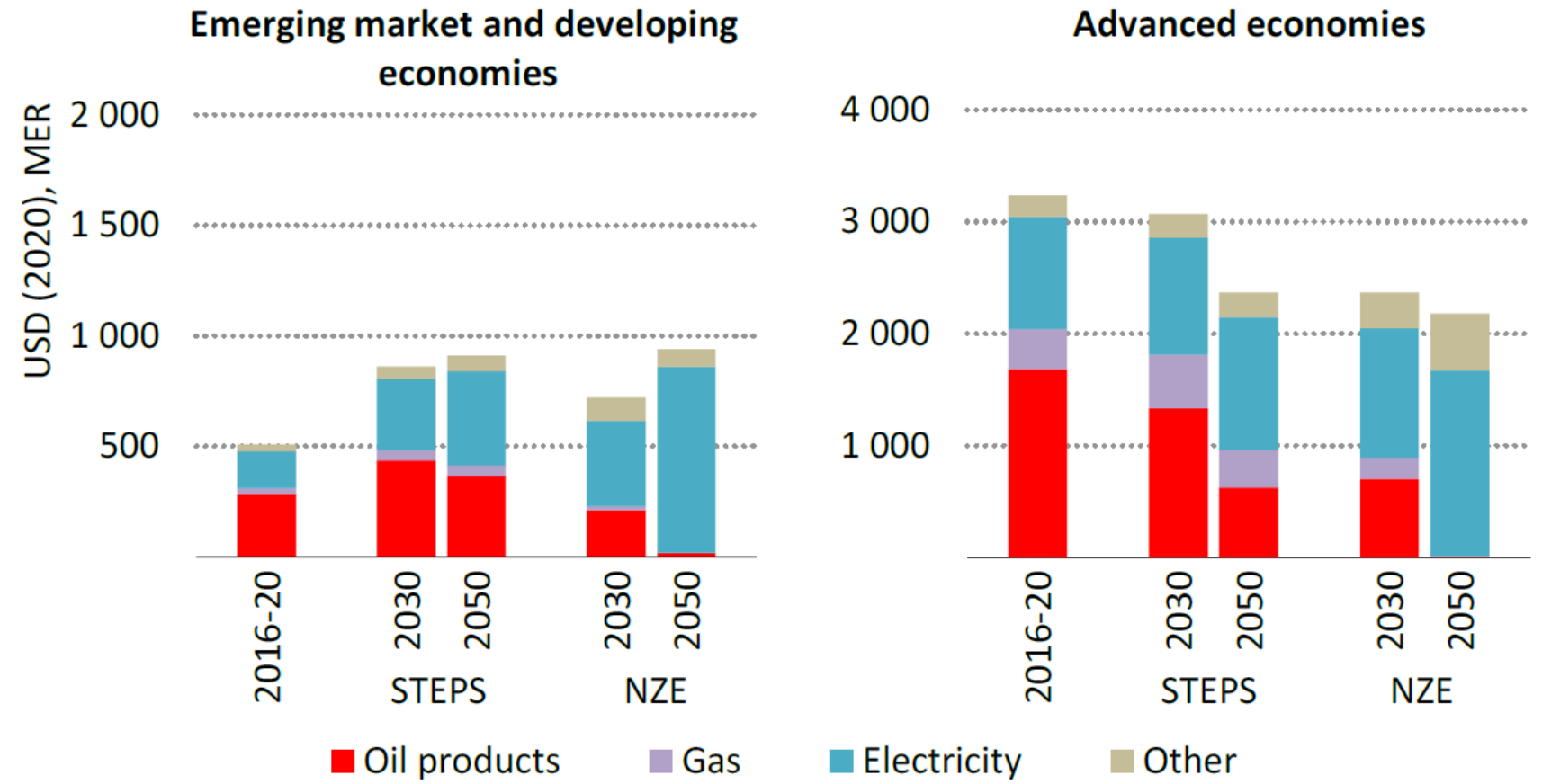
Декарбонизация: о неудобных, но важных вопросах

ЦМАКП, 16 декабря 2021

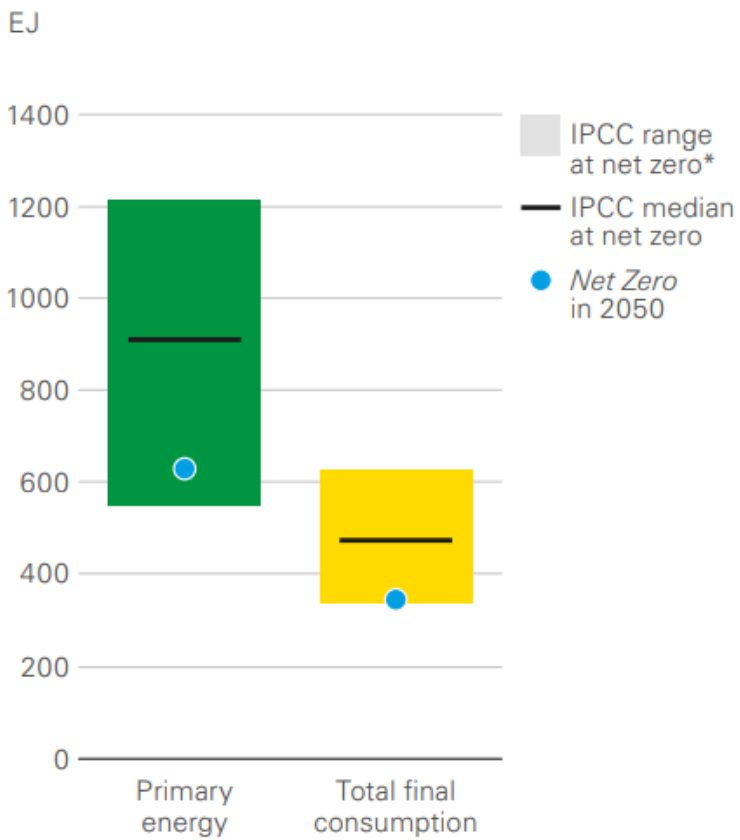
In the STEPS, average household energy bills in advanced economies decline from an average of around USD 3 200 over the last five years to USD 2 400 per household in 2050. In emerging market and developing economies they rise by 80% over this period – more than the growth in average disposable income – as a result of the rapid growth in appliance and vehicle ownership.

Figure 1.20 ▷ Average household energy bills by fuel in the Stated Policies and Net Zero Emissions by 2050 scenarios



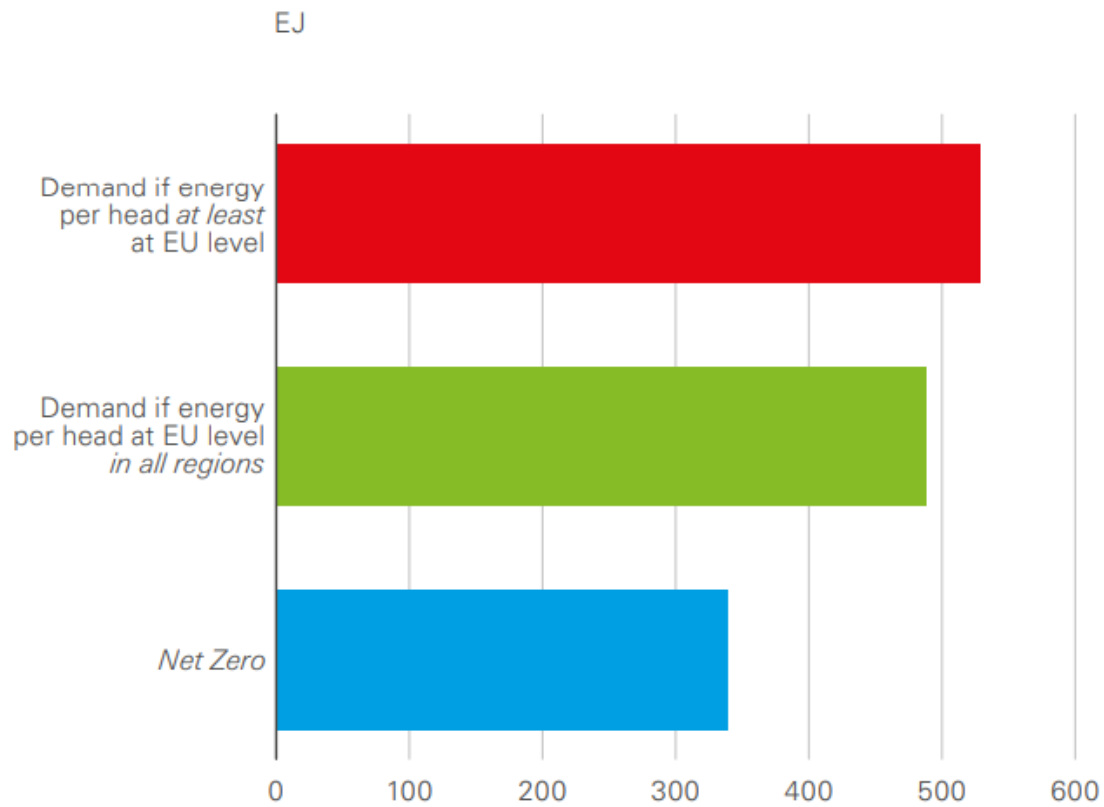
Net-zero energy system: how much energy will the world need?

Global energy demand in IPCC scenarios and *Net Zero*

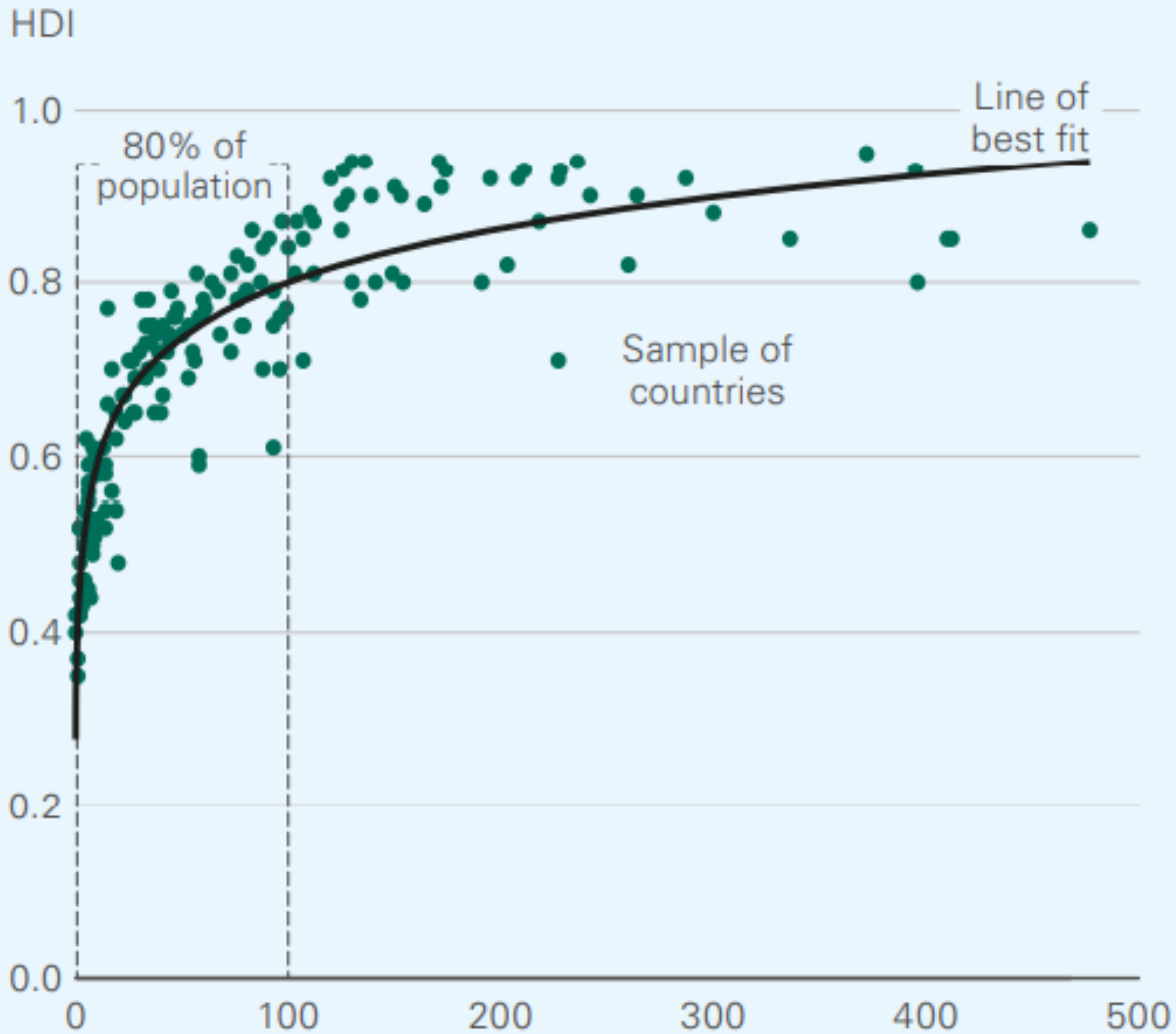


*Ranges show 10th and 90th percentiles of IPCC scenarios

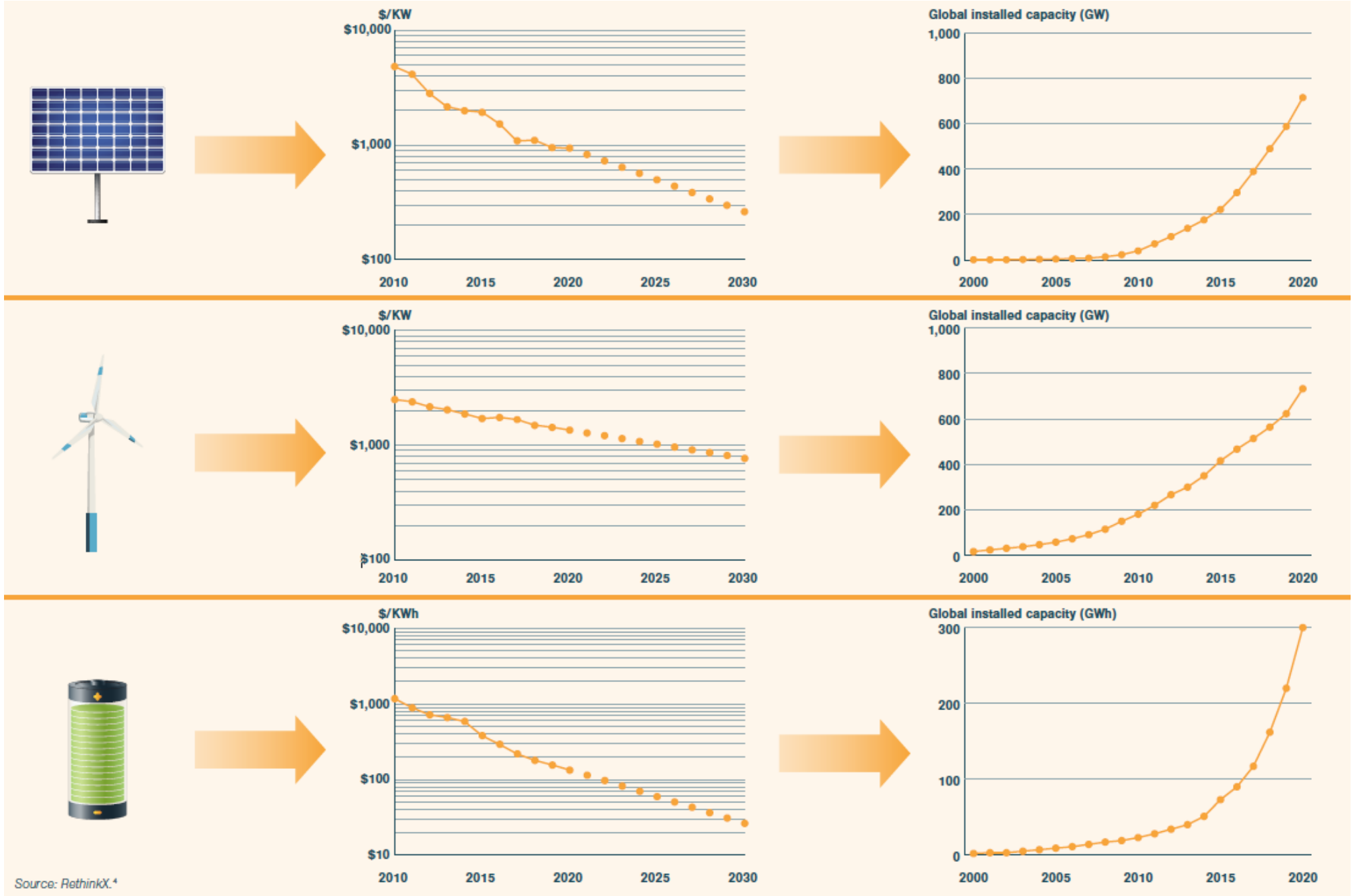
Total final consumption in 2050



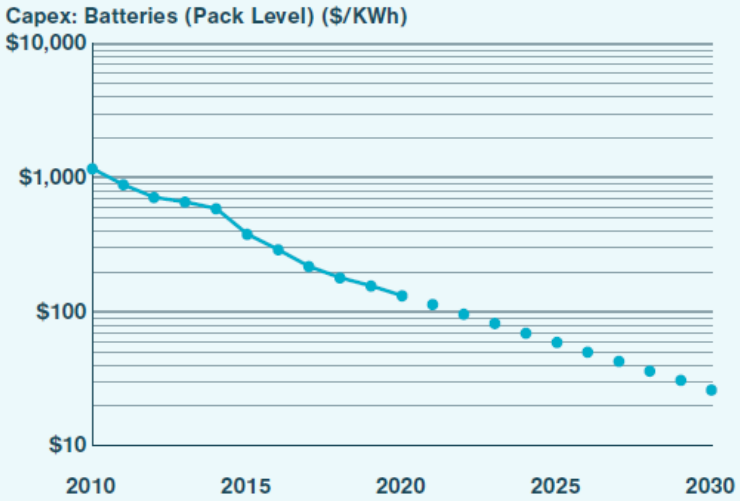
Human development index and energy consumption per head, 2017

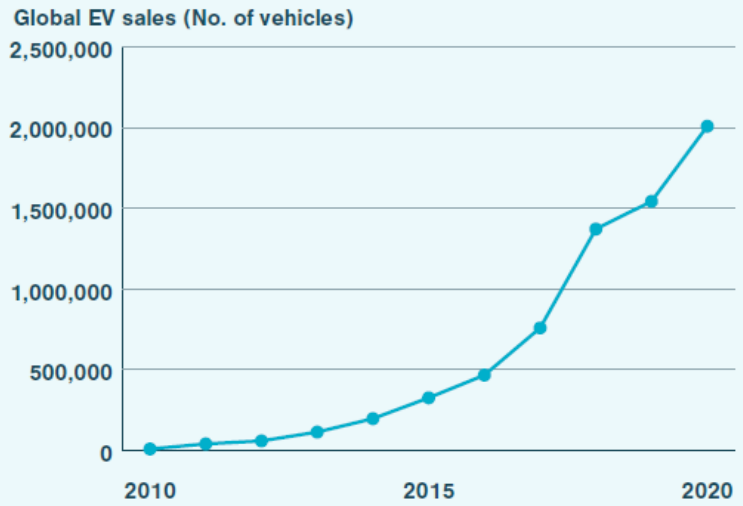


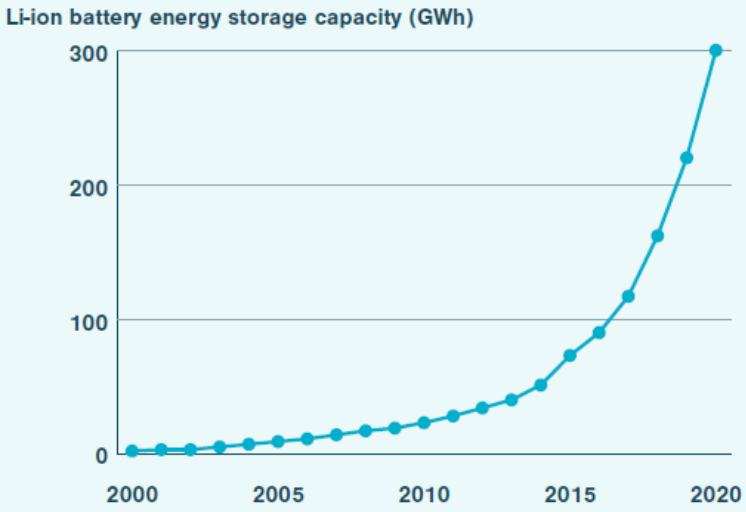
Source: UN 2018



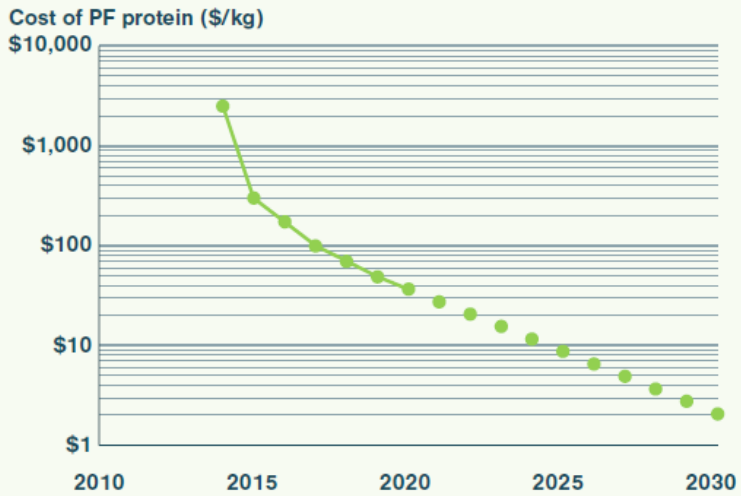
Source: RethinkX.[4]

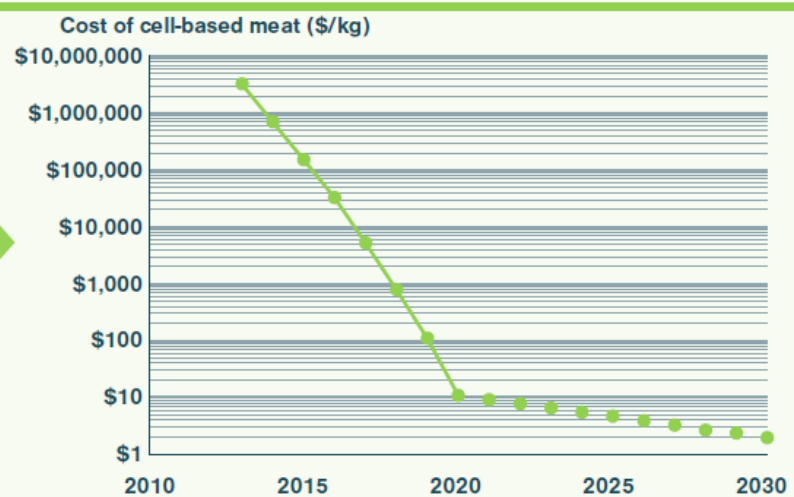


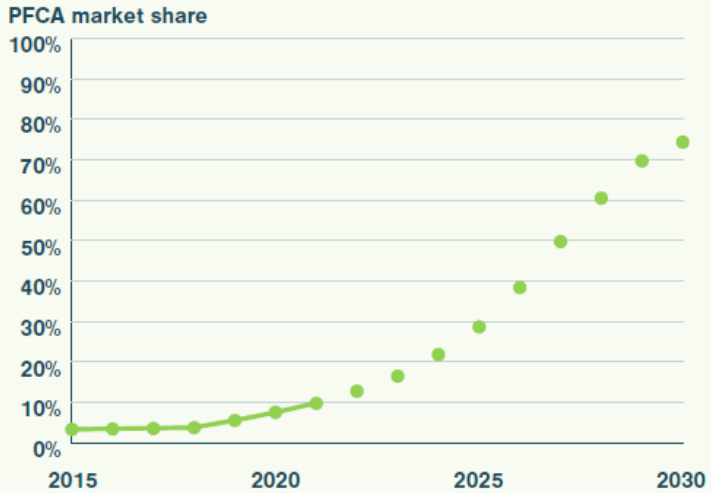




Source: RethinkX.[3]







Source: RethinkX.[2]

Animal grazing land – 2.89 billion hectares
Animal feed cropland – 0.47 billion hectares

Total animal agriculture land used today – 3.3 billion hectares

Disruption of 80% reduces this by 2.7 billion hectares down to just 0.65 billion hectares

For comparison:
United States land area – 0.93 billion hectares
China land area – 0.91 billion hectares
Australia land area – 0.76 billion hectares

Total of all three –
2.6 billion hectares

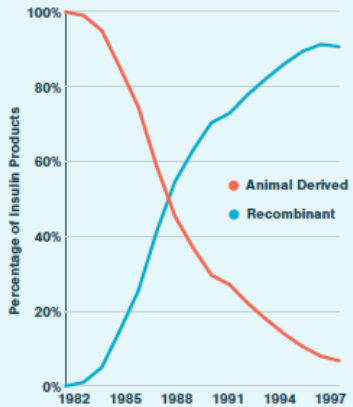
Freed land by 2040 = area of US, China, and Australia combined

Source: RethinkX, Hayek et al., 2020.[23]

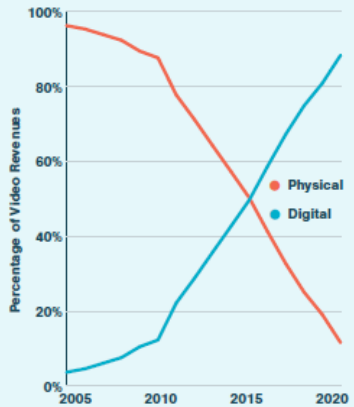
X Marks Disruption – Historical Examples

Red Fabric Dyes

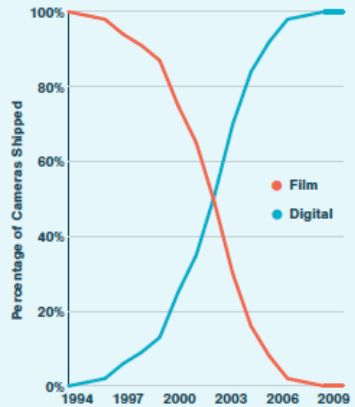
Insulin



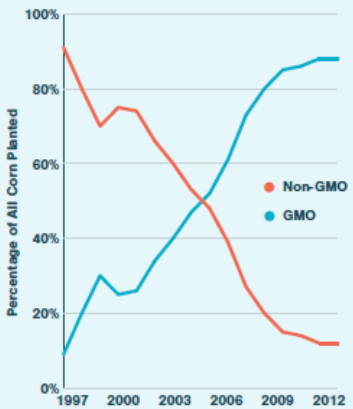
Video



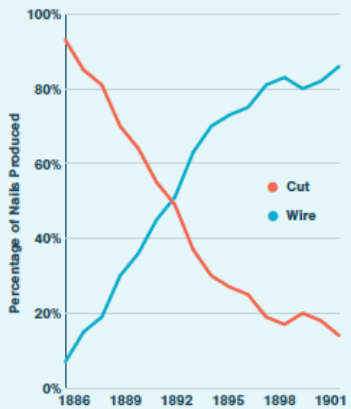
Cameras



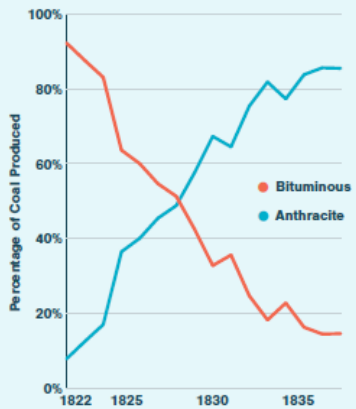
Corn



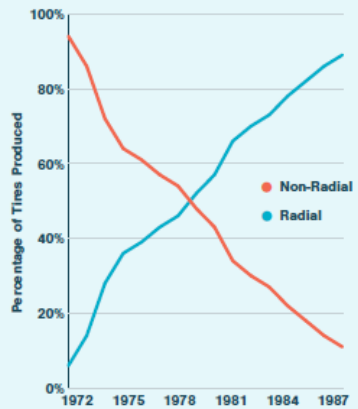
Nails



Coal



Car Tires

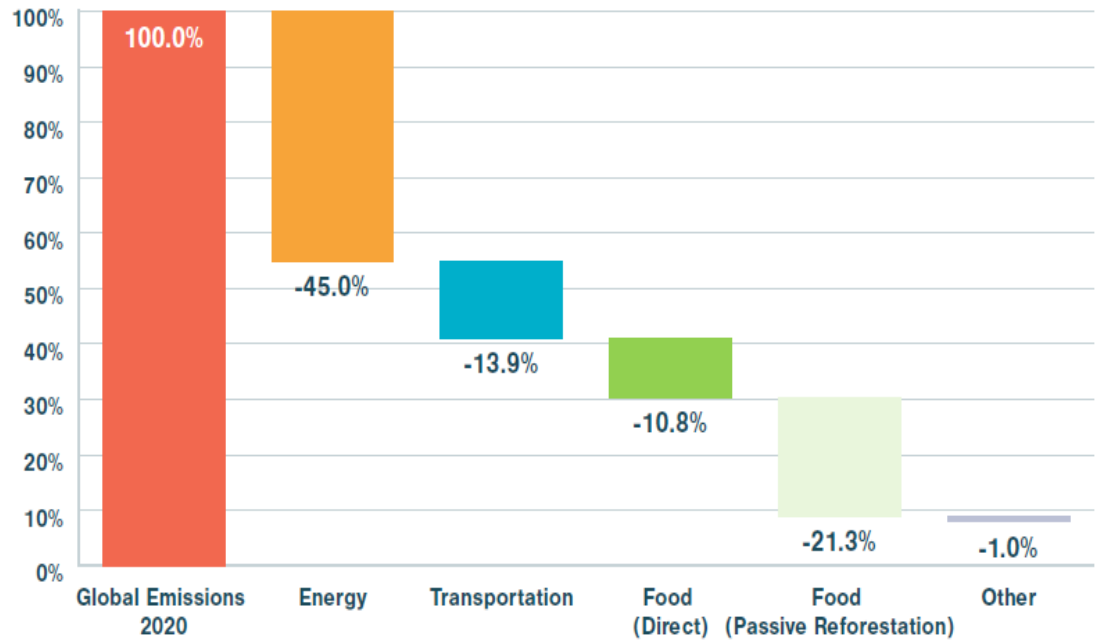


Source: RethinkX, Lopez, 1989., IMS Health, DEG, Widescreen Review, CIPA, USDA, Adams, 2002., NBER, U.S. Census Bureau, Rajan et al., 2000.[29,30,31,32,33,34,35,36,37,38]

Figure 11: Emissions Reductions by 2035 by Decarbonization Readiness Stage in the 'Be Sensible' Scenario

Source: RethinkX.

Figure 7: Emissions Mitigation and Offset by 2035 by Sector in the 'Be Sensible' Scenario



Energy
Residential Buildings
Other industry
Unallocated Fuel Combustion
Iron & Steel
Commercial Buildings
Fugitive Oil & Natural Gas
Chemical & petrochemical (energy)
Fugitive Coal
Energy in Agri & Fishing
Food & tobacco
Non-Ferrous metals
Paper and Pulp
Machinery

Food
Livestock & Manure
Agricultural Soils
Crop Burning
Deforestation
Cropland
Rice Cultivation
Grassland

Transportation
Road Transportation
Aviation
Shipping
Rail
Pipeline

Other
Cement
Chemical & petrochemical (industrial)
Landfills
Wastewater

Source: RethinkX.

Announced Pledges Scenario

	Capital costs (USD/kW)			Capacity factor (%)			Fuel, CO_2 and O&M (USD/MWh)			LCOE (USD/MWh)		
	2020	2030	2050	2020	2030	2050	2020	2030	2050	2020	2030	2050
United States												
Nuclear	5 000	4 800	4 500	90	85	80	30	30	30	105	105	105
Coal	2 100	2 100	2 100	30	10	n.a.	65	125	155	150	410	n.a.
Gas CCGT	1 000	1 000	1 000	50	25	n.a.	40	65	75	65	110	n.a.
Solar PV	1 100	660	460	21	22	23	10	10	10	50	30	25
Wind onshore	1 390	1 290	1 220	42	43	44	10	10	10	35	30	30
Wind offshore	4 040	2 440	1 680	42	46	48	35	20	15	115	70	45
European Union												
Nuclear	6 600	5 100	4 500	75	75	70	35	35	35	150	120	115
Coal	2000	2000	2000	25	n.a.	n.a.	105	165	210	200	n.a.	n.a.
Gas CCGT	1 000	1 000	1 000	50	40	n.a.	70	95	105	95	120	n.a.
Solar PV	840	530	380	13	14	14	10	10	10	55	35	30
Wind onshore	1 500	1 410	1 340	29	29	30	15	15	15	50	45	45
Wind offshore	3 480	2 240	1 540	51	55	58	15	10	10	75	45	30

	Capital costs (USD/kW)			Capacity factor (%)			Fuel, CO_2 and O&M (USD/MWh)			LCOE (USD/MWh)		
	2020	2030	2050	2020	2030	2050	2020	2030	2050	2020	2030	2050
China												
Nuclear	2 800	2 800	2 500	80	80	80	25	25	25	65	65	60
Coal	800	800	800	55	45	5	45	95	150	60	115	290
Gas CCGT	560	560	560	25	25	25	80	105	115	100	125	135
Solar PV	650	400	270	17	18	19	10	5	5	35	20	15
Wind onshore	1 260	1 180	1 110	26	27	27	15	15	10	50	45	40
Wind offshore	2 960	1 820	1 120	34	40	43	25	15	10	100	55	30
India												
Nuclear	2 800	2 800	2 800	75	80	80	30	30	30	70	70	70
Coal	1 200	1 200	1 200	60	60	50	30	35	30	55	55	60
Gas CCGT	700	700	700	45	50	45	75	75	80	90	90	95
Solar PV	600	360	240	20	21	21	5	5	5	35	20	15
Wind onshore	1 040	1 010	990	26	28	29	10	10	10	50	45	40
Wind offshore	2 980	1 880	1 260	32	36	38	25	15	10	135	75	50

Sources: IEA analysis; IRENA Renewable Costing Alliance; IRENA (2021).

Stated Policies Scenario

	Capital costs (USD/kW)			Capacity factor (%)			Fuel, CO_2 and O&M (USD/MWh)			LCOE (USD/MWh)			VALCOE (USD/MWh)		
	2020	2030	2050	2020	2030	2050	2020	2030	2050	2020	2030	2050	2020	2030	2050
United States															
Nuclear	5 000	4 800	4 500	90	90	90	30	30	30	105	100	95	105	100	95
Coal	2 100	2 100	2 100	50	60	60	25	25	25	75	70	70	75	70	65
Gas CCGT	1 000	1 000	1 000	50	45	40	30	35	40	50	65	70	50	60	60
Solar PV	1 100	710	530	21	22	22	10	10	10	50	30	30	55	40	45
Wind onshore	1 390	1 310	1 270	42	43	44	10	10	10	35	30	30	35	35	40
Wind offshore	4 040	2 560	1920	42	46	48	35	25	15	115	70	55	110	70	60
European Union															
Nuclear	6 600	5 100	4 500	75	75	75	35	35	35	150	125	110	145	125	110
Coal	2 000	2 000	2 000	35	40	40	90	120	135	170	185	200	160	165	165
Gas CCGT	1 000	1 000	1 000	45	35	25	80	105	115	110	140	170	100	115	115
Solar PV	840	550	430	13	14	14	10	10	10	55	40	30	60	70	70
Wind onshore	1 500	1 420	1 370	29	29	30	15	15	15	50	45	45	55	60	60
Wind offshore	3 480	2 260	1 720	51	55	58	15	10	10	75	45	35	75	50	45

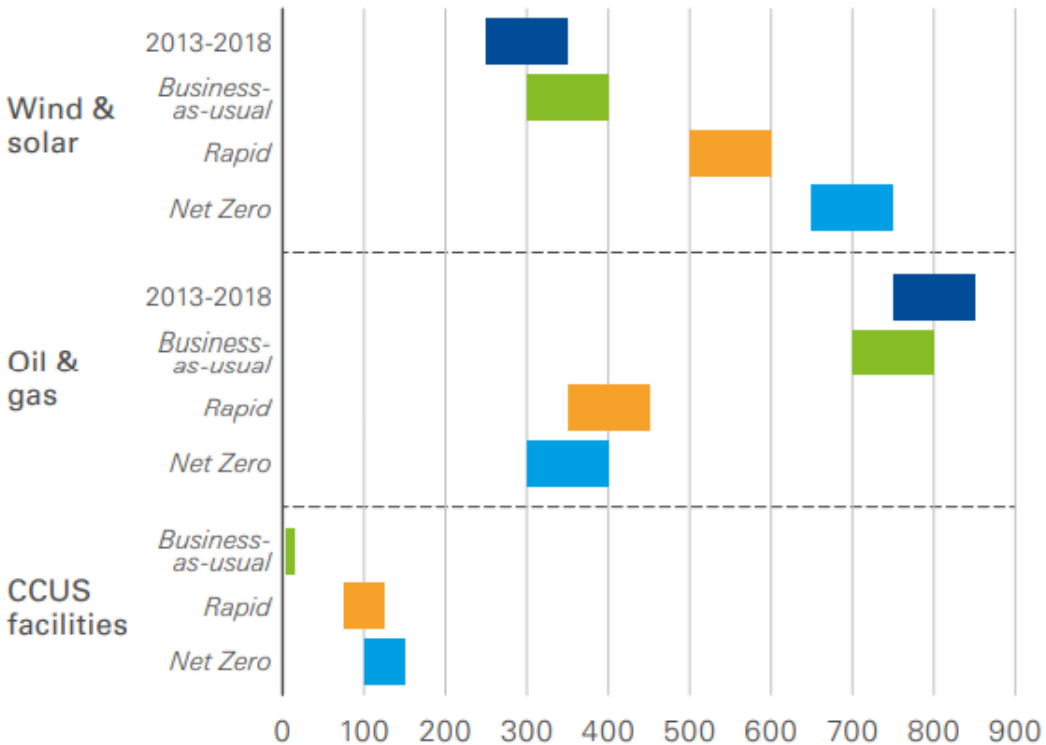
	Capital costs (USD/kW)			Capacity factor (%)			Fuel, CO_2 and O&M (USD/MWh)			LCOE (USD/MWh)			VALCOE (USD/MWh)		
	2020	2030	2050	2020	2030	2050	2020	2030	2050	2020	2030	2050	2020	2030	2050
China															
Nuclear	2 800	2 800	2 500	80	80	80	25	25	25	65	65	60	65	65	60
Coal	800	800	800	55	45	40	45	60	75	60	80	95	60	70	70
Gas CCGT	560	560	560	25	20	20	80	90	100	100	120	130	90	105	95
Solar PV	650	420	310	17	18	19	10	5	5	35	20	15	40	45	50
Wind onshore	1 260	1 190	1 140	26	27	27	15	15	10	50	45	40	50	50	45
Wind offshore	2 960	1 860	1 280	34	40	43	25	15	10	100	55	35	100	60	40
India															
Nuclear	2 800	2 800	2 800	75	80	80	30	30	30	70	70	70	70	70	70
Coal	1 200	1 200	1 200	60	60	50	30	35	30	55	55	55	55	55	50
Gas CCGT	700	700	700	45	50	45	75	75	80	90	90	95	90	80	75
Solar PV	600	380	270	20	21	21	5	5	5	35	20	15	40	35	55
Wind onshore	1 040	1 020	1 000	26	28	29	10	10	10	50	45	40	55	50	50
Wind offshore	2 980	1960	1 440	32	36	38	25	20	15	135	80	55	135	85	65

Sources: IEA analysis; IRENA Renewable Costing Alliance; IRENA (2021).

The energy transition requires significant shifts in the pattern of investment

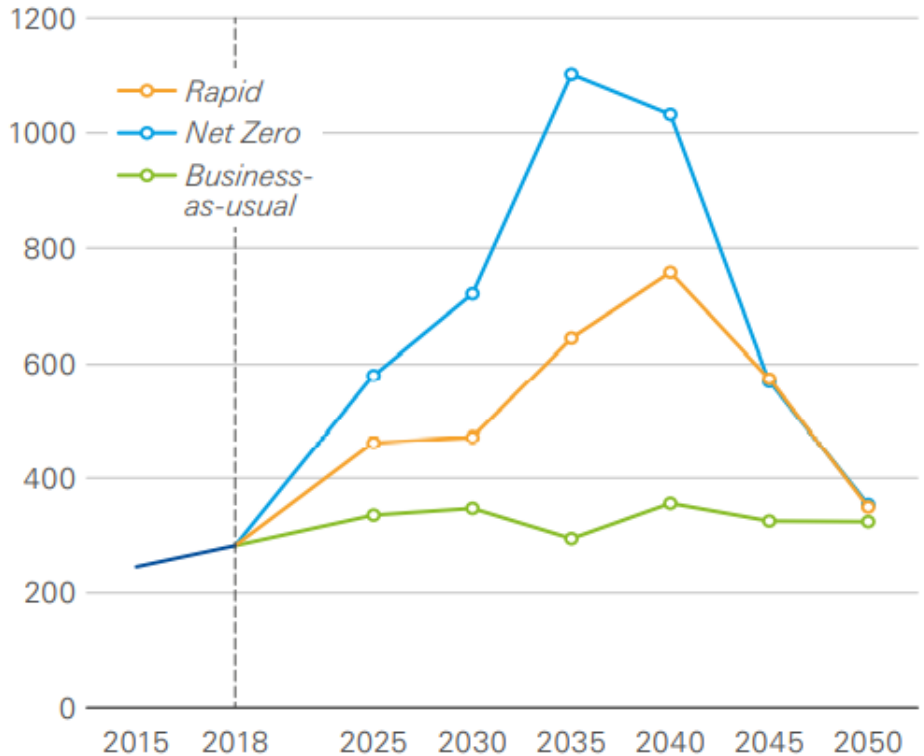
Average annual investment, history and 2020-2050

2018 US$ Billion



Average annual investment in wind and solar

Five-year rolling average, 2018 US$ Billion



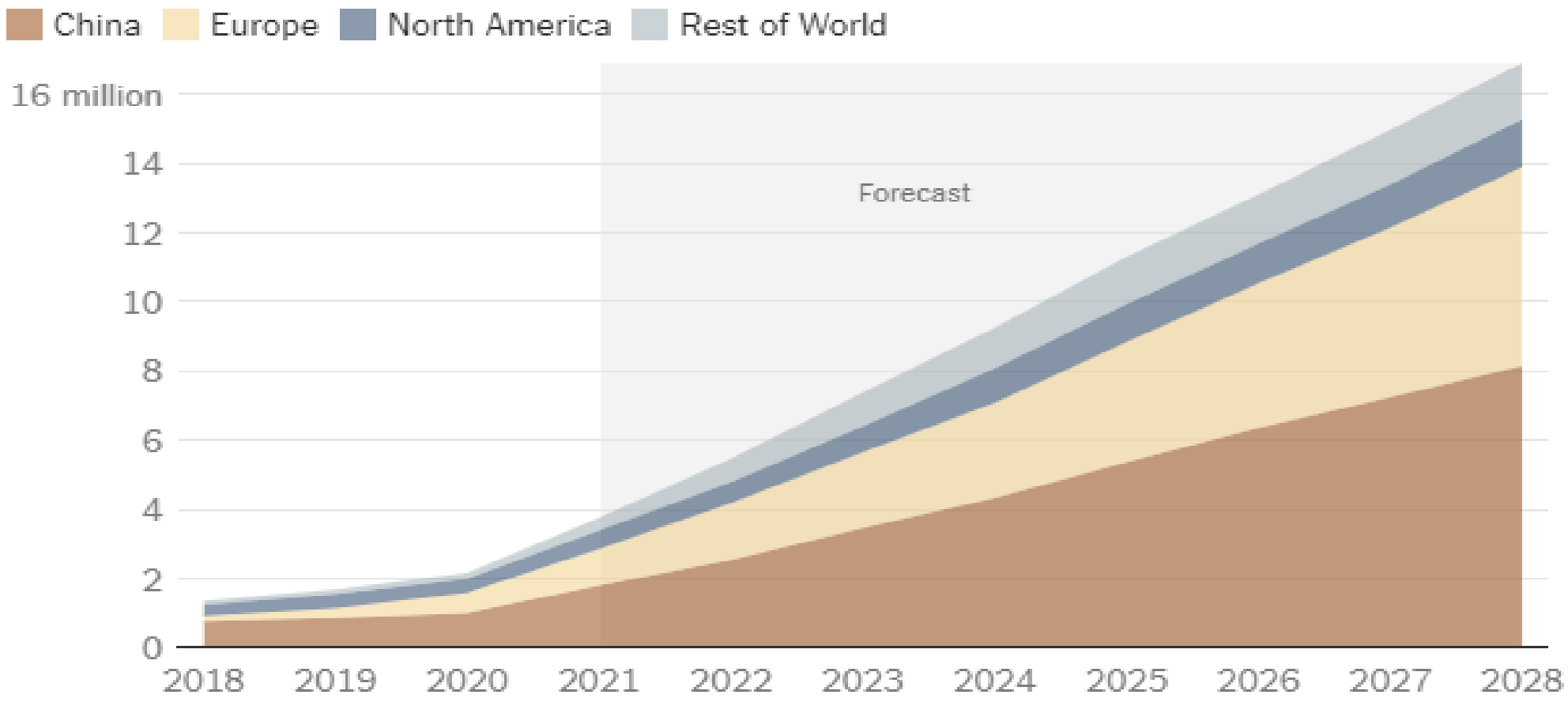
Champions of energy transition

World Leaders in EVs, Wind and Solar (2020)

#	Country	Electric cars 000s	Electric cars Rank	Wind energy GW	Wind energy Rank	Solar energy GW	Solar energy Rank	Average Rank
1	China	4,509	1	282.0	1	254.4	1	1.0
2	United States	1,778	2	117.7	2	75.6	2	2.0
3	Germany	633	3	62.2	3	53.8	4	3.3
4	United Kingdom	435	5	24.7	6	13.6	11	7.3
5	France	416	6	17.4	7	11.7	12	8.3
6	Italy	100	13	10.8	10	21.6	6	9.7
7	Spain	88	14	27.1	5	14.1	10	9.7
8	Japan	293	7	4.2	21	67.0	3	10.3
9	India	13	24	38.6	4	39.2	5	11.0
10	Netherlands	291	8	6.6	15	10.2	13	12.0
11	Australia	27	20	9.5	12	17.6	7	13.0
12	Canada	209	9	13.6	9	3.3	22	13.3
13	Turkey	36	19	8.8	13	6.7	16	16.0
14	Brazil	5	26	17.2	8	7.9	14	16.0
15	South Korea	137	11	1.6	30	14.6	9	16.7

Source: Wind and solar from International Renewable Energy Agency, Renewable Capacity Statistics 2021 (April 2021). Electric vehicles from International Energy Agency, EV Outlook 2021 (April 2021), except for Turkey, where data comes from the Turkish Statistical Institute. Wind and solar refer to year-end installed capacity. Electric vehicles refer to existing stock of battery electric and plug-in hybrid electric vehicles.

China is rapidly expanding annual production of electric cars, and is on a pace to make more than eight million vehicles by 2028 as its companies race to build new factories



China also leads in production of minerals critical for energy transition