中国的温室气体排放将使世界不堪重负吗？
Will China Overwhelm the World with its Greenhouse Gas Emissions?

马克 · 列文
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劳伦斯伯克利国家实验室
Lawrence Berkeley National Laboratory
For EESI
April 5, 2011

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劳伦斯伯克利国家实验室的中国能源研究室
China Energy Group at Lawrence Berkeley National Lab

- 成立于**1988 Established 1988**
- 宗旨：中国能源研究室与中国以及其他国家地区紧密合作，以实现：
  Mission: China Energy Group works collaboratively with groups in China and elsewhere to:
  – 提高中国能效机构的运作能力
    enhance the capabilities of Chinese institution that promote energy efficiency
  – 促进节能政策的发展
    assist in energy efficiency policy development
  – 研究中国的能源使用动态
    research the dynamics of energy use in China.

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主要成就 Key Successes

- 电器能效标准

  Appliance energy efficiency standards

- 工业节能自愿协议

  Voluntary agreements for industry efficiency

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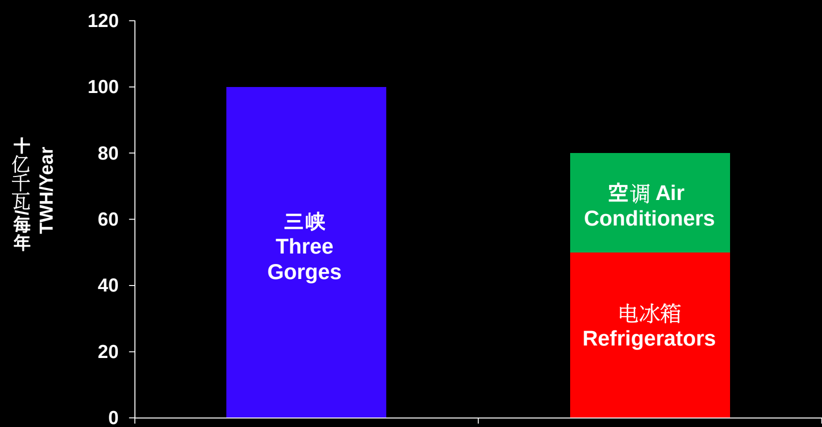
比较： 三峡和电冰箱及空调的能效改进
Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements



节能量按照标准实施十年后的节能量计算
Savings calculated 10 years after standard takes effect.

7

Major New Undertaking

Leadership of 5-yr program:
U.S. China Clean Energy Research Center – Building Energy Efficiency

$25M over for 5 years U.S. side matched by equal contribution from China

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中国的能耗和二氧化碳排放
Energy and Carbon Dioxide Emissions in China

从中国之外看中国

View from Outside China Looking in

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好消息：第1部分
Good News Part I

1980-2002

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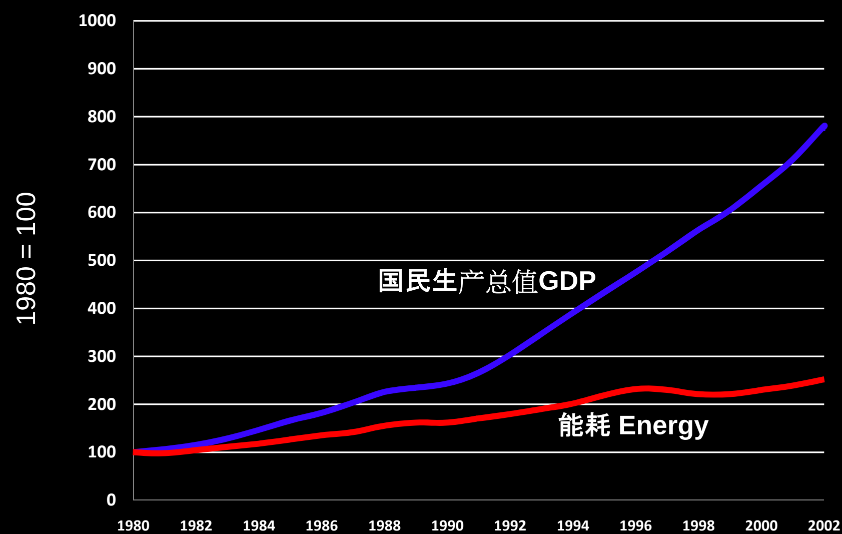
中国的能耗与经济增长
China's Energy & Economic Growth
1980-2002



来源：劳伦斯伯克利国家实验室中国能源研究室
Source: China Energy Group, Lawrence Berkeley National Laboratory

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这期间经济增长和能源消耗增长的“脱钩”并不是偶然的：这是由于中国于1979年制定的政策目标，同时也实施了一系列强有力的政策措施。

This "decoupling" between economic and energy growth was not an accident: it was a goal of China declared in 1979 and was accompanied by a collection of very strong policies

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坏消息
The Bad News

2002-2005

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从**2002**到**2005**年期间，中国的能源强度（单位**GDP**的能源消耗）出现了自**1980**年以来的第一次上升，并产生了显著影响。

From 2002-2005, intensity (energy/unit GDP) increased for the first time since 1980 with very significant consequences

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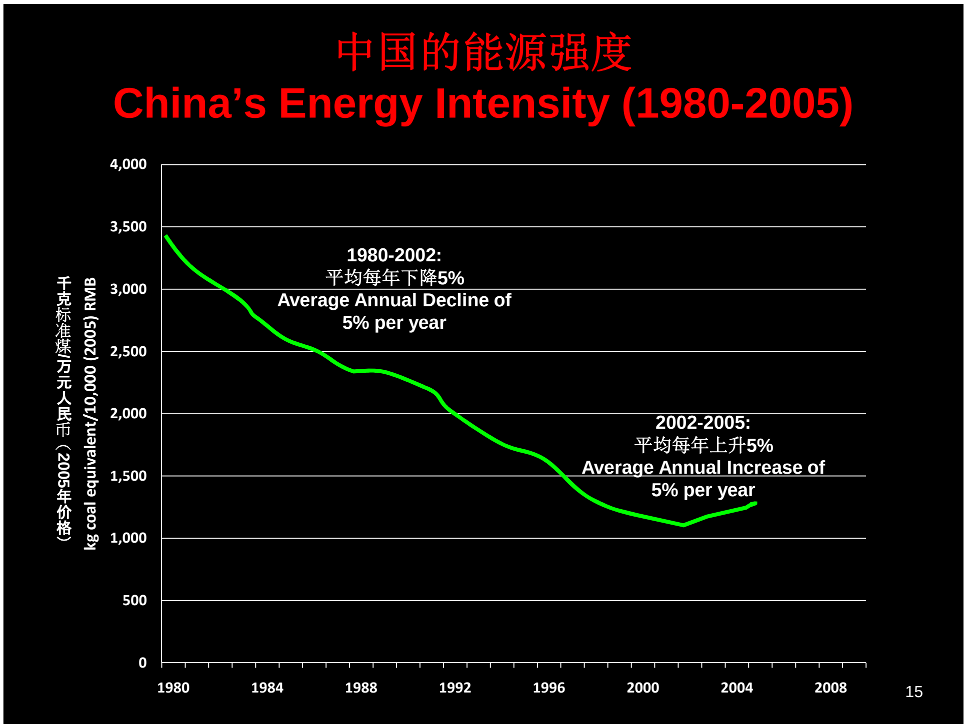
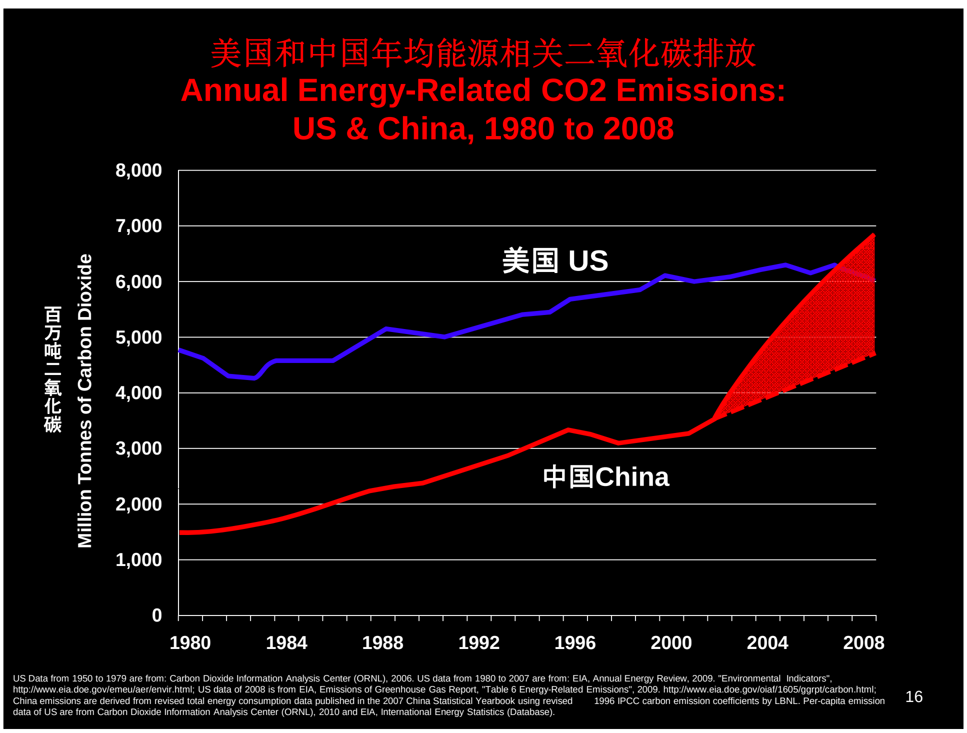

中国的能源强度
China's Energy Intensity (1980-2005)
千克标准煤/万元人民币（2005年价格）
kg coal equivalent/10,000 (2005) RMB
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
1980
1984
1988
1992
1996
2000
2004
2008
1980-2002:
平均每年下降5%
Average Annual Decline of
5% per year
2002-2005:
平均每年上升5%
Average Annual Increase of
5% per year
15


美国和中国年均能源相关二氧化碳排放
Annual Energy-Related CO2 Emissions:
US & China, 1980 to 2008
百万吨二氧化碳
Million Tonnes of Carbon Dioxide
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
1980
1984
1988
1992
1996
2000
2004
2008
美国 US
中国China
US Data from 1950 to 1979 are from: Carbon Dioxide Information Analysis Center (ORNL), 2006. US data from 1980 to 2007 are from: EIA, Annual Energy Review, 2009. "Environmental Indicators", http://www.eia.doe.gov/emeu/aer/envir.html; US data of 2008 is from EIA, Emissions of Greenhouse Gas Report, "Table 6 Energy-Related Emissions", 2009. http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html; China emissions are derived from revised total energy consumption data published in the 2007 China Statistical Yearbook using revised 1996 IPCC carbon emission coefficients by LBNL. Per-capita emission data of US are from Carbon Dioxide Information Analysis Center (ORNL), 2010 and EIA, International Energy Statistics (Database).
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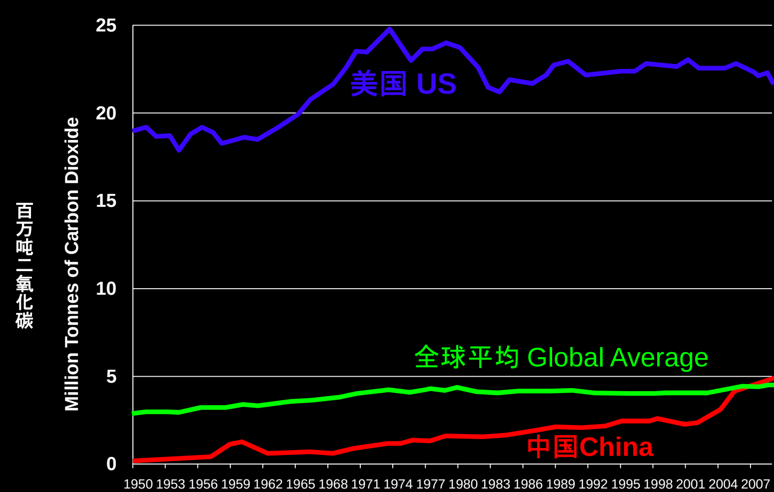
全球、美国及中国人均能源相关二氧化碳排放量
Global, Chinese & U.S. Per-Capita Energy-Related CO2 Emissions – 1950-2008



US Data from 1950 to 1979 are from: Carbon Dioxide Information Analysis Center (ORNL), 2006. US data from 1980 to 2007 are from: EIA, Annual Energy Review, 2009. "Environmental Indicators", http://www.eia.doe.gov/emeu/aer/envir.html; US data of 2008 is from EIA, Emissions of Greenhouse Gas Report, "Table 6 Energy-Related Emissions", 2009. http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html; China emissions are derived from revised total energy consumption data published in the 2007 China Statistical Yearbook using revised 1996 IPCC carbon emission coefficients by LBNL. Population data are from US Census.

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能源消费增长速度明显加快的原因
Reasons for Dramatic Increase in Energy Growth

- **住房、公共建筑，道路以及**铁路等基础建设前所未有的快速增长
  Unprecedented construction boom: houses, commercial buildings, roads, rail
- **加入世界关**贸组织：出口大幅度增长
  Entrance to WTO: export boom
- **政策制度没有**对能源效率给予足够的重视
  Fruits of inattention to energy efficiency policy apparatus

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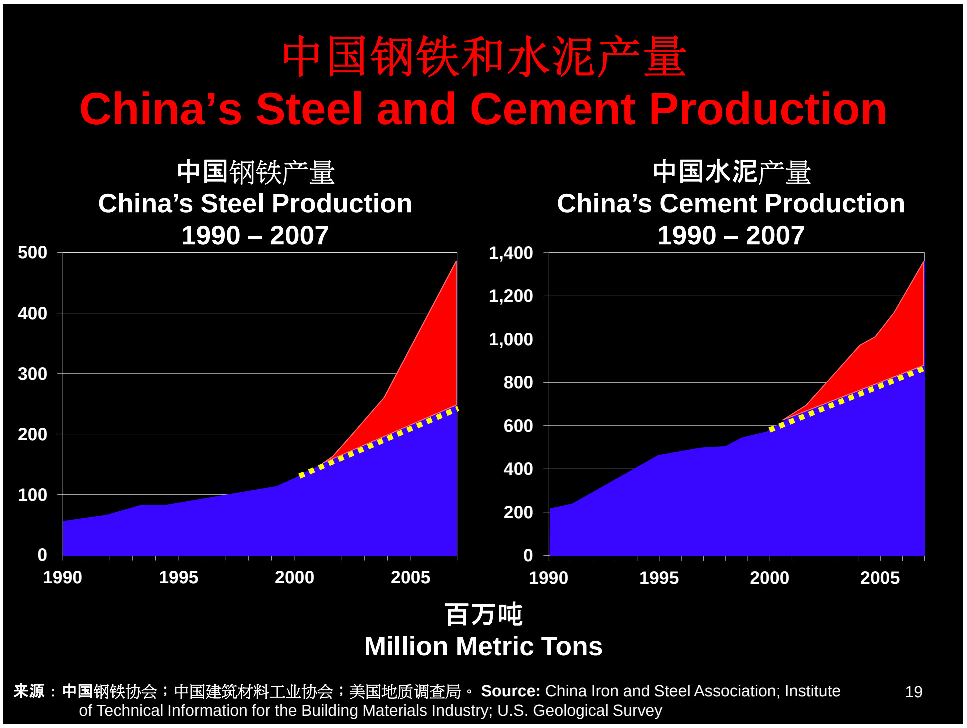
中国钢铁和水泥产量
China's Steel and Cement Production
中国钢铁产量
China's Steel Production
1990 – 2007
中国水泥产量
China's Cement Production
1990 – 2007
500
400
300
200
100
0
1990
1995
2000
2005
1,400
1,200
1,000
800
600
400
200
0
1990
1995
2000
2005
百万吨
Million Metric Tons
来源：中国钢铁协会；中国建筑材料工业协会；美国地质调查局。Source: China Iron and Steel Association; Institute of Technical Information for the Building Materials Industry; U.S. Geological Survey
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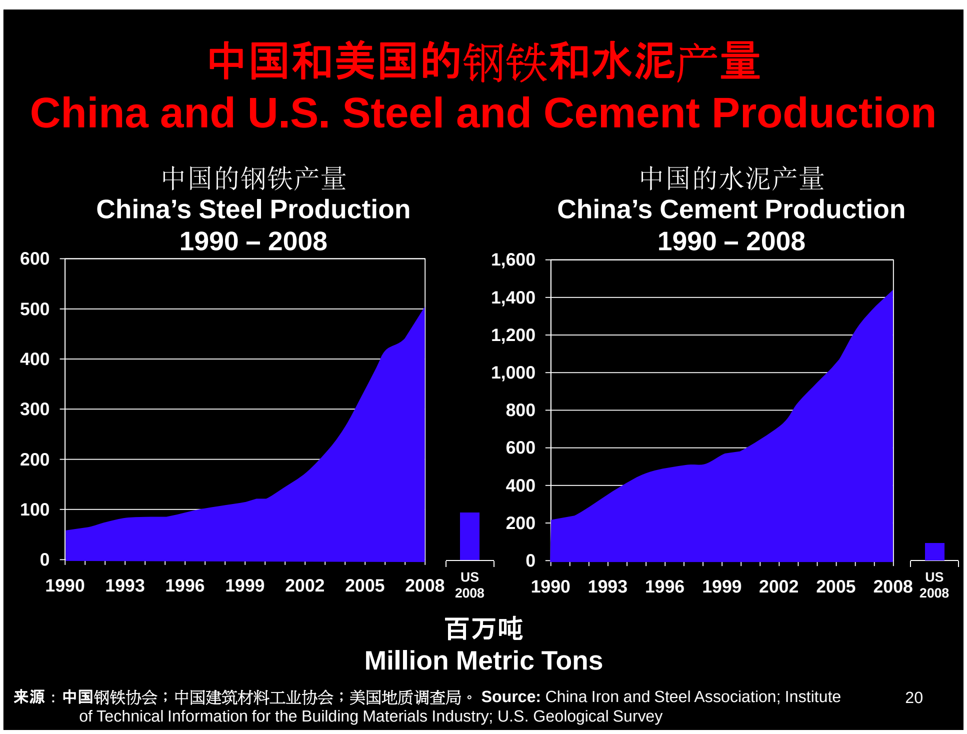
中国和美国的钢铁和水泥产量
China and U.S. Steel and Cement Production
中国的钢铁产量
China's Steel Production
1990 – 2008
中国的水泥产量
China's Cement Production
1990 – 2008
600
500
400
300
200
100
0
1990
1993
1996
1999
2002
2005
2008
US
2008
1,600
1,400
1,200
1,000
800
600
400
200
0
1990
1993
1996
1999
2002
2005
2008
US
2008
百万吨
Million Metric Tons
来源：中国钢铁协会；中国建筑材料工业协会；美国地质调查局。Source: China Iron and Steel Association; Institute of Technical Information for the Building Materials Industry; U.S. Geological Survey
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好消息：第2部分
Good News Part II
2005-2010

2005年中央宣布将在5年内将能源强度降低20%
2005 Announcement by Politburo mandating a 20% energy intensity reduction in 5 years

随后中国总理、全国人大和发改委发表了相似声明
Followed by similar statements and actions by the Premier, the National Peoples Congress, and NDRC

各省市也制定和实施了多项措施
And a multiplicity of actions on the provincial and local levels

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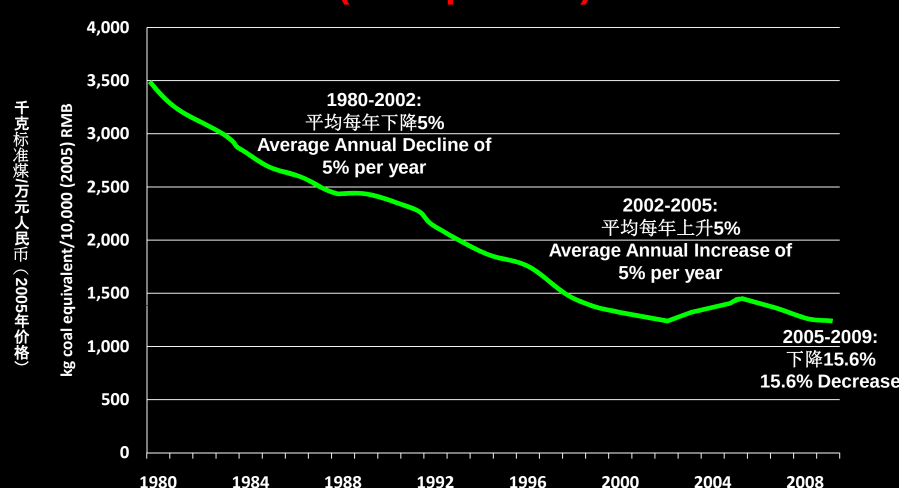
中国的能源强度 （1980年至今）
China’s Energy Intensity
(1980-present)



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几乎所有的政策都实现了它们的目标。

Almost all of the policies achieved their goals

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实现降低20%能源强度所实施的政策
Policies implemented to achieve the 20% energy intensity target

工业 **Industry**

- 十大重点节能工程 **Ten Key Projects**
  - 燃煤工业锅炉（窑炉）改造工程 **renovation of coal-fired industrial boilers**
  - 区域热电联产工程 **district level combined heat and power projects**
  - 余热余压利用工程 **waste heat and pressure utilization**
  - 节约和替代石油工程 **oil conservation and substitution**
  - 电机系统节能工程 **motor system energy efficiency**
  - 能量系统优化工程 **energy systems optimization**
- 千家企业节能行动 **Top-1000 Enterprise Program**
- 关闭小火电和淘汰落后产能 **Small Plant Closures**

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政策(续) Policies (cont)

建筑 Buildings

- 十大重点节能工程 Ten Key Projects
  - 建筑节能工程 Incentives for energy efficiency and conservation in buildings
  - 绿色照明工程 Energy-efficient lighting
  - 政府机构节能工程 Government procurement of energy efficiency products
  - 电器标准和能效标识 Appliance standards and energy-efficiency labels
  - 加强建筑能源标准的实施 Enhanced enforcement of building energy standards
  - 中国北方地区（寒冷地区）建筑节能改造 Heating energy retrofits in N. China
    - 工业结构调整 Industrial restructuring

财政激励 Financial Incentives

- 中央政府奖励基金 Central government funds
- 地方政府奖励基金 Provincial government funds
- 节约每吨标煤奖励200-250元的奖励项目 200-250 RBM/tce saved award program

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对未来的想法
A View of the Future

2010-2050

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LBNL 中国能源研究室
终端能源消耗模型的结果
Results of LBNL China Energy End-Use Model

四年努力的结果：周南（负责人）、
范德维、郑昕、柯晶、蒲思琳和马克·列文
Four-year effort: Nan Zhou (lead), David Fridley, Nina Zheng, Jing Ke, Lynn Price, and Mark Levine

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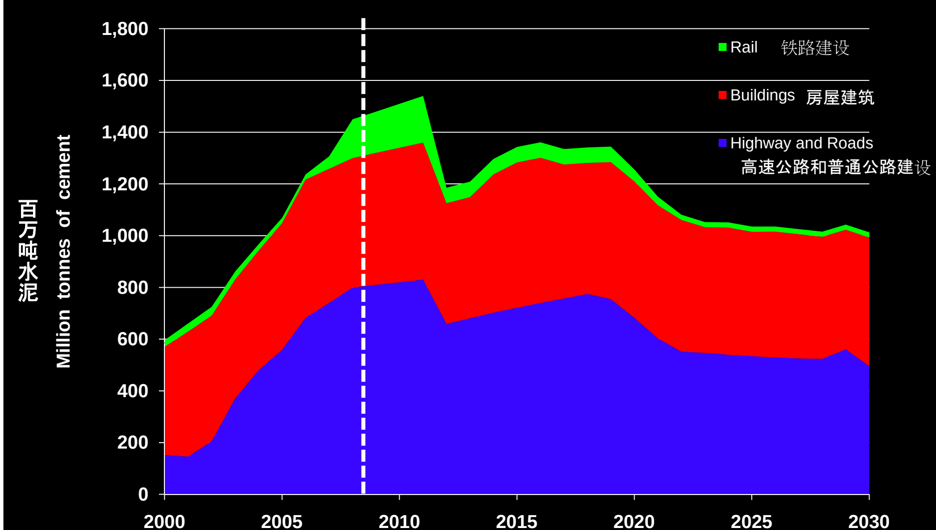
Assumptions #1

- **Urbanization:** 50% (now); projected to increase to 80% (2050)
  - o U.S. 2008: 81.7%, Japan 2008: 66.5%
- **Population:** increase of only 80 million in 40 years
- **GDP Annual Growth Rate:** 7.7% (2010 – 2020); 5.9% (2020 – 2030); 3.4% (2030 – 2050)
  - o U.S.: 2% in 2007, 0.4% in 2008. Japan: 2.4% in 2007, -0.7% in 2008
- **Production of cement, iron & steel, aluminum, glass, polyethylene and ammonia** : physical drivers
  - – e.g. ammonia production is driven by sown area an fertilizer intensity
- **Car ownership:** cars owned per 1000 people—today: 470 in U.S.; 215 in Korea; 435 in Japan; for China in 2050, 250.

Assumptions #2

- Urban residential floor area per capita: 24 m^2 (today); 46m^2 (2050)
  - U.S. 2005: 75.8 m^2, Japan 2003: 35.5 m^2
- Urban appliance saturation: major appliances all close to saturation in 2009
- Appliance efficiency: U.S. levels in 2020; continued improvement
- Commercial floor area per employee: 52 m^2 – between current levels in Japan (36 m^2) and the US (62 m^2)
- Building lifetime: 30 years
  - U.S. commercial buildings: 65 – 80 years, Japan: 30 – 40 years
- Renewable and nuclear energy capacity: wind and nuclear will grow to 450 GW and 300GW respectively by 2050 in CIS, and 500GW and 550GW in AIS.
  - Wind: U.S. had 35.16 GW in 2009, Japan had 2.2 GW in 2009
  - Nuclear: U.S. 2008: 101 GW nuclear installed capacity, Japan 2009: 47.5 GW net capacity
- Ultra super critical share of coal generation: reaches 33% in 2020 and 83% in 2050 in CIS, and 42% in 2020 to 95% in 2050 in AIS

水泥产量 Cement Production



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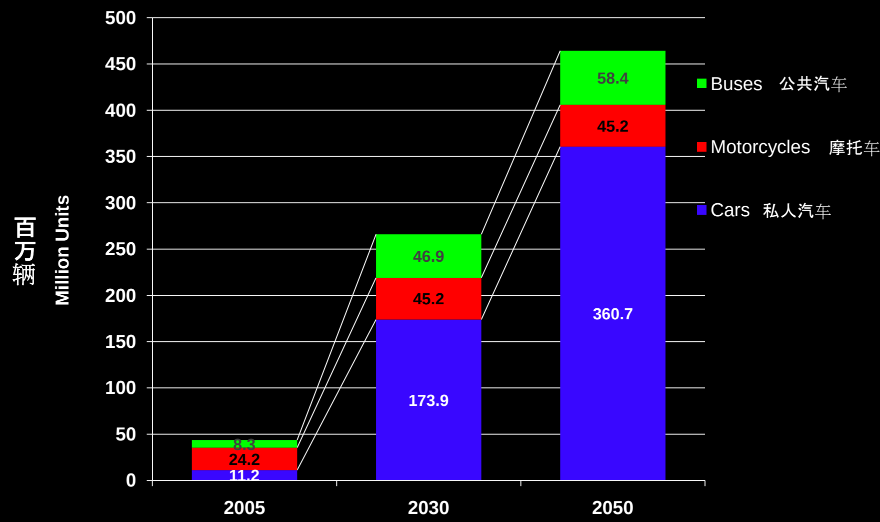
交通车辆 Fleet of Transport Vehicles



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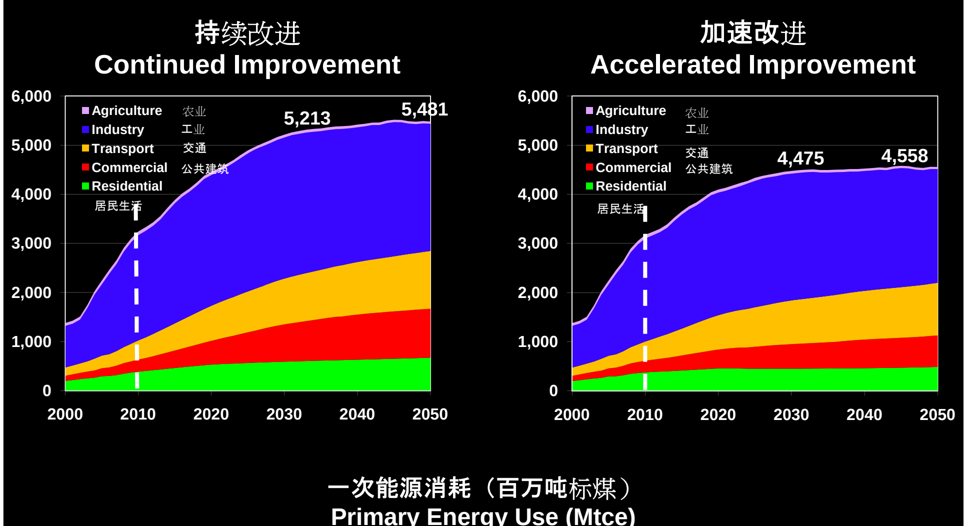
各行业一次能源消耗
Total Primary Energy Use by Sector



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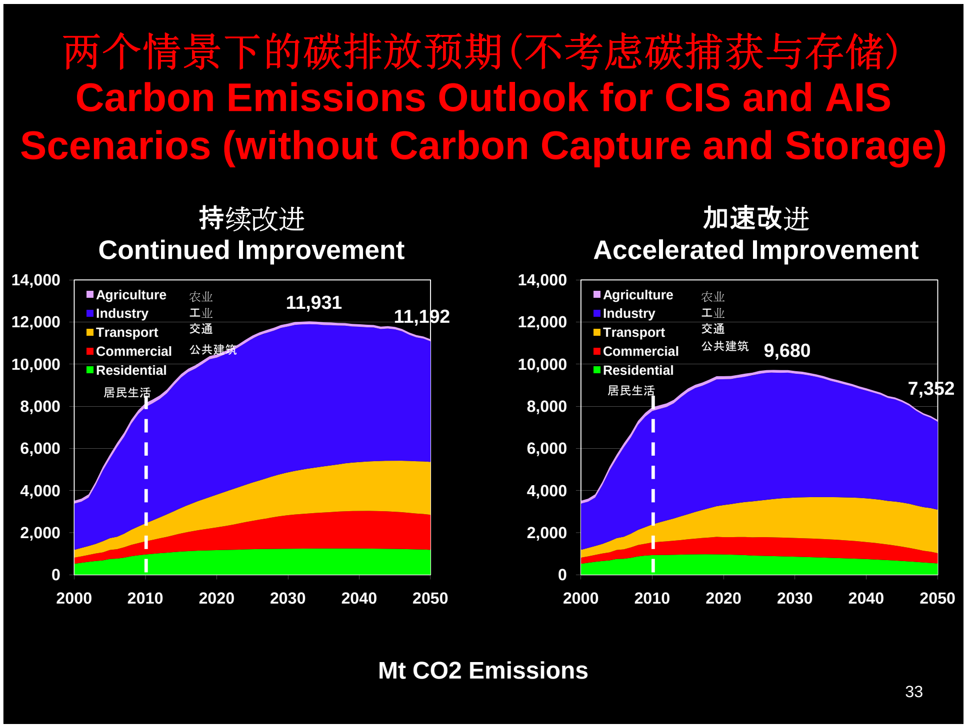
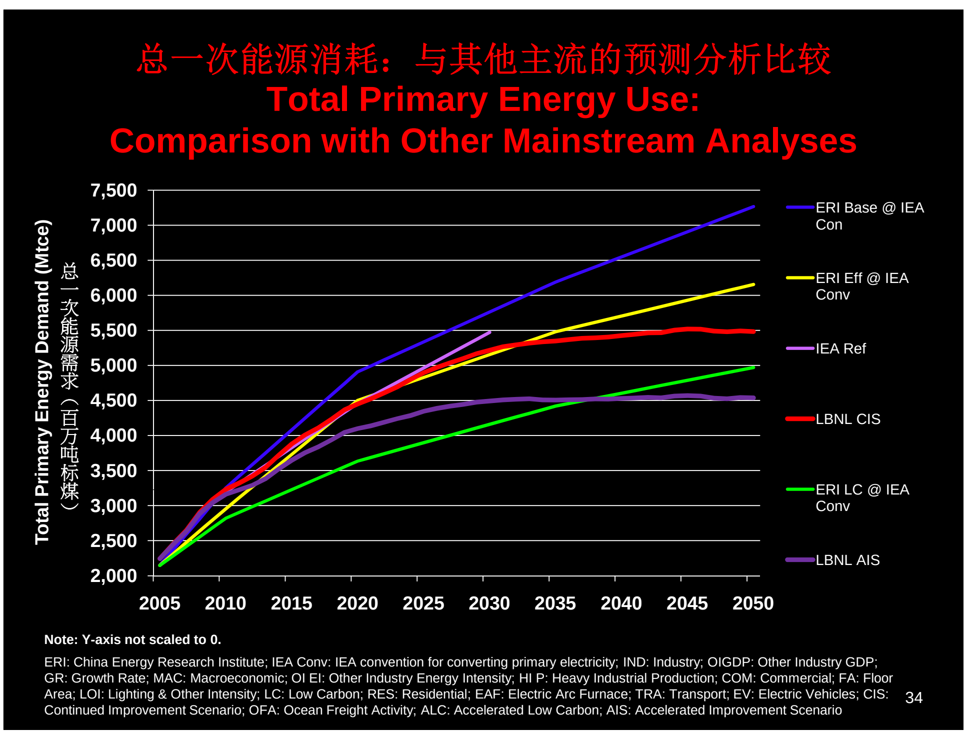

两个情景下的碳排放预期(不考虑碳捕获与存储)
Carbon Emissions Outlook for CIS and AIS Scenarios (without Carbon Capture and Storage)
持续改进
Continued Improvement
加速改进
Accelerated Improvement
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2000
2010
2020
2030
2040
2050
Agriculture 农业
Industry 工业
Transport 交通
Commercial 公共建筑
Residential 居民生活
11,931
11,192
9,680
7,352
Mt CO2 Emissions
33


总一次能源消耗：与其他主流的预测分析比较
Total Primary Energy Use:
Comparison with Other Mainstream Analyses
Total Primary Energy Demand (Mtce)
总一次能源需求（百万吨标煤）
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
2005
2010
2015
2020
2025
2030
2035
2040
2045
2050
ERI Base @ IEA Con
ERI Eff @ IEA Conv
IEA Ref
LBNL CIS
ERI LC @ IEA Conv
LBNL AIS
Note: Y-axis not scaled to 0.
ERI: China Energy Research Institute; IEA Conv: IEA convention for converting primary electricity; IND: Industry; OIGDP: Other Industry GDP; GR: Growth Rate; MAC: Macroeconomic; OI EI: Other Industry Energy Intensity; HI P: Heavy Industrial Production; COM: Commercial; FA: Floor Area; LOI: Lighting & Other Intensity; LC: Low Carbon; RES: Residential; EAF: Electric Arc Furnace; TRA: Transport; EV: Electric Vehicles; CIS: Continued Improvement Scenario; OFA: Ocean Freight Activity; ALC: Accelerated Low Carbon; AIS: Accelerated Improvement Scenario
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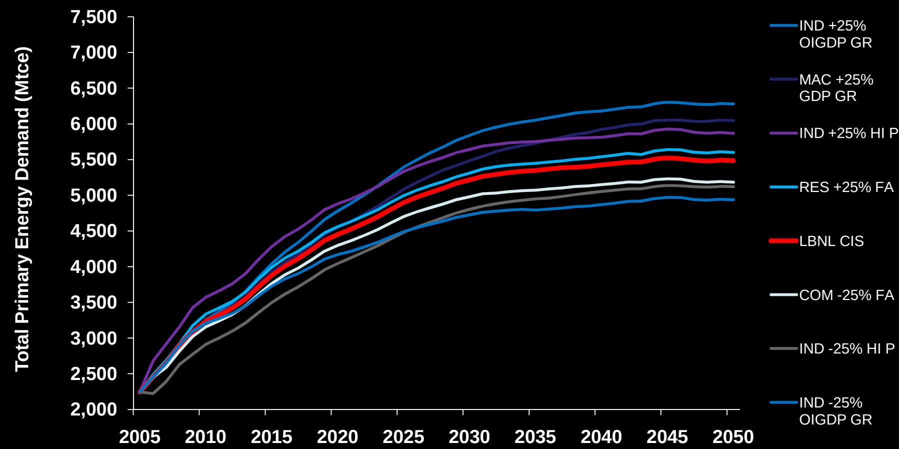
Total Primary Energy Use



Note: Y-axis not scaled to 0.

ERI: China Energy Research Institute; IEA Conv: IEA convention for converting primary electricity; IND: Industry; OIGDP: Other Industry GDP; GR: Growth Rate; MAC: Macroeconomic; OI EI: Other Industry Energy Intensity; HI P: Heavy Industrial Production; COM: Commercial; FA: Floor Area; LOI: Lighting & Other Intensity; LC: Low Carbon; RES: Residential; EAF: Electric Arc Furnace; TRA: Transport; EV: Electric Vehicles; CIS: Continued Improvement Scenario; OFA: Ocean Freight Activity; ALC: Accelerated Low Carbon; AIS: Accelerated Improvement Scenario

劳伦斯伯克利国家实验室的情景分析与其他分析之间的重要区别：我们的分析显示中国的能源消费将在2025年（加速改进情景）或2030年（持续改进情景）开始进入一个平台期

Important Difference between LBNL scenarios and the others: our cases show a plateau beginning around 2025 (AIS) or 2030 (CIS)

The reason our results are from a modeling point of view is that our model has tremendous detail at the end-use level: We account for saturation and energy performance of appliances, heating and cooling equipment, buildings, individual industrial sectors, all types of vehicles.

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结论 I Conclusions I

- 通常认为中国的二氧化碳排放将会在本世纪内持续增长，并且会成为世界最主要的排放国。我们认为不太可能出现这种情况，因为：
  - 电器、居民和商用建筑面积、公路、铁路、化肥使用等都将会在2030年的时间范围达到饱和
  - 城市化率将会在2030年或2035年之后接近峰值
  - 高耗能工业的出口将会降低
  - 人口增长趋缓
- **It is a common belief that China's CO_2 emissions will continue to grow throughout this century and will dominate the world's emissions. We believe this is not likely to be the case because:**
  - **Appliances, residential and commercial floor area, roadways, railways, cement, steel, fertilizer use, etc. will saturate in the 2030 time frame**
  - **Urbanization growth rate peaks by 2030 or 2035**
  - **Exports of energy-intensive industry will decline**
  - **Low population growth**

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结论 II Conclusions II

- 到2025年之前，中国的能源需求增长非常不确定，因为中国将继续建设更多的基础设施
  Until around 2025 – energy demand growth will be highly uncertain in China as it continues to build out its infrastructure
  - 这与发达国家不同，发达国家可以依靠现有政策将能源增长维持在～1%
  - **This is in contrast to developed countries who can count on an energy growth of ~1% with current policies**
- 因此，对中国来说现在接受碳排放绝对值的限制是不合道理的。
  As a result, it makes no sense for China to accept an absolute cap on emissions at this time
- 而另一方面，降低碳排放强度是合理的，因为这保证了进步的空间，无论经济增长是否出现不确定性。
  Reduction of carbon intensity on the other hand makes sense, as this assures improvement regardless of uncertain economic growth rates

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谢谢！！
Thank you!!
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