中国によって排出される温室効果ガスは世界をのみこんでしまうのか。
Will China Overwhelm the World with its Greenhouse Gas Emissions?

Mark D. Levine

ローレンス・バークレー国立研究所
Lawrence Berkeley National Laboratory

RITE International Symposium
東京・日本 Tokyo, Japan
February 9, 2011

中国エネルギーグループ
ローレンス・バークレー国立研究所
China Energy Group at Lawrence Berkeley National Lab

- 1988年創設　**Established 1988**
- 世界でも独特　**Unique in the world**
- 使命：中国エネルギーグループは中国等々にある諸グループと協力し以下に務める

  Mission: China Energy Group works collaboratively with groups in China and elsewhere to:
  - 省エネを推進する中国関連機関の能力向上

    enhance the capabilities of Chinese institution that promote energy efficiency
  - 省エネ政策立案・改善の支援

    assist in energy efficiency policy development
  - 中国におけるエネルギー利用の変遷に関する研究

    research the dynamics of energy use in China.

ローレンス・バークレー国立研究所：中国エネルギーグループ

LBNL's China Energy Group

Energy Policy Assessment, Institution and Capacity Building, Building Energy Efficiency

Mark D. Levine
Group Leader
MDLevine@lbl.gov

Industrial Energy Efficiency, Energy Policy Assessment

Lynn Price
Staff Scientist
LKPrice@lbl.gov

Appliance Standards and Labeling, Modeling and China Energy Scenarios

David Fridley
Deputy Group Leader
Staff Scientist
DGFridley@lbl.gov

Modeling and Scenarios, Appliance Standards and Labeling, Industrial Energy Efficiency, Building Energy Efficiency

Nan Zhou
Scientist
NZhou@lbl.gov

ローレンス・バークレー国立研究所：中国エネルギーグループ

LBNL's China Energy Group

Industrial Energy Efficiency, Demand-side Management, Policy Analysis

Bo Shen
Principal Scientific Engineering Associate BoShen@lbl.gov

Building Energy Efficiency, Modeling and Simulation

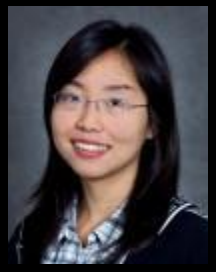
Wei Feng
Science/Engineering Associate

Industrial Energy Efficiency, Policy Analysis

Stephanie Ohshita
Visiting Faculty
SBOhshita@lbl.gov

Appliance Standards and Labeling, Emerging Areas, Policy Analysis

Nina Zheng
Research Associate
XZheng@lbl.gov



Industrial Energy Efficiency, Energy Policy Assessment, China Energy Databook

Hongyou Lu
Senior Research Associate
HYLu@lbl.gov

Institutional Capacity Building, Industrial Energy Efficiency

Cecilia Chen
Research Associate
cfino-chen@lbl.gov

ローレンス・バークレー国立研究所：中国エネルギーグループ

LBNL's China Energy Group

Industrial Energy Efficiency, Policy Analysis

Ali Hasanbeigi
Post Doc
AHasanbeigi@lbl.gov

Modeling and Scenario, Industrial Energy Efficiency

Jing Ke
Post Doc
JKe@lbl.gov

Industrial Energy Efficiency, Modeling and Scenario

Cindy Hou
Visiting Researcher
Xhou@lbl.gov

Modeling and Scenario Forecasting

Yining Qin
Post Doc
YiningQin@lbl.gov

Building Energy Efficiency

Queena Qian
Visiting Researcher
Queena.Qian@dante.lbl.gov

Building Energy Efficiency

Rui Fan
Visiting Researcher
RFan@lbl.gov

主な成功 Key Successes

- 電気製品省エネ基準

  Appliance energy efficiency standards

- 工業における自発的参加・合意

  Voluntary agreements for industry

- 機関設立：北京省エネセンター及びエネルギー財団中国持続可能エネルギープログラム

  Institution building: Beijing Energy Efficiency Center and the Energy Foundation China Sustainable Energy Program

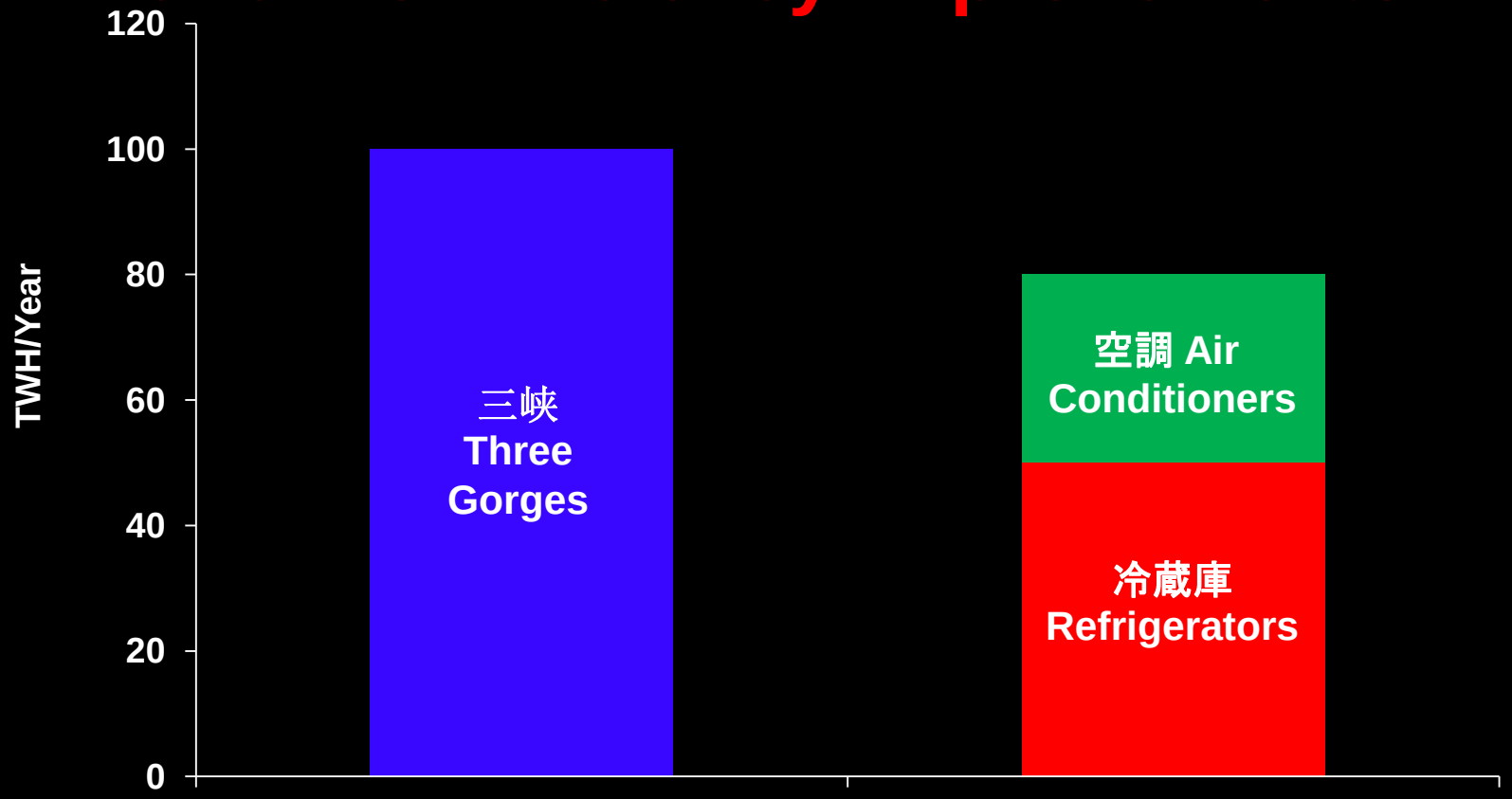
- 中国エネルギー需要モデル

  Energy demand model for China

- 中国人への省エネに関する諸々のトレーニング：1000人以上

  Trained >1000 Chinese in various aspects of energy efficiency

比較:三峡ダムに対する
省エネ改善後の冷蔵庫と空調
Comparison of 3 Gorges to Refrigerator and AC Efficiency Improvements



Savings calculated 10 years after standard takes effect.

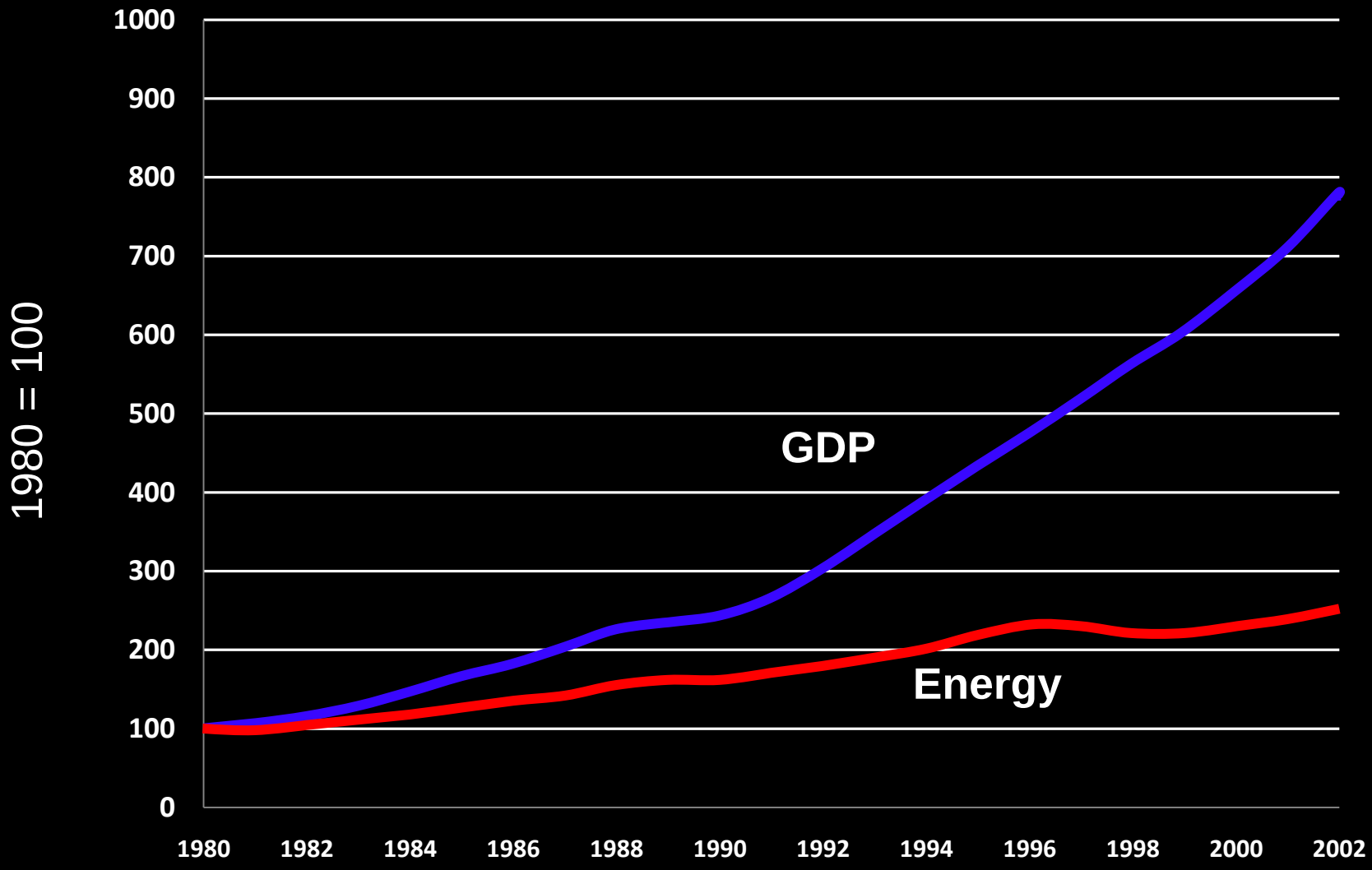
中国における
エネルギーと二酸化炭素排出
Energy and Carbon Dioxide Emissions in China

中国の外から中を見たとき
View from Outside China Looking in

良い知らせ　その1
Good News Part I

1980-2002

中国のエネルギー及び経済成長
China's Energy & Economic Growth
1980-2002



Source: China Energy Group, Lawrence Berkeley National Laboratory

この経済成長とエネルギー増加の「不一致（切り離し）」は偶然ではない：それは1979年に中国が宣言した目標であったし、大変強力な数々の政策によって達成されたものであった。

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

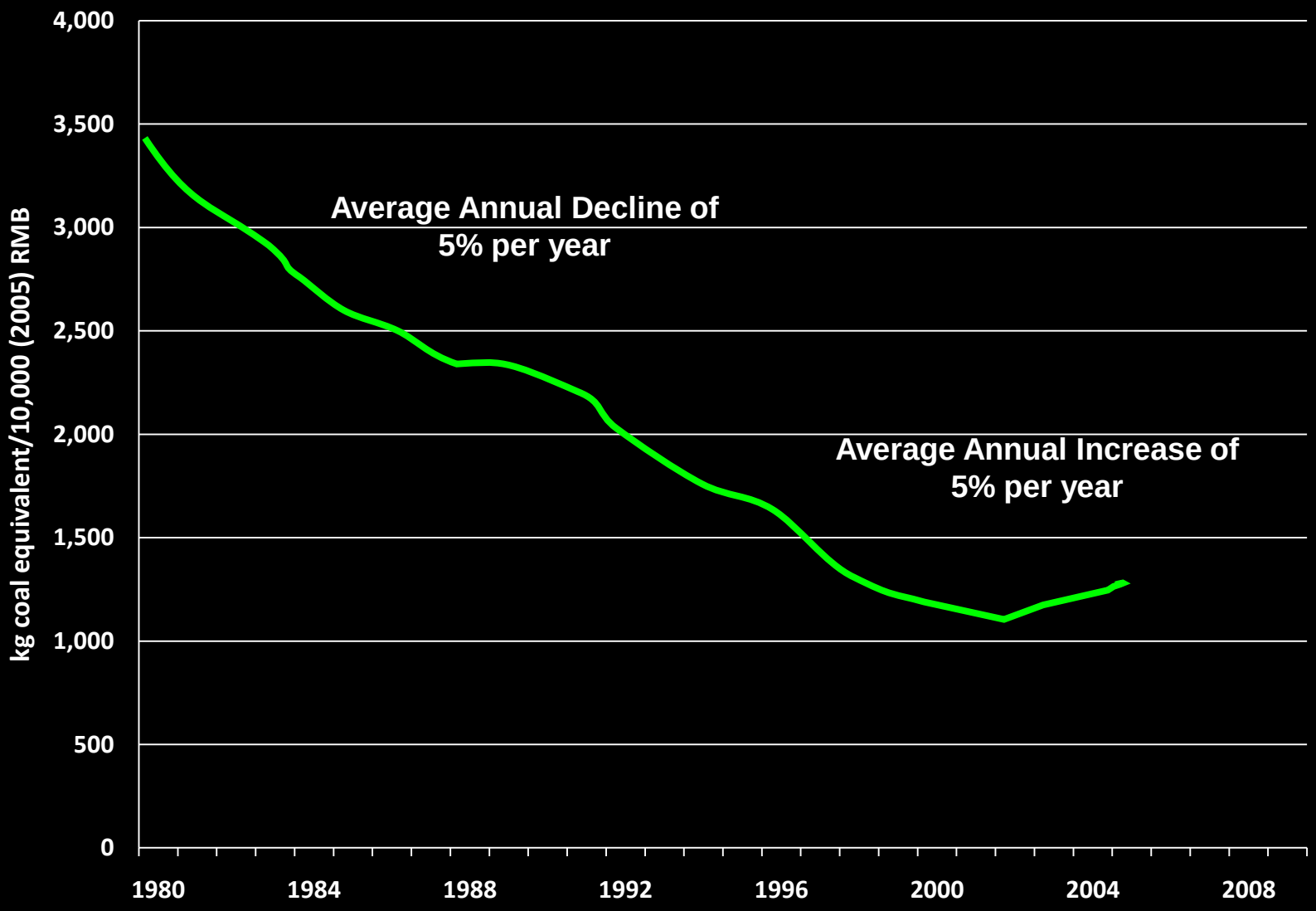
悪い知らせ
The Bad News

2002-2005

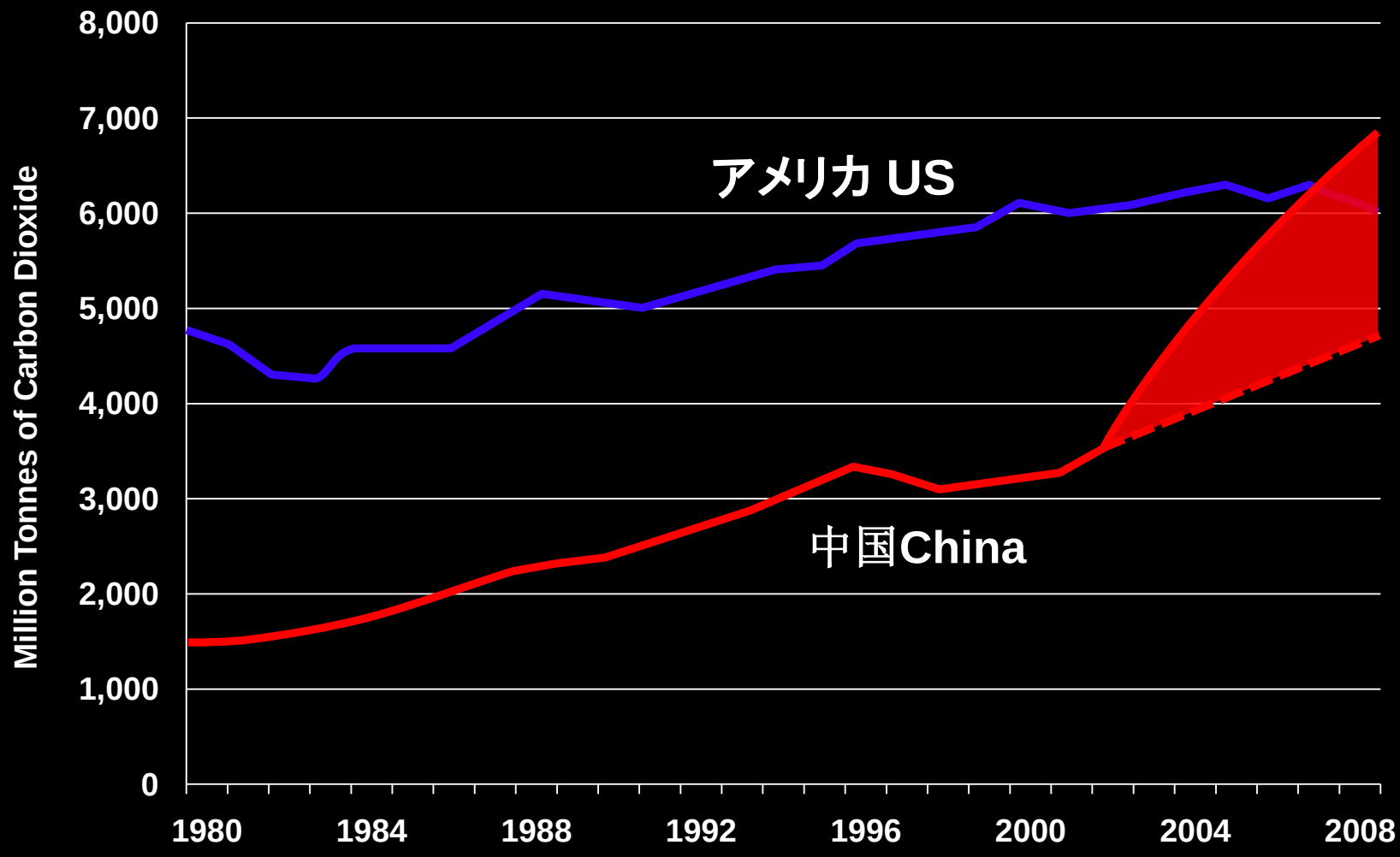
1980年以降初めて、2002年から2005年の間に、GDPに対するエネルギー消費量の割合(エネルギー強度：energy/unit GDP)が増加し、その後に重大な影響を及ぼしている。

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

中国のエネルギー強度
China's Energy Intensity (1980-2005)



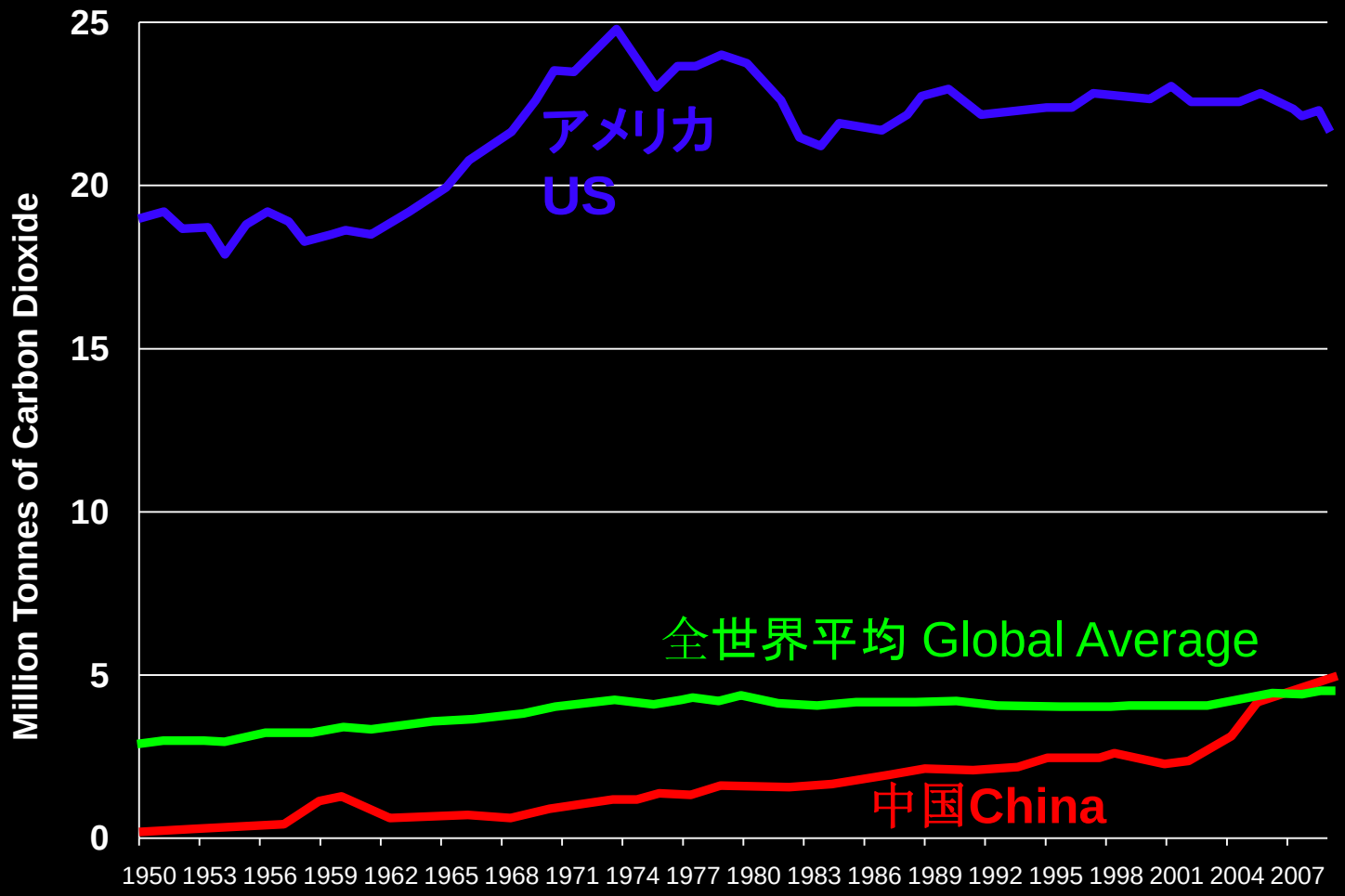
エネルギー関連二酸化炭素の年排出：アメリカ＆中国
Annual Energy-Related CO2 Emissions: US & China, 1980 to 2008



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. Per-capita emission data of US are from Carbon Dioxide Information Analysis Center (ORNL), 2010 and EIA, International Energy Statistics (Database).

全世界、中国、アメリカにおけるエネルギー関連二酸化炭素の一人当たりの排出

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.

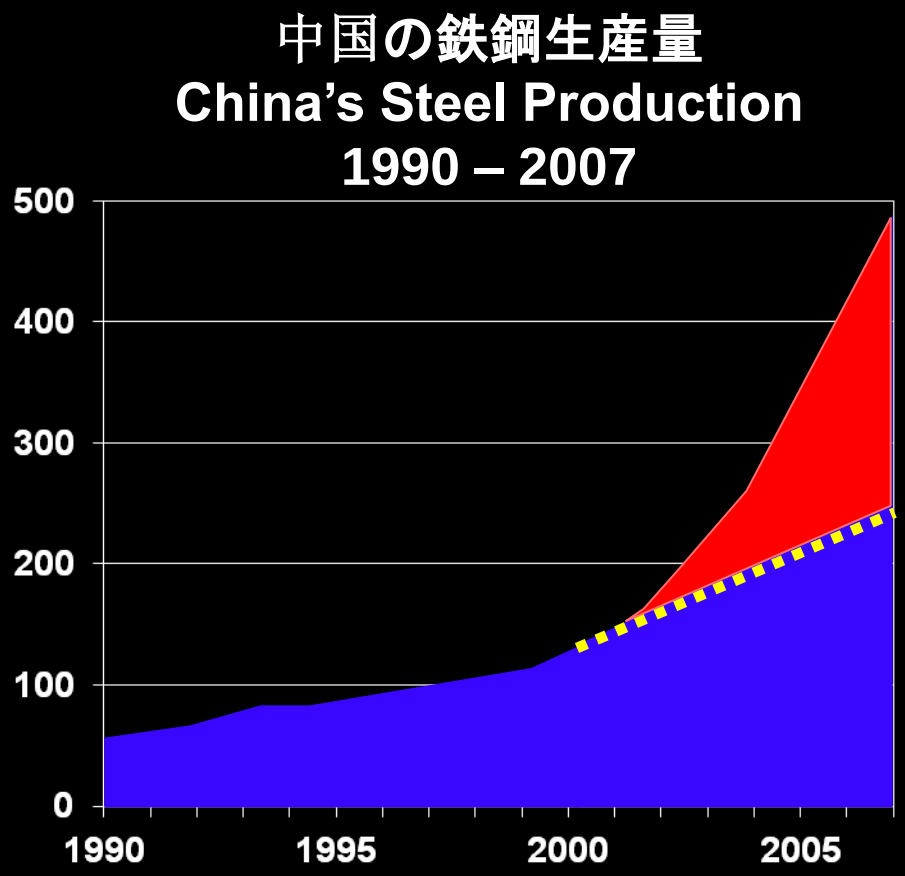
エネルギー消費の急激な増加の原因
Reasons for Dramatic Increase in Energy Growth

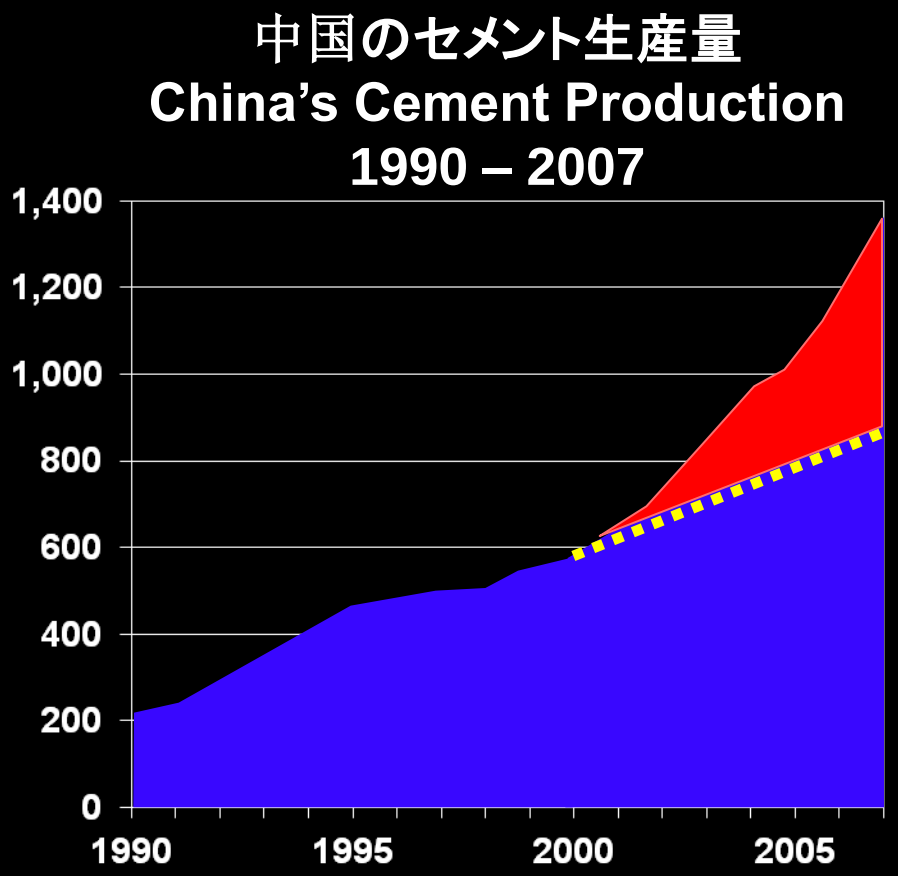
- 前代未聞の建設ブーム：住宅・商工業建物・道路・鉄道
  Unprecedented construction boom: houses, commercial buildings, roads, rail

- WTOへの加入：輸出増加
  Entrance to WTO: export boom

- 省エネ政策担当機関への怠慢（無関心）の結果
  Fruits of inattention to energy efficiency policy apparatus

中国の鉄鋼とセメント生産
China's Steel and Cement Production



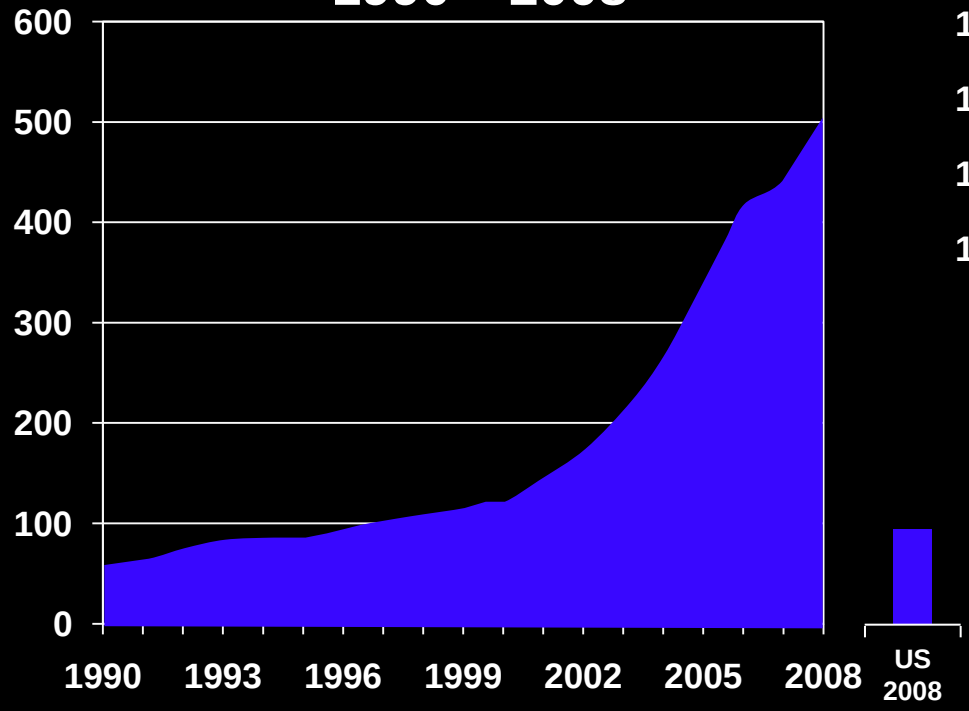


Million Metric Tons

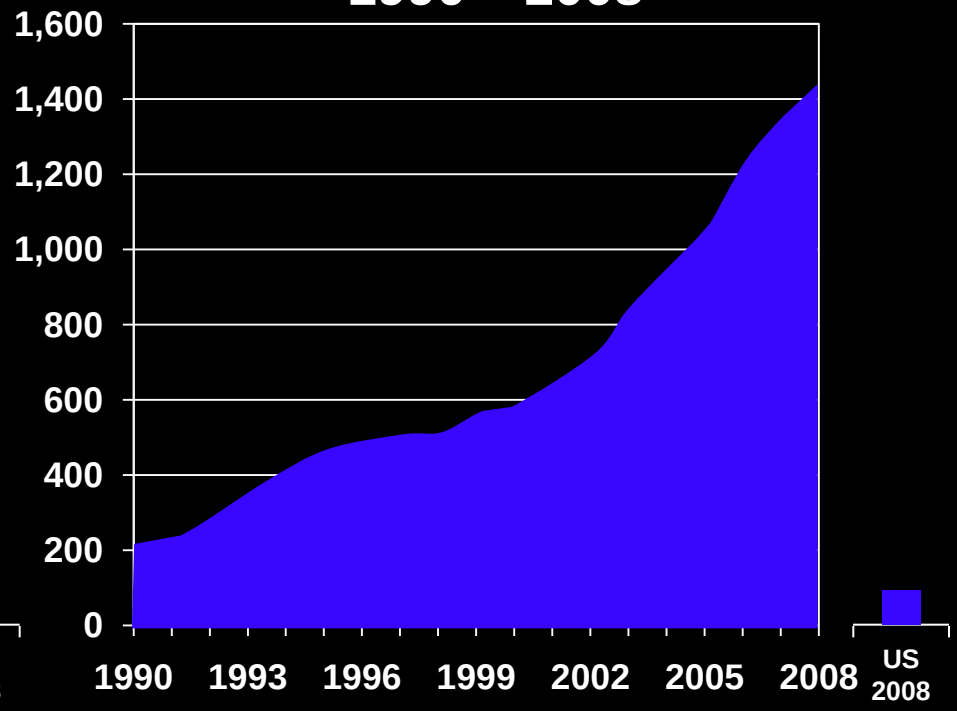
Source: China Iron and Steel Association; Institute of Technical Information for the Building Materials Industry; U.S. Geological Survey

中国とアメリカの鉄鋼及びセメント生産
China and U.S. Steel and Cement Production

中国の鉄鋼生産量
China's Steel Production
1990 – 2008



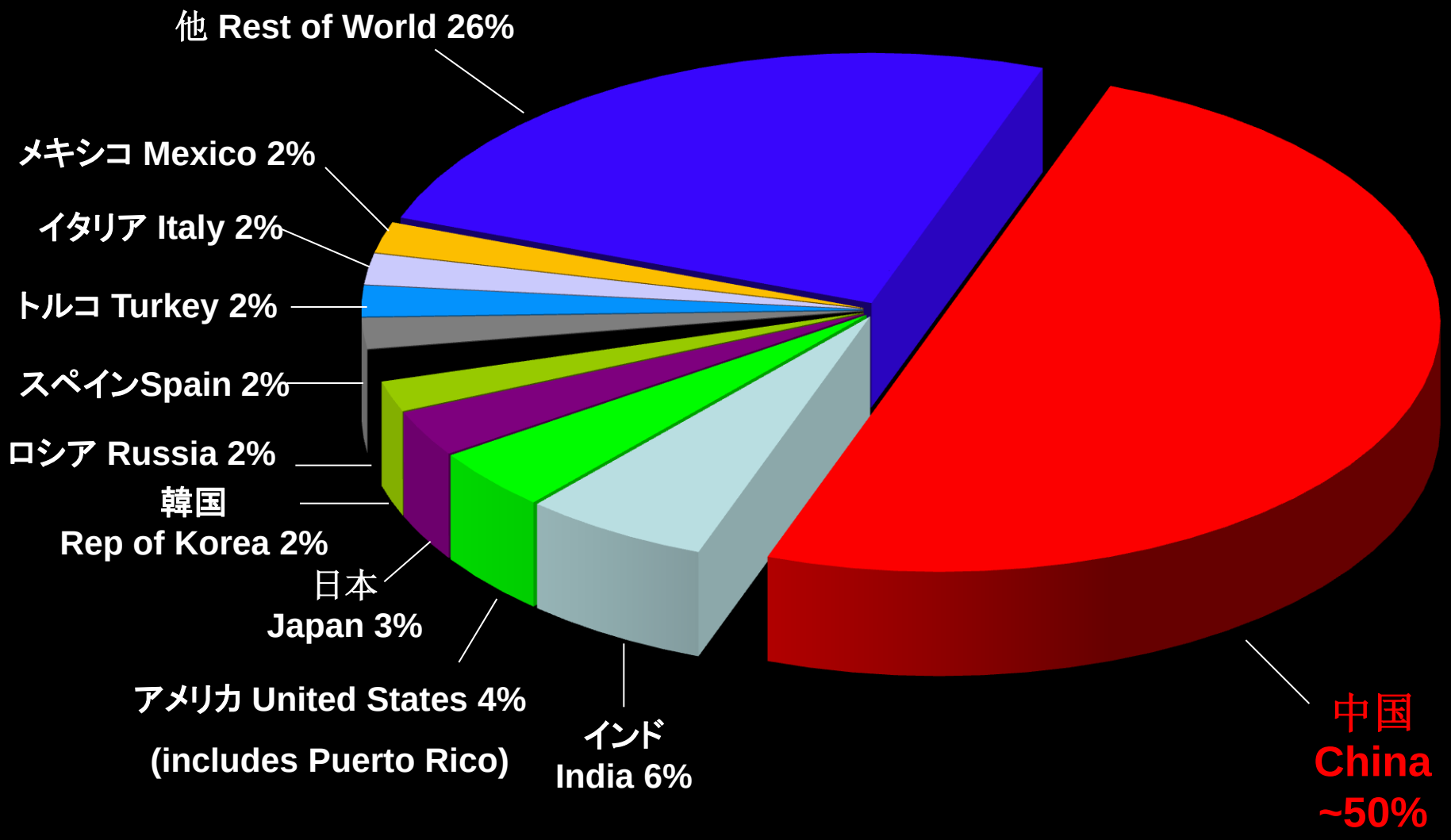
中国のセメント生産量
China's Cement Production
1990 – 2008



Million Metric Tons

Source: China Iron and Steel Association; Institute of Technical Information for the Building Materials Industry; U.S. Geological Survey

2007年世界におけるセメント生産
Cement Production Worldwide: 2007



Source: U.S. Geological Survey 2008. Mineral Commodity Summaries: Cement; China National Bureau of Statistics, 2008

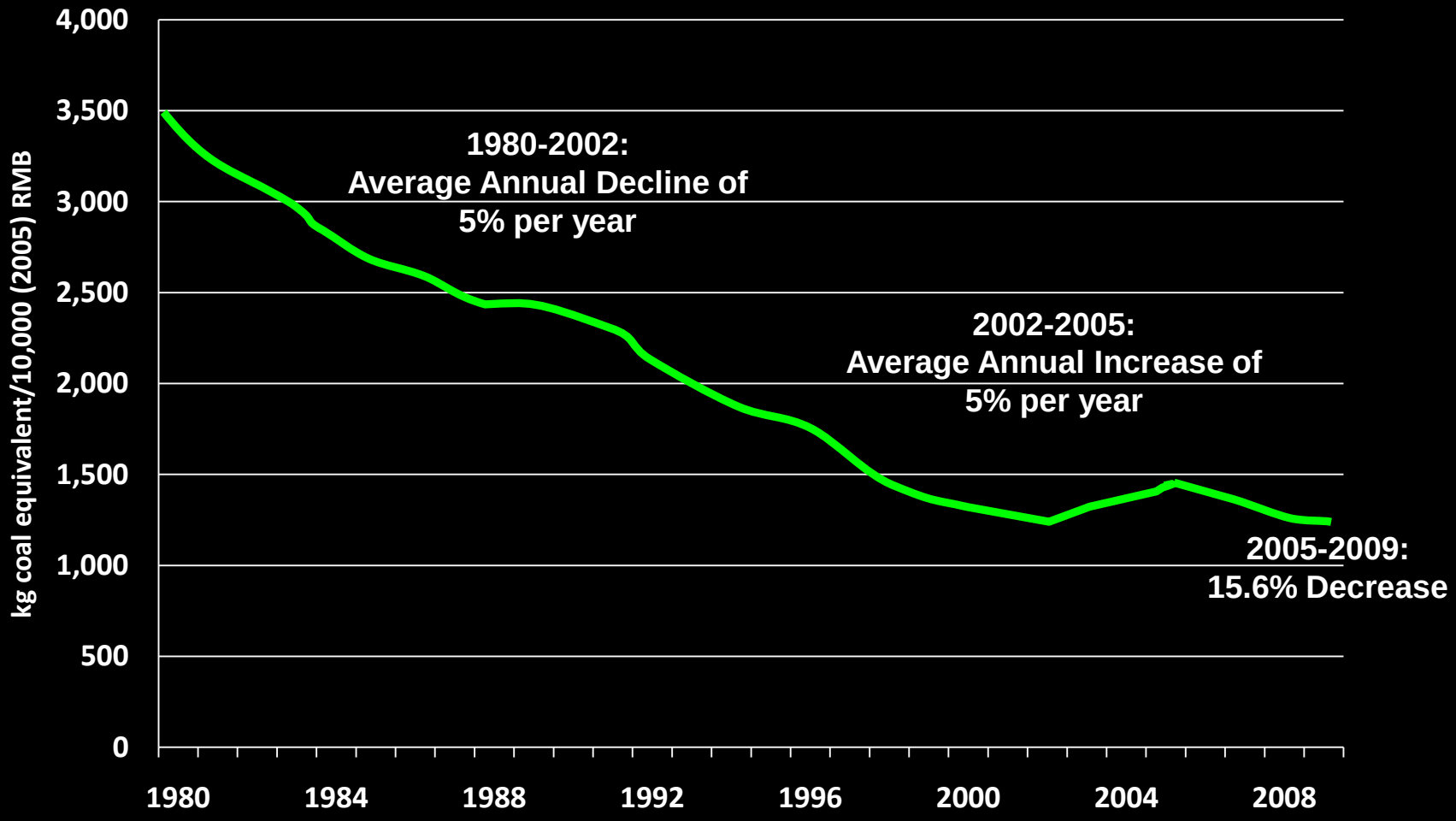
良い知らせ　その２
Good News Part II
2005-2010

2005年、中央政治局が5年でエネルギー強度の
20％減を指示する発表
2005 Announcement by Politburo mandating a 20% energy intensity decrease in 5 years

続けて、行政院長・全国人民代表大会・国家発展改革委員会
発展計画司(NDRC)により同様の宣言や活動
Followed by similar statements and actions by the Premier, the National Peoples Congress, and NDRC

省や地域レベルでの様々な行動・活動
And a multiplicity of actions on the provincial and local levels

中国のエネルギー強度（1980～現在）
China's Energy Intensity
(1980-present)



ほぼ全ての政策がその目標を達成

Almost all of the policies achieved their goals

エネルギー強度20%減達成のために実行された政策
Policies implemented to achieve the 20% energy intensity target

工業 Industry

- **10の主要プロジェクト　Ten Key Projects**
  - 石炭火力工業用ボイラーの刷新　renovation of coal-fired industrial boilers
  - 地域レベルでの熱・電力統合プロジェクト　district level combined heat and power projects
  - 廃熱及び圧力の利用　waste heat and pressure utilization
  - 石油の節約及び代用　oil conservation and substitution
  - モーターシステムの省エネ　motor system energy efficiency
  - エネルギーシステム最適化　energy systems optimization
- **トップ1000企業プログラム　Top-1000 Enterprise Program**
- **小規模プラント閉鎖　Small Plant Closures**

政策（続） Policies (cont)

建物 Buildings

10の主要プロジェクト　Ten Key Projects

建物における省エネに対するインセンテイブ
Incentives for energy efficiency and conservation in buildings

省エネ照明　Energy-efficient lighting

省エネ製品における政府調達
Government procurement of energy efficiency products

電化製品基準と省エネラベル
Appliance standards and energy-efficiency labels

建築物エネルギー基準の施行強化
Enhanced enforcement of building energy standards

中国北方地区における断熱等、建物の省エネ効果改善
Heating energy retrofits in N. China

工業セクターの改革（サービス重視など）　Industrial restructuring

財政的インセンテイブ Financial Incentives

中央政府の資金　Central government funds

地方政府の資金　Provincial government funds

200-250元/tce節約に対する奨励プログラム
200-250 RBM/tce saved award program

未来図
A View of the Future

2010-2050

LBNL 中国エネルギー エンド・ユーズモデルの結果
Results of LBNL China Energy End-Use Model

（4年の成果）

Four-year effort: Nan Zhou (lead), David Fridley, Nina Zheng, Jing Ke, Lynn Price, and Mark Levine

特筆すべき仮定事項
Noteworthy Assumptions

幾分か低い経済成長予測
Somewhat lower annual economic growth projections:
7.7% (2010-2020); 5.9% (2020-2030); 3.4% (2030-2050)

重工業に関する生産出力は物理的要因によって決まる
Physical drivers for the production of heavy industrial outputs
例．アンモニア生産は種がまかれる地域と肥料エネルギー強度で決まる
e.g. ammonia production is driven by sown area and fertilizer energy intensity

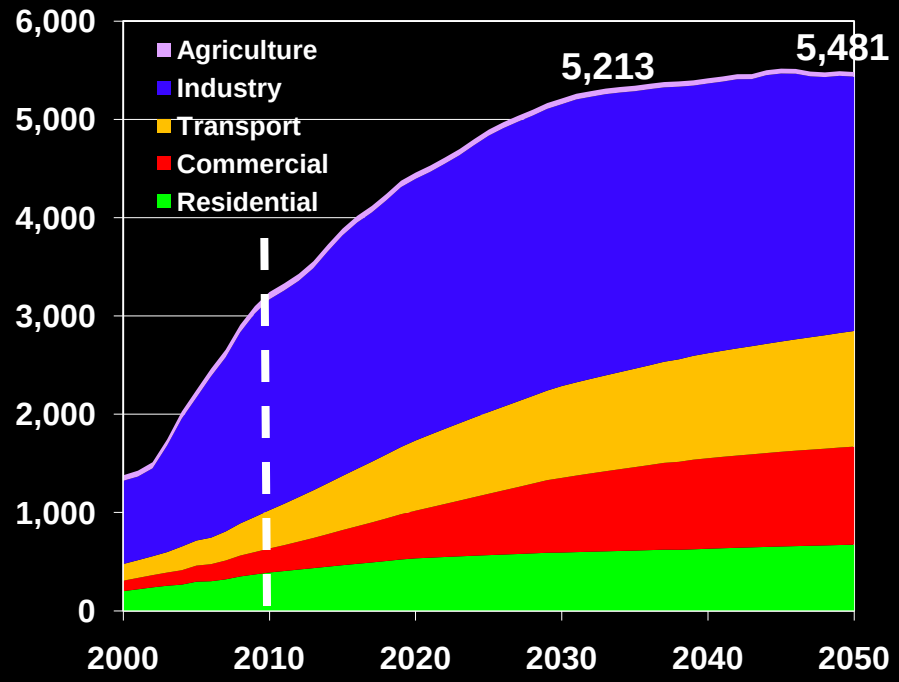
車保有率：2050年には50％、現在のアメリカの各人当たりの車保有数と同じ
Car ownership: 50% as many cars/person in 2050 as the United States has today

新エネルギー及び原子力発電は急速に増加する
Renewable and nuclear electricity grows very fast
2050年までに各300-500ＧＷ （現在のアメリカそれぞれ35、100GW）
300-550 GW for each by 2050 (versus 35 and 100 GW in U.S. today)

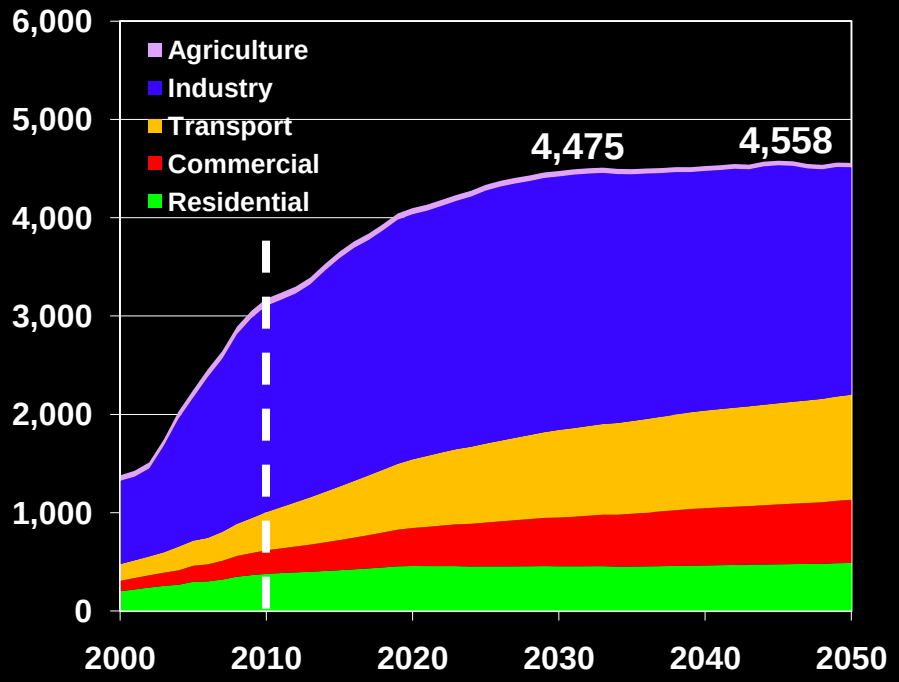
機材・建物・製品・インフラの飽和を十分に勘定
Explicit accounting for saturation of equipment, buildings, products, and infrastructure

セクター毎の一次エネルギー利用
Total Primary Energy Use by Sector

継続的改善があった場合
Continued Improvement



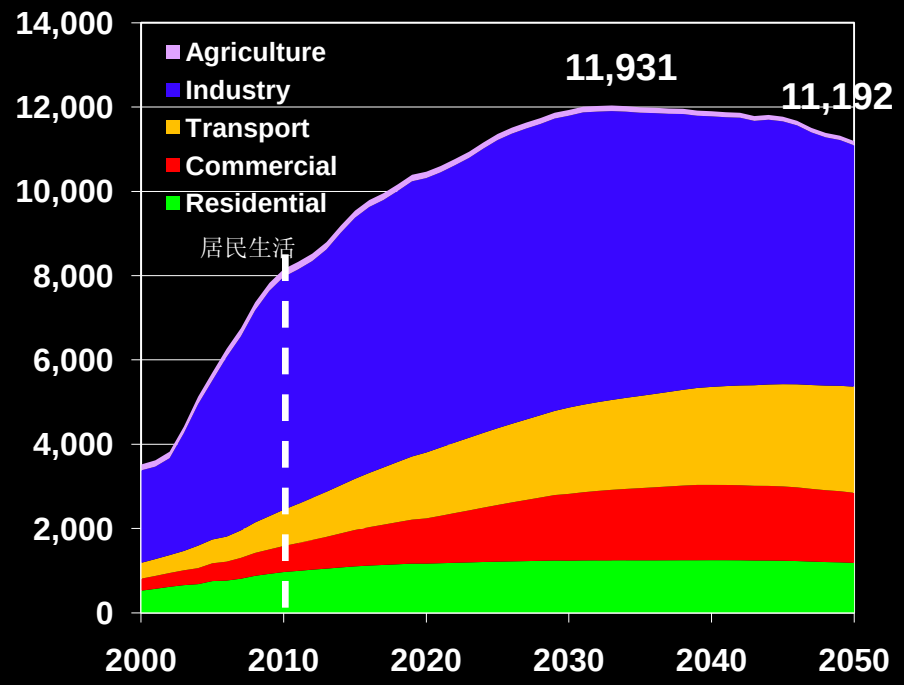
加速的改善があった場合
Accelerated Improvement



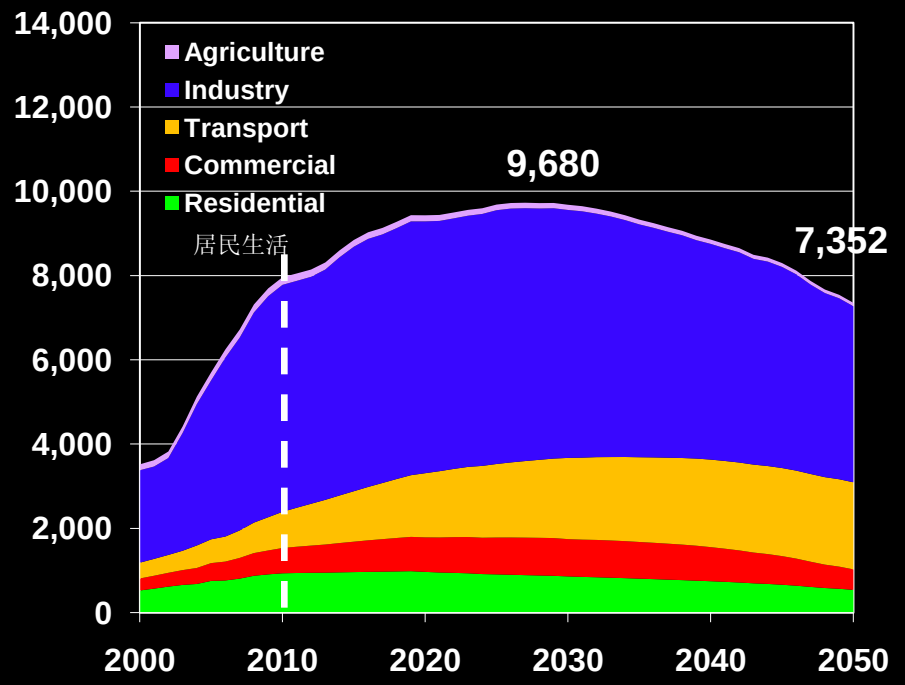
Primary Energy Use (Mtce)

両シナリオにおける炭素ガス排出の見通し(CCSなし)
Carbon Emissions Outlook for CIS and AIS Scenarios (without Carbon Capture and Storage)

継続的改善があった場合
Continued Improvement

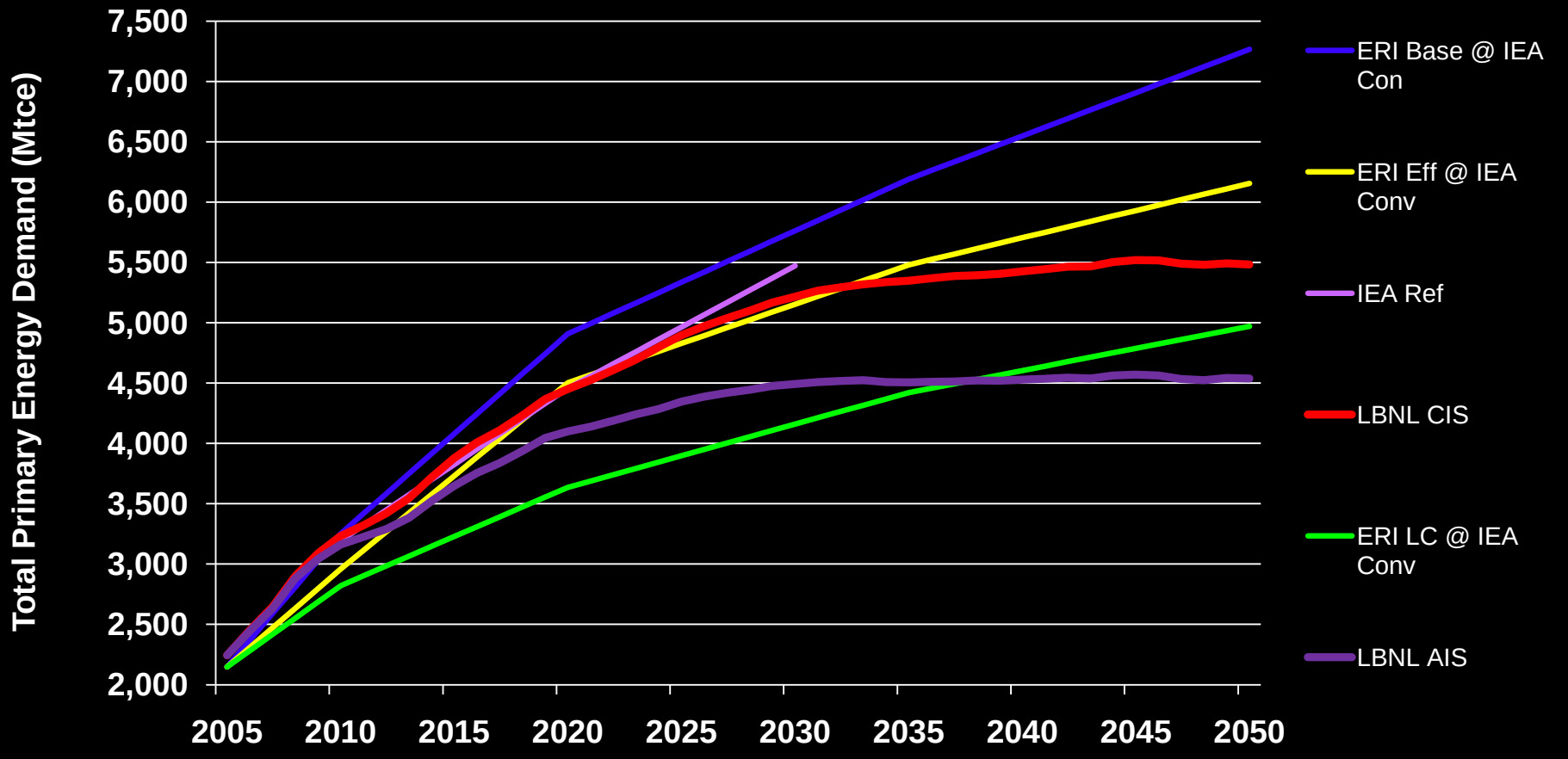


加速的改善があった場合
Accelerated Improvement



Mt CO2 Emissions

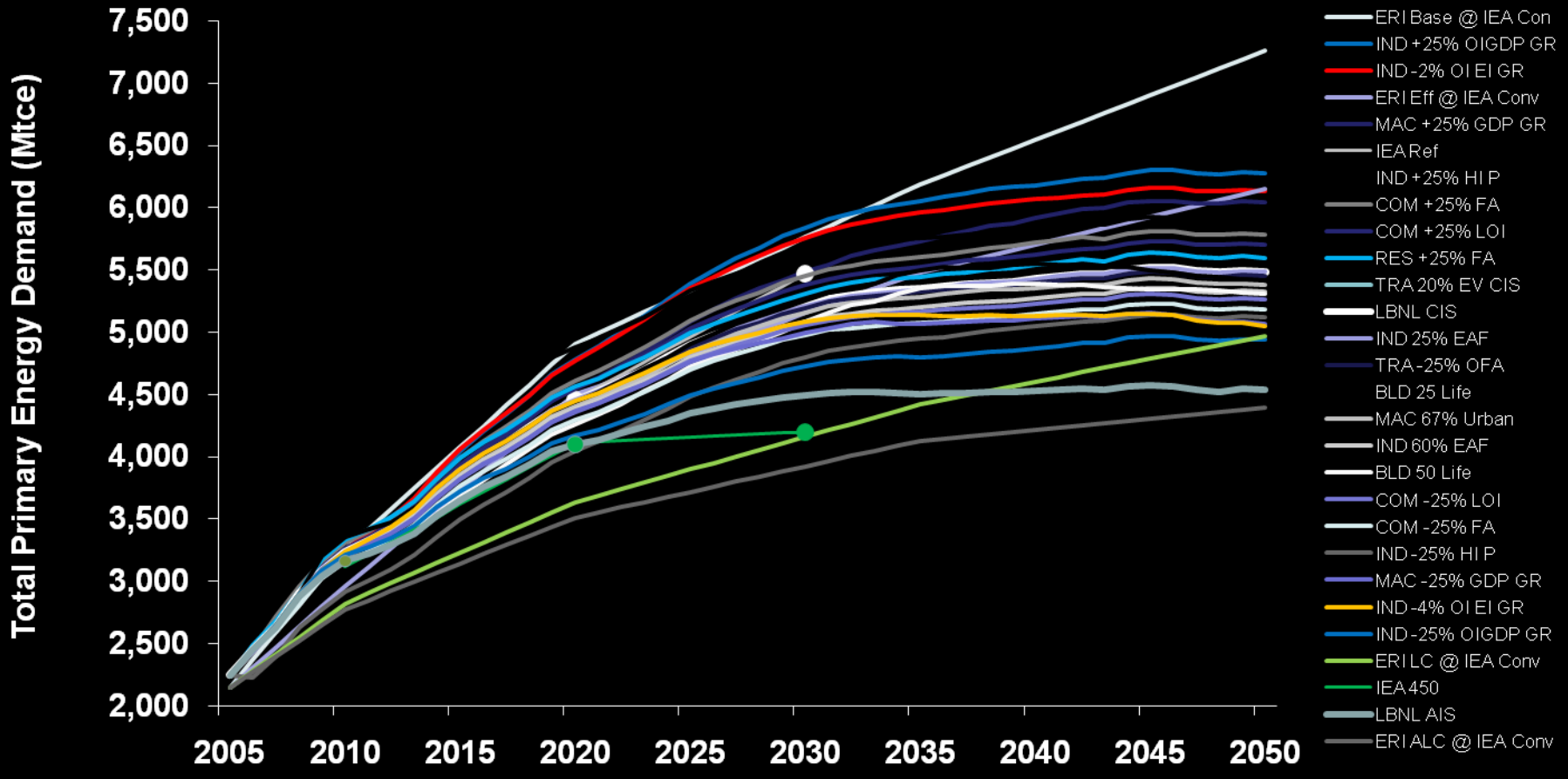
一次エネルギー需要予測:他の主要分析との比較
Total Primary Energy Use: Comparison with Other Mainstream Analyses



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

一次エネルギー需要 感度分析
Total Primary Energy Use Sensitivity Analysis



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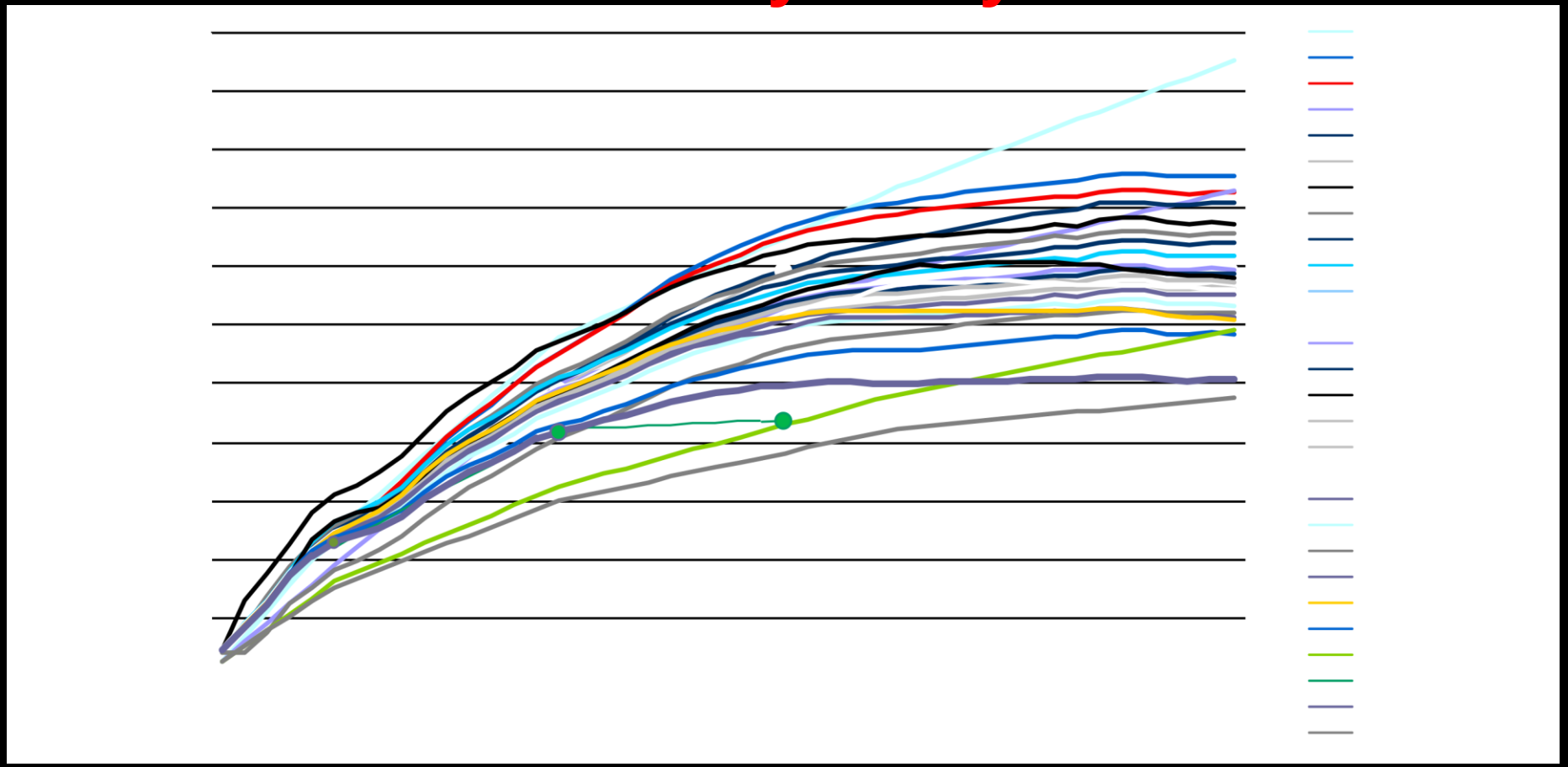

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LBNLシナリオと他分析との大きな違い：我々の分析では2025年(加速的改善)もしくは2030年(継続的改善)頃から需要が一定に落ち着く

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

分析で見られた需要の一定化は実際に同様の時間枠でおこりうると考える
We believe this plateau is very likely to take place in this time frame

- 飽和効果
  Saturation effects
- 都市化の減速
  Slowdown of urbanization
- 低い人口増加率
  Low population growth
- 高付加価値商品など、輸出製品の変化
  Change in exports to high value added products

結論1　Conclusions I

- 一般的には中国は今世紀にかけて今後も二酸化炭素排出を続け、世界の排出量の大きな割合を占めるだろうと考えられている。しかし、以下の理由でそうはならないであろうと我々は考える：
  - 2030年頃までに電化製品・住居・商業地域・道路・鉄道等が飽和状態に至る
  - 都市化の加速は2030年から2035年頃にはピークをむかえる
  - エネルギー多消費型産業の輸出の減少
  - 人口増加率の低下
- **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, 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**

結論2　Conclusions II

- 2025年頃まで：インフラ建設が続く中国におけるエネルギー需要成長は非常に予測が難しい

  Until around 2025 – energy demand growth will be highly uncertain in China as it continues to build out its infrastructure

  - 現状の政策から1%程度のエネルギー成長が見通せる先進国とは対照的である

  - This is in contrast to developed countries who can count on an energy growth of ~1% with current policies

- 結果として、現時点で絶対的な排出上限を中国が受け入れられるわけがない。

  As a result, it makes no sense for China to accept an absolute cap on emissions at this time

- 一方、不確実な経済成長率に関わらず改善が見込める、炭素強度（炭素排出原単位）の減少に取り組むことが考えられる。

  Reduction of carbon intensity on the other hand makes sense, as this assures improvement regardless of uncertain economic growth rates

ありがとうございました。

Thank you!!

Backups

Assumptions #1

- **Urbanization:** 50% (now); 80% projected to increase to 80% (2050)
  - 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)
  - 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

Assumptions for Key Macroeconomic & Industrial Drivers

- **Urbanization:** projected to increase to 80% in 2050 from 45% in 2007
  - U.S. 2008: 81.7%, Japan 2008: 66.5%
- **Population:** will reach 1.41 billion in 2050, an increase of 80 million from 2007
- **GDP Annual Growth Rate:** 7.7% between 2010 to 2020, 5.9% from 2020 to 2030, 3.4% from 2030 to 2050
  - U.S.: 2% in 2007, 0.4% in 2008. Japan: 2.4% in 2007, -0.7% in 2008
- **Production of cement, iron & steel, aluminum, and glass** : based on major physical driver relationships to build environment requirements for growing urban population, with floor space construction area as a proxy. Assume exports remain constant.
- **Production of ammonia and ethylene**: Ammonia production is driven by sown area an fertilizer intensity while ethylene production was based on population and per capita demand for plastics, using current level in Korea and Japan as proxies

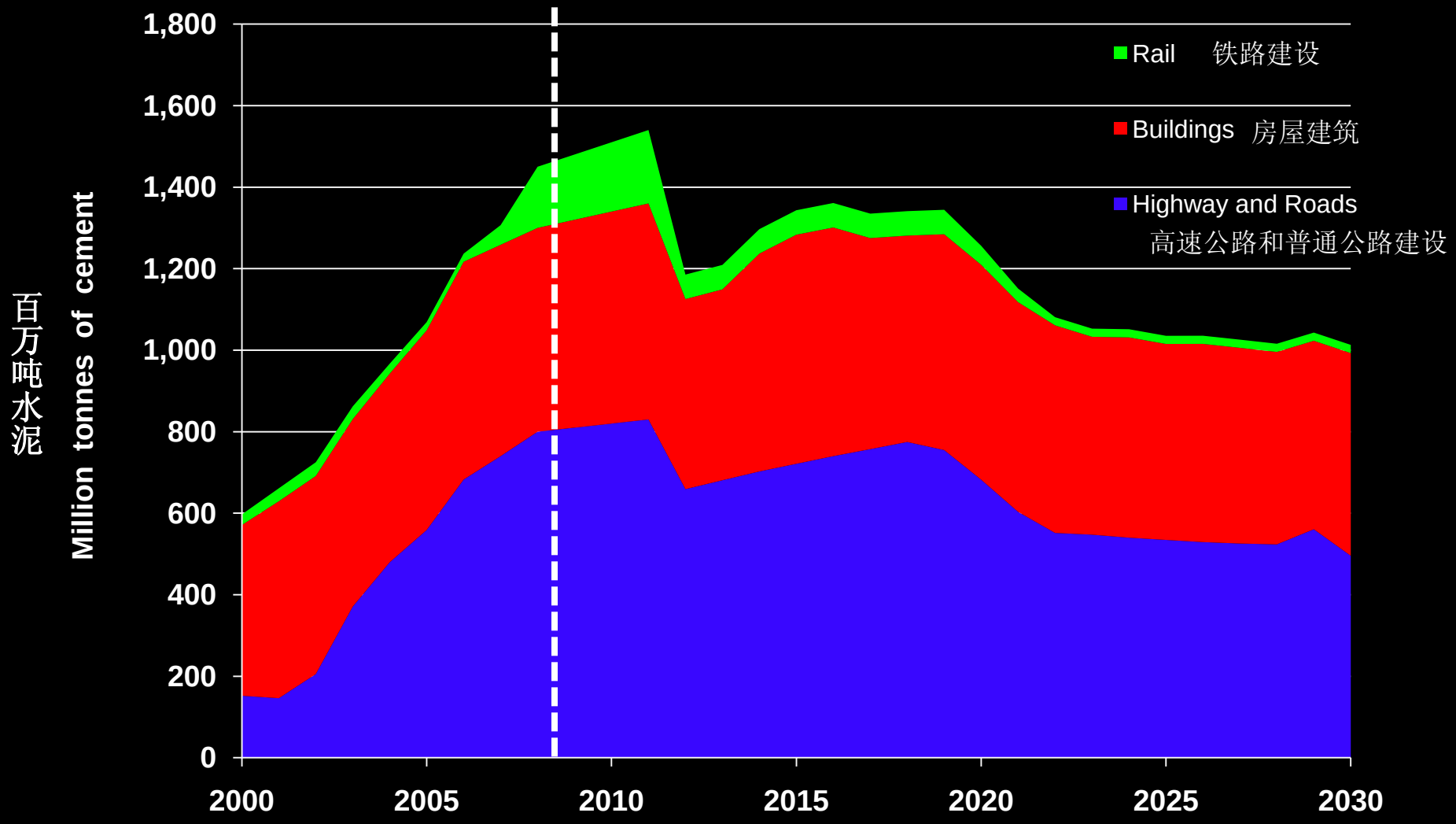
Assumptions about Other Key Drivers (1)

- **Urban residential floor area per capita:** almost double from 24 m^2 to 46m^2 between 2005 and 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
  - US and Japan: major appliances all at or past saturation for the past 20 years
- **Appliance efficiency:** moderate efficiency improvement (1/3 improvement relative to High Efficiency) for CIS and Moderate Improvement of new equipment in 2010 – near Best Practice by 2020
- **Commercial floor area per employee:** an increase of about 25% by 2030 and 86% by 2050 to 53 m^2 compared to 2005,
  - in between Japan in 2002 (36 m^2) and the US (62 m^2) in 2003
- **Tertiary sector employee:** increase by about 33% by 2030 compared to 2005.
  - U.S. 2008: 67% of male employees, 89.9% of female employees. Japan 2008: 60% of male employees, 77% of female employees.

Assumptions about Other Key Drivers (2)

- **Commercial cooling efficiency: Current International Best Practice by 2050 in CIS and by 2020 in AIS**
- **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**
- **Car ownership: reaches 25 %of population by 2050, compared with 21.5 % in Korea and 43.3% in Japan in 2002 and 47.4% in U.S (as measured by cars owned per 1000 people).**

Cement Production



Fleet of Transport Vehicles