Hot Air and Cold Water

The Unexpected Decline in China's Energy Consumption

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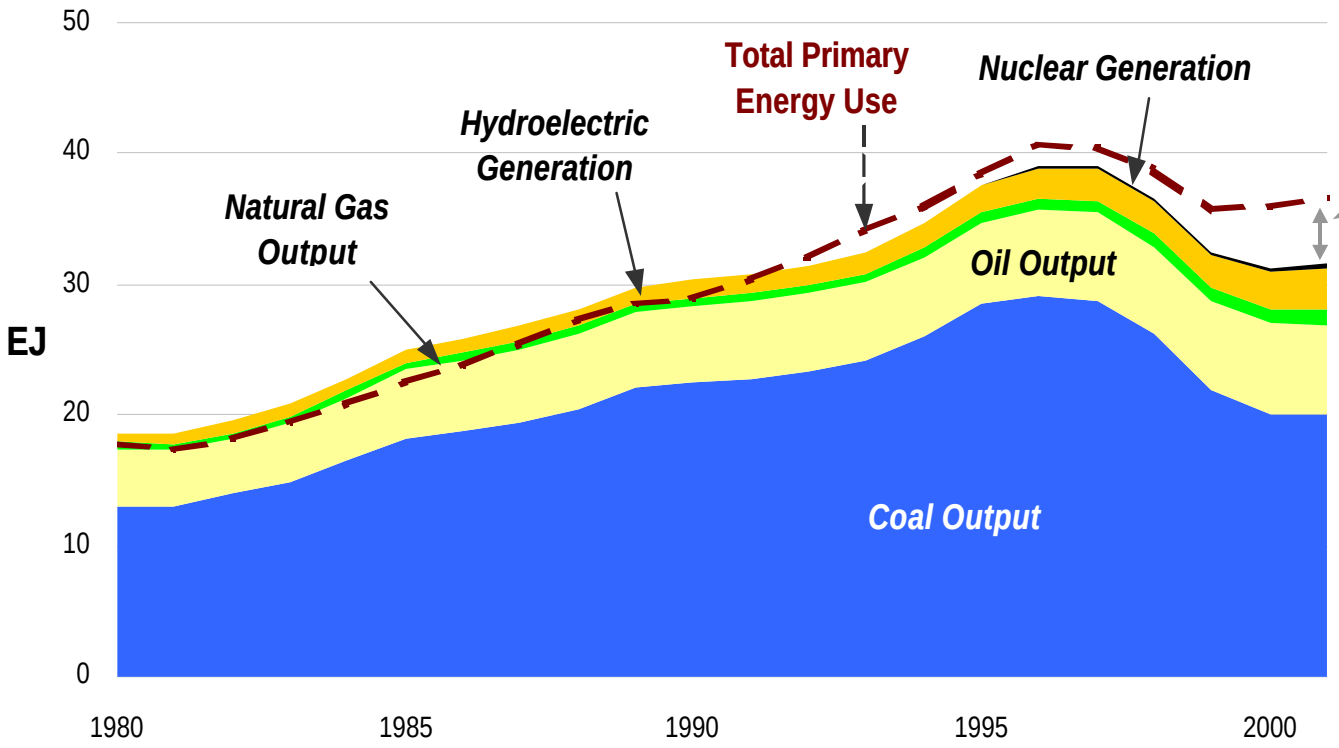
China's energy output peaked in 1996, dropped rapidly, then leveled off, following coal

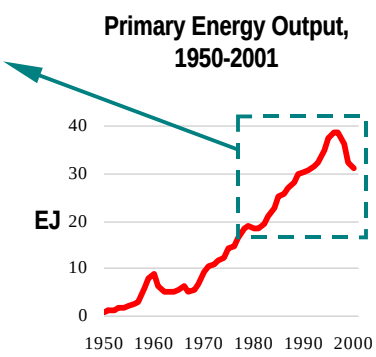
Primary Energy Output and Use, 1980-2001

Energy output is now down 20% from peak, consumption down 10%.



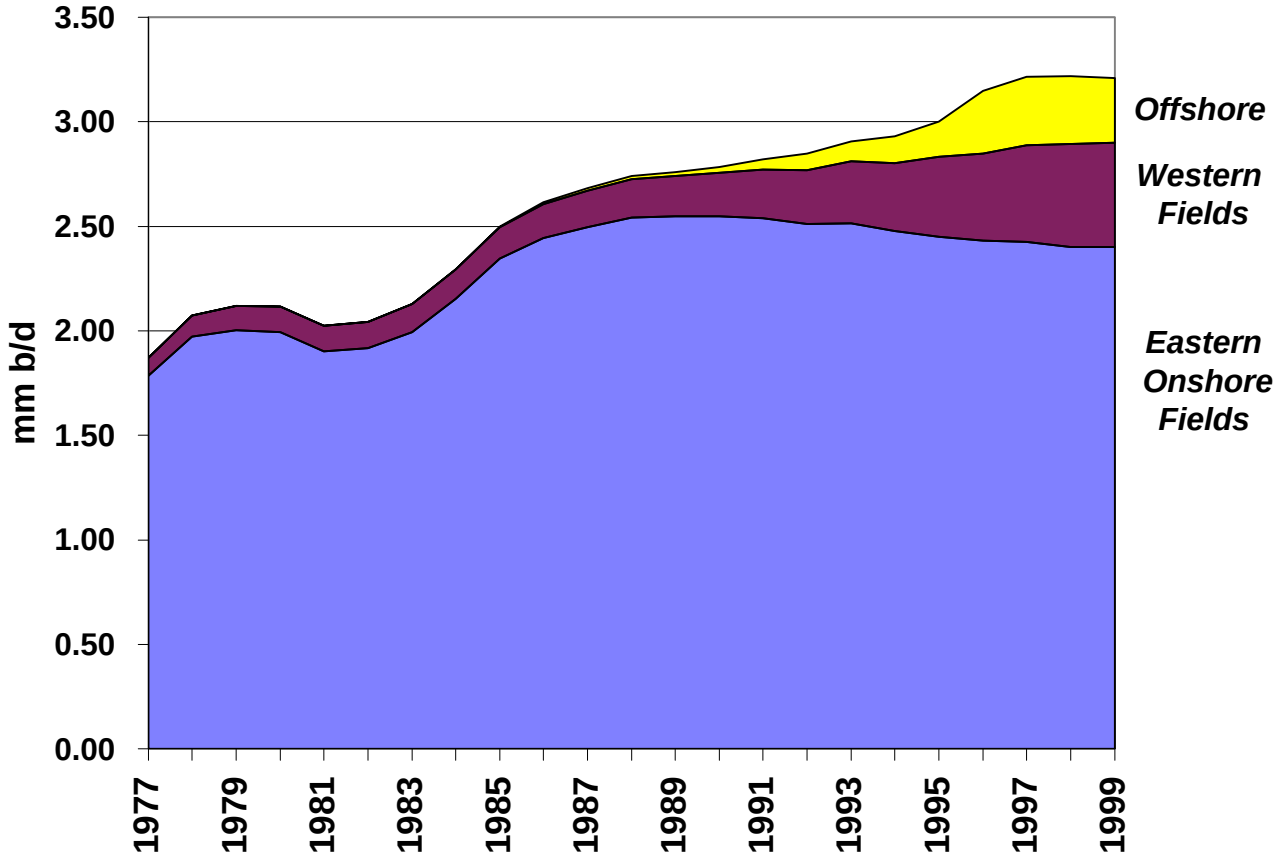
Growing gap filled by:

- *Drawdowns of coal stockpiles*
- *Oil imports*



N.B. 2000 figures are preliminary; 2001 figures are projections.

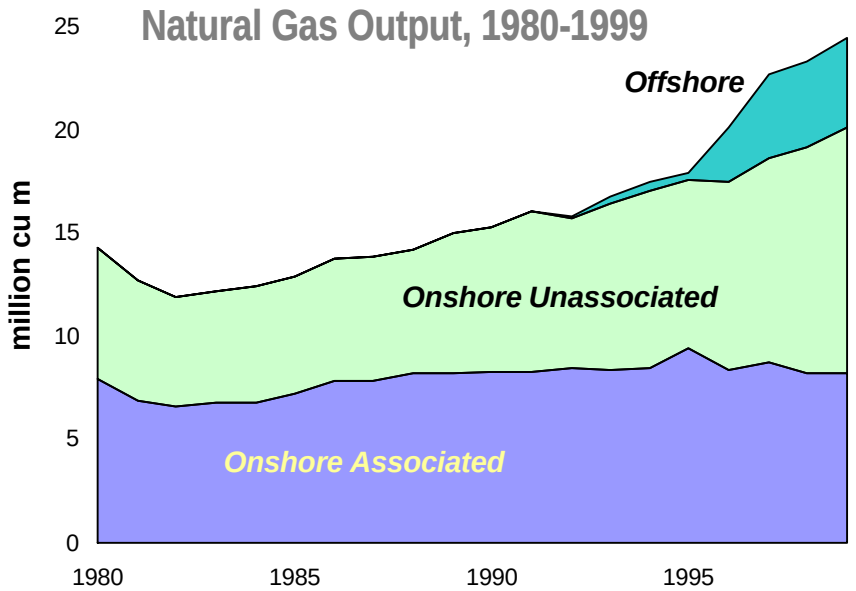
Oil use continues to climb, even as production stagnates, leading to greater import dependence

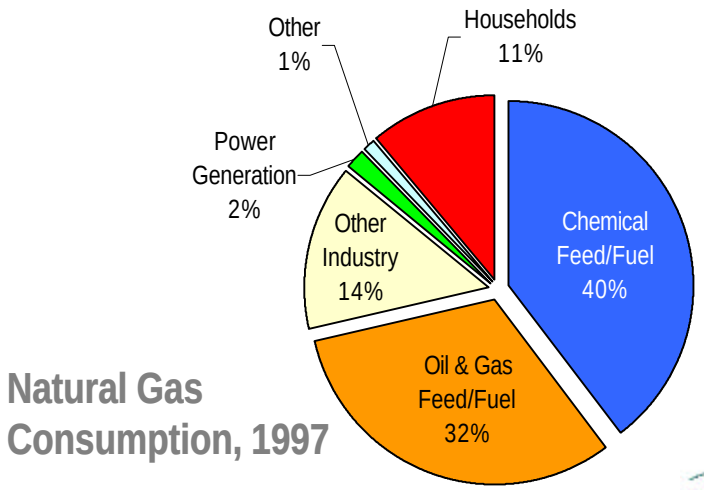


Oil output growth relies on offshore and western fields.

Natural gas use is still small, but set to rise substantially

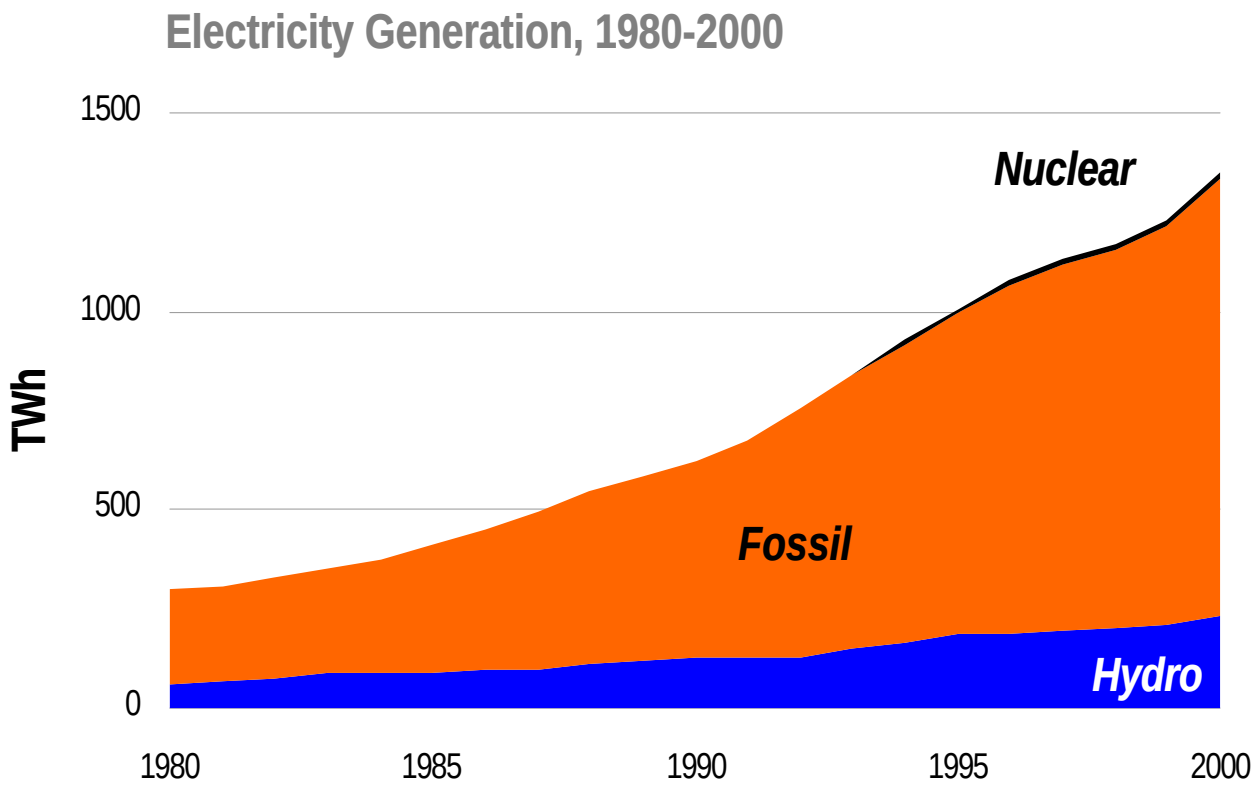
- Goal to raise gas to 6-8% of primary energy by 2010, output to 100 billion m^3.
- Push to increase coal-bed methane output to 10 billion m^3/year by 2010.
- Domestic pipelines in development; international pipelines under discussion.
- Guangdong:
  - priority for gas-fired power;
  - ban on new coal-fired plants;
  - LNG terminal (3 Mt).





Natural Gas Consumption, 1997

Generation and consumption of electricity continues to rise overall



N.B. Power generation breakout for 2000 is estimated.

...despite local exceptions to this trend.

Biomass energy use continues to fall

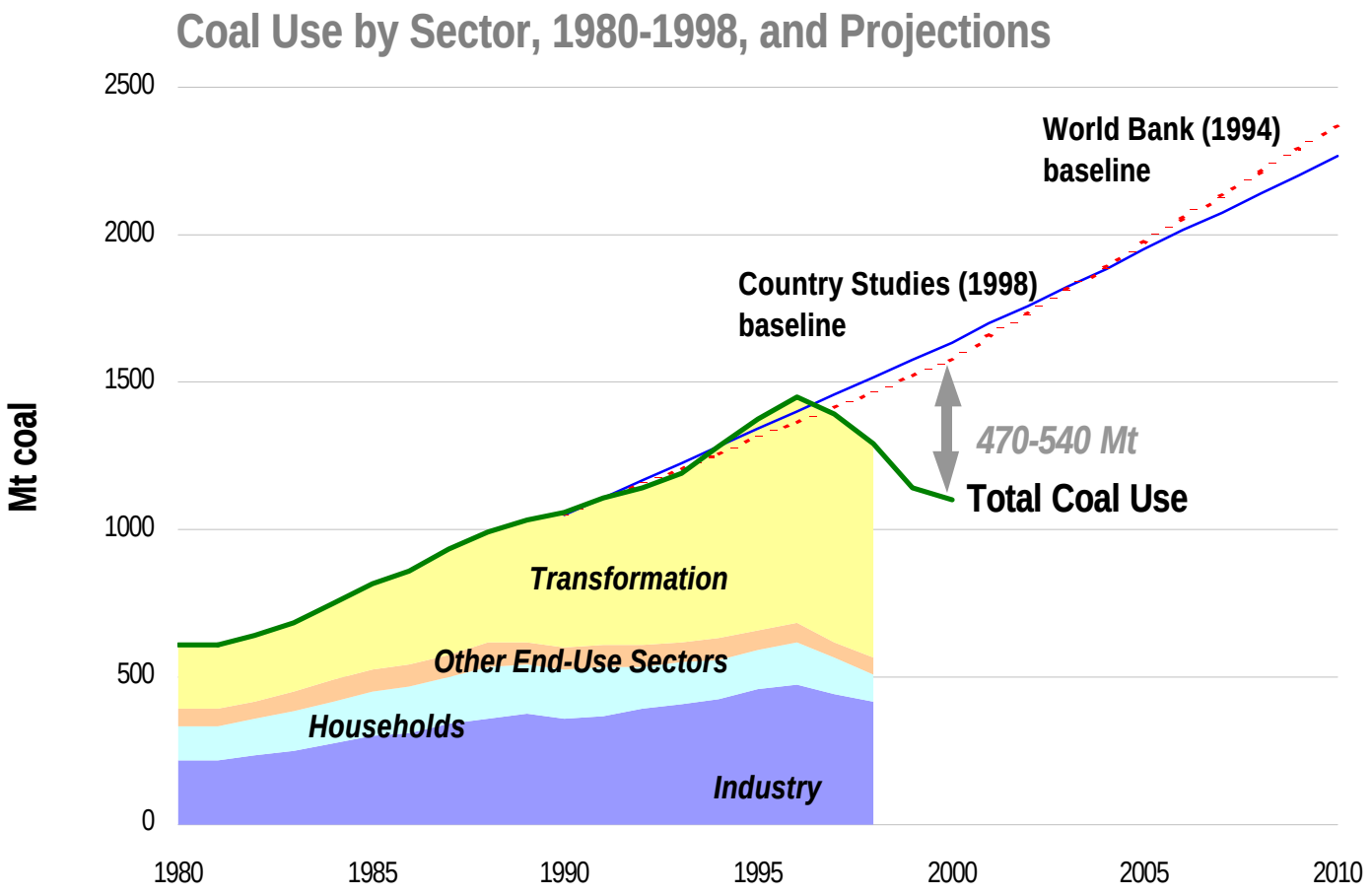
Unit: EJ

Energy Form	1991	1995	1998
Biogas	**0.02**	**0.03**	**0.04**
Crop Stalks	**4.81**	**4.42**	**3.60**
Wood	**3.02**	**2.93**	**2.46**
Total Biomass	**7.85**	**7.39**	**6.10**
Ratio of Biomass to Commercial Energy	***0.26***	***0.19***	***0.16***

Increasingly replaced by fossil fuels,

but still the only fuel for millions of rural families.

Coal is the main actor, especially in industry and power generation



The sharp fall in coal use runs counter to all plans and forecasts.

What could explain the drop in energy use?

Unintentional Policy Impacts *(Economic, Environmental)*

- **Economic system reforms** have shut down inefficient factories (hot air), favoring development of efficient enterprises.
- Non-state sector enterprises have become more energy-efficient in response to strong **competitive pressures**.
- Policies to promote **structural change** in China's economy reduced energy demand, away from industry, towards services.
- Buyers' markets allowed consumers to switch to **higher quality coal**, leading to greater efficiency and lower total demand.
- Relatively **higher prices for electricity** have stimulated energy conservation, leading to substantially lower demand.
- Implementation of **environmental regulations** forced inefficient plants to shut down or become more efficient.

Intentional Policy Impacts *(Energy)*

- **Reforms in the coal sector** that have led to the shutdown of many small mines have reduced "oversupply".
- **Energy-efficiency policies** and investments have reduced energy intensity in all sectors.
- **Elimination of small power generators** has reduced growth in coal demand from electricity generation.
- Urban dwellers are **switching to gas and electricity** for cooking & water heating, from stoves to central heating.

Uncontrolled Factors

- **Slowing economic growth** (cold water) has caused fuel demand from the largest users to fall off,including demand from the utility sector.
- **Normal turnover of capital equipment** has improved average energy efficiency.
- Reductions in energy use are overstated, recent energy and economic **statistics are inaccurate** (more hot air).

Unintentional Policy Impacts

Have economic system reforms shut down inefficient factories?

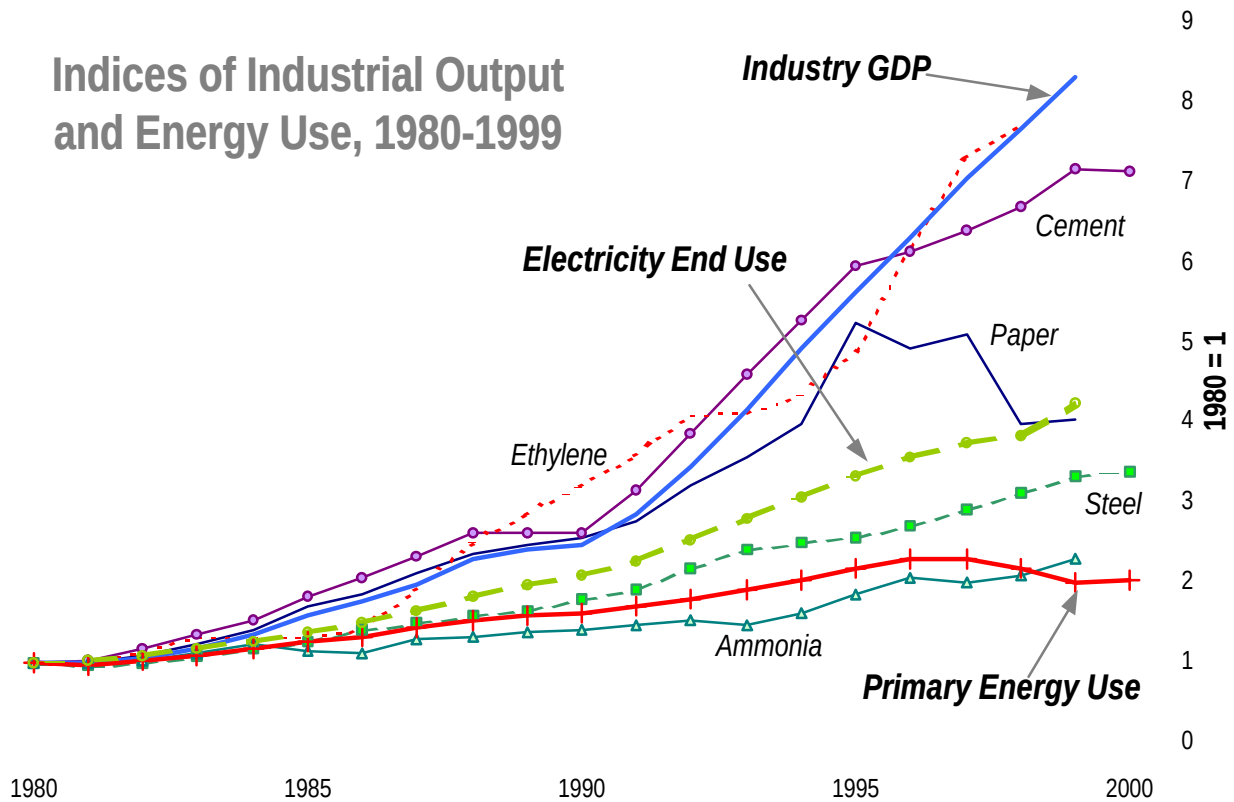
	State-owned	Collective	Private	Other
Number of Enterprises *(thousands)*				
1995	118.0	1,475.0	5,688.2	60.3
1996	127.6	1,591.8	6,210.7	70.2
1997	110.0	1,772.3	5,974.7	77.3
1998	64.7	1,797.8	6,033.8	85.7
1999	61.3	1,659.2	6,126.8	91.8
Gross Output Value per Enterprise *(million 1995 yuan/enterprise)*				
1995	26.46	2.28	0.21	25.26
1996	25.72	2.55	0.23	26.85
1997	30.15	2.53	0.27	31.75
1998	51.30	2.72	0.31	35.88
1999	58.91	3.12	0.35	42.74

There has been substantial attrition in the state-owned sector.

Enterprises appear to be growing larger

Economies/efficiencies of scale?

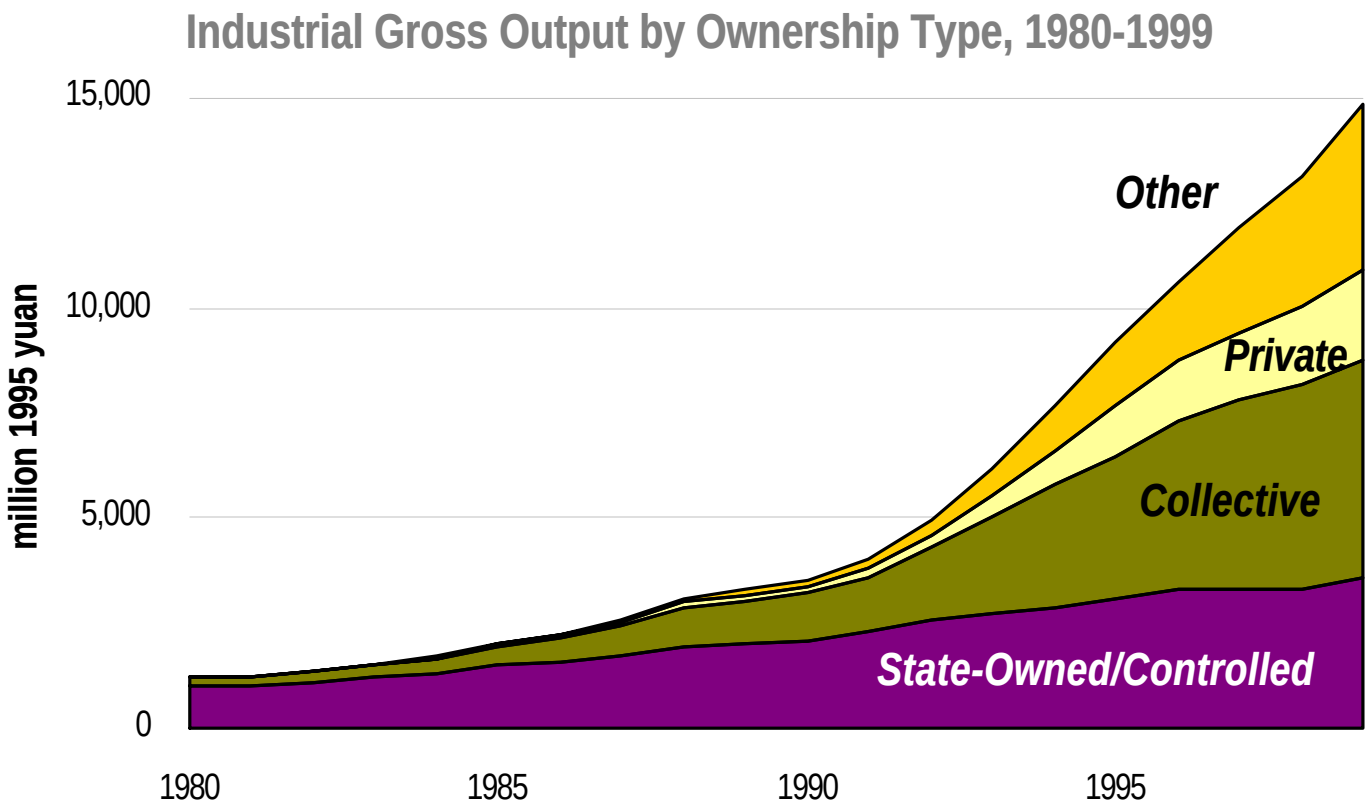
Output of major industrial products keeps rising



Growth in output per plant outpacing shrinkage in number of plants.

- **Replacement of inefficient plants with more-efficient ones probably a large factor.**

Reforms have significantly affected ownership structure of output from industrial enterprises



More output from non-state sectors--but are they more efficient?

Unintentional Policy Impacts

Have non-state sector enterprises become more energy-efficient in response to competitive pressures?

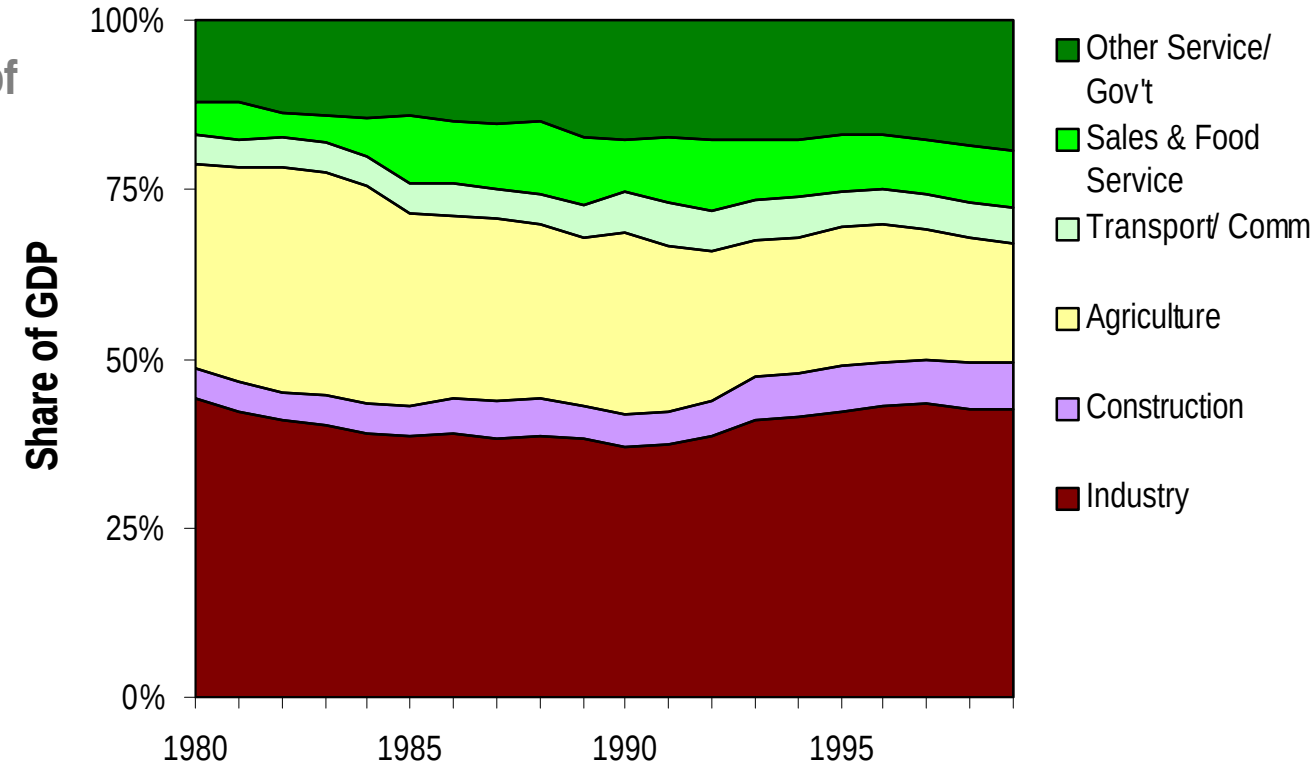
- Economic reforms allowed non-state sector to expand and compete with state sector.
- Typical view of non-state (often rural enterprises): inefficient users of second-hand equipment.
- Significant exceptions, with technology and energy-efficiency among the best in China.
- Exposure to market prices would seem to encourage efforts to lower energy costs, but many barriers.
- No broad-based survey or statistical data, only anecdotal evidence.

 Insufficient evidence, but not likely to be a large factor.

Unintentional Policy Impacts

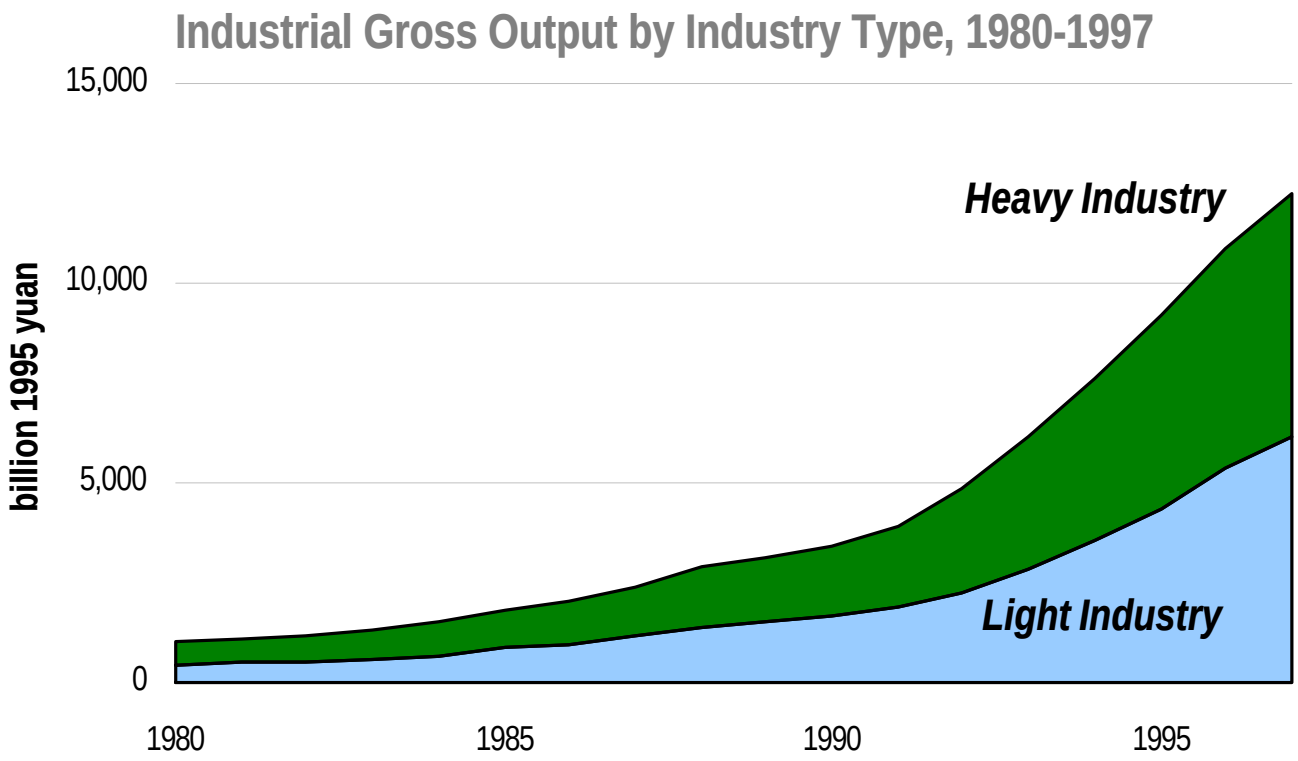
Have policies promoting structural change reduced energy demand, away from industry, towards services?

Sectoral Shares of GDP, 1980-1999



Changes in China's gross economic structure contributed little to the slowdown in energy demand.

Changes within gross industrial structure were also minimal



Split between heavy and light industry remained about the same.

- **Shift among sectors small--but changes in product mix within sectors significant.**

Unintentional Policy Impacts

Have changes in markets led to switching to higher quality coal, and to greater efficiency and lower total demand?

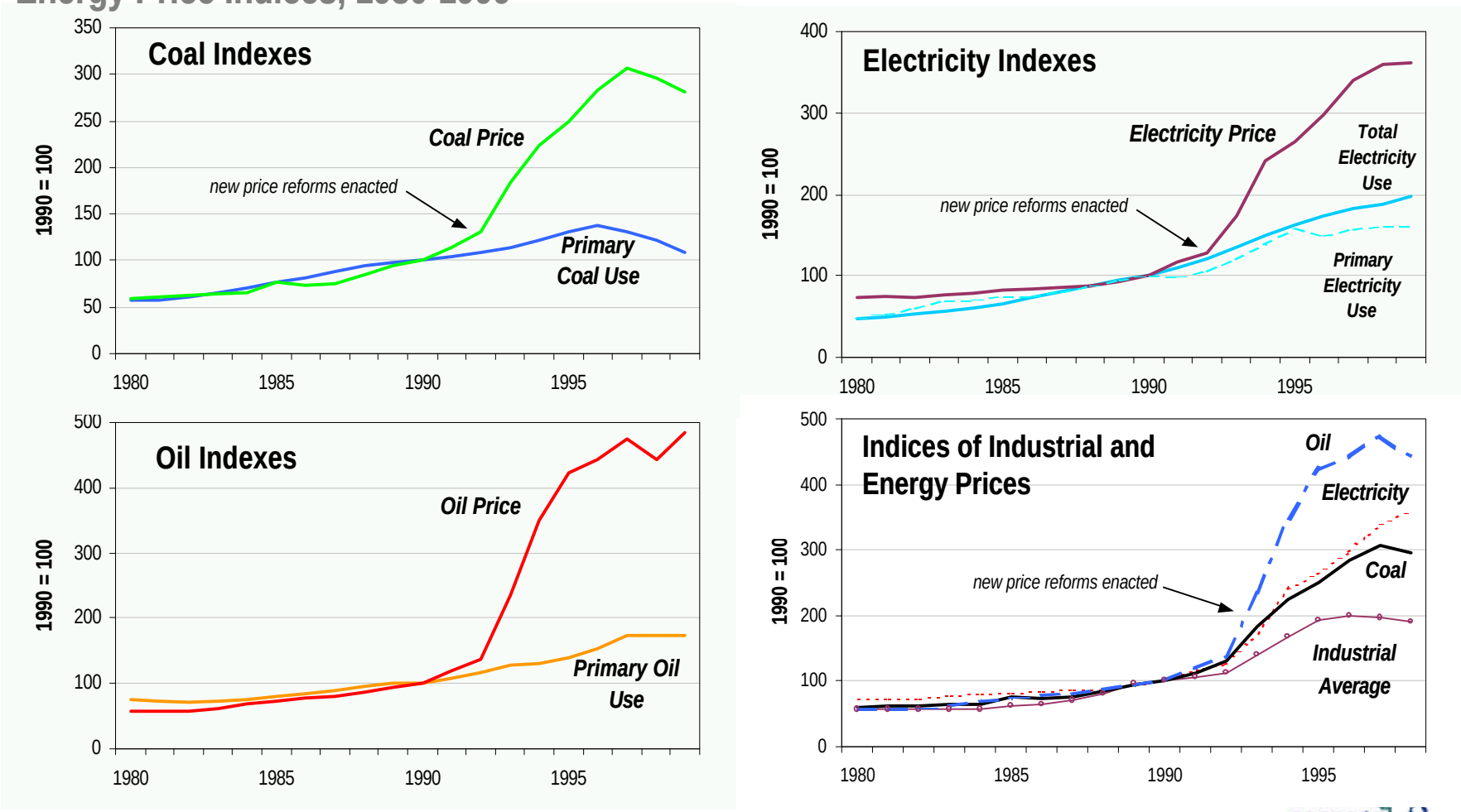
- Utility sector: average heat content of delivered coal was 200 kcal/kg (0.84 MJ/kg) higher in 1997 than in 1996.
- In 1998 the average rose by a further 100 kcal/kg (0.42 MJ/kg).
- Increase in average heat content over the two years would have reduced coal consumption in the power sector by 30 Mt per year, compared to the fall in coal use of about 180 Mt per year.
- With similar quality improvements in other end-use sectors, additional reductions may be another 30 Mt per year.

 Coal quality could have accounted for one-third or more of the drop in coal use from 1996 to 1998.

Unintentional Policy Impacts

Have higher prices for energy stimulated conservation, leading to lower demand?

Energy Price Indices, 1980-1999



Relative energy prices may have encouraged greater energy efficiency

- Conditions right for the operation of market logic to stimulate energy conservation.
- Energy costs sometimes are, but usually are not primary drivers of decisions affecting energy use at the plant level (technology choice, product selection, operations, maintenance).
- Technology and operational choices motivated by other factors (e.g., market demand, convenience, or survival) often have the greatest impact on how energy is used.
- Systematic evidence lacking.

 Impact of prices mixed in with many other factors, but probably moderate; more information needed to determine size of effect.

Unintentional Policy Impacts

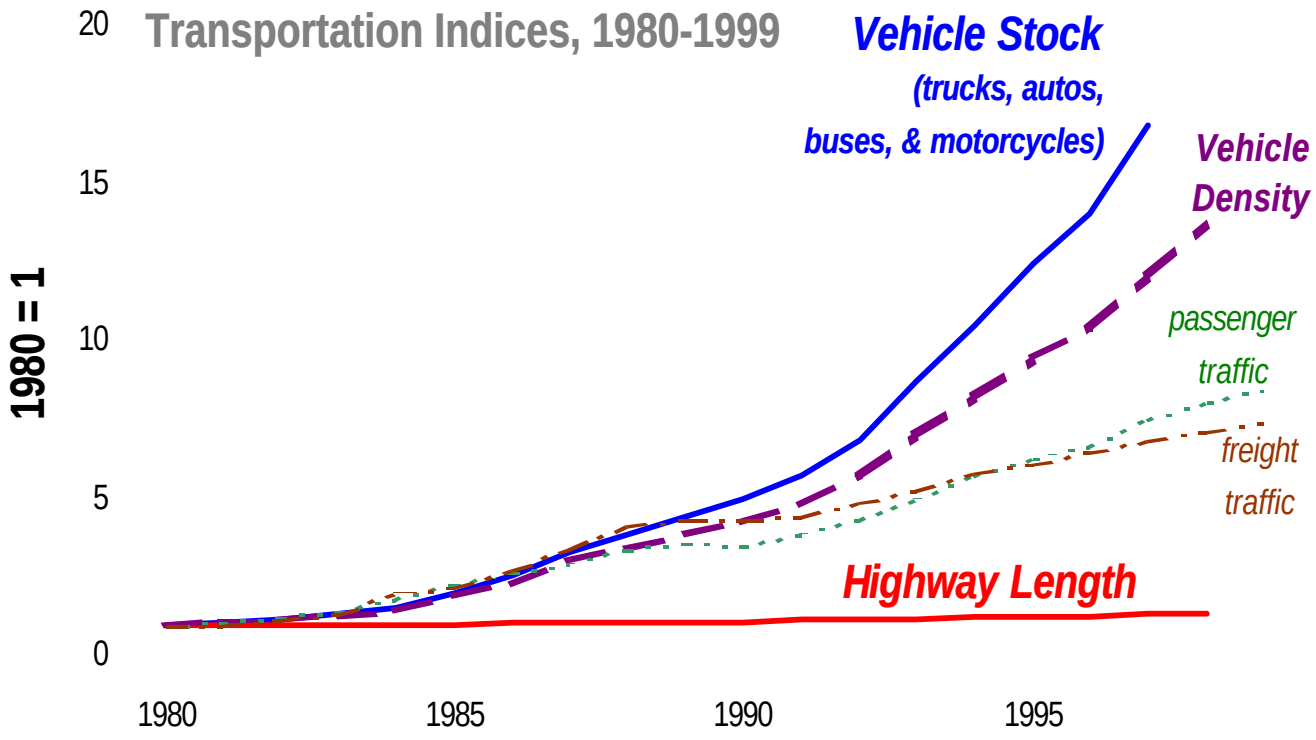
Have environmental regulations forced inefficient plants to shut down or become more efficient?

- National campaigns and local enforcement becoming stricter, leading to shutdowns mainly of smaller plants (paper mills, cement plants, steel mills, chemical fertilizer plants, refineries, and others) and relocations.
- Shutdowns not just motivated by environmental concerns--also financial performance, competition, and safety concerns.
- May have helped push cleaner, less fuel-intensive, but more electricity-intensive processes.
- Systematic evidence lacking. Need to conduct study of plant closures.
- Acid precipitation controls may have a big impact on coal use in future.

Environmental regulations probably made only a small contribution to declining energy use.

Unintentional Policy Impacts--in the opposite direction

Fast pace of road construction, support for auto industry have been driving up oil use.

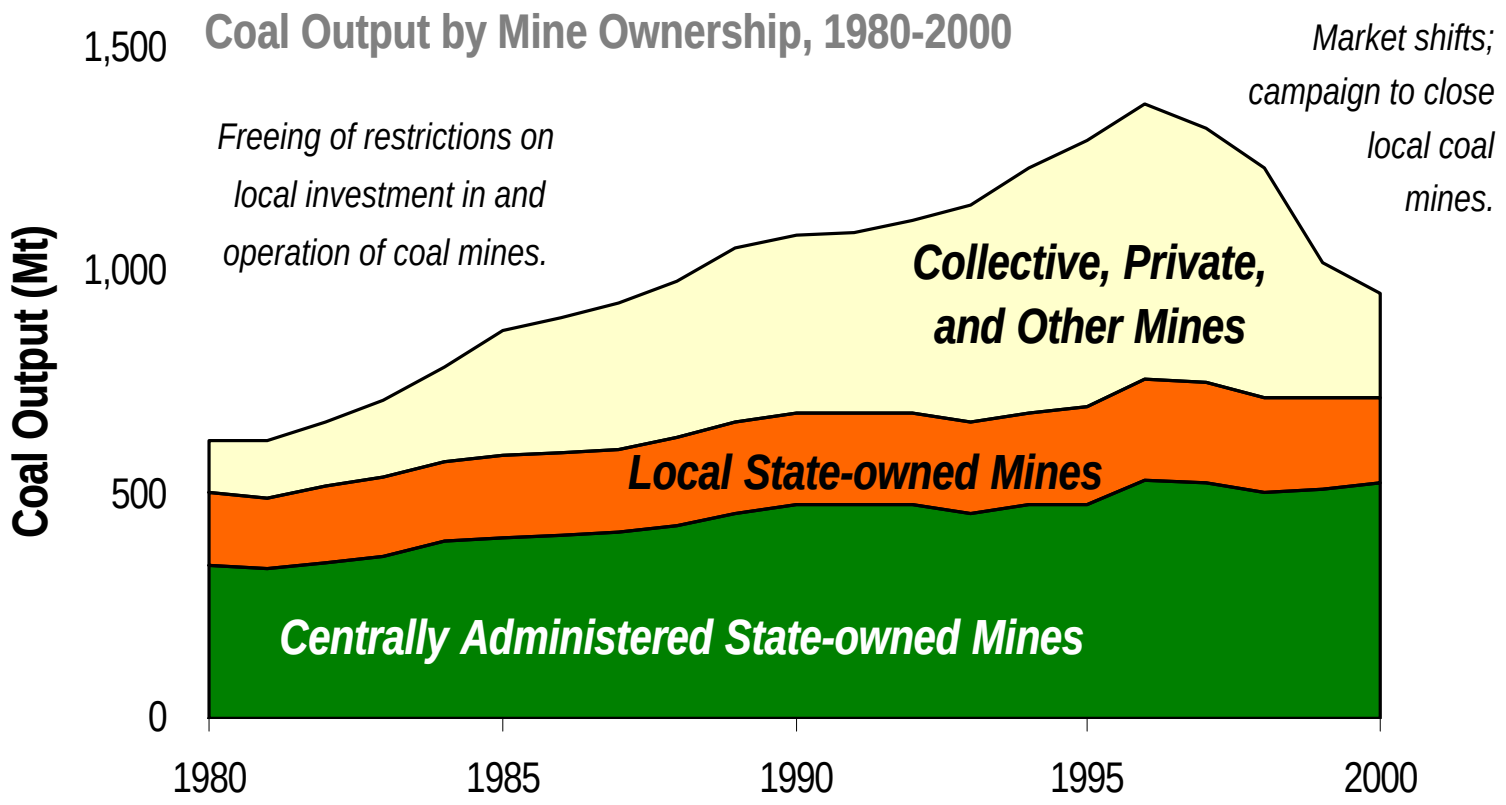


Increasing congestion in cities changing character of air pollution and leading to poor fuel economy.

Have reforms in the coal sector that have led to the shutdown of many small mines reduced "oversupply"?

- In the mid-1990s, China had over 70,000 coal mines. Now it has fewer than 40,000.
- Closure campaign mainly hit small, non-state mines; part of policy to help state sector compete.
- Offered in some Chinese sources as a major reason for falling coal use.
- If true, then one would expect signs of shortages, but none apparent.
  - Coal price fell as coal output dropped; markets are functioning.
  - Coal supply has shrunk considerably while economy has grown.
  - Stock drawdowns have reportedly been significant, but not huge.

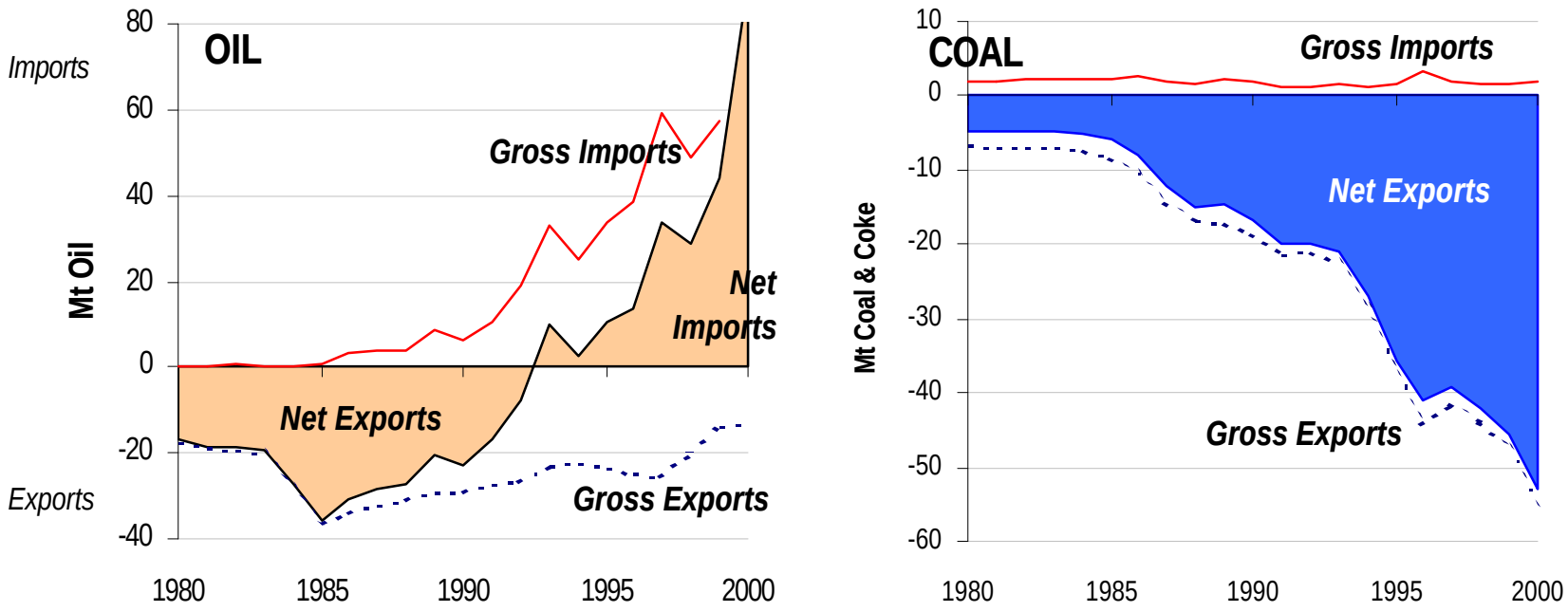
Non-state mines used to be the largest coal producers-- but soon they may be the smallest



Some state-owned mines closed too.

Oil imports and coal exports rising

Oil and Coal Trade, 1980-2000



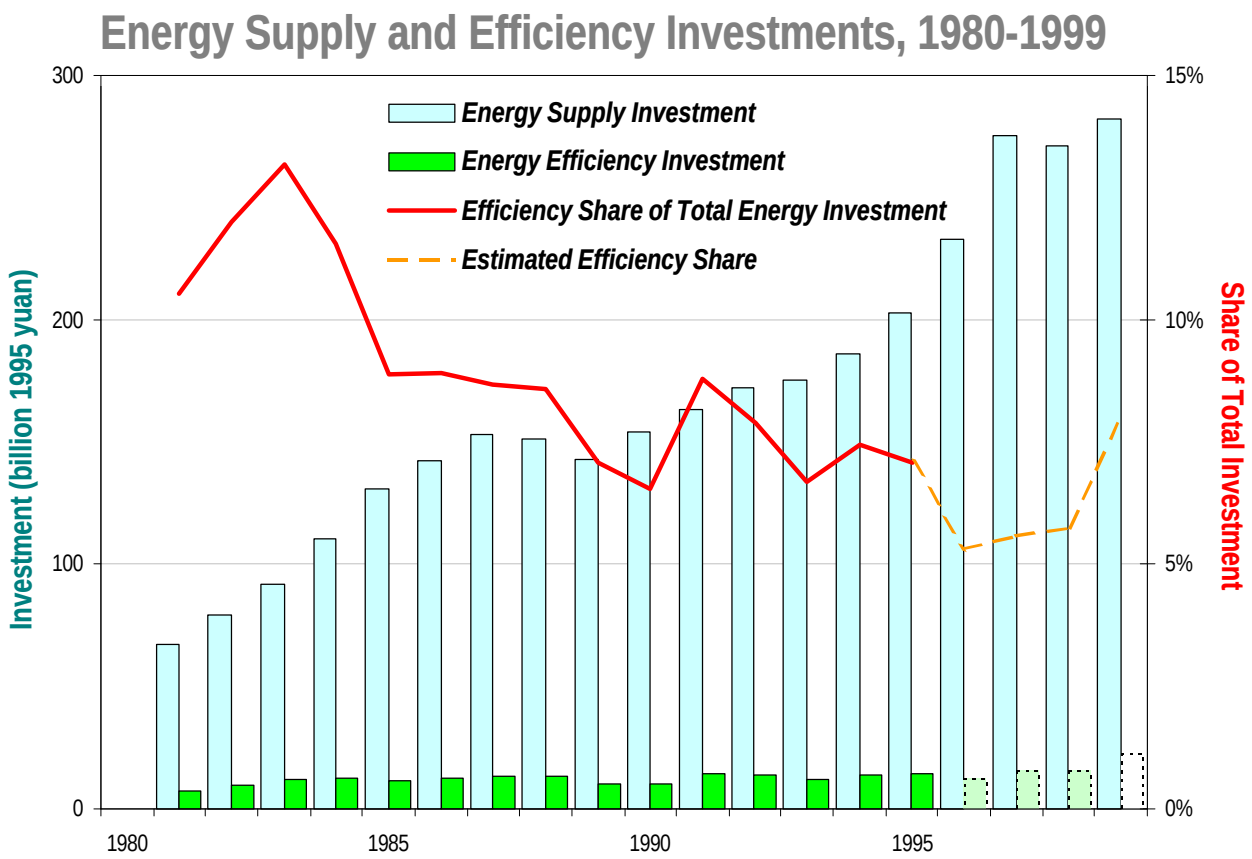
N.B. These are based on official customs figures, and do not include estimates of any smuggled products.

Rising coal exports (heavily promoted by state) imply sufficient domestic supply.

- **Fall in coal use driven more by changes in demand than by changes in supply.**

Intentional Policy Impacts

Have energy-efficiency policies and investments reduced energy intensity?



Financial support for energy efficiency has been substantial.

Many types of programs and policies have promoted greater end-use efficiency...

Since 1980s...

- direct support for energy efficiency projects, China Energy Conservation Investment Corporation
- administrative and regulatory structures to manage energy use
- standards for process and equipment efficiency, building energy codes
- financial incentives
- nationwide network of technical service centers, training, advertising

1998: Energy Conservation Law

- energy efficiency under a more market-oriented economic system
- implementing provisions still being formulated

International assistance projects

- direct assistance for demonstration projects and technology transfer
- to more recent projects for comprehensive transformation of markets

…but quantitative evaluation of their recent effectiveness is lacking.

1980s:

- energy intensity of the economy fell by a third
- one third to one half of that change was attributable to improvements in energy efficiency (Chinese estimates are smaller)
- mainly due to government-led investment programs and regulatory activity
- retrofits of existing equipment, but especially construction of new capacity

1990s:

- less direct government investment, fewer statistics available from which to make estimates
- programs made efficient equipment more widely available than they would have been otherwise; continuing impact despite reforms

- **Taken together, programs to promote energy efficiency probably contributed moderately to falling energy use.**

Intentional Policy Impacts

Has elimination of small power generators reduced growth in coal demand for electricity generation?

Installed Capacity of Coal-Fired Power Plants, 1993 and 1999

	1993			1999			
Unit Size (MW)	No. of units	Total capacity (MW)	% of total	No. of units	Total capacity (MW)	% of total	change in share (% points)
600	6	3,600	3.0%	15	9,000	4.4%	1.4%
300 to <600	73	22,780	19.1%	223	71,379	34.6%	15.5%
200 to <300	162	32,600	27.4%	195	39,230	19.0%	-8.4%
100 to <200	217	23,993	20.1%	316	35,849	17.4%	-2.7%
50 to <100	267	13,530	11.4%	376	19,464	9.4%	-2.0%
<50	1,807	22,583	19.0%	2,499	31,453	15.2%	-3.8%
Total	2,532	119,086	100.0%	3,624	206,374	100.0%	0.0%

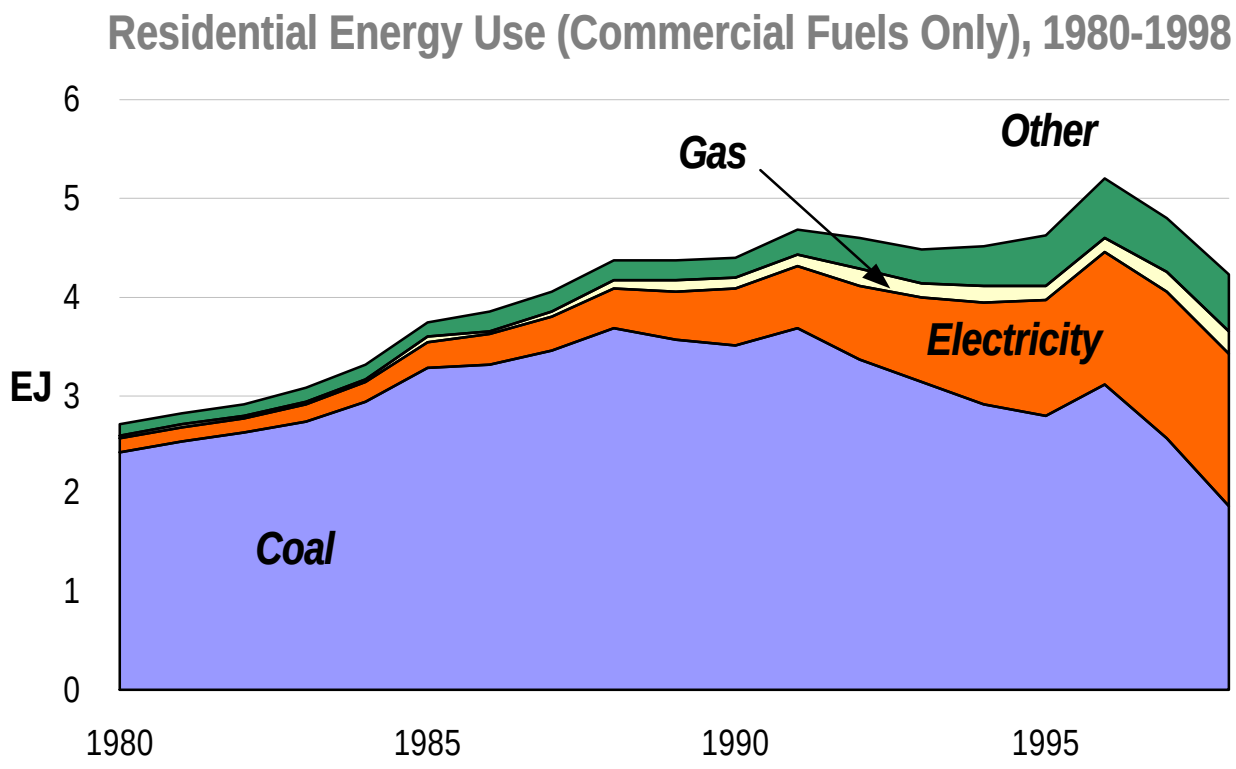
N.B. Includes only generating units over 6 MW.

Large-capacity coal-fired power plants are more numerous--but so are small ones.

- **Elimination of small generators was a contributing factor, and considerable potential remains.**

Intentional Policy Impacts

Have switching to gas and electricity and to central heating among urban dwellers been significant?

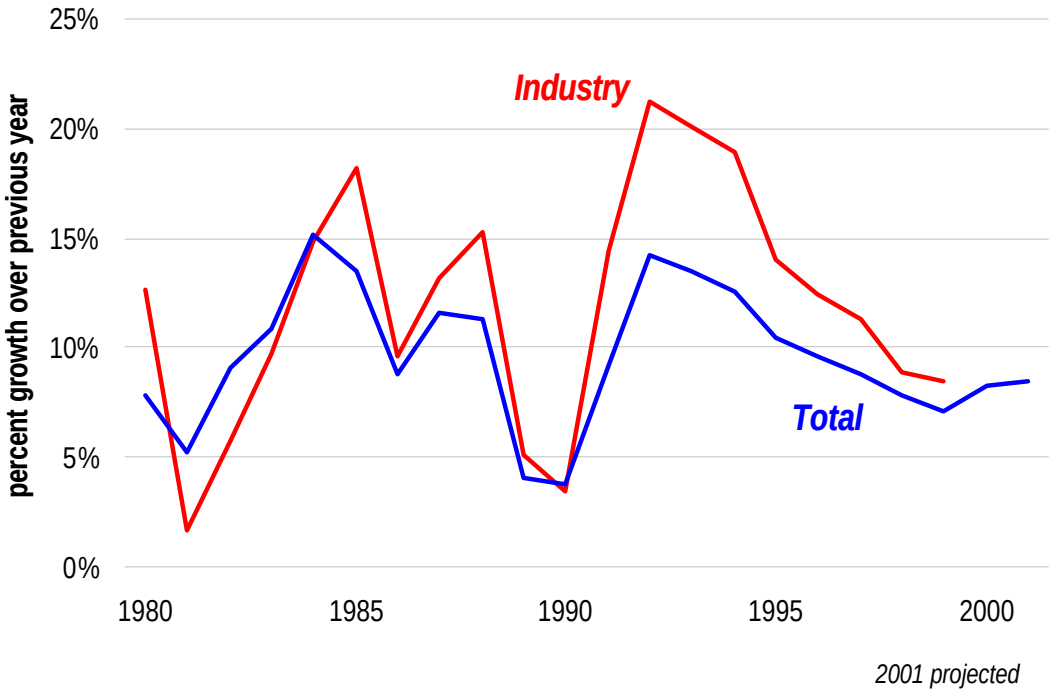


- **Switching of household fuels has has a small net effect since most electricity is from coal-fired power plants.**

Uncontrolled Factors

Has slowing economic growth caused fuel demand from the largest users to fall off?

GDP Growth Rates, 1980-2001



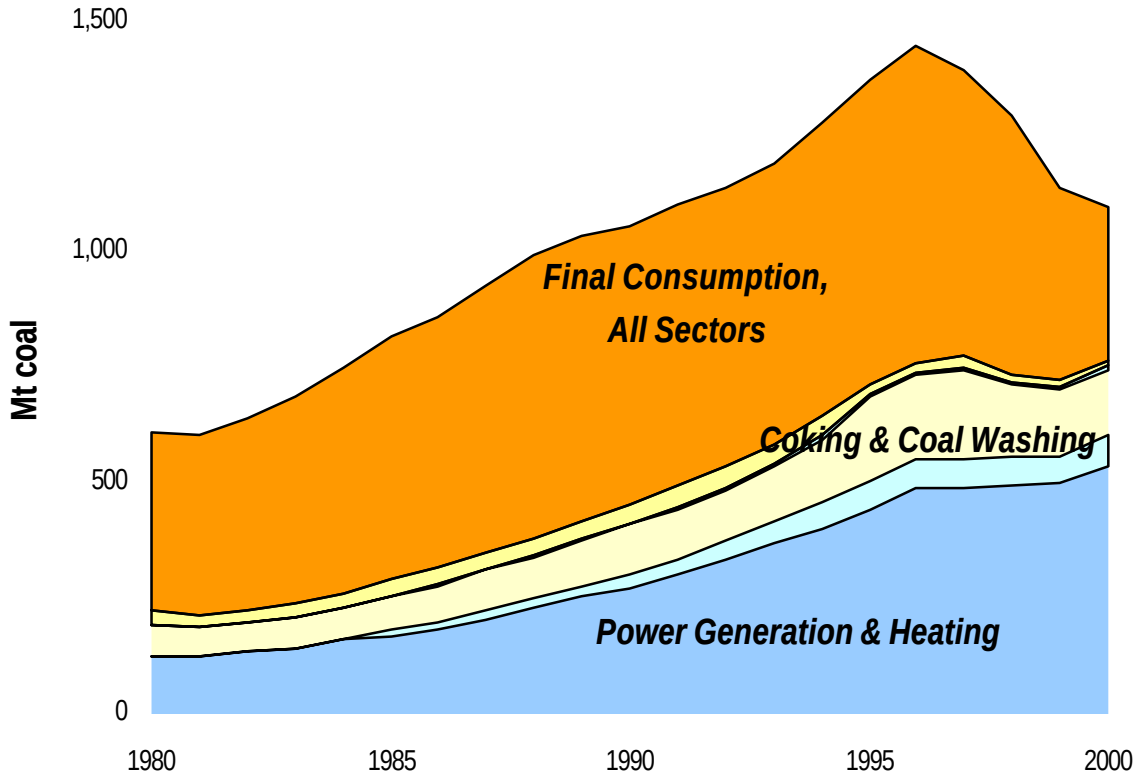
- Slow-down in economic growth due to domestic factors, influence of Asian economic troubles of late 1990s.
- China unlikely to resume very rapid growth of early to mid-1990s.

- **Moderate effect by depressing demand growth.**

Uncontrolled Factors

Has slower economic growth reduced electricity demand growth, cutting utility sector coal use?

Coal Use for Transformation and Direct Consumption, 1980-2000



- **Significant factor in reducing coal demand--but temporary.**

Uncontrolled Factors

Has normal turnover of capital equipment improved average energy efficiency?

Seems logical enough...

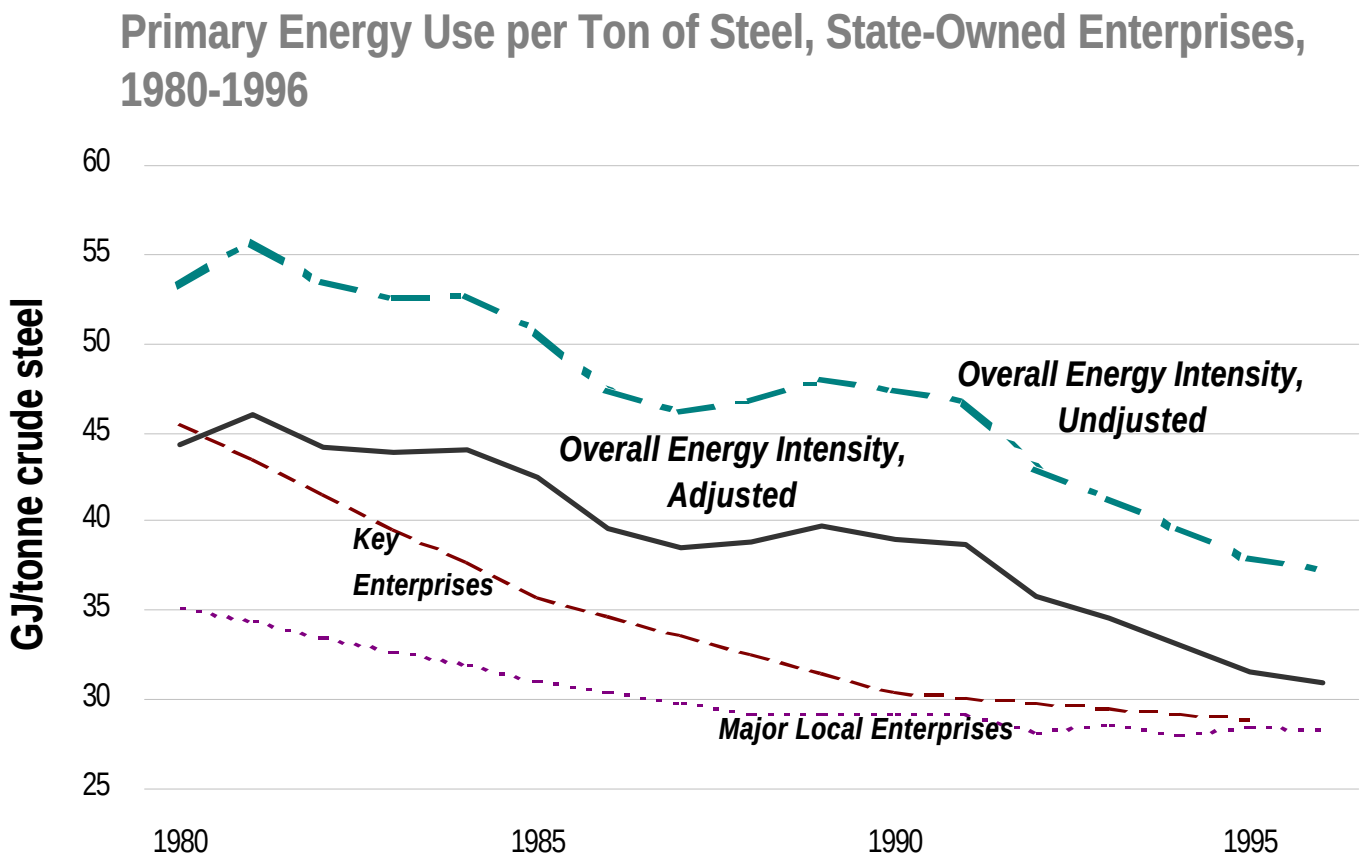
- Most new industrial, transport, and commercial equipment in use has been built in the past decade.
- New equipment generally more efficient than older equipment.
- Evidence from statistics on heavy industrial processed shows slow improvement (1-2% per year).

...but evidence sparse.

- Physical energy intensity statistics are less available than previously, cover shrinking share of economic activity.
- Better, survey-based data are needed.

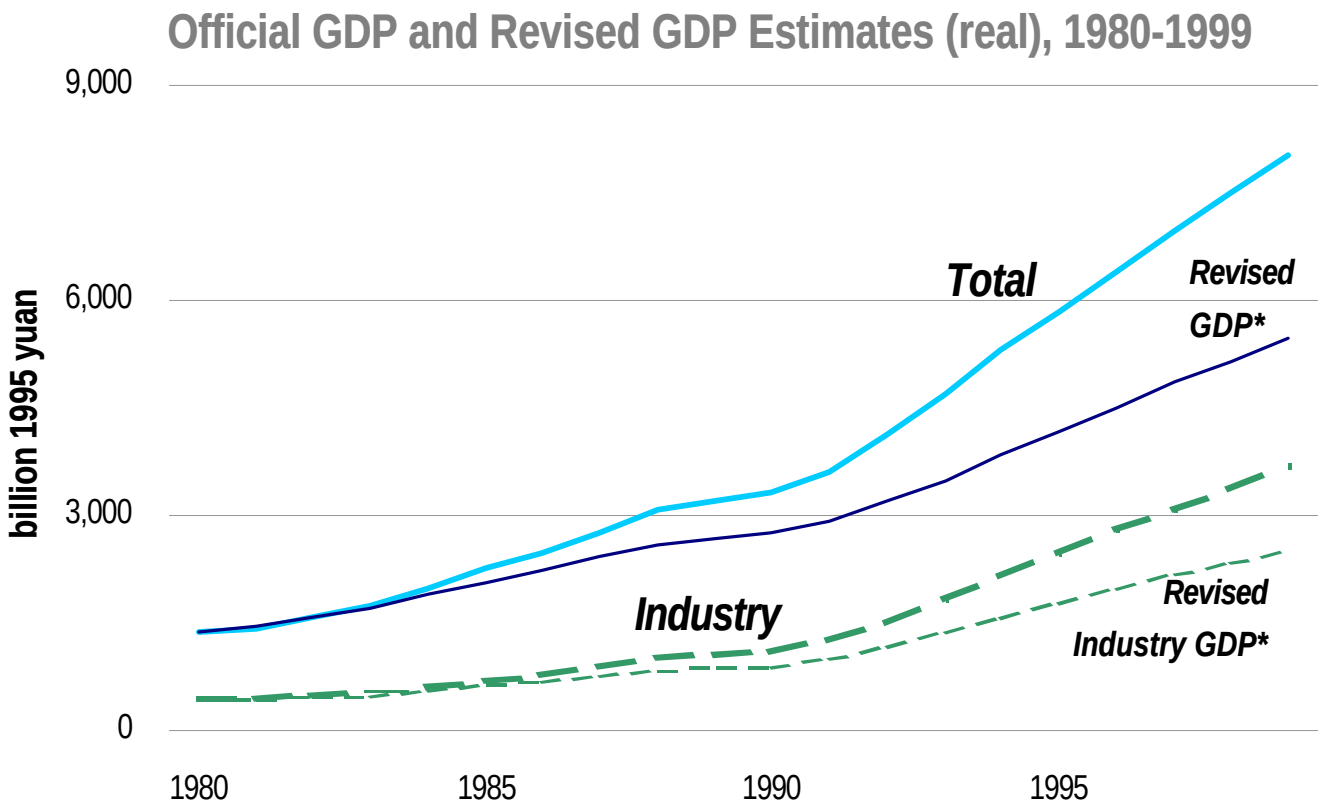
- **Turnover of equipment may have been a major influence in suppressing energy demand, but not provable.**

Some major physical energy intensity indicators have been falling since the early 1980s



Uncontrolled Factors

Have reductions in energy use been overstated due to inaccurate energy and economic statistics been?

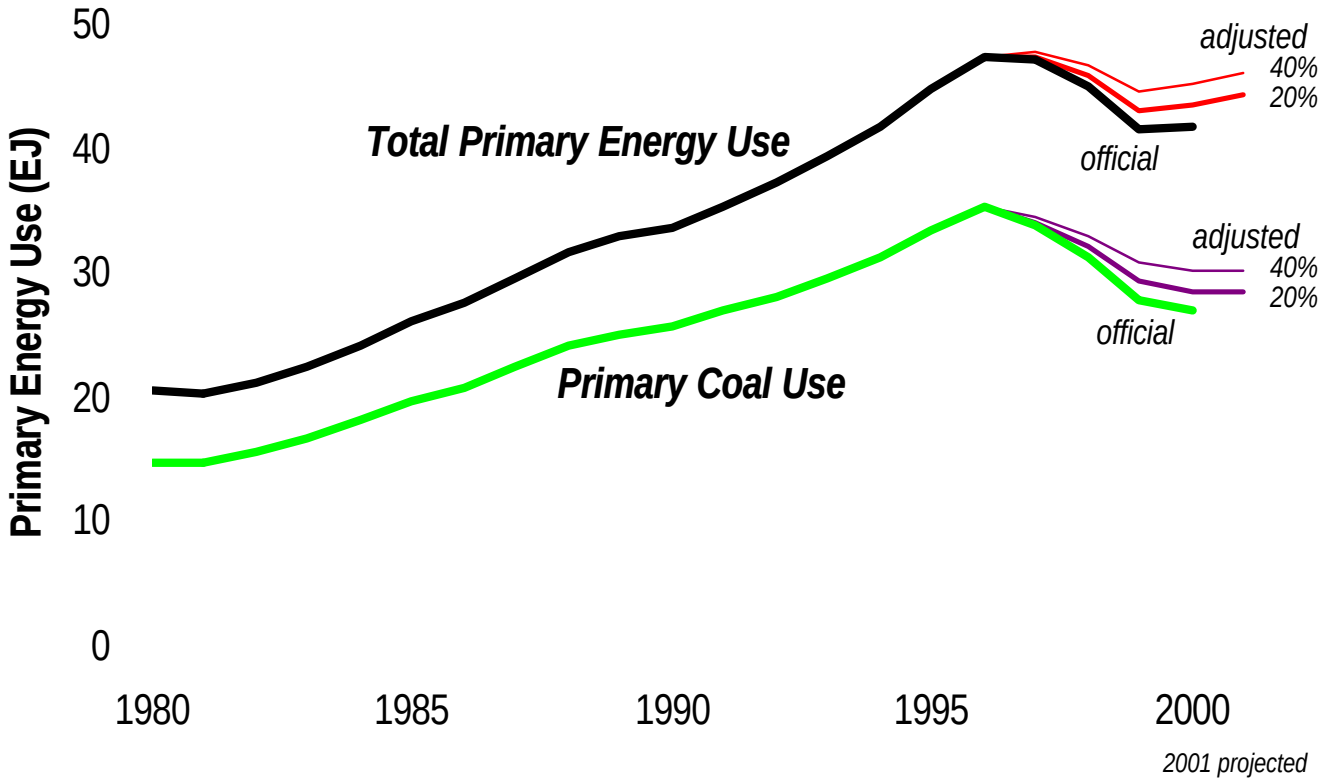


*Revised GDP figures are calculated based on time-series estimates that effectively reduce average annual growth in GDP by about two percentage points over 1980-1999.

Source: SSB, 1998a and 2000; SCMP, 1999b and 1999f; *People's Daily*, 1999a; Maddison, 1997.

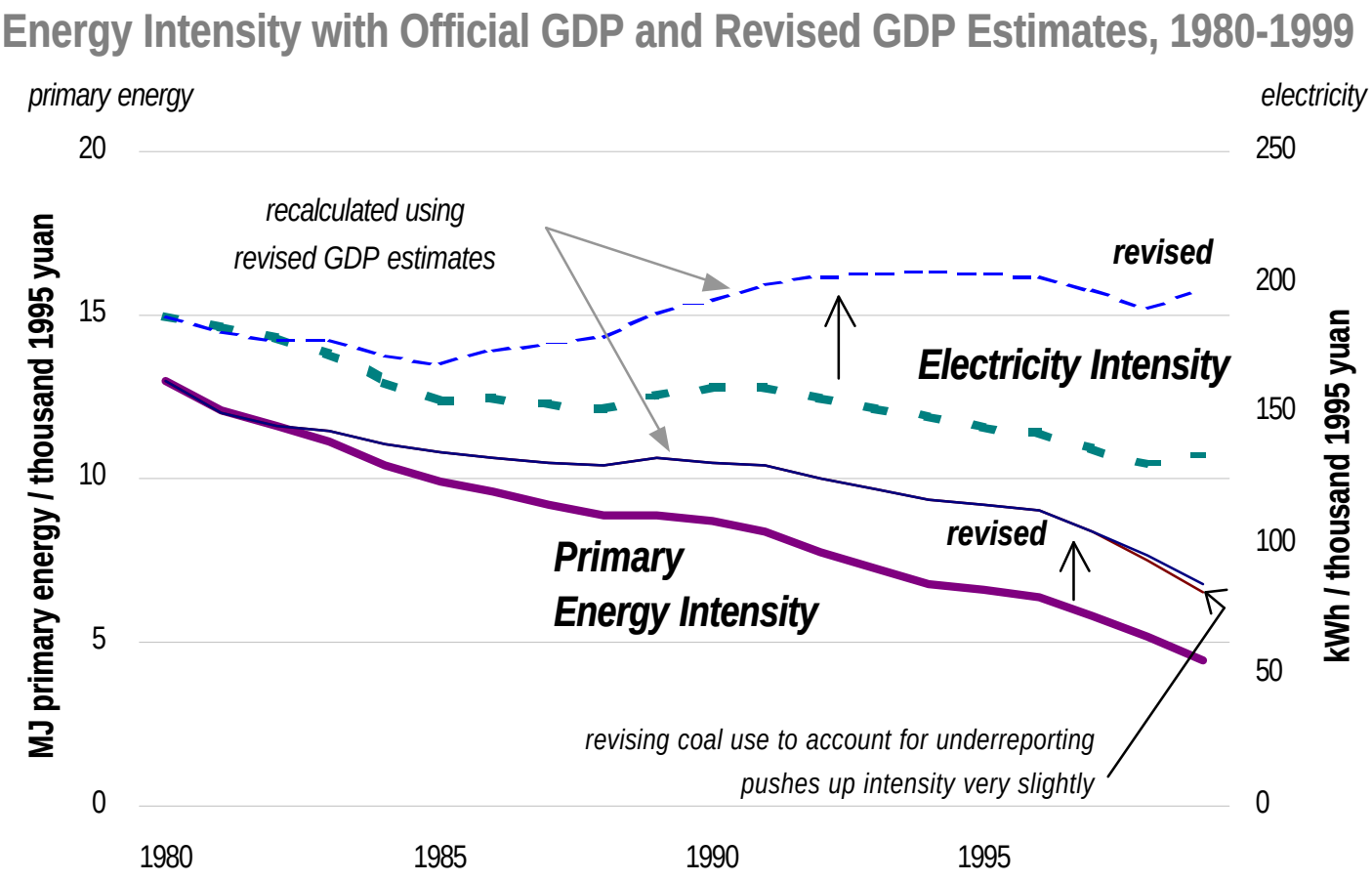
China's GDP may not have grown as fast as reported in official statistics.

If the decline in coal use was overstated by 20% total energy would have risen slightly in 2000 but coal would have remained flat

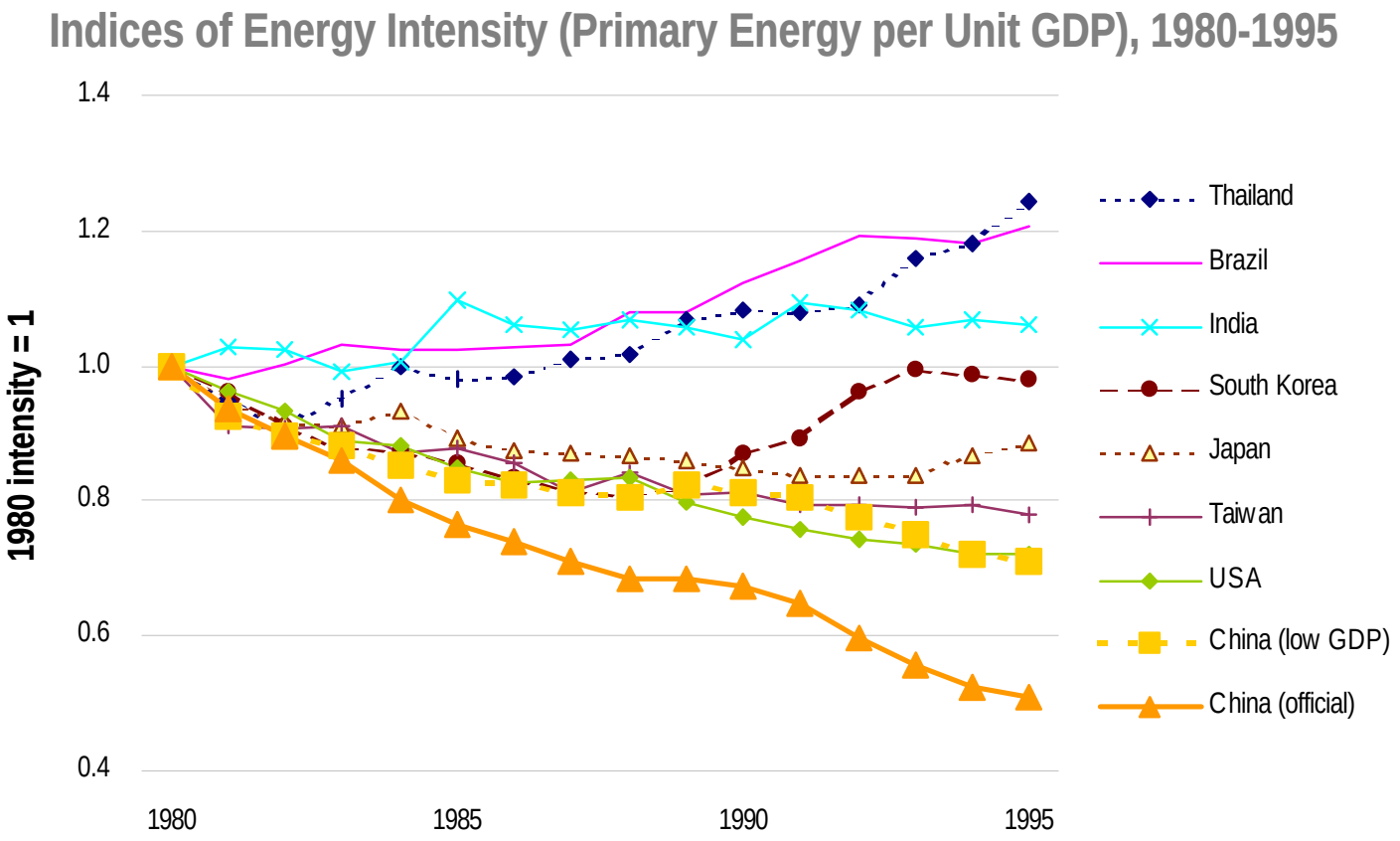


Incentives to hide coal output and use probably led to underreporting.

With revised GDP figures: economic intensity for total energy still declines, no net change for electricity intensity



Revised energy intensity of GDP makes China seem more like other countries

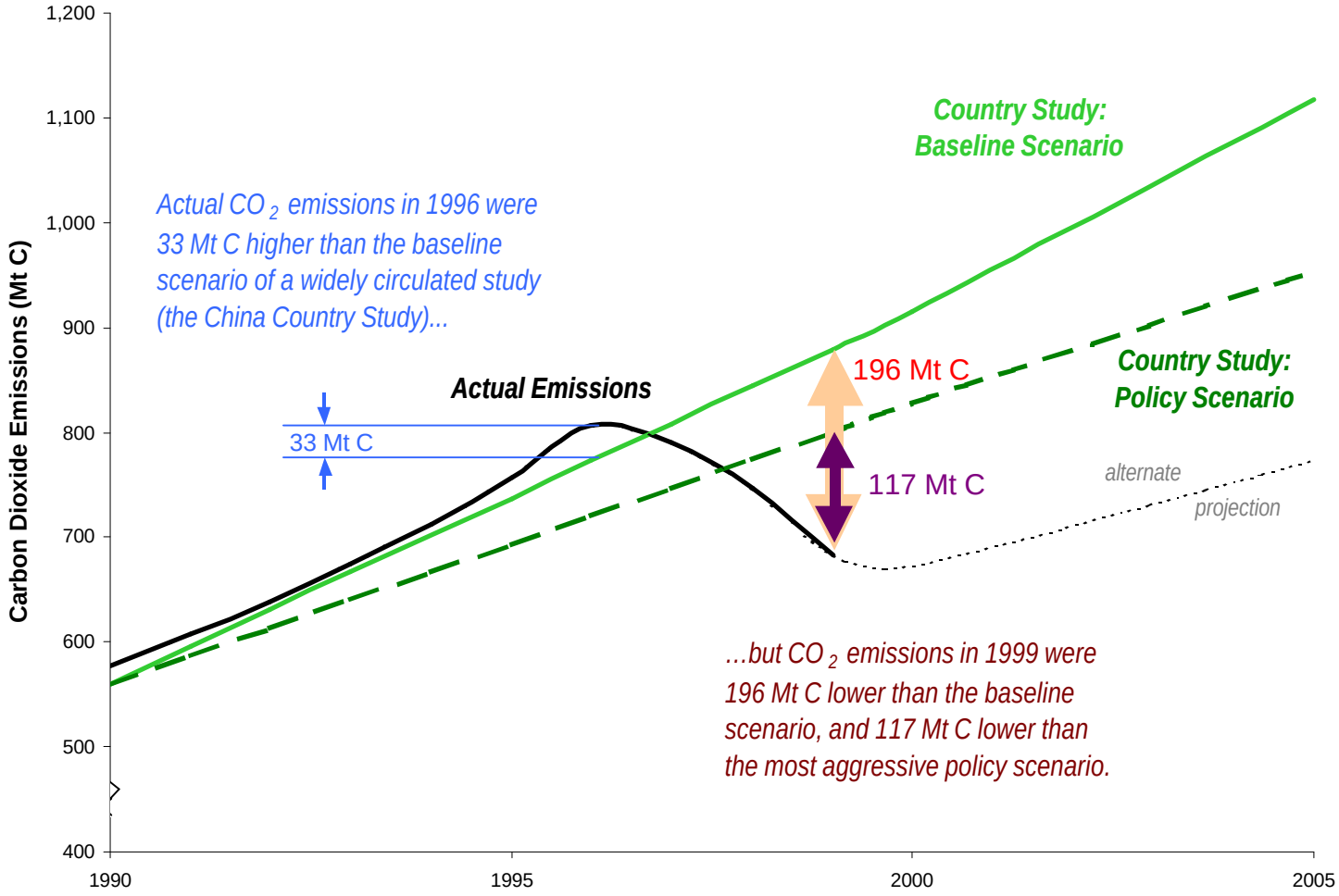


- **Problems with statistics unlikely to change qualitative conclusions.**

Assessment of driving forces

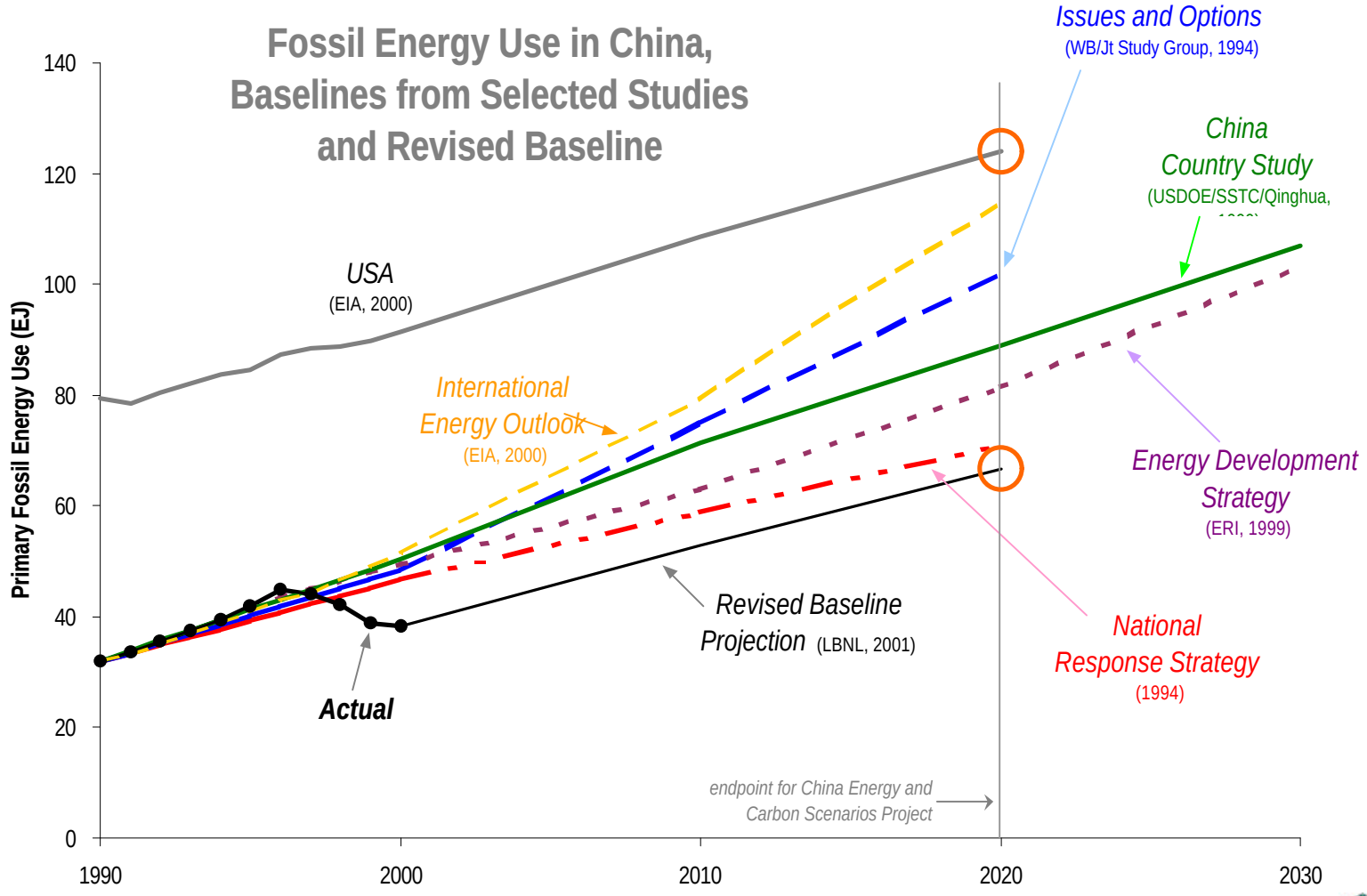
Factor	*Magnitude of Effect*
Unintentional Policy Impacts	
▪ **Economic system reforms** shut inefficient factories, favored efficient ones.	large (one-time?)
▪ Non-state sector enterprises became more efficient due to **competition**.	small to moderate
▪ **Structural change** in China's economy reduced energy demand.	small (large within sectors?)
▪ Buyers' markets allowed consumers to switch to **higher quality coal**.	large (one-time)
▪ **Higher prices for electricity** stimulated energy conservation.	moderate
▪ **Environmental regulations** forced inefficient plants to shut down.	small (potentially large in future)
Intentional Policy Impacts	
▪ **Reforms in the coal sector** shut down small mines, reduced "oversupply".	small
▪ **Energy-efficiency policies** and investments reduced energy intensity.	moderate (enabling, now and in future)
▪ **Elimination of small power generators** reduced growth in coal demand.	small
▪ Urban dwellers **switched to gas and electricity** and to central heating.	small
Uncontrolled Factors	
▪ **Slowing economic growth** caused demand the largest users to fall off.	moderate
▪ **Turnover of capital equipment** improved average energy efficiency.	possibly large
▪ Reductions in energy use are overstated, **statistics are inaccurate**.	small; unlikely to change conclusions

Implications for future carbon emissions



Energy and emissions projections need to be revised downwards.

Alternate baseline: China's energy use in 2020 equivalent to US energy use in 1990

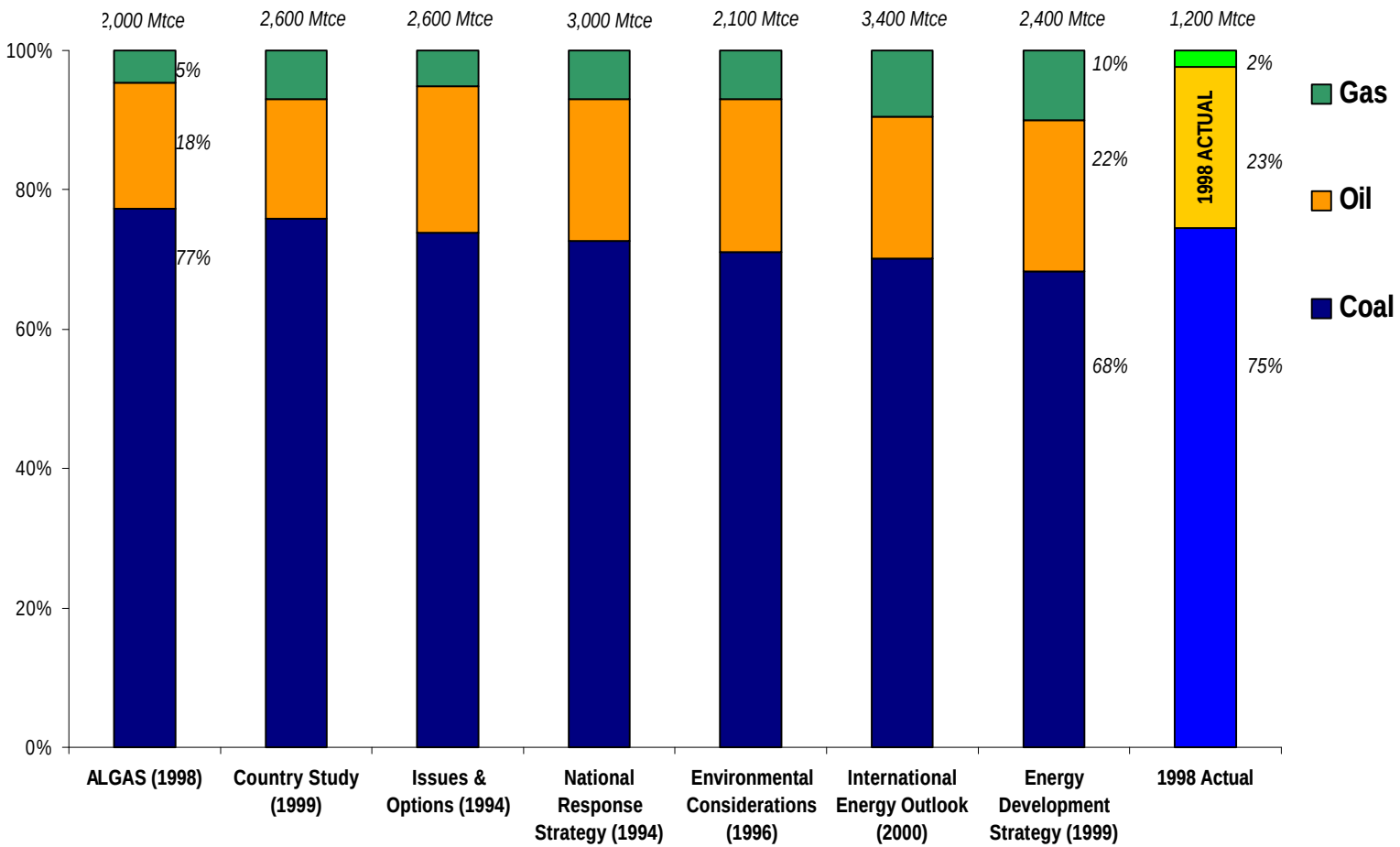


Variations in baseline scenario growth rates

Annual Average Growth	1990-2000	2000-2010	2010-2020
International Energy Outlook 2000	4.9%	4.4%	3.8%
Issues and Options	4.3%	4.4%	3.2%
Country Study	4.6%	3.6%	2.3%
Energy Development Strategy		2.4%	2.6%
National Response Strategy	3.9%	2.3%	1.9%
Actual	1.9%		
Revised baseline projection	1.9%	3.2%	2.4%
USA	1.4%	1.7%	1.3%

Fuel structure will help determine China's future carbon emissions

Fossil Energy Strcuture, Baselines Scenarios



Future Work

More detailed studies on specific factors

- Explore sectoral and product mix changes.
- Examine regional/provincial trends and shifts.
- More thorough study of coal sector: mines, markets, quality.
- Need more detailed data sets; collaboration with Chinese colleagues essential.

Scenarios and projections

- Work with forecasters to revise projections (e.g., EIA)
- Currently working with BECon (China) on China Energy and Carbon Scenarios project (LEAP2000).
- Historical modeling to test impact of various explanations and explore synergies between factors.