ENERGIZING LIFE TOGETHER

CLIMATE CHANGE: CLOSING THE COP21 GAP BY GOING SOLAR

Analysis by REC, June 2016

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Silvester Kindergarten – Tautenhofen-Heggelbach, Germany – 200 REC solar panels – 49 kW system

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Executive Summary

At the COP21 UN Climate Change Conference in Paris in December 2015, 195 countries agreed to reduce or curb greenhouse gas emissions so as to limit global warming to well below 2°C, ideally to 1.5°C above pre-industrial levels. With a joint agreement to achieve net zero emissions between 2050 and 2100, countries are now embarking on the process to mitigate climate change impacts.

Despite the many general statements that COP21 will have a significant impact for renewable energy, including solar, there is as yet little detailed analysis on how much capacity seems to be missing.

This study therefore investigates the impact of the COP21 agreement on the solar industry. Using industry trends and projections to determine the potential contribution of solar energy to meeting emissions reduction targets worldwide, the study uses a REC-developed model to calculate the solar capacities that are likely to be required.

The study determines the cumulative additional solar PV capacity that will be required on a global scale and for some key countries, over and above the current forecasts and trends.

Key findings of the study:

- REC's calculations clearly show that, based on the COP21 targets set during the December 2015 Summit, solar can make a significant contribution.
- To be on track by 2025 to close the emissions gap and avoid further accelerating climate change impacts, the potential solar capacity ramp-up is far larger than industry analysts today expect, resulting in up to 4.8 terawatts above the current forecast of cumulated new solar capacity by 2025.
- There is a shortfall in many countries around the world between renewable energy commitments and required emission reductions:
    - USA: Cumulative solar PV installations of approximately 790 GW are required in the US, which is four times the current forecast installations through 2025
    - Germany: Eliminating nuclear as well as coal as the major emissions contributor in the electricity mix, Germany needs to install 8 GW of above-forecast solar capacity every year to 2025
    - India: Despite a low electricity consumption per capita, India will require cumulative solar installations of 374 GW above the current forecast by 2025 because of the 73% share of coal in its electricity mix today
    - Japan: Cumulative solar capacity of 250 GW in addition to the current forecast is required by 2025
    - Netherlands: Cumulative solar installations of 14 GW are required by 2025, just under double the current forecast
    - Belgium: Cumulative solar installations of 6.3 GW are required, 4.8 times the current forecast

The study concludes that its forecast, although ambitious, is not impossible. However, the calculations of required capacities are a first step in planning a global power transition. This should be the starting point for further elaborations, discussions and implementing country specific mechanisms for incentivizing this transition.

Why this Study?

REC celebrates its 20-year anniversary in 2016. Although two decades is a comparatively short history, in the still young solar industry it makes us one of the longest-standing players worldwide. This longevity is in part because we have consistently taken a wider view of the solar industry, looking beyond the economics to a vision of a sustainable future for our planet. Our vision is to ensure that every person in the world is able to benefit from clean solar energy.

REC therefore salutes the COP21 agreement as a genuine pathway to this sustainable future.

As a leading solar brand in Europe, REC is a thought leader in the industry, and is committed to raising awareness for the contribution that solar energy can make to reducing the impact of climate change. This is the reason for this study.

COP21 Agreement and Impact for the Solar Industry

The COP21 UN Climate Change Conference in Paris in December 2015 marked a new milestone in an unstoppable transition to combating climate change. At this conference, 195 countries agreed to curb greenhouse gas emissions so as to limit global warming to well below 2°C, or ideally to 1.5°C above pre-industrial levels. The majority of countries submitted national pledges, or "Intended Nationally Determined Contributions" (INDC) at or in advance of the conference. There were ambitious pledges from China, the USA, EU and India, the four biggest greenhouse gas emitters worldwide. [1]

With a joint agreement to achieve net zero emissions between 2050 and 2100, countries are now embarking on the process to convert, minimise and address the loss and damage caused by changes to the earth's surface temperature. In May 2016, countries met at the UN Climate Change Conference in Bonn, Germany, to move ahead with the landmark Paris Climate Change Agreement, and prepare for the 22nd Conference of the Parties (COP22) to be held at the end of 2016. At COP22, governments are targeting an accord on the rule book of the Paris Agreement, hammering out concrete steps for taking the agreement into force. Participating countries have also promised to mobilise at least US$ 100 billion every year in climate-related funding by 2020. In addition, to keep this vital process on target, a global review and stock-taking process is planned every five years.[2]

With numerous initiatives emerging from both public and private sectors, there are in fact promising signs of an irreversible transition to more sustainable climate management. France and India, for example, have launched a solar alliance to develop affordable solar energy for all. Under a joint deal between the USA and China, US$ 3.1 billion of funding will be provided to the China South-South Climate Cooperation Fund. 40 governments, businesses and organisations have issued a call to phase out fossil fuel subsidies. Global insurance player Allianz Group is to cut its coal investments and instead double wind energy investments to EUR 4 billion. Individual initiatives are also making progress: Bill Gates and Mark Zuckerberg have put their substantial influence and financial clout behind a major initiative into clean energy research.

However, time is short, and closer analysis reveals that the national pledges fall short of resolving this mammoth challenge. To meet the targets agreed in Paris, there will have to be quick and substantial reductions in greenhouse gas emissions in the decades ahead. Under current policies – that is, including steps already taken to mitigate global warming, temperatures are projected to rise between 3.3°C and 3.9°C by 2100.[3] Even taking into account the mitigating impact of the COP21 pledges and INDCs, the rise in temperature would still be higher than targeted: between 2.4°C and 2.7°C.[4] It is clear that even greater efforts than those submitted for COP21 will be needed to abate emissions enough to keep the temperature increase below 2°C, or even below 1.5°C.

Solar has a key role to play in all these developments. Since around one third of energy-related emissions worldwide derive from the power sector, replacing conventional power with cleaner sources, including solar, can deliver a significant contribution to achieving the COP21 targets.

To date, there is little analysis available on the specific impact of COP21 for the solar industry in terms of required capacities. Other studies, notably the analysis, "Mapping the Gap: The Road

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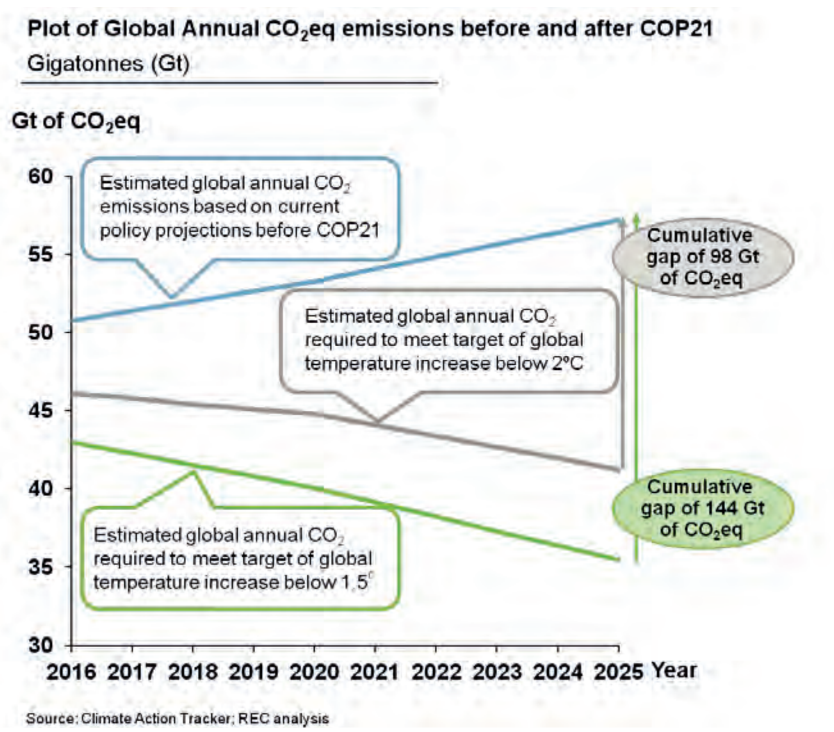
[1] UNFCCC, Press announcement, 12 December 2015, http://newsroom.unfccc.int/unfccc-newsroom/finale-cop21/
[2] UNFCCC, Press announcement, 12 December 2015, http://newsroom.unfccc.int/unfccc-newsroom/finale-cop21/
[3] Climate Action Tracker, Effect of Current Pledges and policies on global temperature, http://climateactiontracker.org/global.html
[4] Climate Action Tracker, Effect of Current Pledges and policies on global temperature, http://climateactiontracker.org/global.html

from Paris – Finance Paths For a 2-Degree Future", published by BNEF and CERES in January 2016,[5] have investigated the financials of the entire energy scenario, but without specifics on capacities. REC therefore set up its own model to calculate the potential solar capacity that is both feasible and necessary to close the emissions gap and meet the declared targets.

REC Study – General Approach and Assumptions

Comparing emissions forecasts under current policies and to limit the global temperature increase to 1.5° C, the world needs to reduce a significant cumulative amount of 144 Gt of CO_2-equivalent emissions (CO_2-eq) by 2025.[6] Of the one third of global CO_2-eq emissions for which the power sector is responsible,[7] REC assumes that solar energy can close 25% of the cumulative CO_2-eq gap. This assumption derives from figures on current solar development worldwide, analyst trend forecasts, and the sharp decrease in PV system costs – of all renewable energy sources, solar is the one getting cheaper the fastest. The other 75% will be contributed by wind, hydro, biomass, nuclear and high-efficiency gas power plants. This study focuses on the two largest contributors of renewable energy, solar and wind.

As a first step, REC investigated only the cumulative CO_2-eq to 2025, rather than taking a longer view, because prompter action will mitigate the impacts of climate change worldwide that are already visible today. 2025 is also a manageable time horizon for stakeholders to envisage the impact of change, and to plan and take action accordingly.



[5] Ceres/ BNEF, MAPPING THE GAP: The Road from Paris, 27 January 2016, http://www.ceres.org/resources/reports/mapping-the-gap-the-road-from-paris/
[6] Climate Action Tracker, CAT Emissions Gaps, http://climateactiontracker.org/global/173/CAT-Emissions-Gaps.html
[7] MIT, Energy and Climate Outlook, 2015

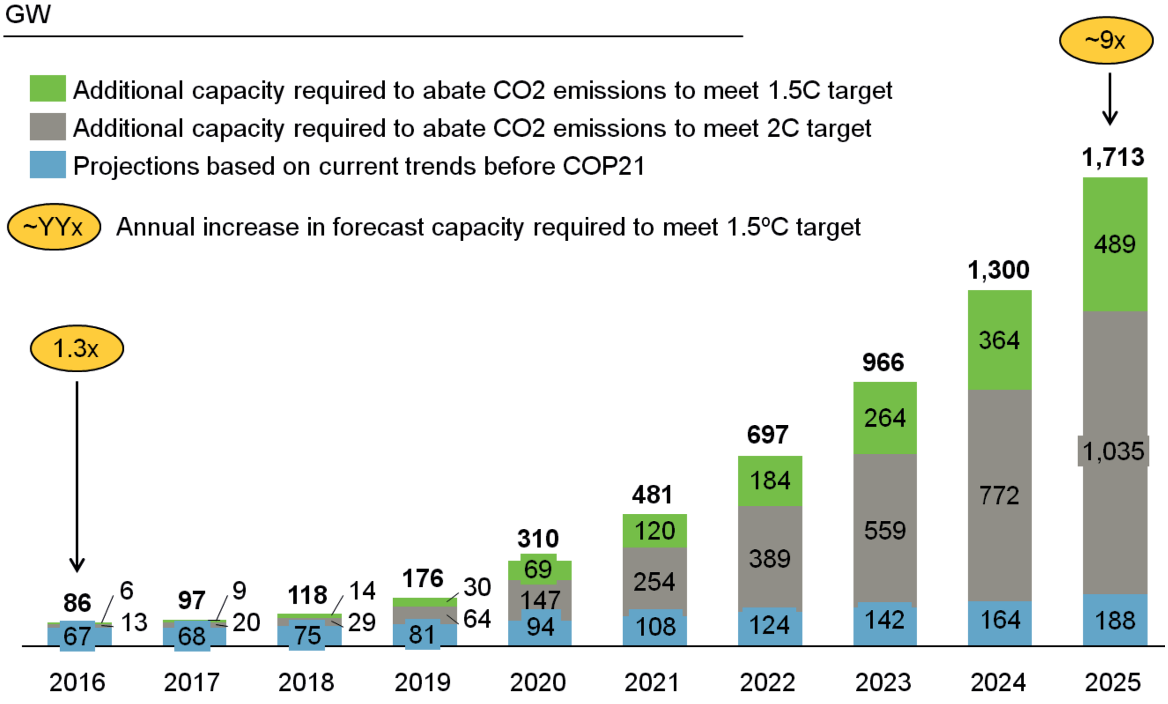
- The CO_2-eq emissions forecasts are taken from Climate Action Tracker.
- REC assumes 700g of CO_2 on average per kilowatt hour from fossil fuels.
- On a global scale, REC assumes an average solar radiation yield of 1,300 kWh per kWp; for country-specific calculations, other local yield levels are considered.
- For the global current trend forecast, REC has taken its forecast from REC's Q4 Solar Market Insight Report to 2019,[8] and for the subsequent years has assumed a CAGR of 15%.
- The charts in the study indicate the annual solar energy capacity that will need to be added. The model also takes into account the emissions which are offset by previously installed PV capacity for each year in the period under investigation.
- Capacities in line with current forecasts are assumed to be already considered in the emissions pathway under the currently implemented policies and therefore do not contribute to closing the emissions gap.
- The study does not consider the amount of energy required to manufacture the PV capacity.

Global Outlook

Limiting the global temperature rise to below 1.5°C will require a sharp ramp-up of additional solar capacity. By 2025, REC has calculated that up to 4,800 GW will be needed in addition to the current trend. Just three years from now, in 2019, there will need to be roughly double the new PV installations than currently forecast. In 2025, the study calculates that nine times the forecast solar capacity will be needed. This ramp-up will meet the contribution of solar energy to closing the CO_2-eq emissions gap and limiting the global temperature rise to below 1.5°C compared to pre-industrial levels.

[8] *REC's Q4 2015 Solar Market Insight Report, 23 February 2016, http://www.recgroup.com/sites/default/files/documents/rec_2015_solar_market_insight_report_0.pdf*

Forecast annual solar PV installations
GW



Source: Climate Action Tracker; REC analysis

With the target of limiting the rise in global temperatures to below 1.5°C, solar installations will have to generate 17,250 TWh of clean electricity between 2016 and 2025. By doing this, solar PV will save 12 Gt of CO_2-eq (equivalent to taking 6 billion cars off the road in Germany[9]) over this timeframe. Solar would then have a 20% share in the global electricity mix, assuming higher electrification rates in future. This is in line with other analysts' forecasts that solar could be the largest source of electricity by 2050, accounting for around 40% of the world's electricity.[10]

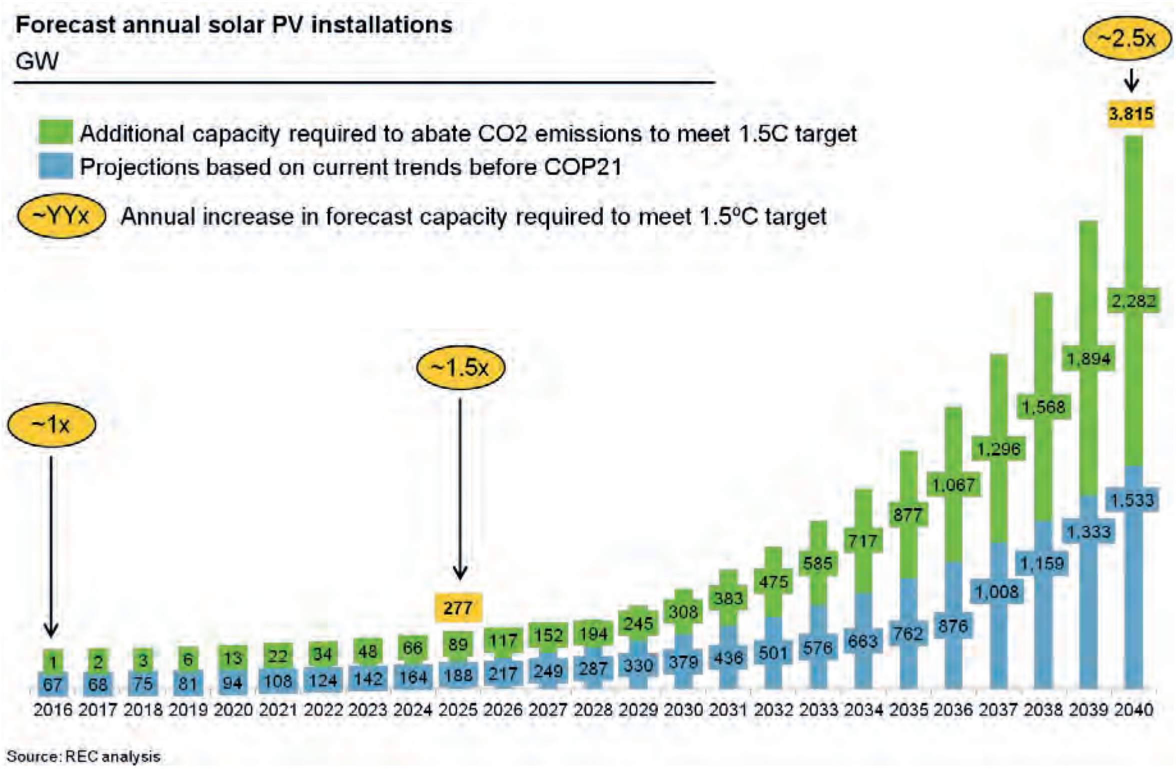
Taking the more modest target of limiting the temperature rise worldwide to below 2°C, the study calculates that a cumulative 98 Gt of CO_2-eq needs to be saved by 2025.[11] This will require additional cumulative PV capacity of 3,300 GW above the current forecast.

This sharp growth in capacity will limit the climate change impacts that are already visible today, such as drought, flooding, extreme weather and reduced crop yields. REC's calculations clearly demonstrate that an early start is imperative. Because of the cumulative effect of the ramp-up on abated emissions, postponing additional efforts will increase the cumulative capacity required by the end of the period under investigation (see the US case in the next section).

If a longer-term view were to be taken for adding required capacity, with a timeframe to 2040, this of course reduces the additional capacity that will be required by 2025. By 2025, 1.5 times the currently forecast solar capacities will have to be added – 89 GW on top of 188 GW to keep the world on track for a 2040 target. However, the additional capacities then have to rise at a steeper rate to 2040 in order to meet the target of limiting the temperature rise to below 1.5°C. In 2040, 2.5 times the annual forecast capacity will be needed: 2,282 GW on top of the forecast

[9] *Statista, vehicle database for Germany for 2015, https://de.statista.com/statistik/kategorien/kategorie/16/themen/129/branche/fahrzeuge-strassenverkehr/*
[10] *Fraunhofer ISE/Agora Energiewende, Current and Future Cost of Photovoltaics. Long-term Scenarios for Market Development, System Prices and LCOE of Utility-Scale PV Systems, 2015; IEA, Technology Roadmap: Solar Photovoltaic Energy – Solar Thermal Electricity, IEA, 2014; Deutsche Bank Markets Research, Crossing the Chasm, 27 February 2015*
[11] *Climate Action Tracker, CAT Emissions Gaps, http://climateactiontracker.org/global/173/CAT-Emissions-Gaps.html*

1,533 GW. This decelerated adoption rate is expected to inevitably increase the impact of climate change in the intervening years.



Sample of Countries Investigated

Limiting emissions is a huge collaborative effort on a global scale, requiring every country to play its part. The study investigates renewable energy commitments and emission reduction targets in various countries, and highlights the shortfall between current targets and the capacity that will actually be needed. However, focusing exclusively on the big players – those with the highest emissions in absolute quantities – will inevitably detract from the shared understanding of the COP21 commitment as a truly global, collaborative effort. The REC study therefore also considers smaller countries in Europe which, although small carbon emitters on a global scale, rank way down the table in terms of their environmental performance.

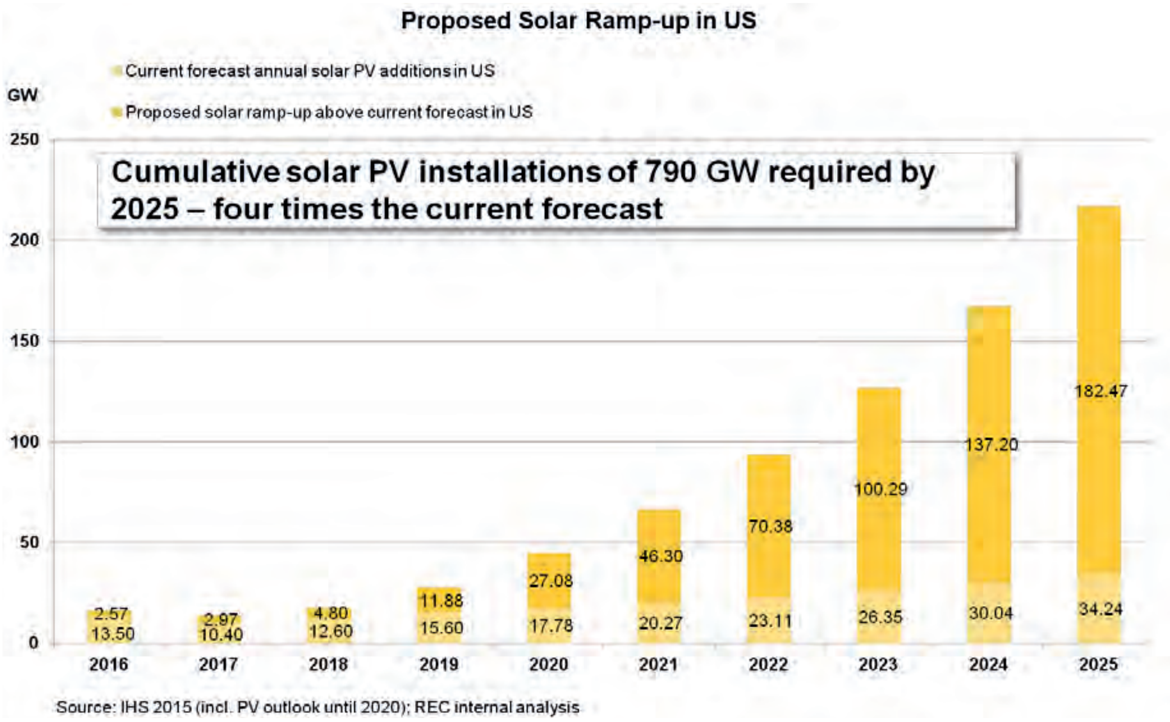
The following sections highlight some of the countries investigated in the study.

USA

The USA is the world's second-largest greenhouse gas emitter after China, and accounts for 15% of global emissions.[12] The combustion of fossil fuels is the largest source. Based on its current share of emissions of 1/3 [13], the US power industry will be responsible for abating around 7.2 Gt of the global 144 Gt total by 2025. This is equivalent to taking approximately 114 million cars off the road. (For comparison, there are currently over 250 million vehicles registered in the USA).[14] Con-

12 *PBL Netherlands Environmental Assessment Agency/European Commission Joint Research Centre, Trends in Global CO2 Emissions; 2015 Report, 2015*
13 *EPA, GHG infographic, https://www.epa.gov/cleanpowerplan*
14 *IHS Automotive, Press Release, 29 July 2015, http://press.ihs.com/press-release/automotive/average-age-light-vehicles-us-rises-slightly-2015-115-years-ihs-reports*

sidering solar PV's increasing importance within the electricity mix, and its ability to be deployed relatively quickly, solar energy can be relied upon to save approximately 25% of this emissions gap. However, to stay on track by 2025 to meet the US share of closing the emissions gap, cumulative solar PV installations of approximately 790 GW are required in the US, which is four times the current forecast installations through 2025. For this calculation, REC assumes a radiation yield of an average 1,600 kWh/kWp, with a CAGR of solar annual additions under the current forecast of 14% as of 2020).



At COP21, the US pledged to reduce greenhouse gas emissions by 26-28% below its 2005 levels by 2025. It also pledged to generate 20% of its electricity from renewable sources by 2030, up from 13% in 2014.[15] The federal Clean Power Plan (CPP) is an important pillar for the US to make their contribution. The plan aims to bring emissions from the power sector to 32% below 2005 levels, with individual targets for each state.[16]

According to Climate Action Tracker, with current policies including the CPP, the US can achieve emissions levels that are around 8-12% lower than 2005 by 2020,[17] a clear sign of progress on climate action. However, with the CPP now on hold owing to a Supreme Court ruling, a shortfall on the target looks more likely.

REC calculations demonstrate that postponing additional solar ramp-up by one year will increase the required cumulative capacity by an additional 7 GW; postponing it by five years will require an additional 93 GW by 2025. In the meantime, the impacts of climate change will continue to extract a cost on the economy.

[15] UNFCCC, INDC US, http://www4.unfccc.int/submissions/INDC/Submission%20Pages/submissions.aspx
[16] Climate Action Tracker, US Rating, http://climateactiontracker.org/countries/usa.html
[17] Climate Action Tracker, US Rating, http://climateactiontracker.org/countries/usa.html

Germany

Germany was until recently cited as a global example in pioneering renewable energy. Its policies on energy transition – moving the country to a low-carbon economy – aimed to stimulate technology innovation as well as drive down emissions and phase out nuclear. However, resolve has weakened, and REC's own investigations show that Germany, far from leading the transition, is in part even slowing down progress.

Germany is responsible for approximately 2% of global CO_2-eq emissions[18] and, at 21.17%, accounts for the highest share in Europe in 2013 [19]. To contribute its share to limiting the global temperature rise to below 1.5°C, Germany will have to drive down emissions by 2.88 Gt by 2025.

As elsewhere, the power sector is the biggest emitter, accounting for approximately 40% of Germany's total.[20] Assuming the sector commits to reducing 40% of cumulative emissions, it is looking at eliminating 1.15 Gt by 2025 – equivalent to taking 50 million cars off the road[21]. If one considers that Germany currently has 45 million cars registered[22], the enormity of the challenge becomes clear.

At 45%, coal has the lion's share in Germany's electricity generation mix.[23] A significant reduction here will close the emissions gap. REC assumes that solar energy can replace around 30% of the coal generated electricity, with the remaining 70% from wind energy.

REC has investigated that there are two main approaches open to Germany. The first step in both would be to eliminate the significant electricity net exports of coal (Germany currently produces more than it uses). In the first pathway, REC has calculated the impact of Germany beginning right away with large annual installations of renewable sources to replace coal electricity for domestic consumption. According to REC's calculations, Germany could in this case introduce roughly equal capacities of renewable energy every year until 2025, and still be able to leave 67.7 TWh of coal electricity in the mix as a secure power generation source in 2025.

[18] EDGAR, Emissions Database for 2014, http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2014; UNFCCC, National Inventory Report on GHG Emissions, 15 April 2016, http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/9492.php; Umweltbundesamt, Treibhausgas-Emissionen in Deutschland, 25 April 2016, http://www.umweltbundesamt.de/daten/klimawandel/treibhausgas-emissionen-in-deutschland

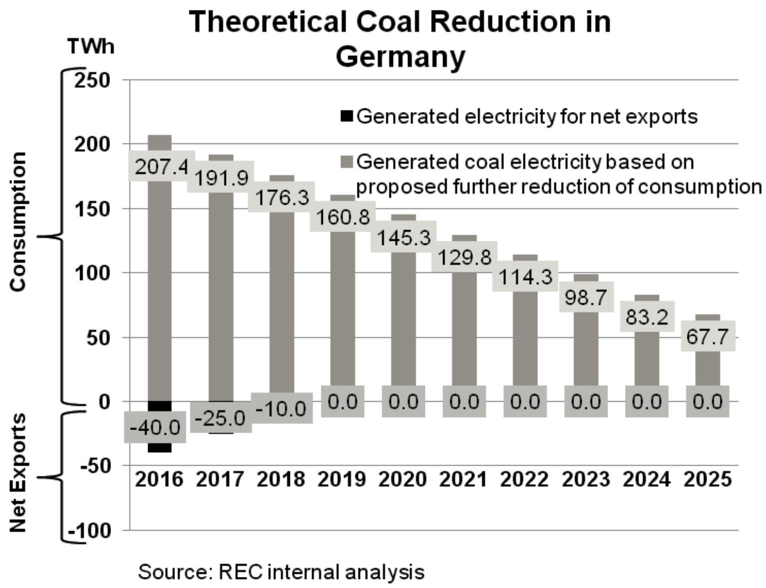
[19] Eurostat, Greenhouse Gas Emission Statistics, December 2015, http://ec.europa.eu/eurostat/statistics-explained/index.php/Greenhouse_gas_emission_statistics

[20] Umweltbundesamt, Übersicht zur Entwicklung der energiebedingten Emissionen und Brennstoffeinsätze in Deutschland 1990-2014, January 2016

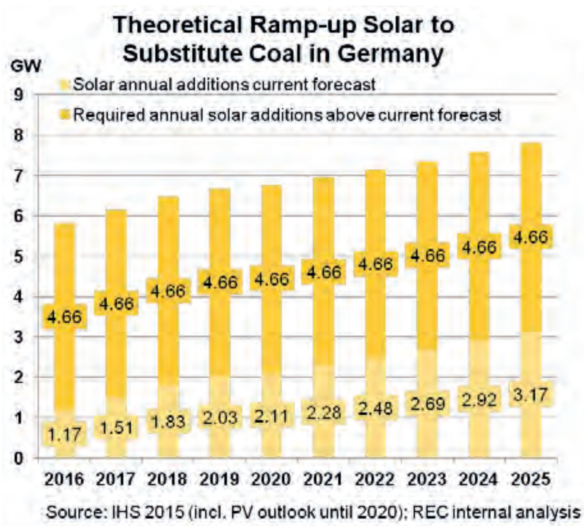
[21] Statista, vehicle database for Germany for 2015, https://de.statista.com/statistik/kategorien/kategorie/16/themen/129/branche/fahrzeuge-strassenverkehr/

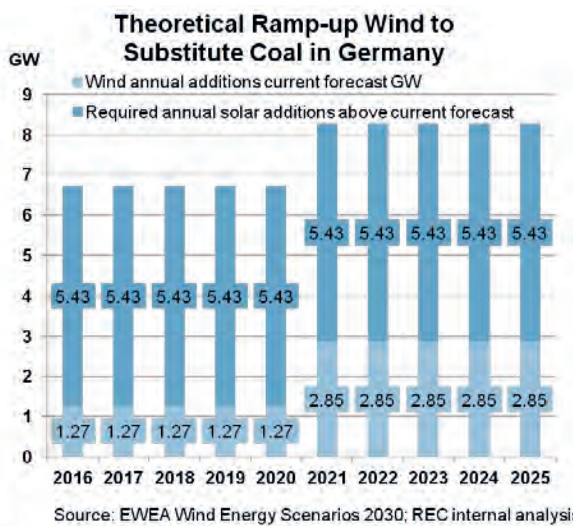
[22] Kraftfahrt-Bundesamt, Figures for January 2016, http://www.kba.de/DE/Statistik/Fahrzeuge/Bestand/bestand_node.html

[23] BMWi, Energiedaten, January 2016



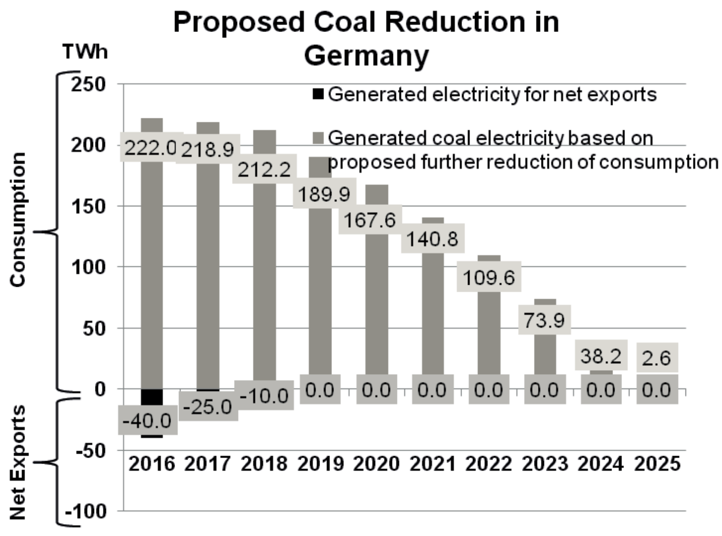
With this pathway, Germany needs to add 4.66 GW of additional solar capacity above the current forecast every year. The actual ramp-up of capacity to 2025 is over three times the level forecast at present. For wind energy, 5.43 GW above the current forecast is required annually, 3.6 times the predicted quantity[24].





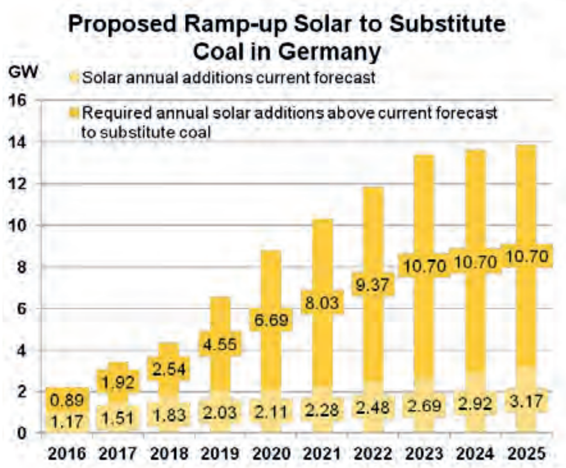
To remain on this trajectory for keeping coal in the mix, Germany will have to begin to ramp-up renewable energy capacity right away, and far above the actual forecast – an unrealistic prospect. It is far more likely that Germany will need a different approach by starting small, and substituting large volumes of coal electricity later down the line. However, owing to the cumulative effect of renewable energy capacities, a later start means that coal has to be virtually completely eliminated if Germany is to close its emissions gap by 2025.

[24] *EWEA, Wind Energy Scenarios for 2030, August 2015*

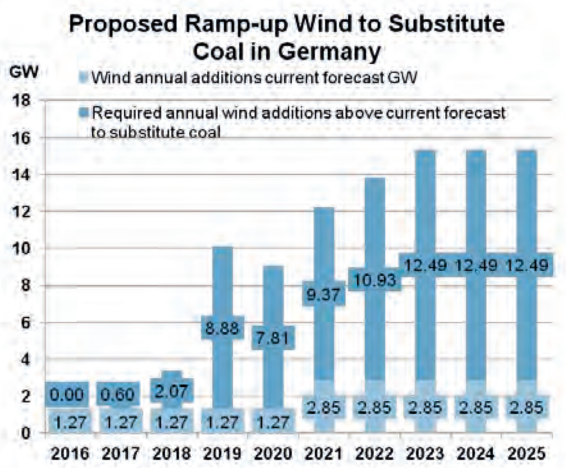


Source: REC internal analysis

Along this second pathway, Germany will need to ramp-up solar capacities four times the current forecast, with figures averaging out at 6.61 GW of above-forecast solar capacity every year to 2025. Furthermore, this pathway will require Germany to add an average 7.71 GW of wind capacity every year in addition to the current forecast. This means the country would have to ramp-up wind capacities 4.7 times the forecast.[25]



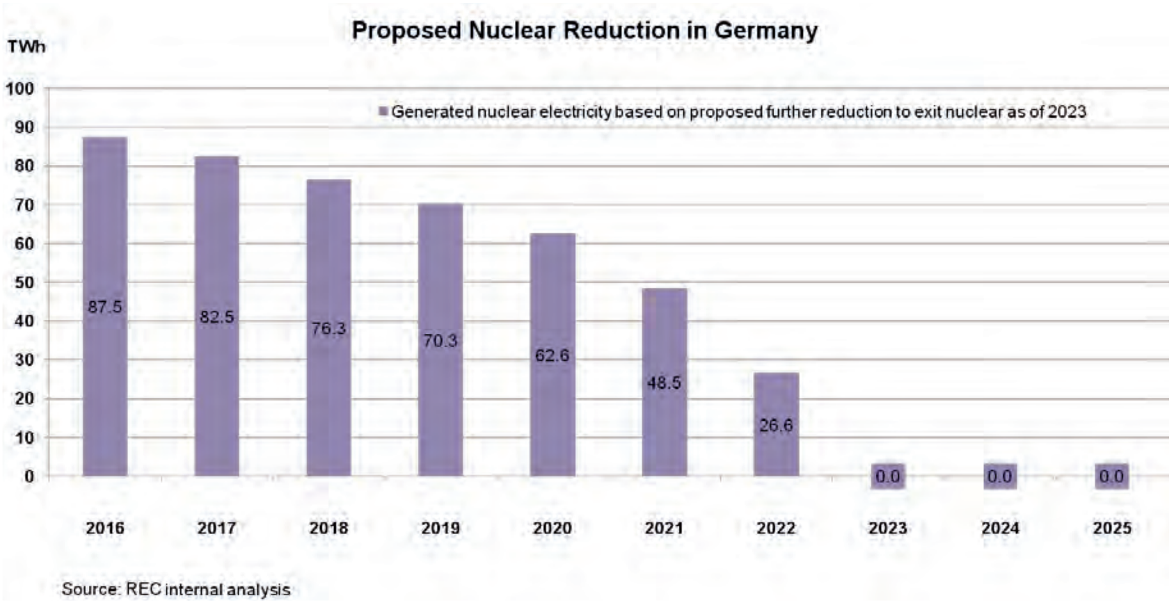
Source: IHS 2015 (incl. PV outlook until 2020); REC internal analysis



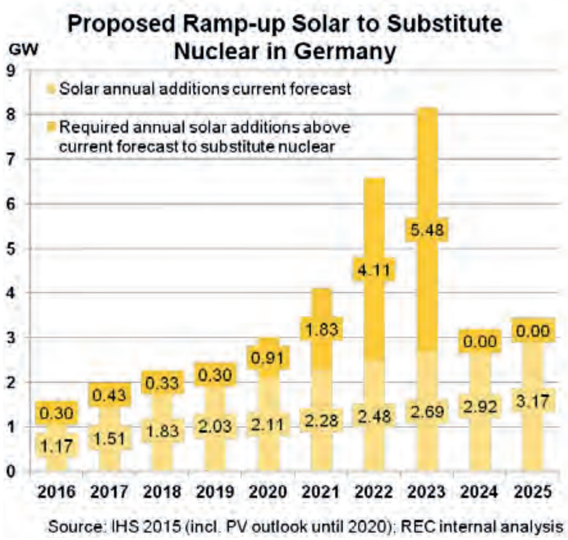
Source: EWEA Wind Energy Scenarios 2030; REC internal analysis

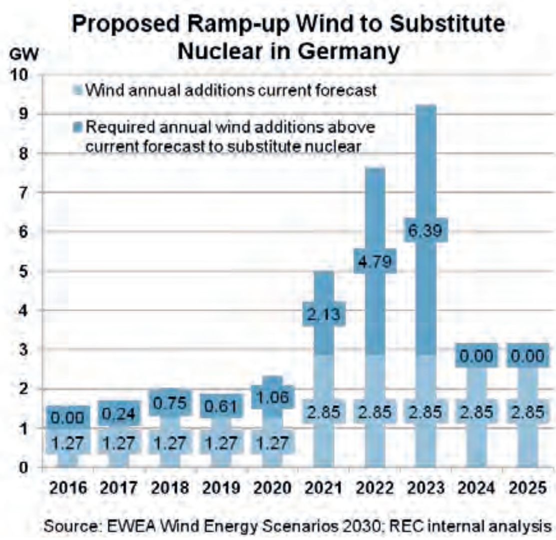
This is already a formidable energy challenge. Yet Germany has even more to contend with. The country's commitment to phase out nuclear power by 2023 leaves a further gap in the energy mix.

[25] *EWEA, Wind Energy Scenarios for 2030, August 2015*

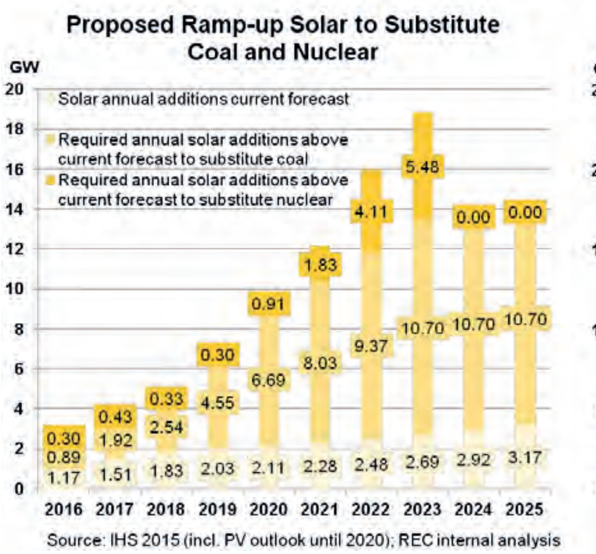


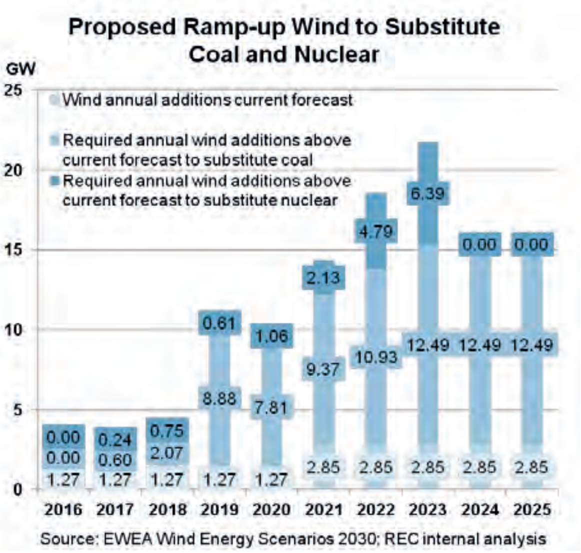
REC's calculations already consider the current forecasts to substitute nuclear power, but it is clear that renewable sources will have to be ramped up over an even steeper curve to fully replace nuclear, installing an additional 1.7 GW of solar capacity on average every year. Germany will need 13.7 GW of cumulative solar capacity by 2023 in addition to its current forecast.



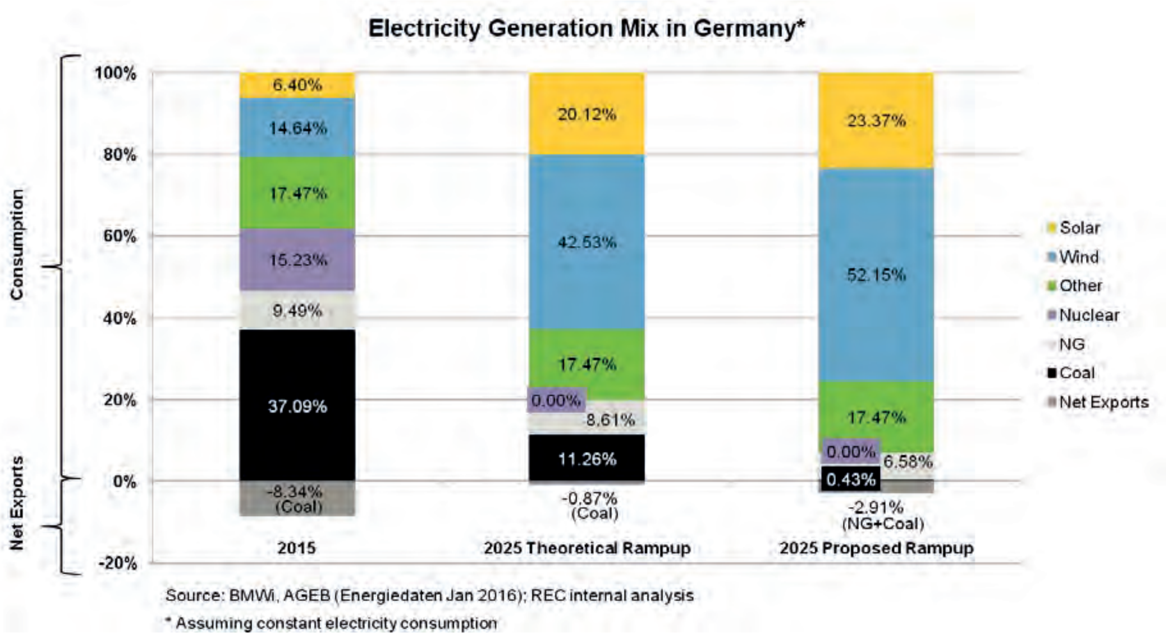


Overall, REC has calculated that, if Germany replaces coal and nuclear power by around 30% solar and approximately 70% wind energy, an average annual 8 GW of solar capacity will be required over and above the current forecast, equivalent to 4.6 times the levels that analysts currently predict. On wind energy, Germany will have to work harder, ramping up capacity by 5.5 times the current forecast[26]: an average 9.31 GW of additional wind capacity will be required every year. The annual caps of 2.5 to 3 GW for solar and wind being discussed at present are clearly far too low.





The proposed ramp-ups will bring solar and wind energy alone (without biomass and hydroelectric sources) to a total share of 75% of the German electricity consumption mix in 2025. The current target – to generate 40% to 45% of electricity from renewable sources by 2025[27] – is far too low to close the emissions gap by 2025, and fully exit the nuclear programme on schedule.



[26] *EWEA, Wind Energy Scenarios for 2030, August 2015*
[27] *BMWi, Die Energie der Zukunft, November 2015*

India

Accounting for approximately 6.5% of global CO_2-eq emissions, India is a relatively large emitter on a global scale, and ranks fourth after China, the US and the 28-member European Union.[28] This is mitigated if one considers figures on a per capita basis: at 1.8 tonnes per person, India has one of the lowest rates worldwide[29]. Although a developing country with limited historical CO_2 emissions, India can still help to close its share of the global CO_2 gap through greater use of renewable energy to meet its growing power requirements.

At present, however, India's emissions are rising, not falling: 2014 saw an increase by 7.8% in emissions, mainly due to an increase in coal consumption.[30] These increases will have to be abated if India is to deliver the contribution stated in its INDC at the COP21 Summit in December 2015. According to its INDC, India aims to generate 40% of its power from non-fossil sources by 2030. At present, non-fossil sources, including nuclear, account for just 19% of the country's power.[31]

The power sector is responsible for approximately 35% of India's emissions,[32] with coal – as elsewhere in the world – a major contributor, accounting for a 73% share in India's power generation. Growth in coal consumption is the main driver of the continued rise in emissions. Despite India's INDC commitment, it is predicted that coal consumption will increase, not decrease, in the years ahead. In fact, analysts predict coal-powered electricity capacity will increase at 5% per year to 2030 to keep up with growth in electricity demand.[33]

Over a fifth of India's population still has no access to electricity.[34] Based on this power poverty as well as on the forecast population and economy growth, the country is expected to be the fastest-growing electricity market in the world over the next decade, with predicted growth of 6% per year.[35] Solar and other renewable sources can play a vital role in both delivering power to remote populations and in helping the country close its share of the global emissions gap to be on track by 2015 in limiting the global temperature rise to below 1.5°C.

REC calculations demonstrate that a more aggressive rollout of renewable energy will enable India's power sector to accomplish this objective. India's total CO_2-eq gap is 9.36 Gt, of which the power sector will need to contribute 3.28 Gt. India's high radiation levels make solar a highly viable power source and, based on renewable energy targets, REC believes that solar can contribute 40% of the abatement required to reduce the cumulated emissions gap (a total of 1.31 Gt).

This will require cumulative solar installations of 374 GW above the current forecast in India by 2025, which is 2.5 times the current forecast. A 15% CAGR is assumed for the current trend between 2020 and 2025, and 900g/kWh for coal power and a radiation yield of 1,440 kWh/kWp.

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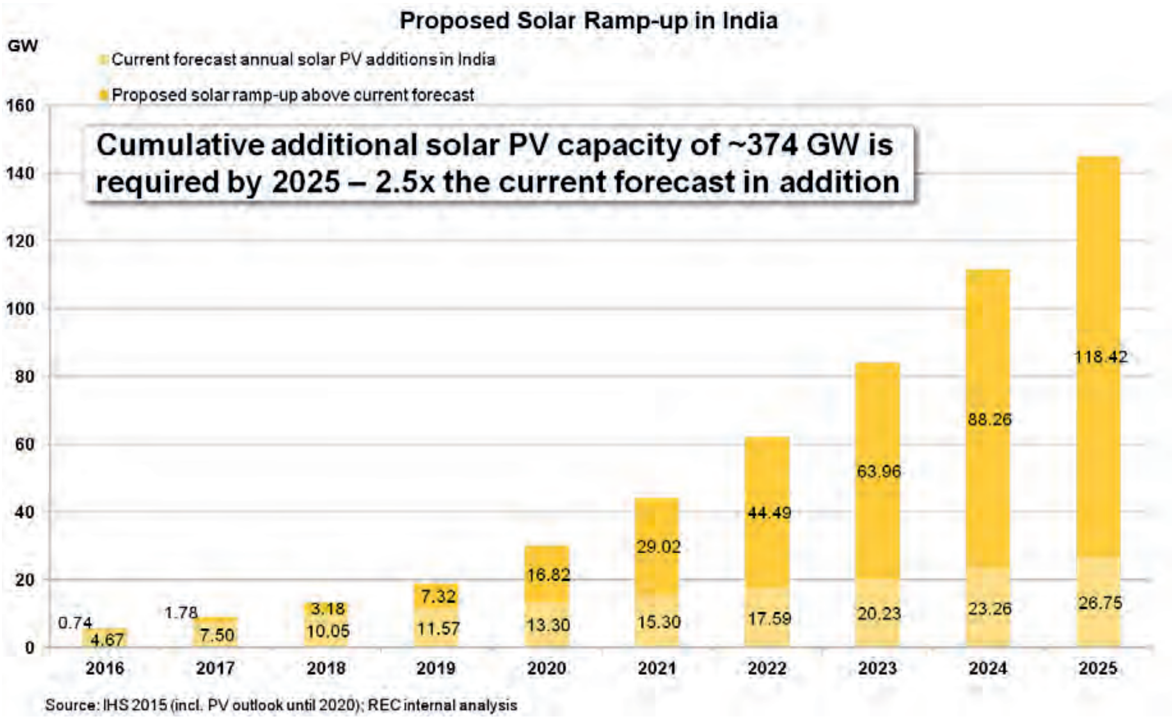
[28] *PBL Netherlands Environmental Assessment Agency/European Commission Joint Research Centre, Trends in global CO2 emissions; 2015 Report, 2015*
[29] *PBL Netherlands Environmental Assessment Agency/European Commission Joint Research Centre, Trends in global CO2 emissions; 2015 Report, 2015*
[30] *PBL Netherlands Environmental Assessment Agency/European Commission Joint Research Centre, Trends in global CO2 emissions; 2015 Report, 2015*
[31] *UNFCCC, INDC of India, http://www4.unfccc.int/submissions/INDC/Published%20Documents/India/1/INDIA%20INDC%20TO%20UNFCCC.pdf*
[32] *PBL Netherlands Environmental Assessment Agency/European Commission Joint Research Centre, Trends in global CO2 emissions; 2015 Report, 2015*
[33] *Climate Action Tracker, India Assessment, http://climateactiontracker.org/*
[34] *World Bank, Access to Electricity data, http://data.worldbank.org/indicator/EG.ELC.ACCS.ZS*
[35] *IEA, World Energy Outlook 2015, 10 November 2015*



The Indian Government has already introduced policies to encourage a shift away from coal power, and in 2010 introduced levies on both home-produced and imported coal (around US$ 3 per metric tonne in 2015-2016 budget).[36] While policies such as this certainly acknowledge the impact that coal as a power source has on the country's overall emissions, India's fast-growing electricity demand has so far limited the impact of the policy on consumption.

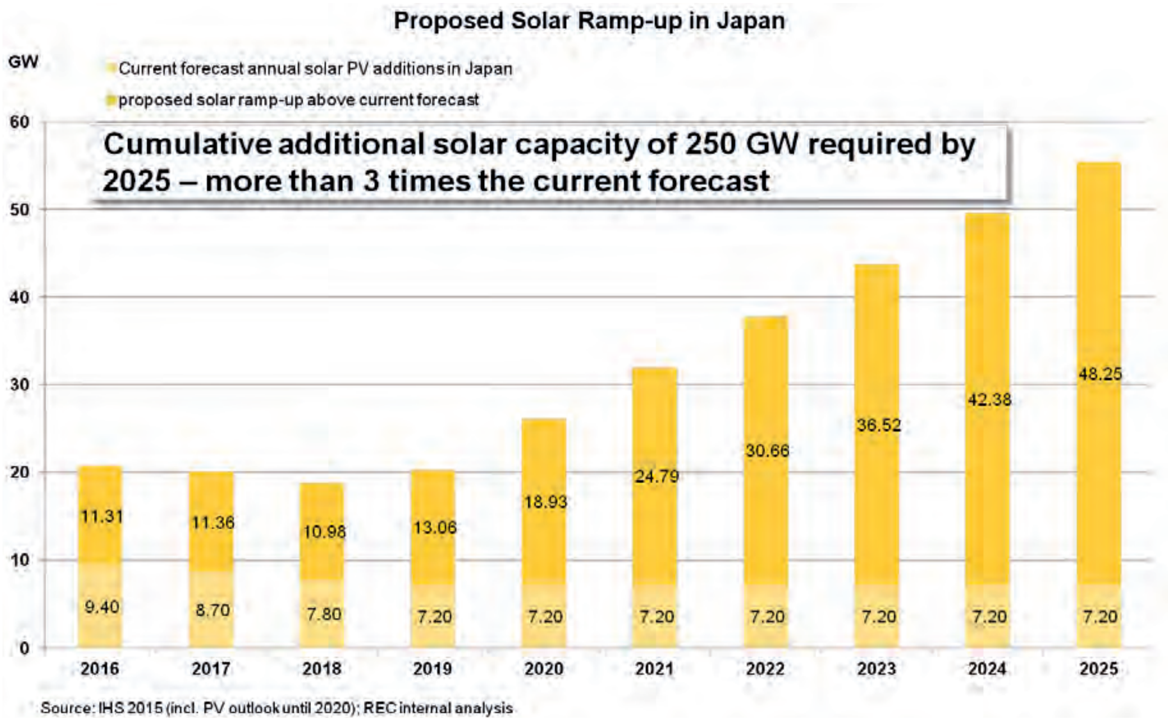
Furthermore, REC calculations demonstrate that although India already targets a significant increase of renewable energy capacity to 175 GW by 2022[37] (100 GW of which is solar; cumulative installed solar power capacity in India reached 4 GW in July 2015), this will be clearly not enough to make the country's contribution to fighting climate change. However, the earlier India can ramp-up its renewable energy capacities, the less additional cumulative capacities will be required to be on track by 2025 for closing the emissions gap. And, based on declining costs for solar PV power in India and globally, the greater job creation benefits associated with distributed solar PV, and the cost externalities associated with coal use, solar PV is a better choice for India – from an economic as well as an environmental standpoint.

Japan

Elsewhere also, pledges do not go far enough. For Japan, the world's fifth largest emissions producer, REC's calculations demonstrate that Japan's COP21 pledge to reduce emissions by 26% by 2030 compared to 2013 levels falls short of what would be required, considering its 3% share in global emissions[38]. REC calculates a gap of 650 Mt in 2025; the pledged reduction would deliver 364 Mt by 2030.

[36] *Minister of Finance, Budget Speech 2015-2016, retrieved from http://www.thehindu.com/news/resources/full-text-of-budget-201516-speech/article6945026.ece*
[37] *MNRE, Schemes for Installing Large Solar Power Plants, 2015*
[38] *EDGAR, Emissions Database for 2014, http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2014*

In Japan, as elsewhere, the rise in emissions is attributable to increased consumption of fossil and solid fuels for generating electricity. Japan's power sector accounts for around 40% of the country's total greenhouse gas emissions[39], which is higher than the global average. The REC calculations assume that solar can reduce the cumulated emissions gap of 1.73 Gt by 25%. Using solar to close this share of the gap, Japan will need cumulative solar capacity of 250 GW above the current forecast by 2025, more than three times the current forecast. This assumes 0% CAGR between 2020 and 2025, and 1,100 kWh/kWp. However, Japan's energy master plan for 2030 targets solar energy capacity of just 53 GW.[40]



With the additional capacity, solar could account for approximately 28% of Japan's electricity consumption mix, much more than the pledged 7%[41]. This assumes total electricity demand of 1,110.7 TWh, without including increased energy efficiencies. This significant expansion will reduce Japan's dependence on fossil fuel imports and ease supply bottlenecks.

The Netherlands and Belgium

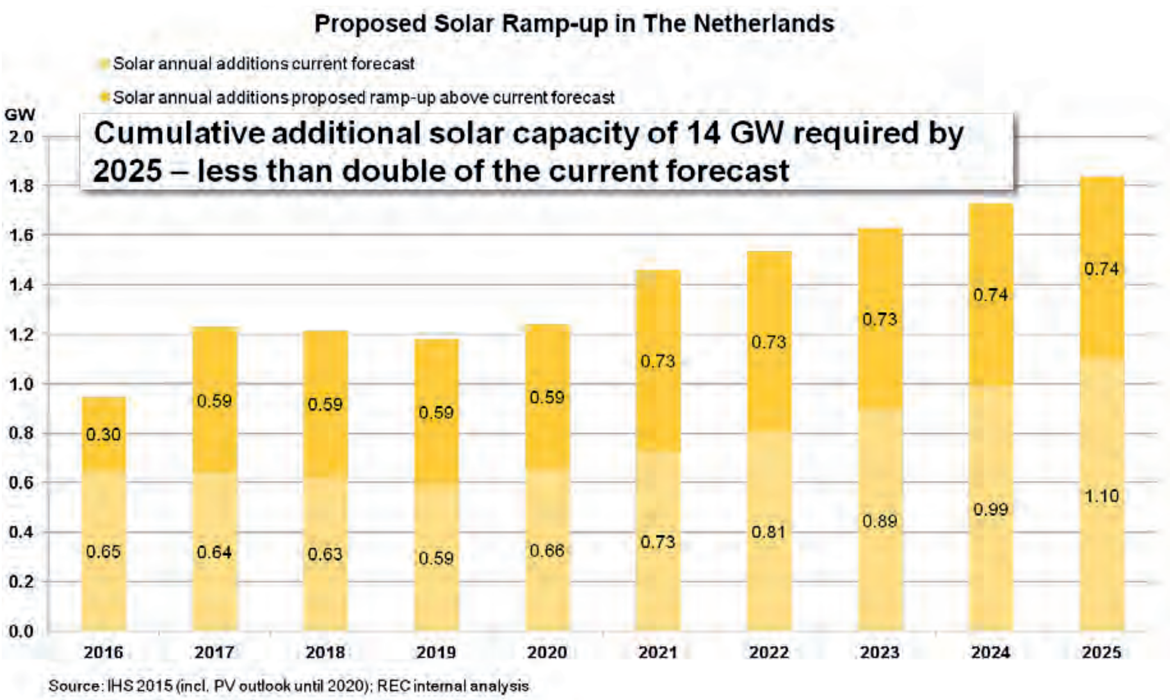
The Netherlands and Belgium, whose shares in total global CO_2-eq emissions are just 0.4% and 0.3% respectively,[42] rank close to the bottom of the table among EU countries on the 2015 Environmental Performance Index (EPI)[43].

In the Netherlands, fifth from bottom on the EPI, the power sector is responsible for approximately 30% of the country's total emissions. Increased use of coal (with 900 g per kilowatt hour of carbon emissions), paired with a reduction in gas power generation, have contrived to make the

[39] *Ministry of the Environment Japan/Greenhouse Gas Inventory Office of Japan (GIO)/CGER/NIES, National Greenhouse Gas Inventory Report of Japan, April 2015*
[40] *METI, The Efforts on Renewable Introduction in Japan – Excerpt from the 4th Strategic Energy Plan of Japan, 20 May 2014, http://eneken.ieej.or.jp/data/5494.pdf*
[41] *UNFCCC, INDC of Japan, http://www4.unfccc.int/submissions/INDC/Published%20Documents/Japan/1/20150717_Japan's%20INDC.pdf*
[42] *EDGAR, Emissions Database for 2014, http://edgar.jrc.ec.europa.eu/overview.php?v=CO2ts1990-2014*
[43] *Yale University, 2016 Environmental Performance Index, 2016*

Netherlands one of the poorest environmental performers in Europe. At present, around 30% of power is generated from coal, and around 50% by NG.[44]

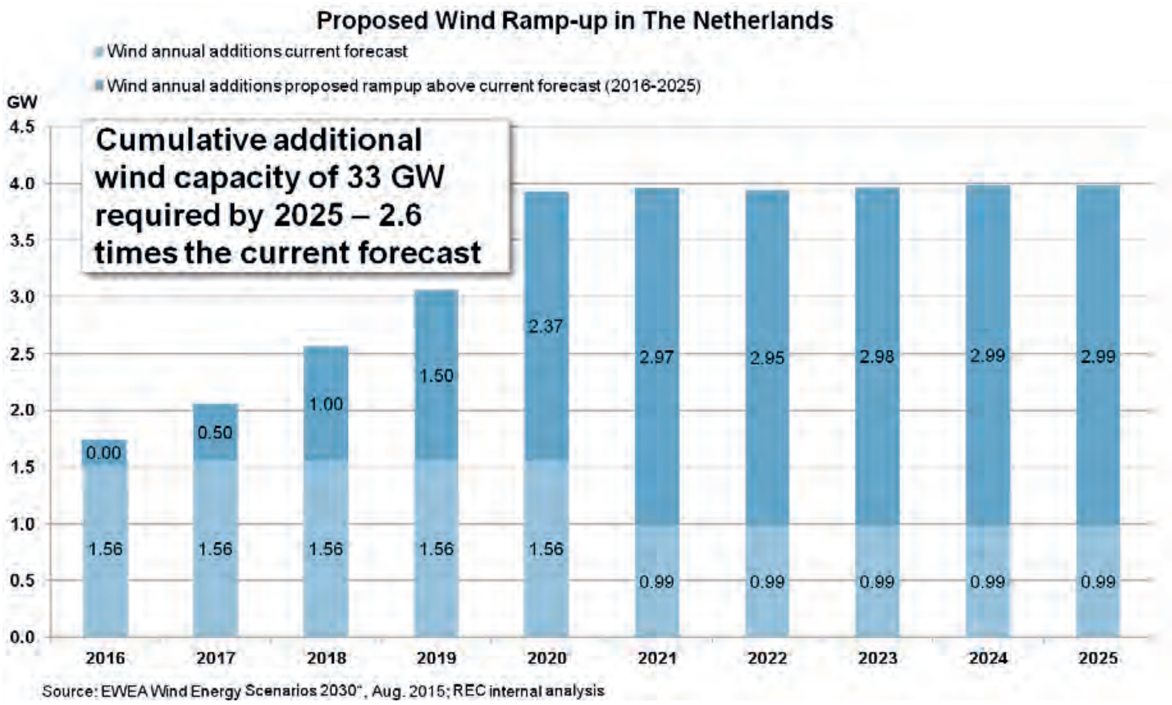
REC's calculations demonstrate that the Netherlands can make its contribution to closing the emissions gap by fully eliminating coal from power generation. The country's cumulated emissions gap in the power sector by 2025 is 173 Mt; cumulative emissions by coal power by 2025 will total 280 Mt. REC also assumes that solar energy can deliver 10%, and wind 90%, to reducing this emissions gap.



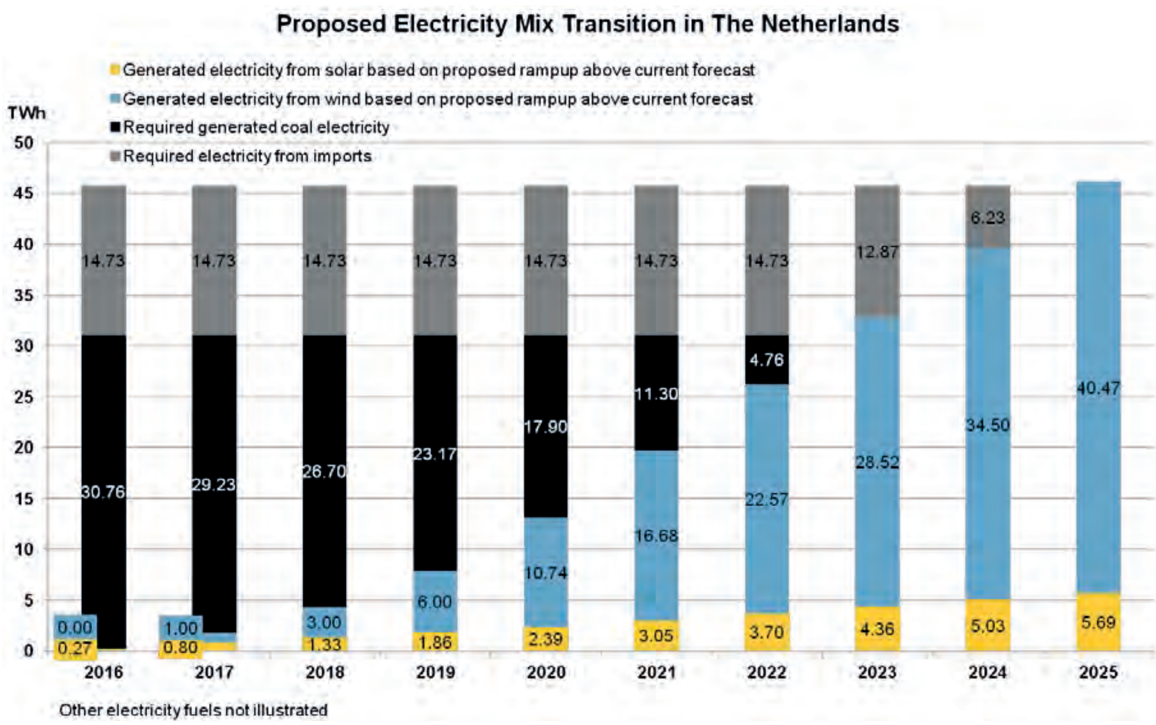
This will require cumulative solar installations of 14 GW, just under double the current forecast (assuming 10.9% CAGR between 2020 and 2025 and 900 kWh/kWp), and cumulative wind installations of 33 GW (assuming 2,000 kWh/kWp, 2.6 times the current forecast[45]), in order to close the emissions gap and make coal fully dispensable as of 2023.

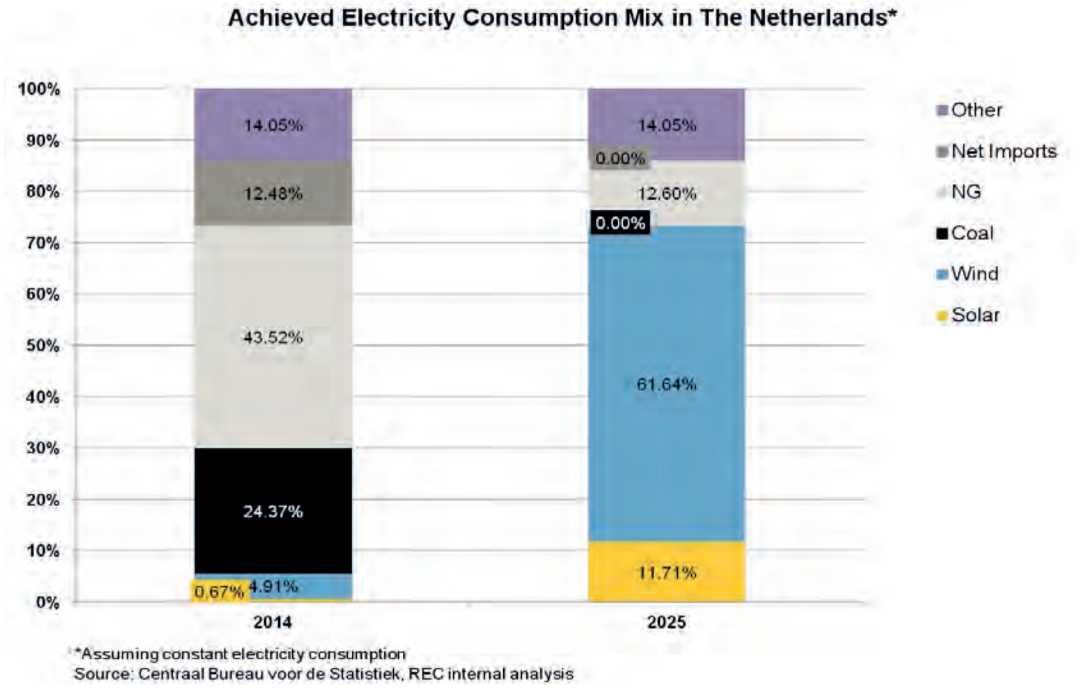
[44] *Centraal Bureau voor de Statistiek, emissions database for 2014, http://statline.cbs.nl/statweb/publication/?vw=t&dm=slen&pa=70946eng&d1=a&d2=a&d3=a&hd=100216-1101&la=en&hdr=g2&stb=t,g1*

[45] *EEA European Environment Agency, NREAP National Renewable Energy Action Plan, 2011; Deloitte, European Energy Market Reform – Country Profile: Netherlands, 2015; BNEF, Country profile Netherlands, https://www.bnef.com/core/*

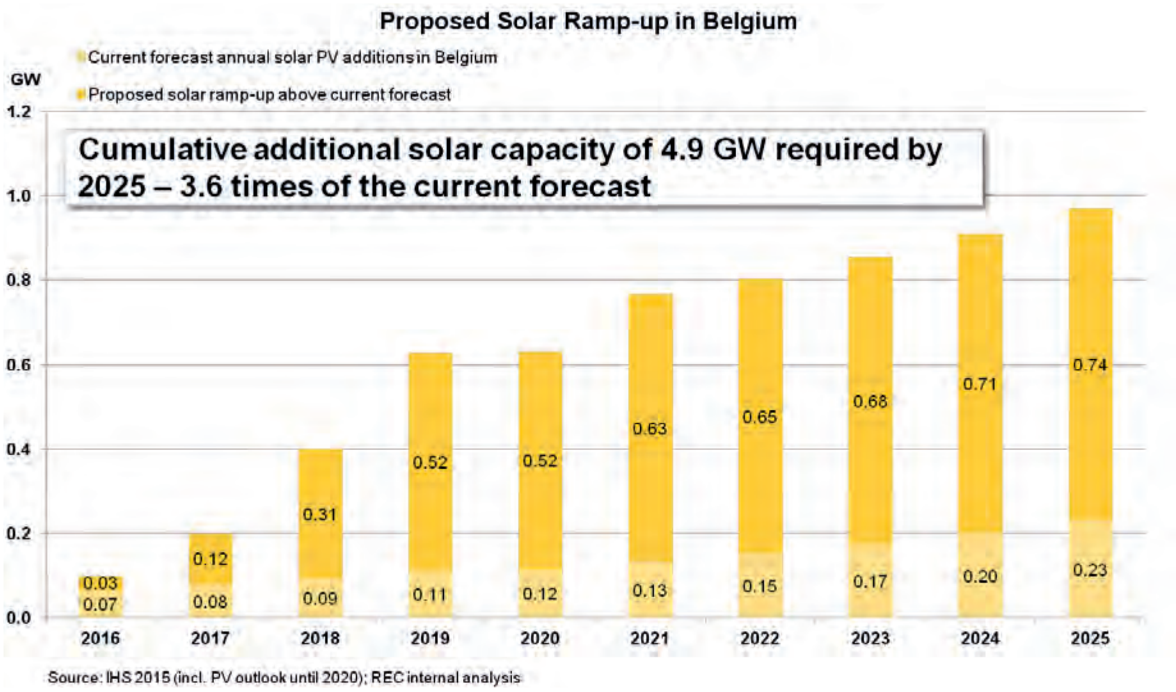


Expanding renewable energy sources on this scale will also make electricity imports unnecessary from 2025 onwards, breaking any dependence on non-domestic power sources. REC has calculated that in 2025, solar can account for almost 12% of the electricity consumption mix. Wind energy can deliver almost 62%.



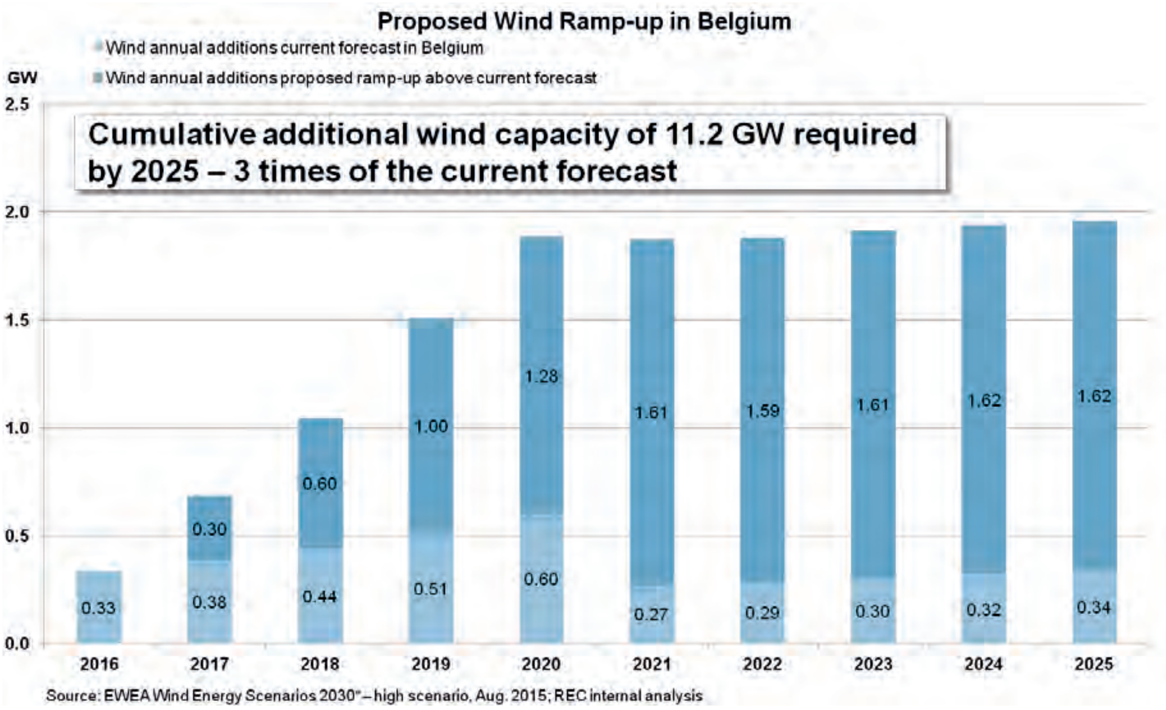


The Netherlands' neighbour Belgium presents a similar picture. Within the EU, it is the second worst environmental performer according to the 2016 Environmental Performance Index.[46] The country's heavy use of combustible fuels – accounting for around half of its electricity production[47] – is the main reason for this low ranking. The Belgian power sector produces approximately 20% of the country's total emissions.[48] Closing the gap will be a challenge, particularly since Belgium, like Germany, has decided to phase out nuclear power generation completely by 2025.

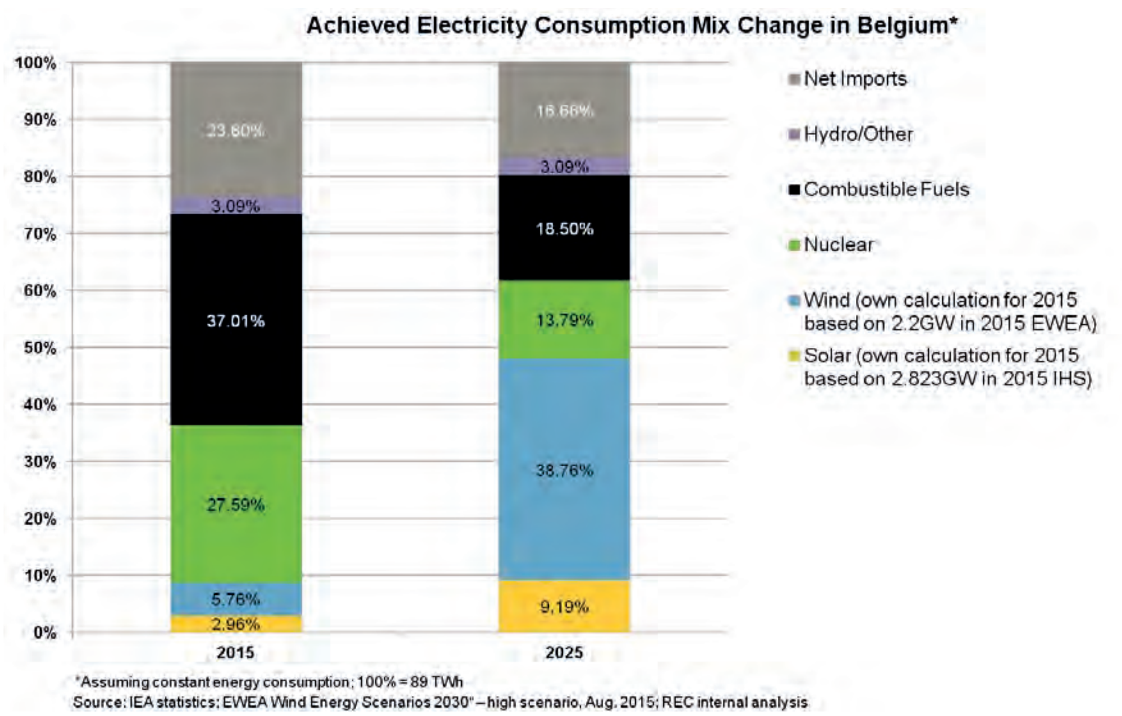


[46] *Yale University, 2016 Environmental Performance Index, 2016*
[47] *IEA, Electricity statistics for 2013, http://www.iea.org/statistics/statisticssearch/report/?country=BELGIUM&product=electricityandheat&year=2013*
[48] *European Commission, EU Energy, Transport and GHG Emissions Trends to 2050, 2013*

REC calculates that the Belgian power sector is in a position to close the emissions gap (Belgium's share is 86 Mt) by 2025 by adding cumulative solar capacity of 4.9 GW above the current forecast, 3.6 times the current forecast. This assumes a CAGR of 14.9% between 2021 and 2025, and 900 kWh/kWp. Belgium will also need to add a cumulative 11.2 GW of wind capacity above the current forecast, three times its current forecast.



By taking early steps to raise solar and wind generation capacities, Belgium will be able to achieve a 9.2% share of its electricity consumption mix through solar in 2025, and 38.8% by wind power, assuming constant consumption. This will enable the country to halve its consumption of combustible fuels, fully eliminate coal, halve its nuclear power generation, and reduce its net electricity imports.



Imperatives Emerging from the Study

REC's calculations show there is a substantial gap between the COP21 commitment and what is actually targeted by governments under current policies. All the countries investigated need to ramp-up their solar and wind capacity beyond current planning levels if they are to have a chance of delivering on their part of the COP21 promise.

None of this extra capacity will appear by itself. It will take increased efforts across all related areas: complementary low carbon energy sources, regulations to incentivise renewable energy, investment security, better storage and smart grids are just some of the factors that will add impetus to this journey. And adequate finance, as always, is key.

The F-Word: Funding

Funding is a common reason why commitments all too often end up being watered down or abandoned altogether. Yet examined in detail, the investment in solar looks an extremely good deal. Every year, global annual fossil fuel subsidies total around US$ 500 billion, which is four times the funds that are currently used to subsidize renewable energy[49]. REC has calculated that with a budget amounting to US$ 44 billion per year, solar energy can abate 25% of the emissions gap in the power sector.

If PV system costs continue to decrease as forecast, the levels of global solar capacity that REC

[49] *IEA, World Energy Outlook, 2015*

has calculated as both possible and necessary can be achieved with total annual investment of up to US$ 157 billion (2025 figure).

This is higher than current trend forecasts: BNEF estimates investments of approximately US$ 120 billion in 2025 [50], and IPCC claims that investments of approximately US$ 147 billion per year into low-carbon electricity supply will be needed in order to restrict the temperature rise to below 2°C [51]. However, it still appears a small price to pay for success in limiting the global temperature rise including impacts and losses from climate change.

The funds are there – as shown by the subsidies spent on fossil fuels. The issue is not where to find the funds, it is about where to allocate them. To give solar energy an opportunity to make a real difference, substantial changes in investment patterns will be necessary, and all costs of other fuel sources should be given far greater consideration than is now the case.

Developments in Associated Areas

Even though the focus of this study is modelling the additional solar capacity that will be needed to deliver solar's contribution to meeting emissions targets, it will clearly not be enough just to bolt on capacity without also addressing related areas. Space is one key issue: how much space can be freed or allocated for solar and wind power – and is that space being used to maximum efficiency? In particular, solar is showing important flexibility in being able to be deployed on ground, rooftops and even water.

Power storage and smart grids will do much to make renewable energies more viable. Efforts are already underway to improve storage of generated solar and wind energy: Deutsche Bank analysts[52], for instance, predict significant improvement over the next five years, and take the view that the expected significant cost reduction could be a major catalyst in accelerating solar adoption worldwide. Coupled with smart grids, which enable greater reliability, efficiency and flexibility in delivering power to consumers, better storage opportunities will raise the appeal of renewable sources.

Yet, as Deutsche Bank analysts point out, this will also require incentive programmes as a way to encourage power companies to introduce the necessary changes to grids. This is a matter for regional and national governments, who can play a key role in getting the essential policies and regulations in place to encourage the transition to renewable energy sources such as solar.

Conclusion and Outlook

In summary, also considering the higher electrification rates that are part of global climate policy strategies for the future, REC calculations forecast that solar energy will account for around 20% of the global electricity mix in 2025. This is in line with analysts' predictions that solar will be the world's most common energy source by 2050, powering 40% of global electricity needs.[53]

The calculations on required capacities can be seen as a first step in planning a global power tran-

[50] *BNEF, New Energy Outlook Solar, 2015*
[51] *IPCC, Climate Change 2014 – Synthesis Report, 2015*
[52] *Deutsche Bank, Solar Industry: "Crossing the Chasm", February 2015*
[53] *Fraunhofer ISE/Agora Energiewende, Current and Future Cost of Photovoltaics. Long-term Scenarios for Market Development, System Prices and LCOE of Utility-Scale PV Systems, 2015*

sition. This should be the starting point for further elaborations, discussions and implementing country specific mechanisms for incentivizing this transition. Unfortunately, in many countries, in Germany for example, the discussions leapfrog this important initial point on what climate change requires, moving straight to the details and target-setting (such as a certain percentage of renewables by a certain year), while losing sight of the big picture – which also has to include areas such as finance, better smart grid and storage technology, regulations and investment incentives.

The REC forecast is certainly ambitious. It is, however, not impossible. With the impetus from agreements reached at the COP21 summit in Paris, worldwide efforts to limit the temperature rise to below 2°C (and ideally below 1.5°C) are now being formalised and hardened. The next step is the 22nd Conference of the Parties (COP22) to be held in November 2016. At COP22, governments are targeting an accord on the rule book of the Paris Agreement, hammering out concrete steps for taking the agreement into force. To meet the targets agreed in Paris, there will have to be quick and substantial reductions in greenhouse gas emissions in the coming decades.

Climate change experts continuously explain that there is a momentous challenge ahead, requiring huge efforts from all sides – governments, businesses, organisations, investors and every single household. This is the clear consensus. However, REC calculations now provide the specifics – in clear numbers – just how much of a challenge this will be.

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Celebrating its 20th anniversary in 2016, REC is a leading European brand of solar panels. Through integrated manufacturing from polysilicon to wafers, cells, panels and turnkey solar solutions, REC strives to help meet the world's growing energy needs. Founded in 1996, REC is a Bluestar Elkem company with headquarters in Norway and operational headquarters in Singapore. REC concluded 2015 with 2,000 employees worldwide, 1.3 GW solar panel production capacity, and annual revenues of USD 755 million.