



Effects of CO₂ constraints in a global gas market

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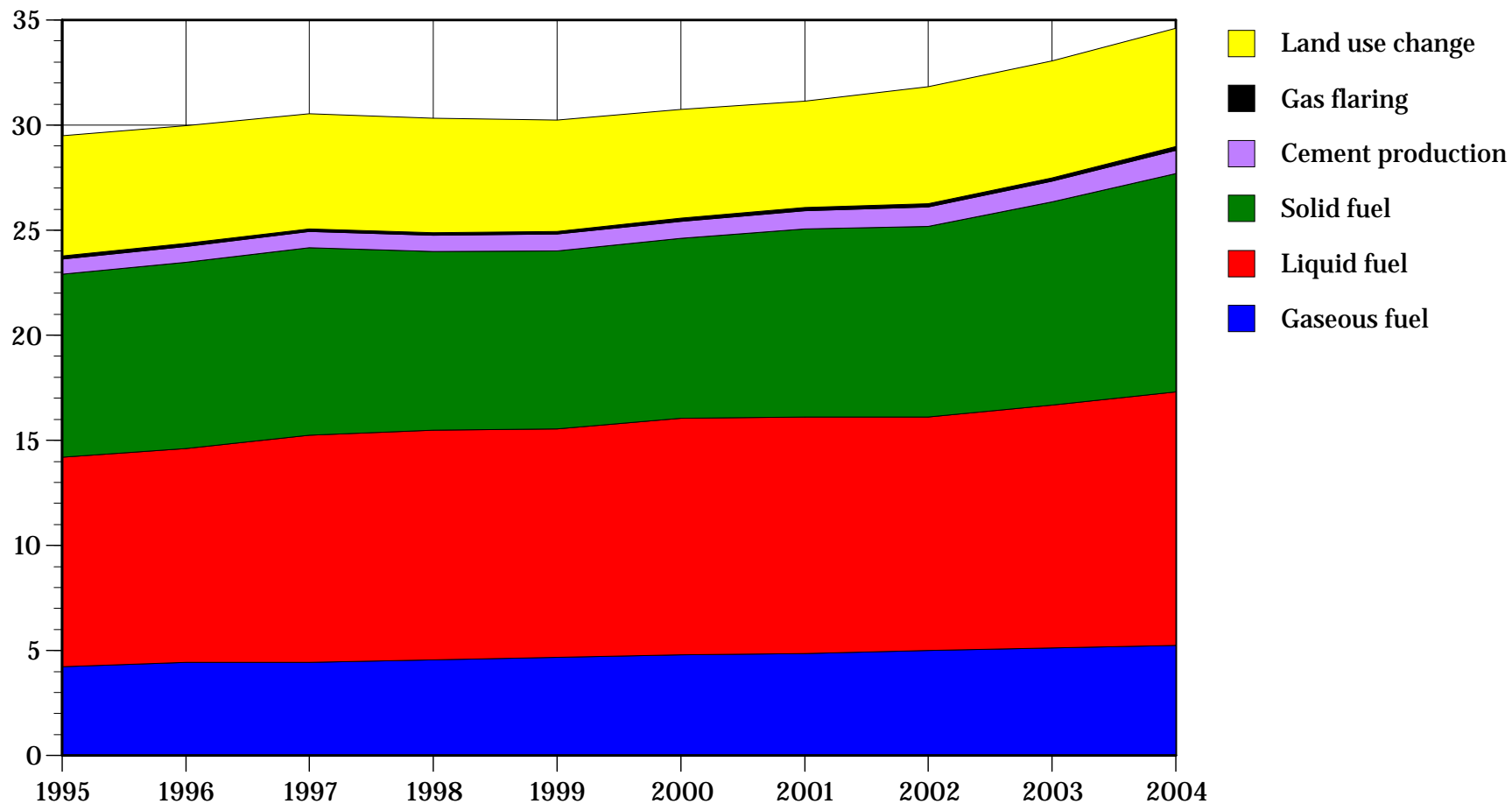
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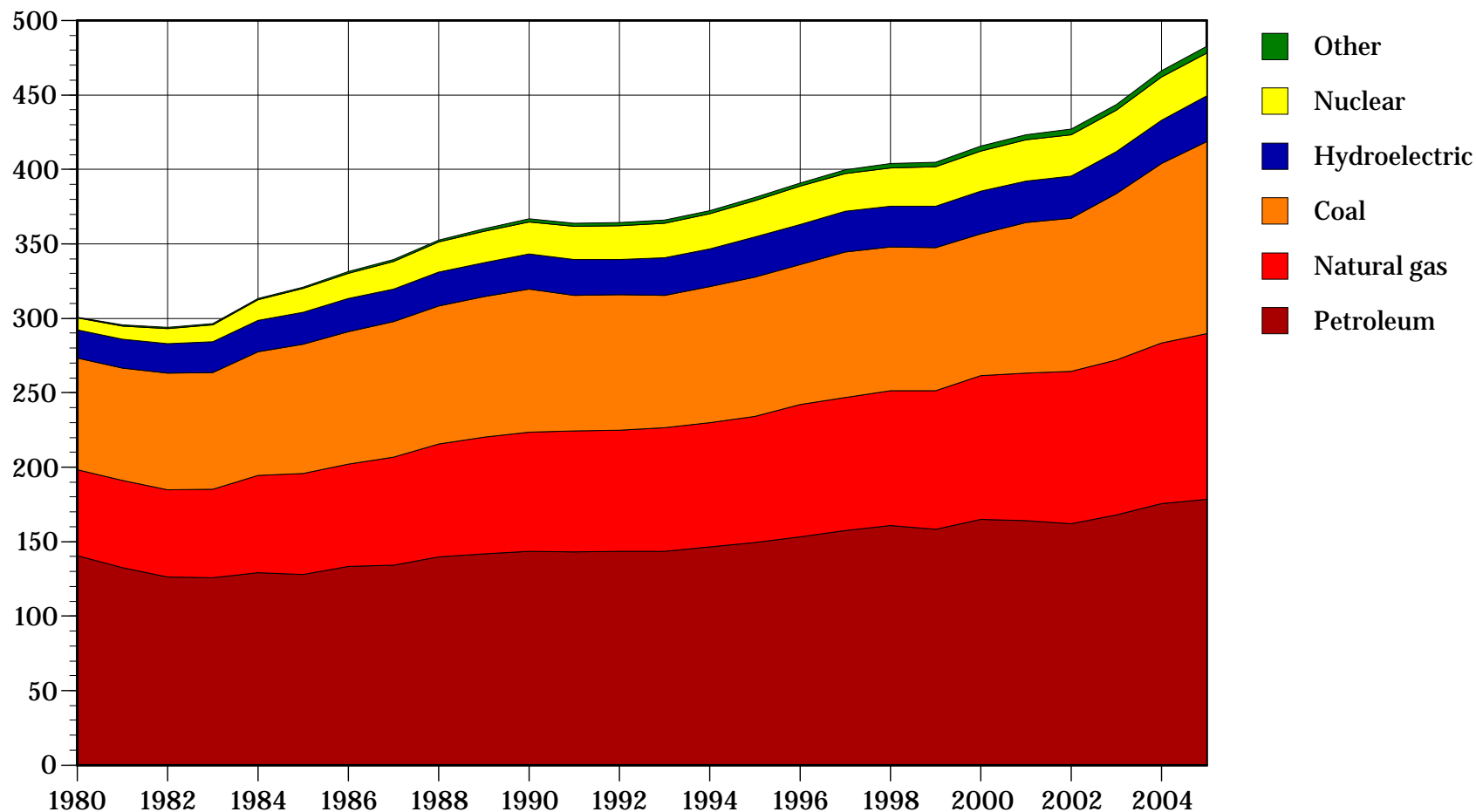


Anthropogenic sources of CO₂ (1995–2004)



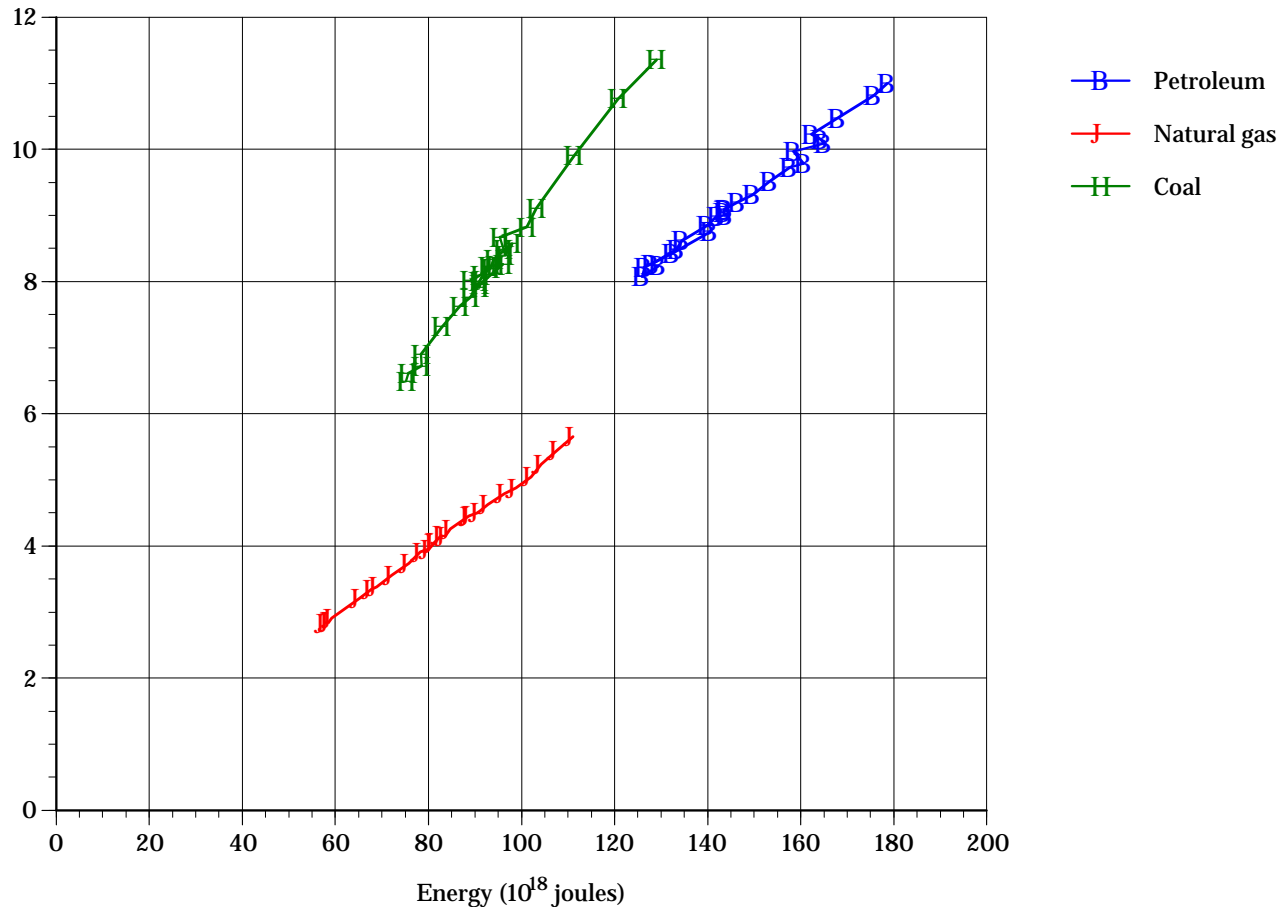


World primary energy supply (1980–2005)





CO₂-intensity of fossil fuels



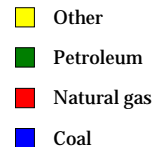
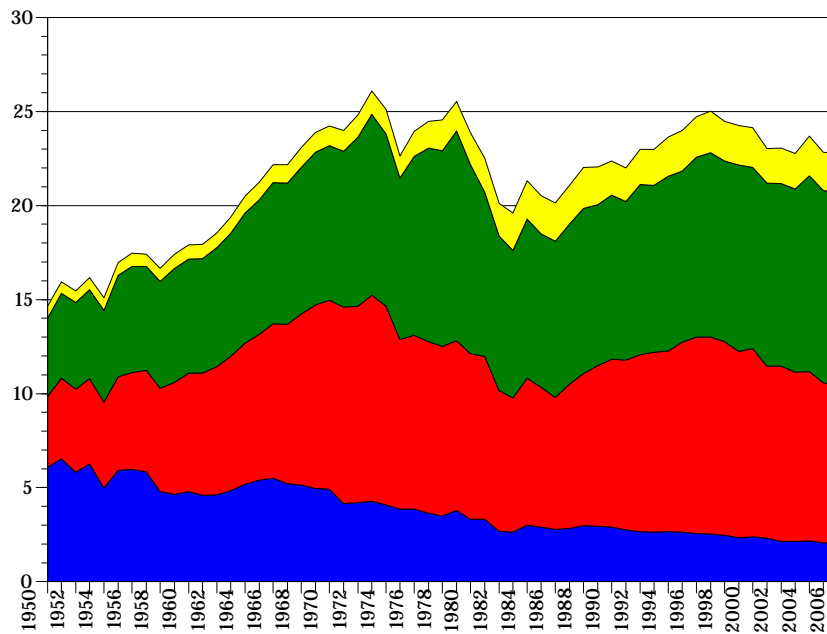
Source: EIA

- ❖ CO₂ emission controls will favor the least CO₂-intensive fossil fuel, natural gas

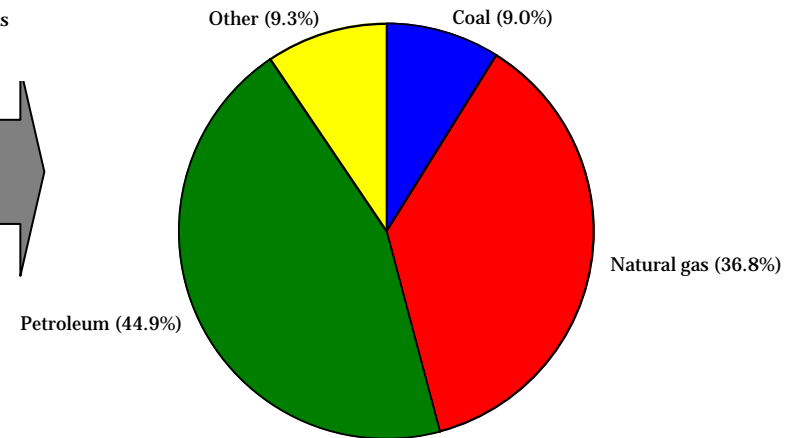


US industrial demand for energy

- Fuel source choice is sensitive to technology, prices and policy



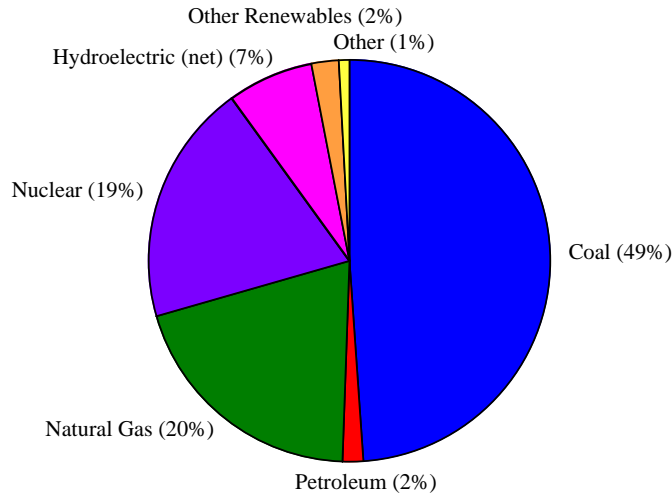
U.S. Industrial demand by source 2006



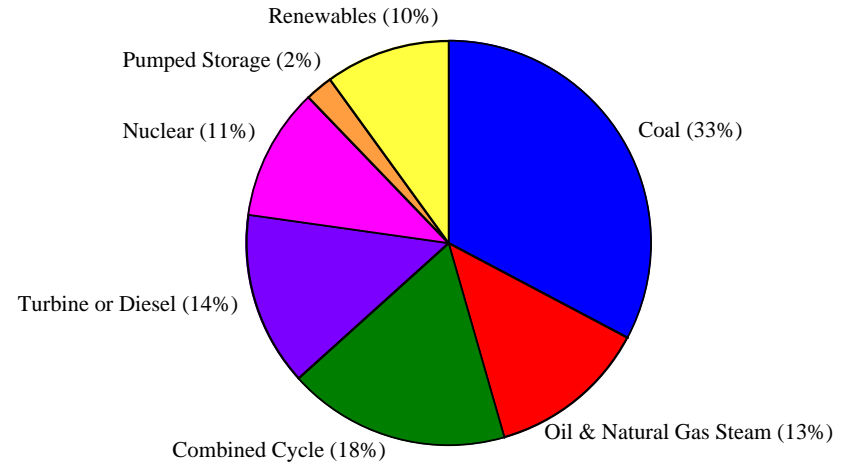


US electricity generation

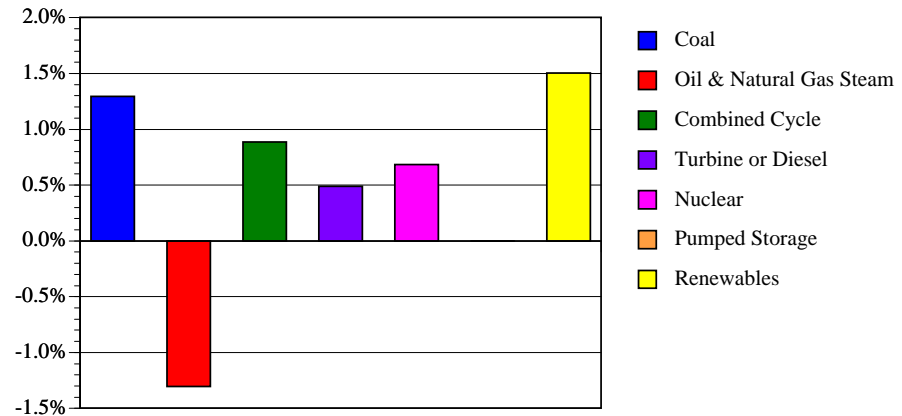
Generation by source 2006



Generating capacity 2005

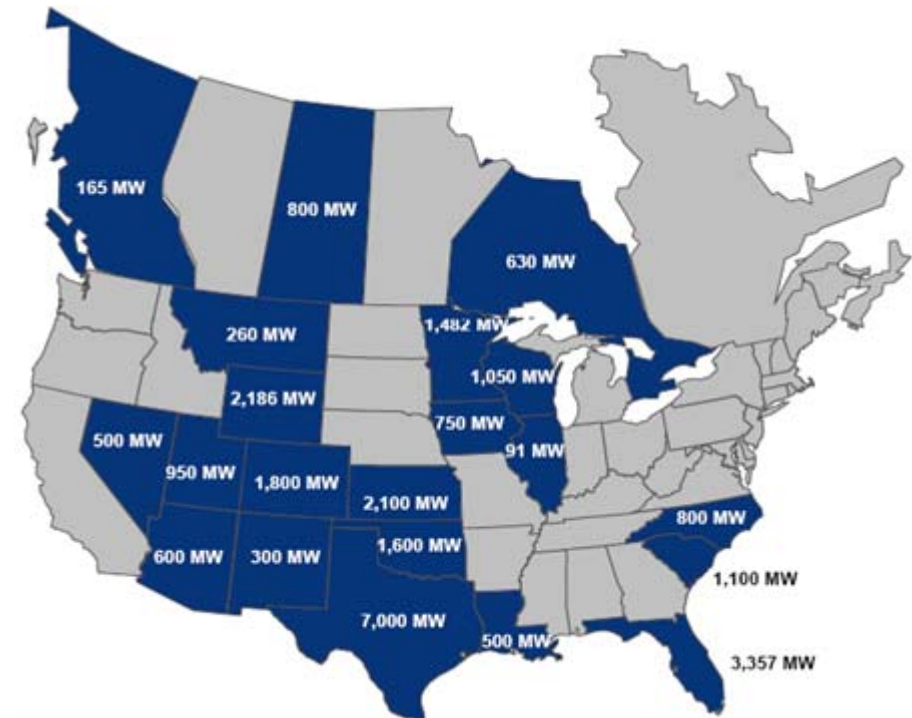


Average annual net capacity growth 2005-2030 in the EIA Annual Energy Outlook, 2008 reference case

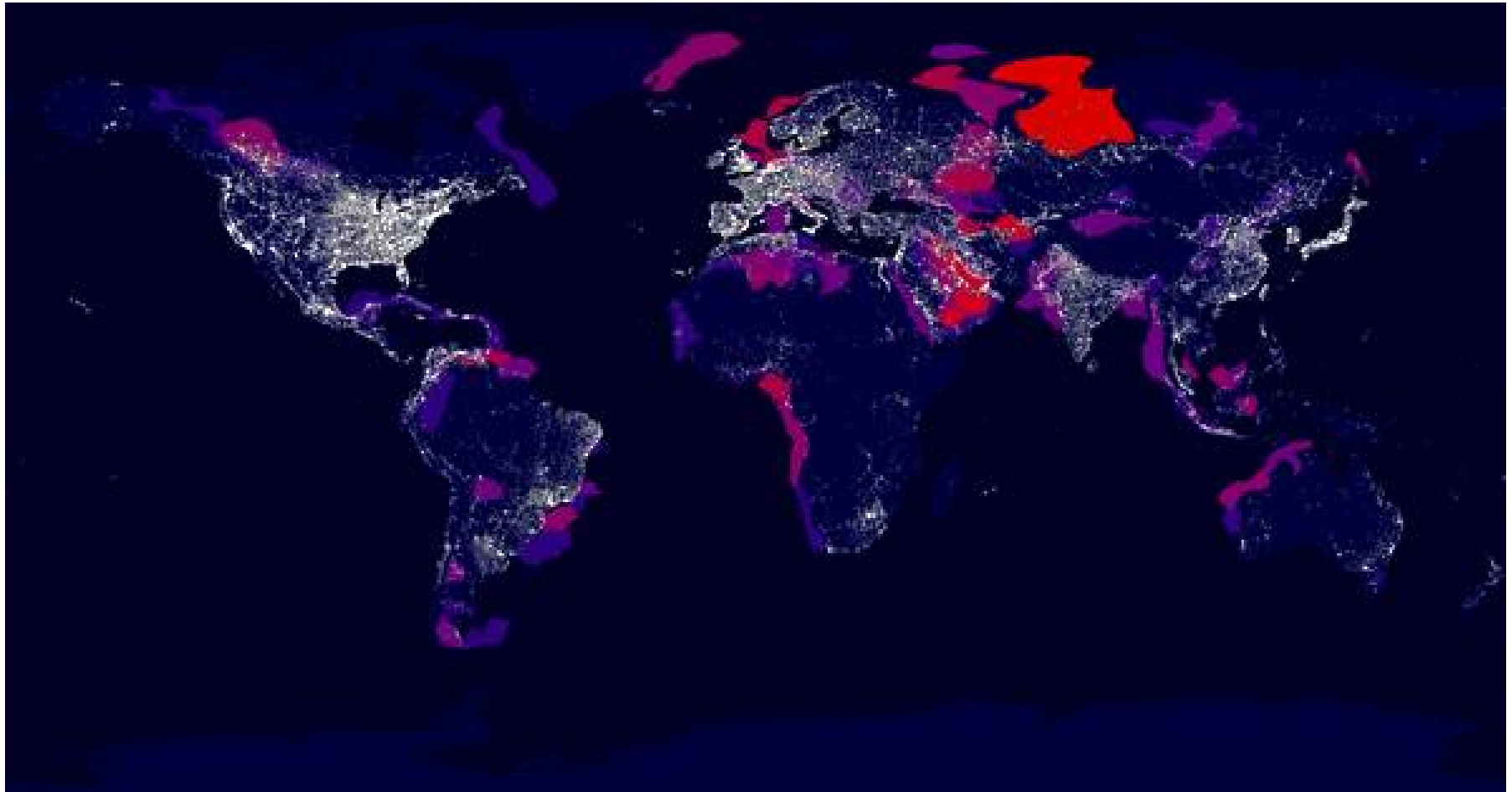


Concern about future CO₂ regulation already is delaying new coal plants

- ❖ Amount of coal capacity cancelled in 2007 is nearly the amount cancelled between 2004 and 2007
- ❖ Some cancellations are also the result of rising construction costs
 - ❖ But these also tend to favor less capital-intensive CCGT and also disadvantage nuclear in addition to coal
- ❖ Despite the cancellations, some coal projects are still proposed
 - ❖ 2,800 of the 6,700 MW still proposed at the beginning of 2008 was IGCC



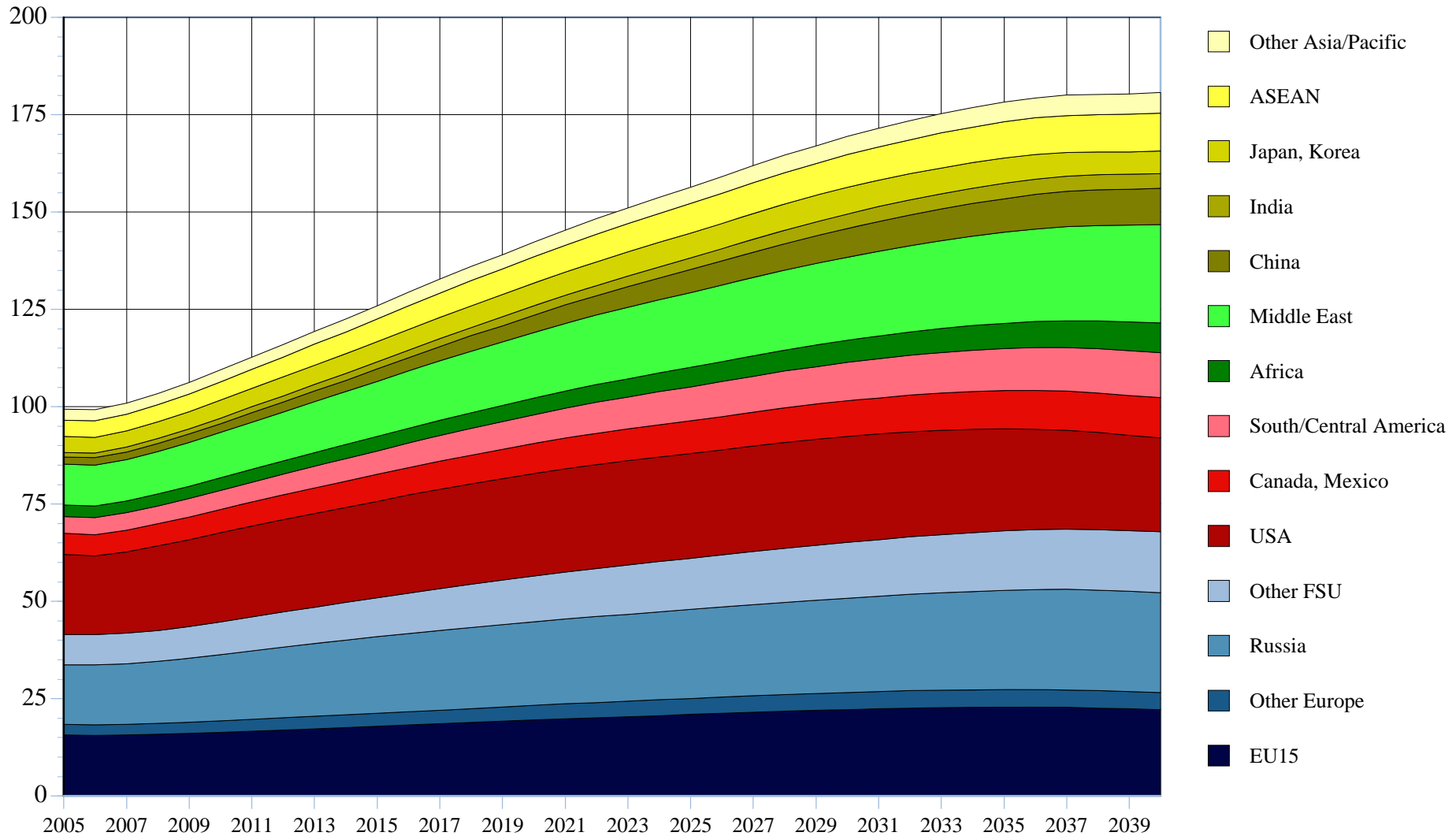
Meeting the “dash to gas”: Natural gas resources and demand



- ❖ Areas with the largest resources are remote from markets, require substantial new infrastructure and, perhaps more importantly, raise energy security concerns



Reference case demand





Reference case summary

- ❖ North America and Europe become the largest LNG importing regions
- ❖ European LNG imports exceed Northeast Asia's by 2016, while North America's also do so by 2026
- ❖ Russia becomes the largest exporting country in the global gas market
 - ❖ Pipelines to Europe
 - ❖ Sakhalin gas to Japan and the Korean peninsula (mostly as LNG)
 - ❖ East Siberian gas to China
 - ❖ LNG from the Barents Sea region beginning in the 2020s with strong growth
- ❖ The Middle East also becomes an important supply region
 - ❖ Qatar is largest exporter in the region
 - ❖ Strong growth post-2025 from Iran and Saudi Arabia, and from Iraq when it is allowed to build
 - ❖ Iran and later Iraq become large sources of pipeline gas exports from the Middle East
- ❖ South American gas is consumed primarily in South America
 - ❖ Trinidad LNG export growth is limited to the near term
 - ❖ Peru exports LNG from the beginning of next decade, but growth is moderate
 - ❖ Venezuelan LNG is significant post-2025



Modeling the effect of CO₂ emission controls

- ❖ Increase the price of energy other than natural gas by 50% in OECD western Europe, North America and Asia, leave it unchanged elsewhere in the world
 - ❖ The increase in energy price will reduce the energy-intensity of GDP, but absent an increase in natural gas prices will raise the demand for natural gas
 - ❖ The endogenously calculated price of natural gas thus also will rise
- ❖ In the US, the demand for natural gas to generate electricity is modeled conditional on the available capacities of the different types of plants
 - ❖ The estimated cross-price elasticity of substitution between fuels is lower in the US
- ❖ In the restricted emissions case, we assumed that all the planned coal-fired capacity additions in the US were required to be natural gas instead
 - ❖ As in the reference case, we still allow substantial development of IGCC with sequestration, along with nuclear and renewables capacity



Caveat 1: Relaxed access restrictions in the US

- ❖ Relaxing restrictions on drilling in the US might satisfy some increased demand resulting from CO₂ emission restrictions
- ❖ Specifically, some Federal lands and offshore areas known to contain significant natural gas reserves are effectively off-limits
 - ❖ Some restrictions are via legislation, executive order, regulation or administrative decisions
 - ❖ Other resources have been rendered uneconomic by Federal and State regulatory requirements that increase costs and create delays
- ❖ Major resources affected include interior Western States, some US offshore areas and the Alaska National Wildlife Refuge and some other areas in Alaska
- ❖ Ultimately, the amount restricted will depend on gas prices and other costs



Outline of restricted areas

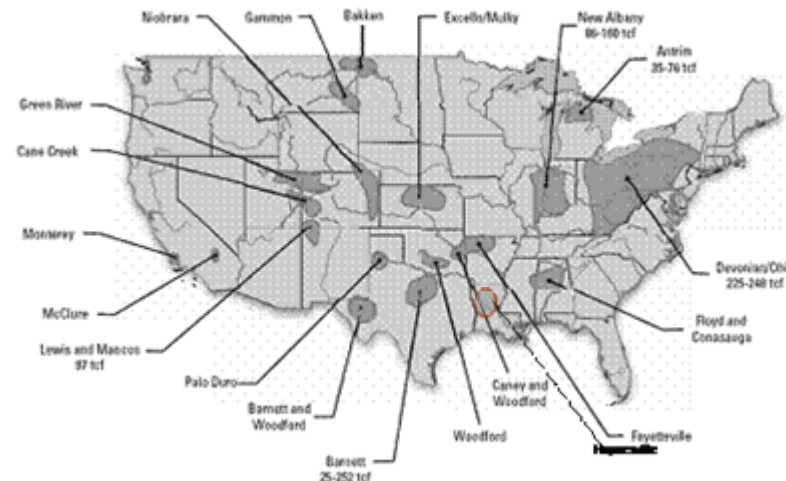
Planning Region/Basin		Resource Off-limits (Tcf)
Rocky Mountains	Montana	9.4
	Wyoming Thrust Belt	0.8
	Green River	39.5
	Powder River	6.0
	Uinta-Piceance	8.4
	San Juan	5.3
OCS	Eastern Gulf of Mexico	22.1
	North Atlantic	18.0
	Middle Atlantic	15.1
	South Atlantic	3.9
	Washington/Oregon	2.3
	North/Central California	6.0
	Southern California	10.0
Total Lower 48		146.8
Alaska	ANWR	8.6
	North Aleutian Basin	8.6
Total		164.0

QuickTime™ and a
TIFF (LZW) decompressor
are needed to see this picture.

Sources: NPC Supply Task Group Report, MMS

Caveat 2: Shale gas

- ❖ The RWGTM currently under-counts prospective vast resources of shale gas likely to be developed in the US and Canada over the next few decades
 - ❖ Recent assessments of technically recoverable resources in 29 identified plays in the lower 48 amount to 274 Tcf compared with 134 Tcf currently in the model (Barnett, Fayetteville, Woodford)



- ❖ We are currently developing an inventory of these resources and their likely costs of exploitation
- ❖ These will be included in the model in the next few months and could be another source that offsets the increased demand for Russian and Middle Eastern gas

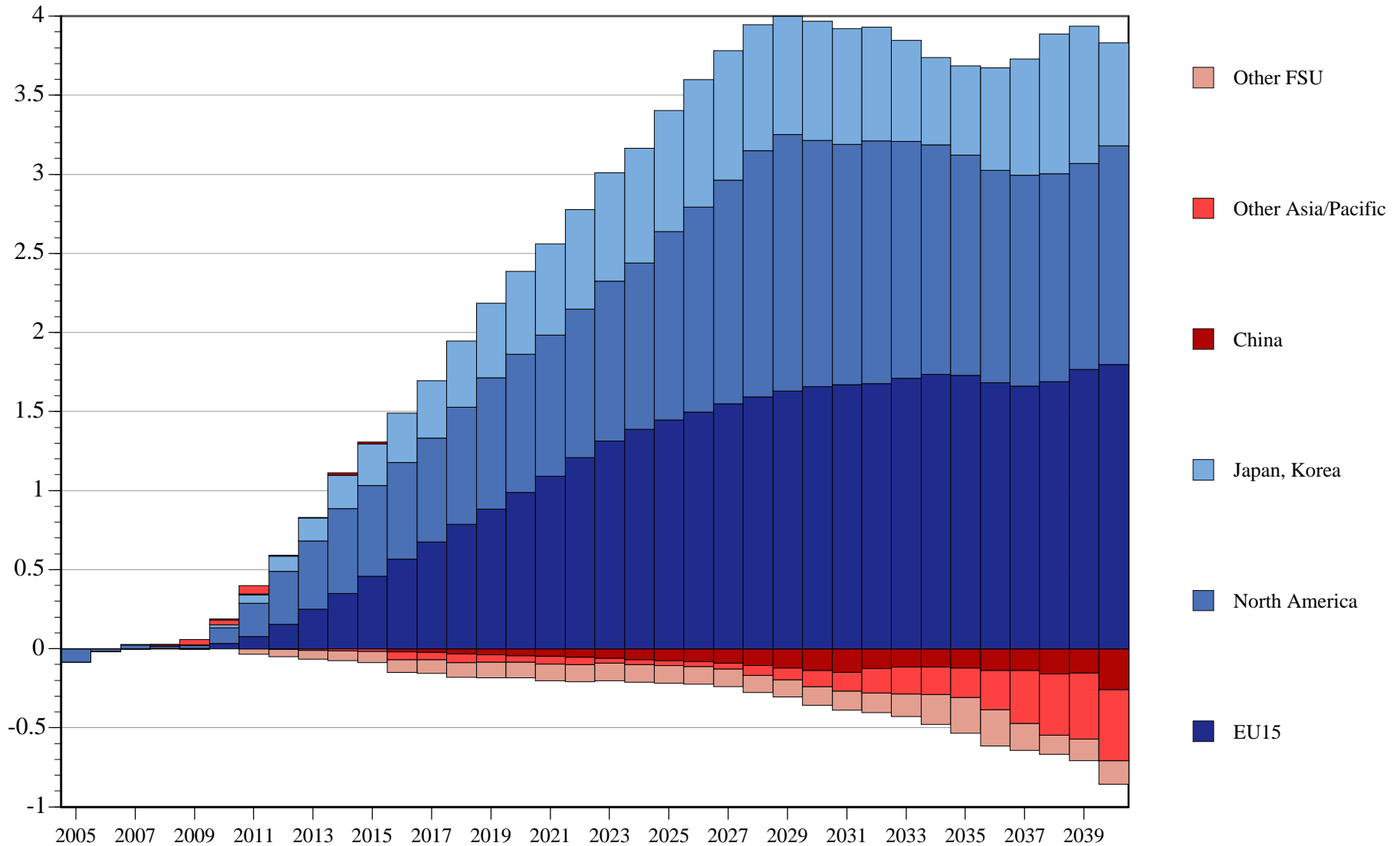


Caveat 3: Demand changes

- ❖ The demand responses in the model reflect historical elasticities of energy demand and of fuel shares
- ❖ New technologies could alter the demand for different types of fuels
- ❖ Examples of technologies that could have large effects:
 - ❖ Improved batteries increasing the demand for electric vehicles
 - ❖ Increased use of compressed natural gas as a vehicle fuel
 - ❖ Improved GTL technology that allows increased substitution of natural gas or even coal for oil as a transportation fuel
 - ❖ More widespread use of smart metering and other technologies that can raise efficiency of electricity use

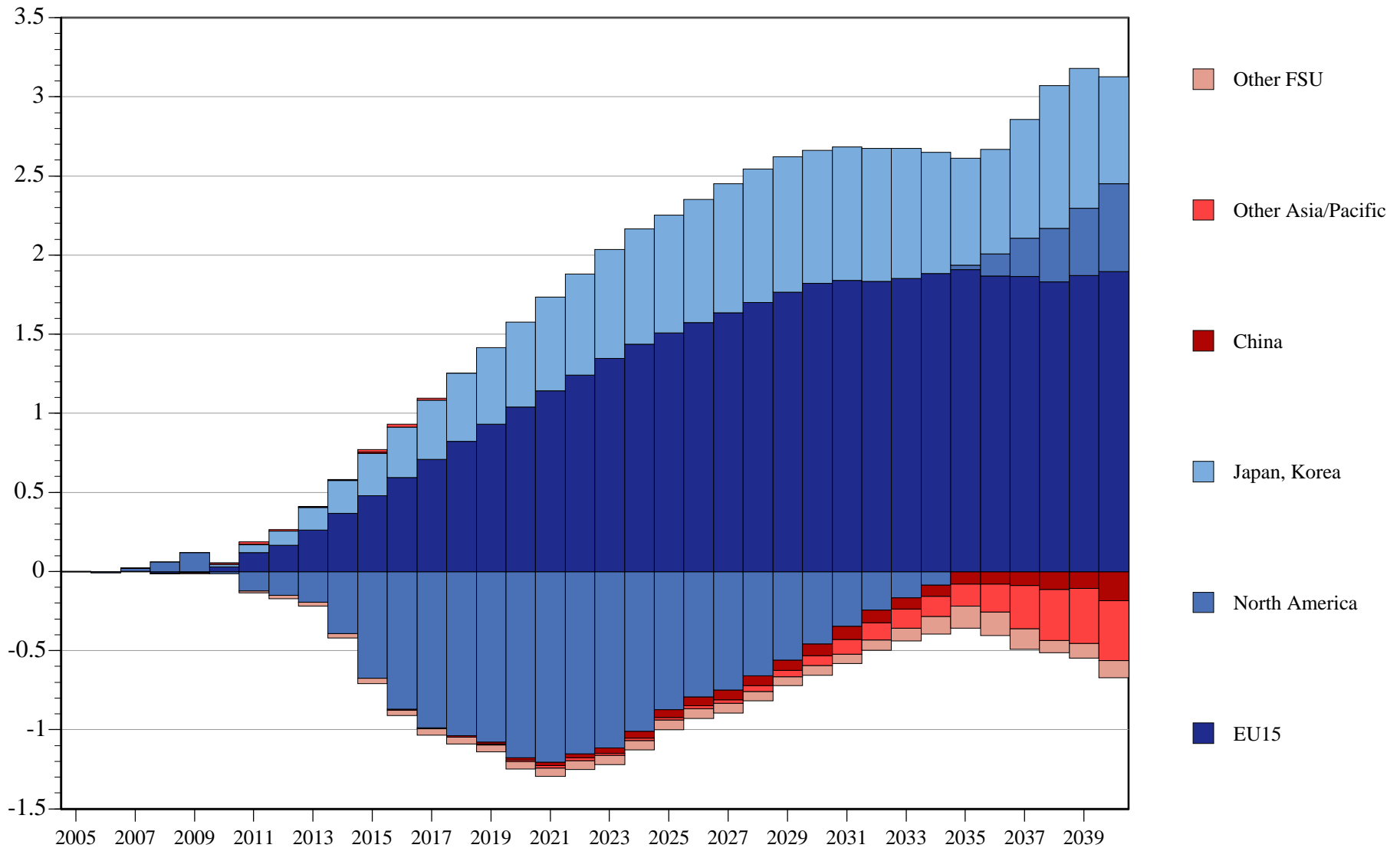


Reduced emissions: Changes in imports



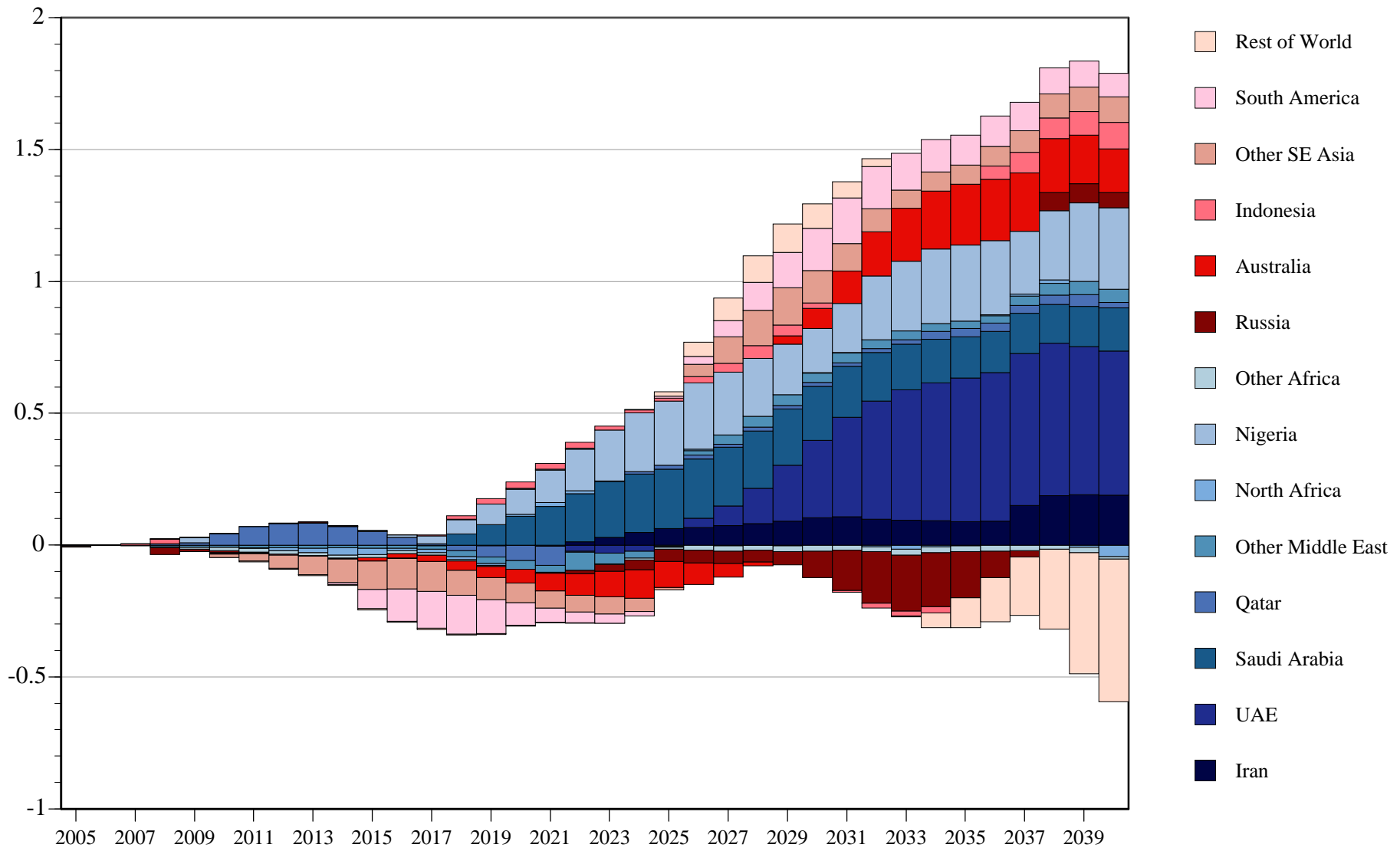


Increased access & reduced emissions: Changes in imports





Increased access & reduced emissions: Change in LNG exports





Concluding remarks

- ❖ Restricting CO₂ emissions will shift primary energy use toward natural gas
- ❖ Developed OECD will become more dependent upon Russia and the Middle East
 - ❖ Arguably, the energy security implications of heavy dependence on Middle Eastern suppliers of LNG are greater than heavy dependence on Middle Eastern suppliers of oil
- ❖ Access to prospective areas currently off-limits in the US can lessen the increased dependence on the Middle East
- ❖ Unless US LNG imports fall to zero, however, greater US supply adds to overall world supply and lowers prices everywhere, but by small amounts
 - ❖ Lower prices stimulate demand and discourage other domestic and foreign supply
- ❖ Increased US domestic supply does displace some Middle East exports
 - ❖ Increased US domestic supply also changes the elasticity of response of the market to disruptions and shocks
 - ❖ However, the effects are unlikely to be large enough to offset the effects of tightened emission controls