



Nordic Development Fund

Global Energy Trends

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Main information sources used in the presentation

- BP 2018: BP Energy Outlook, 2018 Edition
- BP 2019: BP Energy Outlook, 2019 Edition
- IEA 2017: World Energy Outlook 2017
- IEA 2018: World Energy Outlook 2018
- IRENA 2019: Global Energy Transformation, Roadmap to 2050
- IRENA 2019: Renewable Energy Statistics 2019
- REN21 2018: Renewables 2018, Global Status Report

Main energy units explained

- J: joule
 - toe: tonne of oil equivalent
 - Wh: watt-hour

 - M = mega
 - G = giga (1000 mega)
 - T = tera (1000 giga)
 - P = peta (1000 tera)
 - E = exa (1000 peta)
- $1 \text{ Ws} = 1 \text{ J}$
 - $1 \text{ Wh} = 3,600 \text{ J} = 3.6 \text{ kJ}$
 - $1 \text{ EJ} = 1,000,000 \text{ TJ} \approx 23.9 \text{ Mtoe} \approx 277.7 \text{ TWh}$
 - $1 \text{ TJ} = 1,000,000 \text{ MJ} \approx 23.9 \text{ toe} \approx 277.7 \text{ MWh}$

 - Global energy consumption in 2016: $\approx 400 \text{ EJ}$

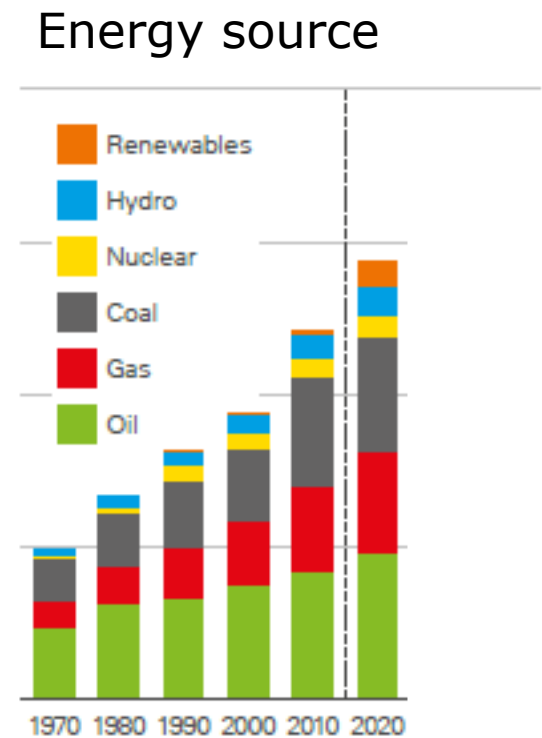
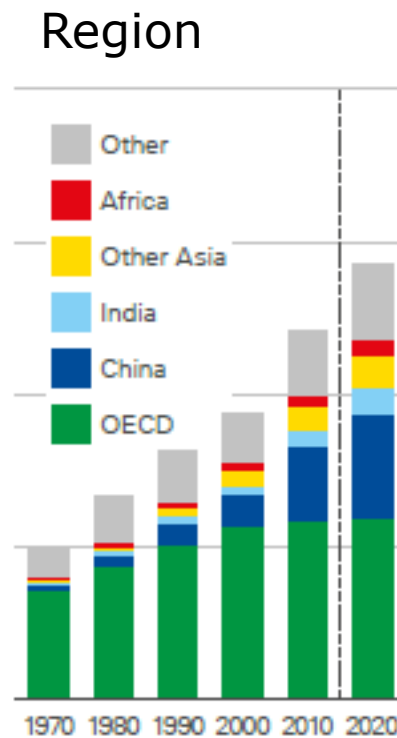
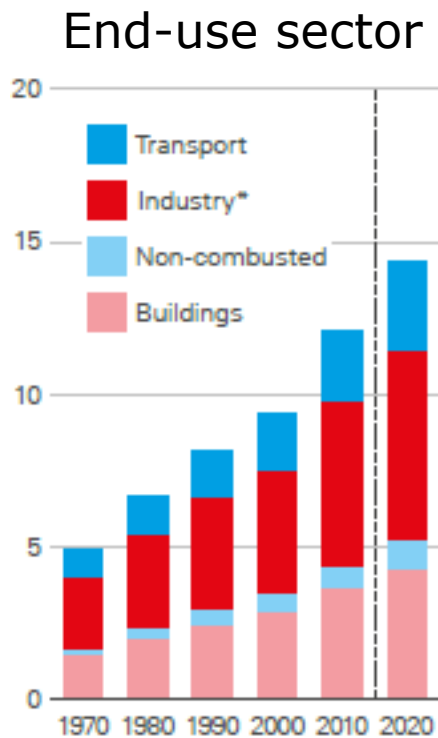
 - Energy consumption in Finland 2017: $1.35 \text{ EJ} / 375 \text{ TWh}$

 - Output of a 4 MW wind turbine $\approx 12,000 \text{ MWh} \approx 43 \text{ TJ}$

 - Hours in one year: 8760 h

Energy sector today, the big picture

Primary energy demand, Billion toe

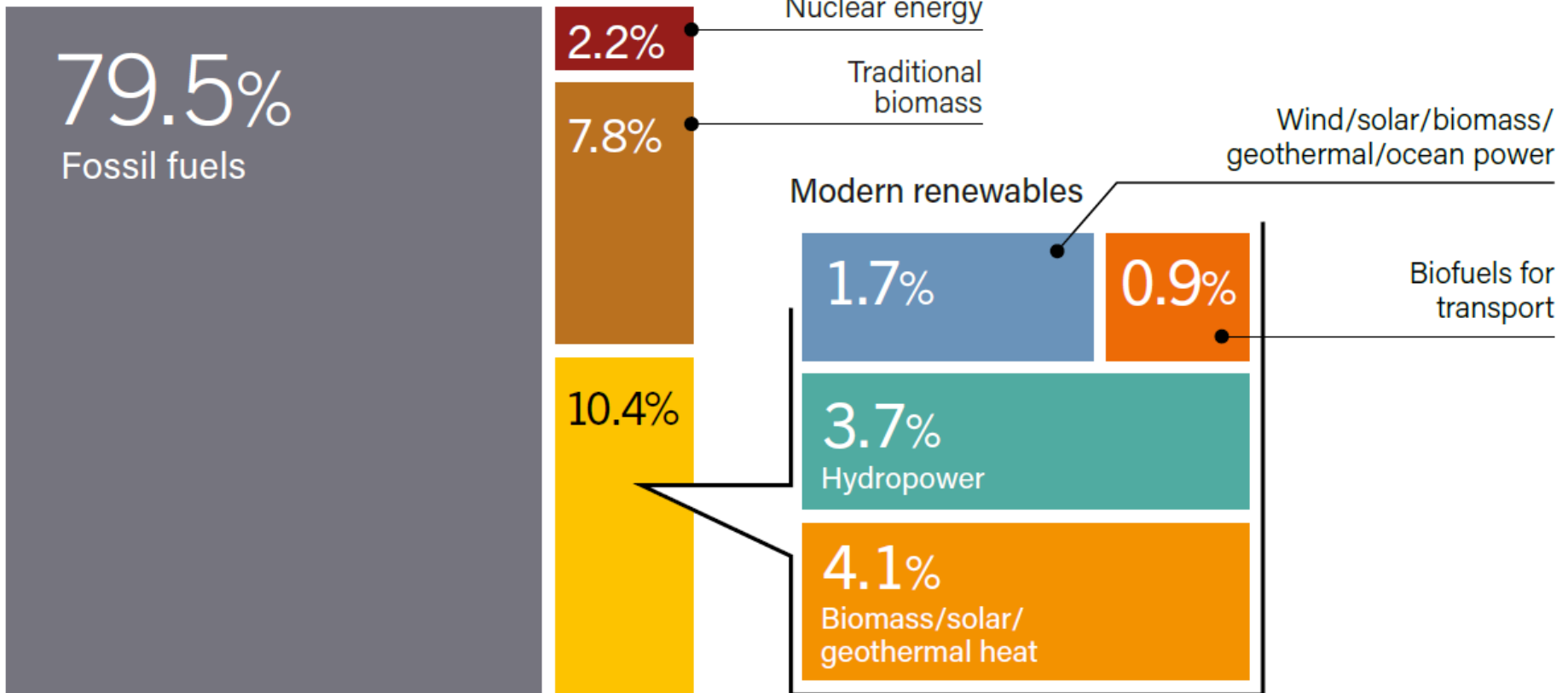


*Industry excludes non-combusted use of fuels

BP 2019

Share of renewable energy in total final energy consumption (TFEC), 2016

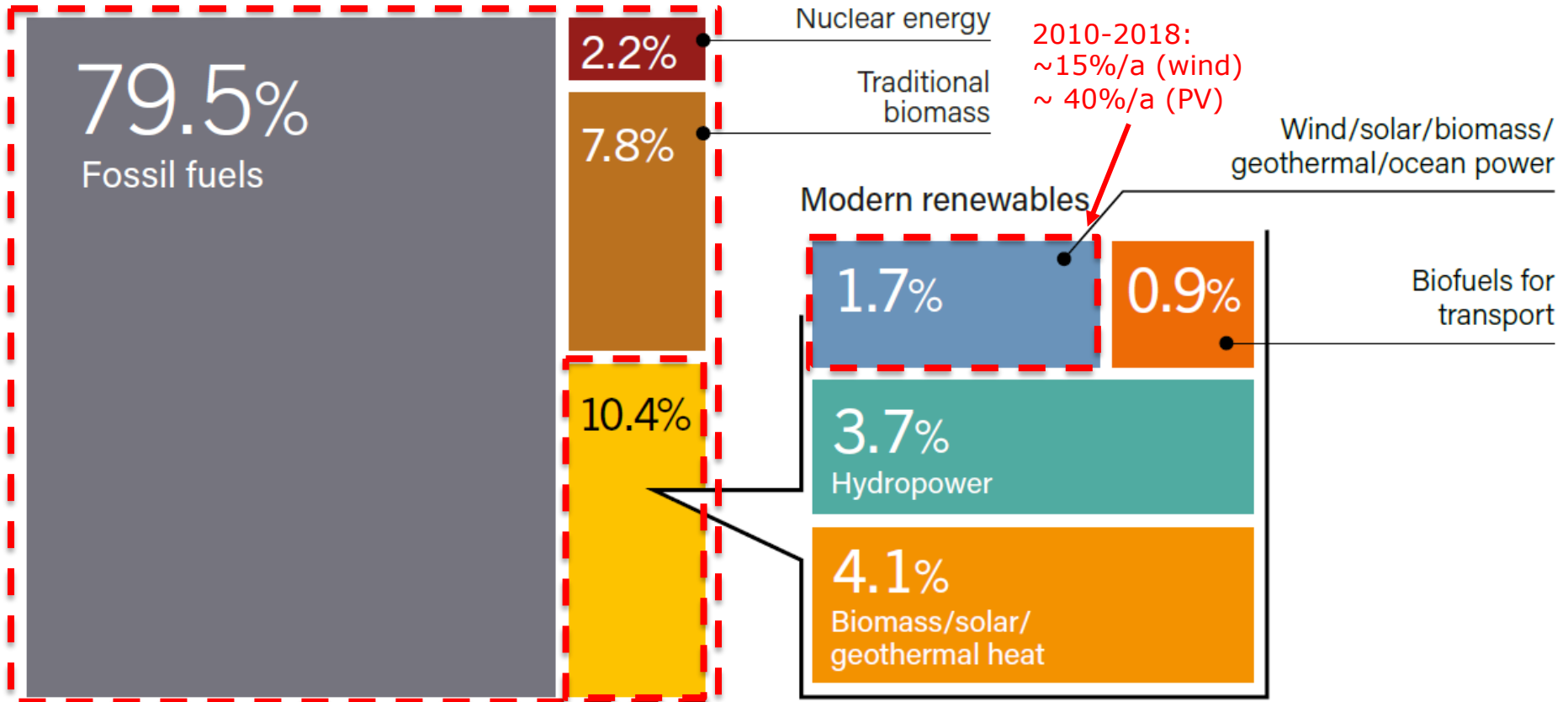
395 EJ



REN21, 2018

Fast growth of renewables, “the zoom-in illusion”

+2-2,5%/a in the past 50 years

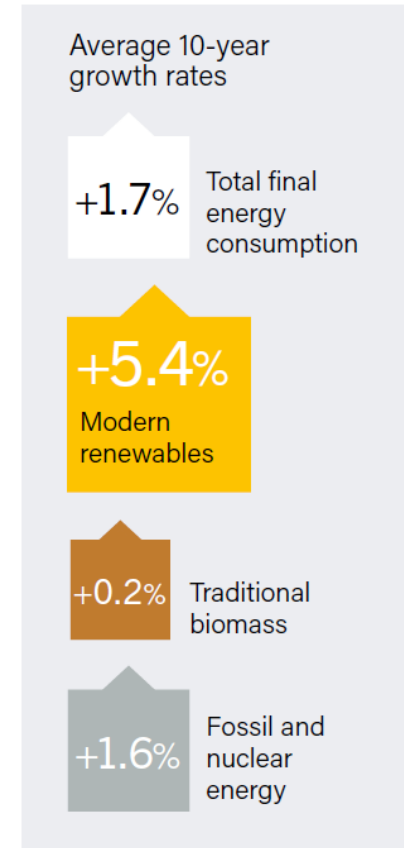
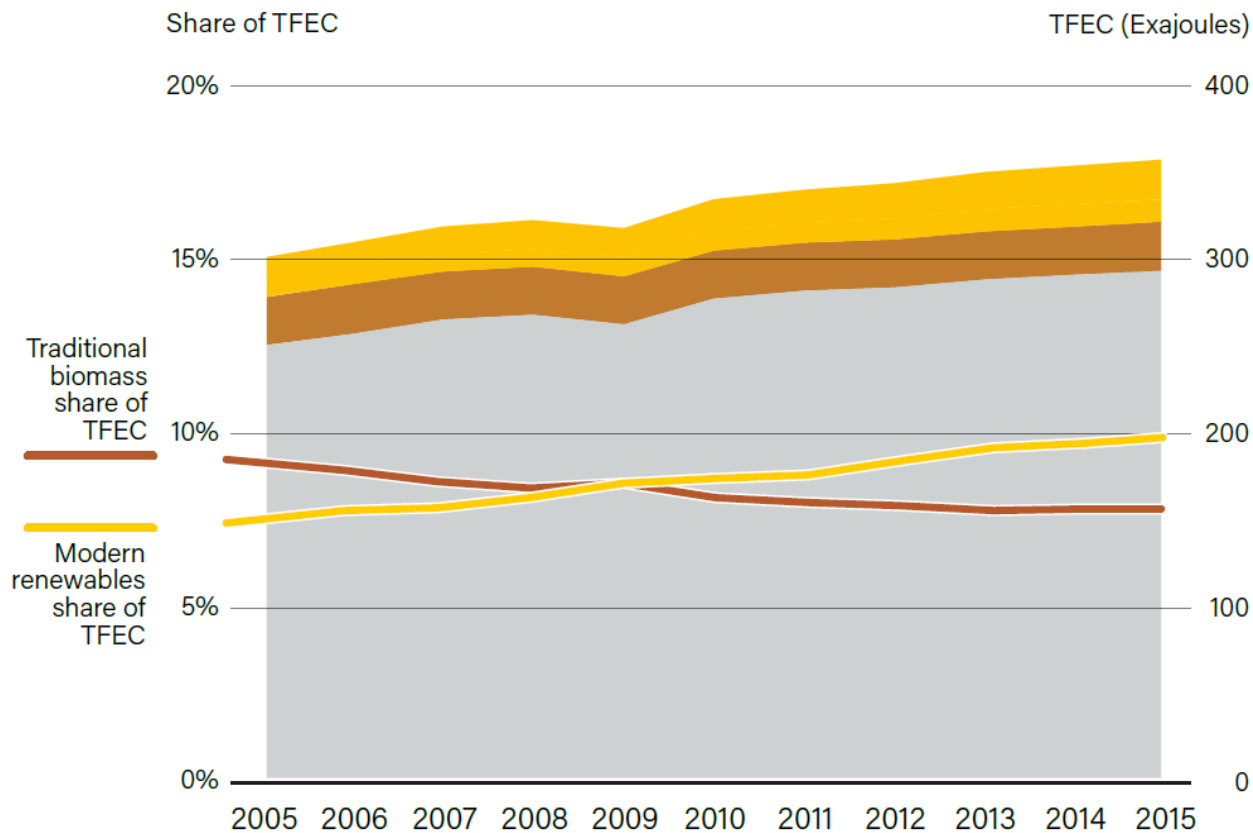


REN21, 2018

~5%/a in 2000-2018

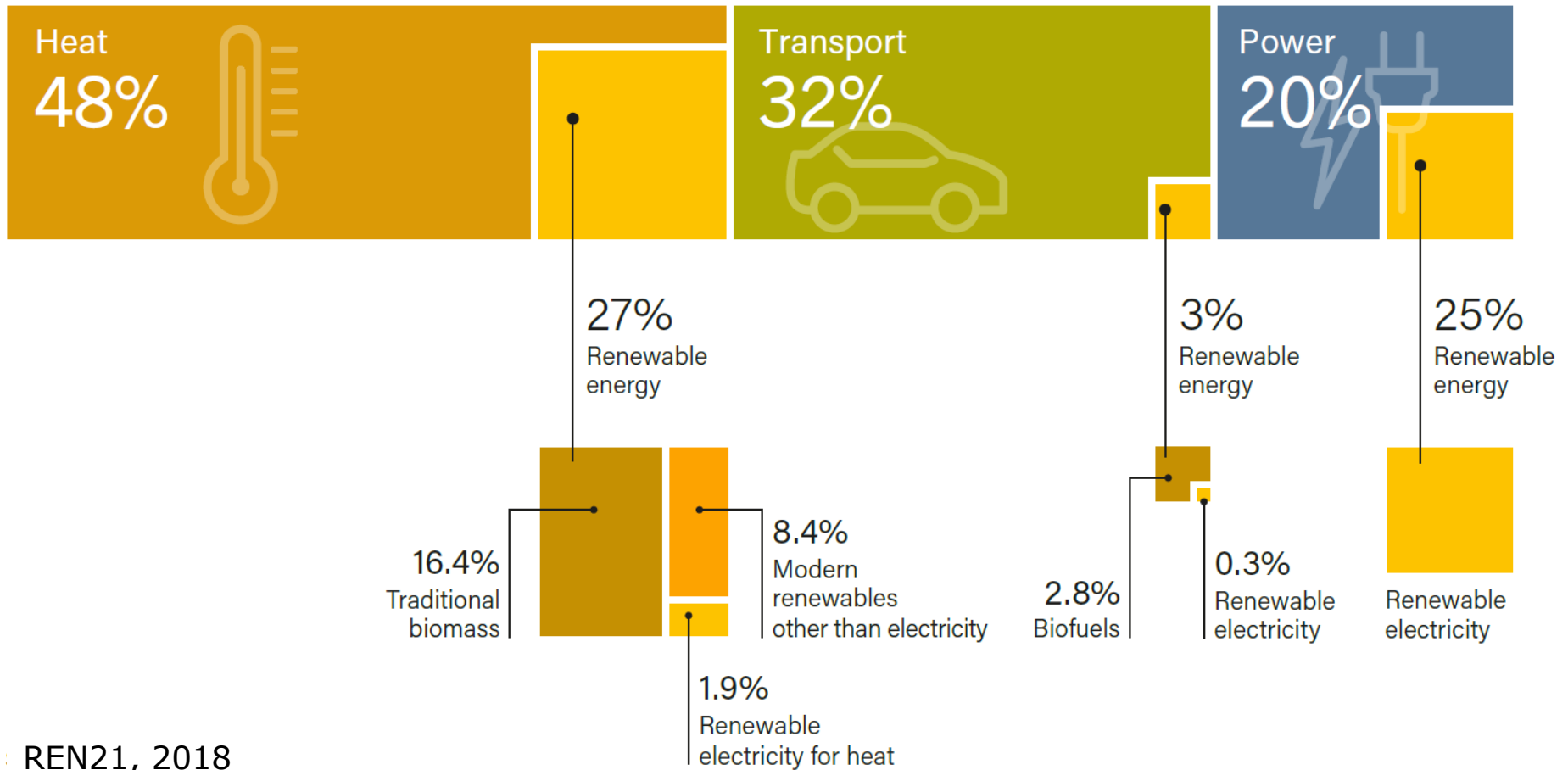
In addition, capacity vs. energy a source of confusion

Global TFEC, 2005-2015



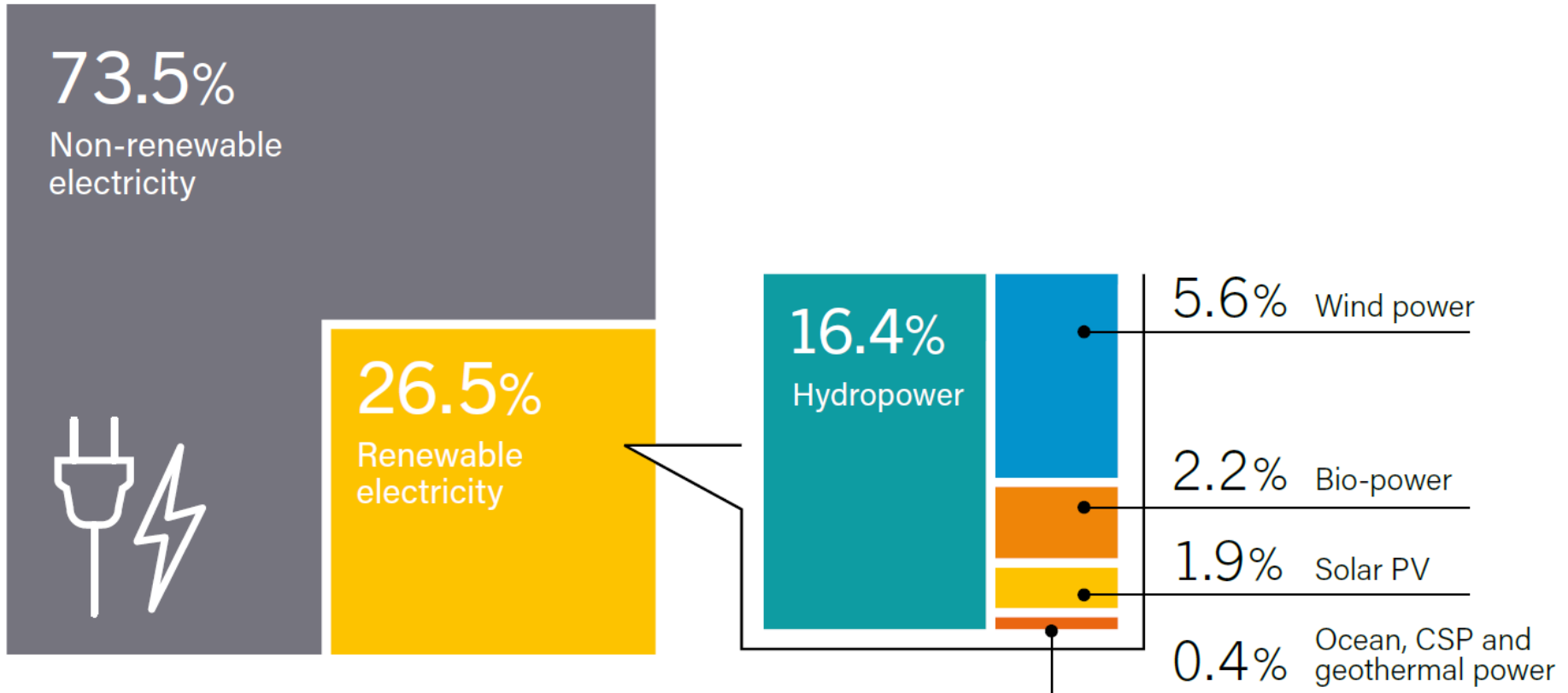
REN21, 2018

Renewable energy in TFEC by sector, 2015



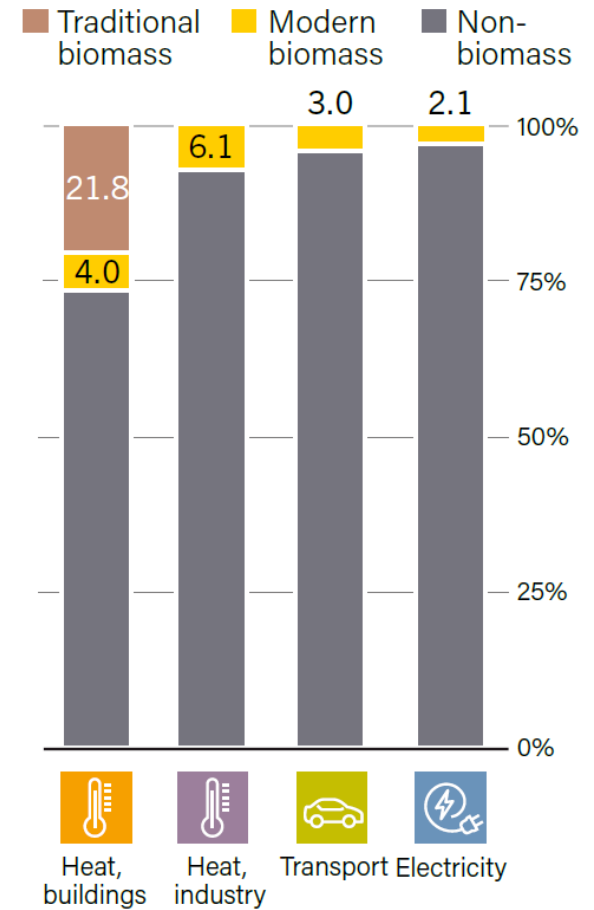
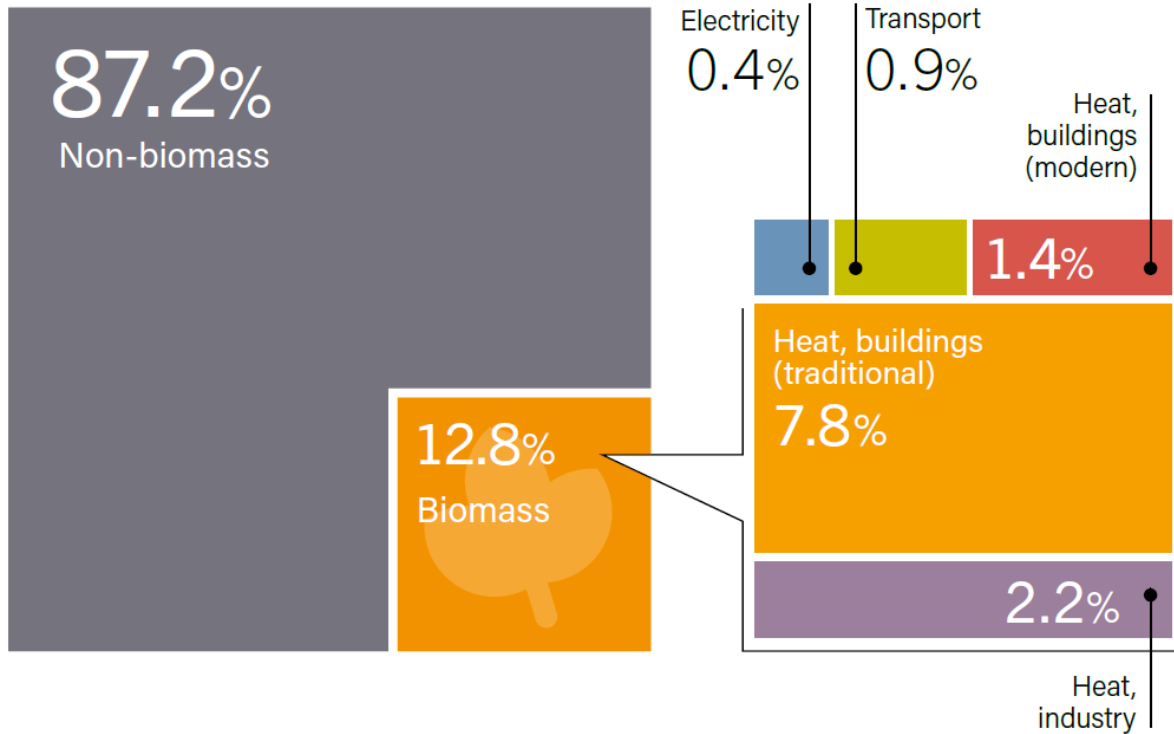
REN21, 2018

Renewable energy in power sector, 2017



REN21, 2018

Bioenergy in the TFEC by sector, 2016



REN21, 2018

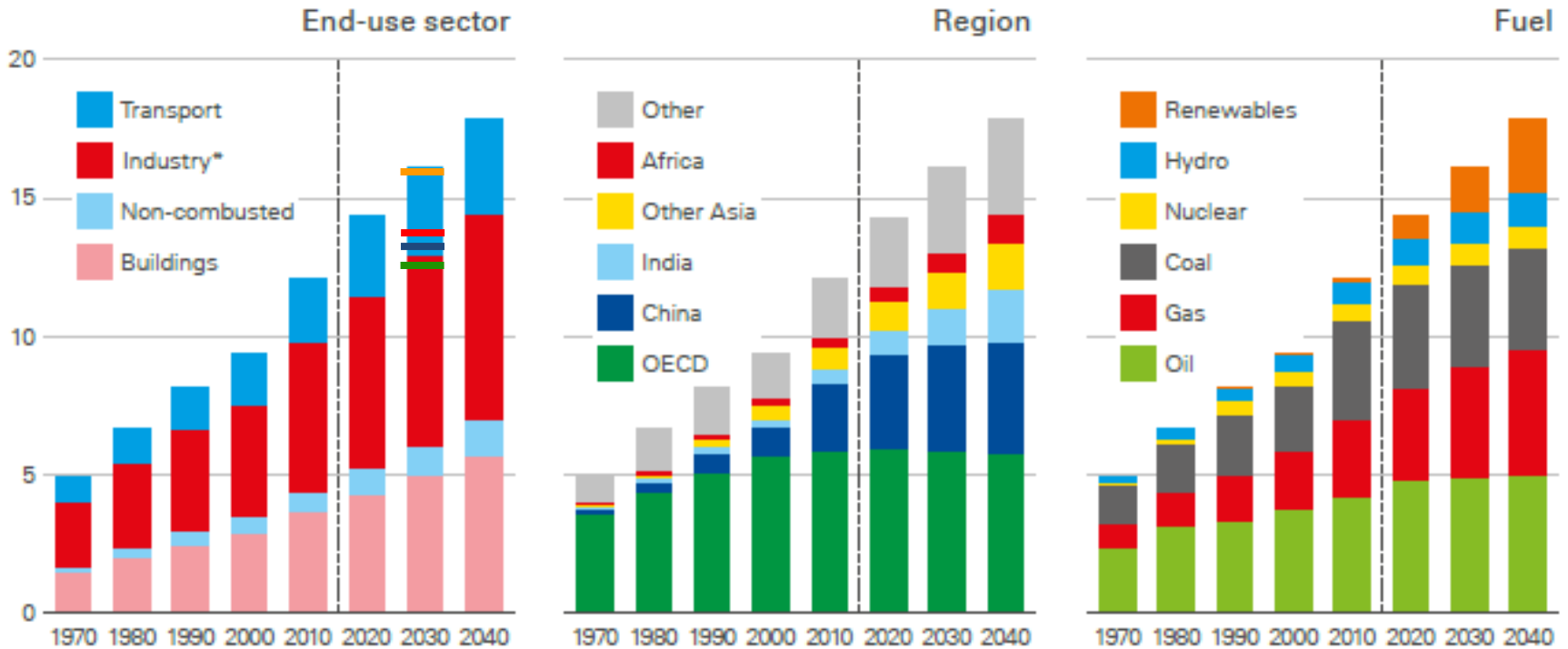
Main trends and drivers in energy sector

Main trends in the global energy sector

- Rapid deployment and falling costs of clean energy technologies
- Electrification of all sectors
- The shift to a more services-oriented economy and a cleaner energy mix in China, the rise of India, other Asian countries and Africa as consumption growth drivers
- The increase of shale gas and shale oil in the United States
- The increase in gas consumption, LNG production and trade, and global harmonisation of gas market
- Increased uncertainty in oil market
- Still increasing energy consumption, use of fossil fuels and therefore GHG emissions

Global primary energy demand, Evolving Transition

Billion toe

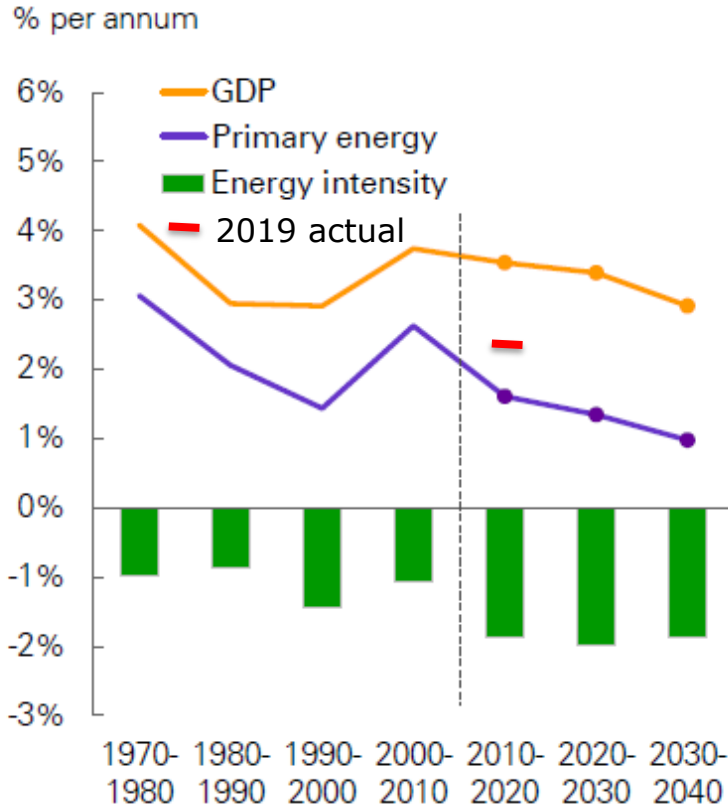


*Industry excludes non-combusted use of fuels

- IEA New Policies Scenario
- IEA 2C Scenario
- IRENA REmap Scenario
- Greenpeace Energy Revolution

BP 2019 / IEA 2018 / IRENA 2019 / Greenpeace 2015

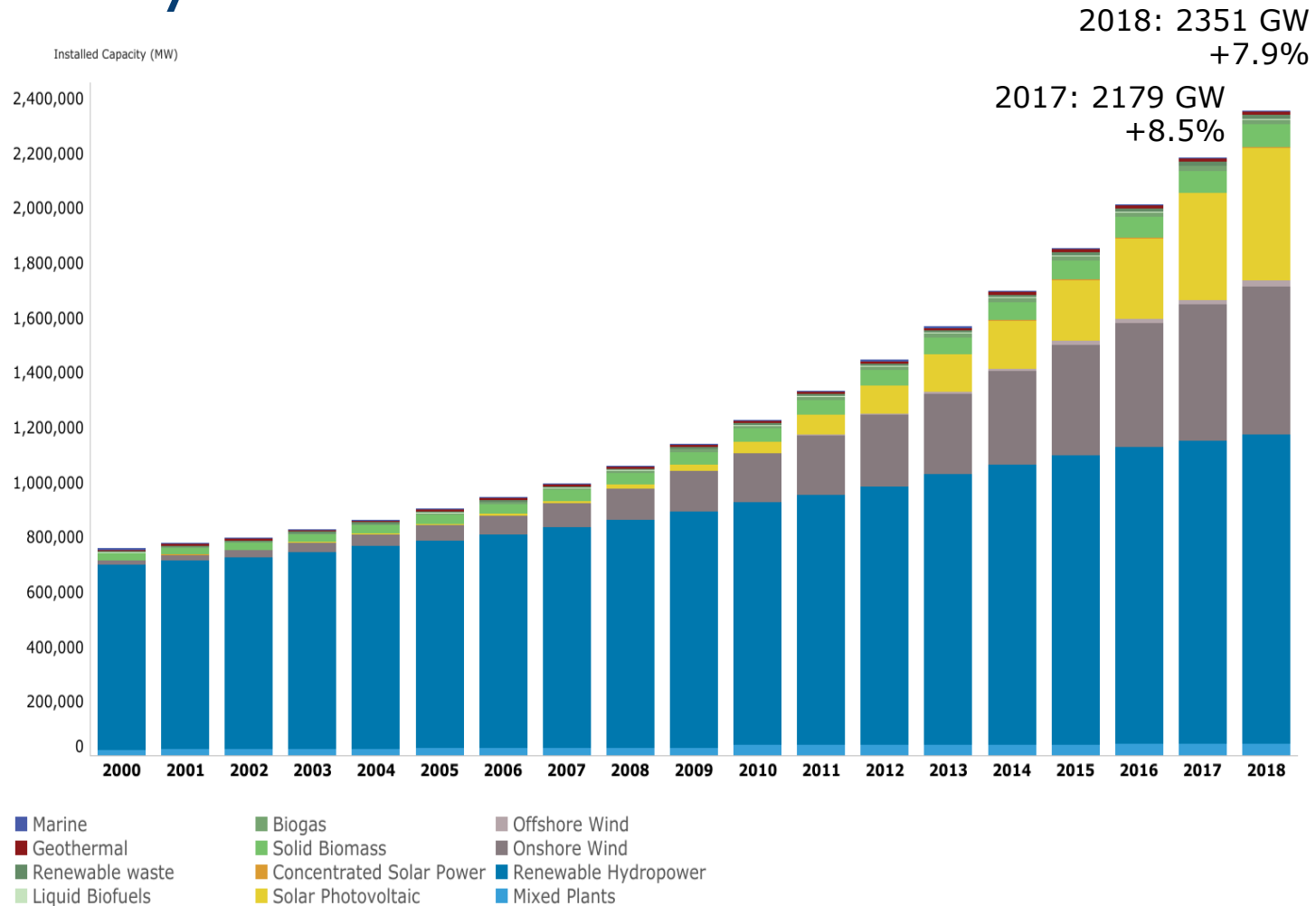
Energy efficiency is key to achieve the climate targets



- Energy efficiency of economies will improve but too slowly
- Most of the 1.5-2C scenarios assume no increase in energy consumption
- In 2018, global energy consumption increased by 2.3%

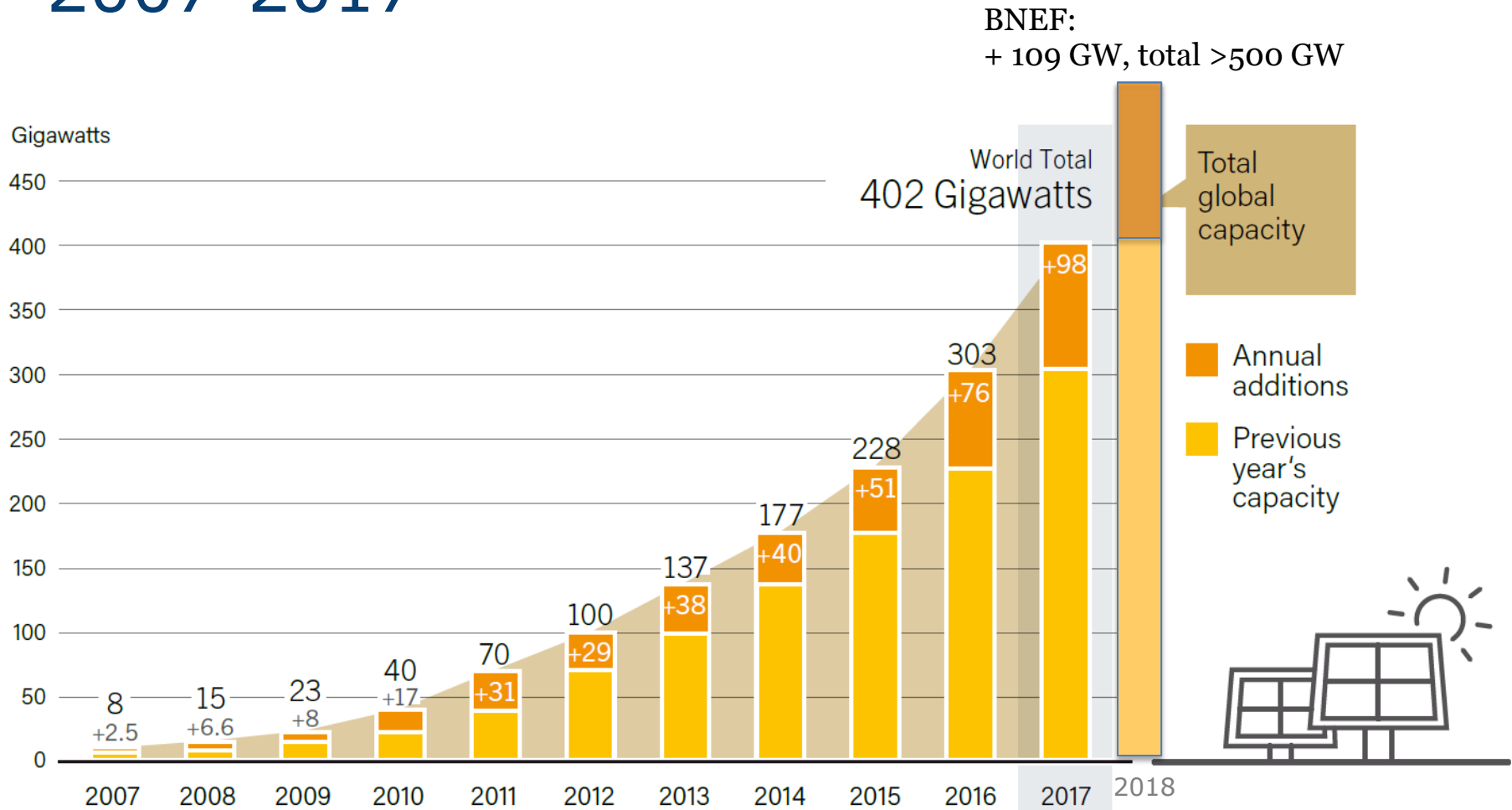
BP 2018

Global installed renewable energy power capacity



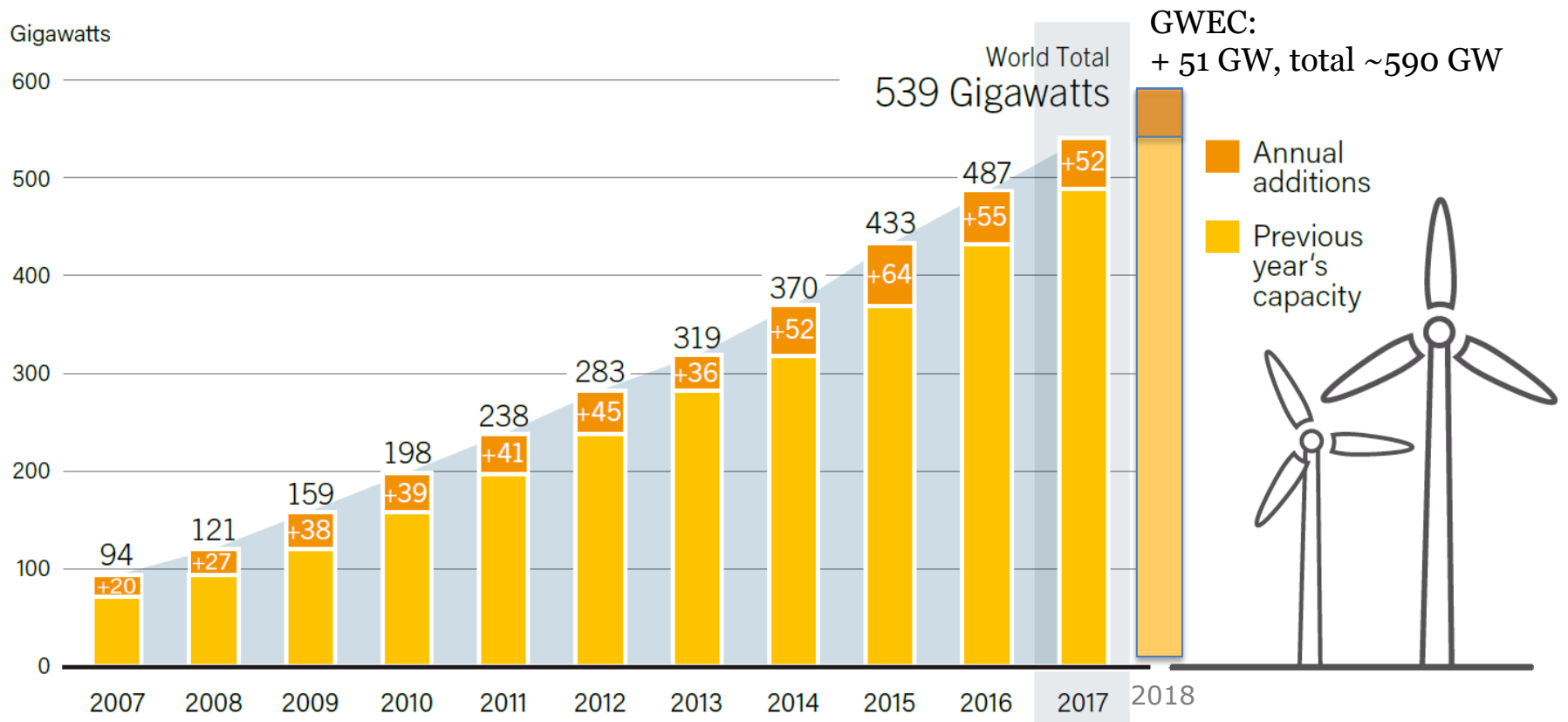
IRENA 2019

Solar PV Global Installed Capacity 2007-2017



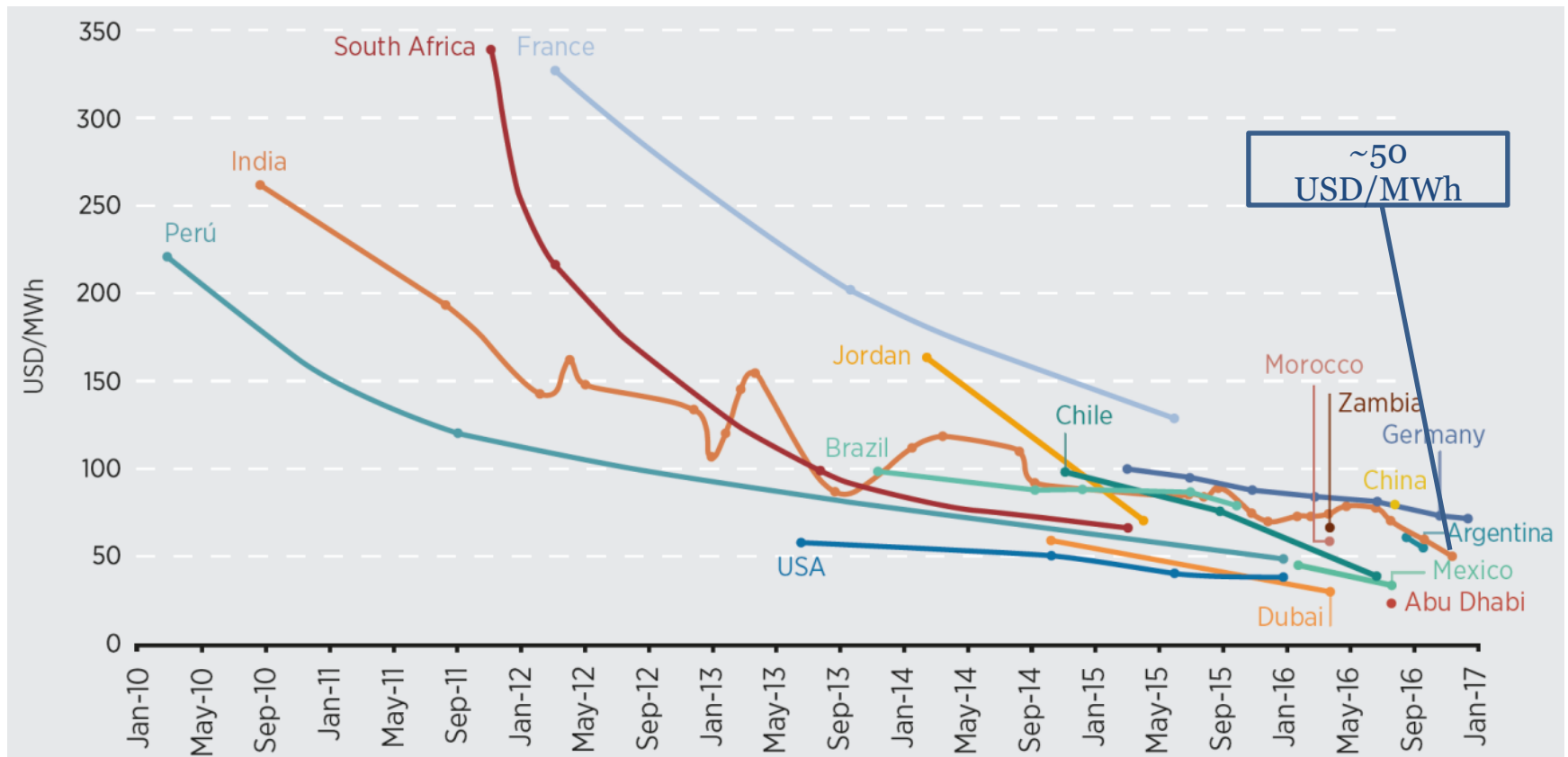
REN21, 2018

Wind Power Global Installed Capacity 2007-2017



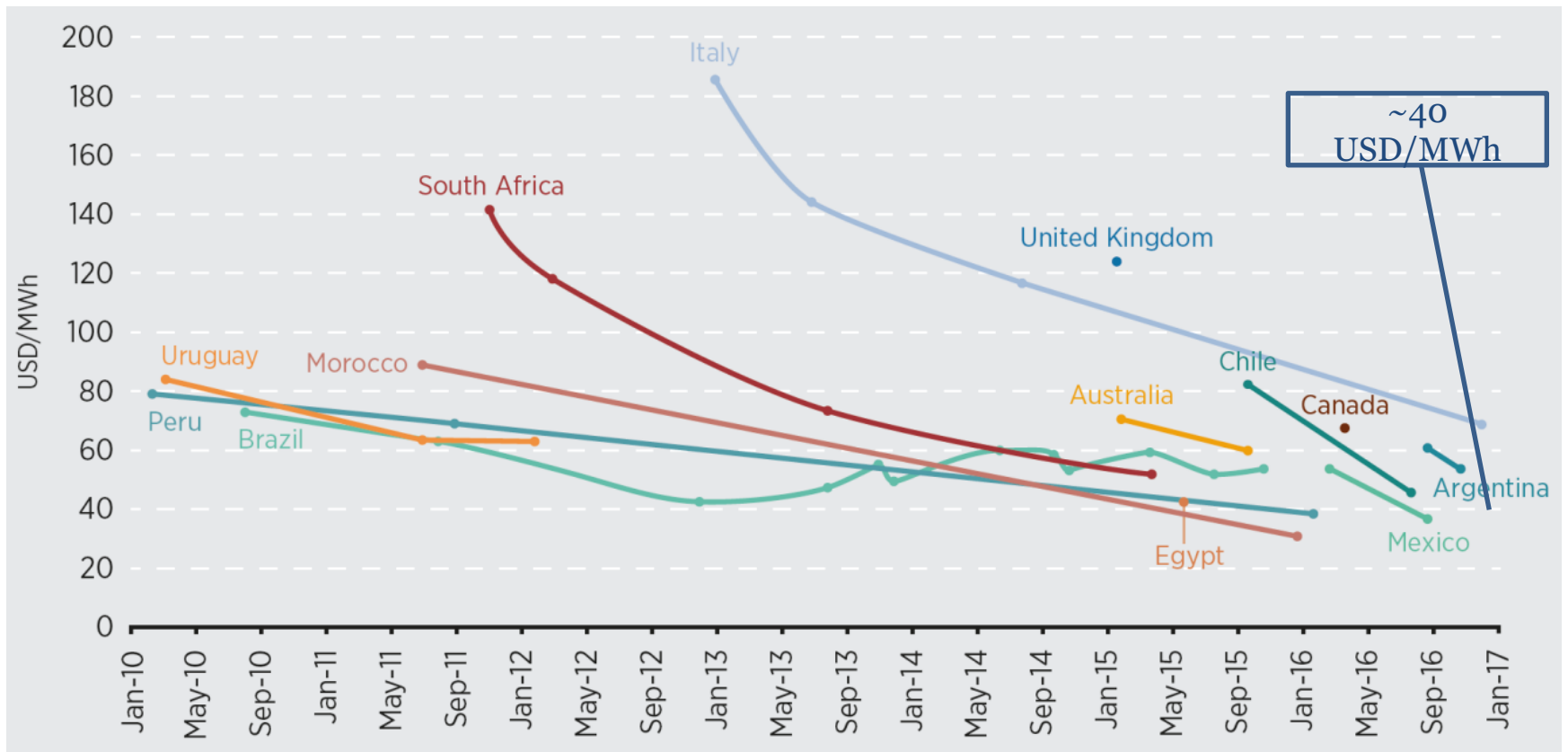
REN21, 2018

Utility-Scale Solar PV Auction Prices 2010-2017



IRENA, 2018

Wind Power Auction Prices 2010-2017

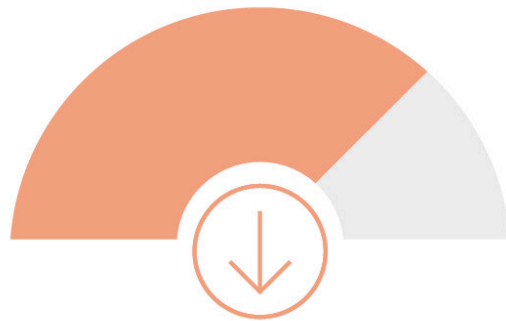


IRENA, 2018

Levelised cost of solar PV and wind power has dropped dramatically during this decade

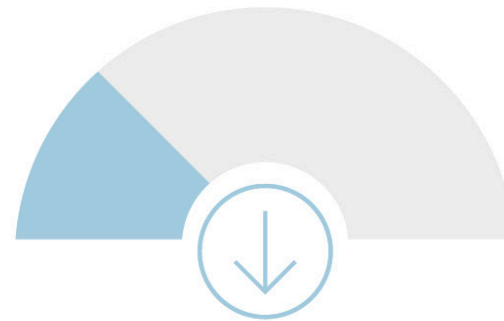
2010-2017

Solar PV



73%

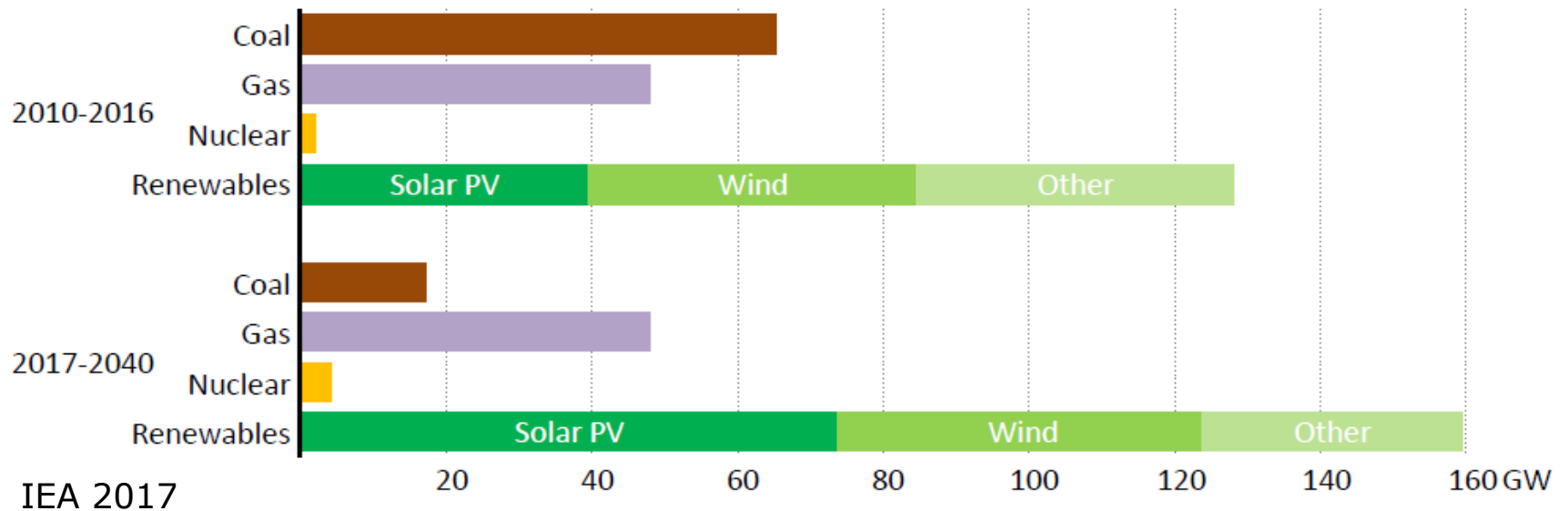
Onshore Wind



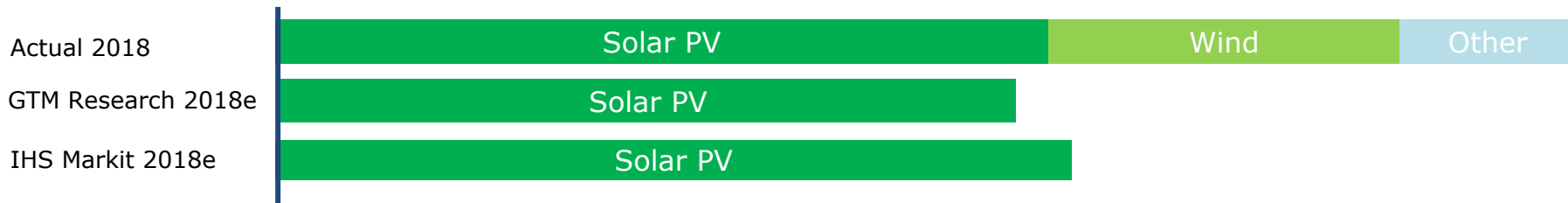
36%

IRENA, 2019

When looking at “base scenarios”...

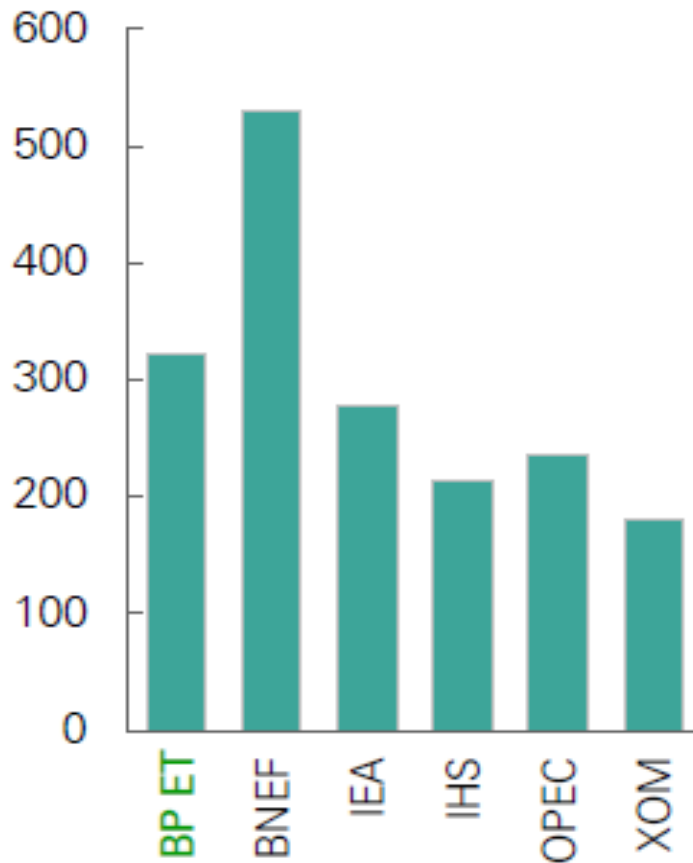


Reality check



Electric vehicles in 2040 (BEV + PHEV)

Millions



- ~2 billion passenger cars in 2040
- Share of EVs <10%-27%
- New forecasts constantly more bullish
- IRENA REmap scenario: >1bn EVs in 2050
- Today 5.6 million EVs, more than 2m sold in 2018

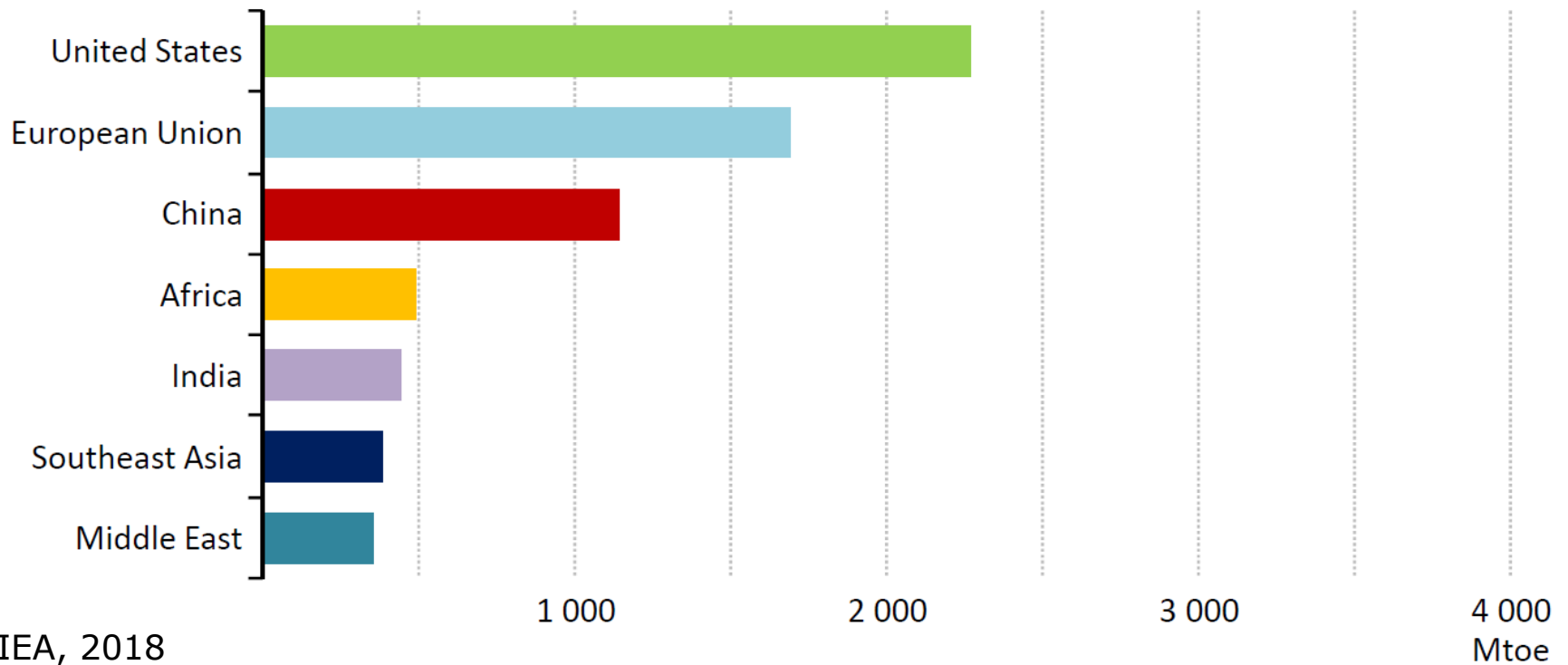
BP, 2018

Electrification, concluding remarks

- Electricity will correspond for much larger share of energy use than today
 - Depending on scenario, power demand to increase by 50-150% by 2040-2050
 - Population growth, increased energy access and increased income lead to more air conditioning and electrical appliances, and a third of the power demand growth comes from industry, also heating and mobility sector electrification play a big role
 - Supply options also play a role; e.g. solar is suitable in many developing countries both in small and large scale, both grid and off-grid, and the development of battery technology and integration with existing diesel generation will help
 - Generally more ways to generate and consume electricity than in the past
 - In 2040, 250m-550m EVs out of 2 billion passenger vehicles in total in 2040
 - VRE challenge is not anymore the LCOE, but rather the technology, regulatory development and needed investments in other required infrastructure to manage the variability and enable the penetration of VRE (links to gas, storage, EV, digitalisation, traditional grid investments, etc)
- Oil demand will decrease gradually in passenger vehicles due to alternative fuels and fuel efficiency, but demand in industry (esp petrochemicals) as well as heavy traffic and aviation and marine will cause oil demand to still increase
 - Oil sector uncertainties related to especially US tight oil resources and EV (and partly other fuel efficiency) adoption
 - Also, increasing consensus that the peak oil will be reached in the first half of 2030s

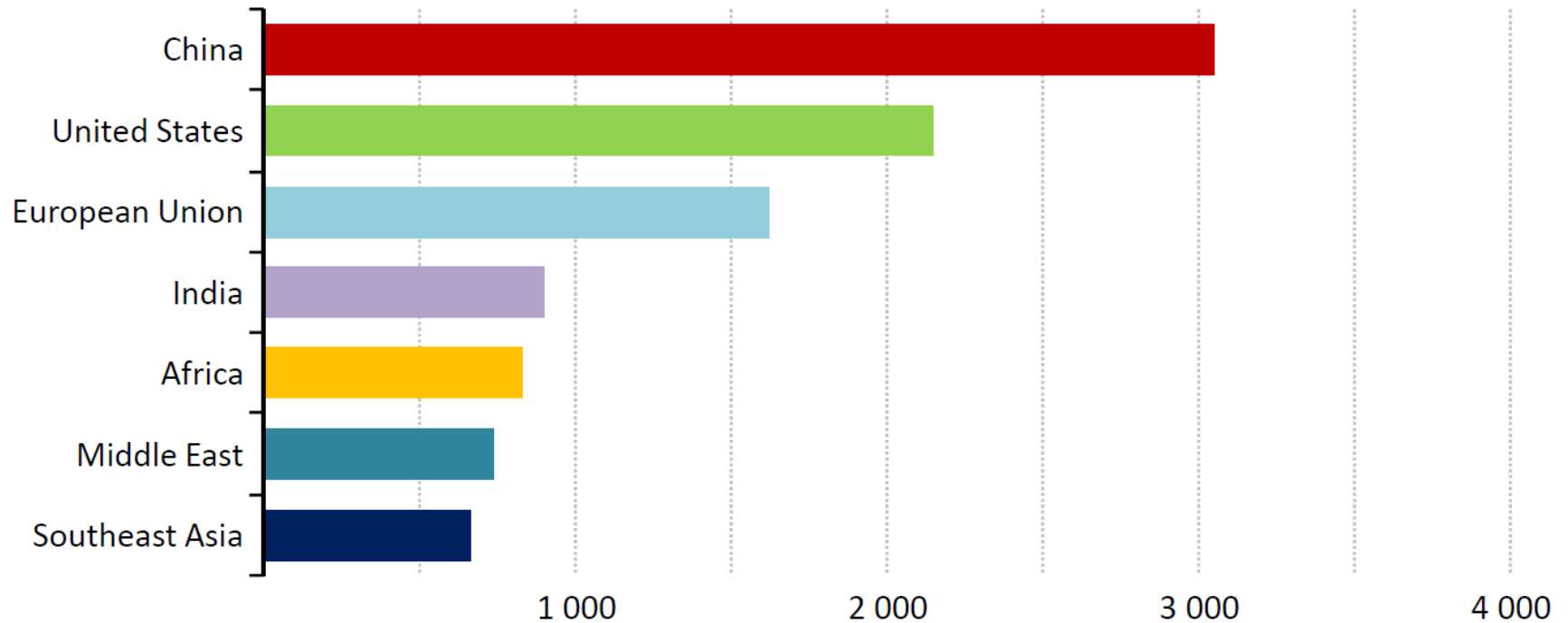
New geography of energy

Energy demand
2000



New geography of energy

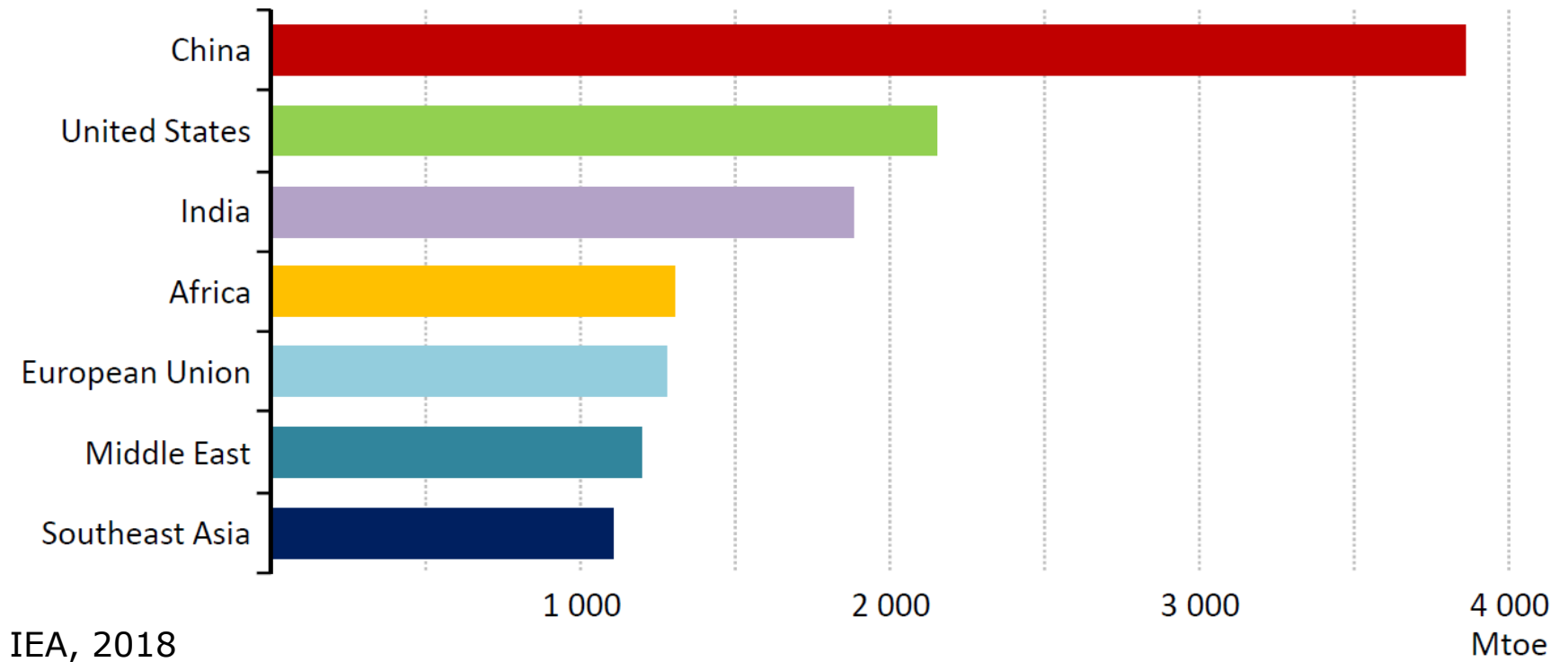
Energy demand
2017



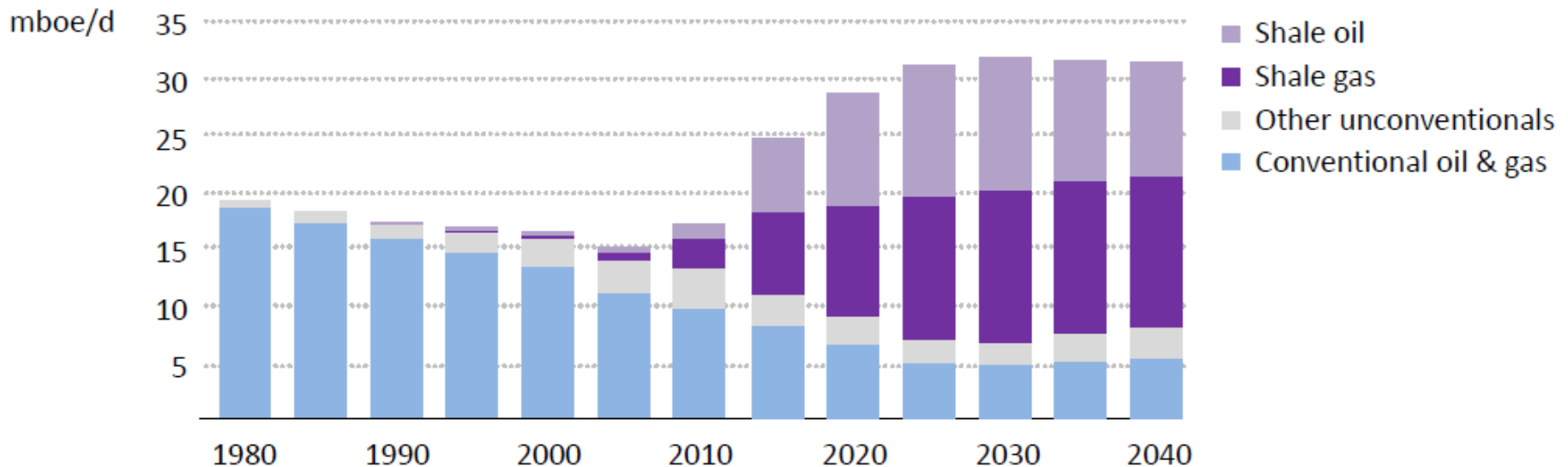
IEA, 2018

New geography of energy

Energy demand
2040



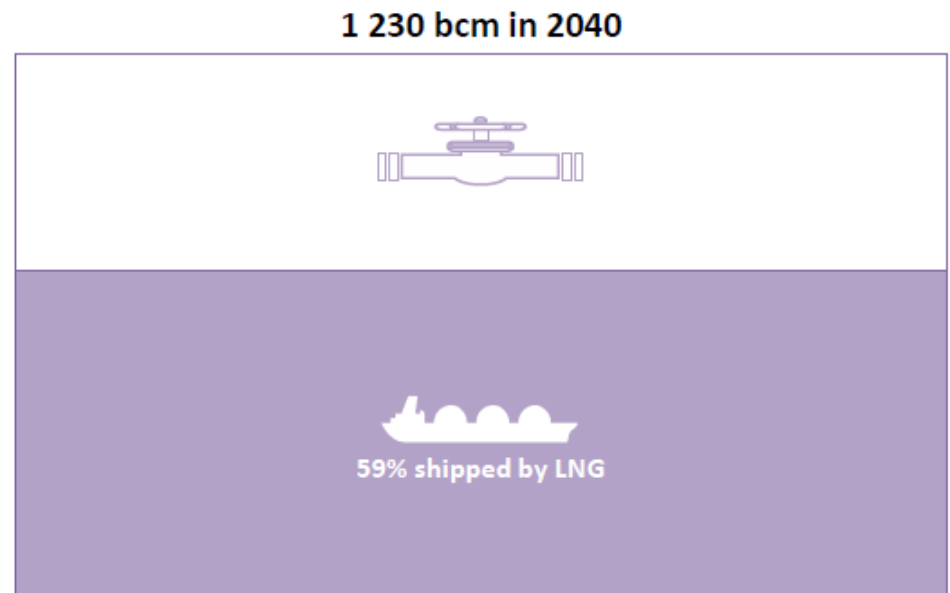
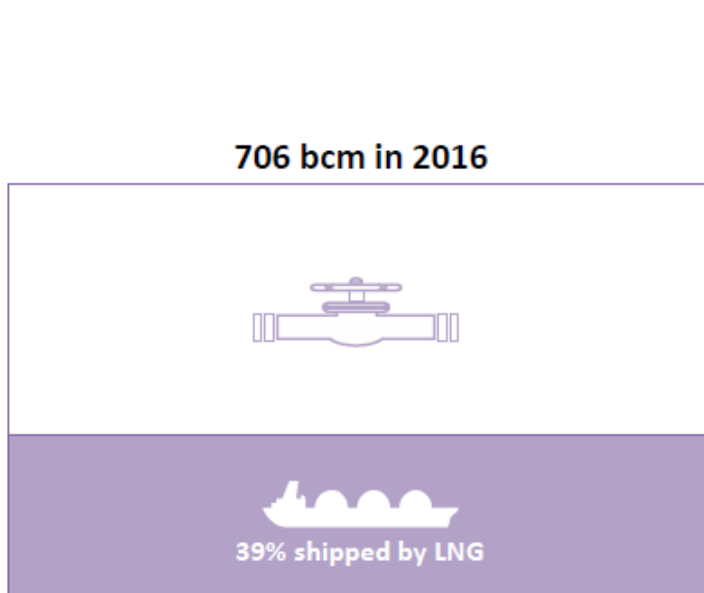
US shale production



IEA 2017

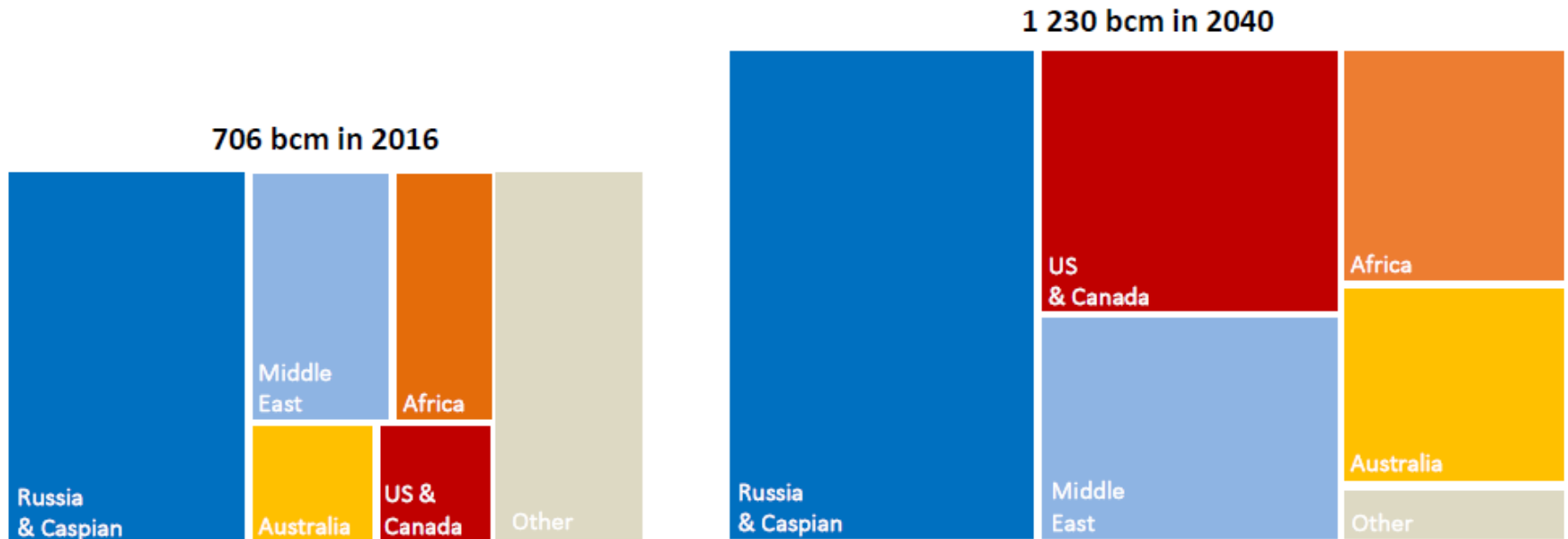
- US already a gas exporter
- Soon to be an oil exporter too, and the largest oil producer in the world
- However, lot of uncertainty in the oil market, many predicting the peak oil in first half of 2030s

Global gas trade becomes more liquid, literally



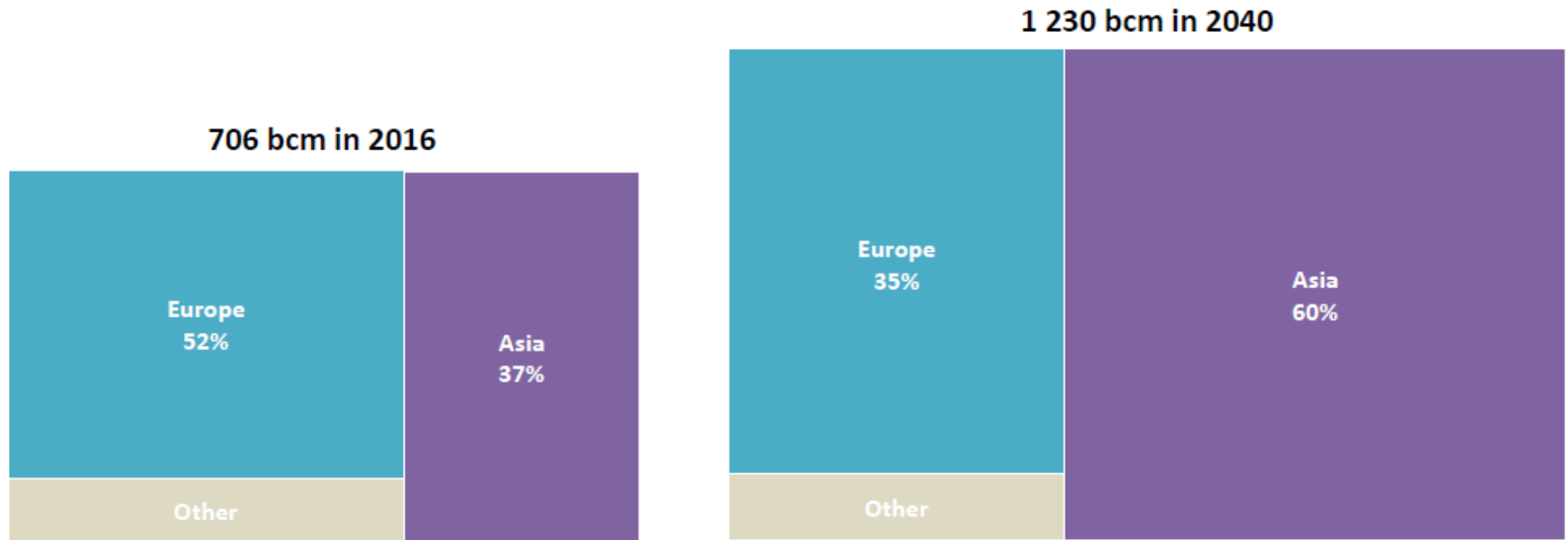
IEA 2017

US and Middle East to increase their position as gas exporters



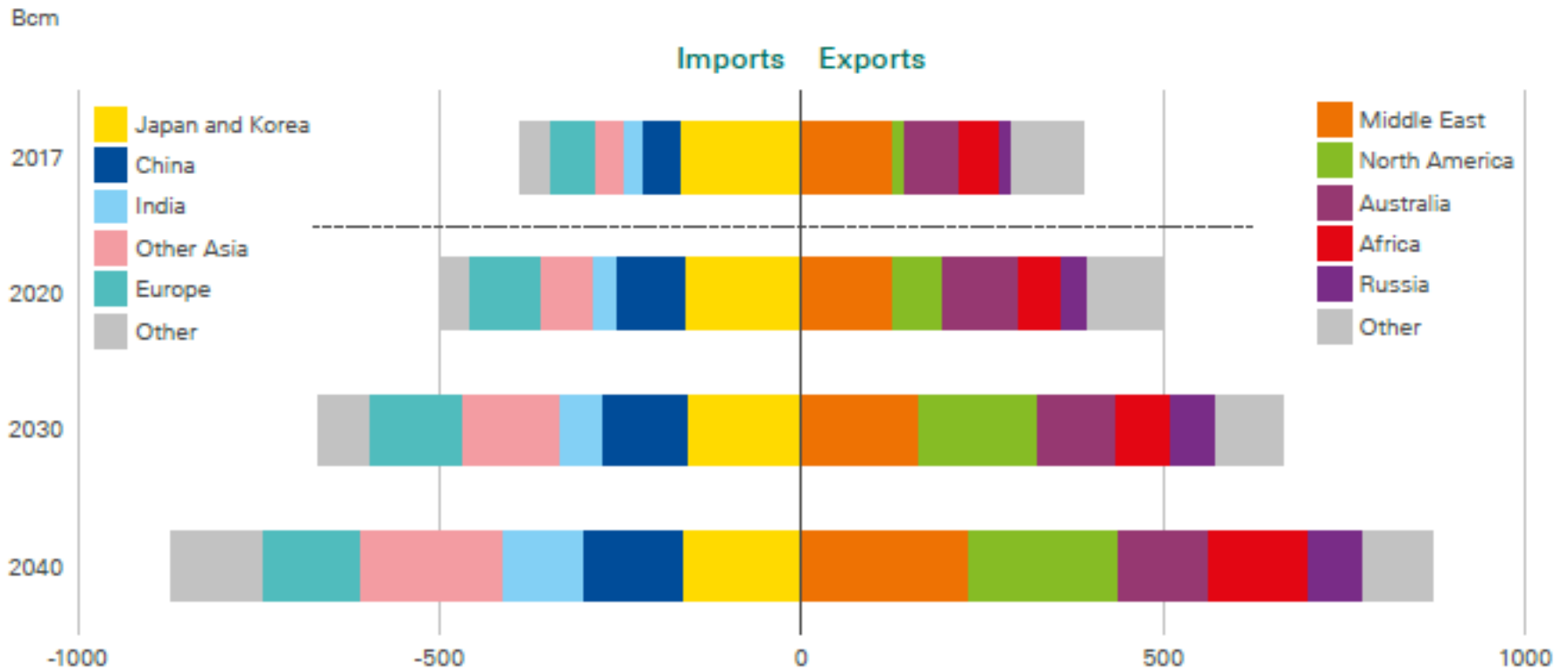
IEA 2017

Asia's role as gas importer grows



IEA 2017

Asia will dominate LNG imports, US & Qatar exports



BP 2019

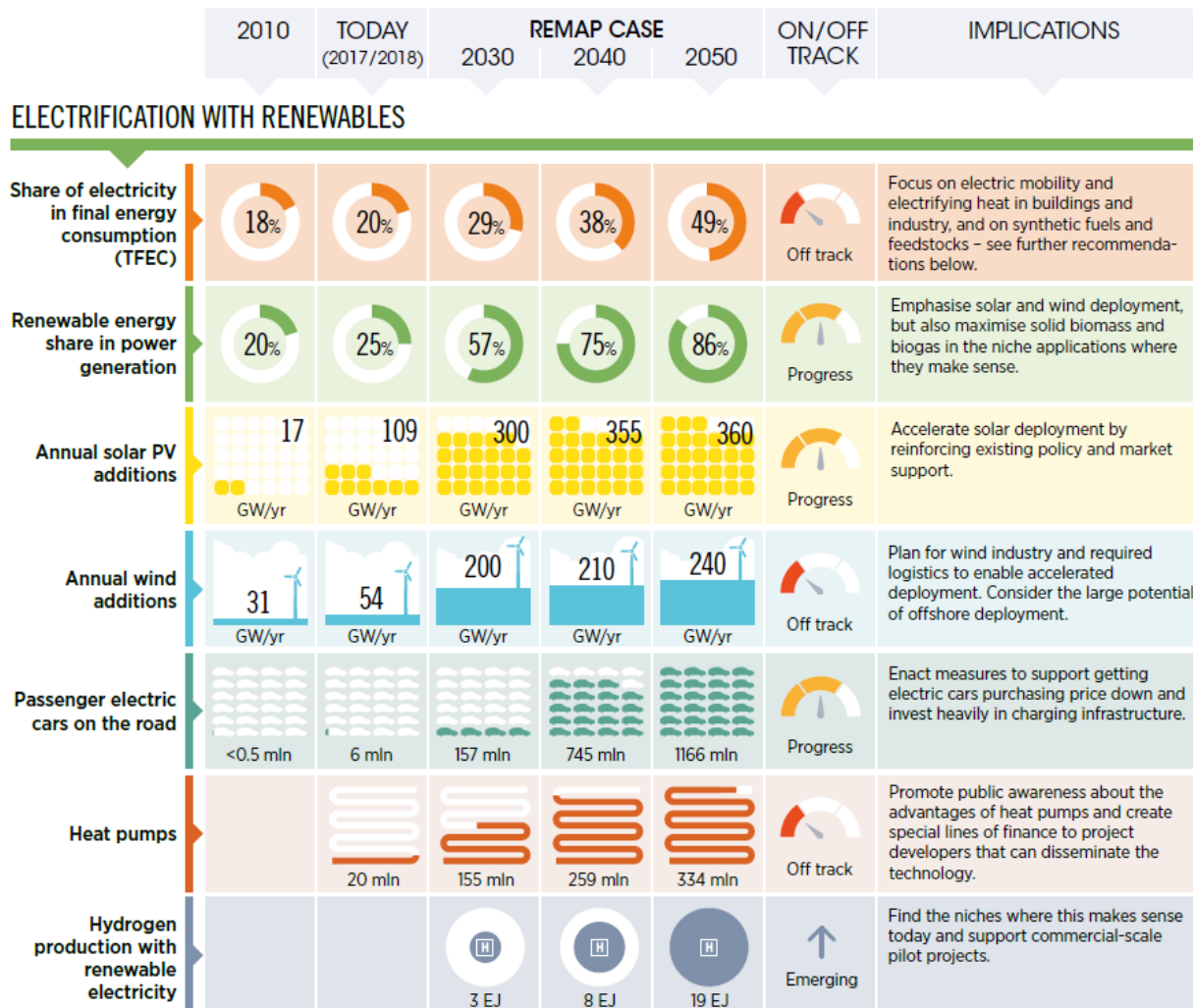
Geographies, concluding remarks

- Huge changes ahead, with fundamental impacts on trade and geopolitics
- Big change going on in China; move from traditional heavy industries and coal dominated power system towards high focus on electrification, cleaner sources, digitalisation, services based growth
 - Current coal based generation causes 2m premature deaths annually
 - Growth in energy demand 8%/a 2000-2012, 2% 2012-2016, and 1% up to 2040
 - Energy efficiency plays a big role, without it the growth could be more than 2%/a
 - But still, in 2040 China per capita consumption will exceed that of the EU
 - China's actions are crucial for cleaner technologies; RE, EE & EV deployment domestically, technology exports, outbound investments; also largest gas importer with the EU, and becoming the largest oil consumer in 2030s, although growth rates will be larger in India and elsewhere
- India, South East Asia, Middle East and Africa increasing their share of energy consumption
- US shale oil and gas a game-changer
 - US already a gas net exporter, will become net exporter of oil too, assuming the vehicle fuel economy improvements take place; if not, US would remain a net importer (oil supply & demand quite balanced in US)
 - The expected growth in oil production by 8mn barrels per day from 2010 to 2025 would be the largest increase ever seen in any country before; same for gas, 630 bcm increase
 - US could become the largest exporter of LNG, even larger than Qatar, by mid- / late-2020

An alternative, ambitious, climate-combatible scenario: IRENA, REmap

- Renewable energy
- Electrification of all sectors
- Energy efficiency

REmap: Electrification with renewables



IRENA, 2019

REmap: Improvement in efficiency and RE LCOE

2010	TODAY (2017/2018)	REMAP CASE			ON/OFF TRACK	IMPLICATIONS
		2030	2040	2050		

ENERGY EFFICIENCY

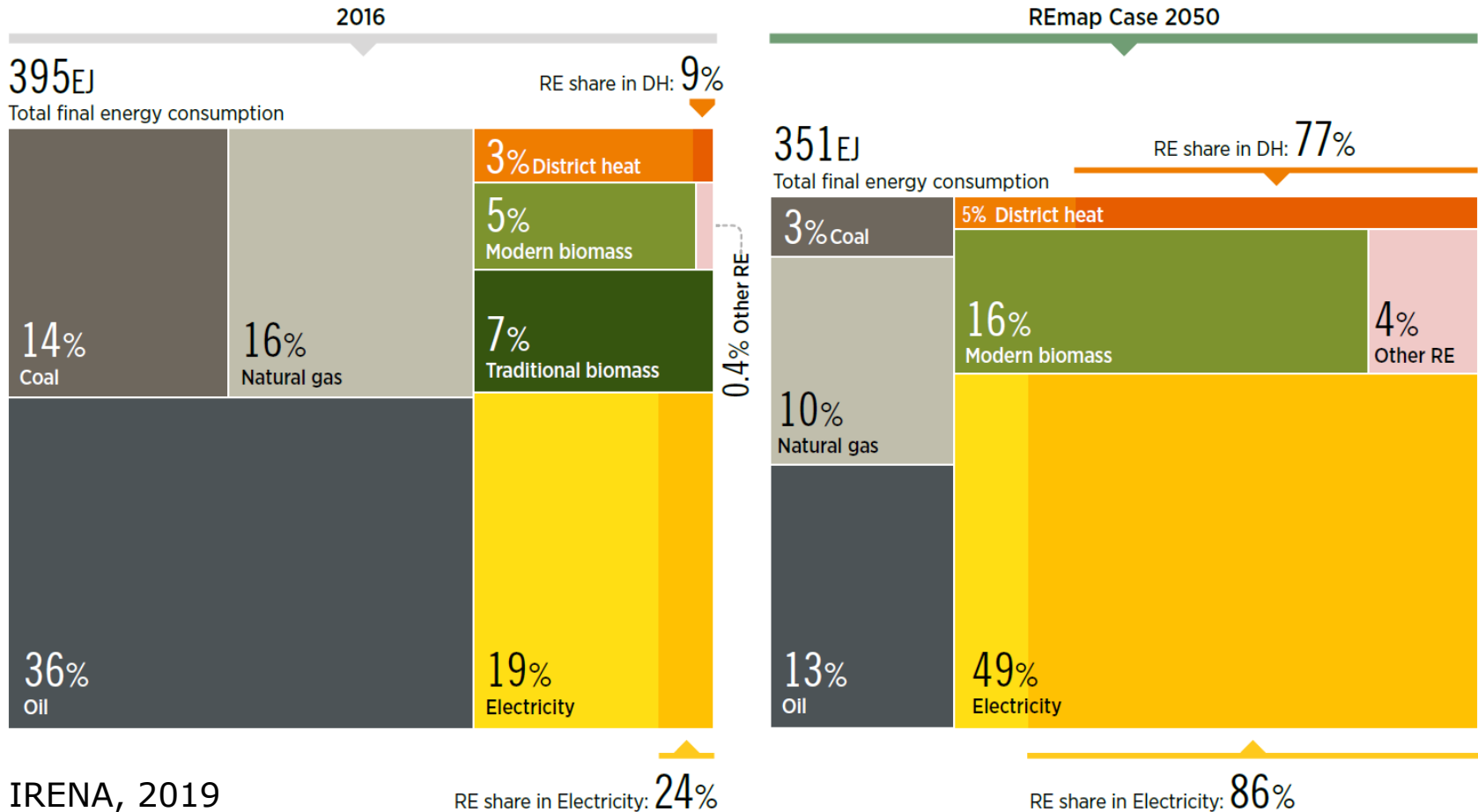
	2000-2010	2010-2017	2016-2030	2016-2040	2016-2050	ON/OFF TRACK	IMPLICATIONS
Energy intensity improvement rate	1.2% per year	2.3% per year	3.3% per year	3.3% per year	3.2% per year	Off track	Promote efficiency standards and efficient appliances and create conditions for project developers that speed deployment of energy efficiency technologies.
Total final energy consumption per capita	51 GJ per cap	53 GJ per cap	43 GJ per cap	41 GJ per cap	38 GJ per cap	Off track	

ELECTRICITY GENERATION AND CONSUMPTION ASPECTS

Onshore wind LCOE	80 USD/MWh	56 USD/MWh	50 USD/MWh	45 USD/MWh	40 USD/MWh	On track	Promote competitive bidding for solar and wind capacity additions and reform market regulation to accommodate these sources
Solar PV LCOE	347 USD/MWh	81 USD/MWh	58 USD/MWh	48 USD/MWh	38 USD/MWh	Progress	
Smart meters in the residential sector		25% of households	50% of households	77% of households	82% of households	Progress	Accelerate smart meter installations in existing buildings and mandate their installation in new buildings.

REmap: Share of RE and electricity in TFEC

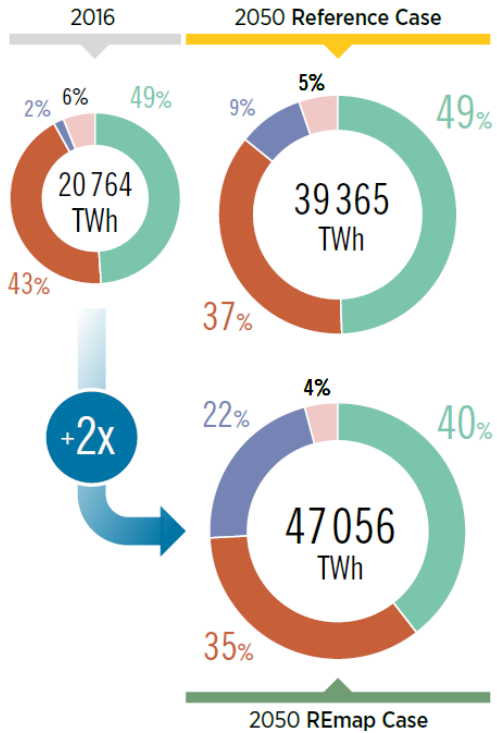
Total final energy consumption breakdown by energy carrier (%)



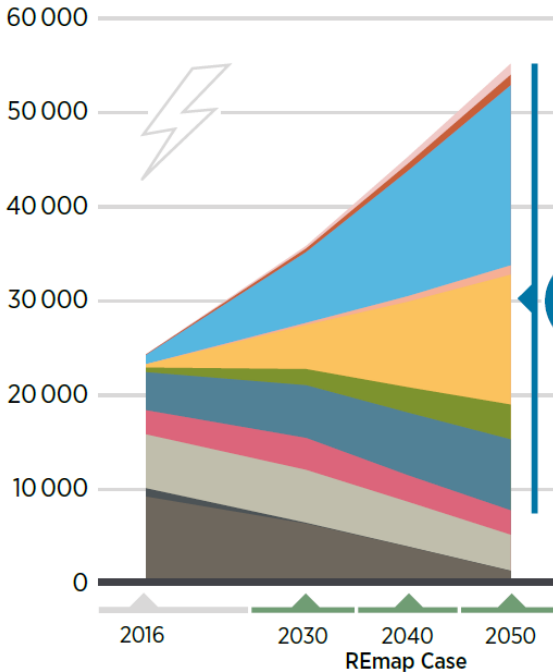
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REmap: Increase in RE based power generation

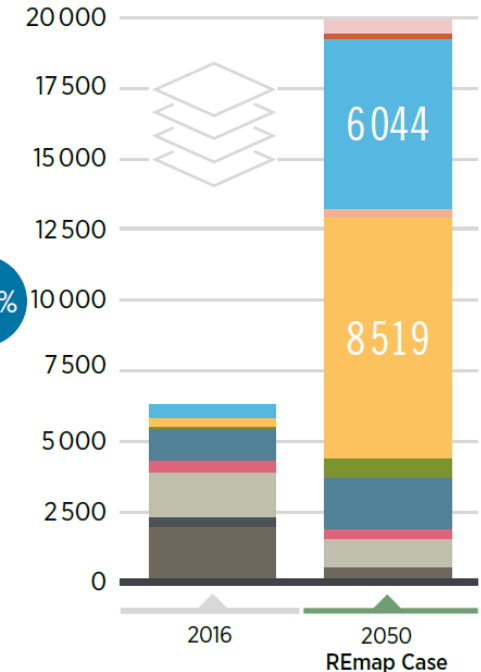
Electricity consumption in end-use sectors (TWh)



Electricity generation (TWh/yr)



Total installed power capacity (GW)

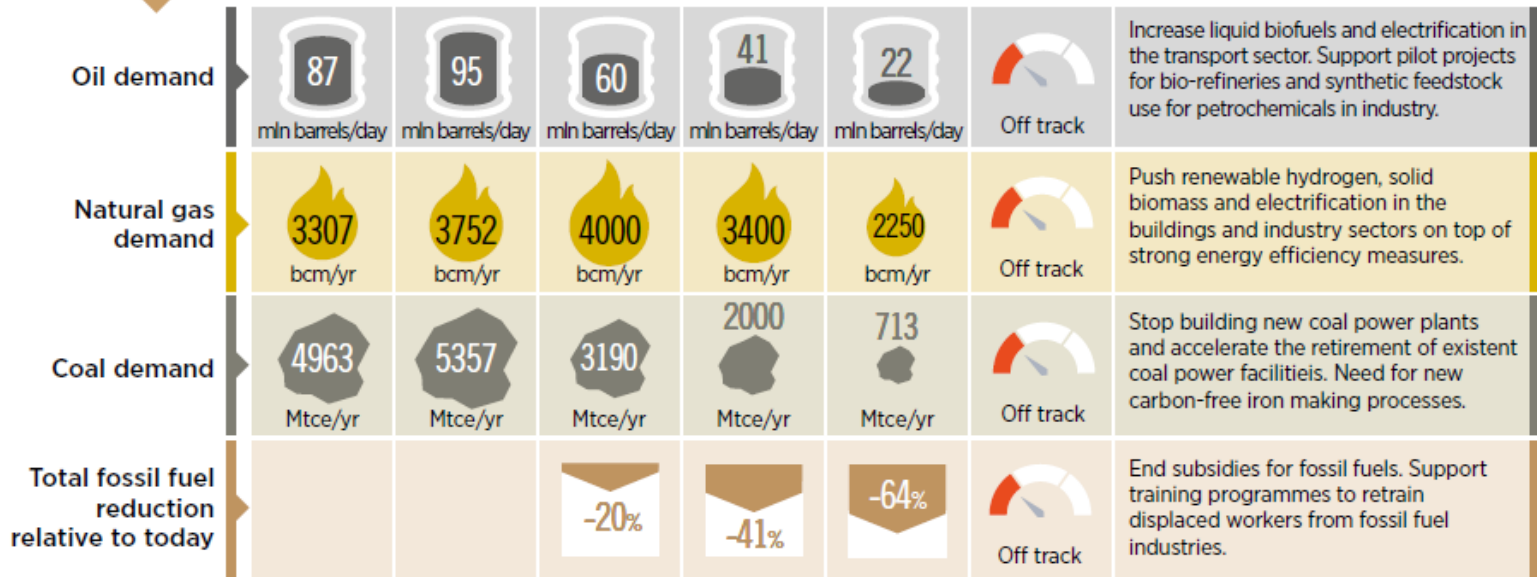


- Coal
- Nuclear
- Solar PV
- Geothermal
- Oil
- Hydro (excl. pumped)
- CSP
- Others (incl. marine)
- Natural gas
- Bioenergy
- Wind (onshore and offshore)

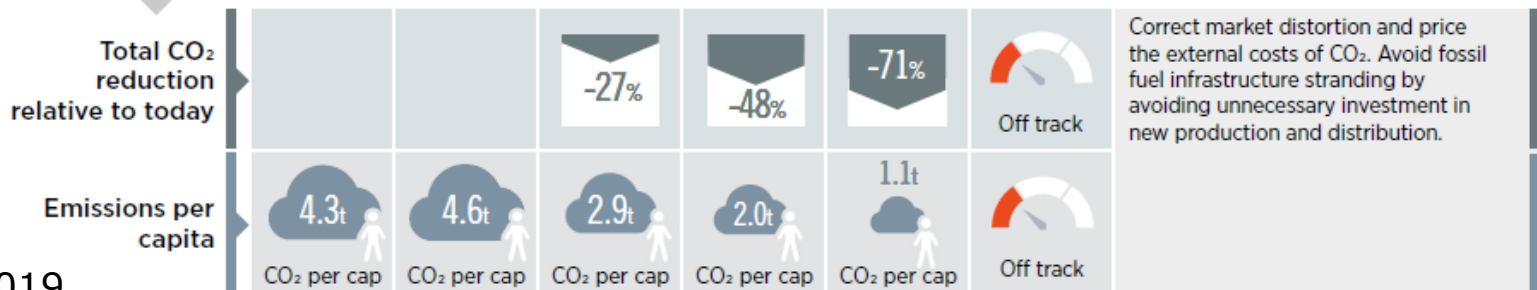
IRENA, 2019

REmap: Fossil fuel and GHG emission reduction

TOTAL FOSSIL FUEL DEMAND

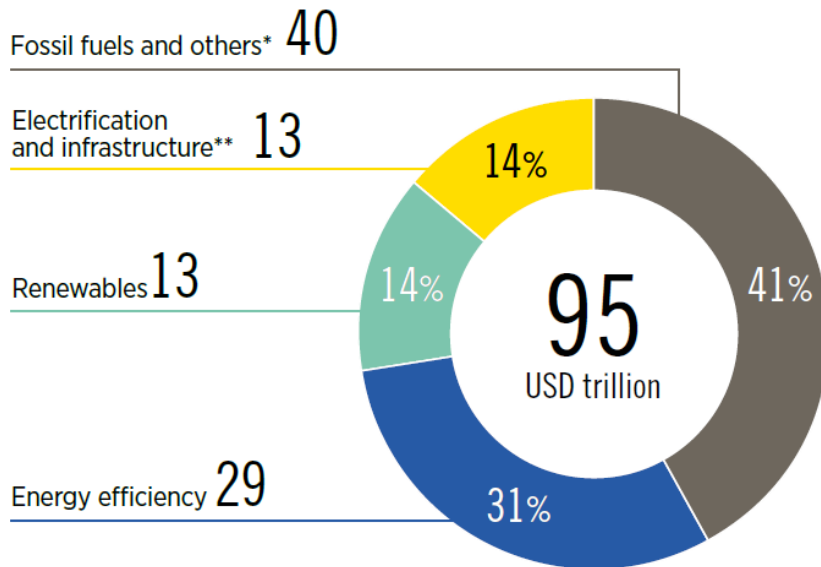


ENERGY-RELATED CO₂ EMISSIONS

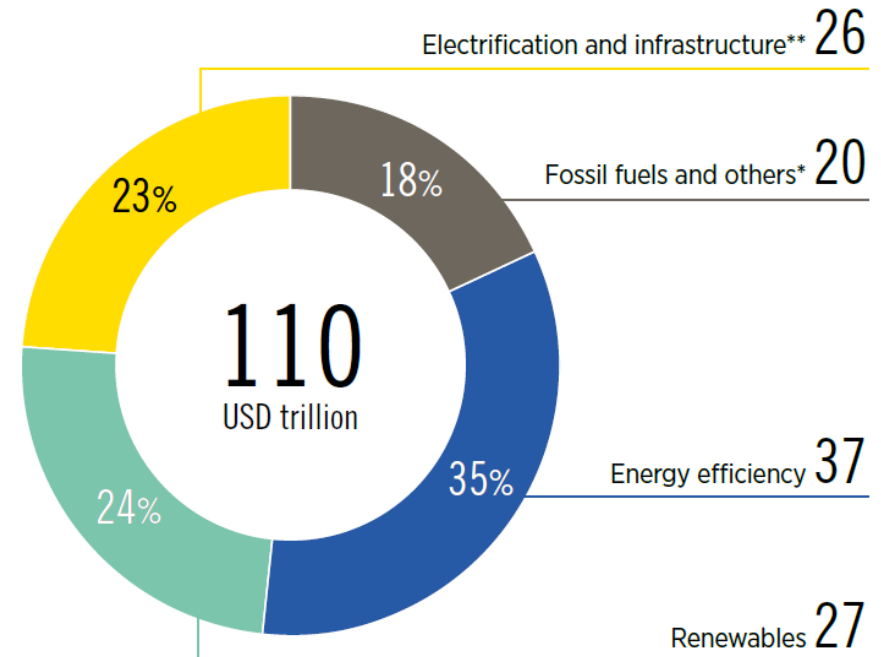


REmap: Investment need and reallocation

Reference Case cumulative investments, 2016-2050
(USD trillion)



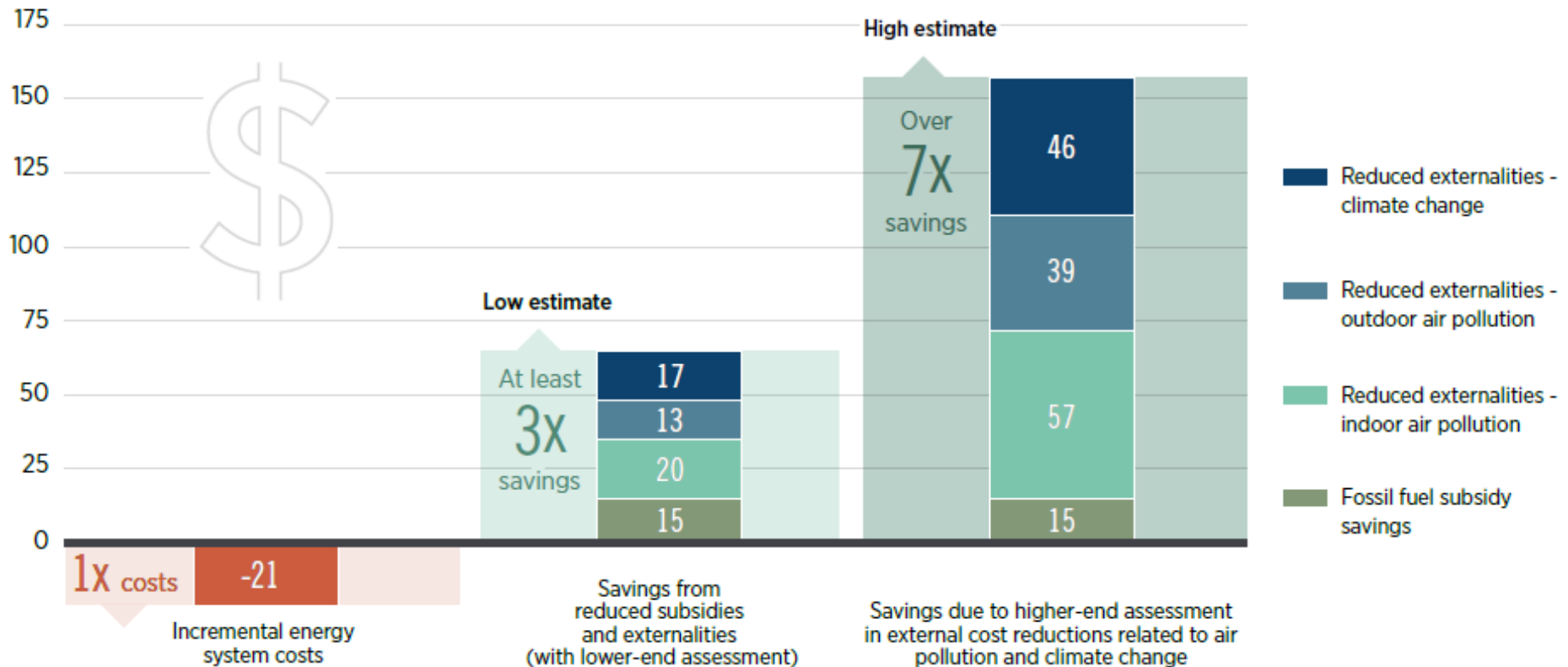
REmap Case cumulative investments, 2016-2050
(USD trillion)



IRENA, 2019

REmap: Total system costs and benefits

Costs and savings for the period 2016-2050 for the REmap Case, compared to the Reference Case (USD trillion)



IKENA, 2019

Final remarks

- Good news:
 - Most of increased energy consumption is met by renewables and other low carbon sources; electrification trend of energy mix is helping
 - Renewables are already the cheapest option for power generation in many places and it's increasingly affordable also in developing countries; cost is not the main challenge; also cost of batteries decreasing fast
 - China is increasing its use of RE fast and can be able to turn its fossil fuel use to absolute decrease in the coming decade; also leading in EVs and batteries
 - Europe and US will be able to virtually stabilise energy consumption and phase out coal entirely in the coming decades, if they want
 - In general, energy consumption increasingly decoupled from GDP growth
 - Much of the solutions (not all) are already available for fast transition; additional investment needs are not huge, and the net economic impact is positive
- Bad news
 - The starting point is really challenging; fossil fuels still account for almost 80% of all energy, with no remarkable decrease so far
 - Even if energy consumption growth is slowing down, and even if RE is growing fast, the (modern) RE is still so small in absolute terms that it cannot even match the smallish energy demand growth, not to talk about replacing existing fossil fuel; curbing the growth in energy demand is crucial
 - Energy efficiency improvement is not happening even nearly as fast as it should
 - In much of Asia (except for China) use of both coal and oil is still set to increase in the coming decades
 - Political decision making is lacking; transition currently driven by market and technology
 - Speed, speed, speed; the progress even in the best countries is insufficient, not to talk about the global average, especially Asia

Thank you

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