Recent development in scenario analysis

Detlef van Vuuren
Scenarios as means to link communities

SSPs

Drivers (population, GDP)

Exposed population, ability to adapt

Energy use, Land use

Emissions

Conc./forcing

Climate/Environmental change

RCPs

Impact
The Scenario Matrix Architecture

- **Forcing level (W/m²)**:
  - 8.5
  - 6.0
  - 4.5
  - 2.6

- **Shared Socio-economic Pathways (SSPs)**: SSP1, SSP2, SSP3, SSP4, SSP5

- **RCPs**

- **Narratives**
- Quantitative drivers

- **Socioeconomic information**

- **Climate information**

**IAM reference scenario** (e.g., SSP3-Ref)

**IAM SSP-RCP scenario** (e.g., SSP3-4.5)
<table>
<thead>
<tr>
<th></th>
<th>SSP1</th>
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The Scenario Matrix

Architecture

Challenge to mitigation

Challenge to adaptation
The Scenario Matrix

Architecture

SSP1: Sustainability

SSP2: Middle of the Road

SSP3: Regional rivalry

SSP4: Inequality

SSP5: Fossil fuel-ed development

Challenge to mitigation

Challenge to adaptation
The Scenario Matrix

Architecture

SSP5: Fossil fuel-ed development
SSP3: Regional rivalry
SSP4: Inequality
SSP2: Middle of the Road
SSP1: Sustainability
- Global cooperation
- Rapid technology dev.
- Strong env. policy
- Low population growth
- Low inequity
- Focus on renewables and efficiency
- Dietary shifts
- Forest protection

UN world

Challenge to mitigation

Challenge to adaptation
The Scenario Matrix Architecture

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

SSP2: Middle of the Road

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

SSP4: Inequality

SSP5: Fossil fuel-ed development

UN world

Challenge to adaptation

Clash of civilisations
The Scenario Matrix Architecture

Challenge to mitigation

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

SSP2: Middle of the Road
- SSP1: Sustainability
  - Global cooperation
  - Rapid technology dev.
  - Strong env. policy
  - Low population growth
  - Low inequity
  - Focus on renewables and efficiency
  - Dietary shifts
  - Forest protection

Markets first

UN world

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

SSP4: Inequality
- Rapid growth, free trade
- High technology development,
- Environment and social goals not a priority: adaptive, technology-fix
- Focus on economic growth

Challenge to adaptation
The Scenario Matrix

Architecture

SSP1: Sustainability
- Global cooperation
- Rapid technology development
- Strong environmental policy
- Low population growth
- Low inequality
- Focus on renewables and efficiency
- Dietary shifts
- Forest protection

SSP2: Middle of the Road
- Markets first

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

SSP4: Inequality
- Have’s and have not’s
- Inequality across and within regions
- Low technology development
- Environment priority for those that can afford
- Limited trade

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

Challenge to adaptation

Challenge to mitigation
Narratives
- GDP
  - Dellink, Crespo, Leimbach et al.
- POP
  - KC & Lutz
- Urbanization
  - Jiang & O’Neill

Model tables

SPAs

O’Neill et al

IAM-based SSPs

Mitigation scenarios

Overview
- Greenhouse gas emissions
- Climate change

Riahi et al

Energy
- Primary energy supply
- Trade
- Power system
- Commodity prices

Bauer et al

Land-use
- Natural area, land cover
- Yields, management
- Fertiliser
- Agriculture land

Popp et al

Air pollution
- Emissions of air pollutants
- Aerosol concentrations
- [deposition, ozone]

Rao et al
Primary energy use (EJ)

- **Baseline**
- **4.5 W/2**
- **2.6 W/2**

**2020 2040 2070 2100**

0.0 0.2 0.4 0.6 0.8 1.0

- Coal intensive
- Slow changes in energy demand
- Transition
- High energy demand

**2°C**:
- 600 EJ, Little BECCS
- 1000 EJ, Strong BECCS

**Coal**

**Oil/gas**

**Other**

**Primary energy**
- Oil w/o CCS
- Gas w/o CCS
- Coal w/o CCS
- Nuclear
- Wind
- Biomass
- Geothermal
- Hydro
- Solar
- BECCS
Power sector

![Graph showing energy consumption in different scenarios (SSP1 to SSP5)]

Legend:
- **Generation Technology**
  - Coal w/o CCS
  - Gas w/o CCS
  - Oil w/o CCS
  - Nuclear
  - Wind
  - Biomass
  - Geothermal
  - Coal w/ CCS
  - Gas w/ CCS
  - Oil w/ CCS
  - Hydro
  - Solar
  - BECCS

**Baseline**

**EJ/yr**

19 September 2016
Diverse set of power sector scenarios

Full decarbonisation of the electricity sector in 2050-2060
### CO2 emissions

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**Climate policy**

**Emissions [CO2]
Fossil Fuels and Industry**

**Avoidance scenarios**

- SSP1
- SSP2
- SSP3
- SSP4
- SSP5

**Co2 emissions [Gt CO2/yr]**

- 150
- 100
- 50
- 0
- -50

**Years**

- 1980
- 2000
- 2020
- 2040
- 2060
- 2100
Scenario matrix architecture forms scenario tool kit

- Provides opportunity for mitigation and impact/adaption research in one structure
Feasibility and costs of targets greatly depend on the SSP

(Mitigation costs as % of GDP)

Mitigation costs are given as area under the MAC and percent of total GDP (2010-2100)
COP21 – agreement on long-term climate objectives

- What do these long-term objectives imply for climate policy (reduction targets)

The universal agreement’s main aim is to keep a global temperature rise this century well below 2 degrees Celsius and to drive efforts to limit the temperature increase even further to 1.5 degrees Celsius above pre-industrial levels.
Paris agreement: ... with the aim to keep temperature rise well below 2 °C (and push for 1.5 °C)

Source: IPCC, 2013/2014

Relationship CO₂ / temperature
1000 GtCO$_2$ is very tight.

Timing
Contribution non-CO$_2$ gasses
Regional contribution

All factors that play a role in UNFCCC negotiations

1.5°C: 400 GtCO$_2$
Negative emissions for sure

Negative emissions: Bio-energy + CCS / reforestation
2°C scenarios have 4 distinct phases

CO₂ Emissions [GtCO₂/yr]

Peak in 2020-2030

Steep emissions reduction

Carbon neutrality

Zero or negative emissions
Delay leads to more rapid decarbonisation after 2030 – and even more stringent reductions

Not strengthening the INDCs (and EU’s 40% goal) make achieving the 2°C target without negative emissions almost unthinkable.

Source: IPCC AR5 database
Netherlands’ climate policy would need to increase level of ambition to be consistent with 2°C

• Prepare in the short-term for acceleration (focus on LT transition)
• International programme on CCS
6 step decarbonisation strategy

1. Increase energy efficiency

2. Decarbonize the electricity asap

3. Electrification where feasible

4. Negative emissions

5. Difficult bit: decarbonize the remainder Biofuels, CCS, H2

6. Mitigate non-CO₂, halt deforestation; reforest
Alternatives

Lifestyle change
Priorities for research agenda

- Join in SSP-based research; elaborate alternative scenarios (‘fill the matrices’)
- Research feasibility of the “default” mitigation strategy – model analysis – but especially combination with transition sciences → How to achieve enough momentum for change
- 1.5°C scenarios → Comparison to 2°C (how much negative emissions are needed)
- Look into alternative pathways
- Map out infrastructure and investment requirements for mitigation strategies
- Connections between mitigation strategies and SDGs (increase support; trade-off LUC)
Thank you for your attention

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