Oxford, 28 November 2014

PHASE CHANGE AND THE GLOBAL ENERGY SYSTEM

SMITH SCHOOL, UNIVERSITY OF OXFORD

Michael Liebreich,
Chairman of the Advisory Board

Twitter: @mliebreich

Bloomberg
NEW ENERGY FINANCE

PHASE CHANGE

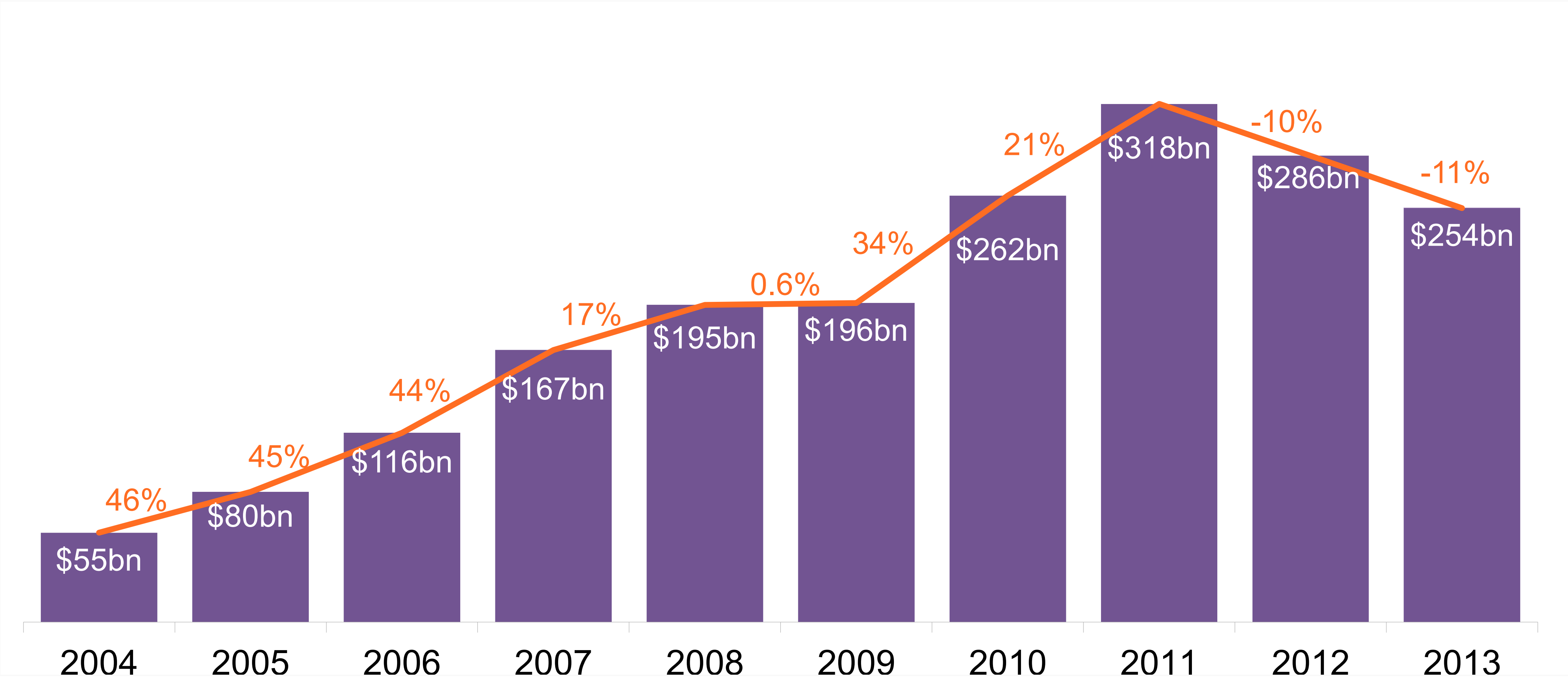
Bloomberg NEW ENERGY FINANCE

Phase Change (n): A change in a feature of a physical system that results in a discrete transition of that system to another state.

Source: Wikipedia Commons; The Free Dictionary

NEW INVESTMENT IN CLEAN ENERGY

2004-13 ($BN)

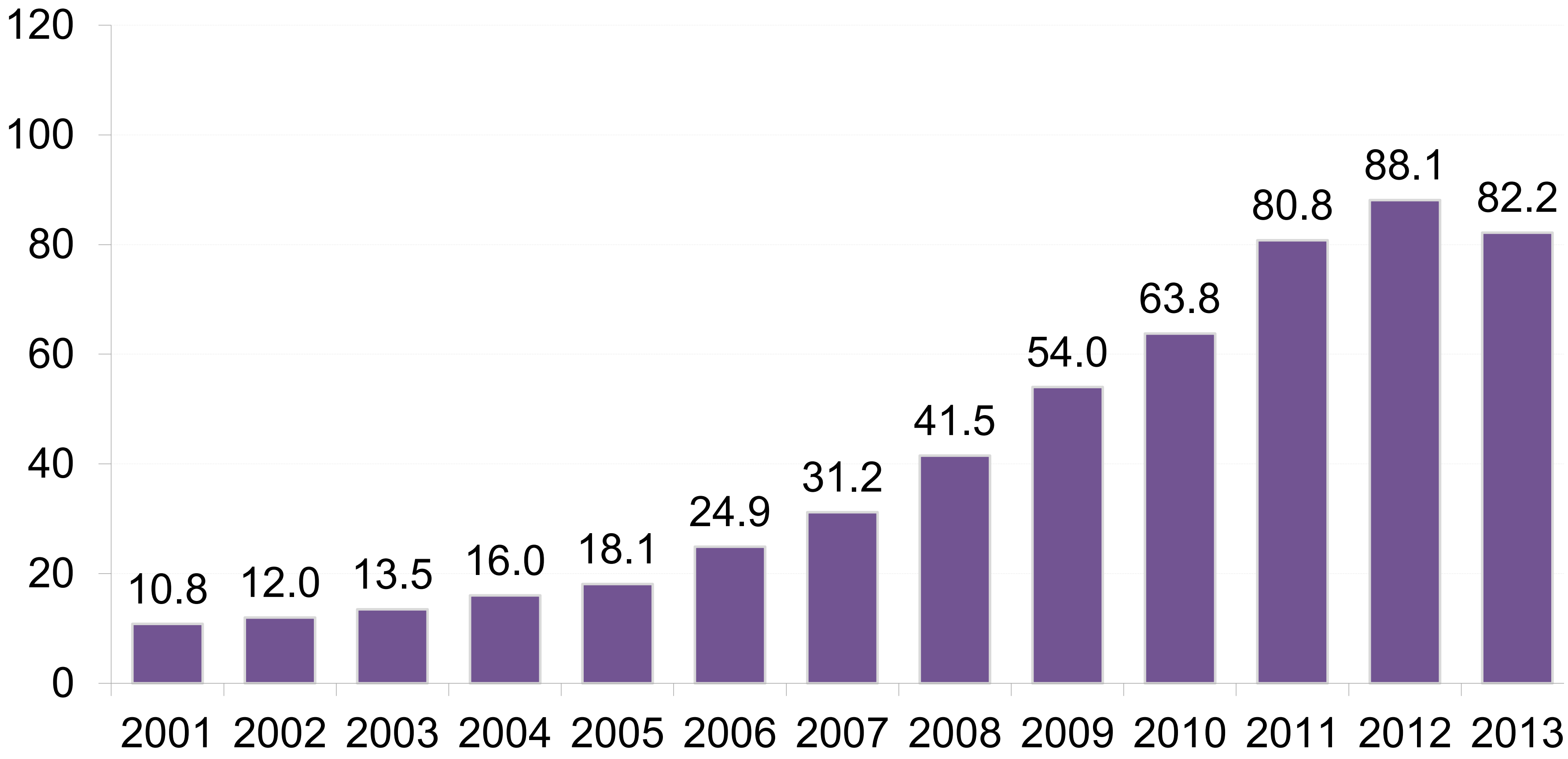


Note: Total values include estimates for undisclosed deals. Includes corporate and government R&D, and spending for digital energy and energy storage projects (not reported in quarterly statistics).

Source: Bloomberg New Energy Finance

RENEWABLE ENERGY NEW BUILD INSTALLATIONS
2001-13 (GW)

Bloomberg NEW ENERGY FINANCE

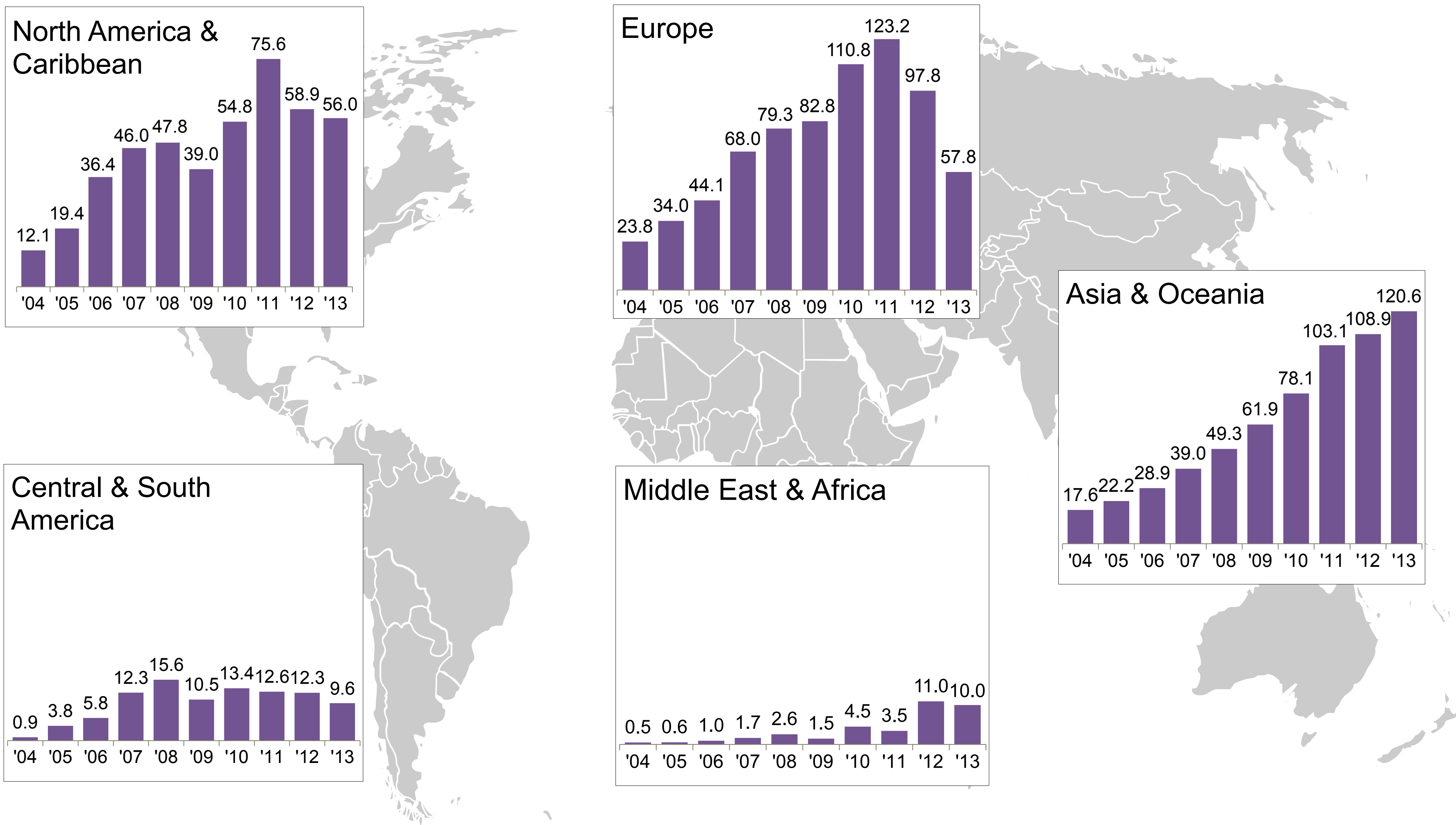


Note: Excludes large-scale hydro

Source: Bloomberg New Energy Finance

NEW INVESTMENT IN CLEAN ENERGY BY REGION
2004-13 ($BN)

Bloomberg NEW ENERGY FINANCE

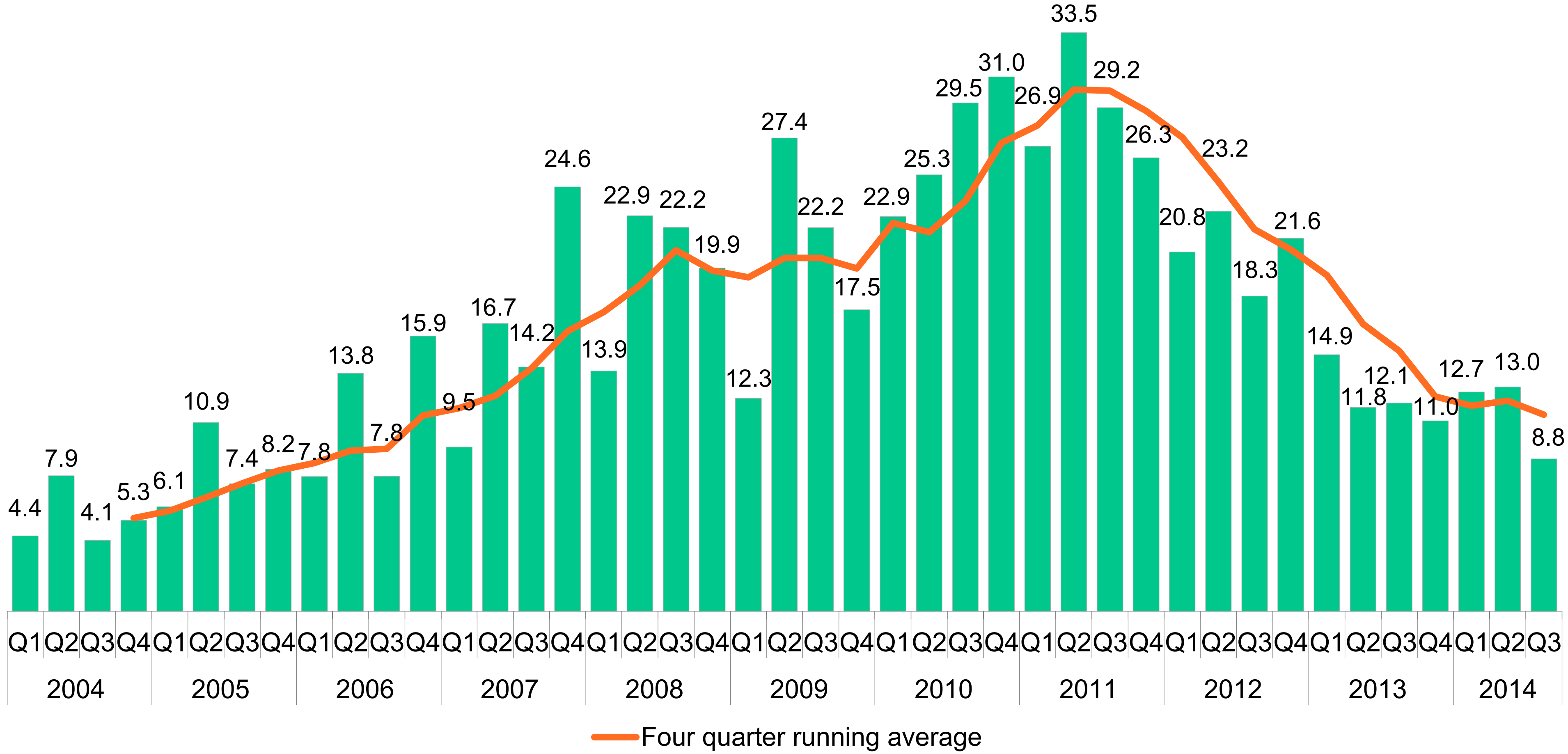


Source: Bloomberg New Energy Finance

NEW INVESTMENT IN CLEAN ENERGY IN EUROPE

Q1 2004-Q3 2014 ($BN)

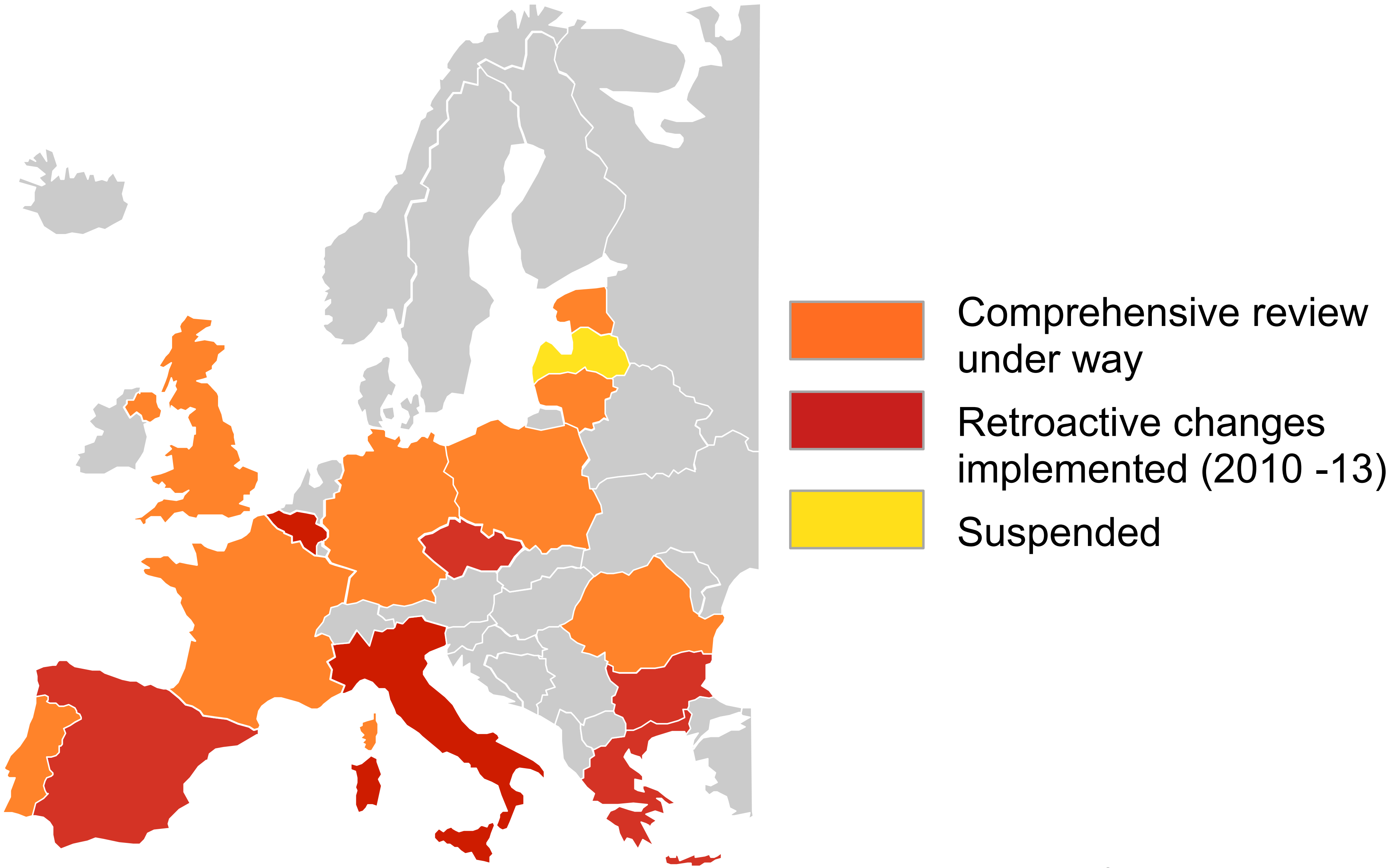
Bloomberg NEW ENERGY FINANCE



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

EUROPEAN POLICY SUPPORT SCHEMES UNDER REVIEW, 2013



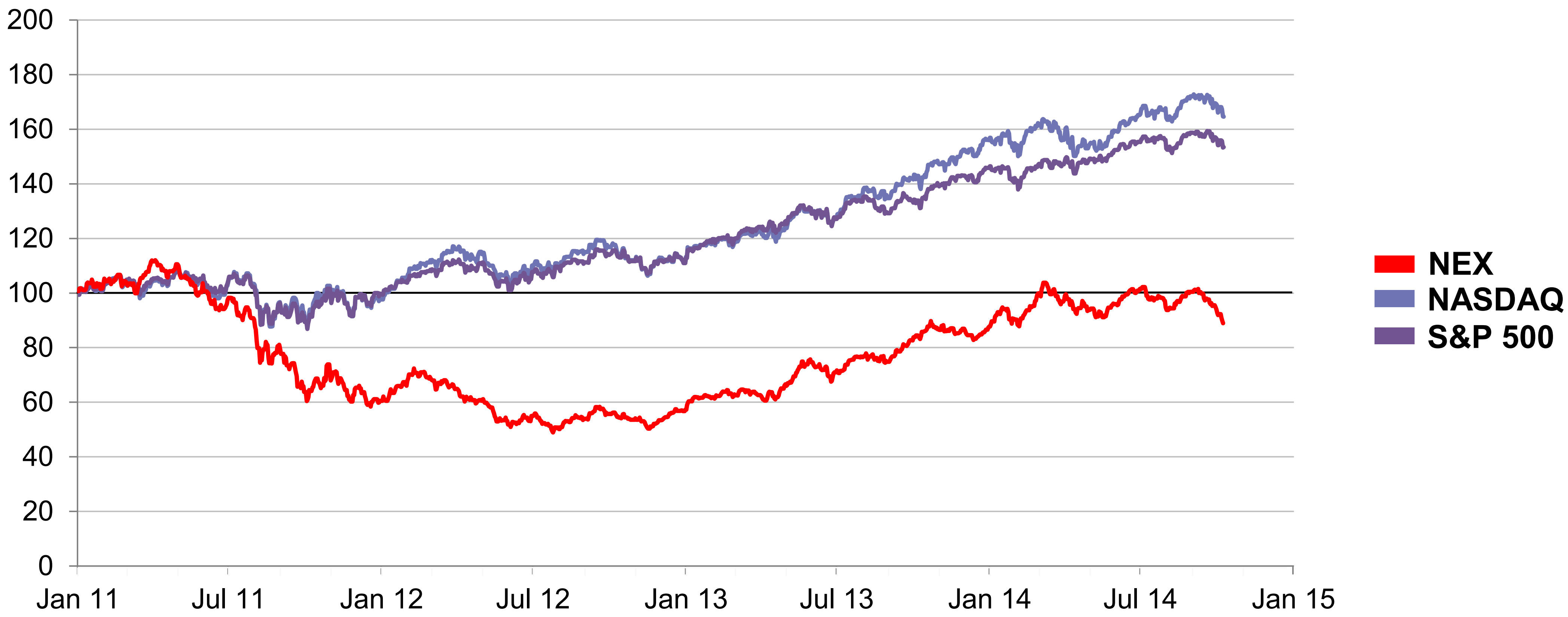
Source: Bloomberg New Energy Finance

2010–13: CONSOLIDATION

Bloomberg NEW ENERGY FINANCE

Source: Bloomberg New Energy Finance

NEX CLEAN ENERGY INDEX 2011 – 2014 YTD



Note: Values as of 08 October 2014; NASDAQ and S&P 500 rebased to 100 on 01 Jan 2011

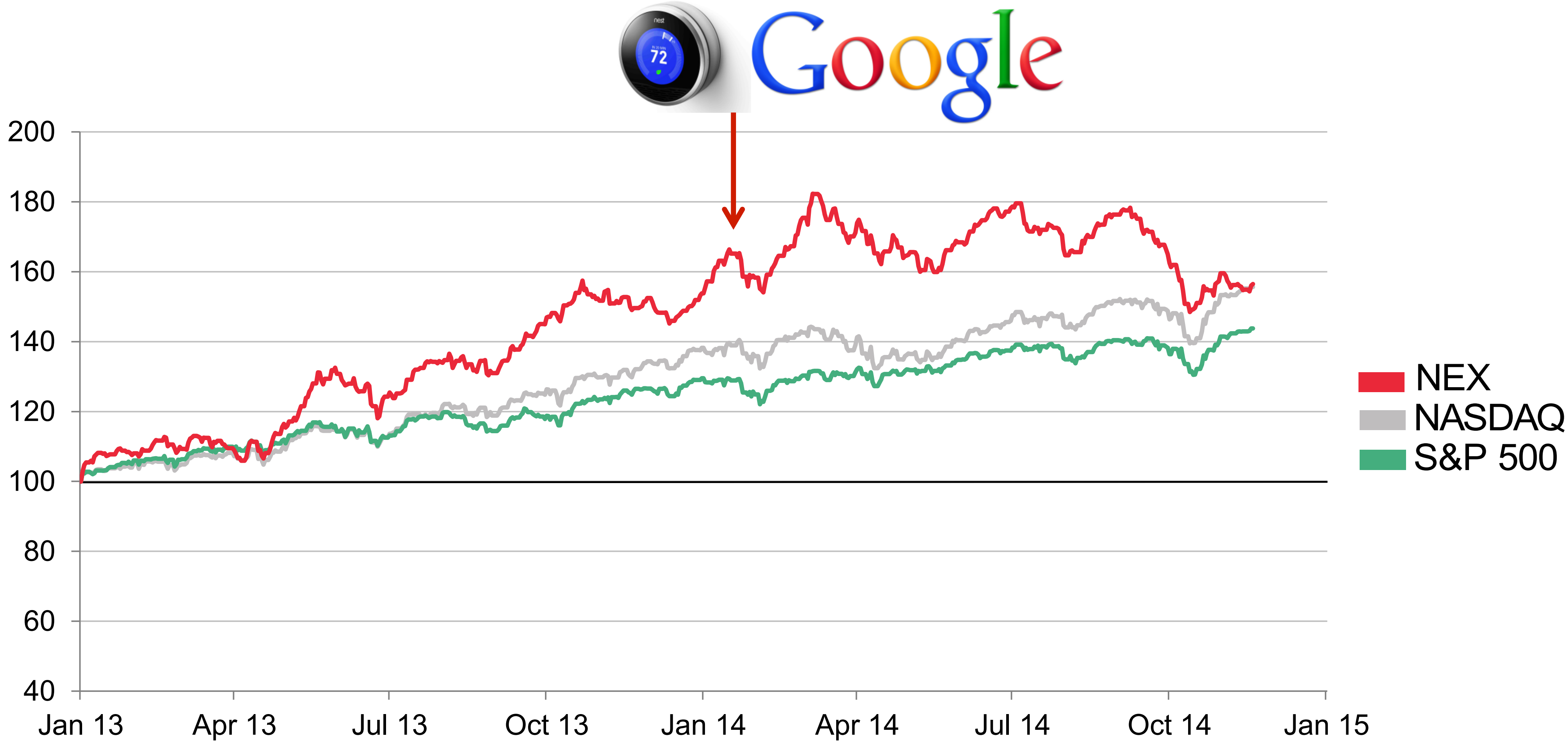
Source: Bloomberg New Energy Finance

5 JANUARY 2014 – CBS/CNBC CLEANTECH CRASH

Credit: CNBC / CBS

NEX CLEAN ENERGY INDEX 2014 YTD

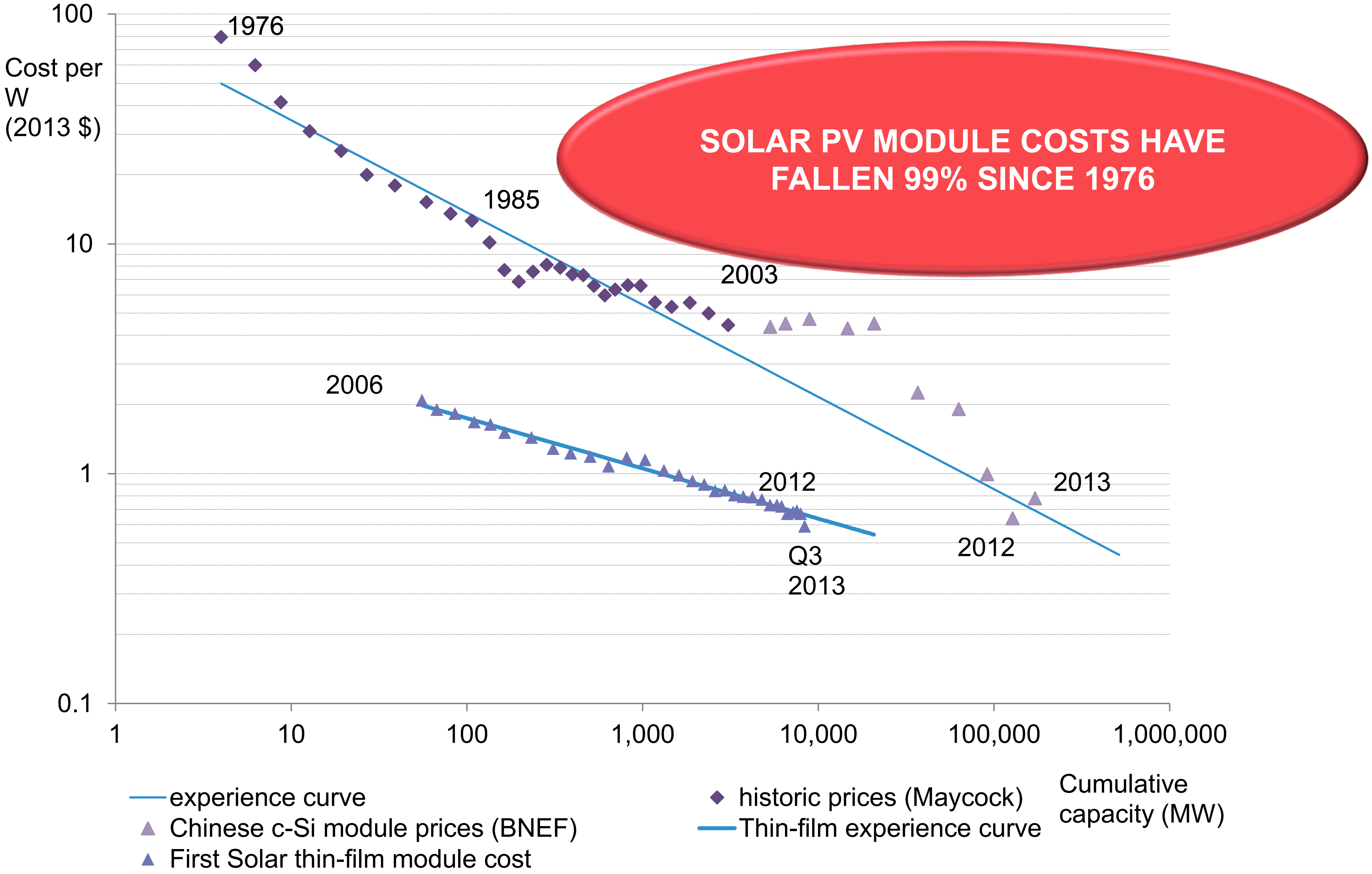
Bloomberg
NEW ENERGY FINANCE



Note: Values as of 19 November 2014; NASDAQ and S&P 500 rebased to 100 on 01 Jan 2013

Source: Bloomberg New Energy Finance

PV EXPERIENCE CURVE
1976-2013 (2013 $/W)

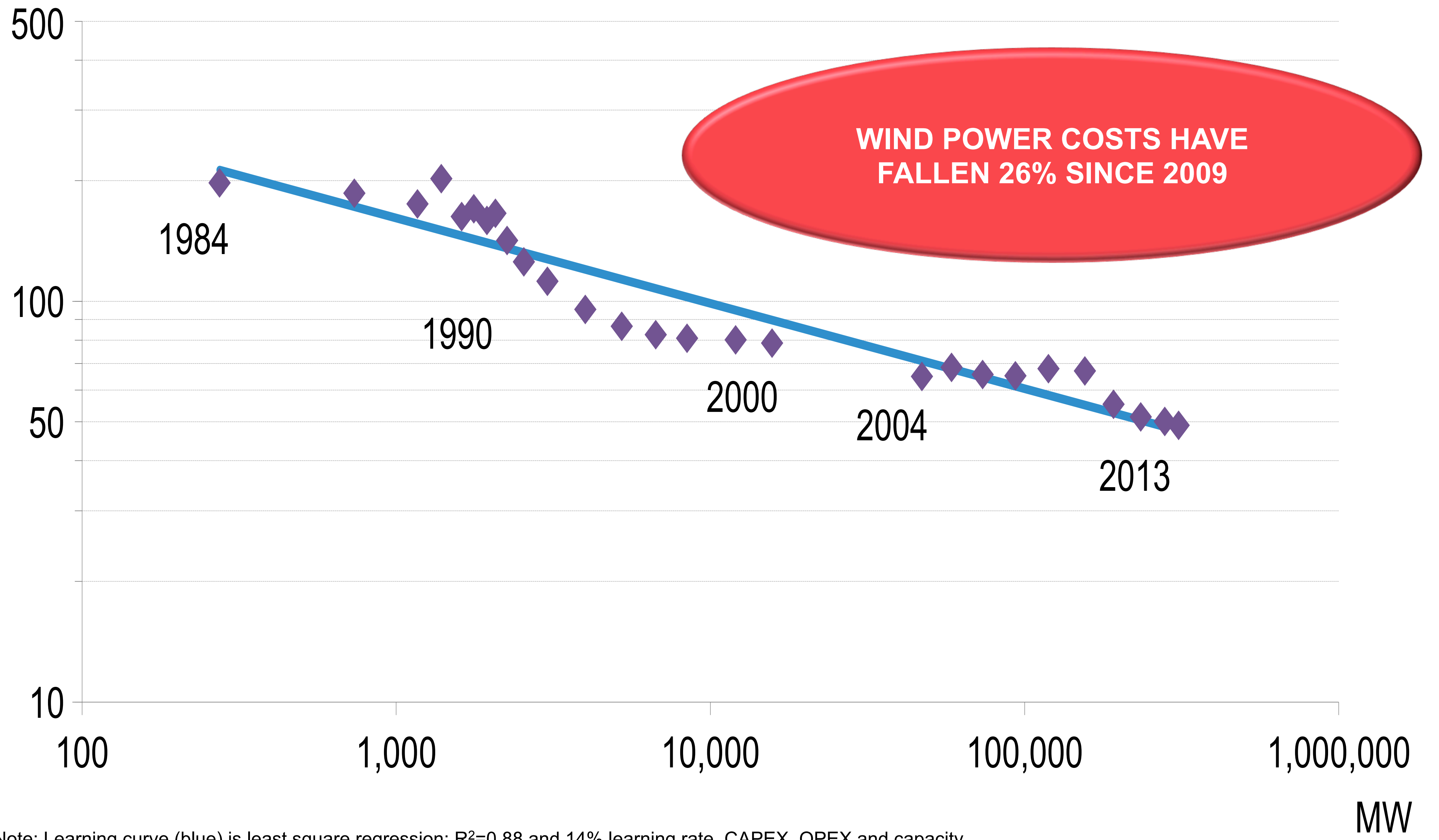


Note: Prices inflation indexed to US PPI.

Source: Paul Maycock, First Solar, Bloomberg New Energy Finance

AVERAGE LEVELISED COST OF ONSHORE WIND

1984-2013 (EUR/MWH)

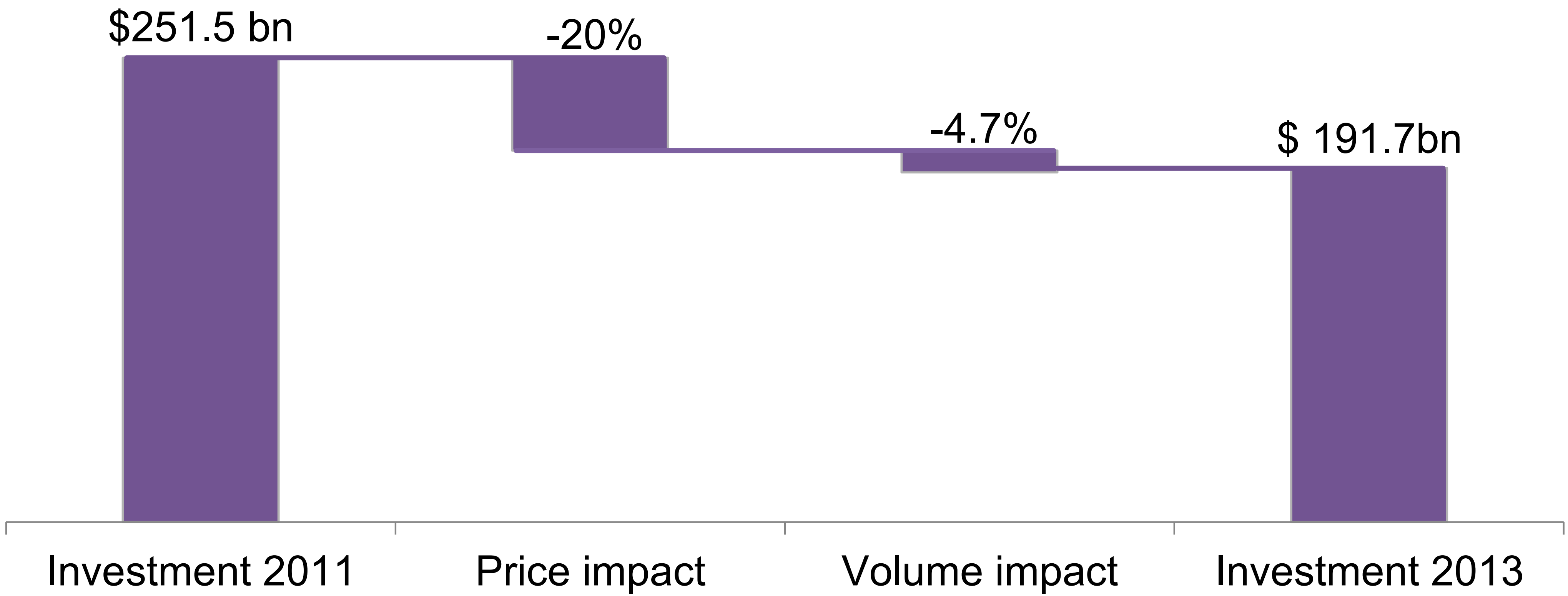


Note: Learning curve (blue) is least square regression: R^2=0.88 and 14% learning rate. CAPEX, OPEX and capacity factor evolution is included in this LCOE analysis; financing assumptions kept constant.

Source: Bloomberg New Energy Finance, ExTool

DRIVERS OF REDUCED ASSET INVESTMENT
2011-13

Bloomberg NEW ENERGY FINANCE

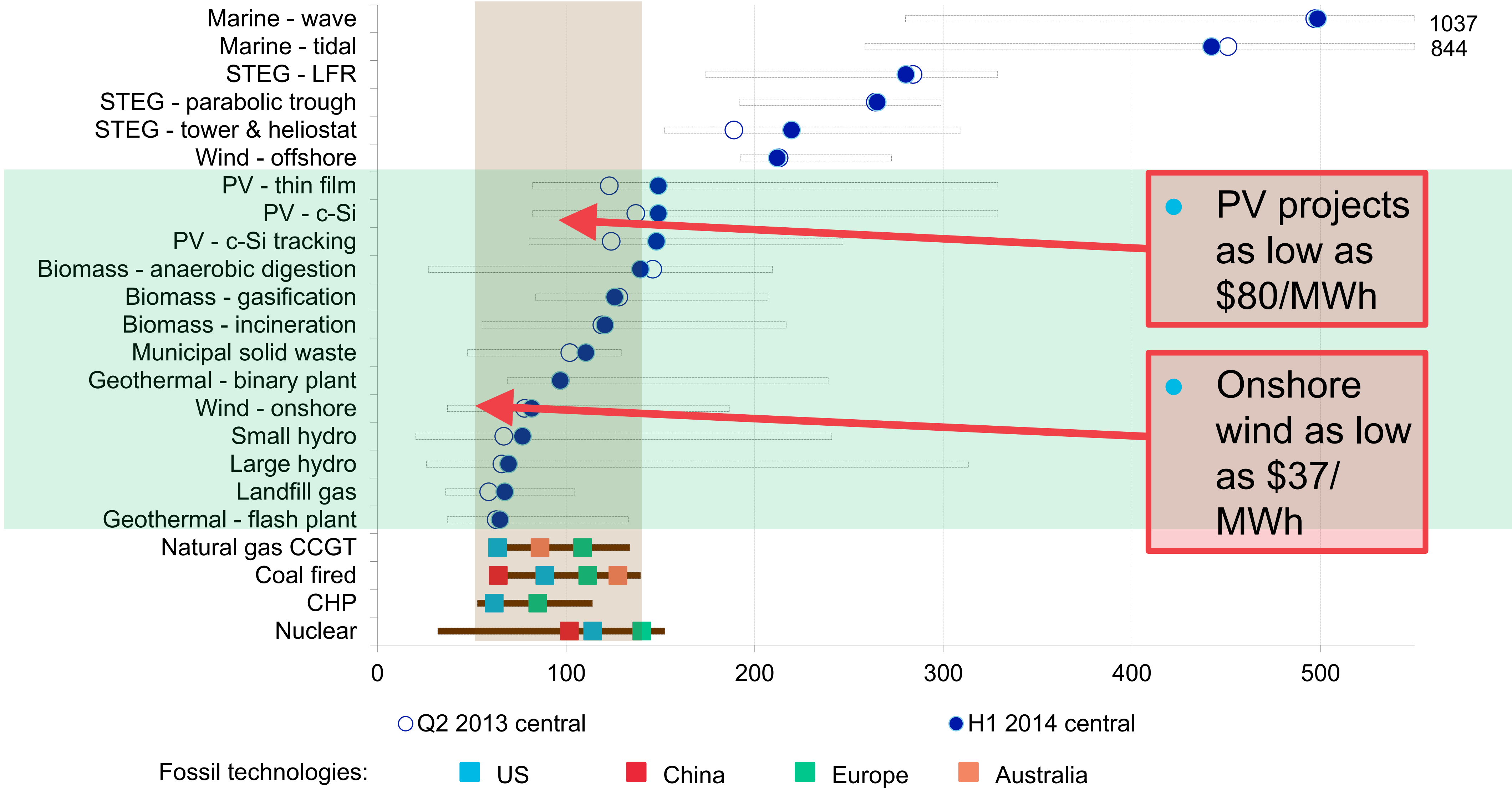


Note: Based on a high level calculation of global figures for all renewable energy sectors. Impacts of regional and sector shifts are internalised here.

Source: Bloomberg New Energy Finance

LEVELISED COST OF ELECTRICITY
H1 2014 ($/MWH)

Bloomberg NEW ENERGY FINANCE

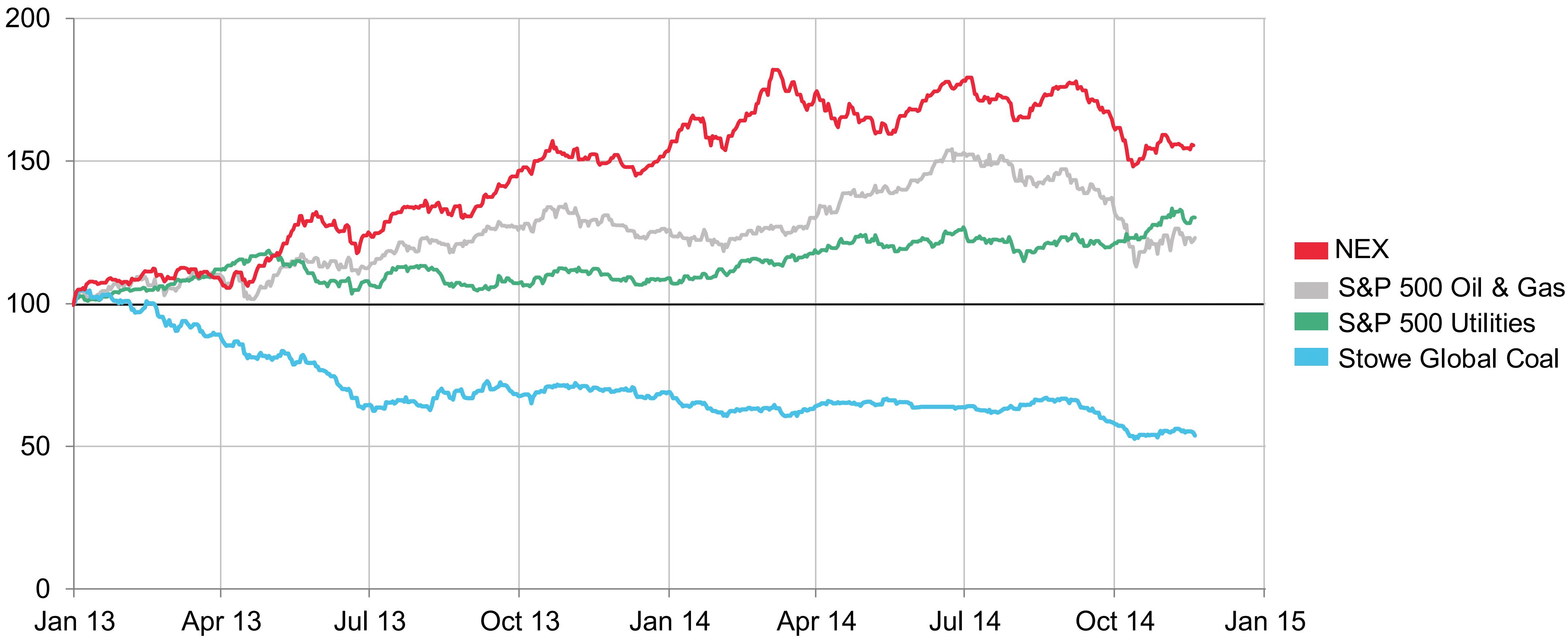


Note: LCOEs for coal and CCGTs in Europe and Australia assume a carbon price of $20/t. No carbon prices are assumed for China and the US.

Source: Bloomberg New Energy Finance

NEX CLEAN ENERGY INDEX 2013 – 2014 YTD

Bloomberg
NEW ENERGY FINANCE

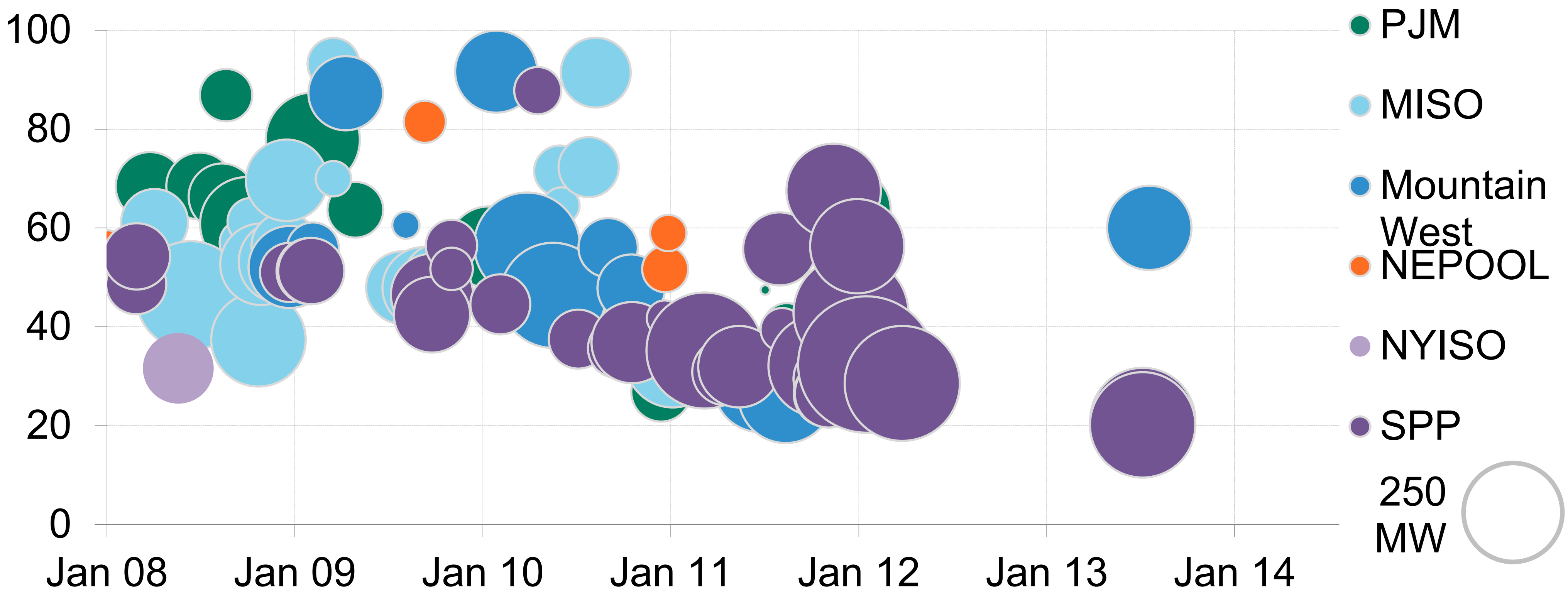


Note: Values as of 21 November 2014; Stowe and S&P 500 rebased to 100 on 01 Jan 2013

Source: Bloomberg New Energy Finance

US WIND PPA PRICES BY SIGNING DATE
H1 2008–H2 2013 ($/MWH)

Bloomberg NEW ENERGY FINANCE



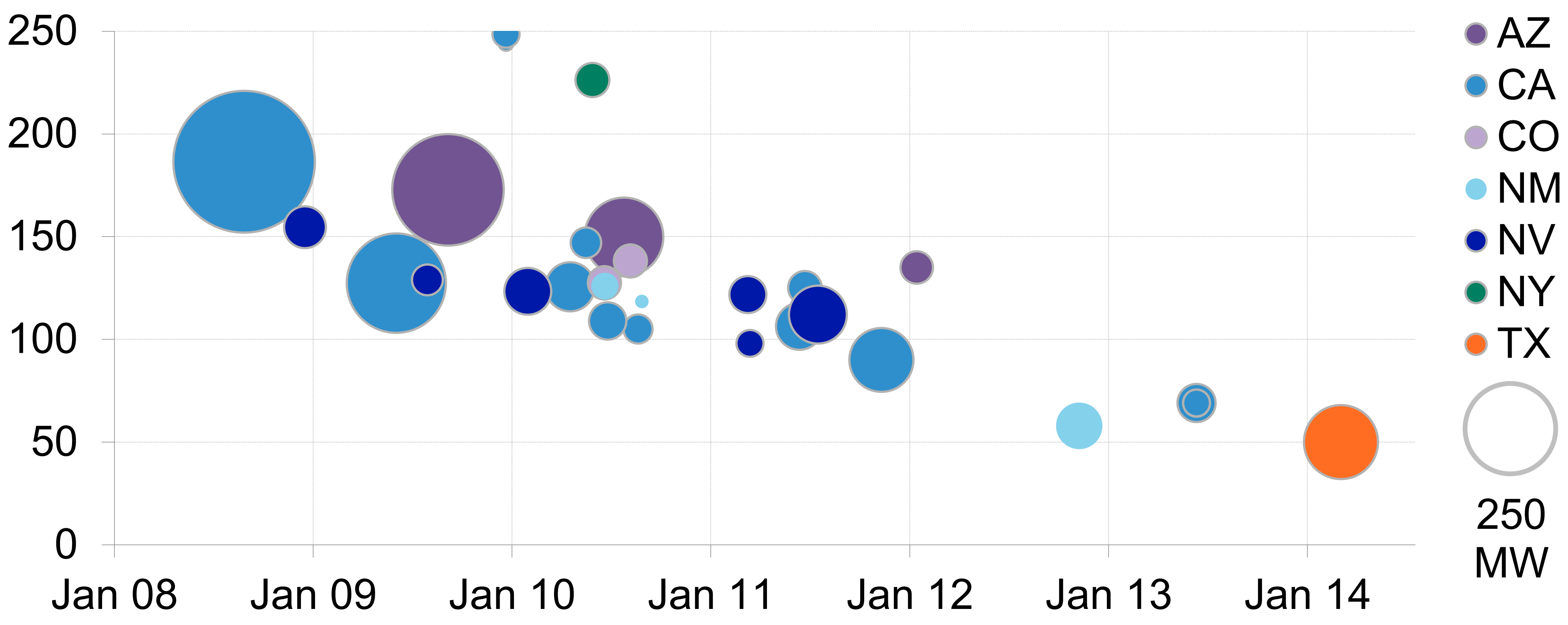
Note: Does not include PPAs under 5MW. ‘PPA price’ is calculated as the average offtake price over the period of project operation. For projects reporting to FERC, the PPA price is calculated as the average selling price over the operating history of the project. For projects not reporting to FERC, the PPA price represents the ‘year1’ selling price.

Source: Bloomberg New Energy Finance, FERC

US SOLAR PPA PRICES BY SIGNING DATE

H1 2008–H2 2013 ($/MWH)

Bloomberg NEW ENERGY FINANCE

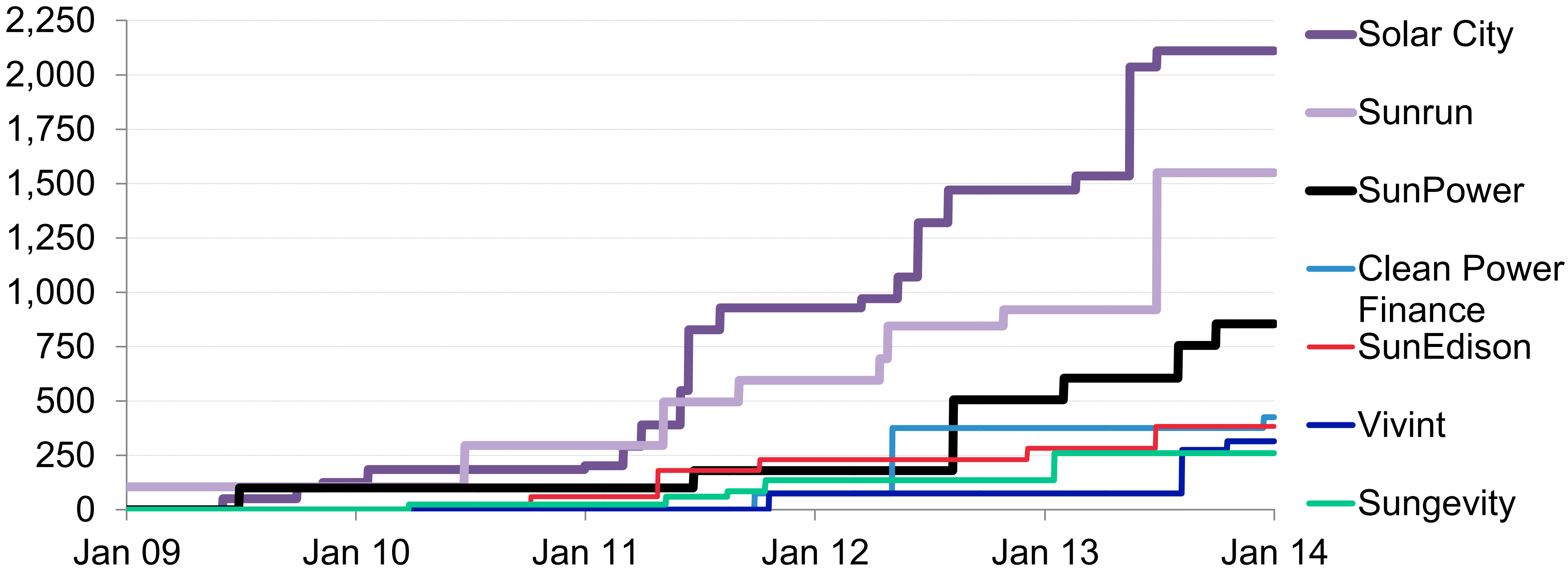


Note: Does not include PPAs under 5MW. 'PPA price' is calculated as the average offtake price over the period of project operation. For projects reporting to FERC, the PPA price is calculated as the average selling price over the operating history of the project. For projects not reporting to FERC, the PPA price represents the 'year1' selling price.

Source: Bloomberg New Energy Finance, FERC

CUMULATIVE FUNDS CLOSED BY SELECTED THIRD-PARTY FINANCIERS, JAN 2009-MAR 2014 ($M)

Bloomberg NEW ENERGY FINANCE

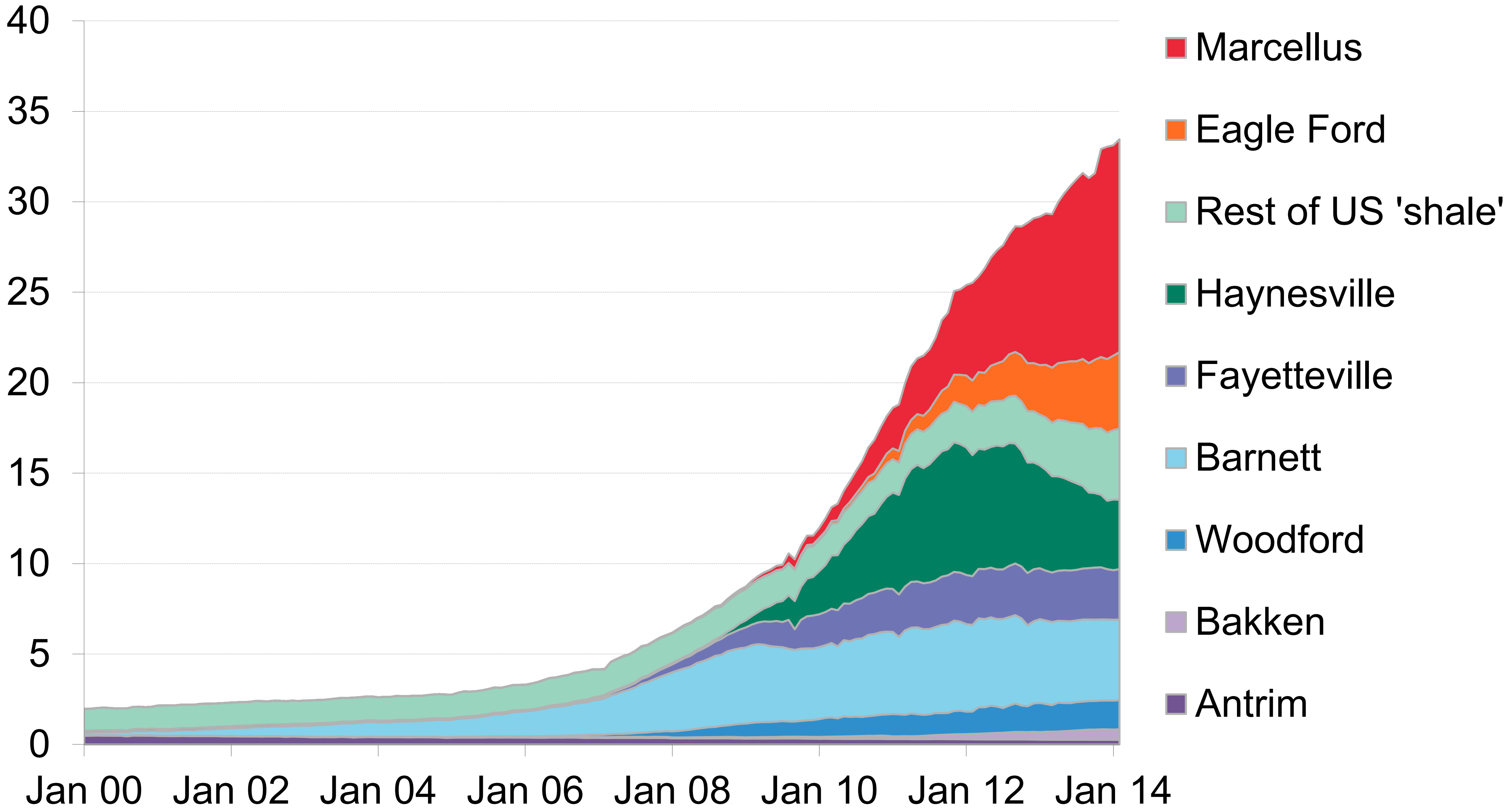


Note: This represents fund size; actual capital invested is lower and non-public. This figure may not include all non-public deals. Does not include all third-party financiers. Each fund contains an unknown combination of equity, tax equity or debt (or an absence of tax equity or debt). *The $300m Clean Power Finance fund raised on 3 May 2012 does not contain tax equity

Source: Bloomberg New Energy Finance

US AGE OF GAS UPDATE 1: VOLUME
SHALE GAS PRODUCTION BY FIELD, (BCFD)

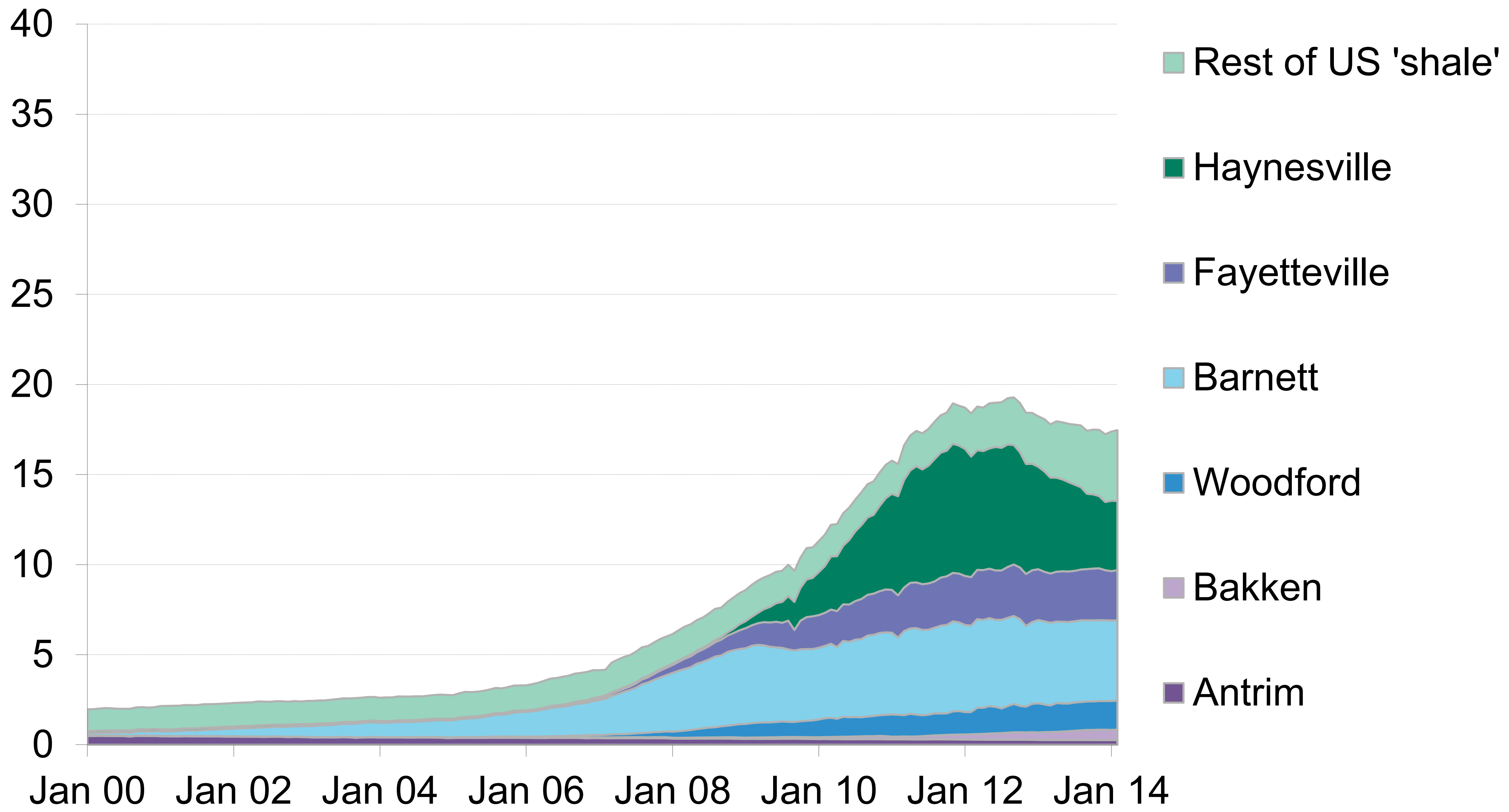
Bloomberg
NEW ENERGY FINANCE



Source: EIA, Bloomberg New Energy Finance

US AGE OF GAS UPDATE 1: VOLUME SHALE GAS PRODUCTION BY FIELD, (BCFD)

Bloomberg NEW ENERGY FINANCE

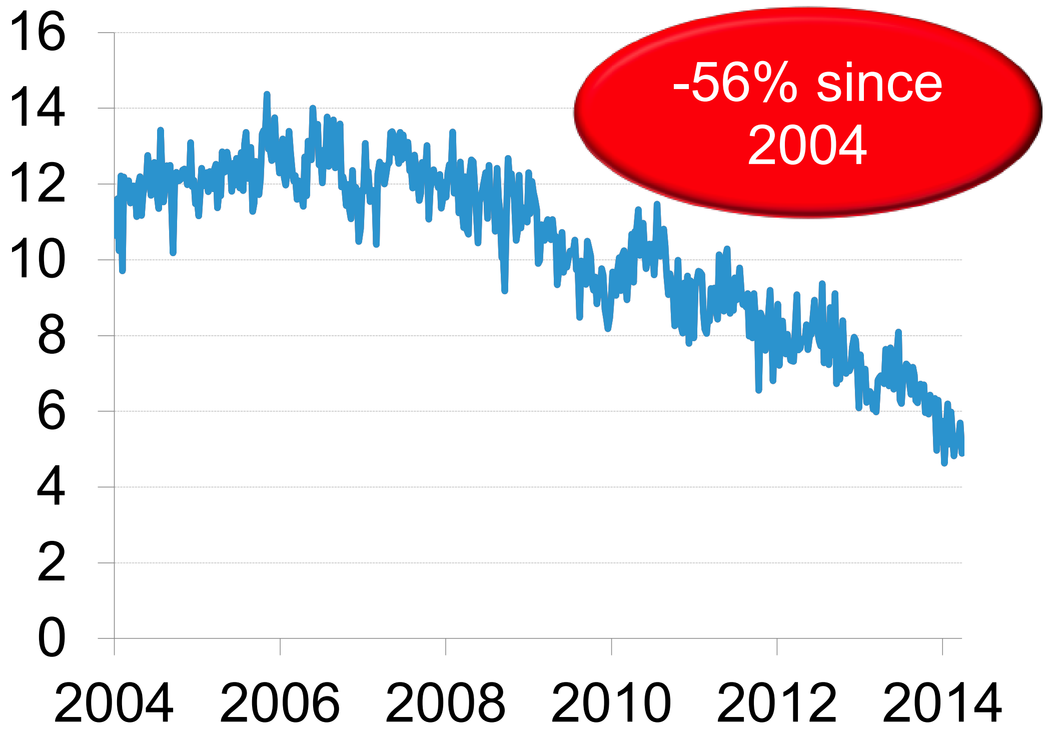


Source: EIA, Bloomberg New Energy Finance

US CRUDE OIL
(M BARRELS / DAY)

Bloomberg NEW ENERGY FINANCE

IMPORTS



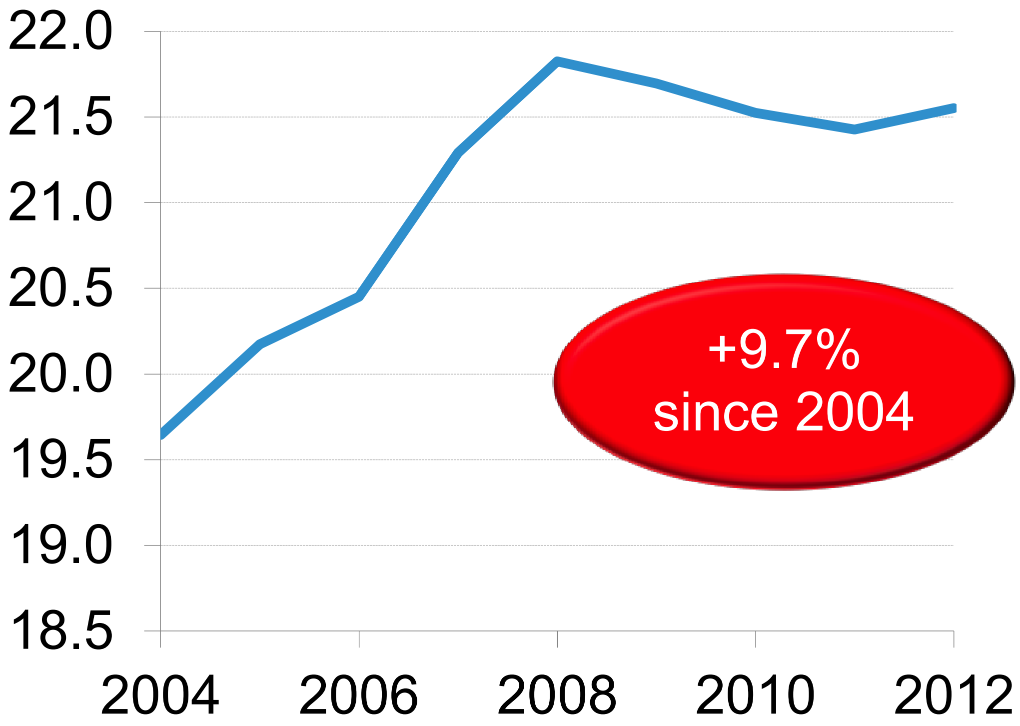
PRODUCTION

Source: EIA; Bloomberg New Energy Finance

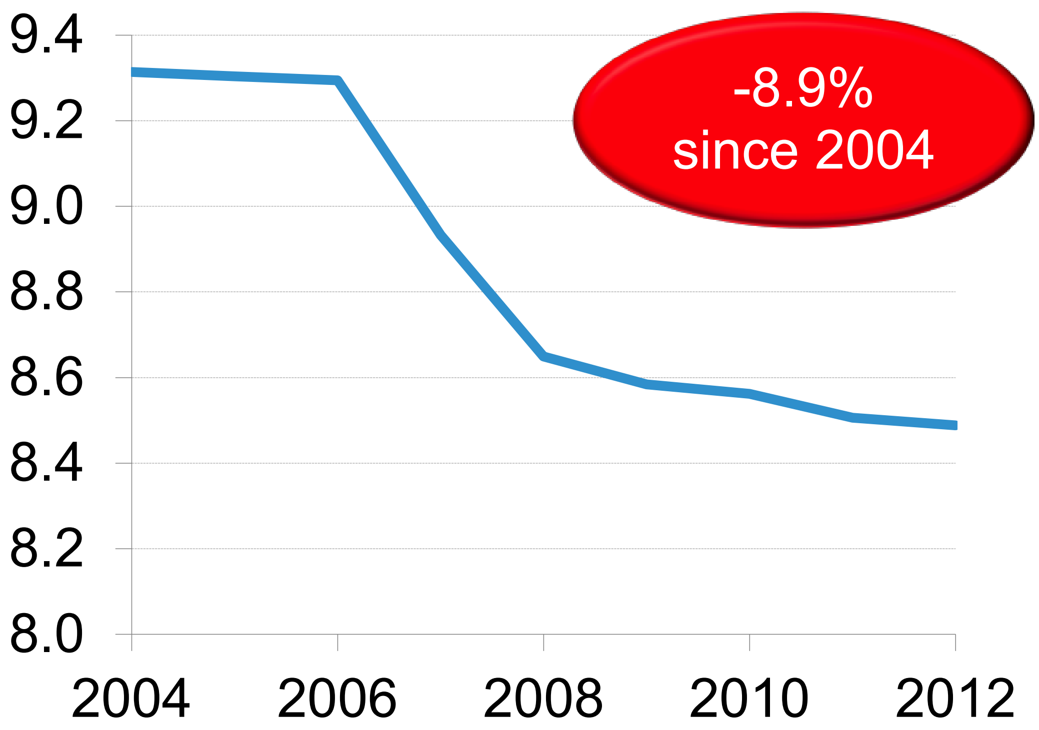
US CAR USE AND FUEL EFFICIENCY

Bloomberg NEW ENERGY FINANCE

FUEL EFFICIENCY (MILES/GALLON)



ANNUAL VEHICLE-DISTANCE TRAVELLED (1,000 MILES PER PERSON)



Note: Mpg figures are sales weighted average. Total vehicle miles grew at 2.7% CAGR between 1971 and 2007

Source: US DOT, University of Michigan Transportation Research Institute, Bloomberg New Energy Finance

CHINA'S AIR QUALITY PROBLEM
(PM2.5 µg per cubic meter)

Bloomberg NEW ENERGY FINANCE

Picture credit: Feng Li/Getty Images

993

Beijing
12 Jan 2013

World Health Organisation Guideline

25

CHINESE PREMIER DECLARES WAR ON POLLUTION

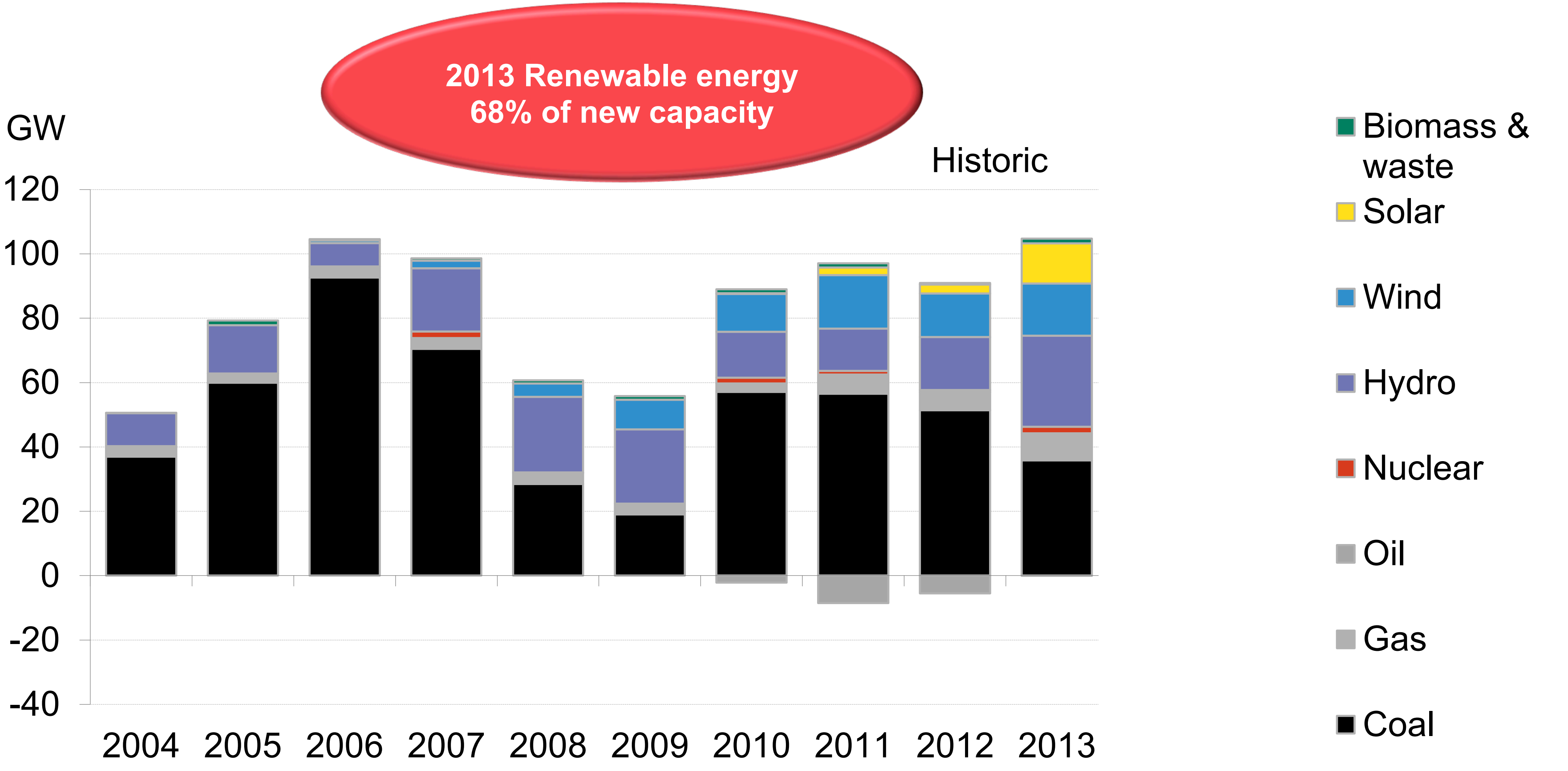
"We will resolutely declare war against pollution as we declared war against poverty"

Li Keqiang
Premier of the People's Republic of China
March 2014

Credit: Bloomberg

CHINA POWER GENERATION CAPACITY ADD BY TECHNOLOGY, 2004-13, 2020 & 2030

Bloomberg NEW ENERGY FINANCE

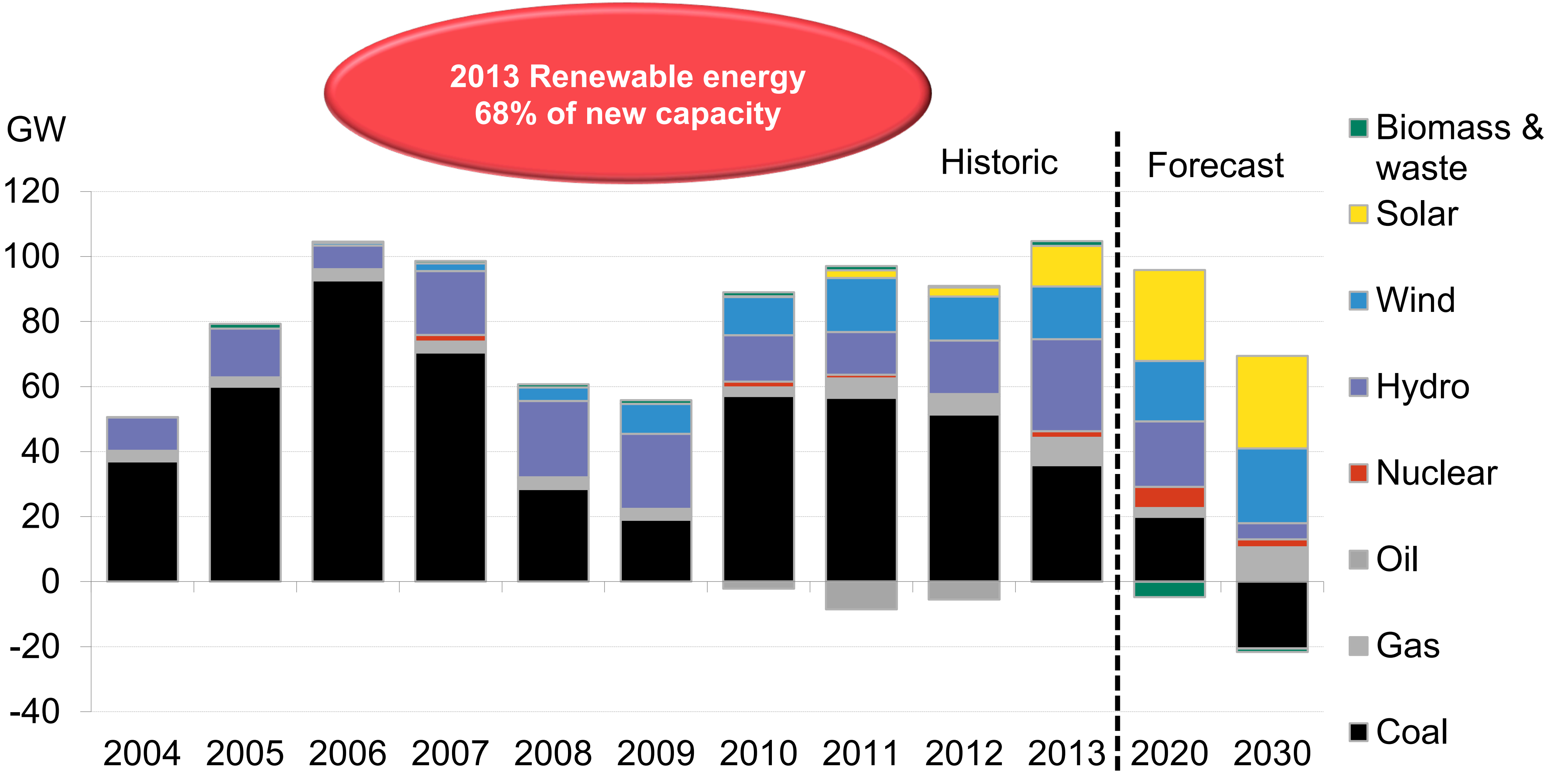


Note: 2020 & 2030 forecasts from BNEF Global Renewable Energy Outlook 2014.

Source: Bloomberg New Energy Finance, China Electricity Council

CHINA POWER GENERATION CAPACITY ADD BY TECHNOLOGY, 2004-13, 2020 & 2030

Bloomberg NEW ENERGY FINANCE

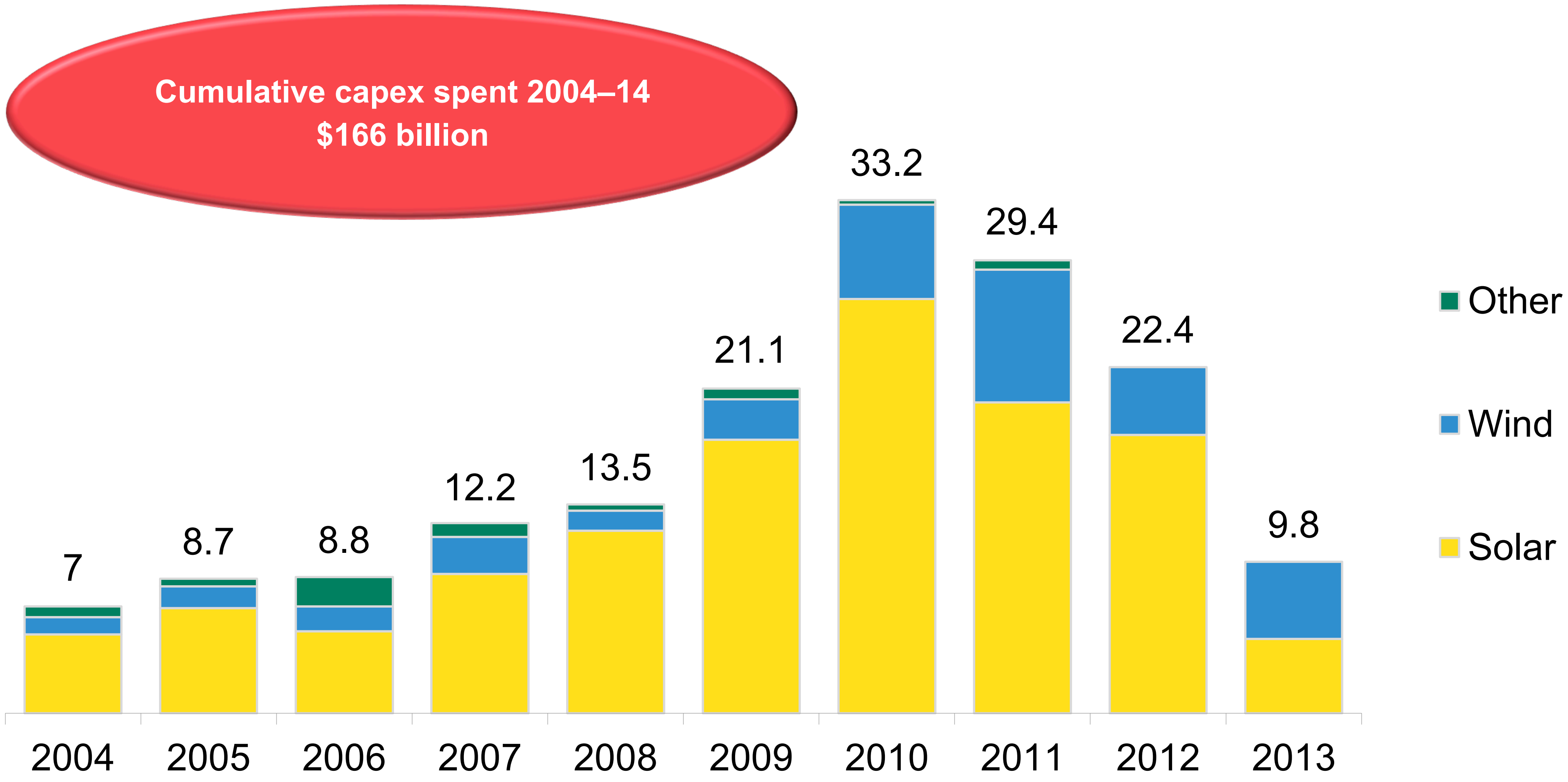


Note: 2020 & 2030 forecasts from BNEF Global Renewable Energy Outlook 2014.

Source: Bloomberg New Energy Finance, China Electricity Council

ENERGIEWENDE 2: INVESTMENT IN RENEWABLE POWER GENERATING CAPACITY, ($ BN)

Bloomberg NEW ENERGY FINANCE

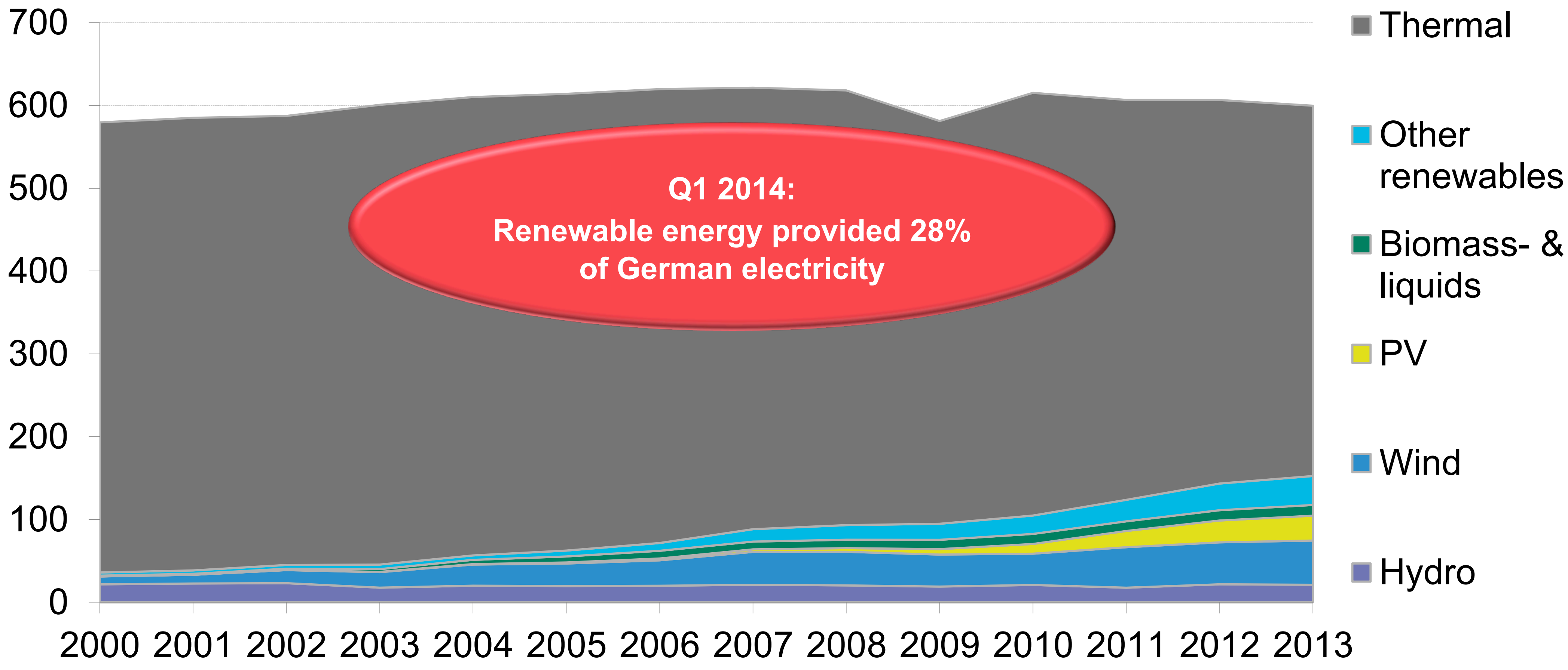


Note: Investment figures includes asset finance and small distributed capacity investment. Biofuels and other non-power generation sectors excluded.

Source: Bloomberg New Energy Finance.

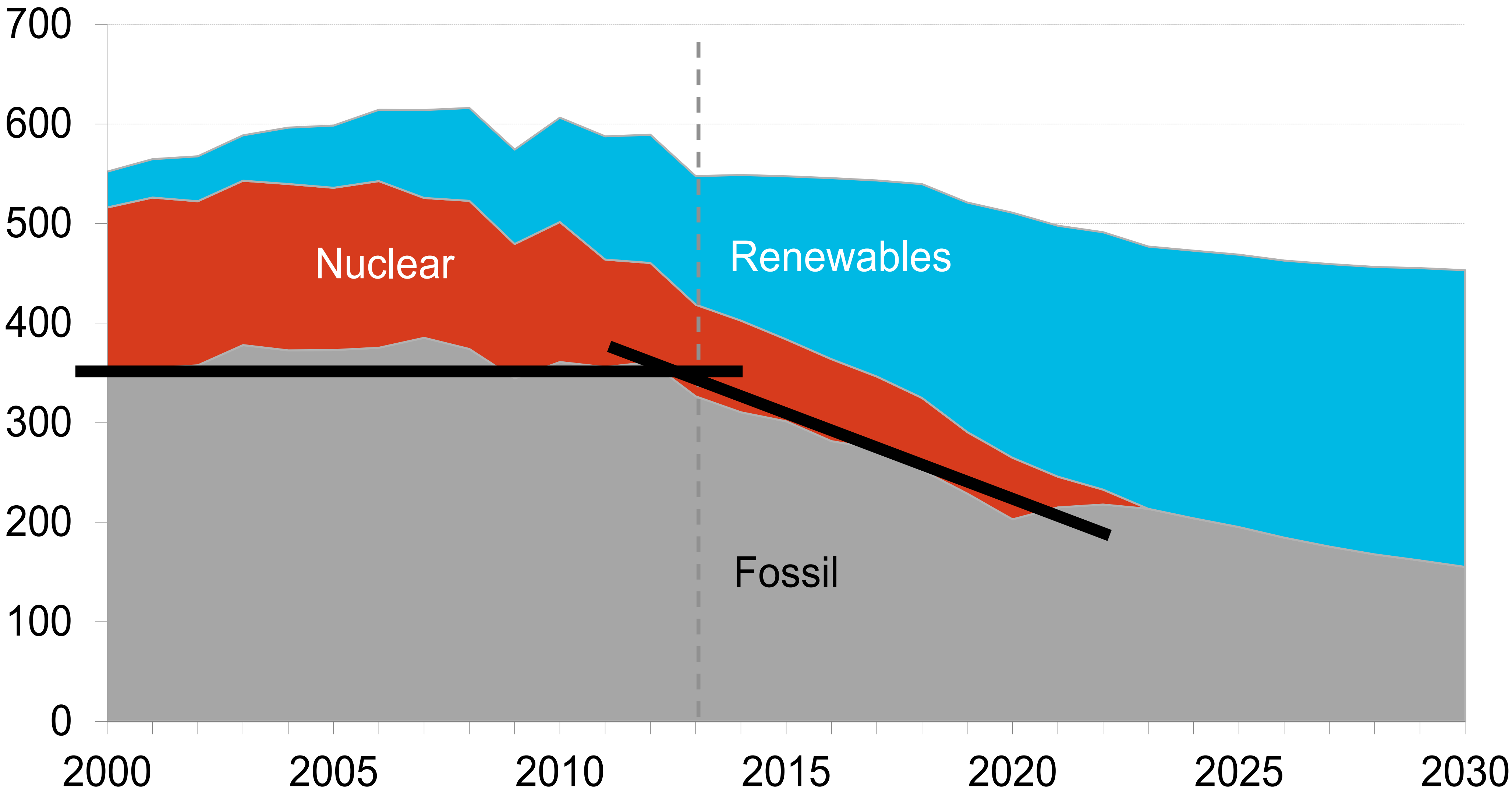
ENERGIEWENDE 1: CHANGES IN GENERATING MIX (TWH)

Bloomberg NEW ENERGY FINANCE



Source: Bloomberg New Energy Finance, BMWI

ENERGIEWENDE
2000–30 (TWH)

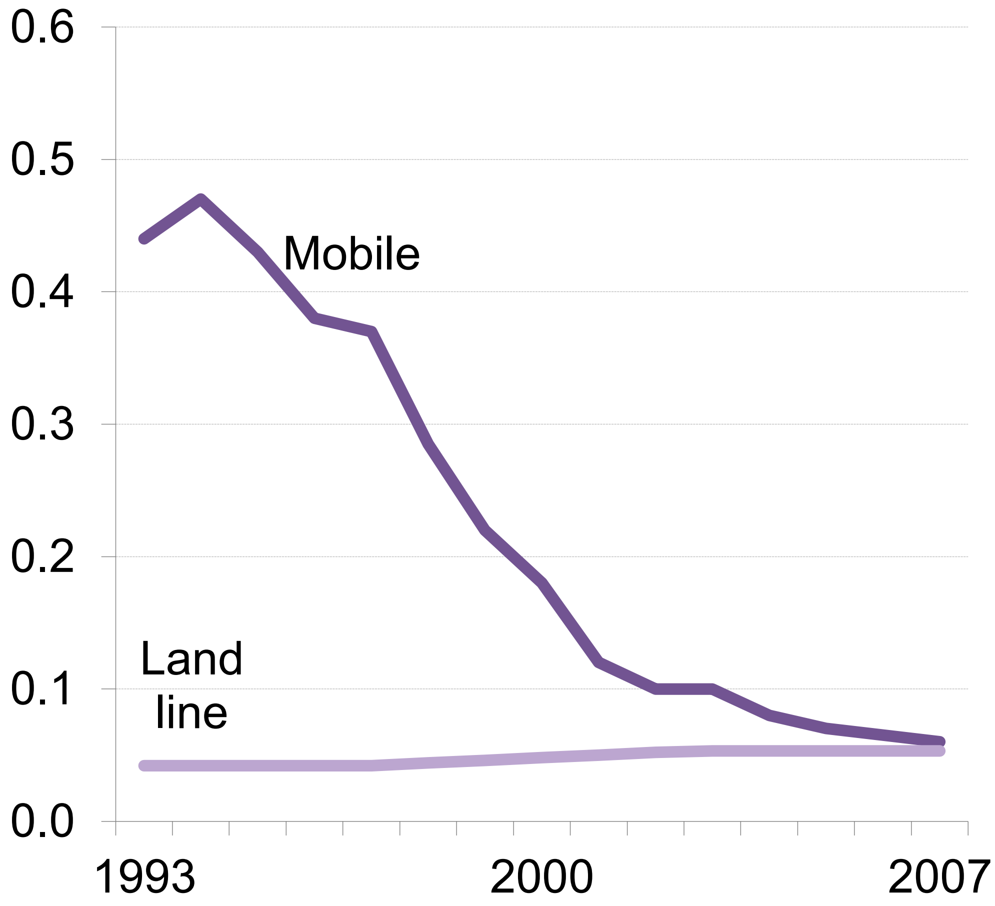


Source: Bloomberg New Energy Finance, Destatis

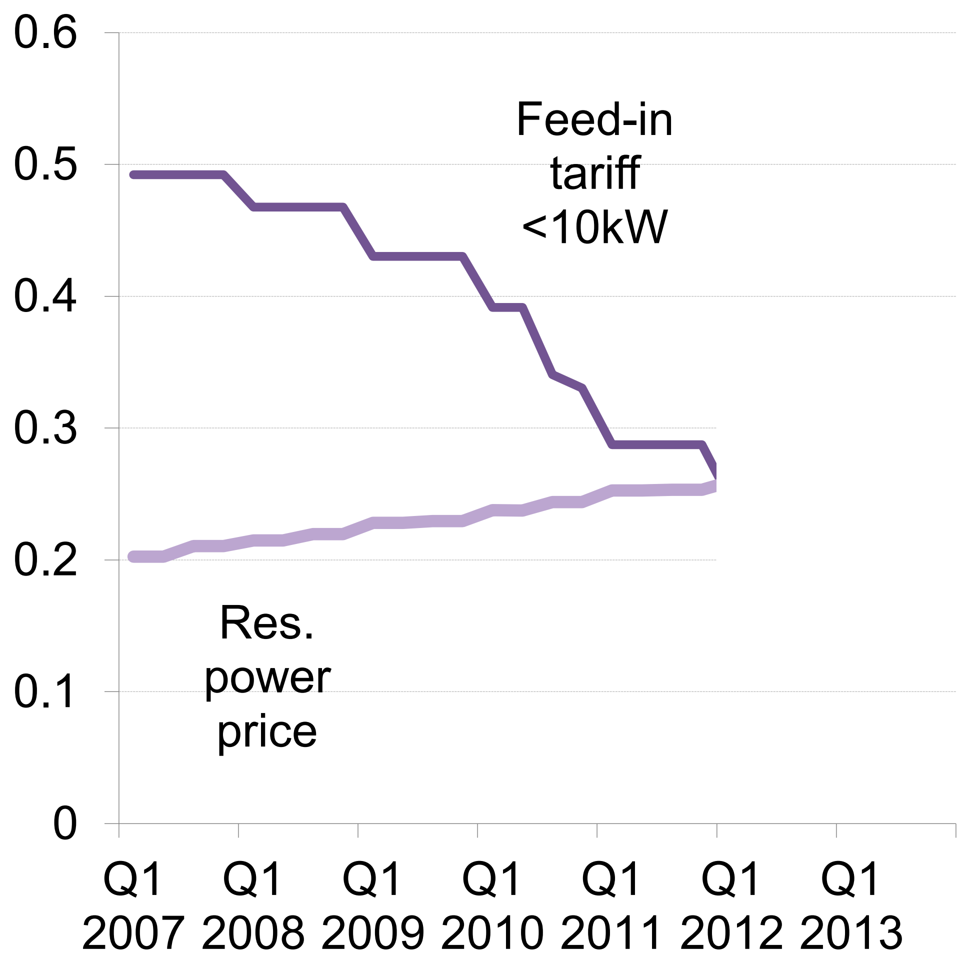
ENERGIEWENDE 4: IMPACT ON RETAIL PRICES

Bloomberg NEW ENERGY FINANCE

US FIXED LINE VS. MOBILE PRICES ($/MIN)



GERMAN FIT VS. RESIDENTIAL POWER PRICES (EUR/MWH)

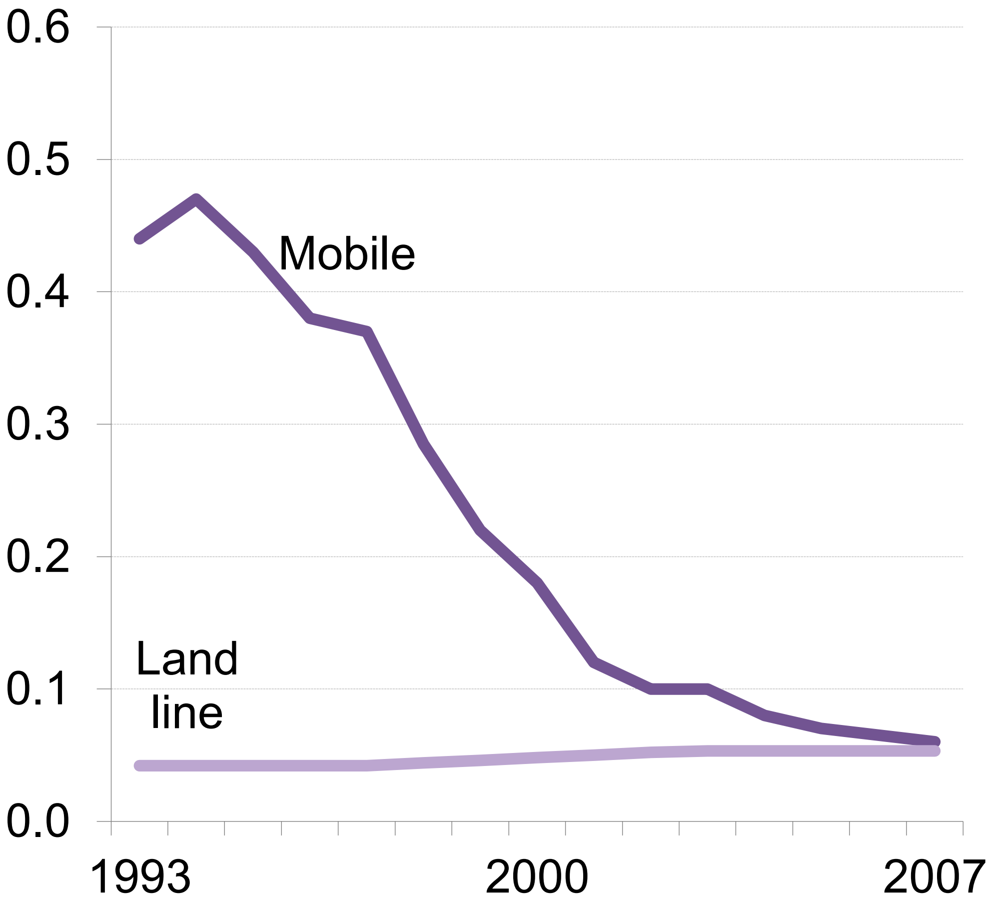


Source: Bloomberg New Energy Finance, Bloomberg L.P., BSW Solar, Eurostat, Federal Communications Commission

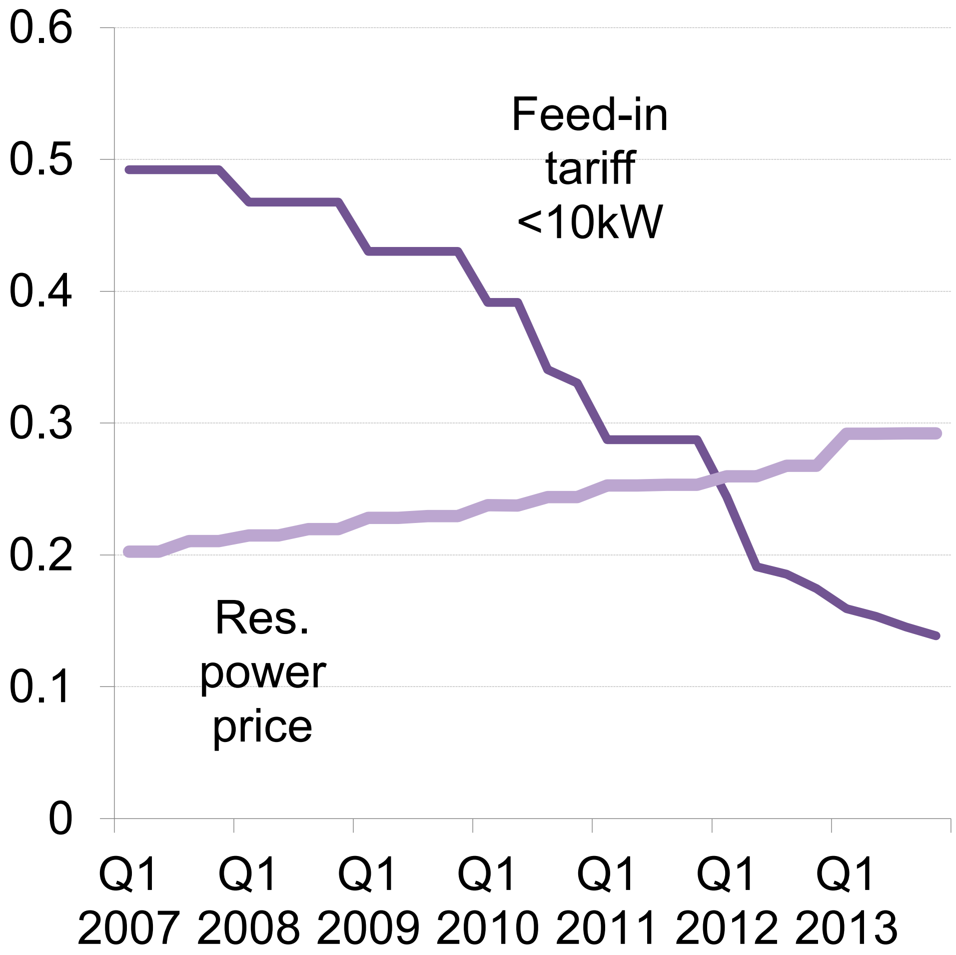
ENERGIEWENDE 4: IMPACT ON RETAIL PRICES

Bloomberg NEW ENERGY FINANCE

US FIXED LINE VS. MOBILE PRICES ($/MIN)



GERMAN FIT VS. RESIDENTIAL POWER PRICES (EUR/MWH)



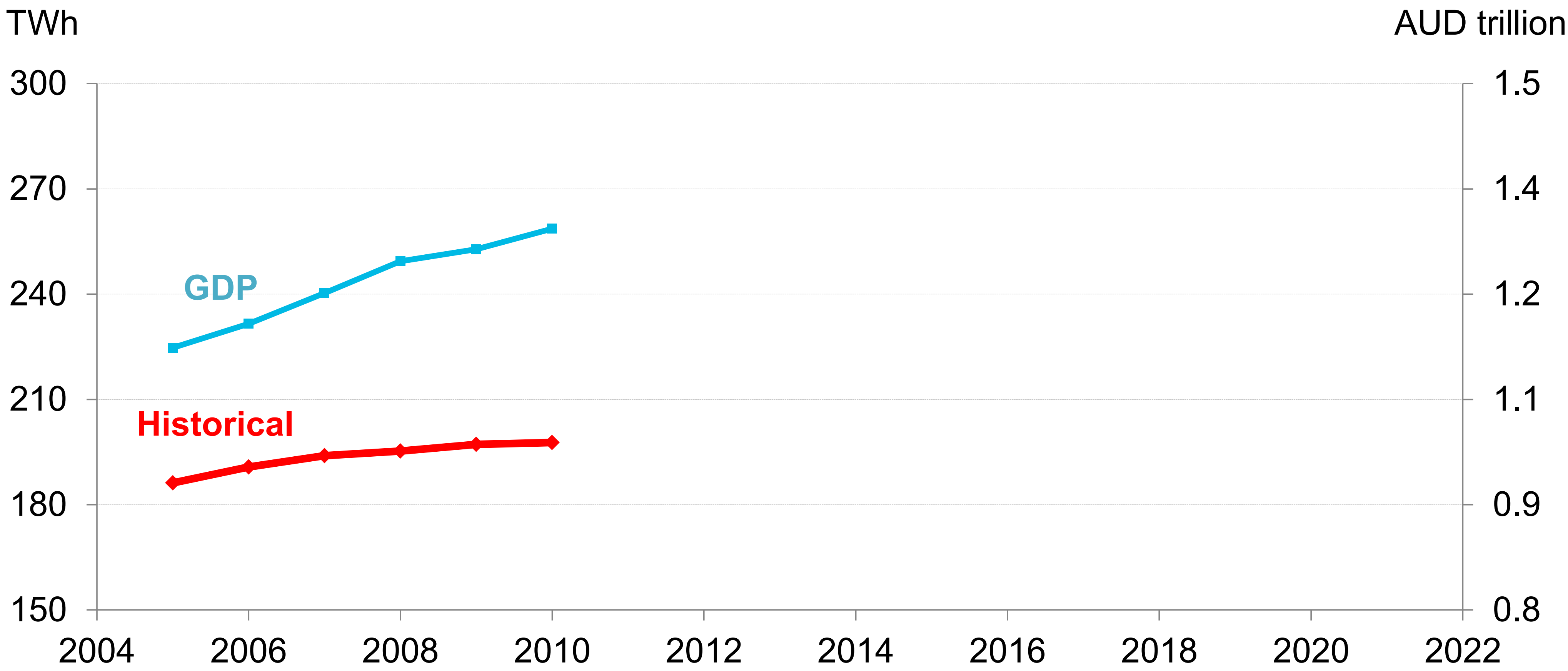
Source: Bloomberg New Energy Finance, Bloomberg L.P., BSW Solar, Eurostat, Federal Communications Commission

ENERGY EFFICIENCY – LED LIGHT BULBS

Bloomberg NEW ENERGY FINANCE

Picture Credit: Philips

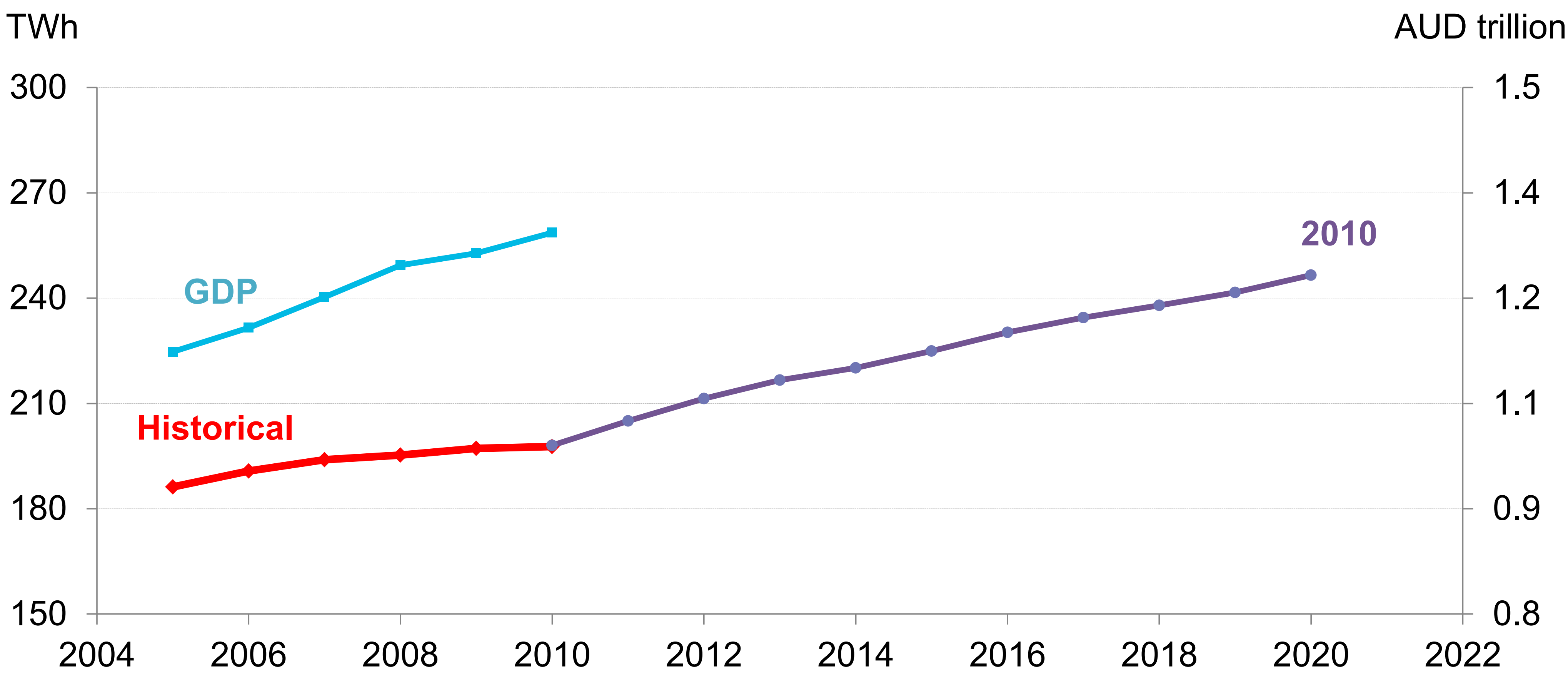
AUSTRALIA NATIONAL ELECTRICITY MARKET ACTUAL VS FORECAST ELECTRICITY DEMAND, 2005–22



Source: Australian Energy Market Operator, Reserve Bank of Australia, Bloomberg New Energy Finance

AUSTRALIA NATIONAL ELECTRICITY MARKET ACTUAL VS FORECAST ELECTRICITY DEMAND, 2005–22

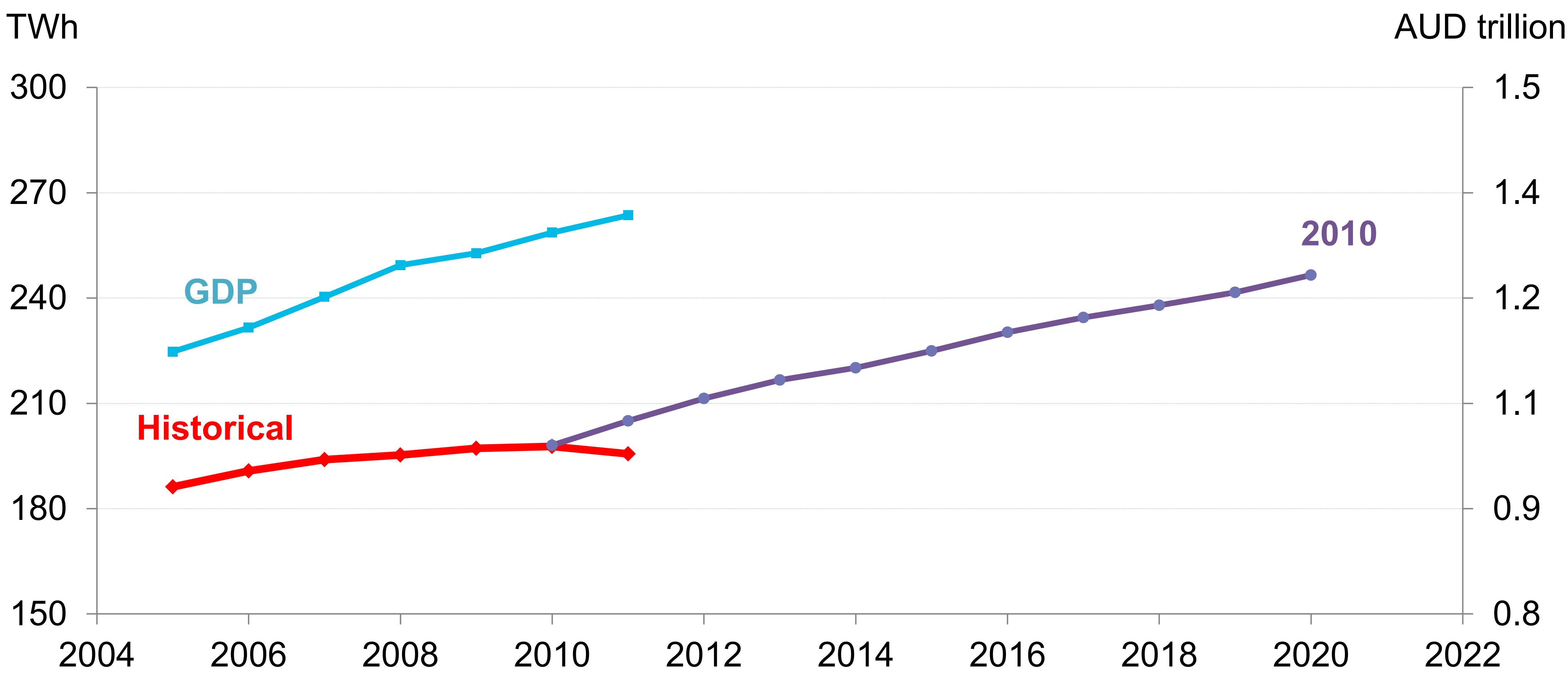
Bloomberg NEW ENERGY FINANCE



Source: Australian Energy Market Operator, Reserve Bank of Australia, Bloomberg New Energy Finance

AUSTRALIA NATIONAL ELECTRICITY MARKET ACTUAL VS FORECAST ELECTRICITY DEMAND, 2005–22

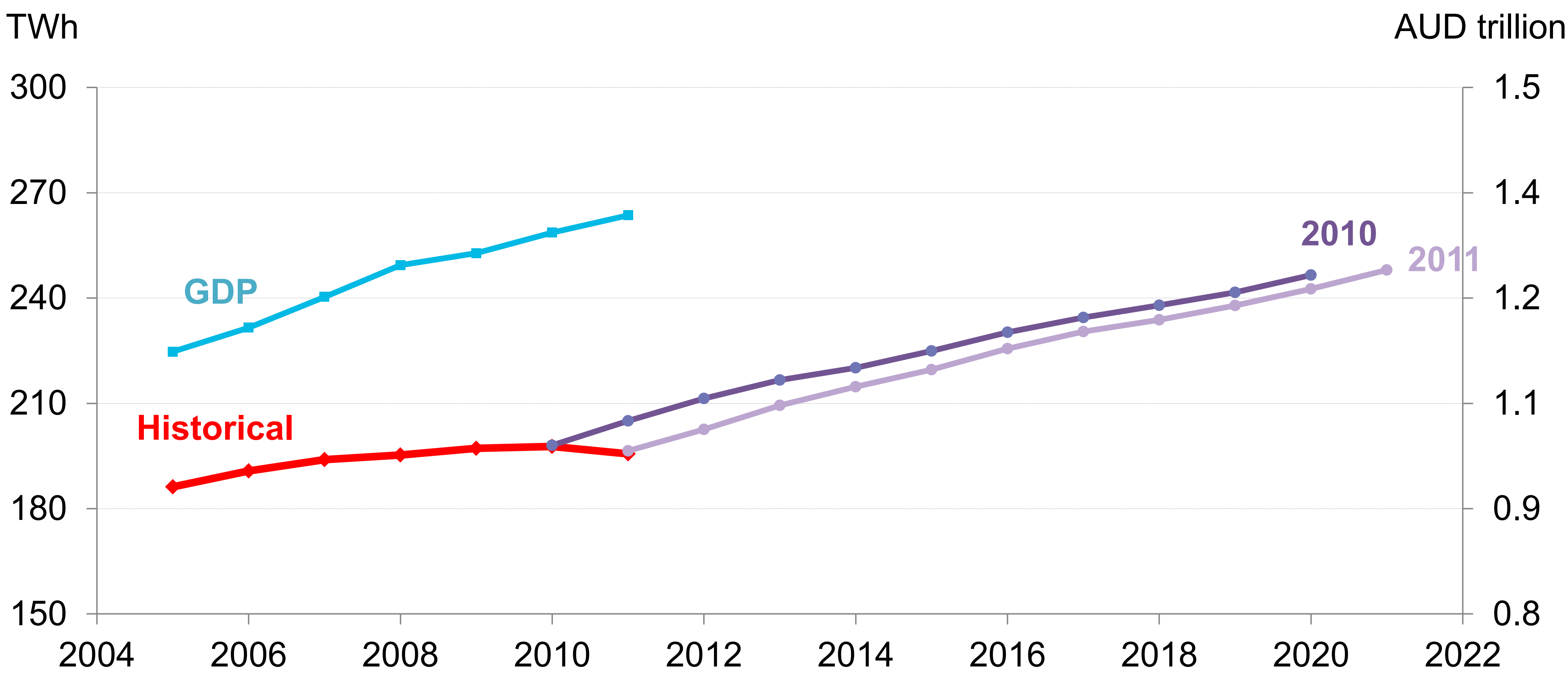
Bloomberg NEW ENERGY FINANCE



Source: Australian Energy Market Operator, Reserve Bank of Australia, Bloomberg New Energy Finance

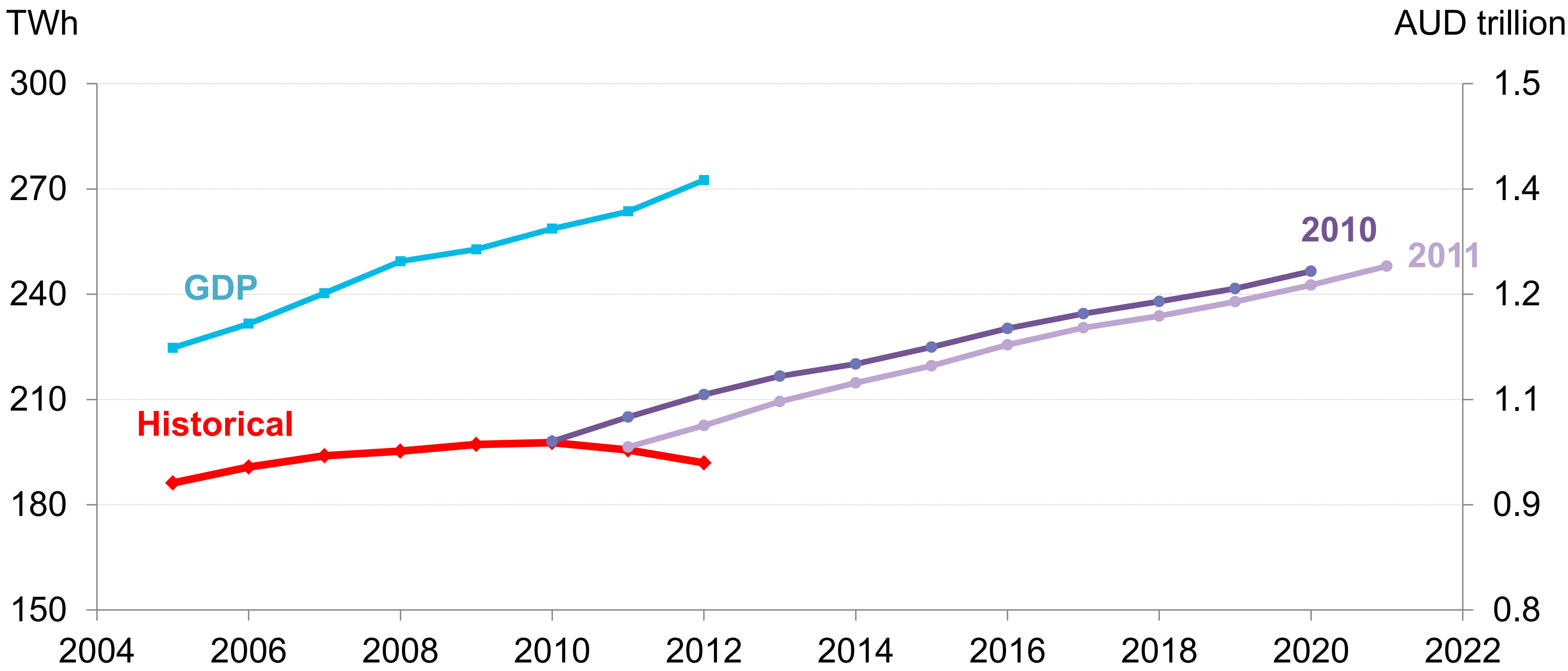
AUSTRALIA NATIONAL ELECTRICITY MARKET ACTUAL VS FORECAST ELECTRICITY DEMAND, 2005–22

Bloomberg NEW ENERGY FINANCE



Source: Australian Energy Market Operator, Reserve Bank of Australia, Bloomberg New Energy Finance

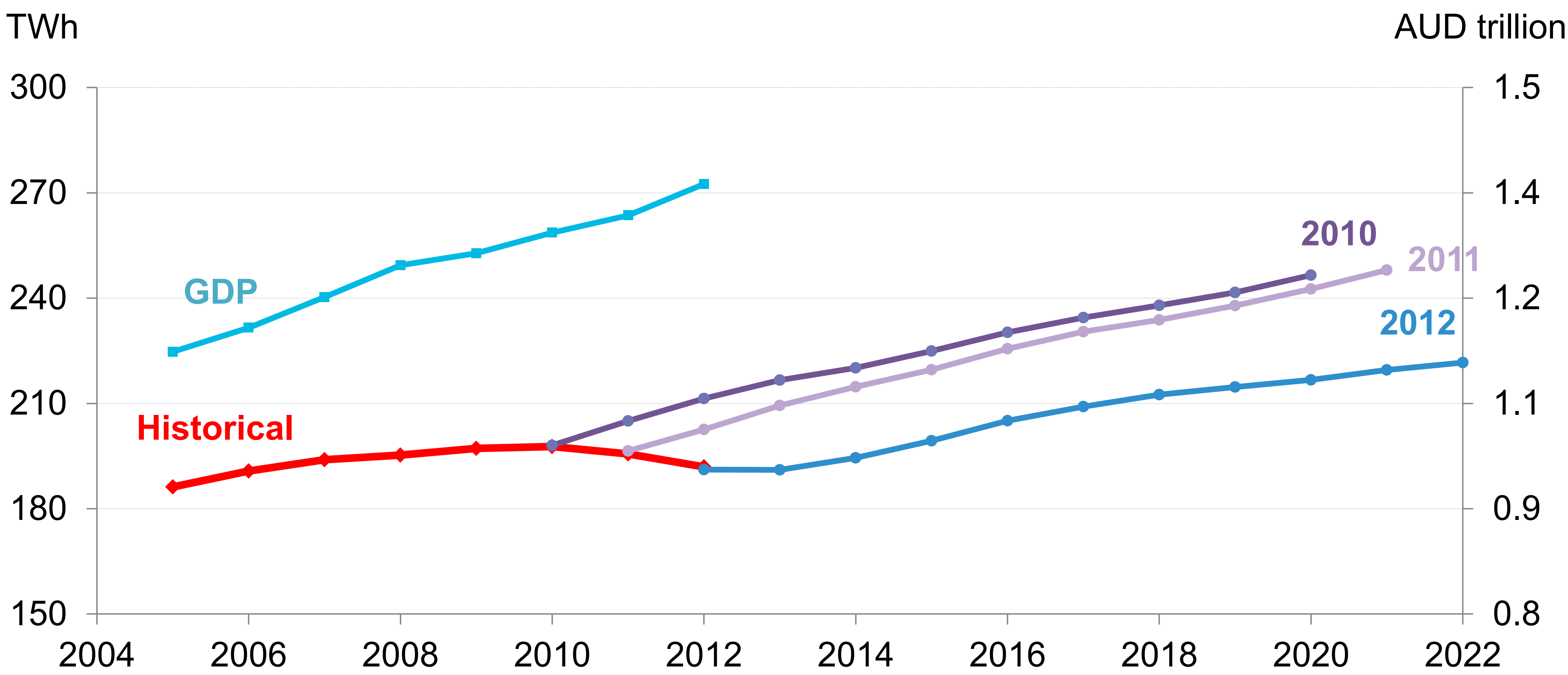
AUSTRALIA NATIONAL ELECTRICITY MARKET ACTUAL VS FORECAST ELECTRICITY DEMAND, 2005–22



Source: Australian Energy Market Operator, Reserve Bank of Australia, Bloomberg New Energy Finance

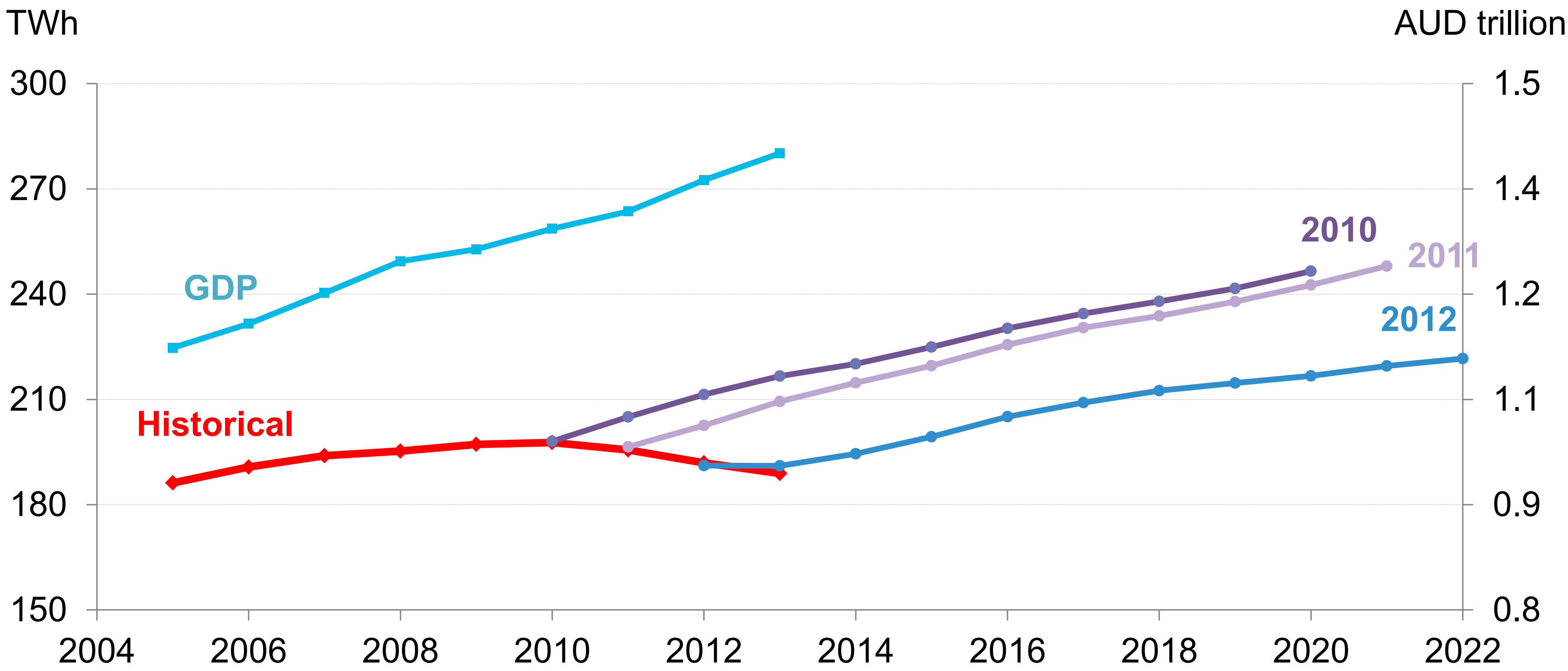
AUSTRALIA NATIONAL ELECTRICITY MARKET ACTUAL VS FORECAST ELECTRICITY DEMAND, 2005–22

Bloomberg NEW ENERGY FINANCE



Source: Australian Energy Market Operator, Reserve Bank of Australia, Bloomberg New Energy Finance

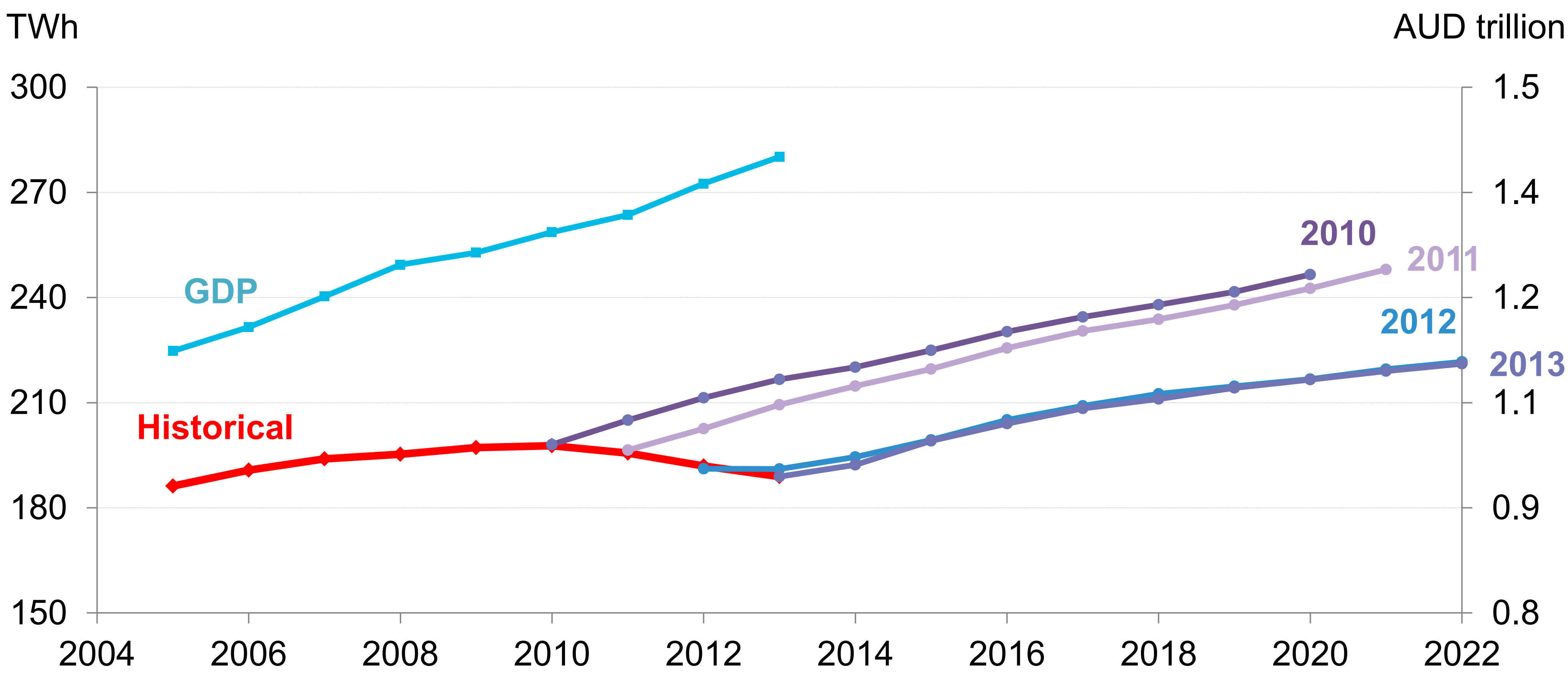
AUSTRALIA NATIONAL ELECTRICITY MARKET ACTUAL VS FORECAST ELECTRICITY DEMAND, 2005–22



Source: Australian Energy Market Operator, Reserve Bank of Australia, Bloomberg New Energy Finance

AUSTRALIA NATIONAL ELECTRICITY MARKET ACTUAL VS FORECAST ELECTRICITY DEMAND, 2005–22

Bloomberg NEW ENERGY FINANCE



Source: Australian Energy Market Operator, Reserve Bank of Australia, Bloomberg New Energy Finance

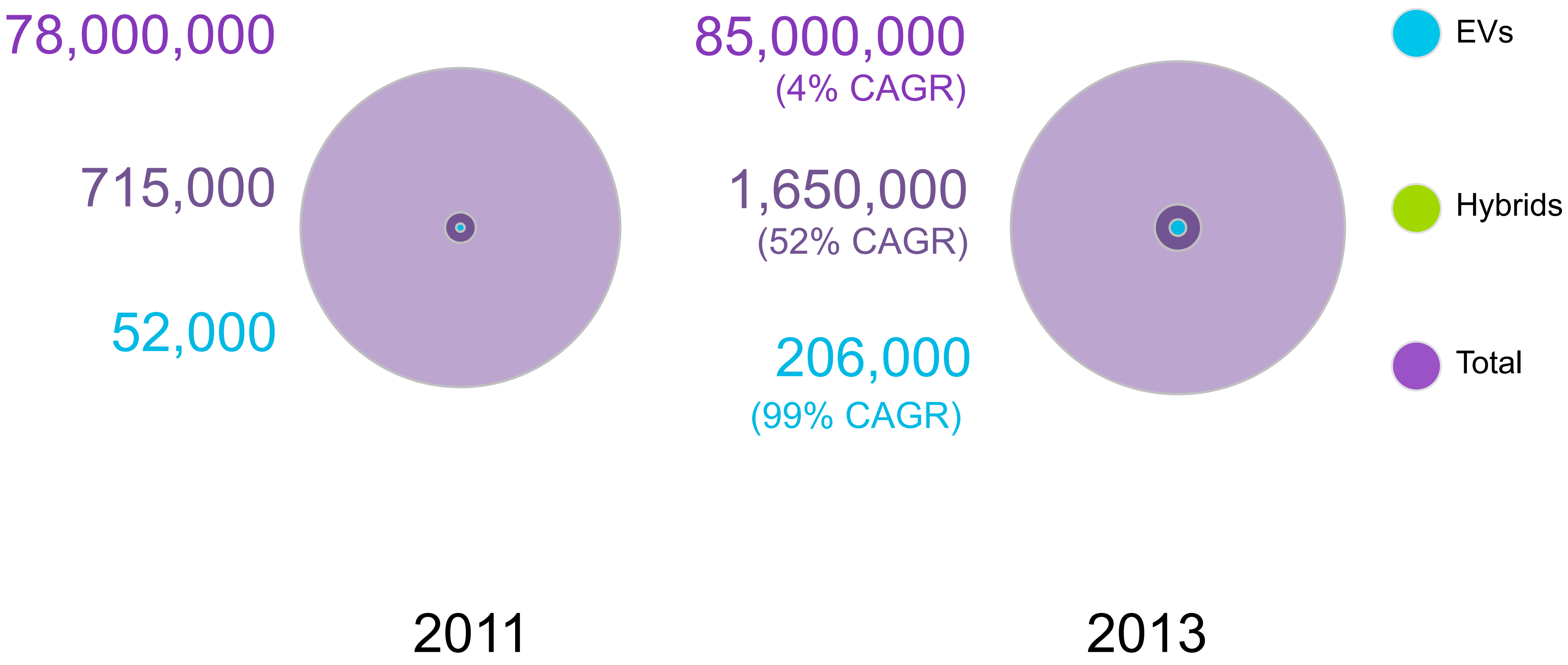
PUBLIC MARKETS – OPEN FOR BUSINESS

Bloomberg NEW ENERGY FINANCE

TESLA

Source: Tesla

GLOBAL ANNUAL EV SALES
2011 & 2013

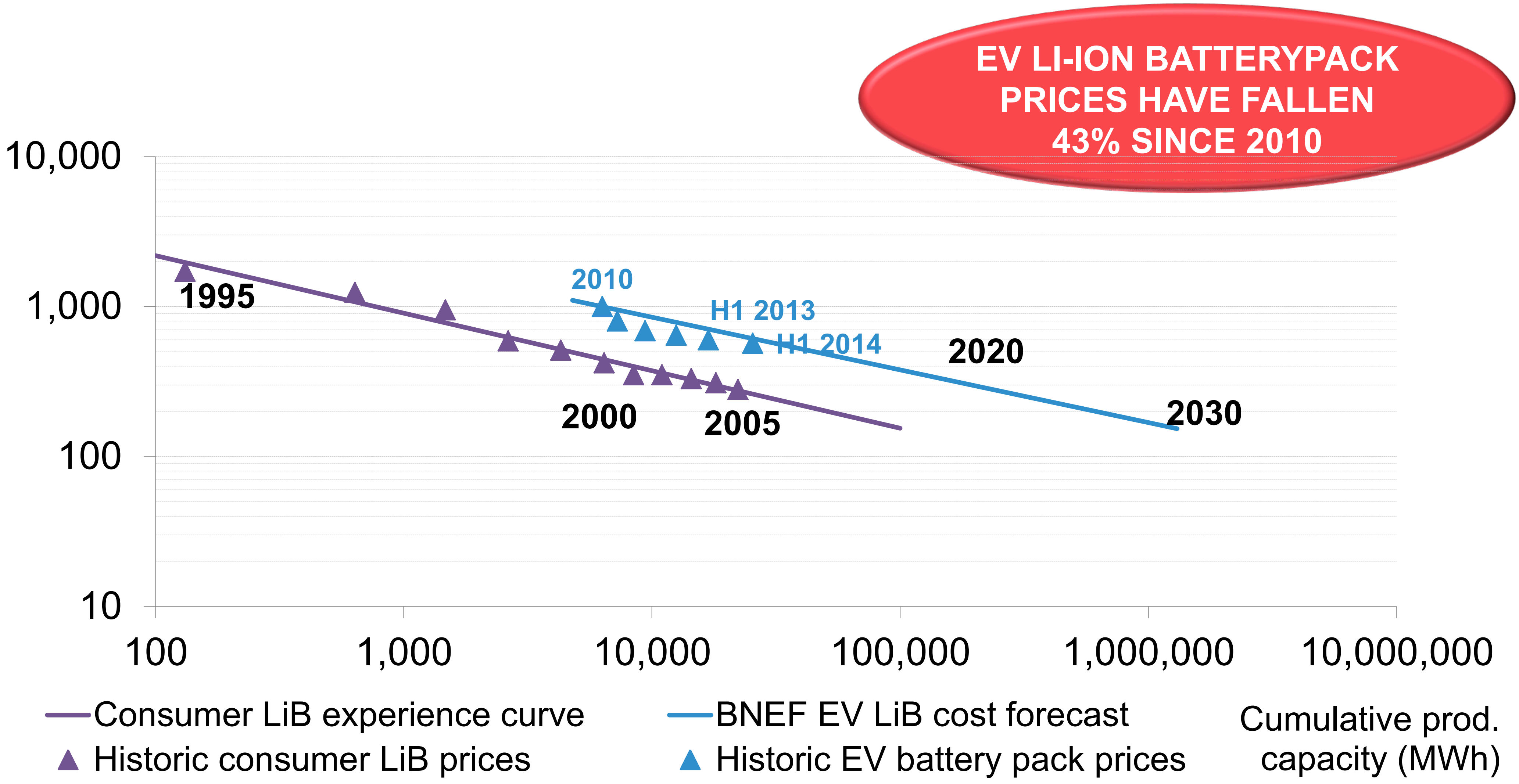


Note: Numbers are rounded.

Source: Bloomberg New Energy Finance

LITHIUM-ION BATTERY EXPERIENCE CURVE
($/KWH)

Bloomberg NEW ENERGY FINANCE

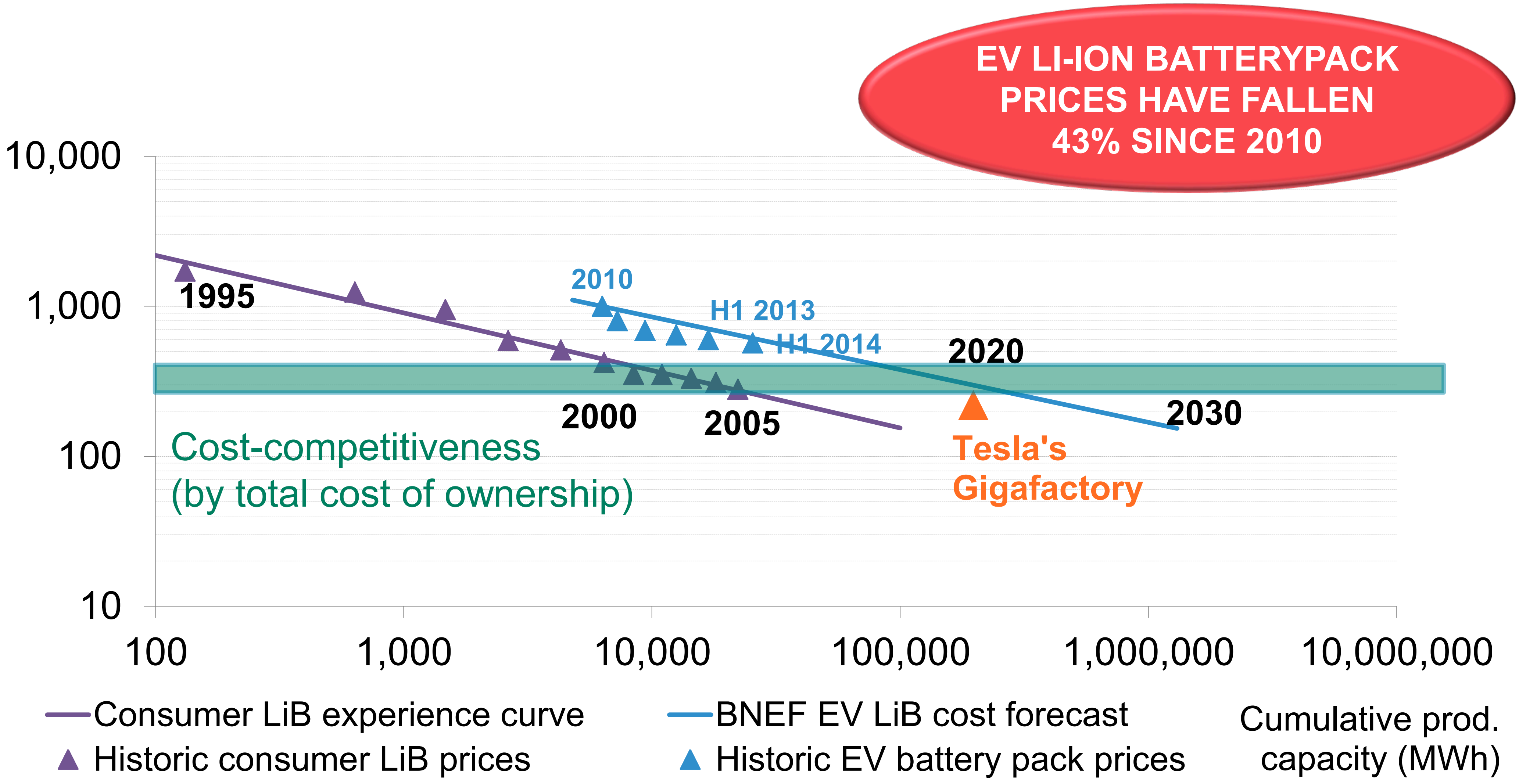


Note: Battery pack prices in 2010 dollars.

Source: Battery University, MIIT, IIT, Bloomberg New Energy Finance

LITHIUM-ION BATTERY EXPERIENCE CURVE
($/KWH)

Bloomberg
NEW ENERGY FINANCE

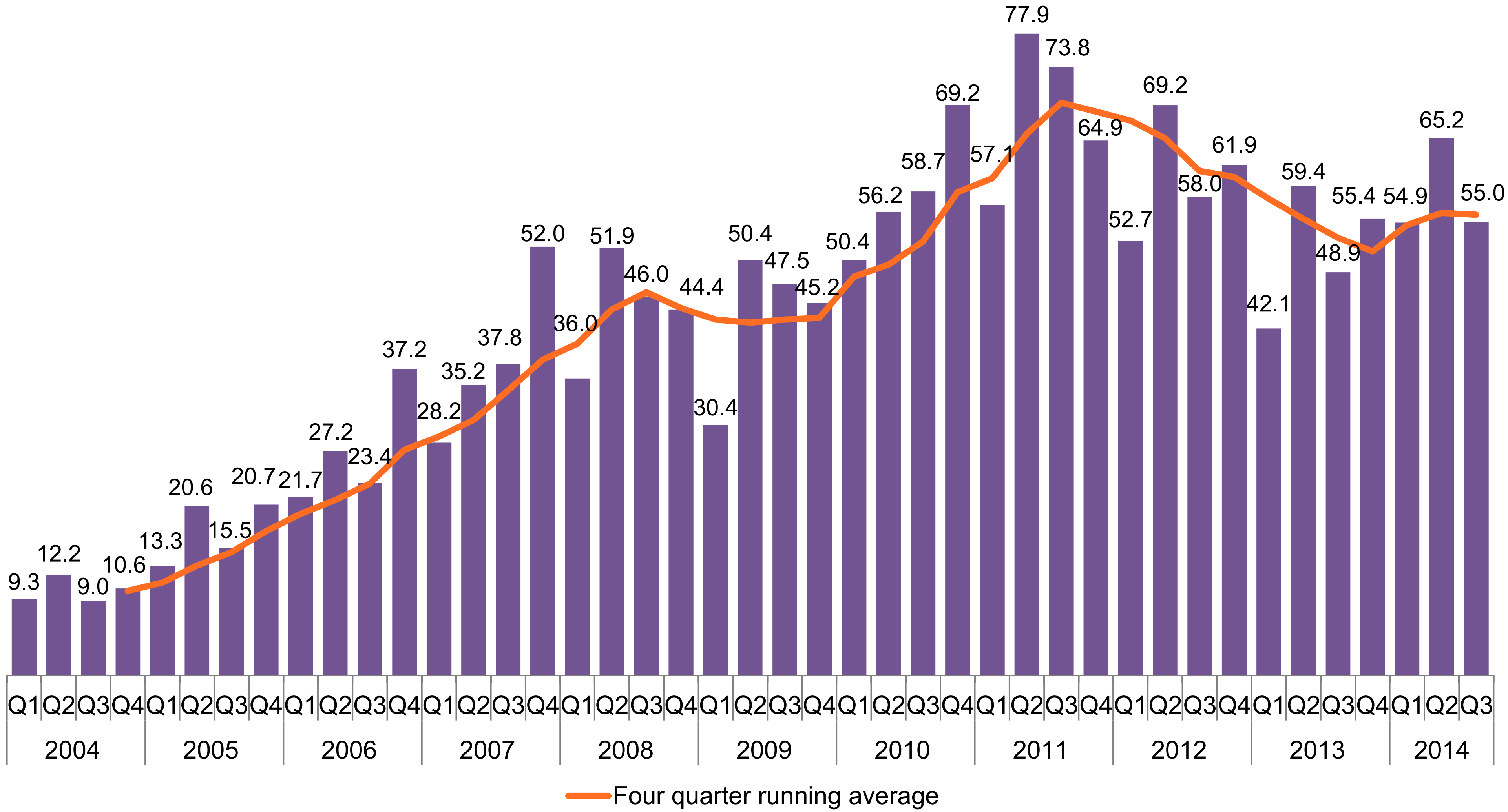


Note: Battery pack prices in 2010 dollars.

Source: Battery University, MIIT, IIT, Bloomberg New Energy Finance

NEW INVESTMENT IN CLEAN ENERGY
Q1 2004-Q3 2014 ($BN)

Bloomberg NEW ENERGY FINANCE



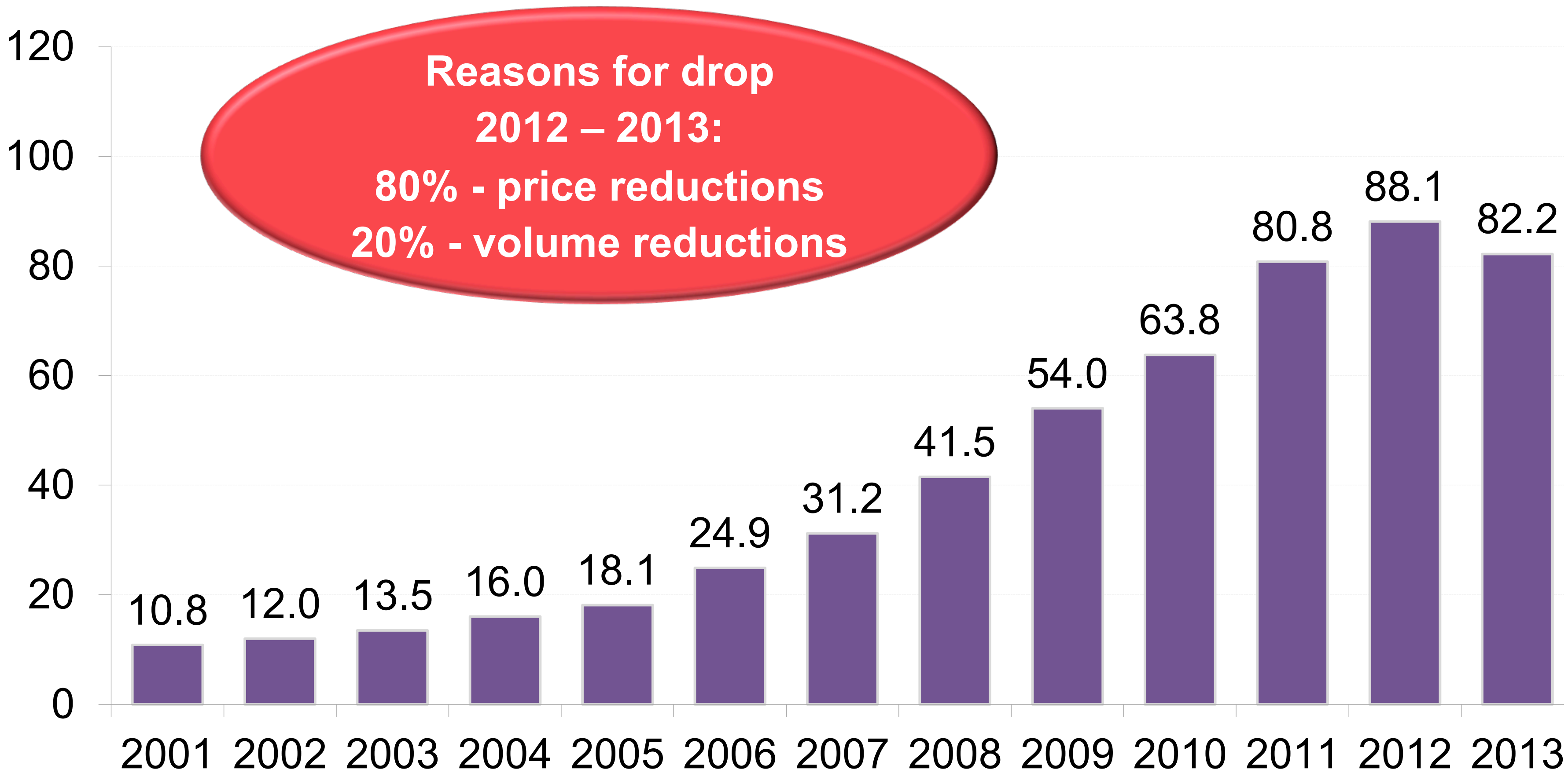
Note: Total values include estimates for undisclosed deals. Excludes corporate and government R&D, and spending for digital energy and energy storage projects (reported in annual statistics only).

Source: Bloomberg New Energy Finance

RENEWABLE ENERGY NEW BUILD INSTALLATIONS

2001-13 (GW)

Bloomberg NEW ENERGY FINANCE

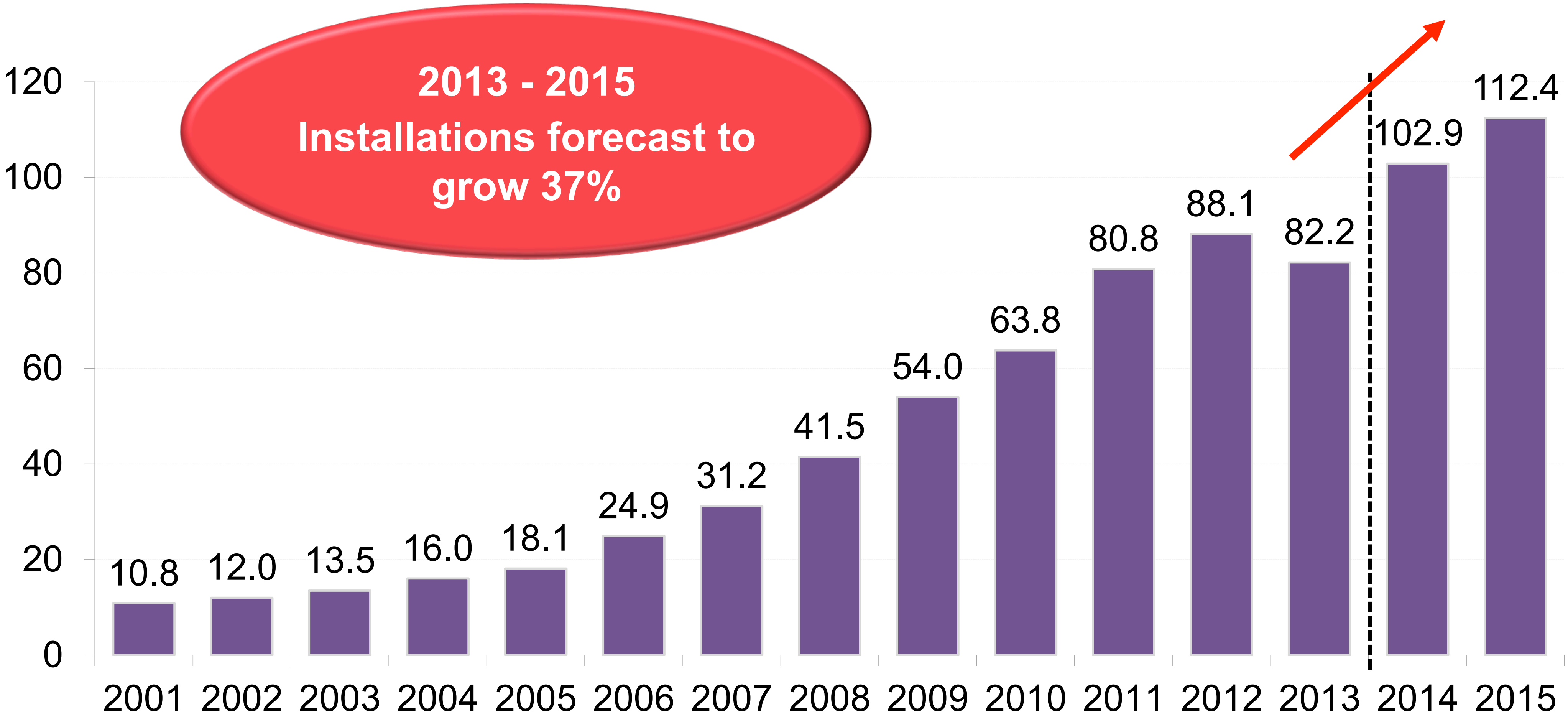


Note: Excludes large-scale hydro

Source: Bloomberg New Energy Finance

CLEAN ENERGY NEW BUILD INSTALLATIONS
2001-13 (GW)

Bloomberg
NEW ENERGY FINANCE

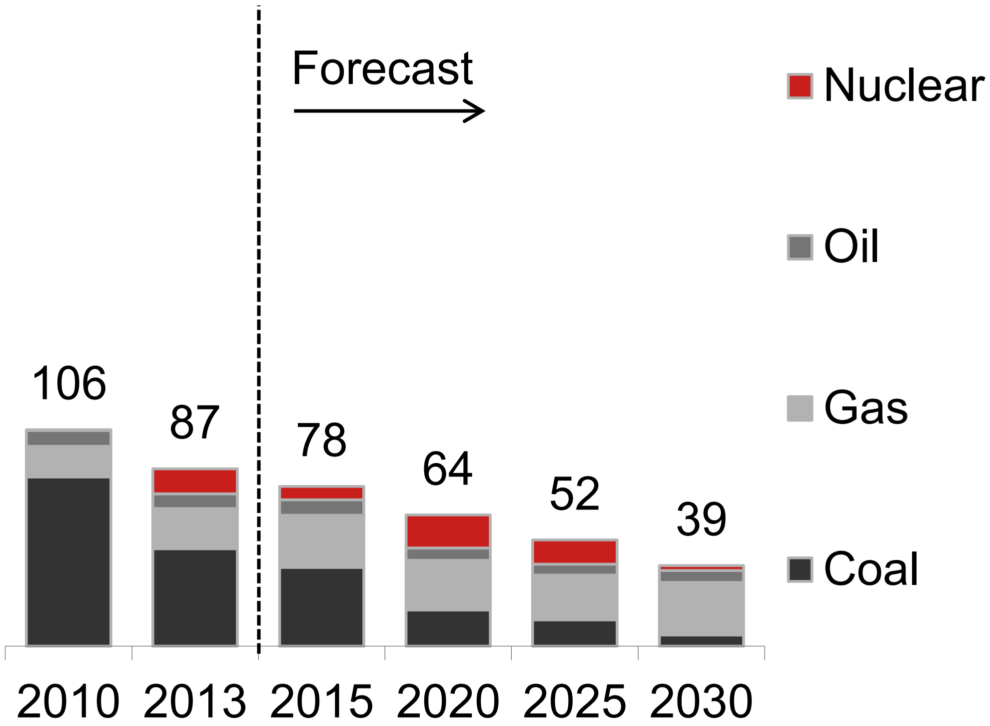


Source: Bloomberg New Energy Finance

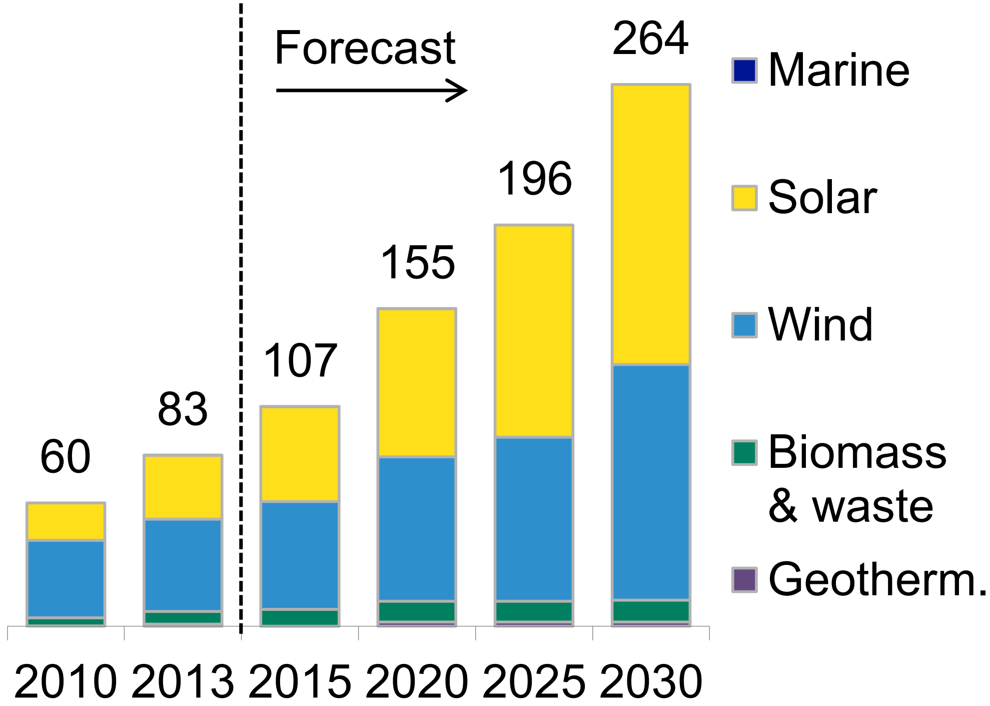
GLOBAL POWER GENERATION CAPACITY ADDITIONS
2010–30 (GW)

Bloomberg NEW ENERGY FINANCE

FOSSIL FUEL AND NUCLEAR



RENEWABLES



Source: Bloomberg New Energy Finance

DIVESTMENT MOVEMENT

Source: GoFossilFree.org

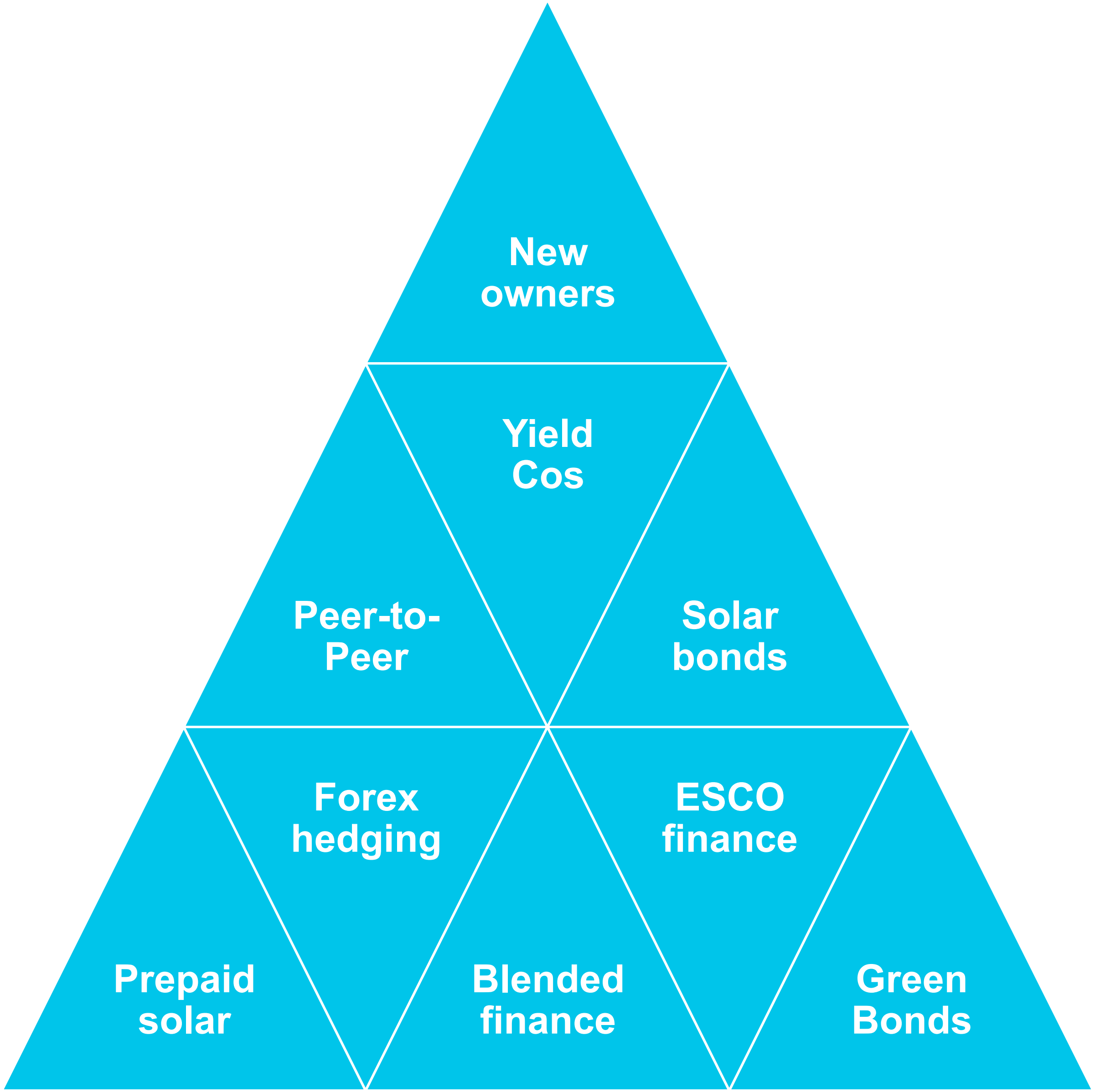
DIVESTMENT MOVEMENT IN PERSPECTIVE

Total size of divested portfolios
(to September 2014) - $50 billion

s

Source: Bloomberg New Energy Finance; Arabella Advisors; GoFossilFree.org

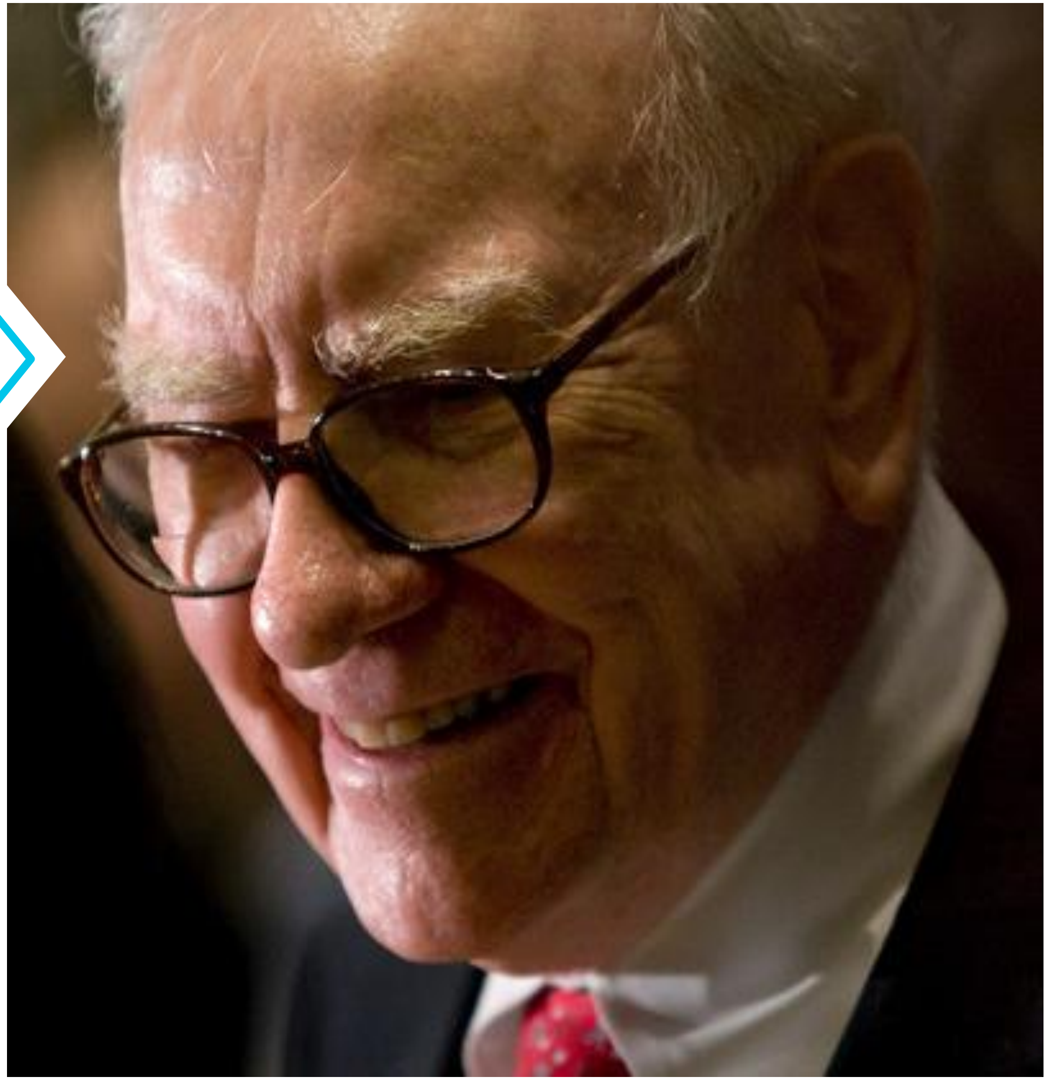
FINANCIAL INNOVATION



Source: Bloomberg New Energy Finance

"We've poured billions and billions and billions of dollars [into renewables]. And we're going to keep doing that as far as the eye can see."

Warren Buffett
CEO Berkshire Hathaway

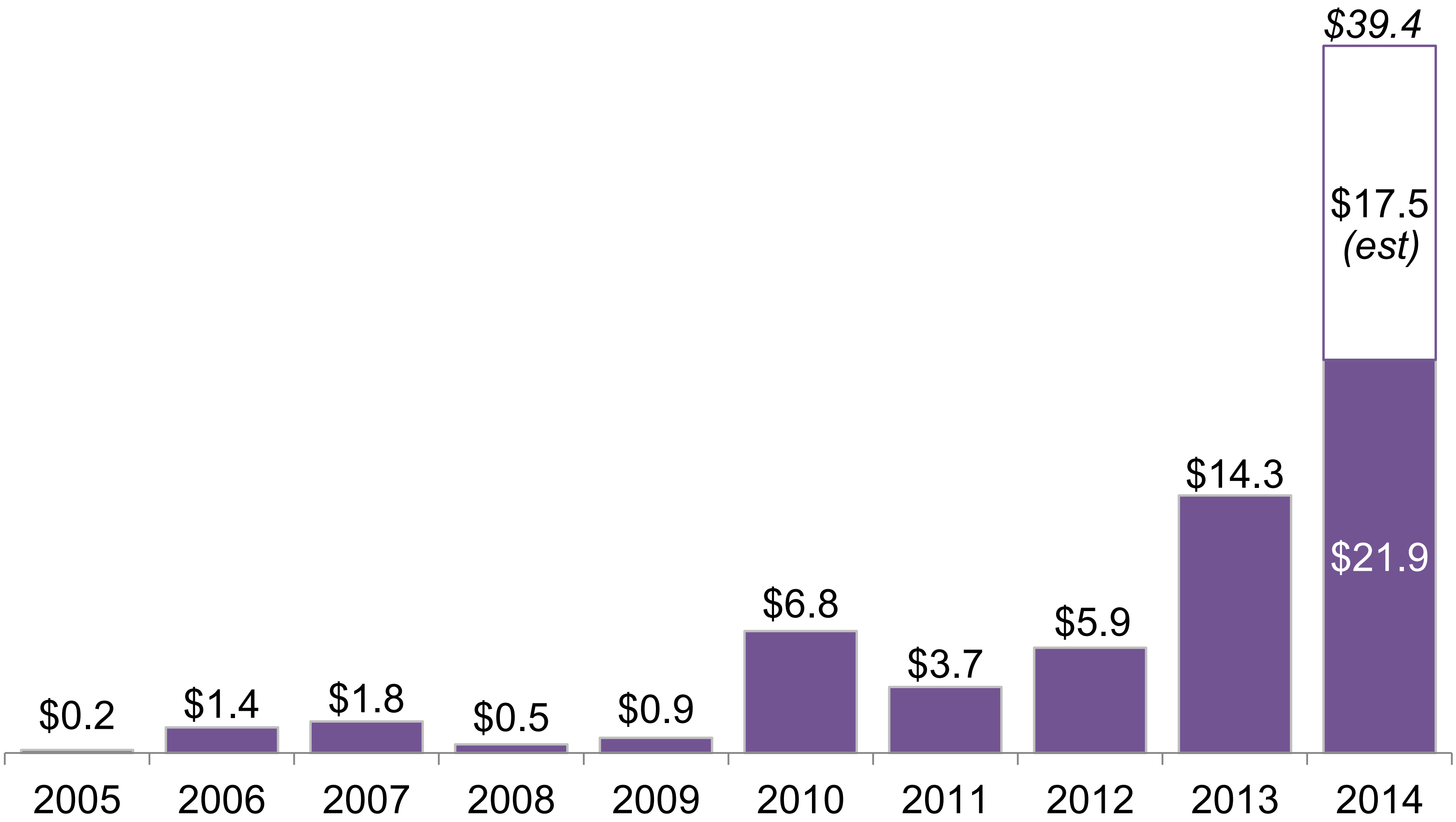


Picture: Bloomberg

GREEN BONDS WILL RAISE AS MUCH MONEY IN 2014 AS FROM 1995 – 2013

Bloomberg NEW ENERGY FINANCE

Green bonds raised, 2004 – 2014 ($bn)

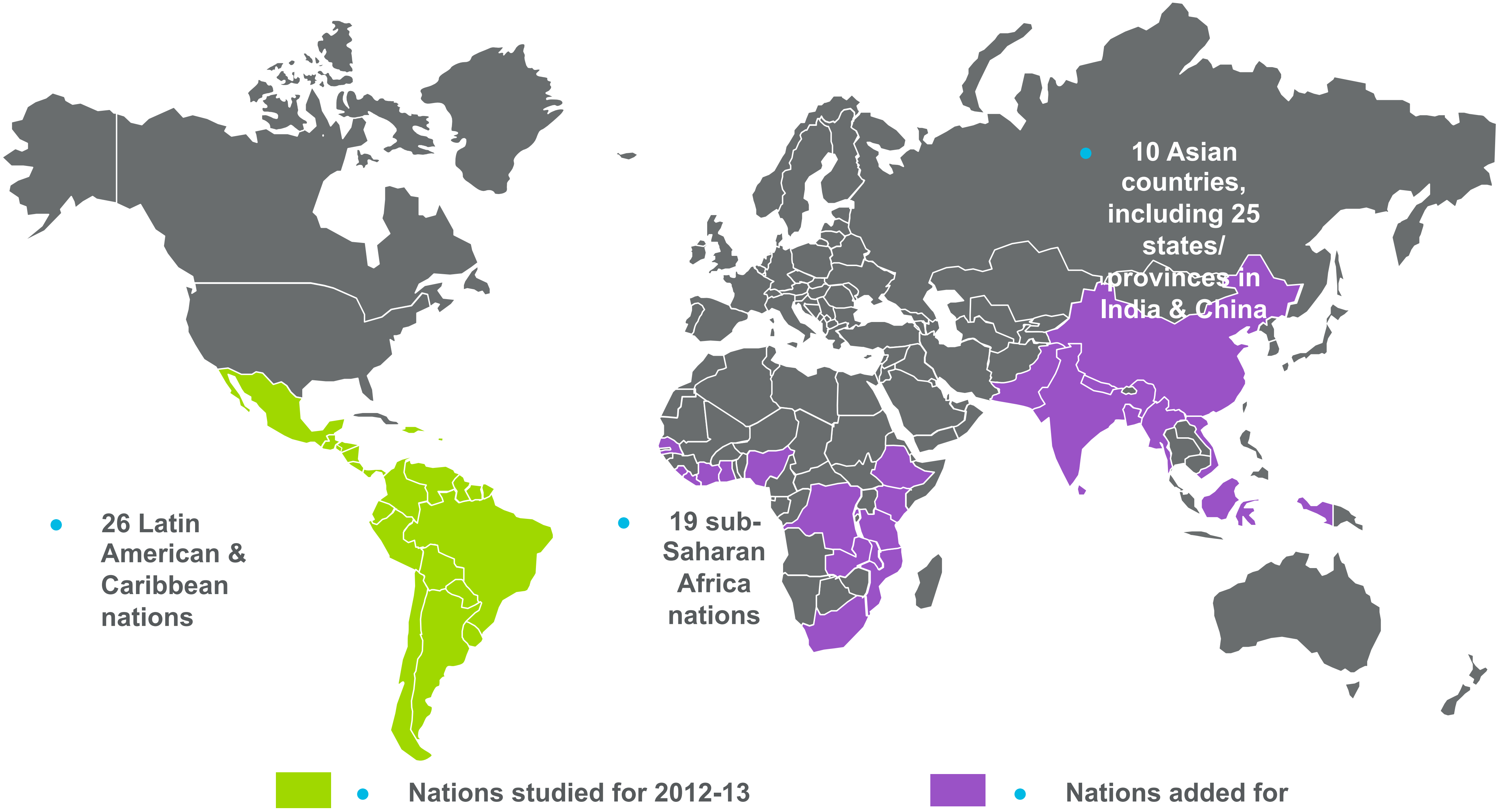


Note: full-year estimate as of 22 July

Source: Bloomberg New Energy Finance

CLIMATESCOPE COUNTRY COVERAGE 2012-13 AND 2014-15

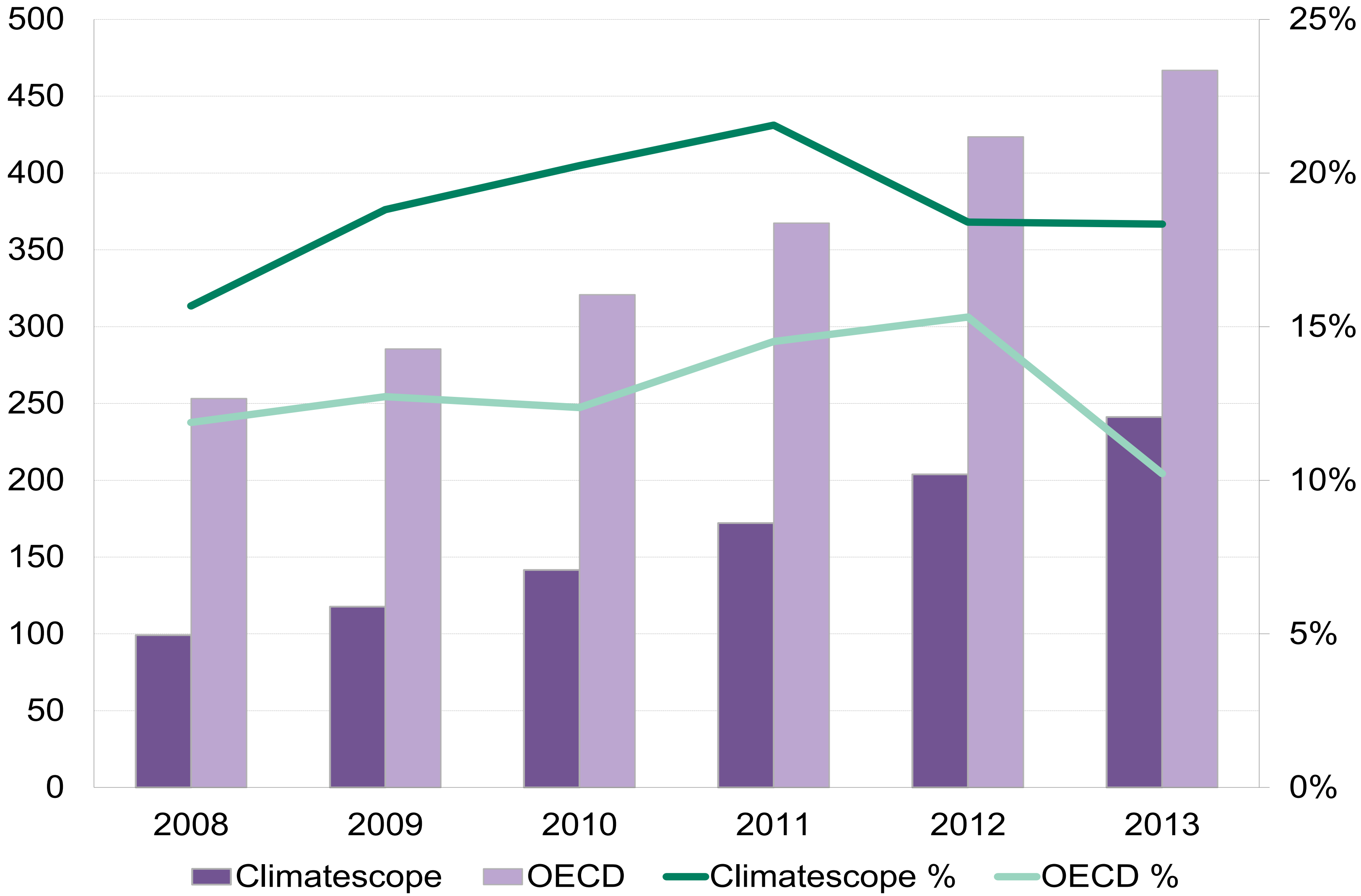
Bloomberg NEW ENERGY FINANCE



POWER CAPACITY & GROWTH, CLIMATESCOPE VS OECD (CUM. CAPACITY, GW, ANNUAL % CHANGE)

Source: Climatescope

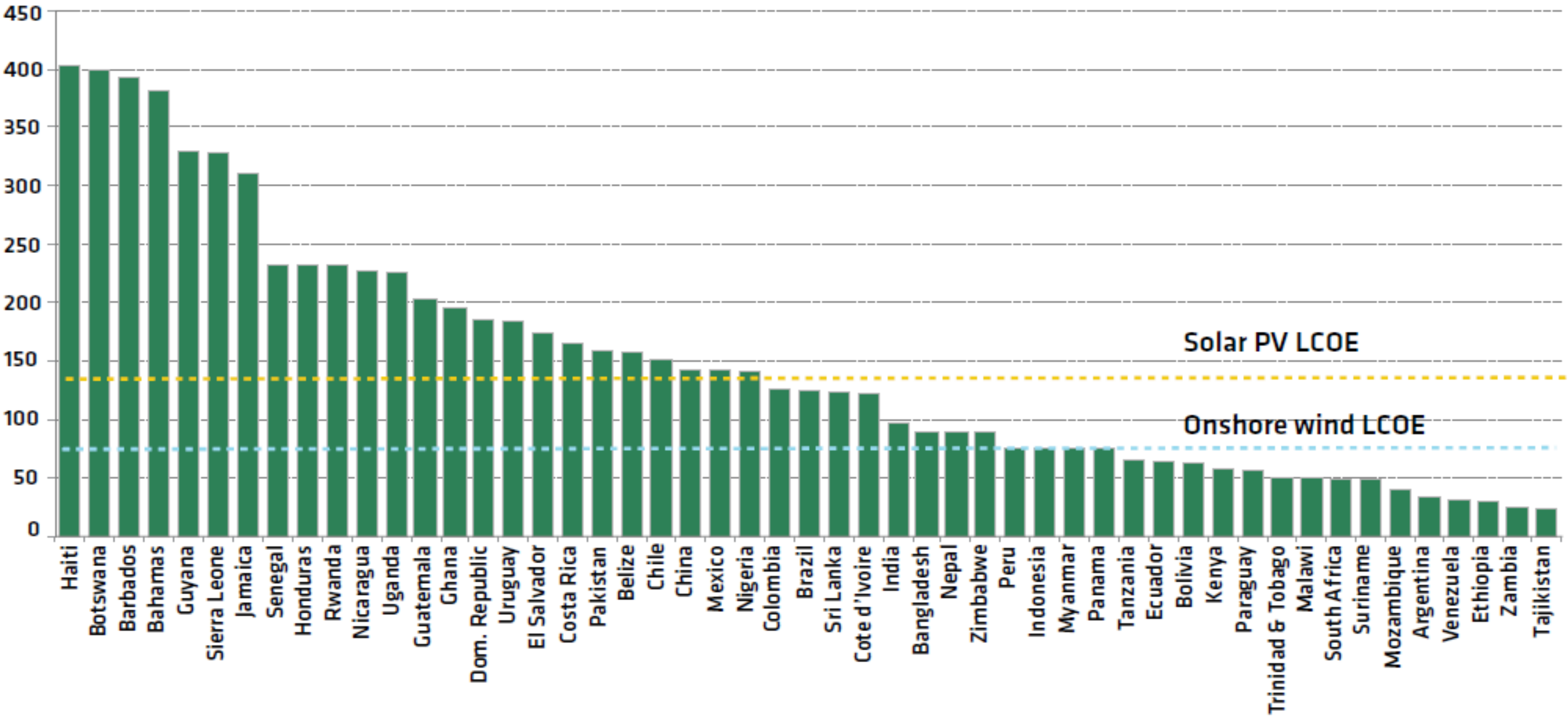
CLIMATESCOPE VS. OECD CLEAN ENERGY INSTALLED CAPACITY (GW) AND GROWTH (%), 2008-13



Note: Large hydro not included in this definition of clean energy

Source: Climatescope 2014

INDUSTRIAL POWER PRICES 2013, CLIMATESCOPE COUNTRIES ($/MWH)



Source: Climatescope 2014

RETAIL POWER PRICES, AFRICA, SOLAR VS KEROSENE ($/WEEK)

Kerosene
$4 per week

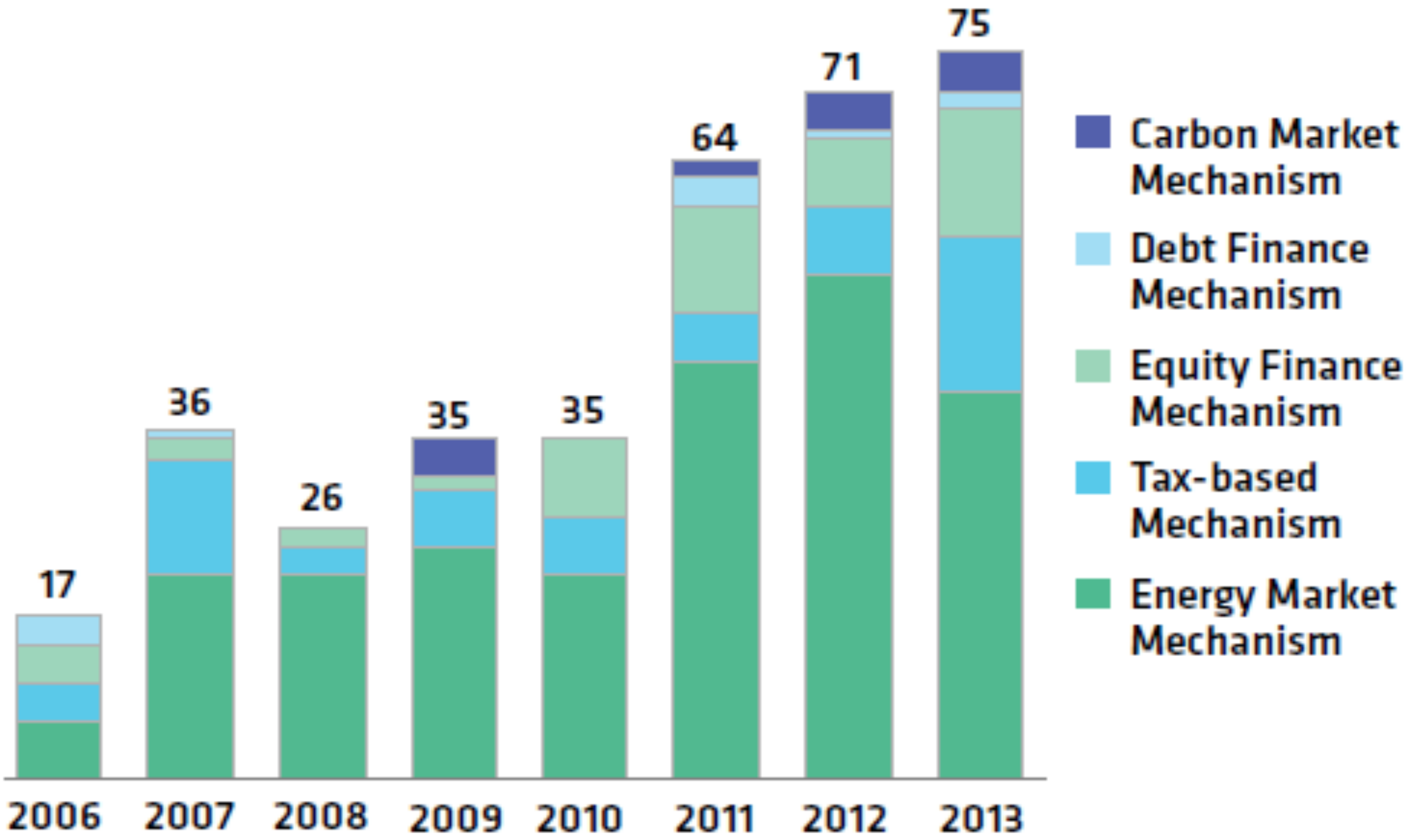
Solar PV
$1 per week

Note: Illustrative figures for cost of 2 lamps plus mobile phone charging, Kenya, 2012

Picture Credit: SolarSister

NEW CLEAN ENERGY POLICIES COMING INTO FORCE BY YEAR OF ESTABLISHMENT, CLIMATESCOPE NATIONS

Bloomberg NEW ENERGY FINANCE



Source: Climatescope 2014

ENERGY SUBSIDIES COMPARED (2012)

Bloomberg NEW ENERGY FINANCE

Fossil Fuels

- $544 bn (consumer subsidies only)
- + $88 bn producer subsidies (G20 only)
- + $83 bn defence (Gulf only)
- + Impact on health, economic volatility
- + Climate

Clean energy

- ~$100 bn

Source: Bloomberg New Energy Finance; IEA; ODI; Rand Corporation

PHASE CHANGE

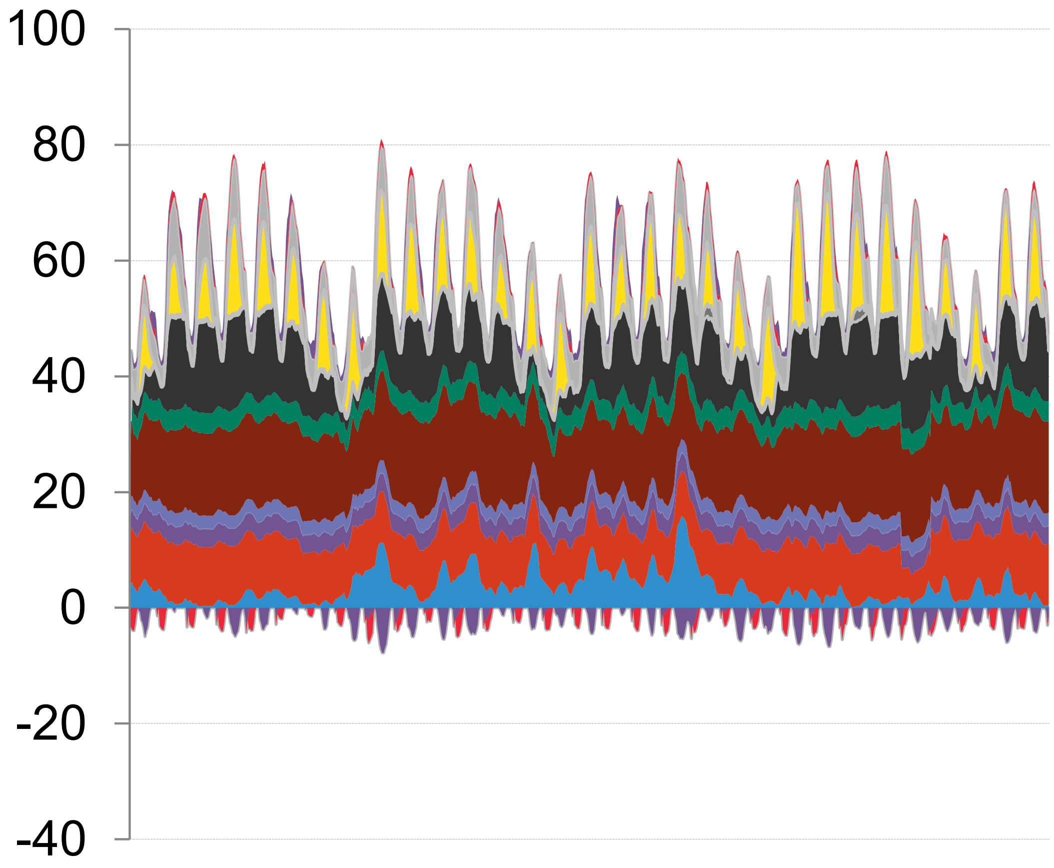
Phase Change (n): A change in a feature of a physical system that results in a discrete transition of that system to another state.

Source: Wikipedia Commons; The Free Dictionary

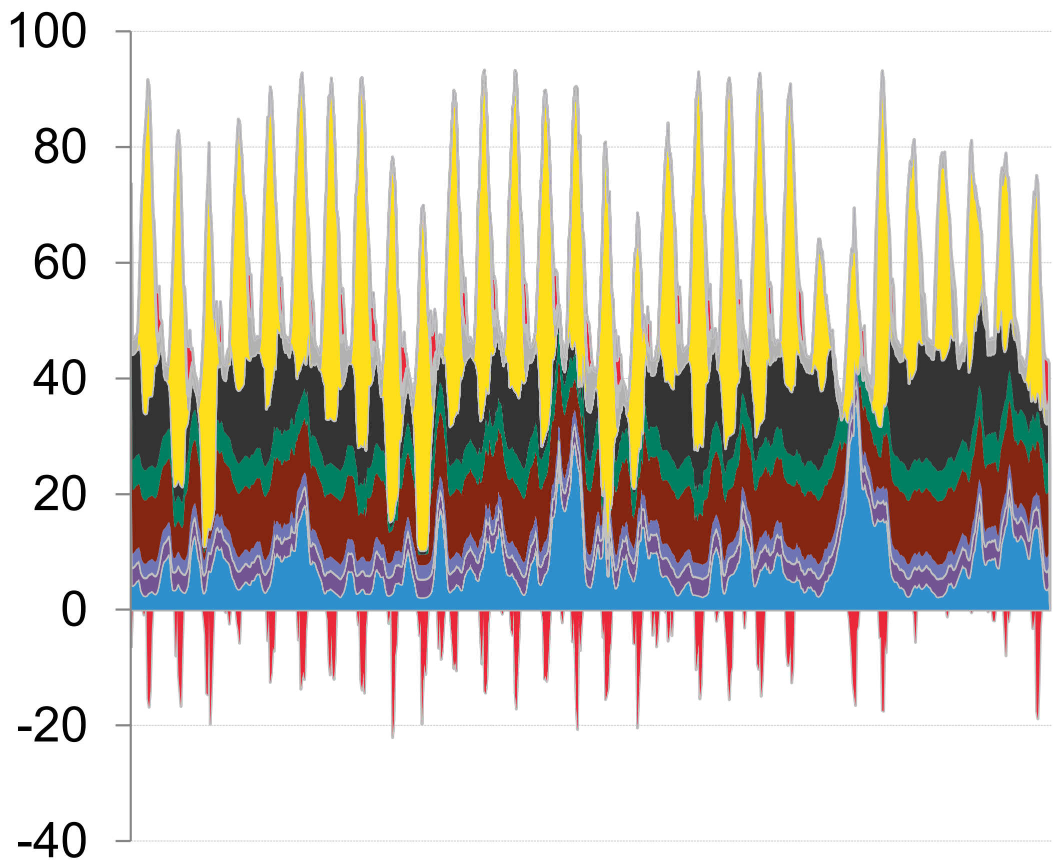
GERMAN HOURLY GENERATION PROFILE
(GW)

Bloomberg NEW ENERGY FINANCE

JULY 2012



JULY 2033

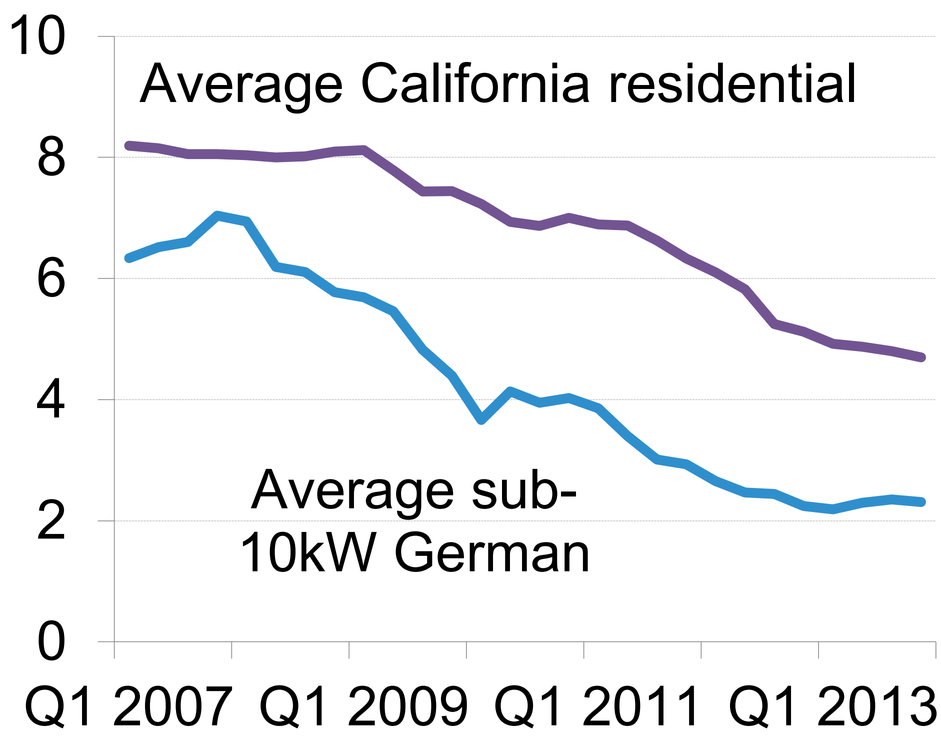


Source: Bloomberg New Energy Finance

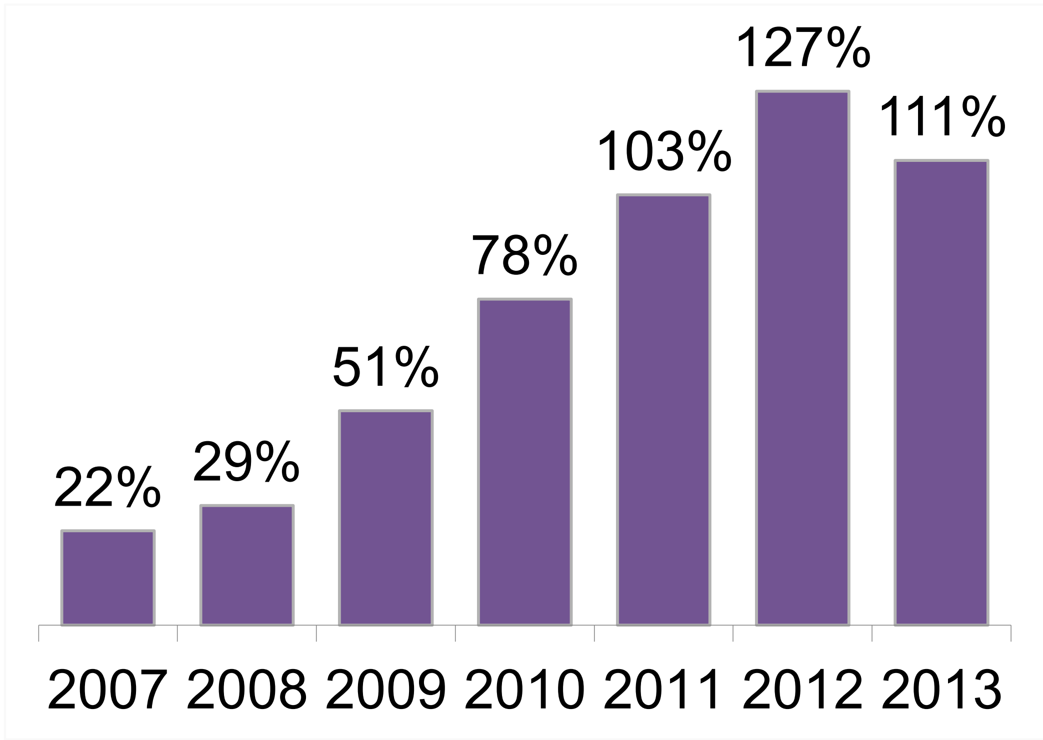
SMALL SOLAR SYSTEM PRICES IN GERMANY AND CALIFORNIA

Bloomberg NEW ENERGY FINANCE

TOTAL SYSTEM COST ($/W)



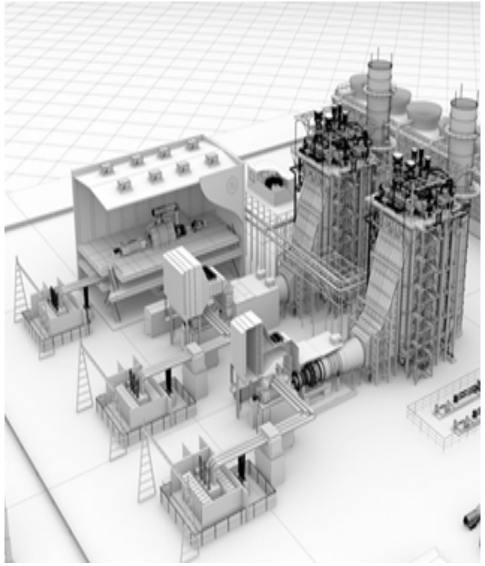
CALIFORNIA PREMIUM TO GERMANY



Source: Bloomberg New Energy Finance, BSW Solar, California Solar Initiative

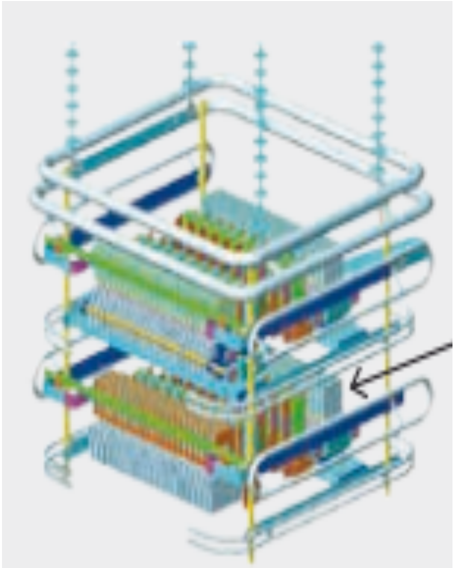
NEXT WAVE OF PHASE-CHANGING TECHNOLOGIES?

FLEXIBLE GAS PEAKERS



- Efficiency of CCGT
- Rapid ramp up & load following
- Within emission limits
- Enables more intermittent generation

ABB Hybrid HVDC Circuit Breaker



- Mechanical/solid state hybrid
- Interrupts 1GW high voltage in 5ms
- “100-year-old problem”
- Enables Internet of HVDC

USB 3.1

- 100W power via USB cable
- No more power cables
- Power TVs, lights, printers, from your PC
- Enables low-V homes

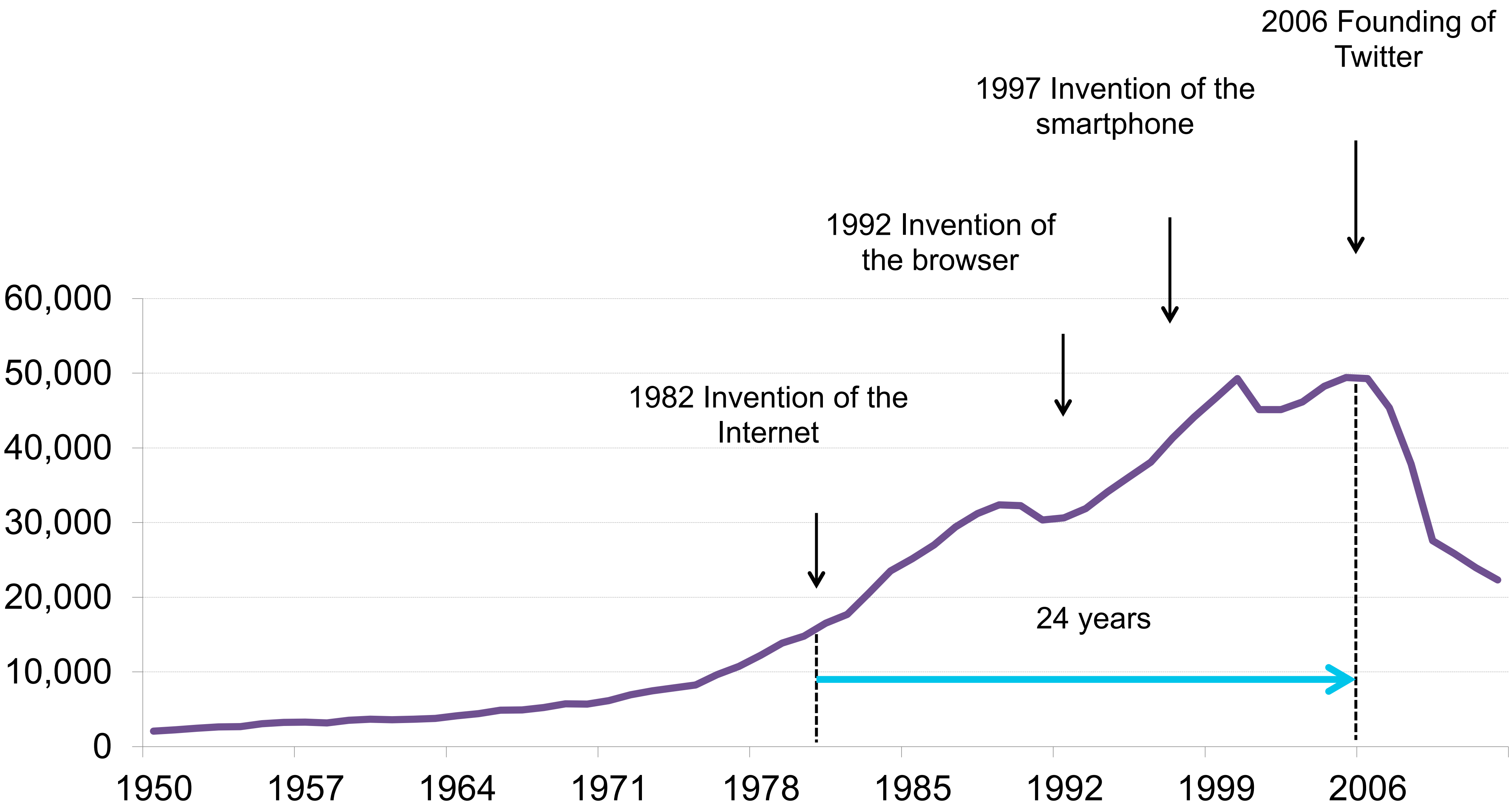
CFCL MICRO-CHP FUEL CELL

- Heat and power from natural gas
- Combined 85% efficiency
- Silent, resilient
- Enables urban DG

Source: GE, ABB, USB 3.1 Group; BlueGen / Ceramic Fuel Cells

PHASE CHANGE–NEWSPAPER REVENUE
($M)

Bloomberg NEW ENERGY FINANCE



Source: Bloomberg L.P. Bloomberg New Energy Finance

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

Michael Liebreich
Twitter: @mliebreich

Unique analysis, tools and data for decision-makers driving change in the energy system

sales.bnef@bloomberg.net

Bloomberg
NEW ENERGY FINANCE