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DE-CNturmoil

(Carbon Neutrality and Sustainability Design of Concrete Structures)

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Development of Cement/Concrete Technology

- ***John Smeaton*** **used hydraulic lime as a joint material for granite blocks in the construction of a lighthouse in *1756*.**
- ***Joseph Aspdin*** **was granted a patent for the method of producing hydraulic cement in *1824*.**
- ***Isamu Hiroi*** **began "100-Year Mortar Durability Tests" in *1897*.**
- **There has been a great development until today,** however **coal** has been used to manufacture cement. Steel production is the same.

De-CarbonNeutralityTurmoil

- **This presentation clarifies what to do now with a clear vision on the nature of the turmoil concerning carbon neutrality in the field of cement/concrete and discusses measures to take steps forward towards this historic transformation to CN.**

What is concrete？

- ***Concrete*** is a quite simple material that combines ***aggregate***, which accounts for about **70%** of its volume, with cement hydrates. Aggregate is the most abundant material on the earth, and so is ***water***, which is necessary for hydration of ***cement***. ***Limestone***, a raw material of cement, is a substance that has been produced by living organisms over a long time.
- Thus, ***”concrete has the characteristic of a material that can be used in large quantities.***

Global Warming and Carbon Neutrality

- Modern society has been created by the use of fossil fuels.
- It is causing a global warming.
- Then, human being has decided not to use fossil fuels, to realize "carbon neutrality," in the future.

Sustainability

- **UN Definition of Sustainable Development,**

"meets the needs of the present without compromising the ability of future generations to meet their own needs" (*Our Common Future,1987*).

"The goals of *economic* and *social* development must be defined in terms of sustainability." The *environmental* capacity has its limitations.

Thus, "sustainability" can be evaluated through environmental, social and economic aspects, which was confirmed in the East Japan Great Earthquake (2011/3/11) *****Sustainable use of concrete, CRC Press*

How to Realize Sustainability in Concrete Structures?

- **Conceptual design,** in which BATs and their alterations are taken into account
- **Extraction of performance requirements** on social, economic and environmental aspects

- Social aspects → safety, resilience, aesthetics, etc. (ACI Building Code, fib MC and others)

- Economic aspects (budget) for LCM (fib MC)

- Environmental aspects → climate change (CO_2), NR, wastes, contaminations, others (fib MC, ISO13315 series)

Carbon Neutrality Turmoil

- **Paris agreement** was adopted in 2015 (COP21), a global plan to keep temperature increases well below 2℃ above pre-industrial levels, but pursue efforts to 1.5 ℃
- **COP28(2023):** away from fossil fuels
- There is no exception in concrete industry, but it seems there is still **some turmoil** in our industry, in which the essence of CN is not being understood.

COP28

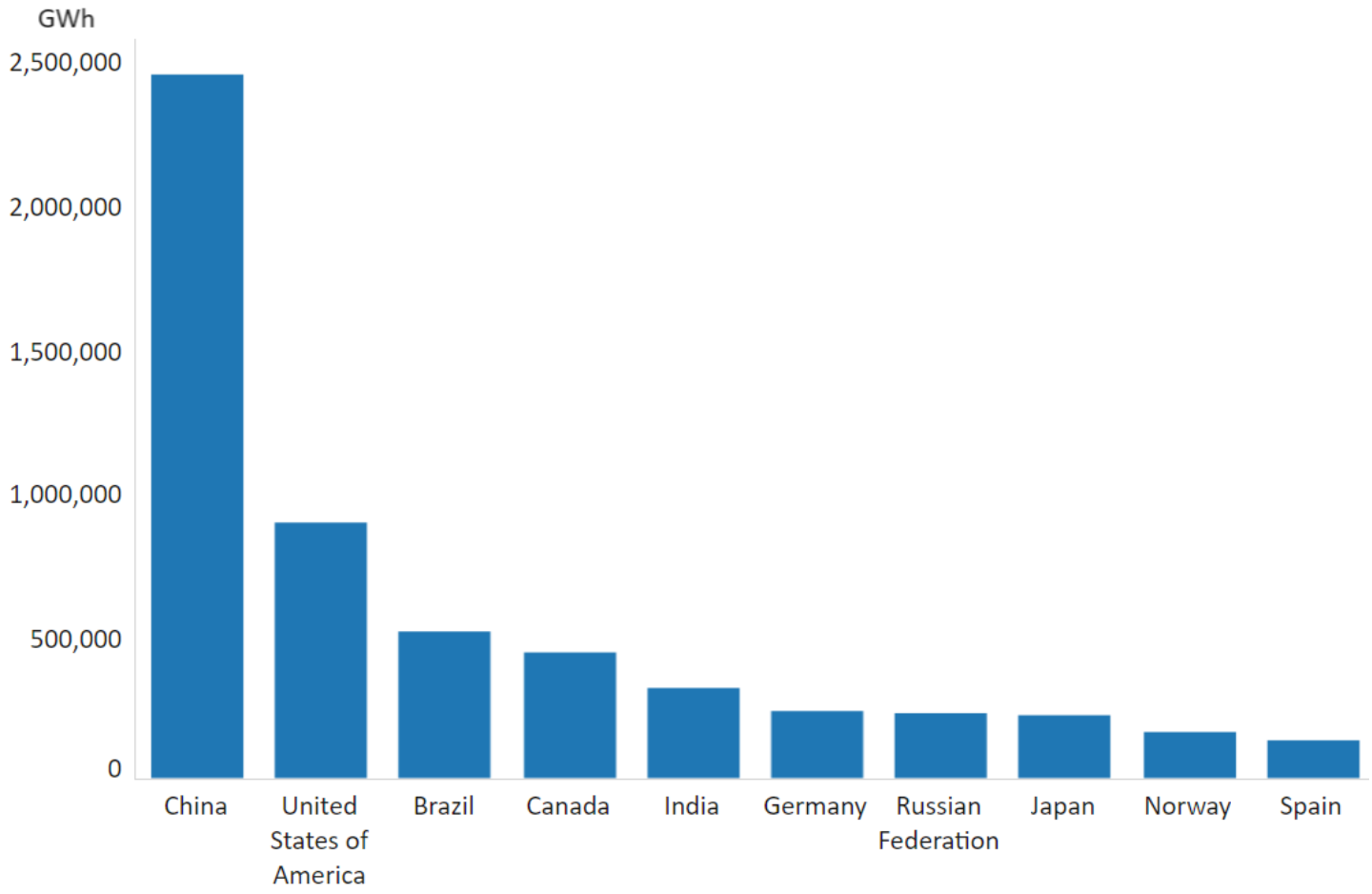
- From fossil fuels to renewable energy

- Targets by 2030

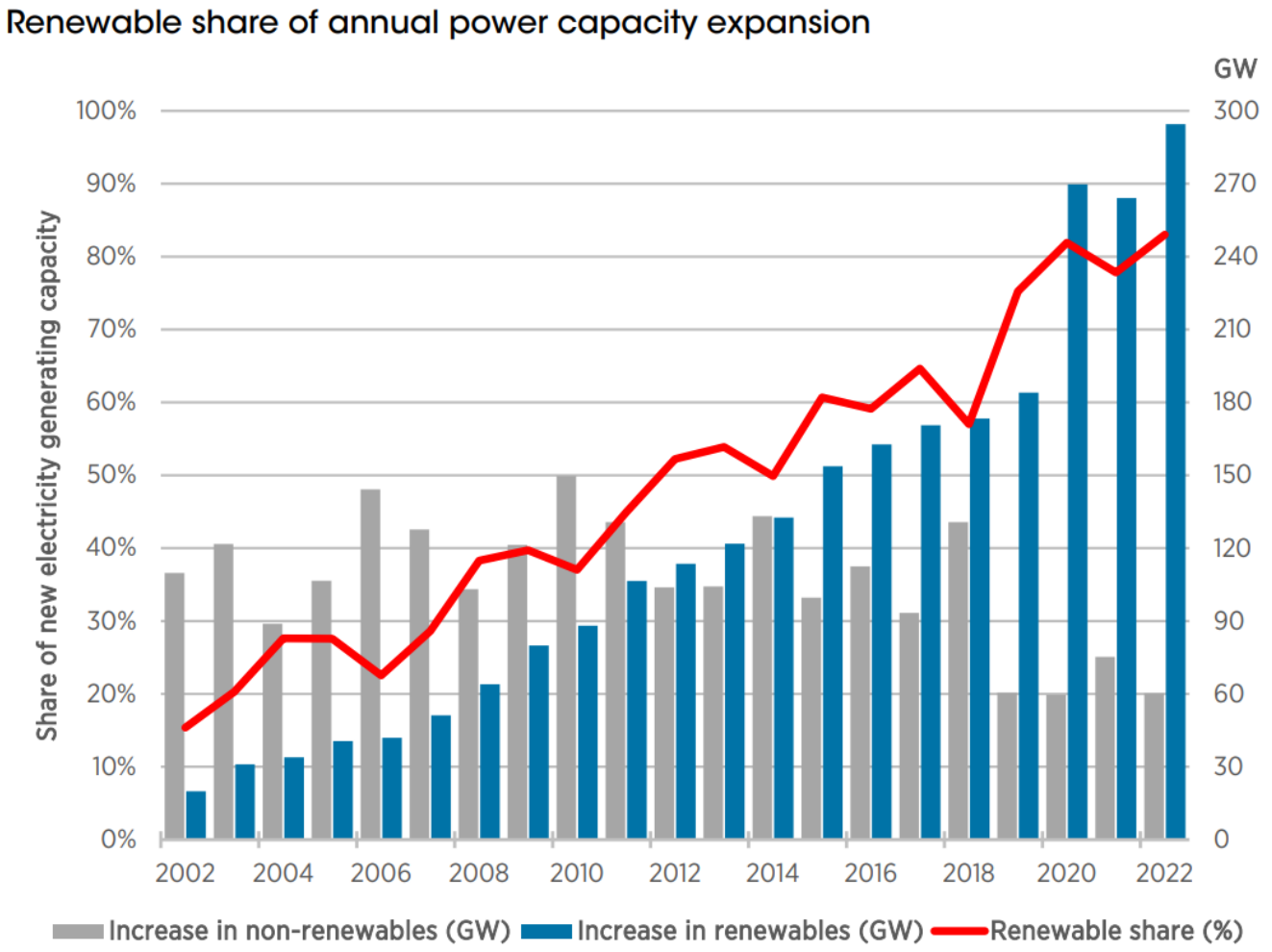
  -Tripling the renewable energy capacity

  - Doubling the energy efficiency

Renewable Energy Capacity
Top 10 Countries (IRENA)

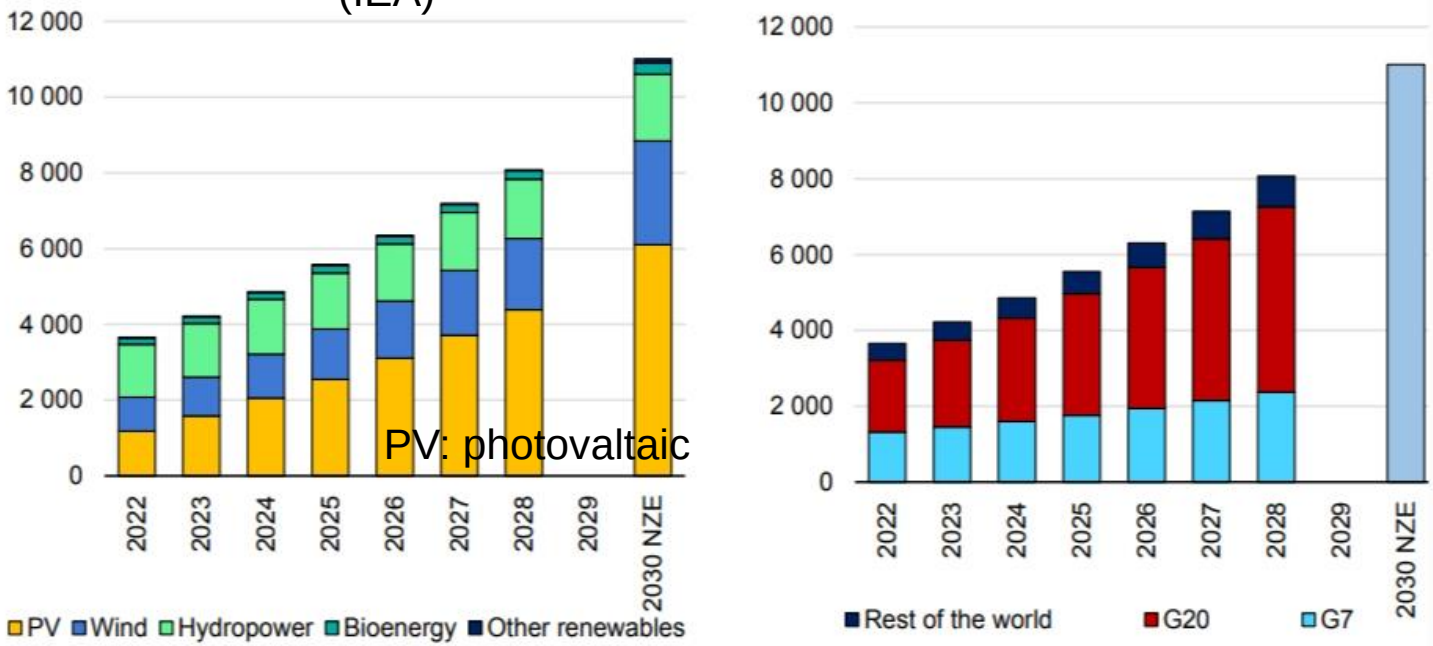


Renewable Share of Annual Power Capacity Expansion (IRENA)



Cumulative renewable electricity capacity in the accelerated case (2022-2028) and Net Zero Scenario (2030)

(IEA)



PV: photovaltaic

What is Essence of CN in Cement/Concrete?

- **Cement production inevitably generates large amounts of CO_2 from its raw materials and fuels.**
- **Therefore, reduction of clinker, use of SCMs, change of cement manufacturing by using new fuels like hydrogen, and/or CCUS of emitted CO_2 should be conducted.**
- **Rational *transition design* to avoid CNturmoil is necessary.**

Tools in Transition Design

- ***Hydrogen fuel***
- ***SCMs*** (Blast furnace slag, fly ash etc.)

  Possible replacement of BFS and FA into cement is 7.3% and 0.27%,respectively.
- ***CC(U)S***

  (U): methanation $CO_2+H_2 \rightarrow CH_4$
- ***Trees***, ***Oceans***

"***Combinations of each tool makes CN possible?***"

How to Reduce CO_2 from Cement Production by Using Each Tool

- **Amount of CO_2 emission from cement**
  4.4 bts x 788.6 kg-CO_2/t ＝ 3.47 bts
- Possible CO_2 reduction
  hydrogen 1.37 bts
  SCMs: 0.25 bts
  CCS: 0.52 bts (5.6 bts × 9.3% share for ct)
  CC(U)S (CO_2+H_2 → CH_4 ???)
- Remaining CO_2

  3.47-1.37-0.25-0.52 = 1.33 bts (3.4%!!!)

  Can we require to ignore this small amount?

If you want to think of trees and oceans?

- Additional CO_2 reduction
  - ✓ Trees: 1.18 bts
    12.64 bts × 9.3%(Cement sector share)
  - ✓ Oceans: 0.98 bts
    10.55 bts × 9.3%(Cement sector share)

Summary

	CO_2 emission	CO_2 reduction
Cement	3.47 bts	—
Hydrogen fuel	—	1.37 bts
SCMs	—	0.25 bts
CC(U)S	—	0.52 bts
Trees, Oceans	—	1.18 + 0.98 bts
Total	3.47 bts	4.30 bts C-negative!

Wildfires
Negative Cascading of GW

- 2023 Canadian wildfires

1.7 bts CO_2 emission (how about Texas fire)

*2022 CO_2 emissions in Canada, USA and Japan are 0.52, 4.8 and 1.0bts, respectively.

**2019 Fossil fuels(IPCC6thReport)

38.0 bts

***Cement manufacturing

3.47 bts → 2.08 if hydrogen is used

US EPA Energy Star Certificate

- 11 cement manufactures received the certificate, a prestigious recognition for being in the top 25% of energy efficiency (global Cement).
- It is important to change wasteful systems, but far from CN.

GX Bond in Japan (2023FY)

- *Hydrogen iron-manufacture*
- *EV battery manufacture*
- *Low-electricity semiconductor manufacture*

“Cement”?

Some plan for hydrogen and CCUS cement manufacture, but slow.

Concluding Remarks

- Cement/concrete technology accumulated over hundreds of years cannot be transformed overnight.
- Low cost has been the basis for conventional technical development. With carbon neutrality demanding a drastic change in the existing technological foundation, there is a need to make drastic changes to the framework of sustainability concerning society, environment, and cost.
- Forget illusion “innovation.” Electricity storage technologies will be needed.
- Nuclear fusion generation !?

Proposals

- We should encourage cement makers to change the production method to utilize a traditional wonderful cement for a sustainable human society, in which de-fossil fuel is used and emitted carbon is captured and used. The steel is the same, (but from blast furnace to electric furnace) .
- Then, concrete industry can concentrate on concrete technology.

What is the essence of our history and solution?

- *Our ancestors had regarded that the Earth is alive. However, what modern humans have conducted are its* ***exploitation*** *from it, its* ***enclosure*** *and* ***propertization(EEP)****.* (Jeremy Rifkin)
- We are facing to global warming and CN!
- The solution is very simple – to quit EEP

Airbus

- ZEROe (zero emission) project

  Hydrogen-powered commercial plane (2035)

From Airbus news

"Sustainability thought is a magic to simply deal with our problems!"
"We need to work properly without turmoil for next generation."

Acknowledgements

I thank you, Dr. Takeju Matsuka, for his help on numerical calculations on CO_2.