

# RENEWABLE ENERGY INSTITUTE

Tokyo

9 September 2016

Michael Liebreich

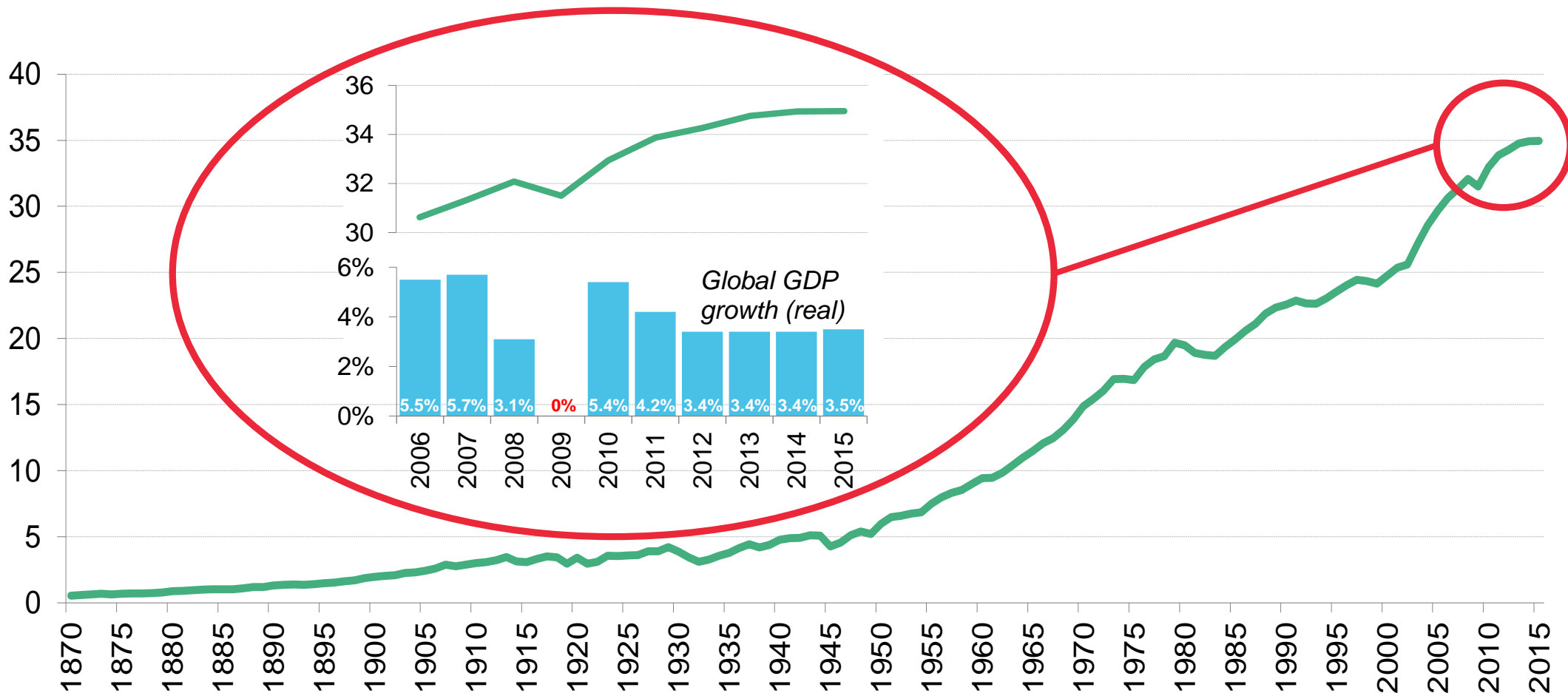
Chairman of the Advisory  
Board

Twitter: @mliebreich

**Bloomberg**  
NEW ENERGY FINANCE

# GLOBAL CARBON EMISSIONS FROM FOSSIL FUELS

(GIGATONNES CO2/YEAR)

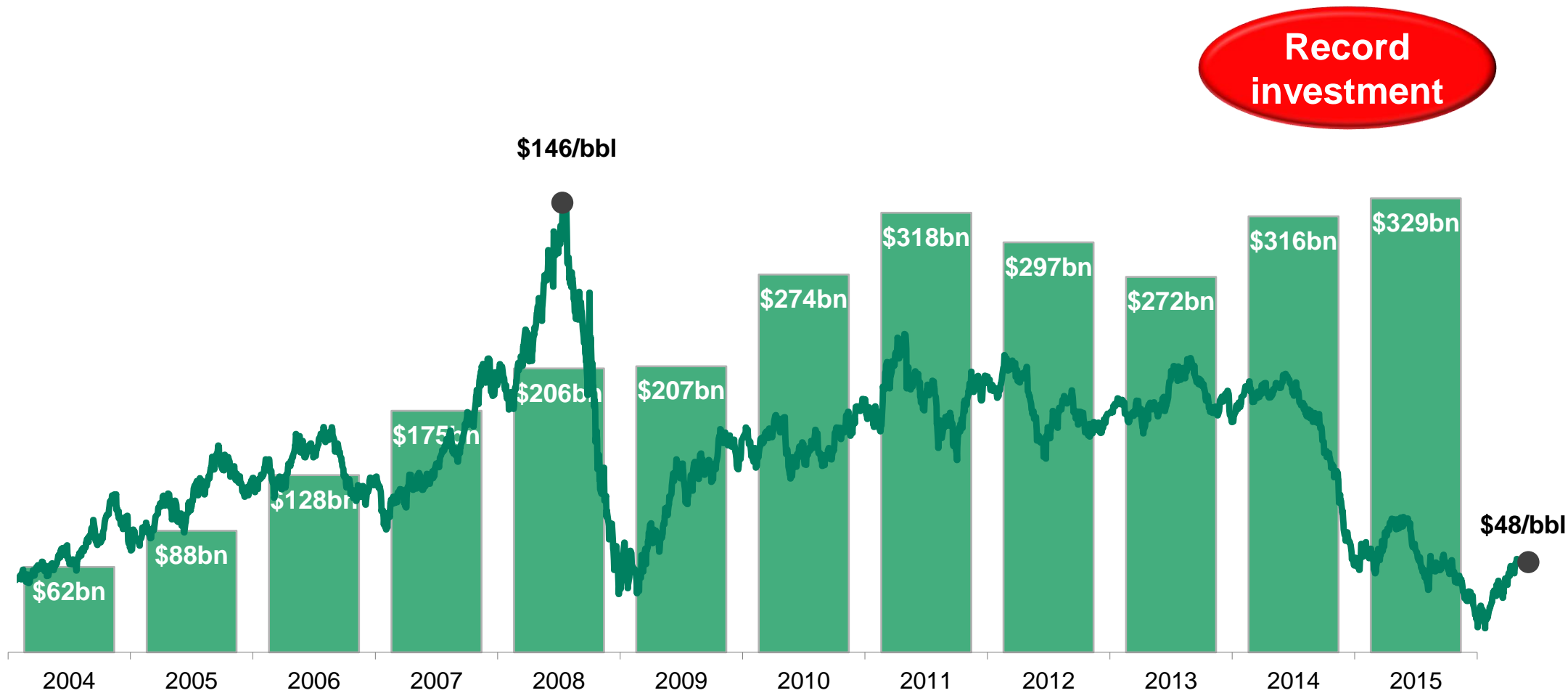


Source: IEA; CDIAC; BP; Bloomberg New Energy Finance

Note: Includes NGL and processing gain, but excludes biofuels

# CLEAN ENERGY INVESTMENT ROSE WHILE OIL PLUMMETED

GLOBAL CLEAN ENERGY INVESTMENT VS WTI CRUDE SPOT 2004-15

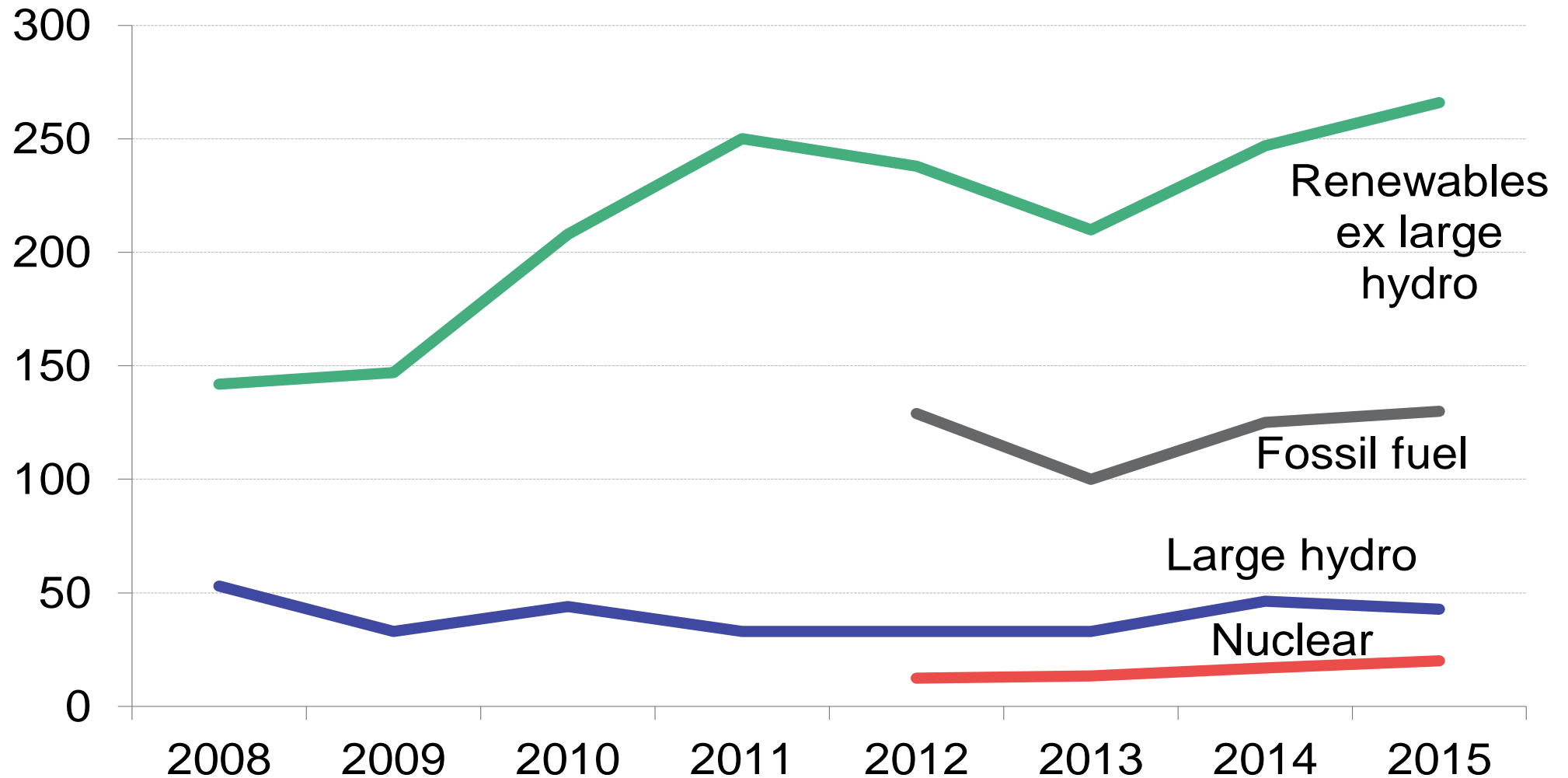


Note: Total values include estimates for undisclosed deals. Includes corporate and government R&D, and spending for digital energy and energy storage projects (not reported in quarterly statistics). Excludes large hydro.

Source: Bloomberg Intelligence, Bloomberg New Energy Finance

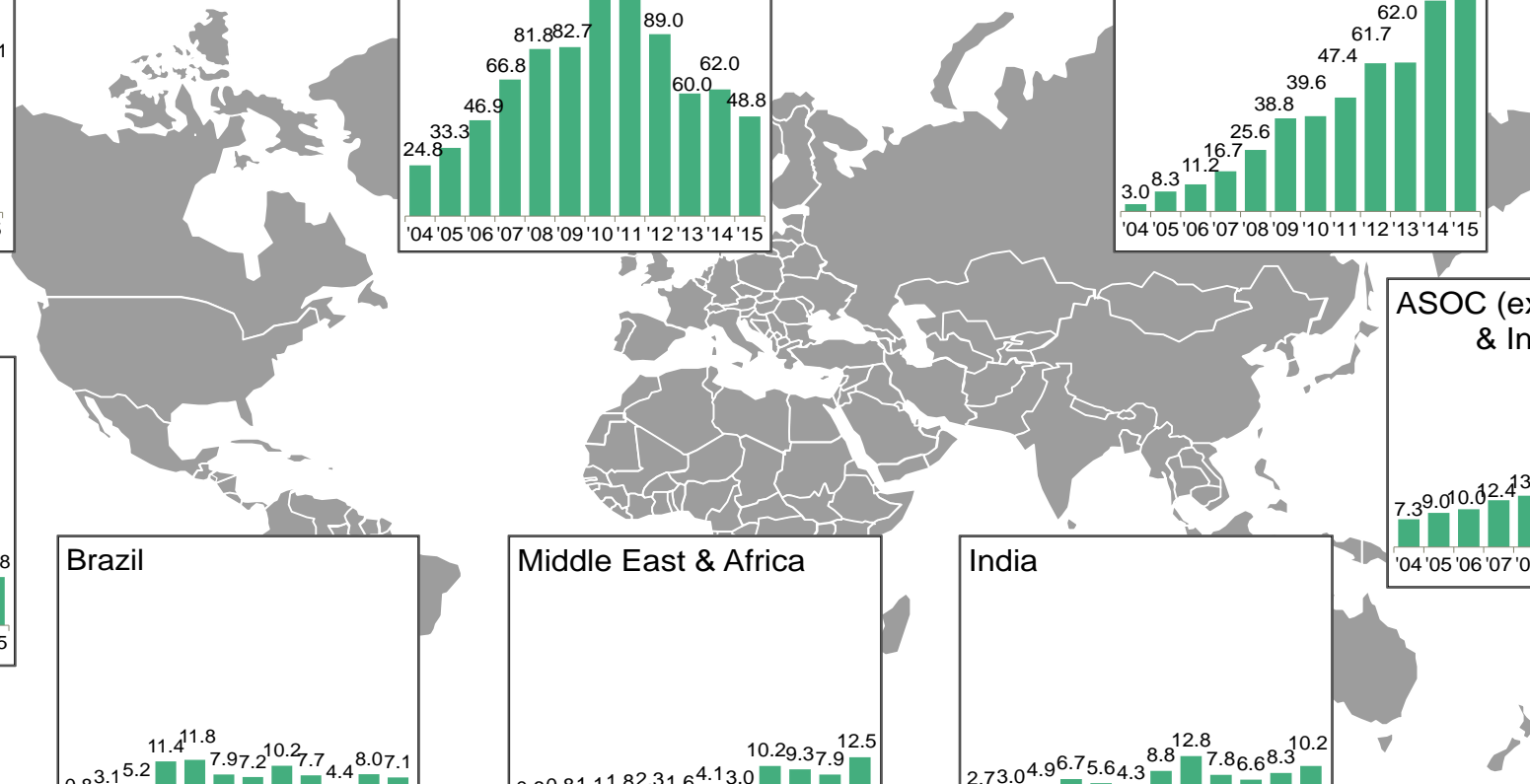
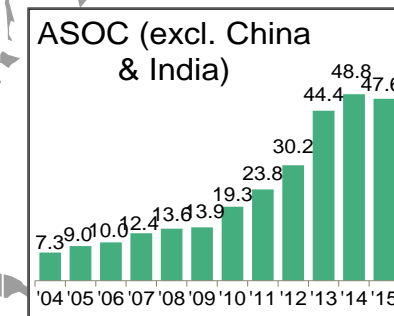
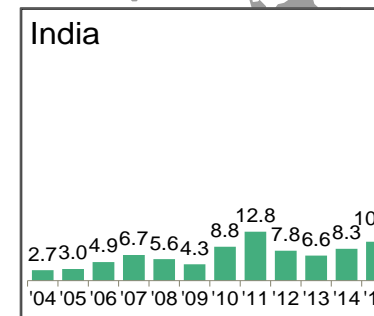
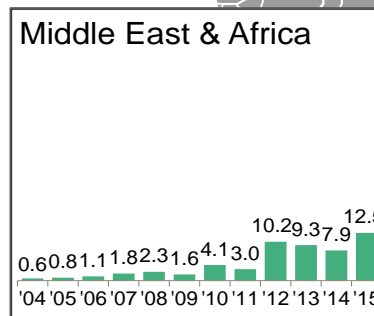
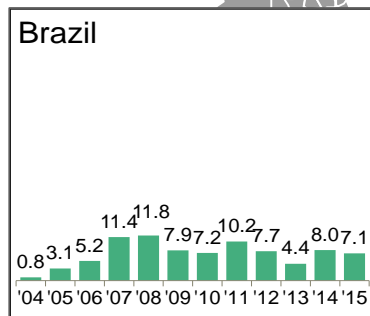
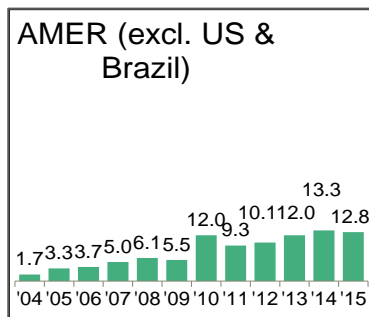
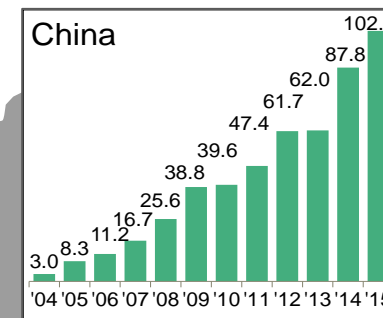
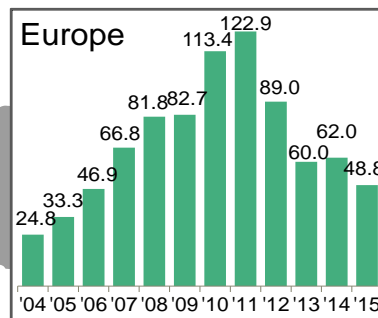
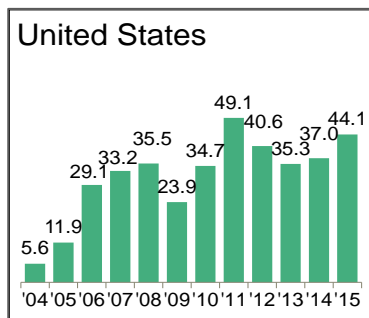
# INVESTMENT IN POWER CAPACITY, 2008–15

(\$BN)



Source: UNEP, Bloomberg New Energy Finance

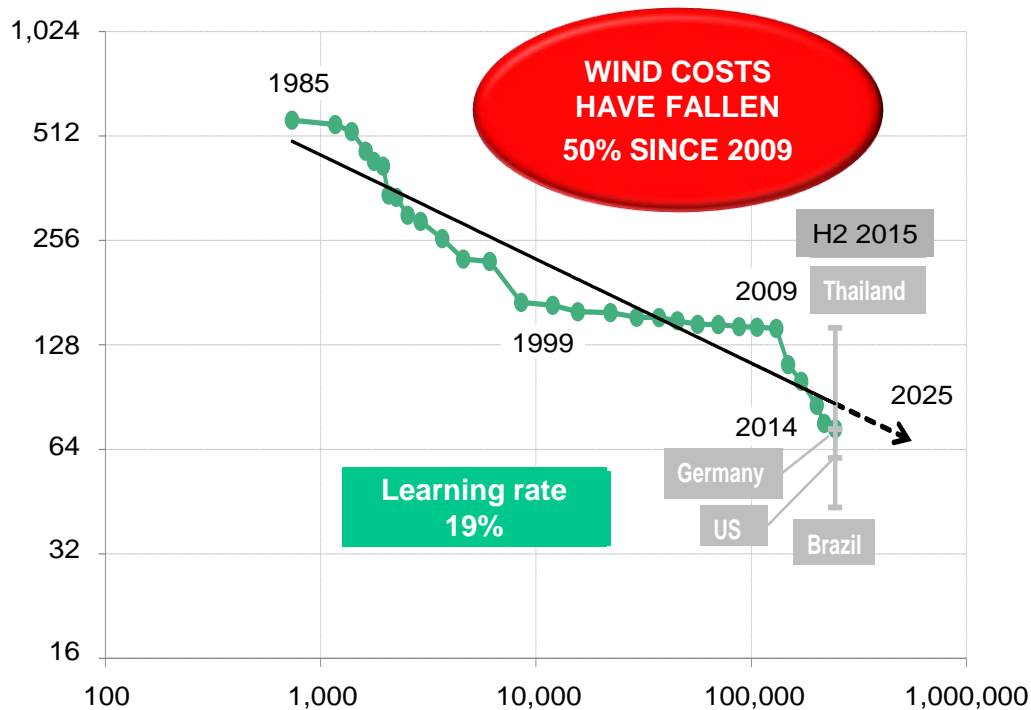
# RENEWABLE ENERGY INVESTMENT, 2004–15 BY REGION (\$BN NOMINAL)



Note: New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals. Source: Bloomberg New Energy Finance

# WIND AND SOLAR EXPERIENCE CURVES

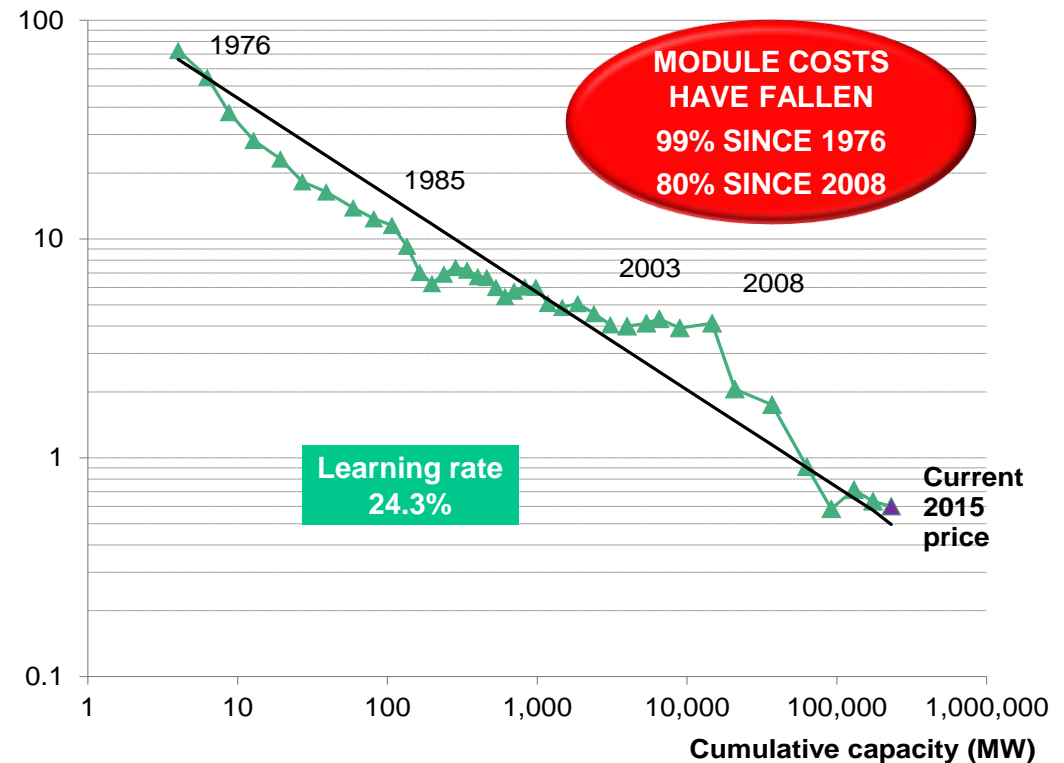
## ONSHORE WIND LEVELISED COST (\$/MWh)



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

# 2011 UNSUBSIDISED CLEAN ENERGY WORLD RECORDS

## ONSHORE WIND



**US\$ 6.2 cents/kWh**

## SOLAR PV



**US\$ 17 cents/kWh**

Source: Bloomberg New Energy Finance; ImagesSiemens; Wikimedia Commons

## ONSHORE WIND



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

## SOLAR PV



Location: Peru  
Bidder: Enel Green Power  
Signed: February 2016  
Construction: 2017  
Price: **US\$ 4.8 c/kWh**

Source: Bloomberg New Energy Finance; ImagesSiemens; Wikimedia Commons



## ONSHORE WIND



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

## SOLAR PV



Location: Coahuila, Mexico  
Bidder: Enel Green Power  
Signed: March 2016  
Construction: 2018  
**Price: US\$ 3.6 c/kWh**

Source: Bloomberg New Energy Finance; ImagesSiemens; Wikimedia Commons

## ONSHORE WIND



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

## SOLAR PV



Location: Dubai  
Bidder: Masdar Consortium  
Signed: May 2016  
Construction: 2019  
**Price: US\$ 2.99 c/kWh**

Source: Bloomberg New Energy Finance; ImagesSiemens; Wikimedia Commons

## ONSHORE WIND



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

## SOLAR PV

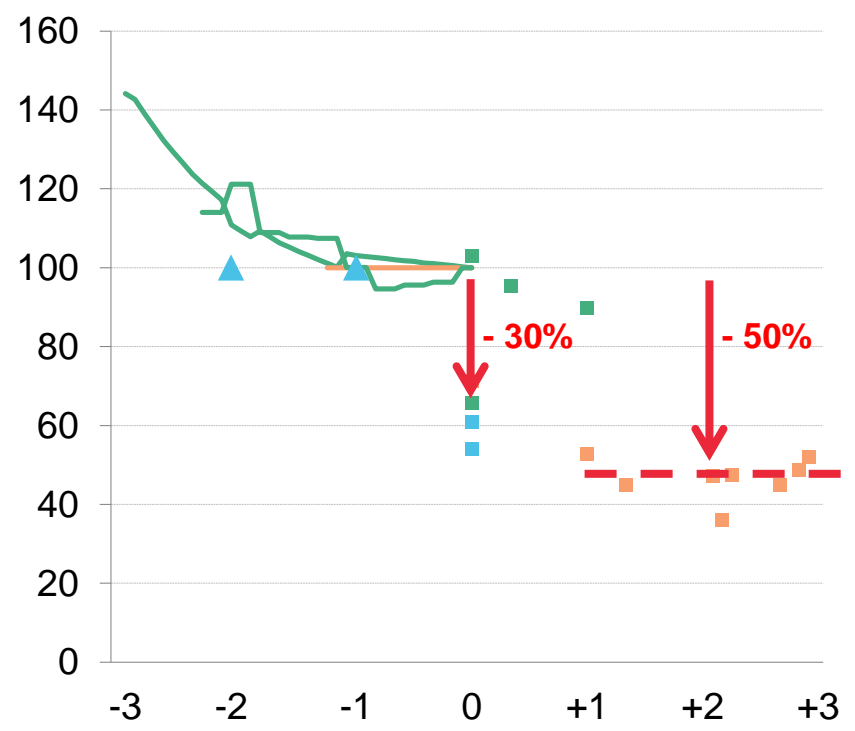


Location: Chile  
Bidder: Solarpack Corporation  
Signed: August 2016  
Construction: 2019  
**Price: US\$ 2.91 c/kWh**

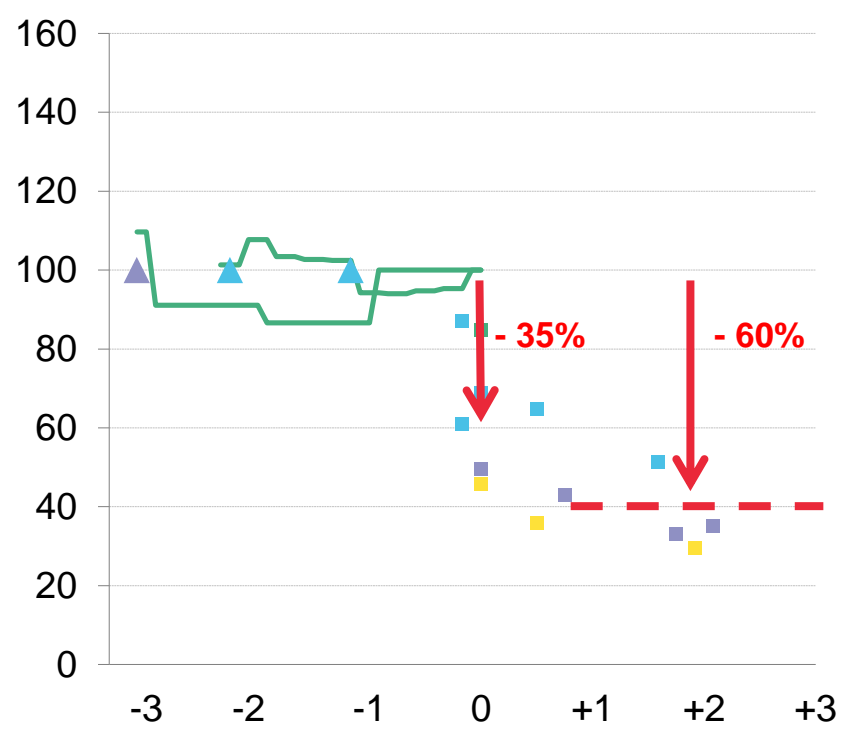
Source: Bloomberg New Energy Finance; ImagesSiemens; Wikimedia Commons

# PRICE IMPACT OF SWITCH FROM FIT TO AUCTIONS, SELECTED COUNTRIES (NORMALISED)

**Solar PV**  
(unit price normalised to 100 at date of first auction)



**Onshore Wind**  
(unit price normalised to 100 at date of first auction)



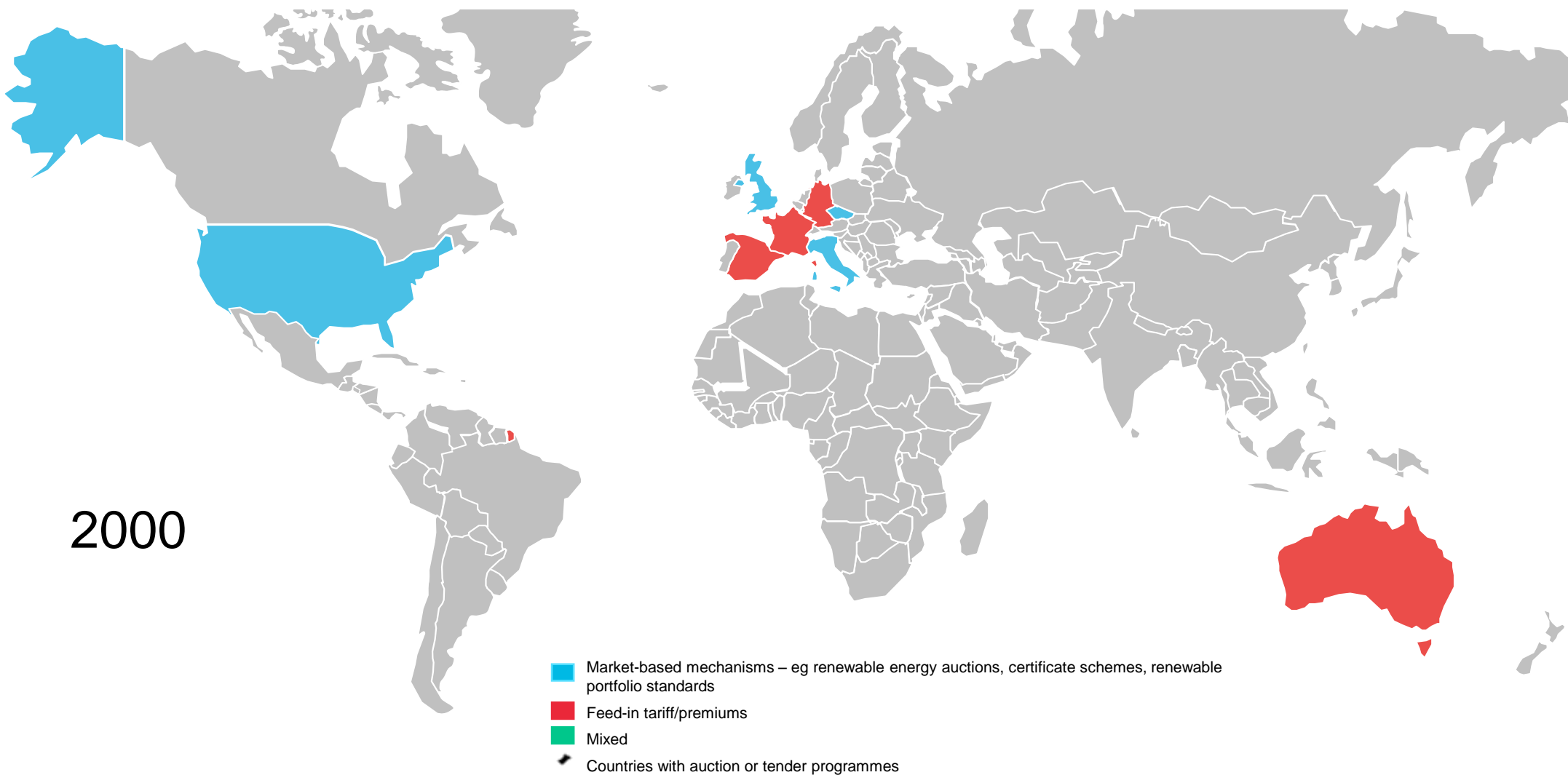
**KEY**

- : tariffs
- : non-tariff price signals
- : auctions

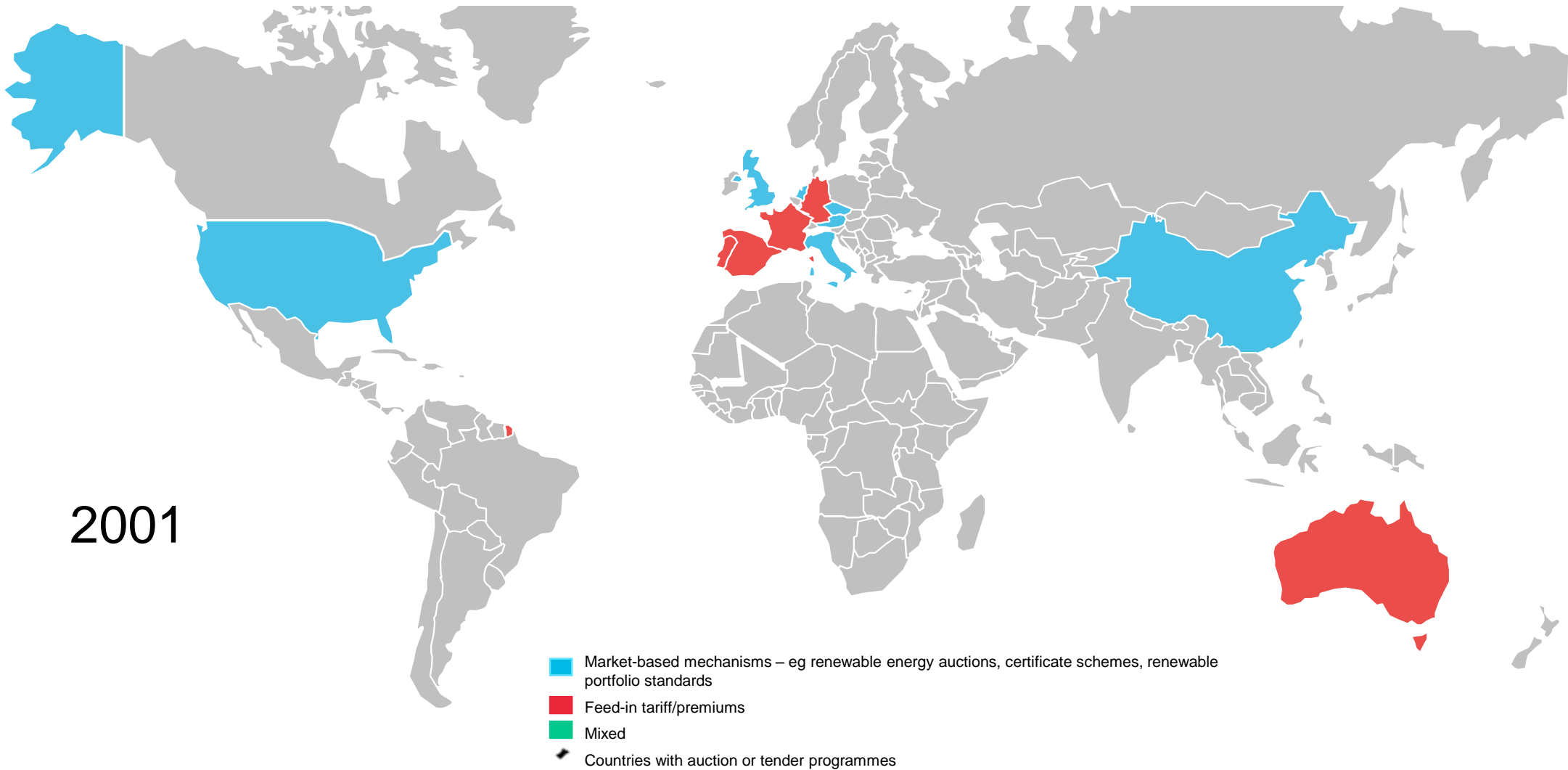
	EMEA
	Other LatAm
	Brazil
	India
	South Africa

Source: Bloomberg New Energy Finance

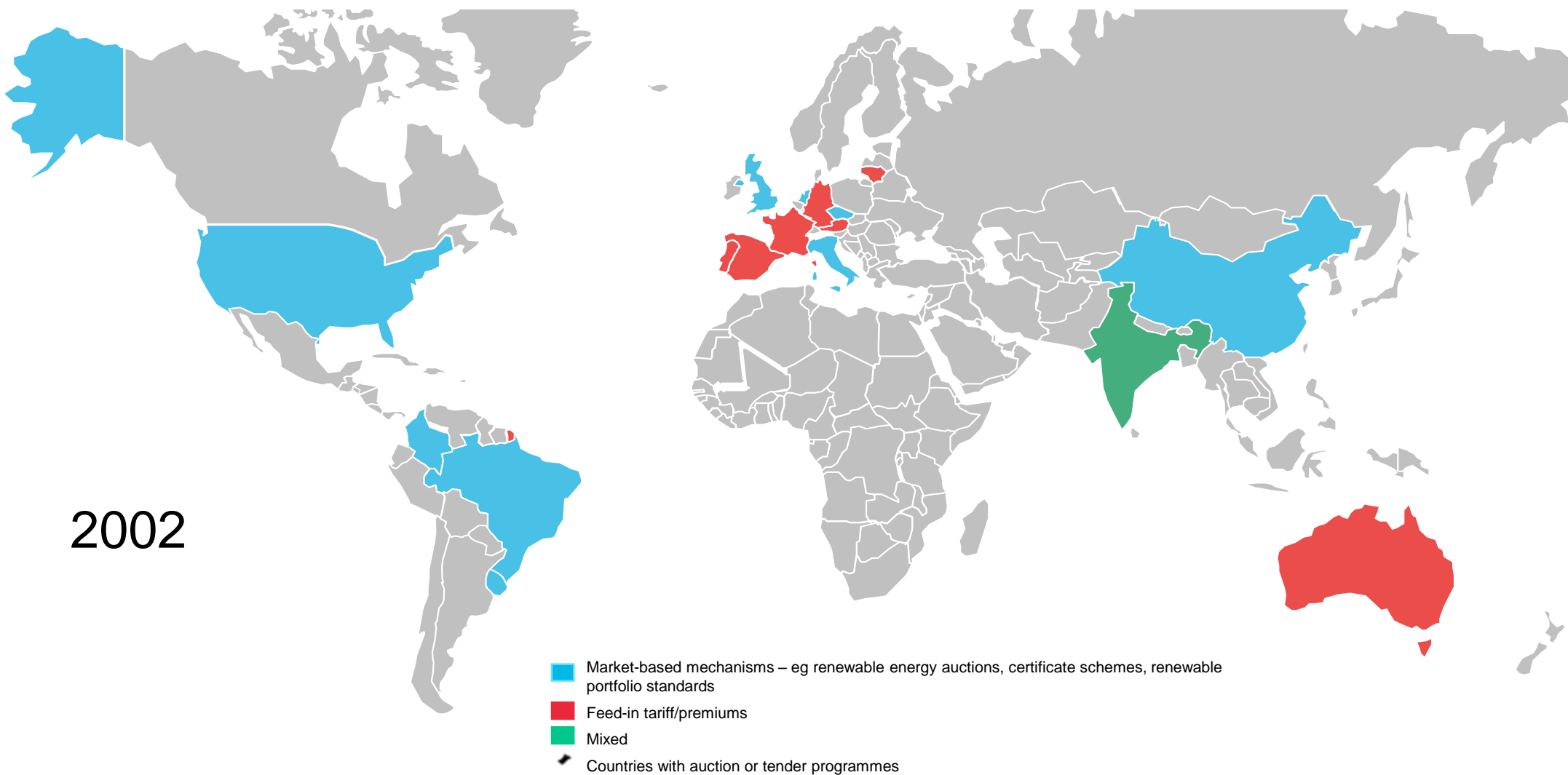
# RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL



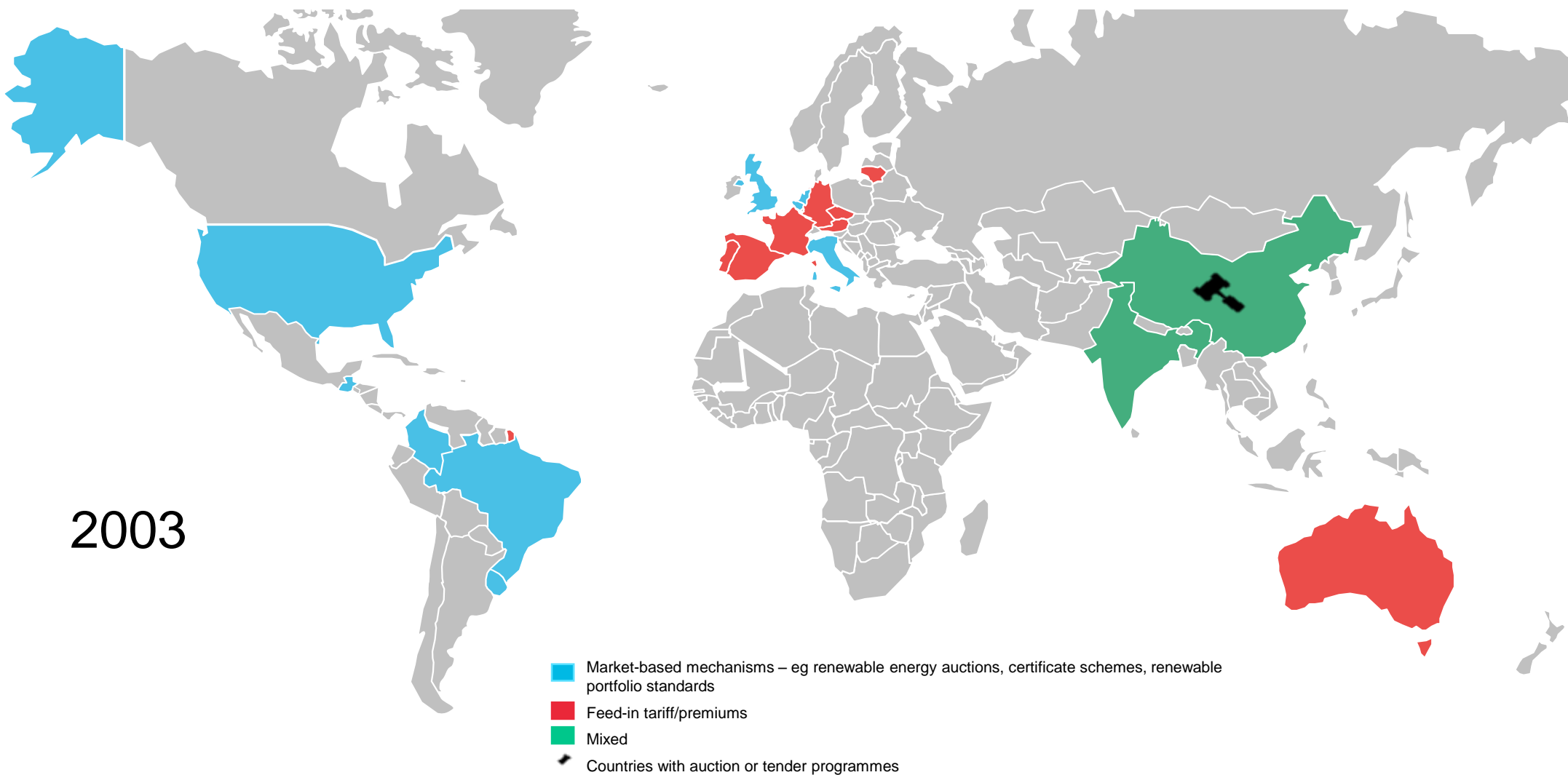
# RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL



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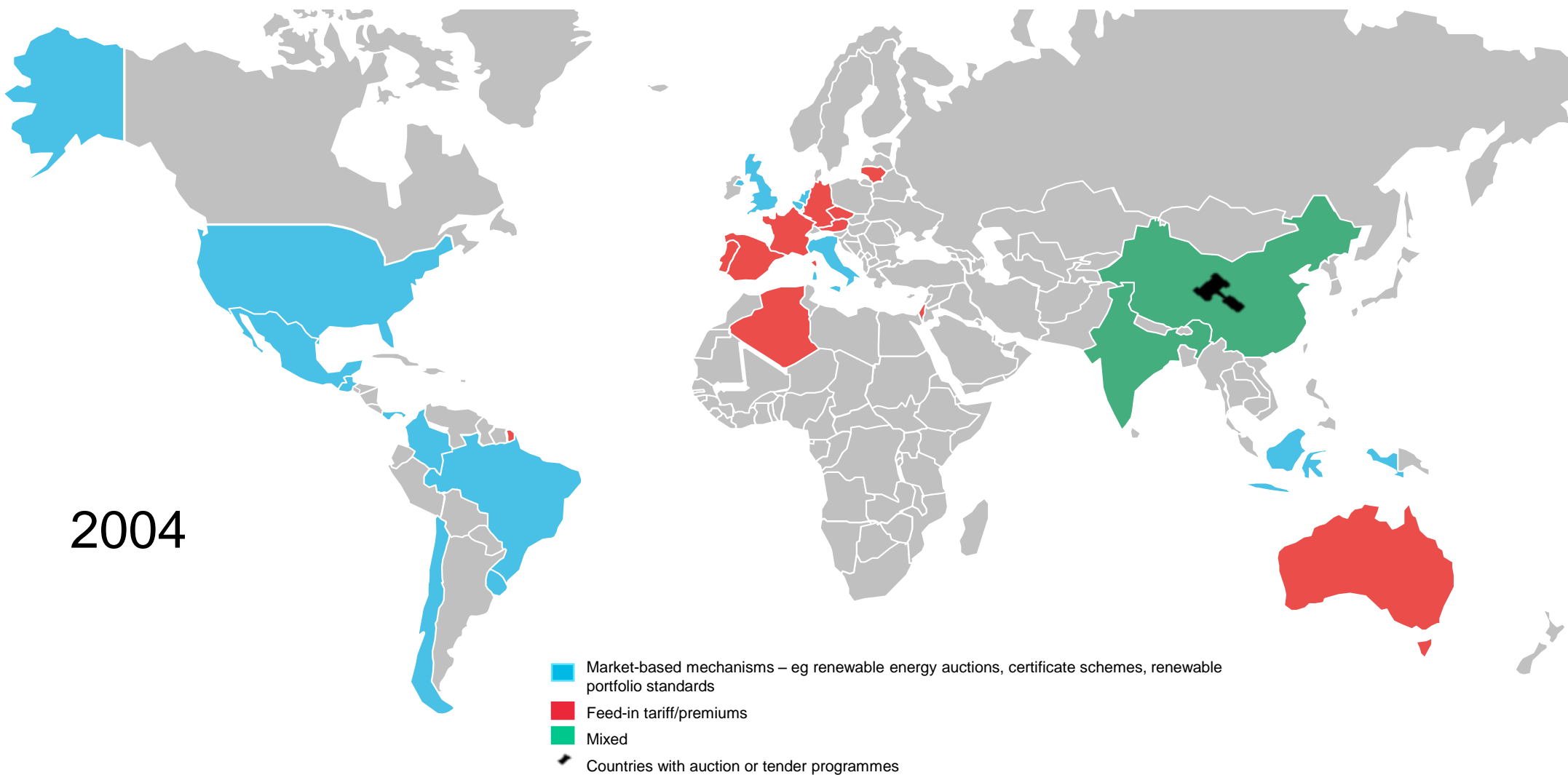


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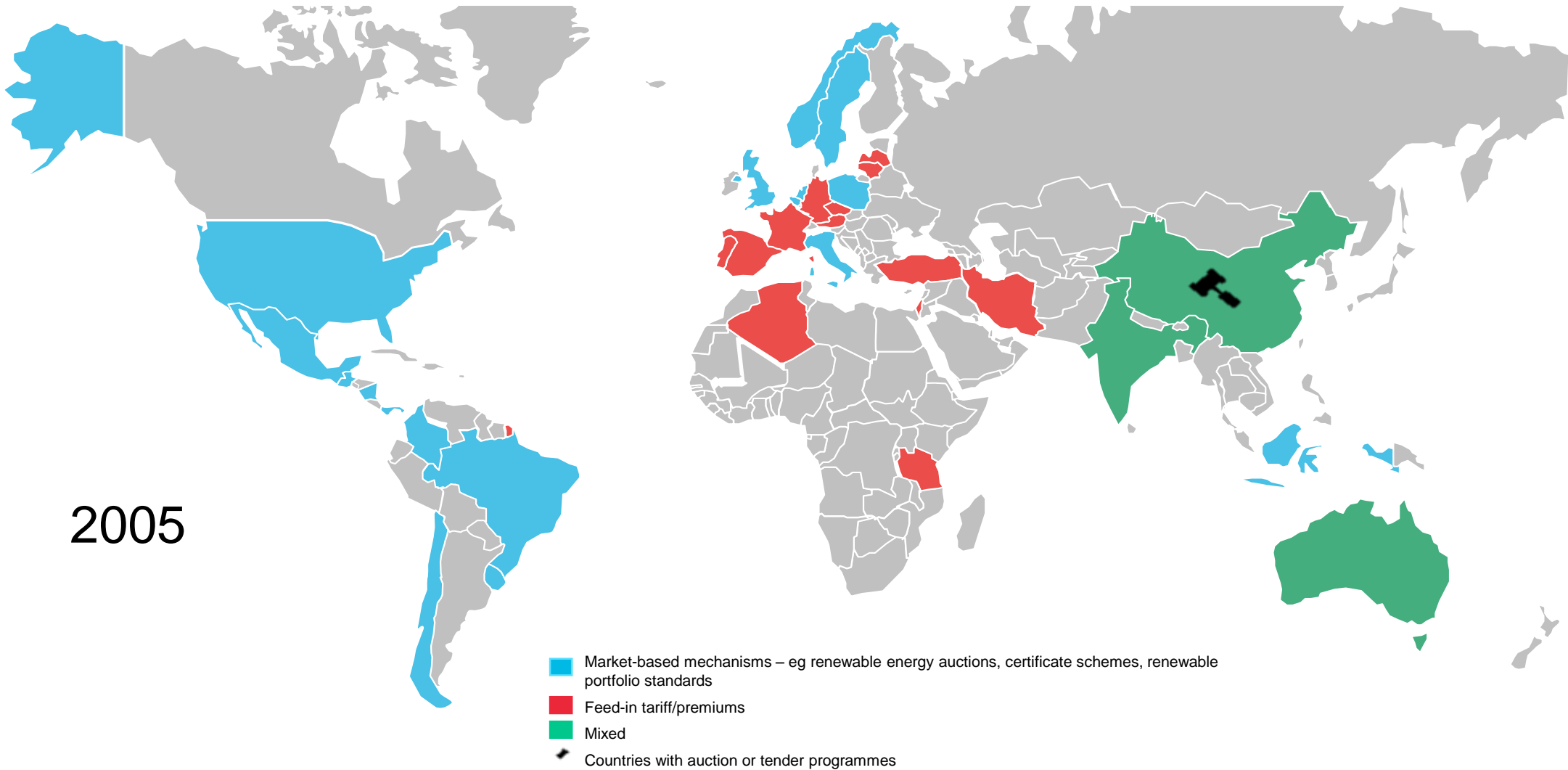




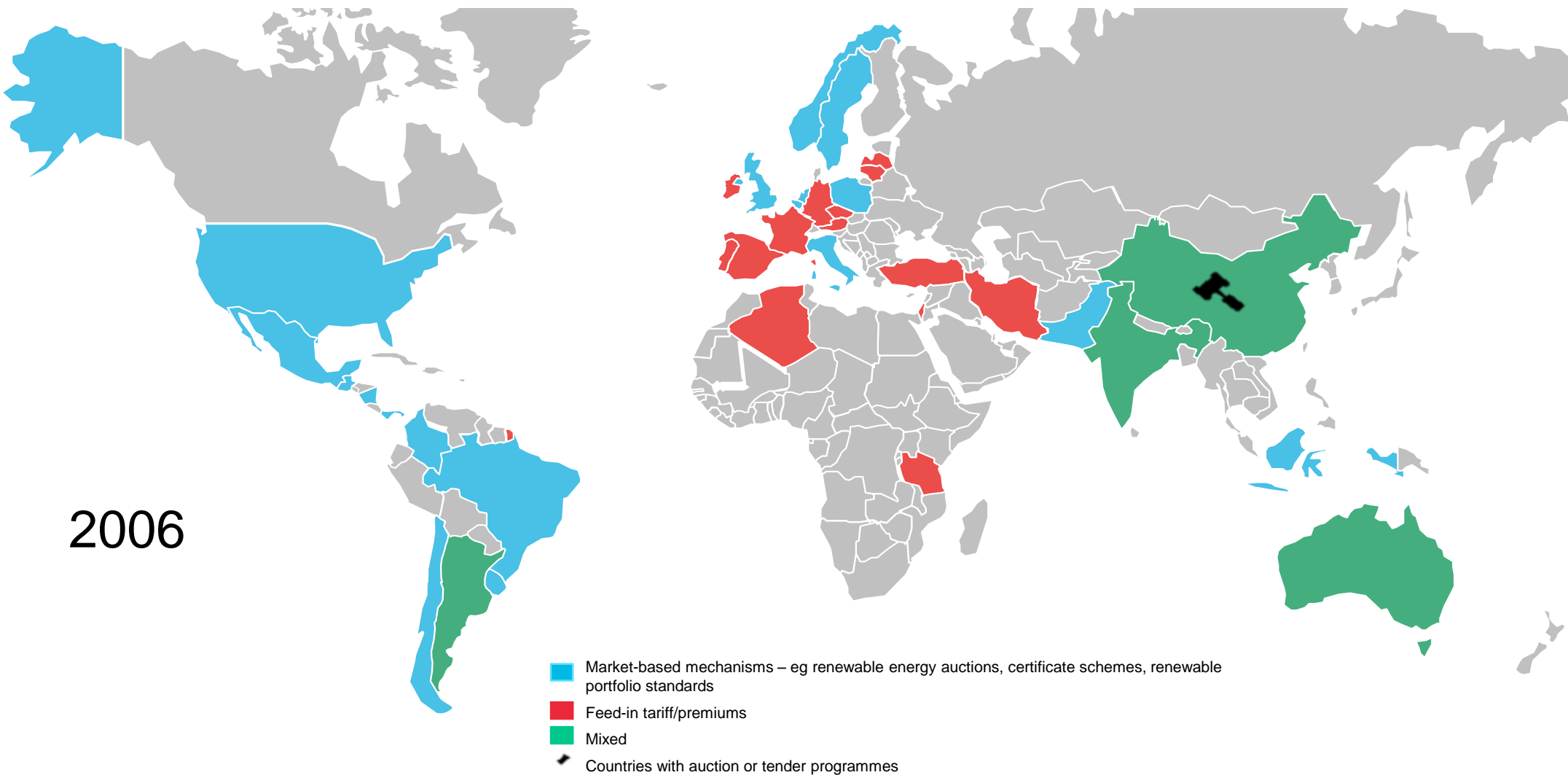
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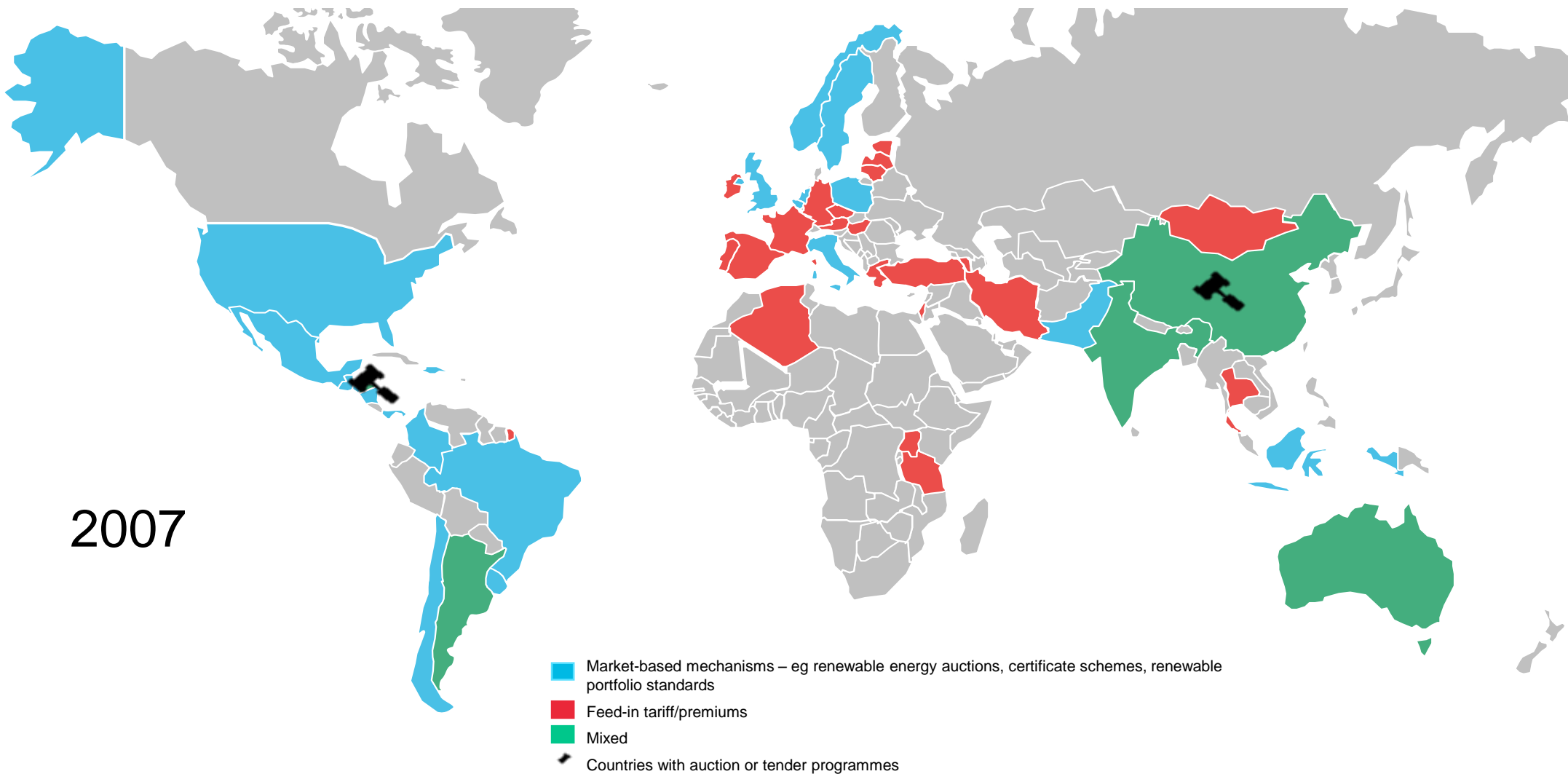
# RENEWABLE ENERGY - THE MARCH OF THE PRICE SIGNAL



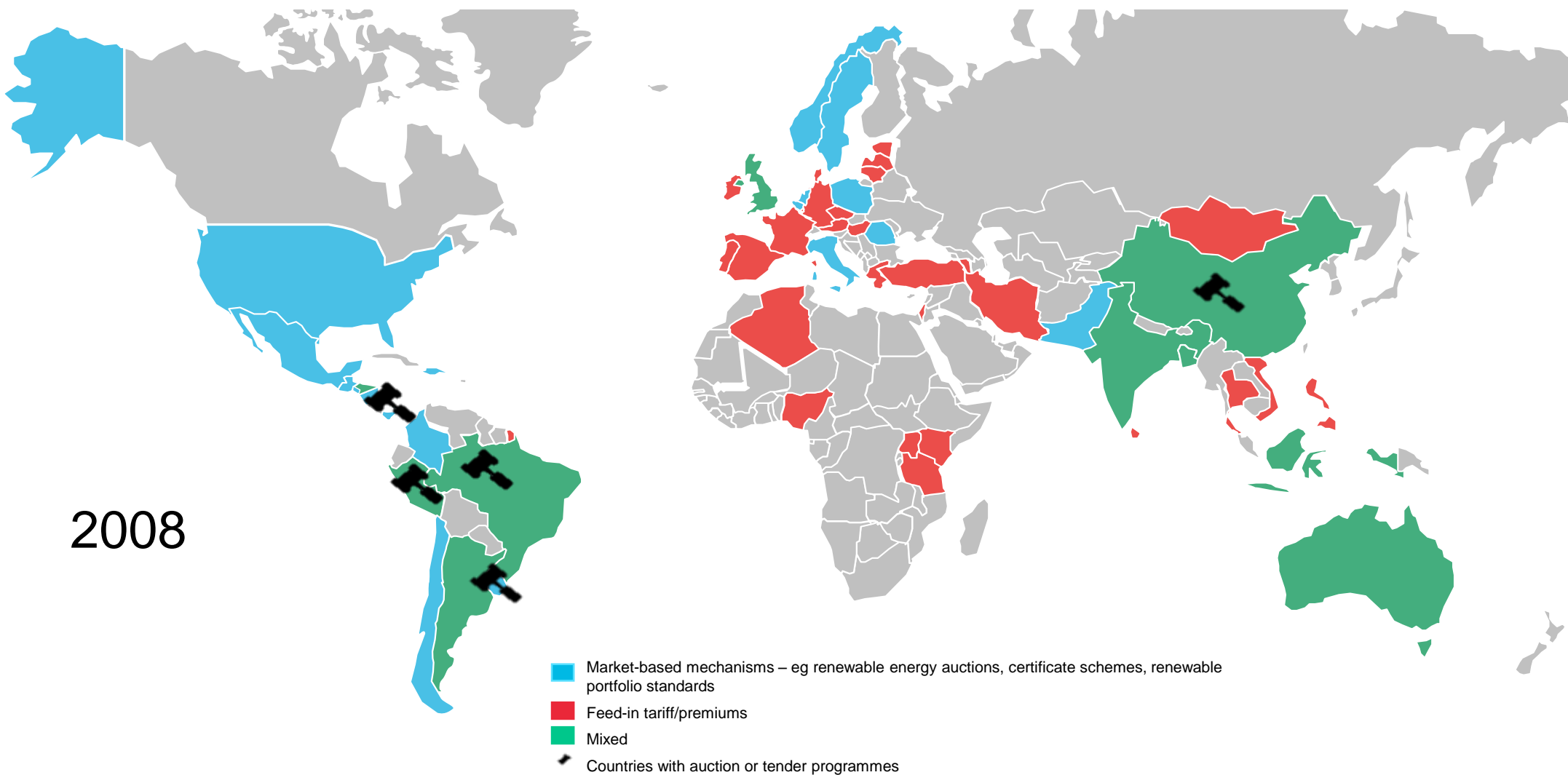
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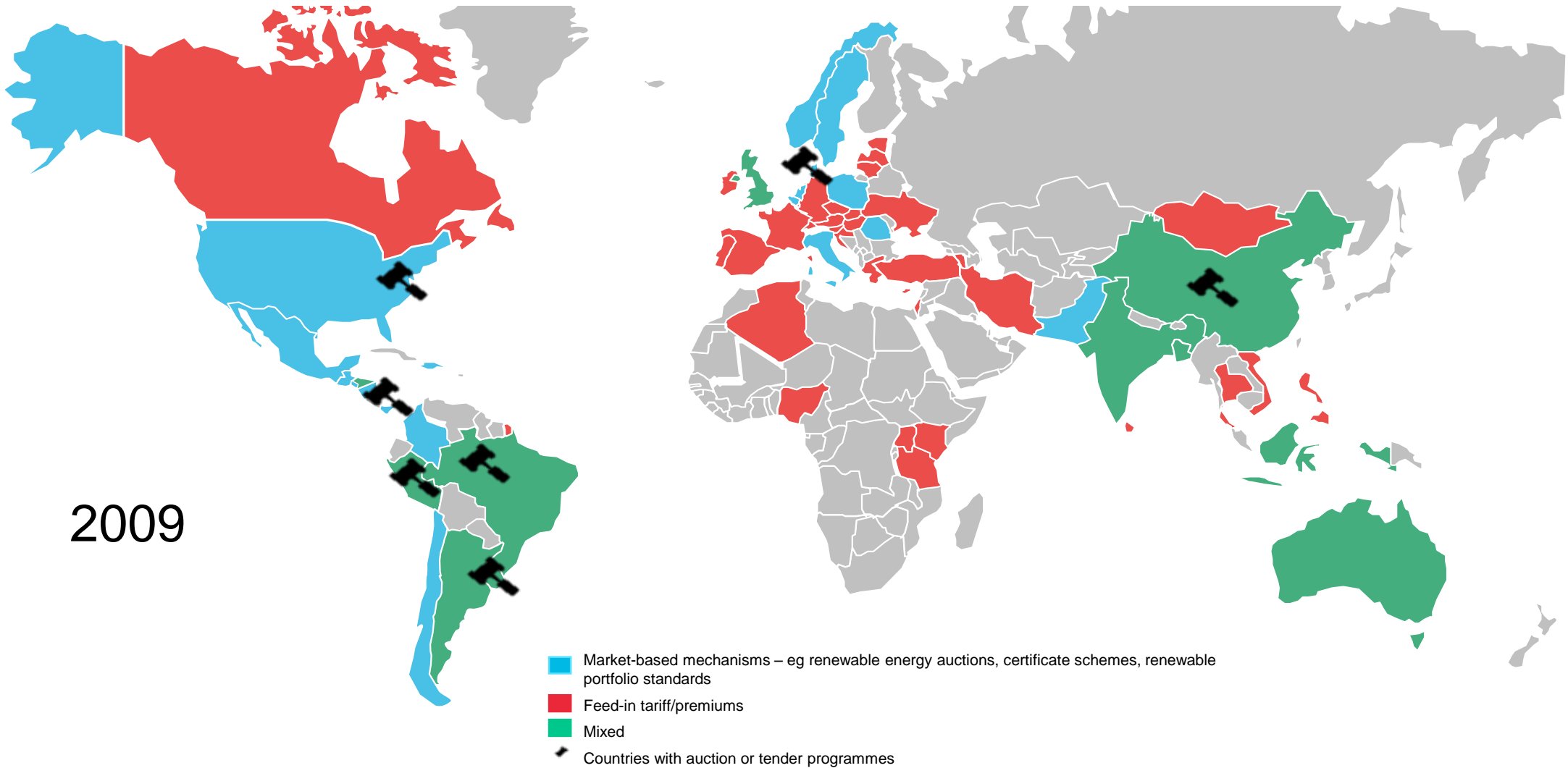
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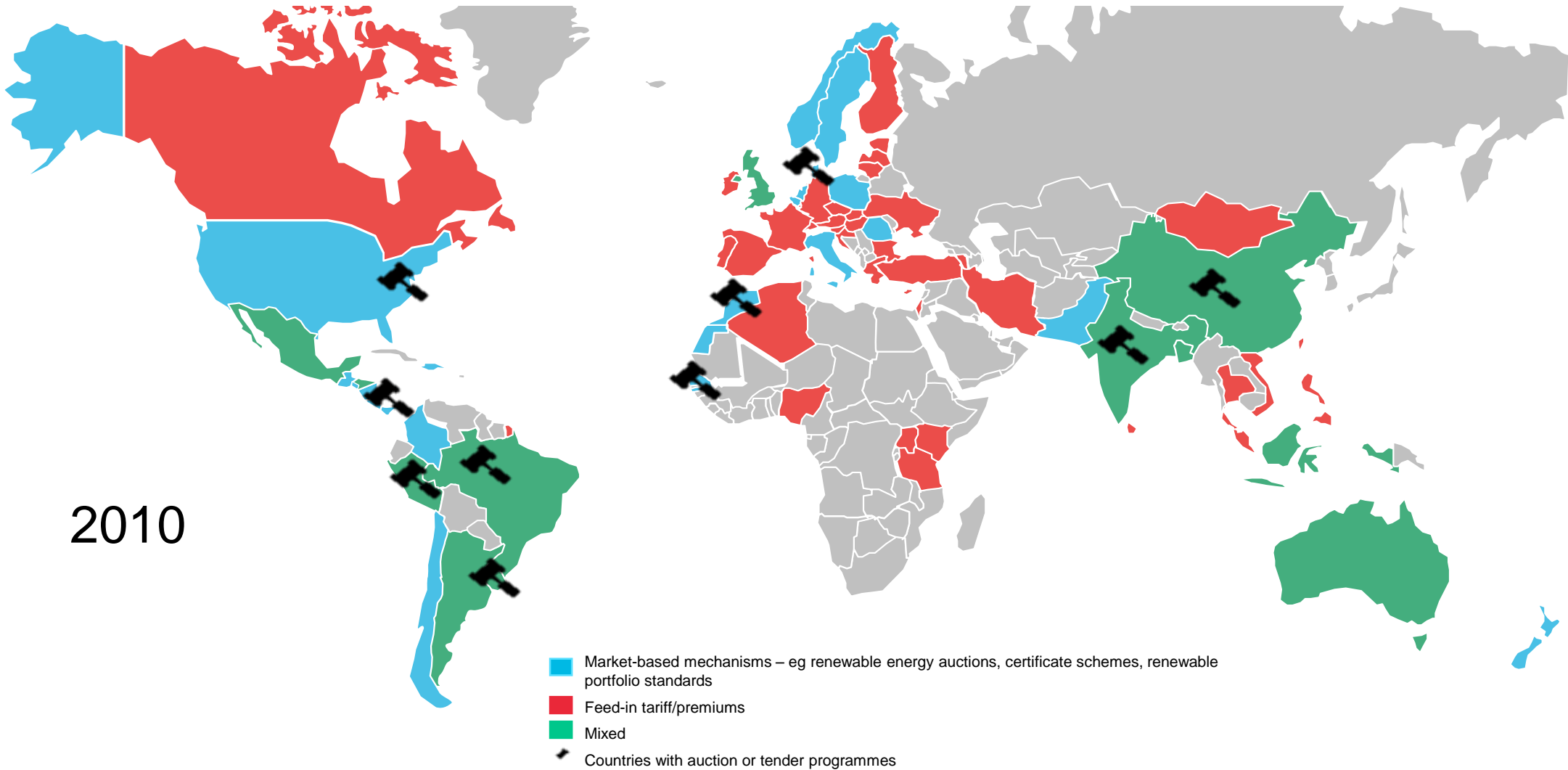
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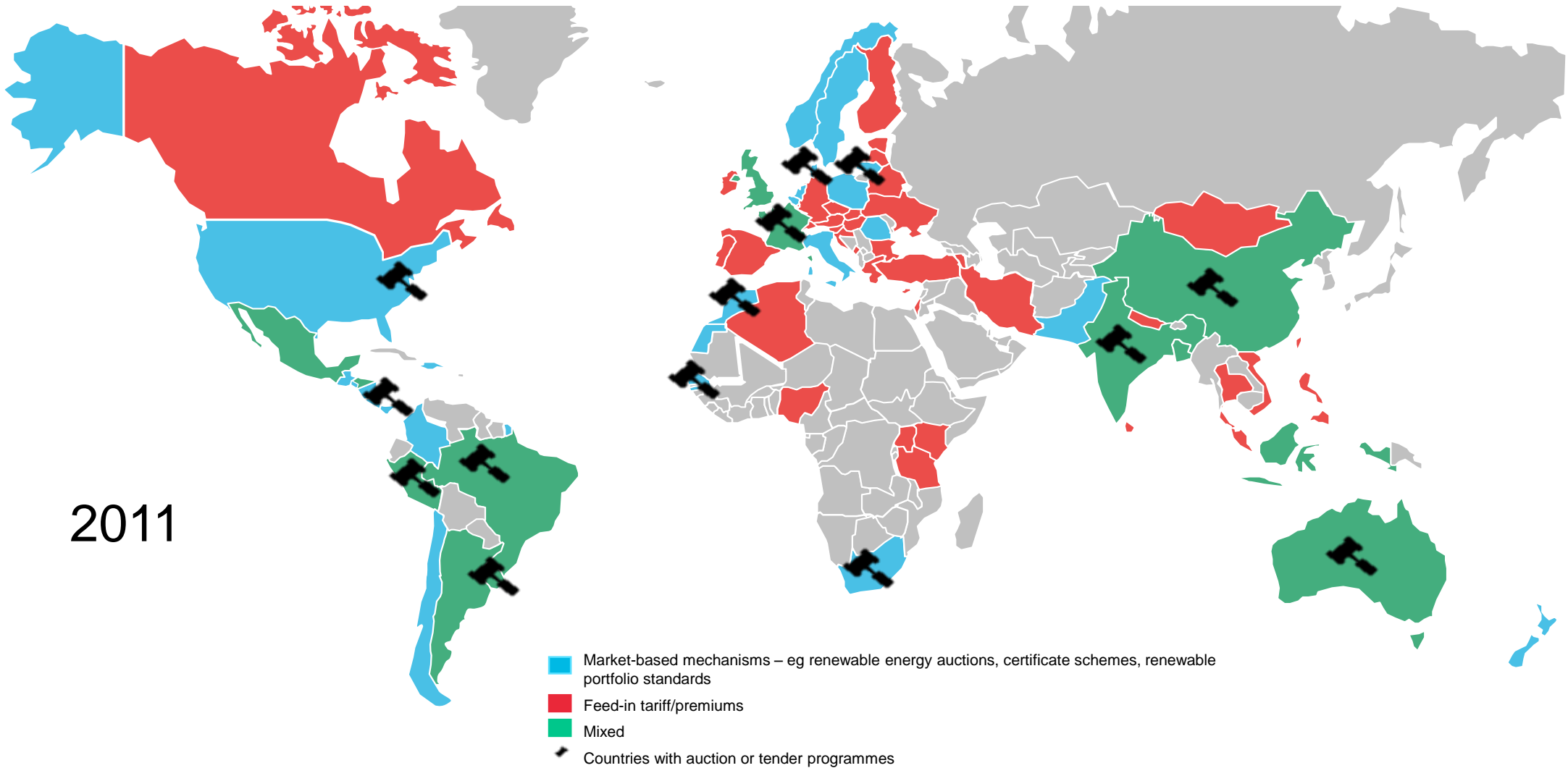
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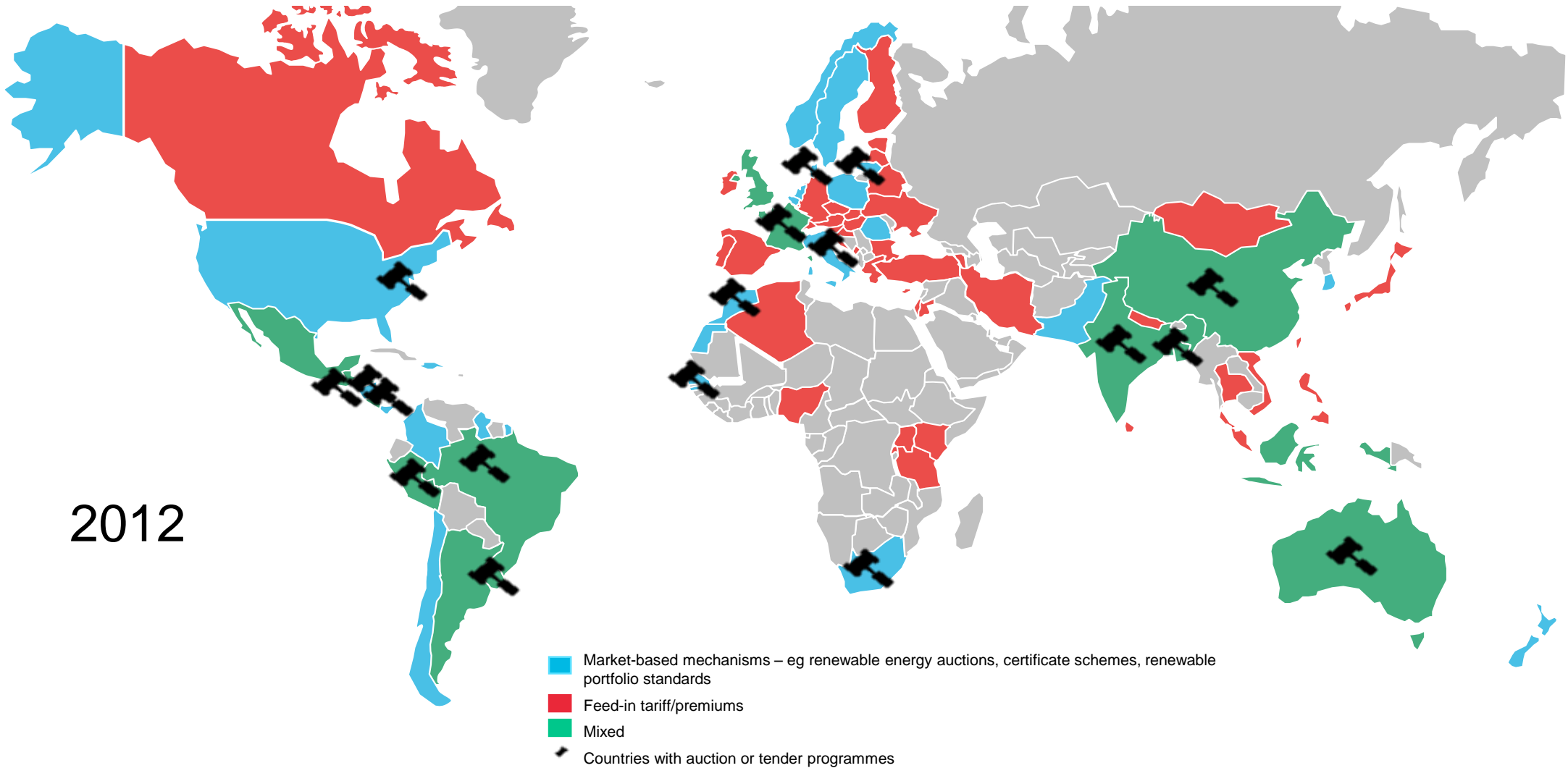


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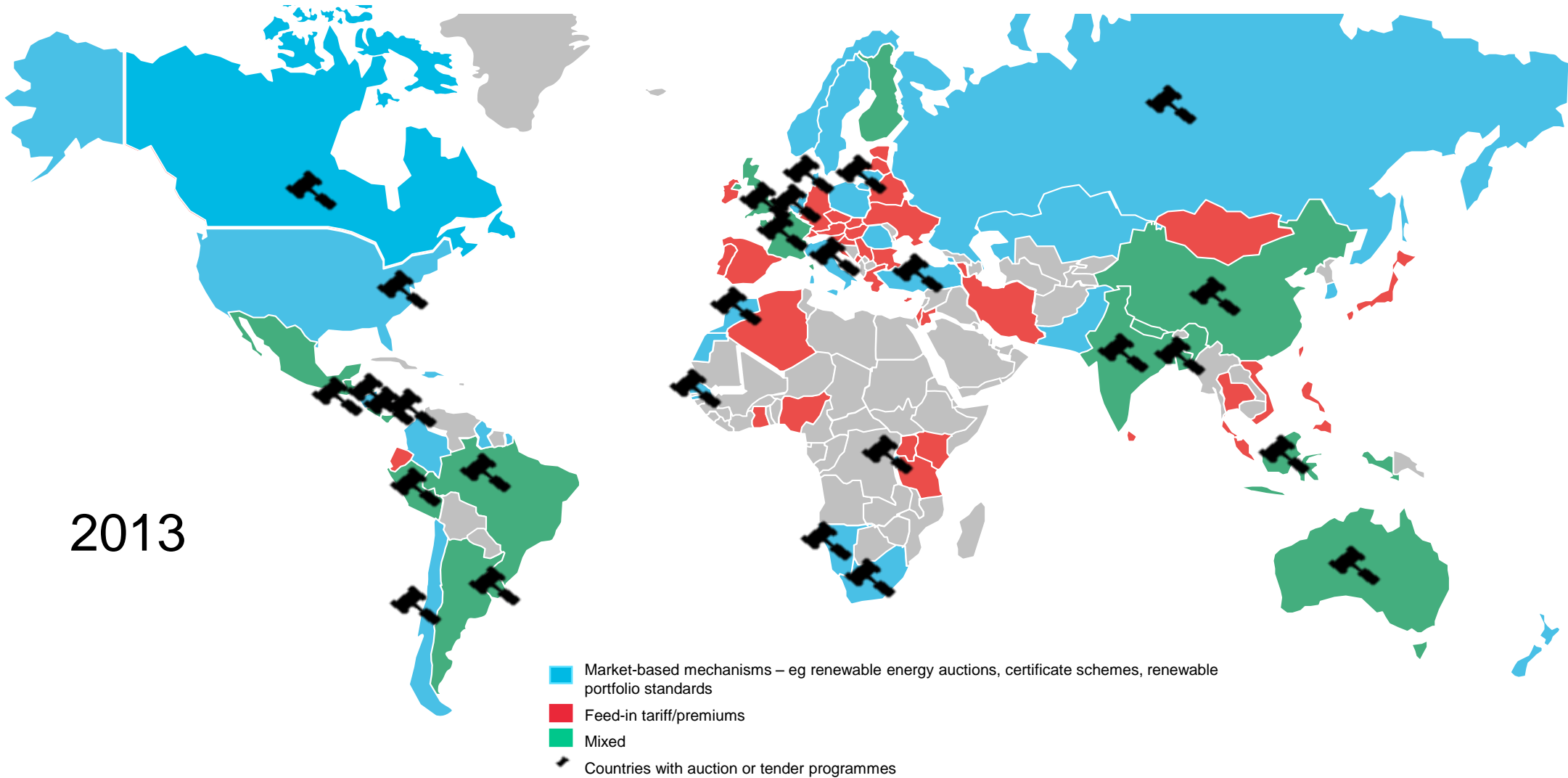




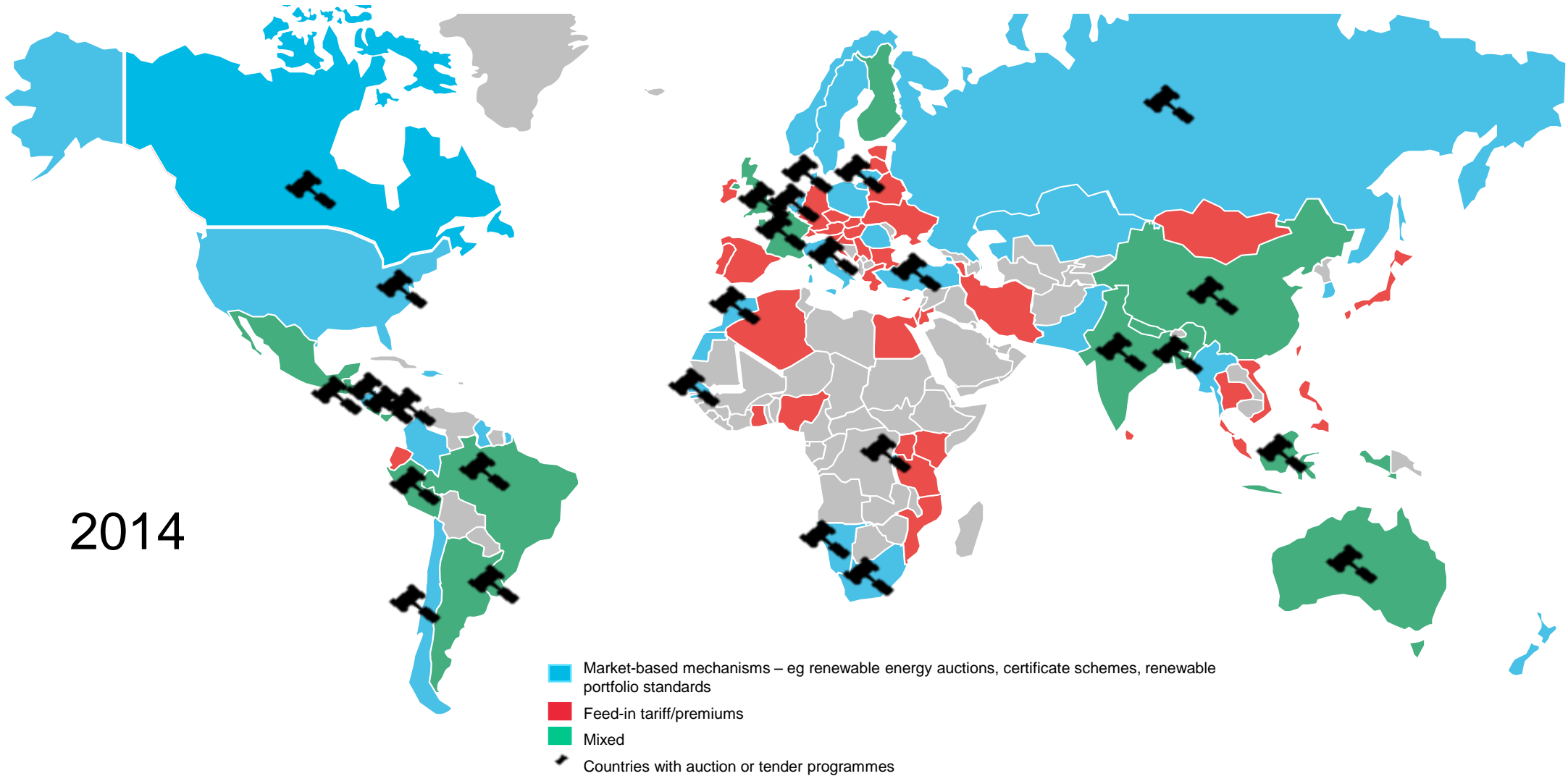
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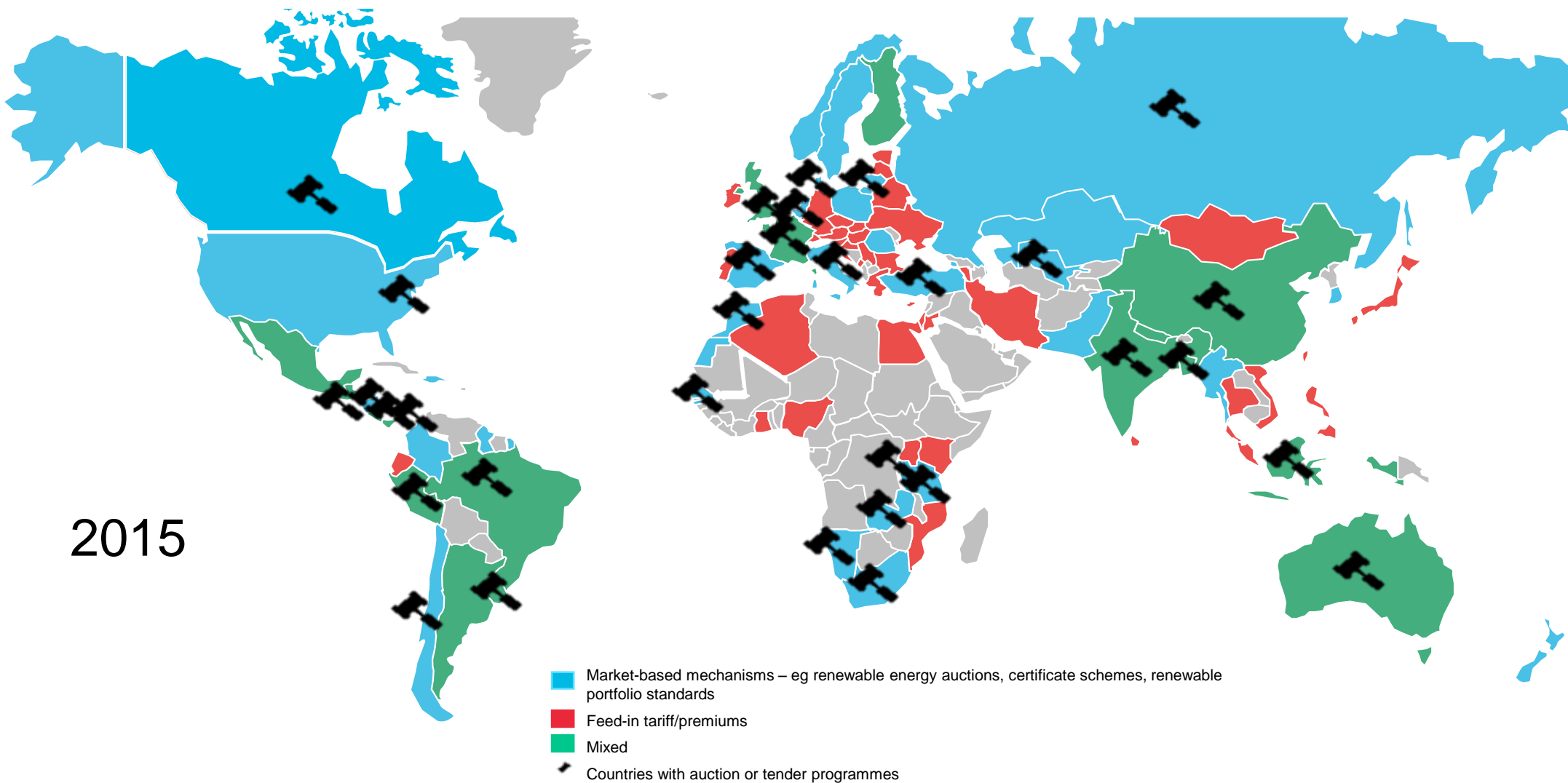
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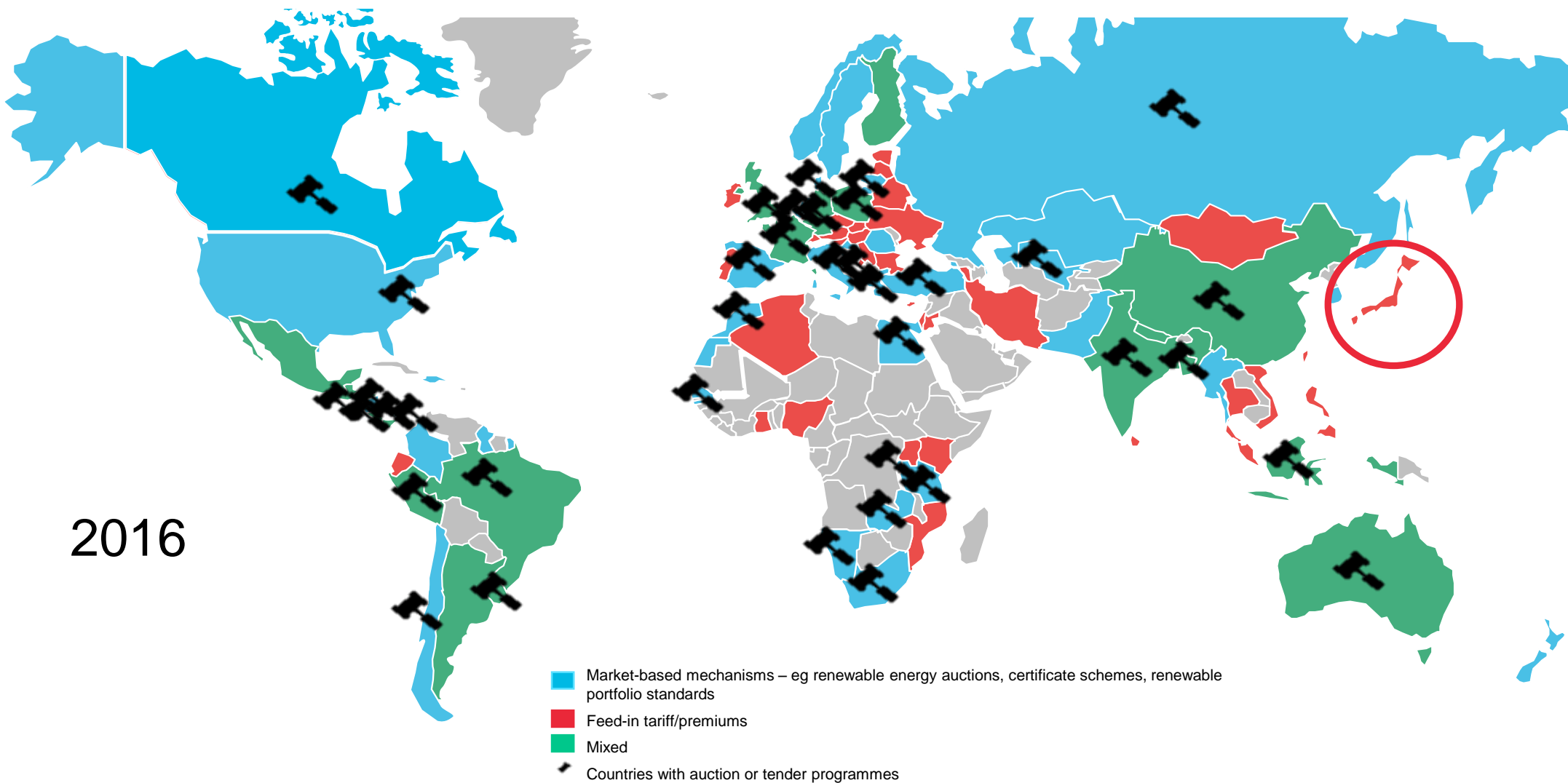
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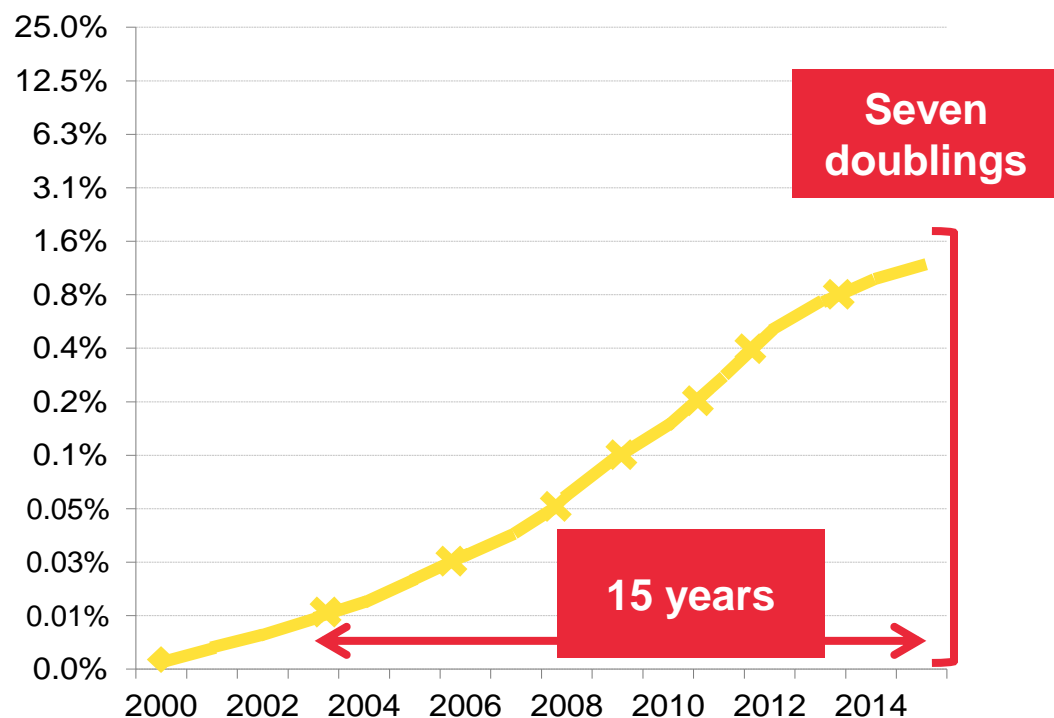
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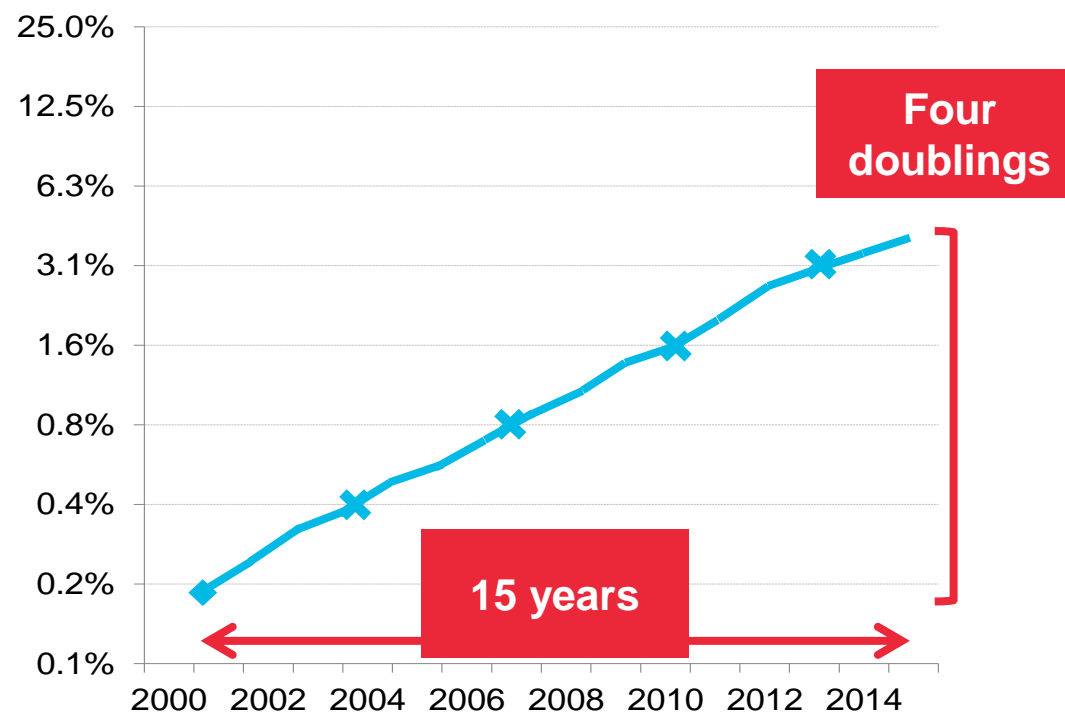
# RENEWABLES SHARE OF GENERATION, 2000–15

(% OF SYSTEM TOTAL)

## SOLAR



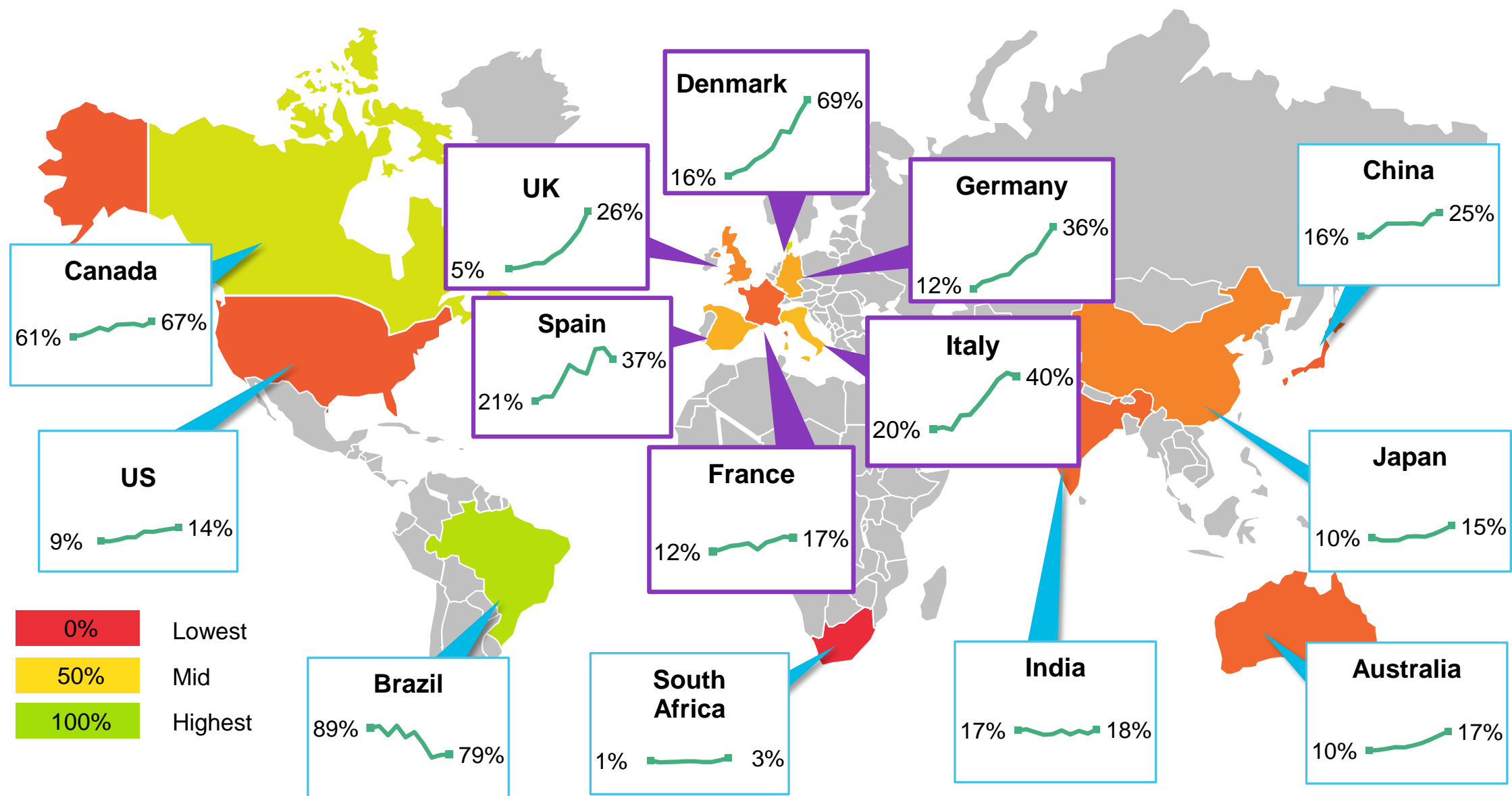
## WIND



Note: Y-axes are logarithmic with base 2

Source: Bloomberg New Energy Finance, BP, UNEP

# RENEWABLE ENERGY PROPORTION OF POWER GENERATION, 10 YEARS TO 2015 (%)

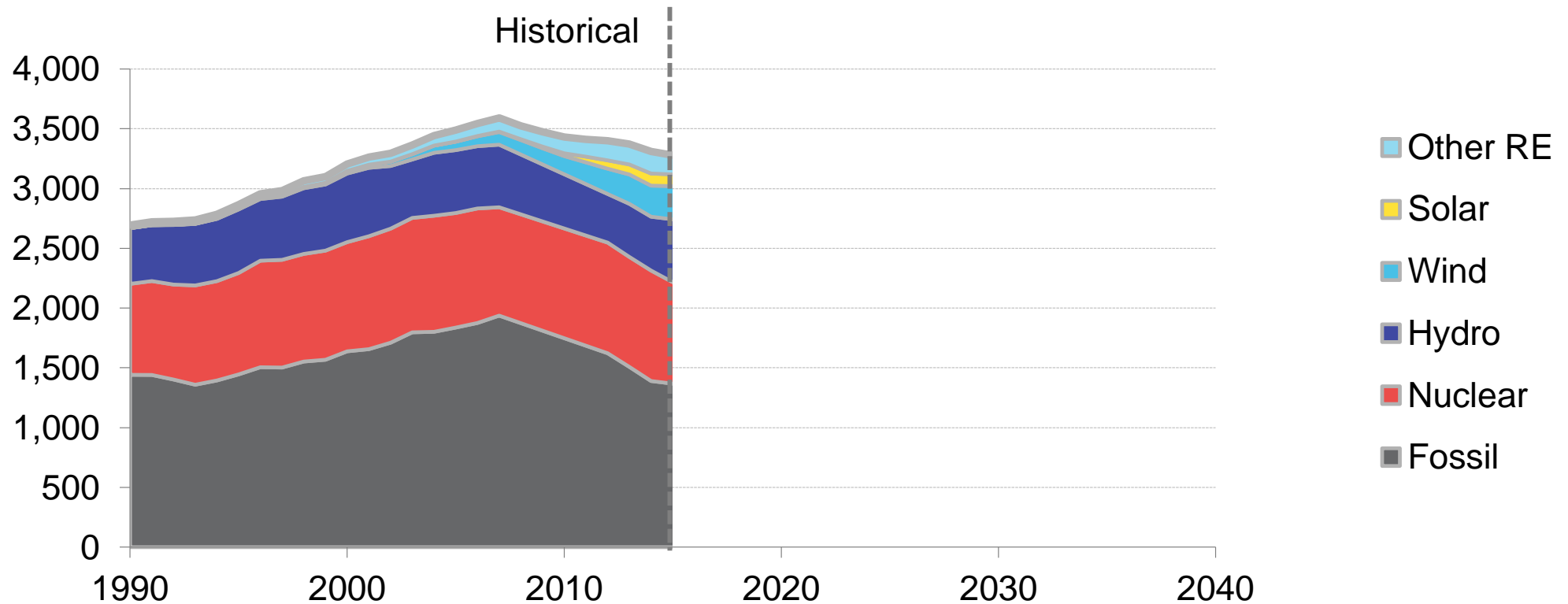


Note: Includes hydro Source: BP Statistical Review of Energy, Bloomberg New Energy Finance

# EUROPE POWER GENERATION BY FUEL TYPE

(TWH/YR)

Intermittent renewables accounted for  
16% of generation in Europe in 2015



Note: Includes EU 28, Norway, Iceland and Switzerland

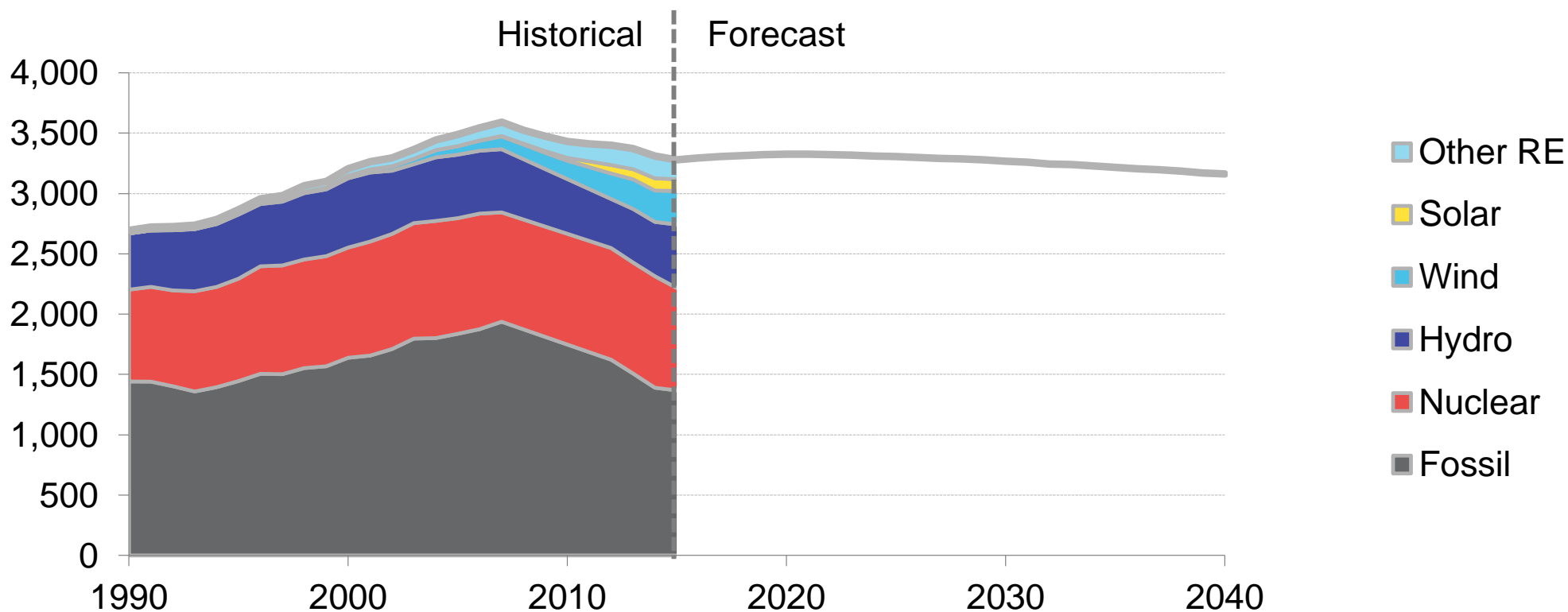
Source: Bloomberg New Energy Finance



# EUROPE POWER GENERATION BY FUEL TYPE

(TWH/YR)

Intermittent renewables accounted for 16% of generation in Europe in 2015



- Assumes power demand from EVs grows to 80TWh/yr by 2040, or 21% of total demand
- GDP growth assumed to be around 2% per year, in line with forecasts from the IMF

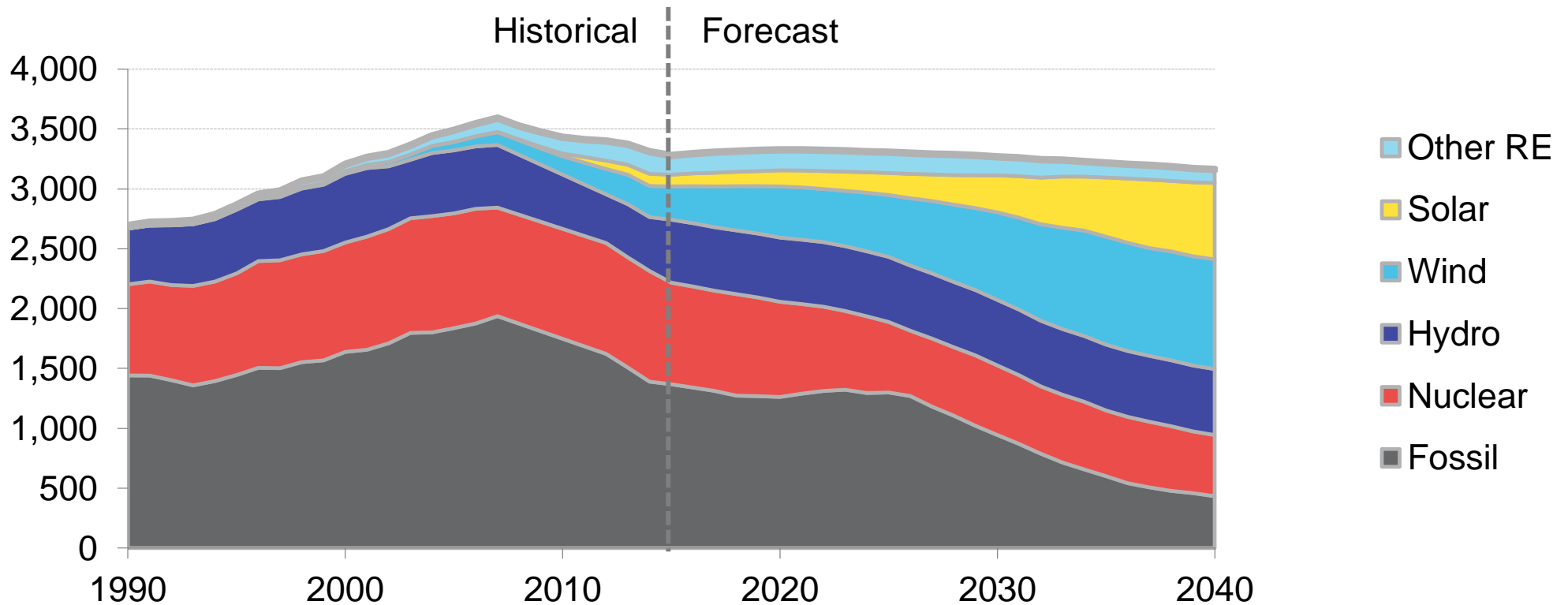
Note: Includes EU 28, Norway, Iceland and Switzerland

Source: Bloomberg New Energy Finance

# EUROPE POWER GENERATION BY FUEL TYPE

(TWH/YR)

Intermittent renewables accounted for 16% of generation in Europe in 2015



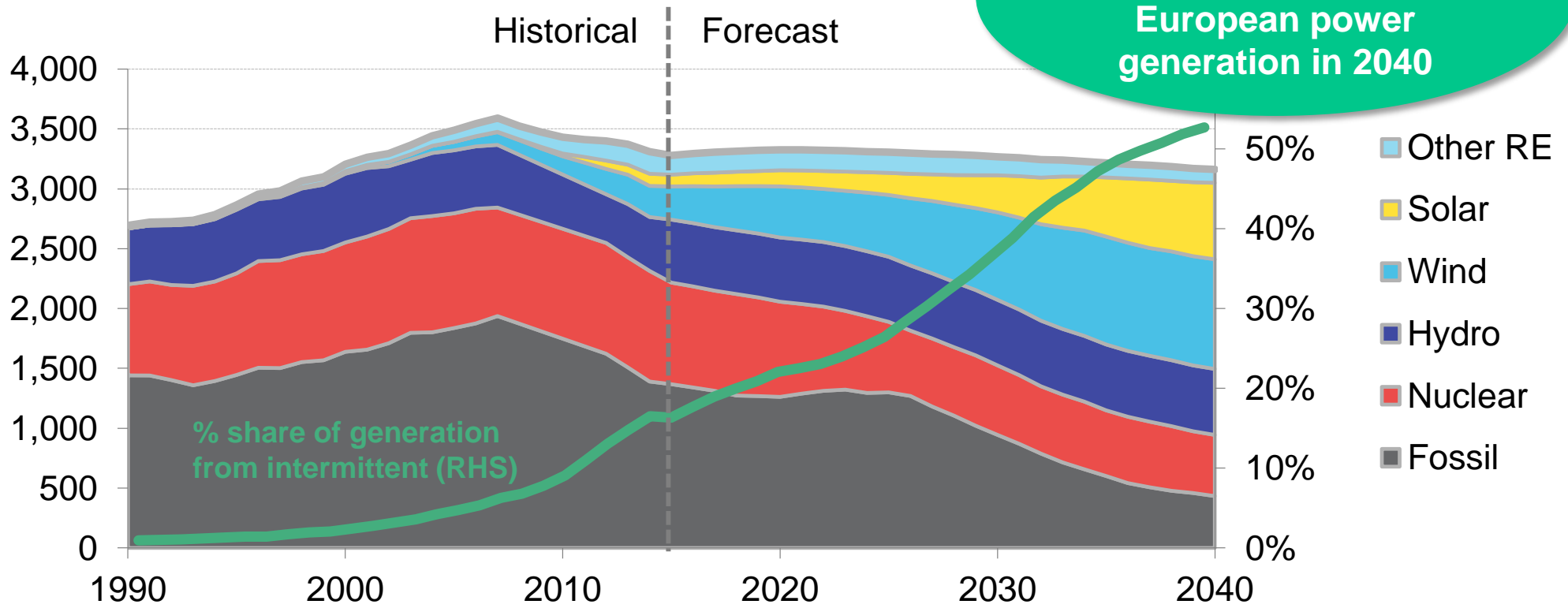
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- GDP growth assumed to be around 2% per year, in line with forecasts from the IMF

# EUROPE POWER GENERATION BY FUEL TYPE

(TWH/YR)

Intermittent renewables accounted for 16% of generation in Europe in 2015

Intermittent renewables will account for 53% of European power generation in 2040



- Assumes power demand from EVs grows to 80TWh/yr by 2040, or 21% of total demand
- GDP growth assumed to be around 2% per year, in line with forecasts from the IMF

Note: Includes EU 28, Norway, Iceland and Switzerland

Source: Bloomberg New Energy Finance

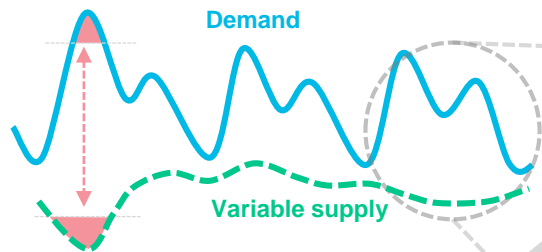
# MANAGING INTERMITTENCY THE BIG CHALLENGE – THE BIG OPPORTUNITY

Years to Months

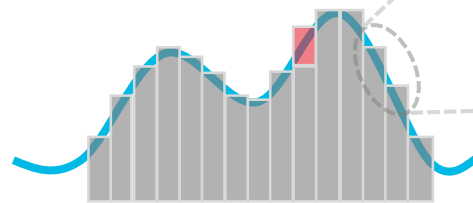
Days to minutes

Seconds to minutes

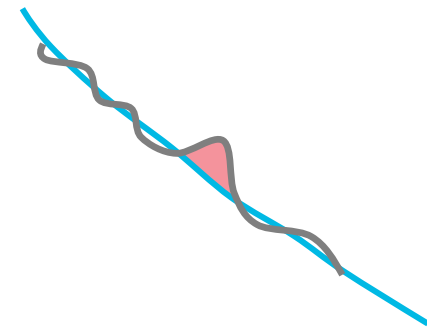
## I. PLANNING FOR EXTREMES



## II. CONTINUOUS BALANCING



## III. CONTROLLING FREQUENCY

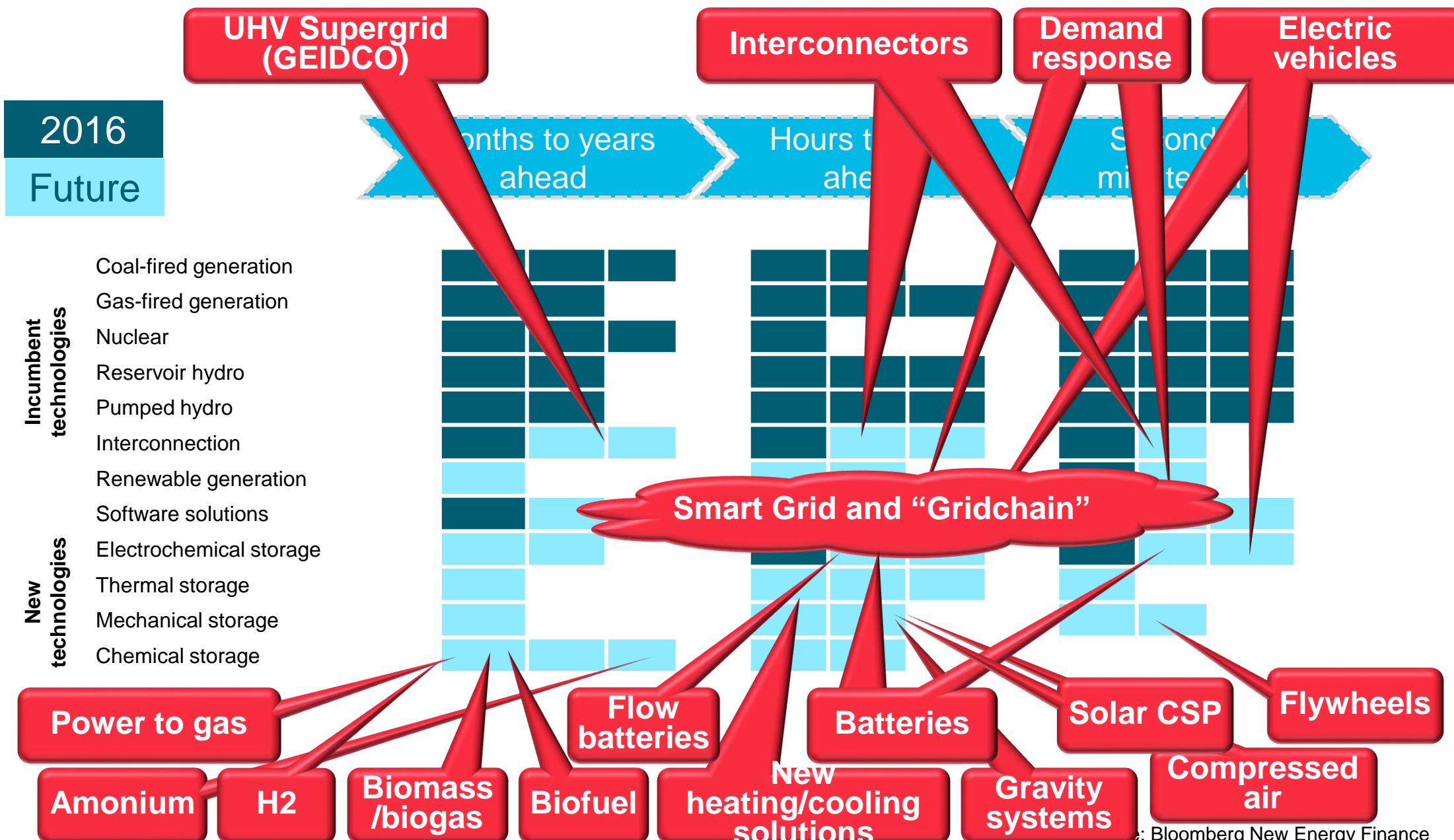


Source: Bloomberg New Energy Finance

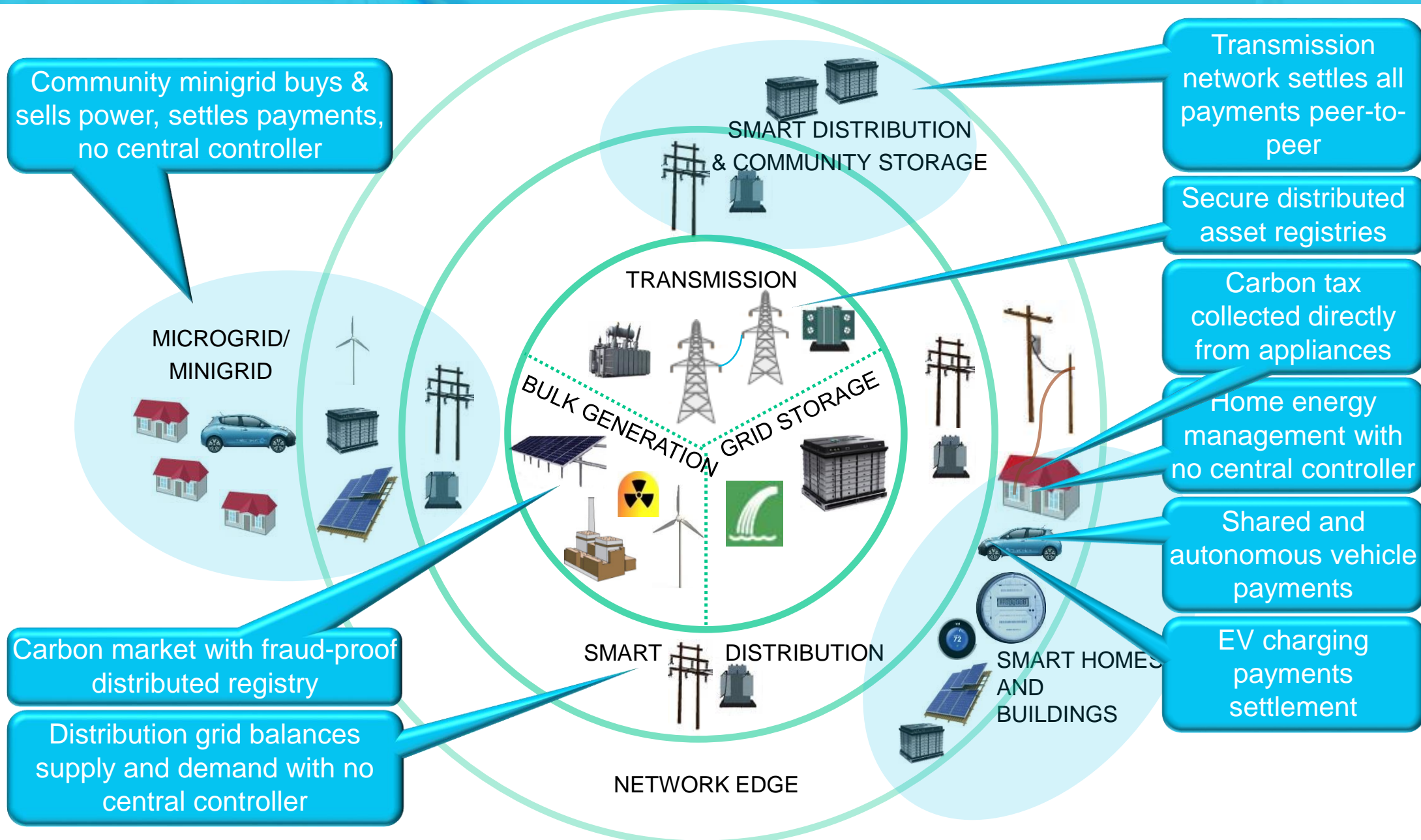
2016



Source: Bloomberg New Energy Finance



# POTENTIAL GRIDCHAIN APPLICATIONS



# EV MASS MARKET

## \$30,000 + 200 MILES RANGE



Tesla Model 3



BMW i3



VW e-Golf



Chevy Bolt

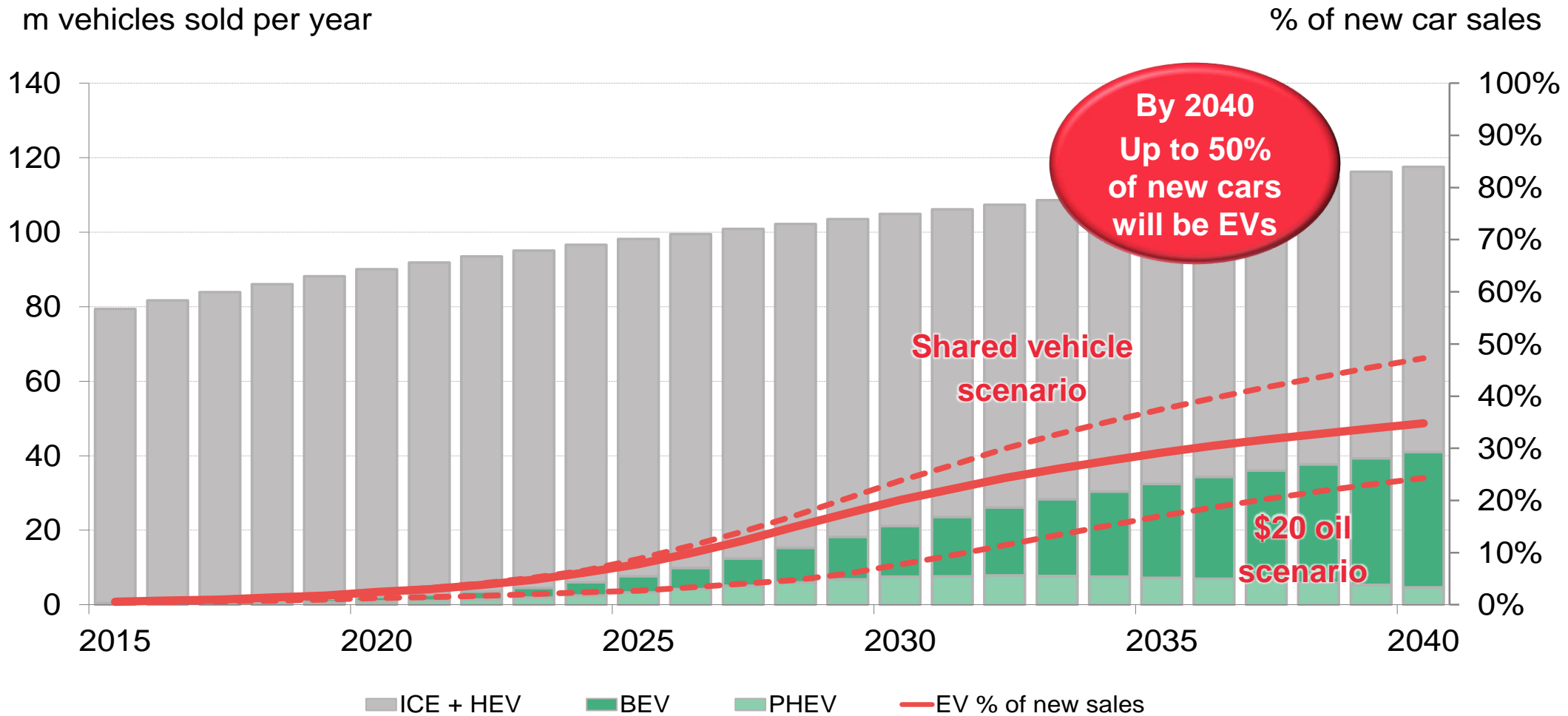


Nissan Leaf

Images: Tesla, BMW, VW, GM, Nissan



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

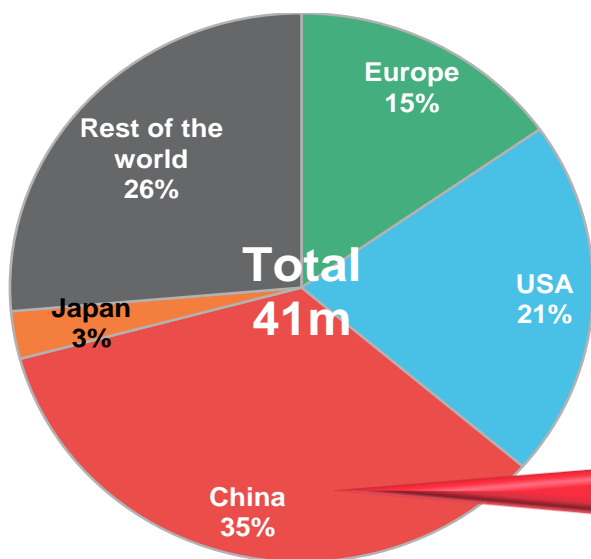


Note: forecast uses Gasoline and electricity prices from EIA's 2015 Annual Energy Outlook 'Low Oil Price' scenario (ranging from \$50 to \$65 per barrel between 2015 and 2025). High scenario assumes greater vehicle utilisation. Low scenario assumes \$20 per barrel oil price

Source: Bloomberg New Energy Finance

# TRANSFORMATION OF TRANSPORTATION IMPACT OF ELECTRIC VEHICLES

## EV SALES BY REGION IN 2040 (MILLION VEHICLES)

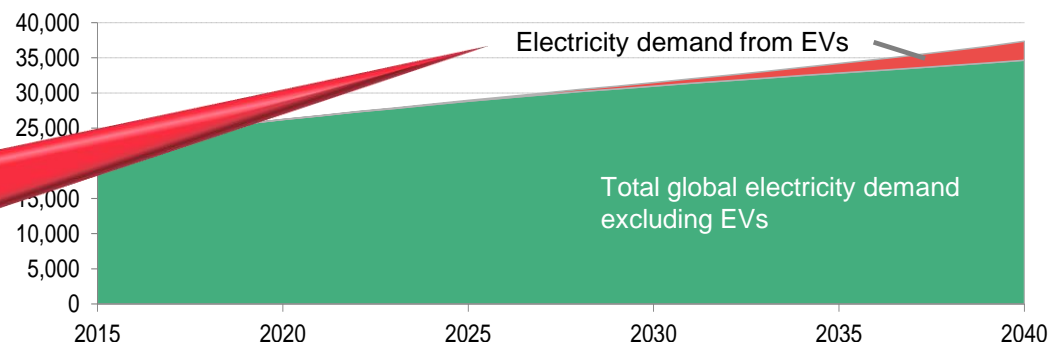


1. Around 10% additional power demand

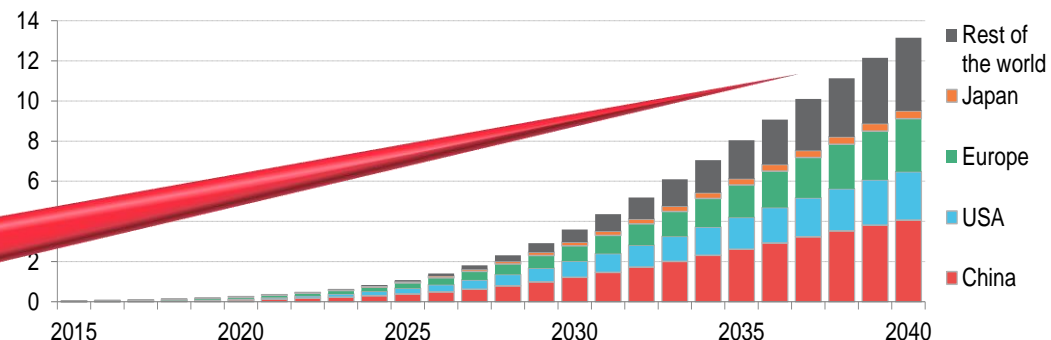
2. Chinese car industry leadership

3. Destruction of 13m bbl/day oil demand

## ELECTRICITY DEMAND FROM EVS (TWH/YR)



## OIL DEMAND DISPLACED BY EVS (MILLION BARRELS / DAY)



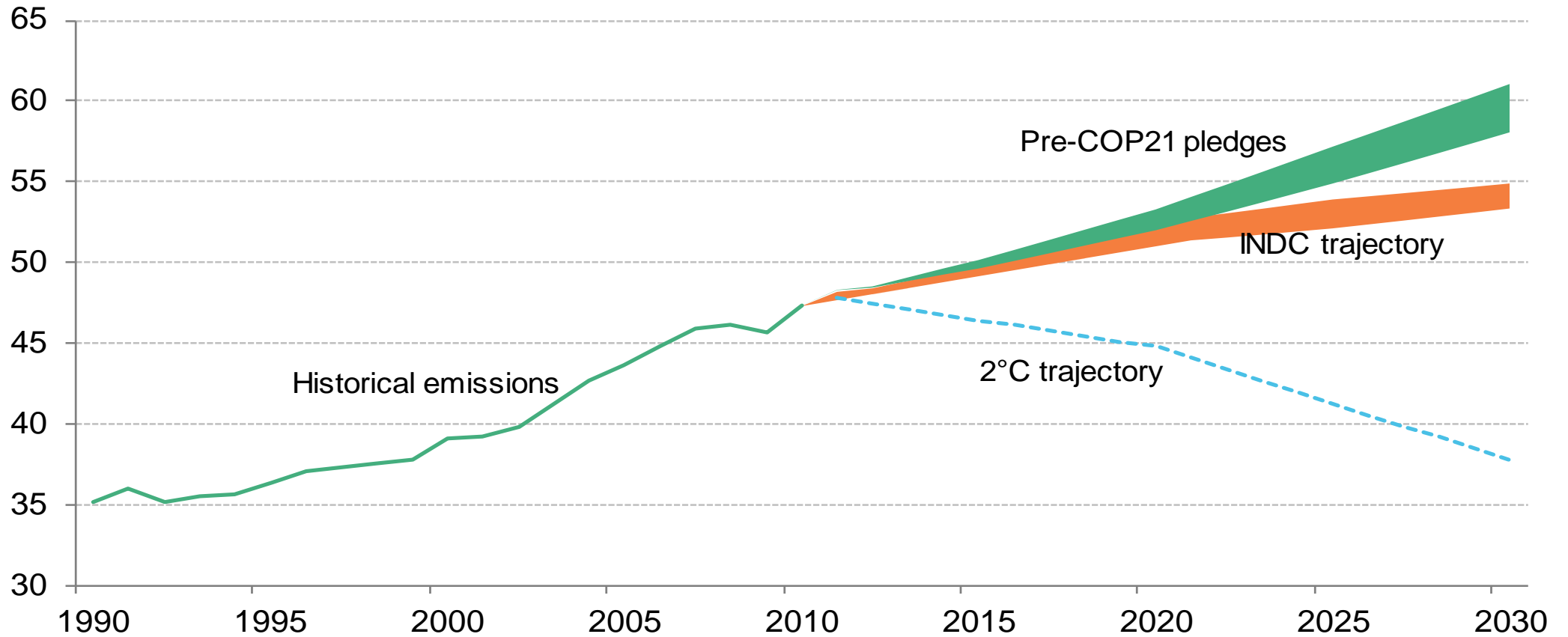
Source: Bloomberg New Energy Finance

A graphic on the left side of the slide features a green and yellow triangle with a white circle cutout. Below the triangle is a white silhouette of the Eiffel Tower.

**PARIS 2015**  
UN CLIMATE CHANGE CONFERENCE  
COP21·CMP11

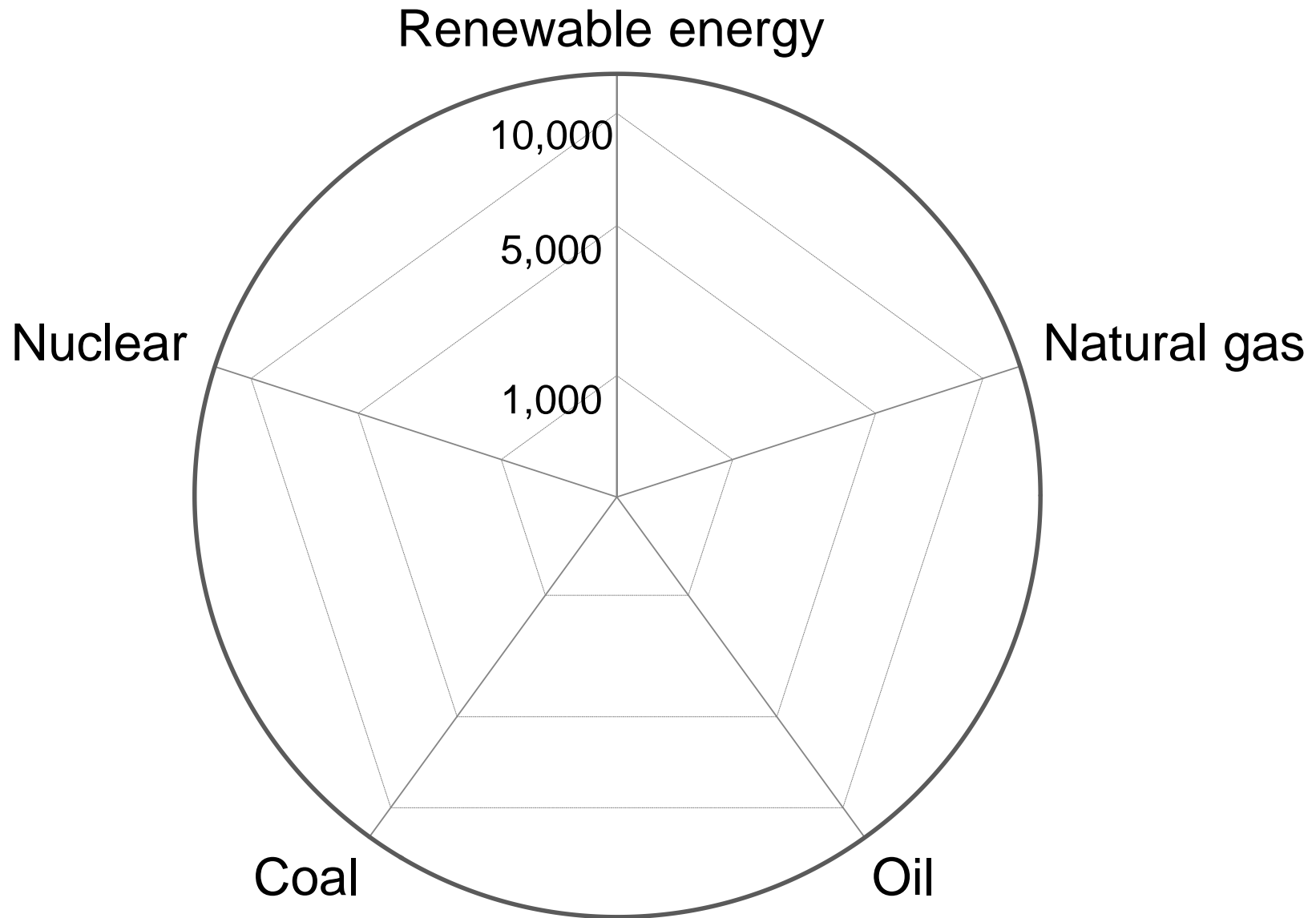
Image: UNFCCC

# GLOBAL GREENHOUSE GAS EMISSIONS (GTCO2)



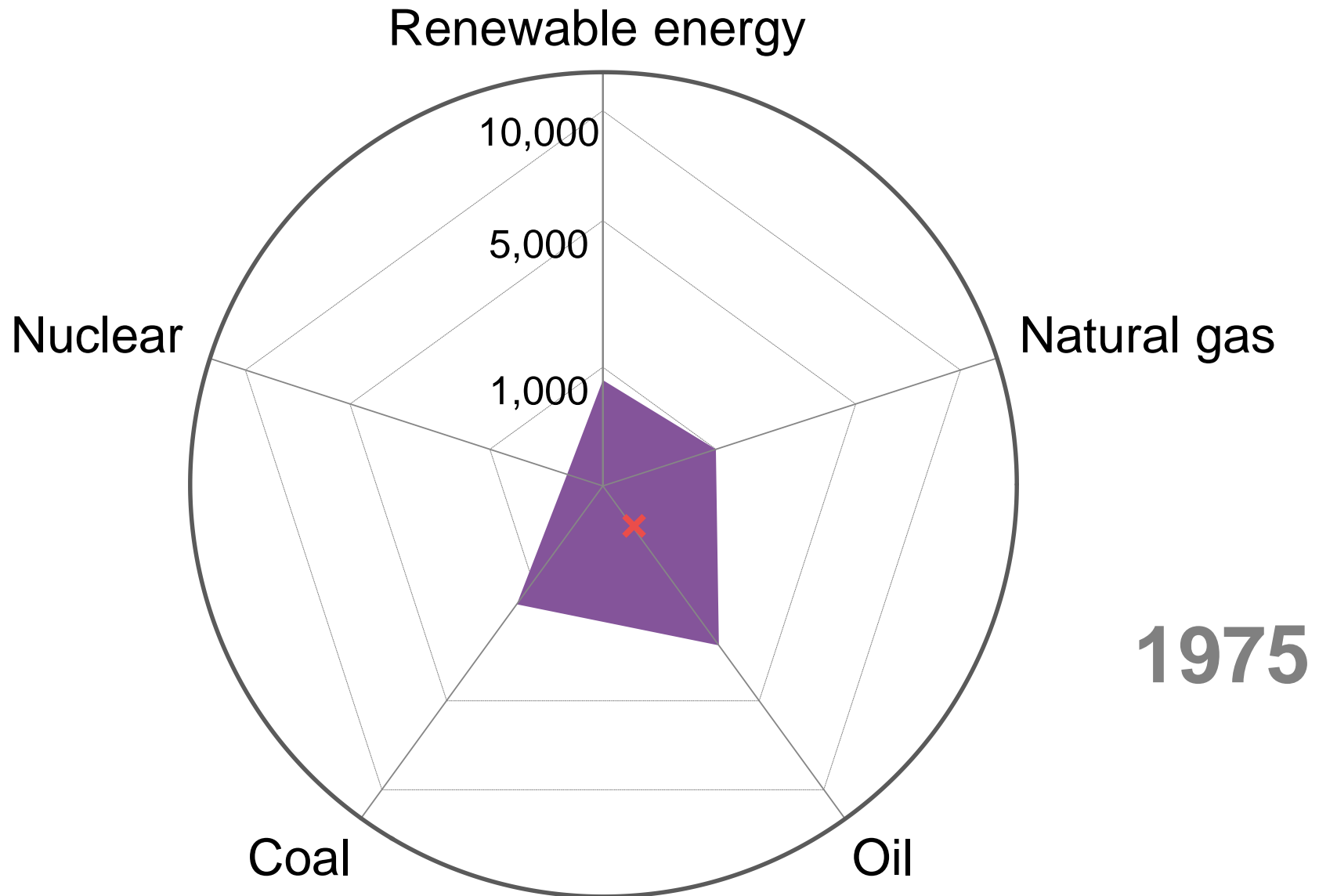
Source: UNFCCC, UNEP, Climate Action Tracker  
Bloomberg New Energy Finance

# GLOBAL PRIMARY ENERGY SUPPLY (MTOE)



Source: Bloomberg New Energy Finance

# GLOBAL PRIMARY ENERGY SUPPLY, 1975 (MTOE)

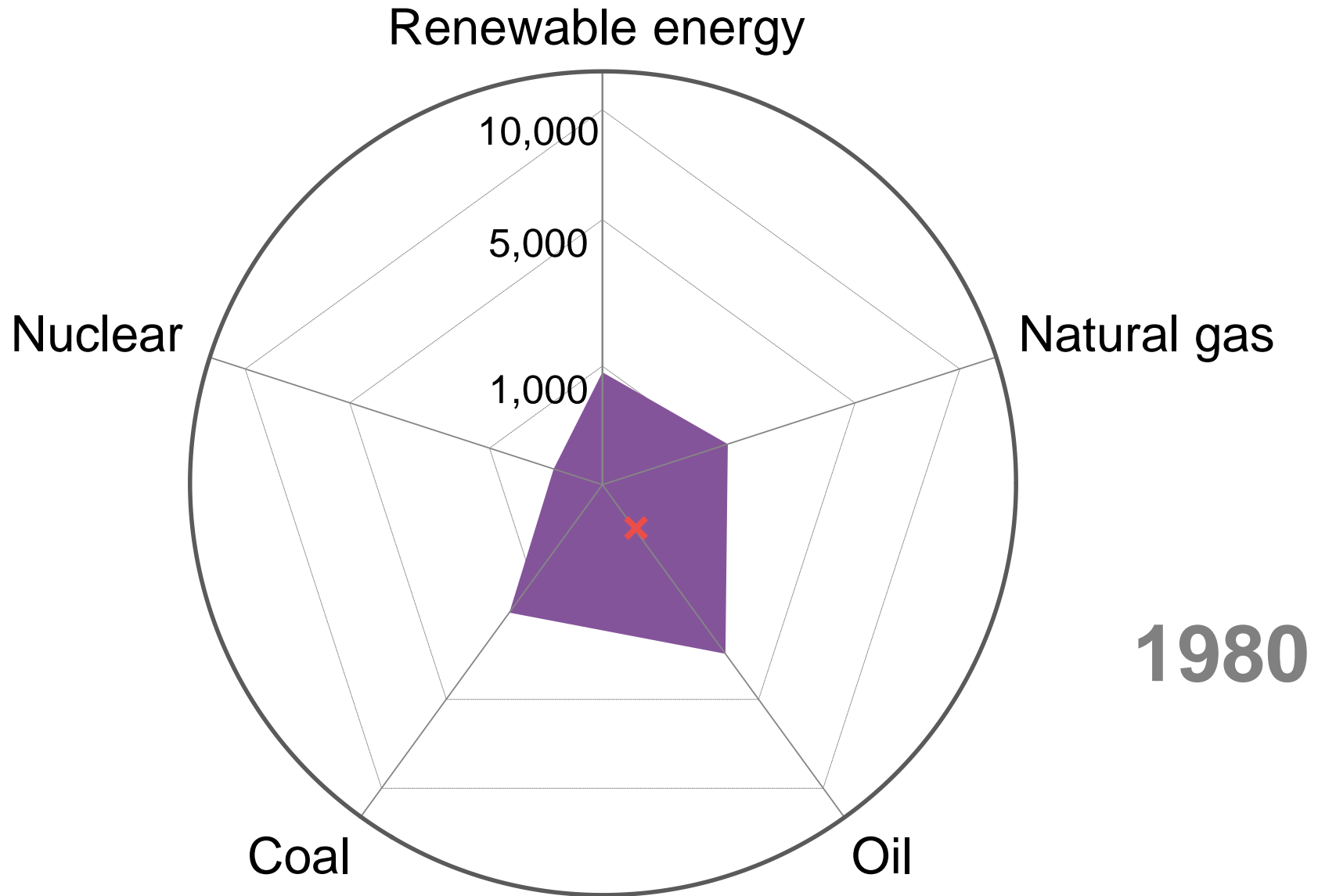


1975

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

Source: Bloomberg New Energy Finance, IEA

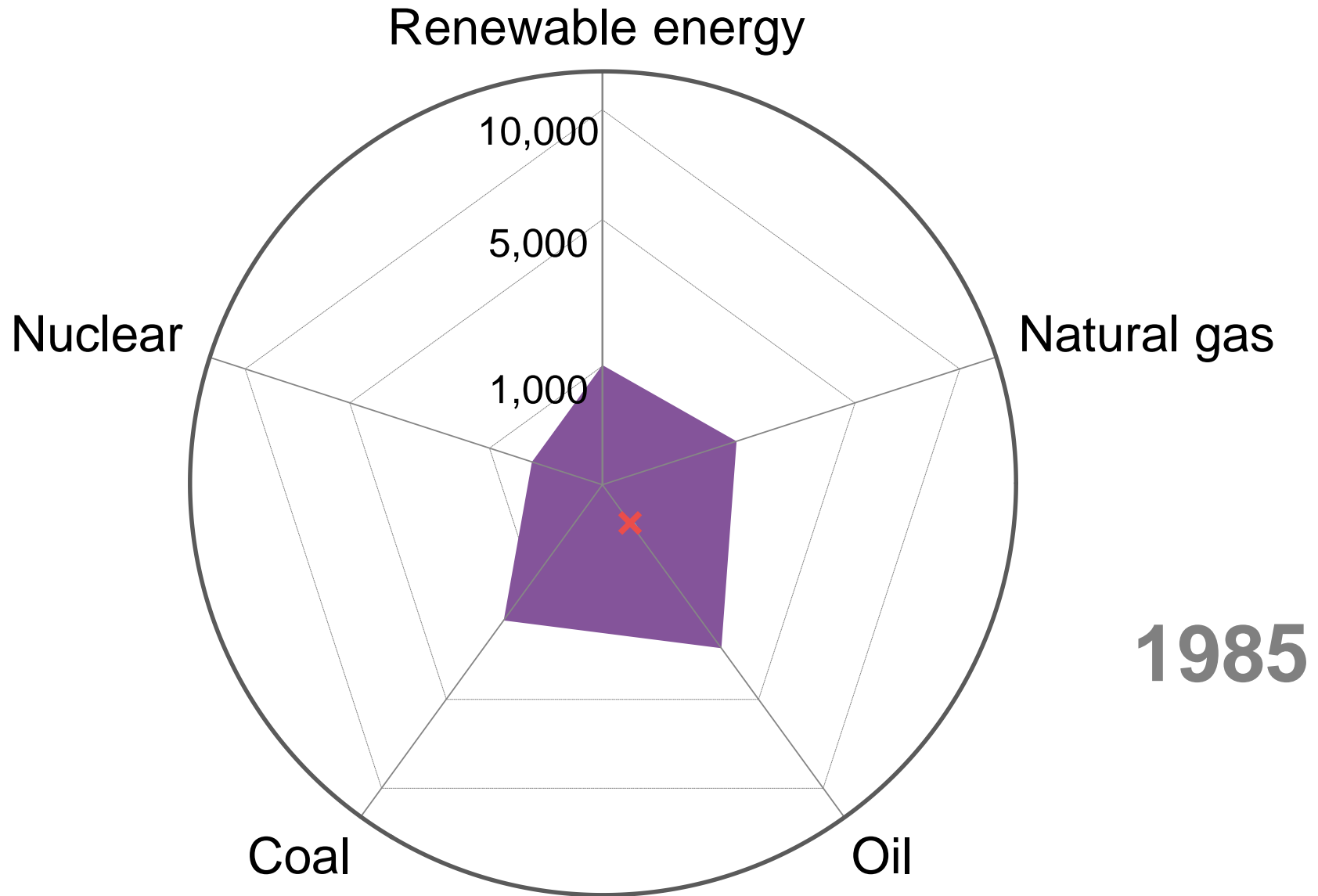
# GLOBAL PRIMARY ENERGY SUPPLY, 1980 (MTOE)



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

Source: Bloomberg New Energy Finance, IEA

# GLOBAL PRIMARY ENERGY SUPPLY, 1985 (MTOE)



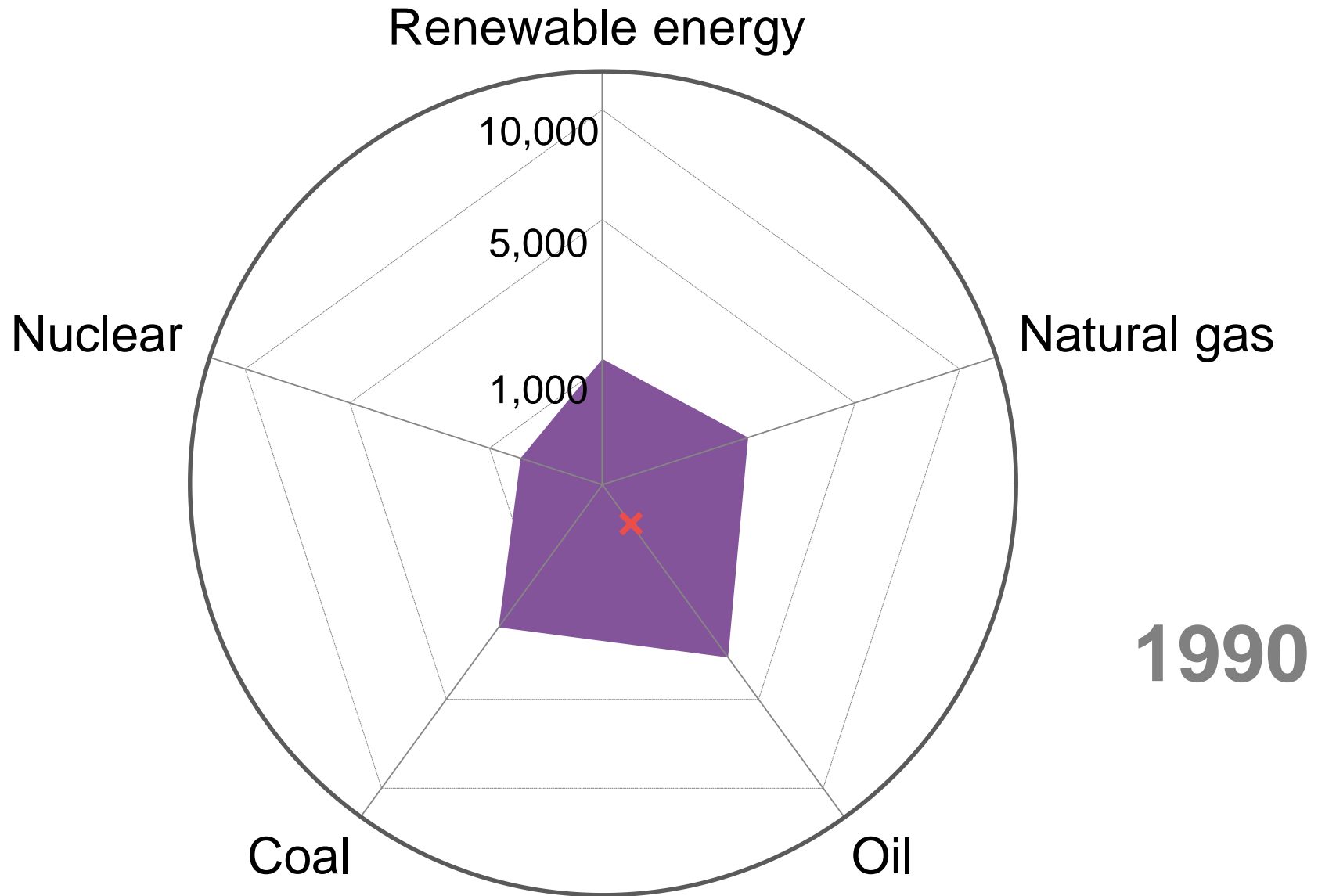
1985

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

Source: Bloomberg New Energy Finance, IEA



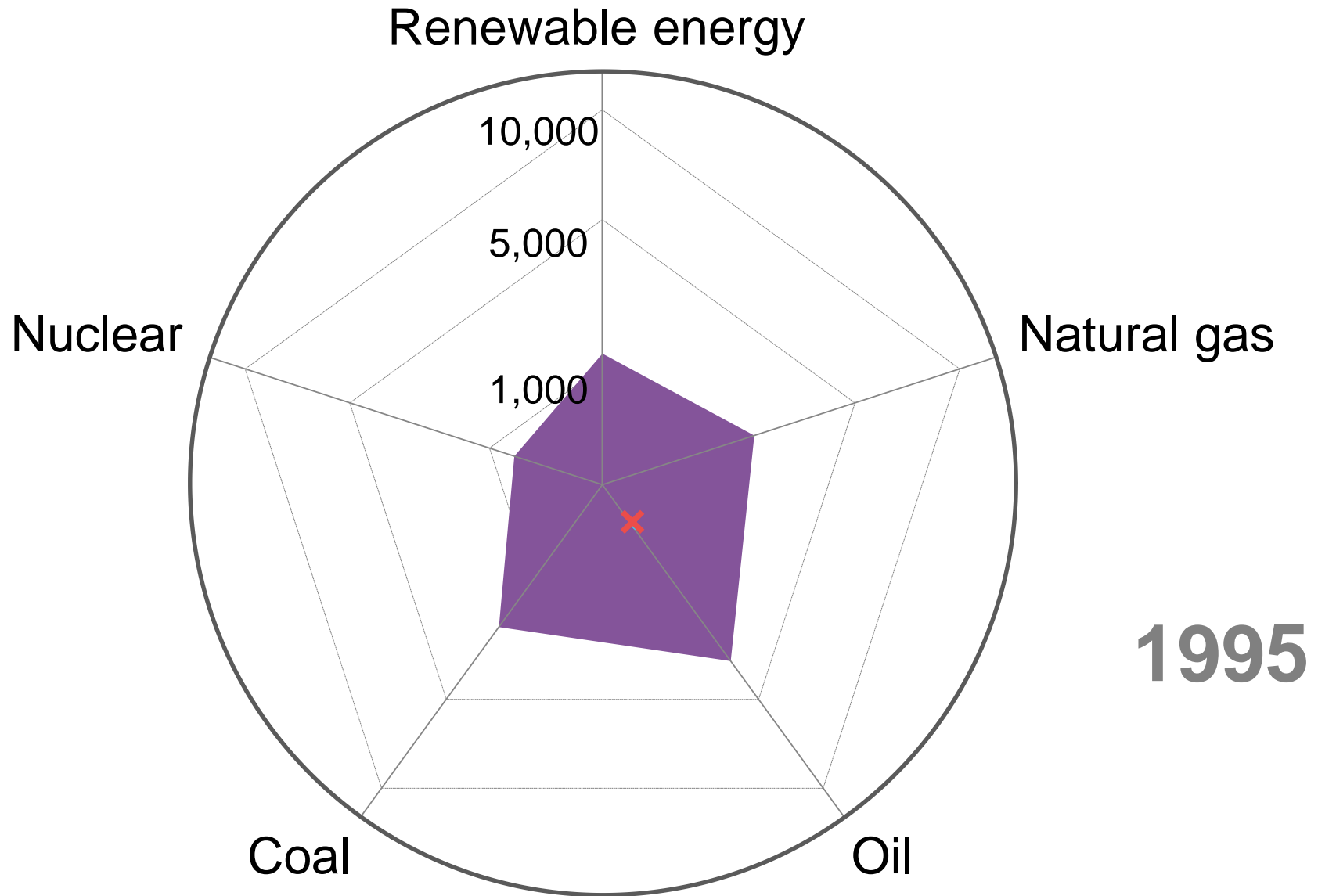
# GLOBAL PRIMARY ENERGY SUPPLY, 1990 (MTOE)



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

Source: Bloomberg New Energy Finance, IEA

# GLOBAL PRIMARY ENERGY SUPPLY, 1995 (MTOE)

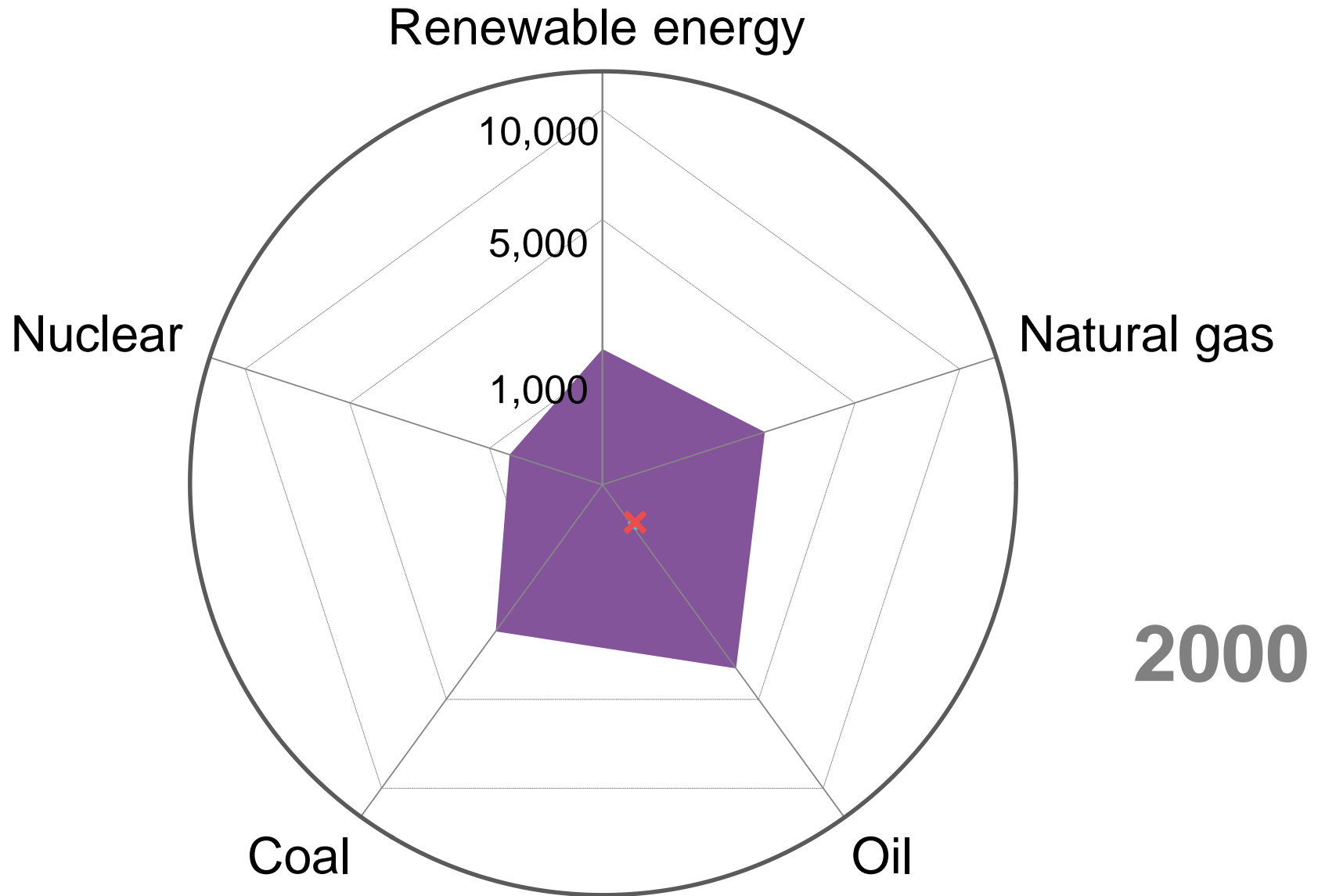


1995

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

Source: Bloomberg New Energy Finance, IEA

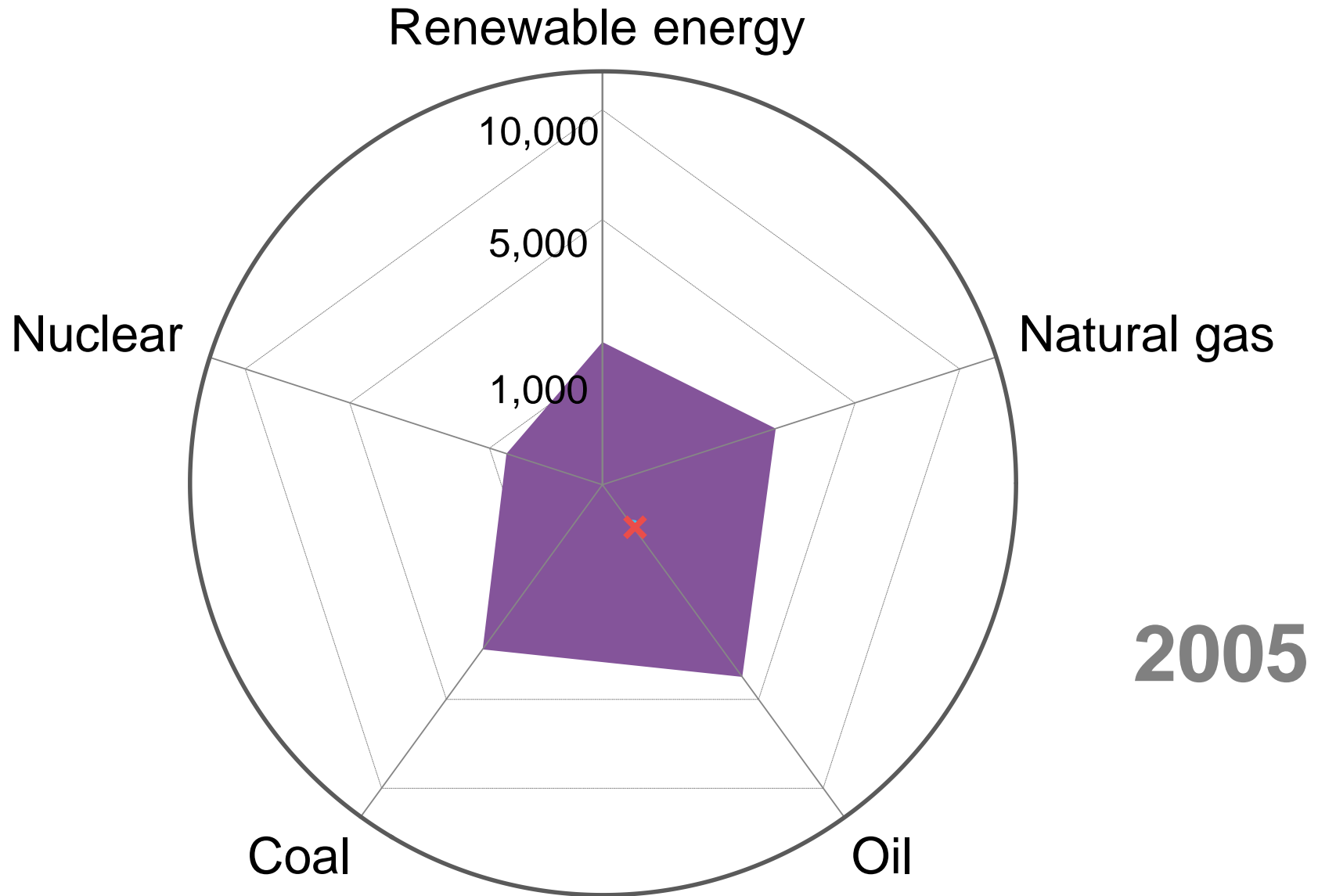
# GLOBAL PRIMARY ENERGY SUPPLY, 2000 (MTOE)



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

Source: Bloomberg New Energy Finance, IEA

# GLOBAL PRIMARY ENERGY SUPPLY, 2005 (MTOE)

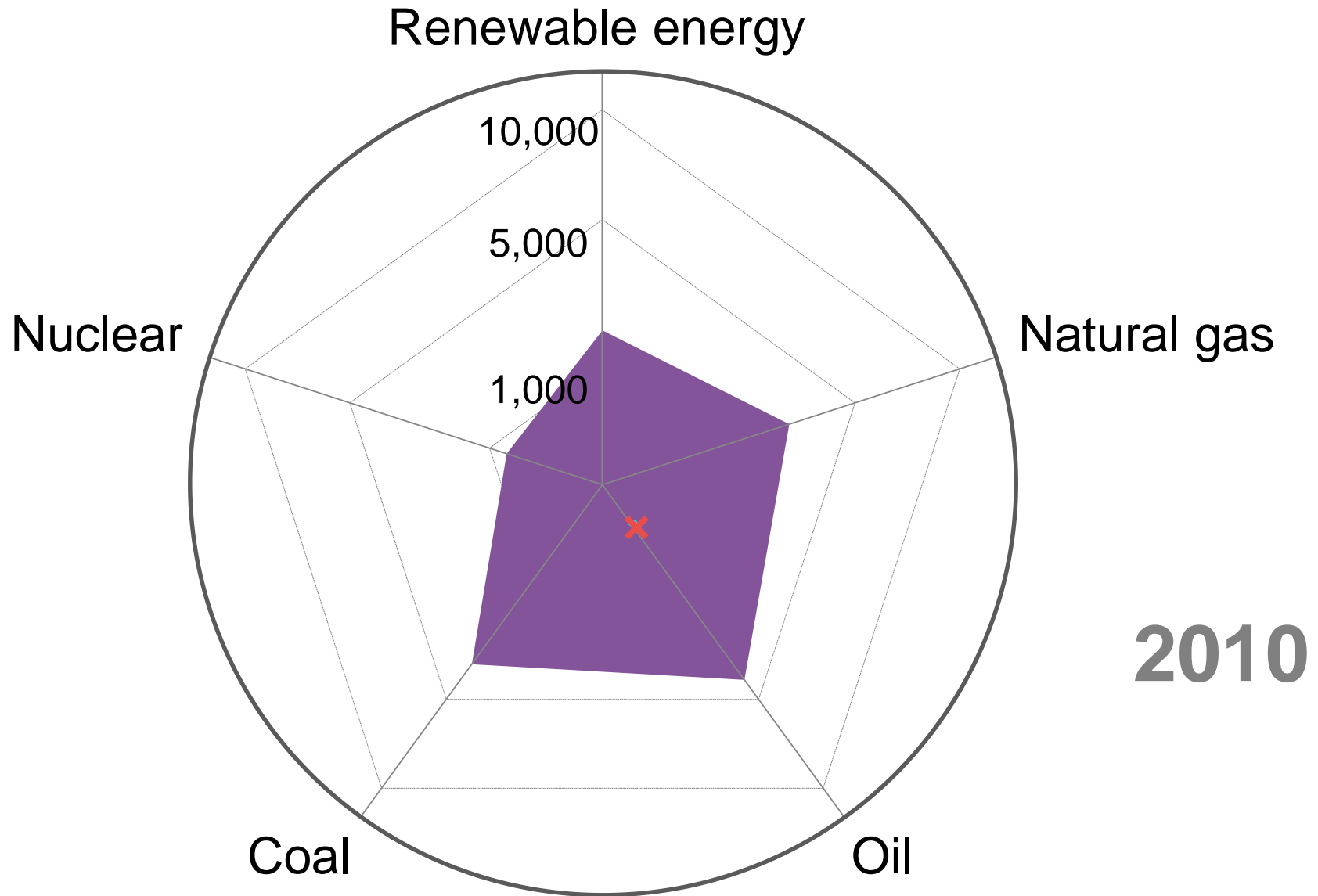


2005

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

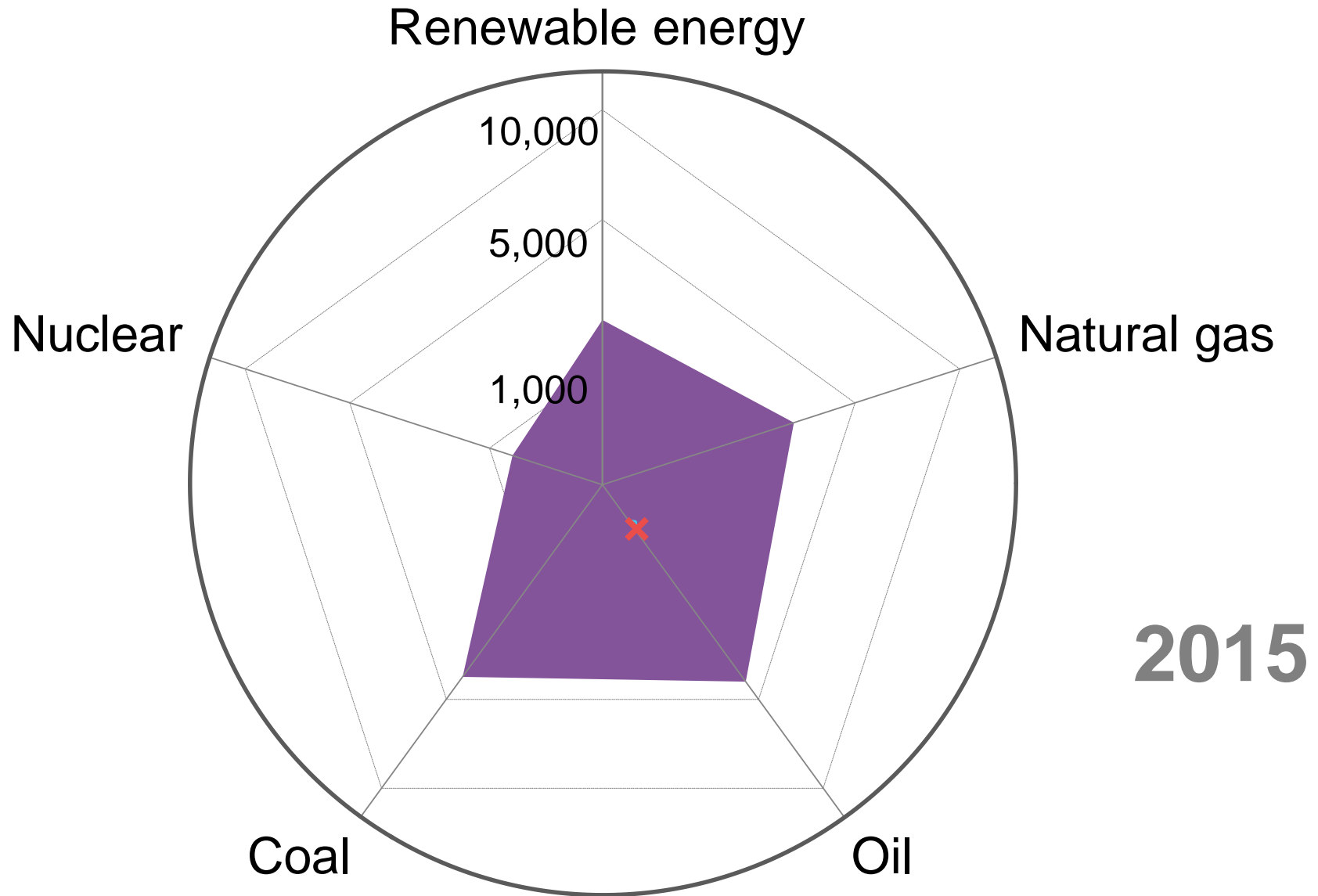
Source: Bloomberg New Energy Finance, IEA

# GLOBAL PRIMARY ENERGY SUPPLY, 2010 (MTOE)



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

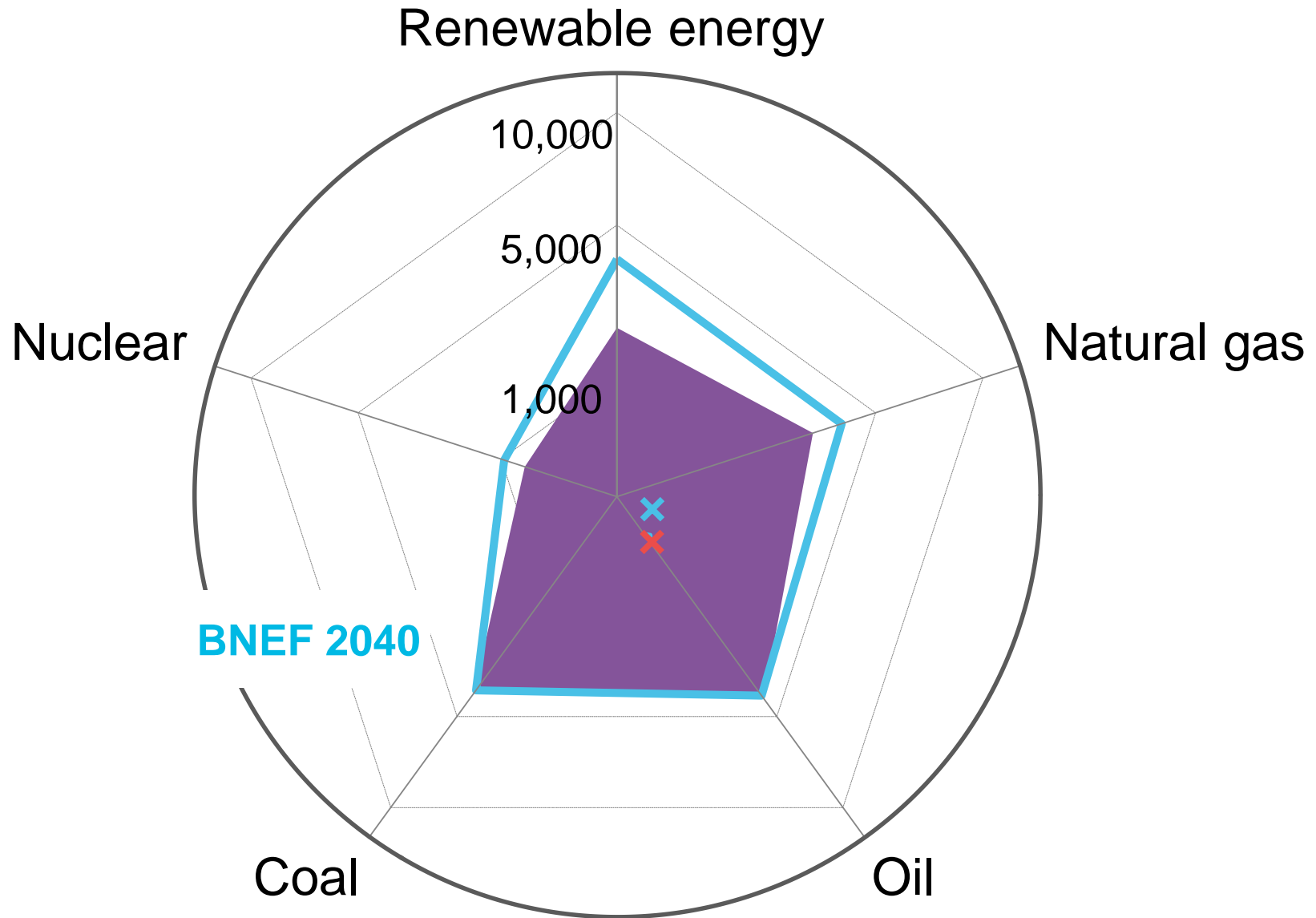
Source: Bloomberg New Energy Finance, IEA



**2015**

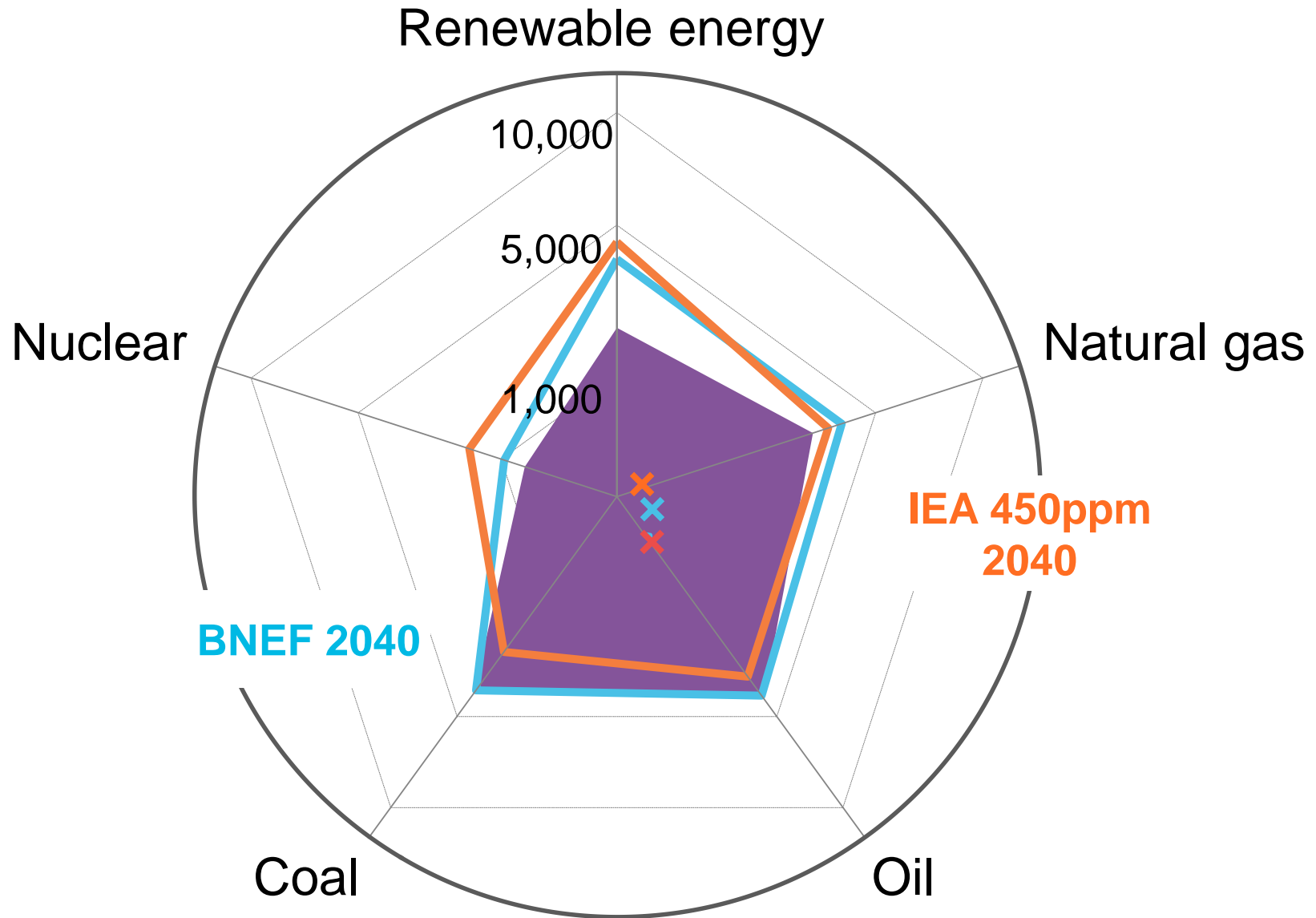
Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total includes bioenergy and hydro.

Source: Bloomberg New Energy Finance, IEA



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

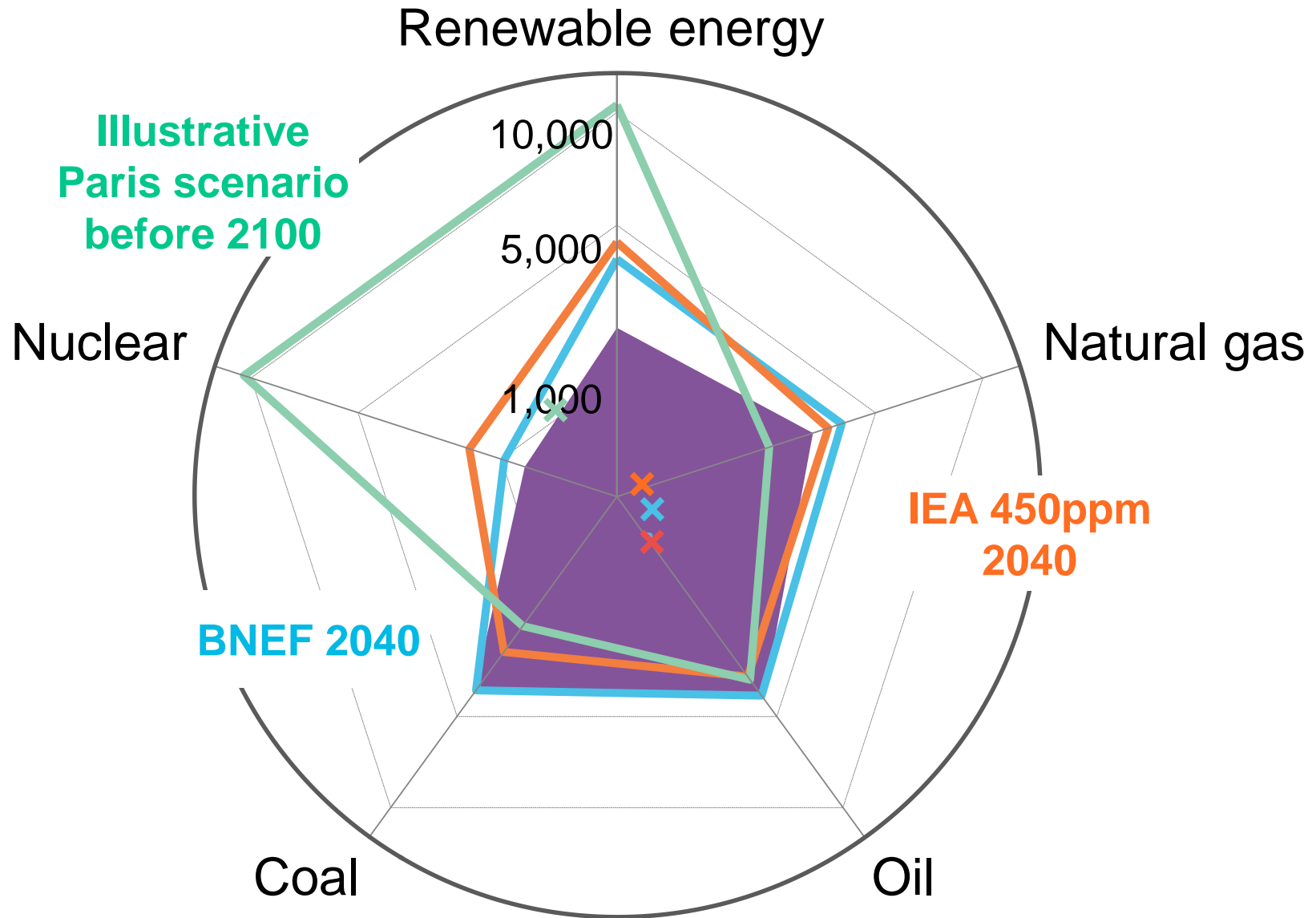
Source: Bloomberg New Energy Finance, IEA



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

Source: Bloomberg New Energy Finance, IEA





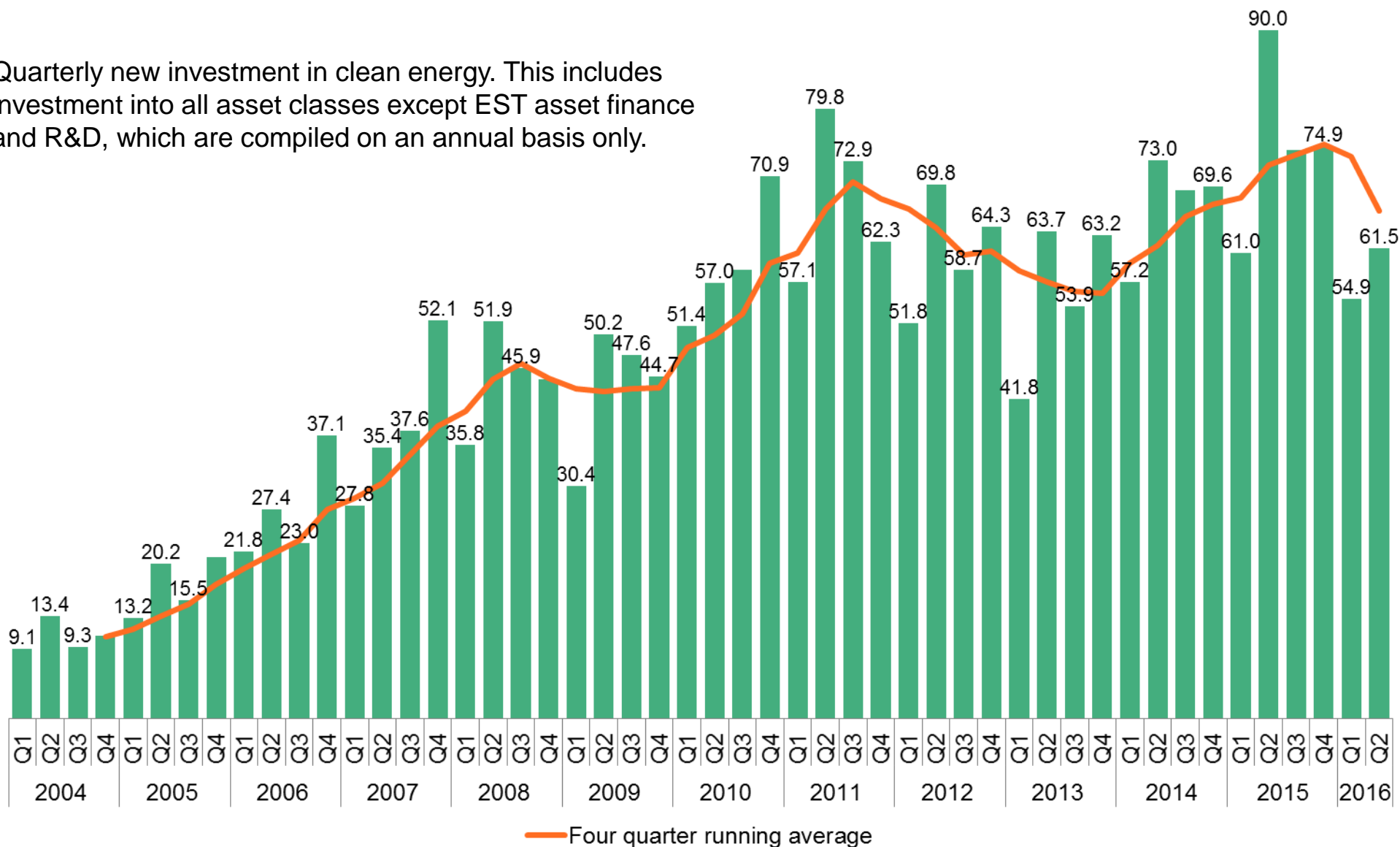
Note: BNEF adjusted IEA NPS forecast using its own electricity generation and EV demand forecast. Renewables total includes bioenergy and hydro. Paris illustrative scenario assumes some carbon capture.

Source: Bloomberg New Energy Finance, IEA

# NEW INVESTMENT IN CLEAN ENERGY

Q1 2004-Q2 2016 (\$BN)

- Quarterly new investment in clean energy. This includes investment into all asset classes except EST asset finance and R&D, which are compiled on an annual basis only.

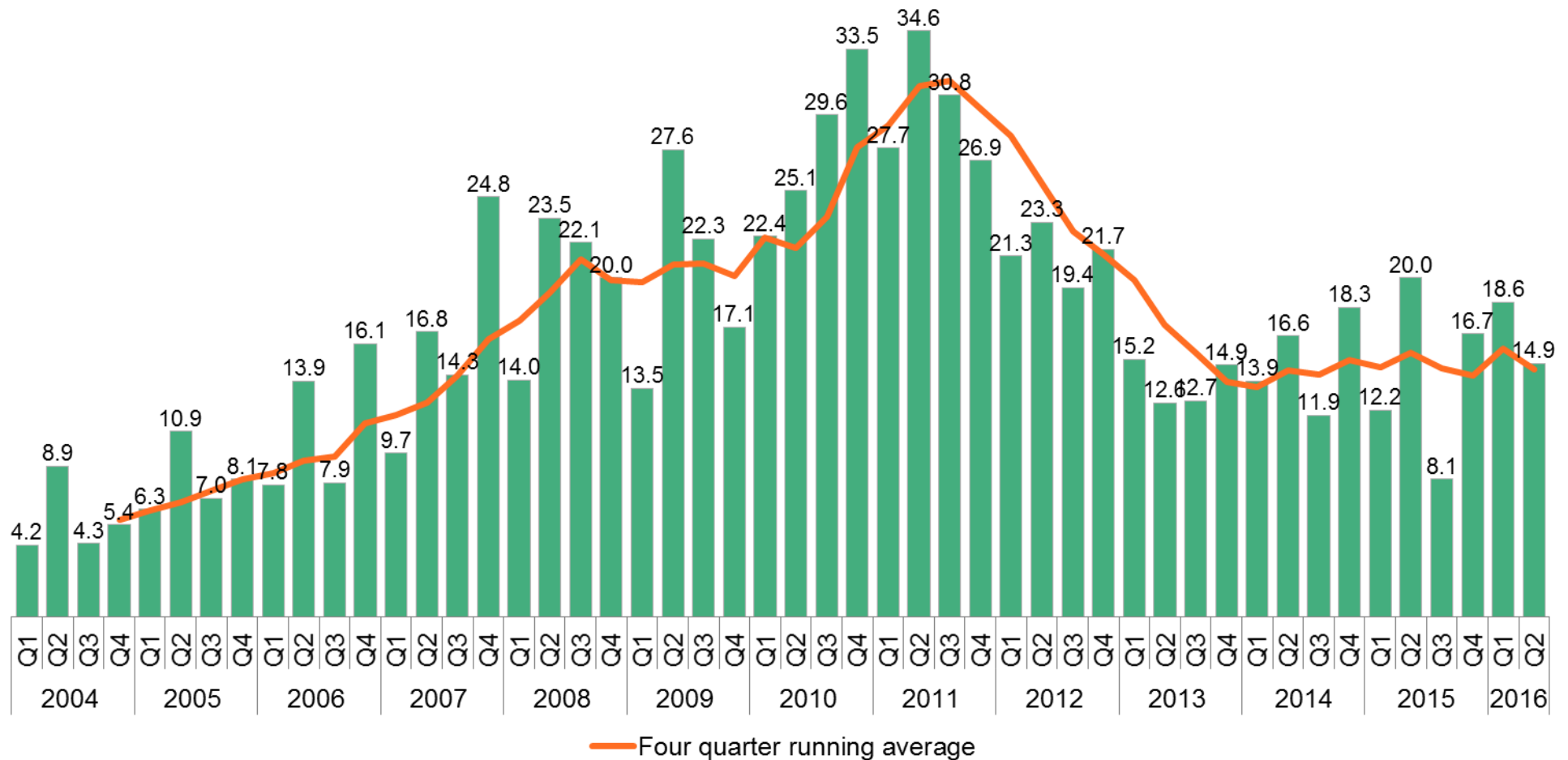


Note: Total values include estimates for undisclosed deals. Excludes corporate and government R&D, and spending for digital energy and energy storage projects (reported in annual statistics only).

Source: Bloomberg New Energy Finance

# NEW INVESTMENT IN CLEAN ENERGY IN EUROPE

Q1 2004-Q2 2016 (\$BN)

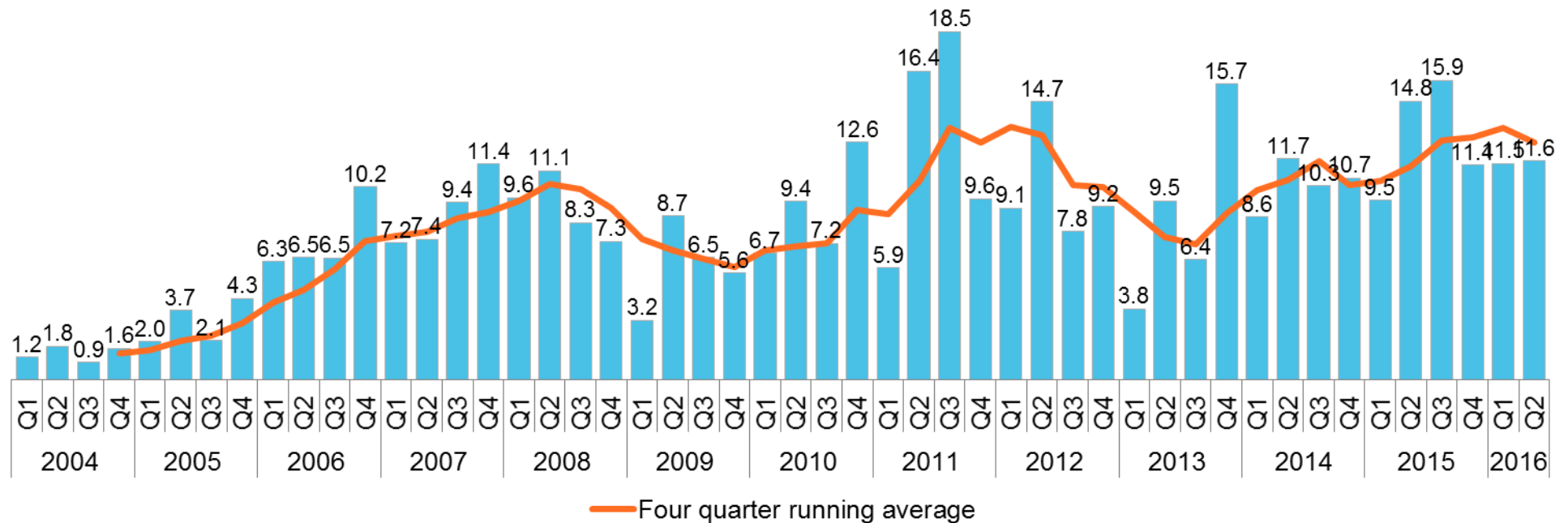


Note: Total values include estimates for undisclosed deals. Excludes corporate and government R&D, and spending for digital energy and energy storage projects (reported in annual statistics only).

Source: Bloomberg New Energy Finance

# NEW INVESTMENT IN CLEAN ENERGY IN THE US

Q1 2004-Q2 2016 (\$BN)

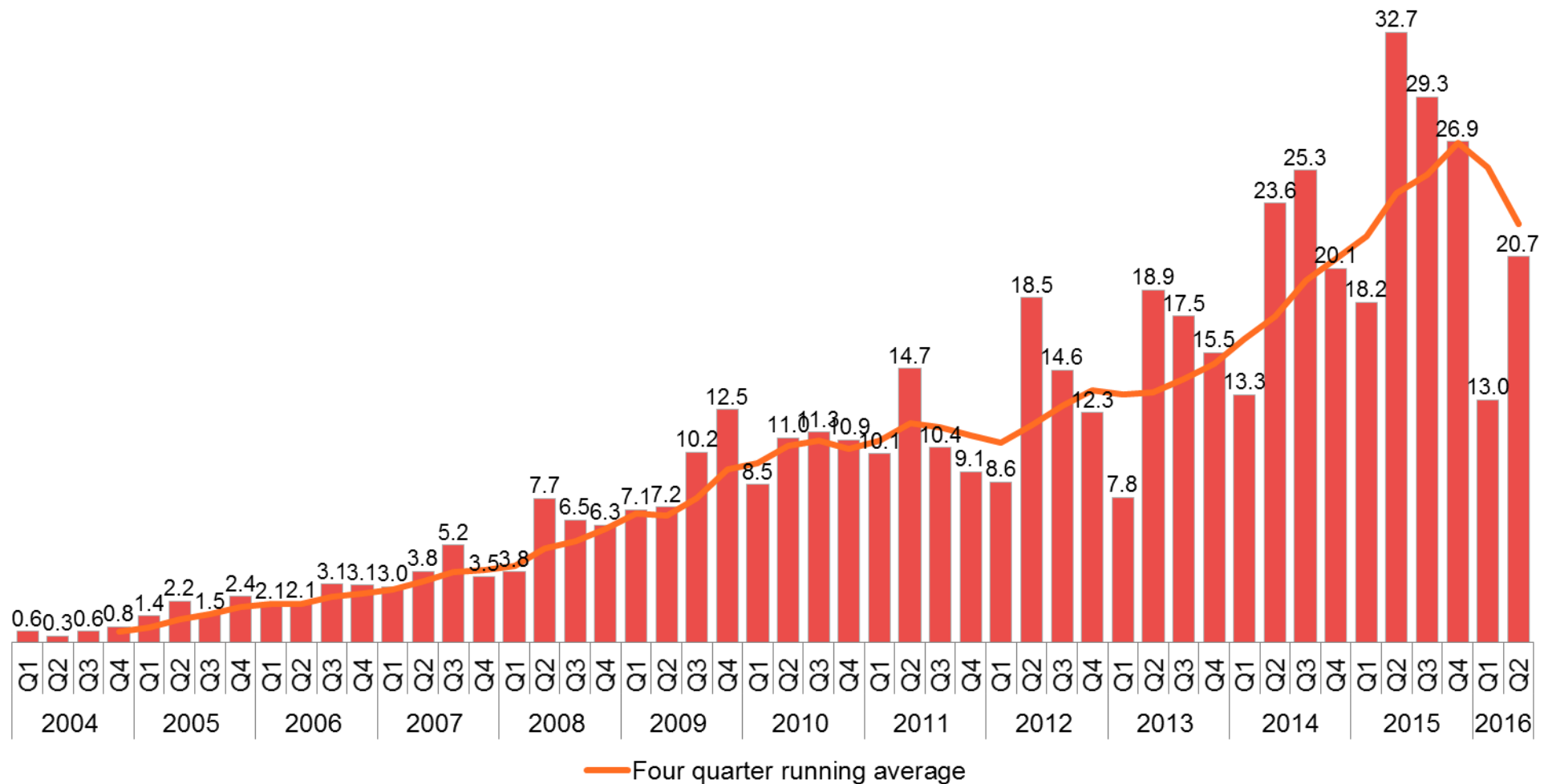


Note: Total values include estimates for undisclosed deals. Excludes corporate and government R&D, and spending for digital energy and energy storage projects (reported in annual statistics only).

Source: Bloomberg New Energy Finance

# NEW INVESTMENT IN CLEAN ENERGY IN CHINA

Q1 2004-Q2 2016 (\$BN)



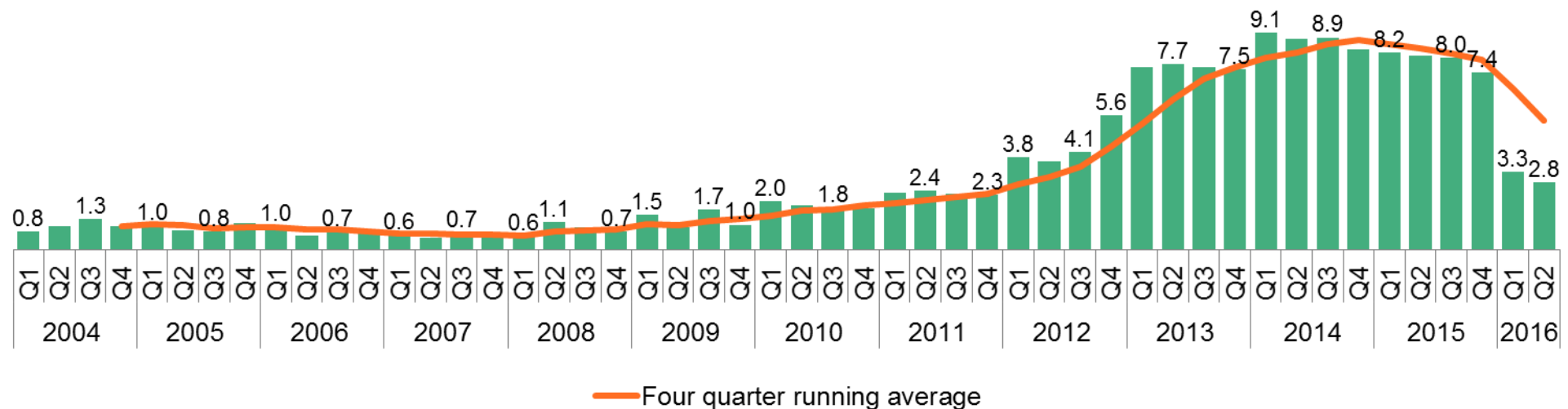
Note: Total values include estimates for undisclosed deals. Excludes corporate and government R&D, and spending for digital energy and energy storage projects (reported in annual statistics only).

Source: Bloomberg New Energy Finance

# NEW INVESTMENT IN CLEAN ENERGY, JAPAN

Q1 2004-Q2 2016 (\$BN)

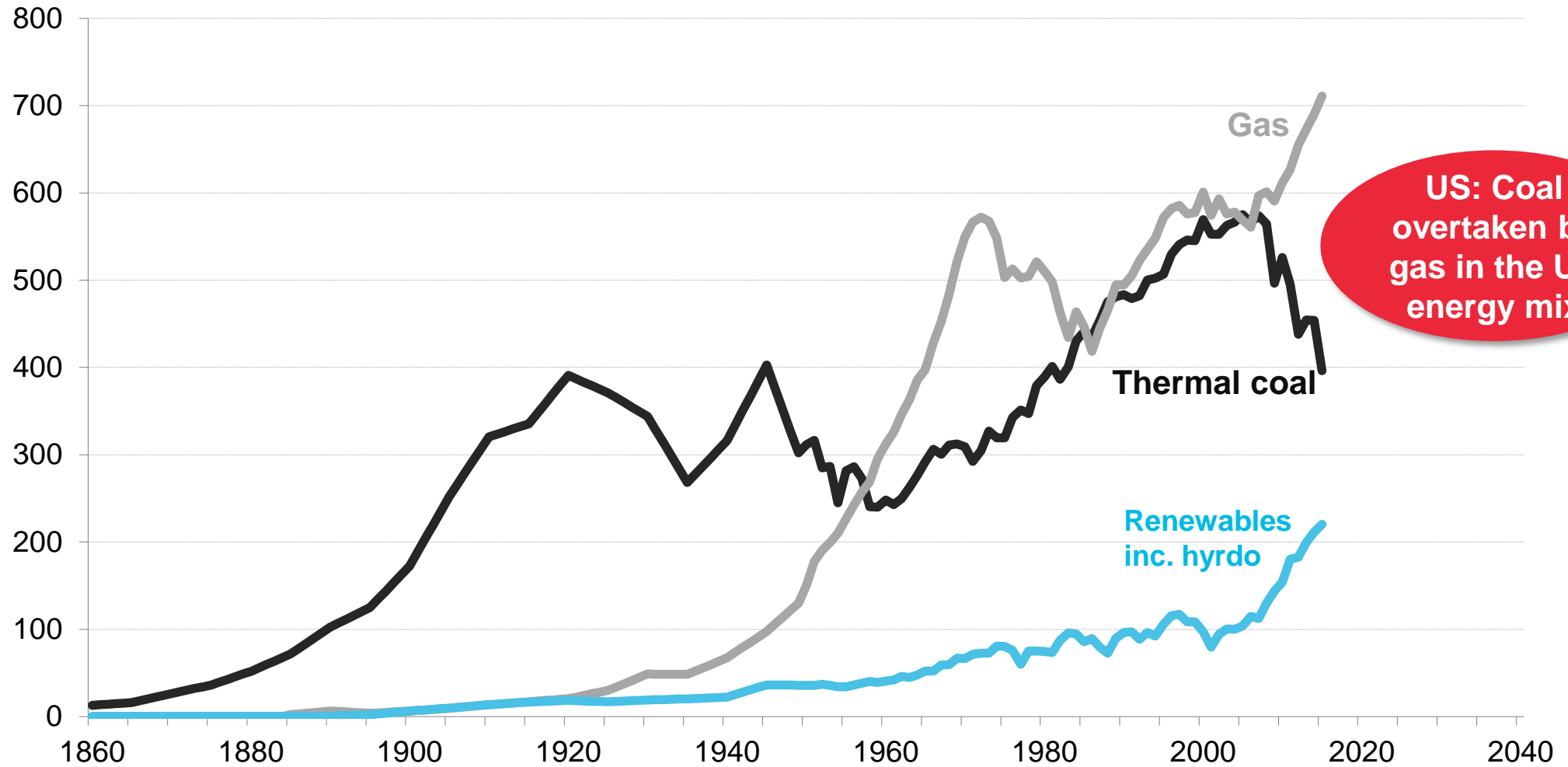
Quarterly new investment in clean energy. This includes investment into all asset classes except EST asset finance and R&D, which are compiled on an annual basis only.



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).

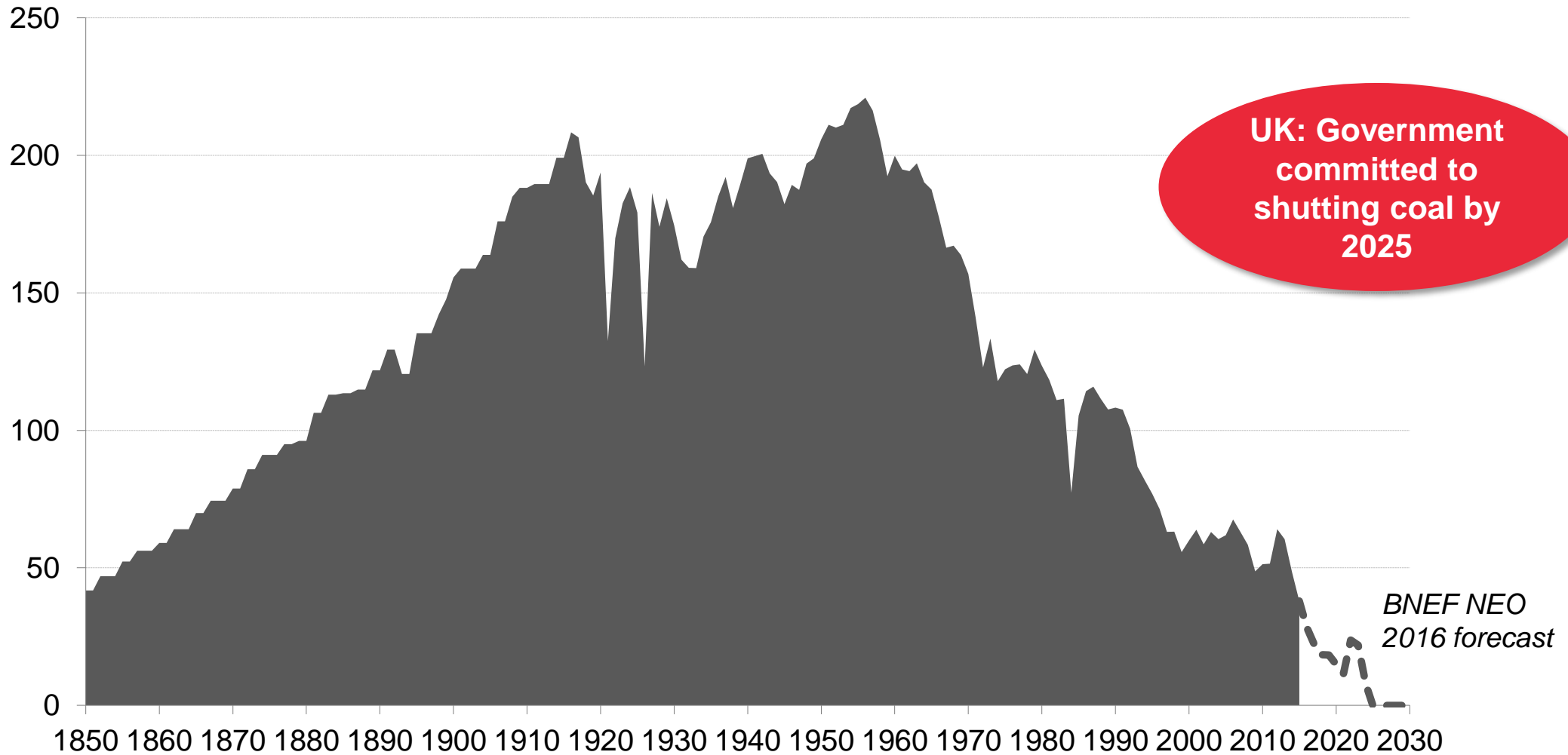
Source: Bloomberg New Energy Finance

# US COAL CONSUMPTION VS GAS AND RENEWABLES, PRIMARY ENERGY (MTOE/YR)



Source: EIA

# UK COAL CONSUMPTION 1850-2030 (MT/YR)

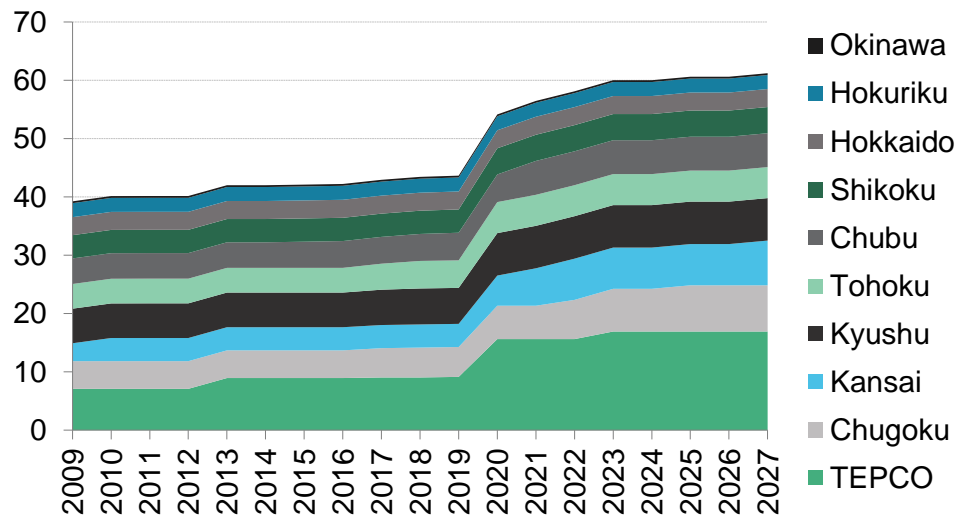


Source: BEIS, Prof. David Rutledge,  
Bloomberg New Energy Finance

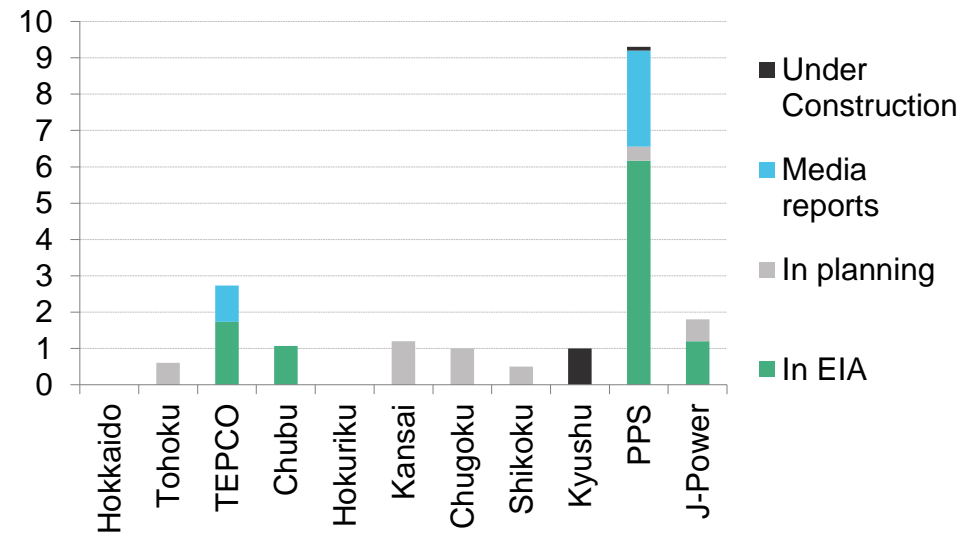


# TOTAL COAL CAPACITY INCLUDING PLANS BY NON-UTILITY(PPS) ENTITIES

## CUMULATIVE COAL CAPACITY BY SUPPLY AREA (GW)



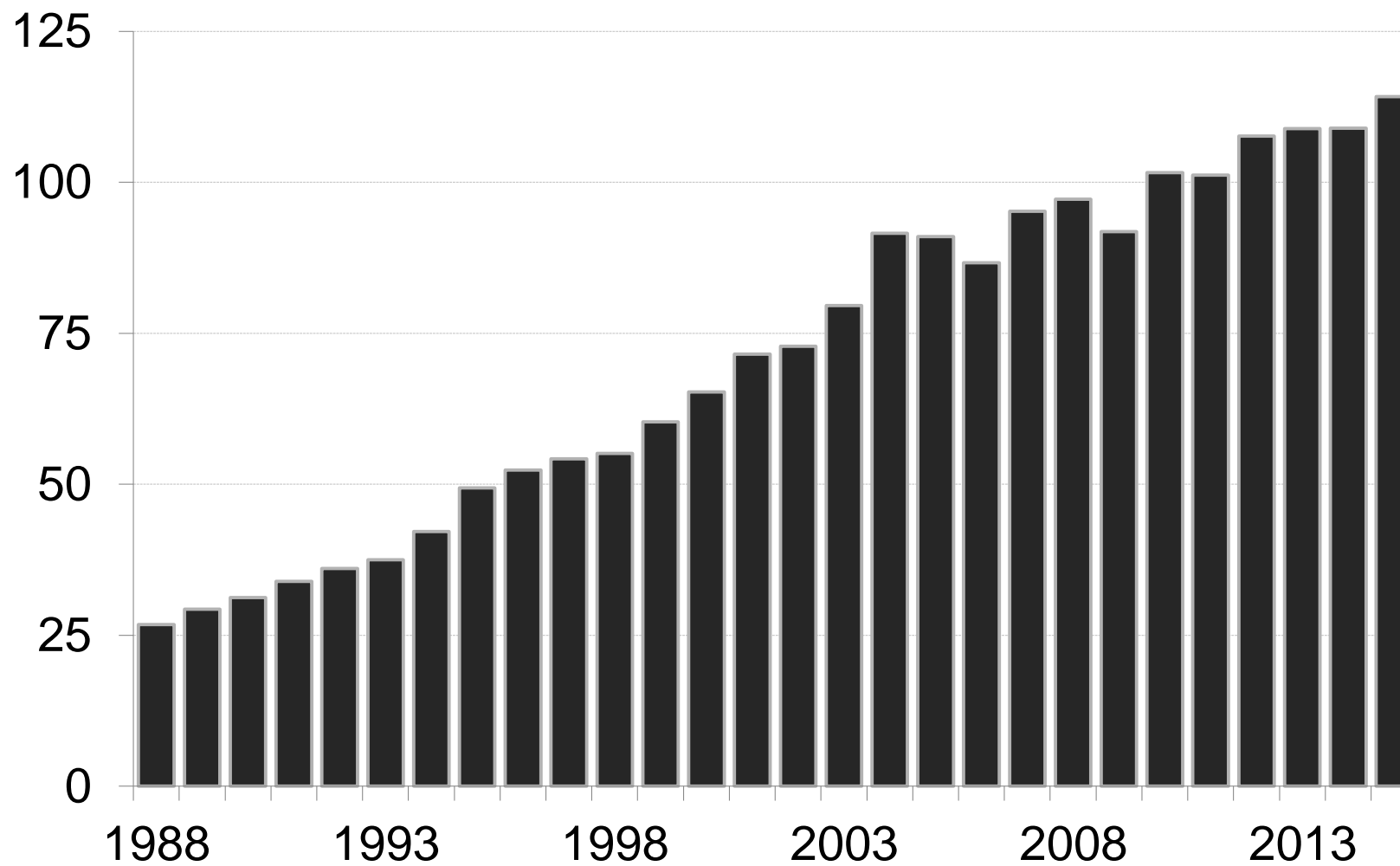
## ADDITIONAL COAL CAPACITY PLANNED BY EACH ENTITY (GW)



Note: Figures includes plants that were announced officially as well as reported in media.

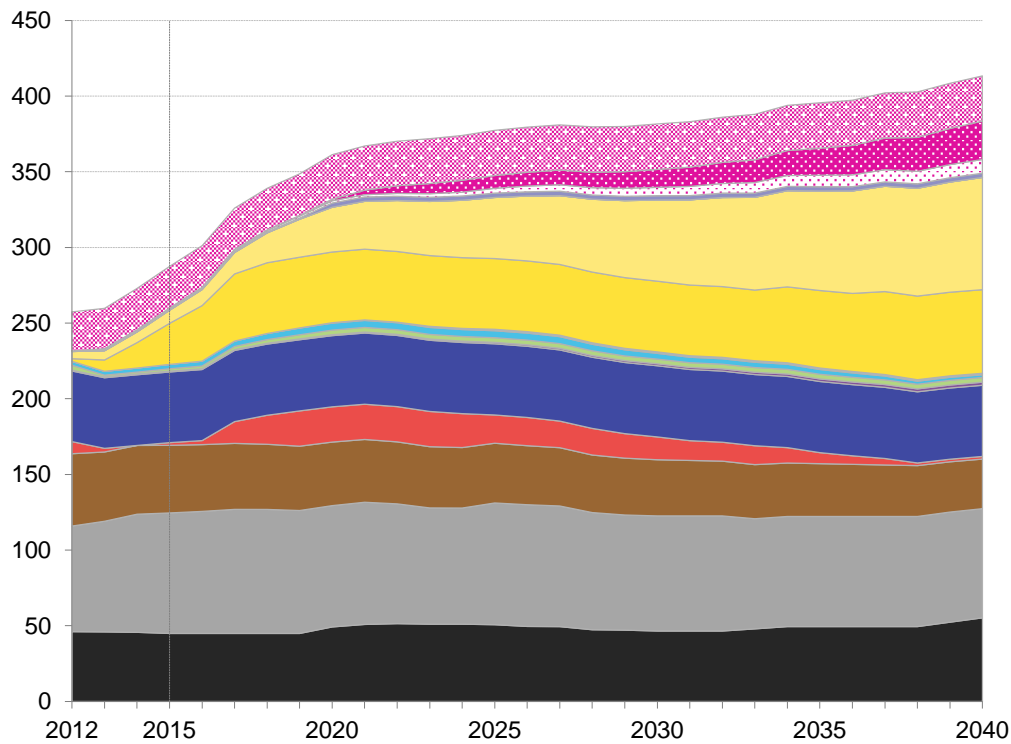
Source: Bloomberg New Energy Finance

# JAPAN THERMAL COAL IMPORT VOLUME (MILLION TONNES)

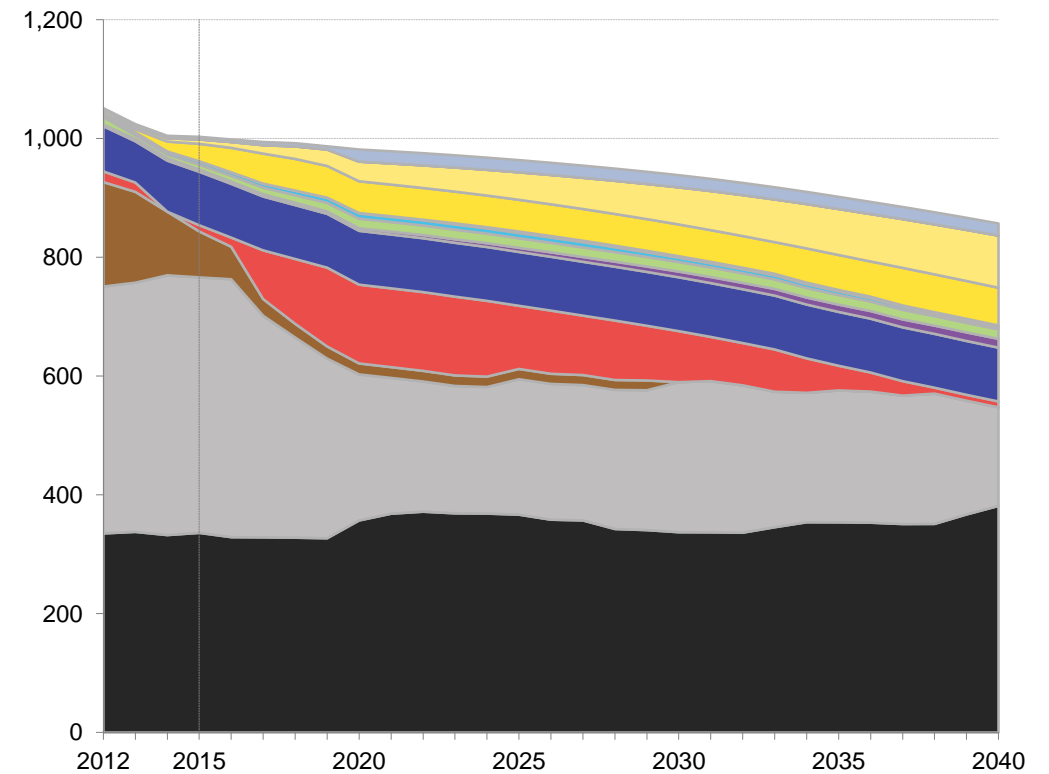


Source: Japan Ministry of Finance

### Cumulative installed capacity (GW)



### Electricity generation (TWh)



Source: Bloomberg New Energy Finance

“

We need an  
energy miracle

”

*Bill Gates*  
*February 2016*



Picture: Bloomberg

# Thanks!

## MARKETS

Renewable Energy  
Energy Smart Technologies  
Advanced Transport  
Gas  
Carbon and RECs

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