

CLIMATE AMBITION BENCHMARKS



10
YEARS
2008 2018



European
Climate
Foundation

**WE MEAN
BUSINESS**

Presentation updated May 2019.

As these trends are all moving rapidly, the examples in this presentation are a snapshot in time. Benchmarks are based on analysis done, in summer 2018, before the 1.5 IPCC special report release, and were updated slightly to take those findings into account in December 2018.

See slides 3, 4, 31-36 for summary of approach and methods, and attached report for full details.

CLIMATE AMBITION BENCHMARKS

Overview

- ▶ **What:** “Climate Ambition Benchmarks” is a project of the ClimateWorks Foundation, the European Climate Foundation and the We Mean Business coalition.
- ▶ The project translates Paris’ global long-term temperature goal into specific benchmarks for ambition based on publicly available data in:
 - 3 sectors: overall economy, power, and transport,
 - Globally, China, EU, India, US
 - 2020, 2030 and 2050
- ▶ **Why:**
 - To inform coordinated strategic efforts to accelerate decarbonization as fast as possible
 - To positively influence the likelihood of achieving this ambition through a compelling shared narrative of the leading edge of what is necessary and possible in key sectors.
- ▶ **How:**
 - Providing specificity to our calls for increased ambition
 - Building the evidence base for the “highest plausible ambition” level in key sectors and key countries

*Recognizing that expectations have a strong role in shaping outcomes, and that ‘over-performance’ relative to globally optimized models will be required in some sectors to compensate for inevitable shortfalls in others, the **benchmarks are designed to anchor expectations at the upper ambition end of what modeling, backcasting and real world trends shows is possible.***

HOW BENCHMARKS WERE DERIVED

The benchmarks define “highest plausible ambition” above and beyond IAMs

1. FROM CAT ASSESSMENT RANGES

For each indicator, a modeling exercise was conducted which included:

- ▶ Publicly available data from global scenarios from integrated assessment models (IAMs) and the IEA that meet the “well below 2C” goal,
- ▶ Back-casting results and projections based on current policies and developments, when those are more ambitious than model results.
- ▶ The most ambitious values from across the available data per country were selected and the results were reviewed per indicator across countries based on expert judgement to reflect data availability and to include considerations of developed/developing country differences.
- ▶ (see annex for additional modelling methodology)



2. TO HIGHEST PLAUSIBLE AMBITION BENCHMARKS

- ▶ Using this modeling as a foundation to ensure that the benchmarks all meet or exceed levels needed to keep warming well below two degrees, and as an indicator of technological plausibility - the benchmarks themselves are set at the highest end of the model and projection ranges.
- ▶ This is to reflect the many actual cost and technological trends that are outperforming modelling assumptions, growing political will, and increasing signs of commitment from the private sector.



NOTES ON CAT ASSESSMENT RANGES

Extensive analysis of publicly available models and trends was used to define ranges of plausibility.

Key methodological parameters are as follows:

- ▶ Paris compatible was defined as “well below 2 degrees”, with scenarios in the scientific literature generally found to satisfy simultaneously:
 - About 85% to hold warming below 2°C throughout the 21st century.
 - About 70% to hold warming below 1.75°C throughout the 21st century,
 - About 50% to limit warming to 1.5°C by 2100
- ▶ With this in mind, model scenarios were collected with around 50% chance to limit warming to 1.5°C by 2100
- ▶ Scenarios that relied too heavily on negative emissions or that resulted in less than a 50% chance of limiting warming to 1.5°C by 2100 were excluded
- ▶ Negative Emissions: excluded GCAM scenarios with maximum BECCS deployments of greater than 500 EJ/year.
- ▶ As there were not many 1.5C scenarios in the literature, a regression analysis was employed on higher temp scenarios and extrapolated to 1.5C — this was possible only for numbers at global level and only for the indicators total GHG emission, and renewable energy share.

PROPOSED BENCHMARKS

What levels of achievement represent the highest plausible ambition, in line with the Paris Agreement's long-term goals, for a given country, sector and indicator?

We could achieve:



1. NET-ZERO GHG EMISSIONS IN MAJOR ECONOMIES BY 2050

EU and US achieving net zero by 2045

China and India by 2050.

Net-Zero Greenhouse gas emissions globally by 2055



2. RENEWABLE AND ZERO CARBON POWER BY 2050

65% of electricity could be from renewable sources globally by 2030 and electricity could be 100% zero carbon by 2050.



3. COAL PHASE OUT IN THE POWER SECTOR BY 2040

US and EU phasing out by 2030

China and India by 2040.



4. EVs REPRESENT 100% OF ALL NEW LIGHT DUTY VEHICLE SALES BY 2030

95% of cars on the road are EV by 2045 in US and EU, by 2055 in China and India.



BENCHMARK 1

NET-ZERO YEAR

GHG EMISSIONS

- ▶ GHG emissions could reach net-zero in all 4 major economies analyzed by 2050.
- ▶ According to our assessment of highest plausible ambition, the **EU and US could achieve net-zero in 2045**, and **China and India in 2050**.
- ▶ Current policy scenario estimates (in brackets for 2020) show that **more needs to be done in all jurisdictions to be on track in the near term**.

GHG Emissions Benchmarks to 2050*

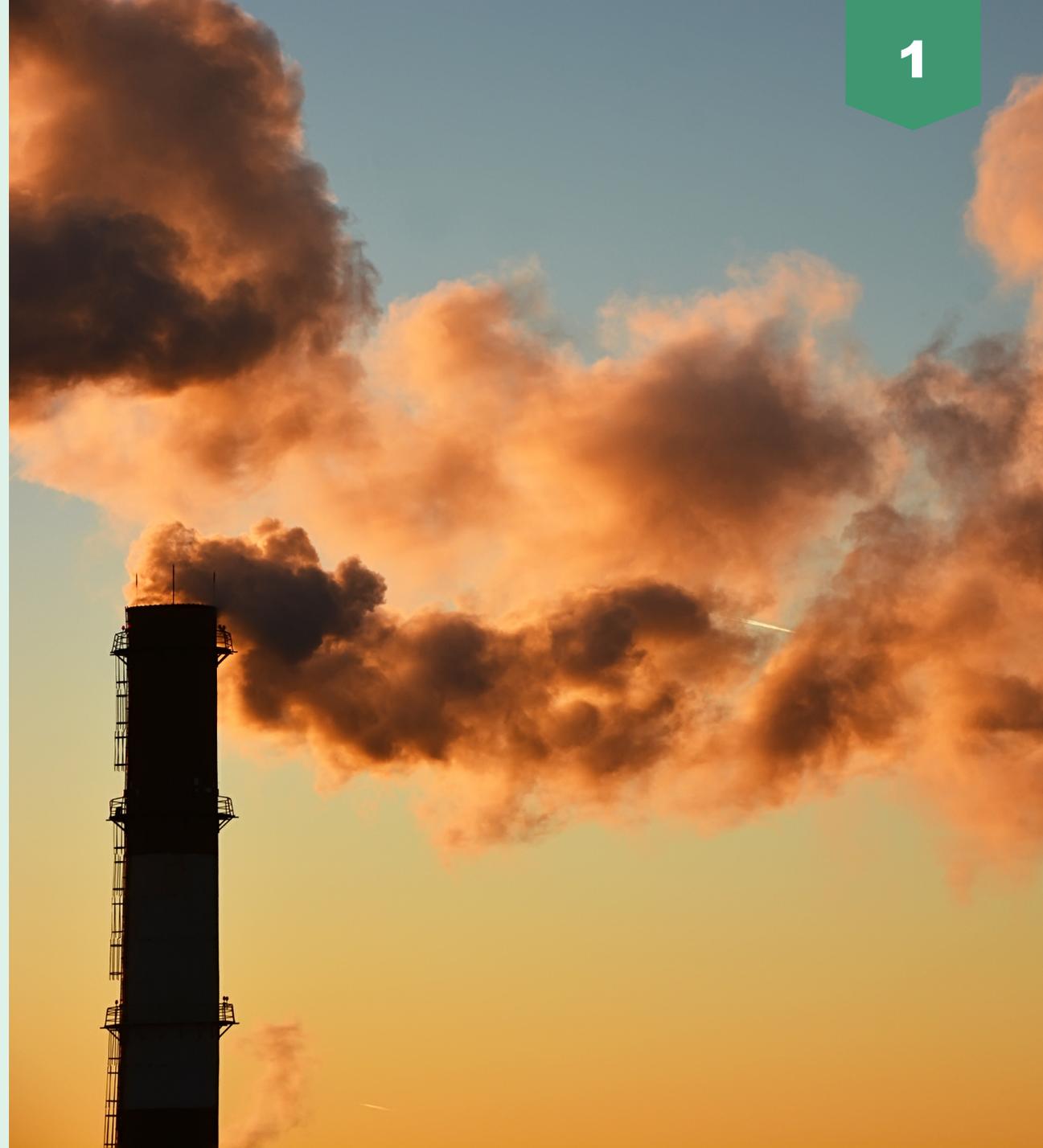
GHG Emissions	2014	2020	2050	Net-0
	Gt CO ₂ e			Year
 GLOBAL	49	45-50 (51-52)	5-15	2055-60
 CHINA	11.5	11-12 (12)	~0	2050-55
 EU	4.2	4 (4)	0	2045-55
 INDIA	2.7	3 (3.5)	0-2	2050-55
 USA	6.7	6-7 (7)	0	2045-50

*Benchmarks from the Climate Action Tracker's Mid-2018 analysis exploring the highest plausible ambition for countries and sectors, determined through IAMs modelling and back-casting analyses (adjusted for country circumstances).

GHG EMISSIONS

What's happening in the real economy?

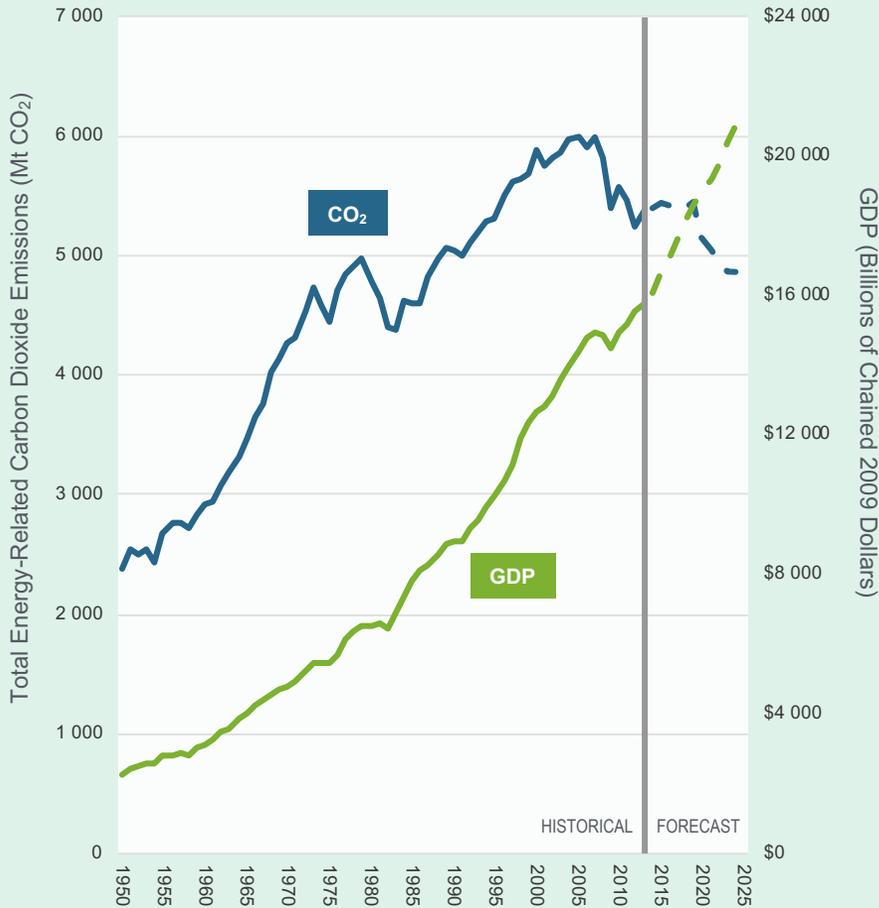
- ▶ EU emissions were reduced by 23% between 1990 and 2016, while the economy grew by 53% over the same period.
- ▶ Analysis shows that at least 35 countries decoupled GHG emissions from economic growth between 2000-2014.
- ▶ IEA figures show that while global GDP grew between 2014-2016, energy-related CO₂ emissions remained flat over those three years – although energy-related CO₂ emissions increased in 2017.



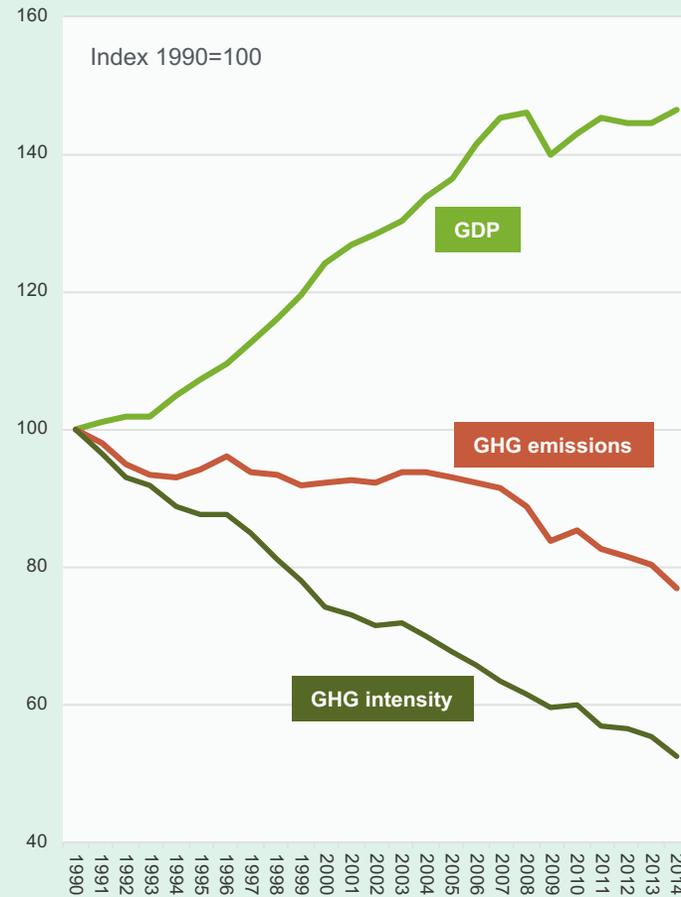
GHG EMISSIONS

What's happening in the real economy?

U.S. CO₂ Emissions and GDP, 1950-2025

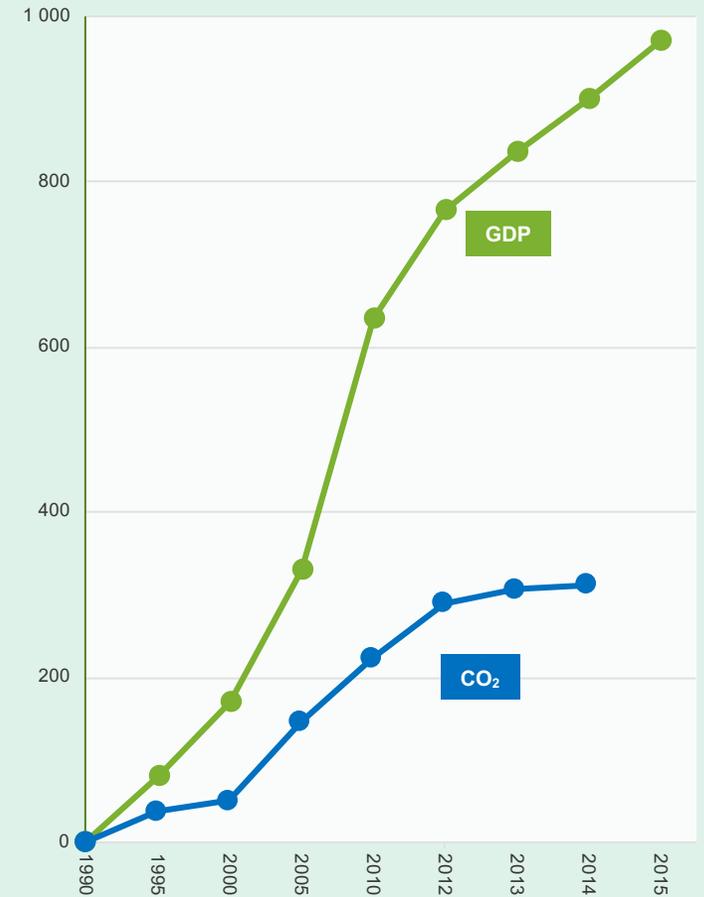


European Union GHG Emissions



(European Commission 2015)

China: Growth in GDP and CO₂ emissions since 1990



Quartz 2016, IEA IMF Figures

GHG EMISSIONS

What's happening in key jurisdictions?

- ▶ A growing number of countries have [pledged to design 2050 deep decarbonisation strategies](#) to align with the Paris Agreement as part of the Carbon Neutrality Coalition: Colombia, Costa Rica, Ethiopia, Finland, France, Germany, Iceland, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Portugal, Republic of the Marshall Islands, Sweden, Canada, Denmark, Spain and the United Kingdom.
- ▶ [Iceland plans](#) to become climate neutral by 2040, and [Sweden has a drawn its 2045 net-zero target](#) into national law. [Finland](#), and the world's 5th largest economy, California, are aiming for 2045, with France, Costa Rica, and Portugal targeting carbon neutrality by 2050. The [UK is currently in the process of reviewing](#) its 2050 target in light of the IPCC's Special Report on 1.5°C.
- ▶ The EU is on track to overachieve on its 2020 emissions reduction target and the European Parliament has supported increasing its 2030 target to 55%, up from to its current target of 40%. It is now working on options for its 2050 deep decarbonization strategy, with the [European Commission](#) and [Parliament](#), and [at least eight EU Member States](#) calling for the EU to commit to net-zero by 2050.
- ▶ China's top climate envoy Xie Zhenhua reported China has [already met several objectives](#) it promised to fulfill by 2020, including cutting its carbon intensity by 40 to 45 percent three years early, and committing to [produce a long-term strategy by 2020](#).
- ▶ Major cities, under the umbrella of C40, have committed to become emissions neutral by 2050, including: Buenos Aires, Barcelona, Cape Town, London, Mexico City, New York City, Paris, and Stockholm. In the US, policies already adopted by states, cities and businesses will reduce US emissions [17% below 2005 levels](#) by 2025, approximately two-thirds of the way to the country's pledge of cutting emissions 26-28% by 2025.
- ▶ India is set to [surpass its commitment](#) to reduce the amount of carbon dioxide produced for every dollar of GDP by 33 to 35% ahead of 2030.

GHG EMISSIONS

Businesses

- ▶ 550+ companies from every industry have committed to setting ambitious science-based emissions reduction targets (SBTs), in line with what the science says is needed to hold global temperature rise below 2°C.
- ▶ Walmart, the world's largest company by revenue, has an approved SBT that includes reducing its Scope 3 emissions by one billion tons by 2030.
- ▶ A growing number of companies in the heavy-emitting sectors have committed to setting SBTs.
 - In the power sector that includes several major European utilities including Enel, Iberdrola and National Grid, plus NRG in the US and Australia's Origin Energy.
 - Mahindra Sanyo Special Steel is the first steel producer to have an approved SBT, while Germany's Heidelberg Cement is the first cement maker to have an approved SBT.
- ▶ 864 additional companies declared their ambition to commit to SBTs within the next two years, in their 2017 disclosures to CDP.
- ▶ 89% of the world's biggest, most environmentally-impactful companies now have carbon emission reduction targets, according to CDP data.
- ▶ A group of leading companies have committed to net-zero GHG emissions by 2050 or earlier, including Maersk, Dalmia Cement and the Mahindra Group.
- ▶ As of 2017, Salesforce achieved net-zero for both its direct and indirect greenhouse gas emissions.



BENCHMARK 2

RENEWABLE AND ZERO CARBON POWER

RENEWABLE AND ZERO CARBON POWER

- ▶ Globally, and in the four countries, power generation could be 100% zero carbon by 2050,
- ▶ Based on rapidly falling costs, technological developments, positively changing policy environments and cost competitiveness of renewables in many regions already, it is plausible to say 65% of electricity could be produced globally from renewable energy sources by 2030.
- ▶ *Note: The analysis was done before the 2018 IPCC SR1.5 publication. 2030 results have been slightly adapted in the table accordingly for the global level, country level could not be adapted.*

Benchmark ranges for RES and Zero Carbon Power*

ZC Electricity	2014 (RES)	2020 (RES)	2030 (RES)	2050 (Zero Carbon)***
	%			
 GLOBAL	23%	27% (-)	65%** (-)	100%*** (-)
 CHINA	23%	26% (-)	40-50% (28-36%)	100%*** (-)
 EU	29%	35-40% (36%)	50-65% (42-52%)	100%*** (-)
 INDIA	15%	23% (22%)	40-45% (20-35%)	100%*** (-)
 USA	13%	20-25% (19%)	40-45% (22-25%)	100%*** (27%)

*Benchmarks derived from the Climate Action Tracker's Mid-2018 analysis exploring the highest plausible ambition for countries and sectors, based on IAMs and other modelling (adjusted for country circumstances).

** Benchmark updated in light of SR1.5 results: The interquartile range for 1.5°C-compatible with "no or limited overshoot" pathways is 47-65% RES of electricity at the global level in 2030 (IPCC 2018, Figure SPM 3B), and the power sector needs to be fully decarbonized by 2050. Renewables show the most promising development (already cost competitive in many regions and other technologies have important challenges and uncertainties on their potential development). Recent trends combined with the modelling and IPCC scenarios suggest therefore that RES of electricity could feasibly reach 65% by 2030.

*** Benchmark updated in light of SR1.5 results: Due to the possibility that there will still be a % of nuclear in the energy mix by 2050, combined with the fact the IPCC SR1.5 considers between 63-81% of RES of electricity by 2050 to be compatible with 1.5°C "no or limited overshoot" pathways (77% for P1, 81% for P2 and 63% P3, IPCC 2018, Figure SPM 3B), we have adopted a technology-neutral benchmark of 100% zero-carbon power by 2050.

RENEWABLE AND ZERO CARBON POWER

Real Economy Trends

- ▶ Total renewable energy capacity reached 2,351 GW in 2018, more than double the installed capacity in 2009 (1,136 GW). But growth rates dropped in 2018, with net capacity additions matching those of 2017.
- ▶ Between 2010-2016, the world added more than twice as much power generating capacity from renewables than fossil fuels, with 2017 seeing a record 157 gigawatts of renewable power commissioned.
- ▶ At the same time, the cost of renewables saw remarkable drop, with the global cost of electricity from utility-scale solar PV falling 73% since 2010, to USD 0.10/kWh for new projects commissioned in 2017.
- ▶ A record number of solar power projects alone equaled more than net additions of coal, gas and nuclear plants put together in 2017.
- ▶ IRENA estimates that prices from all types of renewable energy will be competitive with fossil fuels by 2020.



RENEWABLE AND ZERO CARBON POWER

What's happening in key countries?

- ▶ There are already seven countries at, or near 100% renewable power grids. These are: Iceland (100 percent), Paraguay (100), Costa Rica (99), Norway (98.5), Austria (80), Brazil (75), and Denmark (69.4). More countries are setting out pathways to be 100% renewable by 2050, including Spain.
- ▶ India has increased its [2022 renewable energy target](#) by 28 percent to 227 GW, from its previous goal of 175 GW, and has [recently stated its intention](#) to install 500 GW renewable electricity generation capacity by 2030. India's NDC target is a 40% RE share; from their new draft electricity plan, they envision reaching a 44% RE share by 2027 (275 GW RE out of 620 total). However, investments in coal remain high and electricity demand is supposed to treble by 2030.
- ▶ The **EU** has revised its 2030 renewable energy target from 27% to 32%.
- ▶ **China** plans to install 250GW of wind and 150GW of solar by 2020. [53 GW of solar power was added in China in 2017](#)— more than half the global total. In 2018, China's total renewable energy capacity stood at 696 GW, more than three times the level in 2009 (205 GW).
- ▶ In November 2016, the 48 Climate Vulnerable Forum (CVF) [countries have pledged](#) to use only renewable energy by 2050.
- ▶ **100 cities** are sourcing at least 70% of their electricity from renewables, and 138 cities and towns in the UK and US have committed to a 100% target by 2050.
- ▶ In the United States, more than 80 cities and five counties have committed to 100% renewables. Four states are committed to 100% renewable electricity - California, New Jersey, Hawaii and Nevada.

RENEWABLE AND ZERO CARBON POWER

Businesses

- ▶ 170+ of the world's most influential companies have committed to source 100% renewable electricity through [RE100](#), and more than 25 have already reached their targets, including Autodesk, Elopak, Interface, Marks and Spencer and Sky. RE100 is led by The Climate Group, in partnership with CDP.
- ▶ RE100 members are now creating demand of over 184 TWh of renewable electricity annually, more than enough to power Argentina and Portugal.
- ▶ These companies represent Scope 1+2 emissions equivalent to 0.10 gigatons CO₂e - more than the annual emissions of Belgium.
- ▶ Corporate sourcing of renewables provides a new source of finance, and according to Bloomberg NEF, RE100 members are investing over [\\$94 billion](#). They will need to mobilise the equivalent of 100 GW of RE capacity by 2030, larger than California's electricity grid (Bloomberg NEF).
- ▶ Earlier this year, [Apple announced](#) that 23 of its supply chain manufacturers (including RE100 member [DSM](#)) are now committed to using 100% renewable electricity for all their Apple productions.



BENCHMARK 3

COAL PHASE OUT IN THE POWER SECTOR

COAL PHASE OUT IN POWER SECTOR

- ▶ The table demonstrates **plausible phase-out years** for (unabated) coal from the power sector that **meet the Paris Agreement's target** of keeping global temperature increase well below 2°C.
- ▶ **Coal phase out in the power sector could happen by 2040** globally with EU and US phasing out by 2030 and in China and India by 2040.

Benchmarks for coal phase-out dates*

Coal phase-out	Phase-out year
 GLOBAL	2040-50
 CHINA	2040
 EU	2030
 INDIA	2040-50
 USA	2030-35

*Benchmarks from the Climate Action Tracker's Mid-2018 analysis exploring the highest plausible ambition for countries and sectors, based on IAMs and other modelling, policy and back-casting analyses (adjusted for country circumstances).

COAL PHASE OUT IN POWER SECTOR

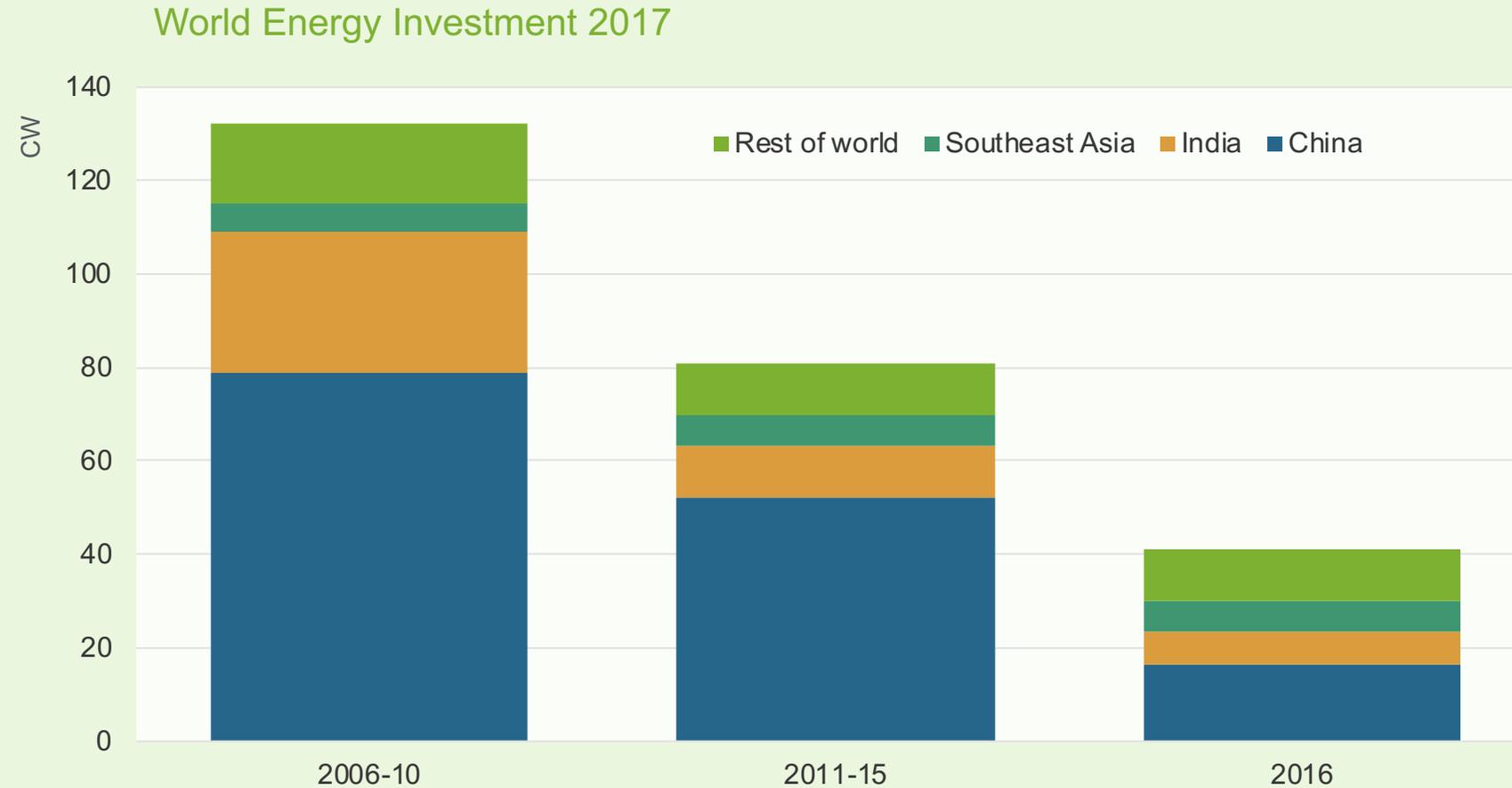
What's the trend in the real economy?

- ▶ Global [investment in coal tumbled](#) by 75% in three years. In 2015, Final Investment Decisions signed off 88 GW for construction, but this fell to 22 GW in 2018.
- ▶ Plans to build coal power plants have decreased dramatically in the past 3 years,
 - **China's** 2015 plans to build 515 GW of new coal capacity currently standing at 76 GW, and
 - **India's** 2015 plans for 218 GW decreased to 63GW today.
 - Within both countries, a growing number of coal plants operating well [below planned levels](#) or are [frozen in construction](#). (see graph on next slide)
- ▶ In the US, a total of 23,400 MW of coal-fueled generation [shut down](#) in 2017 and 2018, up compared to the 14,900 MW shut from 2009 through 2012. 2018 saw the highest level of shutdowns since 2015.



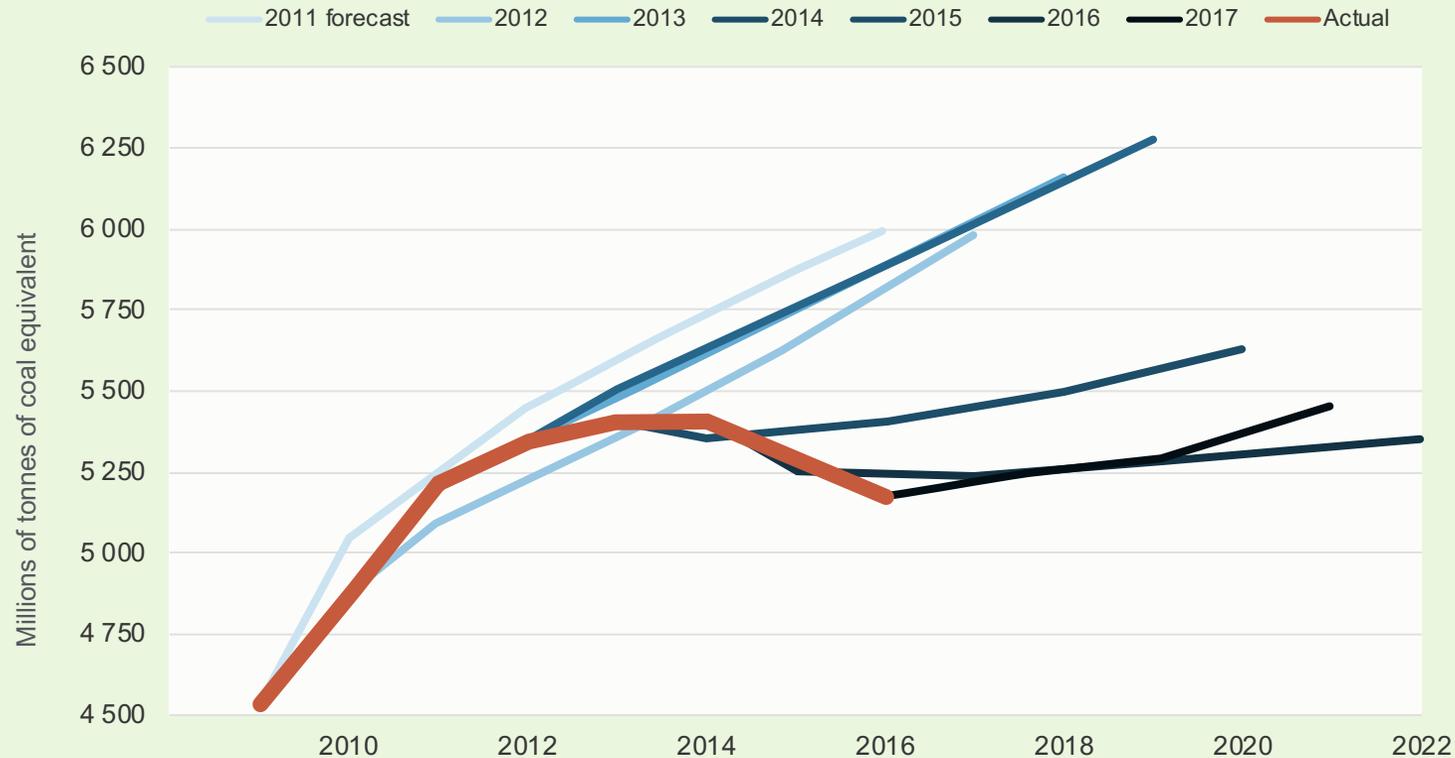
COAL PHASE OUT

Average annual final investment decisions for new coal-fired power capacity



Source: Calculations based on McCoy Power Reports (2017)

COAL PHASE OUT



- ▶ Coal demand projections have repeatedly been overestimated, with phase out rapidly outpacing projections.
- ▶ While still forecasting growth in coal demand, the IEA has had to repeatedly slash its projections to account for the ongoing transition in major energy markets.

Forecasts for global coal demand, made by the IEA in 2011 through 2017 (blue lines), compared to data on actual use (red), in millions of tonnes of coal equivalent. Note the y-axis is truncated. Source: Carbon Brief analysis of IEA coal market reports. Chart by Carbon Brief using Highcharts.

COAL PHASE OUT IN POWER SECTOR

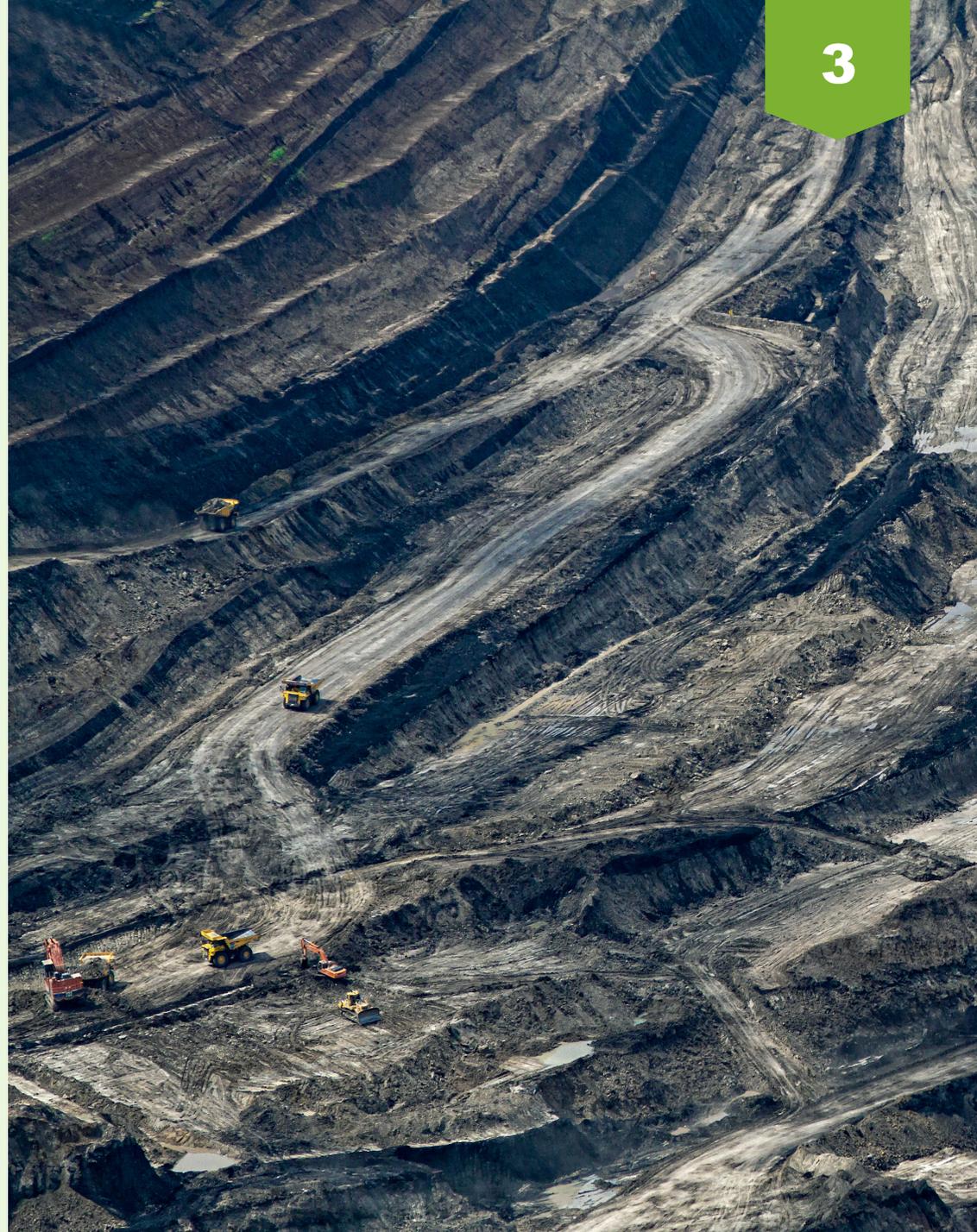
What's happening in key countries?

- ▶ **Powering Past Coal Alliance:** 30 countries, including 5 from the G20, have joined the Powering Past Coal Alliance, which has committed to phasing out traditional coal power plants and to enact a moratorium on unabated new coal.
- ▶ **China** aims to eliminate or halt a total of 109 GW of coal-fired power capacity by the end of this decade while keeping its total installed coal-fired power capacity below 1,100 GW. It eliminated or suspended 65 gigawatts (GW) of coal-fired power capacity in 2017.
- ▶ **Germany's** 'Commission on Growth, Structural Change and Employment,' has recommended that Germany should end coal-fired power generation by 2-35 to 2038, and should switch off 12.5 GW of capacity by 2022.
- ▶ **Ireland** recently became the first country to fully divest from fossil fuels.
- ▶ **The Netherlands** has committed to the phase-out of thermal coal used in power plants by 2030
- ▶ New York has adopted emission rules that will shut down its two remaining coal plants in 2020, and UK pollution standards will shutter all of the country's coal-fired power plants by October 2025.

COAL PHASE OUT IN POWER SECTOR

Businesses

- ▶ Many insurance companies have announced plans to [stop investing in coal](#), including Lloyd's of London, AXA and Allianz.
- ▶ More than 700 large investors have committed to cutting their exposure to fossil fuels in recent years.
- ▶ A growing number of pension funds are committing to divest from fossil fuels, including New York's [\\$189bn pension funds](#).
- ▶ European energy company [Vattenfall has pledged to phase out coal](#), and as part of its Science-based Target, [power utility company Orsted](#) has committed to stop using coal in its power stations by 2023.





BENCHMARK 4

LIGHT DUTY ELECTRIC VEHICLE SALES

EV UPTAKE

- ▶ EVs could reach 100% of all new light duty vehicle sales by 2030
- ▶ 95% of light duty cars on the road are EV by:
 - 2045 in US and EU,
 - 2055 in China and India.

Benchmarks for EV sales share to 2050*

EV Sales Share	2015	2020	2030	2050	>95% sales	>95% stock
	Gt CO ₂ e				Year	
 GLOBAL	0.7%	10% (2-6%)	50-100% (12-24%%)	100% (90%)	2030-40	2045-55
 CHINA	1.0%	20% (9%)	50-100% (-)	100% (-)	2030-40	2055
 EU	1.6%	15% (-)	90-100% (-)	100% (-)	2030-35	2045
 INDIA	0.1%	5% (0.3%)	50-100% (-)	100% (-)	2030-40	2055
 USA	0.8%	10% (9%)	90-100% (-)	100% (65%)	2030-35	2045

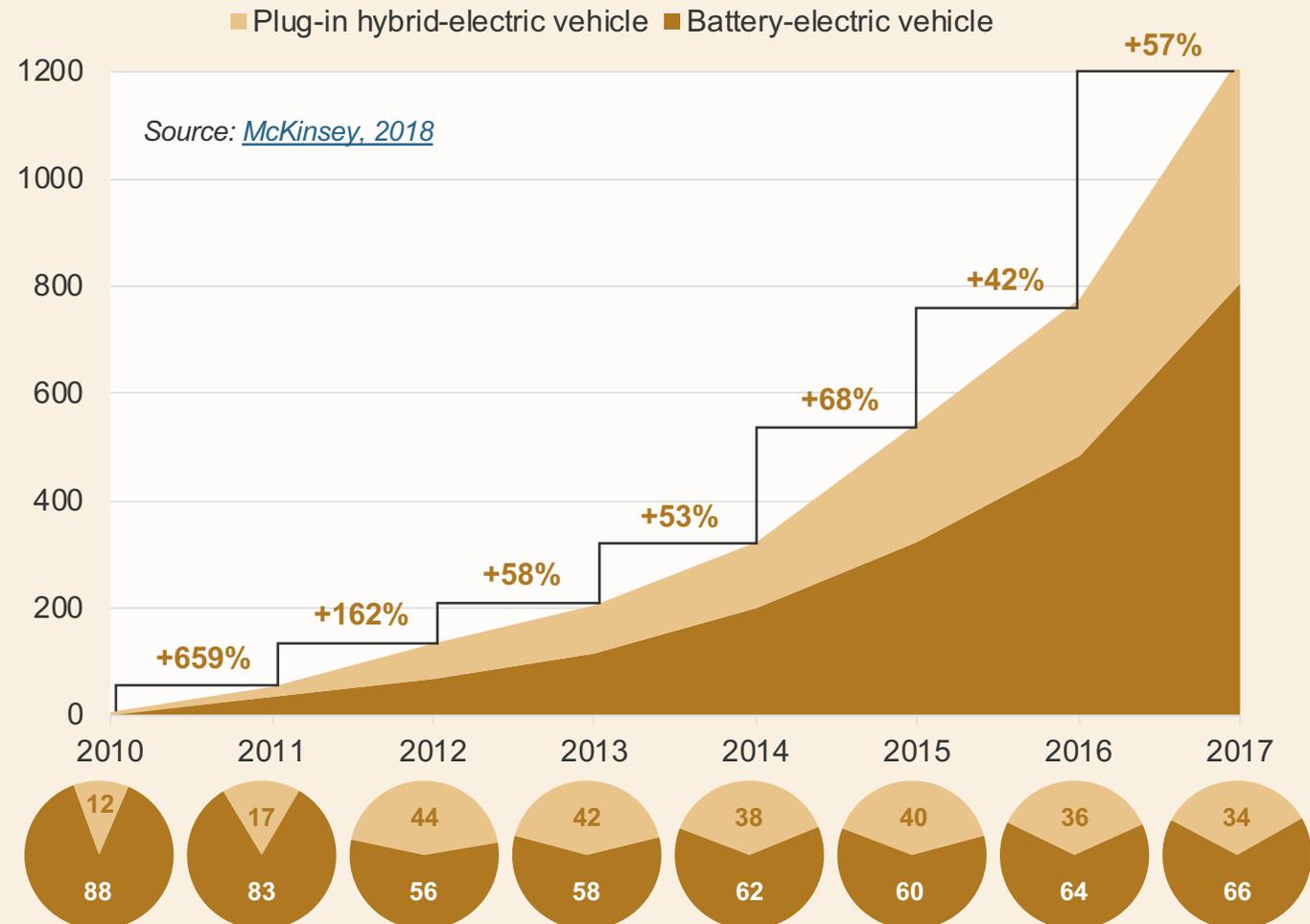
*Transport-sector modelling and market, trend and policy analyses (adjusted for country circumstances) from the Climate Action Tracker's Mid-2018 analysis exploring the highest plausible ambition for countries and sectors.

EV UPTAKE

What's happening in the real economy?

- ▶ Since 2010, **global uptake of EVs has increased significantly each year.**
- ▶ Average year on year increase in EVs uptake was 67.2% between 2012-2017, which was the **first year global sales passed 1m units.**
- ▶ **China's EV market is larger than the EU and US combined, and grew 118% in the first quarter 2019, year on year.**
- ▶ EV prices continue to fall , with a reduction of 73% in the cost of EV battery energy between [2010-2016](#).

Global electric-vehicle sales, 2010-17
Thousands, CAGR¹



EV UPTAKE

What's happening in key countries?

- ▶ More than ten countries have committed to completely phasing out light passenger vehicles power by only gasoline in the coming decades, including France, the UK and Norway.
- ▶ At least eight states in the US have set out goals. The Netherlands has committed to phase out the sales of fossil fuel vehicles by 2030.
- ▶ Major cities around the world have committed to [“fossil-fuel-free streets”](#) to ensure major areas of their cities are zero emission by 2030, including London, Los Angeles, Paris, Rome, Cape Town and Mexico City.
- ▶ **Norway is currently the country with the highest share of EVs in new car registrations worldwide: EVs now account for nearly 30 percent of all new cars sold in Norway.** Norway has policies that provide incentives to EV drivers, such as bus lane access and free public parking. In addition, financial incentives make EVs competitive with fossil fuel cars. Because Norway's power sector is largely based on hydropower, EVs already have had a substantial effect on emissions reductions beyond their improved efficiency compared to internal combustion engine vehicles.

EV UPTAKE

Businesses

- ▶ Auto manufacturers have announced more than \$150 billion in investments to achieve collective production targets of more than 13 million electric vehicles annually around 2025. This is likely be more than 10% of global light-duty vehicle sales, based on publicly announced plans.
- ▶ Virtually all major carmakers have committed to an electric future - Daimler has committed to net-zero carbon cars by the end of 2039 and VW has committed to being carbon neutral by 2050.
- ▶ 39 multinational companies have committed to accelerating the rollout of EVs and charging infrastructure through EV100, including Baidu, Deutsche Post DHL Group, Heathrow Airport, HP Inc., IKEA Group, LeasePlan, METRO AG, PG&E, Unilever and Vattenfall..



PROJECT CHALLENGES

Difficulties related to data collection:

- ▶ Not all models and projections publish values for all indicators and all countries.
- ▶ IAMs do not generally resolve scenarios at country level, making it hard to define consistent country specific benchmarks
- ▶ Assumptions behind models and projections results (e.g. latest RE cost reductions, roll-out of EV sales) are often not systematically communicated and partly not reported at all.
- ▶ With exceptions, indicator values cannot be simply differentiated in terms of weak vs strong dependency on negative emissions technologies, as many more factors change between the limited sets of models and scenarios available.
- ▶ Projections based on current policies and developments are relatively short term and do not reflect the required level of ambition to meet the Paris agreement



LESSONS LEARNED

- ▶ IAM and IEA studies mostly use a least-cost optimization approach. Adjustments had to be made based on expert judgement to include considerations of developed/developing country differences.
- ▶ Limited ability to aggregate corporate, subnational and country-level initiatives for a comparison with global projections.
- ▶ Models often lag behind real world evolutions (e.g. on technology costs).
- ▶ There is not enough granularity to set benchmarks for other sectors (freight and international transport, industry, buildings, agriculture) when looking at publicly available data only.



ANNEXES

METHODOLOGY FOR THE CAT ASSESSMENT WHICH INFORMED THE CAB PROJECT

Note on 2030 benchmarks following IPCC SR1.5

- ▶ The Climate Action Tracker (CAT) report, which informed the Climate Ambition Benchmarks project and the identification of the “highest plausible ambition” benchmarks on slide 5 of this presentation (alongside real economy, political and business trends) was created in the first half of 2018 before publication of the IPCC Special Report on Global Warming of 1.5°C (SR 1.5).
- ▶ The CAT report draws on a set of Integrated Assessment Modelling (IAM) mitigation pathways predating the publication of SR 1.5. The aim of the study was to assess highest plausible ambition on a number of indicators to contribute to limiting warming to below 1.5°C.
- ▶ The report drew from current technological, economic and policy trends, back-casting scenarios, forecasts, and the most ambitious IAM mitigation pathways available at the time.
- ▶ In the context of the SR 1.5 the IAM pathways in the CAT report are typically P4 (high overshoot) pathways, as few P1–3 type pathways were available at the time, and even at this point in time are not generally available at the sectoral and geographical resolution required for the purpose of this report. P1-3 type pathways with “no or limited overshoot” of 1.5°C generally have faster emissions reductions over the next few decades, hence lower emission levels around 2030 and faster transformations in all sectors.

DETAILED STEPS USED IN CAT ASSESSMENT

Benchmark 1: GHG Emissions

- ▶ **CAT assessment approach:** EU net-0 year is based on the more ambitious US benchmark level (2045–2050) and the higher end of the range was selected for India and China (2050–2055). This earlier net-0 year for developed countries reflects the need for developed countries to take the “lead” in climate action. This is also in line with 1.5°C scenario data from IPCC SR1.5 (not public at the time of the report).
- ▶ **Highest-level of ambition from IAMs and IEA:** several Paris compatible model runs are available for this indicator. However, some results are not taken into account because the level of negative emissions is considered too high (GCAM) or regional results are not applicable for some of the countries (Rogelj et al. 2015). IEA ETP CO₂-only data were complemented with non-CO₂ and other emissions from IMAGE to enable comparability of results. The net-zero year for the EU is relatively late compared to other countries, which could have a variety of reasons (differences in cost assumptions, differences in non-CO₂ emissions, differences in amount of BECCS, etc.). With an eye to “highest feasible level of ambition”, IEA ETP values determine the EU zero year, rather than the later IAM-based values.
- ▶ **Back-casting model-based results** are in line with, or only slightly less ambitious than, Paris consistent results from IAMs. Even if the results are not fully consistent with the limit of well below 2 or 1.5°C temperature increase, they suggest that the model results from “step 1” could be considered by the related stakeholders as technically, politically or economically feasible.

DETAILED STEPS USED IN CAT ASSESSMENT

Benchmark 1: GHG Emissions

- ▶ **Projections based on current developments** are less ambitious than model results and do not reflect the level of ambition required to reach Paris Agreement long term goal.
- ▶ **Harmonisation of country specific results:** to ensure consistency of the benchmarks across countries in light of limited data availability, and with our aim of finding the “highest plausible ambition”, we have defined the EU net-0 year based on the more ambitious US benchmark level (2045–2050) and we selected the higher end of the range for India and China (2050–2055). This earlier net-0 year for developed countries reflects the need for developed countries to take the “lead” in climate action. This is also in line with 1.5°C

scenario data that will be published together with the IPCC SR1.5. The broader and most recent 1.5°C literature shows that in 1.5°C pathways, while the net-0 year for CO₂ emissions in Asia is very close to the net-0 year for OECD countries, the net-0 year for total GHG emissions is typically 5–10 years later. Other developing country regions have net-0 years close to OECD for both CO₂ and total GHGs. The “delay” for Asia is explained mostly by methane emissions, with China, India and Indonesia all among the top global CH₄ emitters.

MAIN SOURCES USED IN CAT ASSESSMENT

Benchmark 1: GHG emissions

Paris compatible models:

- ▶ Integrated Model to Assess the Global Environment, “IMAGE 2018” (D. van Vuuren et al., 2018)
- ▶ Global Change Assessment Model, “GCAM 2017” (Joint Global Change Research Institute, 2017)
- ▶ Fifth Assessment Report, “IPCC AR5” (Intergovernmental Panel on Climate Change, 2014)
- ▶ Energy system transformations for limiting end-of-century warming to below 1.5 °C, “Rogelj, et al. 2015” (Rogelj et al., 2015)
- ▶ IEA Energy Technology Perspectives 2017, “IEA ETP” (IEA, 2017a)

Back casting models:

- ▶ Greenpeace, The Energy [R]evolution, 2015, “Greenpeace” (Greenpeace, 2015)
- ▶ Deep Decarbonization Pathways, Country Reports, 2015, “DDP” (Deep Decarbonization Pathways Project, 2015)

Projections based on current policies and developments:

- ▶ Climate Action Tracker, Decarb Portal, 2017, “CAT” (Climate Action Tracker, 2017)
- ▶ Carbon Transparency Initiative, 2016, “CTI” (Carbon Transparency Initiative, 2016)
- ▶ Carbon Transparency Initiative, EU results, 2018, “CTI EU” (Cornet et al., 2018)

DETAILED STEPS USED IN CAT ASSESSMENT

Benchmark 2: Renewable energy share

- ▶ **CAT assessment approach:** The higher end of the range of EU and US model results was selected. Observed growth in China or India is already high and IAMs and IEA probably assume growth rates to continue to be significantly higher than in EU and USA based on current cost assumptions. This might not be considered as realistic, given recent developments, or fair in the longer term in light of the need for developed countries to take the lead. With decreasing costs and more ambitious policies, more renewables can also be expected to be built in the EU and the USA.
- ▶ **Highest-level of ambition from IAMs and IEA:** the large range for the EU reflects the disparities between Western and Eastern Europe. The large differences between the model results within each region reflects the disparities between model assumptions. Models assume that most of the newly built capacity in all countries is renewable, but with different costs assumptions for the different regions (e.g. analysis of results shows that cost assumptions in some models might be higher for Western Europe than for other regions).
- ▶ **Back-casting model based results** vary a lot, being less ambitious (DDP) or more ambitious (Greenpeace and CTI) than the results from Step 1. This reflects the variety of stakeholders' views on what is considered a technically, politically and/or economically feasible RES development in the different regions. CTI EU and Greenpeace results have been taken into account to reflect that a higher level of ambition is possible in the EU for 2030 and 2050. At the global level, the recently published report by IRENA provides a more ambitious level of RES development for 2050 which we selected as higher range of the global benchmark.

DETAILED STEPS USED IN CAT ASSESSMENT

Benchmark 2: Renewable energy share (zero carbon electricity in 2050)

- ▶ **Projections based on current policies and developments:** current policy projections are less ambitious and do not reflect the level of ambition required to reach the Paris Agreement long term goal. However, industry projections (BNEF or others displayed in separate tables because of scoping differences) are significantly higher than other observed projections, suggesting that a higher level of ambition is possible for most regions.
- ▶ **Harmonisation of country specific results:** to reflect differences in data availability as well as most recent developments, we selected the higher end of the range of EU and US results. Observed growth in China or India is already high and IAMs and IEA probably assume growth rates to continue to be significantly higher than in EU and USA based on current cost assumptions. This results in more RES capacity expected to be built in China and India and the renewables share increasing faster. This might not be considered as realistic given recent developments or fair in the longer term in light of the need for developed countries to take the lead. With decreasing costs and more ambitious policies, we expect more renewables will also be built in the EU and the USA.

MAIN SOURCES USED IN CAT ASSESSMENT

Benchmark 2: Renewable energy share

Paris compatible models:

- ▶ Integrated Model to Assess the Global Environment 2018, “IMAGE” (D. van Vuuren et al., 2018)
- ▶ Fifth Assessment Report, “IPCC AR5” (Intergovernmental Panel on Climate Change, 2014)
- ▶ Energy system transformations for limiting end-of-century warming to below 1.5 °C, “Rogelj, et al. 2015” (Rogelj et al., 2015)
- ▶ IEA Energy Technology Perspectives 2017, “IEA ETP” (IEA, 2017a)

Back casting models:

- ▶ Greenpeace, The Energy [R]evolution, 2015, “Greenpeace” (Greenpeace, 2015)
- ▶ Deep Decarbonization Pathways, Country Reports,

2015, “DDP” (Deep Decarbonization Pathways Project, 2015)

Projections based on current policies and developments:

- ▶ Climate Action Tracker, Decarb Portal, 2017, “CAT” (Climate Action Tracker, 2017)
- ▶ Carbon Transparency Initiative, 2016, “CTI” (Carbon Transparency Initiative, 2016)
- ▶ Carbon Transparency Initiative, EU results, 2018, “CTI EU” (Cornet et al., 2018)
- ▶ IRENA, Global Energy Transformation – A roadmap to 2050, 2018, “IRENA” (IRENA, 2018)

DETAILED STEPS USED IN CAT ASSESSMENT

Benchmark 3: Coal phase out in power sector

- ▶ **CAT assessment approach:** The most ambitious part of the range of EU and US model results was selected. Similar to the RES share benchmark, some models might assume faster coal phase-out in non-OECD countries than in OECD countries based on current cost assumptions. This might not be considered as realistic or fair in the longer term in light of differentiation principles.
- ▶ **Highest-level of ambition from IAMs and IEA:** regional phase-out years are applied as an estimate of the latest phase-out year per country in the models. Some results are not taken into account because regional results are not applicable for the country (e.g. Indonesia).
- ▶ **Back-casting model based results** are in line with or less ambitious than IAMs and IEA results. This reflects that some stakeholders consider that the coal phase-out ambition level required to reach Paris Agreement long term goal is technically, politically and/or economically challenging.

DETAILED STEPS USED IN CAT ASSESSMENT

Benchmark 3: Coal phase out in power sector

- ▶ **Projections based on current policies and developments:** only the IEA ETP Reference Technology Scenario is available and most countries do not phase-out coal in the time scale of the scenario (2060).
- ▶ **Harmonisation of country specific results:** to reflect the need for developed countries to take the lead, we selected the most ambitious part of the range of EU and US results. Similar to the RES share benchmark, some models might assume faster coal phase-out in non-OECD countries than in OECD countries based on current cost assumptions. This might not be considered as

realistic or fair in the longer term in light of differentiation principles. With decreasing costs of RES and more ambitious policies, we expect more coal capacity to be shut down before the end of its life in the EU and the USA. To achieve these early shutdowns, the models' assumptions should be reviewed and constrained by up-to-date policies at national level and/or explicitly reflect high costs of coal-fired power plants currently externalised (e.g. impact of air pollution).

MAIN SOURCES USED IN CAT ASSESSMENT

Benchmark 3: Coal phase out in power sector

Paris compatible models:

- ▶ Integrated Model to Assess the Global Environment, “IMAGE 2018” (D. van Vuuren et al., 2018)
- ▶ Energy system transformations for limiting end-of-century warming to below 1.5 °C, “Rogelj, et al. 2015” (Rogelj et al., 2015)
- ▶ IEA Energy Technology Perspectives 2017, “IEA ETP” (IEA, 2017a)

Back casting models:

- ▶ Greenpeace, The Energy [R]evolution, 2015, “Greenpeace” (Greenpeace, 2015)
- ▶ Deep Decarbonization Pathways, Country Reports, 2015, “DDP” (Deep Decarbonization Pathways Project, 2015)

Projections based on current policies and developments:

- ▶ Carbon Transparency Initiative, EU results, 2018, “CTI EU” (Cornet et al., 2018)

DETAILED STEPS USED IN CAT ASSESSMENT

Benchmark 4: EV uptake

- ▶ **CAT assessment approach:** Cars are a global commodity and there are now several countries that are taking or at least planning to take a much faster route towards banning fossil fuel cars in the near future. Therefore the “highest plausible ambition” is broadly aligned in all countries, with the more ambitious end of the range, 100% EV sales share in 2030, being defined by these early movers, while also considering the leading role to be played by OECD countries.
- ▶ **Highest-level of ambition from IAMs and IEA:** in this category only the IEAs Global Electric Vehicle Outlook “beyond 2 degrees” scenario (GEVO B2D) provides insights. The model results are considered as already outdated and new results are expected to be published later this year. The GEVO B2D assumes nearly 100% EV sales by 2050 for all regions. Integrated assessment models do not have the resolution to consider EVs separately or do not provide public data on their shares.
- ▶ **Back-casting model based results** are not available except for the EU with recently published CTI results up to 2030. The model displays a much higher level of ambition than GEVO B2D, demonstrating that higher level of EV sales may be possible. We expect similar level of ambition to be feasible for the US.

DETAILED STEPS USED IN CAT ASSESSMENT

Benchmark 4: EV uptake

- ▶ **Projections based on current policies and developments** are only slightly less ambitious than the GEVO B2D. (2030: 24% of new sales from BNEF compared to 31% in GEVO B2D or 2050: 90% in BofA compared to 91% in GEVO B2D). Car manufacturers' projections for 2025 are also in line with GEVO B2D short term projections. These projections are much higher than GEVO's base case scenario, suggesting that a higher level of ambition is certainly possible. Planned policies at country level are a good indicator of the ambition of some countries towards the phase-out of fossil based cars. The results show that the policy ambition between countries differs from no goals to 100% electric vehicle sales as soon as 2025 or 2030. These targets only cover some countries in the scope of our analysis and none of the announced targets have so far been enshrined in laws or

regulations. But they are considered as a good indication of the level of ambition considered as achievable and are therefore taken into account.

- ▶ **Harmonisation of country specific results:** cars are a global commodity and therefore changes in one country can easily spread to other markets as global manufacturers change their practices. There are now several countries that are taking or at least planning to take a much faster route towards banning fossil fuel cars in near future. Therefore we believe the “highest plausible ambition” is broadly aligned in all countries, with the more ambitious end of the range, 100% EV sales share in 2030, being defined by these early movers, while also considering the leading role to be played by OECD countries.

MAIN SOURCES USED IN CAT ASSESSMENT

Benchmark 4: EV uptake

Paris compatible models:

- ▶ IEA, Mobility Model, 2017, “IEA GEVO 2017” (IEA, 2017b)

Projections based on current policies and developments:

- ▶ BNEF, EV Outlook, 2017, “BNEF” (BNEF, 2017)
- ▶ Navigant Research, EV Market Forecast, 2017, “Navigant Research” (Navigant Research, 2017)
- ▶ UBS, Evidence Lab, 2017, “UBS” (UBS, 2017)
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- ▶ Energy Innovation, Research Note, 2017, “Energy Innovation” (Energy Innovation, 2017)
- ▶ Carbon Transparency Initiative, EU results, 2018, “CTI EU” (Cornet et al., 2018)

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