

# London summit 2017

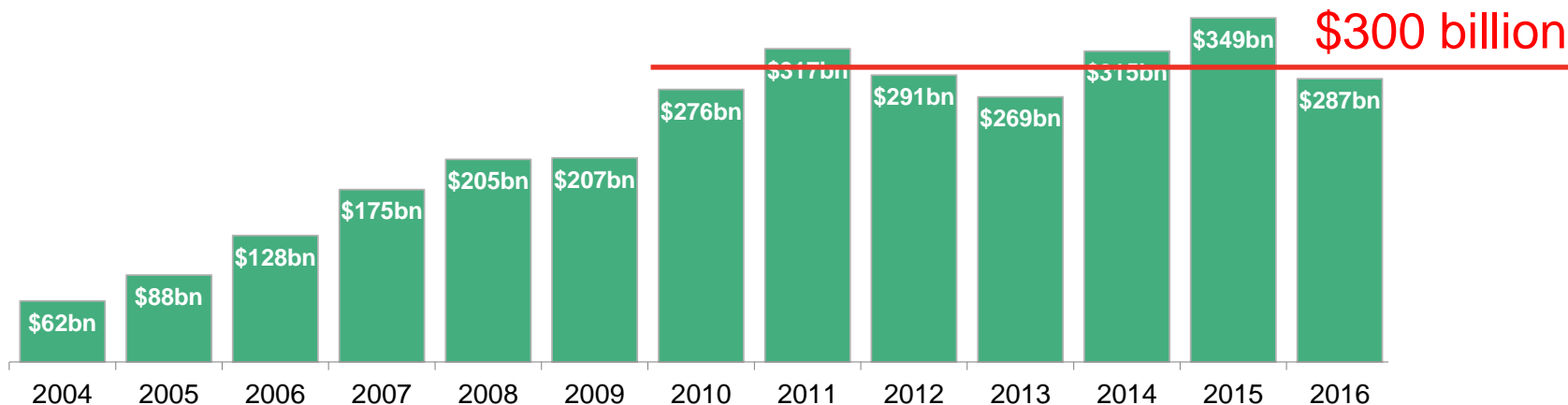
Breaking Clean

Michael Liebreich

September 19, 2017

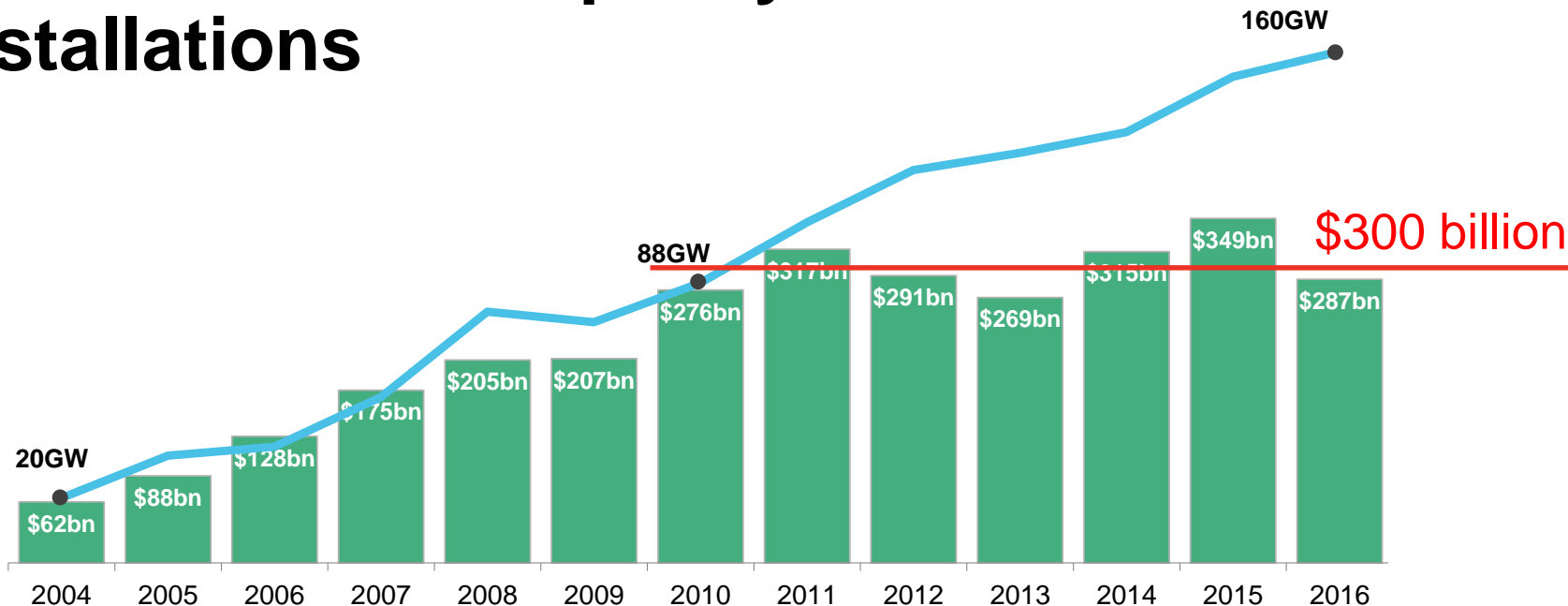
Bloomberg  
New Energy Finance

# Global new clean energy investment and capacity installations



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.

# Global new clean energy investment and capacity installations



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# Plenty of good news – 1



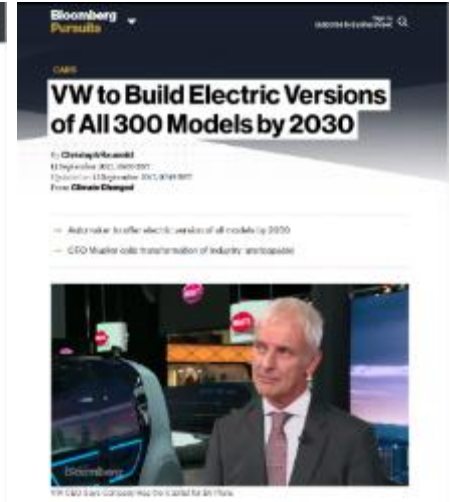
Source: ABC Australia, Independent, Bloomberg, Oilprice.com

# Plenty of good news – 2



Source: Businessgreen, FT, Bloomberg, BBC

# Plenty of good news – 3



Source: The Telegraph, Bloomberg, The Economist



# President Trump



Source: White House

# Trump on climate

## December 2009

“

If we fail to act now, it is scientifically irrefutable that there will be catastrophic and irreversible consequences for humanity and our planet.

”

*Donald J. Trump  
Donald J. Trump Jr  
Eric F. Trump  
Ivanka M. Trump*





# Trump on climate

6 November 2012

“

The concept of global warming was created by and for the Chinese in order to make U.S. manufacturing non-competitive.

”

*Donald Trump*  
*US Presidential Candidate*



Image: IBTimesUK

# Trump on climate

## February/March 2017



Source: White House, EPA



# Trump on climate

1 June 2017

“

The United States will withdraw from the Paris Climate Accord.

”

*Donald Trump  
US President*



*Image: Bloomberg*

# Trump on climate

16 September 2017

“

The U.S. has stated that they will not renegotiate the Paris accord, but they will try to review the terms on which they could be engaged under this agreement.

”

*Miguel Arias Cañete*

*European Commissioner for Climate Action and Energy*

*Wall Street Journal*



*Image: European Union*

# Trump on climate

17 September 2017

“

The President said he's open to finding those conditions where we can remain engaged with others on what we all agree is still a challenging issue.

”

*Rex Tillerson  
US Secretary of State*



*Image: US Department of Energy*

# Trump on climate

16 September 2017

“

There has been no change in the United States' position on the Paris agreement.

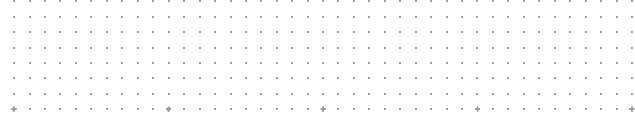
”

*Sarah Huckabee Sanders  
White House Press Secretary*



*Image: Washington Examiner*

# The world's response to Trump on climate



Source: *Emojipedia*



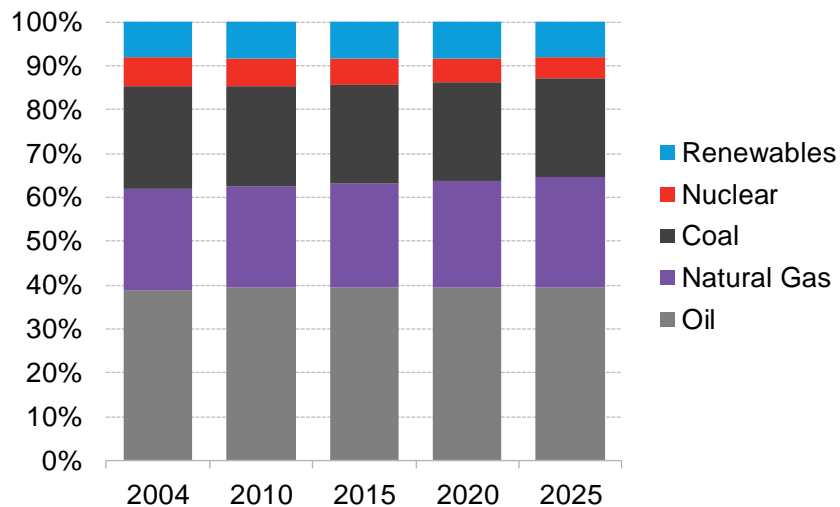
# The world in 2004...



*Source: NASA*

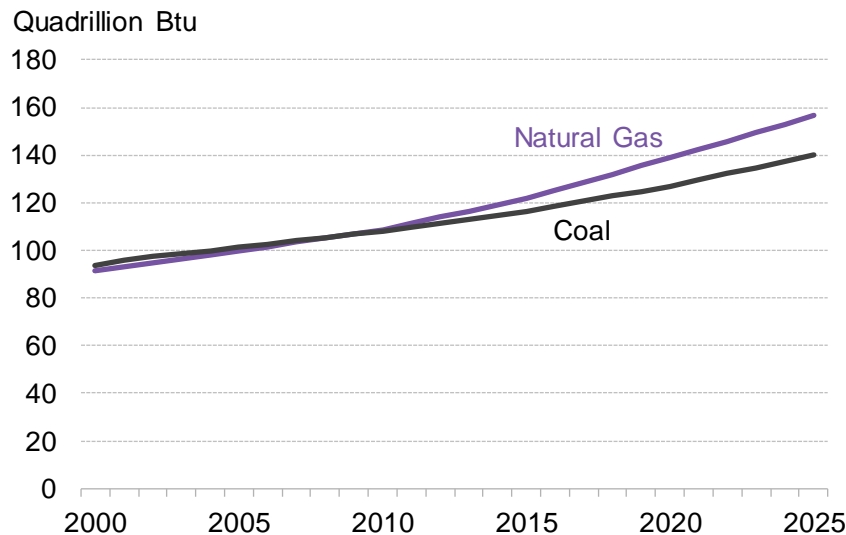
# EIA global energy mix and fuel consumption forecast

## Global energy consumption mix



Source: EIA

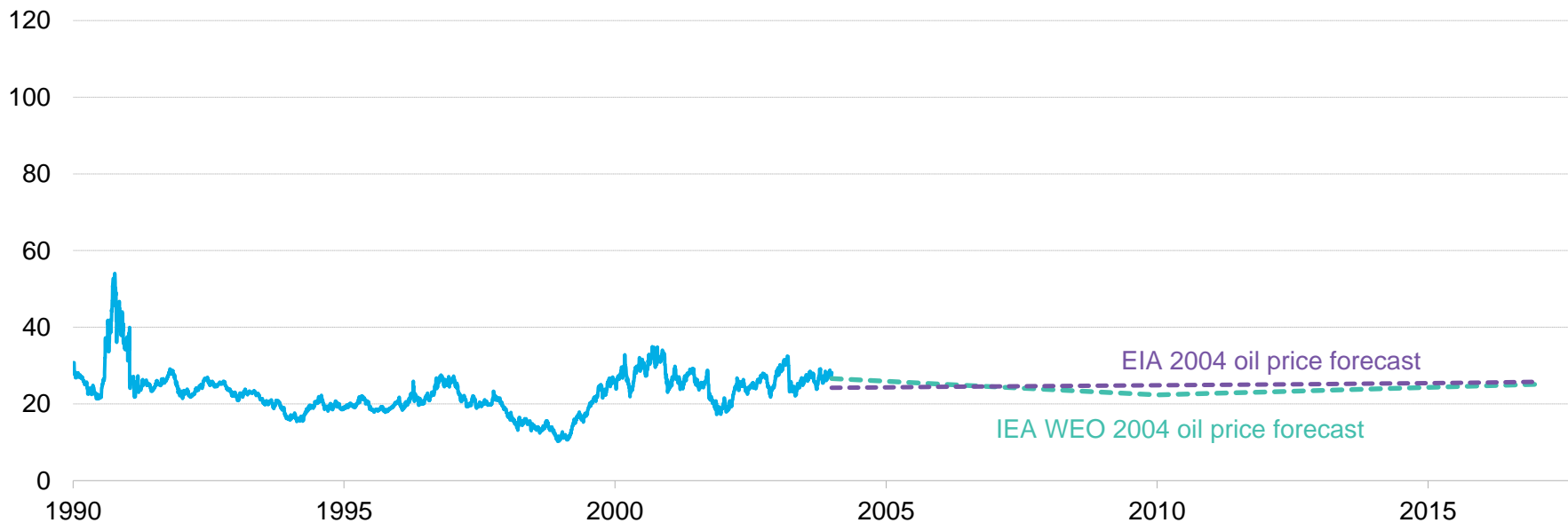
## IEO 2004 world coal and gas consumption



Source: EIA

# Oil price history and 2004 forecast

\$/bbl real 2000

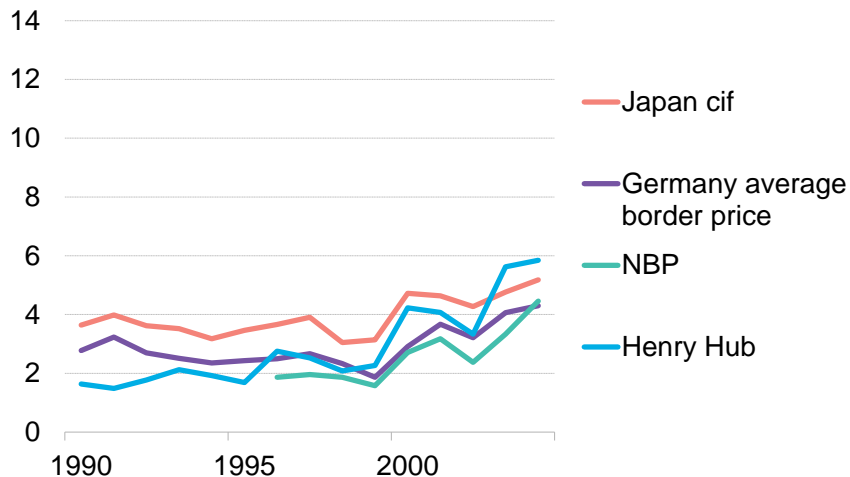


Source: Bloomberg New Energy Finance, IEA

# Gas prices and U.S. imports

## Global gas price benchmarks, 1990-2004

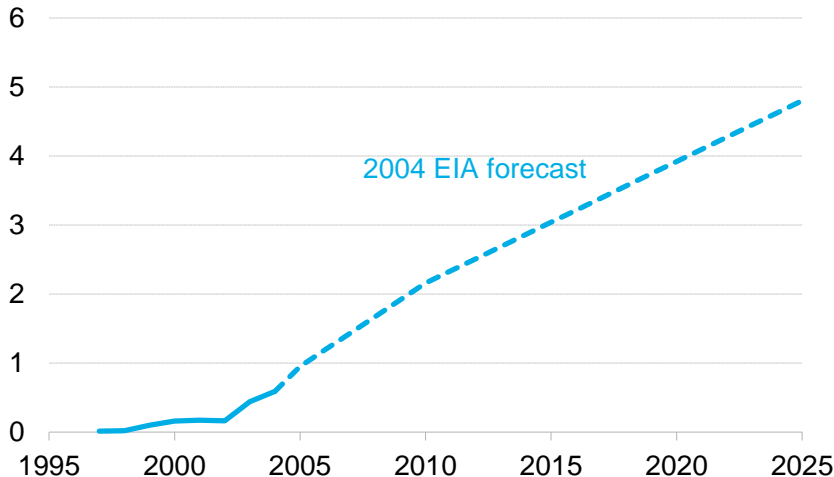
\$/MMBtu



Source: Bloomberg New Energy Finance

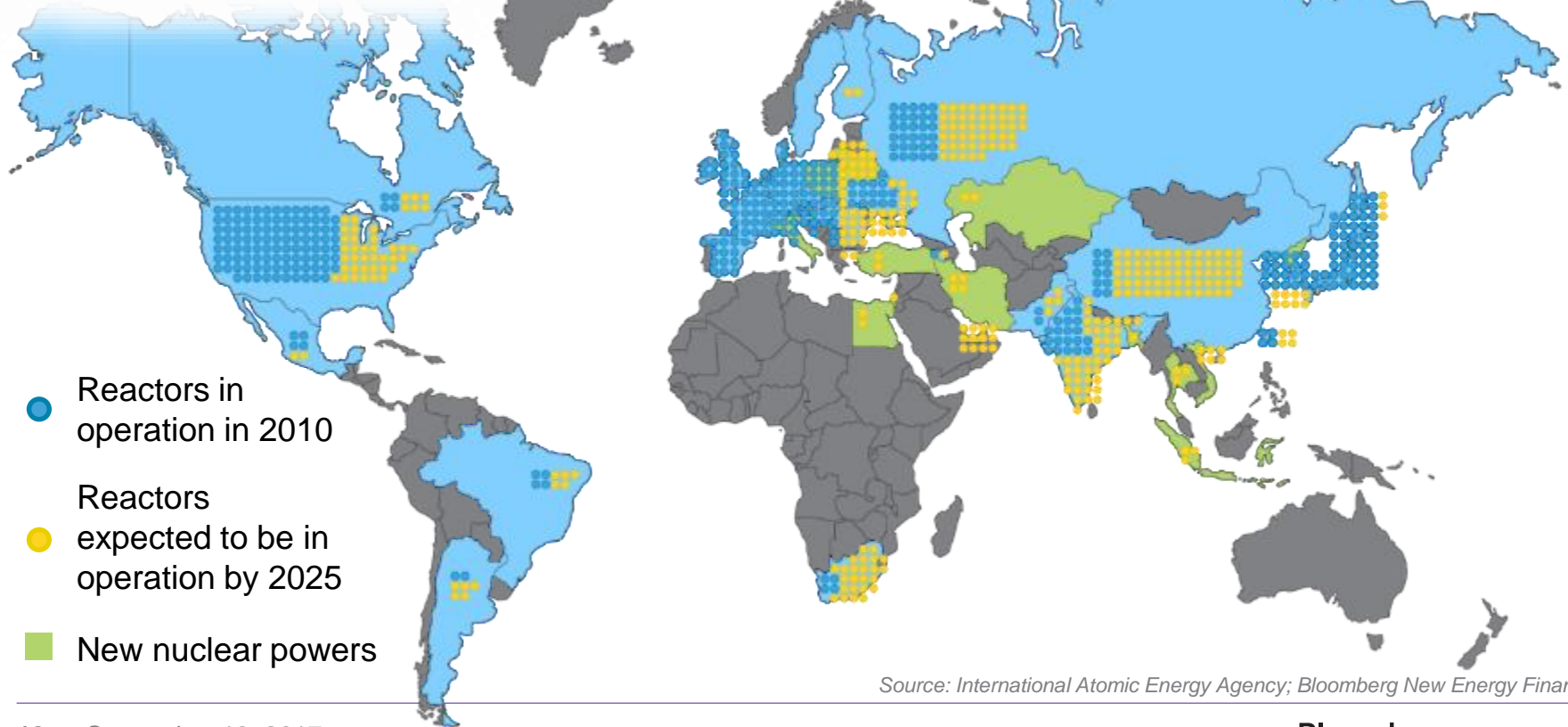
## Net U.S. LNG imports

Trillion cubic feet



Source: Bloomberg New Energy Finance, EIA

# Nuclear was about to undergo a renaissance

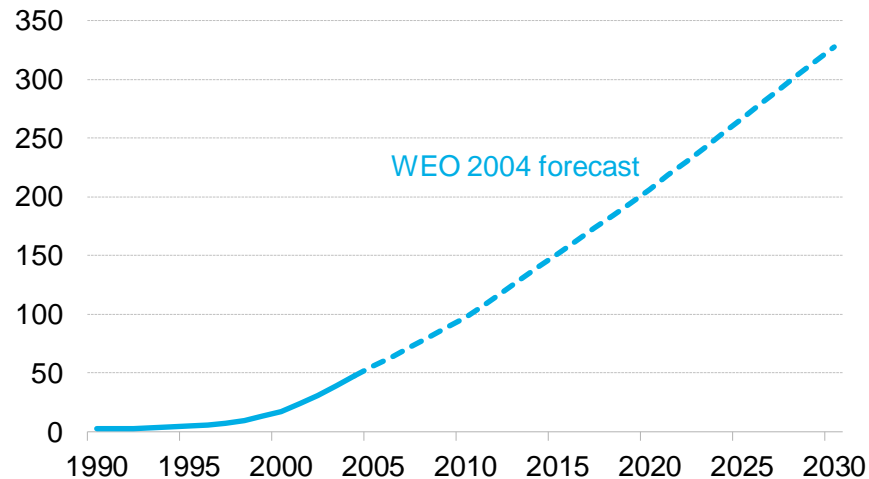


Source: International Atomic Energy Agency; Bloomberg New Energy Finance

# IEA Outlook for renewables in 2004 – cumulative capacity

## Wind

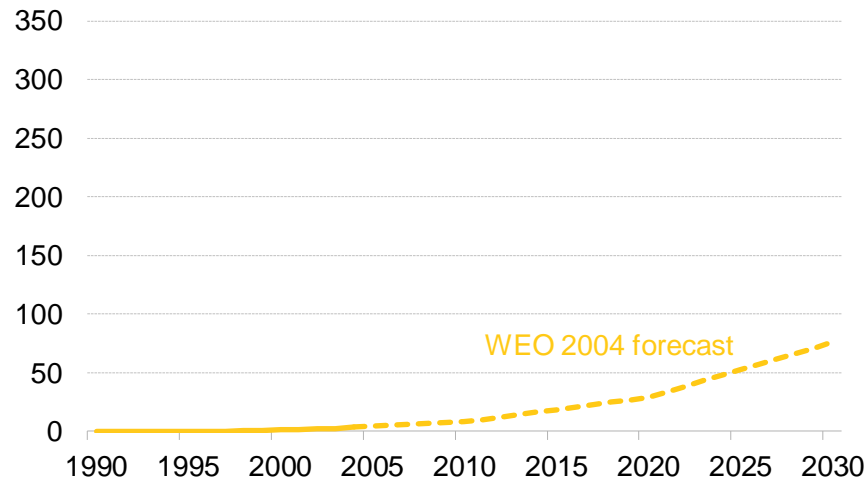
GW installed



Source: Bloomberg New Energy Finance, IEA

## Solar

GW installed

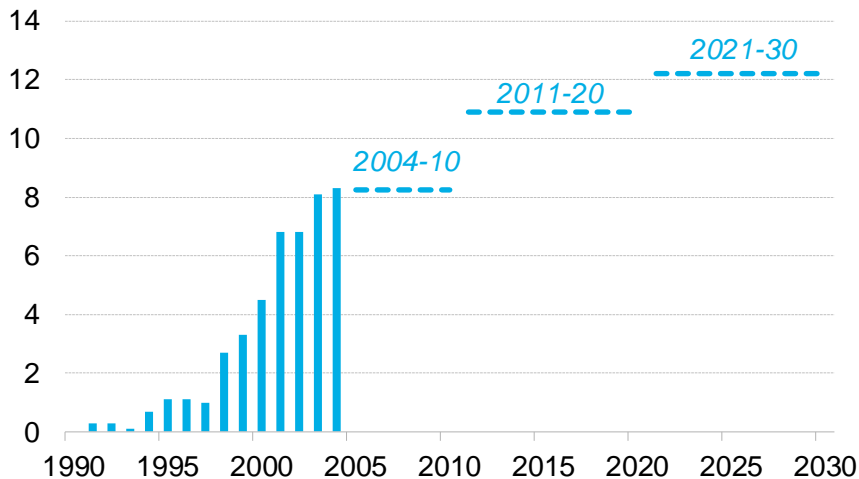


Source: Bloomberg New Energy Finance, IEA

# IEA outlook for renewables in 2004 – annual additions

## Wind

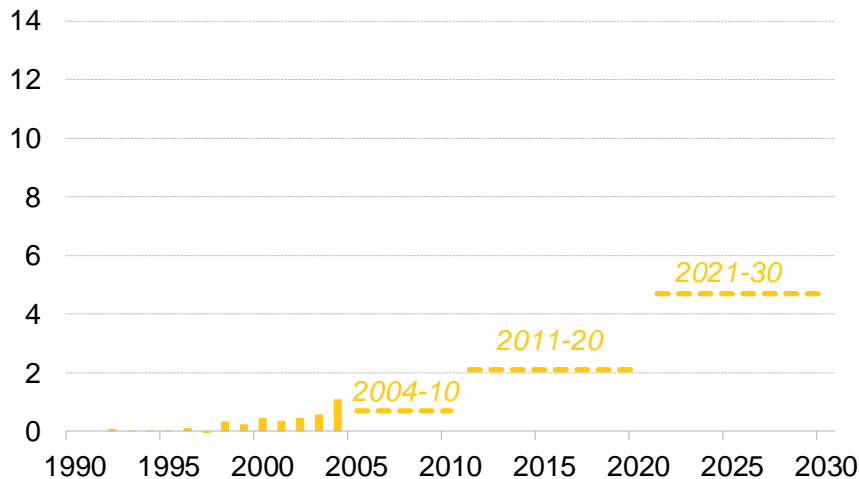
Capacity additions per year (GW)



Source: Bloomberg New Energy Finance, IEA

## Solar

Capacity additions per year (GW)



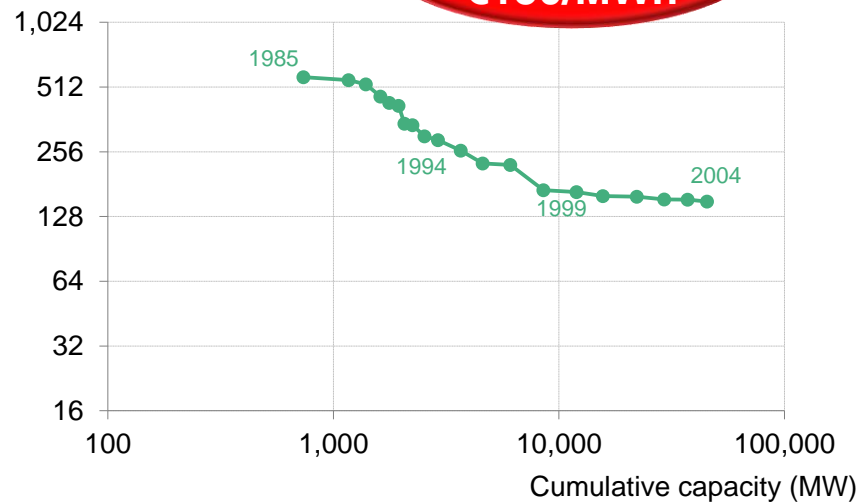
Source: Bloomberg New Energy Finance, IEA



# Wind and solar costs

## Wind

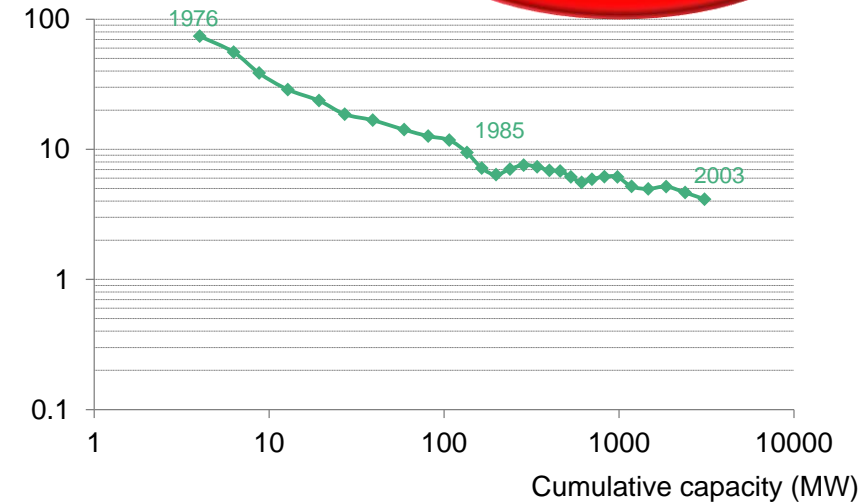
eur/MWh



Source: Bloomberg New Energy Finance

## Solar

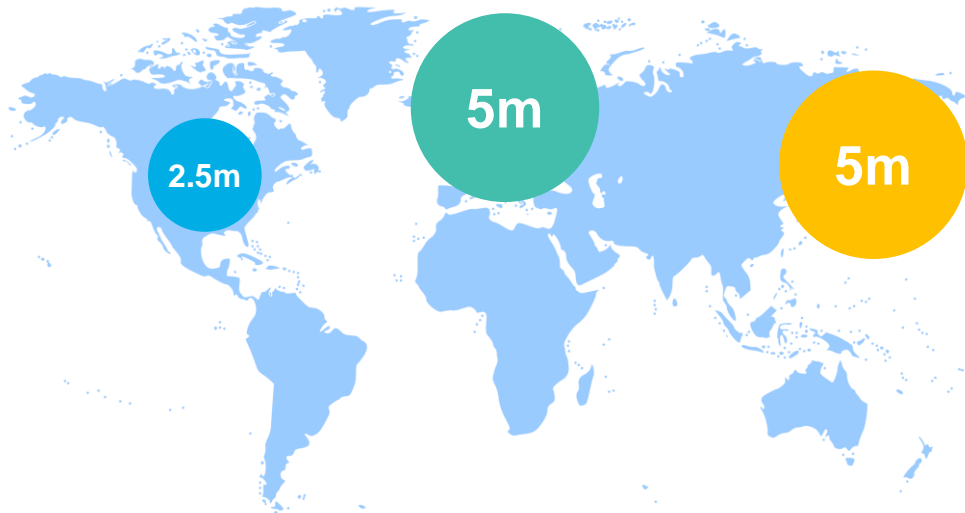
\$/W



Source: Bloomberg New Energy Finance

# H2FC vehicle targets for 2020 in 2004

(m vehicles)



“

Fuel cell vehicles will probably overtake gasoline-powered cars in the next 20 to 30 years

Takeo Fukui, Managing Director,  
Research and Development, Honda Motor Co., Bloomberg  
News, June 5, 1999

“

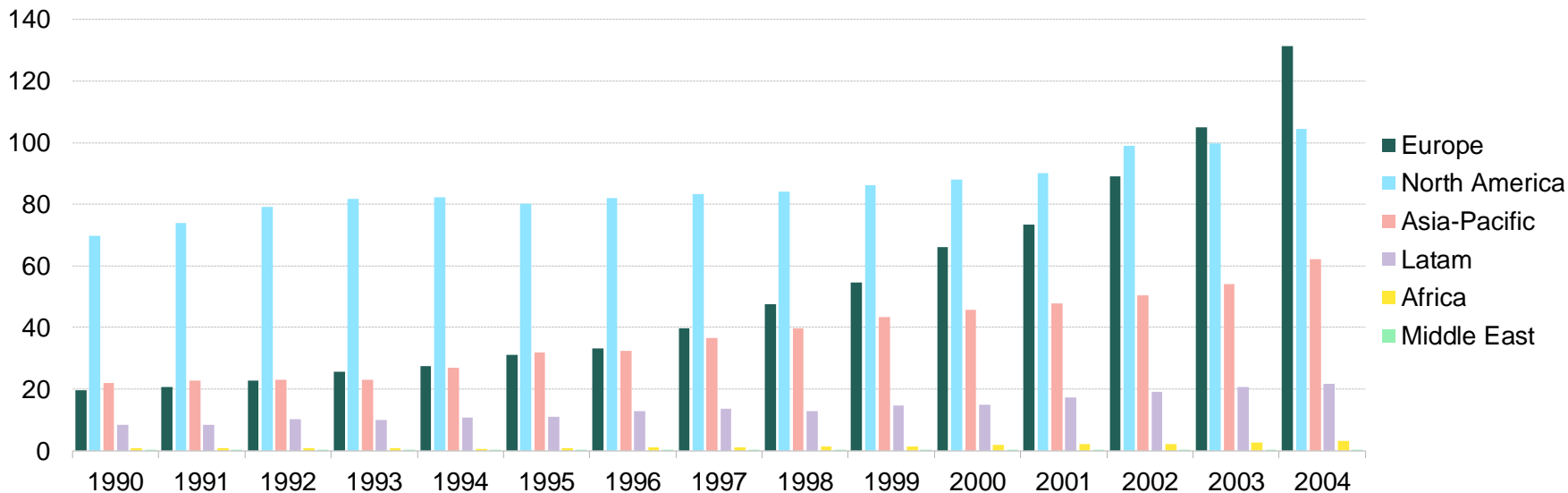
Fuel cells will power cars with little or no waste at all.  
We happen to believe that fuel cell cars are the wave  
of the future; that fuel cells offer incredible opportunity.

US President George W. Bush, February 25, 2002

Source: DOE, European Hydrogen & Fuel Cell Technology Platform, Juhani Laurikko (Premia-EU)

# Renewable electricity generation by region, 1990-2004

TWh per year



Source: Bloomberg New Energy Finance, BP Statistical Review of World Energy

# EU leadership from 2004

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## Celebrating the Environmental Union

**VIEWPOINT**  
Stavros Dimas

**The European Union has been a force for good on environmental issues, argues EU Environment Commissioner Stavros Dimas. By acting together, he says, Europe has achieved far more on climate change, water quality and pollution than individual countries could have managed acting alone.**

“ Since 1972 when the first European environmental policy was launched, the EU has proved a highly effective framework for co-operation on the environment.

For more than 30 years, it has tackled the problems of acid rain, the thinning of the ozone layer, air quality, noise pollution and waste. It has banned pollutants such as lead in petrol.

**“ When the EU speaks with one voice, the rest of the world listens “**  
Send us your comments

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A weekly series of thought-provoking opinion pieces on environmental topics

**Pinch of salt**  
Idea that the world's food production must double "is wrong"

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## EU agrees renewable energy target

**European Union leaders have agreed to adopt a binding target on the use of renewable energy, such as wind and solar power, officials say.**

European Commission President Jose Manuel Barroso said Europe was now able to lead the way on climate change.

The 27 EU states will each decide how they contribute to meeting a 20% boost overall in renewable fuel use by 2020.

The measures could include a ban on filament light bulbs by 2010, forcing people to switch to fluorescent bulbs.

The bulbs last longer but more are more expensive to buy.

In another key measure, agreed on Thursday, EU leaders said they would cut carbon dioxide emissions by 20% from 1990 levels by 2020.

BBC world affairs correspondent Nick Childs says there is an air of real achievement in Brussels.

**VIDEO AND AUDIO NEWS**  
Tony Blair on what the agreement means  
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**INSIDE EUROPE**

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- Q&A: The Lisbon Treaty

**UK and EUROPE**

- UK criticises EU famine response
- Q&A: How UK adopts EU laws

Source: BBC

# Not everyone agreed with the orthodoxy...



# The world in 2004

## Problems

- Climate Change
- Second Gulf War
- Aging power infrastructure (developed world)
- Brownouts (industrialising countries)
- Energy poverty (poorest countries)
- Rise of China

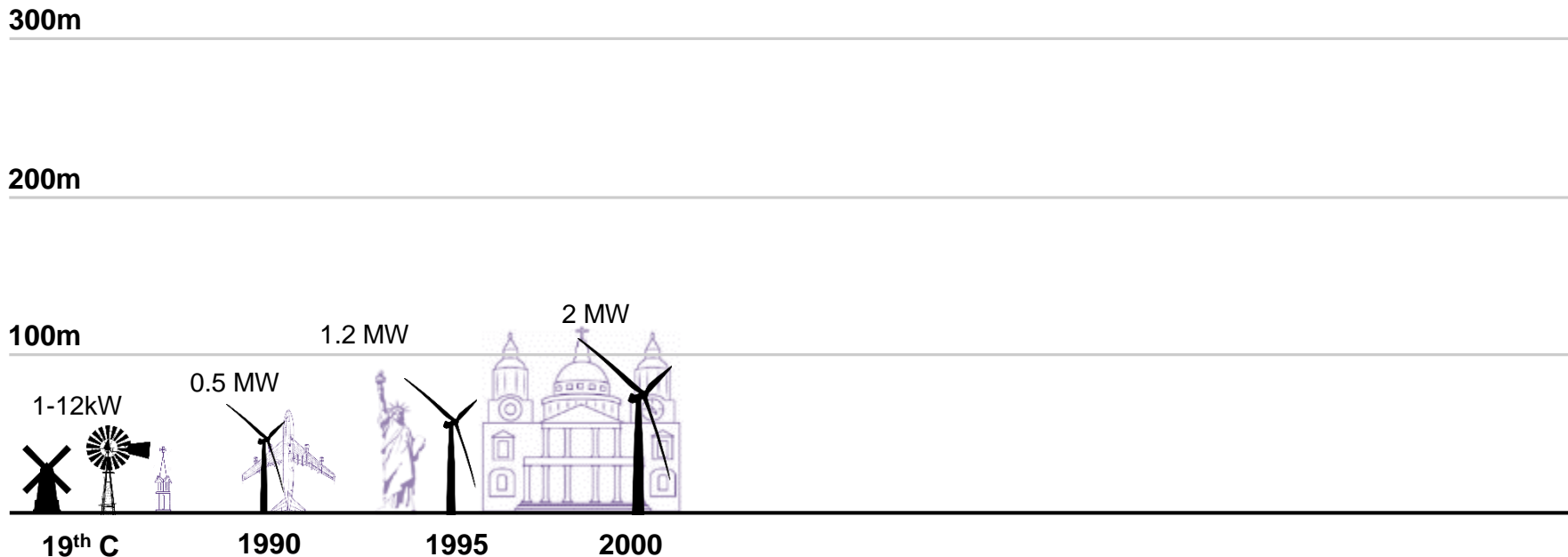
## Opportunities

- Breakthroughs in material sciences
- Experience curves
- Low-cost communications
- Energy deregulation
- Innovation/entrepreneurship
- Availability of capital

Source: New Energy Finance



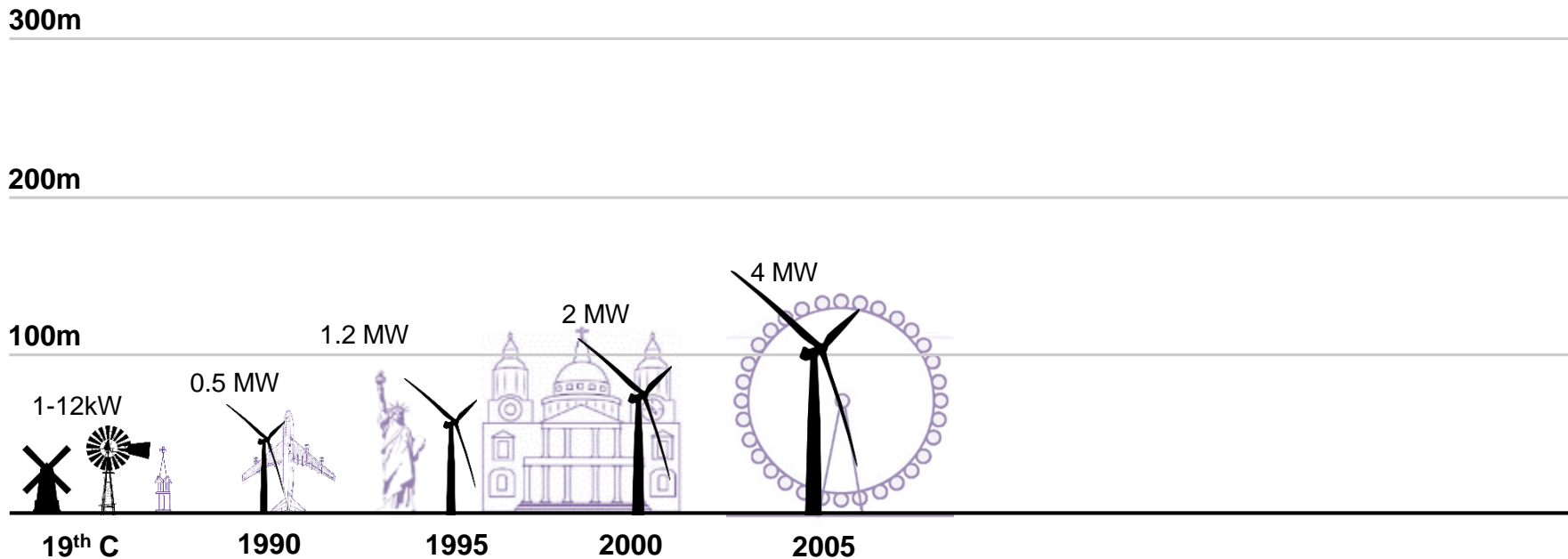
# Evolution of wind turbine heights and output



Sources: Various; Bloomberg New Energy Finance

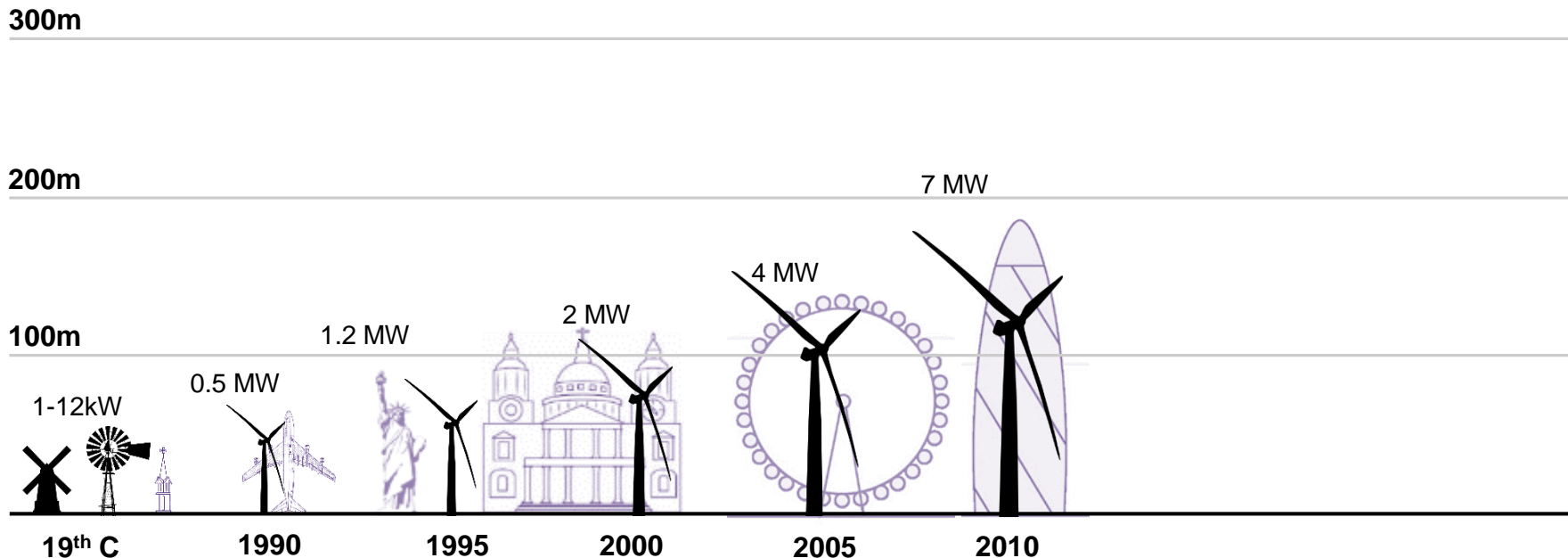


# Evolution of wind turbine heights and output



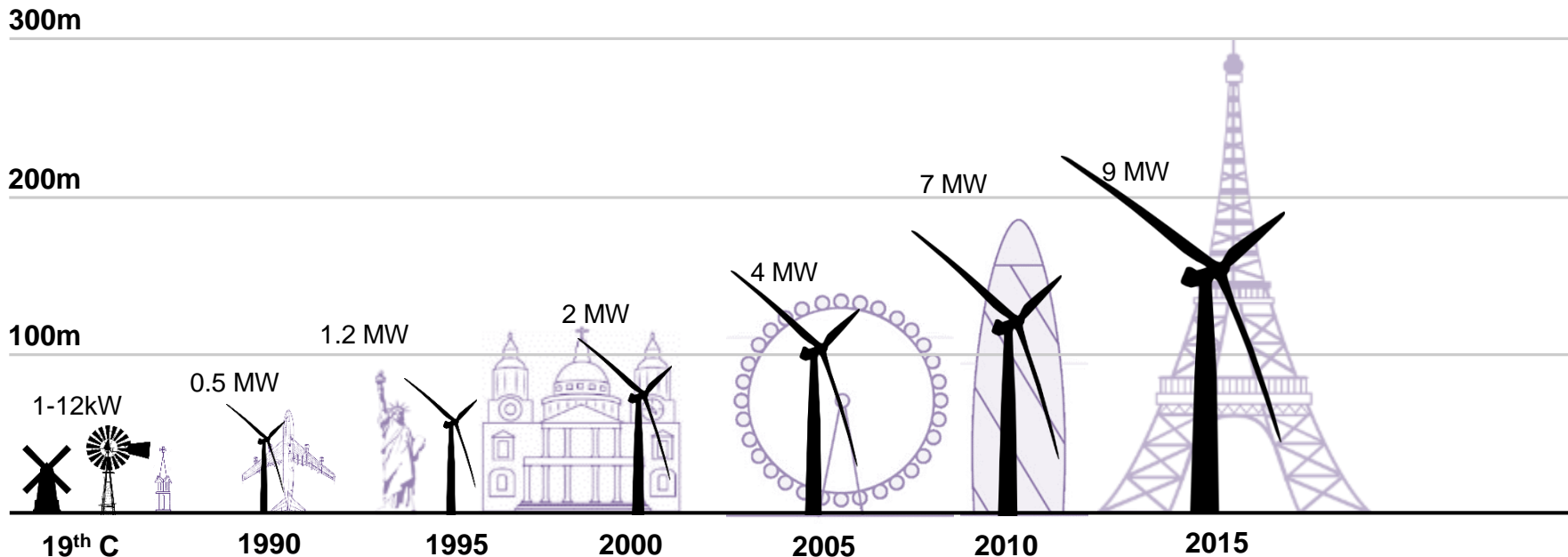
Sources: Various; Bloomberg New Energy Finance

# Evolution of wind turbine heights and output



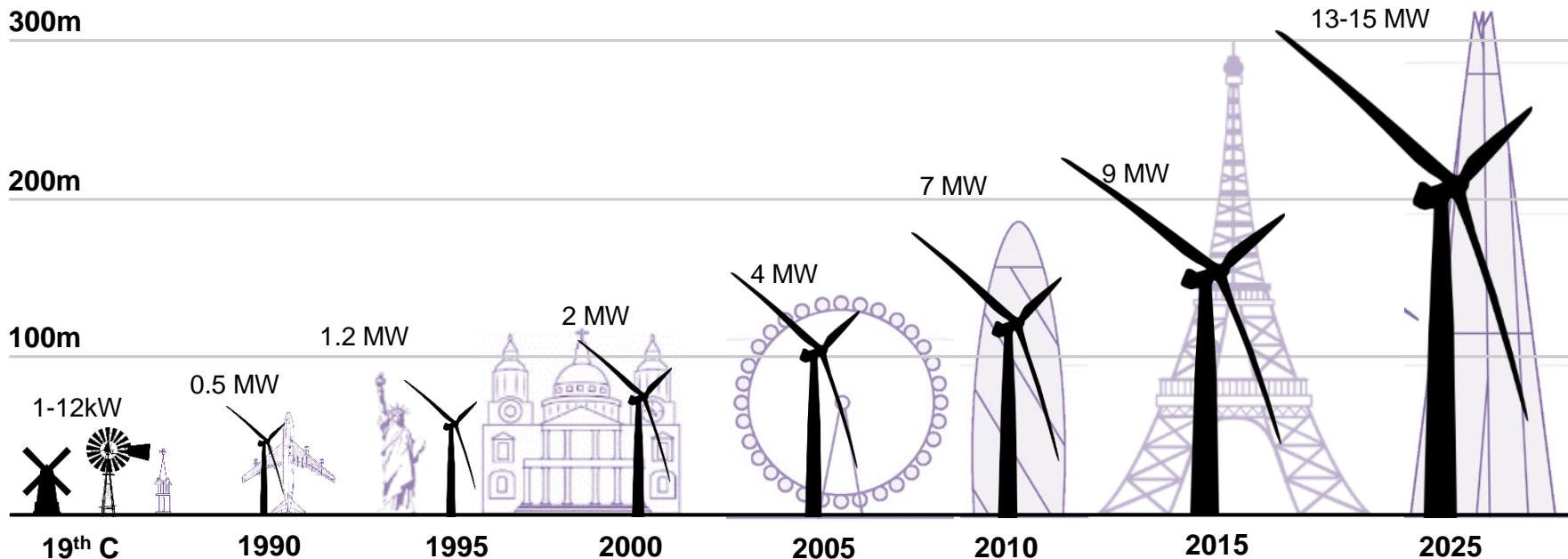
Sources: Various; Bloomberg New Energy Finance

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Sources: Various; Bloomberg New Energy Finance

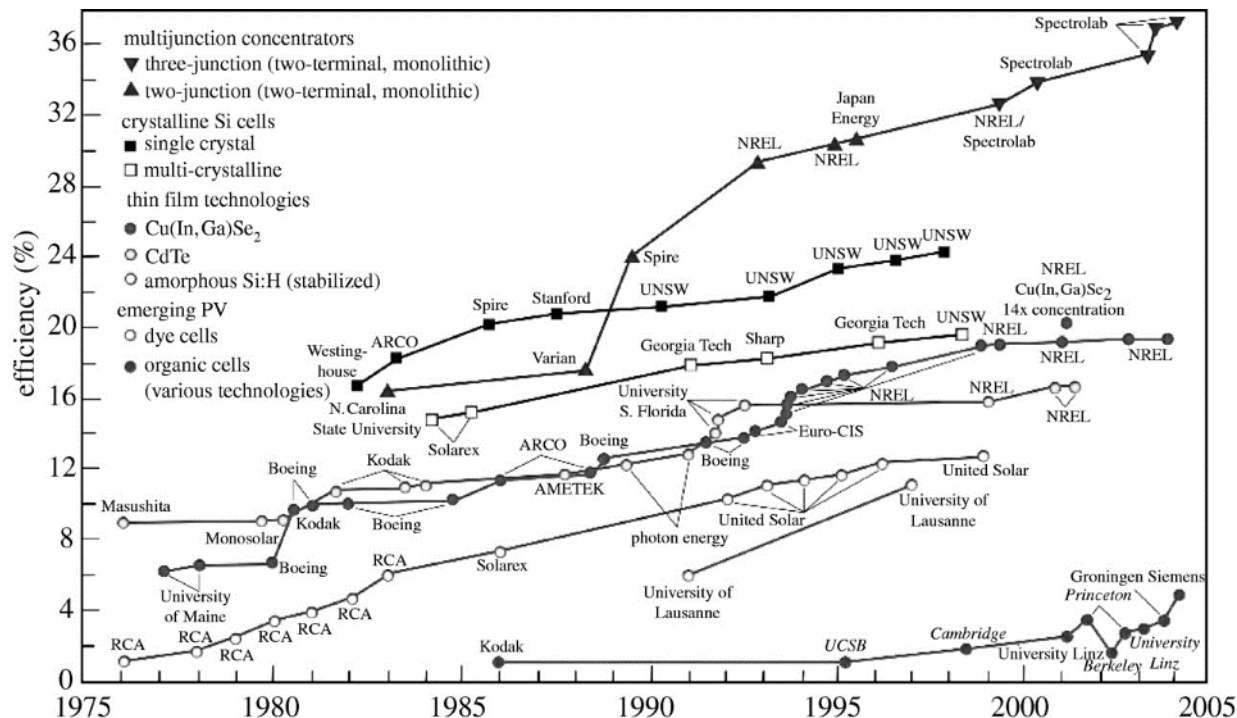
# Evolution of wind turbine heights and output



Sources: Various; Bloomberg New Energy Finance

# Solar cost information

## 2004-style



Source: A. J. Nozik, NREL

## New Energy Finance: the Thesis

Fundamental re-engineering of the world's energy industry around low carbon solutions and architecture



- ✍ Will require trillions of dollars
- ✍ Will take decades
- ✍ Will be funded mainly by world's capital markets

Source: New Energy Finance 2008



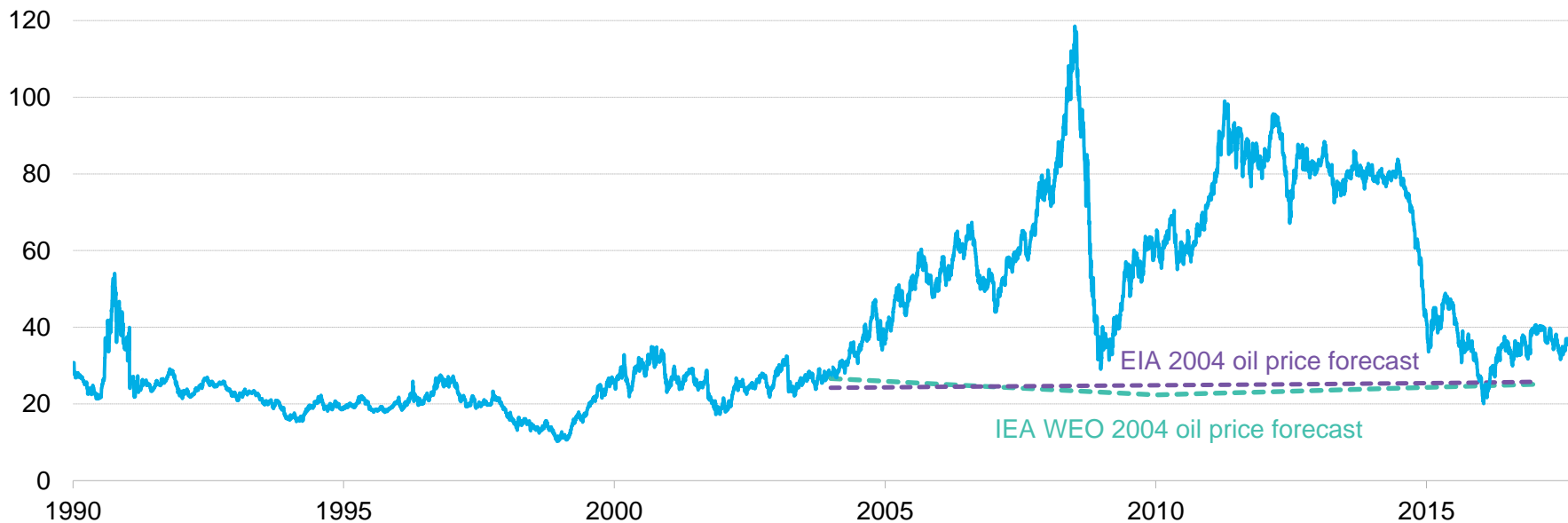
# The world today...



*Image: NASA*

# Oil price

\$/bbl real 2000

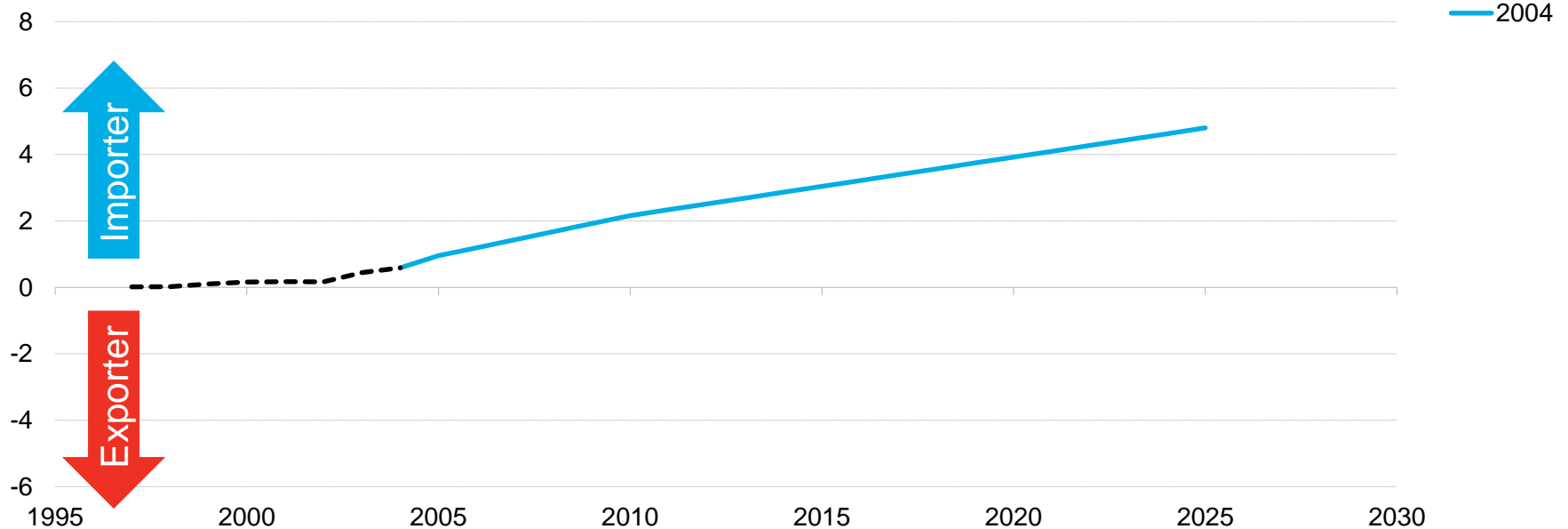


Source: Bloomberg New Energy Finance, EIA



# US Projected net imports of LNG 1997-2030

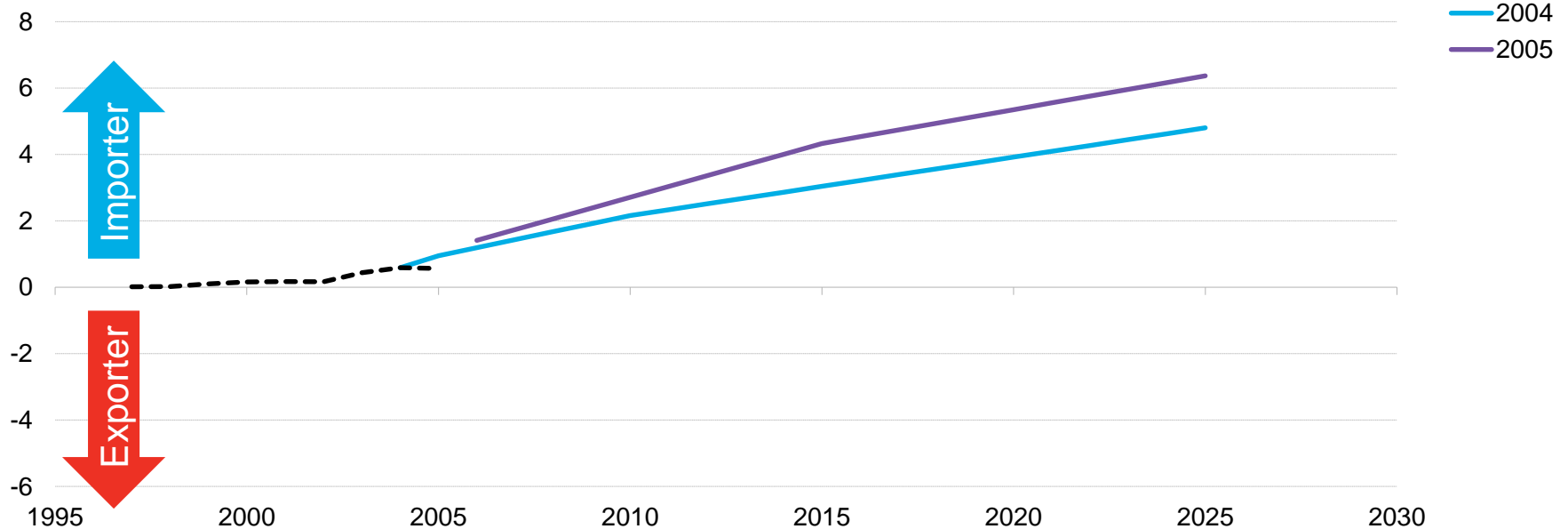
Trillion cubic feet



Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

# US Projected net imports of LNG 1997-2030

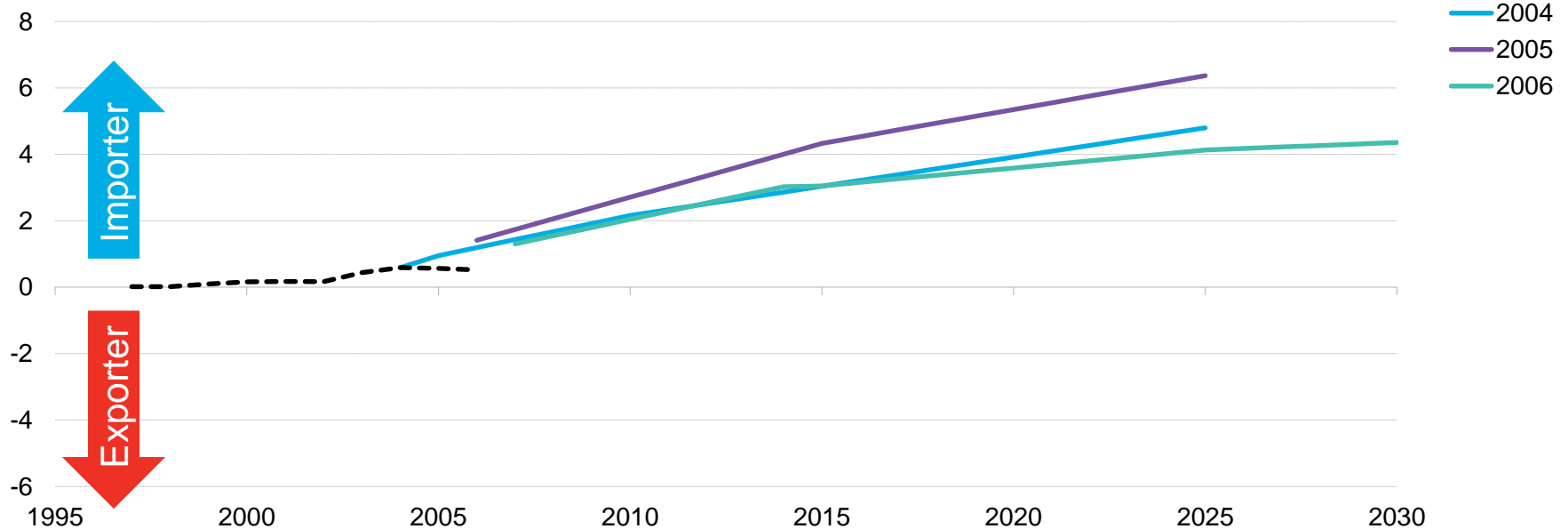
Trillion cubic feet



Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

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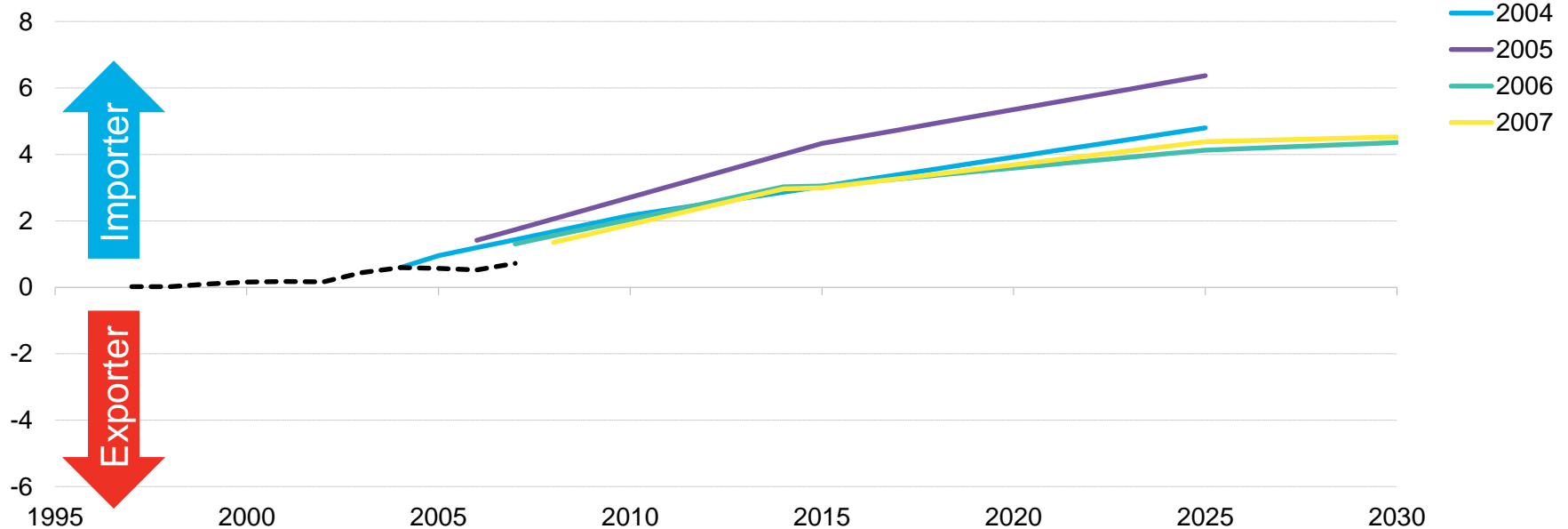
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Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

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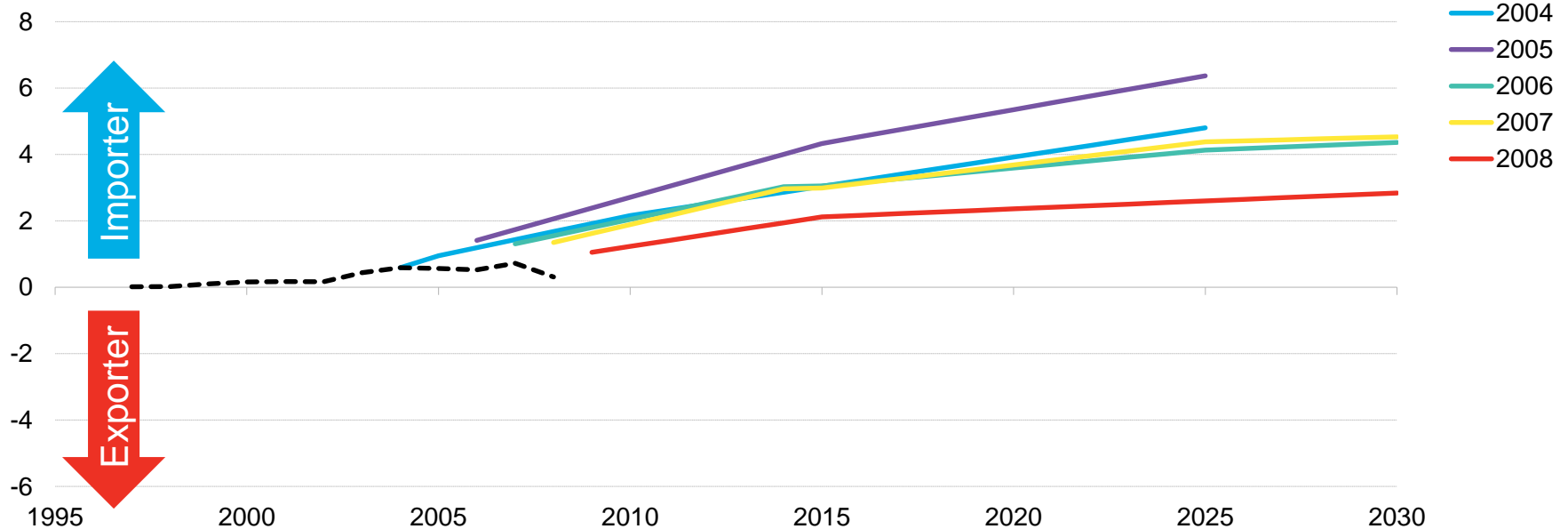
Trillion cubic feet



Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

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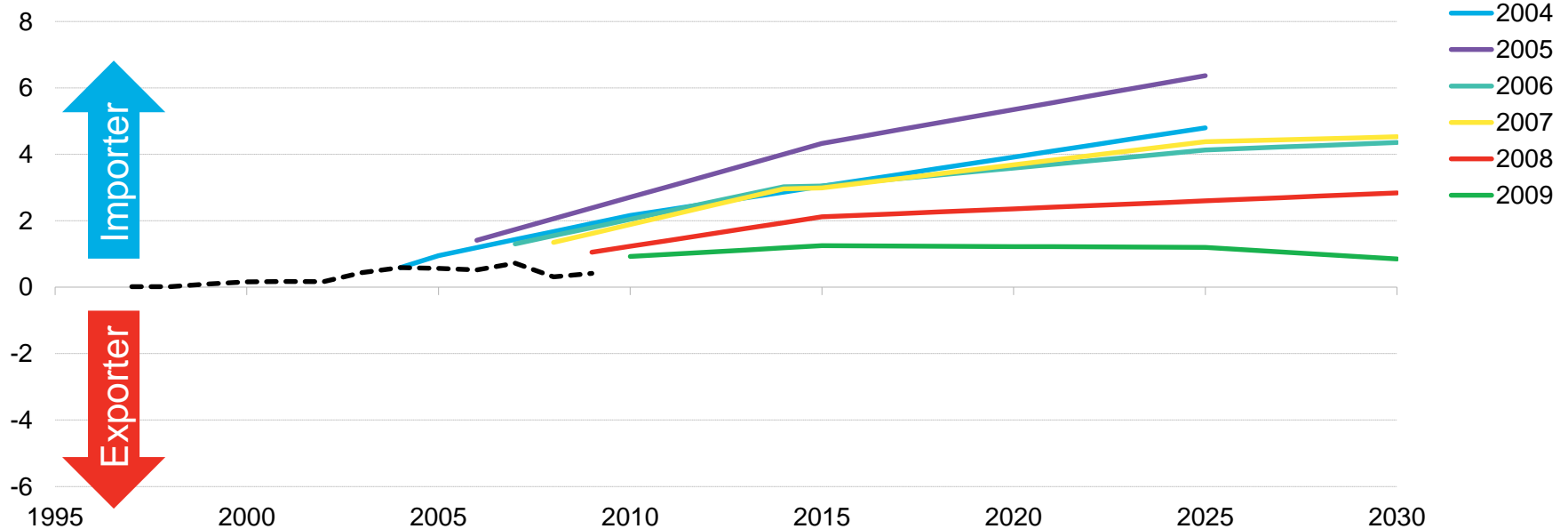
Trillion cubic feet



Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

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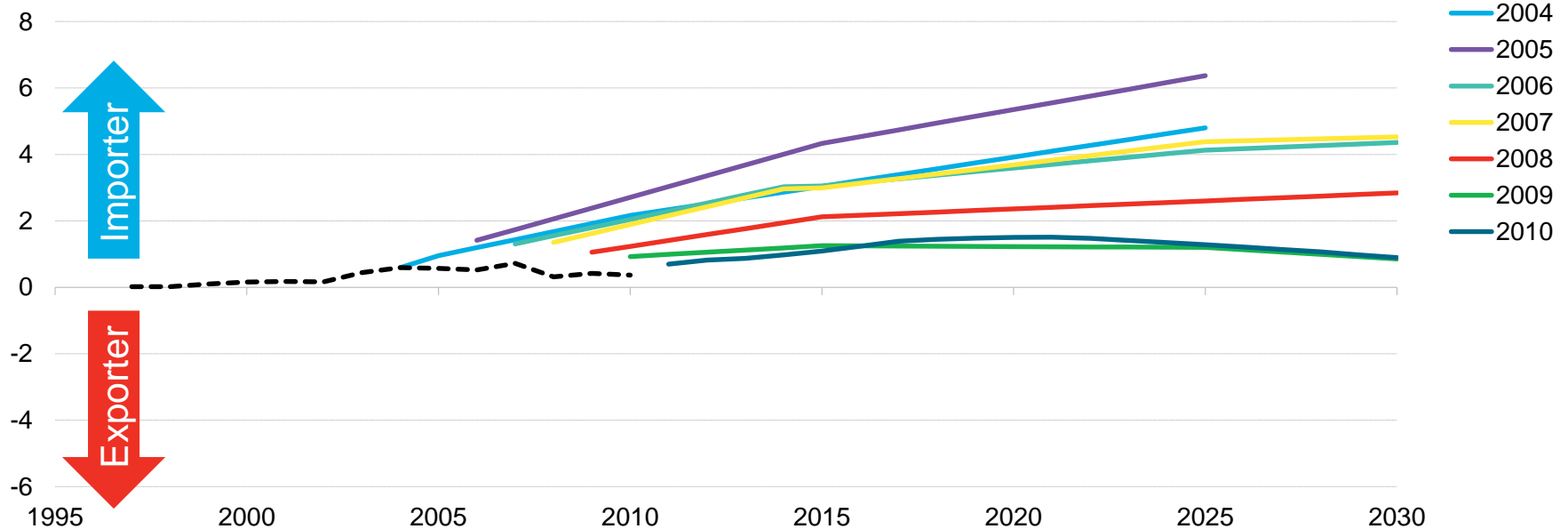
Trillion cubic feet



Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

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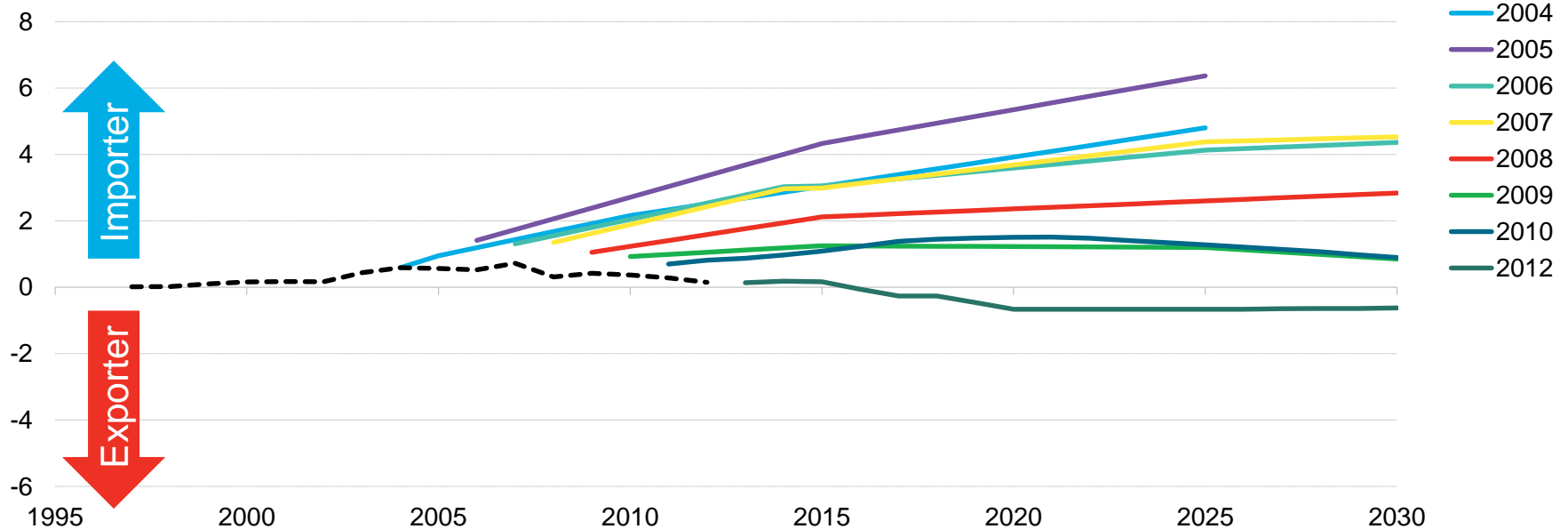
Trillion cubic feet



Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

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Trillion cubic feet

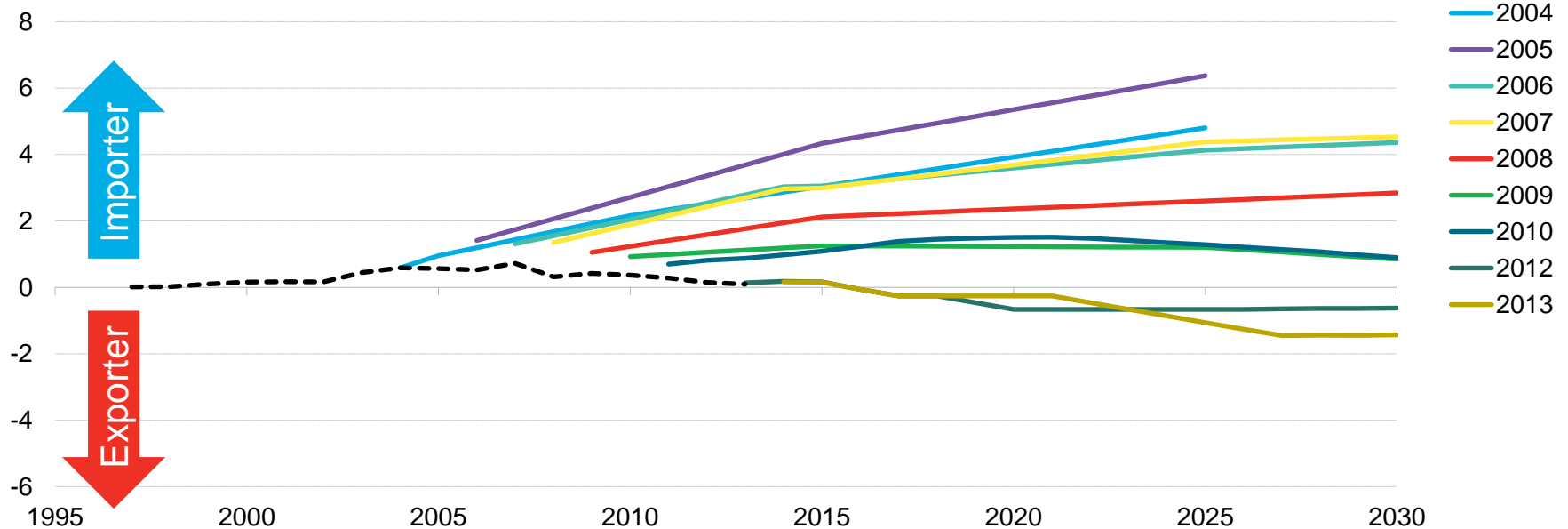


Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance



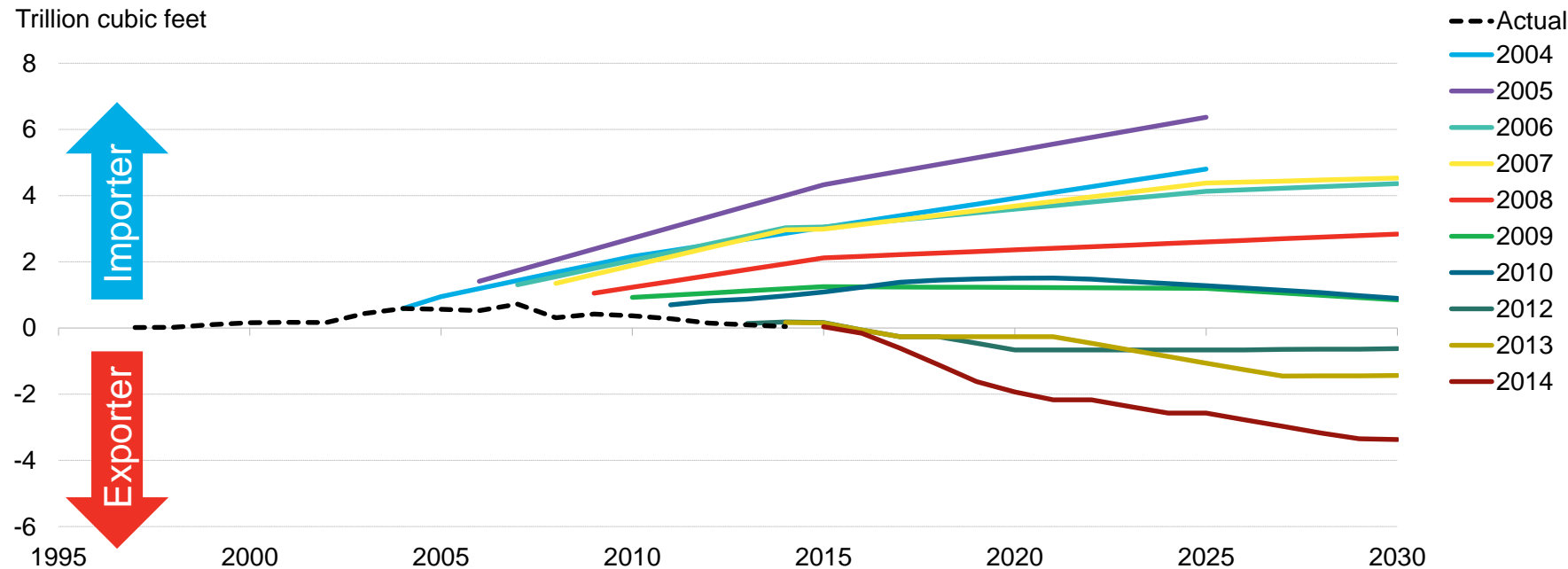
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Trillion cubic feet



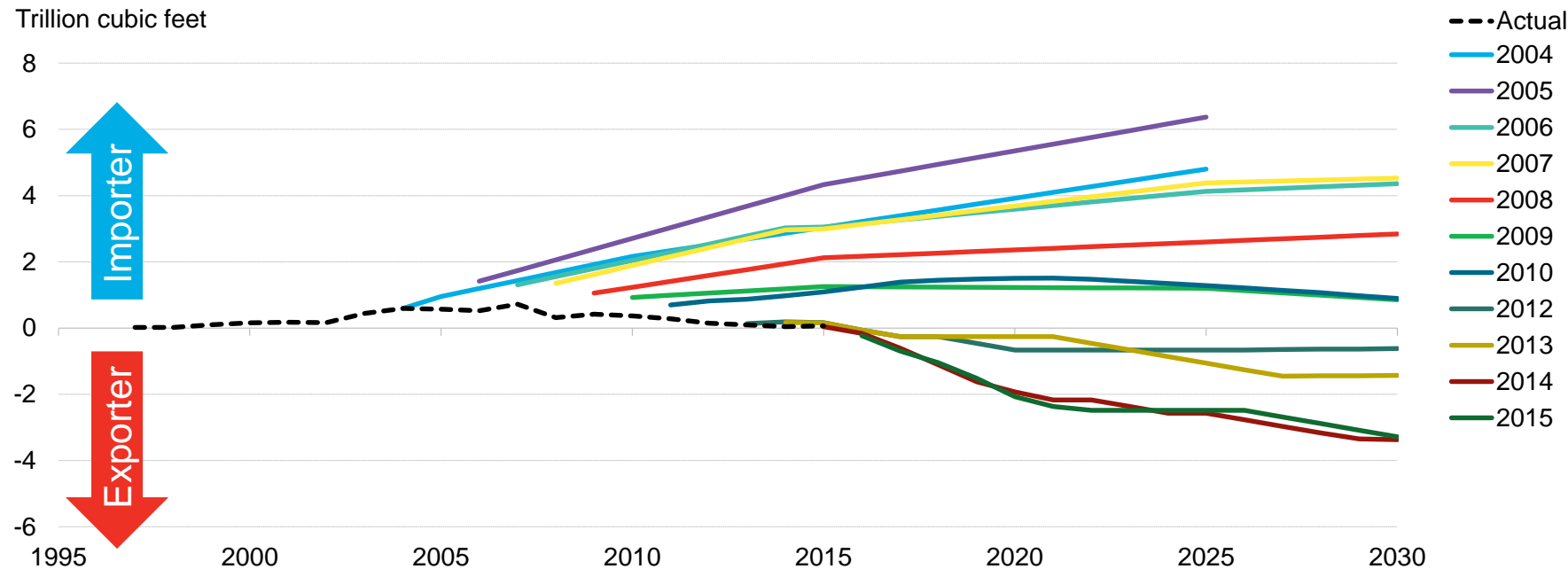
Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

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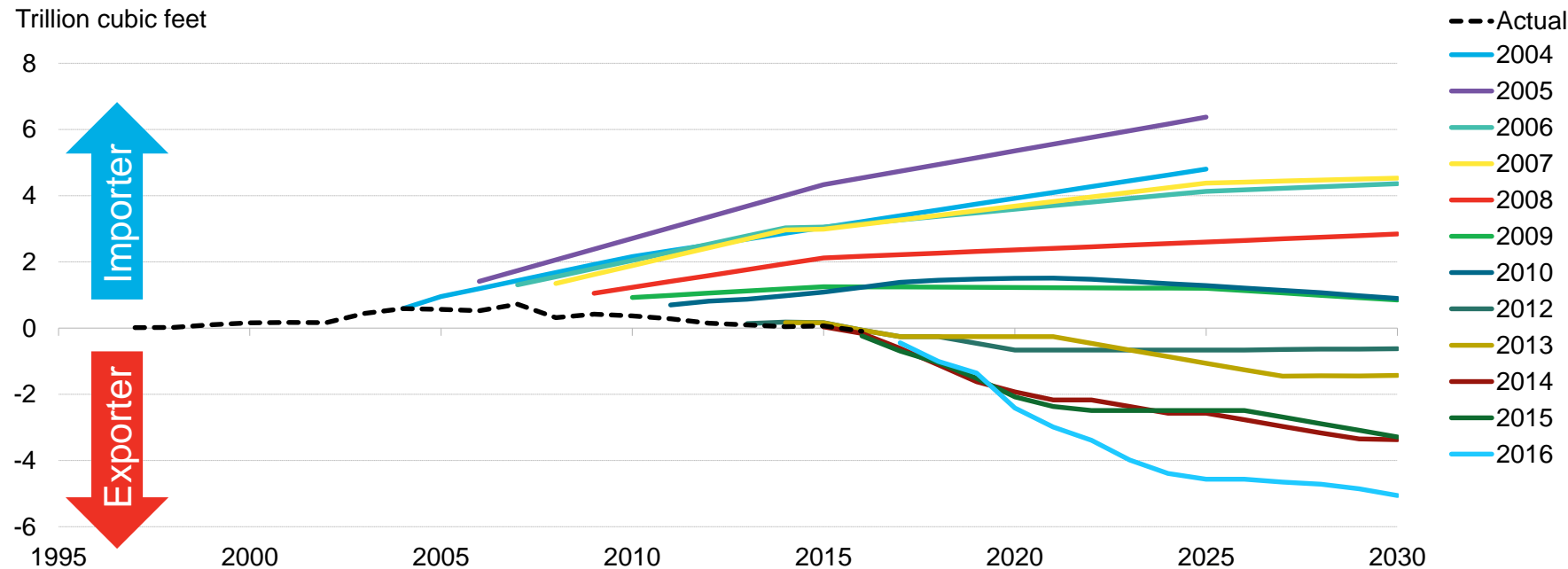
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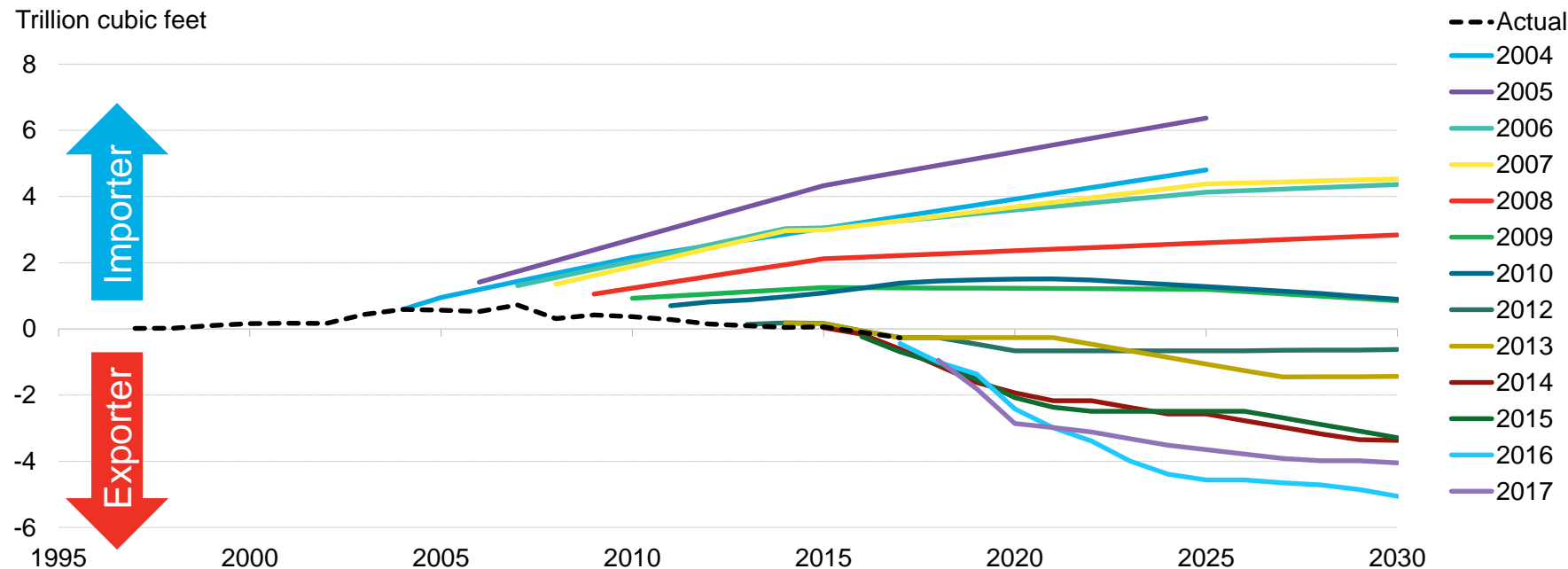
Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

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Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

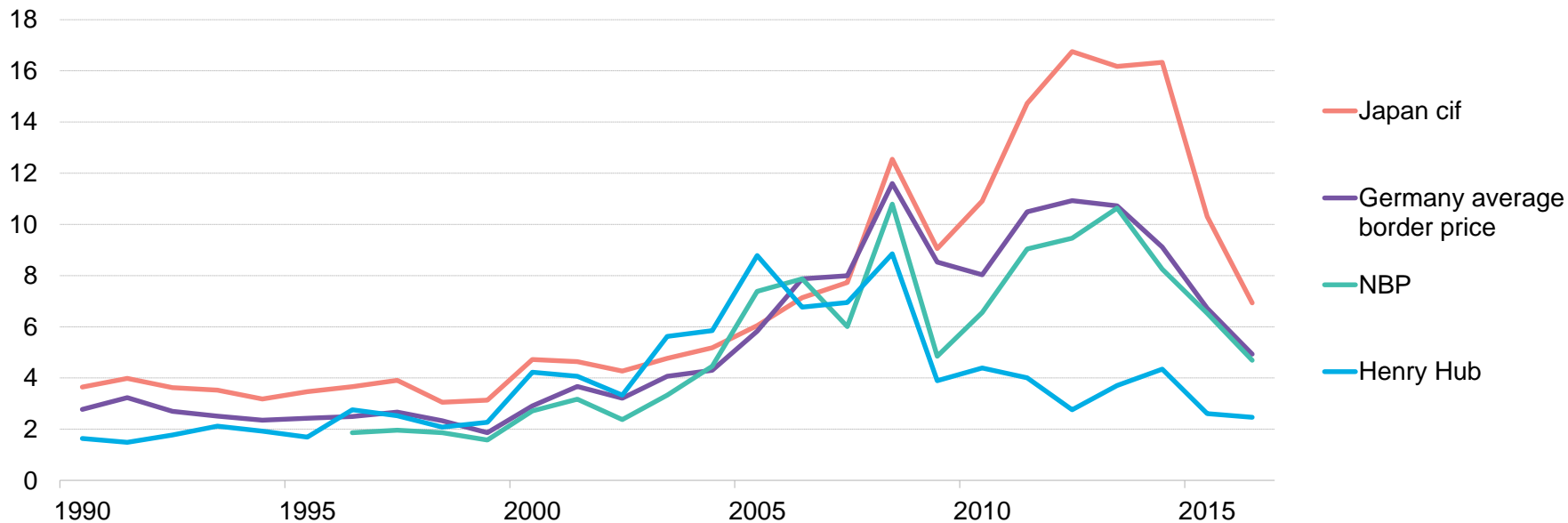
# US Projected net imports of LNG



Source: EIA Annual Energy Outlook; Bloomberg New Energy Finance

# Gas prices

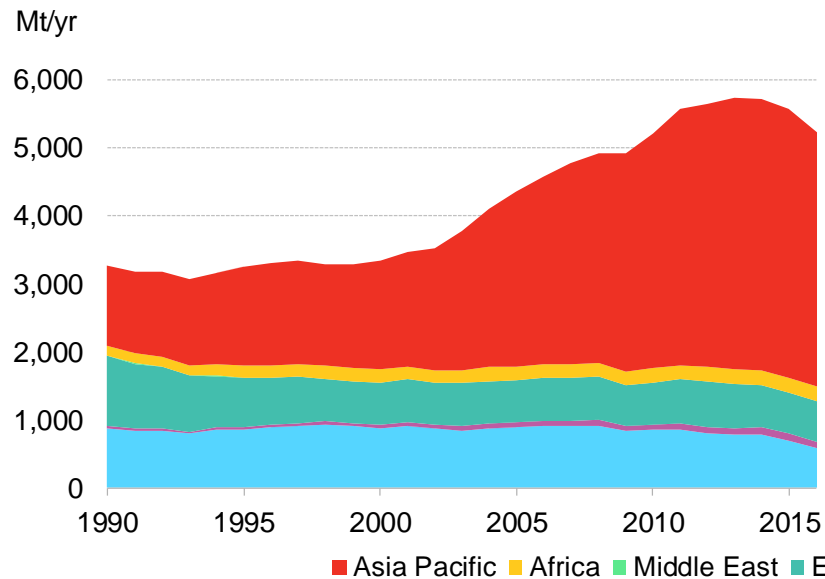
\$/MMBtu



Source: Bloomberg New Energy Finance, BP Statistical Review

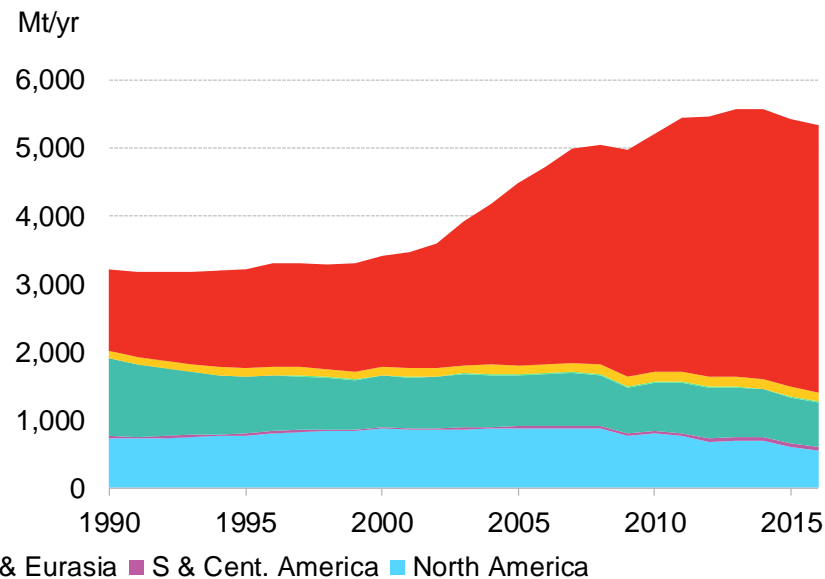
# Coal has peaked

## Coal production



Note: Adjusted to standard coal equivalent

## Coal consumption

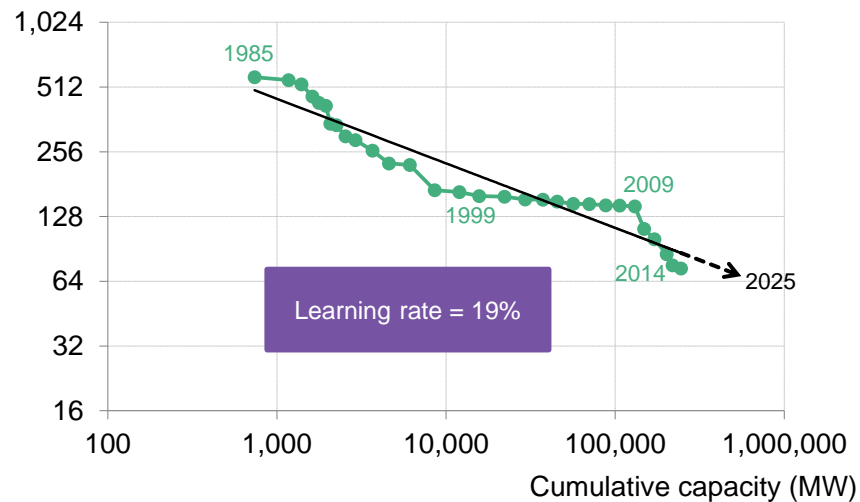


Source: Bloomberg New Energy Finance, BP Statistical Review

# Wind and solar experience curves

## Wind

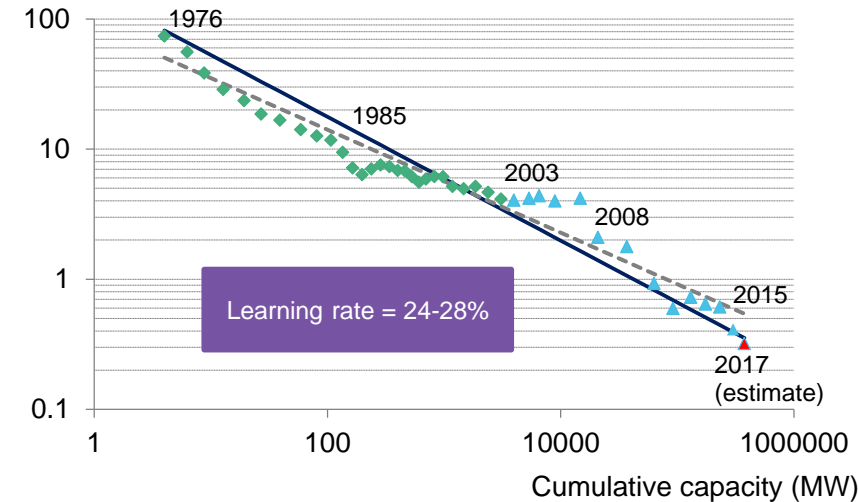
eur/MWh



Source: Bloomberg New Energy Finance

## Solar

\$/W



Source: Bloomberg New Energy Finance



# Unsubsidised clean energy world records 2017

## Solar PV



Country: United Arab Emirates  
Bidder: Marubeni and Jinko Solar  
Signed: 2017  
Construction: 2019  
**Price: US\$ 2.42 c/kWh**

## Onshore wind



Country: Morocco  
Bidder: Enel Green Power  
Signed: 2016  
Construction: 2018  
**Price: US\$ 3.0 c/kWh**

## Offshore wind

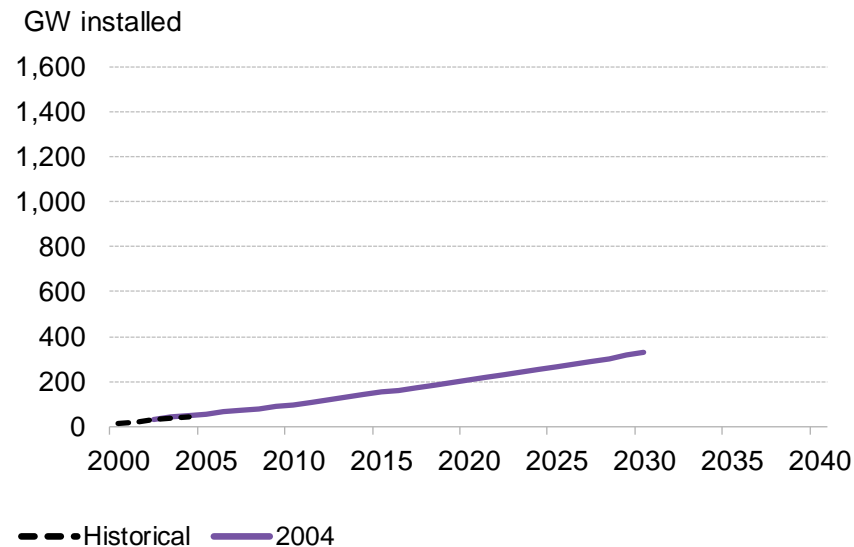


Country: Germany  
Bidder: DONG/EnBW  
Signed: 2016  
Construction: 2024  
**Merchant Price: US\$ 4.9 c/kWh**

Source: Bloomberg New Energy Finance; Images Siemens; Wikimedia Commons; Masdar

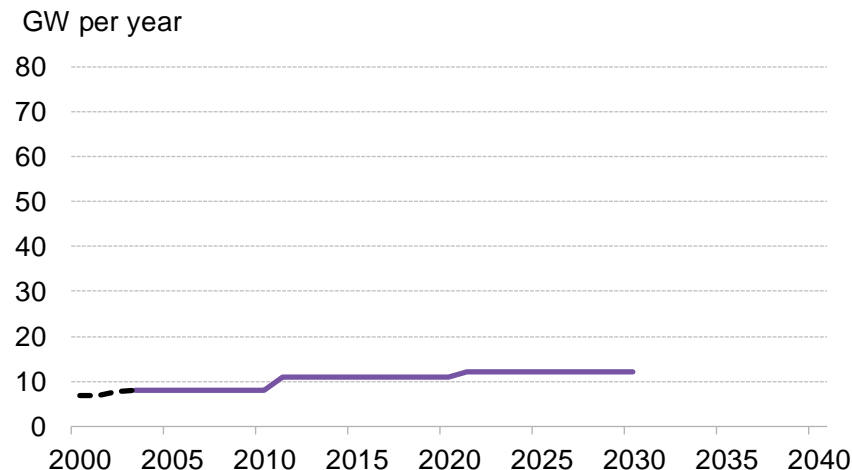
# IEA wind capacity forecast evolution

## Global cumulative wind installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

## Annual wind additions

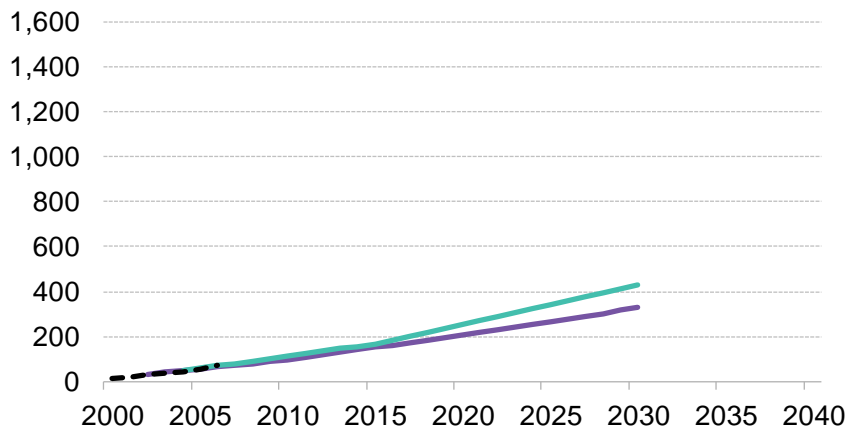


Source: IEA World Energy Outlook

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GW installed

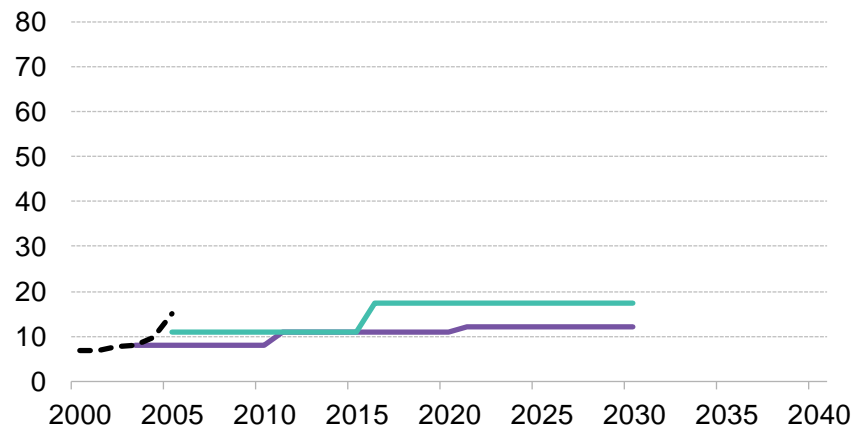


---•--- Historical    2004    2006

Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

## Annual wind additions

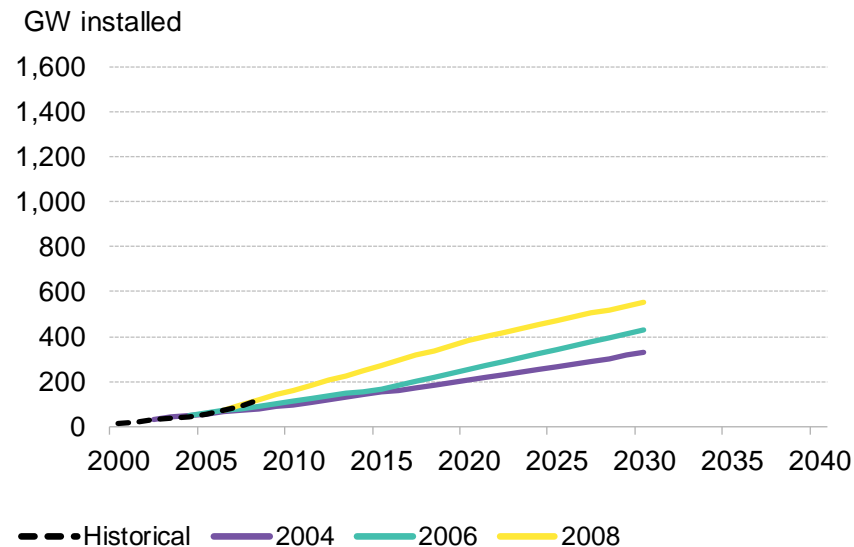
GW per year



Source: IEA World Energy Outlook

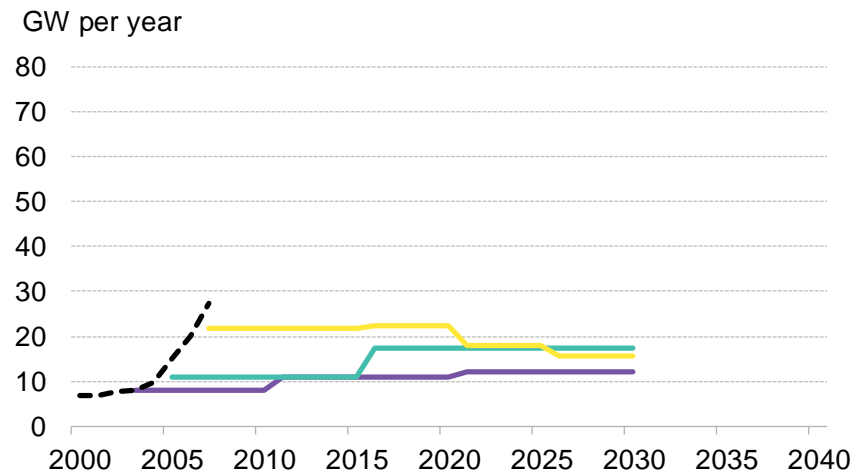
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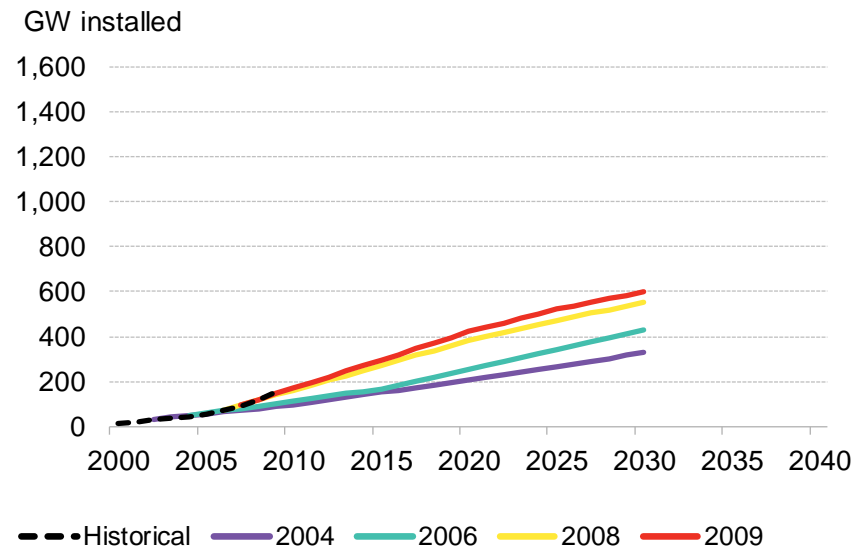
## Annual wind additions



Source: IEA World Energy Outlook

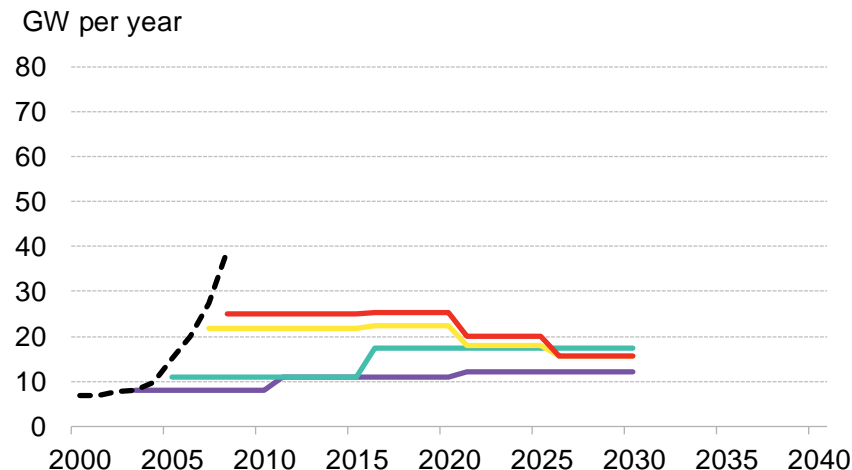
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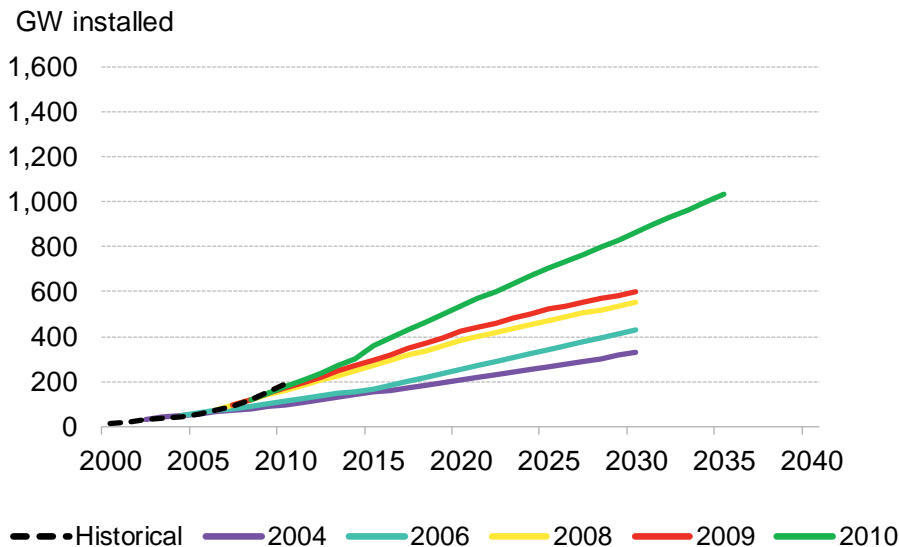
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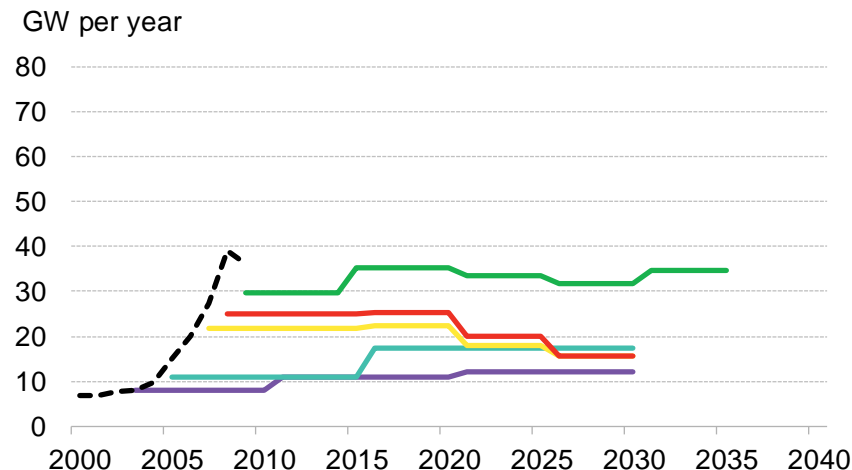
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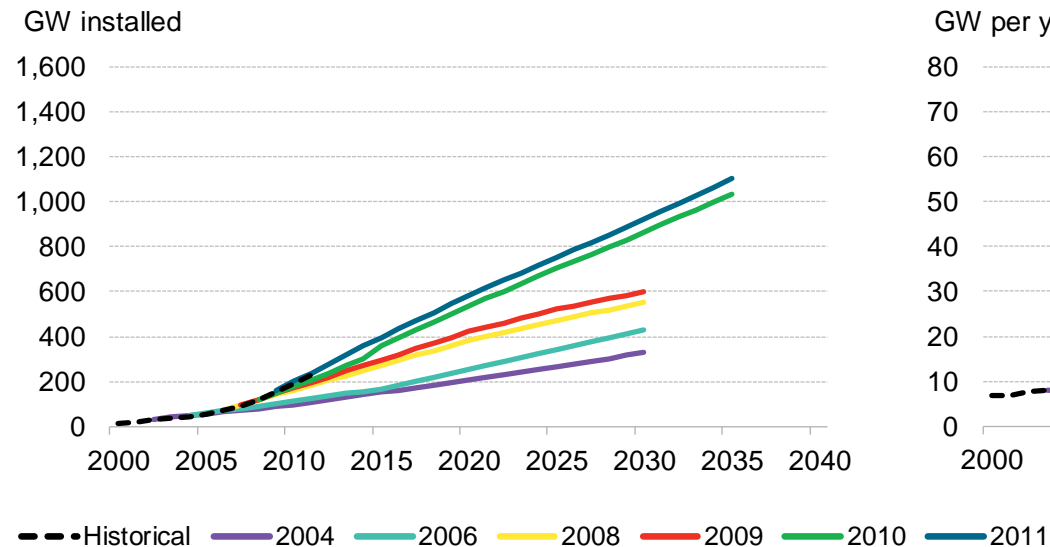
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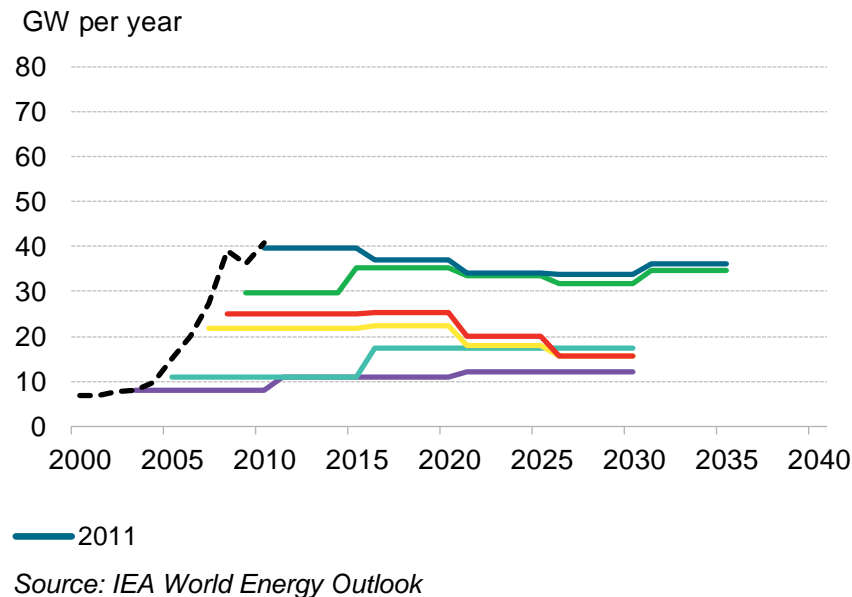
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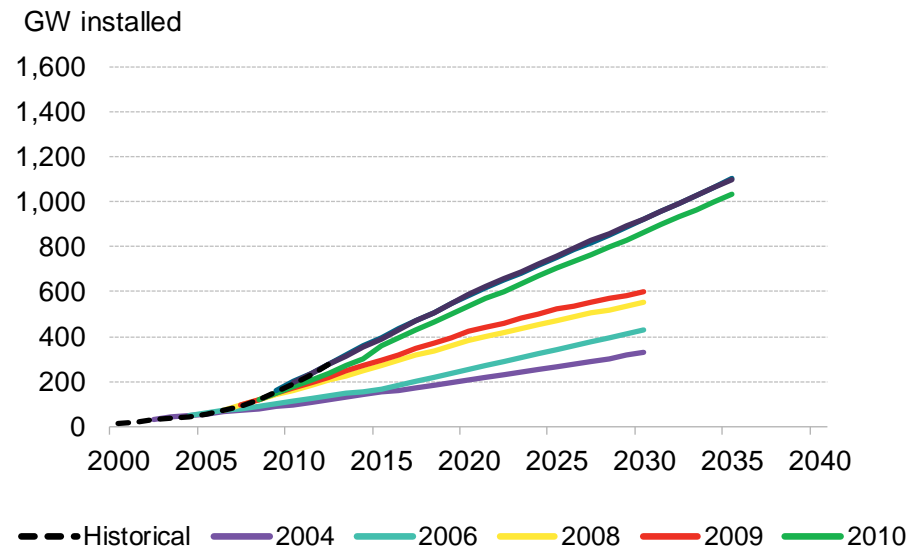
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## Annual wind additions



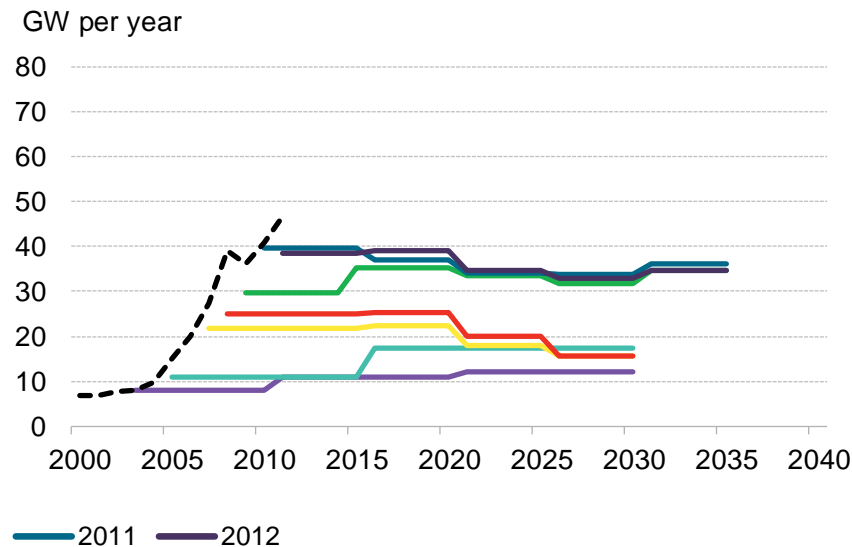
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Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

## Annual wind additions

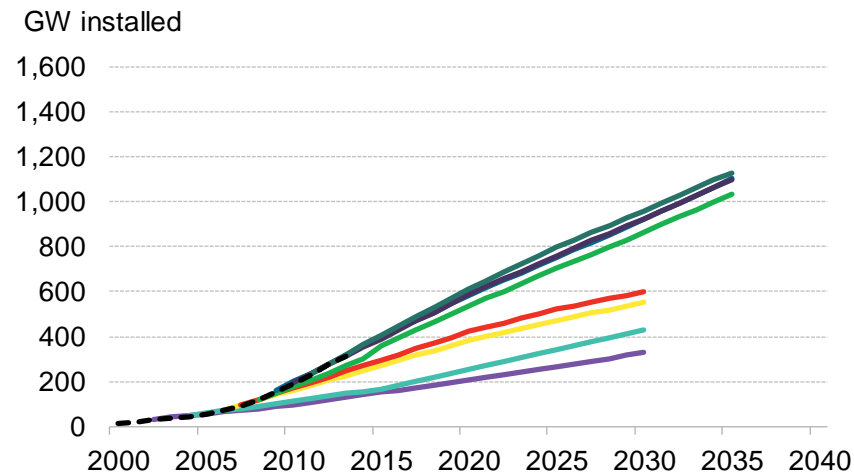


Source: IEA World Energy Outlook



# IEA wind capacity forecast evolution

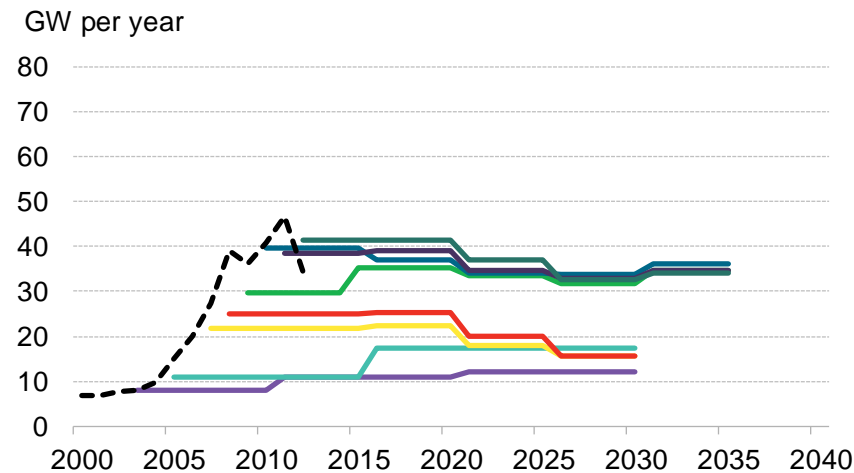
## Global cumulative wind installations



---•--- Historical    2004    2006    2008    2009    2010    2011    2012    2013

Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

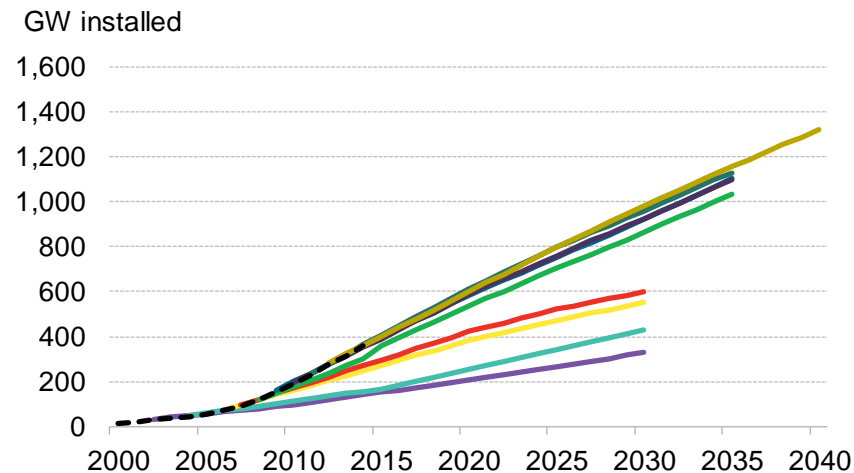
## Annual wind additions



Source: IEA World Energy Outlook

# IEA wind capacity forecast evolution

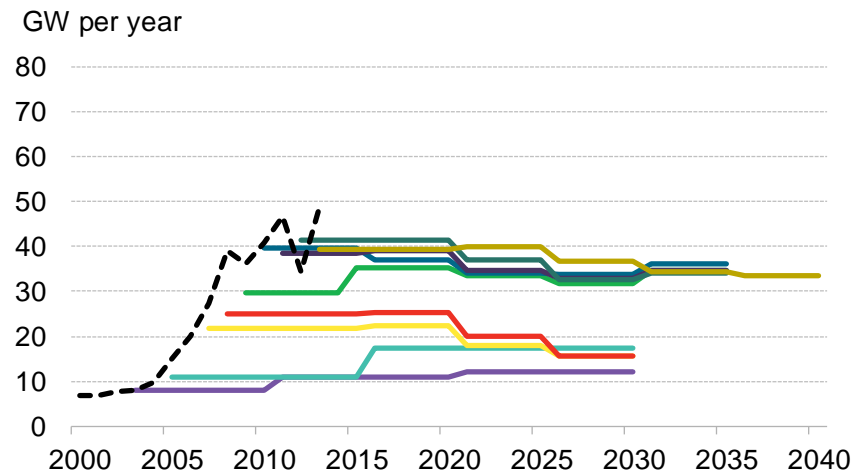
## Global cumulative wind installations



--- Historical    2004    2006    2008    2009    2010    2011    2012    2013    2014

Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

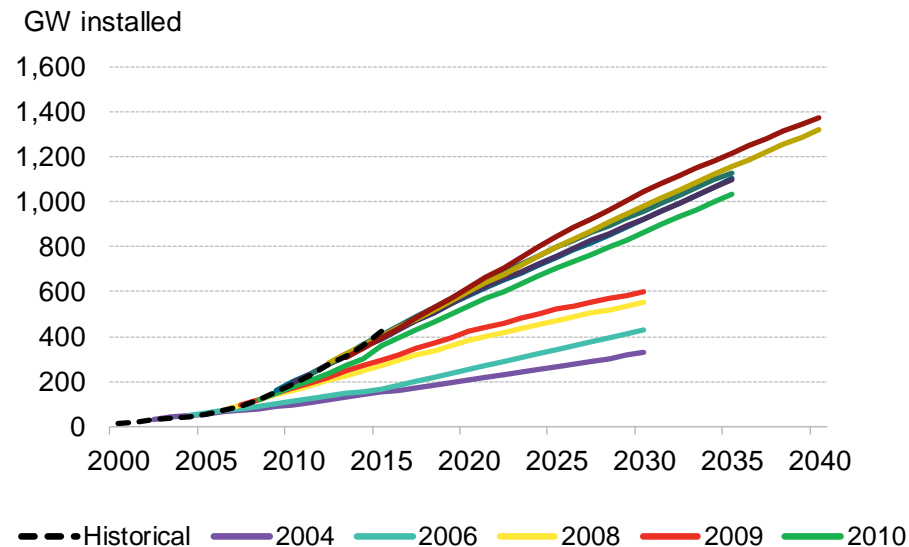
## Annual wind additions



Source: IEA World Energy Outlook

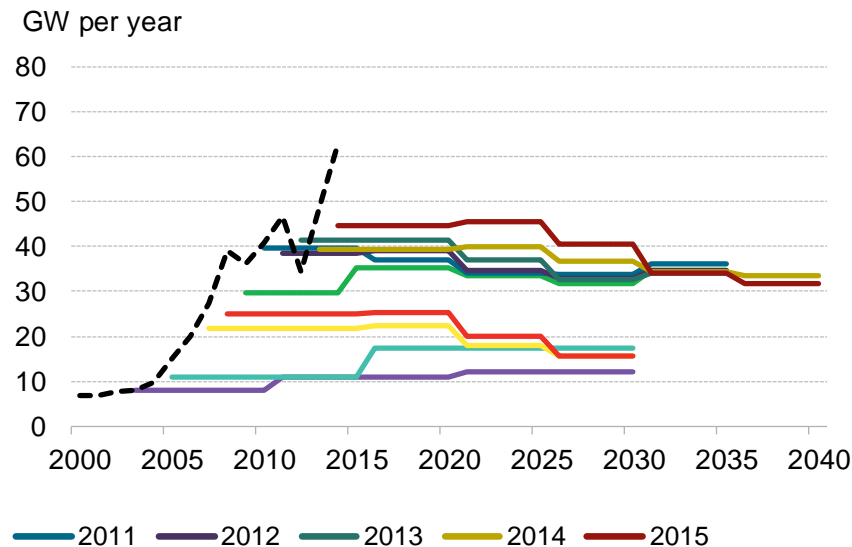
# IEA wind capacity forecast evolution

## Global cumulative wind installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

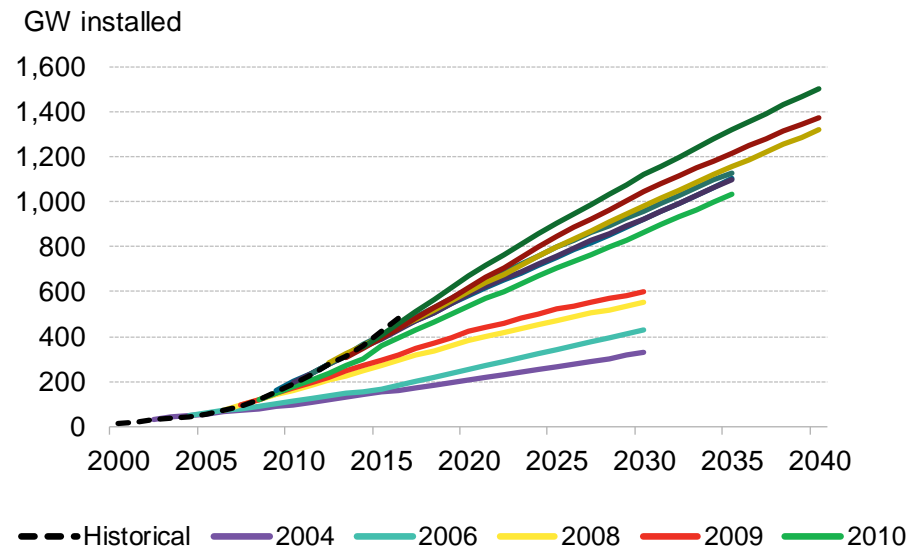
## Annual wind additions



Source: IEA World Energy Outlook

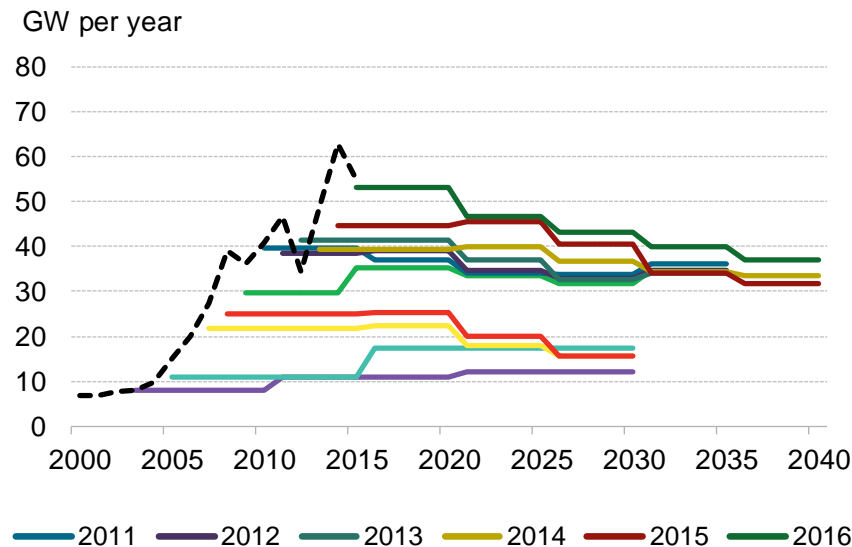
# IEA wind capacity forecast evolution

## Global cumulative wind installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

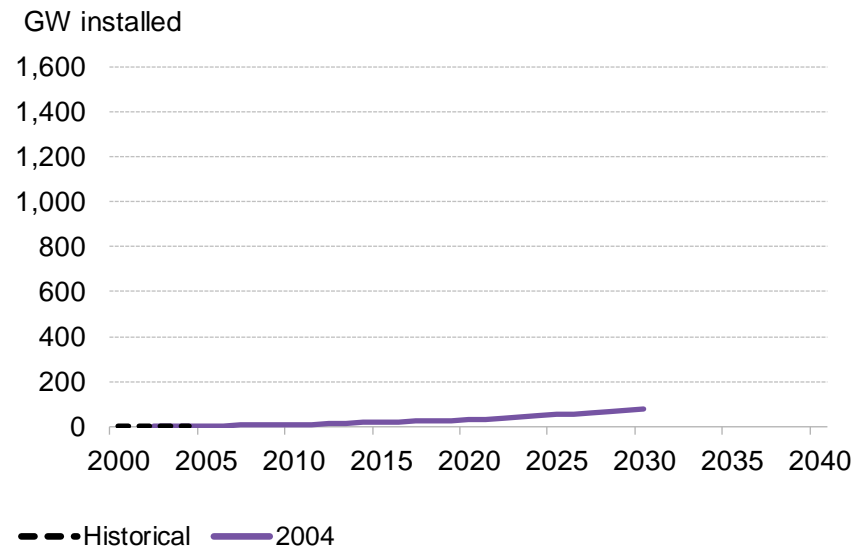
## Annual wind additions



Source: IEA World Energy Outlook

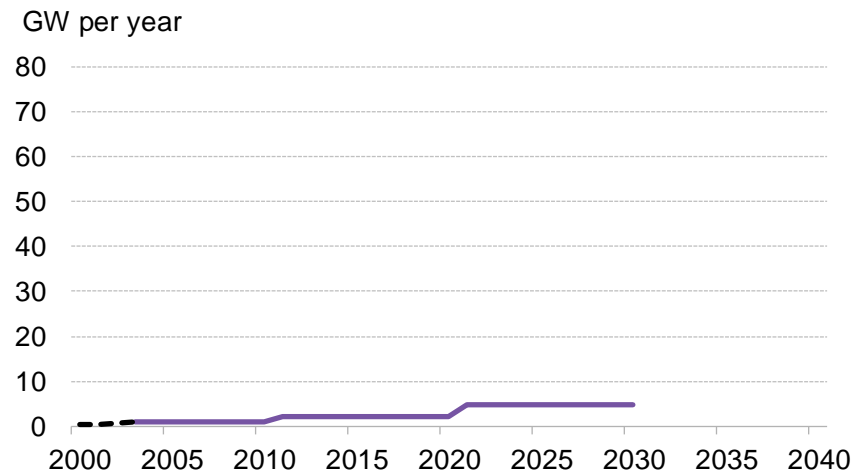
# IEA solar capacity forecast evolution

## Global cumulative solar installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

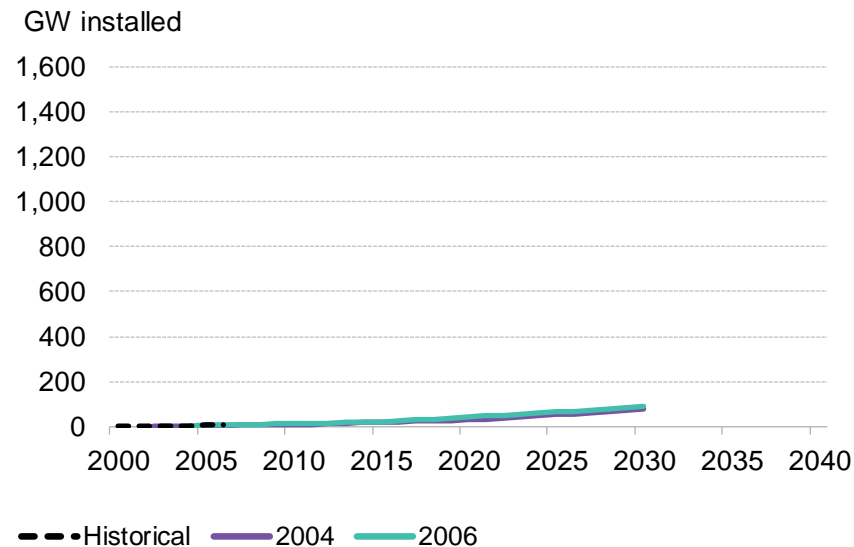
## Annual solar additions



Source: IEA World Energy Outlook

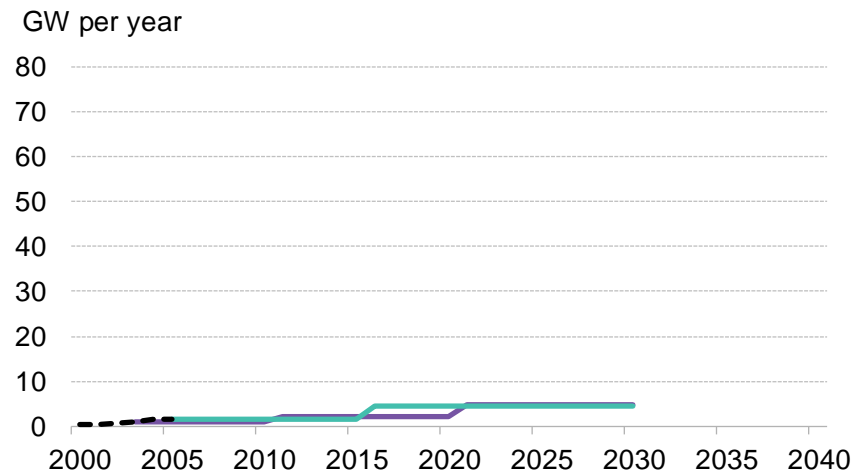
# IEA solar capacity forecast evolution

## Global cumulative solar installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

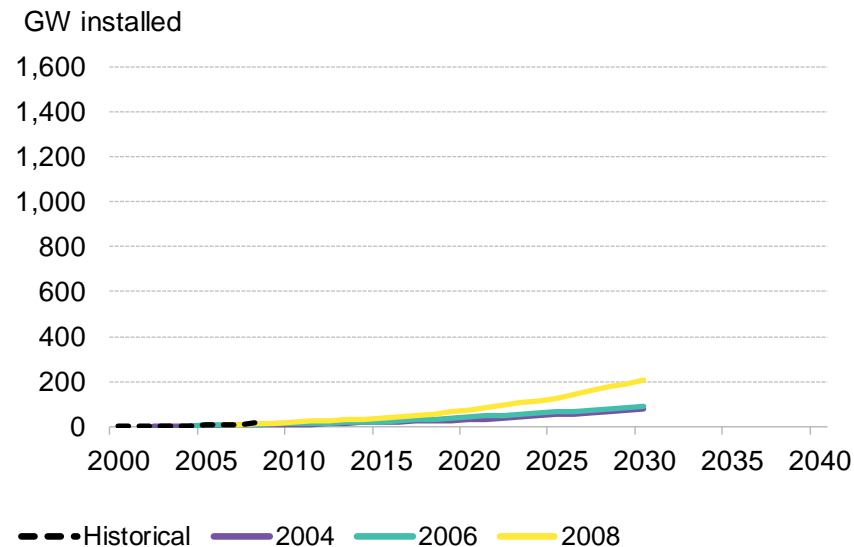
## Annual solar additions



Source: IEA World Energy Outlook

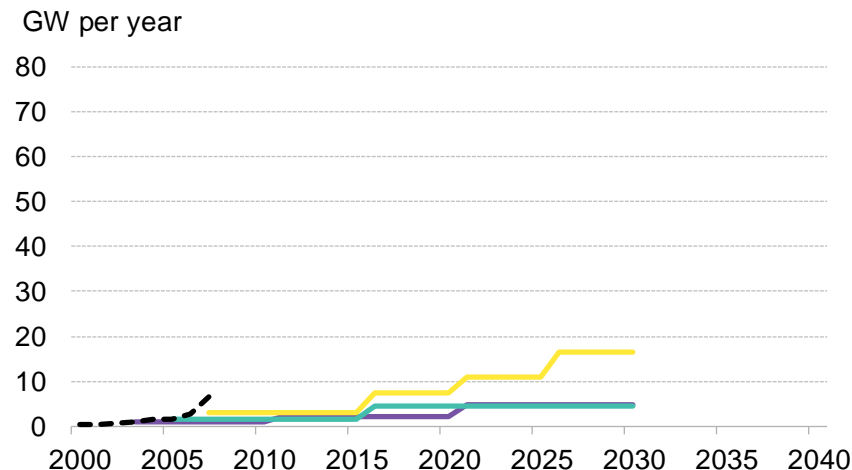
# IEA solar capacity forecast evolution

## Global cumulative solar installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

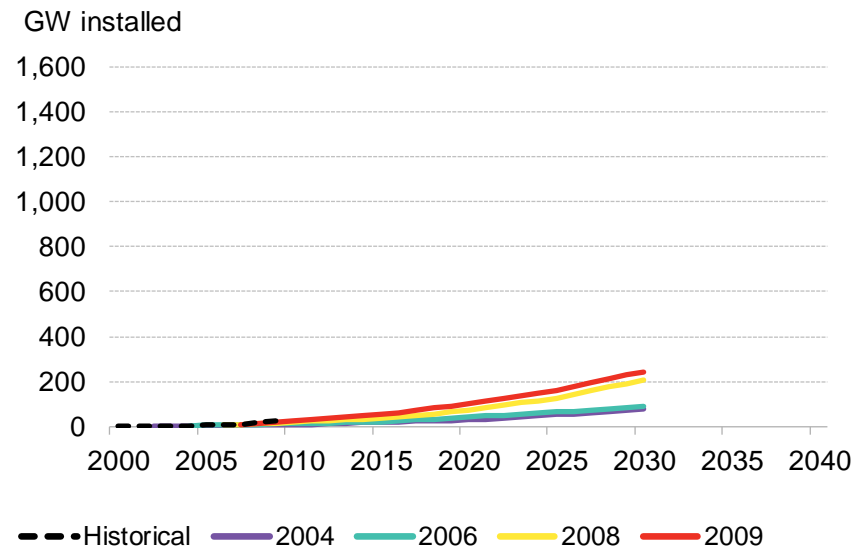
## Annual solar additions



Source: IEA World Energy Outlook

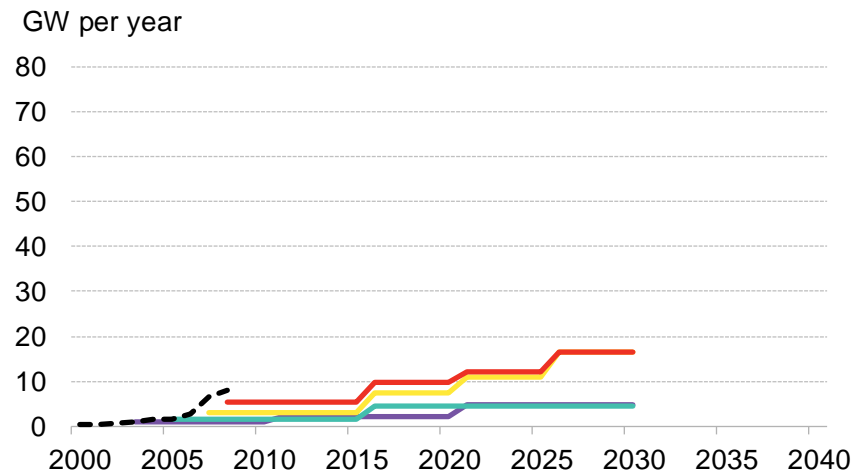
# IEA solar capacity forecast evolution

## Global cumulative solar installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

## Annual solar additions

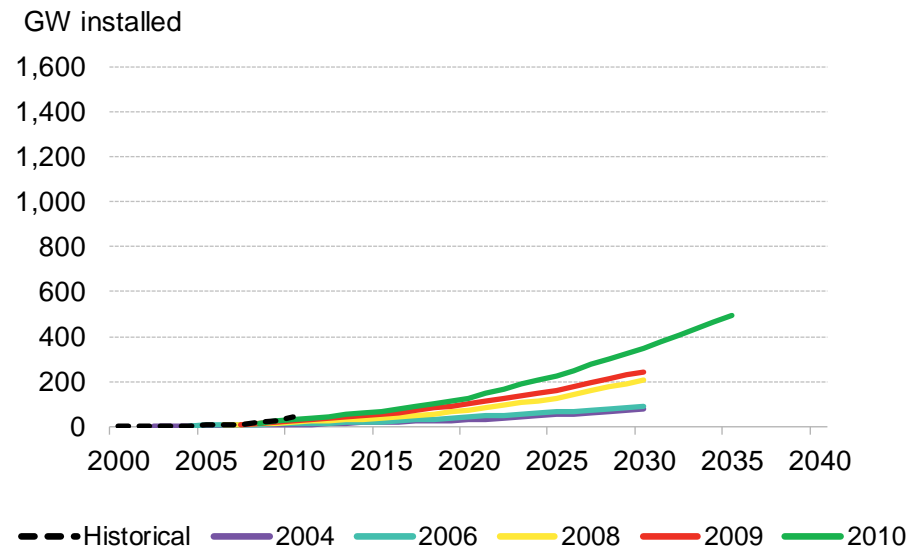


Source: IEA World Energy Outlook



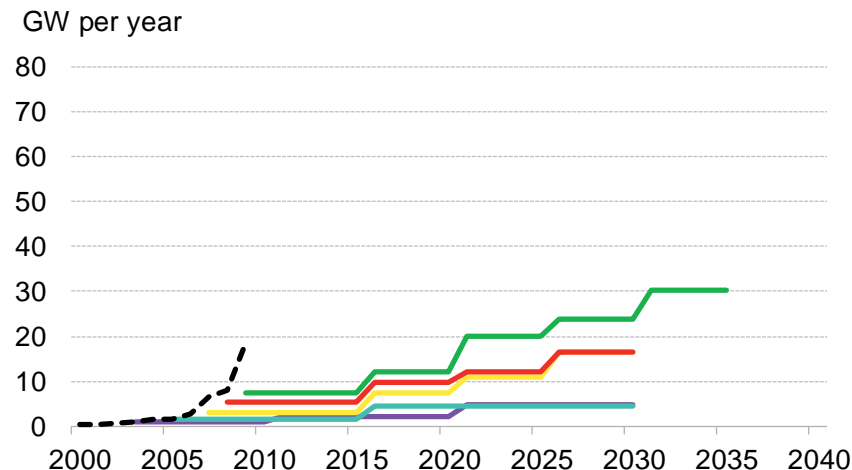
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## Global cumulative solar installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

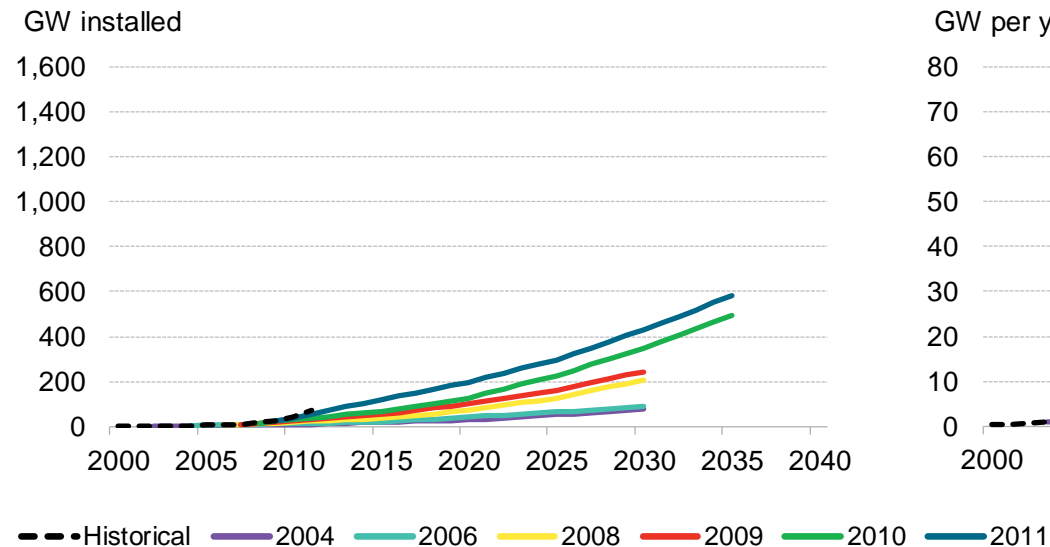
## Annual solar additions



Source: IEA World Energy Outlook

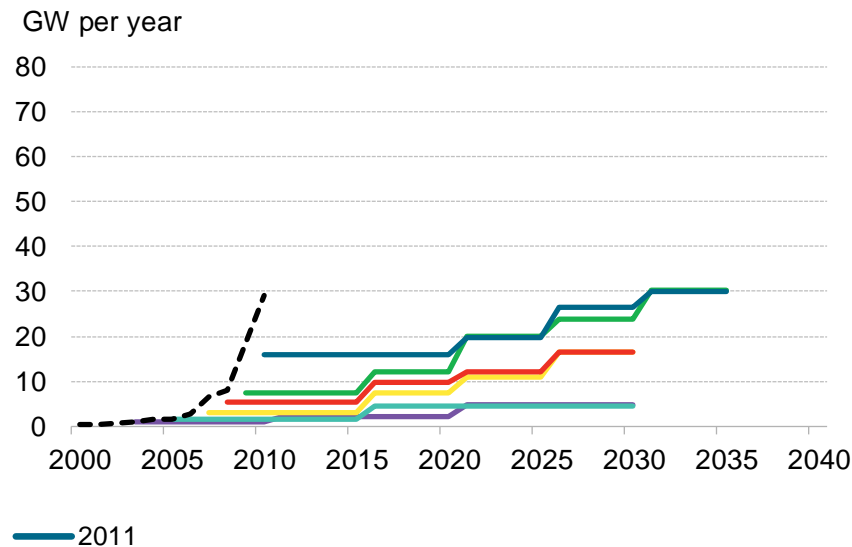
# IEA solar capacity forecast evolution

## Global cumulative solar installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

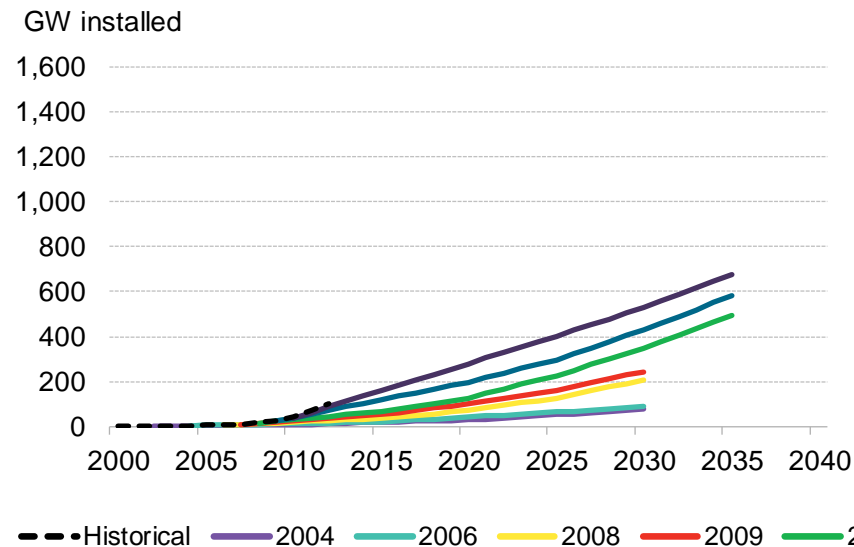
## Annual solar additions



Source: IEA World Energy Outlook

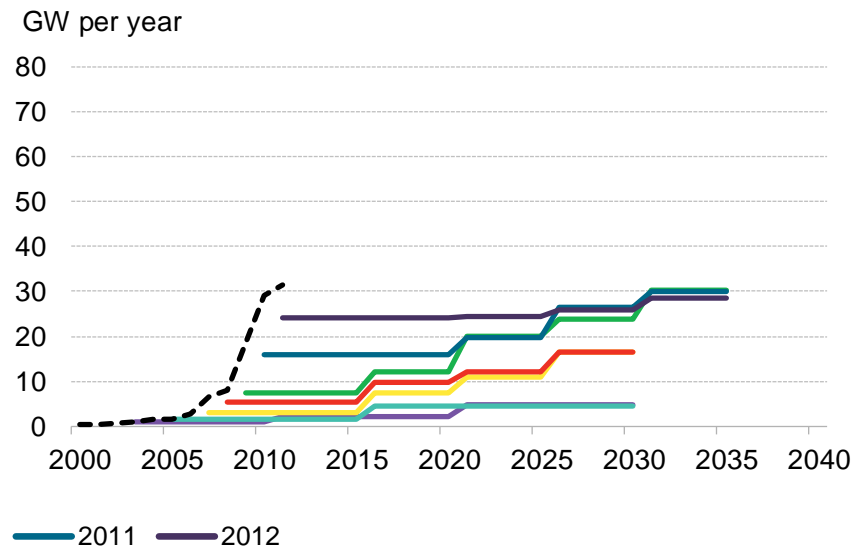
# IEA solar capacity forecast evolution

## Global cumulative solar installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

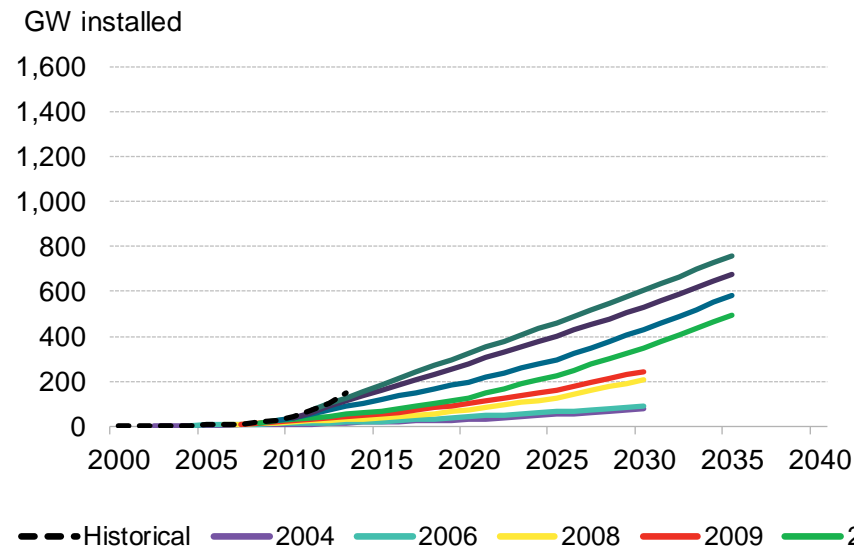
## Annual solar additions



Source: IEA World Energy Outlook

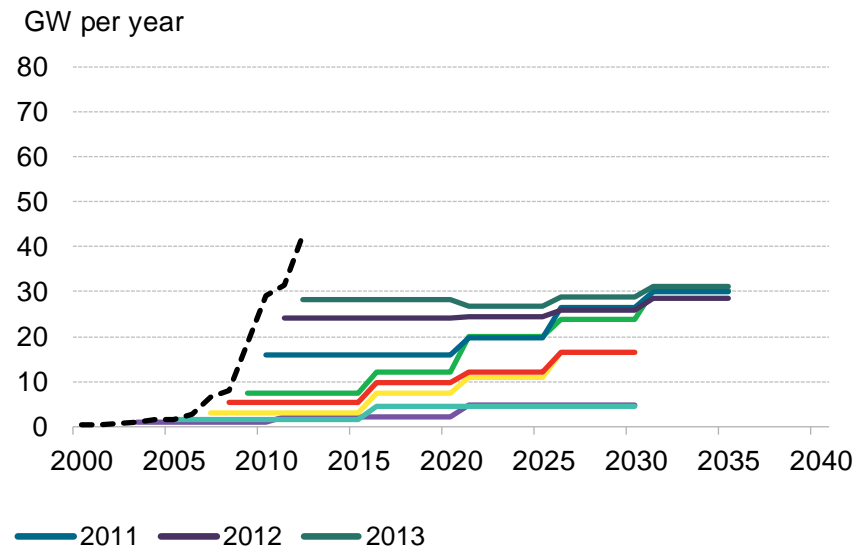
# IEA solar capacity forecast evolution

## Global cumulative solar installations



Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

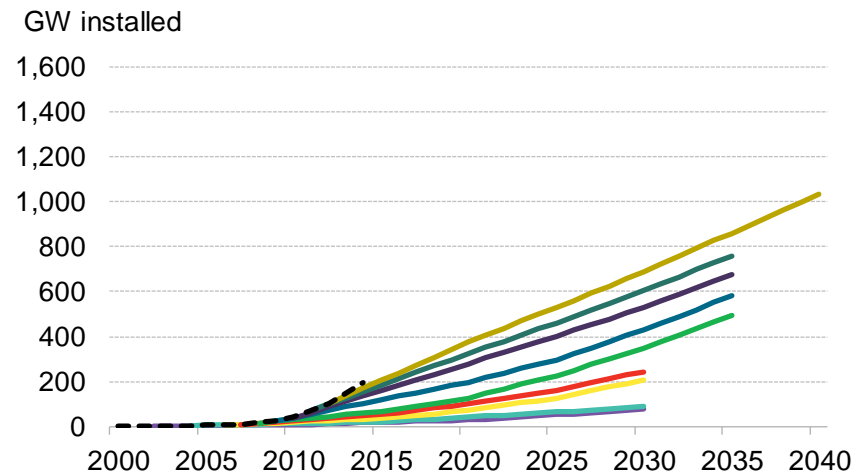
## Annual solar additions



Source: IEA World Energy Outlook

# IEA solar capacity forecast evolution

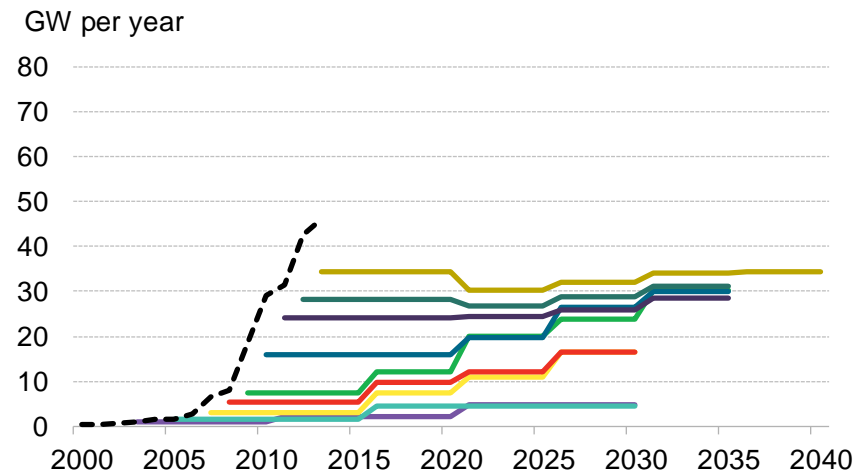
## Global cumulative solar installations



---•--- Historical    2004    2006    2008    2009    2010    2011    2012    2013    2014

Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

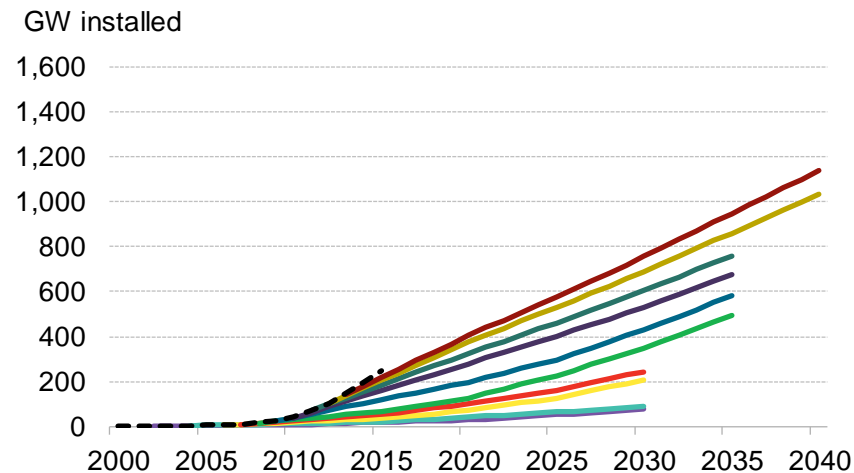
## Annual solar additions



Source: IEA World Energy Outlook

# IEA solar capacity forecast evolution

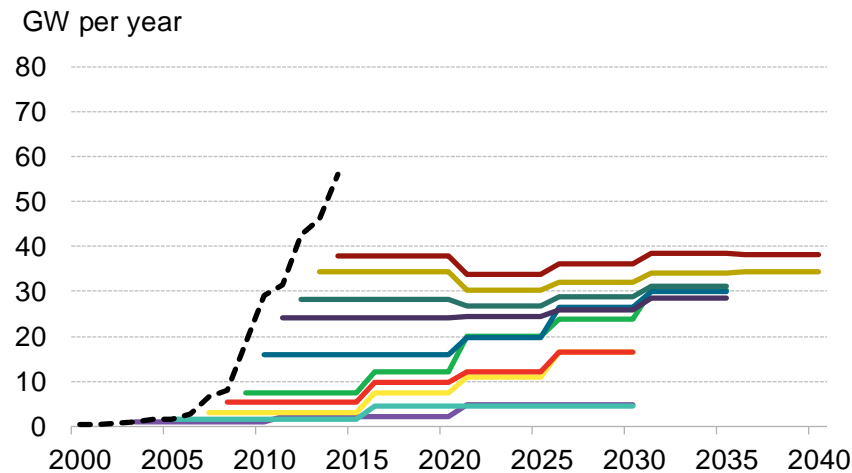
## Global cumulative solar installations



---•--- Historical    2004    2006    2008    2009    2010    2011    2012    2013    2014    2015

Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

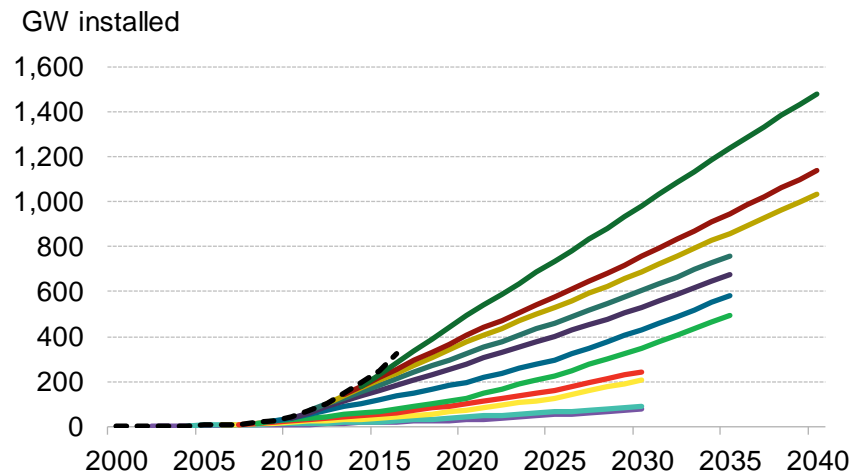
## Annual solar additions



Source: IEA World Energy Outlook

# IEA solar capacity forecast evolution

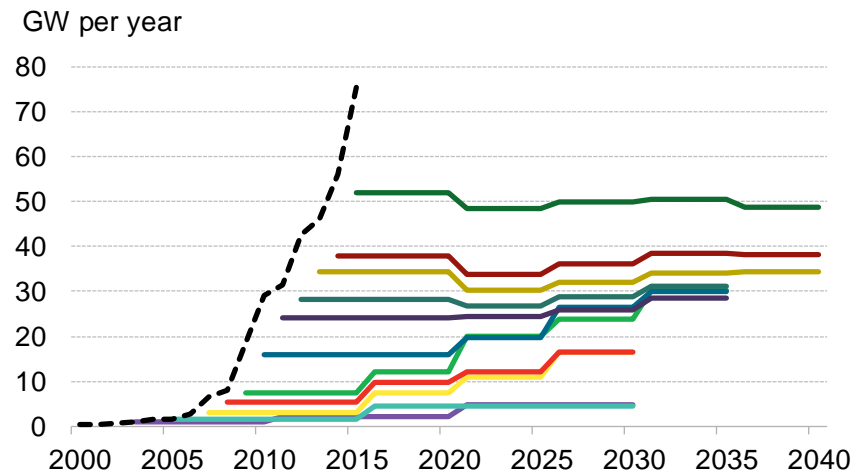
## Global cumulative solar installations



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

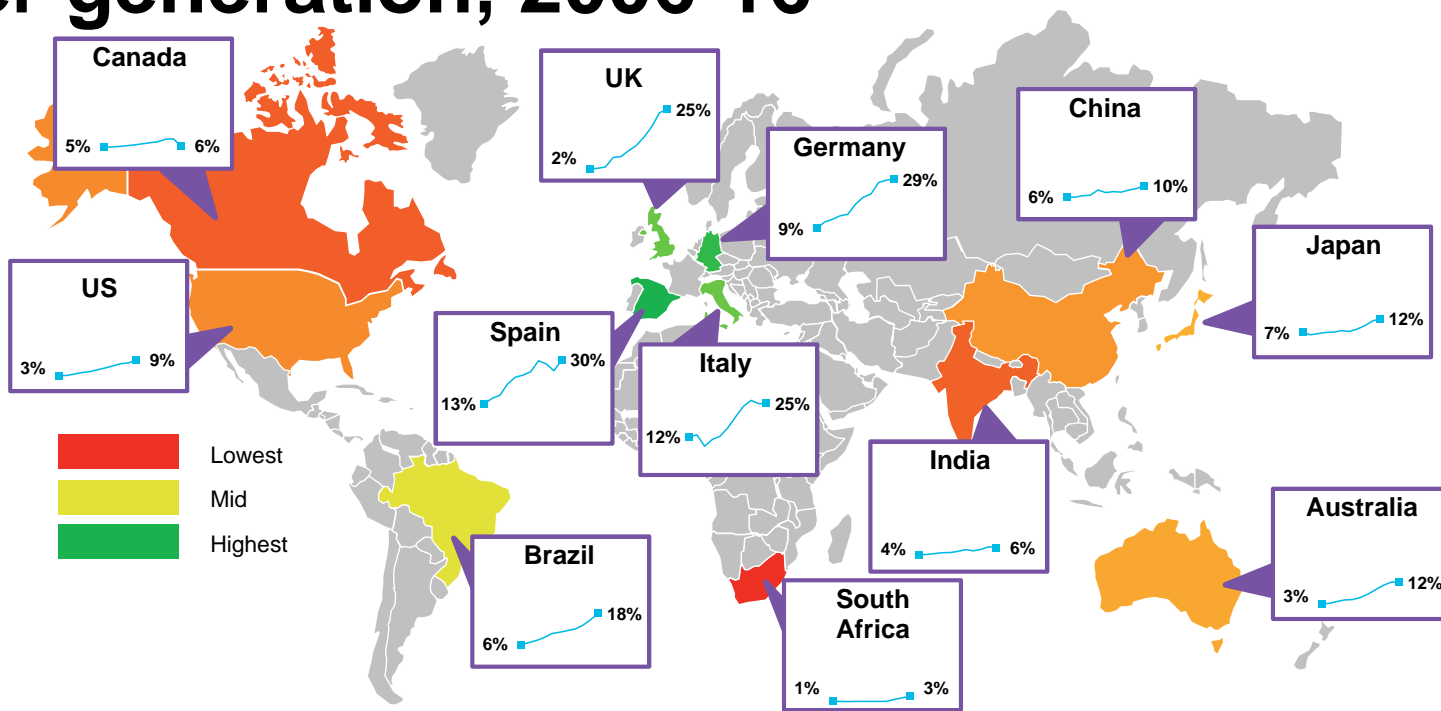
Note: 2004-2009 Reference, 2010-2016 New Policies Scenario

## Annual solar additions



Source: IEA World Energy Outlook

# Renewable energy proportion of power generation, 2006-16

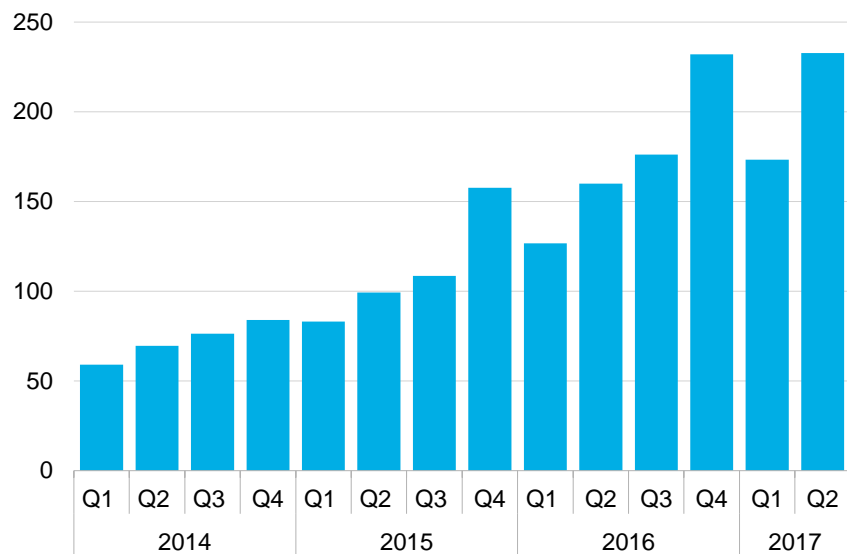


Note: Excludes large hydro Source: Bloomberg New Energy Finance

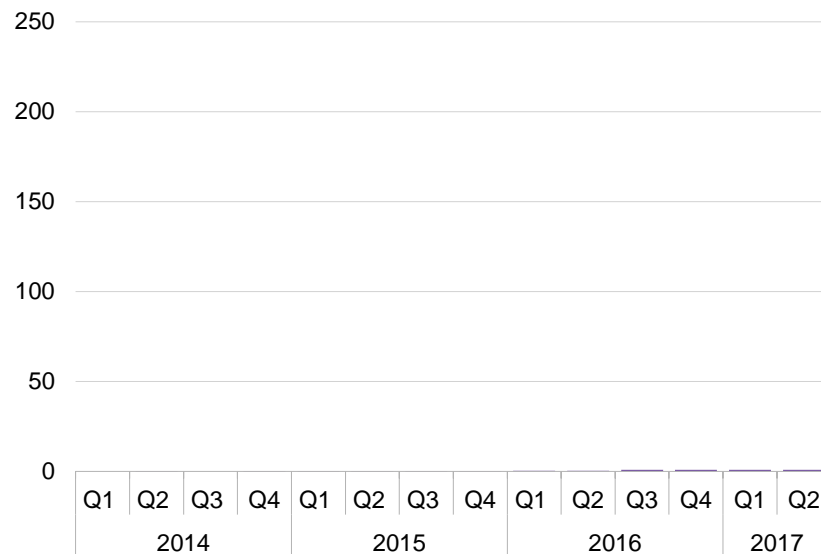


# FCV vs. BEV sales

## Electric vehicles (thousand units)



## Fuel cell vehicles (thousand units)



Source: Bloomberg New Energy Finance

# Black Swans

## Fracking



## Fukushima



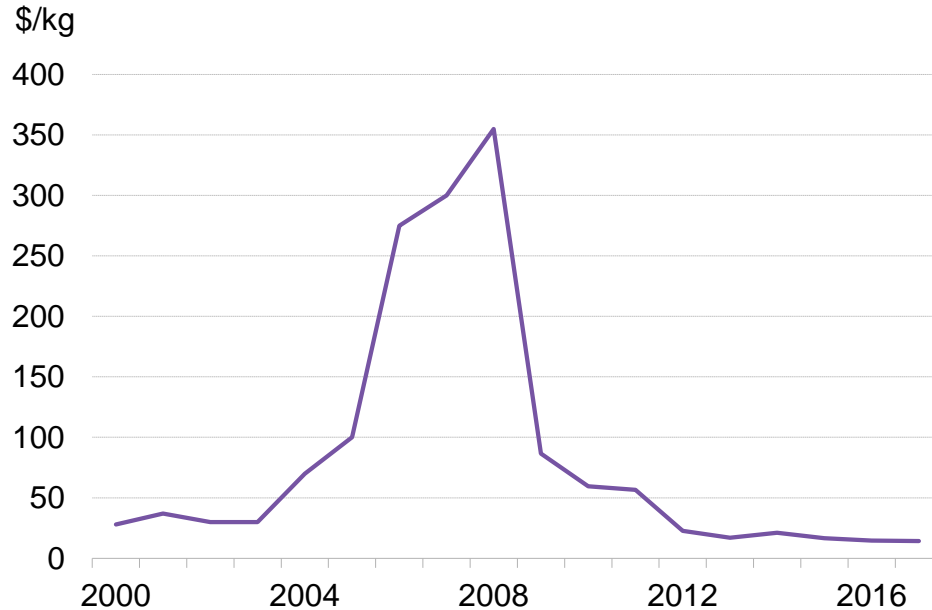
## Elon Musk



*Photos: Wikimedia Commons; DigitalGlobe; Pete Marovich/Bloomberg; KAL/Economist*

# The price of failure

PV grade silicon price index, 2000-2017



Source: Various, Bloomberg New Energy Finance Solar Spot Survey

**SOLYNDRA**

\$1.5 billion



# The price of failure



\$48 billion



# Coal bankruptcies, 2011-2017

STOWE Global Coal Index, 2011-17



**BUMI**  
Investment Pte

**James River**  
COAL COMPANY

**Peabody**  
ENERGY

**Alpha Natural Resources**

**We fuel progress  
around the world.®**

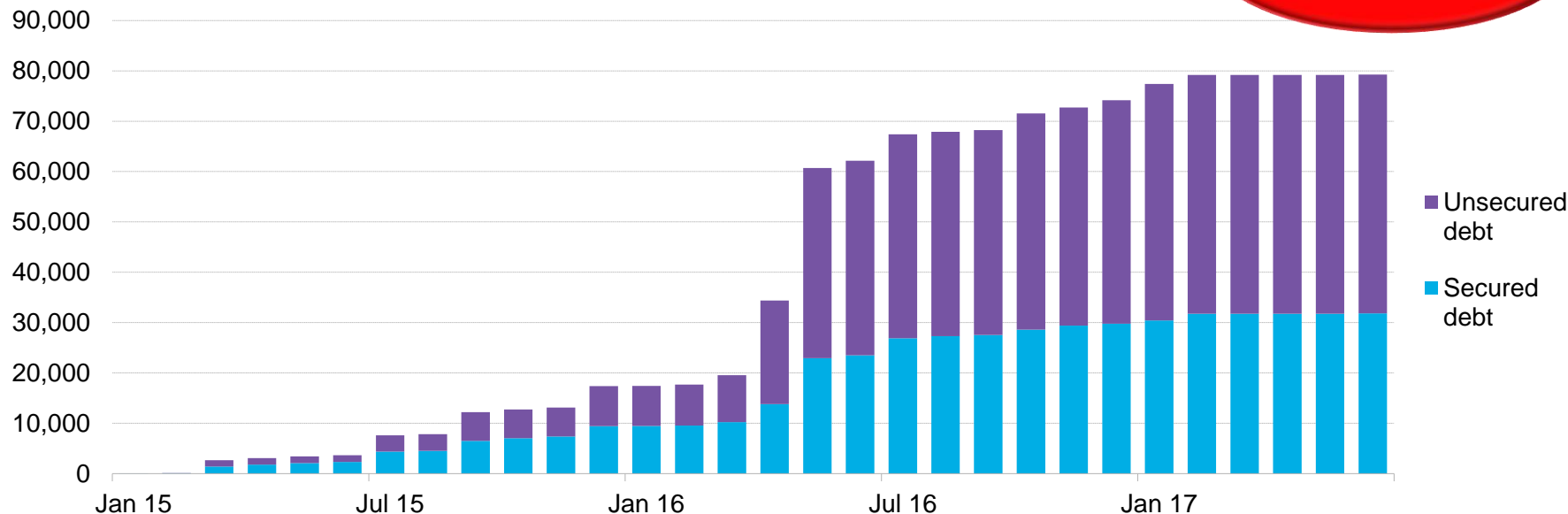
**PATRIOT**  
COAL

**ArchCoal**

**WALTER**  
ENERGY®

# US oil and gas company bankruptcy filings, 2015-present

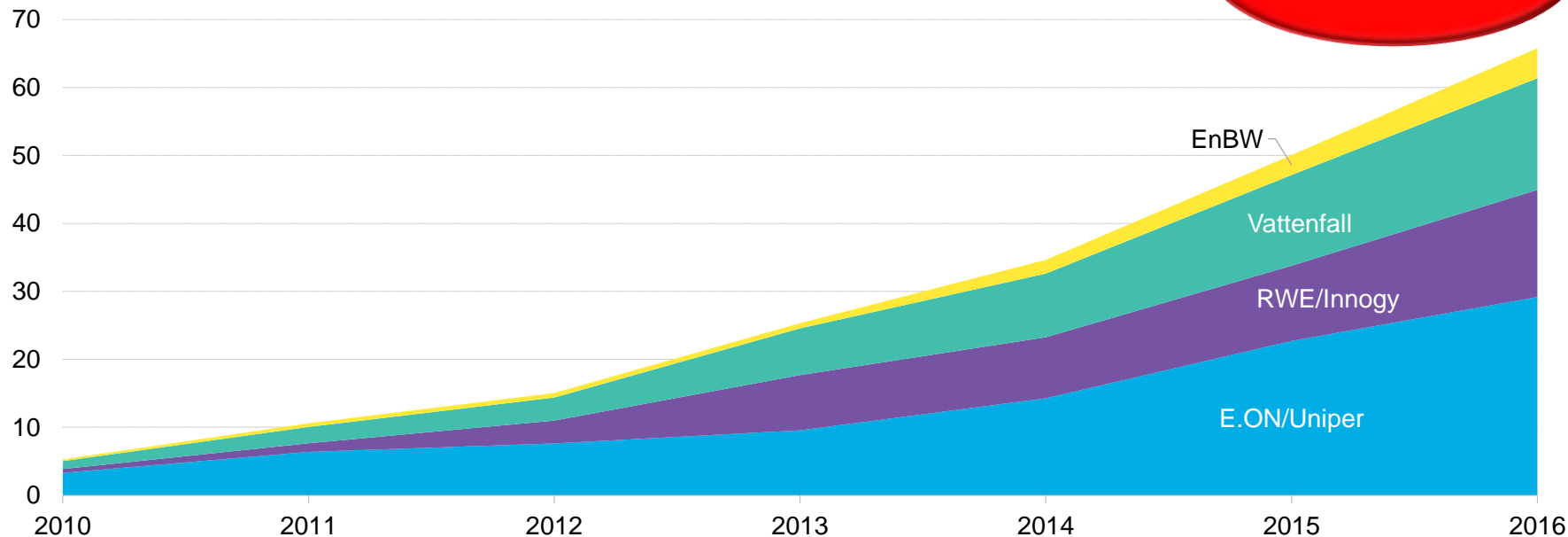
Cumulative outstanding debt of U.S. E&P companies under Chapter 11 protection (\$ million)



Source: Bloomberg New Energy Finance, Haynes and Boone LLP

# German utility balance sheet write-downs

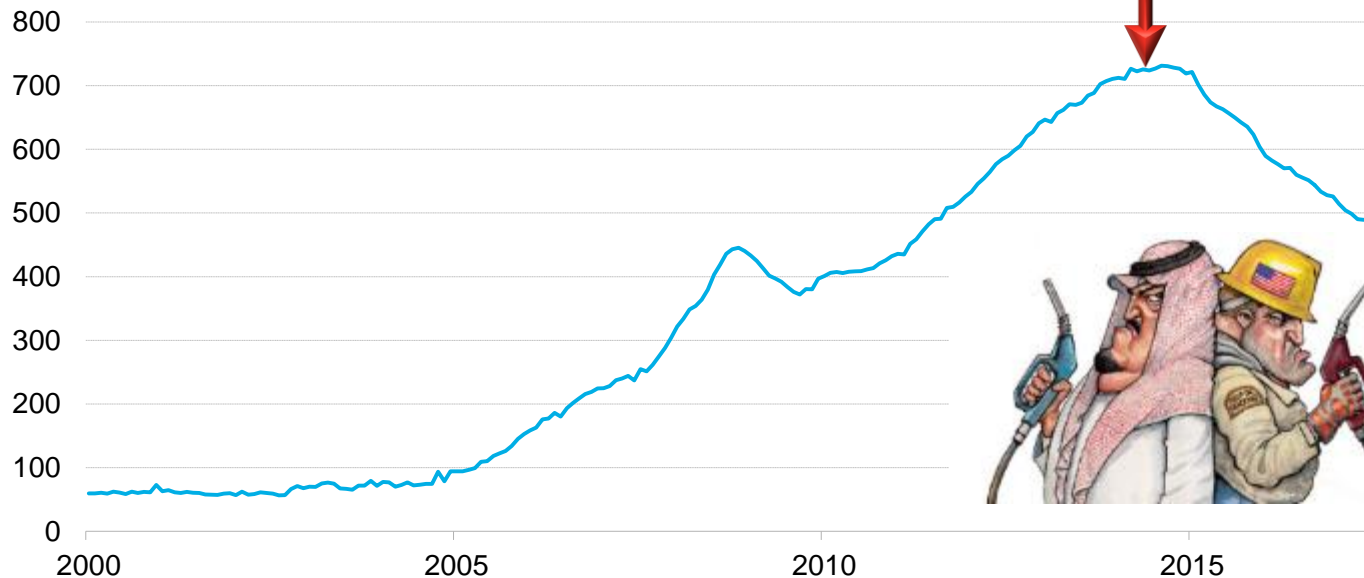
Cumulative (€ billions)



Source: Bloomberg New Energy Finance

# Saudi Arabia's forex reserves

Saudi Arabia reserve foreign exchange holdings (\$bn)



Oil Minister Al Naimi  
declares market share  
war on US shale oil



**\$240bn  
decline in fx  
reserves**



Source: Bloomberg New Energy Finance, The Economist



# Some people are still calling it wrong

“

The social cost of renewable energy should include the cost of stranding thermal power and coal assets.

”

*Arvind Subramanian  
Chief Economic Advisor  
Indian Government*



Image: Financial Express

# Some people are not wrong but misleading

“

Solar and wind is taking over the world.  
We hear it all the time. Only it is wrong -  
now 0.6%, 2040 2.9%.

”

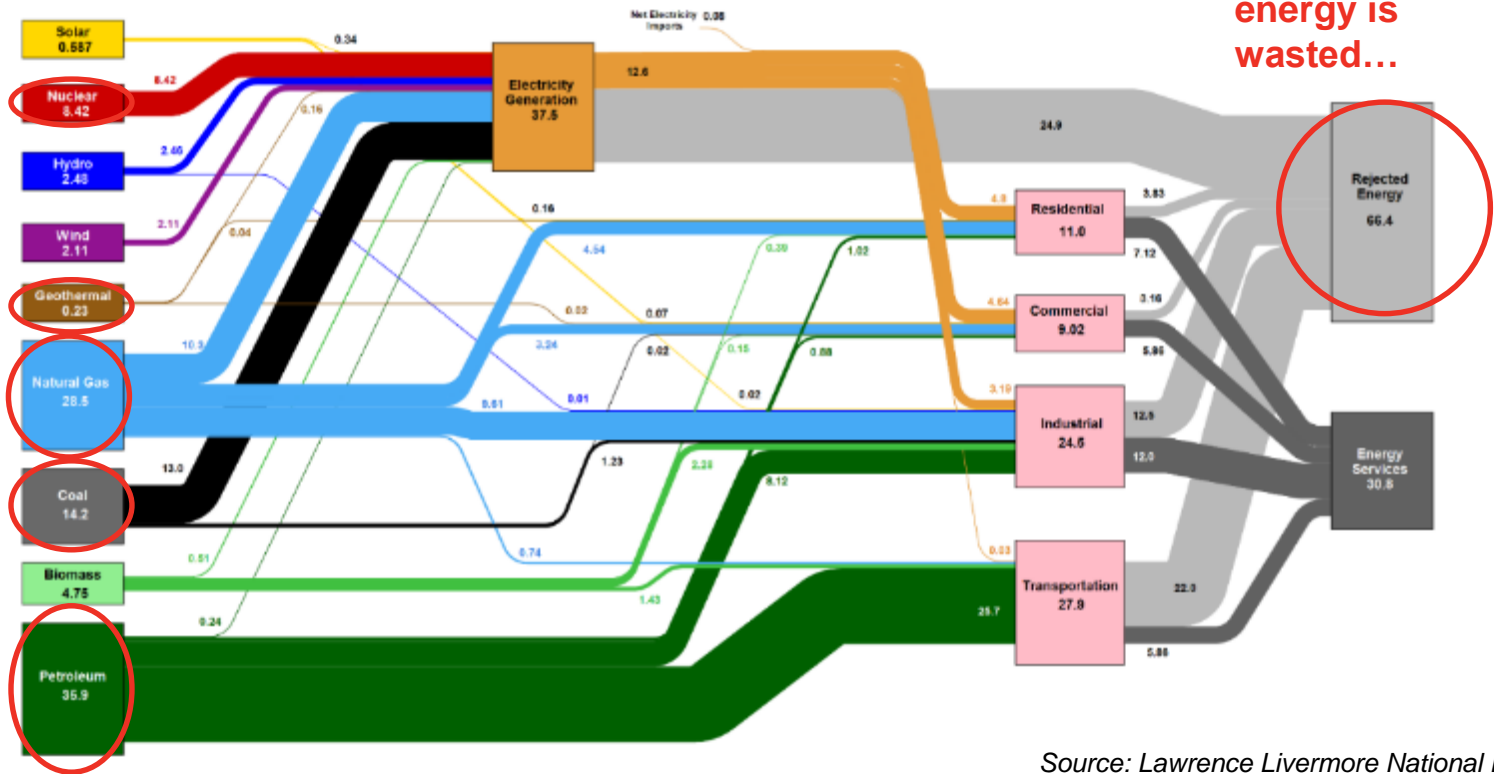
Bjørn Lomborg  
visiting professor at the Copenhagen Business School  
President of the Copenhagen Consensus Center



Image: Lomborg.com

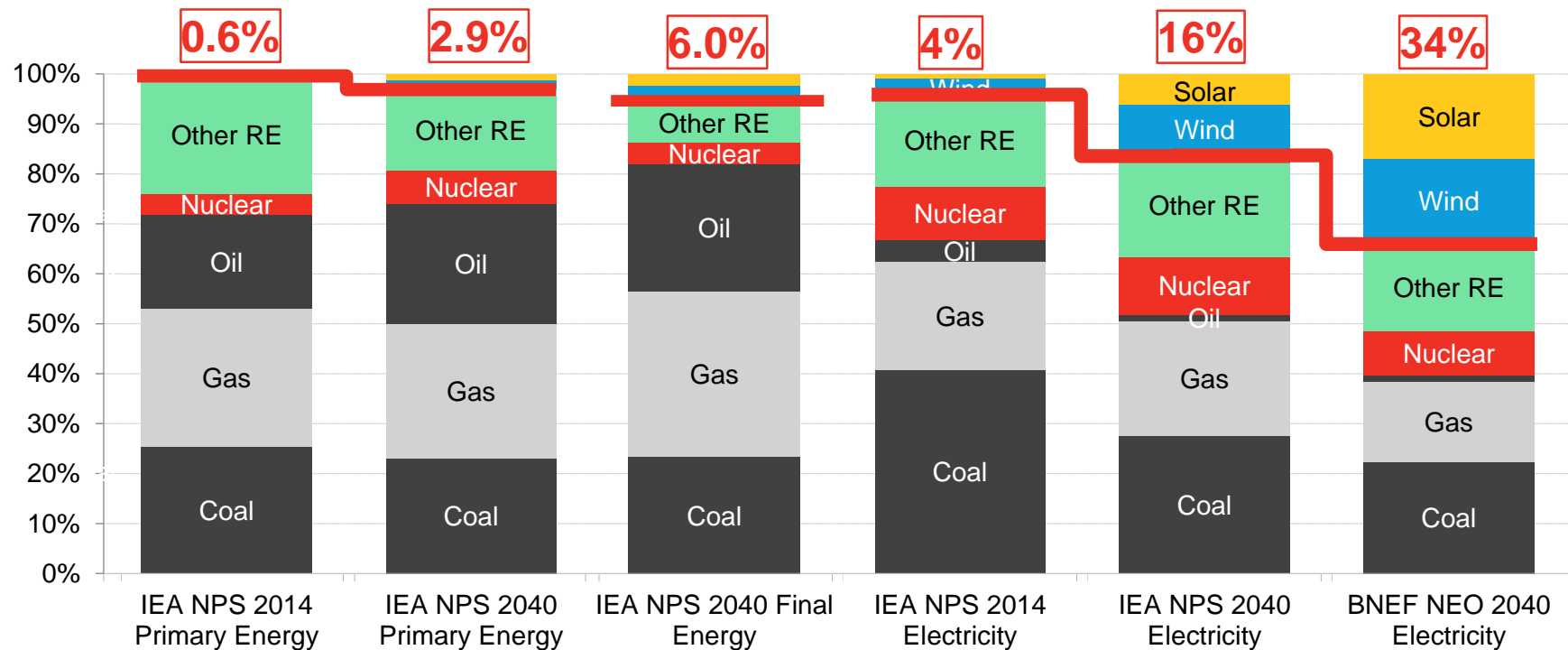
# Sankey for the U.S. in 2016

...almost all  
of it from  
coal, oil, gas  
and nuclear



Source: Lawrence Livermore National Lab

# Contribution of wind and solar



Source: Bloomberg New Energy Finance, IEA

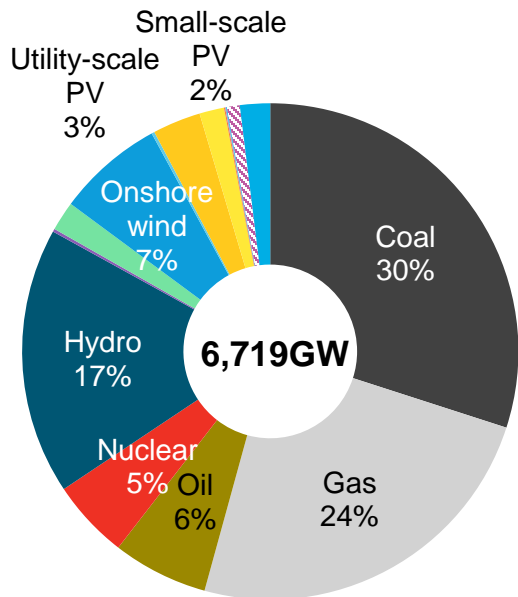
# The world in 2040



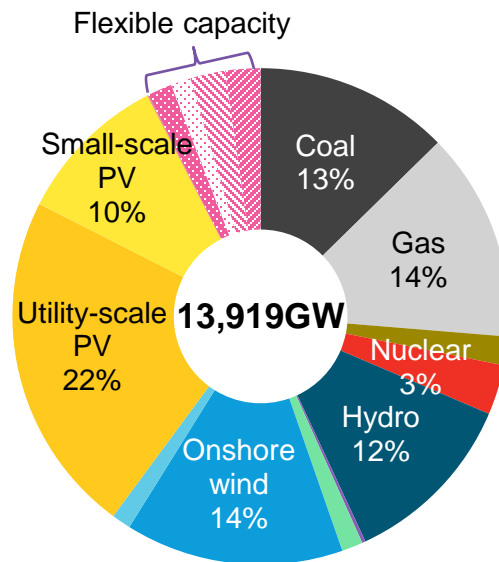
*Image: NASA*

# Solar and wind dominate the future of electricity

Global cumulative installed capacity:  
2016



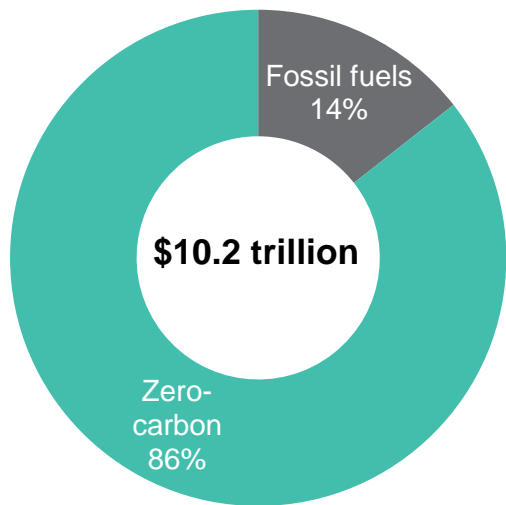
Global cumulative installed capacity:  
2040



Source: Bloomberg New Energy Finance, *NEO 2017*

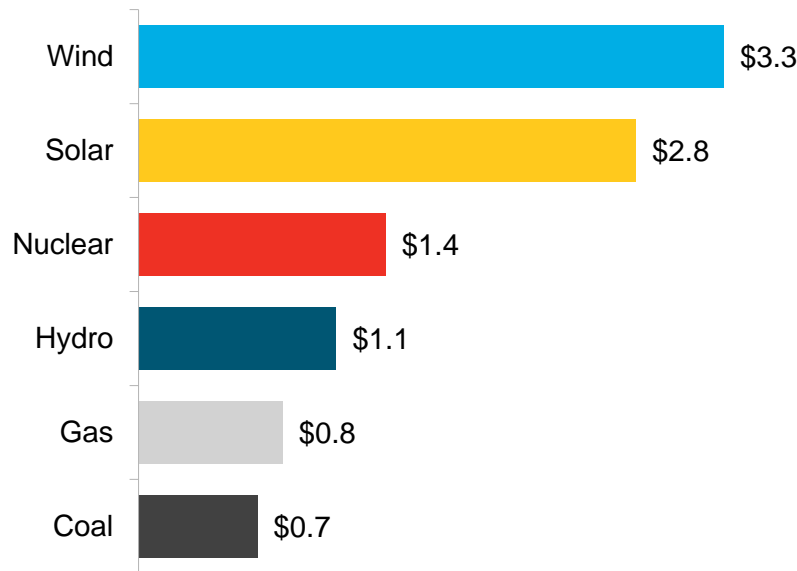
# Solar and wind attract 60% of new investment in power generating capacity

Investment, by technology, 2017-2040



Investment, by technology, 2017-2040

(\$ trillion - 2016 real)

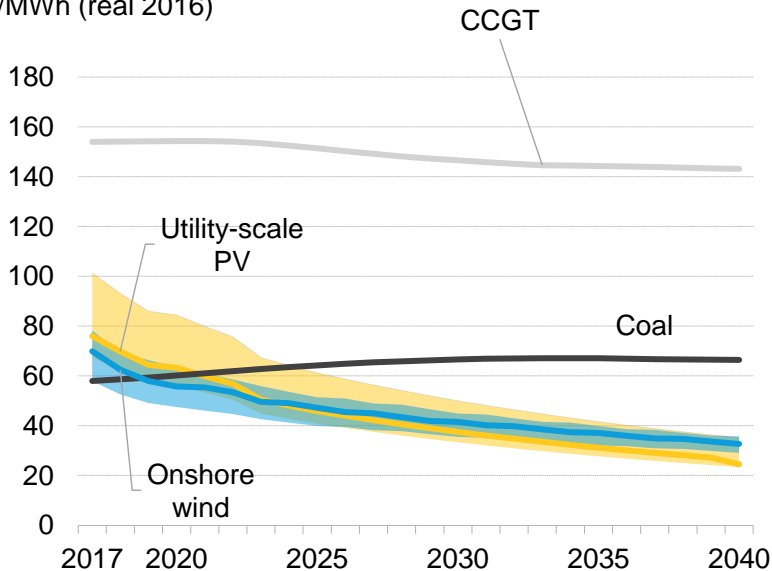


Source: Bloomberg New Energy Finance, NEO 2017

# Tipping point 1: new vs new

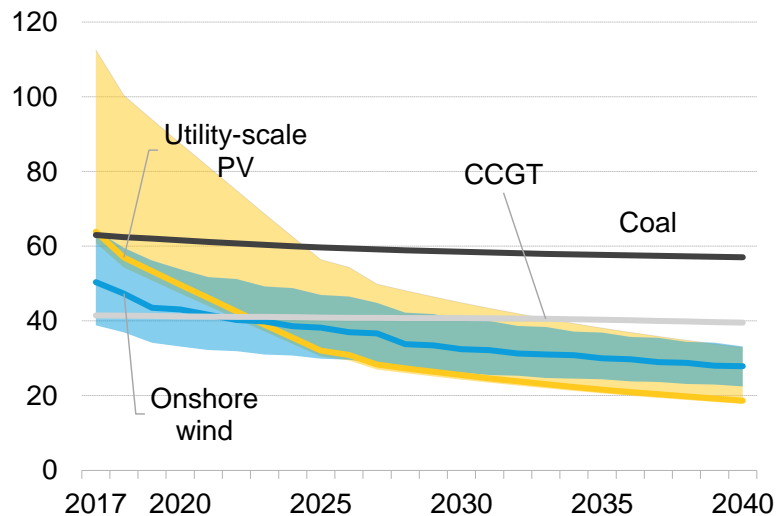
## China

\$/MWh (real 2016)



## U.S.

\$/MWh (real 2016)



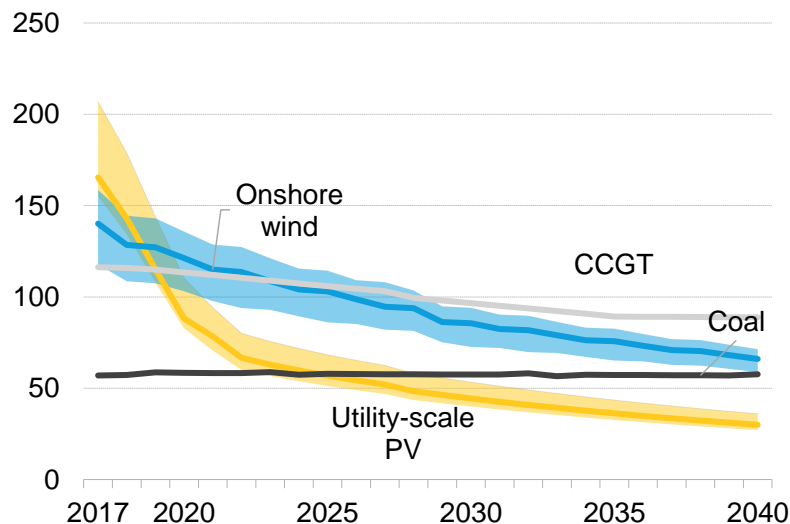
Source: Bloomberg New Energy Finance, *NEO 2017*



# Tipping point 1: new vs new

## Japan

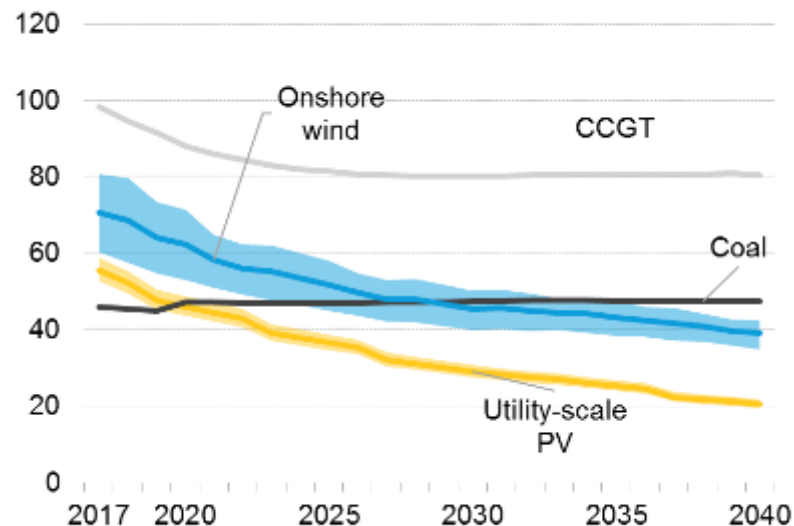
\$/MWh (real 2016)



Source: Bloomberg New Energy Finance, *NEO 2017*

## India

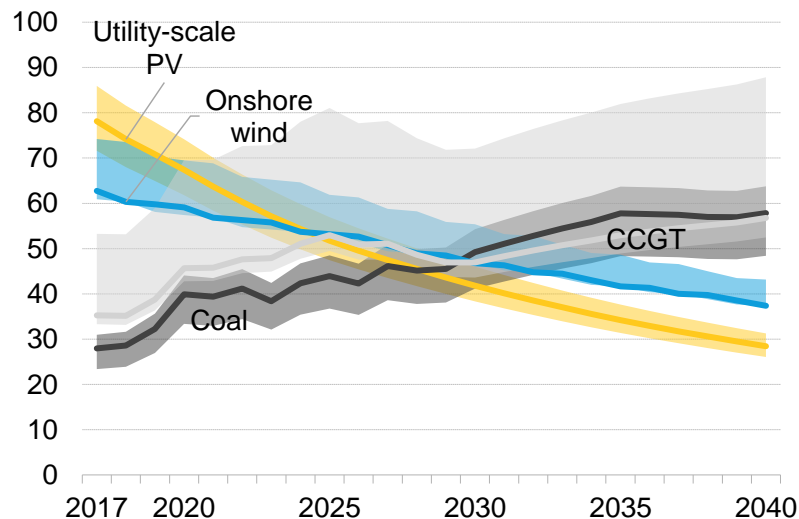
\$/MWh (real 2016)



# Tipping point 2: new vs existing

## Germany

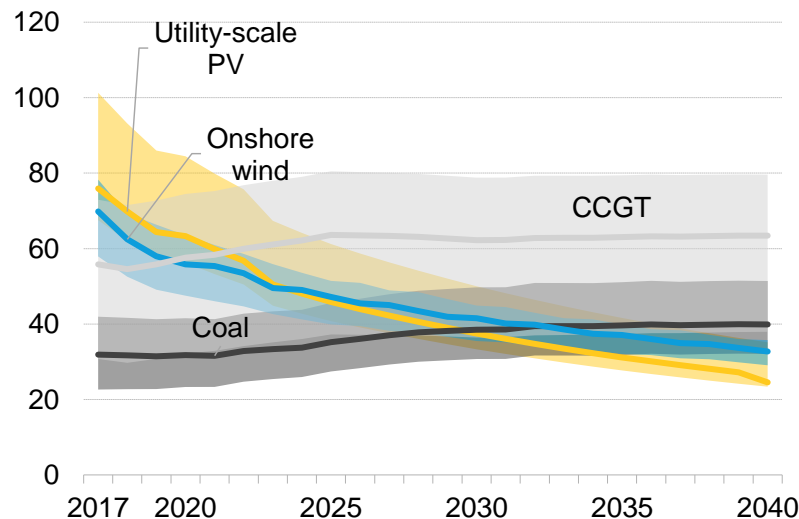
\$/MWh (real 2016)



Source: Bloomberg New Energy Finance, *NEO 2017*

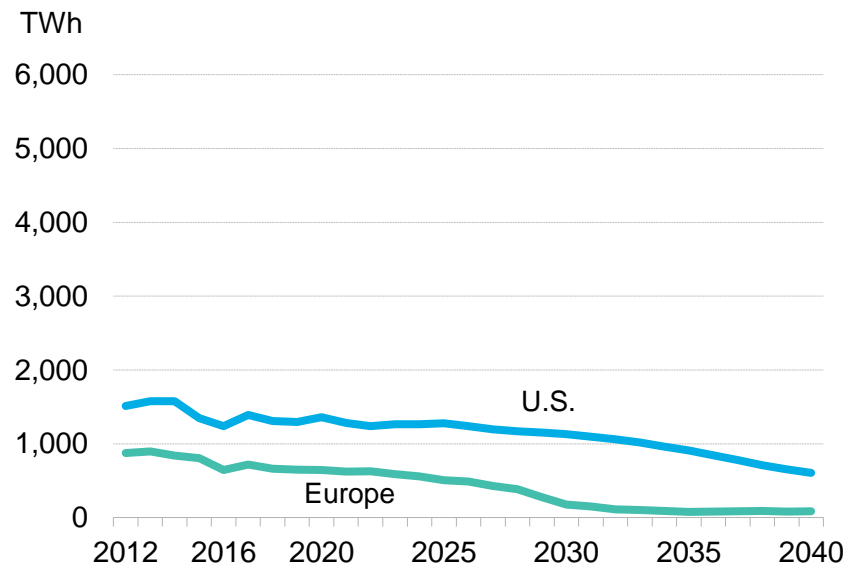
## China

\$/MWh (real 2016)



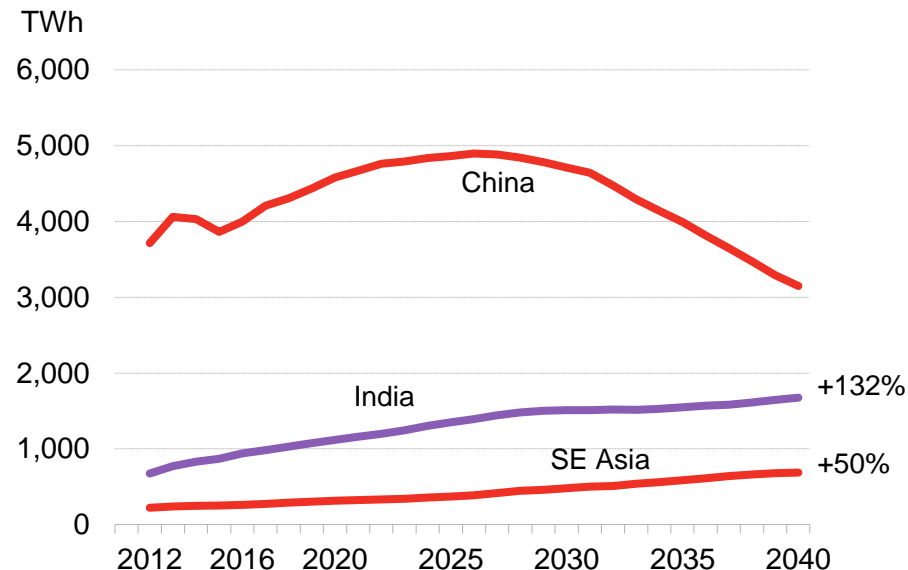
# Poor outlook for coal in U.S., Europe and China

## Coal generation



Source: Bloomberg New Energy Finance

## Coal generation

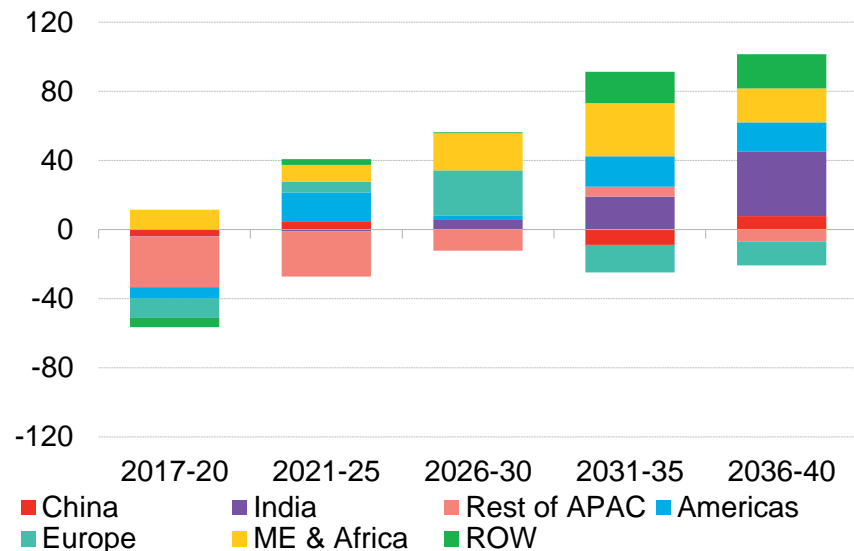


Source: Bloomberg New Energy Finance

# Gas plays an important role, but its not bulk energy

## Incremental change in gas consumption

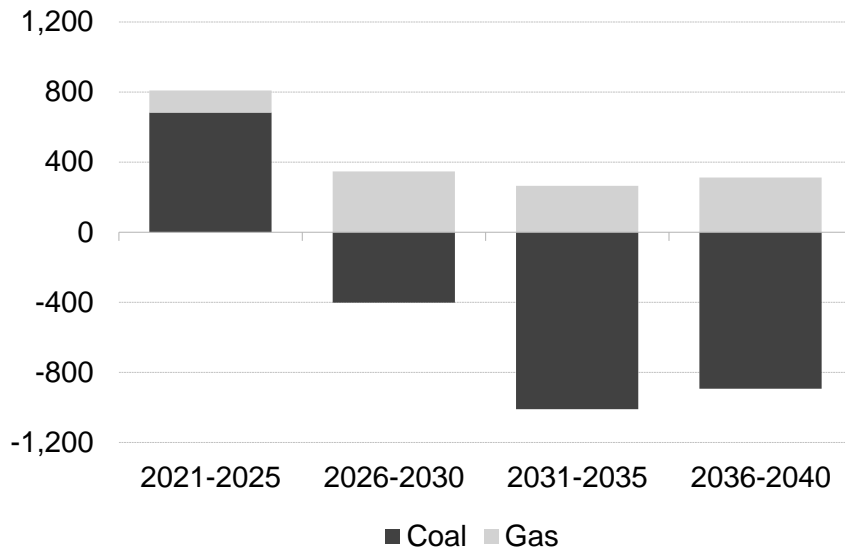
Bcm/yr



Source: Bloomberg New Energy Finance

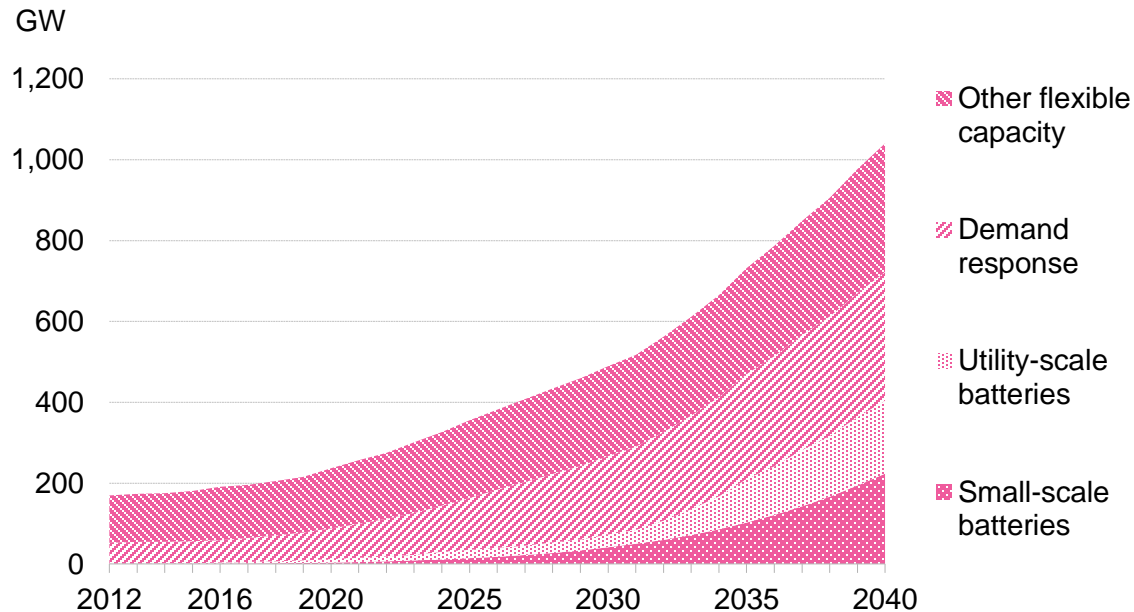
## Incremental change in generation

Δ generation (TWh)



Source: Bloomberg New Energy Finance

# Demand response and batteries meet peak and balance the grid



Source: Bloomberg New Energy Finance

## Top 5 markets in 2040

China 343GW

U.S. 200GW

India 127GW

Japan 62GW

Germany 30GW

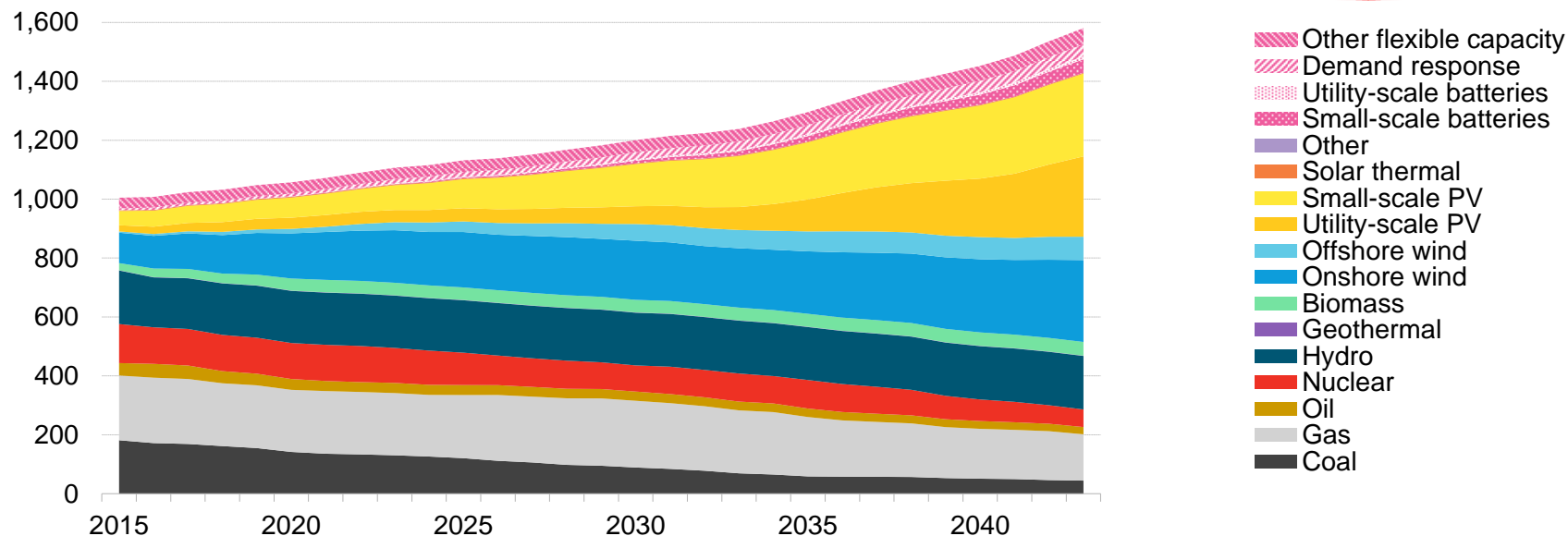
# We need to talk about Europe



*Image: NASA*

# BNEF New Energy Outlook: Europe

Cumulative installed capacity (GW)



**BNEF predicts  
50% renewables  
penetration in  
Europe by 2040**

Source: Bloomberg New Energy Finance

# European policy environment

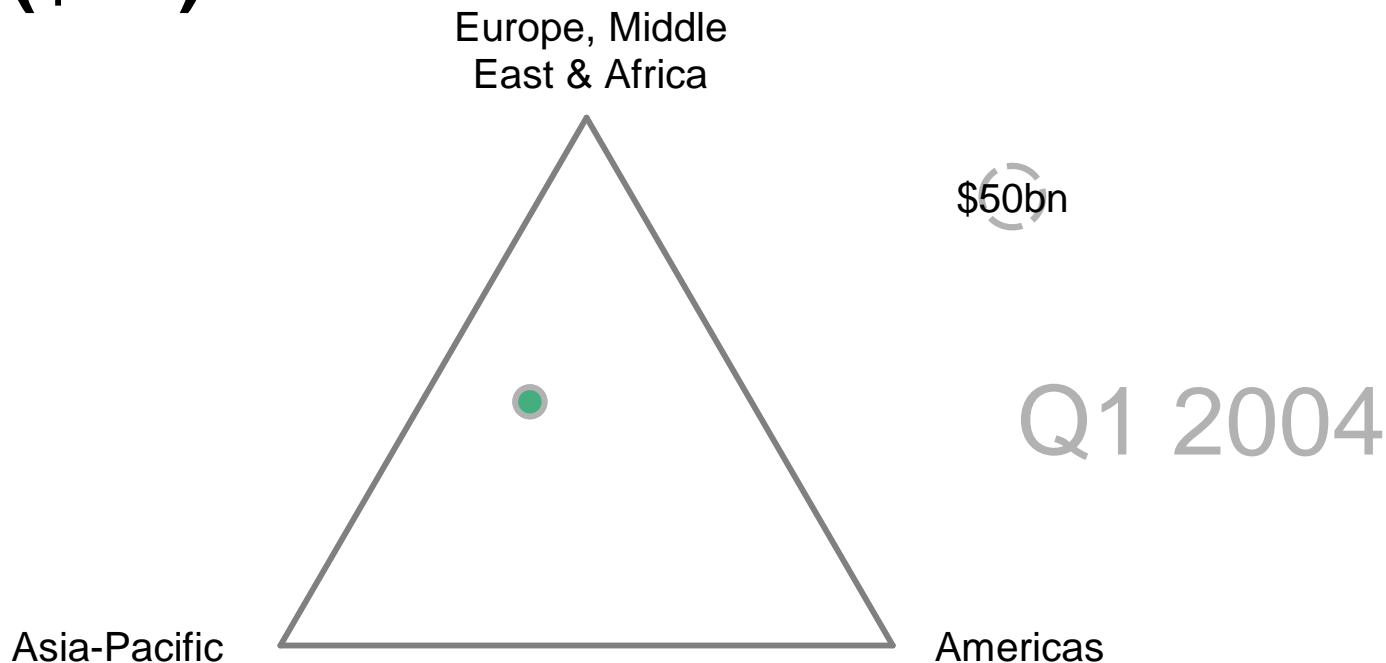
“Stability of incentive programmes,  
planning processes & regulations is a  
big barrier to investment”

8 December 2005

*Source: New Energy Finance*



# New investment in clean energy (\$bn)



*Note: Bubble size represents total global investment per quarter Source: Bloomberg New Energy Finance*

# New investment in clean energy (\$bn)



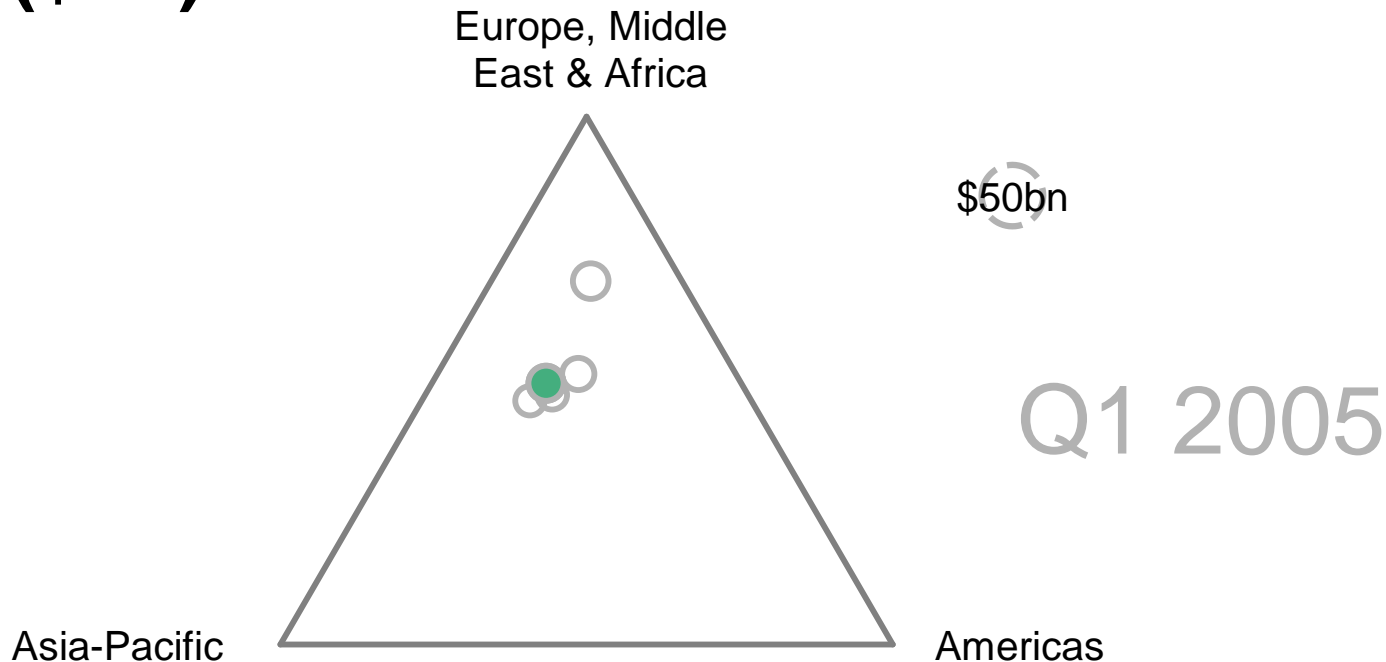
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# New investment in clean energy (\$bn)



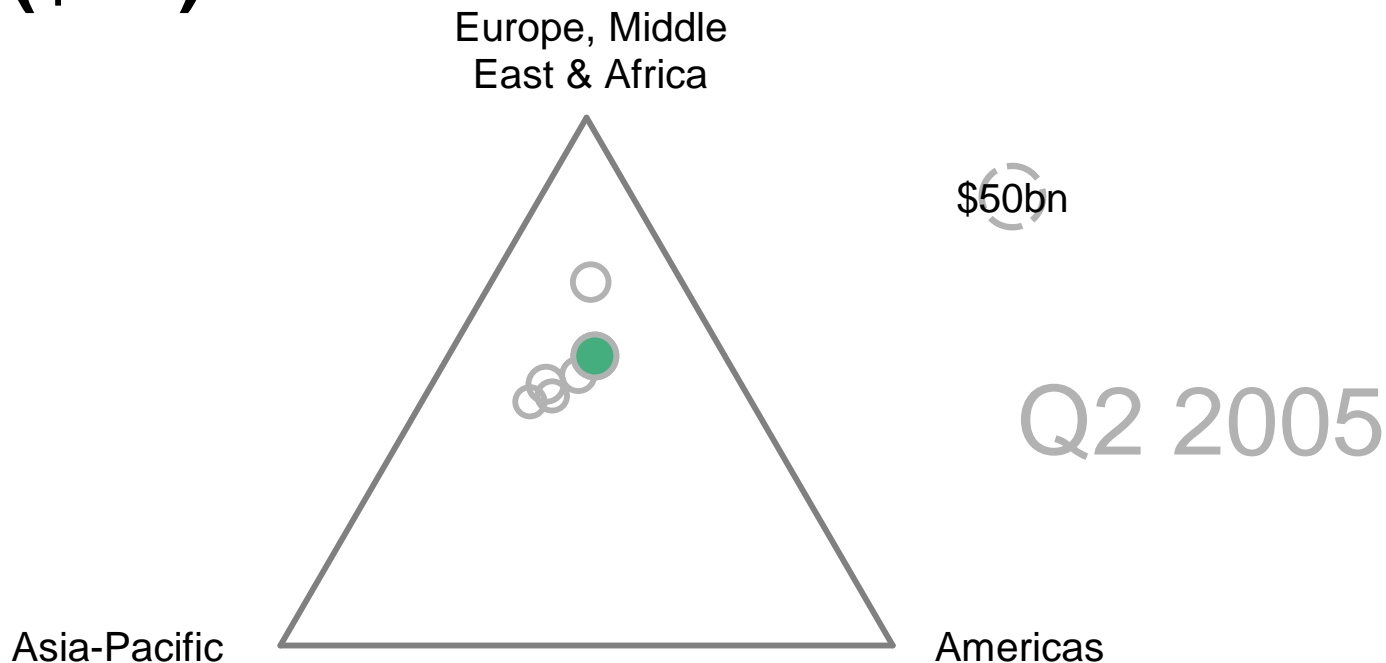
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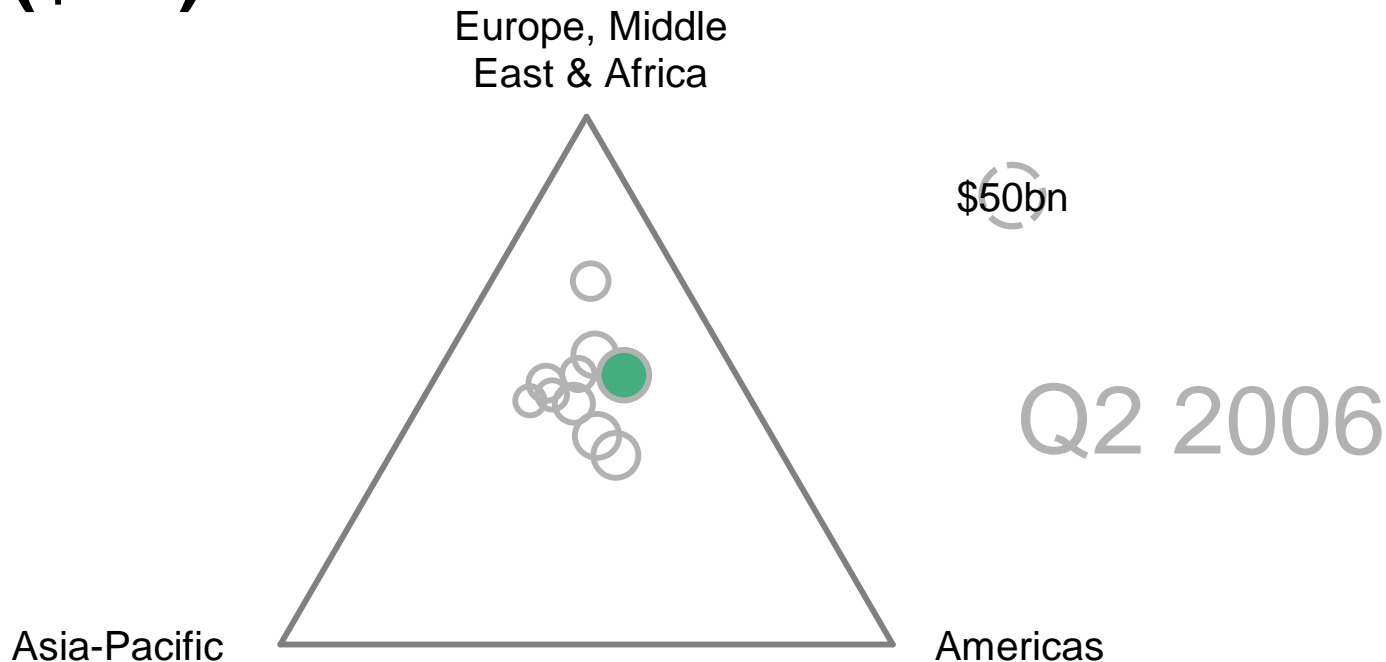
# New investment in clean energy (\$bn)



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# New investment in clean energy (\$bn)



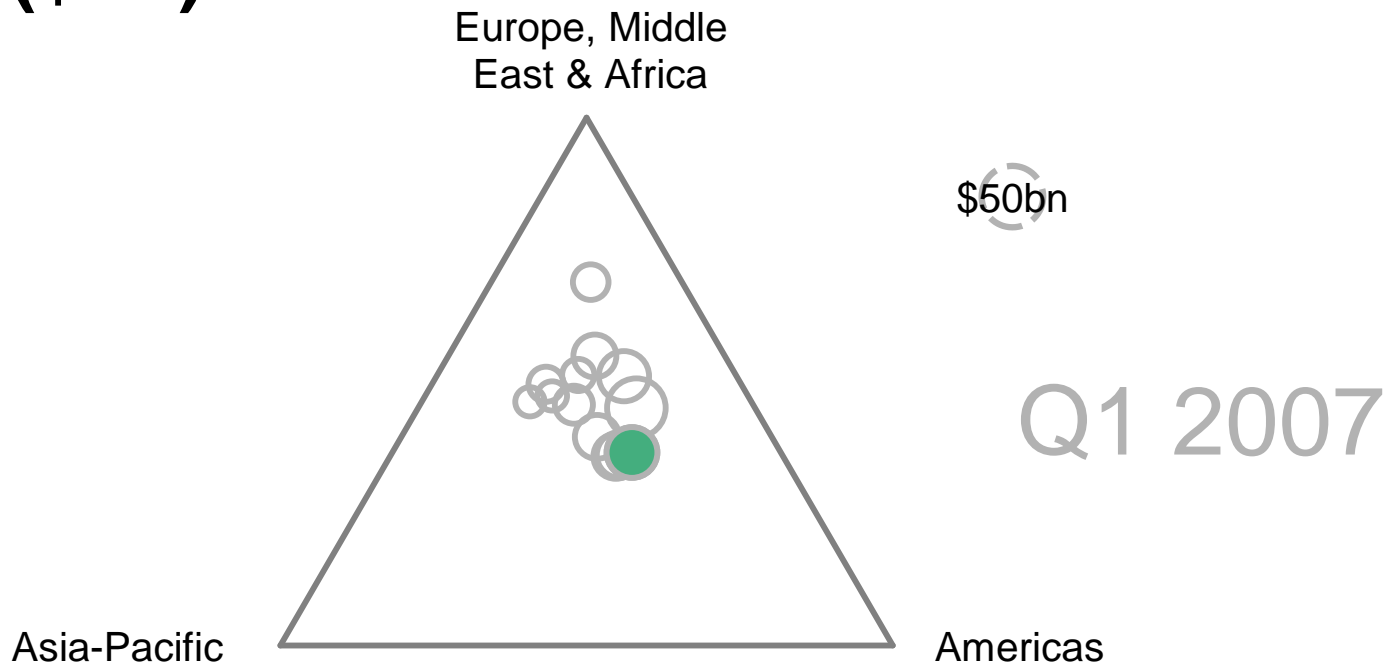
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*Note: Bubble size represents total global investment per quarter Source: Bloomberg New Energy Finance*

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# New investment in clean energy (\$bn)



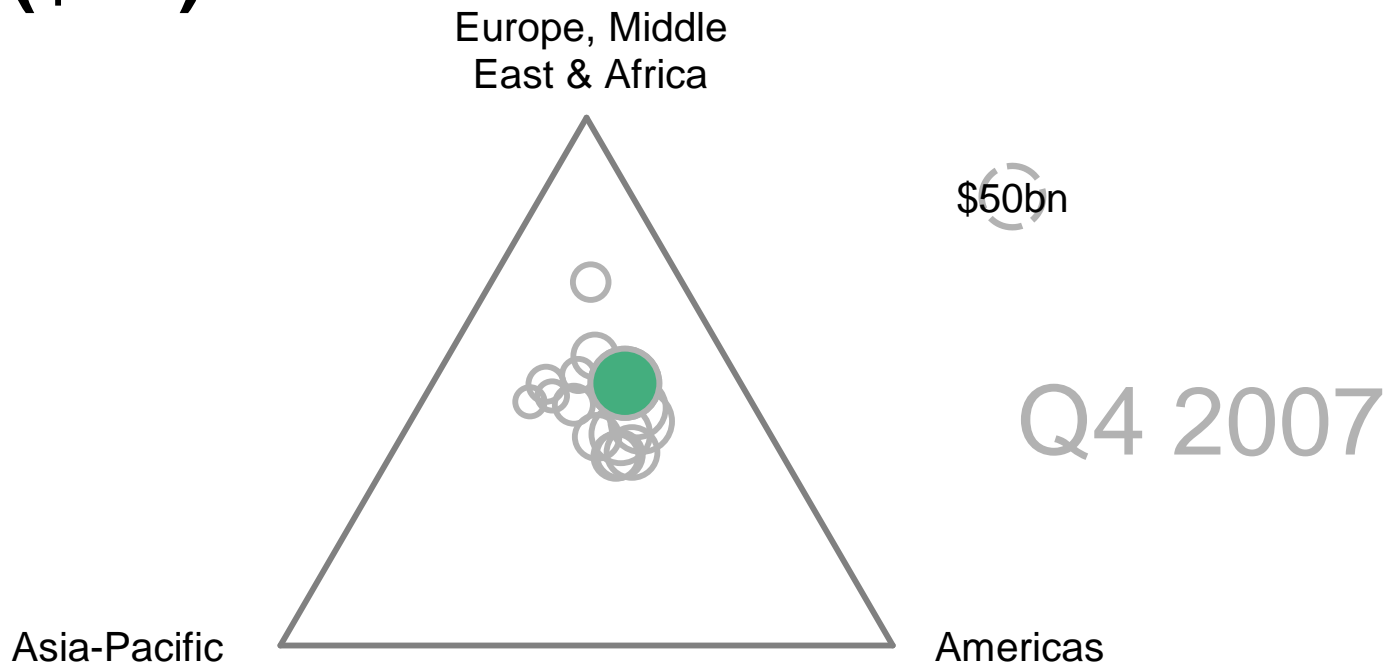
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# New investment in clean energy (\$bn)



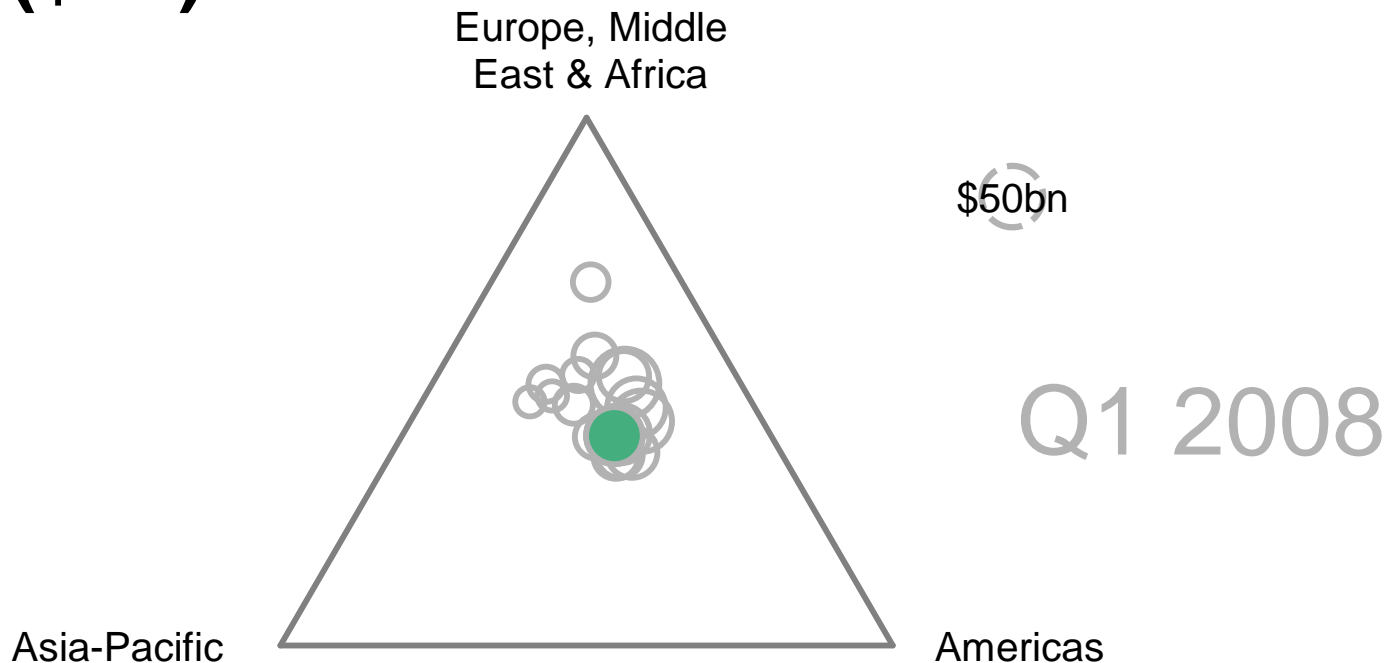
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# New investment in clean energy (\$bn)



*Note: Bubble size represents total global investment per quarter Source: Bloomberg New Energy Finance*

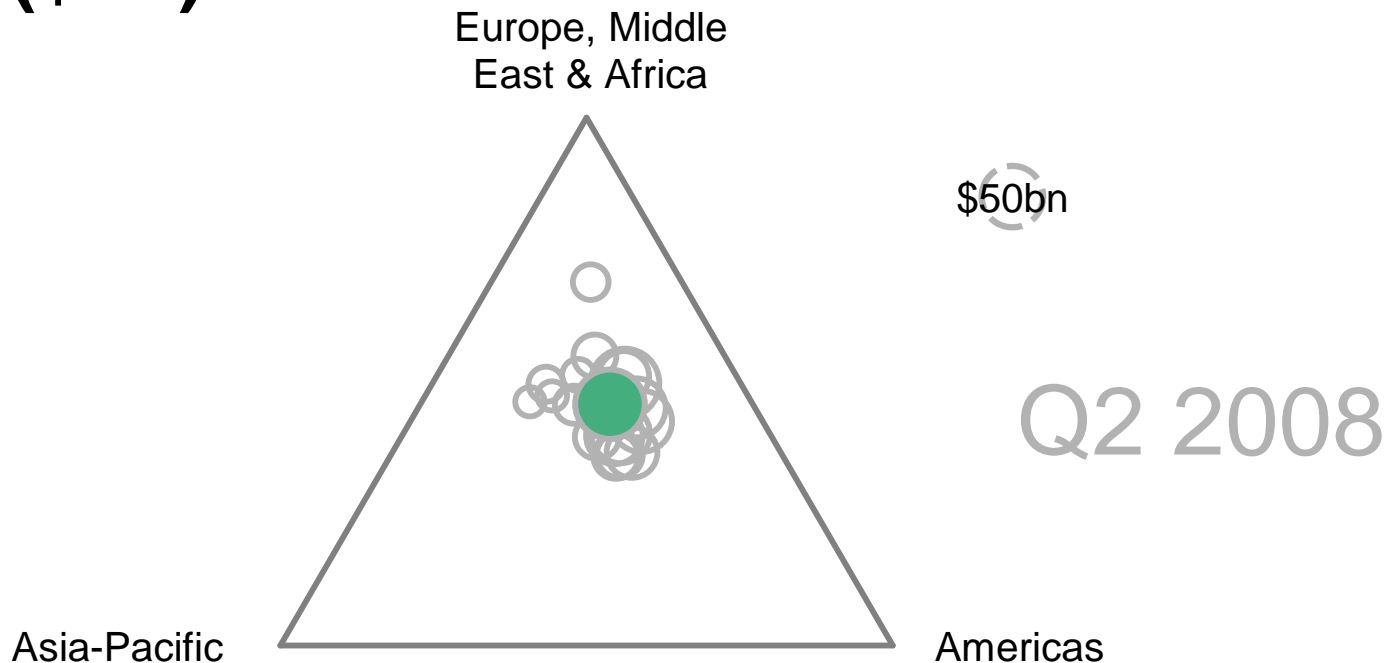
# New investment in clean energy (\$bn)



*Note: Bubble size represents total global investment per quarter Source: Bloomberg New Energy Finance*

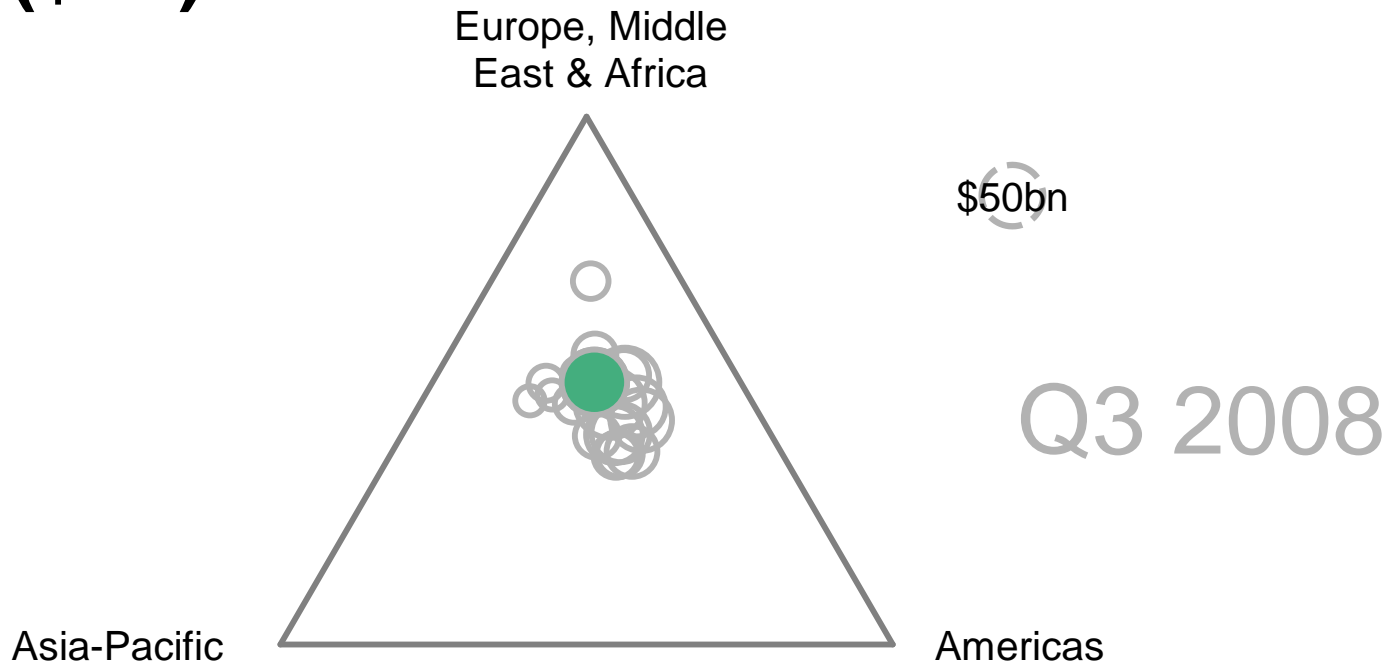


# New investment in clean energy (\$bn)



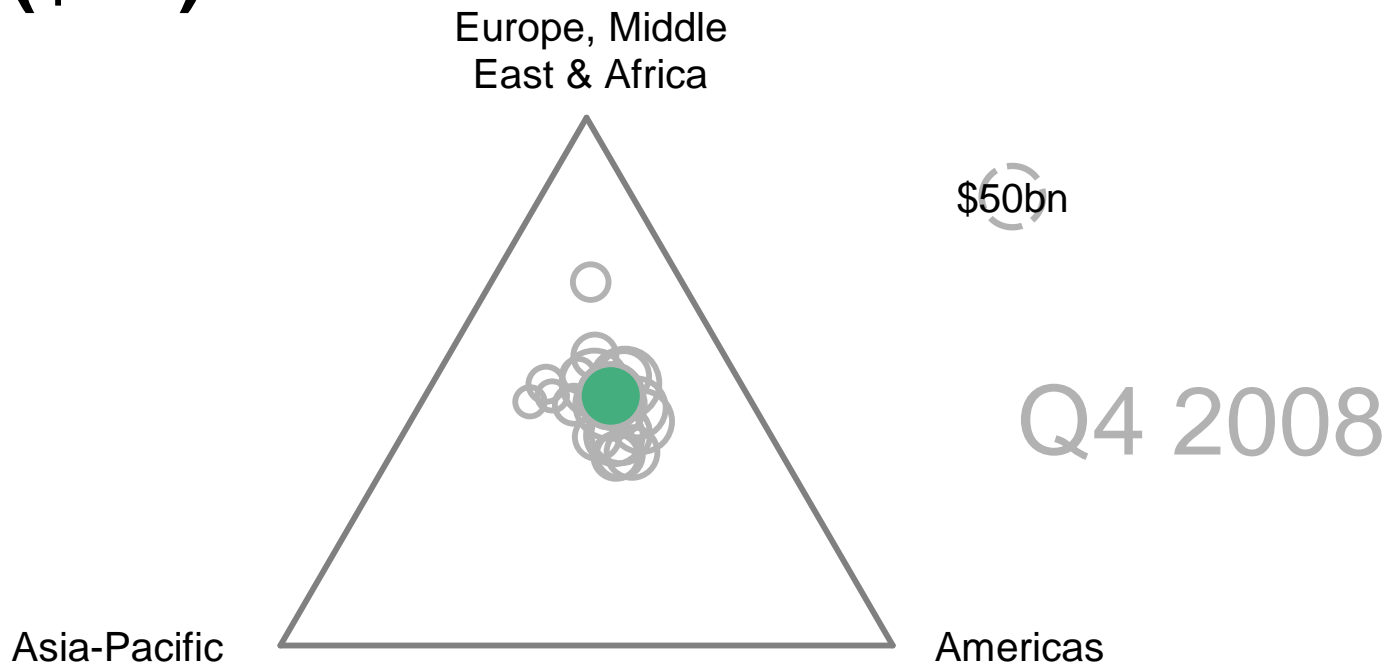
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# New investment in clean energy (\$bn)



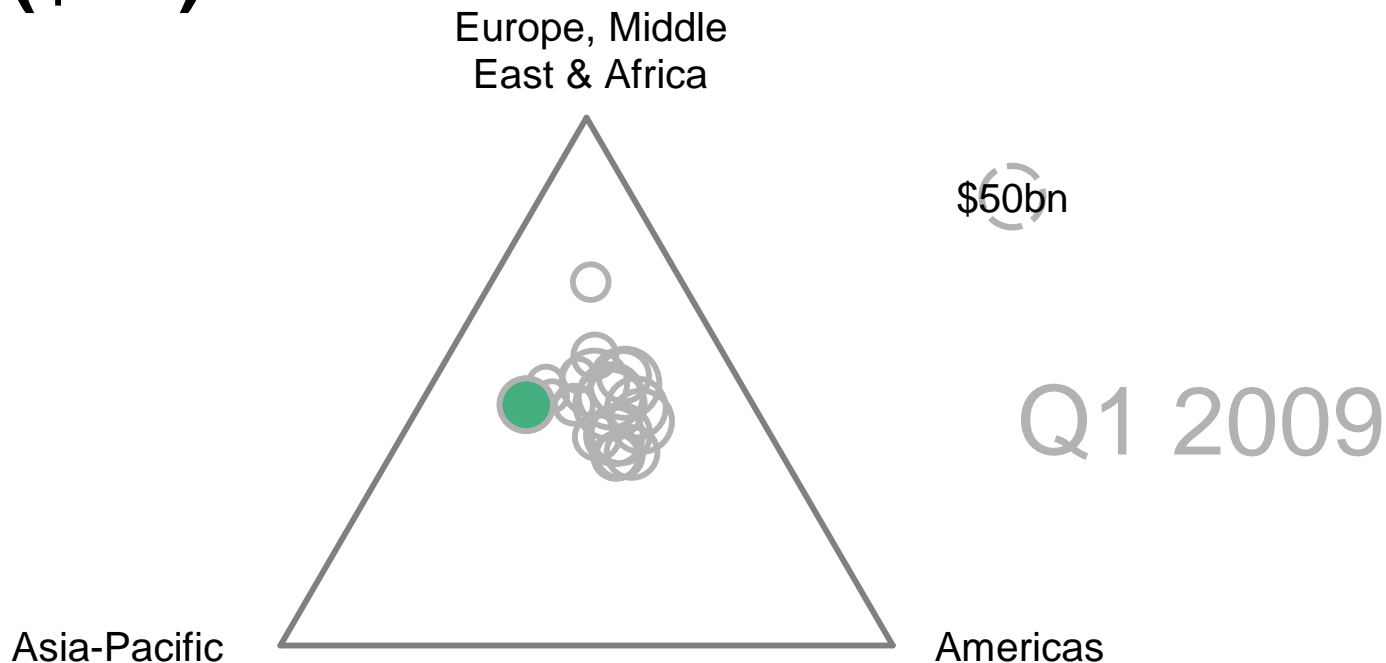
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# New investment in clean energy (\$bn)



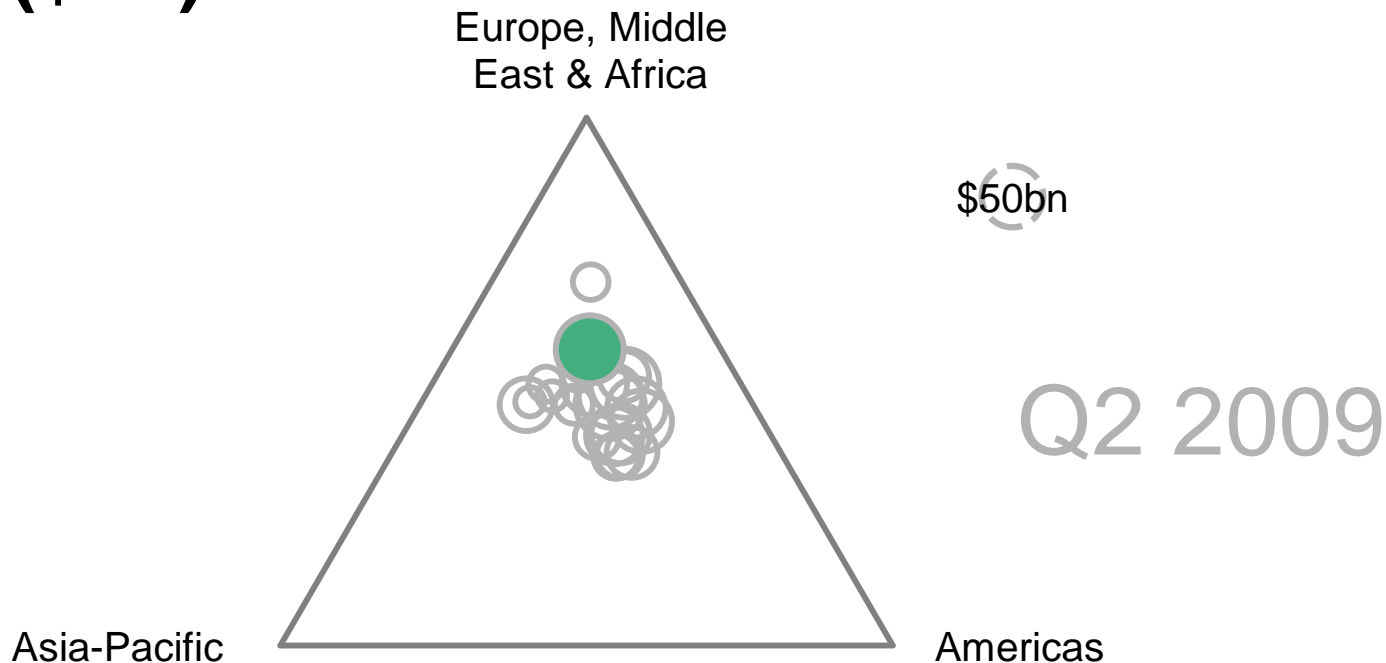
*Note: Bubble size represents total global investment per quarter Source: Bloomberg New Energy Finance*

# New investment in clean energy (\$bn)



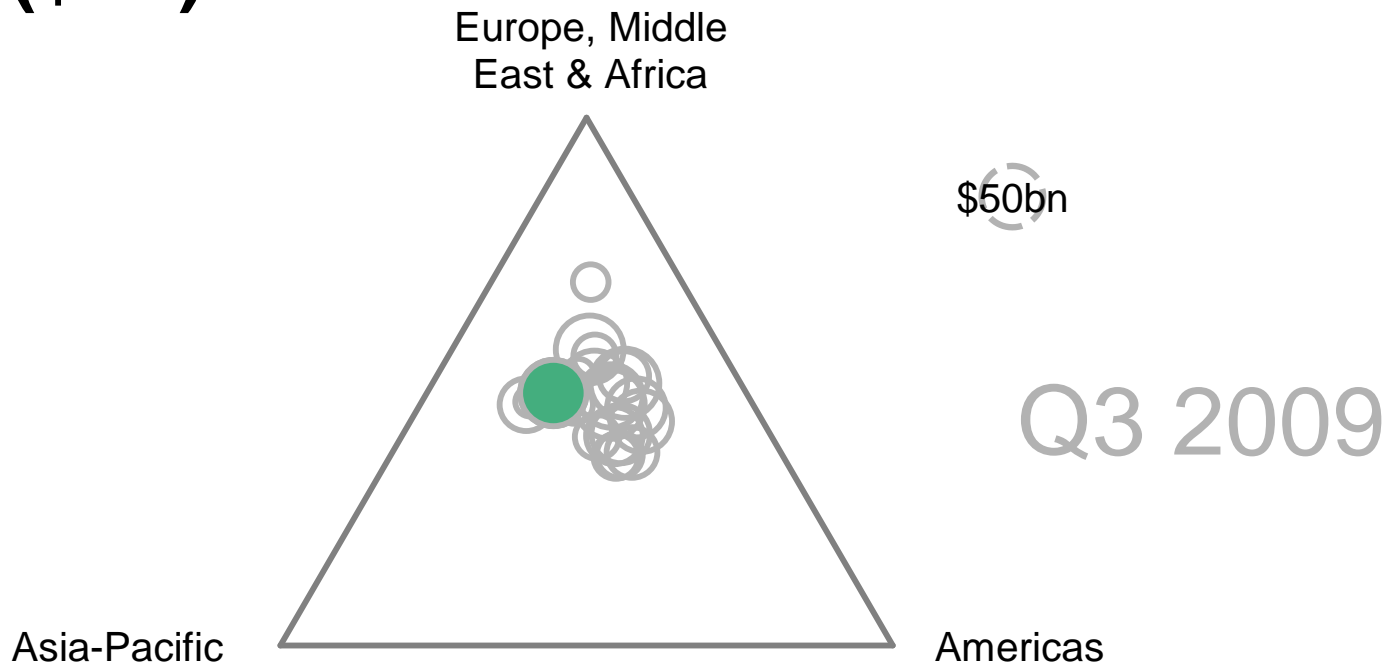
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# New investment in clean energy (\$bn)



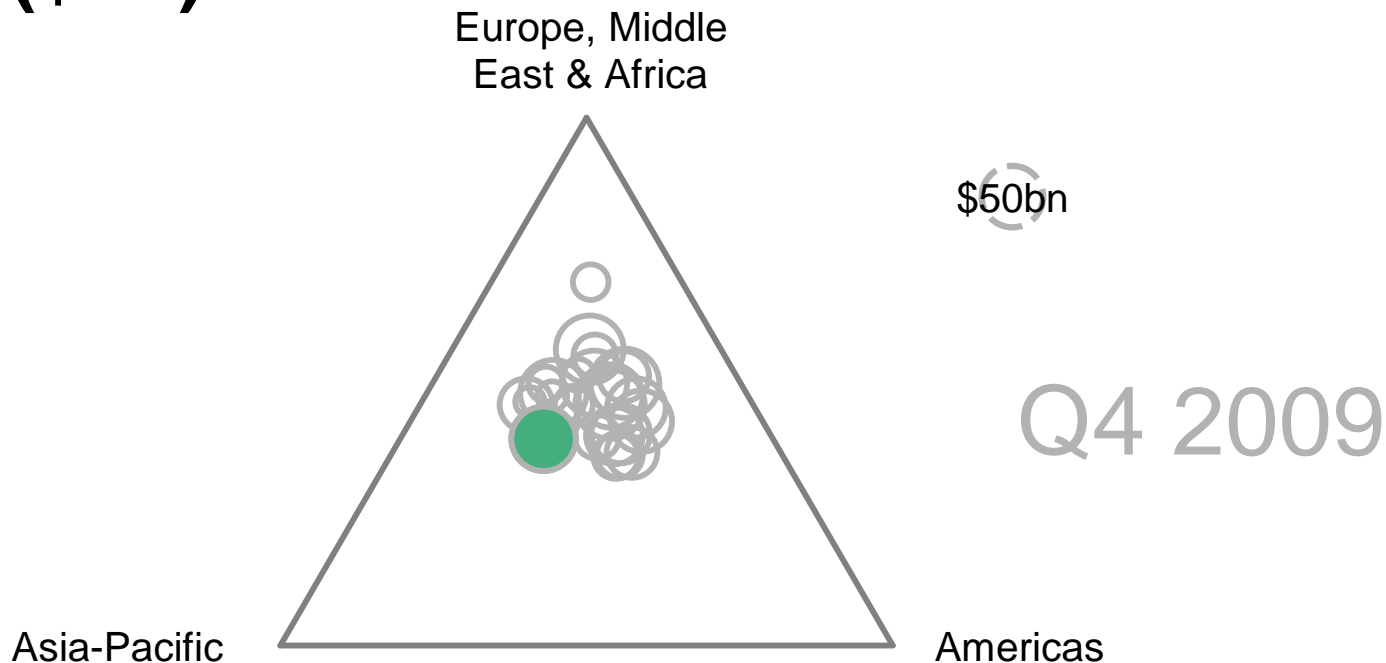
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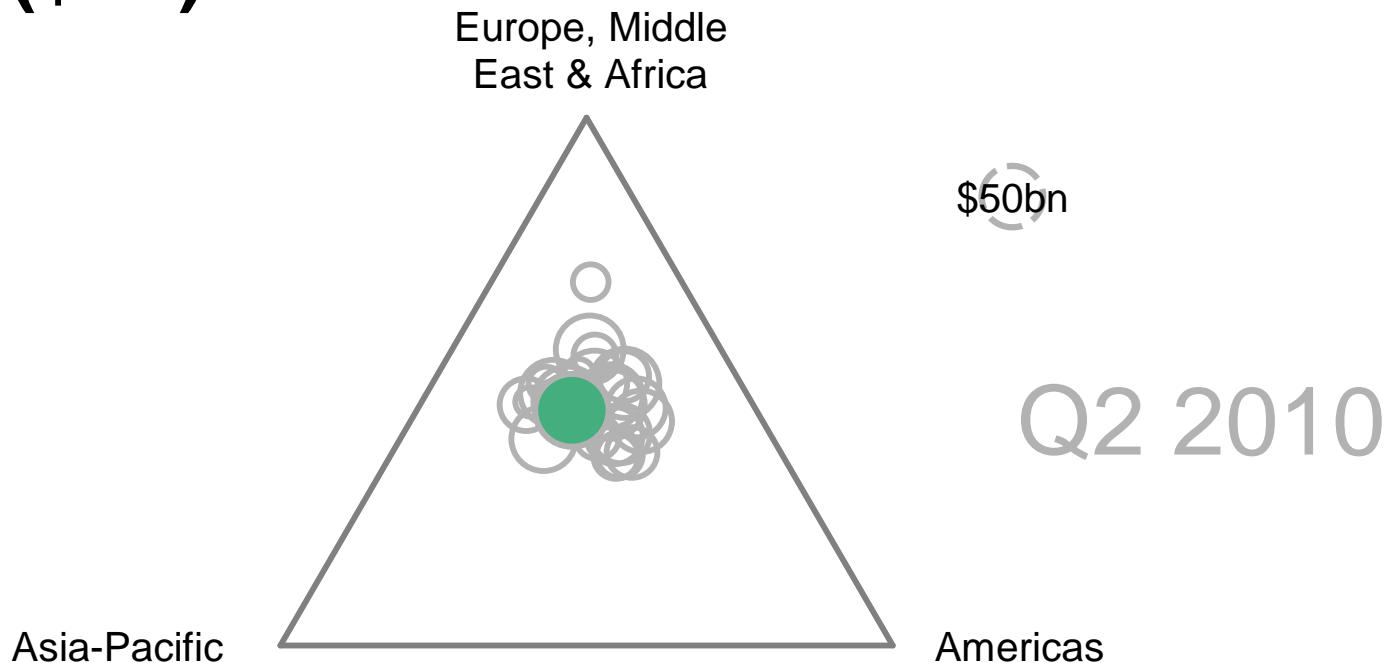
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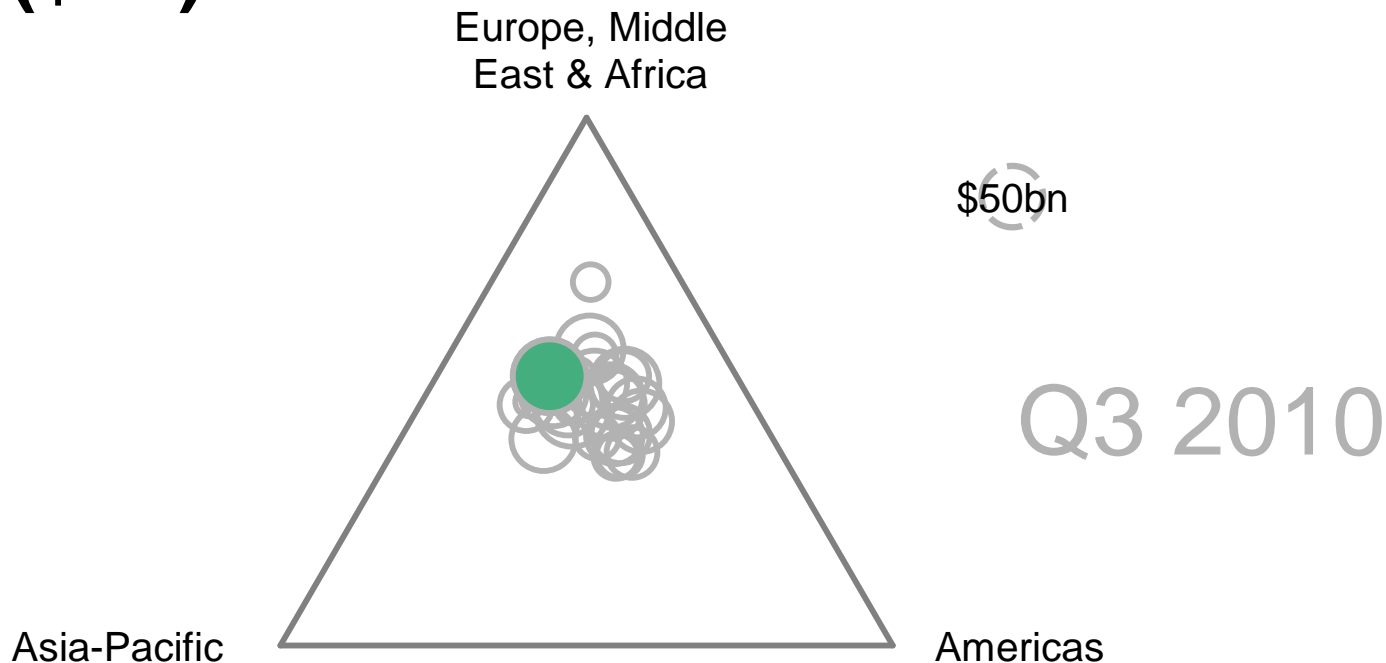


# New investment in clean energy (\$bn)



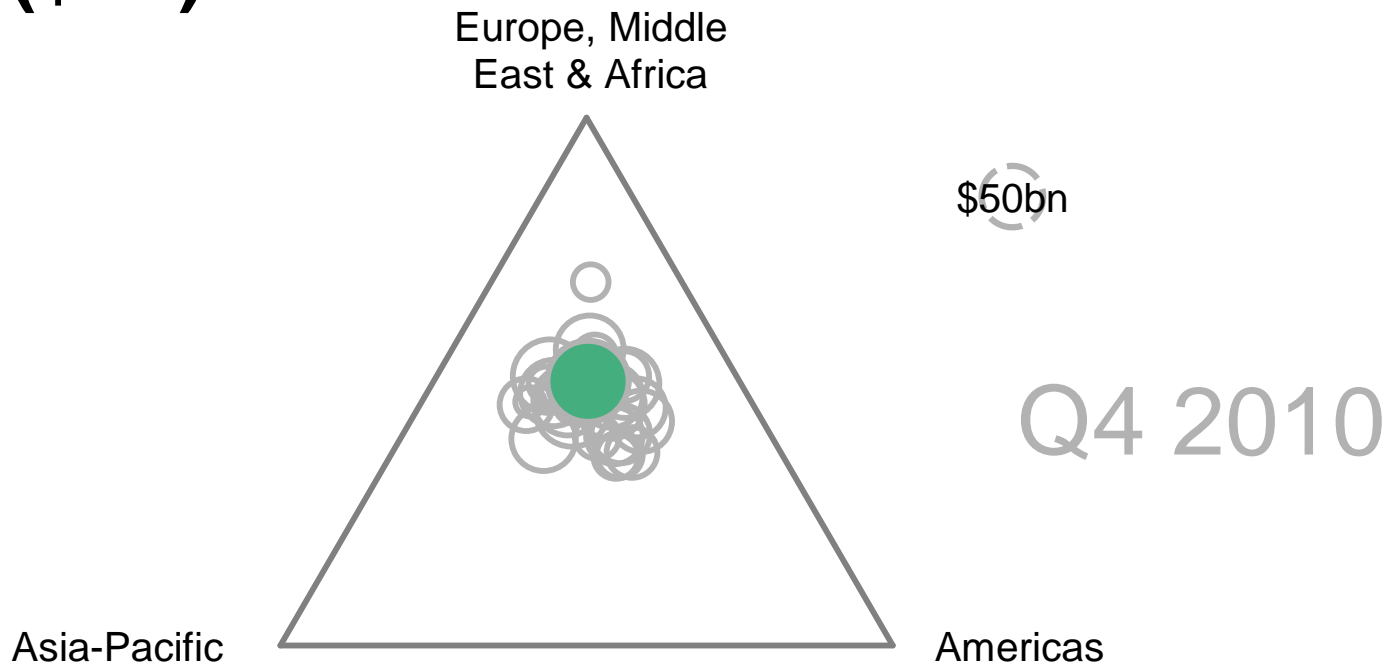
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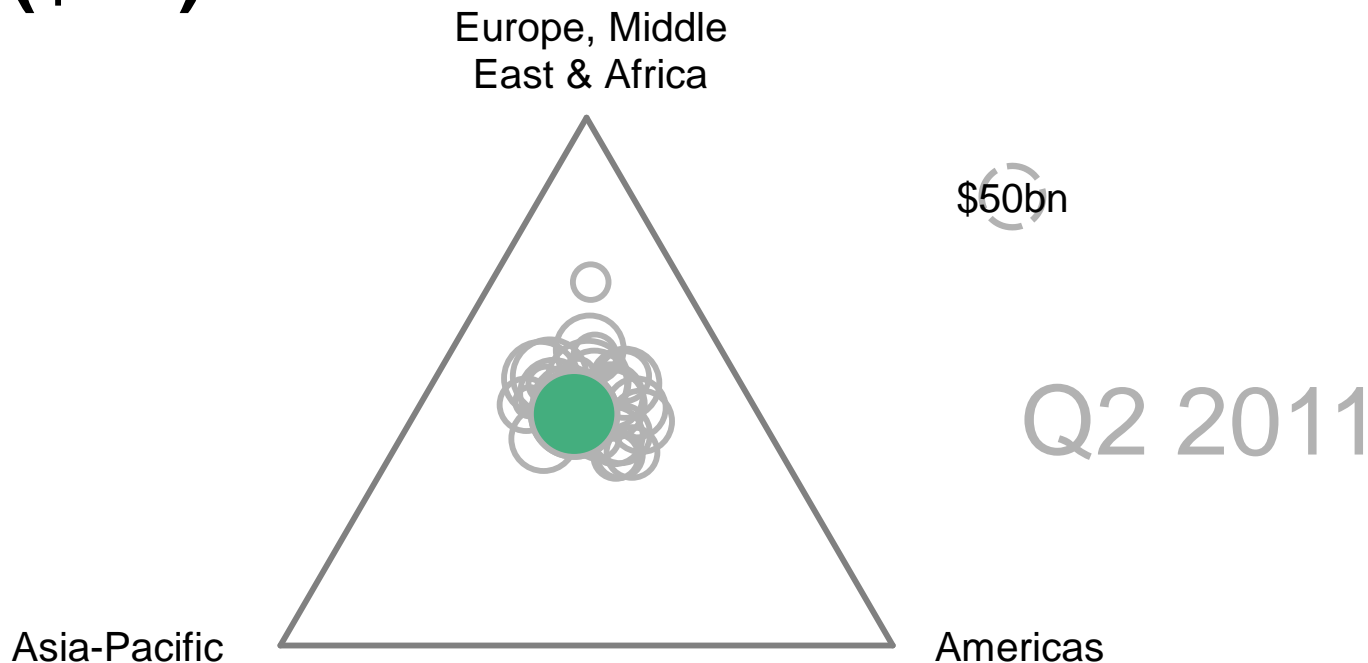
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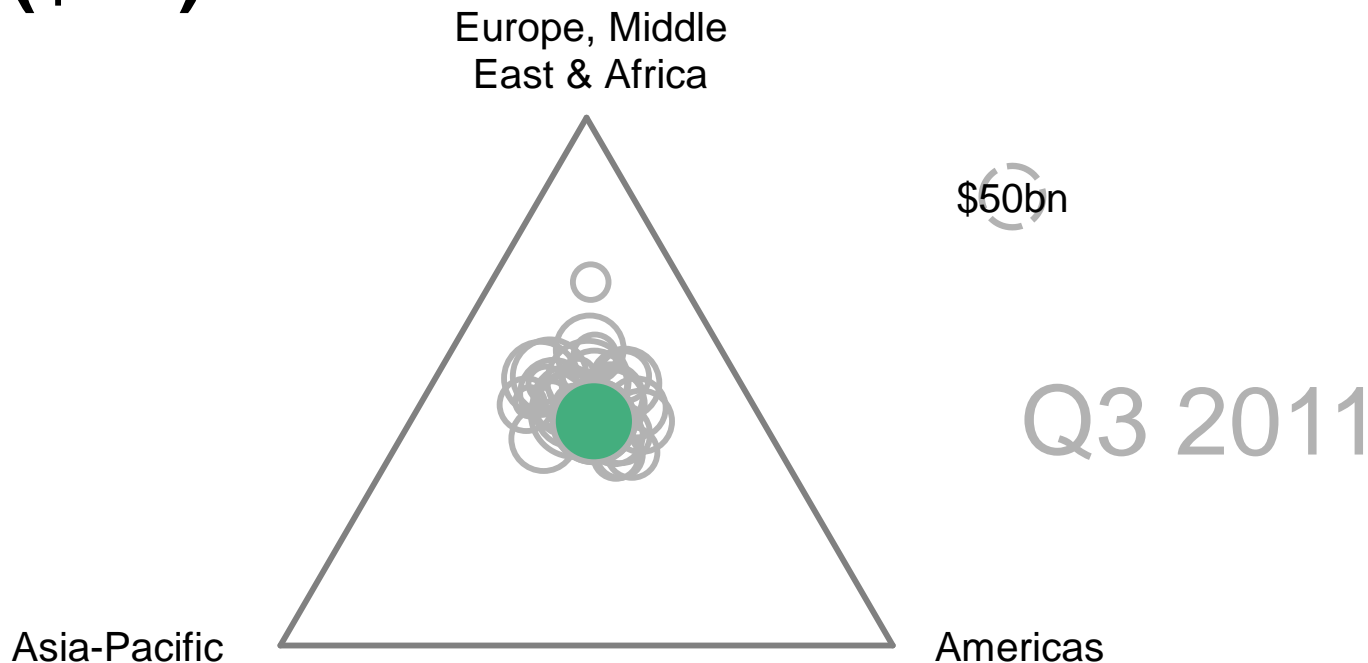
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# New investment in clean energy (\$bn)



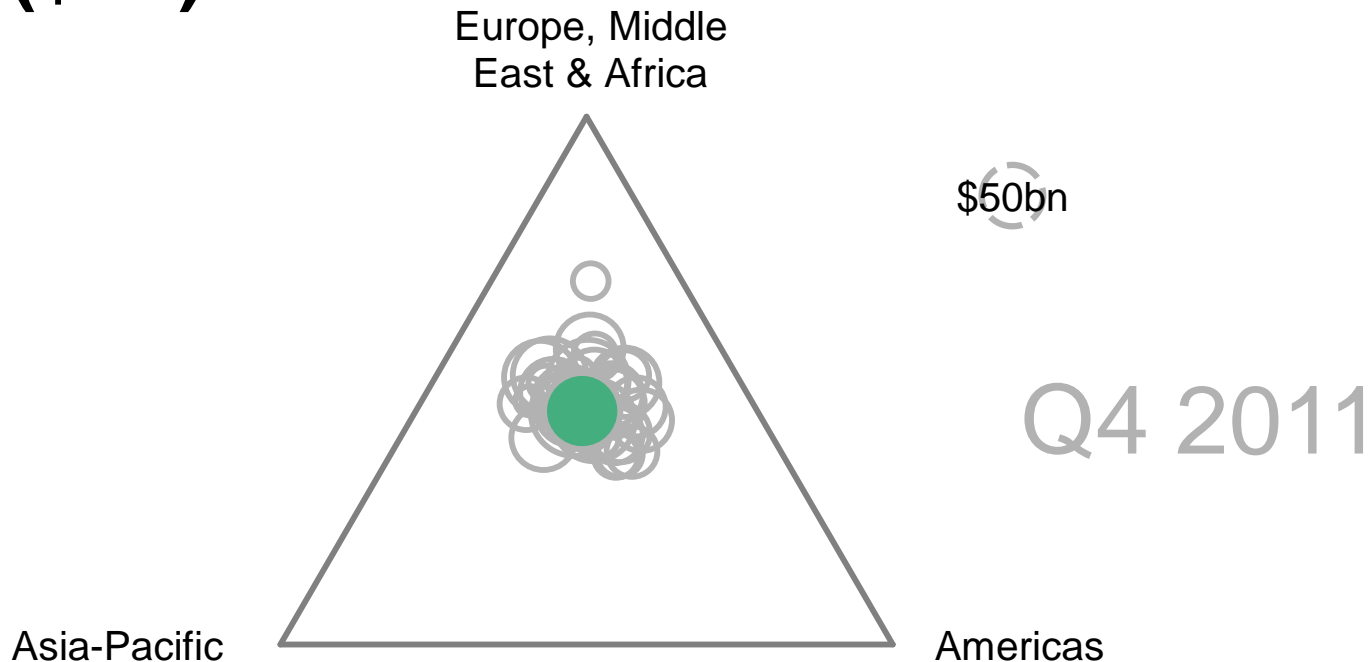
*Note: Bubble size represents total global investment per quarter Source: Bloomberg New Energy Finance*

# New investment in clean energy (\$bn)



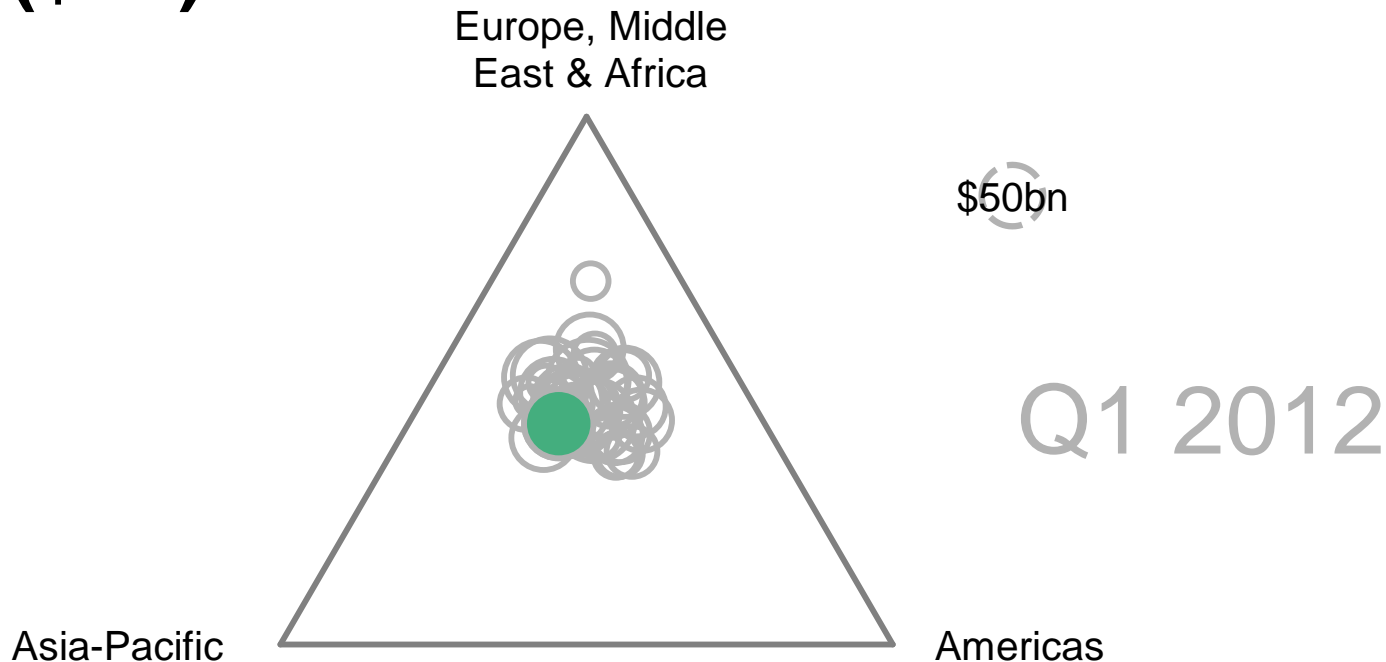
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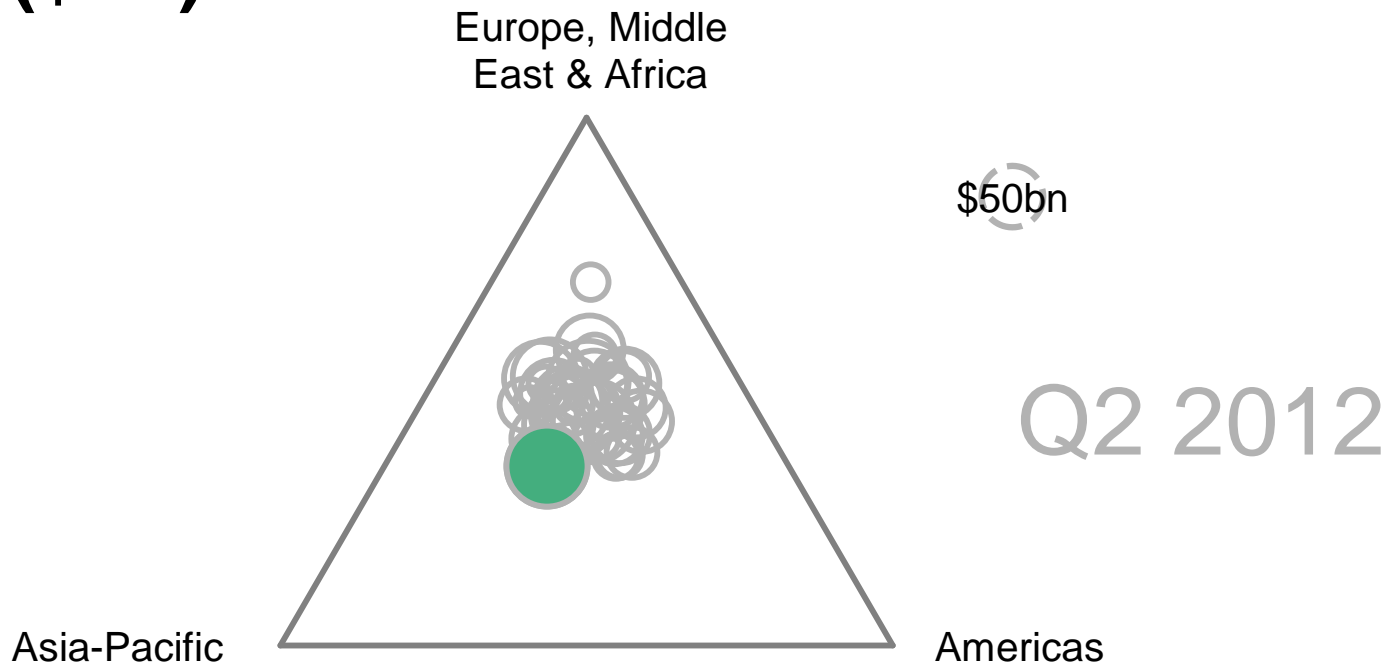
# New investment in clean energy (\$bn)



*Note: Bubble size represents total global investment per quarter Source: Bloomberg New Energy Finance*

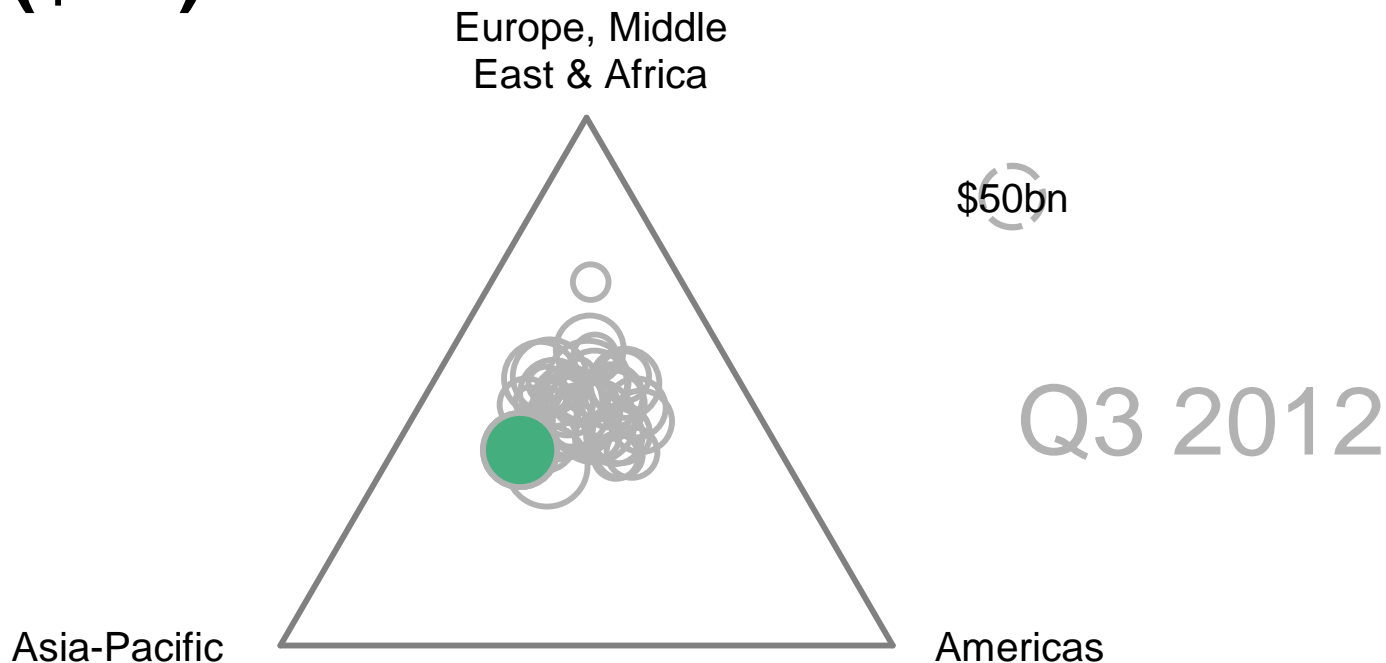


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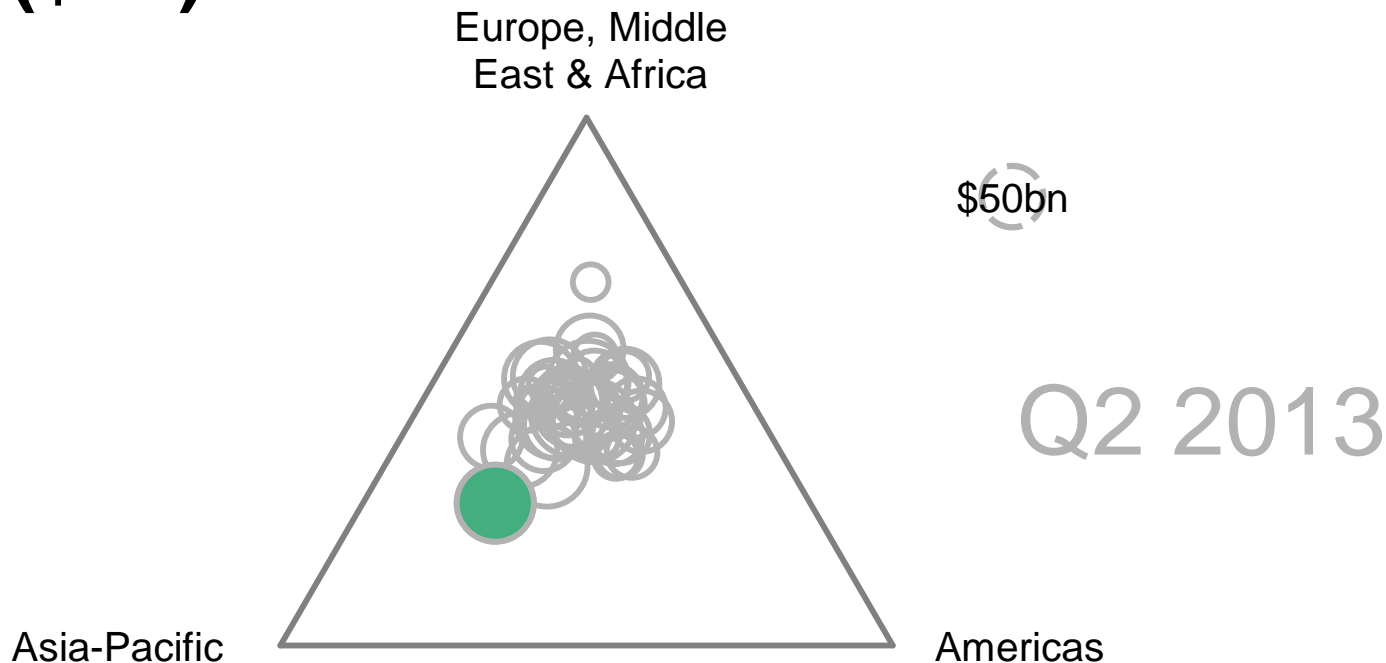
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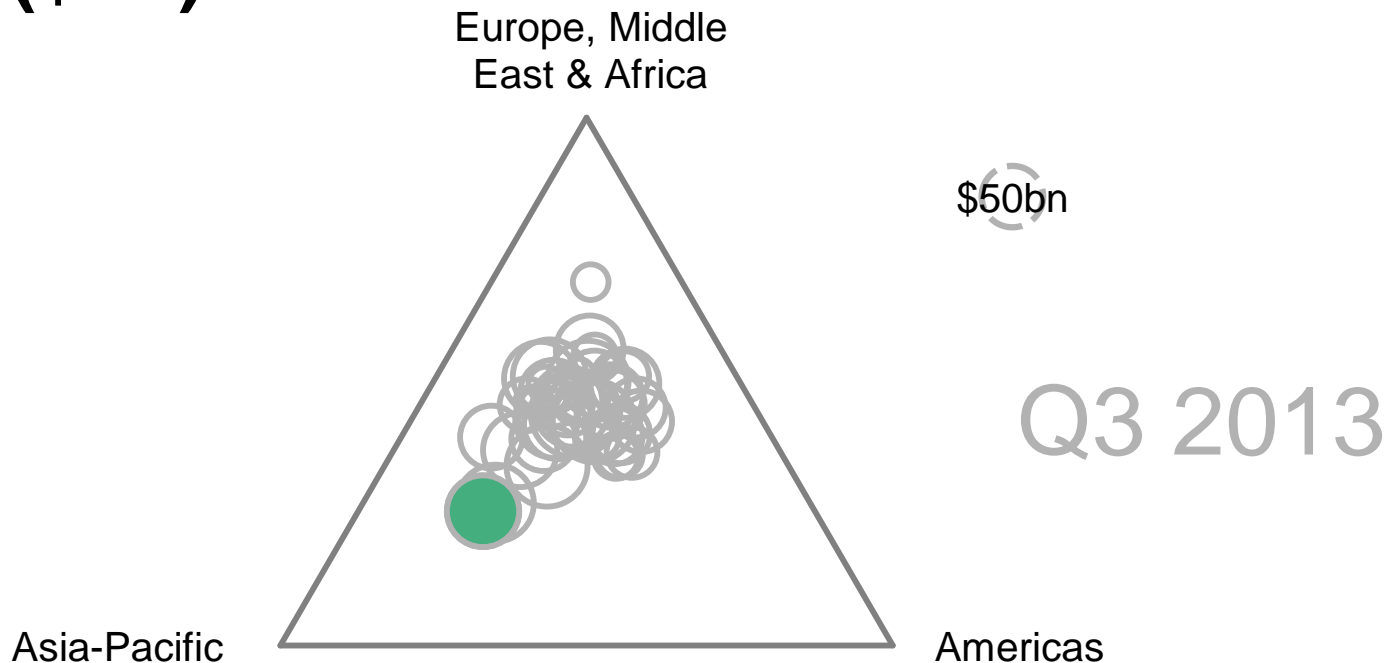
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# New investment in clean energy (\$bn)



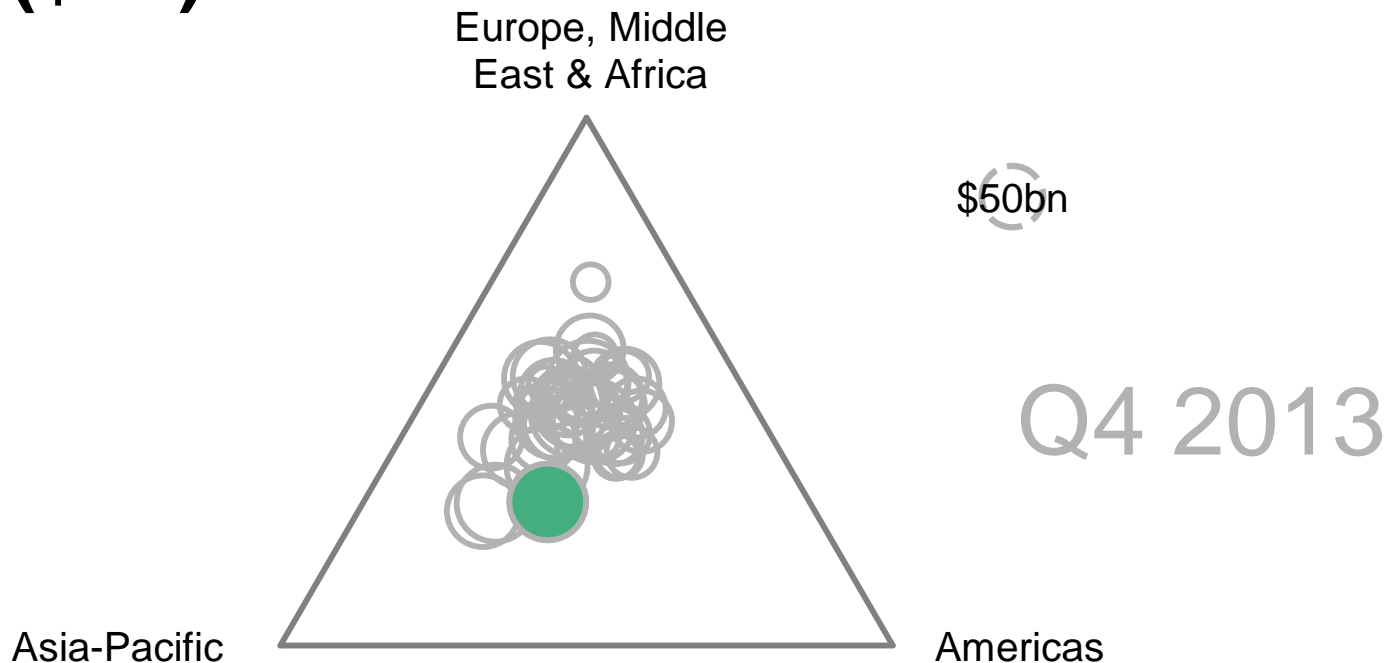
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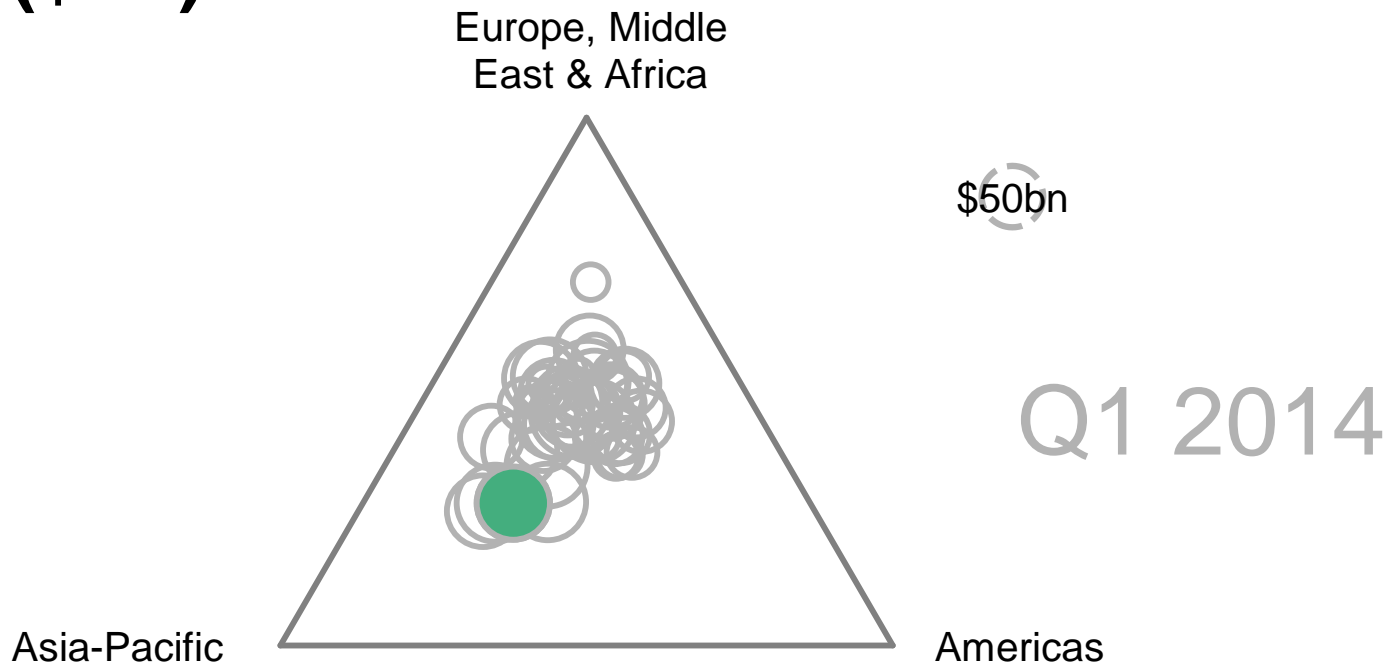
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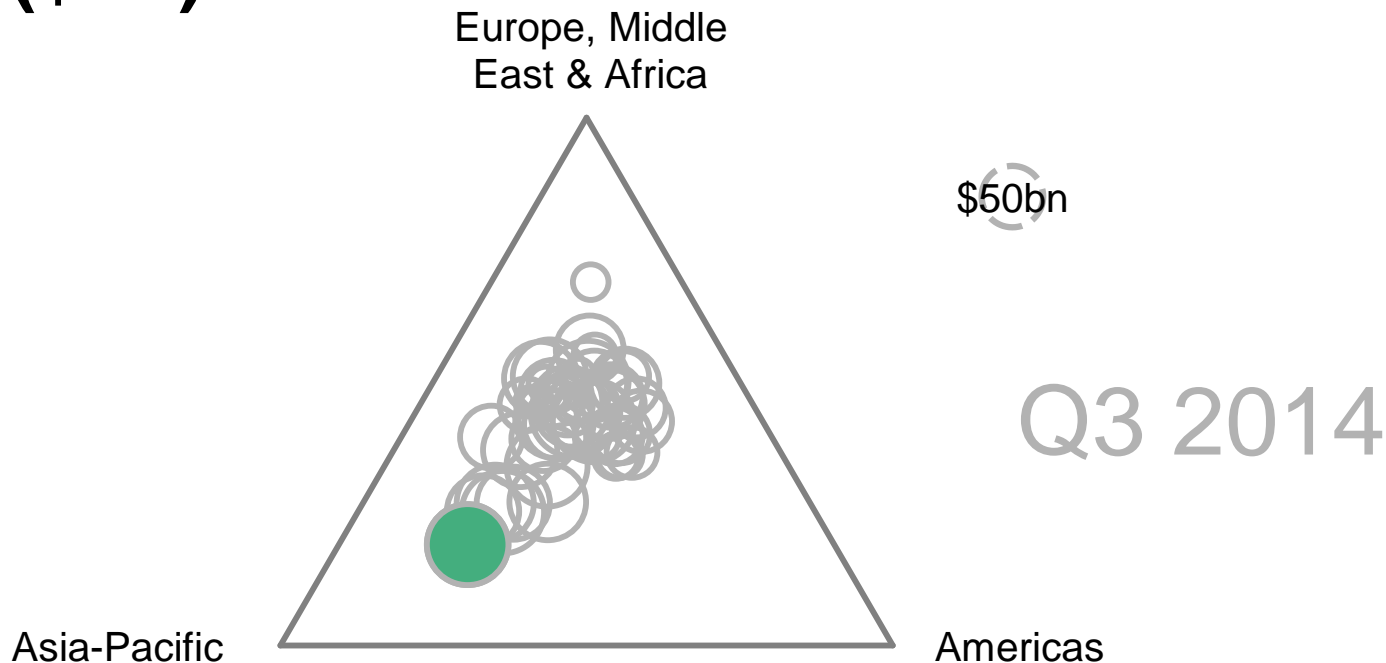


# New investment in clean energy (\$bn)



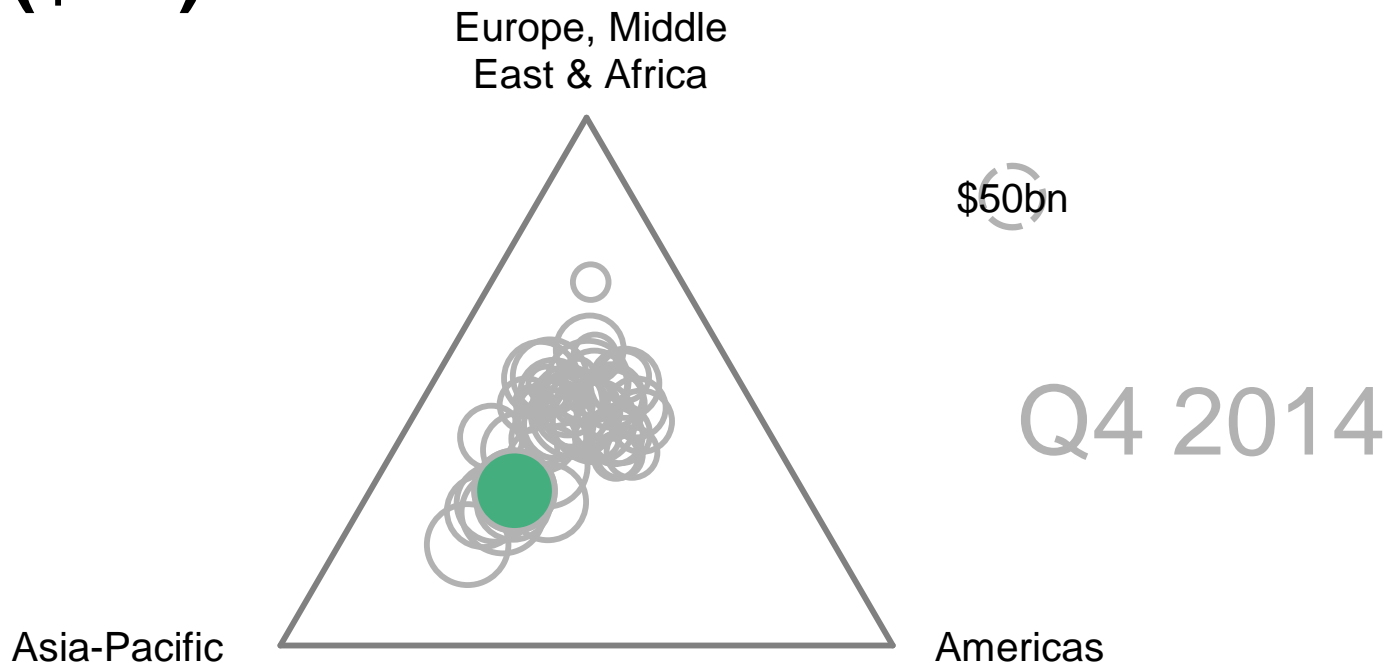
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# New investment in clean energy (\$bn)



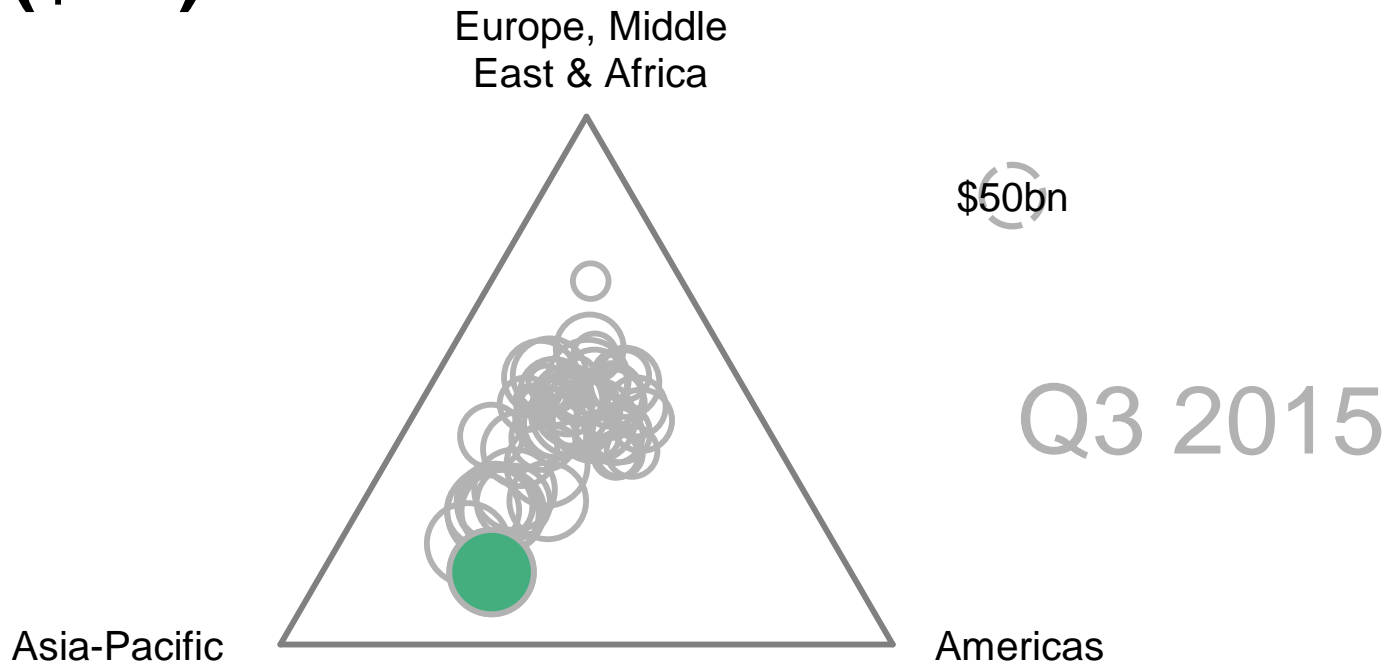
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# New investment in clean energy (\$bn)



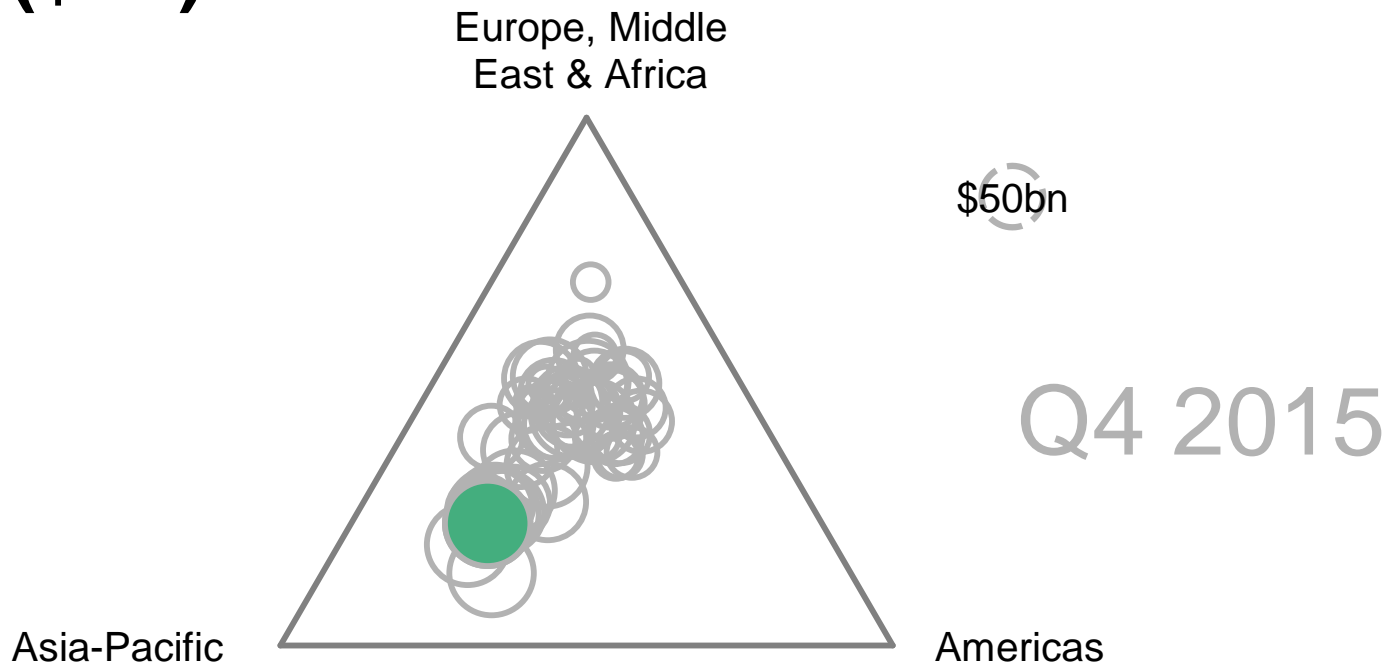
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# New investment in clean energy (\$bn)



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# New investment in clean energy (\$bn)



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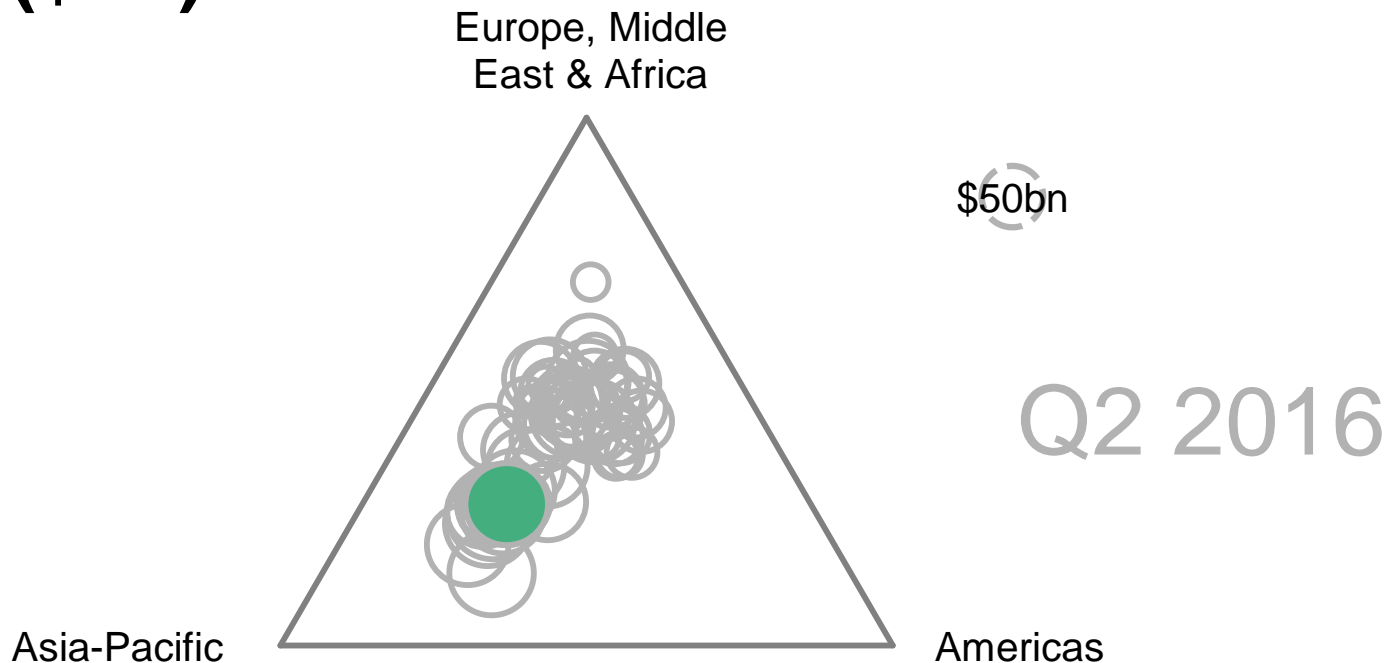
# New investment in clean energy (\$bn)



*Note: Bubble size represents total global investment per quarter Source: Bloomberg New Energy Finance*

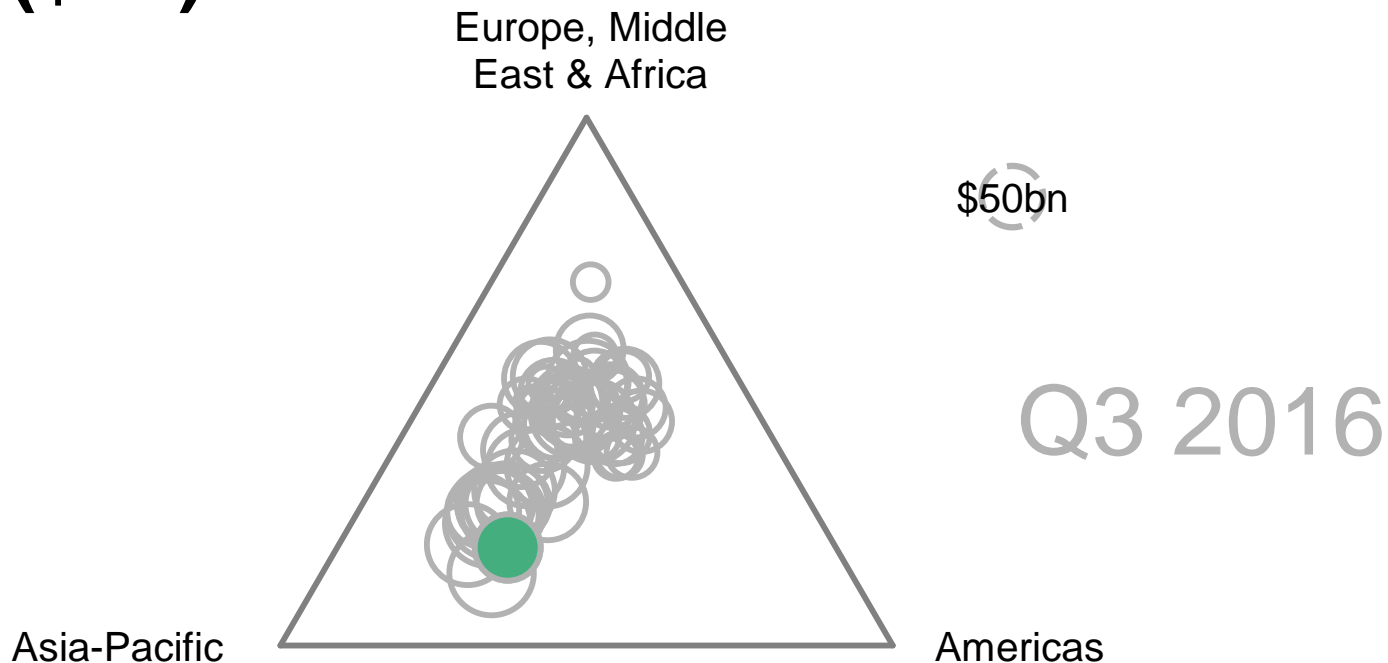


# New investment in clean energy (\$bn)



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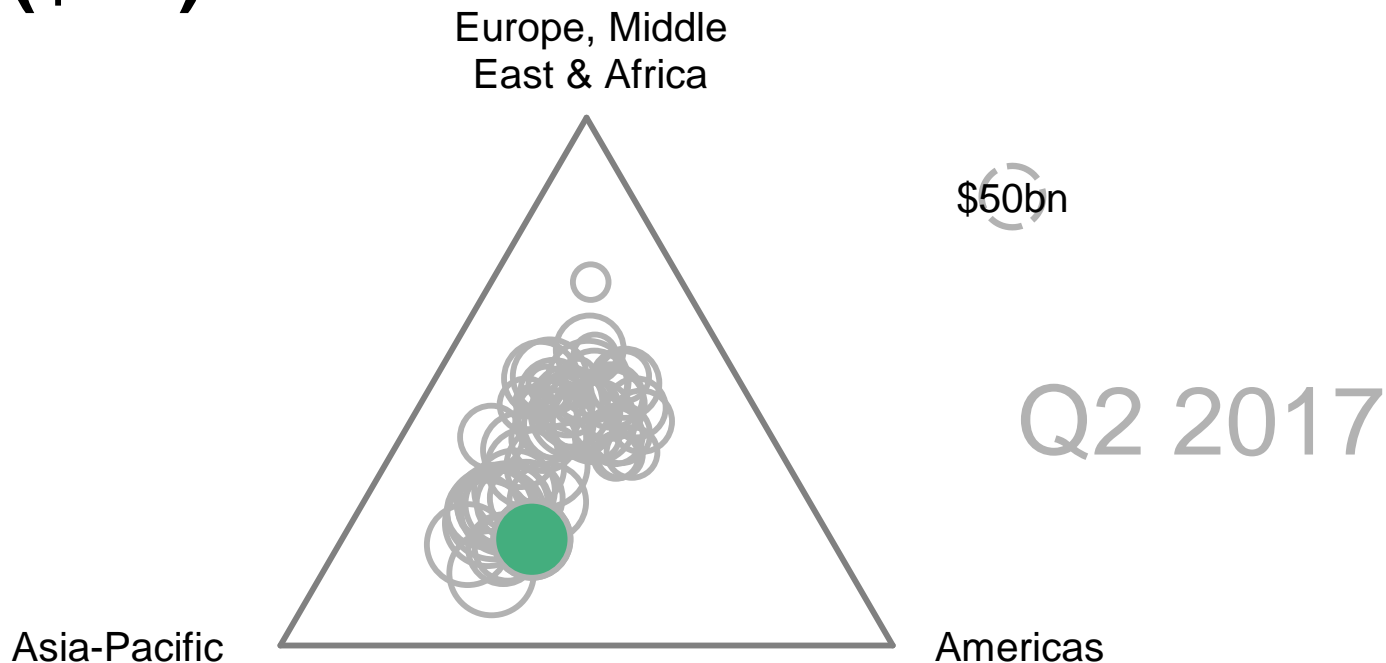
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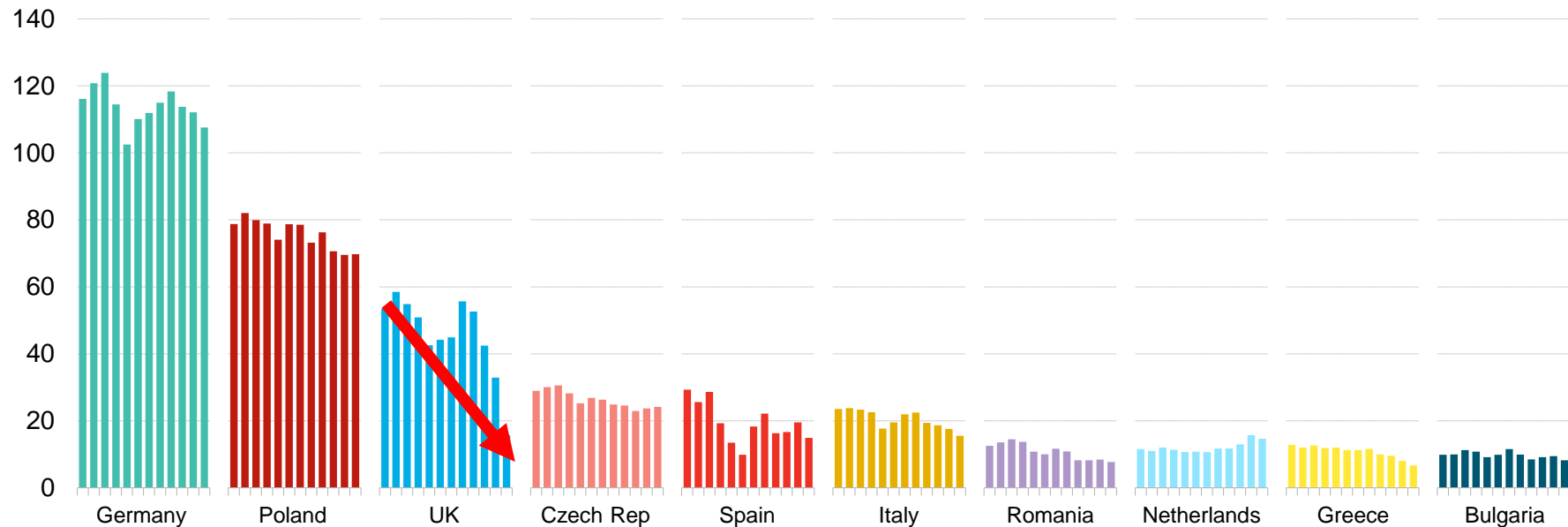
# New investment in clean energy (\$bn)



*Note: Bubble size represents total global investment per quarter Source: Bloomberg New Energy Finance*

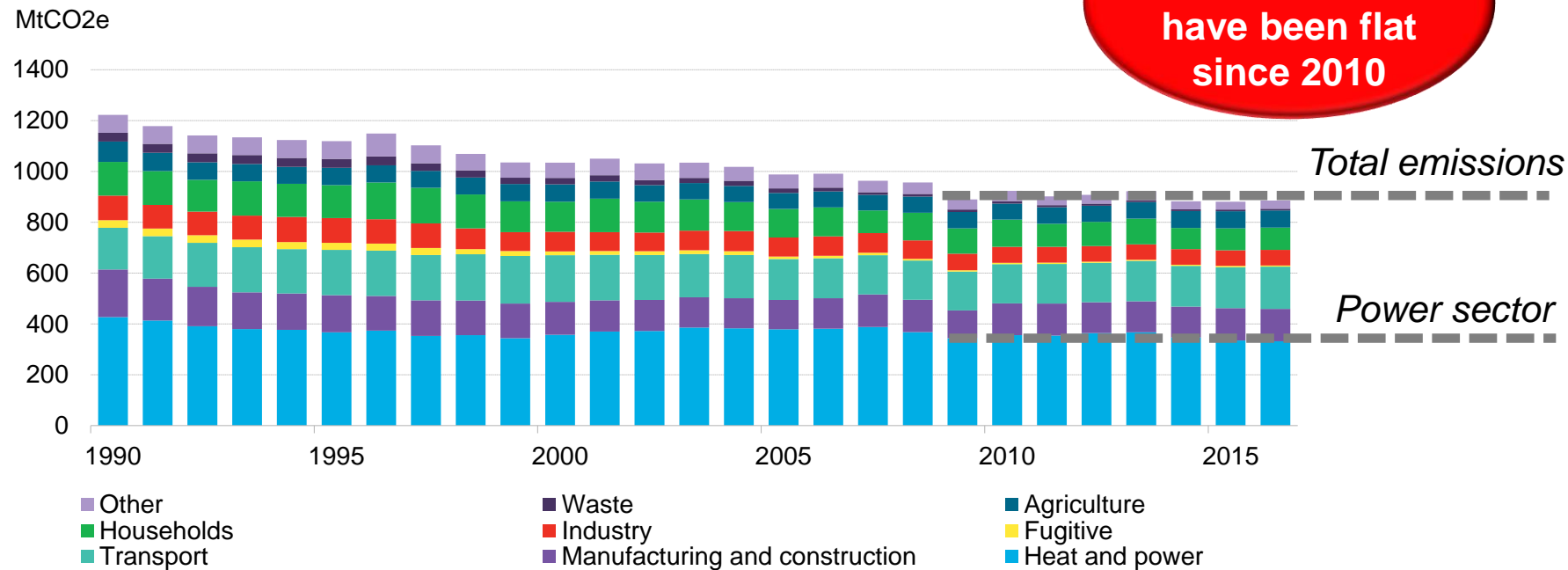
# EU member state coal consumption 2000-16

Mt coal per year



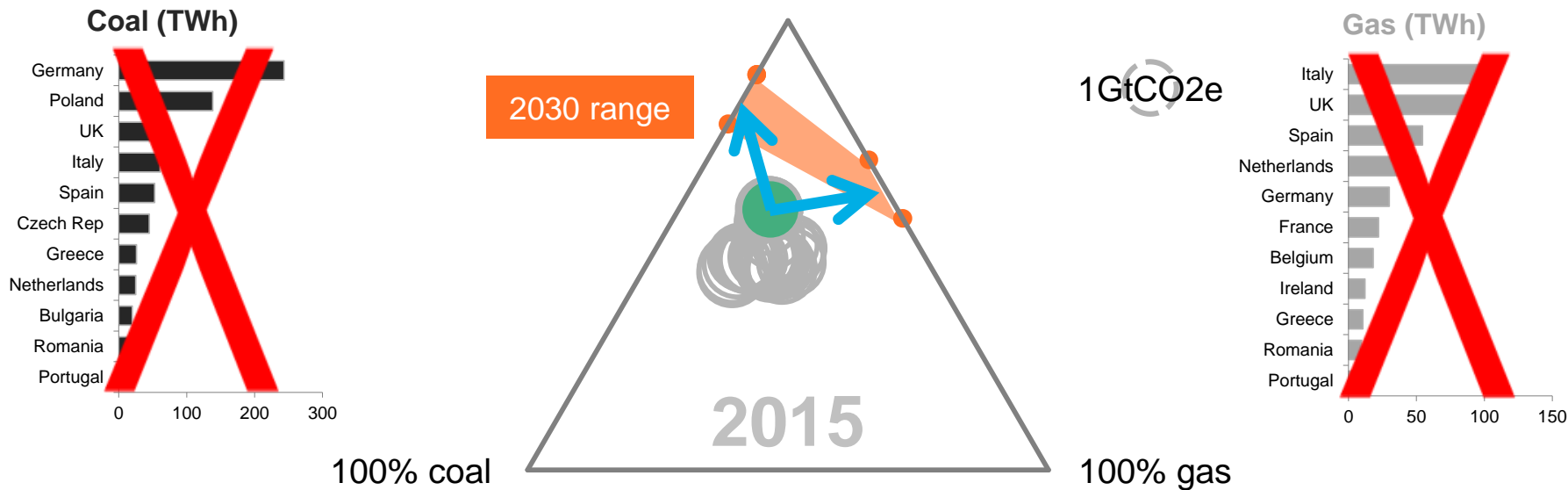
Source: Bloomberg New Energy Finance, BP Statistical Review

# Germany CO2 emissions



Source: UBA; BNEF

# Europe generation mix and emissions

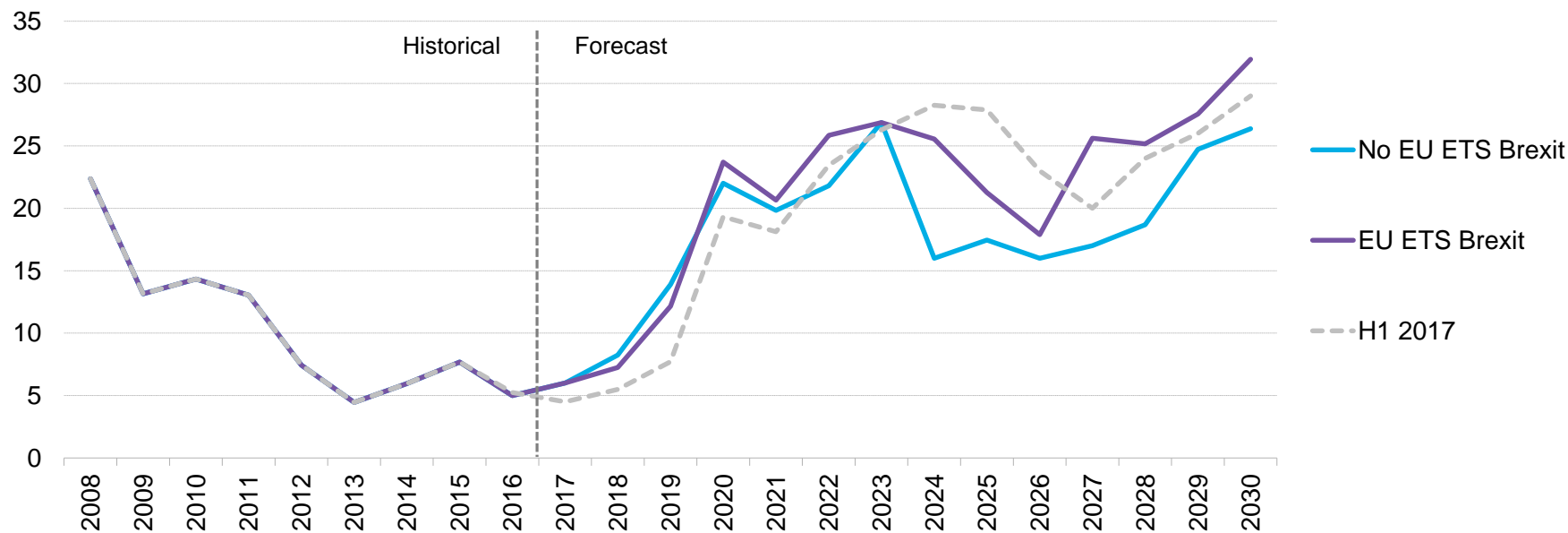


Source: Bloomberg New Energy Finance. Note: Axes show percentage of generation mix, bubble shows total carbon emissions; Coal and gas generation data is for 2015.



# EU ETS price projection

EUR per metric ton, nominal

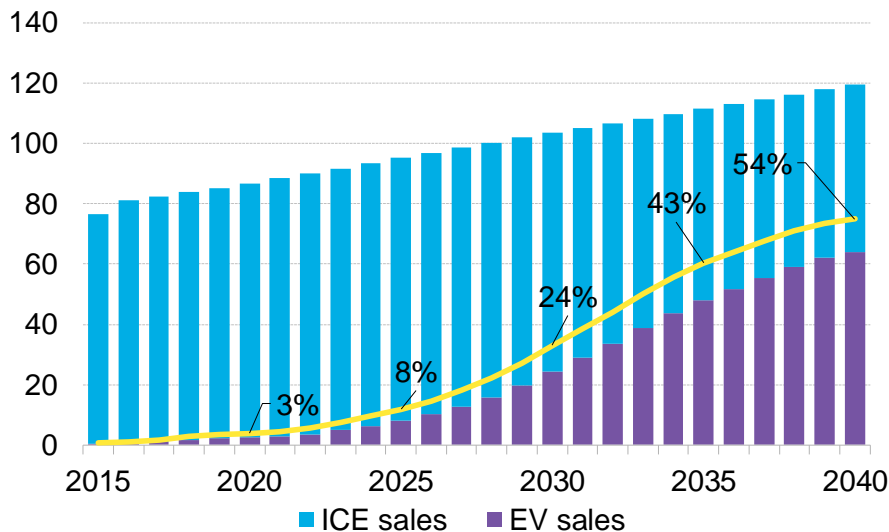


Source: Bloomberg New Energy Finance

# Electric vehicle outlook to 2040

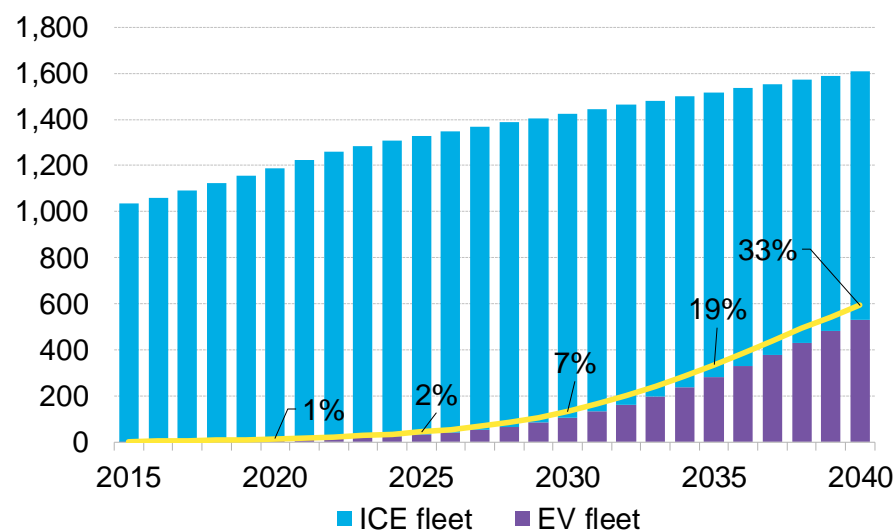
## Annual global light duty vehicle sales

million vehicles



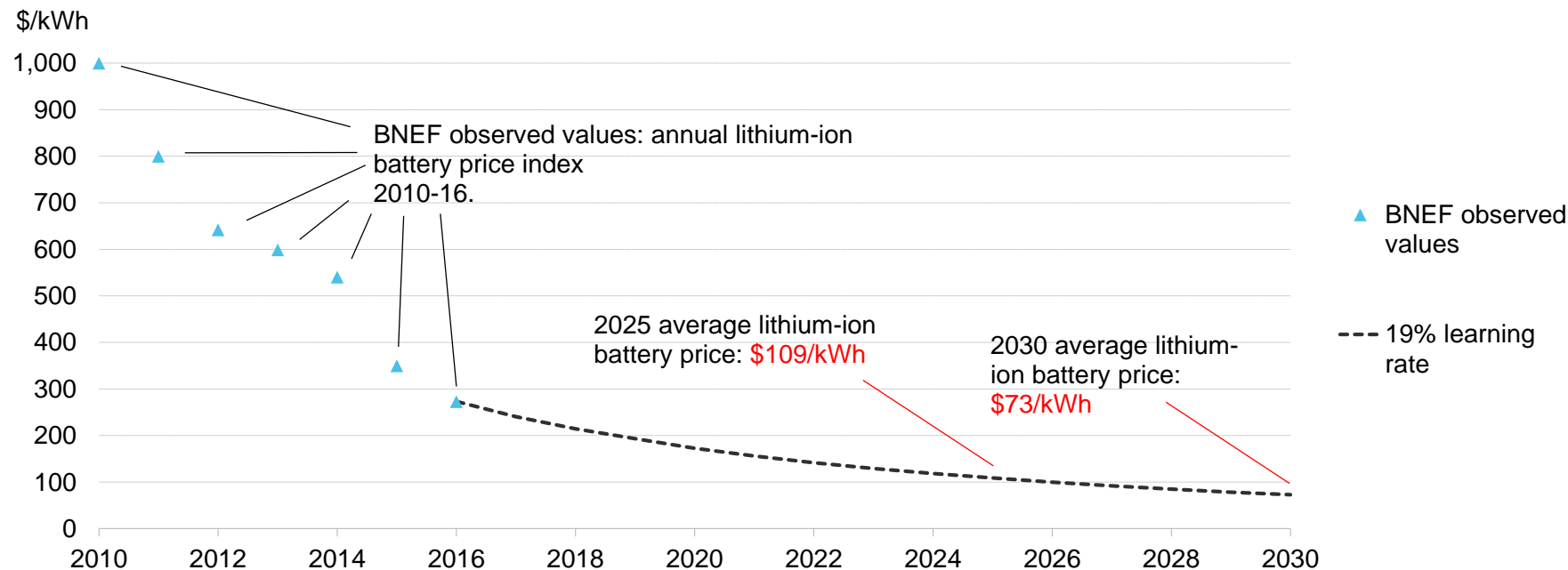
## Global light duty vehicle fleet

million cars on road



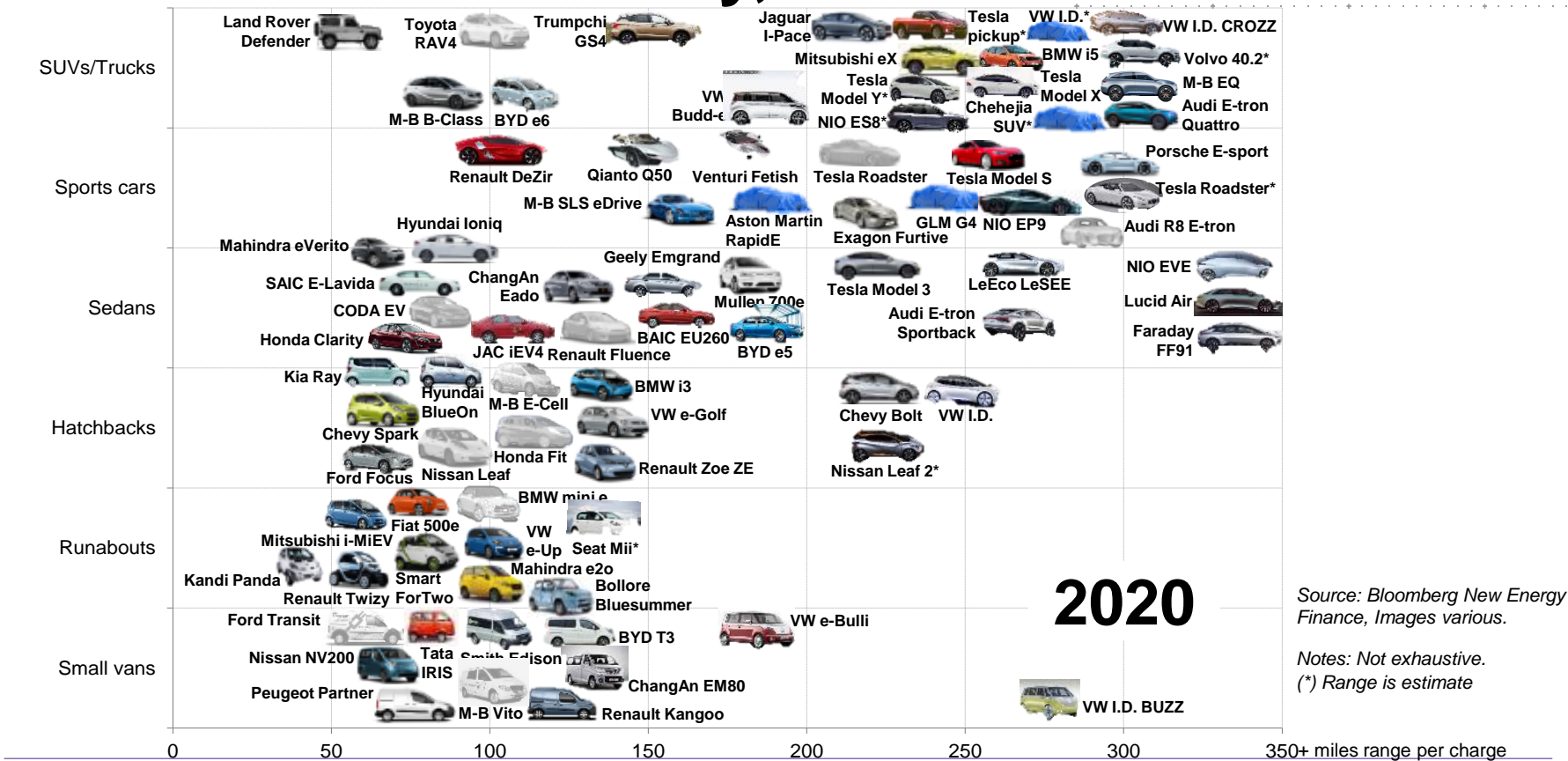
Source: Bloomberg New Energy Finance *EVO* 2017

# Lithium-ion battery prices, historical and forecast



Source: Bloomberg New Energy Finance *EVO 2017*; Note: Prices are an average of BEV and PHEV batteries and include both cell and pack costs. Cell costs alone will be lower. Historical prices are nominal, future ones are in real 2016 U.S. dollars.

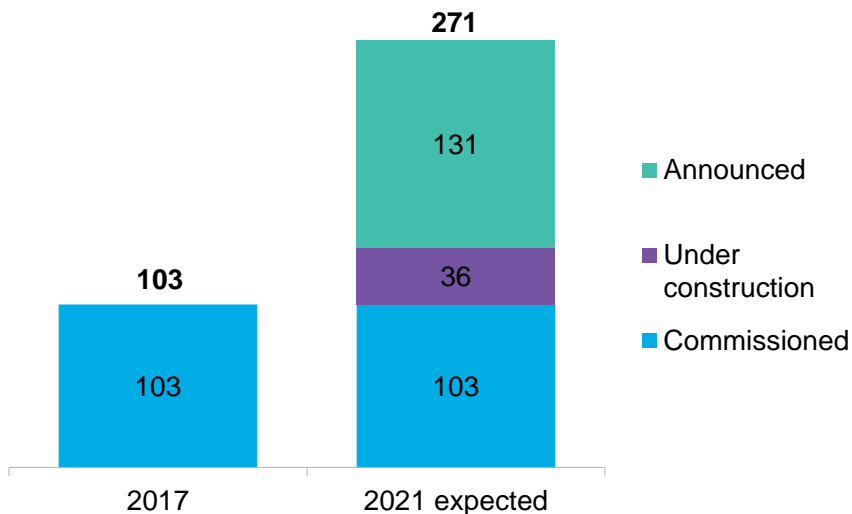
# BEV model availability, 2008-20



# Battery availability and prices

## Global EV Li-ion manufacturing capacity

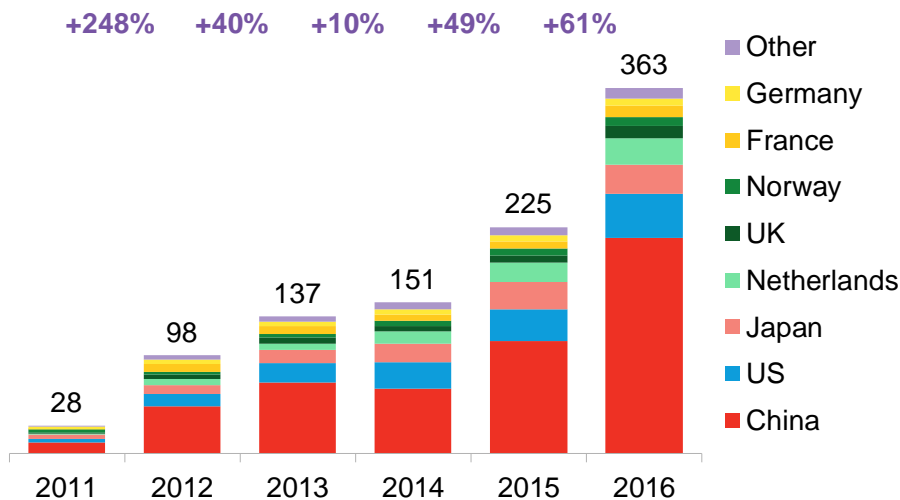
GWh



Source: Bloomberg New Energy Finance *EVO 2017*

## Global EV charging points installed

Thousand units installed

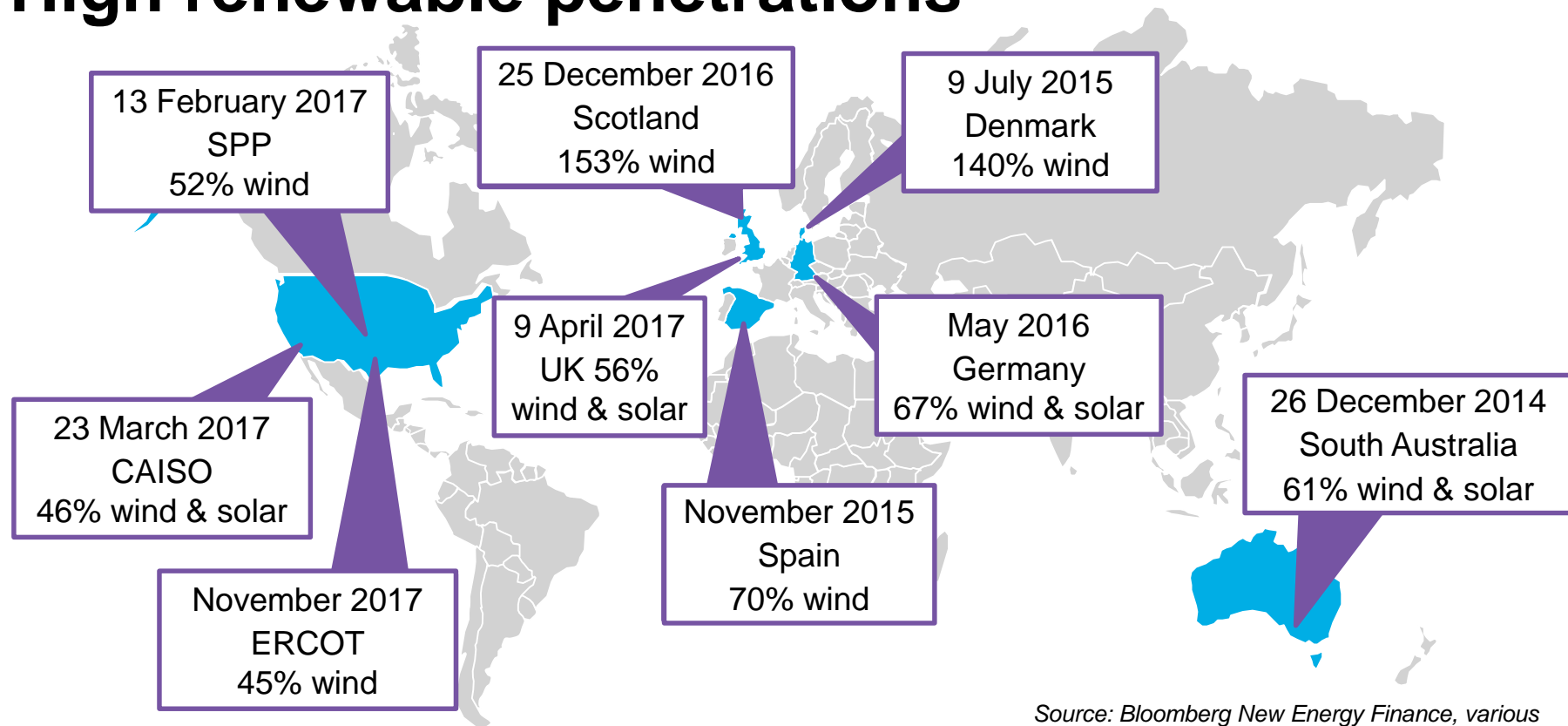


# The big challenge



*Image: NASA*

# High renewable penetrations

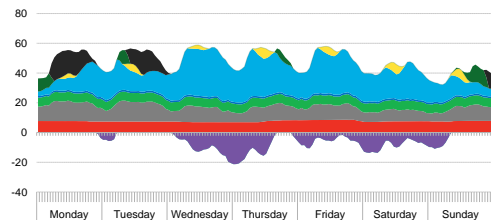


Source: Bloomberg New Energy Finance, various

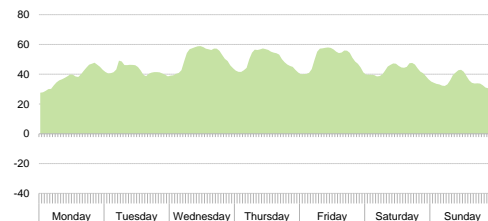
# Future power supply

## Total generation

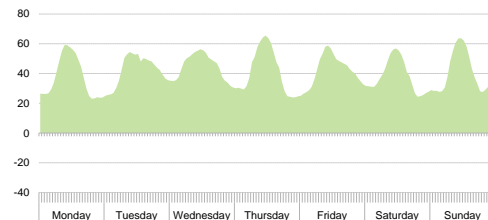
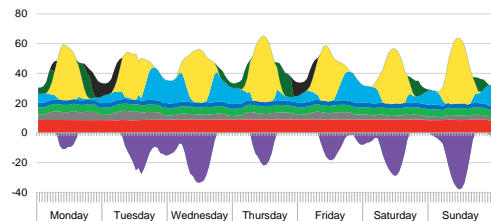
Winter



## Low carbon generation



Summer



■ Peaking fossil ■ Baseload fossil ■ Nuclear ■ CHP ■ Hydro ■ Baseload RE ■ Solar ■ Wind ■ Pumped hydro generation/Storage ■ Imports ■ Exports/curtailment/DR

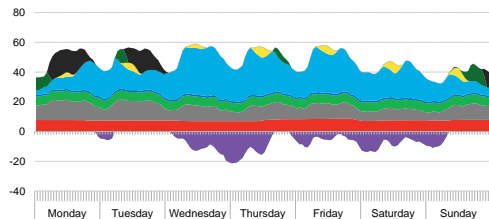
Source: Bloomberg New Energy Finance



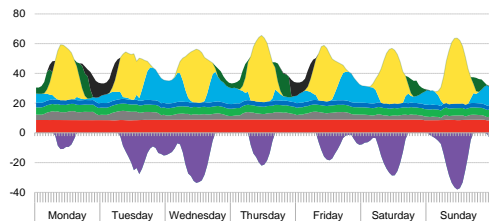
# Future power supply

## Total generation

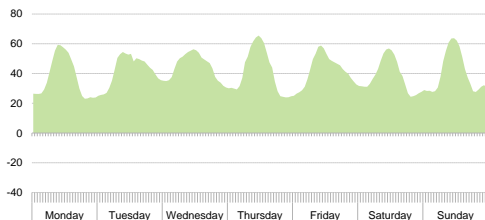
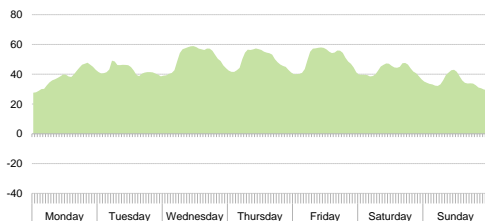
Winter



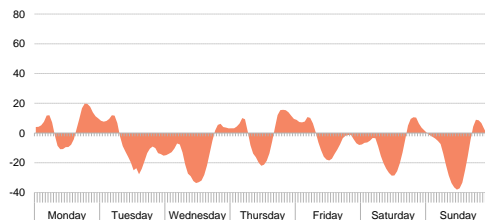
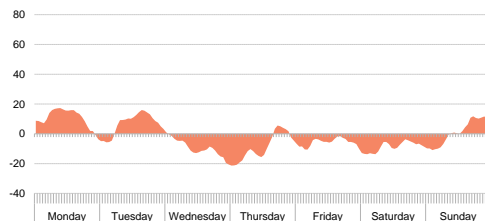
Summer



## Low carbon generation



## Flexible generation



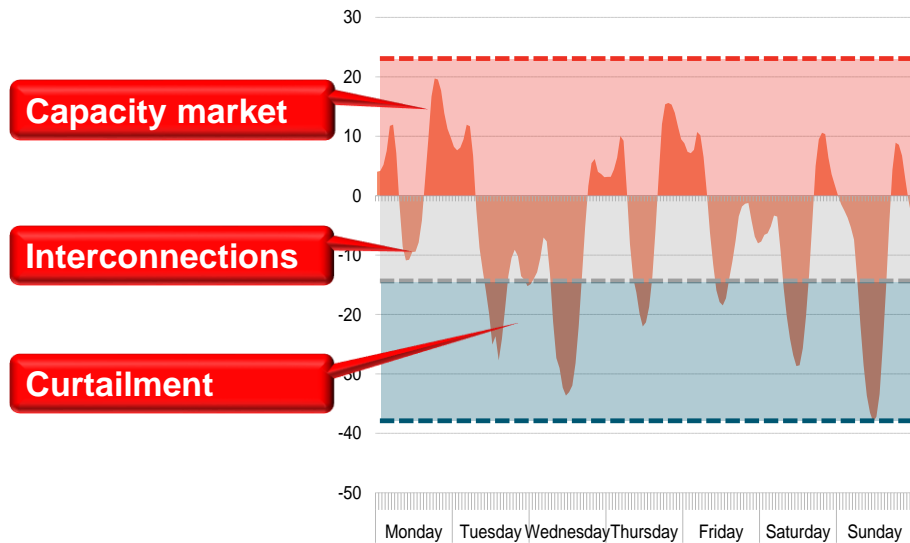
■ Peaking fossil ■ Baseload fossil ■ Nuclear ■ CHP ■ Hydro ■ Baseload RE ■ Solar ■ Wind ■ Pumped hydro generation/Storage ■ Imports ■ Exports/curtailment/DR

Source: Bloomberg New Energy Finance

# Two visions of the future

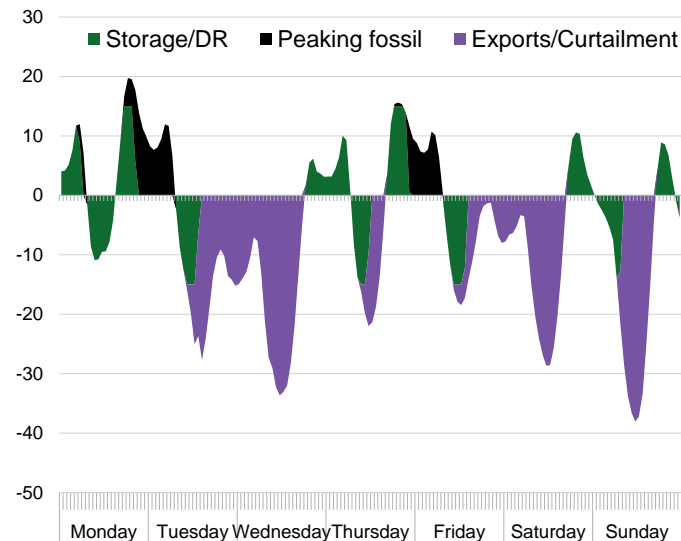
## Option A: Capacity markets

“Central planning lite”



## Option B: Demand-Led

“Telecoms deregulation lite”



Source: Bloomberg New Energy Finance

# New orthodoxy

By 2040...



1/3 of electricity  
will be wind and  
solar



1/3 of cars and  
light trucks will be  
electric



The global  
economy will be  
1/3 more energy  
efficient

...too hard

Shipping/air/freight



Land-use/deforestation



Petrochemicals



Industry



Energy access



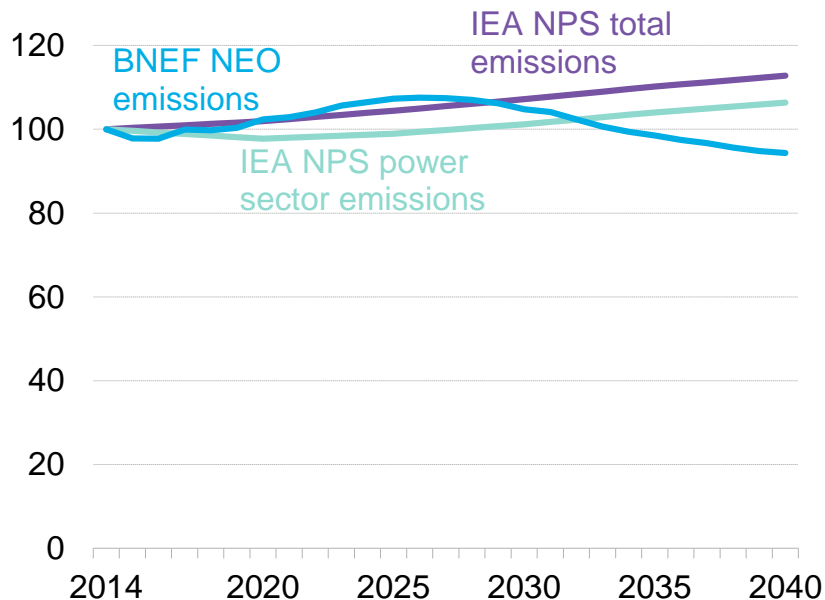
Heat



Source: Bloomberg New Energy Finance, Tesla, Wallpaper Mania, Cleantechica

# New orthodoxy

Rebased to 100 in 2014



Source: Bloomberg New Energy Finance, IEA



Prove  
it  
wrong!

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[sales.bnef@bloomberg.net](mailto:sales.bnef@bloomberg.net)

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Michael Liebreich

[michael@liebreichassociates.com](mailto:michael@liebreichassociates.com)

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