Will China Overwhelm the World with its Greenhouse Gas Emissions?

Mark D. Levine

Lawrence Berkeley National Laboratory

ACEEE Summer Study

Asilomar

August 2010

China Energy Group at Lawrence Berkeley National Lab

- **Established 1988**
- **Unique in the world**
- **Mission: China Energy Group works collaboratively with groups in China and elsewhere to:**
  - **-- enhance the capabilities of Chinese institutions that promote energy efficiency**
  - **-- assist in energy efficiency policy development,**
  - **-- research the dynamics of energy use in China.**

Key Successes

- Appliance energy efficiency standards
- Voluntary agreements for industry
- Institution building: BECon—with Bill Chandler—and CSEP
- Model of energy demand for China
- Trained >500 Chinese in various aspects of energy efficiency

China Energy Group

Mark D. Levine
Group Leader, Senior Staff Scientist
MDLevine@lbl.gov

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

Nate Aden
Senior Research Associate
NTAden@lbl.gov

Lynn Price
Staff Scientist
LKPrice@lbl.gov

Hongyou Lu
Senior Research Associate
HYLu@lbl.gov

Nan Zhou
Scientist
NZhou@lbl.gov

Nina Zheng
Research Associate
XZheng@lbl.gov

China Energy Group

Post Doctoral Fellows and Visiting Researchers

Ali Hasanbeigi
Post Doc
AHasanbeigi@lbl.gov

Yining Qin
Post Doc
YiningQin@lbl.gov

Shuqin Chen
Post Doc
ShuqinChen@lbl.gov

Jing Ke
Visiting Researcher
JKe@lbl.gov

Stephanie Ohshita
Visiting Faculty
SBOhshita@lbl.gov

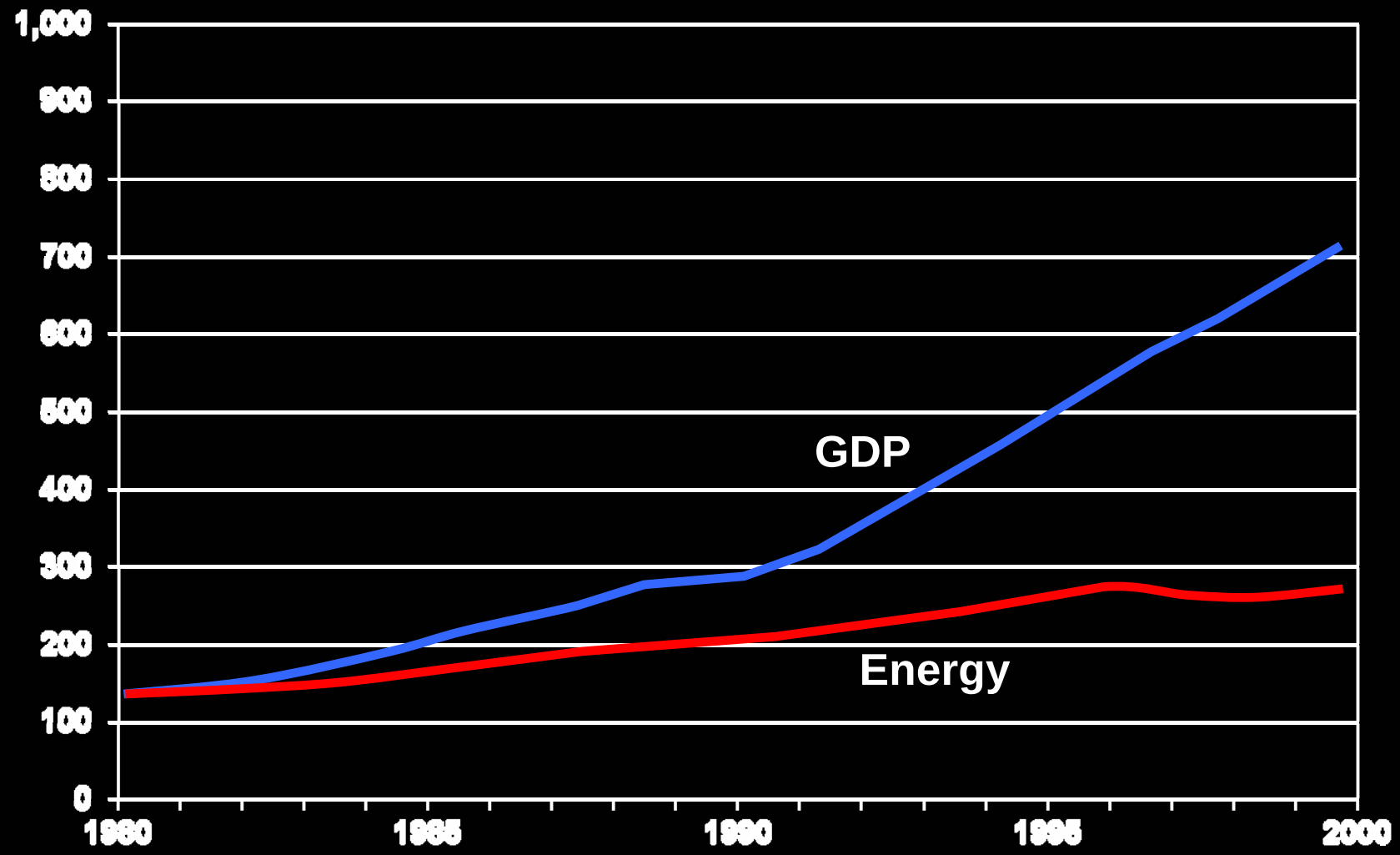
Queena Qian
Visiting Researcher
Queena.Qian@dante.lbl.gov

Energy and Carbon Dioxide Emissions in China

Good News Part I

1980-2002

China's Energy & Economic Growth 1980-2000



Source: China Energy Group, Lawrence Berkeley National Laboratory

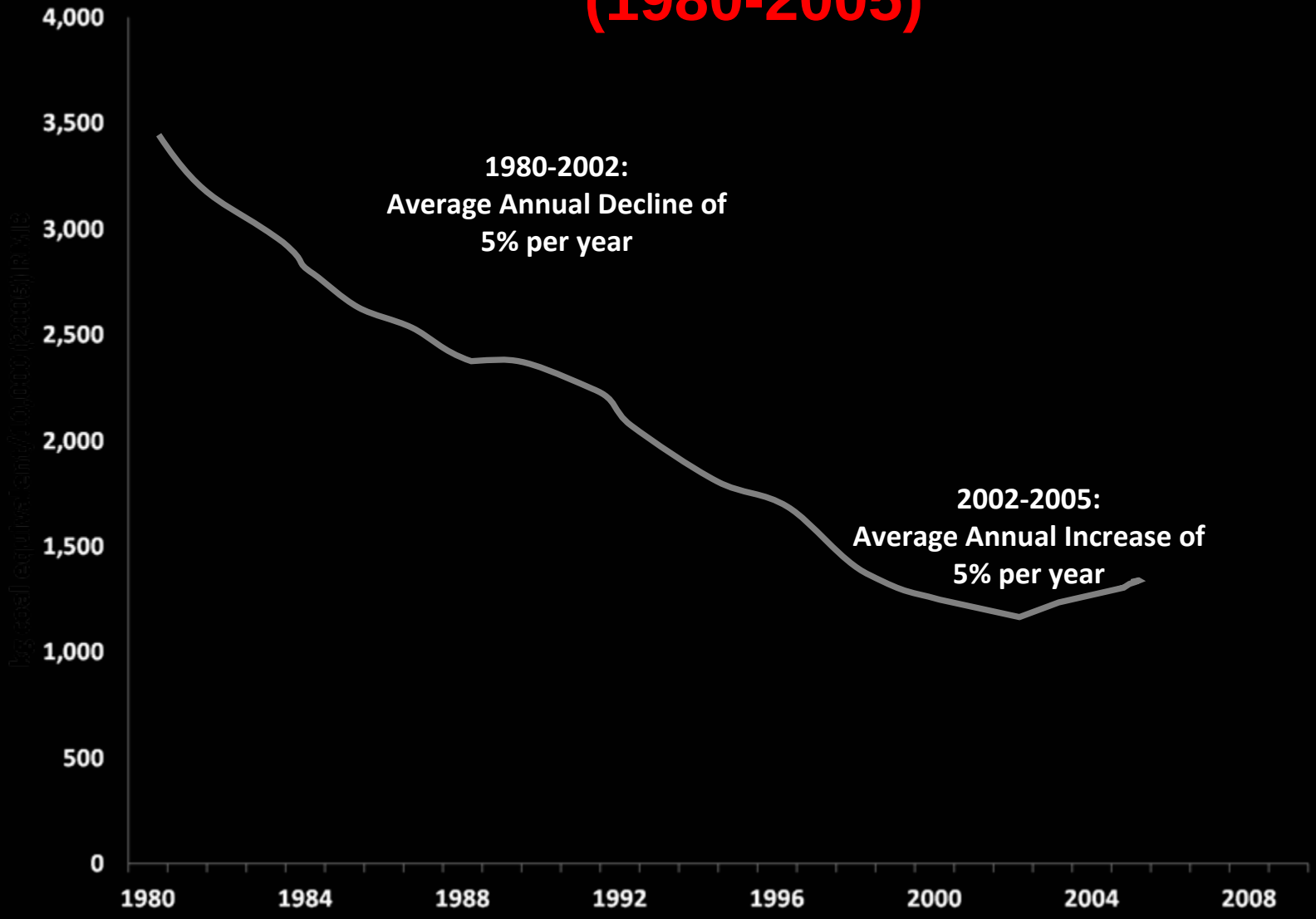
This “decoupling” between economic and energy growth was not an accident: it was a goal of China declared in 1979 and was accompanied by a collection of very strong policies

The Bad News

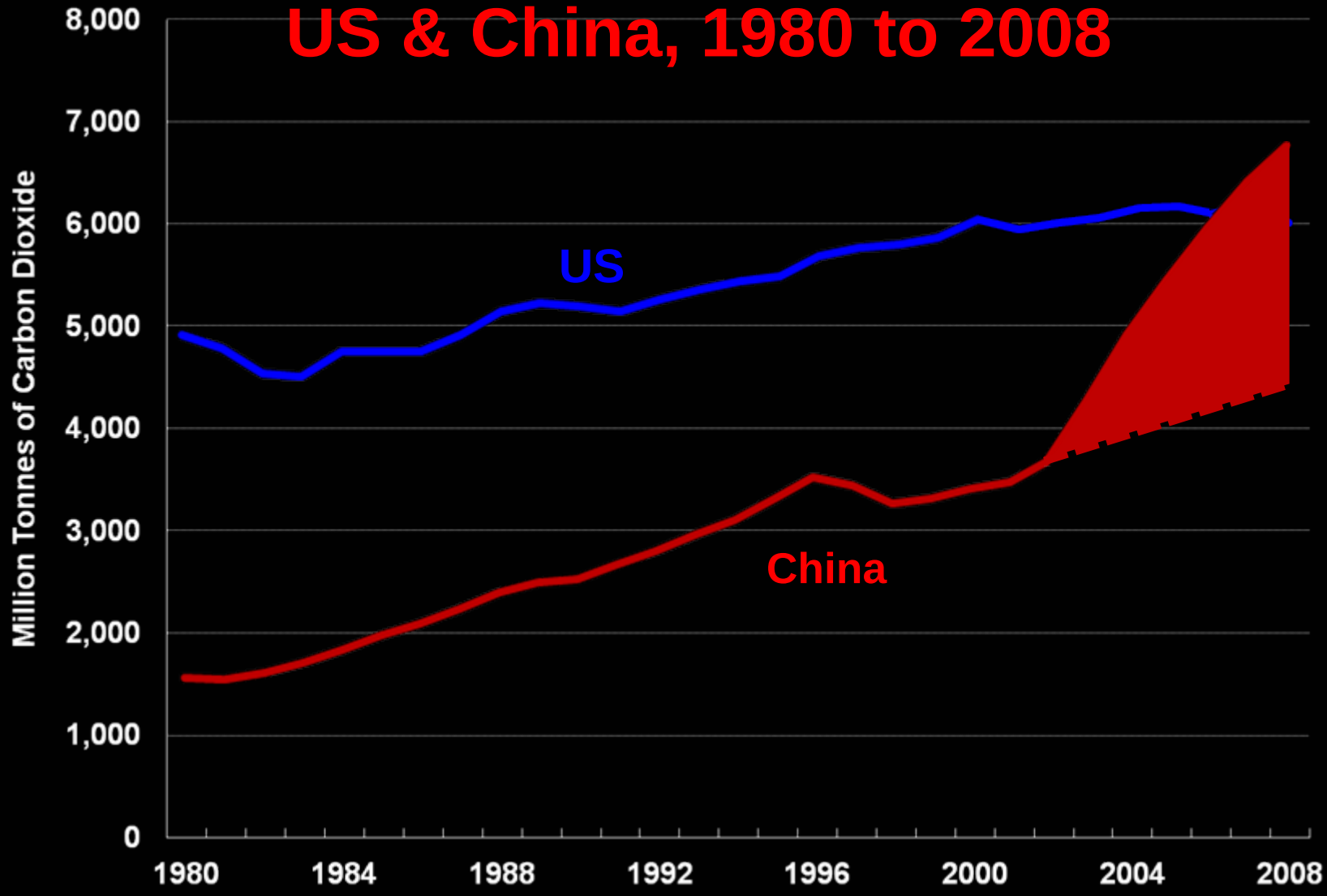
2002-2005

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

China's Energy Intensity
(1980-2005)

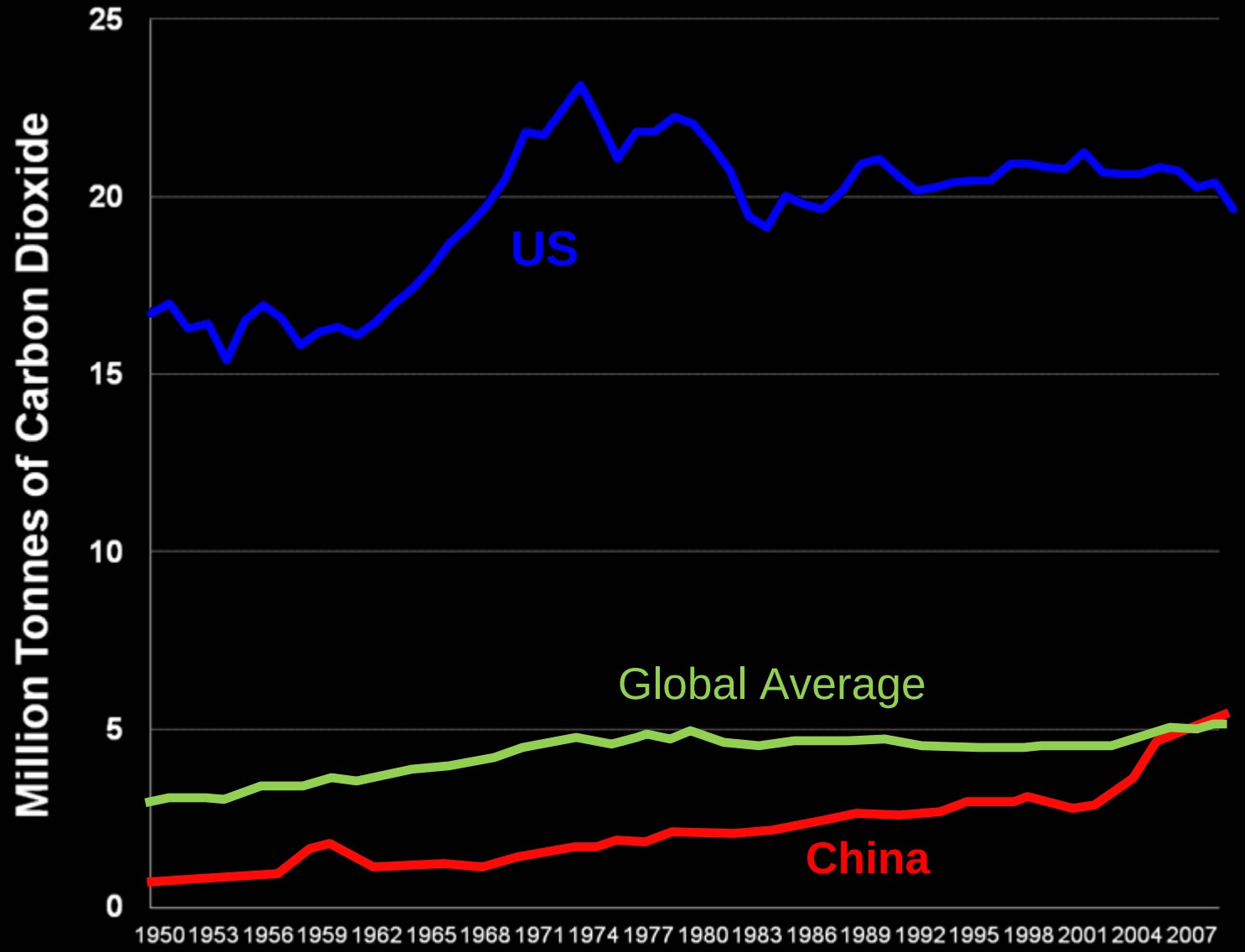


Annual Energy-Related CO2 Emissions: US & China, 1980 to 2008



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).

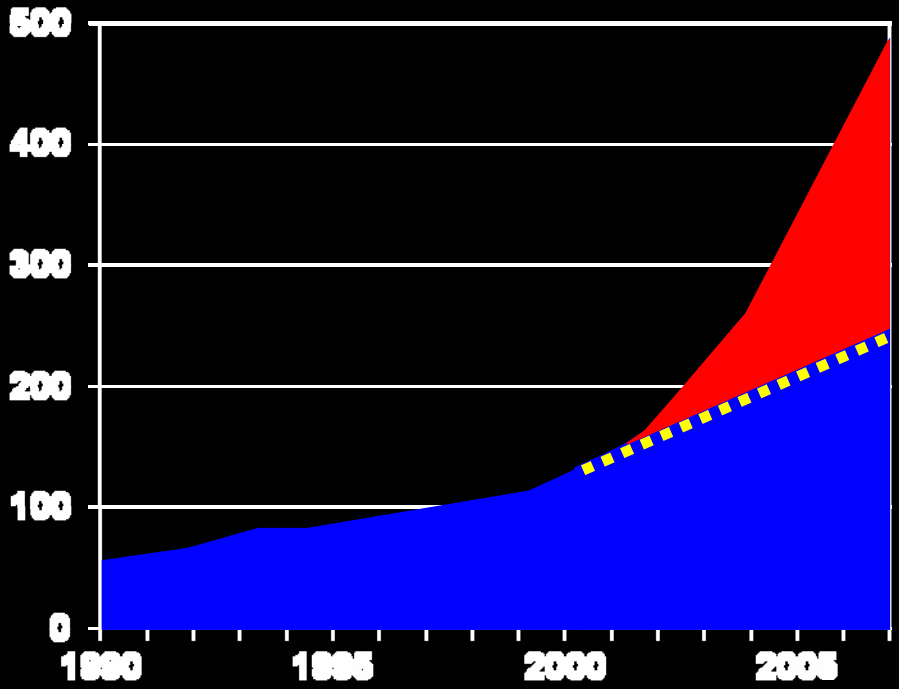
Global, Chinese & U.S. Per-Capita Energy-Related CO2 Emissions – 1950-2008



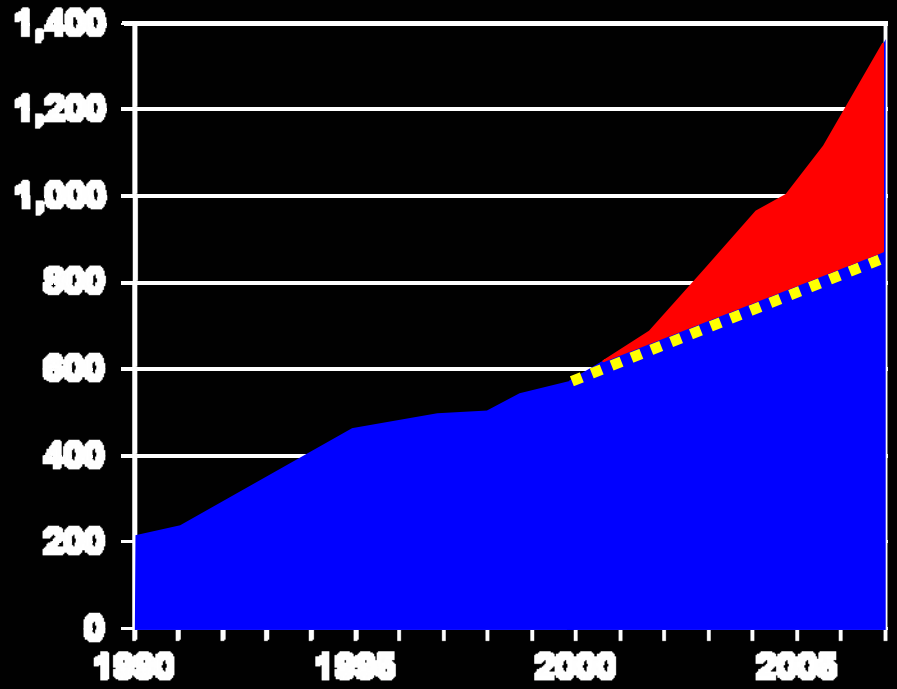
US Data from 1950 to 1979 are from: Carbon Dioxide Information Analysis Center (ORNL), 2006. US data from 1980 to 2007 are from: EIA, Annual Energy Review, 2009. "Environmental Indicators", http://www.eia.doe.gov/emeu/aer/envir.html; US data of 2008 is from EIA, Emissions of Greenhouse Gas Report, "Table 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.

China's Steel and Production

China's Steel Production 1990 – 2007



China's Cement Production 1990 – 2007

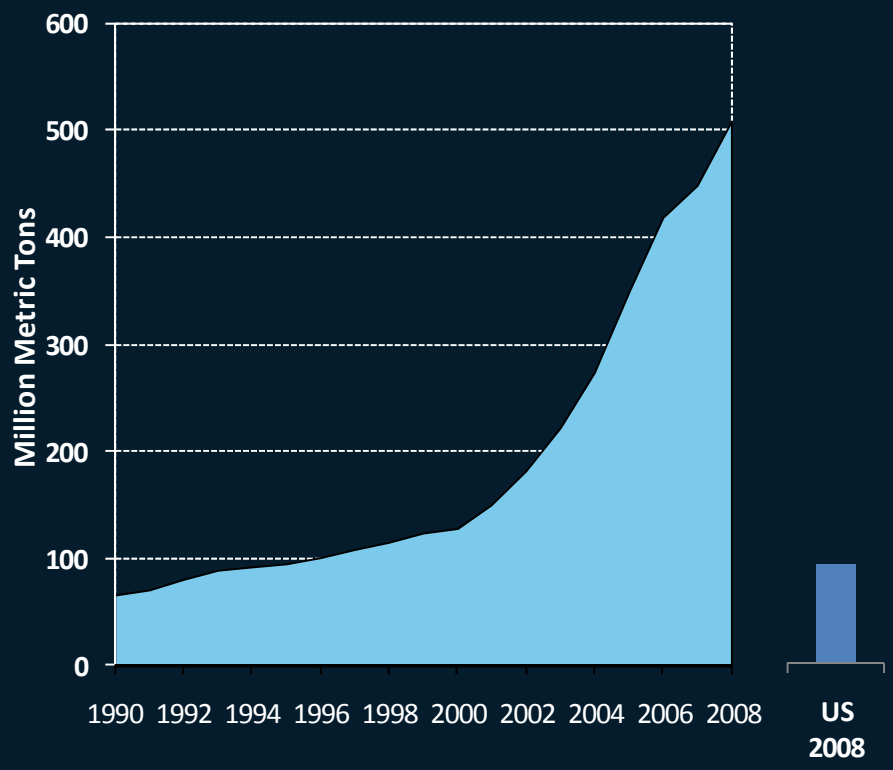


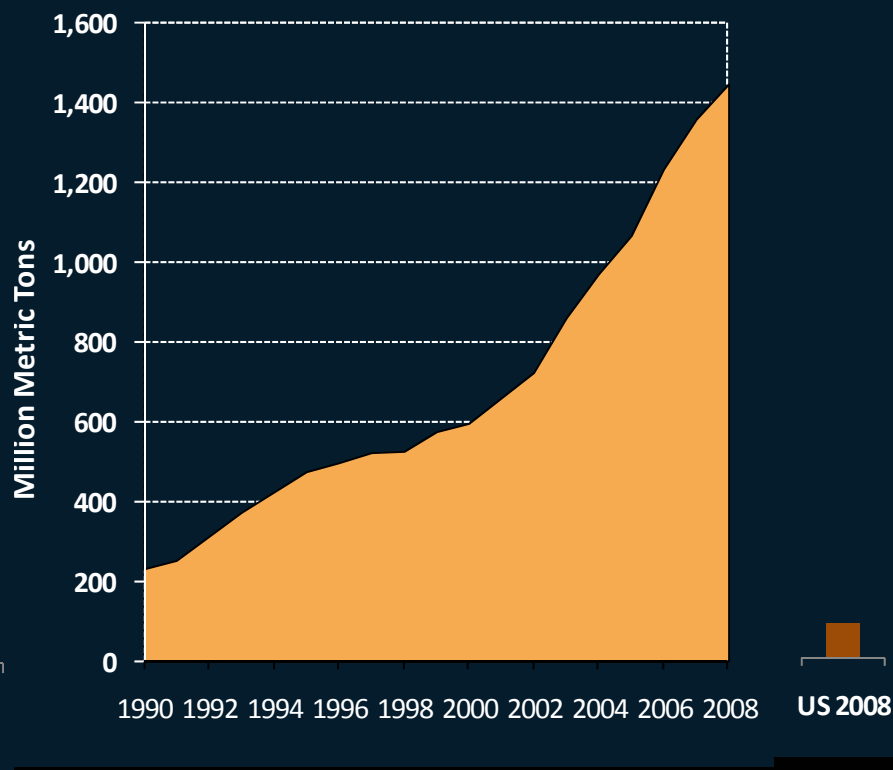
Million Metric Tons

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

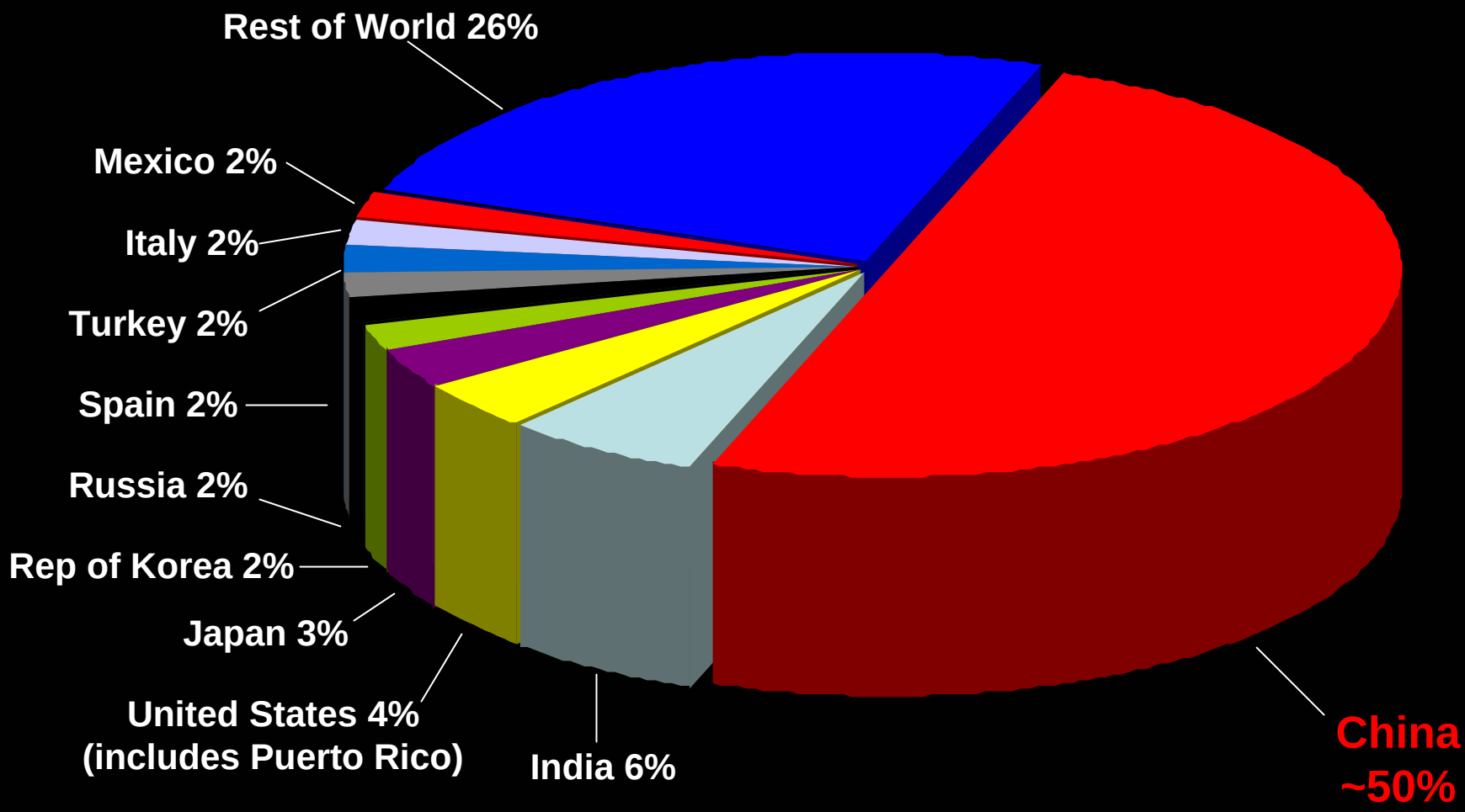
China and U.S. Steel and Cement Production

2. Growing demand for industrial commodities





Cement Production Worldwide: 2007

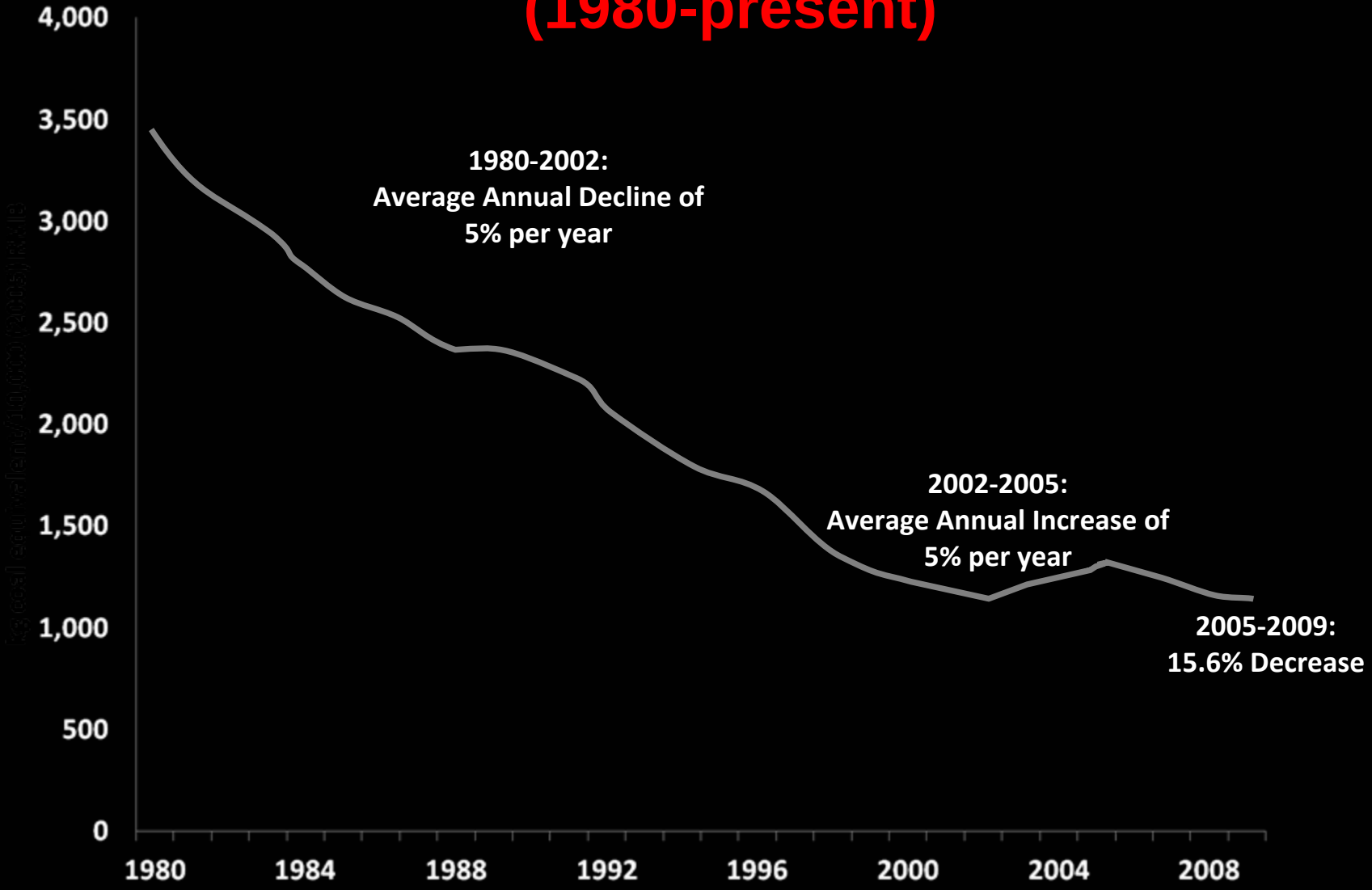


Source: U.S. Geological Survey 2008. Mineral Commodity Summaries: Cement; China National Bureau of Statistics, 2008

Good News Part II

2005-2010

China's Energy Intensity
(1980-present)



Policies implemented to achieve the 20% energy intensity target

- Industry
  - Ten Key Projects
    - renovation of coal-fired industrial boilers
    - district level combined heat and power projects
    - waste heat and pressure utilization
    - oil conservation and substitution
    - motor system energy efficiency
    - energy systems optimization
  - Top-1000 Enterprise Program
  - Small plant closures/industrial restructuring

Policies (cont)

- Buildings
  - Ten Key Projects
    - Incentives for energy efficiency and conservation in buildings
    - energy-efficient lighting
    - government procurement of energy efficiency products
  - Appliance standards and energy-efficiency labels
  - Enhanced enforcement of building energy standards
  - Retrofit in north China (cold regions) to reduce heating energy

- Financial Incentives
  - Central government funds
  - Provincial government funds
  - 200-250 RBM/tce saved award program

With only one exception, the policies achieved their goals

Success: Compliance Rate of Energy Efficiency Standards in Urban Areas

	Rate of Compliance with Building Energy Efficiency Codes							
	2001	2004	2005	2006	2007	2008	2009 (projected)	2010 (projected)
Design phase	5%	54%	59%	96%	97%	98%	100%	100%
Construction phase	2%	20%	23%	54%[1]	71%	81%	92%	100%

[1] According to interview with MOHURD (Wu,2009), the jump in compliance rate from 2005 to 2006 may be because of poor survey data and lack of a stringent effort to understand the situation in the years before 2005.

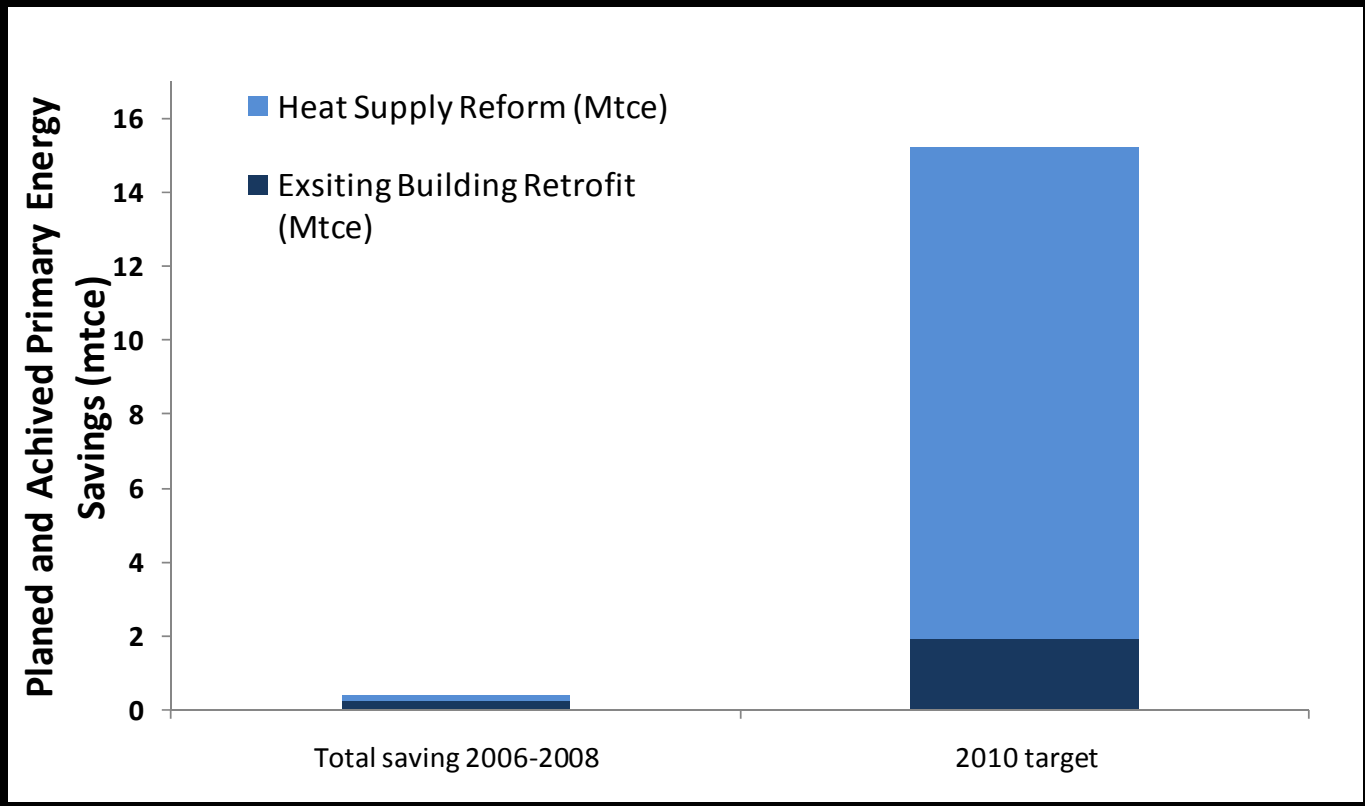
Success: Small Plants Closure and Phase-Out of Outdated Capacity Results, 2006-2008

Industry	Unit	11th FYP Targets	Realized Capacity Closures 2006-2008	Share of Target
Coal mining (production)	Mt	305	250**	82%**
Cement	Mt	250	140	56%
Iron-making	Mt	100	60.59	61%
Steel-making	Mt	55	43.47	79%
Electricity	GW	50	38.26	77%
Pulp & paper	Mt	6.5	5.47	84%
Electrolytic aluminum	Mt	0.65	0.105	16%
Citric acid	Mt	0.08	0.072	90%
Coking	Mt	80	n/a	

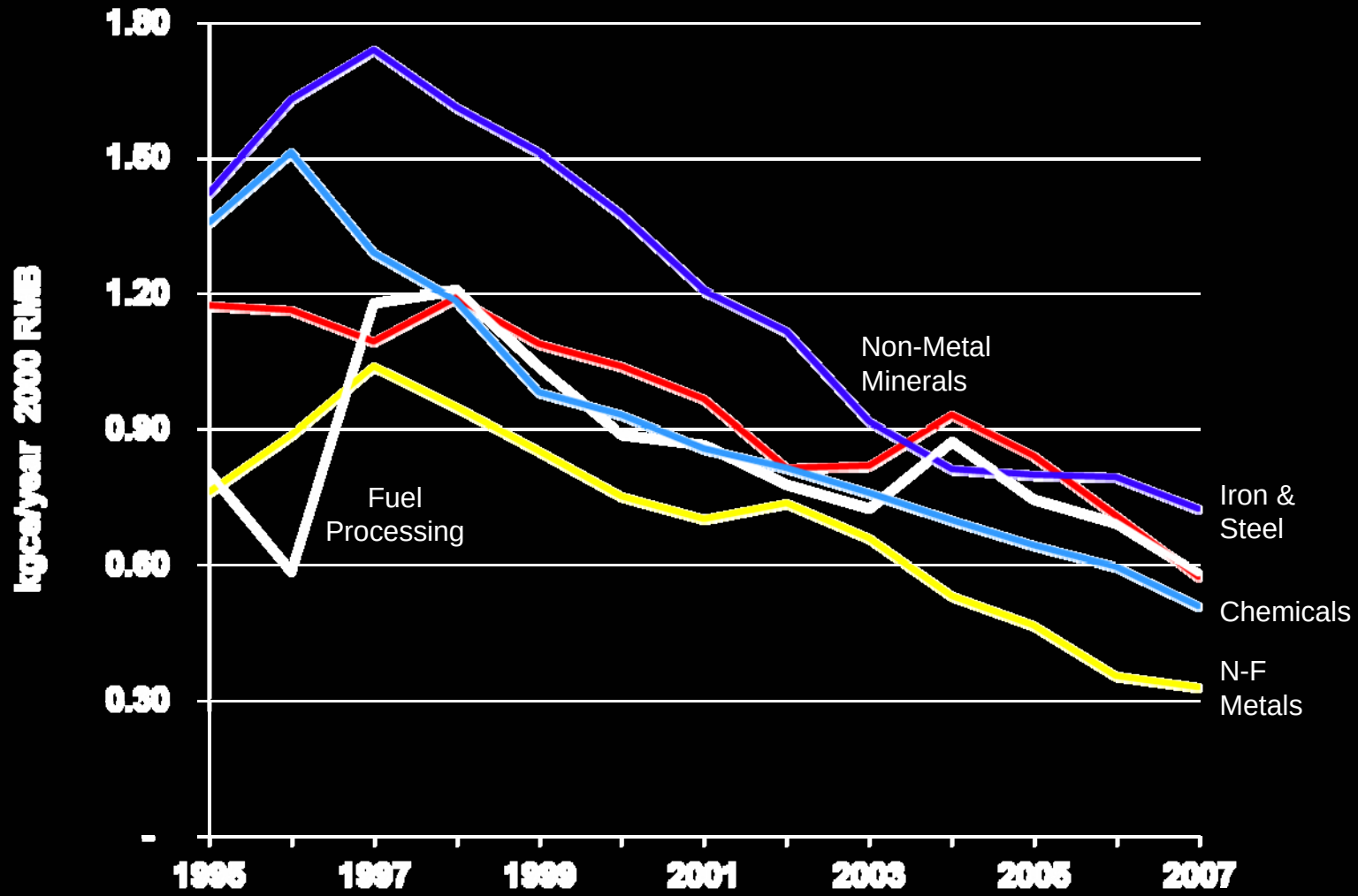
Success: Small Coal-Fired Electricity Plant Closures, 2006-2008

Year	Closed Capacity (GW)	Initial Targets (GW)	Compared to Targets
2006	3.14	n/a	n/a
2007	14.38	10	+43.8%
2008	16.69	13	+28.4%
Total Reported	38.26		

The Exception: Targeted and Achieved Energy Savings through Existing Building Retrofit and Heat Supply Reform



Economic Energy Intensity of Production is Declining



The Future (Good News? Bad News?)

2010-2050

Results of LBNL China Energy End-Use Model

Credits: Nan Zhou (lead), David Fridley, Nina Zhang

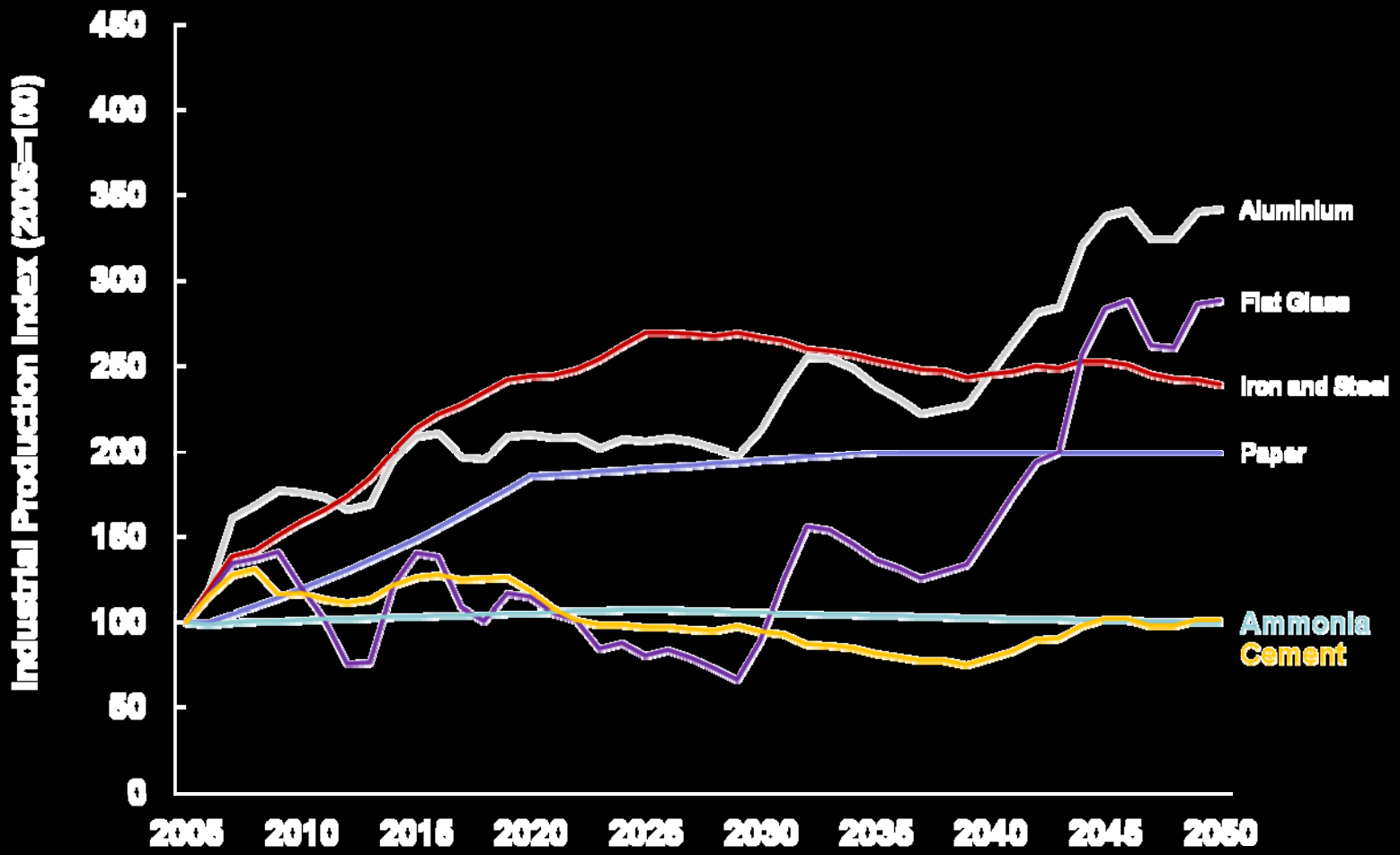
Assumptions

- **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.**

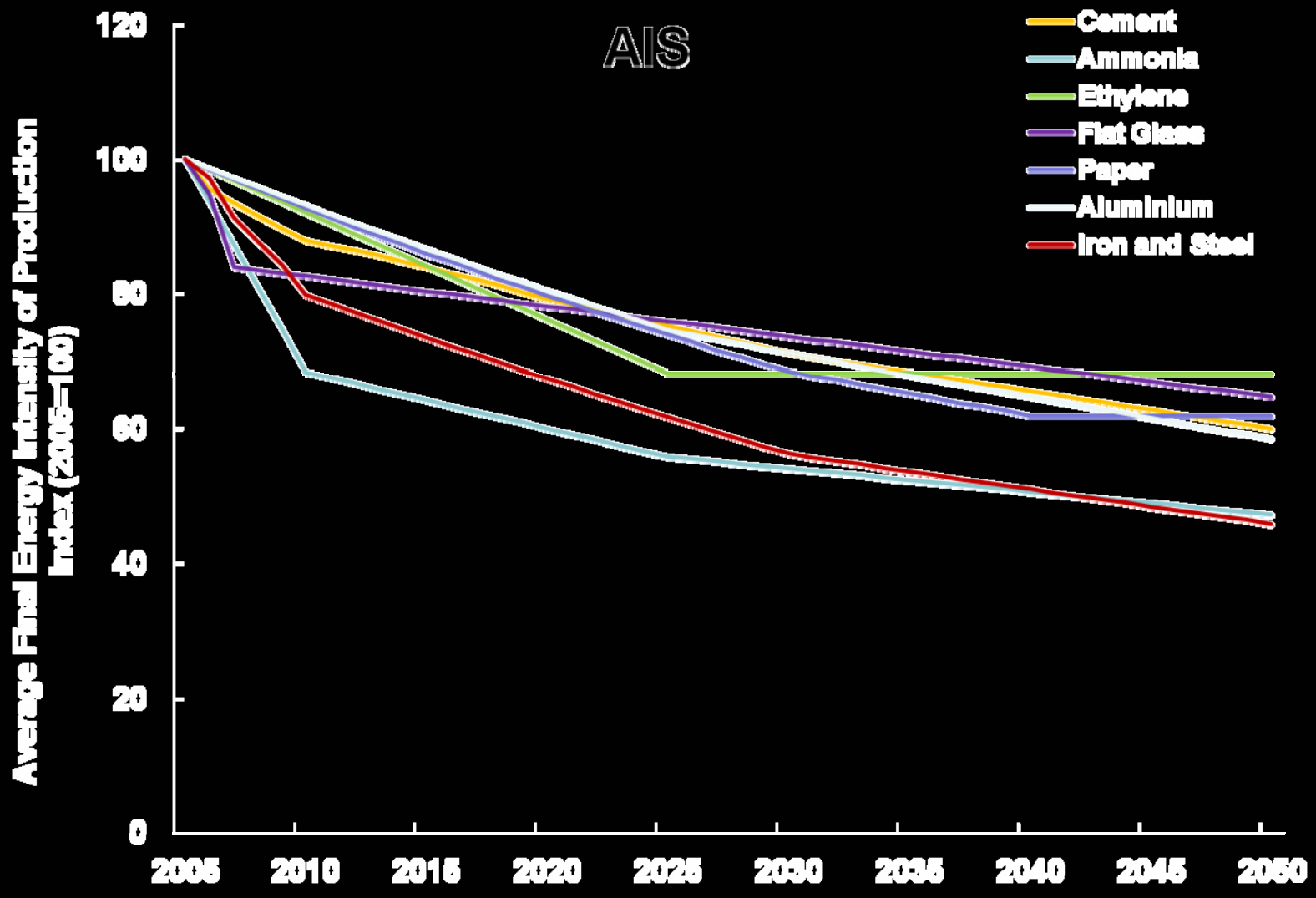
Assumptions

- **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

Industrial Production Projection

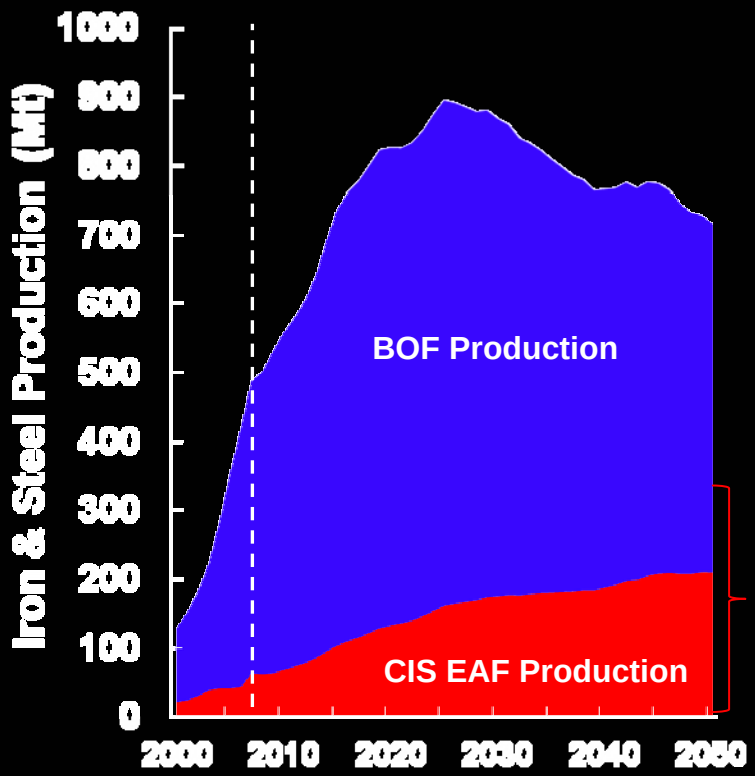


Industrial Energy Intensity Forecasts

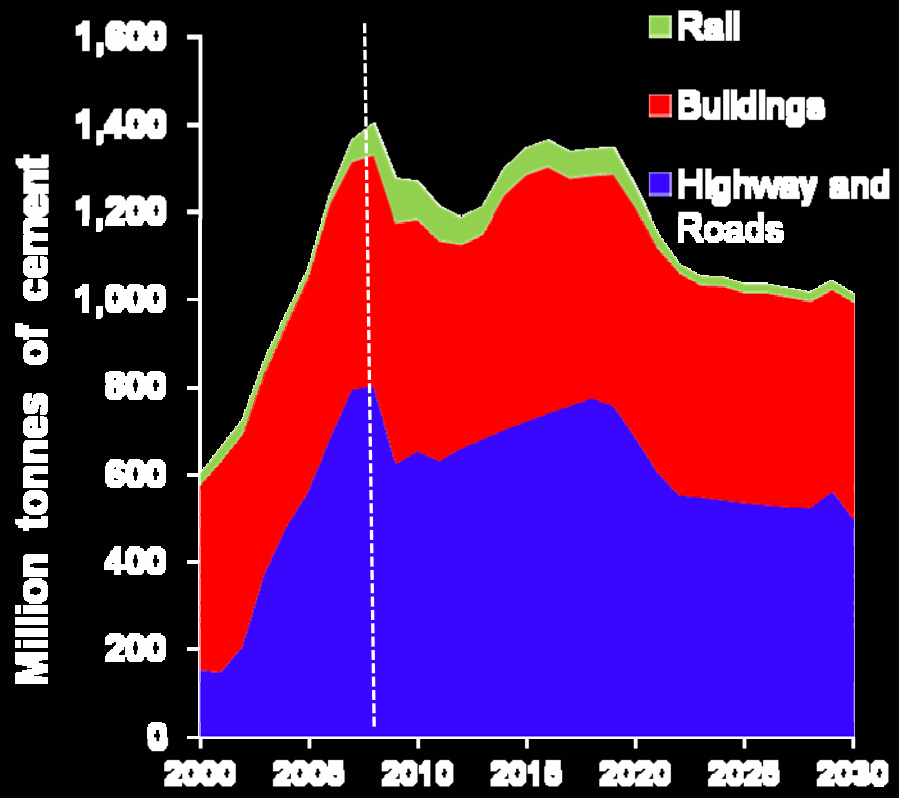


Iron Steel and Cement Production

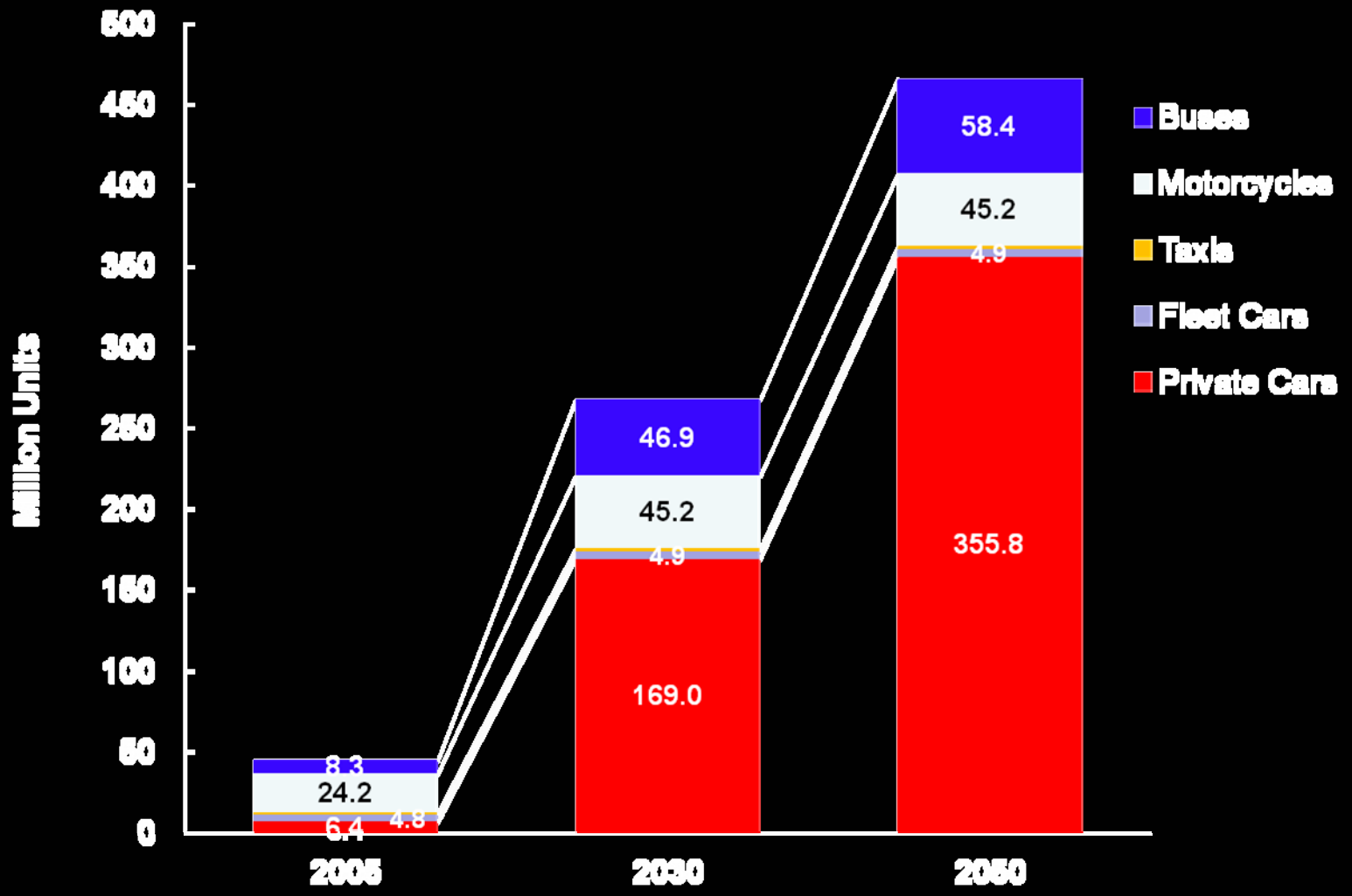
Iron & Steel Production by Technology



Cement Production by Use

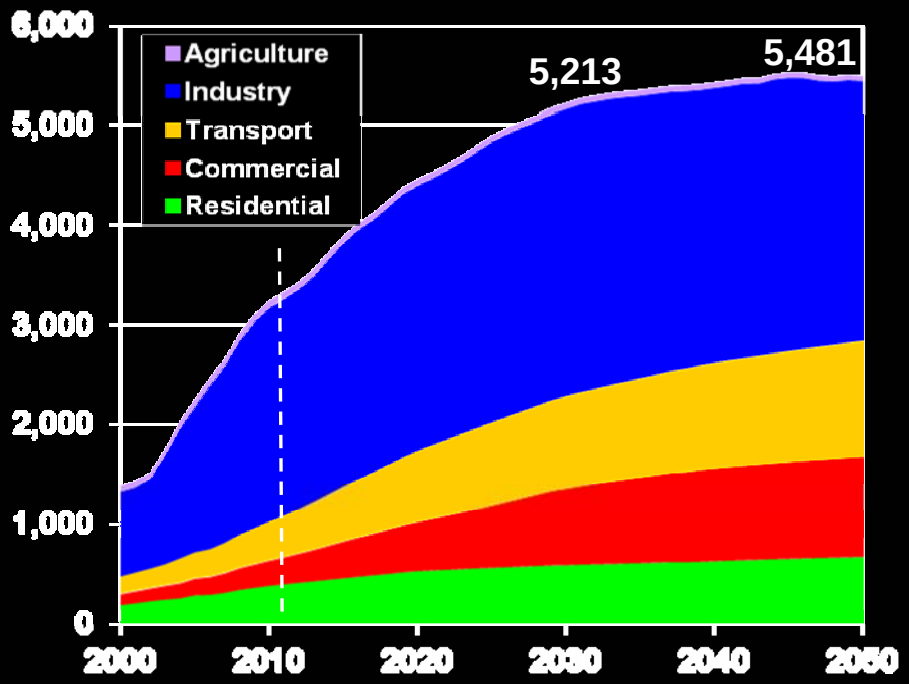


Fleet of Transport Vehicles

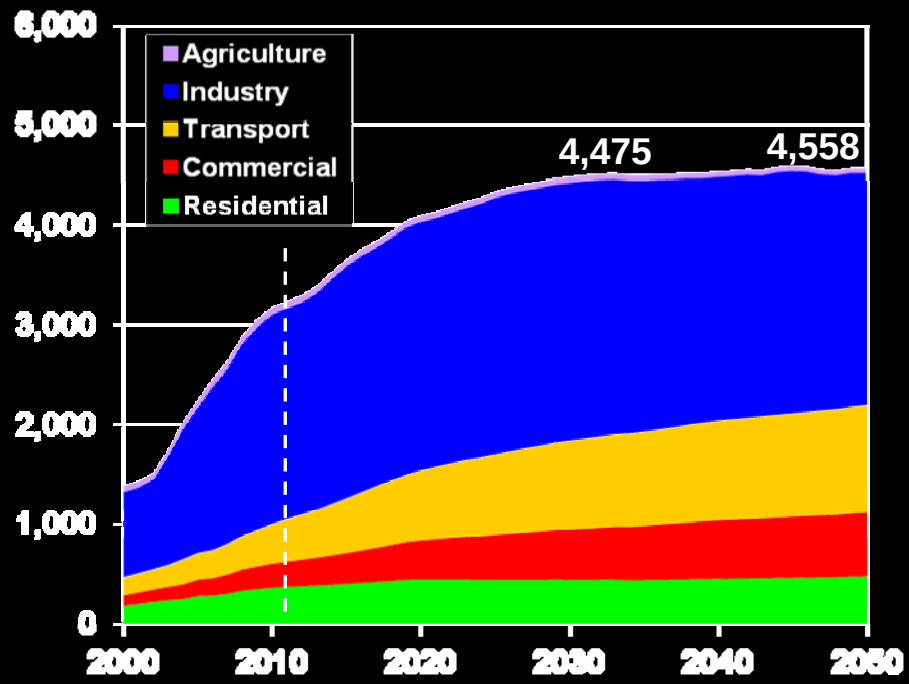


Total Primary Energy Use by Sector

Continued Improvement



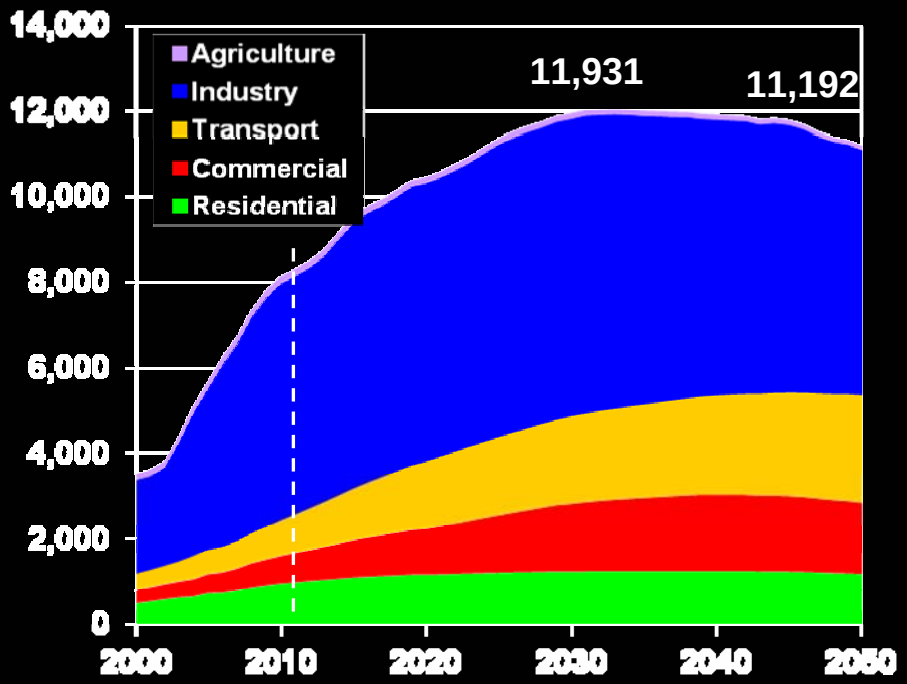
Accelerated Improvement



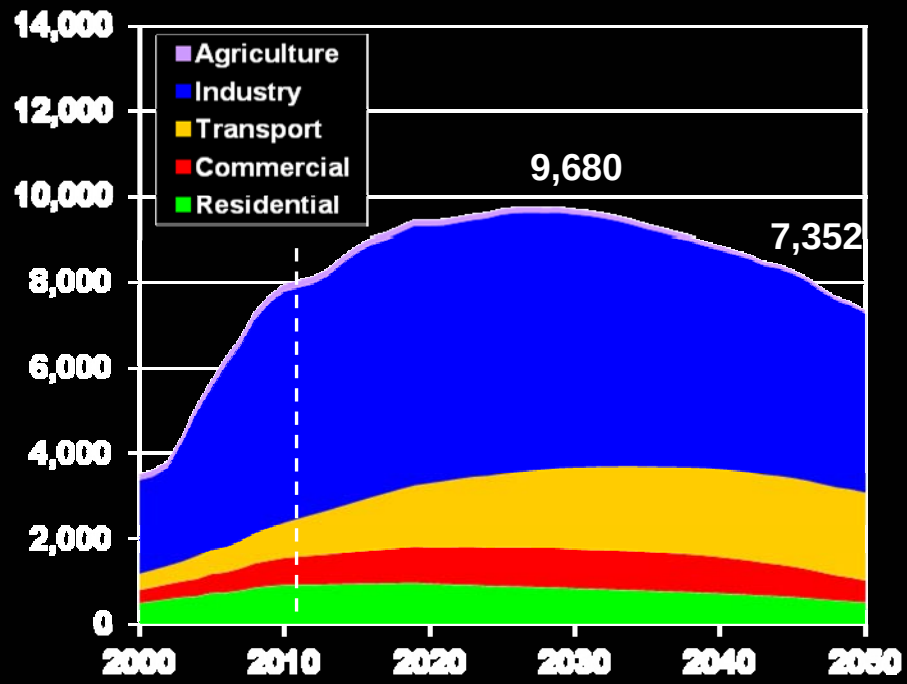
Primary Energy Use (Mtce)

Carbon Emissions Outlook for CIS and AIS Scenarios

Continued Improvement

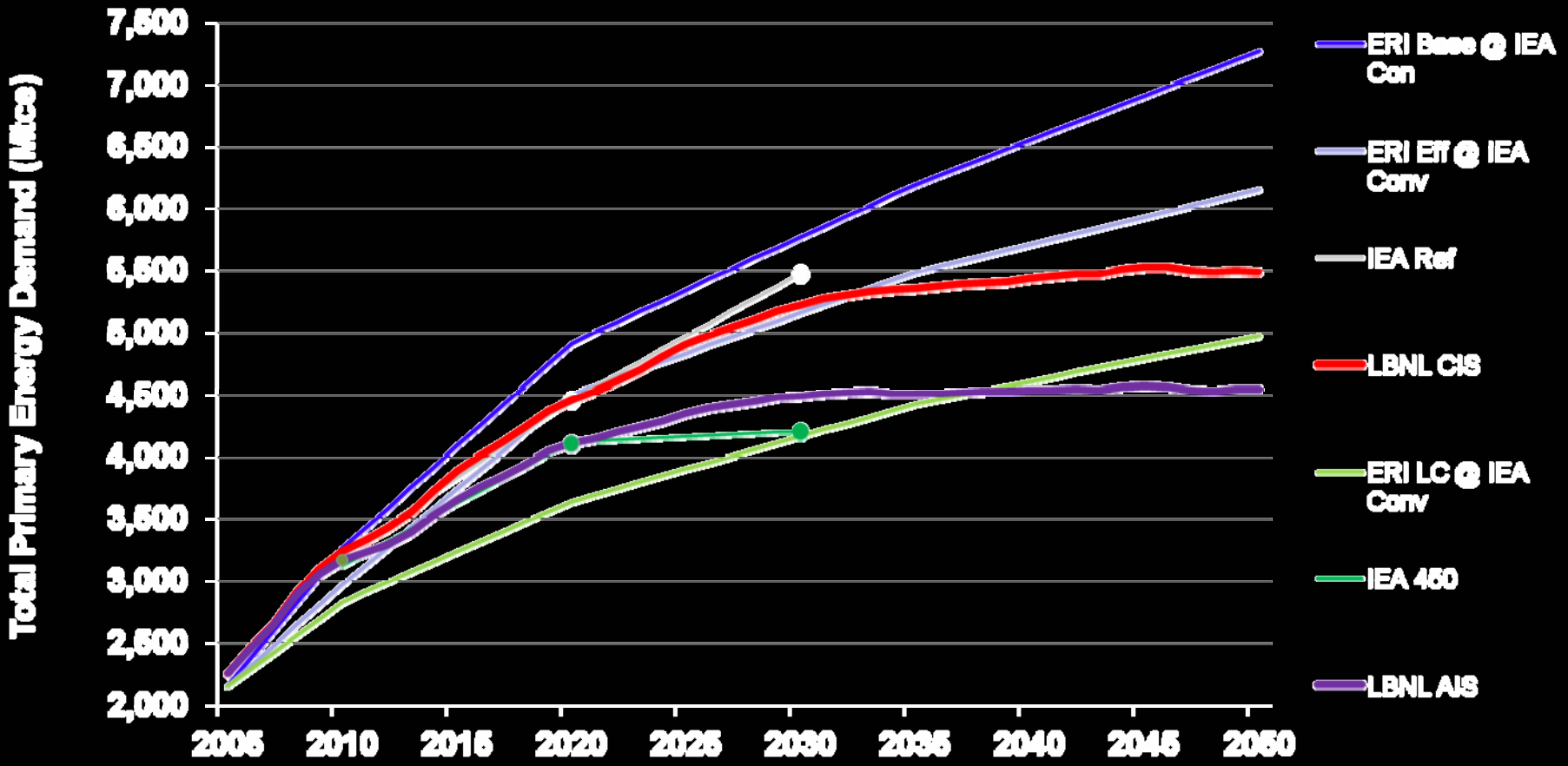


Accelerated Improvement



Mt CO2 Emissions

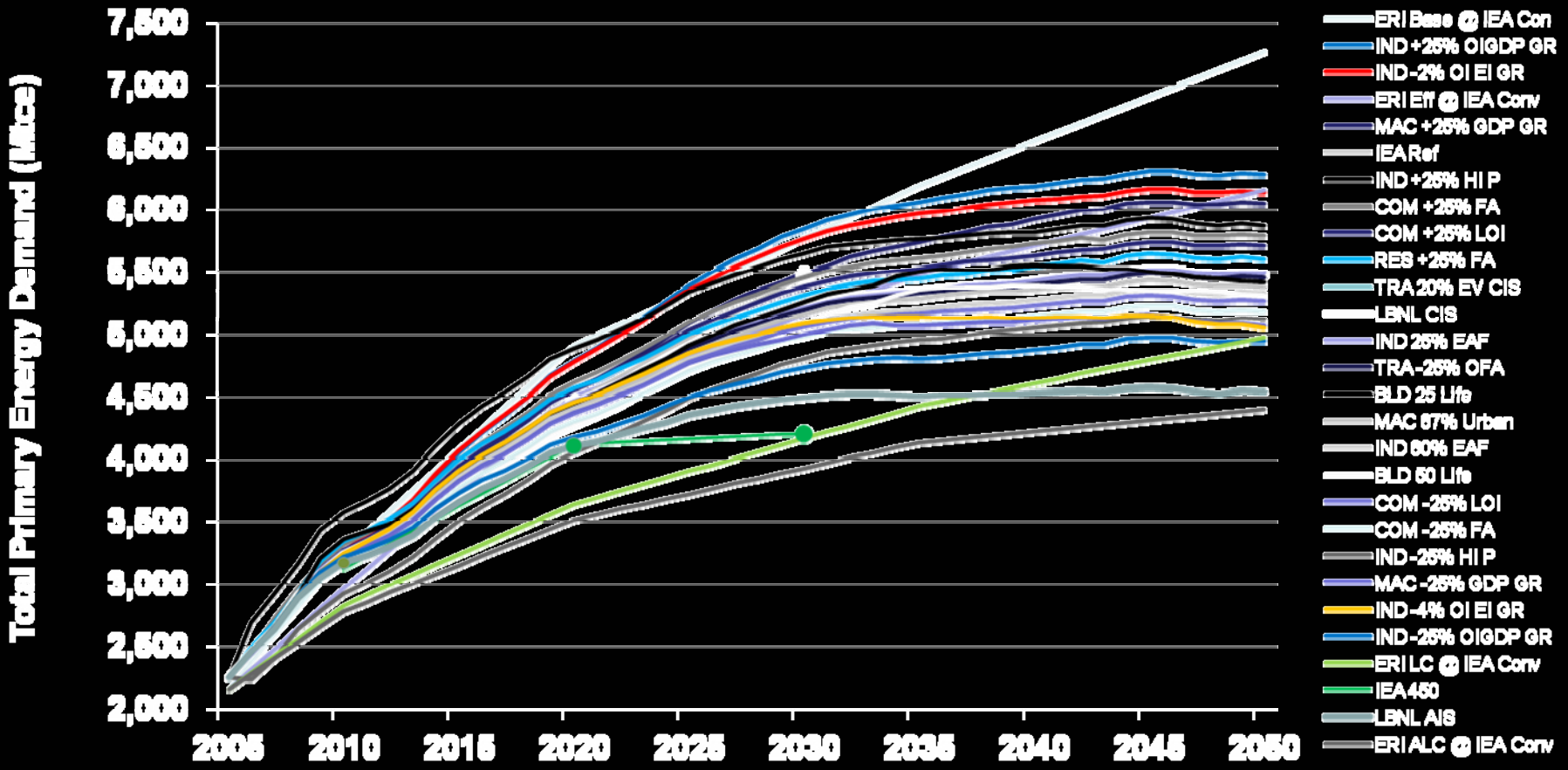
Total Primary Energy Use:
Comparison with Other Mainstream Analyses



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

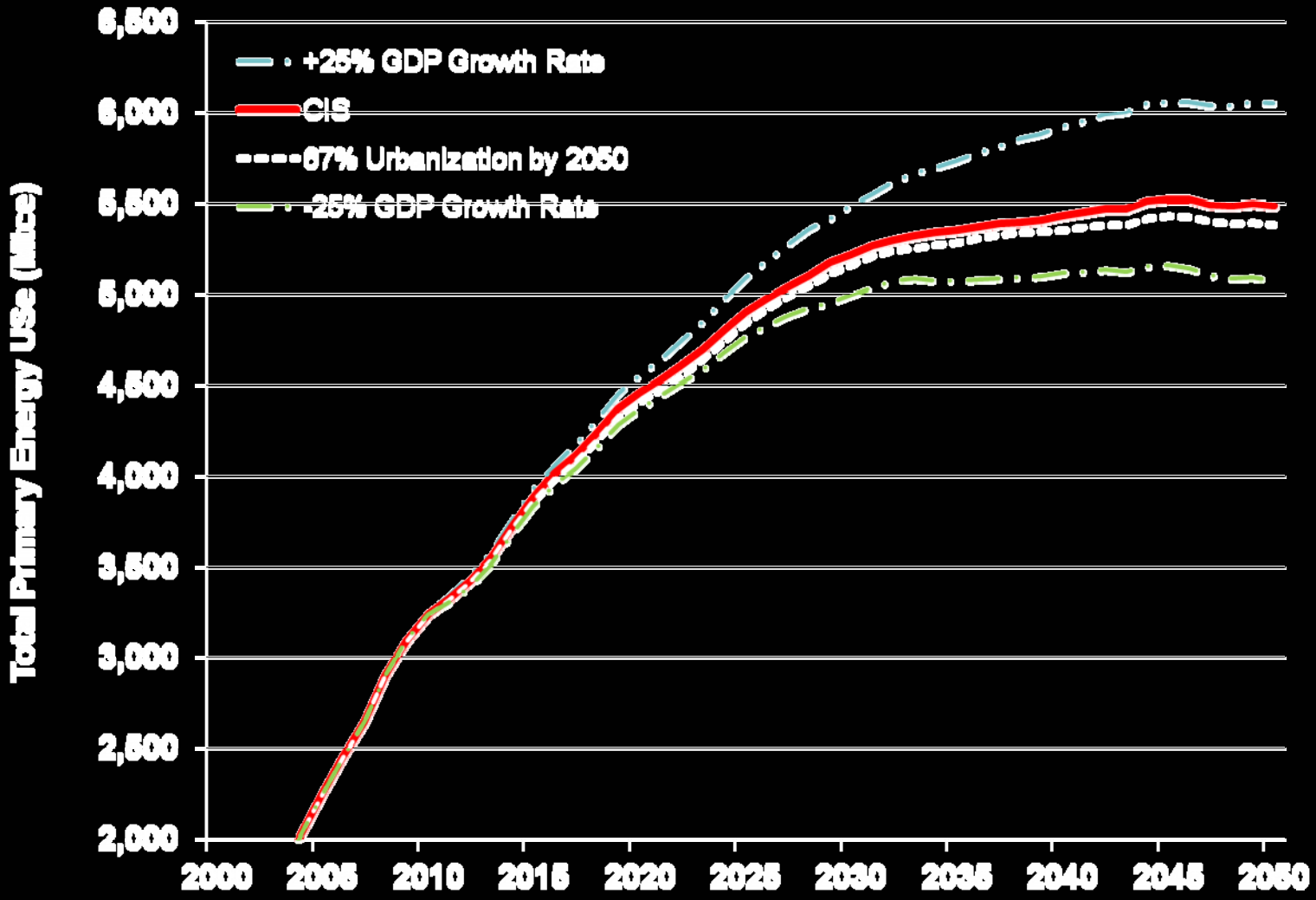
Sensitivity Analyses



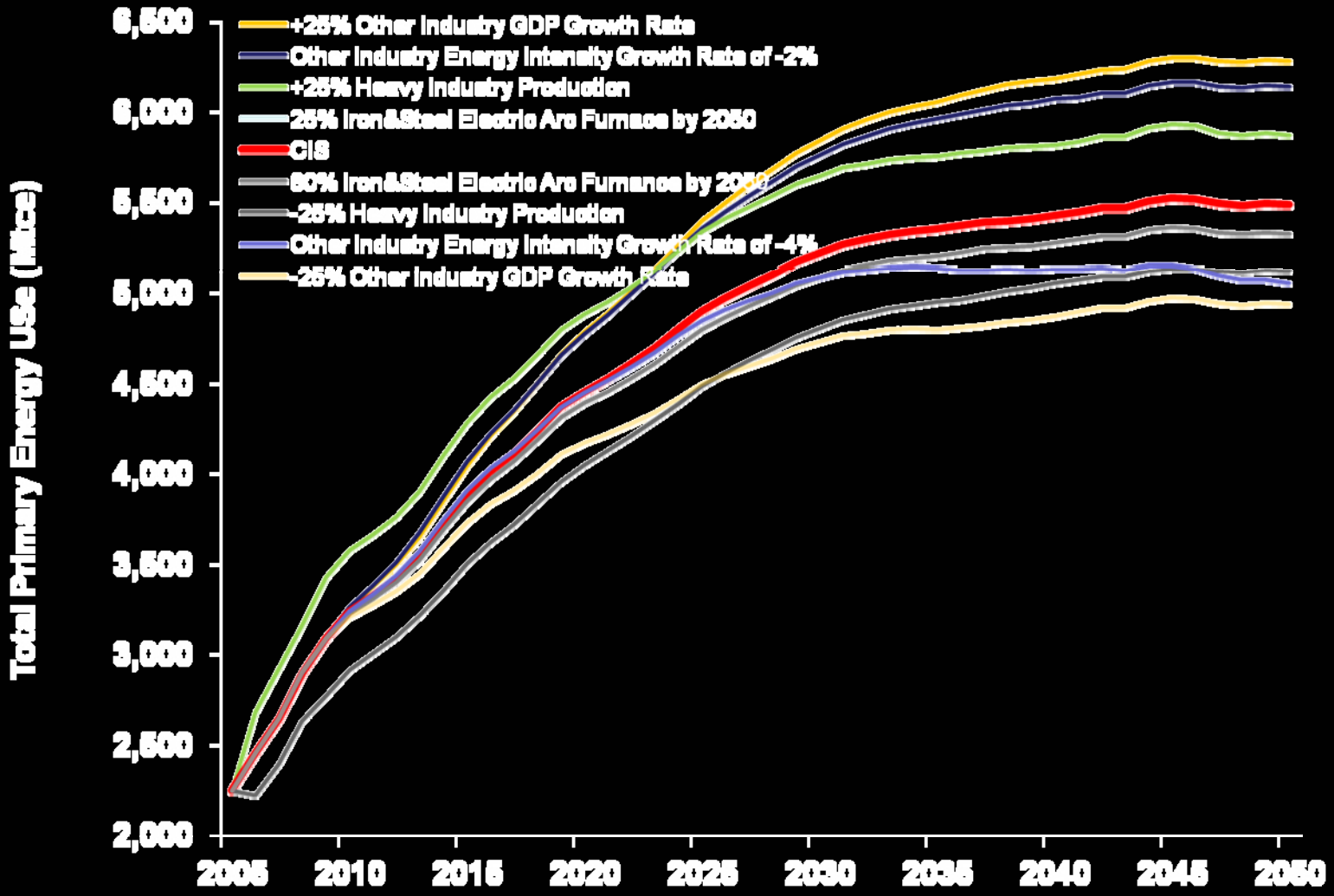
Note: Y-axis not scaled to 0.

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

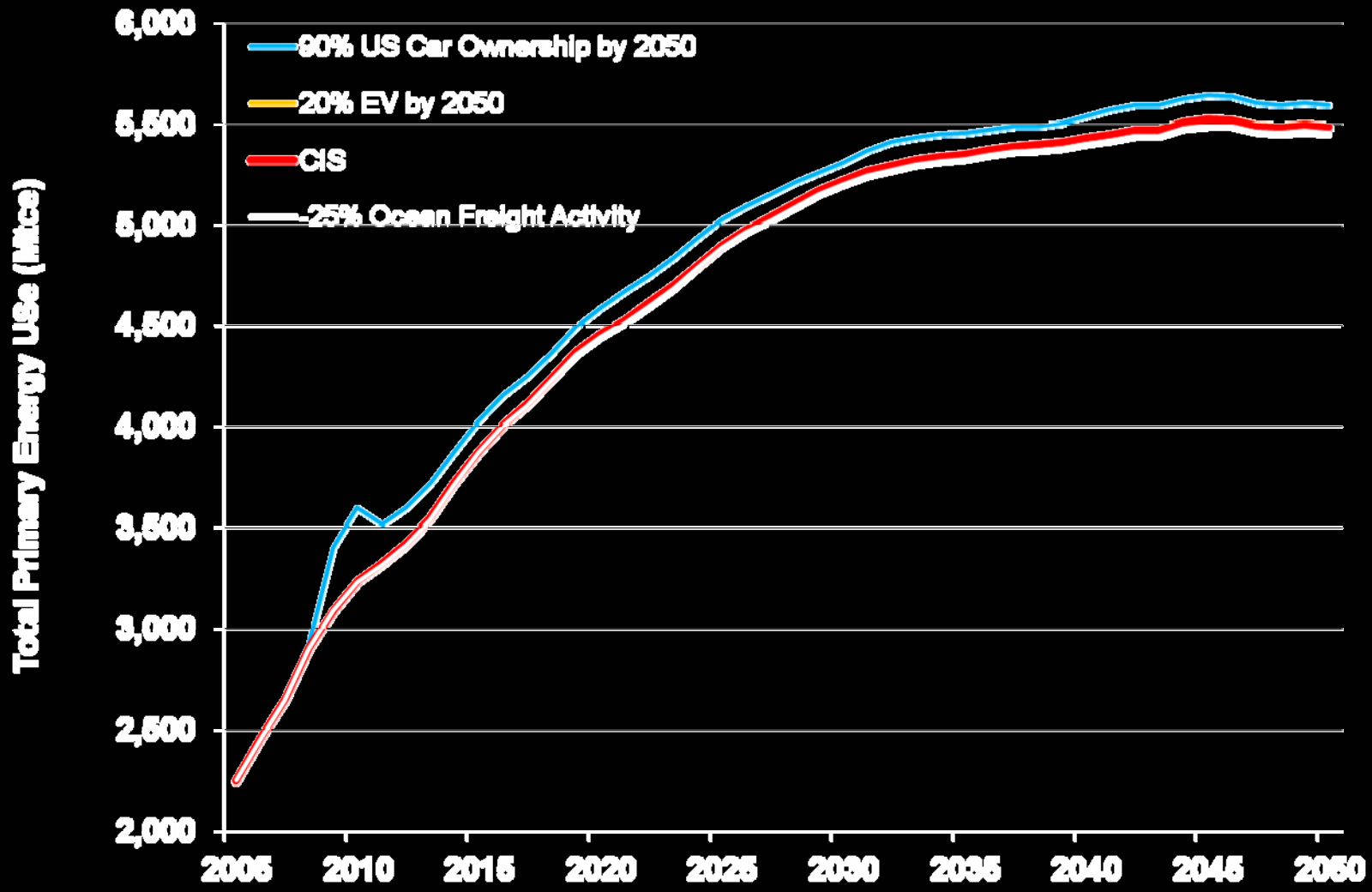
Sensitivity Analysis of Macroeconomic Drivers



Sensitivity Analysis of Industrial Energy Drivers



Sensitivity Analysis of Transport Energy Drivers



- **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, floor area, roadways, fertilizer use, etc. will saturate in the 2030 time frame**

- **Unless the Chinese develop a profligate lifestyle—modeling themselves on a certain country in North America—China will have leveled off in its CO_2 emissions at a much lower per capita level than the United States, Europe, or Japan!!**