U.S.-China-South Korea
Economic and Environmental Modeling Workshop
Energy Research Institute
U.S. Environmental Protection Agency

Energy and Emission Scenarios Analysis for China to 2050

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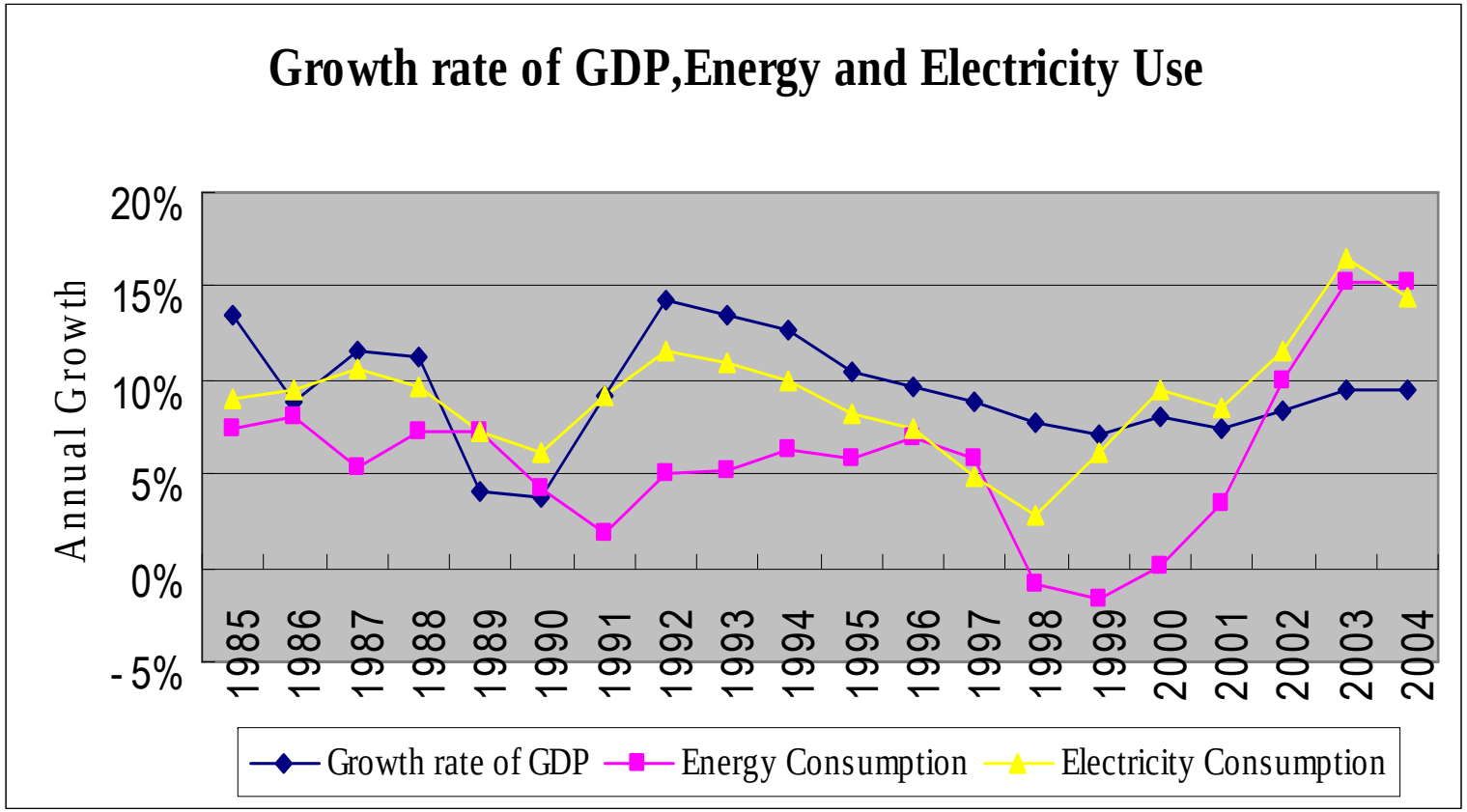
April 20-21, Xin Da Du International Conference Center
Beijing,China

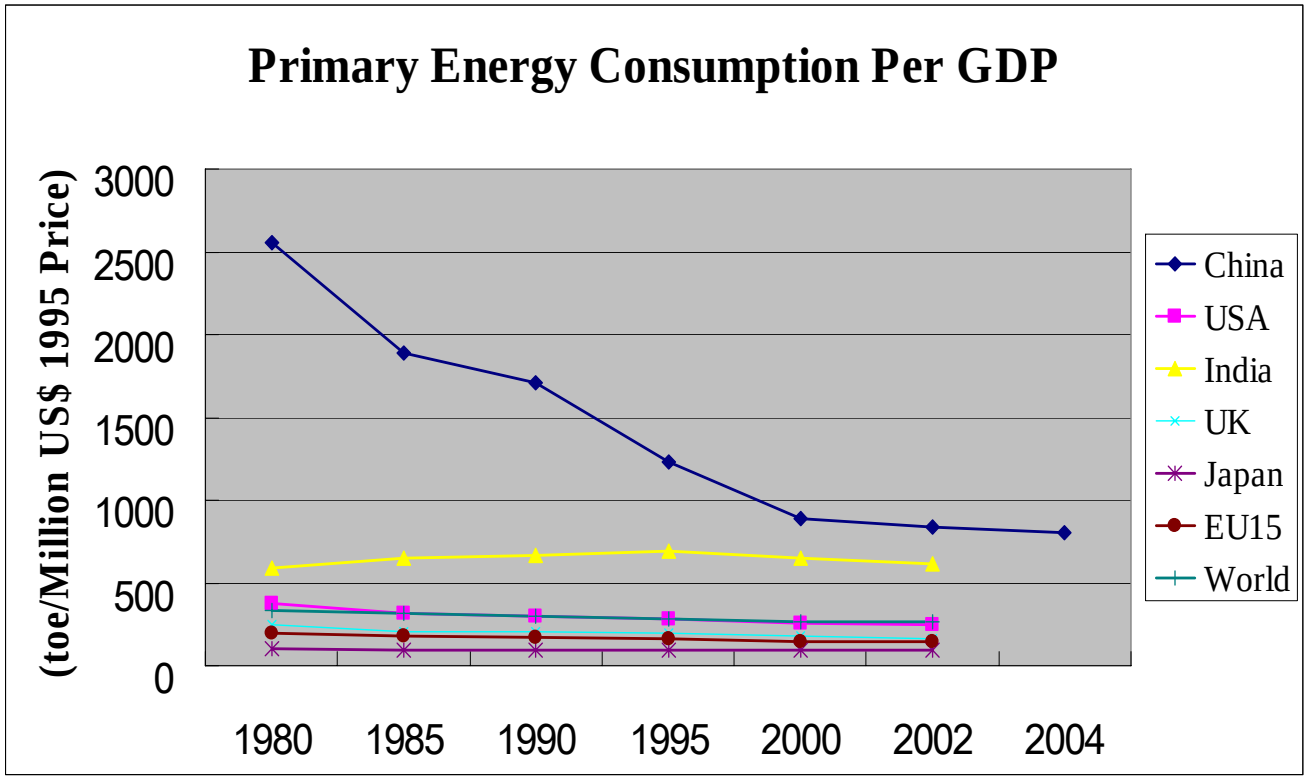
Characteristics of Energy Consumption in China

Energy consumption growing faster than GDP after 2001

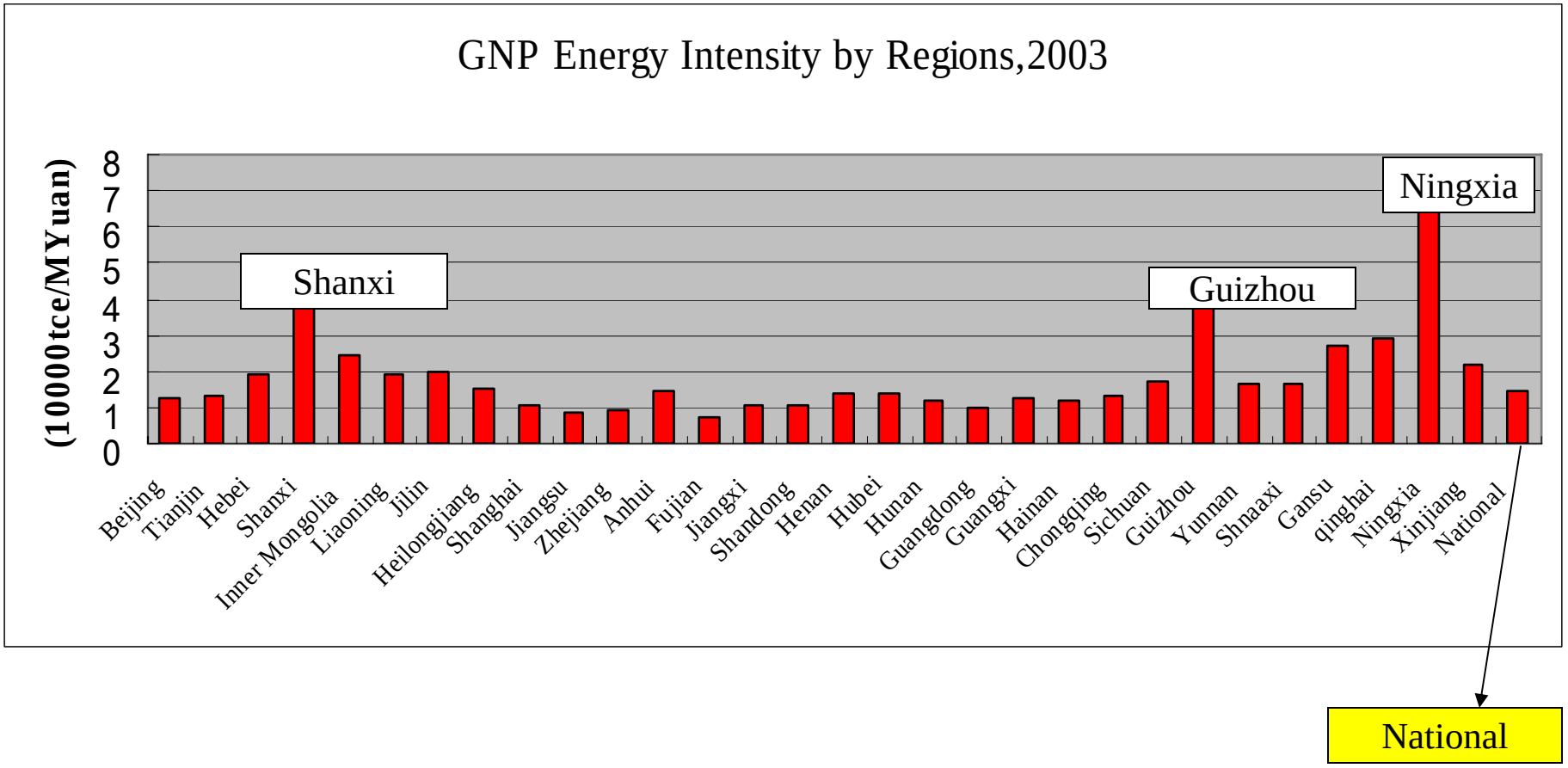


China's GDP Energy Intensity from 1980 to 2004

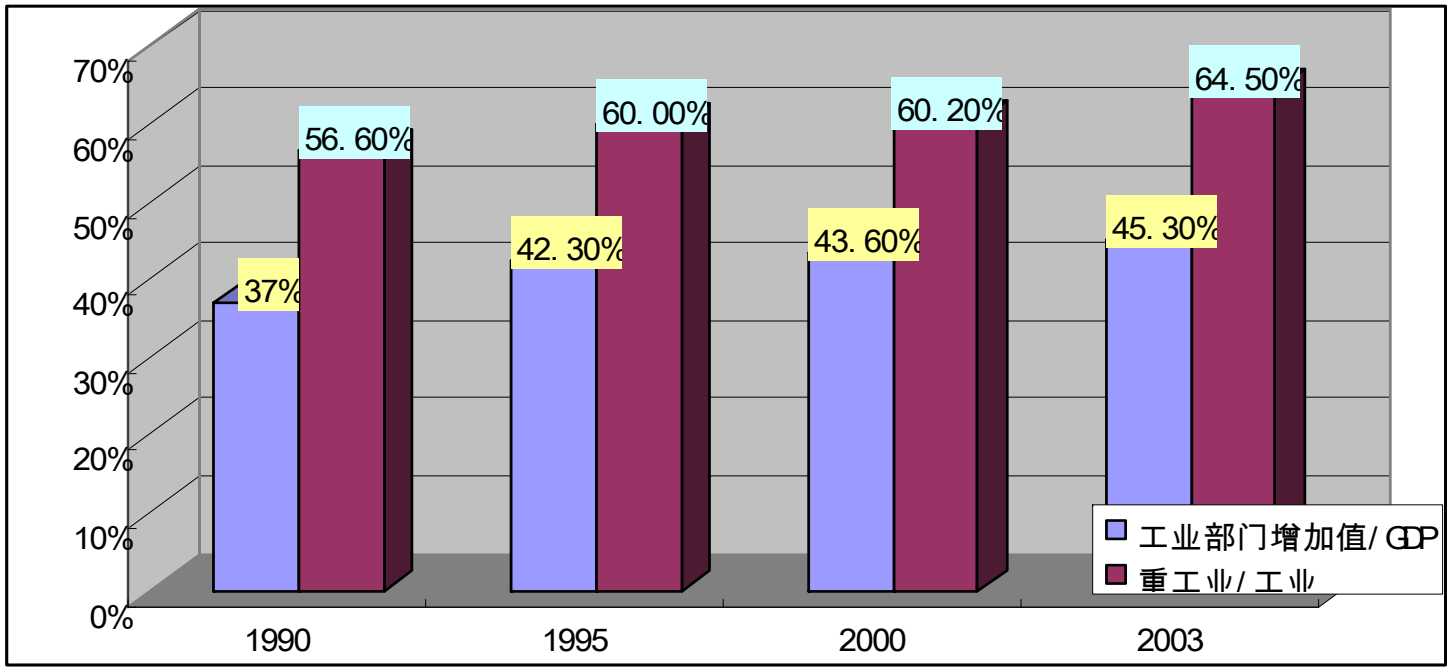
- GDP energy intensity is 837 toe/Million US$ for China in 2002, 3.19 times More than that of average world level, 3.35, 5.65, 9.3 and 1.35 times more than That UAS, EU, Japan and India.
- Energy conservation rate：4.71% from 1980-2004
  5.14% from 1980-2000
  2.54% from 2000-2004



GNP Energy Intensity by Regions of China in 2003



Energy-Efficiency of Energy Intensive Industries in China

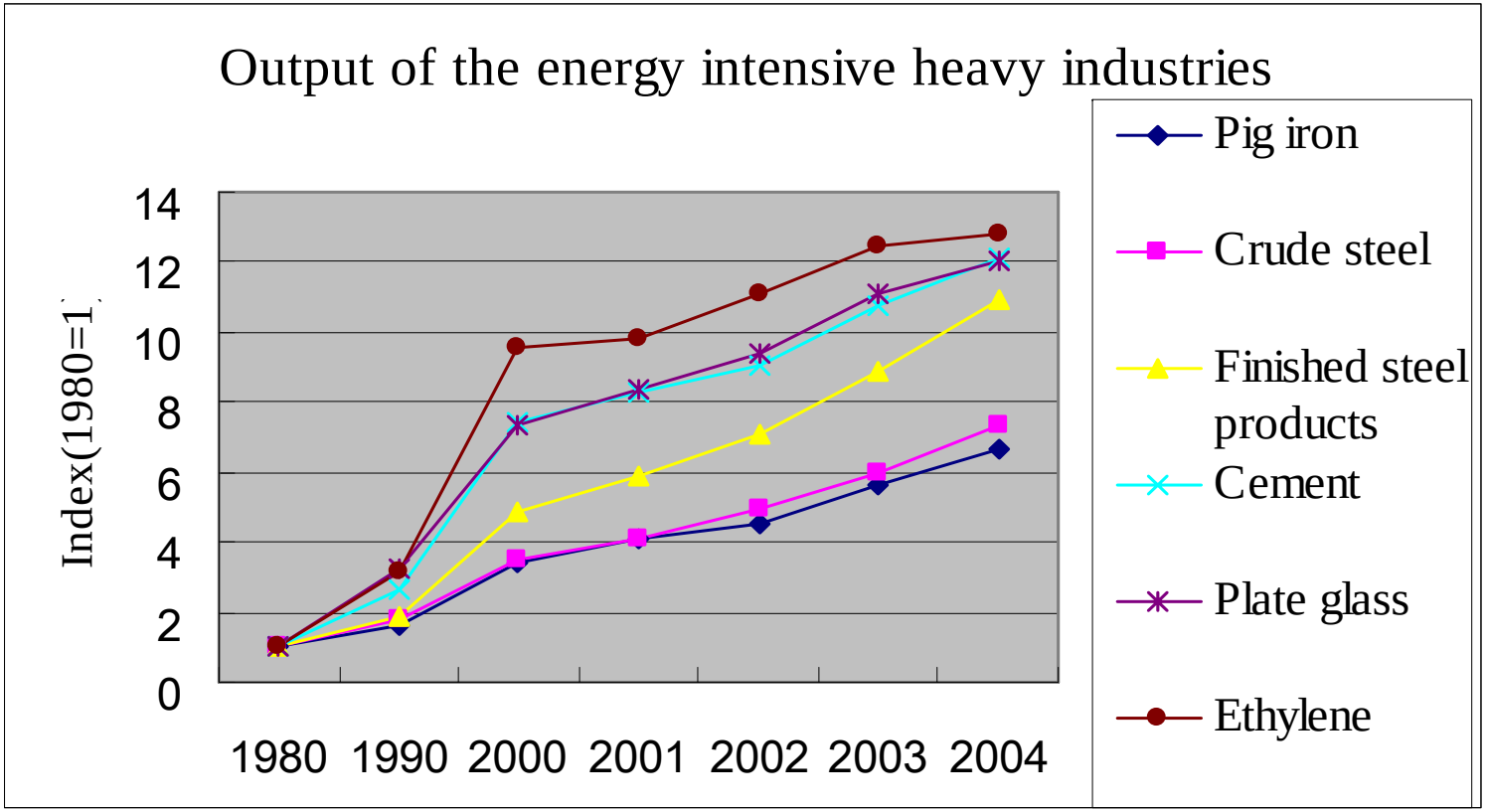


Industry's value added as percentage of GDP increased from 37 % in 1990 to 45.3 % in 2003.

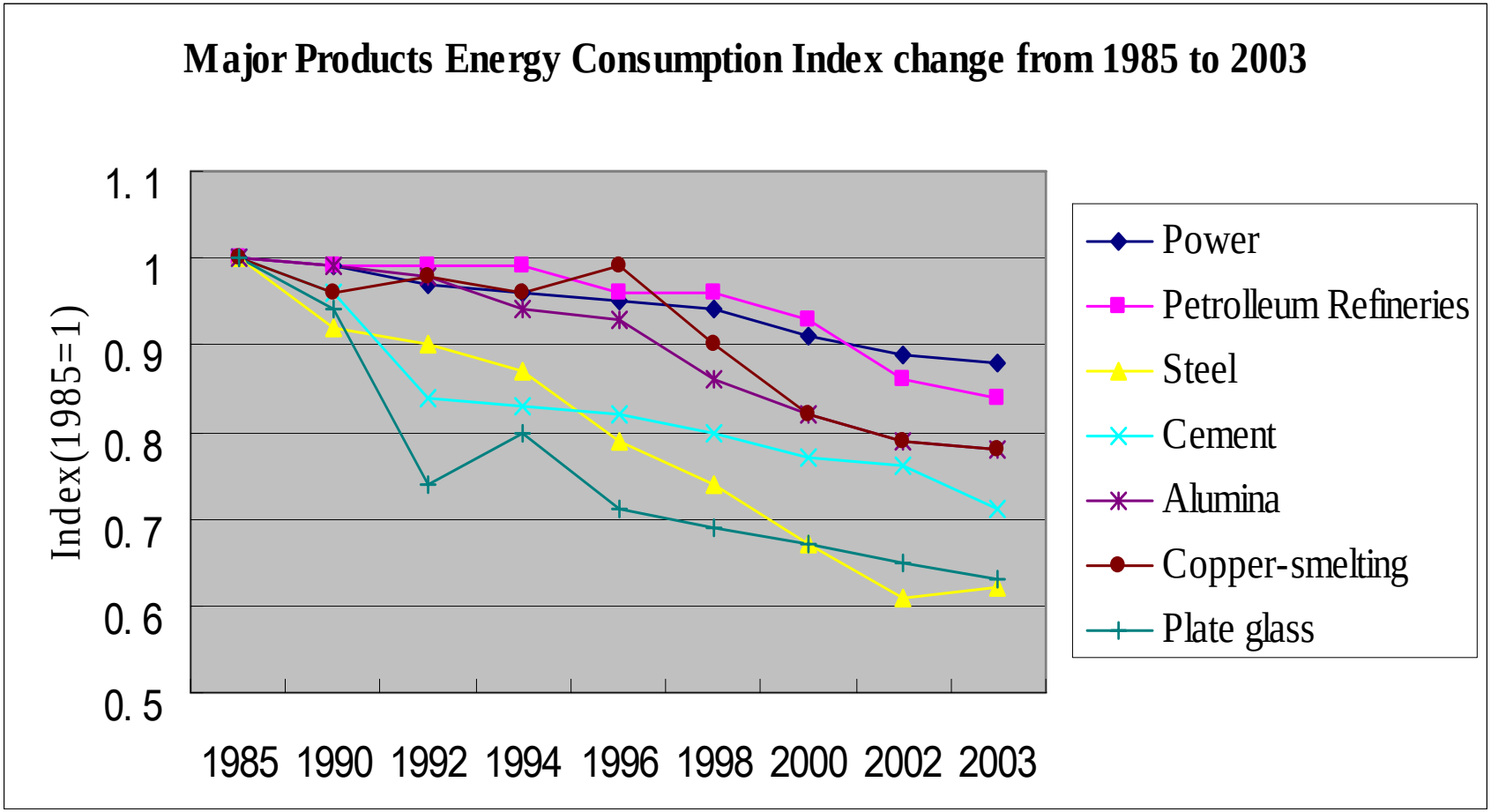
Heavy industry's value added as percentage of Industry's value increased from 56.6 % in 1990 to 64.5% in 2003.

Energy-Efficiency of Energy Intensive Industries in China

Output of the pig iron has increased 5.52 times, crude steel by 6.35 times, finished steel products by 9.96 times, cement by 11.13 times, plate glass by 11.4 times, ethylene by 11.8 times – comparing 2004 to 1980.



Energy-Efficiency of Energy Intensive Industries in China



Energy-Efficiency of Energy Intensive Industries in China

Energy Consumption Indicators of Major Products

	1990	2000	2004	Annual average descend rate	Differences than advanced world level
Power (gce/kWh)	427	392	379	0.95%	21.50%
Steel (kgce/t)	997	784	705	2.44%	15.60%
Cement (kgce/t)	201.1	181	157	1.75%	23.60%
Ethylene (kgce/t)	1580	1125	1004	3.19%	59%
Plate glass (kgce/wt.case)	34.8	30	26	2.10%	31%

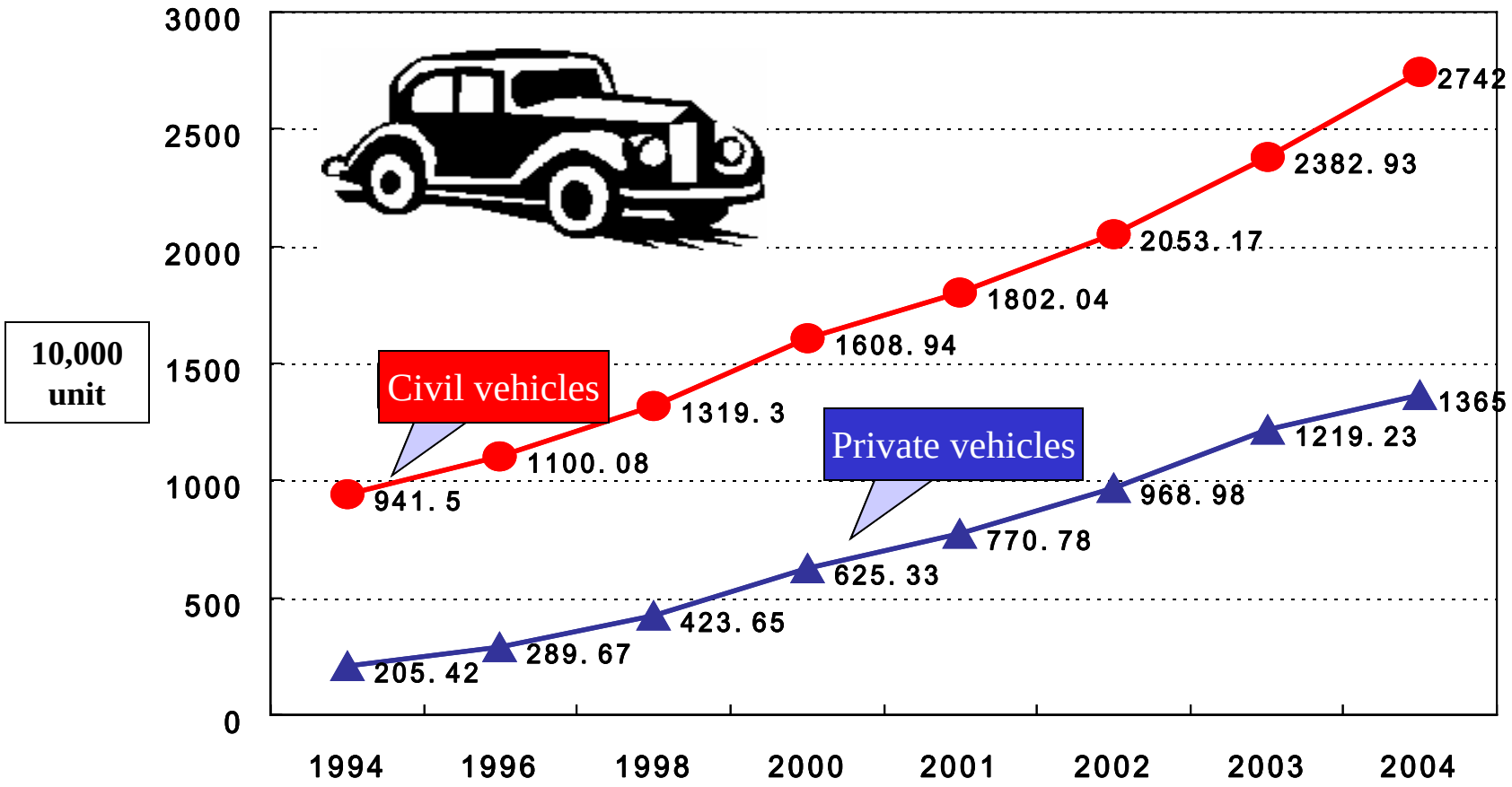
Energy-Efficiency of Building Sector in China

- From 1994 to 2004, the building area increase, from 32.6 billion m^2 to 42.0 billion m^2,with an annually increasing rate of 29%. Since 2000, annual increased area has attained to 1.2-1.6 billion m^2

- In 2003, the energy consumption of building commodity is 376 Mtce, accounting for 31% of energy end us, which is approaching to the ratio of developed countries.

- The living area accounts for above 60% of total area and the energy use for heating, conditioning and lighting account for about 75% of building energy use. The energy use per unit area heating is about 2-3 higher times as that of developed countries with same climate condition.

Energy-Efficiency of Transportation Sector China



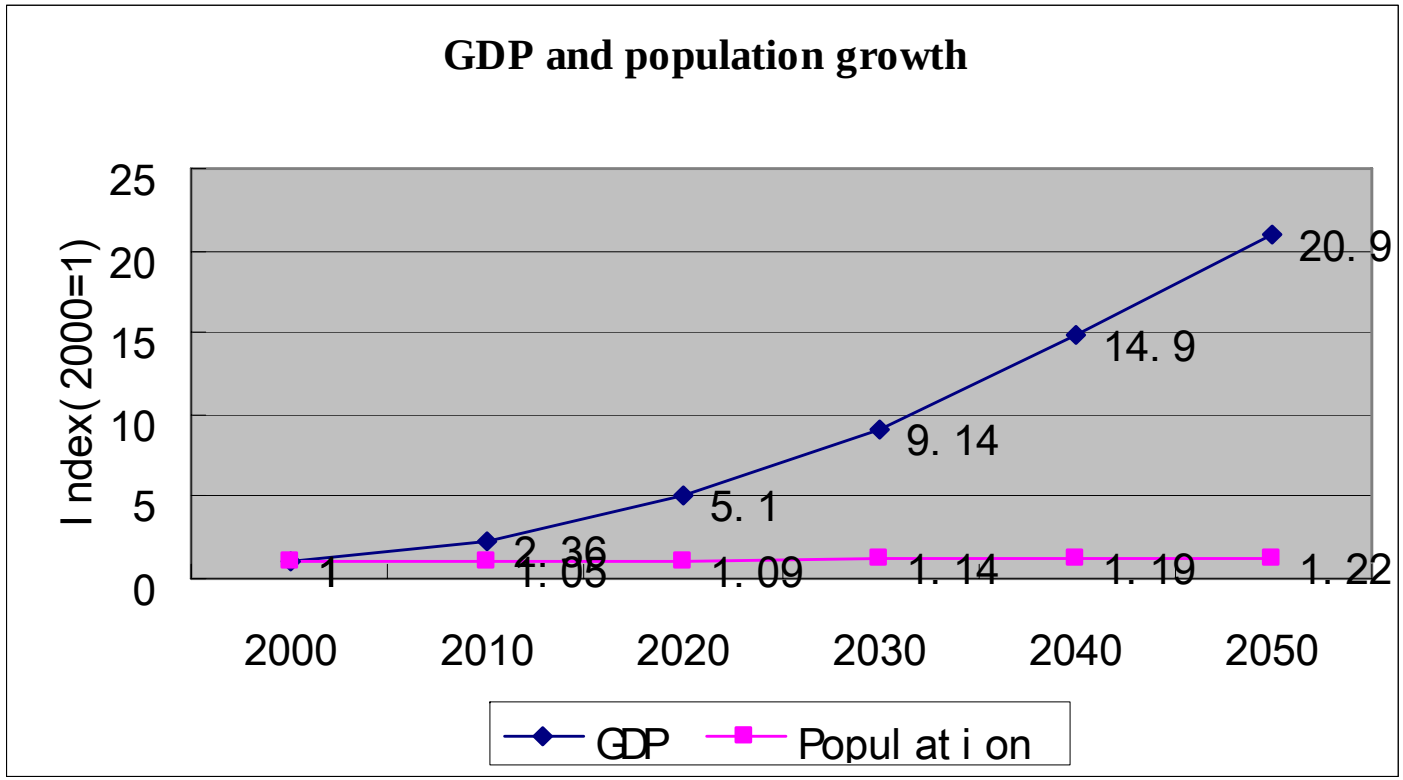
Number of Civil motor vehicles in China

Energy-Efficiency of Transportation Sector China

- Fuel economy level of motor vehicles was 25% lower than that of Europe, 20% lower than that of Japan, 10% lower than the overall level in the United States.
- Oil consumption per 100t-km of freight vehicle was 7.6L, more than double the amount for foreign advanced levels.
- Practical Oil consumption of motor vehicles practical was 30% higher than that of demarcated level.
- Oil consumption level of vessels for inland river transportation was 10-20% higher than that of foreign advanced level vessels.

Drivers of Future Emissions

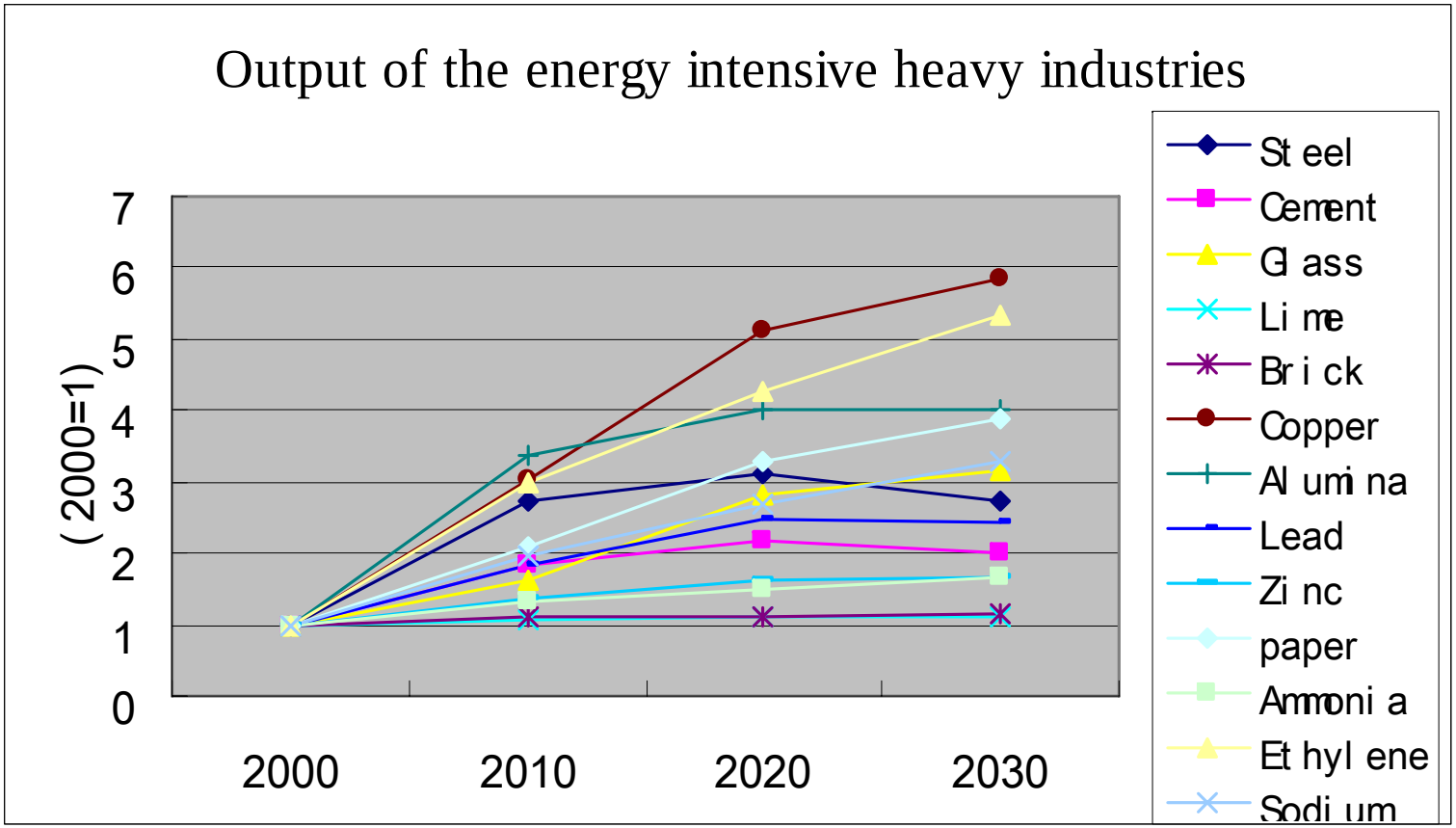
Economic Growth and Population in 2050



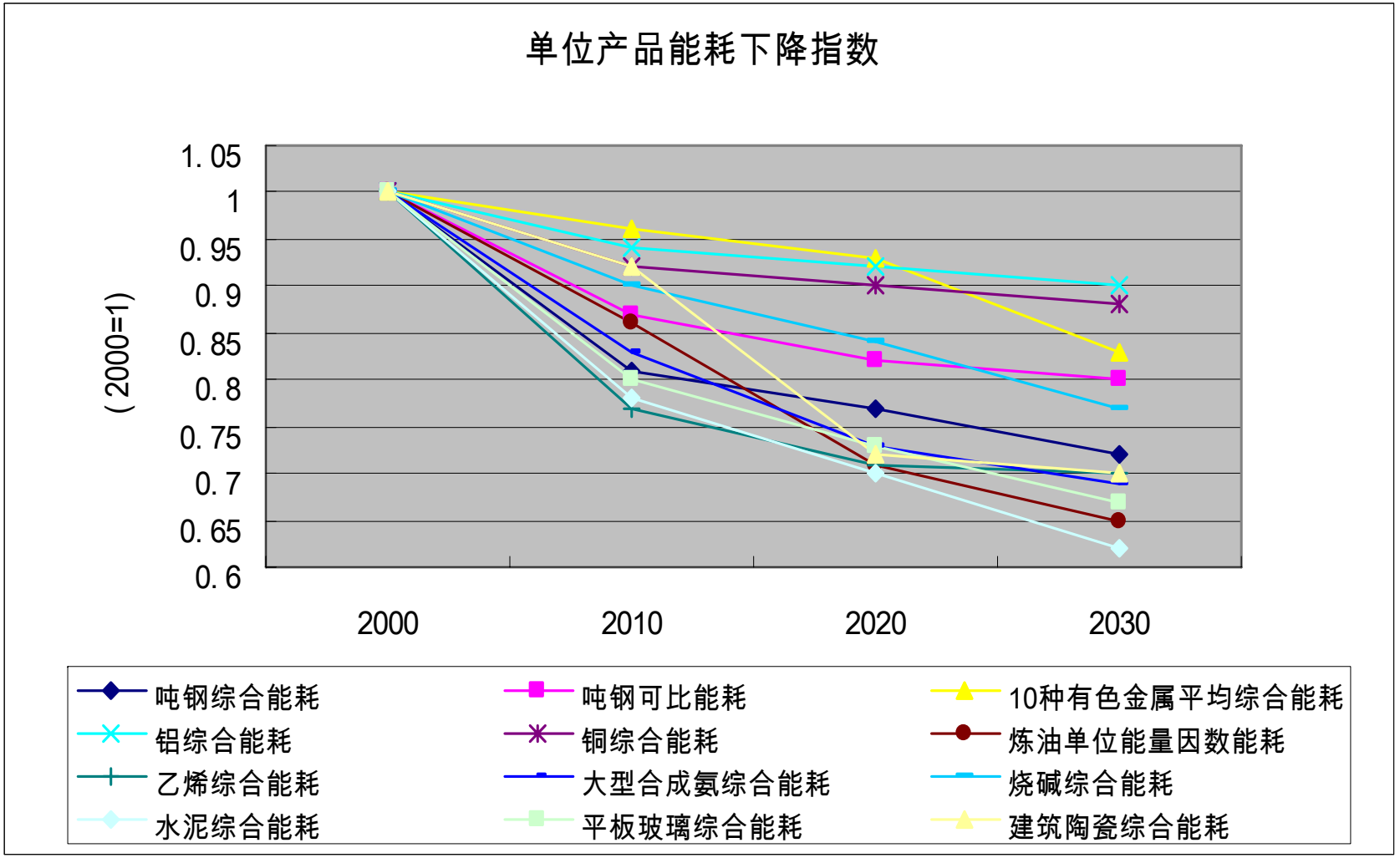
	2000	2010	2020	2030	2040	2050
GDP growth rate %		8.6	8	6.5	5	3.5

Drivers of Future Emissions

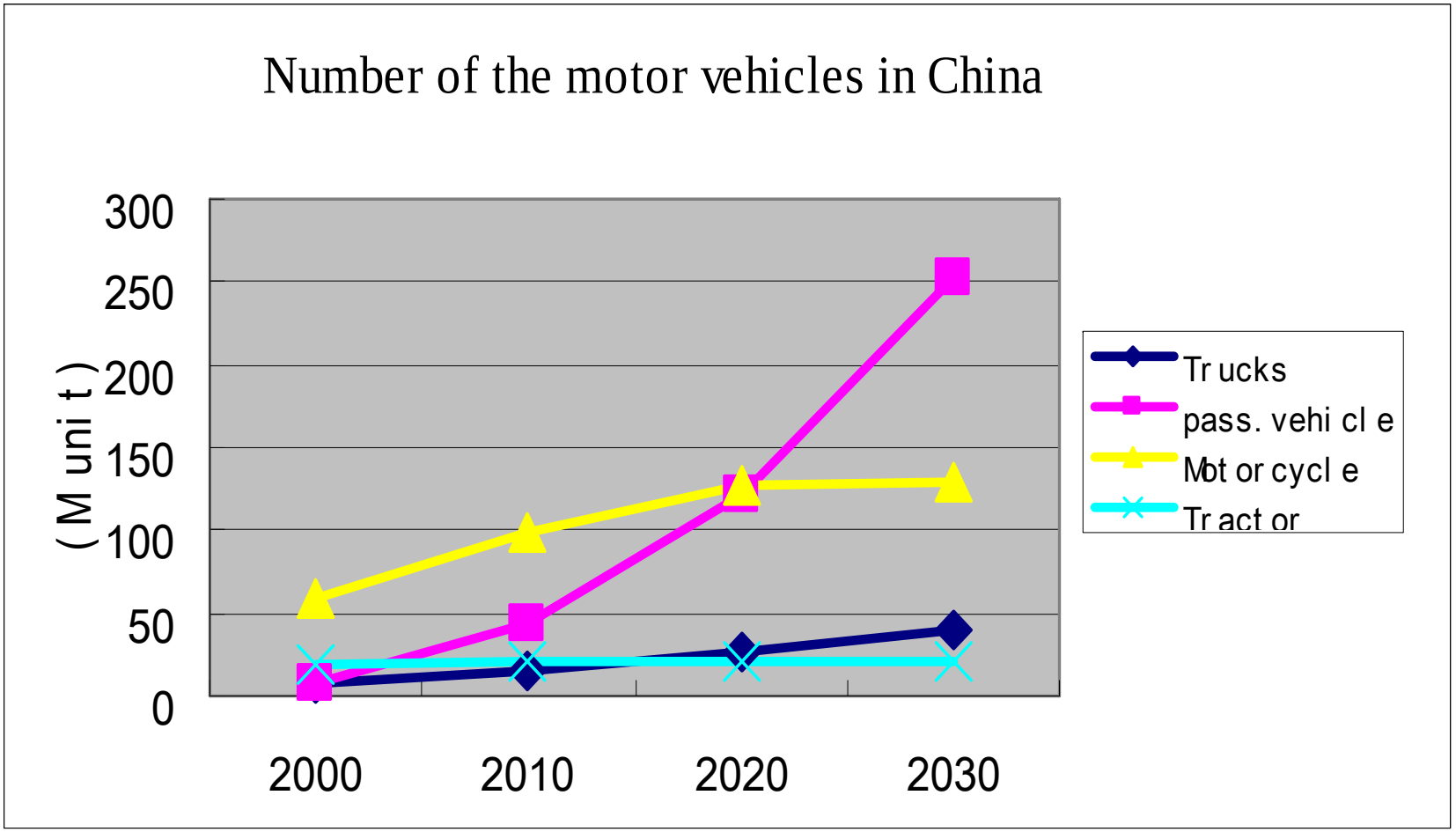
- **Output of the energy intensive heavy industries in 2030**



■ 2000-2030主要高耗能产品的能源效率趋势



The motor vehicles Growth in 2030



The building area Growth in 2030

- The building area of China is expected to attain to 90 billion m^2 in 2020. If multiplied by current energy consumption rate, this will consume about 800 Mtce energy.

- According to the prediction of WB, up to 2015, half of private building in China will be constructed after 2000.

- The building sector will become a high driving force for energy increase and a big consumer of high-quality energy.

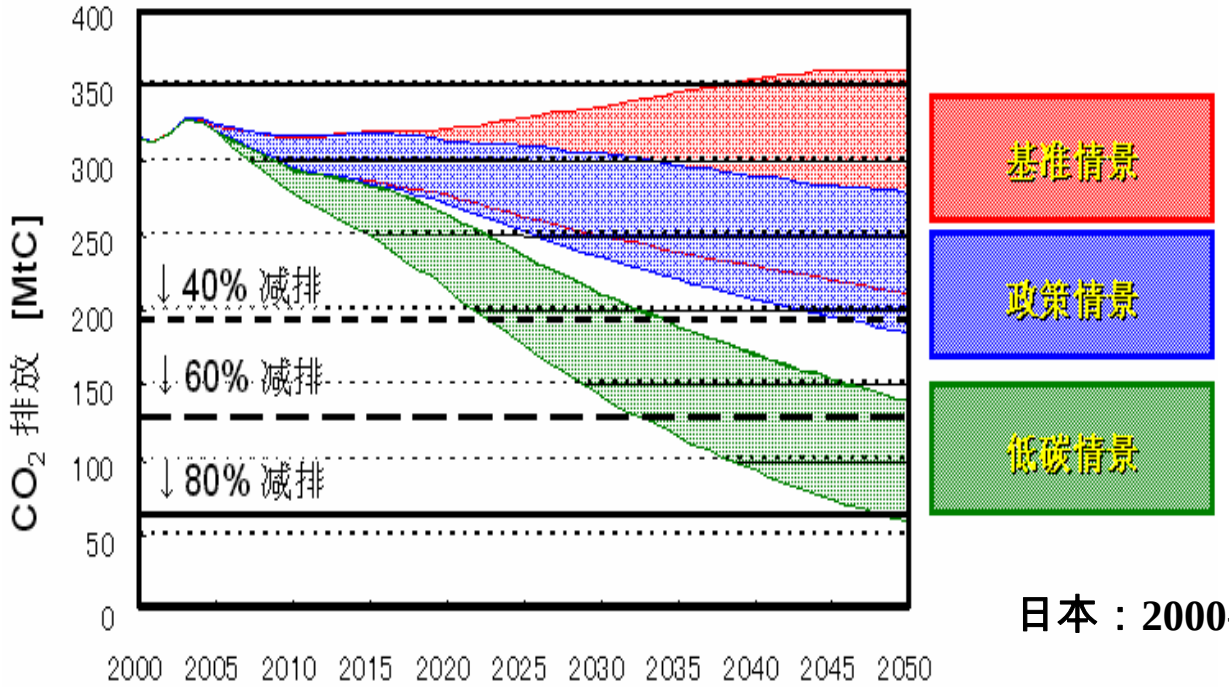
Development strategies and energy-saving goals for China

- 2000-2020: The Chinese government formulate the society and economy development goal for “eleventh-five-year-plan” period, i.e., the annual increase rate of GDP will maintain 8% from 2005 to 2020; the per capita GDP will double from 2000 to 2010; the per GDP energy consumption will decrease by 20% from 2005 to 2010.

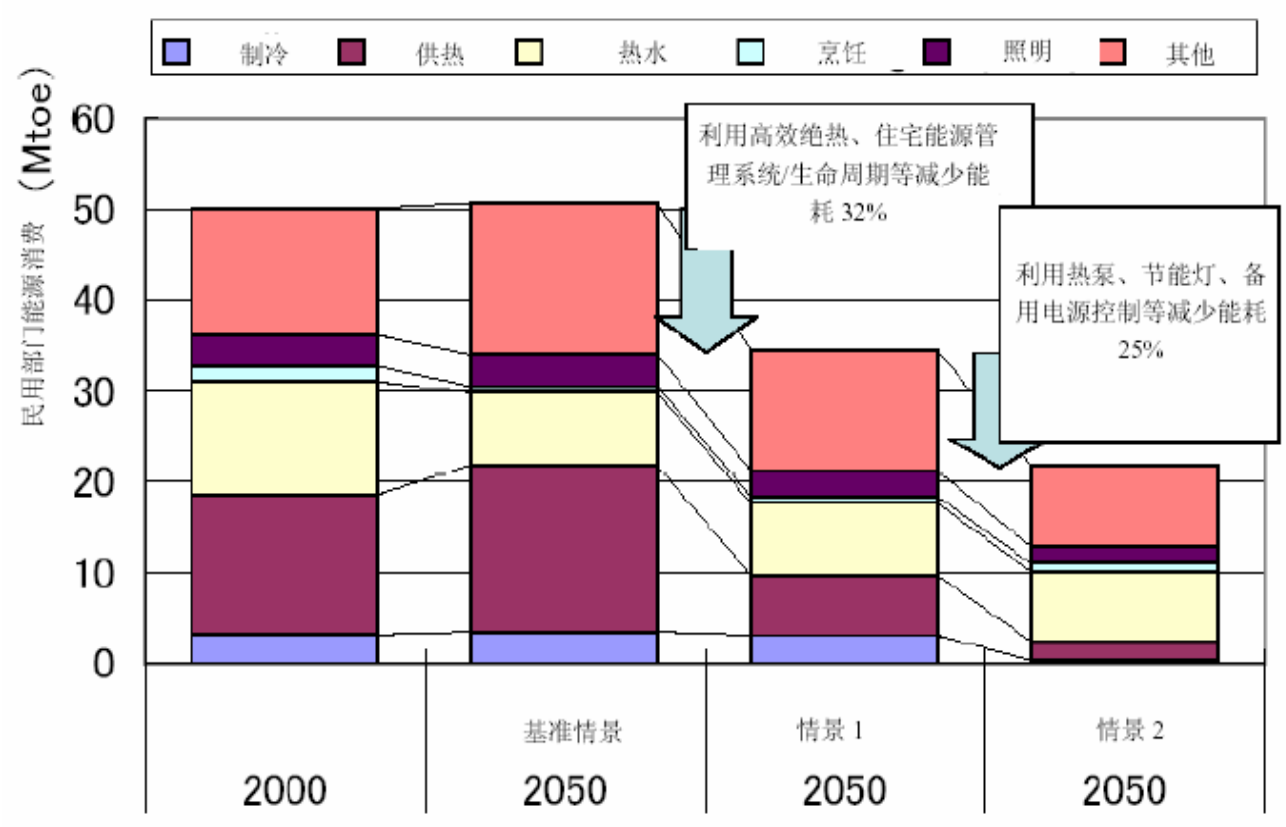
- 2020-2050: The annual GDP increase rate will be around 5%. The energy saving will be strengthened with an annual energy-saving rate of 3%. The clean energy technologies will be utilized broadly, the energy security will be ensured and the sustainable development will be achieved

日本2000-2050年低碳情景减排目标和政策措施设定

《京都议定书》规定	低碳情景减排目标	减排政策措施
2008-2012年，六种温室气体排放比1990年的水平减少6%。	2050/2000：减排60-80%	从能源需求和供应两个方面实施各种减排政策措施。包括：城市系统改革、工业结构调整、发展信息技术、应用可再生能源、发展绿色建筑、建立革新机制、社会机制改革、发展氢能技术、利用可再生能源、发展循环经济、实施全面节约等。例如，城市高效系统的建立和热泵等技术的利用可使建筑部门到2050年实现55%的CO2减排量。

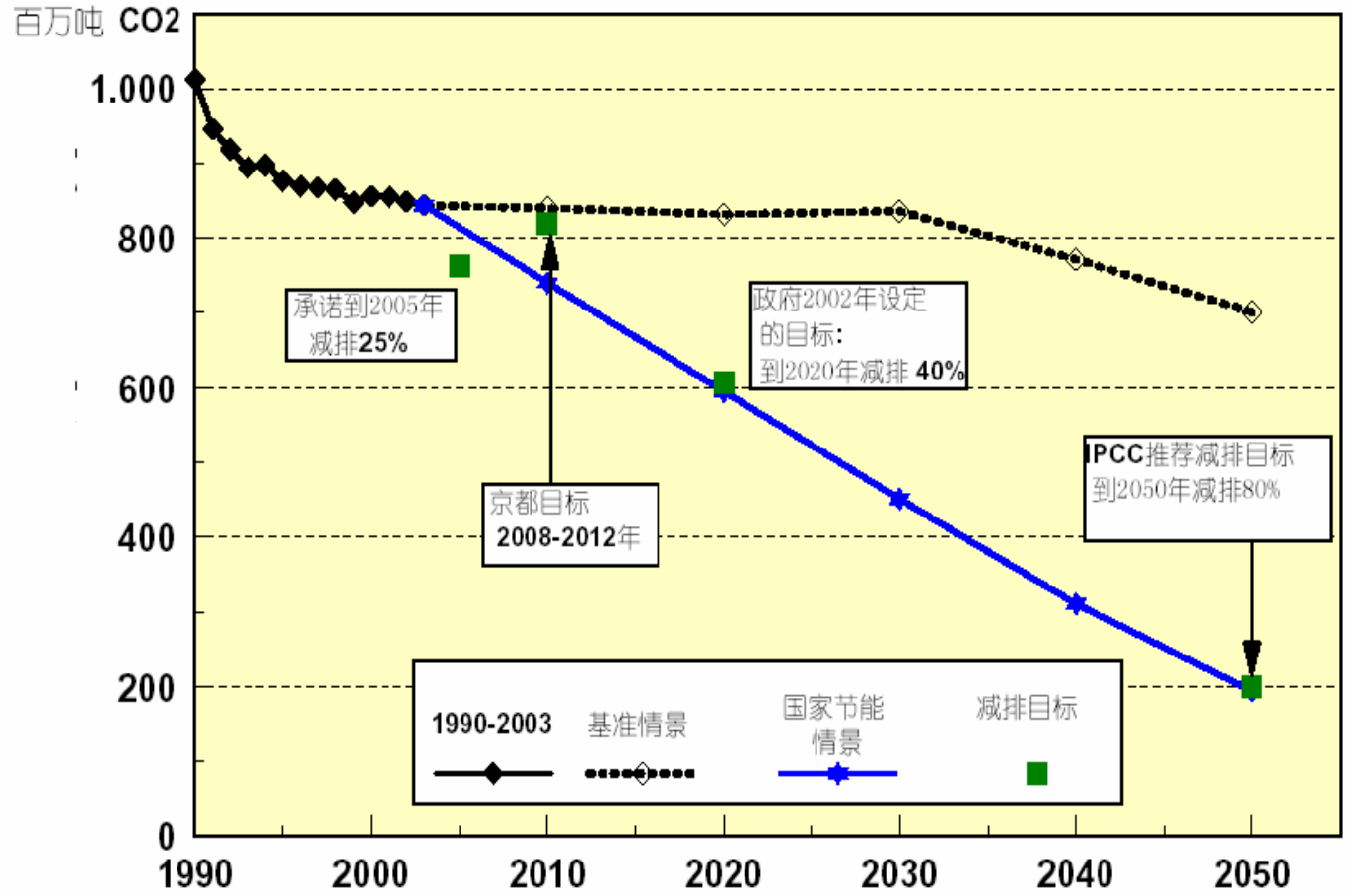


日本：2000-2050年CO2减排目标

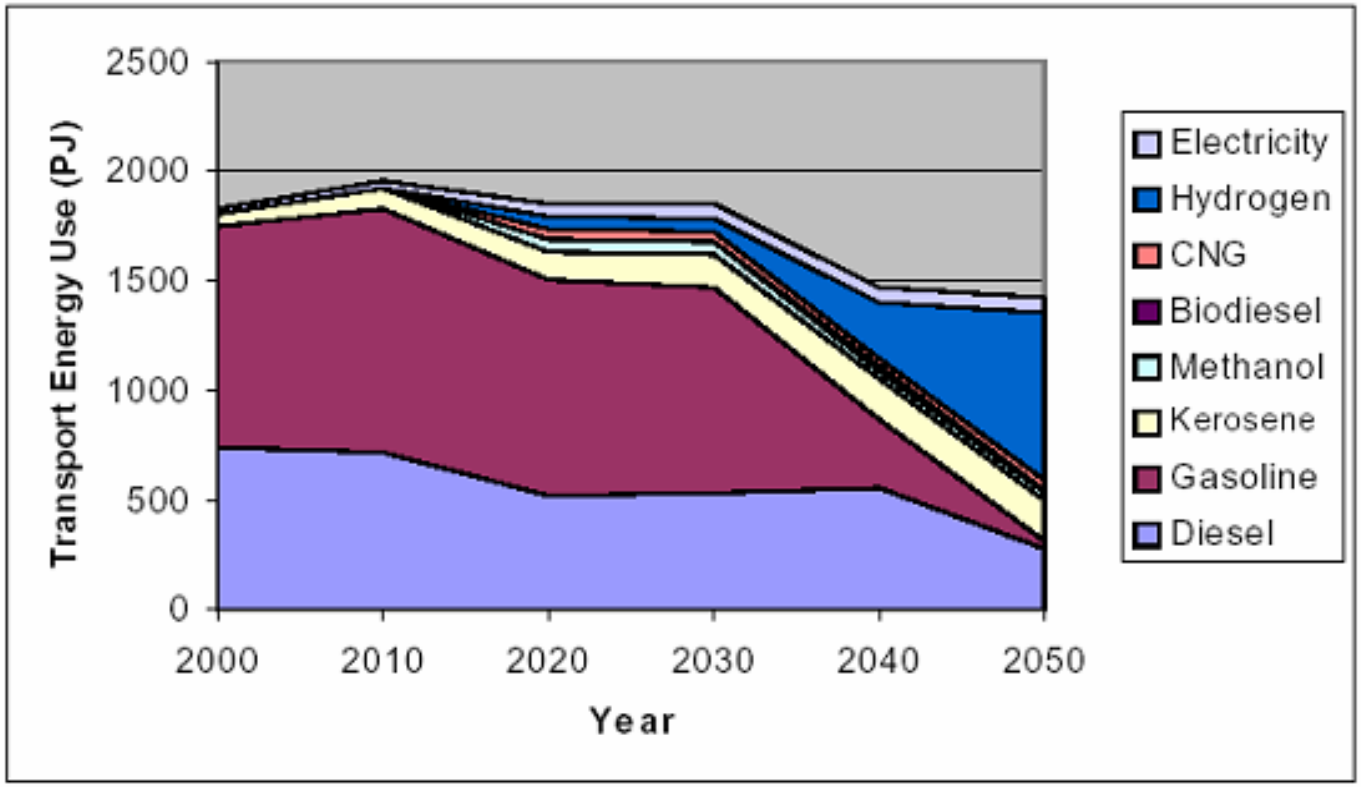


日本民用部门的低碳情景

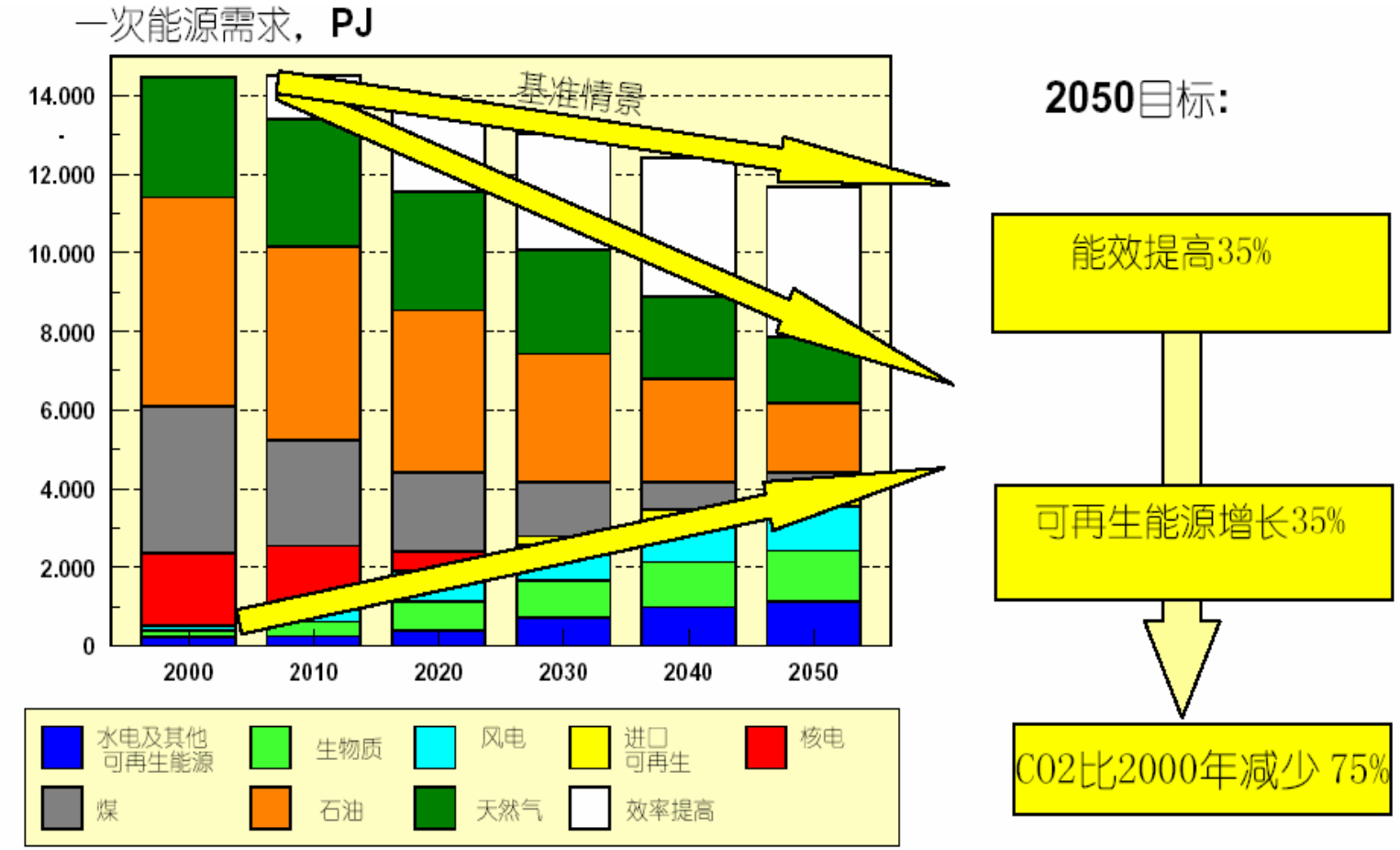
德国：2000-2050减排目标



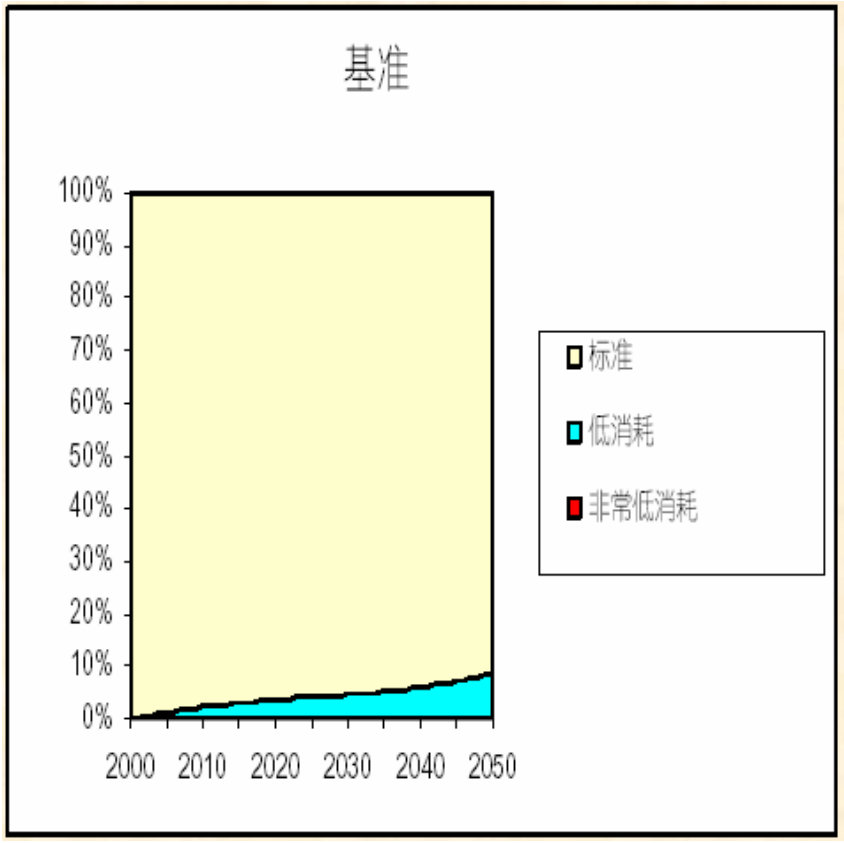
英国：低碳情景下交通部门的燃料结构变化

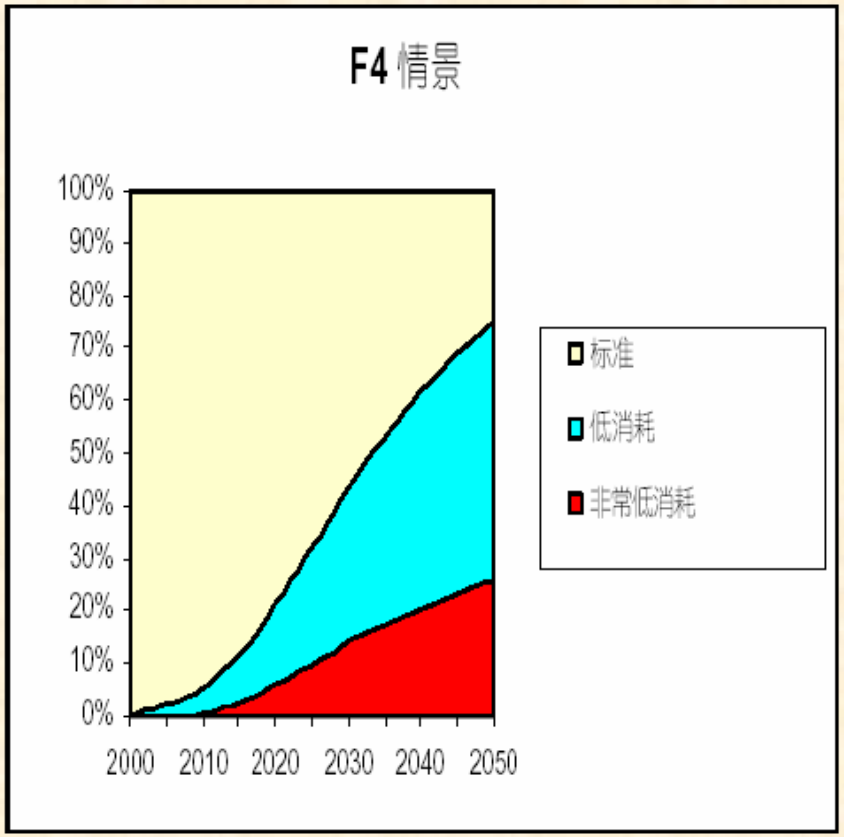


德国：一次能源变化


一次能源需求，PJ
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0
2000
2010
2020
2030
2040
2050
基准情景
水电及其他可再生能源
生物质
风电
进口可再生
核电
煤
石油
天然气
效率提高
2050目标:
能效提高35%
可再生能源增长35%
C02比2000年减少 75%

法国：建筑部门的技术构成
标准、低能耗、超低能耗





德、法、英、日实现低碳情景的主要政策措施和效果

主要政策措施

- 提高节能意识
- 合理利用能源
- 利用再生能源
- 替代煤炭
- 技术创新
- CO2捕捉和储存

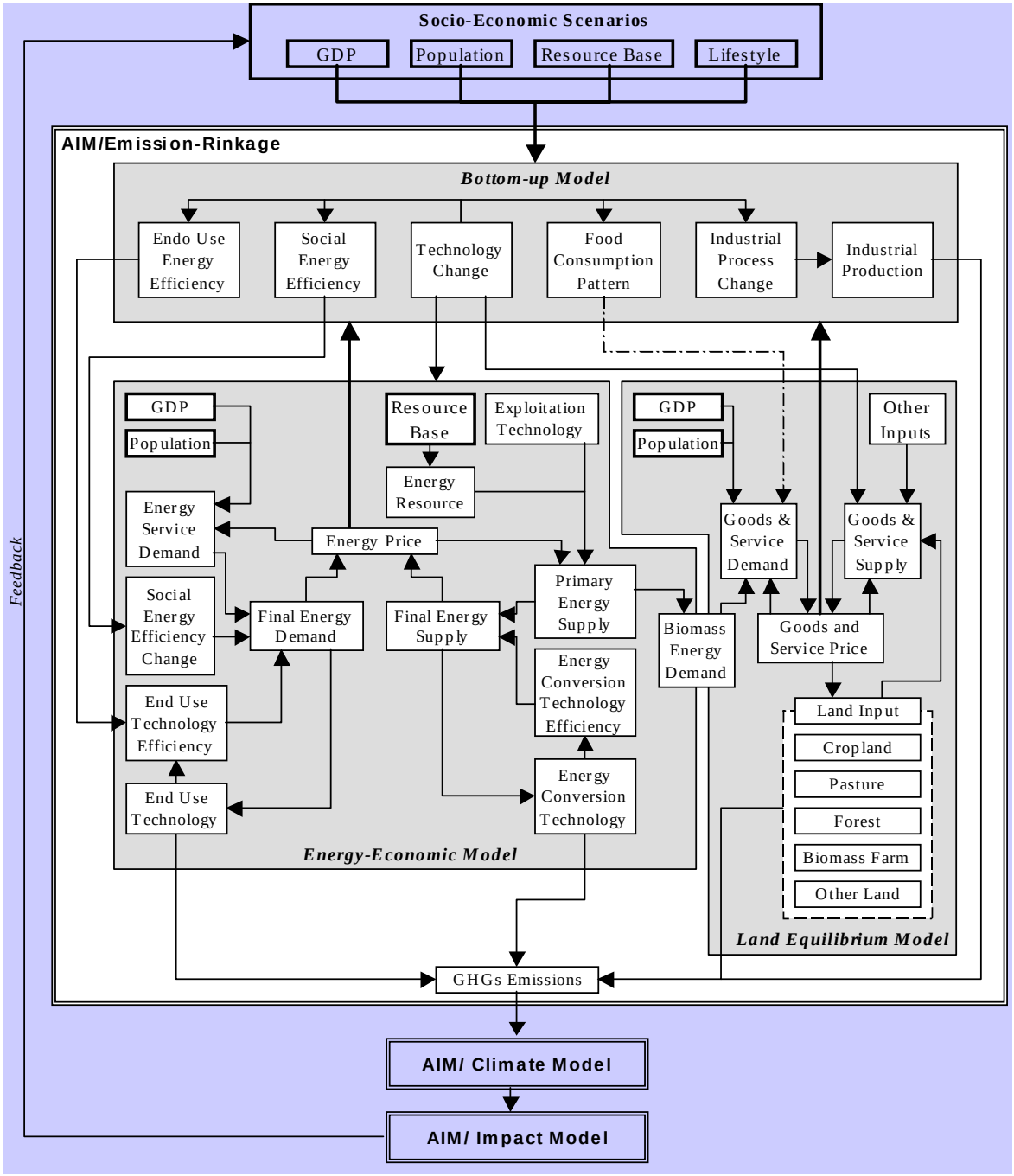
效果

- 促进技术发展及其市场份额
- 成本有效的选择技术
- 减少一次能源需求,优化结构
- 提高终端能源效率
- 电源结构优化、高效、低排放
- 减少CO2排放

附加效益

- 扩大国家的能源基础，减少国家对进口能源的以来，提高供应的安全性；
- 保护有限的化石燃料资源；
- 降低能源服务成本，减少经济风险，从而减少化石能源价格的波动；
- 增加就业，促进技术革新；
- 促进新技术开发和出口增长；
- 提高国家整体的安全性，减少受恐怖袭击的风险；
- 提高国际地位。

IPAC/Energy Emission Model

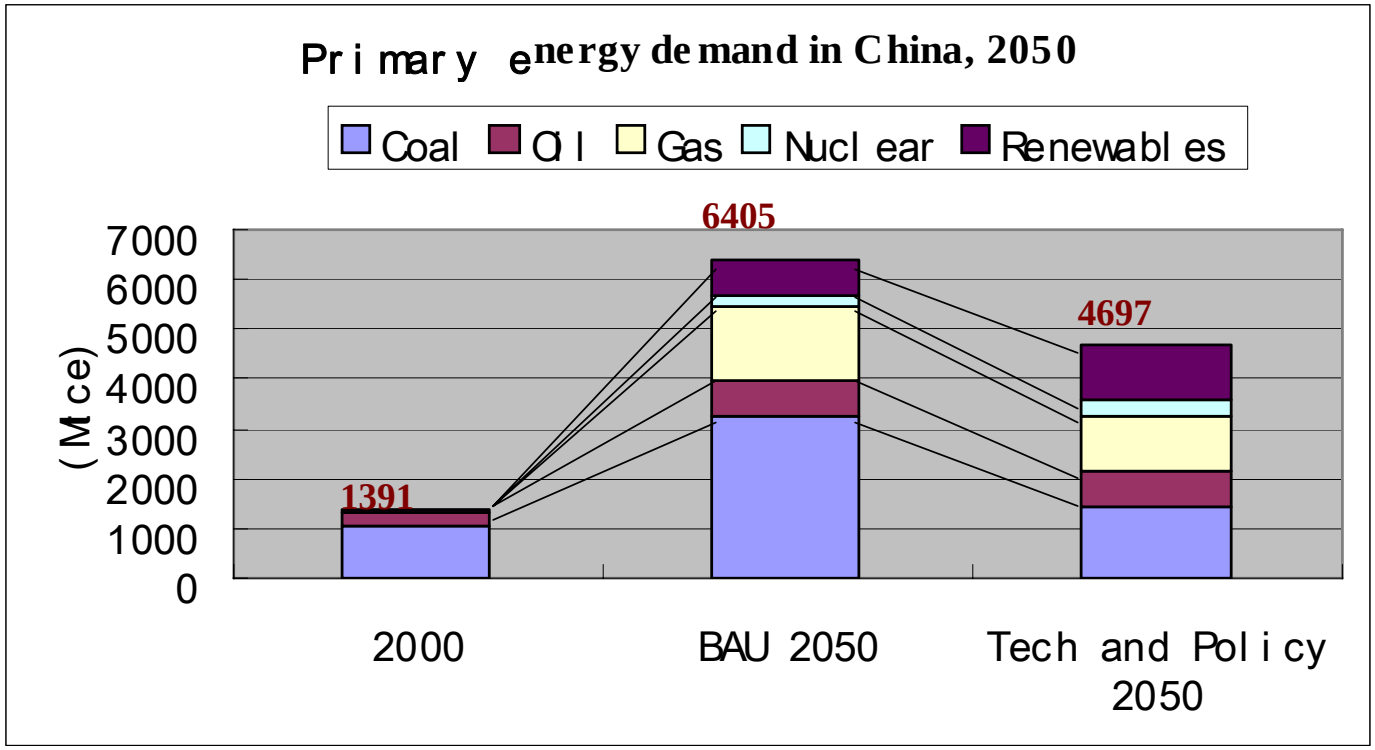


政策措施情景设定			
		基准情景	政策和技术情景
强化节能	高能耗部门	年均节能率2.7%	年均节能率3.6-5%
	建筑	年均节能率1.9%	年均节能率3.0%
	交通	年均节能率1.5%	年均节能率2.8%
开发利用新能源和可再生能源，发展替代能源	生物质能	年均成本下降率3.7%	年均成本下降率5.9%
	水电	2050年达到技术可开采潜力的65%	2050年达到技术可开采潜力的80%
	太阳能风能	2050年发电成本下降到0.7元/千瓦时	2050年发电成本下降到0.5元/千瓦时
	交通	生物柴油、甲醇、乙醇	生物柴油、甲醇、乙醇
发展清洁煤技术	发电	2050年占到7%	2050年35%
	工业部门	2050年占到5%	2050年15%
	机动车	2010年混合动力开始普及,2030年10%	2010年混合动力开始普及,2040年70%
氢能利用	发电	分布式发电3%	分布式发电8%
	交通	燃料电池汽车5%	燃料电池汽车5%
政策和能效标准	能源消费部门	无	2010年开始50元/吨碳,2050年200元
	家用电器、工业、交通	低能耗建筑（节能率50%）,设备能耗标准	超低能耗建筑（节能率超过80%），绿色建筑,设备能耗标准,志
	补贴	无	可再生能源发电0.4元/kWh
	能源技术开发投资	年均增长4%	年均增长6.2%
碳储存、捕获	煤电	2050年4%	2050年15%
	工业部门	2050年1%	2050年5%

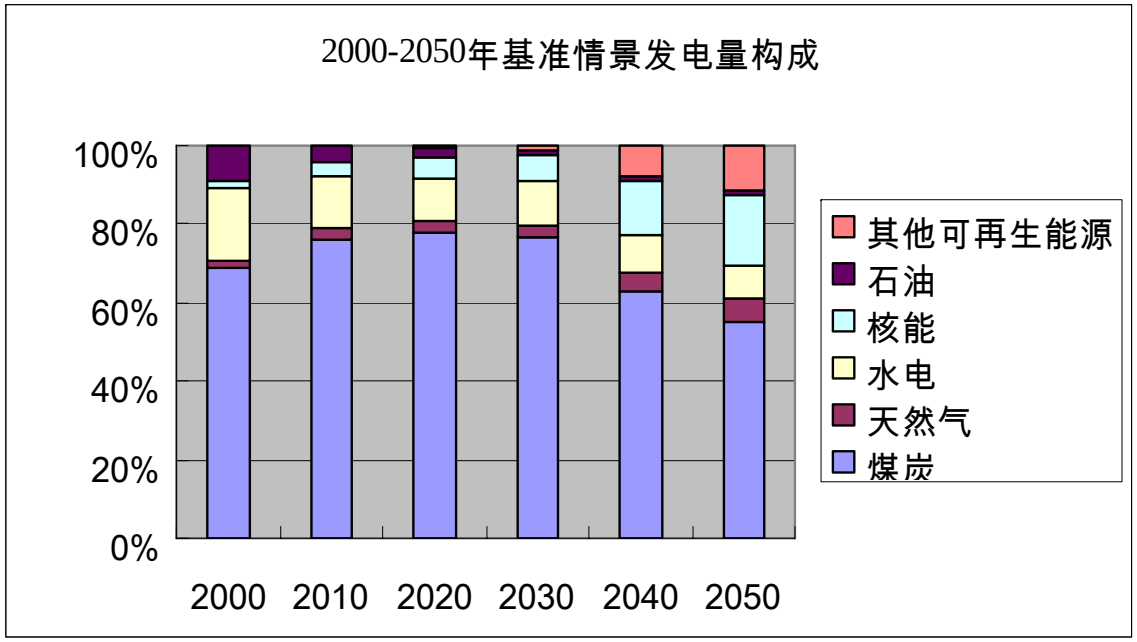
Learning from external experiences(BAU and policy scenario)

Options	Sector/options	Baseline scenario	Policy and technology scenario
Enhanced Energy Saving	Energy Intensive Products	Annual average energy saving rate 2.7%	Annual average energy saving rate 3.6%
	Building	Annual average energy saving rate 1.9%	Annual average energy saving rate 3.0%
	Transport	Annual average energy saving rate 1.5%	Annual average energy saving rate 2.8%
Renewable energy	Biomass	Annual average reduction rate of cost by 3.7%	Annual average reduction rate of cost by 5.9%
	Hydro	65% of technical potential by 2050	80% of technical potential by 2050
	Solar/wind	0.7yuan/kWh by 2050	0.5Yuan/kWh by 2050
Carbon Capture and Sequestration	Coal fired power plants	4% by 2050	15% by 2050
	Industry	1% by 2050	5% by 2050
Clean coal technology	Power generation	7% by 2050	35% by 2050
	Industry	5% by 2050	15% by 2050
Hydrogen	Power generation	Distributed power generation system by 3% in 2050	Distributed power generation system by 8% in 2050
	Transport	Fuel cell vehicle 5%	Fuel cell vehicle 15%
Transport	Vehicle	Hybrid vehicle diffusion start from 2010, 10% by 2030	Hybrid vehicle diffusion start from 2010, 70% by 2040
Policies	Carbon tax	No	50yuan/t-C in 2010, 200yuan/t-C in 2050
	Subsidy	No	Power from renewable energy 0.4yuan/kWh
	Investment Energy technology R&D	Annual average growth rate 4%	Annual average growth rate 6.2%

Modeling analysis result

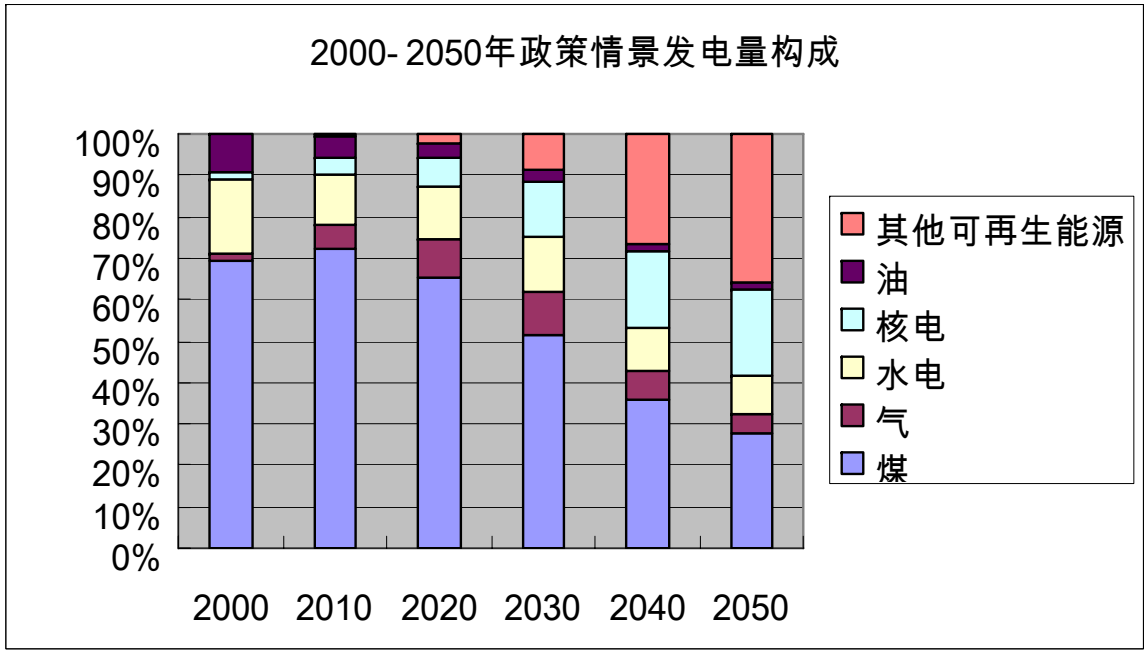


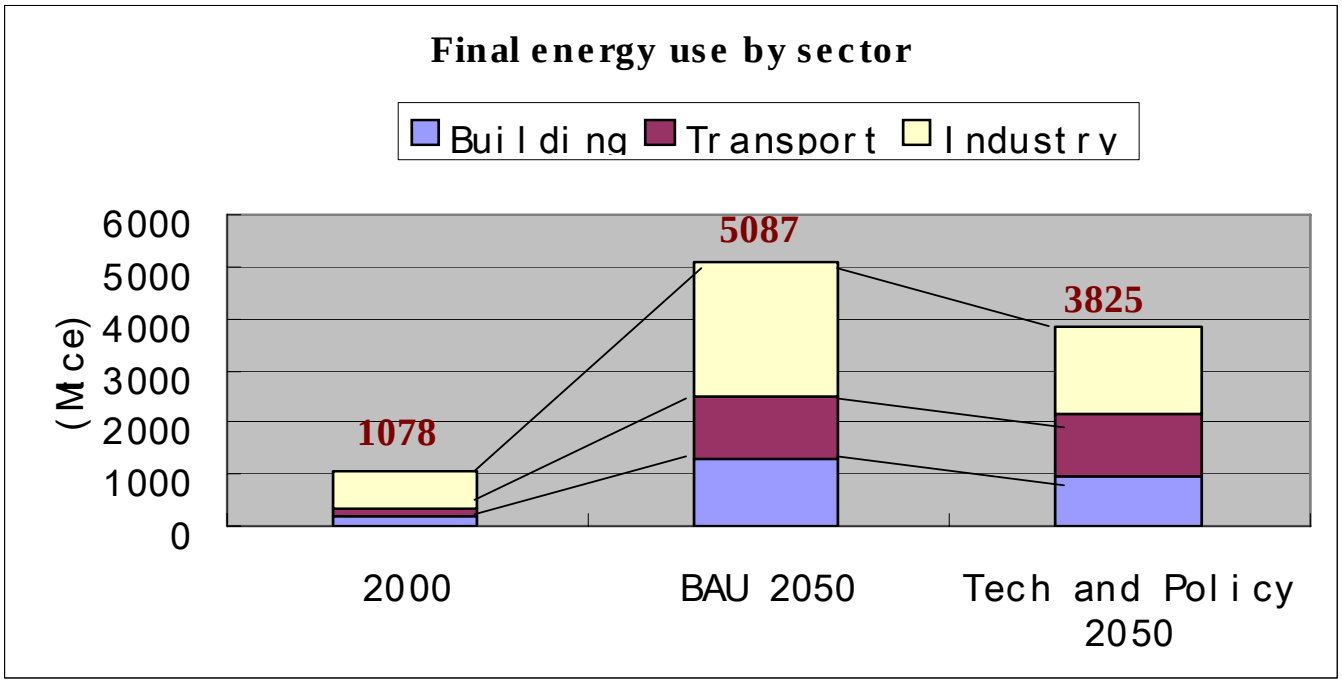
- In policy scenario by 2050:
  - Primary energy demand:1700Mtce would be saved, accounting for 27%;
  - Share of coal would decrease to 30% from 50%;
  - Share of renewable energy would increase to 25% from 11%;
  - Energy structure would be diversified and balanced; ,



In policy case, by 2050

- Renewable energy generation would increase to 35%;
- Nuclear and hydro accounts for 30%;
- Alternative fuel to substitute fossil fuel amounts to almost 1000Mtce
- Generation efficiency would increase to 45% from 30%.



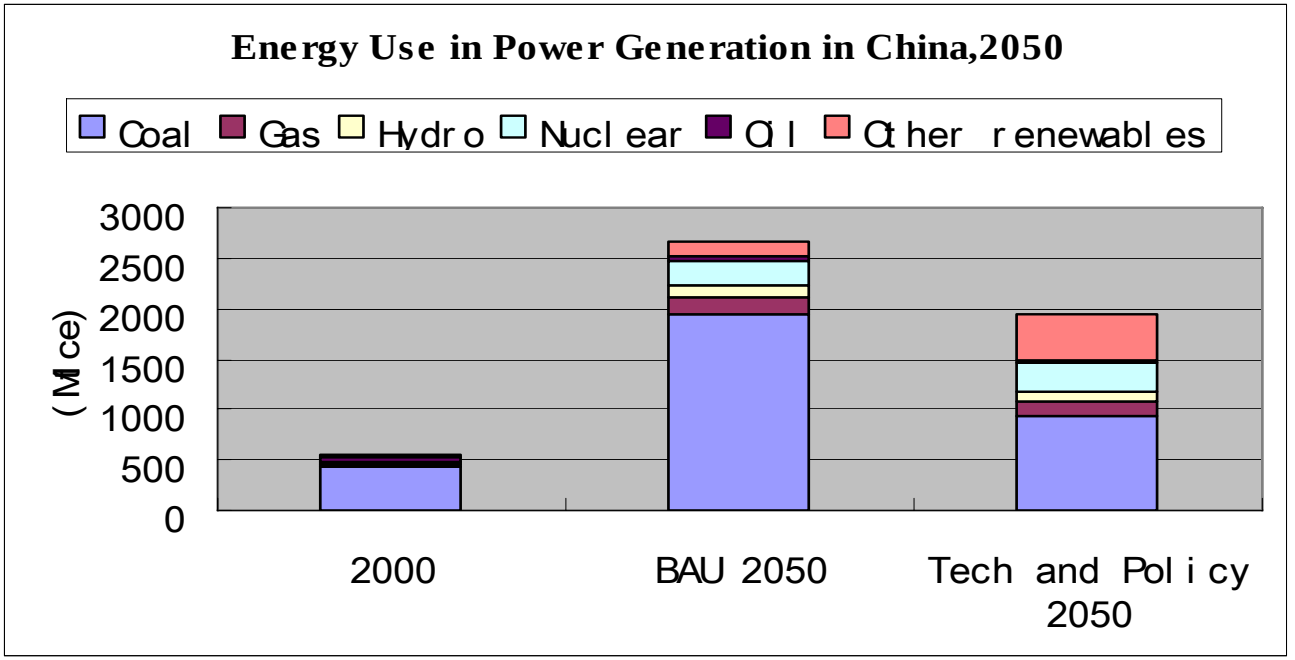


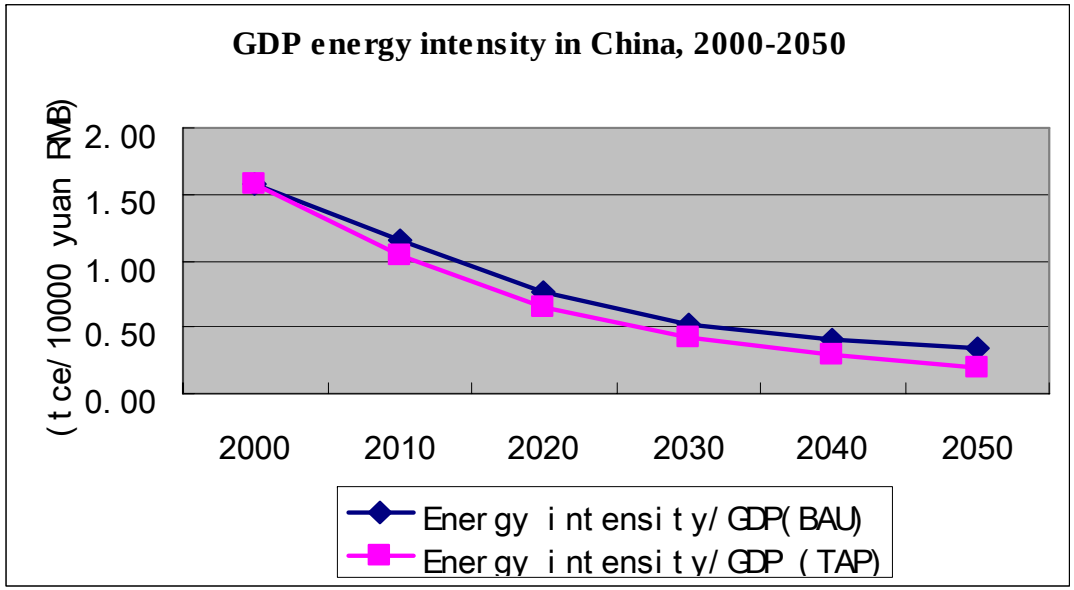
By 2050

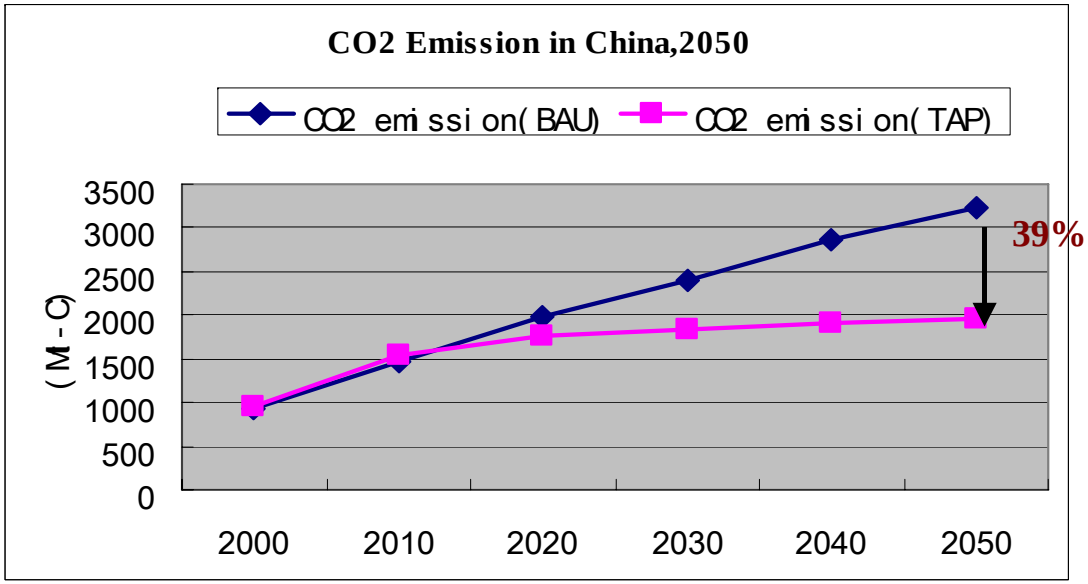
- End-use energy consumption in industries, transportation and building would decrease by 35%, 5% and 24%, respectively;
- Share of industry drops from 55% to 44%; building drops from 26% to 24; However, transportation increases from 24% to 31%.

By 2050年

- 1200Mtce saved in policy case, accounting for 25%;
- Share of coal decreases from 26% to 13%;
- Power increase from 27% to 36%;
- Fuel oil would increase by 6%







Energy demand will be reduced by 27% (1708Mtce) in 2050 by technology and policy scenario compared with baseline scenario .

Energy conservation ratio in 2000~2050

- **BAU**

  2000-2020：3.66%；
  2020-2050：2.76%

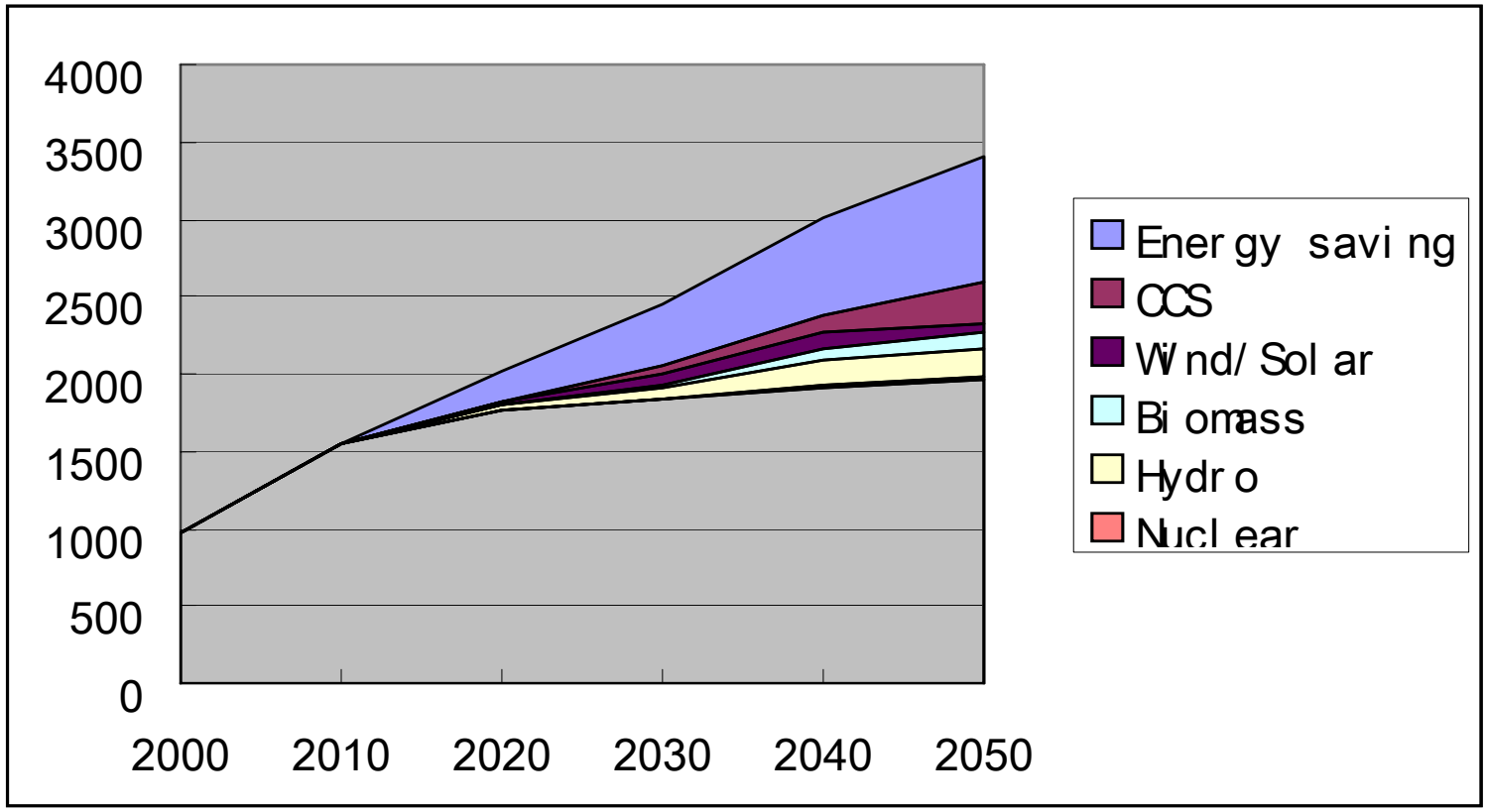
- **Policy case**

  2000-2020：4.54%；
  2020-2050：4.0%

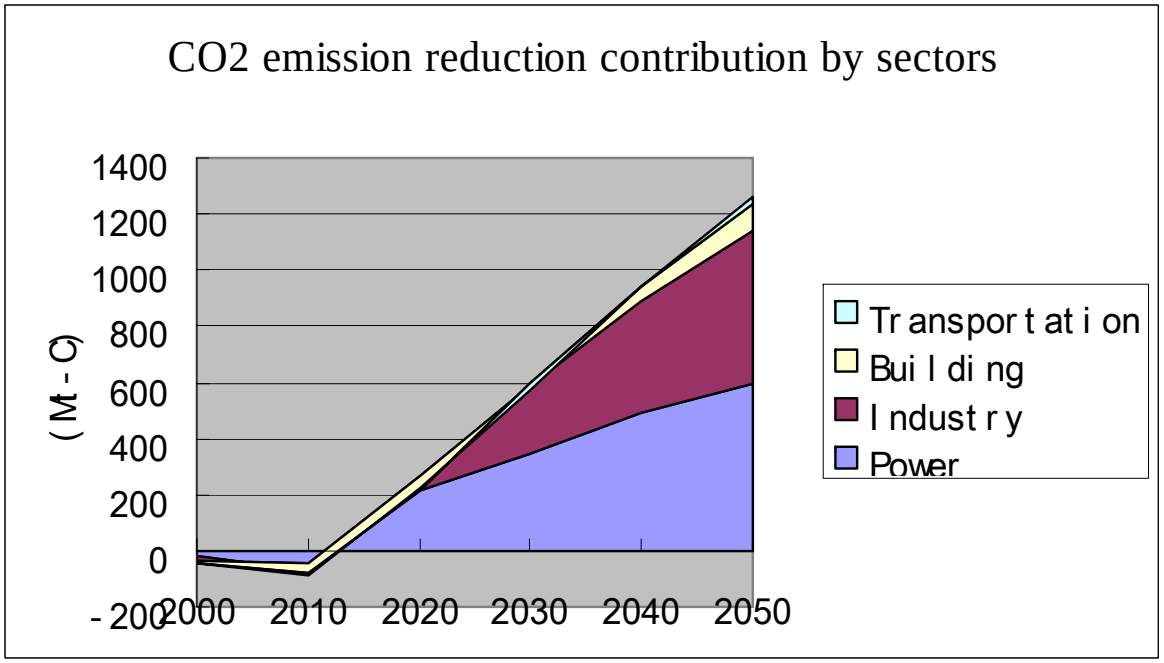
CO2 emission will be reduced 39% (1263Mt-C)in 2050 by technology and policy scenario compared with baseline scenario.

Contributions to CO2 emission reduction from policies, sectors, energy types, technologies

- CO_2 emission reduction contribution (Mt-C) by policies

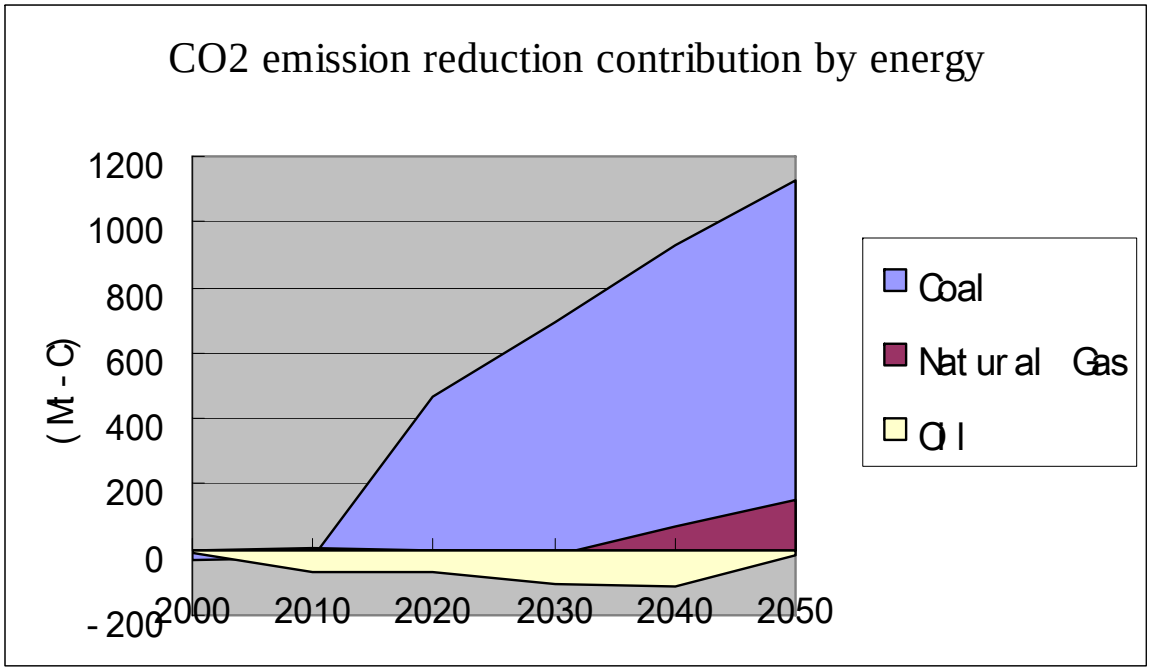


- Energy saving: 64%; CCS:20%; Wind, Biomass, Hydro and Nuclear:16%



CO_2 emission reduction contribution by sectors

- **Power：47%；**
- **Industry：43%；**
- **Building：7%；**
- **Transportation：3%**



CO_2 emission reduction contribution by energy

- **Coal：89%；**
- **Natural gas：12%；**
- **Oil：-1%**

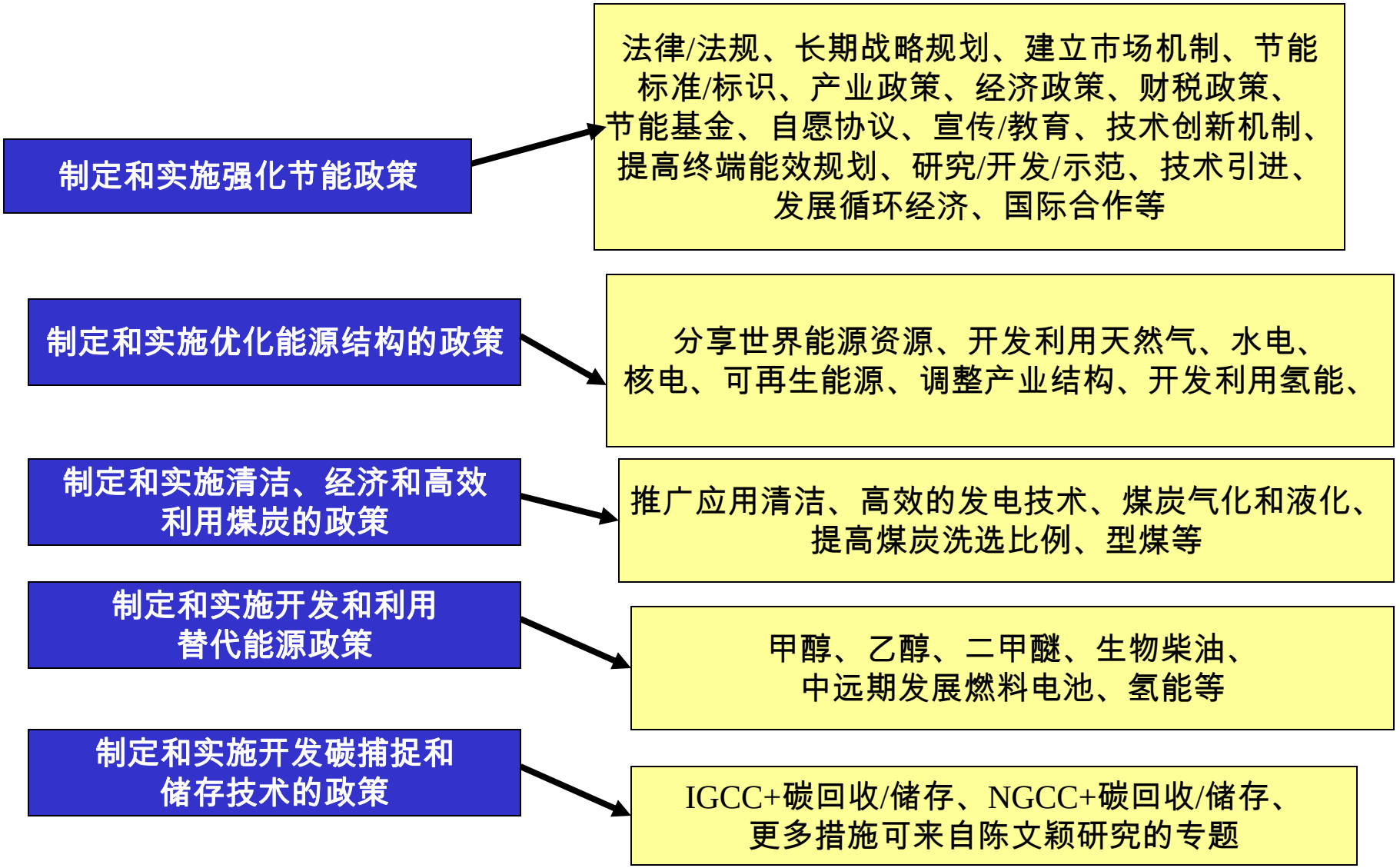
分部门减缓碳排放的优先技术领域

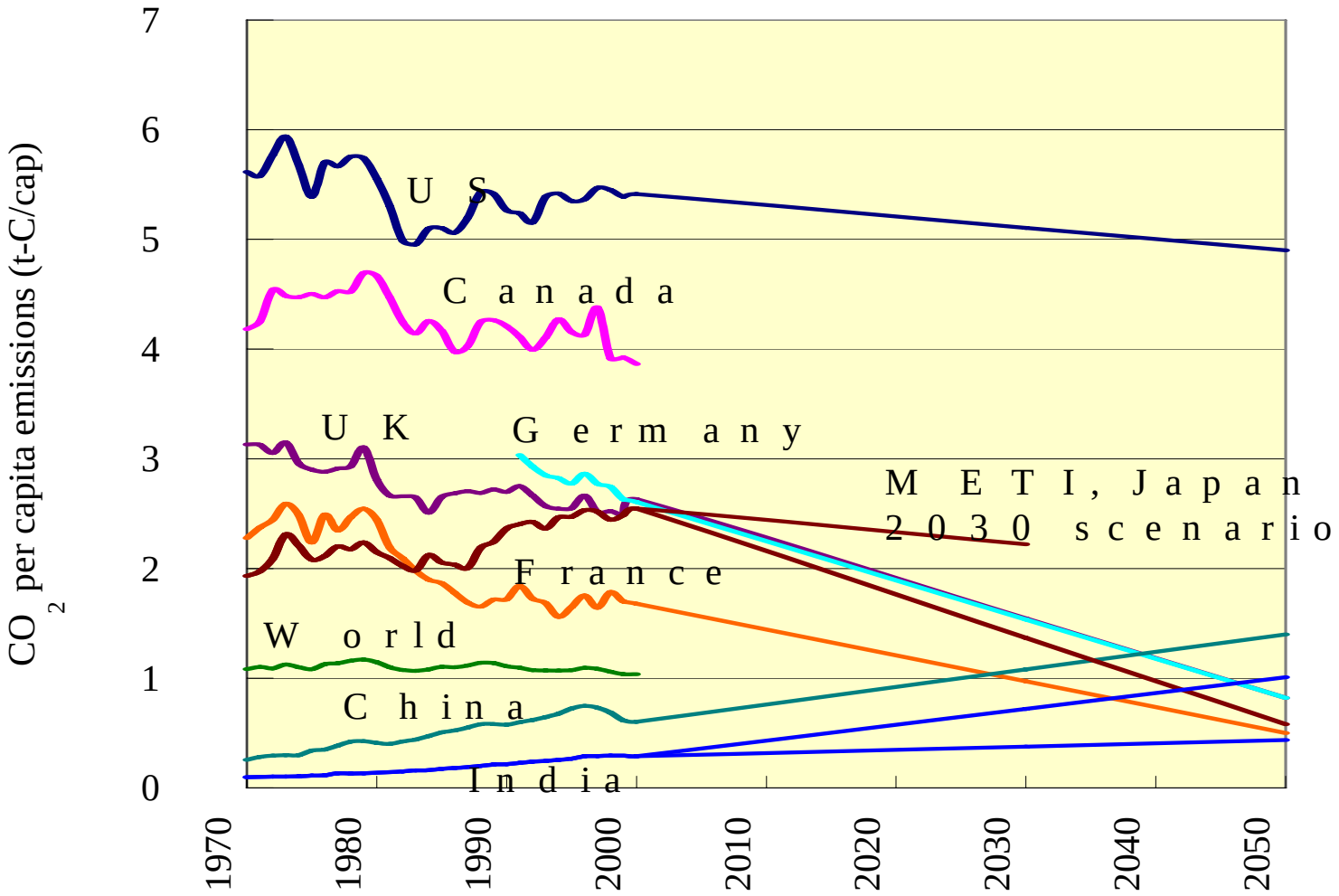
部门	技术
建筑	节能建筑(75%), 先进节能电器(空调, 冰箱, 洗衣机, 液晶电视), 户用太阳能系统, 热泵
交通	混合动力, 先进柴油汽车, 公共交通系统, 生物质燃料
工业	高效工业锅炉, 先进的工业节能技术(钢铁系统, 建材, 玻璃,化工等行业) 高效率的电动机 废弃物循环回收利用技术
能源供应（发电）	IGCC, 分布式发电系统, 多联产技术, PFBC, 先进核电技术
可再生能源	生物质燃烧利用技术, 太阳能发电, 近海风力田2020, 生物质液化, 水电开发技术, 新型薪炭林技术
碳回收/储存	IGCC+碳回收/储存, 多联产技术, NGCC+碳回收/储存
氢能源	燃料电池发电, 燃料电池汽车
非常规能源	深海碳氢化合物2030, 非常规石油

Conclusion

- Energy Saving by technology progress and social efficiency improvement is key for future development economy and GHG emission reduction
- Technologies including advanced and high efficiency technology for energy conservation in the generate electricity, industries, building and transportation sectors.
- Fiscal energy policies including energy tax/carbon tax could be a good option
- Develop international collaboration and technology transfer

政策建议


制定和实施强化节能政策
法律/法规、长期战略规划、建立市场机制、节能标准/标识、产业政策、经济政策、财税政策、节能基金、自愿协议、宣传/教育、技术创新机制、提高终端能效规划、研究/开发/示范、技术引进、发展循环经济、国际合作等
制定和实施优化能源结构的政策
分享世界能源资源、开发利用天然气、水电、核电、可再生能源、调整产业结构、开发利用氢能、
制定和实施清洁、经济和高效利用煤炭的政策
推广应用清洁、高效的发电技术、煤炭气化和液化、提高煤炭洗选比例、型煤等
制定和实施开发和利用替代能源政策
甲醇、乙醇、二甲醚、生物柴油、中远期发展燃料电池、氢能等
制定和实施开发碳捕捉和储存技术的政策
IGCC+碳回收/储存、NGCC+碳回收/储存、更多措施可来自陈文颖研究的专题



Summary of country studies