# Effects of $CO_2$ constraints in a global gas market

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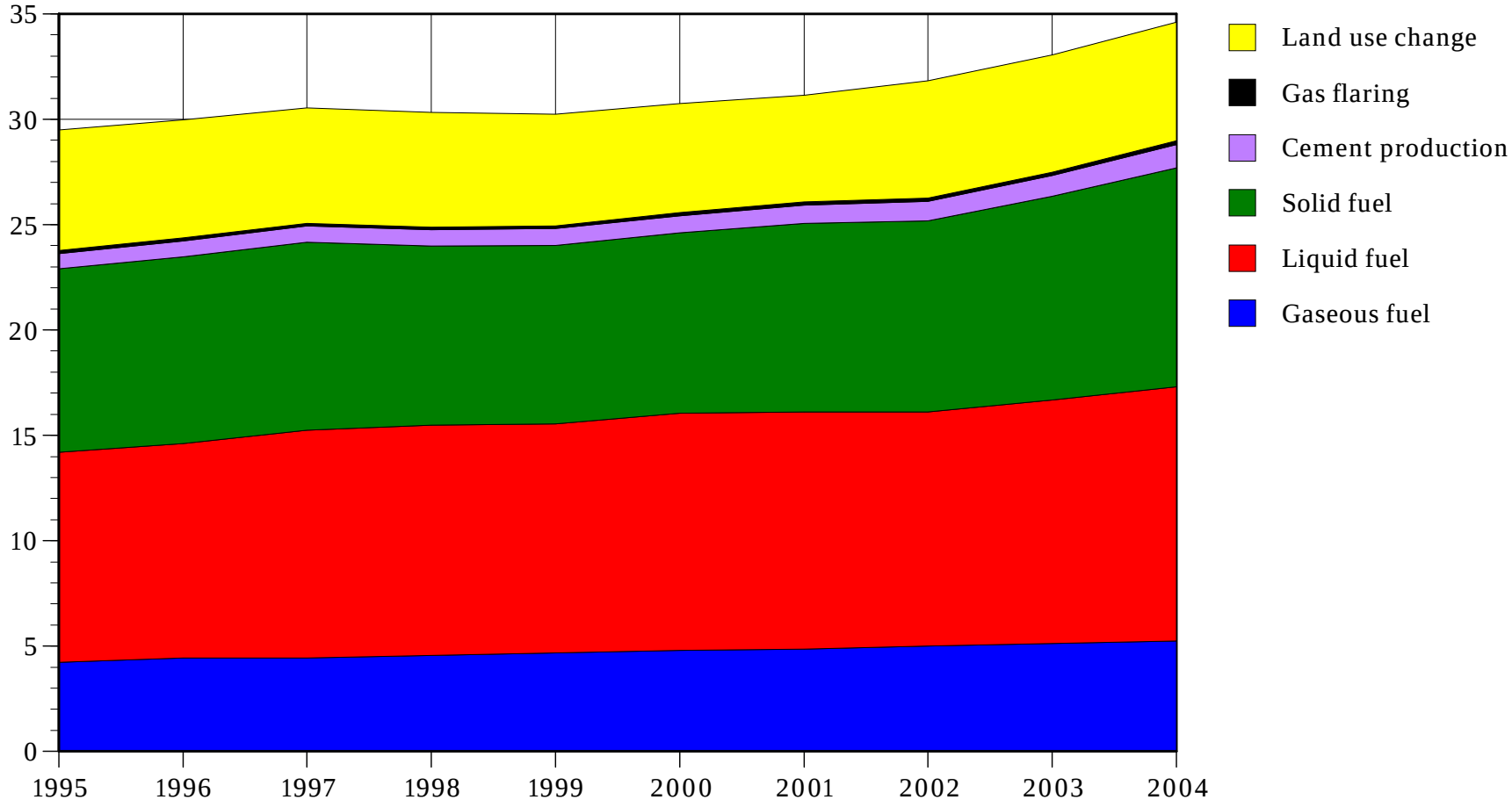
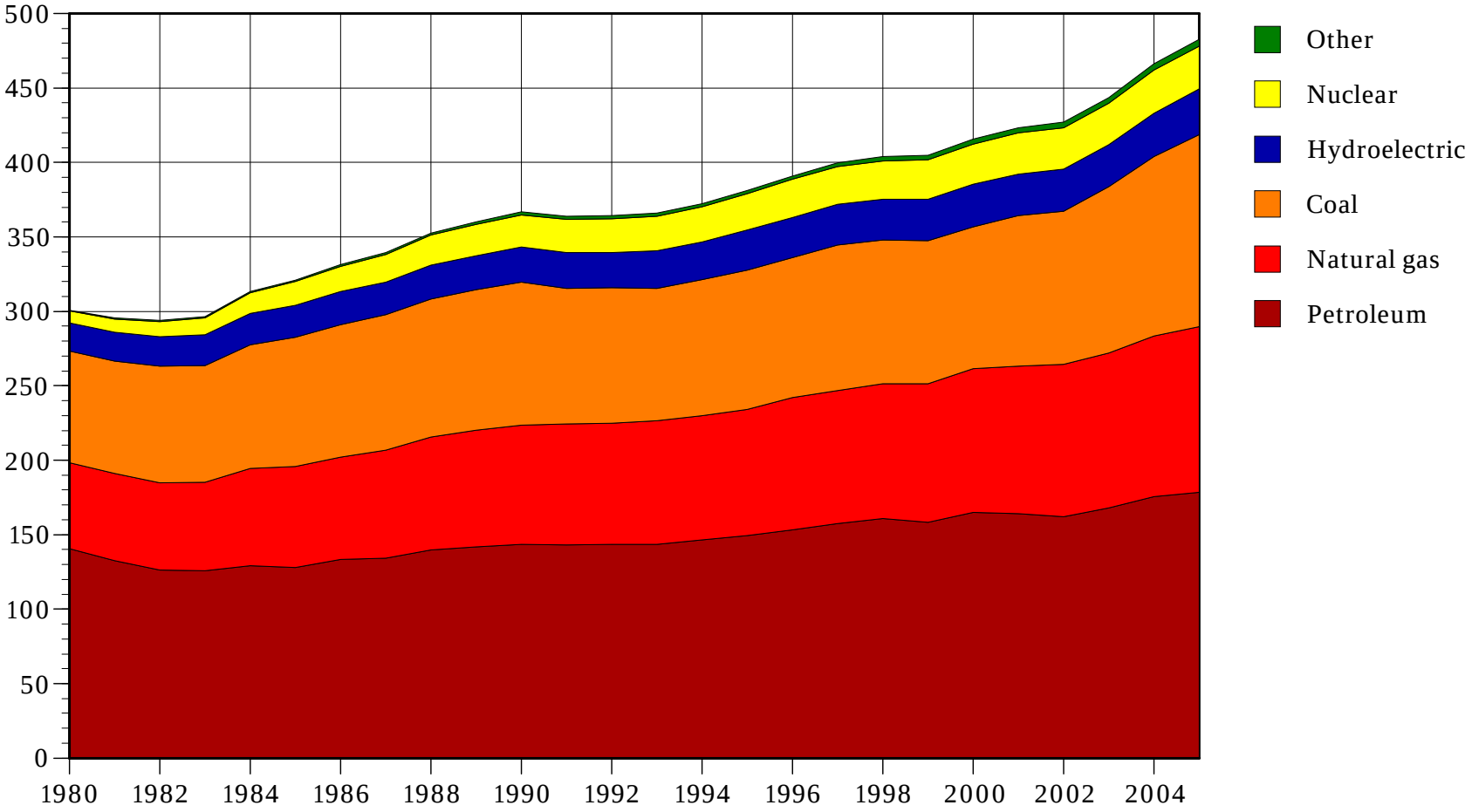
# Anthropogenic sources of $CO_2$ (1995–2004)



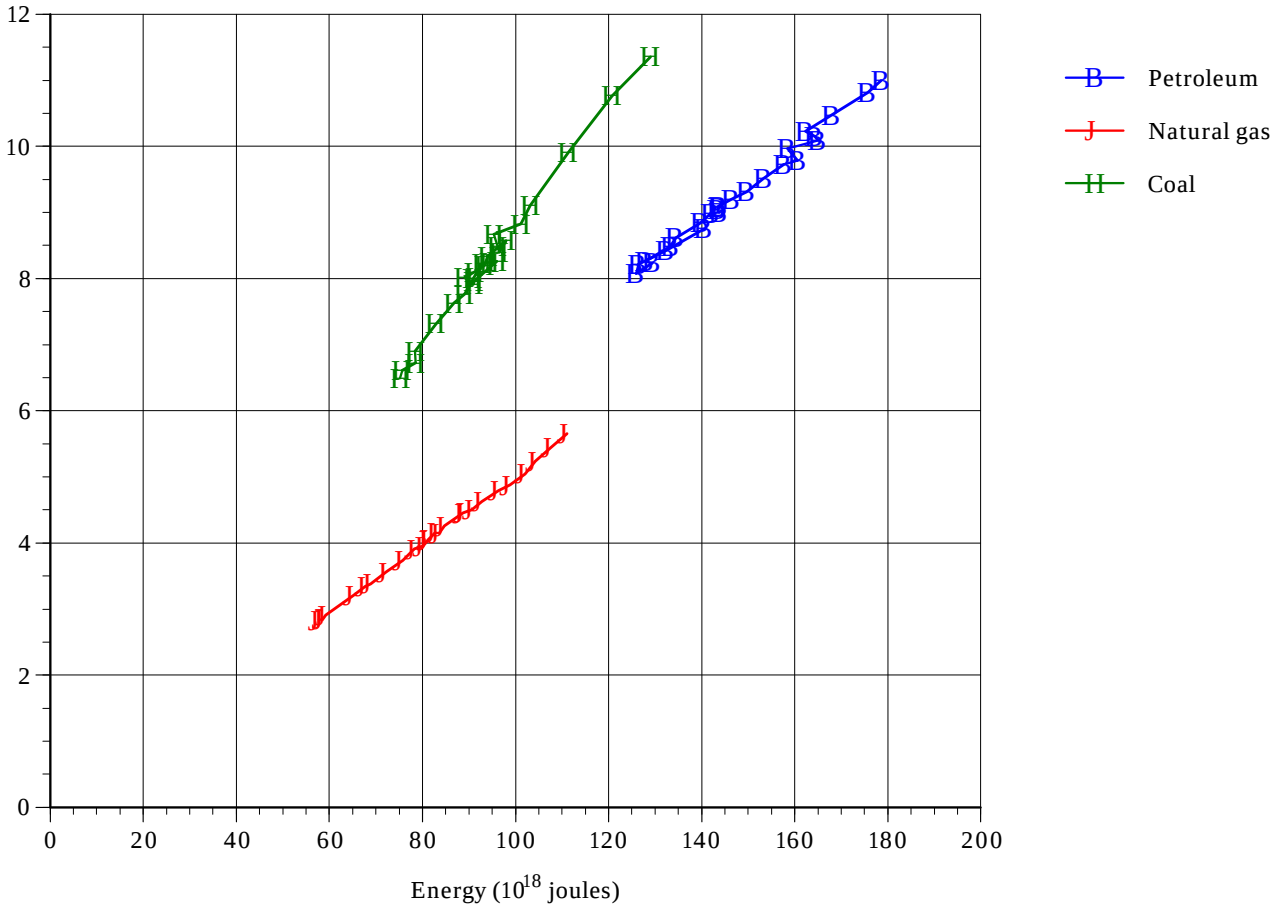

*Source: CDIAC*

# World primary energy supply (1980–2005)




*Source: EIA*

# $CO_2$–intensity of fossil fuels

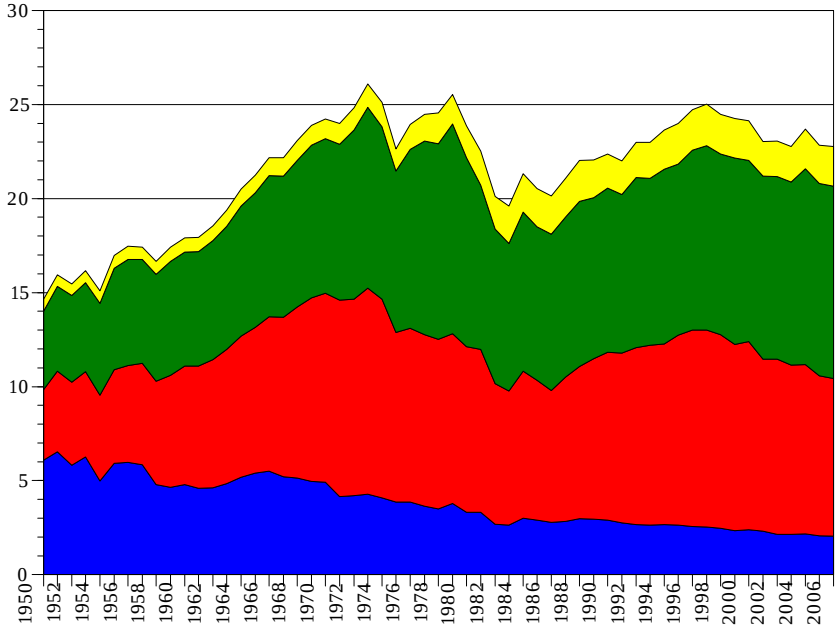


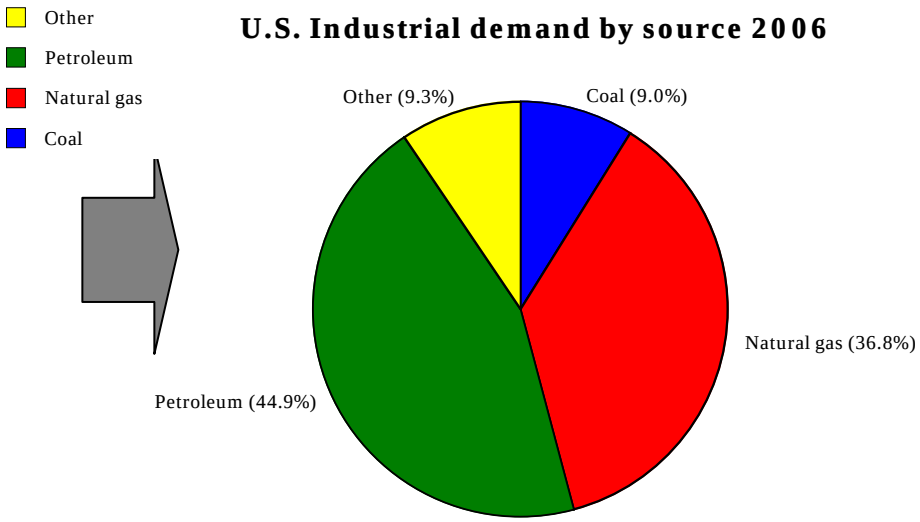

*Source: EIA*

- $CO_2$ emission controls will favor the least $CO_2$-intensive fossil fuel, natural gas

# US industrial demand for energy

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

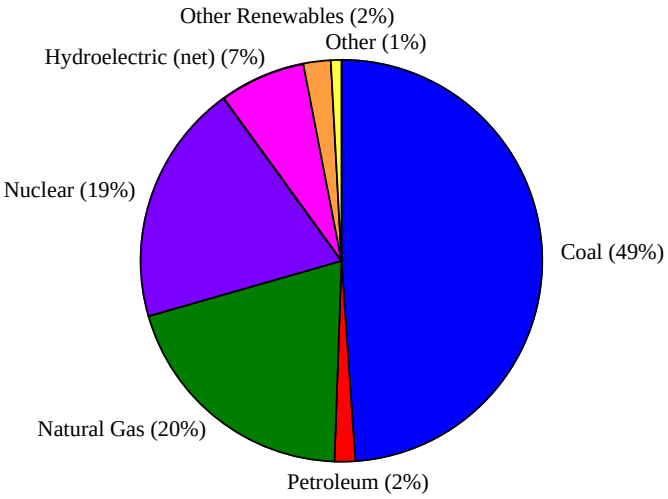


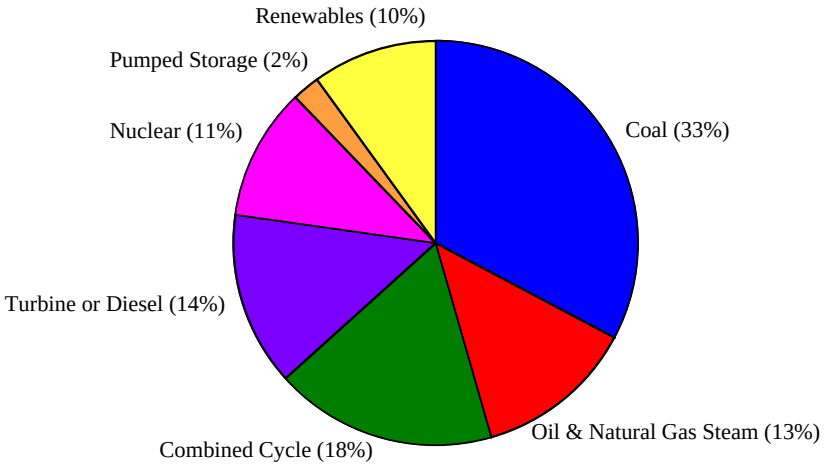

*Source: EIA*

# US electricity generation

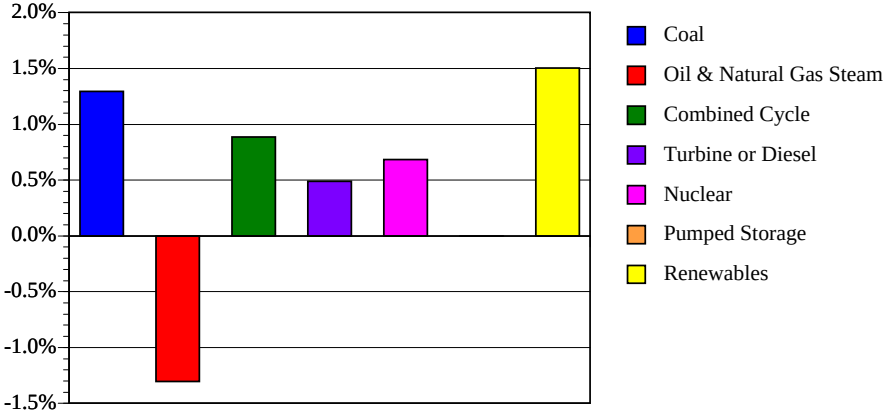
**Generation by source 2006**




**Generating capacity 2005**

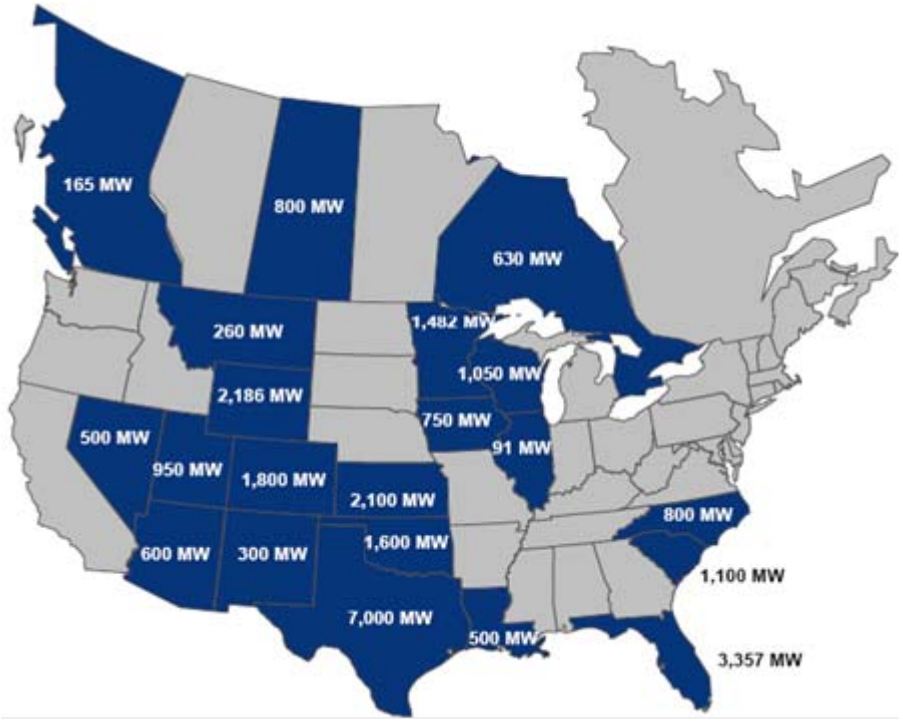



Average annual net capacity growth 2005-2030 in the EIA Annual Energy Outlook, 2008 reference case



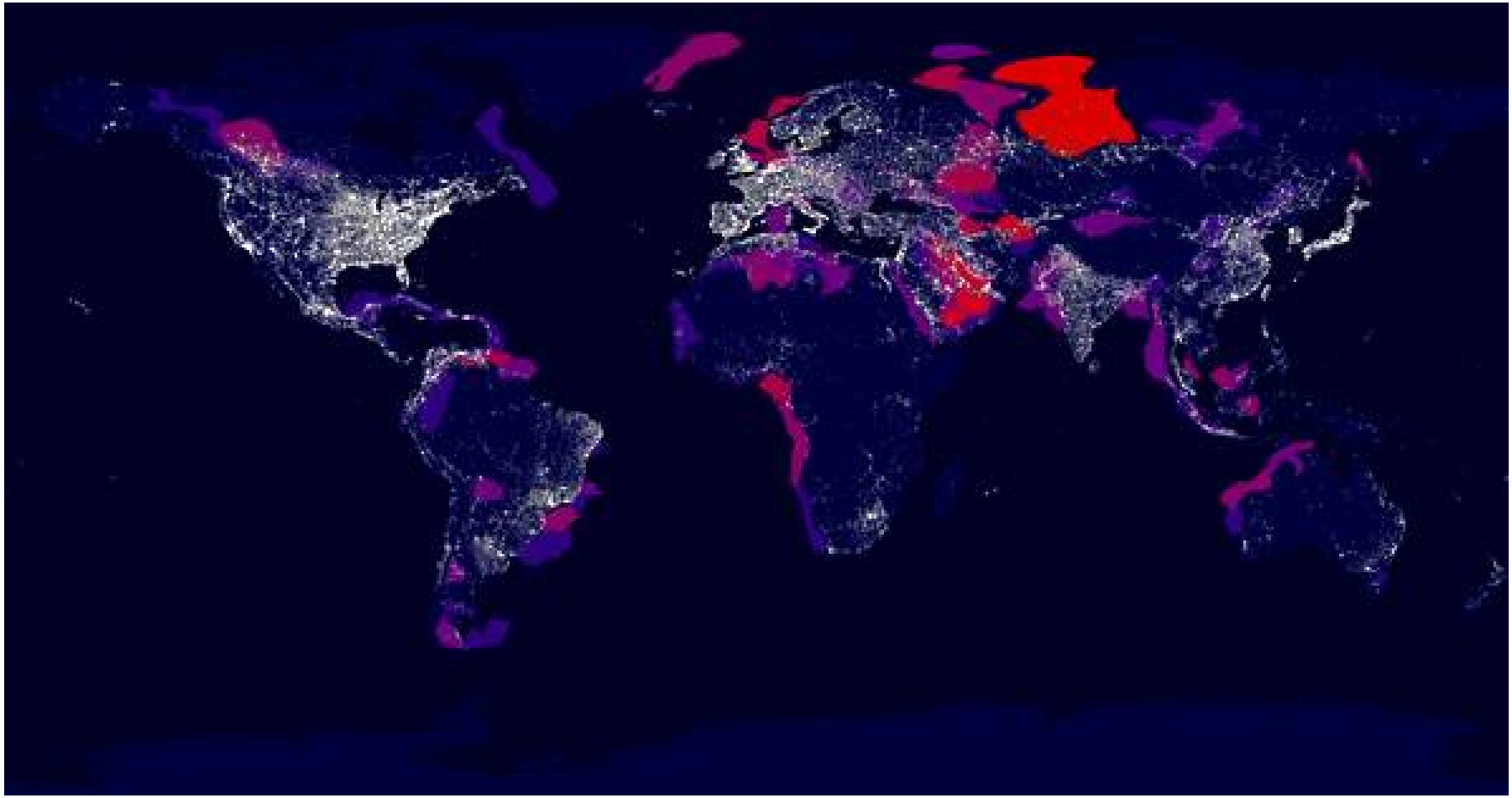
# Concern about future $CO_2$ regulation already is delaying new coal plants

- 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



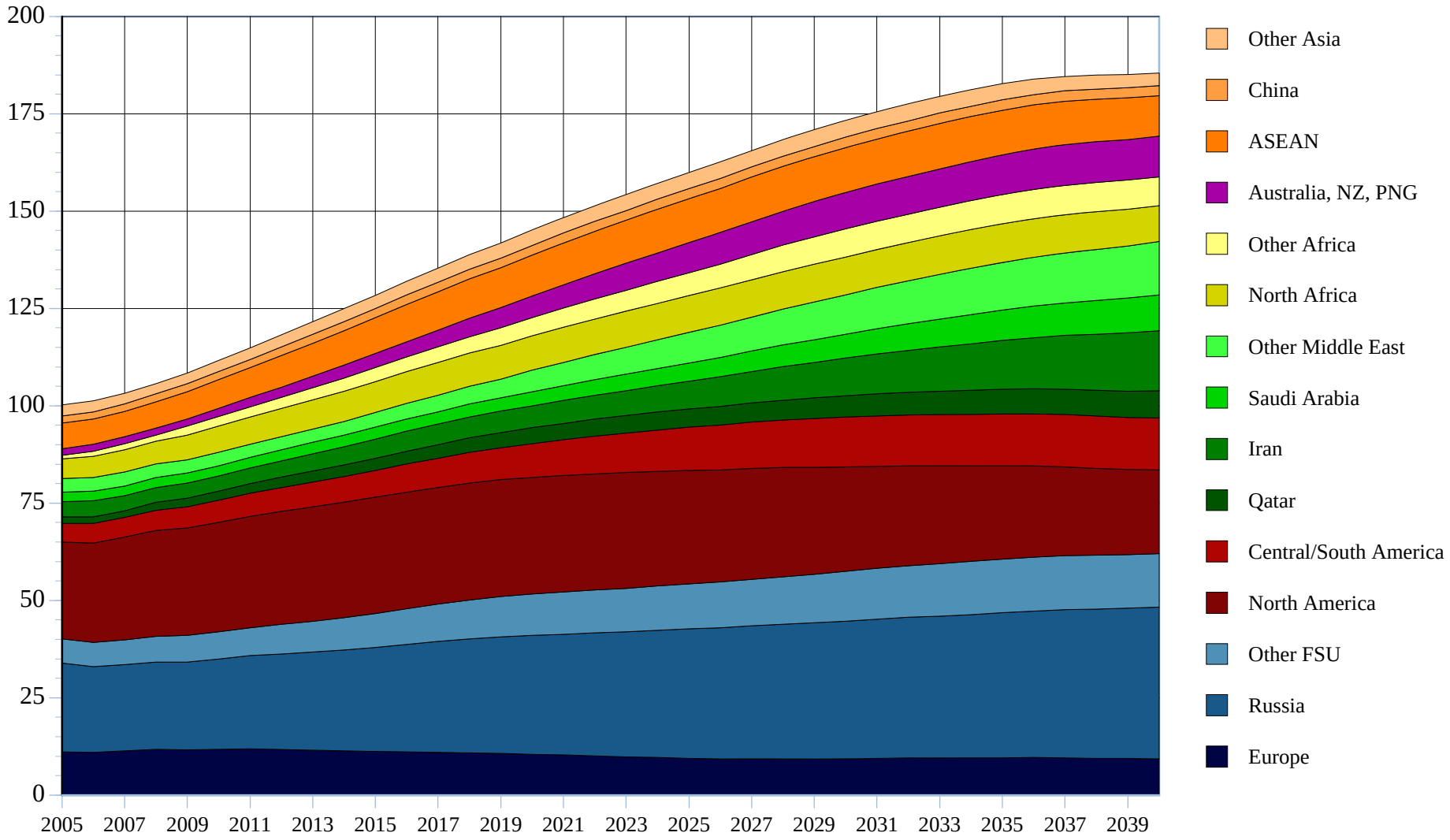

*Source: Wood Mackenzie*

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

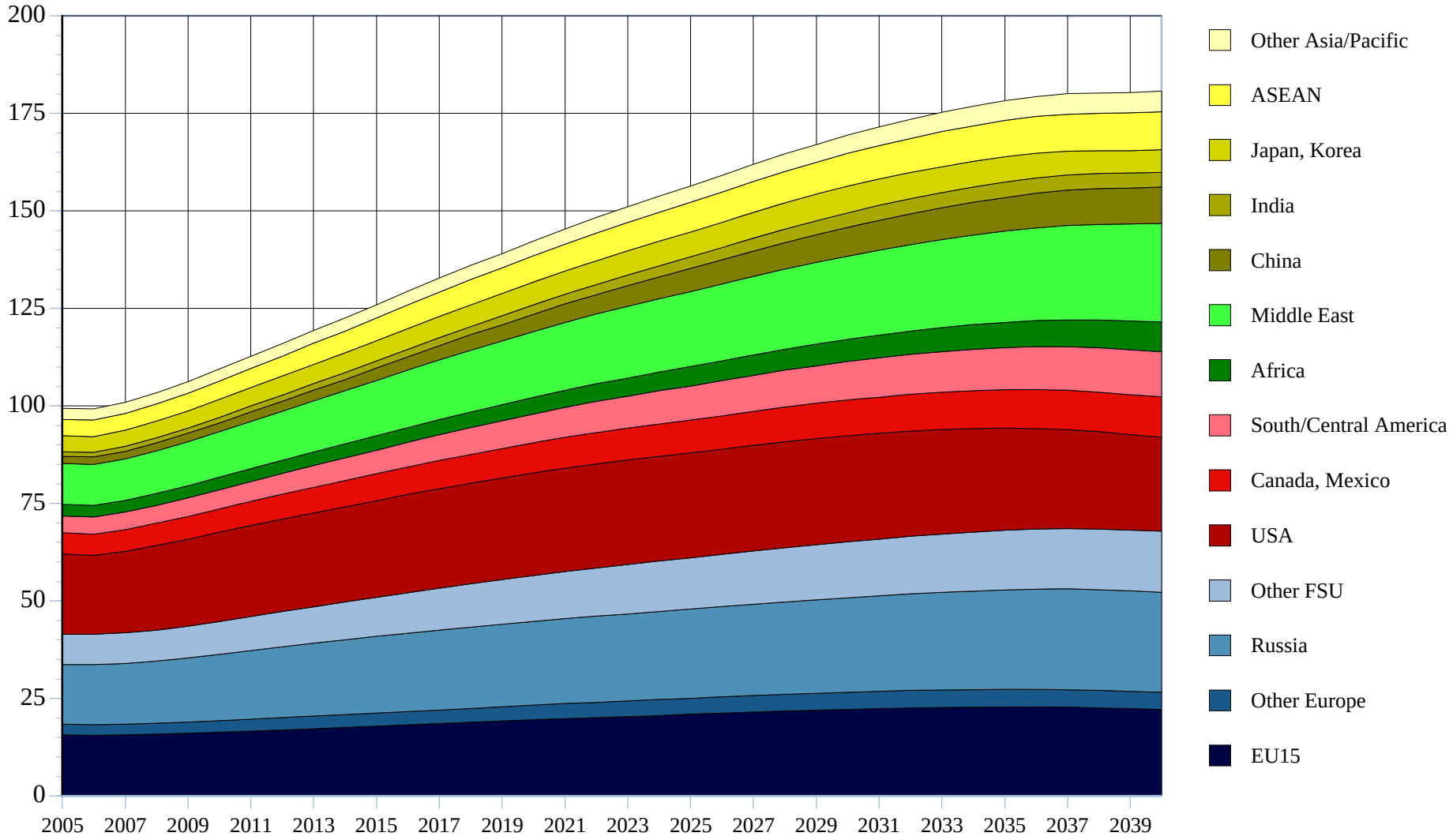


- Areas with the largest resources are remote from markets, require substantial new infrastructure and, perhaps more importantly, raise energy security concerns

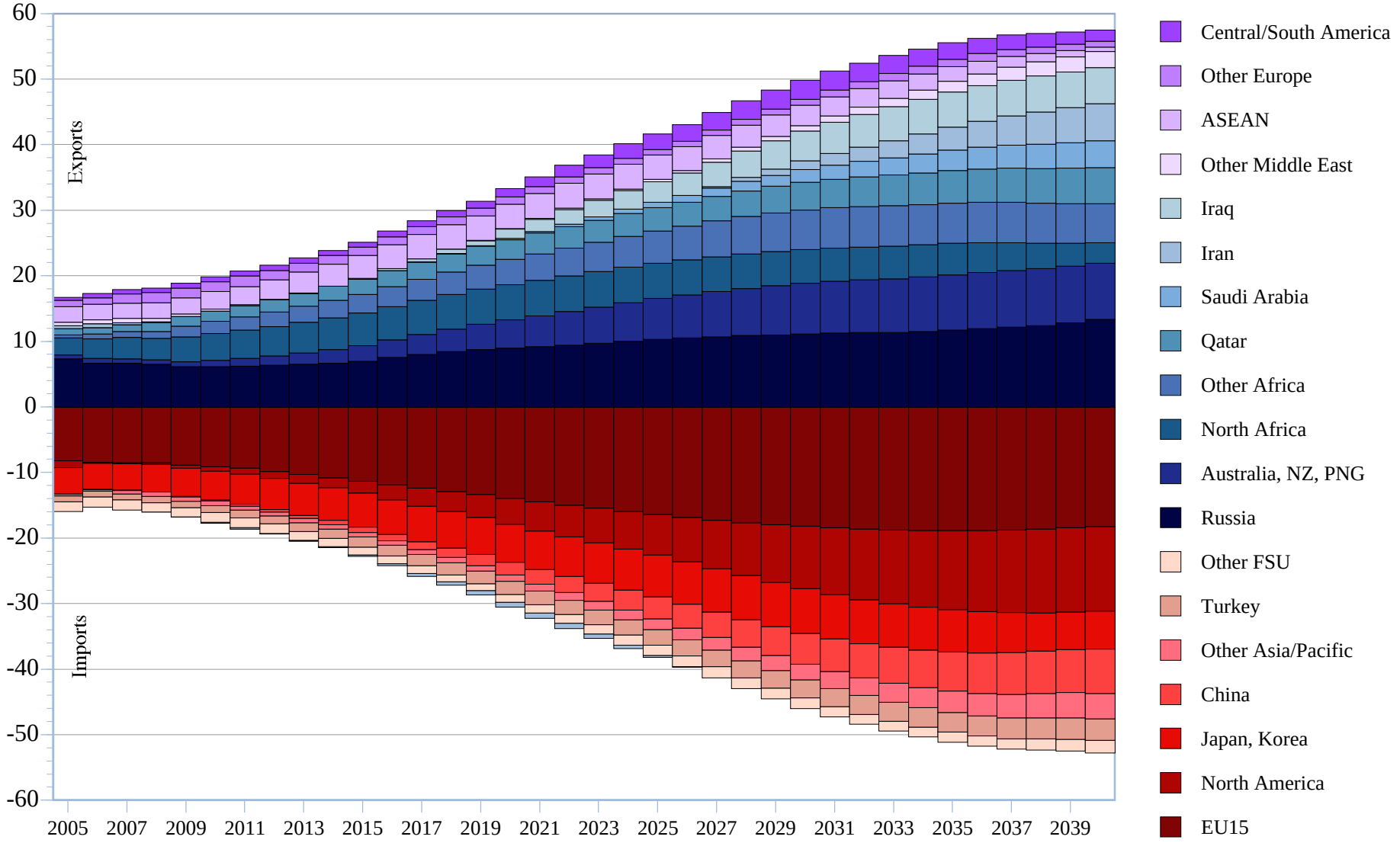
# Reference case supply



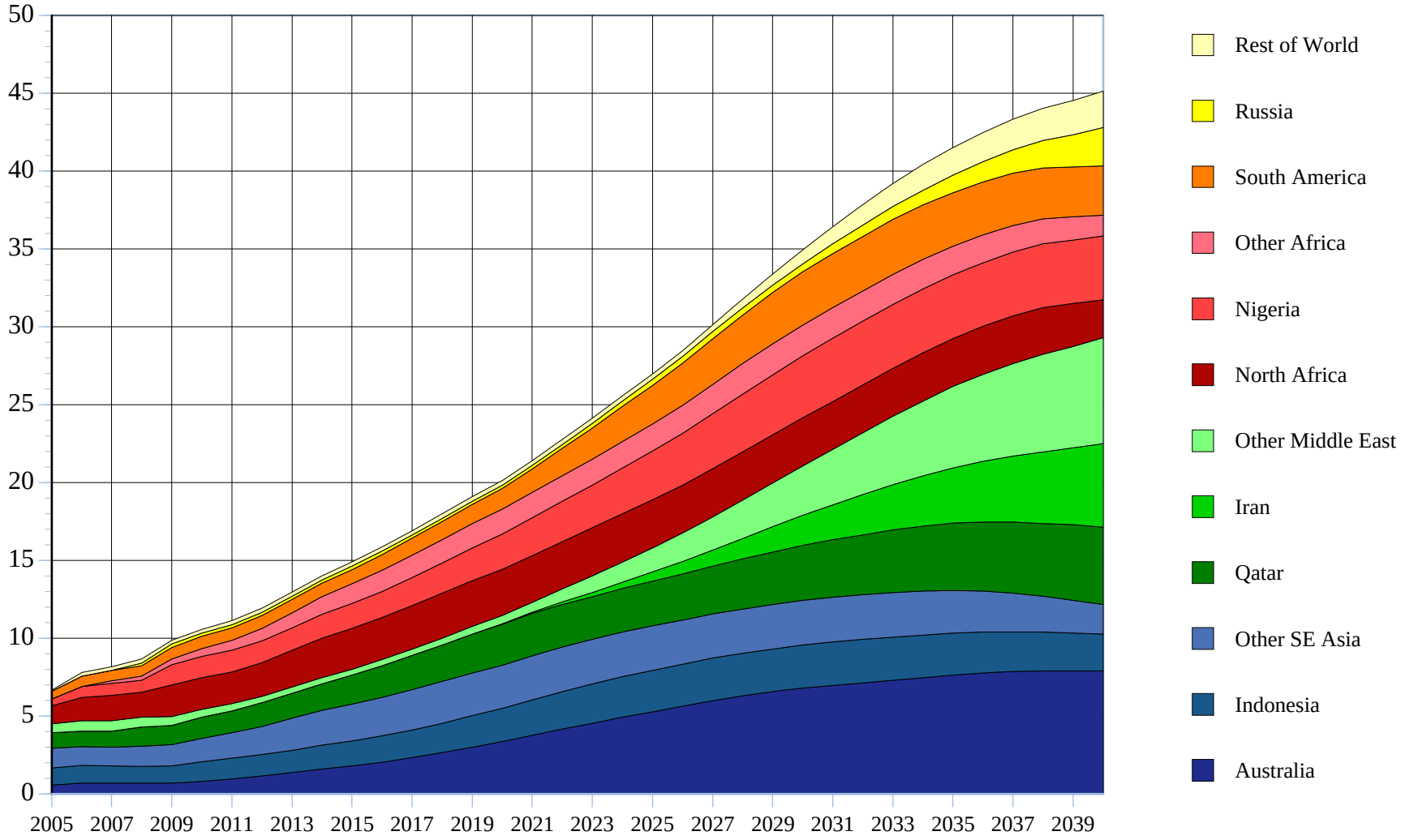
# Reference case demand



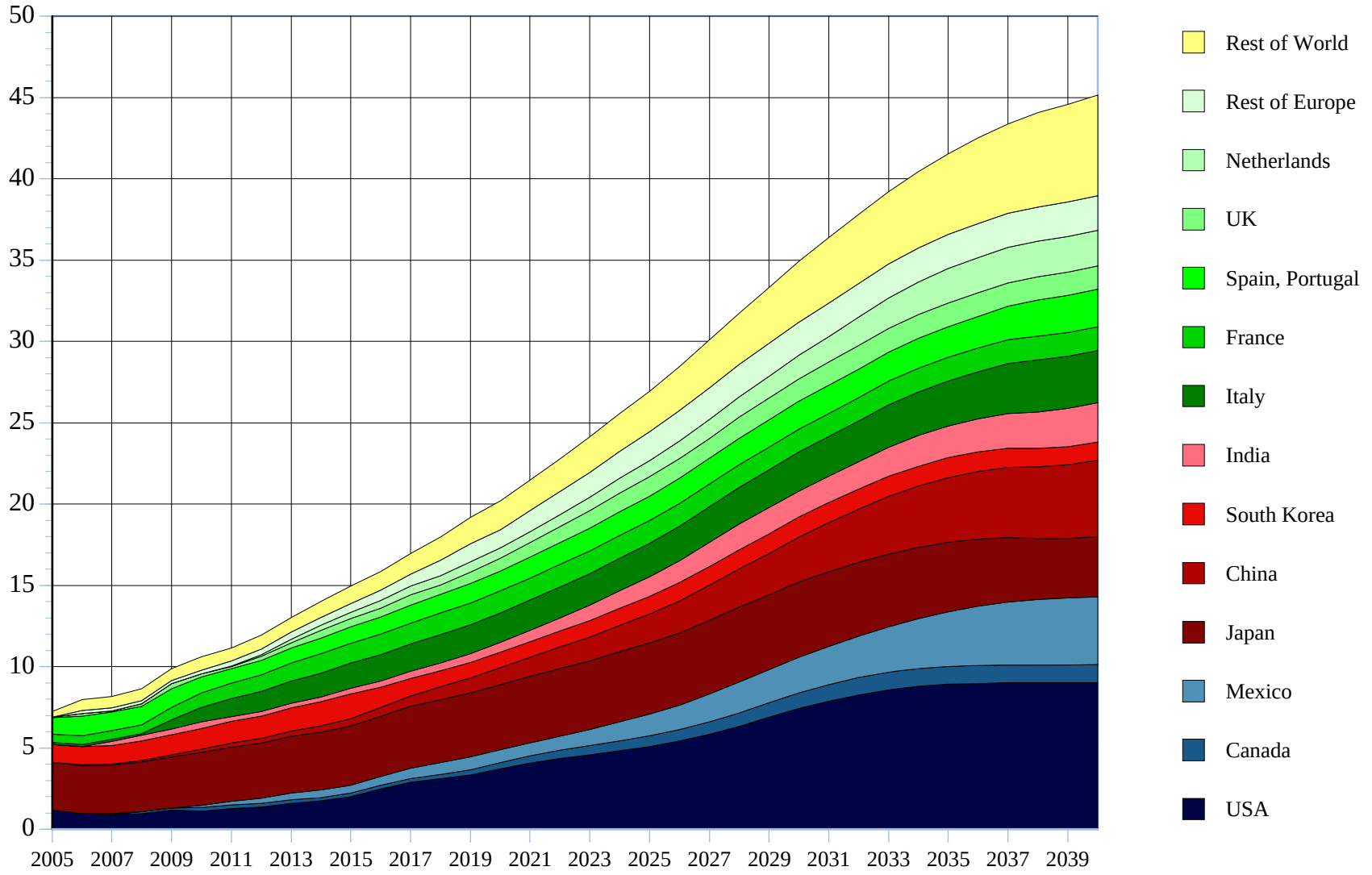
# Reference case trade



# Reference case LNG exports



# Reference case LNG imports



# 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 $CO_2$ 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

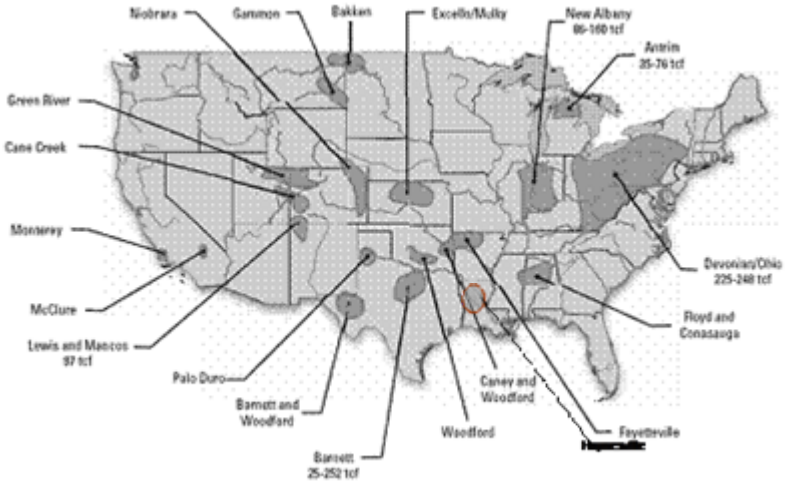
| Planning Region/Basin | | Resource Off-limits (Tcf) |
|---|---|---|
| Rocky Mountains | Montana | 9.4 |
| | Wyoming Thrust Belt | 0.8 |
| | Green River | 39.5 |
| | Powder River | 6.0 |
| | Uinta-Piceance | 8.4 |
| | San Juan | 5.3 |
| OCS | Eastern Gulf of Mexico | 22.1 |
| | North Atlantic | 18.0 |
| | 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)

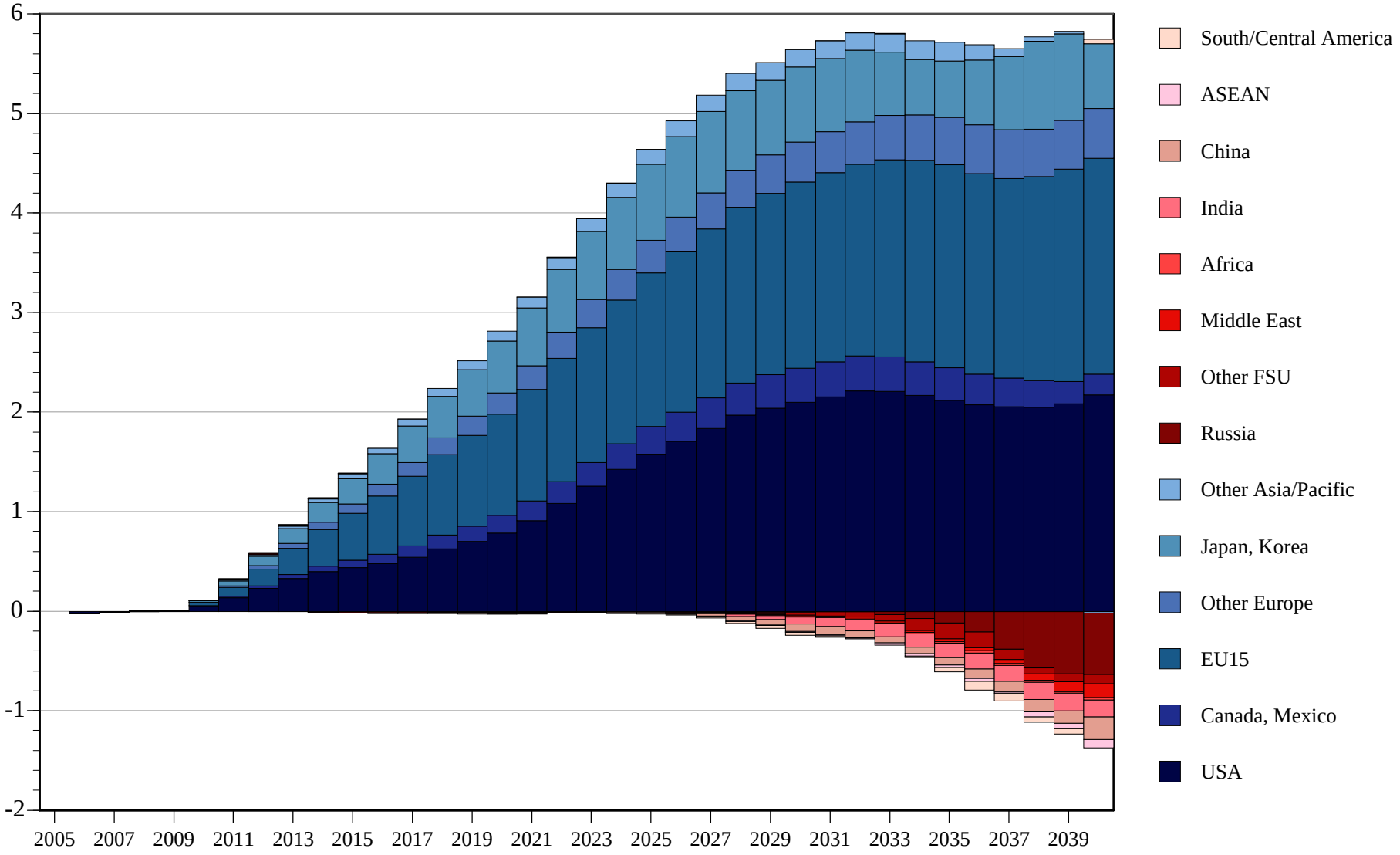



- We are currently developing an inventory of these resources and their likely costs of exploitation
- These will be included in the model in the next few months and could be another source that offsets the increased demand for Russian and Middle Eastern gas

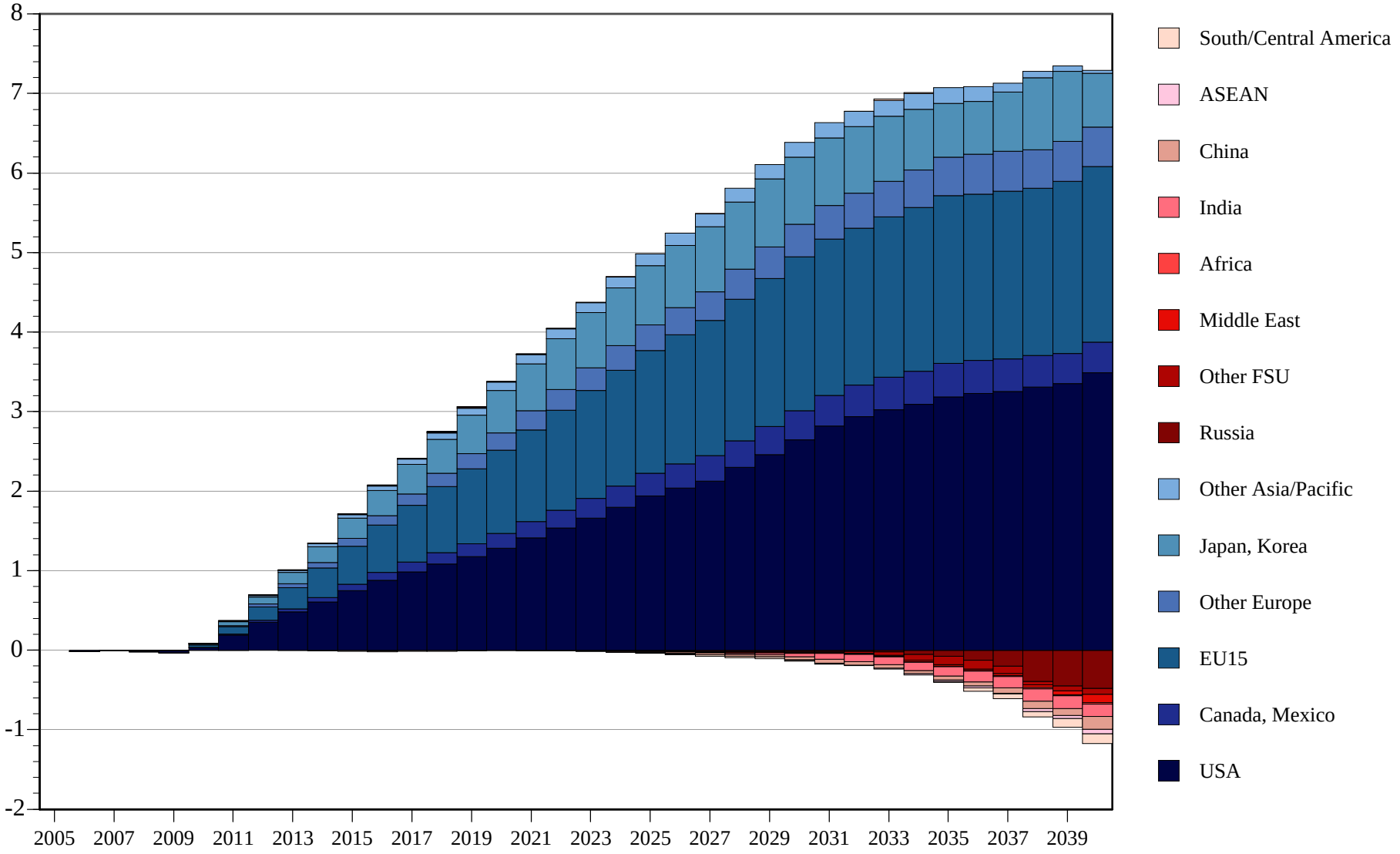
# Caveat 3: Demand changes

- 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

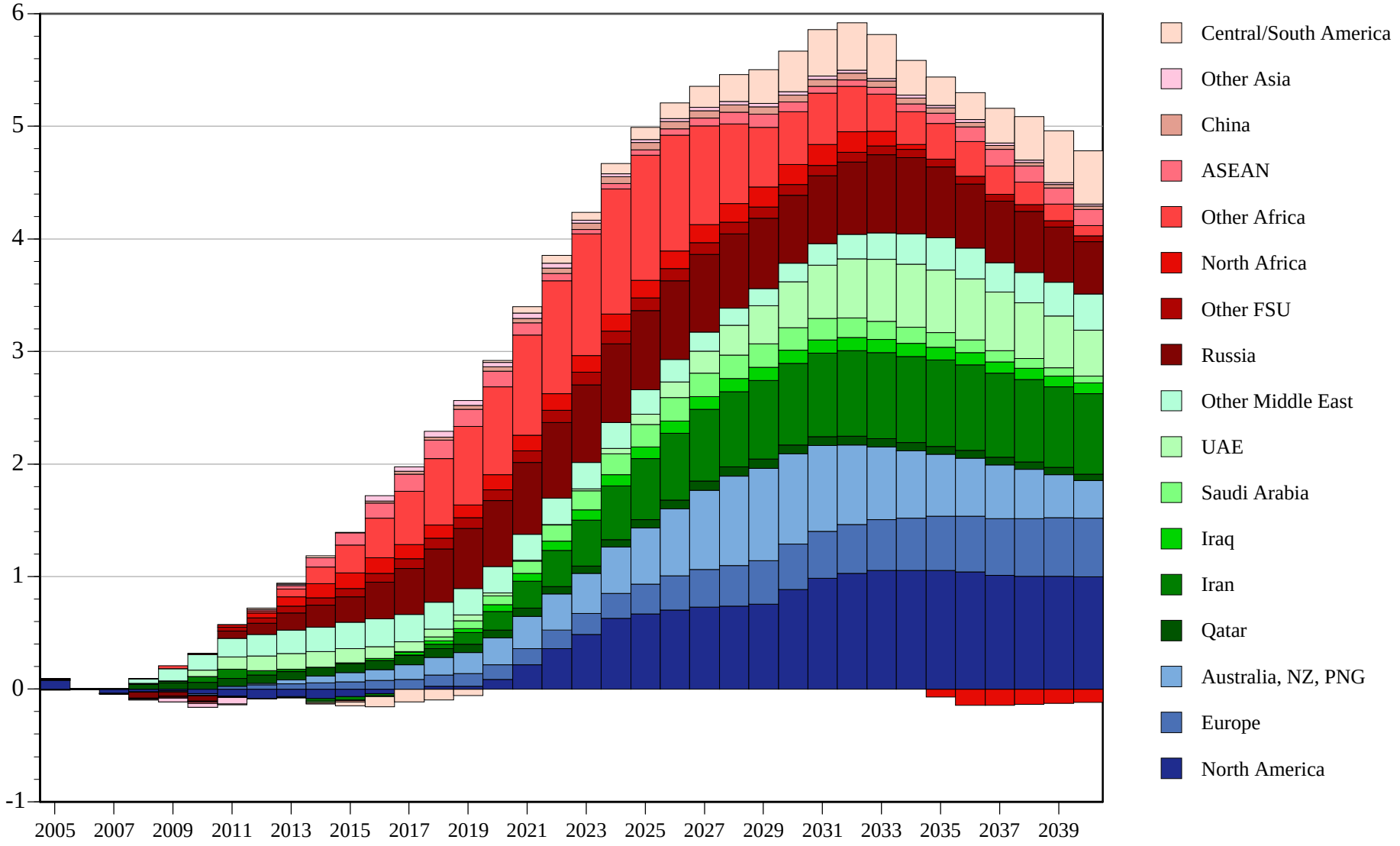
# Reduced emissions: Changes in demand



# Increased access & reduced emissions: Changes in demand



# Reduced emissions: Changes in supply



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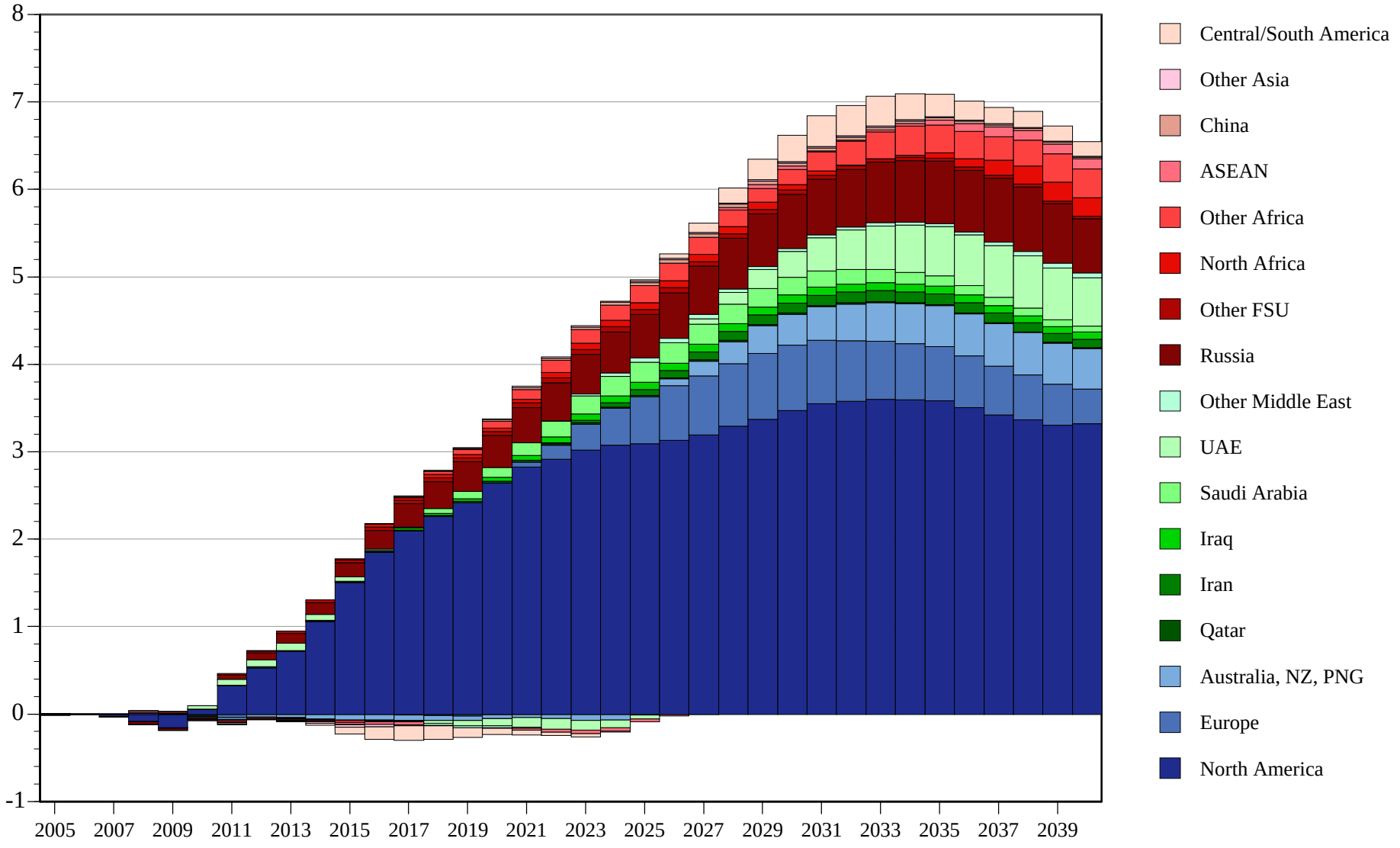
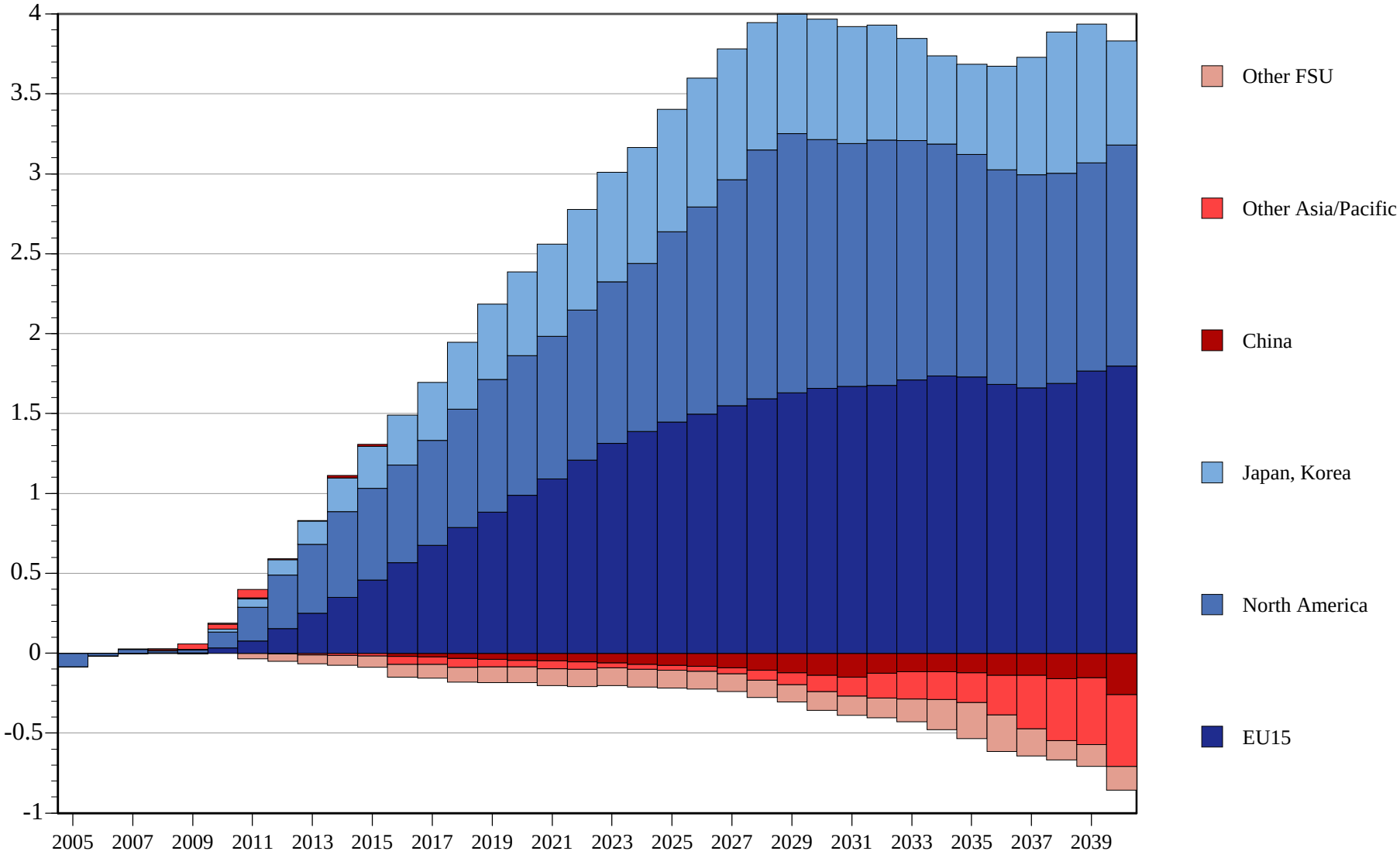


# Reduced emissions: Changes in imports



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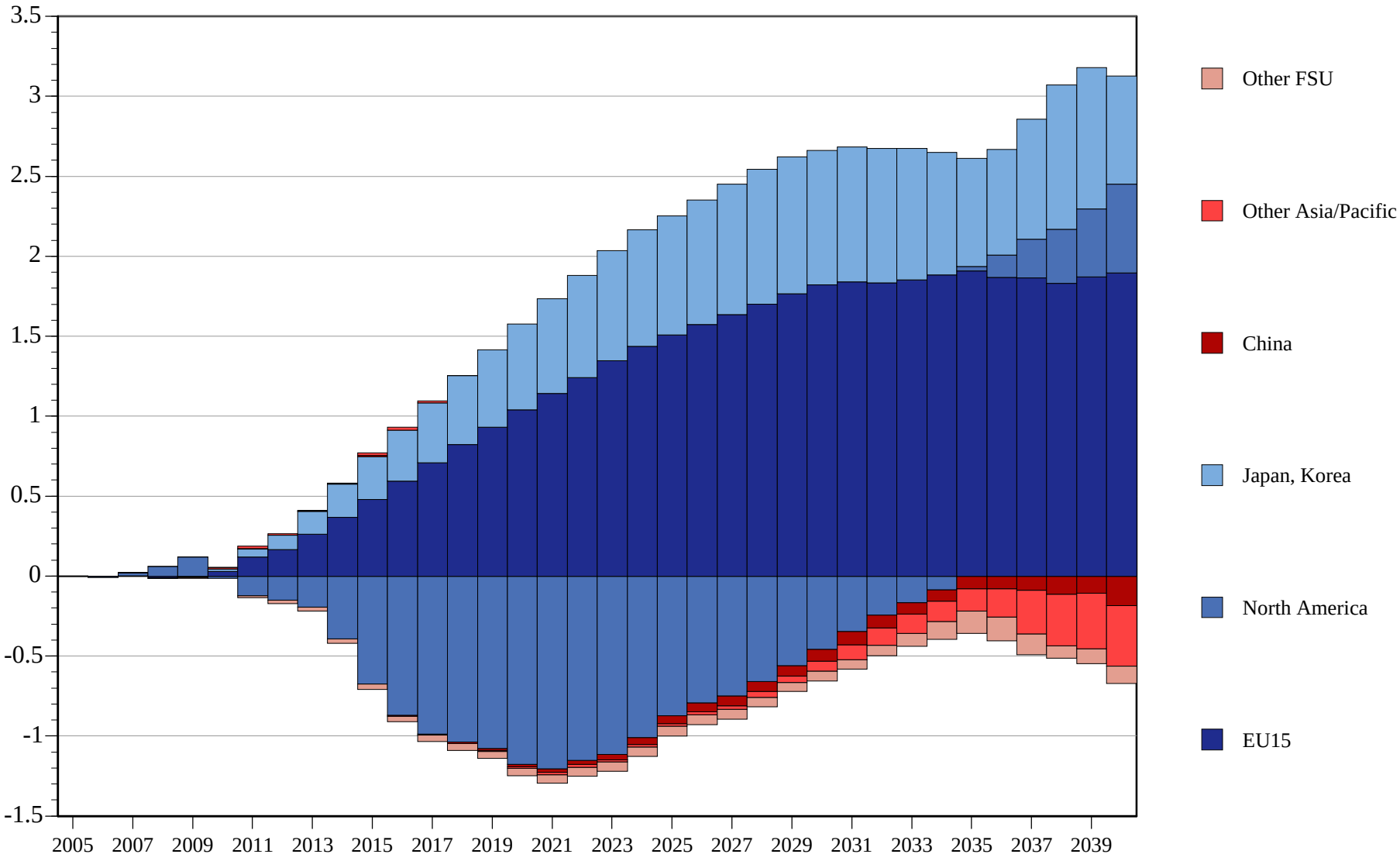
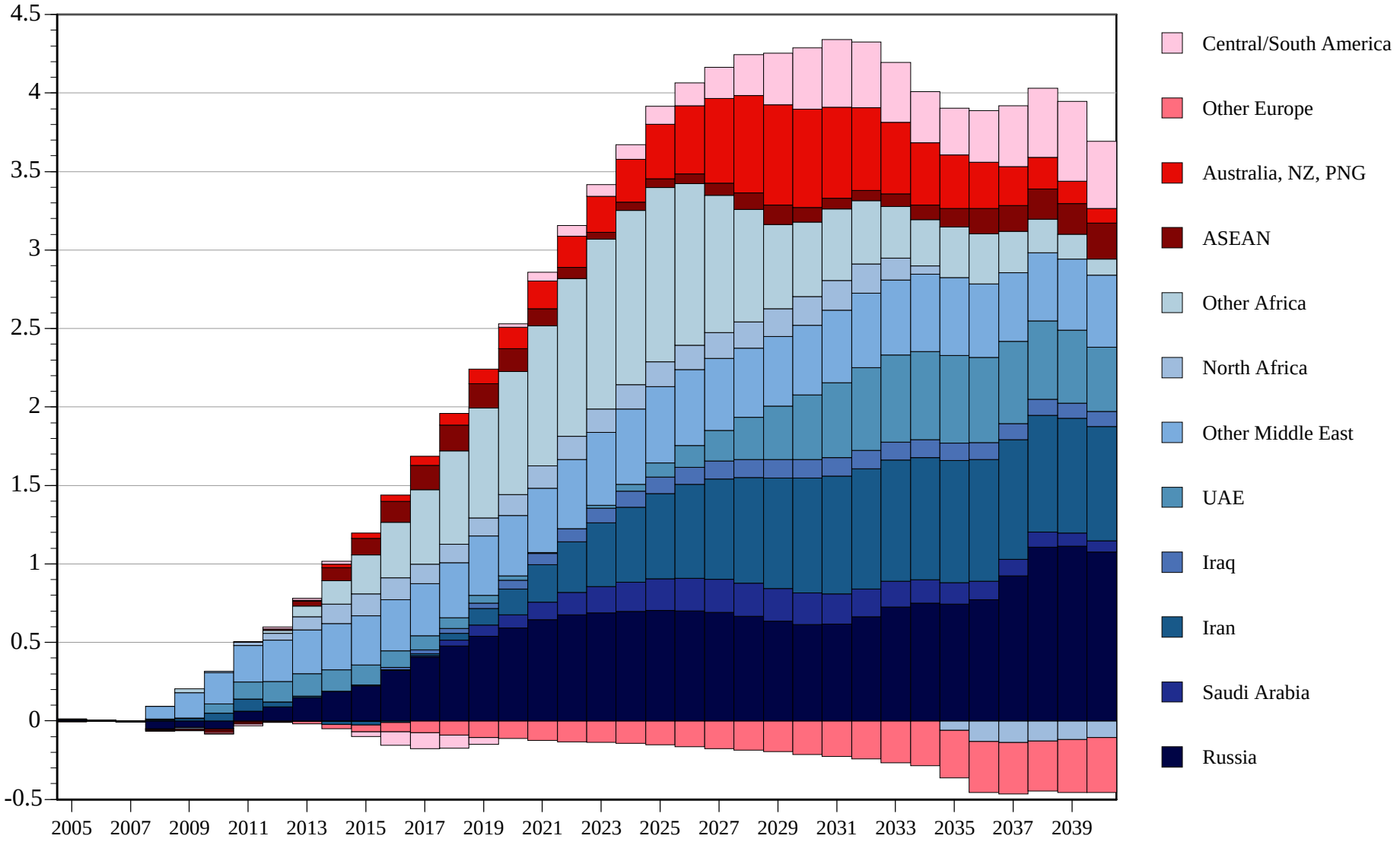


# Reduced emissions: Changes in exports



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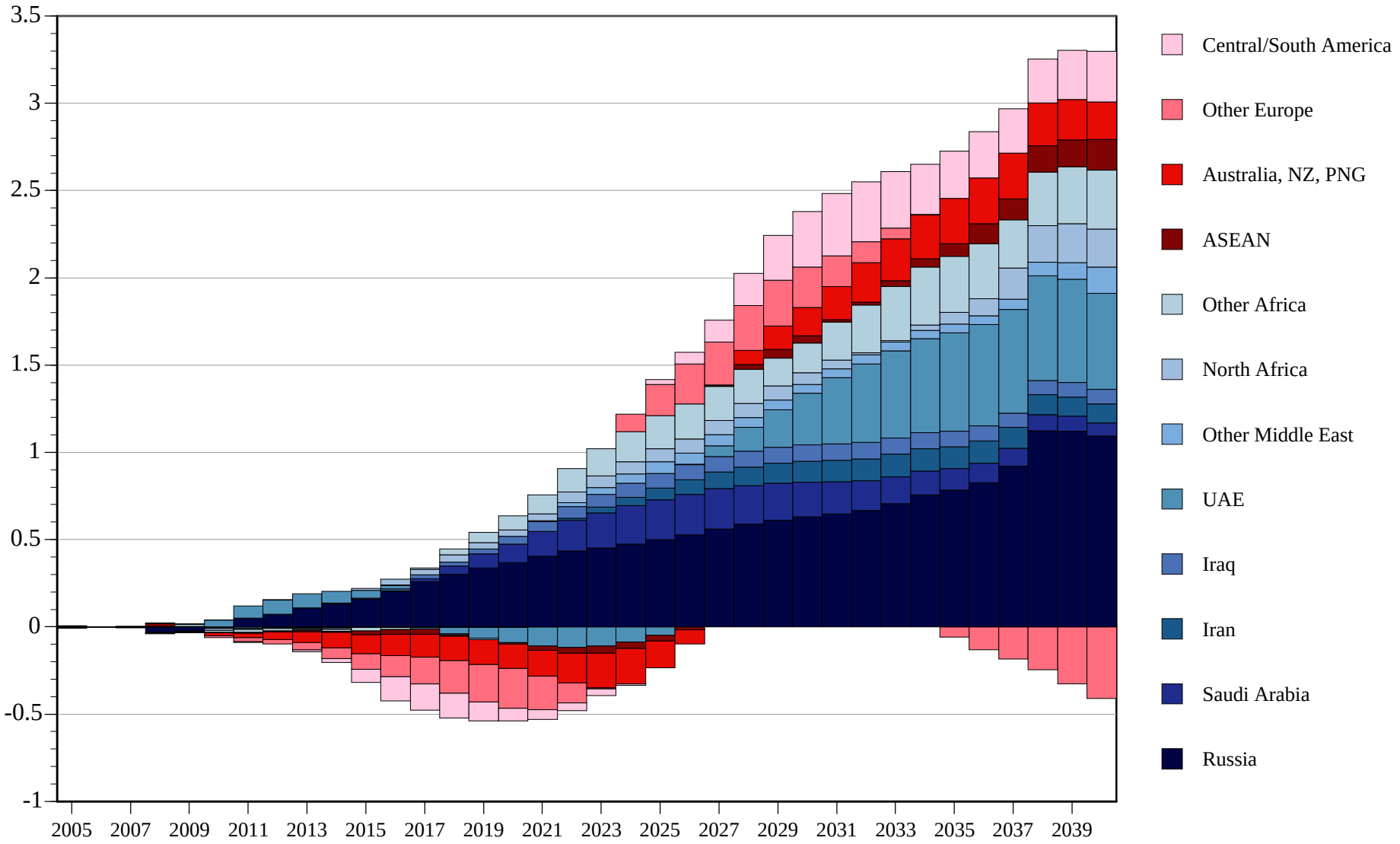
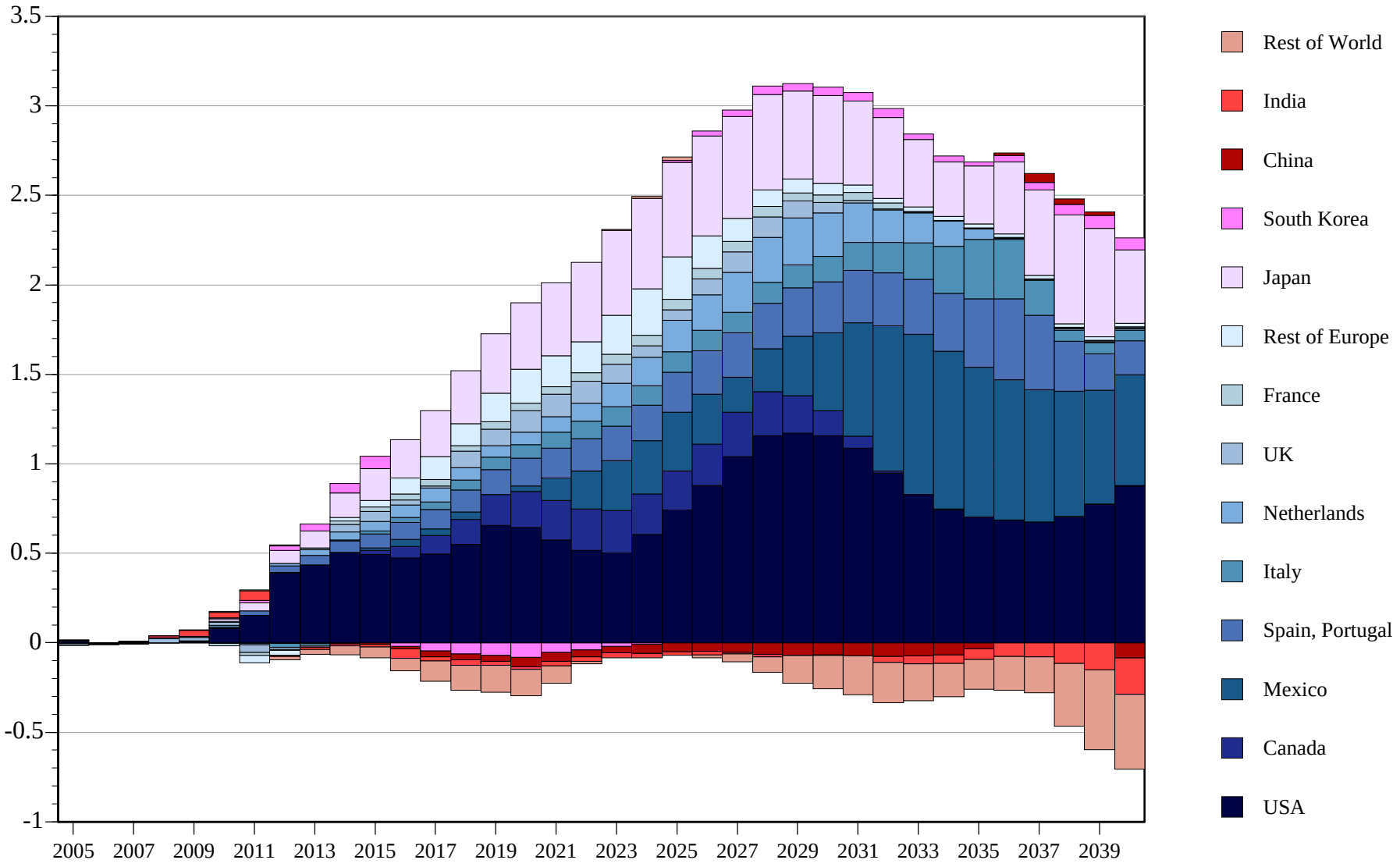
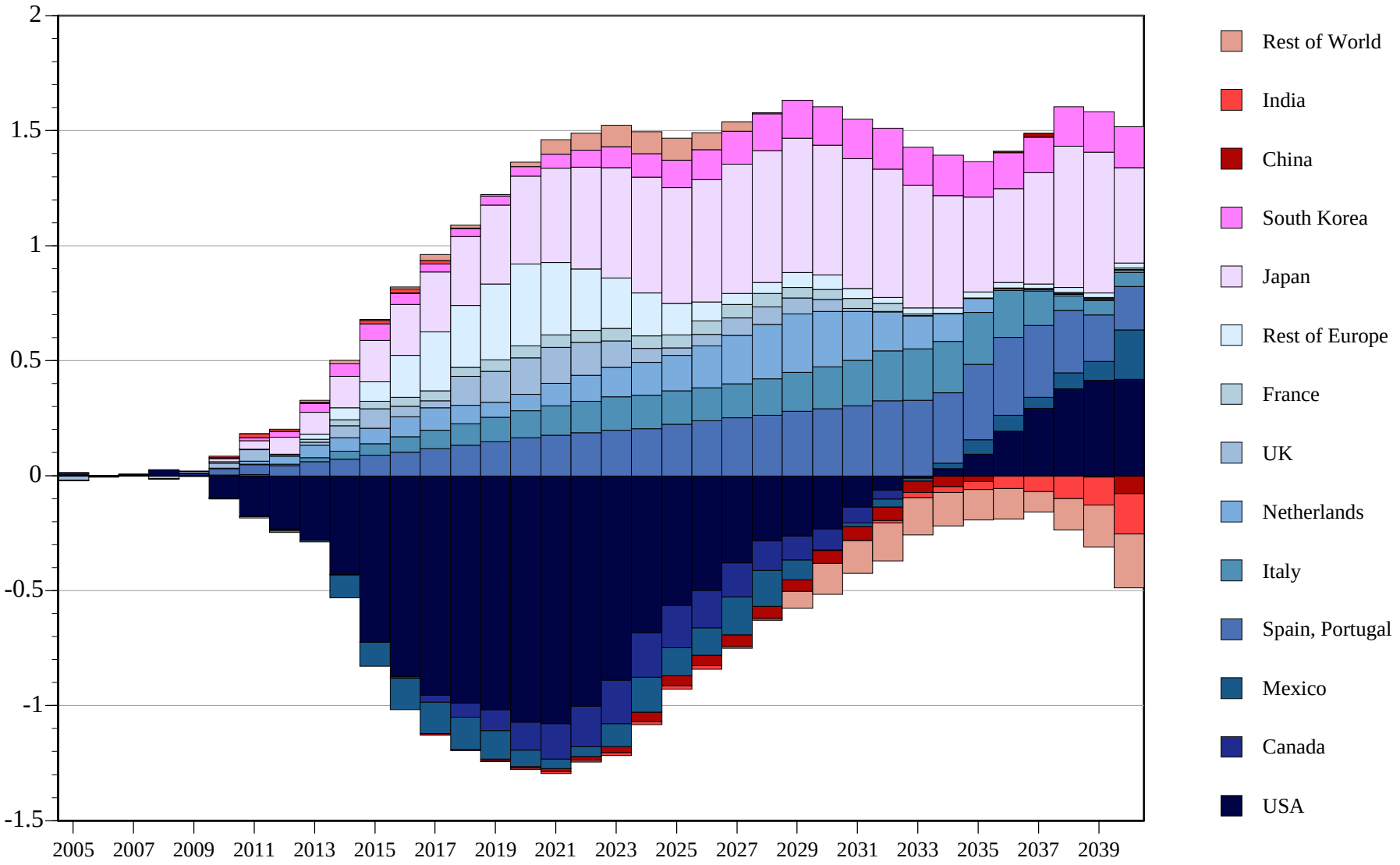


# Reduced emissions: Changes in LNG imports



# Increased access & reduced emissions: Change in LNG imports



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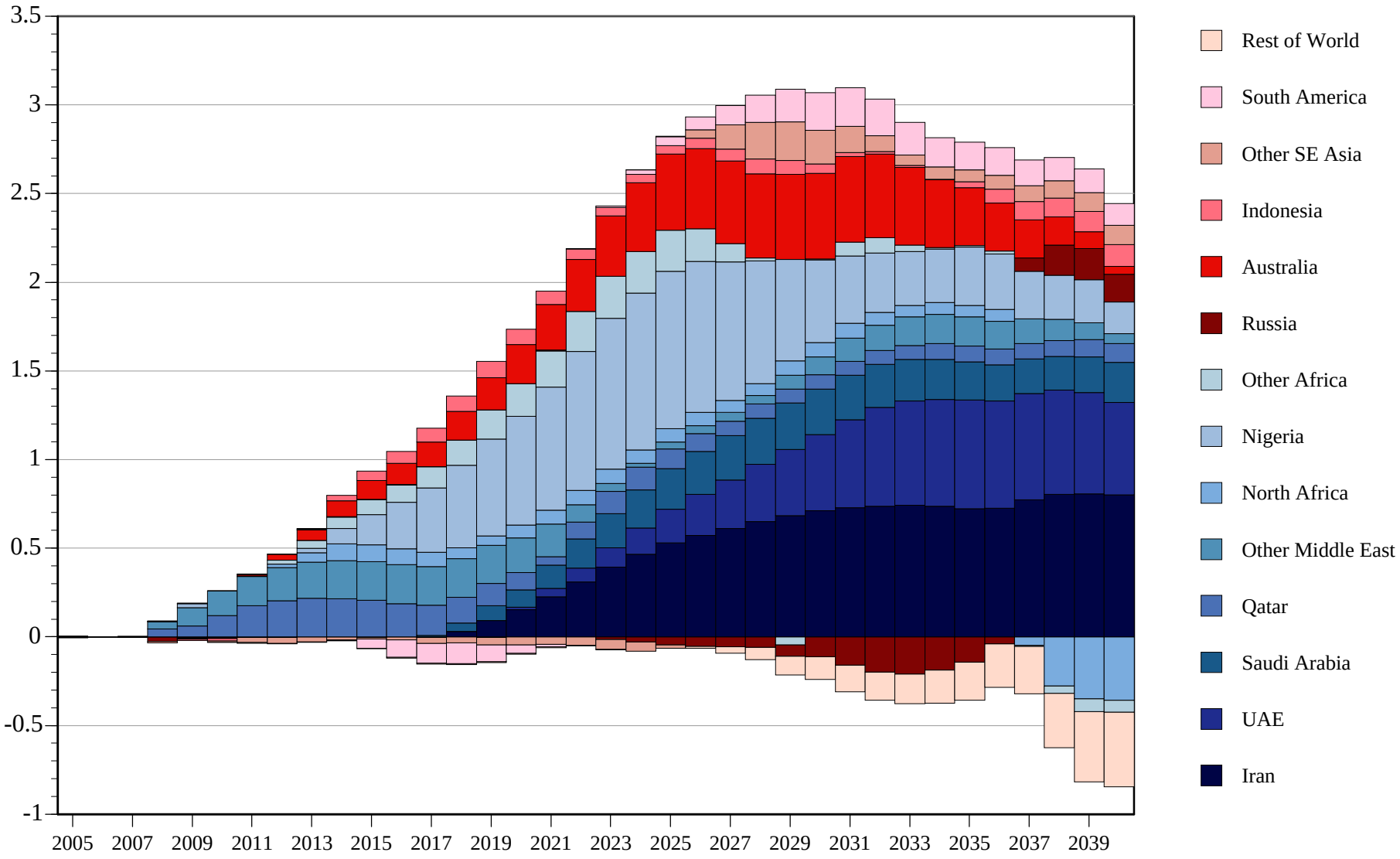
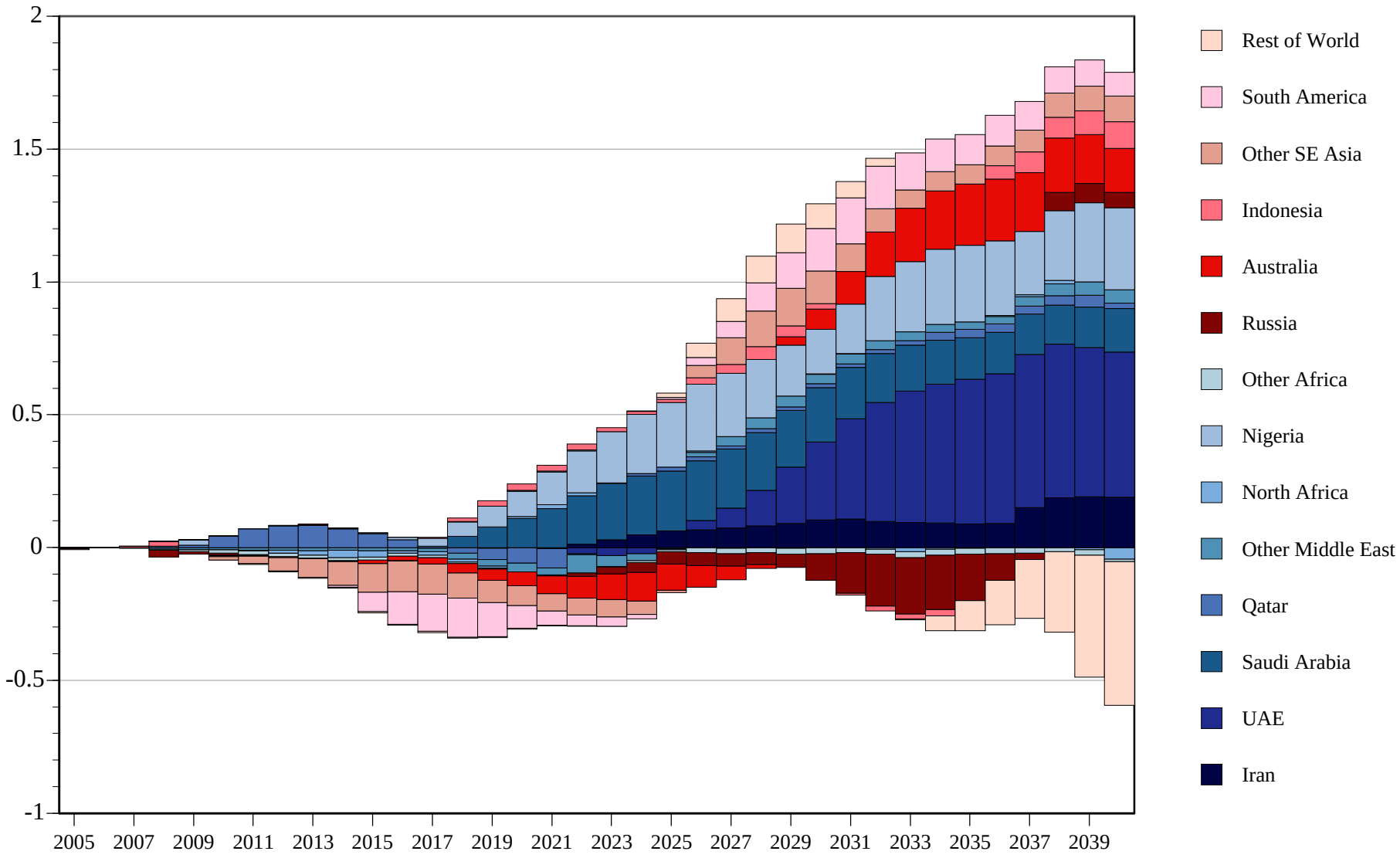


# Increased access & reduced emissions: Change in LNG exports



# 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