ENERGY POVERTY AND DECENTRALIZED RENEWABLE ENERGY

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11TH MAY 2023

ABOUT MYSELF

- B.Sc. (Honors) Zoology major, Botany and Chemistry minor – India
- Masters in Environmental Science Policy and Management – Sweden, UK, Hungary and Greece (Erasmus Mundus Scholar)
- Currently pursuing PhD in Energy Economics – France
- Thesis is on "Assessing the role of smart technologies in decarbonizing households: An economic study of electric vehicles, solar PVs and energy storage"

- 7+ years of work experience in climate change and renewable energy. Employed by UNDP and UNEP
- Projects: E-mobility; Energy efficiency in appliances and cities; RE focus on Solar, Wind and Biomass; Decentralised RE; Sustainability in urban sector, forestry and biodiversity.
- Have lived in 7 countries, worked in/travelled to 35+

WEBINAR OUTLINE

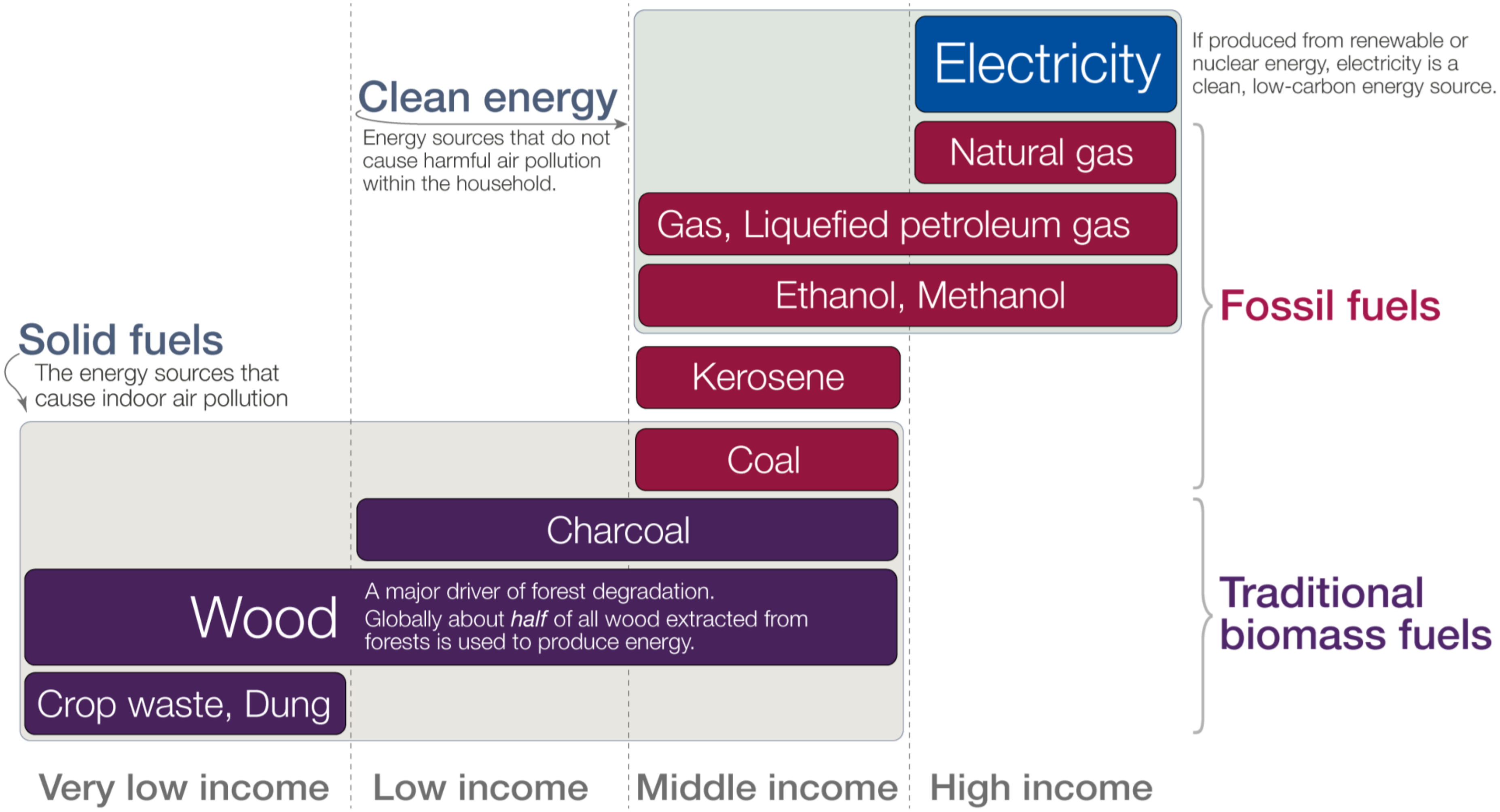
- Context/Need of Energy Transition
- Practical Case Study of Decentralised Renewable Energy Projects
- Role of Smart Technology in combating Energy Poverty eg. Smart Grids

ENERGY TRANSITION

- Energy Transition is a pathway toward transformation of the global energy sector from fossil-based to zero-carbon by the second half of this century.
- At its heart is the need to reduce energy-related CO_2 emissions to limit climate change.
- Decarbonisation of the energy sector requires urgent global action, plus further action needed to reduce carbon emissions and mitigate the effects of climate change.
- Renewable energy and energy efficiency measures can potentially achieve 90% of the required carbon reductions.
- The energy transition will be enabled by smart technology, information technology, policy frameworks and market instruments (IRENA)

ENERGY LADDER

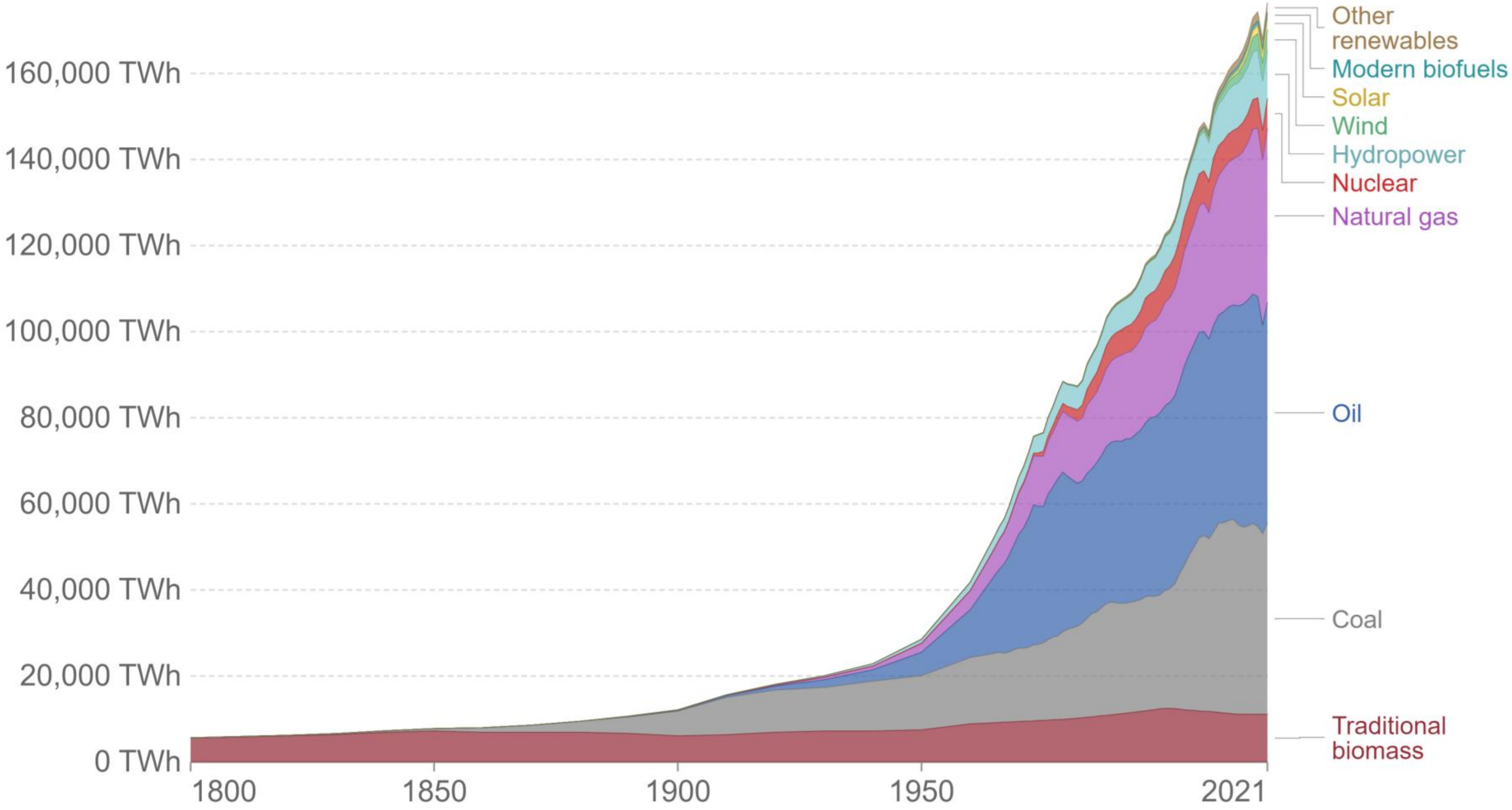
- Income level-wise dominant energy source for cooking and heating
- 40% of the world does not use electricity or gas to cook



GLOBAL PRIMARY ENERGY CONSUMPTION, HISTORIC

- Primary energy sources have been biomass – burning of solid fuels eg wood, crop waste, or charcoal
- 20th century – 50% from coal
- 1900s – first oil, gas, then hydropower
- 1960s – nuclear
- 1980s – modern renewables like solar wind

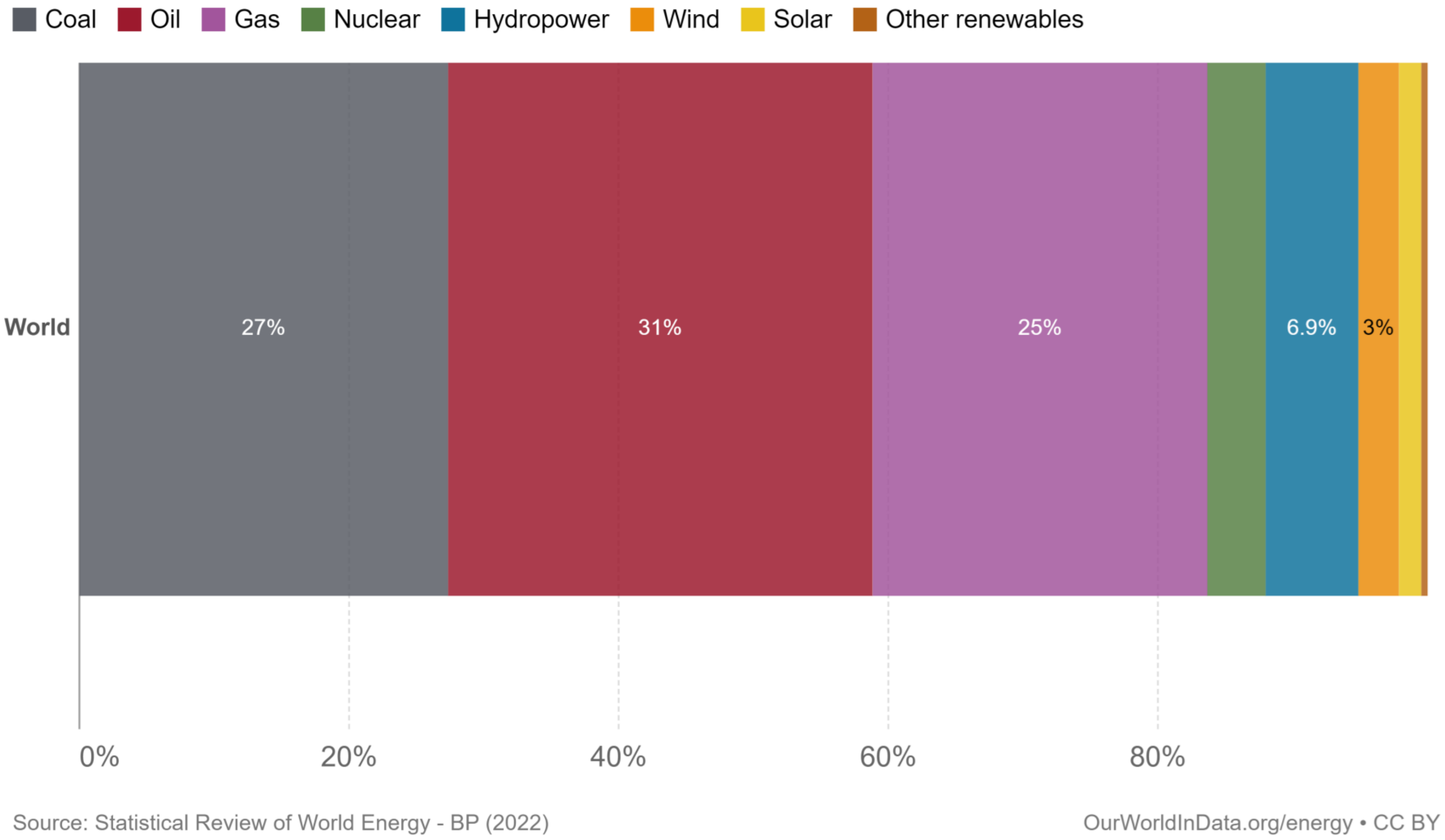
- Energy transitions have been slow in the past. Took decades for energy source to become dominant
- Transition now rapid due to technology advancements



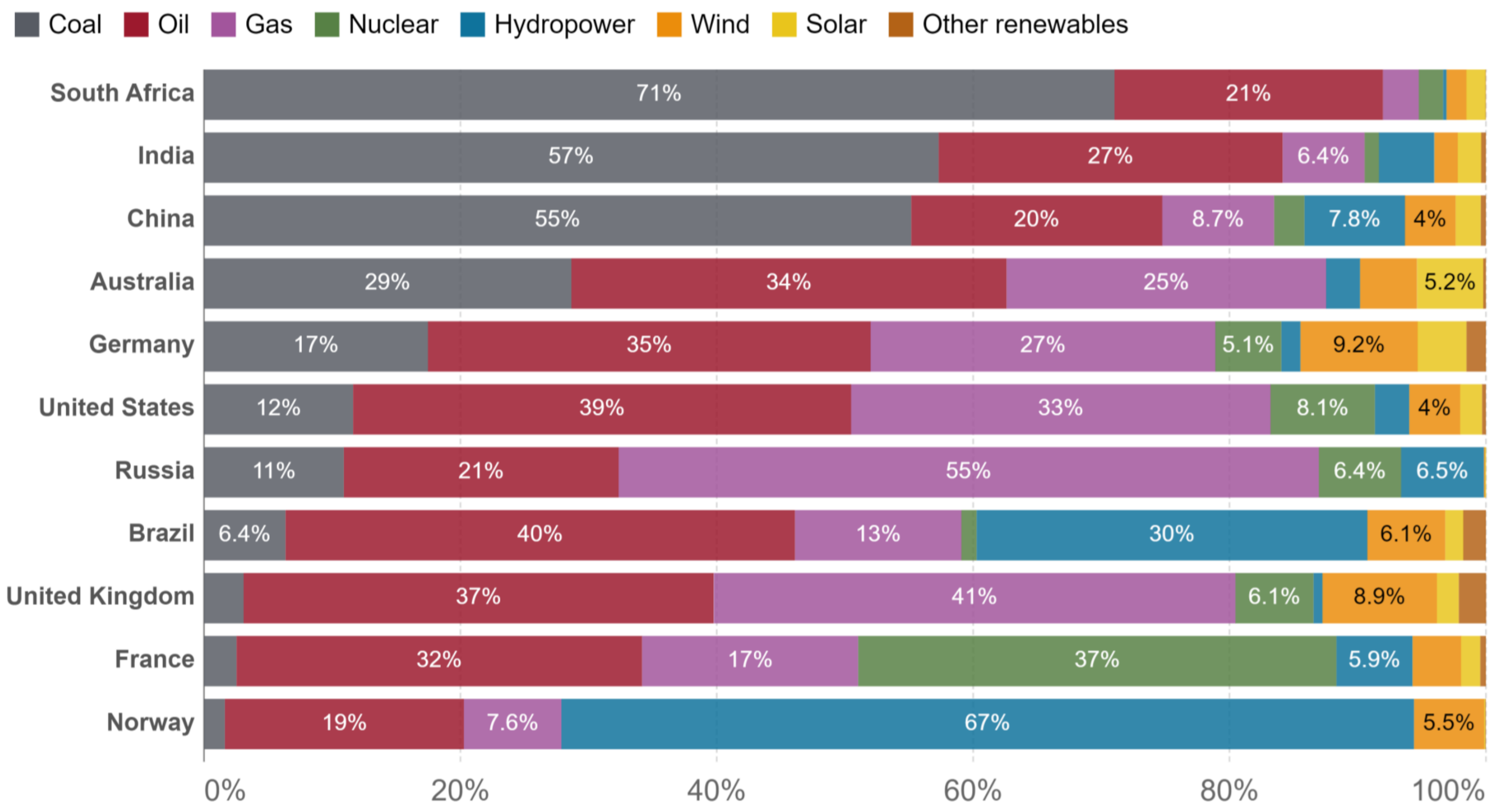
Source: Our World in Data based on Vaclav Smil (2017) and BP Statistical Review of World Energy

GLOBAL PRIMARY ENERGY CONSUMPTION, 2021

- In 2021, global primary energy mix:
  - Coal: 27.6%
  - Oil: 31.6%
  - Gas: 25%
  - Nuclear: 4.4%
  - Hydropower: 7%
  - Wind: 2.6%
  - Solar: 1.4%
  - Other renewables: 0.5%
- Only 16% from low-carbon sources

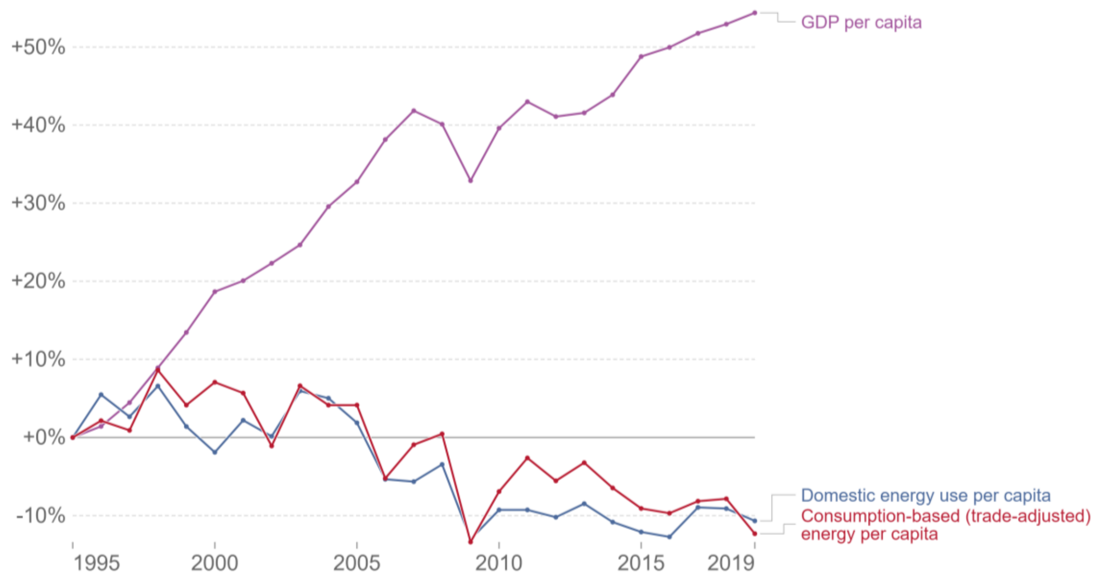


NATIONAL PRIMARY ENERGY CONSUMPTION, 2021

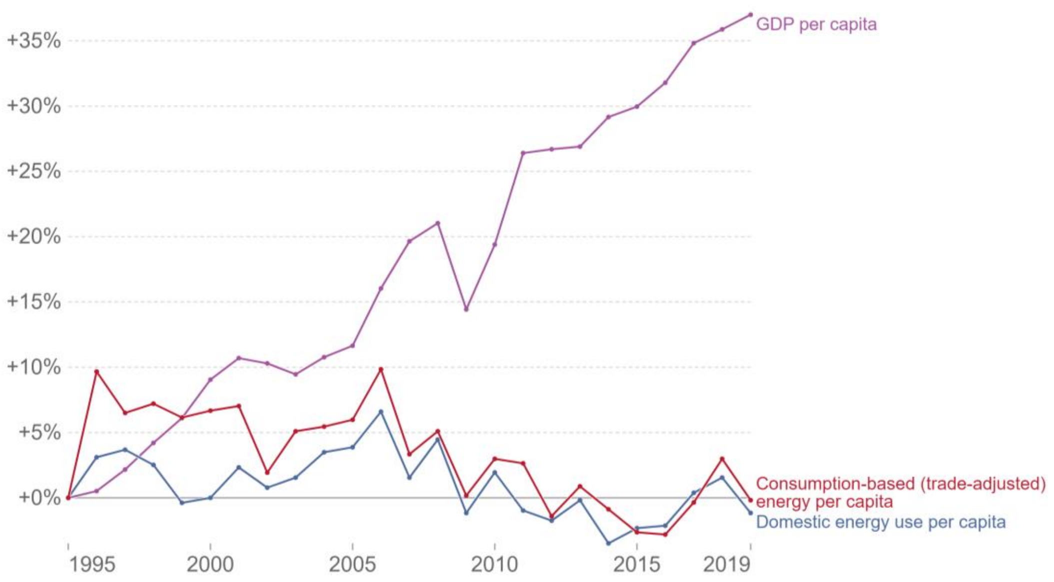


Source: Statistical Review of World Energy - BP (2022)

DECOUPLING EMISSIONS FROM GROWTH



Sweden



Germany

- Consumption based energy use plateaued or fallen due to decarbonisation and increased efficiency measures
- Not only by offshoring manufacturing overseas

CLIMATE CHANGE

- Climate change refers to long-term shifts in temperatures and weather patterns. These shifts may be natural, but since the 1800s, human activities have been the main driver of climate change, primarily due to the burning of fossil fuels (like coal, oil and gas), which produces heat-trapping gases
- Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the Earth, trapping the sun's heat and raising temperatures
- Examples of greenhouse gas emissions that are causing climate change include carbon dioxide and methane. These come from using gasoline for driving a car or coal for heating a building, for example. Clearing land and forests can also release carbon dioxide. Landfills for garbage are a major source of methane emissions
- **Energy, industry, transport, buildings**, agriculture and land use change are among the main emitters
- The Stern Review on the Economics of Climate Change says "Climate change presents a unique challenge for economics: it is the greatest example of market failure we have ever seen."

CLIMATE CHANGE MITIGATION AND ADAPTATION

Mitigation

- "implementing policies to reduce greenhouse gas emissions and enhance sinks", sinks being "any process, activity or mechanism that removes a greenhouse gas or aerosol, or a precursor of a greenhouse gas or aerosol from the atmosphere."
- Often undertaken by high income countries
- High dependency on technological measures

Adaptation

- "initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects"
- Often undertaken by medium and low income countries
- Identification of and work with vulnerable communities very important

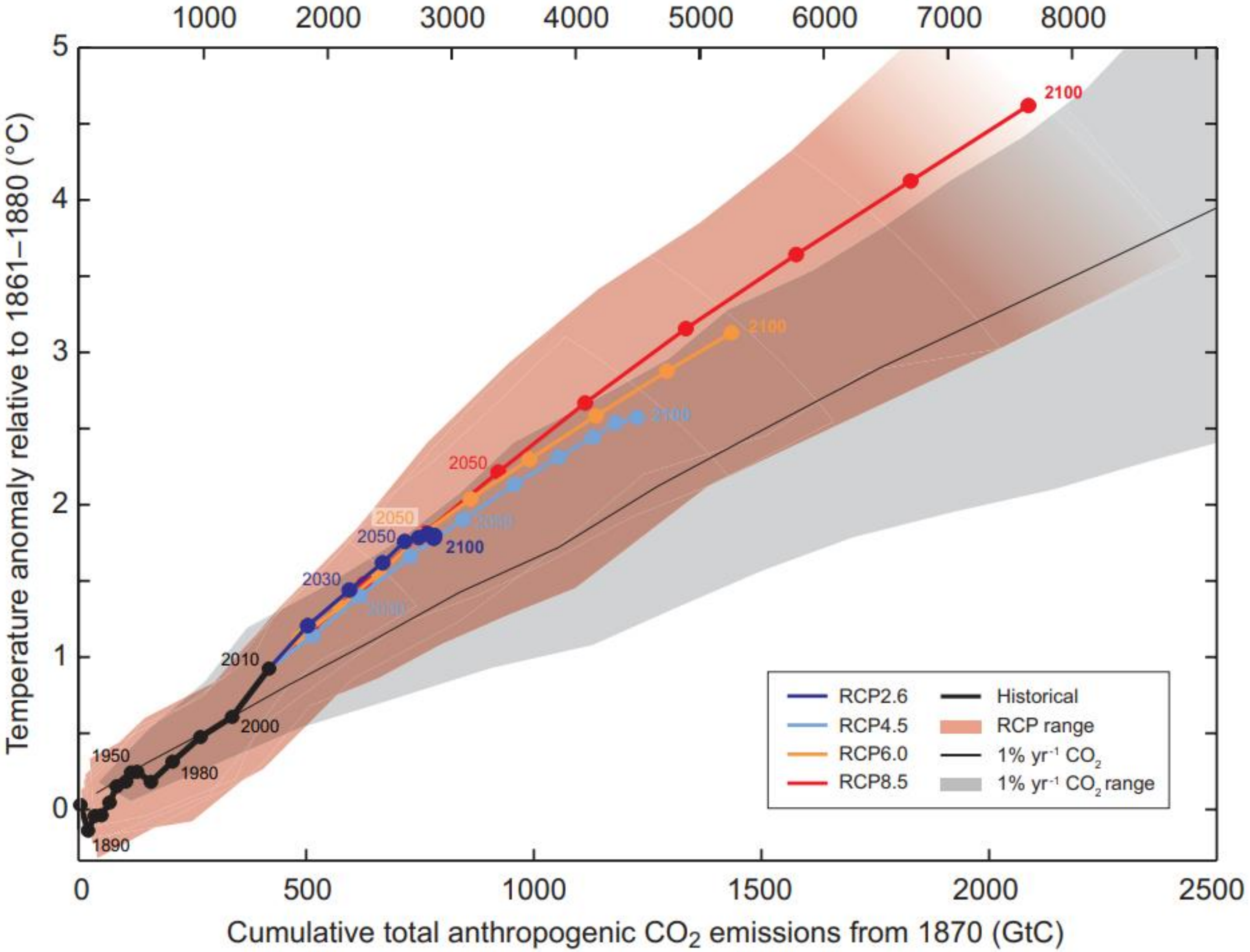
The impacts of climate change will not be borne equally or fairly, between rich and poor, women and men, and older and younger generations.

PARIS AGREEMENT 2015

- The Paris Agreement set out a global framework to avoid dangerous climate change by limiting global warming to well below 2°C and pursuing efforts to limit it to 1.5°C. It also aims to strengthen countries' ability to deal with the impacts of climate change and support them in their efforts.
- The Paris Agreement was the first-ever universal, legally binding global climate change agreement, adopted at the Paris climate conference (COP-21) in December 2015.
- The EU and its Member States are among the ~190 Parties to the Paris Agreement. The EU formally ratified the agreement on 5 October 2016, thus enabling its entry into force on 4 November 2016.
- For the agreement to enter into force, at least 55 countries representing at least 55% of global emissions had to deposit their instruments of ratification
- Major emissions reduction plans (mitigation action)
- Recognised the role of non-Party stakeholders in addressing climate change, including cities, other subnational authorities, civil society, the private sector and others

EMISSIONS SCENARIOS

- Linear relationship between CO2 and temp = Scientifically accurate to link temperature rise with global cumulative CO2 emissions budget
- Fig: cumulative emissions of 3,670 Gt CO2 would maintain the temperature increase below 2◦C with a probability of 66%
- Representative Concentration Pathways (RCPs) – cumulative impact per molecule/year. Methane is low (12 yrs in atmosphere) whereas CO2 stays for centuries
  - RCP 8.5: strongest forcing. CO2 emissions double by 2050 and continue to rise
  - RCP 4.5: moderate forcing. CO2 emissions stabilize by 2050 and decline thereafter to 40% of their current levels by 2080
  - RCP 2.6: weakest forcing. CO2 emissions decline, to less than 1/3 of the current levels by 2050, and become net-negative during the 2080s



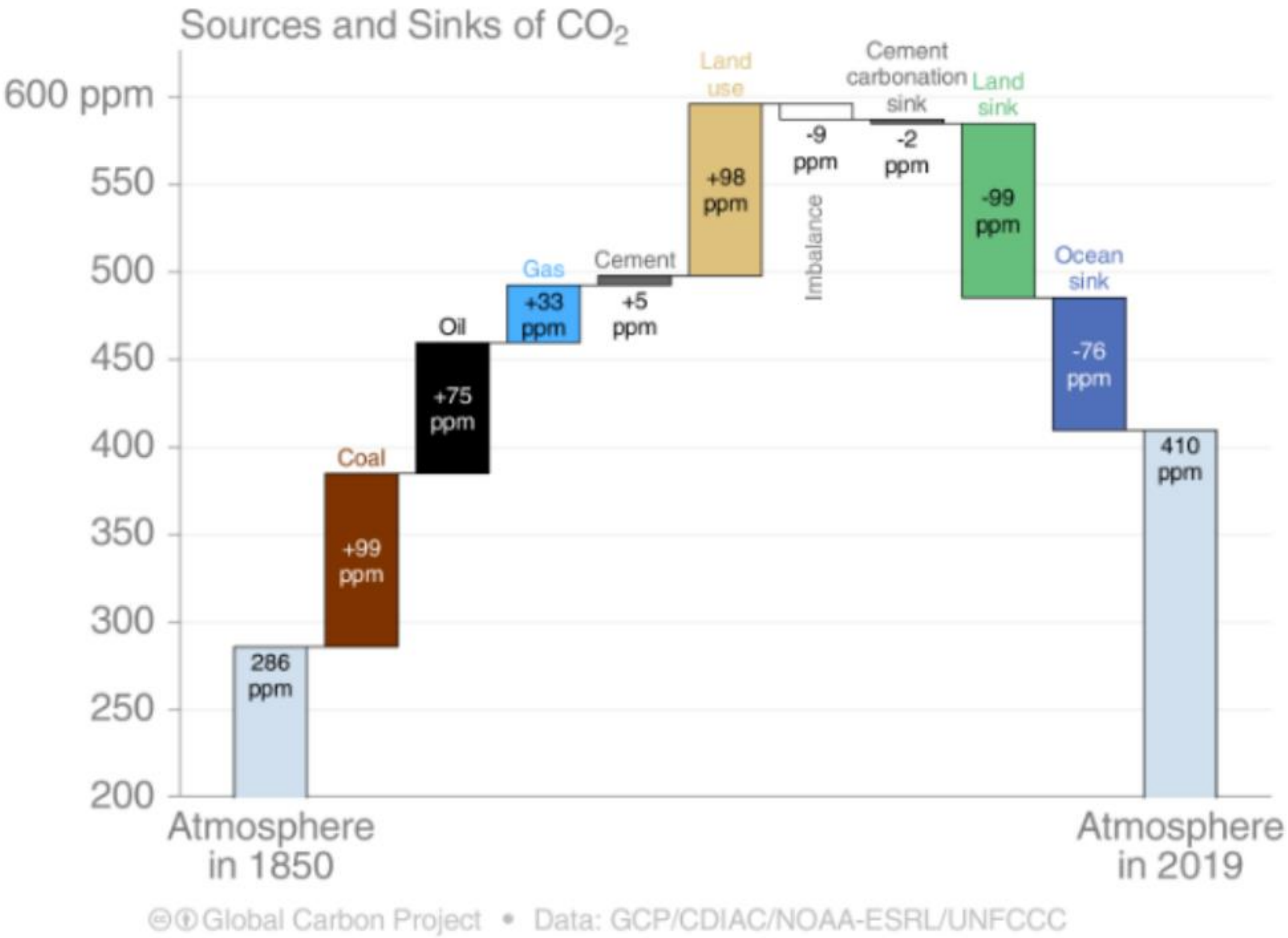
GLOBAL CARBON BUDGET

- Global cumulative CO2 emissions budget is the **global carbon budget**
- Cumulative contributions to global carbon budget since 1850
- Carbon imbalance represents gap in our current understanding of sources and sinks

- Remaining carbon budget (IPCC)

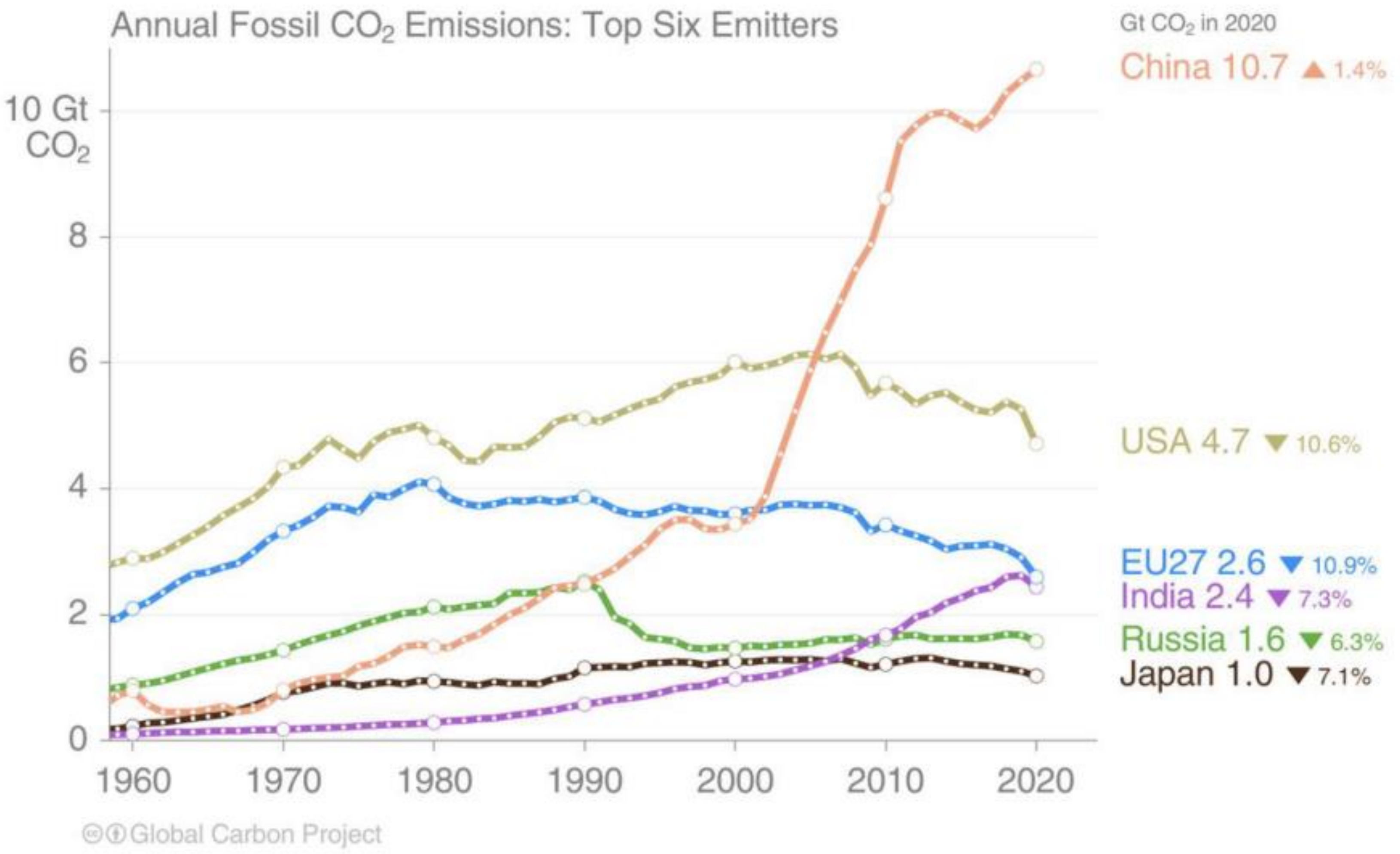
$\Delta T = 2^\circ C$: 1,170 Gt CO2

$\Delta T = 1.5^\circ C$: 420 Gt CO2



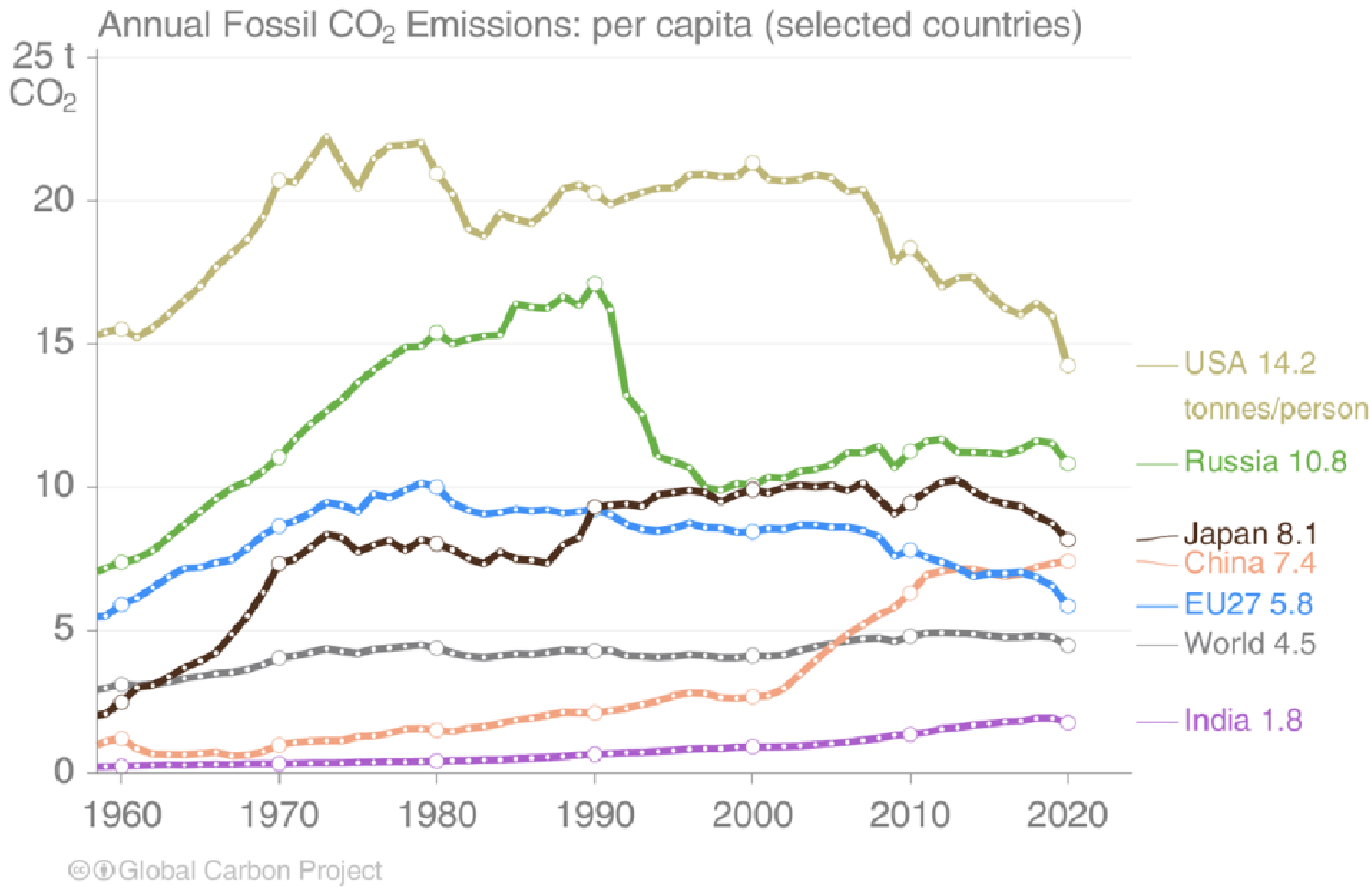
TOP EMITTERS: OVERALL

- The top 6 emitters in 2020 covered 60% of global emissions
  - China 31%
  - USA 14%
  - EU27 7%
  - India 7%
  - Russia 5%
  - Japan 3%
- International aviation and maritime shipping (bunker fuels) contributed 2.9% to global emissions in 2020



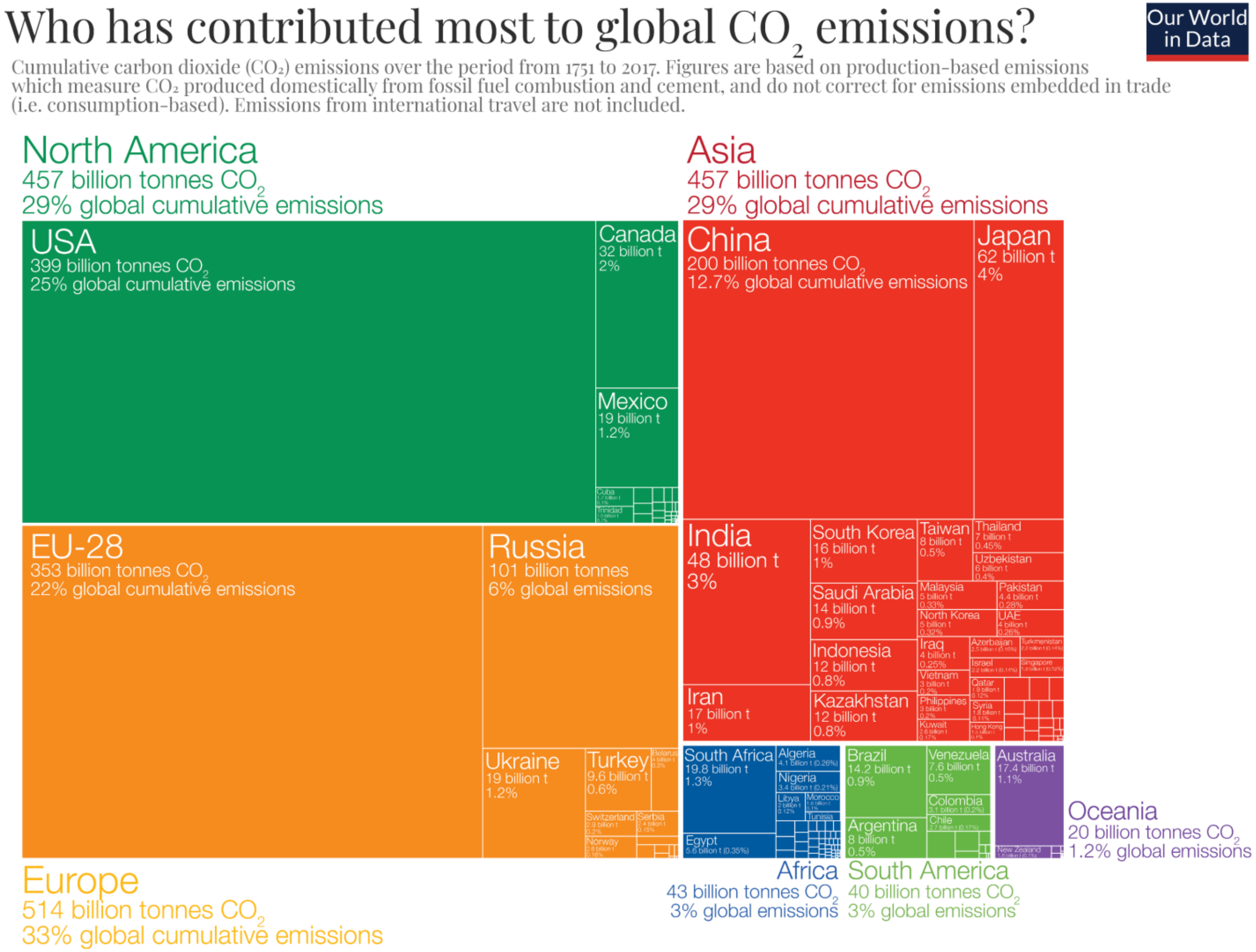
TOP EMITTERS: PER CAPITA

- Production-based emitters vs consumption-based emitters
- Strong correlation between income and emissions /capita
  - Chad, Niger and the Central African Republic = 0.1t
  - 160x lower than USA, AUS, CAN
  - Avg. US, AUS citizen emission in 2 days = Avg Mali, Nigeria citizen in 365 days
- Countries with high standards of living have a high CO_2 footprint
- Large inequalities across EU 27
  - FR, PT, UK < DE, NL, BE
  - Energy source choice ie. RE and nuclear
- Prosperity is primary driver but policy and technology choices make a big difference



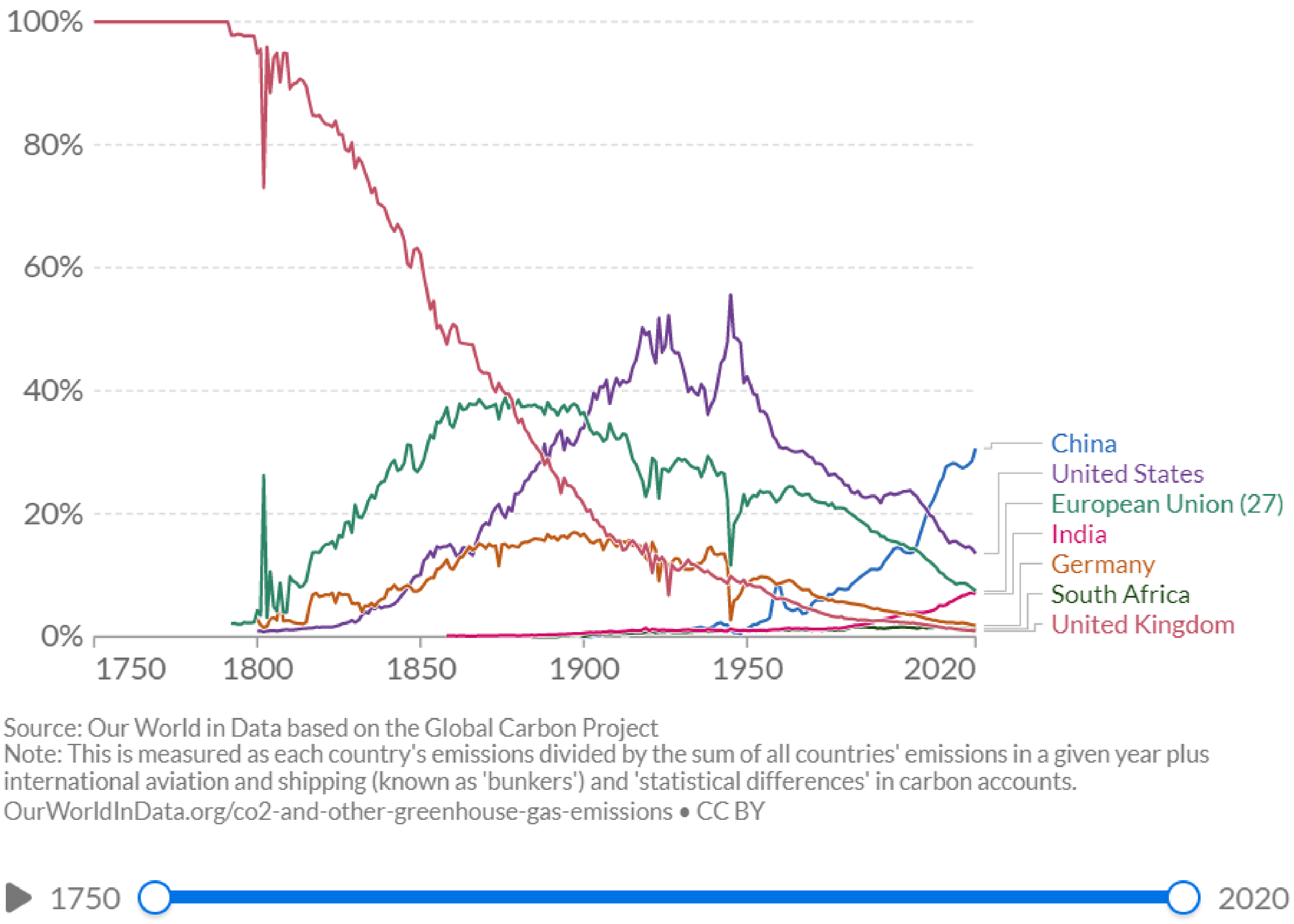
TOP EMITTERS: REGIONAL SHARE

- **Cumulative** emissions
- US has emitted more CO_2 than any other country to date: at around 400 billion tonnes since 1751, it is responsible for 25% of historical emissions
- US 2x more than China – the world's second largest national contributor
- EU-28 (Now EU 27 + UK) large historical contributor at 22%
- many of the large annual emitters today – such as India and Brazil – are not large contributors in a historical context
- Africa's regional contribution very small
  - >0.01% of all emissions in the last 266 years
  - result of very low /capita emissions, historically and currently



ANNUAL SHARE OF GLOBAL CO2 EMISSIONS

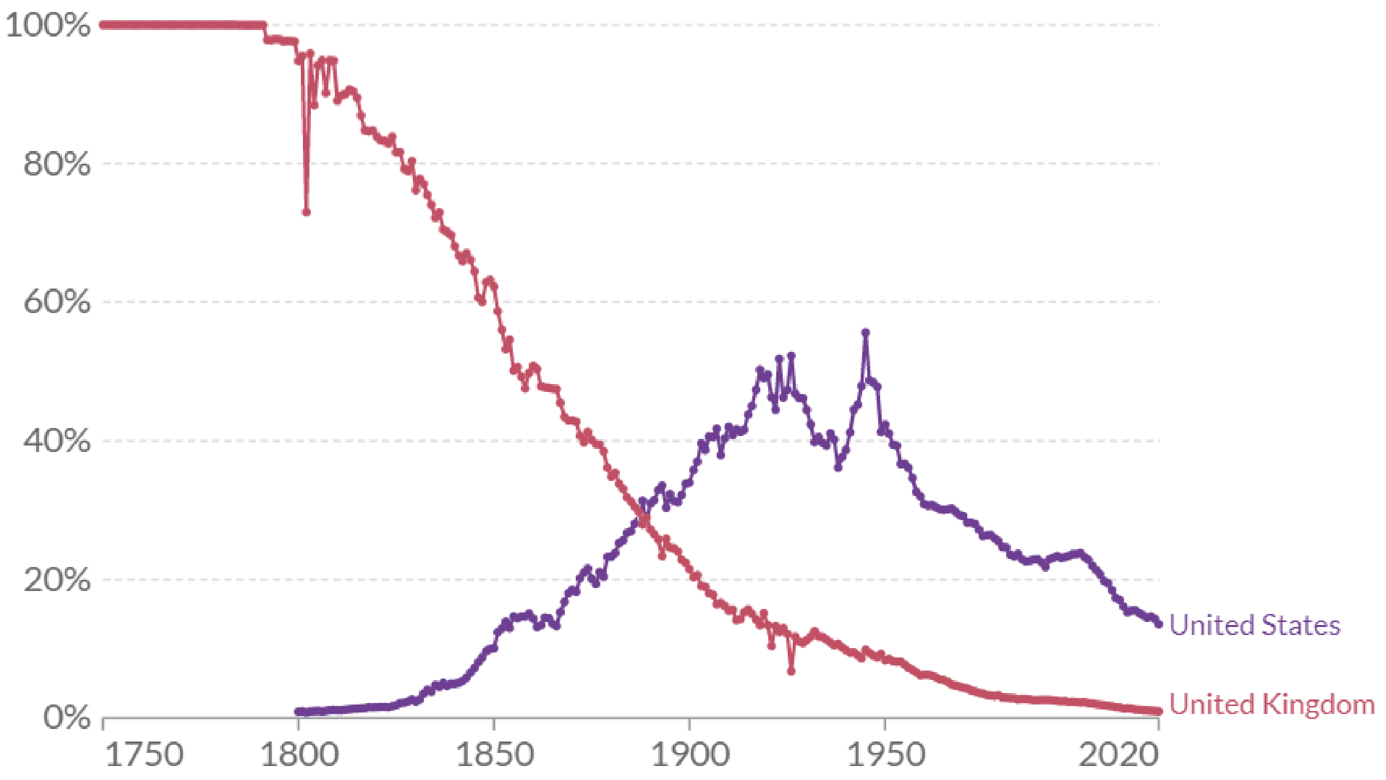
- Historic emissions 1750 - 2020



Source: Our World in Data based on the Global Carbon Project
Note: This is measured as each country's emissions divided by the sum of all countries' emissions in a given year plus international aviation and shipping (known as 'bunkers') and 'statistical differences' in carbon accounts.

ANNUAL SHARE OF GLOBAL CO2 EMISSIONS

- Historic emissions 1750 - 2020
- Till 1888, UK was largest emitter. Overtaken by USA.
- UK was the first country to industrialize: led to massive improvements in living standards



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1750 2020

ANNUAL SHARE OF GLOBAL CO2 EMISSIONS

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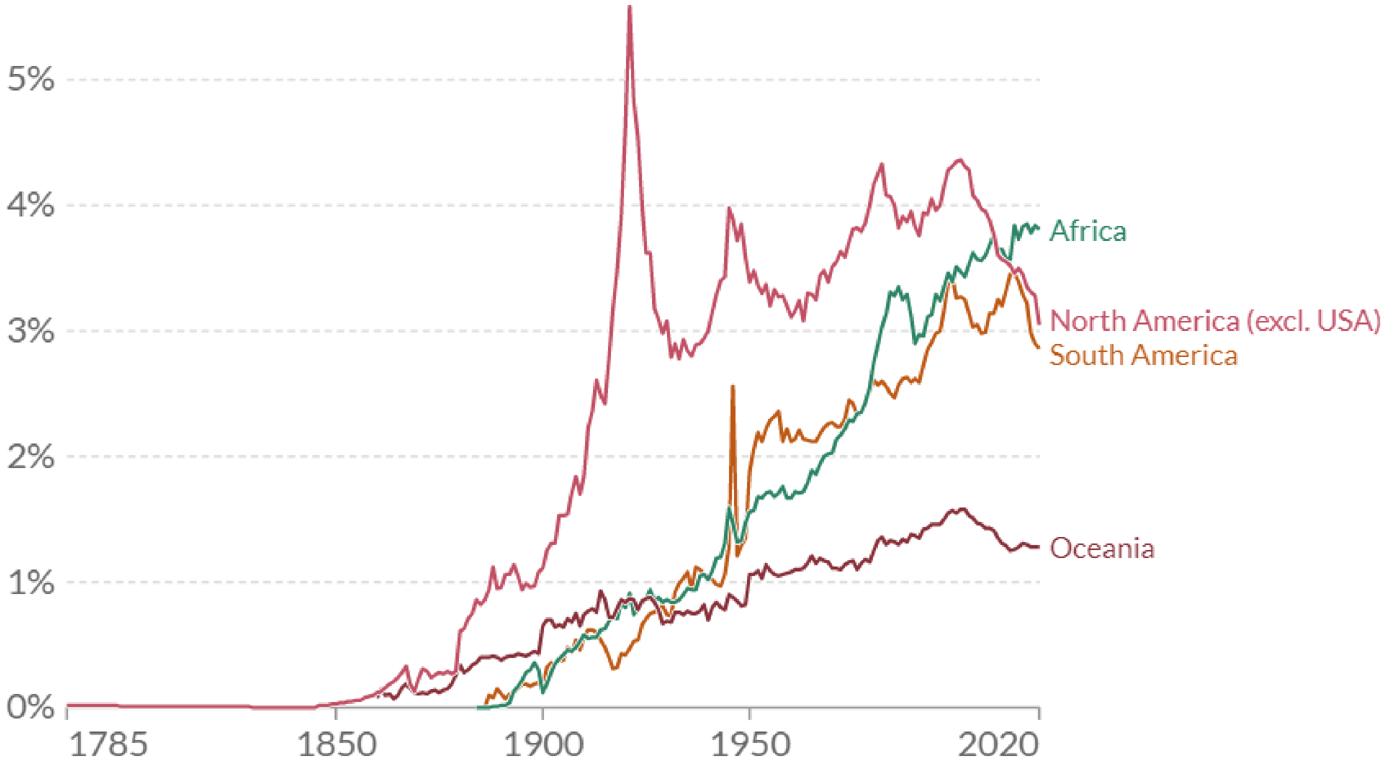
- Followed by other countries specially in Americas, Oceania and Africa



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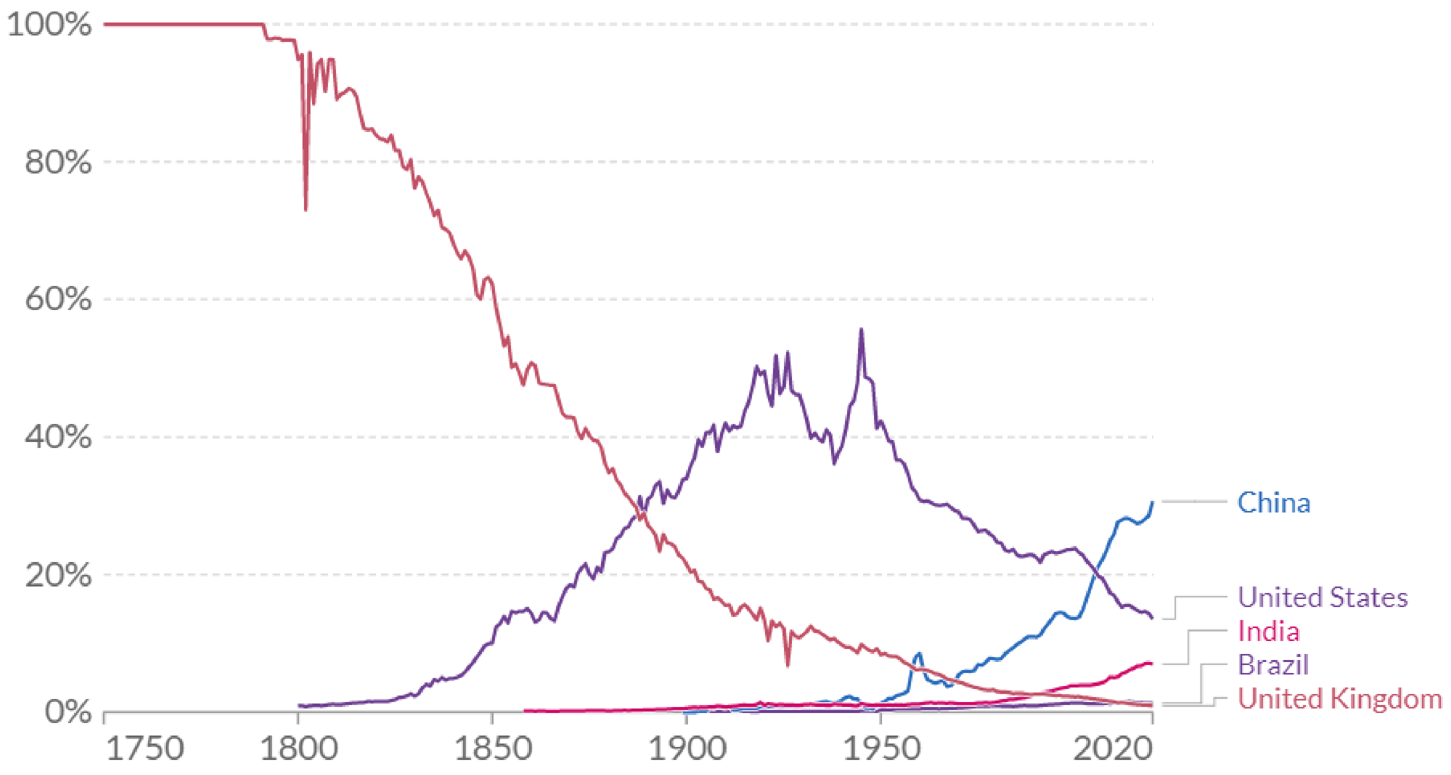
1785 2020

ANNUAL SHARE OF GLOBAL CO2 EMISSIONS

- Historic emissions 1750 - 2020
- Till 1888, UK was largest emitter. Overtaken by USA.
- UK was the first country to industrialize: led to massive improvements in living standards
- Followed by other countries specially in Americas, Oceania and Africa
- Rising CO_2 emissions have clear negative environmental consequences, but they have historically been a by-product of positive improvements in human living conditions



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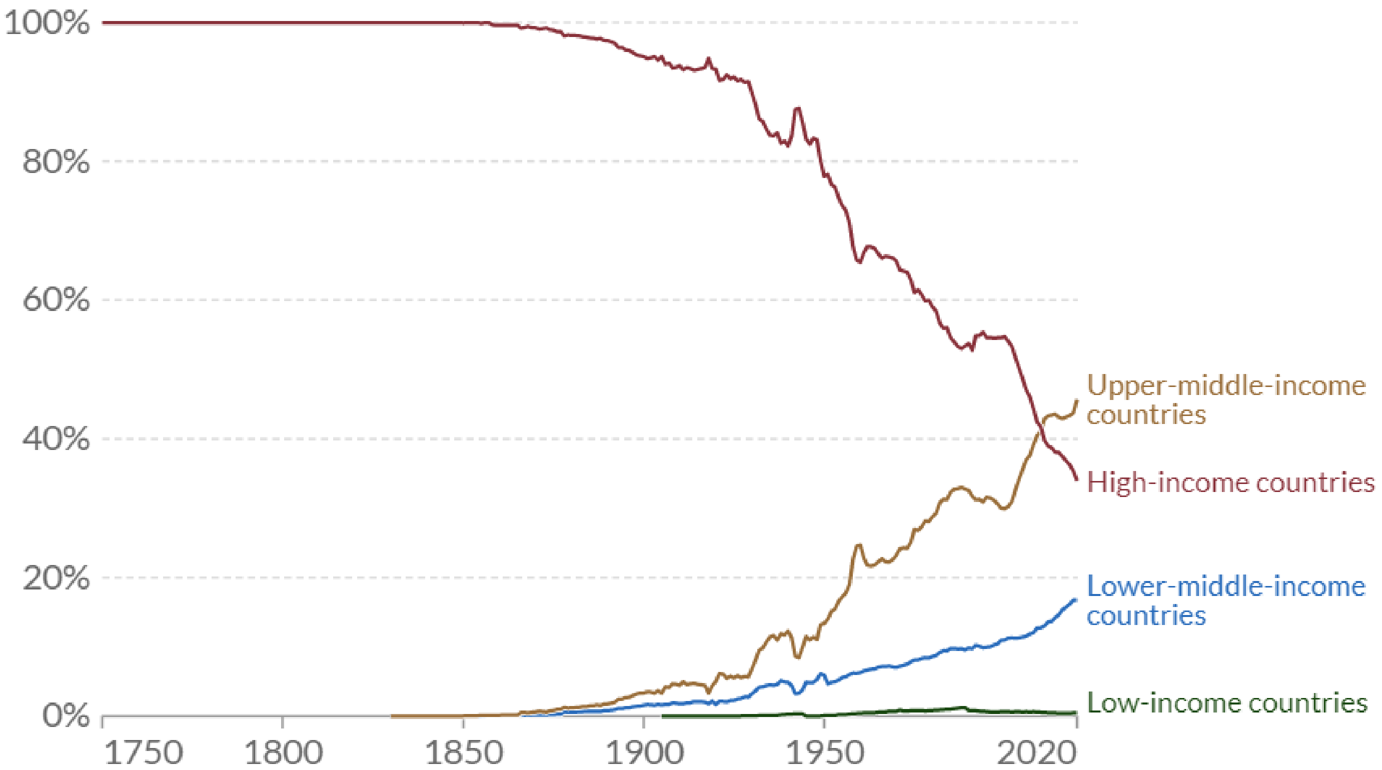
ANNUAL SHARE OF GLOBAL CO2 EMISSIONS

- China, USA and the 28 countries of the EU account for more than half of global emissions
- Asia’s rapid rise in emissions occurred in recent decades
- By-product of improvements in living standards
  - since 1950 life expectancy in Asia inc from 41 to 74 years
  - fall in extreme poverty
  - rise in formal education



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ENERGY VS. ELECTRICITY

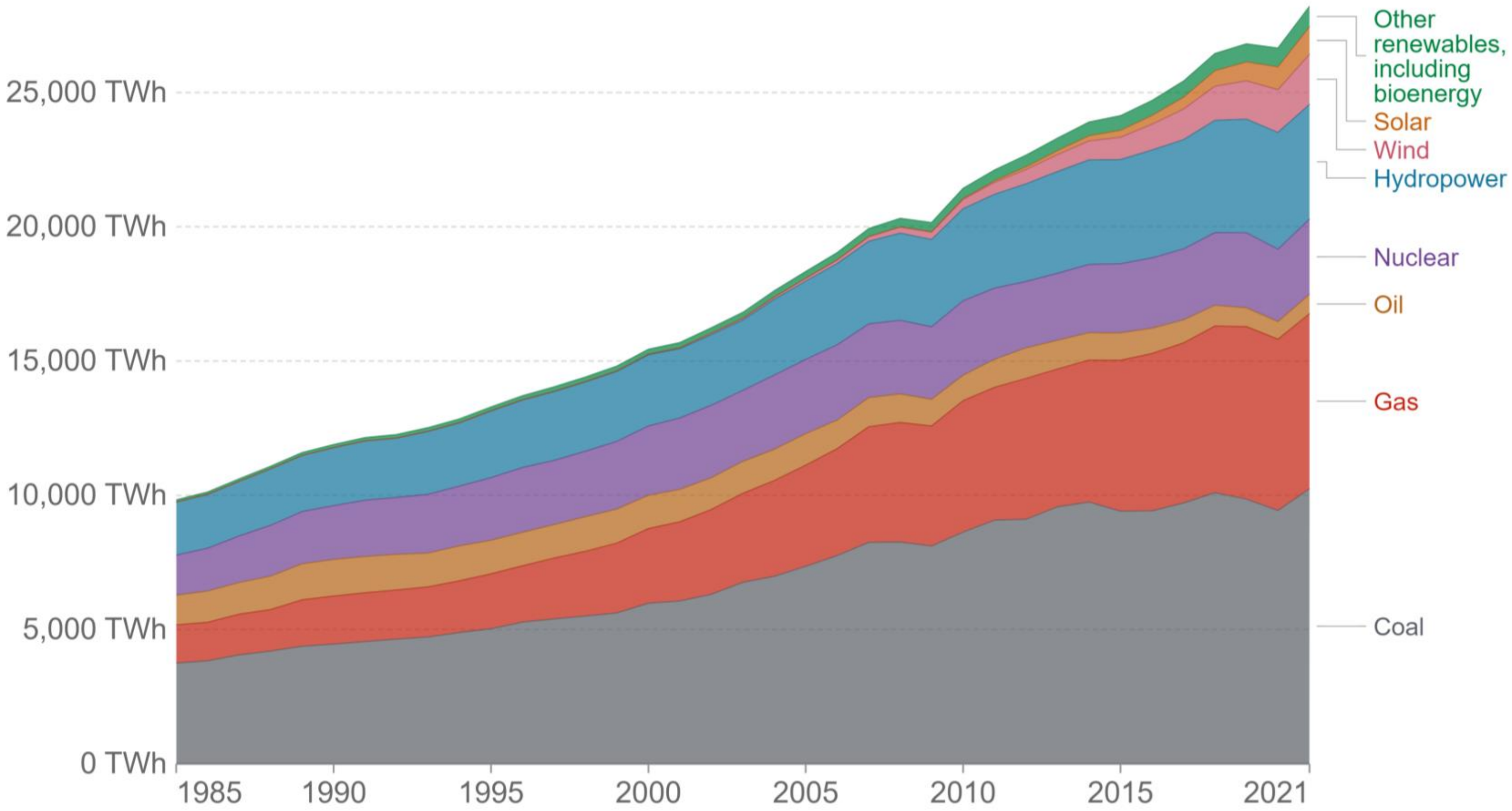
- **Energy**: all capacity to do work
  - Burning firewood for heat
  - Combusting gasoline for movement
  - Spinning turbines for electricity

- **Electricity**: specific type of energy
  - Harnessing light/chemical/mechanical energy
  - Efficiently generated, transported and consumed
  - Other components are transport and heating/cooling

- Emissions reductions goals eg. California to have 100% carbon-free electricity by 2045
  - Producing electricity from clean sources
  - Electrifying existing technology eg. Transport, heating, cooling

GLOBAL ELECTRICITY PRODUCTION, HISTORIC

- In 2021, 1/3rd of electricity came from low carbon sources
- Harder to decarbonise transport and heating/cooling



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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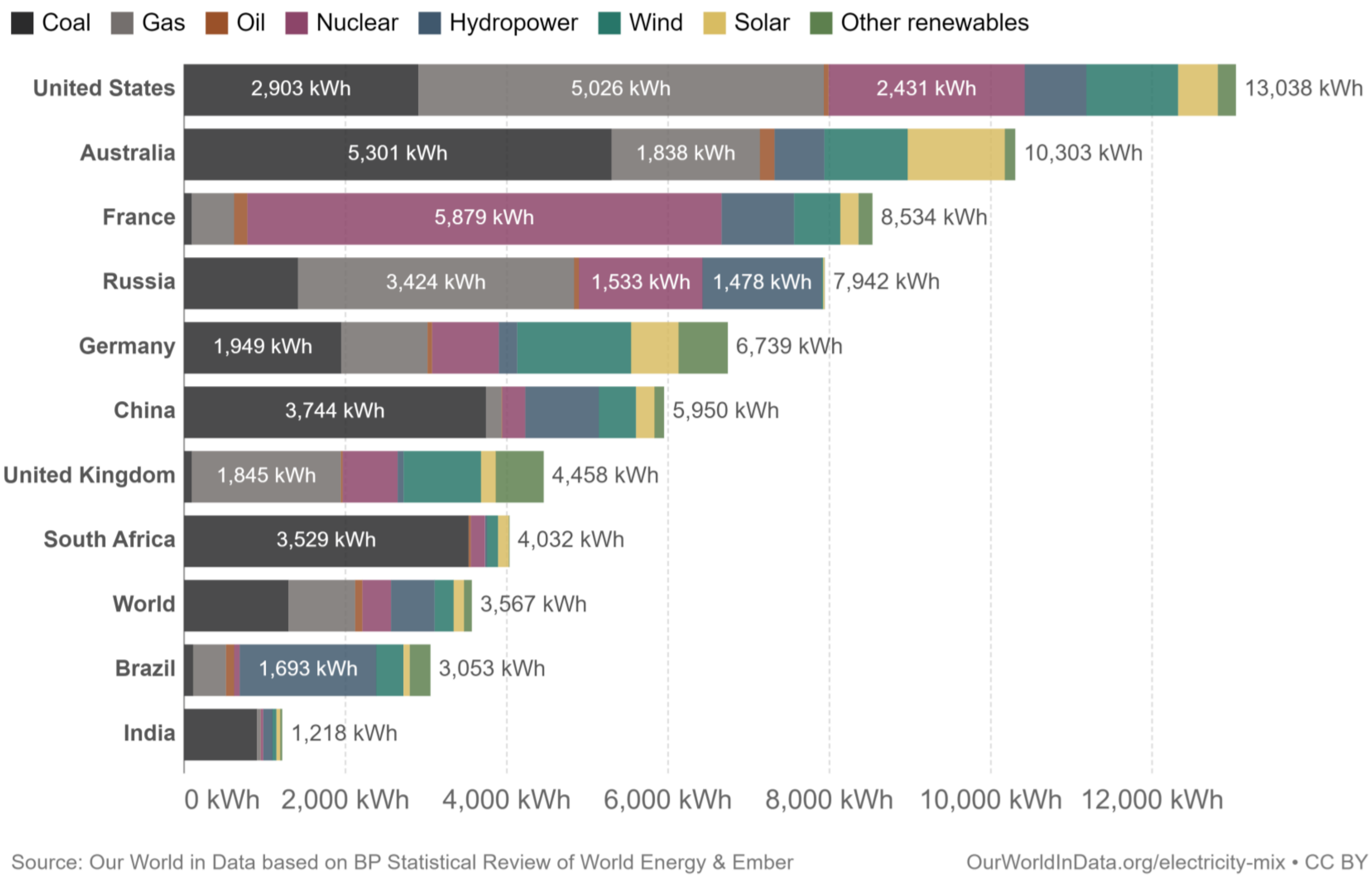
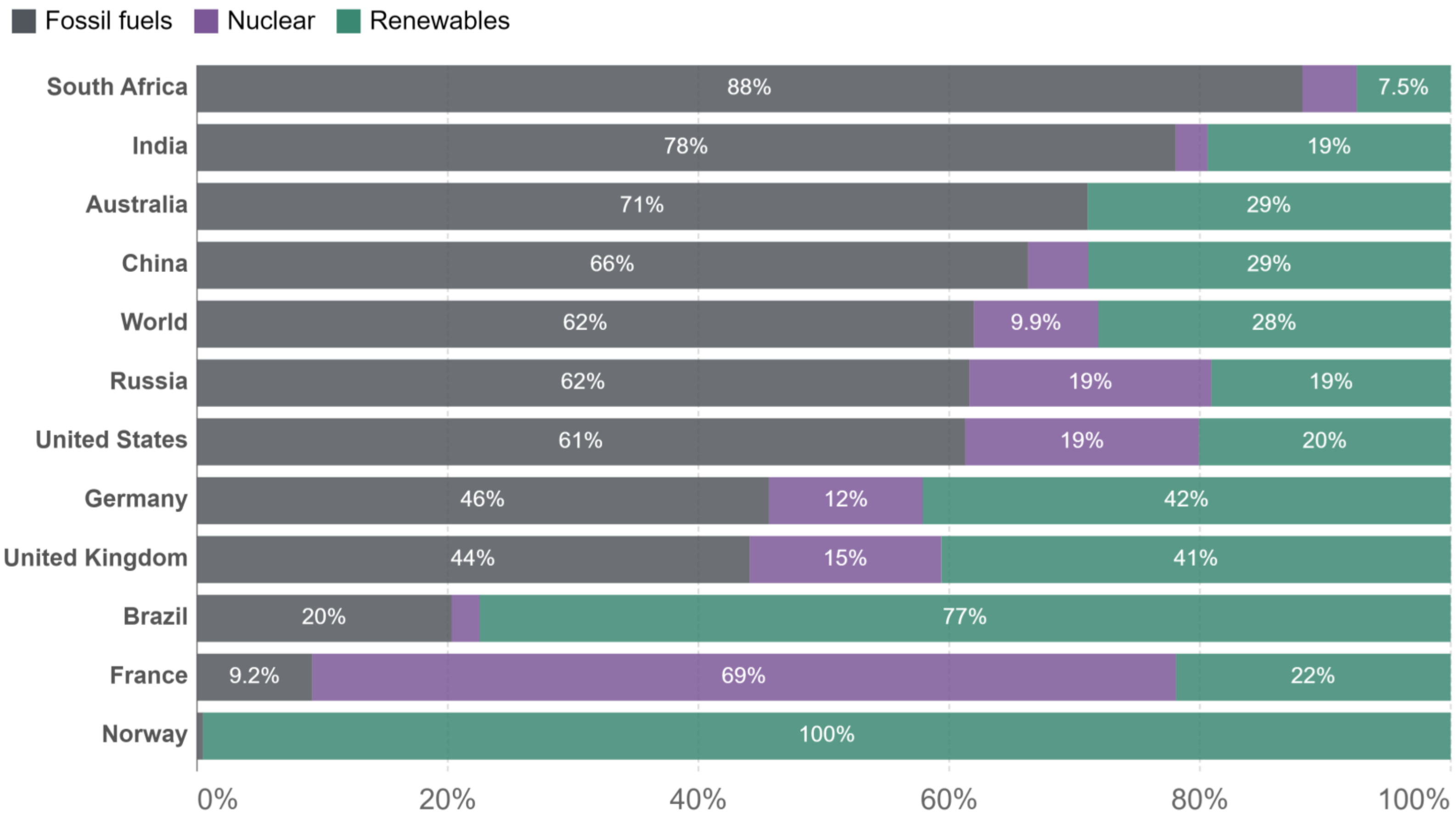
NATIONAL ELECTRICITY PRODUCTION, 2021

- Per capita electricity generation



NATIONAL ELECTRICITY PRODUCTION, 2021

- Consumption from fossil fuels, nuclear and RE



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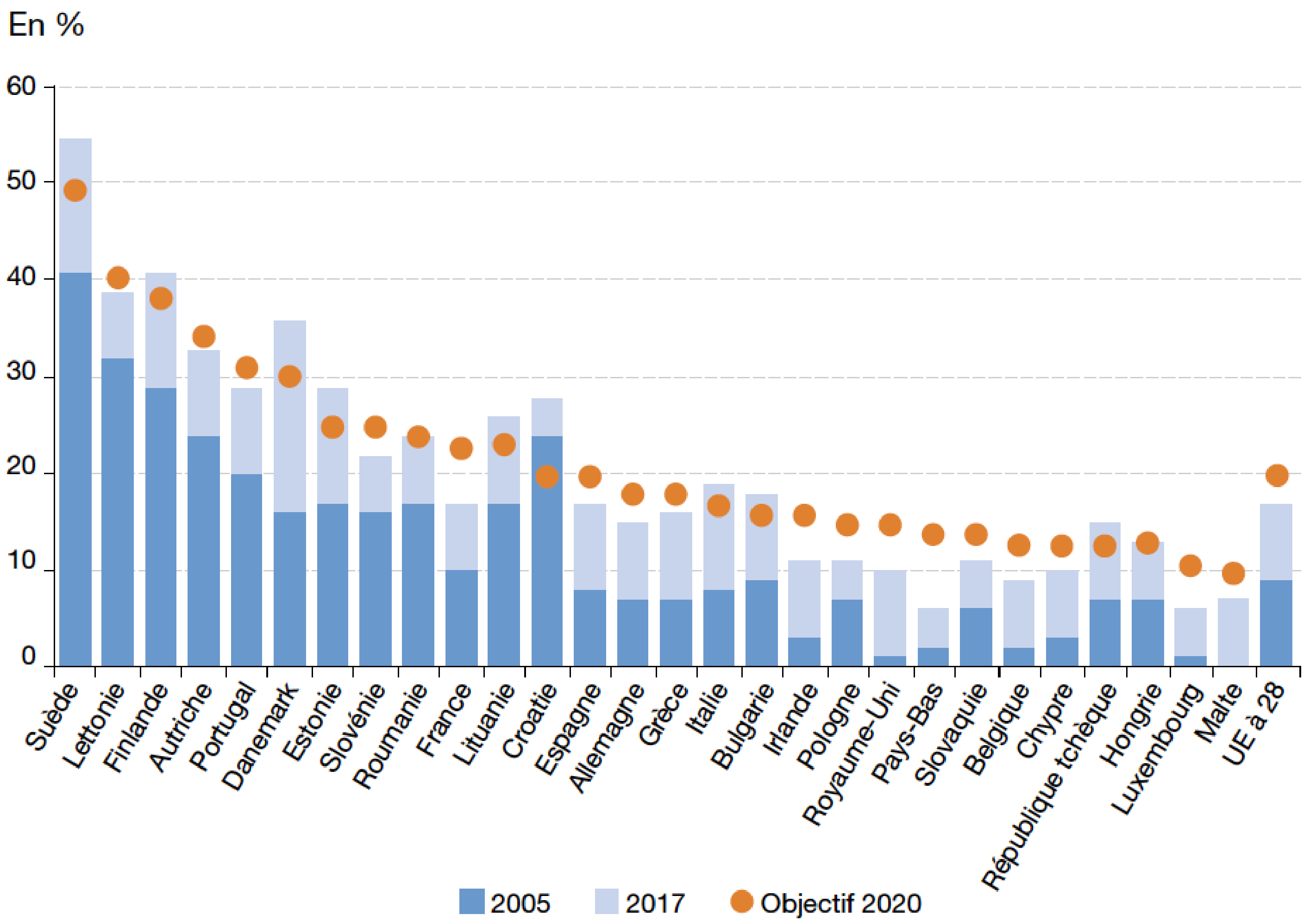
EUROPEAN ENERGY OBJECTIVES

- **Europe** decided to reach the share of renewable energy sources to 32% of total energy consumption by 2030
- EU Energy and Climate framework for 2020 and 2030 include climate policies like:
  - 2020 target - reduce the EU’s GHG emissions by 20%
  - 2030 target - reducing emissions by at least 40% compared to 1990
- Core of the EU's commitment under the Paris Agreement of December 2015



ECONOMIC COST OF CLIMATE CHANGE

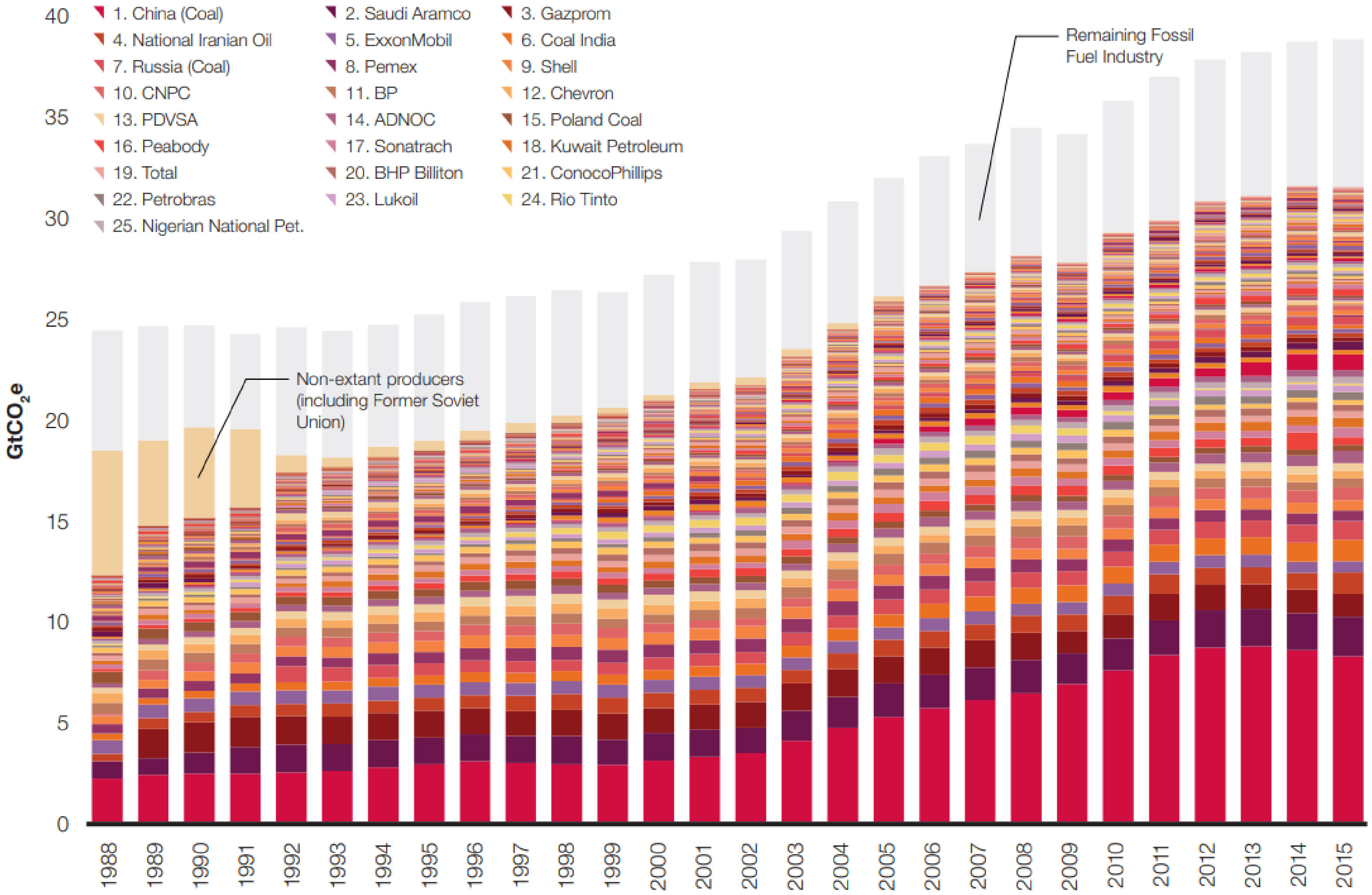
- Temperature increase:
  - If global temperatures rise by 3.2°C, decrease in world GDP by up to 18%
  - This decline could be limited to 4% if targets set in Paris Agreement are met
- Sea Level Rise:
  - Entail more frequent and severe flooding in coastal regions
  - Threatens billions of lives
  - Potential to cause damages in the trillions of dollars for real estate, shipping ports and logistics, manufacturing
- Natural Disasters:
  - Include hurricanes, flash floods, forest fires, mudslides, droughts, and other natural phenomena.
  - Cost the world $640.3 billion over the past 5 years

CLIMATE FINANCE

- "finance that aims at reducing emissions, and enhancing sinks of GHGs and aims at reducing vulnerability of, and maintaining and increasing the resilience the negative impacts of climate change“ (UNFCCC Standing Committee on Finance).
- The term has been used in a narrow sense to refer to transfers of public resources from high income to low income countries, in light of their UN Climate Convention obligations to provide "new and additional financial resources", and in a wider sense to refer to all financial flows relating to climate change mitigation and adaptation.
- $100 billion is required each year to fund required climate investments, according to UN climate negotiations coming from the following sources:
  - Government Budgets
  - Development Banks eg. World Bank, European Development Bank (EDB), Asian Development Bank (ADB)
  - Multi-lateral Finance Institutions eg. Climate Investment Funds (CIFs), Green Climate Fund (GCF), Adaptation Fund (AF), and Global Environment Facility (GEF)
  - Private Actors

TOP EMITTERS: CORPORATIONS

- Operational and product GHG emissions of 100 active companies in 2017
- By 1988 companies knew the destabilizing effects of their products but continued investments
- 100 producers account for 71% of global emissions; 25 for 51
  - 59% state owned eg. Saudi Aramco, Gazprom, National Iranian Oil, Coal India
  - 32% public investor owned eg. ExxonMobil, Shell, BP, Chevron
  - 9% private investor owned eg. Chesapeake, Ultra Petroleum
- Corporate standards – **Science Based Targets Initiative**



ENERGY TRANSITION IN ASIA

- Asia is a critical link in the world's global energy transition. Expected to account for 43% of energy demand by 2040 and 50% of the growth
- Asian region has the largest share of installed RE capacity – 45%, compared to 25% in Europe and 16% in North America.
- Expected to pull further ahead, with the region accounting for 64% of new RE capacity additions globally between 2019 and 2040, taking its overall share to 56% by 2040 (IEA, 2021).

ENERGY TRANSITION IN ASIA

- Asia's growth in renewables driven by India and China and by solar and wind energy.

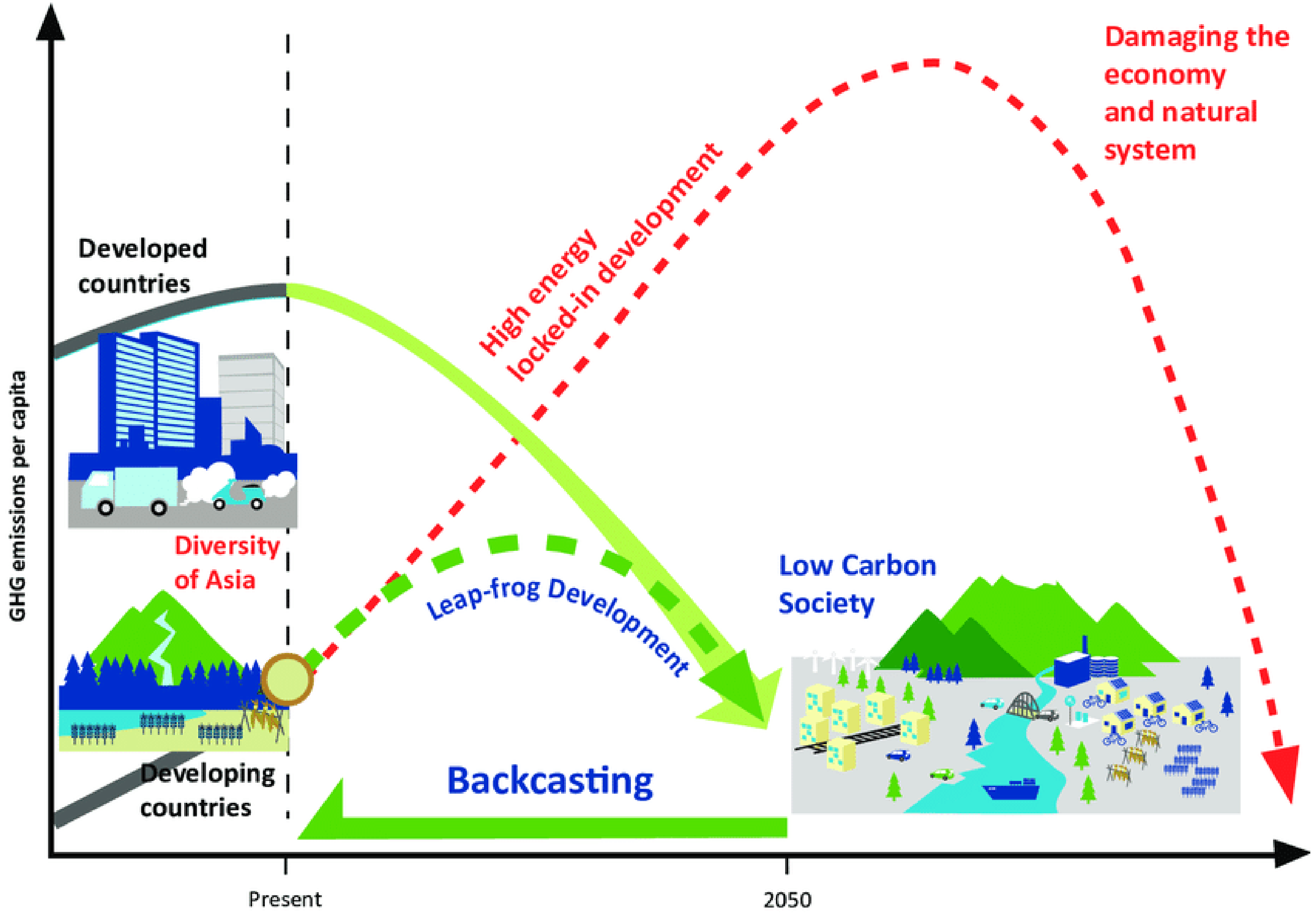
- RE Transition made possible due to:
  - Strong **policy support** from Asian governments is an important catalyst for the adoption of technology and has helped the region catapult into an even stronger position on a range of renewable energy sources.
  - shifting its energy portfolio through **capital reallocation** (public and private finance)
  - More **climate risk and vulnerabilities** provide stronger incentives ie. Additional task of addressing rising energy needs in a sustainable manner
- Asia has experienced some of the steepest drops in prices of electricity from renewables over the past decade, and this has spurred more installation.

ENERGY POVERTY IN ASIA

- Overall energy consumption shifting away from OECD to Asia (primarily China, India and Southeast Asia)
- Still large population remain without access to reliable energy and modern fuels
- Energy poverty high in:
  - Rural areas and marginalised communities
  - Disproportionately affects women and children
- Electricity access
  - ~ 200 million still without access to electricity in Asia
  - more with low quality supply of electricity
- Unprecedented growth combined with energy poverty is counter-intuitive. but makes sense when global consumer supply chains are taken into account along with inequitable distribution of resources and energy access
  - Rural vs urban
  - Commercial areas vs residential areas

ENERGY LEAPFROGGING

- “Leapfrogging” is the ability of a developing country to essentially "skip" less efficient and higher carbon-intensive technologies during the course of their development
- eg. Mobile phones, energy technologies



INNOVATIVE ENERGY INITIATIVES TO COMBAT ENERGY POVERTY

- Low emission and emission reduction tech in polluting sectors eg. Industries, transport, utilities, agriculture waste
- Make existing grids more energy efficient
- Small solar PV based systems for rural households
- Solar-diesel hybrid grids with storage
- Coastal and off-shore wind farms
- Energy access projects eg. Solar rooftops, micro/mini grids with energy storage
- Solar streetlighting etc.

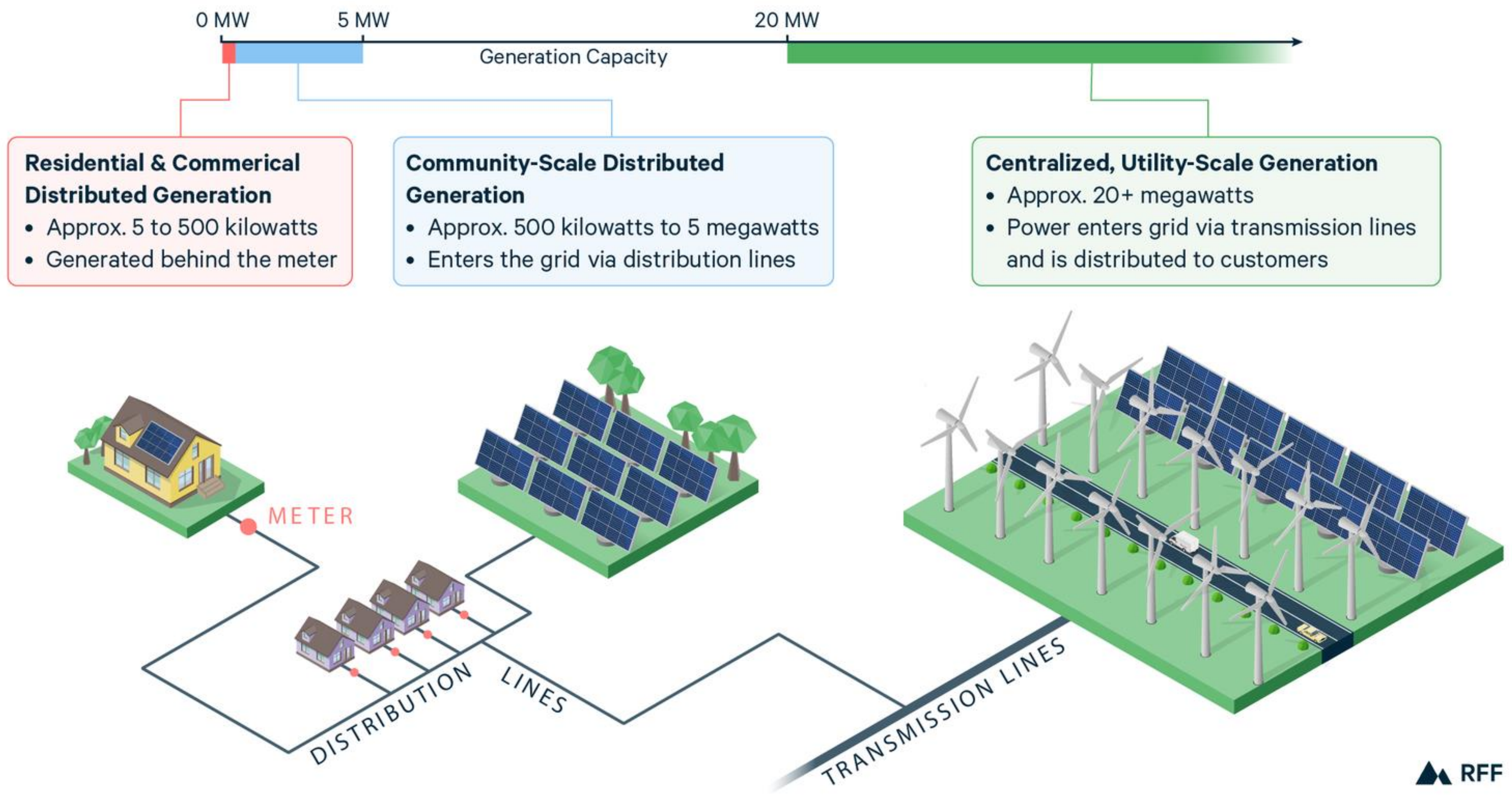
DISTRIBUTED GENERATION

DISTRIBUTED GENERATION

- Variety of tech that generate electricity at or near where it will be consumed
- May serve a single structure, such as a home or business, or it may be part of a microgrid (a smaller grid that is also tied into the larger electricity delivery system), such as at a major industrial facility, a military base, or a large college campus
- When connected to the utility's distribution lines, DG can help support delivery of clean, reliable power to additional customers and reduce electricity losses along transmission and distribution lines

- DG also called **Distributed Renewable Energy (DRE)** when source of electricity is renewable-based.

DG SYSTEM SCALE



DG SYSTEMS

- Usually RE with a combination of other fuel backup

- In the **residential sector**, common systems:
  - Solar photovoltaic panels
  - Small wind turbines
  - Natural-gas-fired fuel cells
  - Emergency backup generators, usually fueled by gasoline or diesel fuel

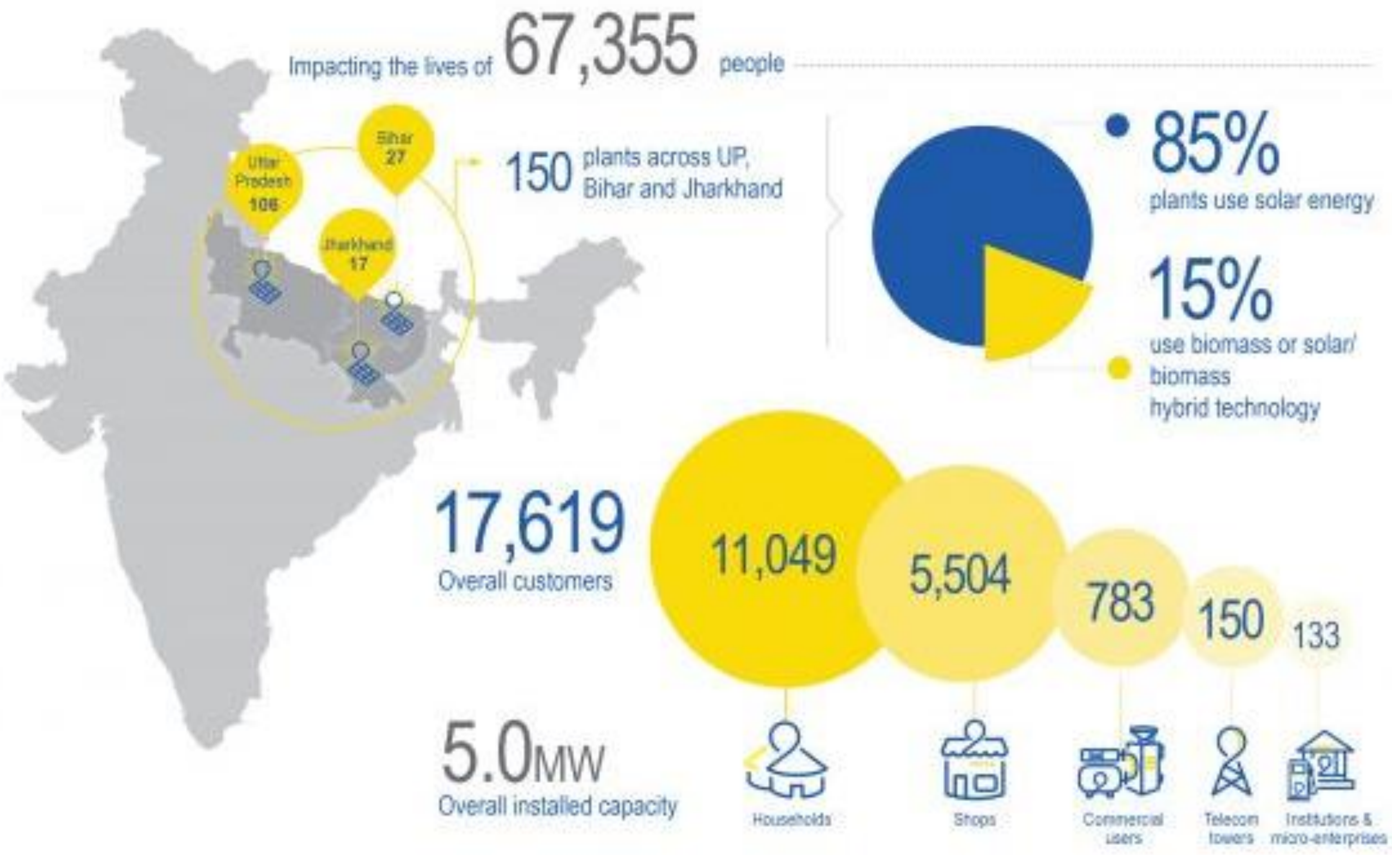
- In the **commercial and industrial sectors**:
  - Combined heat and power systems
  - Solar photovoltaic panels – utility scale
  - Wind
  - Hydropower
  - Biomass combustion or cofiring
  - Municipal solid waste incineration
  - Fuel cells fired by natural gas or biomass
  - Reciprocating combustion engines, including backup generators, which are may be fuelled by oil

DRE POPULARITY

- RE tech, such as solar panels, have become cost-effective for many homeowners and businesses
- Several states and local governments are advancing policies to encourage greater deployment of renewable technologies due to their benefits, including energy security, resiliency, and emissions reductions
- DG systems, particularly combined heat and power and emergency generators, are used to provide electricity during power outages, including those that occur after severe storms and during high energy demand days.
- Grid operators may rely on some businesses to operate their onsite emergency generators to maintain reliable electricity service for all customers during hours of peak electricity use.

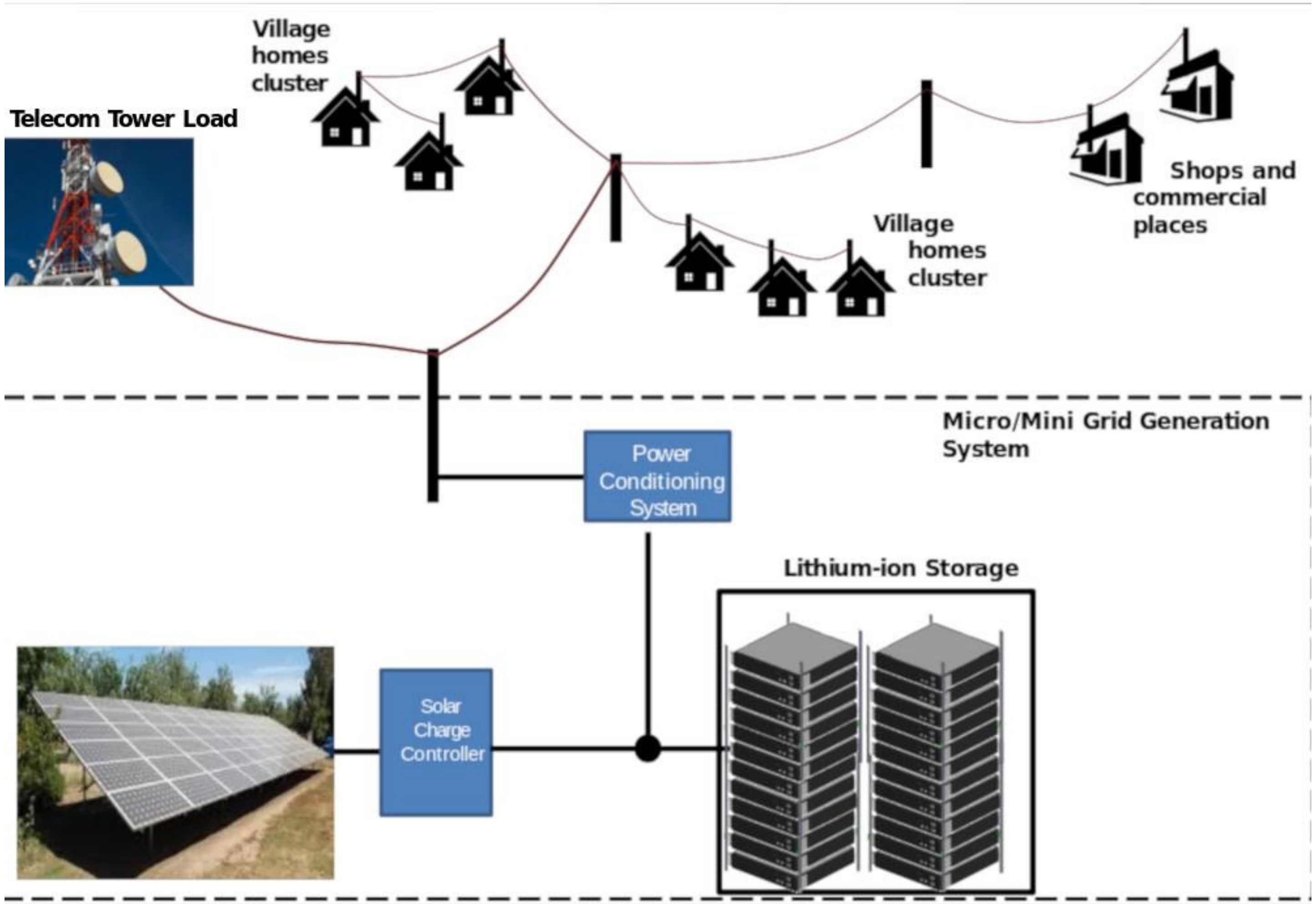
CASE STUDY: INDIA

- Demonstration project: decentralised RE generation for rural development
- ABC Model – Anchor, Business, Community
- 2022:
  - 18.3 MW capacity – solar and biomass
  - ~ 650 mini grids
- Stakeholders
  - Smart Power India (SPI)
  - Ministry of New and Renewable Energy
  - Telecom Operators
  - Energy Supply Company (ESCO)

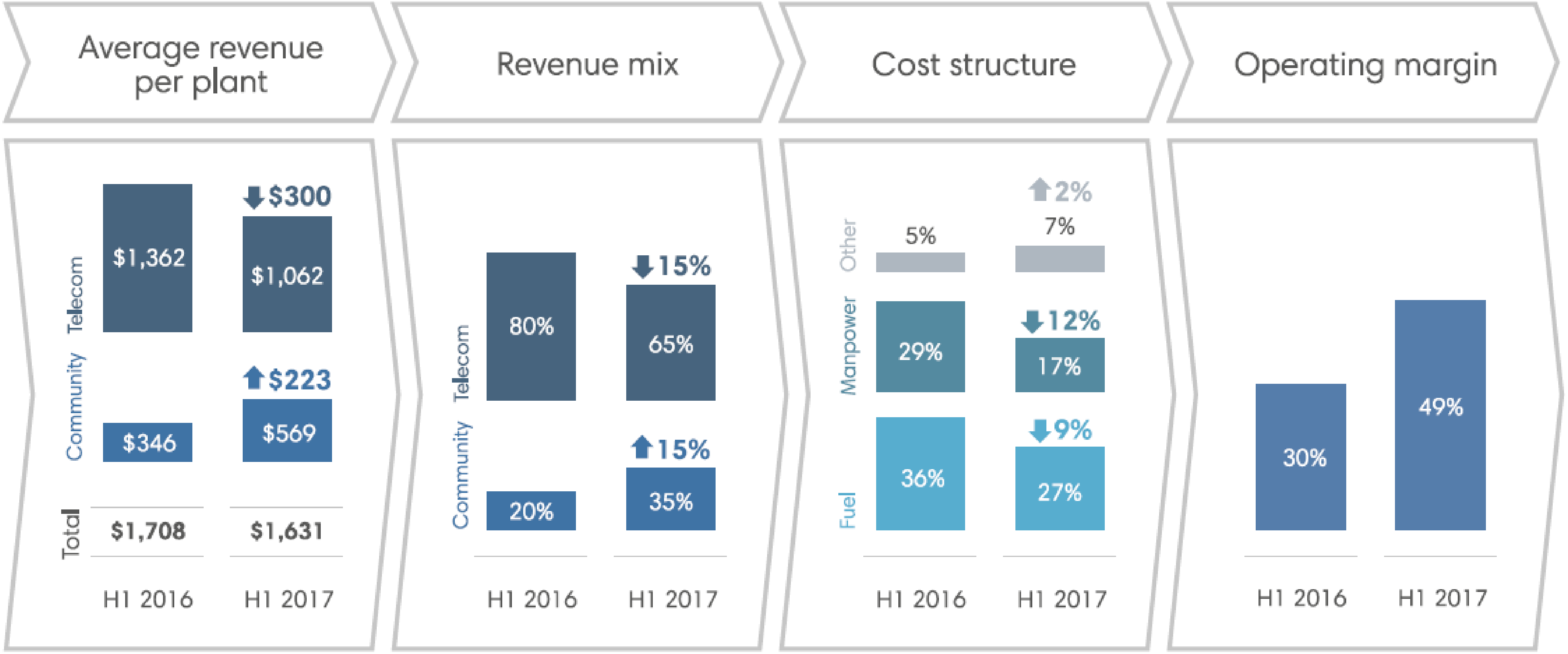


CASE STUDY: INDIA

- Range in power capacity from 10 to 70 kW
- Operating Model:
  - Anchor-based: large 'anchor' business customer that consumes large proportion of the electricity + community for lighting and small/micro enterprises
  - Community-based: only community for lighting, irrigation and small/micro enterprises
- Regular profit margins upto 60% after switch
  - Operating costs reduced due to diesel replacement
  - 49% from anchor load
- Multi-skilling of existing workforce
- Video

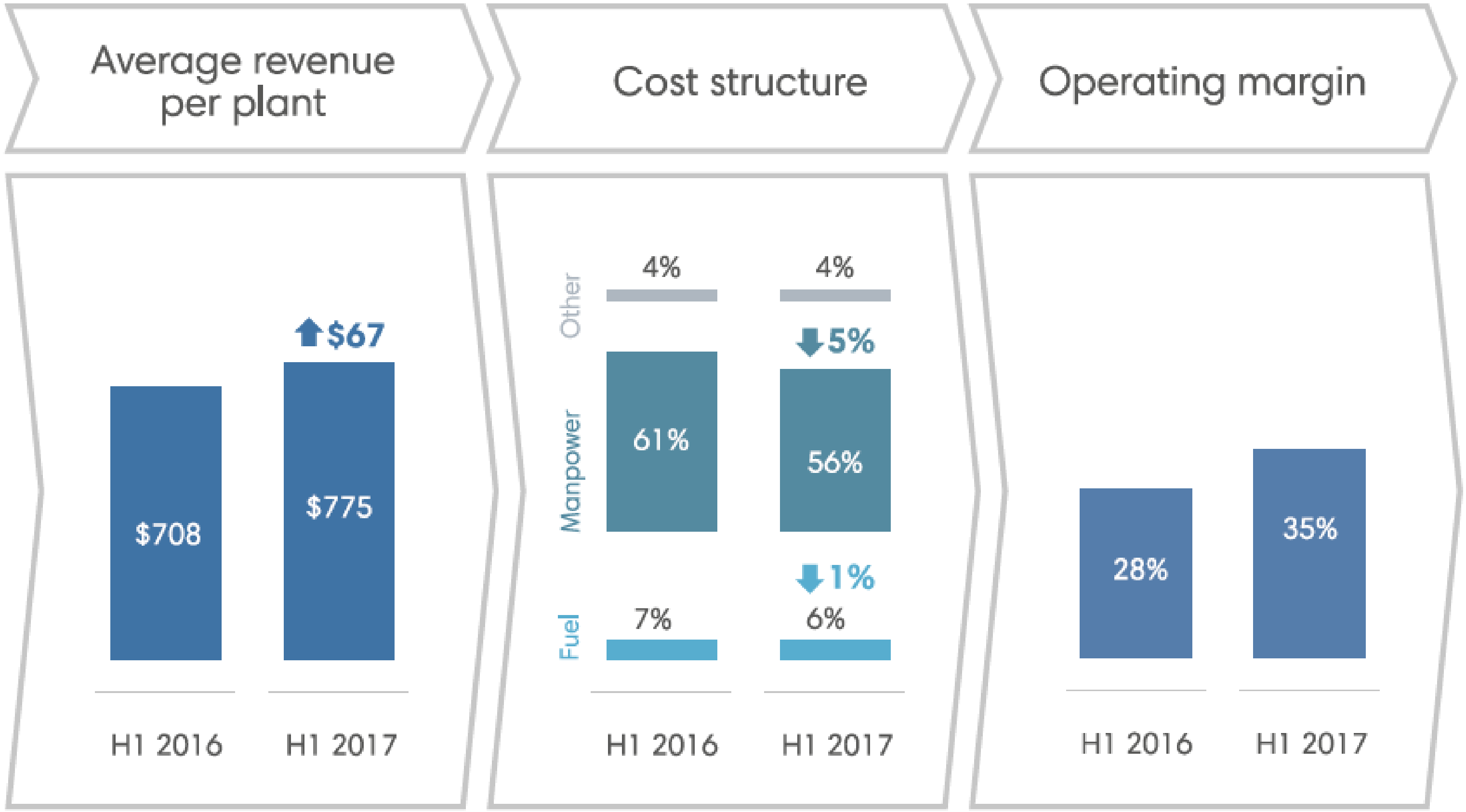


PERFORMANCE OF ANCHOR-BASED DRE SYSTEMS



* Cost structure above reflects the breakdown of the operating ratio, i.e. operating costs as a percentage of total revenues
* Operating margin is the ratio of operating profit to the total revenues
* Exchange rate used for calculations: 1 USD = 65 INR

PERFORMANCE OF NON-ANCHOR DRE SYSTEMS



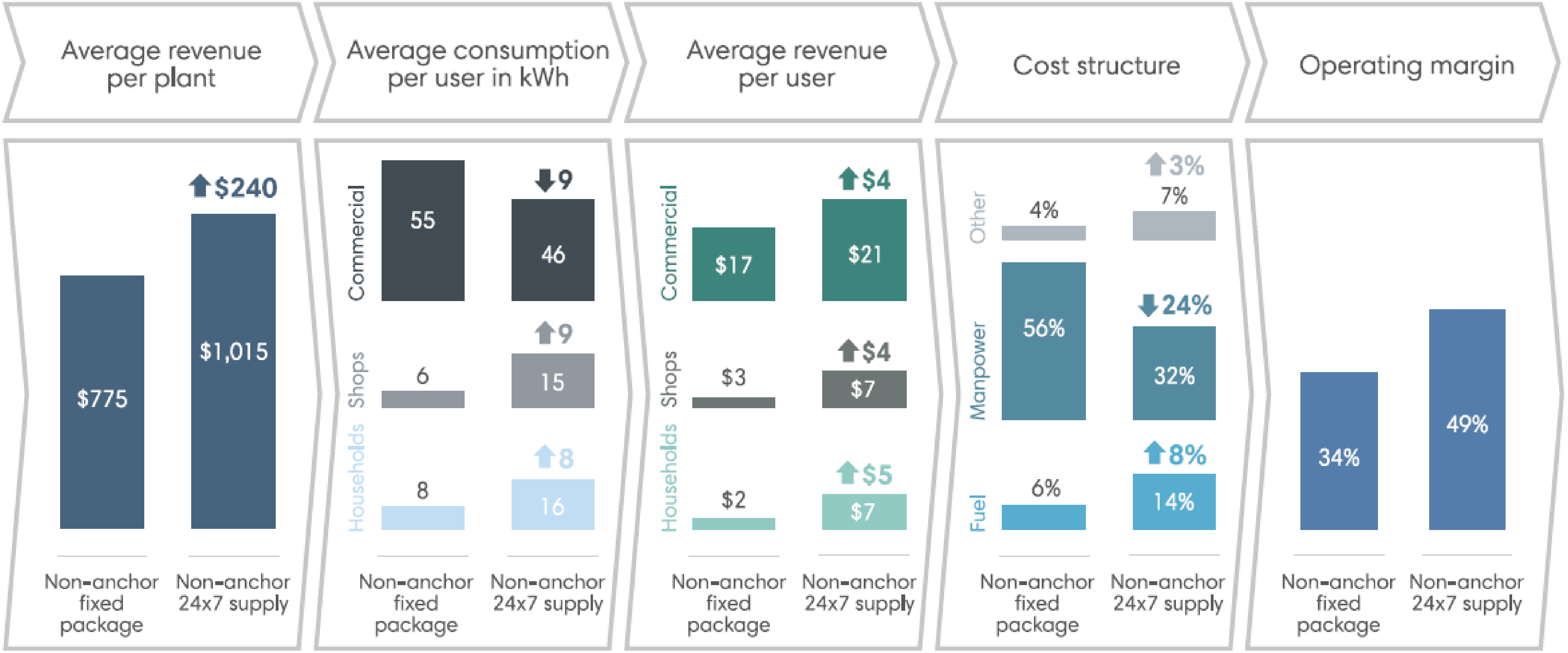
* Cost structure above reflects the breakdown of the operating ratio, i.e. operating costs as a percentage of total revenues
* Operating margin is the ratio of operating profit to the total revenues
* Exchange rate used for calculations: 1 USD = 65 INR

TWO SUPPLY MODELS FOR NON-ANCHOR DRE SYSTEM

	FIXED-PACKAGE MODEL OF NON-ANCHOR MINI-GRIDS	24X7 SUPPLY MODEL OF NON-ANCHOR MINI-GRIDS
Design specifications		
Source of generation	Solar and diesel generator	Solar and biomass[1] generator
Solar capacity	33 kW	20 kW
Alternative fuel capacity	15 kVA	32 kVA
Maximum generation potential	~60,000 kWh per year[2]	~200,000 kWh per year[3]
Sizing of the battery bank	1200 Ah	600 Ah
Metering	Unmetered connections may be present	100% connections must be metered
Business model specifications		
Supply hours	Fixed as defined by ESCO for each customer category	24 hours x 7 day supply
Pricing	Fixed monthly pricing packages based on customer category	Pay-as-you-go using smart meters
Payment mode	Pre-paid	Pre-paid

[1] Biomass refers to organic material that is used as a fuel to generate power
[2] Diesel generator up to 30% of total generation
[3] Biomass operations up to 20 hours per day

COMPARISON BETWEEN TWO NON-ANCHOR MODELS



* Cost structure above reflects the breakdown of the operating ratio, i.e. operating costs as a percentage of total revenues
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CONVERTING DRE TO SMART GRID

- Increasing adoption and consumption of power by Anchor, Business and Community
- Economic activity, penetration of appliances and regularity of wages play important role
  - Economic activity and regularity of wages – indirect benefit of electricity access
  - Penetration of appliances – direct role of DRE
- DRE Operator ie. ESCO started looking at demand expansion along with managing supply side
  - Energy efficient demand expansion = smart appliances
- Bundling energy efficient appliances with existing customer connections
  - Customers started to pay for appliances primarily, with a small additional fee for the electricity usage

SMART GRIDS

- A smart grid is an electricity network that uses digital and other advanced technologies to monitor and manage the transport of electricity from all generation sources to meet the varying electricity demands of end users
- Smart grids coordinate the needs and capabilities of all generators, grid operators, end users and electricity market stakeholders to:
  - operate all system parts efficiently
  - minimise costs and environmental impacts
  - maximise system reliability, resilience and stability

SMART GRID BENEFITS (CONTD)

1. **Mass-scale renewables** – Integrating RE (wind solar) into the grid at levels >20% requires advanced energy management techniques. These include load curtailment, demand response, and energy storage. The EWEA recently published a report recommending the use of demand response as a natural tool for managing variability in wind resources. This is a key message for wind and solar producers, as it increases the size of their potential market.
2. **Clean power market** – The ability to stabilize the power consumption over time for an area using demand response will make it easier to establish a power market. Clean power sources will be able to participate in the market even though they may have a stochastic energy output. This is a benefit to clean power producers.
3. **Support for PHEVs and V2G** – Necessity for enabling the next generation of automotive vehicles. The lack of an integrated communications infrastructure with corresponding price signals will make it difficult to handle the increased load of EVs and PHEVs. Smart chargers, time-of-use rates, and advanced meters will be key players, helping to manage a very complex control problem on already constrained grids. Car manufacturers will benefit from having an integrated, simple charging solution for EV customers.

SMART GRID BENEFITS (CONTD)

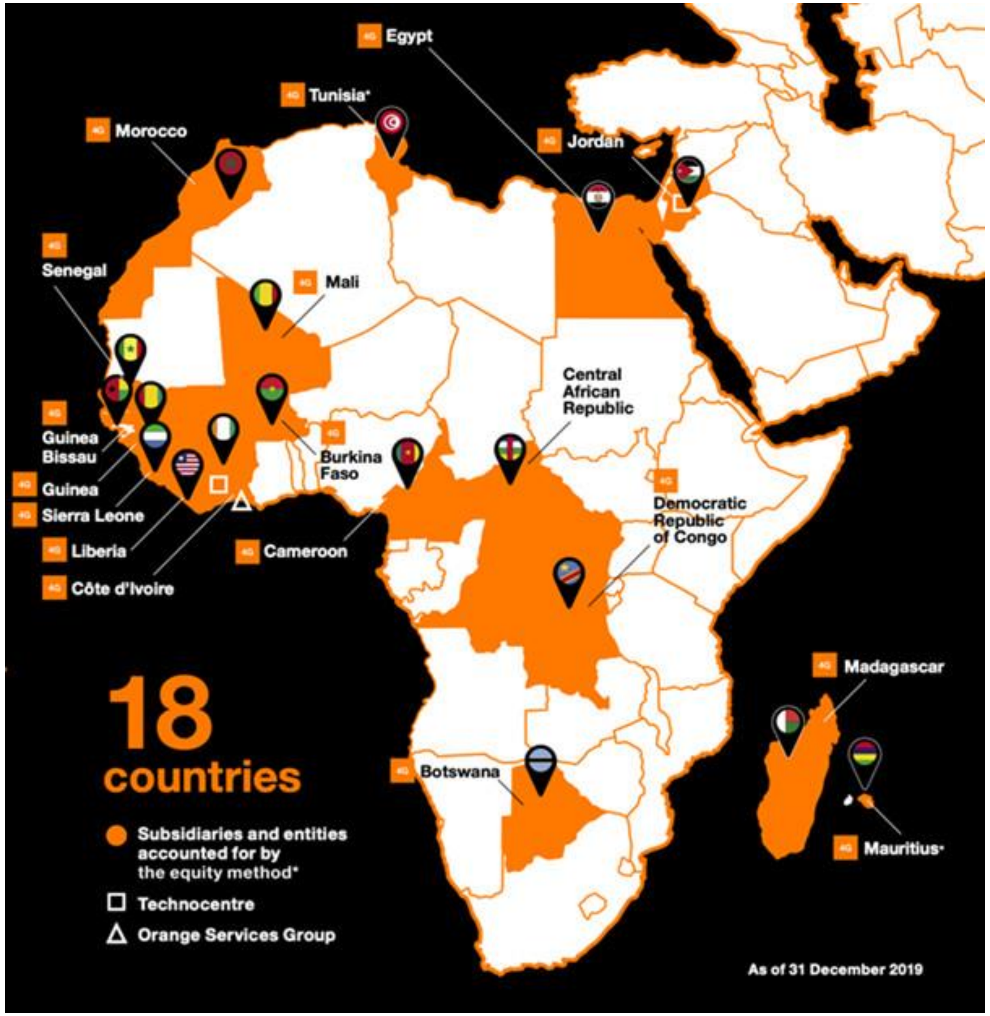
4. **Consumer incentive for conservation** – With the rollout of advanced metering and real-time pricing customers have an economic incentive for reducing power consumption.
5. **Support for more intelligent appliances at the demand-side** – A Smart Grid means intelligent appliances. The Grid-friendly appliances program from Pacific Northwest National Laboratory gives appliances the ability to sense grid stress and reduce their power use to prevent grid emergencies. Appliance manufacturers will be able to market grid-friendly appliances for a premium to consumers.
6. **Demand Response for Managing Air Pollution** – Part of the problem of urban air pollution is that it follows "peak hour" patterns, in many areas exceeding EPA's allowable levels only for a few days or hours during the year. Levels of ozone and particulate matter sometimes reach levels that are harmful to human health. These peaks often correspond with high electricity use, which is a prominent cause of urban air pollution in many places. In the North East, ISO NE estimates projects that their peak electricity demand will increase by 13-20% between 2009 and 2015.
7. **Advanced metering as a method of calculating environmental footprints** – Utilities have the opportunity to dynamically present electricity use alongside with carbon emissions that result from them. Utilities that want to promote their "green electricity" programs can use this to reach environmentally conscious consumers. Recently, E.on utilitity subsidiaries in Louisville became the first utiliites in North America to add a customer's carbon cost to their utility bill. Organizations and individuals can use this to help assess their progress towards their greenhouse gas emissions goals.

SMART APPLIANCES FOR DEMAND SIDE MANAGEMENT

- Anchor – demand response activity, remote monitoring, scheduling and energy consumption adaptation
  - Wifi and 3G enabled automated control system
  - LED lights
  - Smart meters and smart chargers for electric vehicles – 2 and 3 wheelers
  - Smart air conditioners+thermostat that kept office temperature constant
  - Battery
- Businesses – demand response activity, energy consumption adaptation
  - LED lights
  - Smart meters and smart chargers for electric vehicles – 2 wheelers
  - Smart fridge for healthcare center vaccines and medicines
  - Triple phase motors for carpentry, grain mills
- Community – energy consumption adaptation
  - LED lights
  - Smart fans and TVs
  - Irrigation pumps for farming

ANCHOR-BASED DG MODELS

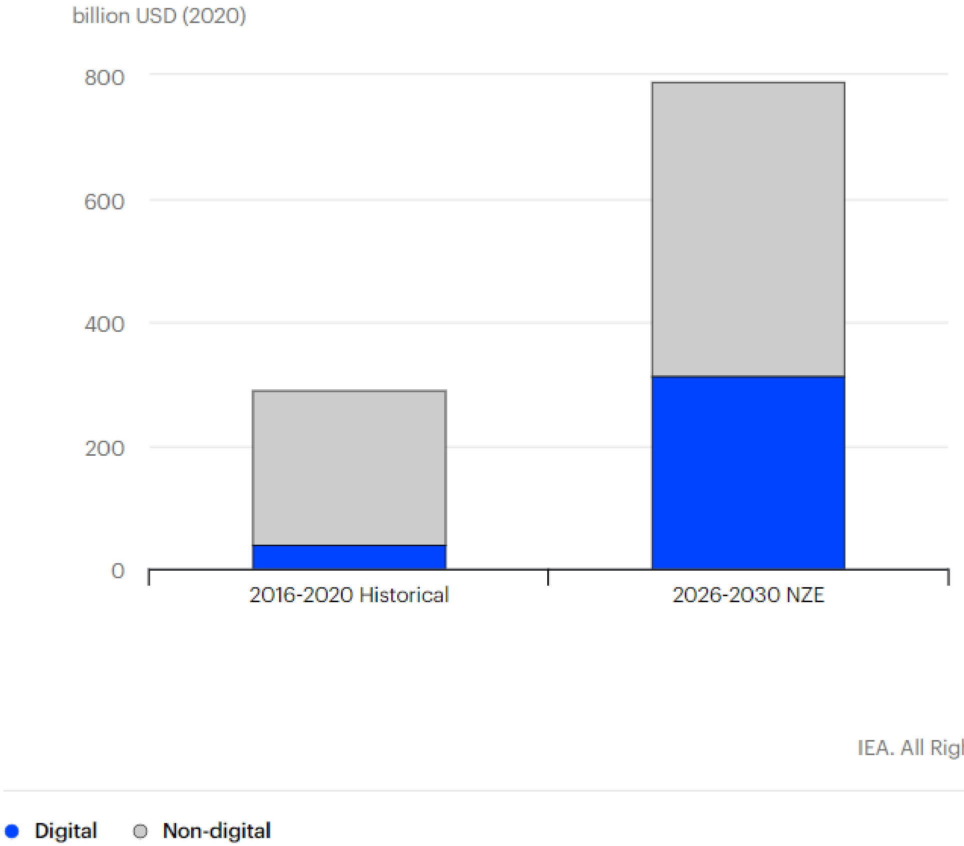
- Large applicability in low and medium income countries with new electricity markets
  - Advanced metering eg. TOU tariffs, dynamic electricity use
  - Solar arrays
  - Intelligent appliances eg. Solar pumps, refrigerators, smart chargers, ACs, thermostats
  - Electric 2 and 3 wheelers, Electric passenger vehicles and e-buses
  - District heating and cooling
- Orange telecom company – partnering with RE micro-grid developers in 18 African countries



SMART GRID INVESTMENTS

- Investments in electricity grids are expected to grow by 10% in 2021 with rising infrastructure spending in Europe, China and the United States
- Ambitious expansion and recovery plans are being included in policies to achieve more resilient and digital grids, as part of the drive to achieve carbon-free electricity generation
- Level of grid investment is set to triple by 2030, especially for smart grids and digital investments, which should account for around 40% of total investments in this decade

Investment spending in electricity networks, 2016-2020 and 2026-2030 in the Net Zero Scenario



SMART GRID MARKETS

- Indicative list from US Dept of Commerce Top Markets report, 2017
- Includes top Smart Grids Markets according to
  - T&D Equipment
  - Smart Grid ICT
  - Energy Storage
- Based on investments, policies and projected trends

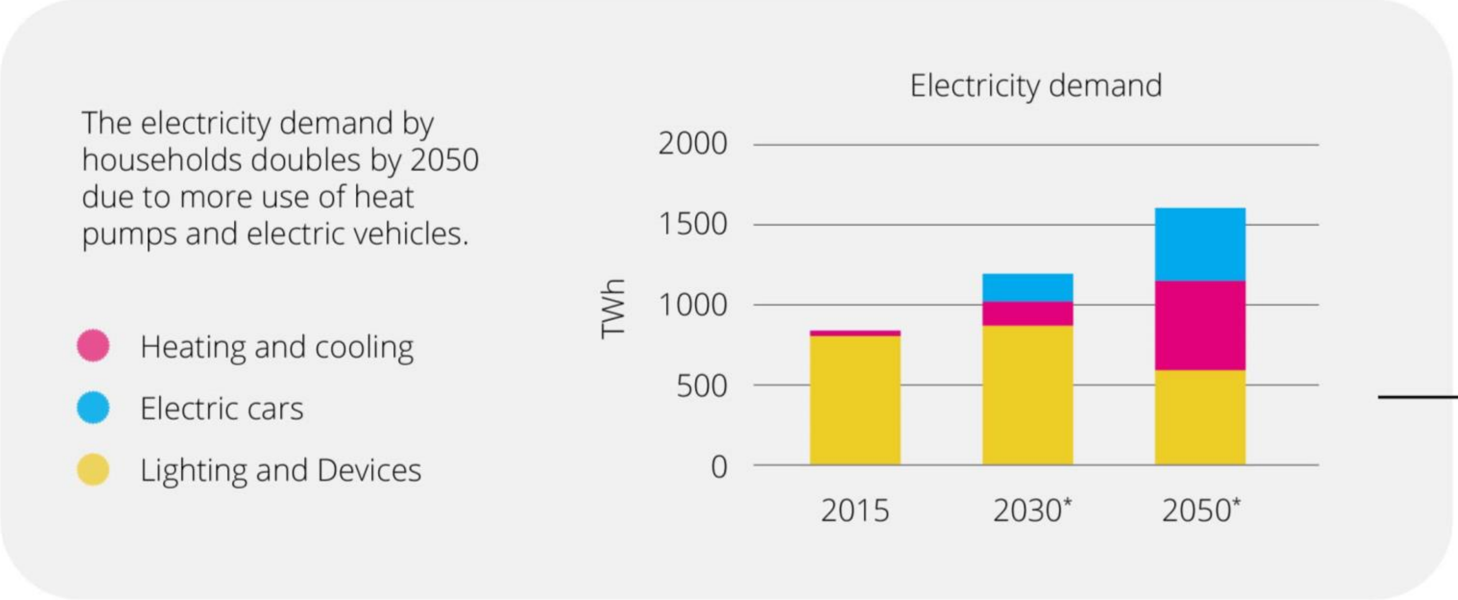
Top Ten SG TMR Ranked Markets, 2017				
RANK	Overall	T&D Equipment	Smart Grid ICT	Energy Storage
1	Canada	Mexico	UK	UK
2	Mexico	Canada	Canada	Denmark
3	Denmark	Ghana	Japan	Canada
4	UK	Ethiopia	Finland	Australia
5	Japan	Vietnam	Denmark	Japan
6	Ireland	Kenya	Mexico	Germany
7	Malaysia	Morocco	Australia	Finland
8	Chile	India	Sweden	Korea
9	India	Malaysia	Germany	Ireland
10	Australia	Philippines	Netherlands	China

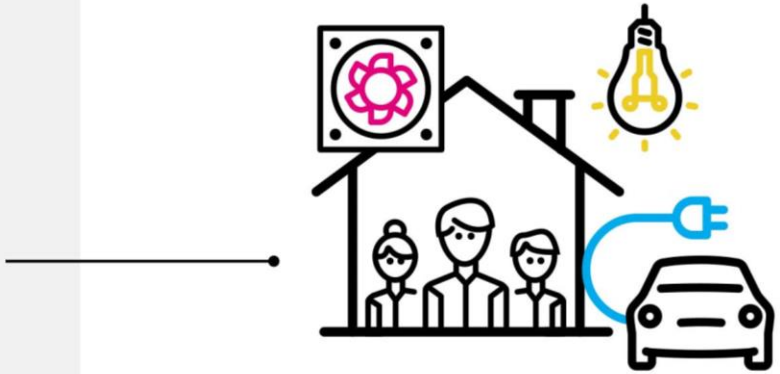
PROSUMERS

- Producing and consuming at the same time = prosumers
- Considered an inevitable step in evolution of electricity customers who live with advanced markets and more RE
- Prosumers can:
  - generate electrical power
  - store it to increase the flexibility of the grid
  - adhere to demand-side management
- Creation of peer-to-peer trading networks with multiple households = energy communities eg. Italy
- Reduced or no charges on self-consumed electricity
- Level playing field
- While regular customers only consume power and pay for it, prosumers generate power to supply part of their load, store energy for self-consumption or DSM programs, and are proactive with the electrical grid in energy tradings = **active customers**

PROSUMERS PROJECTED IN EU BY 2050

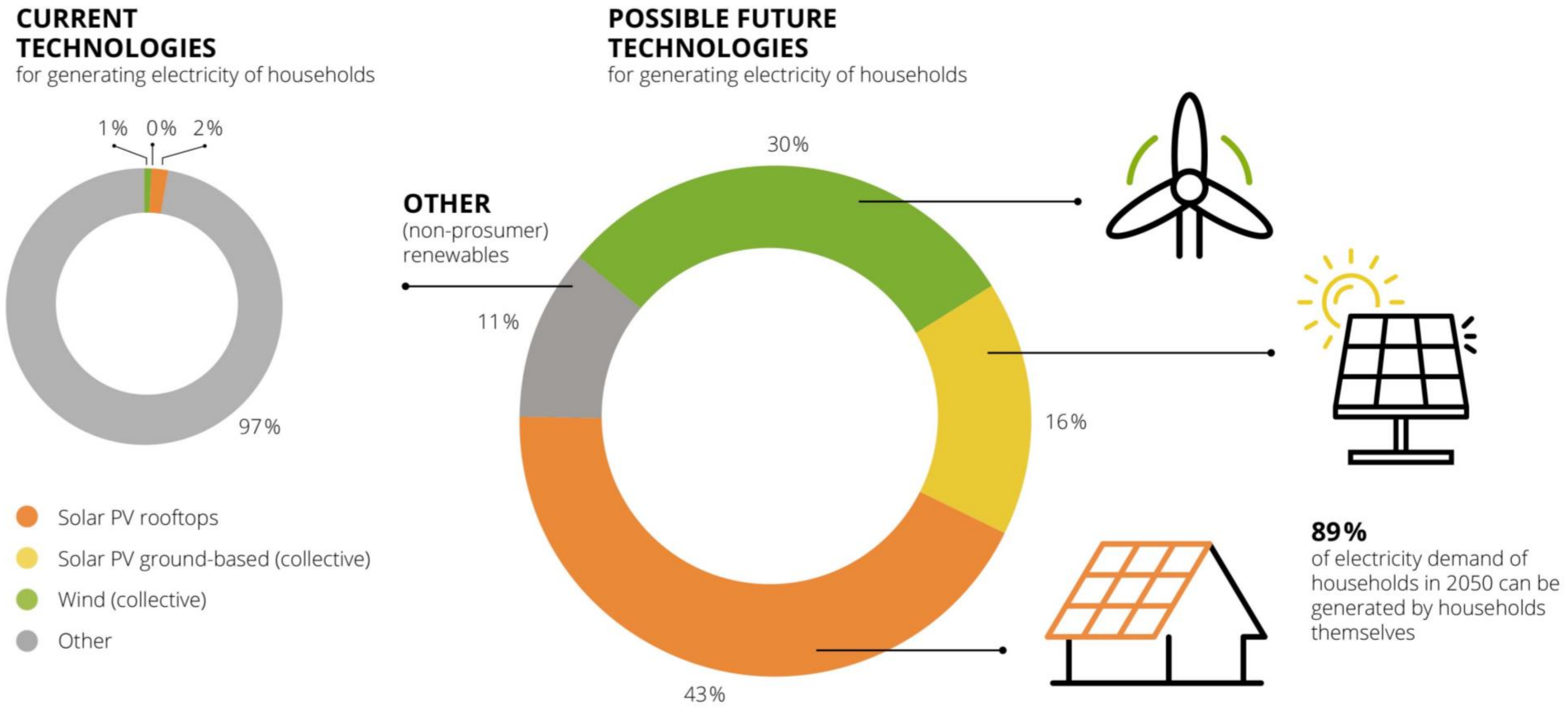
- High potential of electricity generation by prosumers in the EU by 2050
- PROSEU – prosumers for the energy transition



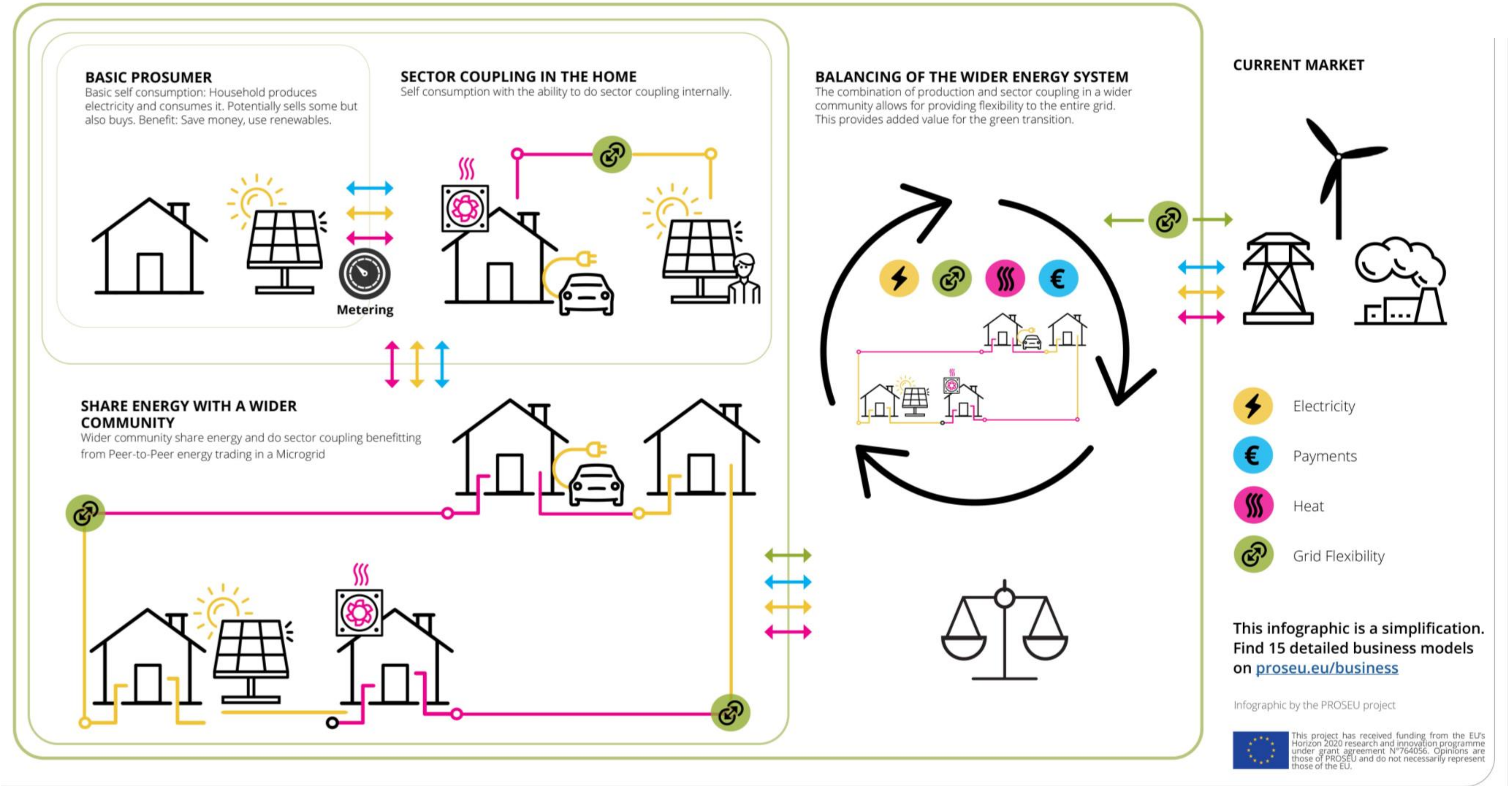


PROSUMERS IN 2050

- Max RE scenario in future years



PROSUMER BUSINESS MODEL



BENEFITS OF PROSUMERISM

- Achieve clean energy self-consumption
- Generate savings by reducing bill costs or selling excess generated energy
- Reduce environmental footprint by generating clean energy
- Increase energy independence from the grid by installing energy storage systems
- Increase the value of your property by including power storage and generation technologies
- Access financial incentives designed for prosumers

EU CASE STUDIES

- **Denmark** – highest increase in prosumers
  - High prices for electricity and taxes
  - Time of Use Tariffs (TOU) and smart meters make it easier for consumers to convert
- **Germany** – highest prosumers per capita
  - High prices for electricity and network usage tariffs
  - Many incentives like FITs, subsidies and tax exemptions for EVs, subsidies for home storage systems
- **Ireland** –industrial and commercial prosumers also
  - Captive solar PV, demand response programs, interruptibility schemes, different financial subsidies
  - Different incentives for hh vs. businesses
- **Lithuania** – 50% energy consumers to become prosumers by 2050
  - Set up remote solar plants, small transmission fee
  - Buy or lease part of remote solar plants: HH can acquire 5 kW out of 1000 kW PV plant

FUTURE TECHNOLOGICAL TRENDS

- Existing energy grids moving from centralised to decentralised production
  - DRE
  - Smart grids
  - Mini/micro grid systems with energy storage
- Development of Smart Cities
  - Combining ICT for urban services like healthcare, mobility, water and waste management
  - Singapore is gold standard for Smart Cities globally
  - Top 15 include many Asian cities
- Evolving electricity markets
- Electrification of transport, industries, heating and cooling

Thank you!

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