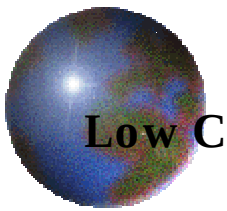
# 上海低碳发展与排放情景

## - 上海市低碳发展与环境效益研究
## 美国能源基金会资助项目



## Low Carbon Development and Emission Scenario in Shanghai, China
## - Using LEAP as an Integrated Energy and Environment Model

Financially supported by Energy Foundation

陈长虹，王冰妍，赵静，戴懿
上海市环境科学研究院

CHEN Changhong, WANG Bingyan, ZHAO Jing, DAI Yi

Shanghai Academy of Environmental Sciences

北京，中国　　Beijing, China

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# 介绍内容 Outline

1. 研究背景 Background
2. 研究目标 Research Targets
3. 情景分析 Scenarios Analysis
4. 政策建议 Policy Recommendations


Expedia
RUSSIA
Chelyabinsk
Omsk
Novosibirsk
Yakutsk
Petropavlovsk-Kamchatskiy
Angara
Lena
Sea of Okhotsk
EUROPE
KAZAKHSTAN
Baku
Irkutsk
Chita
Khabarovsk
Amur
ASIA
Ulaanbaatar
Olan Bator
Tehrān
Toshkent
MONGOLIA
Harbin
Sapporo
Ch'ŏngjin
Ürümqi
Osh
Shenyang
Mashhad
IRAN
Beijing
Tokyo
Kabul
Seoul
Islāmābād
JAPAN
Lanzhou
Taiyuan
Taegu
PACIFIC OCEAN
QINGHAI
Xi'an
PAKISTAN
Lahore
CHINA
Shanghai
TIBET
Masqat
Chengdu
Wuhan
Karāchi
Delhi
Kathmandu
Ahmadābād
Chongqing
Tropic of Cancer
Taipei
Rājshāhi
Dhaka
Dacca
Kunming
INDIA
Kaohsiung
Mumbai
Bombay
Kolkata
Calcutta
Guangzhou
Canton
MYANMAR
Salween
Hanoi
Chennai
Madras
Vientiane
South China Sea
MICRONESIA
Manila
Arabian Sea
Bay of Bengal
Bangkok
VIETNAM
PHILIPPINES
FEDERATED STATES OF MICRONESIA
Malé
Phnom Penh
Davao
Koror
Ho Chi Minh City
Sri Jayawardenepura Kotte
Bandar Seri Begawan
Equator
INDIAN OCEAN
Medan
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# 上海市的能源环境状况

## Energy and Environment Status in Shanghai

- 上海是中国经济最为活跃，人均能源消费量较高的城市，同时又是资源和能源匮乏的城市。

  Shanghai is a Chinese city with a robust economy, highest energy consumption per capita, but lacks energy and resources.

- 2002年，全市GDP达到5409亿元，人均GDP近5000美元。

  GDP in 2002 was 540.9 billion Yuan, and GDP per capita was close to $5000.

# 上海市的能源环境状况

## Energy and Environment Status in Shanghai

- 2002年，全市能源消费总量6050万吨标煤，人均能耗4.5吨标煤(不包括流动人口，包括流动人口为3.3吨标煤)，为全国人均能耗(1.0标煤)的3~4倍。

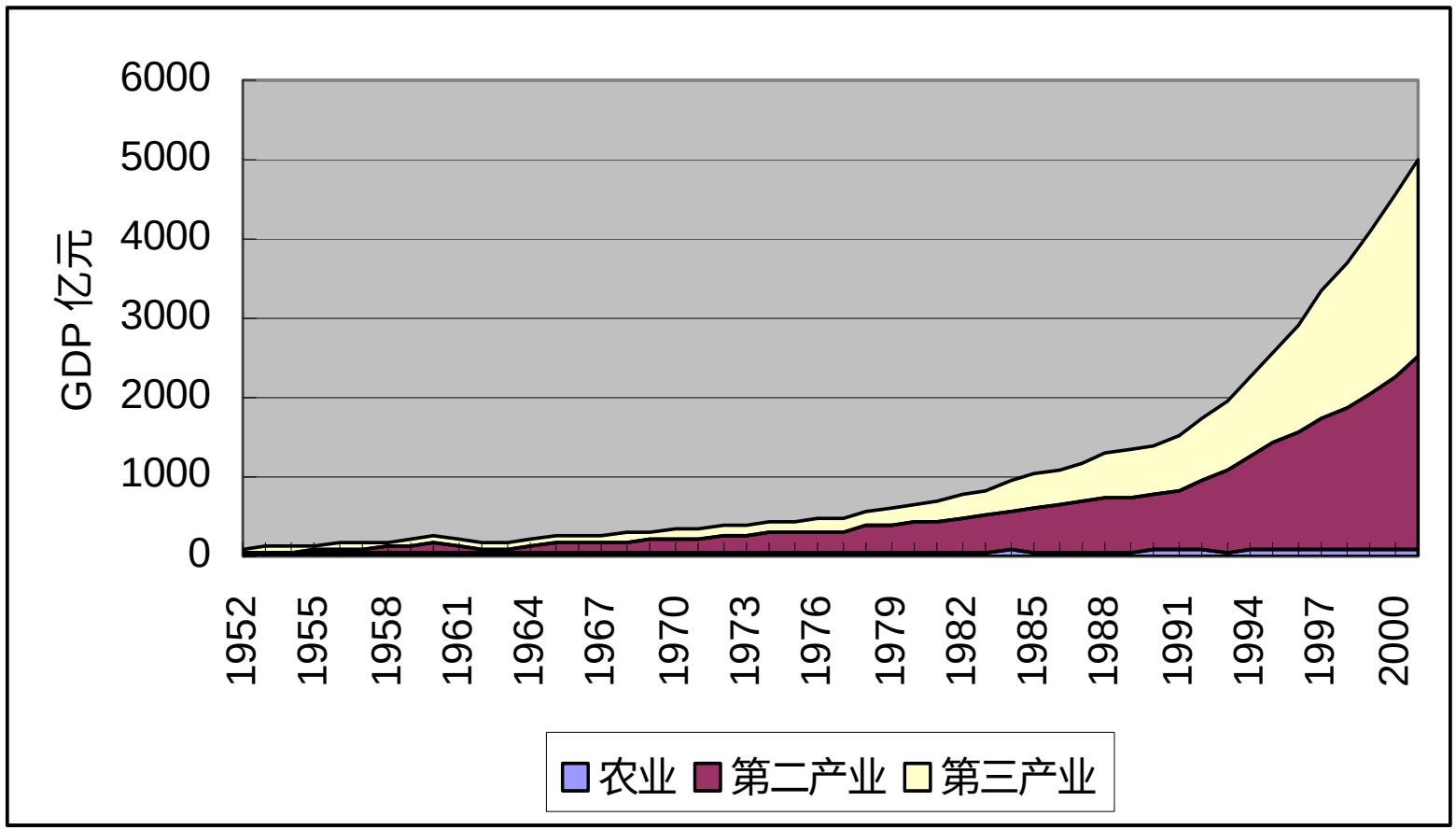
Total energy consumption in 2002 accounted for 60.5 million TCE, and energy use per capita was 4.5 TCE (except for floating population, nearly 3.3 TCE if floating population is counted), about 3-4 times the energy consumption per capita of China (1.0 TCE).

# 上海市能源经济指标与国内其它城市的比较(2002年)

Comparison of Energy Economical Index Between Shanghai and Other Cities in China (in 2002)

| | 单位 | 北京 Beijing | 天津 Tianjin | 广州 Guangzhou | 重庆 Chongqing | 上海 Shanghai |
|---|---|---|---|---|---|---|
| GDP | 亿元 | 3130 | 2051 | 3001 | 1971 | 5409 |
| 产业结构 | 一:二:三 | 3:36:61 | 4:50:46 | 3:41:56 | 16:42:42 | 2:47:51 |
| 人口 | 万人 | 1136 | 1007 | 721 | 3114 | 1334 |
| 能源消费总量 | 万吨标煤 | 4504 | 3022 | 2320 | 2742 | 6119 |
| 第一产业 | % | 2 | 3 | 1 | 7 | 2 |
| 第二产业 | % | 57 | 66 | 64 | 77 | 68 |
| 第三产业 | % | 28 | 19 | 25 | 6 | 23 |
| 生活 | % | 13 | 13 | 10 | 10 | 8 |
| 单位GDP能耗 | 吨标煤/万元 | 1.4 | 1.5 | 0.8 | 1.4 | 1.1 |
| 煤炭消费总量 | 万吨 | 2504 | 2285 | | | 4688 |
| 终端煤炭消费比重 | % | 52 | 41 | | | 21 |
| 能源消费密度 | 万吨标煤/平方公里 | 0.27 | 0.27 | 0.32 | 0.03 | 0.96 |
| 煤炭消费密度 | 万吨/平方公里 | 0.15 | 0.21 | | | 0.74 |
| 人均GDP | 美元/人 | 3340 | 2469 | 5045 | 767 | 4915 |
| 人均能耗 | 吨标煤/人 | 4.0 | 3.0 | 3.2 | 0.9 | 4.5 |

# 1. 上海市国民经济增长 Economic Growth of Shanghai

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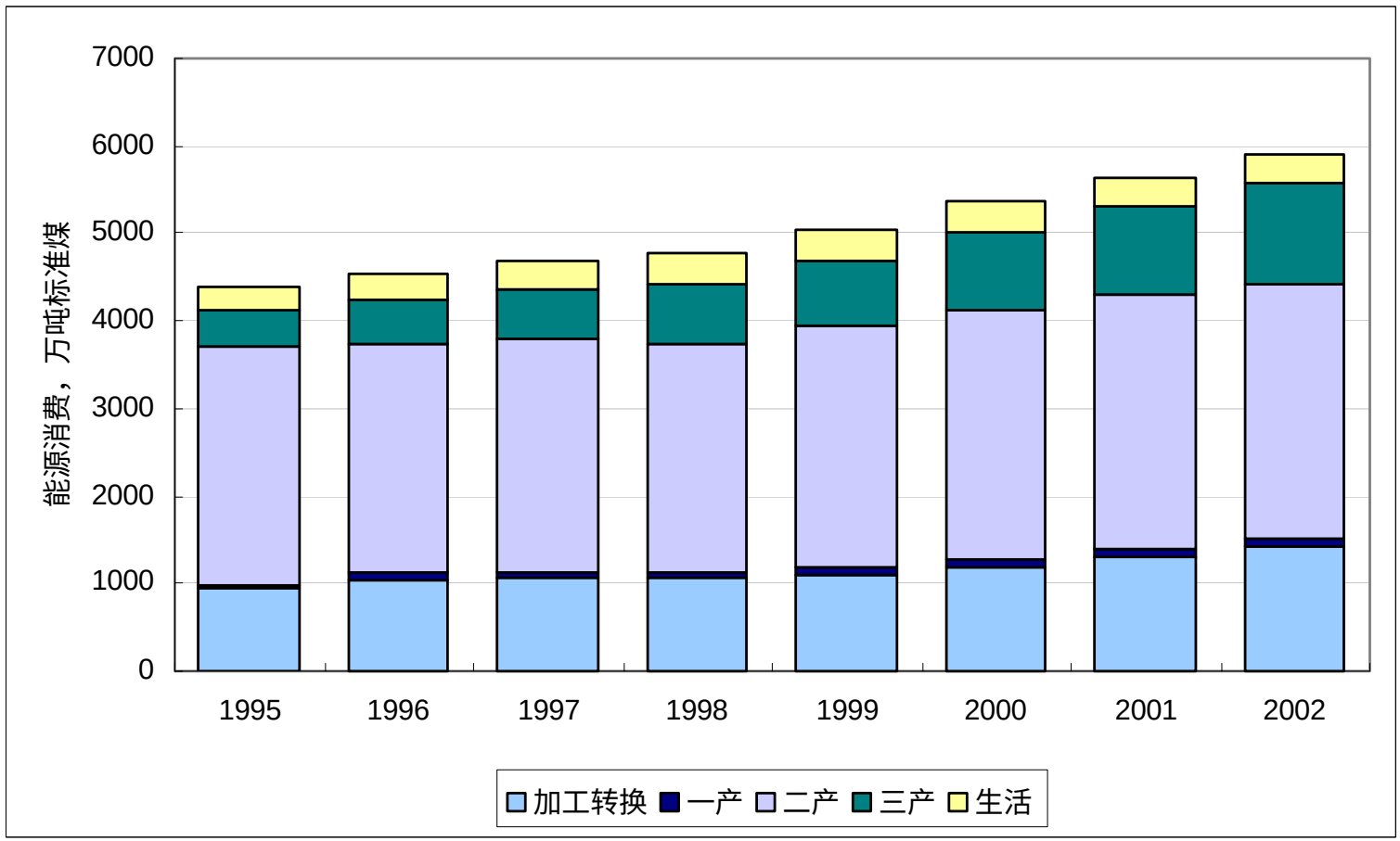
# 3. 上海市能源消费 Energy consumption

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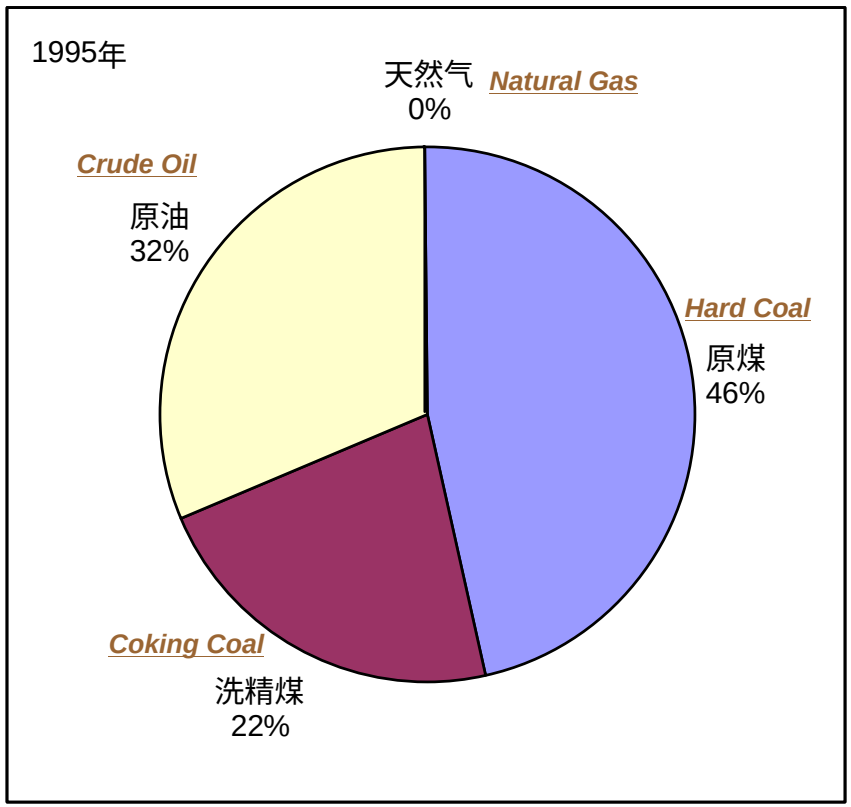
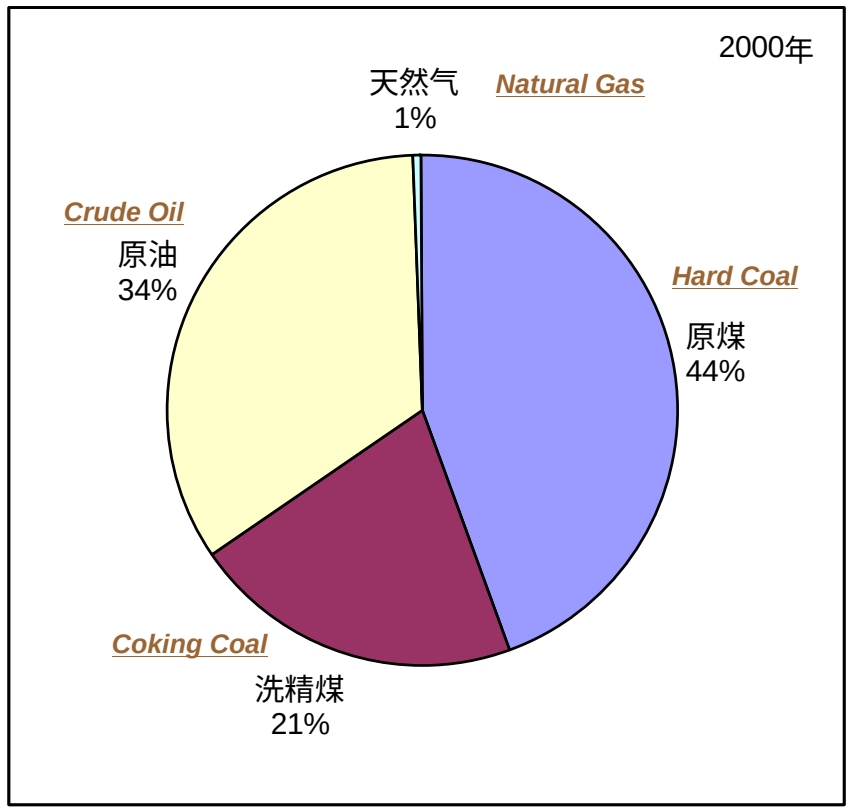
# 4. 上海市一次能源结构 Primary energy structure

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# 上海能源强度：能源强度相对较高

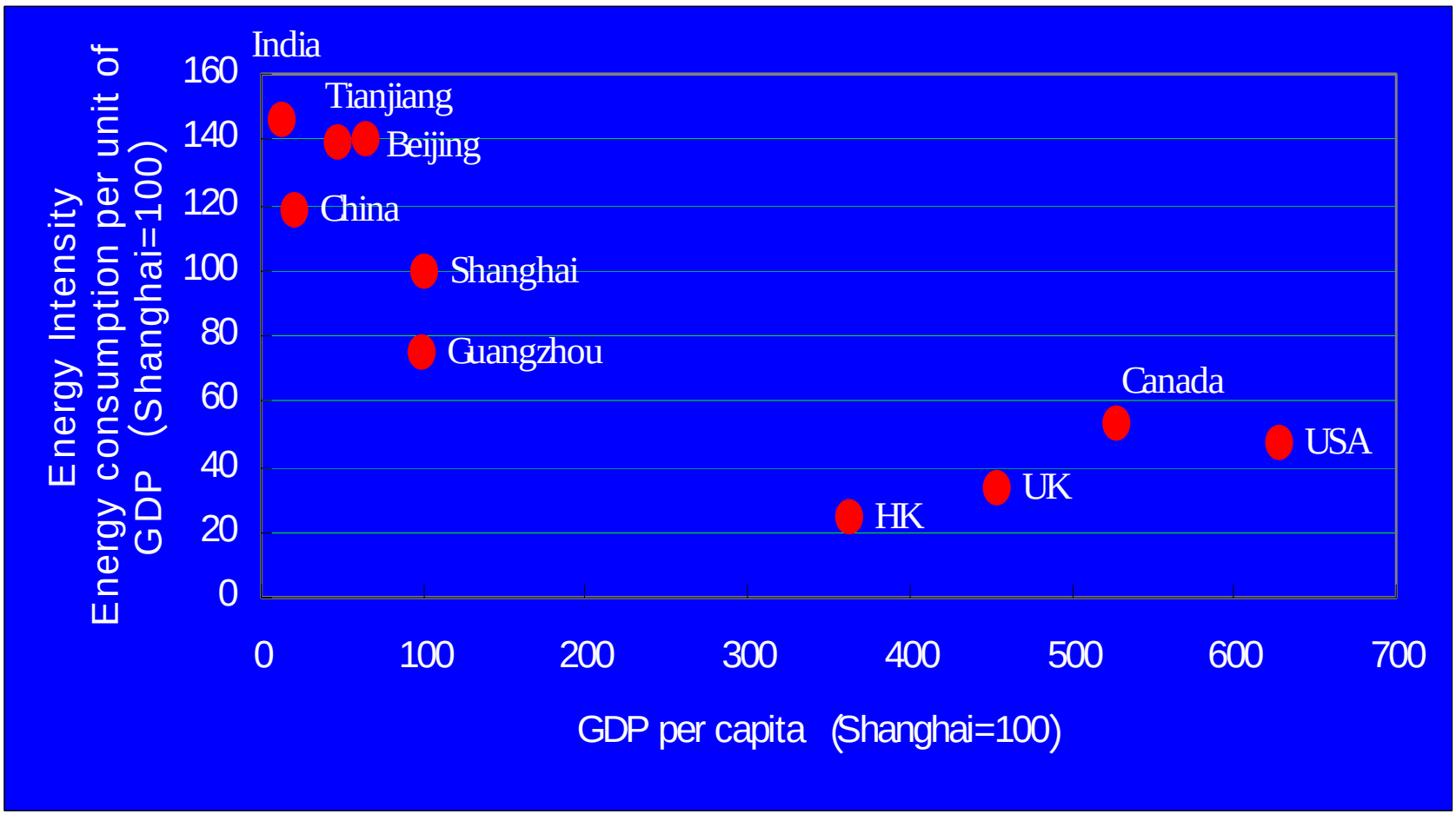
## Energy Intensity in Shanghai： Relatively High

能源效率相对较低 需要调整能源结构，需要提高能源技术

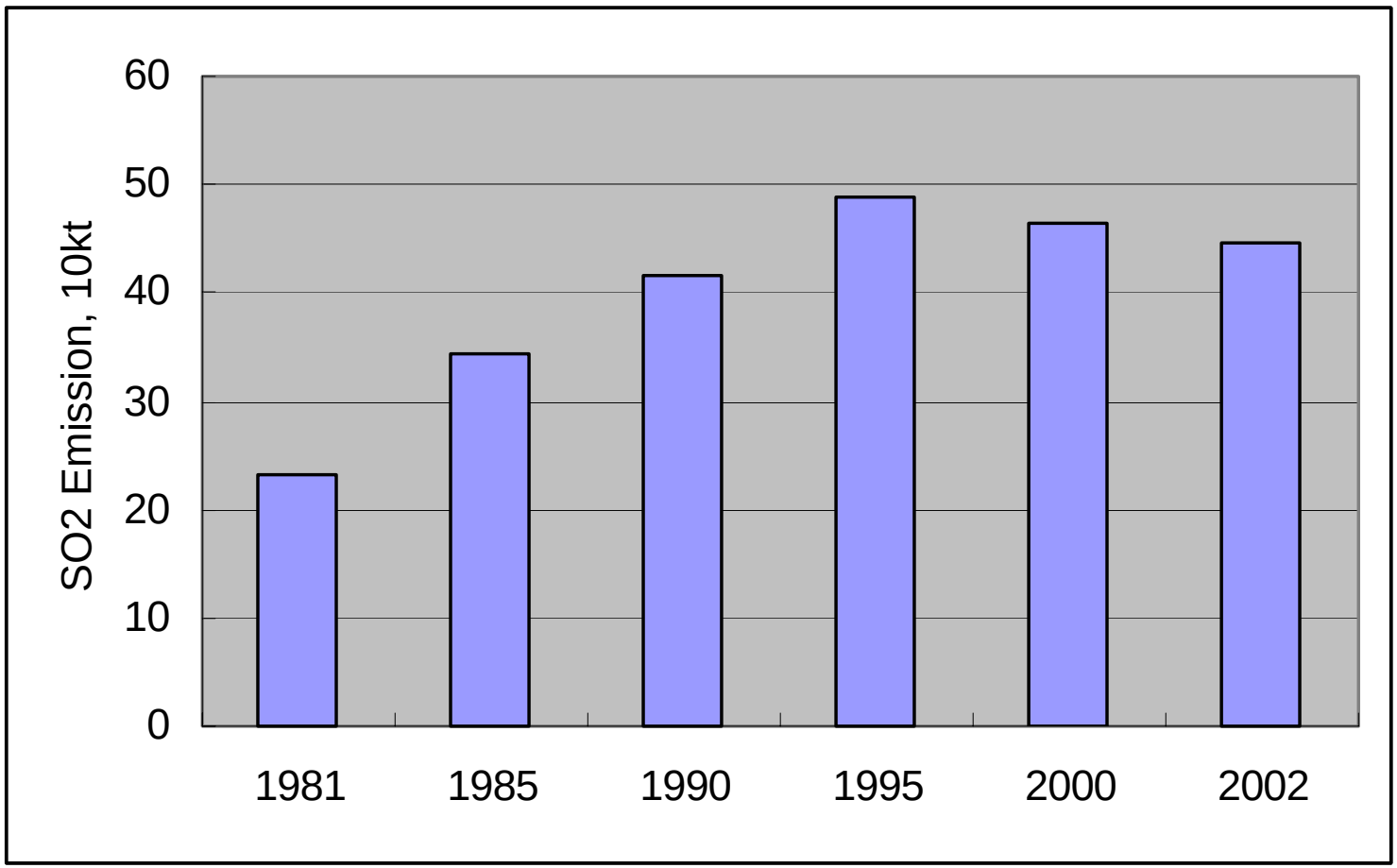
Relatively low in Energy Efficiency Need Energy Structure Adjustment, Technical upgrade

能源效率相对较高

Relatively High in Energy Efficiency



# 5. $SO_2$排放量 $SO_2$ Emission

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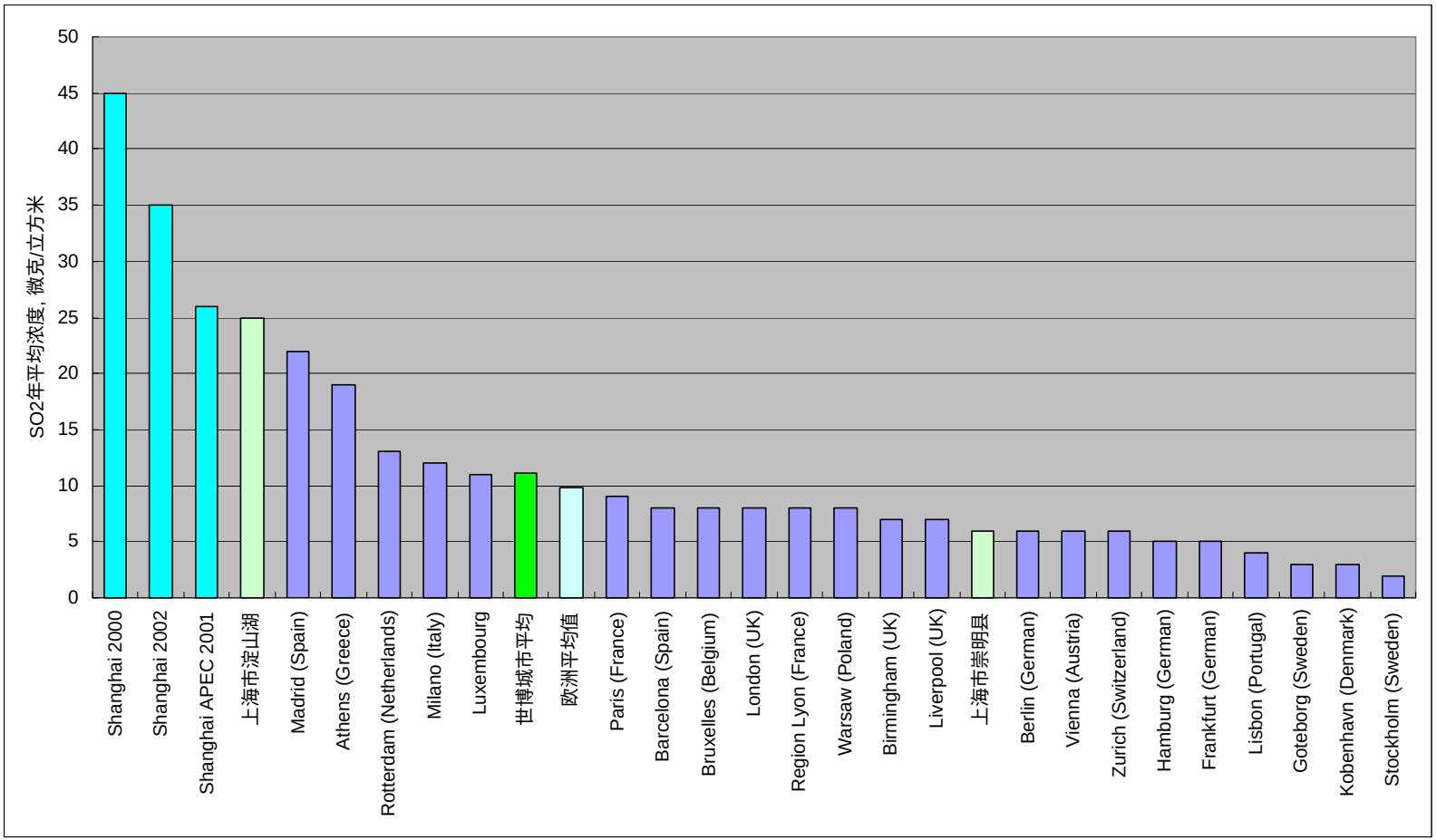
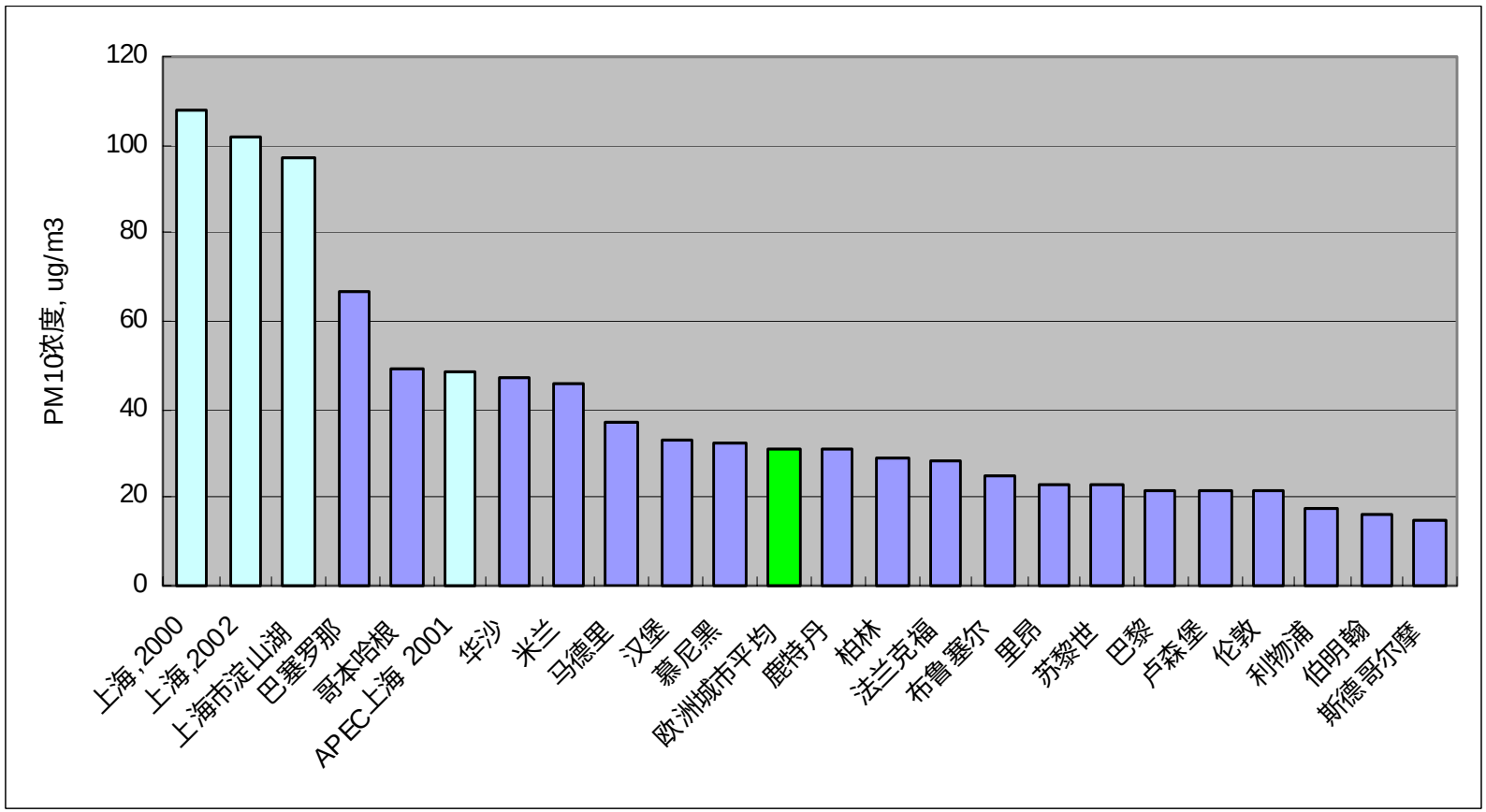
# 8. 环境空气质量与欧洲城市的比较—$SO_2$

## Air quality comparison with Shanghai and European cities-$SO_2$



# 8. 环境空气质量与欧洲城市的比较—$PM_{10}$

## Air quality comparison with Shanghai and European cities-$PM_{10}$

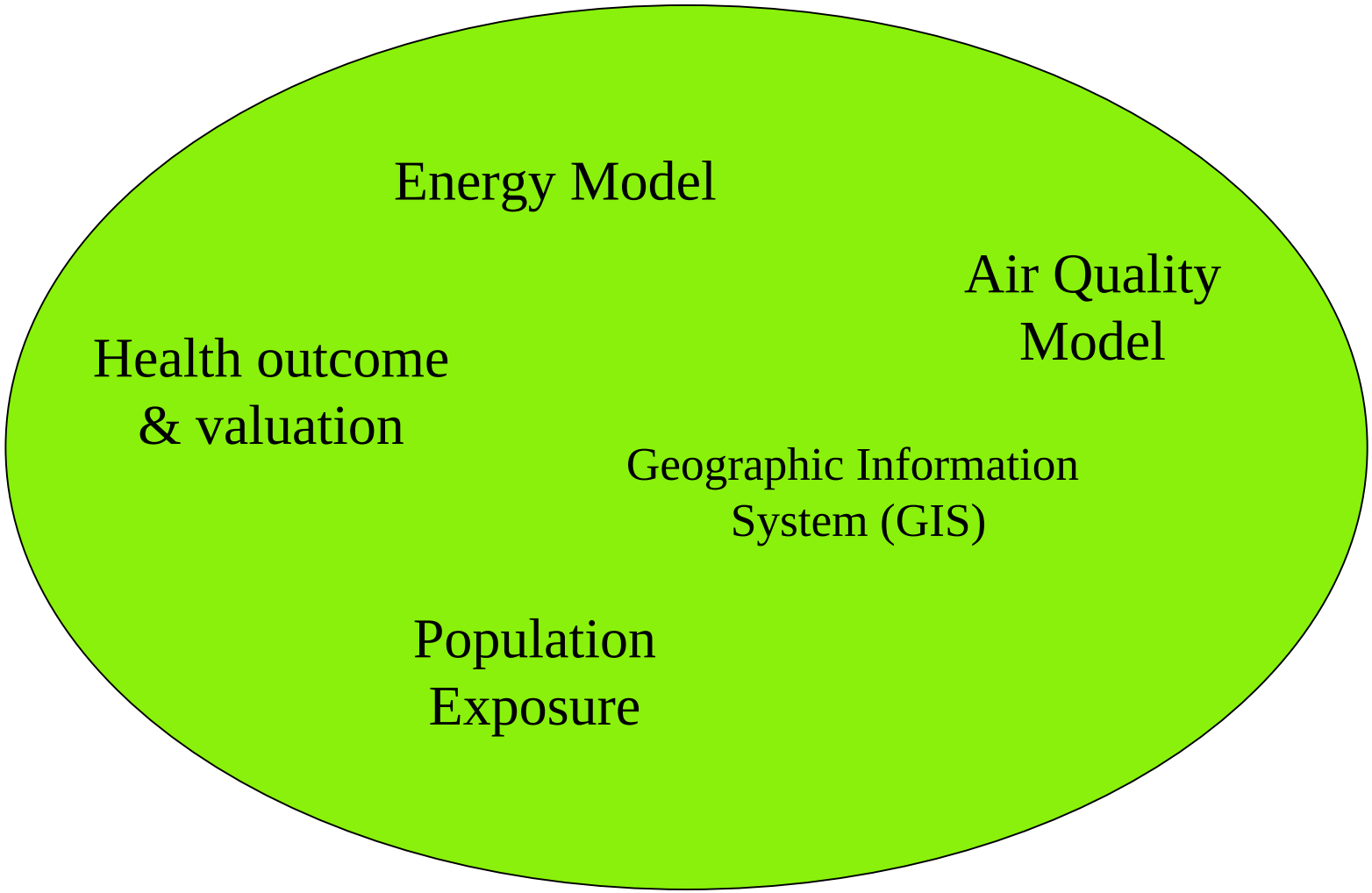


# 研究目标 Research Targets

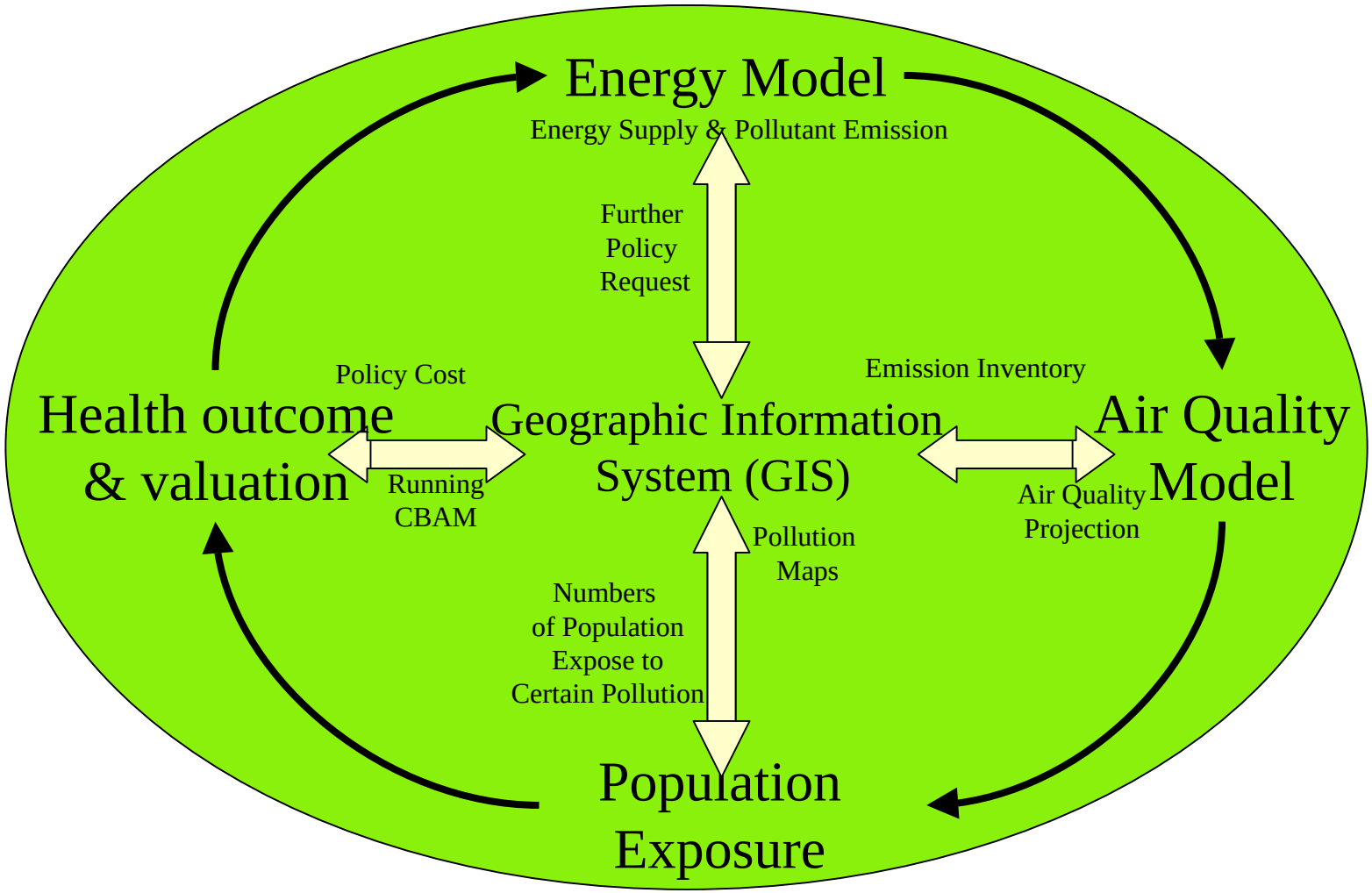
- 探讨低碳发展在减缓本市能源供应压力、减少大气污染物排放、改善环境空气质量及其可取得的附加效应和健康经济学效益，最终为本市能源环境建设提出政策建议。

Study the benefits of low carbon development to reduce energy supply pressures, air pollutants emission control, and ambient air quality improvement. Finally advance policy recommendations for energy environment in Shanghai.

# *Tools and Models to be used for low carbon studies*



# Works of Shanghai Integrated Energy and Environmental Model System



# LEAP模型情景定义

## Definition of Scenarios in LEAP Shanghai

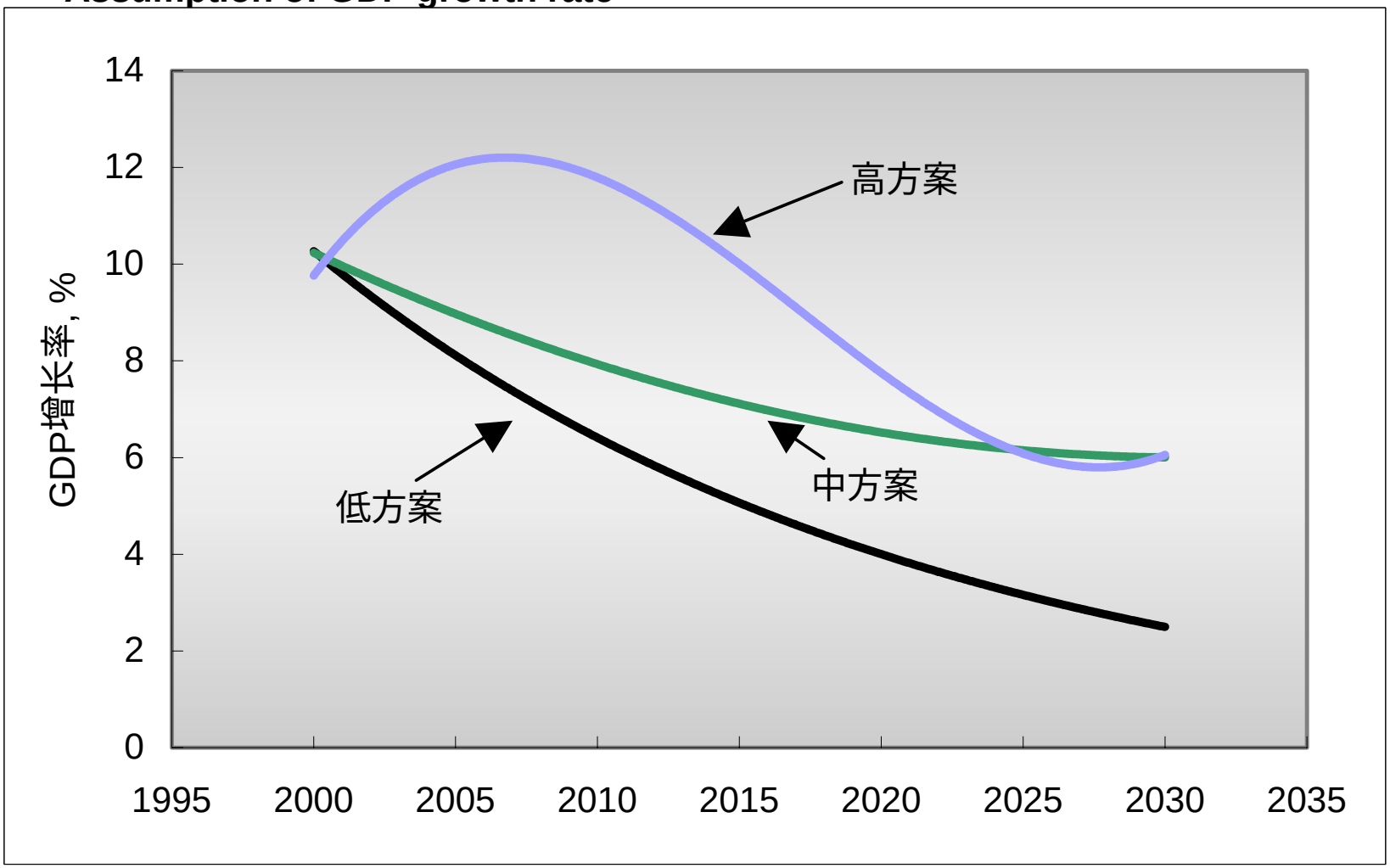
表 4-1　LEAP 模型情景定义

Table 4-1　Definition of Scenarios in LEAP Shanghai

| 主情景 | 子情景 | 单一情景 | LEAP 中的情景名称 | 情景定义 |
|---|---|---|---|---|
| 基础情景 | 经济增长 | Scenario 1 | Scenario 1 | 低经济增长情景 |
| | | Scenario 2 | Scenario 2 | 中经济增长情景 |
| | | Scenario 3 | Scenario 3 | 高经济增长情景 |
| “低大气污染物和二氧化碳排放情景”<br>或<br>“低排放情景” | 低碳发展 | BAU | Scenario 2-BAU | 基础情景(中速经济增长) |
| | | EE | S2_EE_only | 终端部门降低能源强度(节能、提高能源技术) |
| | | COAL+GAS | S2_COAL_GAS | 终端减少煤炭需求，实行天然气替代+天然气替代管道煤气 |
| | | ELEC+WIND | S2_ELEC_WIND | 电厂部分机组采用天然气发电+增加风能发电机组(低碳发电) |
| | 末端治理 | SO2 | S2_ELEC_WIND_SO2a | 电厂部分机组采用天然气发电+增加风能发电机组(低碳发电)+煤电机组烟气脱硫 |
| | | | S2_EE_COAL_GAS_ELEC_WIND_SO2b | 终端部门节能+终端天然气替代煤炭+天然气替代管道煤气+天然气发电+风能发电+煤电机组烟气脱硫+控制燃料含硫量 |
| | | PM | S2_EE_COAL_GAS_ELEC_WIND_SO2b_PM | 终端部门节能+终端天然气替代煤炭+天然气替代管道煤气+天然气发电+风能发电+煤电机组烟气脱硫+控制燃料含硫量+控制烟尘 |
| | 综合情景(低碳发展+末端治理) | 世博情景 | S2_EE_COAL_GAS_ELEC_WIND_SO2c_PM | 世博情景（进一步控制燃料的含硫量，使 SO2 浓度达到世博要求) |

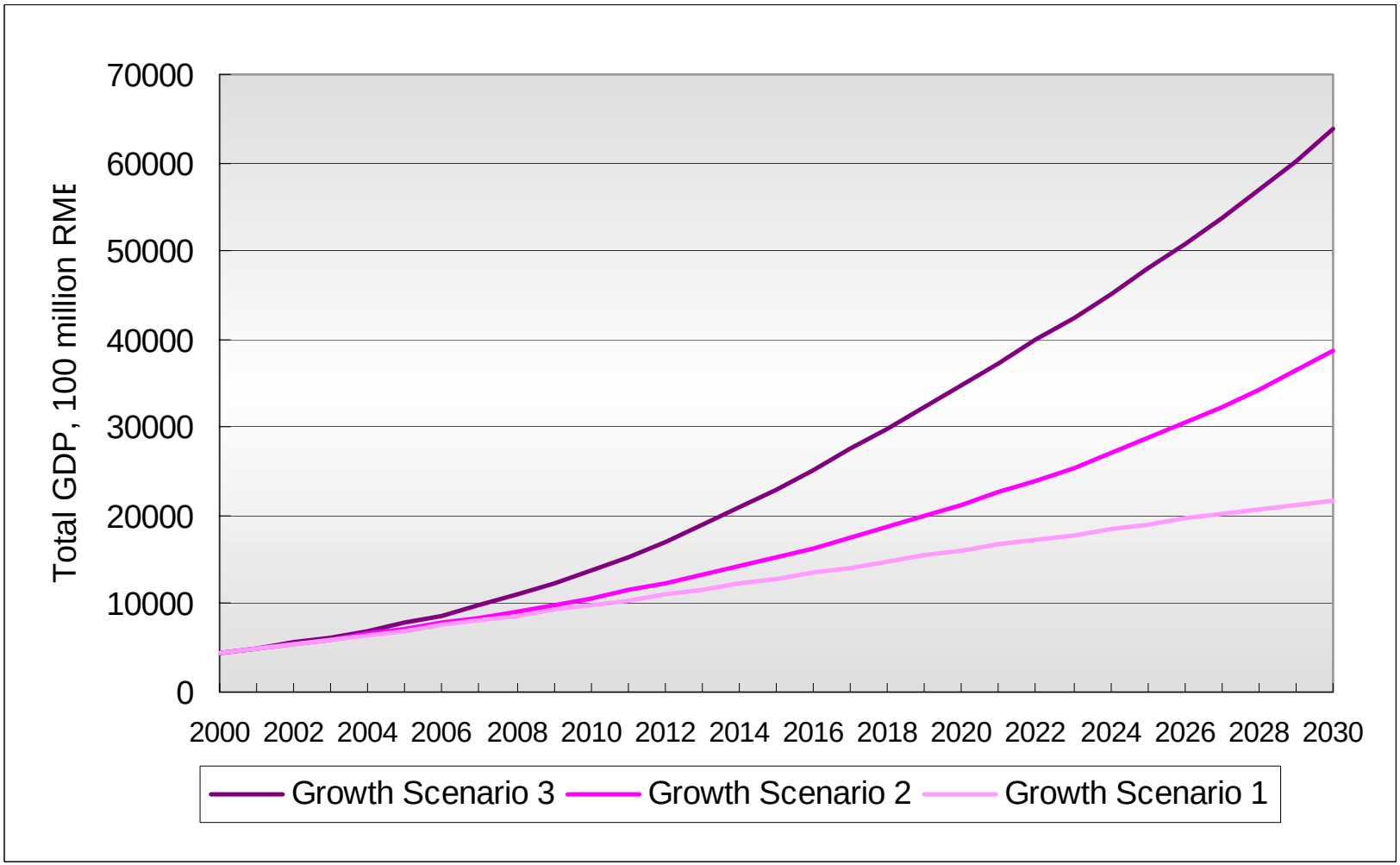
# GDP增长率

- **Assumption of GDP growth rate**



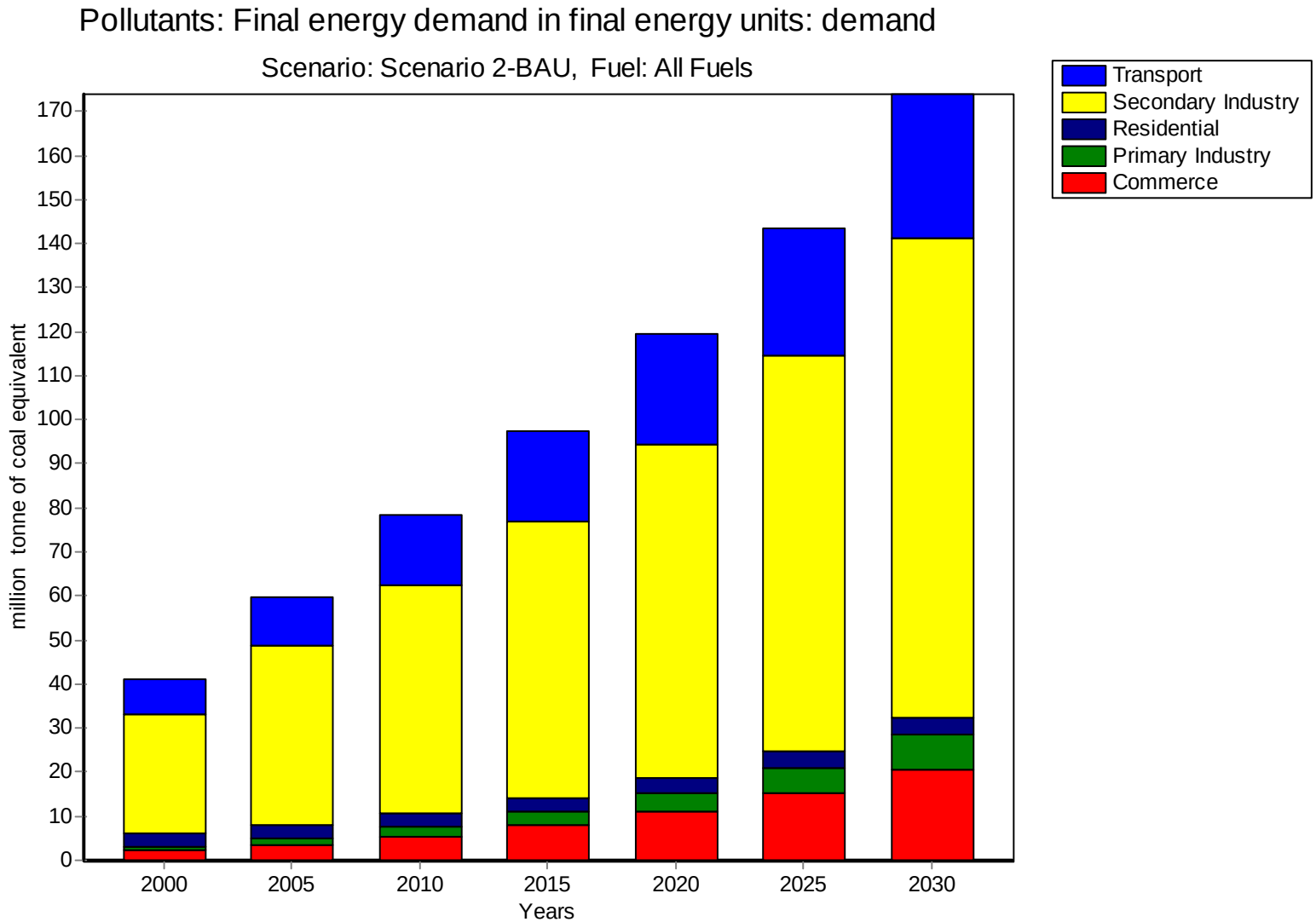
# GDP增长

- **GDP growth scenario**



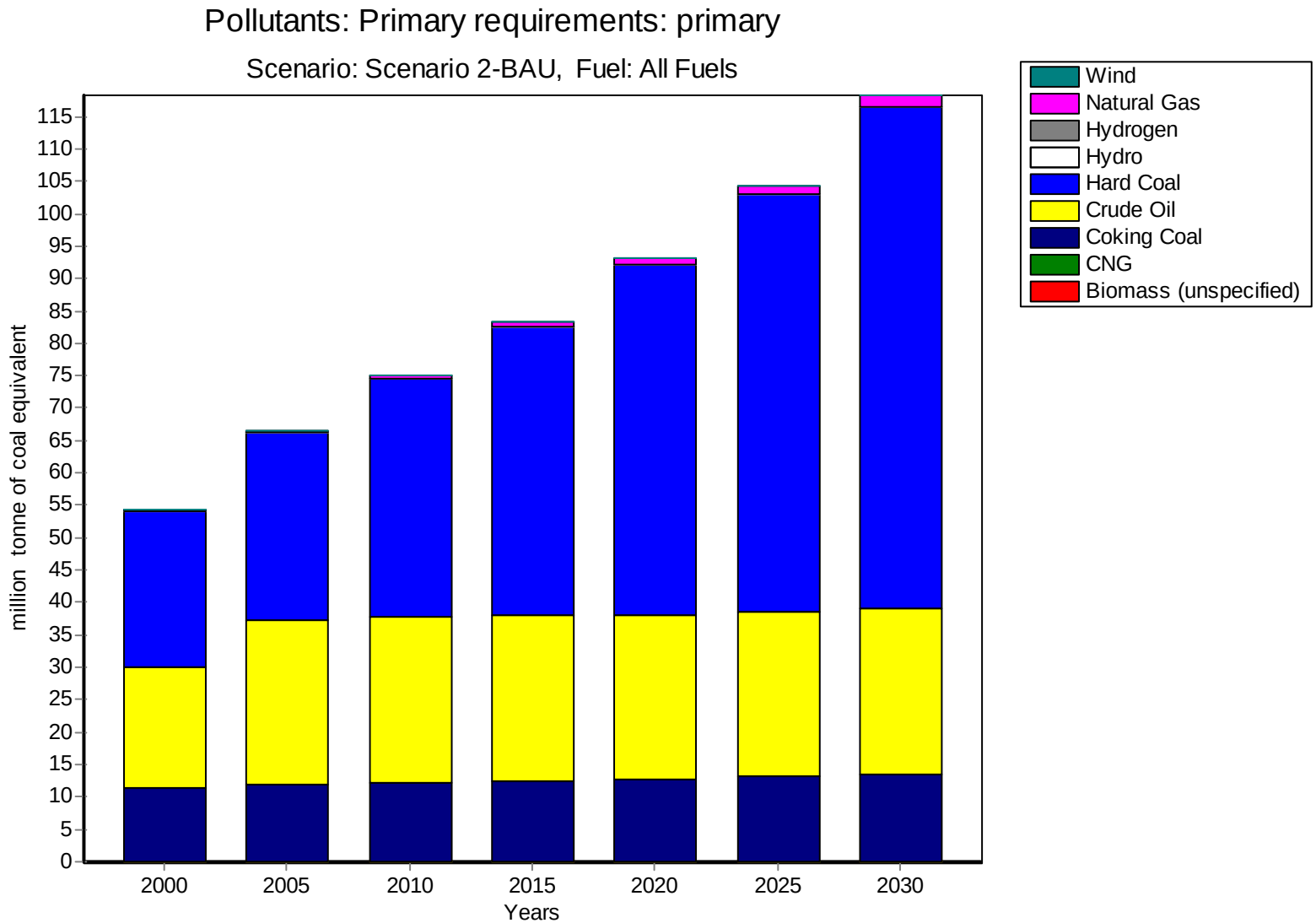
# 上海市中长期终端能源需求

## Medium and Long-term End Energy Demand in Shanghai



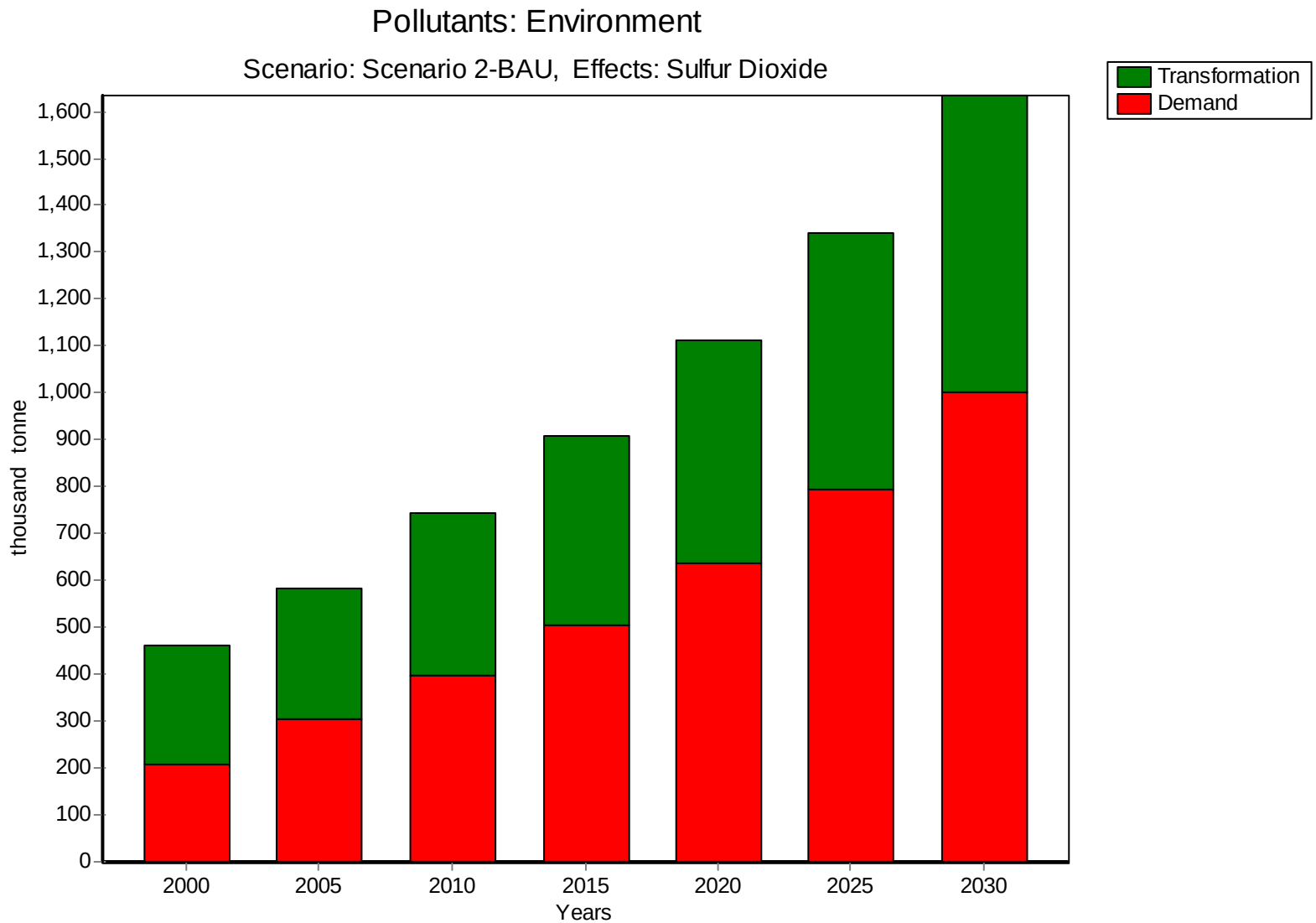
# 上海市中长期一次能源需求

## Medium and Long-term Primary Energy Demand in Shanghai



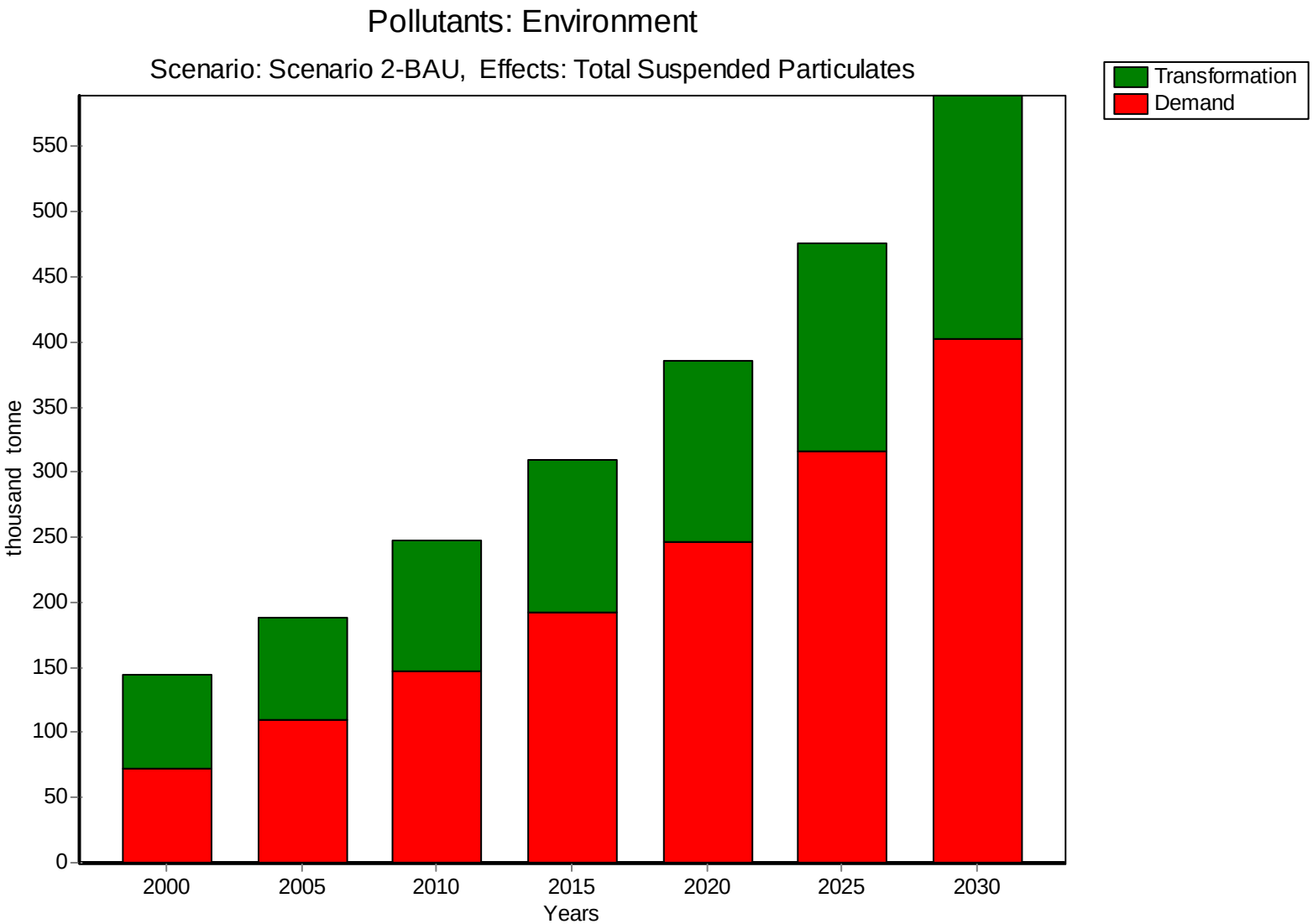
# 全市$SO_2$排放量

## Total $SO_2$ Emissions



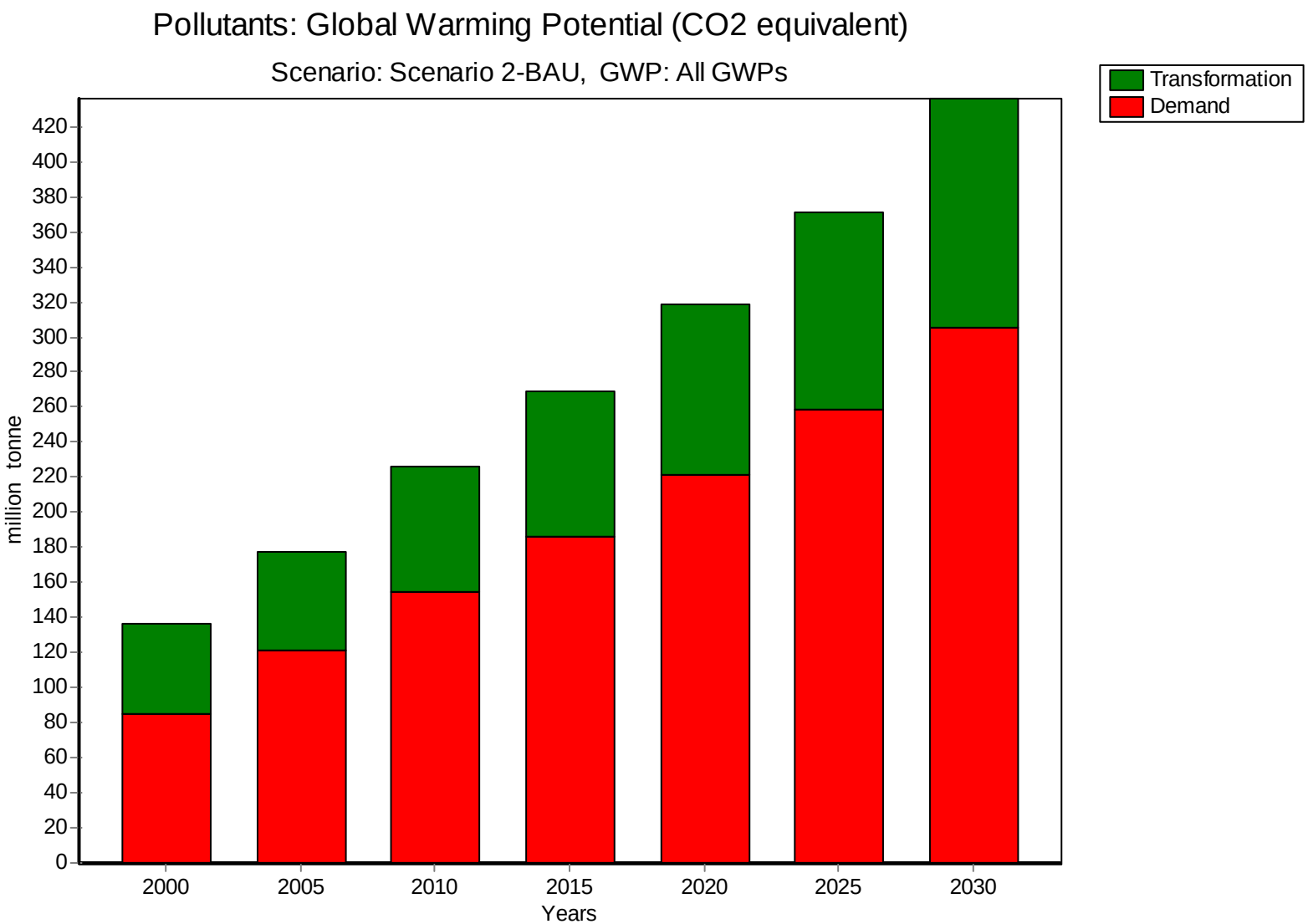
# 全市PM排放量

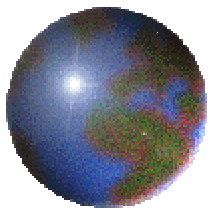
## Total PM Emissions



# 全市$CO_2$排放量

## Total $CO_2$ Emissions





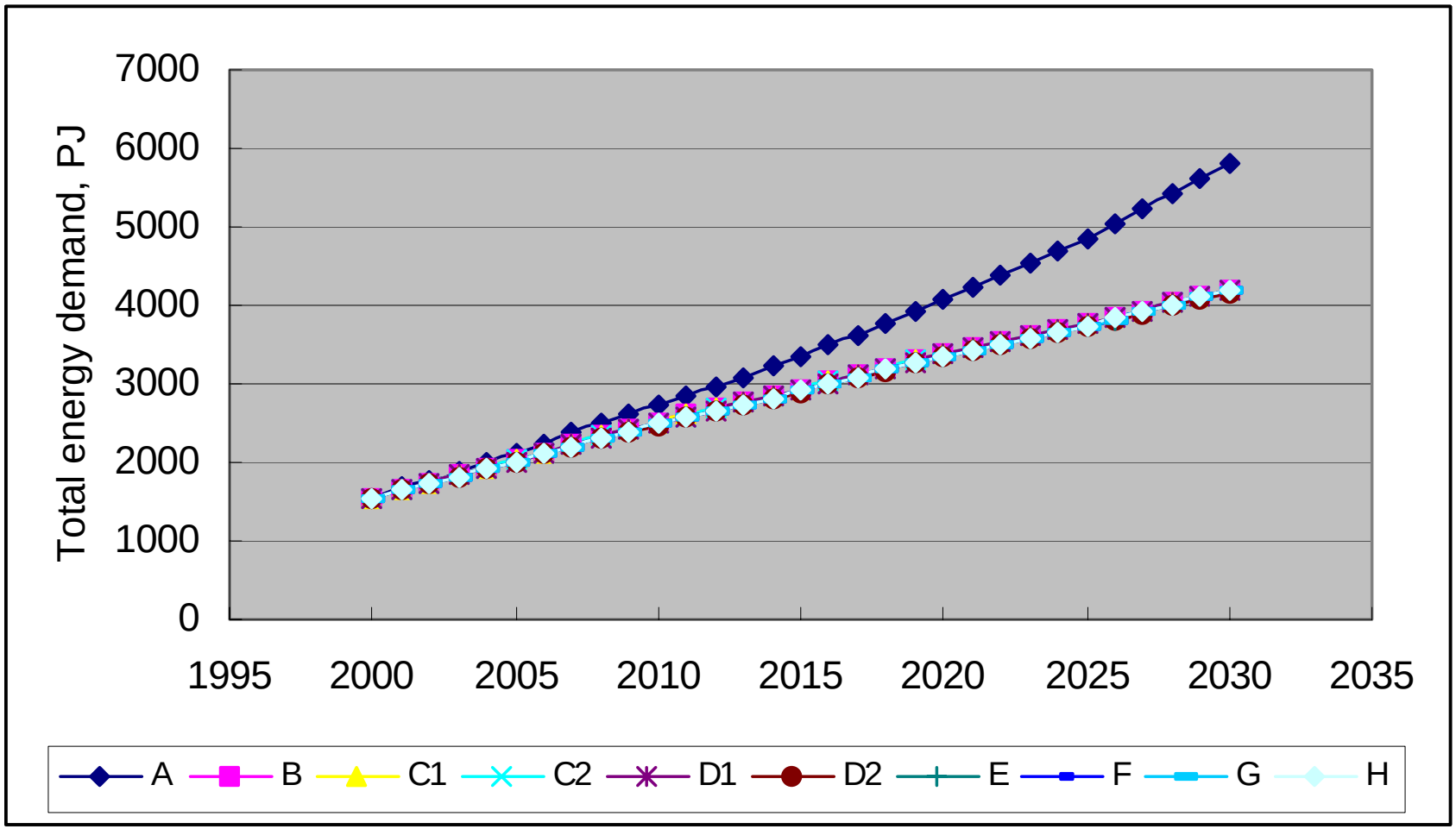
# 低碳发展情景的定义与大气污染物排放情景

## Low Carbon Development Scenarios and Air Pollutants Emissions Scenarios

# 叠加情景的定义 Comprehensive Scenarios

| | 情景名称 |
|---|---|
| A | BAU |
| B | EE |
| C1 | EE+COAL |
| C2 | EE+COAL+GAS |
| D1 | EE+COAL+GAS+ELEC |
| D2 | EE+COAL+GAS+ELEC+WIND |
| E | EE+COAL+GAS+ELEC+WIND+SO2a |
| F | EE+COAL+GAS+ELEC+WIND+SO2b |
| G | EE+COAL+GAS+ELEC+WIND+SO2b+PM |
| H | EE+COAL+GAS+ELEC+WIND+SO2c+PM |

# 一次能源需求量的变化 Primary Energy Demand

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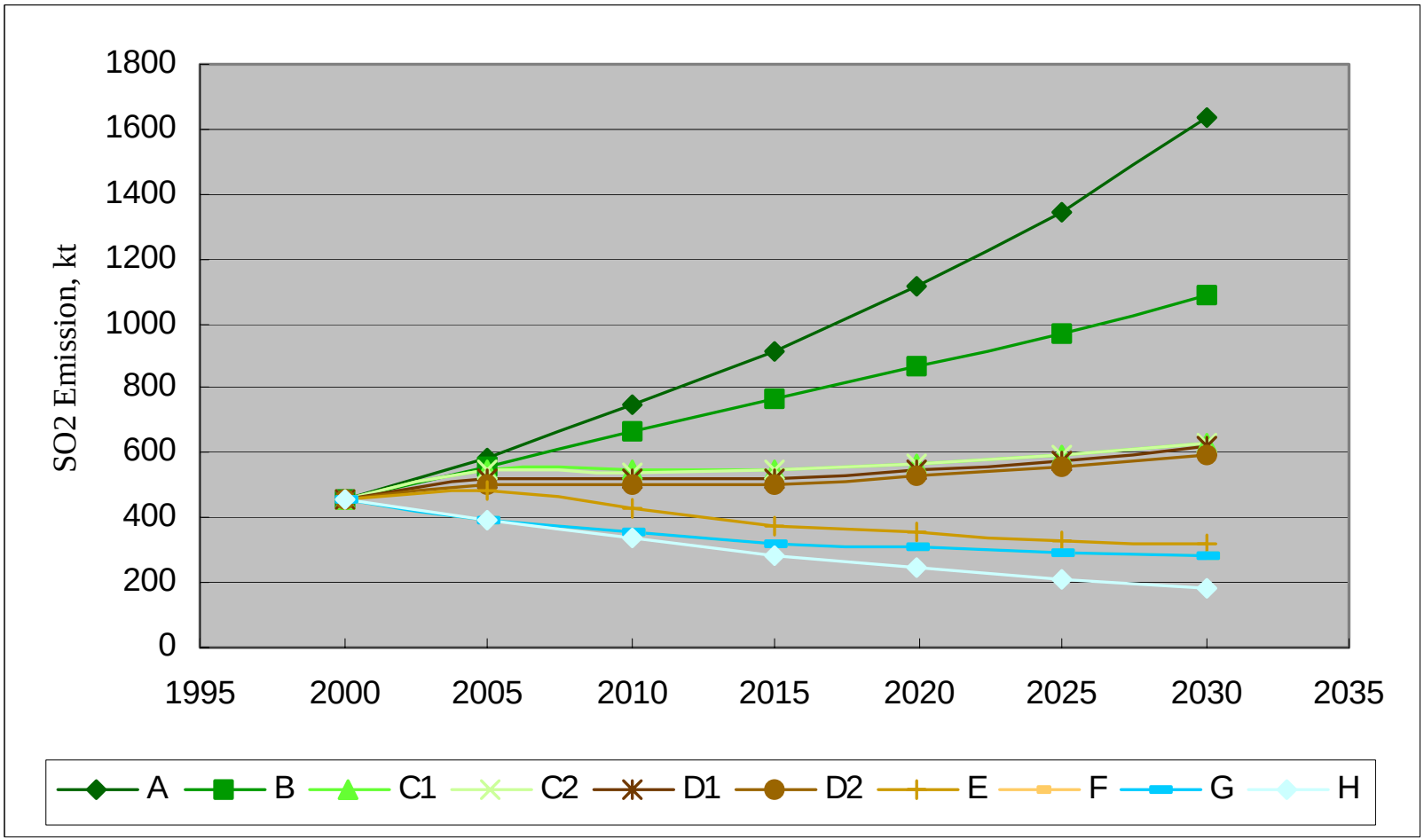
# $SO_2$排放量的变化 $SO_2$ Emissions

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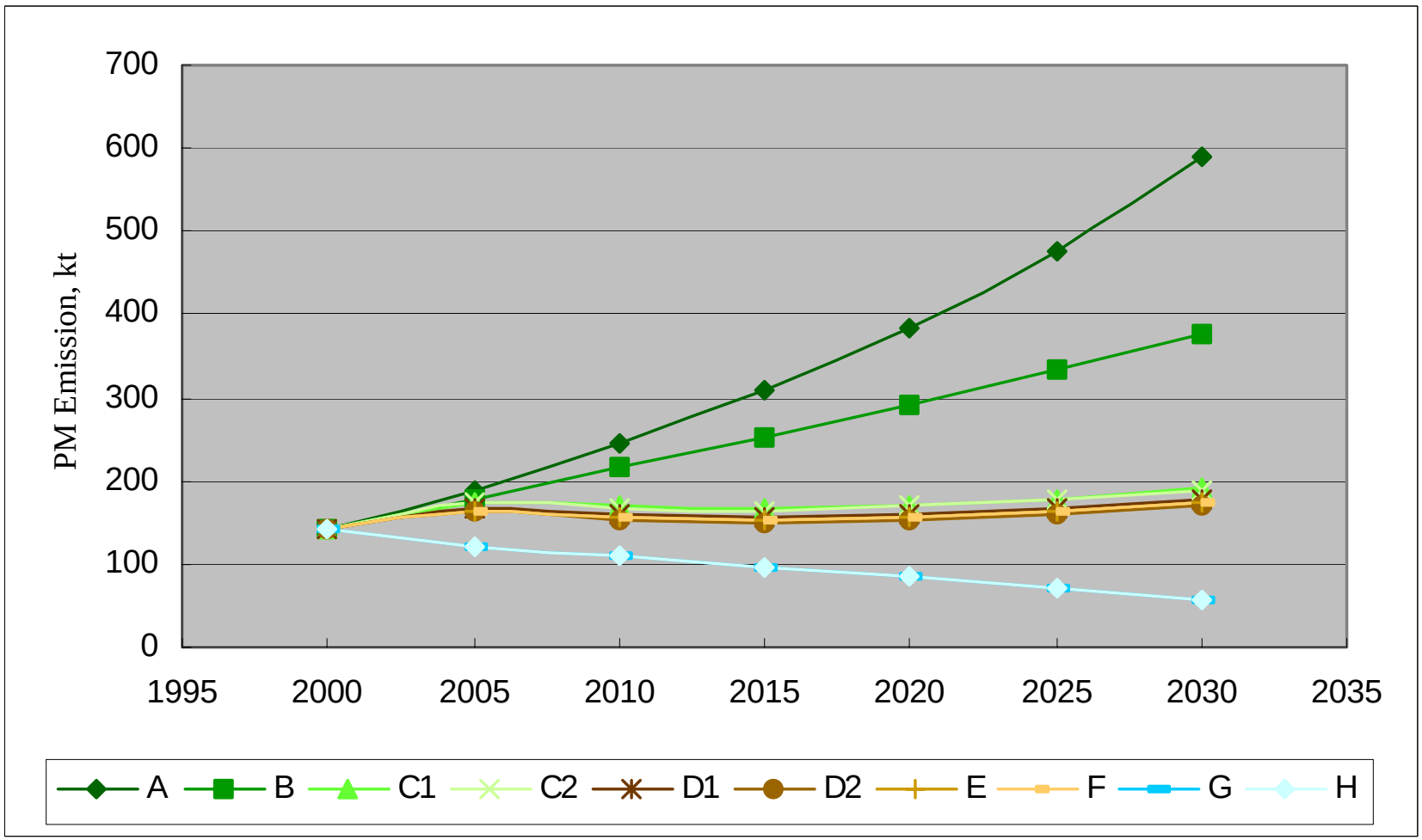
# PM排放量的变化 PM Emissions

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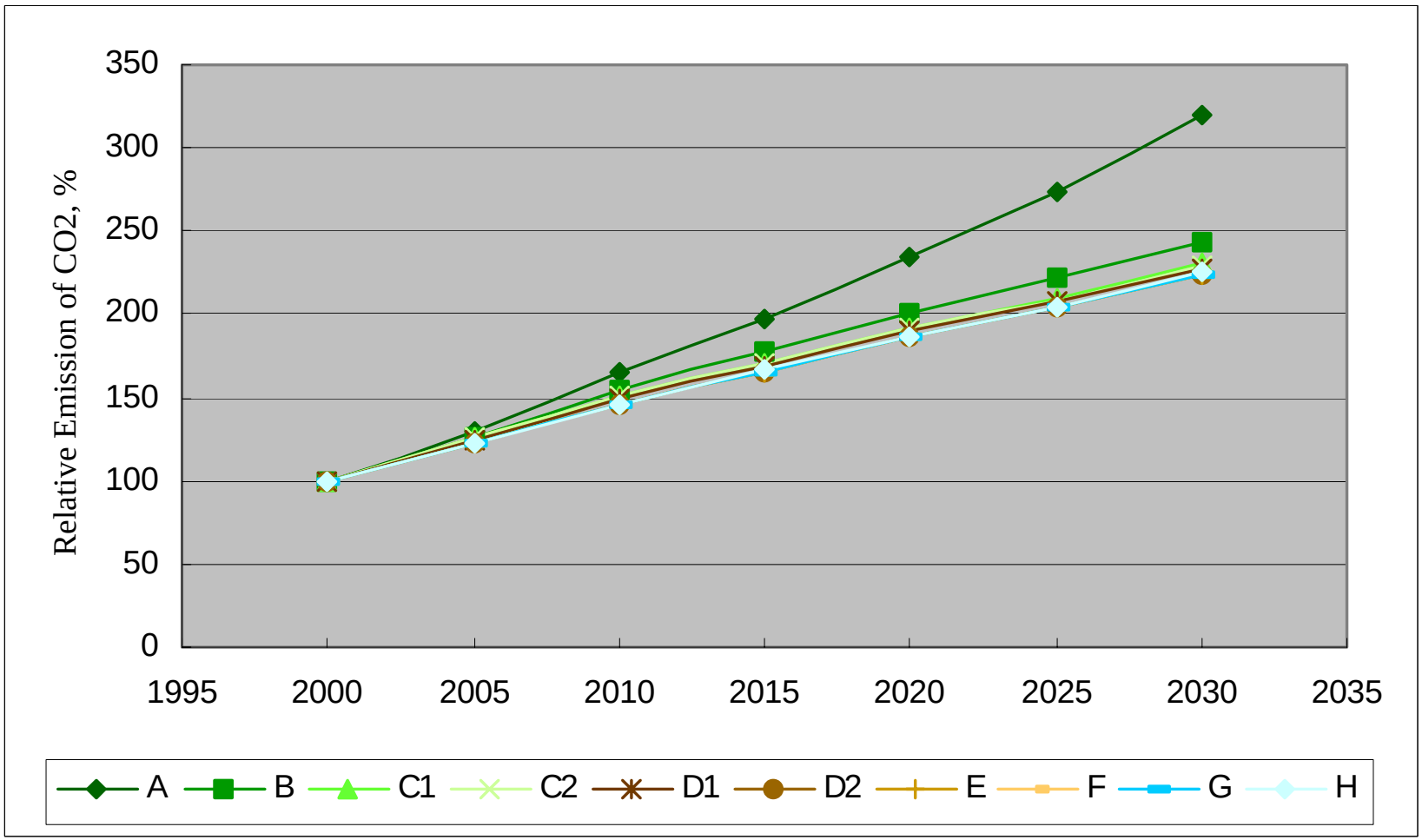
# $CO_2$排放量的变化 $CO_2$ Emissions

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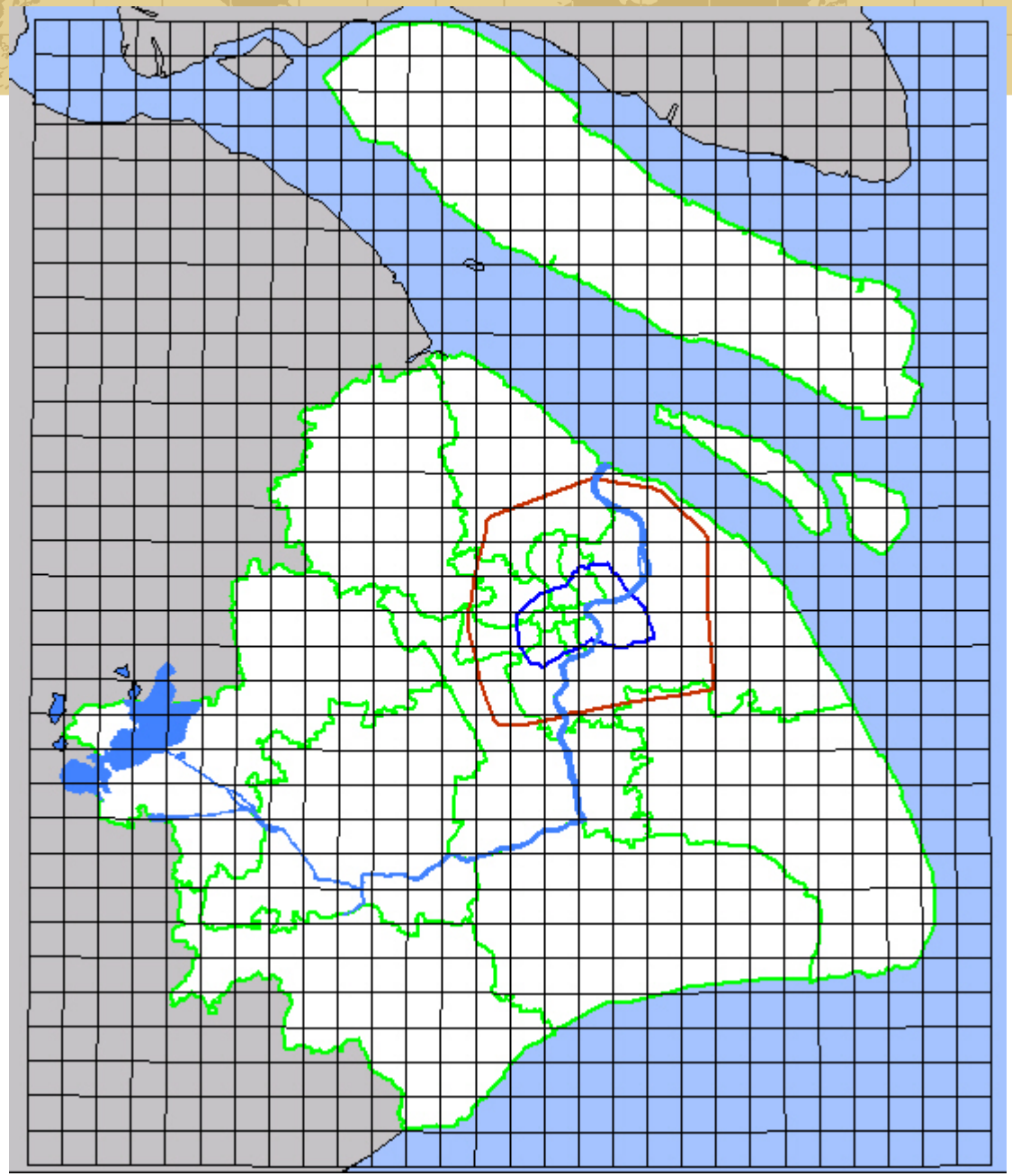
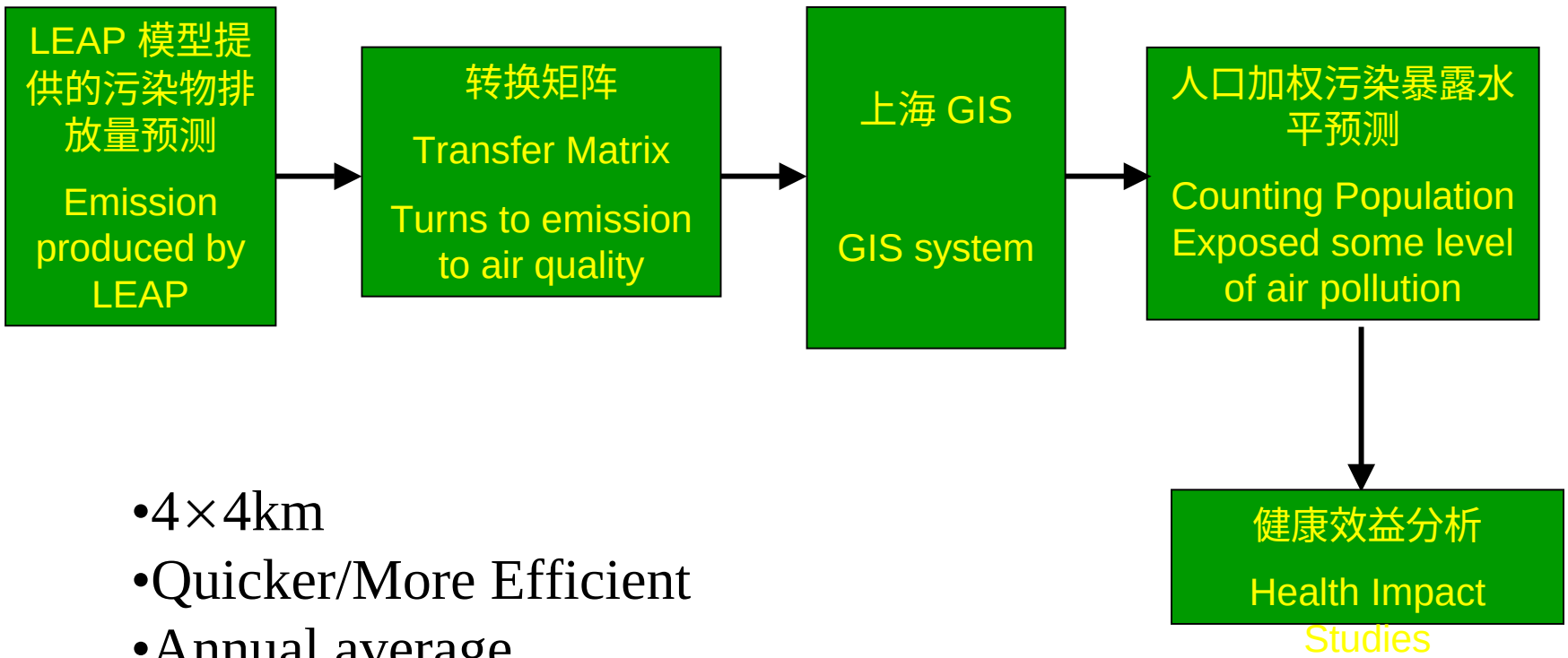
## 计算边界



- 30.655º South to 31.855º North latitude
- 121.983º East to 120.814º West longitude
- 6341 $km^2$ of Shanghai is covered by 924 grids of 32×28

# 转换矩阵Transfer Matrix Model

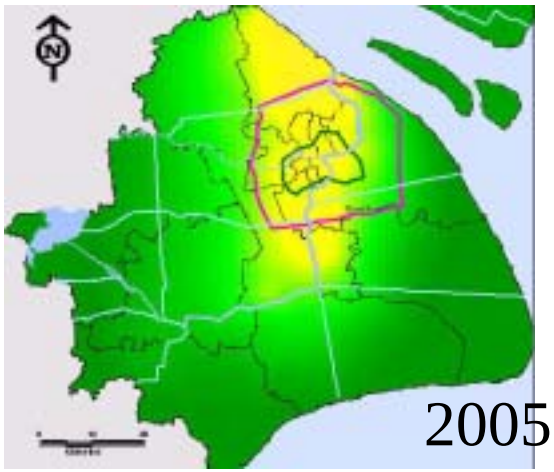


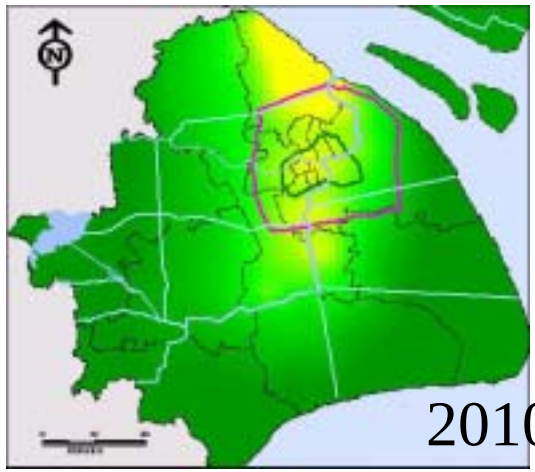

- 4×4km
- Quicker/More Efficient
- Annual average
- SO2/Primary PM10

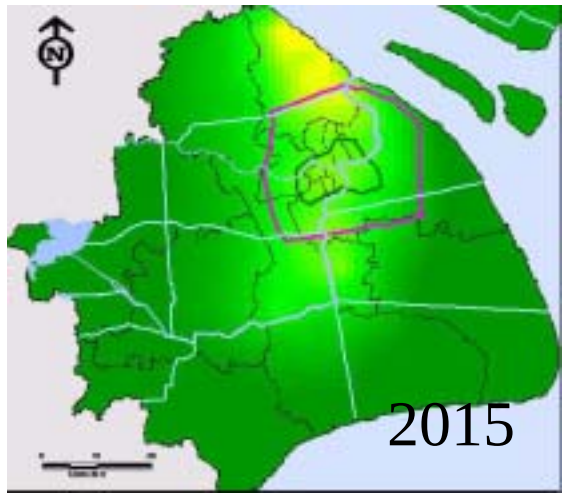
# Example of $PM_{10}$ forecast

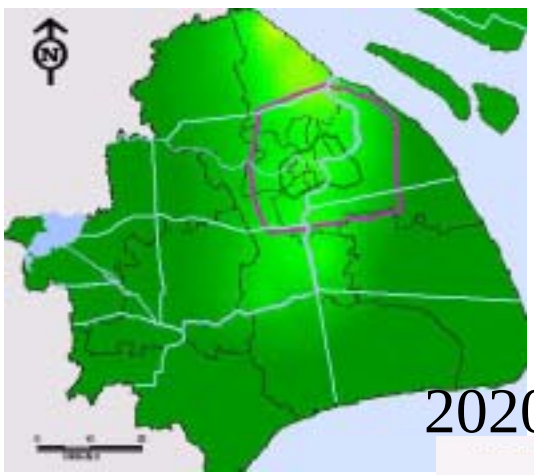
# 暴露水平的变化预测——$PM_{10}$

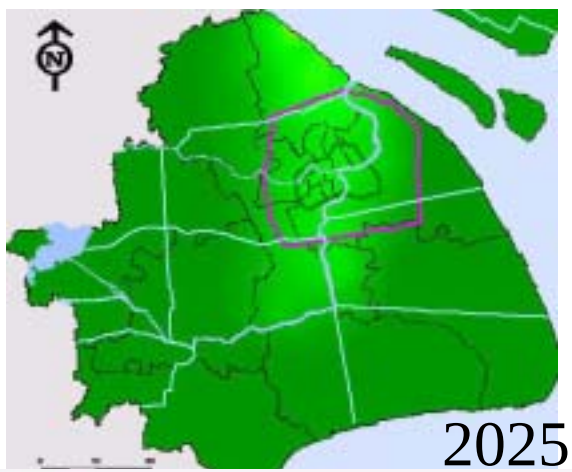
## EE+COAL+GAS+ELEC+WIND+SO2b+PM情景



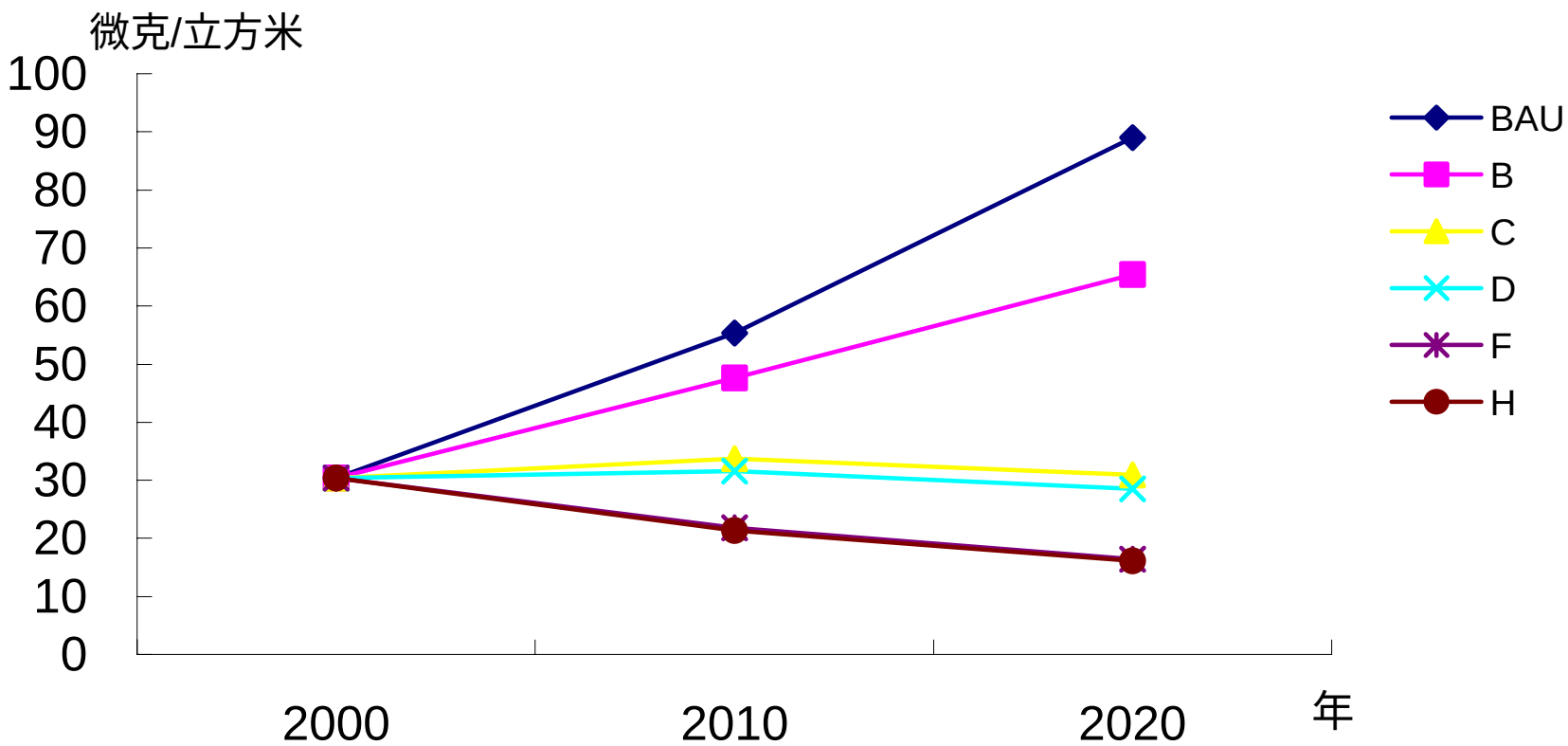



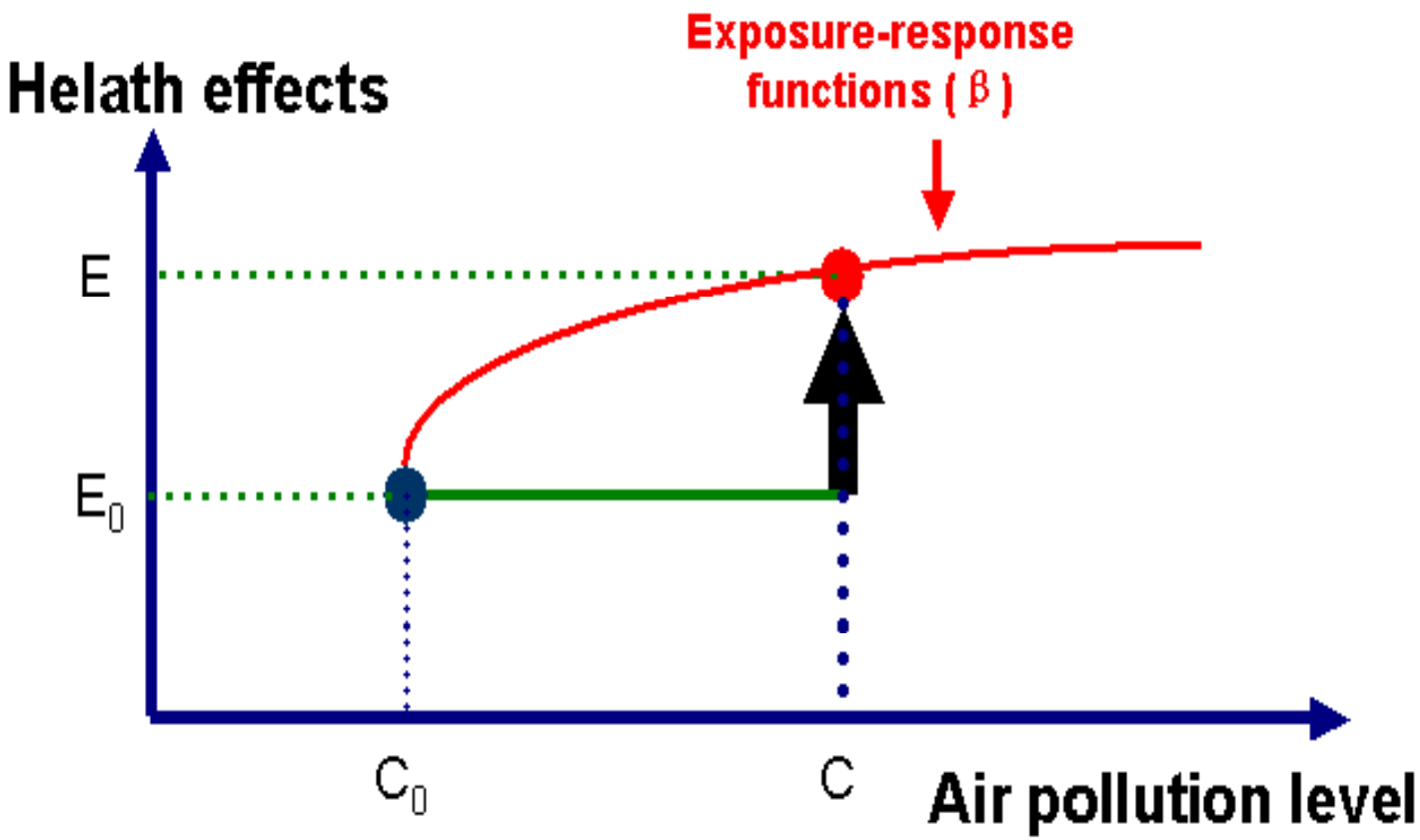


# 大气污染暴露水平的变化 Exposure Level



# 大气污染暴露水平与健康反应

## Air pollution exposure level and response



# 结果：2010年不同低碳发展情景与BAU情景相比获得的健康收益

Results: Health Benefits of Various Low Carbon Development Scenarios Compared with BAU Scenario in 2010

| 健康终点 | EE | GAS | WIND | $SO_2$b | $SO_2$c |
|---|---|---|---|---|---|
| 死亡 | 2804 | 7452 | 8249 | 11470 | 11580 |
| 慢性支气管炎 | 5828 | 15450 | 17100 | 23740 | 23960 |
| 呼吸系统住院人数 | 1570 | 4269 | 4745 | 6710 | 6774 |
| 心血管系统住院人数 | 796 | 2169 | 2412 | 3417 | 3450 |
| 内科门诊 | 111300 | 304600 | 339000 | 481900 | 486500 |
| 儿科门诊 | 11540 | 31590 | 35150 | 49960 | 50450 |
| 急性支气管炎 | 186100 | 493700 | 546400 | 758900 | 765700 |
| 哮喘发作 | 3652 | 9585 | 10590 | 14590 | 14720 |

# 结果：2010年各低碳发展情景与BC情景相比，上海市居民获得健康相关的经济收益（百万美元）

## Results：Economy Benefits of Various Low Carbon Development Scenarios Compared with BAU Scenario in 2010（Million USD）

| 健康终点 | EE | GAS | WIND | $SO_2$b | $SO_2$c |
|---|---|---|---|---|---|
| 死亡 | 450.40 | 1197.00 | 1325.00 | 1842.00 | 1860.00 |
| 慢性支气管炎 | 49.45 | 133.10 | 144.90 | 201.50 | 205.40 |
| 呼吸系统住院人数 | 1.65 | 4.49 | 4.99 | 7.05 | 7.12 |
| 心血管系统住院人数 | 1.23 | 3.35 | 3.72 | 5.28 | 5.33 |
| 内科门诊 | 2.31 | 6.31 | 7.03 | 9.99 | 10.08 |
| 儿科门诊 | 0.24 | 0.65 | 0.73 | 1.04 | 1.05 |
| 急性支气管炎 | 2.00 | 5.32 | 5.88 | 8.17 | 8.22 |
| 哮喘发作 | 0.03 | 0.08 | 0.08 | 0.11 | 0.12 |
| 总和 | **507.31** | **1350.30** | **1492.33** | **2075.13** | **2097.30** |

占上海市当年预测GDP的*0.39%-1.61%*

# 主要结论与政策建议

## Main Conclusion and Policy Recommendations

1. 上海市一次能源以煤炭为主，结构不尽合理

   **Coal is the primary energy source. The structure is not reasonable.**

2. 终端直接燃煤比重依然较高，用能方式有待进一步调整

   **The proportion for coal fired emissions is still very high. The mode of energy use needs further adjustment.**

3. 上海市环境空气质量与欧美城市比较存在较大差距

   **There is still a great disparity of ambient air quality between Shanghai and cities in Europe and USA.**

4. 随着经济的发展，如果没有进一步的控制措施，本市能源需求及大气污染物排放量还将继续增加

   **With the development of economy, energy demand and air pollutants emissions in Shanghai will keep on increasing if there is no further control measure are enacted.**

# 主要结论与政策建议

## Main Conclusion and Policy Recommendations

5. 低碳发展作为一种新的发展模式，将有利于促进经济发展、能源建设、环境保护的协调发展，具有显著的健康经济学效益

As a new develop mode, low carbon development will do benefit on the harmonious development among economy promotion, energy construction and environmental protection and has a remarkable effect on health economics.

# 政策建议 Policy Recommendations

影响一个国家或地区大气污染物排放的主要因素，除经济增长以外，主要包括能源消费强度、能源结构或低碳能源的比重、以及末端治理水平，用 Kaya 公式可表示为：

$$\frac{Emission}{CAP} = \frac{GDP}{CAP} \times \frac{TPES}{GDP} \times \frac{Emission}{TPES} \times (1 - ER)$$

人均排放量　人均 GDP　能源强度　能源结构　末端治理效果

式中：Emission 为常规大气污染物或 $CO_2$ 排放量；

CAP 为当年人口；

GDP 为国内生产总值；

TPES 为一次能源供应总量；

ER 为末端常规大气污染物或 $CO_2$ 排放量削减率。

其中，能源强度是指单位 GDP 的能源消耗量，它与能源技术、能源消费方式、能源利用效率有关。单位能源消费量的排放量（尤其是碳排放）与能源结构，即低碳能源在一次能源中所占的比重有着密切的关系。而末端治理效果往往取决于末端治理的技术水平。

# 政策建议 Policy Recommendations

- 大力提倡节约能源
  - 如果上海每单位GDP能耗降低一个百分点，2010年全市可减少用能35PJ-50PJ（折合标准煤150万吨－200万吨），相当于2000年全市能源消费总量的2%-3%。
- **Positively advocate energy saving**
  - If the energy consumption per GDP in Shanghai drops one percent, total energy use in 2010 can reduce 35PJ-50PJ (nearly 1.5 million-200 million TCE), is 2%-3% of total energy consumption in 2000.

# 政策建议 Policy Recommendations

- **用足用好西气西电，实施向低碳能源方向的转变**
  - 2004年1月1日正式向上海商业供气，为上海市实施低碳发展提供了不可多得的良机。
  - 上海市应充分利用西部大开发、西气东输及西电东送的有利时期，做好由传统经济向低碳经济发展的转变，以低碳能源结构调整为导向，产品结构调整为载体，加大工业内部结构性调整的力度，通过产业结构、产品结构、能源结构的调整，降低每单位GDP的常规大气污染物和二氧化碳排放量。

- **Better utilize natural gas from western China, and shift to the low carbon energy ecnomics**
  - Gas supply to the commercial in Shanghai in Jan 1st, 2004 is a great chance for Shanghai to advance its low carbon development.
  - Shanghai should efficiently hold the advantaged phases of 'Western China Development', 'transferring natural gas from West to the East' and 'transporting electricity from West to the East' to transit traditional economical development to the low carbon. Directed as low carbon energy structure adjustment, bodied as product structure regulation, Enforcing the structural adjustment within industry will reduce the local air pollutants and $CO_2$ emission by the adjustment the structures of industry, products and energy.

# 政策建议 Policy Recommendations

## 削减终端直接燃煤，减少排放量

- 2000年上海市终端用煤量占全市煤炭消费总量的23%。由于终端燃煤锅炉的燃烧效率相对较低，个别炉窑的效率仅为10%左右，这不仅从整体上降低了本市能源系统的能源效率，增加了生产活动的商务成本，同时导致生产企业周边的大气污染。
- 与“零方案”（BAU情景）比较，仅燃煤锅炉的低碳能源替代这一项措施，就可明显减少$SO_2$和PM排放量，减缓$CO_2$排放的增长速度，并可取得显著的健康经济效益。

## Reduction of direct coal burning on the end

- End coal consumption in 2000 took up 23% of the total. Due to the relatively low combustion efficiency of coal burning boiler on the end pipe, the efficiency of single boiler is only 10%, which not only reduces the efficiency of energy system as a whole, increases the business cost of producing activities, but also causes air pollution around the factories.
- Compared with BAU scenario, $SO_2$ and PM emissions will decrease, growth rate of $CO_2$ emission will be mitigated and remarkable health economical benefit will be done if only one measure of low carbon energy substitute to the coal burning boilers.

# 政策建议 Policy Recommendations

## 积极开发和推广使用可再生能源

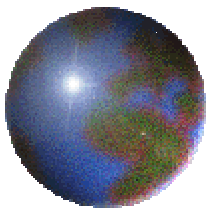
- 上海农村地区每年产生农作物秸秆约300万吨，除部分还田和与畜禽粪便掺混调节有机肥的碳氮比外，作为能源利用的量较少，因此农作物秸秆的综合利用应成为本市可再生能源的重要组成部分之一。

## Develop renewable energies

- There are nearly 3 million t stalks produced every year in rural area in Shanghai. Besides the amount returned to crops and mixed with dejecta to adjust the carbon nitrogen ratio of organic fertilizers, the number used as energy is a little. So comprehensive utilize of stalks should be one of the most important components of renewable energies in Shanghai

# 政策建议 Policy Recommendations

- **积极发展清洁能源，引进先进的能源加工转换技术，提高系统能源效率**
  - 通过CDM机制引进先进的能源技术，改造传统能源利用技术，提高能源效率。
- **Energetically develop clean energies, introduce advanced energy transformation technology and upgrade system energy efficiency**
  - Introduce advanced energy technology, alter traditional energy use, upgrade energy efficiency by CDM mechanism
- **征收高污染高碳环境税**
  - 外部成本内部化，推行优质优价
- **Levy environmental tax for high pollution and carbon emission**
  - Internalize the external cost and levy environmental tax



# 谢谢！
# Thanks!