China's Future Emissions: Perspectives from the Asian Modeling Exercise

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Presented to the 2011 EPRI Global Climate Change Research Seminar

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Office of Science U.S. DEPARTMENT OF ENERGY

Acknowledgements

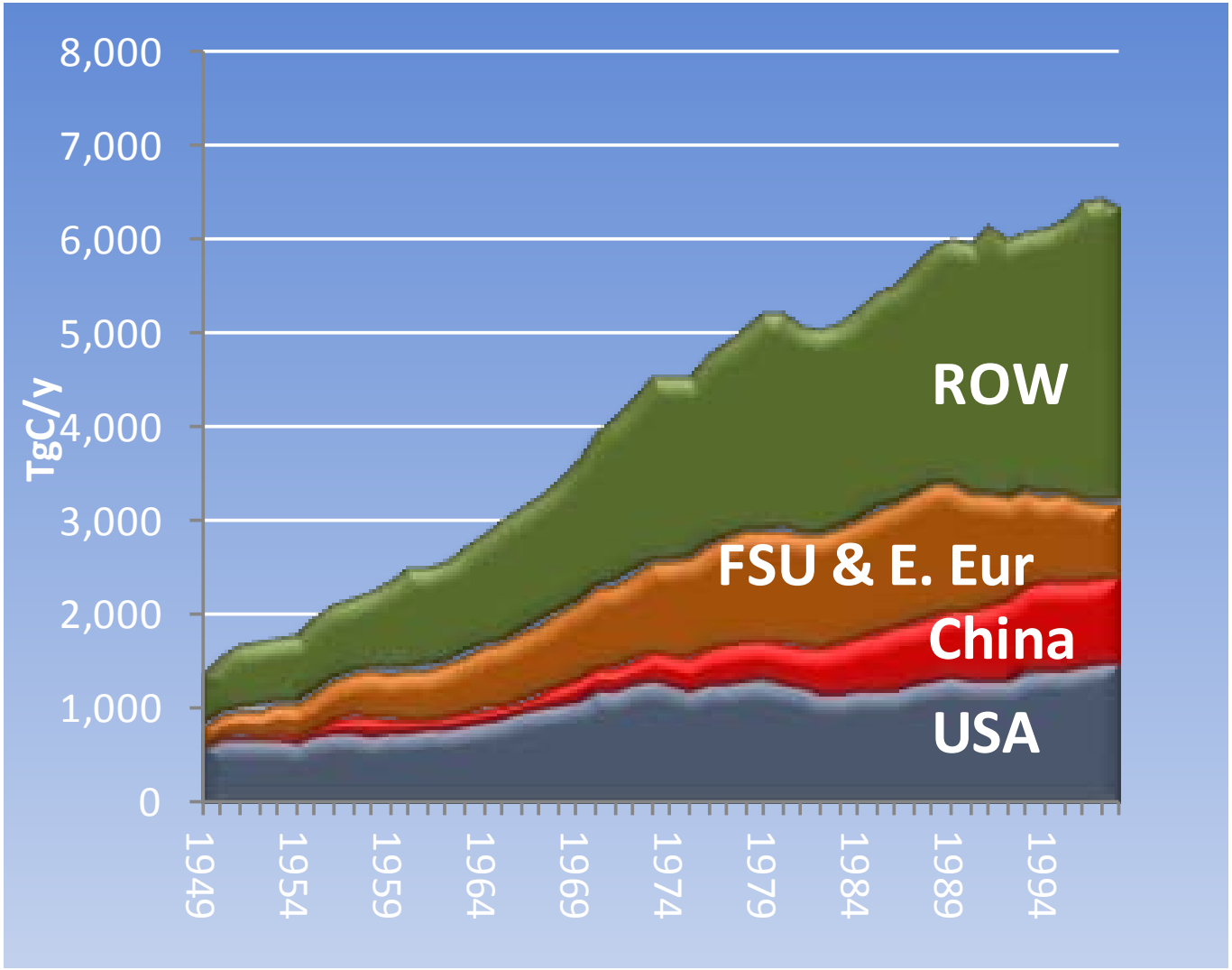
- Thanks to EPRI for long-term research support

- Thanks to Rich Richels for the invitation to present at this meeting.

Overview of the Presentation

- China's economic and emissions growth historically.
- Potential future Chinese emissions—from the perspective of GCAM.
- Importance of local air quality policy for climate change.

Fossil Fuel CO_2 Emissions in the Old Days



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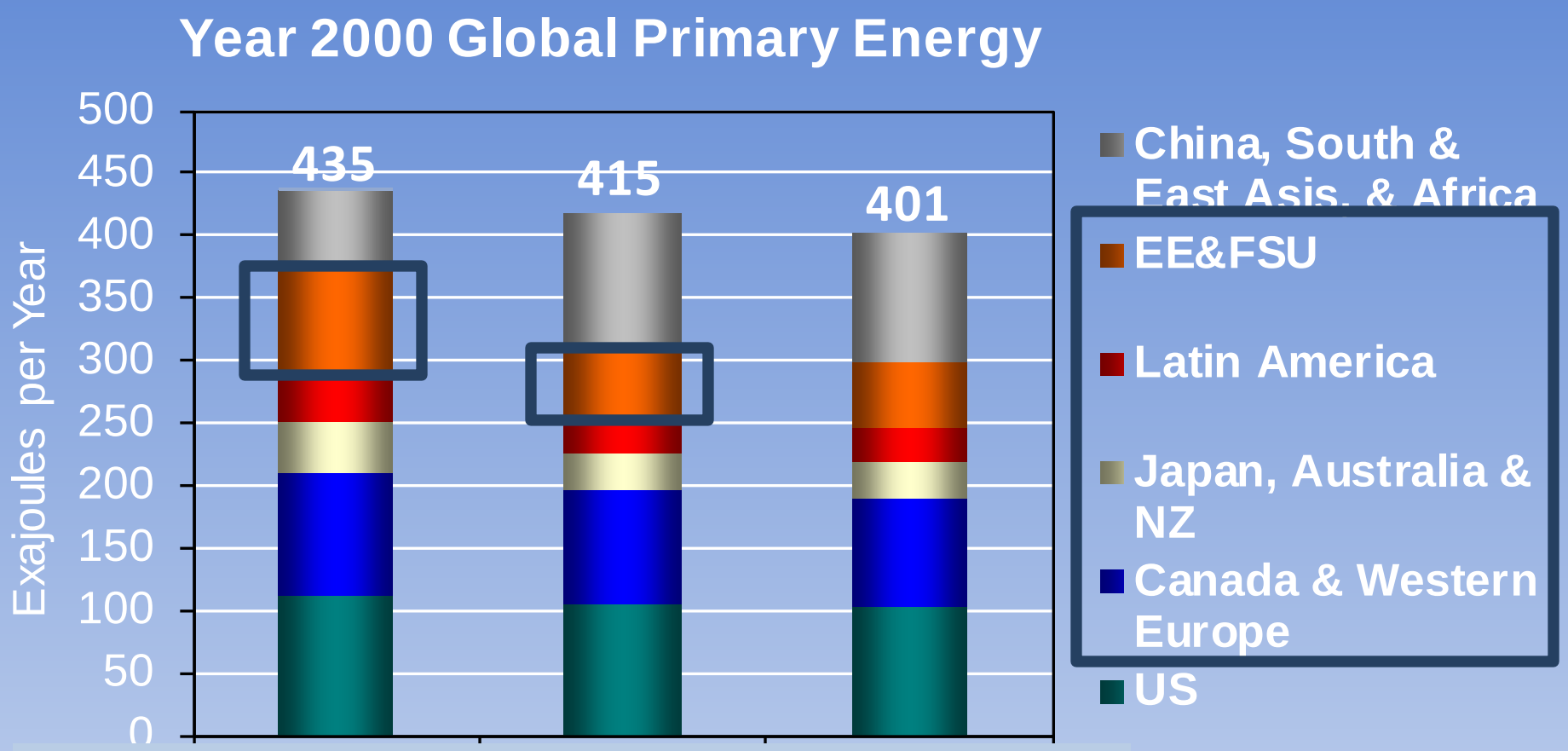
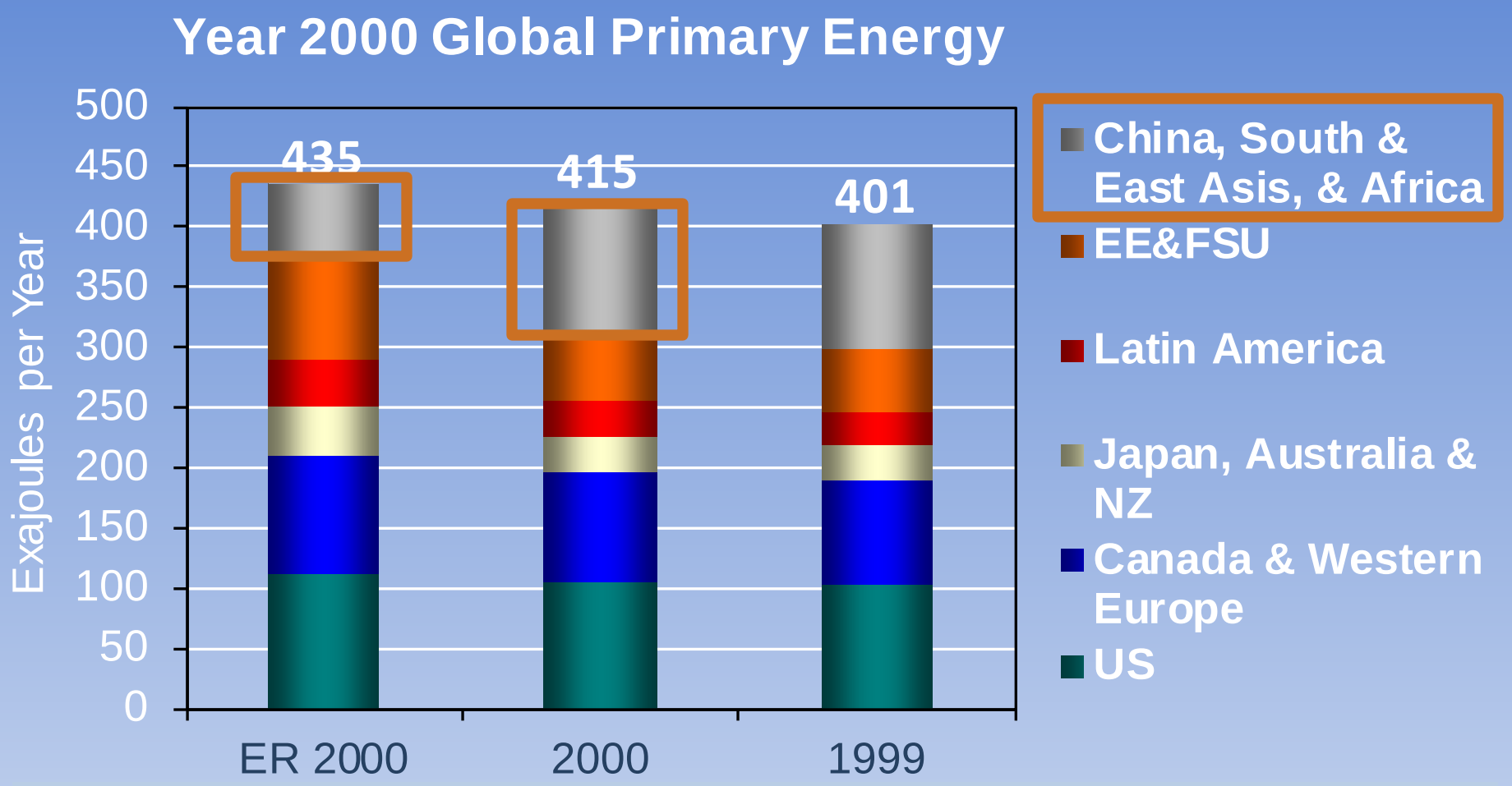
Retrospective of GCAM scenarios



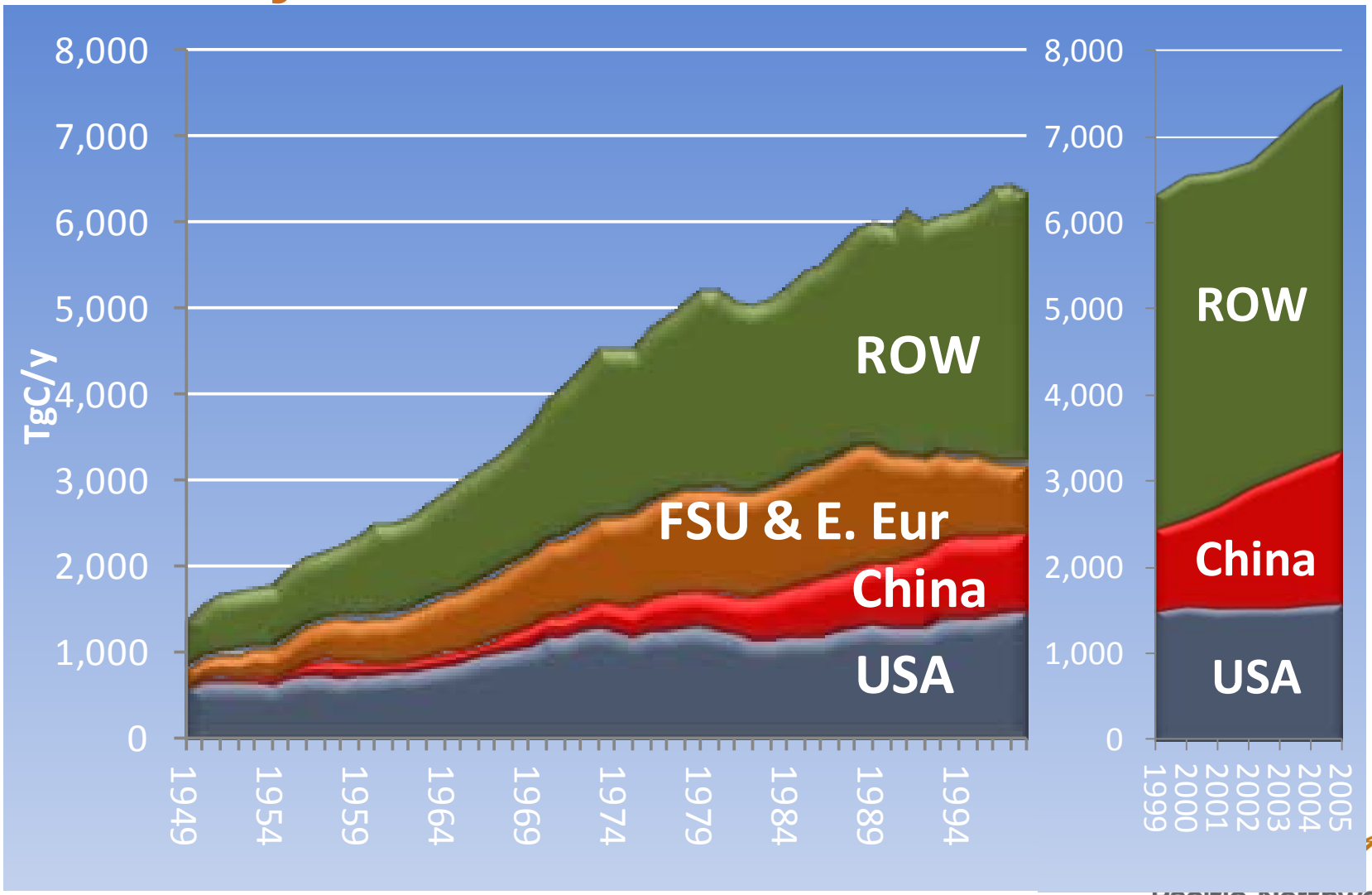
We generally overestimated growth in the OECD and completely failed to foresee the collapse of the Soviet Union

Estimating energy and economic growth in China is a long-standing problem.



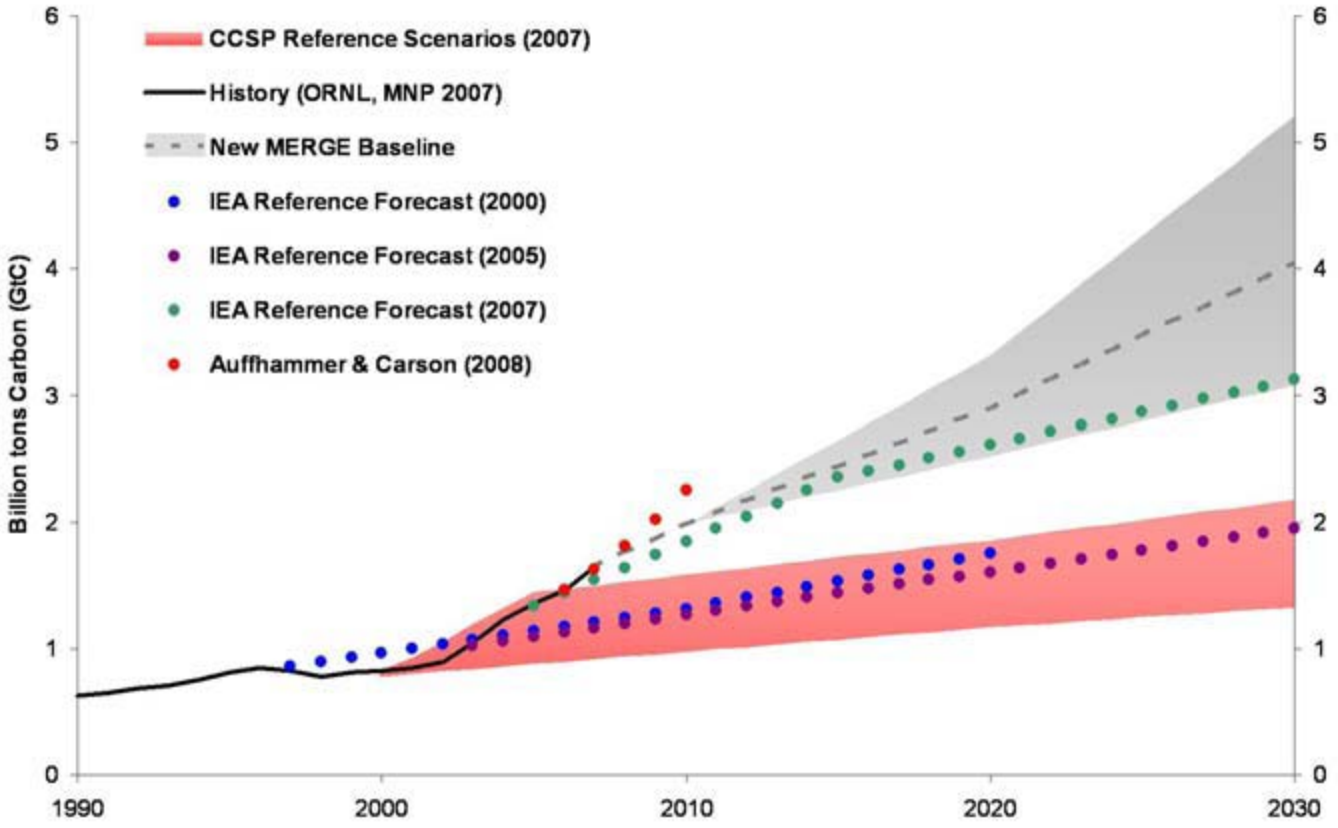
We grossly underestimated economic growth in China.

Fossil Fuel CO_2 Emissions in the Old Days ... And Today



The Importance of a China Focus

- Blanford, Richels & Rutherford showed how much expectations of future Chinese emissions have changed.



The Asia Modeling Exercise

To better articulate the role of Asia in addressing climate change.

- **Kate Calvin has lead the exercise.**
- **Over 50 People are Attending the Fourth Meeting:**
  - Representing Australia, China, Europe, India, Japan, Korea, Nepal, Thailand, USA
- **26 Participating Models:**
  - *AIM-CGE, AIM-Enduse, China MARKAL, DNE21+, EPPA, GCAM, GCAM-IIM, GEM-E3, GRAPE, GTEM, IAMC, IMAGE, IPAC, iPETS, KEI-Linkages, MARIA-23, MERGE, MESSAGE, Nepal MARKAL, PECE, Phoenix, POLES, REMIND, TIAM-World, TIMES-VTT, WITCH*

The CPO Project

EMF

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY

EPRI ELECTRIC POWER RESEARCH INSTITUTE

ERI www.eri.org.cn

KEI 한국환경정책·평가연구원

NIES

Pacific Northwest NATIONAL LABORATORY

清华大学能源环境经济研究所 INSTITUTE of ENERGY, ENVIRONMENT and ECONOMY TSINGHUA UNIVERSITY

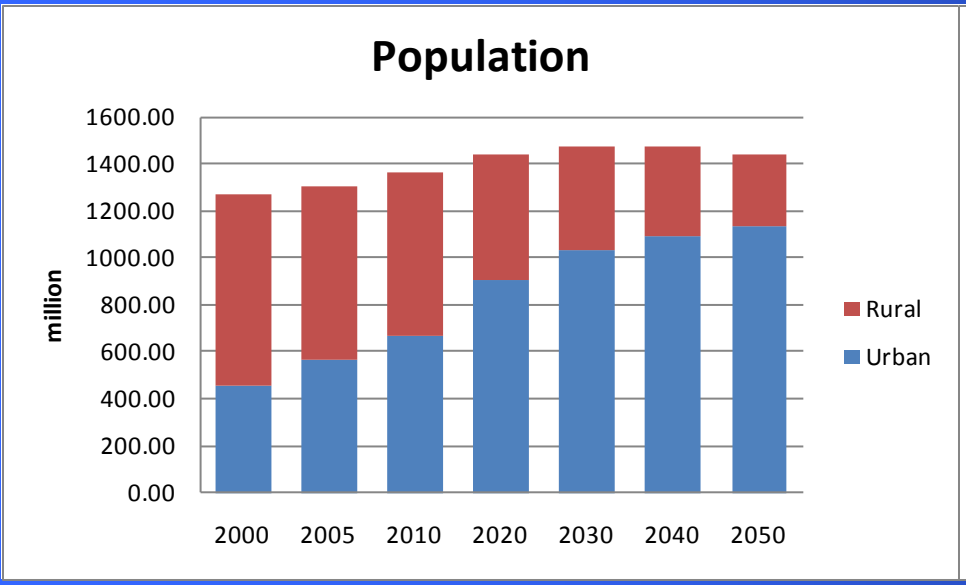
The Asia Modeling Exercise

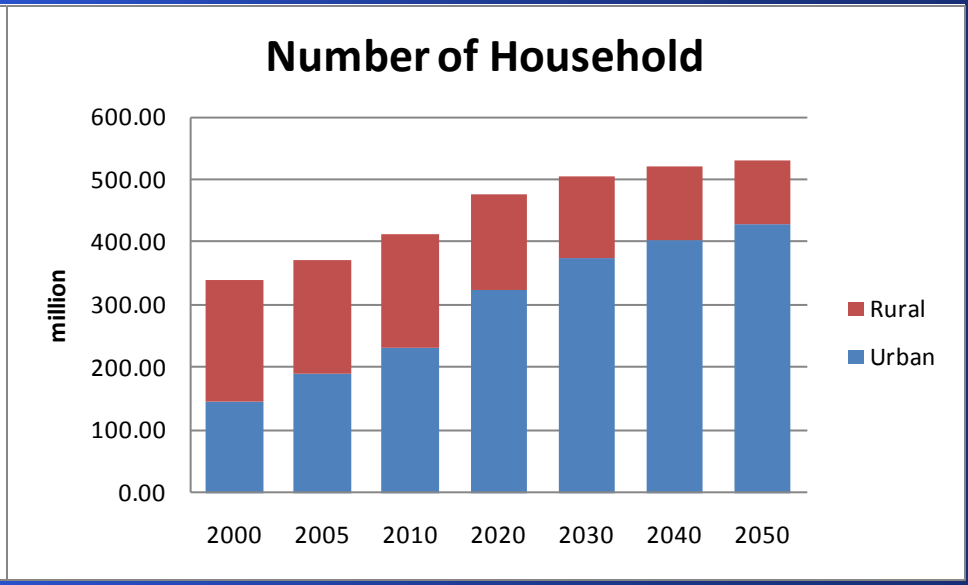
- **Some emerging observations**
- **Data is a big issue—history is uncertain**
- **Modelers exhibit a variety of definitions for "China"**
  - **China 22 vs. China 23**
  - **China bundled with other countries**
- **To say nothing of the variety of future scenarios that the modelers have developed.**

AN UNCERTAIN FUTURE

Population

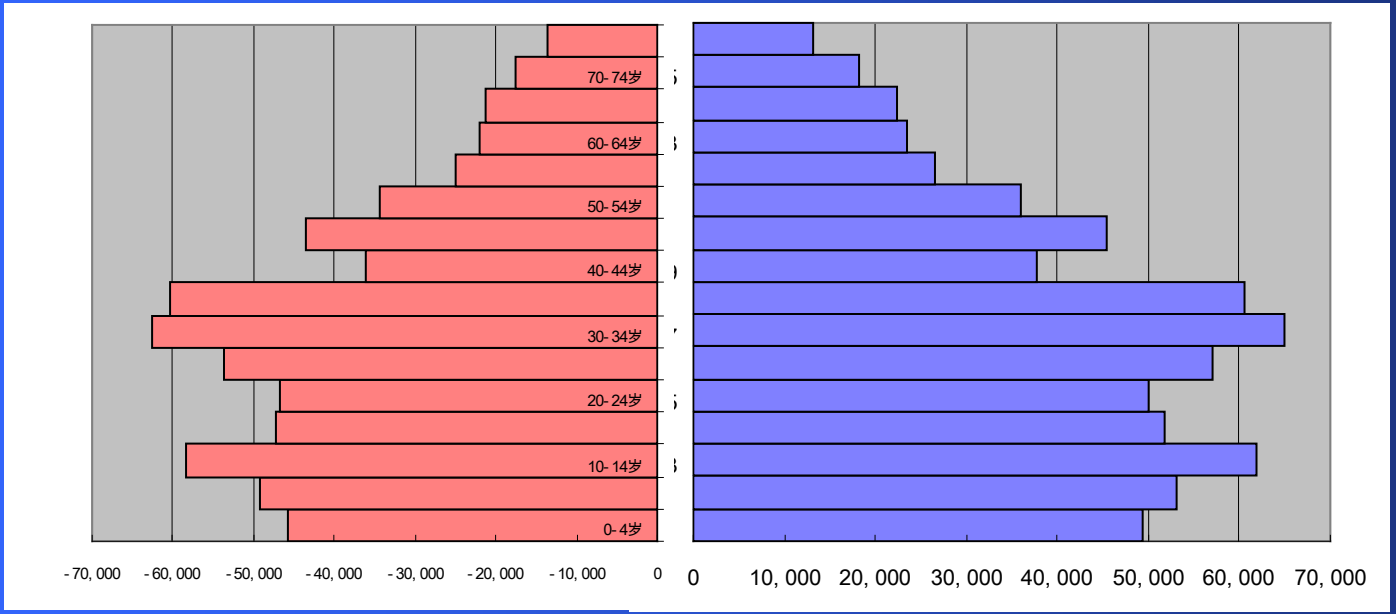
	2005	2010	2020	2030	2040	2050
Population	1307.56	1360.00	1440.00	1470.00	1470.00	1440.00
Urbanization rate	43%	49%	63%	70%	74%	79%
Urban Population	562.12	666.40	907.20	1029.00	1087.80	1137.60
Person per Household	2.96	2.88	2.80	2.75	2.70	2.65
Urban Household	189.91	221.94	288.00	336.76	364.78	380.38
Rural Population	745.44	693.60	532.80	441.00	382.20	302.40
Person per Household	4.08	3.80	3.50	3.40	3.20	3.00
Rural Household	182.71	189.68	181.03	159.97	151.59	144.00



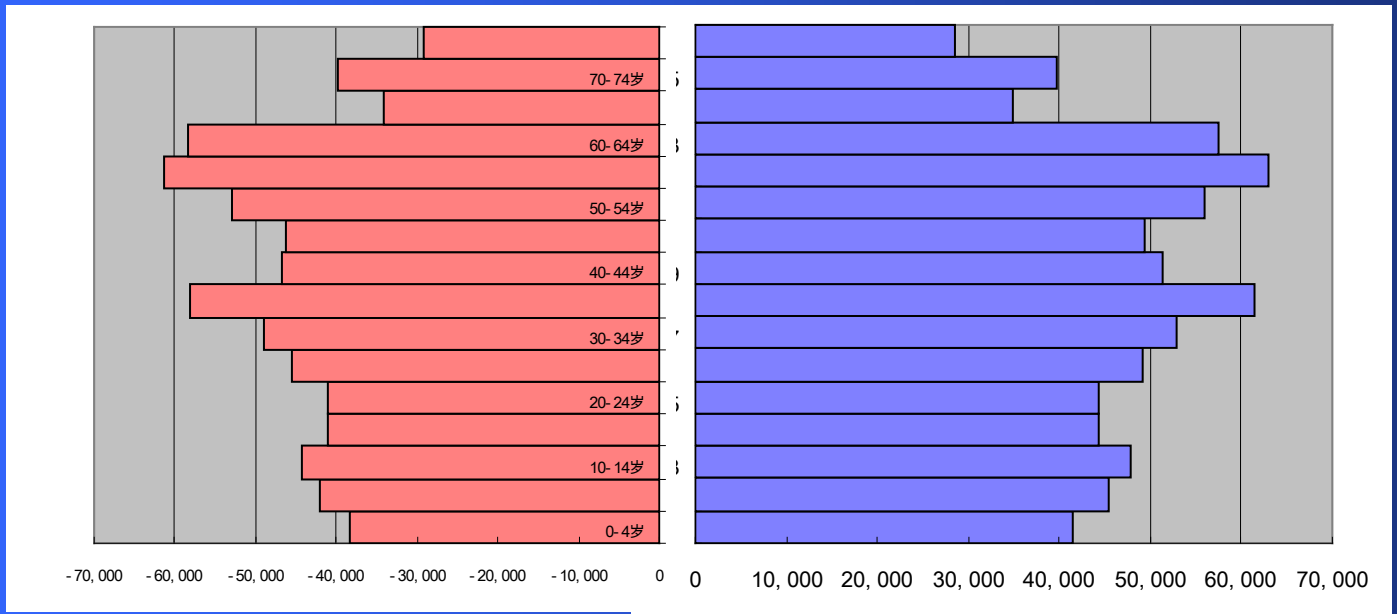


Courtesy Jiang Kejun

2005年人口结构

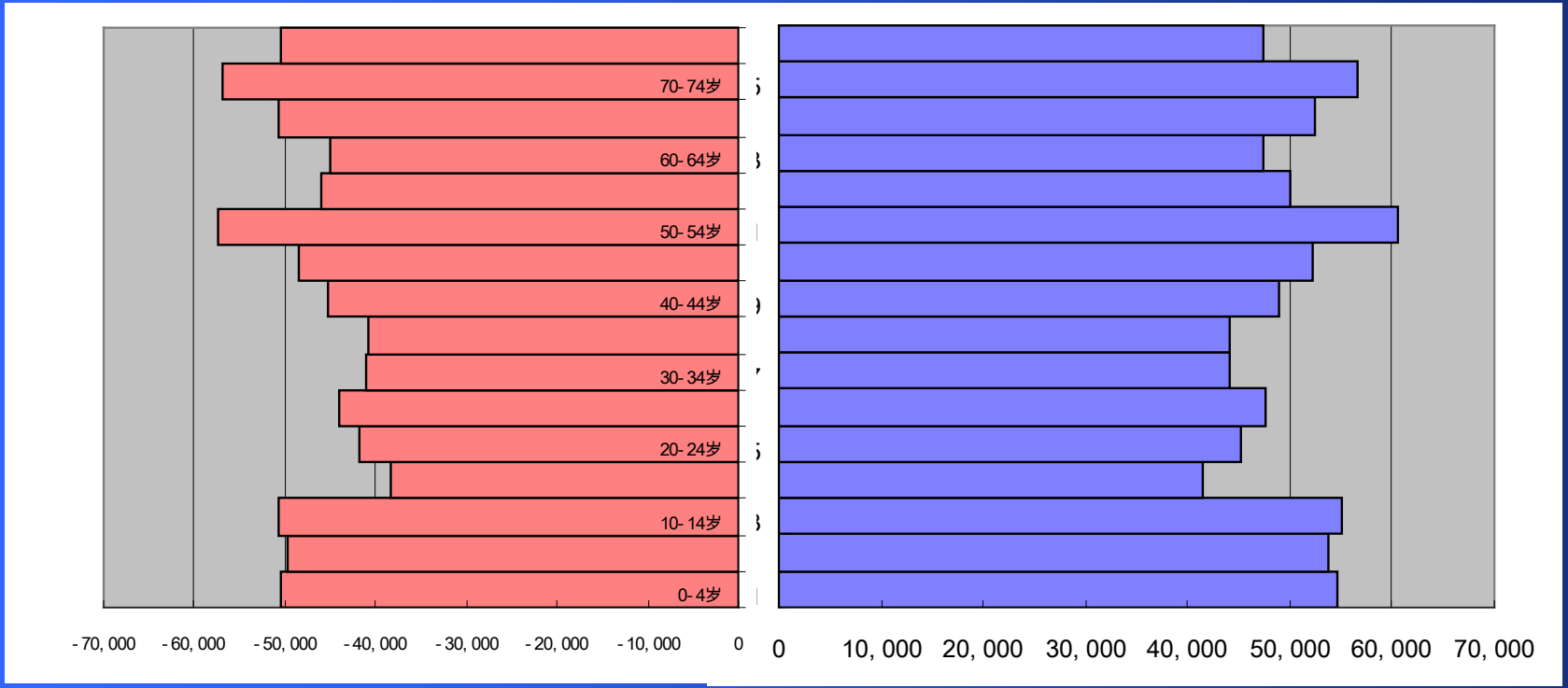


2030年人口结构



Courtesy
Jiang Kejun

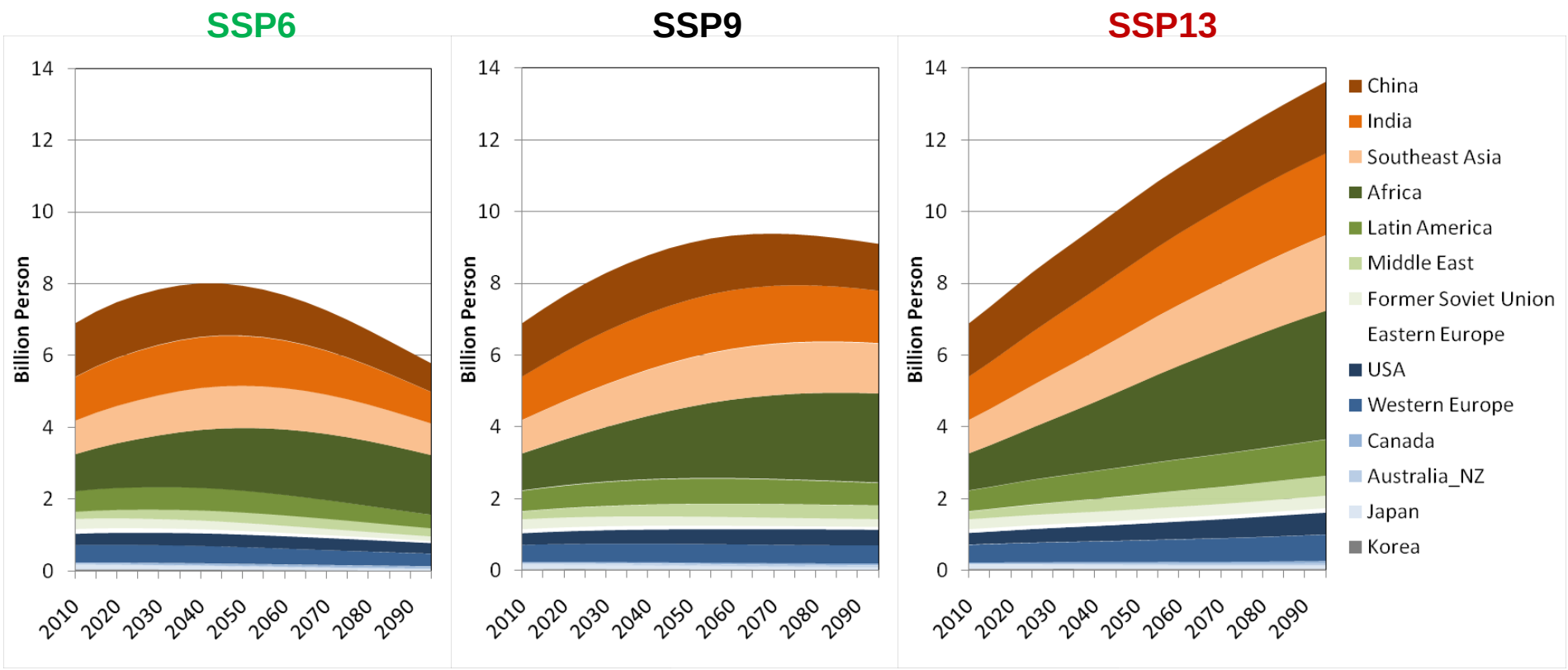
2050年人口结构



Courtesy Jiang Kejun

Populations for the SSPs [billion]

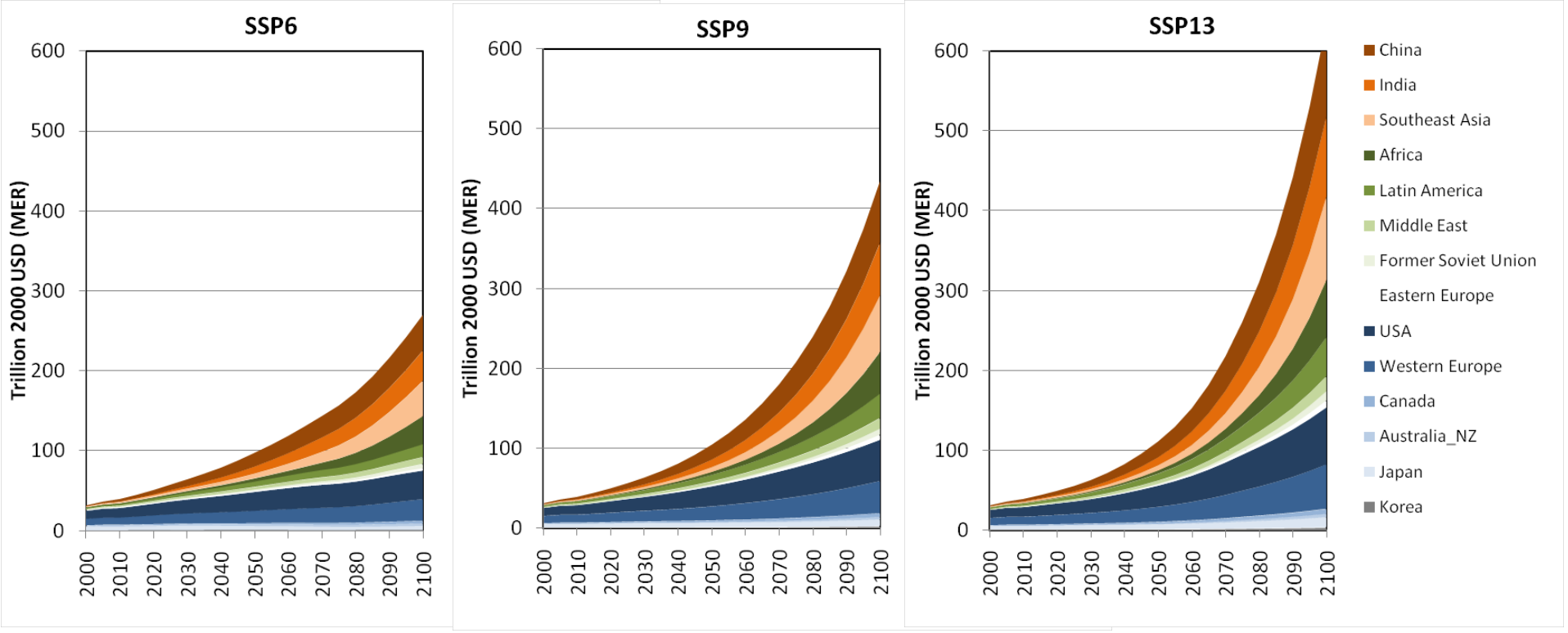
Global



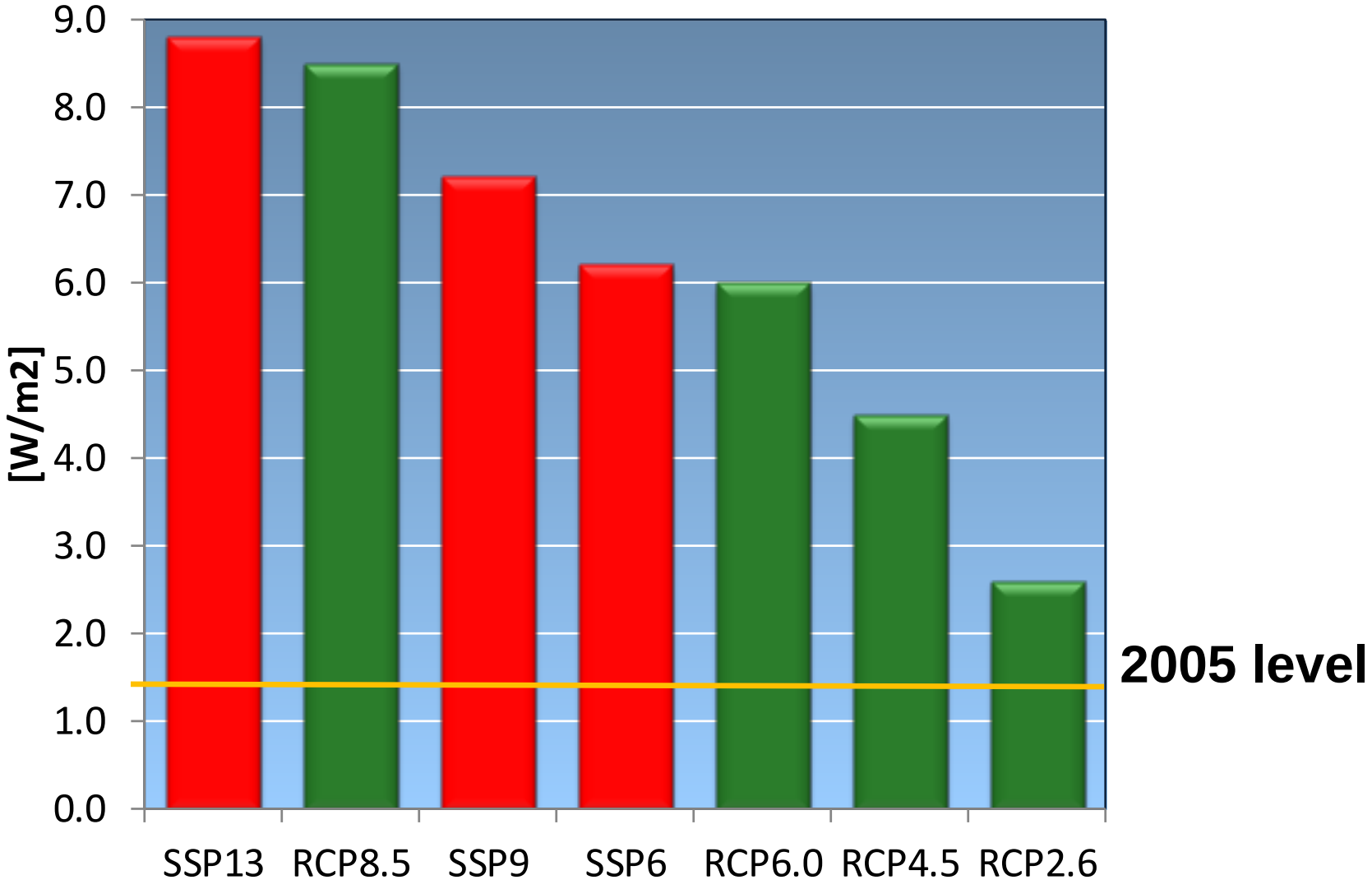
(Based on UN World Population Prospects: The 2008 Revision – Long Range Projections, released in 2011)

Constructed GDP Scenarios [trillion 2000 USD]

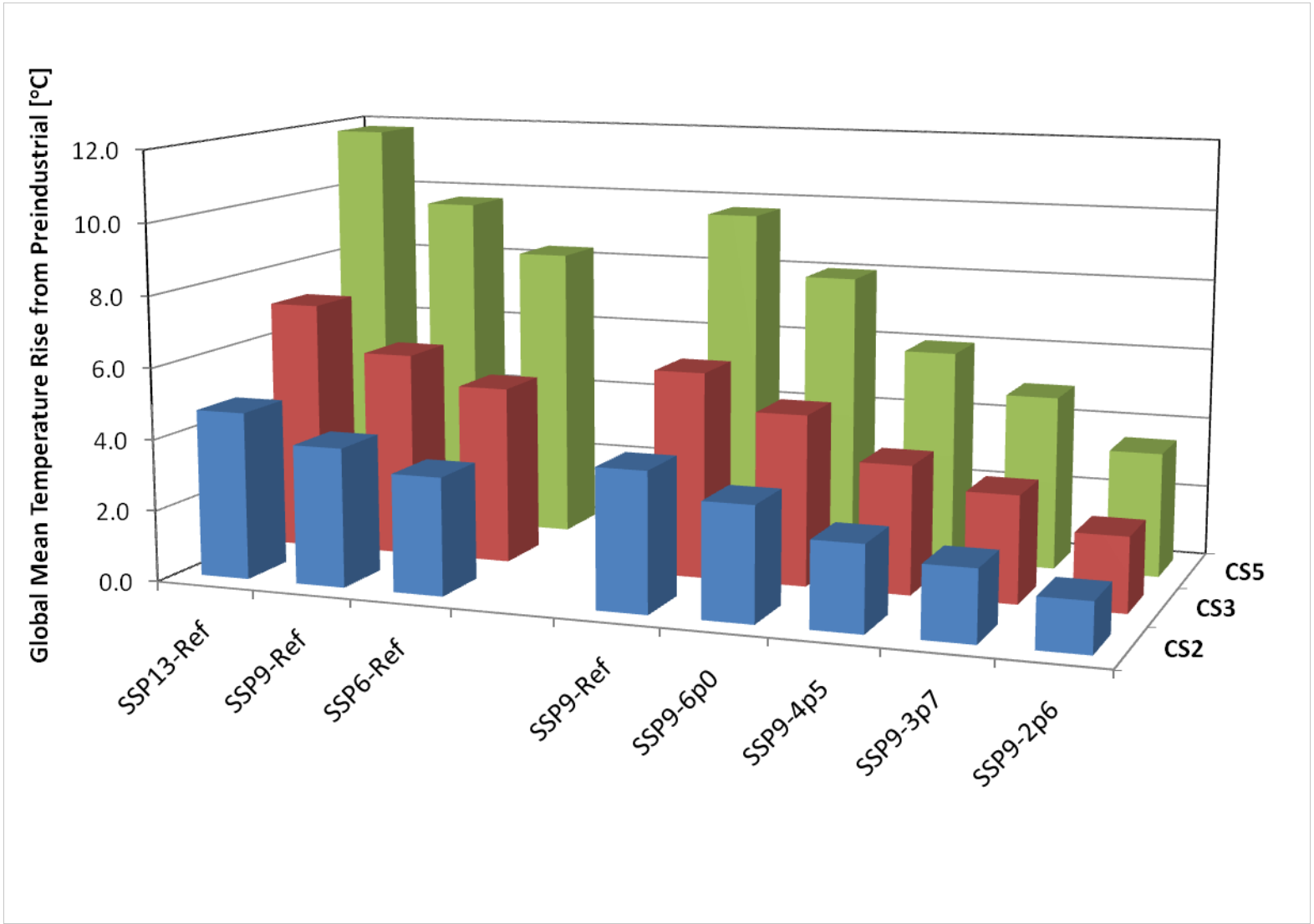
Global



Reference Scenario 2100 Radiative Forcing



Jae, these are updated global temperature figures that you might want to use.



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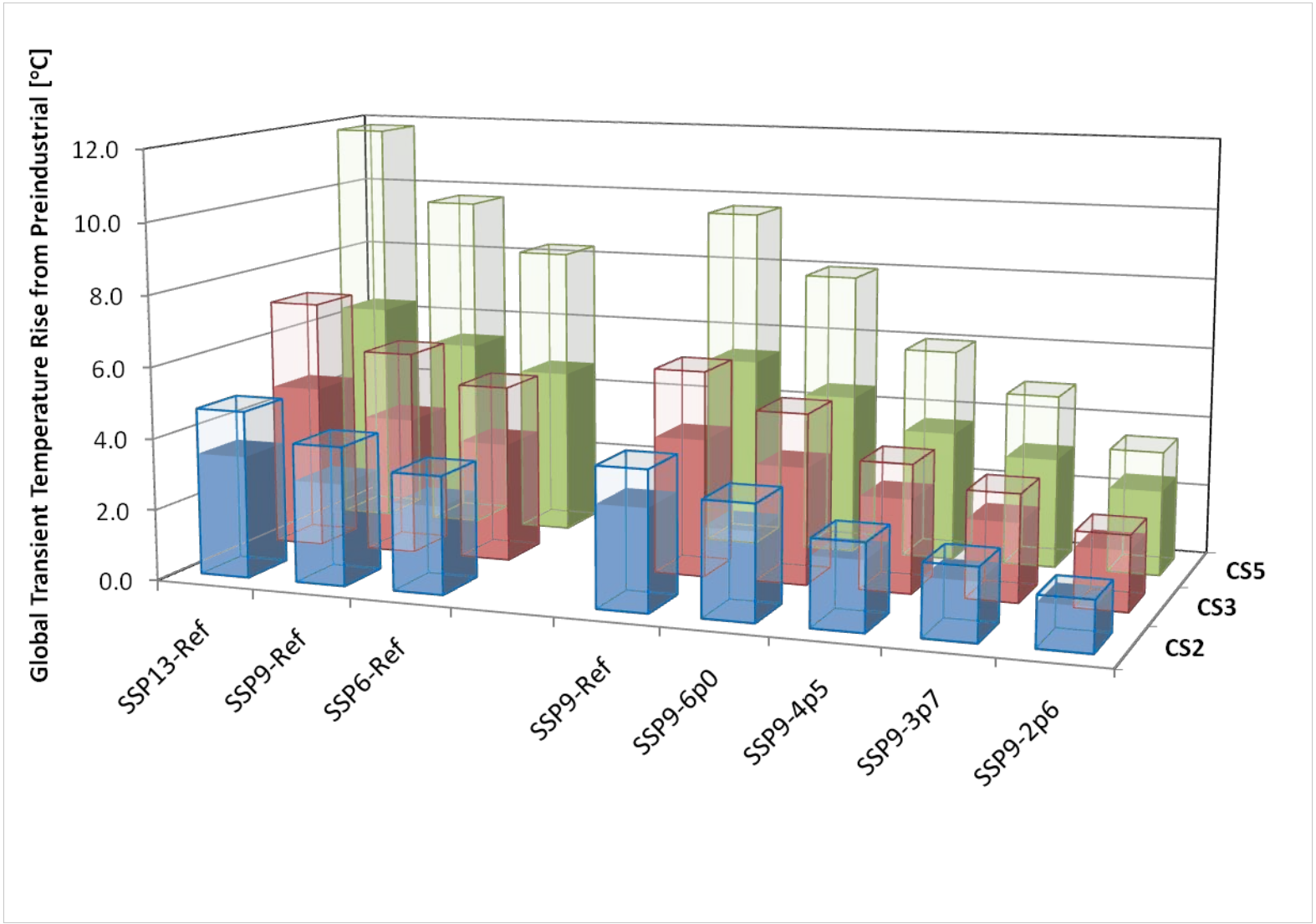
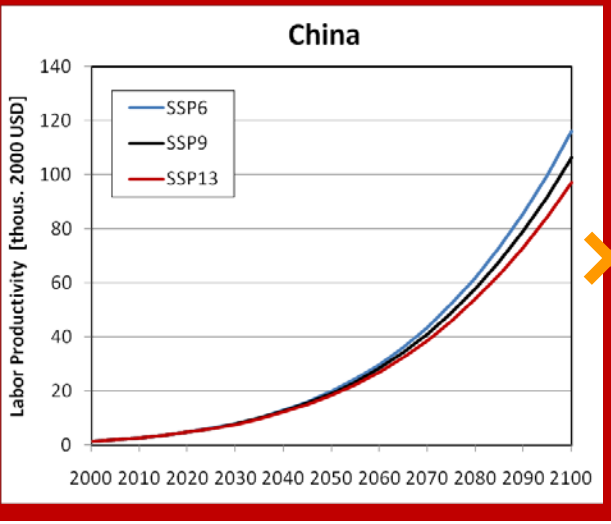


Per capita GDP in China

- Per capita GDP = labor productivity × employed labor force *(work-age population times labor force participation rates x employment rate)*
- Per capita GDP in SSP9 becomes the highest because of the two competing effects: labor productivity vs. demographic composition

Labor productivity



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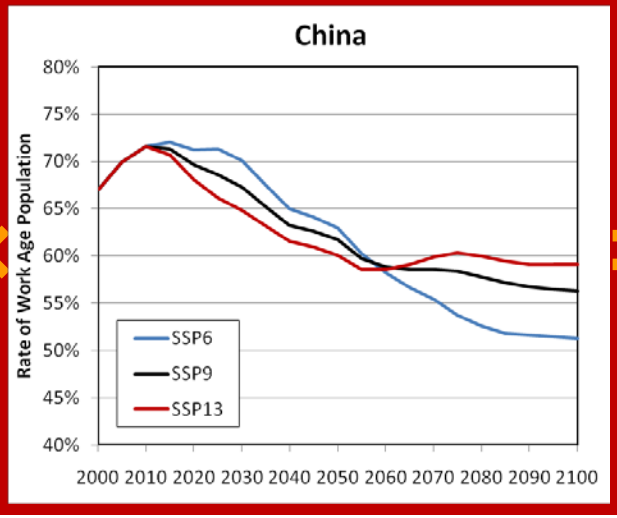
Employed labor force



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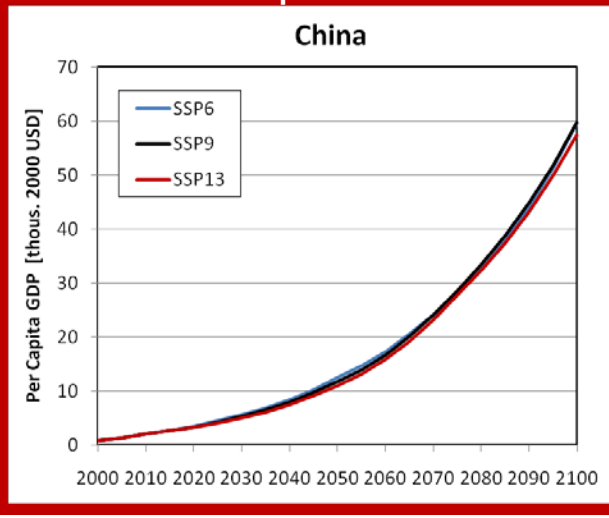
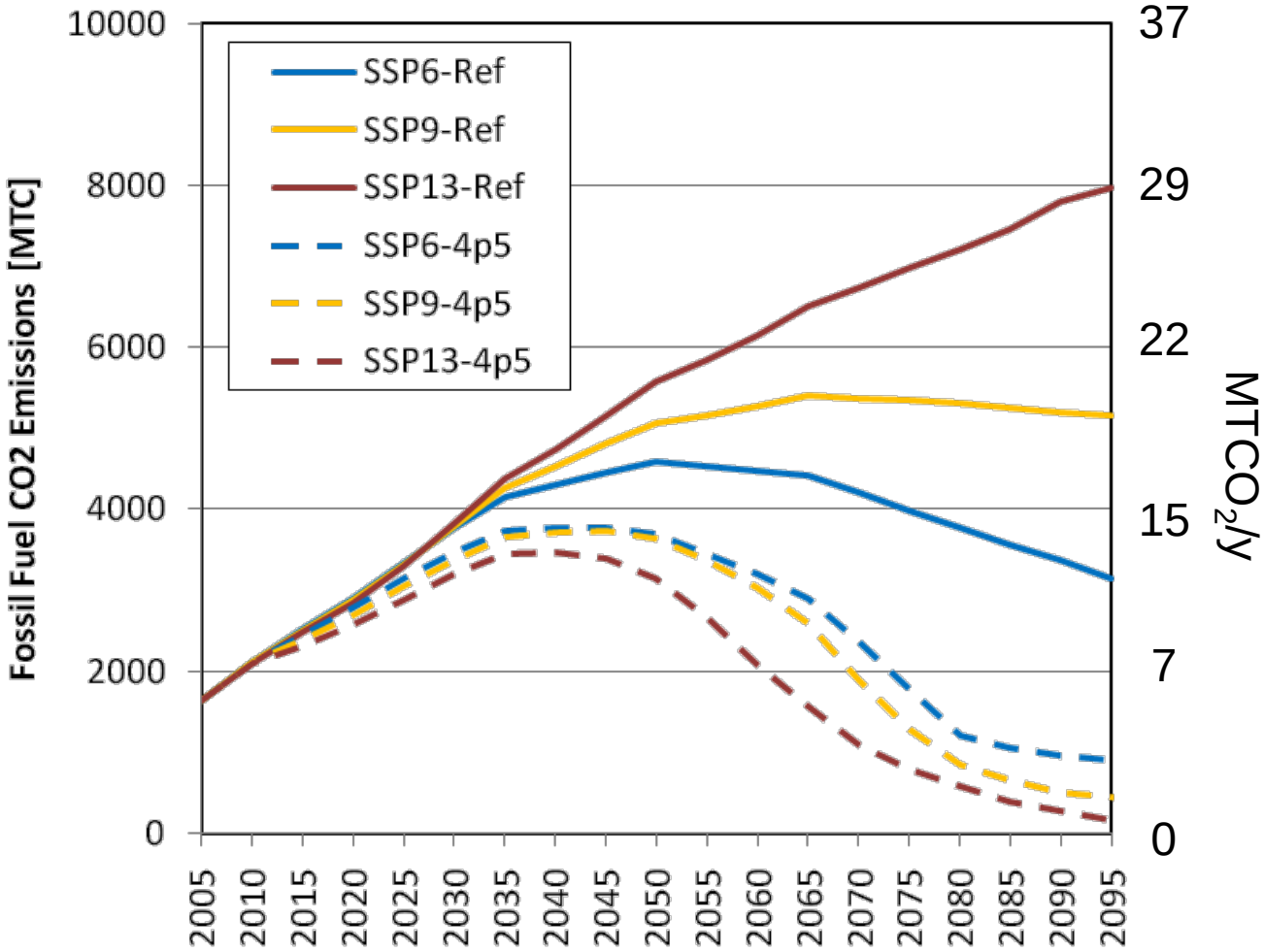
Per capita GDP

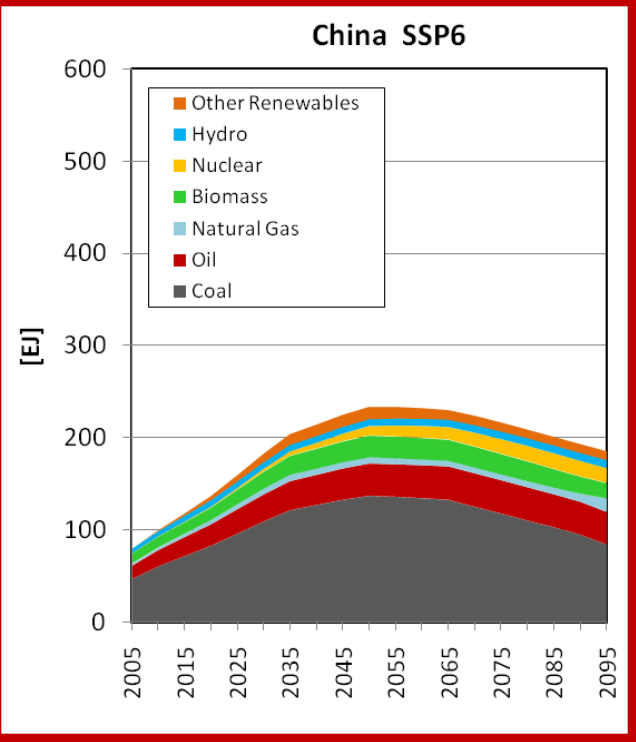


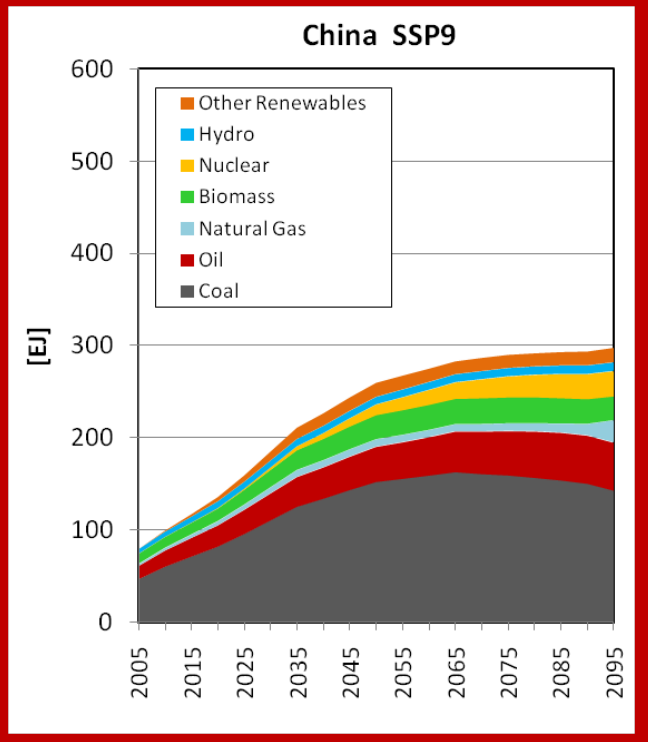
Fossil Fuel CO_2 Emissions in China

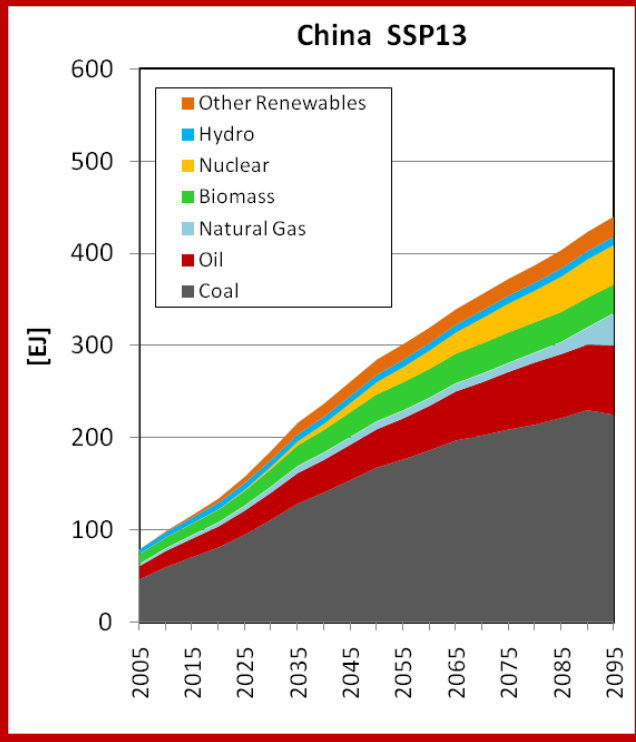


China's Primary Energy Consumption [EJ]: Reference Scenarios

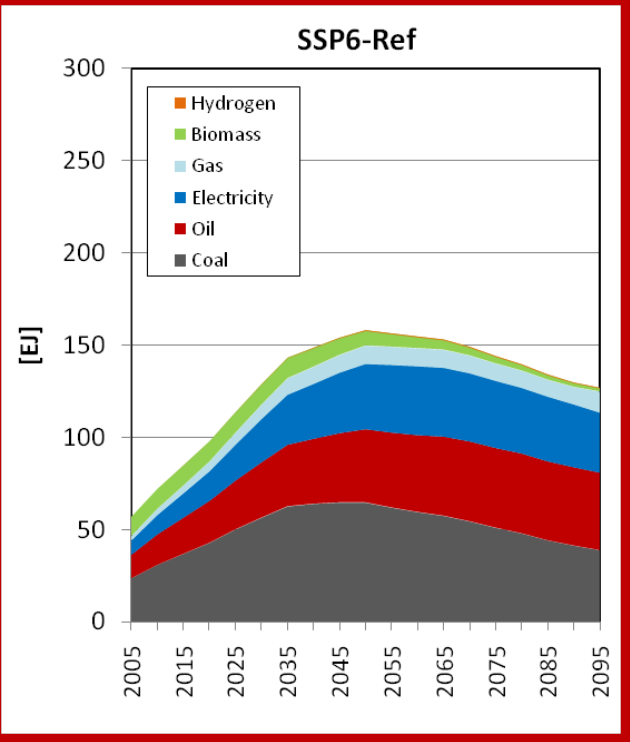
- Coal remains important regardless of the alternative SSPs.

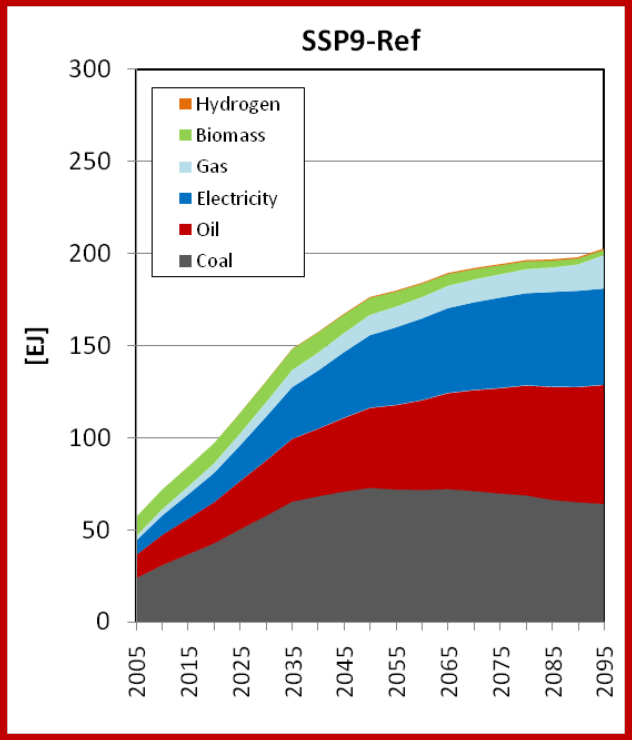


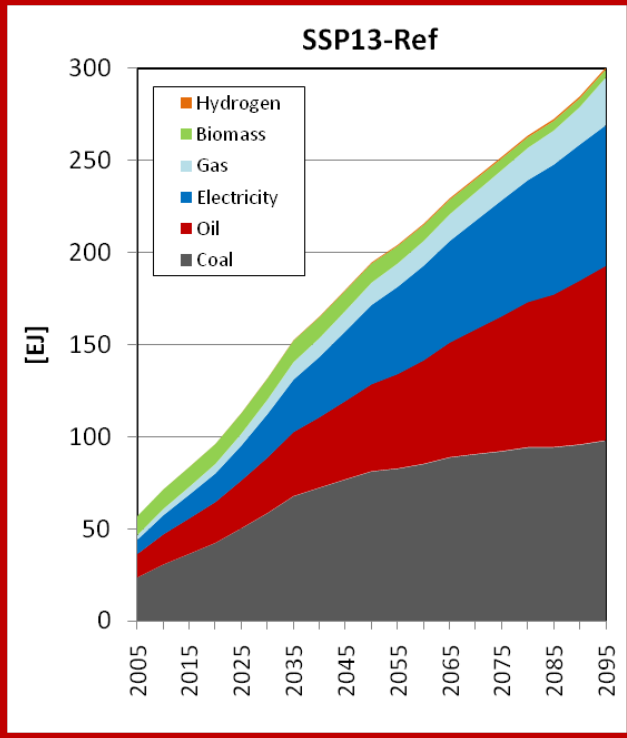




China's Final Energy Consumption [EJ]: Reference Scenarios

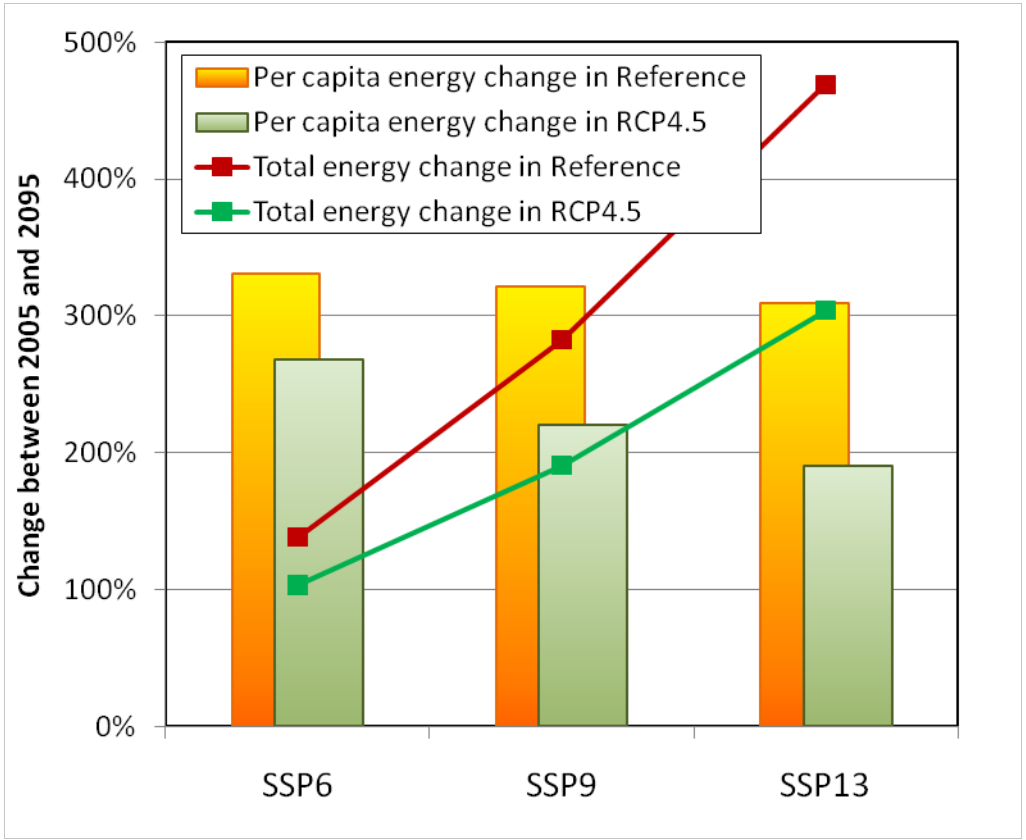






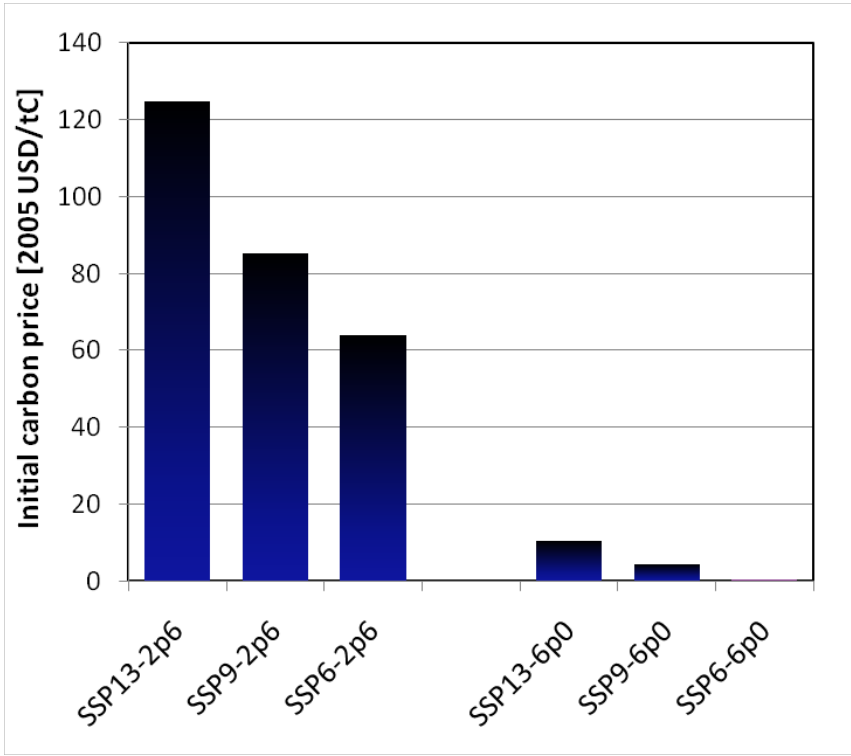
China's Energy Consumption between 2005-2095

- The same trend as global energy consumption
- Overall, the growth is much faster than the global average.

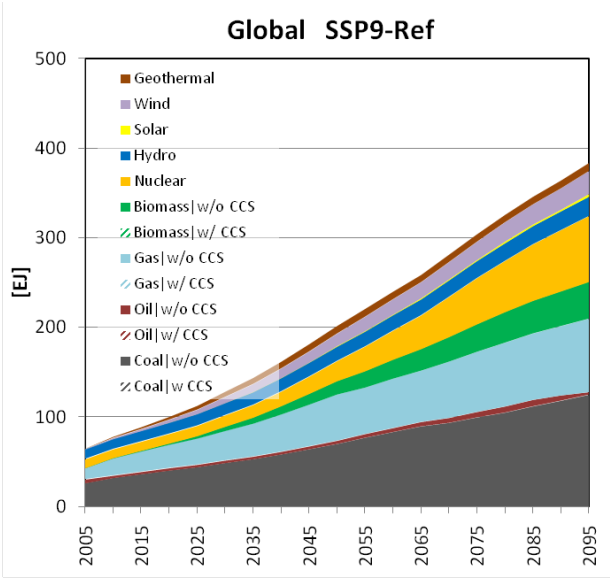


Mitigation under the Three SSPs

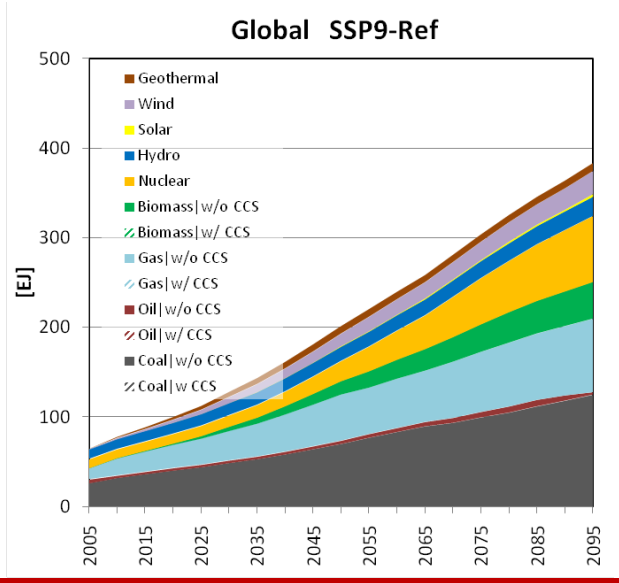
- **We assumed a common global price of carbon applied to ALL emissions (fossil fuel and land-use change).**
  - **RCP 2.6 is an overshoot scenario**
  - **Other stabilization scenarios are "not-to-exceed".**
- We observe difference in the initial price required to stabilize among the SSPs.
- Of course, the big difference in price is between stabilization goals

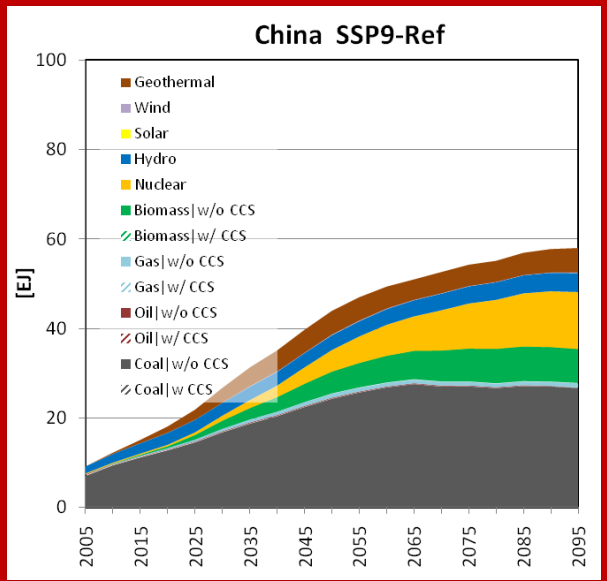


Power Generation by the World and China (SSP9)



Power Generation by the World and China (SSP9)





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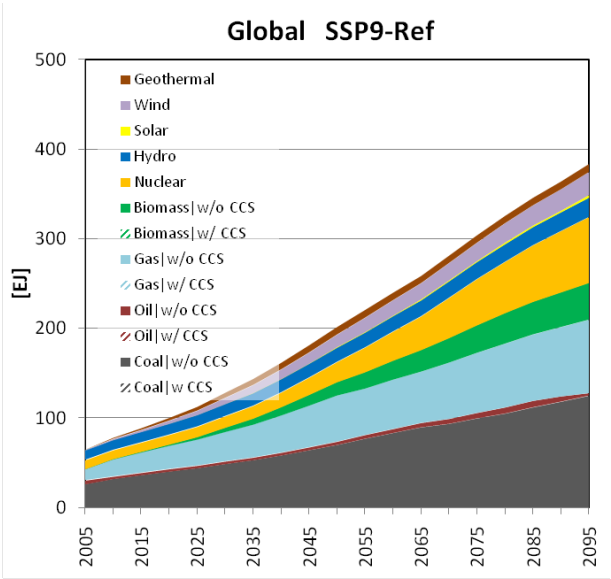
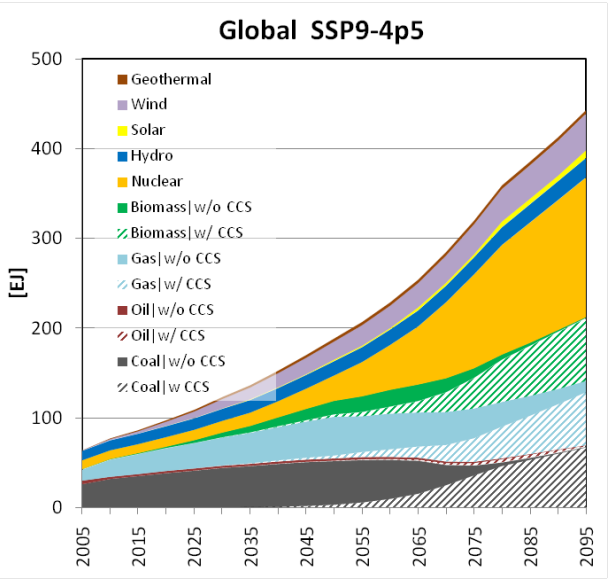
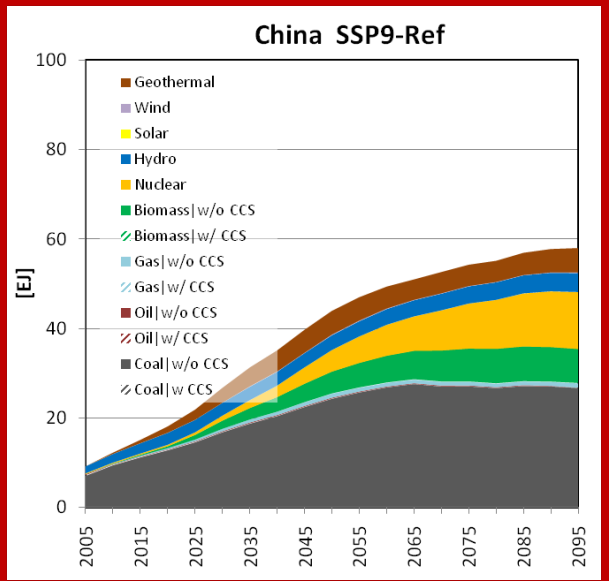
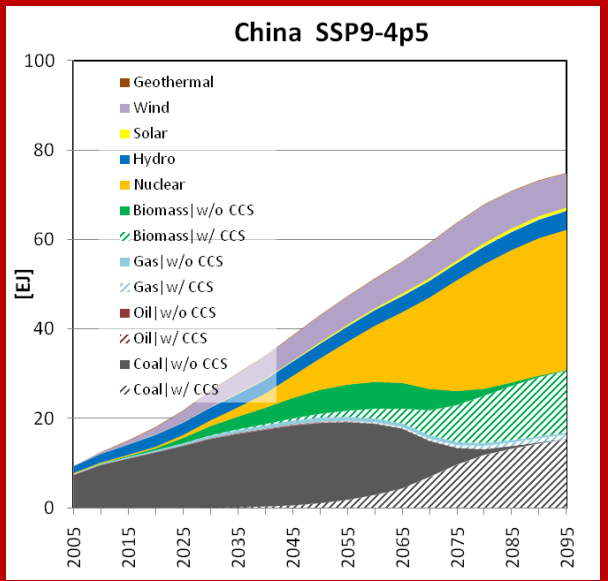
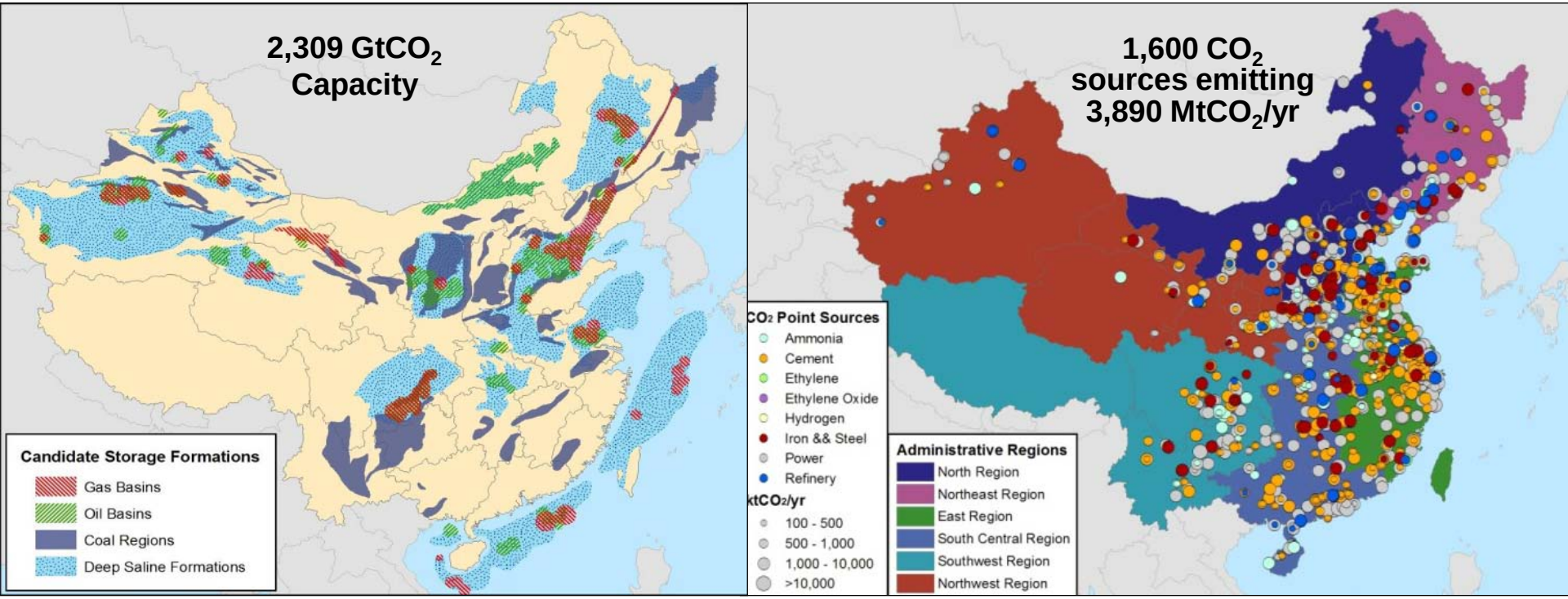






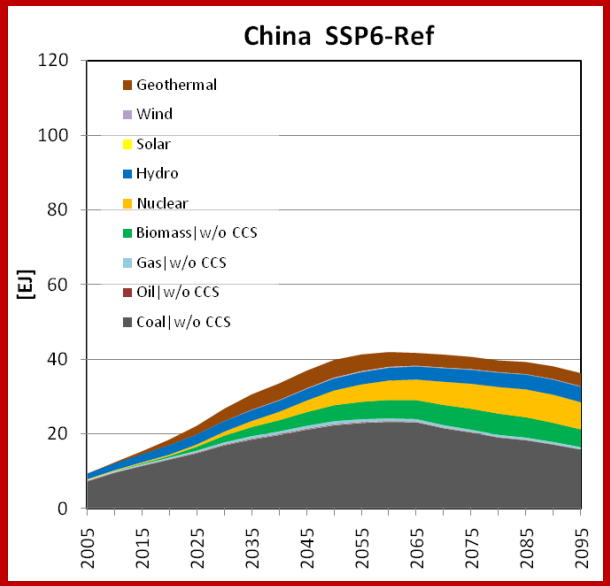


State-of-the-art bottom-up assessments of CCS deployment opportunities for China (2010)

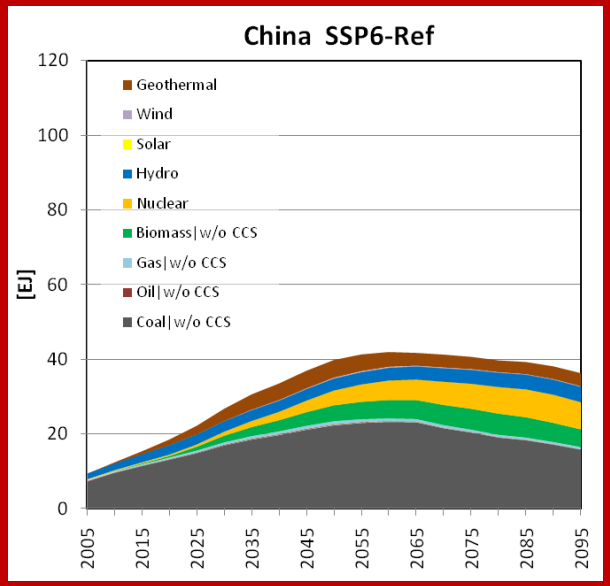


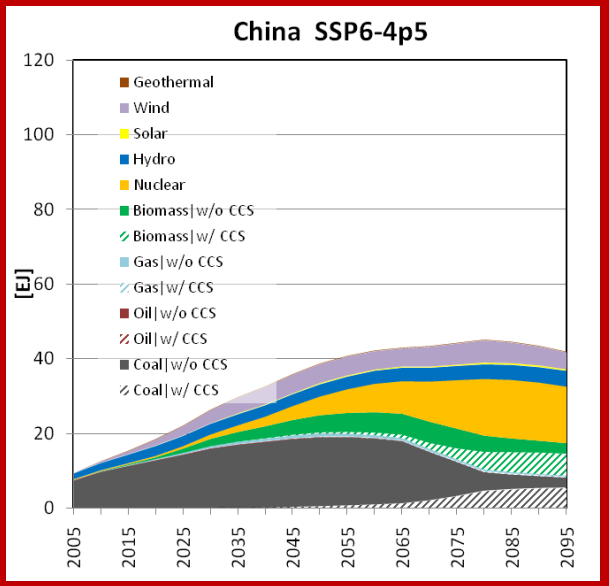
Dahowski, RT, Dooley, JJ, Davidson, CL, Bachu, S and Gupta, N. *Building the Cost Curves for CO_2 Storage: North America.* Technical Report 2005/3. International Energy Agency Greenhouse Gas R&D Programme. Dahowski RT, X Li, CL Davidson, N Wei, and JJ Dooley. 2010. *Regional Opportunities for Carbon Dioxide Capture and Storage in China: A Comprehensive CO_2 Storage Cost Curve and Analysis of the Potential for Large Scale Carbon Dioxide Capture and Storage in the People's Republic of China* . PNNL-19091, Pacific Northwest National Laboratory, Richland, WA.

China’s Power Generation by the SSPs

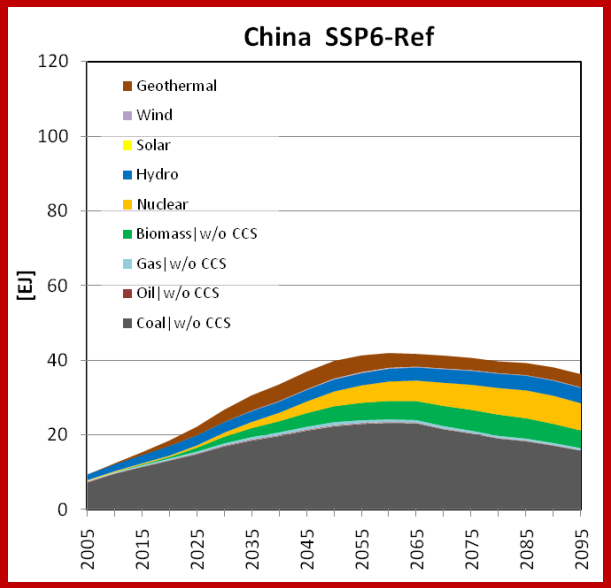


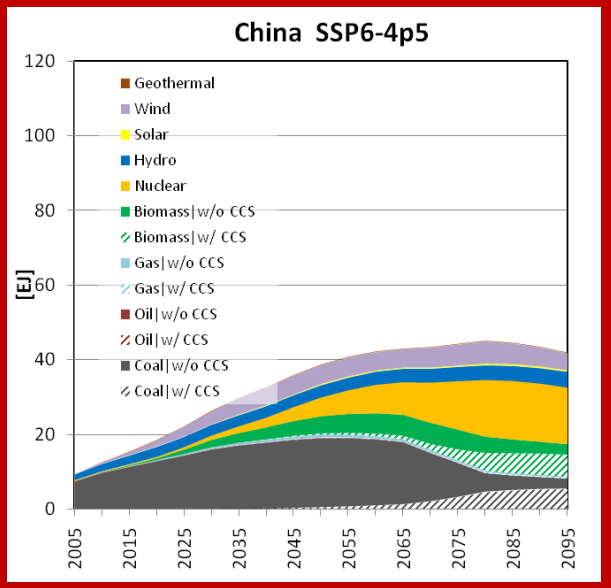
China’s Power Generation by the SSPs

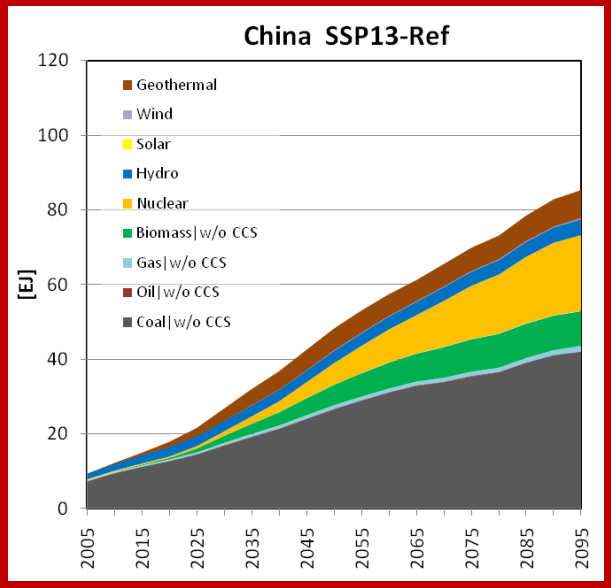


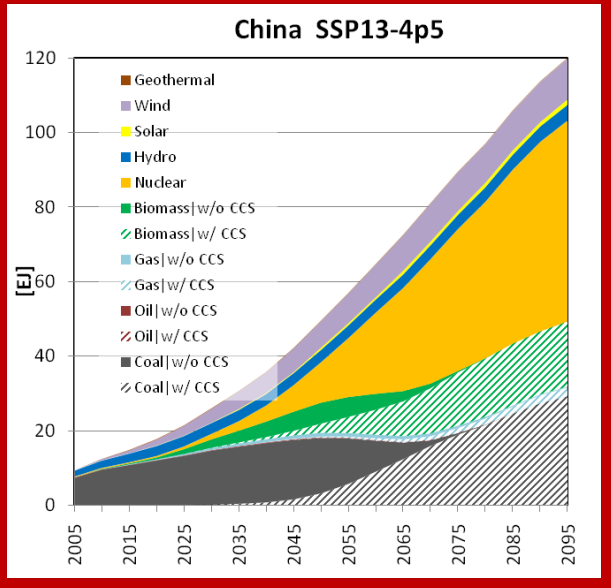


China's Power Generation by the SSPs



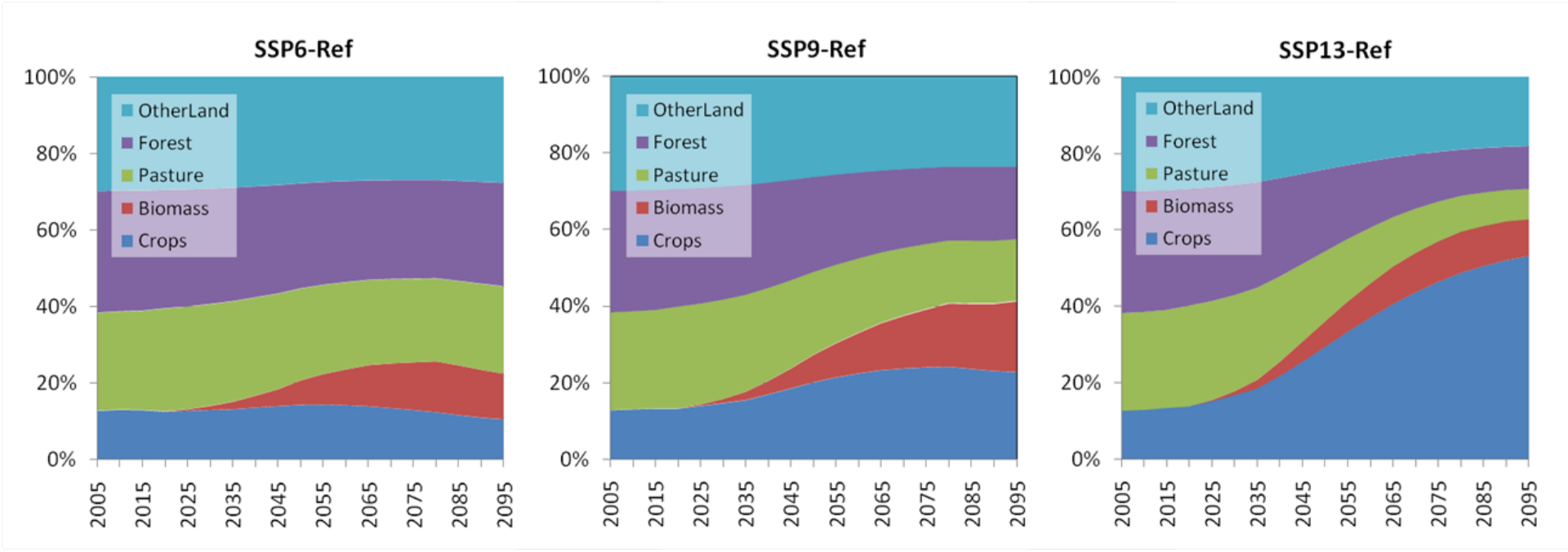




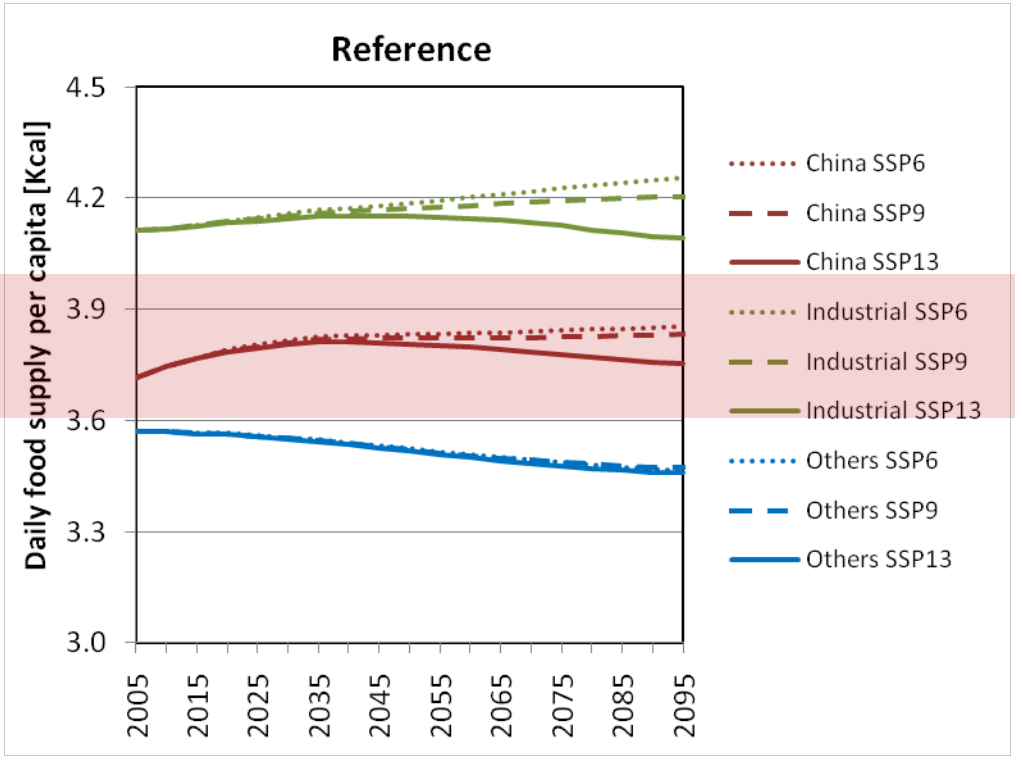


Global Land Use

- Greater population leads to greater crop land use, rapidly displacing the land use for forest, pasture, and bio-energy.



China’s food consumption



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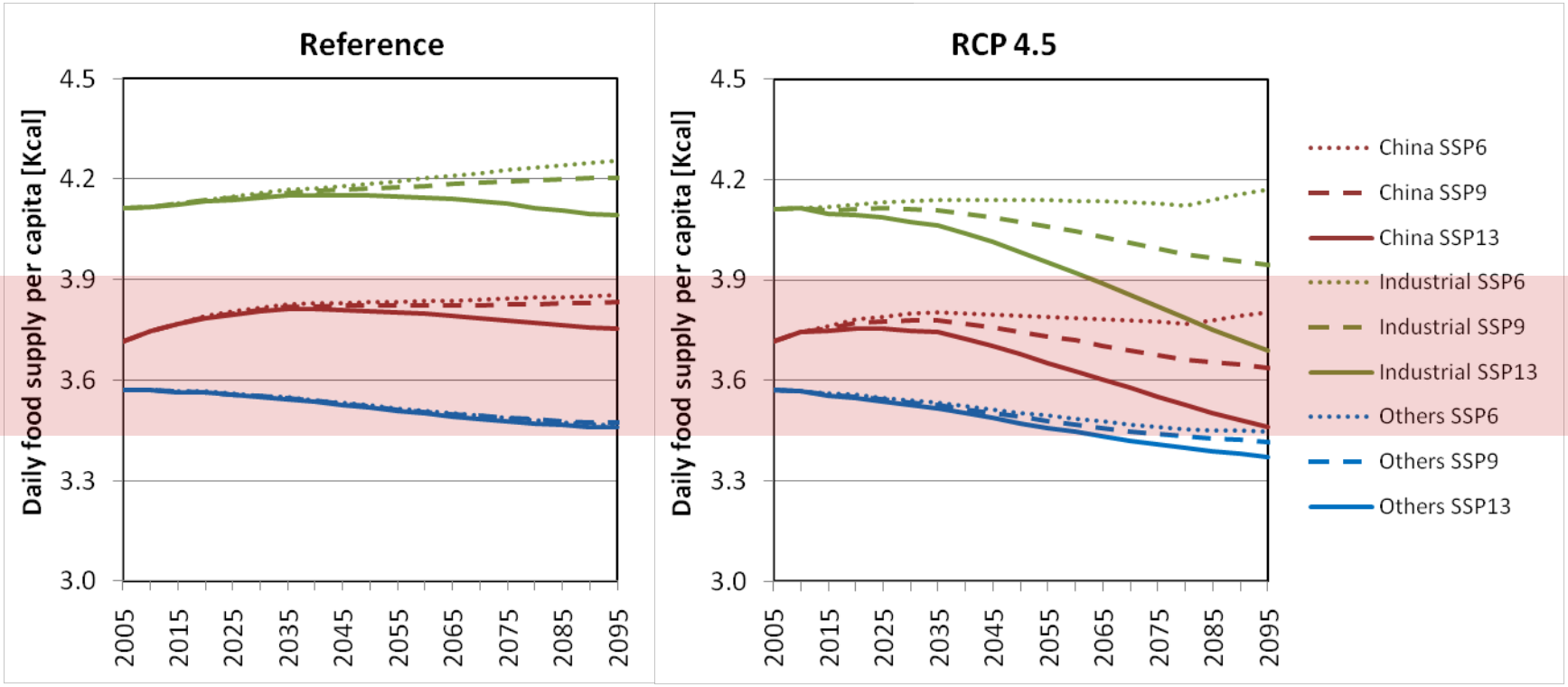
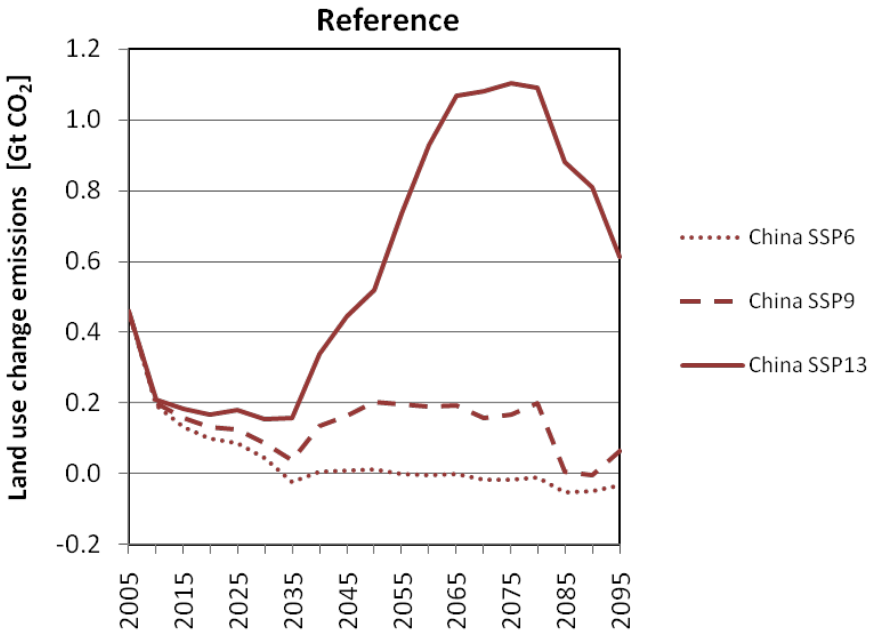
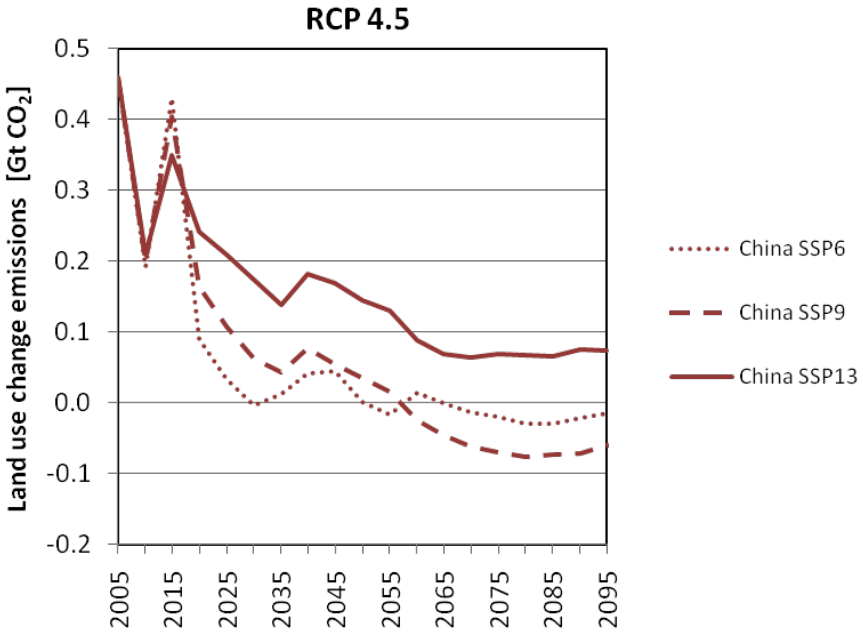


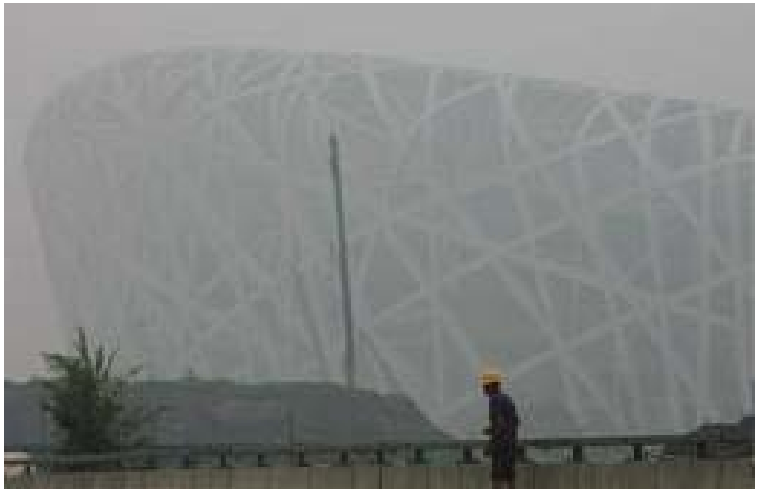
China’s land use change emissions



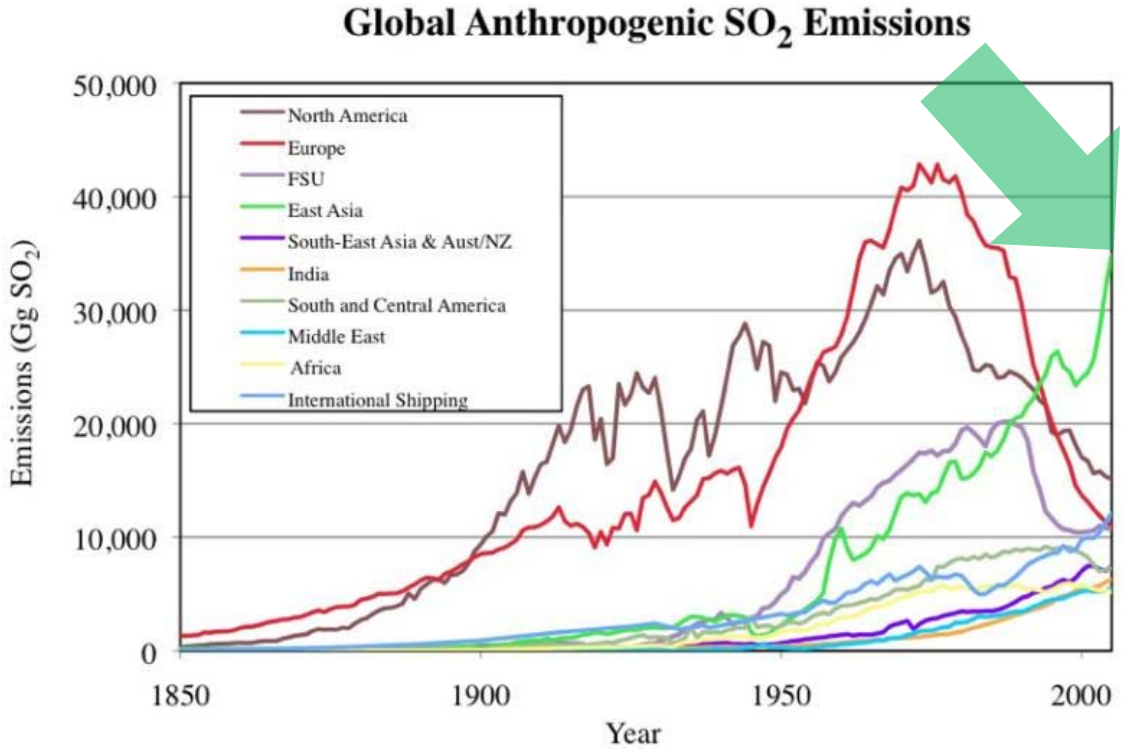


INTERACTIONS WITH OTHER ISSUES

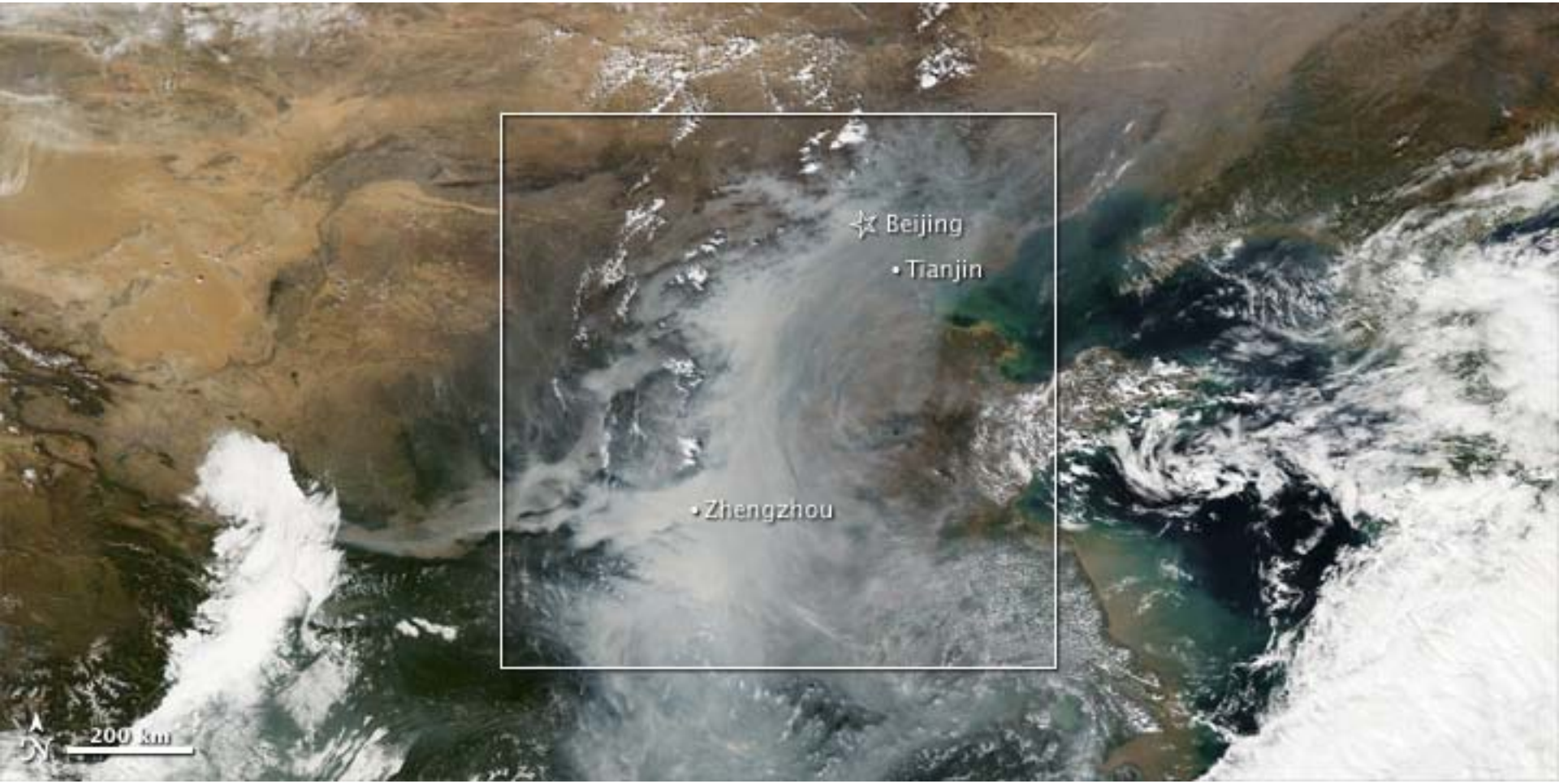
Chinese Air Quality



- China is the largest fossil fuel CO_2 emitter.
- It has severe local air quality issues.
- It is also the world's largest sulfur emitter.

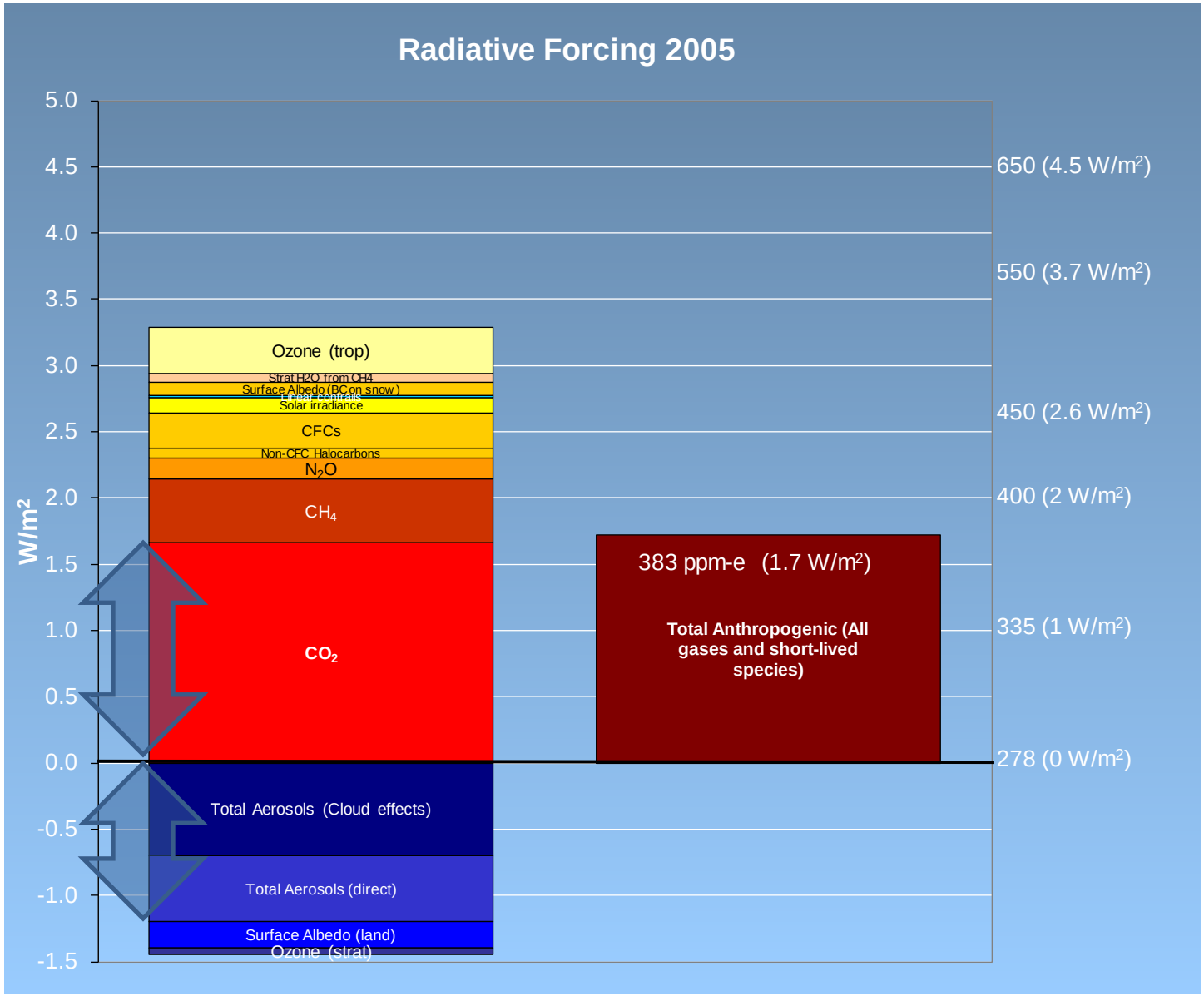


True-color MODIS image from October 22, 2010

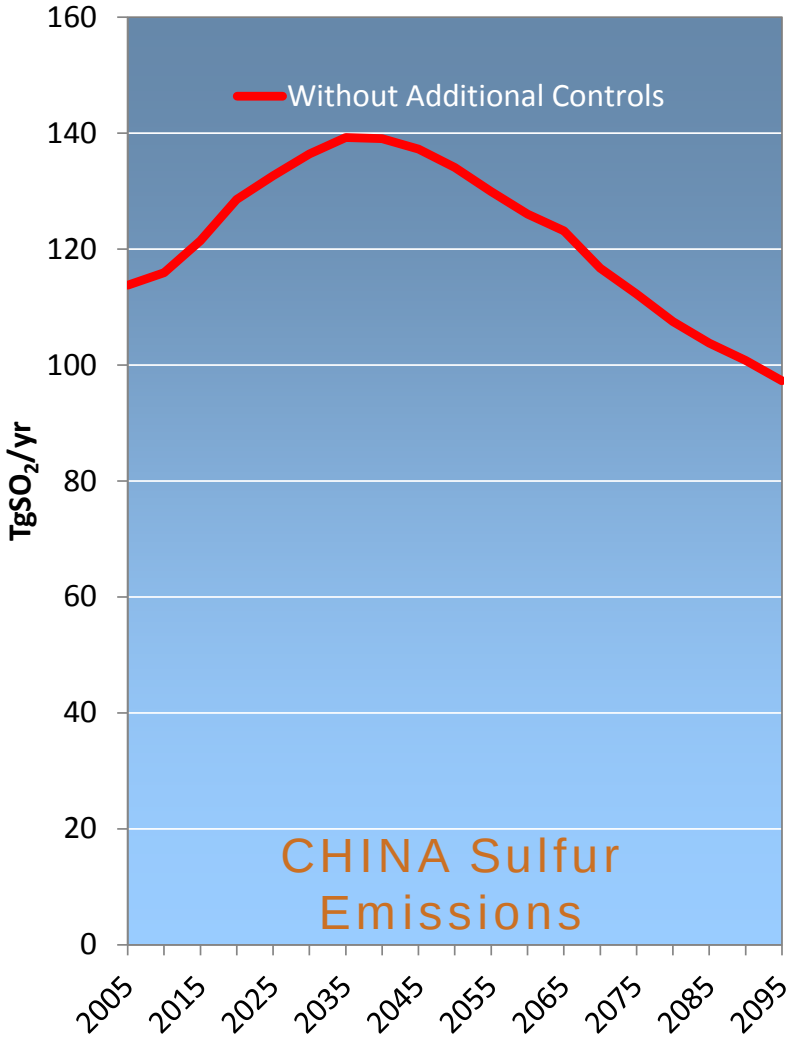


Source: http://earthobservatory.nasa.gov/IOTD/view.php?id=1934

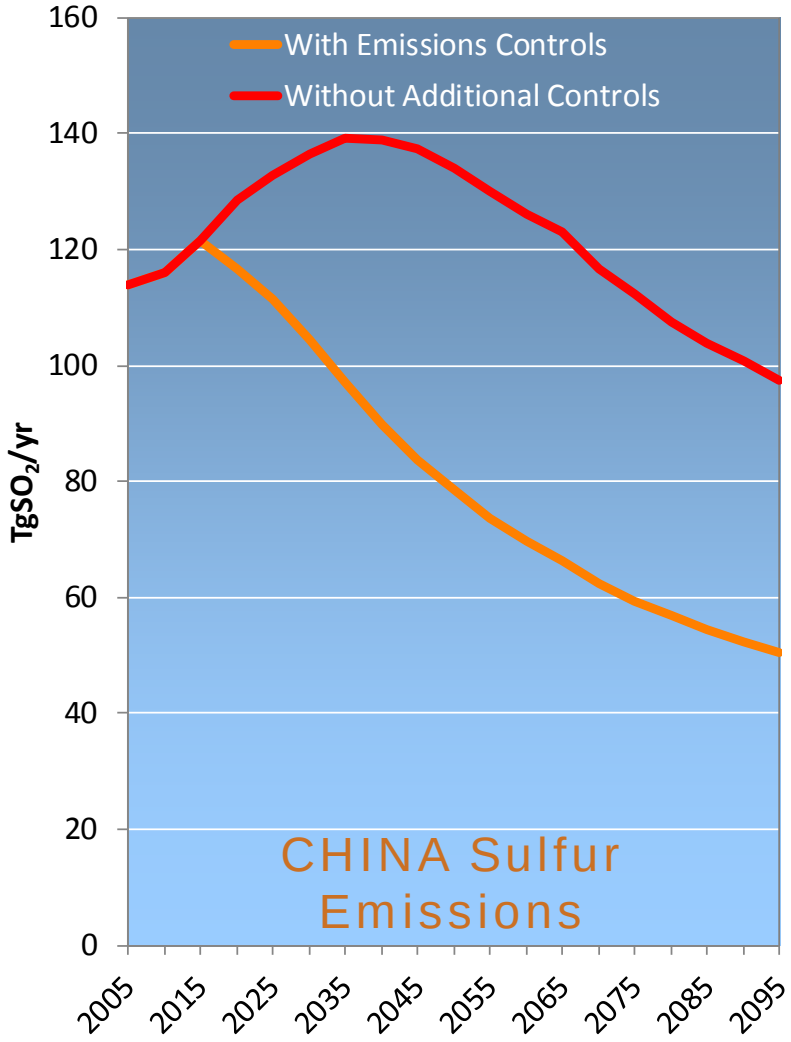
Radiative Forcing: Aerosols are estimated reduce radiative forcing by almost as much as CO_2 increases it!

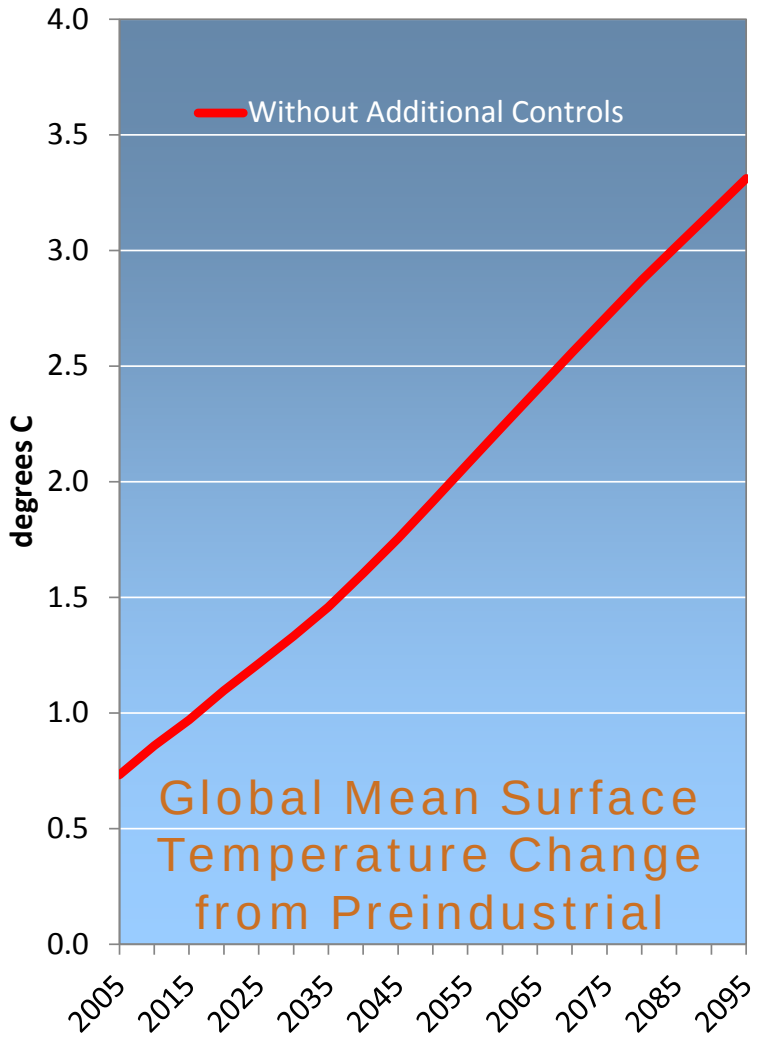


CHINESE Sulfur Emissions



CHINESE Sulfur Emissions and GLOBAL Mean Surface Temperature with Accelerated Sulfur Emissions Policies





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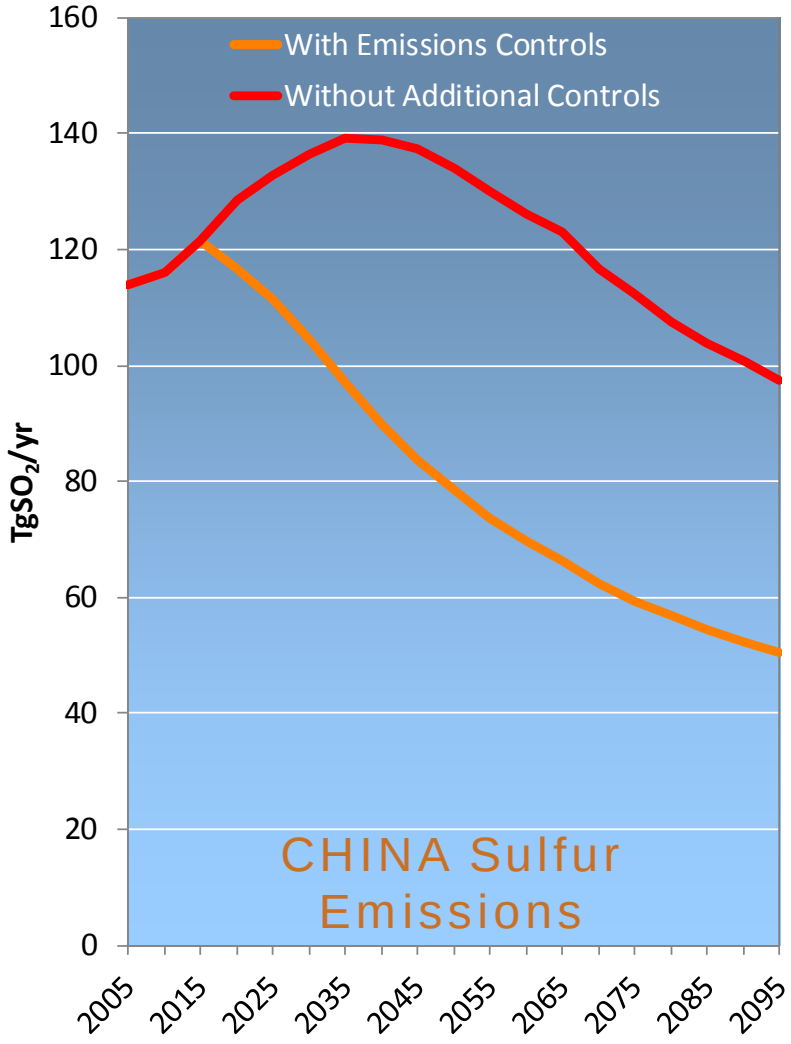
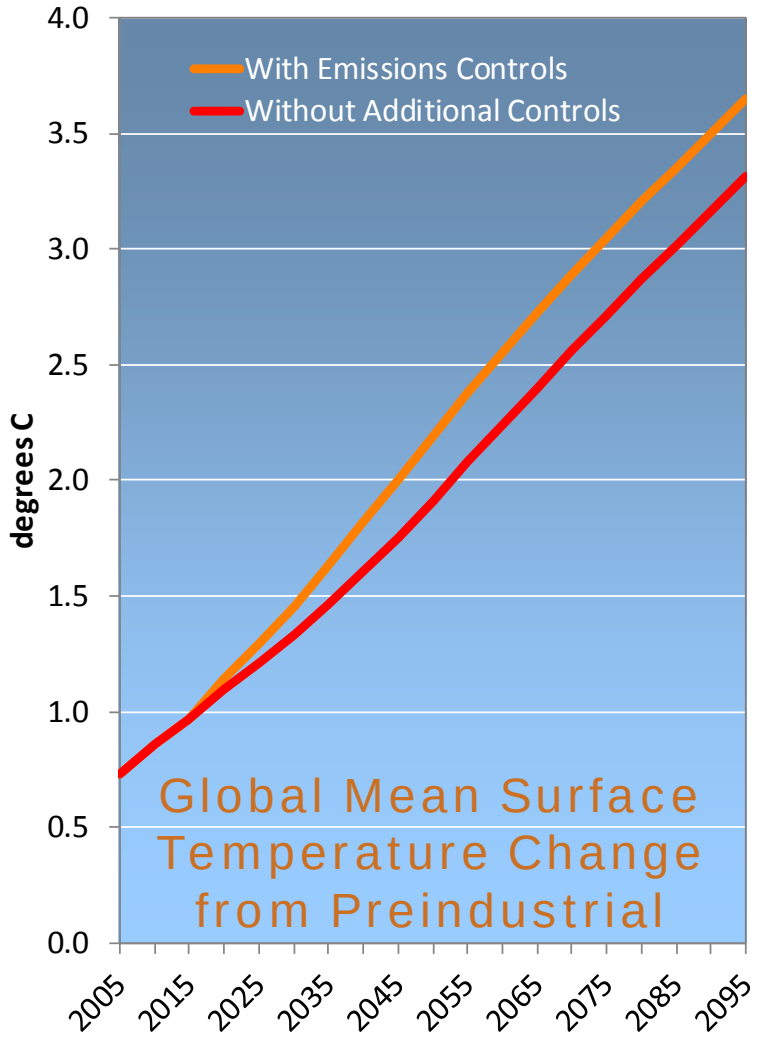
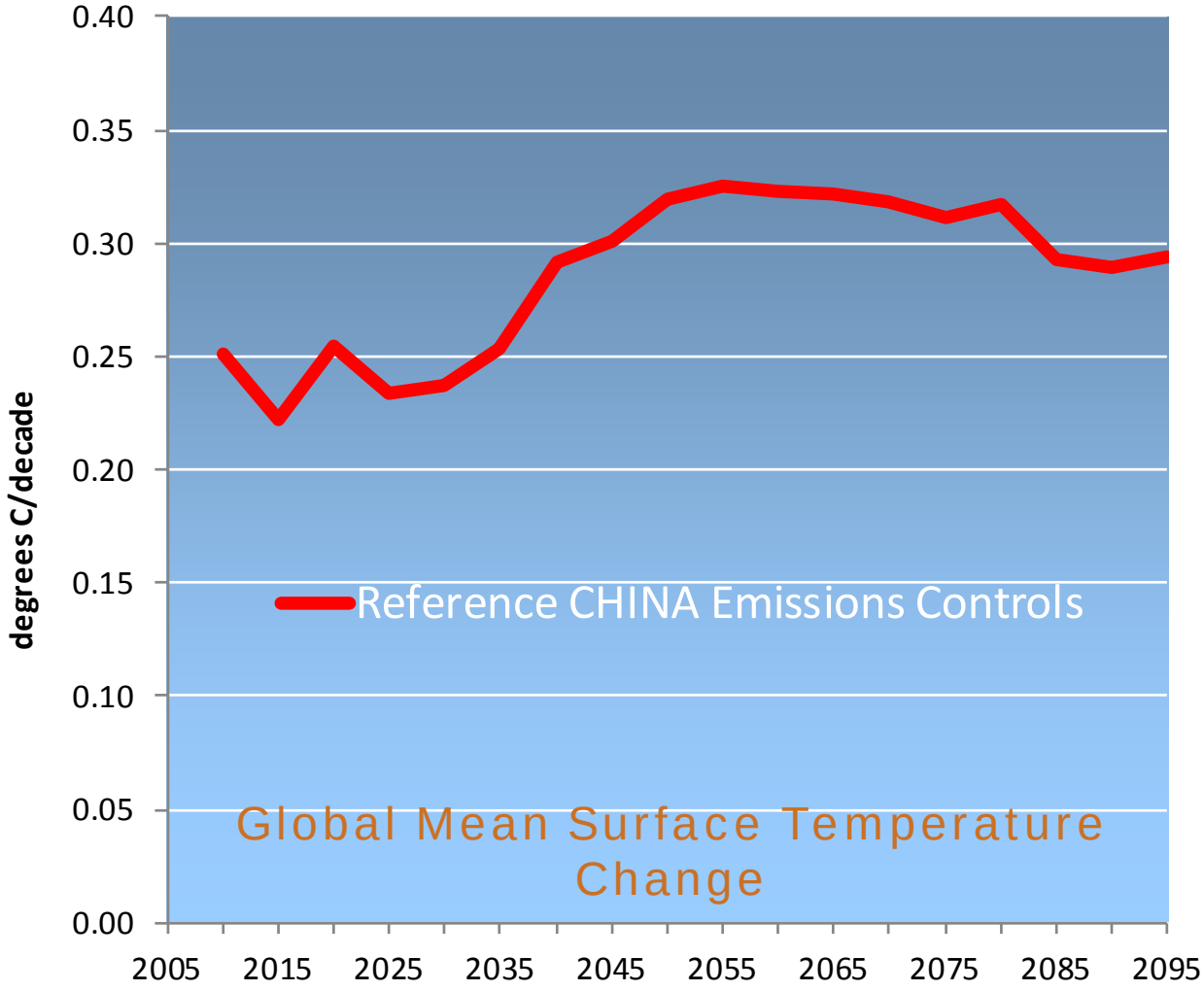
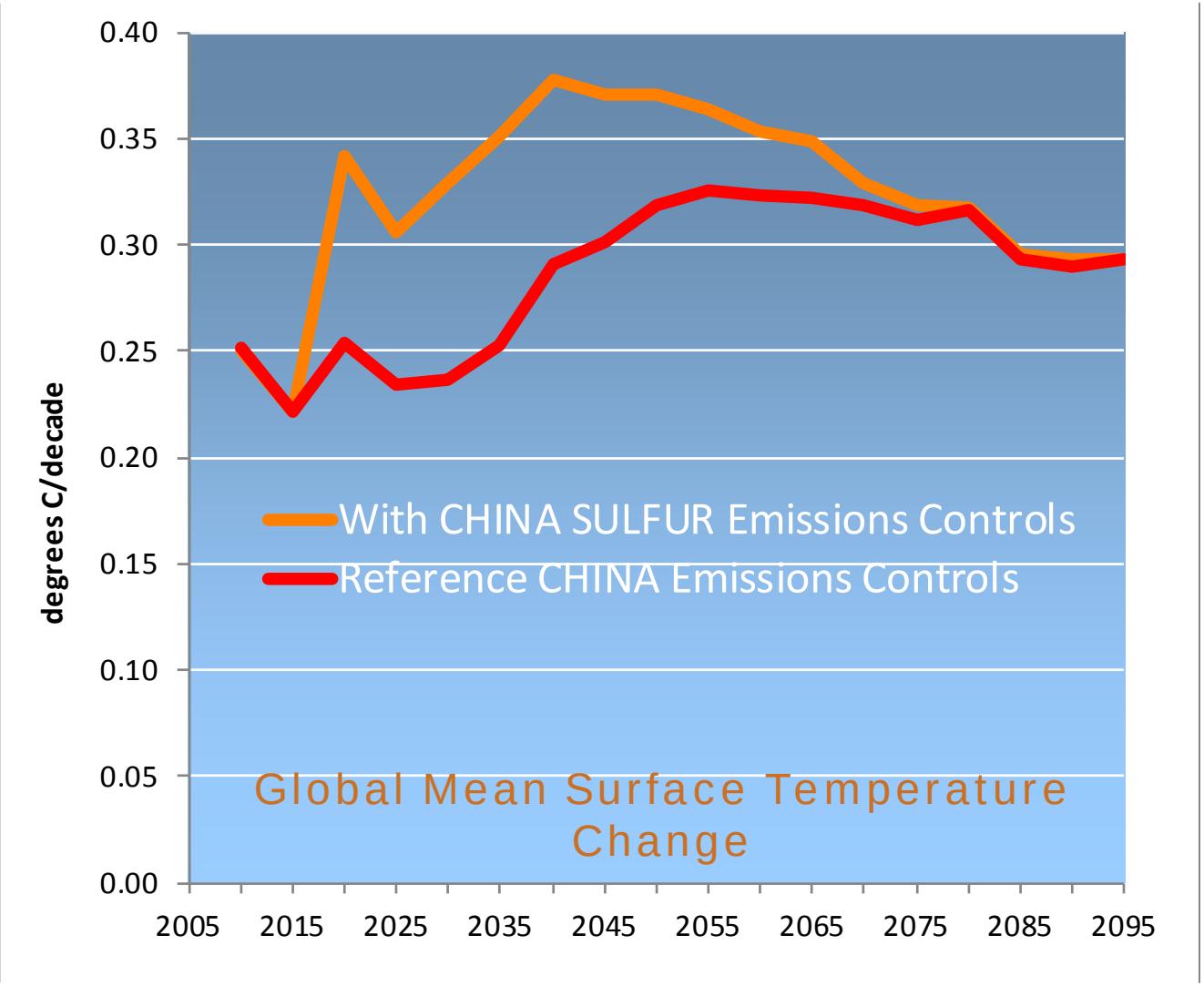




Rate of Climate Change With and Without Accelerated Chinese Sulfur Controls



Rate of Climate Change With and Without Accelerated Chinese Sulfur Controls



Key Points

- China has been surprisingly successful historically—with higher energy and emissions than modelers assumed.
- We should not forget that the future of China is uncertain.
- We have begun to look at different potential developments—beginning with the demographic transition.
- Demographics alone lead to increasingly divergent scenarios with increasingly divergent scales.
- Assumptions about Chinese local air quality policy could be played out in climate change experienced by the rest of the world.

DISCUSSION