5 April 2016

BLOOMBERG NEW ENERGY FINANCE SUMMIT

In search of the miraculous

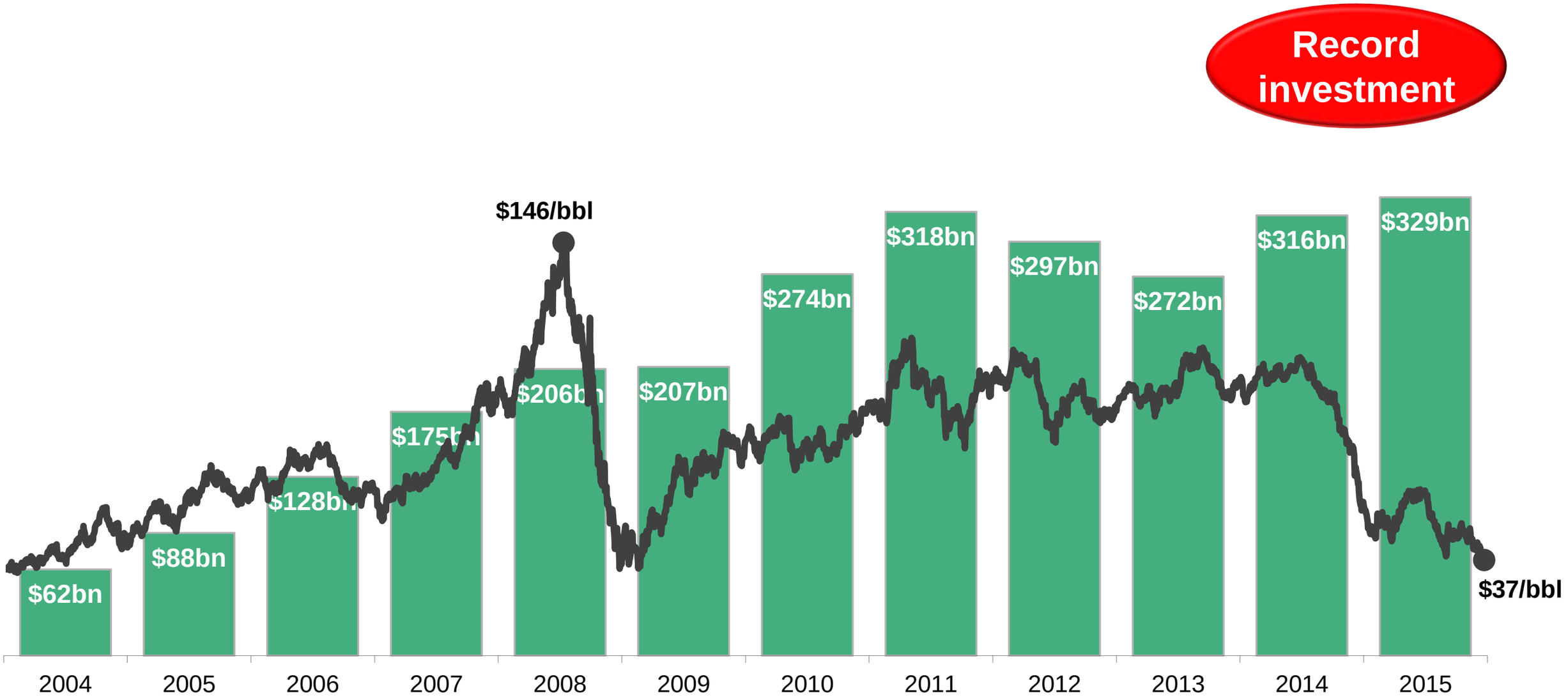
Michael Liebreich

Bloomberg
NEW ENERGY FINANCE

CLEAN ENERGY INVESTMENT ROSE WHILE OIL PLUMMETED

GLOBAL CLEAN ENERGY INVESTMENT VS WTI CRUDE SPOT 2004-15

Bloomberg NEW ENERGY FINANCE



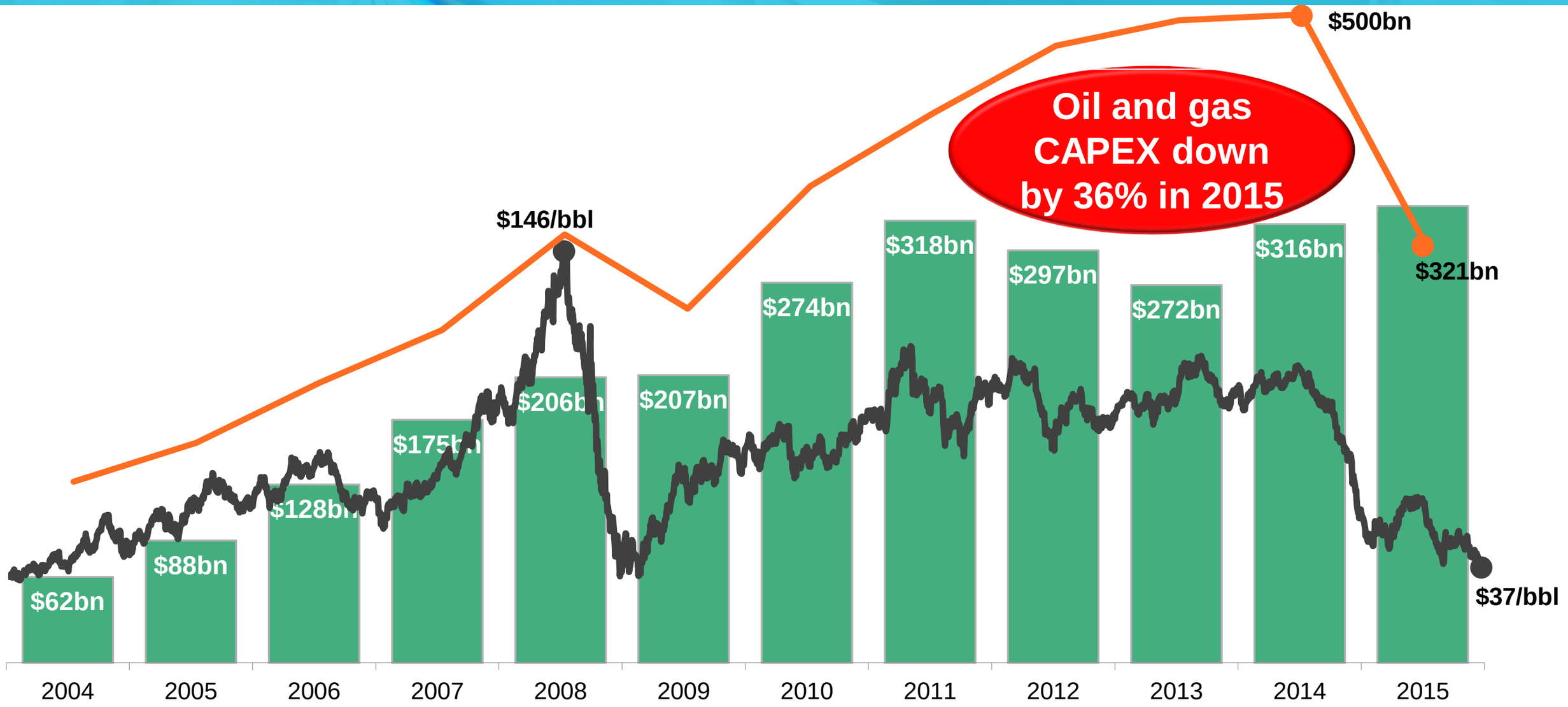
Note: Total values include estimates for undisclosed deals. Includes corporate and government R&D, and spending for digital energy and energy storage projects (not reported in quarterly statistics). Excludes large hydro.

Source: Bloomberg Intelligence, Bloomberg New Energy Finance

CLEAN ENERGY INVESTMENT ROSE WHILE OIL & GAS CAPEX FELL

GLOBAL CLEAN ENERGY INVESTMENT VS OIL & GAS CAPITAL EXPENDITURE

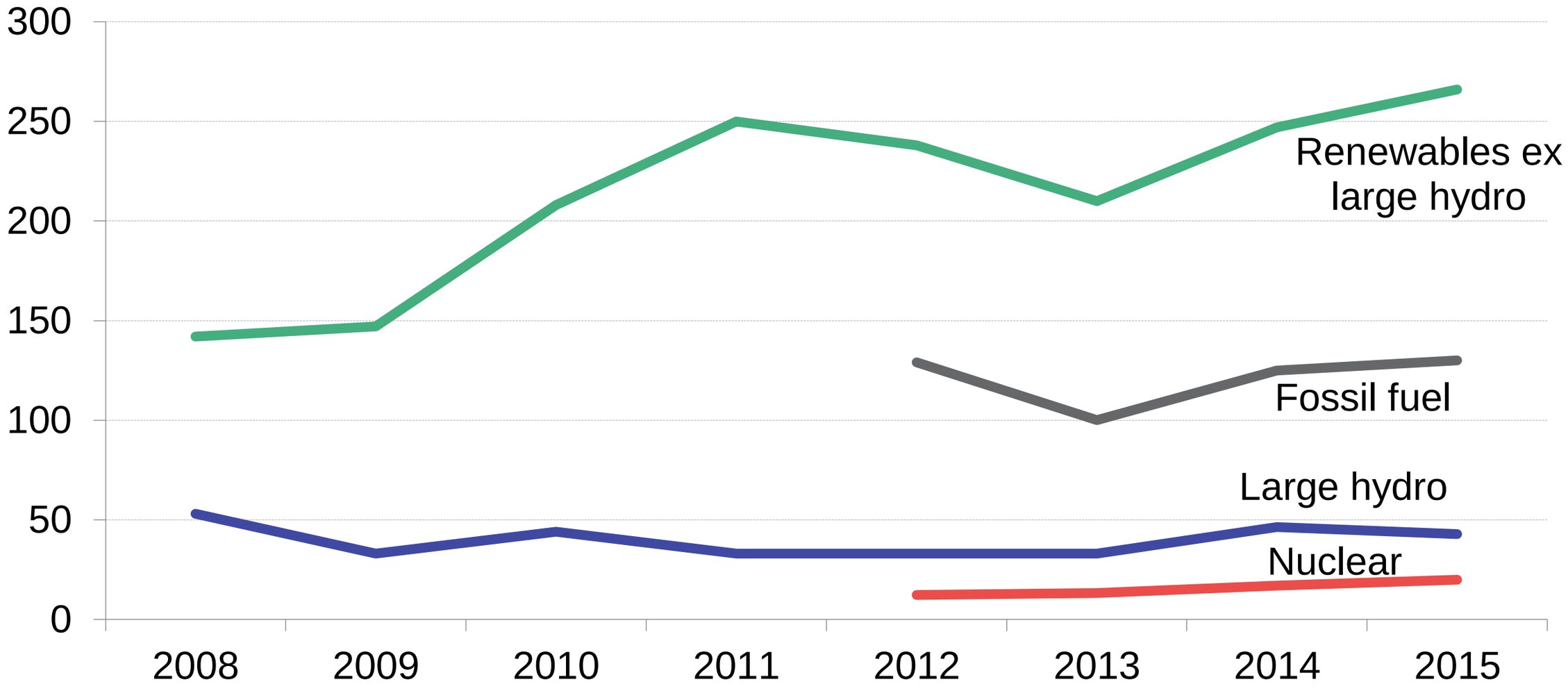
Bloomberg NEW ENERGY FINANCE



Note: Oil and gas CAPEX data refers to total capital spending by integrated global oil firms and US independent E&Ps. Excludes NOCs.

Source: Bloomberg Intelligence, Bloomberg New Energy Finance

INVESTMENT IN POWER CAPACITY, 2008–15
($BN)



Source: UNEP, Bloomberg New Energy Finance

WORLD RECORD: 3-CENT WIND, SUB-4-CENT SOLAR (UNSUBSIDISED)

Bloomberg NEW ENERGY FINANCE

ONSHORE WIND

Location:	Morocco
Bidder:	Enel Green Power
Signed:	January 2016
Price:	US$ 3.0 c/kWh

SOLAR PV

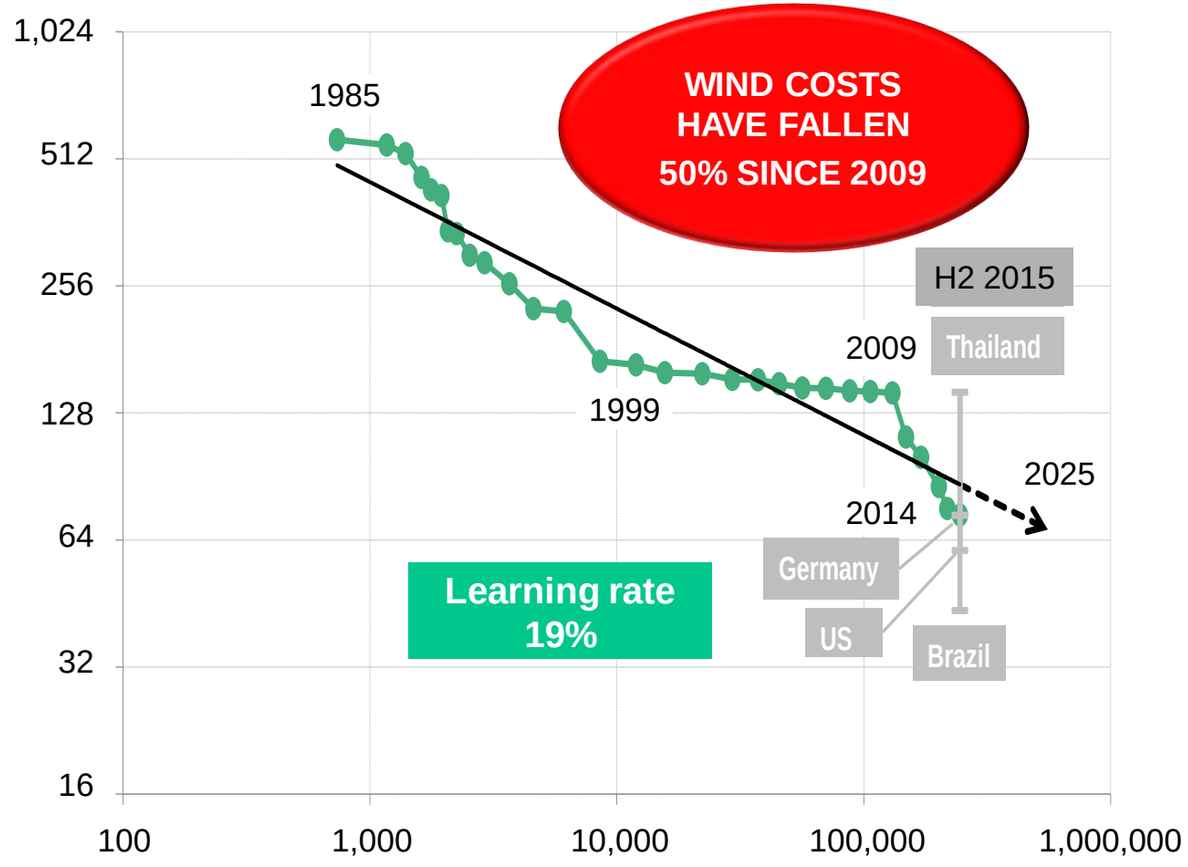
Location:	Coahuila, Mexico
Bidder:	Enel Green Power
Signed:	March 2016
Price:	**US$ 3.6 c/kWh**

Source: Bloomberg New Energy Finance; ImagesSiemens; Wikimedia Commons

WIND AND SOLAR EXPERIENCE CURVES

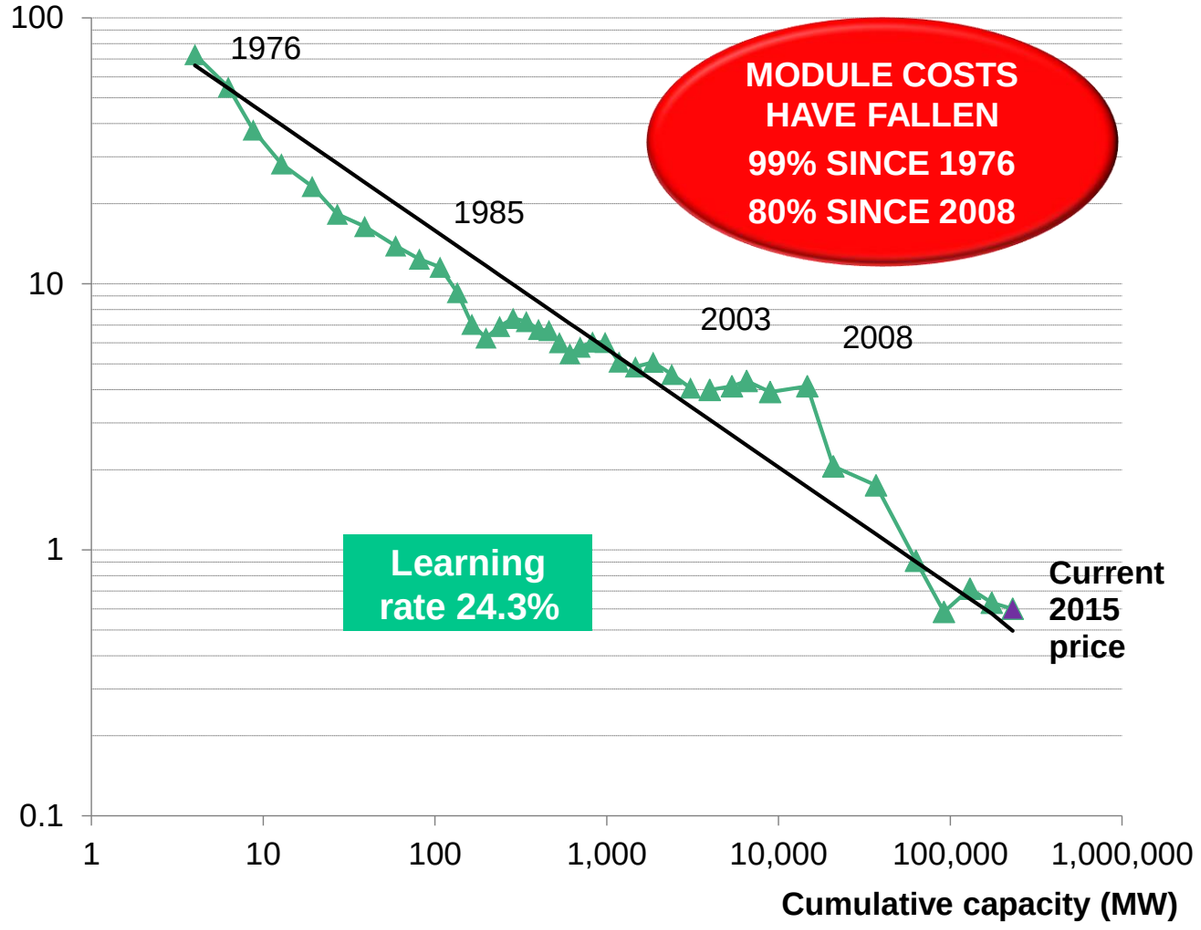
Bloomberg NEW ENERGY FINANCE

ONSHORE WIND LEVELISED COST ($/MWh)



Note: Pricing data has been inflation corrected to 2014. We assume the debt ratio of 70%, cost of debt (bps to LIBOR) of 175, cost of equity of 8% Source: Bloomberg New Energy Finance

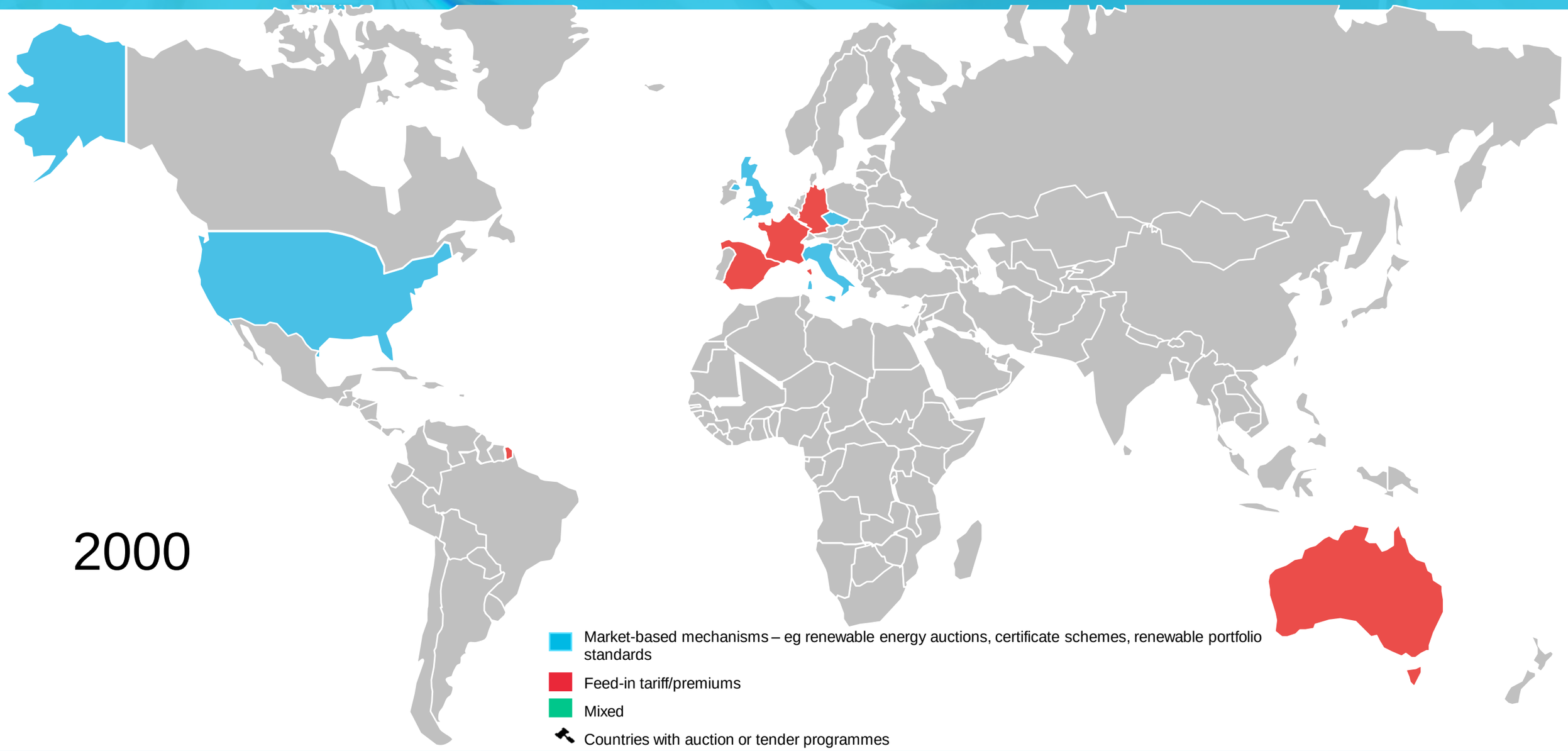
SOLAR PV MODULE COST ($/W)



Note: Prices are in real (2015) USD. 'Current price' is $0.61/W Source: Bloomberg New Energy Finance, Maycock

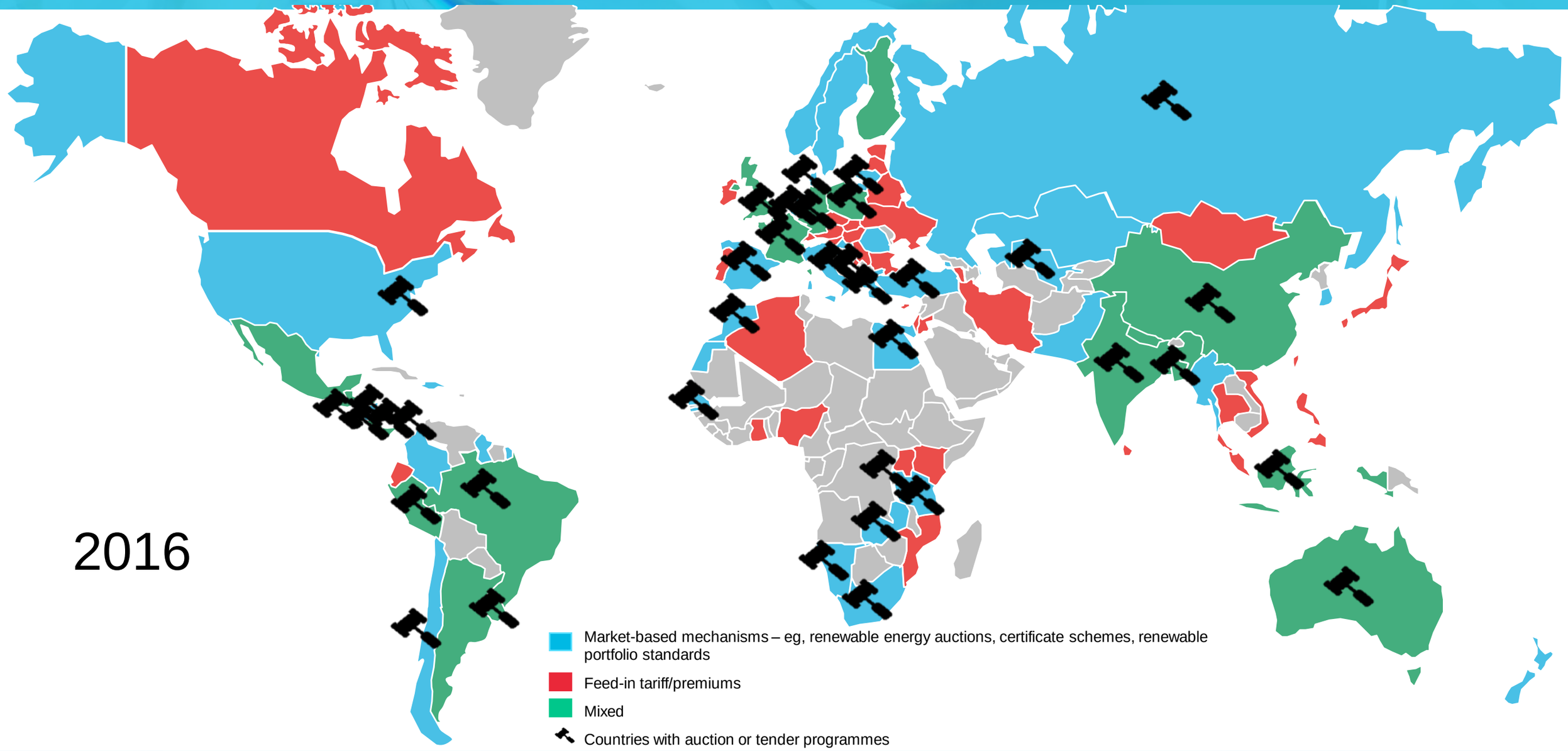
RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

Bloomberg NEW ENERGY FINANCE



RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL

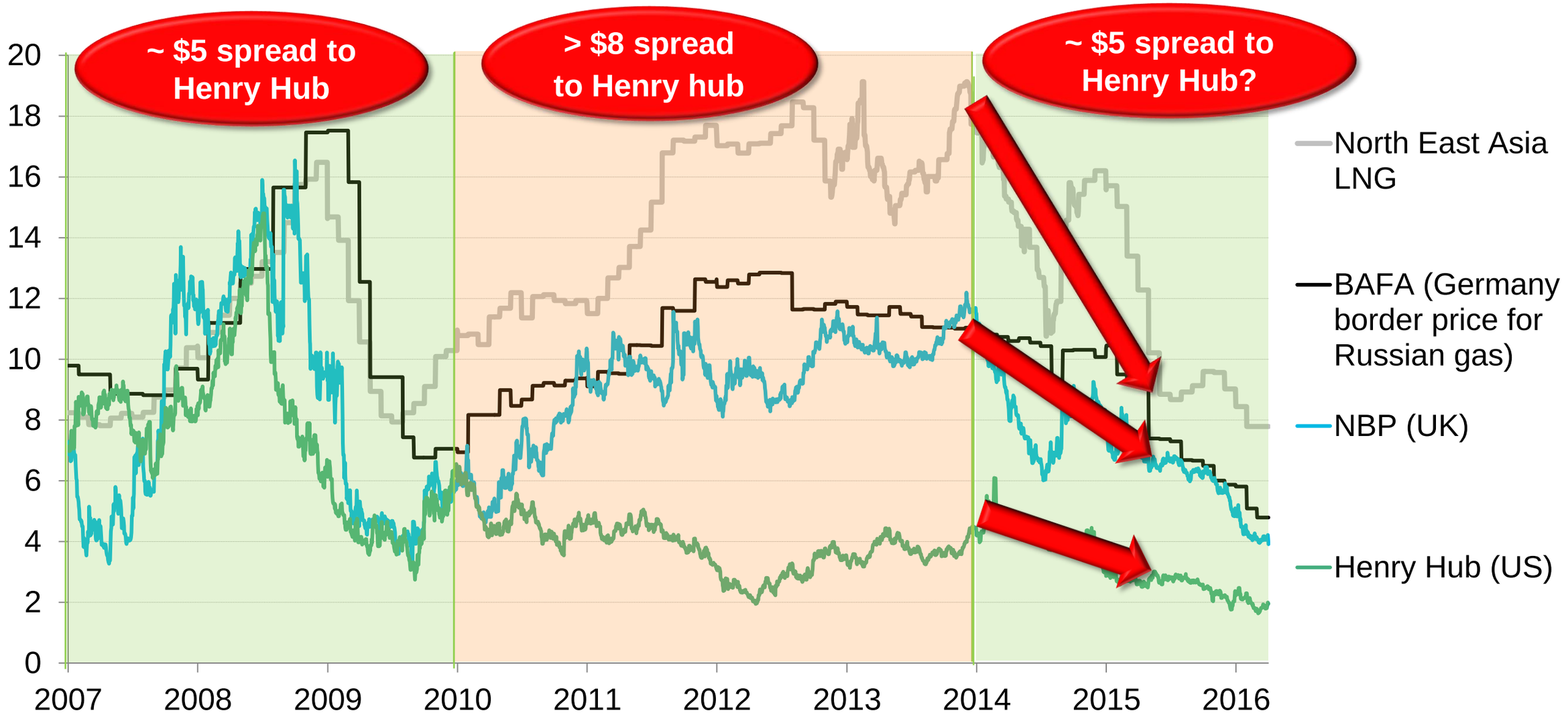
Bloomberg NEW ENERGY FINANCE



AN AGE OF PLENTY...
... AN AGE OF COMPETITION

GLOBAL NATURAL GAS PRICES
($/MMBTU REAL 2016$)

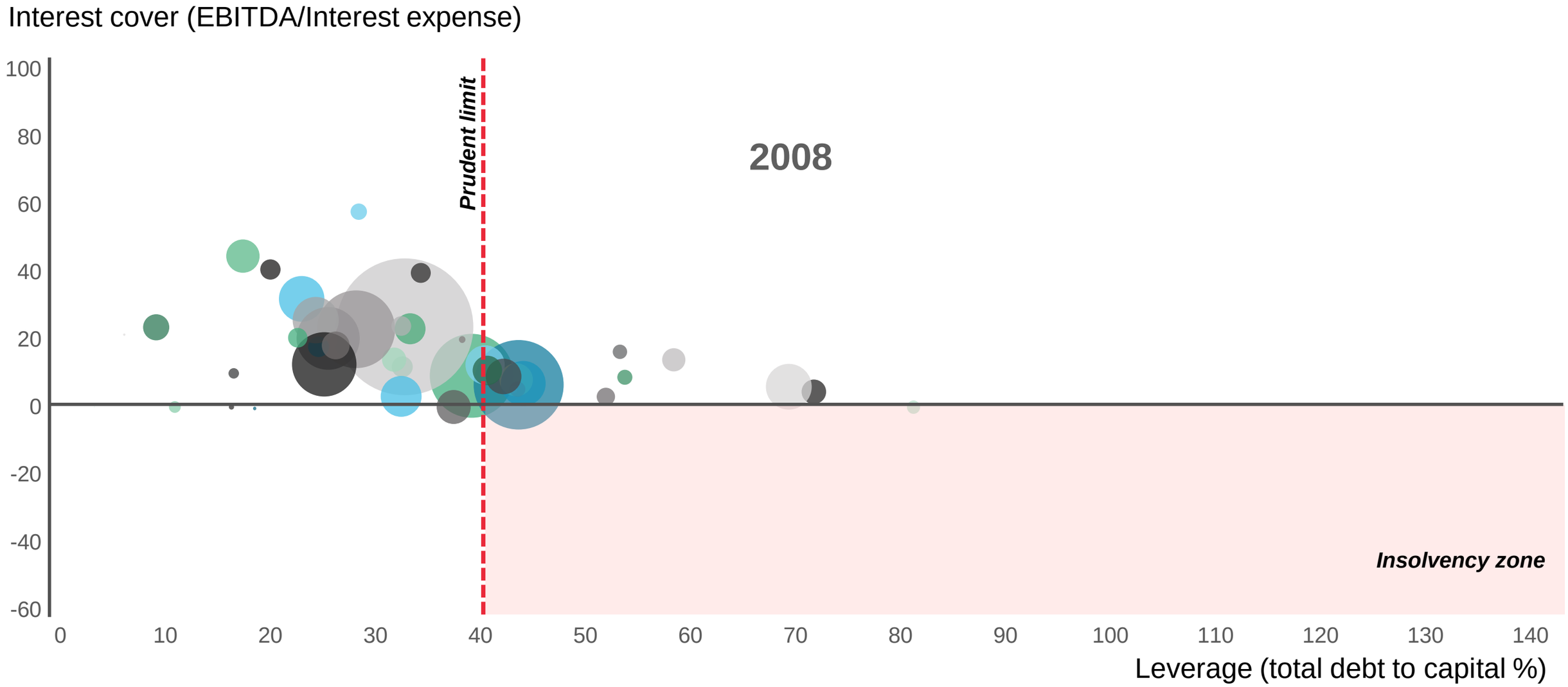
Bloomberg NEW ENERGY FINANCE



Source: Bloomberg New Energy Finance

US INDEPENDENT OIL & GAS PRODUCER SOLVENCY RATIOS

Bloomberg NEW ENERGY FINANCE

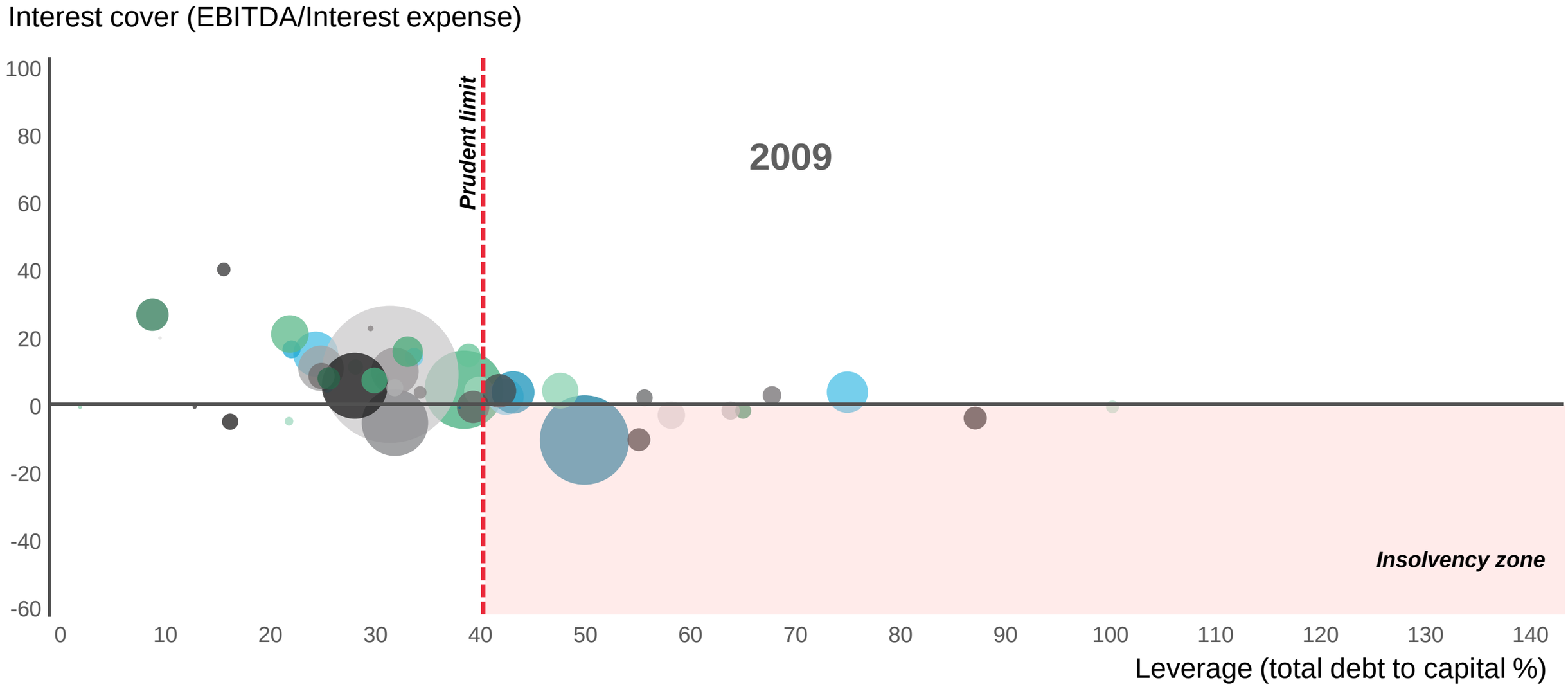


Note: size of bubbles represents net debt position for each company

Source: Bloomberg Intelligence; Bloomberg New Energy Finance

US INDEPENDENT OIL & GAS PRODUCER SOLVENCY RATIOS

Bloomberg NEW ENERGY FINANCE



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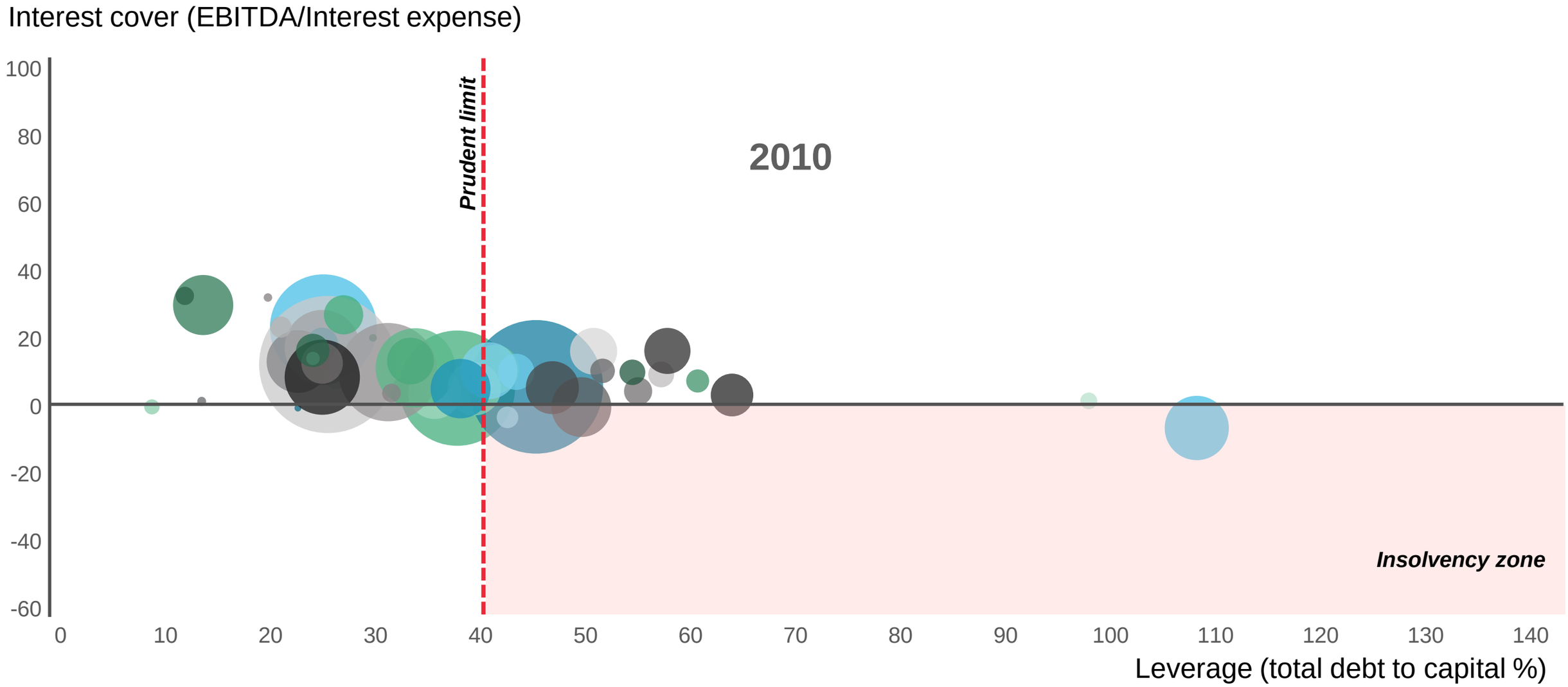
Source: Bloomberg Intelligence; Bloomberg New Energy Finance

US INDEPENDENT OIL & GAS PRODUCER SOLVENCY RATIOS

Bloomberg NEW ENERGY FINANCE



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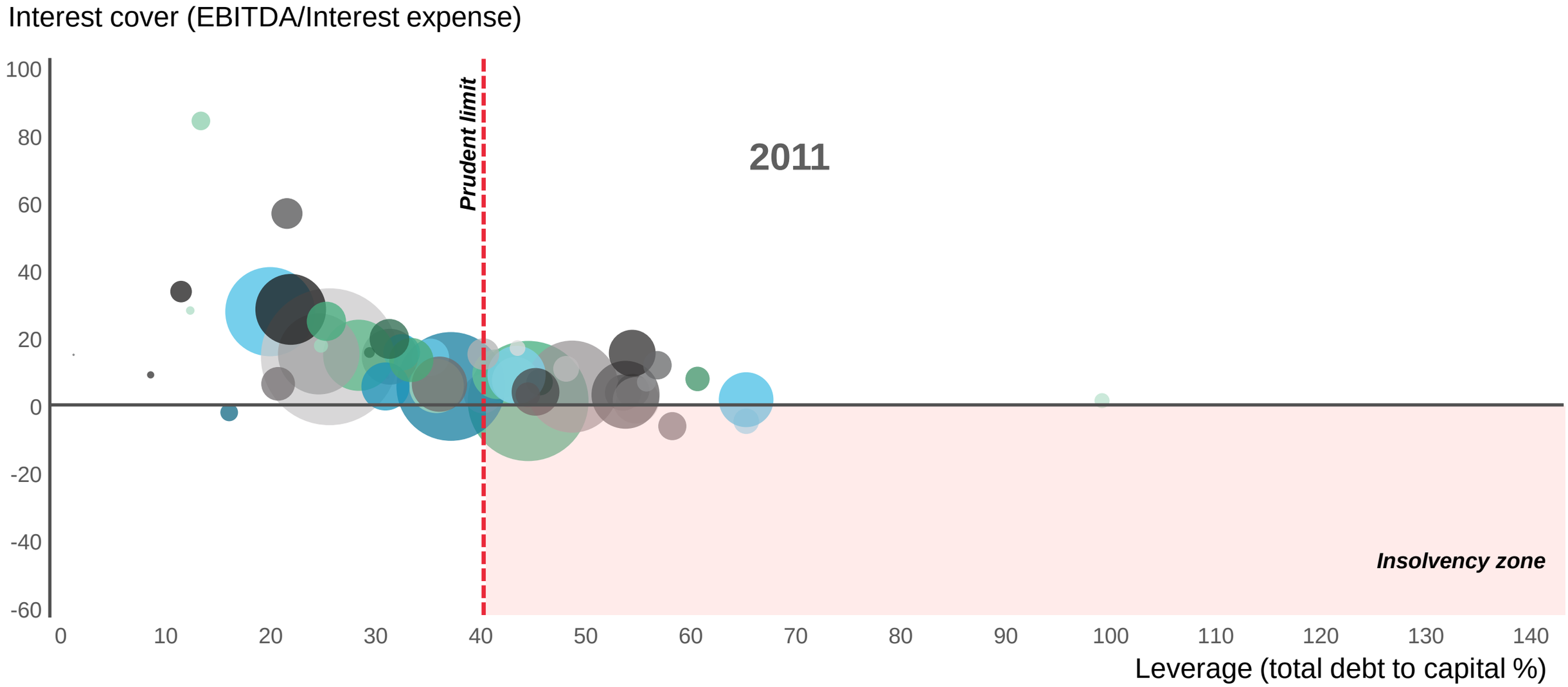
Source: Bloomberg Intelligence; Bloomberg New Energy Finance

US INDEPENDENT OIL & GAS PRODUCER SOLVENCY RATIOS

Bloomberg NEW ENERGY FINANCE

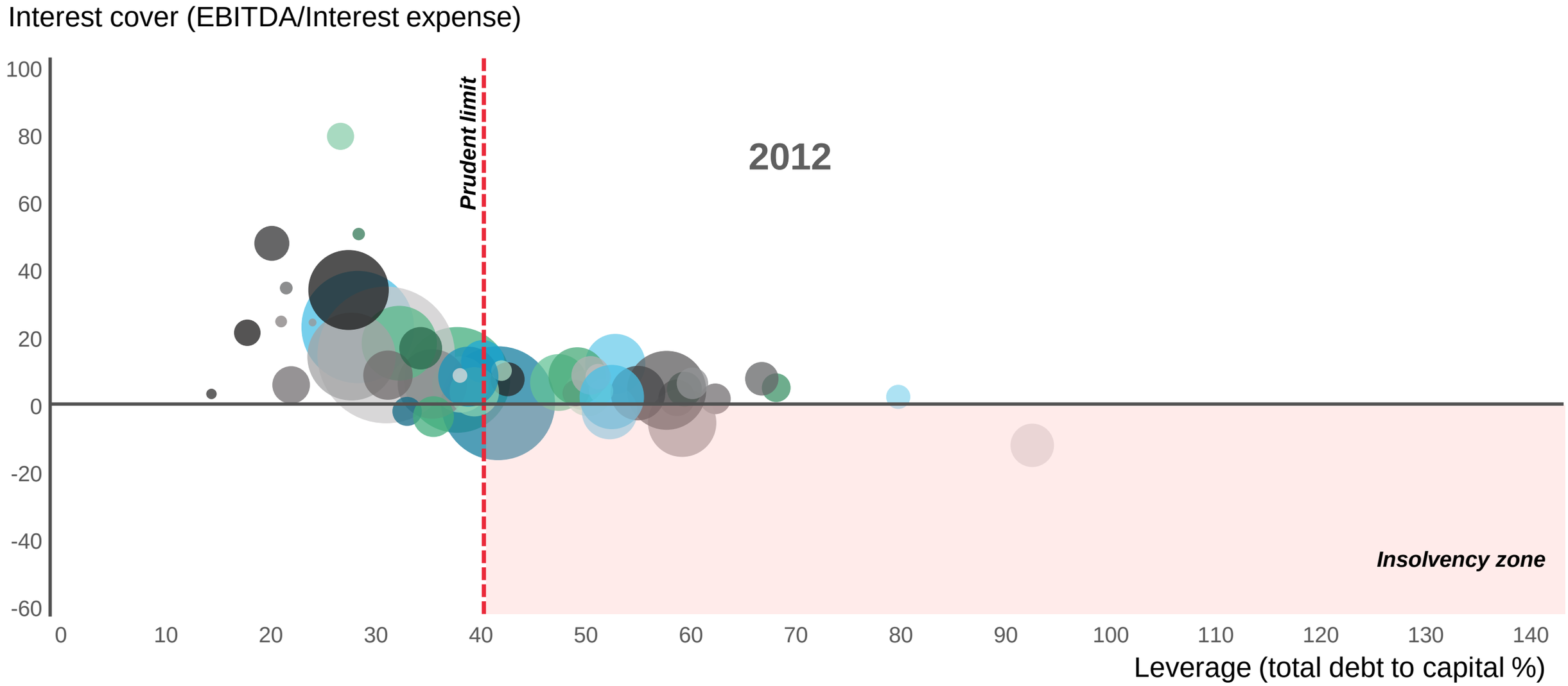


Note: size of bubbles represents net debt position for each company

Source: Bloomberg Intelligence; Bloomberg New Energy Finance

US INDEPENDENT OIL & GAS PRODUCER SOLVENCY RATIOS

Bloomberg NEW ENERGY FINANCE



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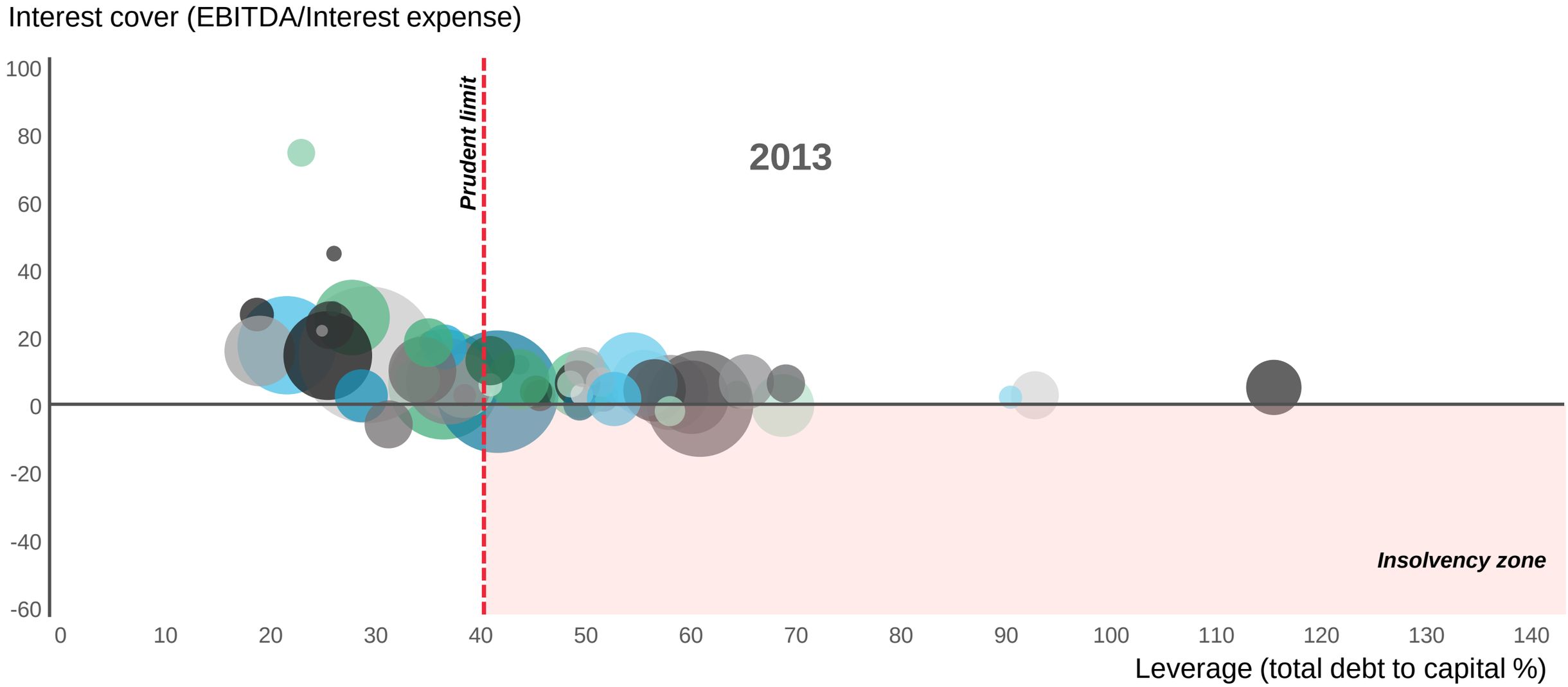
US INDEPENDENT OIL & GAS PRODUCER SOLVENCY RATIOS

Bloomberg NEW ENERGY FINANCE

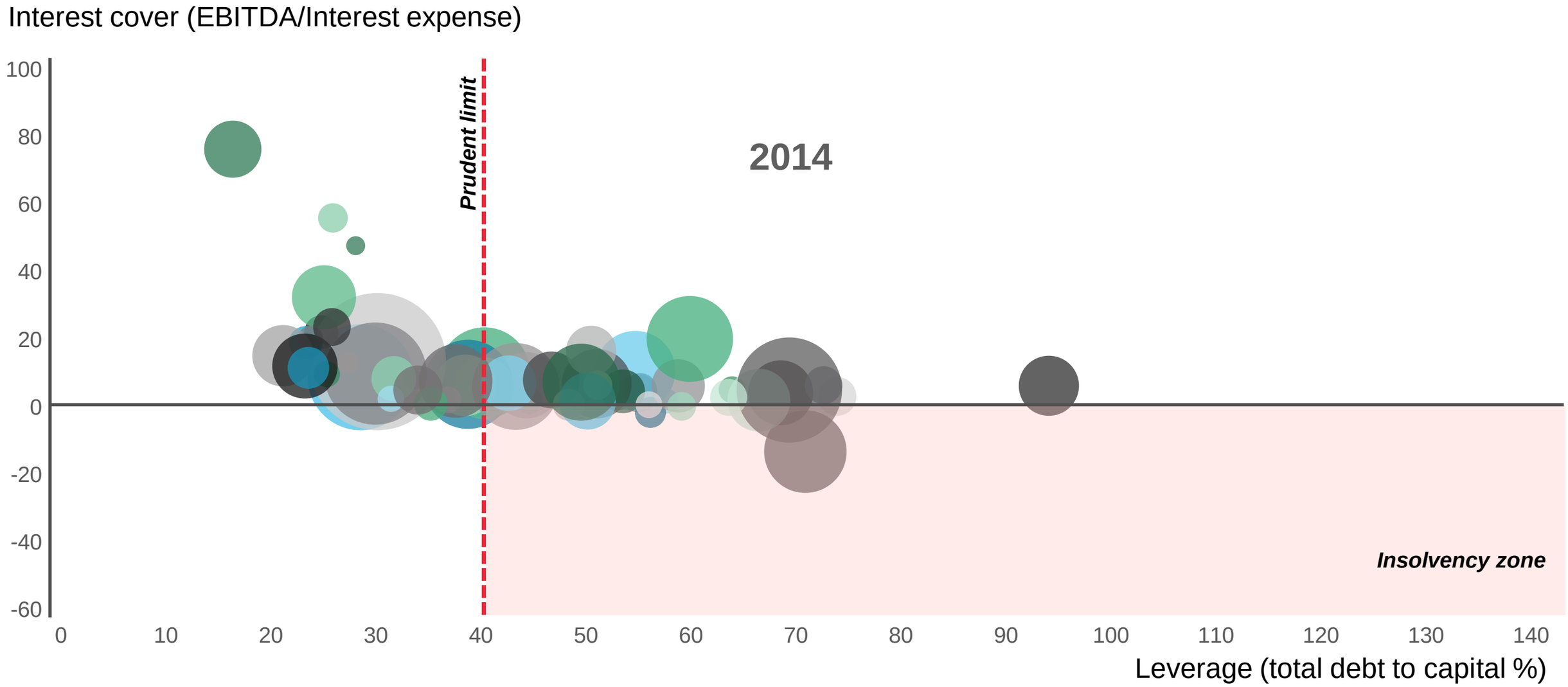


Note: size of bubbles represents net debt position for each company

Source: Bloomberg Intelligence; Bloomberg New Energy Finance

US INDEPENDENT OIL & GAS PRODUCER SOLVENCY RATIOS

Bloomberg NEW ENERGY FINANCE



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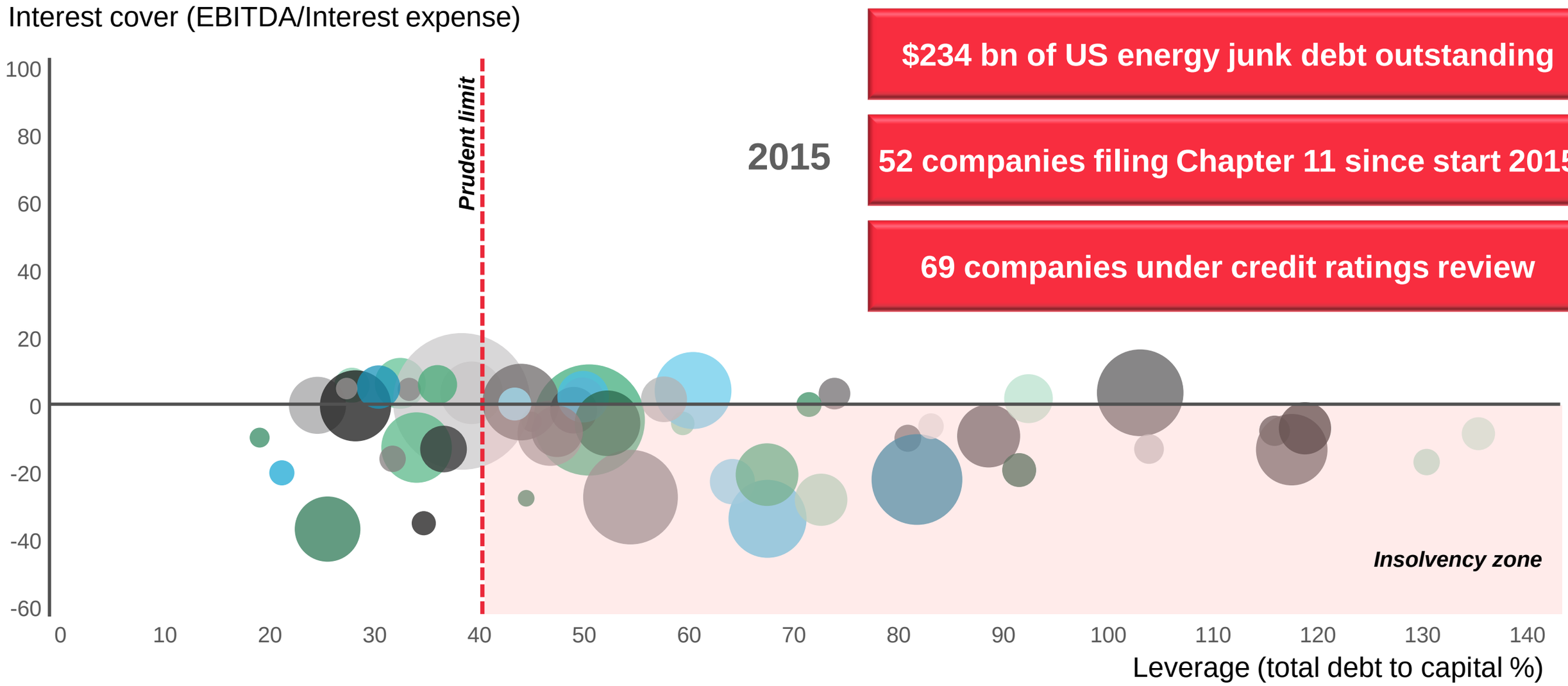
US INDEPENDENT OIL & GAS PRODUCER SOLVENCY RATIOS

Bloomberg NEW ENERGY FINANCE



$234 bn of US energy junk debt outstanding

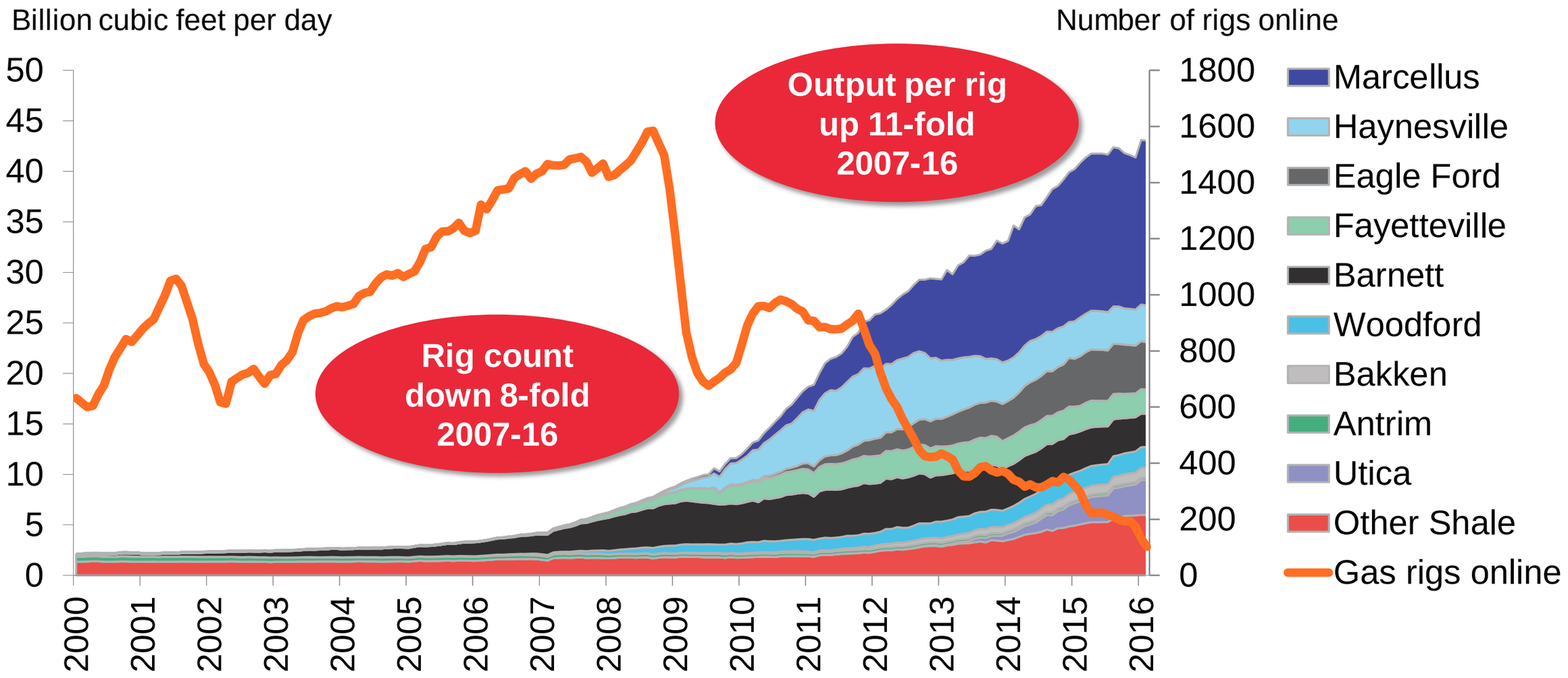
52 companies filing Chapter 11 since start 2015

69 companies under credit ratings review

Note: size of bubbles represents net debt position for each company

Source: Bloomberg Intelligence; Bloomberg New Energy Finance

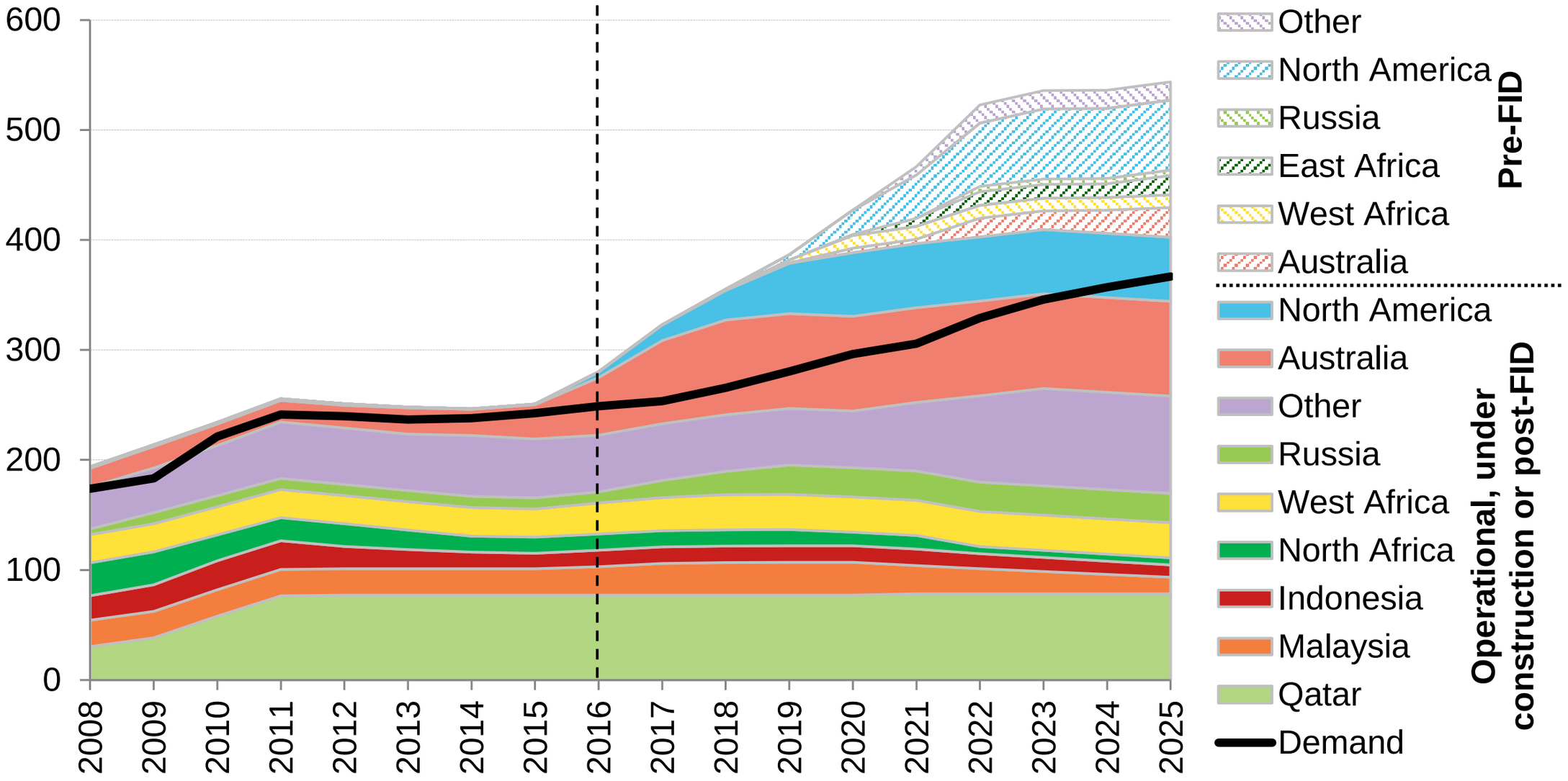
US DRY SHALE GAS PRODUCTION BY PLAY VS RIG COUNT



Source: EIA, Bloomberg New Energy Finance

LNG EXPORT CAPACITY BY COUNTRY/REGION
(MMTPA)

Bloomberg NEW ENERGY FINANCE



Note: Pre final investment decision (Pre-FID) projects with <50% chance of success are excluded.

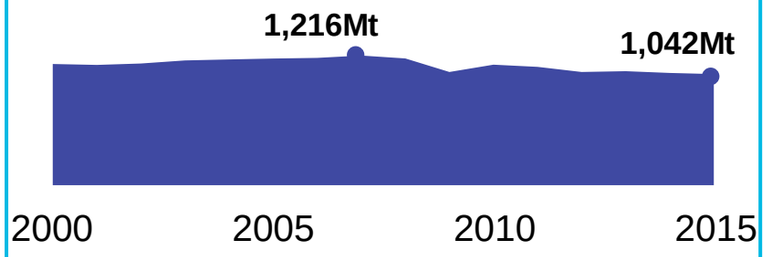
Source: Bloomberg New Energy Finance

COAL CONSUMPTION BY REGION (MTOE)

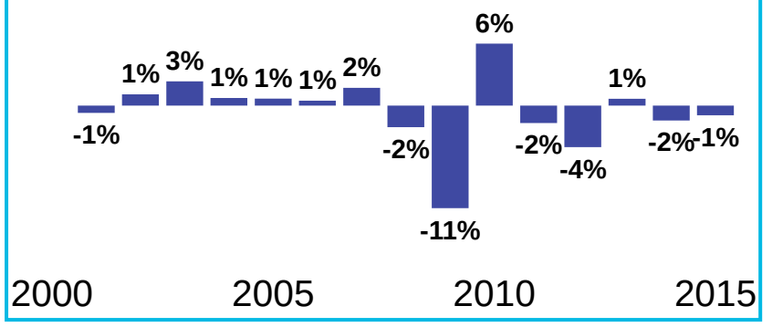
Bloomberg NEW ENERGY FINANCE

OECD - DECLINING

Coal consumption (Mt/yr)

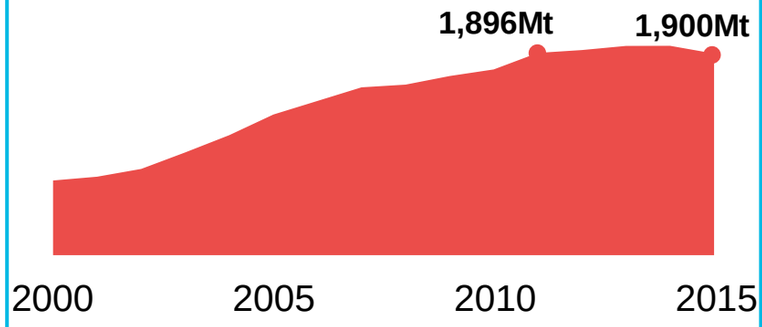


Year on year % change

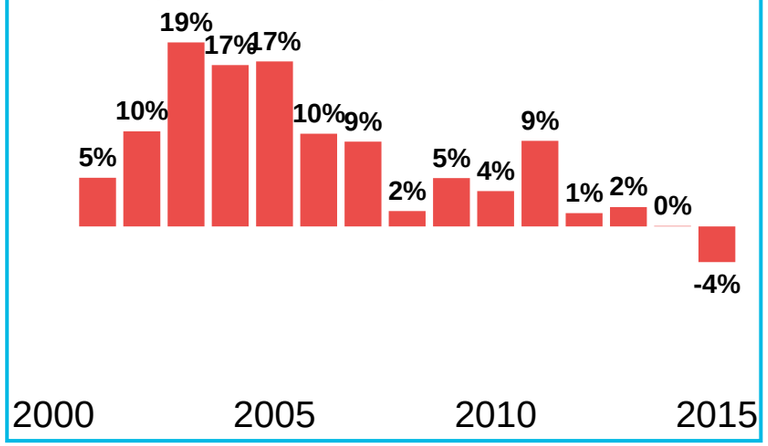


CHINA - FLATTENING

Coal consumption (Mt/yr)

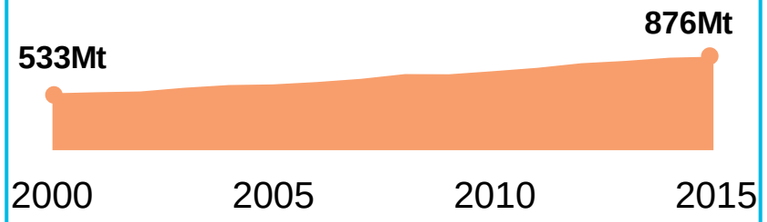


Year on year % change

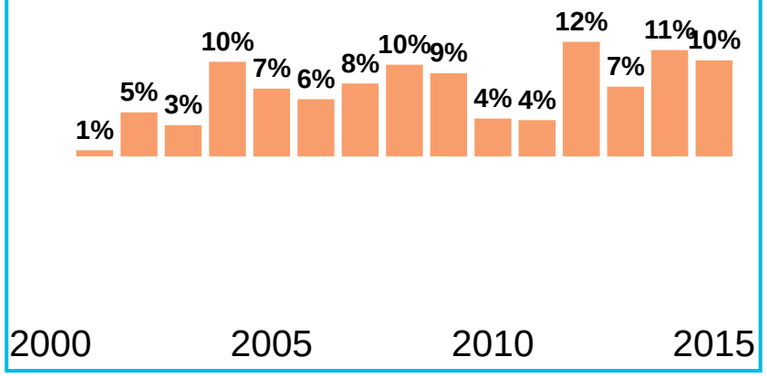


NON-OECD EX CHINA - SLOWING

Coal consumption (Mt/yr)

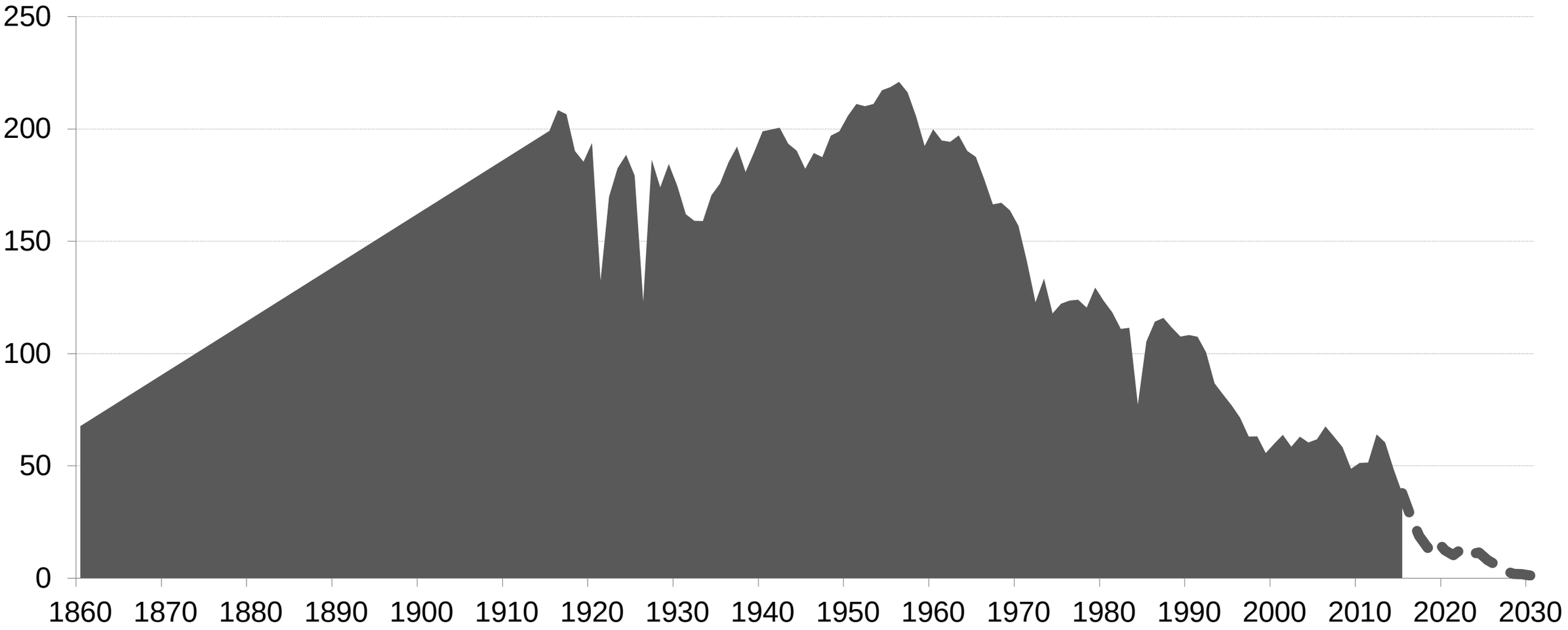


Year on year % change



Source: Bloomberg New Energy Finance

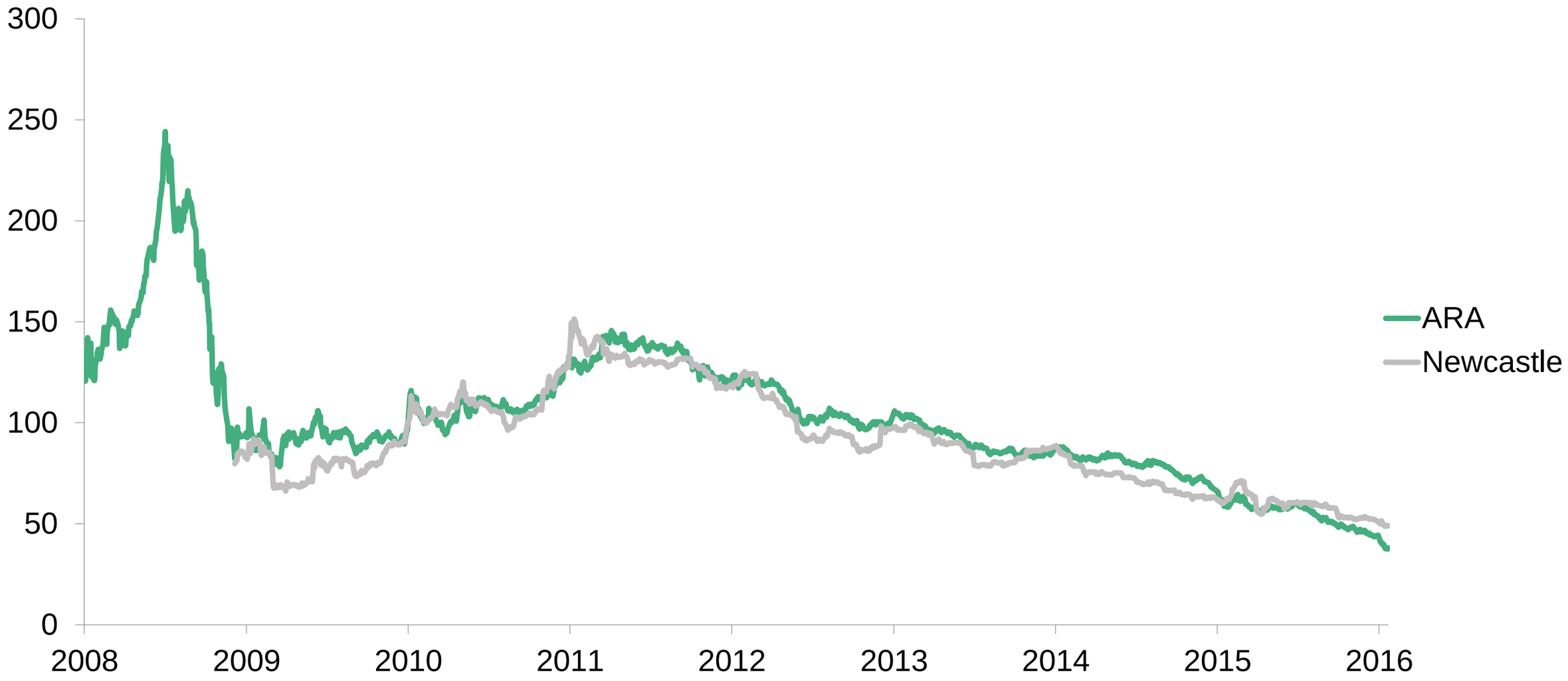
UK COAL DEMAND, 1860–2015
(MT/YR)



Note: Pre-1913, data is available only for 10-year average annual consumption

Source: UK DECC, Bloomberg New Energy Finance

BENCHMARK THERMAL COAL PRICES
($/T REAL 2016$)



Source: Bloomberg New Energy Finance

COAL IN DISTRESS

Bloomberg NEW ENERGY FINANCE

BUMI Investment Pte

PATRIOT COAL

James River COAL COMPANY

Peabody ENERGY

ArchCoal

Alpha Natural Resources

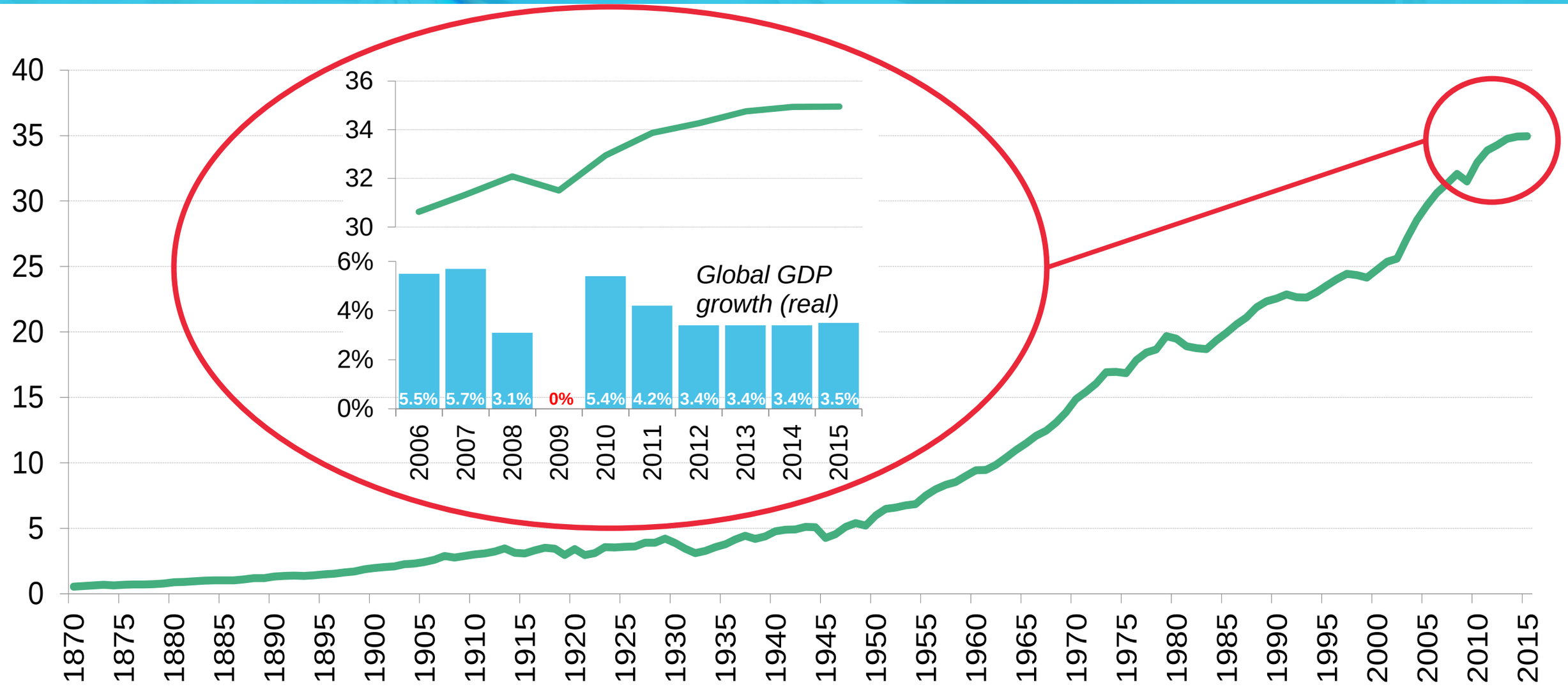
We fuel progress around the world.®

WALTER ENERGY®

Image: various company sources

GLOBAL CARBON EMISSIONS FROM FOSSIL FUELS
(GIGATONNES CO2/YEAR)

Bloomberg NEW ENERGY FINANCE



Note: Includes NGL and processing gain, but excludes biofuels

Source: IEA; CDIAC; BP; Bloomberg New Energy Finance

CLEAN POWER PLAN

Bloomberg NEW ENERGY FINANCE

"The Clean Power Plan is the single most important step America has ever taken in the fight against global climate change"

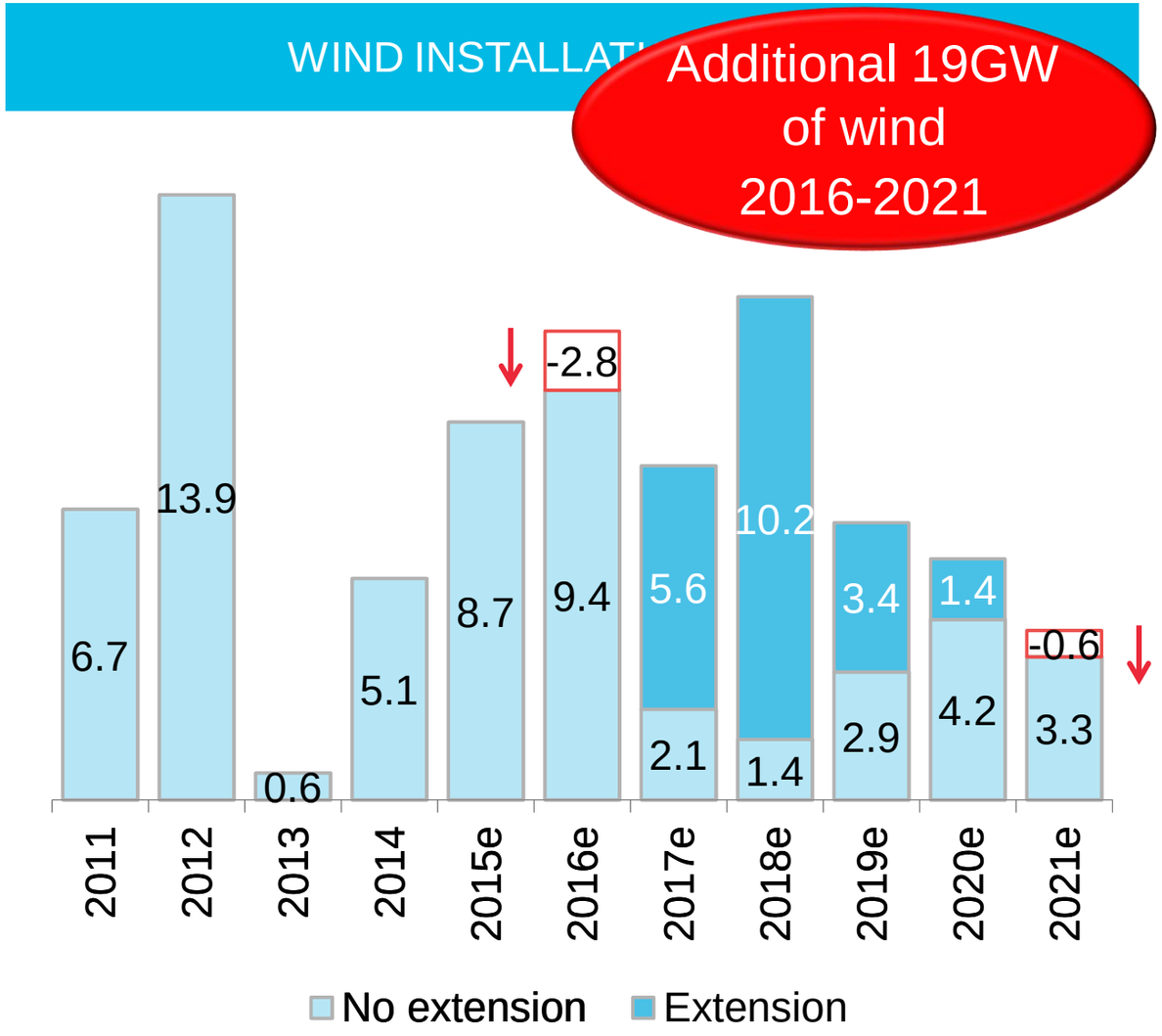
ON HOLD

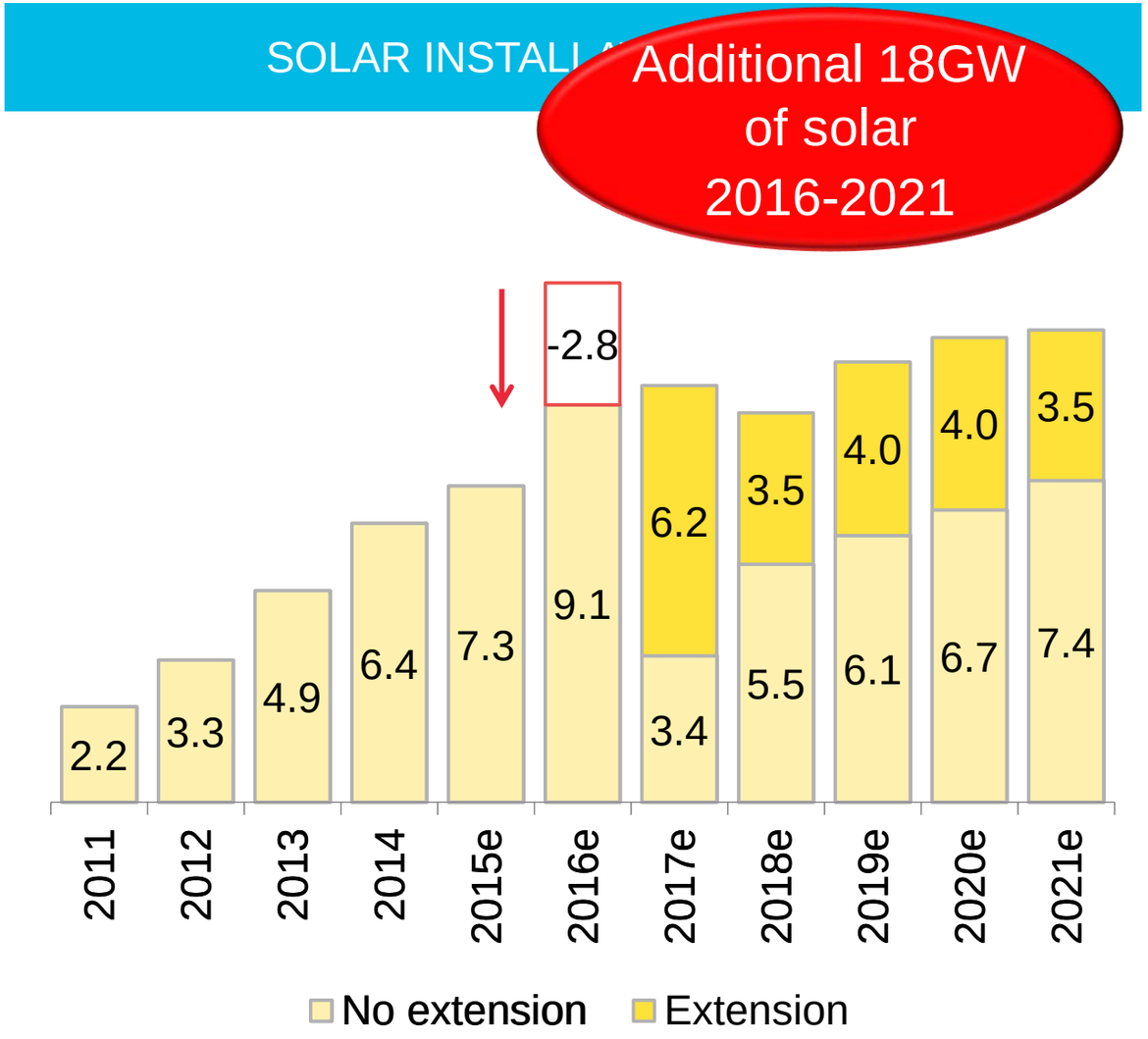
President Obama
Speech 3 August 2015

Picture: Thehigherlearning.com

IMPACT OF PTC & ITC EXTENSION

Bloomberg NEW ENERGY FINANCE





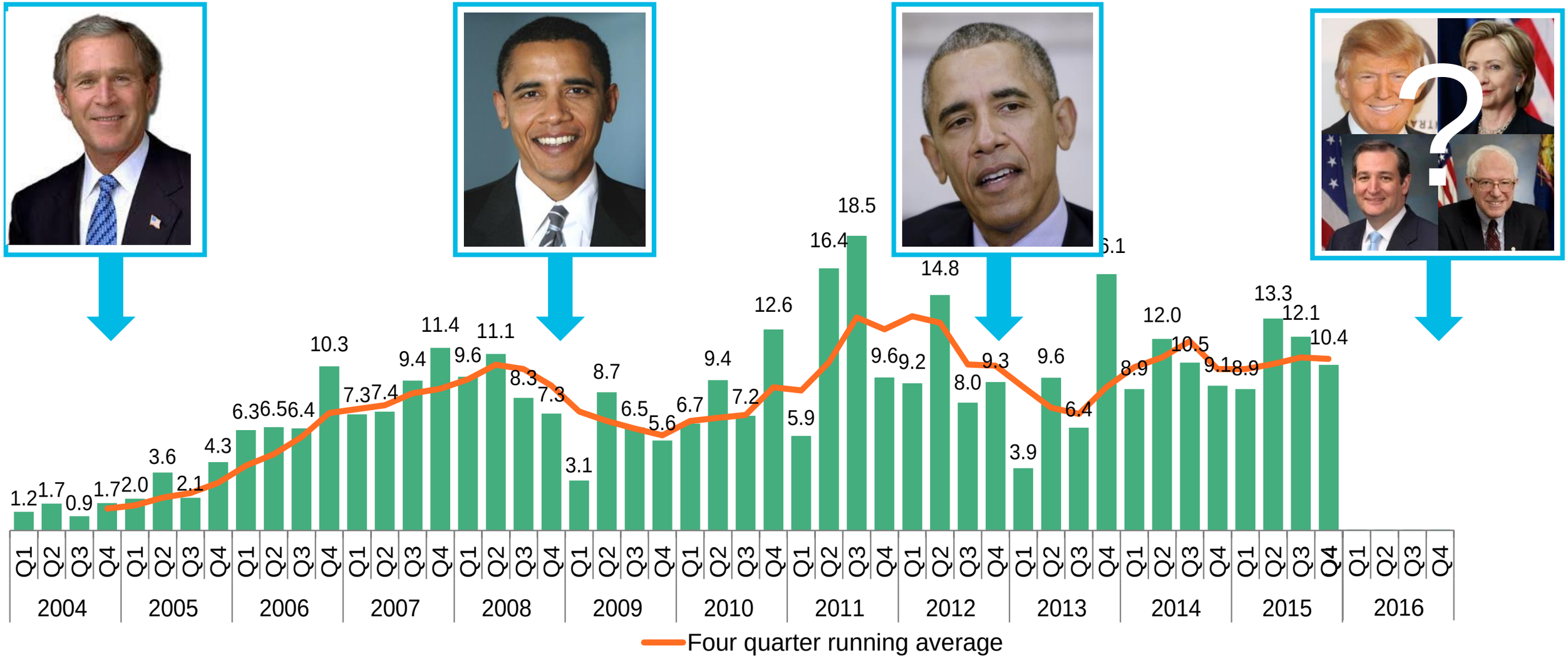
Note: PTC extension case assumes 5-year phase-out. 2015 onwards is forecast. PTC is production tax credit. ITC is investment tax credit

Source: Bloomberg New Energy Finance

NEW INVESTMENT IN THE US

Q1 2004-Q4 2015 ($BN)

Bloomberg NEW ENERGY FINANCE



Note: Total values include estimates for undisclosed deals. Excludes corporate and government R&D, and spending for digital energy and energy storage projects (reported in annual statistics only).

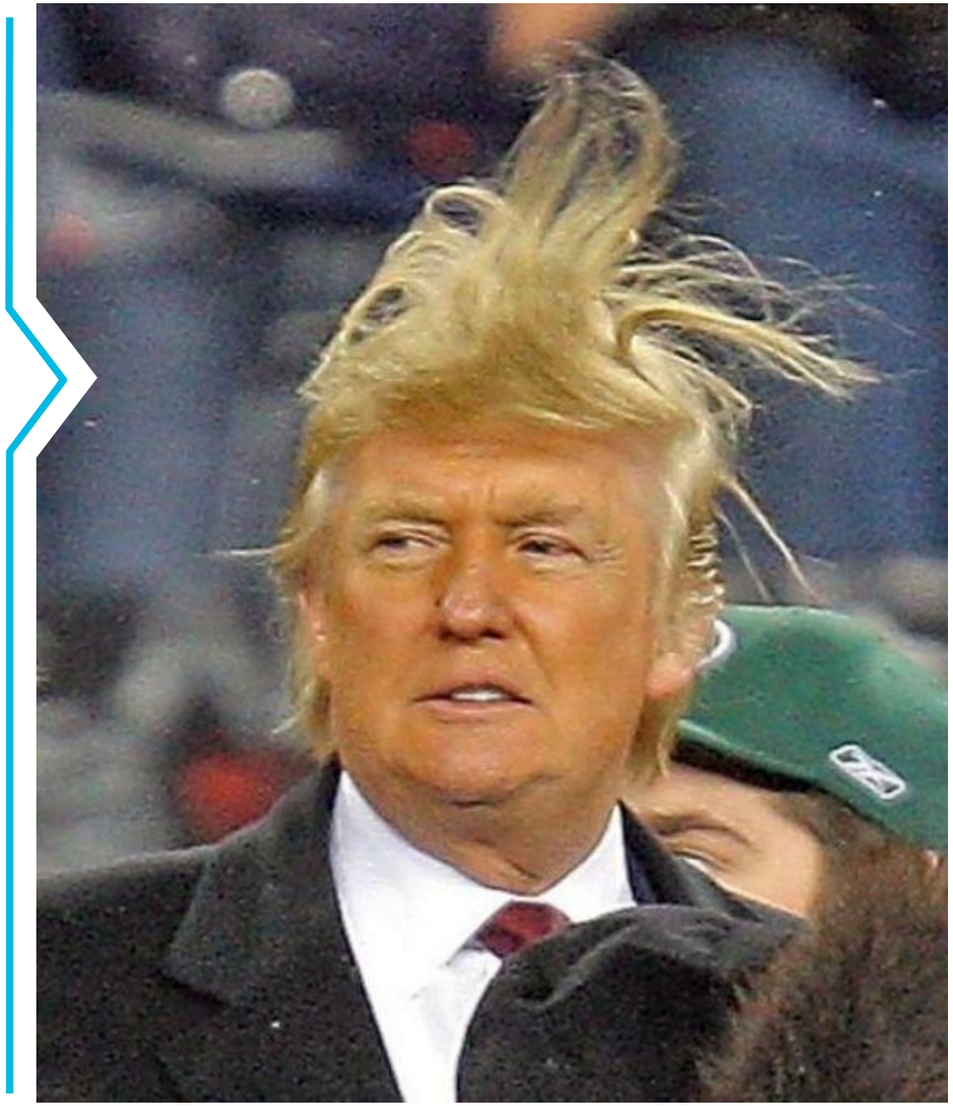
Source: Bloomberg New Energy Finance

TRUMP ON WIND

Bloomberg NEW ENERGY FINANCE

"Wind farms are a disaster for the environment. They kill the birds. They are very expensive in terms of energy. They're made in China."

Donald Trump
Presidential Candidate



Picture: Michael Nagle/Bloomberg

BERNIE ON GAS

Bloomberg NEW ENERGY FINANCE

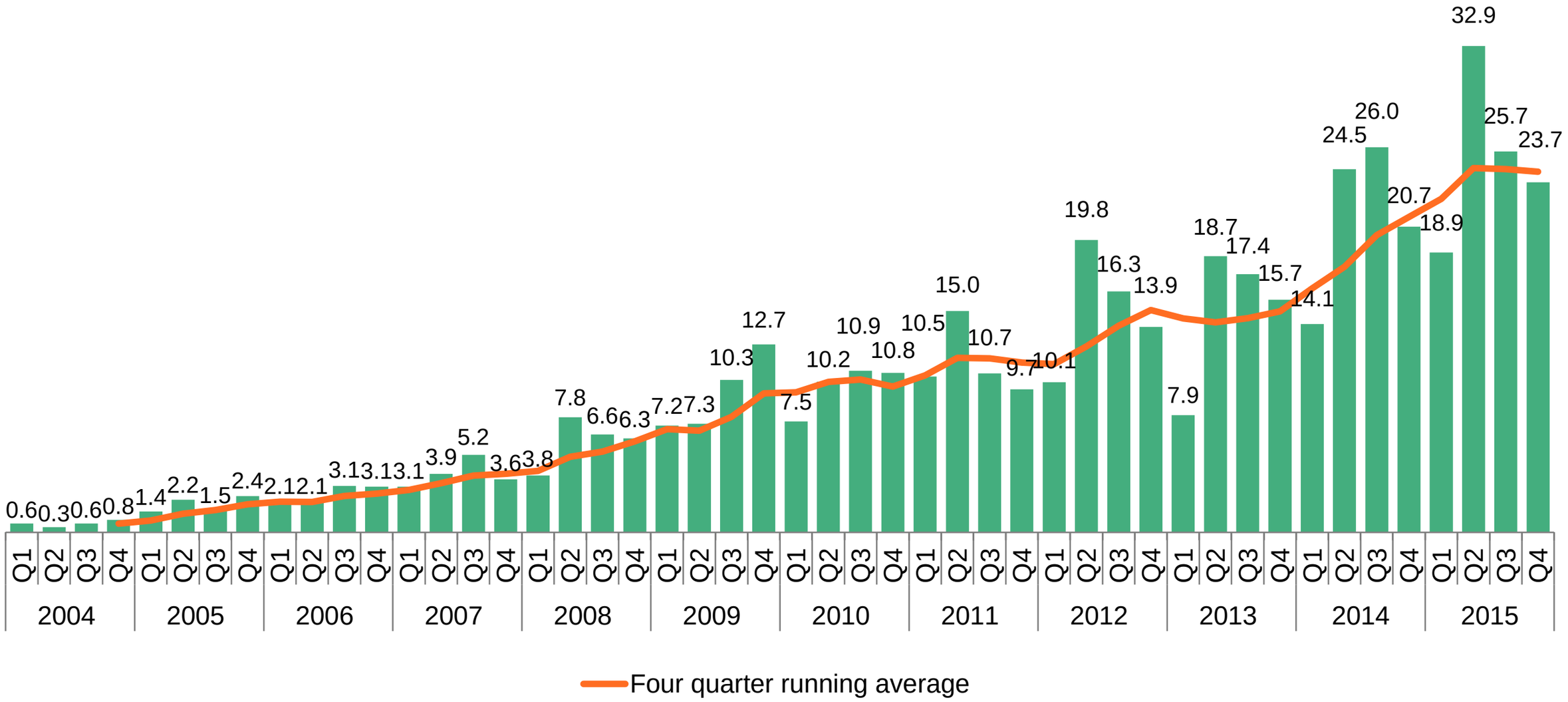
"I am very proud that the State of Vermont has banned fracking. I hope that communities all over America do the same."

Bernie Sanders
Presidential Candidate

Picture: CNN

NEW INVESTMENT IN CHINA

Q1 2004-Q4 2015 ($BN)



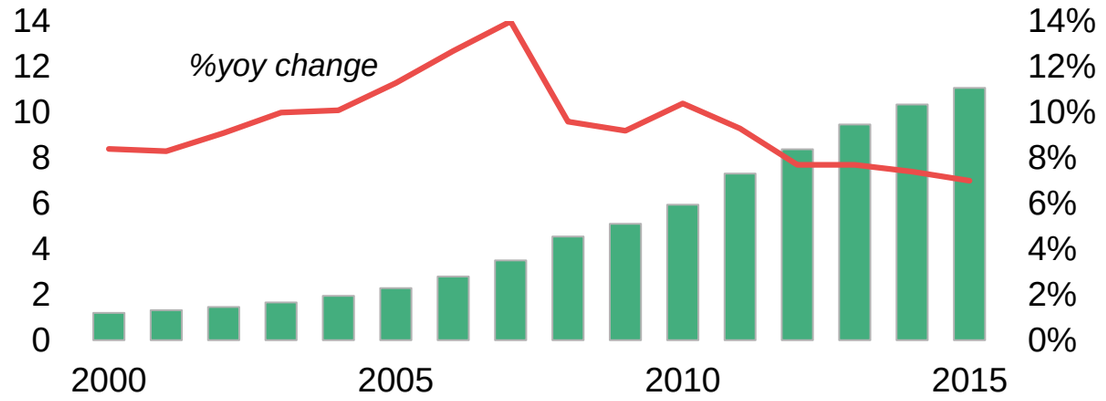
Note: Total values include estimates for undisclosed deals. Excludes corporate and government R&D, and spending for digital energy and energy storage projects (reported in annual statistics only).

Source: Bloomberg New Energy Finance

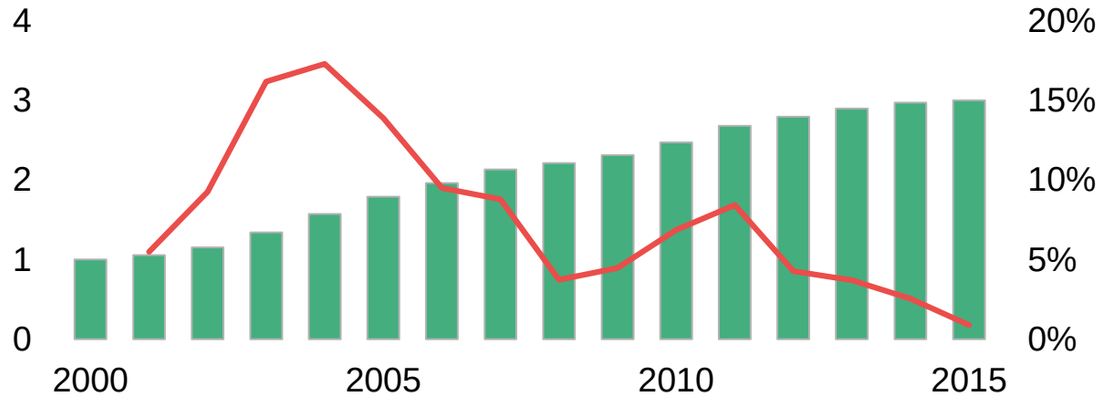
CHINA'S ECONOMY – OFFICIAL STATISTICS

Bloomberg NEW ENERGY FINANCE

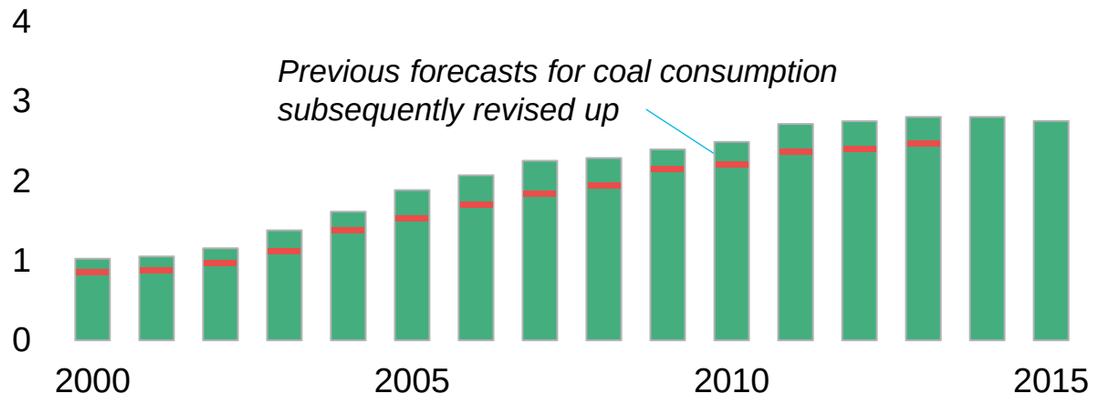
GDP (2013 USD)



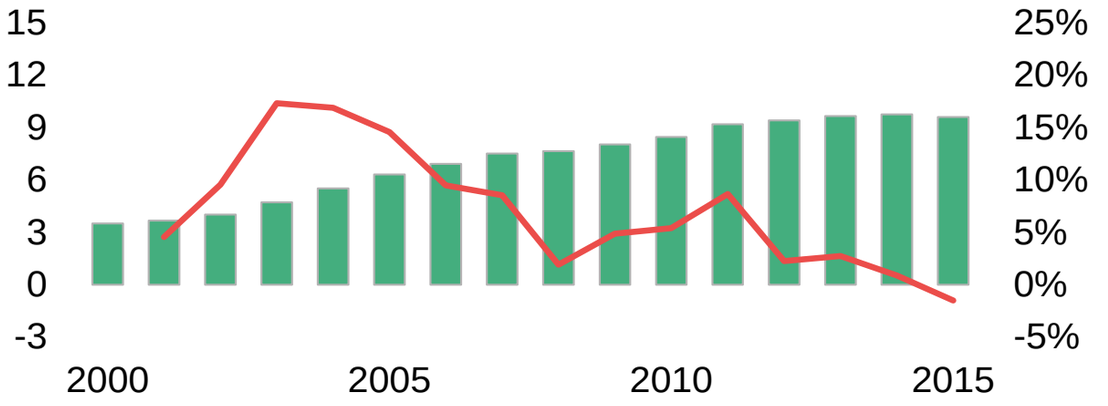
ENERGY (BN TOE)



COAL (MTCE)



EMISSIONS (GTCO2E)

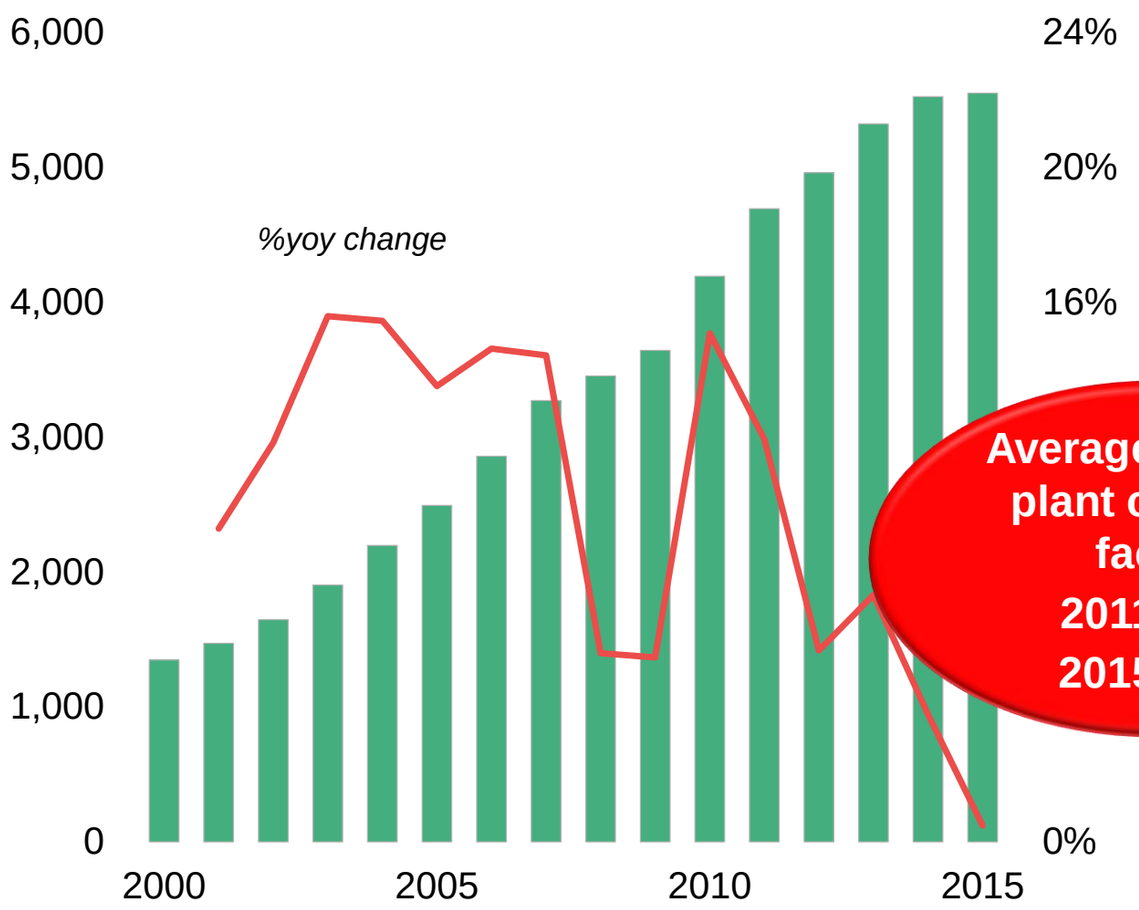


Source: Bloomberg New Energy Finance, National Bureau of Statistics of China

CHINA POWER SECTOR INVESTMENT AND CAPACITY FACTORS

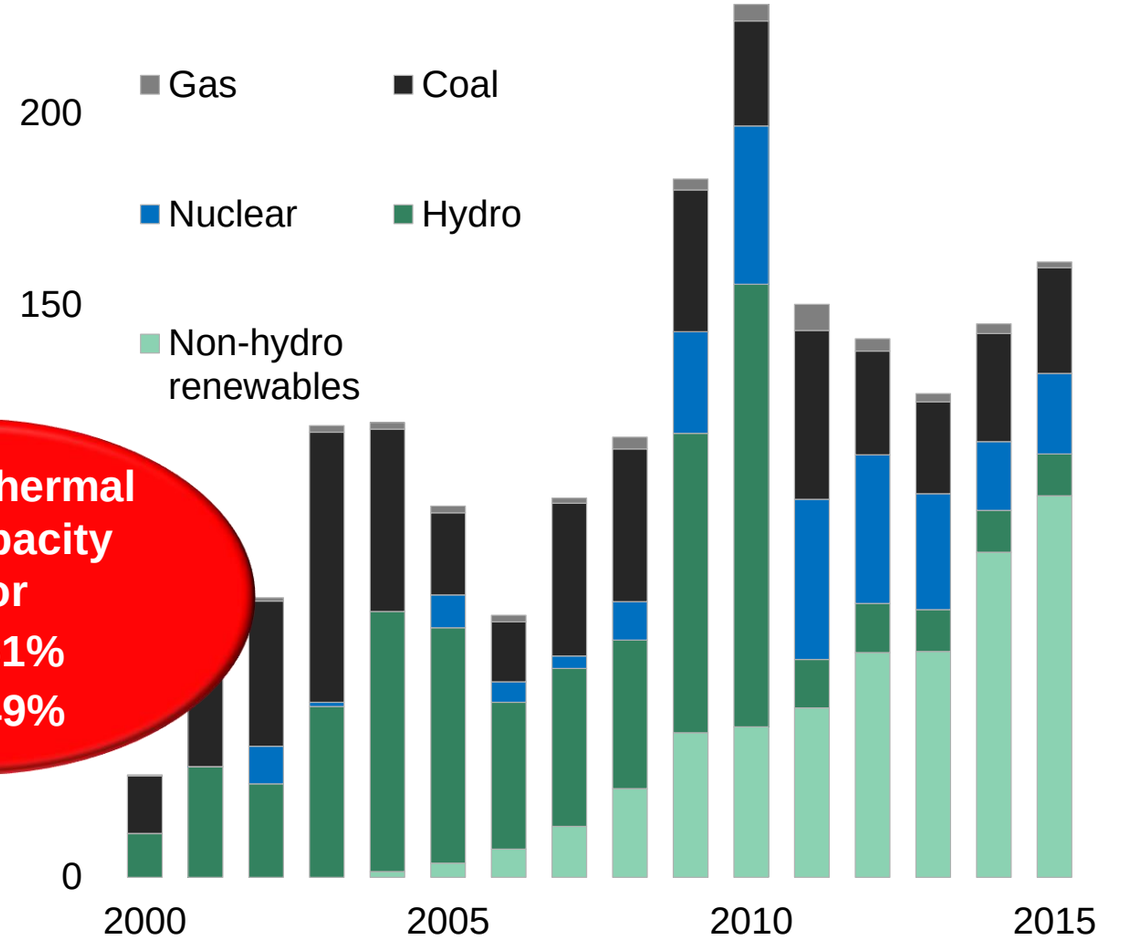
Bloomberg NEW ENERGY FINANCE

POWER CONSUMPTION (TWH)



Average thermal plant capacity factor
2011 61%
2015 49%

INVESTMENT IN GENERATION CAPACITY ($BN/YEAR, REAL 2015$)

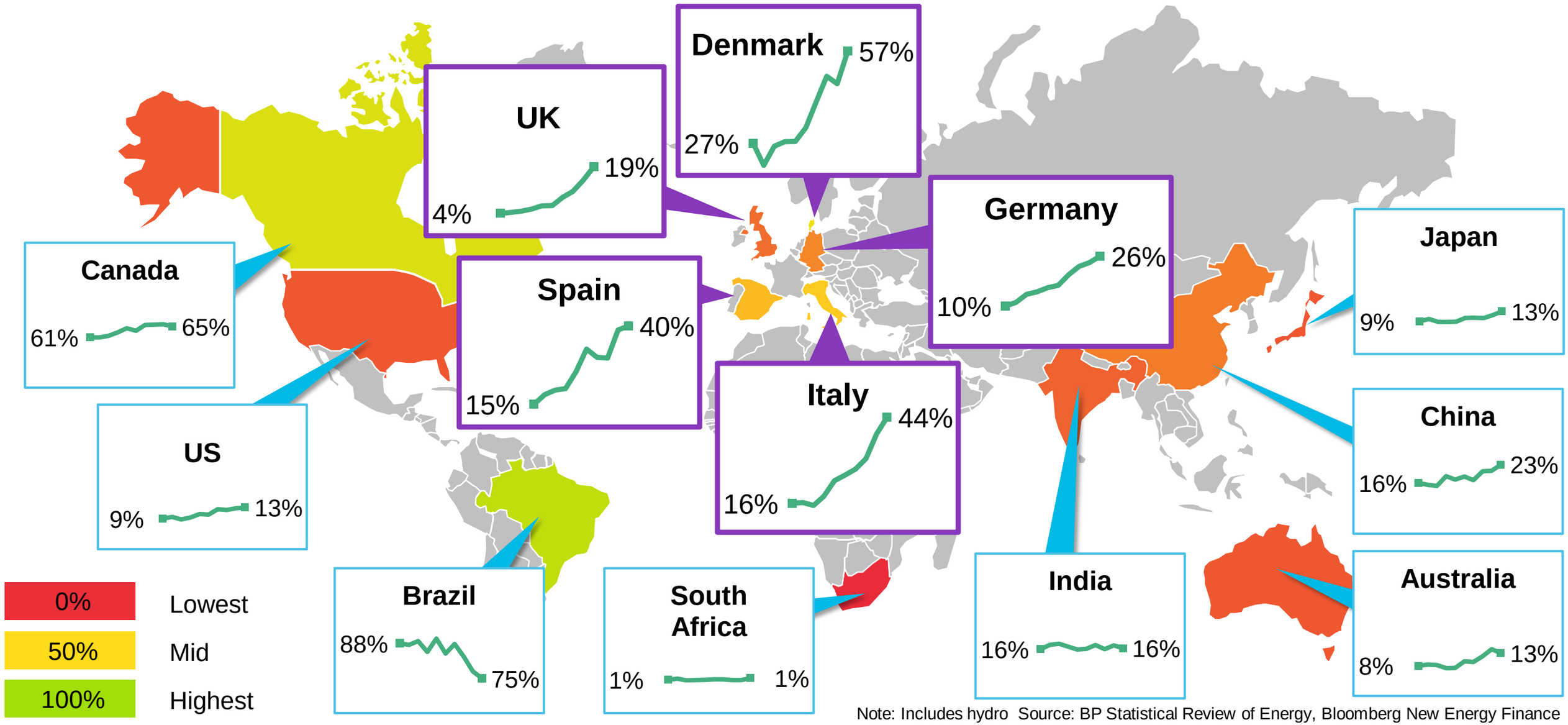


Note, Historical investment data for fossil capacity is based on real data for capacity additions and estimates of costs per unit of capacity. A lead time of three years is assumed for fossil capacity from investment to commissioning, four years for hydro and five years for nuclear plants.

Source: Bloomberg New Energy Finance, China National Bureau of Statistics

RENEWABLE ENERGY PROPORTION OF POWER GENERATION, 10 YEARS TO 2014 (%)

Bloomberg NEW ENERGY FINANCE

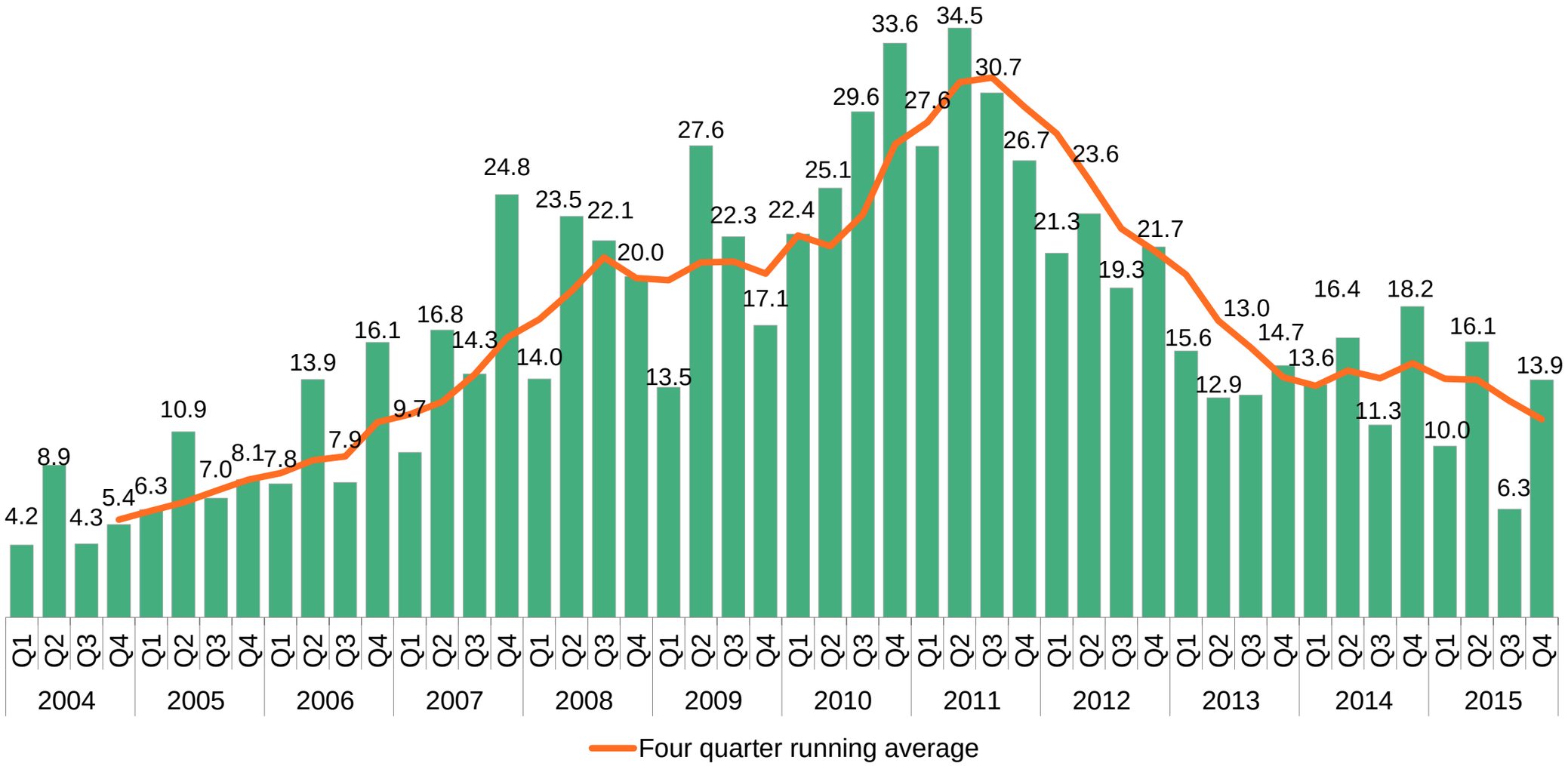


Note: Includes hydro Source: BP Statistical Review of Energy, Bloomberg New Energy Finance

NEW INVESTMENT IN CLEAN ENERGY IN EUROPE

Q1 2004-Q4 2015 ($BN)

Bloomberg NEW ENERGY FINANCE



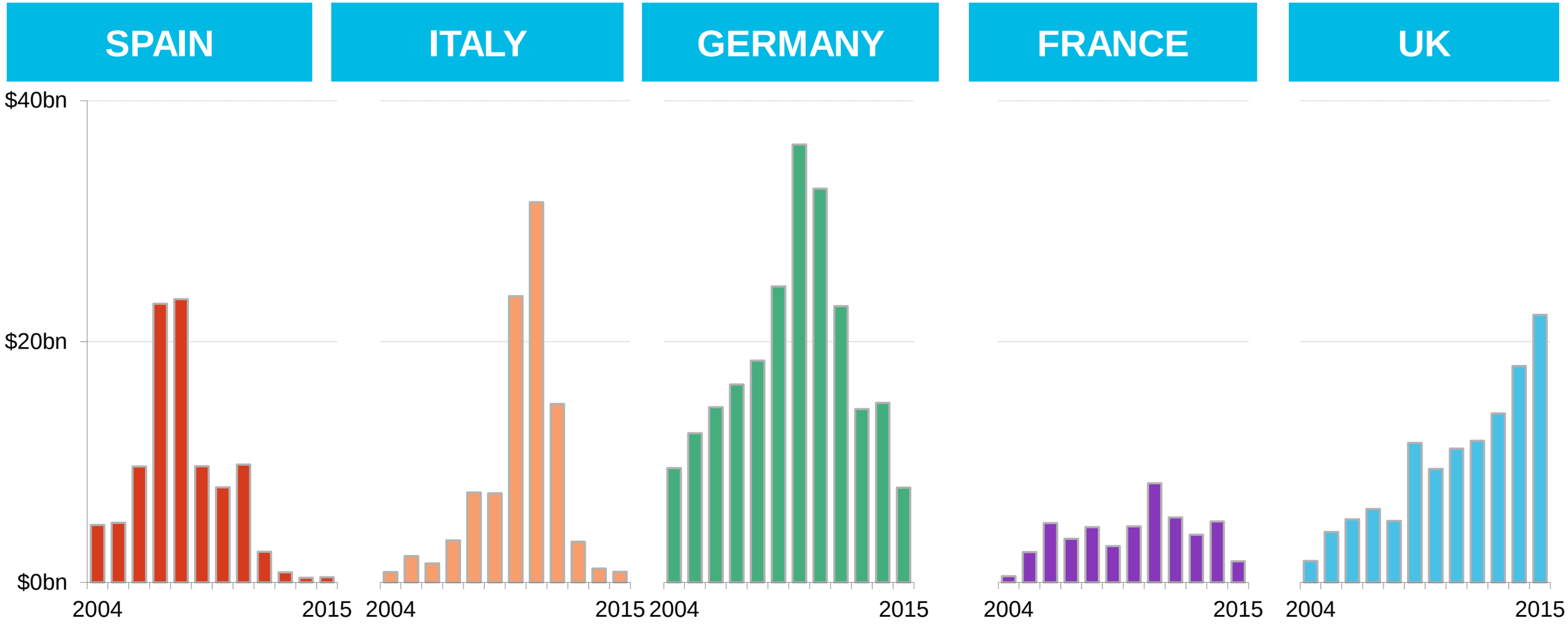
Note: Total values include estimates for undisclosed deals. Excludes corporate and government R&D, and spending for digital energy and energy storage projects (reported in annual statistics only). Excludes large hydro, nuclear and natural gas.

Source: Bloomberg New Energy Finance

NEW INVESTMENT – SELECTED EUROPEAN COUNTRIES

Q1 2004-Q4 2015 ($BN)

Bloomberg NEW ENERGY FINANCE



Note: Total values include estimates for undisclosed deals. Excludes corporate and government R&D, and spending for digital energy and energy storage projects (reported in annual statistics only). Excludes investment in nuclear.

Source: Bloomberg New Energy Finance

PARIS AGREEMENT

Picture: UNFCC

PARIS – LONG TERM VISION

Bloomberg NEW ENERGY FINANCE

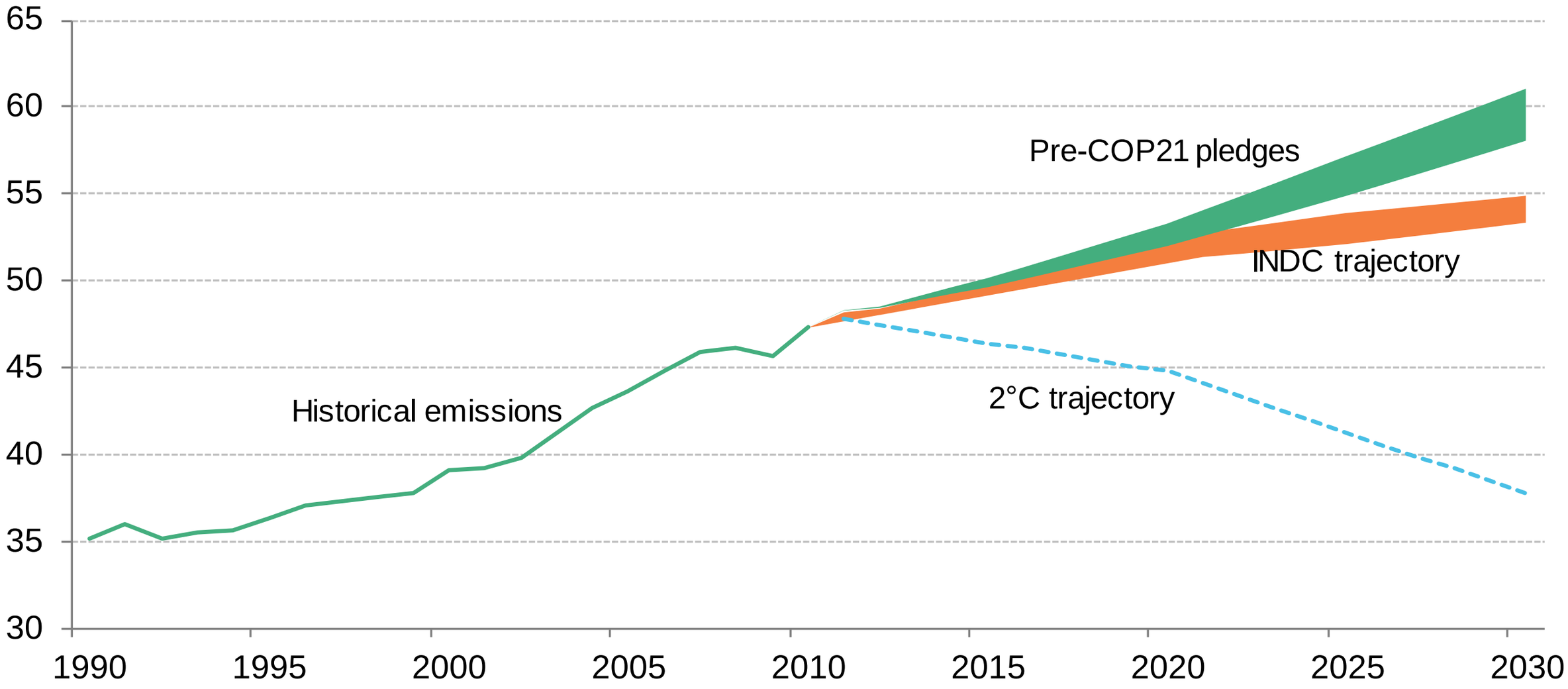
"The world must achieve greenhouse gas neutrality some time in the second half of the century"

Paris Agreement
December 2015

Picture: Wikimedia

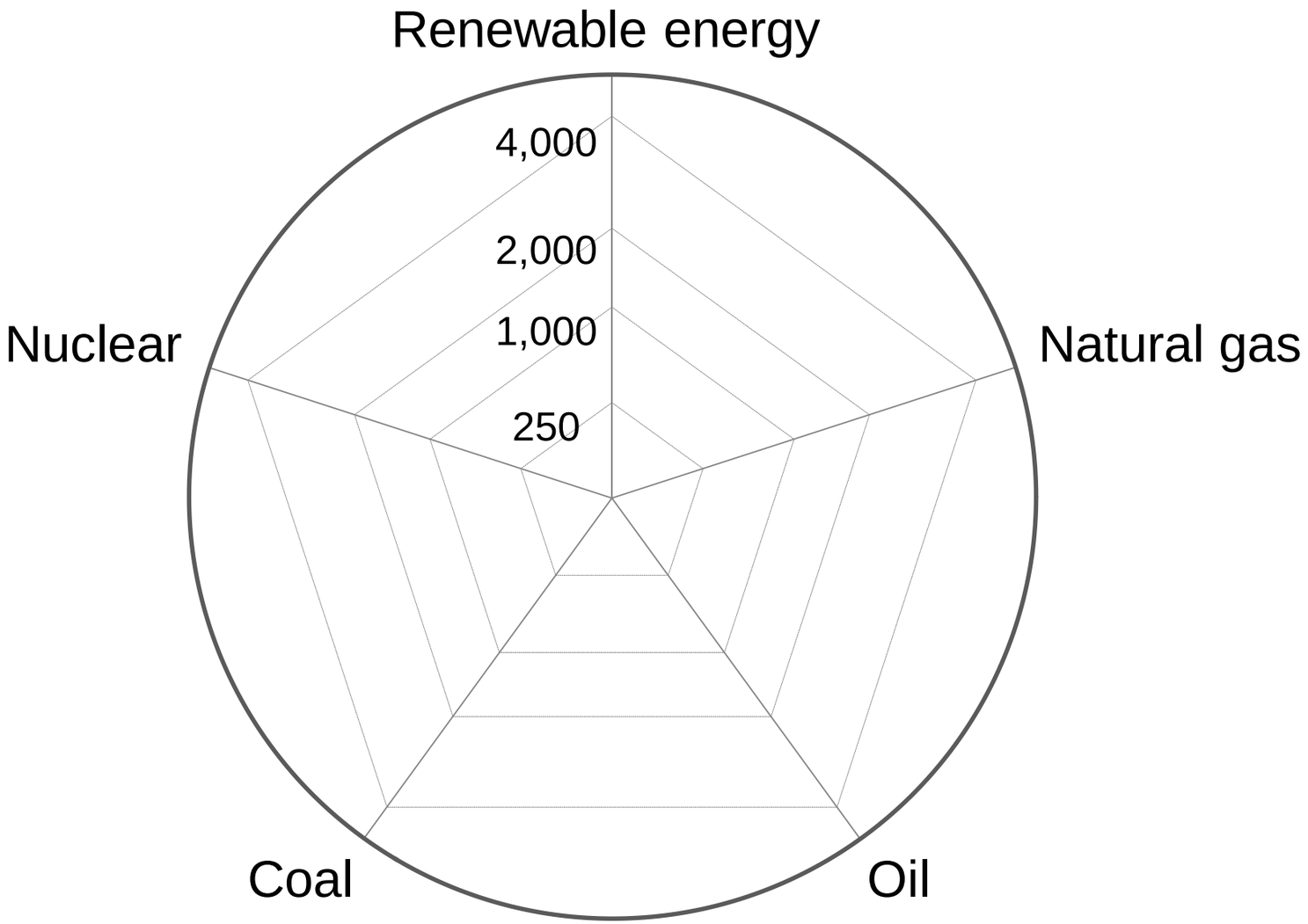
GLOBAL GREENHOUSE GAS EMISSIONS
(GTCO2)

Bloomberg NEW ENERGY FINANCE



Source: UNFCCC, UNEP, Climate Action Tracker, Bloomberg New Energy Finance

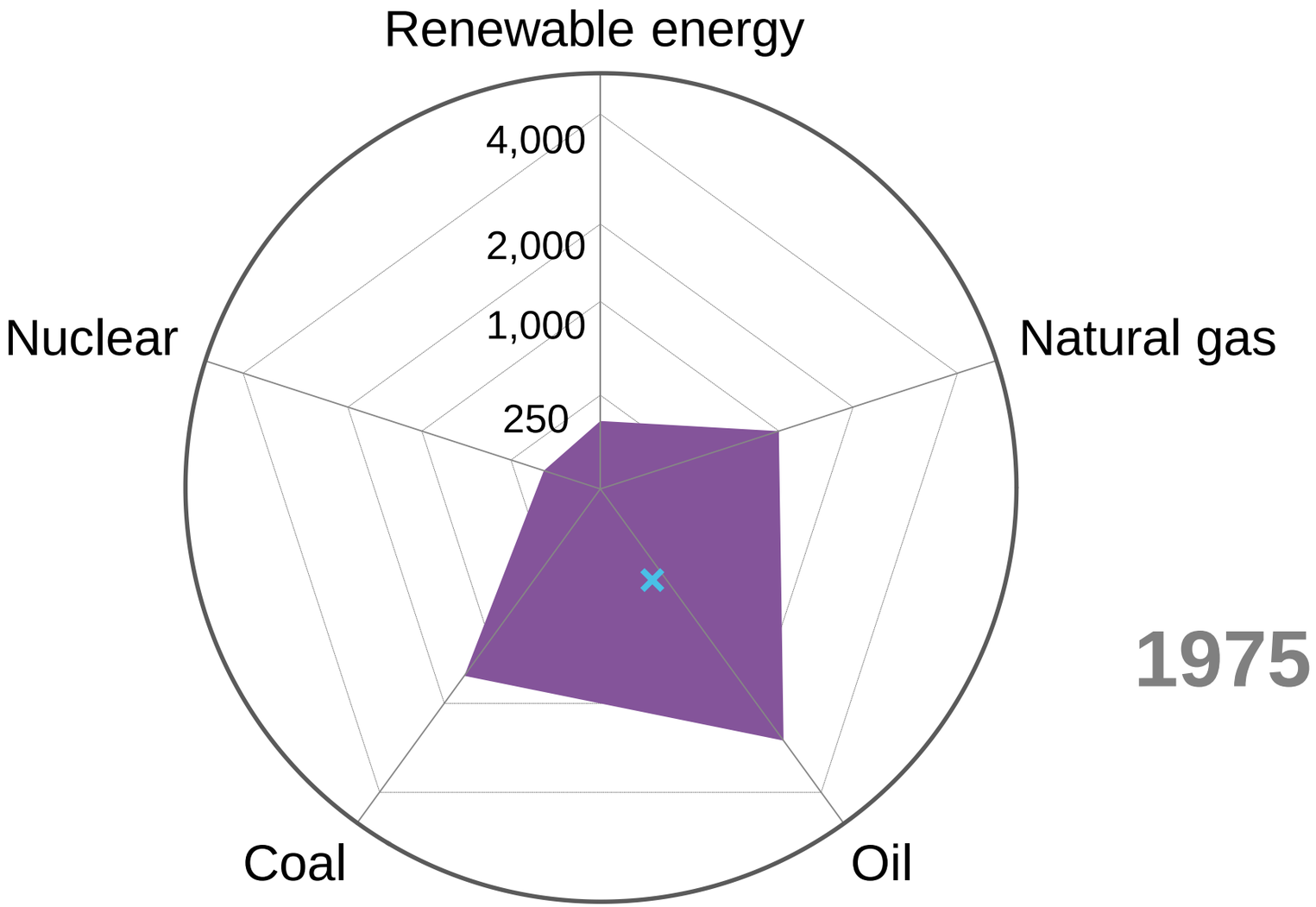
PRIMARY ENERGY SUPPLY CHARTS (MTOE)



Note: The area shows energy consumption, proximity to the axes shows distribution of consumption. The cross shows centre of the area. The line is the historical trend. Axis based on square scale.

Source: Bloomberg New Energy Finance, IEA

GLOBAL PRIMARY ENERGY SUPPLY, 1975 (MTOE)

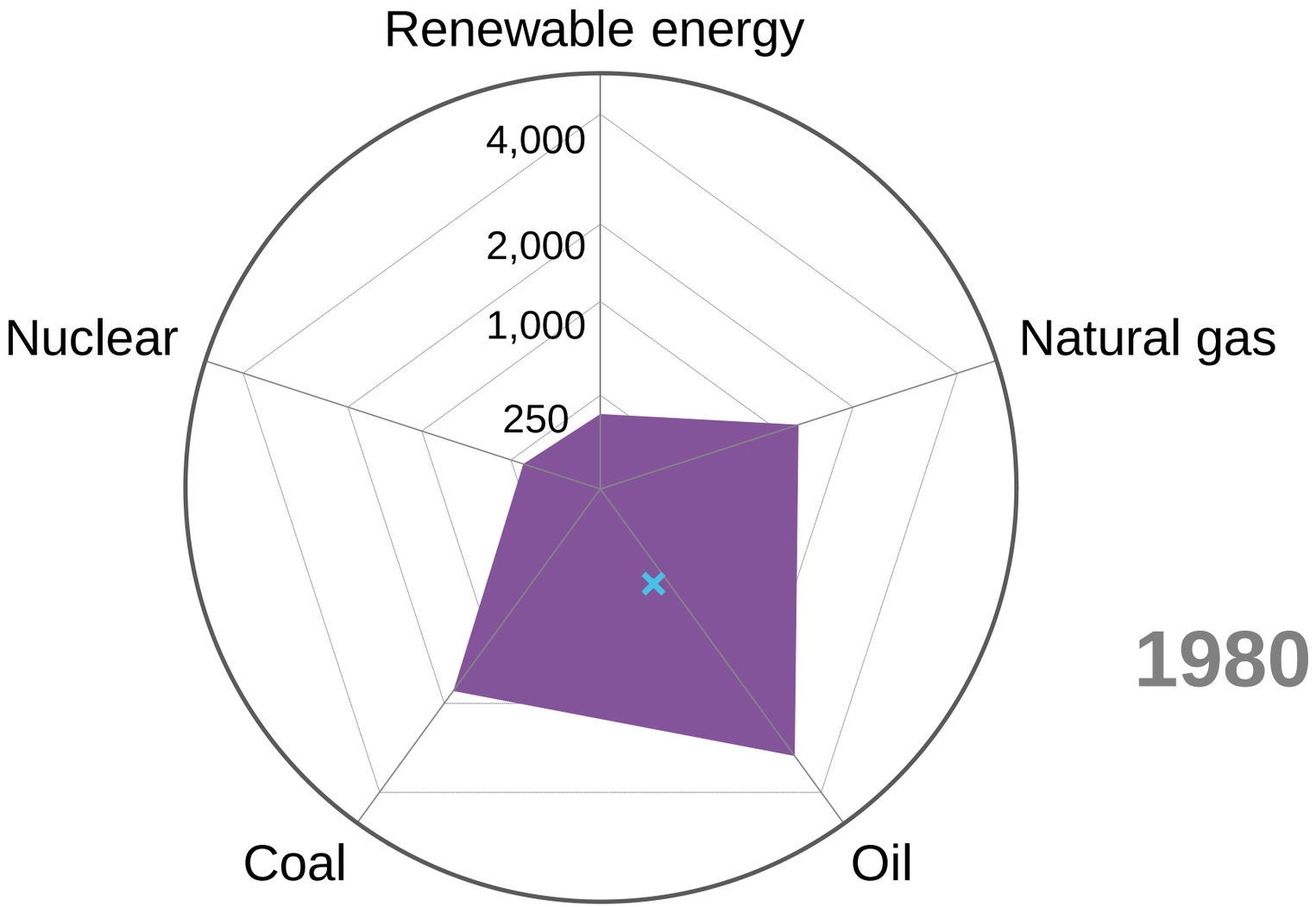


1975

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

GLOBAL PRIMARY ENERGY SUPPLY, 1980 (MTOE)

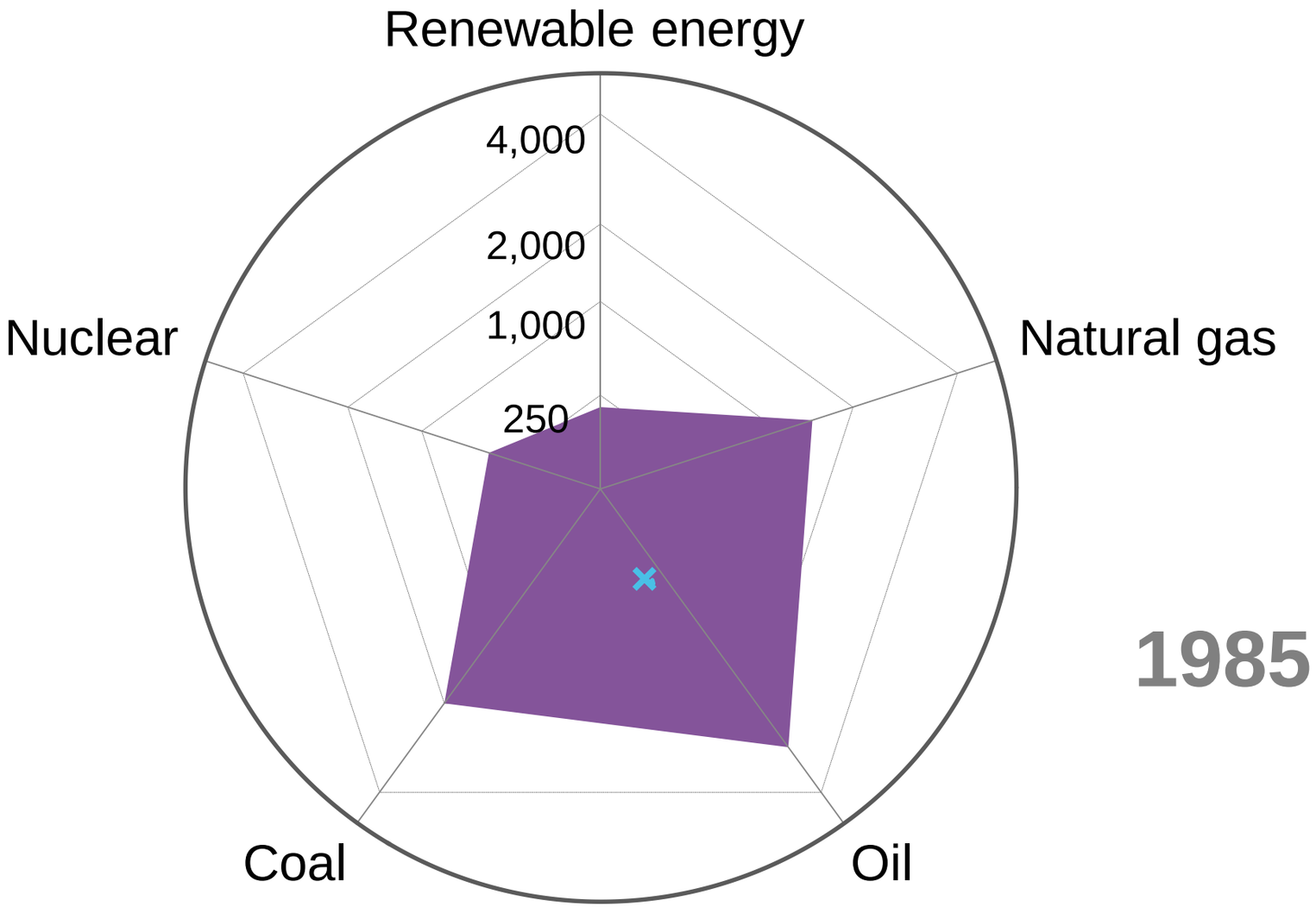


1980

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

GLOBAL PRIMARY ENERGY SUPPLY, 1985 (MTOE)

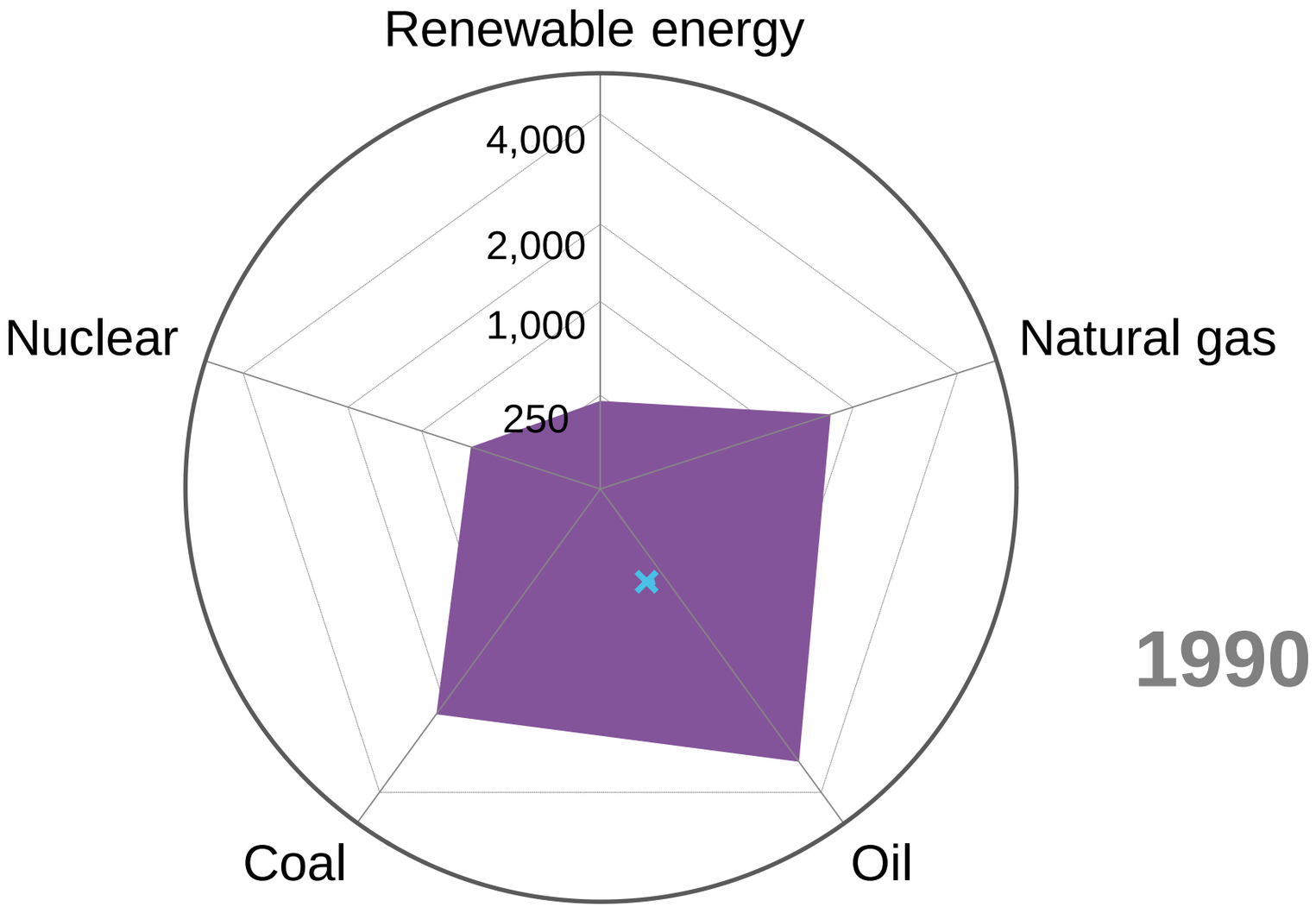


1985

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

GLOBAL PRIMARY ENERGY SUPPLY, 1990 (MTOE)

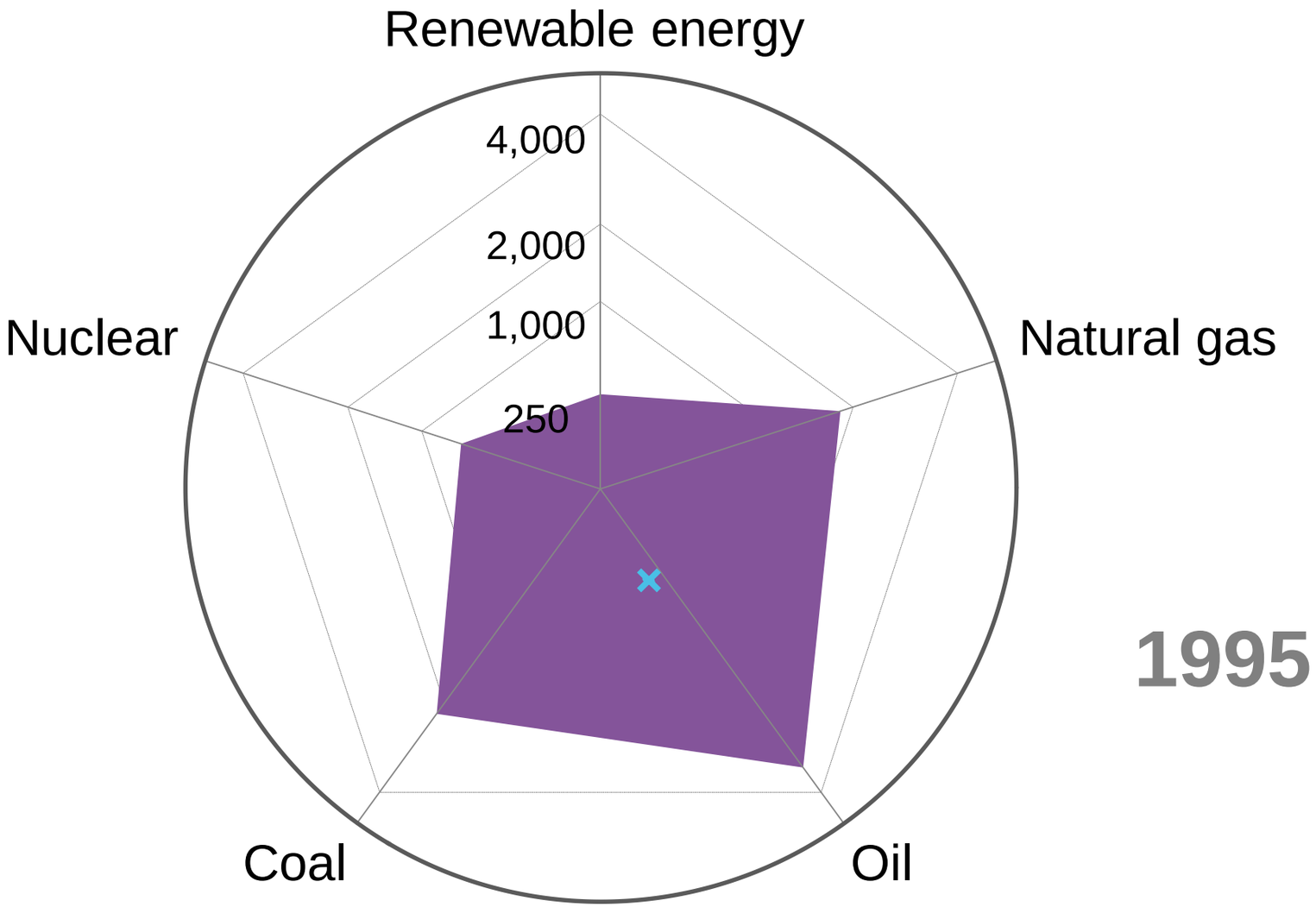


1990

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

GLOBAL PRIMARY ENERGY SUPPLY, 1995 (MTOE)

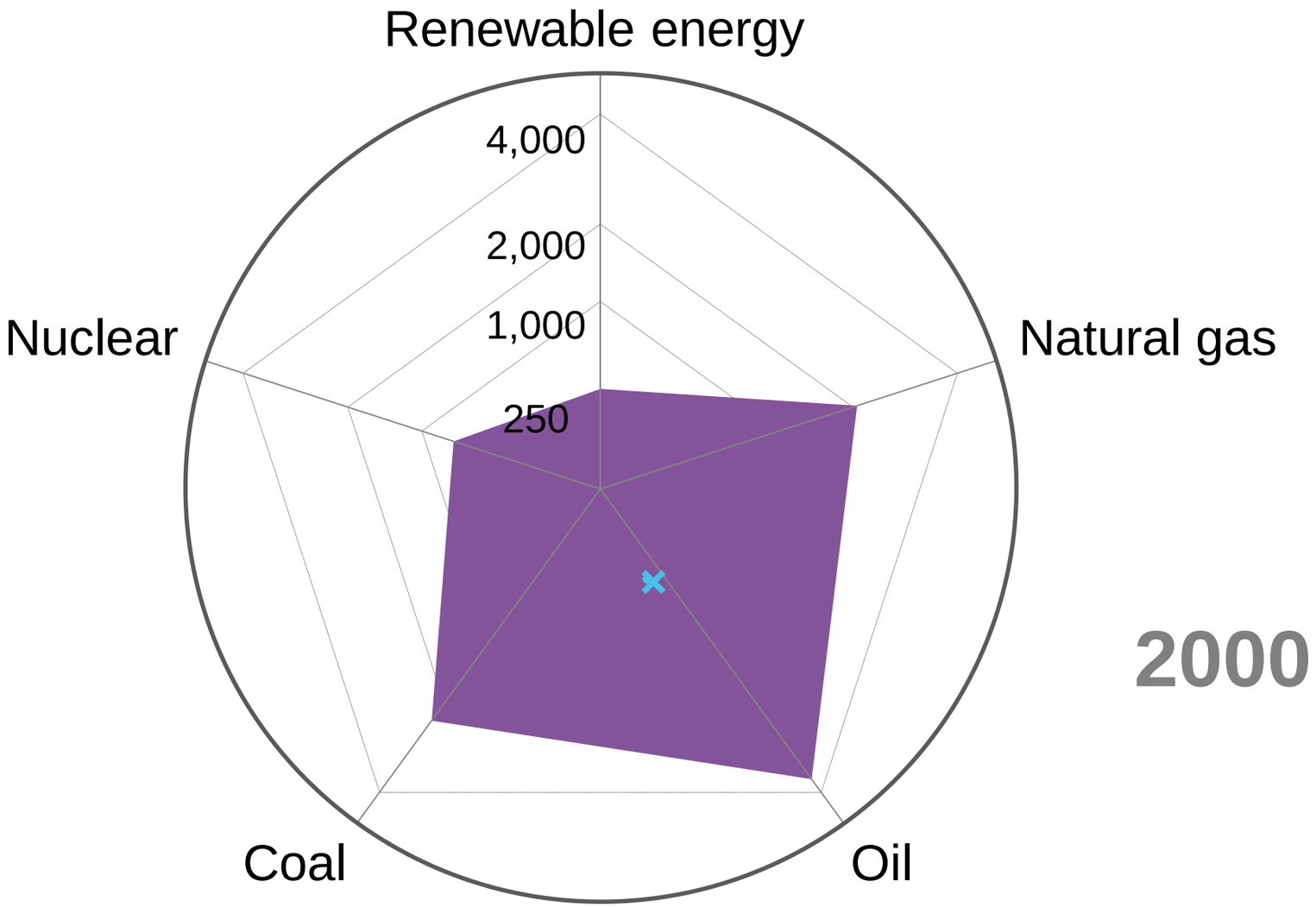


1995

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

GLOBAL PRIMARY ENERGY SUPPLY, 2000 (MTOE)

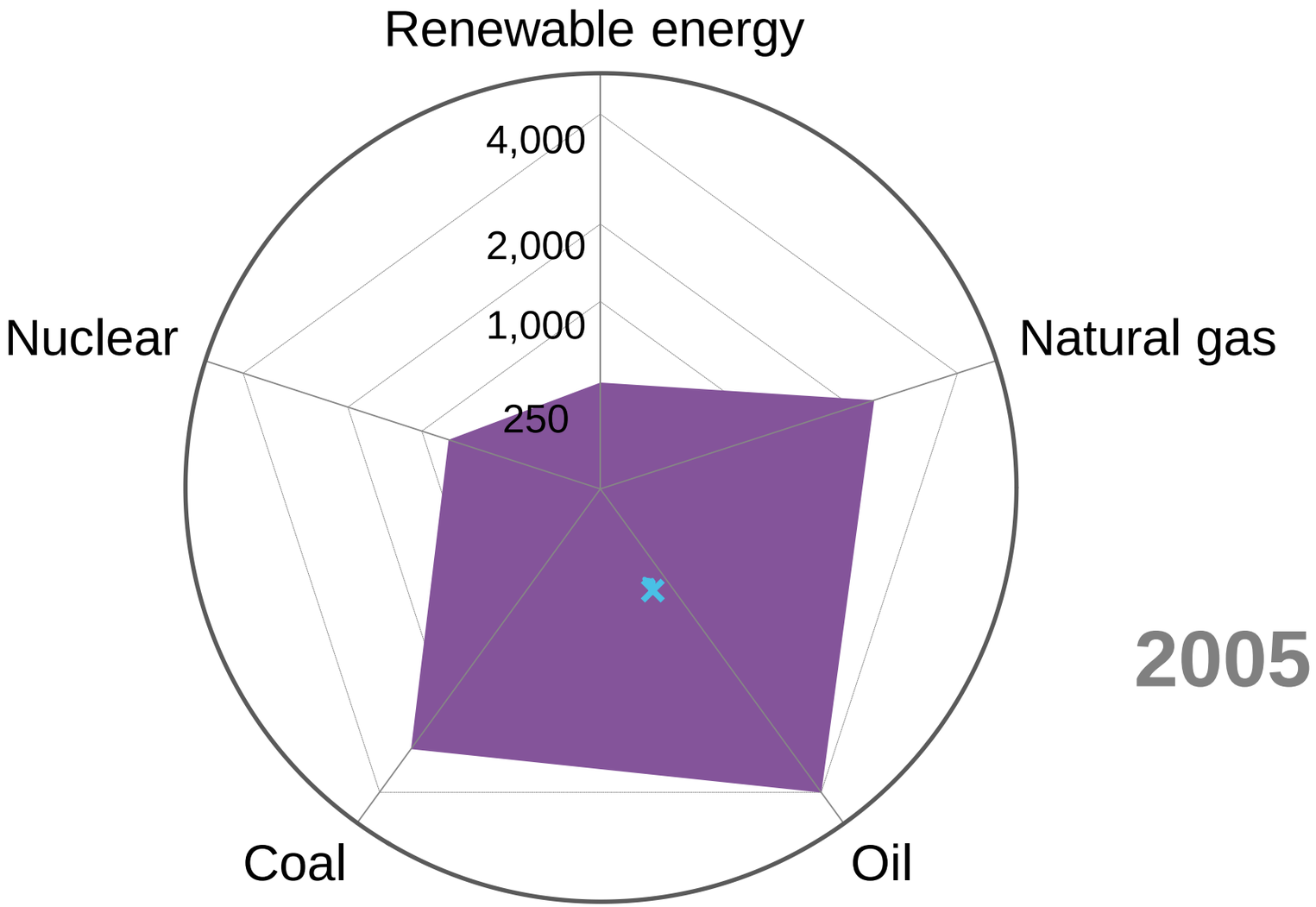


2000

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

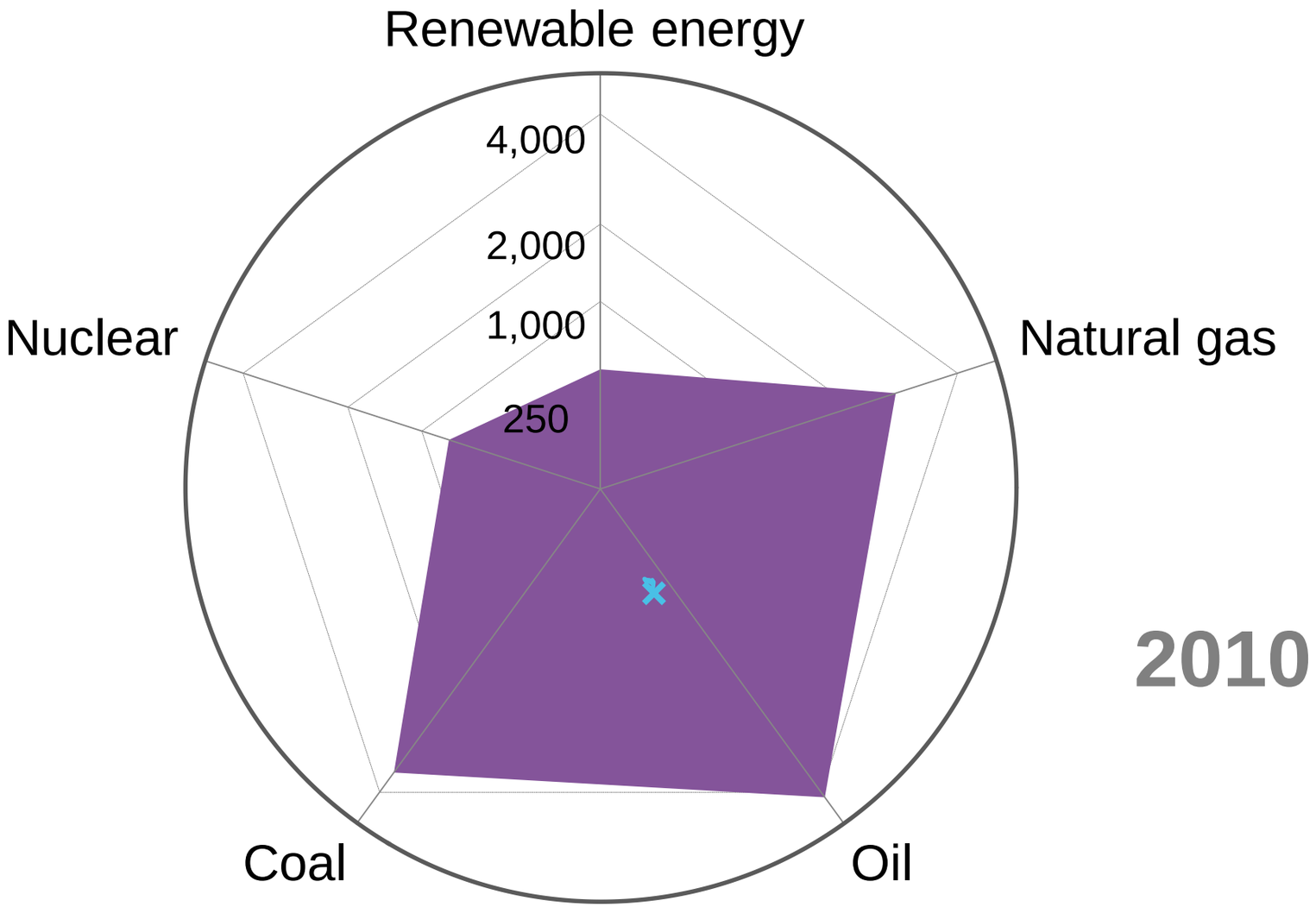
GLOBAL PRIMARY ENERGY SUPPLY, 2005 (MTOE)



Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

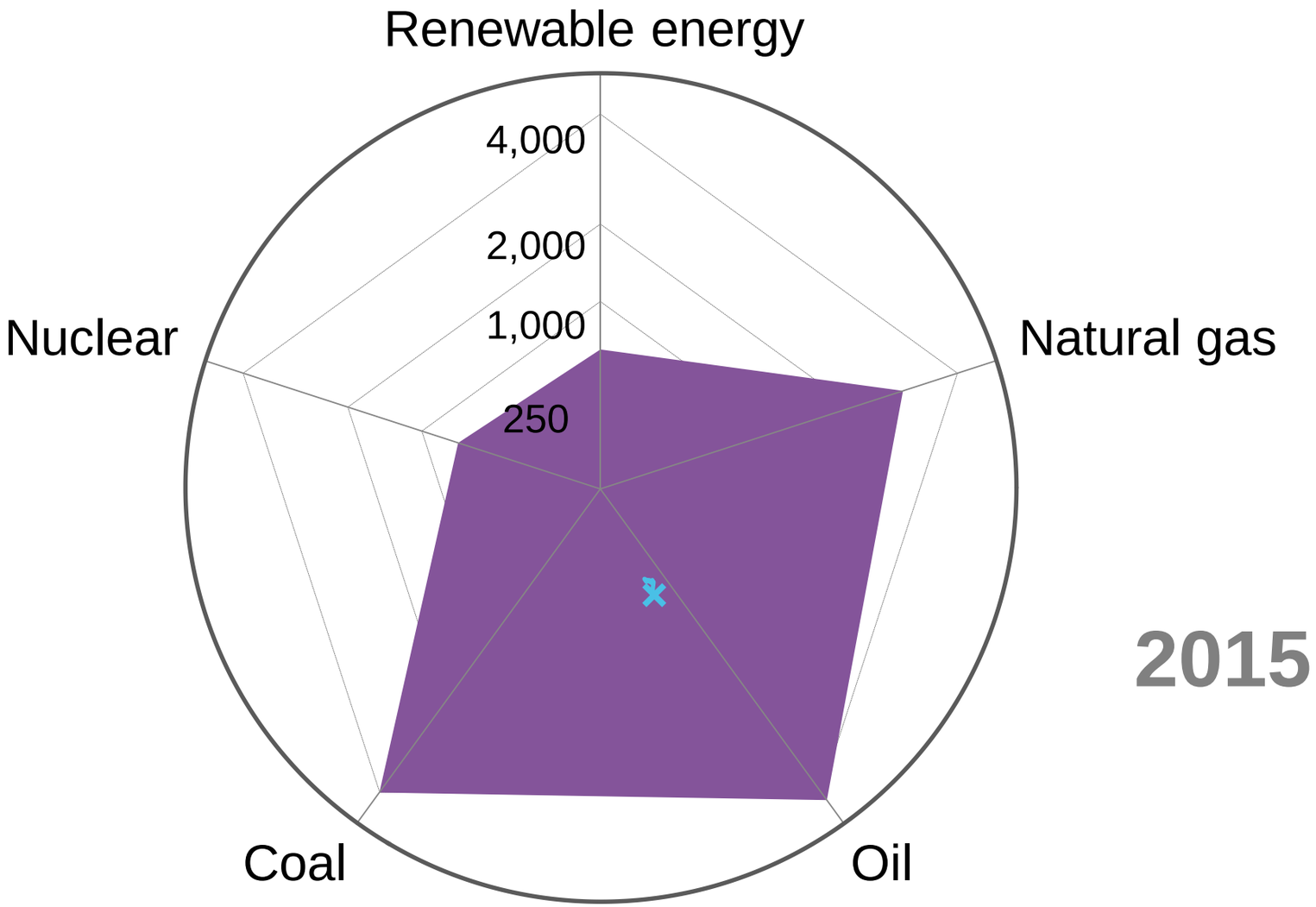
GLOBAL PRIMARY ENERGY SUPPLY, 2010 (MTOE)



Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

GLOBAL PRIMARY ENERGY SUPPLY, 2015 (MTOE)

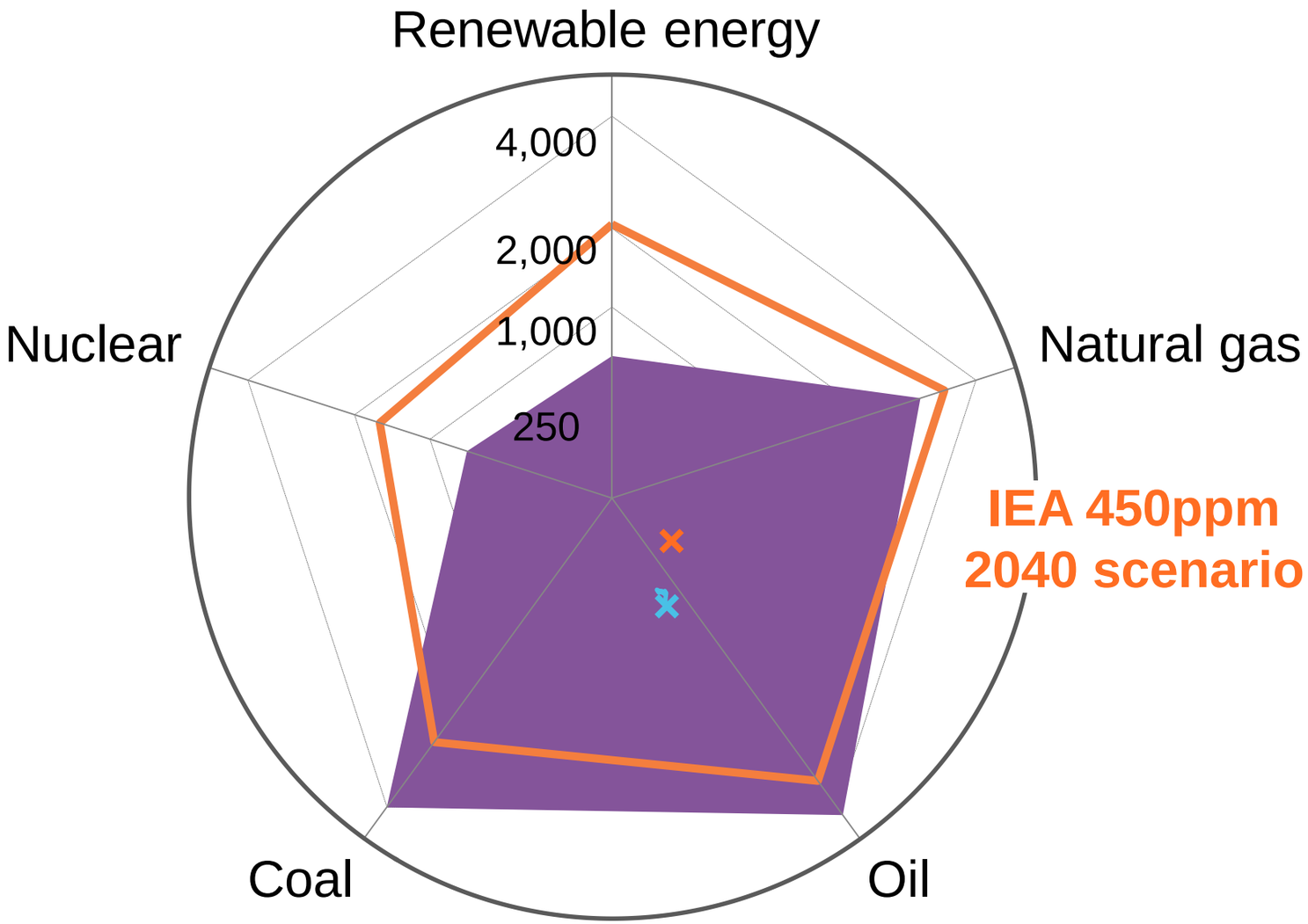


2015

Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

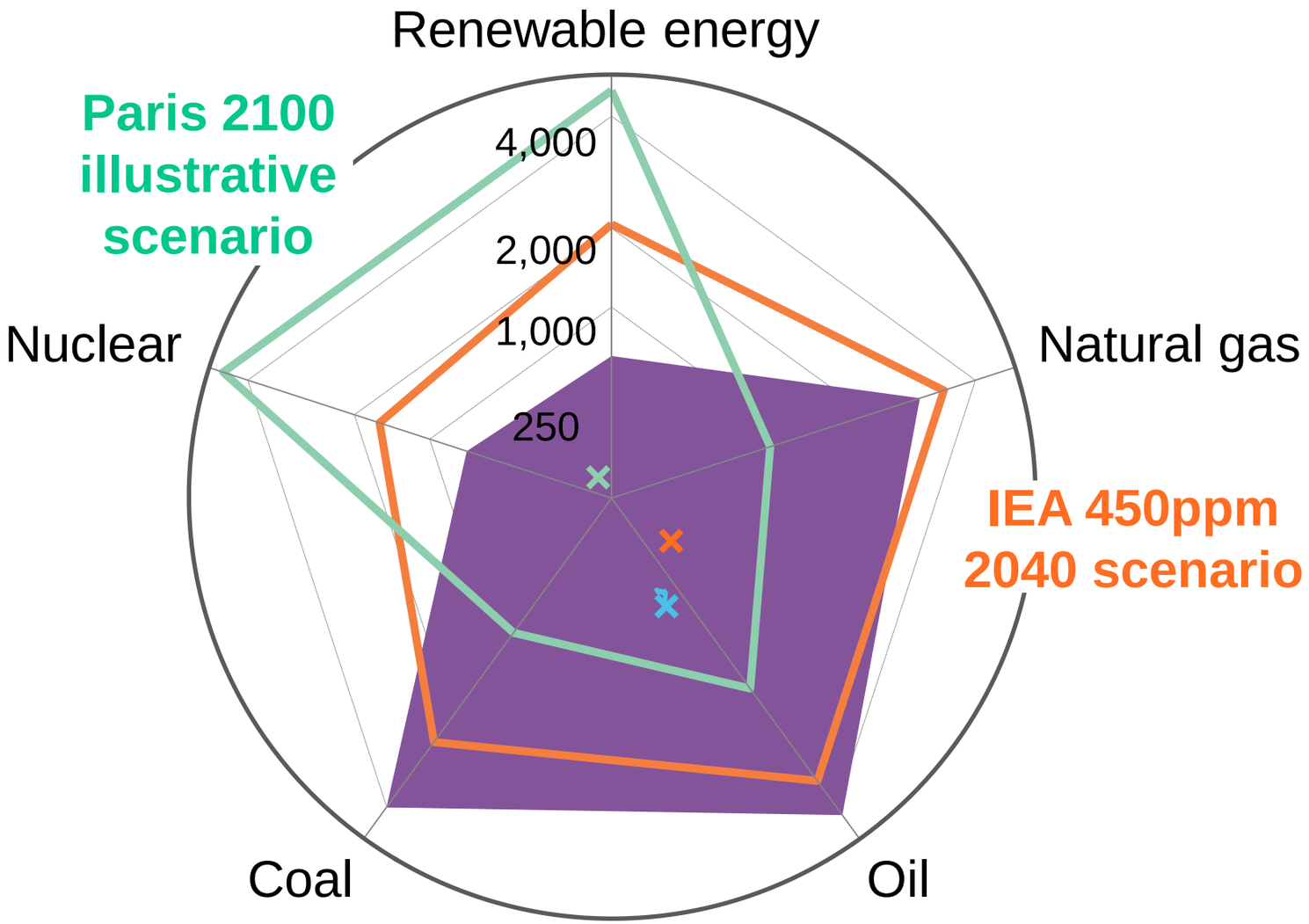
GLOBAL PRIMARY ENERGY SUPPLY (MTOE)



Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

GLOBAL PRIMARY ENERGY SUPPLY (MTOE)



Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total excludes bioenergy.

Source: Bloomberg New Energy Finance, IEA

ENERGY MIRACLE

Bloomberg NEW ENERGY FINANCE

"We need an energy miracle"

Bill Gates
February 2016

Picture: Bloomberg

ENERGY MIRACLE

Bloomberg NEW ENERGY FINANCE

"Within the next 15 years I expect the world will discover a clean energy breakthrough that will save our planet and power our world."

Bill Gates
February 2016

Picture: Bloomberg

HINKLEY C PROJECTED POWER COST (GBP/MWH)

Bloomberg NEW ENERGY FINANCE

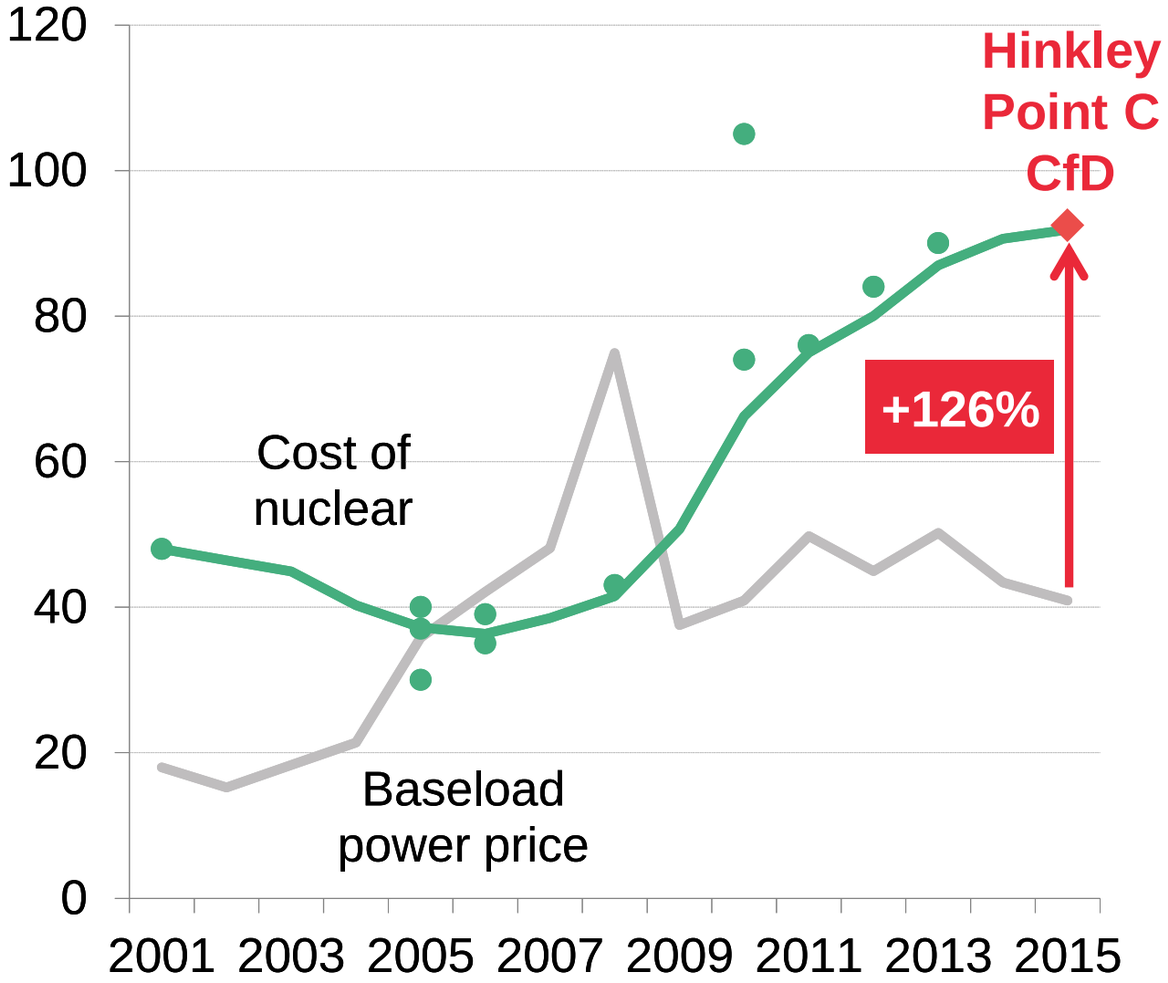
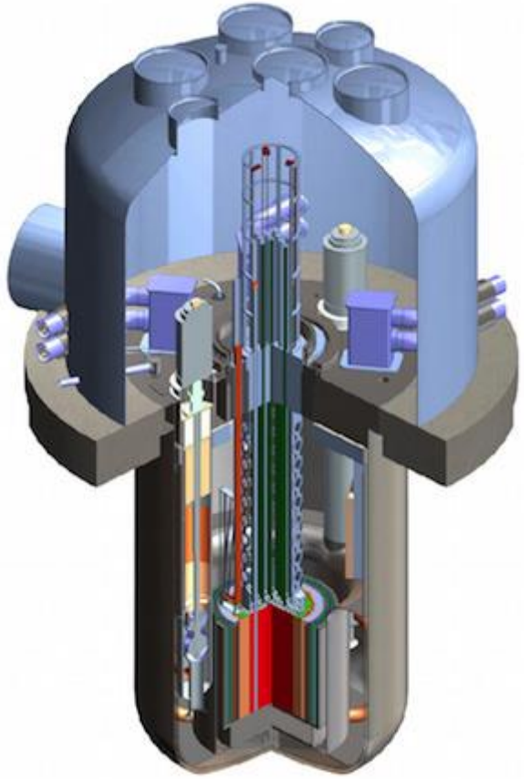


Image: EDF; Source: ECIU, Parsons Brinckerhoff, Mott MacDonald, E.On, EDF, Centrica, Bloomberg New Energy Finance

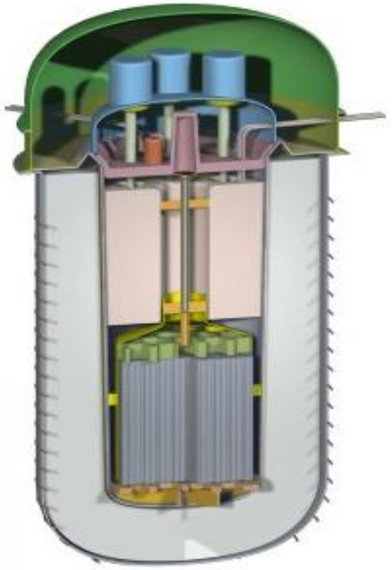
NEXT GENERATION NUCLEAR FISSION

Bloomberg NEW ENERGY FINANCE

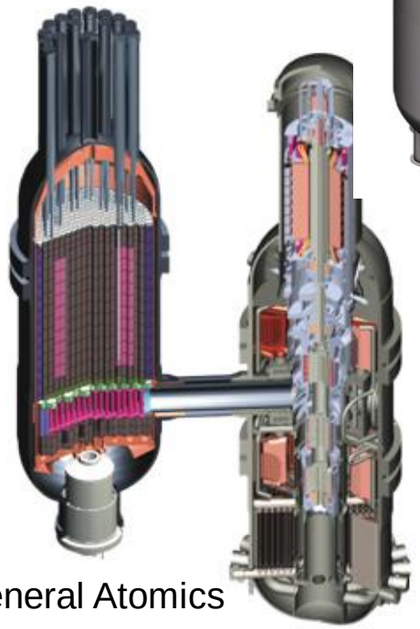


TerraPower TWR

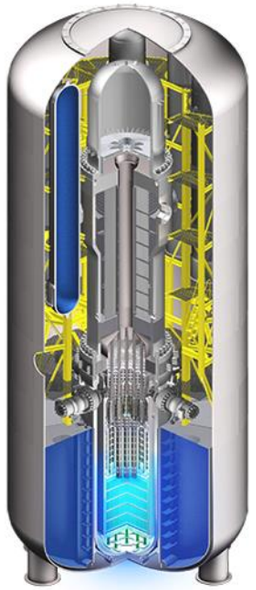
Nuscale SMR



Terrestrial Energy IMSR80

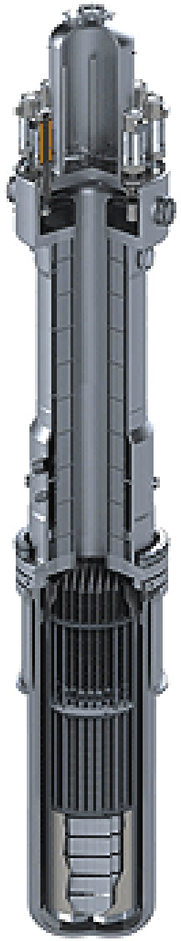


General Atomics EM2



Westinghouse SMR

Holtec SMR-160



Babcock & Wilcox mPower

Note: Not an exhaustive list – excludes Gen IV startups such as Transatomic, Flibe and Upower, and all non-US efforts

Pictures: company websites

NUCLEAR FUSION

Bloomberg NEW ENERGY FINANCE

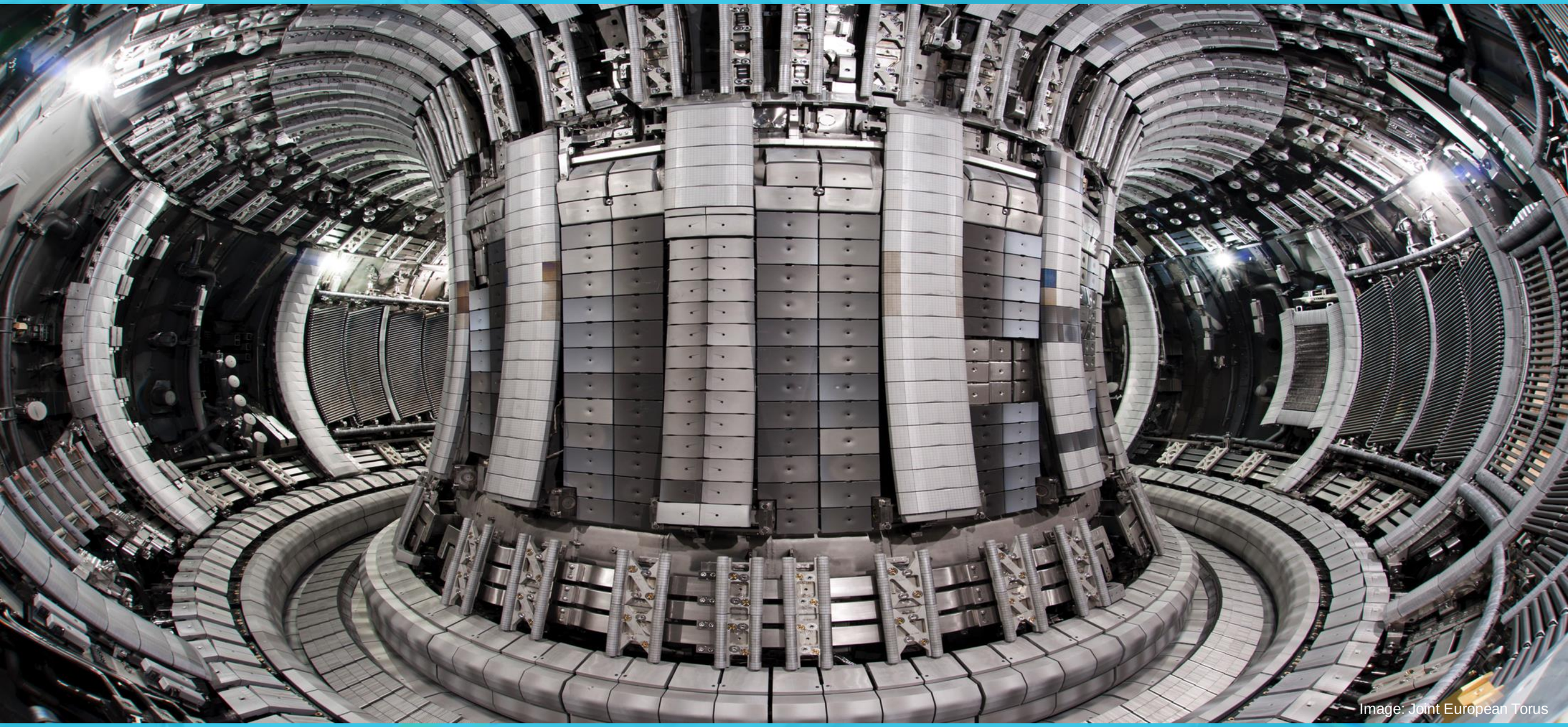
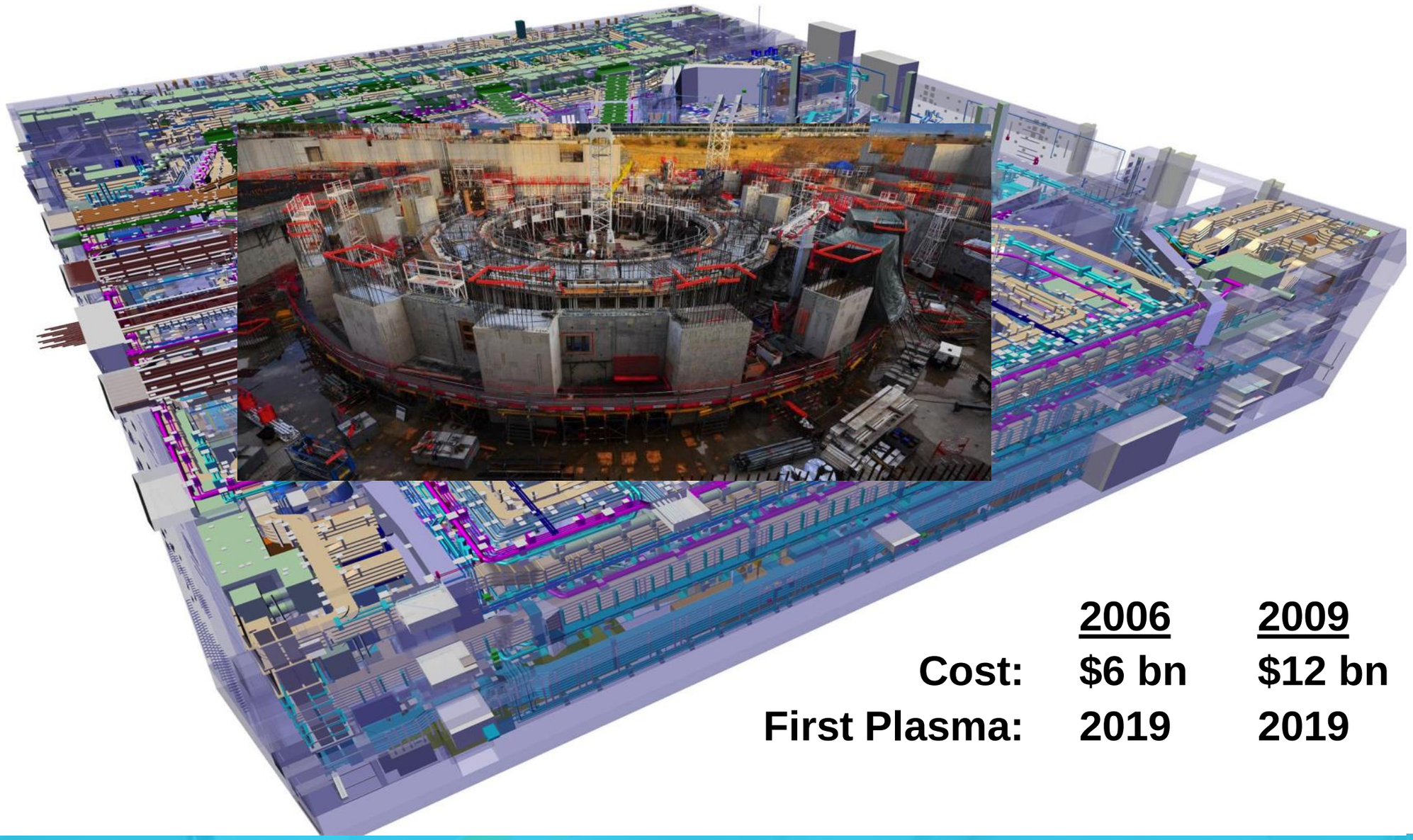


Image: Joint European Torus

ITER CADARACHE



	2006	2009	2014	2016
Cost:	$6 bn	$12 bn	$21 bn	$25 bn?
First Plasma:	2019	2019	2020	2026

Images: ITER collaborative; Source: various

ENERGY MIRACLE – GENERAL FUSION?

Bloomberg NEW ENERGY FINANCE

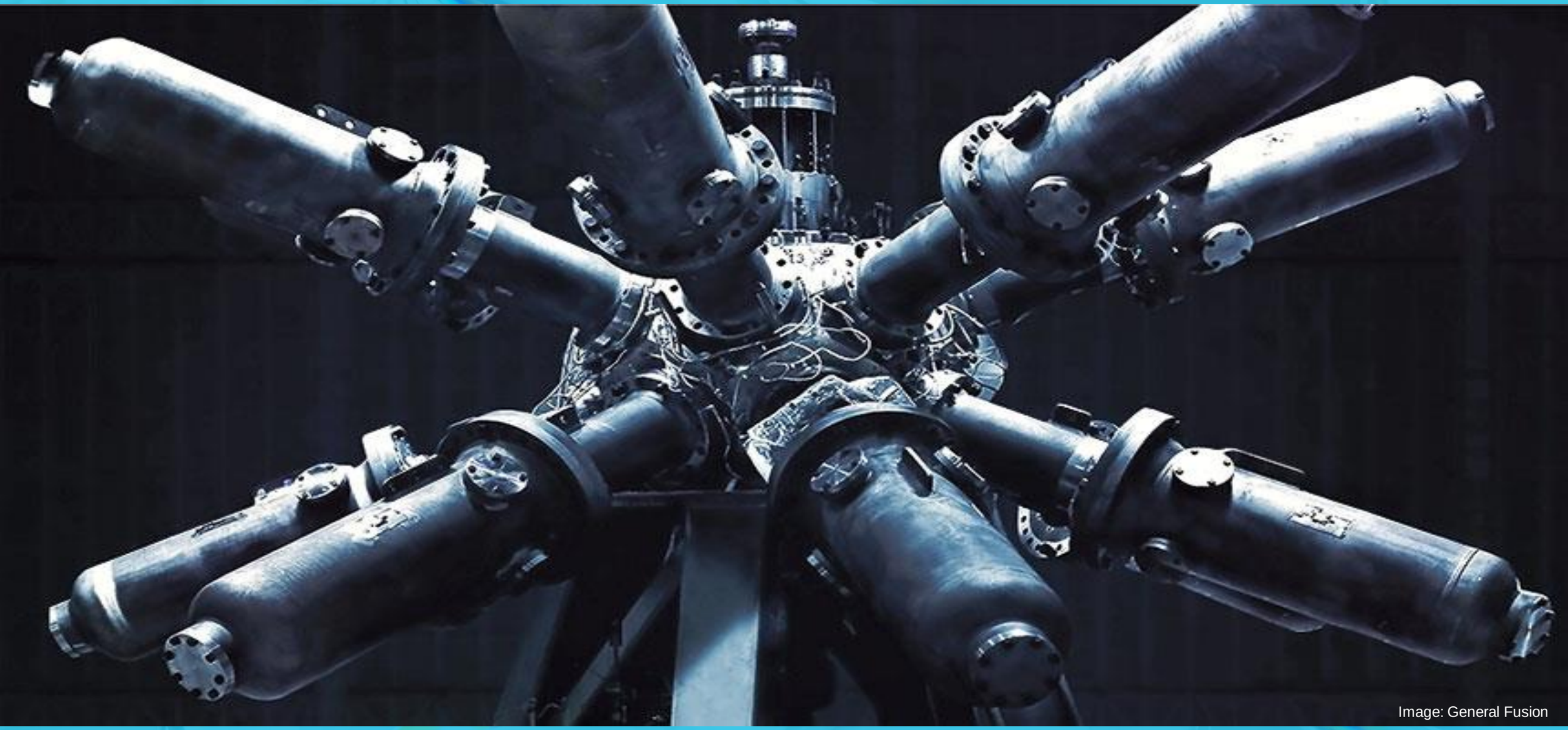


Image: General Fusion

ENERGY MIRACLE – WENDELSTEIN STELLERATOR?

Bloomberg NEW ENERGY FINANCE

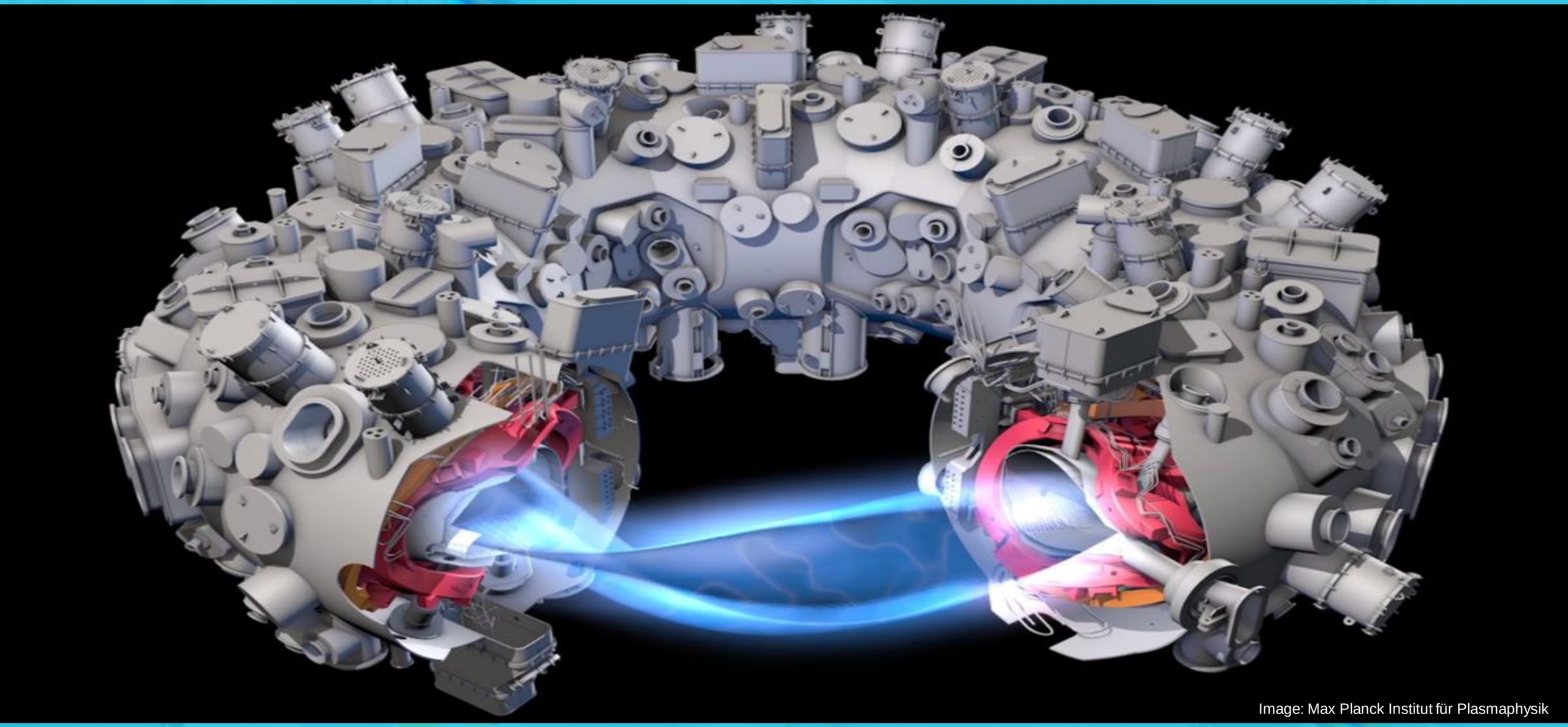
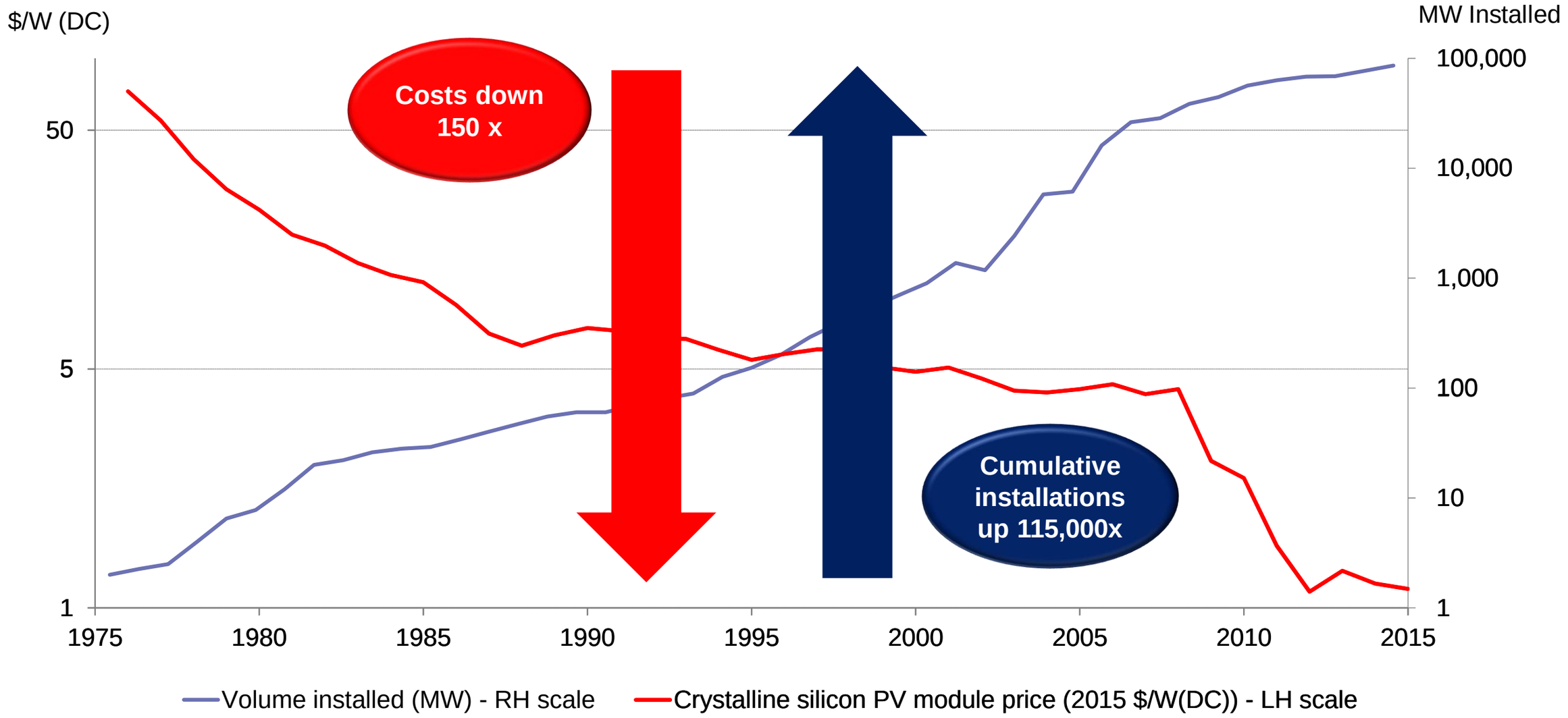


Image: Max Planck Institut für Plasmaphysik

RENEWABLE ENERGY

Bloomberg
NEW ENERGY FINANCE

ENERGY MIRACLE? SOLAR

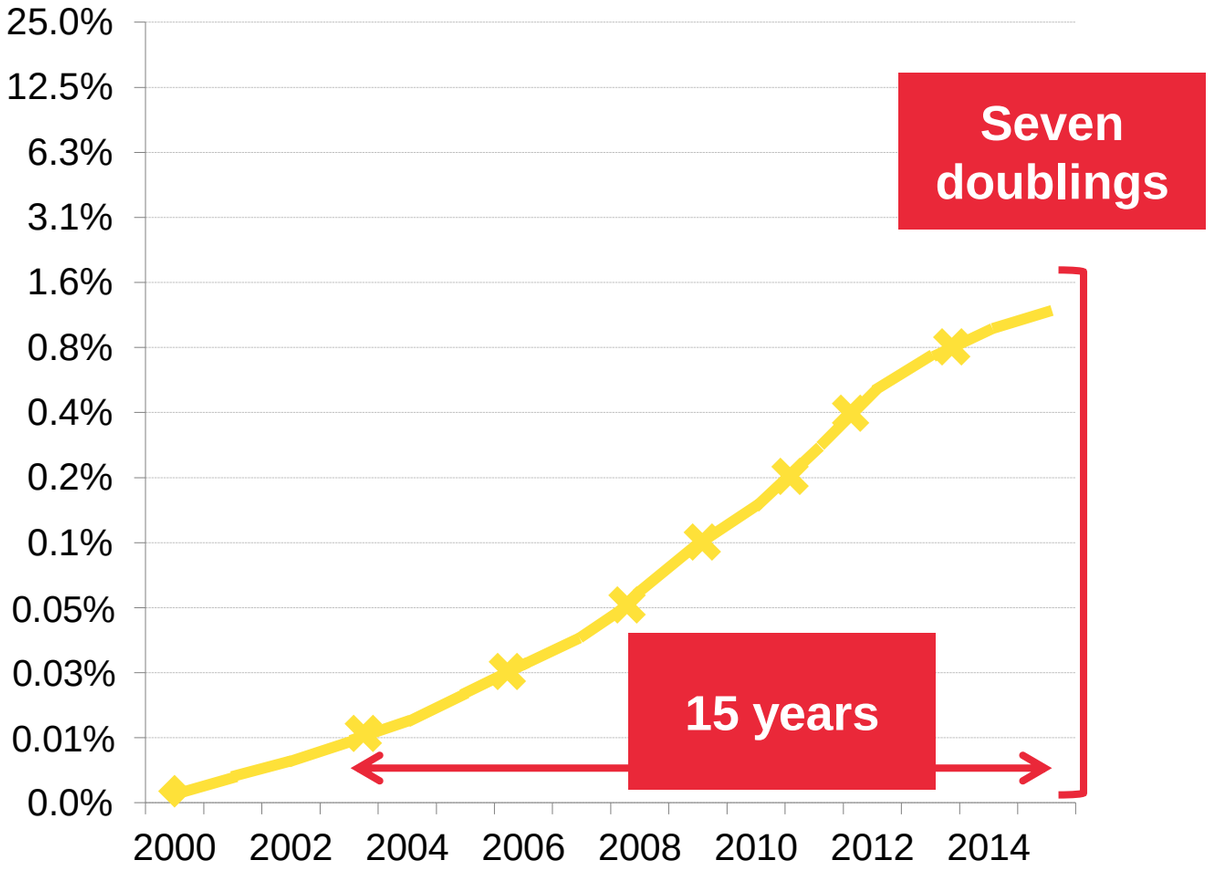


Source: Maycock, Bloomberg New Energy Finance

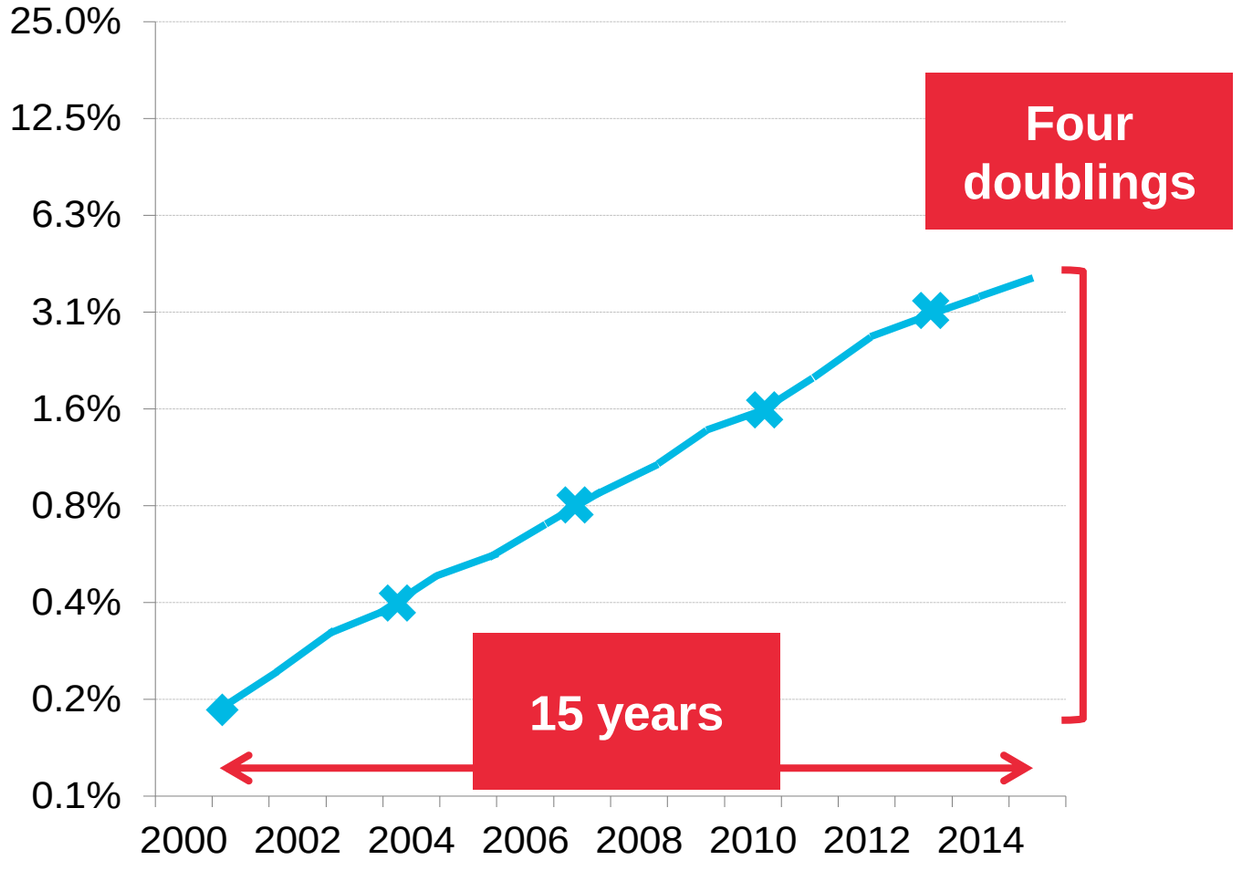
RENEWABLES SHARE OF GENERATION, 2000–15
(% OF SYSTEM TOTAL)

Bloomberg NEW ENERGY FINANCE

SOLAR



WIND



Note: Y-axes are logarithmic with base 2

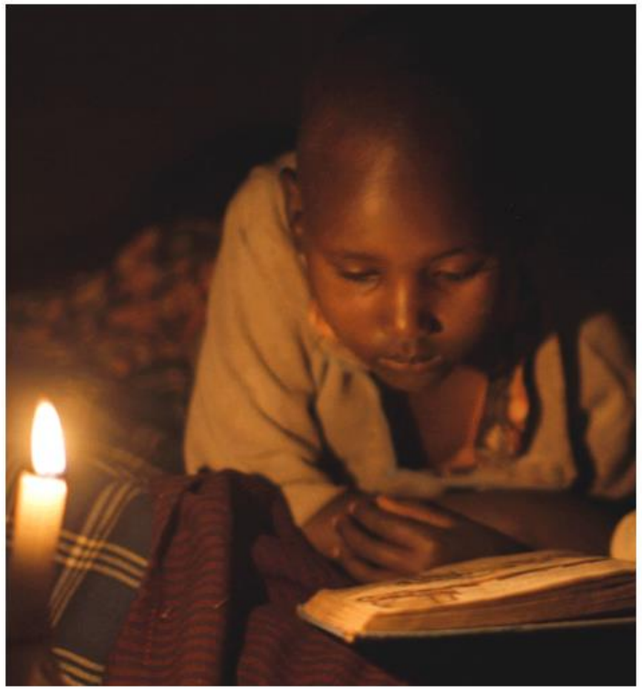
Source: Bloomberg New Energy Finance, BP, UNEP

ENERGY MIRACLE – SOLAR?

Bloomberg NEW ENERGY FINANCE

gatesnotes 2016 Annual Letter

This is a student doing her homework by candlelight.



A young girl studies by candlelight in Tanzania, 2015

I'm always a little stunne this. It's been well over a demonstrated how an inc night into day. (I'm lucky sketches of how he plann dated 1885.) And yet, ther people are still waiting to invention.

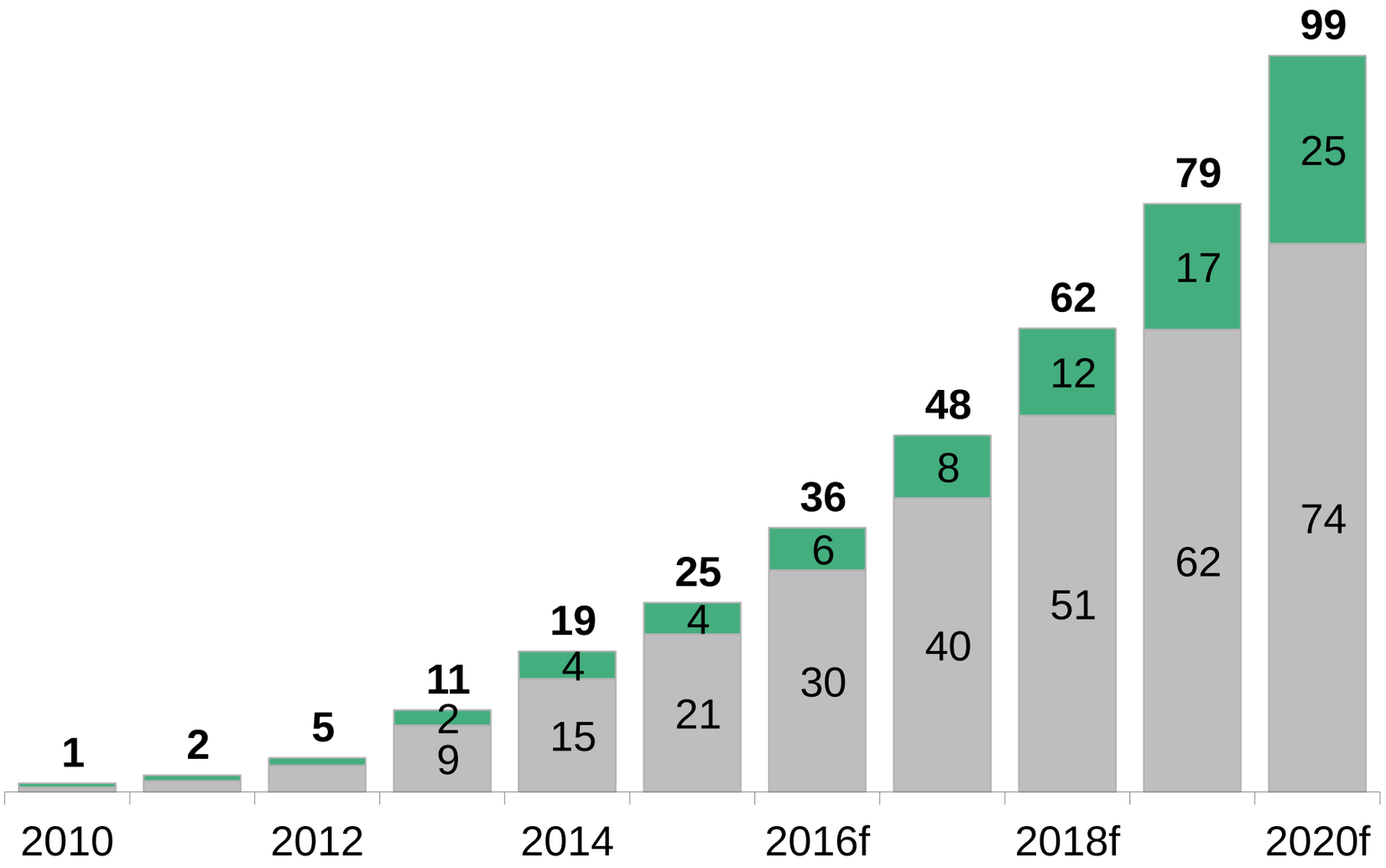
If I could have just one wi would be to find a cheap, our world.

You might be wondering, healthy and find enough t

Images: Gatesnotes.com, D-Light; Source Bloomberg New Energy Finance

OFF-GRID SOLAR USERS
(MILLION HOUSEHOLDS)

Bloomberg NEW ENERGY FINANCE



Large solar home systems

Portable solar lanterns and small home systems

or

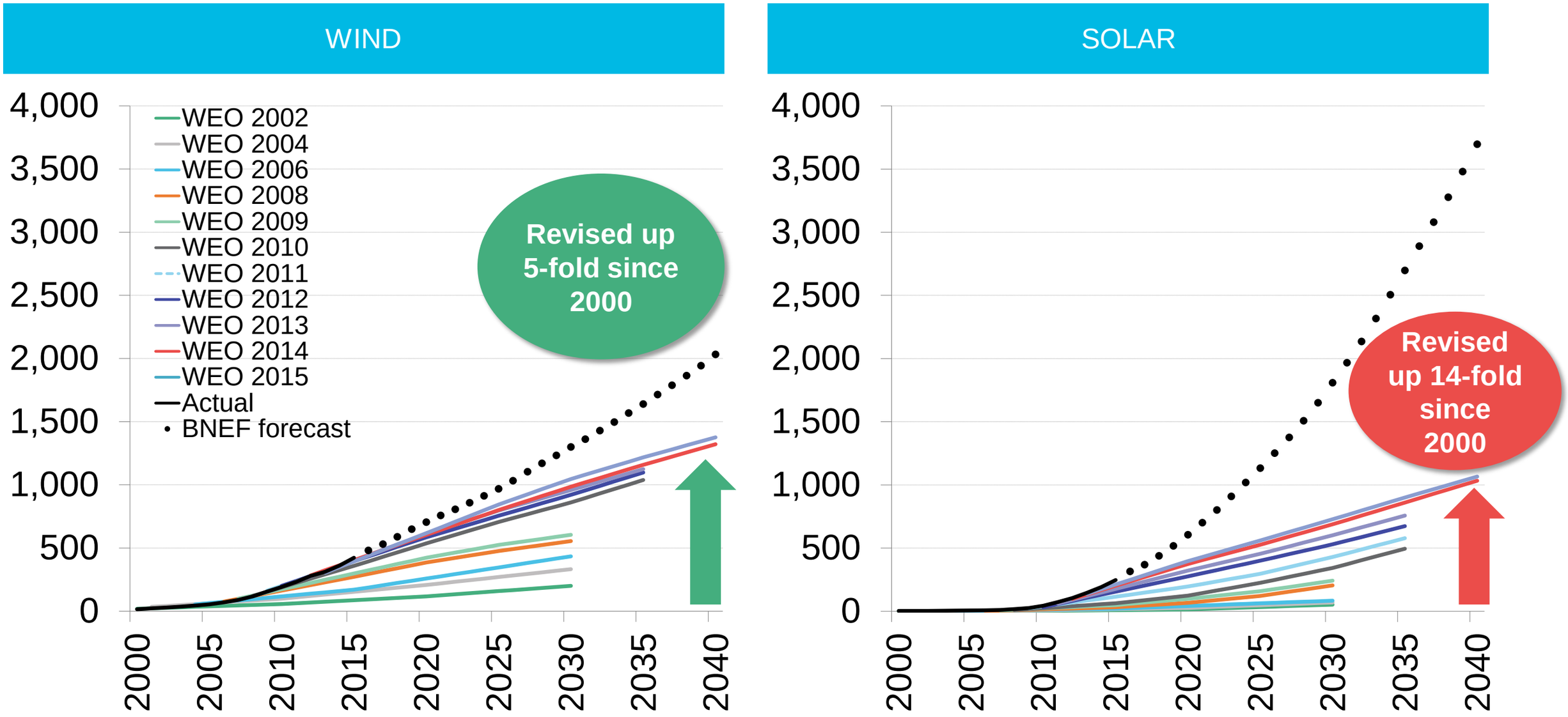
Note: Large solar home systems are defined as larger than 10W solar panels. Historical data is based on Lighting Global and GOGLA data and Bloomberg New Energy Finance estimates.

Source: Bloomberg New Energy Finance, Lighting Global, GOGLA

IEA GLOBAL WIND AND SOLAR CAPACITY FORECASTS VS BNEF

GW INSTALLED

Bloomberg NEW ENERGY FINANCE



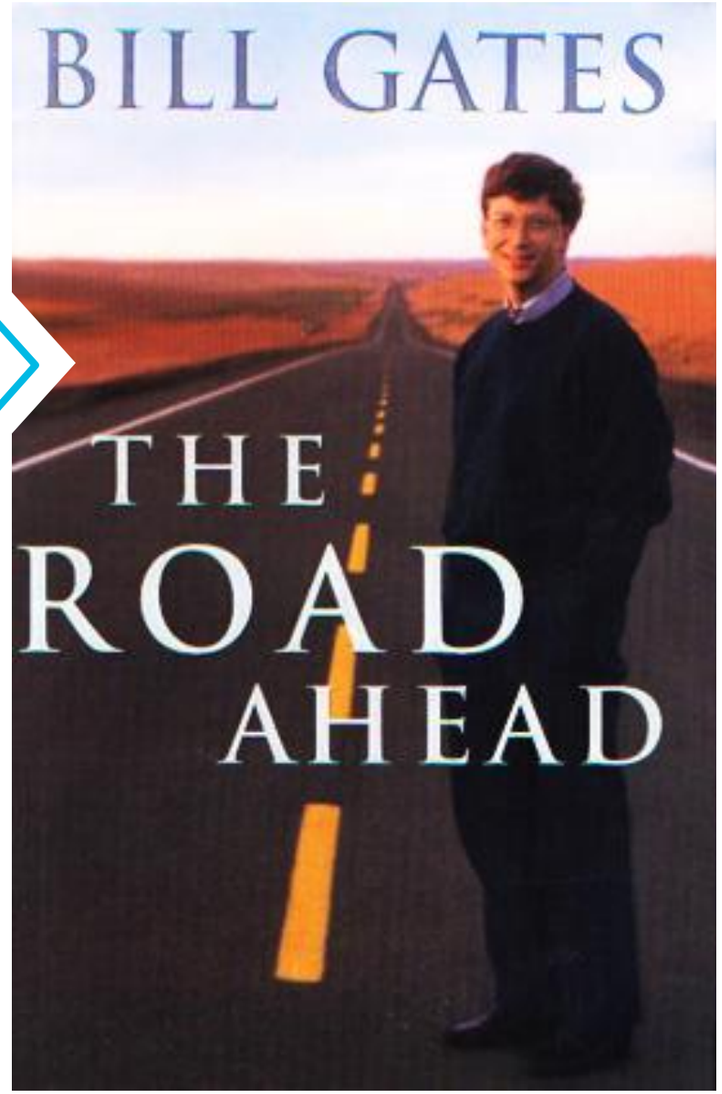
Source: IEA, Bloomberg New Energy Finance,

BILL GATES ON THE INTERNET – 1994

Bloomberg NEW ENERGY FINANCE

"The Internet has enormous potential, but it's important that expectations aren't cranked too high. The total number of users is still a very small portion of the population."

Bill Gates
The Road Ahead
(written 1994)



Picture: Viking/Penguin

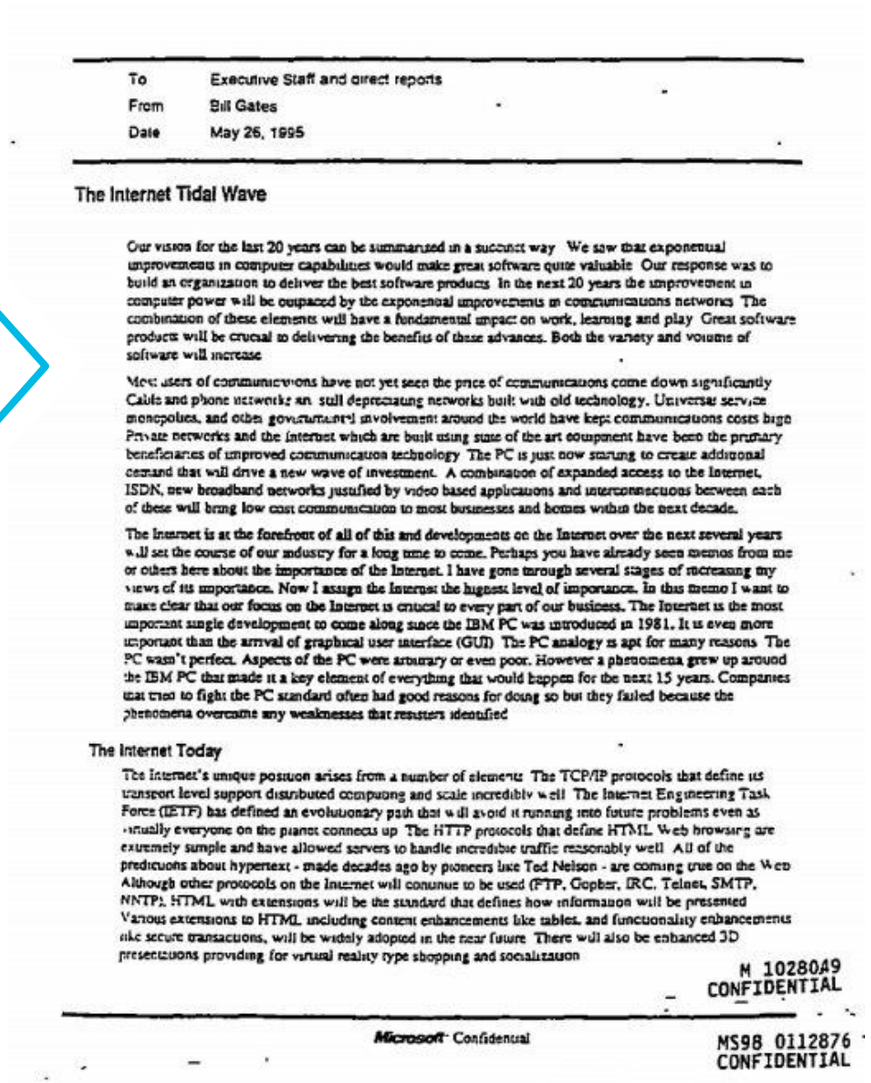
BILL GATES INTERNET TIDAL WAVE MEMO – 1995

Bloomberg NEW ENERGY FINANCE

"Now I assign the Internet the highest level of importance. In this memo I want to make clear that our focus on the Internet is crucial to every part of our business."

Bill Gates

Memo to Microsoft Staff, 1995



To Executive Staff and direct reports
From Bill Gates
Date May 26, 1995

The Internet Tidal Wave

Our vision for the last 20 years can be summarized in a succinct way We saw that exponential improvements in computer capabilities would make great software quite valuable Our response was to build an organization to deliver the best software products In the next 20 years the improvement in computer power will be outpaced by the exponential improvements in communications networks The combination of these elements will have a fundamental impact on work, learning and play Great software products will be crucial to delivering the benefits of these advances. Both the variety and volume of software will increase

Most users of communications have not yet seen the price of communications come down significantly Cable and phone networks are still depreciating networks built with old technology. Universal service monopolies, and other governmental involvement around the world have kept communications costs high Private networks and the Internet which are built using state of the art equipment have been the primary beneficiaries of improved communication technology The PC is just now starting to create additional demand that will drive a new wave of investment. A combination of expanded access to the Internet, ISDN, new broadband networks justified by video based applications and interconnections between each of these will bring low cost communication to most businesses and homes within the next decade.

The Internet is at the forefront of all of this and developments on the Internet over the next several years will set the course of our industry for a long time to come. Perhaps you have already seen memos from me or others here about the importance of the Internet. I have gone through several stages of increasing my views of its importance. Now I assign the Internet the highest level of importance. In this memo I want to make clear that our focus on the Internet is critical to every part of our business. The Internet is the most important single development to come along since the IBM PC was introduced in 1981. It is even more important than the arrival of graphical user interface (GUI) The PC analogy is apt for many reasons The PC wasn't perfect. Aspects of the PC were arbitrary or even poor. However a phenomena grew up around the IBM PC that made it a key element of everything that would happen for the next 15 years. Companies that tried to fight the PC standard often had good reasons for doing so but they failed because the phenomena overcame any weaknesses that resisters identified

The Internet Today

The Internet's unique position arises from a number of elements The TCP/IP protocols that define its transport level support distributed computing and scale incredibly well The Internet Engineering Task Force (IETF) has defined an evolutionary path that will avoid it running into future problems even as virtually everyone on the planet connects up The HTTP protocols that define HTML Web browsing are extremely simple and have allowed servers to handle incredible traffic reasonably well All of the predictions about hypertext - made decades ago by pioneers like Ted Nelson - are coming true on the Web Although other protocols on the Internet will continue to be used (FTP, Gopher, IRC, Telnet, SMTP, NNTP), HTML with extensions will be the standard that defines how information will be presented Various extensions to HTML, including content enhancements like tables, and functionality enhancements like secure transactions, will be widely adopted in the near future There will also be enhanced 3D presentations providing for virtual reality type shopping and socialization

M 1028049
CONFIDENTIAL

Microsoft Confidential

MS98 0112876
CONFIDENTIAL

Image: Microsoft

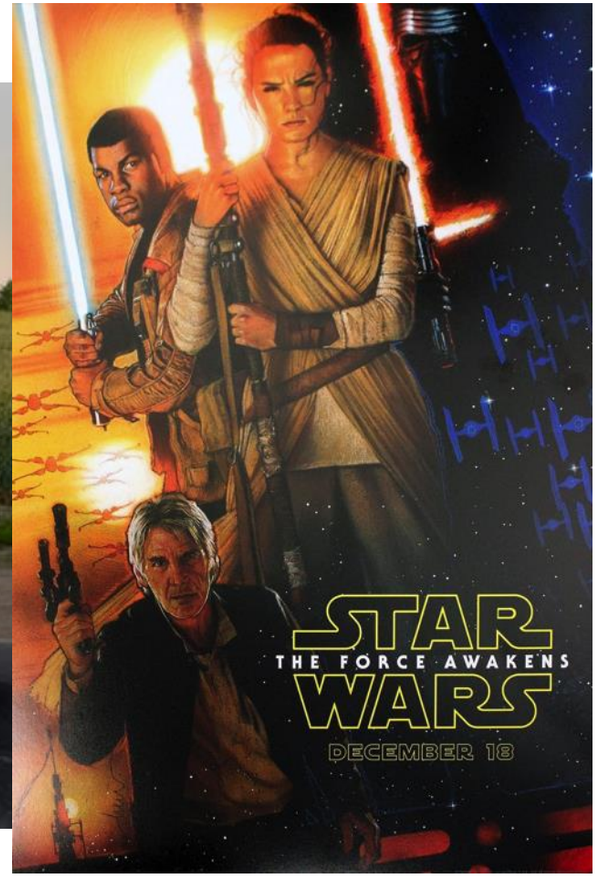
TESLA MODEL 3 – FIRST THREE DAYS

Bloomberg NEW ENERGY FINANCE

iPhone 6
10 million phones
$3.5 billion

276,000 orders
$11.6 billion

Star Wars Force Awakens
1st Weekend box-office
$0.5 billion



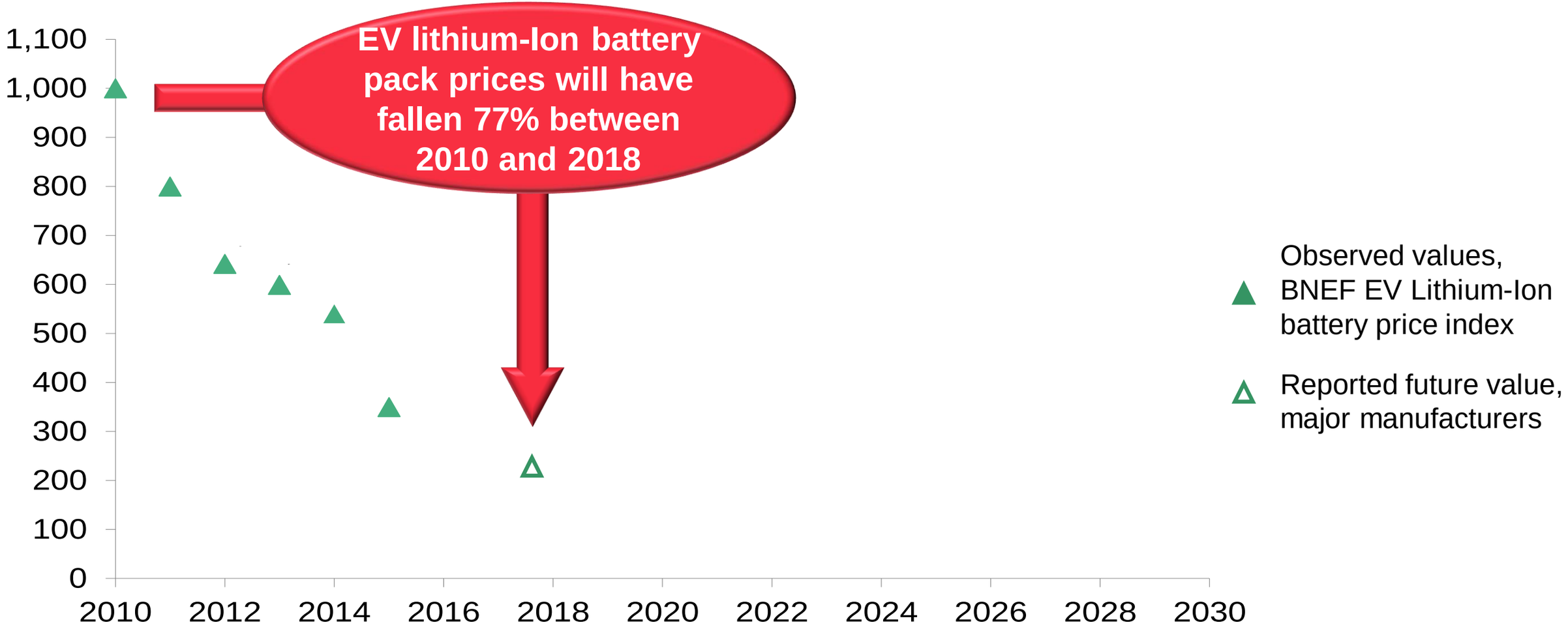
EV MASS MARKET: $30,000 + 200 MILES RANGE

Bloomberg NEW ENERGY FINANCE

Images: Tesla GM; VW; Nissan; Wikimedia Commons

EV LITHIUM-ION BATTERY PACK PRICE
($/KWh)

Bloomberg NEW ENERGY FINANCE

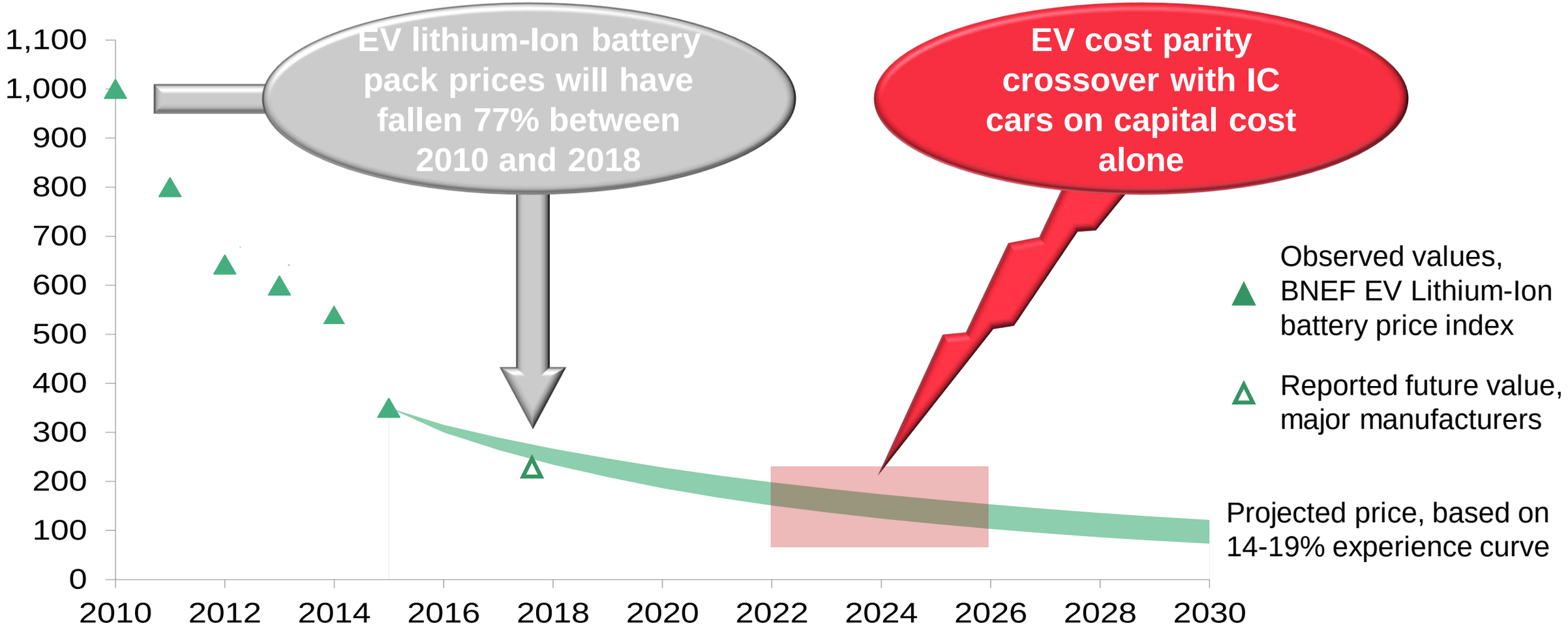


Note: Forecast range based on a learning rate of 14-20%. EV cost parity is calculated on an unsubsidised total cost of ownership (TCO) basis.
Date range reflects cross over with different vehicle classes in the US.

Source: Bloomberg New Energy Finance. EV lithium-ion battery price index

EV LITHIUM-ION BATTERY PACK PRICE
($/KWh)

Bloomberg NEW ENERGY FINANCE

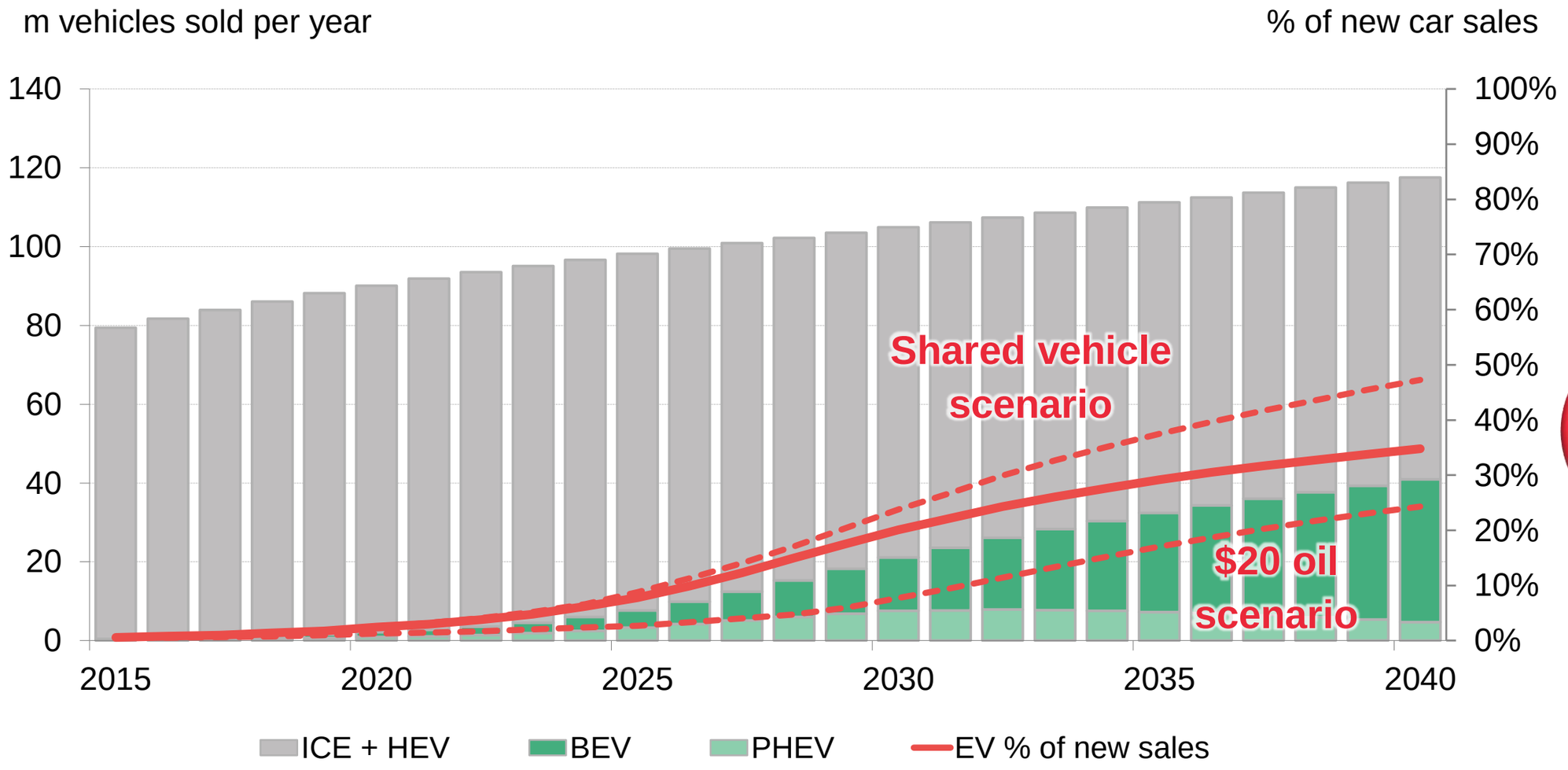


Note: Forecast range based on a learning rate of 14-20%. EV cost parity is calculated on an unsubsidised total cost of ownership (TCO) basis. Date range reflects cross over with different vehicle classes in the US.

Source: Bloomberg New Energy Finance. EV lithium-ion battery price index

GLOBAL LIGHT DUTY VEHICLE AND EV ANNUAL SALES, 2015–40
(M VEHICLES SOLD PER YEAR, %)

Bloomberg NEW ENERGY FINANCE



By 2040 Up to 50% of new cars will be EVs

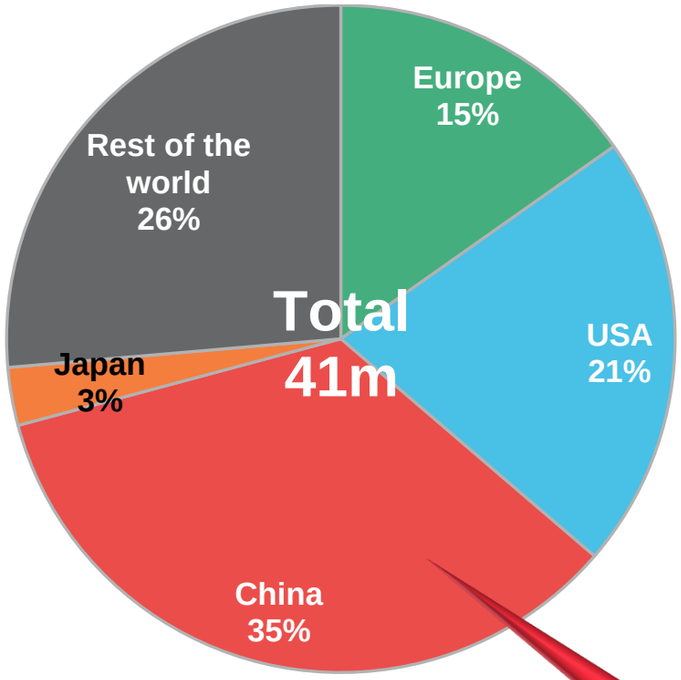
Note: forecast uses Gasoline and electricity prices from EIA's 2015 Annual Energy Outlook 'Low Oil Price' scenario (ranging from $50 to $65 per barrel between 2015 and 2025). High scenario assumes greater vehicle utilisation. Low scenario assumes $20 per barrel oil price

Source: Bloomberg New Energy Finance

ELECTRIFICATION OF TRANSPORTATION - IMPACTS

Bloomberg NEW ENERGY FINANCE

EV SALES BY REGION IN 2040 (MILLION VEHICLES)

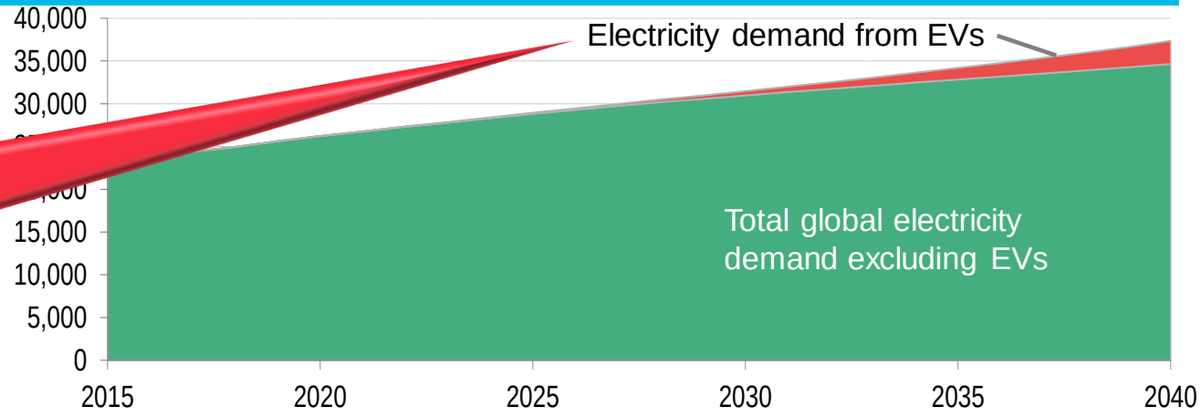


Around 10% additional power demand

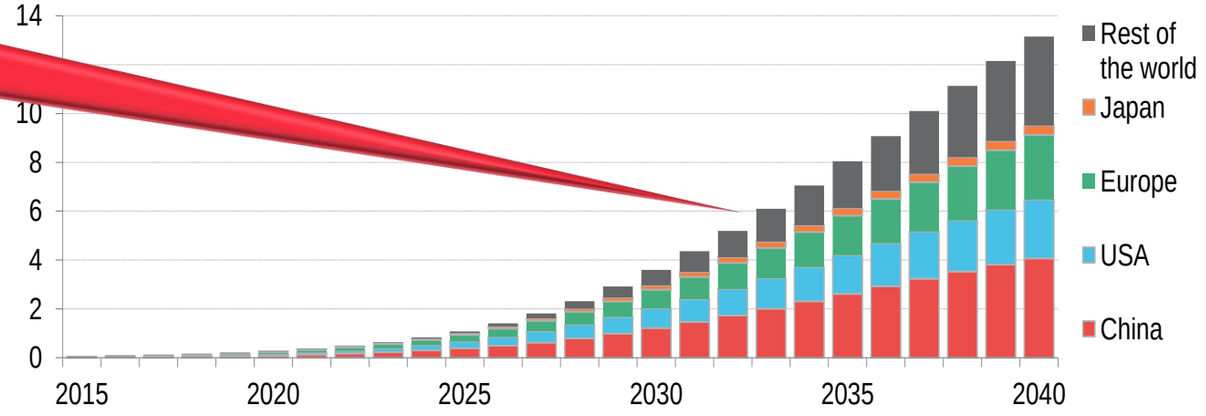
Destruction of 13m bbl/day oil demand

Chinese car industry leadership

ELECTRICITY DEMAND FROM EVS (TWH/YR)



OIL DEMAND DISPLACED BY EVS (MILLION BARRELS / DAY)



Source: Bloomberg New Energy Finance

ENERGY MIRACLE

Bloomberg NEW ENERGY FINANCE

“If you don’t invest in oil and gas, you will see [an oil price of] more than $200 [per barrel]”

Abdalla El-Badri
Secretary General, OPEC

Picture: Viking/Penguin

MATCHING SUPPLY AND DEMAND IS DONE DIFFERENTLY DEPENDING ON THE TIMESCALE

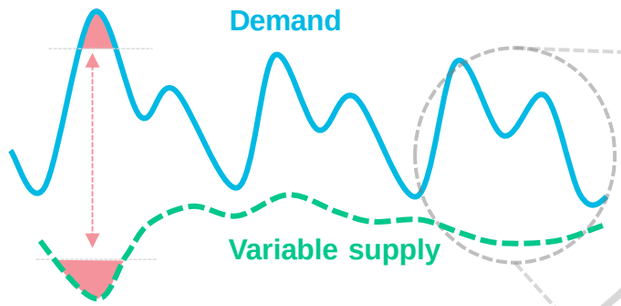
Bloomberg NEW ENERGY FINANCE

Years to Months

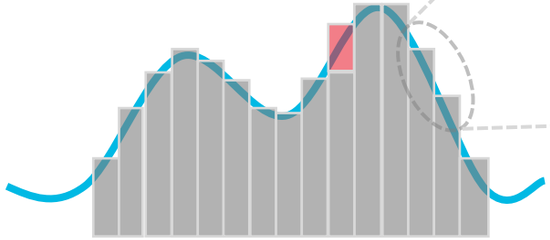
Days to minutes

Seconds to minutes

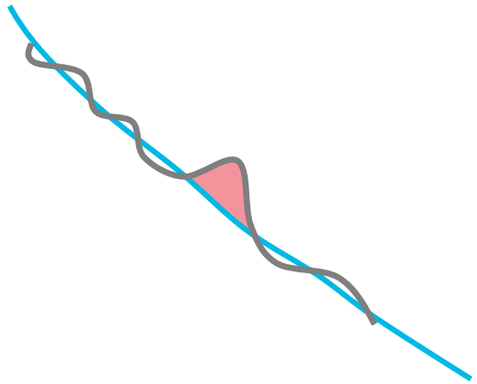
I. PLANNING FOR EXTREMES



II. CONTINUOUS BALANCING



III. CONTROLLING FREQUENCY



TRANSFORMING THE GRID

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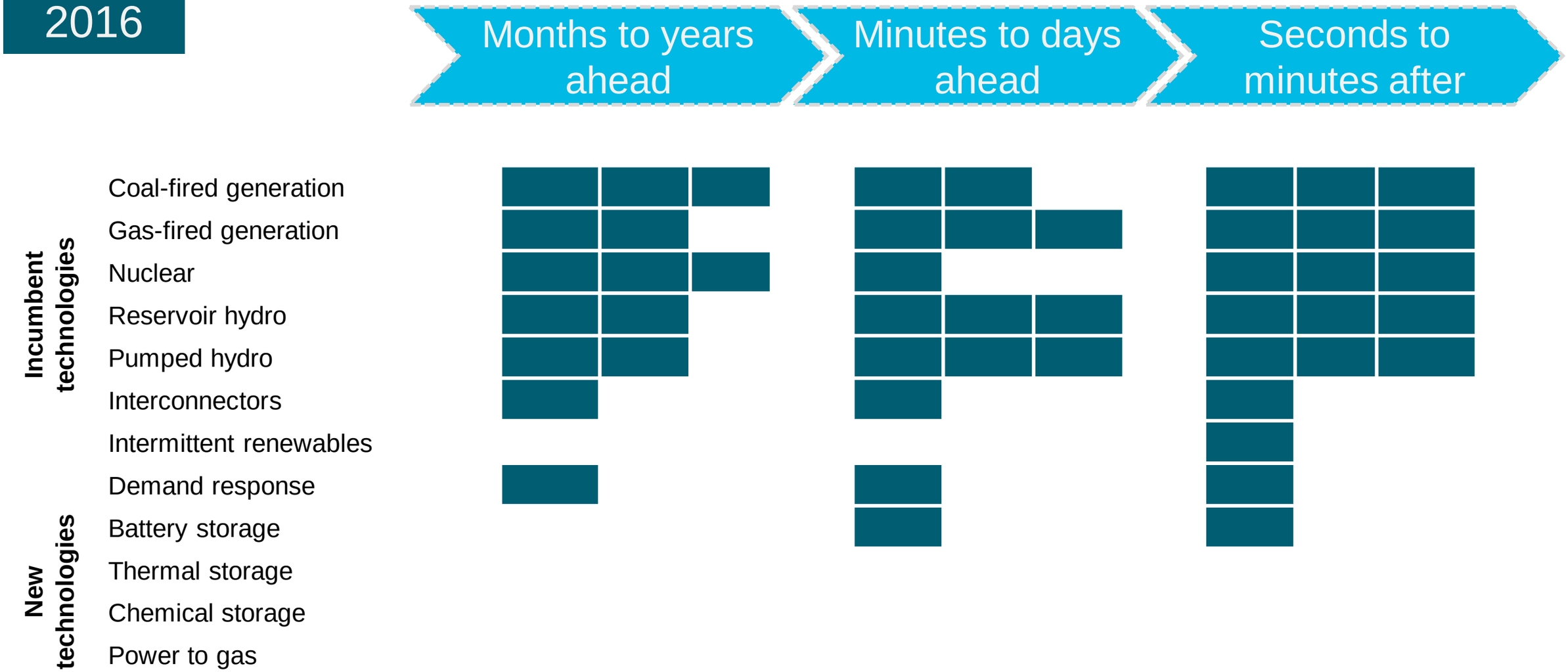
2016



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2016

Future

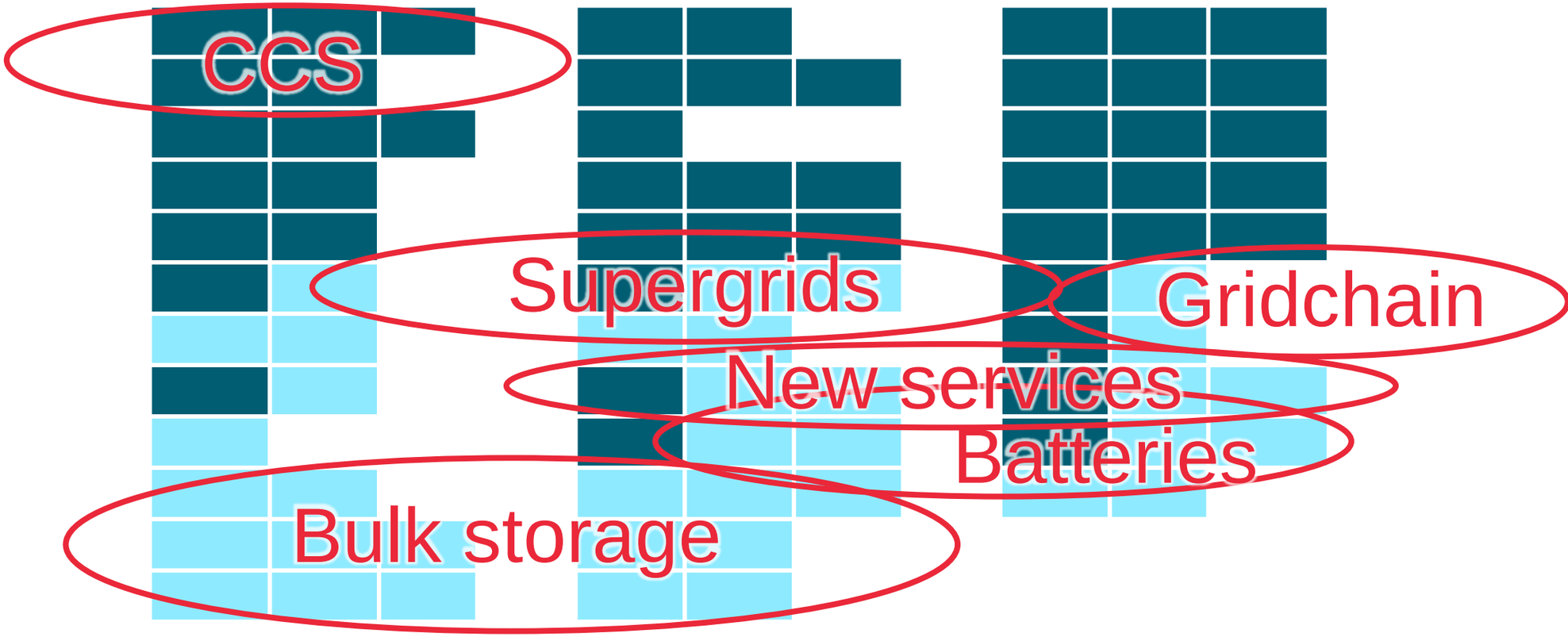
Months to years ahead → Minutes to days ahead → Seconds to minutes after

Incumbent technologies

- Coal-fired generation
- Gas-fired generation
- Nuclear
- Reservoir hydro
- Pumped hydro
- Interconnectors
- Intermittent renewables

New technologies

- Demand response
- Battery storage
- Thermal storage
- Chemical storage
- Power to gas



Thanks!

MARKETS
Renewable Energy
Energy Smart Technologies
Advanced Transport
Gas
Carbon and RECs

SERVICES
Americas Service
Asia Pacific Service
EMEA Service
Applied Research
Events and Workshops

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