Carbon Neutrality + DX = Future Society

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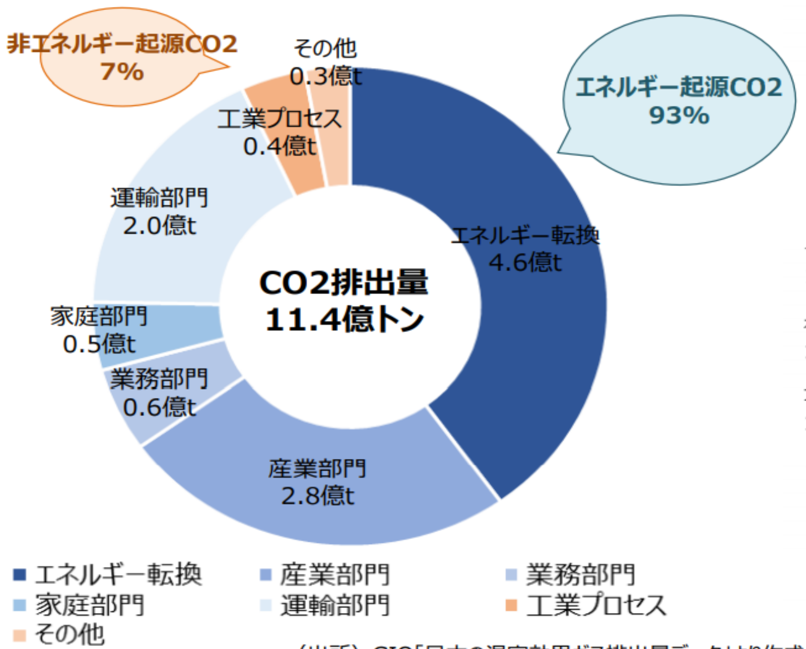
1． Carbon Neutrality and Japanese Industries (1)

● 日本のCO2排出量は、世界で５番目。CO2排出の内訳の太宗はエネルギー起源が占める。

Japan's CO2 Emission (2018)

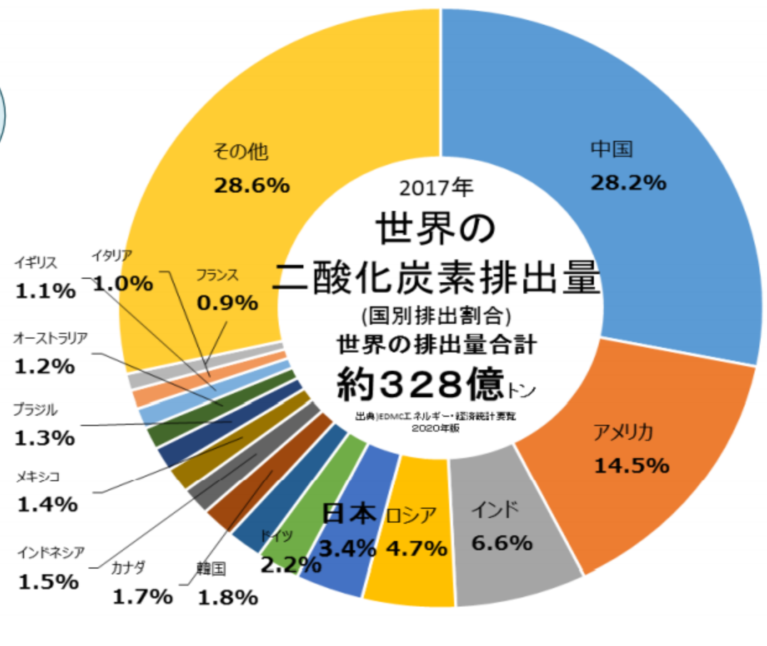
- Energy Conversion
  460 Mil. ton
- Industry
  280 Mil. ton
- Transportation
  200 Mil. ton
- Office
  60 Mil. ton
- Household
  0.5 Mil. ton

日本のCO2排出量（2018）



（出所）GIO「日本の温室効果ガス排出量データ」より作成

世界のCO2排出量（2017）



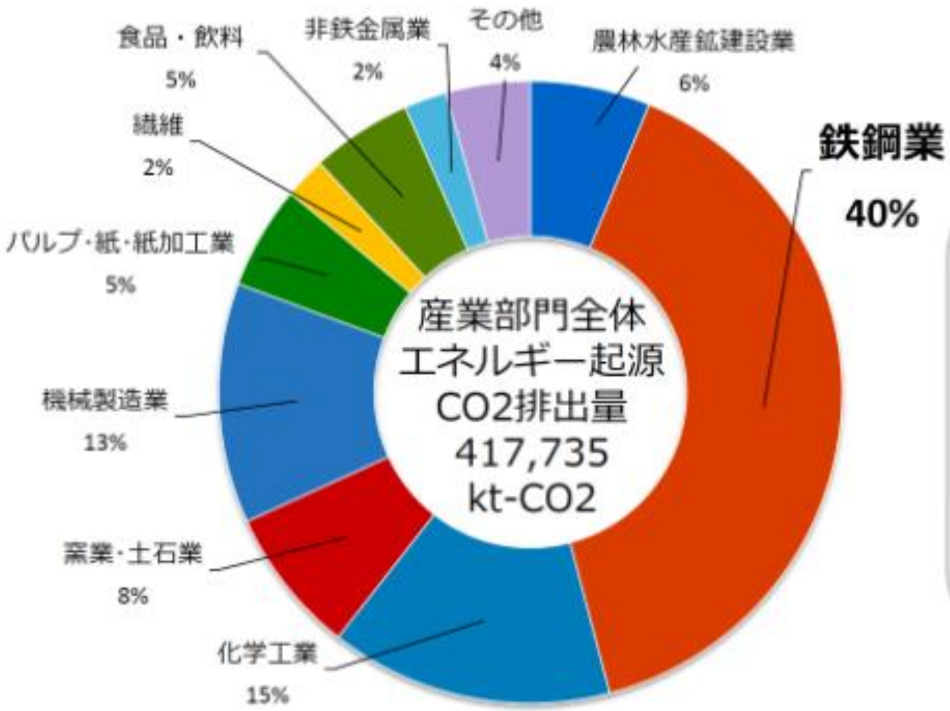
出典）温室効果ガスインベントリオフィスより作成

World CO2 Emission Ranking (2017)

1) China (28.2%)
2) USA (14.5%)
3) India (6.6%)
4) Russia (4.7%)
5) Japan (3.4%)
6) Germany (2.2%)

【Fig. 1】Japan's CO_2 Emission (2018) and World CO_2 Emission Ranking（2017） (Source: METI)

2．Carbon Neutrality and Japanese Industries (2)



GHG(CO2)排出量
(kt-CO2)

- 国 全 体 ：1,306,670
- 産業部門： 417,735
- 鉄 鋼 業 ： 165,741

Japan's Total GHG(CO2) Emission (2016)

= 1,306,670 kt-CO2eq

1) Iron/steel (40%)

2) Chemical (15%)

3) Machinery (13%)

4) Cement/Glass/Ceramics (8%)

5) Pulp/paper (5%)

（出典）国立研究開発法人国立環境研究所「日本の温室効果ガス排出量データ（2016）」

【Fig. 2】Breakdown of Japan's CO_2 Emissions from Industry（2016） （Source : National Inst. for Environmental Studies)

3. Four Directions for Achieving Carbon Neutrality

1） Decarbonization of Energy Supply Sector

～ Promoting renewable energies, Fuel conversion（Fossil to Hydrogen）～

2） Decarbonization of Energy-intensive Industries

～ Process innovation and development of substitute materials for, iron/steel, chemical, cement/glass/ceramic, and paper/pulp industries ～

3） Social Structure Reform and Energy Conservation

～ Office/school/home, transportation/logistics, supply of water/food/energy ～

4） CO_2 Fixation

～ CCS（Carbon Capture and Storage）/CCUS(Carbon Capture, Usage, and Storage), CO2 absorption by forests and coral reefs, etc. ～

4. Process Innovation for Energy-intensive industries

1) Iron/steel: Replace coke (C) by hydrogen (H) for reduction process

→ Challenge: Complete replacement difficult because Hydrogen process is 吸熱反応

2) Chemistry: Establish Non-carbon(naphtha)-based Chemistry

→ Is it possible to increase input of biomass-derived and recycled raw materials?
Challenges: Availability of raw materials/cost/energy input-output ratio （エネ収支）

3) Cement/glass/ceramics: Require new processes without high temp.

→ Challenges: CO_2 can be utilized as raw material for cement? Increase inputs of recycled raw materials? If manufactured under normal temperature, it is the ideal.

＞＞ Disruptive process innovation is required. AI and data science are indispensable.

【Ref.】R&D and Demonstration of New Technology by Iron/steel Industry

【Photo】Experimental/demonstration Furnace by a consortiums composed of iron/steel manufacturers and NEDO (@Kimitsu)
(Source : Iron and Steel Association of Japan HP)

5. Development of New Substitute Materials

1） Iron/steel: Is it possible to make buildings, railroads/roads and automobiles without steel?

→ Requires alternative materials with strength, heat resistance, moldability and low cost

2) Chemistry: Is it possible to realize non-carbon-based chemical materials?

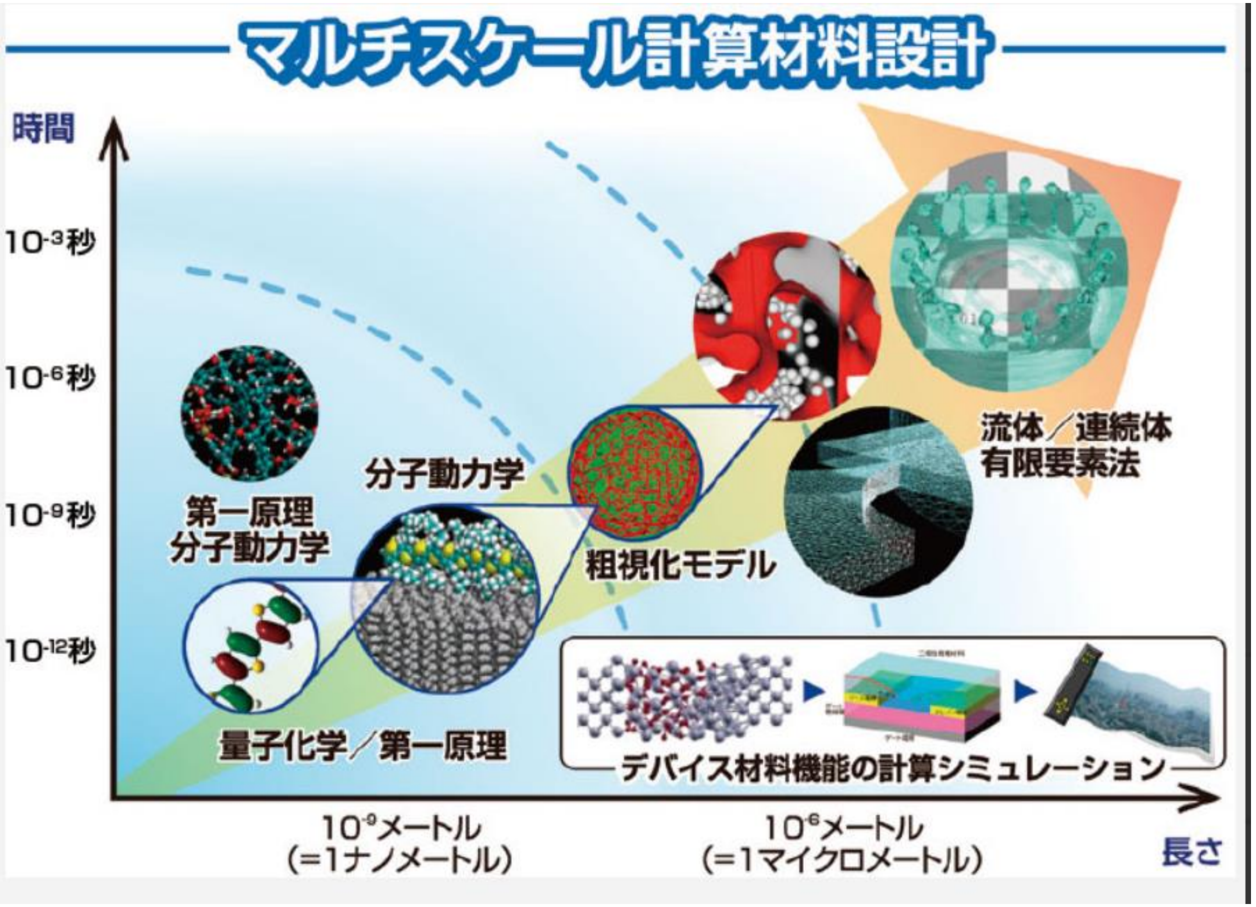
→ What is the primary element, if not Carbon?
Requires a paradigm change from the current academic/industrial structure of chemistry

3） Cement/glass/ceramics:

→ Glass, ceramic and cement are the most familiar materials in human's history.

＞＞ Revolutionary product innovation is required. AI and data science are indispensable.
～ "Intelligent manufacturing" without trial-and-error type of experimental research

【Ref.2】R&D for New Materials with DX



Conceptual illustration of "Multi-scale computational Material Design" by AIST

Vert. axis = time scale (sec)
Horiz. Axis = dimension (m)

- Quantum Chemistry
  / First-principles calculation
- Molecular Dynamics
  / First-principles calculation
- Coarse Graining Model
- Fluid/continuum Mechanics
  + Finite Element Method

【Fig.3】Material design by computations illustrated by AIST Center for Computational Design of Advanced Functional Materials（Source : AIST (Research Inst. of Advanced Industrial Science and Technology) HP）

6. Social structure reform (office/home/factory)

1) Do we really need "offices" and "schools"?

→ COVID-19 pandemic revealed remote work/education is possible for the “most” of our workplaces and schools.

2) What shall we do for places where teleworking is difficult?

→ Factory: Robotization + IoT
→ Logistics: Robotization + autonomous driving and mobility
→ Primary industry sites: Robotization + IoT
→ Shops: Robotization + AR+VR + delivery
→ Science/engineering schools with laboratories (experiments) : AR+VR-assisted class

＊Not every listed things need to be automated. However, it would reduce a considerable amount of people’s flow and logistics. It is useful not only for protecting against infectious diseases, but also for decarbonizing society.

DX is the key to the social reform.

7. Social structure reform (Social infrastructure)

1) Transportation/logistics/community development

→ Connecting "compact cities" (some thousands of people ?)
→ EV as a mobility within a community, live-close-to-office or teleworking from home

2) Water, food and energy supply

→ A locally connected small grid based on renewable energies
(For the time being, a large-scale infrastructure is necessary as a base power source.)
→ Especially for water supply and food production, communities should be connected to a large supply area.

3) Medical care, education, and other basic services

→ Mainly remote operation, but with a large-scale and higher level facilities is required within a certain distance.

＊**DX** is the key to the development and operation of these social infrastructures.

Now, you may be aware that

Carbon Neutrality + DX = Future Society

Thank you very much for your attention.