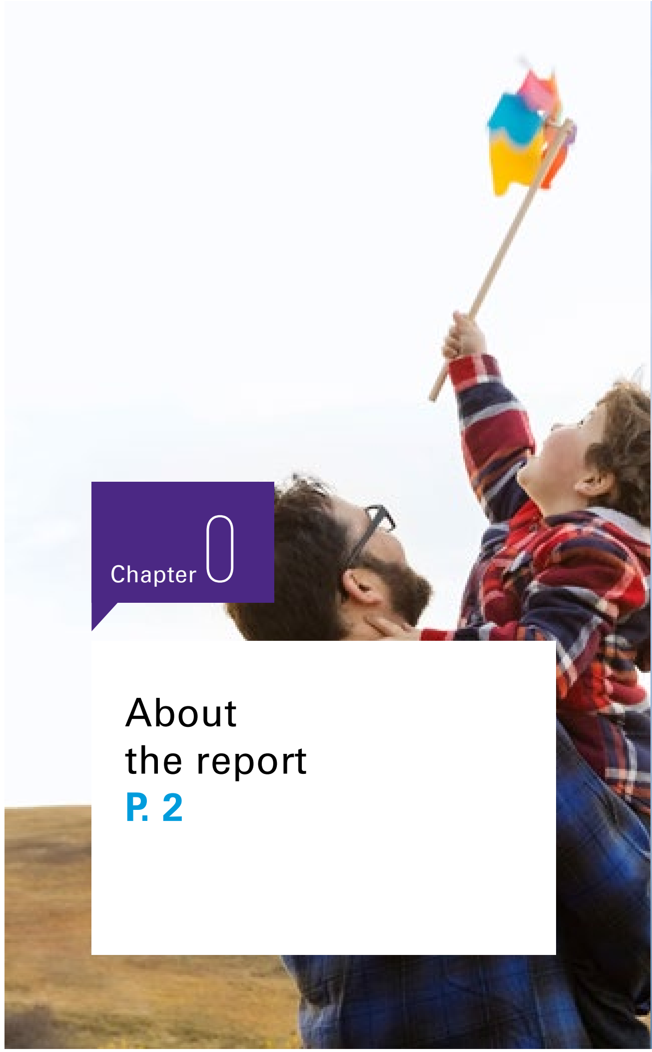
The socioeconomic impacts of wind energy in the context of the energy transition

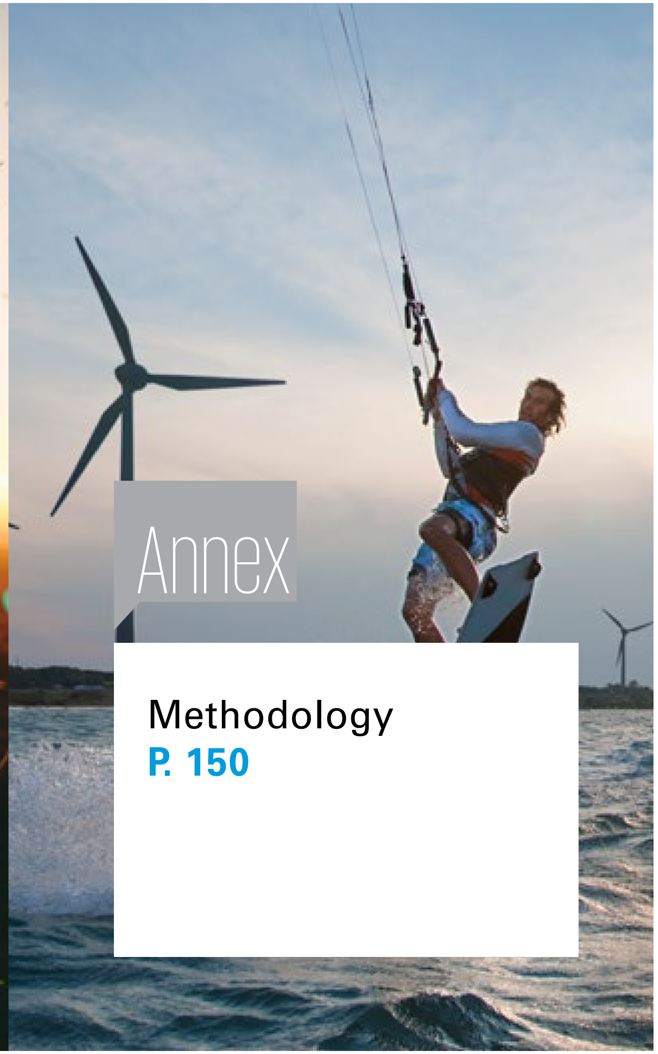
A KPMG study at the request of Siemens Gamesa

October 2019

kpmg.es

Summary





About the report

Aim

To present the socioeconomic impact of wind/renewable energy at a global level, and in seven key countries in which Siemens Gamesa operates (China, Denmark, Germany, India, Mexico, Spain and United Kingdom).

Target audience

Media, broad public and experts (e.g. investors, industry, policymakers, academics), in the seven countries.

Methodology

– Measuring the socioeconomic impact of some form of energy in a sound manner is a complex task. There are large knowledge gaps, data issues and methodological challenges. This report follows the specific indicators that the most reputed and independent international organisations have used (see section "Conceptual Framework of the Report"), collecting such evidence while striving for neutrality. Then, it is presented as uniformly and consistently as data allows, but at the same time in an easy-to-communicate way.

– The project team has followed an exhaustive literature review and data compilation process, using public sources. It has also performed targeted expert interviews by email. Two scenarios are defined, aiming to present two possible futures: a Business as Usual (BaU) and a Sustainable Scenario (SUS). Each represents a compilation of information from the *reference* (current policies in place) and *energy transition* (ambitious policy action) scenarios of key organisations. These include IEA's New Policies / Sustainable Development scenarios, IRENA's Reference / REmap cases, official national-level energy plans, or IPCC's projections. The sources used are listed in the annex.

Disclaimer

- This report has been done at the request of, and contracted, by Siemens Gamesa Renewable Energy, S.A. ("Siemens Gamesa"). Siemens Gamesa had no role in the conduct of the study; the collection, management, analysis and interpretation of data; the drafting or editing; or the preparation of the final report. The work has been carried out by KPMG and is independent of the project sponsor.
- KPMG has been a facilitator of the study, compiling available evidence and interviewing experts. As such, KPMG is not responsible for the opinions of third parties such as institutions or experts cited or quoted in this report. The experts where not compensated for their quotes, and all of them were given the opportunity to review their respective citations (only one did).
- KPMG does not intend to provide any policy recommendation, it only compiles those from the cited organisations. Some analysis and results are based on previously published policy plans, but this does not represent KPMG's endorsment to those plans or to the Administrations that published them.
- The boundaries shown in the maps used do not represent an official KPMG endorsement or acceptance. They have a purely illustrative purpose and aim to convey the specific messages addressed in this report, excluding any positioning on political or geographical issues.

1 Presentation and executive summary

"The energy transition in essential to achieve the UN's 2030 Agenda for Sustainable Development. Universal and affordable access to electricity will empower millions of people around the world and their communities to enjoy a better life. But avoid the worst impacts of climate change, energy will have to be carbon-free.

In this context, renewable energy has a major role to play in putting the world on a sustainable path as it will cut emissions, improve air quality, save water, create good-paying jobs and save lives.

What's required is a wholesale deployment of wind and solar technologies to meet the growing clamor from consumers and from investors for an energy mix that's 100-percent renewable. And the economic feasibility of the energy transition is right before us.

Wind power is ideally positioned to lead that transition, as it is at the cutting edge of technological innovation, driving costs down and market penetration up. In recent years wind energy has become cost competitive with fossil fuels. That's due to new manufacturing methods and bigger, better, more efficient turbines.

But even if the sector is ready for the challenge, more needs to be done to replace fossil fuels while ensuring a stable electricity supply.

Governments around the globe have already committed to the UN agenda and the Paris Agreement, but the political will is still lacking, as are long term strategies and investments to make those ambitious plans reality. Years of experience have taught us that clear emissions-reductions policies help low-carbon technologies grow and become more competitive, making it easier and cheaper to reduce more emissions in the future.

At Siemens Gamesa Renewable Energy we believe it is our responsibility to be a driving force behind this sweeping energy revolution. Insightful and comprehensive studies, like the one conducted by KPMG, are critical to understand the positive contribution of massive deployment of renewable energy for the overall welfare of the people, regardless of how advanced their economic development may be."

Markus Tacke

CEO
Siemens Gamesa Renewable Energy

"One of the real positives in the fight against climate change is the way institutional investors and the wider capital markets have responded.

The investment community has embraced renewables as a highly attractive asset class and we are now in an environment where there are not enough investment-ready renewable projects to satisfy what has become an insatiable demand from investors globally.

Therefore, to address this investment mismatch, it is critical that governments continue to introduce favourable policies particularly in emerging economies. The investment community will respond in kind if policy certainty and stability can be achieved. However, the issue of government policy is not just about support systems - it is also critical to deliver certainty in other areas such as availability of grid , land ownership, and bankable PPA agreements".

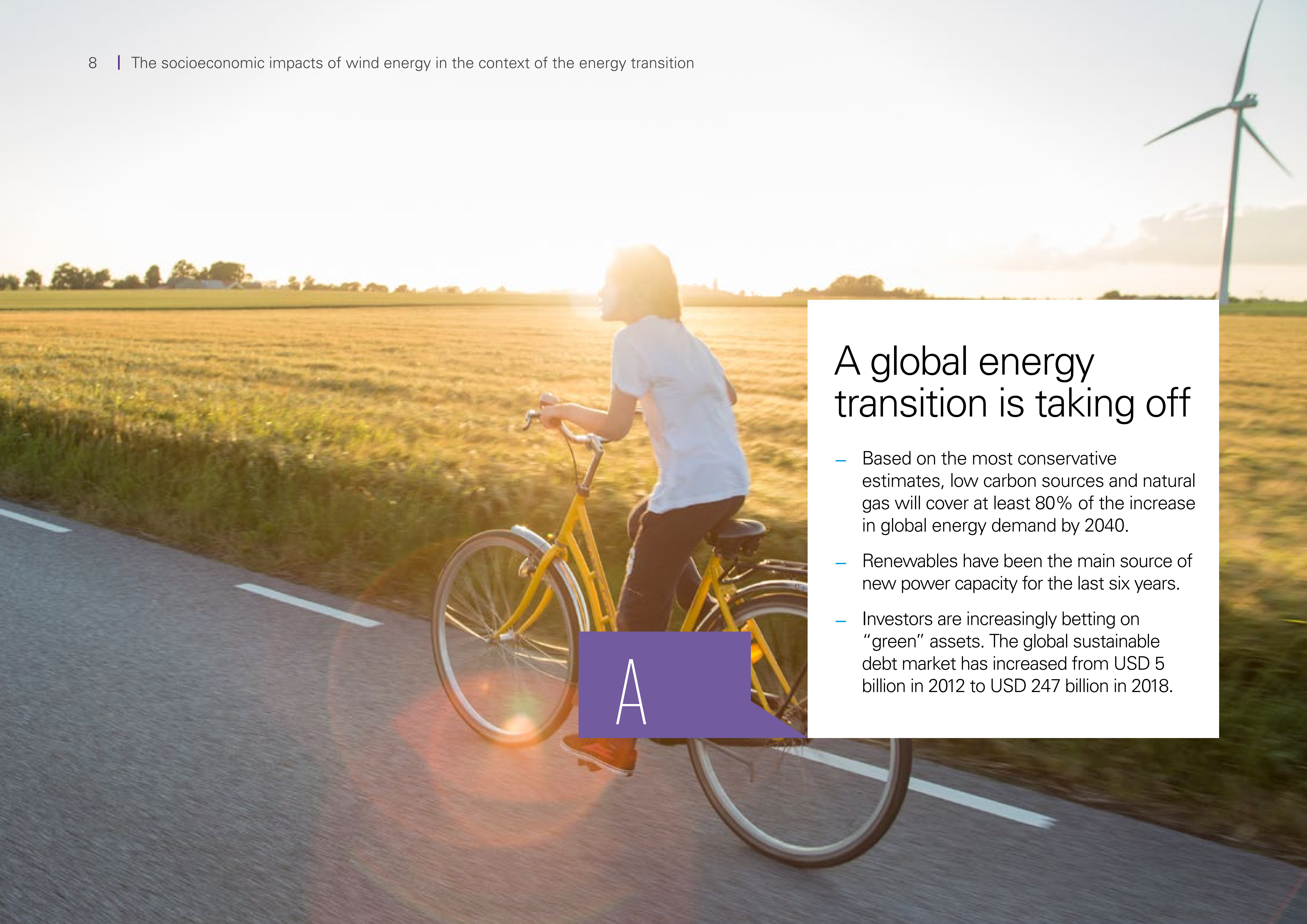
Michael Hayes
Global Renewables Lead KPMG

"By contributing to the mitigation of climate change, the wind energy sector is already making a significant contribution to sustainable development. Furthermore, the wind sector represents more than 300,000 EU jobs, a number which will continue to rise as we move towards net zero greenhouse gas emissions. These are often high quality jobs, which contribute to local employment in rural or disadvantaged areas. Furthermore, replacing fossil fuel dependency with wind power will have a direct impact on the EU's air pollution, which is estimated to cause almost half a million premature deaths per year."

Miguel Arias Cañete

European Commissioner for Climate Action and Energy

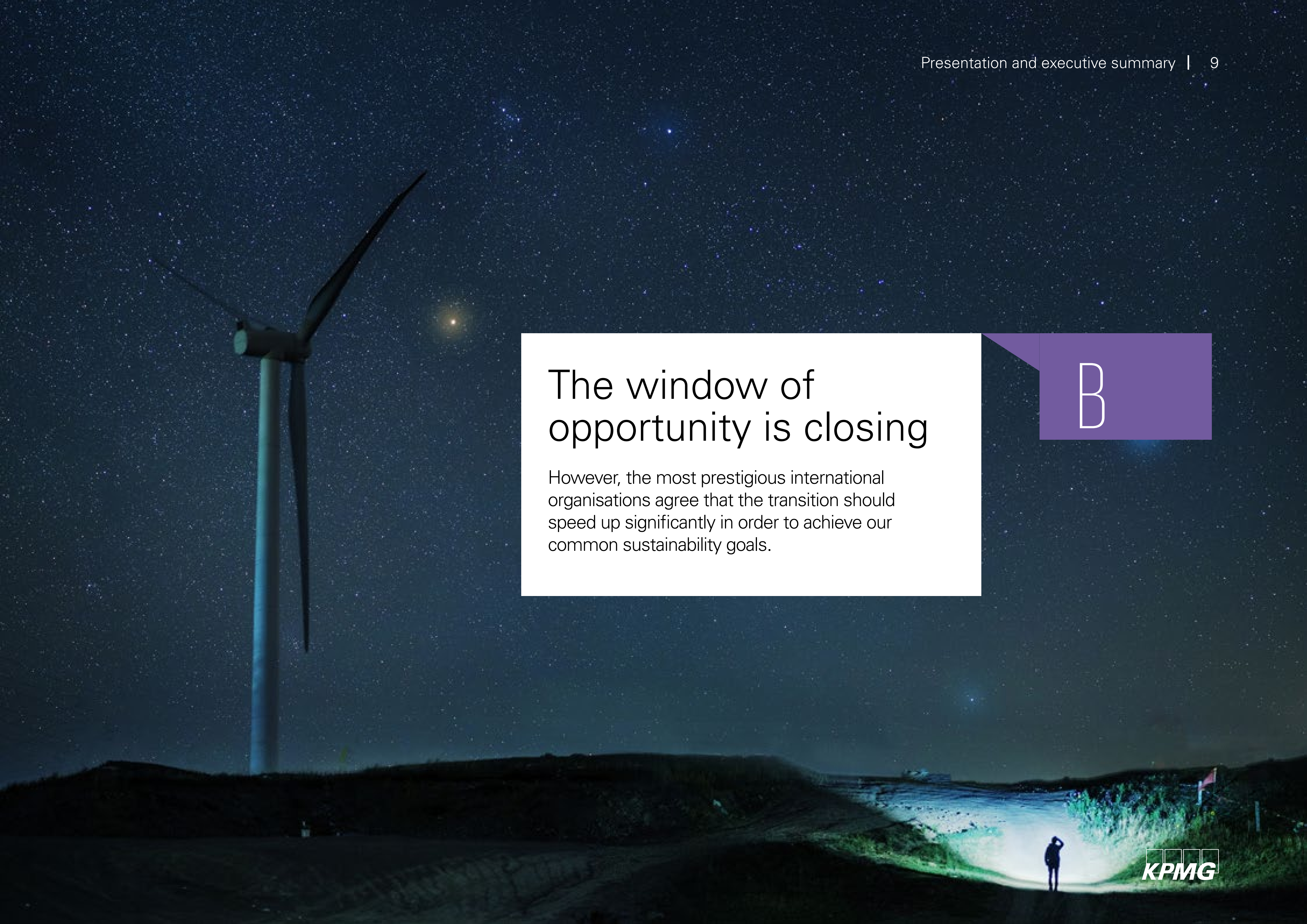
KPMG



A

A global energy transition is taking off

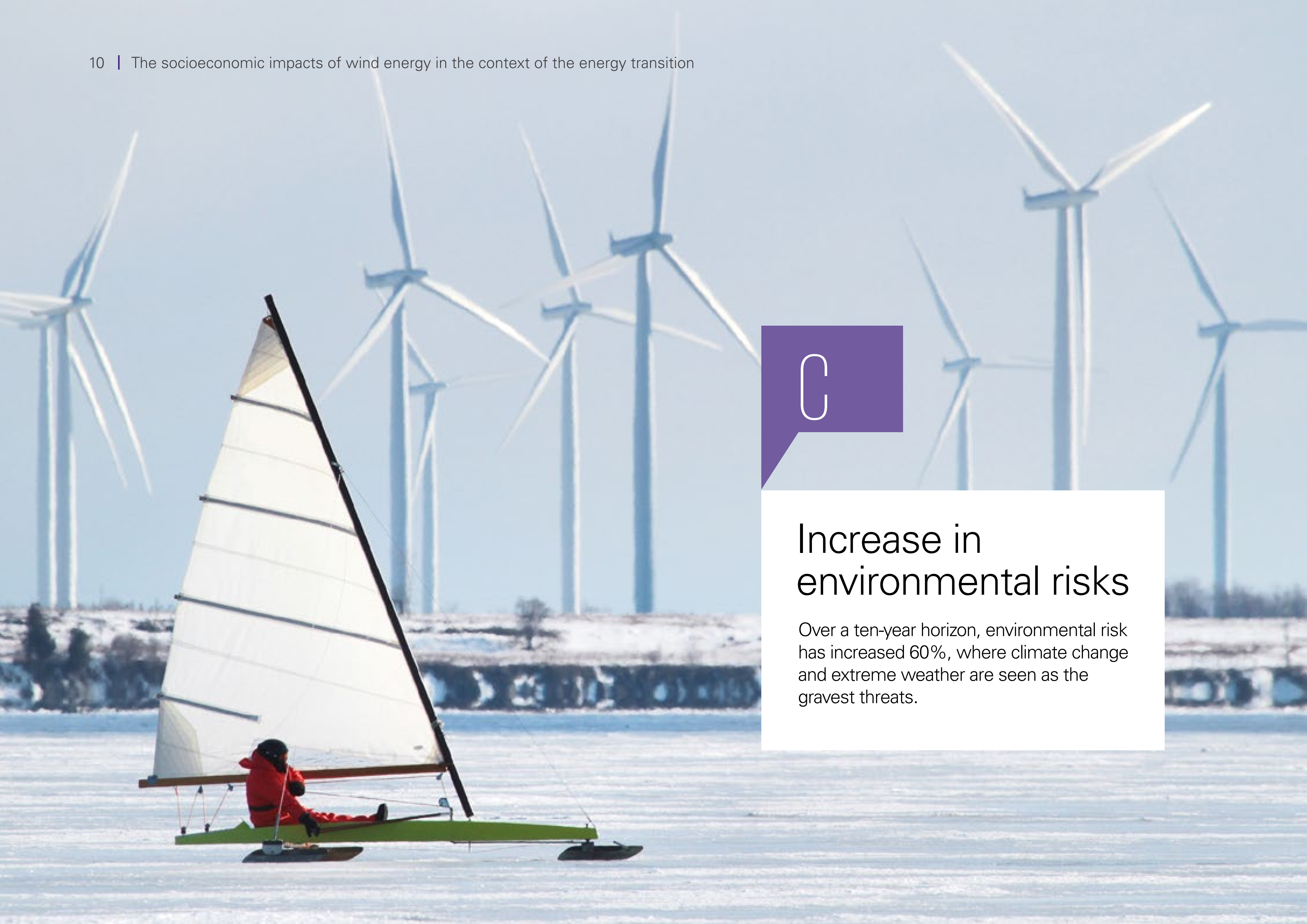
- Based on the most conservative estimates, low carbon sources and natural gas will cover at least 80% of the increase in global energy demand by 2040.
- Renewables have been the main source of new power capacity for the last six years.
- Investors are increasingly betting on "green" assets. The global sustainable debt market has increased from USD 5 billion in 2012 to USD 247 billion in 2018.



B

The window of opportunity is closing

However, the most prestigious international organisations agree that the transition should speed up significantly in order to achieve our common sustainability goals.



C

Increase in environmental risks

Over a ten-year horizon, environmental risk has increased 60%, where climate change and extreme weather are seen as the gravest threats.

D

Wind energy is key to achieving the energy transition

- Its role in power supply could be nine times larger: it could supply up to around 34% of global electric power demand in 2040 (up from 4% today). That is 14,000 TWh, equivalent to total power generation in China, Europe and USA today.
- It could provide around 23% of the carbon emission reductions needed in 2050: 5.6 billion ton CO_2 (equivalent to the yearly emissions of the 80 most polluting cities in the world, home to around 720 million people).
- Investment in clean technologies would approximately double by 2040 with respect current levels. Wind would move from a USD 110 billion to a USD 200 billion annual investment.

E

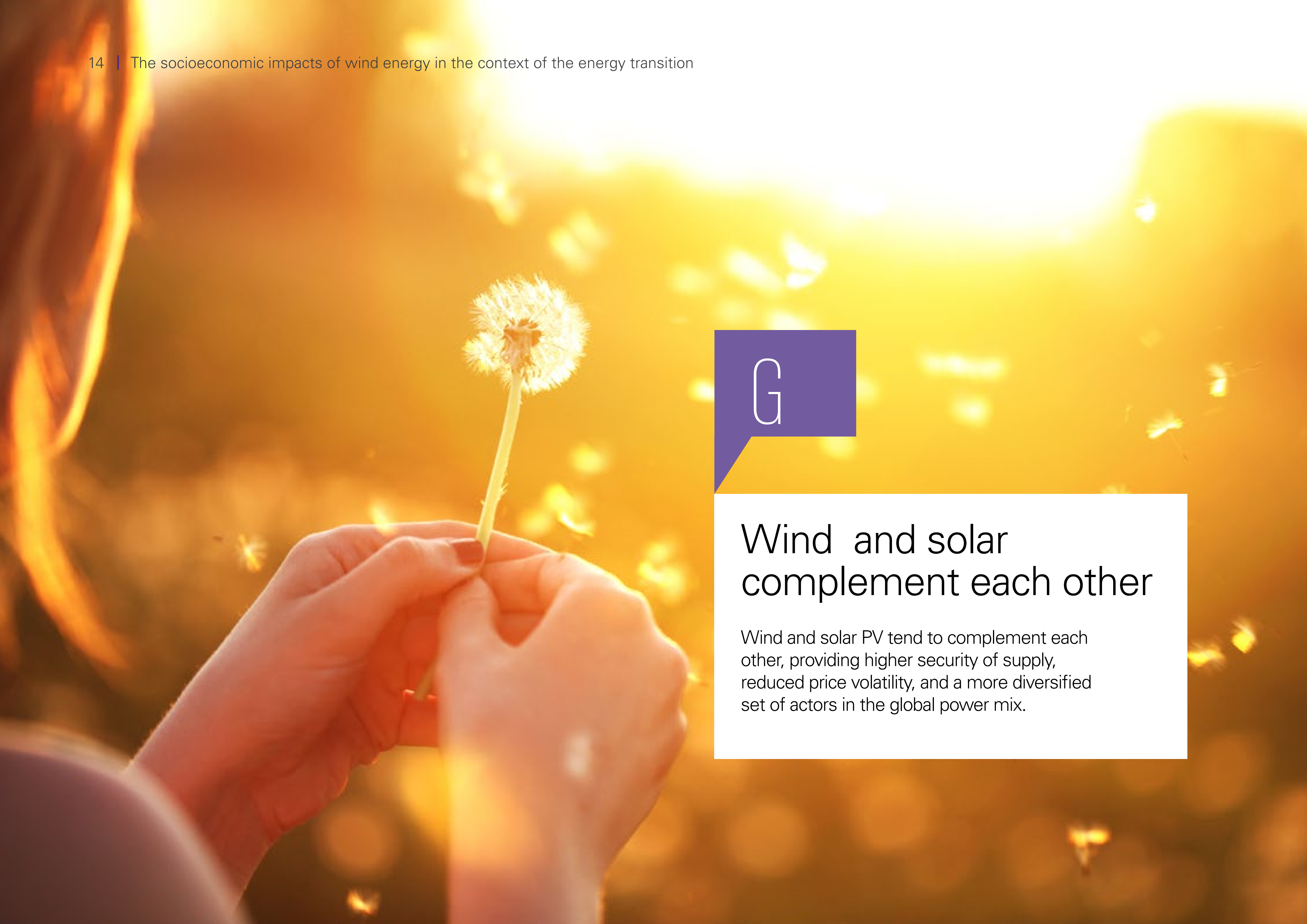
Wind power industry: a leading innovator

The wind industry is at the cutting edge of technological innovation, efficiency gains and cost reductions: turbine sizes and capacity factors have tripled, while generation costs have been reduced by 65% since 1990.

F

The advent of offshore wind

While onshore wind has been the dominant segment for years, offshore wind now grows faster, thanks to impressive technological advances and cost reductions. It presents important advantages, e.g. higher capacity factors, predictability, new economic opportunities in coastal areas (e.g northeast of the UK) and, if floating foundations keep improving, it could supply large coastal demand centres (40% of global population lives <100km from the sea).



G

Wind and solar complement each other

Wind and solar PV tend to complement each other, providing higher security of supply, reduced price volatility, and a more diversified set of actors in the global power mix.

H

Wind is key for sustainability

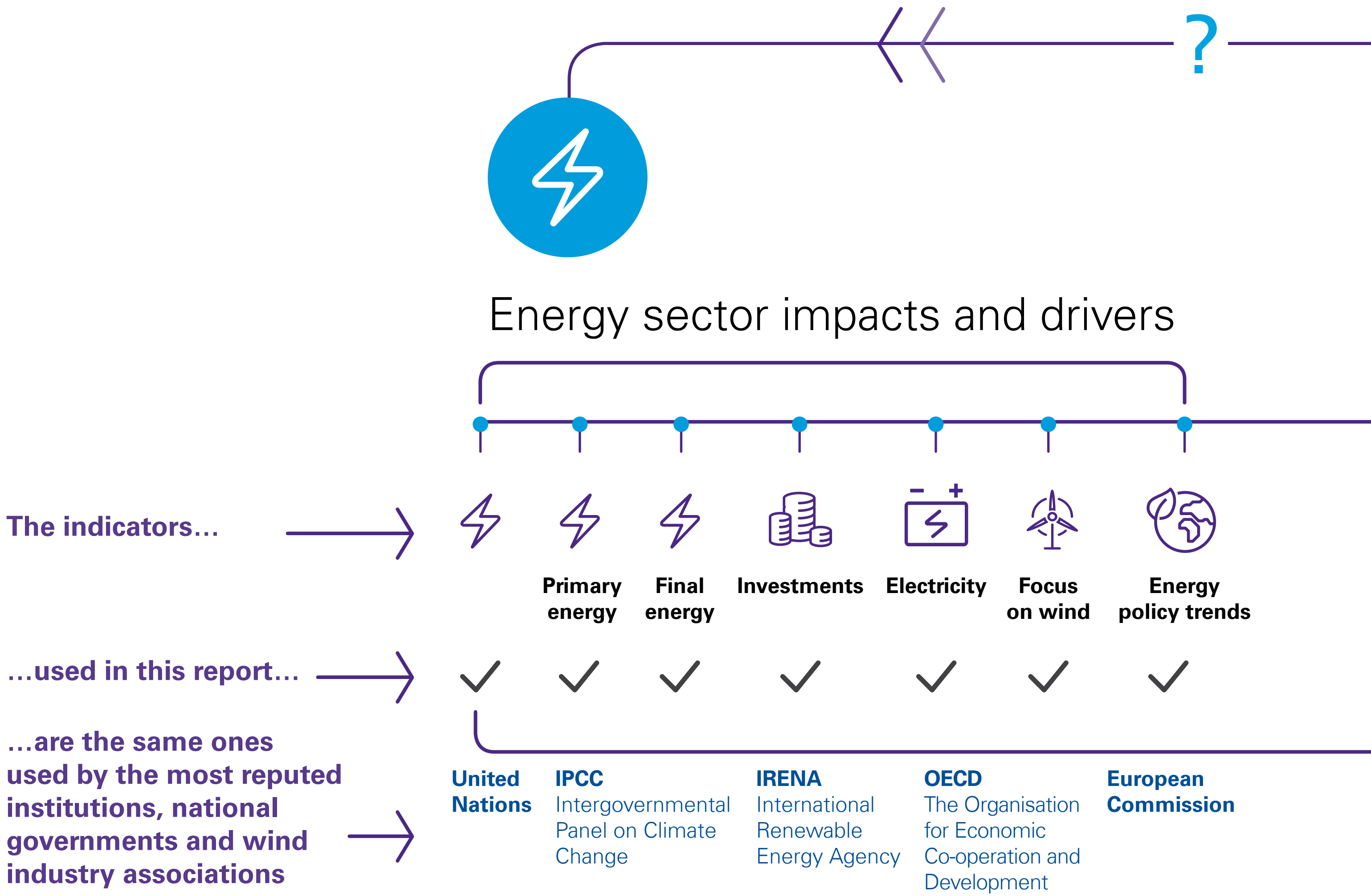
The renewable energy industry is core to many Sustainable Development Goals (SDGs), especially SDG 7, which focuses on access to affordable, reliable, and sustainable energy and SDG 13, which centers on urgent action to fight climate change. Globally, in a Sustainable Scenario*:

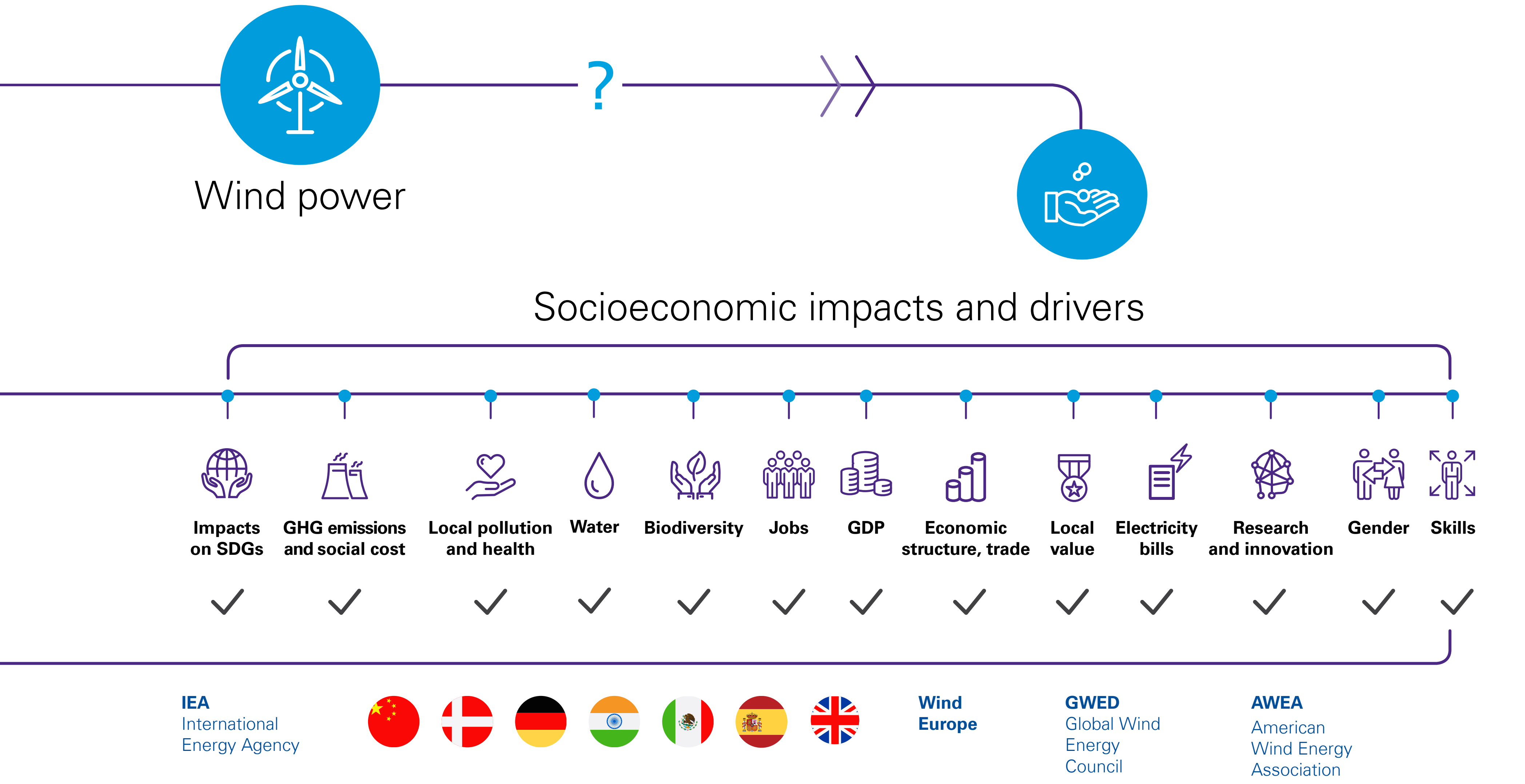
- Total final energy consumption from renewable sources is expected to grow to 22% (from 10% in 2017) and universal access to both electricity and clean cooking would be achieved, by 2030.
- The benefits of CO_2 reductions from wind in 2050 are estimated at $386 billion (reduced social cost), similar to Norway's GDP today.
- All renewables together would reduce air pollution enough to save up to 4 million lives per year in 2030.
- Wind power could save up to 16 billion m^3 of water in 2030 (around 15% of the Dead Sea water). In Europe alone, it would avoid the use of 1,571 million m^3 (the equivalent consumption of 13 million EU households).
- The wind industry could employ three times more people than today, from 1.1 to 3 million people (direct and indirect). Many of these jobs are local and qualified, adding significant economic value to most regions.

**Our Sustainable Scenario is a compilation of information from the energy transition scenarios from the most reputed, independent, international public sources such as IEA (Sustainable Development Scenario), IRENA (REmapCase) or Shell (Sky Scenario).*

Conceptual framework of the report

Measuring the socioeconomic impact of wind is a complex task. There are large knowledge gaps. This report follows the specific indicators that the most reputed and independent international organisations have used. Since wind energy is, in the end, *energy*, it first looks at energy sector impacts and drivers. Then, it looks at broader socieconomic issues.




Wind power
?
Socioeconomic impacts and drivers
Impacts on SDGs
GHG emissions and social cost
Local pollution and health
Water
Biodiversity
Jobs
GDP
Economic structure, trade
Local value
Electricity bills
Research and innovation
Gender
Skills
IEA
International Energy Agency
Wind Europe
GWED
Global Wind Energy Council
AWEA
American Wind Energy Association

2 Key trends and prospects for the global wind energy industry

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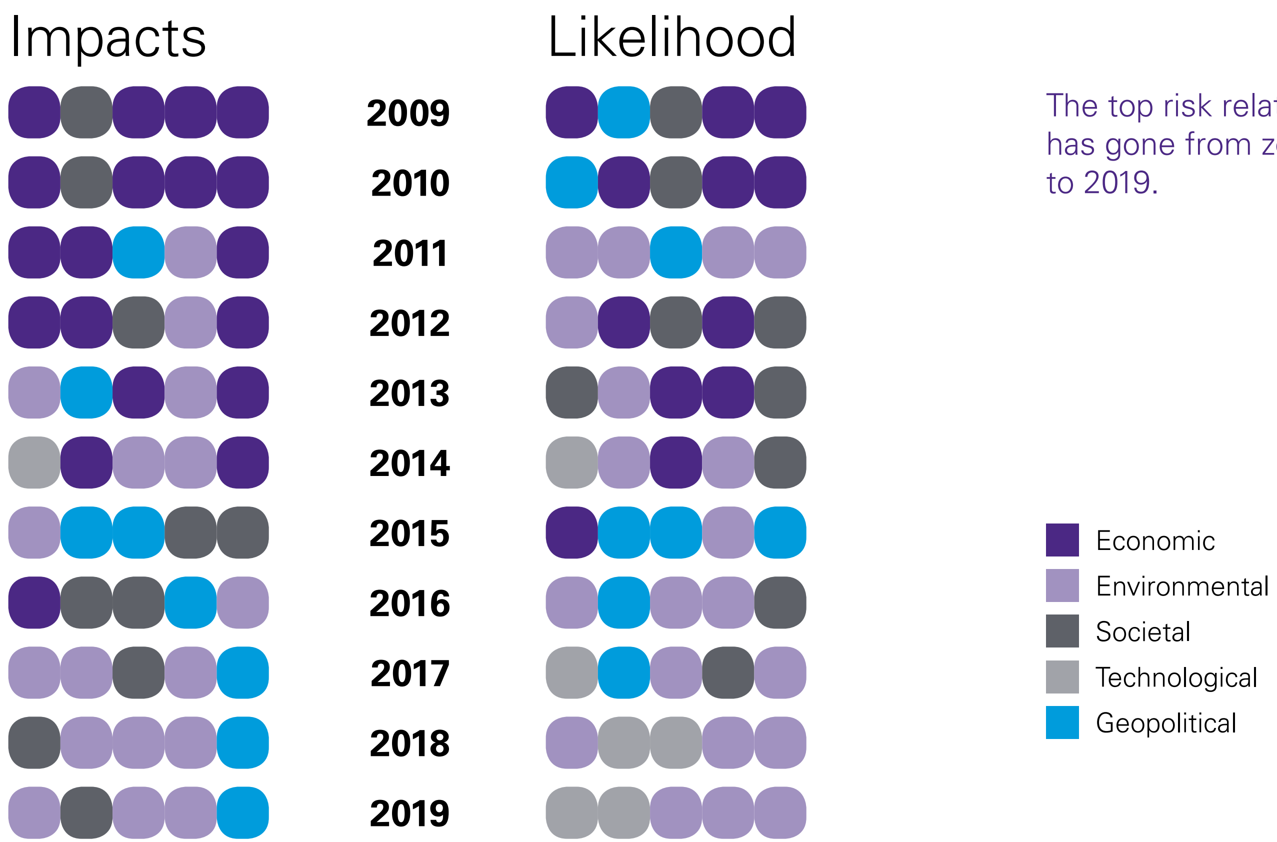
A

Climate change is already here

In the last decade, the risks associated with climate change have become important within the global agenda, as reflected in The Global Risk Report published by the World Economic Forum.

Top 5 risks in terms of:



The top risk related to climate change has gone from zero to 60% from 2009 to 2019.

...and facts

1. 2017 was the warmest year on record according to the WMO.

2. In November 2018, the tides rose 1.5 m above the sea level and 70% of Venice was submerged.

3. 2017 was the U.S.'s most expensive year for climate disasters on record: 16 Billion $.

4. In October 2018, 42 people died and 7,100 structures were destroyed in the deadliest wildfire in California history.

5. 60 per cent of wildlife worldwide has been lost in just over 40 years, and climate change is an increasing cause.

6. Climate change is impacting in the health through deadly heatwaves, spread of diseases, food security, clean air.

A

Source: *WEF (2019). "The Global Risks Report 2019".*

B

Large investors are embracing renewables

Large investors (many of them with a fossil-fuel legacy) are moving towards renewables. This signals a very clear change of focus and may underpin the growth in finance that is needed to fuel the energy transition.

- Close to 1,000 institutional investors with assets valued 6.2 trillion USD have committed to divest from fossil fuels, up from 52 billion USD four years ago - an increase of 11,900%. Norway´s 1 trillion USD wealth fund (raised precisely by selling Norwegian oil) is seriously considering divesting from oil and gas assets, and increasing exposure to renewables.
- Big shareholders are asking oil majors what their vision is for a low carbon future, e.g. recent actions by key European Oil majors, some of them completely changing their business and rebranding such as Orsted (former DONG) and Equinor (former Statoil).
- Most of investments in renewable energies come already from the private sector.

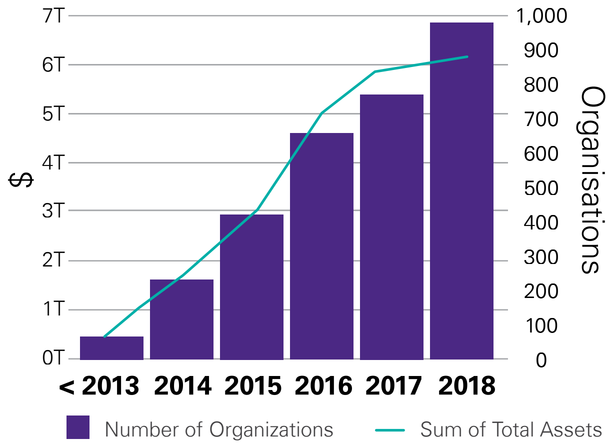
NEWS

Financial Times

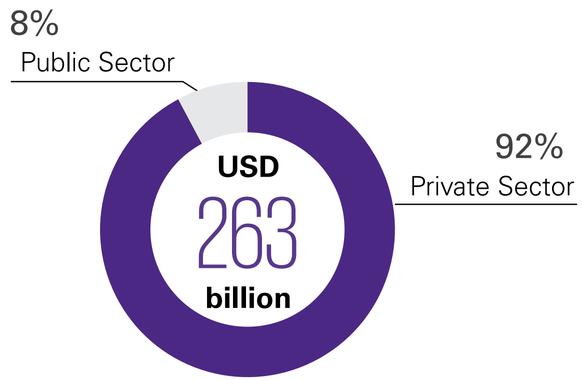
`Thank you Statoil! It's been a pleasure´: Oil major changes name

Rebrand reflects future as "broad energy company´ (not to be confused with an equine vet)

Growth in Divestment Commitments

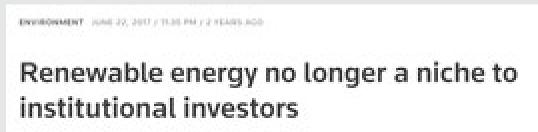


In 2016, private sector led the way in renewable energy investment



- Global "sustainable" debt market is booming: 247 billion USD in 2018, up 4,900% from 2012.
- The EU is examining how to integrate sustainability considerations into its financial policy framework in order to mobilise finance for sustainable growth.
- Renewable energy share is increasing in investment portfolios. Major commercial banks, hedge funds, pension and infrastructure funds increasing the weight of renewables in their investment portfolios.

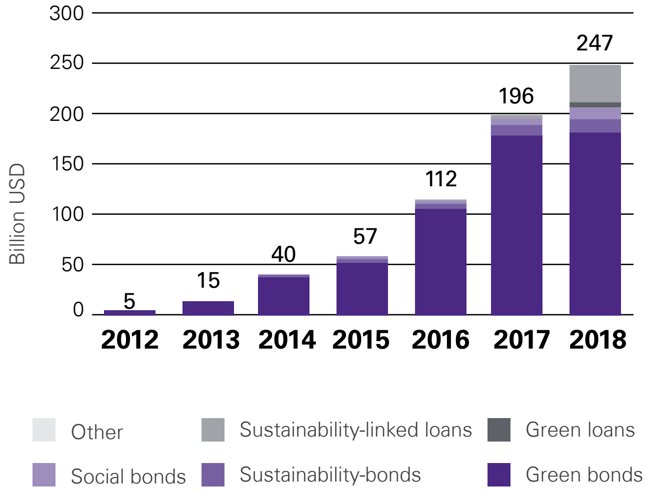
NEWS


Reuters

Renewable energy no longer a niche to institutional investors

"Five or six years ago, funds weren't specifically targeting renewable investment; today it's a key component of infrastructure investment," David Giordano, managing director and head of North American, Latin American and Asia Pacific investments at BlackRock, on the sidelines of the Renewable Energy Finance Forum in New York, 2017.

Global sustainable debt annual issuance, 2012-2018



B

Source: *IRENA (2018). "Corporate sourcing of renewables: Market and Industry trends". Arabella Advisors (2018). "The Global Fossil Fuel Divestment and Clean Energy Investment Movement". BNEF (2019). "Sustainable Debt Market Sees Record Activity in 2018". Financial Times (15th March 2018). "Thank you Statoil it's been a pleasure". Financial Times (3rd December 2015). "Google steps up its purchases of renewable energy". WEF (2019). "The Global Risks Report 2019". BloombergNEF, Bloomberg L.P; Note: 'Other' includes labaled blue bonds.*

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C

Energy consumers are increasingly looking to purchase renewable power

Among other signs, the volume of corporate PPAs (contracts signed between an energy consumer and a renewable energy producer) has soared in the last five years.

- Non-energy players are increasingly setting 100% RE targets, becoming self-consumers or purchasing renewable power. Corporations in 75 countries actively purchased 465 terawatt hours (TWh) of renewable electricity in 2017, a figure close to the yearly demand of France.
- The volume of PPAs has increased at a pace of 5 GW/year in the last three years, as a result, the cumulative volume of global corporate PPAs has quadrupled with respect to 2014 levels.

Financial Times

Google steps up its purchases of renewable energy

RE 100

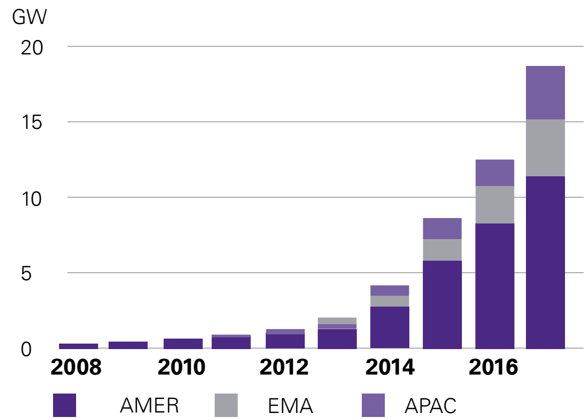
RE-Source
European platform for corporate renewable energy sourcing

REBA
Rapid Entire Body Assessment

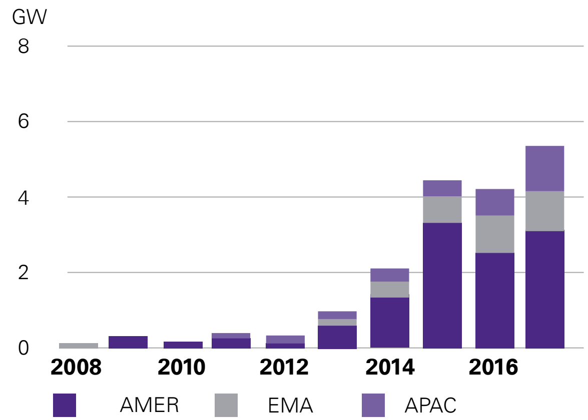
** AMER: North, Central and South America. EMEA: Europe, Middle East, and Africa. a APAC: Asia pacific region.*

Global Corporate PPA Volumes

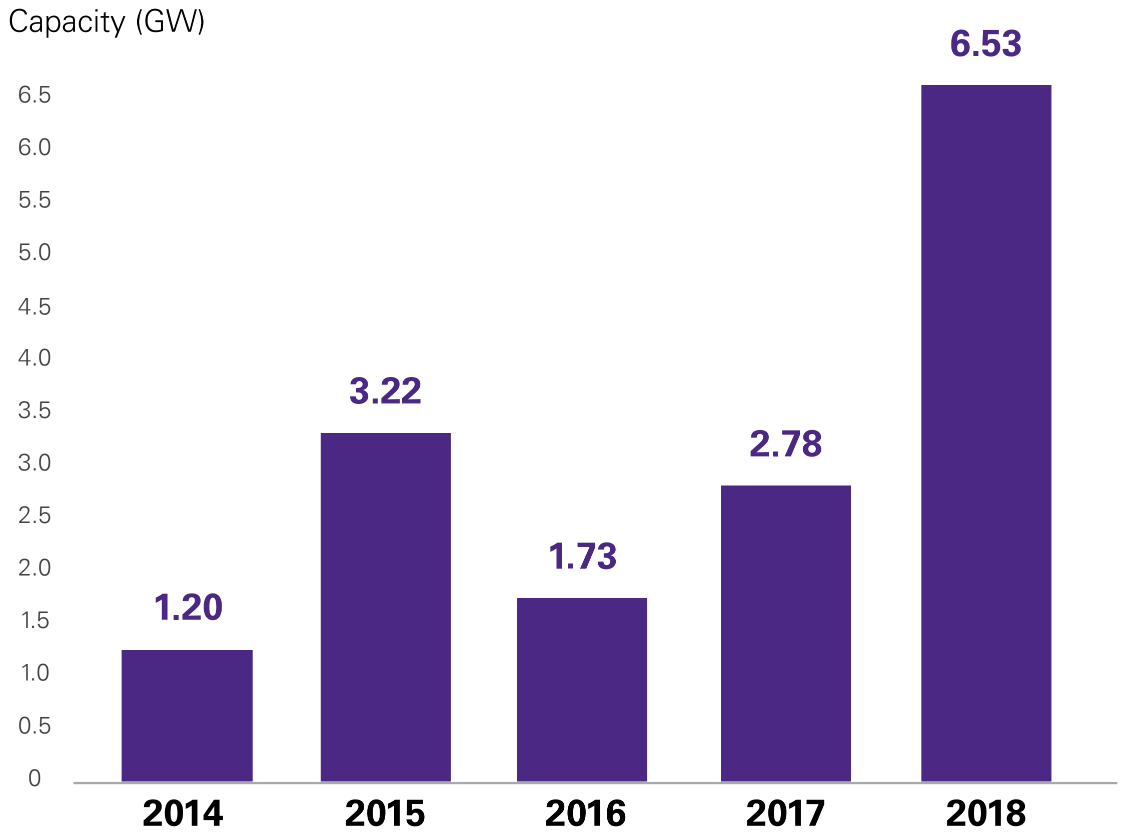
Cumulative



Annual



Corporate Renewable Deals 2104-2018



C

Source: Liebreich Associates (2018) "Global Trends in Clean Energy and Transportation"; Business Renewables Center. As of Decembre 31, 2018. Publicly announced contracted capacity of corporate Power Purchase Agreements, Green Power Purchases, Green Tariffs, and Outright Proyect Ownership in the US, 2014 - 2018. Excludes on-site generation (e.g., rooftop solar PV) and deals with operating plants.

"In recent years, Commercial & Industrial (C&I) companies have stepped up their ambitions to become essential drivers of the renewable energy transition. We have seen a sharp increase in companies committing to sourcing 100% of energy from renewables and numerous examples of companies using pioneering approaches to developing additional renewable energy generation."

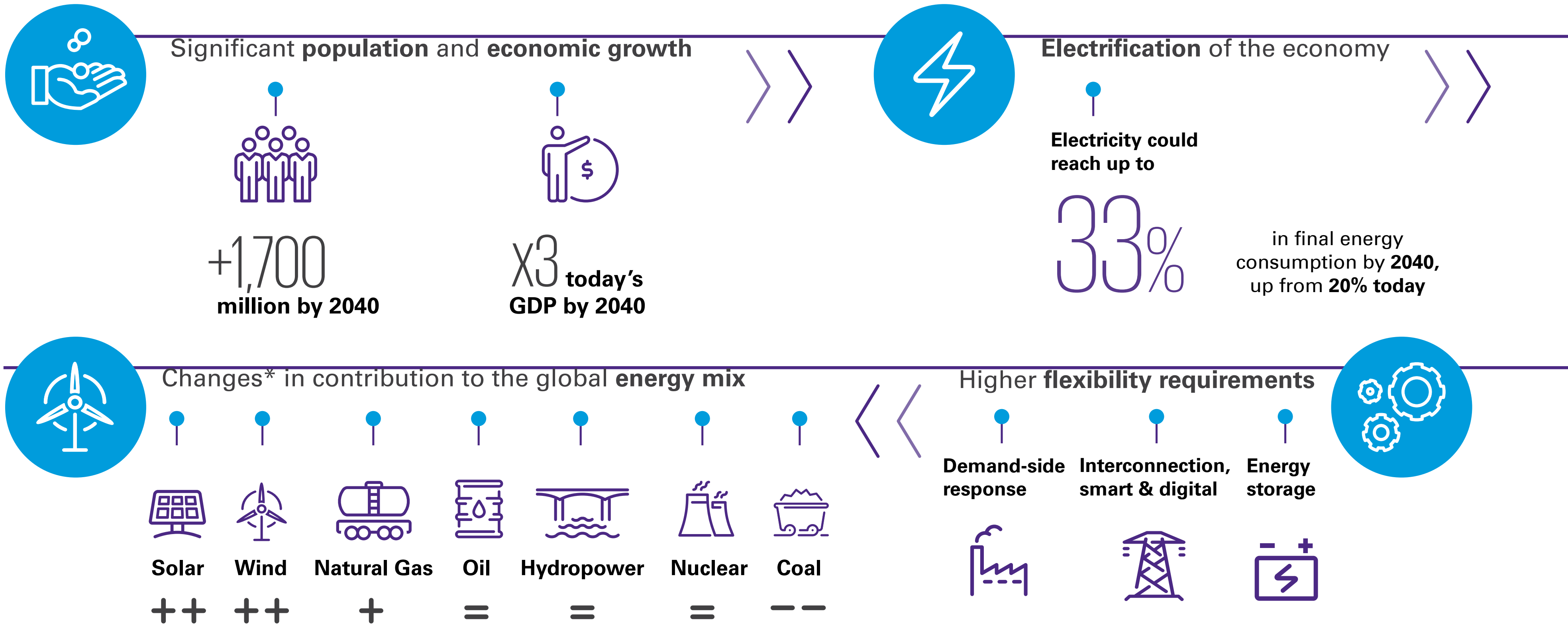
María Mendiluce

Managing Director, Climate, Energy and Circular Economy at World Business Council for Sustainable Development

D

Energy trends that seem to have consensus worldwide

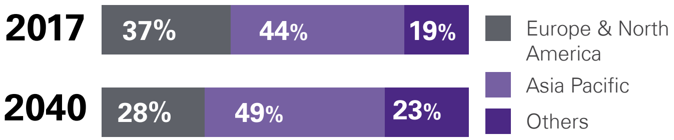
In this context of growing environmental risk and shifting investments, technology is also advancing fast. As such (and independently of the degree of ambition in policies actually implemented to mitigate climate change) the global energy system will be characterised by:



*Summary of the "sentiment" in key reference / business as usual forecasts.

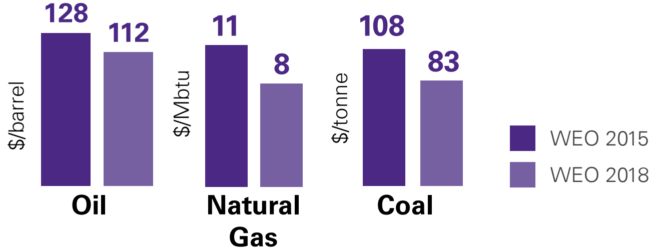
New geography of energy supply and demand

Share in final energy consumption



Lower price growth in fossil fuels

Commodities' prices in 2040 in a business as usual scenario



D

Source: *KPMG from IRENA, IEA, BNEF.*

E

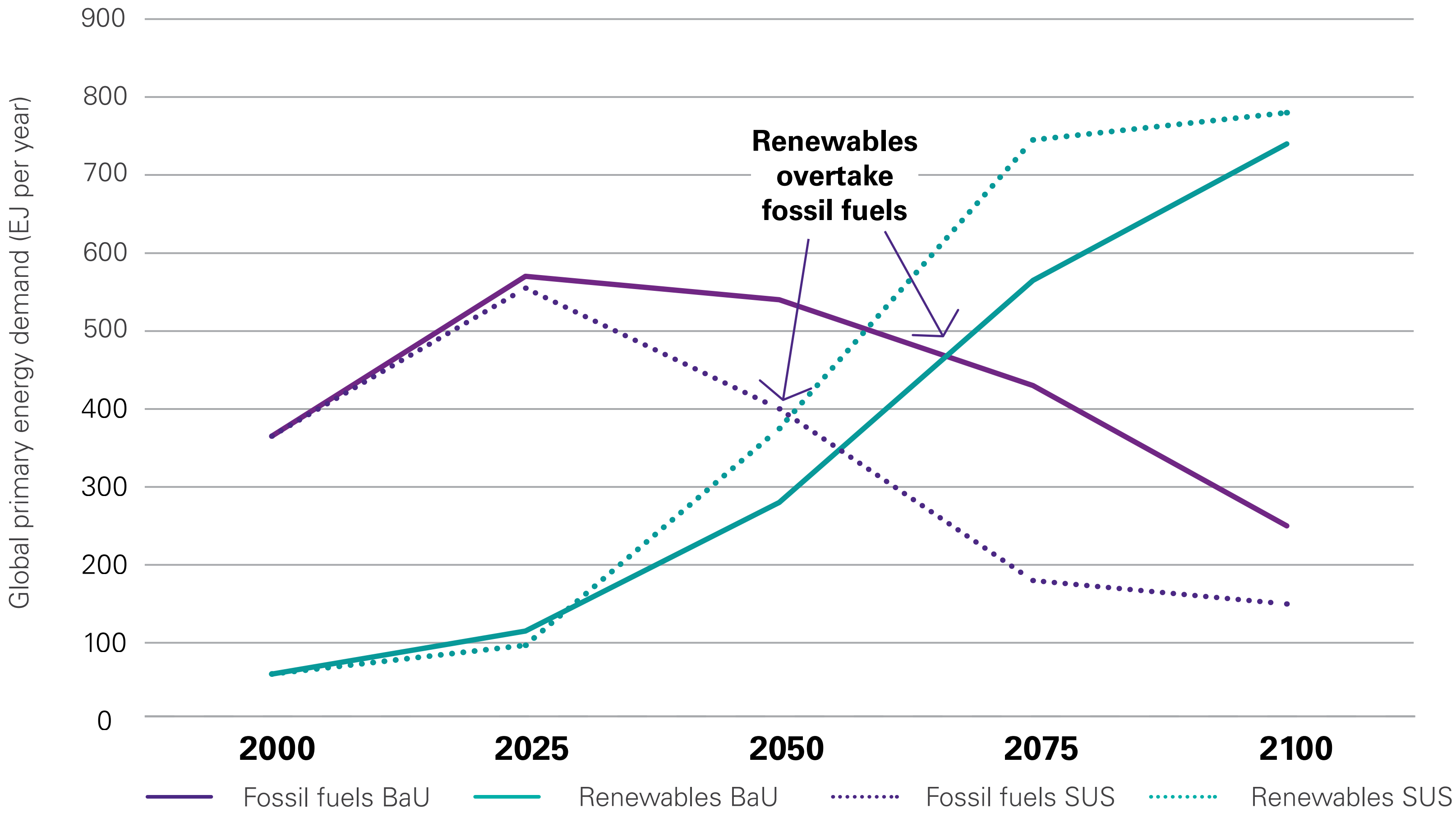
A faster energy transition is needed to achieve sustainability

But such a "consensus" energy sector will not necessarily evolve towards sustainability. A faster energy transition is needed for that. Although the speed of such an energy transformation is uncertain, and very dependent on policy ambition, most forecasters tend to agree on two factors: an eventual peak in fossil fuel use and a rapid uptake of renewables.

The energy transition revolves around the world's commitment to comply with energy-related sustainable **development goals:**

1. **Universal access to affordable & clean energy**
2. **Substantial reduction in air pollution**
3. **Limit the rise in global temperature to *well-below* 2°C above pre-industrial levels**

View of an oil company on the energy transition (Shell's Sky scenario as SUS, and Oceans scenario as BaU)



E

__Source:__ Shell (2018) "Energy Transition Report'.

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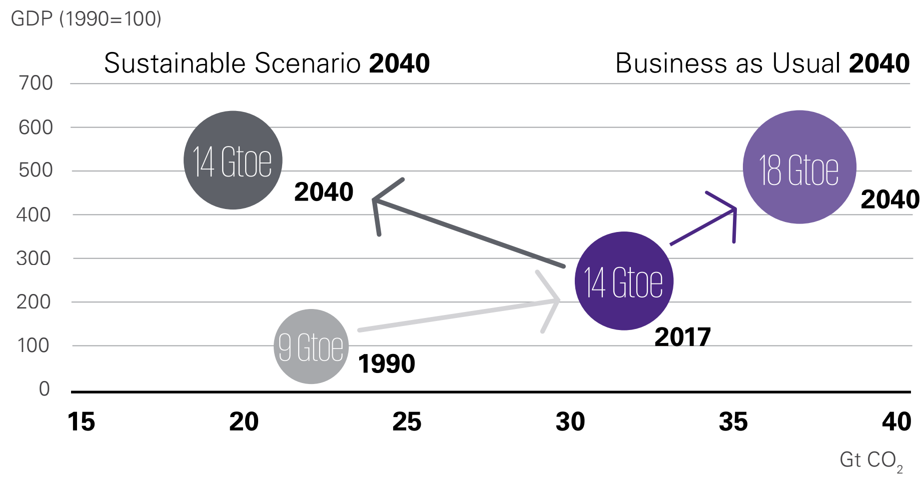
F

The energy transition involves a decarbonized economic growth

Focusing on the goal of limiting climate change, the societal challenge is huge: we should profoundly change our pattern of economic growth. From a carbon-intensive GDP growth to a decarbonized GDP growth, tripling our GDP while keeping global energy demand constant.

Global energy-related CO_2 emissions (Gt CO_2), primary energy demand (Gtoe) and GDP evolution



by 2040, global annual energy-related CO_2 emissions must be reduced by 46-58% **from today's levels**

To achieve sustainability goals, the current strong link between economic growth and fossil fuel use must break. This means a complete reversal of historic trends.

Which road should the world take?

1. **Energy efficiency**

2. **Low-carbon sources**

3. **Strong policy action**

F

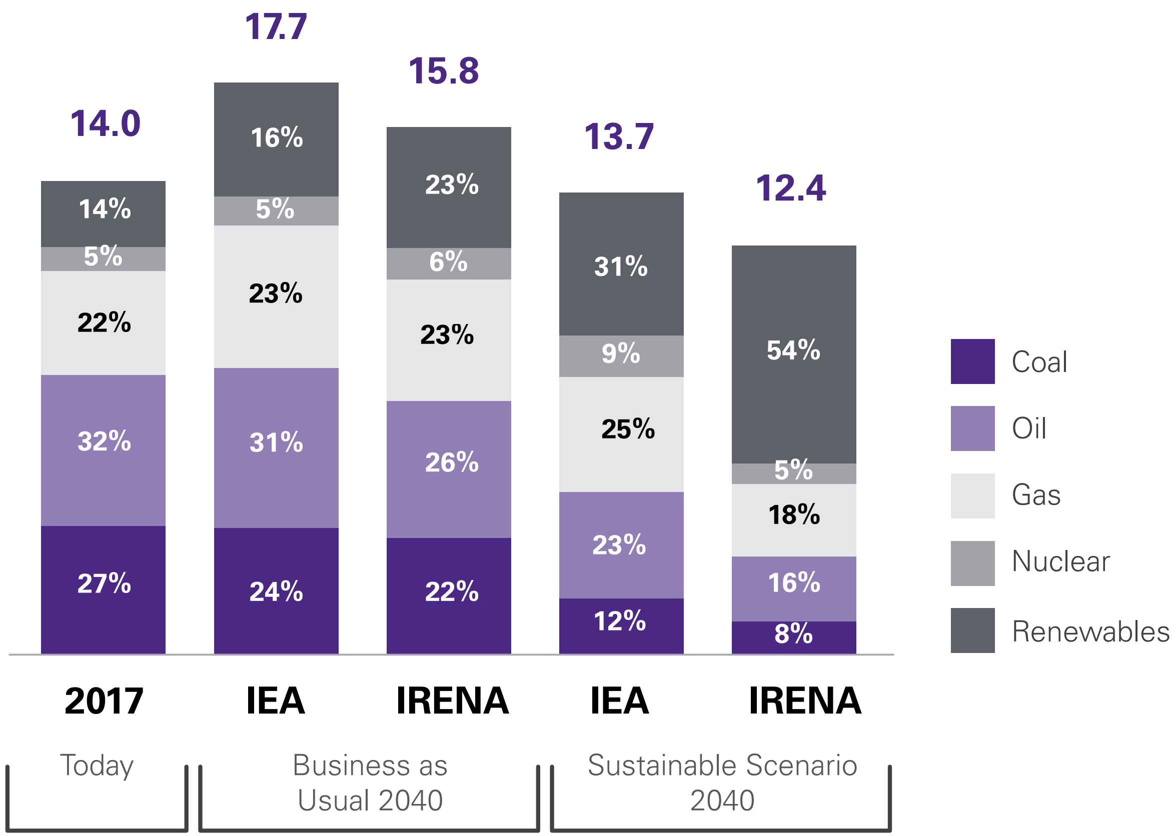
Source: IEA (2018), "World Energy Outlook 2018". IRENA (2018), "Global Energy Transition 2018".

G

The global mix would be very different in a sustainable scenario

Under a scenario where sustainability goals are achieved, energy efficiency keeps global energy demand at today's levels in spite of economic growth, while fossil fuels loose significant market share.

Primary energy demand
Gtoe



G

Renewables shift positions with coal and oil by 2040. While the second are halved, renewables more than double their share by 2040.
For the International Renewable Agency (IRENA), the potential of renewables and energy efficiency is higher than for the International Energy Agency (IEA). In addition to renewables and efficiency, the IEA foresees the achievement of sustainability goals through the deployment of nuclear and CCUS*.

Scenarios

The **business as usual scenario** considers the impacts on the energy sector of those policies and measures approved and implemented in countries` legislation as of mid-2018 (e.g. IEA's New Policies Scenario).

The **sustainable scenario** starts from the three energy-related Sustainable Development Goals to be achieved and then assesses what combination of actions would deliver them (and is mainly based on IEA's Sustainable Development Scenario and on IRENA's REmap case).

**CCUS: Carbon Capture, Utilization and Storage*

G

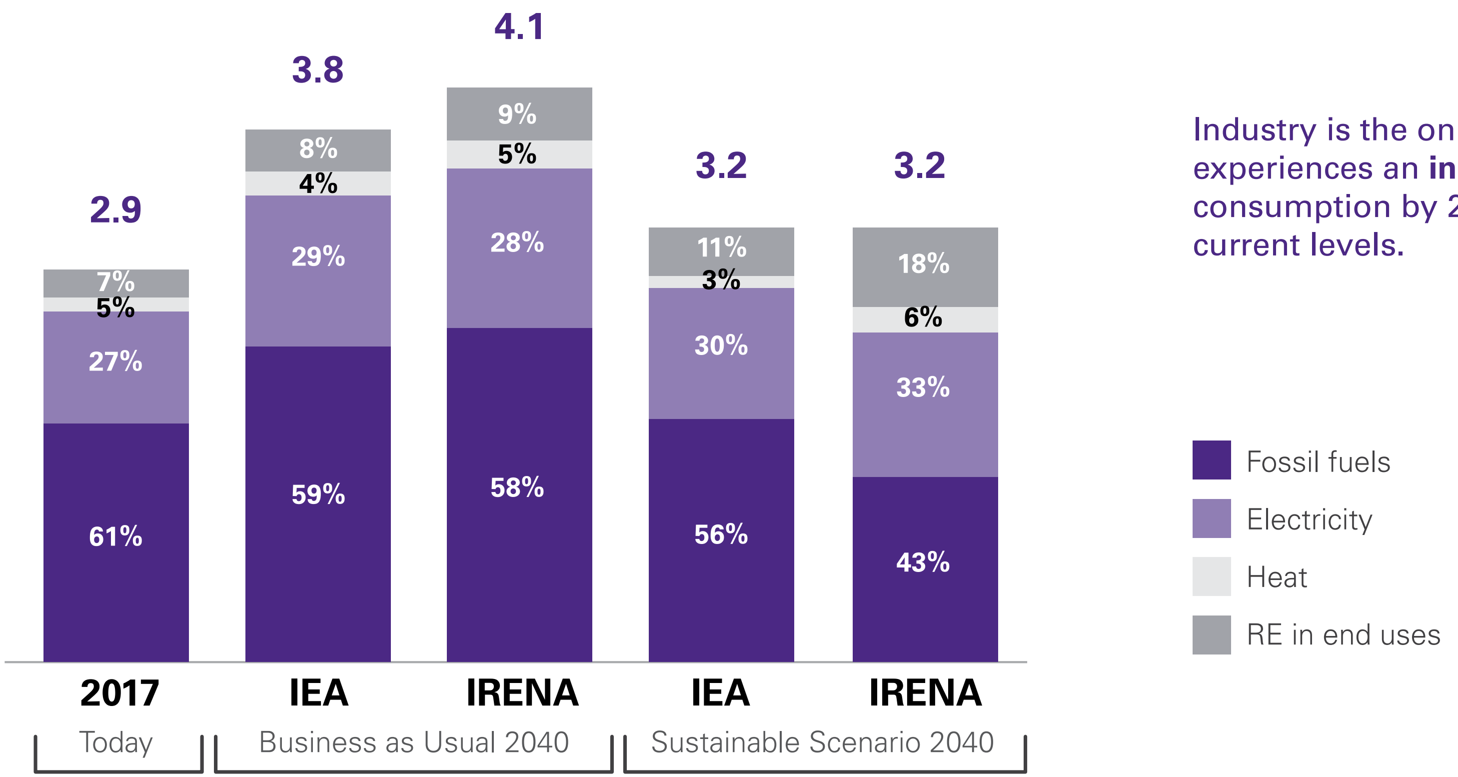
Source: *IEA (2018), "World Energy Outlook 2018". IRENA (2018), "Global Energy Transformation: A roadmap to 2050".*

H

Large changes also in all economic sectors consuming energy

Buildings would electrify and remain the largest consumer of electricity. Power consumption in the transport sector would more than double vs the BaU (electric mobility). Industry is the sector that changes the least.

Industry
Gtoe



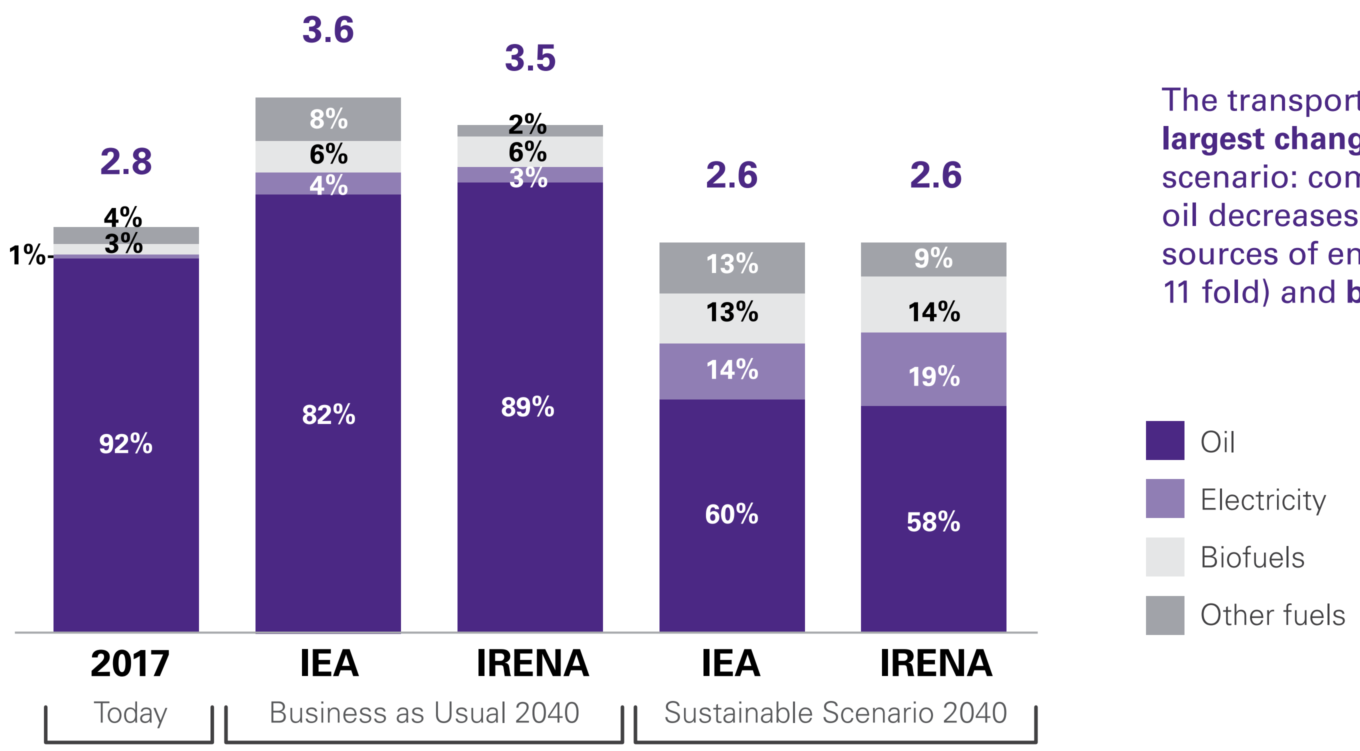
Industry is the only sector that experiences an **increment** in consumption by 2040 with respect to current levels.

H

Source: IEA (2018), "World Energy Outlook 2018". IRENA (2018), "Global Energy Transformation: A roadmap to 2050".

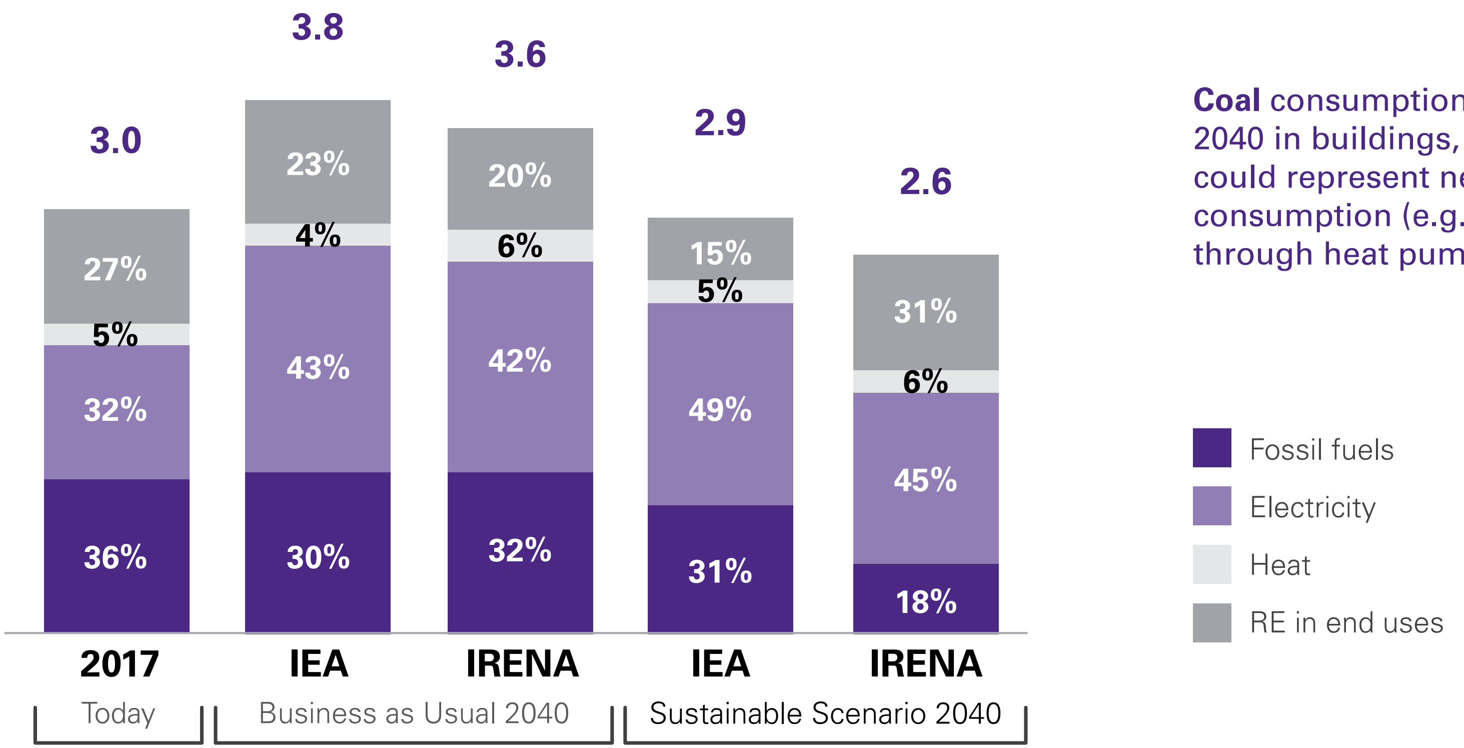
H

Transport
Gtoe



The transport sector presents the **largest change** under the sustainable scenario: compared to current levels, oil decreases by 40%, due to alternative sources of energy like **electricity** (grows 11 fold) and **biofuels.**

Buildings (residential, commercial, etc.)
Gtoe



Coal consumption is eliminated by 2040 in buildings, while **electricity** could represent nearly half of total consumption (e.g. large electrification through heat pumps).

H

Source: IEA (2018), "World Energy Outlook 2018". IRENA (2018), "Global Energy Transformation: A roadmap to 2050".

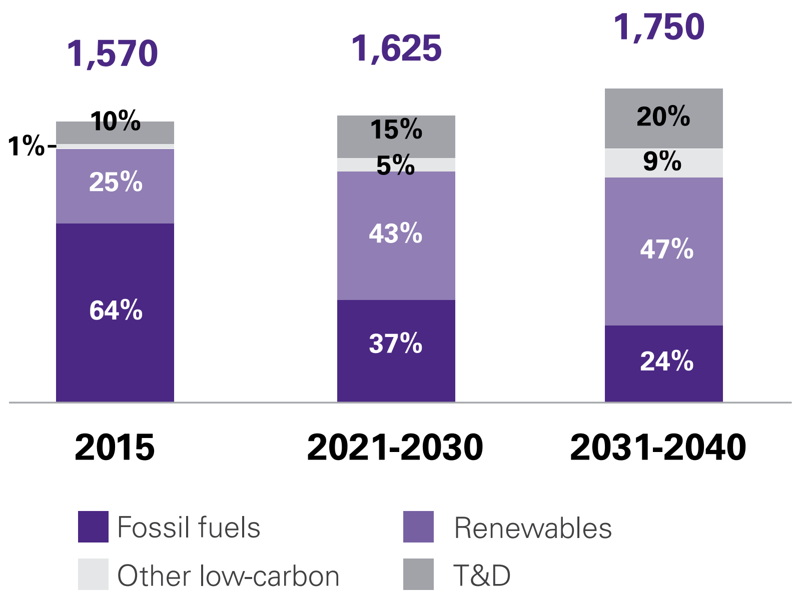
Investment patterns radically change, with power at the core

To achieve a sustainable scenario, energy investment would change completely. On the supply side, total investment volumes stay in today's levels but shift destination. On the demand side total investments would grow 500%.

Investments in the sustainable scenario*

On the supply side, overall investments remain at current levels, but their destination dramatically shifts. Investments in fossil fuels would decline, leaving space to renewables (that nearly double their investment share), power grids and, to a lesser extent, nuclear.

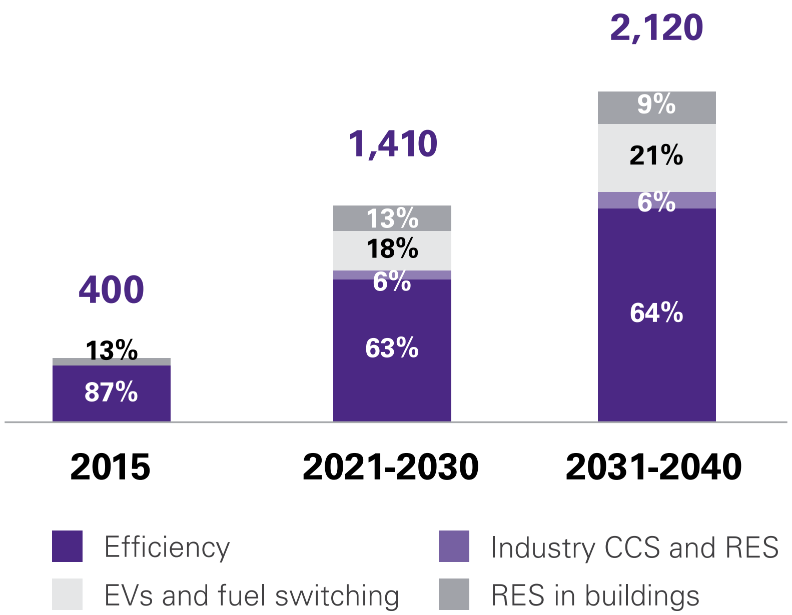
Investments in energy supply, 2015 USD billion, annual average



*Only the sustainable scenario is represented, because it portrays the largest change in investment patterns

On the demand side, investments multiply by five, mainly targeted to energy efficiency measures, electric vehicles and switching fuels (e.g. from oil to biofuels or gas in transport sector).

Investments in energy demand, 2015 USD billion, annual average



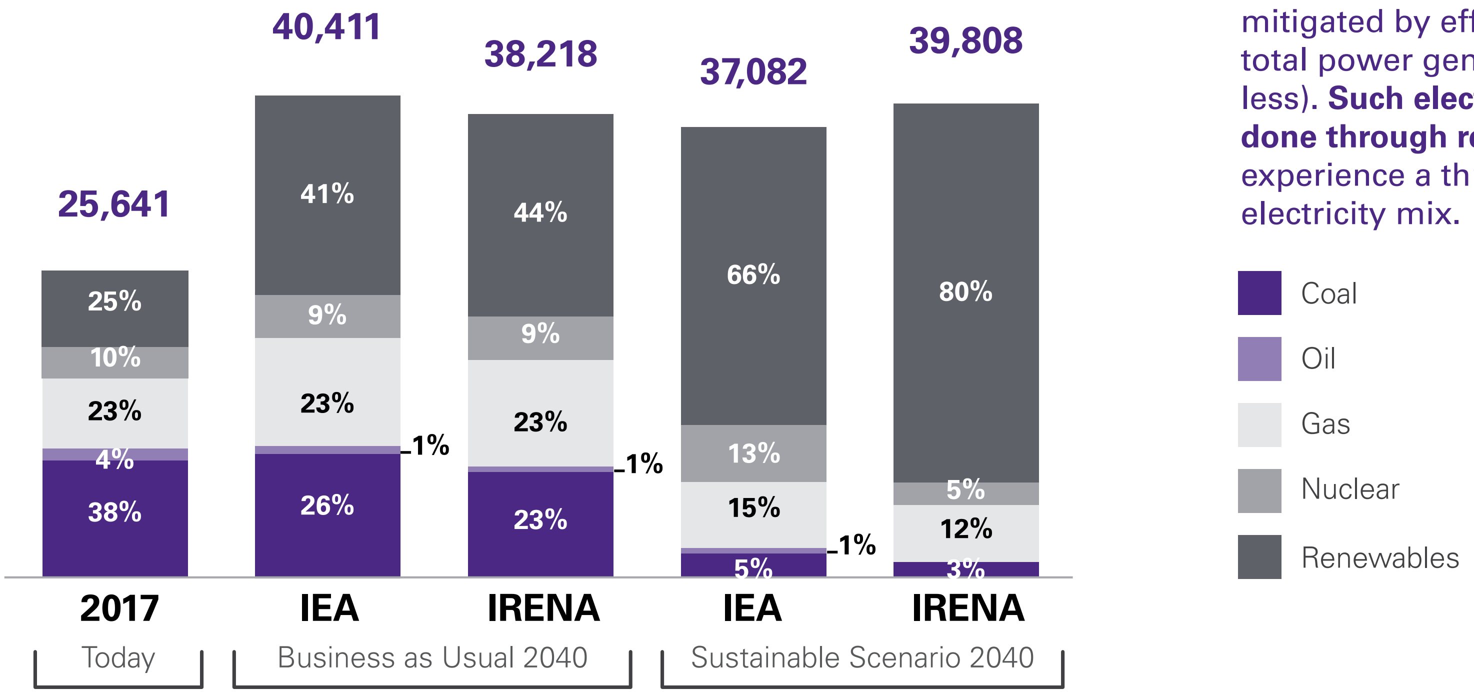
Source: *IEA and IRENA (2017). "Perspectives for the energy transition: Investment needs for a low-carbon energy system".*

J

The electricity mix would undertake the deepest transformation

Under the sustainable scenario, a largely decarbonized power sector would become the backbone of a much more electrified economy. Renewables would be the bulk of power generation.

Electricity generation
TWh



The economy electrifies: total electricity generation is expected to increase by at least 37%, somehow mitigated by efficiency gains (i.e. total power generation grows less). **Such electrification is mainly done through renewables,** which experience a threefold increase in the electricity mix.

J

Source: IEA (2018), "World Energy Outlook 2018". IRENA (2018), "Global Energy Transformation: A roadmap to 2050".

“The main challenges of today’s energy sector are:

Decarbonization of power supply, mobility and cooling & heating. Particularly, in cities.

Integration of variable renewables at large scale and popularization of RE also to provide ancillary services

Decentralization of energy services in urban settlements.”

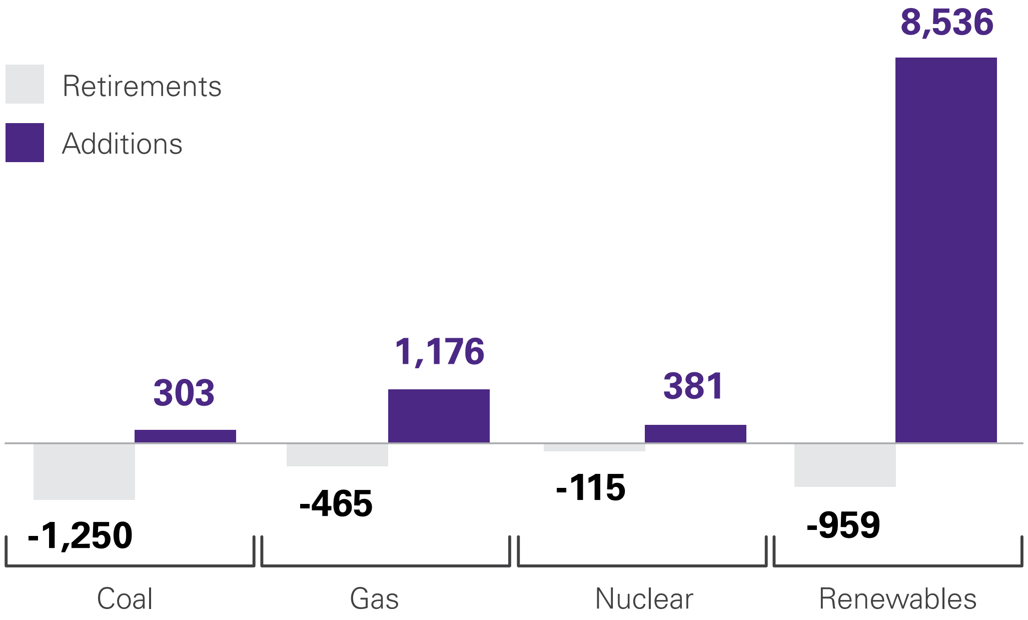
Tabaré A. Currás
Global Energy Advisor

K

Shift in new power generation capacity

Almost all new power generation capacity would be renewable- or gas-based.

Power generation capacity additions and retirements
Cumulative 2018-2040, GW, sustainable scenario.*



**Only the sustainable scenario is represented, because it portrays the largest change in investment patterns.*

K

Source: *IEA and IRENA (2017). "Perspectives for the energy transition: Investment needs for a low-carbon energy system". IRENA (2019), "Renewable capacity highlights".*

"The share of renewables in new electricity generation capacity has increased from about 25% in 2001, passing 50% in 2012 to reach 63% in 2018."

IRENA, 2019

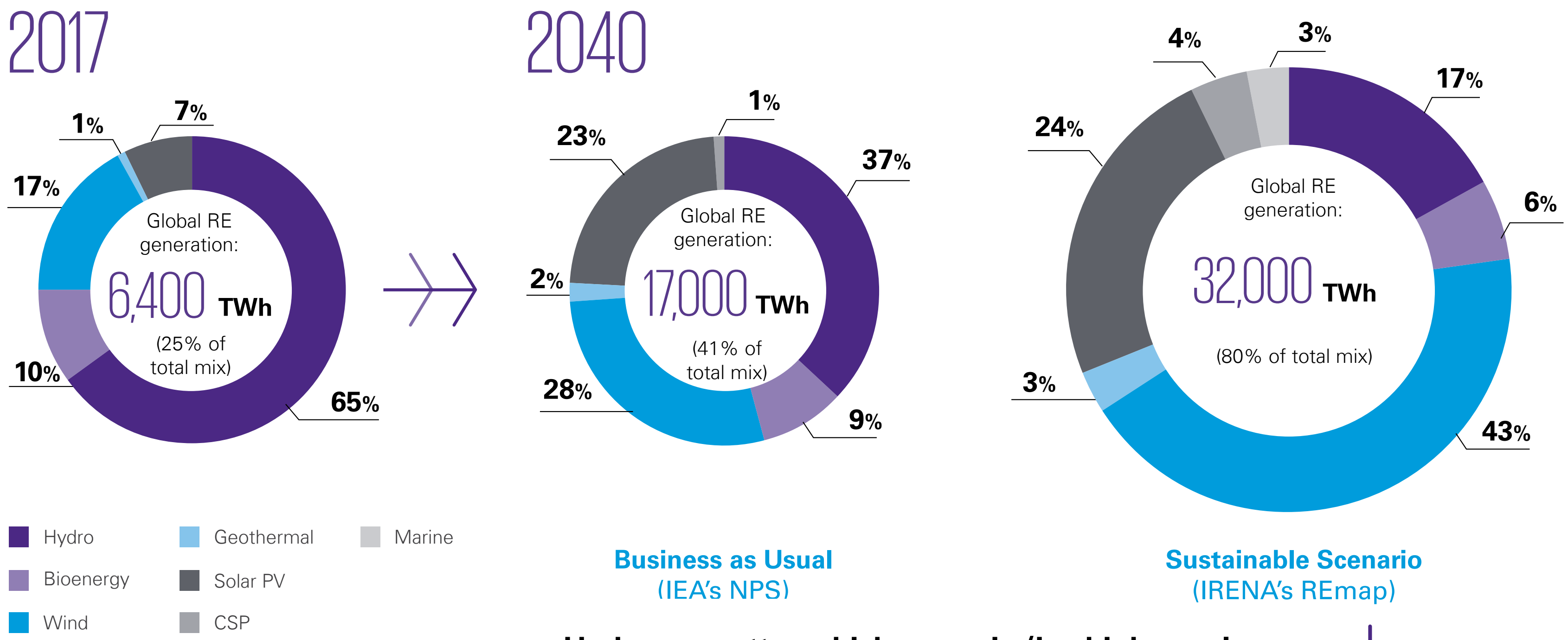
" Renewable capacity highlights"

L

Wind could supply up to 34% of global electricity

Wind (both onshore and offshore) would play a significant role in the energy transition, adding up to 4,000 GW by 2040. Whereas today hydropower is the main renewable source of power globally, in the future wind, hydro and solar PV will share the podium.

Under a sustainable scenario, solar PV and wind generation will boost, diversifying the renewable electricity mix away from hydropower.



Under no matter which scenario (i.e. higher or lower renewable energy deployment), the wind industry (both onshore and offshore) is expected to keep growing, at least moderately.

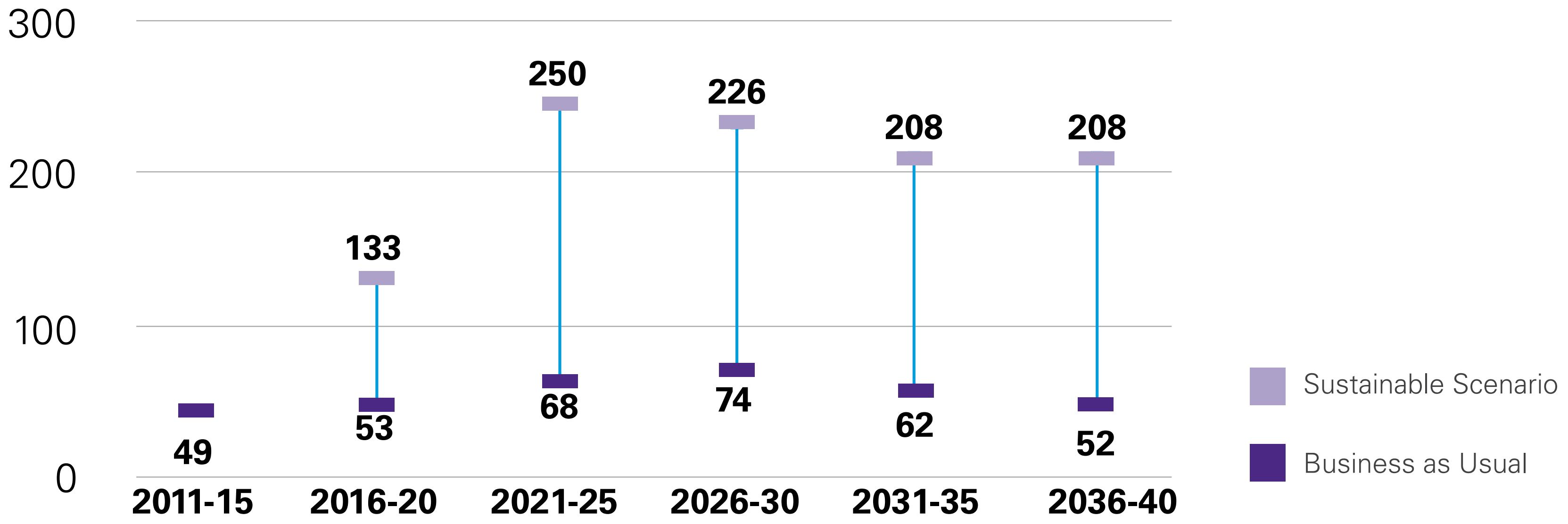
L

Source: *IEA (2018), "World Energy Outlook 2018". IRENA (2018), "Global Energy Transition 2018".*

L

The size of the wind market could be 4 times bigger.

Wind capacity additions (onshore plus offshore)
Period annual average (GW/y)



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Source: *IEA (2018), "World Energy Outlook 2018". IRENA (2018), "Global Energy Transition 2018".*

"Today's energy sector has already shown strong steps towards transitioning into a more sustainable system. The challenge that still lies ahead is to ramp up the pace of change in order to achieve the complete transformation needed to fulfil the objectives of the Paris Agreement. A clean energy system needs diversity, requiring both public and private sector actors to approach the challenge from every possible angle, and implement a range of solutions that work in parallel, complement each other and reinforce each other."

María Mendiluce
Managing Director, Climate, Energy and Circular Economy at World Business Council for Sustainable Development

KPMG

M

Wind and solar tend to complement each other

Indeed, wind and solar PV are not competitors but complements: higher security of supply, reduced price volatility and better use of synergic energy resources, among others. Together with hydropower and other flexible, low-carbon, generation they will be the power mix of the future.

Complementarity in power system expansion

1.

Climate synergies climate variability and adequacy of supply

2.

Ownership diversification
large and small scale developers, more actors

Complementarity in power system operation

3.

Seasonal complementarity
use wind when there is no sun, and vice versa

4.

Portfolio diversification
a diversified power mix is less volatile

Higher supply reliability

Higher supply adequacy

Lower variability

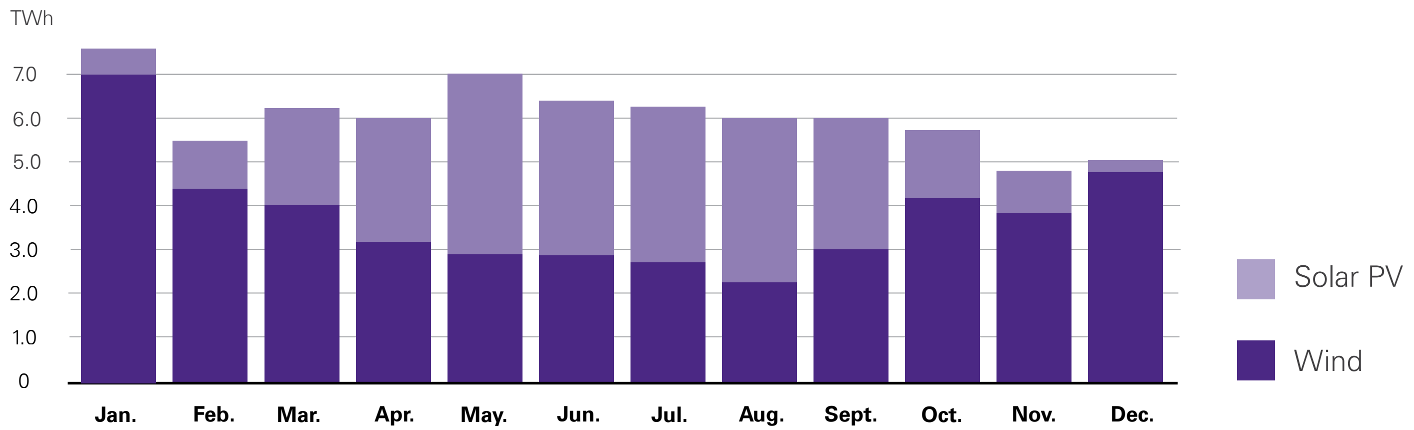
Lower impacts on the grid

Lower short-term volatility of prices

Declines in market concentration reduce opportunities to exercise market power

The availability of wind and sun is complementary in many parts of the world: when it is windy it tends to be less sunny and vice versa.

Monthly complementarity of wind and solar PV technologies in Germany, 2012 (TWh)



M

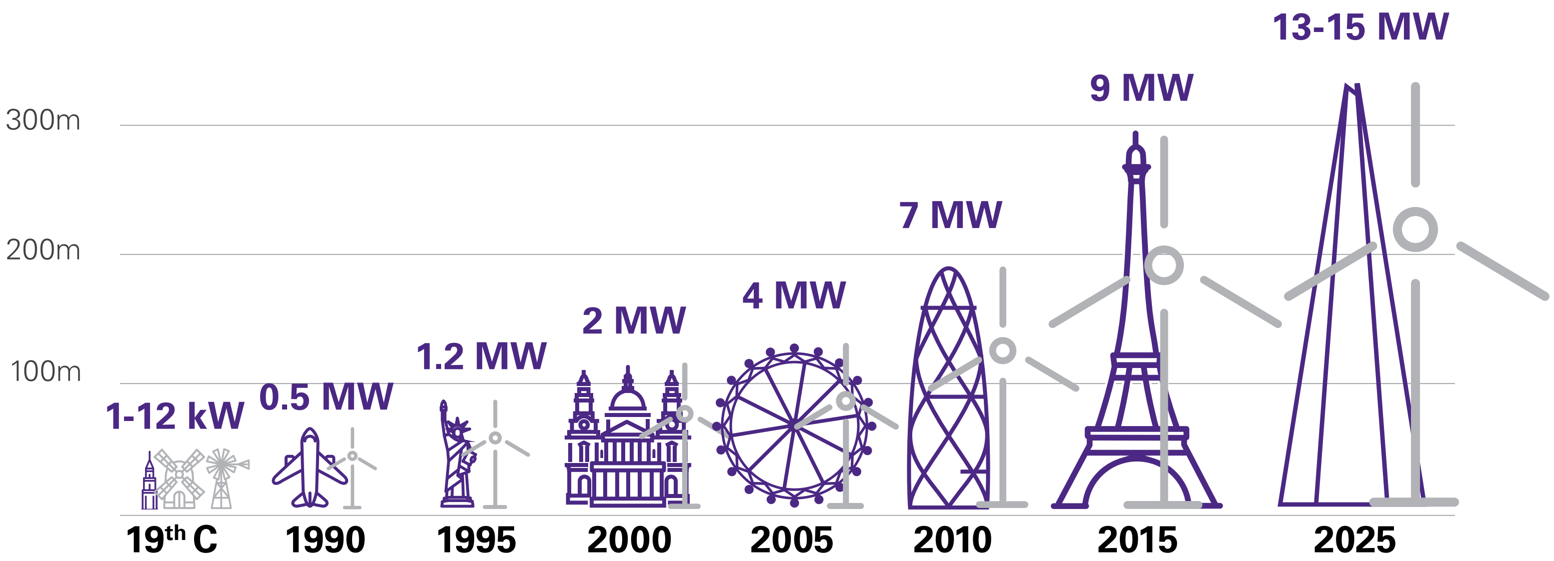
Source: IRENA (2018), "Global Energy Transition 2018". Shahan. Z. (2014), "Solar & Wind power are a match made in heaven".

N

Wind could play such a role thanks to the huge technical advances…

The onshore and offshore wind industry is at the cutting edge of technological innovation and efficiency gains. Taller towers, larger turbines with longer blades, and improved aerodynamics, among others, greatly increase energy yields and raise capacity factors.

Maximum wind turbine heights and power output



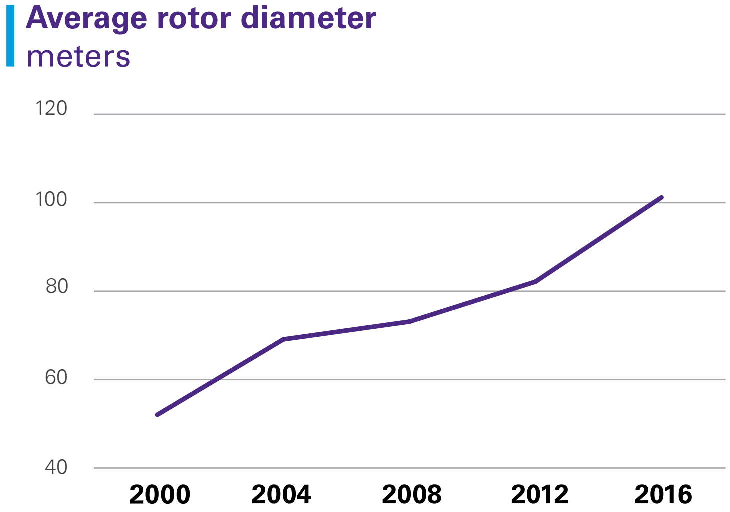
**Illustrative figure to show the cutting edge of the industry, where higher and bigger turbines correspond to offshore wind. According to FTI research, the average size of turbines installed in 2017 was 2.4 MW.*

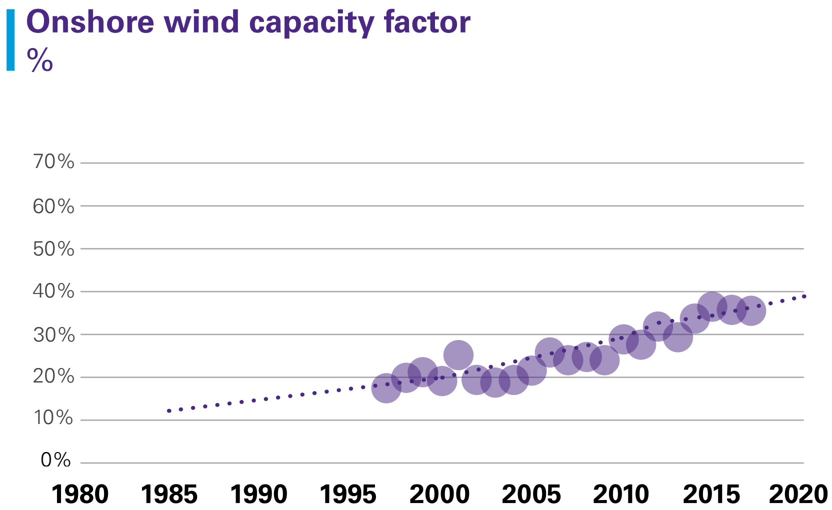
Bigger turbines allow for better energy yield in locations with lower wind speeds, less land use and fewer infrastructures.

Smarter operation and maintenance thanks to **IT developments and digitalisation** (e.g. supercomputers used for predictive maintenance or meteorological forecasts).

New turbine models, allowing lower wind sites to be economically feasible.

Larger rotors and higher hub heights can derive in **higher capacity factors.**





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Source: *Liebreich Associates (2018). "Global Trends in Clean Energy and Transportation". FTI (2017). "Global Wind Market Update - Demand & Supply 2017". Giannakopoulou, E. (2018) "The Power Transition – Trends and the Future" (3er HAEE Conference".*

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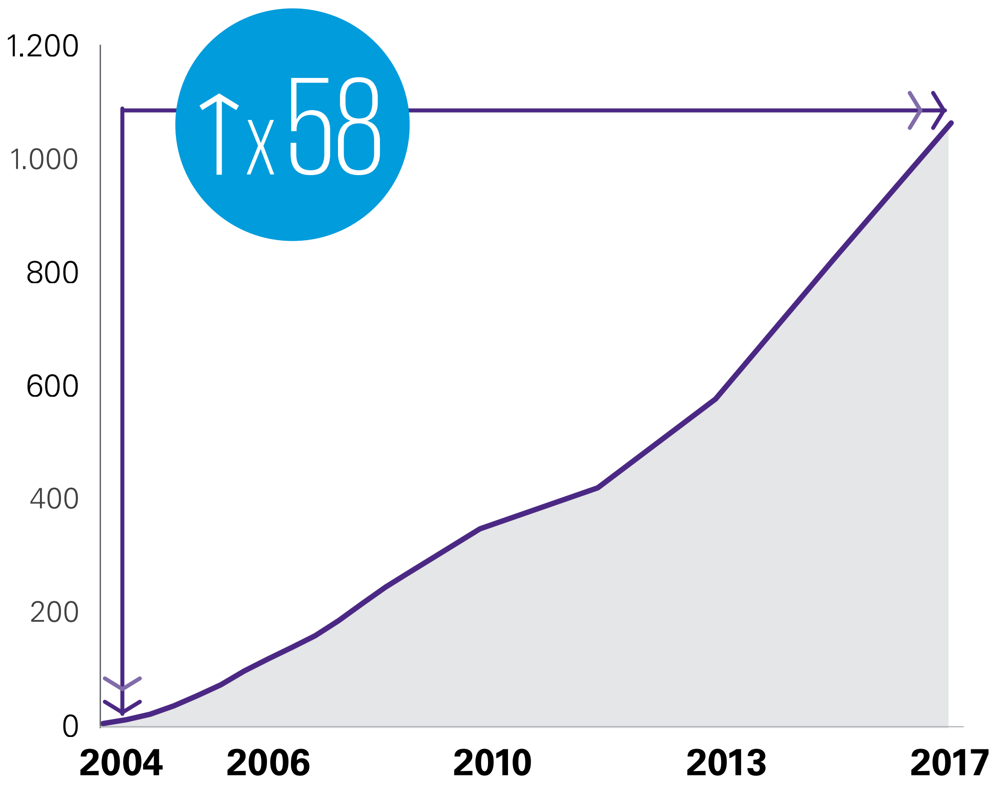
…that have gone hand in hand with rising investments and decreasing costs

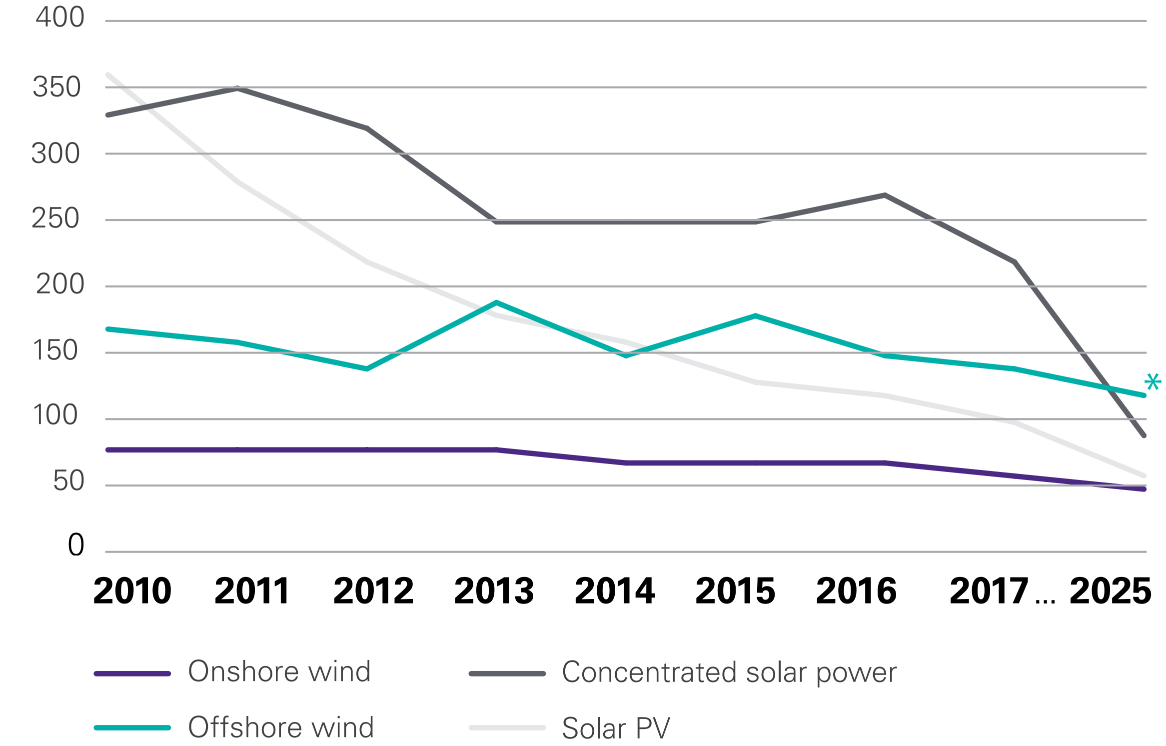
The wind industry has decreased its production costs
by more than 40% from 2010 to date.

Accumulated investment
USD bn



Investment has been mainly driven by support policies (motivated by environmental or security of supply goals) and, more recently, an improved economic case.

LCOE of renewables and fossil fuel-based technologies
USD/MWh

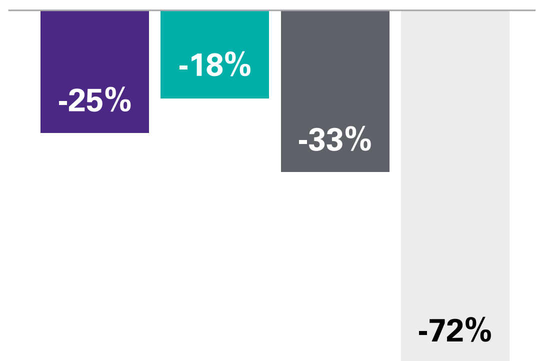


** The 2025 LCOE projection for offshore wind comes from a somehow dated 2016 IRENA's report. Technology seems to be improving faster than expected and, as will be shown in page 57, auction prices in northern Europe have well broken the 100 USD/MWh and are aproaching 50USD/MWh. However, comparing LCOE and auction prices is a complex exercise due to financing considerations, auction design, etc.*

Drivers for falling costs

Technology improvements
Economies of scale
Competitive procurement
Large base of experienced project developers.

To-date cost reduction



O

Source: IRENA (2018). "Global Finance Trends". IRENA (2018), "Renewable Power Generation Costs in 2017". IRENA (2016), "The Power to change: Solar an wind cost reduction potential to 2025".

"The Wind sector is extraordinarily well placed to confront the challenges of the energy transition and decarbonization of the economy. It has the technology, the companies, the cost competitiveness, the know-how, skilled professionals, and an innovative industry. What we need? Long-term vision, political consensus, steady regulatory framework, energy planning with regular auctions, and a macro perspective of all the positive impacts that wind power brings to society."

Rocío Sicre

President of the Spanish Wind Power Association (AEE)

"To accelerate renewables deployment towards SDG 7, the following policy areas will be key:

- **Tailored efforts to support further (and more even) growth in the power sector with a focus on access to affordable financing and enabling policies in emerging markets, and, in markets with higher shares of variable renewables, looking at system integration and adaptation of market design.**
- **Introduce dedicated policies to support greater renewable energy penetration in heating/cooling and transport sectors.**
- **Tap into synergies between energy efficiency and renewables to accelerate the pace of decarbonization, along with electrification of end-uses to enhance overall energy system flexibility.**
- **Accelerating progress towards universal modern energy access through off-grid solutions (stand-alone systems and mini-grids) by integrating these in energy access plans and devising dedicated policies to support deployment.**
- **Consider the socio-economic dimension of the energy transition and introduce holistic policies to maximise benefits across multiple SDGs."**

Rabia Ferroukhi

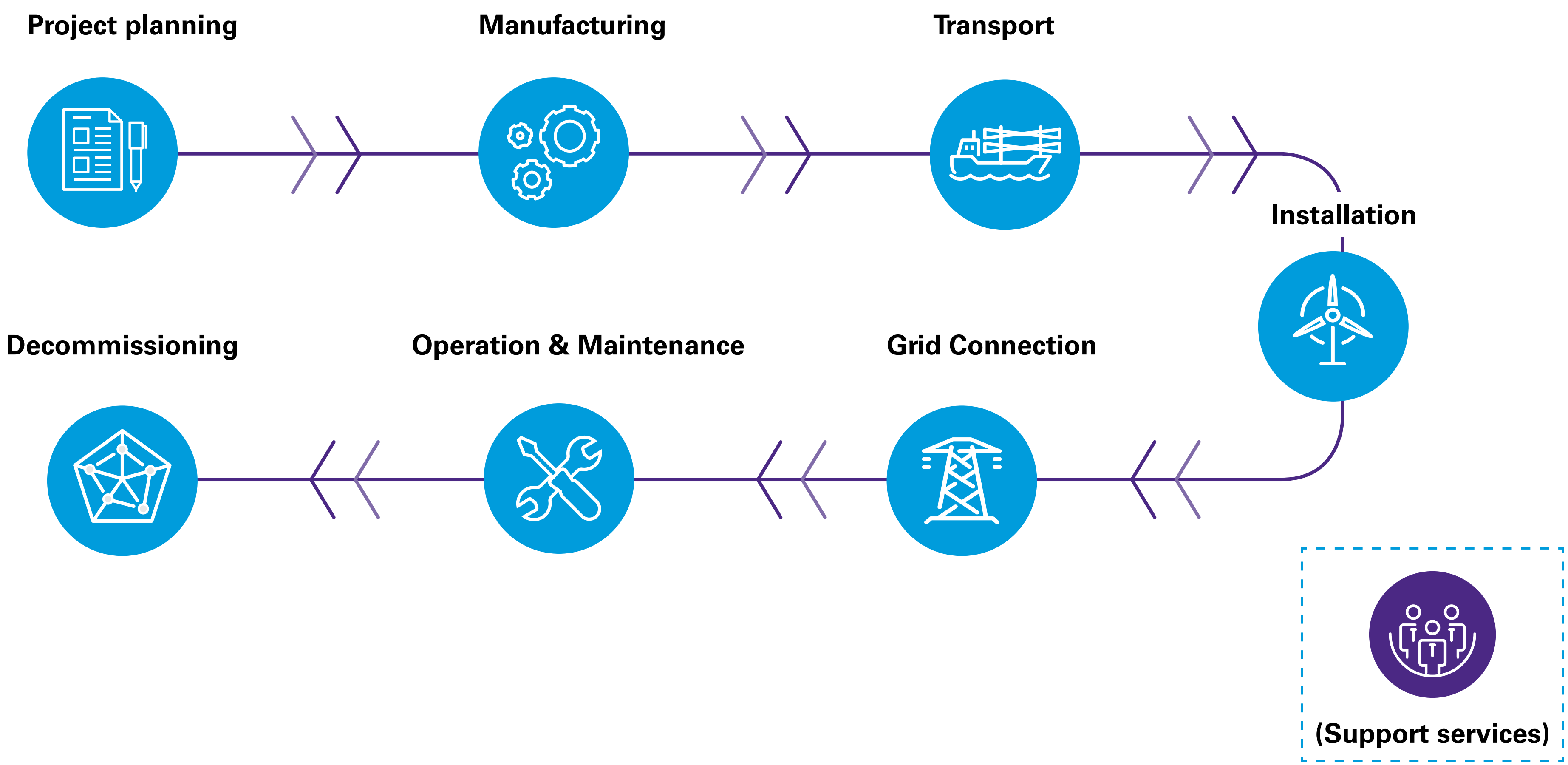
Director of the Knowledge, Policy and Finance division at IRENA

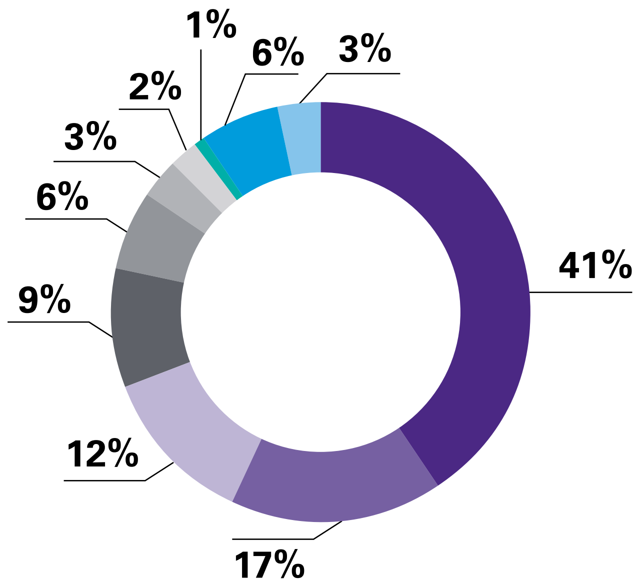
P

The complexity of the wind value chain

The wind supply chain connects a wide range of high-tech industries worldwide, with outstanding logistical challenges. On the turbines manufacturing segment, there are around 46 suppliers worldwide.

Wind value chain





70% Turbines costs

- Drivetrain
- Rotor
- Tower

21% Balance of system

- Electrical Infraestructure
- Assembly and Installation
- Site Access, Staging, and Facilities
- Development Cost
- Lawyers, experts in energy regulation

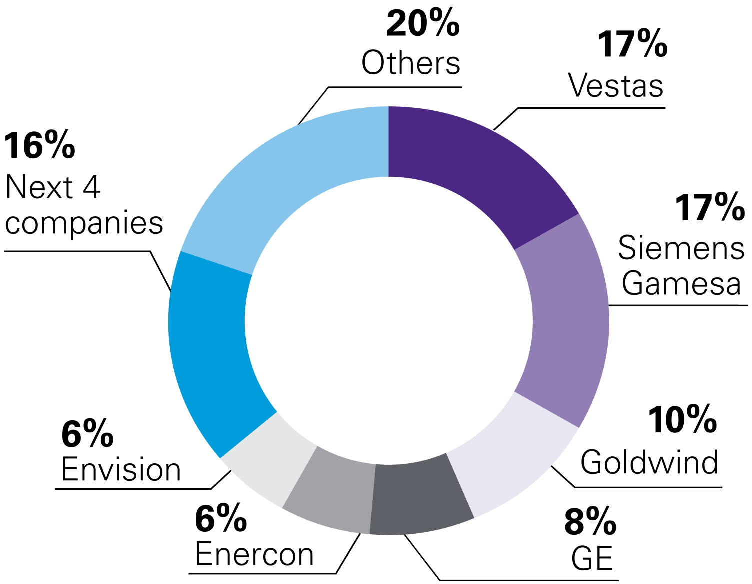
9% Financial costs

- Environmental experts
- Management

P

Sources: ICTSD (2017). "Building Supply Chain Efficiency in Solar and Wind Energy: Trade and Other Policy Considerations". FTI (2017). "Global Wind Market Update - Demand & Supply 2017". IRENA (2017). "Renewable Energy Benefits: Leveraging Local Capacity for Onshore Wind". Vestas (2017), Annual Financial Report. Siemens Gamesa (2017), Annual Financial Report. Goldwind (2017), Annual Financial Report. BCG (2'18). "How the Wind Industry Can Harness Gale-Force Change". REN 21 (2018). "Renewables 2018: Global Status Report". // Twitter, TANGERMED (8th May 2018). "The 100th wind turbine made by Siemens Gamesa in Tanger Med's industrial platform is exported through Tanger Med port". (Picture).

Market share of top global wind turbine suppliers by deliveries, 2017.



Some main challenges of wind players

Regulatory changes driving competition.

New entrants and changing business models (e.g. greater focus on maintenance).

The search for new wind resources implies higher installation costs (offshore wind).

Digital technologies.

	Revenues (Billion EUR 2017)	Gross profits (Billion EUR 2017)
Top 3 players	19.76	2.62

Region	New turbines installed 2017 (units)	%
Asia	11497	53.0
Europe	5596	25.8
North America	2850	13.1
Latin America	1253	5.8
Africa	163	0.8
OECD Pacific	290	1.3
Transition Economies	32	0.1
Middle East	10	0.0
Total fleet	**21691**	**100.0**

P

Sources: ICTSD (2017). "Building Supply Chain Efficiency in Solar and Wind Energy: Trade and Other Policy Considerations". FTI (2017). "Global Wind Market Update - Demand & Supply 2017". IRENA (2017). "Renewable Energy Benefits: Leveraging Local Capacity for Onshore Wind". Vestas (2017), Annual Financial Report. Siemens Gamesa (2017), Annual Financial Report. Goldwind (2017), Annual Financial Report. BCG (2'18). "How the Wind Industry Can Harness Gale-Force Change". REN 21 (2018). "Renewables 2018: Global Status Report". // Twitter, TANGERMED (8th May 2018). "The 100th wind turbine made by Siemens Gamesa in Tanger Med's industrial platform is exported through Tanger Med port". (Picture).

Q

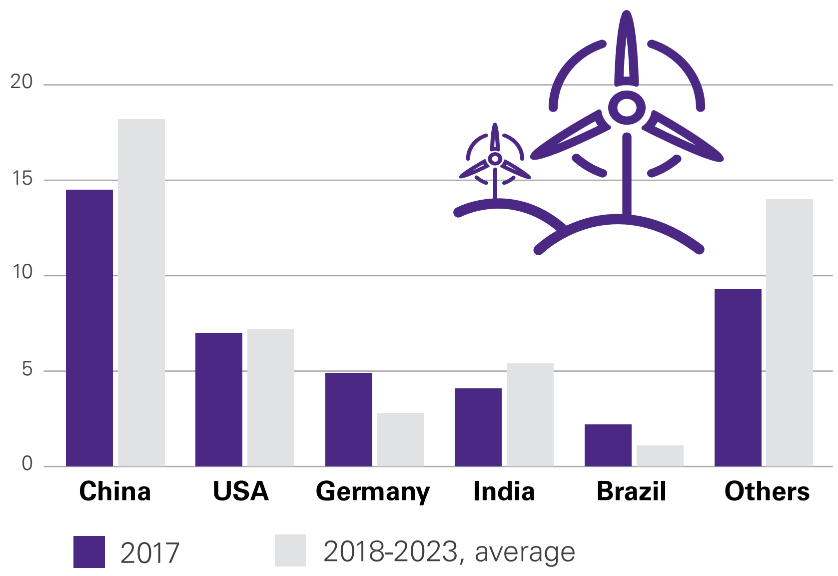
Key differences between onshore and offshore wind markets

The wind industry is divided in two different market segments: onshore and offshore. While onshore has been the dominant one for years, offshore is now growing at a faster pace, thanks to rapid technological advances and cost reductions. The offshore market started in northern Europe, but is expected to expand mainly to Asia and North America.

Two markets of different size

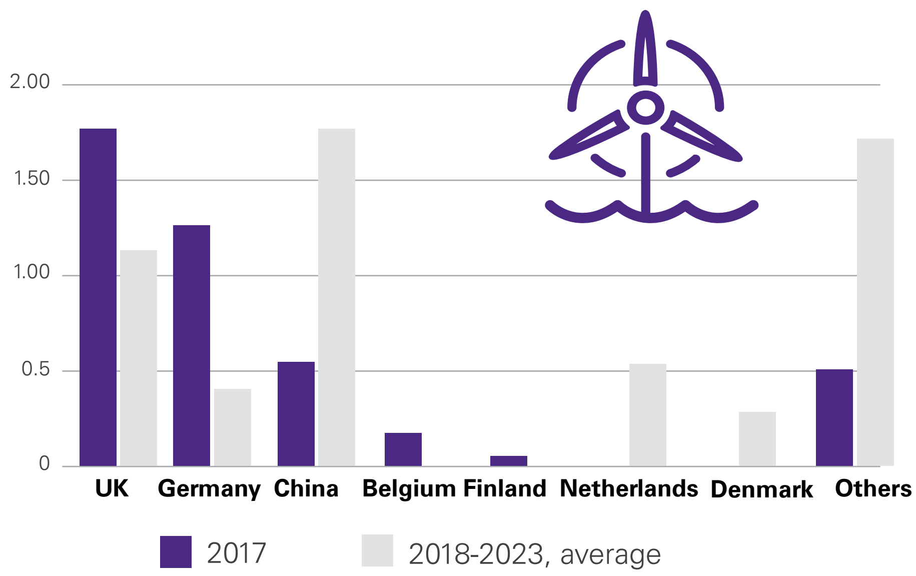
Size of onshore wind market in top countries (GW/y). Business as usual until 2025.

Onshore

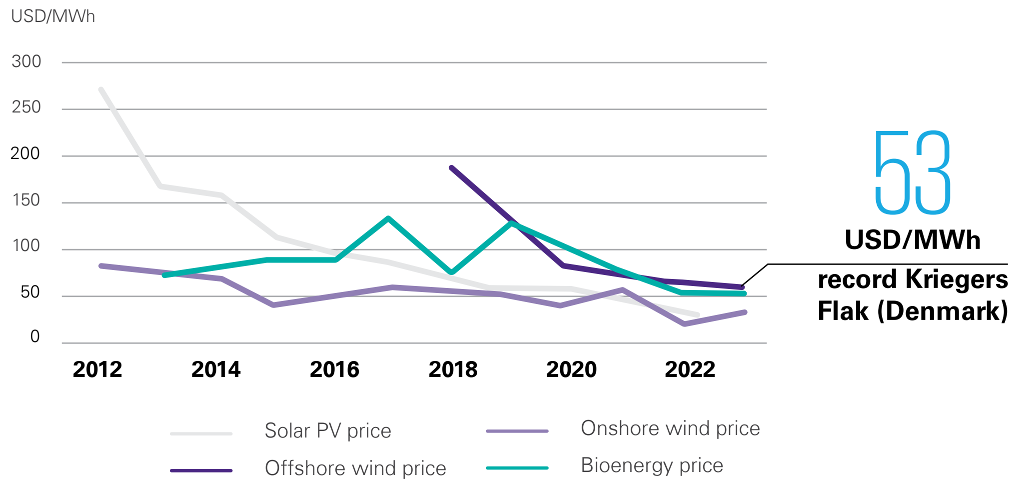


Offshore*

** Data for Belgium, Finland, Netherlands and Denmark not available in IEA 2018 for the periods missing from the graph, since they are not in the "top 5" group in each period*



Fast decreasing offshore auction prices



Offshore wind:

-66%

generation costs from 2017 to 2023

The graph shows a proxy to generation costs per technology: the average price awarded in renewable energy auctions by commissioning date (i.e. when the power plant will come online)

Offshore wind now competing without any support in Northern Europe.

Sources: *IEA (2018) "Renewables 2018: Analysis and Forecasts to 2023"; IEA (2018) World Energy Outlook*

The difficulty in comparing LCOEs and auction prices

The graph in this page shows prices resulting from auctions, while the graph in page 49 showed LCOEs. Both numbers are (and should be) somehow different. Comparing auction prices across the world is a tricky exercise (as pointed by IRENA in numerous reports), since the auctioned product, auction design, and other elements (e.g. cost of finance) could be very different. Comparing auction prices and LCOEs is even harder. As the IEA notes in their "Renewables 2018" report, LCOEs tend to be higher than auction prices for reasons such as: auction prices may not always reflect full costs; they could reflect only a part of the market (e.g. countries with better financing or resources), or they could result from aggressive bidding strategies.

Q

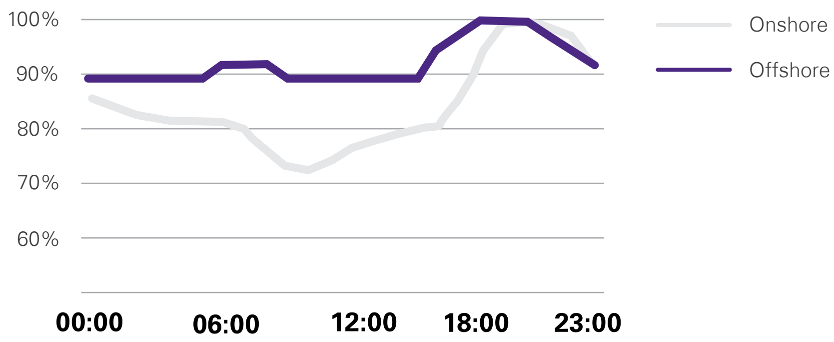
Onshore and offshore present key differences. Offshore offers some advantages.

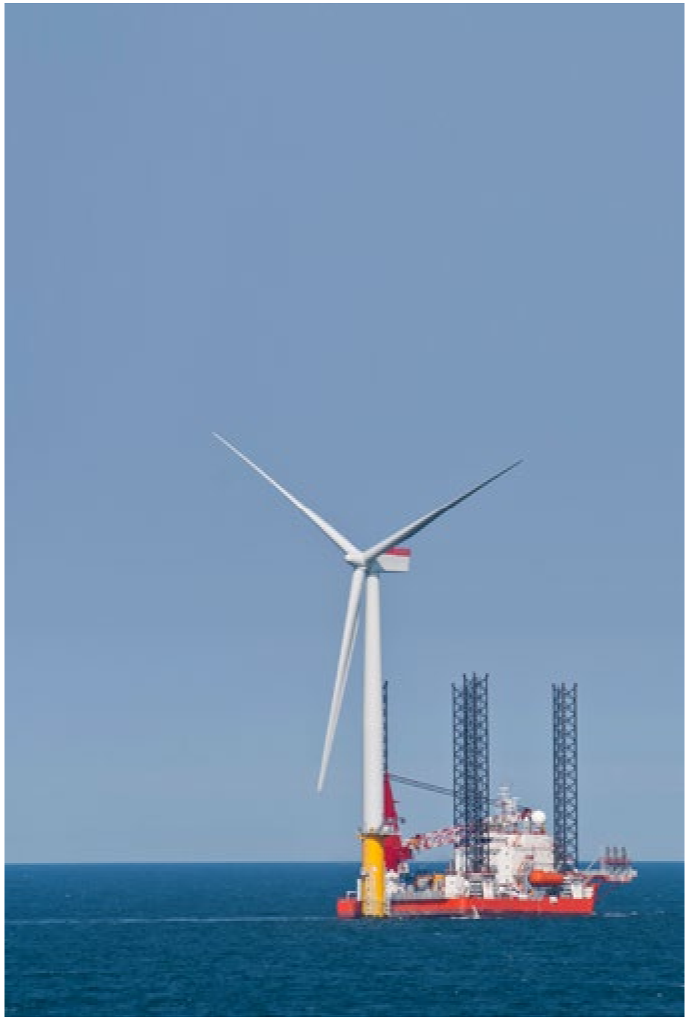
	Onshore	Offshore
Average turbine capacity	~ 2.5 MW	~ 5 MW
Hub heights	~ 170 m	~ 270 m
Capacity factors	~30%	~50%

Offshore wind is less intermittent than onshore and could provide baseload power.

Wind speeds off the coast tend to be much higher, more stable and more predictable than inland.

Illustrative daily generation profile of onshore vs offshore wind
(% of maximum capacity)





Key drivers behind cost reductions in offshore wind: shorter installation times, larger turbines

Larger turbines, bringing economies of scale in logistics, installation and operations (fewer foundations, less cabling, better layouts, less turbines to visit by maintenance teams). Average up from 3 MW in 2010 to 5MW today, 15MW turbines expected by the mid 2020s.

Developer experience and supply chain efficiencies. For instance, installation times (turbine+foundations) have fallen from 3 to 1 day/MW.

Project scale, triggering efficiencies e.g. in using port infrastructure.

Centralised auctions for "brownfield" projects backed by Governments that reduce developer risks.

Q

Sources: BNEF

"Offshore wind has huge potential in many regions (…). However, the industry needs to find the most appropriate technologies for deploying offshore wind in different conditions – for example floating offshore wind in regions with deep water levels, and creating efficient supply chains across the globe."

Henrik Stiesdal

Global Offshore Wind Ambassador at Global Wind Energy Council (GWEC)

Q

Benefits of offshore wind: supply electricity and boost economic activity in coastal areas.

Offshore wind to power large coastal demand centers

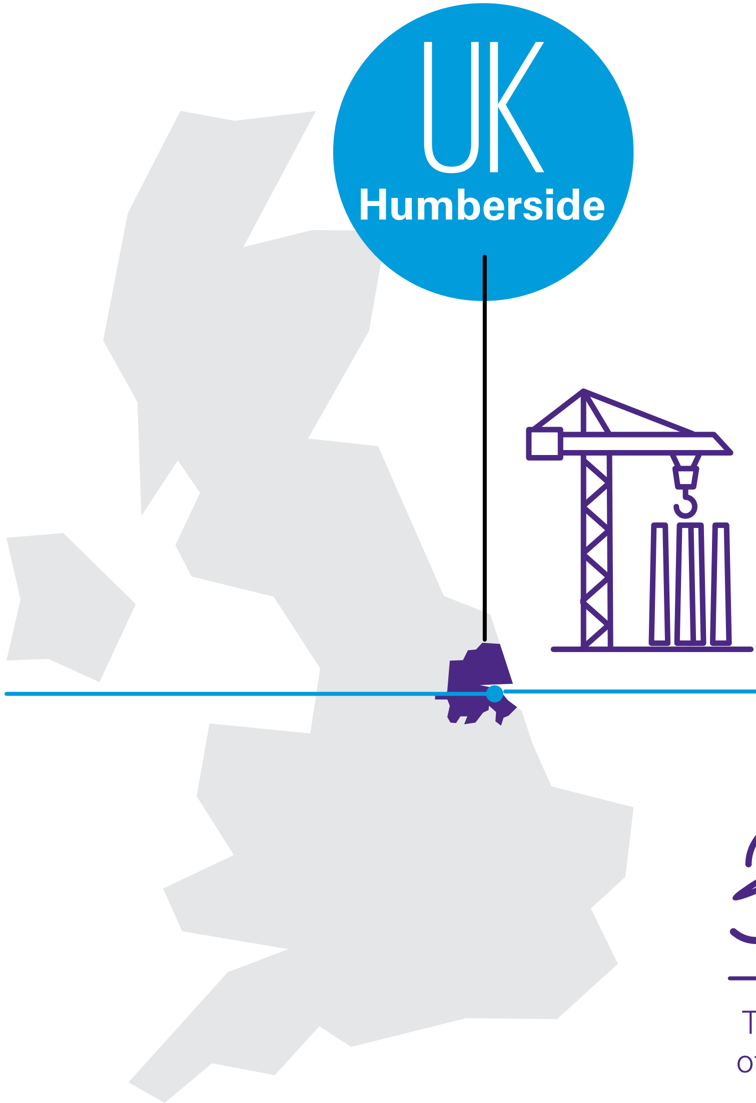
For historical reasons, a large share of the global population is concentrated along the coasts (40% of the lives <100km from the sea). In countries like China or the US, most power demand is in these areas. Offshore wind, located near these locations (possibly in floating platforms if the waters are deep), is a clear alternative to provide them with renewable energy.

Representation of population centers in the USA and China

"Offshore wind technology allows countries to exploit the generally high wind resources offshore, while developing gigawatt-scale programmes close to densely populated coastal areas. This makes offshore wind an important addition to the portfolio of technologies available to decarbonise the energy sector of many countries."

IRENA, 2018

"Offshore innovation widens renewable energy options"



21,000 jobs

2017 report commissioned by the University of Hull:
UK offshore wind jobs could reach 21,000 by 2032, mainly in UK's east coast.

Economic activity and jobs
Offshore can bring substantial benefits to economically deprived coastal communities, such as the case of Humberside in the UK.

ABLE Humber Port

South bank of the Humber Estuary

ABLE Logistic Park

497.5 ha/1,299.5 acres

ABLE Marine Energy Park

366.7 ha/906 acres

The UK's Energy Estuary, a world class offshore wind hub and the UK's busiest port by tonnage.

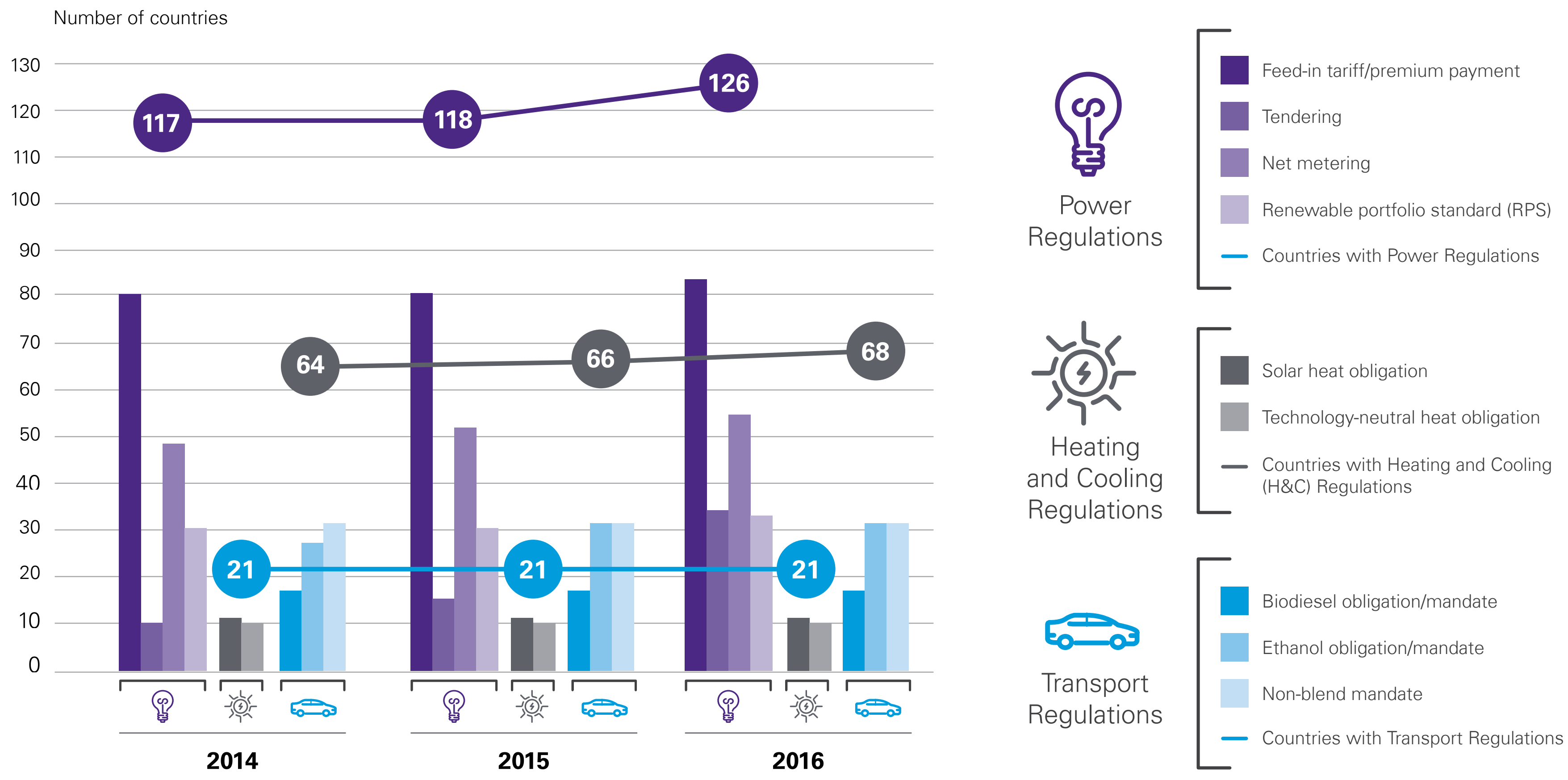
Q

Sources: *Globalsupportinitiative.com, Siemens Gamesa and BBC article "Humber 'envy of world' for offshore wind energy"*

R

Renewable energy policies for the power sector are leading, but need stability

Much of the previous progress has been driven by policy. Policies themselves are also adapting to new realities. Policies for electric renewables are evolving towards market-based mechanisms to drive competition and better integrate renewables.



RE targets: Signal political commitment to reduce uncertainty, set up guidelines and encourage investment. 150 countries with targets in 2017 (many of them as a result of the Paris Agreement) vs 96 in 2010.

Policies are used to implement targets. 126 countries with policies for electric renewables in 2017 vs 78 in 2010.

Initially, feed-in tariffs (FiTs) played a key role to de-risk, and promote investments.

As industry matures, support is shifting from FiTs towards market-based instruments (e.g. auctions), which are driving sharp price reductions.

Power: Regulatory Policies

Some countries have chosen to implement both; using auctions for large-scale projects and FITs/FIPs for smaller projects.

Despite the debate over grid cost recovery, net metering and net billing schemes are increasingly being used to promote distributed generation, which is expected to be a prominent segment of the solar PV market.

Decentralized renewable energy-based solutions for energy access in developing countries is one of the fastest-growing trends.

R

Sources: IRENA, IEA and REN 21 (2018). "Renewable Energy Policies in a Time of Transition".

S

On the contrary, heating & cooling and transportation would require further policy action

Policy interventions in transport are emerging. Heating and cooling is lagging behind.

Power: Non-regulatory Policies

Small and medium developers need attractive financing to undertake investments in renewable energy. Mostly as grants or subsidies to mitigate risks, reduce capital costs or provide equity.

The most popular fiscal policy instruments are reductions in sales, energy, value-added or other taxes to reduce the cost of renewable energy generation by increasing their affordability and profitability.

Voluntary programs in the form of tax reductions for consumers or corporations have been successful with an increasing support.

Heating & Cooling

Lately, there has been a steady growth in the global share of renewables to meet heat demand. However, the pace is much slower than in electricity.

Transport

Most policies to date are related to biofuels; other than that, there is little practical experience fostering renewables in transport. Policies aimed at developing renewable electricity in transport (e.g. EVs) have recently started to emerge.

S

Sources: IRENA, IEA and REN 21 (2018). "Renewable Energy Policies in a Time of Transition".

T

Enhancing energy efficiency policies is crucial for a low carbon economy

Other policies that are gathering pace include fossil fuel subsidy reform, energy efficiency and carbon pricing

Fossil fuel subsidies are being phased out in more and more countries (25+ since 2016), taking advantage of low oil prices.

Strong support for electric mobility and enhanced support to alternative fuels and setting of minimum performance standards.

Increased focus on energy efficiency and emission standards.

- **Standards in order to prevent the refurbishment of inefficient plants.**
- **Industrial plants need to comply with stringent emission limits and have to be fitted with the best available technologies.**
- **Mandatory energy management systems and energy audits.**

Introduction of CO_2 pricing schemes, such as in power and industry.

International agreements on industry energy intensity targets.

T

Source: IEA (2018), "World Energy Outlook 2018".

3 Environmental and socioeconomic impacts of the wind industry

"While it is true that electricity auctions have higher transaction costs for participants, they can be perfectly accessible to small-scale producers. Transaction costs can be reduced via standardization of procedures and market facilitators to ease the participation of smaller players. Local value for communities can be created by adding specific obligations in the product offered in the auctions if this is the case. "

Luiz Barroso

CEO at PSR Energy
Consulting and Analytics, former
CEO of Brazil Energy Planning Entity

Do you think the energy sector will be able to comply with energy-related Sustainable Development Goals? What kind of energy policy do you consider fundamental to achieve them?

"We are already on track to meet Sustainable Development Goal (SDG) 7, the main energy related goal, so I am certain that the energy sector will be able to comply with the SDGs. The clear, stable and forward-looking regulatory framework set up by the Clean Energy package will be fundamental in furthering this success. When fully implemented by 2030, 32% of the EU's energy supply will come from renewable sources. The revised Renewables Directive will be central in this regard and will Europeanise renewable energy by encouraging cross-border renewables projects with clear rules on support schemes."

Miguel Arias Cañete

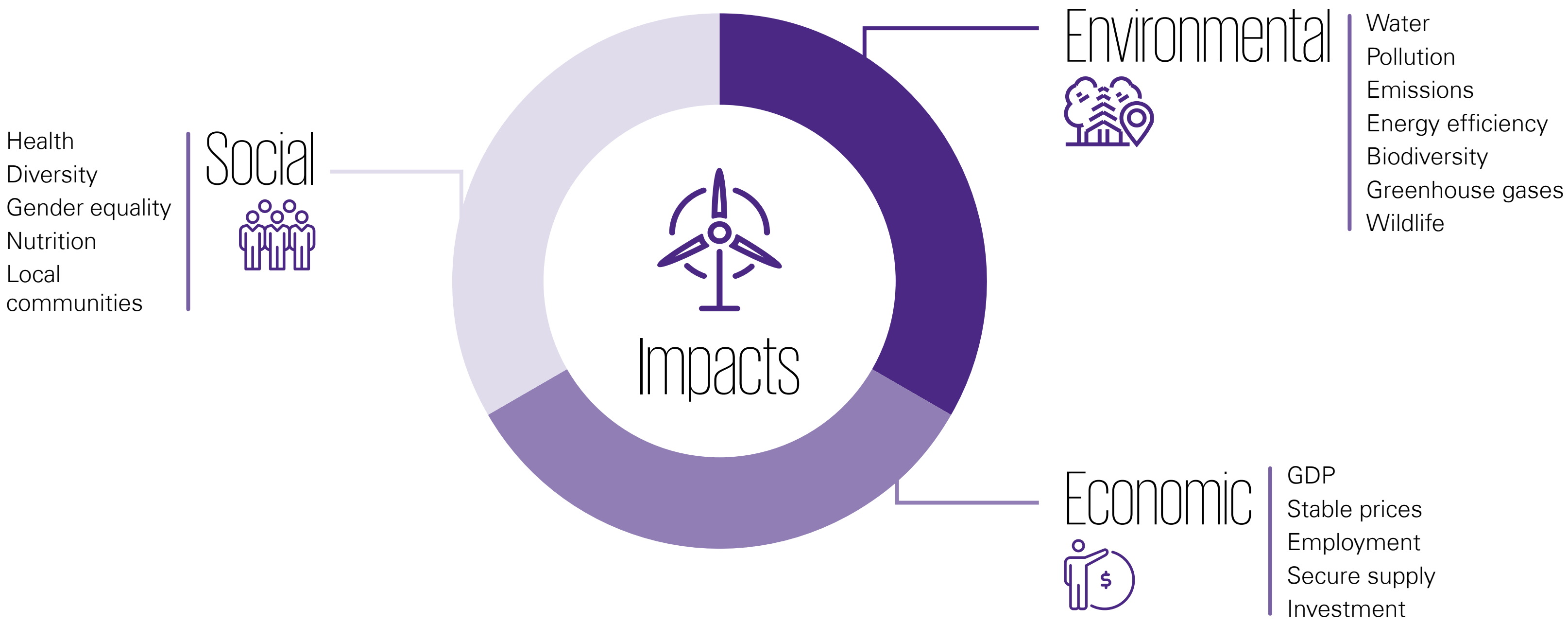
European Commissioner for Climate Action and Energy

A

Renewable energy is a key contributor to sustainable development

Its net impacts go beyond the energy sector, from human wellbeing to employment growth. In addition, renewable energy is core to support significant progress on the Paris Agreement on climate change as well as on the Sustainable Development Goals (SDG), being core on SDG 7 – access to affordable, reliable and sustainable energy.

Renewable energy impacts



Sustainable Development Goals

The renewable energy industry is core to the implementation of SDG 7, which focuses on access to affordable, reliable, and sustainable energy and SDG 13, which centers on urgent action to combat climate change.

Furthermore, it may also indirectly support the achievement of other SDG such as ensuring good health and air quality (SDG 3 and 11), access to clean water (SDG 6), promoting economic growth (SDG 8), contributing to gender equality (SDG 5), fostering innovation (SDG 9) and protecting biodiversity (SDG 15), among others.

SDG 7

SDG 13

A

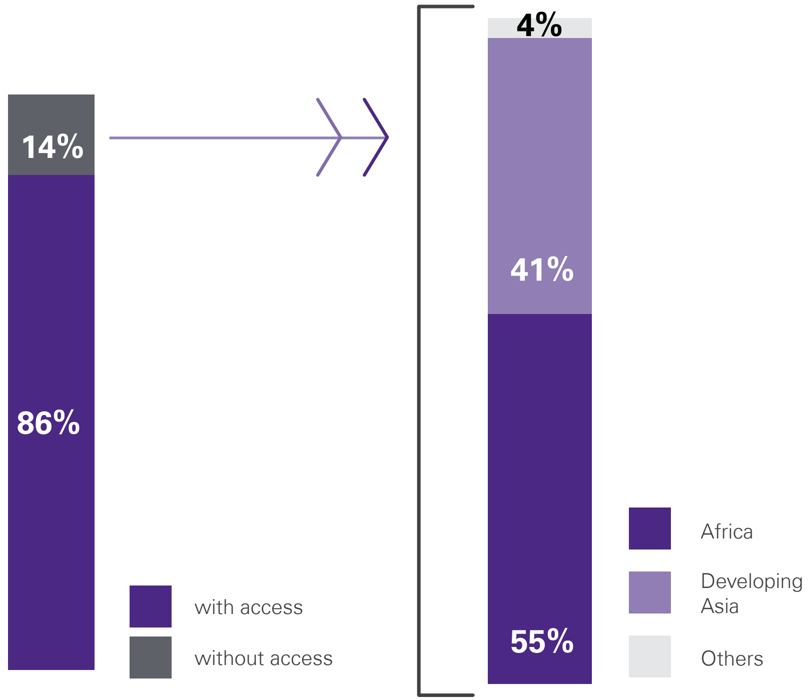
Sources: *IPCC (2011). "Renewable energy sources and climate change mitigation". Newsdesk tool used by KPMG.*

B

Renewables could be key in facilitating universal access to electricity

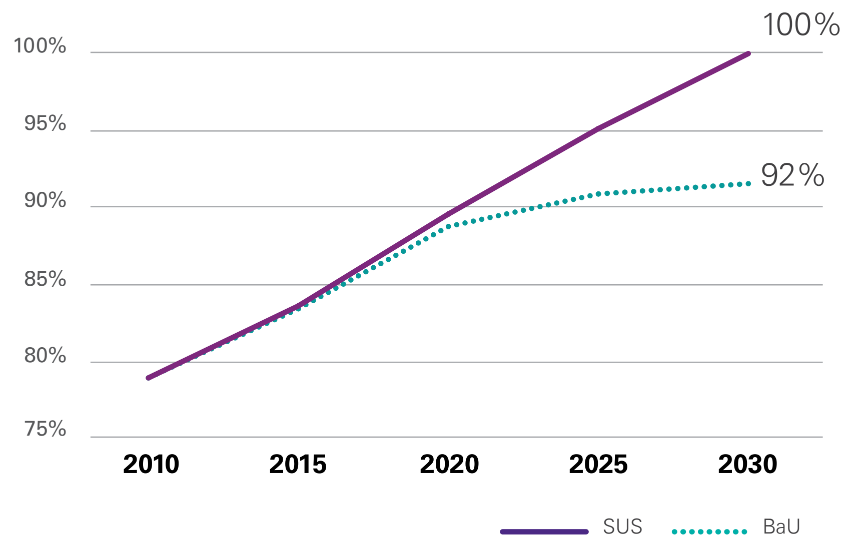
Nowadays, 1,000 million people still live without electricity and 2,700 million do not have access to clean fuels and technologies for cooking. In a Sustainable Scenario, universal access to both electricity and clean cooking is achieved by 2030.

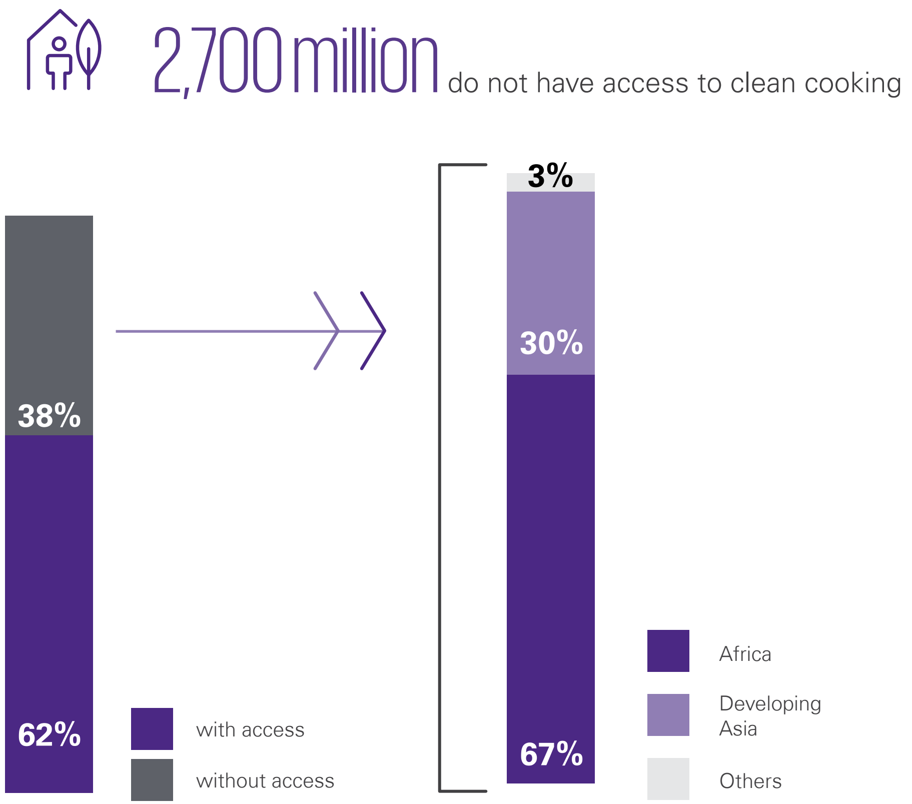
1,000 million people live without electricity



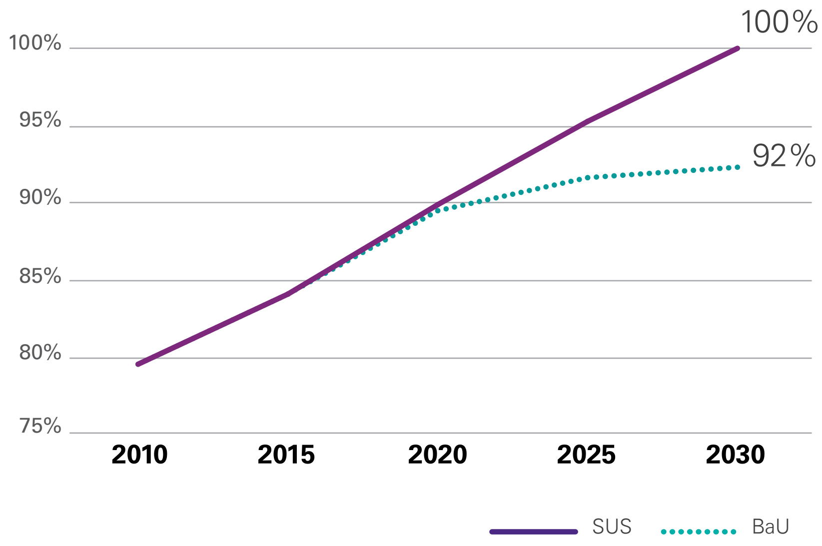
2030 scenario

Percentage of population with access to electricity (%)





2030 scenario
Proportion of population with primary reliance on clean fuels for cooking



B

Sources: IEA (2018), "World Energy Outlook 2018". REN 21 (2018). "Renewables 2018: Global Status Report".

"No one's life should be limited by how they cook. Yet globally, three billion people depend on polluting, open fires or inefficient stoves to cook their food, harming health, the climate, and the environment. Women and girls, who often spend hours cooking and collecting fuel, are disproportionately affected."

Clean Cooking Alliance 2019

"Energy is the cornerstone of economic growth. With access to modern, reliable and affordable energy, a child can study at night, small businesses can thrive, women can walk home under the safety of working streetlights and hospitals can function efficiently and save lives. That is why reaching Sustainable Energy for All's (SEforALL) objectives of universal access to modern energy, doubling the rate of improvement of energy efficiency and doubling the share of renewable energy by 2030 is crucial."

World Bank, Global Tracking Framework 2017

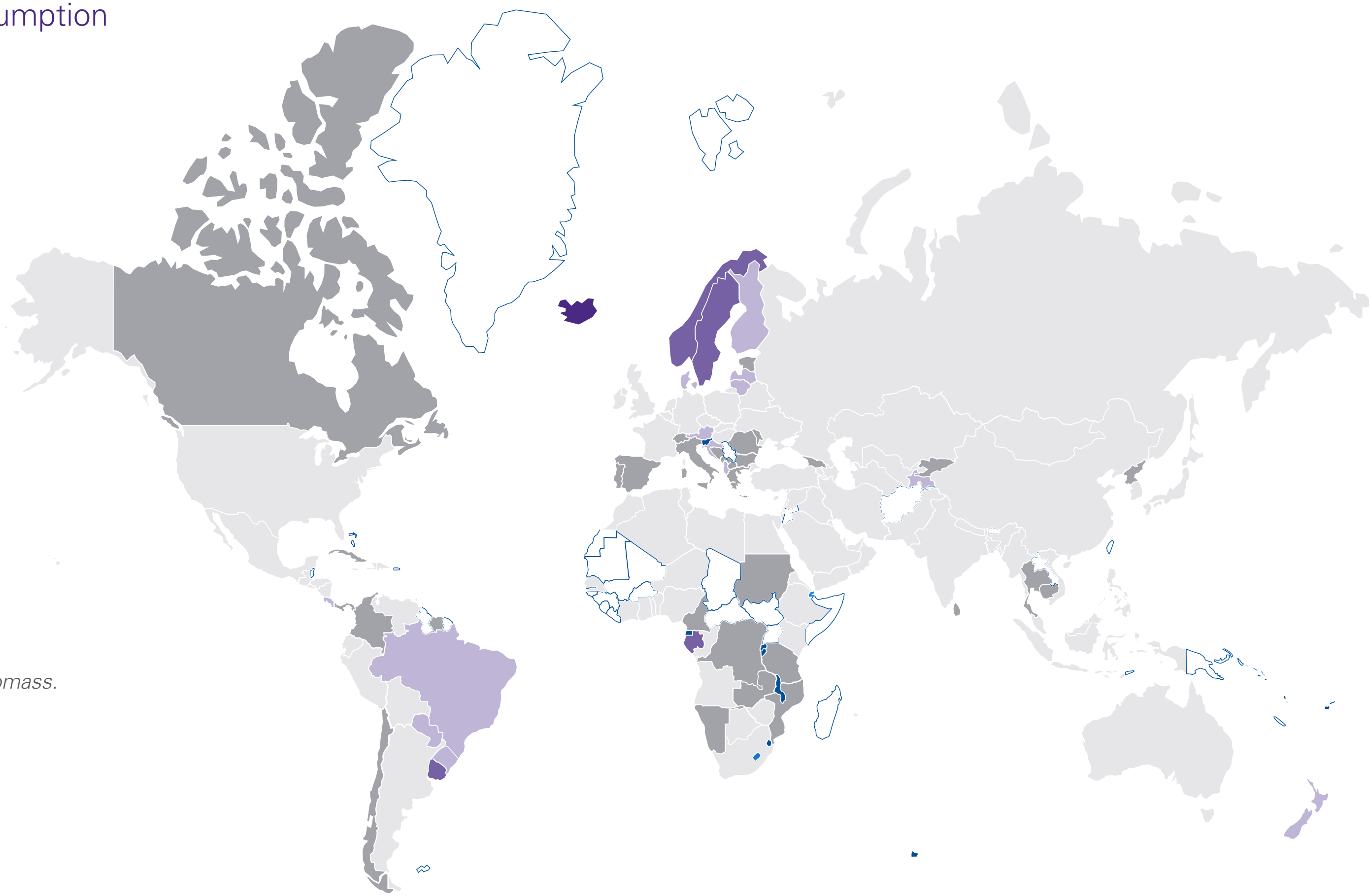
C

Wind and solar further the share, and diversify the mix, of renewables

To date, hydro and bioenergy have been the greatest contributors to clean energy consumption. In the future, wind and solar deployment will play a major role. The world obtained 10% of its total final energy consumption from renewable* sources in 2017. In a Sustainable Scenario, this share is expected to grow to 22% by 2030.

Renewable energy consumption, 2016*
% of total final energy consumption

10% global share of renewables* in total final energy consumption in 2017

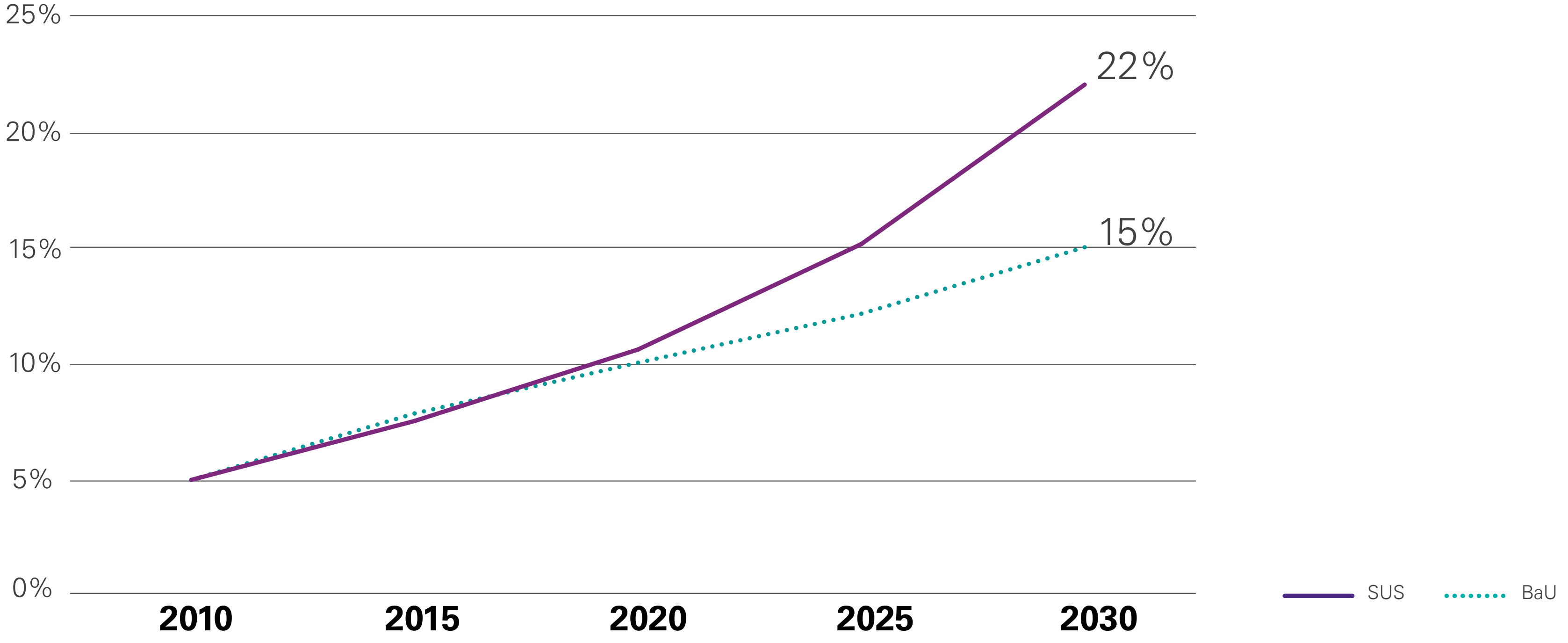


*All figures exclude the traditional use of biomass.

Data not available

0 15 30 45 60 75

2030 scenario
Renewable* share in total final energy consumption



C

Sources: *IEA (2018), "World Energy Outlook 2018".*
The presentation of material in the map does not imply the expression of any opinion on the part of KPMG concerning the legal status of any region, country, territory, city or area or of its authorities, or concerning the delimitation of frontiers or boundaries.

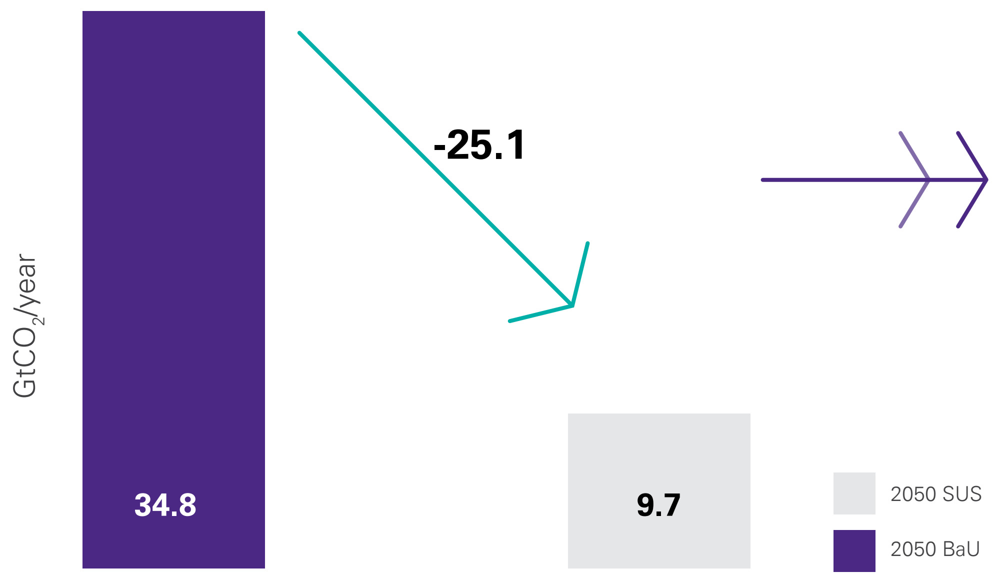
D

The benefits of wind energy to our grandchildren could reach up to $386 billion…

Wind energy is projected to avoid 5.6 billion ton CO_2 by 2050 (the yearly emissions of the 80 most polluting cities in the world, home to around 720 million people). This means benefits of 386,400 million$ related to social cost of carbon.

To meet the below 2°C goal, CO_2 emissions must at least be reduced by 25.1 Gt CO_2 /year by 2050.
In that scenario, wind energy is projected to avoid 5.6 Gt CO_2 by 2050*.

CO_2 emissions by 2050



Estimations:
** 23% attributable to wind energy.*
CSIC: 23.3 tCO_2/Ha/year average CO_2 absorbed by 1 Ha forest .

2050

Annual CO_2 saving…

5,600 million ton

Social cost of carbon saving…

386,400 M$ → x 1.55 **Madrid annual GDP**

Yearly emissions of…

80 **most polluting cities in the world** → 720 **million people living in these cities**

Forest to absorb same CO_2…

240 million ha → x 0.35 **Amazon rainforest**

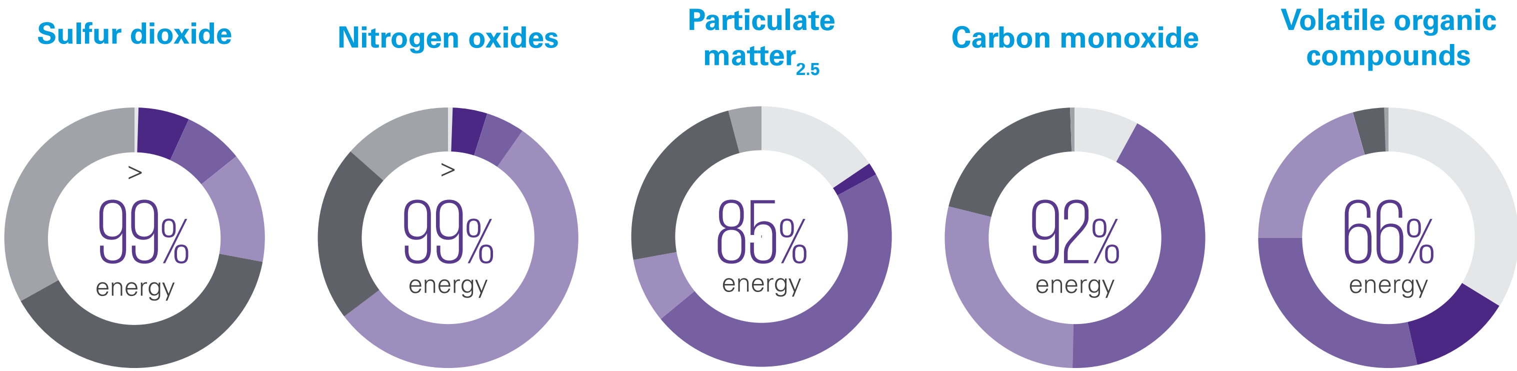
D

Source: IRENA (2018), "Global Energy Transformation". EPA (2017). "The social cost of carbon". Expansión (30 th April 2017). "What are the countries with the most vehicles?". WWF website (2019). "Amazon Deforestation".

... also bringing benefits to urban populations today

Air pollution is set to become the world's top environmental cause of premature mortality. In a Sustainable Scenario, renewables could save up to 4 million lives annually and reduce externalities by at least 1 US$ trillion per year and as much as 3.5 US$ trillion per year by 2030.

Air pollutants with human health impact



Power: Combustion of coal, oil, gas, bioenergy and waste

Industry: Fuel combustion, process emissions

Transport: Exhaust, brake and tyre and road wear, fuel evaporation

Buildings: Cooking, heating and lighting

Fuel supply: Extraction, storage, transport and transformation of fossil fuels

Non-energy: Agriculture, solvents and waste

** Number of deaths that are attributable to air pollution and are considered to have been preventable if the risk had been eliminated.*

*** 2013 estimations from premature mortality caused by exposure to ambient fine particulate matter (PM 2,5) and household air pollution from cooking with solid fuels and ambient ozone.*

**** Total projected savings are considering indoor (associated with traditional bioenergy use) and outdoor pollution.*

One in **eight** of total global deaths is linked to air pollution exposure

7 million premature deaths annually*
(one third in Asia Pacific)

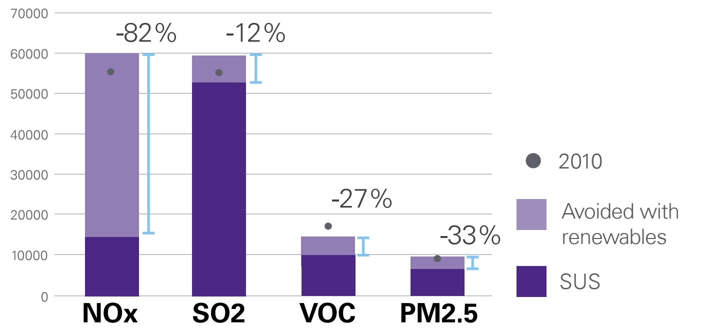
- **21%** pneumonia
- **20%** stroke
- **34%** ischeemaic heart diseese
- **19%** pulmonary disease (COPD)
- **7%** lung cancer

Air pollution costs

5 US$ trillion annually**
caused by ambient and household air pollution

2030 scenario***

Renewable energy would decrease harmful emissions…



Renewable energy would reduce air pollution enough to save up to…

4 **million lives per year**

Renewable energy would reduce health-related cost up to…

1.0 - 3.2 **US$ trillion per year**

E

Source: *WHO (2018), "Health & Climate Change". WHO website (2019), "Deaths linked to air pollution". IEA (2016). "Energy and air pollution". IRENA (2016). "The true cost of fossil fuels: saving on the externalities of air pollution and climate change".*

F

Wind power is the energy source that saves the most water

40% of the world's population is affected by severe water stress conditions and is projected to rise. Wind and solar energy, which have one of the lowest water-consumption footprints, will help to reduce water consumption decreasing shares of nuclear energy or coal thermal power plants.

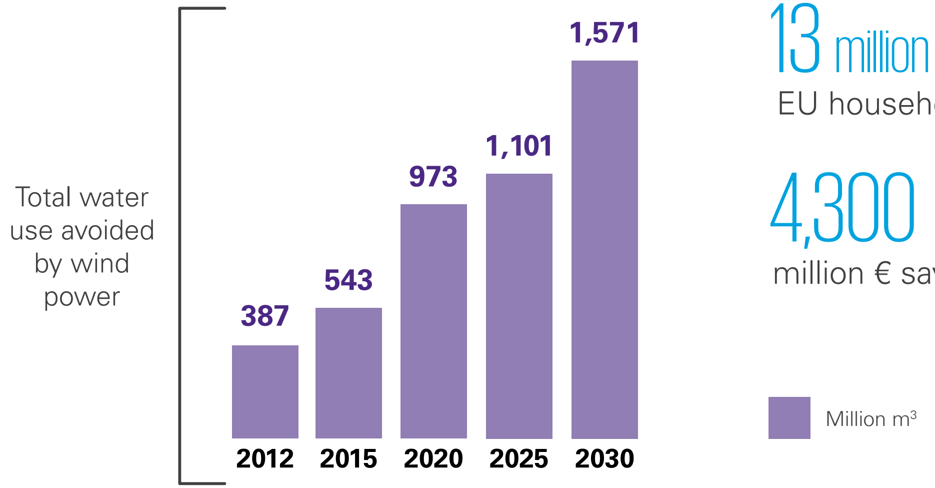
Wind energy could avoid consumption around in 2030 global scenario*

16,000 million m³ x 0.14 Water volume of the Dead Sea

Water use avoided by wind energy (EU)

Assuming that wind energy replaces a mix of fossil fuel and nuclear generation, it will avoid, in a Sustainable Scenario, the consumption of 1.571 million m³ of water per year by 2030.

**In the Sustainable Development Scenario, global freshwater withdrawals in the energy sector decline to reach roughly 275 bcm in 2030 360 bcm in 2016. Increased energy efficiency, the move away from coal-fired power generation, and the increased deployment of solar PV and wind power all contribute to overall lower water withdrawals in the energy sector. Estimations: 25% attributable to wind energy.*



13 million
EU households

4,300
million € savings

F

Source: IEA (2018), "World Energy Outlook 2018". EWEA (2014), "Saving water with wind energy. Wind scenarios for 2030". EEA database (2019), 'European water consumption' (144 litres per person/day). European Commission database (2019), "European household size" (2.3 members).

"The Water-Energy Challenge

Significant amounts of water are needed in almost all energy generation processes, from generating hydropower, to cooling and other purposes in thermal power plants, to extracting and processing fuels. Conversely, the water sector needs energy to extract, treat, and transport water. Both energy and water are used in the production of crops, including those used to generate energy through biofuels. Population growth and rapidly expanding economies place additional demands on water and energy, while several regions around the world are already experiencing significant water and energy shortages."

Thirsty Energy Initiative, World Bank

KPMG

G

The negative impacts of wind energy on biodiversity are limited

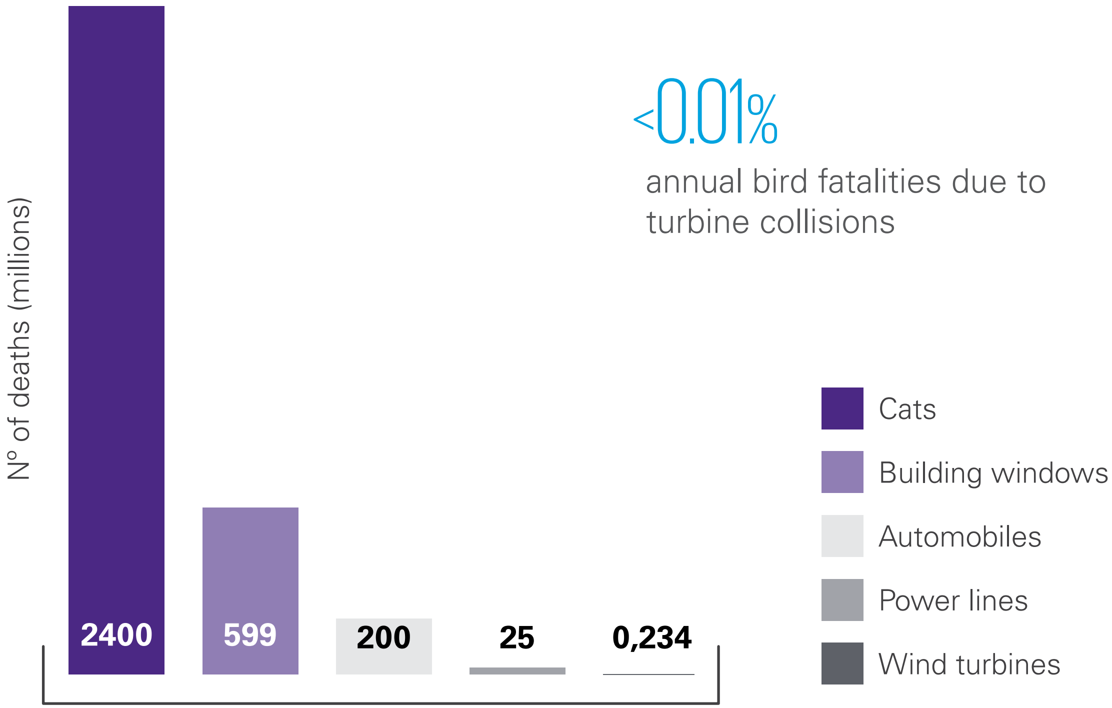
However, wind energy may still have impacts on habitats. The industry is engaged in initiatives to avoid, to reduce or to compensate those impacts.

Impacts...

ANIMALS: wind energy may represent a risk for birds (both residents or migratory) and bats. Collisions, habitat disturbance, interference on movements and, in the case of offshore wind, impacts on marine mammals.

HABITATS: reduction, fragmentation or loss of available habitats.

Global mortality of birds from human-related causes



USA. Direct Mortality of Birds from Anthropogenic Causes. Loss SR, Will T, Marra PP.

Some mitigations measures....

Planning & siting

- Avoidance sensitivity areas
- Site on previously altered landscapes

Construction

- Noise reduction
- Absence of animals

Operation & decommission

- Curtailment or cut-in speed
- Deterrence devices – acoustic, visual and electromagnetic
- Compensation measures- restoration and replacement

G

Source: Wildlife. AWEA; Mainstreaming energy and climate policies into nature conservation. Wind Europe; Mitigation Measures for Wildlife in Wind Energy Development.

“Which measures and initiatives is wind industry engaged with avoiding, reducing or compensating wildlife and biodiversity impacts?

There are three general actions that wind industry can further implement to avoid, reduce or compensate socio-ecological impacts:

- **Increase sustainability along the life of the project (from to design to decommissioning) including impacts on value chain (e.g. wind companies can reduce footprint in operations or services provisioning).**
- **Include social participation mechanisms in design, financing, construction and management of projects, to increase acceptability and reduce risks for infrastructure stranding.’**
- **Improve project location so impacts on landscape, cultural and environmental heritage are avoided or minimized.”**

Tabaré A. Currás
Global Energy Advisor

H

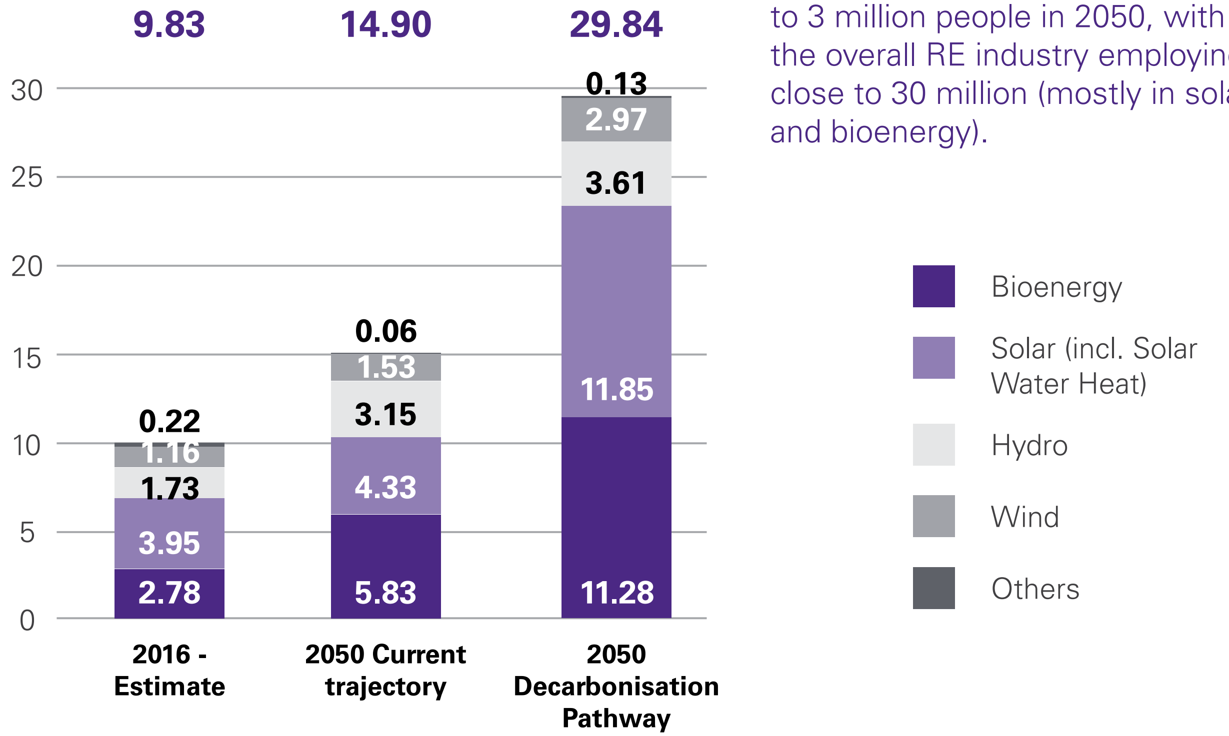
Wind industry creates jobs

The renewable energy industry in general, and particularly wind, is becoming a major employer, and can keep growing.

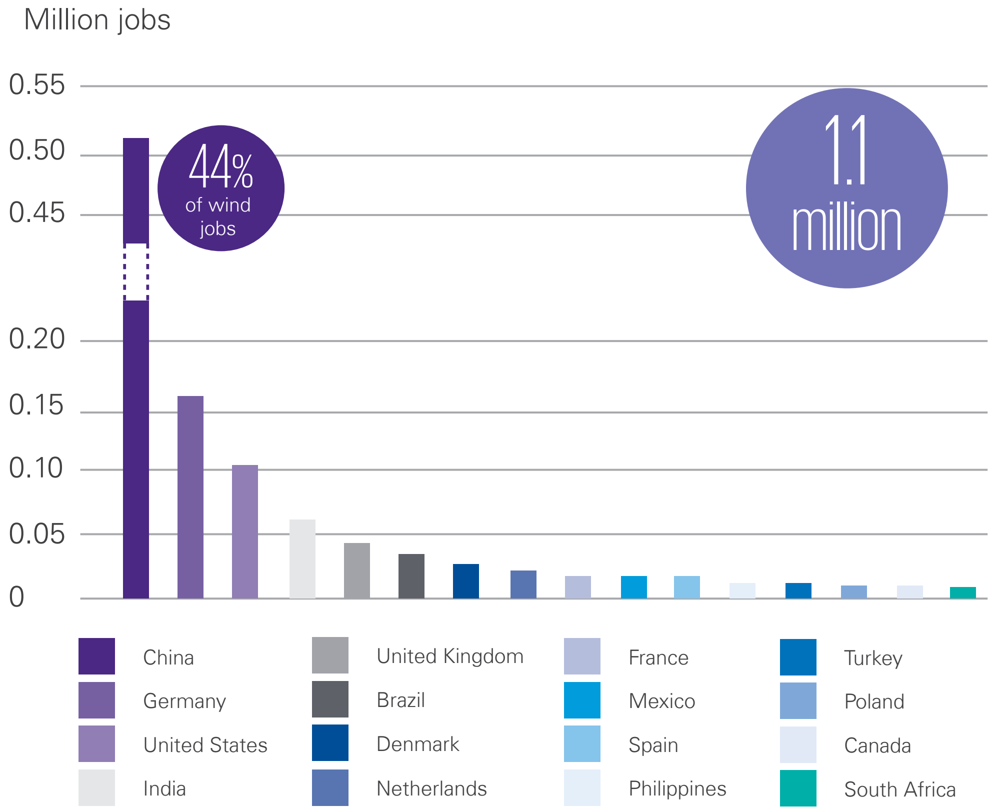
Today, wind energy employs around **3 million people** globally (directly and indirectly), mostly in the larger and more mature onshore segment. The overall RE sector employs around 10 million people.

Decarbonising energy will create millions of renewable energy jobs

In a sustainable scenario, the wind industry could employ close to 3 million people in 2050, with the overall RE industry employing close to 30 million (mostly in solar and bioenergy).



Employment in the wind industry by country, 2016



The energy transition creates jobs

Importantly, in a sustainable scenario, jobs created in energy efficiency, renewables, grids and flexibility would offset jobs lost in fossil fuels (net gain of 12 million jobs in 2050). Economy-wide, impacts are also positive.

H

Source: *IRENA (2018), "Renewable Energy and Jobs – Annual Review 2018". IRENA (2018),"Global Energy Transformation: A roadmap to 2050". IRENA (2018), "Renewable Energy Benefits: Leveraging Local Capacity for Offshore Wind".*

Renewables could enhance economic growth…

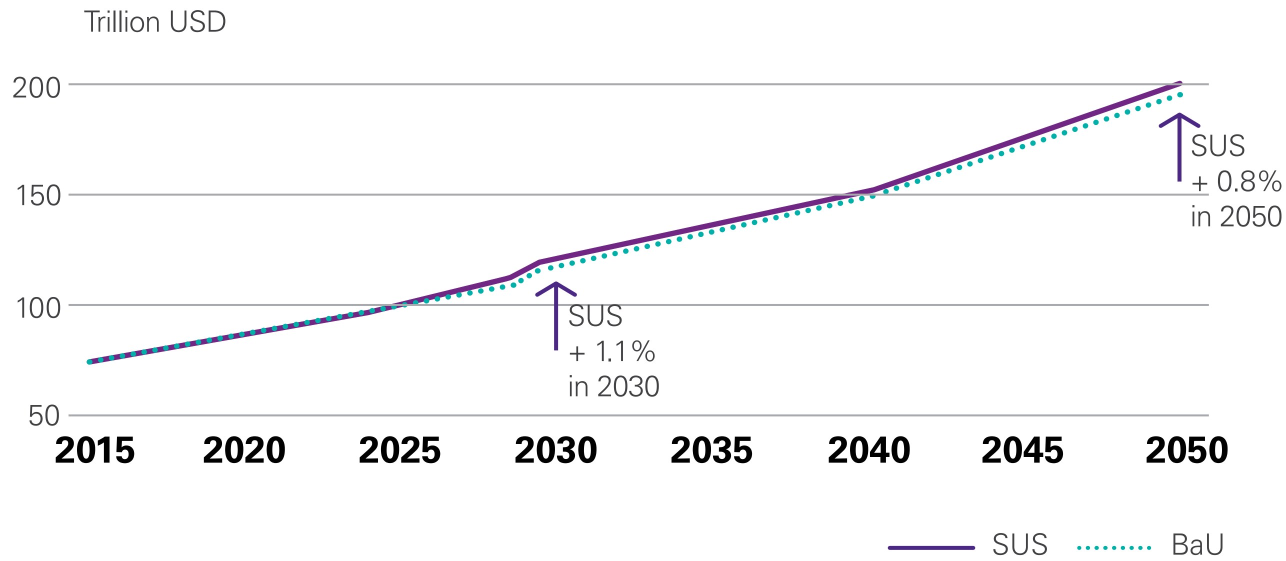
A renewables-based economy increases wealth for everyone: GDP until 2050 would be 20 USD* trillion bigger, around 2500 USD* more per person.

In a sustainable scenario, the global energy transition could make global GDP larger than in the BaU case (1.4% in 2030 and 1% in 2050).

Thanks to the reduced costs of renewables, the energy transition can improve the economy

Global GDP in BaU and SUS

- Global GDP in 2050 would be 2 USD trillion* larger than in the BaU case.
- Cumulative gains from today till 2050 close to 20 USD trillion* (similar to the market capitalisation of all NYSE companies).



*In constant 2015 USD terms.

Deep dive: economic impacts of the energy transition

Some stakeholders believe that the energy transition is negative for the economy. This is based on relevant literature such as the IPCC's Fifth Assessment Report (2014). However, the economic modelling exercises that underpin the IPCC report seem to be based on outdated technology assumptions, and the IPCC allows for positive economic impacts in certain circumstances:

1. **Rapidly improving low-carbon technologies (e.g. better efficiencies and lower costs). This is already taking place (e.g. renewables, electric vehicles).**

2. **Synergic policies such as green tax reforms (e.g. reducing labour/capital taxes while increasing carbon taxes). This can take place in the medium term.**

In addition, IPCC analysis seem to be mainly based on neo-classical economic postulates that assume, for instance, that agents are fully rational, and markets are complete. This is not necessarily the case, and alternative approaches (e.g. post-keynesian) can yield different conclusions.

I

Source: "IRENA (2018), "Global Energy Transformation: A roadmap to 2050". IRENA (2017) "Chapter 3 of Perspectives for the energy transition – investment needs for a low-carbon energy system".

J

...and also, change its economic structure

More investment in fixed assets drive manufacturing and services. Less expenditure in fossil fuels could challenge exporting countries, improve trade balances for importers and reduce energy bills to final consumers.

8 DECENT WORK AND ECONOMIC GROWTH

GDP improvements are mainly due to:

- The stimulus effect of investing in capital-intensive wind, solar and energy efficiency technologies. Global energy investment increases from around 2 trillion USD/y today to 2.5-3.5 trillion USD/y in the next decades, representing a larger share of global GDP.
- Lower energy bills for consumers increase spending power, boosting the economy. These bill reductions are driven by "almost free" wind and solar electricity, and by lower wholesale fossil fuel prices due to reduce demand.

Important structural economic changes will take place:

- Fossil fuel industries see the largest reductions in economic activity.
- Industries related to capital goods (incl. renewables, energy efficiency, electric vehicles, etc.), services and bioenergy experience the highest increases.

Global trade effects on an aggregated level are minor. But on a country by country level the picture is very different:

- Fossil fuel exporters: trade balance worsening.
- Fossil fuel importers: trade balance improvements, if they can create domestic supply chains for low carbon technologies.
- The main trade winners are those that manage to become leaders in low carbon technologies.

J

Source: "IPCC (2018), "Global warming of 1.5°C. An IPCC Special Report". IRENA/IEA (2017) "Perspectives for the energy transition – investment needs for a low-carbon energy system".

"The EU's wind industry, as global technology leader, is already one of the main pillars of the EU's climate action. In 2017, wind capacity grew by 14.8 GW, bringing the EU installed capacity up to 169 GW. And just in 2018, offshore wind energy capacity grew by 18% compared to 2017. As costs decrease and turbines grow, wind is set to thrive. Wind power will dominate in a climate neutral Europe, representing over 50% of the EU's power mix by 2050. Continued investment in our wind industry will ensure its global leadership and the EU's climate leadership are maintained. "

Miguel Arias Cañete

European Commissioner for Climate Action and Energy

K

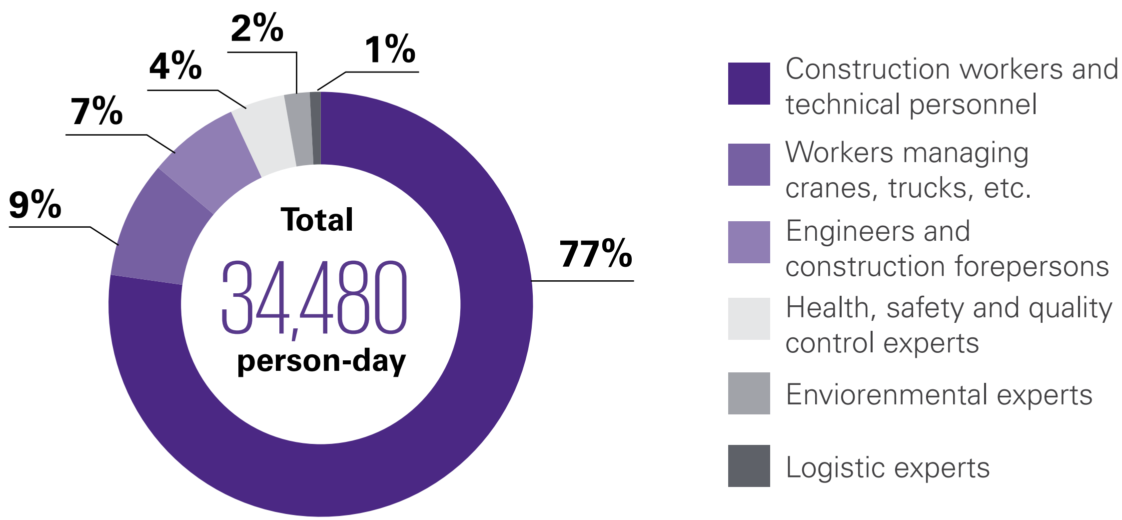
Importantly, wind creates value at a local level

New wind energy plants carry opportunities for domestic value creation at each segment of the value chain, in the form of jobs and income generation for local firms. Most of local jobs are generated in the installation, operation and maintenance phases.

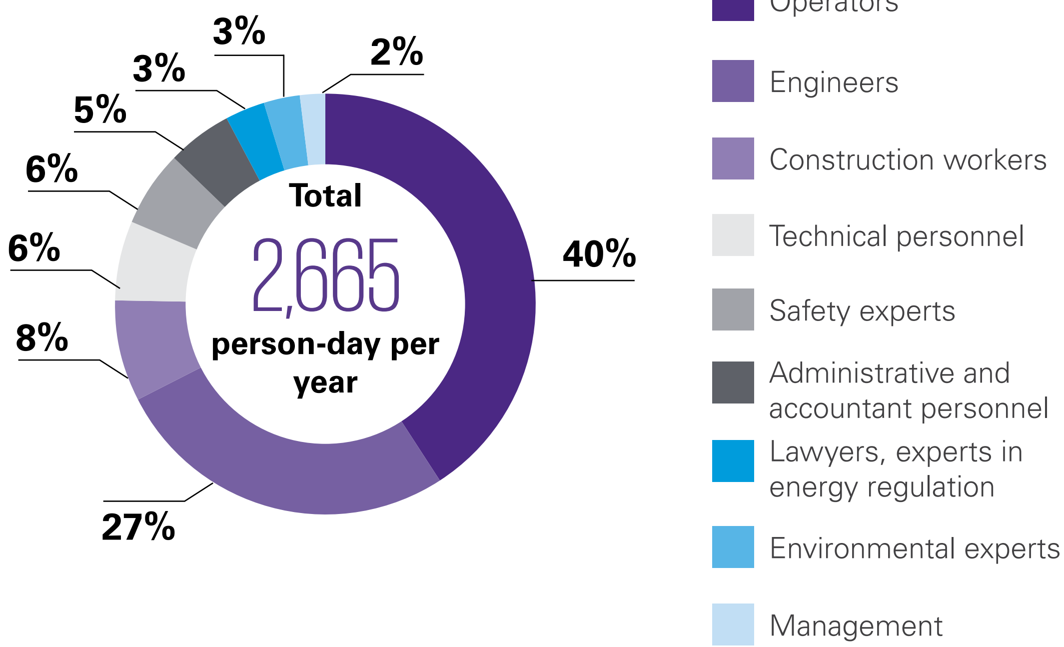
Governments can enhance local value creation further through regulation: **profit sharing policies.**

- The most direct method of profit sharing is through l**ocal taxation**. However, it is contingent on the regulatory framework and often it is not possible or extremely constrained (e.g. Juchitán Mexico).
- More and more countries began to include these schemes as an **additional criteria in feed-in tariffs** (e.g. Ecuador) **and auctions** (e.g. South Africa, Uruguay, Victoria (Australia), El Salvador…).

Distribution of human resources required to install and connect a 50 MW wind farm, by occupation



Distribution of human resources required to operate and maintain a 50 MW wind farm, by occupation



Benefits of community driven projects

1. Community-driven projects generate around ten times more local employment and income.

2. Increase economic resilience of community members because diversifies the sources of income.

3. Broader distribution of assets and influence within the energy system.

4. Increases social acceptance, and it is an opportunity for indigenous people.

Source: IRENA (2017), "Renewable energy benefits: Leveraging local capacity for onshore wind". IRENA (2018), "Renewable energy benefits: Leveraging local capacity for offshore wind". REN 21 (2017), "Renewable Energy Tenders and Community [em]power[ment]". ACEF (2018), "Renewable Energy Tenders and Community [em]power[ment]".

What is wind energy's contribution to sustainable development?

"...it is clear that its major contribution is climate change mitigation, as it reduces greenhouse gas emissions. However, it can also support direct, indirect and induced wealth creation, particularly when projects are designed, developed, run and decommissioned following principles of "localness" (e.g. local ownership, management, operation and content) and sustainability (economic, environmental, social and cultural)."

Tabaré A. Currás
Global Energy Advisor

“Especially in areas with indigenous groups, community-driven renewable energy projects are an opportunity to promote local development, self-determination and identity, while ensuring communities’ control over the mitigation and management of local environmental impacts.

Beyond that, citizen participation helps to build awareness and capacities about energy issues and the importance of energy efficiency improvements, and therefore can lead to a reduction in total energy consumption.”

REN 21, “Renewable Energy Tenders and Community [Em]power[ment]”

L

Wind energy could have positive impacts on the economic development in developing countries

The deployment of wind energy technologies could improve significantly livelihoods in developing countries.

For instance, providing benefits along the agri-food chain. Some examples are:

- Renewable technologies such as wind can provide sustainable, secure and cost-competitive electricity for irrigation, while providing power to other activities at the same time.
- Small wind facilities could generate electricity for lighting and powering appliances for cooling, processing, and running information and communication technologies (ICT).
- Wind threshing mills useful to preserve food over long periods of time.
- Wind mills could increase the efficiency of the process in laborious tasks as hand sawing. The amount of working days needed to saw 60 beams or trunks decreases 20 to 30 times when using wind mills.
- Wind pumps as a low-cost method for mechanization. It could be built locally using available materials (for example bamboo, ropes and discarded plastic), plus it works unattended, have a long-life and no fuels costs.
- Agro-processing machinery running on power generated by wind (this would work only in the presence of a mini-grid).

L

Source: IRENA (2016), "Renewable Energy Benefits Decentralized Solutions in the Agri-food Chain".

M

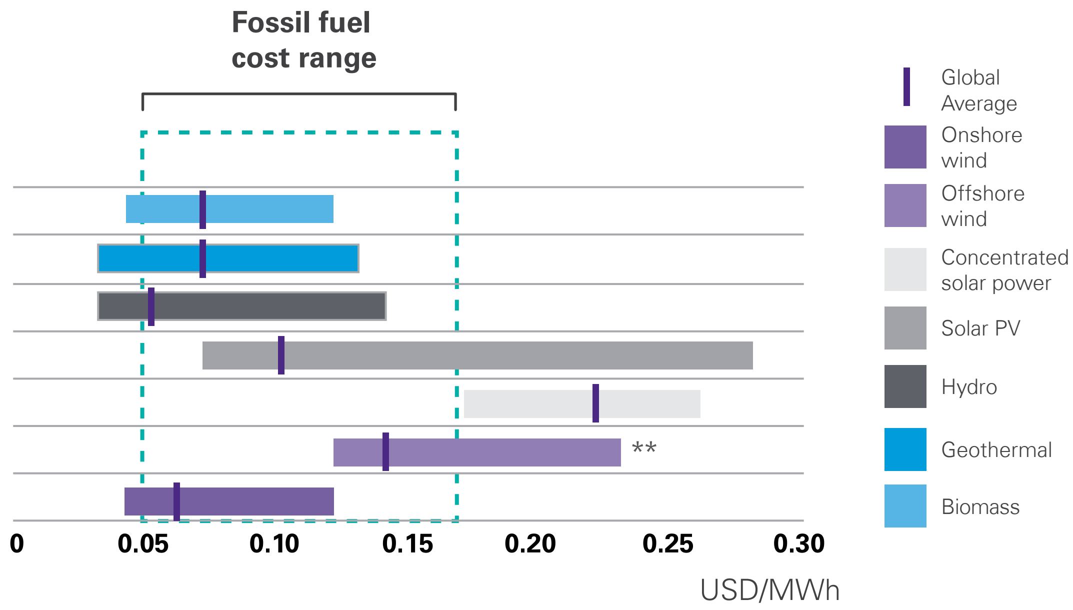
Renewables could save money

Thanks to the large cost reductions, renewables now need much less (or even no) financial support. Together with how they reduce wholesale prices (i.e. low variable generation costs), they could also trigger net savings in electricity bills.

2017's average generation costs (levelised cost of electricity*) from utility-scale renewables fell to within the range of fossil fuels for almost all sources

Average renewable power generation costs in the fossil fuel range in 2017

Spain: 2030 total power **generation costs can be reduced by 2 billion eur/y** with a more ambitious RE penetration
USA, Arizona: NRDC finds that total electricity system cost savings in the high-renewables future between 2020 and 2040 total more **than $4 billion.**
In northern european countries such as Germany or Denmark, wind generation is already making wholesale power prices negative in some hours.



**LCOE is not the only part of the cost equation- system balancing costs may increase, and there is increased need for flexible sources of power and demand response.*
*** Offshore wind technology seems to be improving faster than expected due to impressive technological advances as mentioned in page 49.*

M

NEWS

Bloomberg

Climate Changed

Coal Is Being Squeezed Out of Power by Cheap Renewables

Climate Changed

Coal is being squeezed out of power by cheap renewables

Financial Times

New wind and solar generation costs fall below existing coal plants

Estimates jeopardise Trump´s hopes of reviving mining industry in US

Financial Times

Cheap renewable power can become a disrupter

From Auke Lont, Oslo, Norway

M

Sources: Spanish Government (2019) Spanish National Climate and Energy Integrated Plan. Natural Resources Defence Council and ICF (2018) "New Study: 50% Renewables Would Save AZ More than $4 Billion", IRENA (2018). "Renewable Power Generation Costs in 2017".

"The deployment of renewable energy contributes to sustainable development: it can drive economic growth, create new jobs and enhance human health and welfare.

Wind projects create ample employment opportunities throughout the value chain. IRENA's Leveraging Local Capacity series estimates that the development of a 50-megawatt onshore wind farm requires around 144 420 person-days of work, while a 500-megawatt offshore wind farm requires around 2.1 million person-days of work. A particular aspect of the offshore wind is that the sector can benefit from the many synergies in skills and occupational patterns shared with the offshore oil and gas sector."

Rabia Ferroukhi

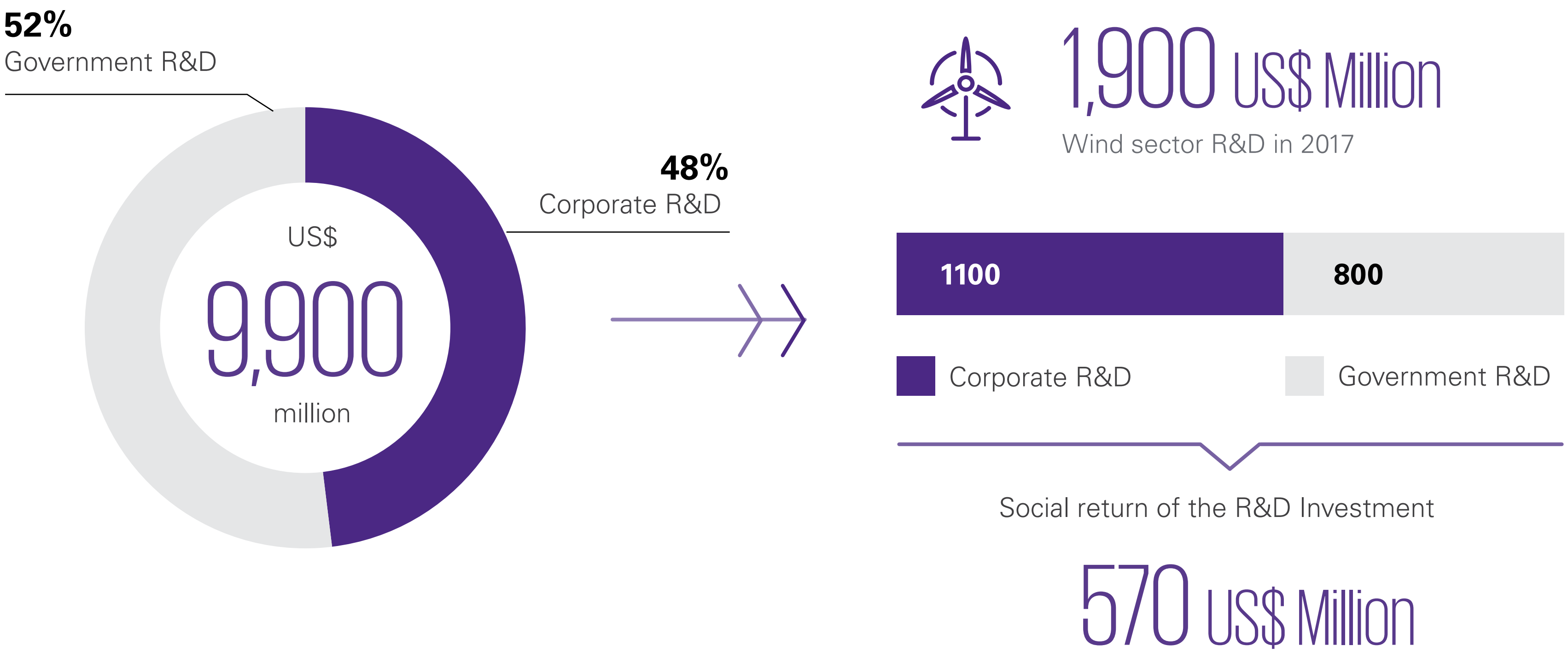
Director of the Knowledge, Policy and Finance division at IRENA

N

Wind is strongly investing in R&D, creating positive effects on society

Investment in renewable energy set a record high in 2017, rising 6% to 9.9 US$ billion. Wind sector was the second biggest recipient of overall renewable energy R&D investment with 1.9 US$ billion, which means 570 US$ million in social return.

Investment in R&D in renewable energy, 2017



N

Source: Bloomberg, Bloomberg New Energy Finance, IEA, IMF, various government agencies. Loelher, M. (2018). "Estimating the Benefits of R&D for Germany". Centre for European Economic Research Discussion Paper No. 18-002. Jones, C. & Williams, J. (1998). "Measuring the Social Return to R&D". The Quarterly Journal of Economics, Oxford University Press, vol. 113(4), pages 1119-1135.

"Wind energy, like any renewable energy, has two main economic advantages. First, its unlimited availability without relying on third countries, contributing to the country's energy security. Secondly, the trade balance benefits, by avoiding the import of fuels and allowing the export of proprietary technology."

Miguel R. Duvison

General Manager of System Operation Red Eléctrica de España (REE, Spanish TSO)

0

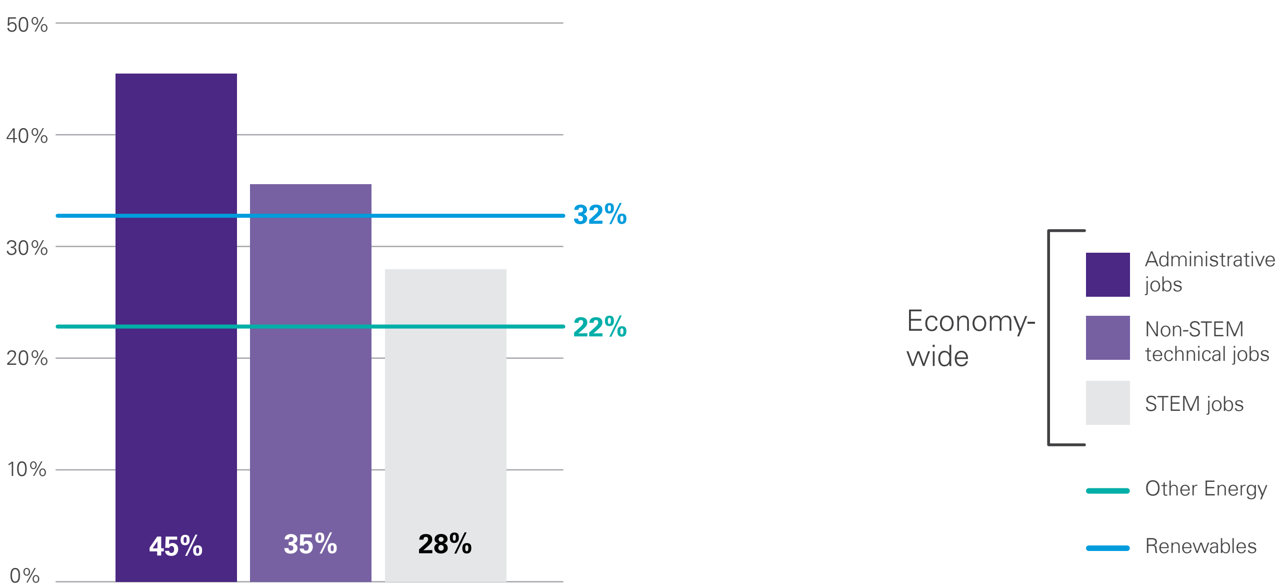
Renewable energy helps in the gender equality agenda, both in large companies and in small rural communities

Renewable energy sector employs relatively more women than other industrial sectors, most of them are highly qualified jobs. The deployment of renewables affects significantly the role of female labour in developing countries.

5 GENDER EQUALITY

Renewable energy is doing better than other energy sectors. However, gender parity is still far.

Share of women in different sectors



Moreover...

There is evidence that electrification through the deployment of renewables in developing countries would have a positive impact on female employment and/or an increase in leisure time, by decreasing the time required for domestic work, allowing that work to be done at night, and/or even enabling/easing their access to the labor market.

For example, a study conducted in Nicaragua used massive government electrification roll-outs "at random" as a natural experiment setting to study its effects (Grogan, 2013). They found that women in electrified households, ceteris paribus, were 23 percentage points more likely to work outside the home. However, there were not significant effects on male labor participation rates.

Other studies carried out in Guatemala and South Africa showed the same results (Dikelman 2010; Grogan 2009).

Gender equality is not only a about fairness, it involves certain outcome improvements such as:

1. Increasing women's engagement, expands the pool of talent for the sector.
2. Women bring new perspectives to the workplace and improve collaboration.
3. Increasing the number of qualified women in an organization leadership board yields better performance overall.

In Europe, Australia and North America, institutions already started to implement measures to improve gender balance in STEM fields, but they are sparse.

O

Source: IRENA (2019),"Renewable Energy: A Gender Perspective". ECREEE and NREL (2015). "Situation analysis of Energy and Gender issues in ECOWAS Member States".

Renewable energy jobs tend to be qualified and bring higher added value

A greater level of skills and qualification, in turn, brings higher salaries, higher taxes paid and broader economic value added.

Jobs created by renewables involve a wide range of occupational and skills requirements.

66% are 'workers and technicians'.

16% are 'experts' (who broadly require tertiary education)

14% are 'engineers and higher degrees' (requiring postgraduate qualifications).

4% are 'administrative personnel'.

Some renewables (e.g. offshore wind, geothermal) could also make use of some existing skills and technology of the oil and gas sector.

Equinor's Hywind wind power park using Siemens Gamesa turbines

"Monica Pettersen exchanged working on Equinor´s Mariner development for working on the Hywind wind turbines. But that wasn´t as big leap as it sounds, either for Monica - or for Equinor.

Hywind combines experience and technology from the oil and gas business with established wind power technology. And the people that did the heavy lifting and planning of the wind turbines are the same people who normally spend their days building oil and gas platforms."

"The transition in employment will necessitate changes in education and training. In the near and medium term, the rapid development of renewable energy will generate significant employment in related equipment manufacturing, project construction and operation and maintenance industries. The overall employment demand of the renewable energy industry will continue to grow over the long-term. To anticipate these changes in energy employment structure, relevant government departments should adjust academic requirements and vocational training, to increase the supply of specialists and professionals for this field."

China Renewable Energy Outlook 2018

4 Specific country trends

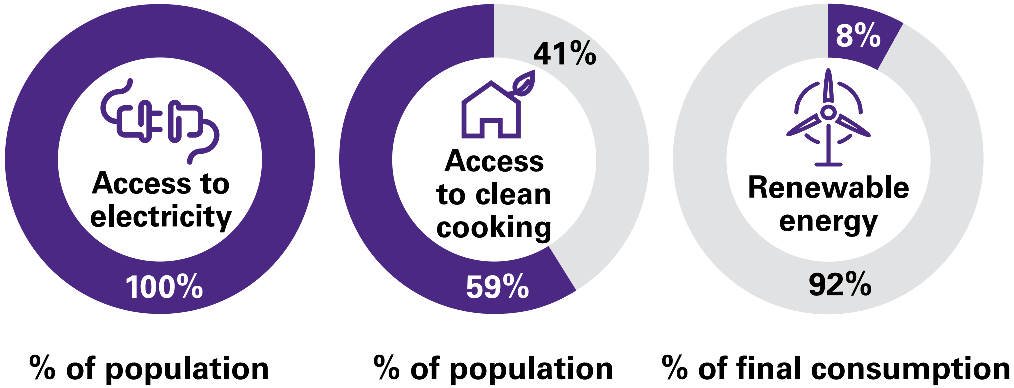
China

China: Current status and deployment of wind energy

China's ambition on renewables increased significantly during the last decade, largely due to severe local pollution problems. China's recent renewable energy policies are focused on two main goals: to alleviate grid integration challenges and the cost-reduction of renewable subsidies.

Current state/situation

Energy-related SDG Indicators, 2016 *:



** RE share to be reviewed up from 8% to 12.4% according to WB, IEA and IRENA.*
https://data.worldbank.org/indicator/EG.FEC.RNEW.ZS
http://resourceirena.irena.org/gateway/dashboard/?topic=15&subTopic=40

Some hot topics in energy policy:

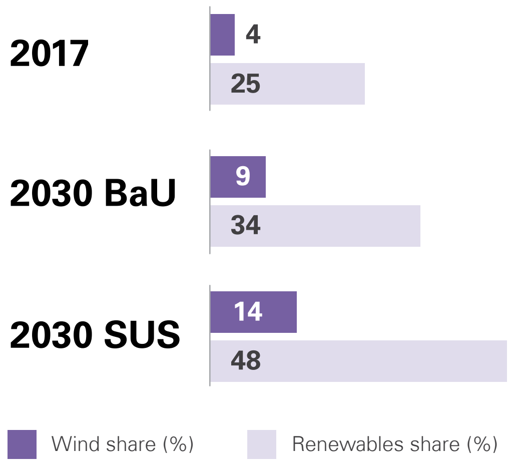
- Limit coal power plant pipeline.
- Raise NDC ambition?
- 13th Five-Year Plan targets.
- From FiT System towards a market-based approach: renewable portfolio standards (rps) / auctions.
- Installation ban in the North China provinces to combat high curtailment.
- Grid integration challenges.
- Promoting capacity expansion in provinces close to demand centers.
- Power sector reform.
- Carbon markets.

Main pledges and targets

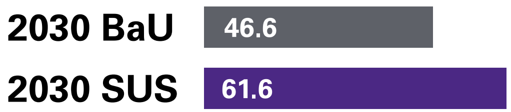
- Renewable energy share target of 35% by 2030, 50% by 2050.
- Peaking of CO_2 emissions around 2030. National coal emissions reduction per unit of GDP by 40% to 45% by 2020 respect to 2005 levels, 60% to 65% by 2030.
- 15% minimum efficiency target by 2020

Projections

Forecasted electricity mix



Wind capacity additions needed (GW/year)

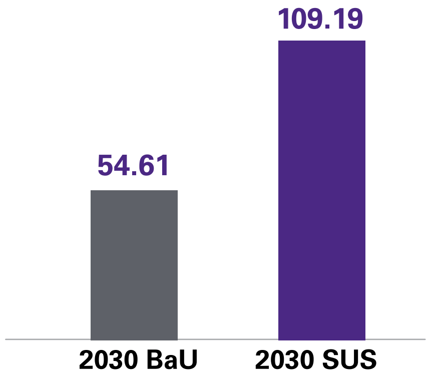


Sources: *China Energy Outlook (2018), WEO (2018), IEA (2018), "Renewables 2018: Analysis and Forecasts to 2023", IRENA (2015) "Renewable energy prospects: United States of America" . Tracking SDG 7. World Bank; Sustainable Development Goal 7. IEA Wind energy scenarios for 2030. EWEA.*

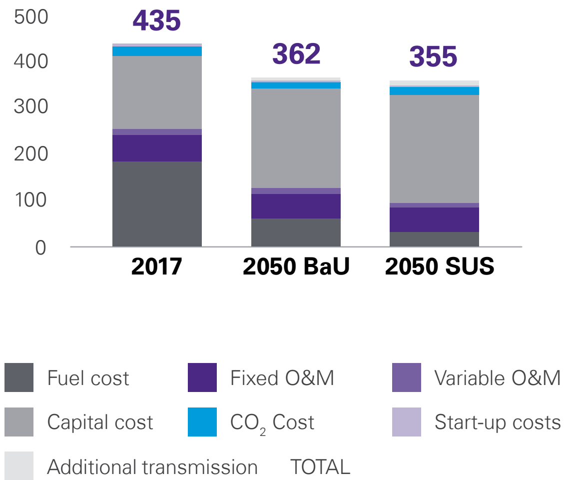
China: Aggregated economic effects of wind energy deployment

When accounting for health and GHG emissions reductions, renewables could save 55 to 228 billion dollars per year in China.

Investment in renewables (US$ billion)



Power system costs (RMB/MWh)



The investment needed to achieve SUS in 2030 would average US$ 145 billion per year until 2030, which represents an increase of US$ 54 billion per year in investments over the BaU scenario. However, when accounting for health and GHG emissions reductions, renewables would imply savings of 55 to 228 billion dollars per year.

On the public policy side, renewables could reduce fossil fuel imports and increase energy security.

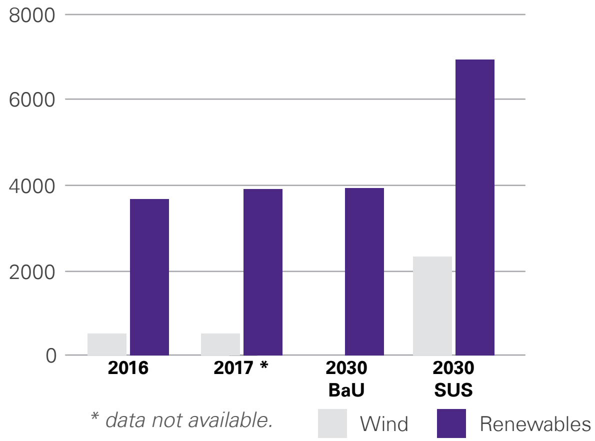
The deployment of renewable energy sources through competitive price mechanisms is expected to reduce power system costs. Subsidies are expected to be phase out, reducing their costs to society.

The level of development of wind energy needed in the Sustainable Scenario would entail an extra GDP growth of

0.4% GDP

with respect to the Business As Usual Scenario by 2030.

Employment impact (thousands of jobs)



Sources: *China Economic Outlook (2018), IRENA (2014) "Renewable energy prospects: China," IRENA (2019) REmap databse.*

China: Social and environmental effects of wind energy development

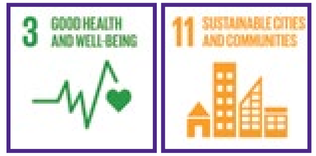
China is mainly focused on local air pollution due their impacts on population. Renewables energy sources could avoid 50% of serious illness and premature mortality cases caused by local pollution.

In a Sustainable Scenario…

16,717 million $
CO_2 emissions avoided by wind energy by 2030

3,851 million m^3
water use avoided by wind energy by 2030

0.6% GDP
health-related cost saved up by renewable energy by 2030*



Wind energy is projected to avoid 334.34 Mt CO_2 by 2030

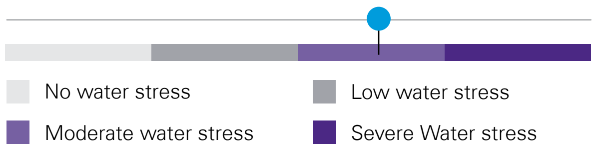
Yearly emissions of...

Equivalent to the annual consumption of

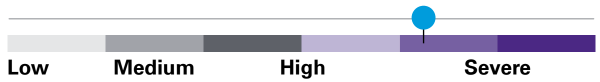
20.7 million **Chinese households**

574 billion $ **savings**

Water stress in China by 2030

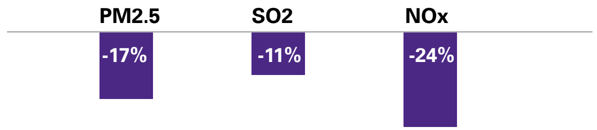


Ambient air pollution (PM2.5)



Air pollutants avoided by 2030 (%)

(compared to 2030 BaU scenario)



Up to 0.25 million premature deaths avoided annually by renewable energy by 2030**

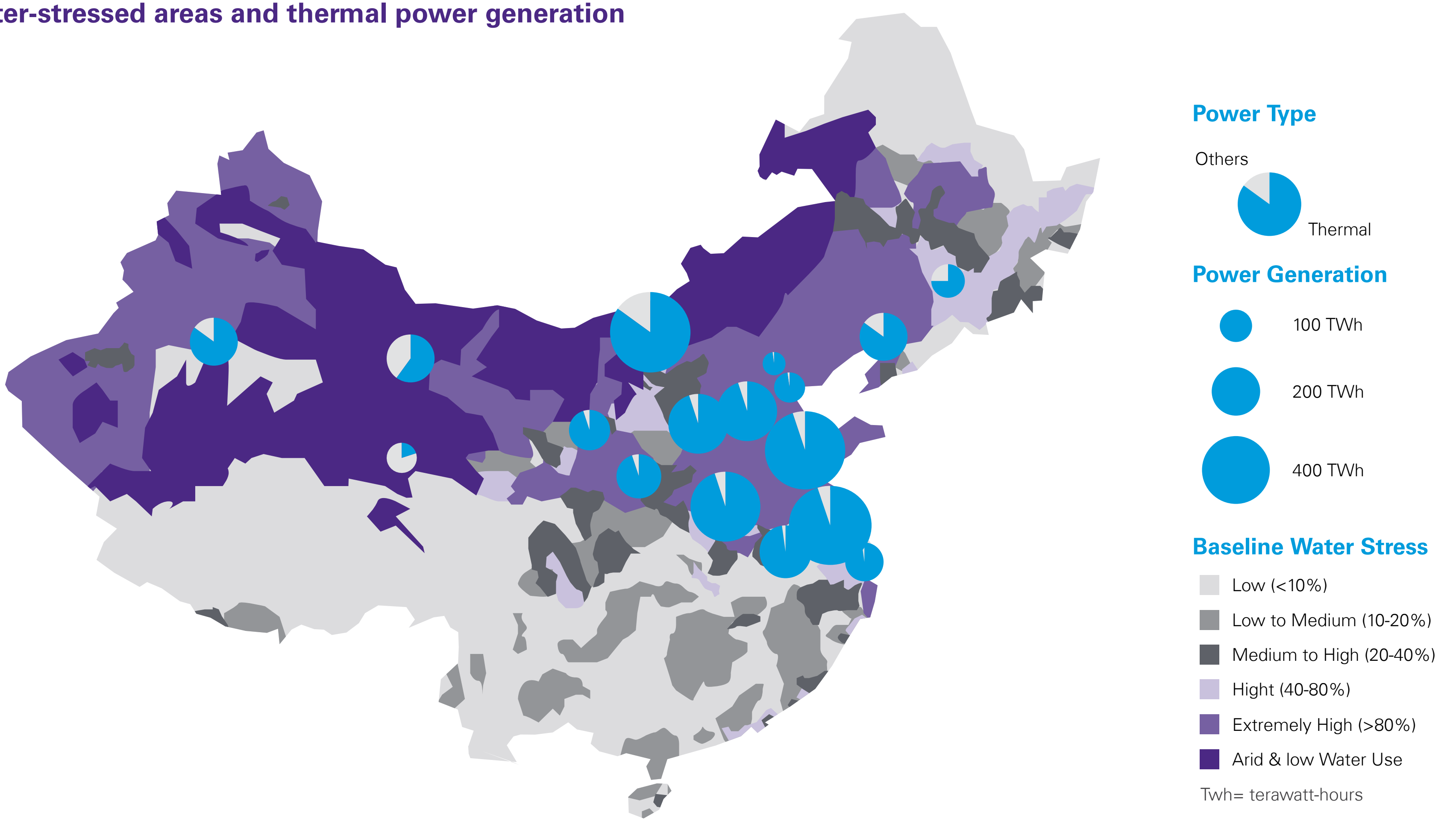
*** In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy.*
*** Due to the higher usage of renewable energy in power generation and end-use sectors, air pollutants emissions in the Sustainable scenario are lower than the BaU scenario.*
**** Premature mortality caused by PM2.5 .*
***Estimations:** Exchange rate on 19/3/6: 1.1308 USD/CNY.*

***Sources:** IEA (2018) "WEO. 2018"; Beijing Municipal Commission of Transport. Statista (178 litres per person/day; 2.87 people per household); Beijing Water Authority (5 yuan/m3) OECD (2008) "Environmental Outlook. Global water stress: 2030". IRENA (2016) "The true cost of fossil fuels: saving on the externalities of air pollution and climate change"; WHO (2016). "Annual mean concentration of PM2.5 in urban areas"; Yang, Xi & Teng, Fei. (2017). "Air quality benefit of China's mitigation target to peak its emission by 2030"; CNREC ((2017 and 2018) "China Renewable Energy Outlook 2017 and 2018".*

China: Social and environmental effects of wind energy development

Water scarcity is enhanced by the location of the coal-based generation capacity, mostly in the east coast (where most population lives). Offshore wind energy could prove an interesting alternative.

Water-stressed areas and thermal power generation



*__Sources:__ China Energy Outlook (2018), IRENA (2016), "Water use in China's power sector: impact of renewables and cooling technologies to 2030". The Social Cost of Carbon. EPA Saving water with wind energy IRENA. The true cost of fossil fuels: saving on the externalities of air pollution and climate change *In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy. The boundaries shown in the maps used do not represent an official KPMG endorsement or acceptance. They have a purely illustrative purpose and aim to convey the specific messages addressed in this report, excluding any positioning on political or geographical issues*
China Water Risk based on CEC data for 2013, projected on the WRI Aqueduct - Baseline Water Stress map.

"With the important milestones set for 2020, 2035 and 2050, China has the ambition to develop a "clean, low carbon, safe and efficient energy system". Nevertheless, renewable energy remains vulnerable to policy choices, and it is important to focus on removing barriers for re-deployment and set incentives to encourage investors and developers to accelerate this massive effort."

Raymond Ng

Head of Energy & Natural Resources, KPMG in China

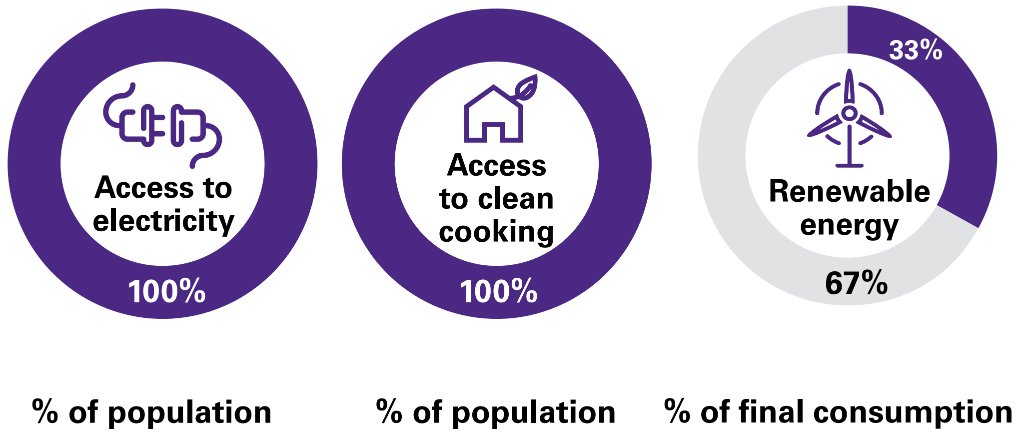
Denmark

Denmark: Current status and deployment of wind energy

Denmark is an early mover on renewable energy adoption, in a context of long term political consensus. It could become the first carbon-neutral country in the World.

Current state/situation

Energy-related SDG indicators, 2016



Some hot topics in energy policy:

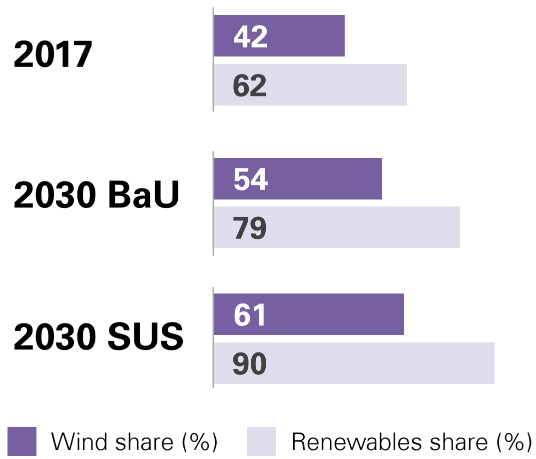
- Bold but credible policies in favor of renewables.
- Viking Link interconnector to UK that will drive up electricity prices in Denmark towards UK levels.
- North Sea Wind Power Hub – a vision to create an island in the North Sea hosting wind farms of up to 30 GW capacity.
- Sector coupling between electricity and gas systems via hydrogen for storage and backup.
- Coal to phase out in electricity production before 2030. Notice that coal accounted around 30% of Danish power generation as of 2016.

Main pledges and targets

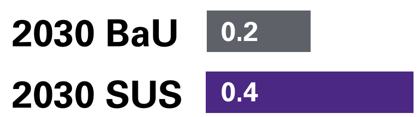
- 55% renewable energy share target in final energy by 2030, 100% by 2050.
- 20% non-ETS GHG emissions reduction by 2020, relative to 2005; at least 39% by 2050 but working on a climate-neutral society (all GHG gas emitted being absorbed).

Projections

Forecasted electricity mix



Wind capacity additions needed (GW/year)



Sources: Danish NECP (2019), Danish Energy Agency (2016) "Energy in Denmark. A Green transition", WEO 2018, IEA (2018), "Renewables 2018: Analysis and Forecasts to 2023". Tracking SDG 7. World Bank; Sustainable Development Goal 7. IEA Wind energy scenarios for 2030. EWEA.

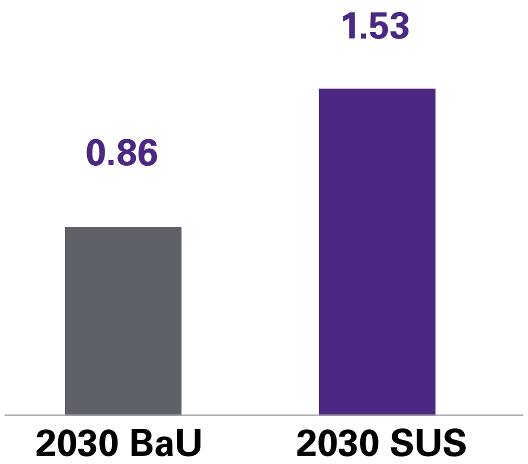
Denmark: Aggregated economic effects of wind energy deployment

The deployment of renewable energy sources in the SUS would imply US$ 600 million in additional investments, yet socioeconomic returns are expected to cover the cost.

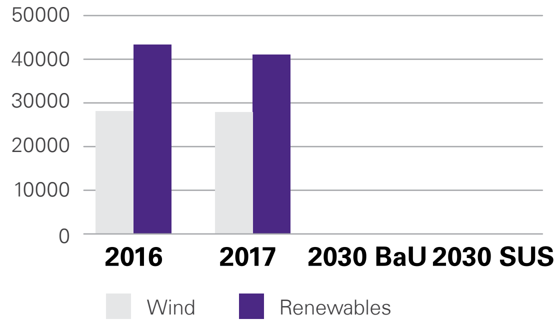
Denmark has spent around € 67 million in public funding on research and development on low-carbon technologies in 2018. However, their ambitious commitments will require new political initiatives and investments. For example, €563 million for technology-neutral energy tenders to fund 800 MW projects by 2030.

Wholesale electricity prices are expected to increase from 30.5 €/MWh in 2017 to 46.08 €/MWh in 2030. This 46% increase over 13 years is mainly caused by increased interconnectivity and higher price convergence with markets with higher prices. Wind and other renewables could mitigate this effect.

Investment in Renewables (US$ billion/year)



Employment impact (number of jobs)



The level of development of wind energy needed in the Sustainable Scenario would entail an extra growth of

0.01% GDP

with respect to the Business As Usual Scenario by 2030.

The low-carbon industry is more intensive in research and innovation. On average of 9 out of 100 employees work in the field of research and innovation, twice than in traditional companies.

**Projections not available for the whole renewables category. However, according to the European Commission, a Sustainable Scenario would increase total economy-wide employment by up to 22,700 additional jobs.*

Sources: *Danish NECP (2019), IRENA (2019) REmap database*

Denmark: Social and environmental effects of wind energy development

Denmark, being a significantly advanced country in terms of renewables, still reaps social benefits of an ever greater ambition.

In a Sustainable Scenario…

141 million $
CO_2 emissions avoided by wind energy by 2030

13 CLIMATE ACTION

37 million m³
water use avoided by wind energy by 2030

6 CLEAN WATER AND SANITATION

0.9% GDP
health-related cost saved up by renewable energy by 2030*

3 GOOD HEALTH AND WELL-BEING

11 SUSTAINABLE CITIES AND COMMUNITIES

Wind energy is projected to avoid 2.83 Mt CO_2 by 2030

Yearly emissions of...

0.2 X Copenhagen → **0.6 million people living in this city**

Equivalent to the annual consumption of

0.4 million Danish households

349 million $ savings

Water stress in Denmark by 2030

No water stress | Low water stress | Moderate water stress | Severe Water stress

Ambient air pollution (PM2.5)

Low | Medium | High | Severe

Air pollutants avoided by 2030 (%) (compared to 2014)

PM2.5	SO2	NOx
-30%	-10%	-40%

Premature deaths avoided by 2030 (persons)

2030 BaU	2800
2030 SUS	2600

-7%

Up to **200 premature deaths**** avoided by annually by renewable energy by 2030

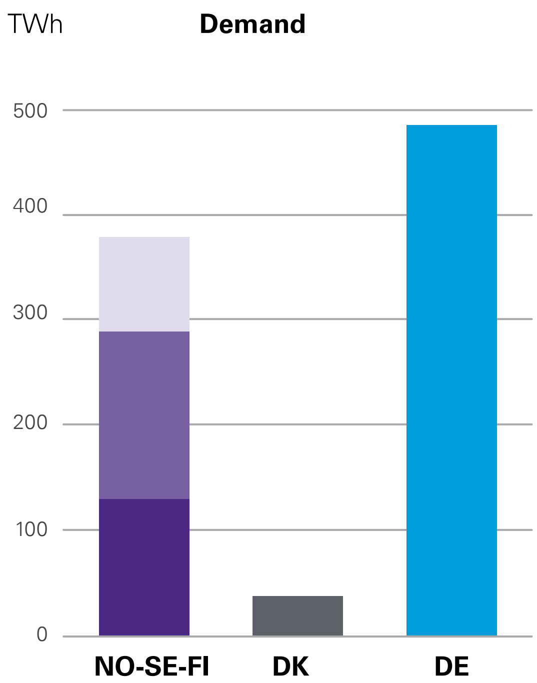
In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy.
*** Reductions in the number of premature deaths is primarily due to slightly lower PM2.5 concentrations, but there is also a small contribution from slightly lower ozone concentrations in 2030.*
***Estimations:** Exchange rate on 19/3/6: 1.1308 USD/EUR.*

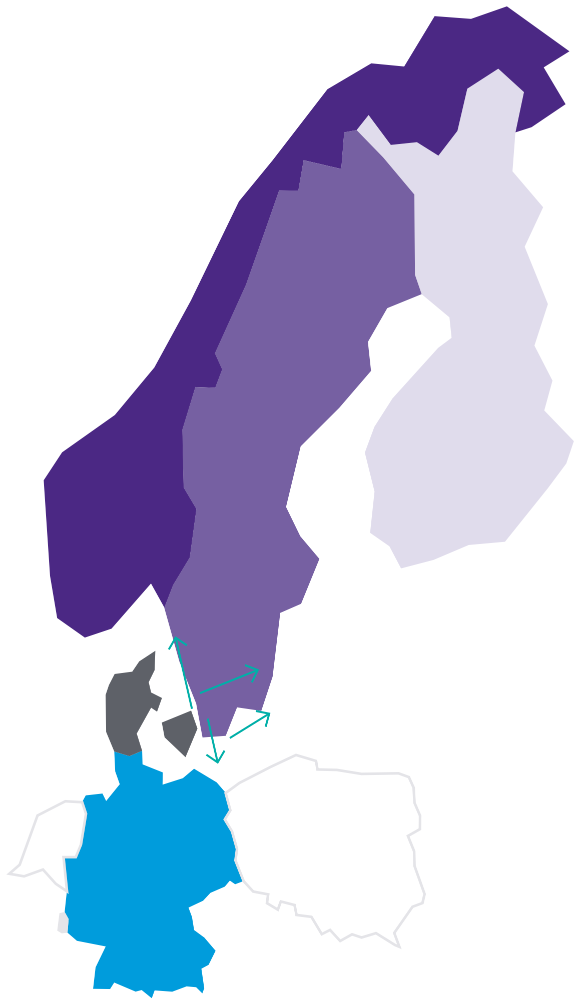
***Sources:** EWEA (2015). "Wind energy scenarios for 2030". EPA (2017). "The social cost of carbon"; . Bicyclist Count in Copenhaguen*
EWEA (2014), "Saving water with wind energy"; Danish Water and Wastewater Association (106 litres per person/day and 2.15 people per household); EurEau (8.25 €/m3;); OECD (2008) "Environmental Outlook. Global water stress: 2030"
IRENA (2016) "The true cost of fossil fuels: saving on the externalities of air pollution and climate change"; WHO (2016). "Annual mean concentration of PM2.5 in urban areas"; Danish Centre For Environment And Energy. "Development in air quality and health effects for 2020 and 2030 in relation to National program for reducing air pollution (NAPCP)"; DCE "Projection of SO2, NOX, NMVOC, particulate matter and black carbon emissions – 2015-2030".

Denmark: Aggregated economic effects of wind energy deployment

Denmark as a possible hub for a large regional electricity market, taking advantage of hydro-wind-solar complementarities.

Denmark`s National Climate and Energy Integrated Plan places great importance on building a strong transmission grid where interconnections with other countries could increase significantly and create a large regional market. This could leverage the synergies between wind (e.g. in Denmark), solar (e.g. in Germany) and hydro (e.g. in the other Scandinavian countries).





Sources: *Danish Energy Agency (2016) "Energy in Denmark. A Green transition". The Social Cost of Carbon. EPA Saving water with wind energy IRENA. The true cost of fossil fuels: saving on the externalities of air pollution and climate change *In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy.*

"Danish Wind has been a success story for the Danish society as it has driven transition towards renewables integration in the energy mix, while creating a myriad of (sub-) suppliers across the entire value chain, thus establishing a sizeable industry and created thousands of jobs.

The Danes broadly support renewables and are demanding still more ambitious plans from the government to assure Denmark's leader position; wind and solar play a central role and one specific challenge being addressed is how to increase capacity and integrate further with the Danish energy mix. To harvest the full potential we start to see initiatives like the North Sea Wind Power Hub - a vision to create an island in the North Sea hosting wind farms of up to 30 GW capacity – while plans on a Viking Link interconnector to UK will influence electricity prices in Denmark in direction of UK levels.

Going forward, Denmark is looking into a future of electrification and increasing sector coupling between electricity and gas systems via hydrogen for conversion, storage and backup. Following this, supplied energy finds alternative routes to consumers, who in turn experience greater freedom of choice and faith in supply from renewables."

Morten Mønster
Head of Advisory,
KPMG Denmark

Germany

Germany: Current status and deployment of wind energy

The *Energiewende* (German "energy transformation") aims to move away from nuclear and fossil fuels towards an energy system based on energy efficiency, renewable energy and economy-wide electrification.

Current state/situation

Energy-related SDG indicators, 2016

% of population | % of population | % of final consumption

Some hot topics in energy policy:

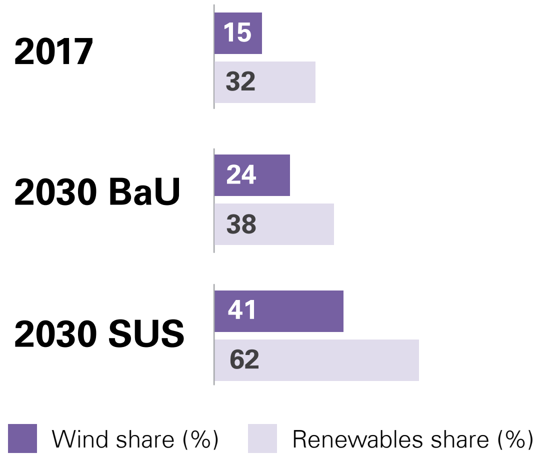
- Ambitious renewable energy goals.
- Change in the electricity production landscape: nuclear phase-out by the end of 2022, estimated coal phase-out by the end of 2038.
- Uncertainty due to the politics of the energy transition.
- Design of RE auctions.
- Electricity tariff design and self-consumption.
- Ageing onshore wind fleet: repowering, Power Purchase Agreements or removal?
- Varying RE permitting issues in different federal states.
- Halting grid expansion constraints.

Main pledges and targets

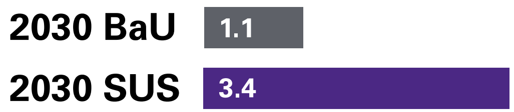
- 40% GHG emissions reduction by 2020 compared to 1990 levels; 55% by 2030, 70% by 2040 and 80-95% by 2050.
- Renewable energy share in gross final energy consumption to increase to 30% by 2030, 60% by 2050.
- Renewable energy share in gross electricity consumption to increase to 50% by 2030, 80% by 2050
- 20% reduction in primary energy consumption compared to 2008 by 2020, 50% by 2050.

Projections

Forecasted electricity mix



Wind capacity additions needed (GW/year)



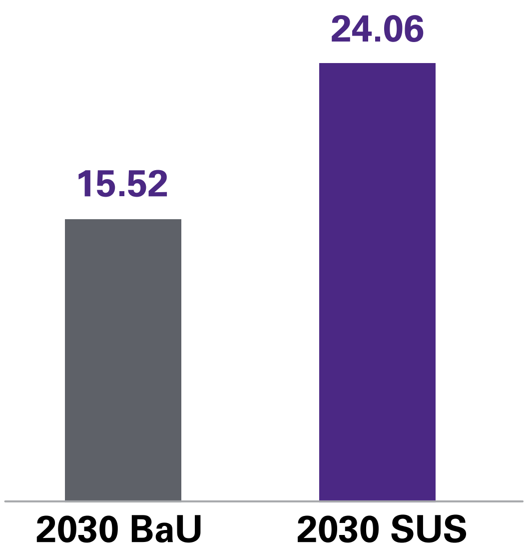
Sources: *German NECP (2019), WEO (2018), IEA (2018), "Renewables 2018: Analysis and Forecasts to 2023". Tracking SDG 7. World Bank; Sustainable Development Goal 7. IEA Wind energy scenarios for 2030. EWEA;*

Germany: Aggregated economic effects of wind energy deployment

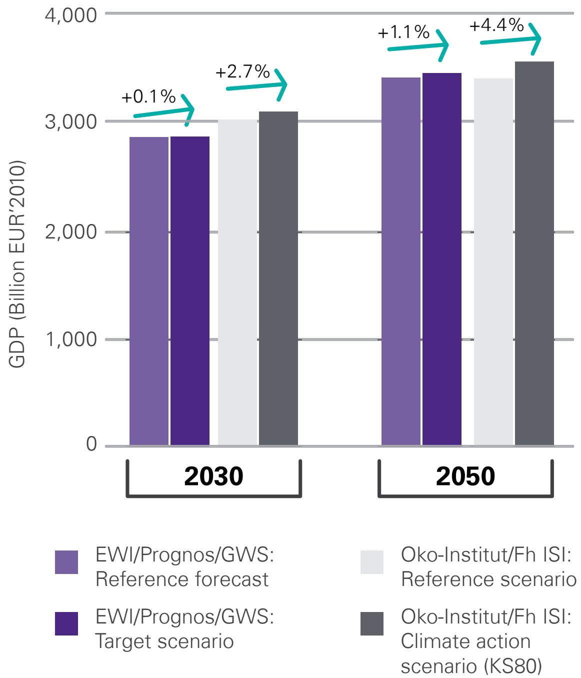
The deployment of renewables would imply US$ 4 billion in additional investments, but could yield GDP improvements.

In order to achieve the renewable energy deployment of the SUS, Germany would have to invest US$ 24 billion per year (on average) to 2030, mainly in power and end-use sectors. The deployment of renewables in the SUS would imply an incremental cost of US$ 8.5 billion per year in 2030 compared to the BaU scenario.

Investment in Renewables (US$ billion/year)

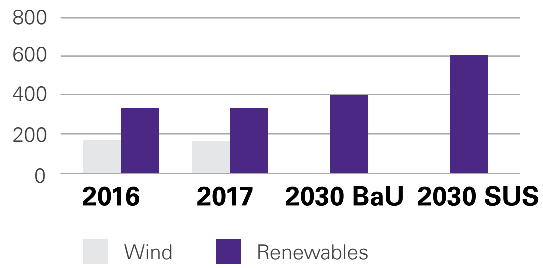


The effect of the energy transition in the German economy



The total economic effects of the energy transition are slightly positive as decreasing imports of coal, oil and natural gas make room for domestic value creation.

Employment impact (thousands of jobs)



The level of development of wind energy expected in the Sustainable Scenario would entail an extra growth of

1.5% GDP

with respect to the Business As Usual Scenario by 2030.

Sources: *German NECP (2019), Agora (2015) "Energiewende 2030: The Big Picture".*

Germany: Social and environmental effects of wind energy development

Wind and other renewable energies could reduce carbon emissions of an equivalent of 6.2 times the vehicles in Berlin and help to mitigate water scarcity problems…

In a Sustainable Scenario…

735 million $
CO_2 emissions avoided by wind energy by 2030

13 CLIMATE ACTION

195 million m^3
water use avoided by wind energy by 2030

6 CLEAN WATER AND SANITATION

0.1% GDP
health-related cost saved up by renewable energy by 2030*

3 GOOD HEALTH AND WELL-BEING

11 SUSTAINABLE CITIES AND COMMUNITIES

Wind energy is projected to avoid 14.7 Mt CO_2 by 2030

Yearly emissions of…

0.4 X Berlin

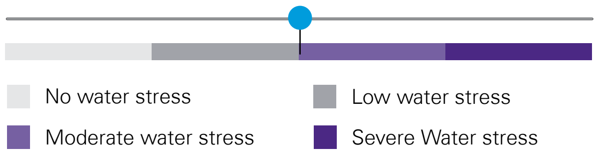
3.6 million people living in this city

Equivalent to the annual consumption of

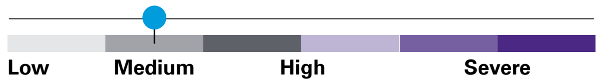
2.2 million German households

264 million $ savings

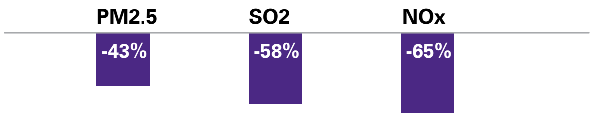
Water stress in Germany by 2030



Ambient air pollution (PM2.5)



Air pollutants avoided by 2030 (%)
(compared to 2005 baseline)



Up to 2.500 premature deaths avoided annually by renewable energy by 2030

*In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy
Estimations: *Exchange rate on 19/3/6: 1.1308 USD/EUR.*

Sources: *EWEA (2015). "Wind energy scenarios for 2030". EPA (2017). "The social cost of carbon". EWEA (2014), "Saving water with wind energy"; Statista, (123 litres per person/day); Statisches Bundesamt (2 people per household); Profile of the German Water Sector 2015, (1.2 €/m3); OECD (2008) "Environmental Outlook. Global water stress: 2030". IRENA (2016) "The true cost of fossil fuels: saving on the externalities of air pollution and climate change"; WHO (2016). "Annual mean concentration of PM2.5 in urban areas"; The Federal Government (2016). "German Sustainable Development Strategy".*

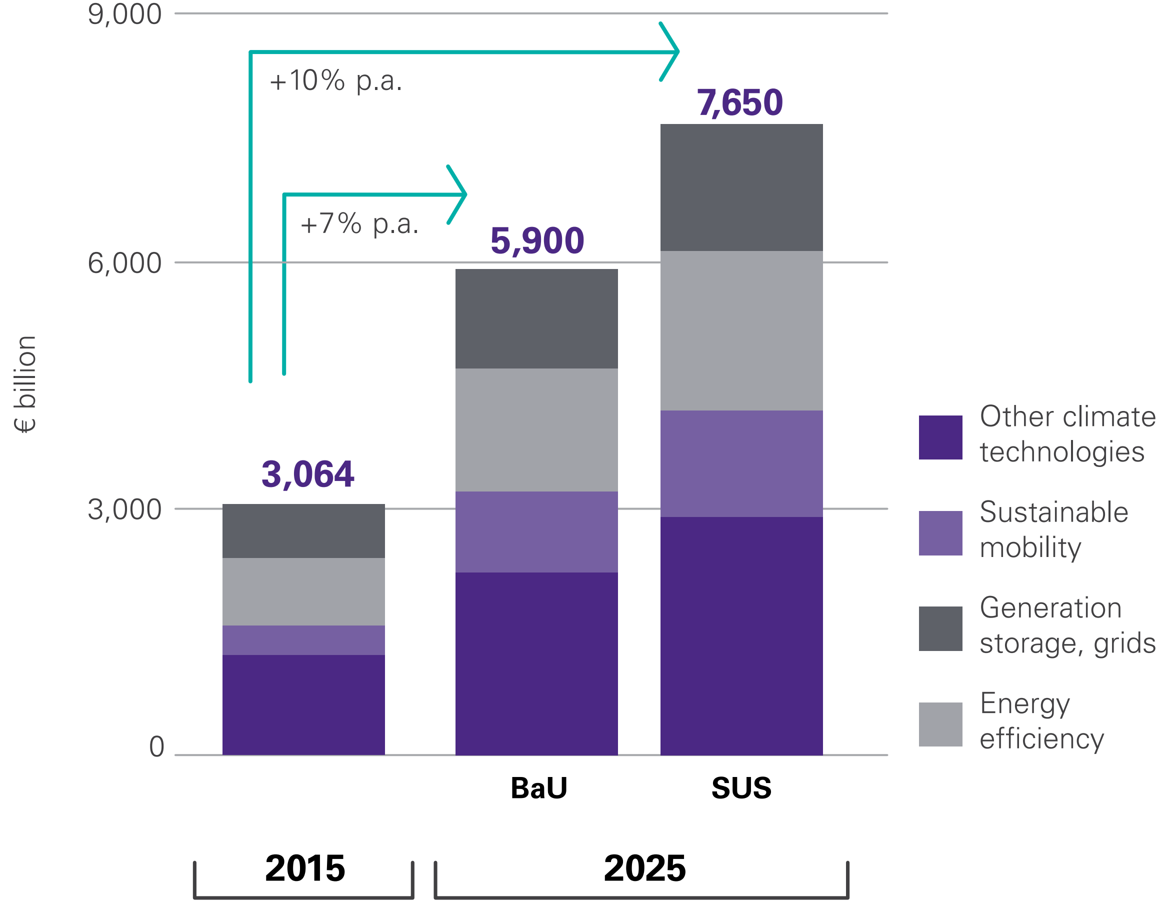
Germany: Social and environmental effects of wind energy deployment

… while providing new economic opportunities and improving their export position.

At national level, Germany is expected to save US$ 2.4 billion annually by 2030 compared to the BaU scenario.

As major leader in energy technologies for mitigating climate change, a sustainable transition would improve Germany's export position and additional positive economic effects.

The effect of the energy transition in the German economy due to the rising exports (global market volume)



Sources: German NECP (2019), Agora (2015) "Energiewende 2030: The Big Picture".

“Germany has ambitious goals for the energy transition and for using more renewable energies. Two decades ago Germany has started to develop RE technologies like wind and solar meeting an increasing demand from Germany and other early adopting countries. With the “Energiewende”, Germany goes down a radical and consequent path and will continue to aim for a sustainable future by integrating more RE, increasing energy efficiency, and significantly reducing GHG emissions. This will take some time and we are curious to see how the energy system will achieve our goals”.

Michael Salcher
Head of Energy & Natural Resources, KPMG Germany

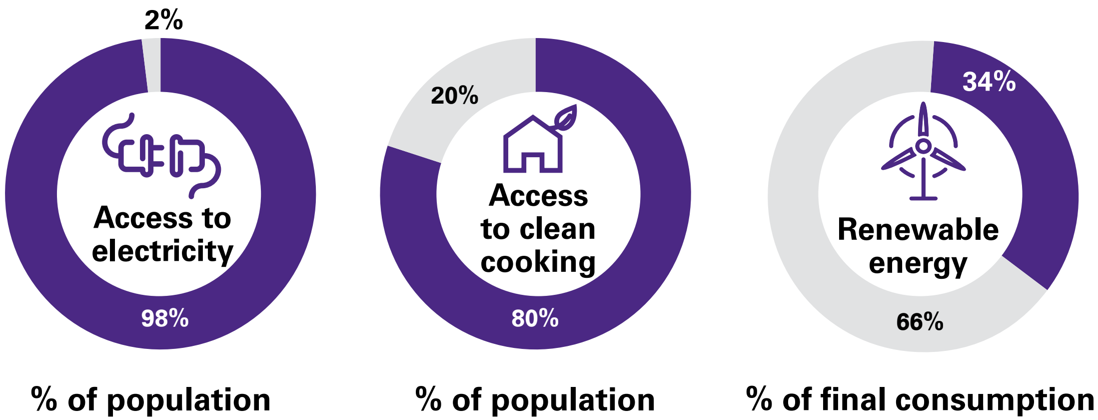
India

India: Current status and deployment of wind energy

India has set quite ambitious renewable energy targets, and has important local pollution and water scarcity problems.

Current state/situation

Energy-related SDG indicators, 2018



Some hot topics in energy policy:

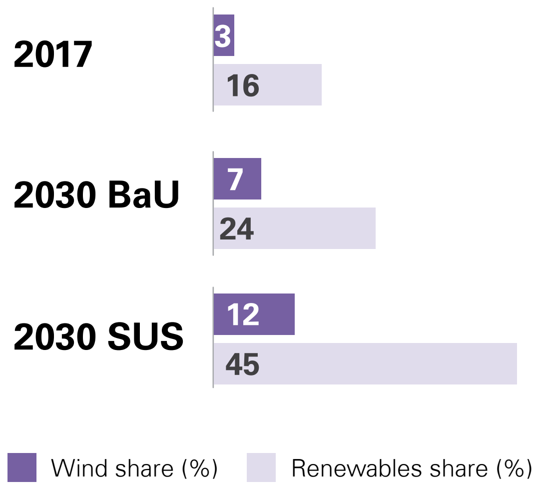
- Universal electricity access.
- Limiting coal power plant pipeline
- Measures to improve financial health of network and distribution utilities.
- Exit from the previous generation-based incentive.
- Strengthening electric grids, reducing loses and improving system integration.
- RE auction scheme, federal and state-level auctions. Timetable?
- Ambitious RE Renewable Purchase Obligation and other fiscal measures to promote renewables targets.

Main pledges and targets

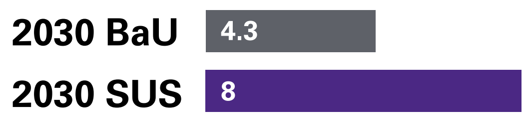
- 6% renewable energy share on gross final consumption by 2022. 40% cumulative electric power installed capacity from non-fossil fuel-based energy resources by 2030.
- 34% reduction in GHG emissions by 2030.
- Despite of not having a concrete numerical target to energy efficiency, efficiency measures lead Indian's strategy to achieve its climate change mitigation commitments. In fact, the Bureau of Energy Efficiency initiated the National Mission for Enhanced Energy Efficiency (NMEEE) in 2008 to carry out such process.

Projections

Forecasted electricity mix



Wind capacity additions needed (GW/year)

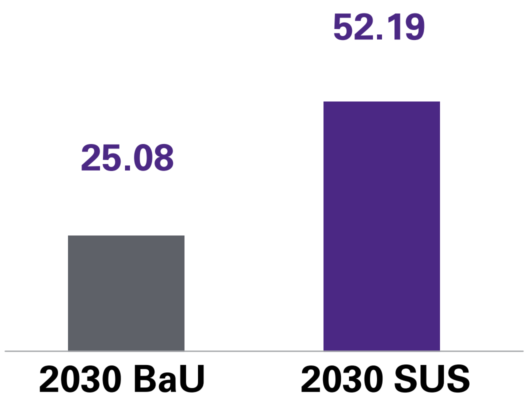


Sources: *"Renewables 2018: Analysis and Forecasts to 2023", WEO (2018), NITI Aayg (2015) "Report on India's Renewable Electricity Roadmap 2030". Tracking SDG 7. World Bank Sustainable Development Goal 7. IEA Wind energy scenarios for 2030. EWEA; China Energy Outlook (2018), IEA (2018).*

India: Aggregated economic effects of wind energy deployment

The deployment of renewables would imply US$ 4 billion in additional investments, but could yield GDP improvements.

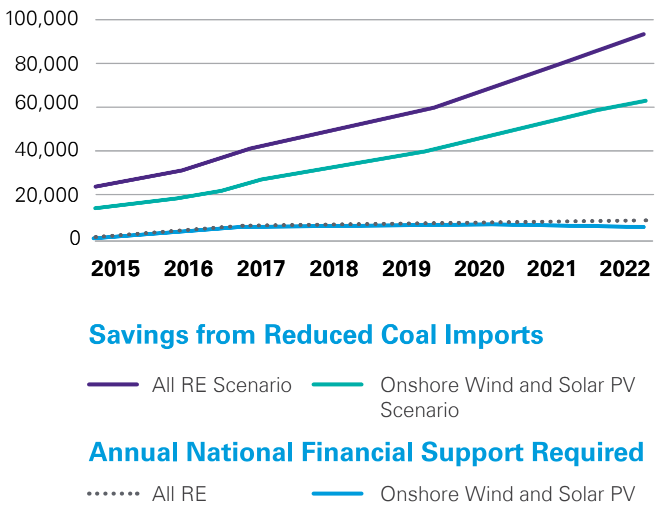
Investment in renewables (US$ billion)



In 2018, renewable energy reached an investment record, US$ 20 billion. The expenditure on onshore wind projects hit record numbers too, according to the IEA.

Financial Support for RE vs. Coal Import Savings

(Savings based upon a coal price of Rs. 4200/tonne)



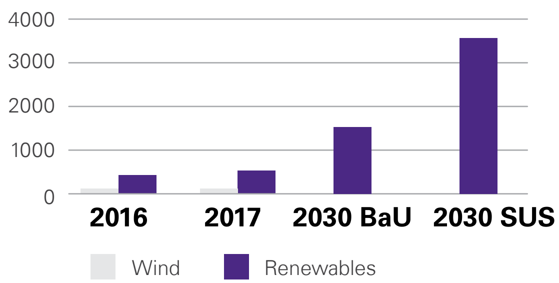
A major benefit lies on the savings on expensive and volatile imported fuels, mainly coal.
Reaching the SUS would reduce the Indian coal bill by more than US$ 8,5 billion.*

The level of development of wind energy needed in the Sustainable Scenario would entail an extra GDP growth of

1.7% GDP

with respect to the Business As Usual Scenario by 2030.

Employment impact (thousands of jobs)



A MNRE study estimates on 152,000 the extra new jobs that would by created in the wind sector in the SUS by 2020.

**However, these figures could be smaller, considering the cheaper current price of domestic coal (around INR 2000/ton to INR 3000/ ton for a GCV of 3300-3800 Kcal/Kg), which represents around 85% of India's thermal coal consumption.*

Sources: *IRENA (2019) REmap database, NITI Aayg (2015) "Report on India's Renewable Electricity Roadmap 2030", NITI Aayog (2018) "SDG India Index. Baseline report".*

India: Social and environmental effects of wind energy development

The benefits derived from the deployment to SUS levels are estimated to account for US$ 8.43 billion annually by 2040. Domestic profit-sharing policies could enhance further the local valued generated.

In a Sustainable Scenario…

4,619 million $
CO_2 emissions avoided by wind energy by 2030

1,195 million m³
water use avoided by wind energy by 2030

3% GDP
health-related cost saved up by renewable energy by 2030*

Wind energy is projected to avoid 92.37 Mt CO_2 by 2030

Yearly emissions of…

1.3 X
Delhi

27
million people living in this city

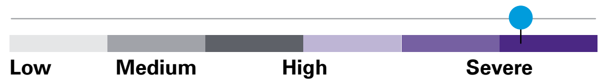
Equivalent to the annual consumption of

8.2 million **Indian households**

17 million $ **savings**

Water stress in Indian by 2030

Ambient air pollution (PM2.5)



Up to 30% air pollution reduction by 2024 by renewable energy (compared to 2017 levels)**

**In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy.*
*** Based on National Clean Air Program 2019-2024 target: 20-30% reduction of PM2.5 and PM10 keeping 2017 as the base year.*
***Estimations:** Exchange rate on 19/3/6: 0.014 USD/INR.*

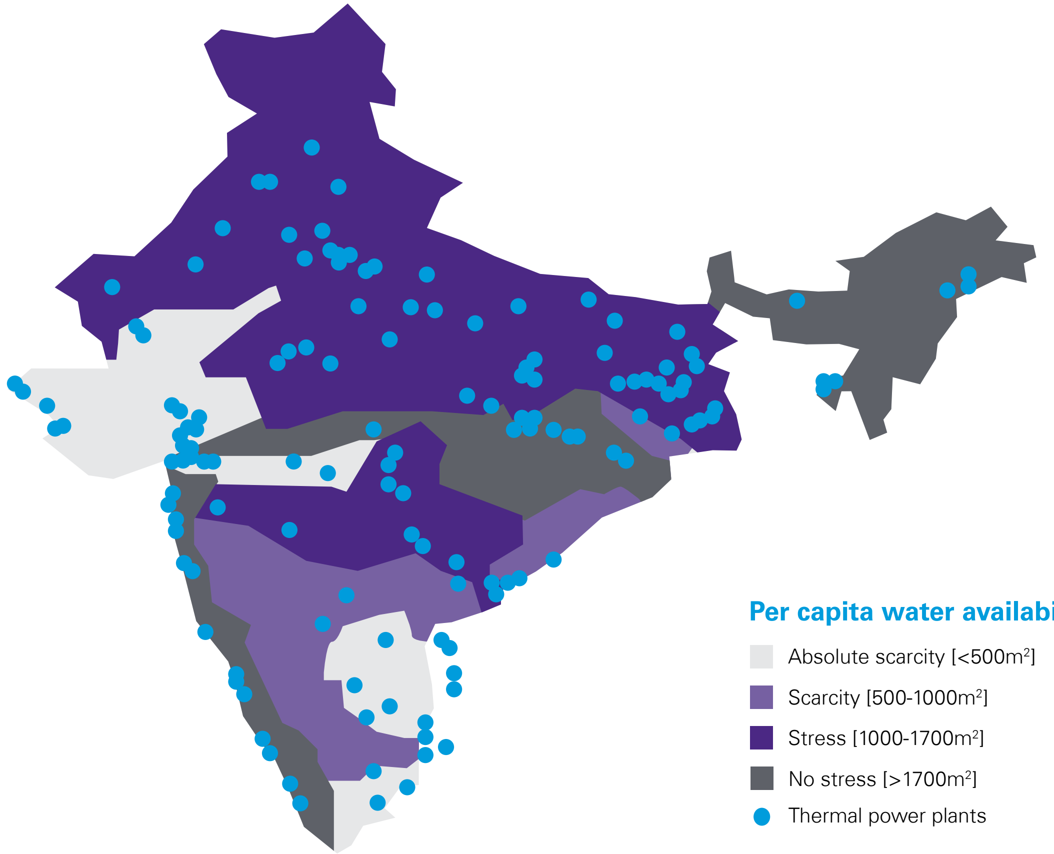
***Sources:** IEA (2018) "WEO. 2018"; Centre for Science and Environment (2015). "Survey to M/s VR Techniche Pvt Ltd to count real-time traffic at nine key entry points into Delhi". Indian Environment Portal, Water Consumption Patterns in Domestic Households in Major Cities (398.3 litres per average Indian household); UNDP India, Urban Water Pricing: Setting the Stage for (1.5 /m3); OECD (2008) "Environmental Outlook. Global water stress: 2030".*
IRENA (2016) "The true cost of fossil fuels: saving on the externalities of air pollution and climate change"; WHO (2016). "Annual mean concentration of PM2.5 in urban areas"; Ministry of Environment, Forest & Climate Change, Government of India (2019). "National Clean Air Programme (NCAP)".

India: Aggregated economic effects of wind energy deployment

Water-efficient sources of energy could reduce up to 90% of water consumption in the power sector.

By 2013, India was already categorized as a high water stress country. Water scarcity is enhanced by the location of coal-based generation plants, as can be seen in the map. In 2014, the UN warned that more than 80% of the coal capacity is located in either water-scarce or water-stressed regions. The deployment more water-efficient sources of electricity (like wind) could reduce up to 90% of water consumption in the sector.

The Water Stress Level of Major River Basins and the distribution of TPPs



Per capita water availability (2010)

- Absolute scarcity [<500m²]
- Scarcity [500-1000m²]
- Stress [1000-1700m²]
- No stress [>1700m²]
- Thermal power plants

Based on Falkenmark Index
[derived from average annual surface water potential]
EFR: East Flowing River
WFR: West Flowing River

Sources: *NITI Aayg (2015) "Report on India's Renewable Electricity Roadmap 2030", NITI Aayog (2018) "SDG India Index. Baseline report". The Social Cost of Carbon. EPA Saving water with wind energy IRENA. The true cost of fossil fuels: saving on the externalities of air pollution and climate change *In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy. UN (2014).*

Note: Map reproduced by KPMG based on the one by the World Resources Institute. The boundaries shown in the maps used do not represent an official KPMG endorsement or acceptance. They have a purely illustrative purpose and aim to convey the specific messages addressed in this report, excluding any positioning on political or geographical issues.

India is now firmly focused on enhancing its share of renewable energy in the basket, with overall installed capacity of renewable energy targeted to grow to 225 GW. This threefold growth will be across technologies with wind making a strong contribution. The report provides an excellent status assessment and account of the growth possibilities of wind power in key geographies including India.

Anish De
Head of Energy and Natural Resources,
KPMG India

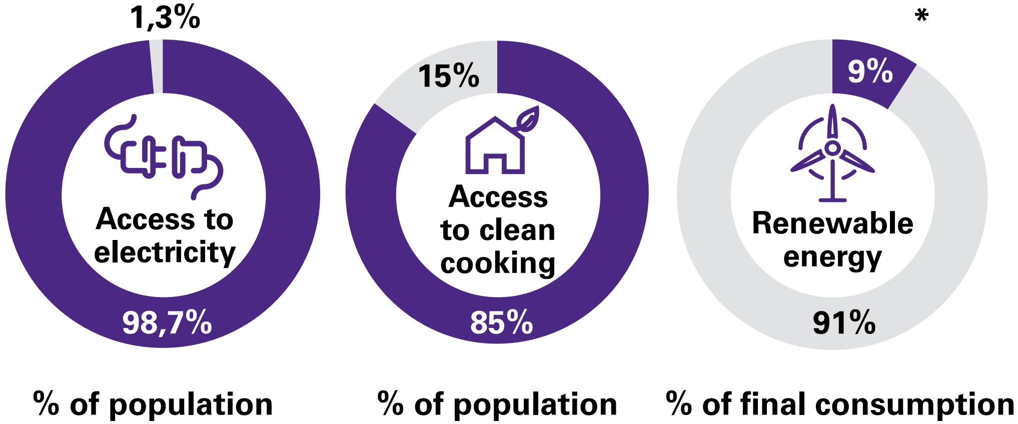
Mexico

Mexico: Current status and deployment of wind energy

Mexico has significantly increased its renewable energy targets since the Paris Agreement and the Energy Reform process started, several years ago. The opening of the sector to private investment is attracting key international players.

Current state/situation

Energy-related SDG Indicators, 2017:



Some hot topics in energy policy:

- Policy shift towards the opening of the energy sector to private investment.
- Mexico pledge to stringent targets.
- Cost of finance.
- Aggressive bidding.
- Recent reform direct PPAs large consumers.
- Recent auction cancellation
- Reinforcement of the electric grid and reduction of losses.

* Share of renewable energy in final consumption (not in power generation), as per IEA, IRENA, UN, World Bank and WHO (2019), "2019 Tracking SDG7. The Energy Progress Report".

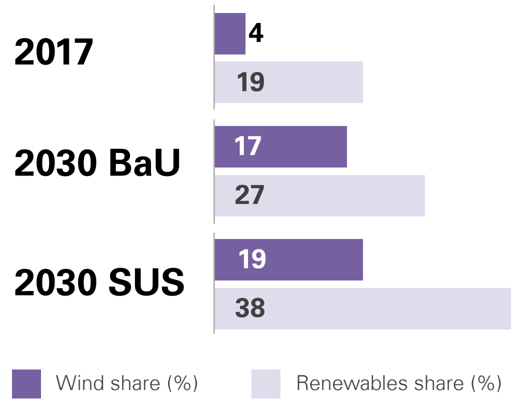
Main pledges and targets

- Specific targets for "clean"* energy share in power generation: 25% by 2018, 30% by 2021, 35% in 2024 and 50% in 2050. CEL (Clean Energy Certificates) obligation for large consumers are the principal measure in place to achieve this goal. The requirement to hold CELs started with a 5% share in 2018 and 5.8% in 2019. This share will increase to 30% by 2021 and 35% in 2024.
- 22% GHG emissions reduction by 2020 with respect to 2000 levels, 50% by 2050.
- Energy efficiency goal: 1.9% average annual reduction in the intensity of final energy consumption for the period 2016-2030, 3.7% for 2031-2050.

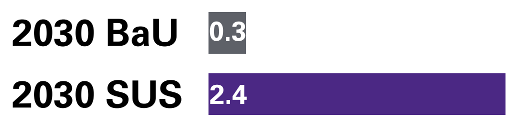
** Includes CHP plants.*

Projections

Forecasted electricity mix



Wind capacity additions needed (GW/year)

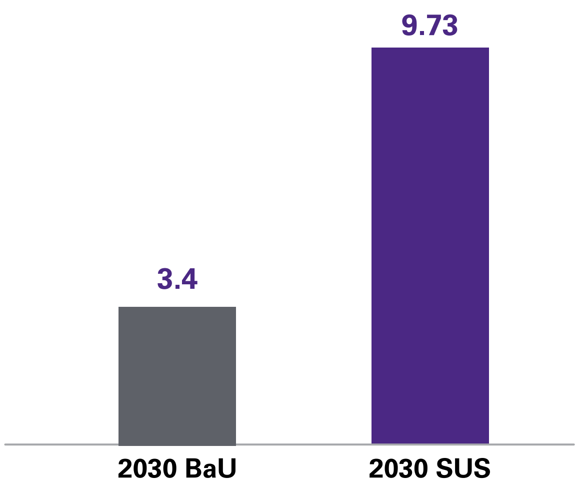


__Sources:__ SENER database (2019), WEO 2018, IEA (2018), "Renewables 2018: Analysis and Forecasts to 2023", SENER "Estrategia para promever el uso de tecnologías y combustibles limpios" (2016). Tracking SDG 7. World Bank; Sustainable Development Goal 7. IEA Wind energy scenarios for 2030. EWEA., Ley de Transición Energética, Diario Oficial de la Federación (24/12/2015).

Mexico: Aggregated economic effects of wind energy deployment

Renewable energy would accelerate GDP growth in Mexico and generate new jobs.

Investment in renewables (USD billion)



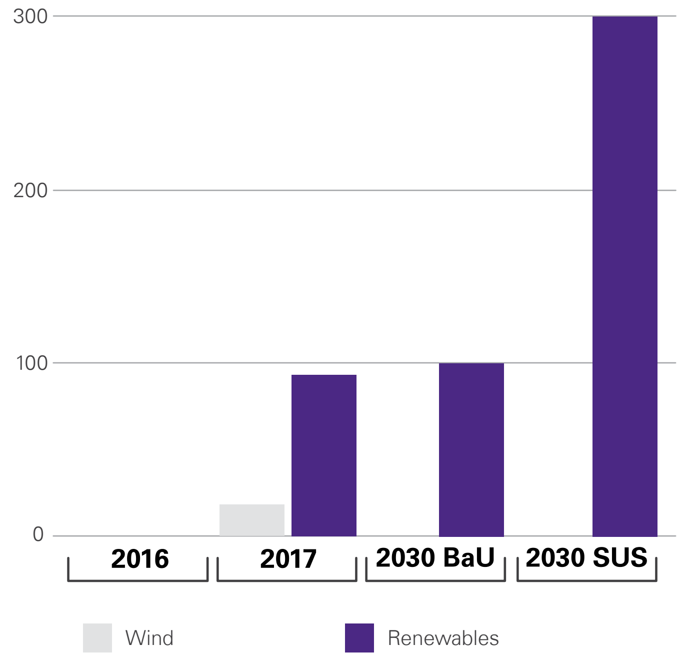
The level of development of wind energy needed in the Sustainable Scenario would entail an extra growth of

1.5% GDP

with respect to the Business As Usual Scenario by 2030.

A clear example of the interest of the markets in RE were the high participation levels in the first electric auctions. In the first two auctions, the investment reached 6.6 USD billion, being awarded the deployment of 52 new clean energy plants.

Employment impact (Thousands of jobs)



The wind sector would generate around 48,000 new jobs (direct and indirect) by 2030.

Sources: *SENER "Estrategia para promever el uso de tecnologías y combustibles limpios" (2016), IRENA Remap database (2019).*

Mexico: Social and environmental effects of wind energy development

Wind and other renewables would have wide benefits for the Mexican society, including large contributions to the mitigation of water scarcity problems.

In a Sustainable Scenario…

1,048 million $
CO_2 emissions avoided by wind energy by 2030

13 CLIMATE ACTION

Wind energy is projected to avoid **20.97 Mt** by 2030

Yearly emissions of...

0.4 X
Ciudad de Mexico

12
million people living in this city

504 million m^3
water use avoided by wind energy by 2030

6 CLEAN WATER AND SANITATION

Equivalent to the annual consumption of

1.5 million **Mexican households**

26 million $ **savings**

Water stress in Mexico by 2030

- No water stress
- Low water stress
- Moderate water stress
- Severe Water stress

0.3% GDP
health-related cost saved up by renewable energy by 2030**

3 GOOD HEALTH AND WELL-BEING

11 SUSTAINABLE CITIES AND COMMUNITIES

Ambient air pollution (PM2.5)

Low | Medium | High | Severe

Up to **3,500 premature deaths**** avoided annually by renewable energy by 2030

** 4 people per household ** 10.1 €/mx$ of water.*
***In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy.*
**** Premature mortality caused by PM2.5 and O3.*
***Estimations:** Exchange rate on 19/3/6: 1.1308 USD/MXN.*

***Sources:** IRENA (2015) "Remap 2030. Mexico"; INEGI. Vehículos de motor registrados en circulación. Sacmex (307 litres per person/day; 4 people per household); Comisión del Agua del Estado de México (10.1 mx$/m3) ; OECD (2008) "Environmental Outlook. Global water stress: 2030" IRENA (2016) "The true cost of fossil fuels: saving on the externalities of air pollution and climate change"; WHO (2016). "Annual mean concentration of PM2.5 in urban areas"; Gobierno del Estado de México (2018). "ProAire 2018-2030" .*

Mexico: social and environmental effects of wind energy deployment

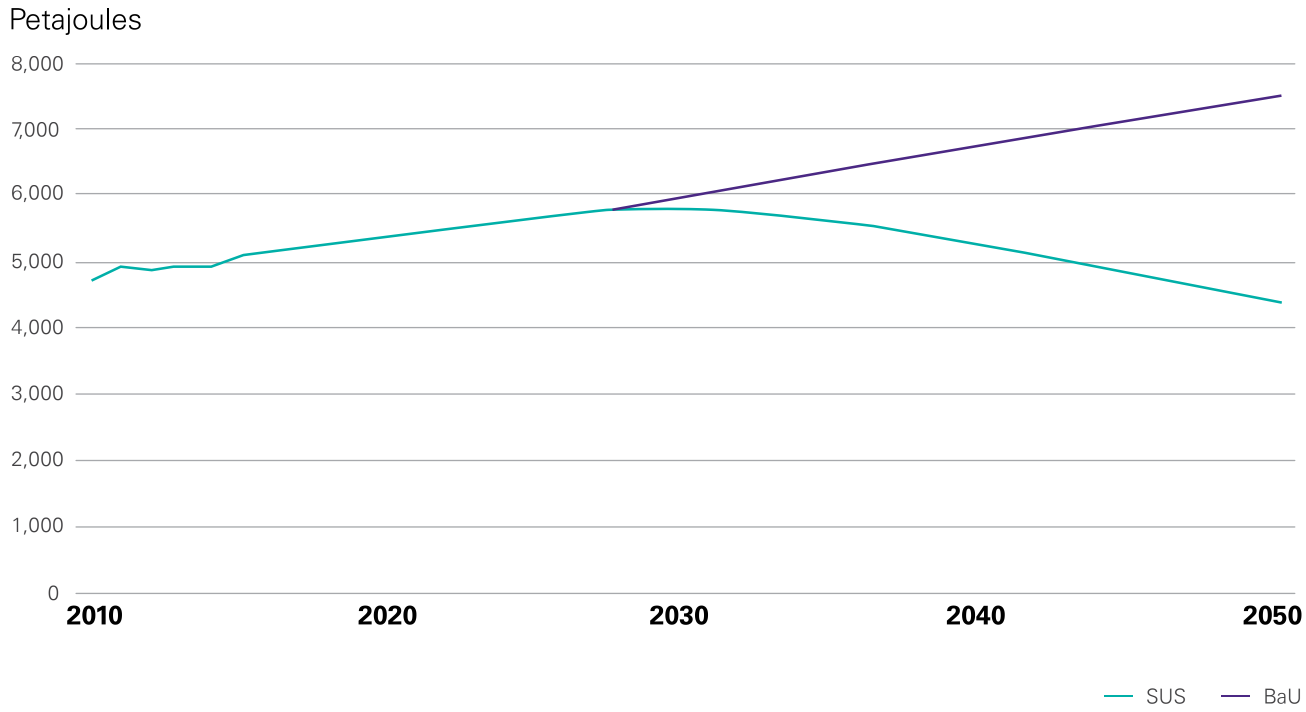
The poorest households would be the ones saving (relatively) the most in a sustainable energy transition. Natural gas imports could decrease significantly.

The increasing deployment of renewables is estimated to reduce up to 15% the monthly electricity bill; being the poor households the ones expected to save the most.

Another benefit from the public policy side, in a Sustainable Scenario the deployment of wind energy would imply a 17% reduction of Natural Gas imports by 2020.

Energy efficiency also plays a major role, in fact, accounts for around 46% reduction of households energy consumption in the last 20 years. The potential to push energy efficiency in a Sustainable Scenario is high, way larger than in the BaU scenario:

Comparison of final energy consumption, 2016-2050



Sources: *SENER "Estrategia para promover el uso de tecnologías y combustibles limpios" (2016), IRENA Remap database (2019). The Social Cost of Carbon. EPA Saving water with wind energy IRENA. The true cost of fossil fuels: saving on the externalities of air pollution and climate change *In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy.*

“If Mexico wants to comply with:

1. **the commitments acquired through the Paris Agreement and,**
2. **its laws and public policies regarding climate change and energy transition,**

then the promotion of new renewable projects needs to be continued during this presidential term.”

Rubén Cruz

Head of Energy and Natural Resources, KPMG Mexico

Spain

Spain: Current status and deployment of wind energy

The latest Spanish Government has set quite ambitious targets to pursue the decarbonization of the economy. These are in track towards its international commitments, but there is political uncertainty.

Current state/situation

Energy -related SDG Indicators, 2016:

% of population | **% of population** | **% of final consumption**

Some hot topics in energy policy:

- Elections / new government / less ambitious targets?
- RE auctions: capacity/year? Technology neutral?
- Evolution of PPA market.
- EU reform of electricity market design.

Main pledges and targets

By 2030:

- 20% reduction (at least), of GHG emissions with respect to 1990 levels.
- 42% share of renewable energy* (at least) in final consumption.
- 39.6% improvement in energy efficiency*.

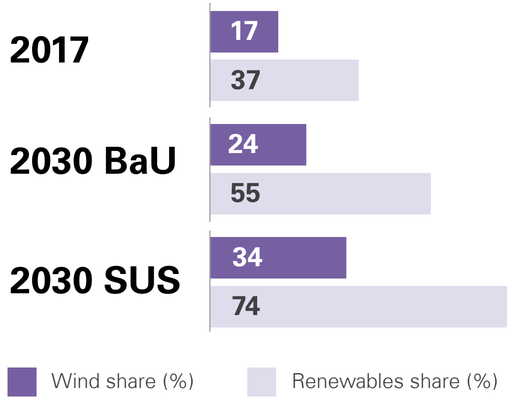
By 2050:

- 90% reduction (at least) in GHG emissions with respect to 1990 levels. Intermediate 2040 target consistent with NECP.
- 100% renewables share in power generation.

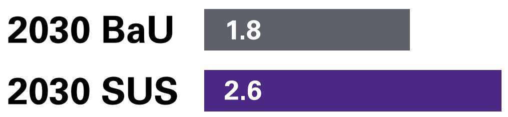
*In the draft bill Spain committed to a 35% renewable energy share by 2030. The formal commitment with the EU is 32%, but the most updated ambition announced in the 2019 NECP is 42% by 2030.
*35% is the formal target but 39,6% is the updated expectation/projection announced in the NECP .

Projections

Forecasted electricity mix



Wind capacity additions needed (GW/year)

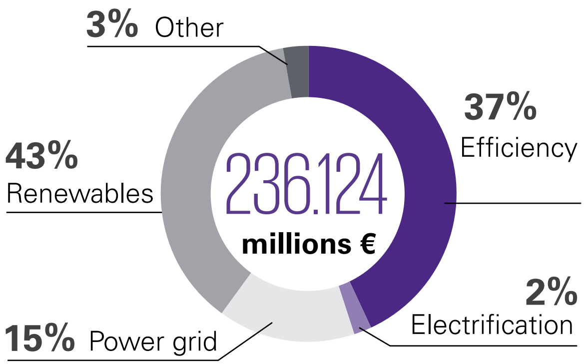


Sources: Spanish NECP (2019), WEO (2018), IEA (2018), "Renewables 2018: Analysis and Forecasts to 2023". Comisión de Expertos de Transición Energética, "Análisis y propuesta para la descarbonización", 2018. Comisión de Expertos de Transición Energética, "Escenarios para el sector energético en España 2030-2050", 2017. "Estudio Macroeconómico. Impacto Sector Eólico en España.", AEE Nov. 2018". European Commission (2016). "Technical report on macroeconomic Member State results of the EUCO policy scenarios". Tracking SDG 7. World Bank; Sustainable Development Goal 7. IEA Wind energy scenarios for 2030.

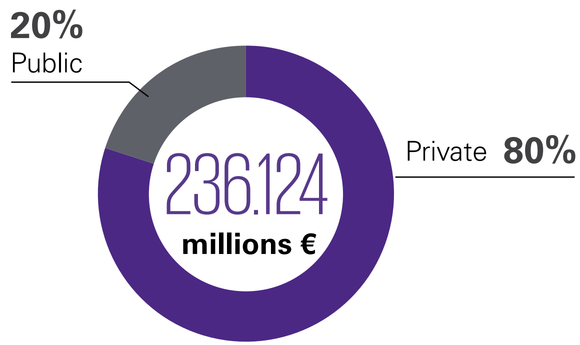
Spain: Aggregated economic effects of wind energy deployment

To achieve the deployment of renewable energy sources in the SUS additional investments are required. However, an improving business case is increasingly attracting private investors. The socioeconomic returns could overcome the costs.

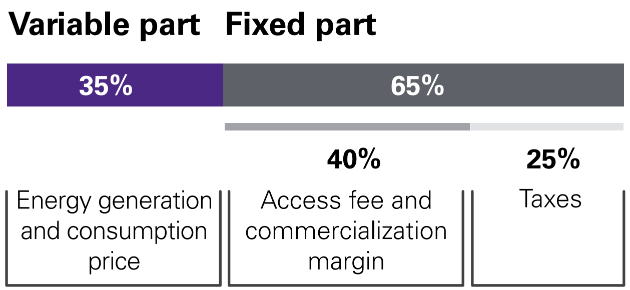
Investment by measure



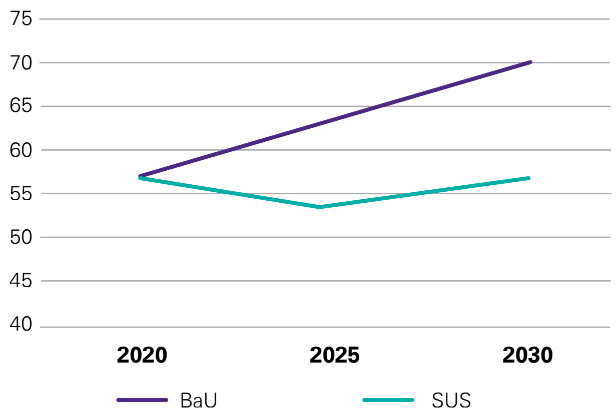
Investment by source



Decomposition of the electric bill



Short-term annual average marginal cost (€/MWh)



Sources: REE. Spanish NECP (2019).

The deployment of renewable energy has a crucial role in the attainment of the sustainable scenario, hence it requires 43% of the total investment in decarbonizing measures.

Due to the large reductions in costs and favorable future prospects for renewables, the vast majority of the funds already comes from private investors (instead of public subsidies like it used to be the case).

The expected return of such investments is positive and significant.

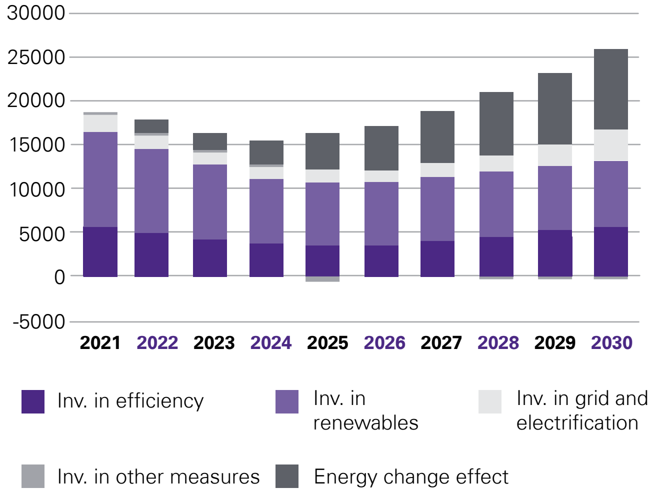
The development of renewable (in the scale necessary for the sustainable scenario) would increase GDP by more than 6000 million euros annually in the period 2021-2030, i.e. 130€ per capita per year.

It would sustain around 150 thousand jobs (direct and indirect) per year, 30 thousand of which just in the wind sector.

Moreover, it would imply additional reductions in the wholesale price, which represents 35% of the total tariff at present.

Recall that wind share within renewable energy is around 45%.

GDP impact by measure (€ million)

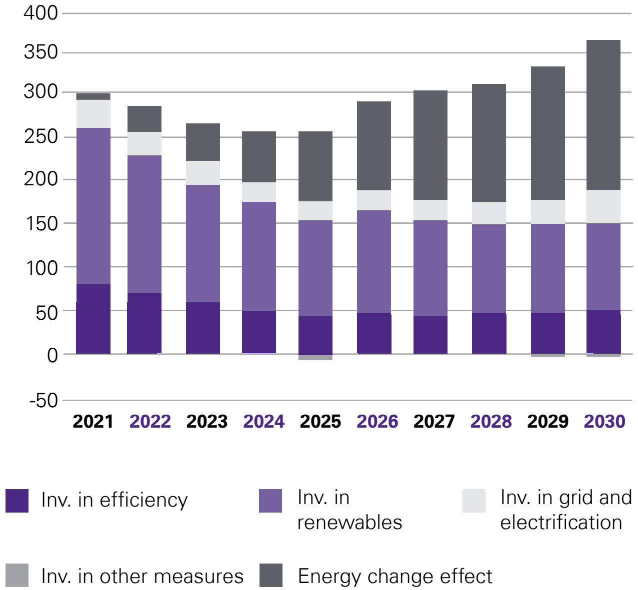


The level of development of wind energy needed in the Sustainable Scenario would entail an extra growth of

0.3% GDP

with respect to the Business As Usual Scenario by 2030.

Employment impact by measure (thousands of people/year)



Sources: *Basque Centre for Climate Change 2019.*

Spain: Social and environmental effects of wind development

The deployment of wind and other renewable energies could have wide economic and health benefits for the Spanish society. It could also help to mitigate water scarcity problems.

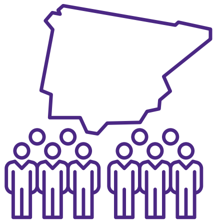
In a Sustainable Scenario...

537 million $
CO_2 emissions avoided by wind energy by 2030

13 CLIMATE ACTION

Wind energy is projected to avoid 10.75 Mt CO_2 by 2030

Yearly emissions of a ...



1 million inhabitants Spanish city

142 million m³
water use avoided by wind energy by 2030

6 CLEAN WATER AND SANITATION

Equivalent to the annual consumption of

1.1 million Spanish households

313 million $ savings

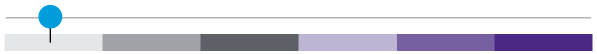
Water stress in Spain by 2030

0.2% GDP
health-related cost saved up by renewable energy by 2030*

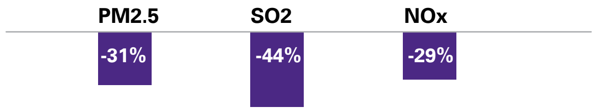
3 GOOD HEALTH AND WELL-BEING

11 SUSTAINABLE CITIES AND COMMUNITIES

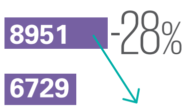
Ambient air pollution (PM2.5)



Air pollutants avoided by 2030 (%)
(compared to 2030 BaU scenario)



Premature deaths avoided by 2030 (persons)



Up to **2,222 premature deaths**** avoided by annually by renewable energy by 2030

**In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy*
*** In a Sustainable Scenario, emissions should decrease due to the higher deployment of renewables, reduction of coal consumption, improved internal combustion engine efficiency and electrification.*
***Estimations:** Exchange rate on 19/3/6: 1.1308 USD/EUR.*

__Sources:__ EWEA (2015). "Wind energy scenarios for 2030"; EPA (2017). "The social cost of carbon"; DGT (2017). "Parque de vehículos, Tablas estadísticas". EWEA (2014), "Saving water with wind energy"; Instituto Nacional de Estadística (136 litres per person/day and 2.5 people per household); EurEau (1.95 €/m3); OECD (2008) "Environmental Outlook. Global water stress: 2030". IRENA (2016) "The true cost of fossil fuels: saving on the externalities of air pollution and climate change"; WHO (2016). "Annual mean concentration of PM2.5 in urban areas"; Government of Spain. 2019. "Integrated National Energy and Climate Plan 2021-2030".

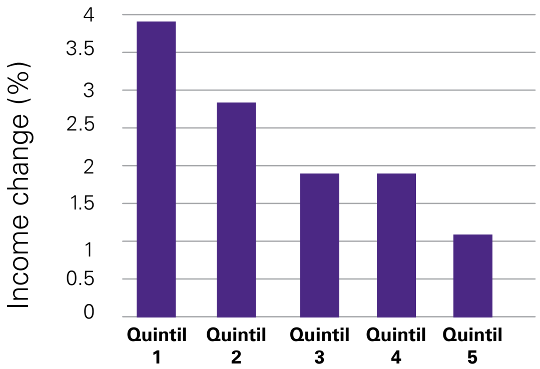
Spain: Social and environmental effects of wind energy deployment

Renewables could translate in savings for households, specially for poorer ones. The economic effects of local pollution would be reduced.

The development of renewable energies, combined with the other official commitments/pledges included/contained in the NECP to move towards a sustainable scenario, would translate into savings in the electricity bill of citizens.

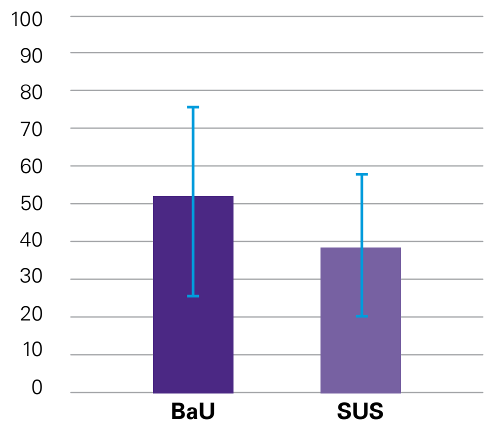
Said savings and resulting increase in disposable income of households would be progressive. The poorest households would save the most in relative terms (3.9% of their income). The richest households would have positive but lower savings in relative terms (1.1%).

Disposable income in 2030 by income quintiles (%)

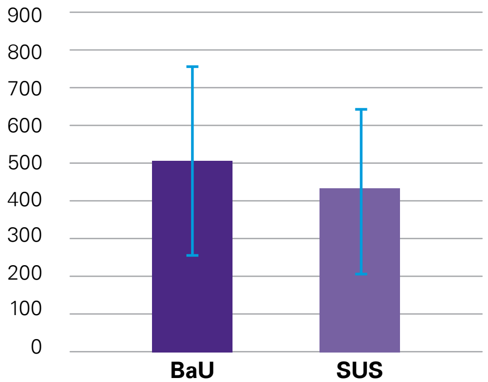


Sources: Basque Centre for Climate Change, 2019. Spanish NECP (2019).

Air pollution damage in 2030 (€ billion)



Air pollution cumulative damage in the period 2021-2030 (€ billion)



Co-benefits in terms of public health are estimated to account for 67 (33 and 100) € billion in the NECP submitted by Spain.

"Spain was a pioneer in the adoption of renewable energy in general, and wind power in particular. After a period of stagnation, new renewable installations have resumed at a strong pace. The recent National Energy and Climate Plan draft published by the Government sets a very ambitious target of 42% renewables on final energy consumption, in which wind power plays a key role with 27 GW net additional capacity to 2030. The main challenge for renewables will be how to be effectively integrated into the system at such high penetrations; storage and interconnections will be key to success."

Alberto Martín Rivals,
Head of Energy & Natural Resources, KPMG Spain

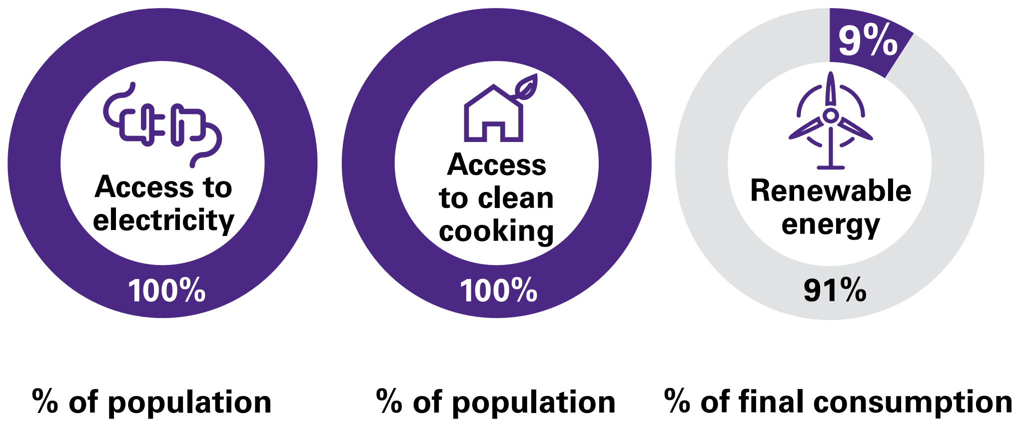
UK

UK: Current status and deployment of wind energy

UK has set quite ambitious targets to reduce GHG emissions. While political uncertainties over Brexit loom over the energy debate, the potential offshore wind market and related exporting industries are high on the agenda.

Current state/situation

Energy-related SDG indicators, 2016



**The EU ambition is a 32,5% efficiency improvement, however in the NECP there commit only to sectorial efficiency targets: 30% in homes and public sector and 20% in business and industry (at least). However, UK is already struggling to reach their commitment of 20% efficiency improvement by 2020.*

Some hot topics in energy policy:

- Reduced renewable electricity policy support, the current government prioritizes limiting the additional costs of renewable energy support on household's bills.
- Gasoline and diesel car sales phase out.
- Coal phase out.
- Strong project pipeline for offshore wind. Steep cost decreases in the segment: to less than £60/ MWh, cheaper than new gas.
- Large potential offshore market.
- Uncertainty on the effects of Brexit on EU ETS.
- Evolution of PPA market.
- Restrictive planning policies for onshore.
- Suspension of Capacity Market (UK's principal mechanism for securing flexible capacity) following ECJ ruling.

Main pledges and targets

By 2030:

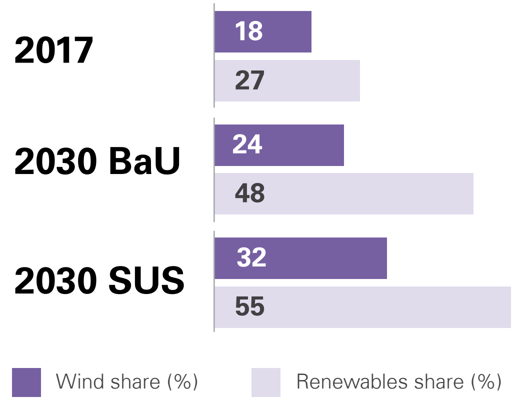
- 32.5% improvement in energy efficiency by 2030.*
- 30 % renewable energy share in power generation by 2020. By 2030, although not an official target, UK's NECP mentions a modelling result from UK Government's Energy and Emissions Projections EEP in which renewables could reach 50% of electricity. There are more ambitious targets at subnational level.
- 20% reduction in primary energy consumption (by 2020).
- Clean Growth Strategy to support businesses to improve energy efficiency by at least 20% by 2030.

By 2050:

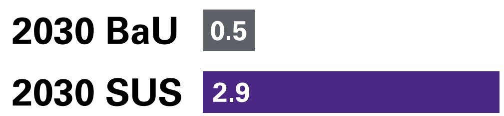
- 34% GHG emissions reduction by 2020 compared to 1990 levels, 80% by 2050; legally binding target.

Projections

Forecasted electricity mix



Wind capacity additions needed (GW/year)



Sources: *UK NECP (2019), WEO 2018, IEA (2018), "Renewables 2018: Analysis and Forecasts to 2023". Tracking SDG 7. World Bank; Sustainable Development Goal 7. IEA Wind energy scenarios for 2030. EWEA, EC (2016), "Technical report on Member State results of the EUCO policy scenarios ", IRENA (2018), "Global Energy Transformation", IRENA (2016), "RE benefits, measuring the economics", IRENA database (2019), Remap country roadmaps, EurObserv'ER database (2019), EC (2018), "Energy statistical pocketbook and country datasheets".*

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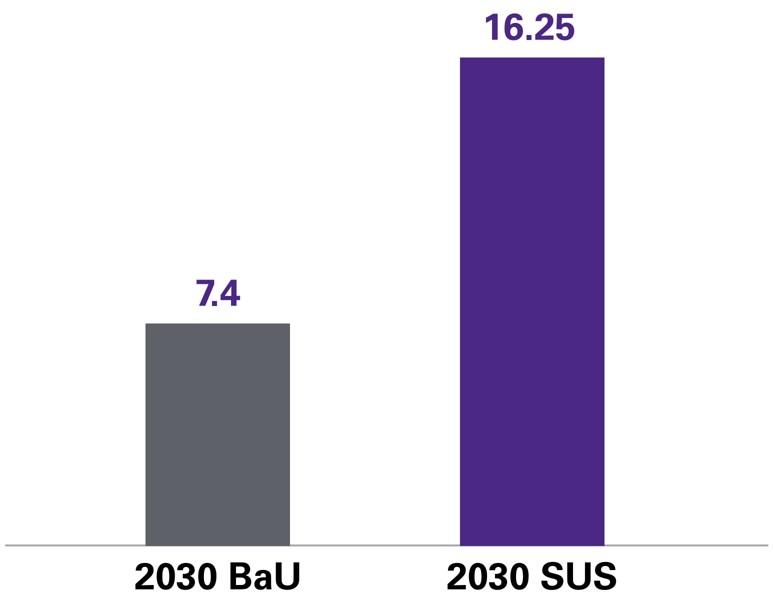
UK: Aggregated economic effects of wind energy deployment

A sustainable scenario would imply $9bn of additional investment.

In order to achieve the renewable energy deployment of the SUS, UK would have to invest US$ 16.25 billion per year (on average) to 2030. The deployment of renewables in the SUS would imply an incremental cost of US$ 9 billion per year in 2030 compared to the BaU scenario.

Yearly investment in renewables until 2030 (average)



"The UK has more offshore wind than any other country in the world. The recent deal between industry and Government aims to deliver 30GW by 2030, which will involve significant further inward investment and moving to deployment of offshore wind without Government subsidies."

Simon Virley
Head of Energy & Natural Resources, KPMG UK

UK: Aggregated economic effects of wind energy deployment

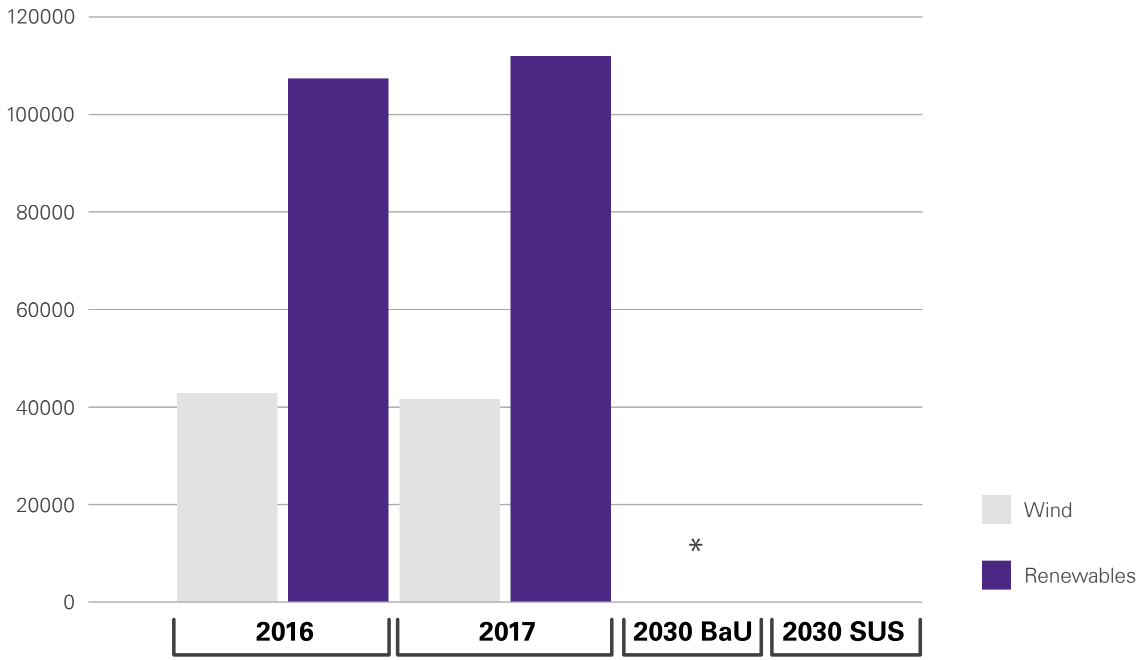
To achieve the deployment of renewable energy sources in the SUS additional investments are required. However, an improving business case is increasingly attracting private investors. The socioeconomic returns could overcome the costs.

The level of development of wind energy needed in the Sustainable Scenario would entail an extra GDP growth of

0.9% GDP

with respect to the Business As Usual Scenario by 2030.

Employment impact by measure (thousands of people/year)



** Projections not available for the whole renewables category. However, according to the European Commission, a Sustainable Scenario would increase total economy-wide employment by up to 227,000 additional jobs.*

Sources: *IRENA (2019), Remap country roadmaps database.*

UK: Social and environmental effects of wind development

The deployment of wind and other renewable energies could reduce carbon emissions of an equivalent of 5.5 times the vehicles in London…

In a Sustainable Scenario…

1,442 million $
CO_2 emissions avoided by wind energy by 2030

13 CLIMATE ACTION

382 million m^3
water use avoided by wind energy by 2030

6 CLEAN WATER AND SANITATION

0.1% GDP
health-related cost saved up by renewable energy by 2030*

3 GOOD HEALTH AND WELL-BEING

11 SUSTAINABLE CITIES AND COMMUNITIES

Wind energy is projected to avoid 28.84 Mt CO_2 by 2030

Yearly emissions of...

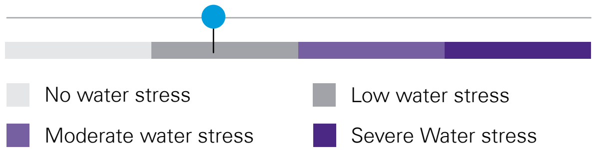
0.3 X London → 9 million people living in this city

Equivalent to the annual consumption of

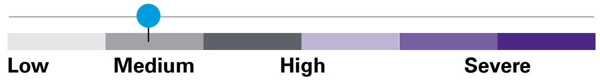
3.1 million **British households**

1.5 billion $ **savings**

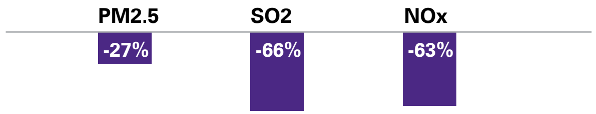
Water stress in UK by 2030



Ambient air pollution (PM2.5)



Air pollutants avoided by 2030** (%)
(compared to 2005 baseline)



Up to 14,000-18,000 premature deaths* avoided by renewable energy by 2030**

*In a Sustainable Scenario, GDP should decrease due to the higher deployment of renewables, cleaner combustion of fossil fuels and reduced use of traditional bioenergy.
** National Atmospheric Emissions Inventory (2012). "UK Emission Projections of Air Quality Pollutants to 2030". NOTE: Emissions projections from Scenario 3, which is base on realistically ambitious assumptions
*** The goal of the Clean Energy Strategy 2019 is to reduce the harm to human health from air pollution by half (28,000-36,000 by 2030).
Estimations: Exchange rate on 19/3/6: 1.1308 USD/GBP.

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UK: Social and environmental effects of wind development

… while providing new economic opportunities.

The UK's government projects a 20 to 25% GHG emissions reduction by 2030 as a result of the policies adopted in the period 2009-2017; while providing new economic opportunities to UK and a 20% increase in energy efficiency for businesses.

In the SUS the UK economy is expected to growth faster delivering £60 to £170 billion of export sales of goods and services by 2030, capturing the gains of UK's leading expertise in wind technologies, power electronic of low-carbon vehicles, electric motors and green finance. In fact, 20% electric vehicles driven in Europe were produced in the UK.

NEWS

The Guardian


Wildlife Energy Pollution

Government throws its weight behind offshore wind power expansion

The Department for Business, Energy and Industrial Strategy (BEIS) said the deal could result in the number of jobs in offshore wind tripling to 27,000 by 2030, boosting the economies of coastal communities near major projects (The Guardian, March 7th 2019)

Sources: *UK NECP (2019).*

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A

Annex: Methodology

I/V

Methodology

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V/V

Methodology

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Wind energy can move a sustainable world

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