Overview of the DNE21+ Model

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1. Features

○ The Model allows the quantitative approach to the complicated relationships and consistent analyses under the assumed preconditions.

○ When emission restrictions are not applied, in the case of Business as Usual (BaU), given the costs of the final energy demand and individual technologies, the model specifies the consistent energy systems (e.g., energy flows, capacities of energy related facilities) whose costs are minimized. When emission restrictions are applied, as to the final reduced energy demand due to rising prices, the model specifies the energy systems whose costs are minimized, meeting the demand

○ Salient features of the model include (1) long term analysis until 2050, (2) analysis of regional differences by the fine regional segregation while maintaining other global issues consistent, and (3) detailed evaluation of global warming measures.

○ The evaluation target is based on CO_2 from the energy sector.

○ Future uncertainties such as energy related security etc. are not taken into account.

2. Model Structure

○ Total worldwide energy system costs for the period from 2000 to 2050 are minimized (an optimization type (linear programming model)).

○ Eight representative time points are used for optimization: 2005, 2010, 2015, 2020, 2025, 2030, 2040, 2050 (2005 represents the period from 2003 to 2007, 2010 represents the period from 2008 to 2012, 2015 represents the period from 2013 to 2017 and so on).

○ The world is divided into 54 regions (America, Canada, Australia, China, India, Russia are divided into further small regions, making a total of 77 regions).

○ Technological costs and energy efficiency of energy supply technologies (various power generation technologies, oil refinery, coal gasification technology, etc.) and carbon dioxide capture, storage and sequestration are explicitly modeled ("Bottom-up approach").

○ Energy Demand Technologies
   · Costs and energy efficiencies of technologies used in energy intensive industries such as steel, cement, paper & pulp, aluminum, some groups of the chemical industry (ethylene, propylene production in the petrochemical industry and ammonia production), transportation (automobiles) and several groups of residential & commercial sector are explicitly modeled ("Bottom-up approach").
   · Other sectors, aggregated into energy demand of fuel types are modeled, without considering specific technologies ("Top-down approach").

○ Interregional transportation of energy (coal, oil natural gas, synthetic oil, ethanol, electrical power and hydrogen) and CO_2 are incorporated in the model.

○ Eight types of primary energy are considered (coal, oil (conventional and unconventional), natural gas (conventional and unconventional), hydro power and geothermal, nuclear, wind power, photovoltaics and biomass).

○ Except for sectors modeled in the bottom-up approach, the final energy demands are divided into four macro types (solid energy demand, liquid energy demand (gasoline demand, light oil demand, heavy oil demand), gaseous energy demand and electricity demand.

○ Electricity demand is modeled so that supply-demand balance is ensured; four kinds of time periods are set based on annual load duration curves, and electricity supply follows varying loads.

○ Various energy conversion processes (various types of electricity generation, coal gasification and liquefaction, natural gas reforming and the like) and carbon dioxide capture, storage and sequestration (CCS) are modeled.
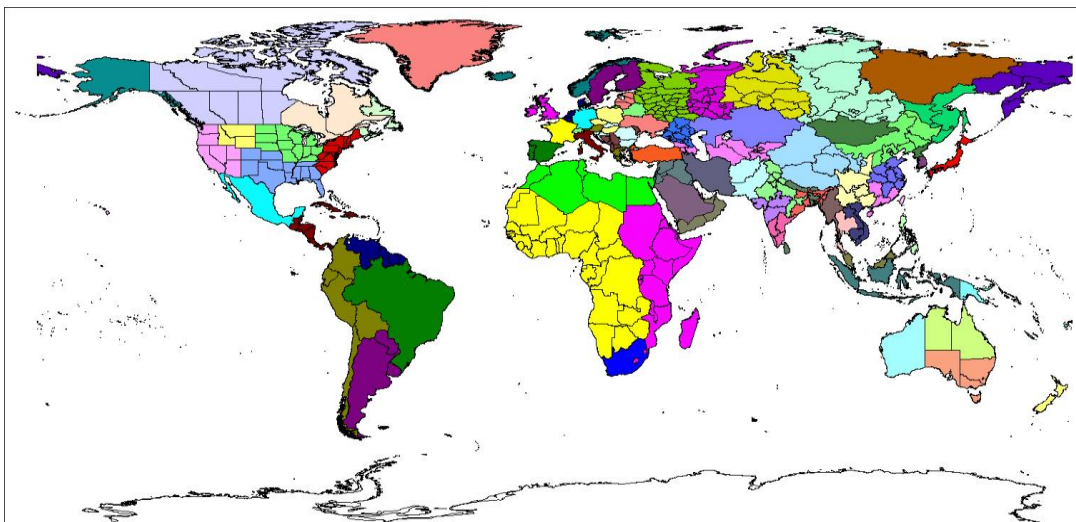

Fig.1: Global regional division in DNE21+

Table 1 Detailed list of global regional division in DNE21+

	DNE21+ Region	Country	Annex I	OECD	EU15	ASEAN
1	United States	United States US Virgin Island Guam Puerto Rico	Y	Y		
2	Canada	Canada	Y	Y		
3	United Kingdom	United Kingdom	Y	Y	Y	
4	France	France Monaco	Y	Y	Y	
5	Germany	Germany	Y	Y	Y	
6	Italy	Italy San Marino Vatican city	Y	Y	Y	
7	Spain, Portugal	Spain Portugal Azores (Port.)	Y Y	Y Y	Y Y	
8	Belgium Netherlands Denmark	Belgium Netherlands Denmark	Y Y Y	Y Y Y	Y Y Y	
9	North Europe	Sweden Finland	Y Y	Y Y	Y Y	
10	Other EU	Austria Ireland Greece Luxembourg	Y Y Y Y	Y Y Y Y	Y Y Y Y	
11	Norway, Iceland	Norway Iceland	Y Y	Y Y		
12	Greenland (Denmark)	Greenland				
13	Other Western Europe	Switzerland Liechtenstein Malta Andorra Faeroe Islands Gibraltar	Y	Y		
14	Japan	Japan	Y	Y		
15	Australia	Australia	Y	Y		
16	New Zealand	New Zealand	Y	Y		
17	Other Oceania	Papua New Guinea Fiji French Polynesia Kiribati Nauru New Caledonia Solomon Islands Tonga American Samoa Vanuatu				
18	China	China Hong Kong				
19	North Korea Mongolia	Democratic People's Republic of Korea Mongolia				
20	Viet Nam Cambodia Laos	Viet Nam Cambodia Lao People's Democratic Republic				Y Y Y
21	Korea	Korea		Y		
22	Malaysia Singapore	Malaysia Singapore				Y Y
23	Indonesia	Indonesia				Y

		East Timor				
24	Thailand	Thailand				Y
25	Philippines	Philippines				Y
26	Brunei	Brunei				Y
27	Chinese Taipei	Taiwan Province of China				
28	India	India				
29	Pakistan Afghanistan	Pakistan Afghanistan				
30	Myanmar	Myanmar				Y
31	Other Asia	Bangladesh Nepal Bhutan Sri Lanka Maldives				
32	Iran	Iran				
33	Saudi Arabia	Saudi Arabia				
34	Bahrain, Oman Qatar, UAE Yemen	Bahrain Oman Qatar United Arab Emirates Yemen				
35	Other Middle East	Iraq Kuwait Jordan Israel Lebanon Syrian Arab Republic Cyprus				
36	Turkey	Turkey		Y		
37	North Africa	Egypt Libyan Arab Jamahiriya Tunisia Algeria Morocco				
38	South Africa	South Africa				
39	South East Africa	Sudan Eritrea Djibouti Ethiopia Somalia Kenya Uganda Rwanda Burundi United Republic of Tanzania Malawi Mozambique Swaziland Lesotho Madagascar Seychelles Comoros Mauritius Reunion				
40	Other S. S. Africa	Angola Benin Botswana Burkina Faso Cameroon Cape Verde Central African Republic Chad				

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		Congo Cote d'Ivoire Democratic Republic of the Congo Equatorial Guinea Gabon Gambia Ghana Guinea Guinea-Bissau Liberia Mali Mauritania Namibia Niger Nigeria Sao Tome and Principe Senegal Sierra Leone Togo Zaire Zambia Zimbabwe Western Sahara				
41	Mexico	Mexico		Y		
42	Other Central America	Bahamas Bermuda Cuba Jamaica Haiti El Salvador Guadeloupe Saint Vincent and the Grenadines Grenada Dominica Dominican Republic Saint Lucia Saint Kitts and Nevis Barbados Antigua & Barbuda Netherlands Antilles Trinidad and Tobago Guatemala Belize Honduras Nicaragua Costa Rica Panama				
43	Brazil	Brazil				
44	Venezuela Guyana Suriname	Venezuela Guyana Suriname French Guiana				
45	Paraguay Uruguay Argentina	Paraguay Uruguay Argentina				
46	Other South America	Colombia Ecuador Peru Bolivia Chile				
47	Russia	Russian Federation	Y			
48	Other Annex I of	Ukraine	Y			

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	FUSSR	Estonia	Y			
		Latvia	Y			
		Lithuania	Y			
49	Belarus	Belarus				
50	Kazakhstan	Kazakhstan				
51	Other FUSSR	Kyrgyzstan				
		Tajikistan				
		Turkmenistan				
		Uzbekistan				
		Armenia				
		Azerbaijan				
		Georgia				
52	OECD E. Europe	Hungary	Y	Y		
		Poland	Y	Y		
		Czech Republic	Y	Y		
53	Other Annex I of East Europe	Bulgaria	Y			
		Romania	Y			
		Slovakia	Y			
		Croatia	Y			
		Slovakia	Y			
54	Other E. Europe	Serbia and Montenegro				
		Former Yugoslavia				
		Albania				
		Bosnia and Herzegovina				
		Republic of Moldova				
		Former Yugoslav Republic of Macedonia				
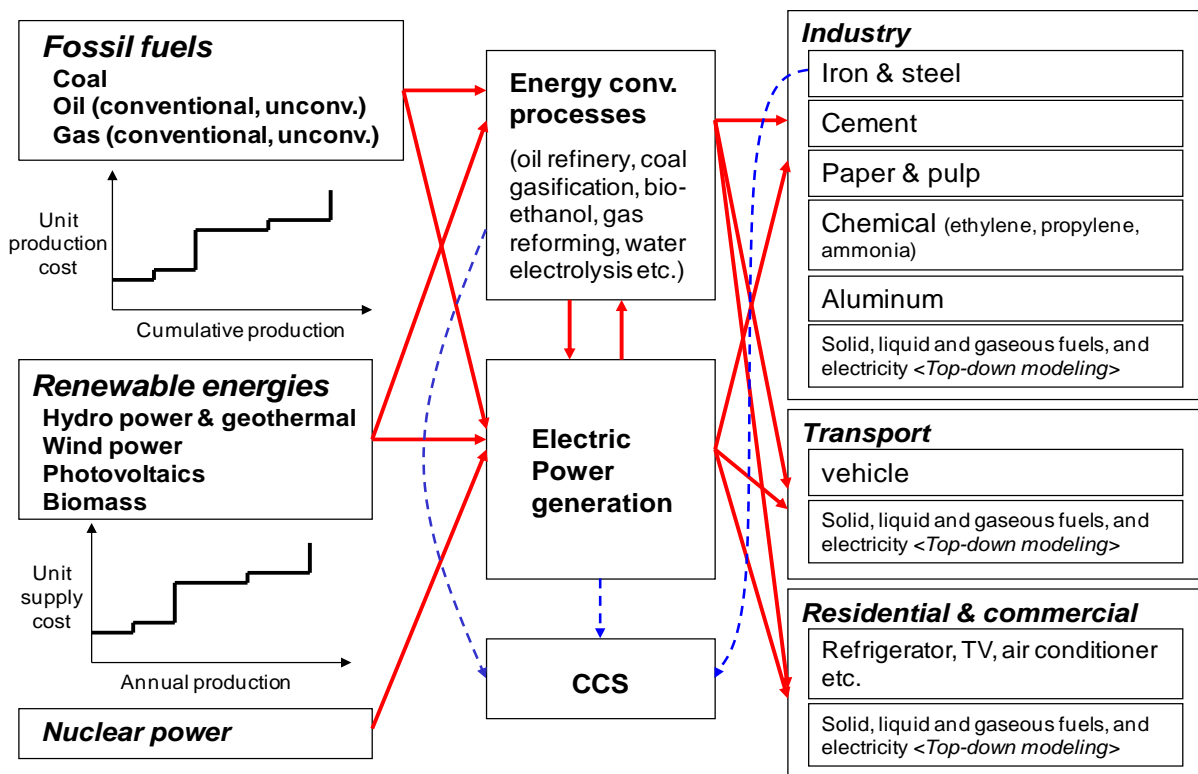
Fig.2 Outline of energy flows in DNE21+

3. Glossary of Terms and Units

3.1 Terms

BaU: Business as Usual, forecast without any specific restriction on CO2 emissions. Even in the absence of such restriction, measures for restricting CO2 emissions may be indirectly adopted, due to the progress of the technologies, or the change of technology choices caused by price increase of oil and others.

3.2 Units

toe : tons of oil equivalent
Mtoe : Million tons of oil equivalent
TWh : terawatt-hour, 1TWh = 0.086 Mtoe

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