

Electrification of Transport, Energy, Emissions, and Economy

Jae Edmonds, Sonny Kim, Stephanie Waldhoff
Joint Global Change Research Institute

02 March 2018

NTNU Transportation Workshop

Trondheim, Norway



Major developments in transportation technology

- Connectedness
 - Autonomous vehicles
 - Sensors and control systems
 - Shared mobility
-
- Fuels
 - Hydrocarbons
 - H₂
 - Electricity



Source: <https://www.its.dot.gov/>

Science questions

- How will alternative transportation technology development paths affect the energy system and greenhouse gas emissions mitigation?
- Three potential futures
 - Hydrocarbons continue
 - Electrification
 - Dual pathway



Source: <https://energy.gov/eere/vehicles/plug-electric-vehicles-and-batteries/>

Experimental design

- All scenarios assume SSP2 (Middle of the Road) underlying socioeconomic drivers
- Policy assumptions
 - Current policies only
- Transport technology pathways
 - SSP2 transport technology
 - Accelerated electric vehicles
 - Phase out of non-electric vehicles



Source: <http://viola.bz/your-life-is-your-road/life-is-a-road-5/>

Transport technology pathways

Technology Scenario	Technology Assumptions
SSP2 transport technology	Passenger Light-Duty BEV Capital Cost: 10 - 50 % greater than ICE BEV Fuel Efficiency: ~3 x better than ICE
Accelerated electric vehicles	Passenger Bus and Freight Truck BEV Capital Cost: Equal to ICE by 2035 BEV Fuel Efficiency: ~3x better than ICE
Phase out of non-electric vehicles	Phase Out ICE by 2050 for Passenger Lt-Duty Passenger Bus Freight Truck

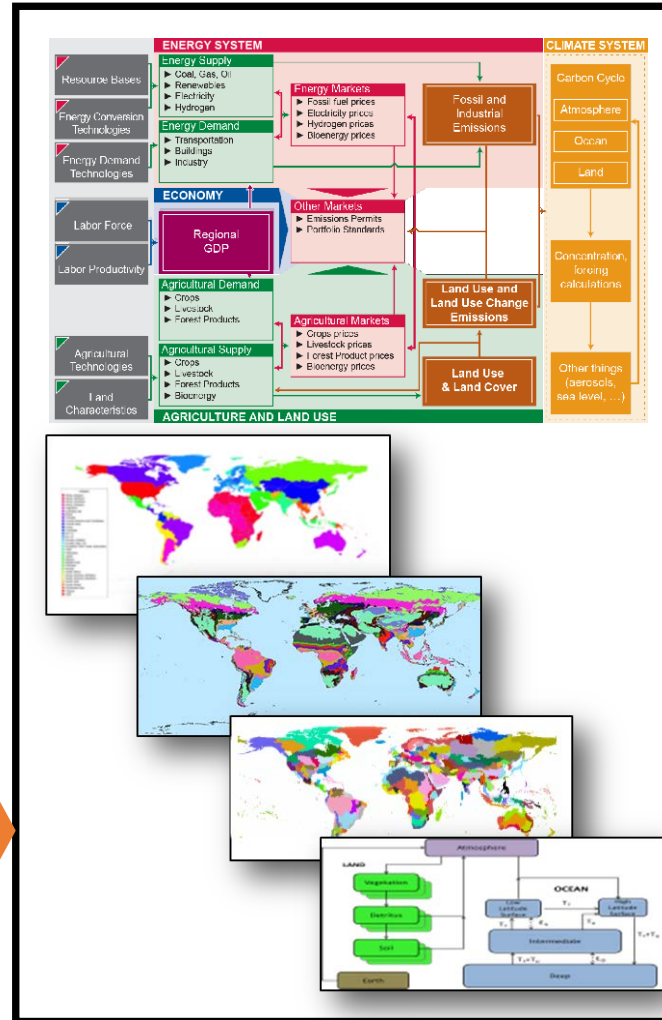
Inputs and Output in GCAM produce conditional forecasts

Scenario Assumptions

- ▶ Socioeconomic assumptions (population, GDP)
- ▶ Energy, land use, and water technologies
- ▶ Policies
- ▶ Resources

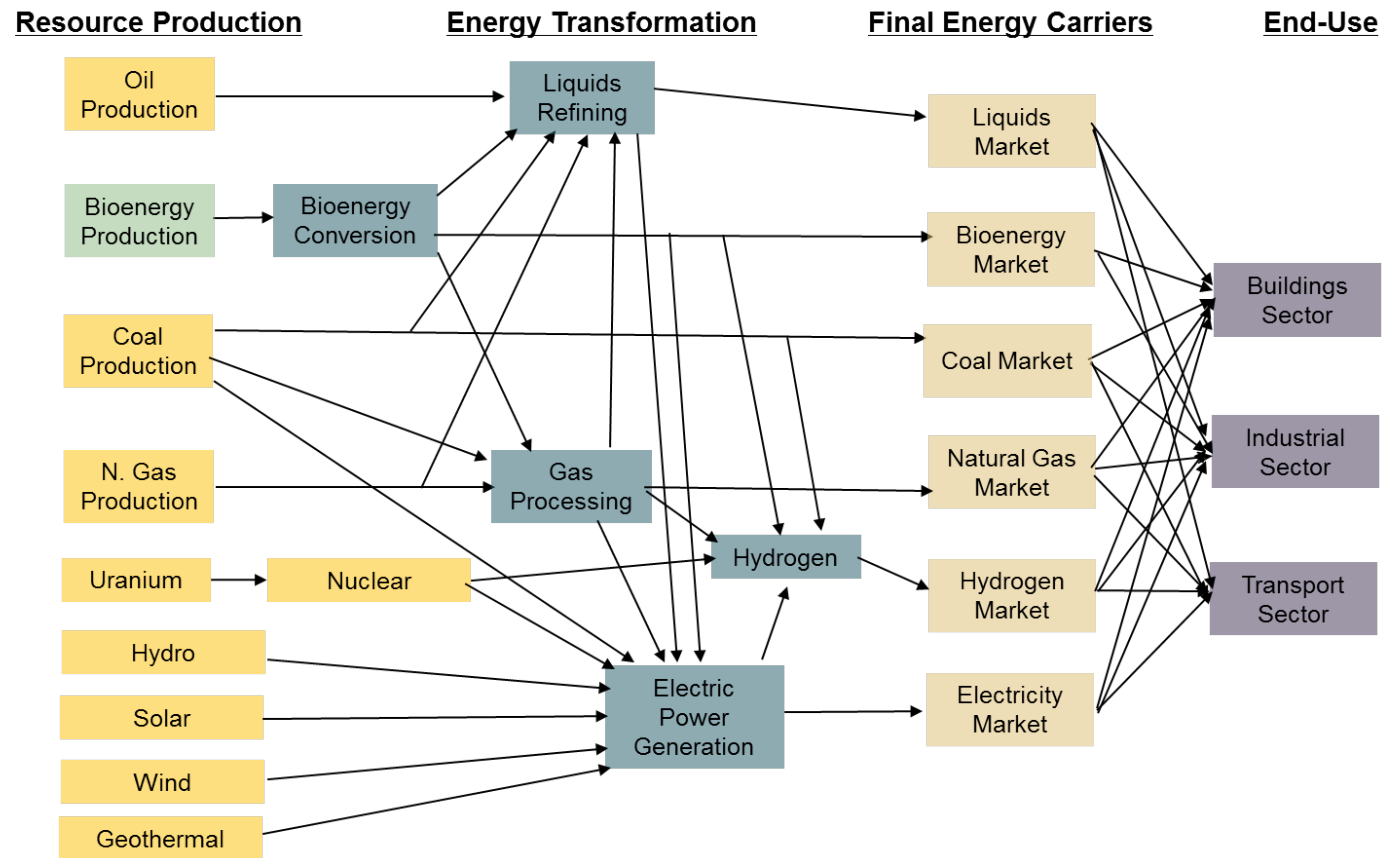
Scenario Outputs

- ▶ Prices and production quantities:
 - Energy sectors
 - Transportation
 - Primary energy resources
 - Agricultural products
- ▶ Land use
 - Crops (by type)
 - Pasture
 - Unmanaged
- ▶ Water demand
 - Raw demand by sector
 - Response to scarcity
- ▶ Atmosphere-Climate
- ▶ Economic indicators
 - Economic losses
 - Income transfer



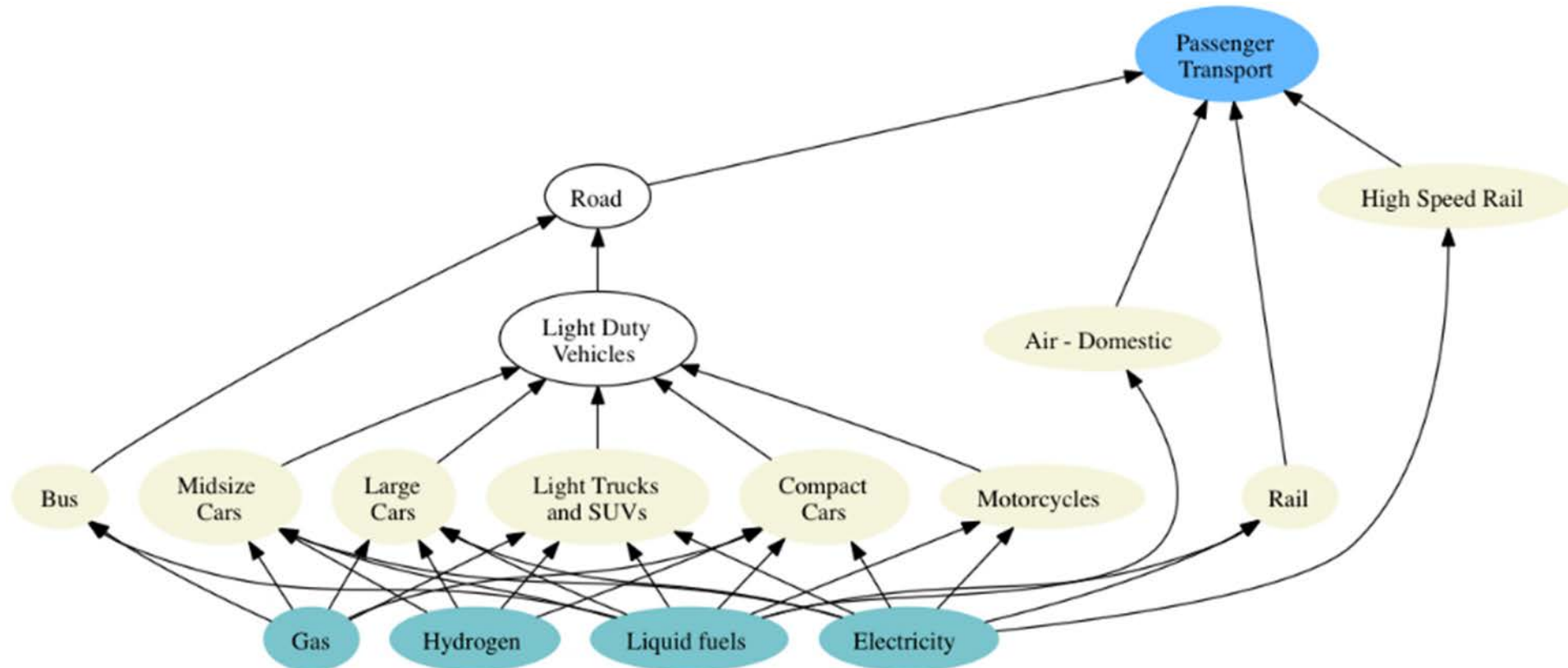
The energy system in GCAM

- The energy system in GCAM links primary energy production with final sectors.

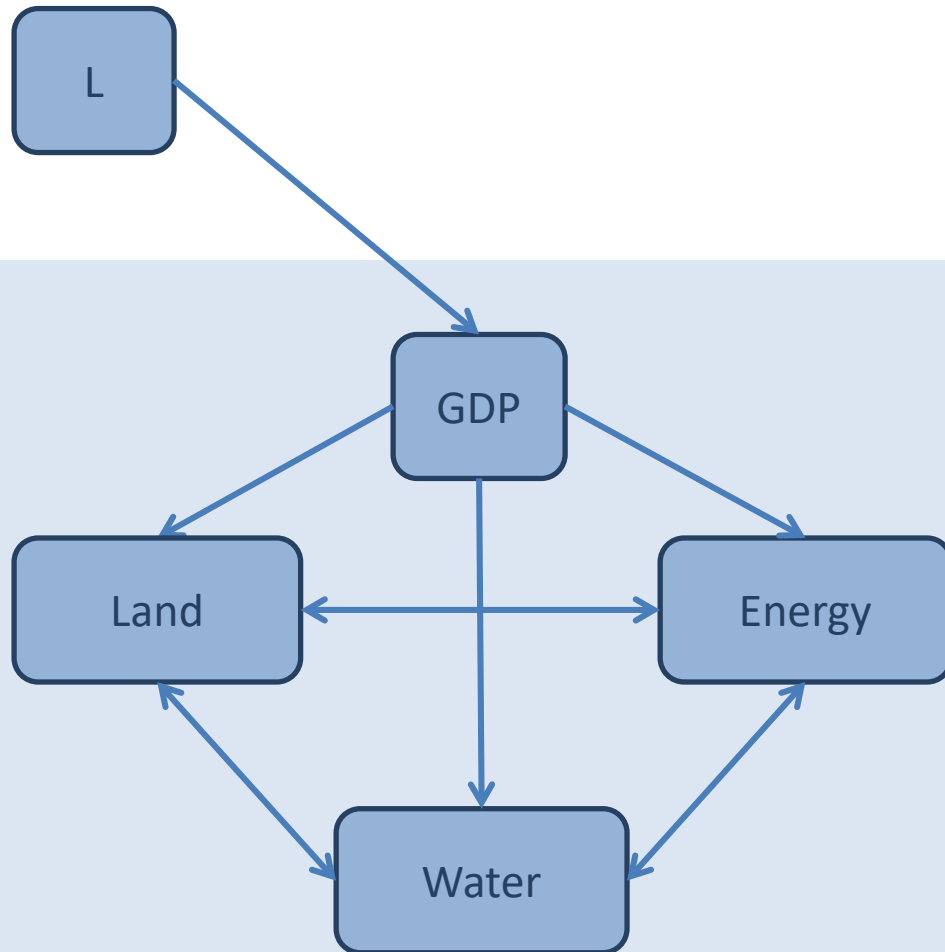


The transport sector in GCAM

- The choice among modes of transportation in the passenger sector is a function of the cost of travel, the time it takes, and income.



Basic GCAM



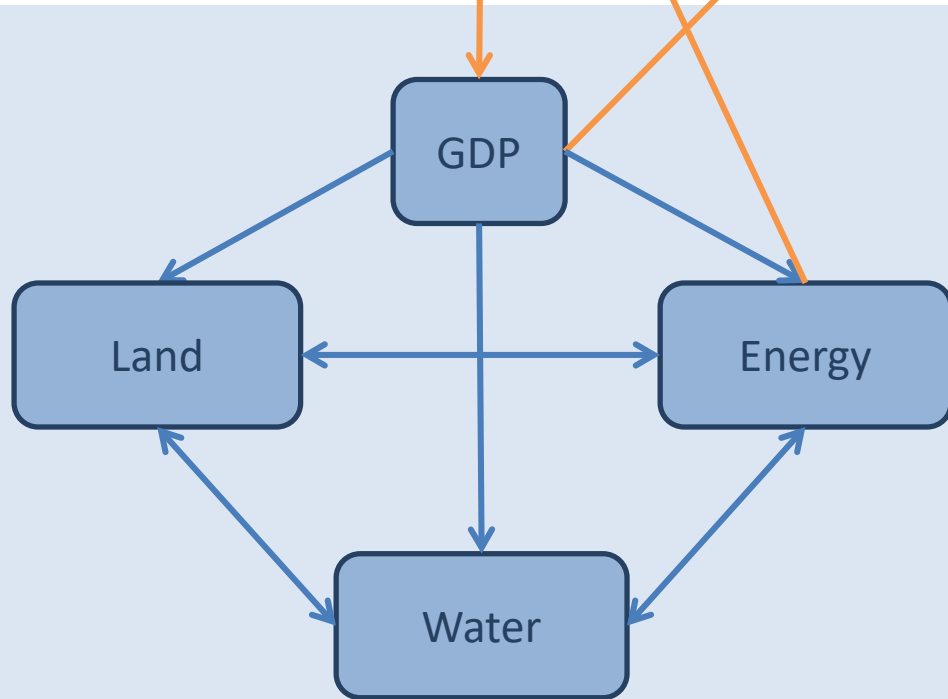
NOTATION
Lm = labor used for materials production
La = labor used in agricultural production
I = investment
K = capital stock
GDP = gross domestic product

Existing GCAM elements

GCAM-Macro



New GCAM-Macro elements



NOTATION
Lm = labor used for materials production
La = labor used in agricultural production
I = investment
K = capital stock
GDP = gross domestic product

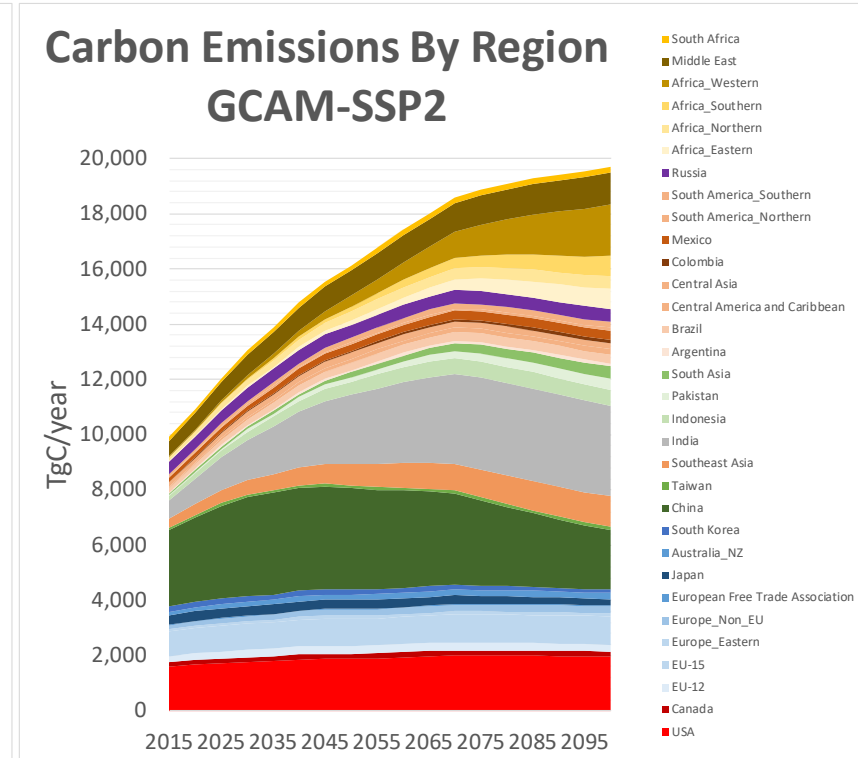
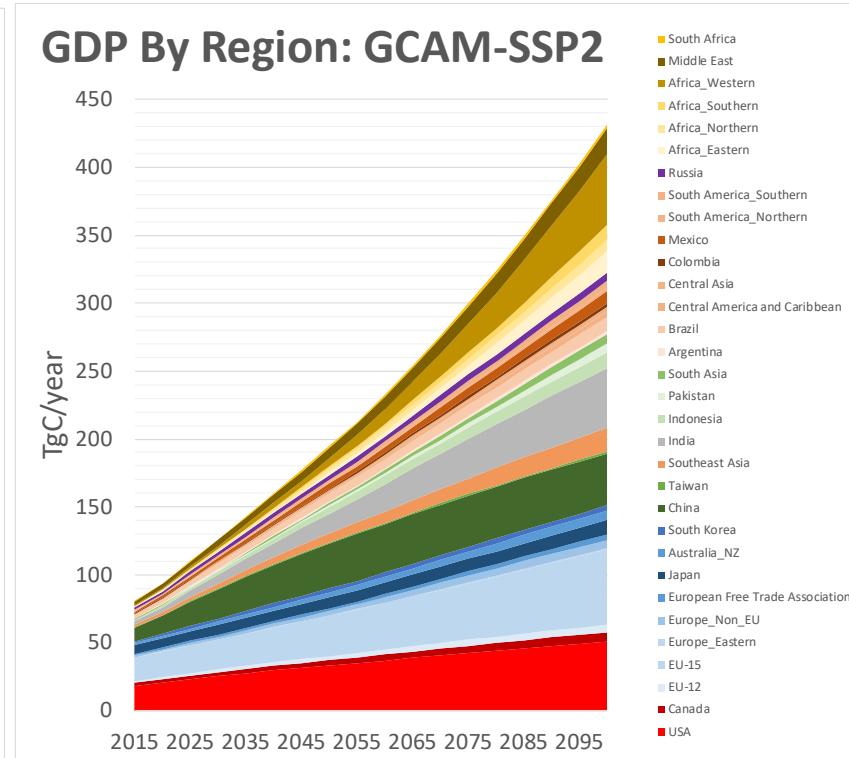
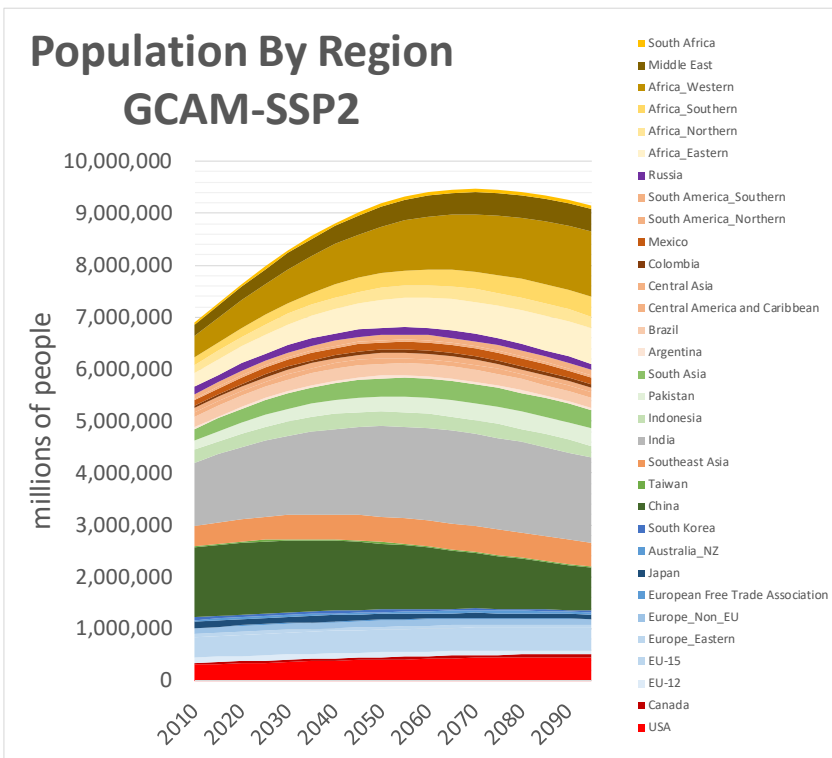
Existing GCAM elements

GCAM-SSP2: GDP and Fossil Fuel Carbon

Population

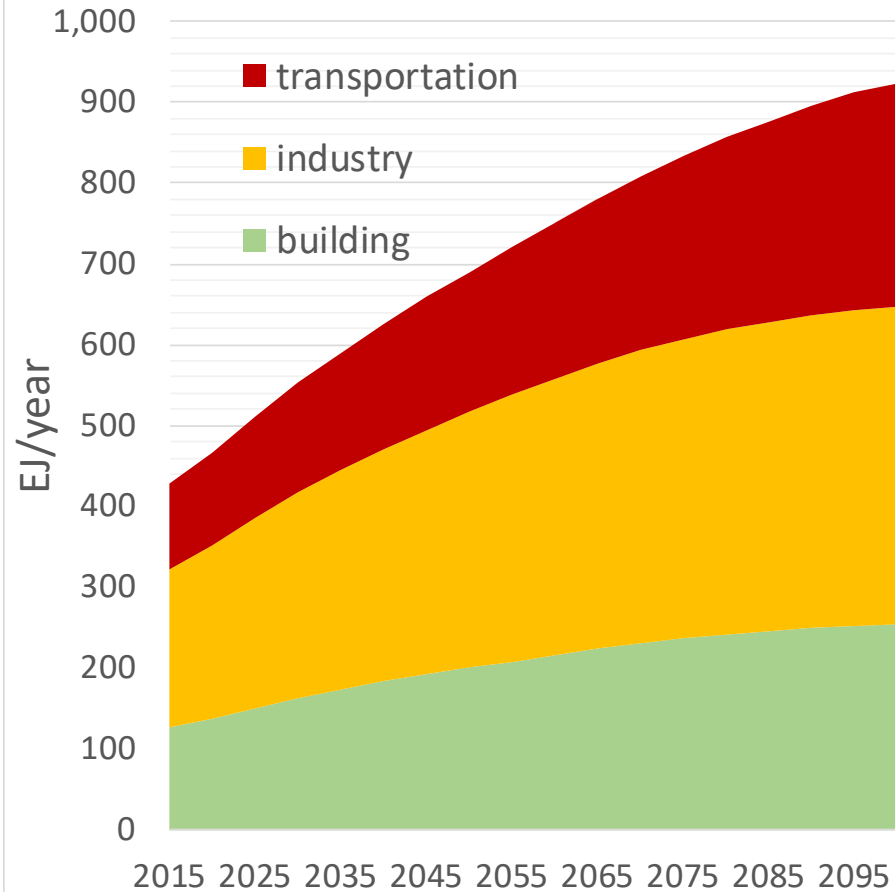
GDP

Carbon

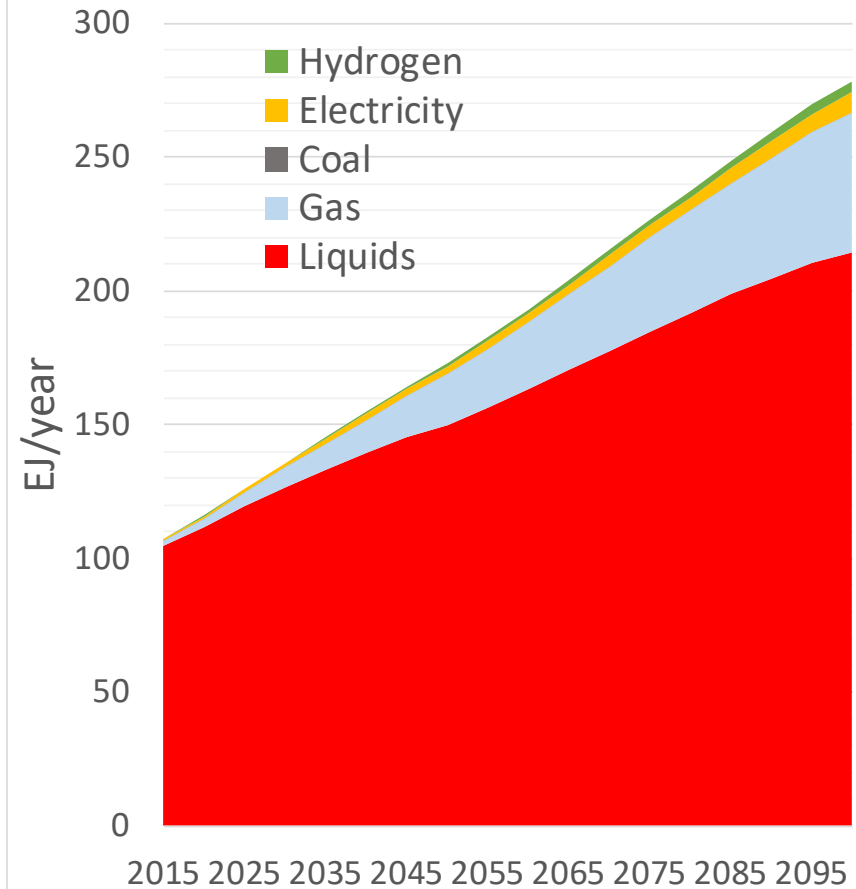


The global energy system

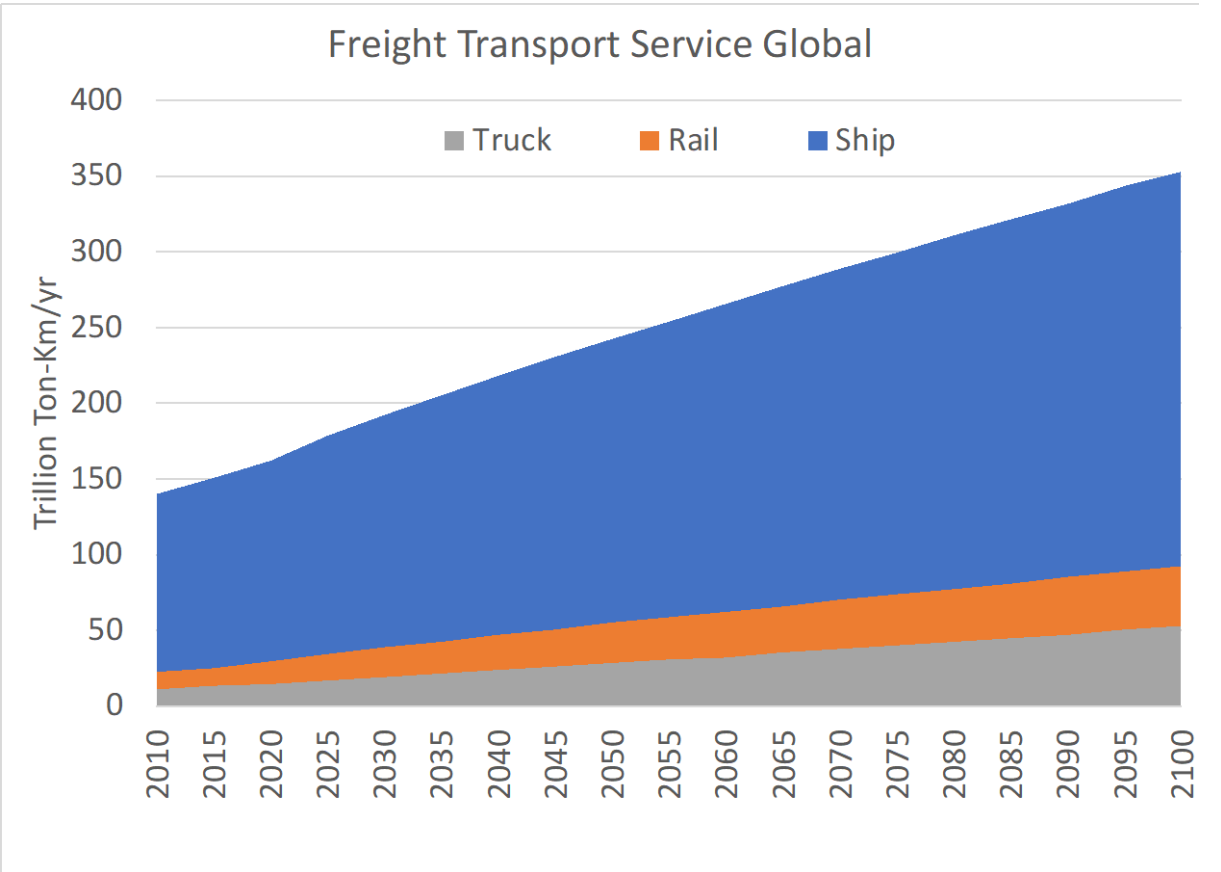
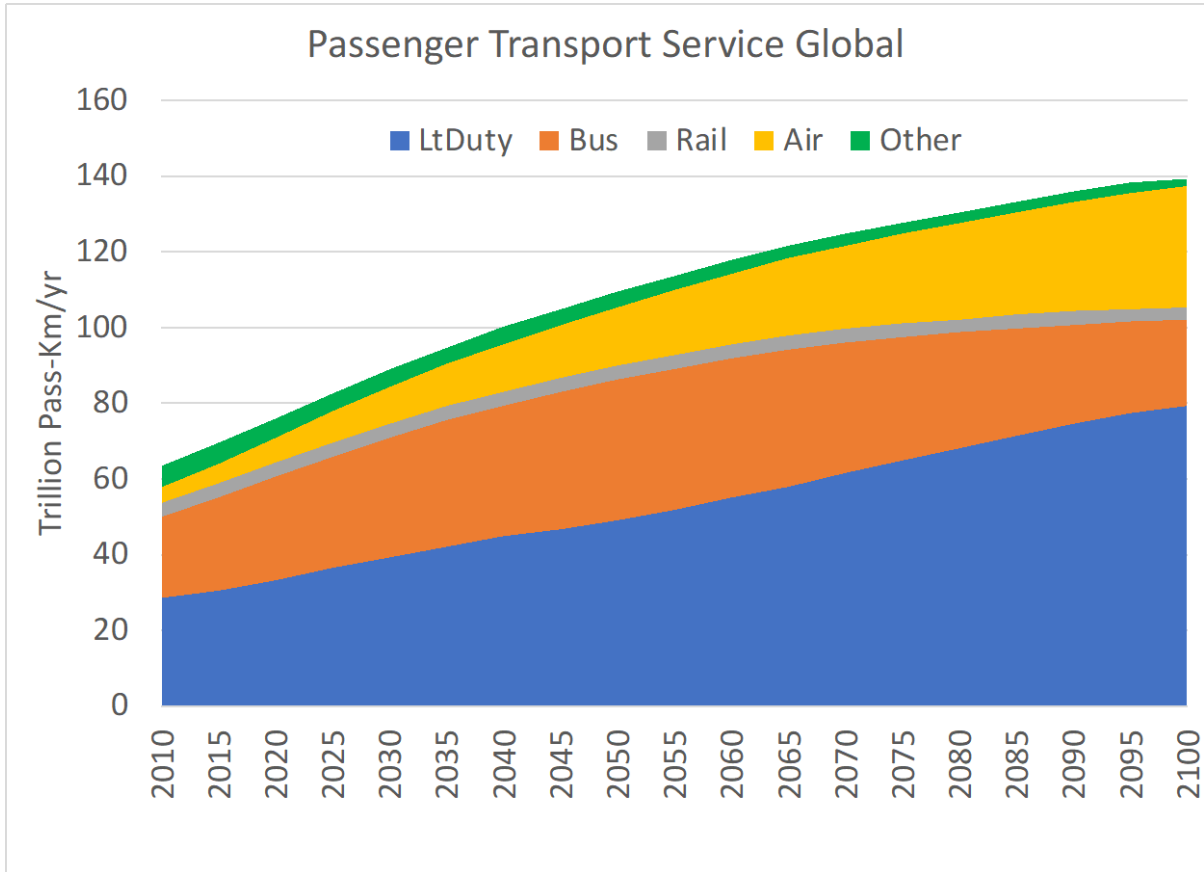
Final Energy by Sector GCAM-SSP2



Transport Fuels: GCAM SSP2



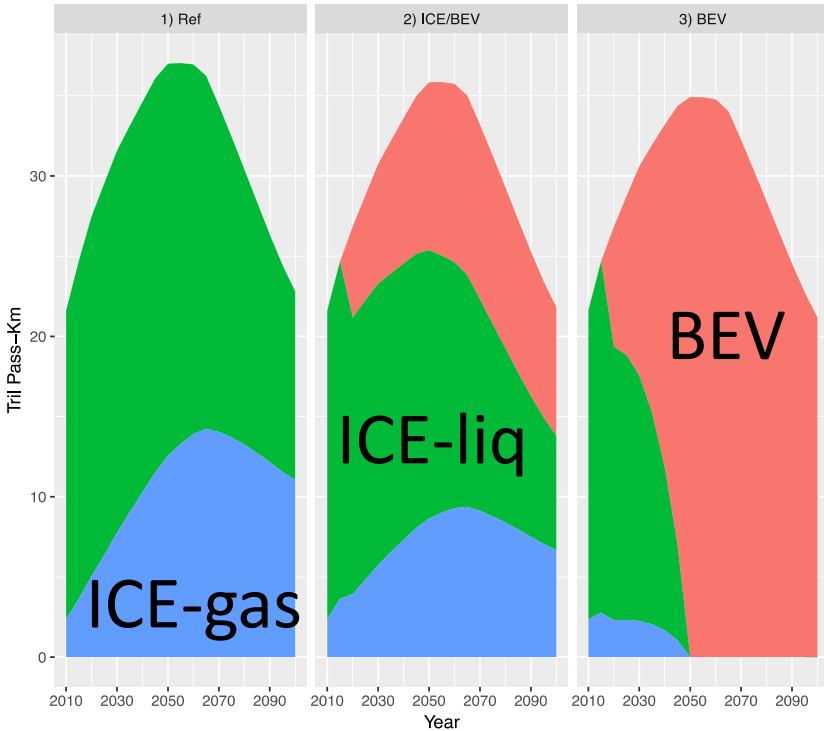
Transportation Service Global – GCAM-SSP2



Global Transport Service : No climate policy

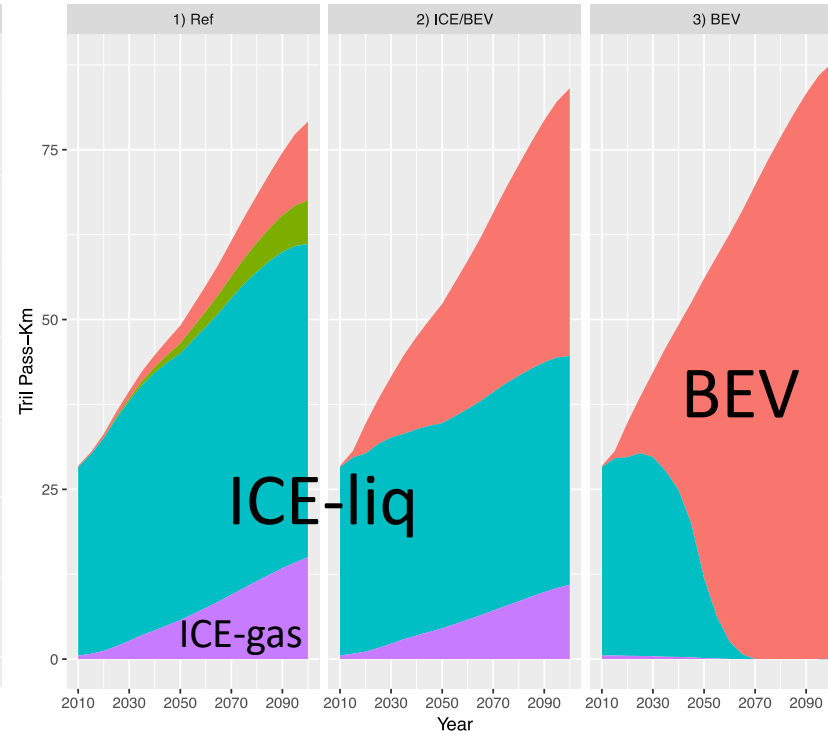
Passenger, Buses

Passenger Bus Service – Ref (no plcy)



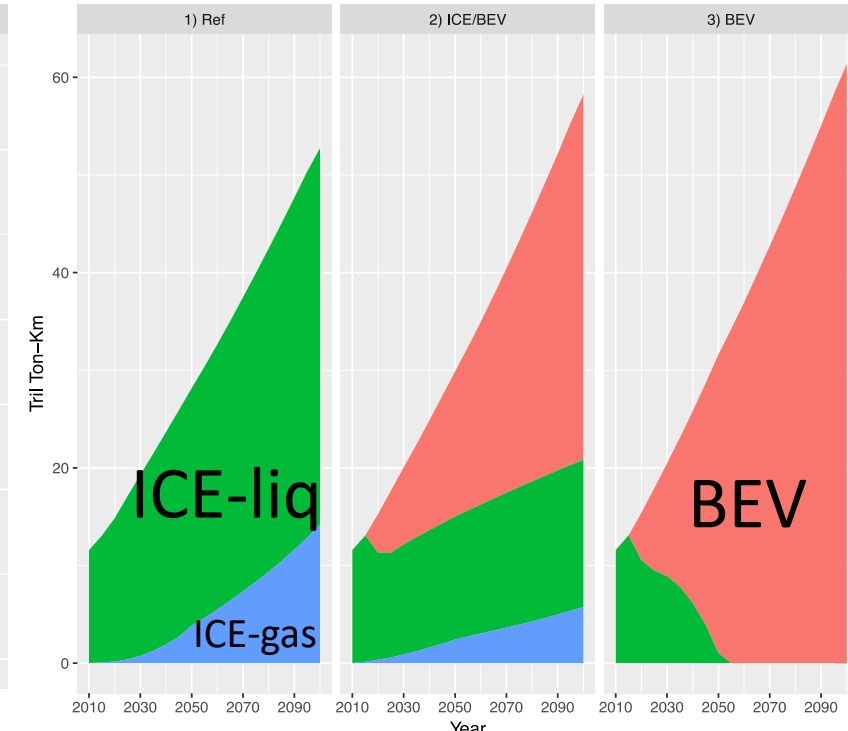
Passenger, LDV

Passenger Lt-Duty Service – Ref (no plcy)



Freight, Truck

Freight Truck Service – Ref (no plcy)

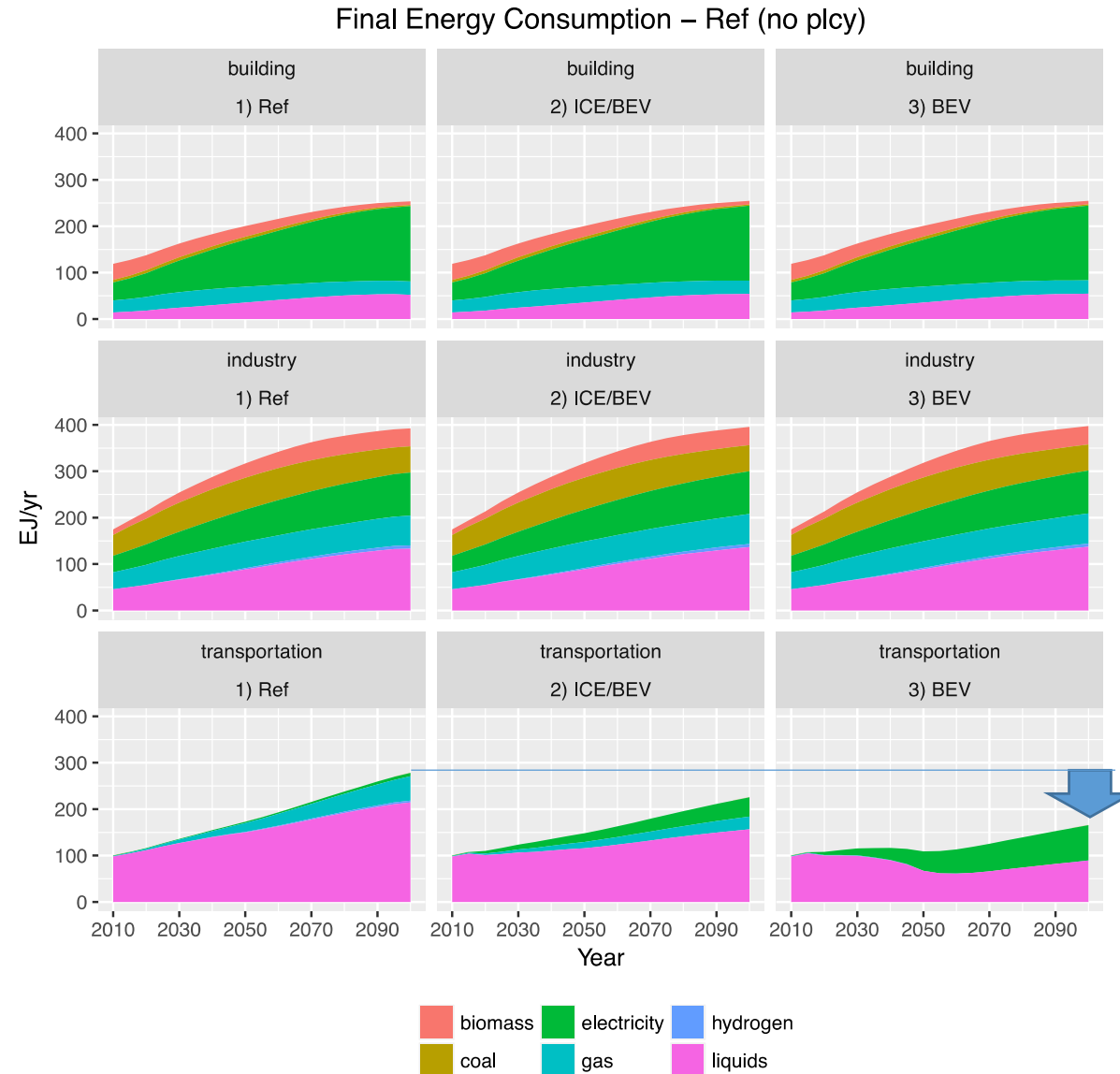


BEV ICE-liq ICE-ngas

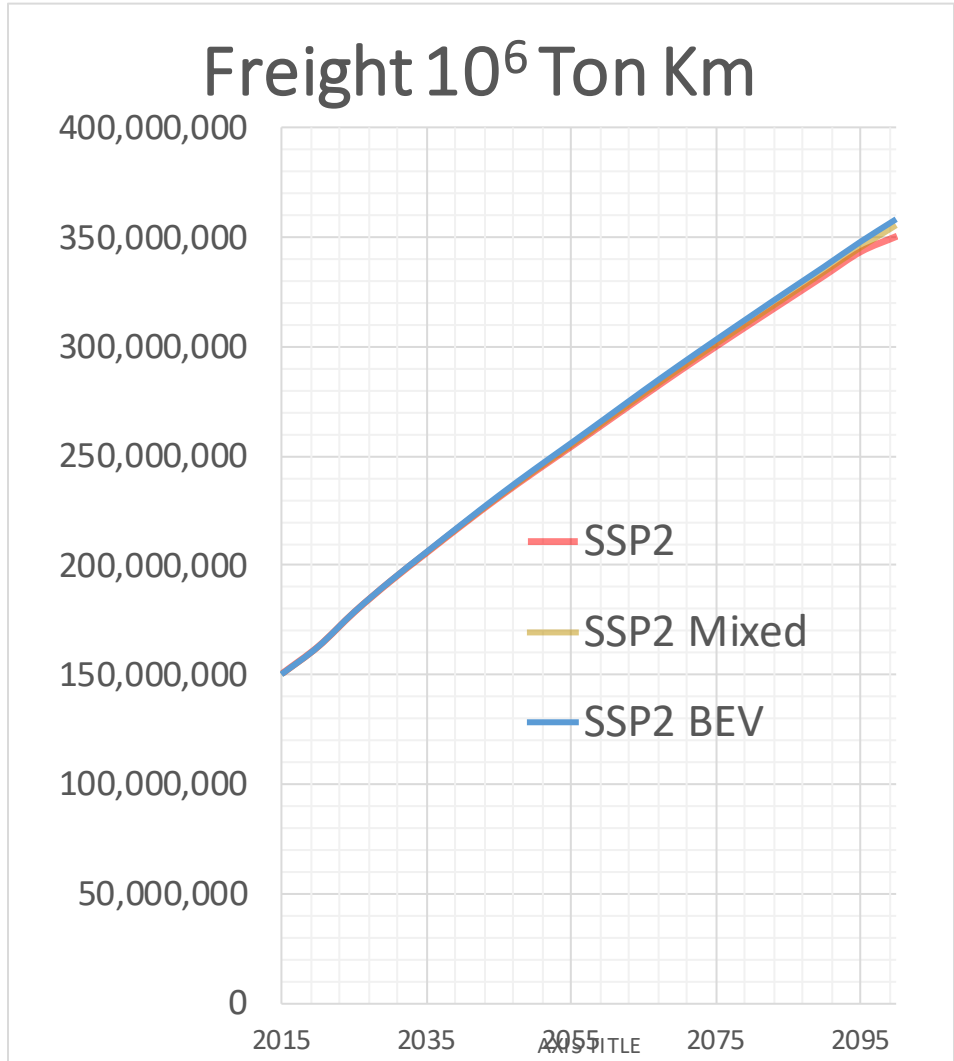
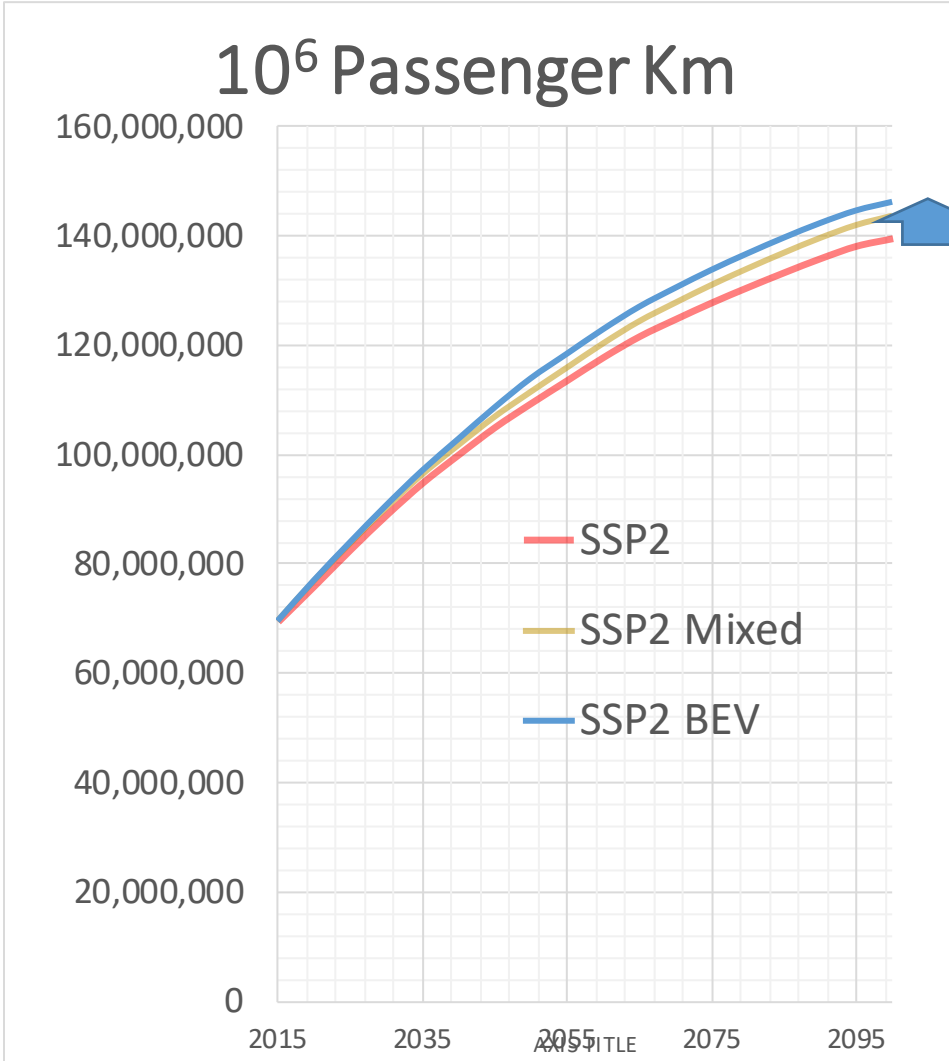
BEV FCEV ICE-liq ICE-ngas

BEV ICE-liq ICE-ngas

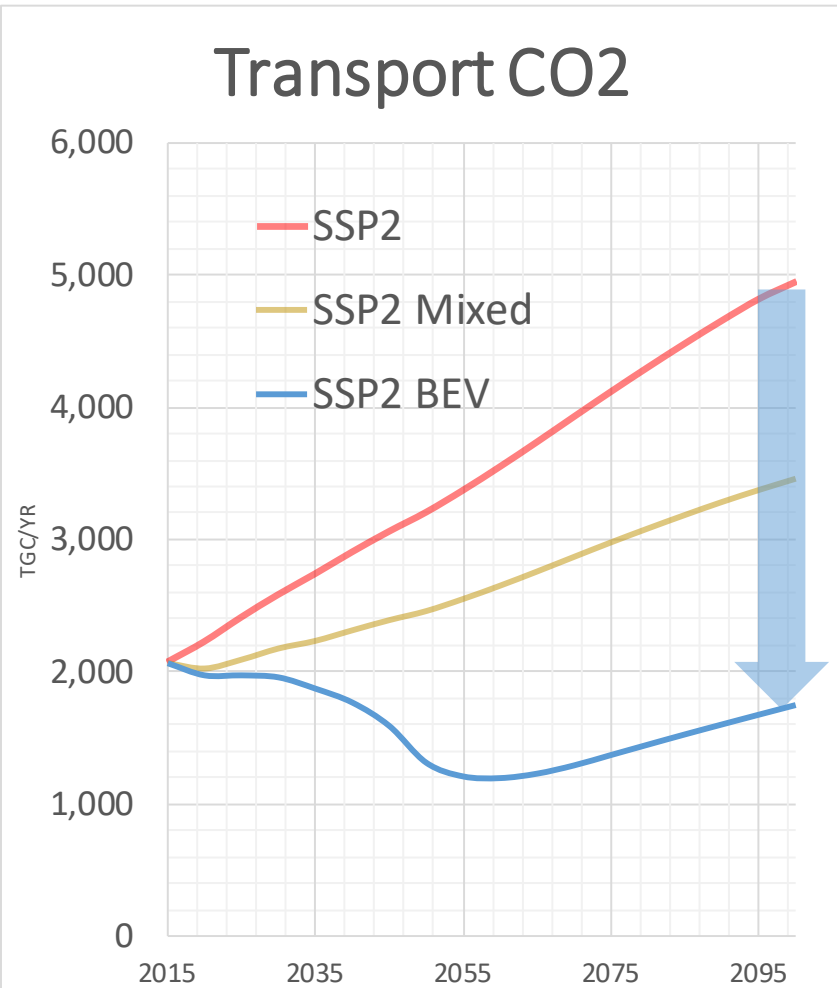
Final Energy Consumption –no climate policy



Transportation Services

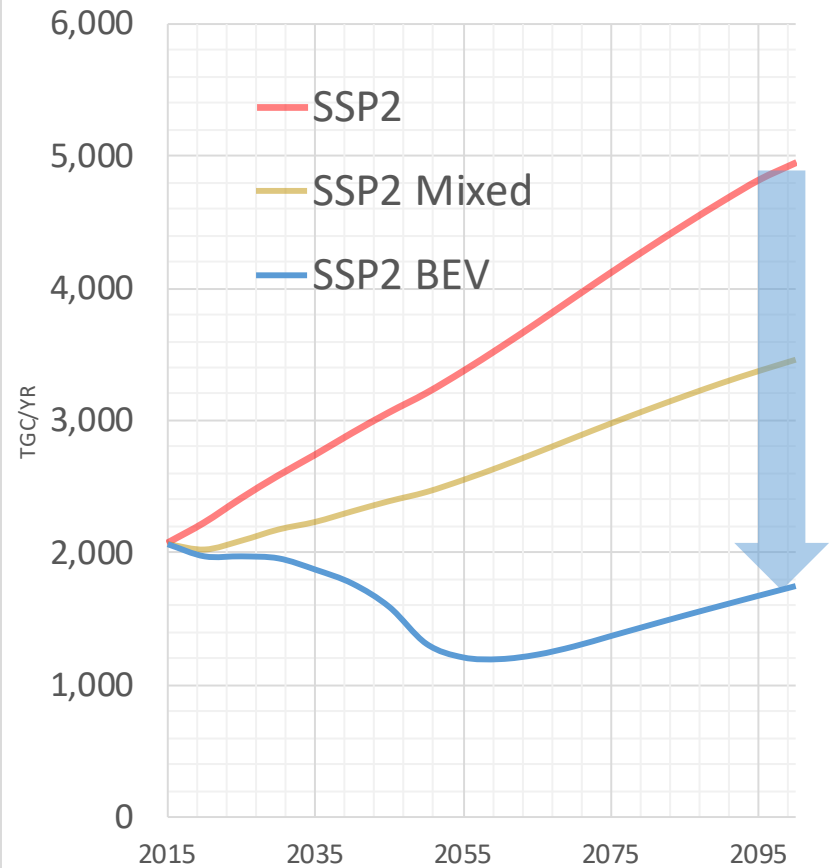


Global Transport and Power CO2

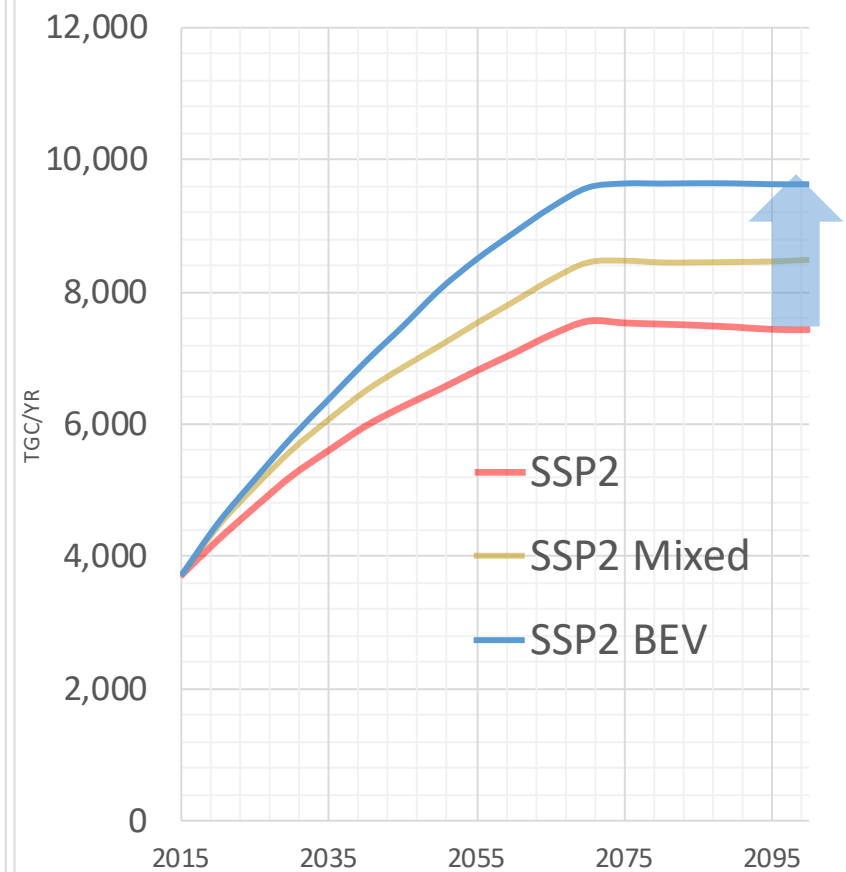


Global Transport and Power CO2

Transport CO2

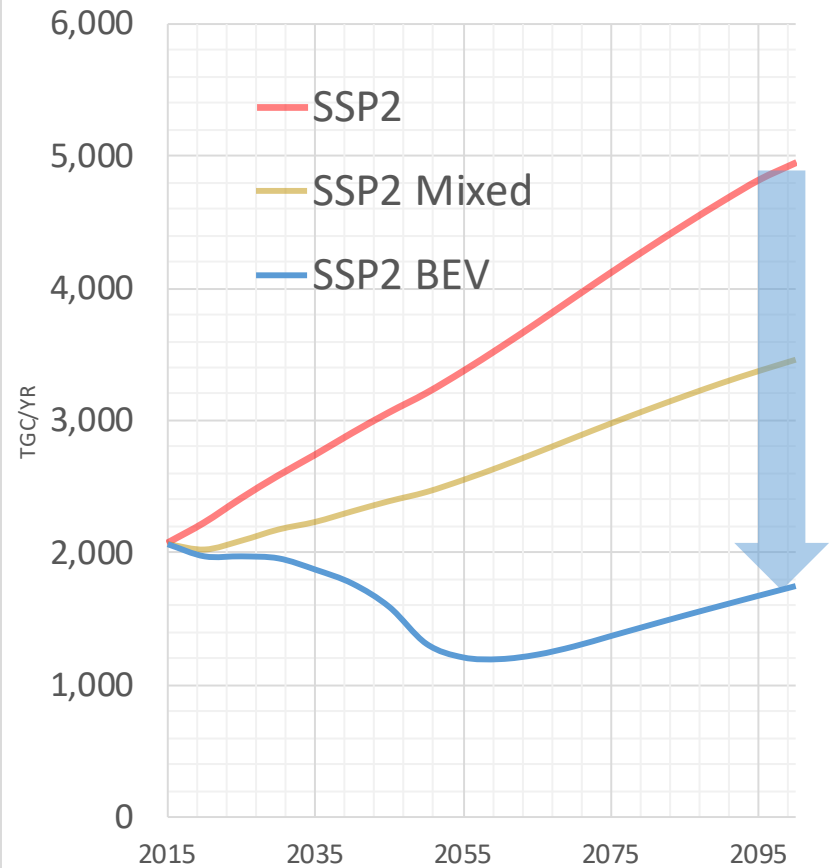


Power Sector CO2

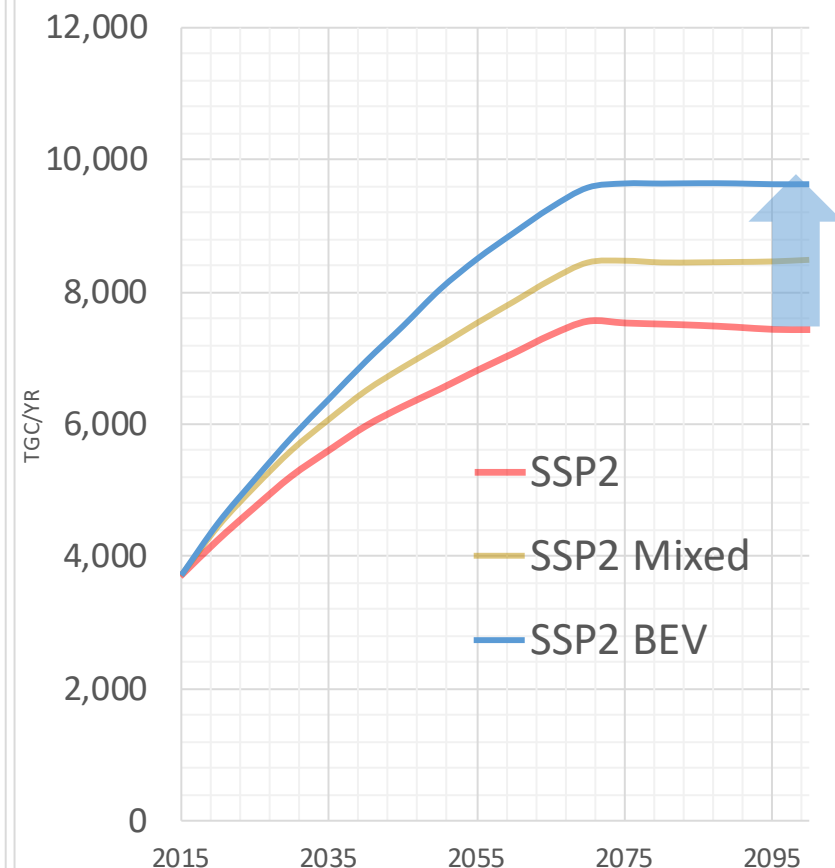


Global Transport and Power CO2

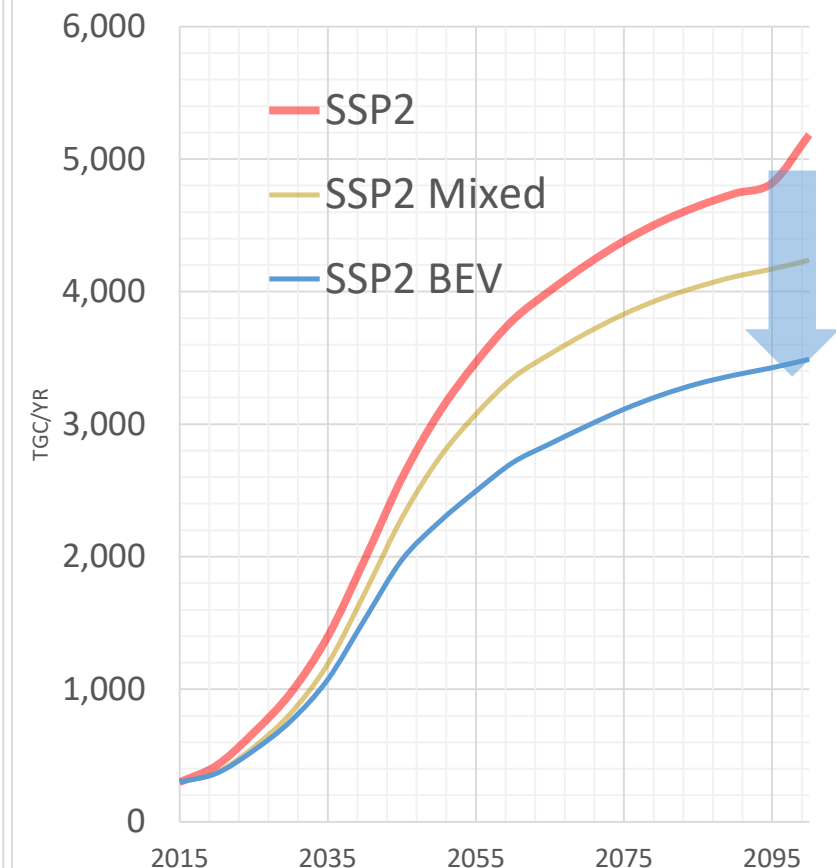
Transport CO2



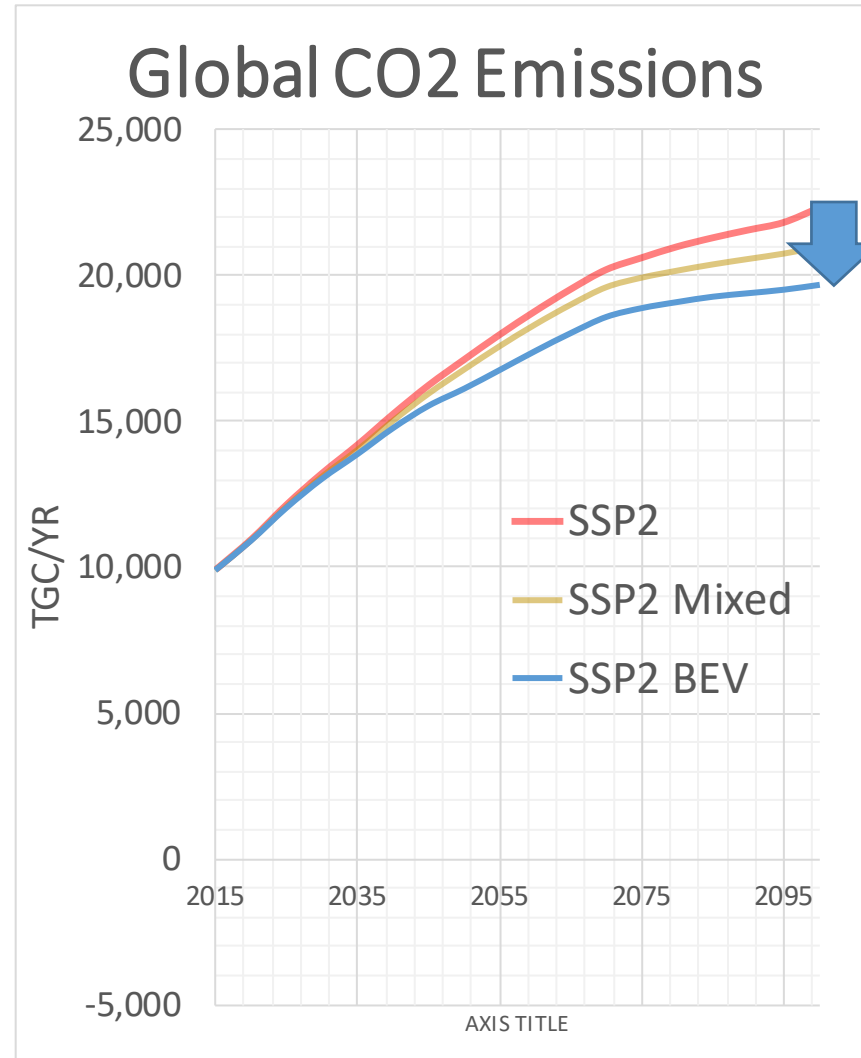
Power Sector CO2



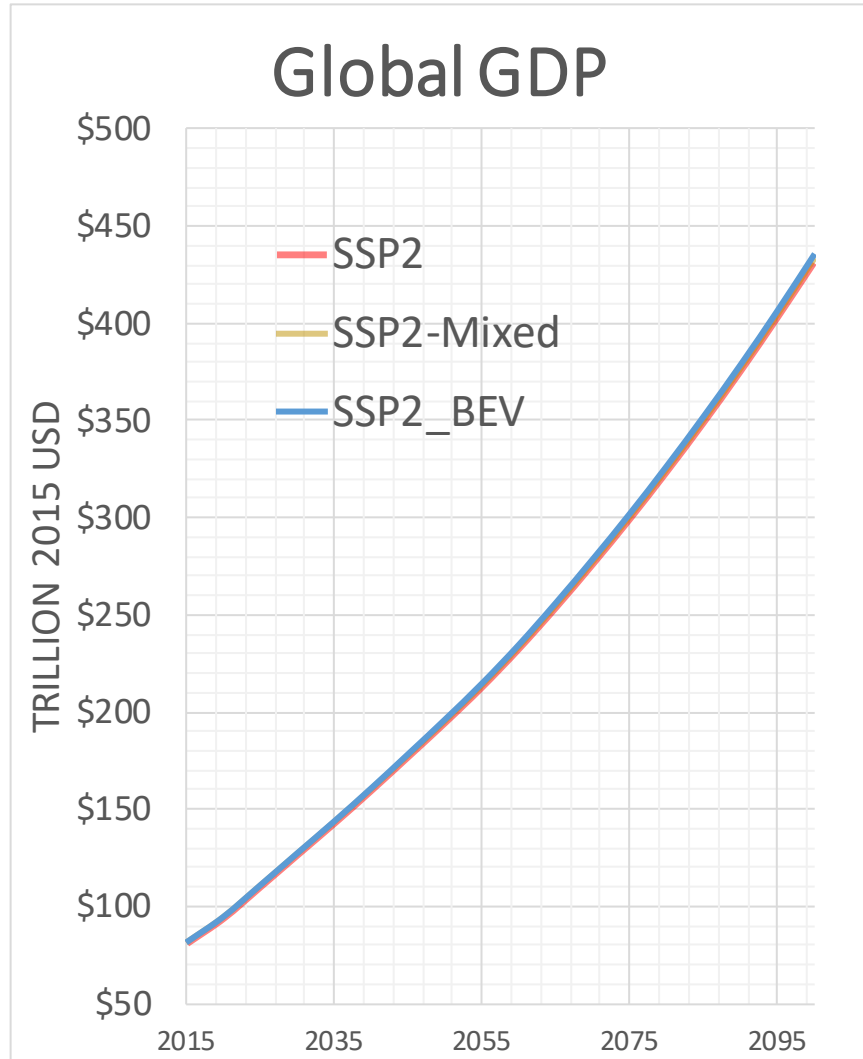
Refining CO2



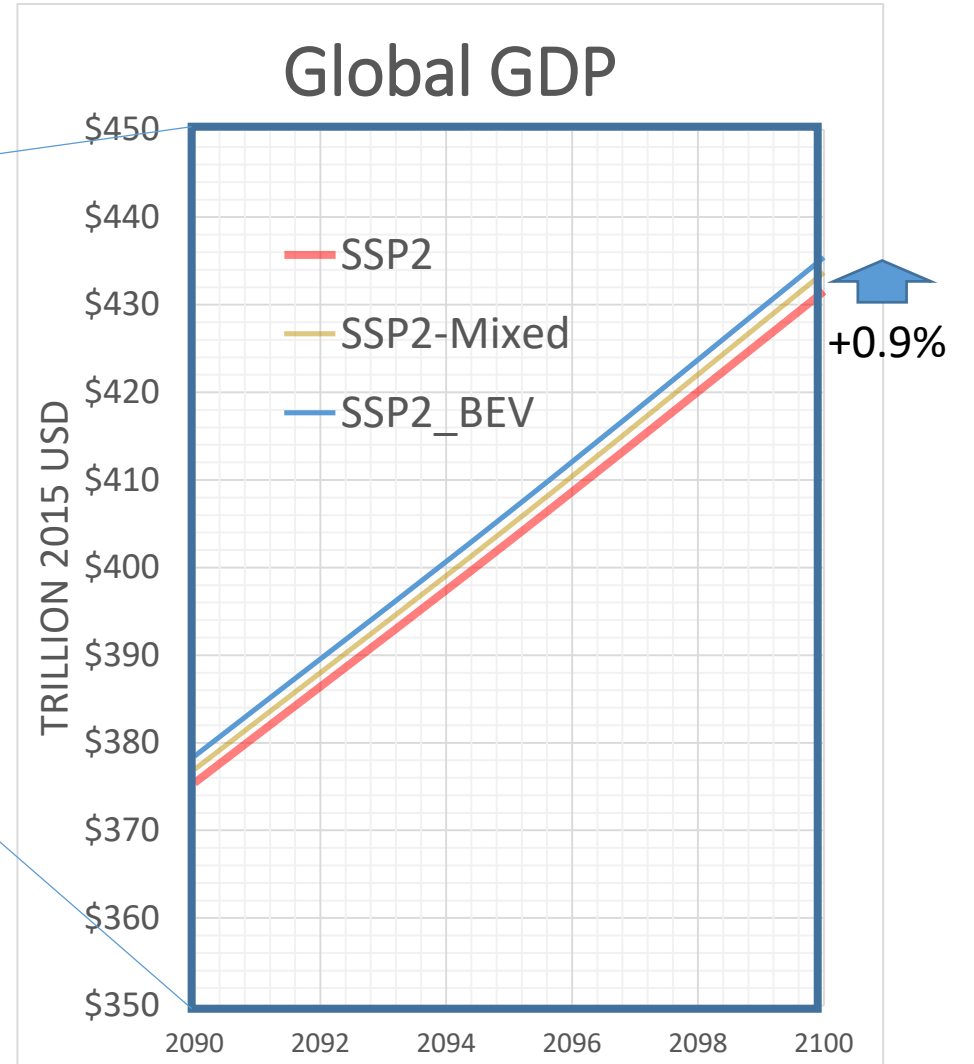
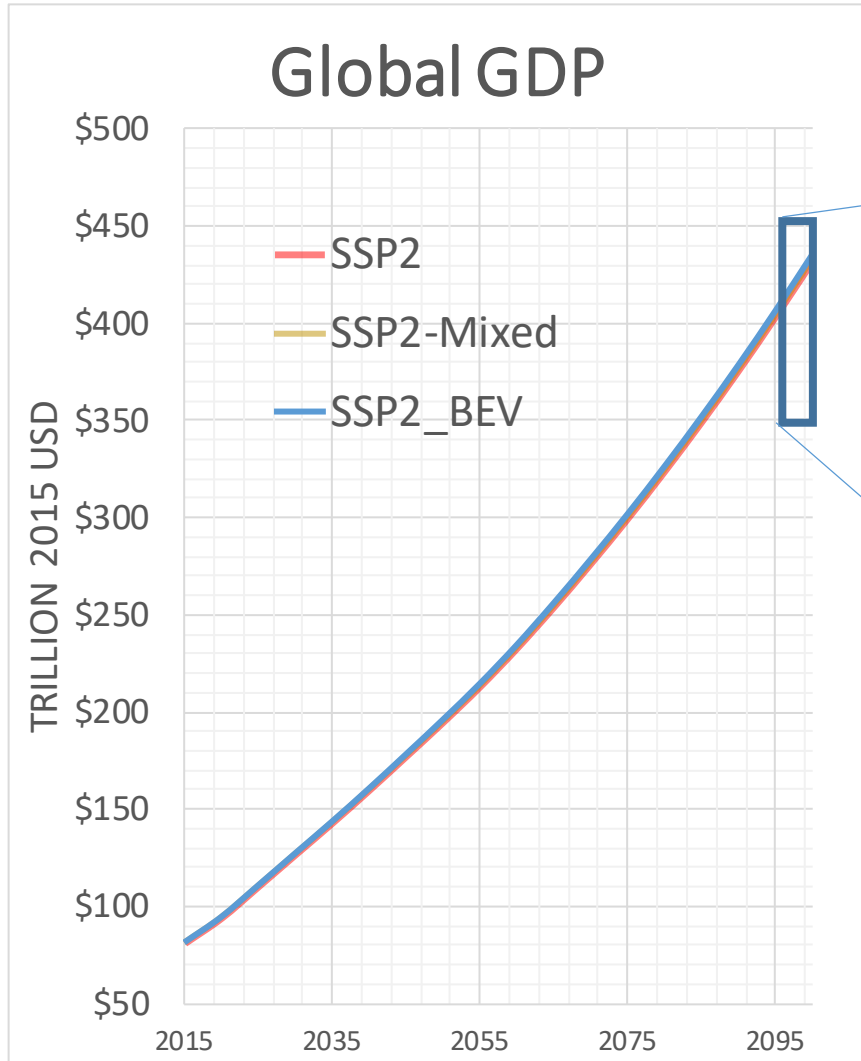
Effect of improvements in electric vehicles and global CO₂ emissions



GDP feedback



GDP feedback



Discussion