# Theme Briefing: Renewables

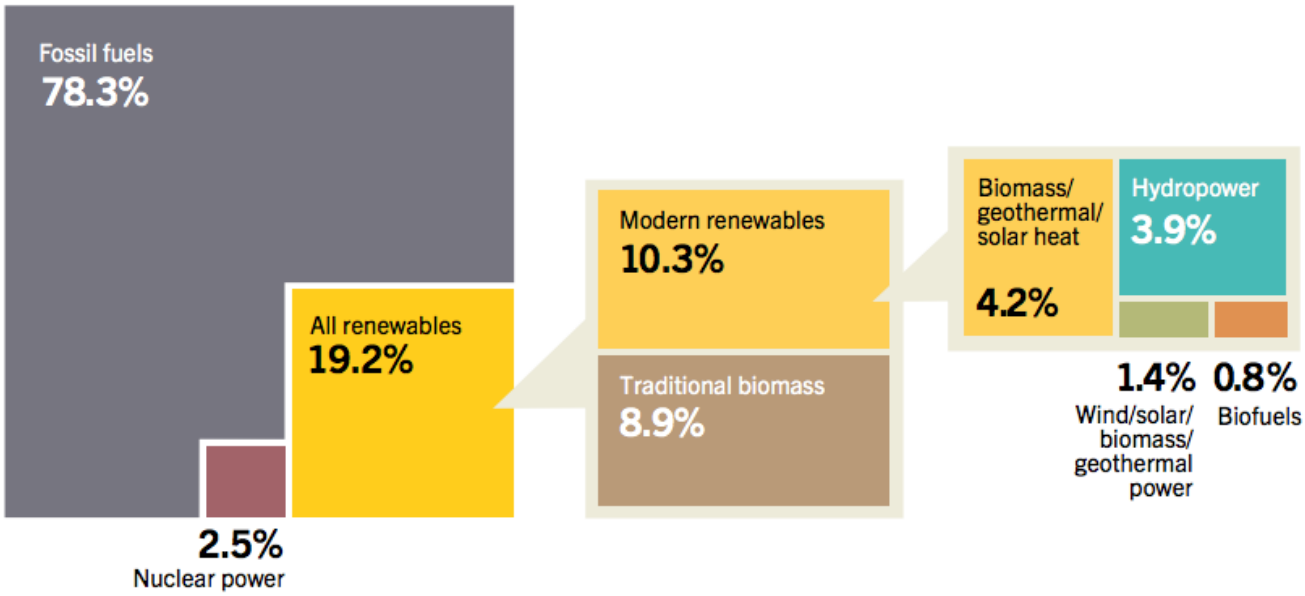
*This briefing has been created to provide accessible facts and figures on the renewables transition. It is accompanied by a spreadsheet with supporting information.*

# The big picture of the renewable transition

## 1. Renewables are providing nearly a quarter of the world's electricity

Renewable power is the second largest source of electricity after coal, providing nearly a quarter of the world's power.

- 23% of global **electricity** came from renewables in 2015, according to the International Energy Agency (IEA). 16.3% of this came from hydropower and 6.2% from wind, solar or bioenergy.
- Renewables including hydro are the world's second largest source of electricity after coal, which provided just under 40% of the world's power in 2015 (IEA).
- Renewable energy capacity overtook coal for the first time in 2015 (IEA) - although because electricity supply from renewables isn't constant, coal still generated more electricity.
- Taking heat and transport into account, renewable power met 19% of global final **energy** consumption in 2014, according to Ren21. But about half of this came from traditional biomass. (Firewood and charcoal in developing countries.)[1]



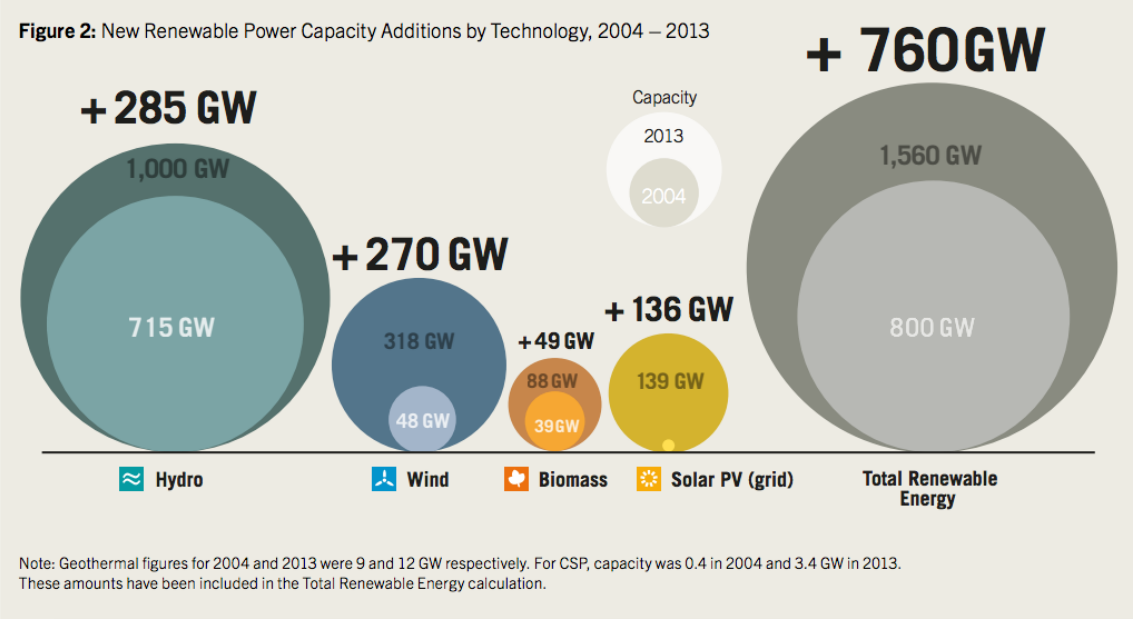

*Estimated renewable energy share of global final energy consumption, 2014. Source: Ren21, 2015*

[1] The IEA, BP and Ren21 all use different methods for calculating these figures. For example BP's estimate that renewables met only 9.3% of global energy demand in 2014 includes only traded commercial fuels for power or transport, and excludes renewable sources of heat. (pers comm and http://www.carbonbrief.org/10-charts-showing-why-carbon-emissions-stalled-last-year).

## 2. The world is now building more renewables than fossil fuel capacity

Renewables are growing rapidly, especially wind and solar. In recent years, more renewable capacity has been built than fossil fuel capacity.

- In 2015, renewable generation capacity increased by 153 gigawatts (GW), according to the IEA - an increase of 15%. Wind (63GW) and solar power (49GW) accounted for about three quarters of the new additions.
- 2013 was the first year more renewable power capacity was built than coal, natural gas and oil combined, according to Bloomberg.[2]
- In 2014, the world had 50 times more solar and nearly seven times more wind than a decade earlier.[3]
- Over the next decade and a half, renewable capacity additions will be an "order of magnitude" larger than coal and gas, according to Michael Liebreich of Bloomberg New Energy Finance.




*Expansion of renewable power globally between 2004 and the end of 2013. Source: Ren21*

## 3. Renewable power is growing faster than expected

The rise of renewable power has repeatedly surprised experts.

- Over the last decade, Greenpeace's optimistic projections for the growth of renewables[4] have proved more accurate than conservative predictions from bodies like the the IEA or the US Energy Information Administration.
- BP admits the company has been "repeatedly surprised" by the growth of renewables. In 2016, BP upped its predictions for renewable energy expansion to 2035 by 14% - its biggest adjustment yet.

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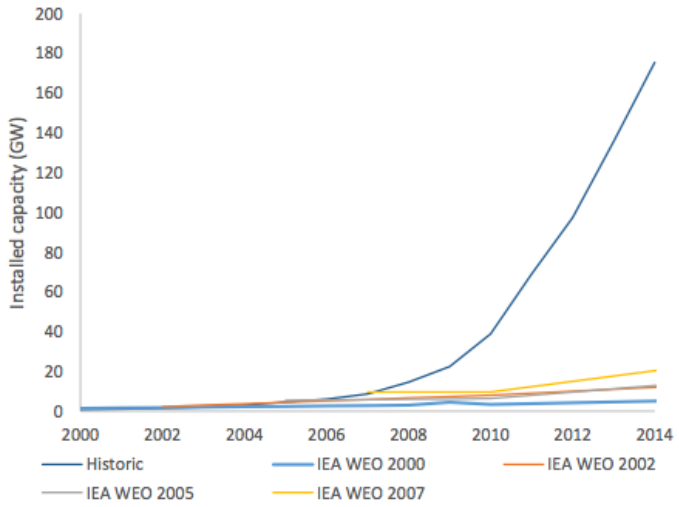
[2] 2015 was the first year that more renewables were added to the power system than any other technology combined, including coal, oil, natural gas and nuclear, according to the IEA. https://www.iea.org/bookshop/734-Medium-Term_Renewable_Energy_Market_Report_2016

[3] In 2004 there was 2.6GW solar PV globally. By the end of 2013 this had grown to 139GW. Wind power capacity grew from 48GW to 318GW over the same time period.

[4] Greenpeace International has published five global 'Energy [R]evolution' scenarios since 2007. The scenario models very high rates of renewables expansion accompanied by phase out or near phase out of fossil fuels.
http://www.greenpeace.org/international/en/campaigns/climate-change/energyrevolution/

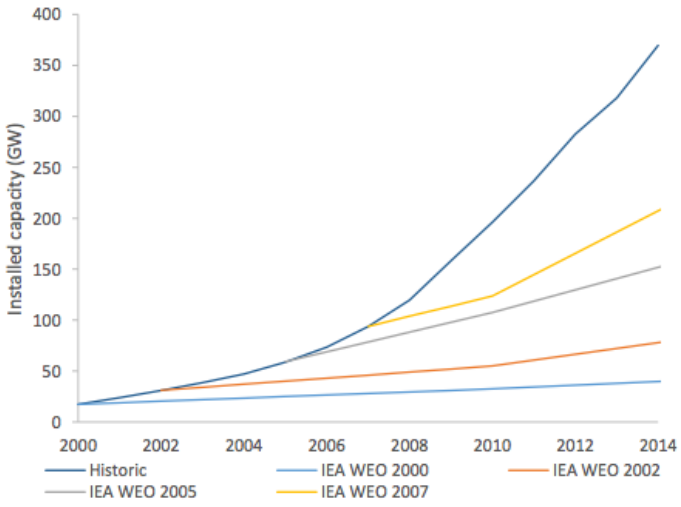
- In 2000, the IEA predicted global solar capacity would quadruple in 15 years. It took just five years. In 2002 it said solar would grow to 14 GW by 2015 - a level reached just three years later. (see graph below)
- The IEA has been criticised for its inaccurately low projections and in 2016 announced it was "significantly increasing" its five year forecast for renewables. But its projection of a 42% growth in renewables by 2021 is still based on the assumption that renewables growth will slow down.
- Many scenarios from the turn of the century projected levels of renewable energy for 2020 that were already surpassed by 2010.

*Figure i.1: IEA solar PV capacity forecasts against actual*




| SCENARIO | IEA WEO 2000 | IEA WEO 2002 | IEA WEO 2005 | IEA WEO 2007 |
|---|---|---|---|---|
| % DIFFERENCE TO ACTUAL IN 2012 | -87.2% | -76.5% | -54.1% | -41.5% |

*Figure i.2: IEA wind capacity forecasts against actual*[2]




| SCENARIO | IEA WEO 2000 | IEA WEO 2002 | IEA WEO 2005 | IEA WEO 2007 |
|---|---|---|---|---|
| % DIFFERENCE TO ACTUAL IN 2012 | -95.6% | -89.7% | -90.1% | -84.6% |

*Faster than expected: IEA projections for growth of renewables, compared with actual. Source: Carbon Tracker*

## 4. More money is being invested in renewables than fossil fuels

More money is now being invested in renewables than fossil fuels. Investment has nearly tripled in the past decade. As costs fall, investors get more for their money, further accelerating renewables deployment.

- Global investment in renewables topped $300 billion in 2013, 2014 and 2015.[5]
- 2015 set a record for investment in renewables. Despite predictions that falling oil and gas prices would hurt clean energy investment, the figure rose 11% in 2015 to $348.5bn[6], 80% of which was in wind and solar. This is nearly six times the amount invested in clean energy in 2004, according to Bloomberg.
- 2011 was the first year more money was invested in renewables than fossil fuels. In 2015, more than twice as much ($265.8 billion) was invested in renewables excluding hydropower than coal and gas (around $130 billion). (UNEP data)
- In 2016 investment fell to $287.5bn, 18% lower than in 2015. The fall occurred partly because wind and solar power became cheaper, meaning developers could install the same amount of capacity for less money. 2016 still saw a record amount of solar power installed, plus the second-ever highest amount of wind.

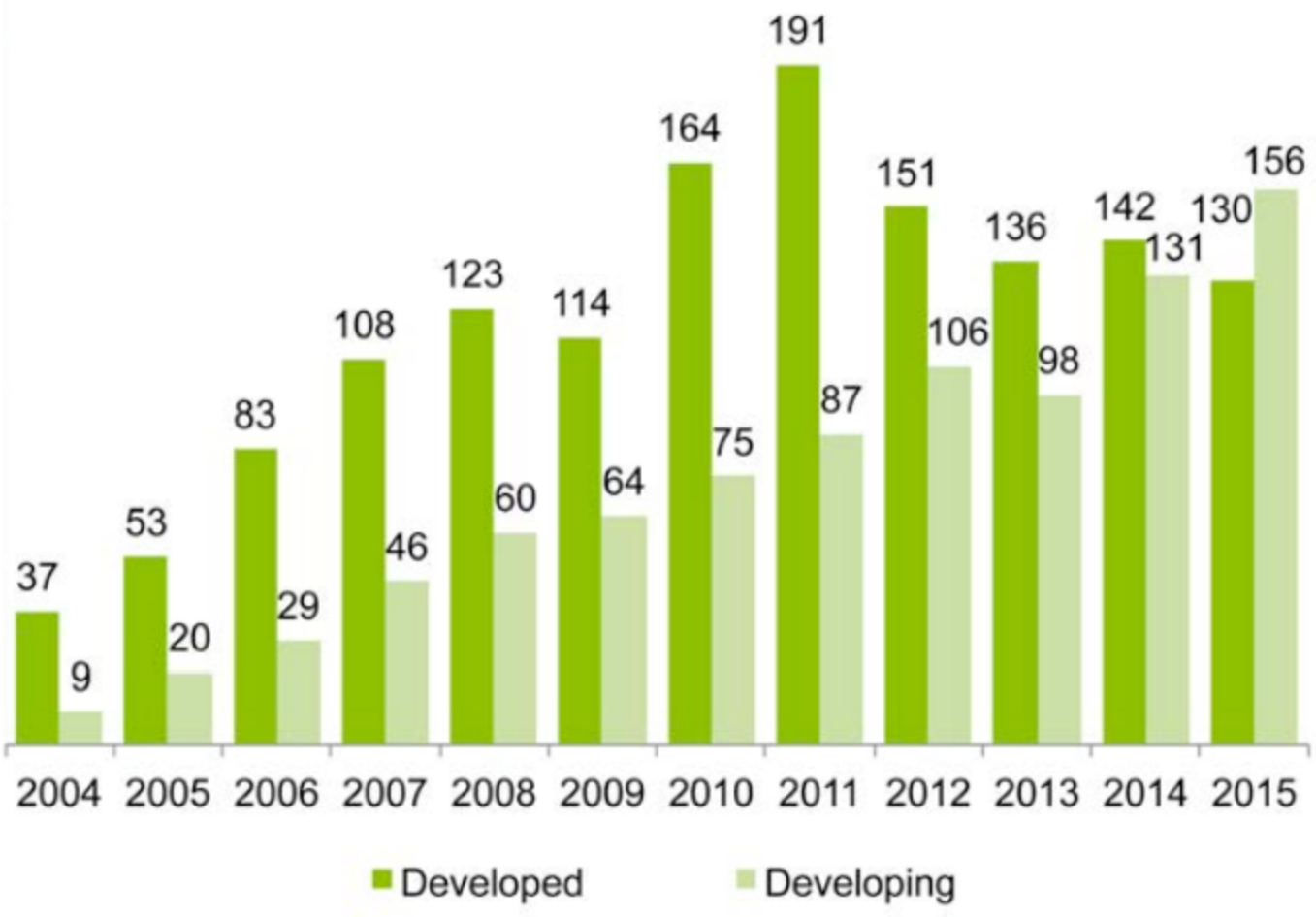
[5] Figures for 2016 not yet available.

[6] This figure is revised upwards from the initial estimate of $328.9 billion
https://about.bnef.com/blog/clean-energy-defies-fossil-fuel-price-crash-to-attract-record-329bn-global-investment-in-2015/

## 5. The fastest renewables growth is in emerging markets

Renewables are growing faster in poor countries than rich ones.

- 2015 was the first year that developing countries invested more in clean energy excluding hydroelectric power than developed economies. (UNEP)
- In 2015, developing economies including China, India and Brazil invested $156 billion in renewables - 19% more than in 2014 and 17 times more than in 2004. Meanwhile, developed countries invested $130 billion, according to UNEP. [7]
- A large amount of this turnaround was due to China, which invested $102.9 billion in non-hydro renewables in 2015, 17% more than 2014.
- 58 emerging countries across Latin America, the Caribbean, Asia and Africa installed 70GW of clean energy in 2015 while countries based in the Organisation for Economic Co-operation and Development (OECD) installed 59GW.
- In five years (2008-2013), the amount of renewable power in developing countries grew by 143%. During the same period the amount of renewables in developed countries grew by 84%.




*Global new investment in renewable energy in developed and developing countries, 2004-2015, $billion. Source: UNEP*

[7] This figure excludes large-scale hydroelectric power.

## 6. Renewables offer access to electricity more cheaply than fossil fuels

Renewable power can offer easier access to energy for rural communities.

- 1.2 billion people worldwide lack access to electricity. 80% of them live in rural areas, mostly in sub-Saharan Africa or developing Asia.
- In these communities, technologies such as solar lanterns and mobile phone chargers can provide basic energy services like lighting or powering household appliances for 4-20% of the cost of a grid connection.
- Renewable power capacity is quicker to build than conventional power plants, uses less water, and is becoming easier to attract financing for, as international bodies withdraw from funding fossil fuels.
- Clean energy companies and NGOs argue that renewable power could provide universal energy access by 2030. One NGO estimate suggests this could be achieved at a cost of $14 billion a year.[8] *(For a more detailed briefing on the global potential for decentralised energy see here)*
- Global resource maps show that both developed and developing countries are endowed with substantial renewable resources. "Africa's reserves of renewable energy resources are the highest in the world," a 2013 African Development Bank report found.

## 7. Renewables may grow faster than expected in the future

Renewables will be the single largest source of electricity in the world in less than a decade and a half, according to conservative predictions. But falling costs may trigger an expansion beyond current expectations.

- Renewables will overtake coal as the world's largest source of electricity by around 2030, according to the IEA's central scenario.[9] Renewables will account for 60% of all new power generation added to the system between 2016 and 2040, it says.
- If the pledges made in Paris are taken into account, the amount of renewable energy supplied by eight of the world's largest economies (Brazil, China, European Union, India, Indonesia, Japan, Mexico and the United States) will double in the next 15 years.
- China and India's pledges alone could double wind and solar by 2030.
- If the renewables expansion drives further cost reductions, it could accelerate the renewable energy transition beyond current expectations. As HSBC puts it, it may "trigger an economically-driven decarbonisation of the power sector."

## 8. Solar power is a disruptive force

The sun could be the world's largest source of electricity by the middle of the century.

- Solar power currently supplies less than 2% of world electricity. But it is growing exponentially. Globally, new capacity additions of solar PV increased six-fold from around 8 GW in 2009 to around 47 GW in 2015.
- About half a million solar panels were installed every day around the world in 2015, according to the IEA.

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[8] The IEA estimated in 2011 that $1 trillion of investment would be needed to achieve universal energy access. In 2012, the IEA slightly upped this estimate to $49 billion a year, but it appears it hasn't updated the scenario since then. More information in our briefing on decentralised energy.

[9] p.262

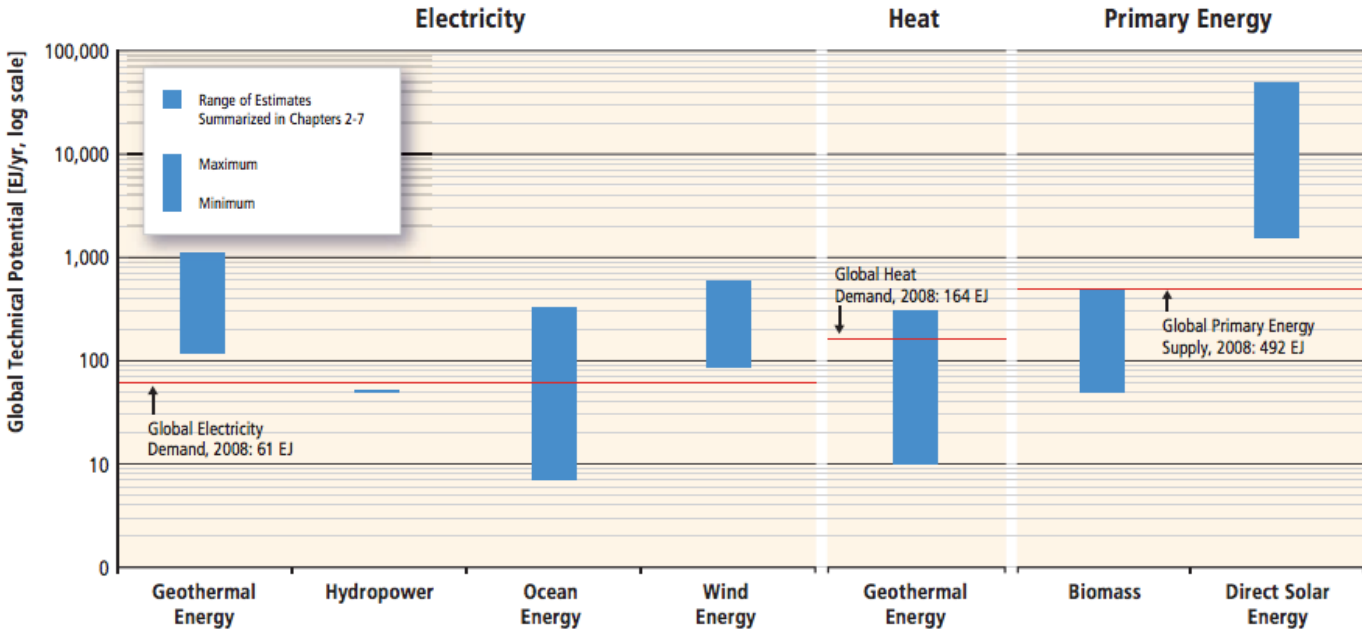
- In the five years to 2015, the amount of solar power installed globally grew more than five-fold from 40GW to 227 GW. By comparison, the entire generation capacity of Africa is 175 GW. (IRENA)
- Solar power has the potential to grow to be very large scale. It could supply 13% of the world's electricity by 2030, according to the International Renewable Energy Agency (IRENA).
- In a scenario where the growth of nuclear and carbon capture and storage are constrained, the IEA predicts that solar power could provide 27% of the world's electricity by the middle of the century. This would make it the largest source of electricity globally.
- The solar resource is "massive by any standard", according to a 2015 study. The US could produce all of its electricity from solar plants covering 0.4% of its land area using current solar technology.
- In order to fulfill its potential, solar panel technology will have to be developed and national electricity grids adapted to cope with a higher level of variable supply. Cutting edge research into cheap and clean forms of energy storage are already underway.
- Decentralised solar power could "seriously threaten" the business models of utilities by reducing demand for the energy they produce, according to McKinsey.
- Consultancy Deloitte argues: "History tells us that sudden, disruptive and largely unpredictable technology shifts do occur". Previous examples of one kind of technology rapidly displacing another include the automobile replacing horse drawn carriages in the early 20th century, mobile phones replacing landlines in the early 21st century and electricity replacing gas lighting.

## 9. Renewables could provide all the world's energy

Renewables have the potential to provide enough energy to satisfy all of humanity's requirements many times over - the only challenge is working out how to capture the energy. Shifting to 100% renewable energy by 2050 is affordable and would bring about a huge cut in global emissions.

- Studies have consistently found that the total global technical potential for renewable energy is "substantially higher than both current and projected future global energy demand".
- In one day, the earth gets enough energy from the sun to satisfy the world's current energy requirements for 20 years. Only a small percentage is available for use by humans - but it is still enough to provide up to 10 times more energy than the world currently uses.
- Solar, wind, geothermal and potentially ocean energy could each potentially supply all the world's current electricity demand.[10]
- Renewables could feasibly supply 100% of the world's energy supply by 2050, according to modelling by Greenpeace. This transition to 100% renewable energy would require US$1 trillion annual investment, but would save an average of $1.07 trillion a year in fuel cost savings.

[10] Figure SPM.4 in the IPCC's 2011 report on renewable energy sources




Range of Estimates of Global Technical Potentials

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Max (in EJ/yr) | 1109 | 52 | 331 | 580 | 312 | 500 | 49837 |
| Min (in EJ/yr) | 118 | 50 | 7 | 85 | 10 | 50 | 1575 |

*Graph: different estimations of the technical potential for different renewable technologies, compared against global electricity demand, heat demand and primary energy supply. Source: IPCC, 2011.*

## 10. Renewables are already cost-competitive with fossil fuels in many places

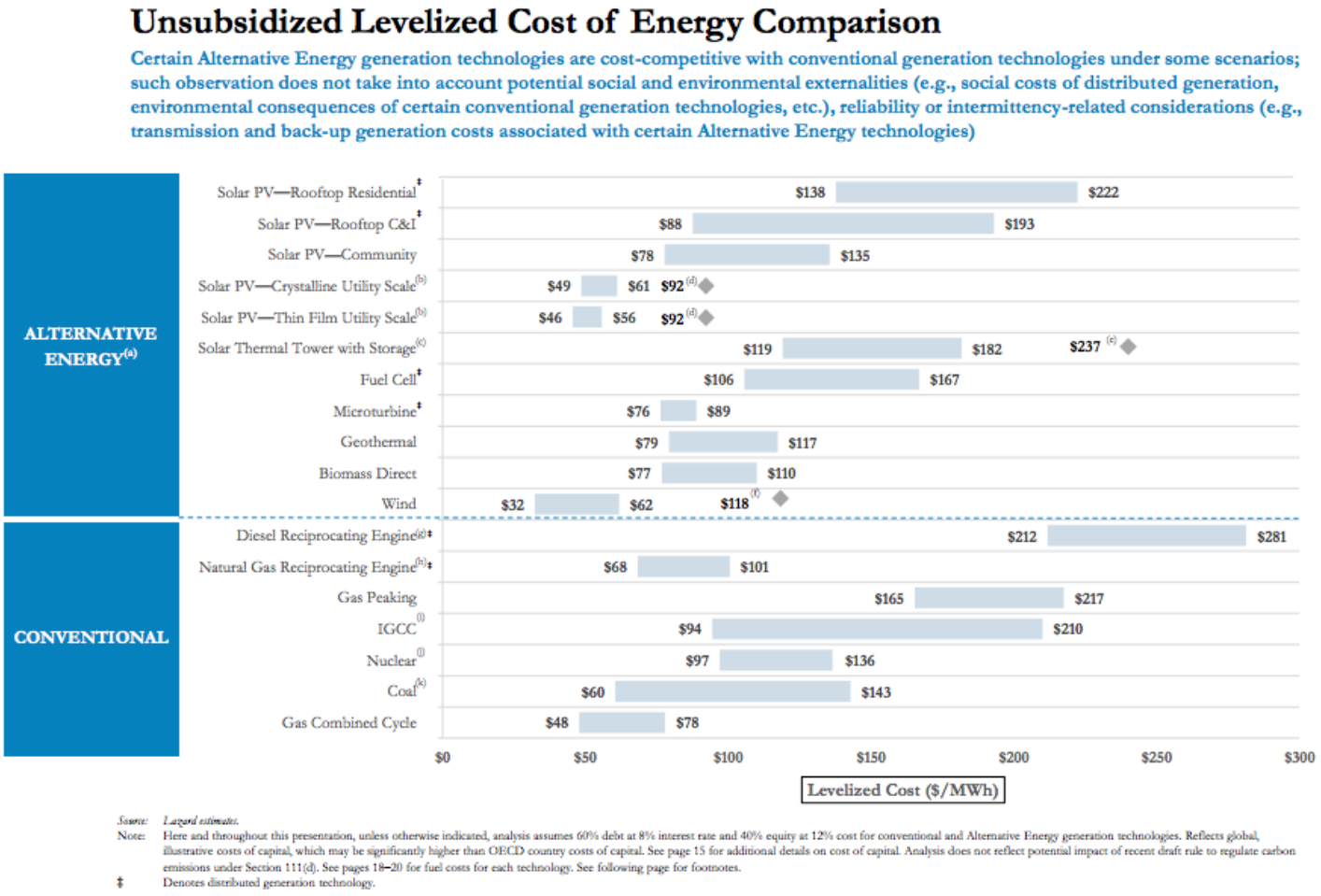
***NB For a more detailed briefing on the cost of generating electricity from renewables compared to fossil fuels, last updated January 2017, please see here.***

The cost of onshore wind and solar is falling dramatically, and in many places renewable power is now cost competitive with, or cheaper than, fossil fuels. The fossil fuel subsidy bill is falling as the world starts towards cleaner energy - but it is still twice the bill for renewable energy.

- The costs of producing electricity from mature technologies like biomass, geothermal and hydropower have been broadly stable since 2010, and comparable to fossil fuels.
- Between 2010 and 2015 the cost of producing electricity from onshore wind fell by about 30%, while the cost of generating electricity from utility-scale solar fell by two-thirds, according to the IEA. The cost of solar modules fell by up to 80% between 2010 and 2015.
- Onshore wind is now one of the most competitive sources of electricity worldwide.
- In the USA, large onshore wind and and solar plants are cost-competitive with fossil fuels, according to research by financial advisory firm Lazard. Onshore wind plants are nearly always cheaper than coal, according to the same figures (see figure below).[11]
- The global average cost of generating electricity from coal was around $60-100/MWh in 2015. Meanwhile the global average cost of producing electricity from onshore wind was around $85/MWh and around $125/MWh for solar PV.

[11] 2016 figures show the levelised cost of electricity varying from $32 to $62 per megawatt-hour for onshore wind; $46 to $61 for utility-scale solar,; $60 to $143 for coal; $48 to $78 for gas.

- In 2015/16 project developers also won contracts to build renewable energy capacity at record low prices - $35 per megawatt-hour for onshore wind in Morocco, $30/MWh for solar PV in Dubai and $29/MWh in Chile.
- Subsidies for renewables-based generation were worth about $150 billion in 2015, while the fossil fuel subsidy bill stood at around $325 billion, according to the IEA. The fossil fuel subsidy bill was lower and the renewable bill higher than in 2014 - but the amount going to subsidise fossil fuels was still more than double the amount supporting renewables.
- This estimate does not include the environmental harms from fossil fuel consumption, including air pollution and climate change. A 2015 IMF working paper suggested that society pays out $5.3 trillion to support fossil fuels once these costs are taken into account.




*Comparison of the levelised costs of different technologies in the USA. Source: Lazard, 2016*

# Sectors

## Transport: electric cars are gaining ground

Transport is a harder sector to decarbonise than power. Even so, in 2015 the growth rate for electric cars equaled the exponential growth of solar. In 2040 there may be 90 times as many electric cars on the road than currently.

- More than a quarter of current energy use comes from the transport sector (road, rail, aviation and sea transport). Nearly all (93%) of the energy the transport sector uses comes from oil products. (IEA)
- 2.8% of all vehicles are fuelled by biofuels and 0.2% by renewable power, according to the IEA.[12]
- The electric car is gaining ground. In 2015, the global threshold of 1 million electric cars on the road was exceeded. By the end of 2015, there was 1.26 million electric cars being used. (IEA)
- Sales rose 60% between 2014 and 2015, although from a low base. For comparison, solar panels are following a similar growth curve of about 50% a year, according to BNEF.
- In 2015, the cost of batteries - a major determinant in the cost of electric vehicles as a whole - fell by more than a third. Unsubsidised electric vehicles will be as affordable as those fuelled by petrol or diesel by 2022, according to analysis by BNEF.
- Sales of electric vehicles will rise by a factor of 90 to 41 million by 2040, BNEF predicts. They will represent just over a third of light vehicle sales in 2040.
- In the IEA's 2°C scenario[13], electric vehicles account for 50% of light vehicle sales in 2040. In this scenario, there is 710 million vehicles on the road and by far the largest market for electric vehicles is in China.
- Decarbonising the transport sector remains a difficult task. Shifting to 100% renewable energy means both a significant role for hydrogen and other synthetic fuels in the transport sector and changes in mobility patterns, behaviour and infrastructure, according to Greenpeace.

## Heat: renewable heat has potential, but isn't growing at the same rate

The potential for renewable sources to supply heat is vast, but expansion is proceeding more slowly in this sector because of a lack of government support.

- Heating and cooling homes and commercial buildings, heating for industrial processes and cooking food together account for more than half of the world's energy consumption. (IEA)
- In 2015 a quarter of global heat supply came from renewable supplies. But two thirds of this came from 'traditional biomass' - burning wood and other fuels for heat and light. (Ren21)
- Modern renewables - geothermal, solar thermal and biomass, excluding traditional use of biomass - met just 9% of global heat demand in 2015, according to the IEA.
- Expansion of renewable heat is proceeding more slowly than renewable power because of a lack of adequate support policies.
- The IEA calls transport and heat the "next frontiers for renewables" because they have the largest untapped potential for switching to cleaner supplies.

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[12] p.400

[13] The IEA's '450 scenario' sets out a pathway to limiting greenhouse concentrations to 450 parts per million, giving around a 50% chance of limiting temperature rise to 2C above pre-industrial levels http://www.worldenergyoutlook.org/indc/scenariosassumptions/

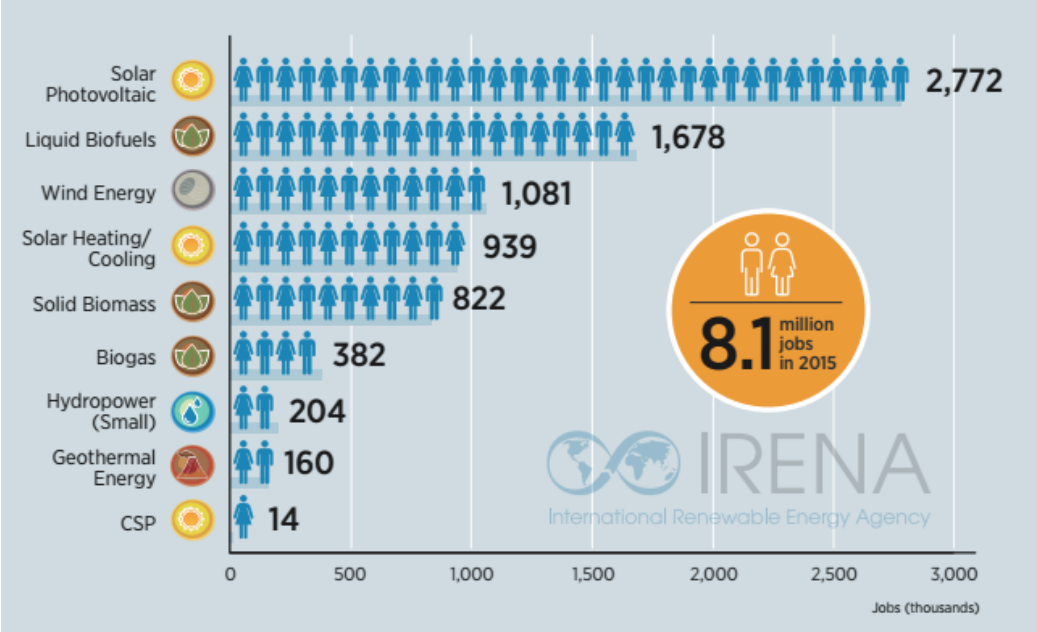
- There is some growth. The market for solar thermal collectors and geothermal heat pumps grew by 9% in 2014 and 6% in 2014, for example. Bio-heat production for buildings and industrial uses grew by 3% between 2014 and 2015.
- The potential for renewable sources to supply heat is vast. Geothermal power could supply 5% of the world's heat demand by the middle of the century, according to the IPCC.

## Economy: Renewables create jobs and boost growth

***NB For a more detailed briefing on jobs in clean economy, please see here.***

The renewable energy industry is already providing more jobs than the coal industry. Ramping up renewable power will contribute to global growth.

- The renewable energy industry (excluding large hydro) employed 8.1 million people in 2015, according to IRENA. A further 1.3 million were directly employed in building, operating or maintaining large hydropower stations.
- The solar industry employed 3.7 million people directly and indirectly in 2016 - more than any other part of the clean energy sector. The wind power industry employed just over 1 million people.
- In the USA, 209,000 people worked in the solar industry in 2015 - 20% higher than in 2014. Jobs in the solar industry grew 12 times as fast as overall job creation in the US economy, and surpassed those in oil and gas extraction or coal mining. (IRENA)
- Clean power and energy efficiency create more jobs than investing in fossil fuels because jobs are concentrated in relatively labour-intensive sectors like manufacturing, construction and maintenance, and renewable energy projects tend to have long and diverse supply chains.
- If renewables' share of final global energy consumption doubled from 18% now to 36% in 2030, the industry would be able to sustain 24.4 million jobs worldwide, according to IRENA.[14]
- More people are employed by the renewable energy industry in China than any other country in the world. The sector employed 3.5 million people in China in 2015 - 44% of total employment in the sector worldwide. (IRENA)




*Renewable energy employment by sector, 2015. Source: IRENA*

[14] More than half of the 18% figure comes from traditional use of bioenergy, which has then disappeared by 2030. http://www.irena.org/remap/ p.29

# Regional case studies

## China

China accounted for 40% of clean energy installed in 2015. It is the biggest player globally in the renewables industry by far.

- China is simultaneously the world's biggest electricity system, the world's largest carbon dioxide emitter, and the world's largest clean energy investor.
- In 2015, China accounted for about 40% of new renewable energy installed worldwide.
- China installed a record high of 33GW of wind and 18GW of solar power in 2015. (BNEF)
- China installed an average of two wind turbines an hour throughout 2015. This is twice its nearest rival, the USA, according to the IEA.
- The IEA projects that the amount of renewable energy capacity installed in China will expand by 60% between 2016 and 2021 - and wind and solar will account for 80% of this increase.
- China will install 36% of all global hydro electricity generation capacity, 40% of all worldwide wind energy and 36% of all solar from 2016 to 2021, according to the IEA.
- China invested $103 billion in renewables in 2015. This about the same as the US ($44.1bn), the UK ($22.2bn) and Japan ($36.2bn), put together, according to figures from the UN.

## Germany

Public support for a massive transition to renewable energy and energy efficiency remains high in Germany.

- Germany's Energiewende literally means "energy turnaround". It creates a shared national vision for an energy transition towards an energy efficient and largely renewable economy.
- The IEA expects renewable energy to be the main source of electricity generation in Germany by 2030.
- In 2010, the German government committed to sourcing 80% of the country's electricity from renewables by 2050. It also agreed to phase out nuclear power by 2022.
- Support measures for renewables mean Germany's renewable energy industry has been growing since the late 1980s. It introduced higher rates for Feed in Tariffs for solar power in 2000.
- On its own, solar PV accounted for about 7.5% of German electricity consumption in 2015.
- Germany's renewable power generation more than tripled between 1999 and 2012. In 2015, 30% of all the power generated in Germany came from renewables.
- Prices for a typical PV rooftop-system in Germany fell by a factor of more than 10 (from around 14,000 euros per kilowatt peak[15] to about 1,300 €/kWp) between 1990 and 2014.
- In July 2016, the government introduced reforms to the Energiewende including limiting the amount of renewable energy that can be built and replacing Feed in Tariffs with auctions. Commentators disagree as to whether these reforms are undermining the Energiewende or the logical next step for a maturing industry.
- Public support for the Energiewende remains high. In May 2016, 93% of Germans said the Energiewende was important or very important for the country's development. In February 2016, nearly

[15] Kilowatt peak refers to the power that a solar panel will produce in ideal conditions http://www.plugintothesun.co.uk/faq/

three quarters (74%) of respondents to a poll said they thought the decision to stop generating from nuclear power and move to renewable energies was “the right decision from today’s perspective”.
- Growth in Germany’s renewable power, particularly solar and wind, has helped reduce the wholesale price of electricity. In August 2015 wholesale prices were half levels in 2011. The price reductions have not yet been passed on to consumers, however.
- Germany is replacing baseload with "flexible, quickly dispatchable power generation”, posing a threat to the traditional business models of utilities.

## India

India is planning a 400% increase in renewable power over the next six years. Solar and wind power are already cost-competitive with imported coal in many parts of India, and costs are falling fast.

- In 2015, India had 37GW of renewable power capacity, excluding large hydropower.[16] Given its potential, this is a relatively small amount - only 7GW more than all the renewable power installed in the UK.
- But India has set a target of having 100 GW solar power, 60 GW wind energy, 10 GW small hydro power, and 5 GW biomass-based power projects operational by March 2022.
- This is nearly a fivefold increase in renewable levels (excluding large hydro).
- India will be the fourth biggest consumer of renewable power by 2030, according to IRENA.
- Solar and wind projects have an advantage over other forms of power because they can be built more quickly. Coal-fired plants generally take five to seven years to be planned and constructed. For wind, the timeline is one to two years, and for solar it is one year.
- The falling price of renewables means they are either already competitive with fossil fuels, or rapidly approaching that point. In 2015 electricity from onshore wind, for example, sold at 3.39-6.50 rupees/kWh. Electricity generated from imported coal is sold within that range, at Rs5-6/kWh.
- In July 2015, two utility-scale solar power plants auctioned solar power at Rs5.27/kWh and Rs3.35/kWh - both competitive with power from imported coal.
- At the Paris climate change negotiations at the end of 2015, India’s prime minister Narendra Modi launched a new global solar alliance. Consisting of more than 120 countries, it aims to mobilise $1tn of investment towards developing solar power around the world, with a particular focus on tropical countries. India is hosting the secretariat and has provided an initial $30 million.

## USA

The US coal industry is declining, while renewable power is growing rapidly. Large wind and solar are now cost-competitive with fossil fuels.

- In 2015, renewable sources of energy accounted for about a tenth of total US energy consumption and 13% of electricity generation.
- In 2015, renewables accounted for more than two thirds of all new power generation. Renewable energy was the biggest source of new power added to US electricity grids.
- The US invested $44.1 billion in renewables in 2015. (UNEP)
- At the same time, US industry’s use of coal fell to a historic low. US demand for energy flatlined in 2015, while GDP grew 2.4%. Overall, US energy consumption has fallen 2.4% since 2007, while its GDP has grown by 10%. (BNEF)

[16] In addition it has 45GW of hydropower.

- In the USA, large wind and and solar plants are now competitive with fossil fuels, according to research by financial advisory firm Lazard.[17]
- The amount of electricity sourced from renewable sources in the USA is expected to increase at a rate of 3.2% a year between 2016 and 2040 even if the Clean Power Plan is not implemented, according to the Energy Information Administration (EIA). This is mainly a result of extended tax cuts from the federal government and the continued dramatic reduction in the capital cost of solar PV systems.

[17] 2016 figures show the levelised cost of electricity varying from $32 to $62 per megawatt-hour for onshore wind; $46 to $61 for utility-scale solar,; $60 to $143 for coal; $48 to $78 for gas.