Emission Scenarios Primer

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Aspen Global Change Institute, Aspen, United States – 7 July 2003
Definition of a Long-Term Scenario II

A scenario is a plausible description of how the future may develop, based on a coherent and internally consistent set of assumptions (“scenario logic”) about key relationships and driving forces (e.g., rate of technology changes, prices). Note that scenarios are neither predictions nor forecasts.

Nakicenovic et al. SRES 2000
SRES SCENARIOS

- Extensive literature review
- Six modeling frameworks
- Full range of driving forces
- Full range of GHG emissions

Nakicenovic et al.  SRES 2000
SRES Scenarios

A1
A2
B1
B2

Economic

Global

Regional

Environmental

Driving Forces

Nakicenovic et al.

SRES 2000

Population
Economy
Technology
Energy
Agriculture
(Land-use)
## Factors of Growth: The Last 200 Years

<table>
<thead>
<tr>
<th></th>
<th>1800</th>
<th>2000</th>
<th>factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>World population, billion</td>
<td>1</td>
<td>6</td>
<td>x 6</td>
</tr>
<tr>
<td>Life expectancy, years*</td>
<td>35</td>
<td>75</td>
<td>x 2</td>
</tr>
<tr>
<td>Work hours per year*</td>
<td>3,000</td>
<td>1,500</td>
<td>÷ 2</td>
</tr>
<tr>
<td>Free time over life*</td>
<td>70,000</td>
<td>300,000</td>
<td>x 4</td>
</tr>
<tr>
<td>Mobility, km/day*</td>
<td>0.04</td>
<td>40</td>
<td>x 1000</td>
</tr>
<tr>
<td>World income, trillion $</td>
<td>0.5</td>
<td>36</td>
<td>x 70</td>
</tr>
<tr>
<td>Global energy use, Gtoe</td>
<td>0.3</td>
<td>10</td>
<td>x 35</td>
</tr>
<tr>
<td>Carbon, energy, GtC</td>
<td>0.3</td>
<td>6</td>
<td>x 22</td>
</tr>
<tr>
<td>Carbon, all sources, GtC</td>
<td>0.8</td>
<td>8</td>
<td>x 10</td>
</tr>
</tbody>
</table>

* (excl. walk)
Population Projections
Range Across Emissions Scenarios

Nakicenovic et al.

IIASA 1998
World Economic Map
Areas of Regions Proportional to 1990 GDP (mer)

DCs = 16% of world GDP (mer); 35% of world GDP (PPP)

Nakicenovic
IIASA & TU-Wien 2003
World Economic Map
Areas of Regions Proportional to 1990 GDP

Nakicenovic
IIASA & TU-Wien 2003
Area of Regions Proportional to 1990 GDP_{mer}

World Economic Map

Nakicenovic

IIASA & TU-Wien 2003
Per Capita Income Across SRES Scenarios

Nakicenovic et al.  IIASA 2000
Gross World Product in MEX and PPP

SRES B2

MEX & PPP in trillion US$

- Annex1 (mex)
- Non-Annex1 (mex)
- World (mex)
- Annex1 (ppp)
- Non-Annex1 (ppp)
- World (ppp)

Nakicenovic & Slentoe
IIASA 2003
Gross World Product
Range Across Emissions Scenarios

GWP (index, 1990=1)

Median
95%
5%
75%
25%
5%

1950 2000 2050 2100

Nakicenovic et al.  IIASA 1998
### PPP Growth

<table>
<thead>
<tr>
<th>Country</th>
<th>1870</th>
<th>1985</th>
<th>Factor</th>
<th>%/yr</th>
</tr>
</thead>
<tbody>
<tr>
<td>UK</td>
<td>59.0</td>
<td>510.9</td>
<td>8.7</td>
<td>1.9</td>
</tr>
<tr>
<td>USA</td>
<td>61.7</td>
<td>2947.1</td>
<td>47.8</td>
<td>3.4</td>
</tr>
<tr>
<td>Canada</td>
<td>4.9</td>
<td>306.8</td>
<td>62.1</td>
<td>3.7</td>
</tr>
<tr>
<td>Japan</td>
<td>17.2</td>
<td>1202.2</td>
<td>69.8</td>
<td>3.8</td>
</tr>
</tbody>
</table>

**SRES range** (B2, B1, A1-MESSAGE) 1990-2100

| OECD90   | 3.6 -- 7.6 | 1.2--1.9 |
| REF      | 6.2--13.2  | 1.7--2.4 |
| ASIA     | 18.9--39.1 | 2.7--3.4 |
| ALM      | 17.1--43.7 | 2.6--3.5 |

Global Primary Energy
Range Across Emissions Scenarios

Nakicenovic et al.
IIASA 1998
Global Final Energy by Form

Final Energy Shares (%)

Grids
(electricity, gas, district heat, hydrogen)

Liquids
(oil products, methanol, ethanol)

Solids (biomass, coal)

Nakicenovic IIASA & TU-Wien 2003
Diffusion of Fossil Technologies
IIASA IPCC SRES and Post-SRES Scenarios

- Conventional Oil Power Plants
- Conventional Coal Power Plants
- Integrated Gasification Combined Cycle (IGCC)
- Hydrogen Production (predominantly Gas)
- Fossil Fuel Cells (predominantly Gas)
- NGCC with carbon removal & disposal
- Natural Gas Combined Cycle (NGCC)
- Shift to NGCC completed

Nakicenovic & Riahi
IIASA 2001
Power Generation in 2050

Electricity, EJ


Nakicenovic IIASA & TU-Wien 2003
Carbon Emissions: Scenarios and Stabilization Profiles

Stabilization at 450, 550, 650 ppmv CO₂

WGI trajectory
WRE trajectory

A1B, A1T, B2, S450, S550, S650

35 Gt in 2100
A1FI (A1C & A1G)

Nakicenovic
IIASA 2003
Global Carbon Dioxide Emissions

Nakicenovic IIASA & TU-Wien 2003
Carbon Dioxide Emissions
Total All Sources

Nakicenovic et al.
IIASA 1998
Global Carbon Dioxide Emissions

40 SRES Scenarios and Literature Range

Global Carbon Dioxide Emissions (index, 1990=1)

Total database range

Minimum in Database

Maximum in Database

1990 range (all scenarios)

Minimum in Database

Maximum in Database

1990 range (all scenarios)

IS92 range

Non-classified

Intervention

Non-intervention

SRES 2000

et al.
Energy-Related Carbon Dioxide Emissions

N = 40 Scenarios

Global Carbon Dioxide Emissions (GtC)

Nakicenovic et al.

SRES 2000
Distribution of Cumulative Carbon Emissions
Across the Range of SRES Scenarios

Technologies: High vs. Medium-Low

Nakicenovic & Slentoe
IIASA 2003
MAJOR CLIMATE CHANGE UNCERTAINTIES
Cumulative CO$_2$ of IPCC SRES scenarios and resulting CO$_2$ concentrations and climate sensitivity in °C temperature change based on MAGICC model.
Distribution of Cumulative Carbon Emissions
Across the Range of Post-SRES Scenarios

Nakicenovic & Slentoe
IIASA 2003
World - Primary Energy Substitution

Nakicenovic
IIASA & TU-Wien 2003