Pathways to Deep Decarbonization in South Korea : Energy Technology Perspectives

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Objective

- This study has been undertaken as a part of the SDSN's international collaborative project to **backcast** national decarbonization trajectories or *technological pathways* and explores deep decarbonization pathways for the Korea.

- This study adopts the global energy-related carbon emissions of ***1.6 ton per capita for 2050*** as the goal.

Prospect of Economic & Social Developments

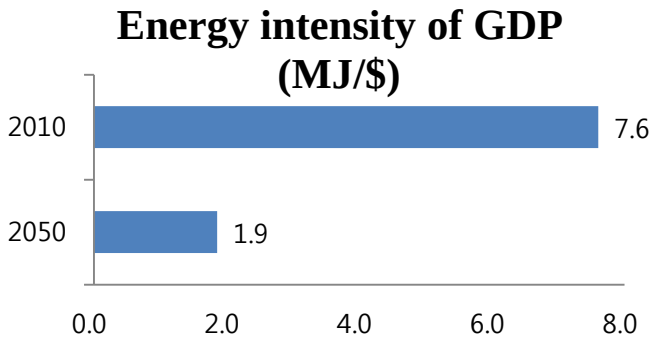
Indicator	Unit	2010	2050
Population	Million person	49	48
GDP	**$Billion (in 2005 prices)**	**1,015**	**2,754**
GDP per capita	**US$/person (in 2005 prices)**	**20,538**	**57,234**
Industrial value added	US$Billion (in 2005 prices)	437	1,170
Residential floor area	Million square meters	1,173	1,017
Commercial floor area	Million square meters	694	1,510
Passenger transport	Billion kilometers traveled	485	451
Freight transport	Billion ton-kilometers	0.8	1.2

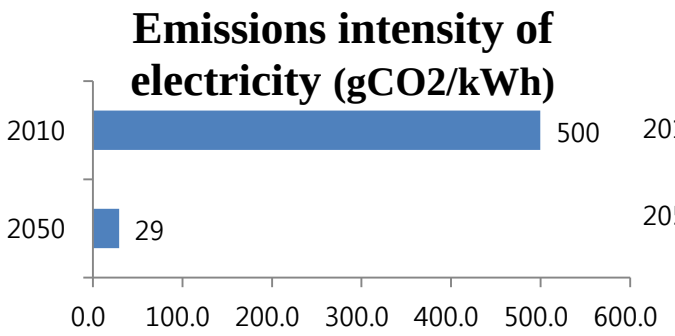
Mission & Target

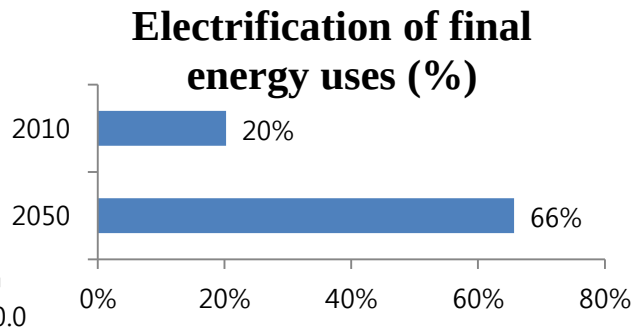
- How to get "an **86.3% reduction** of CO_2 emission from **fuel combustion**, falling from 556 $MtCO_2$ in 2010 to **76 $MtCO_2$ in 2050**."
  - *Key words*: backcast, technology, economic growth

Solutions : 3 pillar

- **Energy efficiency**
- **Fuel switching**
  - switching of final energy to decarbonized electricity
- **Low-carbon electricity** or decarbonization of electricity







Deployment Feasibility by Energy Technology: **Assumptions** (1)

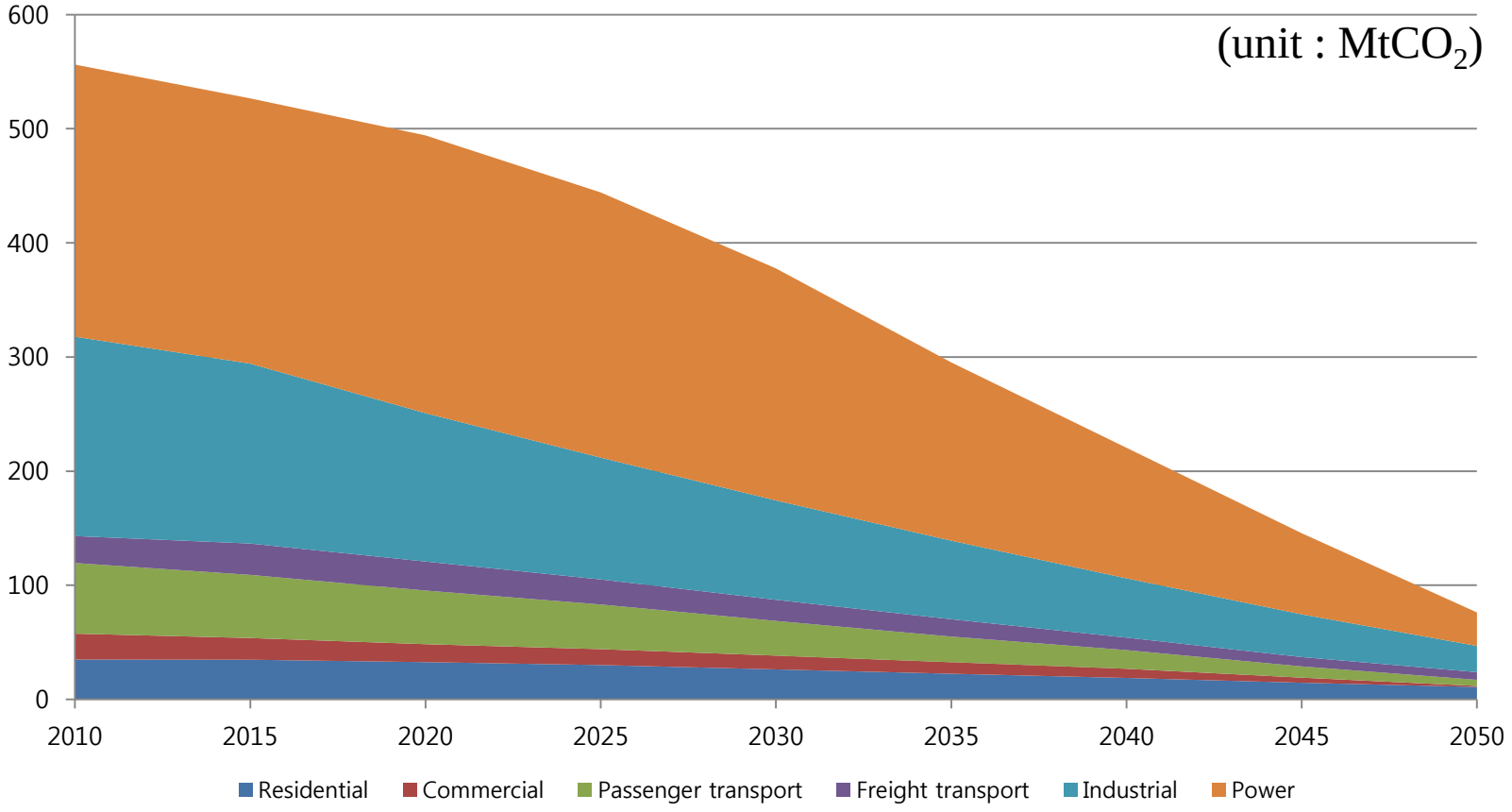
- **LED** replacing all the existing lighting ➔ save energy by **72%**.
- **Improvement of the energy efficiency in heating & cooling** in buildings ➔ save energy by **58.4%**
- **Improvement in the efficiency of fossil fuel cars** & **buses** each by **17%** and **23%** can be achieved by 2050.
- **Blend biodiesel** may be used in all diesel vehicles.

Deployment Feasibility by Energy Technology: **Assumptions** (2)

- **Solar PV** should be installed along public transport routes.
  - Its installation standard is 0.163 GW/km^2.
  - Up to 40% of the total transport road area, about 3,000 km^2, can accommodate **193 GW** of solar PV.

- **CCS** can capture **90%** of carbon emission.
  - The limiting factor for deployment of CCS is the domestic storage capacity.
  - The estimate of the storage potential is about 15 MtCO.

Emission Pathway by Sector



- **The electricity generation sector achieves emission reduction of 88% by 2050 relative to 2010.**
- **Industry achieves emission reduction of 87% during the same period.**

Electricity Generation Sector

Three Scenarios of Power Sector

- **High CCS and Low Renewable Scenario**

  (➔ Conservative Pathway)

- **High Renewable and Low Nuclear Scenario**

  (➔ Green Growth Pathway)

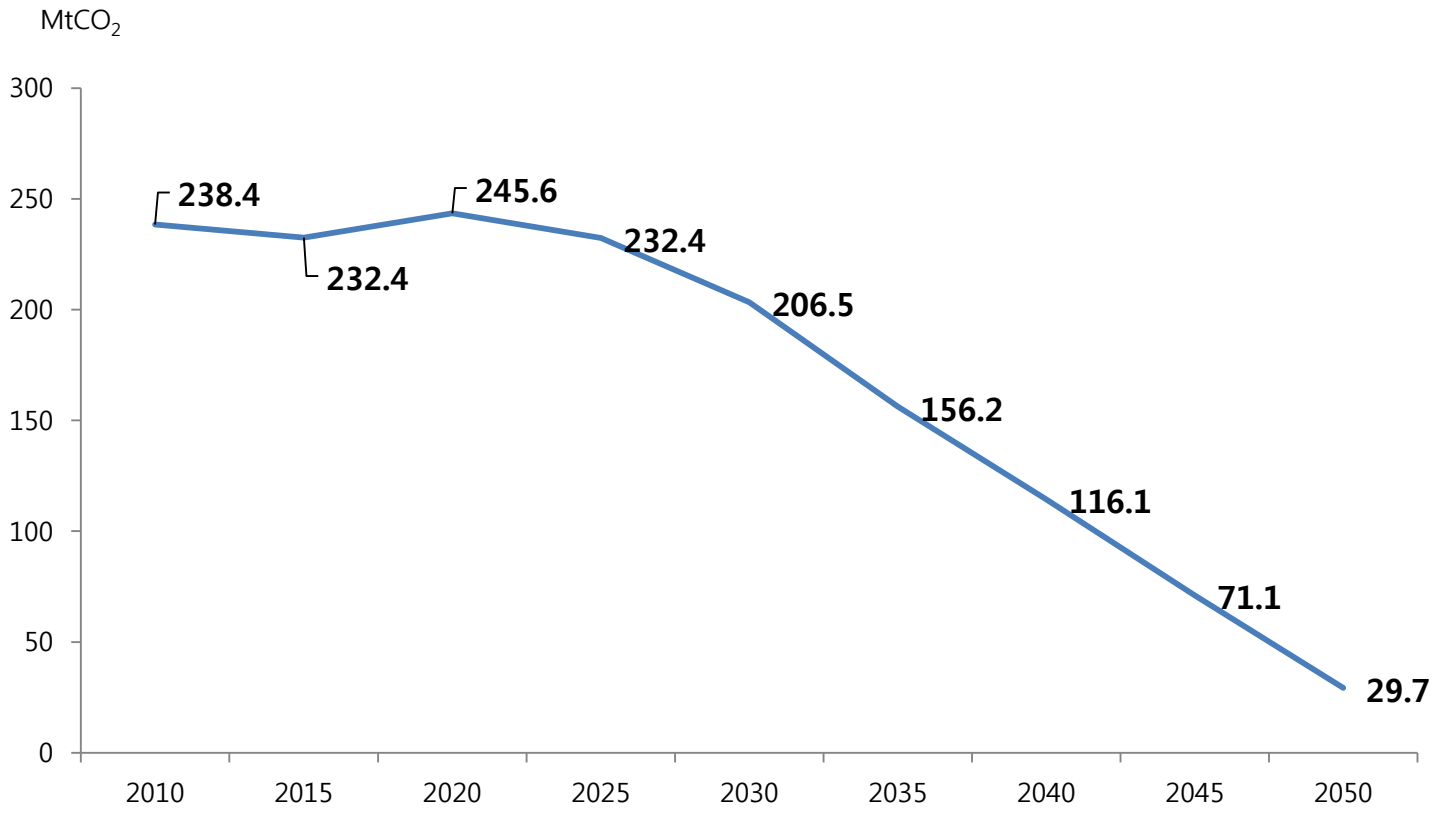
- **High Nuclear and Low CCS Scenario**

  (➔ Controversial Pathway)

1. High CCS and Low Renewable Scenario (Conservative Pathway)

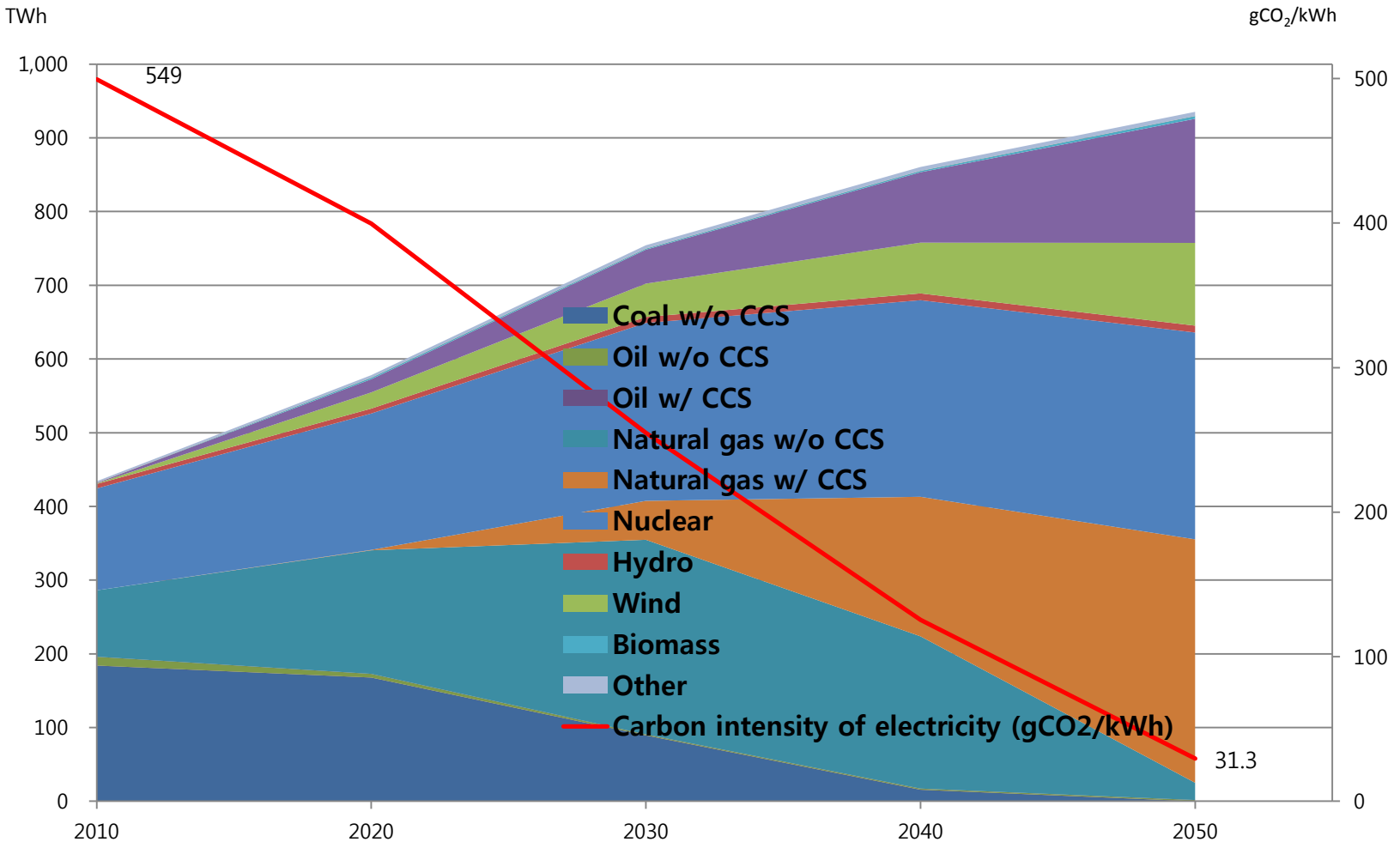
- Electricity generation increases by more than two times from 477 TWh in 2010 to 994 TWh in 2050 while final energy consumption decreases by 33.6%.
- The share of electricity consumption in final energy consumption increases from 20% in 2010 to 66% in 2050.
- Deep decarbonization of the power sector requires reduction of emissions from 238.4 $MtCO_2$ in 2010 to 29.7 $MtCO_2$ in 2050.
  - emission intensity from 549 gCO2/kWh to 31.3 gCO2/kWh
- While the potential for CCS may be high, its contribution remains limited until 2020 because of its currently low level of development but its role becomes pronounced beyond 2020.
- ***Emissions from the power sector increase up to 2020 and declines sharply beyond 2020***.

Emission Pathway of the Electricity Generation Sector



- The coal-fired power generation disappears by 2050 and LNG remains the only fossil fuel used for thermal power generation.
- 93% of the LNG-fired power generation (and 38% of the total power generated) is equipped with CCS.
- Renewable energy such as solar and wind accounts for 30% of total power generation and nuclear power 30%.
- The share of nuclear power in 2050 remains 32%.
- Nuclear power generation increases more than two times over the period in absolute magnitude from 17.5 GW to 36.1 GW.

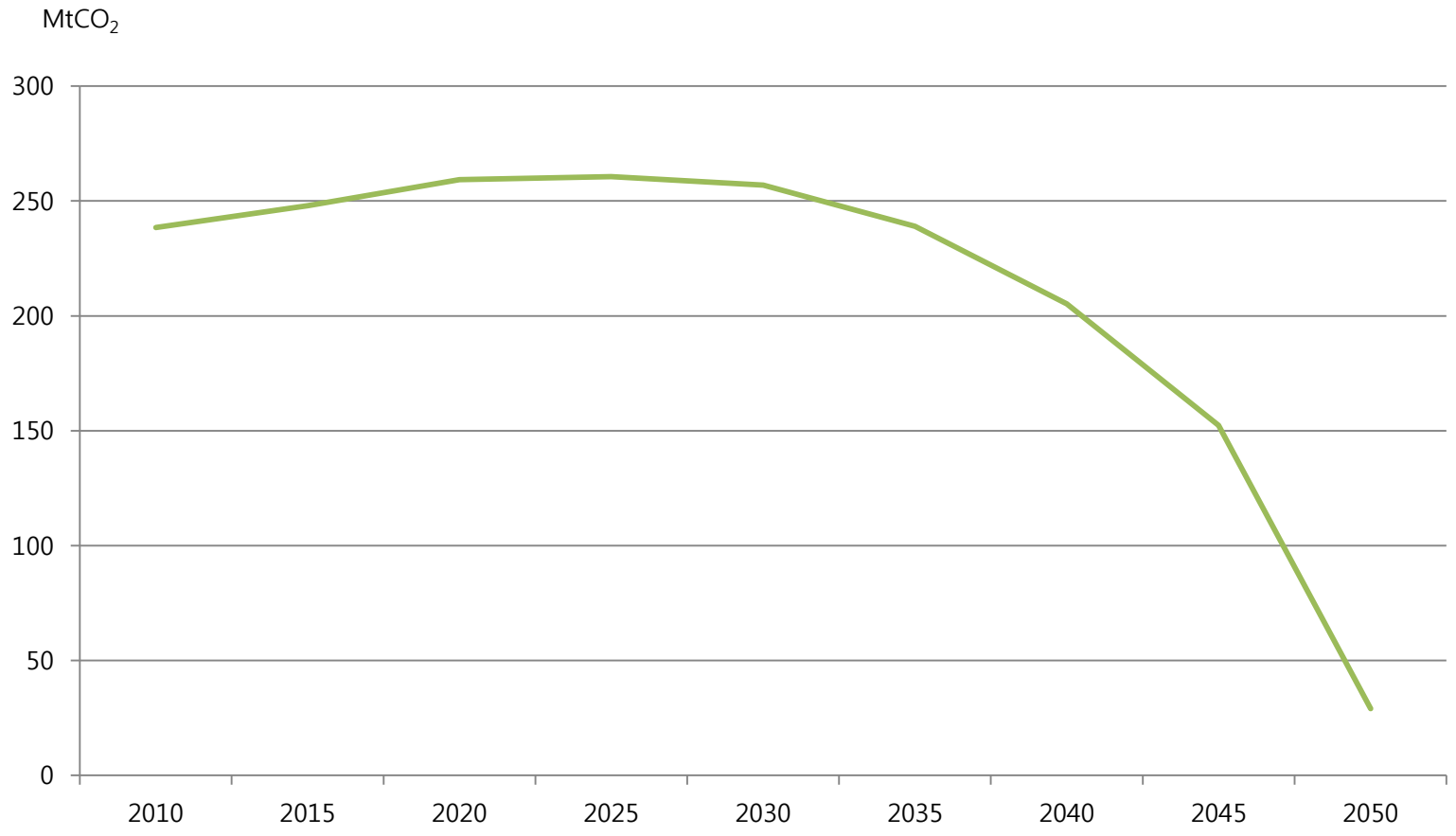
Electricity Generation by Energy Source under the Scenario 1



2. High Renewable and Low Nuclear Scenario (Green Growth Pathway)

- This is a denuclearization pathway with a maximal deployment of renewable energy in electricity generation.
- In 2050, renewable energy accounts for 65% of electricity, including solar and wind power each accounting for 37%p and 19%p.
- Biomass also plays some role, supplying 0.4% of electricity.
- Nuclear power accounts for only 10% of electricity.
- The balance is met mostly by fossil fuels, that is, LNG, which accounts for 30% of electricity, including 20%p with CCS.
- Nuclear power capacity begins to be reduced in 2025 and to 12GW by 2050.

Emissions from Electricity under the High Renewable Scenario

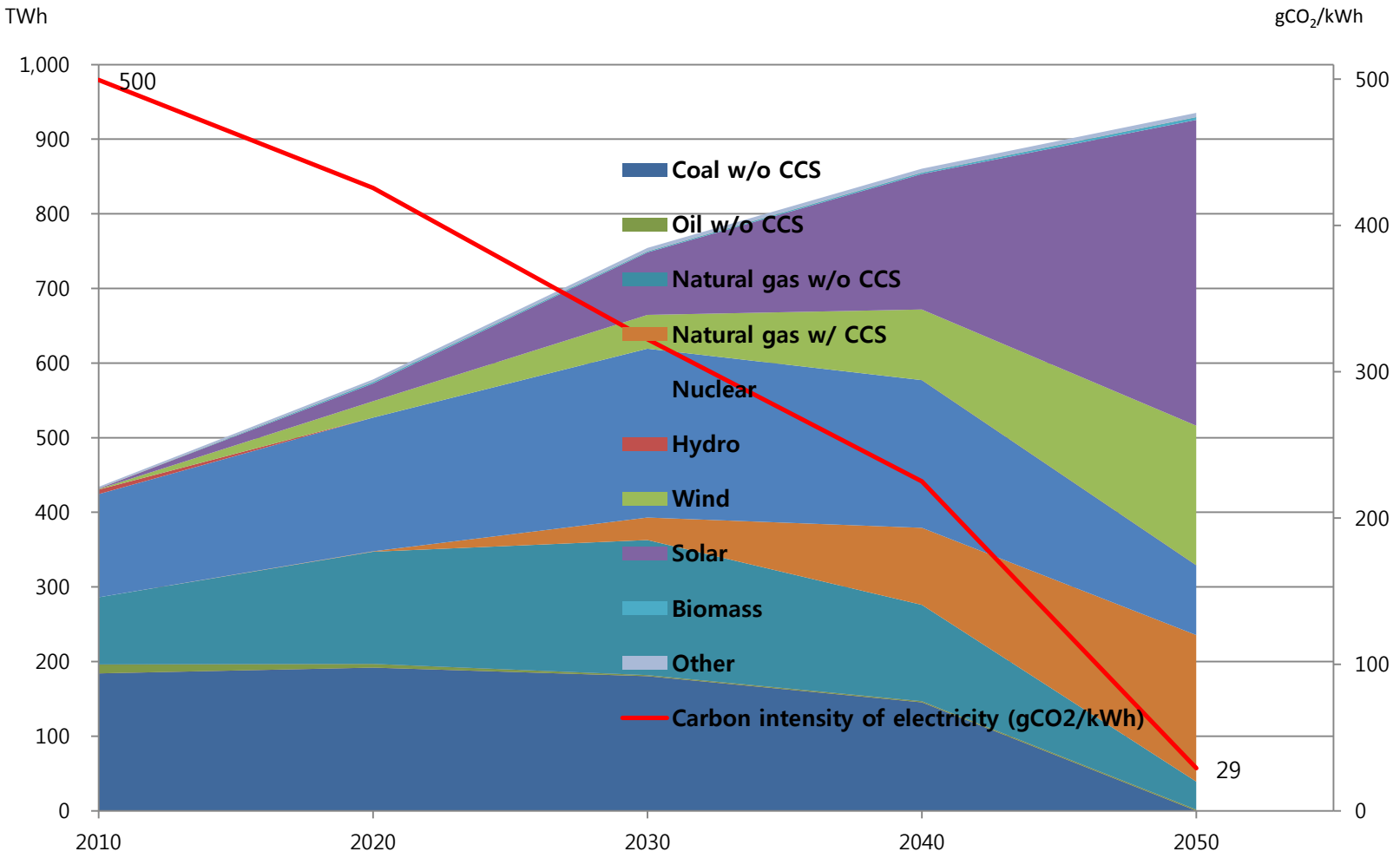


- In this high renewable scenario for electricity generation, the intermittency problem presents a major challenge.

- Improved smart grid and electricity storage technologies will have to be deployed at scale in order to cope with the intermittency of the renewables.

- But huge installations of 228 GW solar and 71 GW wind plants will be met by difficulties with appropriation of the necessary sites and public concerns with possible local environmental problems.

Electricity Generation by Energy Source and Emission Coefficient



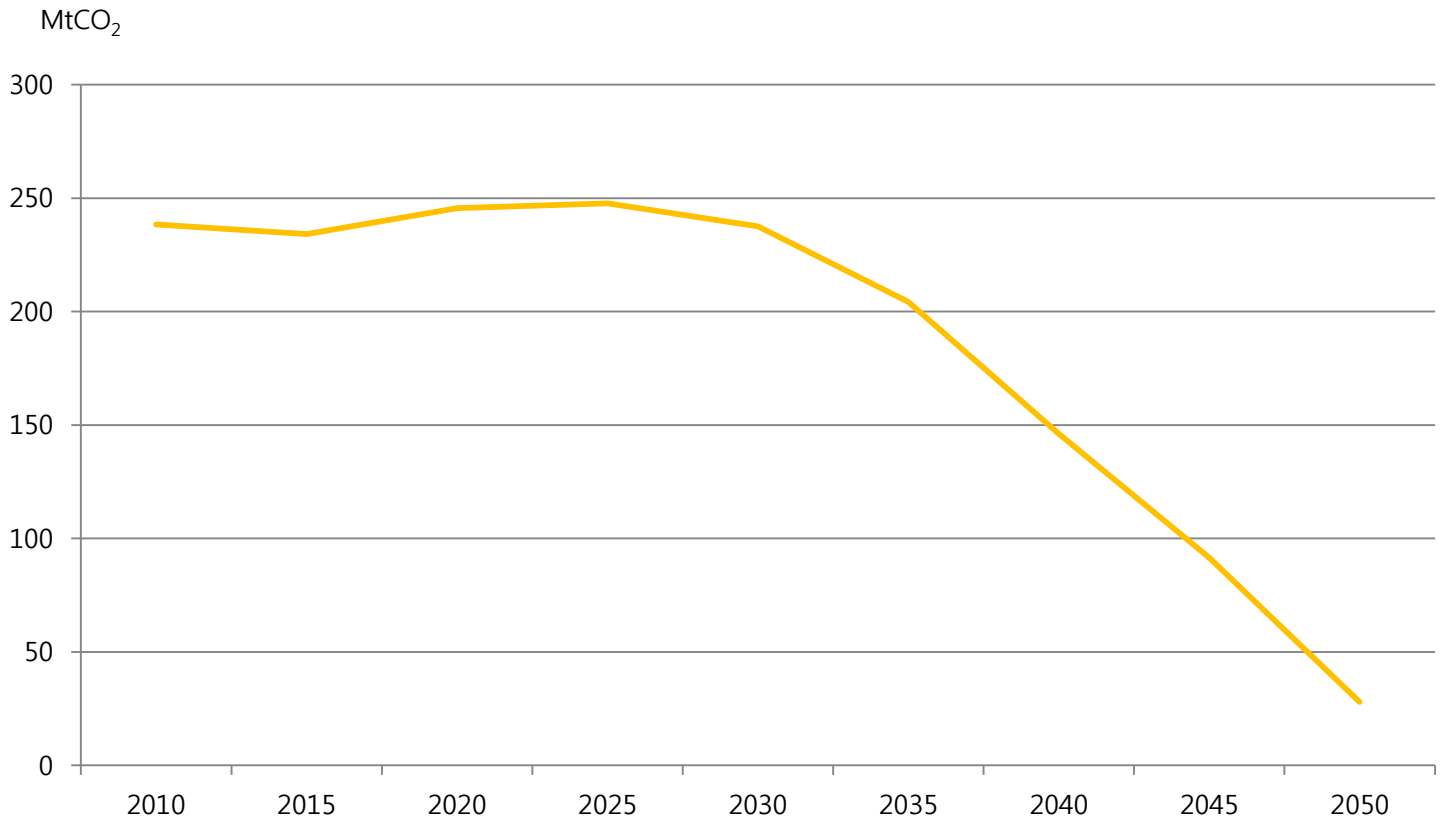
3. High Nuclear and Low CCS Scenario (Controversial Pathway)

- Share of nuclear power increases from 31% of electricity in 2010 to 43% in 2050 while due to the highly uncertain availability of the storage space for captured carbon, the combined share of coal and LNG has been decreased to 8% of electricity, with those fossil fuels accompanied by CCS accounting for only 2.5%p.

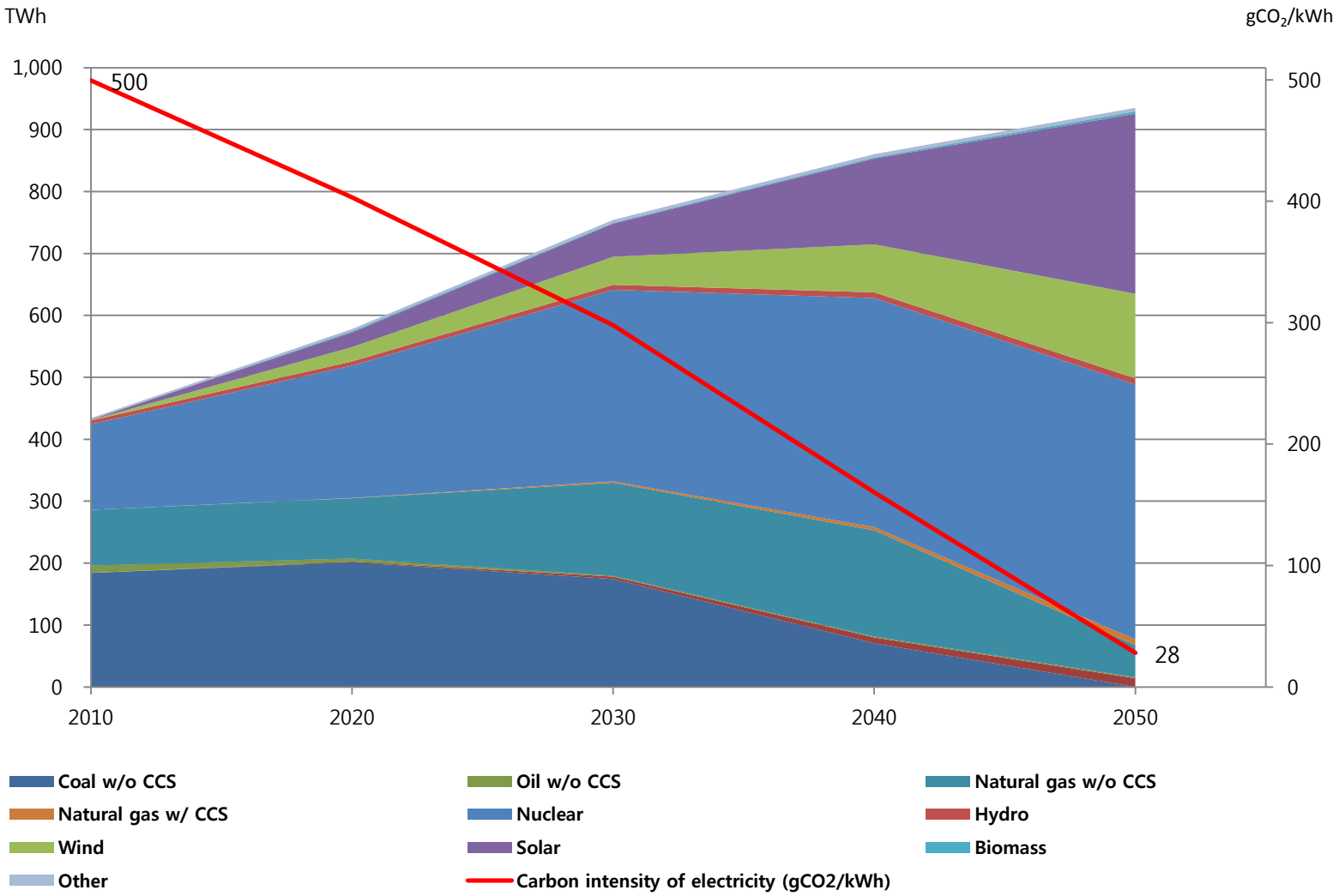
- The resulting balance has been met with expansion of nuclear power to 52GW in terms of capacity.

- This will be a politically highly controversial pathway due to an increasing public concern with the safety of nuclear power generation.

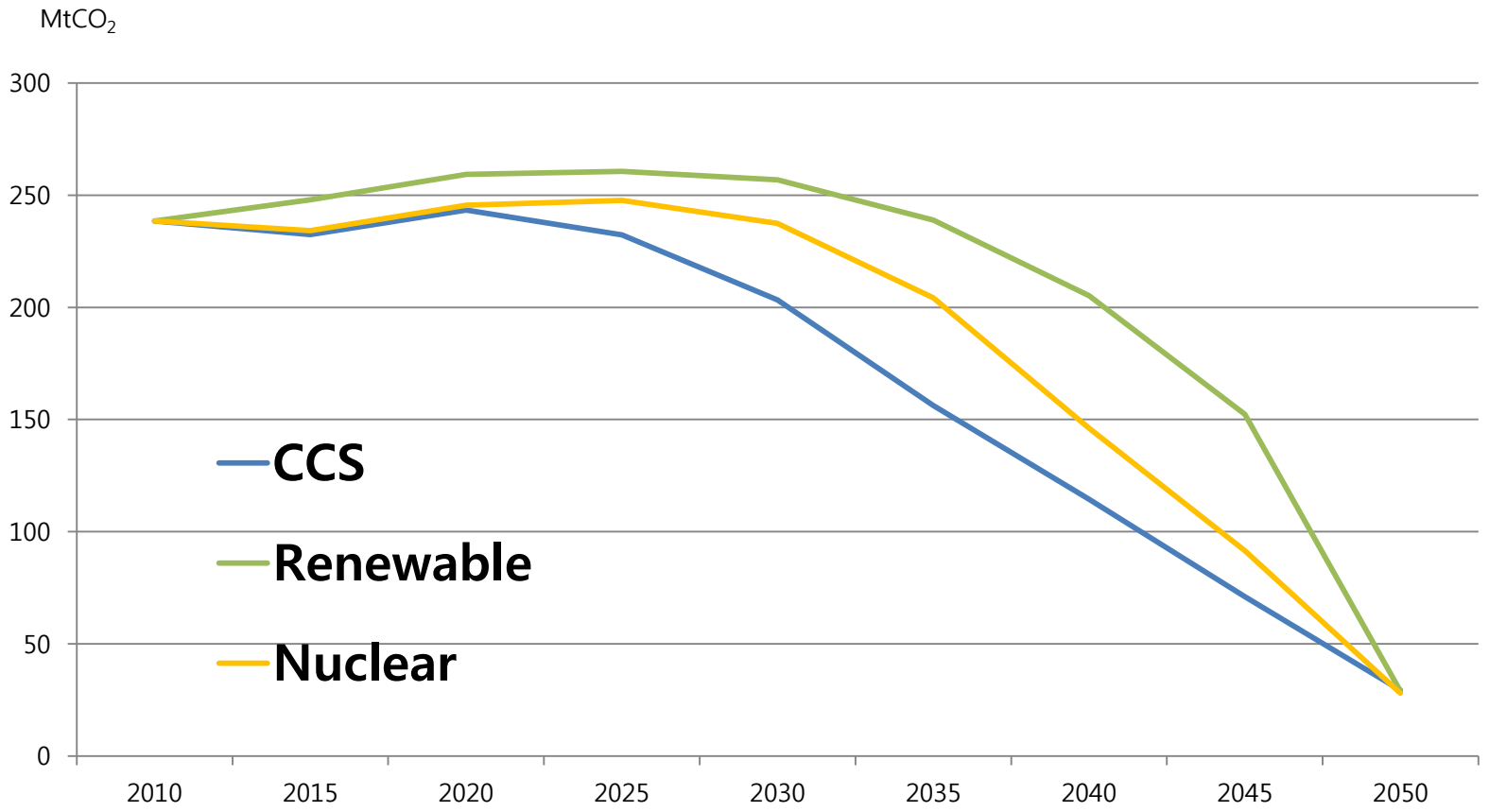
Emission Pathway from Electricity under the High Nuclear Scenario



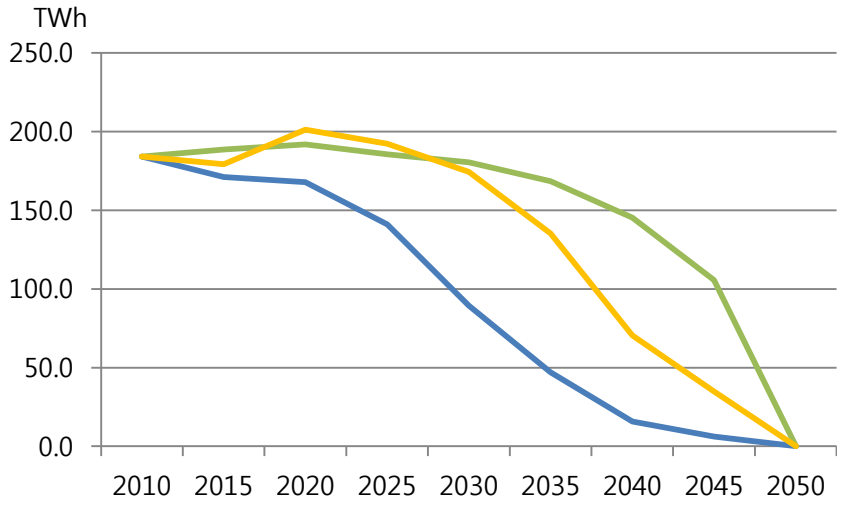
Electricity Generation and Emission Coefficient under the High Nuclear Scenario



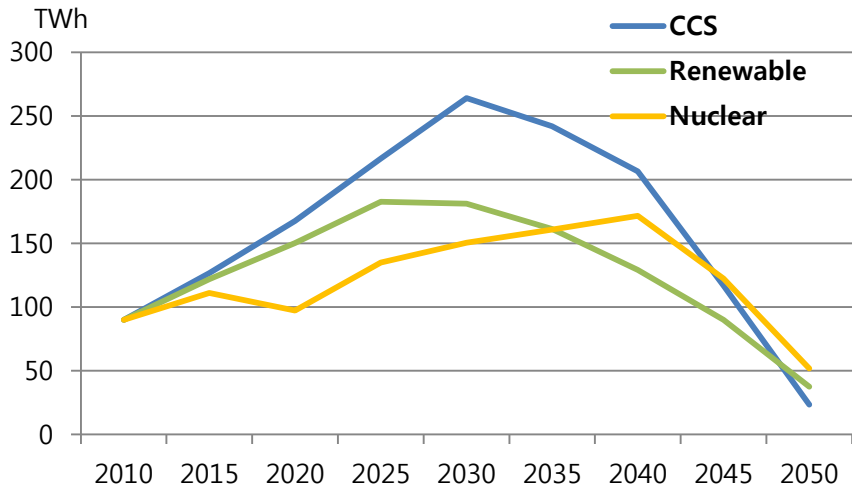
CO2 Emission Pathway by Scenarios



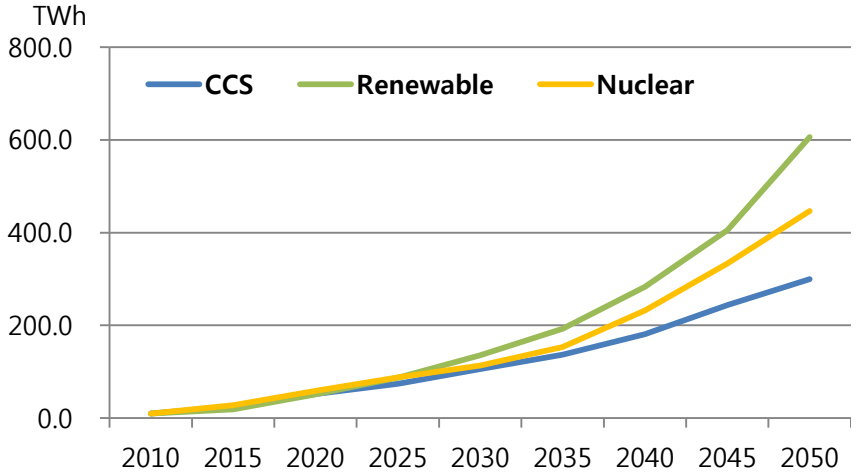
Coal-fired Power Generation Pathway



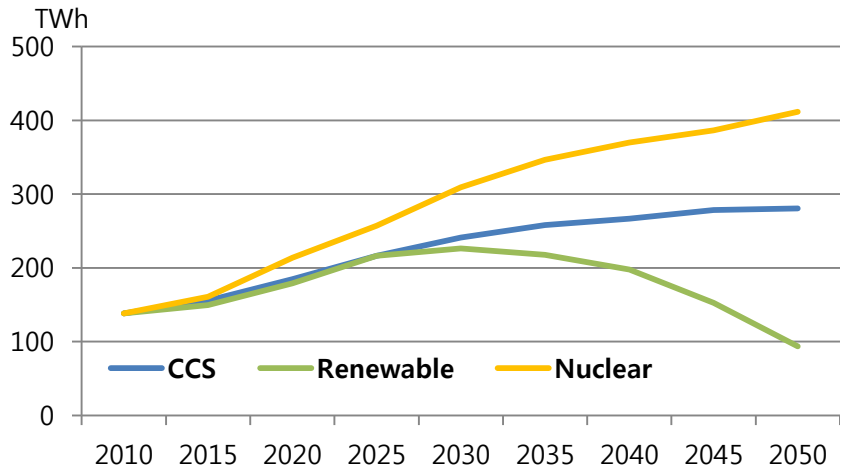
LNG-fired Power Generation Pathway



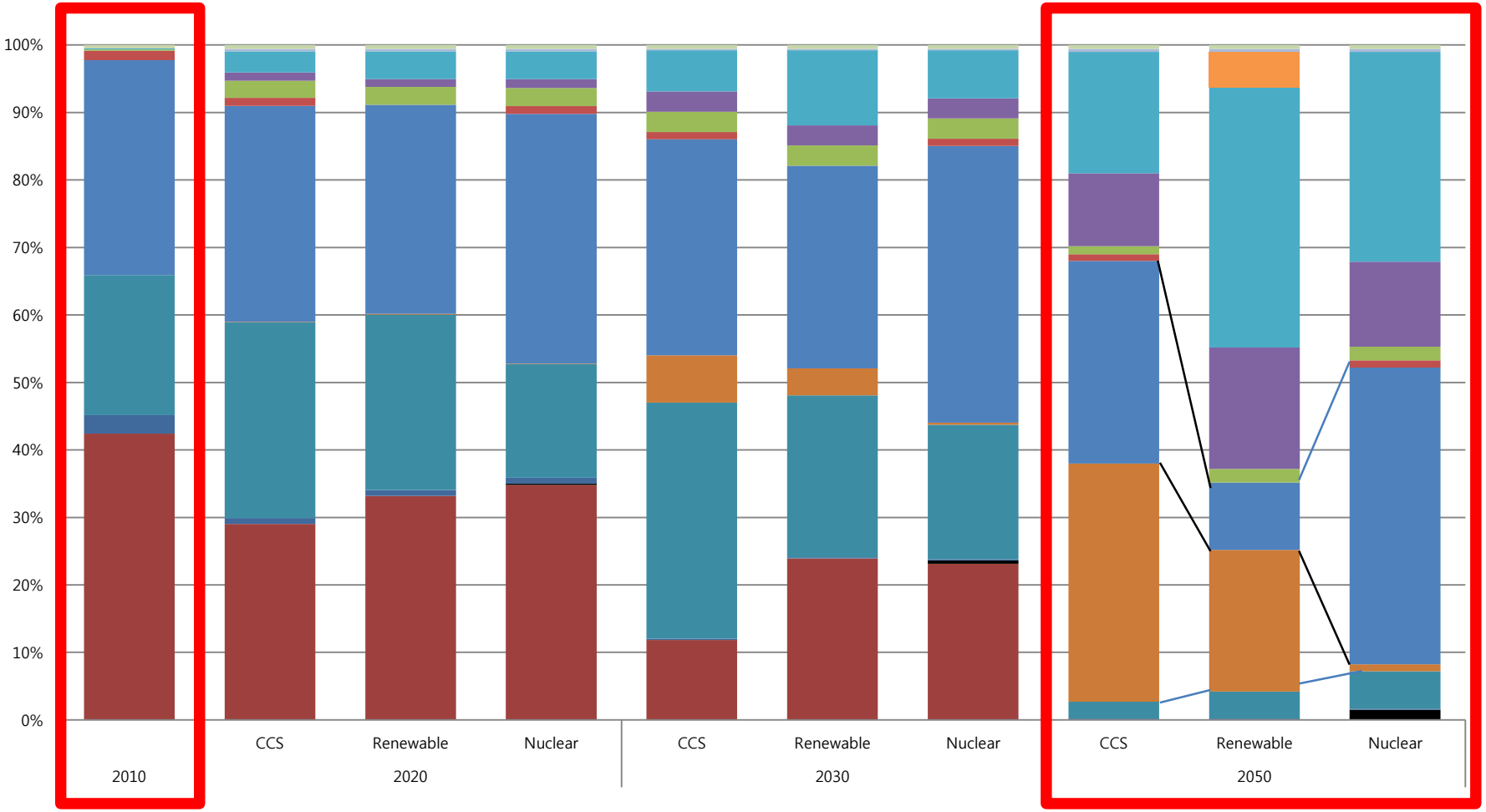
Renewable-fired Electricity Generation Pathway



Nuclear Electricity Generation Pathway



Comparison of Three Scenarios for Deep Decarbonization of Electricity in terms of the Fuel Mix



Potential issue & topics

1. Co-benefits (air quality, etc.)
2. DD and urbanization
3. DD and emissions-intensive materials & heavy industry & exporting economies
4. Global support for national policies: R&D cooperation, carbon pricing rules, emissions trading
5. Necessary modelling methodological advances
6. Uncertainty and dynamic pathway adjustment