



Environmental Energy Technologies Division Lawrence Berkeley National Laboratory

S1-3-1

Overview: Sustainably Meeting China's Growing Energy Needs

For APERC Annual Conference 2014 and Workshops

Nan Zhou

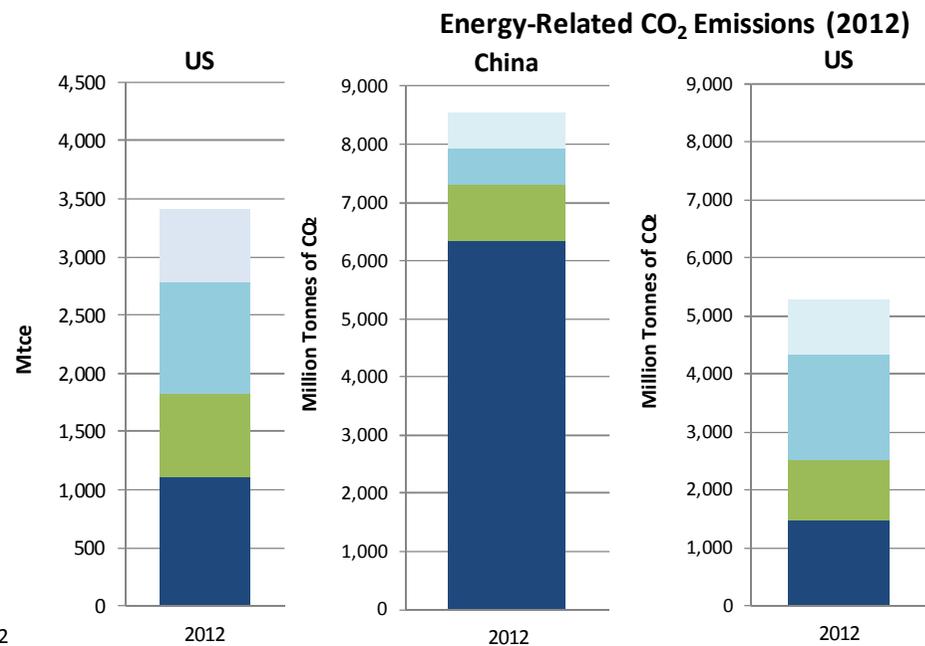
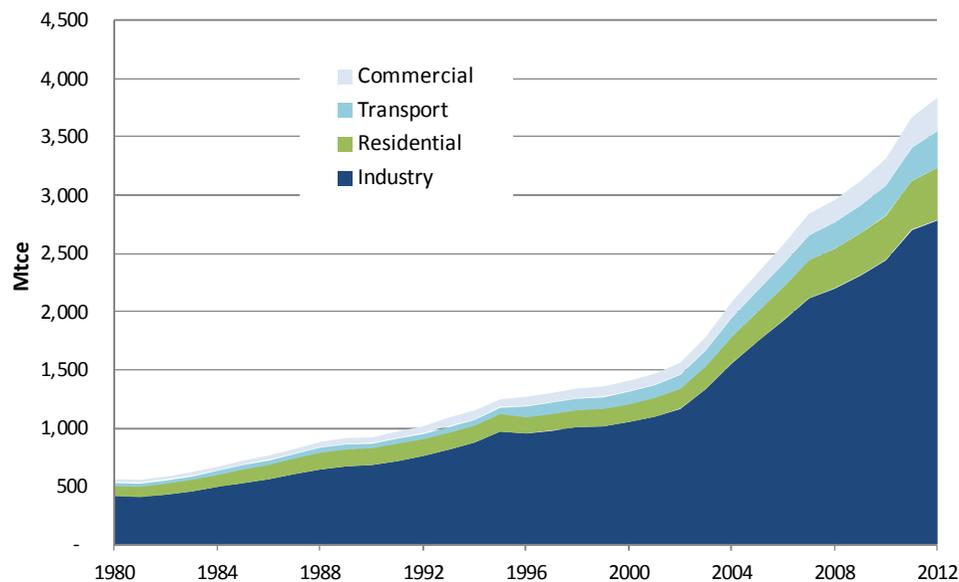
China Energy Group

Lawrence Berkeley National Laboratory

March 26, 2014

Soaring energy demand and skyrocketing CO₂ emission

Primary Energy Use by Sector in China (1980-2012)



National Bureau of Statistics (NBS), 1981-2012. *China Energy Statistical Yearbook*. China Statistics Press. Beijing, China. EIA, 2012. *Annual Energy Outlook*.



Need end-use detail to plan and evaluate energy efficiency policies, programs and targets for long term pathways and short term milestones



Source: NBS, 2013.
 Note: 1 tce = 29.28 GJ = 27.75 MMBtu

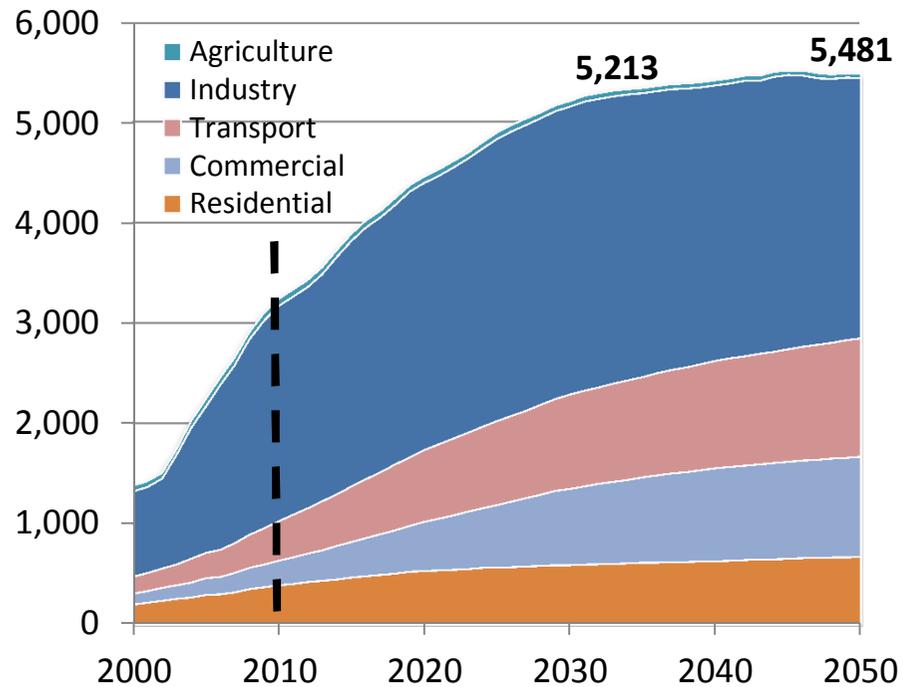
Note: Mtce >> EJ = 0.0293; EJ >> Quads = 0.9478

Overall economy will continue to grow

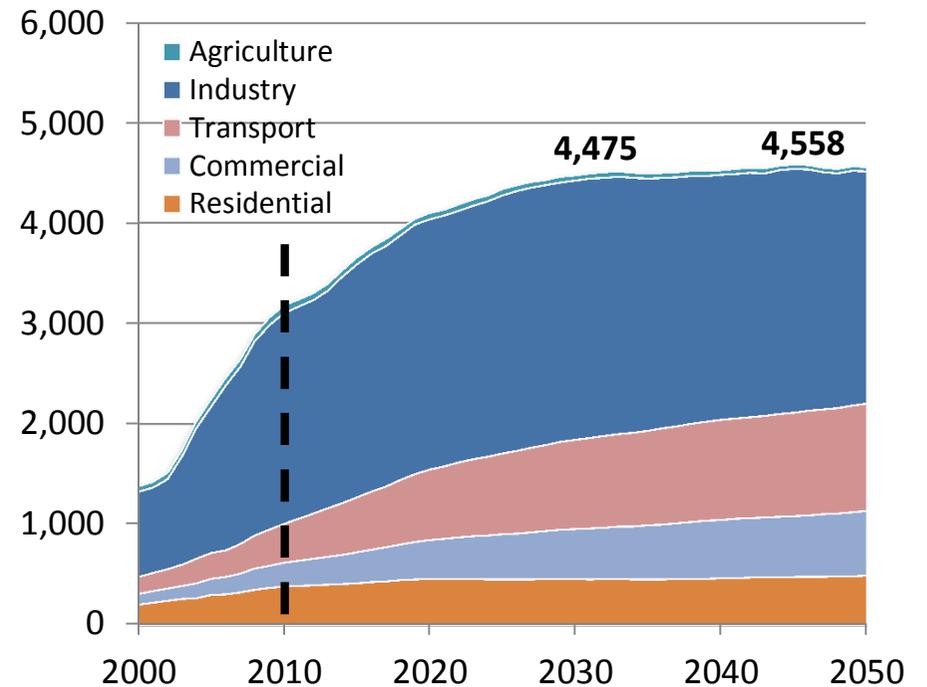
Continued Improvement Scenario (CIS):

- “Meeting China’s planned standards and targets and following international experience in efficiency improvements
- “Planned phase out of inefficient industrial and power plants

Continued Improvement



Accelerated Improvement

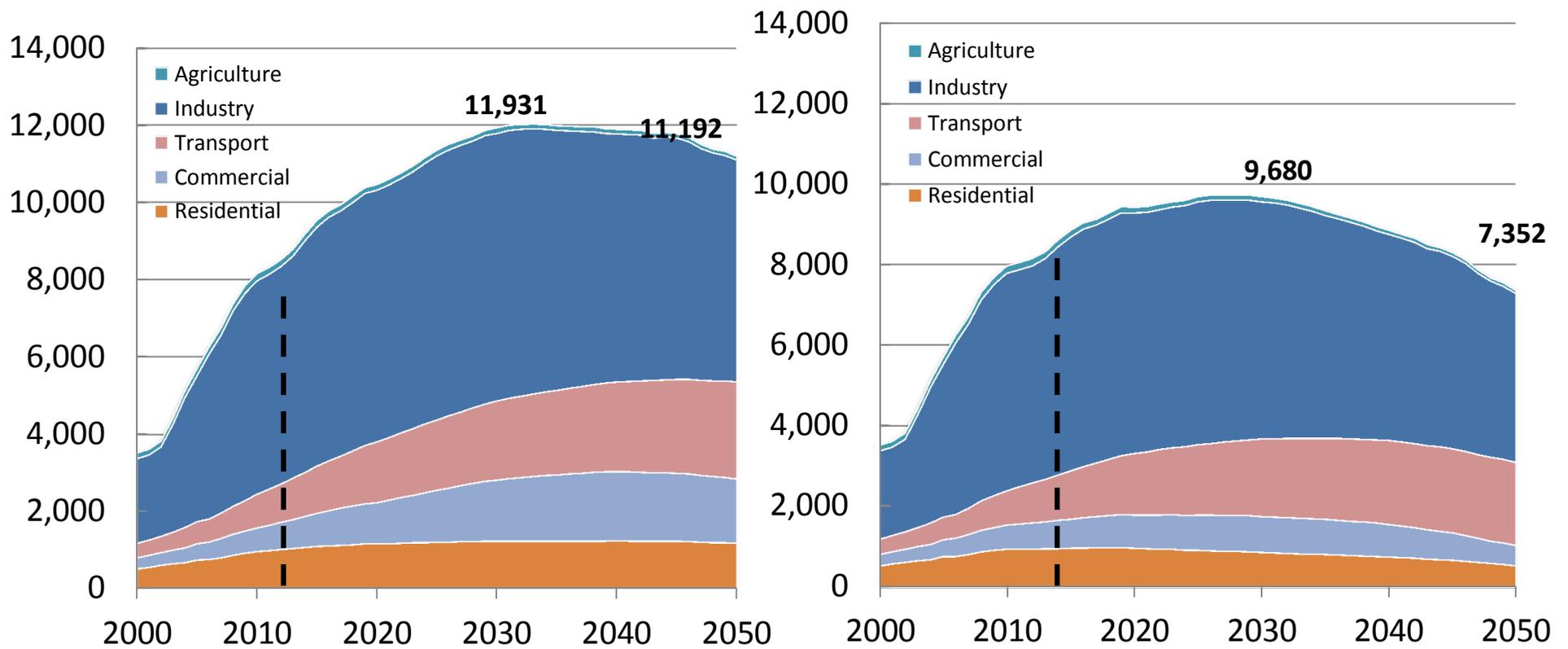


Primary Energy Use (Mtce)

Peaking emission is possible, but depends on aggressive energy efficiency improvement and aggressive decarbonization

Continued Improvement

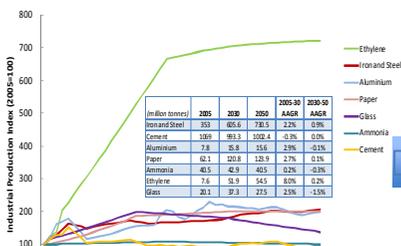
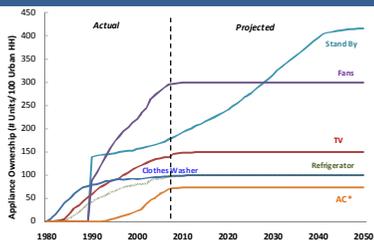
Accelerated Improvement



Mt CO2 Emissions

Many top-down analysis see China growing infinitely. We see it differently.

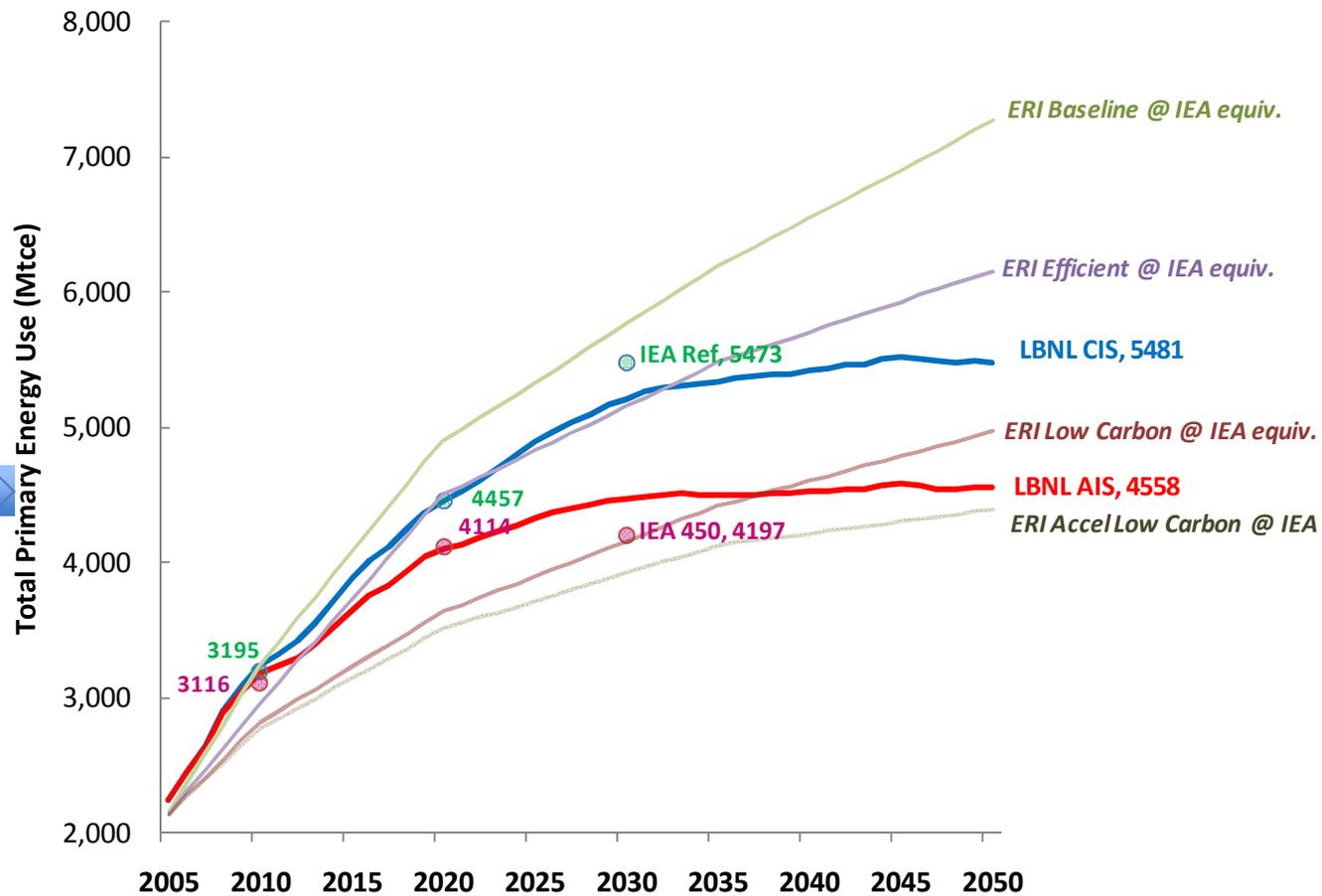
Saturation Effects (appliance, infrastructure construction, fertilizer, etc.)



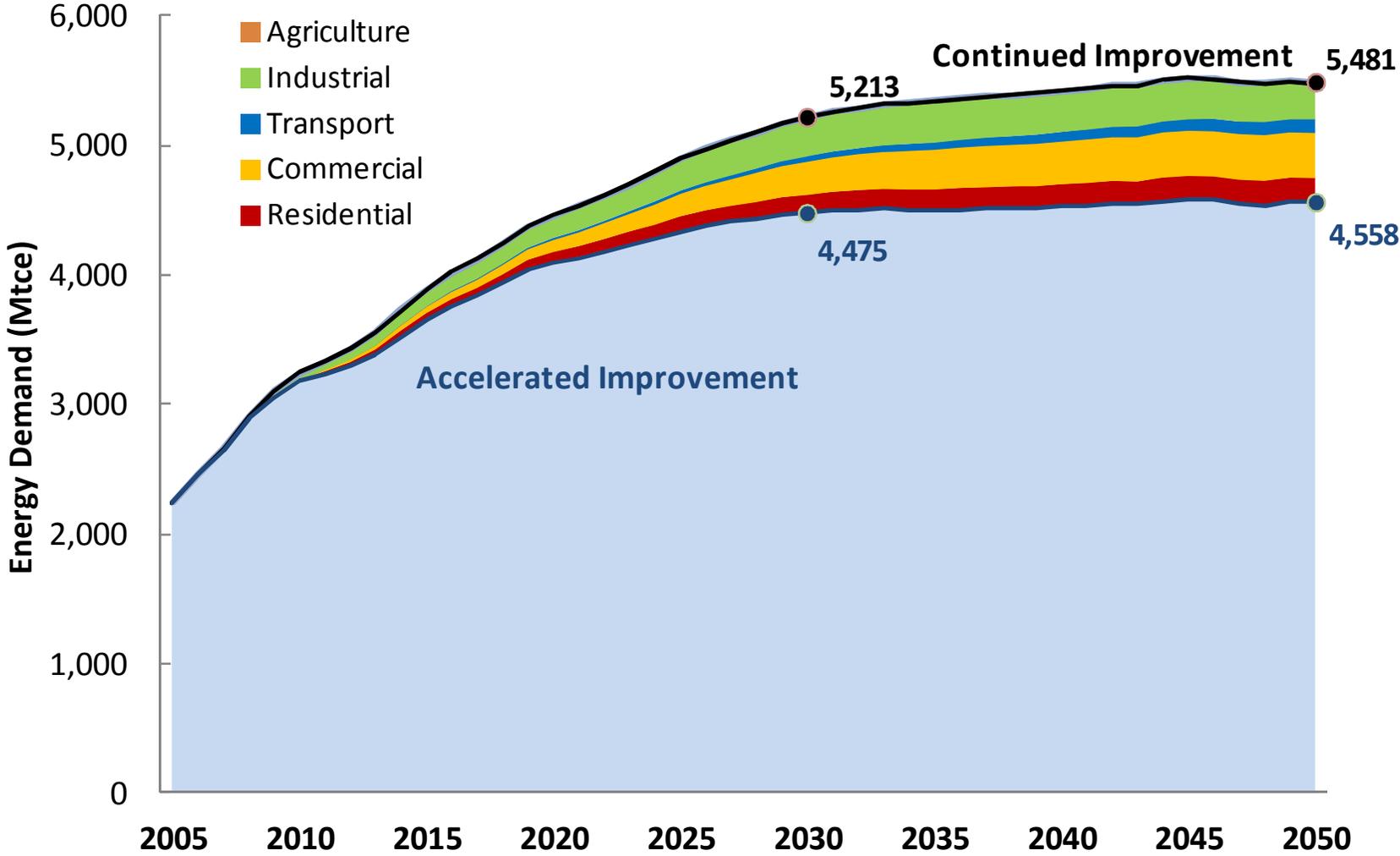
Slowdown of urbanization

Low population growth

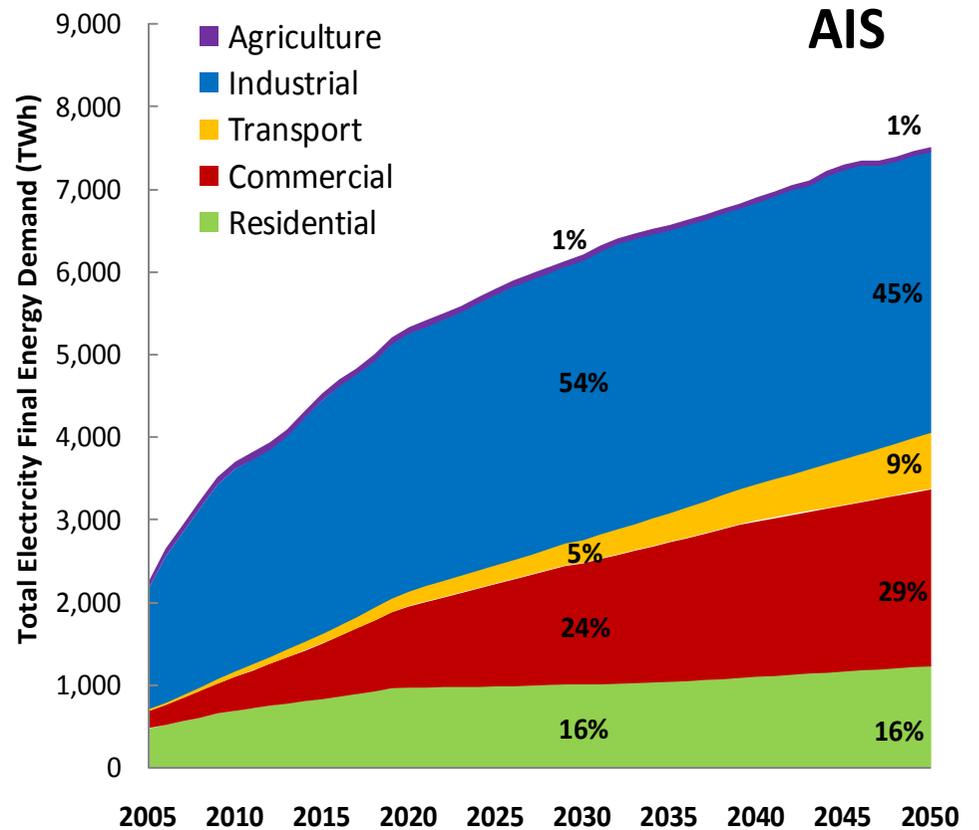
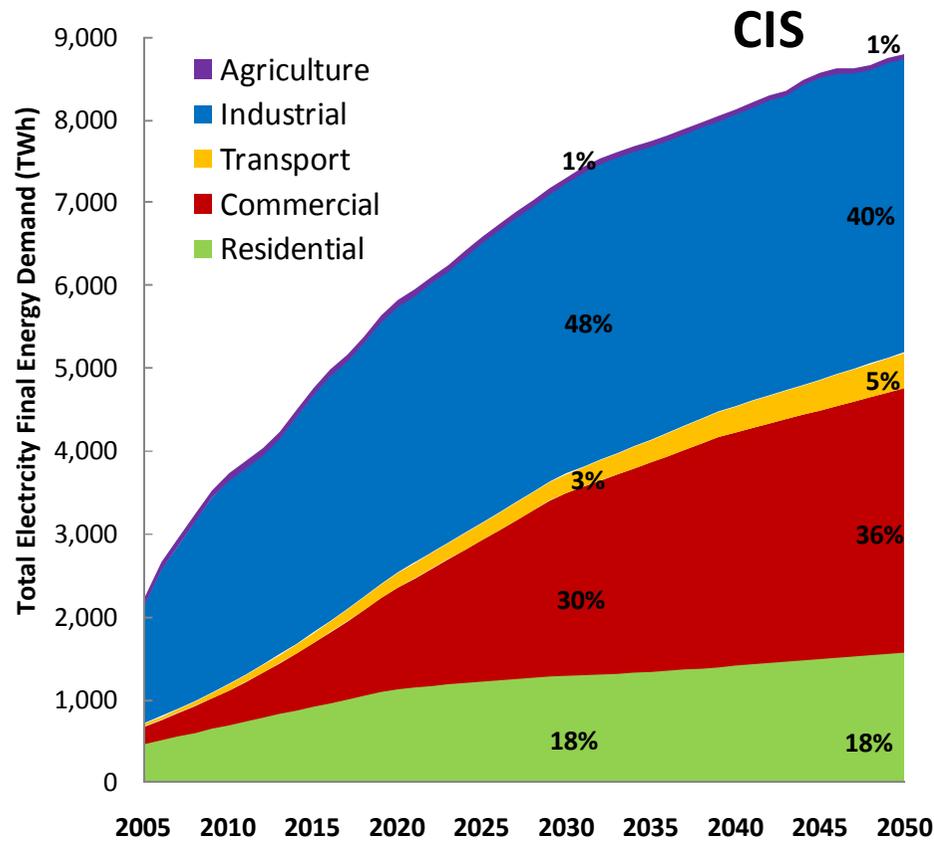
Change in exports to high value added products



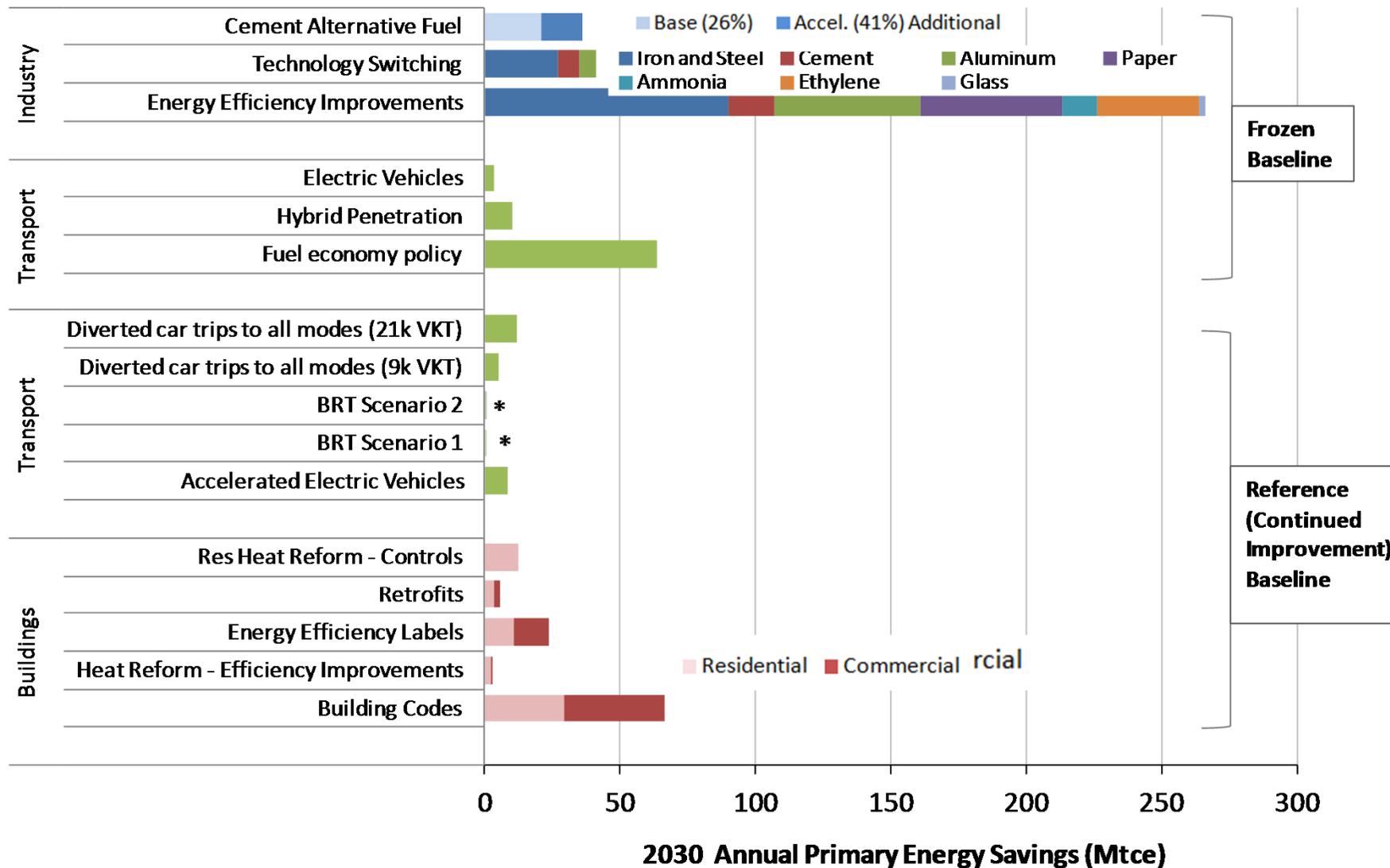
Energy reduction potential greatest in industry in early years, but later in buildings



Commercial sector will become a major electricity consumer, as the service sector comes to dominate China's economic structure

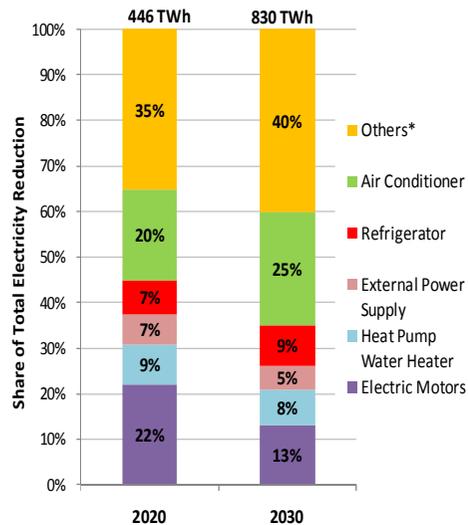


Quantifying the scale of potential impacts of policies within and across sectors to guide policy prioritization



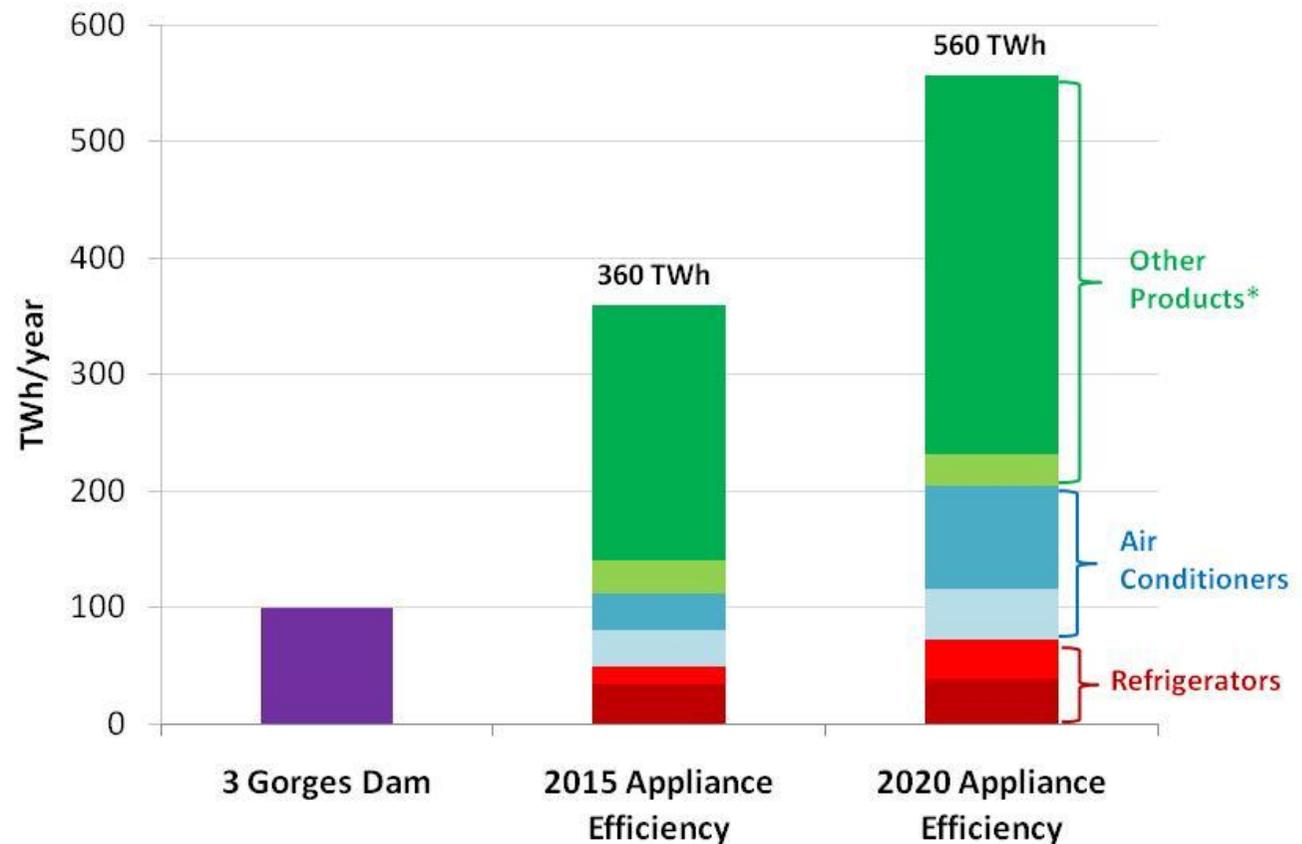
Note: Potential energy savings from building policies only considers heating and cooling, and does not include potential savings from lighting and equipment efficiency improvements.

Impact of appliances standards and labeling (S&L) programs

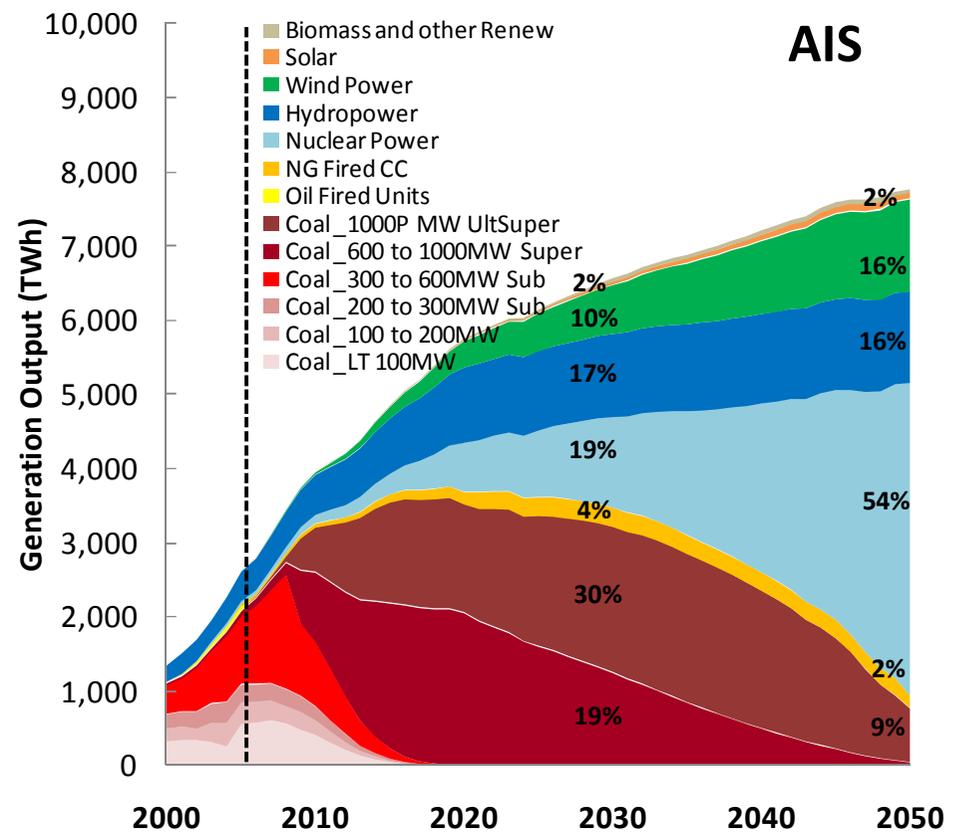
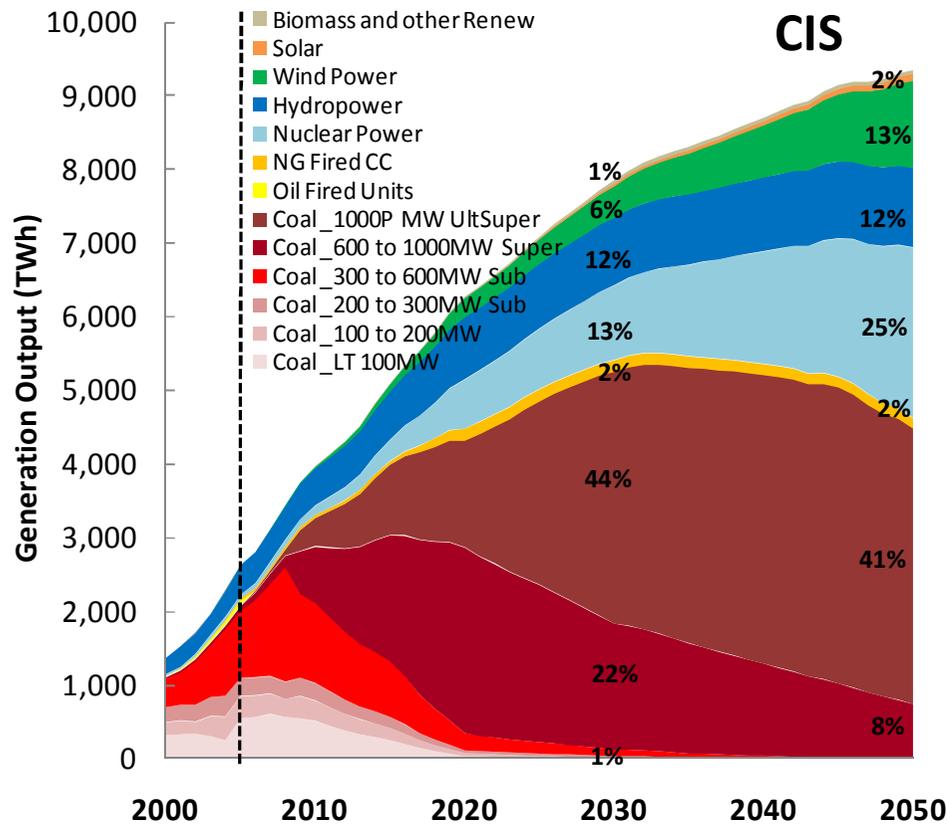


Reduction = 30% of total building electricity demand; 12% of total electricity demand

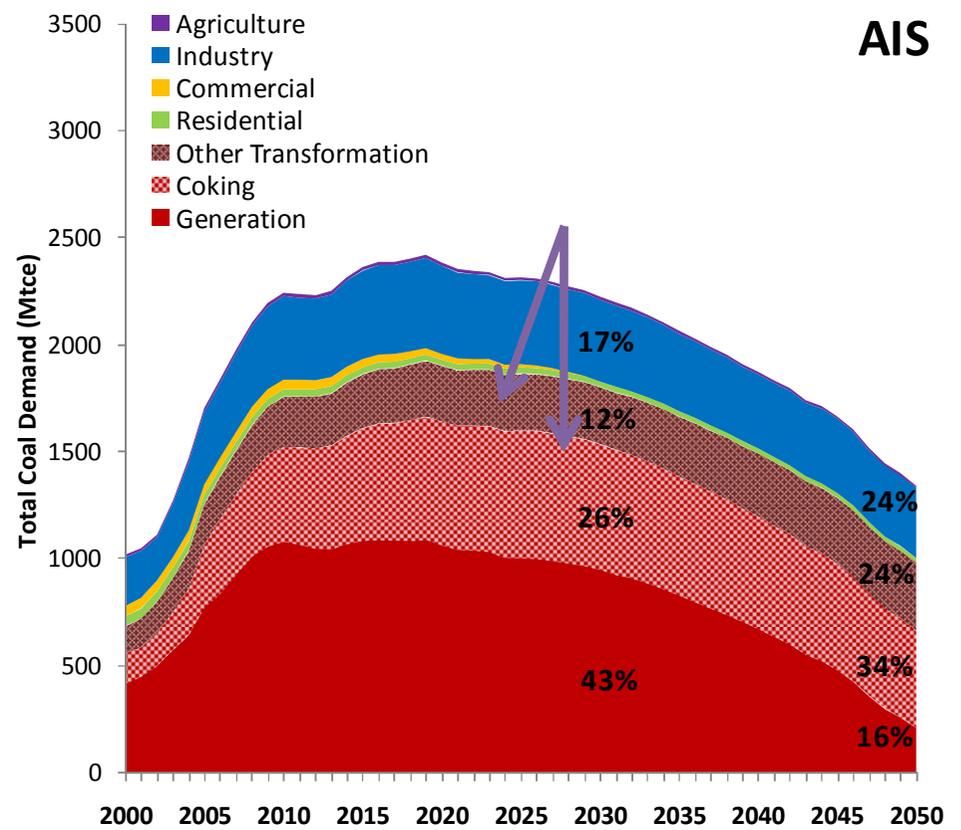
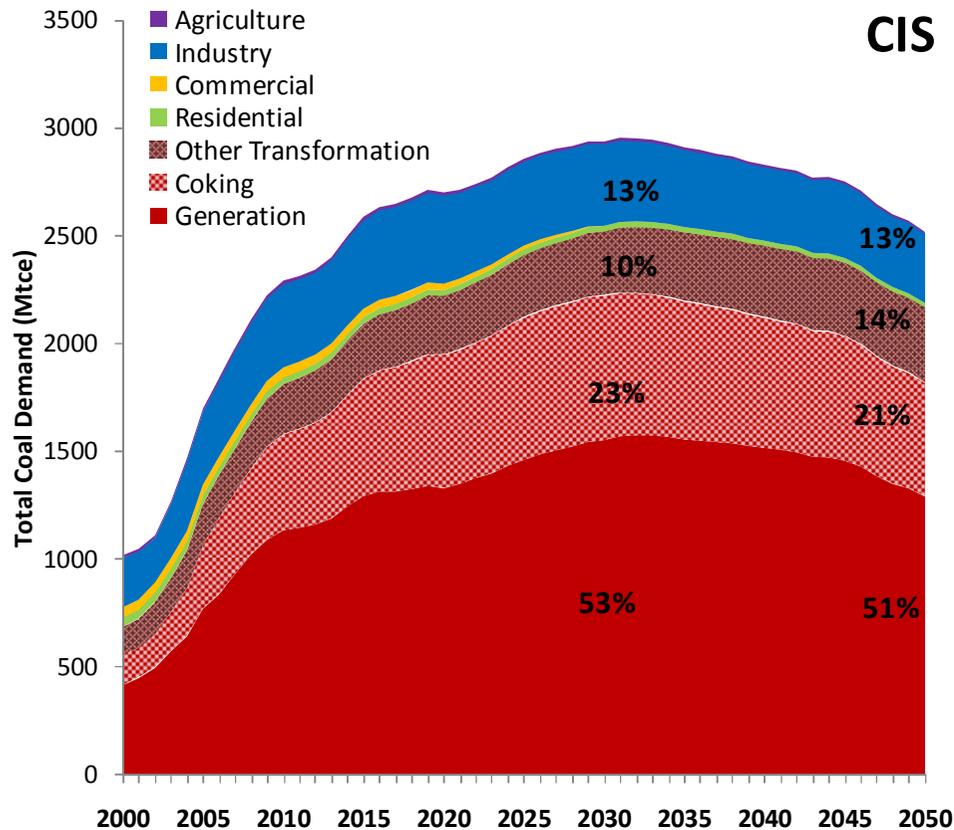
Contextualized impact of S&L programs and benefits of appliance efficiency to reducing need for new generation



Options for decarbonization in power sector, nuclear is crucial



Coal is mostly used in power generation, but will decline as the renewable and nuclear pick up

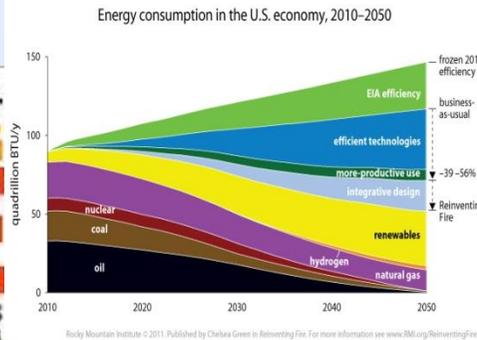
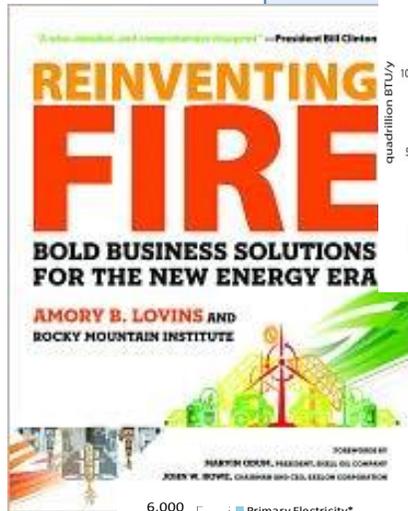


“Half of the coal used in non-power sector

“Fuel switching is limited

“The reduction relies on power sector decarbonization

Reinventing Fire: China- sustainable energy infrastructure to preserve environmental quality and support future growth

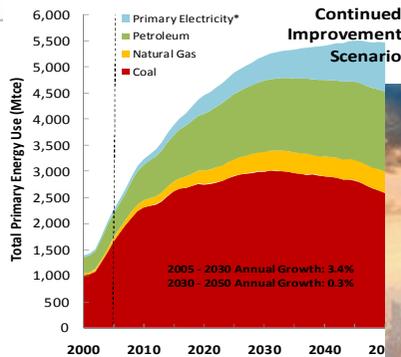


- ◆ *Reinventing Fire* shows how the U.S. could run a 2.6-fold bigger economy by 2050 with no oil, no coal, no nuclear energy, and one-third less natural gas, with a \$5-trillion lower net-present-value cost than business-as-usual—with the transition led by business for profit

- ◆ China's technology leadership allows it to export many solutions to the rest of the world, particularly to developing world

- ◆ Emergence of China leaves a large opportunity for visioning and assessing new energy futures

- ◆ Utilizing CEG's expertise and 8 years of development in long term energy demand modelling



China Energy Group
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国家发展和改革委员会能源研究所
Energy Research Institute National Development And Reform Commission

Reinventing Fire 2050 Buildings Vision



By 2050, buildings and communities in China will be self sustained and resilient with increased comfort levels



Passive Buildings

Integrative Design

Super efficient appliances and space conditioning systems

Renewables, Fuel Switching and Net Zero Energy Buildings

Microgrids and Demand Response

Prefabricated buildings

- “ Passive House for Northern residential building
- “ Natural ventilation and shading for Southern buildings
- “ Day lighting

- “ Bundled and optimized measures
- “ Maximum whole building system energy efficiency in a cost effective way

- “ Super efficient heating and cooling systems
- “ Super efficient AC, refrigerator, clothes washer, LED, and other equipment

- “ Onsite generation
- “ PV, solar thermal, geothermal
- “ From coal to natural gas and electricity

- “ Microgrid with distributed generation
- “ Storage such as battery, EV, fuel cells
- “ Demand response
- “ Smart control

- “ Longer building lifetime
- “ Durable, recyclable material
- “ Less material intensity
- “ Speedy and high quality construction

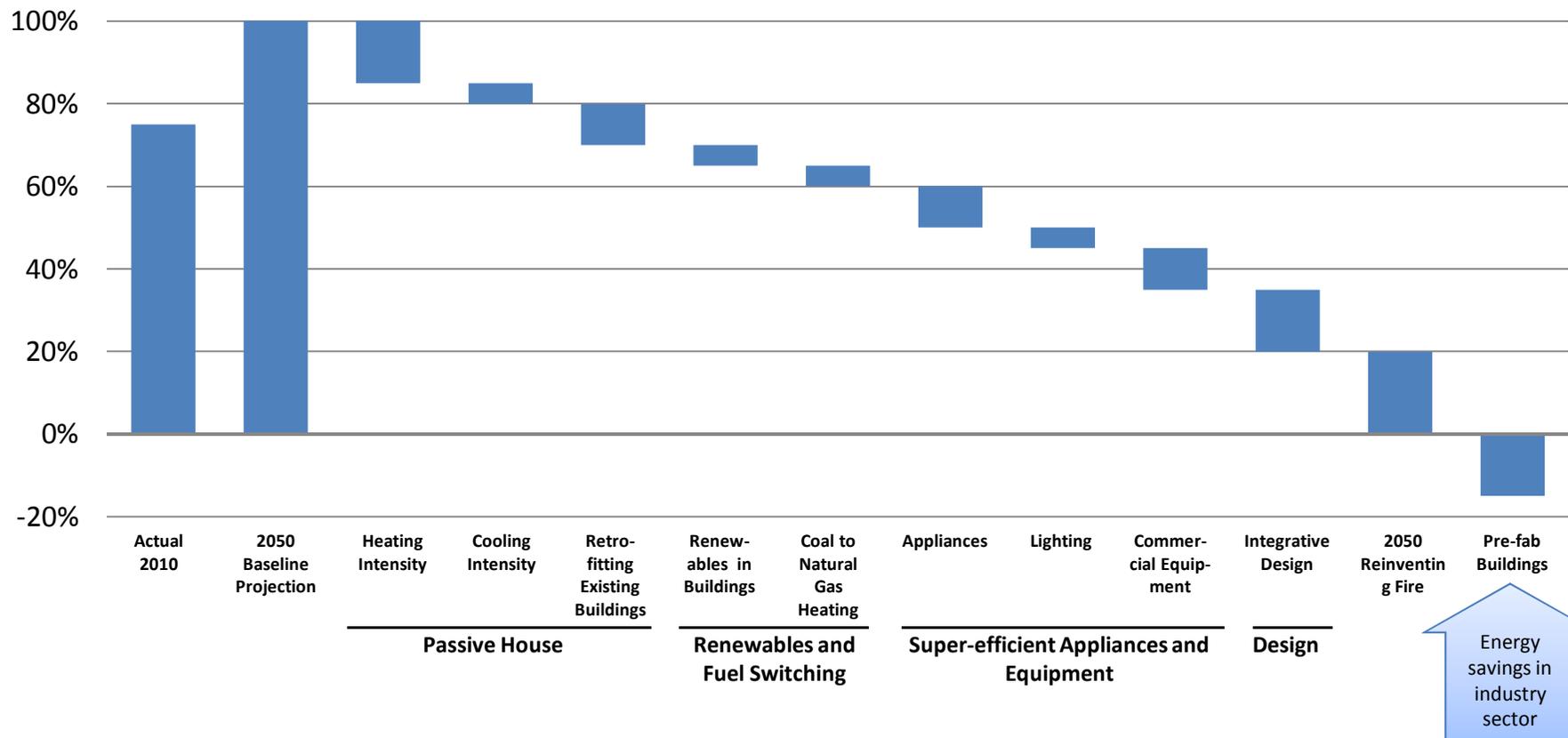
Reinventing Fire SCENARIO: POTENTIAL Buildings IMPACT



**ILLUSTRATIVE –
ANALYSIS NOT COMPLETE**

Buildings energy use can likely be reduced to near net zero

Energy Reductions in the Reinventing Fire Scenario
Indexed (100% = Baseline energy use in 2050)

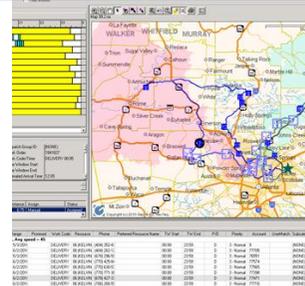


Energy savings in industry sector

Reinventing Fire 2050 Transportation Vision



By 2050, China's transportation system will provide increased mobility, but more efficiently, with fewer emissions, and lower costs



Reduced Private Auto Use	Auto Efficiency, Electrification	Freight Mode Shifting	Freight Logistics/Operations	Freight Vehicle Efficiency	Misc. Other Opportunities
<ul style="list-style-type: none"> “ Smart growth, integrated transport planning, telecommuting “ Parking pricing, vehicle quotas 	<ul style="list-style-type: none"> “ Weight reduction, low rolling resistance tires, aerodynamics “ Advanced ICES, including HEVs “ Electric vehicles 	<ul style="list-style-type: none"> “ Bulk goods and intermodal onto rail “ Some shifting to waterway and pipeline 	<ul style="list-style-type: none"> “ Software and data to improve routes, loads, maintenance, and driver behavior 	<ul style="list-style-type: none"> “ Aerodynamics, low rolling resistance tires, advanced powertrains “ Lightweight hybrid or plug-in electric delivery vans “ Heavier trucks, road trains “ Switching to cleaner fuels 	<ul style="list-style-type: none"> “ Best practices and emerging tech for plane, train, buses, and boat efficiency

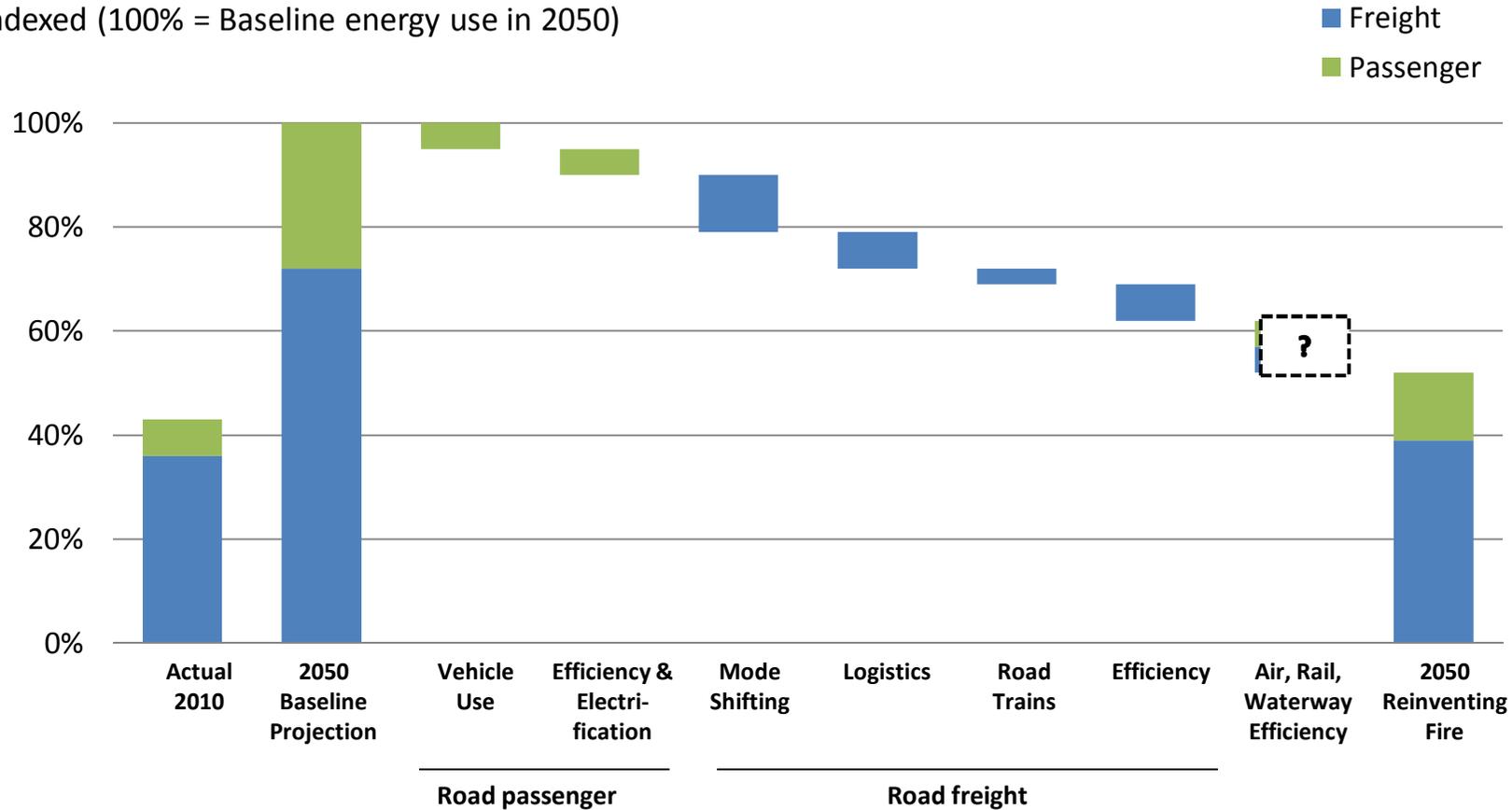
Reinventing Fire Scenario: Potential Transportation Impact



Baseline energy consumption can likely be reduced by at-least 40%

**ILLUSTRATIVE –
ANALYSIS NOT COMPLETE**

Energy Reductions in the Reinventing Fire Scenario
Indexed (100% = Baseline energy use in 2050)



Reinventing Fire 2050 Industry Vision



By 2050, China's industry is world-class in terms of energy efficiency and has moved away from carbon-intensive fuels

Production/ Energy Demand Reduction	Energy Efficiency Improvement	Fuel Switching /CCS	Structural Shift
Higher quality products and materials	Integrative design/system optimization	Lower carbon fuels	More efficient processes within industries
Material recycling, material efficiency	Energy-efficient commercial and emerging technologies	Electrification and on-site electricity generation	Increase high value added, lower intensity industries
By-product synergy/industrial parks	Energy management	CCS	Move from industry to service sector

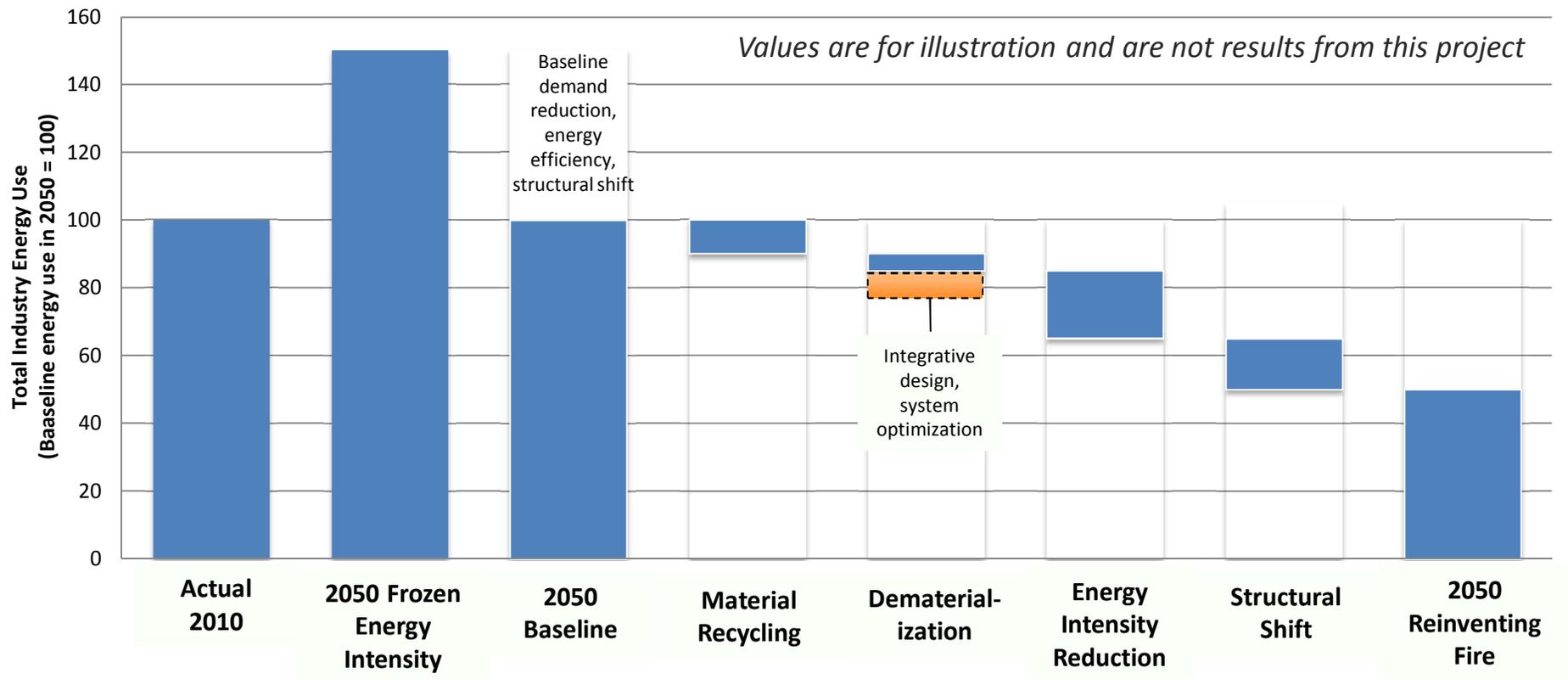
Reinventing Fire SCENARIO: POTENTIAL Industry IMPACT



**ILLUSTRATIVE –
ANALYSIS NOT COMPLETE**

Industry energy consumption can likely be reduced by >50%

Energy Reductions in the Reinventing Fire Scenario
Indexed (100% = Baseline energy use in 2050)



Reinventing Fire 2050 Transformation Sector Vision



By 2050, primary energy demand in the transformation sector will be dramatically reduced, allowing for a large-scale shift to renewable supplies



Electricity

Hybrid grid structure with partial decentralization

Robust 2-way distribution network (significant demand response, EVs, storage, ZNE buildings)

Decarbonized generation sources (i.e., hydro, wind, solar, nuclear); CCS for remaining coal and new gas



Mining and refining

Coal and petroleum use significantly reduced

Local gas resources developed (CBM, unconventional shale)

Biodiesel and biogas



Combined heat and power

Proliferation of Zero Net Energy systems

Integrated district heating designed into compact cities

Thank you!

For more information, please contact

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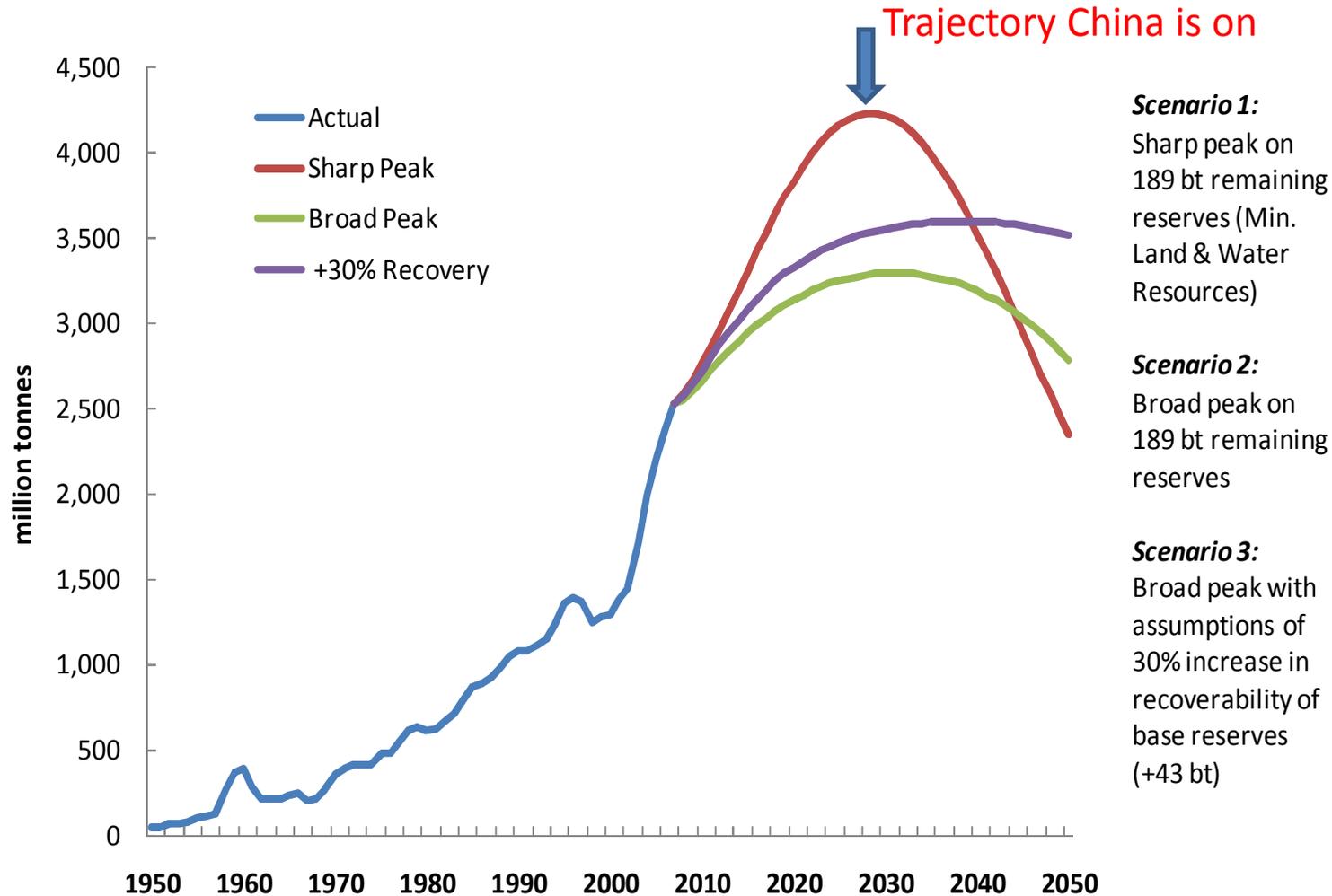
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<http://china.lbl.gov>

Coal:

China's import is growing 50% a year, will be importing all coal available in APEC region in three years with the rate.

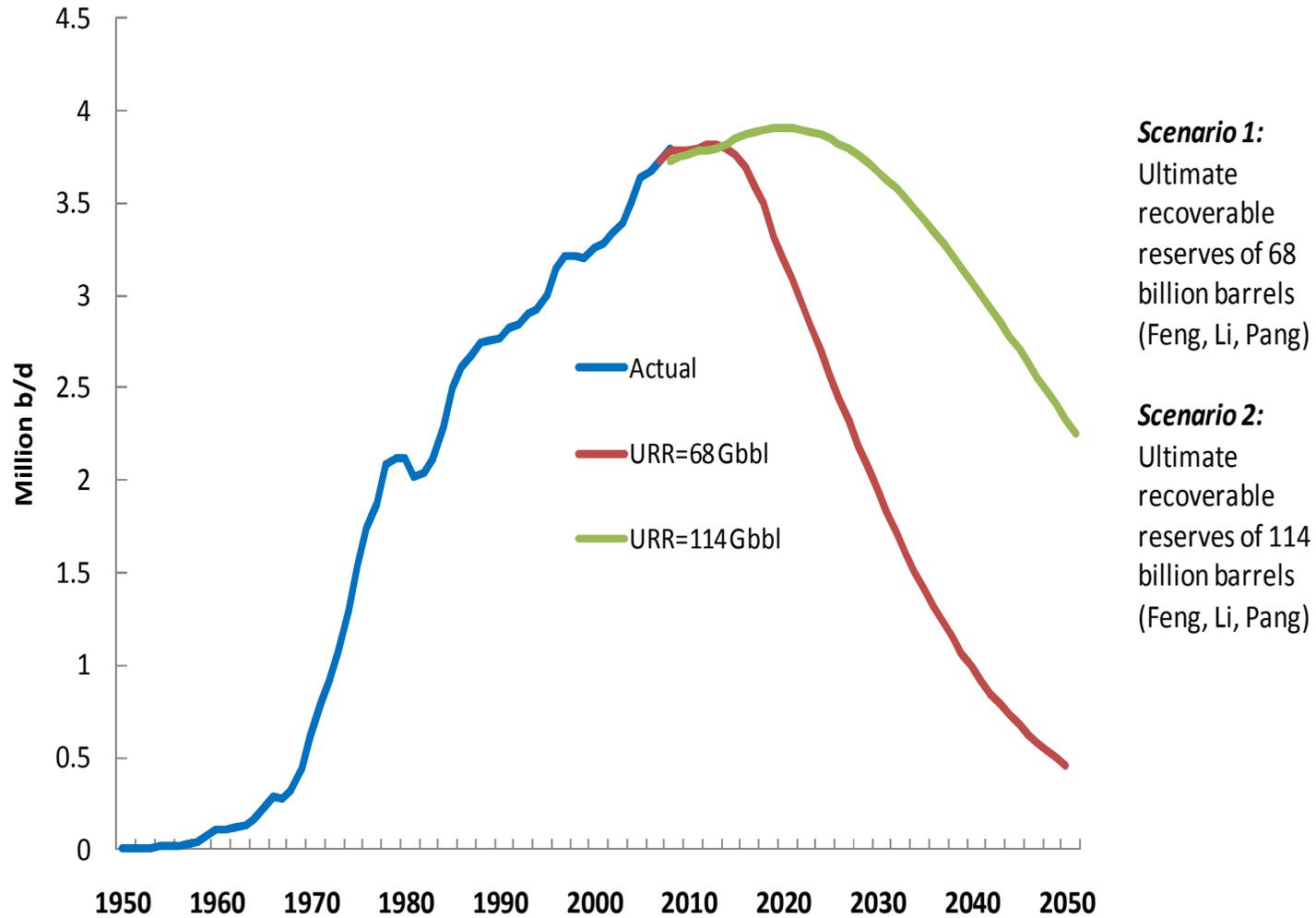


"A supply curve to resource availability

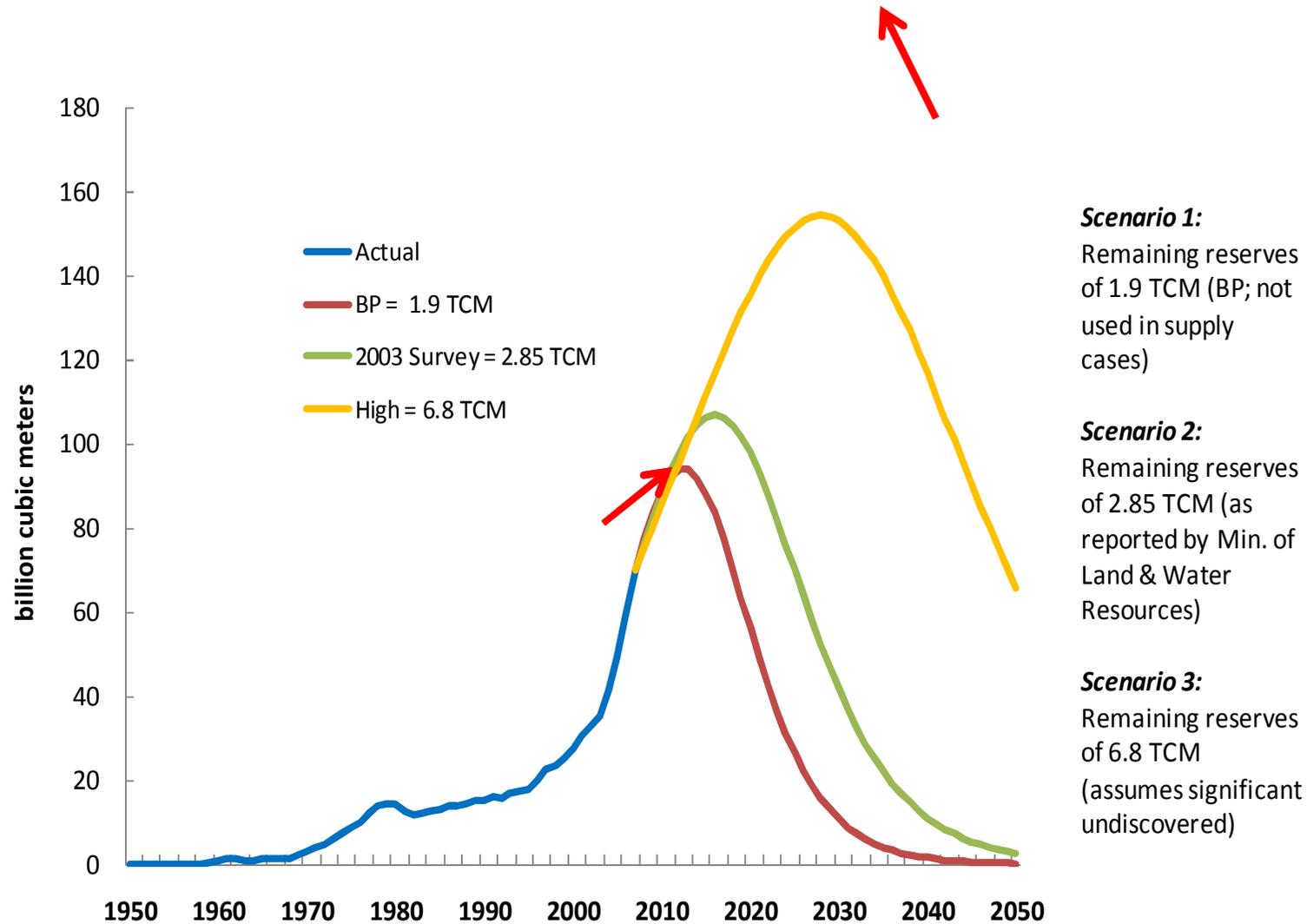
"Suggest coal price will remain strong

Oil:

Domestic production plateaued, additional demand will be import

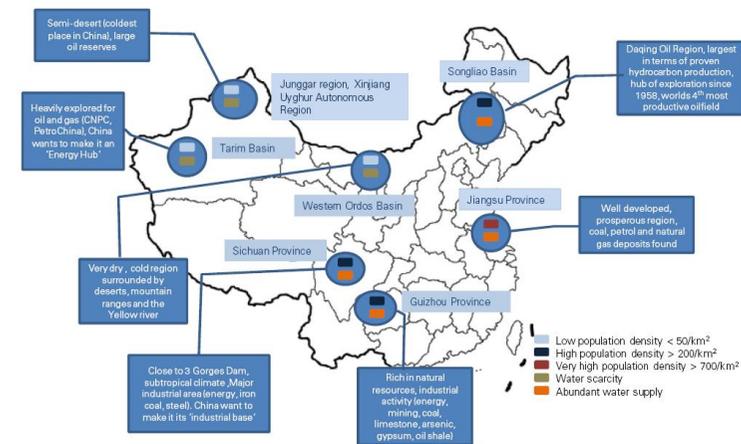
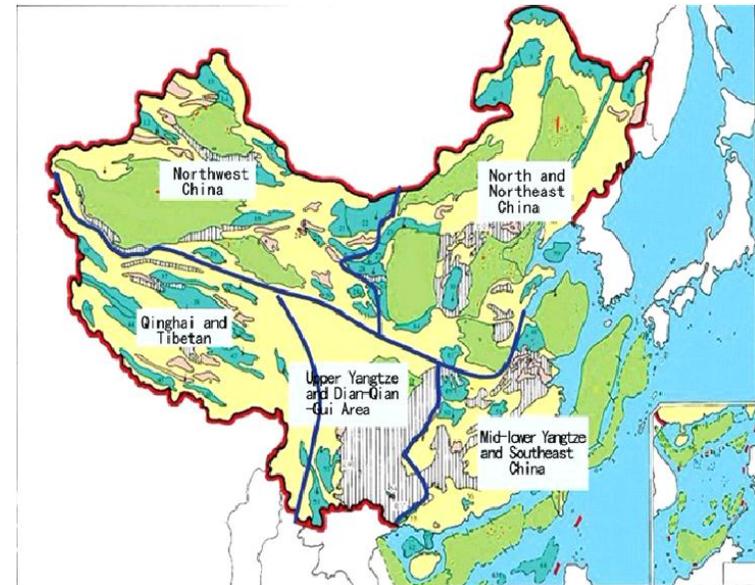


Conventional Gas: Even with most optimistic forecast, will still be limited



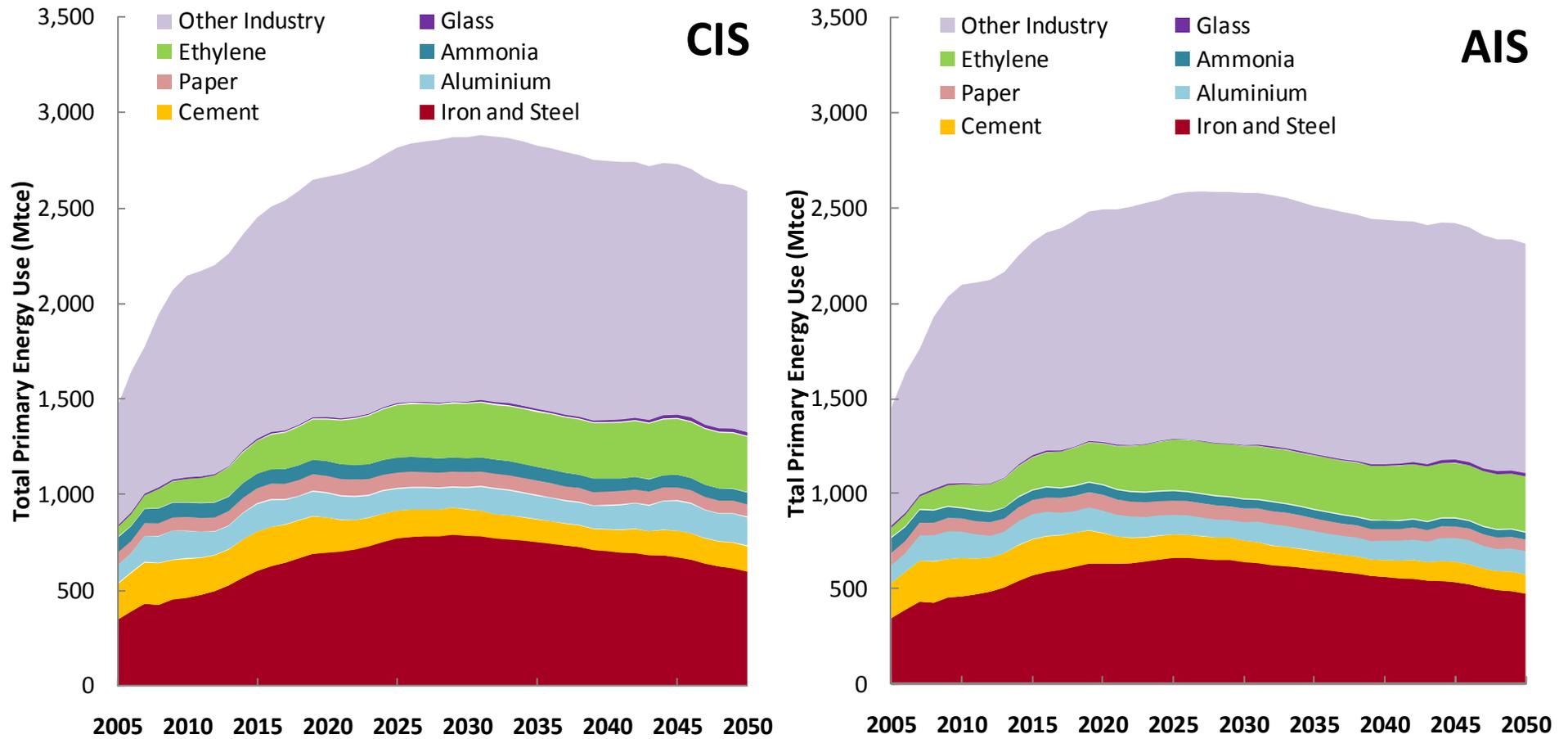
LBNL Key Findings for Alternative Energy Resources

- ◆ Shale gas most abundant alternative resource: recoverable resources of 15-25 tcm
- ◆ Maximum shale gas output in worst/best scenario could displace 105-395 million tonnes of raw coal (3-10% current consumption, thermal equivalent)
- ◆ Modeling shows output peaks within decade of commercialization; commercialization at early stage dependent on several key tech breakthroughs
- ◆ Coal seam methane (CMM, CBM) has ~10 tcm of resources, may be better alternative but R&D breakthroughs also needed
- ◆ Tight gas will become increasing proportion of natural gas supply
- ◆ Tight oil and oil shale unlikely to contribute much to total petroleum output
- ◆ Gas hydrates not major supply prospect; need long-term R&D



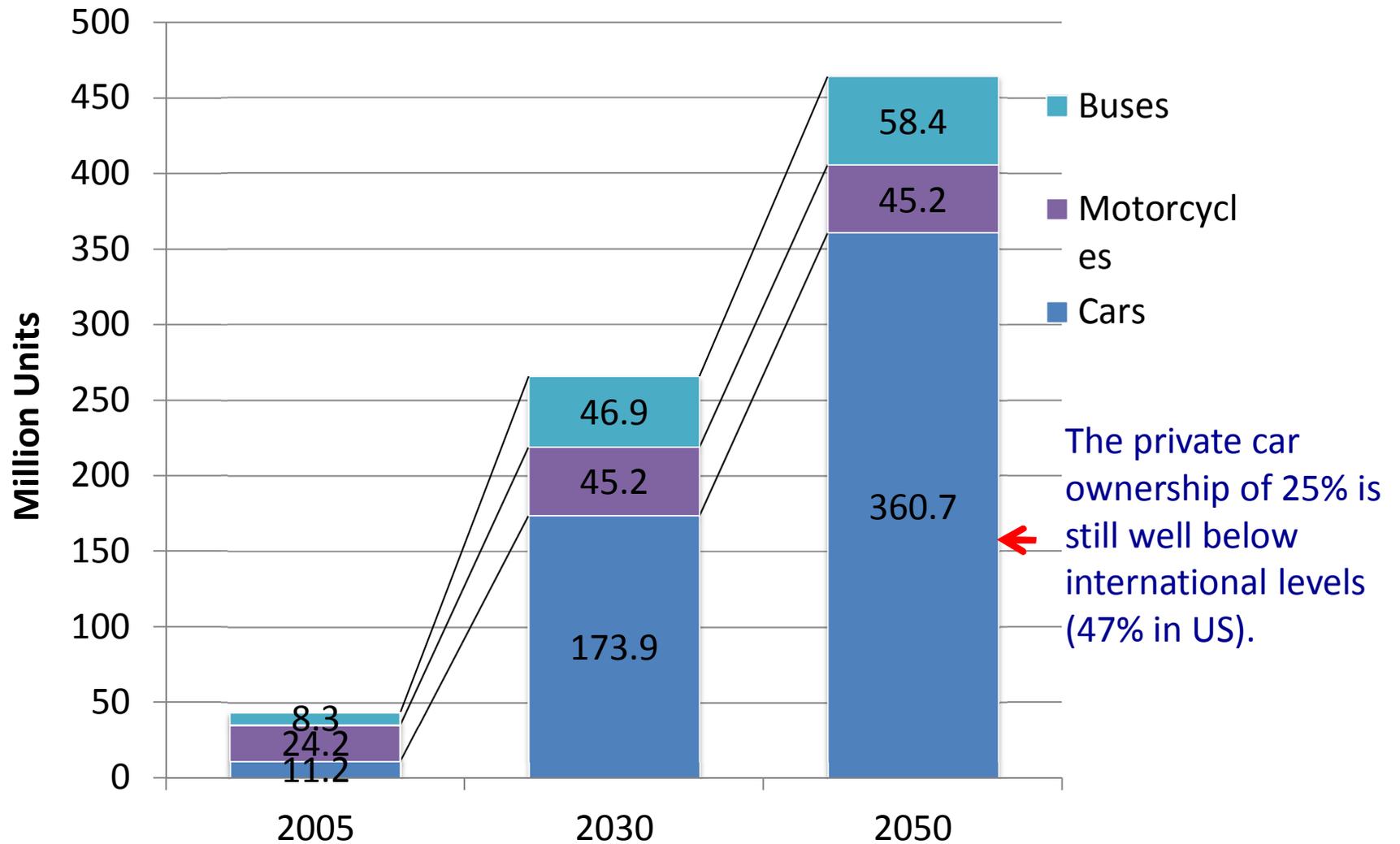
Source: Liu, 2012, 12th Annual U.S.-China Oil & Gas Industry Forum

Most of the industrial energy savings will be from iron & steel and cement sector

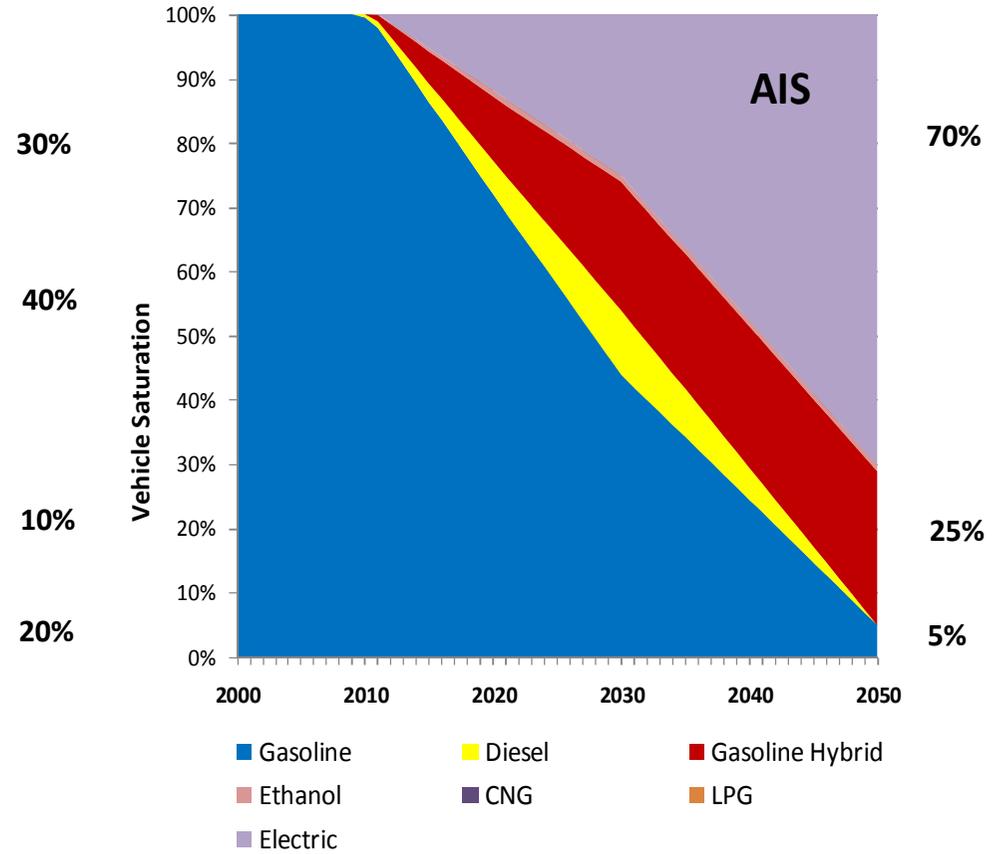
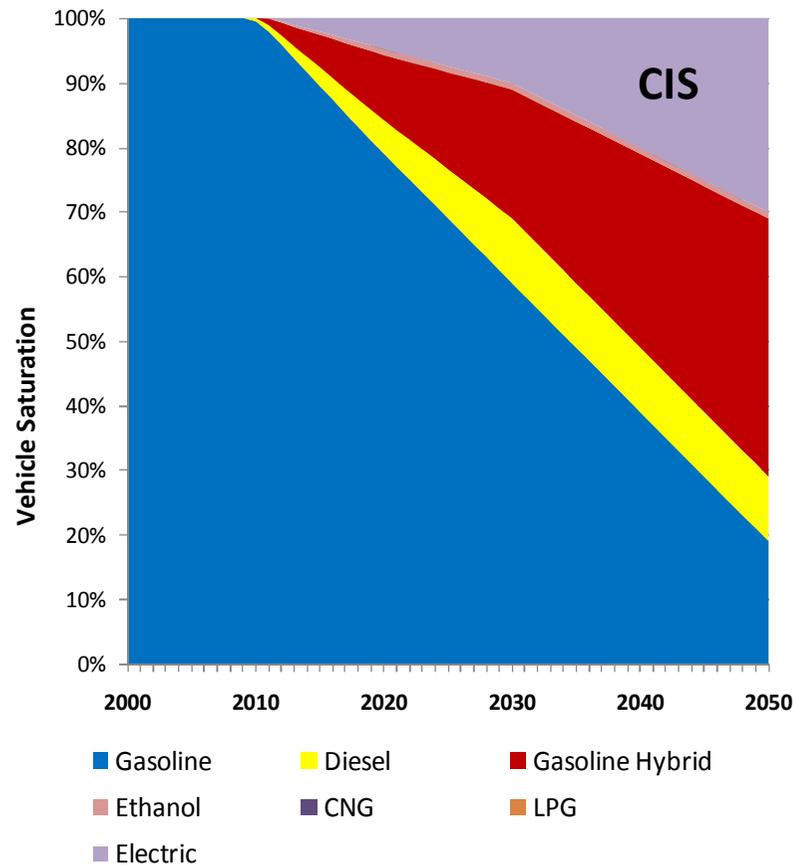


*Other Industry includes manufacturing, chemicals, light industry and all other small industrial subsectors.

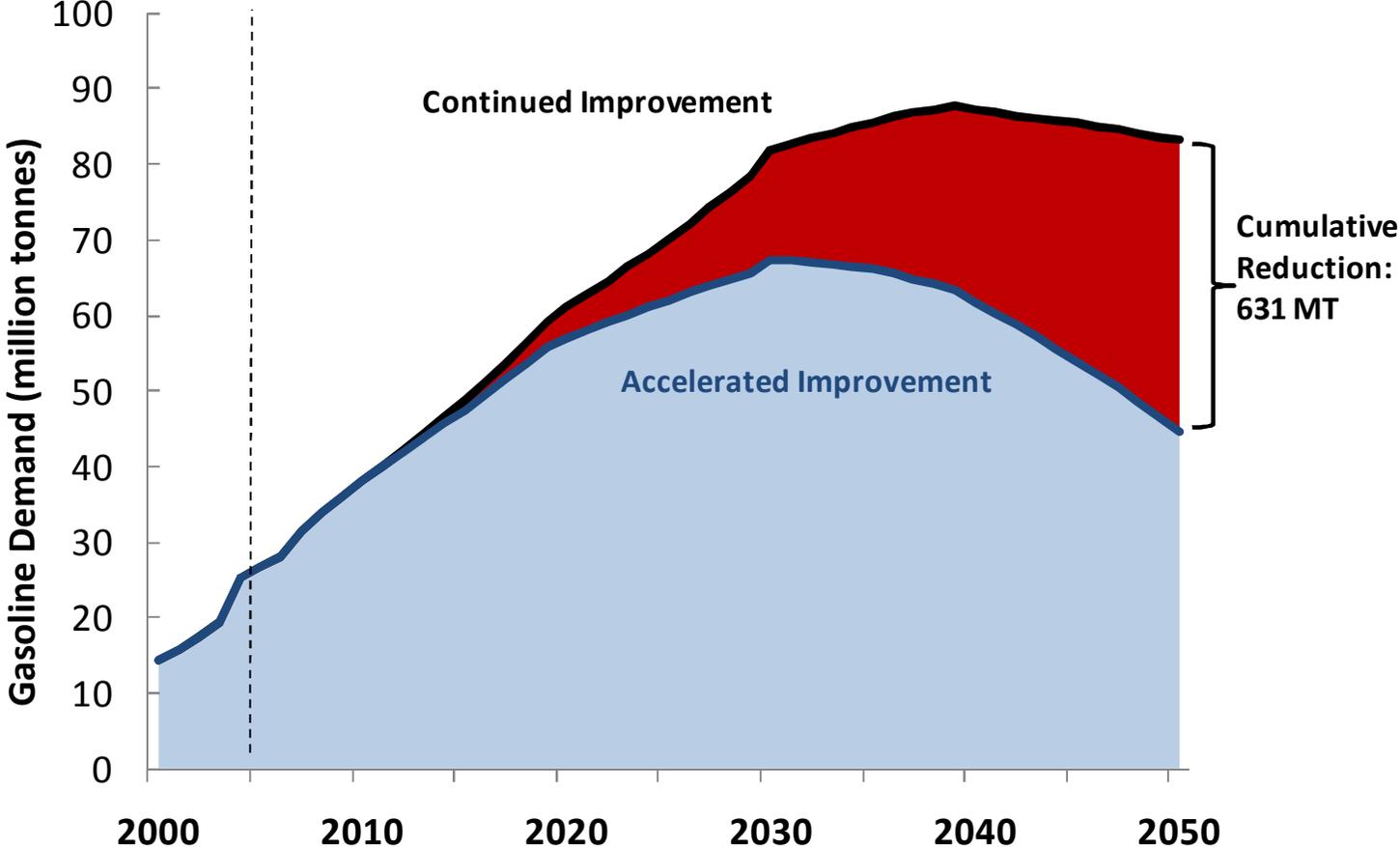
Passenger road transport will be driven by a stock of 420 million vehicles



China is aggressively pursuing electric vehicles

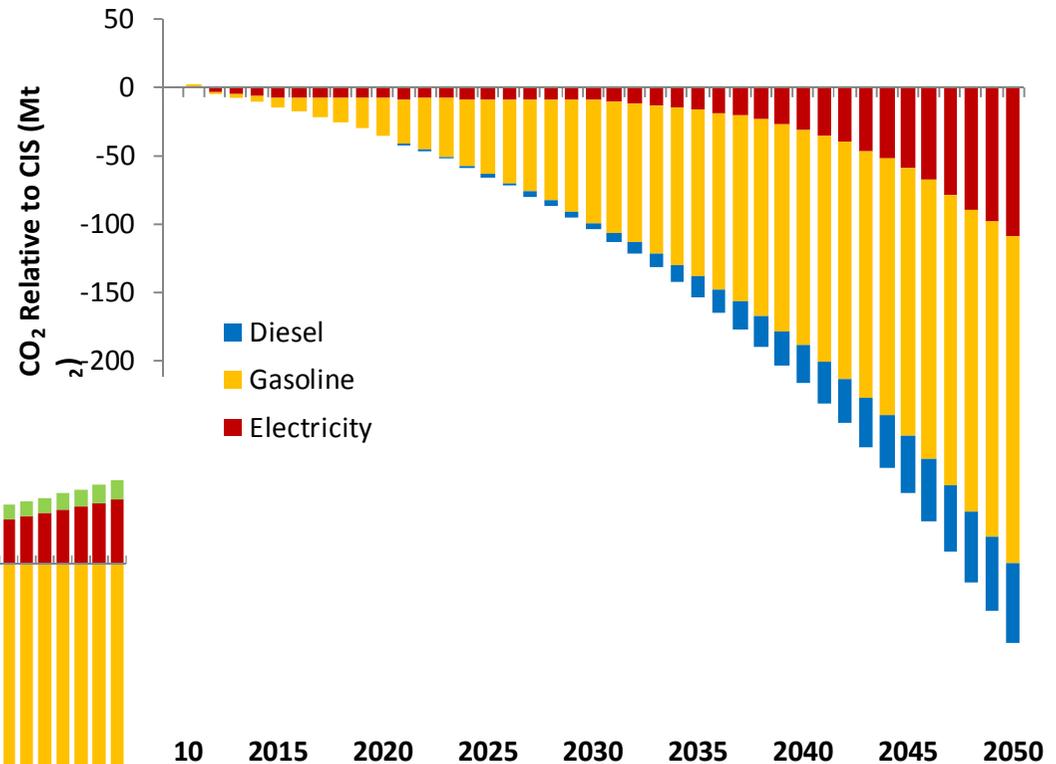
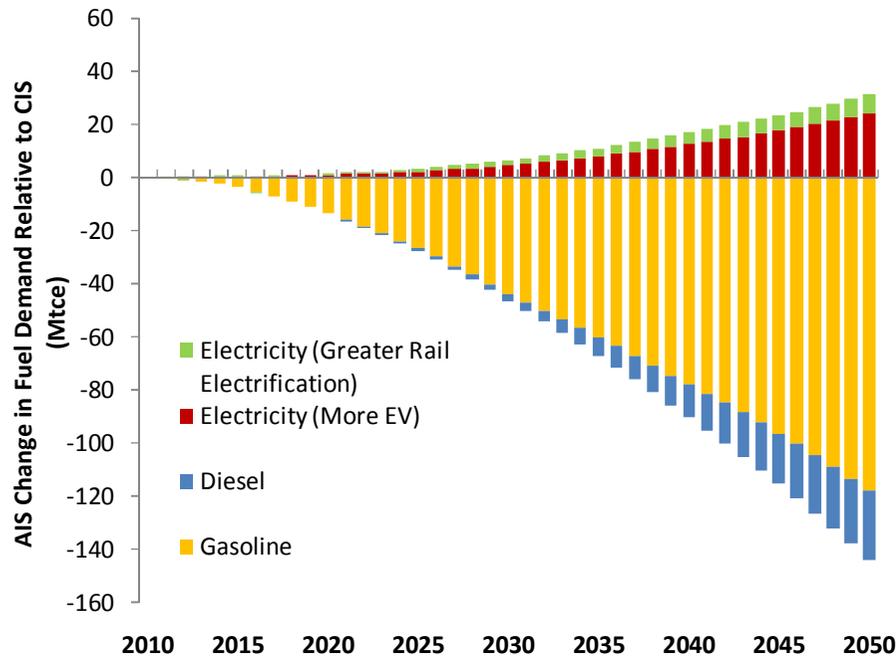


Electric Vehicles Impact on Gasoline Demand



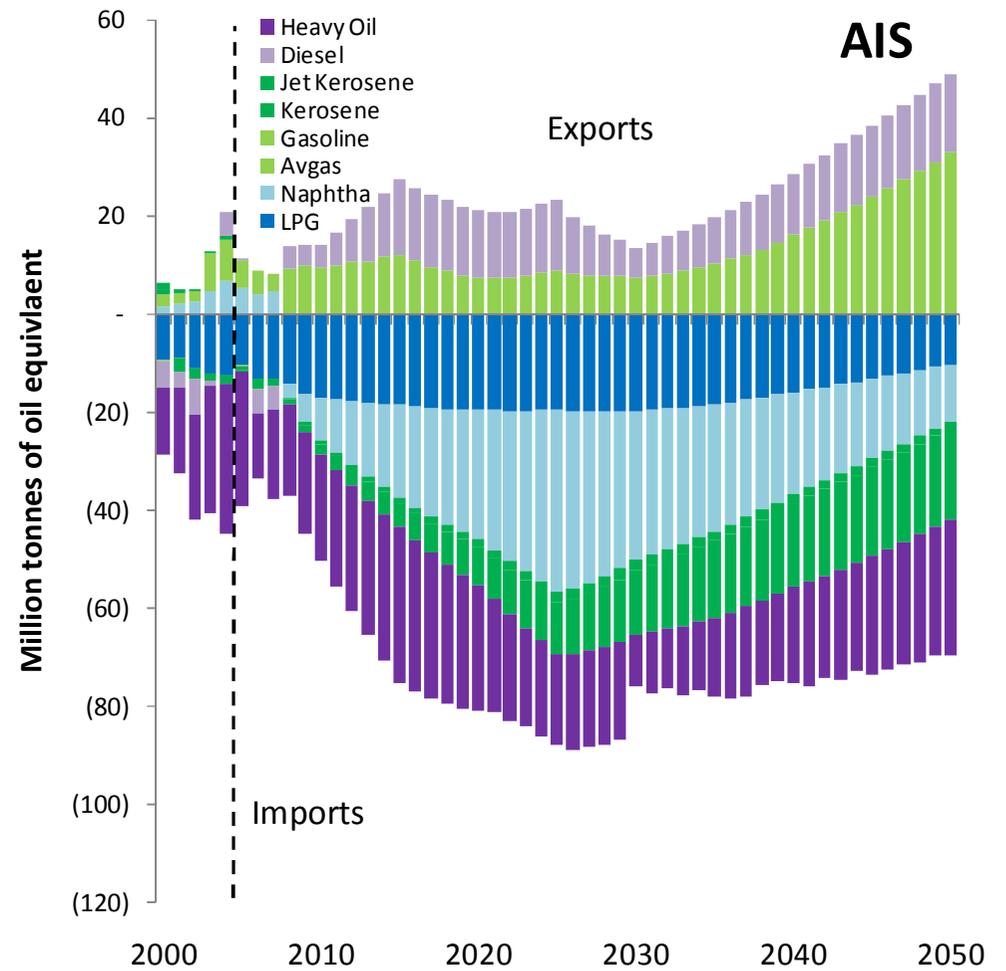
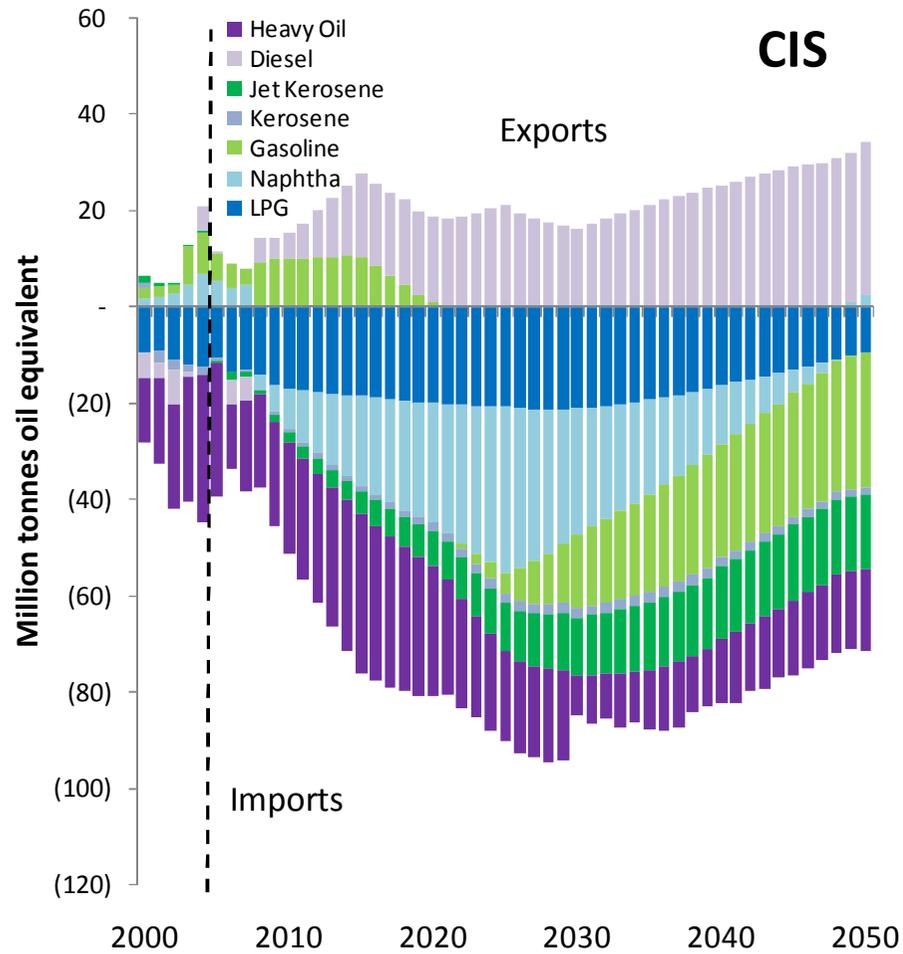
Electric Vehicles and Rail Electrification Impact on CO2, increase use in electricity, but emission offsets by power sector decarbonization from 2015

Electric Vehicles and Rail Electrification Impact on electricity



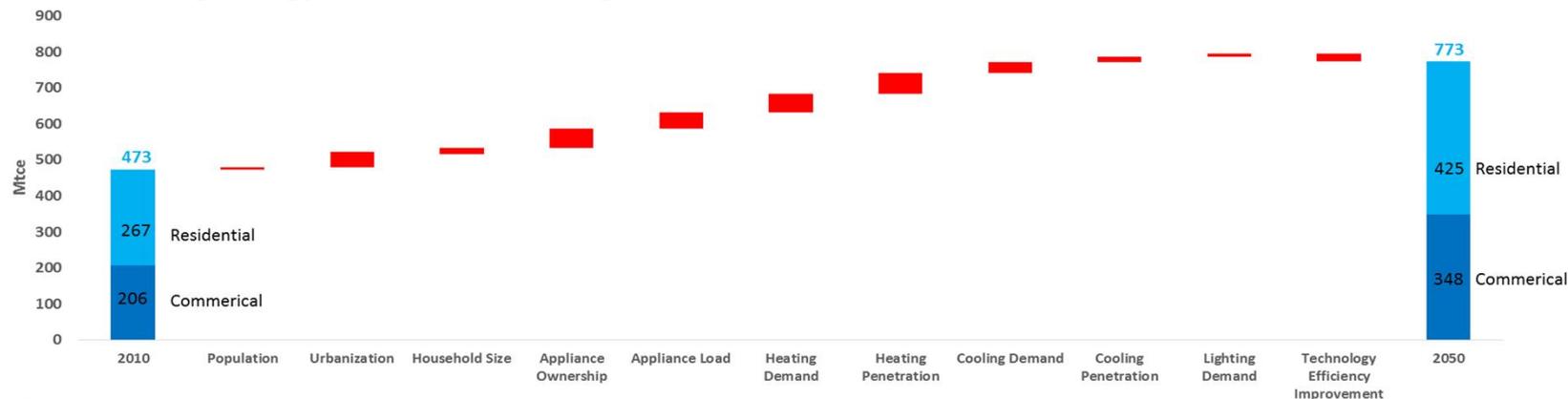
Electric Vehicles and Rail Electrification Impact on CO2

Major Oil Product Imports and Exports: China will export diesel and gasoline due to the efficiency improvement and fuel switching while refinery output portfolio keeps constant.



Most other models for long-term scenarios based on regressions (i.e., future is like the past). Our work is based on detailed end-use (bottom up) modeling

Factors Driving Energy Demand in Buildings



Measures for Energy Reductions

Indexed (100% = Baseline energy use in 2050)

