PBL -Planbureau voor de Leefomgeving

Using model-based scenarios to deal with uncertainties

Detlef van Vuuren

Uncertainty key element of climate research

› Many questions regarding climate policy are about the future:
  – What future level of climate change should we prepared for?
  – What kind of impacts do we need to avoid?
  – How much do we need to reductions in 2050?

  – ...

› But future is inherently uncertain:
  – What do we know about socio-political developments? And will that knowledge survive the next election?
  – What do we know about technology development?
  – What do we know on the success of climate policy?

Types of uncertainty

› Factors contributing to uncertainty
- – Ontic uncertainty (variability)
- – Epistemic uncertainty (limited knowledge)
  - - Probabilities (Baysian)
  - - Conditional statements
  - - Consious not knowing
  - - Ignorance
- - Disagreement among experts
- - Reflexive uncertainty

› These occur at different scales
- - Parameters
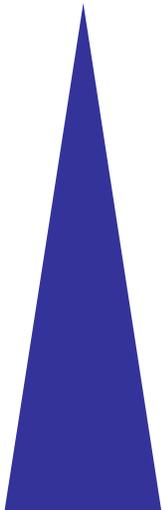- - Models
- - Theories

Annual economic growth?

Energy resources
High growth, if globalisation
Actor interaction
Miracle technology (CSP)
Technology development
Learning from scenarios

- Different types of uncertainty require different tools
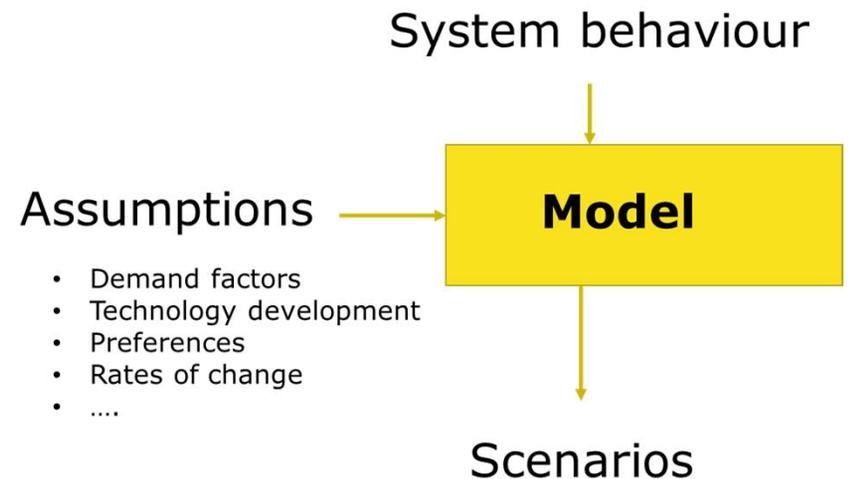- Uncertainty is not equal to complexity

Model-based scenarios to explore the future

– Map out possible futures – indicate opportunities, effort, synergies, trade-offs
– Explore uncertainty and indicate boundaries of possible futures
– Use models to "organise knowledge and complexity" and create scenarios
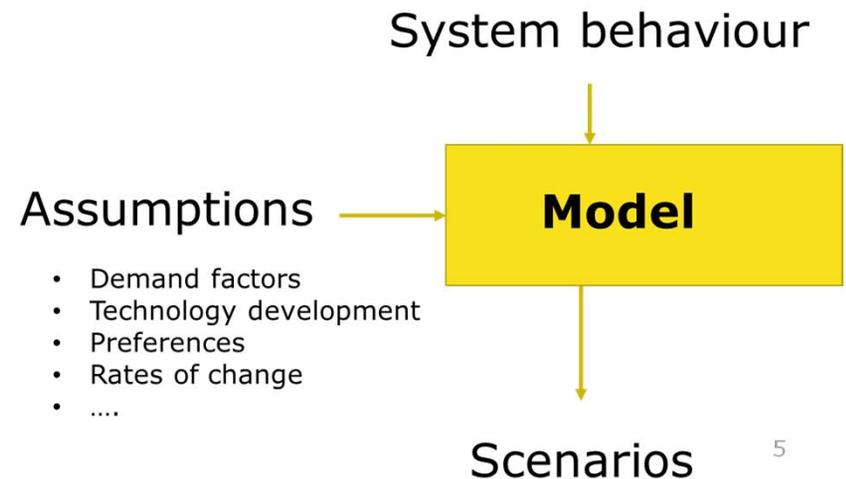
Source: Ottmar Edenhofer

System behaviour

Assumptions ──→ **Model**

- Demand factors
- Technology development
- Preferences
- Rates of change
- ….

Scenarios

Options to deal with deep uncertainty

Just give us the numbers

- › Scenarios without probability (defining plausible futures)
- › Probabilistic methods

- › Mixed methods:
  - – Conditional probability;
  - – hedging
- › Using expert judgement to assigning probalities

- › Single model/multiple model

System behaviour

Assumptions → **Model**

- • Demand factors
- • Technology development
- • Preferences
- • Rates of change
- • ....

Scenarios

Two main scenario methods
(handling uncertainty in different ways)

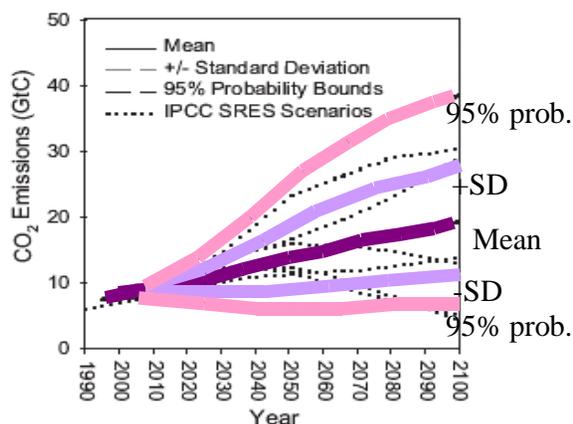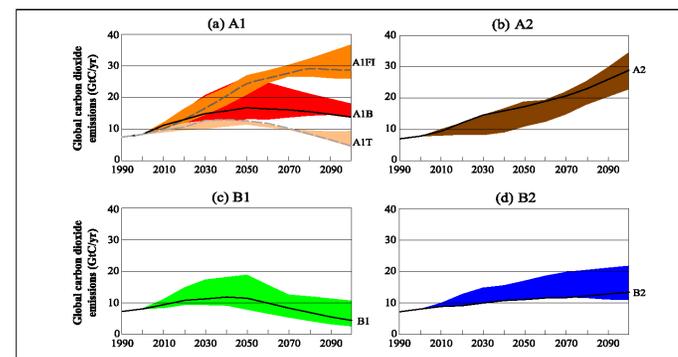
Probalistic
Scenario development

A set of
storyline based
scenarios

Estimate best-guess and uncertainties of all relevant parameter in model; gives best-guess outcome + uncertainty range

Develop storylines around major uncertainties – and use storyline to estimate consistent values for other parameters. Explore the future.

Webster et al. (2001)

Nakicenovic et al (2000)

Planbureau voor de Leefomgeving

Probalistic
Scenario development

A set of
storyline based
scenarios

Absent of information on certainty, policy discussion threatens to deteriorate into a shouting match, where analysis results are used both to support calls for urgent action and to justify doing nothing while we wait for more information... An example of an assessment with uncertainty information is one carried out at the MIT by using formal uncertainty propagation techniques to assess a probability distribution for global mean temperature change.

Future emissions are the product of a large range of very uncertain factors such as population, technology, socio-economic development etc. Storylines are used to define a consistent set of assumptions. Scenarios can help exploring some of these futures; they are not predictions.
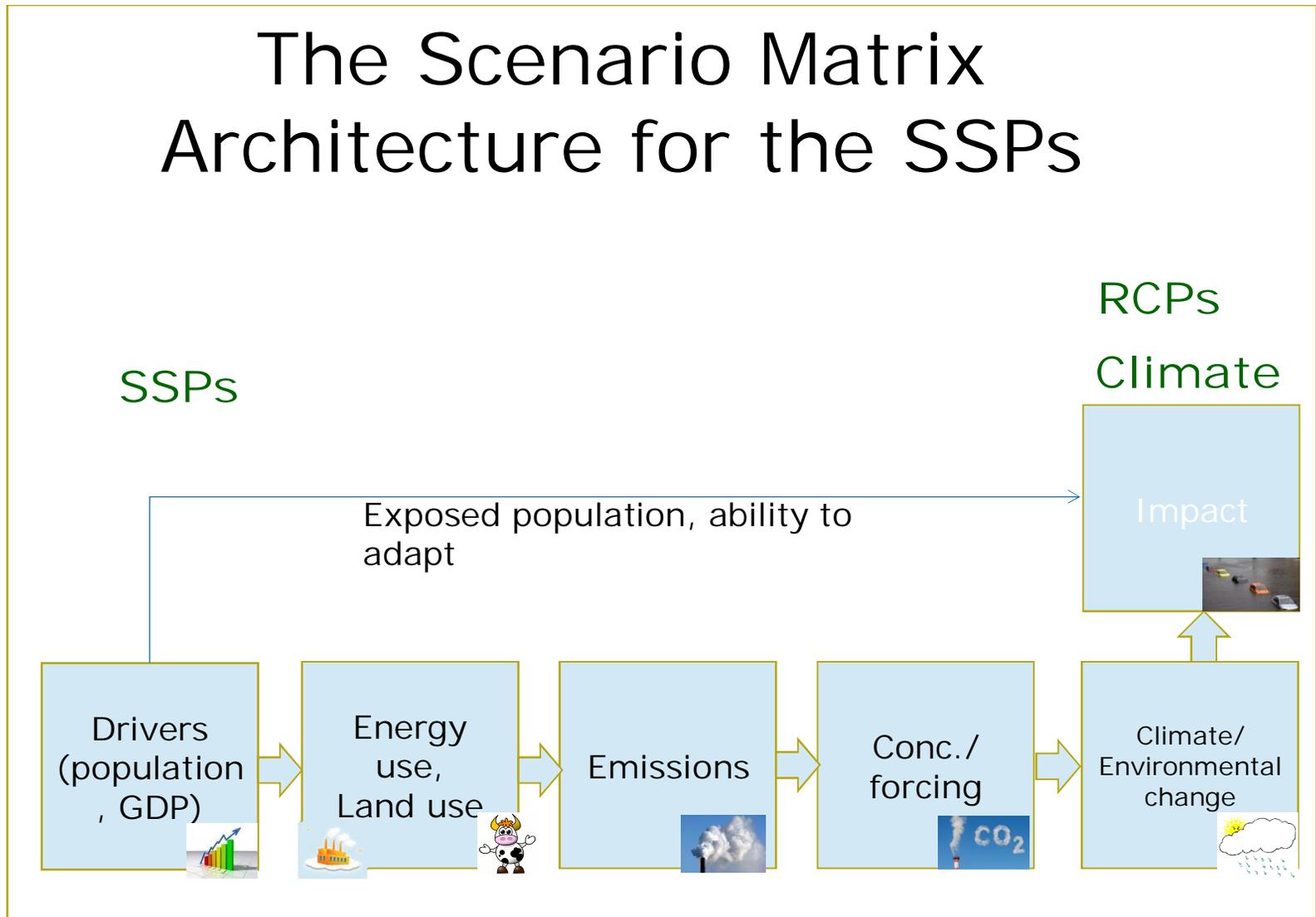
Probalistic
Scenario development

A set of
storyline based
scenarios

Decision-makers need to address risks. Risks are determined by impacts AND probability. For instance, information that an asteroid can destroy the earth can only be properly assessed, if one knows that changes are 1 in a billion.
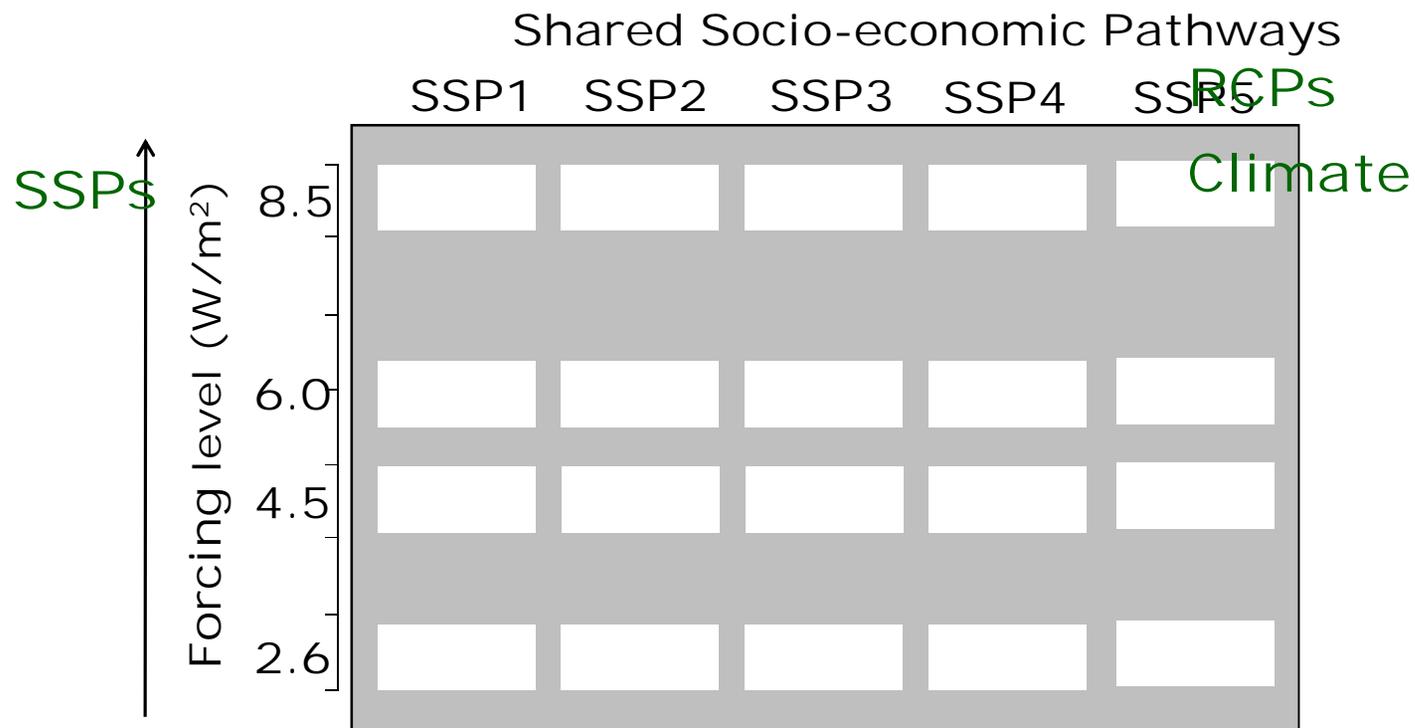
"The probabilistic approach only attempts to assign subjective probabilities in a situation of ignorance forms a dismissal of uncertainty in favor of spuriously constructed expert opinion".
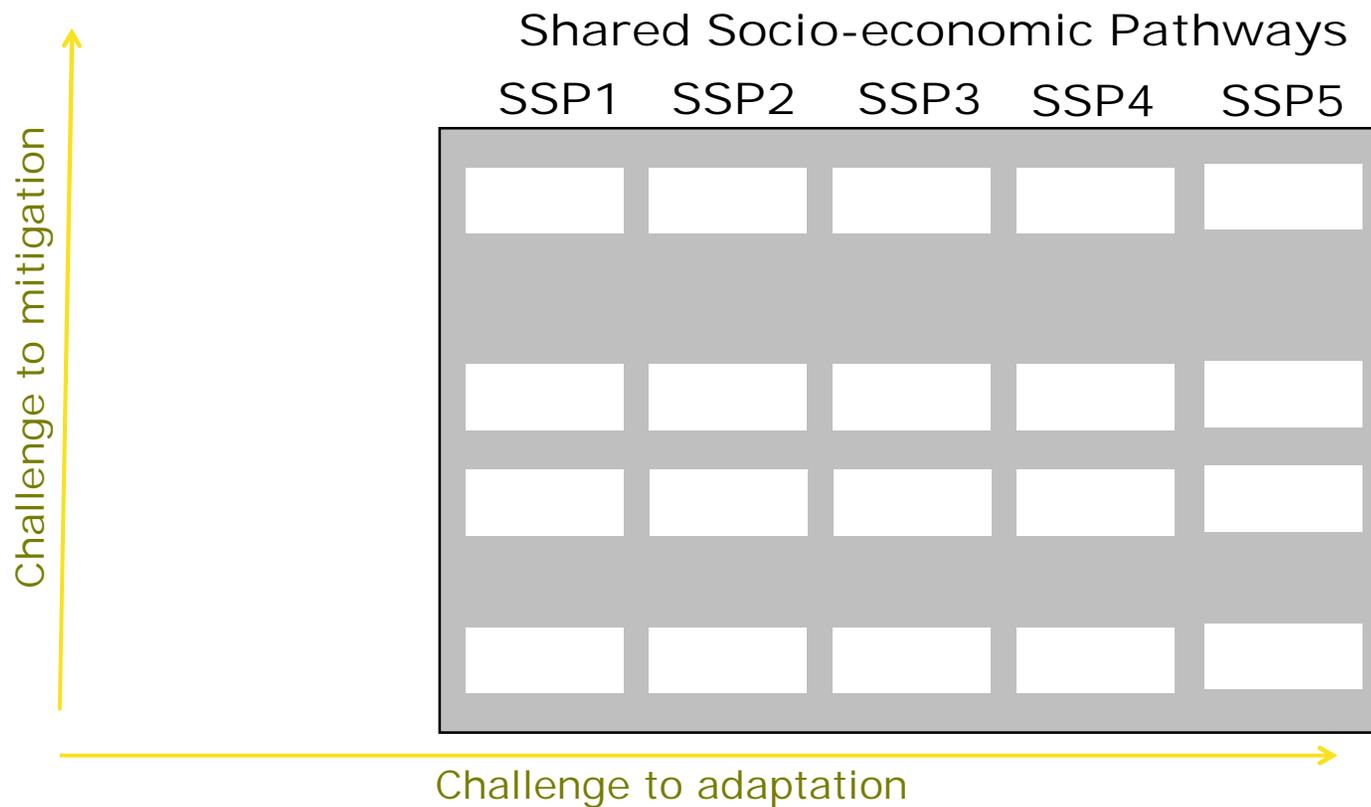
The Scenario Matrix Architecture for the SSPs

SSPs

RCPs

Climate

Exposed population, ability to adapt

Impact

Drivers (population, GDP) → Energy use, Land use → Emissions → Conc./forcing → Climate/Environmental change

The Scenario Matrix Architecture for the SSPs

The Scenario Matrix Architecture for the SSPs

Shared Socio-economic Pathways

Challenge to mitigation

SSP1 SSP2 SSP3 SSP4 SSP5

Challenge to adaptation

Shared Socio-economic Pathways: 5 possible stories about the future

SSP5: Fossil fuel-ed development
- Rapid growth, free trade
- High technology development,
- Environment and social goals not a priority: adaptive, technology-fix
- Focus on economic growth

Markets first

Clash of civilisations

SSP3: Regional rivalry
- Competition among regions
- Low technology development
- Environment and social goals not a priority
- Focus on domestic resources
- High population growth
- Slow economic growth dev. countries

SSP2: Middle of the Road

SSP1:Green growth
- Global cooperation
- Rapid technology dev.
- Strong env. policy
- Low population growth
- Low inequity
- Focus on renewables and efficiency
- Dietary shifts
- Forest protection

UN world

Have's and have not's

SSP4: Inequality
- Inequality across and within regions
- Low technology development
- Environment priority for those that can afford
- Limited trade

Planbureau voor de Leefomgeving

Shared Socio-economic Pathways:
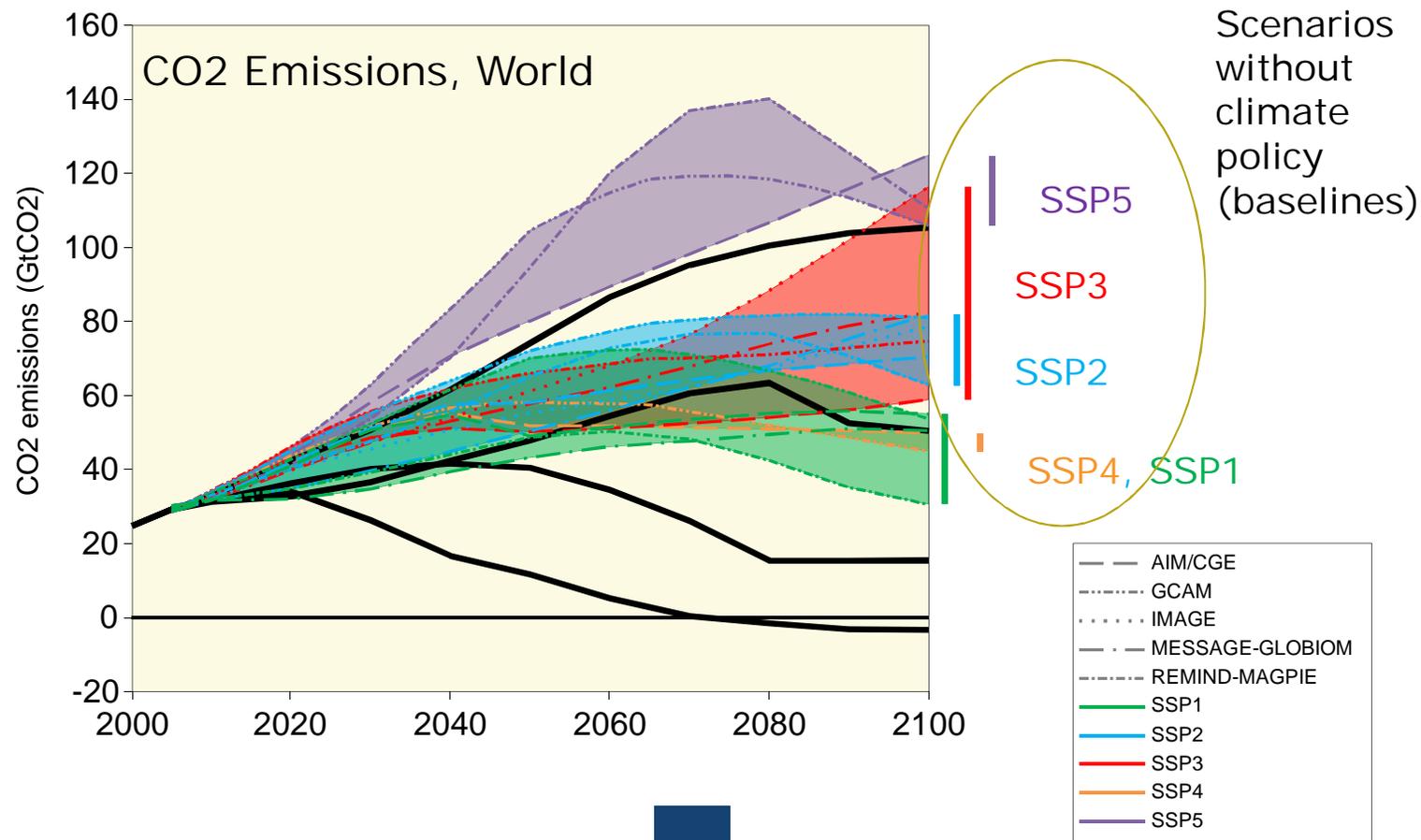# 5 possible stories about the future

- As a result, in all 5 stories without stringent climate policy:
  - further increase in global energy use
  - Fossil fuels continue to be important
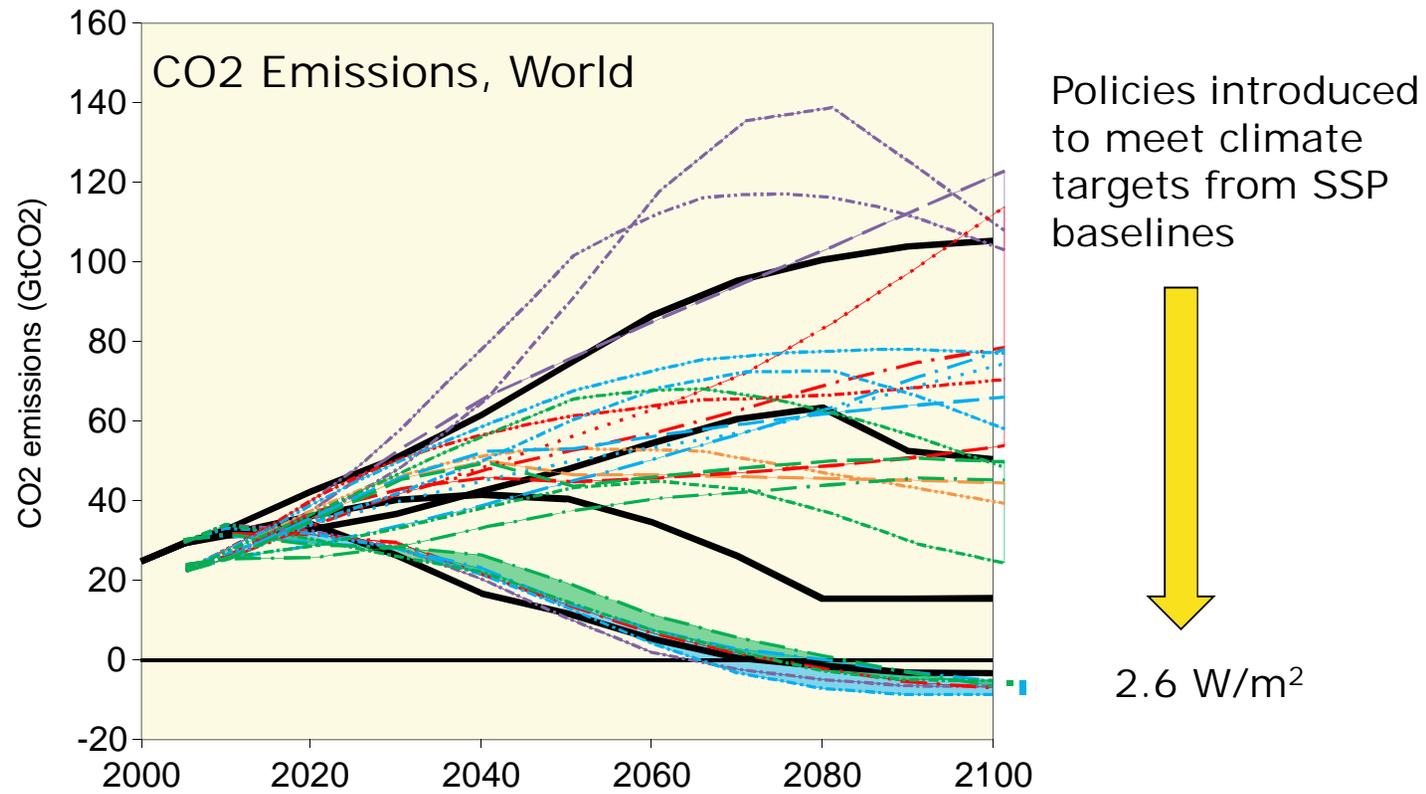 - Thus increasing greenhouse gas emissions

Shared Socio-economic Pathways
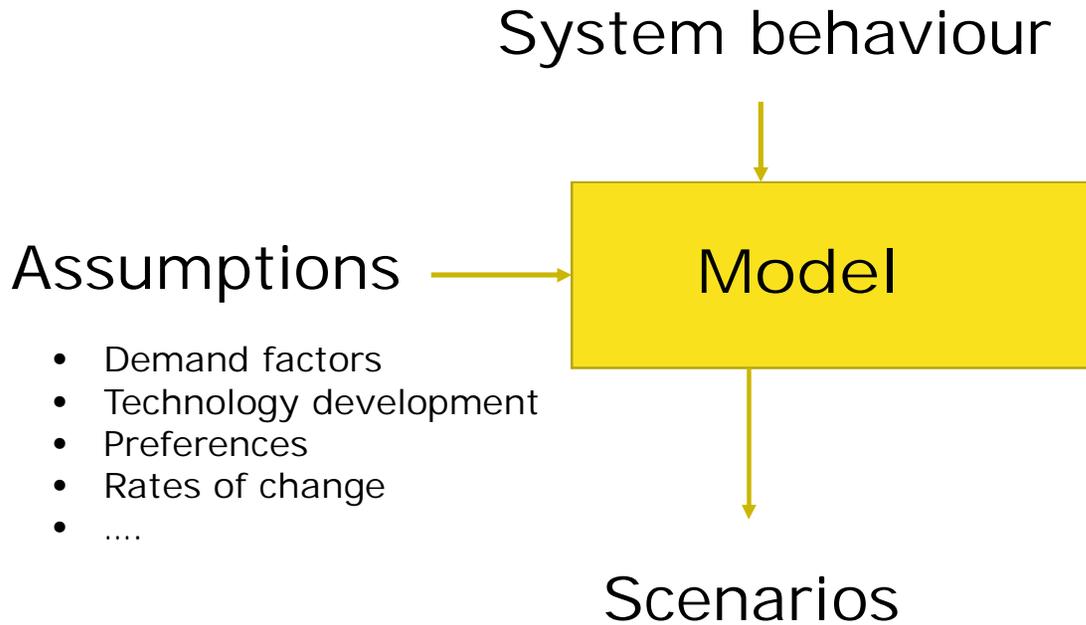
Planbureau voor de Leefomgeving

CO2 Emissions, World

Scenarios without climate policy (baselines)

SSP5

SSP3

SSP2

SSP4, SSP1

Legend:
- AIM/CGE
- GCAM
- IMAGE
- MESSAGE-GLOBIOM
- REMIND-MAGPIE
- SSP1
- SSP2
- SSP3
- SSP4
- SSP5

Shared Socio-economic Pathways

Planbureau voor de Leefomgeving

CO2 Emissions, World

Policies introduced to meet climate targets from SSP baselines

2.6 W/m^2

Probabilistic approach

System behaviour

Model

Assumptions

- Demand factors
- Technology development
- Preferences
- Rates of change
- ....

Scenarios

Gillingham, *K.* W. D. Nordhaus, D. Anthoff, V. Bosetti, G. Blanford, P. Christensen, H. McJeon, J. Reilly, P. Sztorc (2015), Modeling Uncertainty in Climate Change: A Multi-Model Comparison, *NBER wp 21637 also FEEM WP 13*

CO2 emissions, 2100 (billions tons CO2)

Planbureau voor de Leefomgeving
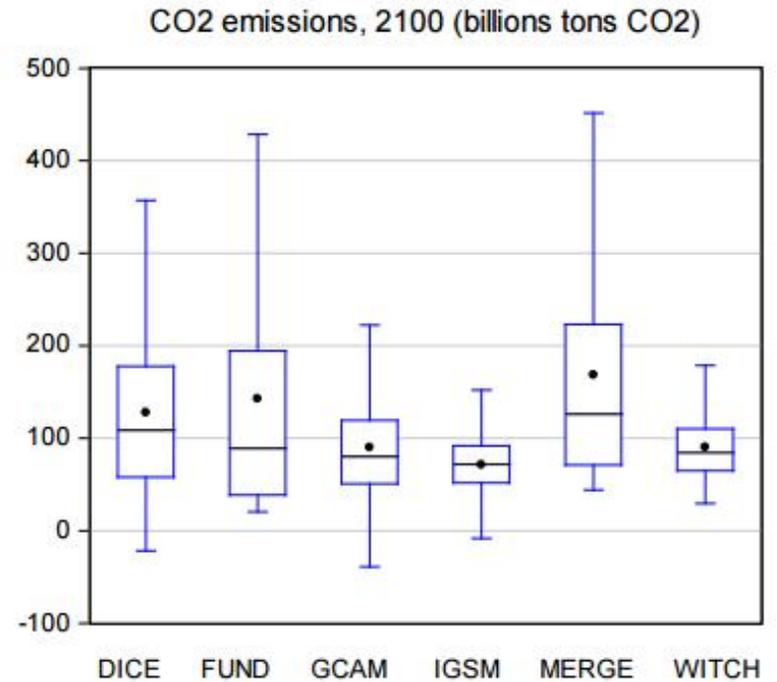
Expert judgement

> Substantive: Elicit probability distributions over 2100 CO2 emission ranges from <u>experts</u>
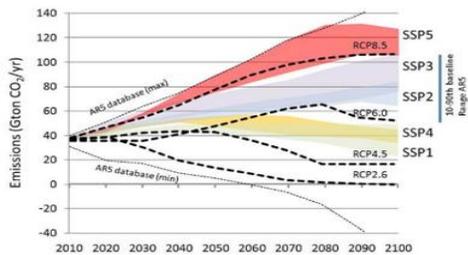
Planbureau voor de Leefomgeving
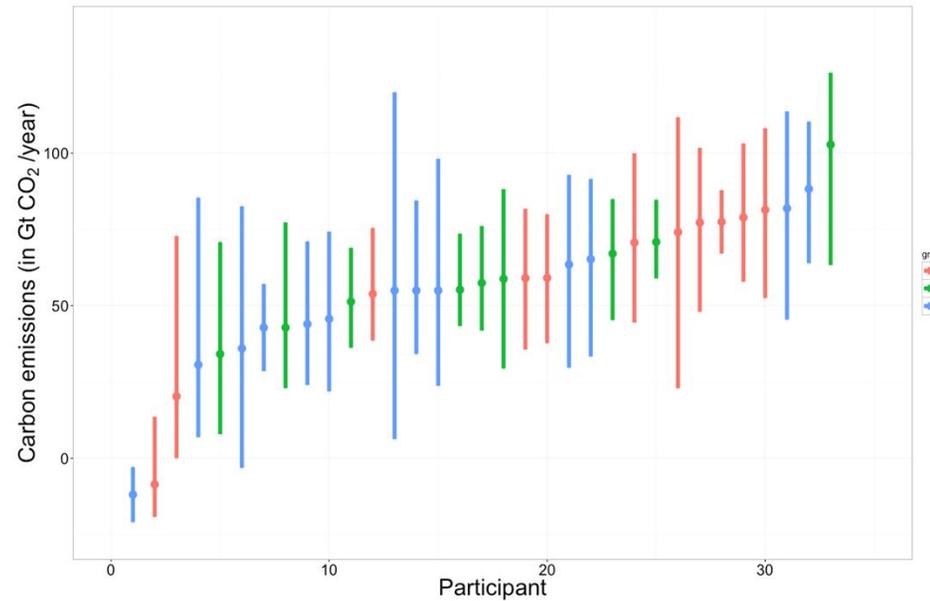
Providing probabilities to emission scenarios

- Scenarios useful instrument to explore futures in face of deep uncertainty
- But can we do more? Obviously, we all have some ideas about more likely / less likely futures
  - What is feasible... technically, economically, politically, socially?
  - Some space is simply more likely because there are more ways to get to it.
  - These ideas are strongly influenced by the moment in time the judgements are made
- Communication is key component