



System Dynamics Model for Analyzing and Measuring the Benefits of Global Earth Observation

Felicjan Rydzak and Michael Obersteiner

International Institute for Applied System Analysis

Project

- European Community's Sixth Framework Programme – “Global Earth Observation – Benefit Estimation: Now, Next and Emerging” (GEOBENE)
- The project objectives: develop *methodologies* and *analytical tools* to *assess societal benefits of GEO* in the domains of: Disasters, Health, Energy, Climate, Water, Weather, Ecosystems, Agriculture and Biodiversity.



Health



Climate



Weather



Agriculture



Disasters



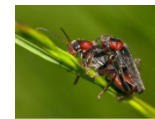
Energy



Water

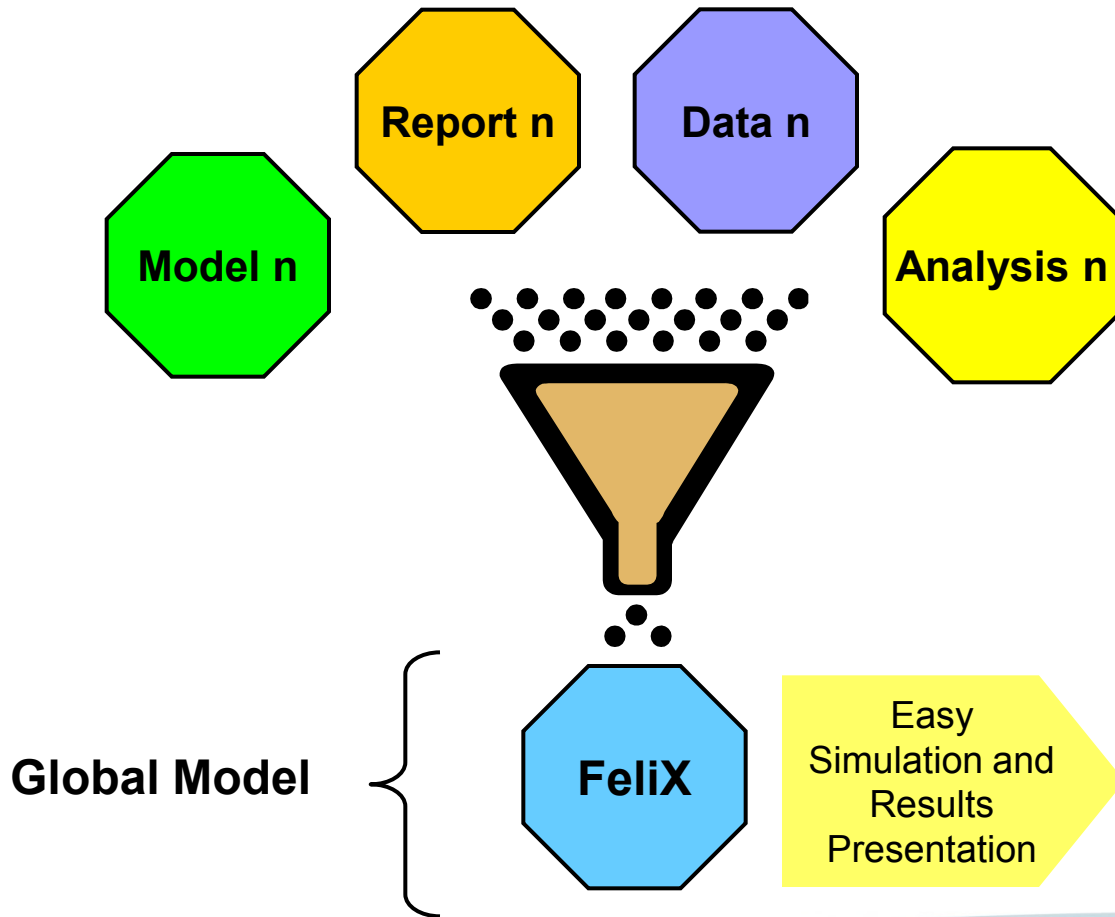


Ecosystem

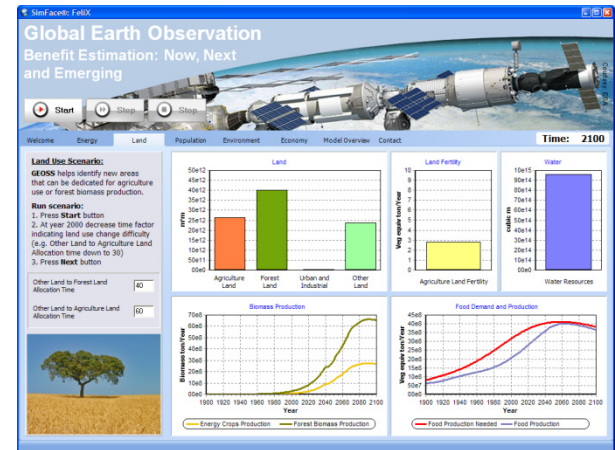


Biodiversity

Integration and benefits measurement

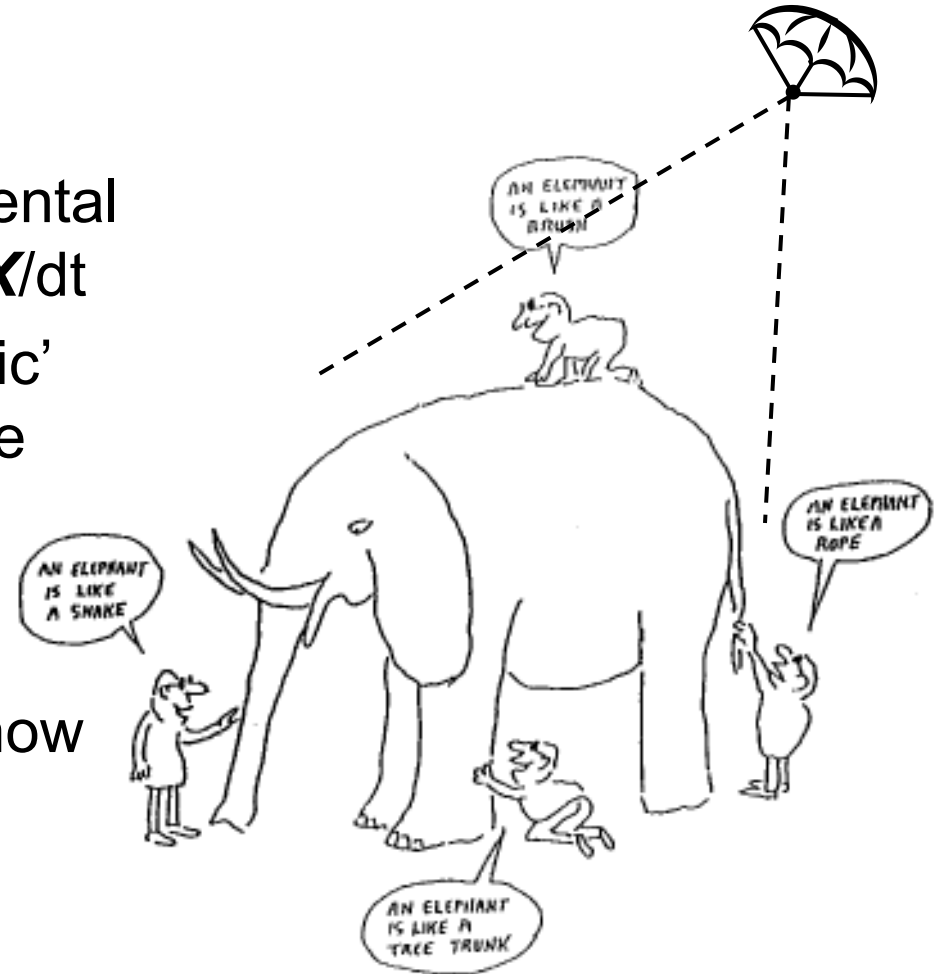


GEO-BENE studies in particular SBAs

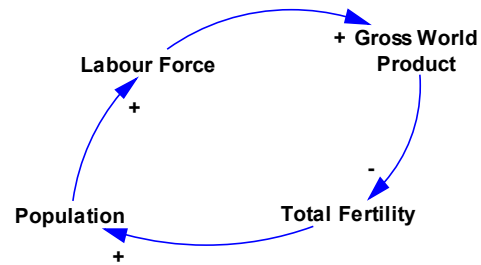


FeliX

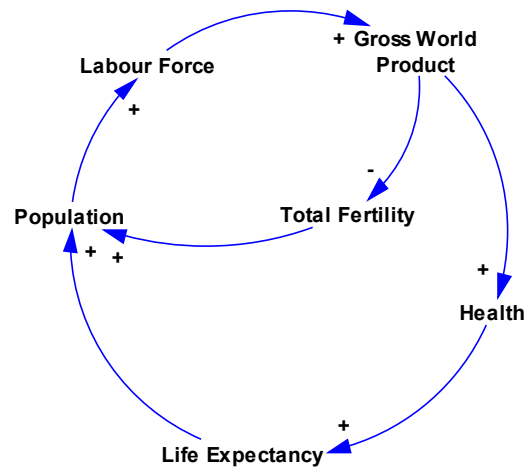
- Full of **Economic-Environmental Linkages** and **Integration dX/dt**
- Global model trying to ‘mimic’ the whole system (the whole ‘elephant’) and make it an experimental field to assess benefits of GEOSS (does GEOSS help us to get to know <and ‘socialize’> with the ‘elephant’?)
- System Dynamics model



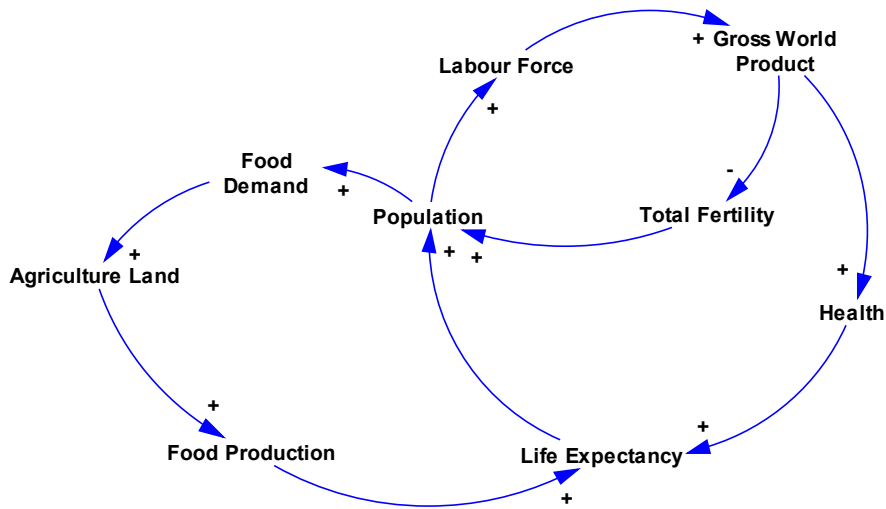
FeliX – Causal Loop Diagram



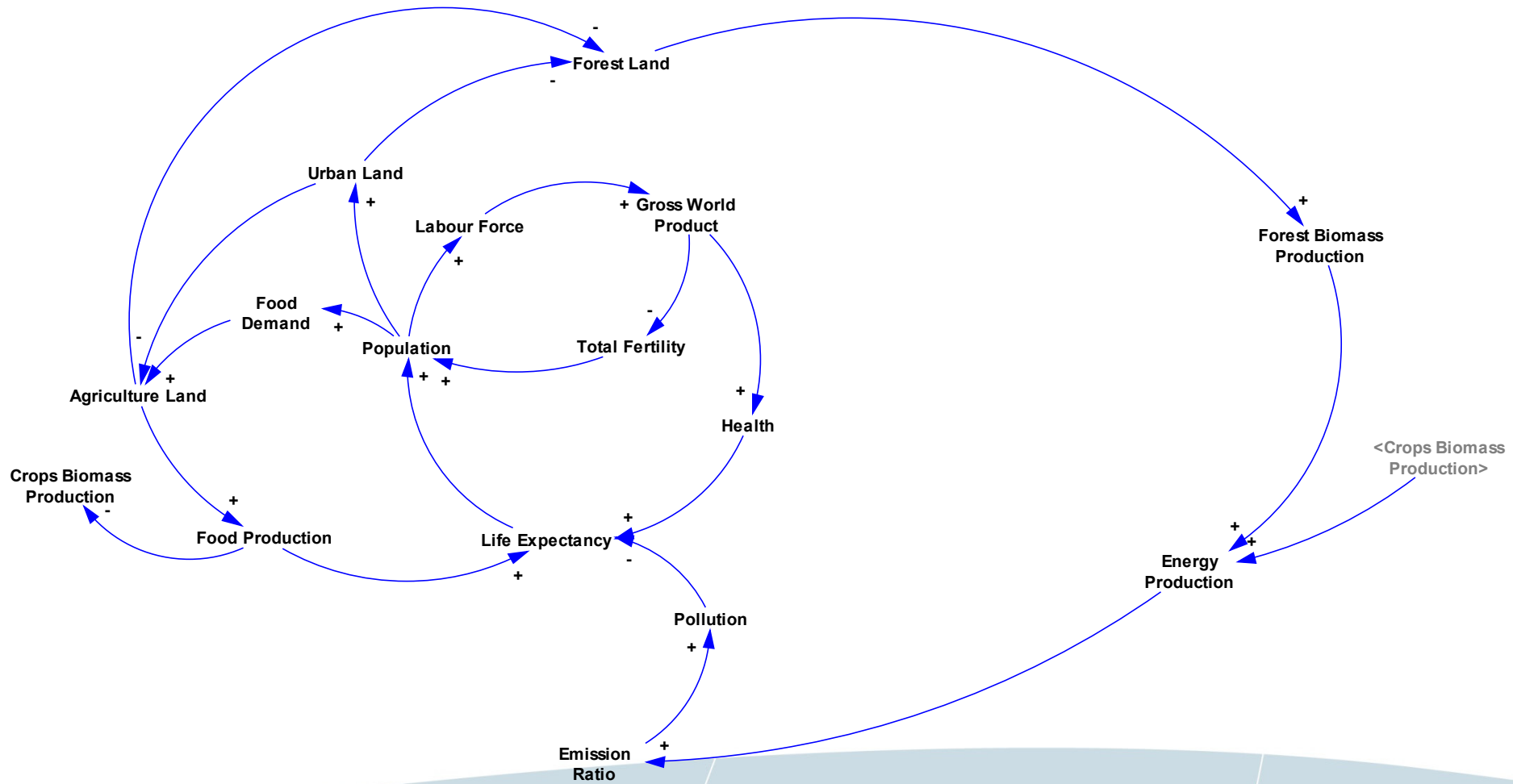
FeliX – Causal Loop Diagram



FeliX – Causal Loop Diagram



FeliX – Causal Loop Diagram



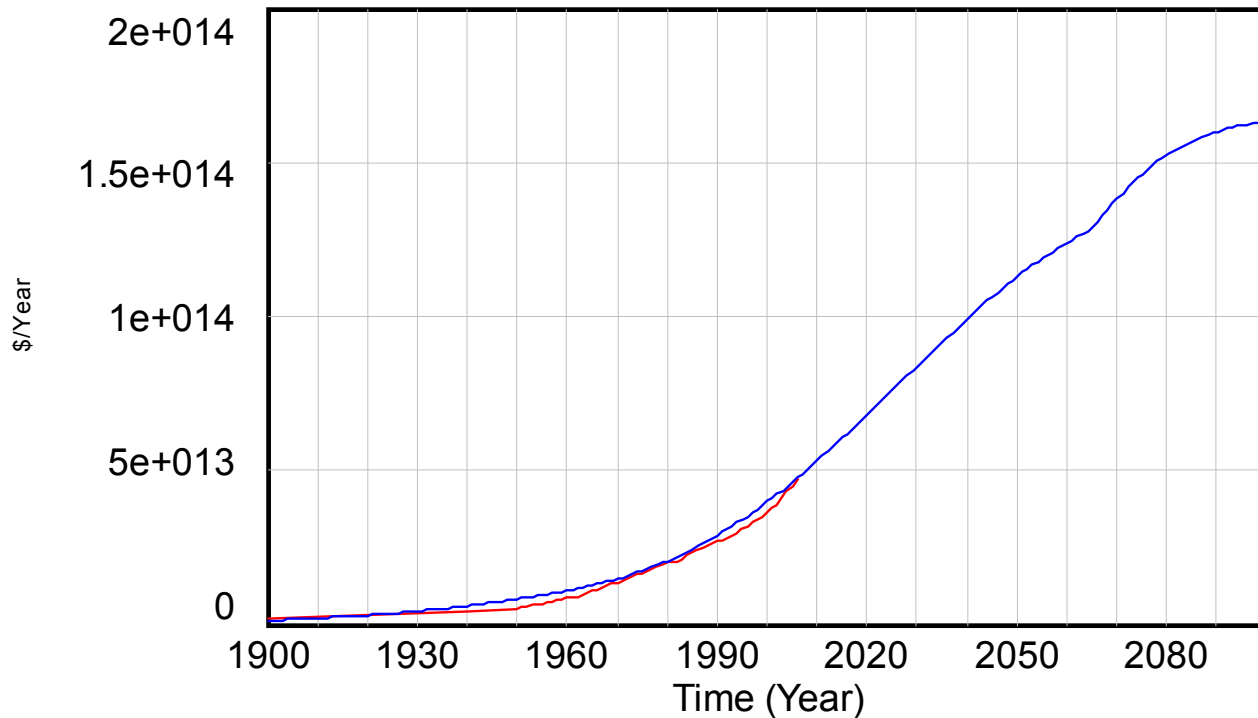
Modeling process



- Information from other models, case studies, reports
- Group Model Building sessions with SME
- Nine model sectors: Economy, Energy, CO2 Emissions, Carbon Cycle, Climate & Environment, Population, Technology, Land, Energy and the Global Earth Observation System of Systems (GEOSS)
- Social Benefits Areas (SBAs) are inherently embedded into the model structure.
- Calibration to historical data (over a period of a century – subject to data availability).

Economy Sector

- in **red** – historical data
- in **blue** – FeliX model Base Run

Gross World Product

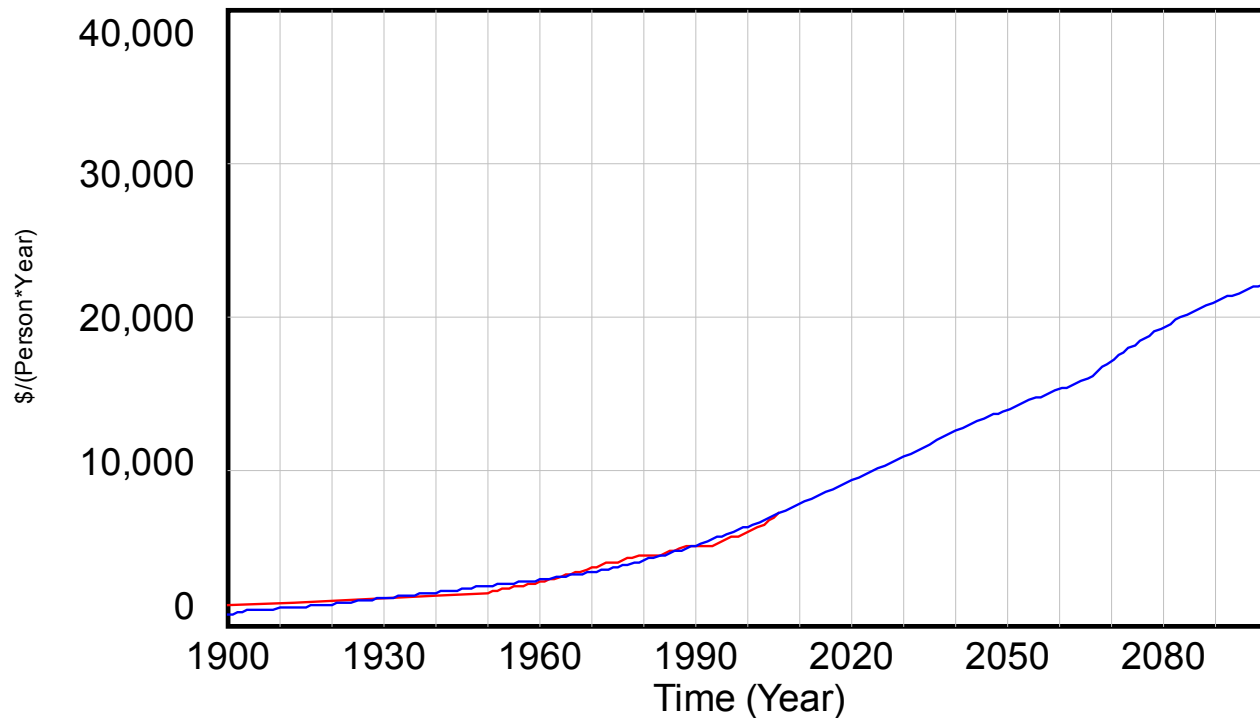


Gross World Product : Base Run 
Gross World Product : Calibration\2009_03_09_Calibration 

Economy Sector

GWP per Capita

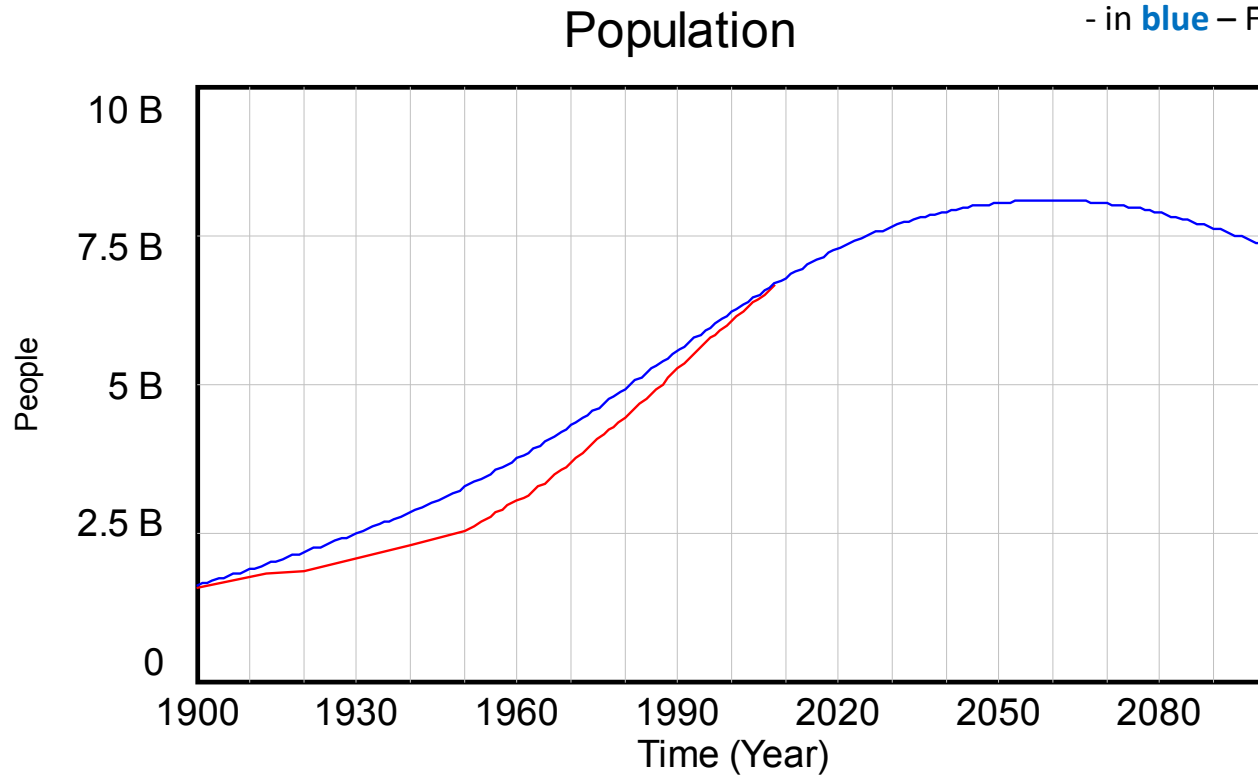
- in **red** – historical data
- in **blue** – FeliX model Base Run



GWP per Capita : Base Run —————
 GWP per Capita : Calibration\2009_03_09_Calibration —————

Population Sector

- in **red** – historical data
- in **blue** – FeliX model Base Run

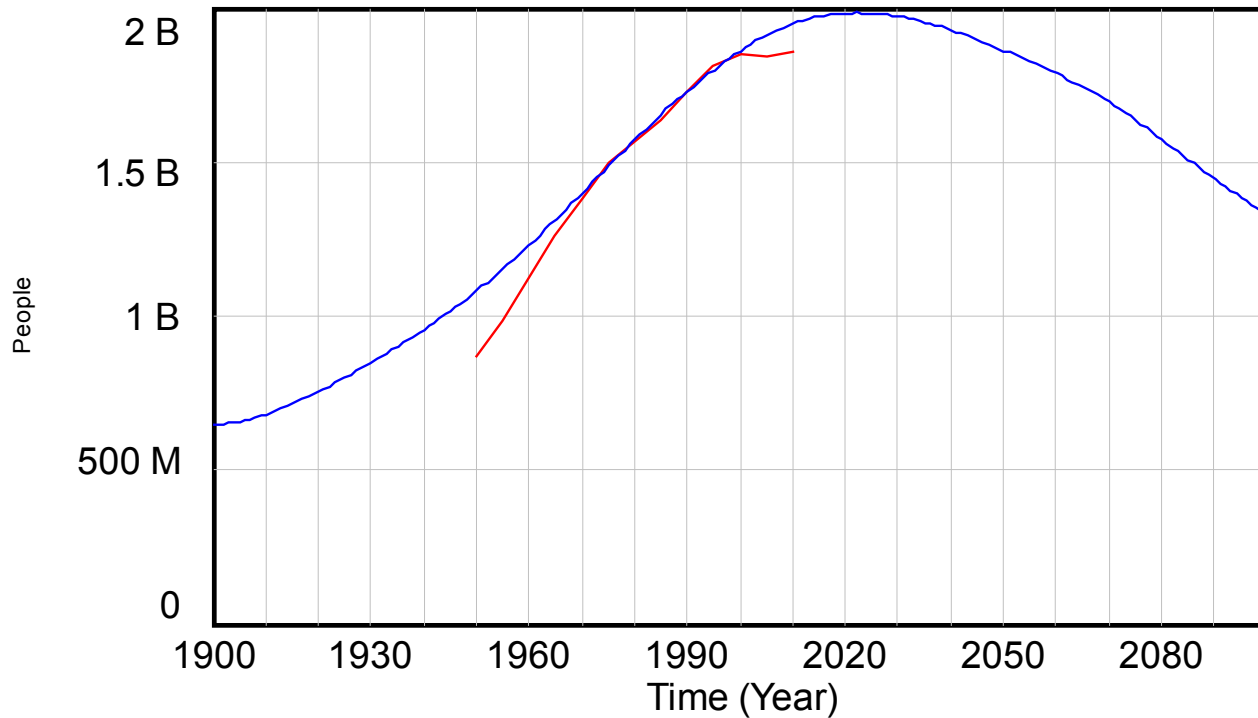


Population : Base Run —————
 Population : Calibration\2009_03_09_Calibration —————

Population Sector

- in **red** – historical data
- in **blue** – FeliX model Base Run

Population 0 to 14

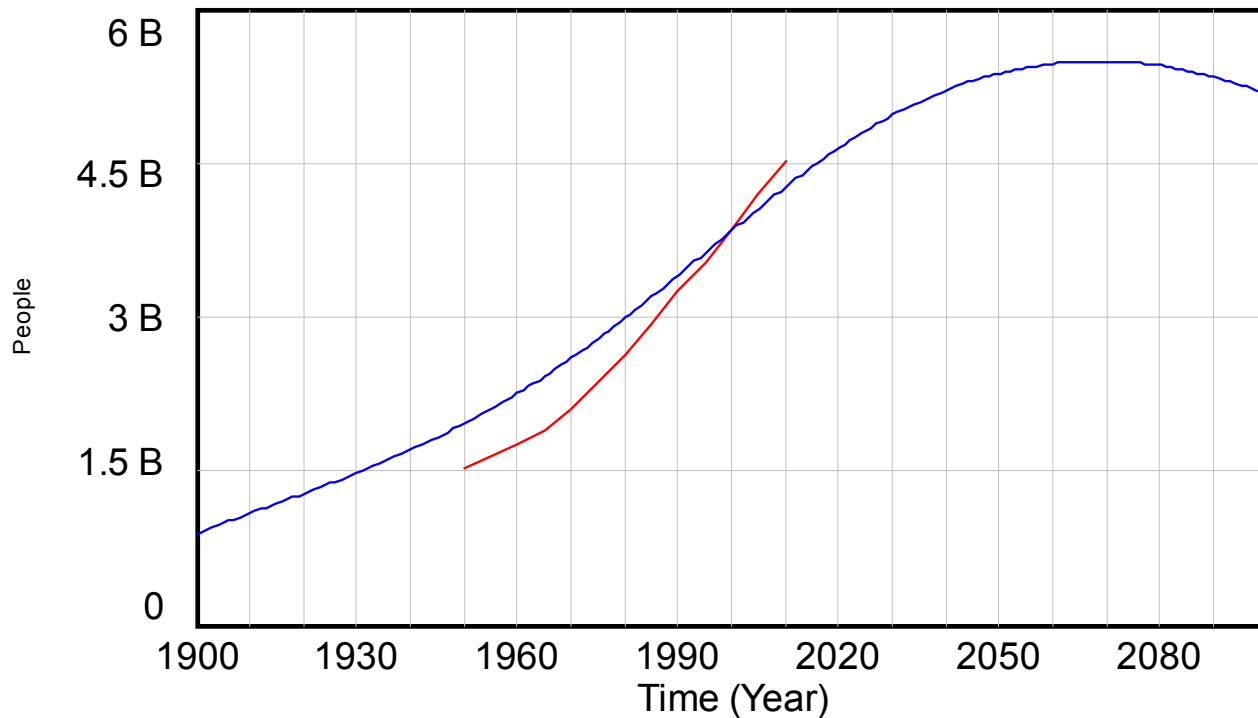




Population 0 to 14 : Base Run —————
 Population 0 to 14 : Calibration\2009_03_09_Calibration —————

Population Sector

Population 15 to 64

- in **red** – historical data
- in **blue** – FeliX model Base Run

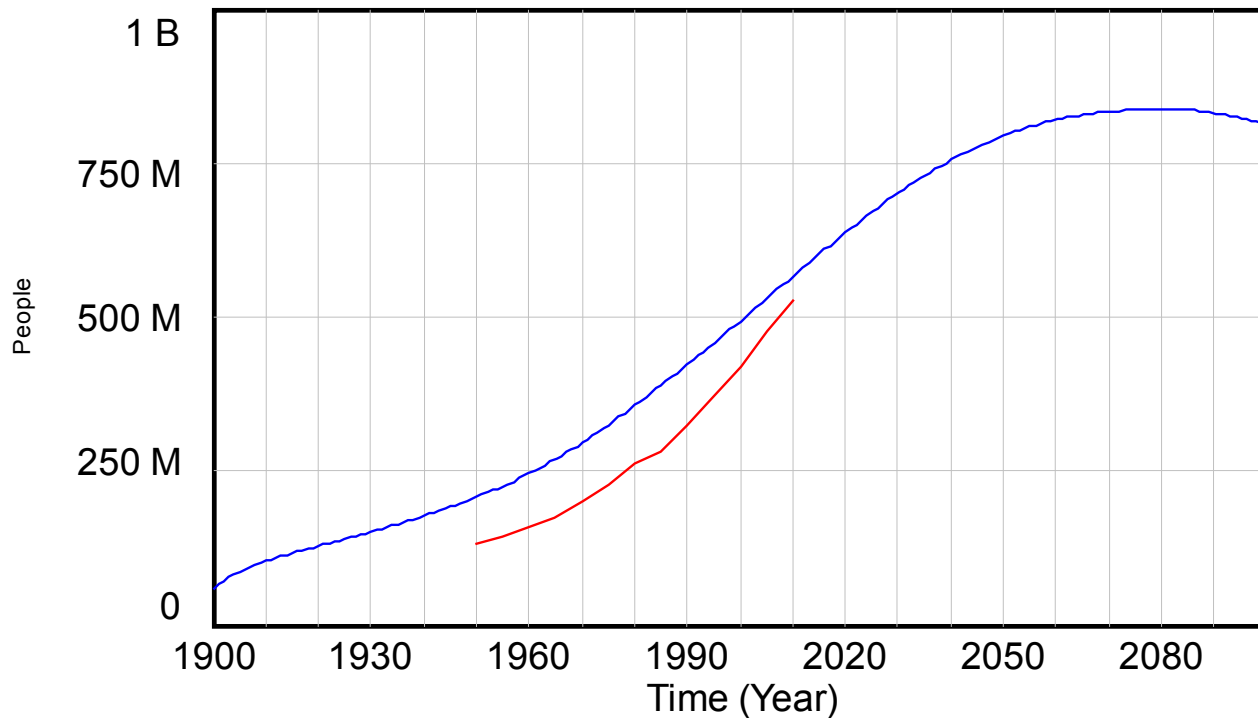


Population 15 to 64 : Base Run 
Population 15 to 64 : Calibration\2009_03_09_Calibration 

Population Sector

Population 65 Plus

- in **red** – historical data
- in **blue** – FeliX model Base Run

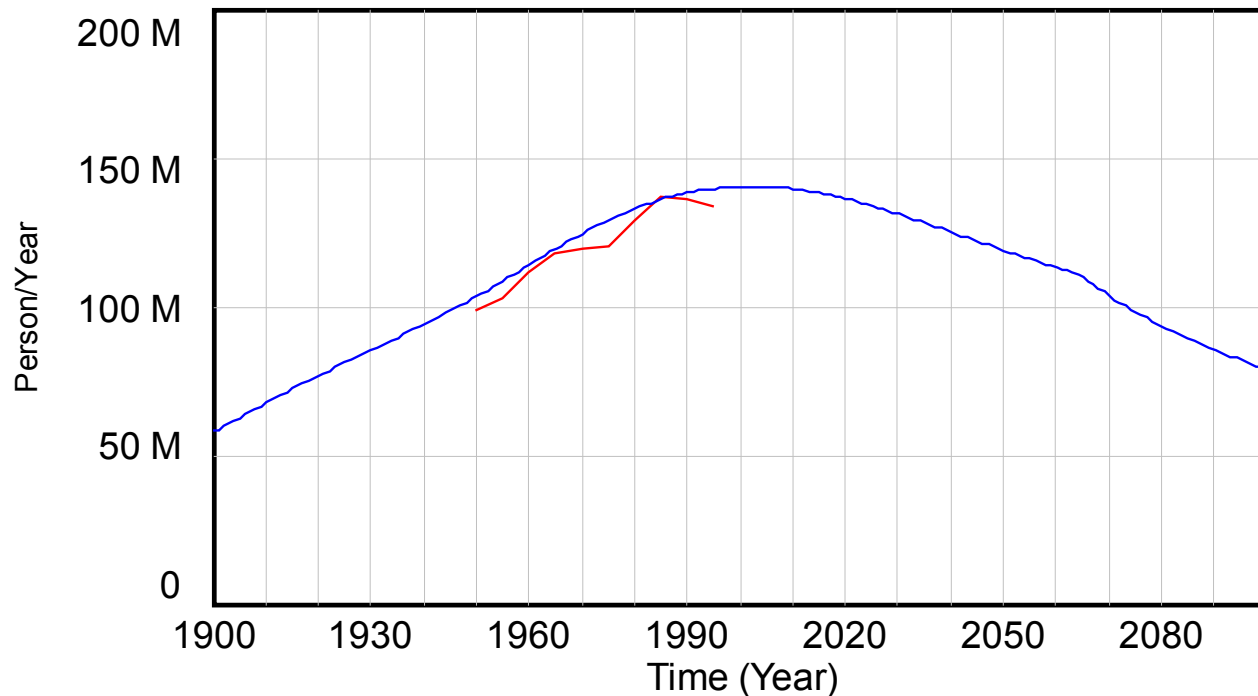


Population 65 Plus : Base Run —————
 Population 65 Plus : Calibration\2009_03_09_Calibration —————

Population Sector

- in **red** – historical data
- in **blue** – FeliX model Base Run

Births Rate

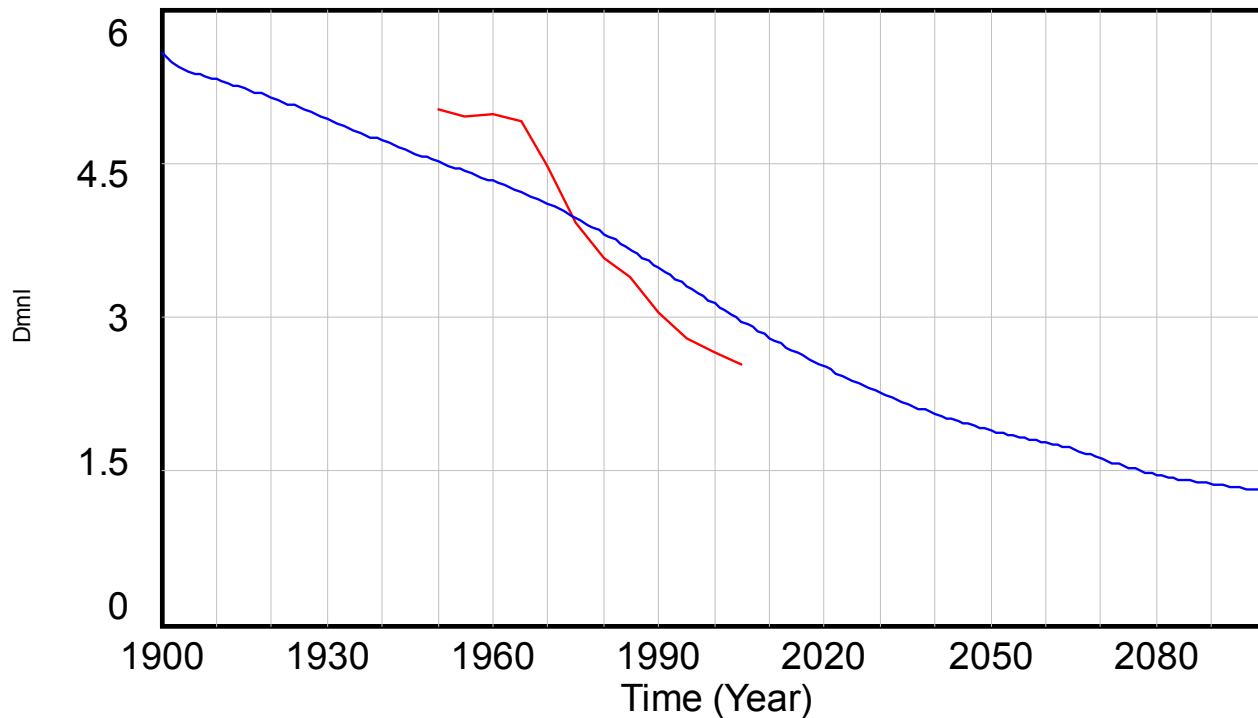


Births Rate : Base Run —————
 Births Rate : Calibration\2009_03_09_Calibration —————

Population Sector

Total Fertility

- in **red** – historical data
- in **blue** – FeliX model Base Run

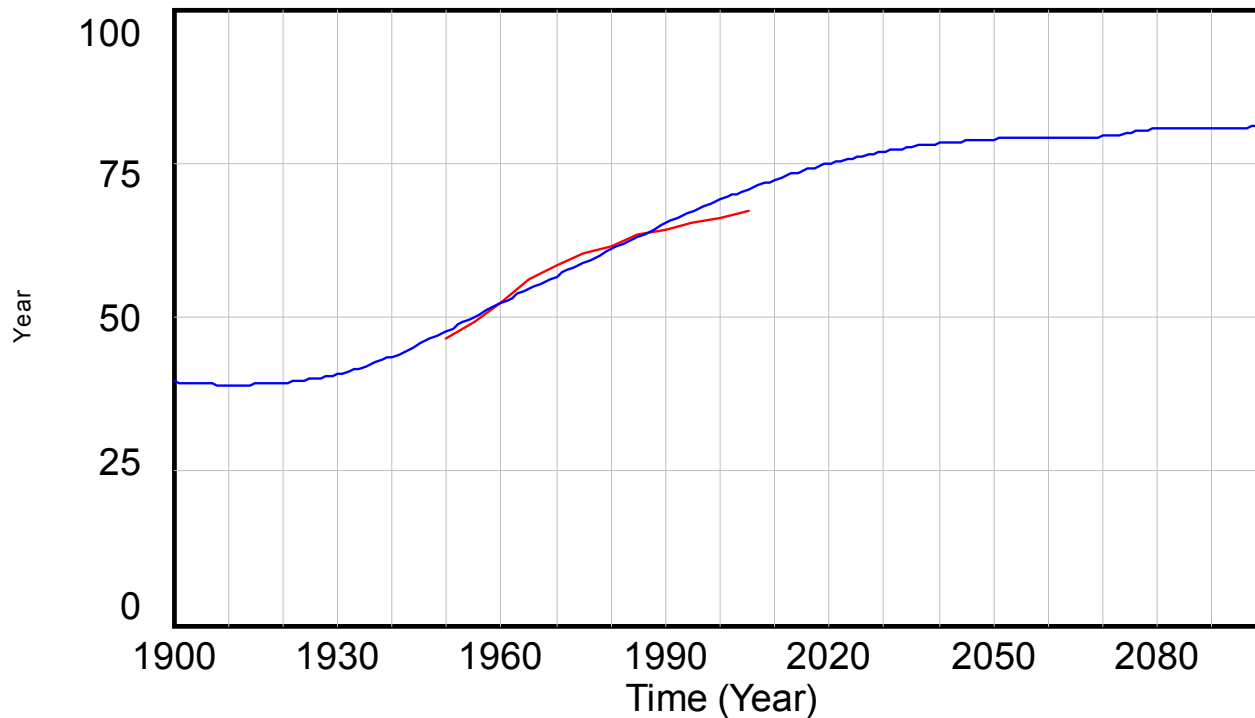


Total Fertility : Base Run —————
 Total Fertility : Calibration\2009_03_09_Calibration —————

Population Sector

Life Expectancy

- in **red** – historical data
- in **blue** – FeliX model Base Run



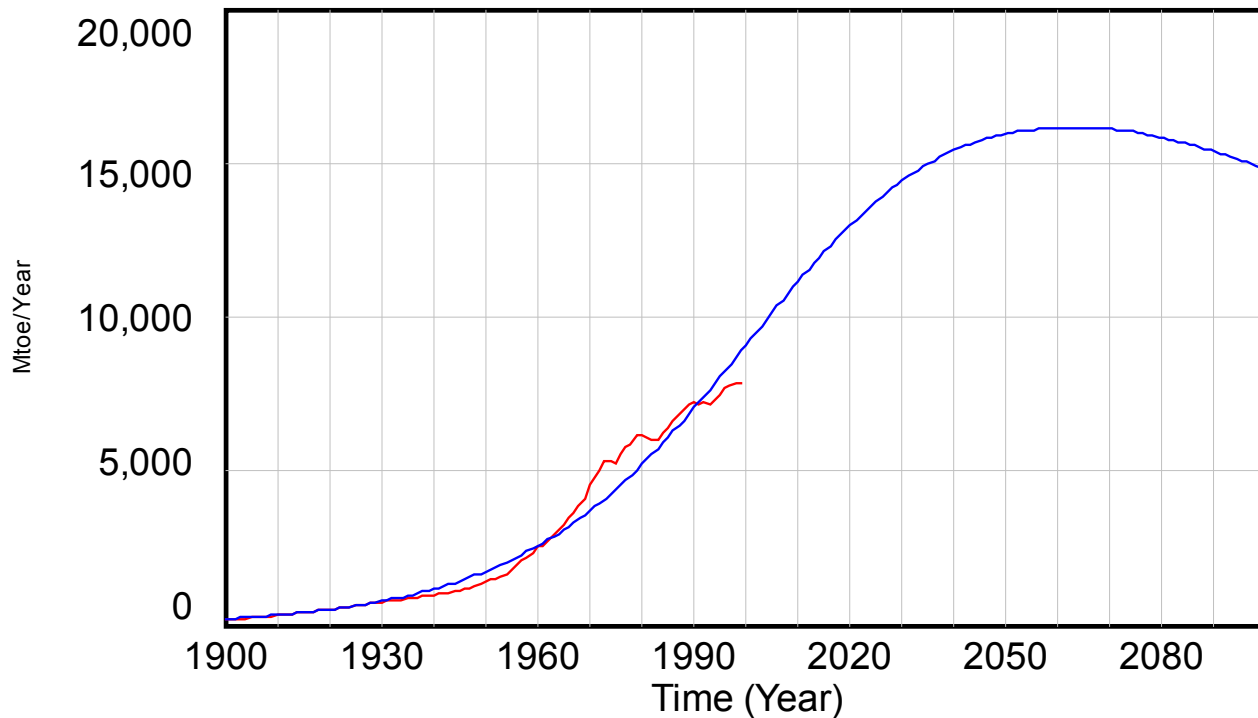
Life Expectancy : Base Run

Life Expectancy : Calibration\2009_03_09_Calibration

Energy Sector

Energy Demand

- in **red** – historical data
- in **blue** – Felix model Base Run

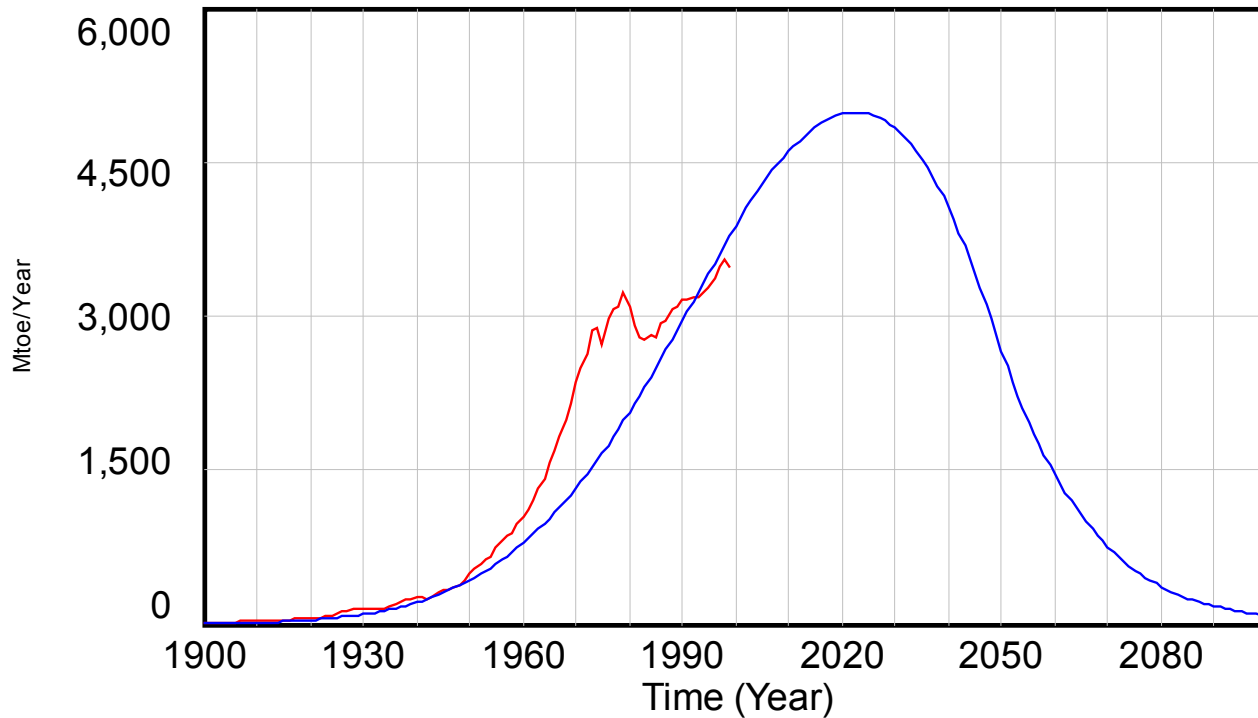


Energy Demand : Base Run —————
 Energy Demand : Calibration\2009_03_09_Calibration —————

Energy Sector

- in **red** – historical data
- in **blue** – FeliX model Base Run

Oil Production

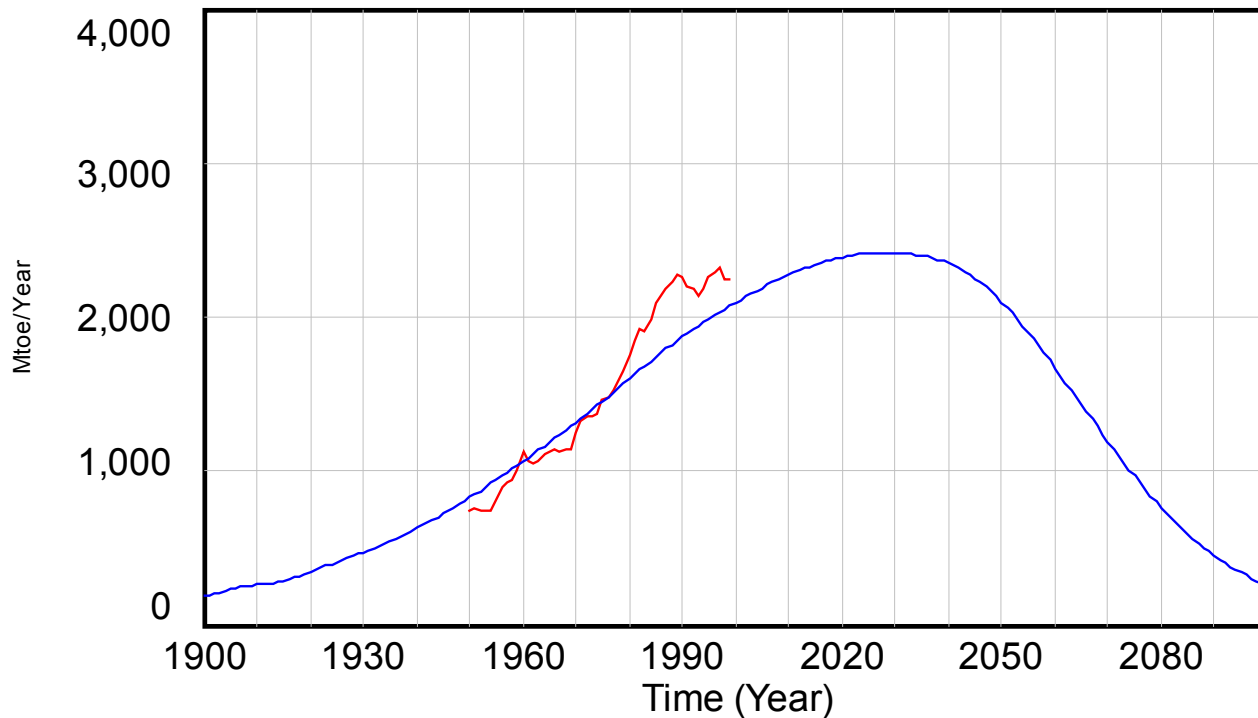


Oil Production : Base Run 
Oil Production : Calibration\2009_03_09_Calibration 

Energy Sector

Coal Production

- in **red** – historical data
- in **blue** – FeliX model Base Run

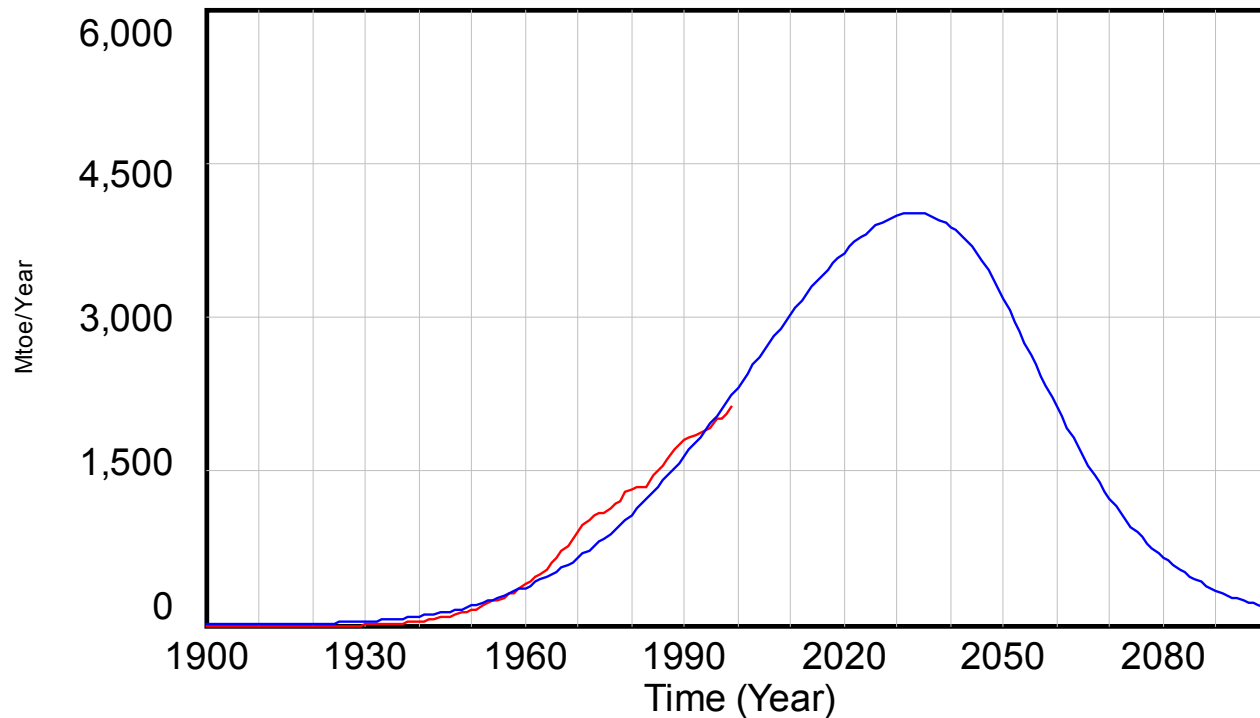


Coal Production : Base Run —————
 Coal Production : Calibration\2009_03_09_Calibration —————

Energy Sector

Gas Production

- in **red** – historical data
- in **blue** – FeliX model Base Run



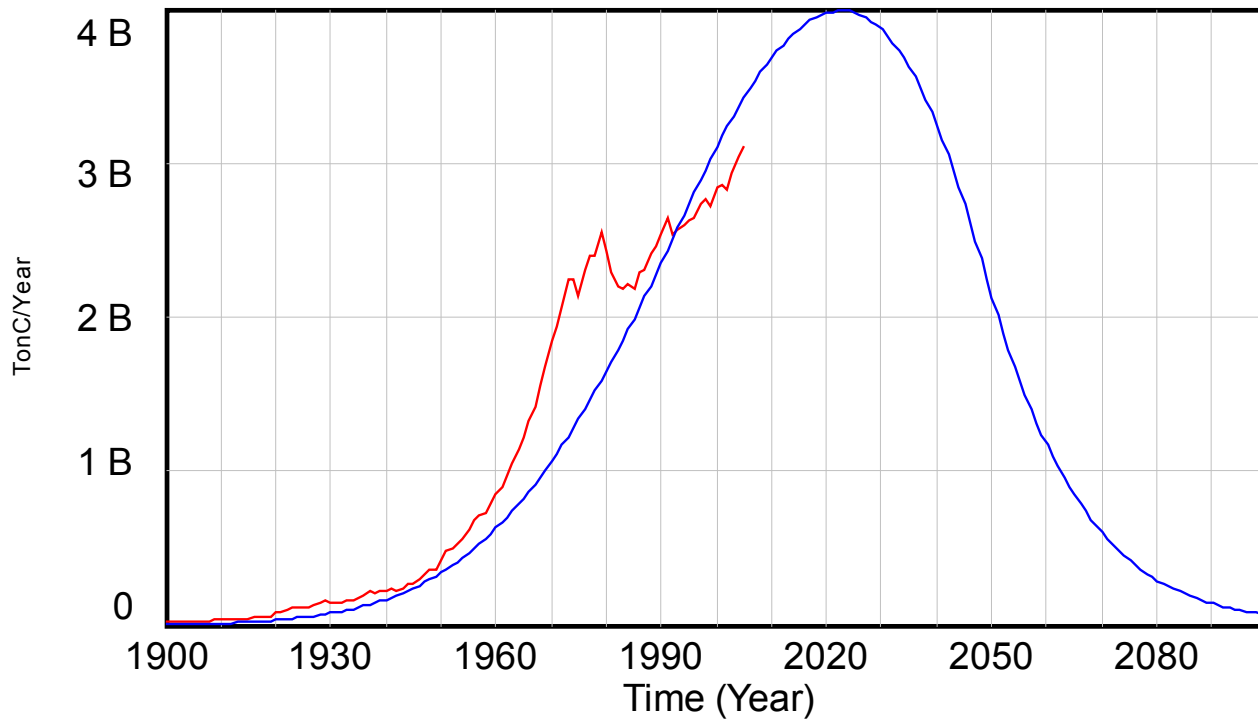
Gas Production : Base Run

Gas Production : Calibration\2009_03_09_Calibration

Energy Sector

CO2 Emission from Oil

- in **red** – historical data
- in **blue** – FeliX model Base Run

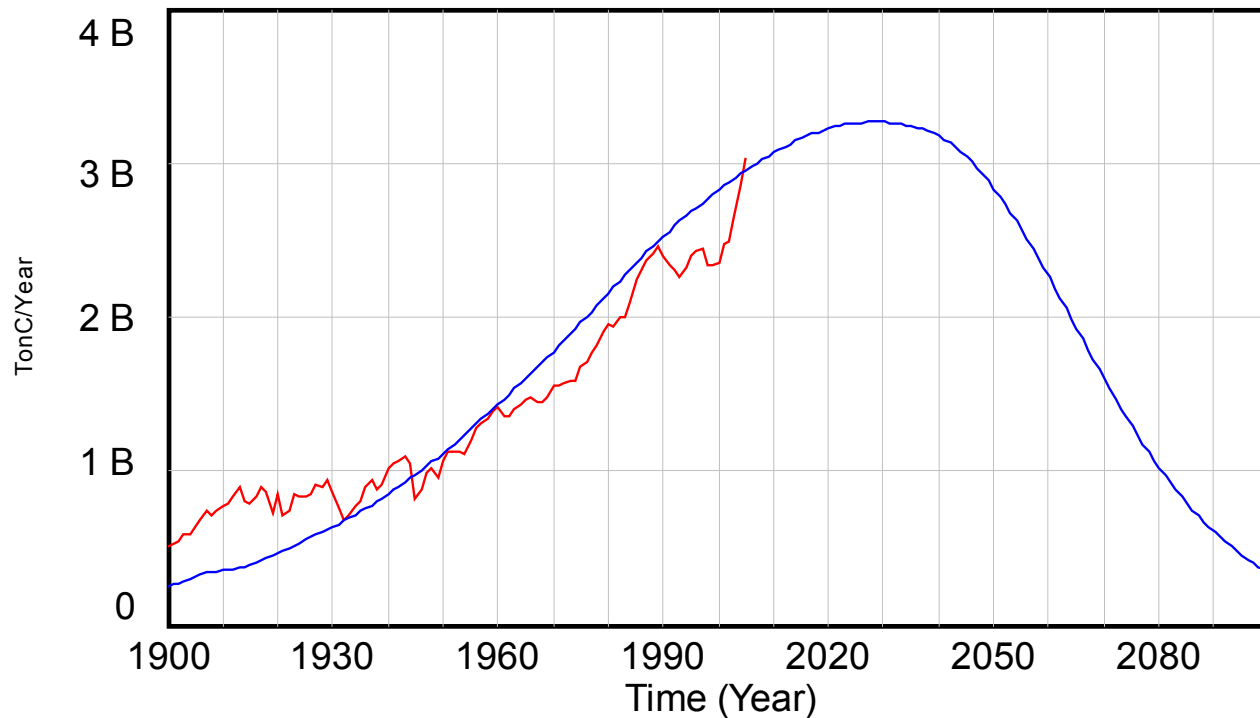


CO2 Emission from Oil : Base Run —————
 CO2 Emission from Oil : Calibration\2009_03_09_Calibration —————

Carbon Cycle Sector

CO2 Emission from Coal

- in **red** – historical data
- in **blue** – Felix model Base Run



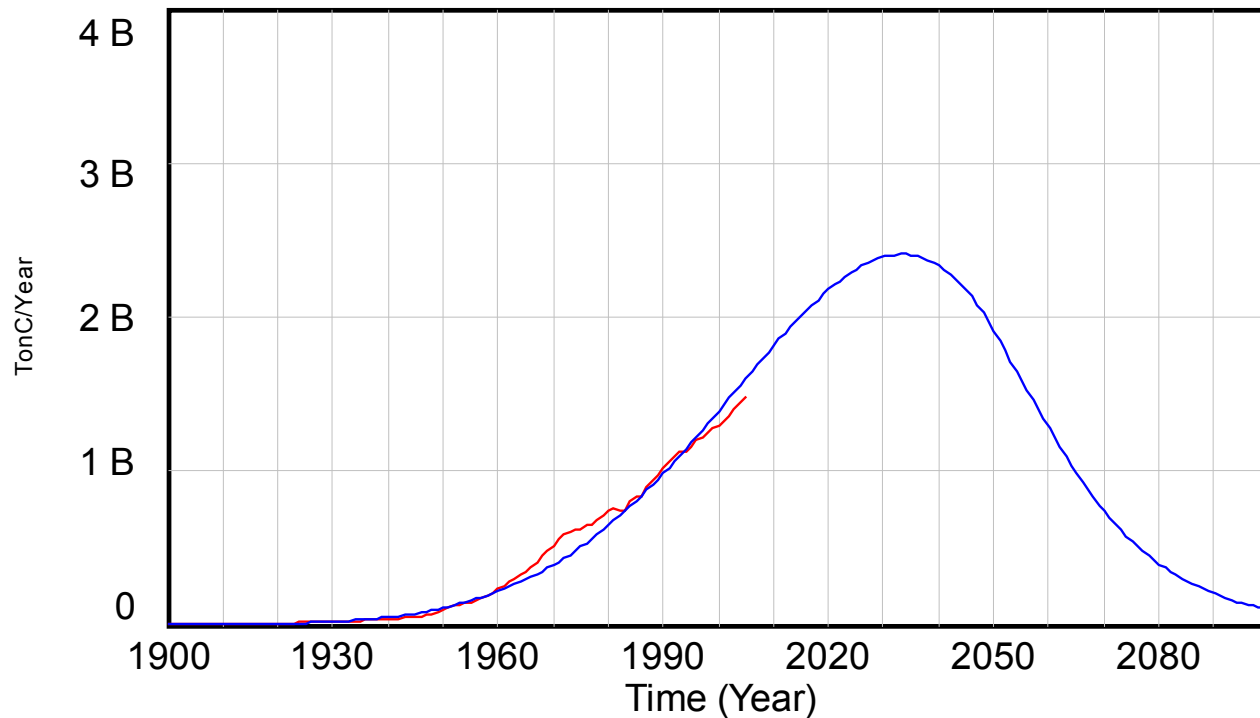
CO2 Emission from Coal : Base Run

CO2 Emission from Coal : Calibration\2009_03_09_Calibration

Carbon Cycle Sector

CO2 Emission from Gas

- in **red** – historical data
- in **blue** – FeliX model Base Run

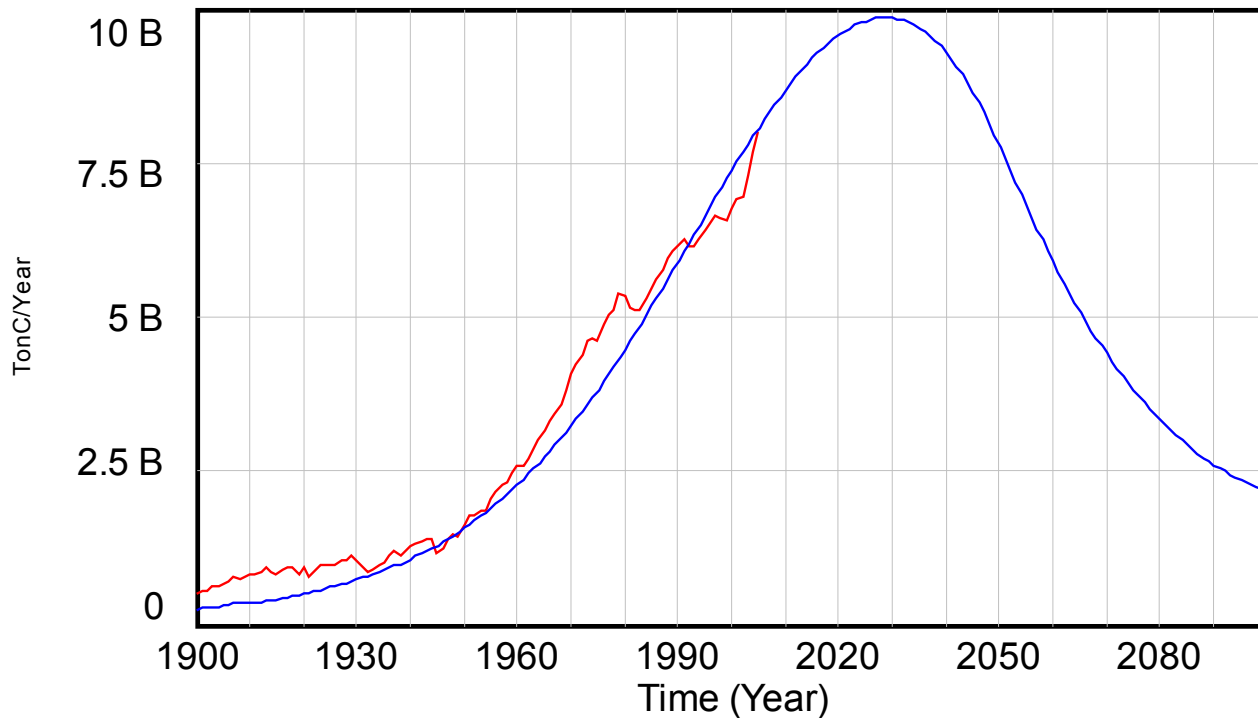


CO2 Emission from Gas : Base Run —————
 CO2 Emission from Gas : Calibration\2009_03_09_Calibration —————

Carbon Cycle Sector

- in **red** – historical data
- in **blue** – FeliX model Base Run

Total CO2 Emission

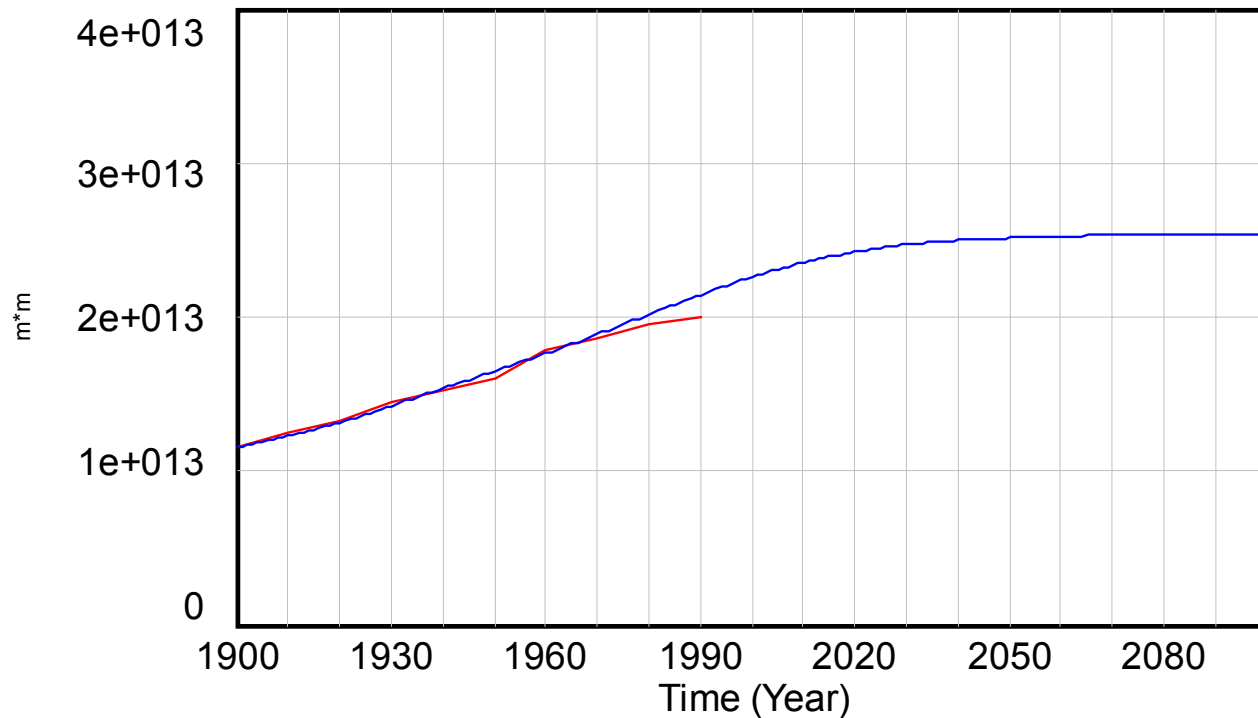


Total CO2 Emission : Base Run —————
 Total CO2 Emission : Calibration\2009_03_09_Calibration —————

Land Use Sector

- in **red** – historical data
- in **blue** – FeliX model Base Run

Agriculture Land

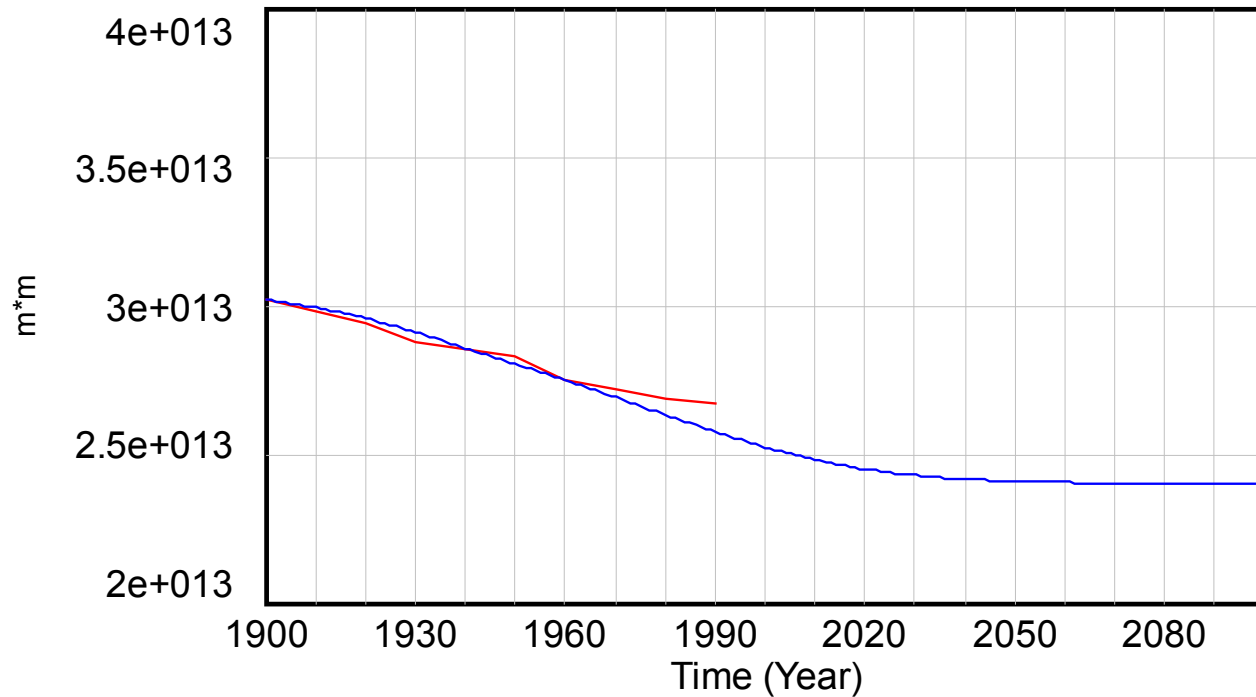


Agriculture Land : Base Run —————
 Agriculture Land : Calibration\2009_03_09_Calibration —————

Land Use Sector

- in **red** – historical data
- in **blue** – FeliX model Base Run

Other Land

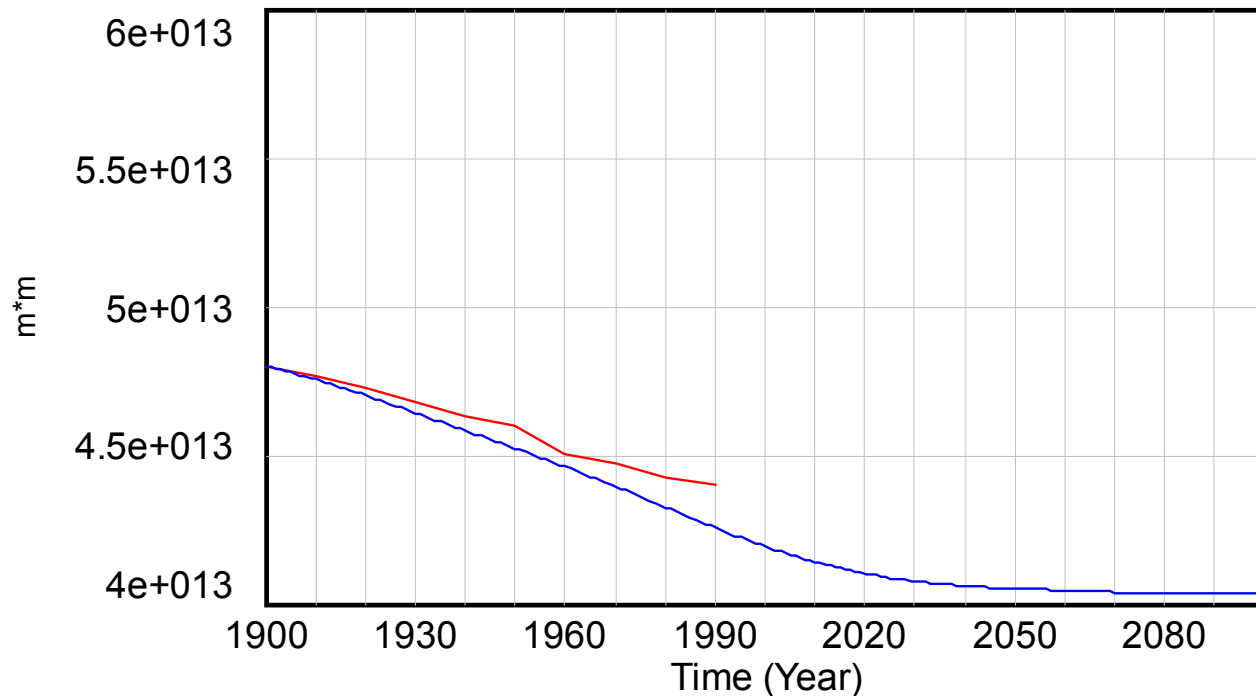




Other Land : Base Run —————
 Other Land : Calibration\2009_03_09_Calibration —————

Land Use Sector

- in **red** – historical data
- in **blue** – Felix model Base Run

Forest Land



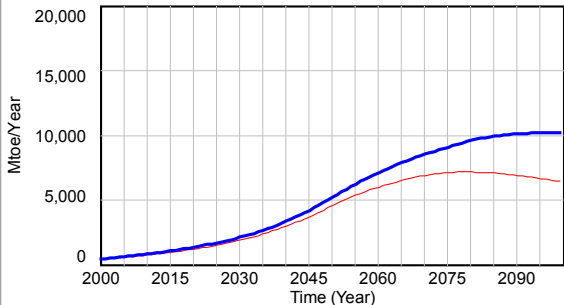
Forest Land : Base Run 
 Forest Land : Calibration\2009_03_09_Calibration 

Energy Scenario



GEOSS through discovery of **additional** or more **appropriate** locations for wind energy installations, as far as available area and weather conditions are concerned, leads to a greater competitiveness of this energy source.

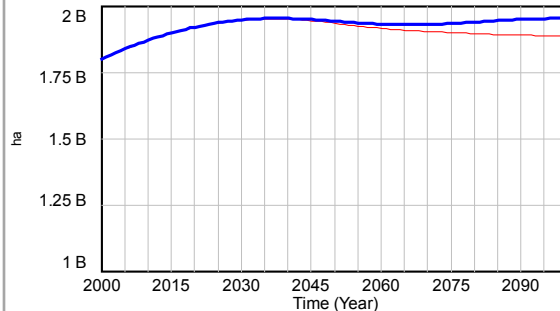
Wind Energy Production



Wind Energy Production : Scenario 1
Wind Energy Production : Base Run

Wind Energy Market Share
Non-GEOSS scenario → 43%
GEOSS Scenario → 68%

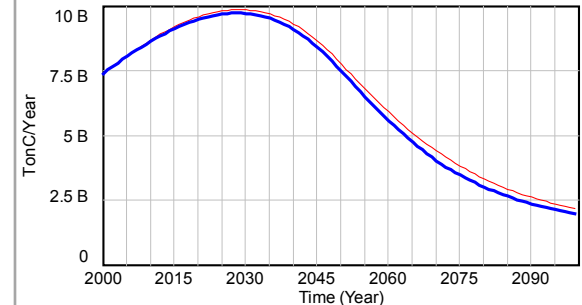
Food Potential Agriculture Land



Food Potential Agriculture Land : Scenario 1
Food Potential Agriculture Land : Base Run

67,242,112 ha saved for food production.
Note: at that time the energy is produced from biomass, solar and wind (nonrenewables constitute only about 2%)

Total CO2 Emission

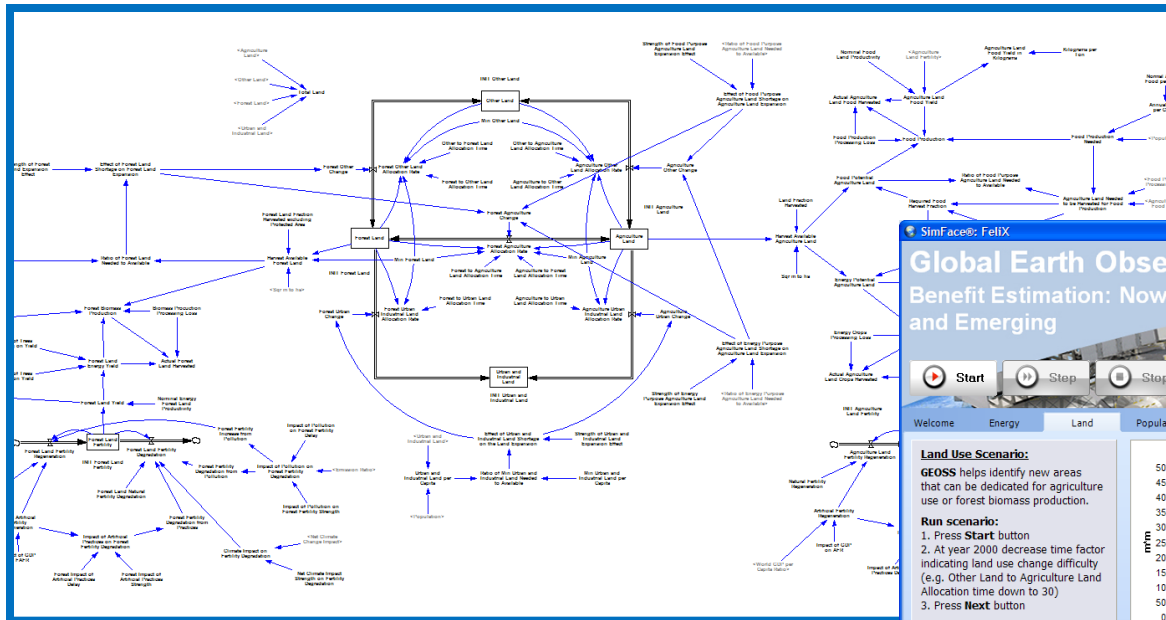


Total CO2 Emission : Scenario 1
Total CO2 Emission : Base Run

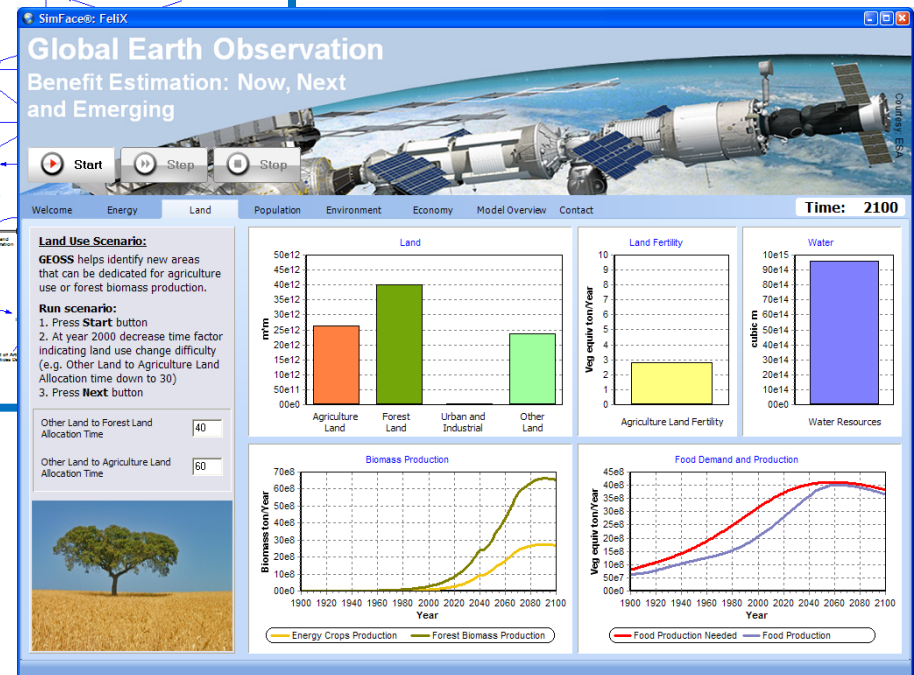
About **15 billions TonsC** less in the atmosphere in case of GEOSS scenario compared to non-GEOSS scenario over the considered period.



Model vs. Simulator



- User friendly!
- Pre-defined GEOSS scenarios



- Access to code
 - Freedom to design of specific simulation experiments
 - The whole model overview
- but*
- Requires specific modeling skills

