And myself!

Almost everything you always wanted to know about energy transition and had no opportunity to ask!

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ABAR – November/2022

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Agenda

- Energy transition: definition
- Motivations/Challenges
- Potential solutions/technologies (opportunities)
- Electrical energy
- R&D initiatives:
  - ✓ Living lab Barao Geraldo: UNICAMP/CPFL Energia Collaboration (ANEEL R&D Program)
  - ✓ CPTEn: UNICAMP/FAPESP/CPFL Energia/Eletrobras/Sima Collaboration (FAPESP Centers for Science and Development (CCD) Program)
- Comments

Energy transition: definitions

- *"Energy transition refers to the global energy sector's shift from fossil-based systems of energy production and consumption — including oil, natural gas and coal — to renewable energy sources like wind and solar, as well as lithium-ion batteries."*

storage systems

Source: What is Energy Transition? S&P Global

- *"Replacing the current global energy system relying overwhelmingly on fossil fuels by biofuels and by electricity generated intermittently from renewable sources will be necessarily a prolonged, multidecadal process."*

Source: Vaclav Smil, Examining energy transitions: A dozen insights based on performance, Energy Research & Social Science, 22, 2016

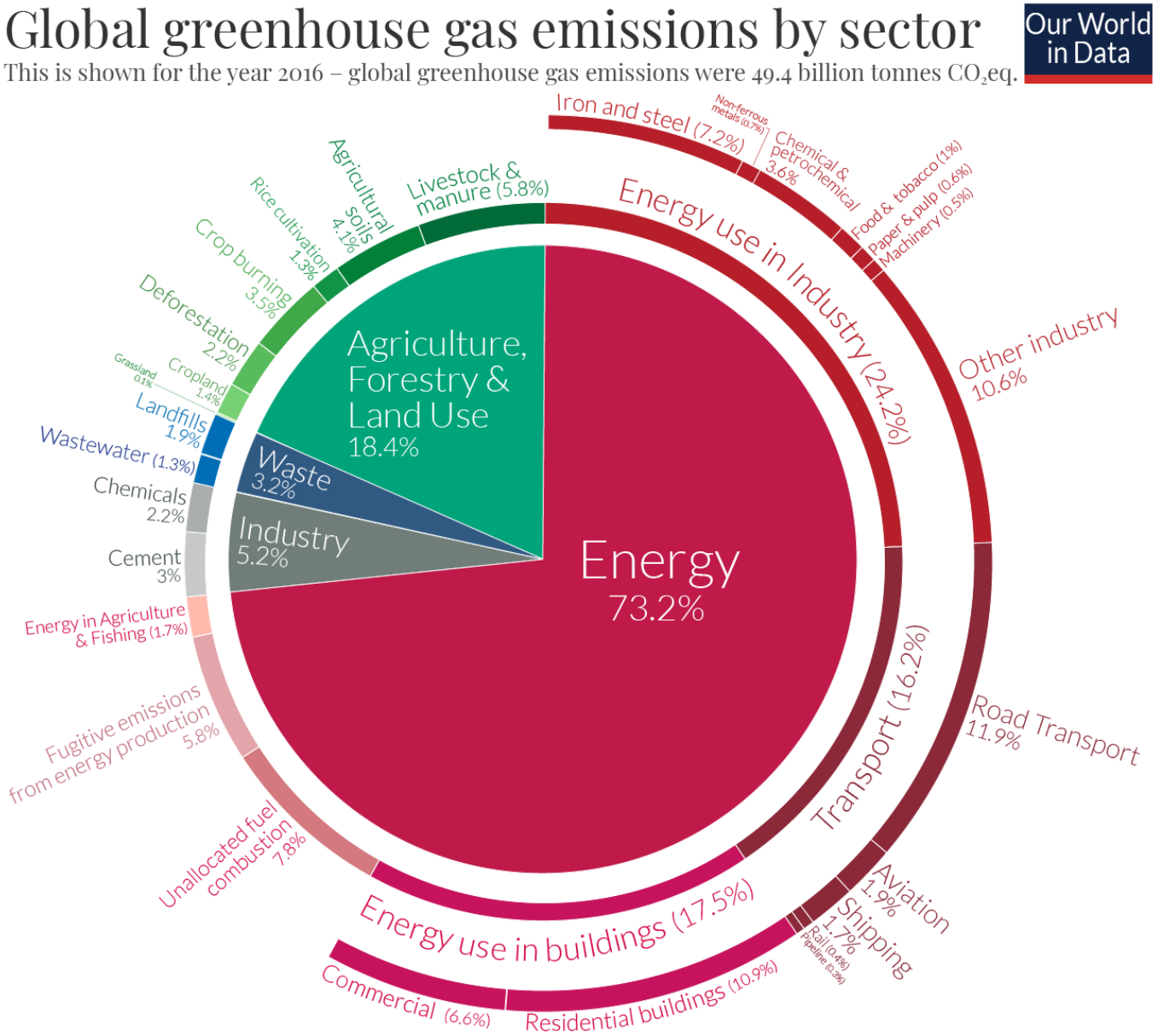
Energy transition is a vast, multidisciplinary theme/subject

Energy transition: historical context

- **Past energy transition (or energy addition):**
  - ✓ Industrial revolution (1700's): from wood to coal – main motivations: need for more energy (mechanization of processes), more efficient and less expensive sources
  - ✓ Past century (1900's): added oil and natural gas – main motivation: need for more energy (mechanized transport), more efficient and less expensive sources
- **Recent energy transition (or energy addition):**
  - ✓ Oil crisis (1970's): renewable energy (solar) and conservation – main motivation: scarcity of fossil fuel (need of diversity), need for more energy (automatization of economy), more efficient and less expensive sources
- **Current energy transition:**
  - ✓ Climate change mitigation: need of replacing fossil fuels with low carbon energy resources

- ✓ In historical energy transition, there is a correlation between an **increasing demand** for energy and **availability of different energy sources**
- ✓ The current transition to sustainable energy differs as it is largely driven by a recognition that **global greenhouse-gas emissions must be brought to zero**

Motivation: climate change mitigation

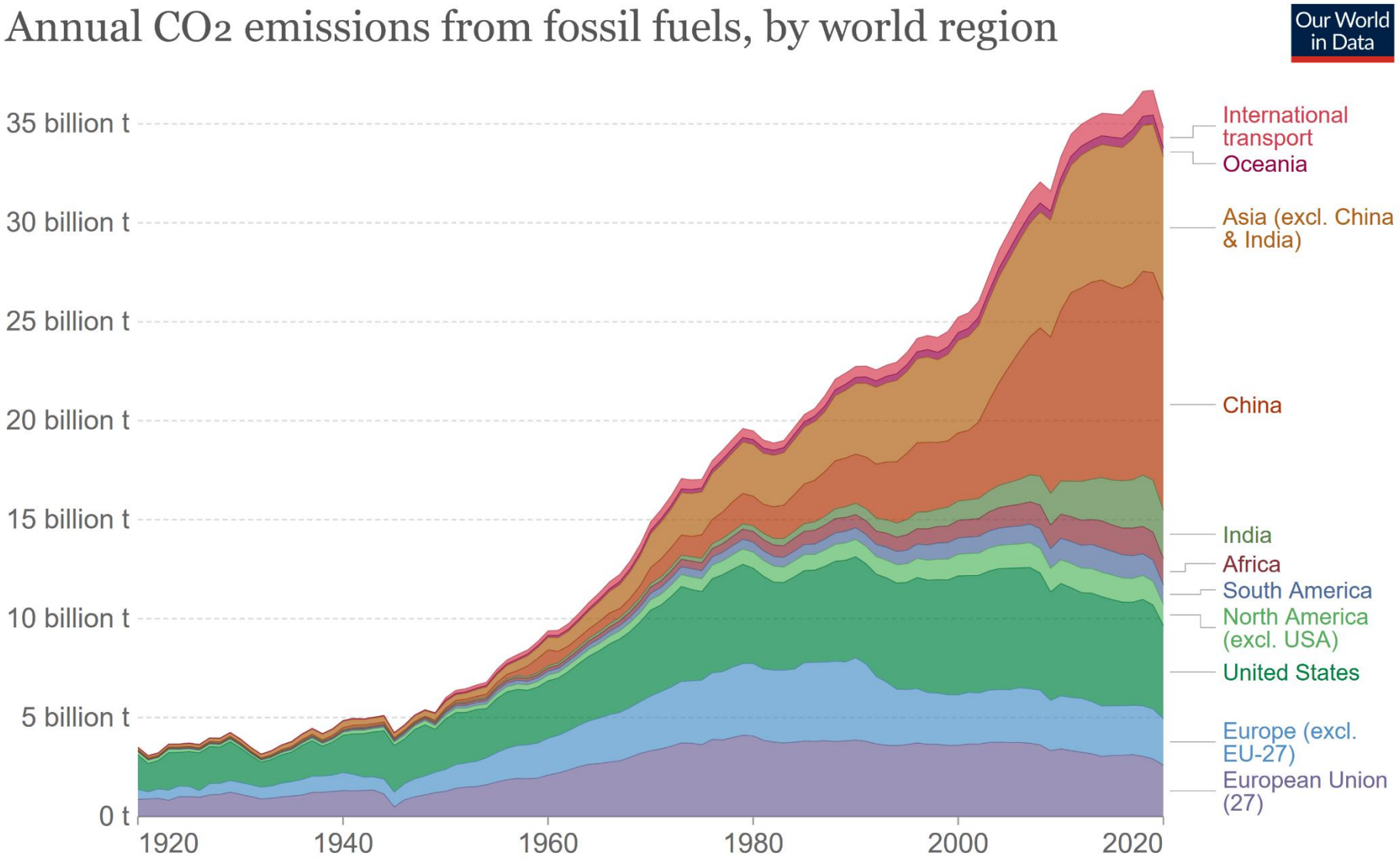


Energy use in:

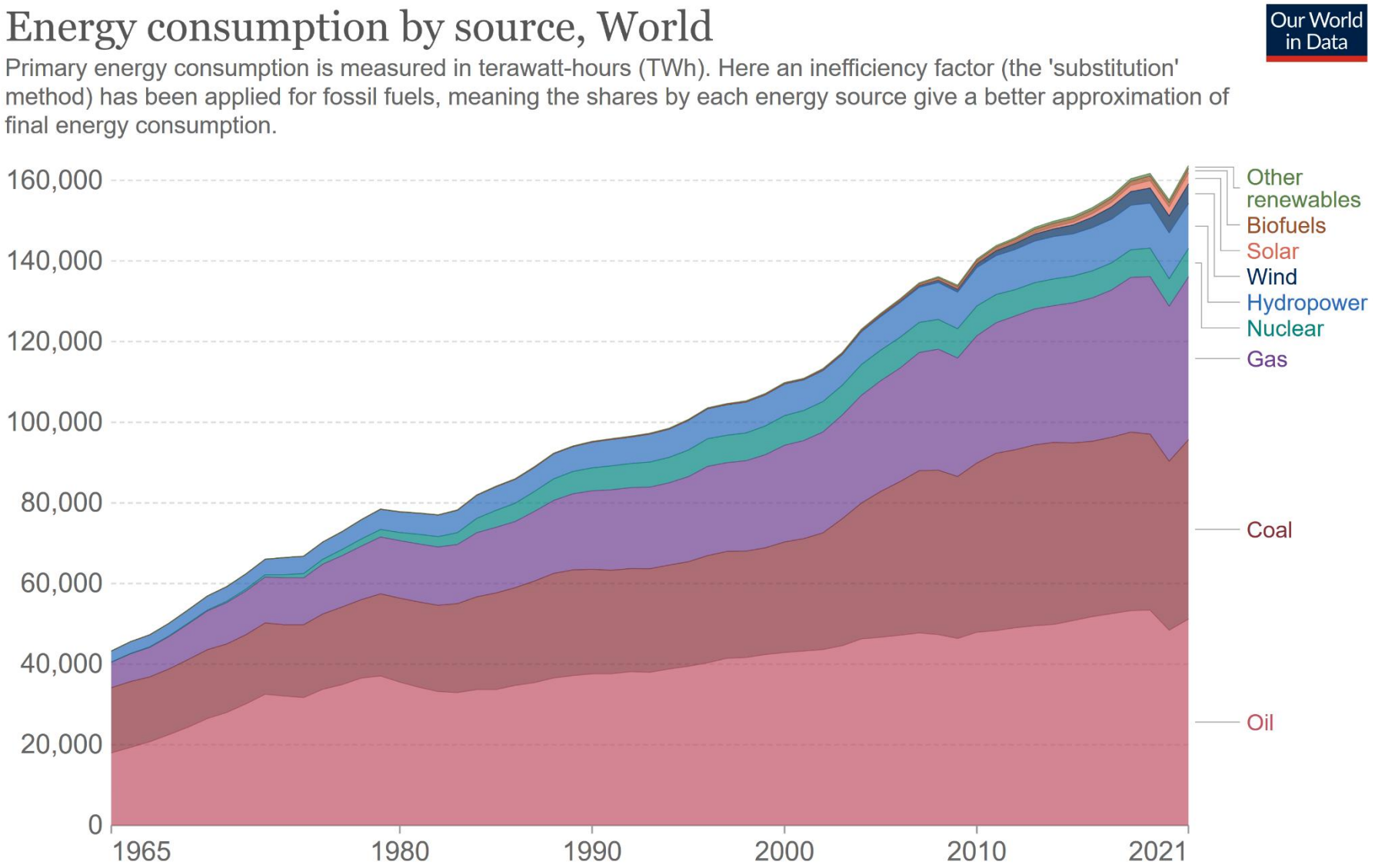
- ✓ Industry
- ✓ Transport
- ✓ Buildings

57.9%

Climate change mitigation: challenge



Energy transition: challenge – where are we?



Energy consumption increased 47.6% between 2001 and 2021

Dependency on fossil fuels

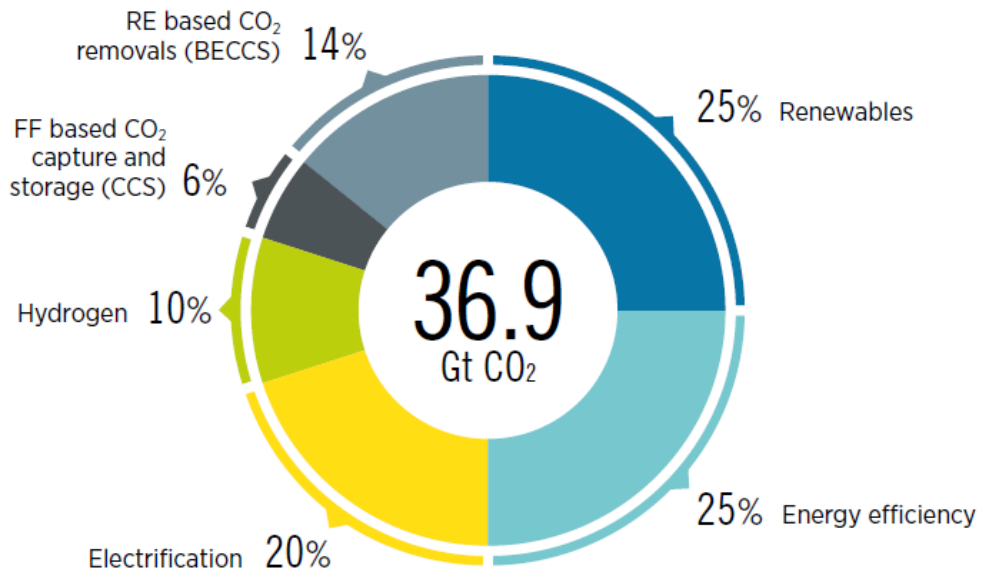
YEAR	%
2001	86.0
2011	86.7
2021	83.1

Potential solutions/technologies

Reducing the emission by 2050 through 5 technological avenues:

1. Renewables: significant increase in generation and direct use of renewable-based electricity
2. Energy efficiency: substantial improvement in energy efficiency
3. Electrification: the electrification of end-use sectors (*e.g.*, electric vehicles and heat pumps) and industry
4. Green hydrogen: clean hydrogen and its derivatives (*e.g.*, ammonia)
5. Carbon capture and storage (CCS): carbon capture and storage from fossil fuel-based processes, mainly in industry, and bioenergy coupled with CCS in electricity, heat generation, and industry

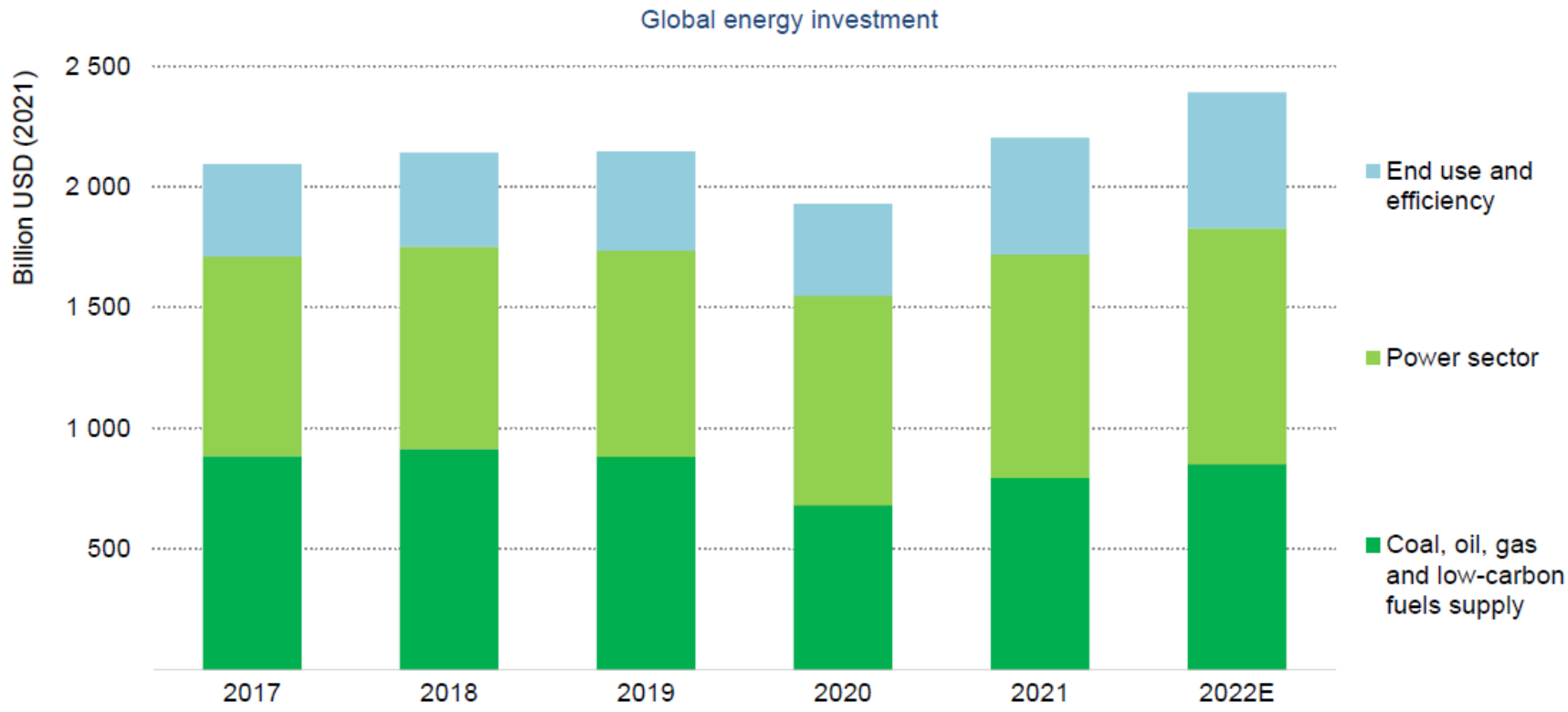
FIGURE ES.1 Reducing emissions by 2050 through six technological avenues



Source: World Energy Transition: Outlook 2022 – 1.5° C Pathway, IRENA (International Renewable Energy Agency)

Opportunities: energy investment

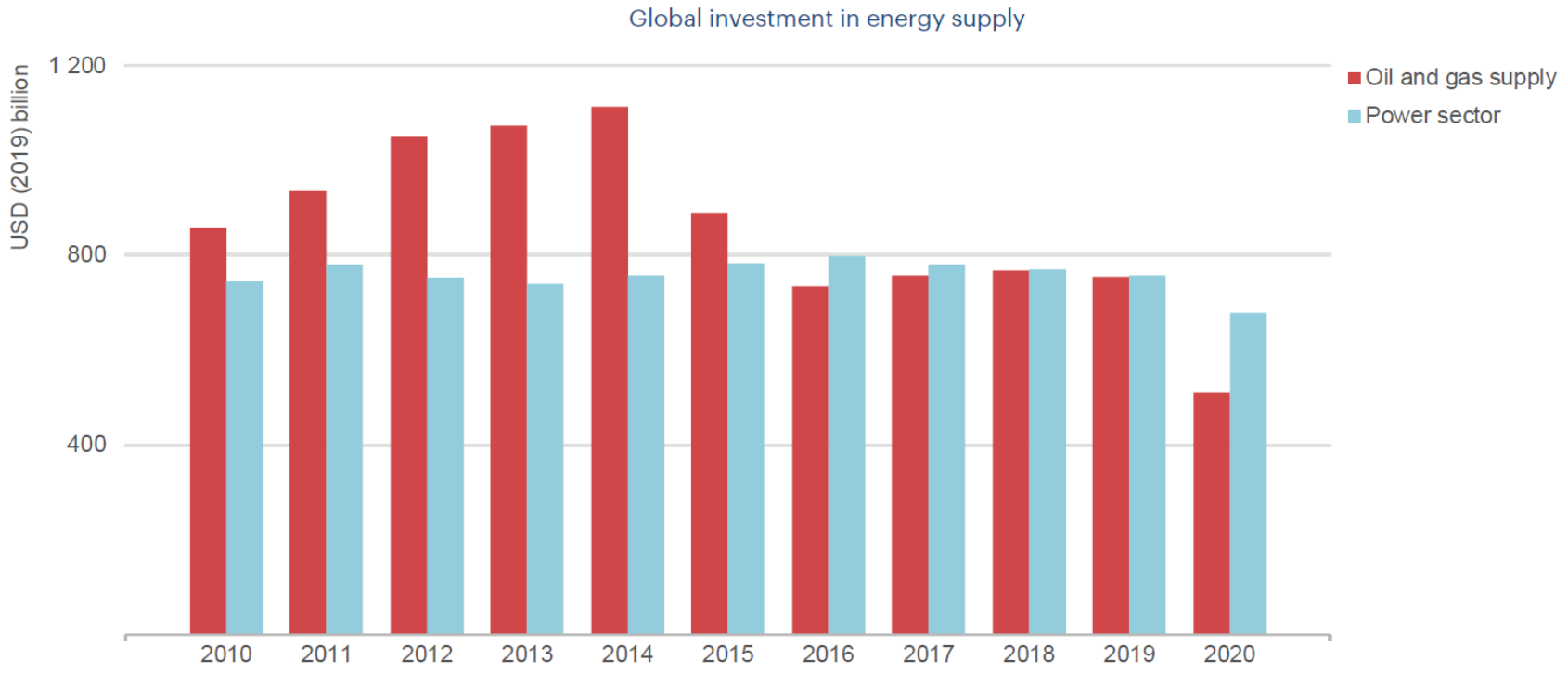
Energy investment is set to pick up by 8% in 2022 against the backdrop of the global energy crisis, but almost half of the increase in capital spending is linked to higher costs



Brazilian GDP (2021): 1.6 Trillion US$

Opportunities: energy investment

Over the last ten years, power sector spending has been relatively stable compared with the rollercoaster ride for oil and gas



Opportunities: energy investment

Diversification plans by oil and gas companies are more ambitious than the underlying clean energy investments

Current diversification options by selected international oil companies and NOCs

Company	Activity and investment in selected alternative businesses						
	Solar PV and wind generation	Geothermal	Electricity services	Bioenergy	CCUS	Low-carbon hydrogen	Nature-based solutions
BP	●	●	●	●	●	●	●
Eni	●		●	●	●	●	●
Shell	●	●	●	●	●	●	●
TotalEnergies	●		●	●	●	●	●
Chevron		●		●	●	●	
ExxonMobil				●	●	●	
ConocoPhillips					●		
Saudi Aramco	●				●	●	
ADNOC	●				●	●	
CNPC	●	●		●	●	●	●
Sinopec	●	●			●	●	
CNOOC	●				●	●	

Notes: ● = growth supported by strategic investments (M&A), project FIDs and/or spending on commercial-scale activities; ● = announced strategy with minor investments, venture capital and/or R&D spending; ● = announced strategy but with limited evidence of investment activity or no announced strategy but minimal investments. Electricity services include battery storage and EV charging. Bioenergy includes advanced biofuels and biomethane.

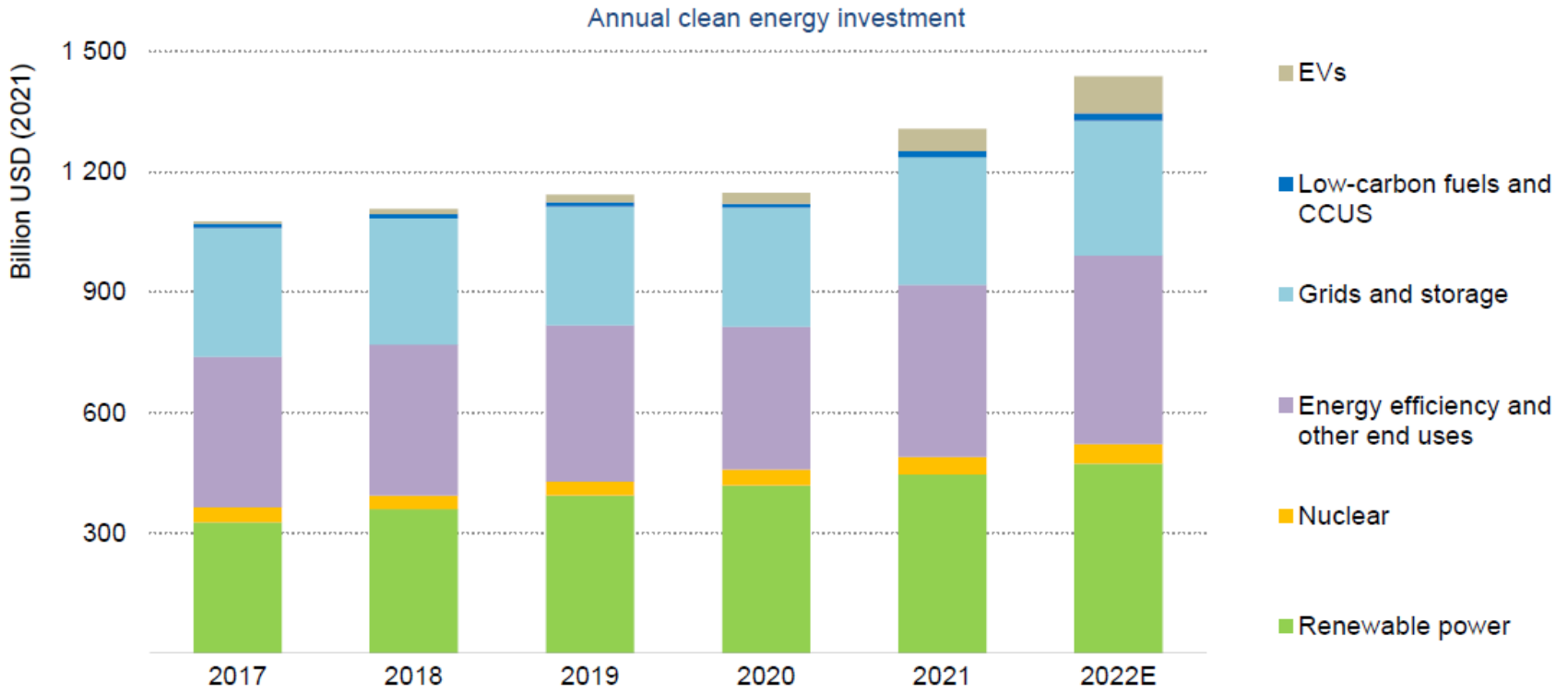
Sources: Company reported strategies, publicly disclosed investments and interviews with Chinese NOCs.

Shell aims to become world's largest electricity company

Source: Reuters Events

Opportunities: clean energy investment

After remaining flat for several years, global clean energy spending is finally ramping up

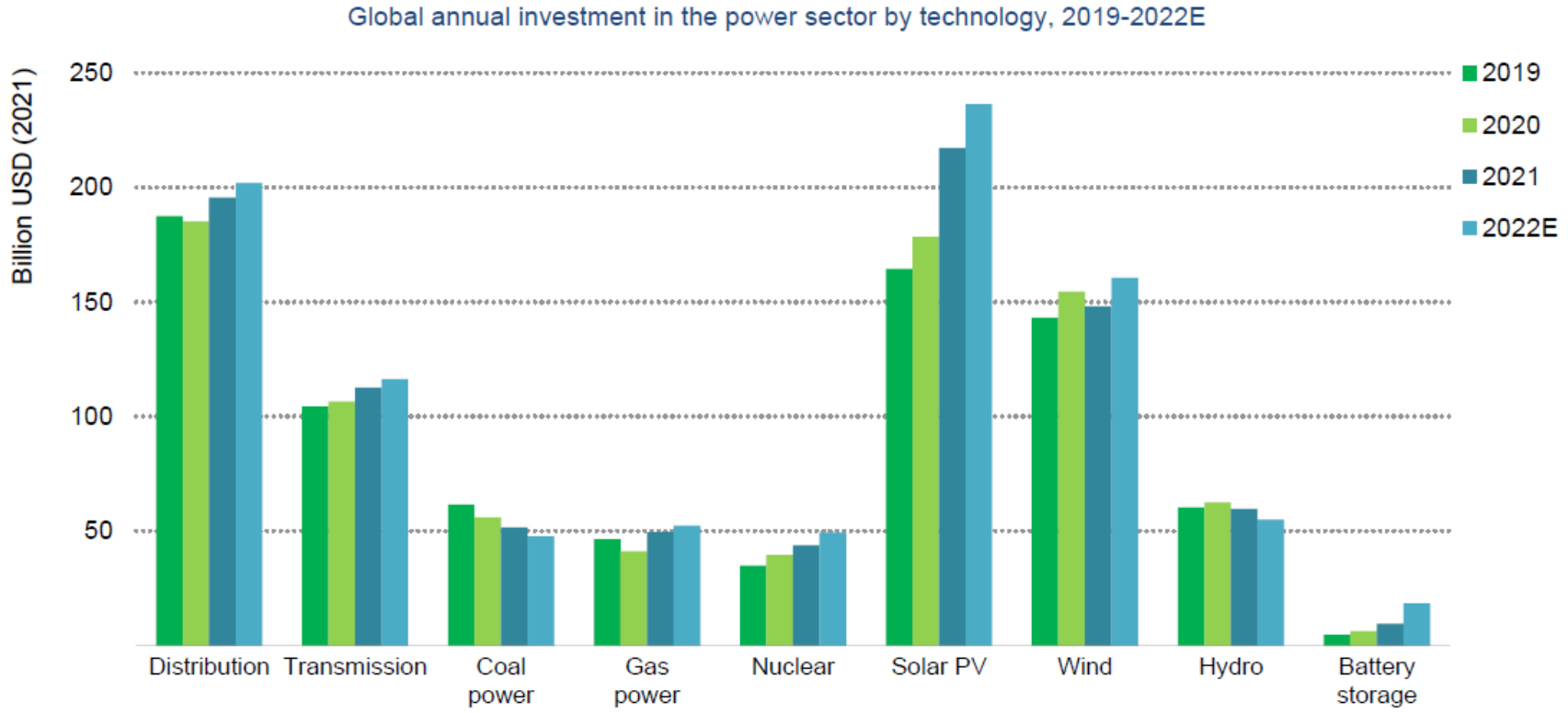


Notes: Energy efficiency and other end-use includes spending on energy efficiency, renewables for end use and electrification in the buildings, transport and industry sectors. Low carbon fuels include modern liquid and gaseous bioenergy, low-carbon hydrogen, as well as hydrogen-based fuels that do not emit any CO2 from fossil fuels directly when used and also emit very little when being produced.

Opportunities: power sector investment

Power sector

Solar PV is leading power sector investment, with positive signs for transmission and distribution networks and an acceleration in battery energy storage

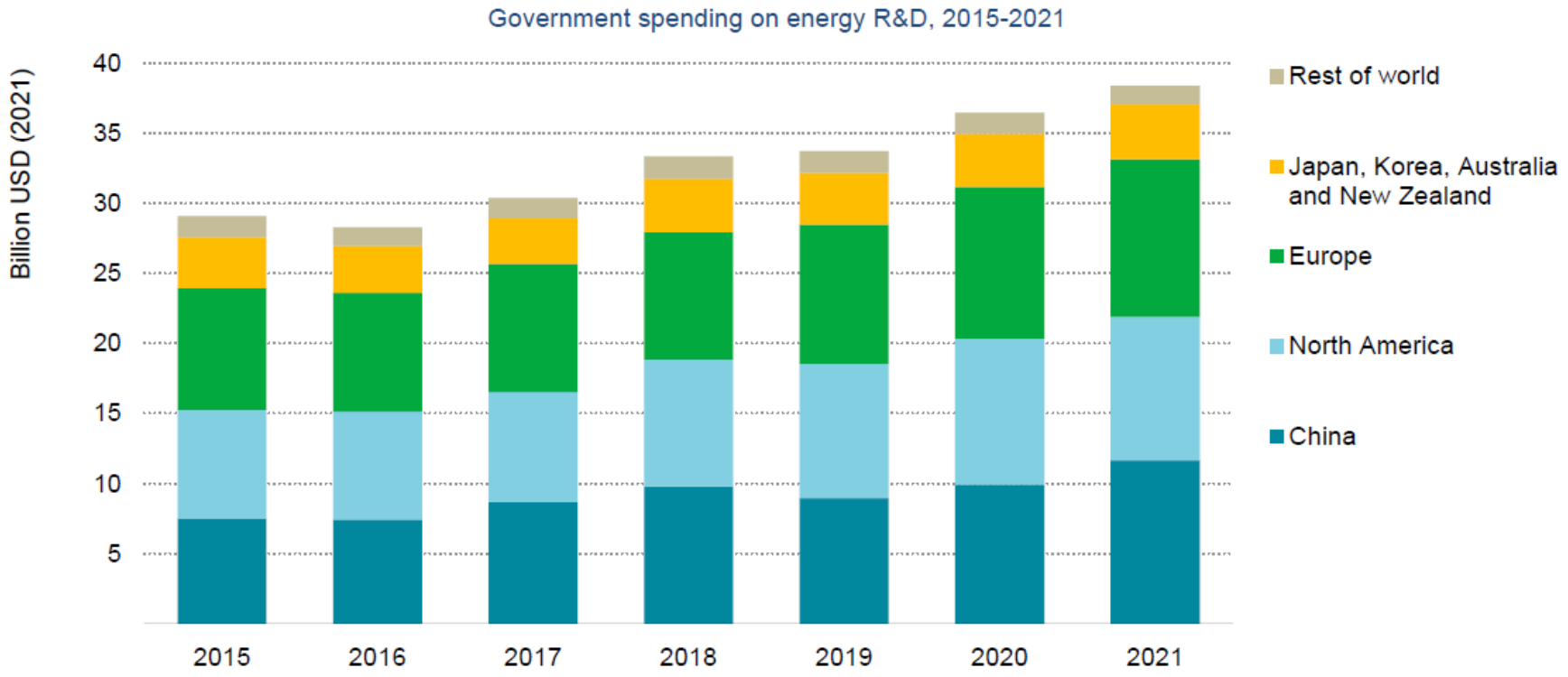


Notes: Gas-fired generation investment includes both large-scale plants and small-scale generating sets and engines; hydropower includes pumped-hydro storage.
Sources: IEA analysis based on calculations from IRENA (2022) and Platts (2022).

Total investment increased
from 800 to 1,000 billion US$ / year

Opportunities: R&D investment – government

Government spending on energy R&D increased in 2021, but Covid-19 uncertainties slowed growth



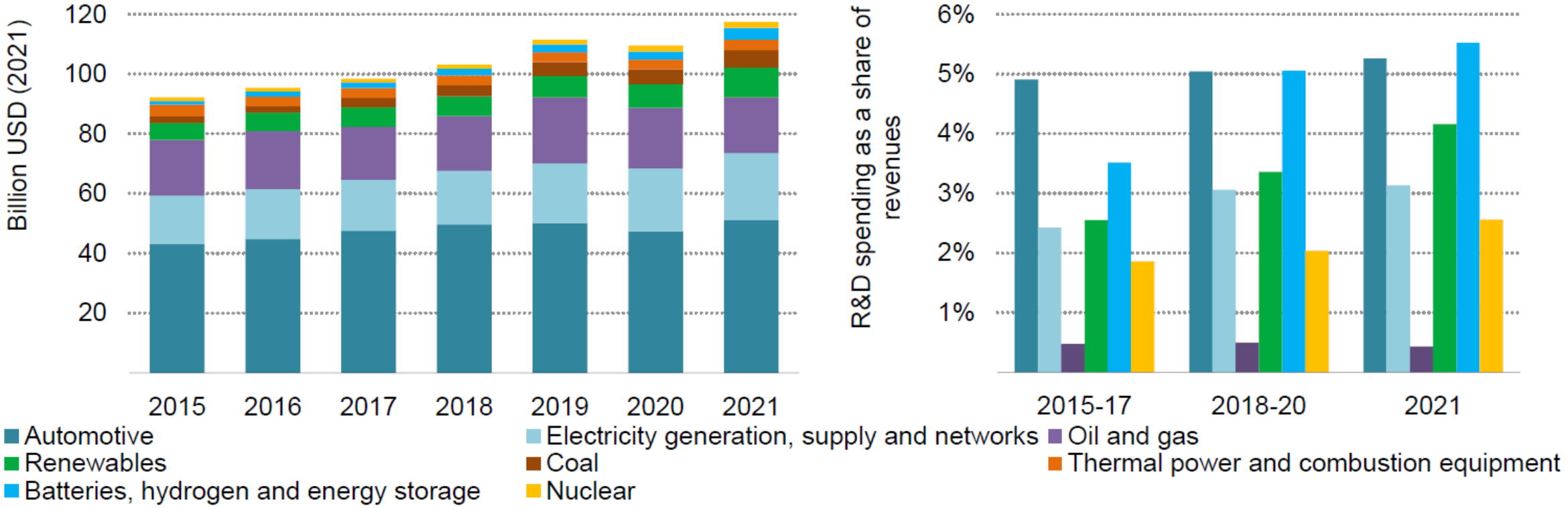
Notes: Includes spending on demonstration projects (i.e. RD&D) wherever reported by governments as defined in IEA documentation; 2021 is a preliminary estimate based on data available by mid-May 2022; state-owned enterprise funds comprise a significant share of the Chinese total, for which the 2021 estimate is based on reported company spending where available; the IEA Secretariat has estimated US data from public sources.

Source: IEA Energy Technology RD&D Budgets: Overview (forthcoming).

Opportunities: R&D investment – corporate

Corporate energy R&D spending returned to growth in 2021, with uplift in China and renewables compensating for tightened budgets elsewhere and among fossil fuel companies

Spending on energy R&D by listed companies (left) and R&D budgets as a share of revenues (right), by sector of activity, 2015-2021



Opportunities: green products/market

Electricity/energy intensive industry:

- Fertilizer industry: the fertilizer industry accounts for about 1.2% of world energy use, and more than 90% of this energy is used in the production of ammonia
- Primary metal industry: the primary metal manufacturing subsector consists of iron and steel mills, alumina and aluminum production and processing, foundries etc.
- Paper and pulp industry: the four largest paper-producing regions (the EU, the US, China, and Japan) account for 80% of the energy use and carbon dioxide emissions
- Cement industry: developing countries account for about 73% of the global cement production

Brazil has a huge potential to produce and export green products with premium value

Sources:

https://consumerenergysolutions.com

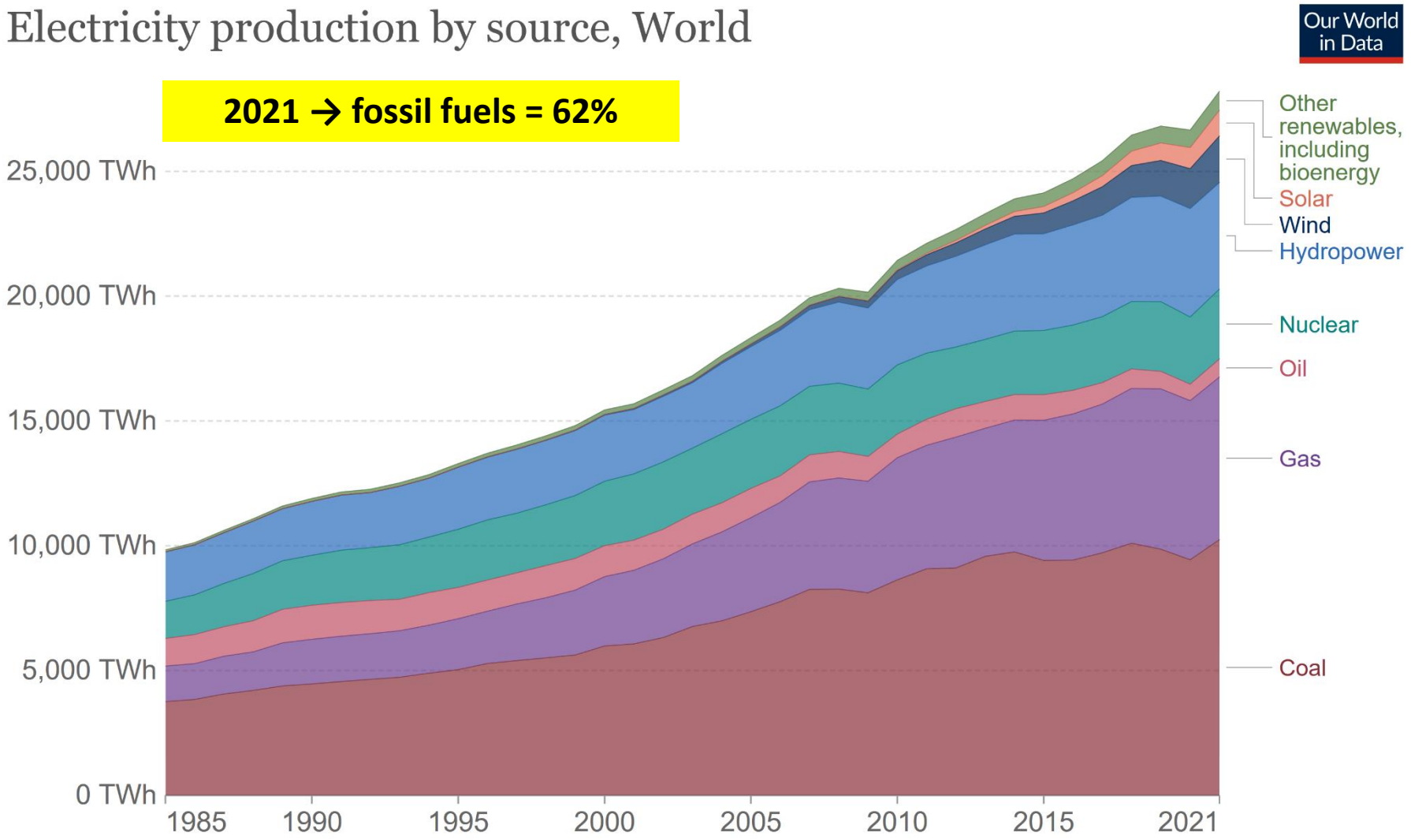
https://goenergylink.com

Electricity sector

*"If a genie offered me one wish, a single breakthrough in just one activity that drives climate change, I'd pick making **electricity**: It's going to play a big role in decarbonizing other parts of the physical economy."*

Bill Gates, on book "How to Avoid a Climate Disaster: The solutions we have and the breakthroughs we need" (2021)

Electricity sector



Source: Our World in Data based on BP Statistical Review of World Energy (2022); Our World in Data based on Ember's Global Electricity Review (2022); Our World in Data based on Ember's European Electricity Review (2022)
Note: 'Other renewables' includes biomass and waste, geothermal, wave and tidal.
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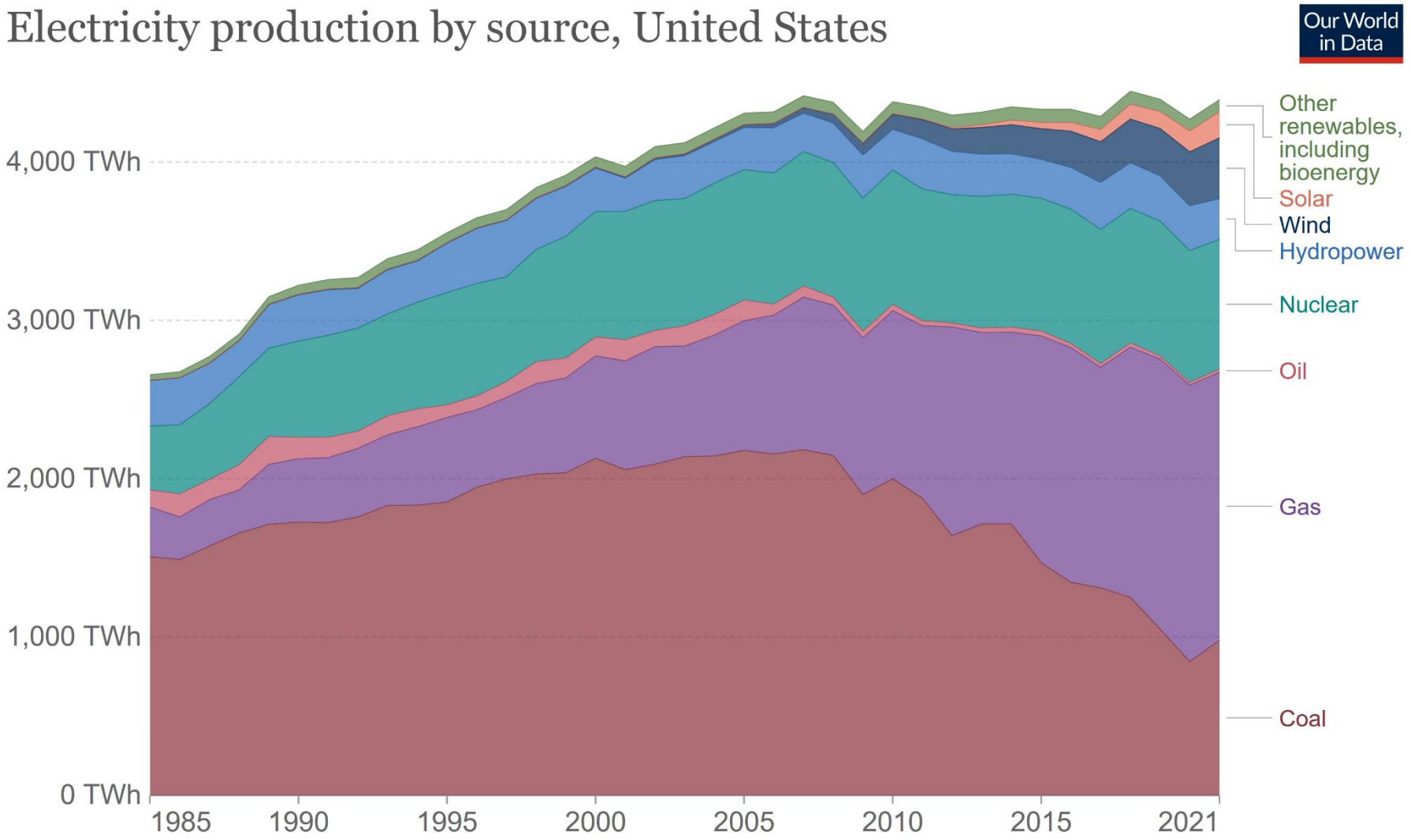
Electricity sector



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Electricity sector

Contribution by source for electricity production in USA for one day (24-hour period)

2015

Source	Period
Coal	8.1 hours
Natural Gas	7.9 hours
Nuclear	4.6 hours
Hydro	1.4 hour
Oil	10.1 min
Wind	1.1 hour
Solar	13.1 min
Other renewables	27.8 min

22.3 hour

2017

Source	Period
Coal	7.3 hour
Natural Gas	7.8 hour
Nuclear	4.7 hour
Hydro	1.7 hour
Oil	7.7 min
Wind	1.4 hour
Solar	26.1 min
Other renewables	27.8 min

21.7 hour

2019

Source	Period
Coal	5.7 hour
Natural Gas	9.3 hour
Nuclear	4.7 hour
Hydro	1.6 hour
Oil	6.5 min
Wind	1.6 hour
Solar	35.4 min
Other renewables	25.2 min

21.4 hour

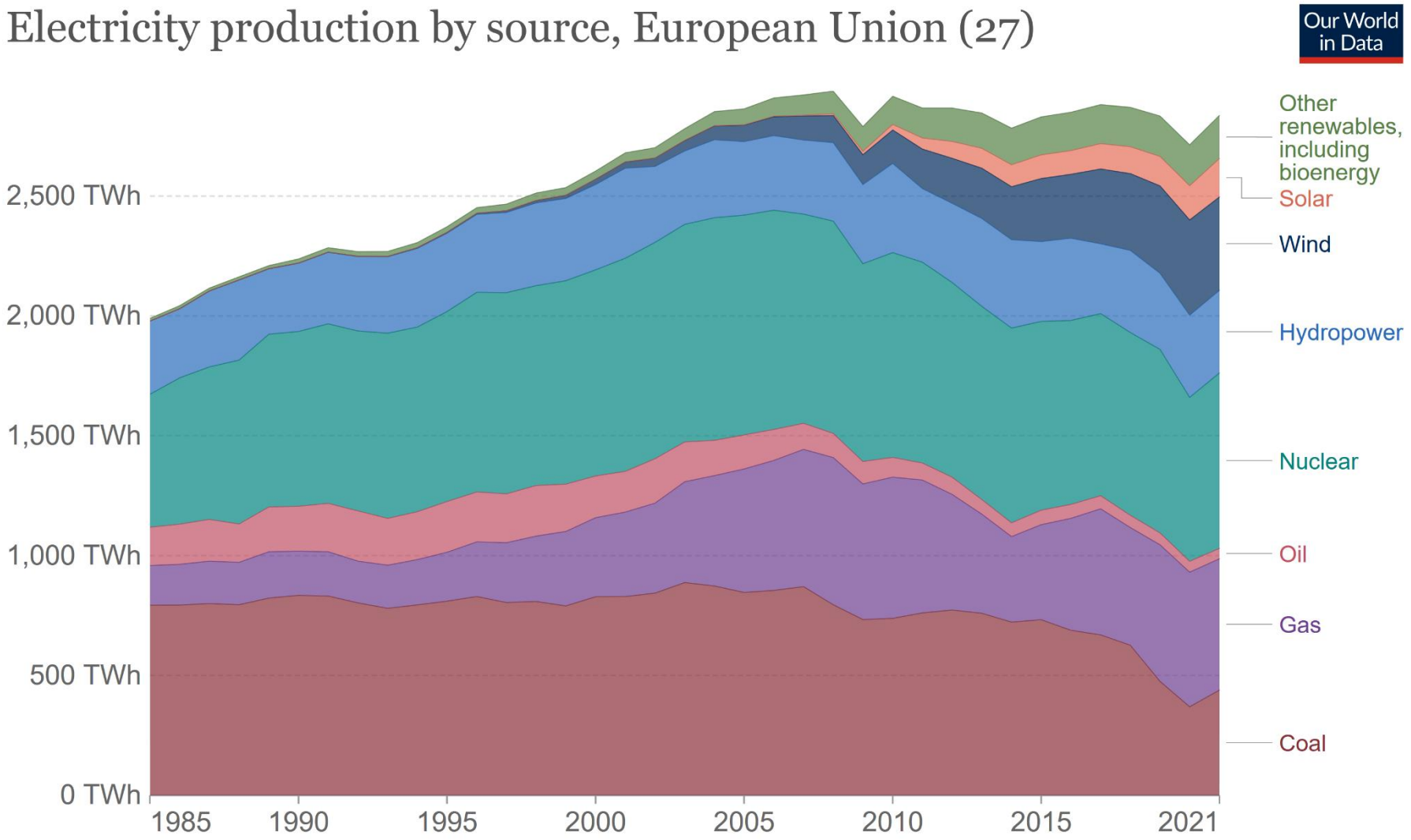
2021

Source	Period
Coal	5.3 hour
Natural Gas	9.3 hour
Nuclear	4.5 hour
Hydro	1.4 hour
Oil	6.6 min
Wind	2.1 hour
Solar	54.2 min
Other renewables	24.7 min

20.6 hour

Electricity production from conventional sources

Electricity sector



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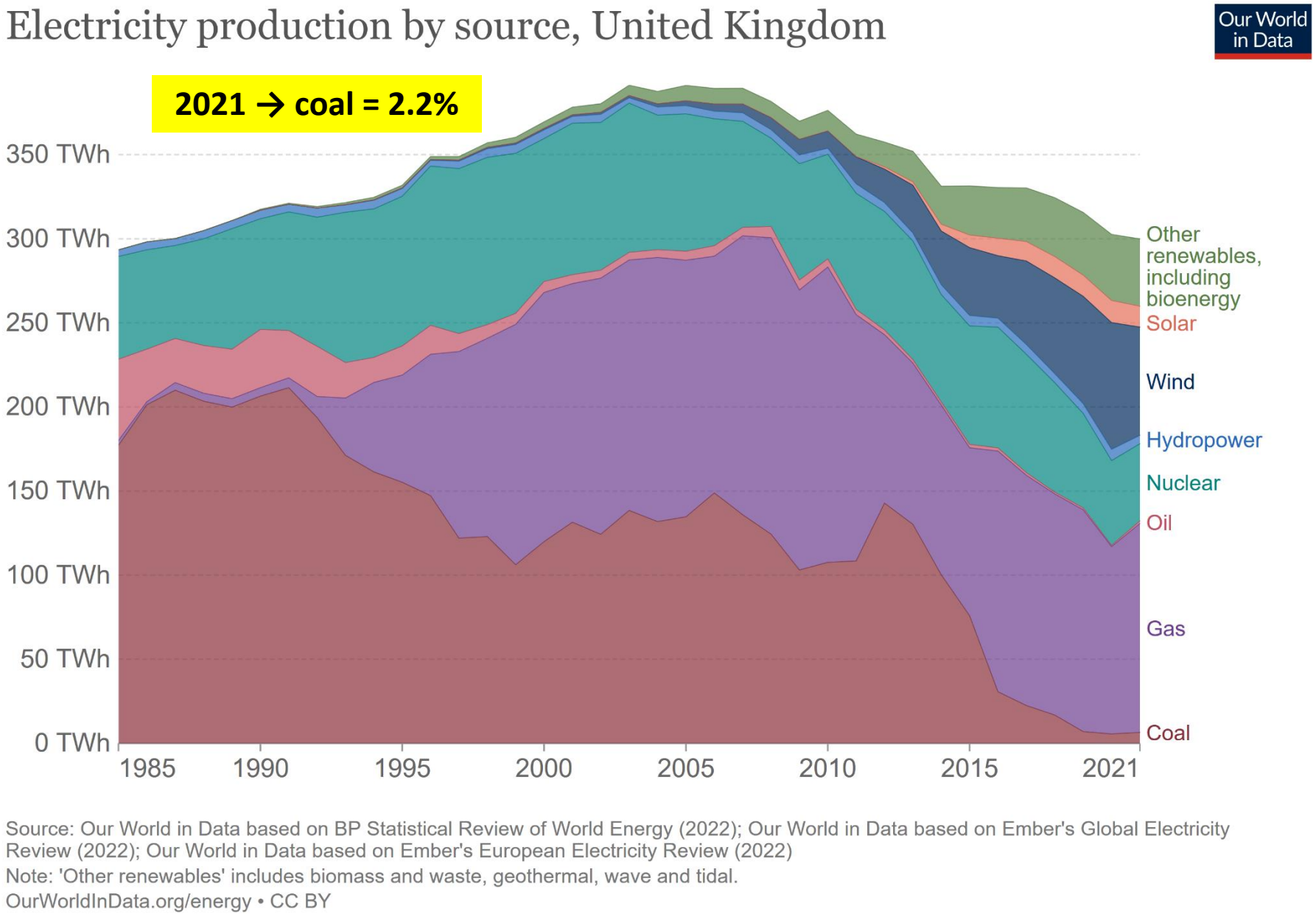
Electricity sector



Electricity sector

UK commitments:

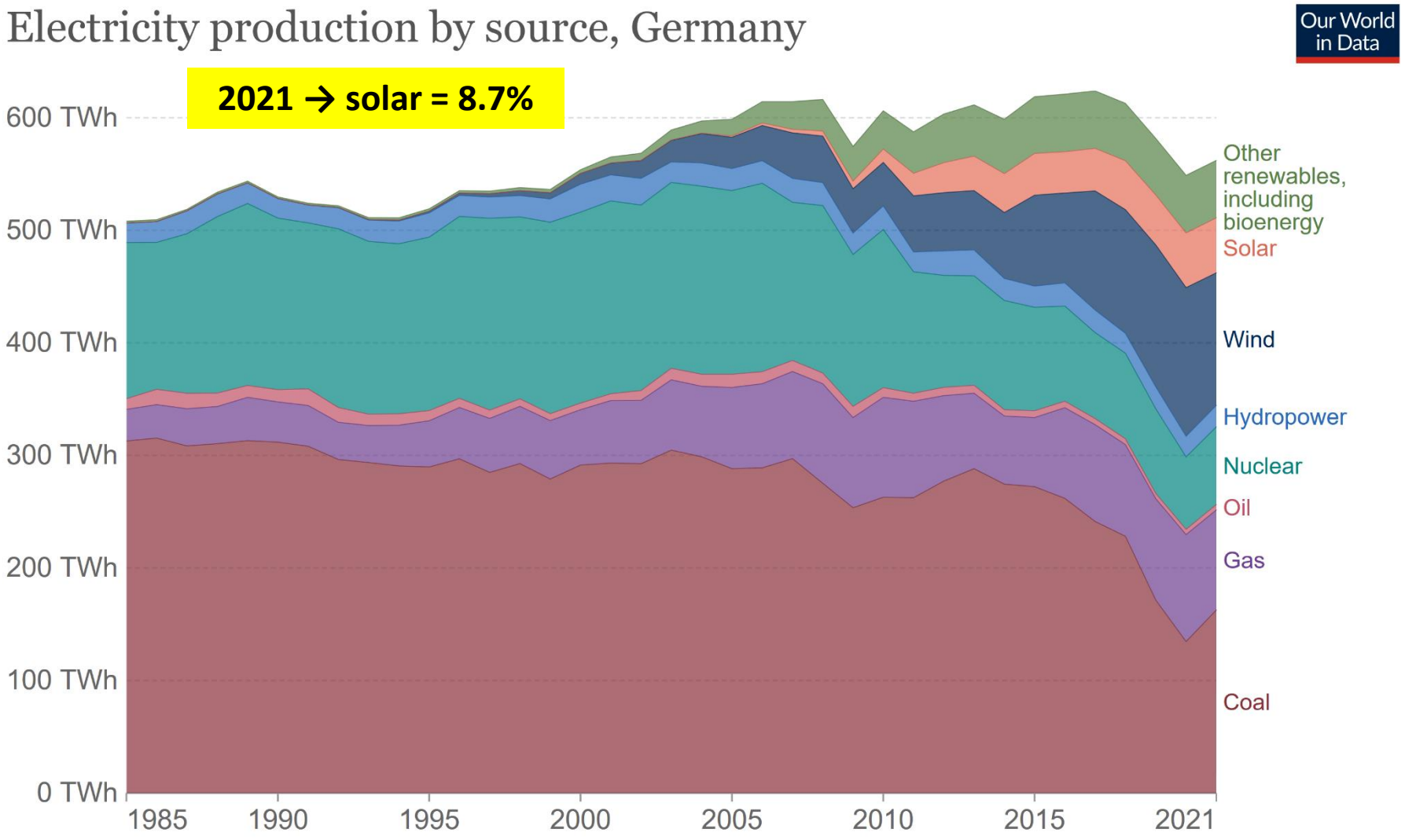
- ✓ All of the UK's electricity to come from clean sources by 2035 (renewable)
- ✓ Installation of 600,000 heat pumps a year by 2028 (electrification)
- ✓ No petrol or diesel cars will be sold in the UK from 2030 (electrification)

UK achievements:

- ✓ In 2020, UK emissions were 48% levels seen in 1990. It is important to add that the impact of COVID-19 restrictions and lockdowns had a large impact on the figures and that such a steep drop is not expected to be permanent
- ✓ The UK met its carbon budgets for the first two four-year cycles (2008-2012 and 2013-2017). It is also on track to meet its target for the 2018-2022 period

Source: 2021 Progress report to parliament – Climate Change Committee (CCC)

Electricity sector



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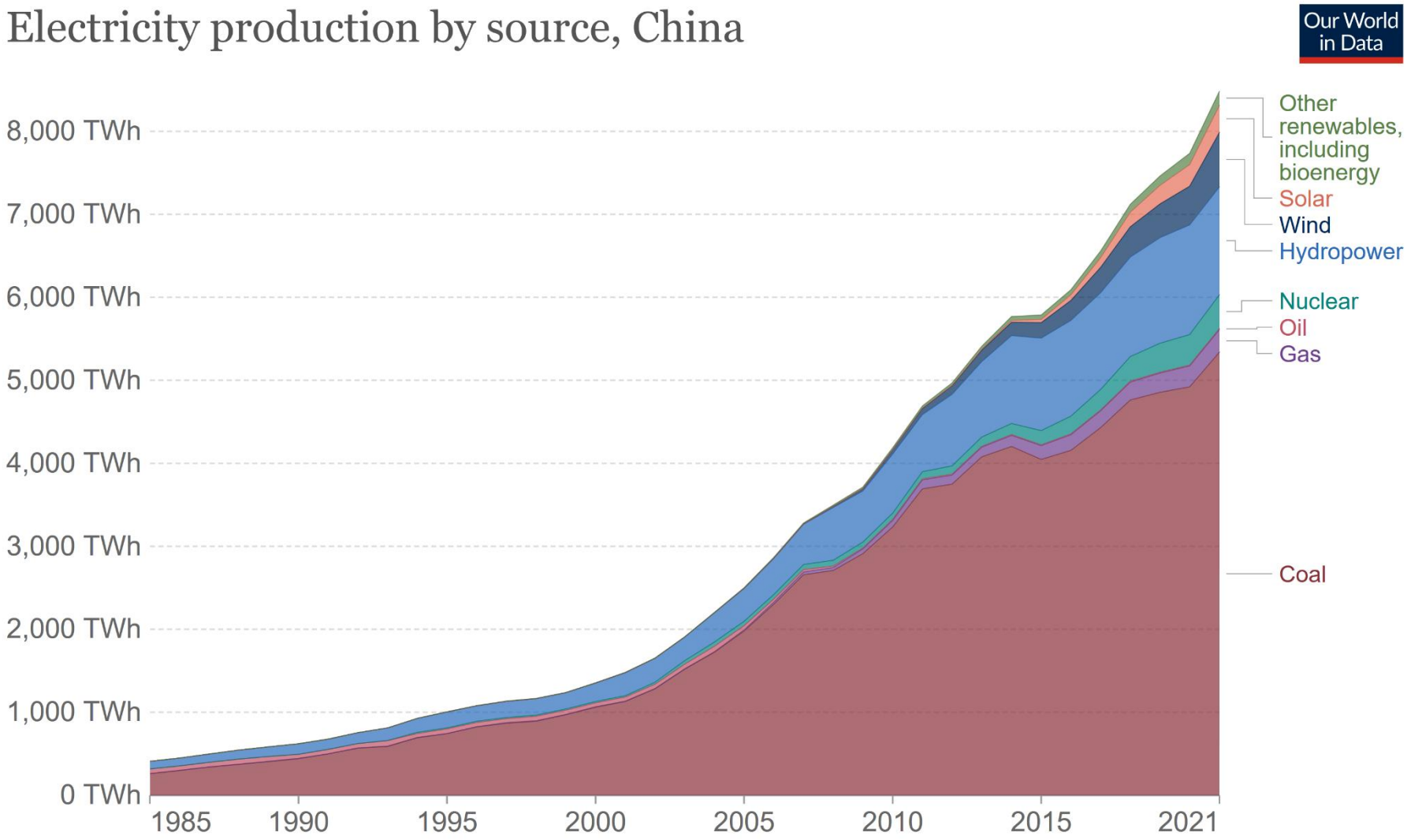
Electricity sector



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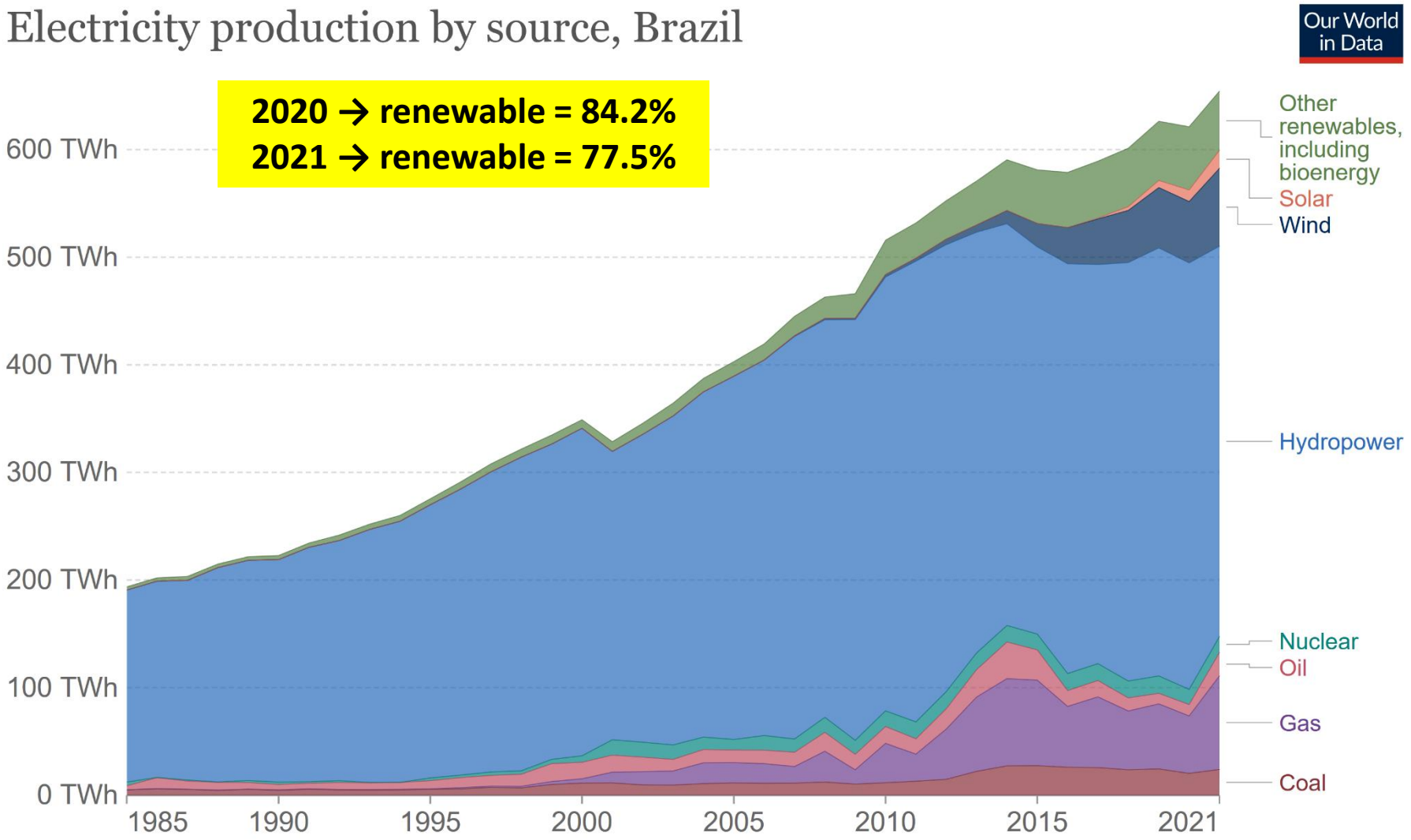
Electricity sector



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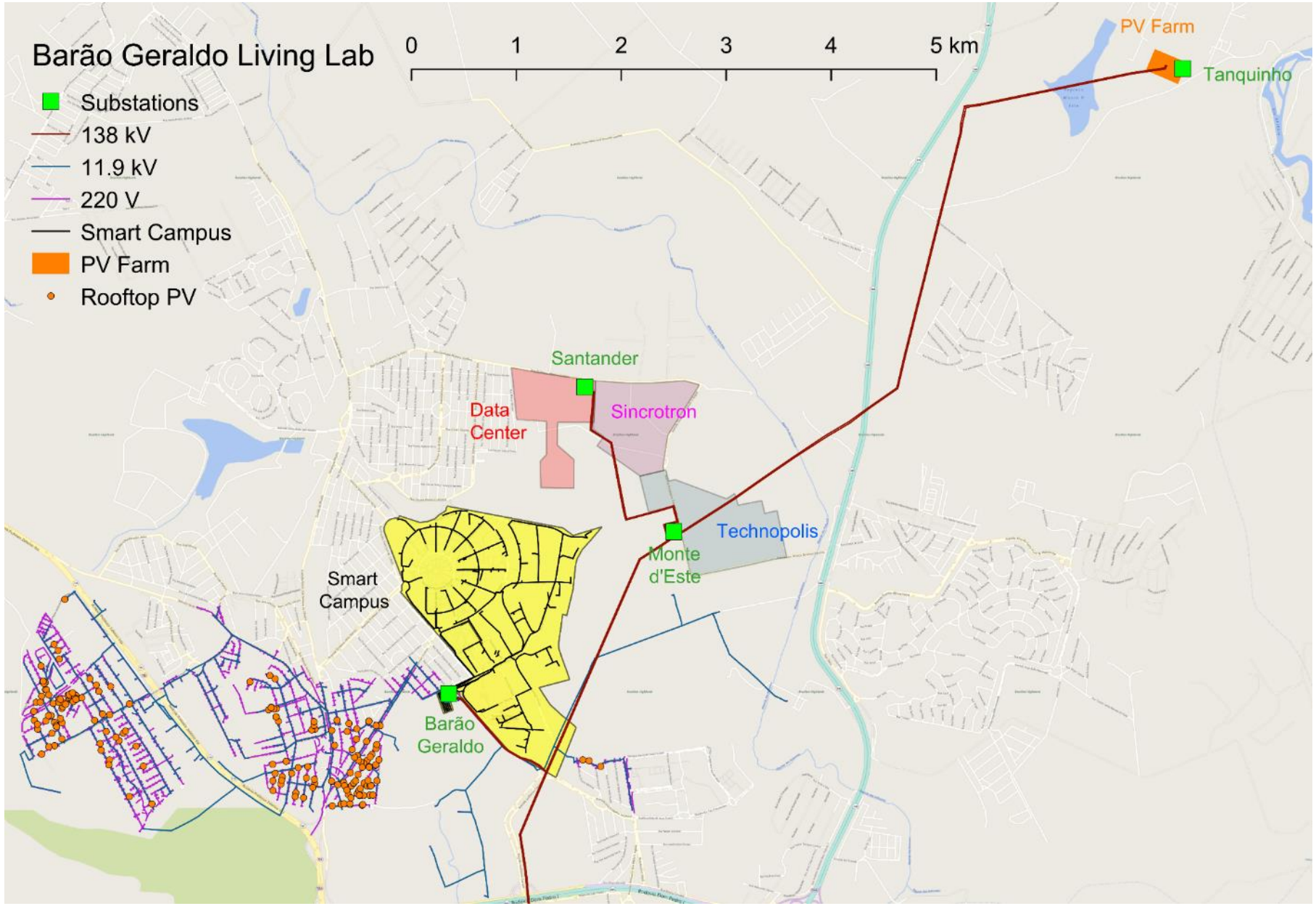
A Platform for smart grid technologies integration: one of the largest living labs in Latin America



A Platform for smart grid technologies integration: one of the largest living labs in Latin America

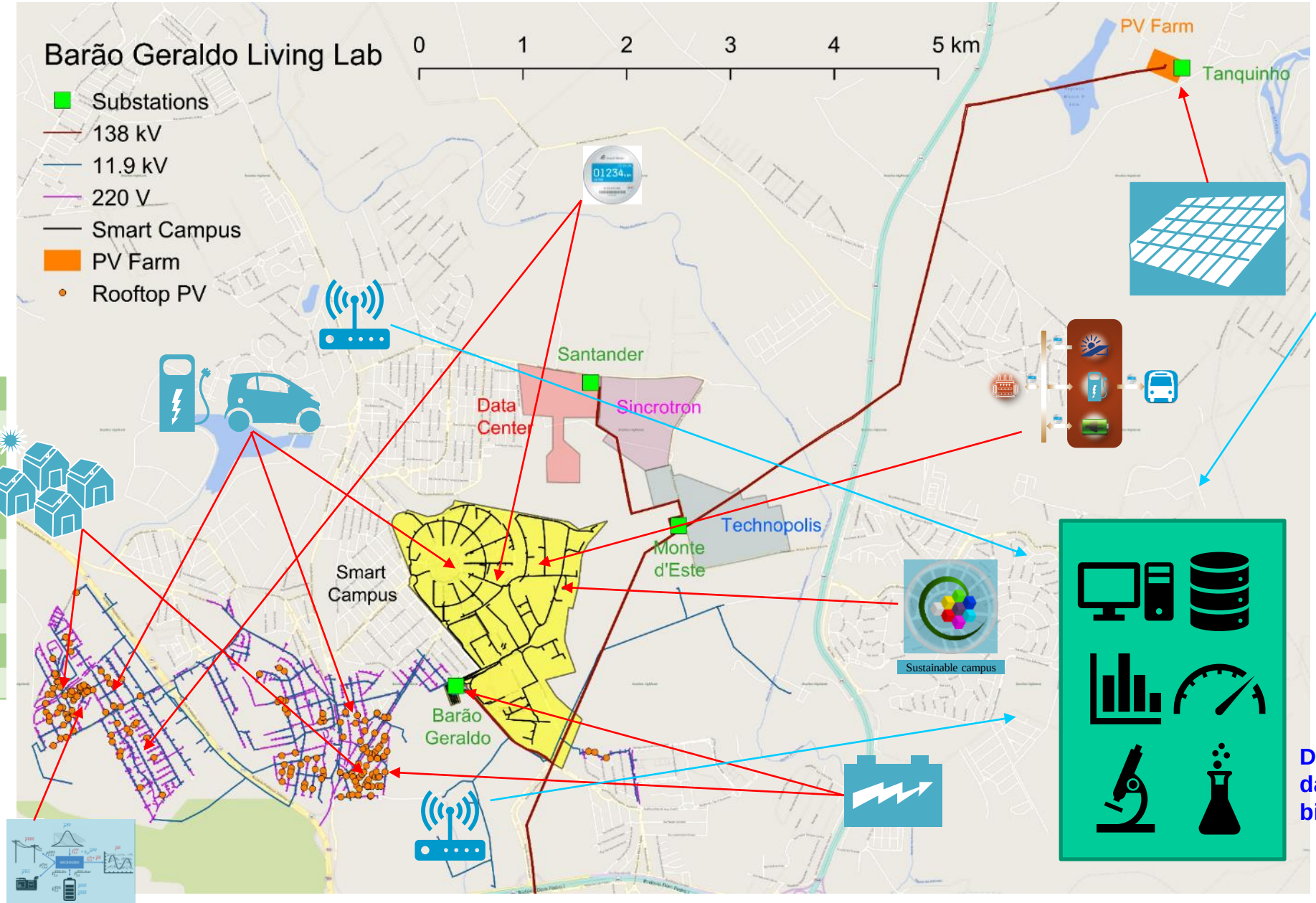
Technologies

PV generators
Electrical vehicles
Storage systems
Smart meters
Electronic-based regulators
Microgrids
A-DMS
Data analytics / Big data

Projects

PA3012: PV rooftop
PA0060: Electric mobility
PA3018: Energy storage
PA3048: Technical losses
PA3047: Volt/var
PA2030: Load disaggregation
PA3032: Sustainable campus
PA3043: Electric bus
CS3060: Electromobility
PA3058: Microgrids

Investment:
~R$ 180 million



UNICAMP

Data science: data analytics / big data

CPTEn: São Paulo Center for Energy Transition Studies

CPTEn

Centro Paulista de Estudos da Transição Energética

FAPESP 60 — SCIENCE, CULTURE AND DEVELOPMENT — 1962 - 2022

Program: Science Centers for Development

R&D Themes

I Artificial Intelligence and Data Science for Energy Management	**II** Regulatory Innovation and Models of Financing and Partnerships	**III** Public Politics and Governance	**IV** Economics Analysis of Prospection and Scenarios
V Education, HH formation, and capacitation for sustainable socioenvironment	**VI** Transition to Renewable Energy and Bioenergy	**VII** Transition to Digital Grids and Smart Consume	**VIII** Innovation for Smart Cities

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PI: Luiz Carlos Pereira da Silva (UNICAMP) – CPTEn

CO-PI: Walmir Freitas (UNICAMP) – Theme VII

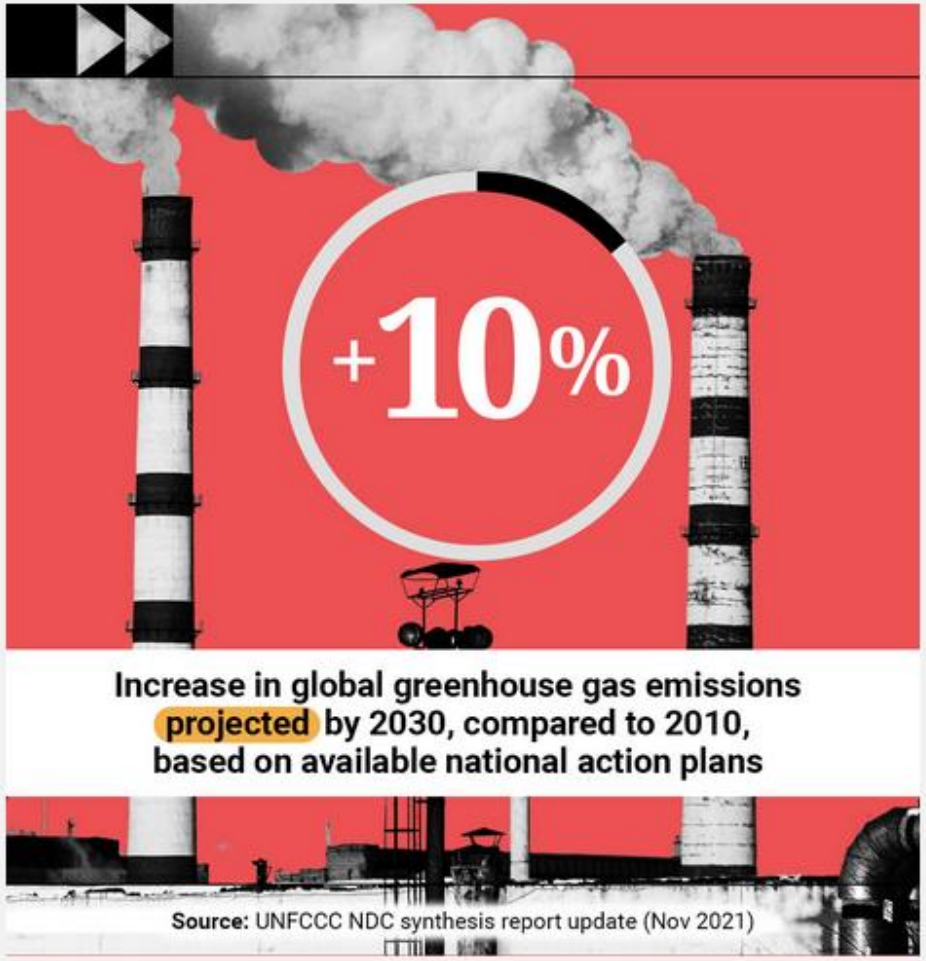
Comments

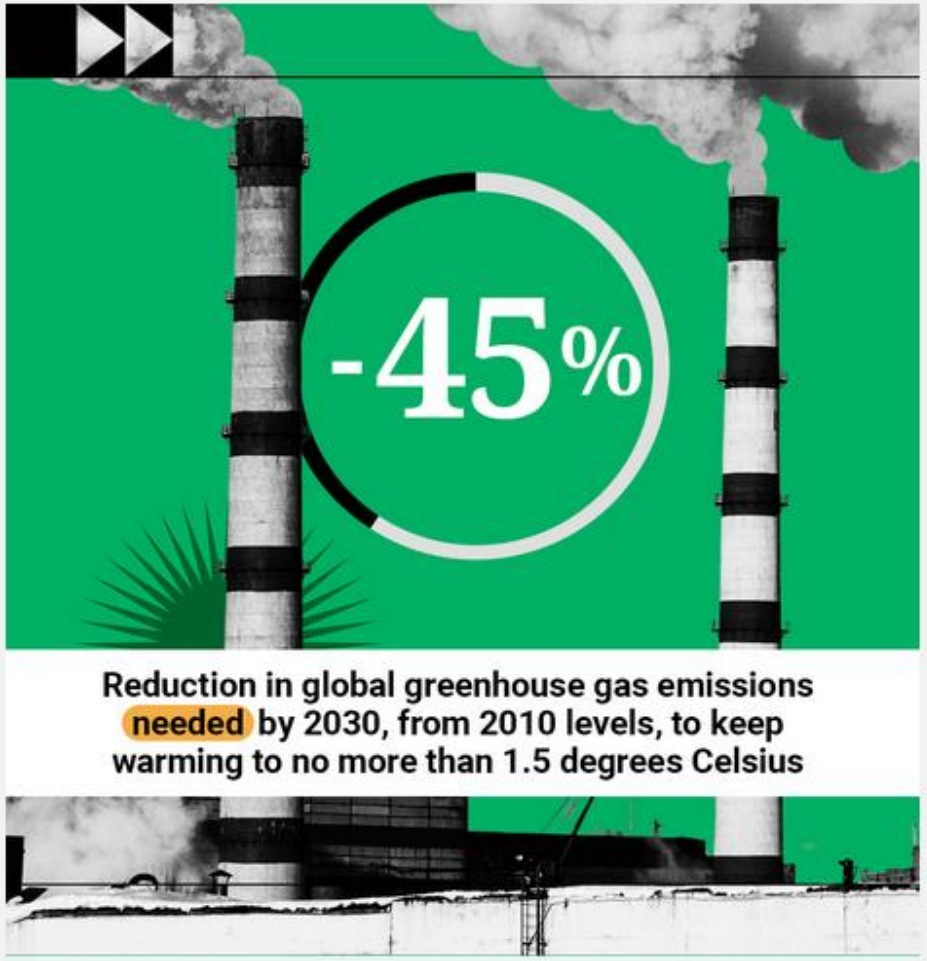
- Energy transition: it is not only a need, but also an opportunity
- Electricity produced by using renewable resources is one of the main vectors to support the transition
- Green products market should increase in the next years
- Brazil has a huge potential to fulfill this market (electrical sector is already green and there are resources to be deployed) – we cannot miss this opportunity
- Warning: it is a very slow process!

Comments

- National plan to:
  - ✓ strengthen the electricity sector
  - ✓ electrify the economy
  - ✓ increase the participation of renewables (wind, solar and hydro)
  - ✓ create products for green markets

The closing window: wake up call!

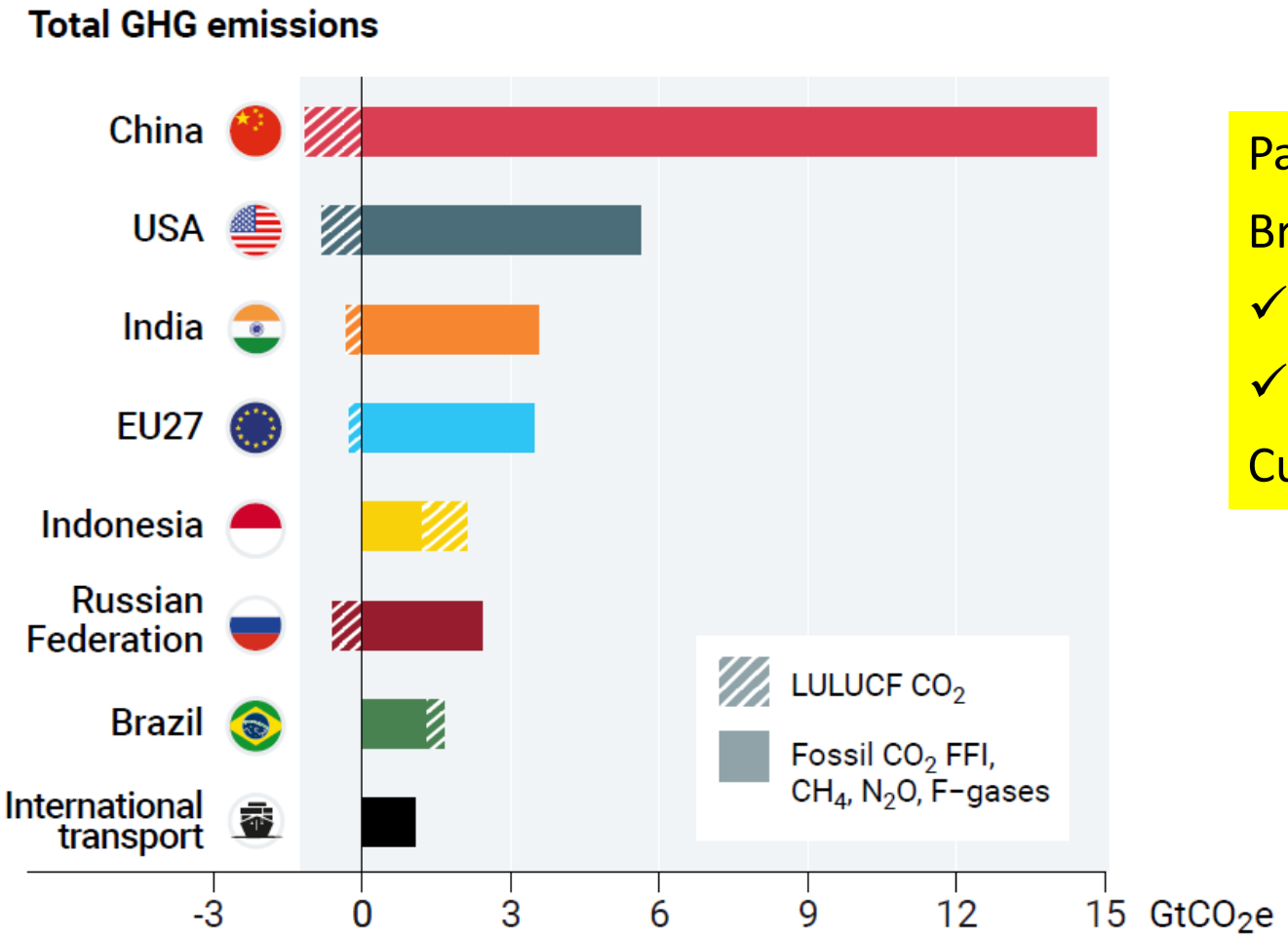




2010 → 2020 = +4.4%

Source: Emissions Gap Report 2022, UN environment programme

The closing window: wake up call!



Paris Agreement 2015

Brazil targets:

- ✓ 2025: 35% reduction wrt 2005
- ✓ 2030: 43% reduction wrt 2005

Current situation (2020): +28.3%

Source: Emissions Gap Report 2022, UN environment programme

Thank you

Walmir Freitas

http://www.dsee.fee.unicamp.br/~walmir