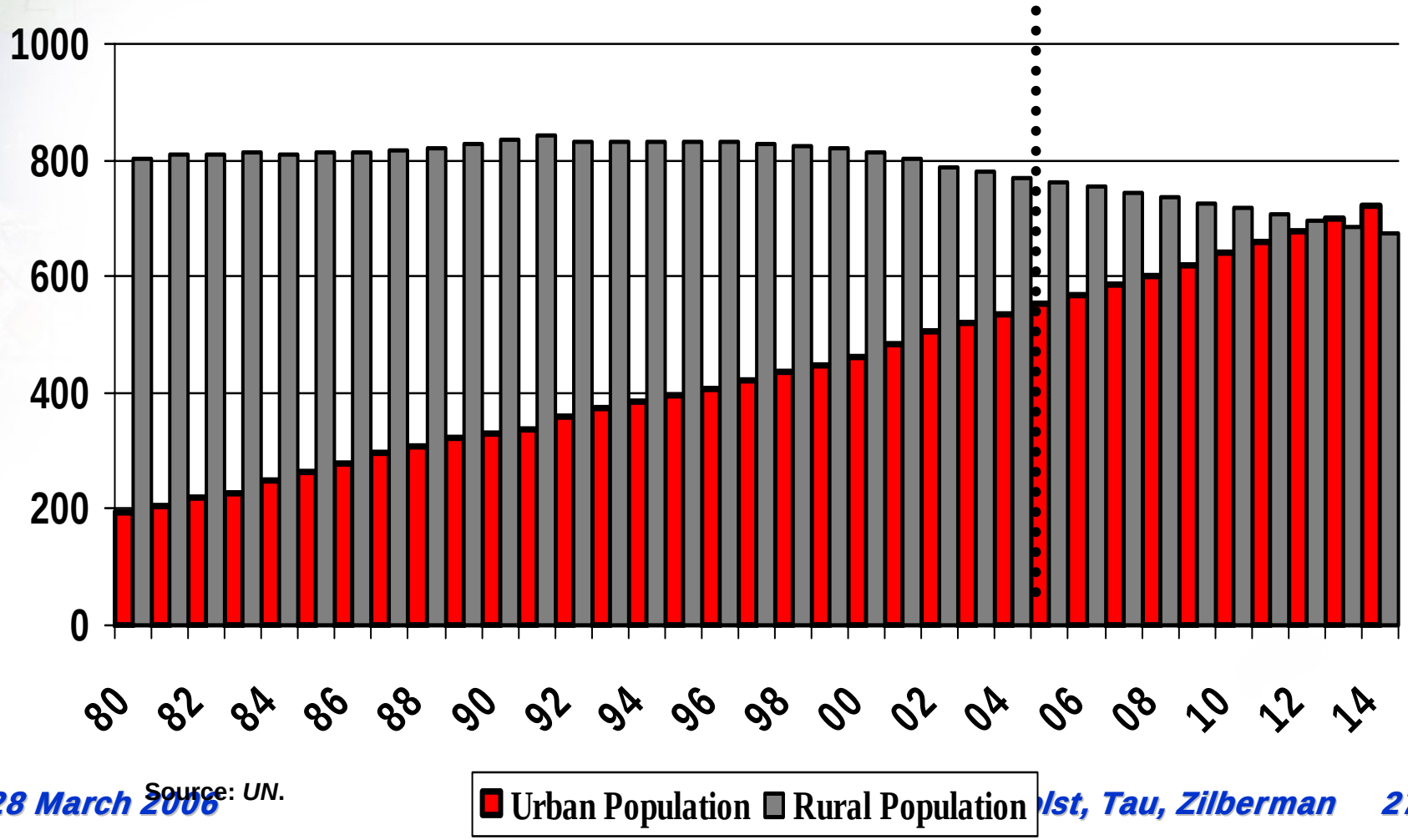
Beijing Overview

- “As the countryside goes, so goes China.”
- True, but the countryside has been moving to the cities lately, and China’s energy future will be decided there.

China's Population is Moving

(Rural and Urban, millions)

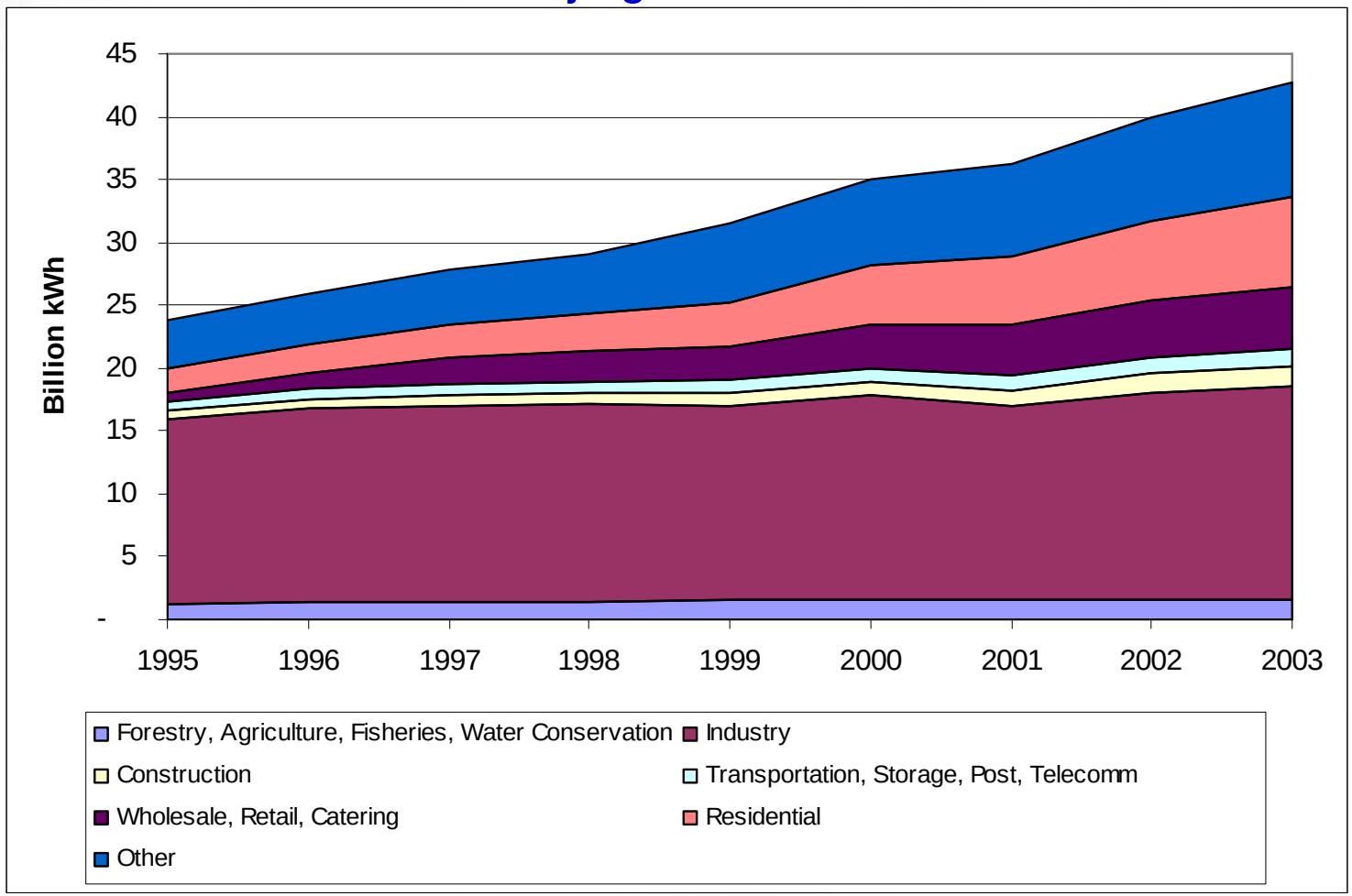
Half a billion people are becoming urban energy consumers.



Source: *UN*.

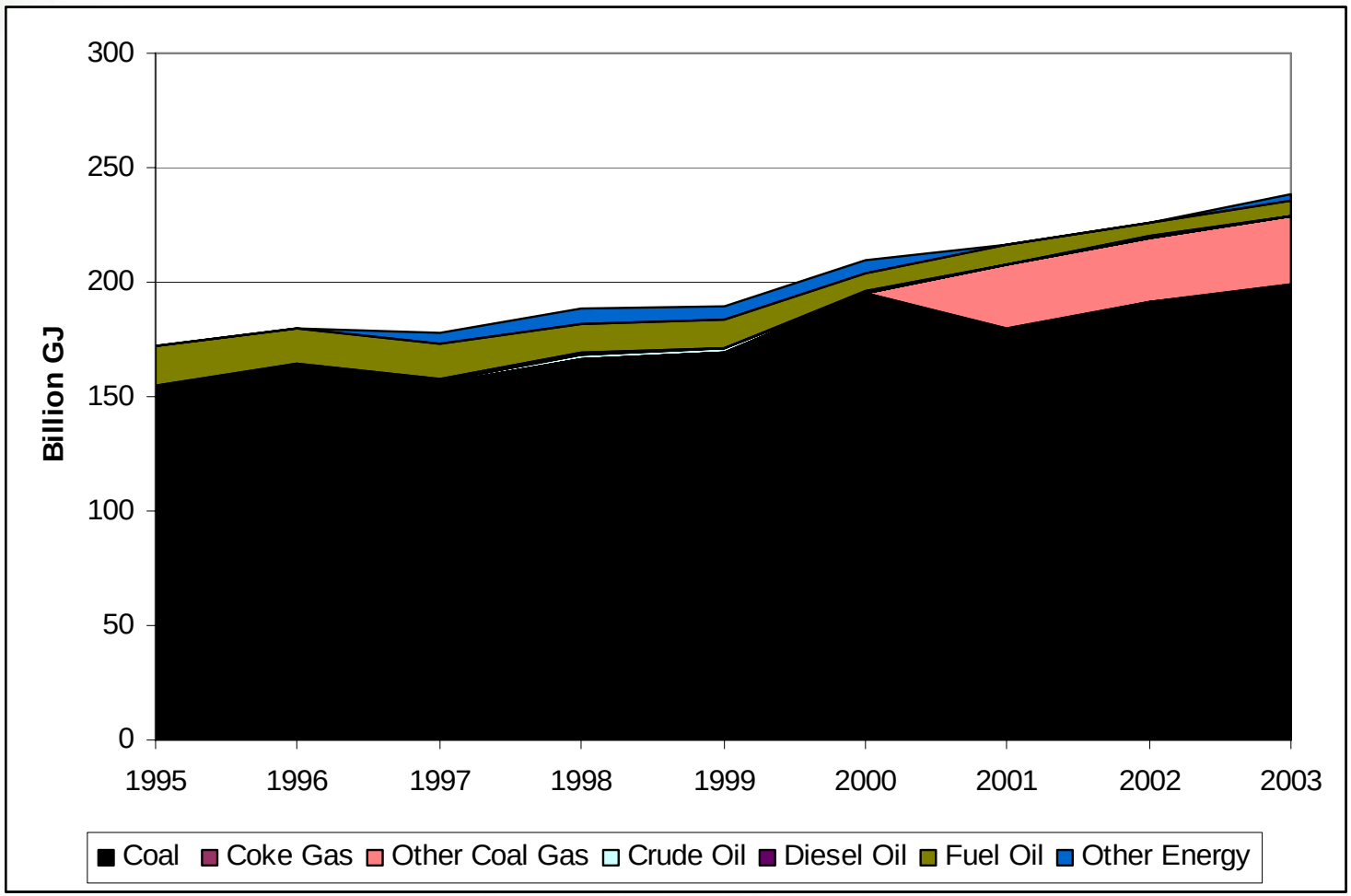
Electricity demand is already accelerating at home and in services.

Electricity Demand by Destination
Beijing 1995-2003

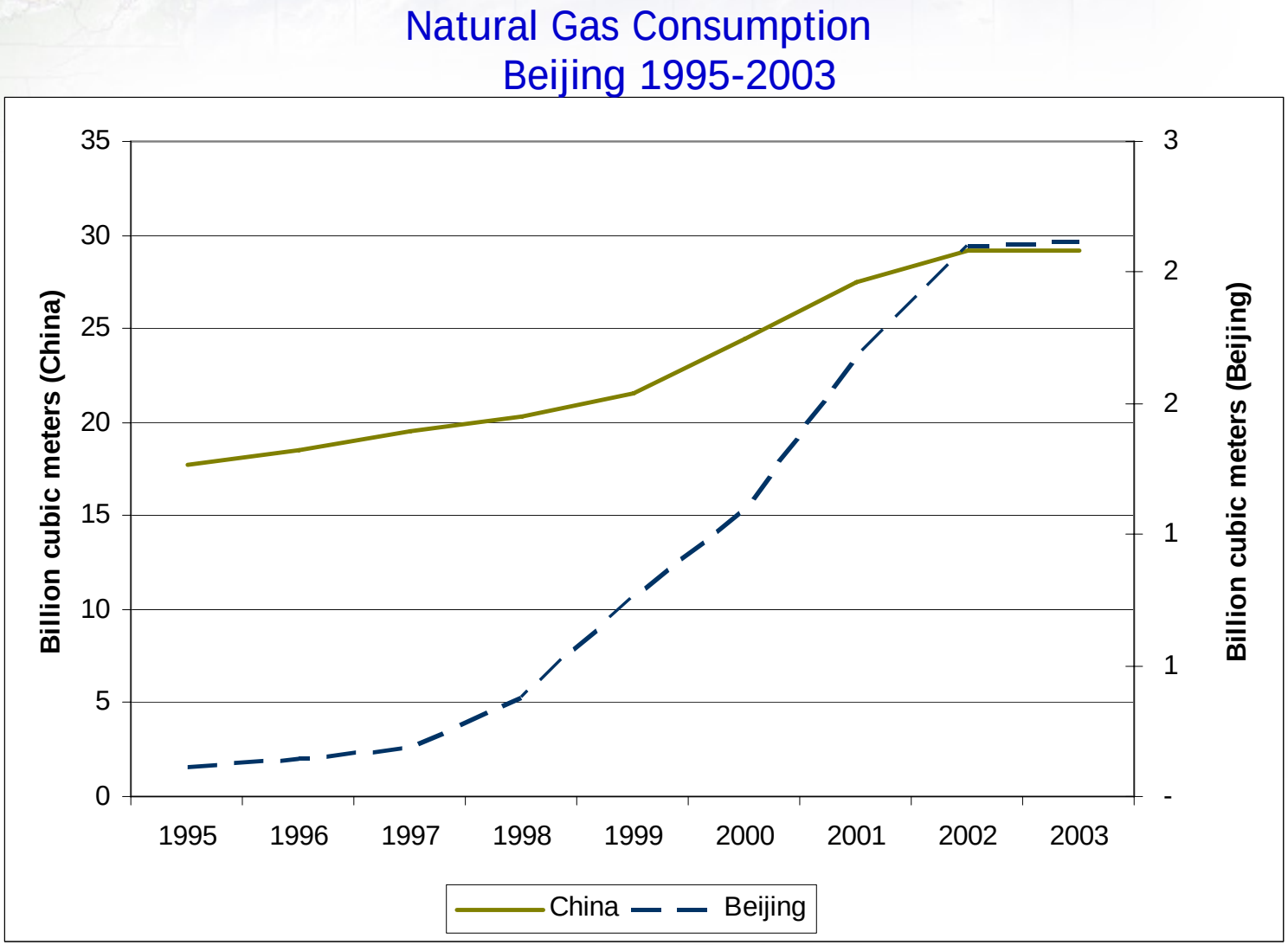


Coal remains the foundation energy source

Energy Inputs for Electricity Generation
Beijing 1995-2003

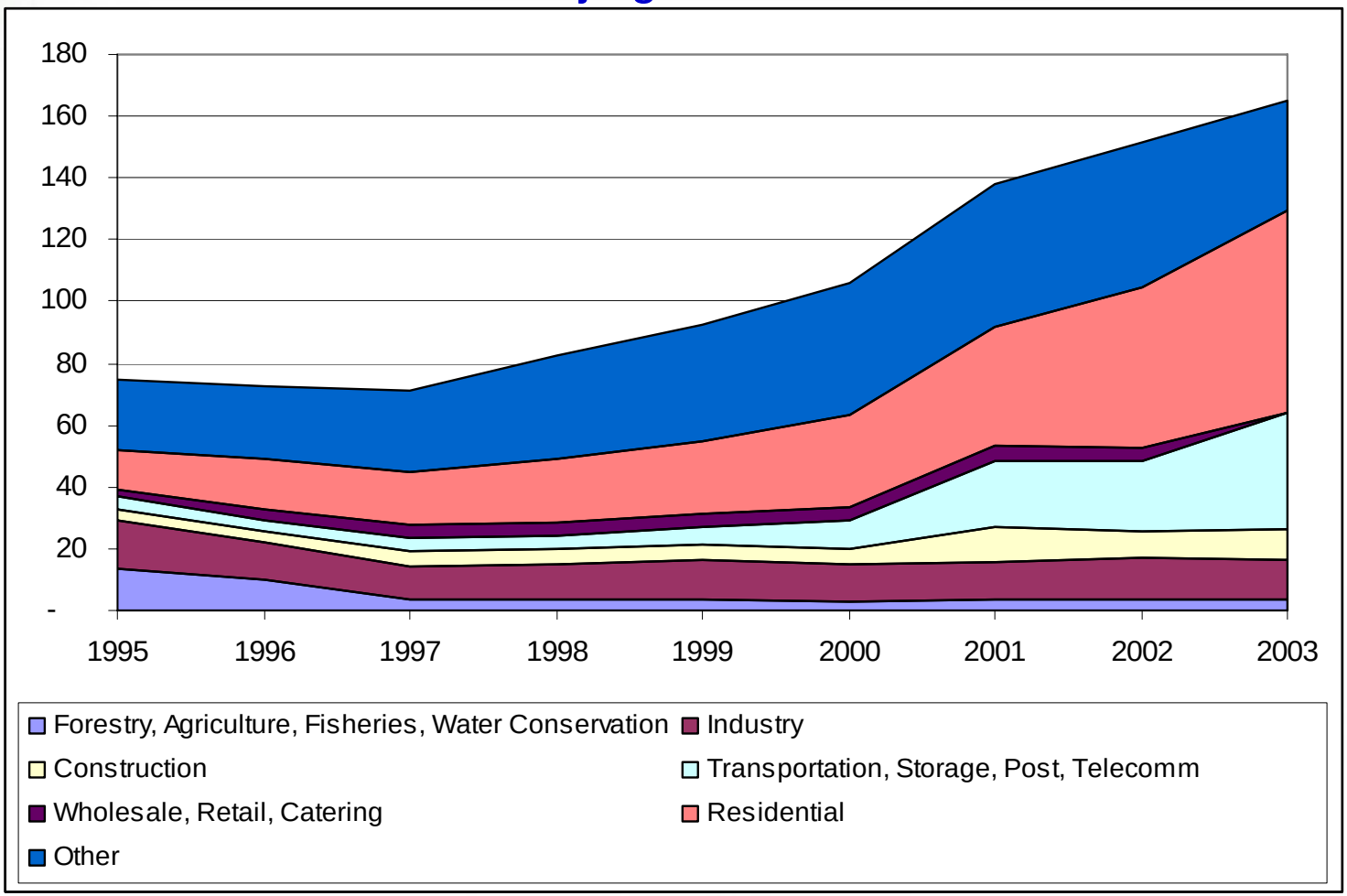


But other Carbon Fuels are Rising Rapidly



Transport fuel growth is rapid and dominated by Households

Gasoline Use by Sector
Beijing 1995-2003



PANDA - Pollution And National Development Assessment

The modeling facility consists of two components:

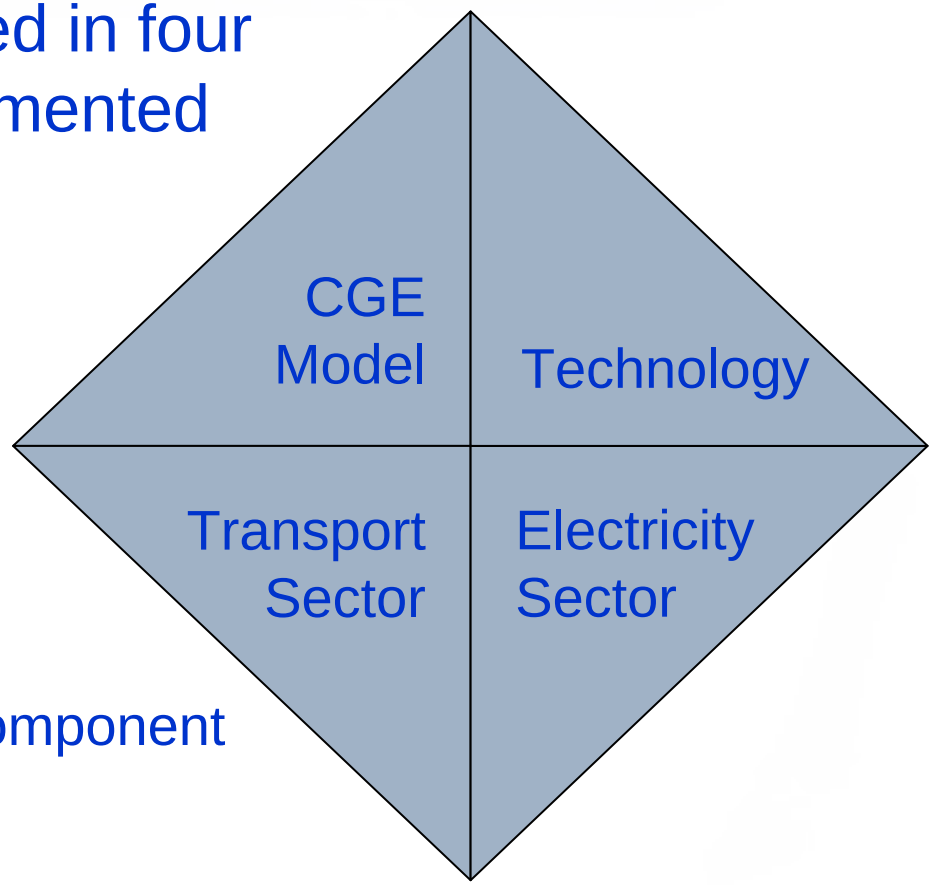
1. Detailed data on economy and emissions
   - 34 sectors
   - 2 household groups
   - detailed fiscal accounts
   - 14 emission categories
2. A dynamic CGE forecasting model focusing on economy-energy-environment

Model Overview

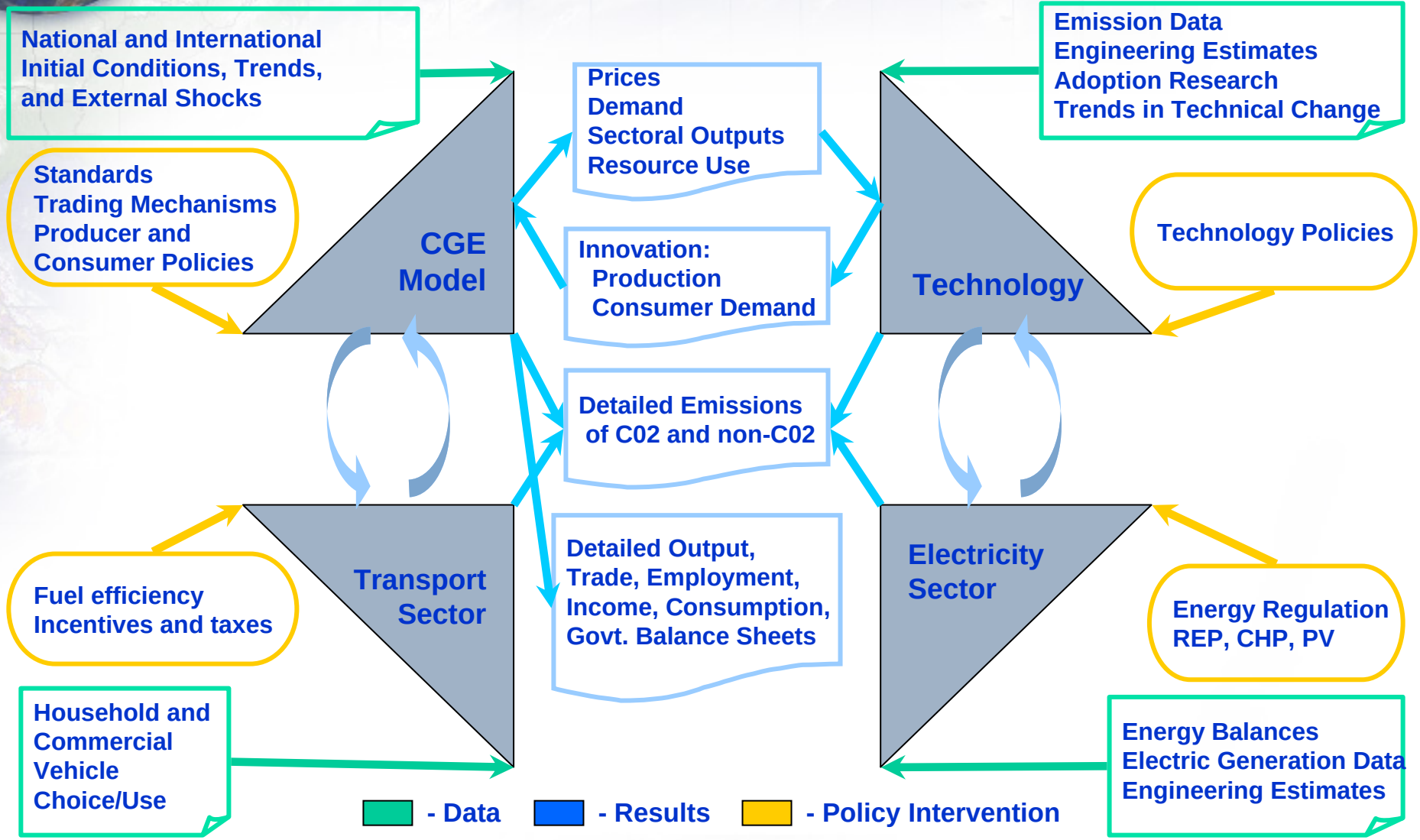
PANDA is being developed in four components and implemented over two time horizons.

Components:

1. Core GE model
2. Technology module
3. Electricity modeling
4. Transportation component



Detailed Methodology



Electricity Sector Modeling

Power generation accounts for a substantial percentage of C02 emissions in China.

Based on detailed producer data, we plan to model technology and emissions in China's electricity sector

- Heterogeneous generation technologies
- Heterogeneous fuels

Transportation Modeling

- The transport sector accounts for sharply rising shares of Chinese C02 emissions
- To meet emission goals, patterns of vehicle use and technology adoption need to be better understood

Time Horizons

PANDA is being developed for scenario analysis over two time horizons:

1. **Policy horizon**: 2005-2025

   Detailed structural change:

   1. 34 sectors
   2. 2 household income groups
   3. Labor by occupation and capital by vintage

2. **Climate horizon**: 2005-2100

   Aggregated:

   1. 5 sectors
   2. 3 income groups
   3. labor and capital

Energy Policy Scenarios

We have seen that the energy/emission challenges for China are in household income/demand growth (transport and electricity).

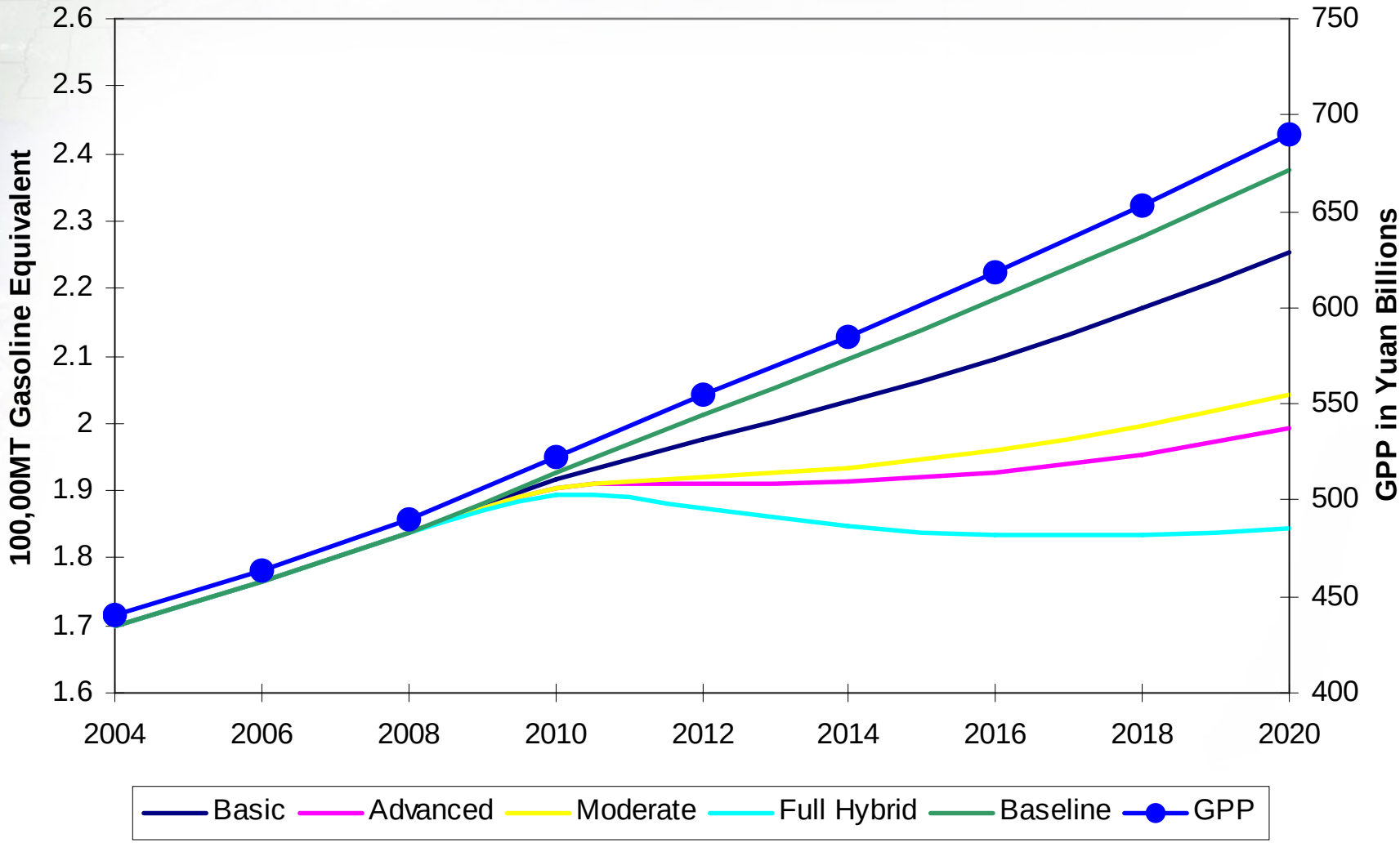
To show how PANDA can support policy analysis, we offer **preliminary** results in two important areas:

1. Vehicle Efficiency Standards (VES)
2. Renewable Energy Portfolio (REP)

Vehicle Efficiency Standards

1. Scenario 1: **Basic Fuel Economy** - Combination of fuel efficiency measures applied to light-duty vehicles starting in 2008 and S-diesel (synthetic diesel) blended with other diesel fuels
2. Scenario 2: **Moderate + Fuel Cell Technologies** - Incorporates fuel efficiency improvements in light-duty vehicles, substantial penetration of light-duty fuel cell vehicles, and again diesel blends of GTL or S-diesel fuels.
3. Scenario 3: **Advanced Fuel Economy** - Scenario 1 with more aggressive fuel economy technologies in light-duty vehicles.
4. Scenario 4: **Full Hybrid Vehicles** - Similar to 3 but even more aggressive with the introduction of all hybrid technologies starting in all light-duty vehicles in 2008. This case is based on ACEEE — full hybrid technologies and costs. The scenario also includes S-diesel blends.

Energy Impact: Efficiency with Growth



Vehicle Efficiency Standards

Results
- Substantial CO2 mitigation (less than half of Baseline growth).
- Gross Provincial Product (GPP) largely unchanged.
- Slight increase in consumer cost.
- Substantial gasoline savings.

Drivers
- Small reduction in auto demand.
- Large reduction in fuel demand.
- Demand diverted from import-intensive autos and fuel to more diversified demand, of which a majority is within-province or domestic services/goods.

Assumptions
- The car stock is homogeneous in use and replacement.
- All savings are in gasoline use.

Critical
- Households are assumed to own and adopt uniformly.
- World oil prices are constant.

Renewable Energy Portfolio

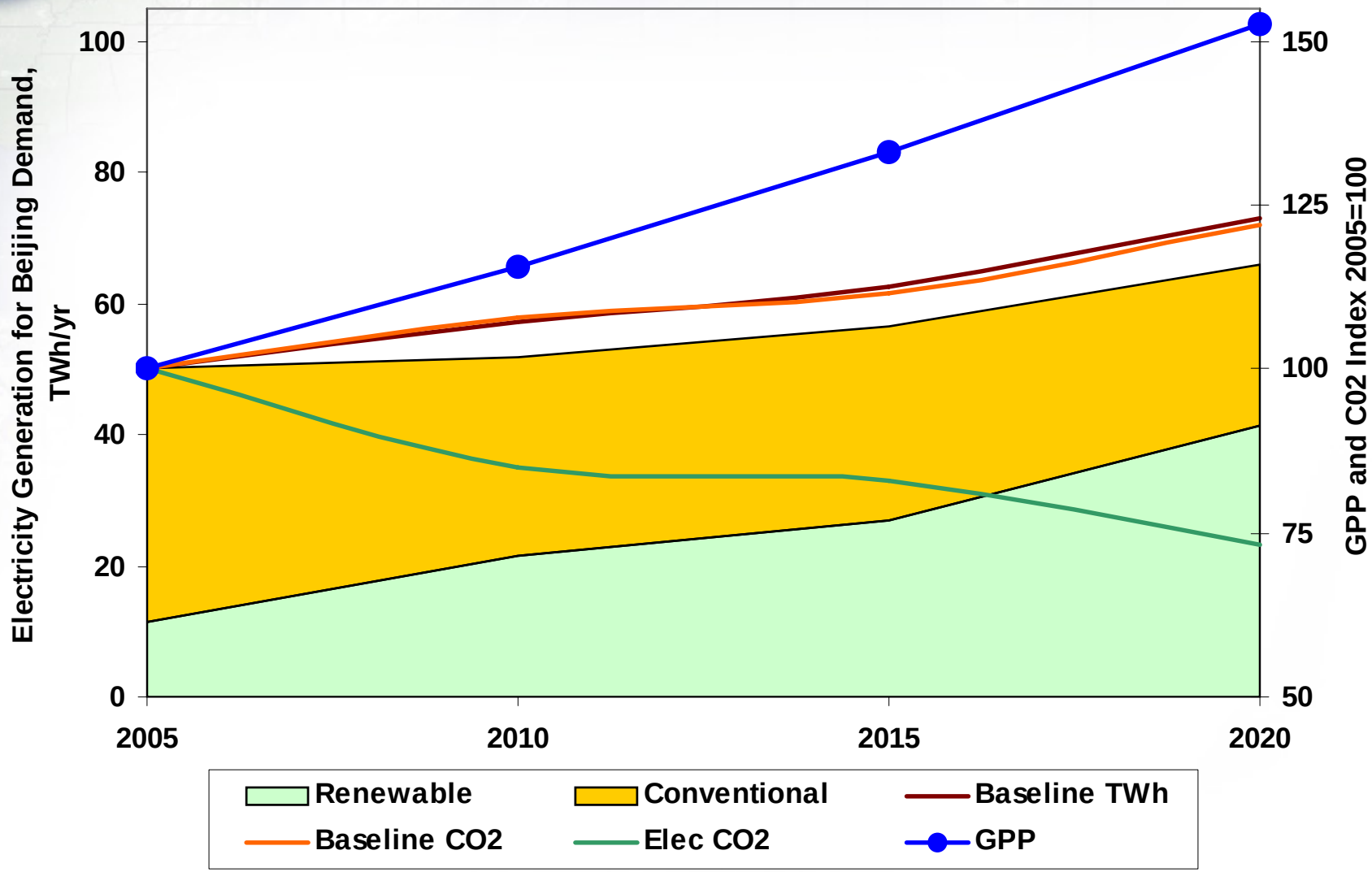
In the long term, residential electricity consumption will be a primary component of energy consumption.

Coal's dominance in electric power fuels may lead to unsustainable CO2 emissions.

In this scenario, we assume that:

1. Renewables technologies (biofuels, solar, etc.) are subsidized to be cost competitive with the current average energy feedstock price.
2. An average progress ratio of 80%, i.e. renewable adoption costs fall 80% with each doubling of the renewable technology market.
3. Decarbonization (efficiency gains in convention electricity technology) of 2%/year.

Emissions and Output: Market-oriented Renewable Scenario



RES: Renewable Energy Portfolio

Results
- Potentially significant CO2 mitigation
- GPP largely unchanged from Baseline trend.

Drivers
- Significant substitution of fuel sources toward renewables

Assumptions
- The policy is uniformly implemented across the generating industry.
- All savings are in reduction of fossil fuel inputs.
- No adoption or other direct adjustment costs.
- Alternative energy source is as polluting as the service sector.

Critical
- Electricity generators are assumed adopt uniformly and costlessly.
- National energy prices are constant.

Conclusion: Innovation, Efficiency, and Growth

- China is the world's most dynamic economy, which presents unique opportunities and challenges for policy makers and private stakeholders.
- The environment-growth trade-off is a fallacy, and in China we can prove this.
- Energy efficiency policies re-direct demand toward more labor-intensive, higher value added sectors than energy, stimulating employment and income growth.
- The Energy sector needs to join IT, Biotech, and other knowledge-intensive Chinese industries to establish global standards for technical innovation and economic growth.

Scenario Extensions

- Market-oriented policies: Cap and trade schemes
- Incentive policies: Taxes/subsidies for abatement, clean up, and technology adoption, modeling both collection and recycling/rebate components
- Energy market policies
- More renewables options
- Photo-voltaic policies
- Carbon Sequestration
- Exogenous (e.g. federal) policy shocks
  - Taxes and subsidies
  - Regulation (env., trade, labor, R&D, etc.)

Quo Vadis?