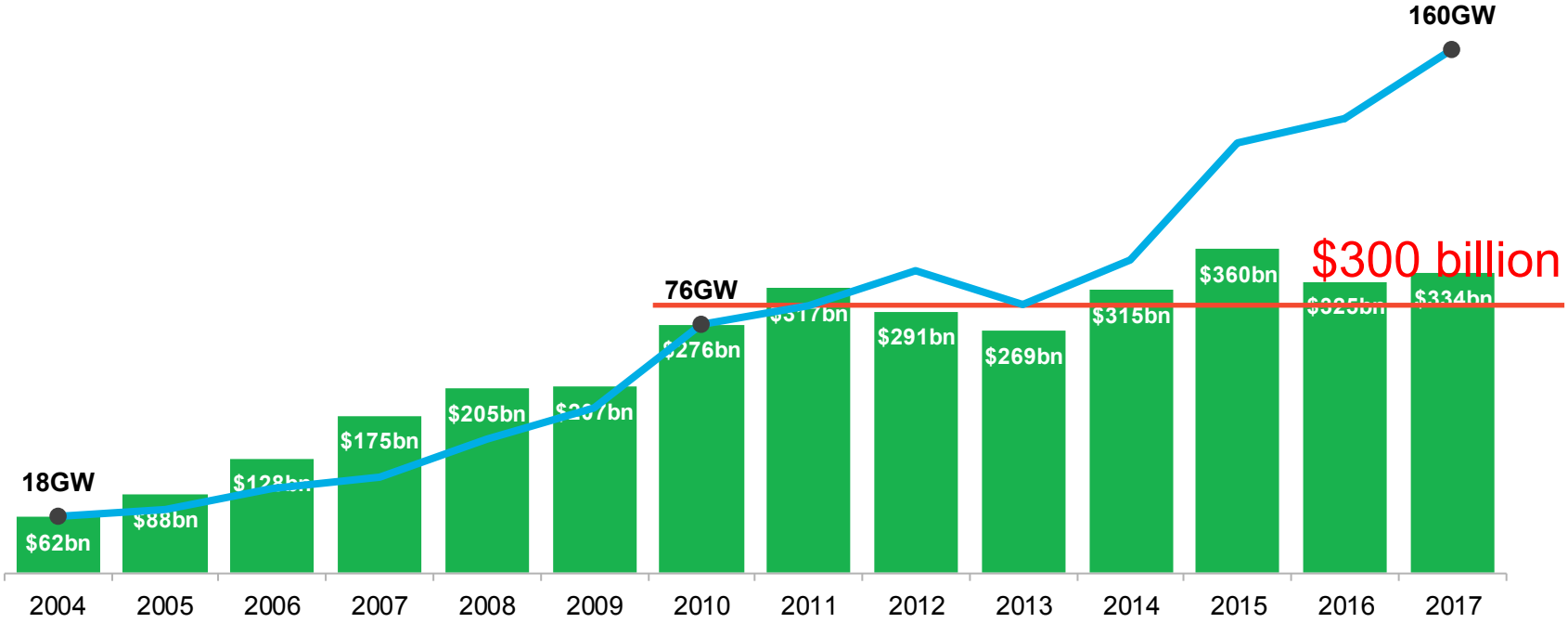
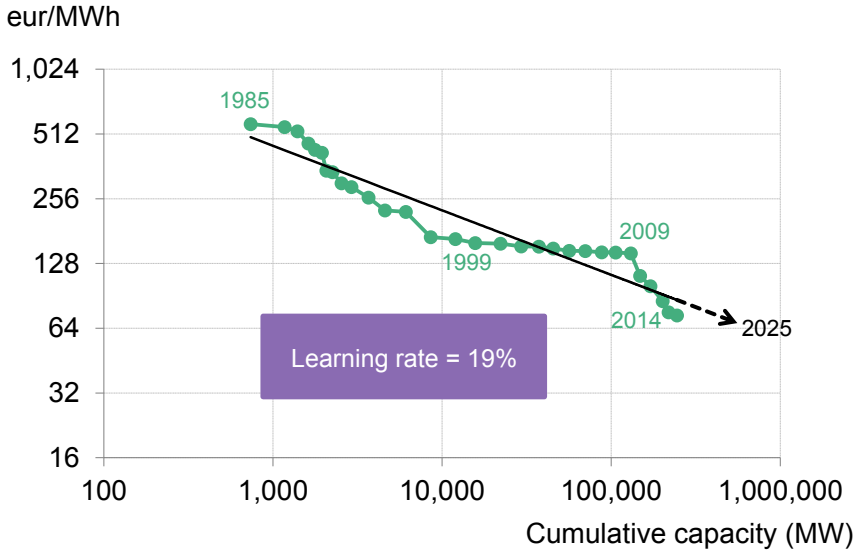
Global new clean energy investment and capacity installations – 2017



Total values include estimates for undisclosed deals. Includes corporate and government R&D, and spending for digital energy and energy storage projects (not reported in quarterly statistics). Excludes large hydro. *Source: BNEF, IRENA*

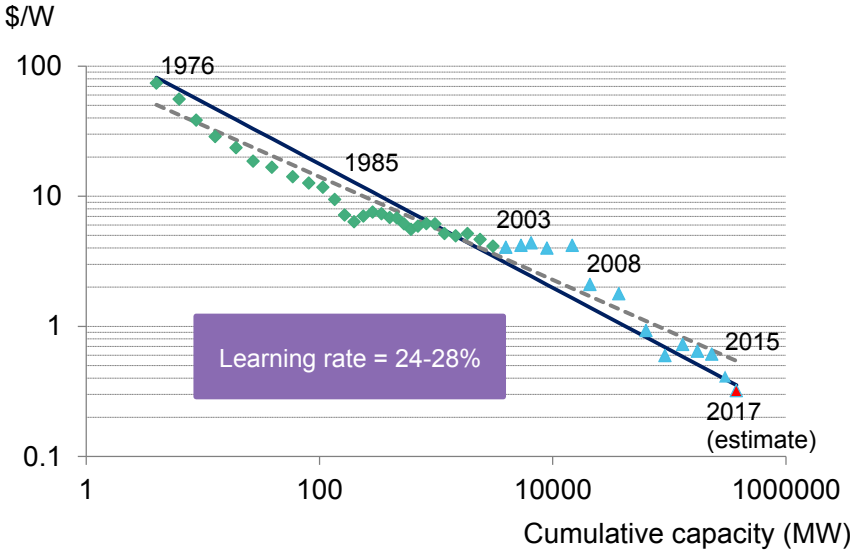
Wind and solar experience curves

Wind



Source: Bloomberg New Energy Finance

Solar



Source: Bloomberg New Energy Finance

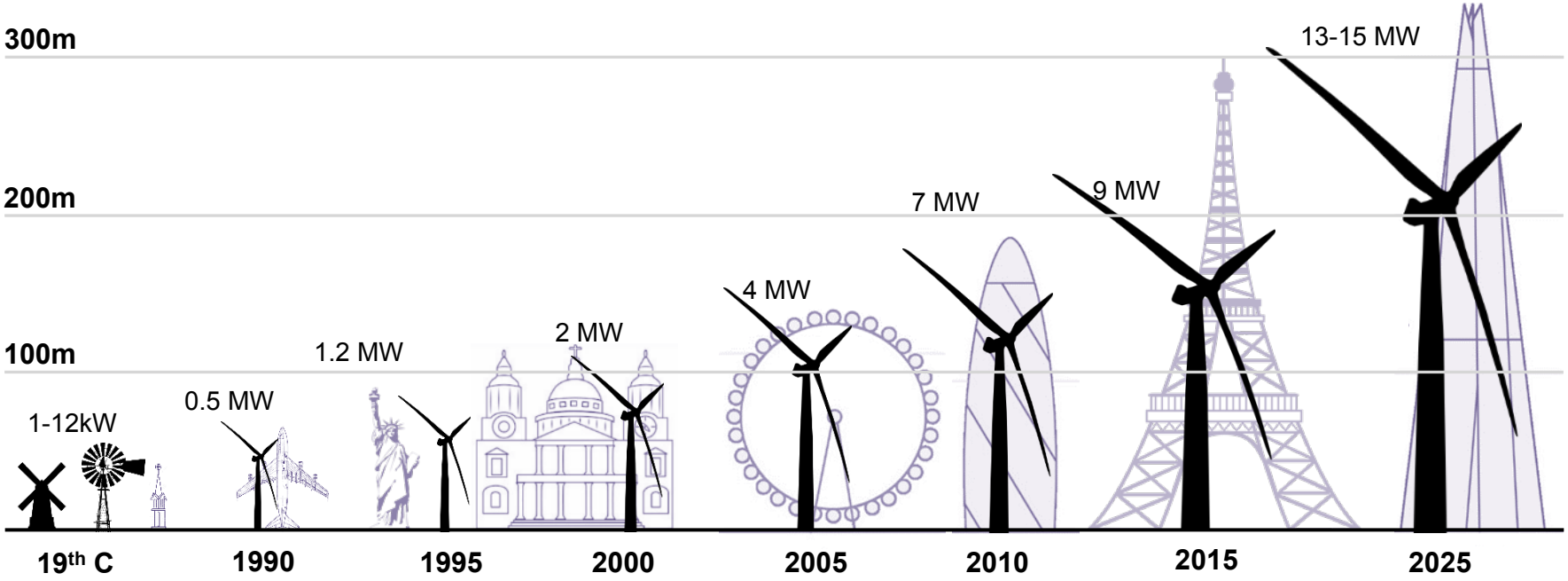
Solar scale-up 2005-2017

2005

2017

Image: Nissan; Kamuthi Solar Plant

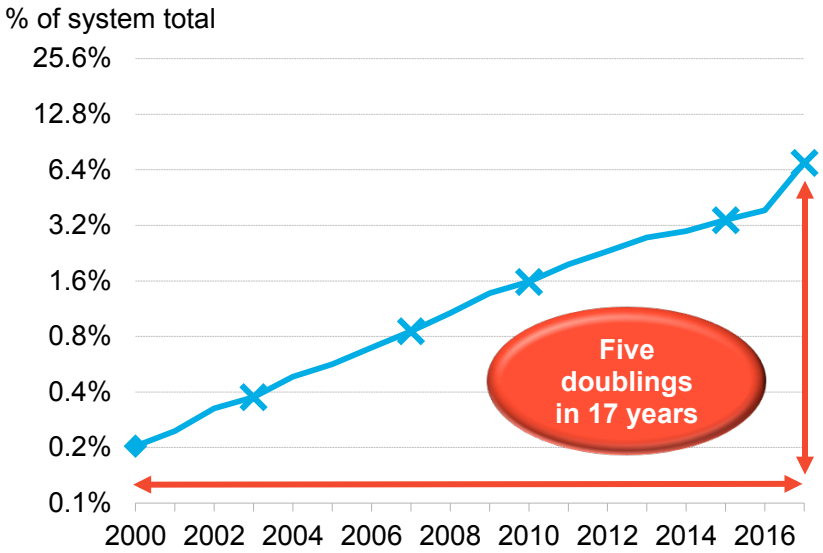
Evolution of wind turbine heights and output



Sources: Various; Bloomberg New Energy Finance

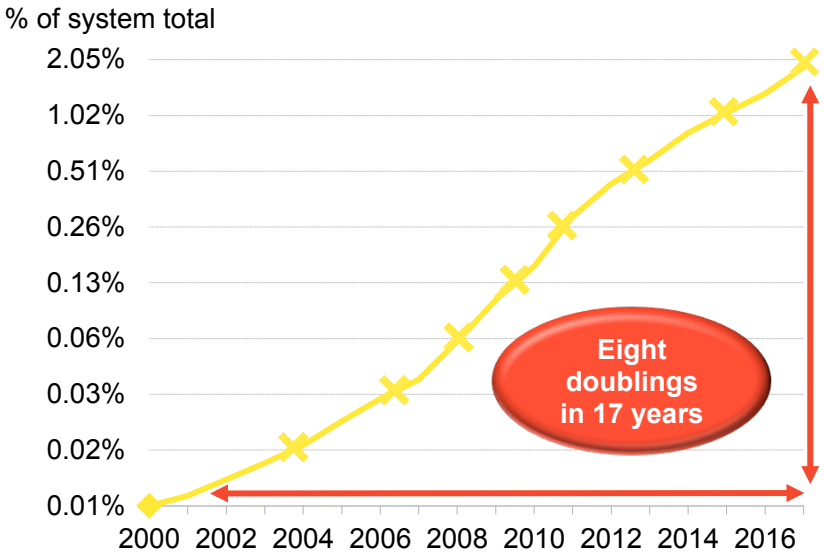
Variable renewables share of power generation 2000-2017

Wind



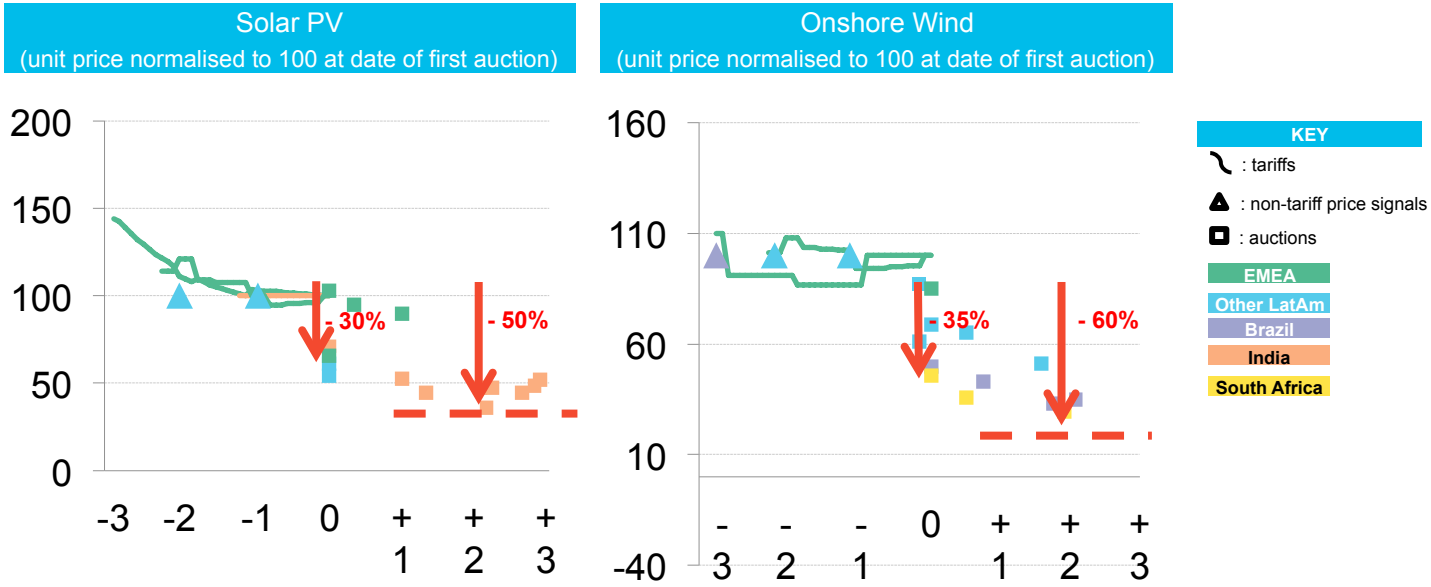
Note: Y-axes are logarithmic with base 2

Solar



Source: BP; Bloomberg New Energy Finance

Price impact of switch from FiT to auctions, selected countries (normalised)



Source: Bloomberg New Energy Finance

Unsubsidised clean energy world records 2018

Solar PV

Country:	Mexico
Bidder:	Enel
Signed:	Nov 2017
Construction:	2018
Price:	**US$ 1.97 c/kWh**

Onshore wind

Country:	Mexico
Bidder:	Neoen
Signed:	Nov 2017
Construction:	2019
Price:	**US$ 1.77 c/kWh**

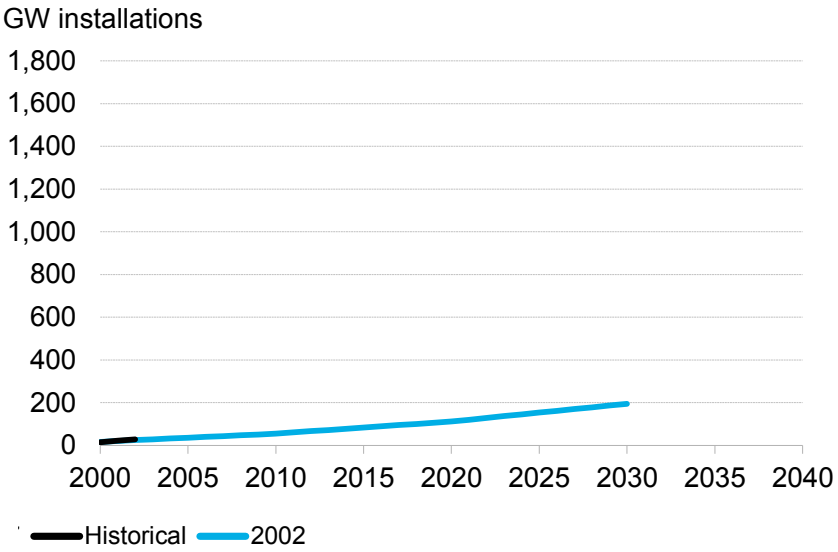
Offshore wind

Country:	Germany
Bidder:	DONG/EnBW
Signed:	2016
Construction:	2024
Merchant Price:	**US$ 4.9 c/kWh**

Source: Various manufacturers and project developers; images are illustrative only

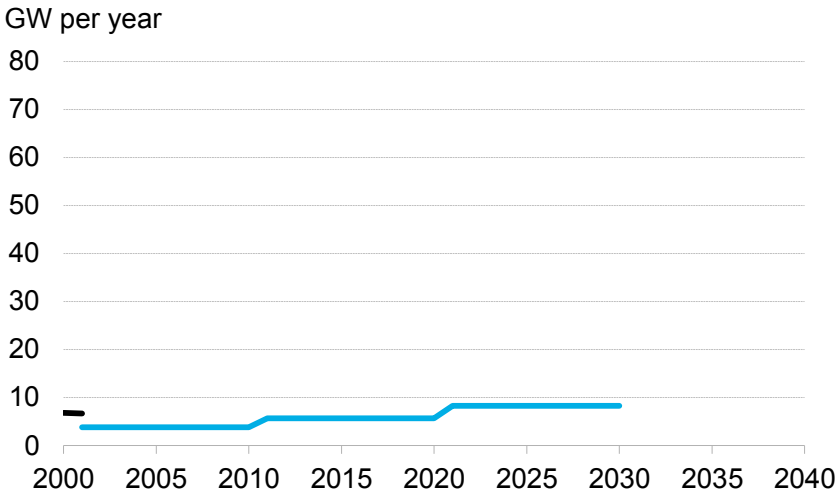
IEA wind capacity forecast evolution

Global cumulative wind installations



Note: 2002-2009 Reference, 2010-2017 New Policies Scenario

Annual wind additions



Source: IEA World Energy Outlook

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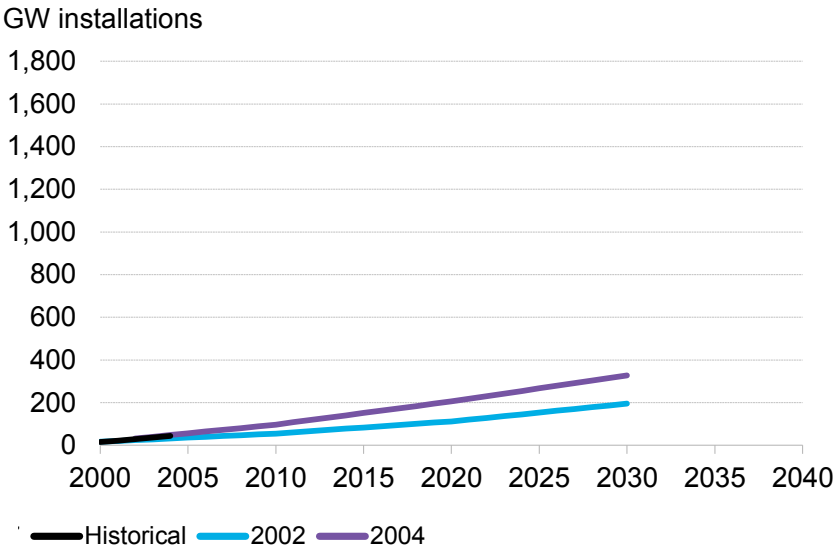
Global cumulative wind installations



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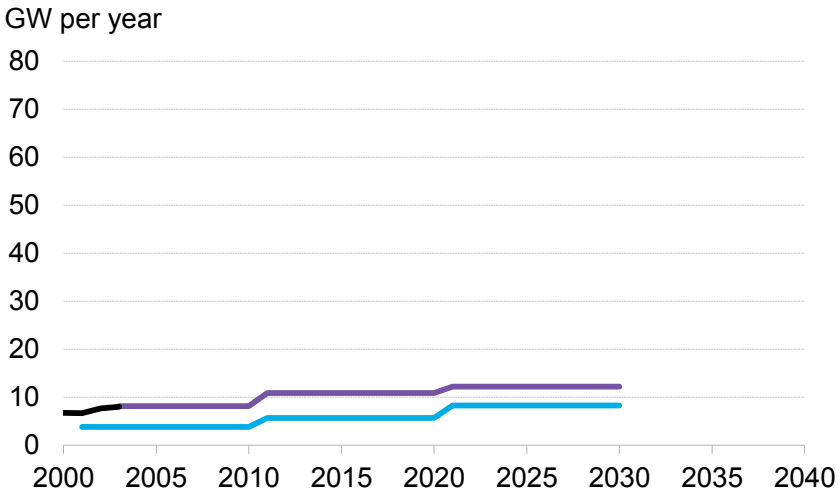
Annual wind additions



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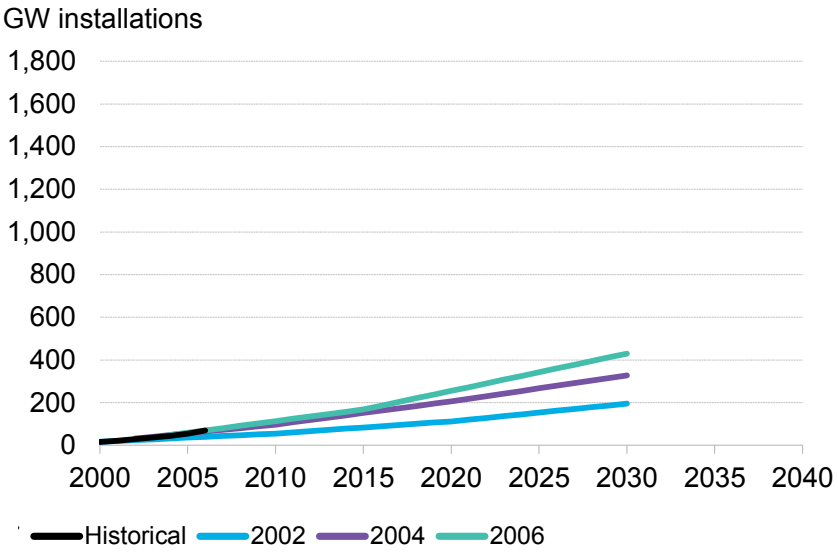

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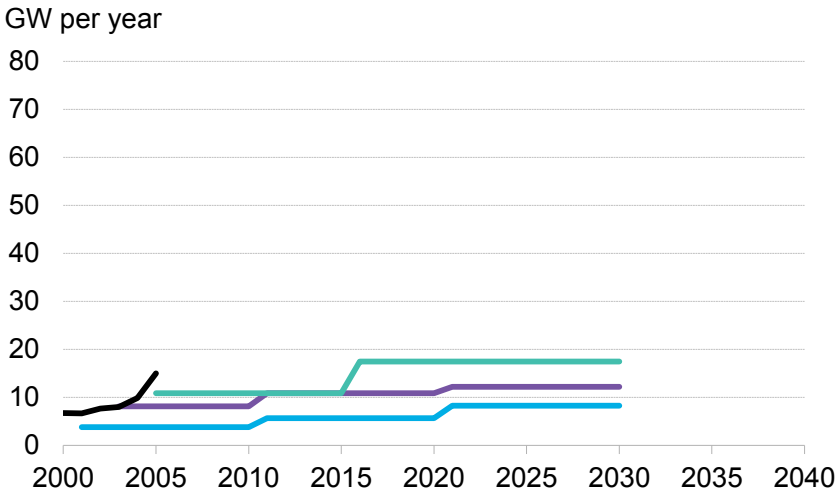
Annual wind additions



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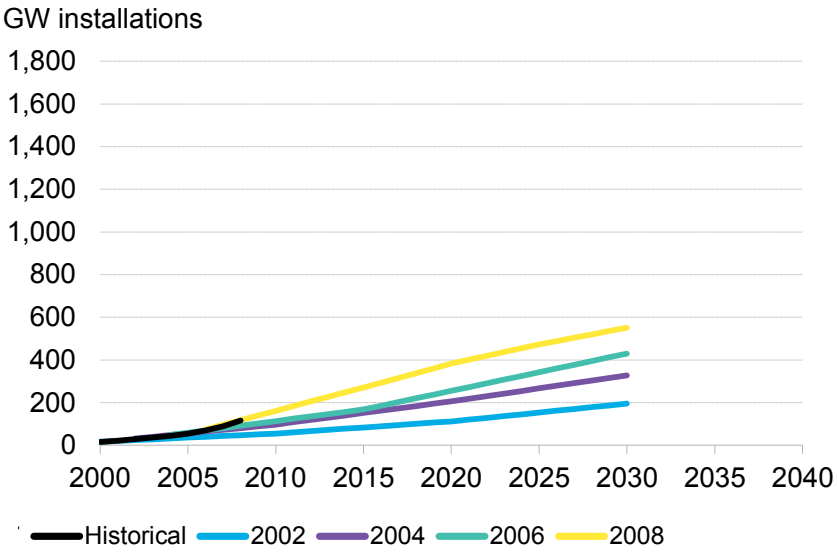

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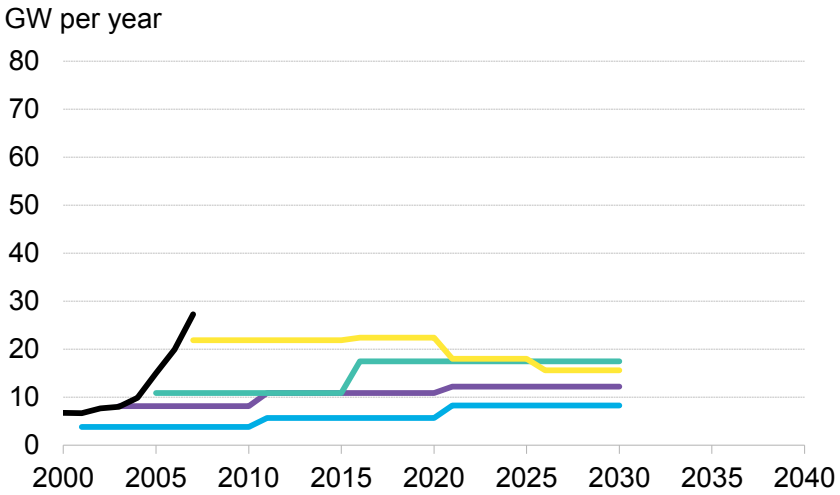
Annual wind additions



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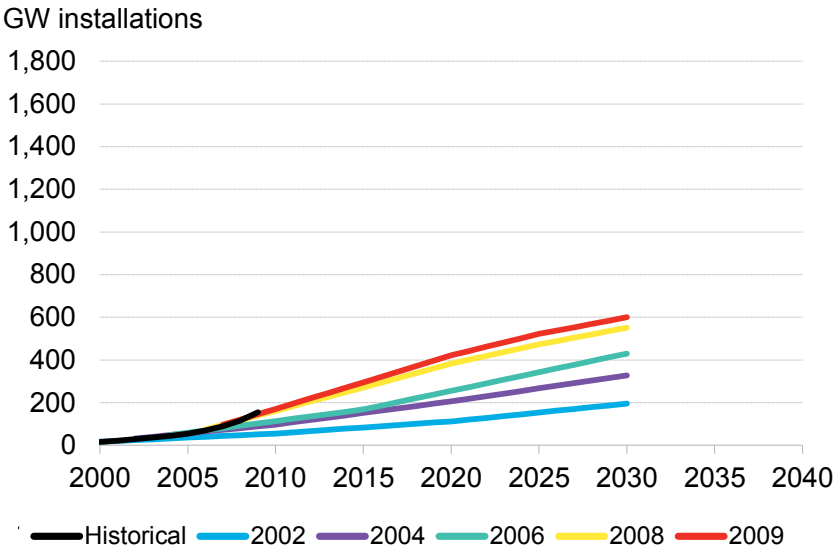
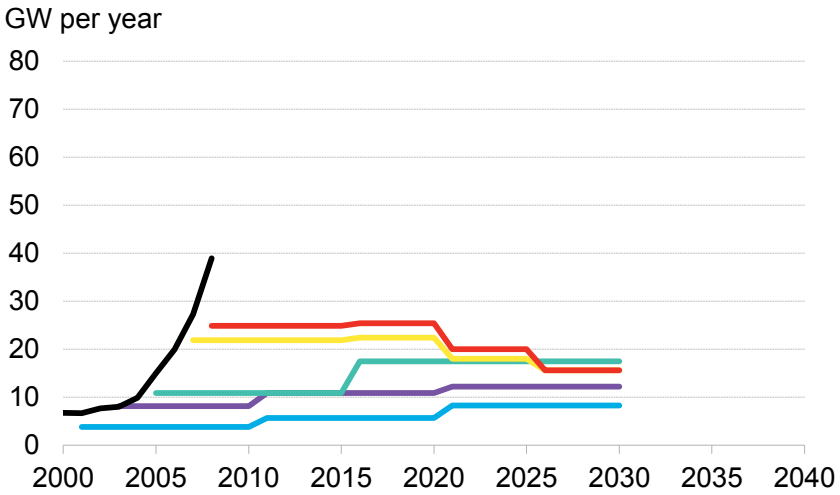


Note: 2002-2009 Reference, 2010-2017 New Policies Scenario

Annual wind additions



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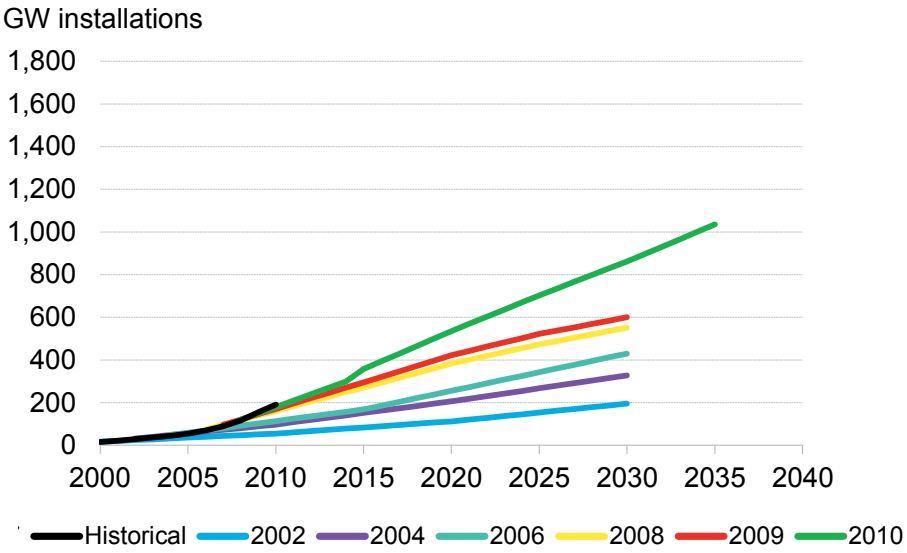
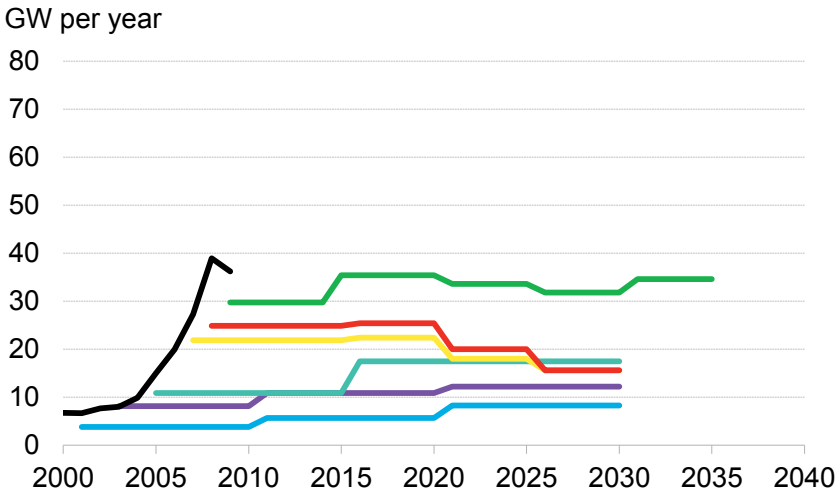
Global cumulative wind installations



Note: 2002-2009 Reference, 2010-2017 New Policies Scenario

Annual wind additions



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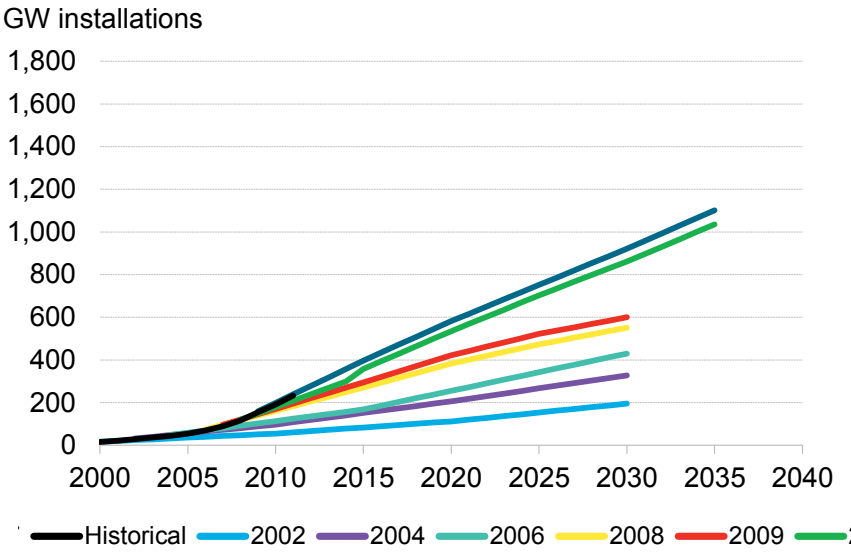
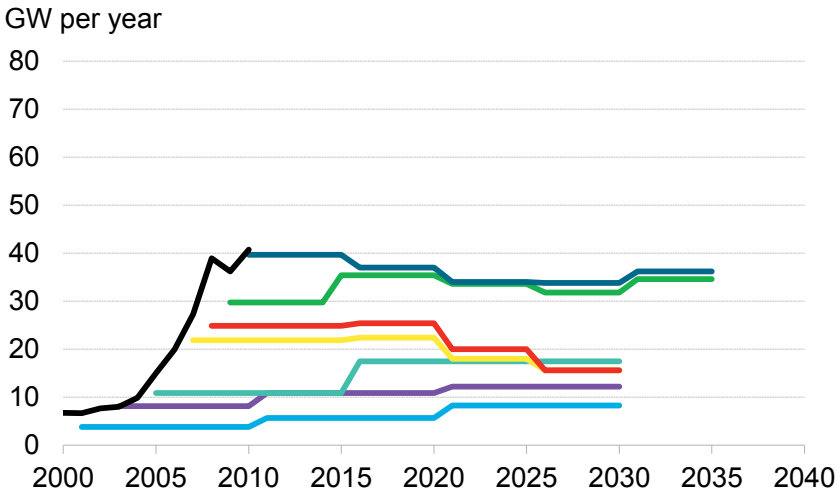
Global cumulative wind installations



Note: 2002-2009 Reference, 2010-2017 New Policies Scenario

Annual wind additions



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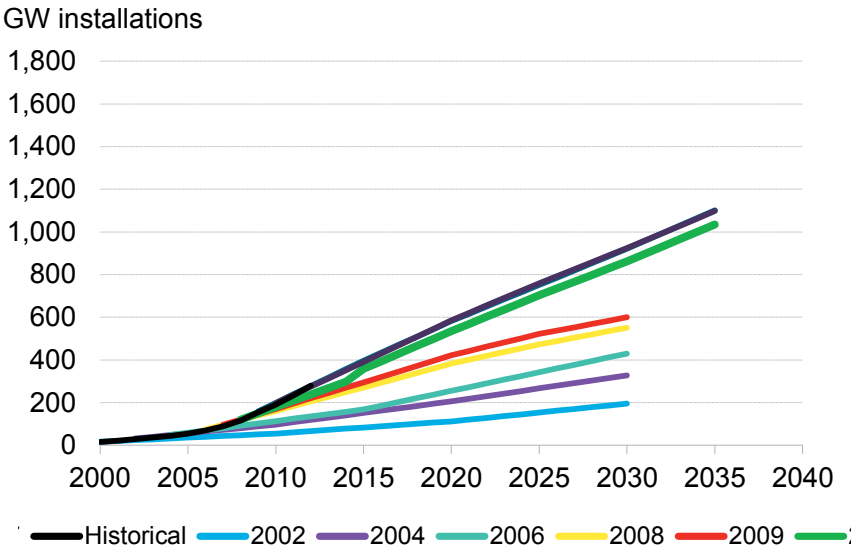
IEA wind capacity forecast evolution

Global cumulative wind installations



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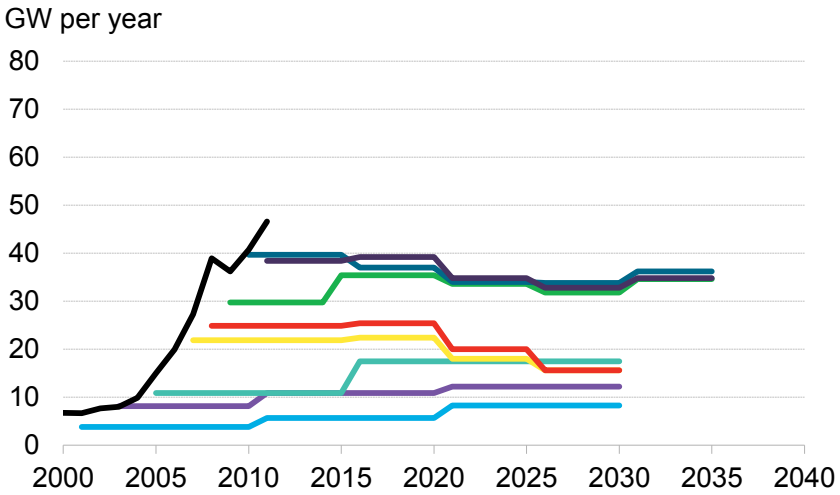
Annual wind additions



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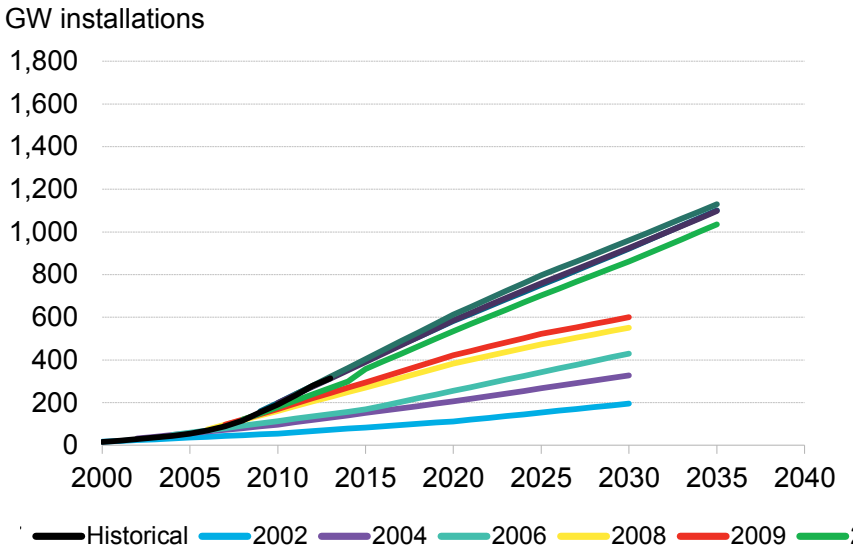
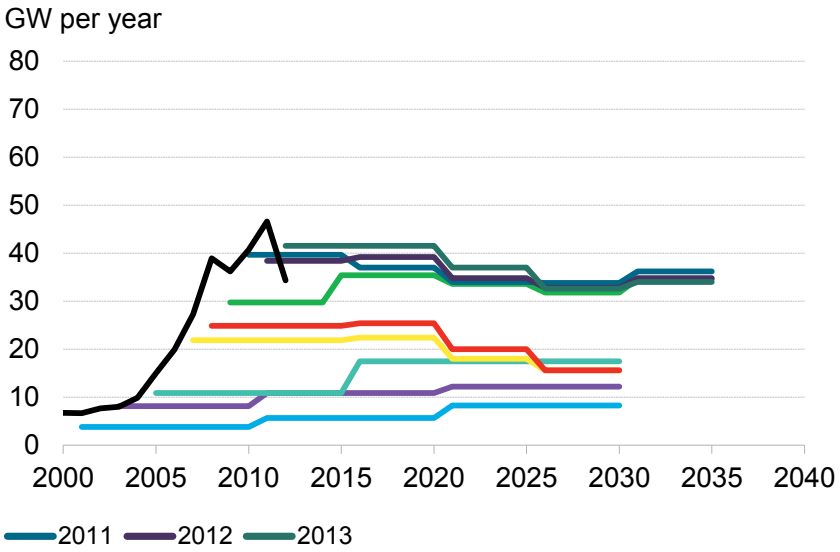
Global cumulative wind installations



Annual wind additions



Historical 2002 2004 2006 2008 2009 2010 2011 2012 2013

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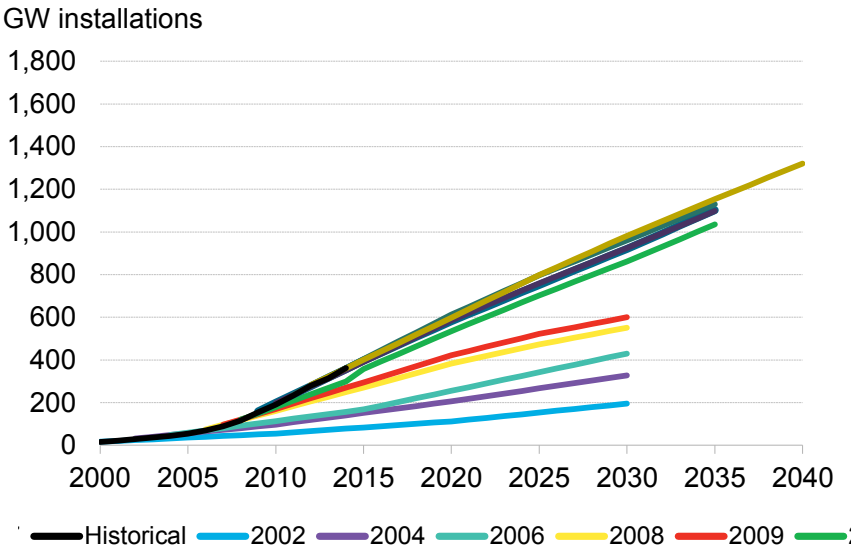
IEA wind capacity forecast evolution

Global cumulative wind installations



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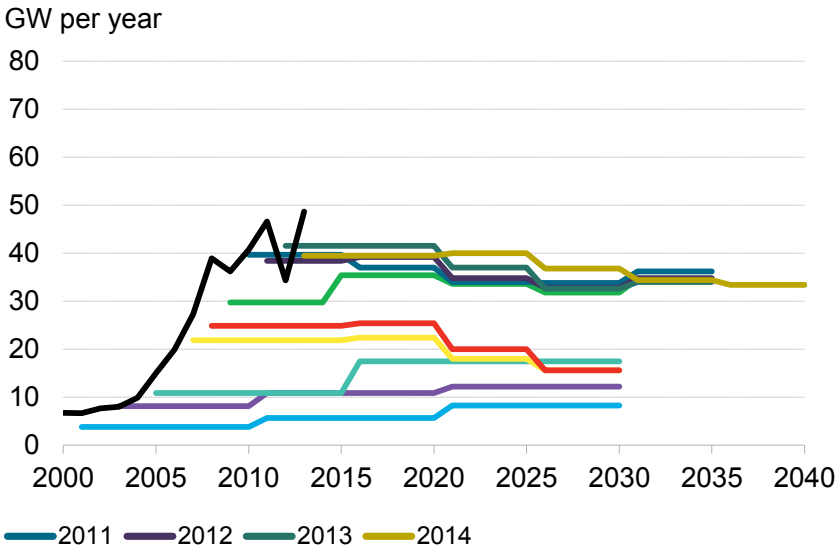

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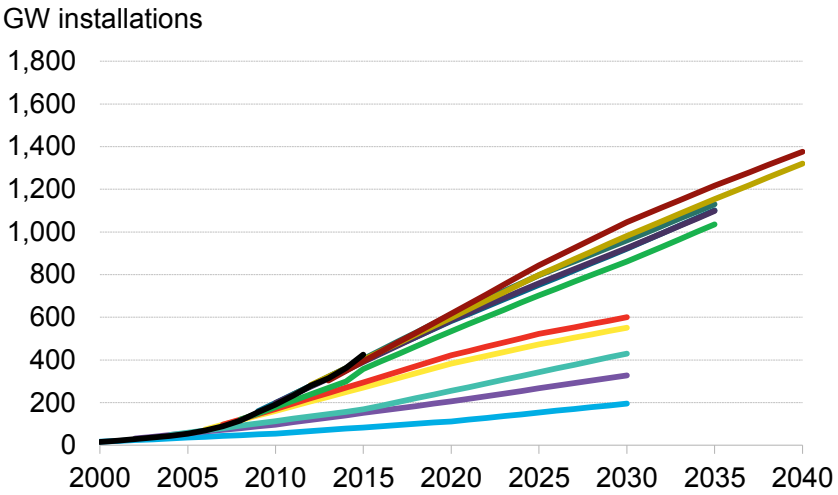
Global cumulative wind installations



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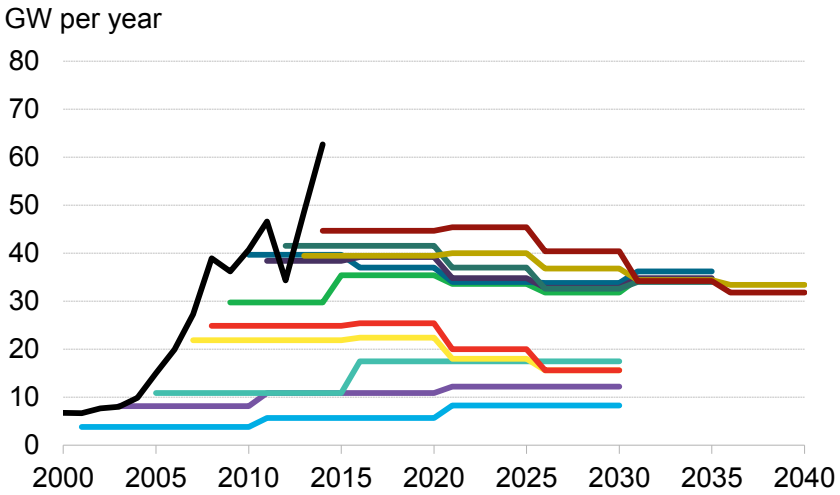

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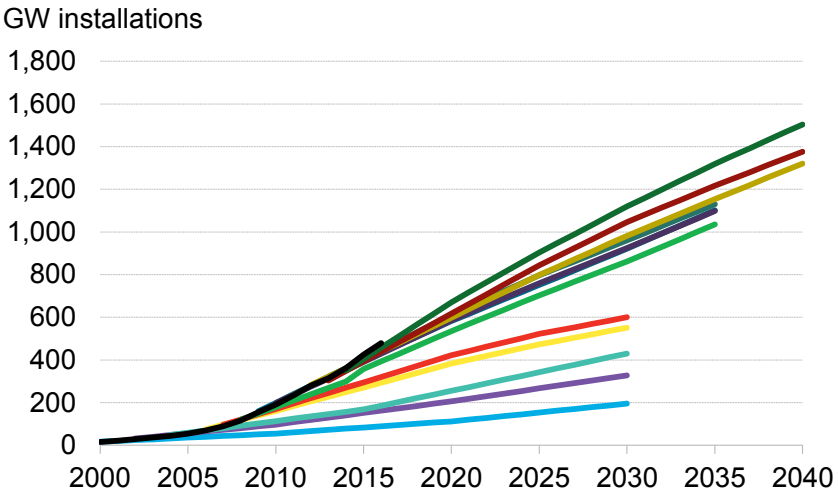
Global cumulative wind installations



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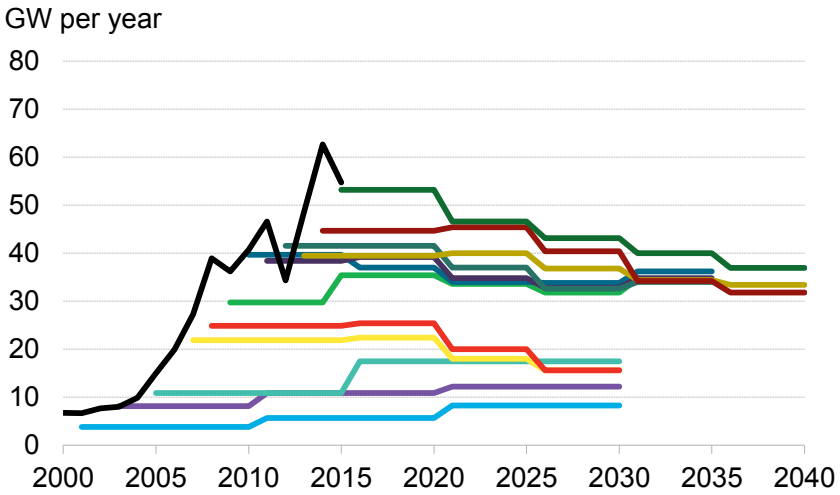

Historical 2002 2004 2006 2008 2009 2010 2011 2012 2013 2014 2015 2016

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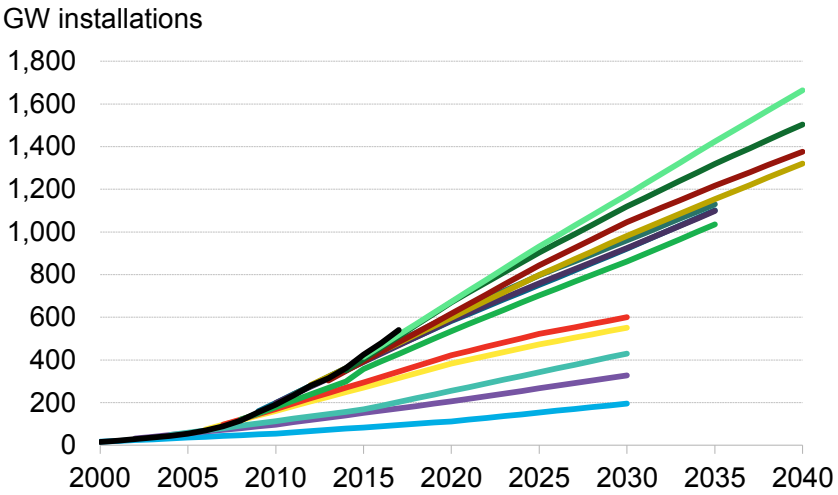
IEA wind capacity forecast evolution

Global cumulative wind installations



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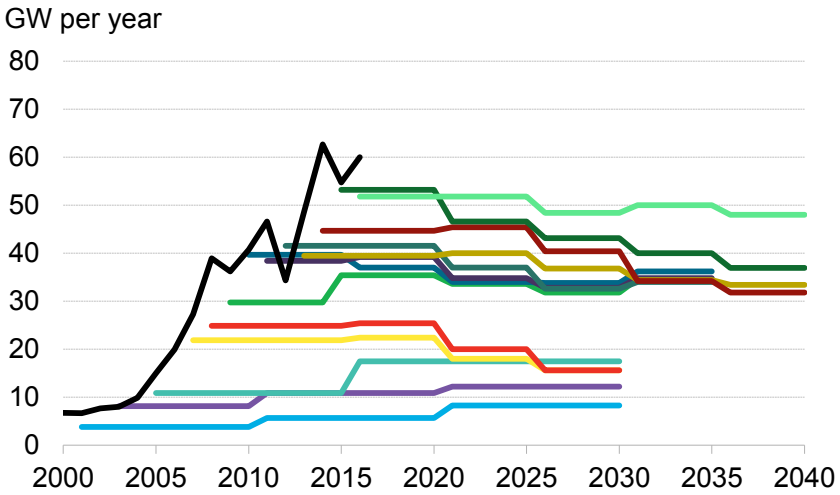

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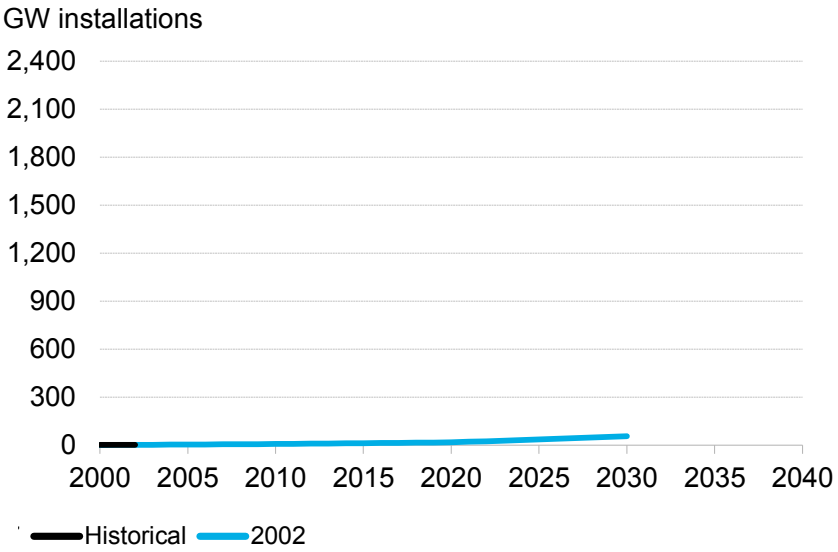
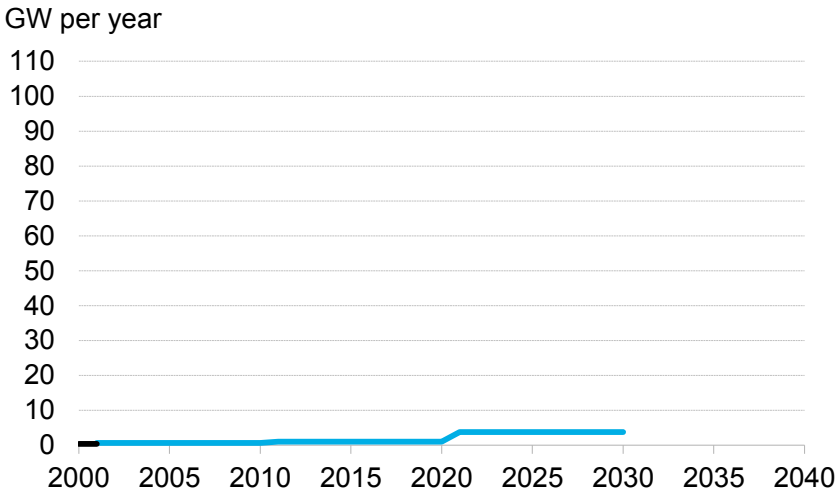
IEA solar capacity forecast evolution

Global cumulative solar installations



Note: 2002-2009 Reference, 2010-2017 New Policies Scenario

Annual solar additions



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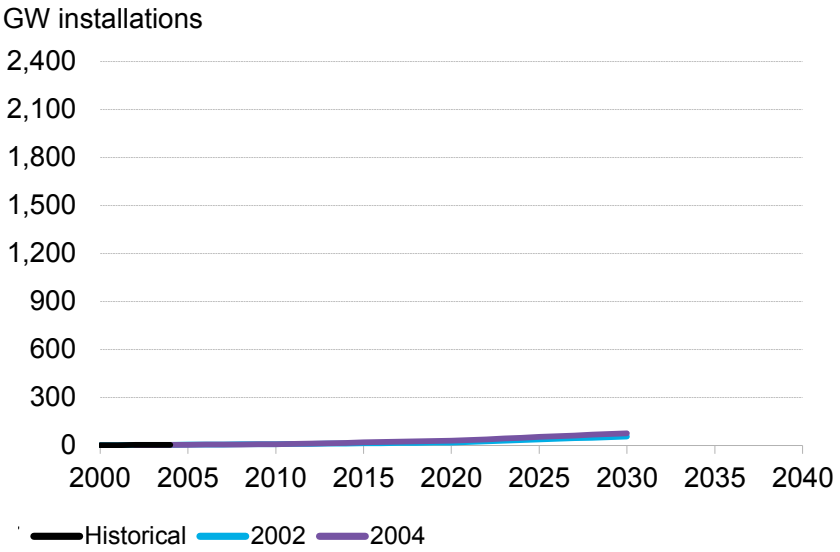
Global cumulative solar installations



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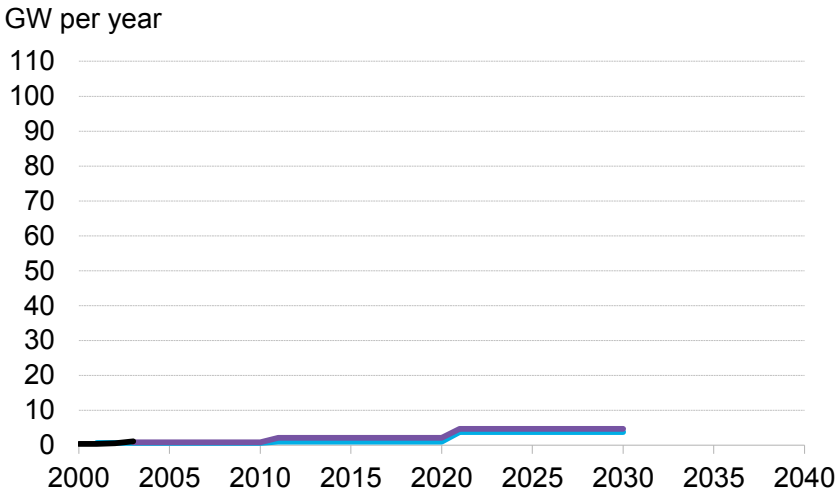

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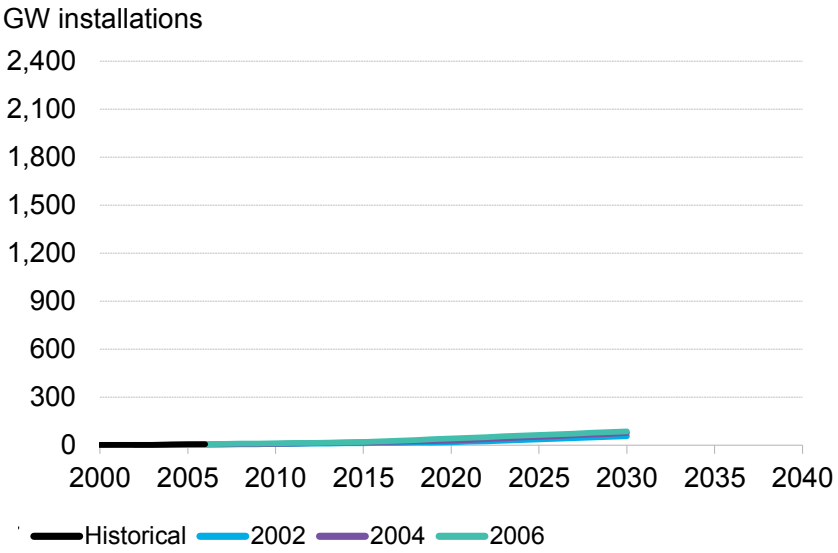
Global cumulative solar installations



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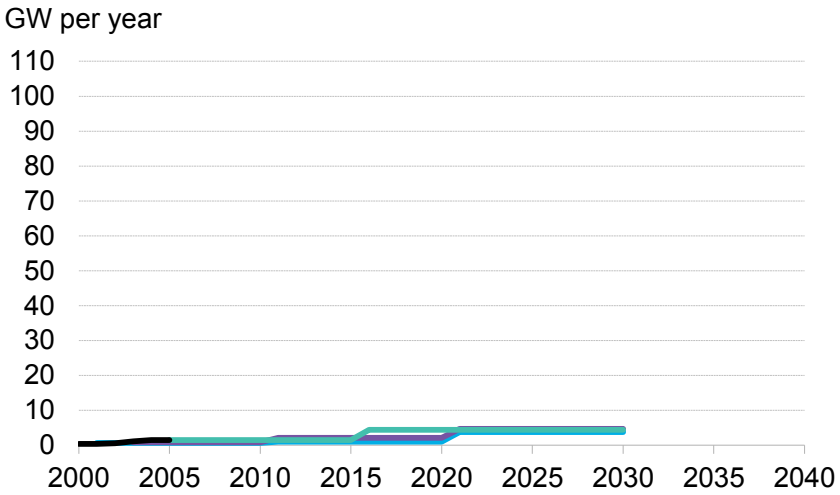
Annual solar additions



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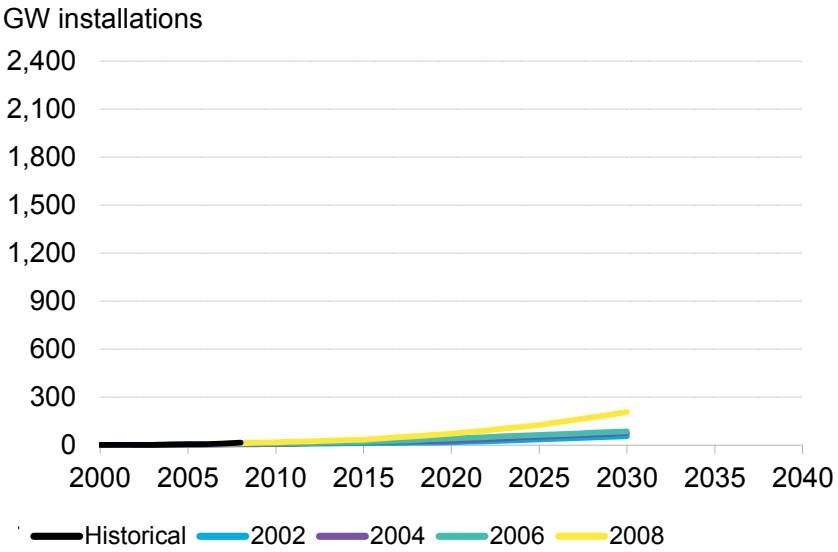
Global cumulative solar installations



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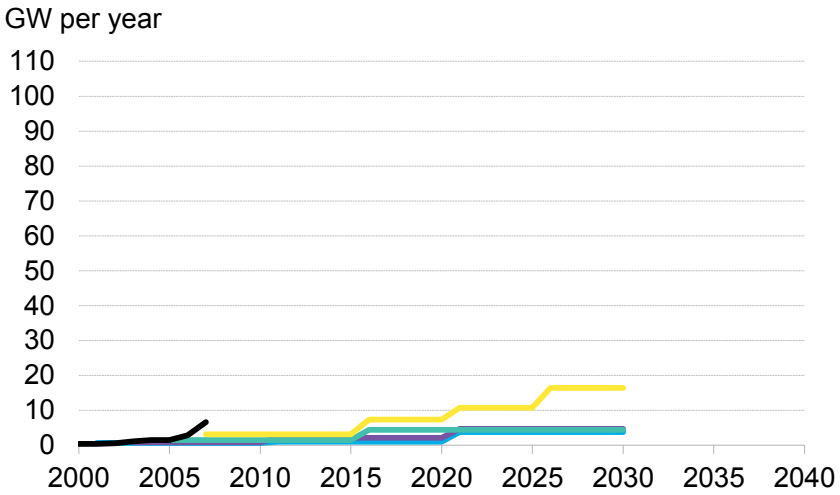

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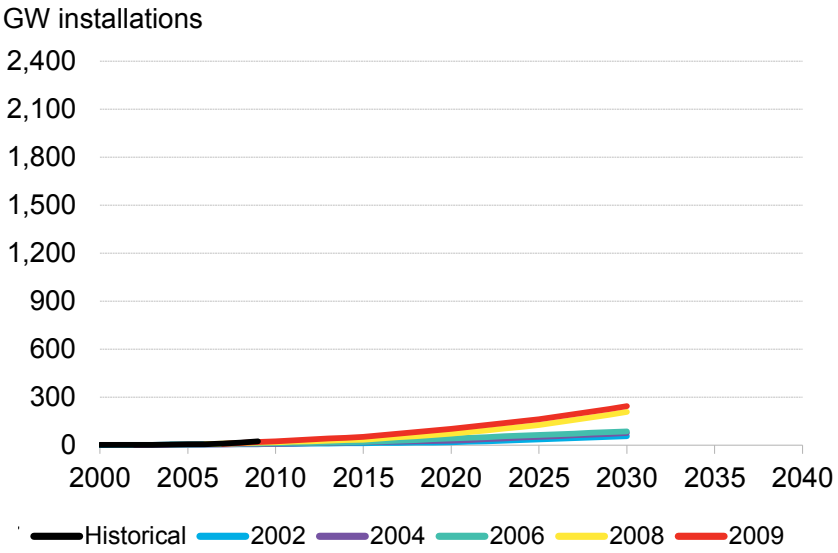

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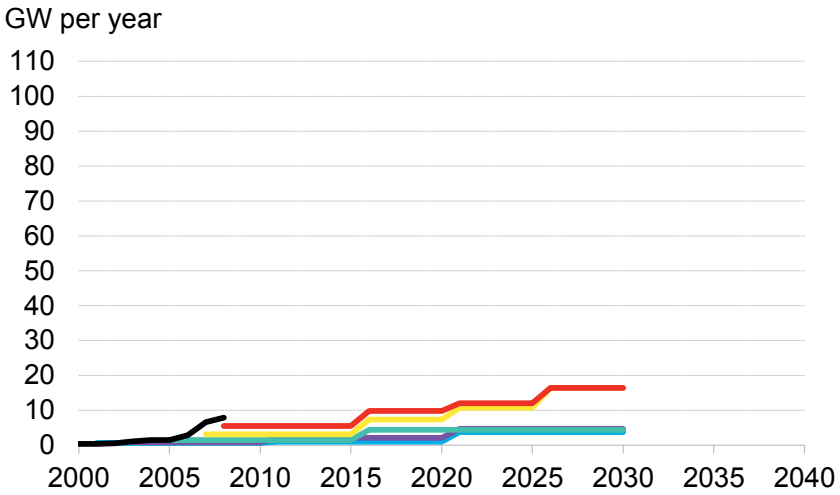

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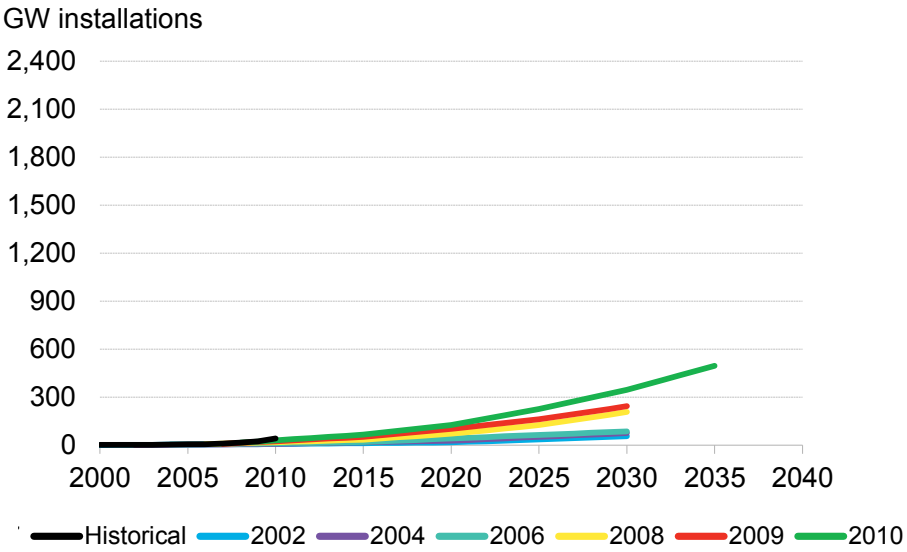

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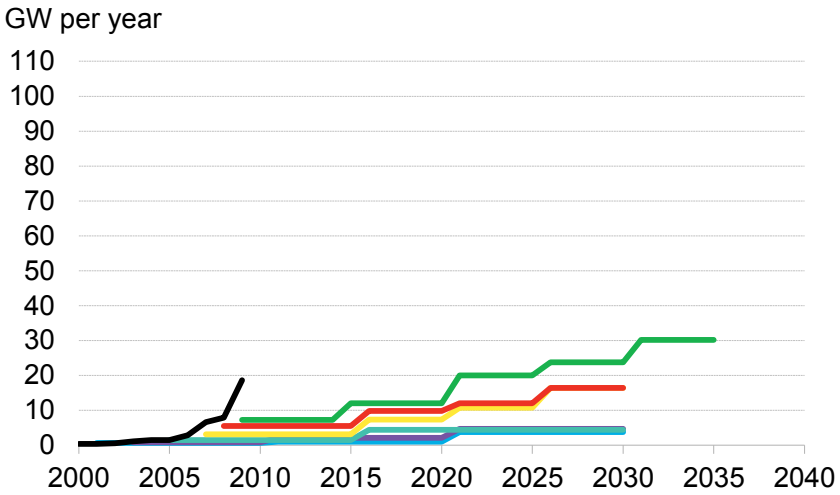
Annual solar additions



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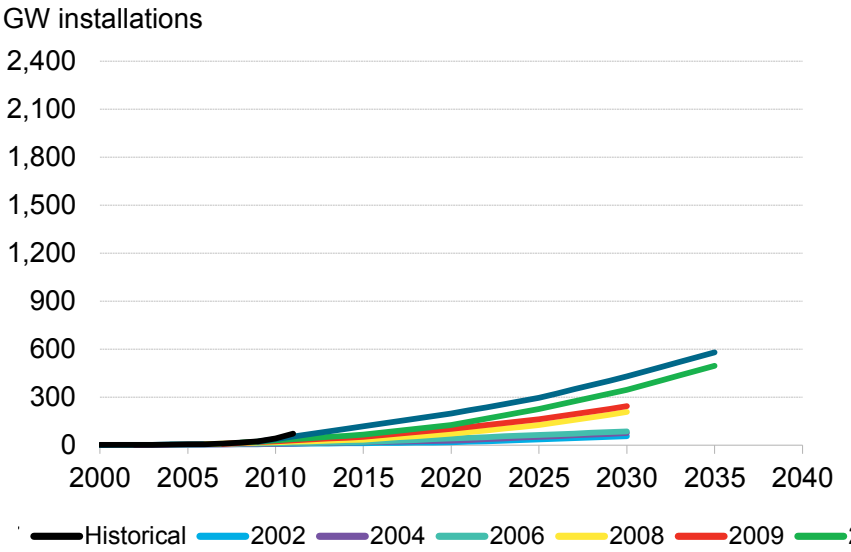
IEA solar capacity forecast evolution

Global cumulative solar installations



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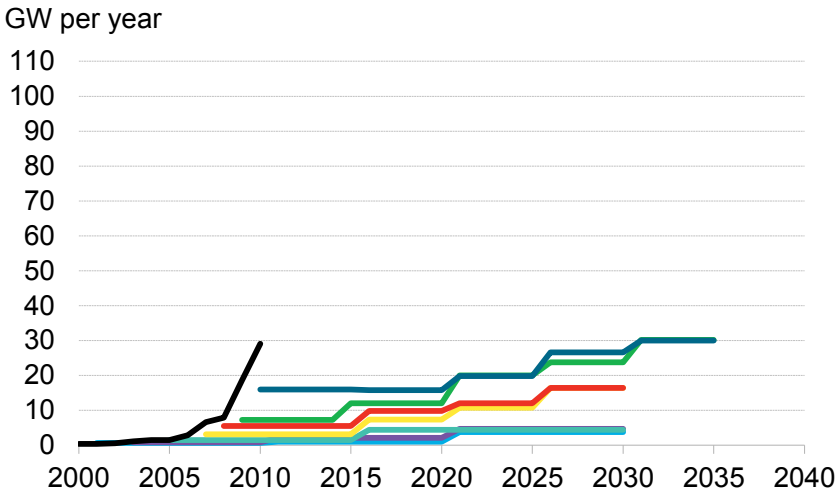
Annual solar additions



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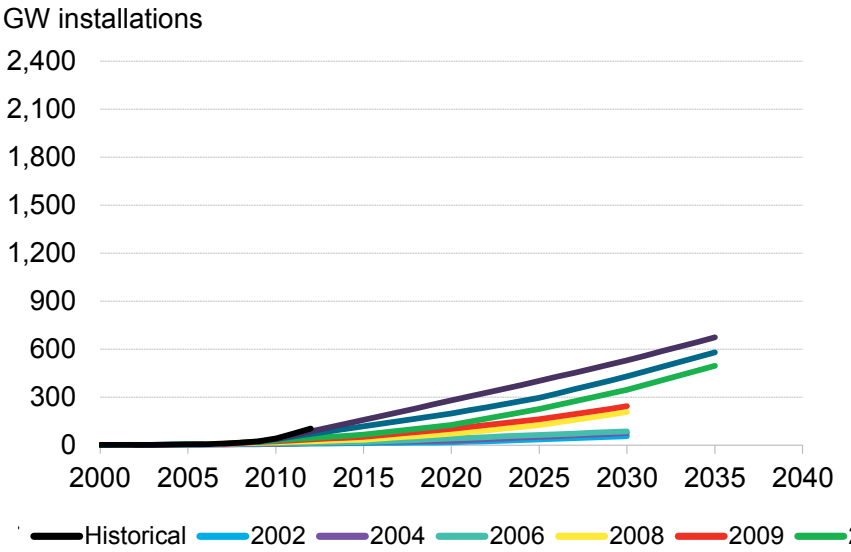
Global cumulative solar installations



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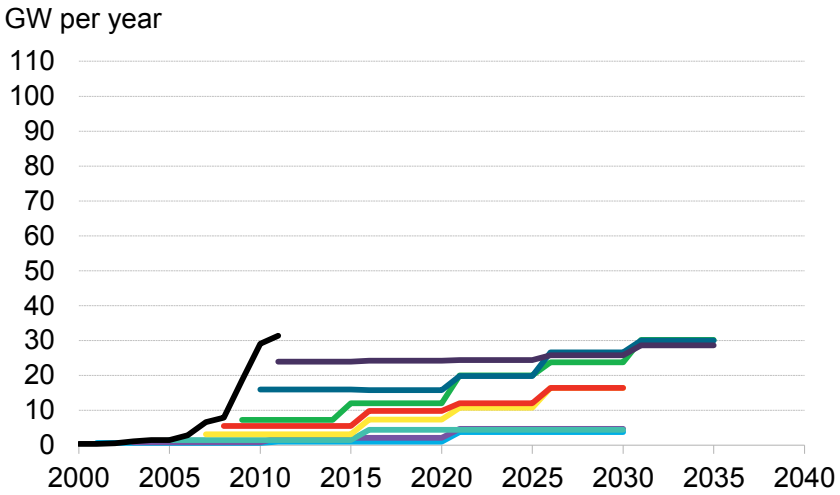
Annual solar additions



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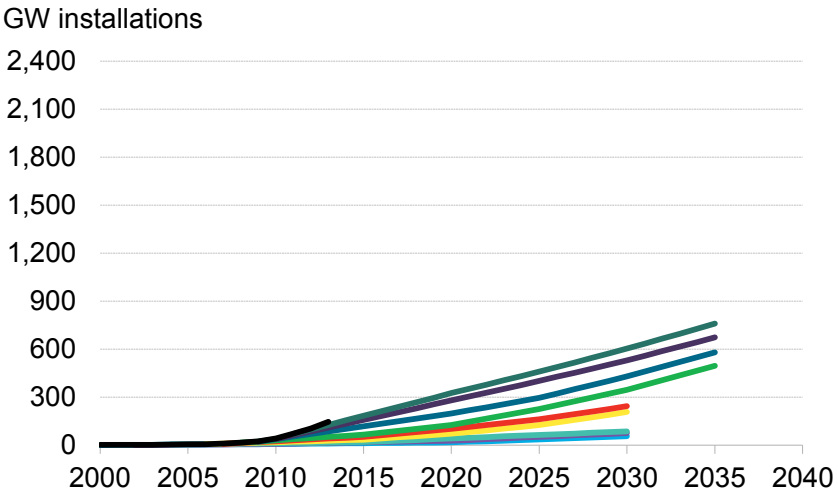
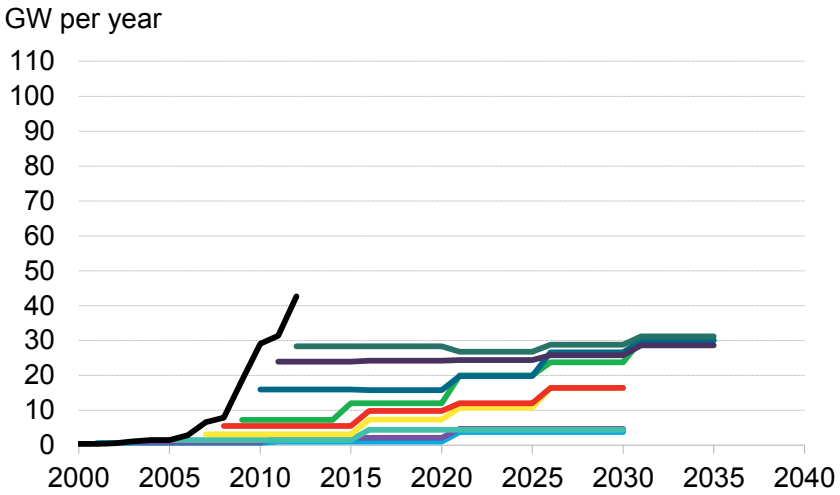
IEA solar capacity forecast evolution

Global cumulative solar installations



Annual solar additions



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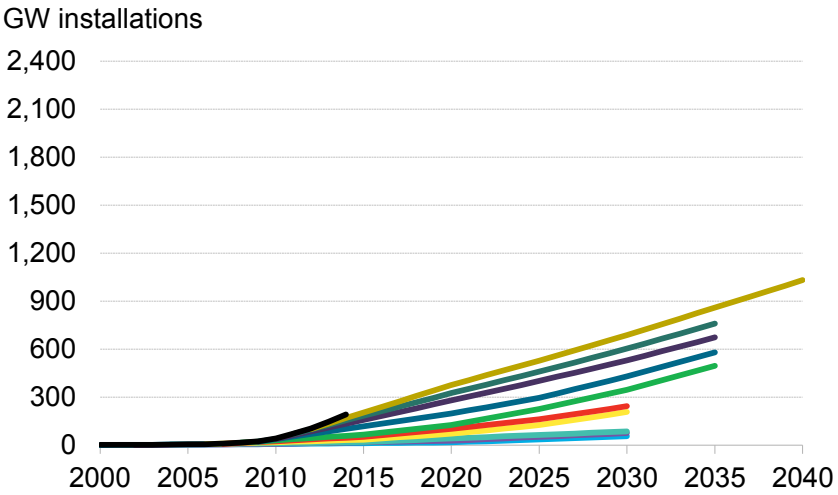
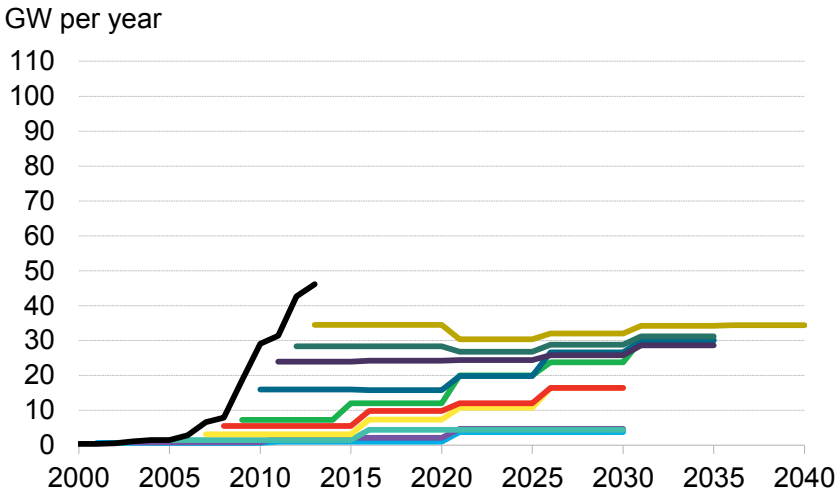


Annual solar additions



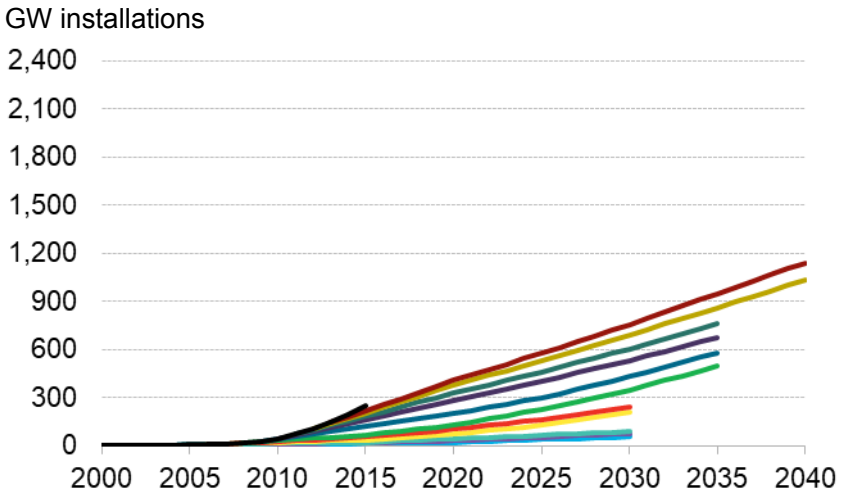
Historical 2002 2004 2006 2008 2009 2010 2011 2012 2013 2014

Note: 2002-2009 Reference, 2010-2017 New Policies Scenario

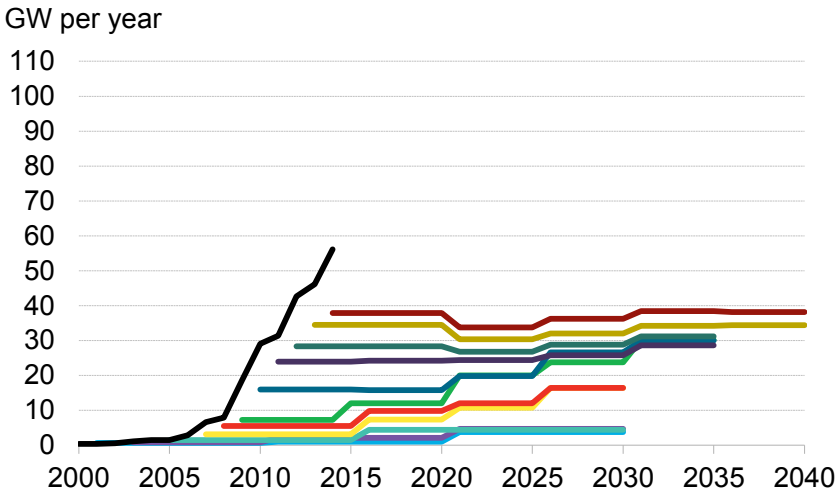
Source: IEA World Energy Outlook

IEA solar capacity forecast evolution

Global cumulative solar installations



Annual solar additions



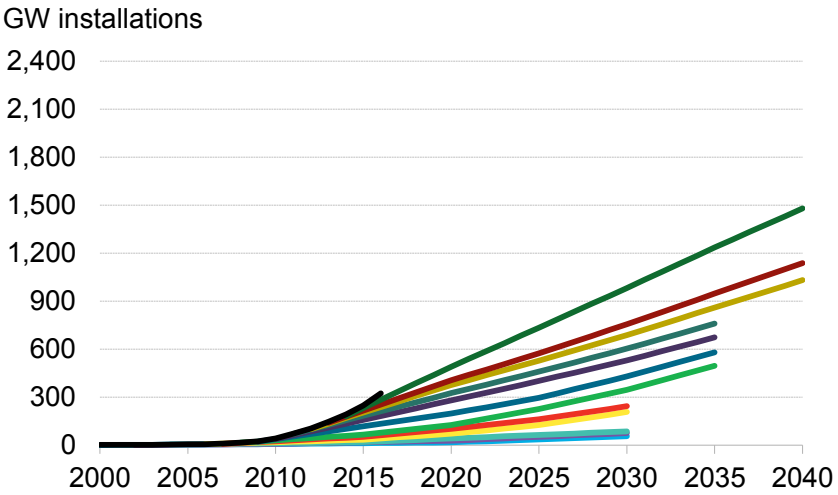
Historical 2002 2004 2006 2008 2009 2010 2011 2012 2013 2014 2015

Note: 2002-2009 Reference, 2010-2017 New Policies Scenario

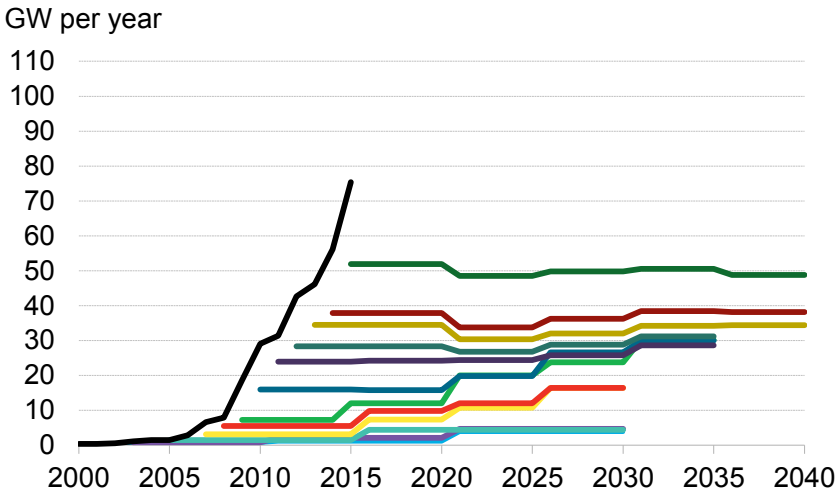
Source: IEA World Energy Outlook

IEA solar capacity forecast evolution

Global cumulative solar installations



Annual solar additions



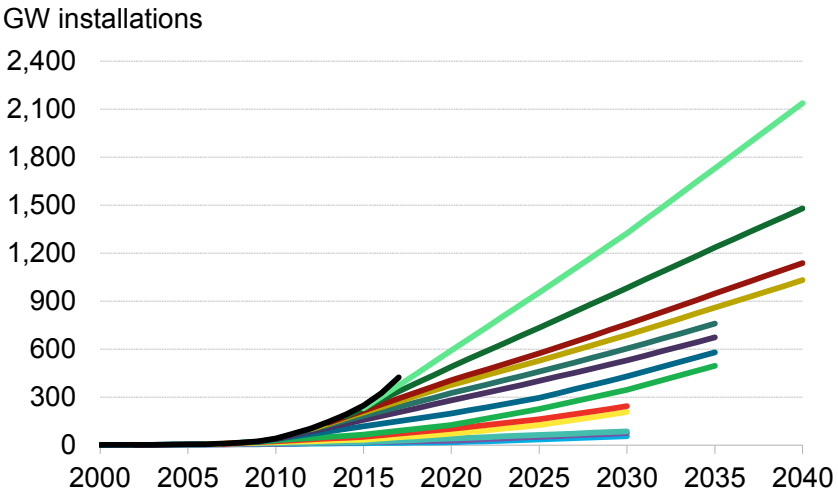
Historical 2002 2004 2006 2008 2009 2010 2011 2012 2013 2014 2015 2016

Note: 2002-2009 Reference, 2010-2017 New Policies Scenario

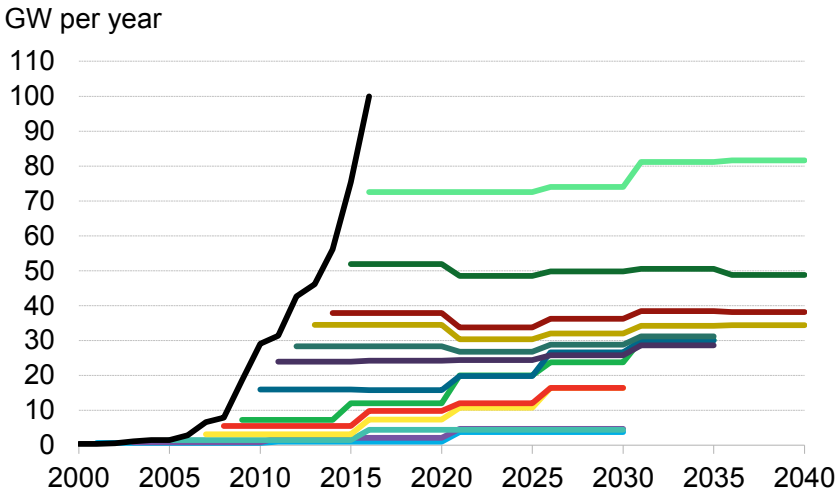
Source: IEA World Energy Outlook

IEA solar capacity forecast evolution

Global cumulative solar installations



Annual solar additions



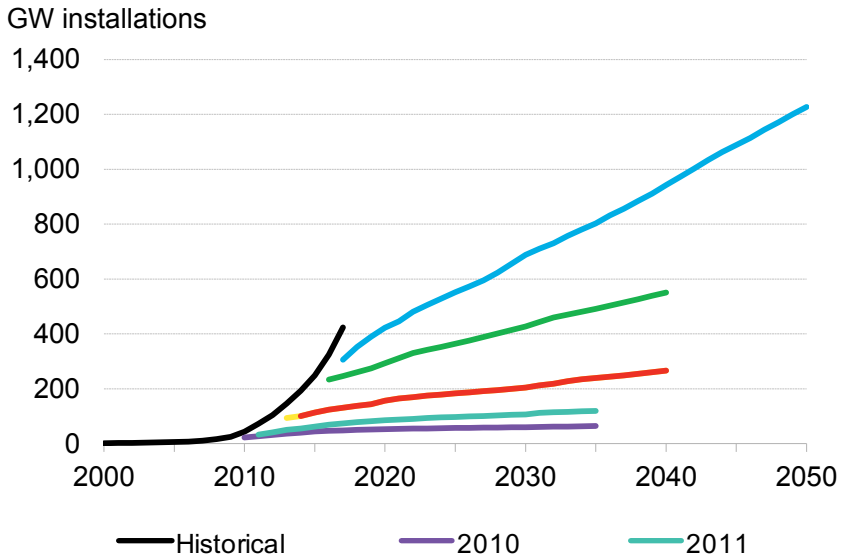
Historical 2002 2004 2006 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017

Note: 2002-2009 Reference, 2010-2017 New Policies Scenario

Source: IEA World Energy Outlook

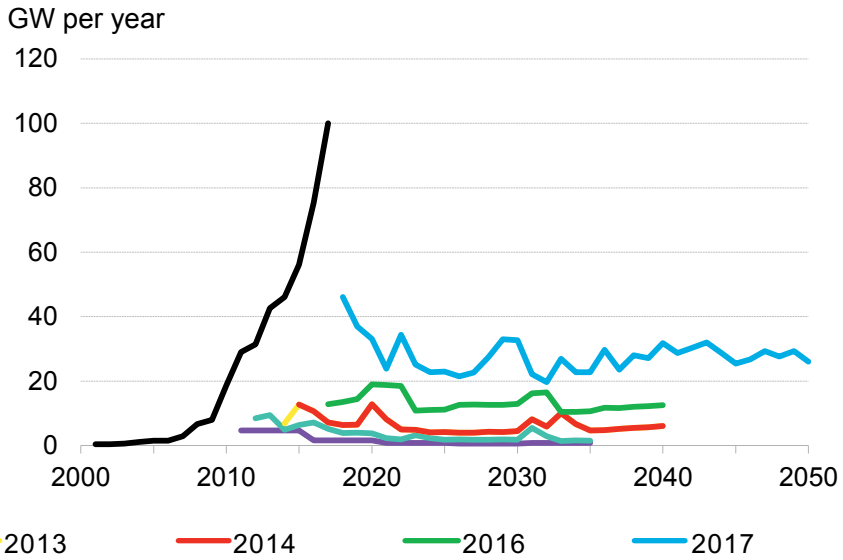
EIA solar capacity forecast evolution

Global cumulative solar installations



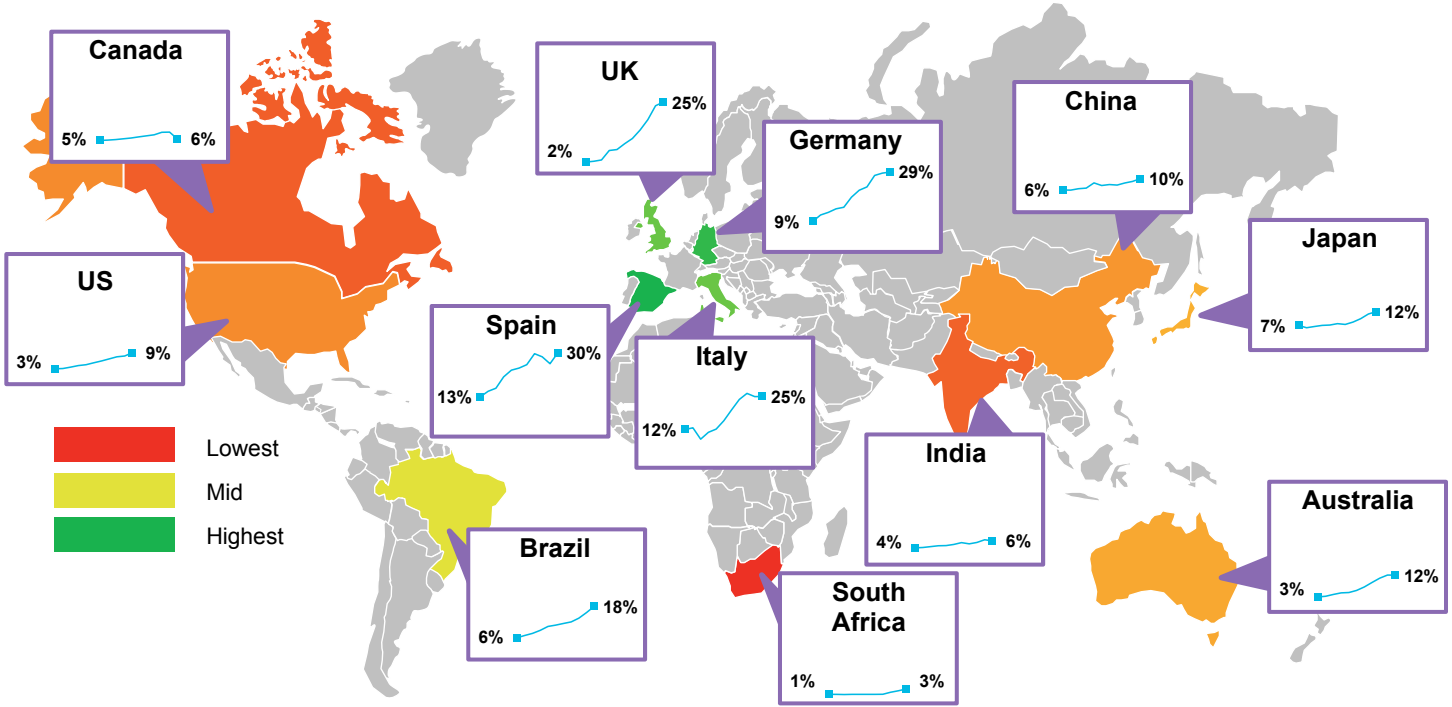
Note: Reference scenario

Annual solar additions



Source: EIA International Energy Outlook

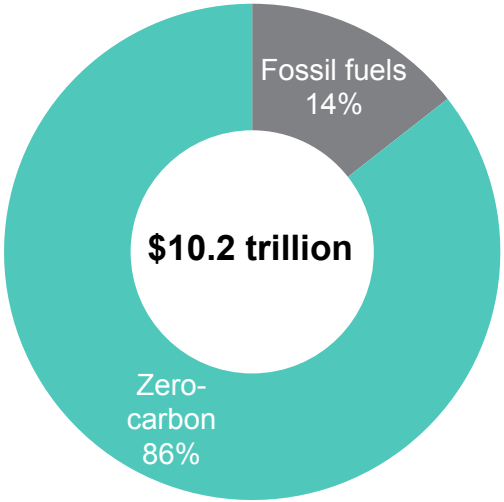
Renewable energy proportion of power generation, 2006-16



Note: Excludes large hydro Source: Bloomberg New Energy Finance

Solar and wind attract 60% of new investment in power generating capacity

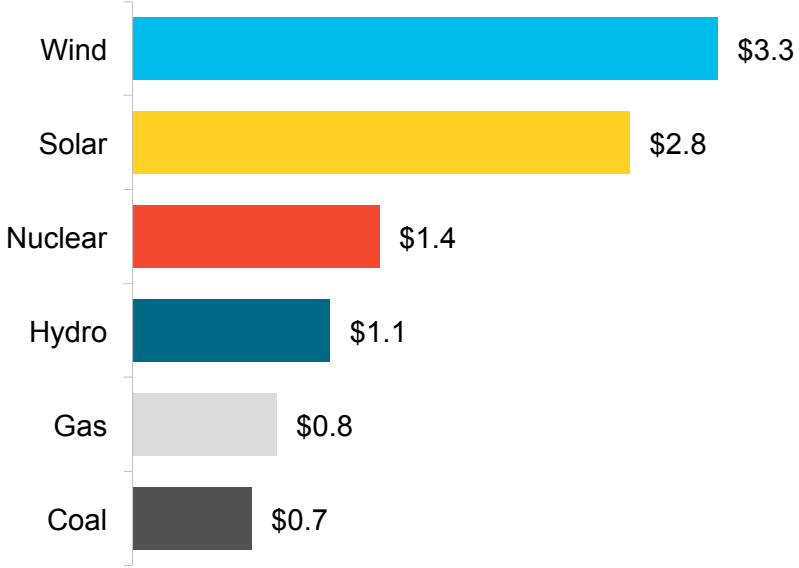
Investment, by technology, 2017-2040



Source: Bloomberg New Energy Finance, NEO 2017

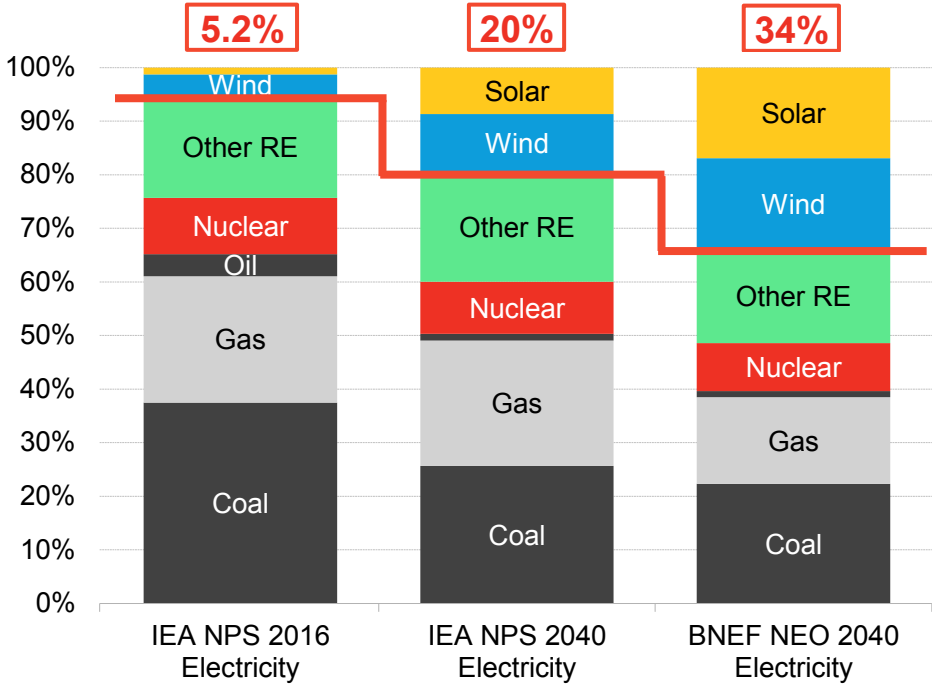
Investment, by technology, 2017-2040

($ trillion - 2016 real)



Wind and solar contribution to global power generation

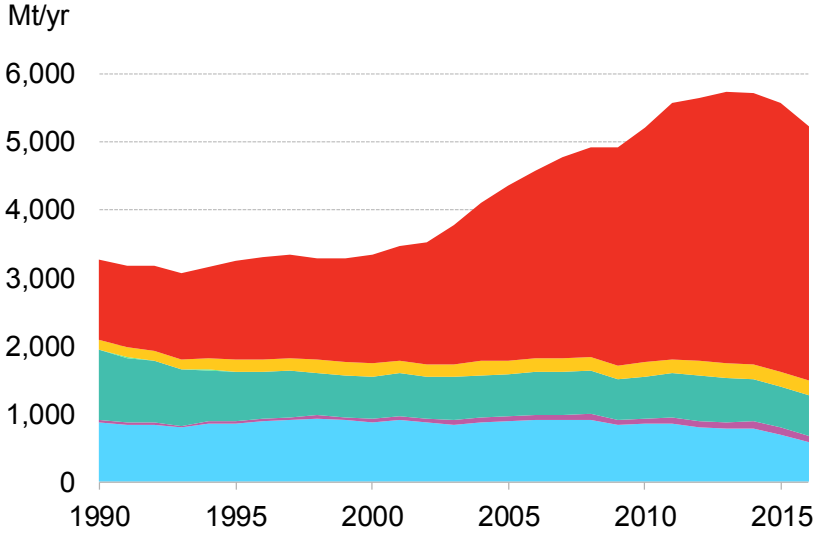
By 2040
20 to 34% of power globally will be from variable sources



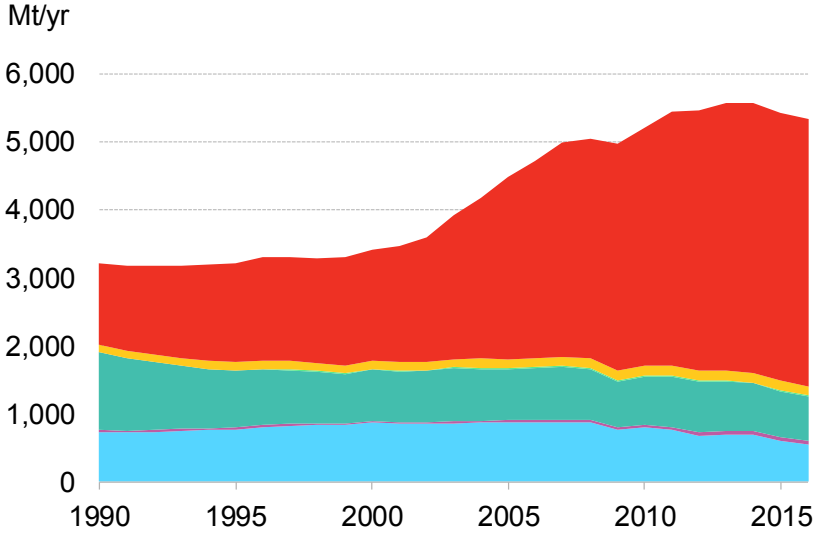
Source: BNEF; IEA WEO; Liebreich Associates

Coal has peaked

Coal production



Coal consumption

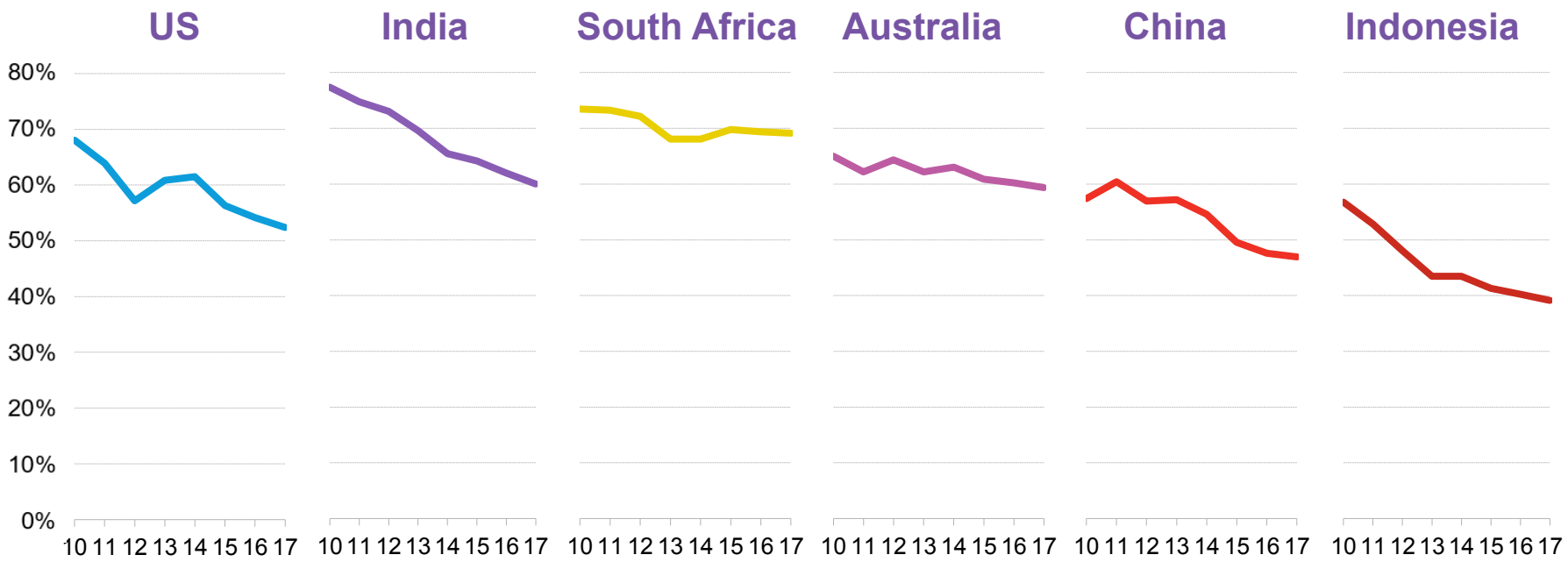


Asia Pacific Africa Middle East Europe & Eurasia S & Cent. America North America

Note: Adjusted to standard coal equivalent

Source: Bloomberg New Energy Finance, BP Statistical Review

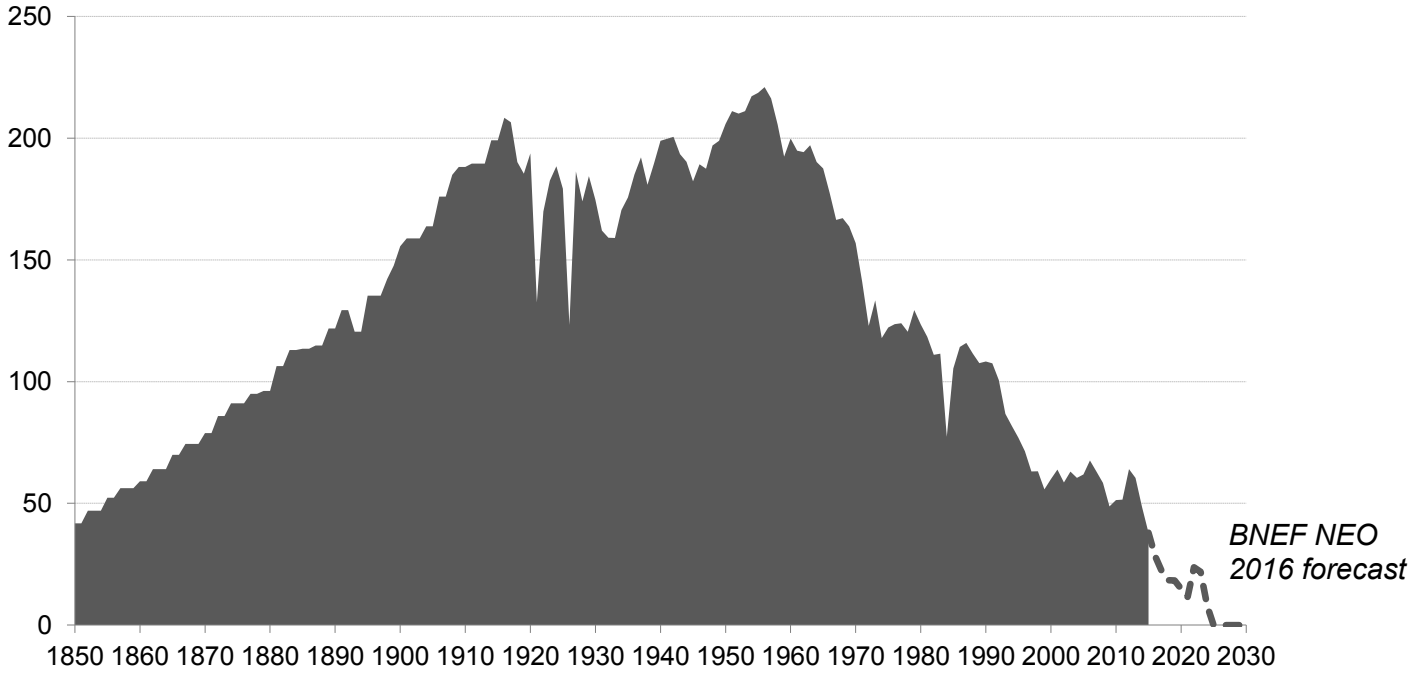
Coal capacity factors, selected countries



Notes: Based on end-of-year capacity figures; 2017 is estimated

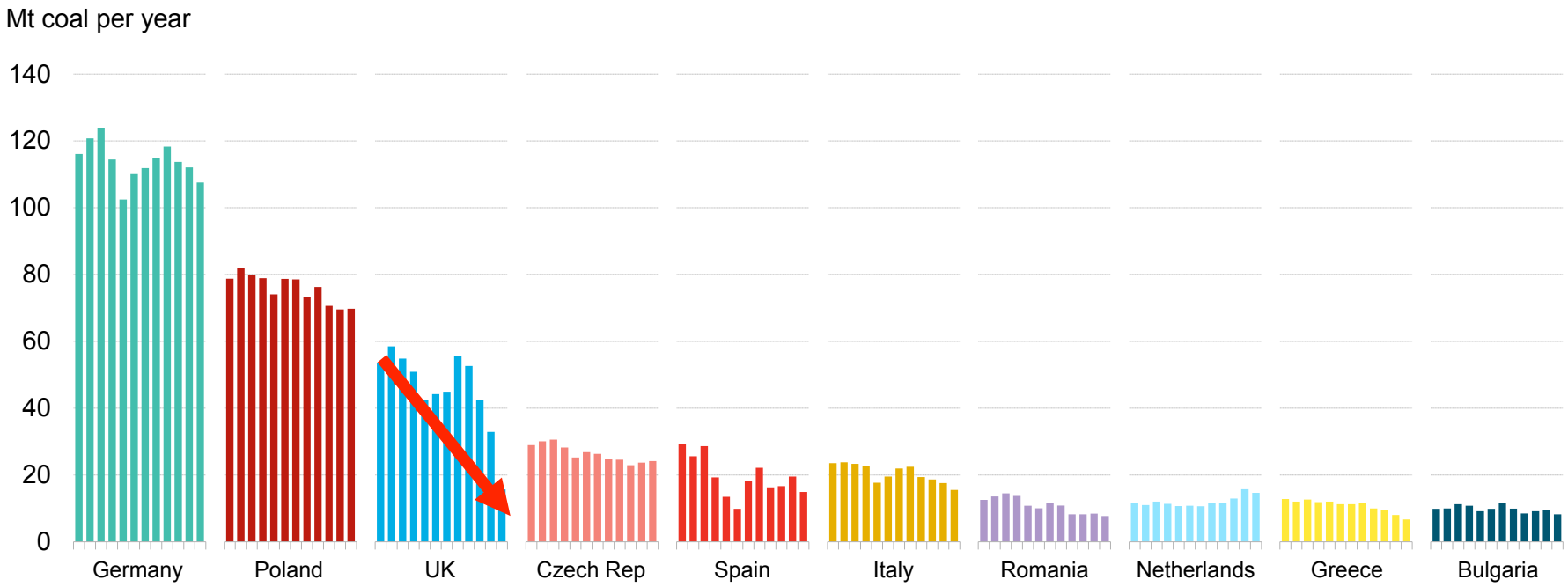
Source: BNEF, IEA, EIA, India CEA, NERSA, Australia DOWS

UK coal consumption 1850-2030 (mt/yr)



Source: BEIS, Prof. David Rutledge, Bloomberg New Energy Finance

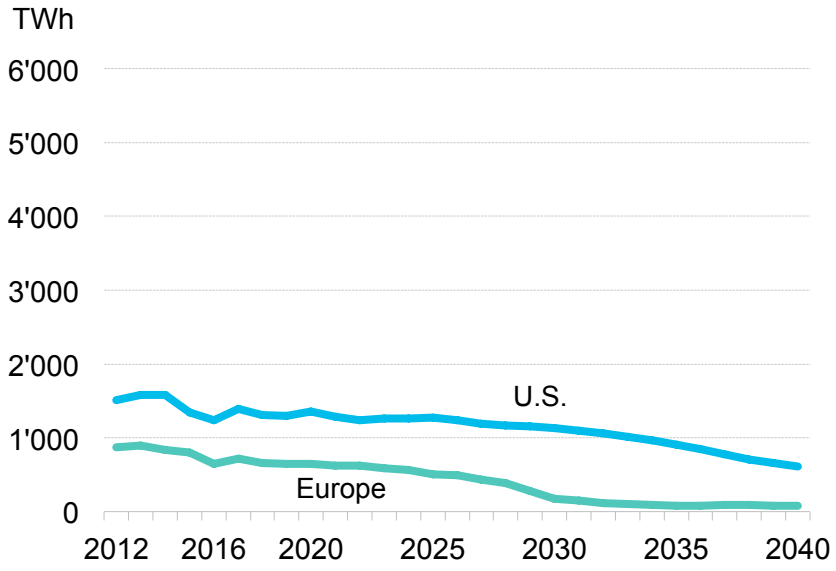
EU member state coal consumption 2000-16



Source: Bloomberg New Energy Finance, BP Statistical Review

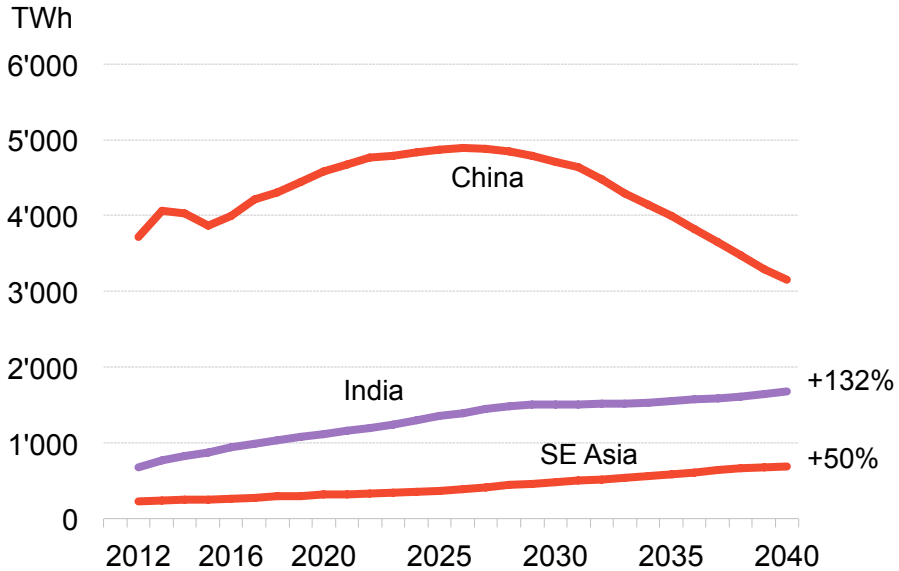
Poor outlook for coal in U.S., Europe and China

Coal generation



Source: Bloomberg New Energy Finance

Coal generation



Source: Bloomberg New Energy Finance

Price of renewable energy in India

“The cost of solar power is now cheaper than coal in this country.”

Piyush Goyal
Minister of State for Power, Coal, New & Renewable Energy and Mines, India

Image: Twitter

Making America Great Again

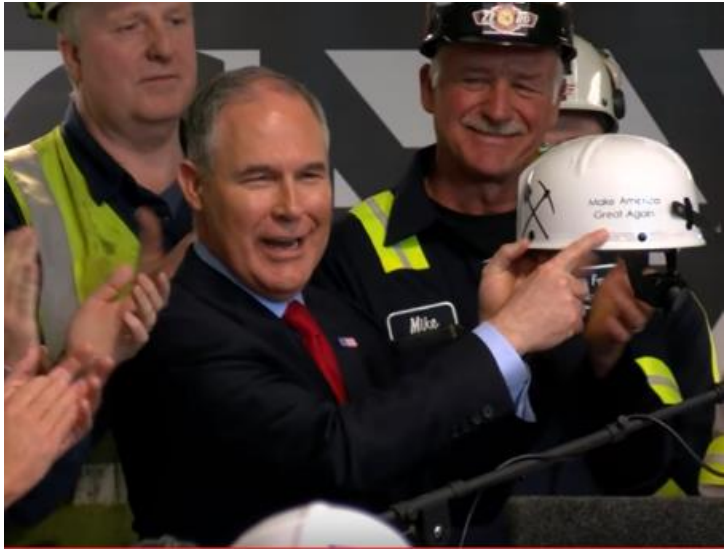
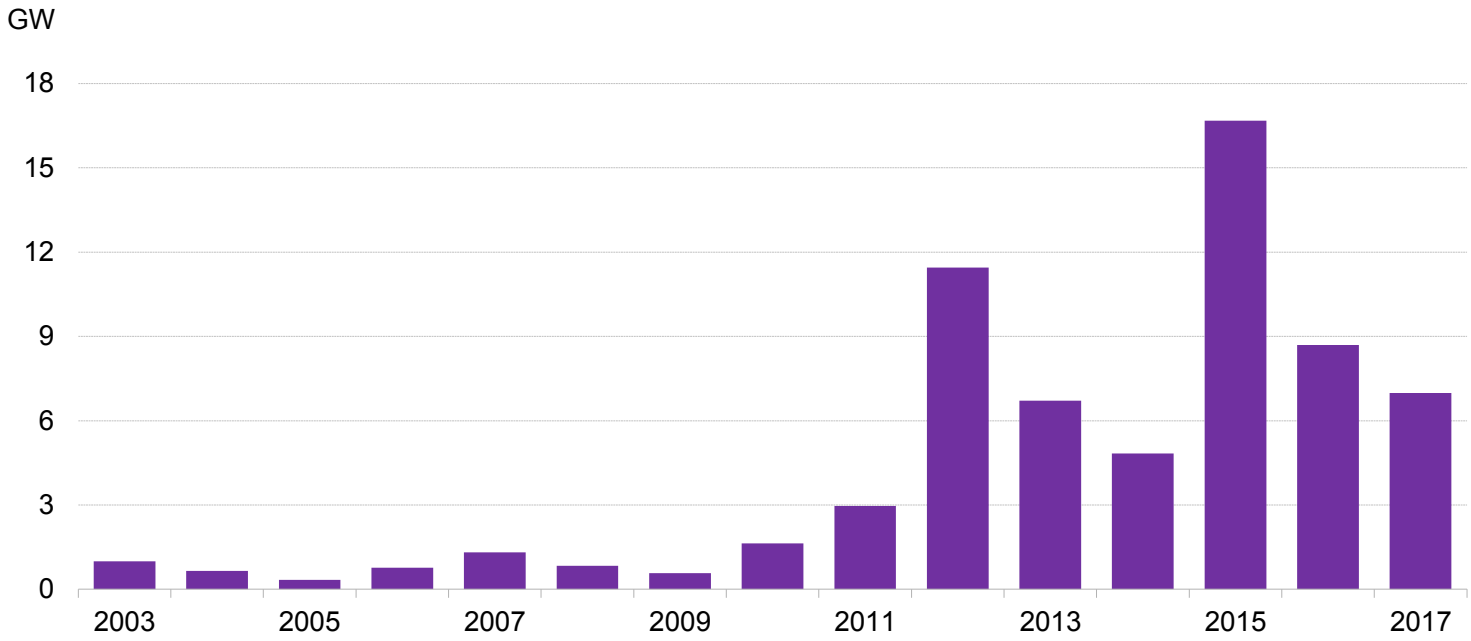


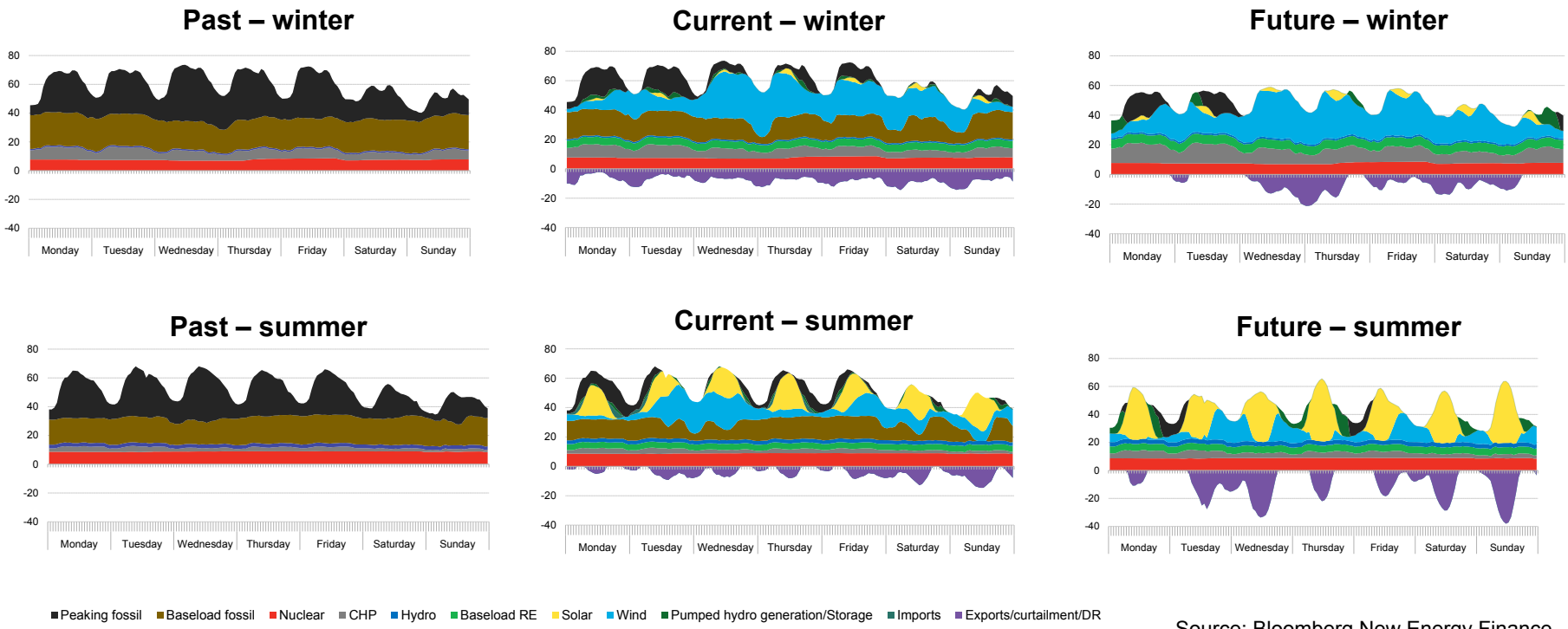
Image: White House; EPA

Coal plant retirements in US



Source: EIA, CleanTechnica

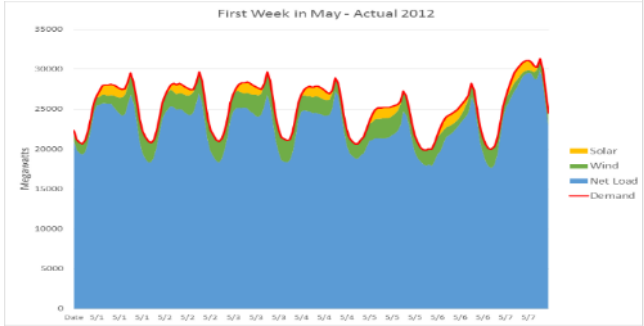
Evolving structure of power supply
Germany



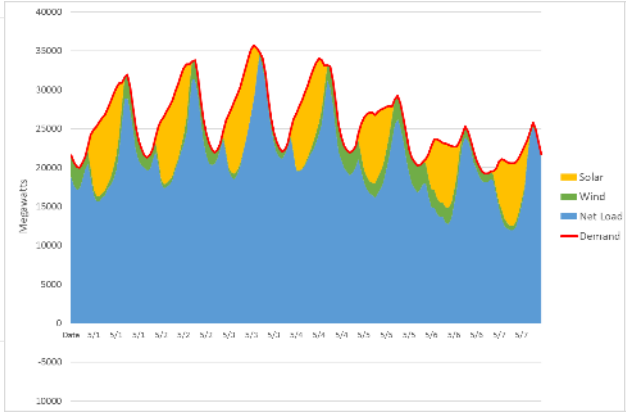
Source: Bloomberg New Energy Finance

Evolving structure of power supply
California

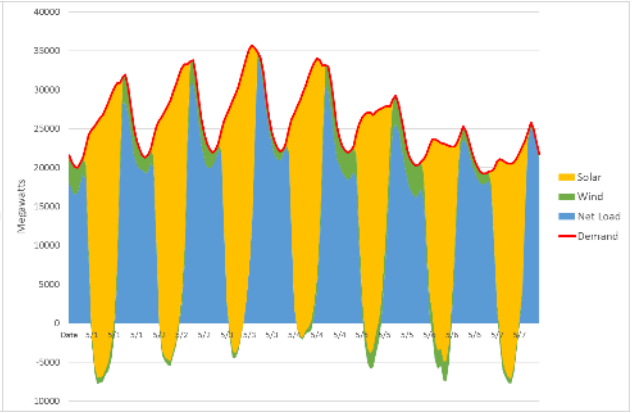
First week of May 2012 (actual)



First week of May 2017 (actual)

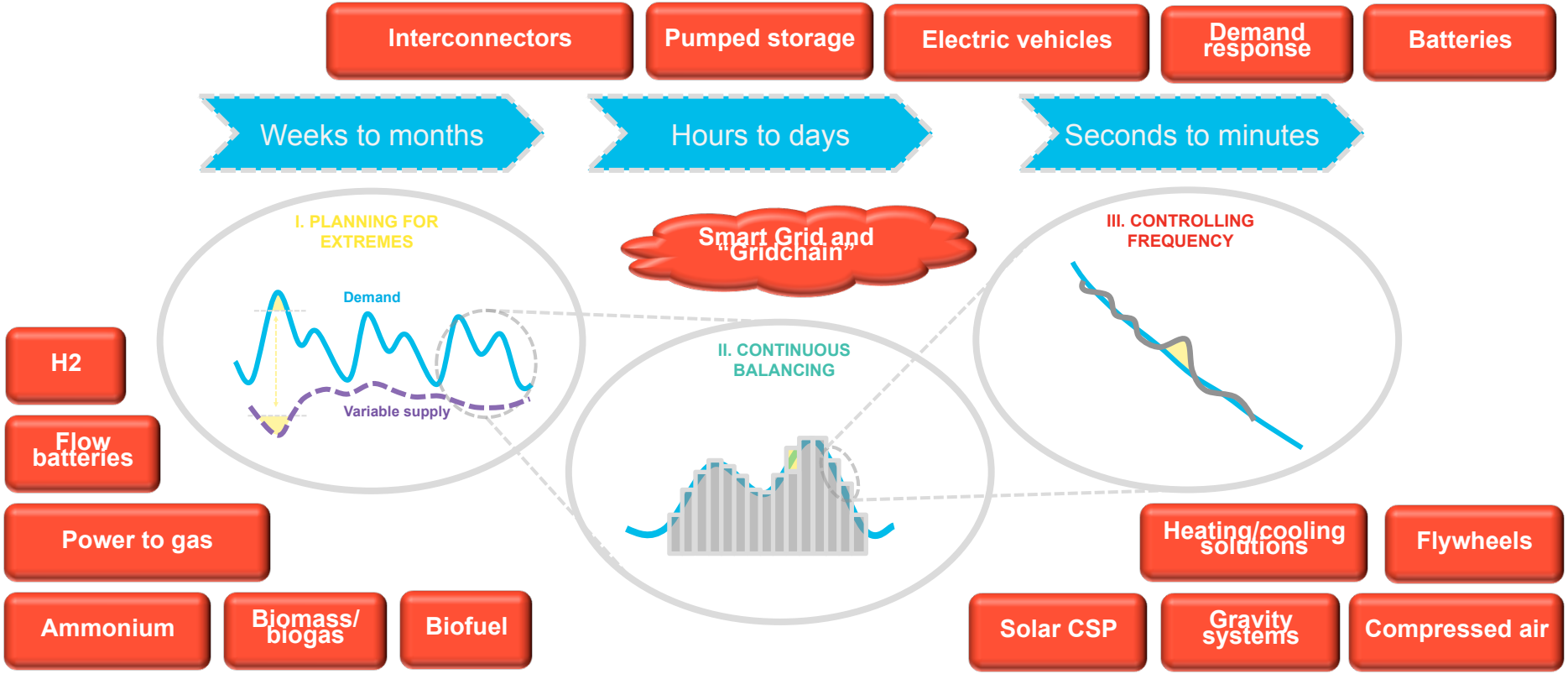


First week of May 2030 (modelled)



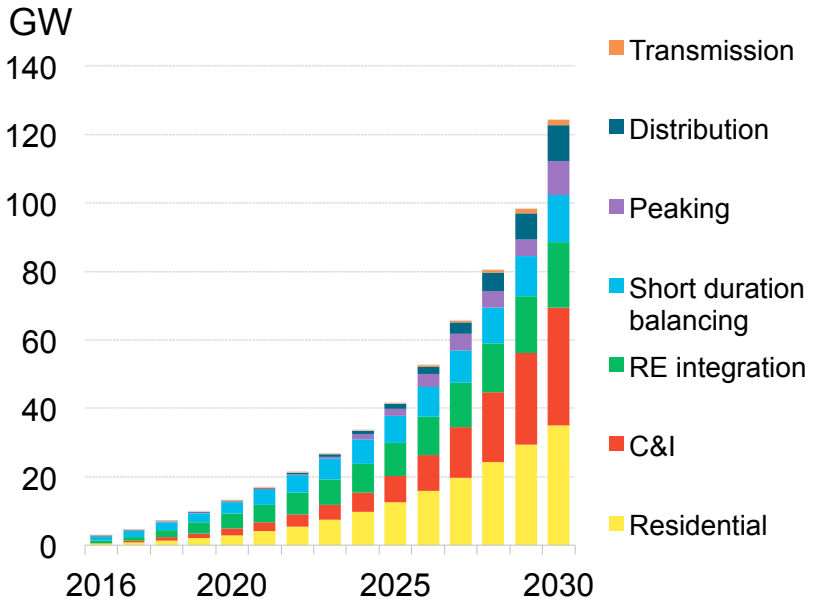
Source: CAISO OASIS; CPUC proposed IRP; LS Power; CESA; Bloomberg New Energy Finance

Balancing the grid



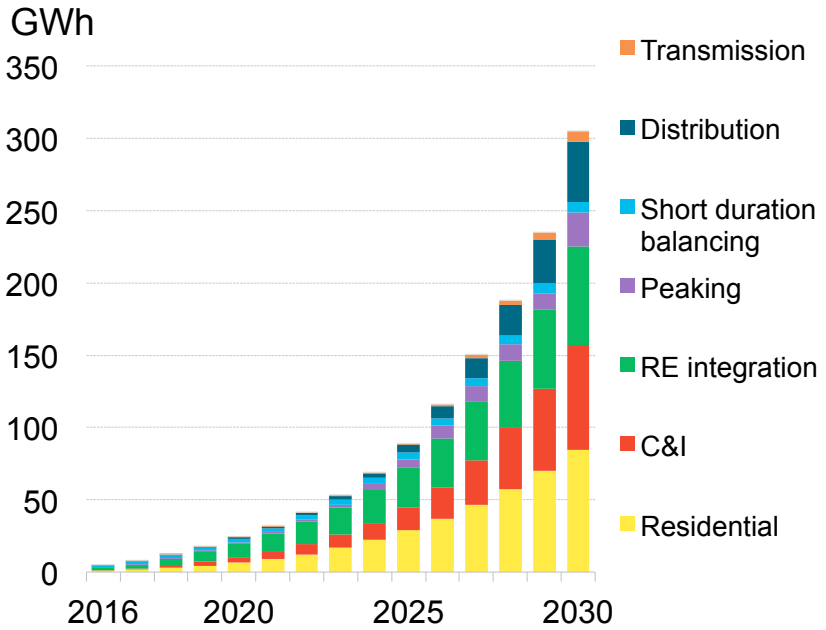
Cumulative storage deployments

Based on power output



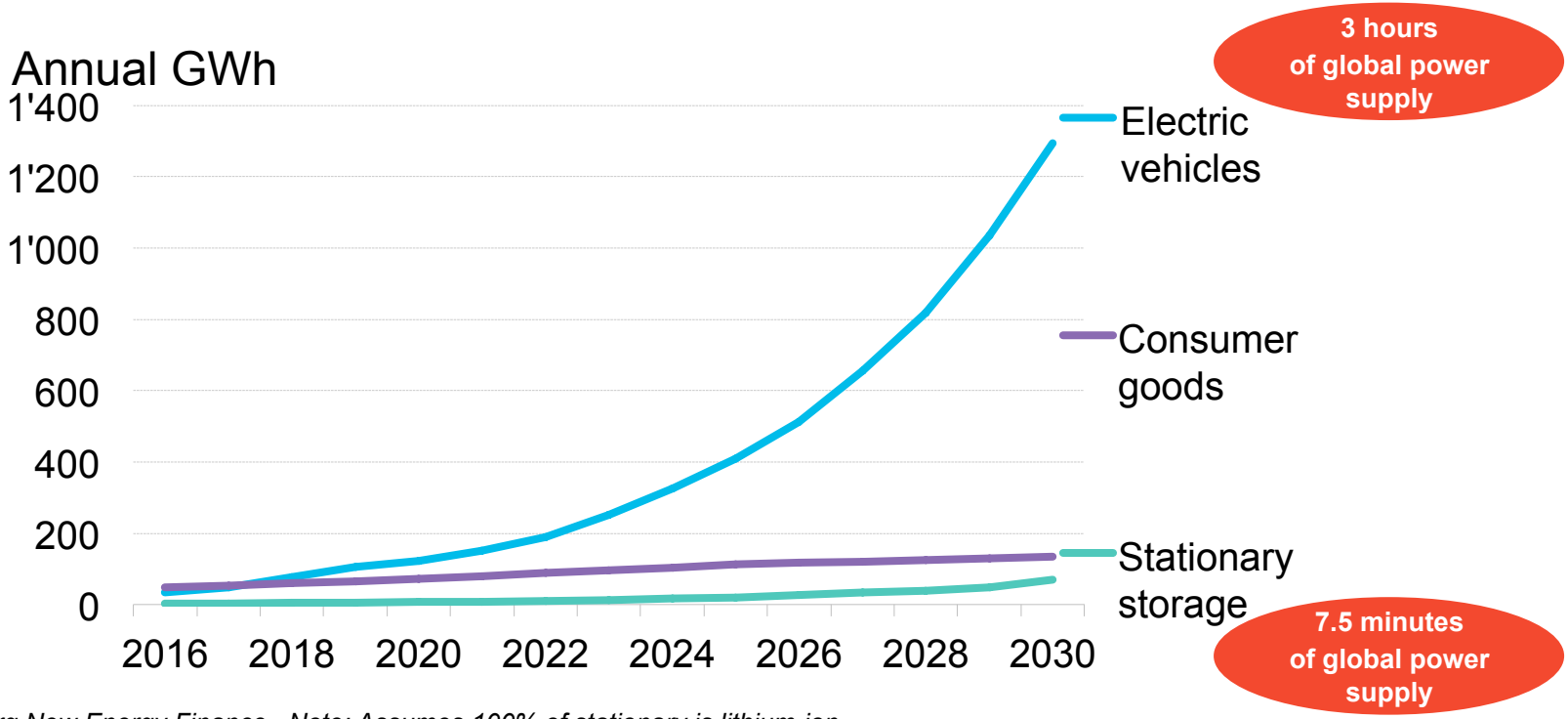
Source: Bloomberg New Energy Finance

Based on energy capacity



Source: Bloomberg New Energy Finance

Global lithium-ion demand by market segment



Source: Bloomberg New Energy Finance. Note: Assumes 100% of stationary is lithium-ion.

ICE and electric vehicle fleet

CARS AND TRUCKS IN USE WORLDWIDE, 2016

1.4 billion

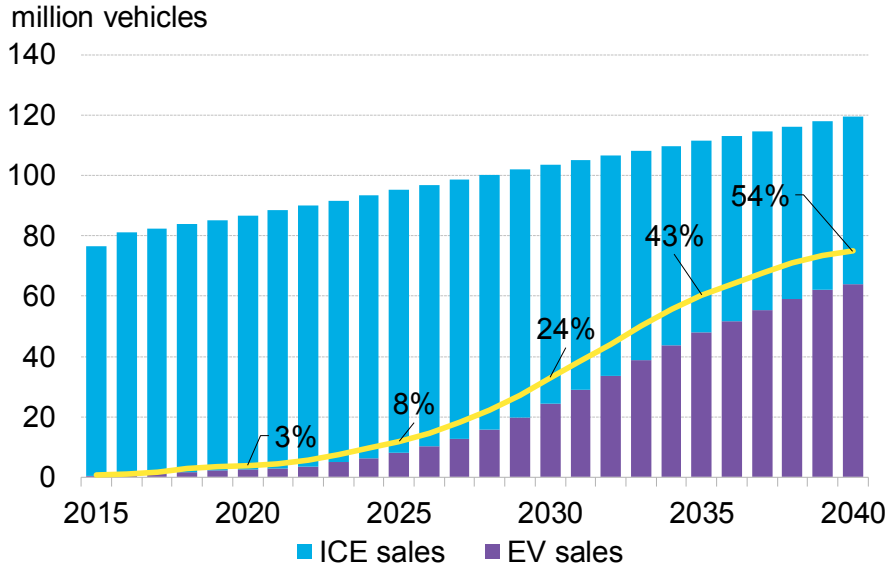
ELECTRIC VEHICLES IN USE WORLDWIDE, END 2017

2.8 million (to scale)

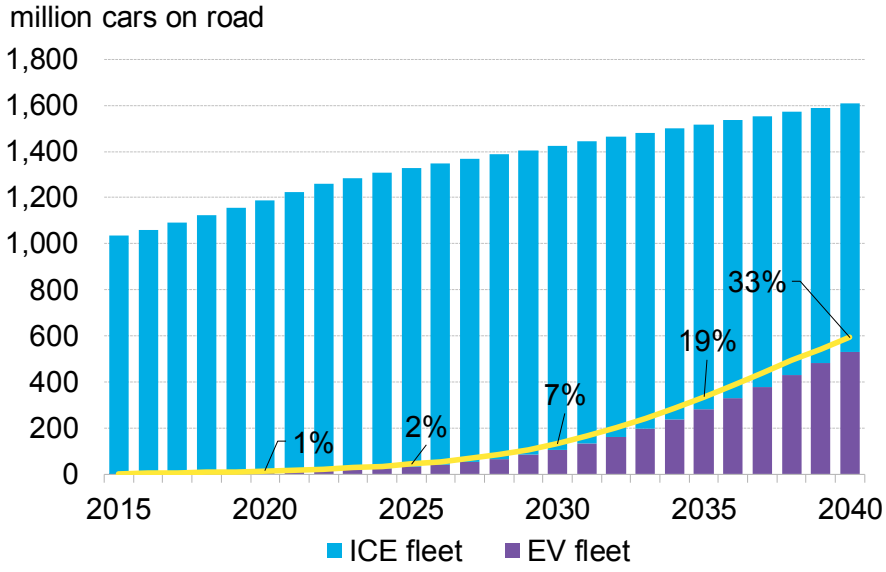
Source: Bloomberg New Energy Finance, International Organization of Motor Vehicle Manufacturers

BNEF Electric vehicle outlook to 2040

Annual global light duty vehicle sales



Global light duty vehicle fleet

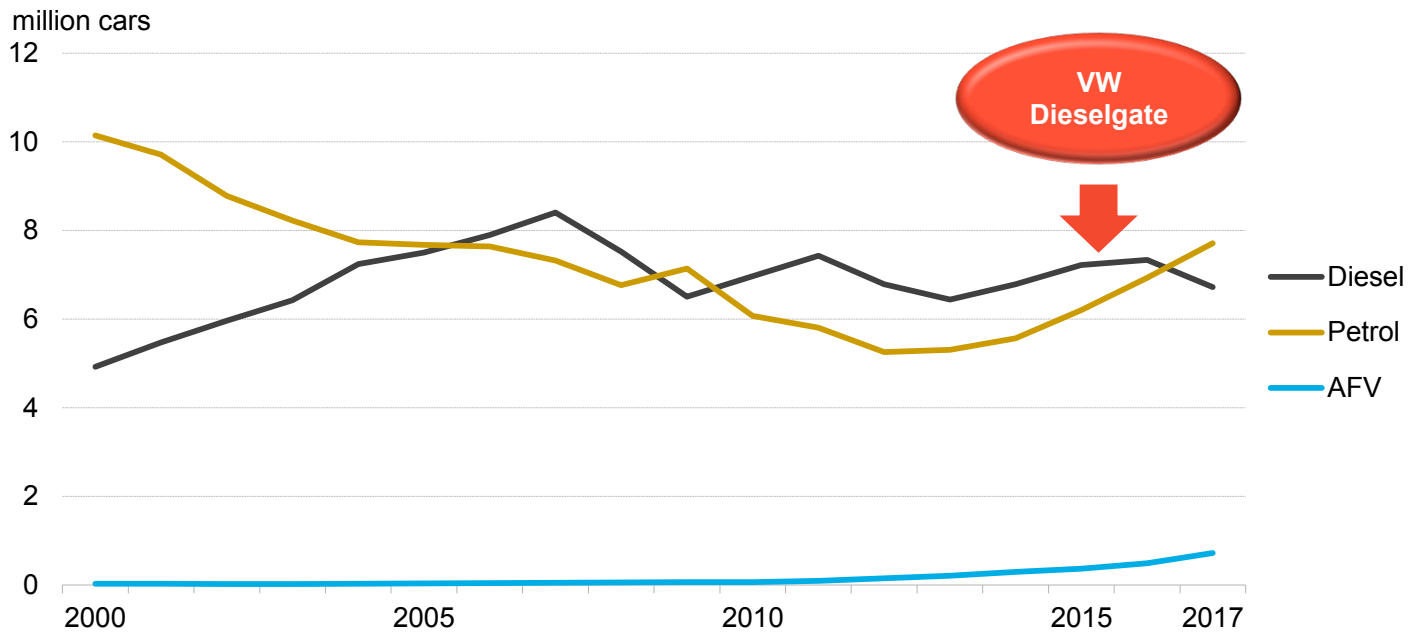


Source: Bloomberg New Energy Finance EVO 2017

London

Image: HHRCA

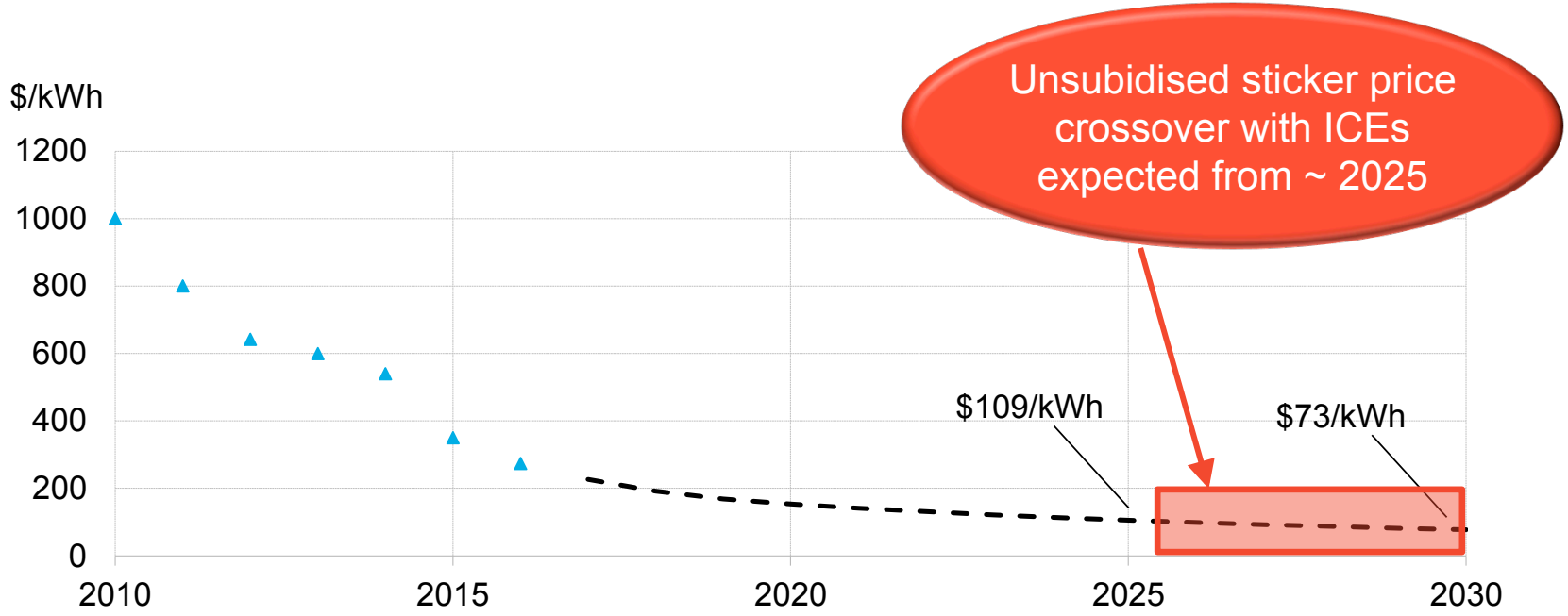
Europe-26 car registrations by fuel type 2000- 2017



Note: Alternatively Fueled Vehicles (AFVs) include hybrid, plug-in hybrid, and pure electric vehicles.

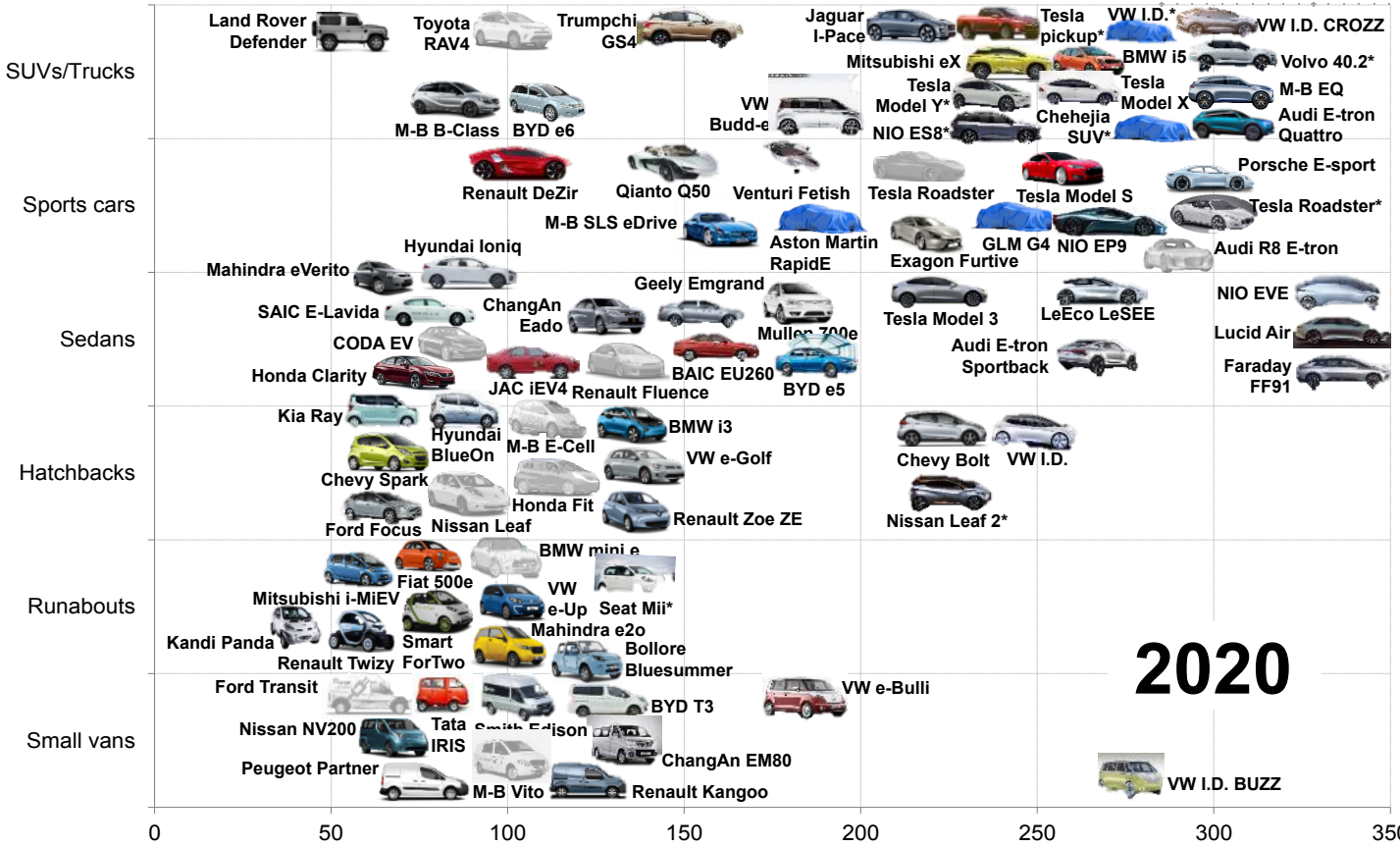
Source: JATO, Liebreich Associates

Battery pack costs to fall another 70% by 2030



Source: Bloomberg New Energy Finance

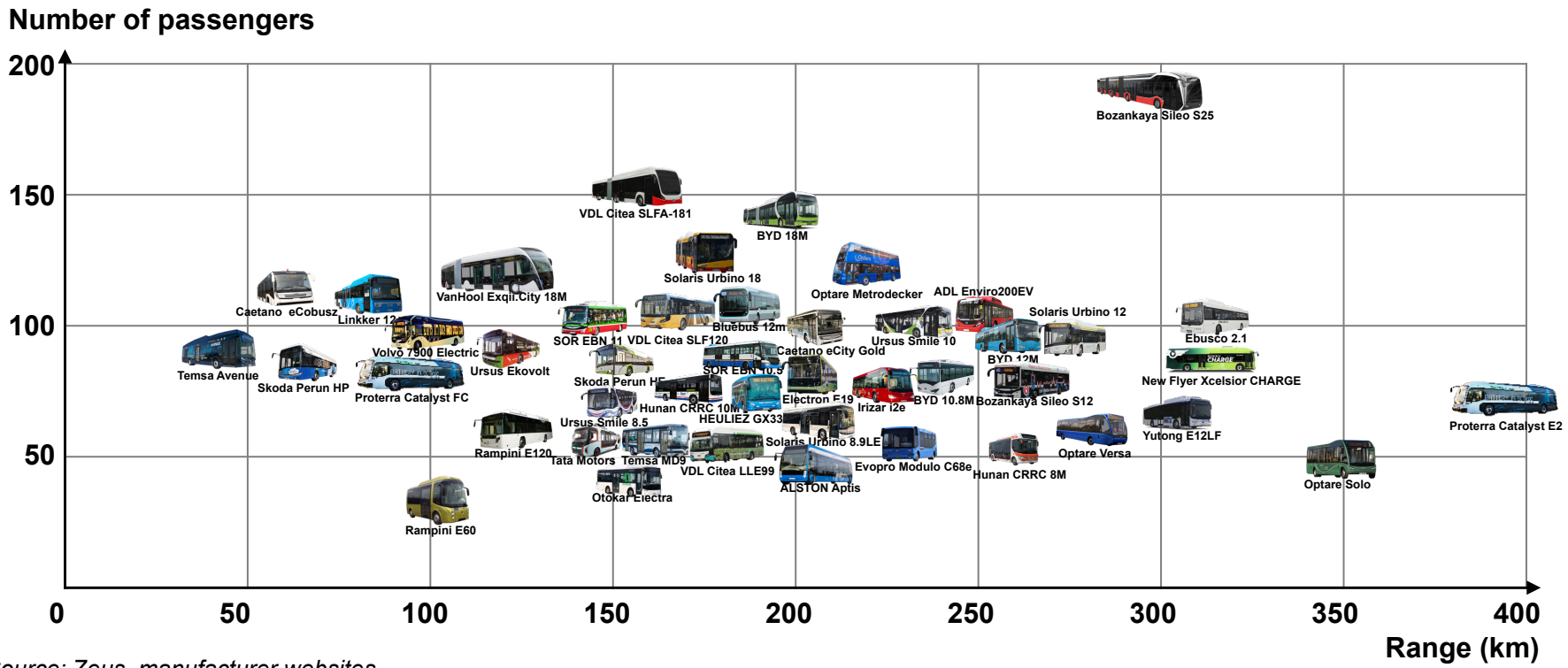
BEV model availability, 2008-20



Source: Bloomberg New Energy Finance, Images various.

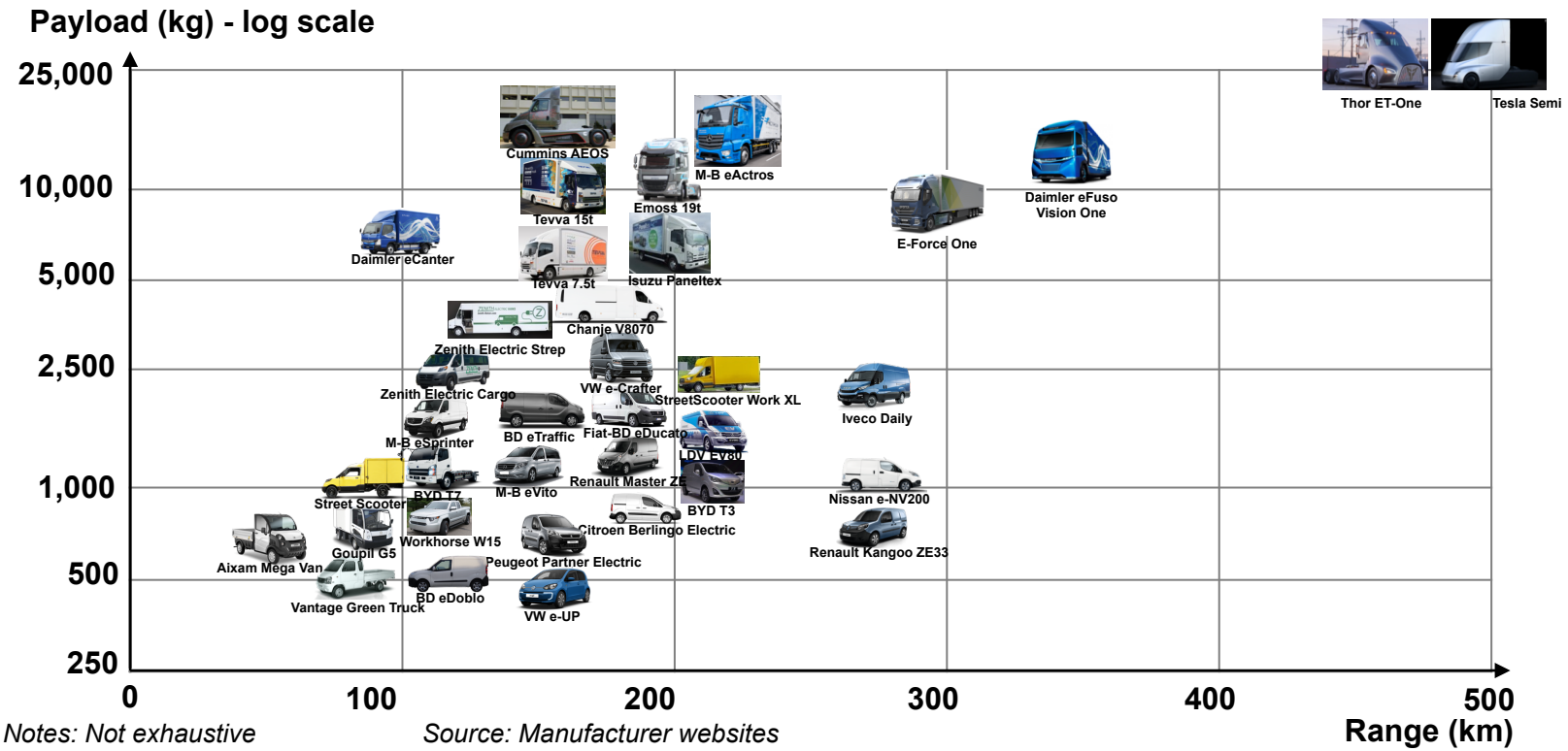
Notes: Not exhaustive.
(*) Range is estimate

City electric buses – 2020



Source: Zeus, manufacturer websites

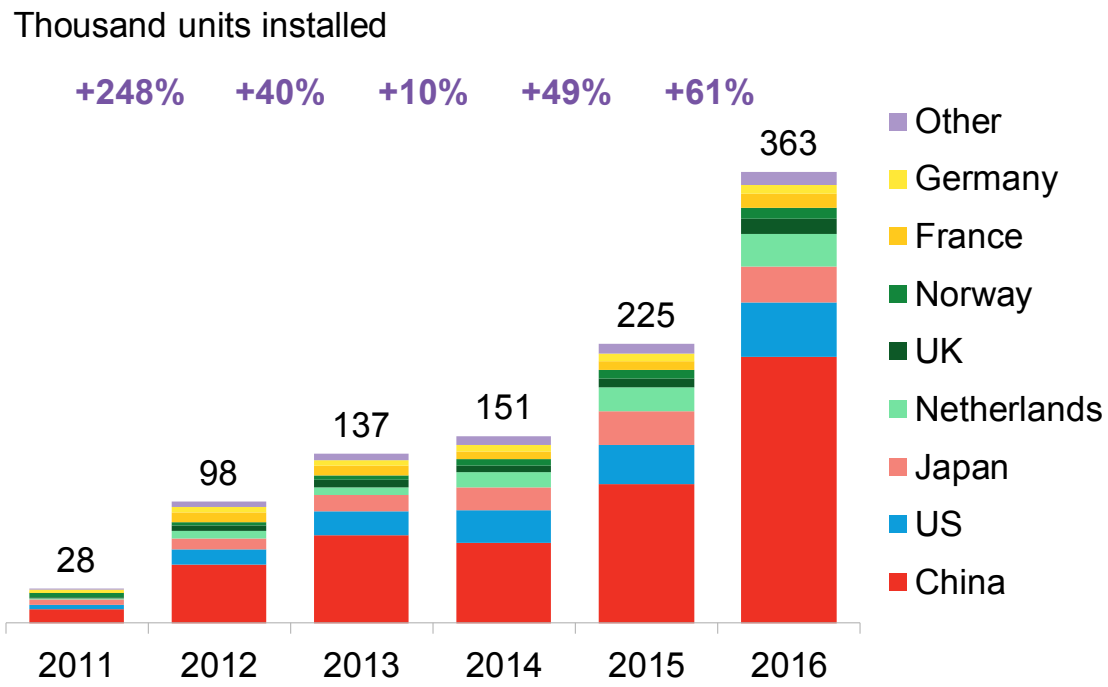
Commercial BEV availability 2022



Notes: Not exhaustive

Source: Manufacturer websites

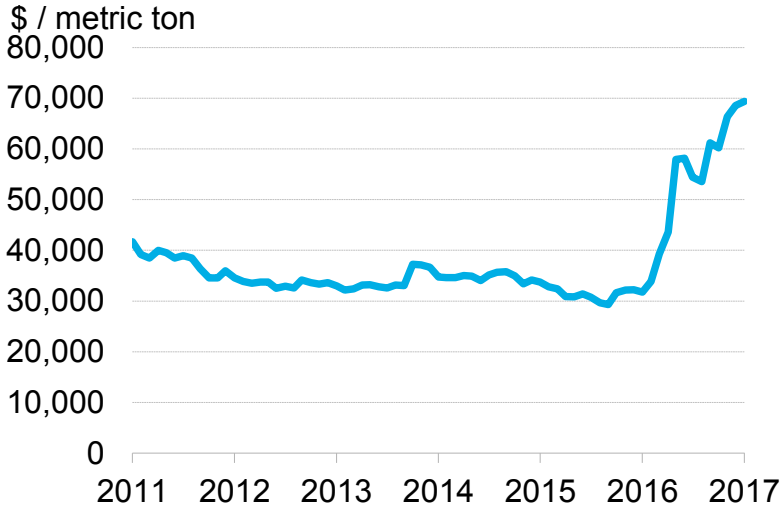
Global EV charging points



Source: Bloomberg New Energy Finance EVO 2017

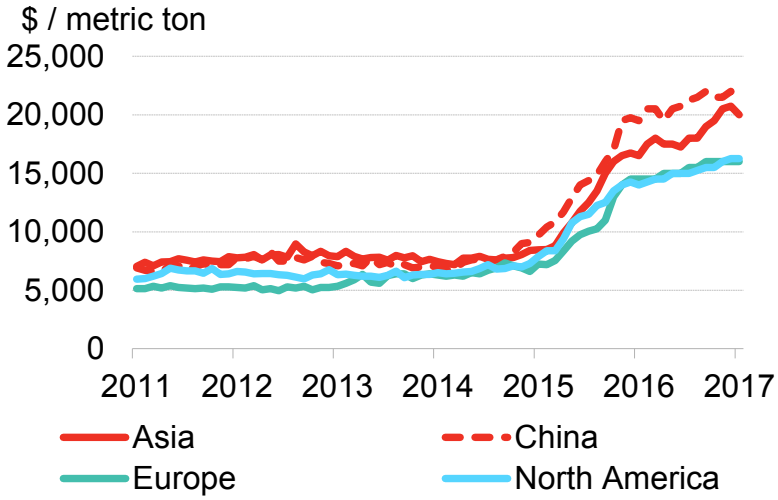
Lithium and cobalt prices

China Shanghai Cobalt



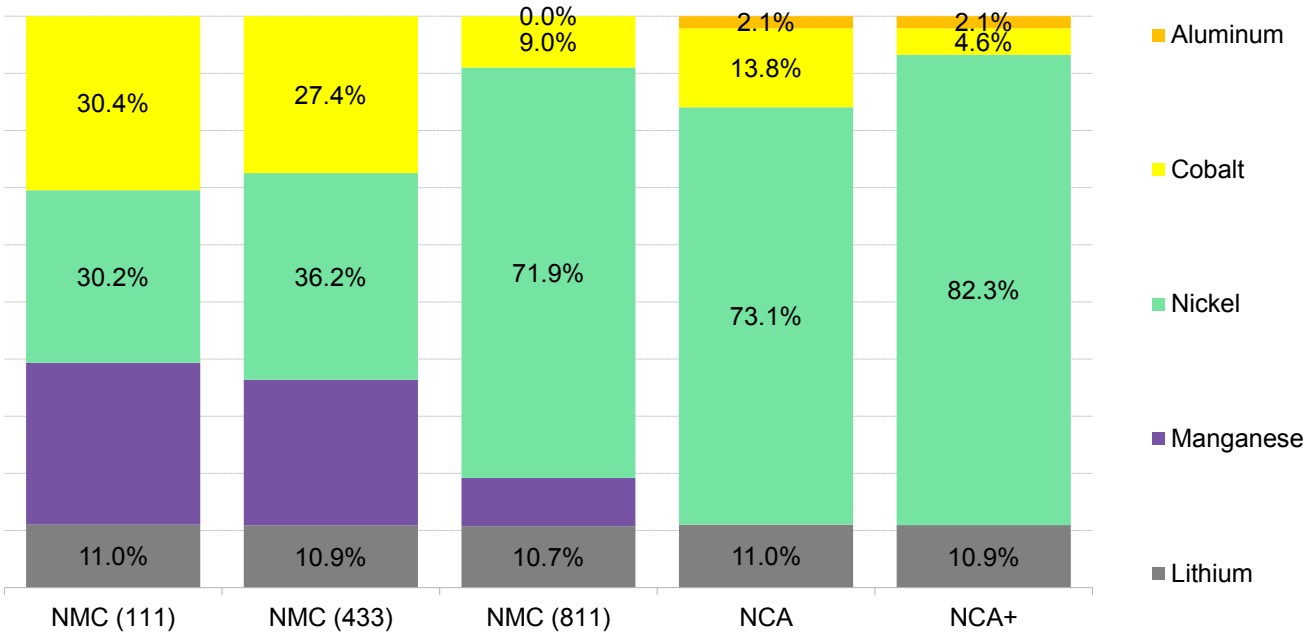
Source: Antaike Information Development Co., Bloomberg

Lithium hydroxide



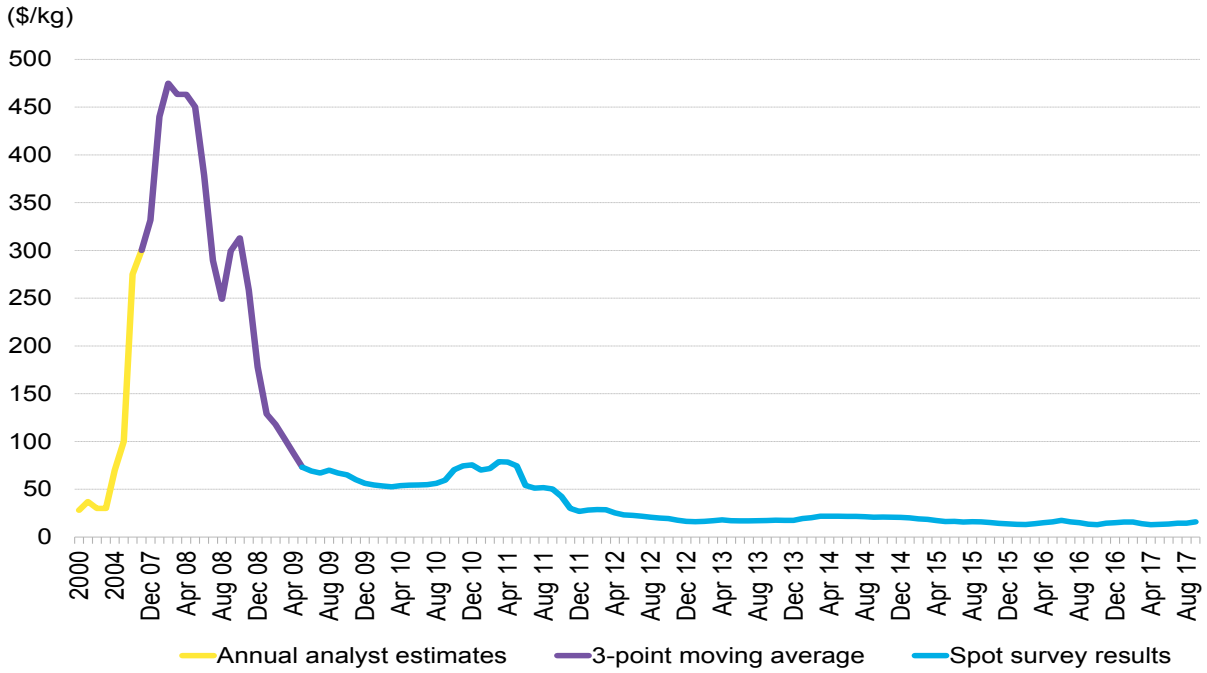
Source: Benchmark Mineral Intelligence

Cathode metal content



Source: Bloomb

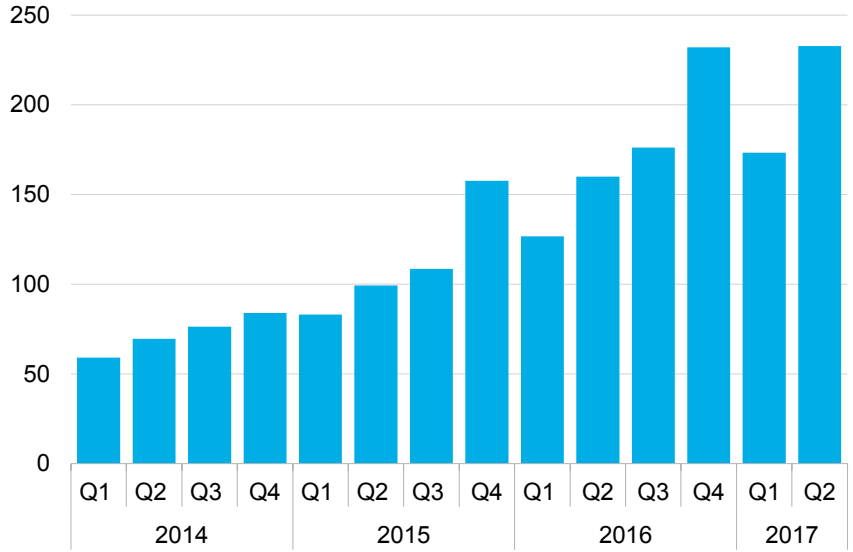
Spot price of solar-grade silicon, year 2000 – September 2017



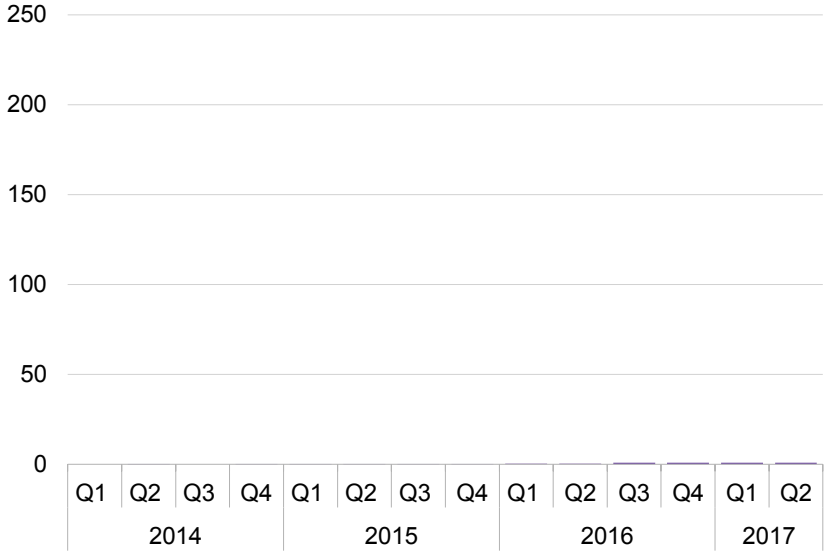
Source: Various, Bloomberg New Energy Finance. Note: Annual data 2000-07 from various industry sources. Data November 2007–May 2009 based on a 3-point moving average of actual spot deals. Consistent monthly data collection using the Spot Price Index began in May 2009.

BEV vs. FCV sales

Electric vehicles (**thousand units**)

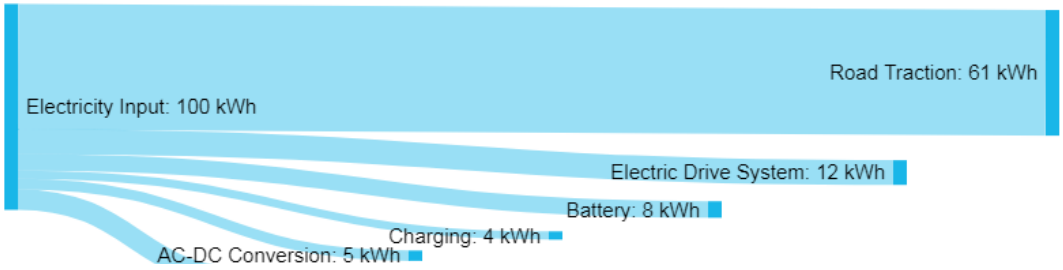


Fuel cell vehicles (**thousand units**)

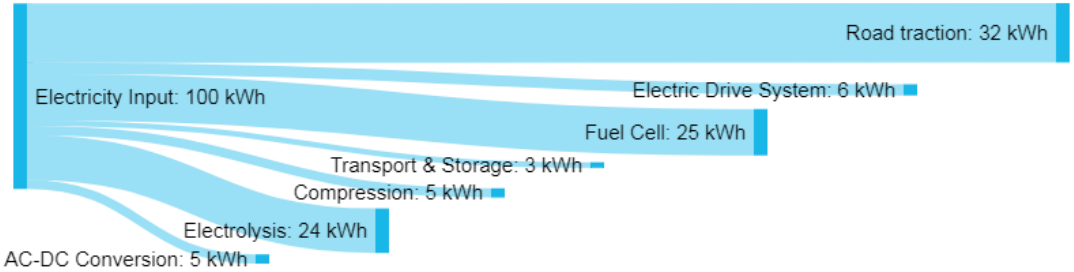


Source: Bloomberg New Energy Finance

BEV and H2FC efficiencies compared



BEV
"Wind-to-wheel" efficiency
61%



FCV
"Wind-to-wheel" efficiency
32%

Source: Bloomberg New Energy Finance

New orthodoxy by 2040:

Welcome to the Three-Third World

1/3 of electricity
will be wind and solar

1/3 of cars and light trucks
will be electric

1/3 more energy-productivity
of the global economy

Source: Liebreich Associates; Images:Tesla, Wallpaper Mania, Cleantechnica

Beyond the Three-Third World

Industry

Shipping/air/freight

Agriculture

Chemicals

Energy access

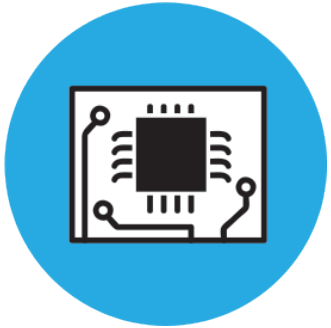
Heat

Source: Bloomberg New Energy Finance, Tesla, Wallpaper Mania, Cleantechnica; Wikipedia Commons

Demand side re-engineering

Images: Naked Energy; Climeon; Danfoss; SaltX; Sonnen; Radbot; Optiwatt; PassivSystems; Sunamp

Digitisation of infrastructure



Ubiquitous chips and sensors

Ubiquitous communications

Ubiquitous processing and storage (cloud to network edge)

Artificial intelligence and machine learning

Source: Bloomberg New Energy Finance

Drake’s Landing Solar Community

~95% year-round heating from solar

45 minutes drive from Calgary Olympic park

Image: Okotoks

Risks / Opportunities for Switzerland

Risks

- Dependency on imported gas
- Dependency on imported electricity:
  - French nuclear
  - German intermittency

- High energy costs
- Failure to meet climate goals

Opportunities

- Grid services (storage, flexibility)
- Export opportunities
  - Technology (material science, software)
  - Engineering
  - Services
- Finance
- Convening

Source: Liebreich Associates

Thanks!

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