

# Stabilization and the Energy Sector

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# Outline

- Stabilization Basics
  - Definitions
  - Historic data and future projections
- Recent Stabilization Scenario Analysis: EMF 22
  - Crosswalk between EMF 22 scenarios and policy proposals
  - Insights related to incomplete participation
  - Insights related to technology

# Stabilization Basics

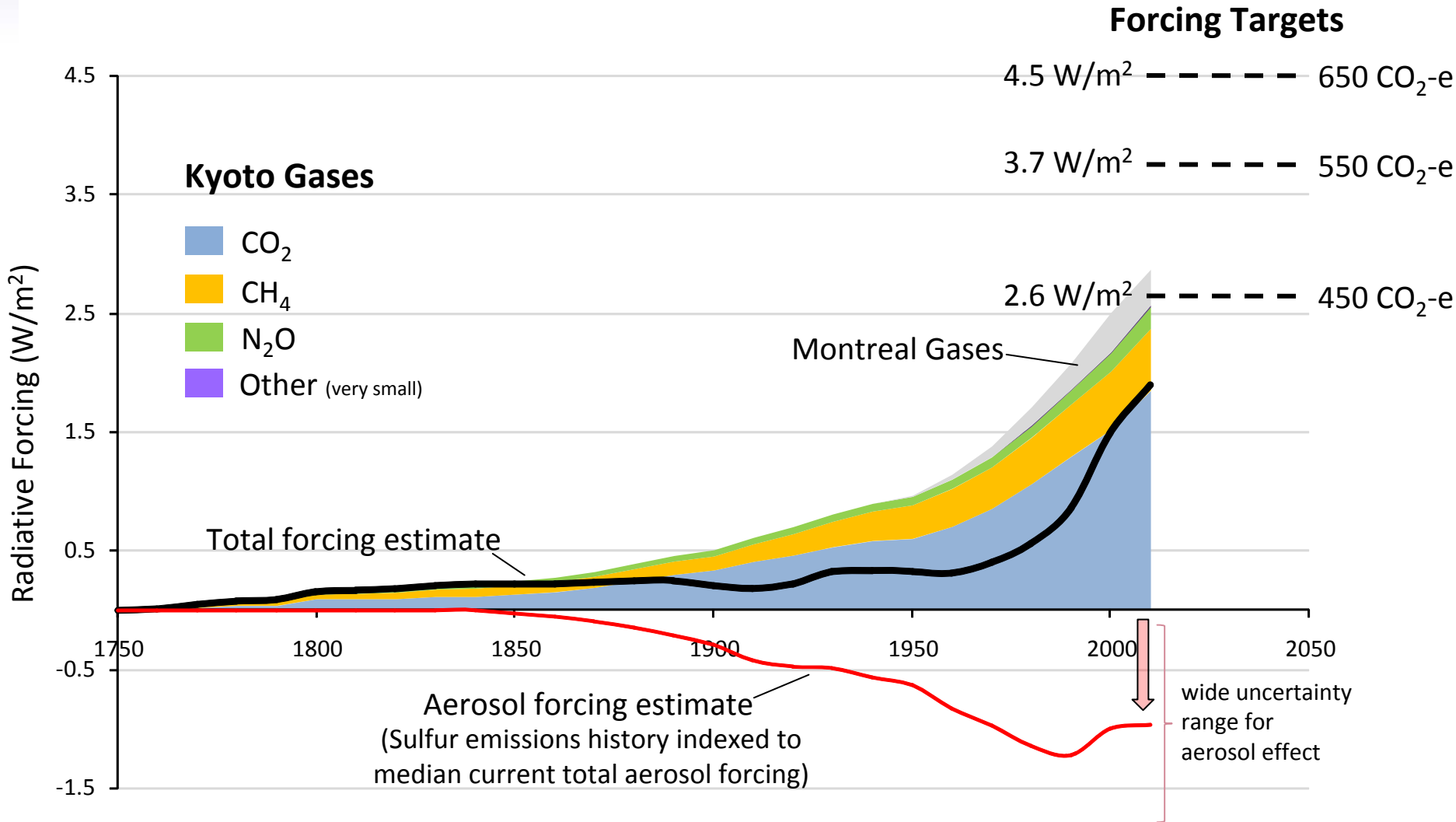
- Emissions →

Concentrations →

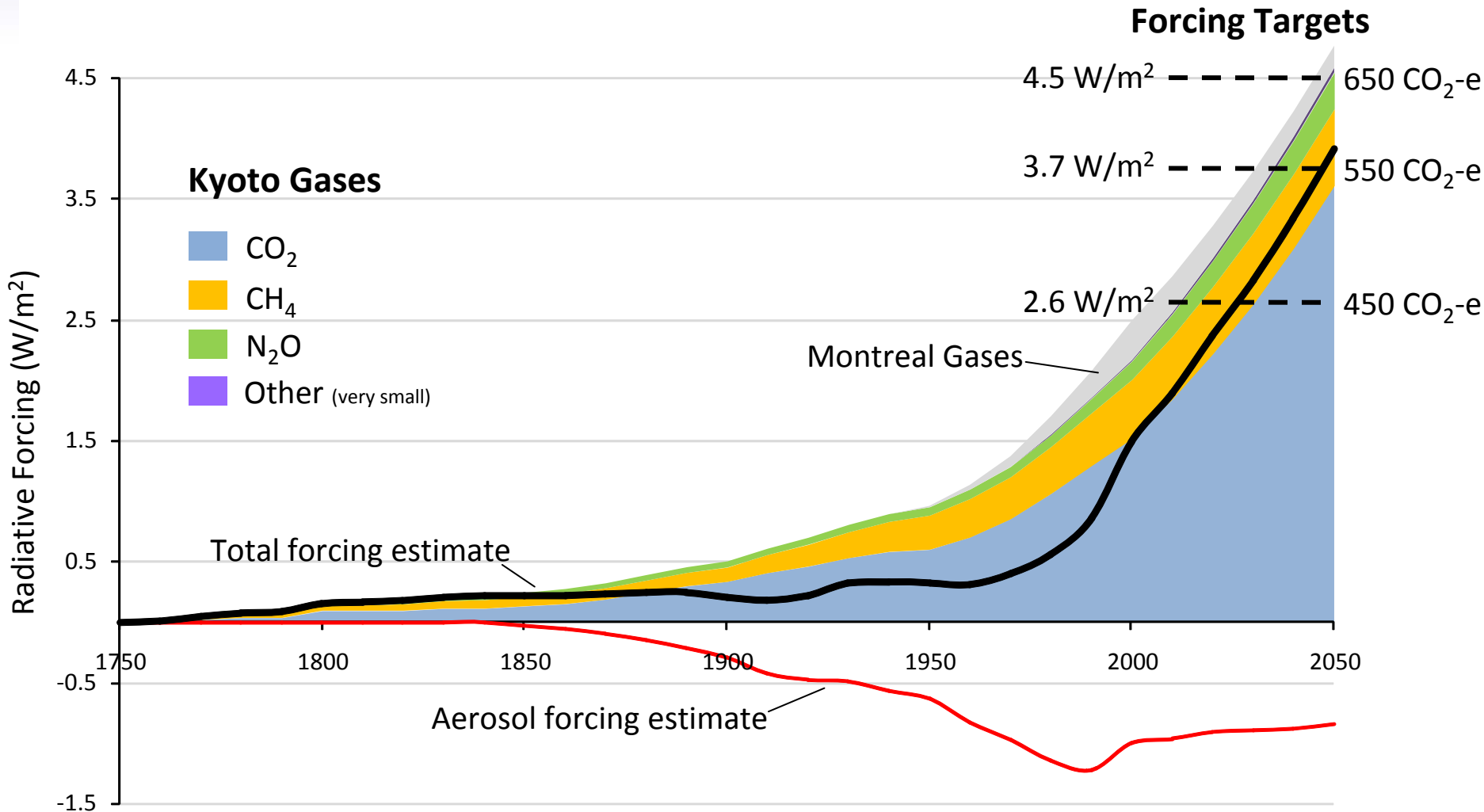
Radiative Forcing = change in Earth's heat balance

- Many forcing agents, including long-lived gases and aerosols
- Agents have different properties, but (global) forcing is additive
- Kyoto Protocol applied to all greenhouse gases (except ozone-depleting gases covered by Montreal Protocol), **not** to aerosols
- Total forcing from Kyoto gases can be expressed as a “CO<sub>2</sub> equivalent concentration” – refers to the concentration from CO<sub>2</sub> alone that would cause the same forcing level

# Historic Global Greenhouse Forcing



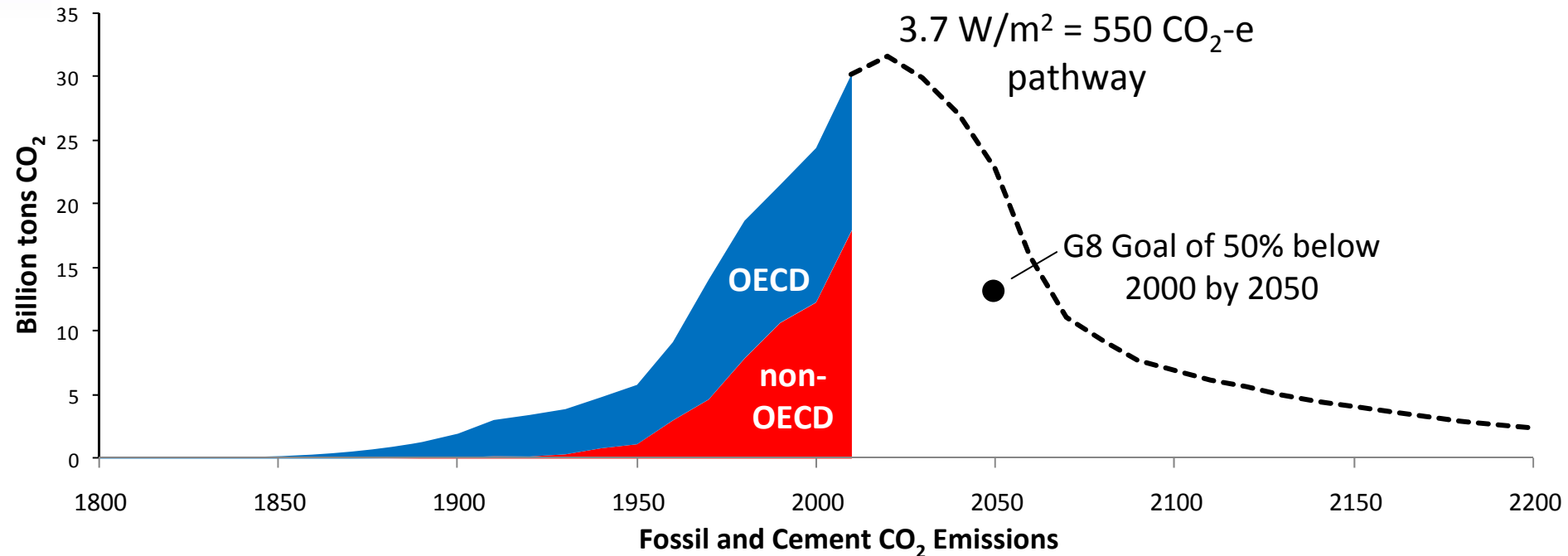
# Greenhouse Forcing Projections in MERGE BAU



# What does stabilization mean for temperature?

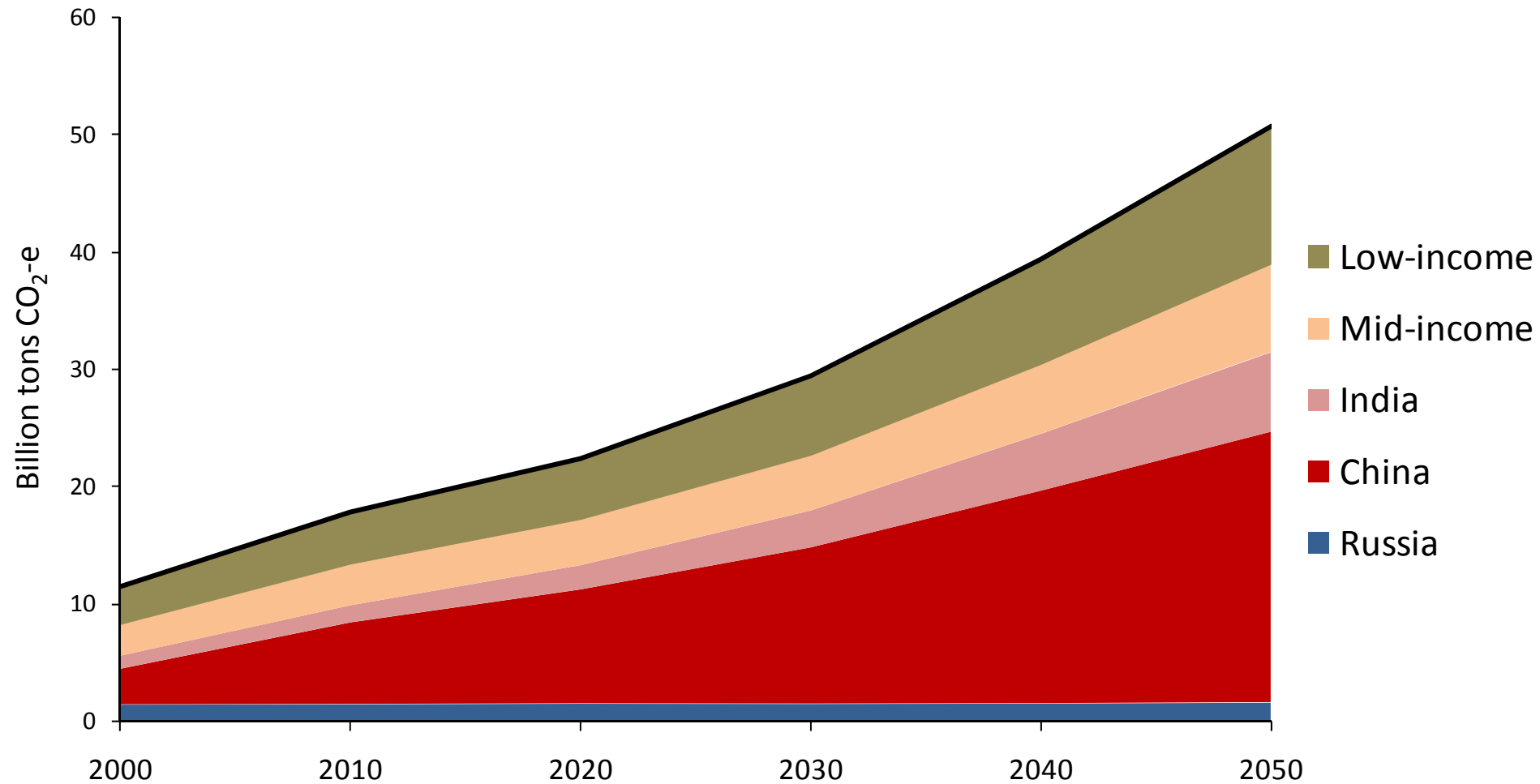
- Depends on climate sensitivity and thermal lags
  - Both are *very uncertain*
- Climate sensitivity is defined as the equilibrium temperature increase in response to sustained forcing equivalent to a doubling of atmospheric CO<sub>2</sub> (i.e. 550 CO<sub>2</sub>-e or 3.7 W/m<sup>2</sup>)
- Median value from is 3°C, scales linearly with forcing
$$\begin{array}{l} 550 \text{ CO}_2\text{-e} = 3.7 \text{ W/m}^2 \rightarrow 3^\circ\text{C (median)} \\ 450 \text{ CO}_2\text{-e} = 2.6 \text{ W/m}^2 \rightarrow \sim 2^\circ\text{C (median)} \end{array}$$
- With “overshoot”, all bets are off

# What does stabilization mean for emissions?

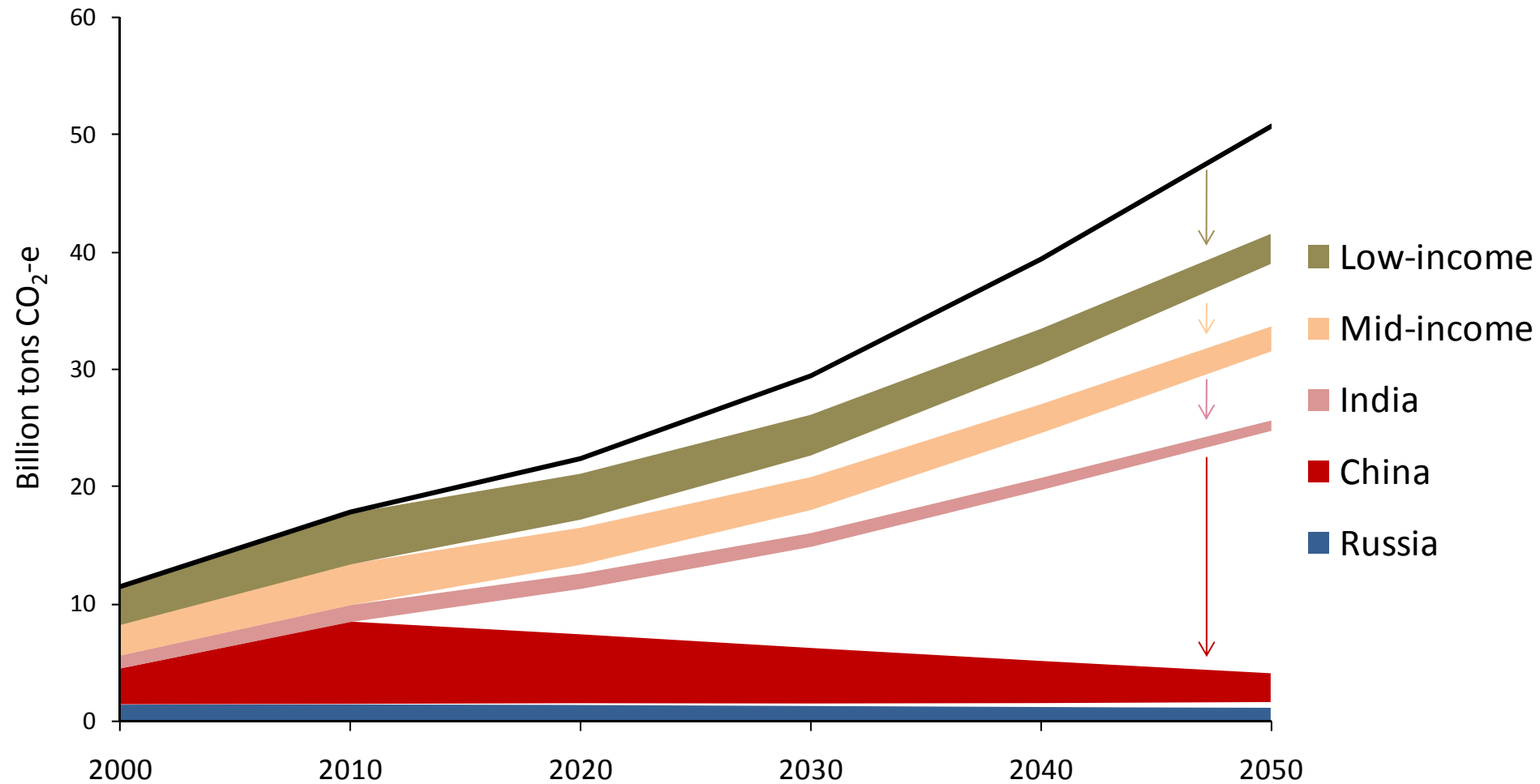


*50% global reduction below 2000 levels +  
80% below for OECD →  
20% below for non-OECD*

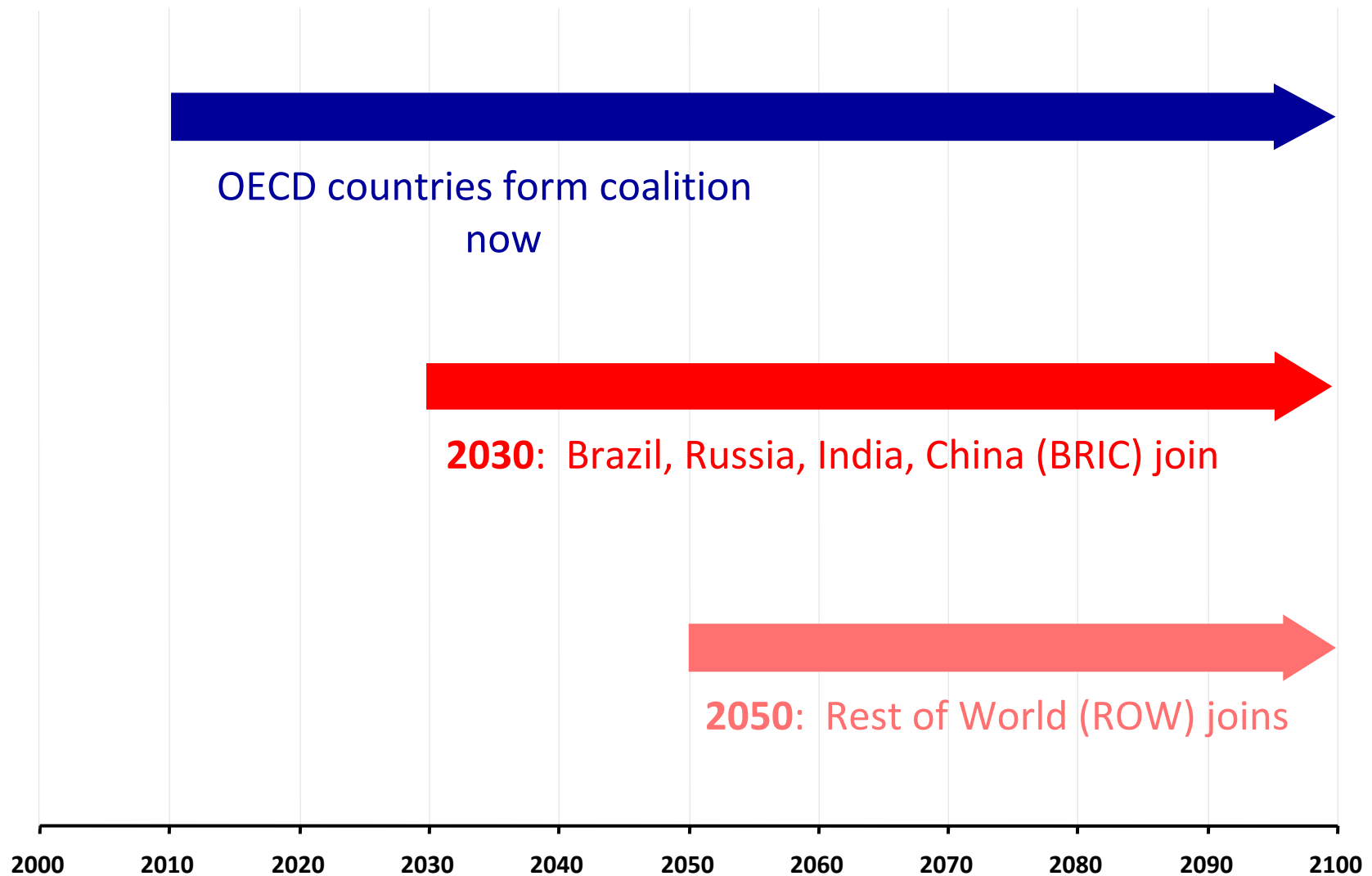
# Baseline Emissions for Non-OECD



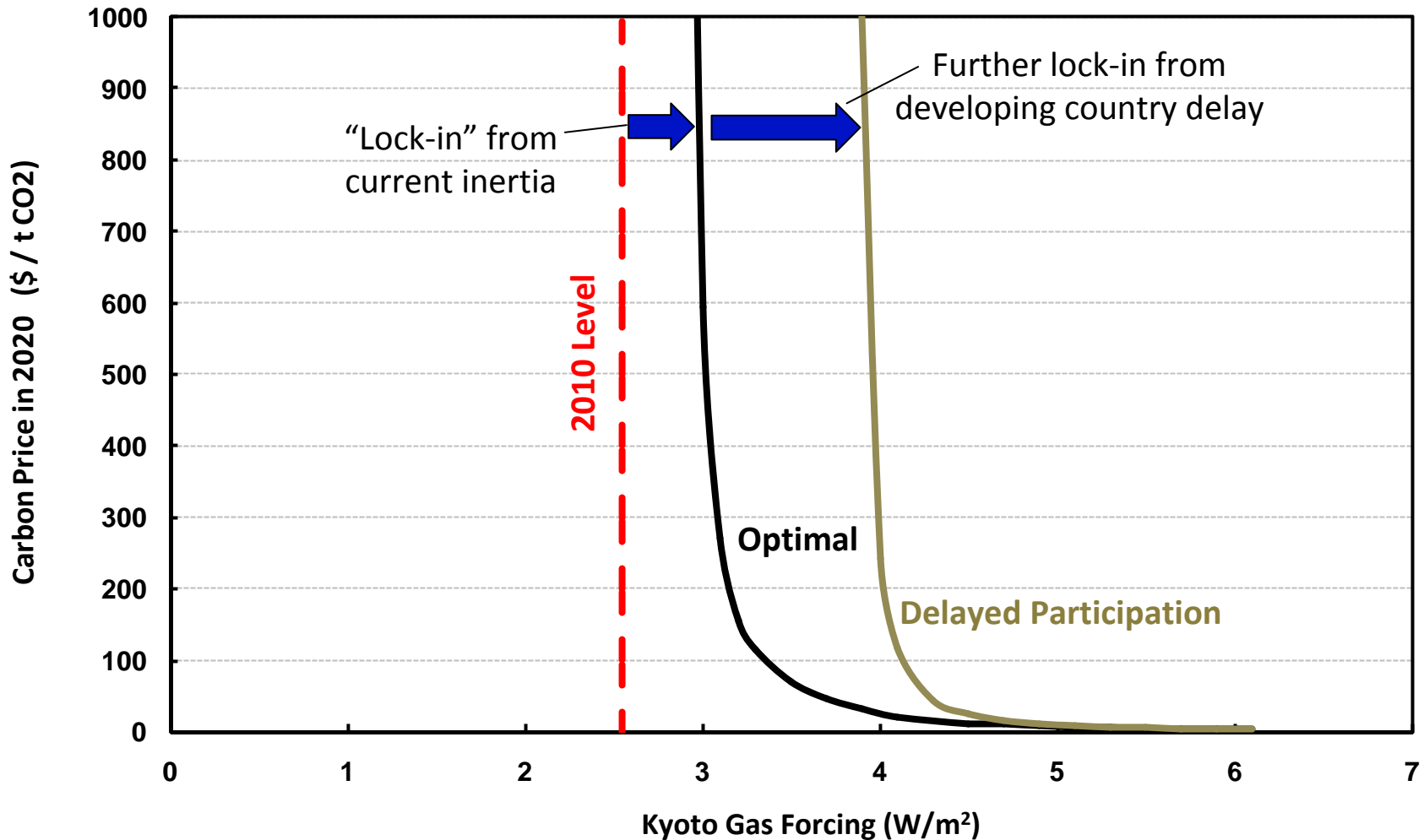
# 20% below 2000 = 80% below BAU in 2050



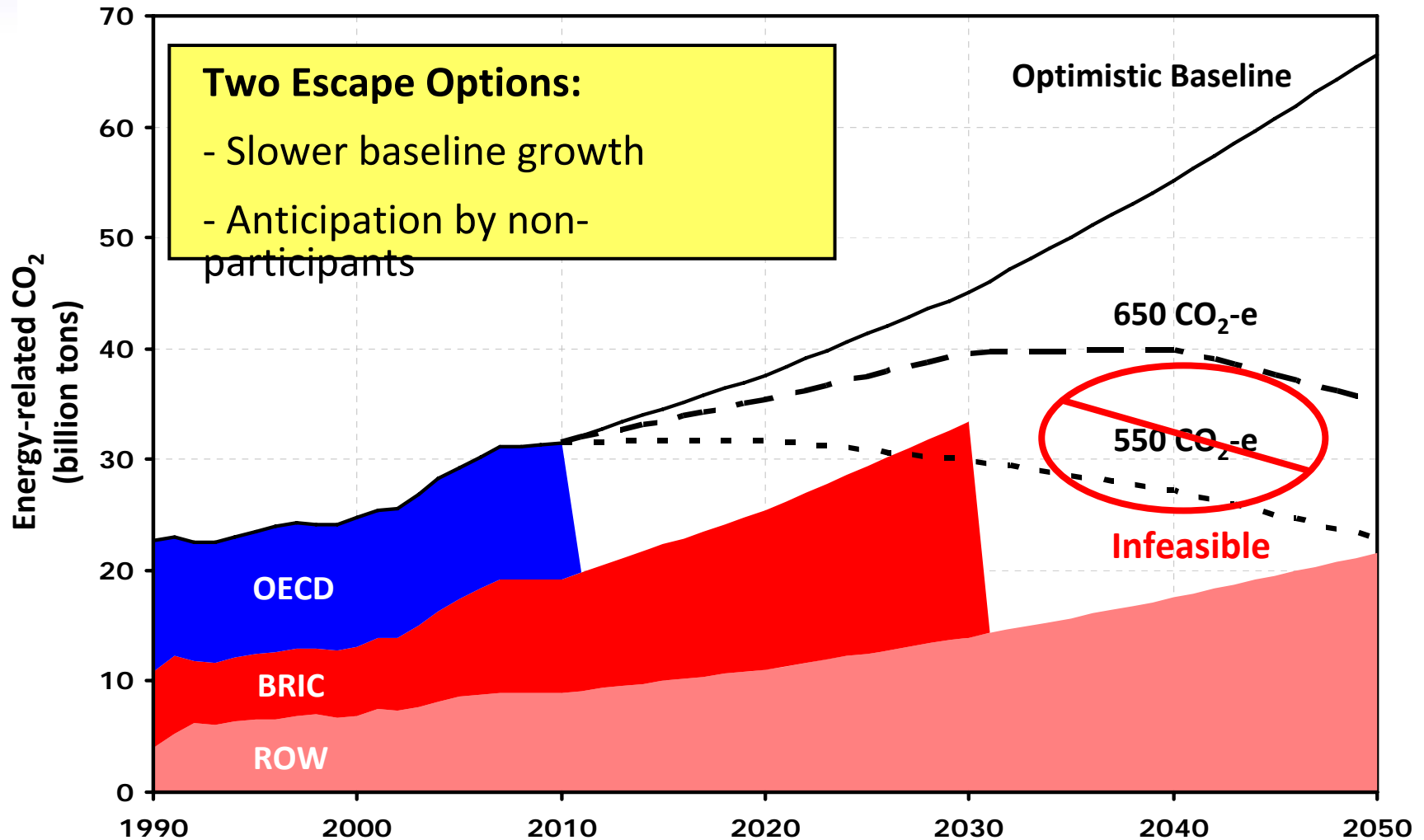
# EMF 22 Delayed Participation Storyline



# Cost Asymptotes for Stabilization in MERGE



# Emissions before joining coalition by group



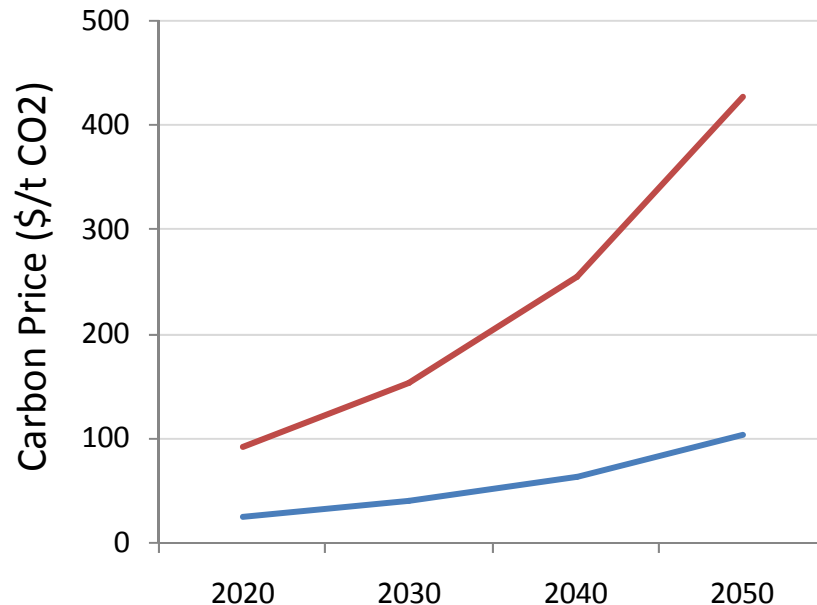
# What does stabilization mean for technology?

- Transformation of energy systems has two main attributes:
  - De-carbonization of electric sector
  - Electrification at end-use
  
- Key electric sector technologies:
  - Carbon capture and storage (CCS)
  - Nuclear
  - Renewables, particularly wind and biomass
  - Increased supply cost drives big changes on demand side

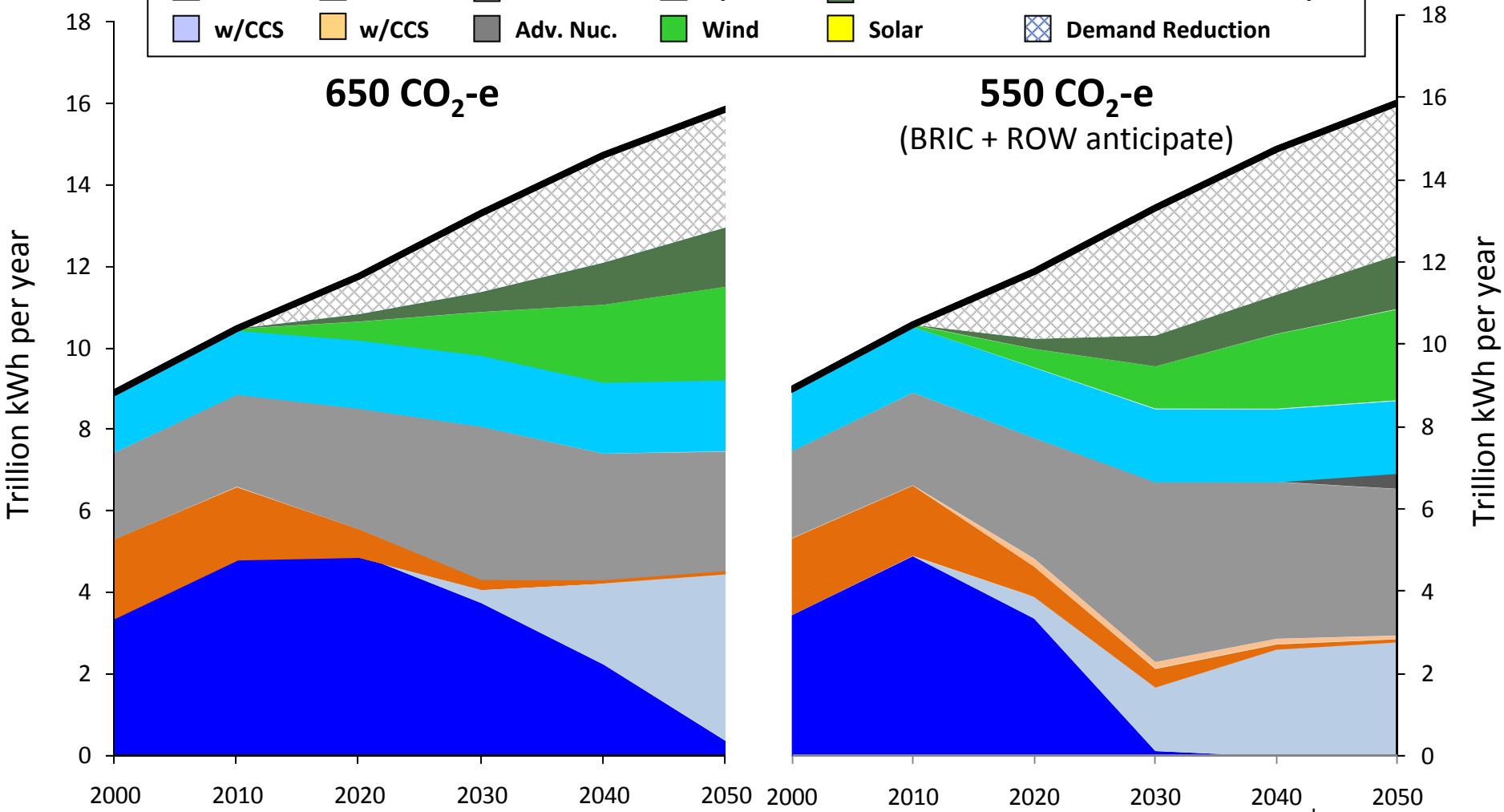
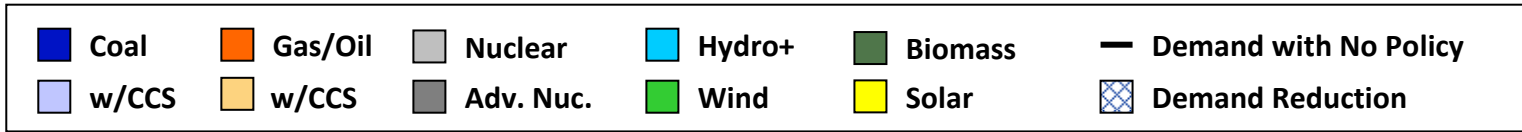
# Global Technology Scenarios in MERGE

- OECD and developing countries will rely on the same technologies, but dynamics and scale will be very different
- Consider two stabilization scenarios with delayed participation:

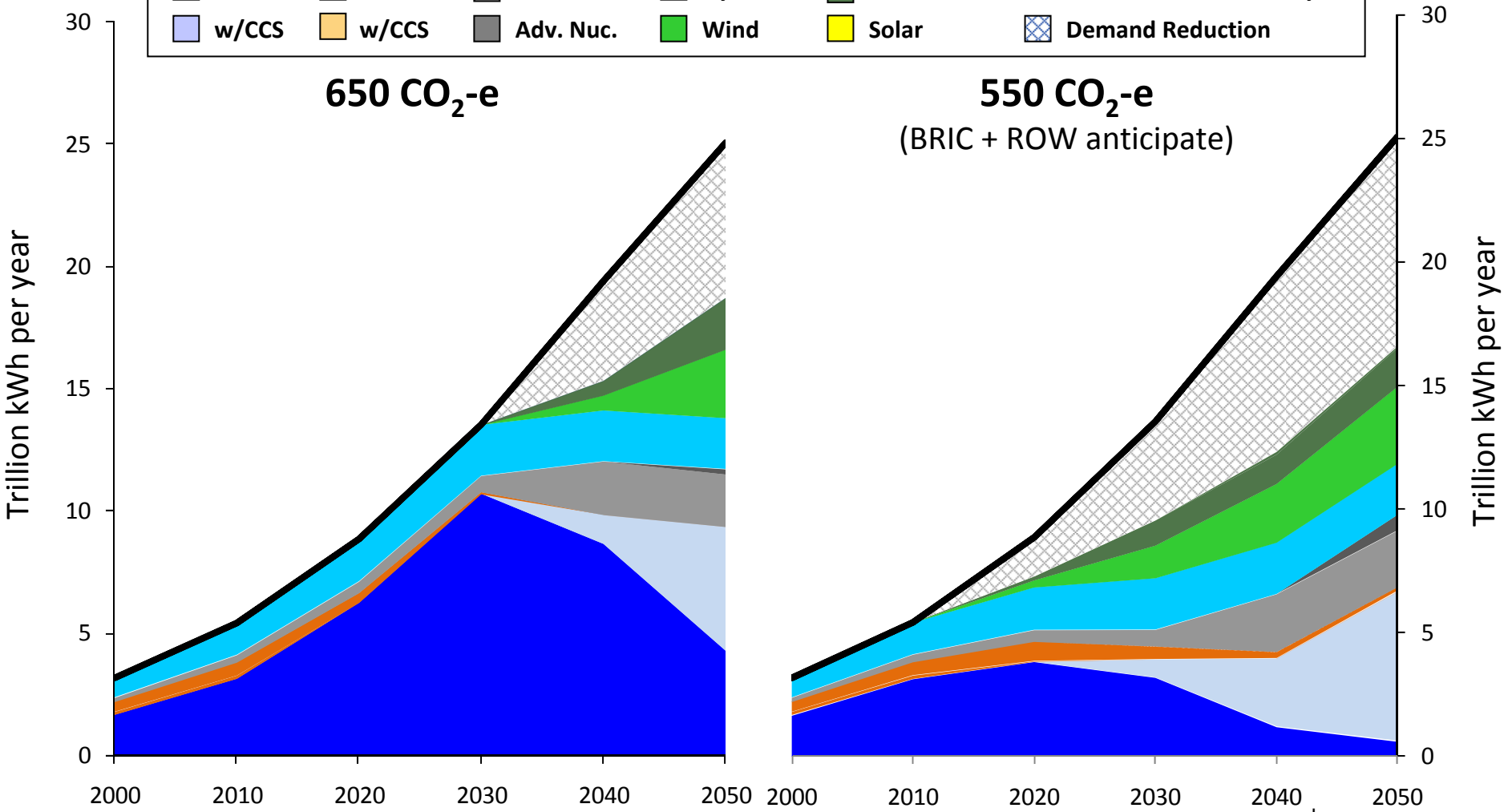
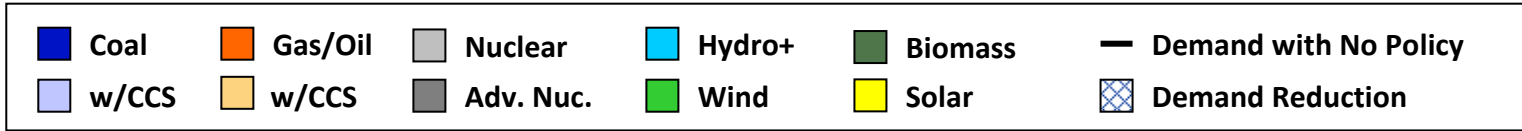
- 650 CO<sub>2</sub>-e —  
*(no anticipation by developing countries)*
- 550 CO<sub>2</sub>-e —  
*(developing countries anticipate future targets)*



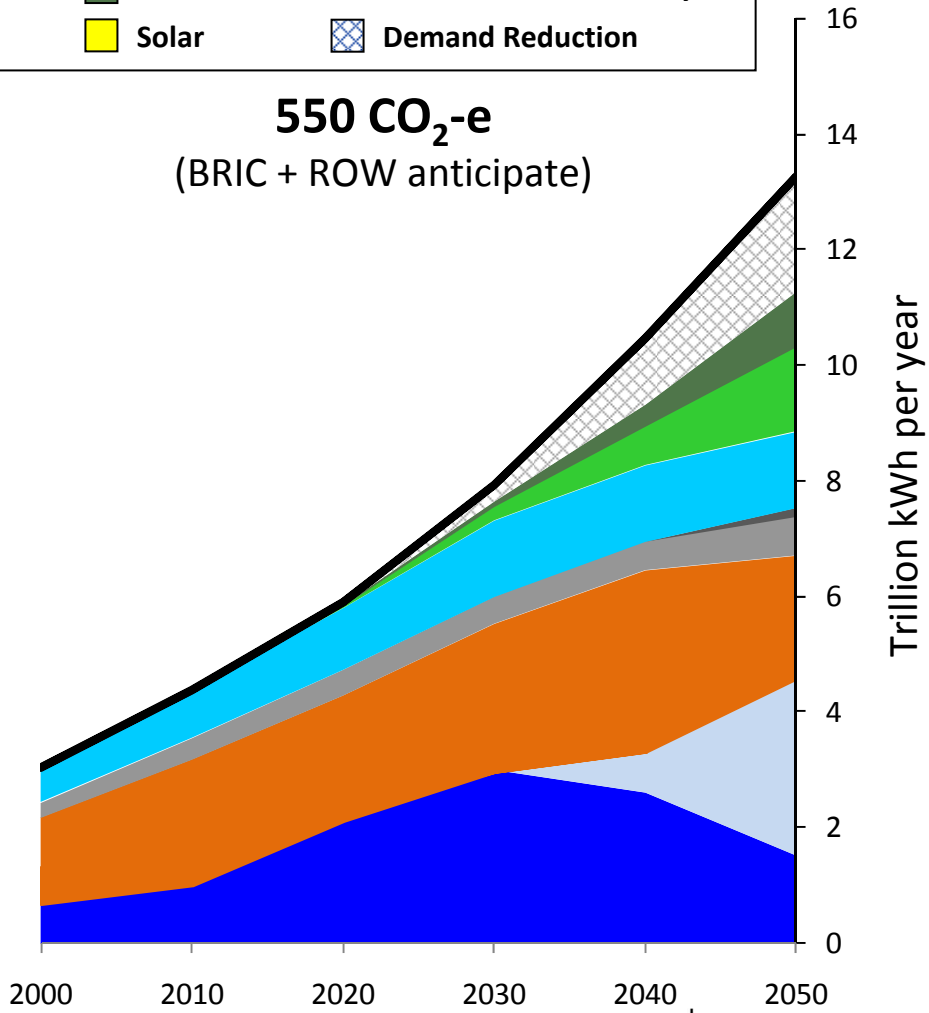
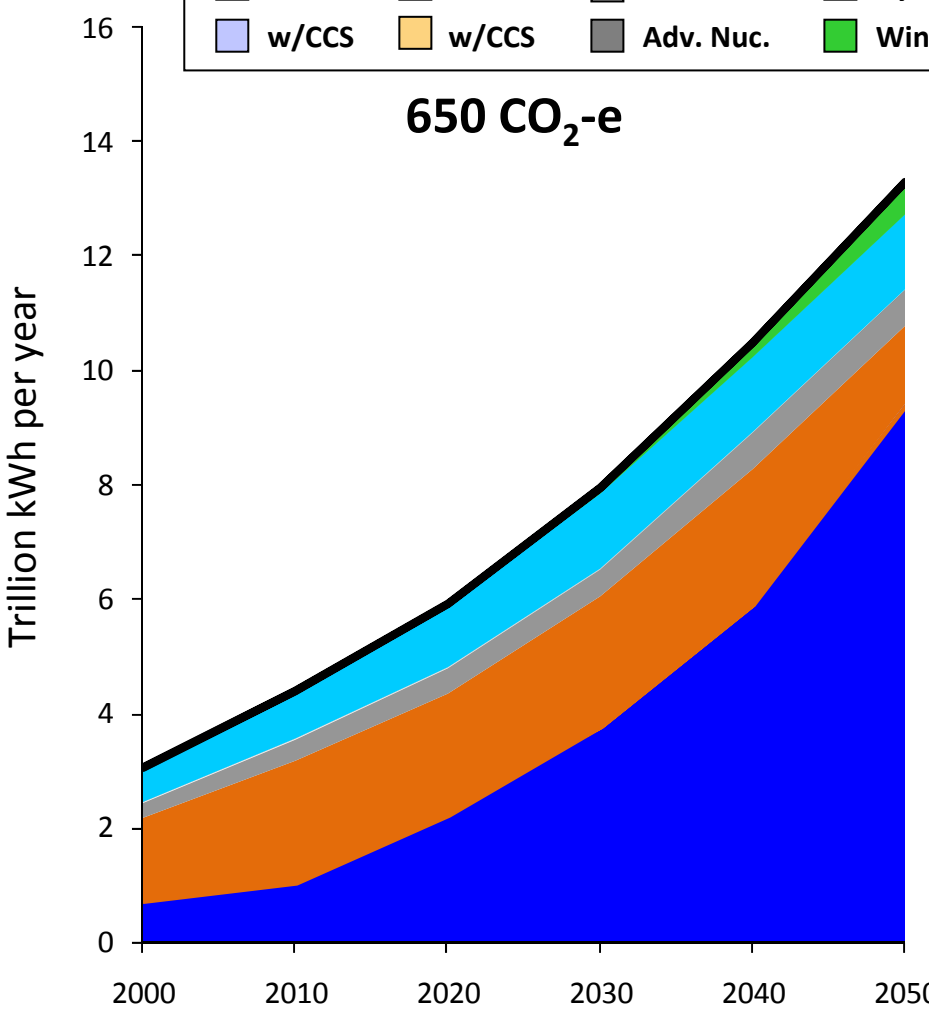
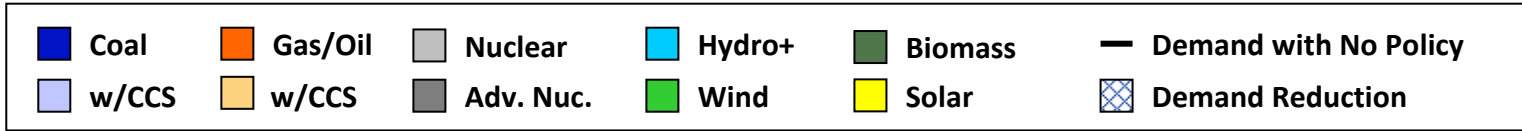
# Electric Generation in OECD (Effect of Target)



# Electric Generation in BRIC (Effect of Target)



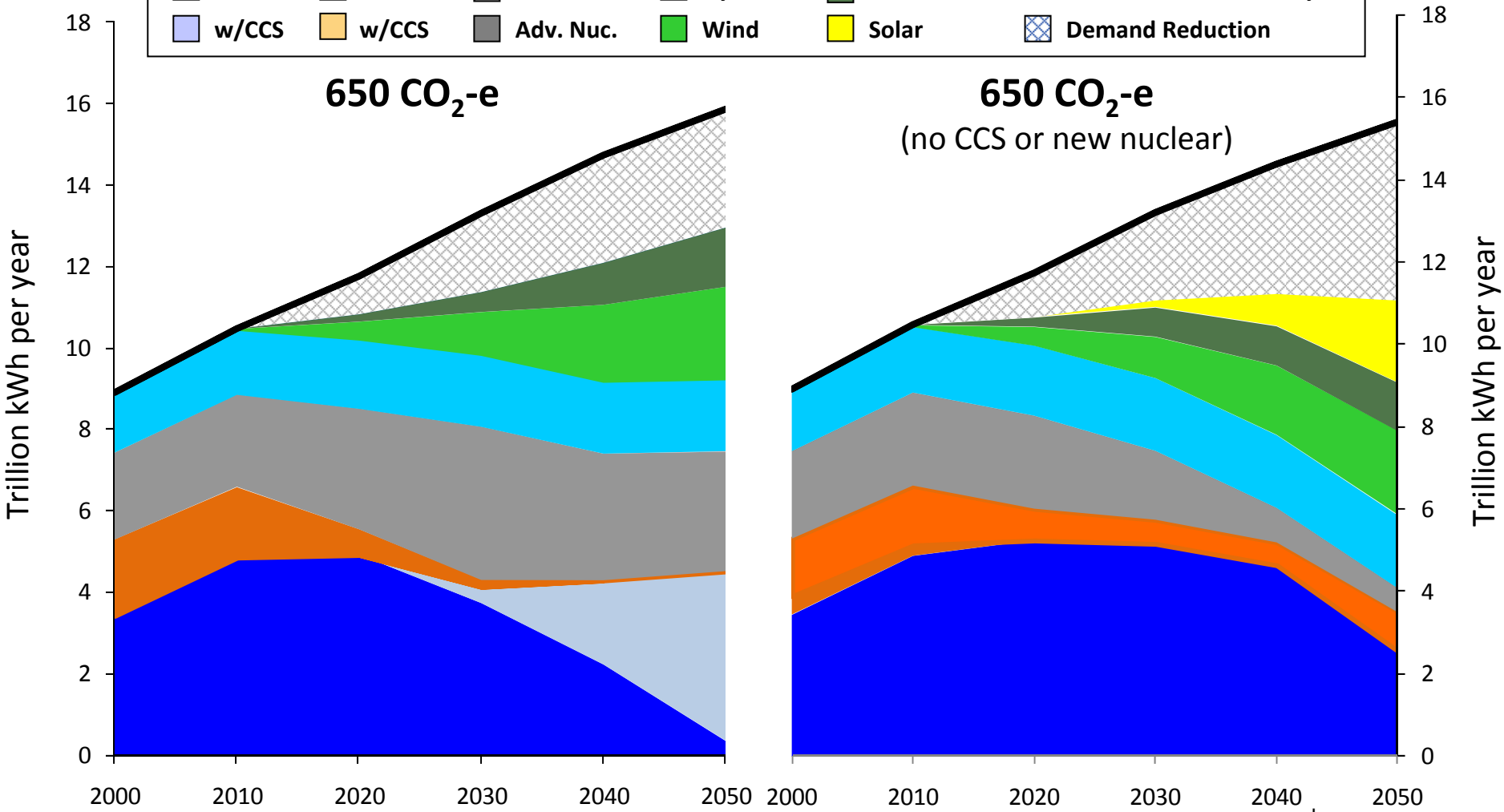
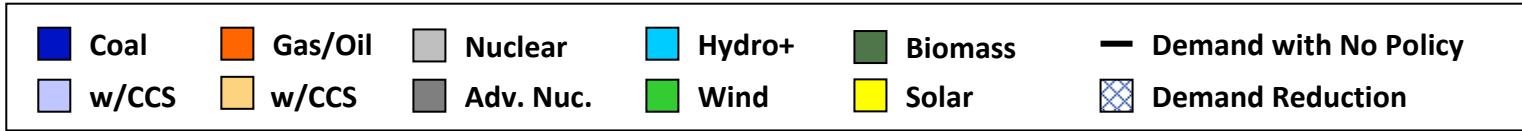
# Electric Generation in ROW (Effect of Target)



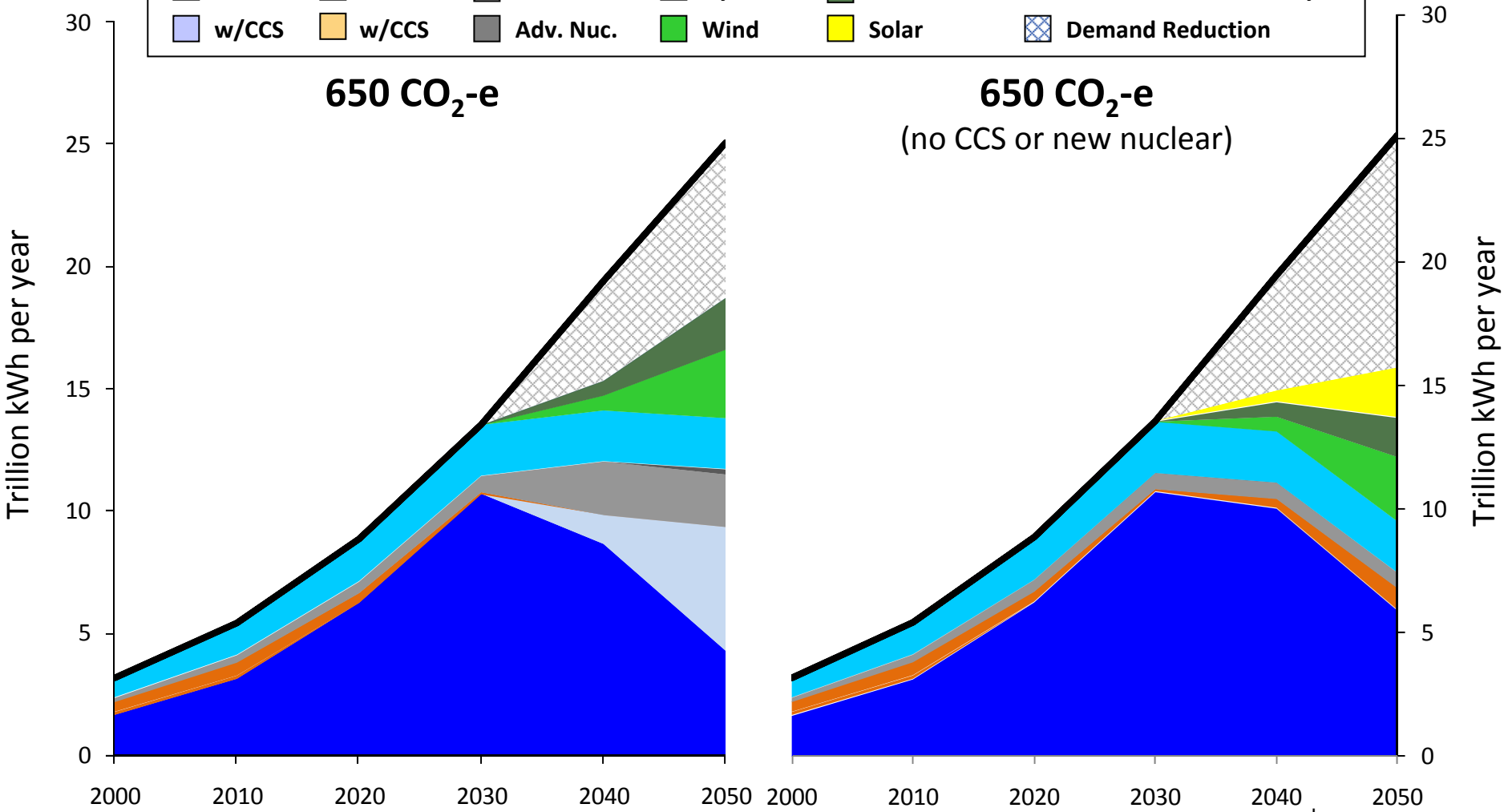
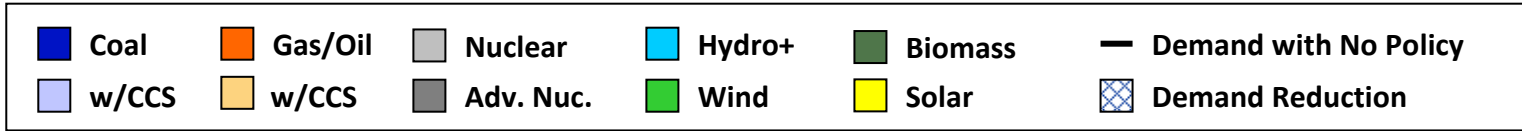
# What happens without CCS or New Nuclear?

- 550 CO<sub>2</sub>-e scenario no longer feasible (even with anticipation)
- 650 CO<sub>2</sub>-e scenario more expensive
  - More reliance on higher cost renewables
  - More demand side changes with higher prices
- Increased total cost is a measure of the value of technology
  - ~\$1 trillion in US alone (in 650 CO<sub>2</sub>-e scenario)
  - ~\$10 trillion globally

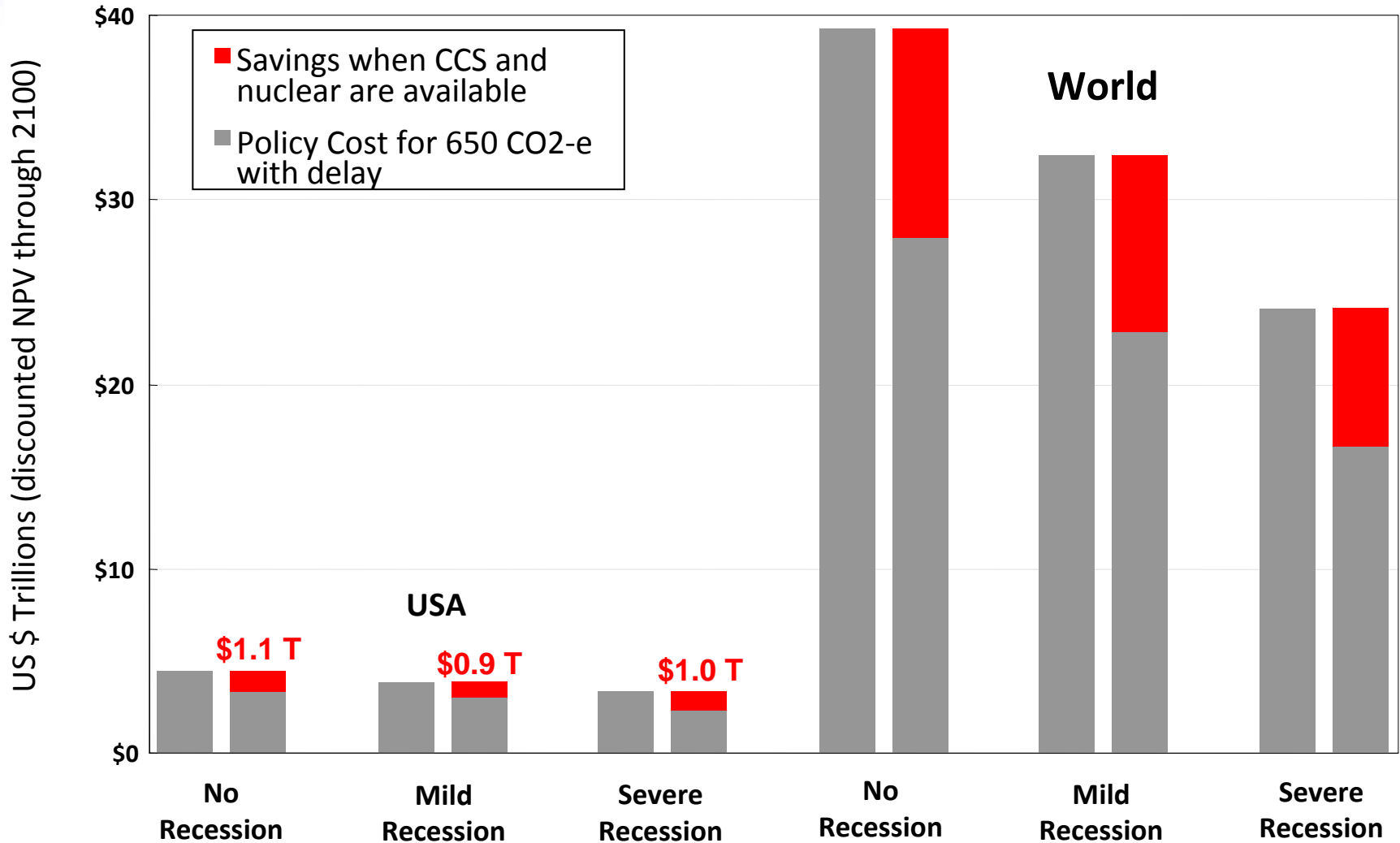
# Electric Generation in OECD (Effect of Technology)



# Electric Generation in BRIC (Effect of Technology)



# Value of Technology: CCS and New Nuclear



# Conclusions

- Aggressive not-to-exceed targets for global climate variables depend critically on abatement outside of the OECD  
*(in **addition** to OECD abatement)*
- Once they are participating, developing countries present huge opportunity for technology:
  - Fast growth means more new capital needs
  - Scale is much larger: 80% of population is outside OECD
  - The sooner the better (for all concerned)



# Together...Shaping the Future of Electricity