



Frankfurt School
FS-UNEP Collaborating Centre
for Climate & Sustainable Energy Finance

A photograph of an offshore wind farm with several white wind turbines on orange foundations in the sea. A small boat is visible in the distance.

GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2016



United Nations Environment Programme

Bloomberg
NEW ENERGY FINANCE

Frankfurt School-UNEP Centre/BNEF. 2016.

Global Trends in Renewable Energy Investment 2016, <http://www.fs-unep-centre.org> (Frankfurt am Main)

Copyright © Frankfurt School of Finance & Management gGmbH 2016.

This publication may be reproduced in whole or in part in any form for educational or non-profit purposes without special permission from the copyright holder, as long as provided acknowledgement of the source is made. Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance would appreciate receiving a copy of any publication that uses this publication as source.

No use of this publication may be made for resale or for any other commercial purpose whatsoever without prior permission in writing from Frankfurt School of Finance & Management gGmbH.

Disclaimer

Frankfurt School of Finance & Management: The designations employed and the presentation of the material in this publication do not imply the expression of any opinion whatsoever on the part of the Frankfurt School of Finance & Management concerning the legal status of any country, territory, city or area or of its authorities, or concerning delimitation of its frontiers or boundaries. Moreover, the views expressed do not necessarily represent the decision or the stated policy of the Frankfurt School of Finance & Management, nor does citing of trade names or commercial processes constitute endorsement.

Cover photo courtesy of Teun van den Dries/Shutterstock.com

Photos on pages 13, 16, 18, 24, 27, 31, 33, 34, 46, 55, 58, 61, 67 from Bloomberg Mediasource

Photos on other pages reproduced with the permission of: Grupo Clavijo (page 28); AES (page 37); Axpo Holdings (page 41); Acciona (44), Absolute Solar and Wind (page 49); Mainstream Renewable Power (pages 50, 64, 73); Masdar (page 51); Rame Energy (page 57); Voith (page 65); ORE Catapult (page 69); 3Sun (page 63); Voith (page 65); OpenHydro (page 67); Tidal Energy Ltd (page 71); Martifer Solar (page 75); Minesto (page 77); Solarpack (page 79); wpd (page 81)

ACKNOWLEDGEMENTS

This report was commissioned by UNEP's Division of Technology, Industry and Economic (DTIE) in cooperation with Frankfurt School-UNEP Collaborating Centre for Climate & Sustainable Energy Finance and produced in collaboration with Bloomberg New Energy Finance.

CONCEPT AND EDITORIAL OVERSIGHT

Angus McCrone (Lead Author, Chief Editor)

Ulf Moslener (Lead Editor)

Francoise d'Estais

Eric Usher

Christine Grüning

CONTRIBUTORS

Joseph Byrne

Luke Mills

David Strahan

Rohan Boyle

Bryony Collins

Kieron Stopforth

Lisa Becker

COORDINATION

Angus McCrone

DESIGN AND LAYOUT

The Bubblegate Company Limited

MEDIA OUTREACH

Moira O'Brien-Malone (UNEP)

Shereen Zorba (UNEP)

Sophie Loran (UNEP)

Terry Collins

Jennifer MacDonald (Bloomberg)

Angelika Werner (Frankfurt School of Finance & Management)

THANKS TO THE FOLLOWING EXPERTS WHO REVIEWED AND PROVIDED FEEDBACK ON THE DRAFT REPORT:

Mark Fulton, Tanja Faller, Michaela Pulkert, Tom Thorsch Krader, Tobias Rinke, Sabine Miltner, Barbara Buchner, Federico Mazza, Pdraig Oliver, Rodney Boyd, Donovan Escalante, Valerio Micale, Dario Abramskiehn, Jessica Williams

Supported by the Federal Republic of Germany



Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

METHODOLOGY AND DEFINITIONS

All figures in this report, unless otherwise credited, are based on the output of the Desktop database of Bloomberg New Energy Finance – an online portal to the world's most comprehensive database of investors, projects and transactions in clean energy.

The Bloomberg New Energy Finance Desktop collates all organisations, projects and investments according to transaction type, sector, geography and timing. It covers many tens of thousands of organisations (including start-ups, corporate entities, venture capital and private equity providers, banks and other investors), projects and transactions.

METHODOLOGY

The following renewable energy projects are included: all biomass and waste-to-energy, geothermal, and wind generation projects of more than 1MW; all hydropower projects of between 1MW and 50MW; all wave and tidal energy projects; all biofuel projects with a capacity of one million litres or more per year; and all solar projects, with those less than 1MW estimated separately and referred to as small-scale projects, or small distributed capacity, in this report.

The 2015 Global Trends report concentrates on renewable power and fuels and does not cover energy-smart technologies such as smart grid, electric vehicles and power storage – except for

the box on EVs at the end of Chapter 2 and the discussion of renewables and storage in Chapter 3.

The main body of the report also does not cover large hydro-electric projects of more than 50MW, since this technology has been mature for decades and is at a very different stage of its roll-out than, for instance, wind or solar. However there is brief coverage of large hydro in the Executive Summary and in the box at the end of Chapter 5.

Where deal values are not disclosed, Bloomberg New Energy Finance assigns an estimated value based on comparable transactions. Deal values are rigorously back-checked and updated when further information is released about particular companies and projects. The statistics used are historic figures, based on confirmed and disclosed investment.

Annual investment is estimate for small-scale commercial and residential projects such as rooftop solar. These figures are based on annual installation data, provided by industry associations and REN21. Bloomberg New Energy Finance continuously monitors investment in renewable energy. This is a dynamic process: as the sector's visibility grows, information flow improves. New deals come to light and existing data are refined, meaning that historical figures are constantly updated.

This 2016 report contains revisions to a number of investment figures published in the 2015 edition of Global Trends in Renewable Energy Investment. Revisions reflect improvements made by Bloomberg New Energy Finance to its data during the course of the last 12 months, and also new transactions in 2014 and before that have since come to light.

DEFINITIONS

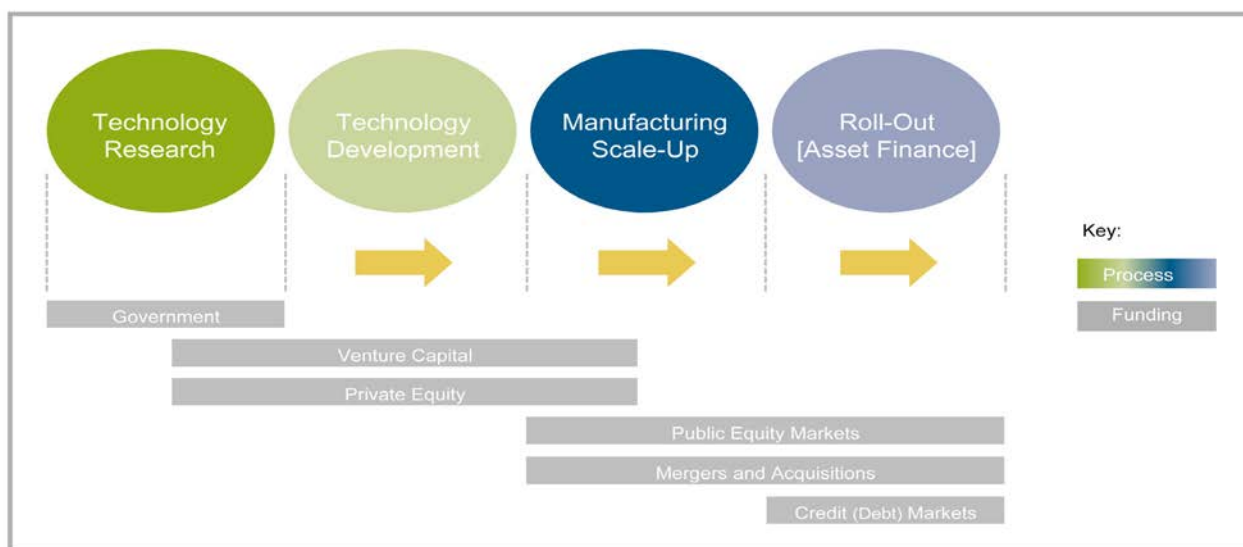
Bloomberg New Energy Finance tracks deals across the financing continuum, from R&D funding and venture capital for technology and early-stage companies, through to asset finance of utility-scale generation projects. Investment categories are defined as follows:

Venture capital and private equity (VC/PE): all money invested by venture capital and private equity funds in the equity of specialist companies developing renewable energy technology. Investment in companies setting up generating capacity through special purpose vehicles is counted in the asset financing figure.

Public markets: all money invested in the equity of specialist publicly quoted companies developing renewable energy technology and clean power generation.

Asset finance: all money invested in renewable energy generation projects (excluding large hydro), whether from internal company balance sheets, from loans, or from equity capital. This excludes refinancings.

Mergers and acquisitions (M&A): the value of existing equity and debt purchased by new corporate buyers, in companies developing renewable energy technology or operating renewable power and fuel projects.



REN21's annual **Renewables Global Status Report (GSR)** was first released in 2005.

The GSR grew out of an effort to portray the status of renewable energy worldwide. Over the past decade the GSR has grown in scope and depth, paralleling the tremendous advances in renewable energy policy, markets and industries. The report is the product of systematic data collection resulting in thousands of data points, the use of hundreds of documents and personal communication with experts from around the world. It draws on the expertise of a multi-stakeholder community of over 500 experts. The Global Status Report is the sister publication to UNEP Global Trends in Renewable Energy Investment; the latest edition will be released in June 2016.

KEY FINDINGS

- 2015 produced a new record for global investment in renewable energy. The amount of money committed to renewables excluding large hydro-electric projects rose 5% to \$285.9 billion, exceeding the previous record of \$278.5 billion achieved in 2011. This record was achieved despite exchange rate shifts that depressed the dollar value of investments in other currency zones, and despite sharp falls in oil, coal and gas prices that protected the competitive position of fossil fuel generation.
- Even more striking was that the amount of generating capacity added in wind and solar photovoltaics last year came to 118GW, far above the next highest annual figure, 2014's 94GW. Overall, renewables excluding large hydro made up 53.6% of the gigawatt capacity of all technologies installed in 2015, the first time it has represented a majority.
- Global investment in renewable power capacity¹, at \$265.8 billion, was more than double dollar allocations to new coal and gas generation, which was an estimated \$130 billion in 2015. However, the huge weight of conventional generation capacity already built meant that new, clean technologies only accounted for just over 10% of world electricity last year, as Chapter 2 shows. However, this did prevent the emission of some 1.5 gigatonnes of CO₂ in 2015.
- Even though 2015 produced a record for overall investment, the sky is far from entirely blue. The United Nations climate change conference in Paris in December 2015, known as COP21, produced an unprecedented agreement among 195 countries to act for zero net emissions in the second half of the century. Nevertheless, the global emission trend remains worrying, as energy-related emissions are not forecast to peak until the late 2020s, at the earliest.
- Last year was also notable as the first in which investment in renewables excluding large hydro in developing countries outweighed that in developed economies. The developing world including China, India and Brazil committed a total of \$156 billion, up 19% on 2014, while developed countries invested \$130 billion, down 8%. A large element in this turnaround was China, which lifted its investment by 17% to \$102.9 billion, or 36% of the world total.
- However, other developing countries also raised their game – India saw its commitments rise 22% to \$10.2 billion, while Brazil (\$7.1 billion, down 10%), South Africa (\$4.5 billion, up 329%), Mexico (\$4 billion, up 105%) and Chile (\$3.4 billion, up 151%) all joined it in the list of the top 10 investing countries in 2015. The list of developing countries investing more than \$500 million last year also included Morocco, Uruguay, the Philippines, Pakistan and Honduras.
- Investment in Europe slipped 21% to \$48.8 billion, despite that continent's record year for financings of offshore wind, at \$17 billion, up 11%. The US enjoyed a 19% bounce in renewable energy commitments to \$44.1 billion, its highest since 2011, with solar accounting for just over two thirds of that total. Japan attracted \$36.2 billion, almost the same as in 2014, thanks to its continuing boom in small-scale PV.
- Renewable generation costs continue to fall, particularly in solar photovoltaics. In the second half of 2015, the global average levelised cost of electricity for crystalline silicon PV was \$122 per MWh, down from \$143 in H2 2014. Specific projects are going ahead at tariffs well below that – the record-breaker so far being a 200MW plant in Dubai being built by ACWA Power International, awarded a contract in January 2015 at just \$58.50 per MWh.
- Public market investment in renewable energy totalled \$12.8 billion in 2015, down 21% on the previous year's figure but close to the average for the years since 2008. The 2015 figure was unusually lopsided, however, with North American 'yieldcos' and European quoted project funds accounting for \$6.2 billion of new equity, and US manufacturer and project developer SunEdison issuing \$2 billion of convertibles. The US yieldco equity raising spree came to an almost complete halt after July as a result of a sharp share price correction. Overall, clean energy shares edged down 0.6% in 2015, in line with the US S&P500 index.
- Policy support for renewables remains fickle. A less friendly turn by the new UK government after the May 2015 election has been one example, and another may be the US Supreme Court's decision in February 2016 to allow all legal objections to the Environmental Protection Agency's Clean Power Plan to be heard before it can be implemented. It is also possible that the recent big fall in coal, oil and gas prices may tempt some developing countries to keep relying on fossil-fuel capacity for longer.
- There is rising interest in battery storage as an adjunct to solar and wind projects and to small-scale PV systems. In 2015, some 250MW of utility-scale electricity storage (excluding pumped hydro and lead-acid batteries) were installed worldwide, up from 160MW in 2014. Announced projects reached 1.2GW. The potential for storage to help balance variable renewable electricity generation, in both developed countries and remote developing country locations off the grid, is this year's Focus topic and is discussed in Chapter 3.

¹ Investment in large hydro-electric dams is not included in that figure. It is estimated to have been \$43 billion in 2015.

EXECUTIVE SUMMARY

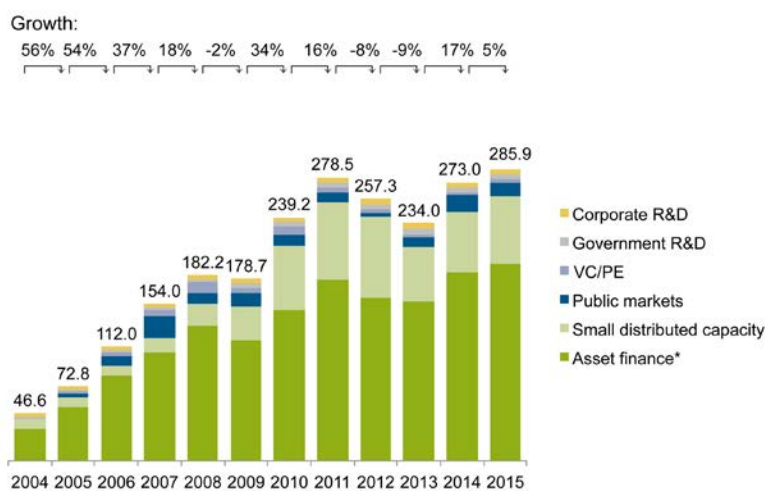
Renewable energy set new records in 2015 for dollar investment, the amount of new capacity added and the relative importance of developing countries in that growth. All this happened in a year in which prices of fossil fuel commodities – oil, coal and gas – plummeted, causing distress to many companies involved in the hydrocarbon sector. So far, the drivers of investment in renewables, including climate change policies and improving cost-competitiveness, have been more than sufficient to enable renewables to keep growing their share of world electricity generation at the expense of carbon-emitting sources.

Last year saw global investment in renewables¹ rise 5% to \$285.9 billion, taking it above the previous record of \$278.5 billion reached in 2011 at the peak of the 'green stimulus' programmes and the German and Italian rooftop solar booms. Figure 1 shows that the 2015 total was more than six times the figure set in 2004, and that investment in renewables has been running at more than \$200 billion per year

for six years now. Over the 12 years shown on the chart, the total amount committed has reached \$2.3 trillion.

More impressive in a way than the new dollar investment record set last year was the result in terms of gigawatts of capacity added. In 2015, some 134GW of renewables excluding large hydro were commissioned, equivalent to some 53.6% of all power generation capacity completed in that year – the first time it has represented a majority. Of the renewables total, wind accounted for 62GW installed, and solar photovoltaics 56GW, record figures and sharply up from their 2014 additions of 49GW and 45GW respectively.

FIGURE 1. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY ASSET CLASS, 2004-2015, \$BN



*Asset finance volume adjusts for re-invested equity. Total values include estimates for undisclosed deals

Source: UNEP, Bloomberg New Energy Finance

Figure 2 shows the make-up of the record investment figure in 2015. At the left edge of the chart are the categories relating to the backing of early-stage companies and technology. Venture capital investment in renewables was \$1.3 billion last year, up 36% but still far behind its peak level of \$3.2 billion in 2008. Next along is corporate and government research and

¹ Excluding large hydro-electric projects of more than 50MW. See later in the Executive Summary and the Box at the end of Chapter 5 for discussion of large hydro in 2015.

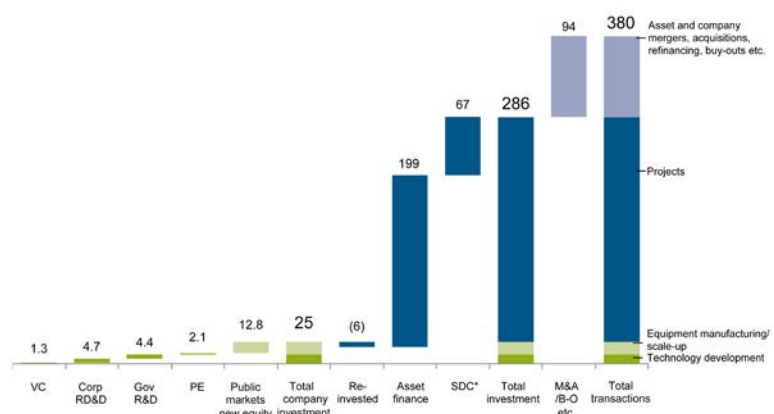


development spending on renewables. The former was up 3% on the previous year at \$4.7 billion and the latter down 3% at \$4.4 billion. Private equity expansion capital was \$2.1 billion in 2015, up 32% on 2014 but less than a third of the peak, 2008 figure of \$6.7 billion. The last part of that technology/corporate level funding is equity raising by specialist renewable energy companies on the public markets. This was \$12.8 billion last year, down 21% on the previous 12 months but close to its average over the last eight years.

The biggest components of investment in 2015 were asset finance of utility-scale projects such as wind farms and solar parks, at \$199 billion, some 6% above the previous year, and spending on small distributed capacity – local and rooftop solar projects of less than 1MW capacity – which was up 12% at \$67.4 billion. There is also an adjustment of \$5.8 billion for reinvested equity (money that

was raised in the categories on the left of Figure 2 that then ended up going into asset finance or small projects). Finally, on the right of Figure 2 is acquisition activity of \$93.9 billion, up 7%. This is a mix of asset acquisitions, refinancings, corporate mergers and takeovers, and buy-outs.

FIGURE 2. GLOBAL TRANSACTIONS IN RENEWABLE ENERGY, 2015, \$BN



SDC = small distributed capacity. Total values include estimates for undisclosed deals. Figures may not add up exactly to totals, due to rounding.

Source: UNEP, Bloomberg New Energy Finance

FIGURE 3. GLOBAL TRENDS IN RENEWABLE ENERGY INVESTMENT 2016 DATA TABLE, \$BN

Category	Year Unit	2004 \$bn	2005 \$bn	2006 \$bn	2007 \$bn	2008 \$bn	2009 \$bn	2010 \$bn	2011 \$bn	2012 \$bn	2013 \$bn	2014 \$bn	2015 \$bn	2014-15 Growth %	2004-15 CAGR %
1. Total investment		46.6	72.8	112.0	154.0	182.2	178.7	239.2	278.5	257.3	234.0	273.0	285.9	5%	18%
1.1 New investment		46.6	72.8	112.0	154.0	182.2	178.7	239.2	278.5	257.3	234.0	273.0	285.9	5%	18%
1.2 Total transactions		55.5	99.1	147.9	212.7	241.6	242.9	297.6	352.0	324.9	301.1	360.4	379.8	5%	19%
2. New Investment by Value Chain															
2.1 Technology development															
2.1.1 Venture capital		0.4	0.6	1.2	2.1	3.2	1.6	2.5	2.5	2.4	0.8	1.0	1.3	36%	13%
2.1.2 Government R&D		1.9	2.0	2.2	2.7	2.8	5.4	4.9	4.8	4.7	5.2	4.5	4.4	-3%	8%
2.1.3 Corporate R&D		3.2	2.9	3.1	3.5	4.0	4.1	4.2	5.1	5.0	6.6	4.5	4.7	3%	3%
2.2 Equipment Manufacturing															
2.2.1 Private equity expansion capital		0.3	1.0	3.1	3.6	6.7	2.9	5.4	2.4	1.6	1.4	1.6	2.1	32%	18%
2.2.2 Public markets		0.3	3.6	9.3	21.4	10.9	12.9	11.2	10.0	3.8	10.1	16.2	12.8	-21%	42%
2.3 Projects															
2.3.1 Asset finance		32.0	52.6	84.5	109.8	135.8	120.2	152.9	181.4	163.3	158.0	188.4	199.0	6%	18%
Of which re-invested equity		0.0	0.1	0.7	3.2	3.6	1.9	4.4	3.4	2.8	1.9	3.7	5.8	59%	-
2.3.3 Small distributed capacity		8.5	10.2	9.4	14.1	22.3	33.5	62.6	75.7	79.3	53.9	60.4	67.4	12%	21%
Total financial investment		32.3	57.2	97.5	133.7	163.1	157.7	197.5	229.3	207.3	189.4	223.3	234.4	5%	18%
Govt R&D, corporate R&D, small projects		13.6	15.2	14.7	20.3	29.1	43.0	71.7	85.7	89.0	65.6	69.5	76.5	10%	17%
Total New Investment		46.6	72.8	112.0	154.0	182.2	178.7	239.2	278.5	257.3	234.0	273.0	285.9	5%	18%
3. M&A Transactions															
3.1 Private equity buy-outs		0.8	3.7	1.9	3.6	5.1	2.2	1.9	3.0	3.3	0.5	2.6	3.5	36%	14%
3.2 Public markets investor exits		0.4	2.4	2.7	4.0	0.9	2.5	4.9	0.2	0.4	1.7	1.8	1.8	1%	16%
3.3 Corporate M&A		2.4	7.6	11.9	20.4	16.9	21.8	19.4	29.7	10.2	16.3	11.8	19.2	63%	21%
3.4 Project acquisition & refinancing		5.3	12.5	19.5	30.7	36.4	37.7	32.3	40.6	53.7	48.6	71.2	69.3	-3%	26%
4. New Investment by Sector															
4.1 Wind		19.0	29.0	39.8	61.2	75.4	79.8	98.7	84.2	81.9	90.6	105.7	109.6	4%	17%
4.2 Solar		11.9	16.1	22.2	38.9	61.6	64.4	103.7	154.8	146.2	119.1	143.8	161.0	12%	27%
4.3 Biofuels		4.0	9.6	28.2	28.3	18.5	10.4	10.1	10.3	7.2	5.7	4.7	3.1	-35%	-2%
4.4 Biomass & w-t-e		7.7	9.7	11.9	16.2	17.1	14.7	15.7	18.0	13.5	10.5	10.4	6.0	-42%	-2%
4.5 Small hydro		2.6	7.3	7.6	6.7	7.6	6.2	7.9	7.2	6.4	5.5	5.5	3.9	-29%	4%
4.6 Geothermal		1.2	1.0	1.5	1.9	1.7	2.9	2.8	3.7	1.8	2.4	2.6	2.0	-23%	5%
4.7 Marine		0.0	0.1	0.9	0.8	0.2	0.3	0.3	0.3	0.3	0.2	0.4	0.2	-42%	14%
Total		46.6	72.8	112.0	154.0	182.2	178.7	239.2	278.5	257.3	234.0	273.0	285.9	5%	18%
5. New Investment by Geography															
5.1 United States		5.6	11.9	29.1	33.2	35.5	23.9	34.7	49.1	40.6	35.3	37.0	44.1	19%	21%
5.2 Brazil		0.8	3.1	5.2	11.4	11.8	7.9	7.2	10.2	7.7	4.4	8.0	7.1	-10%	21%
5.3 AMER (excl. US & Brazil)		1.7	3.3	3.7	5.0	6.1	5.5	12.0	9.3	10.1	12.0	13.3	12.8	-3%	20%
5.4 Europe		24.8	33.3	46.9	66.8	81.8	82.7	113.4	122.9	89.0	60.0	62.0	48.8	-21%	6%
5.5 Middle East & Africa		0.6	0.8	1.1	1.8	2.3	1.6	4.1	3.0	10.2	9.3	7.9	12.5	58%	32%
5.6 China		3.0	8.3	11.2	16.7	25.6	38.8	39.6	47.4	61.7	62.0	87.8	102.9	17%	38%
5.7 India		2.7	3.0	4.9	6.7	5.6	4.3	8.8	12.8	7.8	6.6	8.3	10.2	22%	13%
5.8 ASOC (excl. China & India)		7.3	9.0	10.0	12.4	13.6	13.9	19.3	23.8	30.2	44.4	48.8	47.6	-2%	19%
Total		46.6	72.8	112.0	154.0	182.2	178.7	239.2	278.5	257.3	234.0	273.0	285.9	5%	18%

New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals.

Source: UNEP, Bloomberg New Energy Finance

The regional split of investment in 2015 is shown in Figure 3. The stand-out contribution to the rise in investment to a new record came from China, which lifted its outlays by 17% to \$102.9 billion, some 36% of the global total. Investment also increased in the US, up 19% at \$44.1 billion; in Middle East and Africa, up 58% at \$12.5 billion, helped by project development in South Africa and Morocco; and in India, up 22% at \$10.2 billion. However, it fell in Europe by 21% to \$48.8 billion, that continent's lowest figure for nine years – despite record commitments to offshore wind projects. Investment fell 10% to \$7.1 billion in Brazil, and was also slightly lower in the Americas excluding the US and Brazil, at \$12.8 billion, largely due to a weaker Canadian figure; and in Asia excluding China and India, at \$47.6 billion. Much more detail on the regional and country trends can be found in Chapter 1.

DEVELOPING WORLD AHEAD

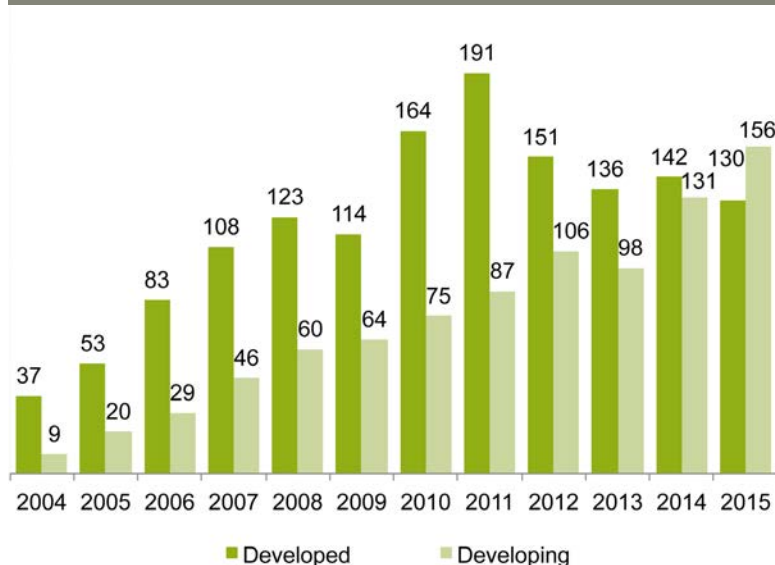
Renewable energy technologies such as wind and solar used to be seen by some critics as a luxury, affordable only in the richer parts of the world. This has been an inaccurate view for a long time, but 2015 was the first year in which investment in

renewables excluding large hydro was higher in developing economies than in developed countries. Figure 4 shows that the developing world invested \$156 billion last year, some 19% up on 2014 and a remarkable 17 times the equivalent figure for 2004, of \$9 billion.² Developed countries invested \$130 billion in 2015, down 8% and their lowest tally since 2009.

A large part of the record-breaking investment in developing countries took place in China. Indeed that country has been the single biggest reason for the near-unbroken uptrend for the developing world as a whole since 2004. However, it was not just China – India also raised its commitment to renewables in 2015, and developing countries excluding China, India and Brazil lifted their investment by 30% last year to an all-time high of \$36 billion, some 12 times their figure for 2004.

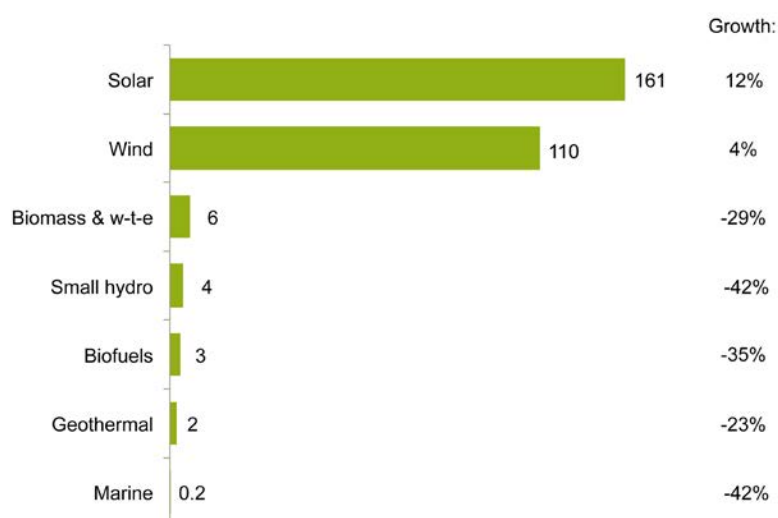
Among those “other developing” economies, those putting the largest sums into clean power were South Africa, up 329% at \$4.5 billion as a wave of projects winning contracts in its auction programme reached financial close; Mexico, 105% higher at \$4 billion, helped by funding from

² The definition of developing world used in this report is all non-OECD countries plus Mexico, Chile and Turkey. Even on a simple OECD versus non-OECD countries comparison, the latter would still have invested more than the former in 2015.

FIGURE 4. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY: DEVELOPED V DEVELOPING COUNTRIES, 2004-2015, \$BN

New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals. Developed volumes are based on OECD countries excluding Mexico, Chile, and Turkey.

Source: UNEP, Bloomberg New Energy Finance

FIGURE 5. GLOBAL NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2015, AND GROWTH ON 2014, \$BN

New investment volume adjusts for re-invested equity. Total values include estimates for undisclosed deals.

Source: UNEP, Bloomberg New Energy Finance

development bank Nafin for nine wind projects; and Chile, 151% higher at \$3.4 billion, on the back of a jump in solar project financings. Morocco, Turkey and Uruguay also saw investment beat the \$1 billion barrier in 2015.

50MW a 29% decline to \$3.9 billion; biofuels (the second-biggest sector behind wind back in 2006) a 35% drop to \$3.1 billion; geothermal a 23% setback to \$2 billion; and marine (wave and tidal) a 42% slip to just \$215 million.

Investment in the developed world has been on a downward trend, more or less consistently, since 2011, when it peaked at \$191 billion, some 47% higher than the 2015 outturn. This decline has been a little to do with the US, where there was a rush of investment in 2011 as projects and companies tried to catch the Treasury grant and Federal Loan Guarantee programmes before they expired; but much more to do with Europe, where allocations fell by 60% between 2011 and 2015. That big drop reflected a mix of factors including retroactive cuts in support for existing projects in Spain, Romania and several other countries, an economic downturn in southern Europe that made electricity bills more of a political issue, the fading of solar booms in Germany and Italy, and the big fall in the cost of PV panels over recent years. The two factors pushing in the opposite (positive) direction in Europe in recent years have been strong investment in the UK, and the growth of the offshore wind sector in the North Sea.

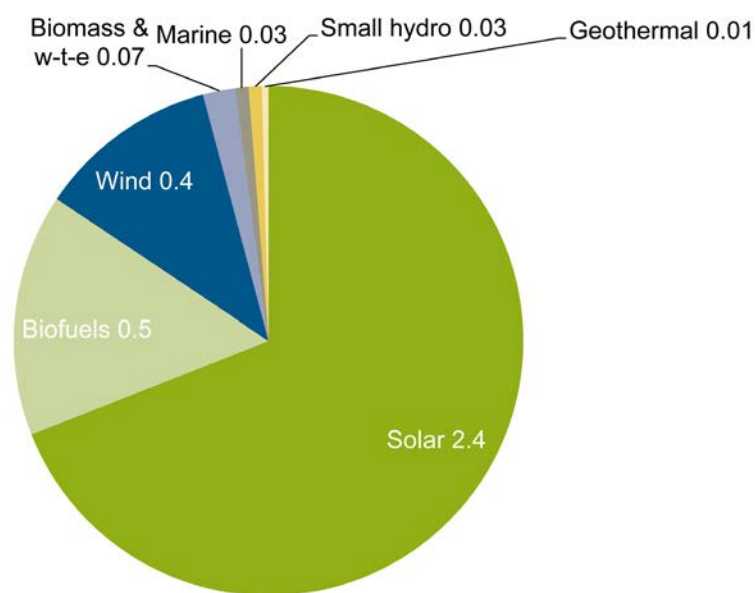
Figure 5 shows the sector split for global investment. Over recent years, renewables have become more and more dominated by wind and solar, with the smaller sectors losing relative importance, and in 2015 this process continued. Solar saw a 12% increase to \$161 billion, and wind a 4% boost to \$109.6 billion – both records, although not by as huge a margin as their gigawatt installation figures.³ Biomass and waste-to-energy suffered a 42% fall to \$6 billion; small hydro projects of less than

³ There are several reasons why GW installations grew more quickly than dollar investment in 2015 for wind and solar. One was the rise in the US currency, which depressed dollar figures for projects in euro, yen, yuan and other currency zones. A second was lower costs per MW in solar. A third was the growing share of China in overall investment. Chinese wind and solar projects are typically at the low end of the global cost range.

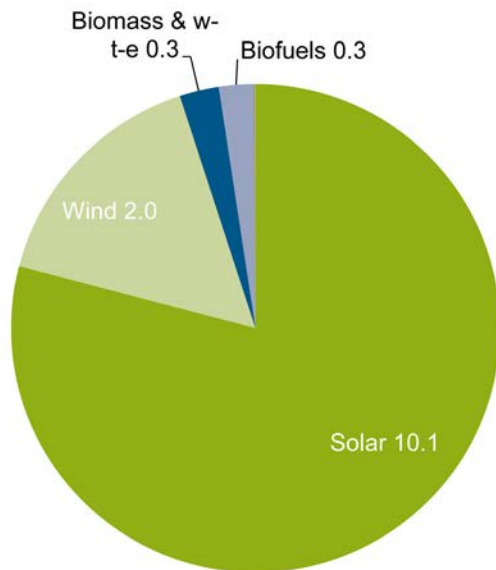


The split was somewhat different for venture capital and private equity funding specifically. This type of money tends to go to the newer technologies, rather than the more mature ones, so it is no surprise in Figure 6 to see solar dominating with \$2.4 billion last year, up 58%, and biofuels – particularly second-generation based on non-food crops – come second with \$523 million, down 3%. Solar also took the lion's share of public market investment in 2015, at \$10.1 billion in Figure 7, up 21%, with wind second at \$2 billion, down 69%. However, the public market figures were heavily influenced last year by equity issuance from North American 'yieldcos' and European quoted project funds, many of which own projects in both solar and wind, so the sector split for their fundraisings is somewhat arbitrary.

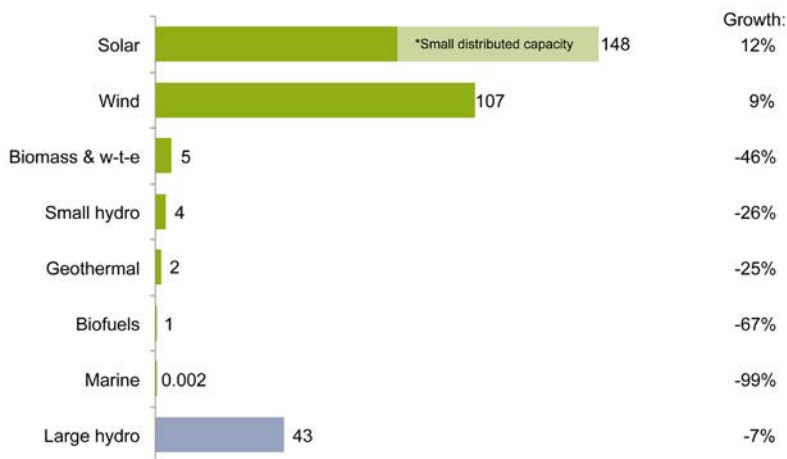
FIGURE 6. VC/PE NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2015, \$BN



Source: UNEP, Bloomberg New Energy Finance

FIGURE 7. PUBLIC MARKETS NEW INVESTMENT IN RENEWABLE ENERGY BY SECTOR, 2015, \$BN

Source: UNEP, Bloomberg New Energy Finance

FIGURE 8. RENEWABLE ENERGY ASSET FINANCE AND SMALL DISTRIBUTED CAPACITY INVESTMENT BY SECTOR, 2015, AND GROWTH ON 2014, \$BN

Total values include estimates for undisclosed deals.
 Source: UNEP, Bloomberg New Energy Finance

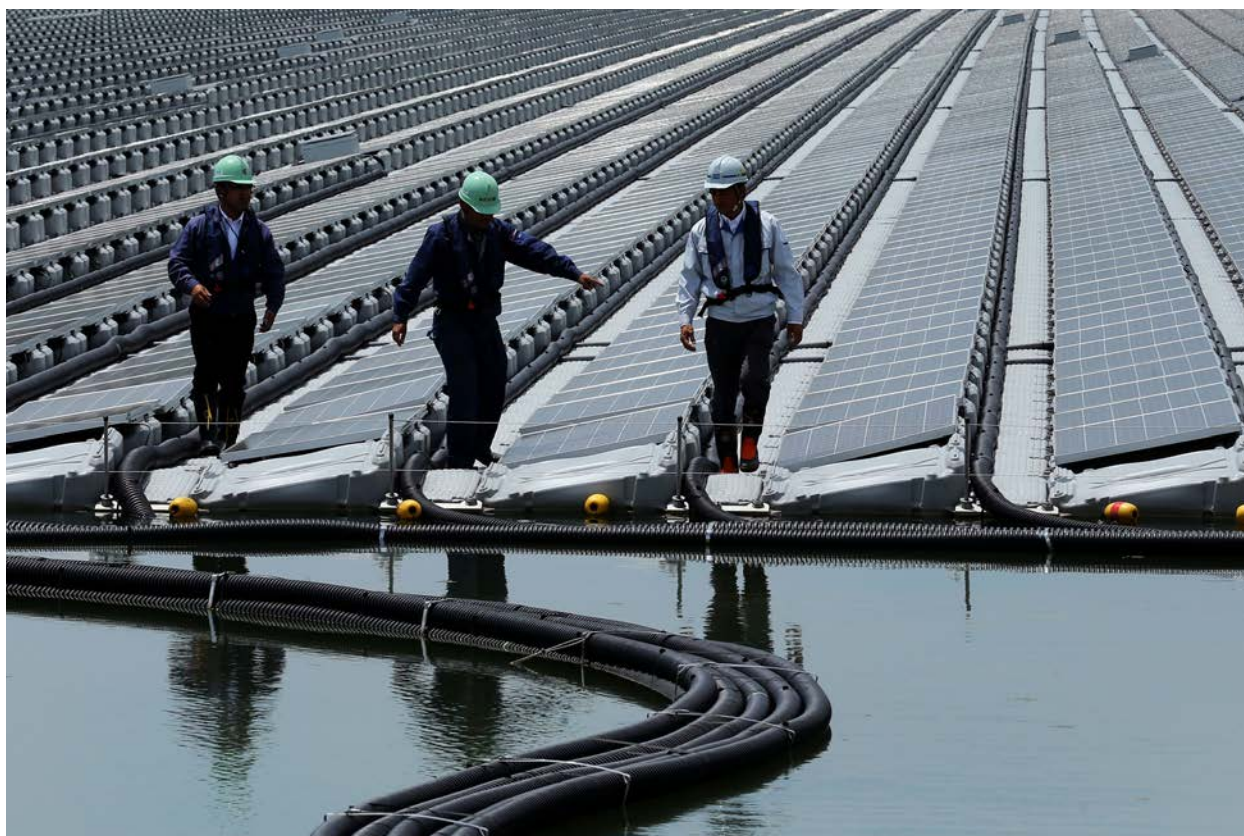
The really big financial flows to renewable energy in 2015 came at the roll-out stage, rather than the technology development stage. Figure 8 shows that solar (utility-scale and small-scale) was by far the largest sector for capacity investment, reaching \$148.3 billion, up 12% on the year before. As well

as conventional solar parks and rooftop installations, last year saw the financing of a number of floating solar photovoltaic projects on lakes and reservoirs, mostly in the single-digit MW range.

Commitments for new wind capacity rose 9% to \$107 billion. Perhaps more interesting was the sub-sector split with onshore wind garnering \$83.8 billion, up 3%, while offshore wind attracted a record \$23.2 billion, up 39% compared to 2014, mostly in Europe but also including a first wave of Chinese sea-based projects. The offshore wind arrays financed worldwide last year were more than 20 in number, with eight of them having estimated project costs of between \$1 billion and \$2.9 billion. There was also a 30MW floating offshore wind project financed in Scotland. See Chapter 5 for details.

Figure 8 also shows the capacity investment comparison between wind and solar and the smaller clean energy sectors, the largest of which was biomass and waste-to-energy at \$5.2 billion, and also between all of those and large hydro. Some \$43 billion of large hydro-electric projects of more than 50MW are estimated to have reached the 'final investment decision' stage in 2015, down 7% on the previous year. This would put large hydro at 40% the size of wind in terms of new investment last year, and just 29% of the size of solar, although of course prior decades of development mean that the installed base of 50MW-plus hydro-electric dams is still, at around 925GW, much bigger than that of wind and solar (671GW

combined).



ENERGY ABUNDANT, COMPETITION ON COSTS

The global energy sector has changed out of all recognition since the summer of 2014. Oil, as measured by the Brent crude contract, fell in price from a high of \$115.71-a-barrel on 19 June of that year, to \$27.10 on 20 January 2016, a decline of 76%. The ARA coal contract dropped from \$84-a-tonne on 28 April 2014 to \$36.30 on 17 February 2016, intensifying a downward trend that has been unfolding since its high of \$135 in 2011. The US Henry Hub natural gas price slid from around \$4.50 per MMBtu in June 2014 to \$1.91 in mid-February 2016.

However, cheaper fossil fuels have not materially damaged prospects for renewables so far. Competition between fossil fuels and renewables is rarely a simple one-or-other choice. Oil does not compete directly with renewable power, except in a few crude-producing countries that burn oil to make electricity, and in remote regions using diesel generators. Gas does compete more directly with wind and solar, but while gas prices in Europe

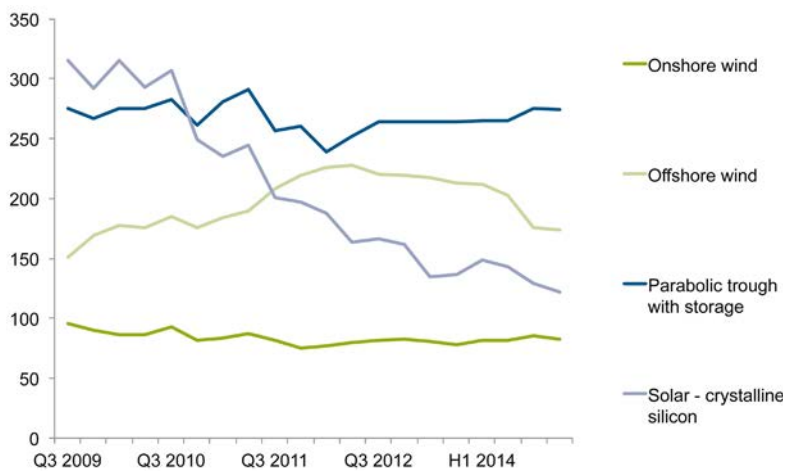
and Asia have fallen, they remain far above US levels. Coal also competes with renewables but, as with gas, decision-makers are unlikely to make power station choices on the basis of short-term spot commodity prices. In addition, new coal-fired plants may be more difficult to finance than those of cleaner technologies, given rising investor concern about exposure to stranded assets and the climate priorities of development banks.

Meanwhile, renewables have their own advantages. Wind farms can be built in nine months or so, solar parks in three-to-six months, whereas coal and gas plants take several years, and nuclear even longer. So developing countries in a hurry for new capacity may opt for speed. And, while fossil fuel costs have been falling, renewables and especially solar have also been getting more competitive.

Figure 9 shows the change in levelised costs of electricity⁴ for four different renewable power technologies over a six-year period. Onshore wind has seen its average global LCOE decline from \$96 per MWh in the third quarter of 2009 to \$83 per MWh in late 2015, a reduction of 14%. The equivalent for offshore wind actually increased for

⁴ Levelised costs of electricity include not just running costs but also the costs of development, construction and financing. LCOEs vary greatly by country, depending on the resource. The figures used here are global averages.

FIGURE 9. GLOBAL AVERAGE LEVELISED COST OF ELECTRICITY FOR WIND AND SOLAR, Q3 2009 TO H2 2015, \$ PER MWH



Source: Bloomberg New Energy Finance

several years, as projects moved out into deeper water, but have started to come down more recently. Average costs were around \$174 per MWh in the second half of last year. The LCOE for solar thermal parabolic trough plants has hardly changed and remains around \$275 per MWh.

The spectacular mover has been solar photovoltaics, the biggest single sub-sector in renewables. The average global levelised cost for crystalline-silicon PV has plummeted from \$315 per MWh in Q3 2009 to \$122 in late 2015, a drop of 61%, reflecting deflation in module prices, balance-of-plant costs and installation expenses. And there is an advance guard of projects taking place in particular countries now at much lower figures – examples including the ACWA installation in Dubai that went ahead with a \$58.50-per-MWh tariff in January 2015, and auctions in India in late 2015 and early 2016 that have seen solar projects win capacity with bids of \$64 per MWh (Fortum Finnsuurya Energy in Rajasthan) and \$68 (SunEdison and Softbank in Andhra Pradesh).

Many governments in developed and developing countries are moving towards auctions as a way of awarding capacity to renewable energy developers at relatively keen prices – continuing a trend that was discussed in last year's Global Trends report. In South Africa, for instance, the 2015 auctions awarded contracts to onshore wind at 41% less in local currency terms than the first auctions, back in

2011. In the UK, the first Contract-for-Difference auction, held in February 2015, saw winning bids for onshore wind at 11% below what was available under the preceding green certificate regime. Two contracts for offshore wind were awarded at 14% and 18% below the officially-set strike price. In Germany, the second PV auction in 2015 awarded contracts 7.5% below the previous feed-in tariff level.

None of this means that all obstacles for renewables have gone away, far from it. Challenges include national electricity monopolies in some developing countries that are not familiar with, or are resistant to, variable wind and solar generation. Then there are concerns in many developed economies about how variable generation can be balanced, and how it can be guaranteed that the lights will stay on (the subject of balancing and the potential of storage technologies are explored in Chapter 3). There are depressed wholesale electricity prices in many developed countries that are making it difficult to make a return on investing in any new generating plant, renewable or otherwise. There is a lack of investor confidence in a number of significant countries because of past political events or energy policy decisions, from Ukraine to Spain, and Argentina to Greece.

In some countries, local financing options are plentiful; in others they are few and far between – the sources of finance for renewable energy are discussed in Chapter 4. And some jurisdictions have local regulations that make renewables difficult to develop, even if the natural resource is good – small-scale solar in Turkey being one of the many examples. Finally, there are also issues resulting from rapid build-out of renewables. One important example is curtailment of new wind farms in China, as the grid struggles to match electricity demand that is growing less rapidly than before with increased power generation capacity.

THE UNITED NATIONS ENVIRONMENT PROGRAMME

The United Nations Environment Programme (UNEP) is the leading global environmental authority that sets the global environmental agenda, promotes the coherent implementation of the environmental dimension of sustainable development within the United Nations system and serves as an authoritative advocate for the global environment. Established in 1972, UNEP's mission is to provide leadership and encourage partnership in caring for the environment by inspiring, informing, and enabling nations and peoples to improve their quality of life without compromising that of future generations.



FRANKFURT SCHOOL OF FINANCE & MANAGEMENT

Frankfurt School of Finance & Management is a research-led business school accredited by AACSB International and EQUIS. Frankfurt School offers educational programmes in financial, economic and management subjects, including bachelor's and master's degrees, a doctoral programme, executive education, certified courses of study, open seminars and training courses for professionals as well as seminars and workshops for those in vocational training. In addition to its campus in Frankfurt, the FS has study centres in Hamburg and Munich and five offices in developing countries. It is a globally connected business school with nearly 100 partner universities. More information from www.frankfurt-school.de

FRANKFURT SCHOOL – UNEP COLLABORATING CENTRE FOR CLIMATE & SUSTAINABLE ENERGY FINANCE

The Frankfurt School – UNEP Collaborating Centre for Climate & Sustainable Energy Finance, a strategic cooperation between the Frankfurt School of Finance & Management and UNEP. The Centre is committed to facilitating the necessary structural change of energy supply and use around the globe by helping to catalyse private sector capital flow towards investments in sustainable energy and climate change mitigation and adaptation. The Centre combines project implementation on the ground with think-tank activities. Its experts experiment with new financial mechanisms and implement cutting-edge projects, and inform policy development. The primary objective is to mobilise significantly increased levels of sustainable energy and climate finance, bridging the public-private sector gap and thereby contributing to the development of a global green economy. Together with partners in different institutions, the Centre is elaborating and field-testing new financial instruments, products and services that serve the growing markets for energy-efficient and clean energy production.



BLOOMBERG NEW ENERGY FINANCE

Bloomberg New Energy Finance (BNEF) provides unique analysis, tools and data for decision makers driving change in the energy system. With unrivalled depth and breadth, we help clients stay on top of developments across the energy spectrum from our comprehensive web-based platform. BNEF has 200 staff based in London, New York, Beijing, Cape Town, Hong Kong, Munich, New Delhi, San Francisco, São Paulo, Singapore, Sydney, Tokyo, Washington D.C., and Zurich. For more information on Bloomberg New Energy Finance, see <http://about.bnef.com>, or contact us at sales.bnef@bloomberg.net for more information on our services.





Frankfurt School
FS-UNEP Collaborating Centre
for Climate & Sustainable Energy Finance

**Frankfurt School – UNEP Collaborating Centre
Frankfurt School of Finance & Management**

Sonnemannstrasse 9–11
60314 Frankfurt am Main
<http://fs-unep-centre.org>
www.frankfurt-school.de
E-Mail: fs_unep@fs.de
Phone: +49 (0)69 154008-647
Fax: +49 (0)69 154008-4647

Supported by the Federal Republic of Germany:



Federal Ministry for the
Environment, Nature Conservation,
Building and Nuclear Safety

