Center for Geothermal Energy Research (CGER)

Anders Nermoen and Fionn Iversen

16.02.2023

Norwegian Center for Geothermal Energy Research

09:00 Oppmøte / frokost

09:25: Velkommen, Fionn Iversen

09:30 FoU energisystem / K2 intro, Knut Kismul, HVL

09:50 «Det grønne skiftet - energiomstillingen», Anders Nermoen, NORCE

10:10 Geotermsk forskning på UiB, Ivar Stefansson, UiB

10:40 Omvisning på K2 ved Øyvind Henne

11:15 Lunsj

12:00 Energibrønner og energisystemer i Bergensområdet, Kirsti Midttømme

12:20 Silje Bordvik - Utfelling av silica fra superkritisk damp, IFE

12:40 Oppsummering, diskusjon, veien videre vår/høst 2023, Anders / Fionn

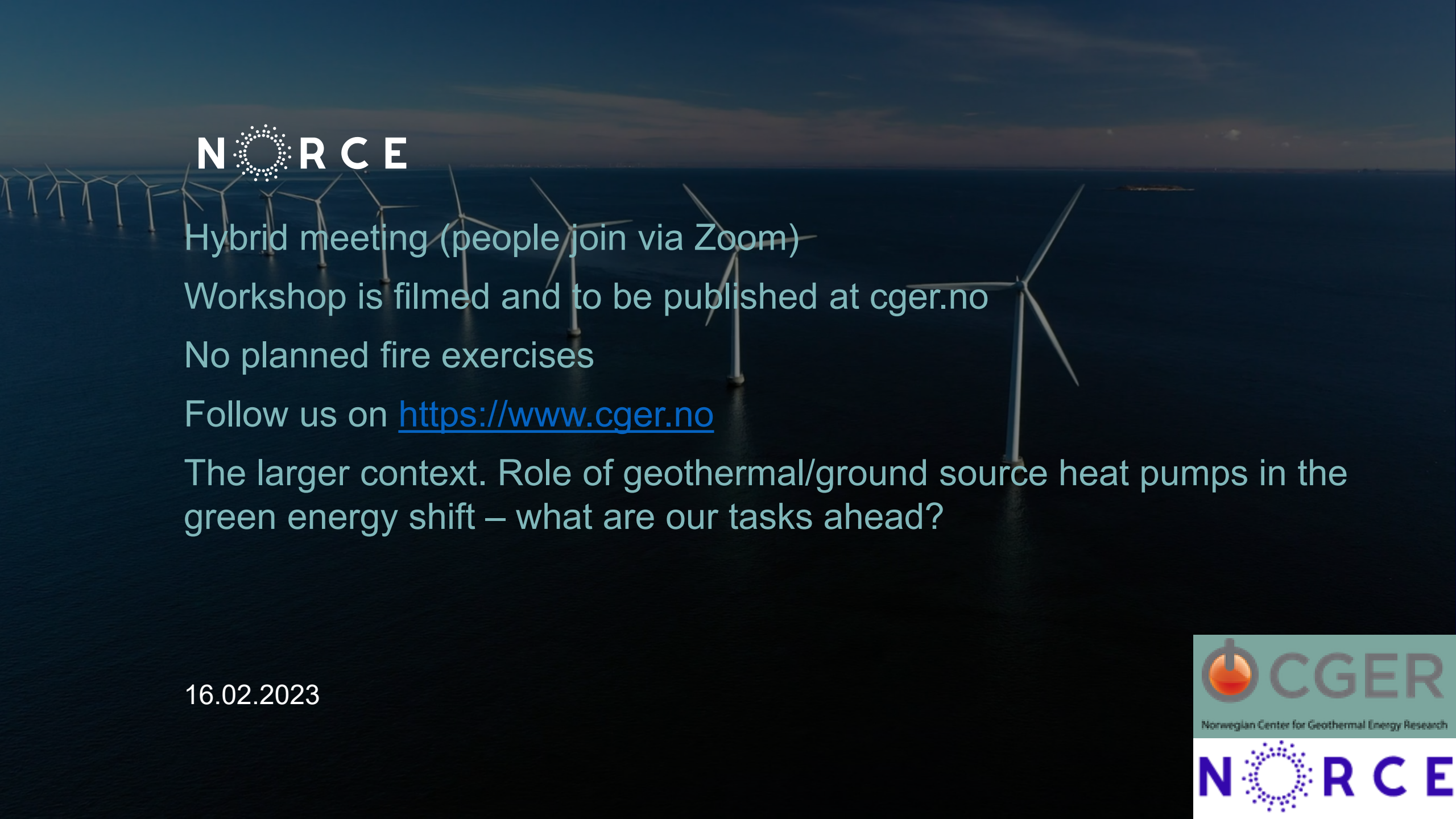
Acknowledge Bergen Kommune for their support

Activities:

1. 26th January – Matchmaking Epicenter Oslo
2. **16th February – Network meeting at HVL, Bergen**
3. 7th March – Joint event with GCE Node, Kristiansand
4. 5th-6th June – GeoEnergy 2023 (int. conf.), Bergen

16.02.2023

Norwegian Center for Geothermal Energy Research



Hybrid meeting (people join via Zoom)

Workshop is filmed and to be published at cger.no

No planned fire exercises

Follow us on https://www.cger.no

The larger context. Role of geothermal/ground source heat pumps in the green energy shift – what are our tasks ahead?

16.02.2023

Our World in Data

Global direct primary energy consumption

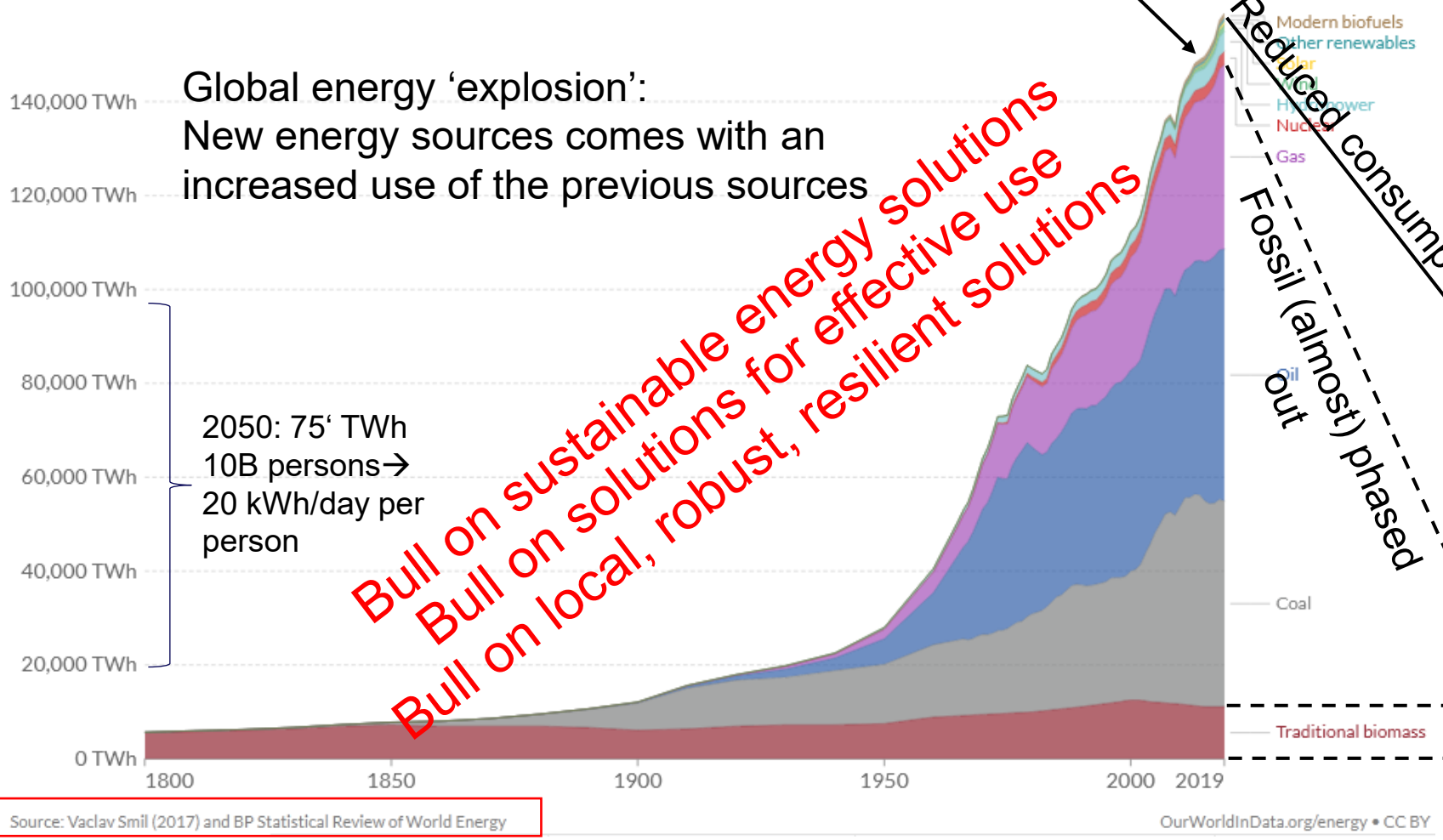
Direct primary energy consumption does not take account of inefficiencies in fossil fuel production.

Relative

Det 'dawning' green shift (2000-now)

Green energy shift (2023-2050)

Global energy 'explosion':
New energy sources comes with an increased use of the previous sources



https://ourworldindata.org/grapher/global-primary-energy?stackMode=relative&country=~OWID_WRL

Efficiency **gains** by electrification:

- **Smart solutions**
- **Integrated systems**
- **New environmental friendly technologies**

Increased electricity production from renewable green sources

Hard-to-abate emissions compensated by CCS for net zero

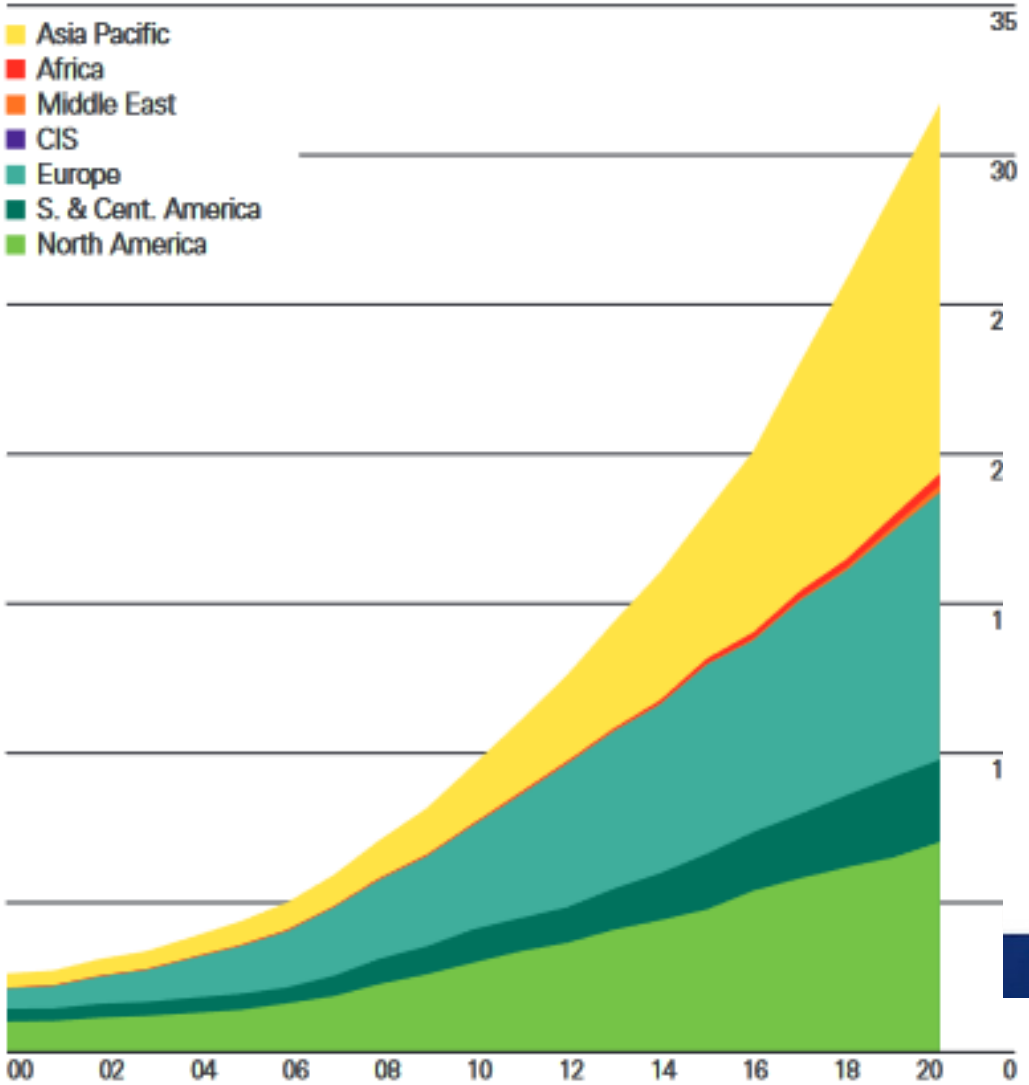
Constant (reduced?), nature crisis

★ *Environmental cost* of consumption

Maintain 'good life' for 10 billion

Renewables consumption by region

Exajoules



Renewables generation by source

Terawatt-hours

Last decade was about reducing the cost of making electrons when the sun was shining or the wind was blowing

Price hurdle is behind us – so what now?

Wind cost per kWh (US)

Solar PV cost per watt

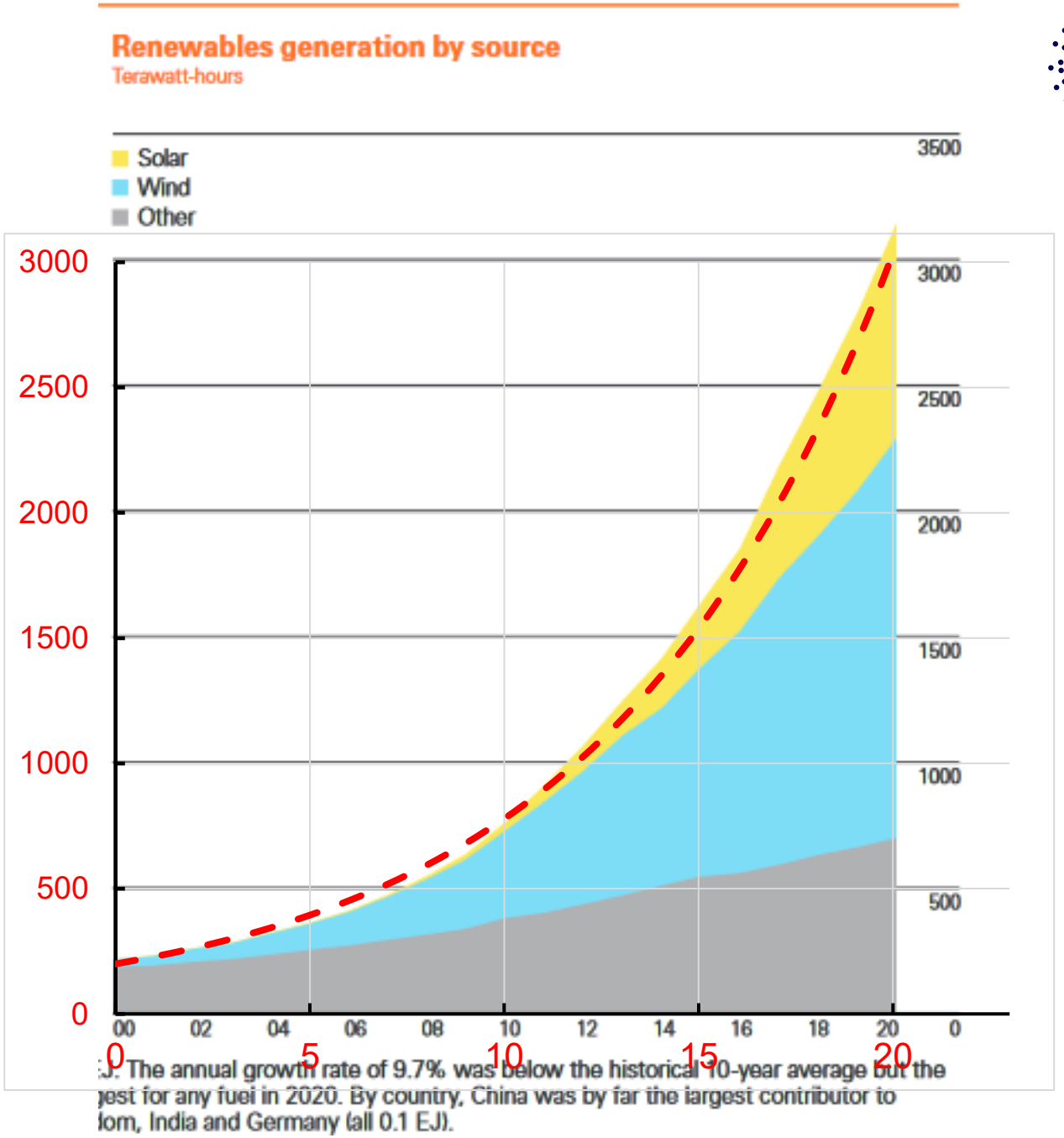
REPLACING FUELS WITH SUNLIGHT

Heliogen

Renewable energy consumption (including biofuels but excluding hydro) grew by 2.9 EJ. The annual growth rate of 9.7% was below the historical 10-year average but the absolute increase in energy terms was roughly in-line with the last 4 years and the largest for any fuel in 2020. By country, China was by far the largest contributor to renewables growth (1.0 EJ), followed by the US (0.4 EJ), then Japan, the United Kingdom, India and Germany (all 0.1 EJ).

Source: Statistical review of world energy, BP. 1 Exajoule = 278 TWh

Growth rate 13.5%
Growth rate 2021-2022: 15%
Target: 75 000 TWh



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https://www.statista.com/statistics/668764/annual-solar-module-manufacturing-globally/

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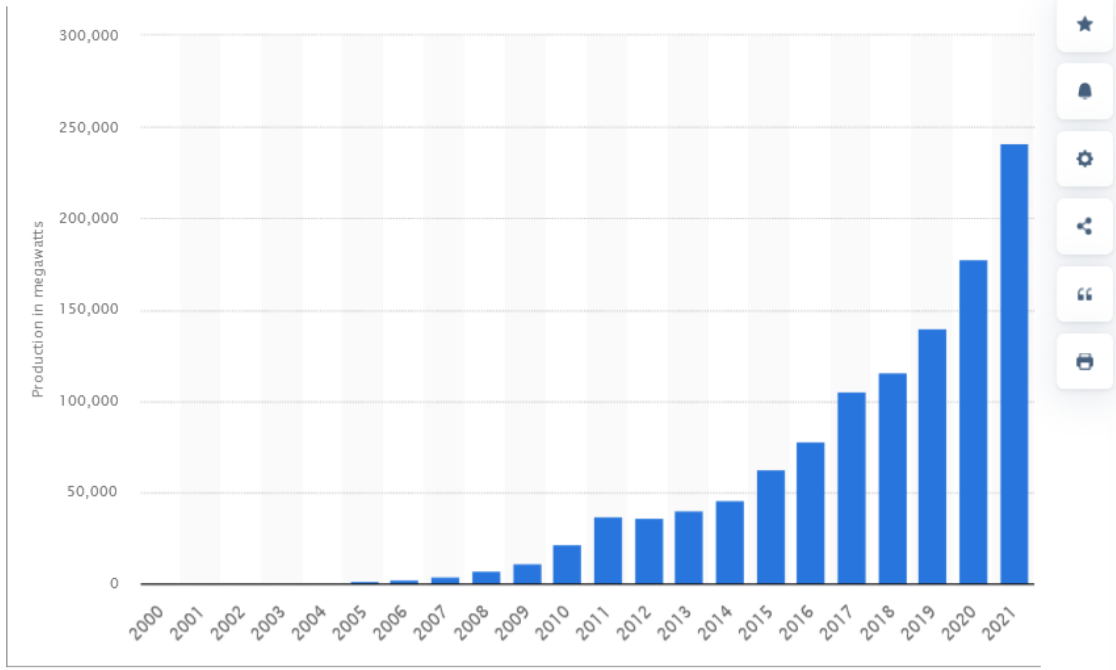
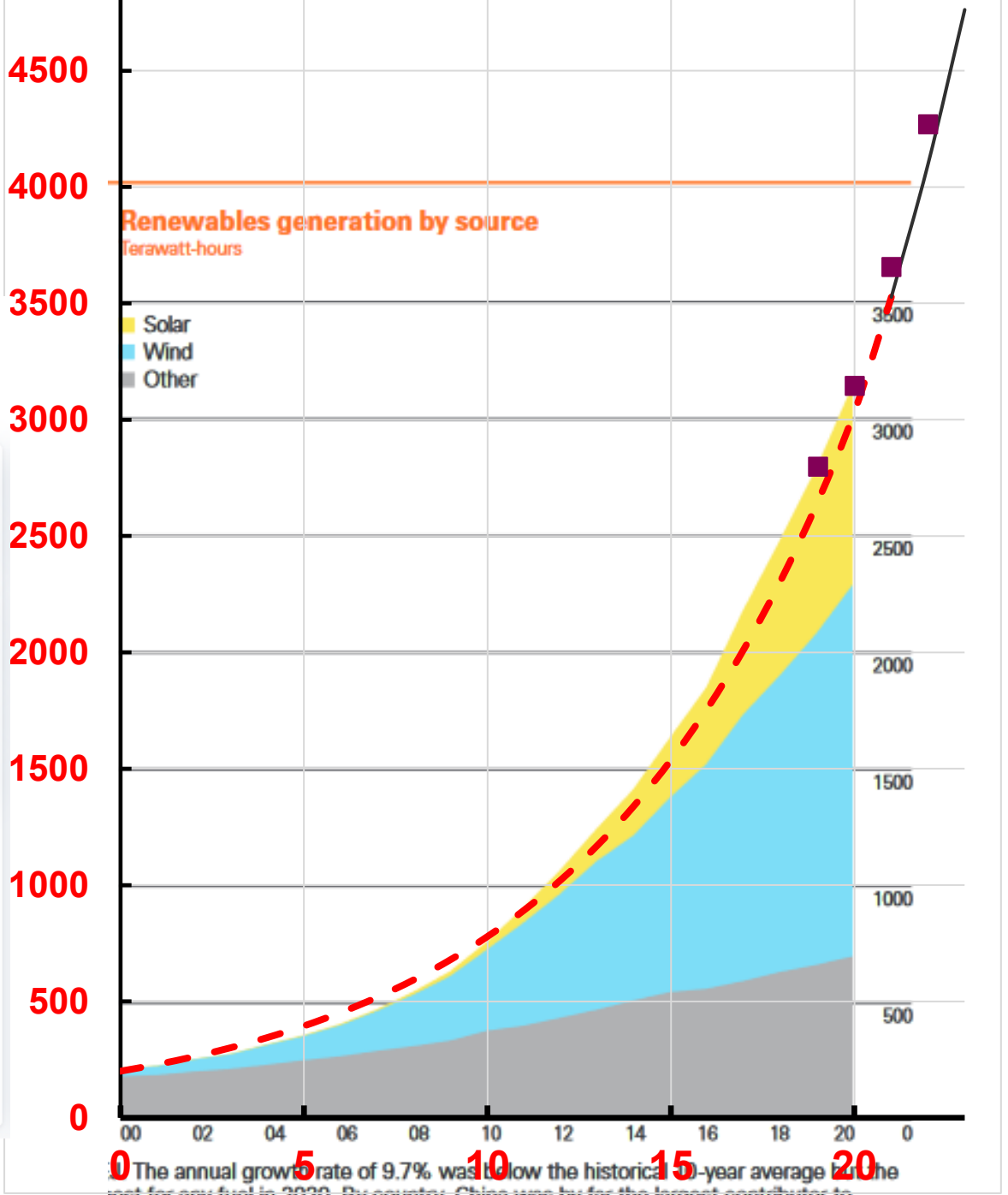
Annual solar module production globally from 2000 to 2021

(in megawatts)





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https://wwindea.org/worldwide-windpower-boom-continues-in-2022/

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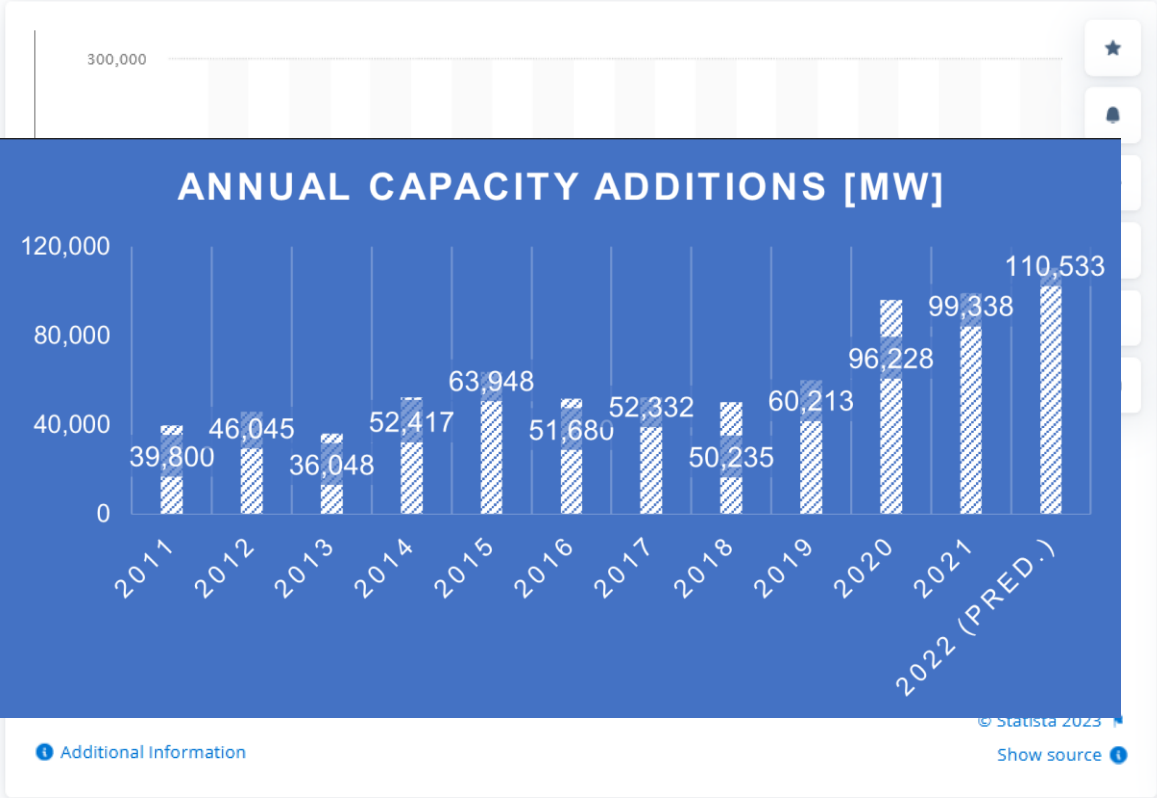
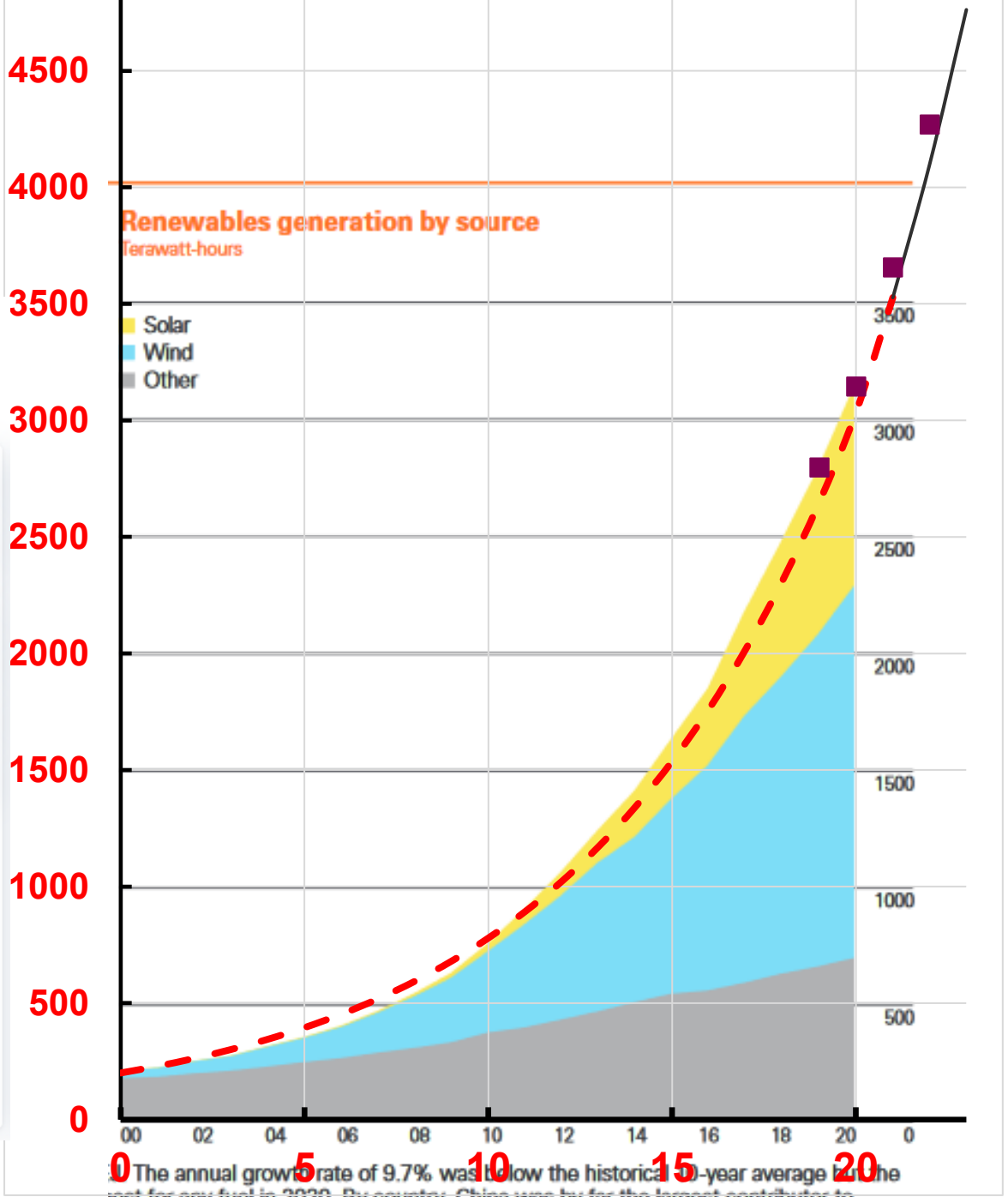
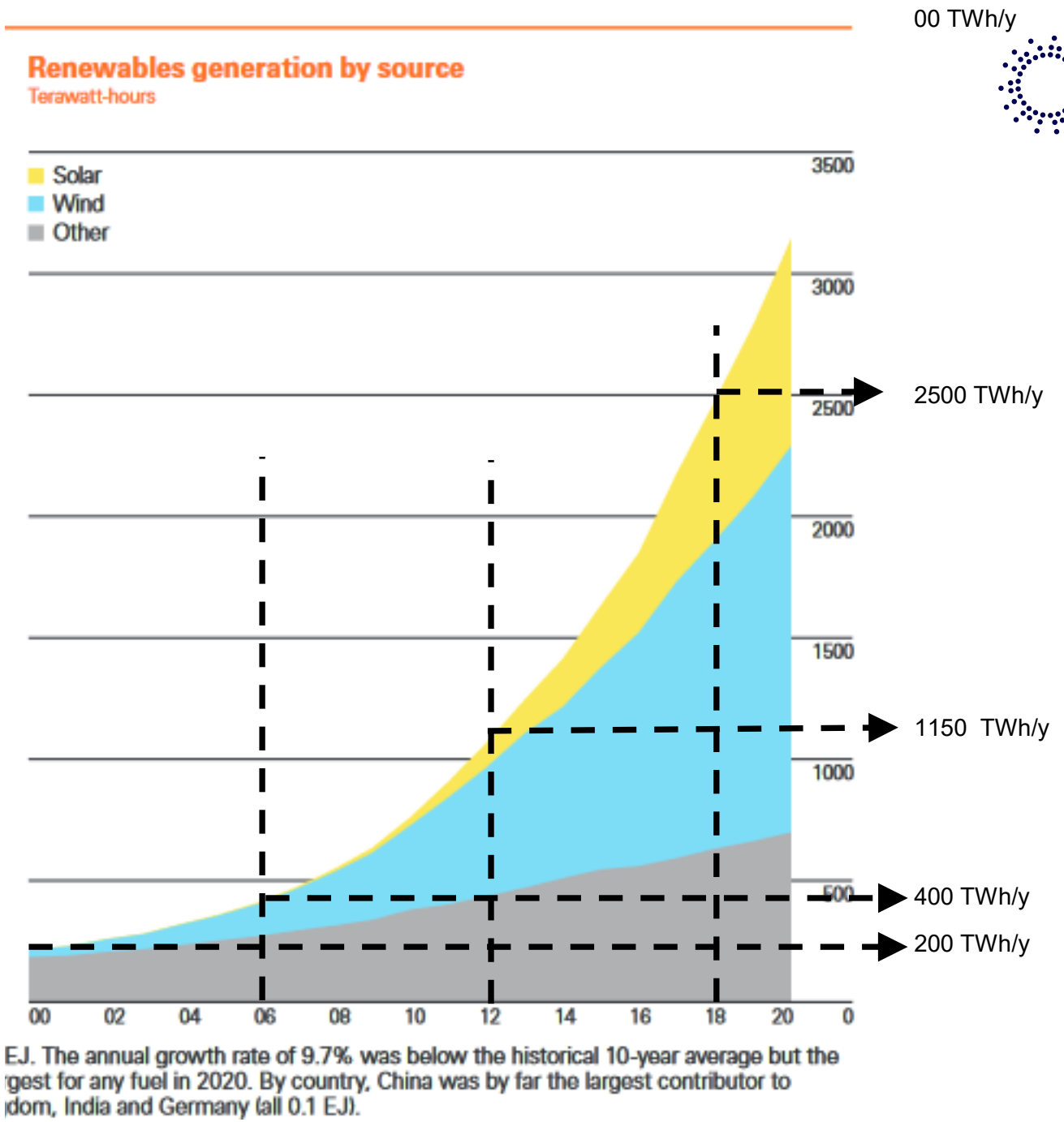




Dawning green energy shift:

Doubling of renewable energy, low emission electrical energy on the market each 6 year

Doubling each 6 year:	
TWh/year	Year
2500	2018
5000	2024
10000	2030
20000	2036
40000	2042
80000	2048



Hick-ups and possibilities on the way to a decarbonized energy system

Energy: heat, electric and molecular. Integrated energy systems combine energy forms.

For heat, why use electricity?

Energy must be:

1. **Produced**. Fluctuating weather, seasonal variation.
2. **Transported** (or not?). Local produce – local use. Distributed / centralized. Fair. Local stakes local gains
3. **Stored** and accessible at demand via molecules, batteries, hydro dams, and heat in PCM or in the ground to even out daily and seasonal variation. Integrated energy systems.
4. **Consumed**. More effective use same service. User flexibility (timing, buy when cheap).

→ Energy system must provide sufficient energy every second, every day, all seasons, all year.

→Sufficient for all to maintain good life

→At reasonable cost.

→Without harming other values dear to us.

How?

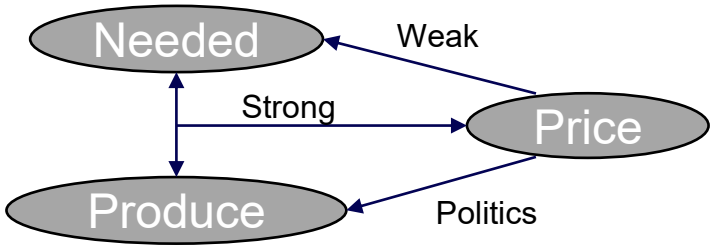
The challenge

Price system: ‘Gap’ between the needed energy and what is produced from the ‘cheaper’ sources vary. When more energy is needed (within each hour), the market demands also the more expensive energy sources. The cheapest energy is sold first, and the price of the most expensive energy source needed to balance the market determines the price of all kWh’s supplied.

‘Stiff’ relation between consumption, production and price → extreme price fluctuations.

How do price-signal affect the need? Not much. (10%ish reduced consumption in 2022).

How can price signals affect the production rate? Difficult.



Given this, how to bring down energy cost for the consumers:

a) How much used? Can it be reduced? Energy mapping/energy efficiency (maintain good life with less).

b) Price per unit (compensation)

c) Own production (bio/wood, solar, geothermal). Used or sold.

d) User flexibility (buy when price is low and store heat/electric/ molecules for later use).

Norway: Electricity for heat 75 TWh/year for cooling and heating (60%)

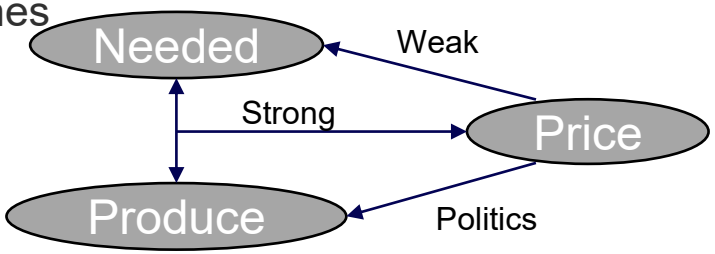
Smart users do not pay much for energy these days (reduce consumption, produce themselves and buy when cheap).

Reduced consumption, distributed production and user flexibility is good for the user AND the society:

a) reduced peak demand reduces the need for buildouts/power-ups and transmission lines

b) Less conflict due to encroachment and less areal use demand (cost of conflicts?)

c) reduced need for price compensation (50 BNOK in 2023)



→ Smarter way forward: A balanced governmental support between price compensation and aids for a rolled out societal green energy shift, where everybody get and everybody can contribute to free electric energy.

→ This will reduce price fluctuations and **shield** people for future price fluctuations.

→ Diversified systems that is robust and resilient. Sabotage. Unstable world situation.

→ Free electrical energy use aids the decarbonization of our society

No silver bullet. Many ways forward. Many solutions. Some choices are simpler. Consumer can become producer.

We argue that geothermal energy and ground source heat pumps is excellently positioned to ease the green energy shift.

What are our show-stoppers? Technical **vs** economic potential? Politics and market? People? Investments? Myths? Facts?

Where do we go forward? Importance of coming together

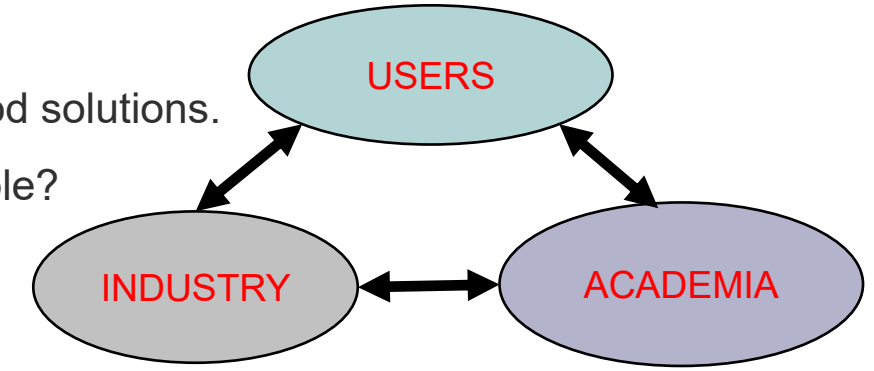
We have different roles. Learn to know the others. All are advanced. Stay humble.

A good solution map energy **need,** geological **possibilities** to **design** and **build** good solutions.

Market failure: Who thinks about energy efficiency when energy is free and accessible?

Who can afford long-term investments when the energy is expensive?

→Boom this decade, if we overcome the market failure (politics?)



Who keeps track of geothermal / ground source heat pump portfolio in Norway? Measure of political success!

Who makes sure the existing infrastructure is being run optimal?

Who makes sure learning points are transferred between projects and companies? Always build better.

How to make best use of the energy we produce in Norway?

- **Together we accelerate - Sharing is caring - Enough work for all**

CGER
Norwegian Center for Geothermal Energy Research

NORCE

Thank you. Takk. Merci. Gracias. Obrigado.

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